

Package ‘terra’

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Description

Methods for spatial data analysis with vector (points, lines, polygons) and raster (grid) data. Methods for vector data include geometric operations such as intersect and buffer. Raster methods include local, focal, global, zonal and geometric operations. The predict and interpolate methods facilitate the use of regression type (interpolation, machine learning) models for spatial prediction, including with satellite remote sensing data. Processing of very large files is supported. See the manual and tutorials on <<https://rspatial.org/>> to get started.

License GPL (>= 3)

URL <https://rspatial.org/>, <https://rspatial.github.io/terra/>

BugReports <https://github.com/rspatial/terra/issues>

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Contents

terra-package	8
activeCat	23
add	24
add_abline	25
add_box	26
add_grid	26
add_legend	27
add_mtext	28
adjacent	29
aggregate	30
agitate	32
align	33
all.equal	34
animate	35
app	36
approximate	38
Arith-methods	40
ar_info	41
as.character	42
as.data.frame	43
as.lines	44
as.list	45
as.points	46
as.polygons	47
as.raster	48
atan2	49
autocorrelation	50
barplot	51
bestMatch	52
boundaries	54
boxplot	55
buffer	56
c	57
cartogram	59

catalyze	60
cells	61
cellSize	62
centroids	64
chunk	65
clamp	66
clamp_ts	67
classify	68
click	70
coerce	71
colors	72
combineGeoms	74
Compare-methods	75
compareGeom	77
concat	78
contour	79
costDist	80
cover	82
crds	83
crop	84
crosstab	86
crs	87
datatype	89
deepcopy	90
densify	91
density	92
deprecated	93
depth	93
describe	94
diff	95
dimensions	96
direction	98
disagg	99
distance	100
divide	103
dots	105
draw	106
elongate	107
erase	108
expand	109
ext	111
extend	112
extract	114
extractAlong	117
extractRange	118
extremes	119
factors	120
fillHoles	122

fillTime	124
flip	125
flowAccumulation	126
focal	128
focal3D	130
focalCpp	132
focalMat	134
focalPairs	135
focalReg	136
focalValues	137
forceCCW	138
freq	138
gaps	140
gdal	140
geom	143
geomtype	144
global	145
graticule	146
gridDist	147
halo	148
headtail	149
hist	150
hull	151
identical	152
ifel	153
image	154
impose	155
initialize	156
inplace	157
inset	159
interpIDW	161
interpNear	162
interpolation	163
intersect	166
is.bool	168
is.empty	170
is.flipped	170
is.lonlat	171
is.rotated	172
is.valid	173
k_means	174
lapp	175
layerCor	177
legend_cont	179
linearUnits	180
lines	181
makeTiles	183
makeVRT	185

map.pal	186
map_extent	187
mask	188
match	189
Math-methods	190
mem	192
merge	193
mergeTime	195
meta	196
metags	196
modal	197
mosaic	198
na.omit	200
NAflag	200
names	201
nearest	202
NIDP	204
normalize.longitude	205
north	206
not.na	207
nseg	208
options	209
origin	210
pairs	211
panel	212
patches	213
perim	214
persp	215
pitfinder	216
plet	217
plot	220
plotRGB	226
plot_extent	228
plot_graticule	229
prcomp	230
predict	231
princomp	234
project	236
proj_pipelines	239
quantile	241
query	242
rangeFill	243
rapp	244
rast	246
rasterize	250
rasterizeGeom	251
rasterizeWin	253
rcl	254

readwrite	255
rectify	257
regress	258
relate	259
rep	261
replace_dollar	262
replace_layers	263
replace_values	264
resample	265
rescale	266
RGB	267
roll	269
rotate	270
rowSums	271
same.crs	272
sapp	273
sbar	274
scale	275
scale_linear	276
scatterplot	277
scoff	278
sds	279
segregate	281
sel	282
selectHighest	283
selectRange	284
serialize	285
setValues	286
shade	287
sharedPaths	288
shift	289
sieve	290
simplifyGeom	291
sort	292
sources	293
SpatExtent-class	294
SpatRaster-class	295
spatSample	295
SpatVector-class	298
spin	298
split	299
sprc	300
stretch	301
subset	303
subset_dollar	304
subset_double	306
subset_single	307
subst	308

summarize	310
summary	313
surfArea	314
svc	315
syndif	316
tapp	317
terrain	318
tessellate	320
text	322
thin	323
thresh	324
tighten	325
tile_apply	326
time	328
tmpFiles	330
toMemory	331
topology	332
transpose	333
trim	334
union	335
unique	336
units	337
update	338
values	340
varnames	341
vect	343
vector_layers	346
viewshed	347
voronoi	348
vrt	349
vrt_files	350
warp_scale	351
watershed	352
weighted.mean	353
where	354
which.lyr	355
width	355
window	356
wrap	357
wrapCache	358
writeCDF	359
writeRaster	361
writeVector	363
xapp	364
xmin	365
xyRowColCell	367
zonal	369
zoom	371

terra-package	<i>Description of the methods in the terra package</i>
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Description

terra provides methods to manipulate geographic (spatial) data in "raster" and "vector" form. Raster data divide space into rectangular grid cells and they are commonly used to represent spatially continuous phenomena, such as elevation or the weather. Satellite images also have this data structure, and in that context grid cells are often referred to as pixels. In contrast, "vector" spatial data (points, lines, polygons) are typically used to represent discrete spatial entities, such as a road, country, or bus stop.

The package implements two main classes (data types): `SpatRaster` and `SpatVector`. `SpatRaster` supports handling large raster files that cannot be loaded into memory; local, focal, zonal, and global raster operations; polygon, line and point to raster conversion; integration with modeling methods to make spatial predictions; and more. `SpatVector` supports all types of geometric operations such as intersections.

Additional classes include `SpatExtent`, which is used to define a spatial extent (bounding box); `SpatRasterDataset`, which represents a collection of sub-datasets for the same area. Each sub-dataset is a `SpatRaster` with possibly many layers, and may, for example, represent different weather variables; and `SpatRasterCollection` and `SpatVectorCollection` that are equivalent to lists of `SpatRaster` or `SpatVector` objects. There is also a `SpatGraticule` class to assist in adding longitude/latitude lines and labels to a map with another coordinate reference system.

These classes hold a C++ pointer to the data "reference class". You should not write scripts that directly access this pointer, as its user-interface is not stable. These pointers make the code run fast, but they cannot be "serialized". That is they cannot be recovered from a saved R session, or passed to nodes on a computer cluster. Generally, you should use `writeRaster` to save `SpatRaster` objects to disk (and pass a filename or cell values to cluster nodes). Also see `wrap` and `saveRDS`. See these [guidelines](#) for parallelization with terra objects.

The "terra" package is a replacement of the "raster" package. "terra" has a very similar, but simpler, interface; it is faster, and it can do much more. At the bottom of this page there is a table that shows differences in the methods between the two packages.

Below is a list of some of the most important methods grouped by theme.

SpatRaster

I. Creating, combining and sub-setting

<code>rast</code>	Create a <code>SpatRaster</code> from scratch, file, or another object
<code>c</code>	Combine <code>SpatRasters</code> (multiple layers)
<code>add<-</code>	Add a <code>SpatRaster</code> to another one

<code>subset</code>	Select layers of a SpatRaster
<code>[[</code>	Select layers of a SpatRaster
<code>\$</code>	Select a layer of a SpatRaster
<code>[[<-</code>	Replace or add a SpatRaster layer
<code>\$<-</code>	Replace or add a SpatRaster layer
<code>selectRange</code>	Select cell values from different layers using an index layer
<code>rep</code>	Repeat layers or a SpatRaster
<code>split</code>	Make a list of single layer SpatRasters
<code>as.character</code>	Get a character representation of a SpatRaster geometry

II. Changing the spatial extent or resolution

Also see the methods in section VIII

<code>merge</code>	Combine SpatRasters with different extents (but same origin and resolution)
<code>mosaic</code>	Combine SpatRasters with different extents using a function for overlapping cells
<code>crop</code>	Select a geographic subset of a SpatRaster
<code>window / window<-</code>	Get or set a processing window for virtual cropping
<code>extend</code>	Add rows and/or columns to a SpatRaster
<code>trim</code>	Trim a SpatRaster by removing exterior rows and/or columns that only have NAs
<code>aggregate</code>	Combine cells of a SpatRaster to create larger cells
<code>disagg</code>	Subdivide cells
<code>resample</code>	Resample (warp) values to a SpatRaster with a different origin and/or resolution
<code>project</code>	Project (warp) values to a SpatRaster with a different coordinate reference system
<code>shift</code>	Adjust the location of SpatRaster
<code>flip</code>	Flip values horizontally or vertically
<code>rotate</code>	Rotate values around the date-line (for lon/lat data)
<code>t</code>	Transpose a SpatRaster

III. Local (cell based) methods

Apply-like methods:

<code>app</code>	Apply a function to all cells, across layers, typically to summarize (as in <code>base::apply</code>)
<code>tapp</code>	Apply a function to groups of layers (as in <code>base::tapply</code> and <code>stats::aggregate</code>)
<code>lapp</code>	Apply a function to a SpatRaster, using its layers as arguments
<code>sapp</code>	Apply a function to each layer
<code>rapp</code>	Apply a function to a spatially variable range of layers
<code>xapp</code>	Apply a function across two SpatRasters layer-wise

Arithmetic, logical, and standard math methods:

Arith-methods	Standard arithmetic methods (+, -, *, ^, %, %/, /)
Compare-methods	Comparison methods for SpatRaster (==, !=, >, <, <=, >=, is.na, is.finite)
not.na	a one-step equivalent to !is.na
Summary-methods	mean, max, min, median, sum, range, prod, any, all, stdev, which.min, which.max, anyNA, noNA, allNA
modal	Modal value across layers
Logic-methods	Boolean methods (!, &,)
Math-methods	abs, sign, sqrt, ceiling, floor, trunc, cummax, cummin, cumprod, cumsum, log, log10, log2, log1p, acos, acosh, asin, asinh, atan, atanh, exp, expm1, cos, cosh, sin, sinh, tan, tanh, round, signif
scale_linear	Linear rescaling to a numeric range
weighted.mean	Weighted mean of raster layers
where.min / where.max	Layer index of min/max per cell
match / %in%	Value matching for SpatRaster
rowSums / rowMeans	row summaries
colSums / colMeans	column summaries
as.bool	create a Boolean (logical) SpatRaster
as.int	create an integer (whole numbers) SpatRaster

Other methods:

approximate	Compute missing values for cells by interpolation across layers
roll	Rolling functions such as the rolling mean
clamp	Restrict cell values to a minimum and/or maximum value
cellSize	Compute the area of cells
surfArea	Surface area per raster cell considering slope
classify	(Re-)classify values
subst	Substitute (replace) cell values
cover	First layer covers second layer except where the first layer is NA
init	Initialize cells with new values
mask	Replace values in a SpatRaster based on values in another SpatRaster
which.lyr	which is the first layer that is TRUE?
segregate	Make a 0/1 layer for each unique value
rangeFill	Make a 0/1 SpatRaster for a time series
extractRange	Extract min-max range across layers
regress	Cell-based regression models
selectHighest	Keep highest values across layers
thresh	Threshold raster layers
identical	Test near-identity of SpatRaster objects
all.equal	Compare SpatRaster objects with a degree of tolerance
divide	Divide rasters in areas of equal cell value sums

IV. Zonal and global methods

<code>expand</code>	Compute the summed area of cells
<code>crossstab</code>	Cross-tabulate two SpatRasters
<code>freq</code>	Frequency table of SpatRaster cell values
<code>global</code>	Summarize SpatRaster cell values with a function
<code>quantile</code>	Quantiles
<code>layerCor</code>	Correlation between layers
<code>stretch</code>	Stretch values
<code>scale</code>	Scale values
<code>summary</code>	Summary of the values of a SpatRaster (quantiles and mean)
<code>unique</code>	Get the unique values in a SpatRaster
<code>zonal</code>	Summarize a SpatRaster by zones in another SpatRaster

V. Situation (spatial context) based methods

<code>adjacent</code>	Identify cells that are adjacent to a set of cells of a SpatRaster
<code>boundaries</code>	Detection of boundaries (edges)
<code>distance</code>	Shortest distance to a cell that is not NA or to or from a vector object
<code>gridDist</code>	Shortest distance through adjacent grid cells
<code>costDist</code>	Shortest distance considering cell-varying friction
<code>direction</code>	Direction (azimuth) to or from cells that are not NA
<code>focal</code>	Focal (neighborhood; moving window; convolution) functions
<code>focal3D</code>	Three dimensional (row, col, lyr) focal functions
<code>focalCpp</code>	Faster focal by using custom C++ functions
<code>focalReg</code>	Regression between layers for focal areas
<code>focalPairs</code>	Apply a function (e.g. a correlation coefficient) to focal values for pairs of layers
<code>focalMat</code>	Make a focal weights matrix
<code>focalValues</code>	Extract focal window values
<code>patches</code>	Find patches (clumps)
<code>sieve</code>	Sieve filter to remove small patches
<code>autocor</code>	Compute global or local spatial autocorrelation
<code>terrain</code>	Compute slope, aspect and other terrain characteristics from elevation data
<code>viewshed</code>	Compute viewshed (showing areas that are visible from a particular location)
<code>shade</code>	Compute hill shade from slope and aspect layers
<code>watershed</code>	Watersheds from flow directions
<code>flowAccumulation</code>	Flow accumulation from flow directions
<code>pitfinder</code>	Find pits in elevation
<code>NIDP</code>	Immediate upstream flow counts

VI. Model predictions

<code>predict</code>	Predict a non-spatial (regression or classification) model to a <code>SpatRaster</code>
<code>interpolate</code>	Predict a spatial model to a <code>SpatRaster</code>
<code>interpIDW</code>	Inverse-distance-weighted interpolation
<code>interpNear</code>	Nearest neighbor interpolation
<code>k_means</code>	k-means clustering of <code>SpatRaster</code> data
<code>princomp</code> and <code>prcomp</code>	Principal Component Analysis (PCA) with raster data

VII. Accessing cell values

Apart from the functions listed below, you can also use indexing with `[]` with cell numbers, and row and/or column numbers

<code>values</code>	cell values (fails with very large rasters)
<code>values<-</code>	Set new values to the cells of a <code>SpatRaster</code>
<code>setValues</code>	Set new values to the cells of a <code>SpatRaster</code>
<code>as.matrix</code>	Get cell values as a matrix
<code>as.array</code>	Get cell values as an array
<code>as.data.frame</code>	get cell values as a data.frame (including class labels)
<code>extract</code>	Extract cell values from a <code>SpatRaster</code> (with cell numbers, coordinates, points, lines, or polygons)
<code>extractAlong</code>	Extract cell values along a line such that the values are in the right order
<code>spatSample</code>	Take a sample (regular, random, stratified, weighted) sample from a <code>SpatRaster</code>
<code>minmax</code>	Get the minimum and maximum value of the cells of a <code>SpatRaster</code> (if known)
<code>setMinMax</code>	Compute the minimum and maximum value of a <code>SpatRaster</code> if these are not known

VIII. Getting and setting dimensions and some other properties

Get or set basic parameters of `SpatRasters`. If there are values associated with a `SpatRaster` (either in memory or via a link to a file) these are lost when you change the number of columns or rows or the resolution. This is not the case when the extent is changed (as the number of columns and rows will not be affected). Similarly, with `crs` you can set the coordinate reference system, but this does not transform the data (see [project](#) for that).

<code>ncol</code>	The number of columns
<code>nrow</code>	The number of rows
<code>ncell</code>	The number of cells (can not be set directly, only via <code>ncol</code> or <code>nrow</code>)
<code>res</code>	The resolution (x and y)
<code>nlyr</code>	Get or set the number of layers
<code>names</code>	Get or set the layer names
<code>varnames / varnames<-</code>	Get or set dataset names
<code>longnames / longnames<-</code>	Get or set dataset names
<code>xres</code>	The x resolution (can be set with <code>res</code>)

<code>yres</code>	The y resolution (can be set with <code>res</code>)
<code>xmin</code>	The minimum x coordinate (or longitude)
<code>xmax</code>	The maximum x coordinate (or longitude)
<code>ymin</code>	The minimum y coordinate (or latitude)
<code>ymax</code>	The maximum y coordinate (or latitude)
<code>ext</code>	Get or set the extent (minimum and maximum x and y coordinates; "bounding box")
<code>origin</code>	The origin of a <code>SpatRaster</code>
<code>sources</code>	Get the filename(s) to which a <code>SpatRaster</code> is linked
<code>inMemory</code>	Are the data sources in memory (or on disk)?
<code>toMemory</code>	Force data sources to memory (not recommended)?
<code>compareGeom</code>	Compare the geometry of <code>SpatRasters</code>
<code>NAflag</code>	Set the NA value (for reading from a file with insufficient metadata)
<code>units / units<-</code>	Layer measurement units
<code>is.rotated</code>	Whether a <code>SpatRaster</code> is rotated
<code>is.flipped</code>	Whether a <code>SpatRaster</code> is flipped
<code>datatype</code>	Storage datatype of layers
<code>scoff / scoff<-</code>	Scale-offset values

IX. Computing row, column, cell numbers and coordinates

Cell numbers start at 1 in the upper-left corner. They increase within rows, from left to right, and then row by row from top to bottom. Likewise, row numbers start at 1 at the top of the raster, and column numbers start at 1 at the left side of the raster.

<code>xFromCol</code>	x-coordinates from column numbers
<code>yFromRow</code>	y-coordinates from row numbers
<code>xFromCell</code>	x-coordinates from cell numbers
<code>yFromCell</code>	y-coordinates from cell numbers
<code>xyFromCell</code>	x and y coordinates from cell numbers
<code>colFromX</code>	Column numbers from x-coordinates (or longitude)
<code>rowFromY</code>	Row numbers from y-coordinates (or latitude)
<code>rowColFromCell</code>	Row and column numbers from cell numbers
<code>cellFromXY</code>	Cell numbers from x and y coordinates
<code>cellFromRowCol</code>	Cell numbers from row and column numbers
<code>cellFromRowColCombine</code>	Cell numbers from all combinations of row and column numbers
<code>cells</code>	Cell numbers for a <code>SpatVector</code> or <code>SpatExtent</code>

X. Depth related methods

`depth` can be used to explicitly get or set a third or fourth dimension of a `SpatRaster`.

<code>depth</code>	Get or set depth dimension values
<code>depthName</code>	Set or get the depth name
<code>depthUnit</code>	Set or get the depth unit

XI. Time related methods

`time` can be used to explicitly get or set a third or fourth dimension of a `SpatRaster`.

<code>time</code>	Get or set time
<code>fillTime</code>	can add empty layers in between existing layers to assure that the time step between layers is constant
<code>mergeTime</code>	combine multiple rasters, perhaps partly overlapping in time, into a single time series
<code>clamp_ts</code>	Clamp time-series values

XII. Methods for categorical rasters

<code>is.factor</code>	Are there categorical layers?
<code>levels</code>	Get active categories, or set categories
<code>activeCat</code>	Get or set the active category
<code>cats</code>	Get categories (active and inactive)
<code>set.cats</code>	Set categories in place
<code>concats</code>	Combine <code>SpatRasters</code> with different categories
<code>catalyze</code>	Create a layer for each category
<code>as.numeric</code>	use the active category to create a non-categorical <code>SpatRaster</code>
<code>as.factor</code>	Make the layers of a <code>SpatRaster</code> categorical

XIII. Writing `SpatRaster` files

Basic:

<code>writeRaster</code>	Write all values of <code>SpatRaster</code> to disk. You can set the filetype, datatype, compression.
<code>writeCDF</code>	Write <code>SpatRaster</code> data to a netCDF file

Advanced:

<code>readStart</code>	Open file connections for efficient multi-chunk reading
<code>readValues</code>	Read some values from an opened file
<code>readStop</code>	Close file connections
<code>writeStart</code>	Open a file for writing
<code>writeValues</code>	Write some values to an opened file
<code>writeStop</code>	Close the file after writing
<code>blocks</code>	Get blocksize for reading files (when not writing)

XIV. Tiles

<code>chunk</code>	Iterate over raster chunks
<code>makeVRT</code>	Build a GDAL virtual raster (VRT) from files
<code>vrt</code>	Virtual raster from filenames or a collection
<code>vrt_tiles</code>	List VRT tile sources

XV. Miscellaneous SpatRaster methods

<code>terraOptions</code>	Show, set, or get session options, mostly to control memory use and to set write options
<code>sources</code>	Show the data sources of a SpatRaster
<code>tmpFiles</code>	Show or remove temporary files
<code>mem_info</code>	memory needs and availability
<code>inMemory</code>	Are the cell values in memory?
<code>deepcopy</code>	Deep copy of SpatRaster
<code>describe</code>	Summarize raster file sources
<code>same.crs</code>	Compare two CRS strings
<code>ar_info</code>	Inspect NetCDF-like multi-array files
<code>gdal</code>	set GDAL warning level
<code>set/getGDALconfig</code>	GDAL session utilities
<code>meta</code>	Metadata from a SpatRaster
<code>metags / metags<-</code>	Arbitrary metadata tags
<code>tighten</code>	combine data sources into one

XVI. SpatRasterDataset

A SpatRasterDataset contains SpatRasters that represent sub-datasets for the same area. They all have the same extent and resolution.

<code>sds</code>	Create a SpatRasterDataset from a file with subdatasets (ncdf or hdf) or from SpatRasters
<code>[or \$</code>	Extract a SpatRaster
<code>names</code>	Get the names of the sub-datasets

XVII. SpatRasterCollections

A SpatRasterCollection is a vector of SpatRaster objects. Unlike for a SpatRasterDataset, there the extent and resolution of the SpatRasters do not need to match each other.

sprc	create a SpatRasterCollection from (a list of) SpatRasters
length	how many SpatRasters does the SpatRasterCollection have?
crop	crop a SpatRasterCollection
impose	force the members of SpatRasterCollection to the same geometry
merge	merge the members of a SpatRasterCollection
mosaic	mosaic (merge with a function for overlapping areas) the members of a SpatRasterCollection
[extract a SpatRaster

SpatVector

XVIII. Create SpatVector objects

vect	Create a SpatVector from a file (for example a "shapefile") or from another object
vector_layers	list or delete layers in a vector database such as GPKG
rbind	append SpatVectors of the same geometry type
unique	remove duplicates
na.omit	remove empty geometries and/or fields that are NA
project	Project a SpatVector to a different coordinate reference system
writeVector	Write SpatVector data to disk
centroids	Get the centroids of a SpatVector
voronoi	Voronoi diagram
delauay	Delaunay triangles
hull	Compute a convex, circular, or rectangular hull around the (geometries of) a SpatVector
fillHoles	Remove or extract holes from polygons
densify	Add vertices along lines or polygons
thinNodes	Remove vertices along lines or polygons
split	Split a SpatVector based on values of an attribute

XIX. Properties of SpatVector objects

geom	returns the geometries as matrix or WKT
crds	returns the coordinates as a matrix
ncol	The number of columns (of the attributes)
nrow	The number of rows (of the geometries and attributes)
names	Get or set the layer names

<code>ext</code>	Get the extent (minimum and maximum x and y coordinates ("bounding box"))
<code>crs</code>	The coordinate reference system (map projection)
<code>linearUnits</code>	returns the linear units of the crs (in meter)
<code>is.lonlat</code>	Test if an object has (or may have) a longitude/latitude coordinate reference system
<code>geomtype</code>	Geometry type string
<code>is.lines / is.points</code>	Geometry type tests
<code>is.polygons</code>	

XX. Geometric queries

<code>adjacent</code>	find adjacent polygons
<code>expanse</code>	computes the area covered by polygons
<code>nearby</code>	find nearby geometries
<code>nearest</code>	find the nearest geometries
<code>relate</code>	geometric relationships such as "intersects", "overlaps", and "touches"
<code>perim</code>	computes the length of the perimeter of polygons, and the length of lines

XXI. Geometric operations

<code>erase</code> or "-"	erase (parts of) geometries
<code>intersect</code> or "*"	intersect geometries
<code>union</code> or "+"	Merge geometries
<code>cover</code>	update polygons
<code>symdif</code>	symmetrical difference of two polygons
<code>aggregate</code>	dissolve smaller polygons into larger ones
<code>buffer</code>	buffer geometries
<code>disagg</code>	split multi-geometries into separate geometries
<code>crop</code>	clip geometries using a rectangle (SpatExtent) or SpatVector
<code>divide</code>	divide polygons into equal areas
<code>thin</code>	remove geometries that are too close to another

XXII. SpatVector attributes

We use the term "attributes" for the tabular data (data.frame) associated with vector geometries.

<code>extract</code>	spatial queries between <code>SpatVector</code> and <code>SpatVector</code> (e.g. point in polygons)
<code>spatSample</code>	Take a regular or random point sample from polygons or lines
<code>sel</code>	select - interactively select geometries
<code>click</code>	identify attributes by clicking on a map
<code>merge</code>	Join a table with a <code>SpatVector</code>
<code>as.data.frame</code>	get attributes as a <code>data.frame</code>
<code>as.list</code>	get attributes as a list
<code>values</code>	Get the attributes of a <code>SpatVector</code>
<code>values<-</code>	Set new attributes to the geometries of a <code>SpatVector</code>
<code>sort</code>	sort <code>SpatVector</code> by the values in a field
<code>query</code>	Read features from a <code>SpatVectorProxy</code>

XXIII. Change geometries (for display, experimentation)

<code>shift</code>	change the position geometries by shifting their coordinates in horizontal and/or vertical direction
<code>spin</code>	rotate geometries around an origin
<code>rescale</code>	shrink (or expand) geometries, for example to make an inset map
<code>flip</code>	flip geometries vertically or horizontally
<code>t</code>	transpose geometries (switch x and y)
<code>agitate</code>	Randomly perturb coordinates for plotting

XXIV. Geometry properties and topology

<code>width</code>	the minimum diameter of the geometries
<code>clearance</code>	the minimum clearance of the geometries
<code>sharedPaths</code>	shared paths (arcs) between line or polygon geometries
<code>simplifyGeom</code>	simplify geometries
<code>gaps</code>	find gaps between polygon geometries
<code>fillHoles</code>	get or remove the polygon holes
<code>makeNodes</code>	create nodes on lines
<code>mergeLines</code>	connect lines to form polygons
<code>removeDupNodes</code>	remove duplicate nodes in geometries and optionally rounds the coordinates
<code>is.valid</code>	check if geometries are valid
<code>makeValid</code>	attempt to repair invalid geometries
<code>snap</code>	make boundaries of geometries identical if they are very close to each other
<code>erase</code> (single argument)	remove parts of geometries that overlap
<code>union</code> (single argument)	create new polygons such that there are no overlapping polygons
<code>rotate</code>	rotate to (dis-) connect them across the date-line
<code>normalize.longitude</code>	move geometries that are outside of the -180 to 180 degrees range.
<code>elongate</code>	make lines longer by extending both sides
<code>combineGeoms</code>	combine geometries that overlap, share a border, or are within a minimum distance of each other

<code>forceCCW</code>	force counter-clockwise polygon winding
-----------------------	---

XXV. SpatVectorCollections

A SpatVectorCollection is a vector of SpatVector objects.

<code>svc</code>	create a SpatVectorCollection from (a list of) SpatVector objects
<code>length</code>	how many SpatVectors does the SpatVectorCollection have?
<code>[</code>	extract a SpatVector

XXVI. Coordinate reference system method

<code>crs</code>	Get or set the coordinate reference system (map projection) of a Spat* object
<code>is.lonlat</code>	Test if an object has (or may have) a longitude/latitude coordinate reference system
<code>linearUnits</code>	returns the linear units of the crs (in meter)

Other classes

XXVII. SpatExtent

<code>ext</code>	Create a SpatExtent object. For example to <code>crop</code> a Spatial dataset
<code>intersect</code>	Intersect two SpatExtent objects, same as -
<code>union</code>	Combine two SpatExtent objects, same as +
<code>Math-methods</code>	round/floor/ceiling of a SpatExtent
<code>align</code>	Align a SpatExtent with a SpatRaster
<code>draw</code>	Create a SpatExtent by drawing it on top of a map (plot)

XXVIII. SpatGraticule

<code>graticule</code>	Create a graticule
<code>crop</code>	crop a graticule
<code>plot<SpatGraticule></code>	plot a graticule

General methods**XXIX. Conversion between spatial data objects from different packages**

You can coerce SpatRasters to Raster* objects, after loading the raster package, with `as(object, "Raster")`, or `raster(object)` or `brick(object)` or `stack(object)`

<code>rast</code>	SpatRaster from matrix and other objects
<code>vect</code>	SpatVector from sf or Spatial* vector data
<code>sf::st_as_sf</code>	sf object from SpatVector
<code>rasterize</code>	Rasterizing points, lines or polygons
<code>rasterizeWin</code>	Rasterize points with a moving window
<code>rasterizeGeom</code>	Rasterize attributes of geometries such as "count", "area", or "length"
<code>as.points</code>	Create points from a SpatRaster or SpatVector
<code>as.lines</code>	Create lines from a SpatRaster or SpatVector
<code>as.polygons</code>	Create polygons from a SpatRaster
<code>as.contour</code>	Contour lines from a SpatRaster

XXX. Plotting**Maps:**

<code>plot</code>	Plot a SpatRaster or SpatVector. The main method to create a map
<code>panel</code>	Combine multiple plots
<code>points</code>	Add points to a map
<code>lines</code>	Add lines to a map
<code>polys</code>	Add polygons to a map
<code>text</code>	Add text (such as the values of a SpatRaster or SpatVector) to a map
<code>halo</code>	Add text with a halo to a map
<code>map.pal</code>	Color palettes for mapping
<code>image</code>	Alternative to plot to make a map with a SpatRaster
<code>plotRGB</code>	Combine three layers (red, green, blue channels) into a single "real color" plot
<code>plot<SpatGraticule></code>	plot a graticule
<code>sbar</code>	Add a scale bar to a map

<code>north</code>	Add a north arrow to a map
<code>inset</code>	Add a small inset (overview) map
<code>add_legend</code>	Add a legend to a map
<code>add_box</code>	Add a bounding box to a map
<code>map_extent</code>	Get the coordinates of a map's axes positions
<code>dots</code>	Make a dot-density map
<code>cartogram</code>	Make a cartogram
<code>persp</code>	Perspective plot of a SpatRaster
<code>contour</code>	Contour plot or filled-contour plot of a SpatRaster
<code>colorize</code>	Combine three layers (red, green, blue channels) into a single layer with a color-table
<code>add_abline</code>	Add abline to a map
<code>add_mtext</code>	Add margin text (mtext)
<code>add_grid</code>	Add a reference grid
<code>animate</code>	Animate raster or vector layers
<code>plet</code>	Make an interactive (leaflet) map
<code>scatter plot</code>	Scatter plot of two SpatRasters
<code>has.colors</code>	Do layers in a SpatRaster have a color table?
<code>coltab / coltab<-</code>	Get or set color tables

Interacting with a map:

<code>zoom</code>	Zoom in to a part of a map by drawing a bounding box on it
<code>click</code>	Query values of SpatRaster or SpatVector by clicking on a map
<code>sel</code>	Select a spatial subset of a SpatRaster or SpatVector by drawing on a map
<code>draw</code>	Create a SpatExtent or SpatVector by drawing on a map

Other plots:

<code>plot</code>	x-y scatter plot of the values of (a sample of) the layers of two SpatRaster objects
<code>hist</code>	Histogram of SpatRaster values
<code>barplot</code>	Bar plot of a SpatRaster
<code>density</code>	Density plot of SpatRaster values
<code>pairs</code>	Pairs plot for layers in a SpatRaster
<code>boxplot</code>	Box plot of the values of a SpatRaster

Comparison with the raster package

XXXI. New method names

terra has a single class SpatRaster for which raster has three (RasterLayer, RasterStack, RasterBrick). Likewise there is a single class for vector data SpatVector that replaces six

Spatial* classes. Most method names are the same, but note the following important differences in methods names with the raster package

raster package	terra package
raster, brick, stack	<code>rast</code>
rasterFromXYZ	<code>rast(, type="xyz")</code>
stack, addLayer	<code>c</code>
addLayer	<code>add<-</code>
area	<code>cellSize</code> or <code>expand</code>
approxNA	<code>approximate</code>
calc	<code>app</code>
cellFromLine, cellFromPolygon,	<code>cells</code>
cellsFromExtent	<code>cells</code>
cellStats	<code>global</code>
clump	<code>patches</code>
compareRaster	<code>compareGeom</code>
corLocal	<code>focalPairs</code>
coordinates	<code>crds</code>
couldBeLonLat	<code>is.lonlat</code>
disaggregate	<code>disagg</code>
distanceFromPoints	<code>distance</code>
drawExtent, drawPoly, drawLine	<code>draw</code>
dropLayer	<code>subset</code>
extent	<code>ext</code>
getValues	<code>values</code>
isLonLat, isGlobalLonLat	<code>is.lonlat</code>
layerize	<code>segregate</code>
layerStats	<code>layerCor</code>
movingFun	<code>roll</code>
NAvalue	<code>NAflag</code>
nlayers	<code>nlyr</code>
overlay	<code>lapp</code>
unstack	<code>as.list</code>
projectRaster	<code>project</code>
rasterToPoints	<code>as.points</code>
rasterToPolygons	<code>as.polygons</code>
readAll	<code>toMemory</code>
reclassify, subs, cut	<code>classify</code>
sampleRandom, sampleRegular	<code>spatSample</code>
shapefile	<code>vect</code>
stackApply	<code>tapp</code>
stackSelect	<code>selectRange</code>

XXXII. Changed behavior

Also note that even if function names are the same in terra and raster, their output can be different. In most cases this was done to get more consistency in the returned values (and thus fewer

errors in the downstream code that uses them). In other cases it simply seemed better. Here are some examples:

<code>resample</code>	Results are not numerically identical when using <code>method="bilinear"</code> , especially at edges, and when
<code>as.polygons</code>	By default, terra returns dissolved polygons
<code>quantile</code>	computes by cell, across layers instead of the other way around
<code>extract</code>	By default, terra returns a matrix, with the first column the sequential ID of the vectors. raster returns a list (for lines or polygons) or a matrix (for points, but without the ID column). You can use <code>list=TRUE</code> to get the results as a list
<code>values</code>	terra always returns a matrix. raster returns a vector for a RasterLayer
<code>Summary-methods</code>	With raster, <code>mean(x, y)</code> and <code>mean(stack(x, y))</code> return the same result, a single layer with the mean of all cell values. This is also what terra returns with <code>mean(c(x, y))</code> , but with <code>mean(x, y)</code> the parallel mean is returned – that is, the computation is done layer-wise, and the number of layers in the output is the same as that of x and y (or the larger of the two if they are not the same). This affects all summary functions (<code>sum</code> , <code>mean</code> , <code>median</code> , <code>which.min</code> , <code>which.max</code> , <code>min</code> , <code>max</code> , <code>prod</code> , <code>any</code> , <code>all</code> , <code>stdev</code>), except <code>range</code> , which is not implemented for this case (you can use <code>min</code> and <code>max</code> instead)

Contributors

Except where indicated otherwise, the methods and functions in this package were written by Robert Hijmans. Andrew Gene Brown and Márcia Barbosa contributed many improvements to the code and documentation. Krzysztof Dyba contributed to documentation and github management and issues. The configuration scripts were written by Roger Bivand. Some of code using the GEOS library was adapted from code by Edzer Pebesma for `sf`. Emanuele Cordano contributed functionality for catchment related computations. Michael Chirico, Barry Rowlingson, and Michael D. Sumner also made important contributions.

This package is an attempt to climb on the shoulders of giants (GDAL, PROJ, GEOS, NCFD, GeographicLib, Rcpp, R). Many people have contributed by asking questions or [raising issues](#). Feedback and suggestions by Kendon Bell, Jean-Luc Dupouey, Sarah Endicott, Derek Friend, Alex Ilich, Agustin Lobo, Gerald Nelson, Jakub Nowosad, and Monika Tomaszewska have been especially helpful.

activeCat

Active category

Description

Get or set the active category of a multi-categorical SpatRaster layer

Usage

```
## S4 method for signature 'SpatRaster'
activeCat(x, layer=1)
## S4 replacement method for signature 'SpatRaster'
activeCat(x, layer=1)<-value
```

Arguments

x	SpatRaster
layer	positive integer, the layer number or name
value	positive integer or character, indicating which column in the categories to use. Note that when a number is used this index is zero based, and "1" refers to the second column. This is because the first column of the categories has the cell values, not categorical labels

Value

integer

See Also

[levels](#), [cats](#)

Examples

```
set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE) + 10
d <- data.frame(id=11:13, cover=c("forest", "water", "urban"), letters=letters[1:3], value=10:12)
levels(r) <- d

activeCat(r)
activeCat(r) <- 3
activeCat(r)
```

add	<i>Add (in place) a SpatRaster to another SpatRaster or to a SpatRaster-Dataset or SpatRasterCollection</i>
-----	---

Description

Add (in place) a SpatRaster to another SpatRaster. Comparable with `c`, but without copying the object.

Usage

```
## S4 replacement method for signature 'SpatRaster,SpatRaster'
add(x)<-value

## S4 replacement method for signature 'SpatRasterDataset,SpatRaster'
add(x)<-value

## S4 replacement method for signature 'SpatRasterCollection,SpatRaster'
add(x)<-value
```

Arguments

x	SpatRaster, SpatRasterDataset or SpatRasterCollection
value	SpatRaster

Value

SpatRaster

See Also

[c](#)

Examples

```
r <- rast(nrows=5, ncols=9, vals=1:45)
x <- c(r, r*2)
add(x) <- r*3
x
```

add_abline

add vertical and/or horizontal lines to a map made with terra

Description

Adaptation of [abline](#) that allows adding a horizontal or vertical lines to a map. This function will place the lines in the locations within the mapped area as delineated by the axes. It is meant to be used when you specify your own tick marks, such that [add_grid](#) does not work.

Also see [graticule](#)

Usage

```
add_abline(h=NULL, v=NULL, ...)
```

Arguments

h	the y-value(s) for horizontal line(s)
v	the x-value(s) for vertical line(s)
...	additional graphical parameters for drawing lines

See Also

[add_grid](#), [graticule](#), [add_legend](#), [add_box](#), [add_grid](#), [add_mtext](#)

Examples

```
v <- vect(system.file("ex/lux.shp", package="terra"))
atx <- seq(xmin(v), xmax(v), .1)
aty <- seq(ymin(v), ymax(v), .1)
plot(v, pax=list(xat=atx, yat=aty), ext=ext(v)+.2)
add_abline(h=aty, v=atx, lty=2, col="gray")
```

add_box	<i>draw a box</i>
---------	-------------------

Description

Similar to [box](#) allowing adding a box around a map. This function will place the box around the mapped area.

Usage

```
add_box(...)
```

Arguments

... arguments passed to [lines](#)

See Also

[add_legend](#), [add_grid](#), [add_mtext](#)

Examples

```
v <- vect(system.file("ex/lux.shp", package="terra"))
plot(v)
add_box(col="red", lwd=3, xpd=TRUE)
```

add_grid	<i>add a grid to a map made with terra</i>
----------	--

Description

Adaptation of [grid](#) that allows adding a grid to a map. This function will place the grid in the locations within the mapped area as delineated by the axes.

If you set the tick marks yourself, you can use [add_abline](#) to create a grid:

Also see [graticule](#)

Usage

```
add_grid(nx=NULL, ny=nx, col="lightgray", lty="dotted", lwd=1)
```

Arguments

nx, ny	number of cells of the grid in x and y direction. When NULL, as per default, the grid aligns with the tick marks on the corresponding default axis (i.e., tickmarks as computed by axTicks). When NA, no grid lines are drawn in the corresponding direction
col	character or (integer) numeric; color of the grid lines
lty	character or (integer) numeric; line type of the grid lines
lwd	non-negative numeric giving line width of the grid lines

See Also

[graticule](#), [add_abline](#), [add_legend](#), [add_box](#), [add_grid](#), [add_mtext](#)

Examples

```
v <- vect(system.file("ex/lux.shp", package="terra"))
plot(v)
add_grid()
```

add_legend	<i>add a custom legend</i>
------------	----------------------------

Description

Wrapper around [legend](#) that allows adding a custom legend to a map using a keyword such as "topleft" or "bottomright". This function will place the legend in the locations within the mapped area as delineated by the axes.

Usage

```
add_legend(x, y, xpd=TRUE, ...)
```

Arguments

x	The keyword to be used to position the legend (or the x coordinate)
y	The y coordinate to be used to position the legend (is x is also a coordinate)
xpd	logical. If TRUE, the legend can be added outside the map area
...	arguments passed to legend

See Also

[add_box](#), [add_grid](#), [add_mtext](#)

Examples

```
v <- vect(system.file("ex/lux.shp", package="terra"))
plot(v)
points(centroids(v), col="red")
legend("topleft", legend = "centroids", pch = 20, xpd=NA, bg="white", col="red")
add_legend("topright", legend = "centroids", pch = 20, col="red")
```

add_mtext

add a margin text

Description

Similar to [mtext](#) allowing adding a text to the margins of a map. This function uses the margins around the mapped area; not the margins that R would use.

Usage

```
add_mtext(text, side=3, line=0, ...)
```

Arguments

text	character or expression vector specifying the text to be written
side	integer indicating the margin to use (1=bottom, 2=left, 3=top, 4=right)
line	numeric to move the text in or outwards.
...	arguments passed to text

See Also

[add_legend](#), [add_grid](#), [add_box](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)

plot(r, axes=FALSE, legend=FALSE)
add_box()
for (i in 1:4) add_mtext("margin text", i, cex=i, col=i, line=2-i)
```

adjacent	<i>Adjacent cells or polygons</i>
----------	-----------------------------------

Description

Identify cells that are adjacent to a set of raster cells. Or identify adjacent polygons

Usage

```
## S4 method for signature 'SpatRaster'
adjacent(x, cells, directions="rook", pairs=FALSE, include=FALSE, symmetrical=FALSE)

## S4 method for signature 'SpatVector'
adjacent(x, type="rook", pairs=TRUE, symmetrical=FALSE)
```

Arguments

x	SpatRaster, or SpatVector of polygons
cells	vector of cell numbers for which adjacent cells should be found. Cell numbers start with 1 in the upper-left corner and increase from left to right and from top to bottom
directions	character or matrix to indicated the directions in which cells are considered connected. The following character values are allowed: "rook" or "4" for the horizontal and vertical neighbors; "bishop" to get the diagonal neighbors; "queen" or "8" to get the vertical, horizontal and diagonal neighbors; or "16" for knight and one-cell queen move neighbors. If directions is a matrix it should have odd dimensions and have logical (or 0, 1) values
pairs	logical. If TRUE, a two-column matrix of pairs of adjacent cells is returned. If x is a SpatRaster and pairs is FALSE, an n*m matrix is returned where the number of rows n is length(cells) and the number of columns m is the number of neighbors requested with directions
include	logical. Should the focal cells be included in the result?
type	character. One of "rook", "queen", "touches", or "intersects". "queen" and "touches" are synonyms. "rook" exclude polygons that touch at a single node only. "intersects" includes polygons that touch or overlap
symmetrical	logical. If TRUE and pairs=TRUE, an adjacent pair is only included once. For example, if polygon 1 is adjacent to polygon 3, the implied adjacency between 3 and 1 is not reported

Value

matrix

Note

When using global lon/lat rasters, adjacent cells at the other side of the date-line are included.

See Also

[relate](#), [nearby](#), [nearest](#)

Examples

```
r <- rast(nrows=10, ncols=10)
adjacent(r, cells=c(1, 5, 55), directions="queen")
r <- rast(nrows=10, ncols=10, crs="+proj=utm +zone=1 +datum=WGS84")
adjacent(r, cells=11, directions="rook")

#same as
rk <- matrix(c(0,1,0,1,0,1,0,1,0), 3, 3)
adjacent(r, cells=11, directions=rk)

## note that with global lat/lon data the E and W connect
r <- rast(nrows=10, ncols=10, crs="+proj=longlat +datum=WGS84")
adjacent(r, cells=11, directions="rook")

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
a <- adjacent(v, symmetrical=TRUE)
head(a)
```

aggregate

Aggregate raster or vector data

Description

Aggregate a `SpatRaster` to create a new `SpatRaster` with a lower resolution (larger cells). Aggregation groups rectangular areas to create larger cells. The value for the resulting cells is computed with a user-specified function. See [resample](#) for aggregating cells with a factor that is not an integer.

You can also aggregate ("dissolve") a `SpatVector`. This either combines all geometries into one geometry, or it combines the geometries that have the same value for the variable(s) specified with argument `by`.

Usage

```
## S4 method for signature 'SpatRaster'
aggregate(x, fact=2, fun="mean", ..., cores=1, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatVector'
aggregate(x, by=NULL, dissolve=TRUE, fun="mean", count=TRUE, ...)
```

Arguments

`x` `SpatRaster` or `SpatVector`

<code>fact</code>	positive integer. Aggregation factor expressed as number of cells in each direction (horizontally and vertically). Or two integers (vertical (<code>fact[1]</code>) and horizontal (<code>fact[2]</code>) aggregation factor) or three integers (when also aggregating over layers)
<code>fun</code>	function used to aggregate values. Either an actual function, or for the following, their name: "mean", "max", "min", "median", "sum", "modal", "any", "all", "none", "prod", "which.min", "which.max", "table", "sd" (sample standard deviation) and "std" (population standard deviation)
<code>...</code>	additional arguments passed to <code>fun</code> , such as <code>na.rm=TRUE</code>
<code>cores</code>	positive integer. If <code>cores > 1</code> , a 'parallel' package cluster with that many cores is created. Ignored for C++ level implemented functions that are listed under <code>fun</code>
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If <code>TRUE</code> , <code>filename</code> is overwritten
<code>wopt</code>	list with named options for writing files as in <code>writeRaster</code>
<code>by</code>	character. The variable(s) used to group the geometries
<code>dissolve</code>	logical. Should borders between aggregated geometries be dissolved?
<code>count</code>	logical. If <code>TRUE</code> and <code>by</code> is not <code>NULL</code> , a variable "agg_n" is included that shows the number of input geometries for each output geometry

Details

Aggregation starts at the upper-left end of a `SpatRaster`. If a division of the number of columns or rows with `factor` does not return an integer, the extent of the resulting `SpatRaster` will be somewhat larger than that of the original `SpatRaster`. For example, if an input `SpatRaster` has 100 columns, and `fact=12`, the output `SpatRaster` will have 9 columns and the maximum x coordinate of the output `SpatRaster` is also adjusted.

The function `fun` should take multiple numbers, and return one or more numeric values. If multiple numbers are returned, the length of the returned vector should always be the same, also, for example, when the input is only `NA` values. For that reason, `range` works, but `unique` will fail in most cases.

Value

`SpatRaster`

See Also

[disagg](#) to disaggregate, and [resample](#) for more complex changes in resolution and alignment

Examples

```
r <- rast()
# aggregated SpatRaster, no values
ra <- aggregate(r, fact=10)

values(r) <- runif(ncell(r))
# aggregated raster, max of the values
```

```

ra <- aggregate(r, fact=10, fun=max)

# aggregated raster, 'fact' parameter contains two values, max of the values
# same result as above
rb <- aggregate(r, fact=c(10,10), fun=max)

# groups of 10 rows and 2 columns are combined into new cells
rc <- aggregate(r, fact=c(10,2), fun=max)

# multiple layers
s <- c(r, r*2)
x <- aggregate(s, 20)

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
va <- aggregate(v, "ID_1")

plot(va, "NAME_1", lwd=5, plg=list(x="topright"), mar=rep(2,4))
lines(v, lwd=3, col="light gray")
lines(va)
text(v, "ID_1", halo=TRUE)

```

agitate

Add noise to (jitter) a SpatVector of points

Description

Add noise to (jitter) a SpatVector of points. Points are moved randomly within a specified distance.

Usage

```

## S4 method for signature 'SpatVector'
agitate(x, maxdist)

```

Arguments

x	SpatVector. All other objects are passed to jitter
maxdist	positive number. The maximum distance from the original location, in meter for lon/lat, otherwise in the units of the CRS

Value

SpatVector

Examples

```
## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- as.points(vect(f)[1])
p <- agitate(v, 2500)
```

align

*Align a SpatExtent***Description**

Align an SpatExtent with a SpatRaster. This can be useful to create a new SpatRaster with the same origin and resolution as an existing SpatRaster. Do not use this to force data to match that really does not match (use e.g. [resample](#) or (dis)aggregate for this).

It is also possible to align a SpatExtent to a clean divisor.

Usage

```
## S4 method for signature 'SpatExtent,SpatRaster'
align(x, y, snap="near")

## S4 method for signature 'SpatExtent,numeric'
align(x, y)
```

Arguments

x	SpatExtent
y	SpatRaster or numeric
snap	Character. One of "near", "in", or "out", to determine in which direction the extent should be aligned. To the nearest border, inwards or outwards

Value

SpatExtent

See Also[ext](#), [draw](#)**Examples**

```
r <- rast()
e <- ext(-10.1, 9.9, -20.1, 19.9)
ea <- align(e, r)
e
ext(r)
ea

align(e, 0.5)
```

all.equal	<i>Compare two SpatRaster, SpatVector, or SpatExtent objects for equality</i>
-----------	---

Description

Compare two objects for (near) equality

In the case of SpatRasters, first the attributes of the objects are compared. If these are the same, a (perhaps small) sample of the raster cells is compared as well.

The sample size used can be increased with the maxcell argument. You can set it to Inf, but for large rasters your computer may not have sufficient memory. See the examples for a safe way to compare all values.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
all.equal(target, current, maxcell=100000, ...)
```

```
## S4 method for signature 'SpatVector,SpatVector'
all.equal(target, current, ...)
```

```
## S4 method for signature 'SpatExtent,SpatExtent'
all.equal(target, current, ...)
```

Arguments

target	SpatRaster, SpatVector, or SpatExtent
current	object of the same class as target
maxcell	positive integer. The size of the regular sample used to compare cell values
...	additional arguments passed to all.equal.numeric to compare cell values for SpatRaster and geometry and attribute values for SpatVectors

Value

Either TRUE or a character vector describing the differences between target and current.

See Also

[identical](#), [compareGeom](#)

Examples

```
x <- sqrt(1:100)
mat <- matrix(x, 10, 10)
r1 <- rast(nrows=10, ncols=10, xmin=0, vals = x)
r2 <- rast(nrows=10, ncols=10, xmin=0, vals = mat)
```

```

all.equal(r1, r2)
all.equal(r1, r1*1)
all.equal(rast(r1), rast(r2))

# compare geometries
compareGeom(r1, r2)

# Compare all cell values for near equality
# as floating point number imprecision can be a problem
m <- minmax(r1 - r2)
all(abs(m) < 1e-7)

# comparison of cell values to create new SpatRaster
e <- r1 == r2

```

animate

Animate a map

Description

Animate (sequentially plot) the layers of a `SpatRaster`, or a `SpatVectorCollection`, or the variables or geometries of a `SpatVector`, to create a movie.

Usage

```

## S4 method for signature 'SpatRaster'
animate(x, pause=0.25, main, range=NULL, maxcell=50000, n=1, ...)

## S4 method for signature 'SpatVector'
animate(x, pause=0.25, main="", n=1, vars=NULL, range=NULL, add=NULL, ...)

## S4 method for signature 'SpatVectorCollection'
animate(x, pause=0.25, n=1, vars=NULL, range=NULL, ext=NULL, add=NULL, ...)

```

Arguments

x	SpatRaster or SpatVector
pause	numeric. How long should the pause be between layers?
main	title for each layer. For <code>SpatRaster</code> , if not supplied, the z-value is used if available. Otherwise the names are used.
range	numeric vector of length 2. Range of values to plot, If <code>NULL</code> the range of all layers is used for rasters, or all variables for vectors if they are all numeric. If <code>NA</code> the range of each individual layer is used
maxcell	positive integer. Maximum number of cells to use for the plot. If <code>maxcell < ncell(x)</code> , <code>spatSample(type="regular")</code> is used before plotting
n	integer > 0. Number of plotting loops

<code>vars</code>	numeric or character to indicate the variables to animate. If this is NULL, the geometries are animated instead
<code>ext</code>	SpatExtent object (or an object for which <code>ext</code> returns one) setting the spatial extent of the plot.
<code>add</code>	logical. Add the geometries to the current plot? When looping over geometries: if TRUE, add all geometries to the current plot. If NULL, add is set to FALSE for the first geometry and TRUE for the remaining ones. This argument is ignored when <code>vars</code> is not NULL
<code>...</code>	additional arguments passed to <code>plot</code>

Value

None

Author(s)

A. Márcia Barbosa, Robert J. Hijmans

See Also[plot](#)**Examples**

```
r <- rast(system.file("ex/logo.tif", package="terra"))
animate(r, n=1)

v <- vect(system.file("ex/lux.shp", package="terra"))
animate(v[1:3, ], n=1, pause=0.3)
# animate(v, vars=names(v))

s <- svc(as.lines(v[3:5,]), v, v[1:3,], as.points(v))
animate(s, col="blue", alpha=0.3, pause=0.3)

# you can save an animation to file like this
# animation::saveGIF(terra::animate(v), "animation.gif")
```

app

*Apply a function to the cells of a SpatRaster***Description**

Apply a function to the values of each cell of a SpatRaster. Similar to [apply](#) – think of each layer in a SpatRaster as a column (or row) in a matrix.

This is generally used to summarize the values of multiple layers into one layer; but this is not required.

app calls function fun with the raster data as first argument. Depending on the function supplied, the raster data is represented as either a matrix in which each layer is a column, or a vector representing a cell. The function should return a vector or matrix that is divisible by ncell(x). Thus, both "sum" and "rowSums" can be used, but "colSums" cannot be used.

You can also apply a function fun across datasets by layer of a SpatRasterDataset. In that case, summarization is by layer across SpatRasters.

Usage

```
## S4 method for signature 'SpatRaster'
app(x, fun, ..., cores=1, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterDataset'
app(x, fun, ..., cores=1, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster or SpatRasterDataset
fun	a function that operates on a vector or matrix. This can be a function that is defined in base-R or in a package, or a function you write yourself (see examples). Functions that return complex output (e.g. a list) may need to be wrapped in your own function to simplify the output to a vector or matrix. The following functions have been re-implemented in C++ for speed: "sum", "mean", "median", "modal", "which", "which.min", "which.max", "min", "max", "prod", "any", "all", "none", "sd", "std", "first". To use the base-R function for say, "min", you could use something like fun=function(i) min(i) or the equivalent fun = \ (i) min(i)
...	additional arguments for fun. These are typically numerical constants. They should <i>never</i> be another SpatRaster
cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created and used. You can also supply a cluster object. Ignored for functions that are implemented by terra in C++ (see under fun)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Details

To speed things up, parallelization is supported, but this is often not helpful, and it may actually be slower. There is only a speed gain if you have many cores (> 8) and/or a very complex (slow) function fun. If you write fun yourself, consider supplying a cppFunction made with the Rcpp package instead (or go have a cup of tea while the computer works for you).

Value

SpatRaster

See Also

[lapp](#), [tapp](#), [Math-methods](#), [roll](#); [global](#) to summarize the values of a single SpatRaster

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
x <- c(r, sqrt(r), r+50)
s <- app(x, fun=sum)
s
# for a few generic functions like
# "sum", "mean", and "max" you can also do
sum(x)

## SpatRasterDataset
sd <- sds(x, x*2, x/3)
a <- app(sd, max)
a
# same as
max(x, x*2, x/3)
# and as (but slower)
b <- app(sd, function(i) max(i))

## also works for a single layer
f <- function(i) (i+1) * 2 * i + sqrt(i)
s <- app(r, f)
# same as above, but that is not memory-safe
# and has no filename argument
s <- f(r)

## Not run:
#### multiple cores
test0 <- app(x, sqrt)
test1 <- app(x, sqrt, cores=2)

testfun <- function(i) { 2 * sqrt(i) }
test2 <- app(x, fun=testfun, cores =2)

## this fails because testfun is not exported to the nodes
# test3 <- app(x, fun=function(i) testfun(i), cores=2)
## to export it, add it as argument to fun
test3 <- app(x, fun=function(i, ff) ff(i), cores =3, ff=testfun)

## End(Not run)
```

approximate

Estimate values for cell values that are NA by interpolating between layers

Description

approximate uses the stats function [approx](#) to estimate values for cells that are NA by interpolation across layers. Layers are considered equidistant, unless argument `z` is used, or `time(x)` returns values that are not NA, in which case these values are used to determine distance between layers.

For estimation based on neighboring cells see [focal](#)

Usage

```
## S4 method for signature 'SpatRaster'
approximate(x, method="linear", yleft, yright,
            rule=1, f=0, ties=mean, z=NULL, NArule=1,filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>method</code>	specifies the interpolation method to be used. Choices are "linear" or "constant" (step function; see the example in approx)
<code>yleft</code>	the value to be returned before a non-NA value is encountered. The default is defined by the value of <code>rule</code> given below
<code>yright</code>	the value to be returned after the last non-NA value is encountered. The default is defined by the value of <code>rule</code> given below
<code>rule</code>	an integer (of length 1 or 2) describing how interpolation is to take place at for the first and last cells (before or after any non-NA values are encountered). If rule is 1 then NAs are returned for such points and if it is 2, the value at the closest data extreme is used. Use, e.g., <code>rule = 2:1</code> , if the left and right side extrapolation should differ
<code>f</code>	for <code>method = "constant"</code> a number between 0 and 1 inclusive, indicating a compromise between left- and right-continuous step functions. If <code>y0</code> and <code>y1</code> are the values to the left and right of the point then the value is $y_0*(1-f)+y_1*f$ so that <code>f = 0</code> is right-continuous and <code>f = 1</code> is left-continuous
<code>ties</code>	Handling of tied 'z' values. Either a function with a single vector argument returning a single number result or the string "ordered"
<code>z</code>	numeric vector to indicate the distance between layers (e.g., depth). The default is <code>time(x)</code> if these are not NA or else <code>1:nlys(x)</code>
<code>NArule</code>	single integer used to determine what to do when only a single layer with a non-NA value is encountered (and linear interpolation is not possible). The default value of 1 indicates that all layers will get this value for that cell; all other values do not change the cell values
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[focal](#), [fillTime](#)

Examples

```
r <- rast(ncols=5, nrows=5)
r1 <- setValues(r, runif(ncell(r)))
r2 <- setValues(r, runif(ncell(r)))
r3 <- setValues(r, runif(ncell(r)))
r4 <- setValues(r, runif(ncell(r)))
r5 <- setValues(r, NA)
r6 <- setValues(r, runif(ncell(r)))
r1[6:10] <- NA
r2[5:15] <- NA
r3[8:25] <- NA
s <- c(r1,r2,r3,r4,r5,r6)
s[1:5] <- NA
x1 <- approximate(s)
x2 <- approximate(s, rule=2)
x3 <- approximate(s, rule=2, z=c(1,2,3,5,14,15))
```

Arith-methods

Arithmetic

Description

Standard arithmetic operators for computations with SpatRasters. Computations are local (applied on a cell by cell basis). If multiple SpatRasters are used, these must have the same geometry (extent and resolution). These operators have been implemented:

`+`, `-`, `*`, `/`, `^`, `%%`, `%%/`

You can also use a SpatRaster and a vector or a matrix. If you use a SpatRaster with a vector of multiple numbers, each element in the vector is considered a layer (with a constant value). If you use a SpatRaster with a matrix, the number of columns of the matrix must match the number of layers of the SpatRaster. The rows are used to match the cells. That is, if there are two rows, these match cells 1 and 2, and they are recycled to 3 and 4, etc.

The following methods have been implemented for (SpatExtent, SpatExtent): `+`, `-`, and the following for (SpatExtent, numeric): `+`, `-`, `*`, `/`, `%%`

Value

SpatRaster or SpatExtent

See Also

[ifel](#) to conveniently combine operations and [Math-methods](#) or [app](#) to use mathematical functions not implemented by the package.

Examples

```

r1 <- rast(ncols=10, nrows=10)
v <- runif(ncell(r1))
v[10:20] <- NA
values(r1) <- v
r2 <- rast(r1)
values(r2) <- 1:ncell(r2) / ncell(r2)
r3 <- r1 + r2
r2 <- r1 / 10
r3 <- r1 * (r2 - 1 / r2)

b <- c(r1, r2, r3)
b2 <- b * 10

### SpatExtent methods
x <- ext(0.1, 2.2, 0, 3)
y <- ext(-2, 1, -2,2)
# union
x + y
# intersection
x * y

e <- x %% 2
e
e * 2
e / 2
e + 1
e - 1

```

ar_info

ar_info

Description

Describe a multi-dimensional array (netcdf) file

Usage

```
ar_info(x, what="describe", simplify=TRUE, filter=TRUE, array="")
```

Arguments

x	character. The name of a netcdf (or similar) raster file
what	character that (partially) matches "describe", "arrays" or "dimensions"
simplify	logical. If TRUE and what="describe", simplify the output for readability
filter	logical. If TRUE and what="describe" filter arrays that (probably) dimensions
array	character. Required when what="dimensions"

Value

character or data.frame

See Also

[describe](#)

as.character

Create a text representation of (the skeleton of) an object

Description

Create a text representation of (the skeleton of) an object

Usage

```
## S4 method for signature 'SpatExtent'  
as.character(x)  
  
## S4 method for signature 'SpatRaster'  
as.character(x)
```

Arguments

x SpatRaster

Value

character

Examples

```
r <- rast()  
ext(r)  
ext(c(0, 20, 0, 20))
```

as.data.frame *SpatRaster or SpatVector to data.frame*

Description

Coerce a SpatRaster or SpatVector to a data.frame

Usage

```
## S4 method for signature 'SpatVector'
as.data.frame(x, row.names=NULL, optional=FALSE, geom=NULL, ...)

## S4 method for signature 'SpatRaster'
as.data.frame(x, row.names=NULL, optional=FALSE, xy=FALSE,
cells=FALSE, time=FALSE, na.rm=NA, wide=TRUE, ...)
```

Arguments

x	SpatRaster or SpatVector
geom	character or NULL. If not NULL, either "WKT" or "HEX", to get the geometry included in Well-Known-Text or hexadecimal notation. If x has point geometry, it can also be "XY" to add the coordinates of each point
xy	logical. If TRUE, the coordinates of each raster cell are included
time	logical. If TRUE, the time data is included (if available)
na.rm	logical. If TRUE, cells that have a NA value in at least one layer are removed. If the argument is set to NA only cells that have NA values in all layers are removed
cells	logical. If TRUE, the cell numbers of each raster cell are included
wide	logical. If FALSE, the data.frame returned has a "long" format
...	Additional arguments passed to the data.frame
row.names	This argument is ignored
optional	This argument is ignored

Value

data.frame

See Also

[as.list](#), [as.matrix](#). See [geom](#) to only extract the geometry of a SpatVector

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
as.data.frame(v)
```

`as.lines`*Conversion to a SpatVector of lines*

Description

Conversion of a SpatRaster, SpatVector or SpatExtent to a SpatVector of lines.

Usage

```
## S4 method for signature 'SpatRaster'  
as.lines(x, na.rm=FALSE)
```

```
## S4 method for signature 'SpatVector'  
as.lines(x)
```

```
## S4 method for signature 'SpatExtent'  
as.lines(x, crs="")
```

```
## S4 method for signature 'matrix'  
as.lines(x, crs="", segments=FALSE)
```

Arguments

<code>x</code>	SpatRaster, SpatVector, SpatExtent or matrix. If <code>x</code> is a matrix it should have two columns for a single line, or four columns, where each row has the start and end coordinates (x, y) for lines
<code>na.rm</code>	logical. Only show lines for cells that are not NA?
<code>crs</code>	character. The coordinate reference system (see crs)
<code>segments</code>	logical. Should (poly-)lines or polygons be disaggregated into their line-segments? See disagg

Value

SpatVector

See Also

[as.points](#), [as.polygons](#)

Examples

```
r <- rast(ncols=2, nrows=2)  
values(r) <- 1:ncell(r)  
  
as.lines(r)  
  
as.lines(ext(r), crs=crs(r))
```

```

p <- as.polygons(r)
as.lines(p)

## with a matrix
s <- cbind(1:5, 1:5)
e <- cbind(1:5, 0)

as.lines(s)
as.lines(cbind(s, e), "+proj=longlat")

```

as.list

Coerce a Spat object to a list*

Description

Coerce a `SpatRaster`, `SpatRasterCollection`, `SpatRasterDataset`, `SpatVector` or `SpatVectorCollection` to a list. With a `SpatRaster`, each layer becomes a list element. With a `SpatRasterCollection` or `SpatRasterDataset`, each `SpatRaster` becomes a list element. With a `SpatVector`, each variable (attribute) becomes a list element. With a `SpatVectorCollection`, each `SpatVector` becomes a list element.

Usage

```

## S4 method for signature 'SpatRaster'
as.list(x, geom=NULL, ...)

## S4 method for signature 'SpatRasterCollection'
as.list(x, ...)

## S4 method for signature 'SpatVector'
as.list(x, geom=NULL, ...)

## S4 method for signature 'SpatVectorCollection'
as.list(x, ...)

```

Arguments

x	<code>SpatRaster</code> , <code>SpatRasterDataset</code> , <code>SpatRasterCollection</code> , or <code>SpatVector</code>
geom	character or <code>NULL</code> . If not <code>NULL</code> , and x is a <code>SpatVector</code> , it should be either "WKT" or "HEX", to get the geometry included in Well-Known-Text or hexadecimal notation. If x has point geometry, it can also be "XY" to add the coordinates of each point. If x is a <code>SpatRaster</code> , any value that is not <code>NULL</code> will return a list with the parameters describing the geometry of the <code>SpatRaster</code> are returned
...	additional arguments. These are ignored

Value

list

See Also

see [coerce](#) for as.data.frame with a SpatRaster; and [geom](#) to only extract the geometry of a SpatVector

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
as.list(v)
```

```
s <- rast(system.file("ex/logo.tif", package="terra")) + 1
as.list(s)
```

as.points

*Conversion to a SpatVector of points***Description**

Conversion of a SpatRaster, SpatVector or SpatExtent to a SpatVector of points.

Usage

```
## S4 method for signature 'SpatRaster'
as.points(x, values=TRUE, na.rm=TRUE, na.all=FALSE)
```

```
## S4 method for signature 'SpatVector'
as.points(x, multi=FALSE, skiplast=TRUE)
```

```
## S4 method for signature 'SpatExtent'
as.points(x, crs="")
```

Arguments

x	SpatRaster, SpatVector or SpatExtent
values	logical; include cell values as attributes?
multi	logical. If TRUE a multi-point geometry is returned
skiplast	logical. If TRUE the last point of a polygon (which is the same as the first point) is not included
na.rm	logical. If TRUE cells that are NA are ignored
na.all	logical. If TRUE cells are only ignored if na.rm=TRUE and their value is NA for all layers instead of for any layer
crs	character. The coordinate reference system (see crs)

Value

SpatVector

See Also[as.lines](#), [as.points](#)**Examples**

```
r <- rast(ncols=2, nrows=2)
values(r) <- 1:ncell(r)

as.points(r)

p <- as.polygons(r)
as.points(p)
```

as.polygons

Conversion to a SpatVector of polygons

Description

Conversion of a SpatRaster, SpatVector or SpatExtent to a SpatVector of polygons.

Usage

```
## S4 method for signature 'SpatRaster'
as.polygons(x, round=TRUE, aggregate=TRUE, values=TRUE,
na.rm=TRUE, na.all=FALSE, extent=FALSE, digits=0, ...)

## S4 method for signature 'SpatVector'
as.polygons(x, extent=FALSE)

## S4 method for signature 'SpatExtent'
as.polygons(x, crs="")
```

Arguments

x	SpatRaster, SpatVector or SpatExtent
round	logical; If TRUE and aggregate=TRUE, values are rounded before aggregation. If this value is FALSE the SpatVector returned can have very many polygons and can be very large
aggregate	logical; combine cells with the same values? If TRUE only the first layer in x is processed
values	logical; include cell values as attributes?

extent	logical. if TRUE, a polygon for the extent of the SpatRaster or SpatVector is returned. If x is a SpatRaster, the polygon has vertices for each row and column, not just the four corners of the raster. This can be useful for more precise projection. If that is not required, it is more efficient to get the extent represented by only the four corners with <code>as.polygons(ext(x), crs=crs(x))</code>
na.rm	logical. If TRUE cells that are NA are ignored
na.all	logical. If TRUE cells are only ignored if na.rm=TRUE and their value is NA for all layers instead of for any layer
digits	integer. The number of digits for rounding (if round=TRUE)
crs	character. The coordinate reference system (see crs)
...	additional arguments. For backward compatibility. Will be removed in the future

Value

SpatVector

See Also[as.lines](#), [as.points](#)**Examples**

```
r <- rast(ncols=2, nrows=2)
values(r) <- 1:ncell(r)

p <- as.polygons(r)
p
```

as.raster

*Coerce to a "raster" object***Description**

Implementation of the generic [as.raster](#) function to create a "raster" (small r) object. Such objects can be used for plotting with the [rasterImage](#) function. NOT TO BE CONFUSED with the Raster* (big R) objects defined by the 'raster' package!

Usage

```
## S4 method for signature 'SpatRaster'
as.raster(x, maxcell=500000, col)
```

Arguments

x	SpatRaster
maxcell	positive integer. Maximum number of cells to use for the plot
col	vector of colors. The default is <code>map.pal("viridis", 100)</code>

Value

'raster' object

Examples

```
r <- rast(ncols=3, nrows=3)
values(r) <- 1:ncell(r)
as.raster(r)
```

 atan2

Two argument arc-tangent

Description

For SpatRasters x and y , $\text{atan2}(y, x)$ returns the angle in radians for the tangent y/x , handling the case when x is zero. See [Trig](#)

See [Math-methods](#) for other trigonometric and mathematical functions that can be used with SpatRasters.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
atan2(y, x)

## S4 method for signature 'SpatRaster,SpatRaster'
atan_2(y, x, filename, ...)
```

Arguments

y	SpatRaster
x	SpatRaster
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

See Also

[Math-methods](#)

Examples

```
r1 <- rast(nrows=10, ncols=10)
r2 <- rast(nrows=10, ncols=10)
values(r1) <- (runif(ncell(r1))-0.5) * 10
values(r2) <- (runif(ncell(r1))-0.5) * 10
atan2(r1, r2)
```

autocorrelation *Spatial autocorrelation*

Description

Compute spatial autocorrelation for a numeric vector or a `SpatRaster`. You can compute standard (global) Moran's I or Geary's C, or local indicators of spatial autocorrelation (Anselin, 1995).

Usage

```
## S4 method for signature 'numeric'
autocor(x, w, method="moran")

## S4 method for signature 'SpatRaster'
autocor(x, w=matrix(c(1,1,1,1,0,1,1,1,1),3), method="moran",
  global=TRUE, standardize=FALSE)
```

Arguments

<code>x</code>	numeric or <code>SpatRaster</code>
<code>w</code>	Spatial weights defined by or a rectangular matrix. For a <code>SpatRaster</code> this matrix must the sides must have an odd length (3, 5, ...)
<code>global</code>	logical. If TRUE global autocorrelation is computed instead of local autocorrelation
<code>standardize</code>	logical. If TRUE, apply row standardization to the weights matrix. This divides each weight by the row sum so that the weights for each cell sum to one. For Moran's I, row standardization ensures that the result is bounded between -1 and 1. Only used when <code>global=TRUE</code>
<code>method</code>	character. If <code>x</code> is numeric or <code>SpatRaster</code> : "moran" for Moran's I and "geary" for Geary's C. If <code>x</code> is numeric also: "Gi", "Gi*" (the Getis-Ord statistics), locmor (local Moran's I) and "mean" (local mean)

Details

The default setting uses a 3x3 neighborhood to compute "Queen's case" indices. You can use a filter (weights matrix) to do other things, such as "Rook's case", or different lags.

Value

numeric or `SpatRaster`

References

Moran, P.A.P., 1950. Notes on continuous stochastic phenomena. *Biometrika* 37:17-23
 Geary, R.C., 1954. The contiguity ratio and statistical mapping. *The Incorporated Statistician* 5: 115-145

Anselin, L., 1995. Local indicators of spatial association-LISA. *Geographical Analysis* 27:93-115
https://en.wikipedia.org/wiki/Indicators_of_spatial_association

See Also

The `spdep` package for additional and more general approaches for computing spatial autocorrelation

Examples

```
### raster
r <- rast(nrows=10, ncols=10, xmin=0)
values(r) <- 1:ncell(r)

autocor(r)

# row-standardized (result bounded between -1 and 1)
autocor(r, standardize=TRUE)

# rook's case neighbors
f <- matrix(c(0,1,0,1,0,1,0,1,0), nrow=3)
autocor(r, f)

# local
rc <- autocor(r, w=f, global=FALSE)

### numeric (for vector data)
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- relate(v, relation="touches")

# global
autocor(v$AREA, w)

# local
v$Gi <- autocor(v$AREA, w, "Gi")
plot(v, "Gi")
```

barplot

Bar plot of a SpatRaster

Description

Create a barplot of the values of the first layer of a `SpatRaster`. For large datasets a regular sample with a size of approximately `maxcells` is used.

Usage

```
## S4 method for signature 'SpatRaster'
barplot(height, maxcell=1000000, digits=0, breaks=NULL, col, ...)
```

Arguments

height	SpatRaster
maxcell	integer. To regularly subsample very large datasets
digits	integer used to determine how to round the values before tabulating. Set to NULL or to a large number if you do not want any rounding
breaks	breaks used to group the data as in cut
col	a color generating function such as rainbow (the default), or a vector of colors
...	additional arguments for plotting as in barplot

Value

A numeric vector (or matrix, when `beside = TRUE`) of the coordinates of the bar midpoints, useful for adding to the graph. See [barplot](#)

See Also

[hist](#), [boxplot](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
barplot(r, digits=-1, las=2, ylab="Frequency")

op <- par(no.readonly = TRUE)
par(mai = c(1, 2, .5, .5))
barplot(r, breaks=10, col=c("red", "blue"), horiz=TRUE, digits=NULL, las=1)
par(op)
```

bestMatch

bestMatch

Description

Determine for each grid cell which reference it is most similar to. A reference consists of a `SpatVector` with reference locations, or a `data.frame` or matrix in which each column matches a layer name in the `SpatRaster`.

Similarity is computed with the mean absolute or the mean squared differences between the cell and the reference, or with an alternative function you provide. It may be important to first scale the input.

Usage

```
## S4 method for signature 'SpatRaster,SpatVector'
bestMatch(x, y, labels=NULL, fun="squared", ...,
  filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRaster,data.frame'
bestMatch(x, y, labels=NULL, fun="squared", ...,
  filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRaster,matrix'
bestMatch(x, y, labels=NULL, fun="squared", ...,
  filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
y	SpatVector, data.frame or matrix
labels	character. labels that correspond to each class (row in y
fun	character. One of "abs" for the mean absolute difference, or "squared" for the mean squared difference. Or a true function like <code>terra:::match_sqr</code>
...	additional arguments passed to fun. For the built-in functions this can be <code>na.rm=TRUE</code>
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
f <- system.file("ex/logo.tif", package = "terra")
r <- rast(f)

# locations of interest
pts <- vect(cbind(c(25.25, 34.324, 43.003), c(54.577, 46.489, 30.905)))
pts$code <- LETTERS[1:3]

plot(r)
points(pts, pch=20, cex=2, col="red")
text(pts, "code", pos=4, halo=TRUE)

x <- scale(r)

s1 <- bestMatch(x, pts, labels=pts$code)
plot(s1)

# same result
```

```
e <- extract(x, pts, ID=FALSE)
s2 <- bestMatch(x, e, labels=c("Ap", "Nt", "Ms"))
```

boundaries *Detect boundaries (edges)*

Description

Detect boundaries (edges). Boundaries are cells that have more than one class in the 4 or 8 cells surrounding it, or, if `classes=FALSE`, cells with values and cells with NA.

Usage

```
## S4 method for signature 'SpatRaster'
boundaries(x, classes=FALSE, inner=TRUE, directions=8,
falseval=0, ignoreNA=FALSE, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>inner</code>	logical. If TRUE, "inner" boundaries are returned, else "outer" boundaries are returned
<code>classes</code>	character. Logical. If TRUE all different values are (after rounding) distinguished, as well as NA. If FALSE (the default) only edges between NA and non-NA cells are considered
<code>directions</code>	integer. Which cells are considered adjacent? Should be 8 (Queen's case) or 4 (Rook's case)
<code>falseval</code>	numeric. The value to use for cells that are not a boundary and not NA
<code>ignoreNA</code>	logical. If TRUE and <code>classes=TRUE</code> external boundaries (with NA cells) are ignored, only boundaries between classes are returned (and the value of argument <code>inner</code> is irrelevant)
<code>filename</code>	character. Output filename
<code>...</code>	options for writing files as in writeRaster

Value

SpatRaster. Cell values are either 1 (a boundary) or 0 (not a boundary), or NA

See Also

[focal](#), [patches](#)

Examples

```
r <- rast(nrows=18, ncols=36, xmin=0)
r[150:250] <- 1
r[251:450] <- 2
bi <- boundaries(r)
bo <- boundaries(r, inner=FALSE)
bc <- boundaries(r, classes=TRUE)
#plot(bc)
```

boxplot

Box plot of SpatRaster data

Description

Box plot of layers in a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'
boxplot(x, y=NULL, maxcell=100000, ...)
```

Arguments

x	SpatRaster
y	NULL or a SpatRaster. If x is a SpatRaster it used to group the values of x by "zone"
maxcell	Integer. Number of cells to sample from datasets
...	additional arguments passed to <code>graphics::boxplot</code>

Value

boxplot returns a list (invisibly) that can be used with `bxp`

See Also

[pairs](#), [hist](#)

Examples

```
r1 <- r2 <- r3 <- rast(ncols=10, nrows=10)
set.seed(409)
values(r1) <- rnorm(ncell(r1), 100, 40)
values(r2) <- rnorm(ncell(r1), 80, 10)
values(r3) <- rnorm(ncell(r1), 120, 30)
s <- c(r1, r2, r3)
names(s) <- c("Apple", "Pear", "Cherry")

boxplot(s, notch=TRUE, col=c("red", "blue", "orange"), main="Box plot", ylab="random", las=1)
```

```

op <- par(no.readonly = TRUE)
par(mar=c(4,6,2,2))
boxplot(s, horizontal=TRUE, col="lightskyblue", axes=FALSE)
axis(1)
axis(2, at=0:3, labels=c("", names(s)), las=1, cex.axis=.9, lty=0)
par(op)

## boxplot with 2 layers
v <- vect(system.file("ex/lux.shp", package="terra"))
r <- rast(system.file("ex/elev.tif", package="terra"))
y <- rasterize(v, r, "NAME_2")
b <- boxplot(r, y)
bxp(b)

```

buffer

Create a buffer around vector geometries or raster patches

Description

Calculate a buffer around all cells that are not NA in a `SpatRaster`, or around the geometries of a `SpatVector`.

`SpatRaster` cells inside the buffer distance get a value of 1.

Note that the distance unit of the buffer width parameter is meters if the CRS is (+proj=longlat), and in map units (typically also meters) if not.

If your data has a longitude/latitude CRS do **not** project them to a planar CRS because that makes the results less precise (see Examples).

Usage

```
## S4 method for signature 'SpatRaster'
buffer(x, width, background=0, include=TRUE, filename="", ...)
```

```
## S4 method for signature 'SpatVector'
buffer(x, width, quadsegs=10, capstyle="round",
       jointstyle="round", mitrelimit=NA, singlesided=FALSE)
```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
width	numeric. Unit is meter if x has a longitude/latitude CRS, or in the units of the coordinate reference system in other cases (typically also meter). The value should be > 0 if x is a <code>SpatRaster</code> . If x is a <code>SpatVector</code> , this argument is vectorized, meaning that you can provide a different value for each geometry in x; and you can also use the name of a variable in x that has the widths
filename	character. Output filename

...	additional arguments for writing files as in writeRaster
background	numeric. value to assign to cells outside the buffer. If this value is zero or FALSE, a boolean SpatRaster is returned
include	logical. If TRUE the raster cells that are not NA are included in the buffer. Otherwise these cells get the background value
quadsegs	positive integer. Number of line segments to use to draw a quart circle
capstyle	character. One of "round", "square" or "flat". Ignored if <code>is.lonlat(x)</code>
joinstyle	character. One of "round", "mitre" or "bevel". Ignored if <code>is.lonlat(x)</code>
mitrelimit	numeric. Place an upper bound on a mitre join to avoid it from extending very far from acute angles in the input geometry. Ignored if <code>is.lonlat(x)</code>
singlesided	logical. If TRUE a buffer is constructed on only one side of each input line. Ignored if <code>is.lonlat(x)</code>

Value

Same as x

See Also

[distance](#), [elongate](#)

Examples

```
r <- rast(ncols=36, nrows=18)
r[500] <- 1
b <- buffer(r, width=5000000)
plot(b)

v <- vect(rbind(c(170,10), c(0,60)), crs="+proj=merc")
b <- buffer(v, 20)
plot(b)
points(v)

crs(v) <- "+proj=longlat"
b <- buffer(v, 1500000)
plot(b)
points(v)
```

Description

With `c` you can:

- Combine `SpatRaster` objects. They must have the same extent and resolution. However, if `x` is empty (has no cell values), its geometry is ignored with a warning. Two empty `SpatRasters` with the same geometry can also be combined (to get a summed number of layers). Also see [add<-](#)
- Add a `SpatRaster` to a `SpatRasterDataset` or `SpatRasterCollection`
- Add `SpatVector` objects to a new or existing `SpatVectorCollection`

To append `SpatVectors`, use `rbind`.

Usage

```
## S4 method for signature 'SpatRaster'  
c(x, ..., warn=TRUE)  
  
## S4 method for signature 'SpatRasterDataset'  
c(x, ...)  
  
## S4 method for signature 'SpatRasterCollection'  
c(x, ...)  
  
## S4 method for signature 'SpatVector'  
c(x, ...)  
  
## S4 method for signature 'SpatVectorCollection'  
c(x, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> , <code>SpatVector</code> , <code>SpatRasterDataset</code> or <code>SpatVectorCollection</code>
<code>warn</code>	logical. If <code>TRUE</code> , a warning is emitted if <code>x</code> is an empty <code>SpatRaster</code>
<code>...</code>	as for <code>x</code> (you can only combine raster with raster data and vector with vector data)

Value

Same class as `x`

See Also

[add<-](#)

Examples

```
r <- rast(nrows=5, ncols=9)  
values(r) <- 1:ncell(r)  
x <- c(r, r*2, r*3)
```

`cartogram`*Cartogram*

Description

Make a cartogram, that is, a map where the area of polygons is made proportional to another variable. This can be a good way to map raw count data (e.g. votes).

Usage

```
## S4 method for signature 'SpatVector'  
cartogram(x, var, type="nc", inside=FALSE, exp=1)
```

Arguments

<code>x</code>	<code>SpatVector</code>
<code>var</code>	character. A variable name in <code>x</code>
<code>type</code>	character. Cartogram type, one of "nc" (non-contiguous) or "circles" (dorling)
<code>inside</code>	logical to compute the centroids. See <code>centroids</code>
<code>exp</code>	positive numeric that can be used to scale the output polygons

Value

`SpatVector`

See Also

[plot](#), [rescale](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")  
v <- vect(f)  
v$value <- 1:12  
pnc <- cartogram(v, "value", "nc")  
pcirc <- cartogram(v, "value", "circles")  
plot(v, col="light gray", border="gray")  
lines(pnc, col="red", lwd=2)  
lines(pcirc, col="blue", lwd=2)
```

`catalyze`*Factors to numeric*

Description

Change a categorical layer into one or more numerical layers. With `as.numeric` you can transfer the active category values to cell values in a non-categorical `SpatRaster`. `catalyze` creates new layers for each category.

Usage

```
## S4 method for signature 'SpatRaster'  
as.numeric(x, index=NULL, filename="", ...)
```

```
## S4 method for signature 'SpatRaster'  
catalyze(x, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>index</code>	positive integer or category indicating the category to use. If <code>NULL</code> the active category is used
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

Author(s)

Andrew Gene Brown, Robert J. Hijmans

See Also

[activeCat](#), [cats](#)

Examples

```
set.seed(0)  
r <- rast(nrows=10, ncols=10)  
values(r) <- sample(3, ncell(r), replace=TRUE) + 10  
d <- data.frame(id=11:13, cover=c("forest", "water", "urban"), letters=letters[1:3], value=10:12)  
levels(r) <- d  
catalyze(r)  
  
activeCat(r) <- 3  
as.numeric(r)
```

cells	<i>Get cell numbers</i>
-------	-------------------------

Description

Get the cell numbers covered by a `SpatVector` or `SpatExtent`. Or that match values in a vector; or all non NA values.

Usage

```
## S4 method for signature 'SpatRaster,missing'
cells(x, y)

## S4 method for signature 'SpatRaster,numeric'
cells(x, y, pairs=FALSE)

## S4 method for signature 'SpatRaster,SpatVector'
cells(x, y, method="simple", weights=FALSE, exact=FALSE,
      touches=is.lines(y), small=TRUE)

## S4 method for signature 'SpatRaster,SpatExtent'
cells(x, y)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>y</code>	<code>SpatVector</code> , <code>SpatExtent</code> , 2-column matrix representing points, numeric representing values to match, or missing
<code>method</code>	character. Method for getting cell numbers for points. The default is "simple", the alternative is "bilinear". If it is "bilinear", the four nearest cells and their weights are returned
<code>weights</code>	logical. If TRUE and y has polygons, the approximate fraction of each cell that is covered is returned as well
<code>pairs</code>	logical. If TRUE the cell values matched area also returned
<code>exact</code>	logical. If TRUE and y has polygons, the exact fraction of each cell that is covered is returned as well
<code>touches</code>	logical. If TRUE, values for all cells touched by lines or polygons are extracted, not just those on the line render path, or whose center point is within the polygon. Not relevant for points
<code>small</code>	logical. If TRUE, values for all cells in touched polygons are extracted if none of the cells center points is within the polygon; even if touches=FALSE

Value

numeric vector or matrix

Examples

```

r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
r[c(1:25, 31:100)] <- NA
r <- ifel(r > 28, r + 10, r)

# all cell numbers of cells that are not NA
cells(r)

# cell numbers that match values
x <- cells(r, c(28,38))
x$lyr.1

# cells for points
m <- cbind(x=c(0,10,-30), y=c(40,-10,20))
cellFromXY(r, m)

v <- vect(m)
cells(r, v)
cells(r, v, method="bilinear")

# cells for polygons
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
r <- rast(v)
cv <- cells(r, v)

```

cellSize

Area covered by each raster cell

Description

Compute the area covered by individual raster cells.

Computing the surface area of raster cells is especially relevant for longitude/latitude rasters.

But note that for both angular (longitude/latitude) and for planar (projected) coordinate reference systems raster cells sizes are generally not constant, unless you are using an equal-area coordinate reference system. For planar CRSs, the area is therefore not computed based on the linear units of the coordinate reference system, but rather by transforming cells to longitude/latitude. If you do not want that correction, you can use `transform=FALSE` or `init(x, prod(res(x)))`

Usage

```

## S4 method for signature 'SpatRaster'
cellSize(x, mask=FALSE, lyrs=FALSE, unit="m", transform=TRUE, rcx=100, filename="", ...)

```

Arguments

x	SpatRaster
mask	logical. If TRUE, cells that are NA in x are also NA in the output
lyrs	logical. If TRUE and mask=TRUE, the output has the same number of layers as x. That is only useful if cases where the layers of x have different cells that are NA
unit	character. One of "m", "km", or "ha"
transform	logical. If TRUE, planar CRS data are transformed to lon/lat for accuracy
rcx	positive integer. The maximum number of rows and columns to be used to compute area of planar data if transform=TRUE. If x has more rows and/or columns, the raster is aggregated to match this limit, and values for the original cells are estimated by bilinear interpolation (see <code>resample</code>). This can save a lot of time
filename	character. Output filename
...	additional arguments for writing files as in <code>writeRaster</code>

Value

SpatRaster

See Also

[expand](#), [surfArea](#)

Examples

```
# SpatRaster
r <- rast(nrows=18, ncols=36)
v <- 1:ncell(r)
v[200:400] <- NA
values(r) <- v

# size of each raster cell
a <- cellSize(r)

# illustration of distortion
r <- rast(ncols=90, nrows=45, ymin=-80, ymax=80)
m <- project(r, "+proj=merc")

bad <- init(m, prod(res(m)) / 1000000, wopt=list(names="naive"))
good <- cellSize(m, unit="km", names="corrected")
plot(c(good, bad), nc=1, mar=c(2,2,1,6))
```

`centroids`*Centroids*

Description

Get the centroids of polygons or lines, or centroid-like points that are guaranteed to be inside the polygons or on the lines.

Or get the (weighted) centroid of the cells with values (not NA) of a `SpatRaster`.

Usage

```
## S4 method for signature 'SpatVector'  
centroids(x, inside=FALSE)
```

```
## S4 method for signature 'SpatRaster'  
centroids(x, weighted=FALSE)
```

Arguments

<code>x</code>	<code>SpatVector</code>
<code>inside</code>	logical. If TRUE the points returned are guaranteed to be inside the polygons or on the lines, but they are not the true centroids. True centroids may be outside a polygon, for example when a polygon is "bean shaped", and they are unlikely to be on their line
<code>weighted</code>	logical. If TRUE the centroids are computed as the weighted means of the coordinates of cells with values

Value

`SpatVector` of points

Examples

```
f <- system.file("ex/lux.shp", package="terra")  
v <- vect(f)  
x <- centroids(v)  
y <- centroids(v, TRUE)
```

```
f <- system.file("ex/elev.tif", package="terra")  
r <- rast(f)  
centroids(r)
```

 chunk

Make a SpatRaster method memory-safe

Description

This method allows for running a function that takes a `SpatRaster` as first argument in chunks (tiles). This can be useful if the function is not memory-safe, typically because it reads all the raster cell values into memory.

This method is not designed to be especially efficient, and there might be more efficient ways to accomplish what the goal of the function that is not memory-safe.

Also, some functions must have access to all cells at once to be valid. In those cases, `chunk` would return incorrect results.

Usage

```
## S4 method for signature 'SpatRaster'
chunk(x, fun, ..., n=NULL, buffer=0, filename="", wopt=list())
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>fun</code>	function that takes a <code>SpatRaster</code> as first argument
<code>...</code>	additional arguments for <code>fun</code>
<code>n</code>	NULL or positive integer to specifying the number of rows and columns for each chunk (or 2 numbers for a different number of rows and columns, as in getFileExtents)
<code>buffer</code>	integer. The number of additional rows and columns added to each tile. Can be a single number, or two numbers to specify a separate number of rows and columns. This allows for creating overlapping tiles that can be used for computing spatial context dependent values with e.g. focal . The expansion is only inside <code>x</code> , no rows or columns outside of <code>x</code> are added
<code>filename</code>	character. Output filename
<code>wopt</code>	list with additional arguments for writing files as in writeRaster

Value

`SpatRaster`

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
f <- function(x, a = 0) {
  print("chunk")
  sum(x) + a
}
```

```
x <- chunk(s, f, a=100)
```

 clamp

Clamp values

Description

Clamp values to a minimum and maximum value. That is, all values below a lower threshold value and above the upper threshold value become either NA, or, if values=TRUE, become the threshold value

Usage

```
## S4 method for signature 'SpatRaster'
clamp(x, lower=-Inf, upper=Inf, values=TRUE, filename="", ...)

## S4 method for signature 'numeric'
clamp(x, lower=-Inf, upper=Inf, values=TRUE, ...)
```

Arguments

x	SpatRaster
lower	numeric with the lowest acceptable value (you can specify a different value for each layer). Or a SpatRaster that has a single layer or the same number of layers as x
upper	numeric with the highest acceptable value (you can specify a different value for each layer). Or a SpatRaster that has a single layer or the same number of layers as x
values	logical. If FALSE values outside the clamping range become NA, if TRUE, they get the extreme values
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[classify](#), [subst](#)

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
rc <- clamp(r, 25, 75)
rc
```

clamp_ts	<i>clamp time series data</i>
----------	-------------------------------

Description

clamp time-series data that are S shaped. The value in layers before the minimum value in a cell can be set to that minimum value, and the value in layers after the maximum value for a cell can be set to that maximum value.

Usage

```
## S4 method for signature 'SpatRaster'
clamp_ts(x, min=FALSE, max=TRUE, filename="", ...)
```

Arguments

x	SpatRaster
min	logical. If TRUE the time-series is clamped to the minimum value
max	logical. If TRUE the time-series is clamped to the maximum value
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[clamp](#), [cummin](#), [cummax](#)

Examples

```
sigm <- function(x) { .8 / (1 + exp(-(x-10))) + runif(length(x))/4 }
r <- rast(ncols=10, nrows=10, nlyr=50)
s <- seq(5.2, 15,.2)
set.seed(1)
values(r) <- t(replicate(100, sigm(s)))

x <- clamp_ts(r, TRUE, TRUE)

plot(unlist(r[4]))
lines(unlist(x[4]))
```

classify	<i>Classify (or reclassify) cell values</i>
----------	---

Description

Classify values of a SpatRaster. The function (re-)classifies groups of values to other values.

The classification is done based on the argument `rc1`. You can classify ranges by specifying a three-column matrix "from-to-becomes" or change specific values by using a two-column matrix "is-becomes". You can also supply a vector with "cuts" or the "number of cuts".

With "from-to-becomes" or "is-becomes" classification is done in the row order of the matrix. Thus, if there are overlapping ranges or values, the first time a number is within a range determines the reclassification value.

With "cuts" the values are sorted, so that the order in which they are provided does not matter.

Usage

```
## S4 method for signature 'SpatRaster'
classify(x, rc1, include.lowest=FALSE, right=TRUE,
         others=NULL, brackets=TRUE, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>rc1</code>	<p>matrix for classification. This matrix must have 1, 2 or 3 columns. If there are three columns, the first two columns are "from" "to" of the input values, and the third column "becomes" has the new value for that range.</p> <p>The two column matrix ("is", "becomes") can be useful for classifying integer values. In that case, the arguments <code>right</code> and <code>include.lowest</code> are ignored. For this case, an optimized hash-based lookup is used for improved performance. Floating point values are supported and are matched exactly.</p> <p>A single column matrix (or a vector) is interpreted as a set of cuts if there is more than one value. In that case the values are classified based on their location in-between the cut-values.</p> <p>If a single number is provided, that is used to make that number of cuts, at equal intervals between the lowest and highest values of the SpatRaster.</p>
<code>include.lowest</code>	logical, indicating if a value equal to the lowest value in <code>rc1</code> (or highest value in the second column, for <code>right=FALSE</code>) should be included.
<code>right</code>	<p>logical. If TRUE, the intervals are closed on the right (and open on the left). If FALSE they are open at the right and closed at the left. "open" means that the extreme value is <i>not</i> included in the interval. Thus, right-closed and left open is $(0, 1] = \{x \mid 0 < x \leq 1\}$. You can also close both sides with <code>right=NA</code>, that is only meaningful if you "from-to-becomes" classification with integers. For example to classify 1-5 -> 1, 6-10 -> 2, 11-15 -> 3. That may be easier to read and write than the equivalent 1-5 -> 1, 5-10 -> 2, 10-15 -> 3 with <code>right=TRUE</code> and <code>include.lowest=TRUE</code></p>

others	numeric. If not NULL all values that are not matched are set to this value. Otherwise they retain their original value.
brackets	logical. If TRUE, intervals are have parenthesis or brackets around them to indicate whether they are open or closed. Only applies if <code>rcl</code> is a vector (or single column matrix)
filename	character. Output filename
...	Additional arguments for writing files as in writeRaster

Value

SpatRaster

Note

`classify` works with the "raw" values of categorical rasters, ignoring the levels (labels, categories). To change the labels of categorical rasters, use [subst](#) instead.

For model-based classification see [predict](#)

Author(s)

Andrew Gene Brown, Robert J. Hijmans

See Also

[subst](#) for simpler from-to replacement, and [clamp](#)

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- (0:99)/99

## from-to-becomes
# classify the values into three groups
# all values >= 0 and <= 0.25 become 1, etc.
m <- c(0, 0.25, 1,
       0.25, 0.5, 2,
       0.5, 1, 3)
rclmat <- matrix(m, ncol=3, byrow=TRUE)
rc1 <- classify(r, rclmat, include.lowest=TRUE)

## cuts
# equivalent to the above, but now a categorical SpatRaster is returned
rc2 <- classify(r, c(0, 0.25, 0.5, 1), include.lowest=TRUE, brackets=TRUE)
freq(rc2)

## is-becomes
x <- round(r*3)
unique(x)
# replace 0 with NA
y <- classify(x, cbind(0, NA))
```

```

unique(y)

# multiple replacements
m <- rbind(c(2, 200), c(3, 300))
m

rcx1 <- classify(x, m)
unique(rcx1)

rcx2 <- classify(x, m, others=NA)
unique(rcx2)

```

click

Query by clicking on a map

Description

Click on a map (plot) to get the coordinates or the values of a `SpatRaster` or `SpatVector` at that location. For a `SpatRaster` you can also get the coordinates and cell number of the location.

Note that for many installations this does to work well on the default RStudio plotting device. To work around that, you can first run `dev.new(noRStudioGD = TRUE)` which will create a separate window for plotting, then use `plot()` followed by `click()` and click on the map. It may also help to set your RStudio "Tools/Global Options/Appearance/Zoom" to 100

Usage

```

## S4 method for signature 'SpatRaster'
click(x, n=10, id=FALSE, xy=FALSE, cell=FALSE, type="p", show=TRUE, ...)

## S4 method for signature 'SpatVector'
click(x, n=10, id=FALSE, xy=FALSE, type="p", show=TRUE, ...)

## S4 method for signature 'missing'
click(x, n=10, id=FALSE, type="p", show=TRUE, ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code> , or missing
<code>n</code>	number of clicks on the plot (map)
<code>id</code>	logical. If TRUE, a numeric ID is shown on the map that corresponds to the row number of the output
<code>xy</code>	logical. If TRUE, xy coordinates are included in the output
<code>cell</code>	logical. If TRUE, cell numbers are included in the output
<code>type</code>	one of "n", "p", "l" or "o". If "p" or "o" the points are plotted; if "l" or "o" they are joined by lines. See locator
<code>show</code>	logical. Print the values after each click?
<code>...</code>	additional graphics parameters used if type != "n" for plotting the locations. See locator

Value

The value(s) of `x` at the point(s) clicked on (or touched by the box drawn). A `data.frame` with the value(s) of all layers of `SpatRaster x` for the cell(s) clicked on; or with the attributes of the geometries of `SpatVector x` that intersect with the box drawn).

Note

The plot only provides the coordinates for a spatial query, the values are read from the `SpatRaster` or `SpatVector` that is passed as an argument. Thus, you can extract values from an object that has not been plotted, as long as it spatially overlaps with the extent of the plot.

Unless the process is terminated prematurely values at most `n` positions are determined. The identification process can be terminated, depending on how you interact with R, by hitting `Esc`, or by clicking the right mouse button and selecting "Stop" from the menu, or from the "Stop" menu on the graphics window.

See Also

[draw](#)

Examples

```
## Not run:
r <-rast(system.file("ex/elev.tif", package="terra"))
plot(r)
click(r, n=1)
## now click on the plot (map)

## End(Not run)
```

coerce

Coercion to vector, matrix or array

Description

Coercion of a `SpatRaster` to a vector, matrix or array. Or coerce a `SpatExtent` to a vector or matrix

Usage

```
## S4 method for signature 'SpatRaster'
as.vector(x, mode='any')

## S4 method for signature 'SpatRaster'
as.matrix(x, wide=FALSE, ...)

## S4 method for signature 'SpatRaster'
as.array(x)
```

```
## S4 method for signature 'SpatRasterDataset'
as.array(x)

## S4 method for signature 'SpatExtent'
as.vector(x, mode='any')

## S4 method for signature 'SpatExtent'
as.matrix(x, ...)
```

Arguments

x	SpatRaster or SpatVector
wide	logical. If FALSE each layer in the SpatRaster becomes a column in the matrix and each cell in the SpatRaster becomes a row. If TRUE each row in the SpatRaster becomes a row in the matrix and each column in the SpatRaster becomes a column in the matrix
mode	this argument is ignored
...	additional arguments (none implemented)

Value

vector, matrix, or array

See Also

[as.data.frame](#) and [as.polygons](#)

Examples

```
r <- rast(ncols=2, nrows=2)
values(r) <- 1:ncell(r)

as.vector(r)
as.matrix(r)
as.matrix(r, wide=TRUE)
as.data.frame(r, xy=TRUE)
as.array(r)

as.vector(ext(r))
as.matrix(ext(r))
```

colors

Color table

Description

Get or set color table(s) associated with a SpatRaster. Color tables are used for associating colors with values, for use in mapping (plot).

Usage

```
## S4 method for signature 'SpatRaster'
coltab(x)

## S4 replacement method for signature 'SpatRaster'
coltab(x, ..., layer=1)<-value

## S4 method for signature 'SpatRaster'
has.colors(x)
```

Arguments

x	SpatRaster
layer	positive integer, the layer number or name
value	a two-column data.frame (first column the cell value, the second column the color); a vector of colors (the first one is the color for value 0 and so on); or a four (value,red,green,blue) or five (including alpha) column data.frame also from 0 to n; or NULL to remove the color table. You can also supply a list of such data.frames to set a color table to all layers
...	additional arguments (none implemented)

Value

data.frame

Examples

```
r <- rast(ncols=3, nrows=2, vals=1:6)
x <- c(r, r)
names(x) <- c("A", "B")

coltb <- data.frame(value=1:6, col=rainbow(6, end=.9))
coltb

plot(r)

has.colors(r)
coltab(r) <- coltb
plot(r)
has.colors(r)

tb <- coltab(r)
class(tb)
dim(tb[[1]])

coltab(x, layer="B") <- coltb
```

 combineGeoms

Combine geometries

Description

Combine the geometries of one `SpatVector` with those of another. Geometries can be combined based on overlap, shared boundaries and distance (in that order of operation).

The typical use-case of this method is when you are editing geometries and you have a number of small polygons in one `SpatVector` that should be part of the geometries of the other `SpatVector`; perhaps because they were small holes in between the borders of two `SpatVectors`.

To append `SpatVectors` use `'rbind'` and see methods like `intersect` and `union` for "normal" polygons combinations.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
combineGeoms(x, y, overlap=TRUE, boundary=TRUE, distance=TRUE,
append=TRUE, minover=0.1, maxdist=Inf, dissolve=TRUE, erase=TRUE)
```

Arguments

<code>x</code>	<code>SpatVector</code> of polygons
<code>y</code>	<code>SpatVector</code> of polygons geometries that are to be combined with <code>x</code>
<code>overlap</code>	logical. If <code>TRUE</code> , a geometry is combined with the geometry it has most overlap with, if the overlap is above <code>minover</code>
<code>boundary</code>	logical. If <code>TRUE</code> , a geometry is combined with the geometry it has most shared border with
<code>distance</code>	logical. If <code>TRUE</code> , a geometry is combined with the geometry it is nearest to
<code>append</code>	logical. Should remaining geometries be appended to the output? Not relevant if <code>distance=TRUE</code>
<code>minover</code>	numeric. The fraction of the geometry in <code>y</code> that overlaps with a geometry in <code>x</code> . Below this threshold, geometries are not considered overlapping
<code>maxdist</code>	numeric. Geometries further away from each other than this distance (in meters) will not be combined
<code>dissolve</code>	logical. Should internal boundaries be dissolved?
<code>erase</code>	logical. If <code>TRUE</code> no new overlapping areas are created

Value

`SpatVector`

See Also

[union](#), [erase](#), [intersect](#), [sharedPaths](#), [aggregate](#), [rbind](#)

Examples

```
x1 <- vect("POLYGON ((0 0, 8 0, 8 9, 0 9, 0 0))")
x2 <- vect("POLYGON ((10 4, 12 4, 12 7, 11 7, 11 6, 10 6, 10 4))")

y1 <- vect("POLYGON ((5 6, 15 6, 15 15, 5 15, 5 6))")
y2 <- vect("POLYGON ((8 2, 9 2, 9 3, 8 3, 8 2))")
y3 <- vect("POLYGON ((2 6, 3 6, 3 8, 2 8, 2 6))")
y4 <- vect("POLYGON ((2 12, 3 12, 3 13, 2 13, 2 12))")

x <- rbind(x1, x2)
values(x) <- data.frame(xid=1:2)
crs(x) <- "+proj=utm +zone=1"

y <- rbind(y1, y2, y3, y4)
values(y) <- data.frame(yid=letters[1:4])
crs(y) <- "+proj=utm +zone=1"

plot(rbind(x, y), border=c(rep("red",2), rep("blue", 4)), lwd=2)
text(x, "xid")
text(y, "yid")

v <- combineGeoms(x, y)
plot(v, col=c("red", "blue"))

v <- combineGeoms(x, y, boundary=FALSE, maxdist=1, minover=.05)
plot(v, col=rainbow(4))
```

Description

Standard comparison and logical operators for computations with `SpatRasters`. Computations are local (applied on a cell by cell basis). If multiple `SpatRasters` are used, these must have the same geometry (extent and resolution). These operators have been implemented:

Logical: `!`, `&`, `|`, `isTRUE`, `isFALSE`

Compare: `==`, `!=`, `>`, `<`, `<=`, `>=`, `is.na`, `is.nan`, `is.finite`, `is.infinite`

See `not.na` for the inverse of `is.na`, and `noNA` to detect cells with missing value across layers.

The compare and logic methods implement these operators in a method that can return `NA` instead of `FALSE` and allows for setting an output filename.

The terra package does not distinguish between `NA` (not available) and `NaN` (not a number). In most cases this state is represented by `NaN`.

If you use a `SpatRaster` with a vector of multiple numbers, each element in the vector is considered a layer (with a constant value). If you use a `SpatRaster` with a matrix, the number of columns of the matrix must match the number of layers of the `SpatRaster`. The rows are used to match the cells. That is, if there are two rows, these match cells 1 and 2, and they are recycled to 3 and 4, etc.

The following method has been implemented for (**`SpatExtent`**, **`SpatExtent`**): `==`

Usage

```
## S4 method for signature 'SpatRaster'
compare(x, y, oper, falseNA=FALSE, filename="", overwrite=FALSE, ...)

## S4 method for signature 'SpatRaster'
logic(x, oper, falseNA=FALSE, filename="", overwrite=FALSE, ...)
```

Arguments

x	SpatRaster
y	SpatRaster or numeric
oper	character. Operator name. For compare this can be one of "=", "!", ">", "<", ">=", "<=" and for logic it can be one of "!", "is.na", "not.na", "allNA", "anyNA", "noneNA", "is.infinite", "is.finite", "isTRUE", "isFALSE"
falseNA	logical. Should the result be TRUE, NA instead of TRUE, FALSE?
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files as in writeRaster

Value

SpatRaster or SpatExtent

See Also

[all.equal](#), [Arith-methods](#). See [ifel](#) to conveniently combine operations and [Math-methods](#) or [app](#) to apply any R function to a SpatRaster.

Examples

```
r1 <- rast(ncols=10, nrows=10)
values(r1) <- runif(ncell(r1))
r1[10:20] <- NA
r2 <- rast(r1)
values(r2) <- 1:ncell(r2) / ncell(r2)

x <- is.na(r1)
!x
r1 == r2
compare(r1, r2, "=")
compare(r1, r2, "=", TRUE)
```

compareGeom	<i>Compare geometries</i>
-------------	---------------------------

Description

Evaluate whether two SpatRasters have the same extent, number of rows and columns, projection, resolution, and origin (or a subset of these comparisons).

Or evaluate whether two SpatVectors have the same geometries, or whether a SpatVector has duplicated geometries.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
compareGeom(x, y, ..., lyrs=FALSE, crs=TRUE, warncrs=FALSE, ext=TRUE,
rowcol=TRUE, res=FALSE, stopOnError=TRUE, messages=FALSE, tolerance=NULL)

## S4 method for signature 'SpatVector,SpatVector'
compareGeom(x, y, tolerance=0)

## S4 method for signature 'SpatVector,missing'
compareGeom(x, y, tolerance=0)
```

Arguments

x	SpatRaster or SpatVector
y	Same as x. If x is a SpatRaster, y can also be a list of SpatRasters. If x is a SpatVector, y can be missing
...	Additional SpatRasters
lyrs	logical. If TRUE, the number of layers is compared
crs	logical. If TRUE, coordinate reference systems are compared
warncrs	logical. If TRUE, a warning is given if the crs is different (instead of an error)
ext	logical. If TRUE, bounding boxes are compared
rowcol	logical. If TRUE, number of rows and columns of the objects are compared
res	logical. If TRUE, resolutions are compared (redundant when checking extent and rowcol)
stopOnError	logical. If TRUE, code execution stops if raster do not match
messages	logical. If TRUE, warning/error messages are printed even if stopOnError=FALSE
tolerance	numeric. For SpatRaster objects this is the difference in raster extent (expressed as the fraction of the raster resolution) that can be ignored when comparing alignment of rasters. If NULL the value shown by <code>link{terraOptions}</code> is used

Value

logical (SpatRaster) or matrix of logical (SpatVector)

Examples

```
r1 <- rast()
r2 <- rast()
r3 <- rast()
compareGeom(r1, r2, r3)
nrow(r3) <- 10
```

```
## Not run:
compareGeom(r1, r3)
```

```
## End(Not run)
```

concats

Concatenate categorical rasters

Description

Combine two categorical rasters by concatenating their levels.

Usage

```
## S4 method for signature 'SpatRaster'
concats(x, y, filename="", ...)
```

Arguments

x	SpatRaster (with a single, categorical, layer)
y	SpatRaster (with a single, categorical, layer)
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[cats](#)

Examples

```

set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE)
levels(r) <- data.frame(id=1:3, cover=c("forest", "water", "urban"))

rr <- rast(r)
values(rr) <- sample(1:3, ncell(rr), replace=TRUE)
levels(rr) <- data.frame(id=c(1:3), color=c("red", "green", "blue"))

x <- concats(r, rr)
x
levels(x)[[1]]

```

contour

Contour plot

Description

Contour lines (isolines) of a `SpatRaster`. Use `add=TRUE` to add the lines to the current plot. See `graphics::contour` for details.

if `filled=TRUE`, a new filled contour plot is made. See `graphics::filled.contour` for details.

`as.contour` returns the contour lines as a `SpatVector`.

Usage

```

## S4 method for signature 'SpatRaster'
contour(x, maxcells=100000, filled=FALSE, ...)

## S4 method for signature 'SpatRaster'
as.contour(x, maxcells=100000, ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code> . Only the first layer is used
<code>maxcells</code>	maximum number of pixels used to create the contours
<code>filled</code>	logical. If <code>TRUE</code> , a <code>filled.contour</code> plot is made
<code>...</code>	any argument that can be passed to <code>contour</code> or <code>filled.contour</code> (<code>graphics</code> package)

See Also

[plot](#)

Examples

```

r <- rast(system.file("ex/elev.tif", package="terra"))
plot(r)
contour(r, add=TRUE)

v <- as.contour(r)
plot(r)
lines(v)

contour(r, filled=TRUE, nlevels=5)

## if you want a SpatVector with contour lines
template <- disagg(rast(r), 10)
rr <- resample(r, template)
rr <- floor(rr/100) * 100
v <- as.polygons(rr)
plot(v, 1, col=terrain.colors(7))

## to combine filled contours with contour lines (or other spatial data)

br <- seq(100, 600, 100)
plot(r, breaks=br)
lines(as.contour(r, levels=br))

## or
x <- as.polygons(classify(r, br))
plot(x, "elevation")

```

costDist

Cost-distance

Description

Use a friction (cost) surface to compute the cost-distance from any cell to the border of one or more target cells.

Distances are computed by summing local distances between cells, which are connected with their neighbors in 8 directions, and assuming that the path has to go through the centers of one of the neighboring raster cells.

Distances are multiplied with the friction, thus to get the cost-distance, the friction surface must express the cost per unit distance (speed) of travel.

Usage

```

## S4 method for signature 'SpatRaster'
costDist(x, target=0, scale=1, maxiter=50, nearest=FALSE, filename="", ...)

```

Arguments

x	SpatRaster
target	numeric. value of the target cells (where to compute cost-distance to)
scale	numeric. Scale factor. The cost distance is divided by this number
maxiter	numeric. The maximum number of iterations. Increase this number if you get the warning that costDistance did not converge
nearest	logical. If TRUE, a second layer is returned with the cell number of the nearest target cell
filename	character. output filename (optional)
...	additional arguments as for writeRaster

Value

SpatRaster. If nearest=TRUE, a two-layer SpatRaster with the cost-distance in the first layer and the cell number of the nearest target in the second layer

See Also

[gridDist](#), [distance](#)

Examples

```
r <- rast(ncols=5, nrows=5, crs="+proj=utm +zone=1 +datum=WGS84",
xmin=0, xmax=5, ymin=0, ymax=5, vals=1)
r[13] <- 0
d <- costDist(r)
plot(d)
text(d, digits=1)

r <- rast(ncols=10, nrows=10, xmin=0, xmax=10, ymin=0, ymax=10,
vals=10, crs="+proj=utm +zone=1 +datum=WGS84")
r[4:5, c(1,10)] <- -10
r[2:3, 1] <- r[1, 2:4] <- r[2, 5] <- 0
r[3, 6] <- r[2, 7] <- r[1, 8:9] <- 0
r[, 4] <- 30
r[6, 6:10] <- NA
r[6:9, 6] <- NA

d <- costDist(r, -10, nearest=TRUE)
plot(d)
```

cover	<i>Replace values with values from another object</i>
-------	---

Description

Replace missing (NA) or other values in `SpatRaster` `x` with the values of `SpatRaster` `y`. Or replace missing values in the first layer with the first value encountered in other layers.

For polygons: areas of `x` that overlap with `y` are replaced by `y` or, if `identity=TRUE` intersected with `y`.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
cover(x, y, values=NA, filename="", ...)

## S4 method for signature 'SpatRaster,missing'
cover(x, y, values=NA, filename="", ...)

## S4 method for signature 'SpatVector,SpatVector'
cover(x, y, identity=FALSE, expand=TRUE)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>y</code>	Same as <code>x</code> or missing if <code>x</code> is a <code>SpatRaster</code>
<code>values</code>	numeric. The cell values in <code>x</code> to be replaced by the values in <code>y</code>
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster
<code>identity</code>	logical. If <code>TRUE</code> overlapping areas are intersected rather than replaced
<code>expand</code>	logical. Should parts of <code>y</code> that are outside of <code>x</code> be included?

Value

`SpatRaster`

Examples

```
r1 <- r2 <- rast(ncols=36, nrows=18)
values(r1) <- 1:ncell(r1)
values(r2) <- runif(ncell(r2))
r2 <- classify(r2, cbind(-Inf, 0.5, NA))
r3 <- cover(r2, r1)

p <- vect(system.file("ex/lux.shp", package="terra"))
e <- as.polygons(ext(6, 6.4, 49.75, 50))
```

```

values(e) <- data.frame(y=10)

cv <- cover(p, e)
plot(cv, col=rainbow(12))
ci <- cover(p, e, identity=TRUE)
lines(e, lwd=3)

plot(ci, col=rainbow(12))
lines(e, lwd=3)

```

crds

Get the coordinates of SpatVector geometries or SpatRaster cells

Description

Get the coordinates of a SpatVector or SpatRaster cells. A matrix or data.frame of the x (longitude) and y (latitude) coordinates is returned.

Usage

```

## S4 method for signature 'SpatVector'
crds(x, df=FALSE, list=FALSE)

## S4 method for signature 'SpatRaster'
crds(x, df=FALSE, na.rm=TRUE, na.all=FALSE)

```

Arguments

x	SpatRaster or SpatVector
df	logical. If TRUE a data.frame is returned instead of a matrix
list	logical. If TRUE a list is returned instead of a matrix
na.rm	logical. If TRUE cells that are NA are excluded. Ignored if the SpatRaster is a template with no associated cell values
na.all	logical. If TRUE cells are only ignored if na.rm=TRUE and their value is NA for all layers instead of for any layer

Value

matrix or data.frame

See Also

[geom](#) returns the complete structure of SpatVector geometries. For SpatRaster see [xyFromCell](#)

Examples

```
x1 <- rbind(c(-175,-20), c(-140,55), c(10, 0), c(-140,-60))
x2 <- rbind(c(-125,0), c(0,60), c(40,5), c(15,-45))
x3 <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
x4 <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))
z <- rbind(cbind(object=1, part=1, x1), cbind(object=2, part=1, x2),
          cbind(object=3, part=1, x3), cbind(object=3, part=2, x4))
colnames(z)[3:4] <- c('x', 'y')
z <- cbind(z, hole=0)
z[(z[, "object"]==3 & z[, "part"]==2), "hole"] <- 1

p <- vect(z, "polygons")
crds(p)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
g <- crds(v)
head(g)
```

crop

Cut out a geographic subset

Description

Cut out a part of a `SpatRaster` or `SpatVector`.

You can crop a `SpatRaster` with a `SpatExtent`, or with another object from which an extent can be obtained. Note that the `SpatRaster` returned may not have the exactly the same extent as the `SpatExtent` supplied because you can only select entire cells (rows and columns), and you cannot add new areas. See methods like [resample](#) and [disagg](#) to force `SpatRasters` to align and [extend](#) to add rows and/or columns.

You can only crop rectangular areas of a `SpatRaster`, but see argument `mask=TRUE` for setting cell values within `SpatRaster` to NA; or use the [mask](#) method after `crop` for additional masking options.

You can crop a `SpatVector` with another `SpatVector`. If these are not polygons, the minimum convex hull is used. Unlike with [intersect](#) the geometries and attributes of `y` are not transferred to the output. You can also crop a `SpatVector` with a rectangle (`SpatRaster`, `SpatExtent`).

Usage

```
## S4 method for signature 'SpatRaster'
crop(x, y, snap="near", mask=FALSE, touches=TRUE, extend=FALSE, filename="", ...)

## S4 method for signature 'SpatRasterDataset'
crop(x, y, snap="near", extend=FALSE)

## S4 method for signature 'SpatRasterCollection'
crop(x, y, snap="near", extend=FALSE)
```

```
## S4 method for signature 'SpatVector'
crop(x, y, ext=FALSE)

## S4 method for signature 'SpatGraticule'
crop(x, y)
```

Arguments

x	SpatRaster or SpatVector
y	SpatRaster, SpatVector, SpatExtent, or any other object that has a SpatExtent (ext returns a SpatExtent)
snap	character. One of "near", "in", or "out". Used to align y to the geometry of x
mask	logical. Should y be used to mask? Only used if y is a SpatVector, SpatRaster or sf
touches	logical. If TRUE and mask=TRUE, all cells touched by lines or polygons will be masked, not just those on the line render path, or whose center point is within the polygon
extend	logical. Should rows and/or columns be added if y is beyond the extent of x? Also see extend
filename	character. Output filename
...	additional arguments for writing files as in writeRaster
ext	logical. Use the extent of y instead of y. This also changes the behavior when y is an extent in two ways: (1) points that are on the extent boundary are removed and (2) lon/lat extents that go beyond -180 or 180 degrees longitude are wrapped around the earth to include areas at the other end of the dateline

Value

SpatRaster

See Also

[intersect](#), [extend](#)

See [window](#) for a virtual and sometimes more efficient way to crop a dataset.

Examples

```
r <- rast(xmin=0, xmax=10, ymin=0, ymax=10, nrows=25, ncols=25)
values(r) <- 1:ncell(r)
e <- ext(-5, 5, -5, 5)
rc <- crop(r, e)

# crop and mask
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
f <- system.file("ex/lux.shp", package="terra")
```

```

v <- vect(f)
cm <- crop(r, v[9:12,], mask=TRUE)
plot(cm)
lines(v)

# crop vector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
e <- ext(6.15, 6.3, 49.7, 49.8)
x <- crop(v, e)
plot(x, "NAME_1")

```

crosstab

Cross-tabulate

Description

Cross-tabulate the layers of a `SpatRaster` to create a contingency table.

Usage

```

## S4 method for signature 'SpatRaster,missing'
crosstab(x, digits=0, long=FALSE, useNA=FALSE)

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>digits</code>	integer. The number of digits for rounding the values before cross-tabulation
<code>long</code>	logical. If TRUE the results are returned in 'long' format data.frame instead of a table
<code>useNA</code>	logical, indicating if the table should includes counts of NA values

Value

A table or data.frame

Author(s)

Andrew Gene Brown, Robert J. Hijmans

See Also

[freq](#), [zonal](#)

Examples

```

r <- s <- rast(nc=5, nr=5)
set.seed(1)
values(r) <- runif(ncell(r)) * 2
values(s) <- runif(ncell(r)) * 3
x <- c(r, s)

crosstab(x)

rs <- r/s
r[1:5] <- NA
s[20:25] <- NA
x <- c(r, s, rs)
crosstab(x, useNA=TRUE, long=TRUE)

```

crs

Get or set a coordinate reference system

Description

Get or set the coordinate reference system (CRS), also referred to as a "projection", of a `SpatRaster` or `SpatVector`.

Setting a new CRS does not change the data itself, it just changes the label. So you should only set the CRS of a dataset (if it does not come with one) to what it *is*, not to what you would *like* it to be. See [project](#) to *transform* an object from one CRS to another.

Usage

```

## S4 method for signature 'SpatRaster'
crs(x, proj=FALSE, describe=FALSE, parse=FALSE)

## S4 method for signature 'SpatVector'
crs(x, proj=FALSE, describe=FALSE, parse=FALSE)

## S4 method for signature 'character'
crs(x, proj=FALSE, describe=FALSE, parse=FALSE)

## S4 replacement method for signature 'SpatRaster'
crs(x, warn=FALSE)<-value

## S4 replacement method for signature 'SpatVector'
crs(x, warn=FALSE)<-value

```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
proj	logical. If TRUE the crs is returned in PROJ-string notation

describe	logical. If TRUE the name, EPSG code, and the name and extent of the area of use are returned if known
warn	logical. If TRUE, a message is printed when the object already has a non-empty crs
value	character string describing a coordinate reference system. This can be in a WKT format, as a <authority:number> code such as "EPSG:4326", or a PROJ-string format such as "+proj=utm +zone=12" (see Note)
parse	logical. If TRUE, wkt parts are parsed into a vector (each line becomes an element)

Value

character or modified SpatRaster/Vector

Note

Projections are handled by the PROJ/GDAL libraries. The PROJ developers suggest to define a CRS with the WKT2 or <authority>:<code> notation. It is not practical to define one's own custom CRS with WKT2, and the <authority>:<code> system only covers a handful of (commonly used) CRSs. To work around this problem it is still possible to use the deprecated PROJ-string notation (+proj=...) with one major caveat: the datum should be WGS84 (or the equivalent NAD83) – if you want to transform your data to a coordinate reference system with a different datum. Thus as long as you use WGS84, or an ellipsoid instead of a datum, you can safely use PROJ-strings to represent your CRS; including to define your own custom CRS.

You can also set the crs to "local" to get an informal coordinate system on an arbitrary Euclidean (Cartesian) plane with units in meter.

Examples

```
r <- rast()
crs(r)
crs(r, describe=TRUE, proj=TRUE)

crs(r) <- "+proj=lcc +lat_1=48 +lat_2=33 +lon_0=-100 +ellps=WGS84"
crs(r)

# You can use epsg codes
crs(r) <- "epsg:25831"
crs(r, describe=TRUE)$area

crs("epsg:25831", describe=TRUE)
```

datatype	<i>Data type of a SpatRaster or SpatVector</i>
----------	--

Description

Get the data types of the fields (attributes, variables) of a SpatVector or of the file(s) associated with a SpatRaster. A (layer of a) SpatRaster has no datatype if it has no values, or if the values are in memory.

Usage

```
## S4 method for signature 'SpatRaster'
datatype(x, bylyr=TRUE)
```

```
## S4 method for signature 'SpatVector'
datatype(x)
```

Arguments

x	SpatRaster or SpatVector
bylyr	logical. If TRUE a value is returned for each layer. Otherwise, a value is returned for each data source (such as a file)

Details

Setting the data type is useful if you want to write values to disk with [writeRaster](#). In other cases you can use functions such as [round](#) and [floor](#), or [as.bool](#)

raster datatypes are described by 5 characters. The first three indicate whether the values are integer or decimal values. The fourth character indicates the number of bytes used to save the values on disk, and the last character indicates whether the numbers are signed (that is, can be negative and positive values) or not (only zero and positive values allowed)

The following raster datatypes are available:

Datatype definition	minimum possible value	maximum possible value
INT1U	0	255
INT2U	0	65,535
INT4U	0	4,294,967,296
INT8U	0	18,446,744,073,709,551,616
INT1S	-128	128
INT2S	-32,767	32,767
INT4S	-2,147,483,647	2,147,483,647
INT8S	-9,223,372,036,854,775,808	9,223,372,036,854,775,808
FLT4S	-3.4e+38	3.4e+38
FLT8S	-1.7e+308	1.7e+308

For all integer and byte types the lowest (signed) or highest (unsigned) value is used to store NA. For float types NaN is used (following the IEEE 754 standard).

Note that very large integer numbers may be imprecise as they are internally represented as decimal numbers.

Also note that NaN may not be equally supported by all implementations. For example OGR SQL and SQLite queries generally convert NaN values to NULL.

INT4U and INT8U are available but they are best avoided as R does not support 32-bit or 64-bit unsigned integers. INT8U is a special case where the NA store value is 18446744073709549568 (UINT64_MAX - 1101) because of precision in decimal representation.

INT8U and INT8S require GDAL version 3.5 or higher. INT1S requires GDAL version 3.7 or higher.

Value

character

See Also

[Raster data types](#) to check / set the type of SpatRaster values.

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
datatype(v)

f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
datatype(r)

# no data type
datatype(rast())
```

deepcopy

Deep copy

Description

Make a deep copy of a SpatRaster or SpatVector. This is occasionally useful when using an in-place replacement function that does not make copy, such as [set.ext](#).

Usage

```
## S4 method for signature 'SpatRaster'
deepcopy(x)

## S4 method for signature 'SpatVector'
deepcopy(x)
```

Arguments

x SpatRaster or SpatVector

Value

Same as x

Examples

```
r <- rast(ncols=10, nrows=10, nl=3)
x <- r
y <- deepcopy(r)
ext(r)
set.ext(x, c(0,10,0,10))
ext(x)
ext(r)
ext(y)
```

densify

Add additional nodes to lines or polygons

Description

Add additional nodes to lines or polygons. This can be useful to do prior to using project such that the path does not change too much.

Usage

```
## S4 method for signature 'SpatVector'
densify(x, interval, equalize=TRUE, flat=FALSE)
```

Arguments

x SpatVector

interval positive number, specifying the desired minimum distance between nodes. The unit is meter for lonlat data, and in the linear unit of the crs for planar data

equalize logical. If TRUE, new nodes are spread at equal intervals between old nodes

flat logical. If TRUE, the earth's curvature is ignored for lonlat data, and the distance unit is degrees, not meter

Value

SpatVector

See Also

[simplifyGeom](#), [thinNodes](#)

Examples

```

v <- vect(rbind(c(-120,-20), c(-80,5), c(-40,-60), c(-120,-20)),
  type="polygons", crs="+proj=longlat")
vd <- densify(v, 200000)

p <- project(v, "+proj=robin")
pd <- project(vd, "+proj=robin")

# good
plot(pd, col="gray", border="red", lwd=10)
points(pd, col="gray")

# bad
lines(p, col="blue", lwd=3)
points(p, col="blue", cex=2)
plot(p, col="blue", alpha=.1, add=TRUE)
legend("topright", c("good", "bad"), col=c("red", "blue"), lty=1, lwd=3)

## the other way around does not work
## unless the original data was truly planar (e.g. derived from a map)
x <- densify(p, 250000)
y <- project(x, "+proj=longlat")
# bad
plot(y)
# good
lines(vd, col="red")

```

density

Density plot

Description

Create density plots of the cell values of a `SpatRaster`

Usage

```

## S4 method for signature 'SpatRaster'
density(x, maxcells=100000, plot=TRUE, main, ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>maxcells</code>	the maximum number of (randomly sampled) cells to be used for creating the plot
<code>plot</code>	if TRUE produce a plot, else return a density object
<code>main</code>	character. Caption of plot(s)
<code>...</code>	additional arguments passed to <code>plot</code>

Value

density plot (and a density object, returned invisibly if plot=TRUE)

Examples

```
logo <- rast(system.file("ex/logo.tif", package="terra"))
density(logo)
```

deprecated	<i>deprecated methods</i>
------------	---------------------------

Description

This method is no longer available. Use [gridDist](#) instead

Usage

```
## S4 method for signature 'SpatRaster'
gridDistance(x, ...)
```

Arguments

x	object
...	additional arguments

depth	<i>depth of SpatRaster layers</i>
-------	-----------------------------------

Description

Get or set the depth of the layers of a SpatRaster. Experimental.

Usage

```
## S4 method for signature 'SpatRaster'
depth(x)

## S4 replacement method for signature 'SpatRaster'
depth(x)<-value

## S4 method for signature 'SpatRaster'
depthName(x)

## S4 replacement method for signature 'SpatRaster'
depthName(x)<-value
```

```
## S4 method for signature 'SpatRaster'
depthUnit(x)

## S4 replacement method for signature 'SpatRaster'
depthUnit(x)<-value
```

Arguments

x	SpatRaster
value	numeric vector (depth), or character (depthName and depthUnit)

Value

numeric or SpatRaster

See Also

[time](#)

Examples

```
s <- rast(nlyr=3)

depth(s) <- c(0, pi/2, pi)
depth(s)

depthName(s) <- "angle"
depthUnit(s) <- "radians"
s
```

describe

describe

Description

Describe the properties of spatial data in a file as generated with the "GDALInfo" tool.

Usage

```
## S4 method for signature 'character'
describe(x, sds=FALSE, meta=FALSE, parse=FALSE, options="", print=FALSE, open_opt="")

## S4 method for signature 'SpatRaster'
describe(x, source, ...)
```

Arguments

x	character. The name of a file with spatial data. Or a fully specified subdataset within a file such as "NETCDF:\AVHRR.nc\":NDVI"
sds	logical. If TRUE the description or metadata of the subdatasets is returned (if available)
meta	logical. Get the file level metadata instead
parse	logical. If TRUE, metadata for subdatasets is parsed into components (if meta=TRUE)
options	character. A vector of valid options (if meta=FALSE) including "json", "mm", "stats", "hist", "nogcp", "nomd", "norat", "noct", "nofl", "checksum", "proj4", "listmdd", "mdd <value>" where <value> specifies a domain or 'all', "wkt_format <value>" where value is one of 'WKT1', 'WKT2', 'WKT2_2015', or 'WKT2_2018', "sd <subdataset>" where <subdataset> is the name or identifier of a sub-dataset. See https://gdal.org/en/latest/programs/gdalinfo.html . Ignored if sds=TRUE
print	logical. If TRUE, print the results
open_opt	character. Driver specific open options
source	positive integer between 1 and nsrc(x)
...	additional arguments passed to the describe<character> method

Value

character (invisibly, if print=FALSE)

See Also

[ar_info](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
describe(f)
describe(f, meta=TRUE)
#g <- describe(f, options=c("json", "nomd", "proj4"))
#head(g)
```

diff

Lagged differences

Description

Compute the difference between consecutive layers in a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
diff(x, lag=1, filename="", ...)
```

Arguments

x	SpatRaster
lag	positive integer indicating which lag to use
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
d <- diff(s)
```

dimensions

Dimensions of a SpatRaster or SpatVector and related objects

Description

Get the number of rows (nrow), columns (ncol), cells (ncell), layers (nlyr), sources (nsrc), the size size (nlyr(x)*ncell(x)), or spatial resolution of a SpatRaster.

length returns the number of sub-datasets in a SpatRasterDataset or SpatVectorCollection.

For a SpatVector length(x) is the same as nrow(x).

You can also set the number of rows or columns or layers. When setting dimensions, all cell values are dropped.

Usage

```
## S4 method for signature 'SpatRaster'
ncol(x)

## S4 method for signature 'SpatRaster'
nrow(x)

## S4 method for signature 'SpatRaster'
nlyr(x)

## S4 method for signature 'SpatRaster'
ncell(x)

## S4 method for signature 'SpatRaster'
nsrc(x)

## S4 replacement method for signature 'SpatRaster,numeric'
```

```
ncol(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
nrow(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
nlyr(x)<-value

## S4 method for signature 'SpatRaster'
res(x)

## S4 replacement method for signature 'SpatRaster,numeric'
res(x)<-value

## S4 method for signature 'SpatRaster'
xres(x)

## S4 method for signature 'SpatRaster'
yres(x)

## S4 method for signature 'SpatVector'
ncol(x)

## S4 method for signature 'SpatVector'
nrow(x)

## S4 method for signature 'SpatVector'
length(x)
```

Arguments

x	SpatRaster or SpatVector or related objects
value	For ncol and nrow: positive integer. For res: one or two positive numbers

Value

integer

See Also

[ext](#)

Examples

```
r <- rast()
ncol(r)
nrow(r)
nlyr(r)
```

```

dim(r)
nsrc(r)
ncell(r)

rr <- c(r,r)
nlyr(rr)
nsrc(rr)
ncell(rr)

nrow(r) <- 18
ncol(r) <- 36
# equivalent to
dim(r) <- c(18, 36)

dim(r)
dim(r) <- c(10, 10, 5)
dim(r)

xres(r)
yres(r)
res(r)

res(r) <- 1/120
# different xres and yres
res(r) <- c(1/120, 1/60)

```

direction

Direction

Description

The direction (azimuth) to or from the nearest cell that is not NA. The direction is expressed in radians, unless you use argument degrees=TRUE.

Usage

```

## S4 method for signature 'SpatRaster'
direction(x, from=FALSE, degrees=FALSE, method="cosine", filename="", ...)

```

Arguments

x	SpatRaster
from	Logical. Default is FALSE. If TRUE, the direction from (instead of to) the nearest cell that is not NA is returned
degrees	Logical. If FALSE (the default) the unit of direction is radians.
method	character. Should be "geo", or "cosine". With "geo" the most precise but slower geodesic method of Karney (2003) is used. The "cosine" method is faster but less precise
filename	Character. Output filename (optional)
...	Additional arguments as for writeRaster

Value

SpatRaster

See Also[distance](#)**Examples**

```
r <- rast(ncol=36,nrow=18, crs="+proj=merc")
values(r) <- NA
r[306] <- 1
b <- direction(r, degrees=TRUE)
plot(b)

crs(r) <- "+proj=longlat"
b <- direction(r)
plot(b)
```

disagg

*Disaggregate raster cells or vector geometries***Description**

SpatRaster: Create a SpatRaster with a higher resolution (smaller cells). The values in the new SpatRaster are the same as in the larger original cells.

SpatVector: Separate multi-objects (points, lines, polygons) into single objects; or further into segments (for lines or polygons).

Usage

```
## S4 method for signature 'SpatRaster'
disagg(x, fact, method="near", filename="", ...)
```

```
## S4 method for signature 'SpatVector'
disagg(x, segments=FALSE)
```

Arguments

x	SpatRaster or SpatVector
fact	positive integer. Aggregation factor expressed as number of cells in each direction (horizontally and vertically). Or two integers (horizontal and vertical aggregation factor) or three integers (when also aggregating over layers)
method	character. Either "near" for nearest or "bilinear" for bilinear interpolation
segments	logical. Should (poly-)lines or polygons be disaggregated into their line-segments?
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also[aggregate](#), [resample](#)**Examples**

```
r <- rast(ncols=10, nrows=10)
rd <- disagg(r, fact=c(10, 2))
ncol(rd)
nrow(rd)
values(r) <- 1:ncell(r)
rd <- disagg(r, fact=c(4, 2))
```

distance

*Geographic distance***Description**

If *x* is a **SpatRaster**:

If *y* is missing this method computes the distance, for all cells that are NA in SpatRaster *x* to the nearest cell that is not NA (or other values, see arguments "target" and "exclude").

If *y* is a numeric value, the cells with that value are ignored. That is, distance to or from these cells is not computed.

If *y* is a SpatVector, the distance to that SpatVector is computed for all cells, optionally after rasterization.

The distance is always expressed in meter if the coordinate reference system is longitude/latitude, and in map units otherwise. Map units are typically meter, but inspect `crs(x)` if in doubt.

Results are more precise, sometimes much more precise, when using longitude/latitude rather than a planar coordinate reference system, as these distort distance.

If *x* is a **SpatVector**:

If *y* is missing, a distance matrix between all objects in *x* is computed. A distance matrix object of class "dist" is returned.

If *y* is a SpatVector, the geographic distance between all objects is computed (and a matrix is returned). If both sets have the same number of points, and `pairwise=TRUE`, the distance between each pair of objects is computed, and a vector is returned.

If *x* is a **matrix**:

x should consist of two columns, the first with "x" (or longitude) and the second with "y" coordinates (or latitude). If *y* is also a matrix, the distance between each point in *x* and all points in *y* is computed, unless `pairwise=TRUE`

If *y* is missing, the distance between each point in *x* with all other points in *x* is computed, unless `sequential=TRUE`

Usage

```
## S4 method for signature 'SpatRaster,missing'
distance(x, y, target=NA, exclude=NULL, unit="m", method="haversine",
maxdist=NA, values=FALSE, filename="", ...)

## S4 method for signature 'SpatRaster,SpatVector'
distance(x, y, unit="m", rasterize=FALSE, method="haversine", filename="", ...)

## S4 method for signature 'SpatVector,SpatVector'
distance(x, y, pairwise=FALSE, unit="m", method="haversine",
use_nodes=FALSE, names=NULL)

## S4 method for signature 'SpatVector,ANY'
distance(x, y, sequential=FALSE, pairs=FALSE, symmetrical=TRUE, unit="m",
method="haversine", use_nodes=FALSE, names=NULL)

## S4 method for signature 'matrix,matrix'
distance(x, y, lonlat, pairwise=FALSE, unit="m", method="geo")

## S4 method for signature 'matrix,missing'
distance(x, y, lonlat, sequential=FALSE, pairs=FALSE, symmetrical=TRUE,
unit="m", method="geo")
```

Arguments

x	SpatRaster, SpatVector, or two-column matrix with coordinates (x,y or lon,lat)
y	missing, numeric, SpatVector, or two-column matrix
target	numeric. The value of the cells for which distances to cells that are not NA should be computed
exclude	numeric. The value of the cells that should not be considered for computing distances
unit	character. Can be either "m" or "km"
method	character. One of "geo", "cosine" or "haversine". With "geo" the most precise but slower method of Karney (2003) is used. The other two methods are faster but less precise
maxdist	numeric. Distances above this value are set to NA
values	logical. If TRUE, the value of the nearest non-target cell is returned instead of the distance to that cell
rasterize	logical. If TRUE distance is computed from the cells covered by the geometries after rasterization. This can be much faster in some cases
filename	character. Output filename
...	additional arguments for writing files as in writeRaster
sequential	logical. If TRUE, the distance between sequential geometries is returned
pairwise	logical. If TRUE and if x and y have the same size (number of rows), the pairwise distances are returned instead of the distances between all elements

lonlat	logical. If TRUE the coordinates are interpreted as angular (longitude/latitude). If FALSE they are interpreted as planar
pairs	logical. If TRUE a "from", "to", "distance" matrix is returned
symmetrical	logical. If TRUE and pairs=TRUE, the distance between a pair is only included once. The distance between geometry 1 and 3 is included, but the (same) distance between 3 and 1 is not
use_nodes	logical. If TRUE and the crs is longitude/latitude, the nodes (vertices) of lines or polygons are used to compute distances, instead of the lines that connect them. This is faster, but can be less precise if the nodes are far apart
names	character. One (or two) variable names in x (and y) to label the distance matrix

Value

SpatRaster, numeric, matrix, or a distance matrix (object of class "dist")

Note

A distance matrix can be coerced into a regular matrix with `as.matrix`

References

Karney, C.F.F., 2013. Algorithms for geodesics, *J. Geodesy* 87: 43-55. doi:10.1007/s00190-012-0578-z.

See Also

[nearest](#), [nearby](#), [gridDist](#), [costDist](#)

Examples

```
#lonlat
r <- rast(ncols=36, nrows=18, crs="+proj=longlat +datum=WGS84")
r[500] <- 1
d <- distance(r, unit="km")
plot(d / 1000)

#planar
rr <- rast(ncols=36, nrows=18, crs="+proj=utm +zone=1 +datum=WGS84")
rr[500] <- 1
d <- distance(rr)

rr[3:10, 3:10] <- 99
e <- distance(rr, exclude=99)

p1 <- vect(rbind(c(0,0), c(90,30), c(-90,-30)), crs="lonlat")
values(p1) <- data.frame(ID=LETTERS[1:3])
dp <- distance(r, p1)

d <- distance(p1)
d
```

```

as.matrix(d)

p2 <- vect(rbind(c(30,-30), c(25,40), c(-9,-3)), crs="+proj=longlat +datum=WGS84")
values(p2) <- data.frame(ID=letters[1:3])
dd <- distance(p1, p2, names=c("ID", "ID"))
dd
pd <- distance(p1, p2, pairwise=TRUE)
pd
pd == diag(dd)

# polygons, lines
crs <- "+proj=utm +zone=1"
p1 <- vect("POLYGON ((0 0, 8 0, 8 9, 0 9, 0 0))", crs=crs)
p2 <- vect("POLYGON ((5 6, 15 6, 15 15, 5 15, 5 6))", crs=crs)
p3 <- vect("POLYGON ((2 12, 3 12, 3 13, 2 13, 2 12))", crs=crs)
p <- rbind(p1, p2, p3)
L1 <- vect("LINESTRING(1 11, 4 6, 10 6)", crs=crs)
L2 <- vect("LINESTRING(8 14, 12 10)", crs=crs)
L3 <- vect("LINESTRING(1 8, 12 14)", crs=crs)
lns <- rbind(L1, L2, L3)
pts <- vect(cbind(c(7,10,10), c(3,5,6)), crs=crs)

distance(p1,p3)
distance(p)
distance(p,pts)
distance(p,lns)
distance(pts,lns)

```

divide
Subdivide a raster or polygons

Description

Divide a `SpatRaster` into `n` parts with approximately the same sum of weights (cell values).

Divides a `SpatVector` of polygons into `n` compact and approximately equal area parts. The results are not deterministic so you should use `set.seed` to be able to reproduce your results. If you get a warning about non-convergence, you can increase the number of iterations used with additional argument `iter.max`

Usage

```
## S4 method for signature 'SpatRaster'
divide(x, n=2, start="ns", as.raster=FALSE, na.rm=TRUE)
```

```
## S4 method for signature 'SpatVector'
divide(x, n=5, w=NULL, alpha=1, ...)
```

Arguments

<code>x</code>	SpatRaster or SpatVector of polygons
<code>n</code>	numeric. Can be a single positive integer to indicate the number of parts (SpatVector) or the number of splits (SpatRaster). If <code>x</code> is a SpatRaster, it can also be a vector with values -2, -1, 1, or 2. Where 1 means one split and 2 means two splits, and the negative sign indicates an East-West (vertical) split as opposed to a North-South split. If <code>x</code> is a SpatVector it can be a list with at least one of these elements: <code>horizontal</code> and <code>vertical</code> that specify the proportions of the area that splits should cover. This can either be a single fraction such as <code>1/3</code> , or a sequence of fractions in ascending order such as <code>c(1/4, 1/2, 1)</code>
<code>start</code>	character. To indicate the initial direction of splitting the raster. "ns" for North-South (horizontal) or "ew" for East-West (vertical)
<code>as.raster</code>	logical. If FALSE a SpatVector is returned. If TRUE, a SpatRaster is returned. If NA a list with a SpatRaster and a SpatVector is returned
<code>na.rm</code>	logical. If TRUE cells in <code>x</code> that are NA are not included in the output
<code>w</code>	SpatRaster with, for example, environmental data
<code>alpha</code>	numeric. One or two numbers that act as weights for the x and y coordinates
<code>...</code>	additional arguments such as <code>iter.max</code> passed on to kmeans

Value

SpatVector or SpatRaster, or a list with both

See Also

[thresh](#); [makeTiles](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- divide(r, 3)
# plot(r); lines(x)
```

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
d <- divide(v, 3)
dv <- divide(v, list(h=.5))
```

dots*Make a dot-density map*

Description

Create the dots for a dot-density map and add these to the current map. Dot-density maps are made to display count data. For example of population counts, where each dot represents n persons. The dots are returned as a `SpatVector`. If there is an active graphics device, the dots are added to it with [points](#).

Usage

```
## S4 method for signature 'SpatVector'  
dots(x, field, size, ...)
```

Arguments

<code>x</code>	<code>SpatVector</code>
<code>field</code>	character of numeric indicating field name. Or numeric vector of the same length as <code>x</code>
<code>size</code>	positive number indicating the number of cases associated with each dot
<code>...</code>	graphical arguments passed to <code>points</code>

Value

`SpatVector` (invisibly)

See Also

[plot](#), [cartogram](#), [points](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")  
v <- vect(f)  
v$population <- 1000*(1:12)^2  
plot(v, lwd=3, col="light gray", border="white")  
d <- dots(v, "population", 1000, col="red", cex=.75)  
lines(v)  
d
```

`draw`*Draw a polygon, line, extent, or points*

Description

Draw on a plot (map) to get a `SpatVector` or `SpatExtent` object for later use. After calling the function, start clicking on the map. When you are done, press ESC. You can also preset the maximum number of clicks.

Note that for many installations this does not work well on the default RStudio plotting device. To work around that, you can first run `dev.new(noRStudioGD = TRUE)` which will create a separate window for plotting, then use `plot()` followed by `draw()` and clicking on the map. It may also help to set your RStudio "Tools/Global Options/Appearance/Zoom" to 100

Usage

```
## S4 method for signature 'character'
draw(x="extent", col="red", lwd=2, id=FALSE, n=1000, xpd=TRUE, ...)
```

Arguments

<code>x</code>	character. The type of object to draw. One of "extent", "polygon", "line", or "points"
<code>col</code>	the color to be used
<code>lwd</code>	the width of the lines to be drawn
<code>id</code>	logical. If TRUE, a numeric ID is shown on the map
<code>n</code>	the maximum number of clicks (does not apply when <code>x=="extent"</code> in which case <code>n</code> is always 2)
<code>xpd</code>	logical. If TRUE, you can draw outside the current plotting area
<code>...</code>	additional graphics arguments for drawing

Value

`SpatVector` or `SpatExtent`

See Also

[click](#)

elongate *elongate lines*

Description

Elongate SpatVector lines

Usage

```
## S4 method for signature 'SpatVector'
elongate(x, length=1, flat=FALSE)
```

Arguments

x	SpatVector
length	positive number indicating how much the lines should be elongated at each end. The unit is meter if the crs is lonlat and it is the same as the linear unit of the crs on other cases (also meter in most cases)
flat	logical. If TRUE, the earth's curvature is ignored for lonlat data, and the distance unit is degrees, not meter

Value

SpatVector

See Also

[buffer](#), [crop](#), [erase](#), [extend](#)

Examples

```
v <- vect(cbind(c(0,1,2), c(0,0,2)), "lines", crs="lonlat")
e <- elongate(v, 100000)
plot(e)
points(e)
geom(e)
```

erase

Erase parts of a SpatVector object

Description

Erase parts of a SpatVector with another SpatVector or with a SpatExtent. You can also erase (parts of) polygons with the other polygons of the same SpatVector.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'  
erase(x, y)
```

```
## S4 method for signature 'SpatVector,missing'  
erase(x, sequential=TRUE)
```

```
## S4 method for signature 'SpatVector,SpatExtent'  
erase(x, y)
```

Arguments

x	SpatVector
y	SpatVector or SpatExtent
sequential	logical. Should areas be erased sequentially? See Details

Details

If polygons are erased sequentially, everything that is covered by the first polygon is removed from all other polygons, then everything that is covered by (what is remaining of) the second polygon is removed, etc.

If polygons are not erased sequentially, all overlapping areas are erased and only the areas covered by a single geometry are returned.

Value

SpatVector or SpatExtent

See Also

[crop](#) and [intersect](#) for the inverse.

The equivalent for SpatRaster is [mask](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

# polygons with polygons or extent

e <- ext(5.6, 6, 49.55, 49.7)
x <- erase(v, e)

p <- vect("POLYGON ((5.8 49.8, 6 49.9, 6.15 49.8, 6 49.6, 5.8 49.8))")
y <- erase(v, p)

# lines with polygons
lms <- as.lines(rast(v, ncol=10, nrow=10))[12:22]
eln <- erase(lms, v)
plot(v)
lines(lms, col='blue', lwd=4, lty=3)
lines(eln, col='red', lwd=2)

## self-erase
h <- convHull(v[-12], "NAME_1")
he <- erase(h)
plot(h, lwd=2, border="red", lty=2)
lines(he, col="gray", lwd=3)
```

expanses	<i>Get the expanses (area) of individual polygons or for all (summed) raster cells</i>
----------	--

Description

Compute the area covered by polygons or for all raster cells that are not NA.

This method computes areas for longitude/latitude rasters, as the size of the cells is constant in degrees, but not in square meters. But it can also be important if the coordinate reference system is planar, but not equal-area.

For vector data, the best way to compute area is to use the longitude/latitude CRS. This is contrary to (erroneous, but popular) belief that you should use a planar coordinate reference system. Where applicable, the transformation to lon/lat is done automatically, if `transform=TRUE`.

Note that it is important that polygon geometries are valid. If they are not valid, the computed area may be wrong. You can check for validity with [is.valid](#) and fix some problems with [makeValid](#)

Usage

```
## S4 method for signature 'SpatRaster'
expanses(x, unit="m", transform=TRUE, byValue=FALSE,
zones=NULL, wide=FALSE, usenames=FALSE)
```

```
## S4 method for signature 'SpatVector'
expansE(x, unit="m", transform=TRUE)
```

Arguments

x	SpatRaster or SpatVector
unit	character. Output unit of area. One of "m", "km", or "ha"
transform	logical. If TRUE, planar CRS are transformed to lon/lat for accuracy
byValue	logical. If TRUE, the area for each unique cell value is returned
zones	NULL or SpatRaster with the same geometry identifying zones in x
wide	logical. Should the results be in "wide" rather than "long" format?
usenames	logical. If TRUE layers are identified by their names instead of their numbers

Value

SpatRaster: data.frame with at least two columns ("layer" and "area") and possibly also "value" (if byValue is TRUE), and "zone" (if zones is TRUE). If x has no values, the total area of all cells is returned. Otherwise, the area of all cells that are not NA is returned.

SpatVector: numeric (one value for each (multi-) polygon geometry).

See Also

[cellSize](#) for a the size of individual cells of a raster, that can be summed with [global](#) or with [zonal](#) to get the area for different zones; [surfArea](#) for a raster with elevation values, taking into account the sloping nature of the surface.

Examples

```
### SpatRaster
r <- rast(nrows=18, ncols=36)
v <- 1:ncell(r)
v[200:400] <- NA
values(r) <- v

# summed area in km2
expansE(r, unit="km")

# all cells
expansE(rast(r), unit="km")

r <- rast(ncols=90, nrows=45, ymin=-80, ymax=80)
m <- project(r, "+proj=merc")

expansE(m, unit="km")
expansE(m, unit="km", transform=FALSE)

m2 <- c(m, m)
values(m2) <- cbind(c(1,2,NA,NA), c(11:14))
expansE(m2, unit="km", byValue=TRUE, wide=TRUE)
```

```

v <- vect(system.file("ex/lux.shp", package="terra"))
r <- rast(system.file("ex/elev.tif", package="terra"))
r <- round((r-50)/100)
levels(r) <- data.frame(id=1:5, name=c("forest", "water", "urban", "crops", "grass"))
expanse(r, byValue=TRUE)

g <- rasterize(v, r, "NAME_1")
expanse(r, byValue=TRUE, zones=g, wide=TRUE)

### SpatVector
v <- vect(system.file("ex/lux.shp", package="terra"))

a <- expanse(v)
a
sum(a)

```

ext

Create, get or set a SpatExtent

Description

Get a SpatExtent of a SpatRaster, SpatVector, or other spatial objects. Or create a SpatExtent from four numbers (xmin, xmax, ymin, ymax).

You can set the extent of a SpatRaster, but you cannot set the extent of a SpatVector (see [rescale](#) for that). See [set.ext](#) to set the extent in place.

Usage

```

## S4 method for signature 'SpatRaster'
ext(x, cells=NULL)

## S4 method for signature 'SpatVector'
ext(x)

## S4 method for signature 'numeric'
ext(x, ..., xy=FALSE)

## S4 replacement method for signature 'SpatRaster,SpatExtent'
ext(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
ext(x)<-value

```

Arguments

<code>x</code>	SpatRaster, SpatVector, a numeric vector of length four (xmin, xmax, ymin, ymax), a single numeric (xmin; see additional arguments under . . .), or missing (in which case the output is the global extent in lon-lat coordinates)
<code>cells</code>	positive integer (cell) numbers to subset the extent to area covered by these cells
<code>value</code>	SpatExtent, or numeric vector of length four (xmin, xmax, ymin, ymax)
<code>...</code>	if <code>x</code> is a single numeric value, additional numeric values for xmax, ymin, and ymax
<code>xy</code>	logical. Set this to TRUE to indicate that coordinates are in (xmin, ymin, xmax, ymax) order, instead of in the terra standard order of (xmin, xmax, ymin, ymax)

Value

A [SpatExtent](#) object.

See Also

[xmin](#), [xmax](#), [ymin](#), [ymax](#)

Examples

```

ext()

r <- rast()
e <- ext(r)
as.vector(e)
as.character(e)

ext(r) <- c(0, 2.5, 0, 1.5)
r
er <- ext(r)

round(er)
# go "in"
floor(er)
# go "out"
ceiling(er)

ext(r) <- e

```

Description

Enlarge the spatial extent of a `SpatRaster`. See [crop](#) if you (also) want to remove rows or columns.

Note that you can only enlarge `SpatRasters` with entire rows and columns. Therefore, the extent of the output `SpatRaster` may not be exactly the same as the requested. Depending on argument `snap` it may be a bit smaller or larger.

You can also enlarge a `SpatExtent` with this method, or with an algebraic notation (see examples)

Usage

```
## S4 method for signature 'SpatRaster'
extend(x, y, snap="near", fill=NA, filename="", overwrite=FALSE, ...)

## S4 method for signature 'SpatExtent'
extend(x, y)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatExtent</code>
<code>y</code>	If <code>x</code> is a <code>SpatRaster</code> , <code>y</code> should be a <code>SpatExtent</code> , or an object from which it can be extracted (such as <code>SpatRaster</code> and <code>SpatVector</code> objects). Alternatively, you can provide one, two or four non-negative integers indicating the number of rows and columns that need to be added at each side (a single positive integer when the number of rows and columns to be added is equal; or 2 number (columns, rows), or four (left column, right column, bottom row, top row). If <code>x</code> is a <code>SpatExtent</code> , <code>y</code> should likewise be a numeric vector of 1, 2, or 4 elements
<code>snap</code>	character. One of "near", "in", or "out". Used to align <code>y</code> to the geometry of <code>x</code>
<code>fill</code>	numeric. The value used to for the new raster cells
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, <code>filename</code> is overwritten
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster` or `SpatExtent`

See Also

[trim](#), [crop](#), [merge](#), [ext](#), [resample](#), [elongate](#)

Examples

```
r <- rast(xmin=-150, xmax=-120, ymin=30, ymax=60, ncols=36, nrows=18)
values(r) <- 1:ncell(r)
e <- ext(-180, -100, 40, 70)
re <- extend(r, e)

# extend with a number of rows and columns (at each side)
```

```

re2 <- extend(r, c(2,10))

# SpatExtent
e <- ext(r)
e
extend(e, 10)
extend(e, c(10, -10, 0, 20))

# add 10 columns / rows on all sides
e + 10
# double extent
e * 2
# increase extent by 25%
e * 1.25

```

extract

Extract values from a SpatRaster

Description

Extract values from a `SpatRaster` for a set of locations. The locations can be a `SpatVector` (points, lines, polygons), a `data.frame` or matrix with (x, y) or (longitude, latitude – in that order!) coordinates, or a vector with cell numbers.

When argument `y` is a `SpatVector` the first column has the ID (record number) of the `SpatVector` used (unless you set `ID=FALSE`).

Alternatively, you can use `zonal` after using `rasterize` with a `SpatVector` (this may be more efficient in some cases).

Usage

```

## S4 method for signature 'SpatRaster,SpatVector'
extract(x, y, fun=NULL, method="simple", cells=FALSE, xy=FALSE,
        ID=TRUE, weights=FALSE, exact=FALSE, touches=is.lines(y), small=TRUE,
        layer=NULL, bind=FALSE, raw=FALSE, search_radius=0, wide=FALSE, ...)

```

```

## S4 method for signature 'SpatRaster,SpatExtent'
extract(x, y, cells=FALSE, xy=FALSE)

```

```

## S4 method for signature 'SpatRaster,matrix'
extract(x, y, cells=FALSE, method="simple")

```

```

## S4 method for signature 'SpatRaster,numeric'
extract(x, y, xy=FALSE, raw=FALSE)

```

```

## S4 method for signature 'SpatVector,SpatVector'
extract(x, y, count=FALSE)

```

Arguments

x	SpatRaster or SpatVector of polygons
y	SpatVector (points, lines, or polygons). Alternatively, for points, a 2-column matrix or data.frame (x, y) or (lon, lat). Or a vector with cell numbers
fun	function to summarize the extracted data by line or polygon geometry. You can use fun=table to tabulate raster values for each line or polygon geometry. If weights=TRUE or exact=TRUE only mean, sum, min, max and table are accepted — and these functions will consider the fraction of a cell that is covered when computing the mean or the sum). Ignored if y has point geometry
method	character. method for extracting values with points ("simple" or "bilinear"). With "simple" values for the cell a point falls in are returned. With "bilinear" the returned values are interpolated from the values of the four nearest raster cells
cells	logical. If TRUE the cell numbers are also returned, unless fun is not NULL. Also see cells
xy	logical. If TRUE the coordinates of the cells are also returned, unless fun is not NULL. See xyFromCell
ID	logical. Should an ID column be added? If so, the first column returned has the IDs (record numbers) of y
weights	logical. If TRUE and y has polygons, the approximate fraction of each cell that is covered is returned as well. This changes the effect of argument fun
exact	logical. If TRUE and y has polygons, the exact fraction of each cell that is covered is returned as well. This changes the effect of argument fun
touches	logical. If TRUE, values for all cells touched by lines or polygons are extracted, not just those on the line render path, or whose center point is within the polygon. Not relevant for points; and always considered TRUE when weights=TRUE or exact=TRUE
small	logical. If TRUE, values for all cells in touched polygons are extracted if none of the cells center points is within the polygon; even if touches=FALSE
layer	character or numeric to select the layer to extract from for each geometry. If layer is a character it can be a name in y or a vector of layer names. If it is numeric, it must be integer values between 1 and nlyr(x)
bind	logical. If TRUE, a SpatVector is returned consisting of the input SpatVector y and the cbind-ed extracted values
raw	logical. If TRUE, a matrix is returned with the "raw" numeric cell values. If FALSE, a data.frame is returned and the cell values are transformed to factor, logical, or integer values, where appropriate
search_radius	positive number. A search-radius that is used when y has point geometry. If this value is larger than zero, it is the maximum distance used to find the a cell with a value that is nearest to the cell that the point falls in if that cell that has a missing (NA) value. The value of this nearest cell, the distance to the original cell, and the new cell number are returned. The radius should be expressed in m if the data have lon/lat coordinates or in the distance unit of the crs in other cases (typically also m). For lon/lat data, the mean latitude of the points is used to compute the distances, so this may be imprecise for data with a large latitudinal range

wide	logical. Only relevant when fun="table". If TRUE, and x has a single layer, the table is returned in the wide format
...	additional arguments to fun if y is a SpatVector. For example na.rm=TRUE. Or arguments passed to the SpatRaster, SpatVector method if y is a matrix (such as the method and cells arguments)
count	logical. If TRUE and x has polygons geometry and y has points geometry, the number of points in polygons is returned

Value

data.frame, matrix or SpatVector

See Also

[values](#), [zonal](#), [extractAlong](#), [extractRange](#), [rapp](#)

Examples

```
r <- rast(ncols=5, nrows=5, xmin=0, xmax=5, ymin=0, ymax=5)
values(r) <- 1:25
xy <- cbind(lon=c(0.5,2.5), lat=c(0.5,2.5))
p <- vect(xy, crs="+proj=longlat +datum=WGS84")

extract(r, xy)
extract(r, p)

r[1,]
r[5]
r[,5]

r[c(0:2, 99:101)]

f <- system.file("ex/meuse.tif", package="terra")
r <- rast(f)

xy <- cbind(179000, 330000)
xy <- rbind(xy-100, xy, xy+1000)
extract(r, xy)

p <- vect(xy)
g <- geom(p)
g

extract(r, p)

x <- r + 10
extract(x, p)

i <- cellFromXY(r, xy)
x[i]
r[i]
```

```

y <- c(x,x*2,x*3)
y[i]

## extract with a polygon
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v <- v[1:2,]

rf <- system.file("ex/elev.tif", package="terra")
x <- rast(rf)
extract(x, v, mean, na.rm=TRUE)

z <- rast(v, resolution=.1, names="test")
values(z) <- 1:ncell(z)
e <- extract(z, v, ID=TRUE)
e
tapply(e[,2], e[,1], mean, na.rm=TRUE)

x <- c(z, z*2, z/3)
names(x) <- letters[1:3]

e <- extract(x, v, ID=TRUE)
de <- data.frame(e)
aggregate(de[,2:4], de[,1,drop=FALSE], mean)

```

extractAlong

extract values along lines

Description

Extract raster values along a line. That is, the returned values are ordered along the line. That is not the case with [extract](#)

Usage

```
extractAlong(x, y, ID=TRUE, cells=FALSE, xy=FALSE, online=FALSE, bilinear=TRUE)
```

Arguments

x	SpatRaster
y	SpatVector with lines geometry
ID	logical. Should an ID column be added? If so, the first column returned has the IDs (record numbers) of input SpatVector y
cells	logical. If TRUE the cell numbers are also returned
xy	logical. If TRUE the coordinates of the cells traversed by y are also returned. See xyFromCell
online	logical. If TRUE the returned coordinates are snapped to y

`bilinear` logical. If TRUE the returned raster values computed with bilinear interpolation from the nearest four cells. Only relevant if `online=TRUE`

Value

`data.frame`

See Also

[extract](#)

Examples

```
r <- rast(ncols=36, nrows=18, vals=1:(18*36))
cds1 <- rbind(c(-50,0), c(0,60), c(40,5), c(15,-45), c(-10,-25))
cds2 <- rbind(c(80,20), c(140,60), c(160,0), c(140,-55))
lines <- vect(list(cds1, cds2), "lines")

extractAlong(r, lines)
```

`extractRange`

Extract values for a range of layers from a SpatRaster

Description

Extract values from a `SpatRaster` for a set of locations and a range of layers. To extract values for a single or all layers, use [extract](#)

Usage

```
## S4 method for signature 'SpatRaster'
extractRange(x, y, first, last, lyr_fun=NULL,
  geom_fun=NULL, ID=FALSE, na.rm=TRUE, bind=FALSE, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>y</code>	<code>SpatVector</code> (points, lines, or polygons). Alternatively, for points, a 2-column matrix or <code>data.frame</code> (x, y) or (lon, lat). Or a vector with cell numbers
<code>first</code>	layer name or number, indicating the first layer in the range of layers to be considered
<code>last</code>	layer name or number, indicating the last layer in the range to be considered
<code>lyr_fun</code>	function to summarize the extracted data across layers
<code>geom_fun</code>	function to summarize the extracted data for each line or polygon geometry. Ignored if <code>y</code> has point geometry
<code>ID</code>	logical. Should an ID column be added? If so, the first column returned has the IDs (record numbers) of <code>y</code>

<code>na.rm</code>	logical. Should missing values be ignored?
<code>bind</code>	logical. If TRUE, the extracted values are cbind-ed to y
<code>...</code>	additional arguments passed to <code>extract</code>

Value

numeric or data.frame

See Also

[extract](#)

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
xy <- data.frame(x=c(50,80), y=c(30, 60))
extract(r, xy)
extract(r, xy, layer=c("red", "green"))

extractRange(r, xy, first=1:2, last=3:2)
extractRange(r, xy, first=1:2, last=3:2, lyr_fun=sum)
```

extremes

Get or compute the minimum and maximum cell values

Description

The minimum and maximum value of a `SpatRaster` are returned or computed (from a file on disk if necessary) and stored in the object.

Usage

```
## S4 method for signature 'SpatRaster'
minmax(x, compute=FALSE)
## S4 method for signature 'SpatRaster'
hasMinMax(x)
## S4 method for signature 'SpatRaster'
setMinMax(x, force=FALSE)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>compute</code>	logical. If TRUE min and max values are computed if they are not available
<code>force</code>	logical. If TRUE min and max values are recomputed even if already available

Value

minmax: numeric matrix of minimum and maximum cell values by layer

hasMinMax: logical indicating whether the min and max values are available.

setMinMax: nothing. Used for the side-effect of computing the minimum and maximum values of a SpatRaster

See Also

[where.min](#), [where.max](#)

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
minmax(r)
```

factors

Categorical rasters

Description

A SpatRaster layer can represent a categorical variable (factor). Like [factors](#), SpatRaster categories are stored as integers that have an associated label.

The categories can be inspected with `levels` and `cats`. They are represented by a `data.frame` that must have two or more columns, the first one identifying the (integer) cell values and the other column(s) providing the category labels.

If there are multiple columns with categories, you can set the "active" category to choose the one you want to use.

`cats` returns the entire `data.frame`, whereas `levels` only return two columns: the index and the active category.

To set categories for the first layer of a SpatRaster, you can provide `levels<-` with a `data.frame` or a list with a `data.frame`. To set categories for multiple layers you can provide `levels<-` with a list with one element (that either has a `data.frame` or is `NULL`) for each layer. Use `categories` to set the categories for a specific layer or specific layers.

`droplevels` removes categories that are not used (declared but not present as values in the raster) if `levels=NULL`.

`simplifyLevels` combines duplicate levels into one.

`addCats` adds additional categories to a layer that already is categorical. It adds new variables, not new levels of an existing categorical variable.

`combineLevels` combines the levels of all layers of `x` and sets them to all layers. That fails if there are labeling conflicts between layers

Usage

```

## S4 method for signature 'SpatRaster'
levels(x)

## S4 replacement method for signature 'SpatRaster'
levels(x)<-value

## S4 method for signature 'SpatRaster'
cats(x, layer)

## S4 method for signature 'SpatRaster'
categories(x, layer=1, value, active=1, ...)

## S4 method for signature 'SpatRaster'
droplevels(x, level=NULL, layer=1)

## S4 method for signature 'SpatRaster'
simplifyLevels(x, filename="", overwrite=FALSE, ...)

## S4 method for signature 'SpatRaster'
addCats(x, value, merge=FALSE, layer=1)

combineLevels(x, assign=TRUE)

```

Arguments

x	SpatRaster
layer	the layer name or number (positive integer); or 0 for all layers
value	a data.frame (ID, category) that define the categories. Or NULL to remove them
active	positive integer, indicating the column in value to be used as the active category (zero based to skip the first column with the cell values; that is 1 is the second column in value)
level	the categories to remove for the layer specified with layer
merge	logical. If TRUE, the categories are combined with merge using the first column of value as ID. If FALSE the categories are combined with cbind
assign	logical. Assign the combined levels to all layers of x? If FALSE, the levels are returned
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files as in writeRaster

Value

SpatRaster, data.frame, list of data.frames (levels, cats), or logical (is.factor)

See Also

[activeCat](#), [catalyze](#), [set.cats](#), [as.factor](#), [is.factor](#)

Examples

```

set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE)
is.factor(r)

cls <- data.frame(id=1:3, cover=c("forest", "water", "urban"))
levels(r) <- cls
is.factor(r)
r

plot(r, col=c("green", "blue", "light gray"))
text(r, digits=3, cex=.75, halo=TRUE)

levels(r) <- data.frame(id=1:3, cover=c("forest", "water", "forest"))
levels(simplifyLevels(r))

# raster starts at 3
x <- r + 2
is.factor(x)

# Multiple categories
d <- data.frame(id=3:5, cover=cls[,2], letters=letters[1:3], value=10:12)
levels(x) <- d
x

# get current index
activeCat(x)
# set index
activeCat(x) <- 3
activeCat(x)
activeCat(x) <- "letters"
plot(x, col=c("green", "blue", "light gray"))
text(x, digits=3, cex=.75, halo=TRUE)

r <- as.numeric(x)
r

p <- as.polygons(x)
plot(p, "letters", col=c("green", "blue", "light gray"))

```

Description

Remove the holes in SpatVector polygons. If inverse=TRUE the holes are returned (as polygons).
Or remove "holes" in SpatRasters.

Usage

```
## S4 method for signature 'SpatVector'
fillHoles(x, inverse=FALSE)
```

```
## S4 method for signature 'SpatRaster'
fillHoles(x, nearest=FALSE)
```

Arguments

x	SpatVector
inverse	logical. If TRUE the holes are returned as polygons
nearest	logical. If FALSE only holes that are surrounded by cells with the same value are filled. Otherwise, the values of the nearest cell that is not NA is assigned

Value

SpatVector

See Also

[snap](#), [gaps](#)

Examples

```
x <- rbind(c(50,0), c(140,60), c(160,0), c(140,-55))
hole <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))

z <- rbind(cbind(object=1, part=1, x, hole=0),
          cbind(object=1, part=1, hole, hole=1))
colnames(z)[3:4] <- c('x', 'y')
p <- vect(z, "polygons", atts=data.frame(id=1), crs="local")
p

f <- fillHoles(p)
g <- fillHoles(p, inverse=TRUE)

plot(p, lwd=16, border="gray", col="light yellow")
polys(f, border="blue", lwd=3, density=4, col="orange")
polys(g, col="white", lwd=3)

## SpatRaster
v <- vect(c("POLYGON ((81.572 36.629, 98.508 9.624, 80 0, 99.902 -10.349,
84.662 -34.709, 50 0, 81.572 36.629))", "POLYGON ((140 60, 160 0,
140 -55, 84.662 -34.709, 99.902 -10.349, 105 -13, 120 2, 105 13,
```

```

98.508 9.624, 81.572 36.629, 140 60))"))
v <- rbind(v, shift(p, -120))
v$ID <- 1:nrow(v)
r <- rasterize(v, rast(xmin=-80, crs="local"), "ID")

f1 <- fillHoles(r)
f2 <- fillHoles(r, nearest=TRUE)

```

fillTime

Fill time gaps in a SpatRaster

Description

Add empty layers in between existing layers such that the time step between each layer is the same. See [approximate](#) to estimate values for these layer (and other missing values)

Usage

```

## S4 method for signature 'SpatRaster'
fillTime(x, filename="", ...)

```

Arguments

x	SpatRaster
filename	character. Output filename
...	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[approximate](#)

Examples

```

r <- rast(system.file("ex/logo.tif", package="terra"))
s <- c(r, r)
time(s) <- as.Date("2001-01-01") + c(0:2, 5:7)
time(s)
ss <- fillTime(s)
time(ss)

a <- approximate(ss)

```

flip *Flip or reverse a raster*

Description

Flip the values of a `SpatRaster` by inverting the order of the rows (`direction= "vertical"`) or the columns (`direction="horizontal"`).

`rev` is the same as a horizontal *and* a vertical flip.

Usage

```
## S4 method for signature 'SpatRaster'  
flip(x, direction="vertical", filename="", ...)
```

```
## S4 method for signature 'SpatVector'  
flip(x, direction="vertical")
```

```
## S4 method for signature 'SpatRaster'  
rev(x)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>direction</code>	character. Should (partially) match "vertical" to flip by rows, or "horizontal" to flip by columns
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[trans](#), [rotate](#)

Examples

```
r <- rast(nrow=18, ncol=36)  
m <- matrix(1:ncell(r), nrow=18)  
values(r) <- as.vector(t(m))  
rx <- flip(r, direction="h")  
  
values(r) <- as.vector(m)  
ry <- flip(r, direction="v")  
  
v <- rev(r)
```

flowAccumulation *Flow accumulation*

Description

Computes flow accumulation or the total contributing area in terms of numbers of cells upstream of each cell.

Usage

```
## S4 method for signature 'SpatRaster'  
flowAccumulation(x, weight=NULL, filename="", ...)
```

Arguments

x	SpatRaster with flow direction, see terrain .
weight	SpatRaster with weight/score data. For example, cell area or precipitation
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Details

The algorithm is an adaptation of the one proposed by Zhou et al, 2019.

Value

SpatRaster

Author(s)

Emanuele Cordano

References

Zhou, G., Wei, H. & Fu, S. A fast and simple algorithm for calculating flow accumulation matrices from raster digital elevation. *Front. Earth Sci.* 13, 317–326 (2019). doi:10.1007/s11707-018-0725-9. Also see: <https://ica-abs.copernicus.org/articles/1/434/2019/>

See Also

[terrain](#), [watershed](#), [NIDP](#)

Examples

```

elev1 <- array(NA,c(9,9))
elev2 <- elev1
dx <- 1
dy <- 1
for (r in 1:nrow(elev1)) {
  y <- (r-5)*dx
  for (c in 1:ncol(elev1)) {

    x <- (c-5)*dy
    elev1[r,c] <- 5*(x^2+y^2)
    elev2[r,c] <- 10+5*(abs(x))-0.001*y
  }
}

## Elevation raster
elev1 <- rast(elev1)
elev2 <- rast(elev2)

t(array(elev1[],rev(dim(elev1)[1:2])))
t(array(elev2[],rev(dim(elev2)[1:2])))

plot(elev1)
plot(elev2)

## Flow direction raster
flowdir1<- terrain(elev1,v="flowdir")
flowdir2<- terrain(elev2,v="flowdir")

t(array(flowdir1[],rev(dim(flowdir1)[1:2])))
t(array(flowdir2[],rev(dim(flowdir2)[1:2])))

plot(flowdir1)
plot(flowdir2)

##
flow_acc1 <- flowAccumulation((flowdir1))
flow_acc2 <- flowAccumulation((flowdir2))

weight <- elev1*0+10

flow_acc1w <- flowAccumulation(flowdir1,weight)
flow_acc2w <- flowAccumulation(flowdir2,weight)

t(array(flow_acc1w[],rev(dim(flow_acc1w)[1:2])))
t(array(flow_acc2w[],rev(dim(flow_acc2w)[1:2])))

plot(flow_acc1w)
plot(flow_acc2w)

```

```
## Application with example elevation data

elev <- rast(system.file('ex/elev.tif',package="terra"))
flowdir <- terrain(elev,"flowdir")

weight <- cellSize(elev,unit="km")
flowacc_weight <- flowAccumulation(flowdir,weight)
flowacc <- flowAccumulation(flowdir)
```

focal

*Focal values***Description**

Calculate focal ("moving window") values for each cell.

Usage

```
## S4 method for signature 'SpatRaster'
focal(x, w=3, fun="sum", ..., na.policy="all", fillvalue=NA,
expand=FALSE, silent=TRUE, cores=1, cpkgs=NULL,
filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
w	window. The window can be defined as one (for a square) or two numbers (row, col); or with an odd-sized weights matrix. See Details.
fun	function that takes multiple numbers, and returns a numeric vector (one or multiple numbers). For example, mean, modal, min or max
...	additional arguments passed to fun such as na.rm
na.policy	character. Can be used to determine the cells of x for which focal values should be computed. Must be one of "all" (compute for all cells), "only" (only for cells that are NA) or "omit" (skip cells that are NA). Note that the value of this argument does not affect which cells around each focal cell are included in the computations (use na.rm=TRUE to ignore cells that are NA for that)
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
expand	logical. If TRUE, the value of the cells in the virtual rows and columns outside of the raster are set to be the same as the value on the border. Only available for "built-in" funs such as mean, sum, min and max
silent	logical. If TRUE error messages are printed that may occur when trying fun to determine the length of the returned value. This can be useful in debugging a fun that does not work

cores	controls per-block parallelism when fun is a user-supplied R function (the "built-in" funs such as "mean" and "sum" are already multi-threaded via TBB and ignore cores). Can be a positive integer (the number of local PSOCK workers), an existing <code>parallel::cluster</code> , the string "future" to use the currently registered future plan , or a future strategy itself (e.g. <code>future::multisession</code>). The per-block focal-values matrix is split into row-chunks and dispatched across workers
cpkgs	character. Names of R packages to load on each worker when <code>cores > 1</code> – pass any package that fun depends on
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Details

`focal` The window used must have odd dimensions. If you need even sides, you can use a matrix and add a column or row of NA's to mask out values.

Window values are typically 1 or NA to indicate whether a value is used or ignored in computations, respectively. NA values in `w` can be useful for creating non-rectangular (e.g. circular) windows.

A weights matrix of numeric values can also be supplied to `w`. In the case of a weights matrix, cells with NA weights will be ignored, and the rest of the values in the focal window will be multiplied by the corresponding weight prior to 'fun' being applied. Note, `na.rm` does not need to be TRUE if `w` contains NA values as these cells are ignored in computations.

The "mean" function is a special case, where supplying weights to `w` will instead calculate a weighted mean.

The "sum" function returns NA if all focal cells are NA and `na.rm=TRUE`. R would normally return a zero in these cases. See the difference between `focal(x, fun=sum, na.rm=TRUE)` and `focal(x, fun=\(i) sum(i, na.rm=TRUE))`

Example weight matrices

Laplacian filter: `filter=matrix(c(0,1,0,1,-4,1,0,1,0), nrow=3)`

Sobel filters (for edge detection):

`fx=matrix(c(-1,-2,-1,0,0,0,1,2,1), nrow=3)`

`fy=matrix(c(1,0,-1,2,0,-2,1,0,-1), nrow=3)`

Value

SpatRaster

Note

When using global lon/lat rasters, the focal window "wraps around" the date-line.

See Also

[focalMat](#), [focalValues](#), [focal3D](#), [focalPairs](#), [focalReg](#), [focalCpp](#)

Examples

```

r <- rast(ncols=10, nrows=10, ext(0, 10, 0, 10))
values(r) <- 1:ncell(r)

f <- focal(r, w=3, fun=function(x, ...) quantile(x, c(.25, .5, .75), ...), na.rm=TRUE)

f <- focal(r, w=3, fun="mean")

# the following two statements are equivalent:
a <- focal(r, w=matrix(1/9, nc=3, nr=3))
b <- focal(r, w=3, fun=mean, na.rm=FALSE)

# but this is different
d <- focal(r, w=3, fun=mean, na.rm=TRUE)

## illustrating the effect of different
## combinations of na.rm and na.policy
v <- vect(system.file("ex/lux.shp", package="terra"))
r <- rast(system.file("ex/elev.tif", package="terra"))
r[45:50, 45:50] <- NA

# also try "mean" or "min"
f <- "sum"
# na.rm=FALSE
plot(focal(r, 5, f), fun=lines(v))

# na.rm=TRUE
plot(focal(r, 5, f, na.rm=TRUE), fun=lines(v))

# only change cells that are NA
plot(focal(r, 5, f, na.policy="only", na.rm=TRUE), fun=lines(v))

# do not change cells that are NA
plot(focal(r, 5, f, na.policy="omit", na.rm=TRUE), fun=lines(v))

# does not do anything
# focal(r, 5, f, na.policy="only", na.rm=FALSE)

# parallel apply for a user-supplied R function (no effect on built-in funcs)
r <- rast(ncols=200, nrows=200, ext(0, 200, 0, 200), vals=runif(40000))
f <- focal(r, w=5, fun=function(x) quantile(x, 0.9, na.rm=TRUE), cores=2)

```

focal3D

*Three-dimensional focal values***Description**

Calculate focal ("moving window") values for the three-dimensional neighborhood (window) of focal cells. See [focal](#) for two-dimensional focal computation.

Usage

```
## S4 method for signature 'SpatRaster'
focal3D(x, w=3, fun=mean, ..., na.policy="all", fillvalue=NA, pad=FALSE,
padvalue=fillvalue, expand=FALSE, silent=TRUE,
filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
w	window. A rectangular prism (cuboid) defined by three numbers or by a three-dimensional array. The values are used as weights, and are usually zero, one, NA, or fractions. The window used must have odd dimensions. If you desire to use even sides, you can use an array, and pad the values with rows and/or columns that contain only NAs.
fun	function that takes multiple numbers, and returns one or multiple numbers for each focal area. For example mean, modal, min or max
...	additional arguments passed to fun such as na.rm
na.policy	character. Can be used to determine the cells of x, in the central layer, for which focal values should be computed. Must be one of "all" (compute for all cells), "only" (only for cells that are NA) or "omit" (skip cells that are NA). Note that the value of this argument does not affect which cells around each focal cell are included in the computations (use na.rm=TRUE to ignore cells that are NA in the computation of the focal value)
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
pad	logical. Add virtual layers before the first and after the last layer
padvalue	numeric. The value of the cells in the virtual layers
expand	logical. Add virtual layers before the first or after the last layer that are the same as the first or last layers. If TRUE, arguments pad and padvalue are ignored
silent	logical. If TRUE error messages are printed that may occur when trying fun to determine the length of the returned value. This can be useful in debugging a function passed to fun that does not work
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[focal](#)

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
x <- focal3D(r, c(5,5,3), na.rm=TRUE)

a <- array(c(0,1,0,1,1,1,0,1,0, rep(1,9), 0,1,0,1,1,1,0,1,0), c(3,3,3))
a[a==0] <- NA
z <- focal3D(r, a, na.rm=TRUE)
```

focalCpp

*Compute focal values with an iterating C++ function***Description**

Calculate focal values with a C++ function that iterates over cells to speed up computations by avoiding an R loop (with `apply`).

See [focal](#) for an easier to use method.

Usage

```
## S4 method for signature 'SpatRaster'
focalCpp(x, w=3, fun, ..., fillvalue=NA,
silent=TRUE, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
w	window. The window can be defined as one (for a square) or two numbers (row, col); or with an odd-sized weights matrix. See the Details section in focal
fun	cppFunction that iterates over cells. For C++ functions that operate on a single focal window, or for R functions use focal instead. The function must have at least three arguments. The first argument can have any name, but it must be a <code>Rcpp::NumericVector</code> , <code>Rcpp::IntegerVector</code> or a <code>std::vector<double></code> . This is the container that receives the focal values. The other two arguments <code>ni</code> and <code>wi</code> must be of type <code>size_t</code> . <code>ni</code> represents the number of cells and <code>nw</code> represents the size of (number of elements in) the window
...	additional arguments to fun
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
silent	logical. If TRUE error messages are printed that may occur when trying fun to determine the length of the returned value. This can be useful in debugging a fun that does not work
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also[focal](#), [focalValues](#)**Examples**

```
## Not run:
library(Rcpp)
cppFunction(
  'NumericVector sum_and_multiply(NumericVector x, double m, size_t ni, size_t nw) {
    NumericVector out(ni);
    // loop over cells
    size_t start = 0;
    for (size_t i=0; i<ni; i++) {
      size_t end = start + nw;
      // compute something for a window
      double v = 0;
      // loop over the values of a window
      for (size_t j=start; j<end; j++) {
        v += x[j];
      }
      out[i] = v * m;
      start = end;
    }
    return out;
  }'
)

nr <- nc <- 10
r <- rast(ncols=nc, nrows=nr, ext= c(0, nc, 0, nr))
values(r) <- 1:ncell(r)

raw <- focalCpp(r, w=3, fun=sum_and_multiply, fillvalue=0, m=10)

# same as
f1 <- focal(r, w=3, fun=sum, fillvalue=0) *10
all(values(f1) == values(raw))

# and as
ffun <- function(x, m) { sum(x) * m }
f2 <- focal(r, w=3, fun=ffun, fillvalue=0, m=10)

# You can also use an R function with focalCpp but this
# is not recommended

R_sm_iter <- function(x, m, ni, nw) {
  out <- NULL
  for (i in 1:ni) {
```

```

start <- (i-1) * nw + 1
out[i] <- sum(x[start:(start+nw-1)]) * m
}
out
}

fr <- focalCpp(r, w=3, fun=R_sm_iter, fillvalue=0, m=10)

## End(Not run)

```

focalMat	<i>Focal weights matrix</i>
----------	-----------------------------

Description

Make a focal ("moving window") weight matrix for use in the `focal` function. The sum of the values adds up to one.

Usage

```
focalMat(x, d, type=c('circle', 'Gauss', 'rectangle'), fillNA=FALSE)
```

Arguments

<code>x</code>	SpatRaster
<code>d</code>	numeric. If <code>type=circle</code> , the radius of the circle (in units of the crs). If <code>type=rectangle</code> the dimension of the rectangle (one or two numbers). If <code>type=Gauss</code> the size of sigma, and optionally another number to determine the size of the matrix returned (default is $3*\text{sigma}$)
<code>type</code>	character indicating the type of filter to be returned
<code>fillNA</code>	logical. If TRUE, zeros are set to NA such that they are ignored in the computations. Only applies to <code>type="circle"</code>

Value

matrix that can be used with `focal`

Examples

```

r <- rast(ncols=180, nrows=180, xmin=0)
focalMat(r, 2, "circle")

focalMat(r, c(2,3), "rect")

# Gaussian filter for square cells
gf <- focalMat(r, 1, "Gauss")

```

focalPairs	<i>Focal function across two layers</i>
------------	---

Description

Calculate values such as a correlation coefficient for focal regions in two neighboring layers. A function is applied to the first and second layer, then to the second and third layer, etc.

Usage

```
## S4 method for signature 'SpatRaster'
focalPairs(x, w=3, fun, ..., fillvalue=NA,
           filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster with at least two layers
w	numeric or matrix to define the focal window. The window can be defined as one (for a square) or two numbers (row, col); or with an odd-sized weights matrix. See the Details section in focal . Note that if a matrix with numbers other than zero or one are used, the values are used as weights. For this to work, fun must have an argument weights
fun	a function with at least two arguments (one for each layer). There is a built-in function "pearson" (for both the weighted and the unweighted Pearson correlation coefficient. This function has an additional argument <code>na.rm=FALSE</code>
...	additional arguments for fun
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[layerCor](#), [focalReg](#), [focal](#), [focal3D](#)

Examples

```

r <- rast(system.file("ex/logo.tif", package="terra"))
set.seed(0)
r[[1]] <- flip(r[[1]], "horizontal")
r[[2]] <- flip(r[[2]], "vertical") + init(rast(r,1), runif)
r[[3]] <- init(rast(r,1), runif)

x <- focalPairs(r, w=5, "pearson", na.rm=TRUE)
plot(x)

# suppress warning "the standard deviation is zero"
suppressWarnings(x <- focalPairs(r, w=5, "pearson", use="complete.obs"))

z <- focalPairs(r, w=9, function(x, y) mean(x) + mean(y))

```

focalReg

*Focal regression***Description**

Calculate values for a moving-window by comparing the value in one layers with the values in one to many other layers. A typical case is the computation of the coefficients for a focal linear regression model.

Usage

```

## S4 method for signature 'SpatRaster'
focalReg(x, w=3, fun="ols", ..., fillvalue=NA, filename="", overwrite=FALSE, wopt=list())

```

Arguments

x	SpatRaster with at least two layers. The first is the "Y" (dependent) variable and the remainder are the "X" (independent) variables
w	numeric or matrix to define the focal window. The window can be defined as one (for a square) or two numbers (row, col); or with an odd-sized weights matrix. See the Details section in focal . Note that if a matrix with numbers other than zero or one are used, the values are used as weights. For this to work, fun must have an argument weights
fun	a function with at least two arguments (one for each layer). There is a built-in function "ols" for both the weighted and unweighted Ordinary Least Square regression. This function has an additional argument <code>na.rm=FALSE</code> and <code>intercept=TRUE</code>
...	additional arguments for fun
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also[focal](#), [focal3D](#), [focalValues](#)**Examples**

```
r <- rast(ncols=10, nrows=10, ext(0, 10, 0, 10))
values(r) <- 1:ncell(r)
x <- c(r, init(r, runif) * r)
f <- focalReg(x, 3)
```

focalValues

*Get focal values***Description**

Get a matrix in which each row had the focal values of a cell. These are the values of a cell and a rectangular window around it.

Usage

```
## S4 method for signature 'SpatRaster'
focalValues(x, w=3, row=1, nrows=nrow(x), fill=NA)
```

Arguments

x	SpatRaster or SpatVector
w	window. The window can be defined as one (for a square) or two odd numbers (row, col); or with an odd sized matrix
row	positive integer. Row number to start from, should be between 1 and nrow(x)
nrows	positive integer. How many rows?
fill	numeric used as values for imaginary cells outside the raster

Value

matrix

Examples

```
r <- rast(ncol=4, nrow=4, crs="+proj=utm +zone=1 +datum=WGS84")
values(r) <- 1:ncell(r)
focalValues(r)
```

forceCCW	<i>force counter-clockwise polygons</i>
----------	---

Description

Assure that the nodes of outer rings of polygons are in counter-clockwise order.

Usage

```
## S4 method for signature 'SpatVector'
forceCCW(x)
```

Arguments

x SpatVector of polygons

Value

SpatVector

Examples

```
p <- vect("POLYGON ((2 45, 2 55, 18 55, 18 45, 2 45))")
pcc <- forceCCW(p)
geom(pcc, wkt=TRUE)
```

freq	<i>Frequency table</i>
------	------------------------

Description

Frequency table of the values of a SpatRaster. NAs are not counted unless value=NA.

You can provide a SpatVector or additional SpatRaster to define zones for which to do tabulations.

Usage

```
## S4 method for signature 'SpatRaster'
freq(x, digits=0, value=NULL, bylayer=TRUE, usenames=FALSE,
zones=NULL, wide=FALSE, touches=FALSE)
```

Arguments

x	SpatRaster
digits	integer. Used for rounding the values before tabulation. Ignored if NA
value	numeric. An optional single value to only count the number of cells with that value. This value can be NA
bylayer	logical. If TRUE tabulation is done by layer
usenames	logical. If TRUE layers are identified by their names instead of their numbers Only relevant if bylayer is TRUE
zones	SpatRaster or SpatVector to define zones for which the tabulation should be done
wide	logical. Should the results be by "wide" instead of "long"?
touches	logical. If TRUE, all cells touched by lines or polygons will be included, not just those on the line render path, or whose center point is within the polygon. Only relevant if zones is a SpatVector

Value

A data.frame with 3 columns (layer, value, count) unless bylayer=FALSE in which case a data.frame with two columns is returned (value, count).

Author(s)

Andrew Gene Brown, Robert J. Hijmans

Examples

```
r <- rast(nrows=10, ncols=10)
set.seed(2)
values(r) <- sample(5, ncell(r), replace=TRUE)

freq(r)

x <- c(r, r/3)
freq(x, bylayer=FALSE)
freq(x)

freq(x, digits=1)
freq(x, digits=-1)

freq(x, value=5)
```

gaps	<i>Find gaps between polygons</i>
------	-----------------------------------

Description

Get the gaps between polygons of a SpatVector

Usage

```
## S4 method for signature 'SpatVector'
gaps(x)
```

Arguments

x SpatVector

Value

SpatVector

See Also

[sharedPaths](#), [topology](#), and [fillHoles](#) to get or remove polygon holes

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
h <- convHull(v[-12], "NAME_1")
g <- gaps(h)
```

gdal	<i>GDAL version, supported file formats, cache size, and PROJ coordinate transformation control</i>
------	---

Description

Set the GDAL warning level or get a data.frame with the available GDAL drivers (file formats), or, if warn=NA and drivers=FALSE, you get the version numbers of one or all of the GDAL, PROJ and GEOS libraries.

GDAL is the software library that terra builds on to read and write spatial data and for some raster data processing. PROJ is used for transformation of coordinates ("projection") and GEOS is used for geometric operations with vector data.

The current GDAL configuration options are obtained with `getGDALconfig` and changed with `setGDALconfig`. `proj_ok` checks if the PROJ database with CRS definitions can be found.

`projNetwork` controls whether PROJ can access network resources for coordinate transformations. By default, network access is enabled to provide high-accuracy grid-based datum transformations where available. When disabled, PROJ falls back to "ballpark transformations" (of unknown accuracy) which could lead to errors of hundreds of meters in some cases. When enabled, PROJ downloads transformation grids from <https://cdn.proj.org>, requiring network connectivity and valid SSL certificates. After a successful run, the files are cached locally.

`projPaths` gets or sets the search paths that PROJ uses to find coordinate system definitions and transformation grids. This allows users to specify custom locations for PROJ data files, such as when using offline installations or custom grid files. By default, it operates on PROJ search paths, but can also set GDAL search paths when `with_proj=FALSE`.

Usage

```
gdal(warn=NA, drivers=FALSE, ...)
gdalCache(size=NA)
setGDALconfig(option, value="")
getGDALconfig(option)
clearVSICache()
libVersion(lib="all", parse=FALSE)
unloadGDALdrivers(x)
proj_ok()
projNetwork(enable, url="")
projPaths(paths, with_proj = TRUE)
```

Arguments

<code>warn</code>	If NA and <code>drivers=FALSE</code> , the version of the library specified by <code>lib</code> is returned. Otherwise, the value should be an integer between 1 and 4 representing the level of GDAL warnings and errors that are passed to R. 1 = warnings and errors; 2 = errors only (recoverable errors as a warning); 3 = irrecoverable errors only; 4 = ignore all errors and warnings. The default setting is 2
<code>drivers</code>	logical. If TRUE a data.frame with the raster and vector data formats that are available.
<code>...</code>	additional arguments (for backwards compatibility only)
<code>size</code>	numeric. The new cache size in MB
<code>option</code>	character. GDAL configuration option name, or a "name=value" string (in which case the value argument is ignored)
<code>value</code>	character. value for GDAL configuration option. Use "" to reset it to its default value
<code>lib</code>	character. "gdal", "proj", or "geos", or any other value to get the versions numbers of all three
<code>parse</code>	logical. Should the version be parsed into three numerical values (major, minor and sub versions)?
<code>x</code>	character. Drivers names such as "GTiff" to be unloaded. Or "" to reload all drivers

enable	logical. If TRUE, enable PROJ network access for high-accuracy grid-based transformations. If FALSE, disable network access and use ballpark transformations. If missing, return the current network status
url	character. Optional URL for PROJ network endpoint. If empty string (default), uses PROJ's default network settings (https://cdn.proj.org)
paths	character. Vector of file paths to directories containing PROJ data files. If missing, returns the current search paths
with_proj	logical. If TRUE (default), set PROJ search paths. If FALSE, set GDAL search paths

Value

character vector of search paths. When setting paths, the result is returned invisibly.

Note

While some spatial analyses may not be greatly affected by PROJ network settings (ballpark vs. grid-based transformations), the differences can be significant, especially when a transformation involves a shift in datum between different coordinate reference systems. For applications requiring high positional accuracy, ensure network access is enabled or grids are locally available. Grids can be pre-downloaded using the `projsync` utility or installed via system packages, such as `proj-data` on Ubuntu/Debian systems. Downloaded grids are cached locally and then reused for subsequent transformations.

On Windows, PROJ network access may fail with SSL certificate errors (e.g. "schannel: Cert-GetCertificateChain trust error"). If you see these warnings during `project` operations, you can use `projNetwork(FALSE)` to disable network access and silence them. To fix the underlying SSL issue, ensure your system's certificate store is up to date, or install the required PROJ datum grids locally.

See Also

[describe](#) for file-level metadata "GDALinfo"

Examples

```
gdal()
gdal(2)
#head(gdal(drivers=TRUE))
libVersion("all", TRUE)
projNetwork()
projPaths()
projPaths(c("/custom/proj/path"))
```

 geom

Get the geometry (coordinates) of a SpatVector

Description

Get the geometry of a SpatVector. If `wkt=FALSE`, this is a five-column matrix or data.frame: the vector object ID, the IDs for the parts of each object (e.g. five polygons that together are one spatial object), the x (longitude) and y (latitude) coordinates, and a flag indicating whether the part is a "hole" (only relevant for polygons).

If `wkt=TRUE`, the "well-known text" representation is returned as a character vector. If `hex=TRUE`, the "hexadecimal" representation is returned as a character vector. If `wkb=TRUE`, the "well-known binary" representation is returned as a list of raw vectors.

Usage

```
## S4 method for signature 'SpatVector'
geom(x, wkt=FALSE, hex=FALSE, wkb=FALSE, df=FALSE, list=FALSE, xnm="x", ynm="y")
```

Arguments

<code>x</code>	SpatVector
<code>wkt</code>	logical. If TRUE the WKT geometry is returned (unless hex is also TRUE)
<code>hex</code>	logical. If TRUE the hexadecimal geometry is returned
<code>wkb</code>	logical. If TRUE the raw WKB geometry is returned (unless either of hex or wkt is also TRUE)
<code>df</code>	logical. If TRUE a data.frame is returned instead of a matrix (only if <code>wkt=FALSE</code> , <code>hex=FALSE</code> , and <code>list=FALSE</code>)
<code>list</code>	logical. If TRUE a nested list is returned with data.frames of coordinates
<code>xnm</code>	character. If <code>list=TRUE</code> the "x" column name for the coordinates data.frame
<code>ynm</code>	character. If <code>list=TRUE</code> the "y" column name for the coordinates data.frame

Value

matrix, vector, data.frame, or list

See Also

[crds](#), [xyFromCell](#)

Examples

```

x1 <- rbind(c(-175,-20), c(-140,55), c(10, 0), c(-140,-60))
x2 <- rbind(c(-125,0), c(0,60), c(40,5), c(15,-45))
x3 <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
x4 <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))
z <- rbind(cbind(object=1, part=1, x1), cbind(object=2, part=1, x2),
          cbind(object=3, part=1, x3), cbind(object=3, part=2, x4))
colnames(z)[3:4] <- c('x', 'y')
z <- cbind(z, hole=0)
z[(z[, "object"]==3 & z[, "part"]==2), "hole"] <- 1

p <- vect(z, "polygons")
geom(p)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
g <- geom(v)
head(g)

w <- geom(v, wkt=TRUE)
substr(w, 1, 60)

```

geomtype

Geometry type of a SpatVector

Description

Get the geometry type (points, lines, or polygons) of a SpatVector. See [datatype](#) for the data types of the fields (attributes, variables) of a SpatVector.

Usage

```

## S4 method for signature 'SpatVector'
geomtype(x)

## S4 method for signature 'SpatVector'
is.points(x)

## S4 method for signature 'SpatVector'
is.lines(x)

## S4 method for signature 'SpatVector'
is.polygons(x)

```

Arguments

x SpatVector

Value

character

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

geomtype(v)
is.polygons(v)
is.lines(v)
is.points(v)

names(v)
datatype(v)
```

global

global statistics

Description

Compute global statistics, that is summarized values of an entire SpatRaster.

If *x* is very large global can fail, except when *fun* is one of these built-in functions "mean", "min", "max", "sum", "prod", "range" (min and max), "rms" (root mean square), "sd" (sample standard deviation), "std" (population standard deviation), "isNA" (number of cells that are NA), "notNA" (number of cells that are not NA), "anyNA", "anynotNA". Note that "anyNA" and "anynotNA" cannot be combined with other functions.

The reason that this can fail with large raster and a custom function is that all values need to be loaded into memory. To circumvent this problem you can run `global` with a sample of the cells.

You can compute a weighted mean or sum by providing a SpatRaster with weights.

Usage

```
## S4 method for signature 'SpatRaster'
global(x, fun="mean", weights=NULL, maxcell=Inf, ...)
```

Arguments

<i>x</i>	SpatRaster
<i>fun</i>	function to be applied to summarize the values by zone. Either as one or more of these built-in character values: "max", "min", "mean", "sum", "range", "rms" (root mean square), "sd", "std" (population sd, using <i>n</i> rather than <i>n</i> -1), "isNA", "notNA", "anyNA", "anynotNA"; or a proper R function (but these may fail for very large SpatRasters unless you specify <i>maxcell</i>)
...	additional arguments passed on to <i>fun</i>
<i>weights</i>	NULL or SpatRaster
<i>maxcell</i>	positive integer used to take a regular sample of <i>x</i> . Ignored by the built-in functions.

Value

A data.frame with a row for each layer

See Also

[zonal](#) for "zonal" statistics, and [app](#) or [Summary-methods](#) for "local" statistics, and [extract](#) for summarizing values for polygons. Also see [focal](#) for "focal" or "moving window" operations.

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
global(r, "sum")
global(r, "mean", na.rm=TRUE)
x <- c(r, r/10)
global(x, c("sum", "mean", "sd"), na.rm=TRUE)

global(x, function(i) min(i) / max(i))
```

graticule

Create a graticule

Description

Create a graticule. That is, a grid of lon/lat lines that can be used on a projected map.

The object returned, a `SpatGraticule`, can be plotted with `plot` and `lines`. There is also a `crop` method.

Usage

```
graticule(lon=30, lat=30, crs="")
```

Arguments

lon	numeric. Either a single number (the interval between longitudes), or a vector with longitudes
lat	numeric. Either a single number (the interval between latitudes), or a vector with latitudes
crs	character. The coordinate reference system to use

Value

`SpatGraticule`

See Also

[plot<SpatGraticule>](#).

Examples

```
g <- graticule(60, 30, crs="+proj=robin")
g
graticule(90, c(-90, -60, -23.5, 0, 23.5, 60, 90), crs="+proj=robin")
```

gridDist	<i>Distance on a grid</i>
----------	---------------------------

Description

The function calculates the distance to cells of a `SpatRaster` when the path has to go through the centers of the eight neighboring raster cells.

The default distance (when `scale=1`, is meters if the coordinate reference system (CRS) of the `SpatRaster` is longitude/latitude (`+proj=longlat`) and in the linear units of the CRS (typically meters) in other cases.

Distances are computed by summing local distances between cells, which are connected with their neighbors in 8 directions.

The shortest distance to the cells with the target value is computed for all cells that are not NA. Cells that are NA cannot be traversed and are ignored, unless the target itself is NA, in which case the distance to the nearest cell that is not NA is computed for all cells that are NA.

Usage

```
## S4 method for signature 'SpatRaster'
gridDist(x, target=0, scale=1, maxiter=50, nearest=FALSE, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>target</code>	numeric. value of the target cells (where to compute distance to)
<code>scale</code>	numeric. Scale factor. For longitude/latitude data 1 = "m" and 1000 = "km". For planar data that is also the case of the distance unit of the crs is "m"
<code>maxiter</code>	numeric. The maximum number of iterations. Increase this number if you get the warning that <code>costDistance</code> did not converge. Only relevant when target is not NA
<code>nearest</code>	logical. If TRUE, a second layer is returned with the cell number of the nearest target cell. Only relevant when target is not NA
<code>filename</code>	character. output filename (optional)
<code>...</code>	additional arguments as for writeRaster

Value

`SpatRaster`. If `nearest=TRUE`, a two-layer `SpatRaster` with the distance in the first layer and the cell number of the nearest target in the second layer

See Also

See [distance](#) for "as the crow flies" distance, and [costDist](#) for distance across a landscape with variable friction

Examples

```
# global lon/lat raster
r <- rast(ncol=10,nrow=10, vals=1)
r[48] <- 0
r[66:68] <- NA
d <- gridDist(r)
plot(d)

# planar
crs(r) <- "+proj=utm +zone=15 +ellps=GRS80 +datum=NAD83 +units=m +no_defs"
d <- gridDist(r)
plot(d)

# distance to cells that are not NA
rr <- classify(r, cbind(1, NA))
dd <- gridDist(rr, NA)
```

halo

Add halo-ed text to a plot

Description

Add text to a plot that has a "halo". That is, a buffer around it to enhance visibility.

Usage

```
halo(x, y=NULL, labels, col="black", hc="white", hw=0.1, ...)
```

Arguments

x, y	numeric. coordinates where the text labels should be written
labels	character. The text to be written
col	character. The main color to be used
hc	character. The halo color
hw	numeric. The halo width
...	additional arguments to pass to text

See Also

[text](#), [plot](#)

Examples

```
r <- rast(nrows=4, ncols=4)
values(r) <- 1:ncell(r)
plot(r, col="blue", legend=FALSE)

text(-100, 20, "hello", cex=2)
halo(50, 20, "hello", cex=2)

halo(0, -20, "world", font=3, hc="light blue", cex=2, hw=.2)
halo(0, 90, "world", font=2, cex=2, hw=.2, xpd=TRUE, pos=2)
halo(0, 90, "world", col="white", font=2, hc="blue", cex=2, hw=.2, xpd=TRUE, pos=4)
```

headtail

head and tail of a SpatRaster or SpatVector

Description

Show the head (first values) or tail (last values) of a SpatRaster or of the attributes of a SpatVector.

Usage

```
head(x, ...)
tail(x, ...)
```

Arguments

x	SpatRaster or SpatVector
...	additional arguments passed on to other methods

Value

matrix (SpatRaster) or data.frame (SpatVector)

See Also

[show](#), [geom](#)

Examples

```
r <- rast(nrows=25, ncols=25)
values(r) <- 1:ncell(r)
head(r)
tail(r)
```

hist *Histogram*

Description

Create a histogram of the values of a `SpatRaster`. For large datasets a sample of `maxcell` is used.

Usage

```
## S4 method for signature 'SpatRaster'  
hist(x, layer, maxcell=1000000, plot=TRUE, maxnl=16, main, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>layer</code>	positive integer or character to indicate layer numbers (or names). If missing, all layers up to <code>maxnl</code> are used
<code>maxcell</code>	integer. To regularly sample very large objects
<code>plot</code>	logical. Plot the histogram or only return the histogram values
<code>maxnl</code>	positive integer. The maximum number of layers to use. Ignored if <code>layer</code> is not missing
<code>main</code>	character. Main title(s) for the plot. Default is the value of <code>names</code>
<code>...</code>	additional arguments. See hist

Value

This function is principally used for plotting a histogram, but it also returns an object of class "histogram" (invisibly if `plot=TRUE`).

See Also

[pairs](#), [boxplot](#)

Examples

```
r1 <- r2 <- rast(nrows=50, ncols=50)  
values(r1) <- runif(ncell(r1))  
values(r2) <- runif(ncell(r1))  
rs <- r1 + r2  
rp <- r1 * r2  
  
opar <- par(no.readonly =TRUE)  
par(mfrow=c(2,2))  
plot(rs, main='sum')  
plot(rp, main='product')  
hist(rs)  
a <- hist(rp)
```

```

a
x <- c(rs, rp, sqrt(rs))
hist(x)
par(opar)

```

hull *Convex, concave, rectangular and circular hulls*

Description

Compute hulls around `SpatVector` geometries. This can be the convex hull, the minimal bounding rotated rectangle, the minimal bounding circle, or a concave hull. The concaveness of the concave hull can be specified in different ways.

The old method `convHull` is deprecated and will be removed in a future version.

Usage

```

## S4 method for signature 'SpatVector'
hull(x, type="convex", by="", param=1, allowHoles=TRUE, tight=TRUE)

```

Arguments

<code>x</code>	<code>SpatVector</code>
<code>type</code>	character. One of "convex", "rectangle", "circle", "concave_ratio", "concave_length"
<code>by</code>	character (variable name), to get a new geometry for groups of input geometries
<code>param</code>	numeric between 0 and 1. For the "concave_*" types only. For <code>type="concave_ratio"</code> this is the edge length ratio value, between 0 and 1. For <code>type="concave_length"</code> this the maximum edge length (a value > 0). For <code>type="concave_polygons"</code> this specifies the maximum Edge Length as a fraction of the difference between the longest and shortest edge lengths between the polygons. This normalizes the maximum edge length to be scale-free. A value of 1 produces the convex hull; a value of 0 produces the original polygons
<code>allowHoles</code>	logical. May the output polygons contain holes? For "concave_*" methods only
<code>tight</code>	logical. Should the hull follow the outer boundaries of the input polygons? For "concave_length" with polygon geometry only

Details

A concave hull is a polygon which contains all the points of the input. It can be a better representation of the input data (typically points) than the convex hull. There are many possible concave hulls with different degrees of concaveness. These can be created with argument `param`.

The hull is constructed by removing the longest outer edges of the Delaunay Triangulation of the space between the polygons, until the target criterion `param` is reached. If `type="concave_ratio"`, `param` expresses the ratio between the lengths of the longest and shortest edges. 1 produces the convex hull; 0 produces a hull with maximum concaveness. If `type="concave_length"`, `param` specifies the maximum edge length. A large value produces the convex hull, 0 produces the hull of maximum concaveness.

Value

SpatVector

Examples

```
p <- vect(system.file("ex/lux.shp", package="terra"))
h <- hull(p)

plot(p)
lines(h, col="orange")

hh <- hull(p, "convex", by="NAME_1")
lines(hh, col="purple")

pts <- centroids(p)
plot(pts, ext=ext(p)+0.1)
lines(hull(pts, type="convex"), col="darkgreen")
lines(hull(pts, type="rect"), col="blue")
lines(hull(pts, type="circle"), col="red")
```

 identical

Compare two SpatRaster, SpatVector or SpatExtent objects for equality

Description

When, comparing two SpatRasters for equality, first the attributes of the objects are compared. If these are the same, a the raster cells are compared as well. This can be time consuming, and you may prefer to use a sample instead with [all.equal](#)

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
identical(x, y)

## S4 method for signature 'SpatVector,SpatVector'
identical(x, y)

## S4 method for signature 'SpatExtent,SpatExtent'
identical(x, y)
```

Arguments

x	SpatRaster, SpatVector, or SpatExtent
y	object of the same class as x

Value

single logical value

See Also

[all.equal](#), [compareGeom](#)

Examples

```
x <- sqrt(1:100)
mat <- matrix(x, 10, 10)
r1 <- rast(nrows=10, ncols=10, xmin=0, vals = x)
r2 <- rast(nrows=10, ncols=10, xmin=0, vals = t(mat))

identical(r1, r2)
identical(r1, r1*1)
identical(rast(r1), rast(r2))
```

ifelse

ifelse for SpatRasters

Description

Implementation of [ifelse](#) for SpatRasters. This method allows for a concise expression of what can otherwise be achieved with a combination of [classify](#), [mask](#), and [cover](#).

`ifelse` is an R equivalent to the Con method in ArcGIS (`arcpy`).

Usage

```
## S4 method for signature 'SpatRaster'
ifelse(test, yes, no, filename="", ...)
```

Arguments

<code>test</code>	SpatRaster with logical (TRUE/FALSE) values
<code>yes</code>	SpatRaster or numeric
<code>no</code>	SpatRaster or numeric
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```

r <- rast(nrows=5, ncols=5, xmin=0, xmax=1, ymin=0, ymax=1)
values(r) <- c(-10:0, NA, NA, NA, 0:10)

x <- ifel(r > 1, 1, r)
# same as
a <- classify(r, cbind(1, Inf, 1))
# or
b <- app(r, fun=function(i) {i[i > 1] <- 1; i})
# or
d <- clamp(r, -Inf, 1)
# or (not recommended for large datasets)
e <- r
e[e>1] <- 1

## other examples
f <- ifel(is.na(r), 100, r)

z <- ifel(r > -2 & r < 2, 100, 0)

# nested expressions
y <- ifel(r > 1, 1, ifel(r < -1, -1, r))

k <- ifel(r > 0, r+10, ifel(r < 0, r-10, 3))

```

image

SpatRaster image method

Description

Plot (make a map of) the values of a `SpatRaster` via `image`. See `plot` if you need more fancy options such as a legend.

Usage

```

## S4 method for signature 'SpatRaster'
image(x, y=1, maxcell=500000, ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>y</code>	positive integer indicating the layer to be plotted, or a character indicating the name of the layer
<code>maxcell</code>	positive integer. Maximum number of cells to use for the plot
<code>...</code>	additional arguments as for graphics: <code>image</code>

See Also

`plot`

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
image(r)
image(r, col=rainbow(24))
```

impose	<i>Impose the geometry of a SpatRaster to those in a SpatRasterCollection.</i>
--------	--

Description

Warp the members of a SpatRasterCollection to match the geometry of a SpatRaster.

Usage

```
## S4 method for signature 'SpatRasterCollection'
impose(x, y, filename="", ...)
```

Arguments

x	SpatRasterCollection
y	SpatRaster
filename	character. Output filename
...	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[resample](#)

initialize

Initialize a SpatRaster with values

Description

Create a SpatRaster with values reflecting a cell property: "x", "y", "xy", "col", "row", "cell" or "chess". Alternatively, a function can be used. In that case, cell values are initialized without reference to pre-existing values. E.g., initialize with a random number (fun=runif). While there are more direct ways of achieving this for small objects (see examples) for which a vector with all values can be created in memory, the init function will also work for SpatRasters with many cells.

Usage

```
## S4 method for signature 'SpatRaster'
init(x, fun, ..., filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
fun	function to be applied. This must be either single number, multiple numbers, a function, or one of a set of known character values. A function must take the number of cells as a single argument to return a vector of values with a length equal to the number of cells, such as fun=runif. Allowed character values are "x", "y", "row", "col", "cell", and "chess" to get the x or y coordinate or both, row, col or cell number or a chessboard pattern (alternating 0 and 1 values)
...	additional arguments passed to fun
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
r <- rast(ncols=10, nrows=5, xmin=0, xmax=10, ymin=0, ymax=5)
x <- init(r, fun="cell")
y <- init(r, fun=runif)

# initialize with a single value
z <- init(r, fun=8)
```

inplace

Change values in-place

Description

These "in-place" replacement methods assign new value to an object without making a copy. That is efficient, but if there is a copy of the object that you made by standard assignment (e.g. with `y <- x`), that copy is also changed.

`set.names` is the in-place replacement version of `names<-`.

`set.ext` is the in-place replacement version of `ext<-`.

`set.values` is the in-place replacement version of `[<-`.

`set.cats` is the in-place replacement version of `categories`.

`set.crs` is the in-place replacement version of `crs<-`.

`set.window` is the in-place replacement version of `window<-`.

Usage

```
## S4 method for signature 'SpatRaster'
set.names(x, value, index=1:nlyr(x), validate=FALSE)
## S4 method for signature 'SpatRasterDataset'
set.names(x, value, index=1:length(x), validate=FALSE)
## S4 method for signature 'SpatVector'
set.names(x, value, index=1:ncol(x), validate=FALSE)

## S4 method for signature 'SpatRaster'
set.ext(x, value)
## S4 method for signature 'SpatVector'
set.ext(x, value)

## S4 method for signature 'SpatRaster'
set.crs(x, value)
## S4 method for signature 'SpatVector'
set.crs(x, value)

## S4 method for signature 'SpatRaster'
set.values(x, cells, values, layer=0)
## S4 method for signature 'SpatRasterDataset'
set.values(x)

## S4 method for signature 'SpatRaster'
set.cats(x, layer=1, value, active=1)

## S4 method for signature 'SpatRaster'
set.RGB(x, value, type="rgb")
```

Arguments

x	SpatRaster
value	character for set.names. For set.cats: a data.frame with columns (value, category) or vector with category names. For set.RGB 3 or 4 numbers indicating the RGB(A) layers
index	positive integer indicating layer(s) to assign a name to
validate	logical. Make names valid and/or unique?
cells	cell numbers or missing
values	replacement values or missing to load all values into memory
layer	positive integer(s) indicating to which layer(s) to you want to assign these categories or to which you want to set these values. A number < 1 indicates "all layers"
active	positive integer indicating the active category (column number in value, but not counting the first column)
type	character. The color space. One of "rgb" "hsv", "hsi" and "hsl"

Value

logical (invisibly)

Examples

```
s <- rast(ncols=5, nrows=5, nlyrs=3)
x <- s
names(s)
names(s) <- c("a", "b", "c")
names(s)
names(x)

x <- s
set.names(s, c("e", "f", "g"))
names(s)
names(x)

set.ext(x, c(0,180,0,90))

f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)

#values from file to memory
set.values(r)

# change values
set.values(r, 1:1000, 900)
```

inset	<i>Make an inset map</i>
-------	--------------------------

Description

Make an inset map or scale the extent of a SpatVector

Usage

```
## S4 method for signature 'SpatVector'
inset(x, e, loc="", scale=0.2, background="white",
      perimeter=TRUE, box=NULL, pper, pbox, offset=0.1, add=TRUE, ...)
```

```
## S4 method for signature 'SpatRaster'
inset(x, e, loc="", scale=0.2, background="white",
      perimeter=TRUE, box=NULL, pper, pbox, offset=0.1, add=TRUE, ...)
```

```
## S4 method for signature 'SpatVector'
inext(x, e, y=NULL, gap=0)
```

Arguments

x	SpatVector, SpatRaster
e	SpatExtent to set the size and location of the inset. Or missing
loc	character. One of "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right", "center"
scale	numeric. The relative size of the inset, used when x is missing
background	color for the background of the inset. Use NA for no background color
perimeter	logical. If TRUE a perimeter (border) is drawn around the inset
box	SpatExtent or missing, to draw a box on the inset, e.g. to show where the map is located in a larger area
pper	list with graphical parameters (arguments) such as col and lwd for the perimeter line
pbox	list with graphical parameters (arguments) such as col and lwd for the box (line)
offset	numeric. Value between 0.1 and 1 to indicate the relative distance between what is mapped and the bounding box
add	logical. Add the inset to the map?
...	additional arguments passed to plot for the drawing of x
y	SpatVector. If not NULL, y is scaled based with the parameters for x. This is useful, for example, when x represent boundaries, and y points within these boundaries
gap	numeric to add space between the SpatVector and the SpatExtent

Value

scaled and shifted `SpatVector` or `SpatRaster` (returned invisibly)

See Also

[sbar](#), [rescale](#), [shift](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
x <- v[v$NAME_2 == "Diekirch", ]

plot(x, density=10, col="blue")
inset(v)

# more elaborate
plot(x, density=10, col="blue")
inset(v, col = "brown", border="lightgrey", perimeter=TRUE,
      pper=list(col="orange", lwd=3, lty=2),
      box=ext(x), pbox=list(col="blue", lwd=2))

cols <- rep("light grey", 12)
cols[2] <- "red"
e <- ext(c(6.2, 6.3, 49.9, 50))
b <- ext(x)+0.02
inset(v, e=e, col=cols, box=b)

# with a SpatRaster
ff <- system.file("ex/elev.tif", package="terra")
r <- rast(ff)
r <- crop(r, ext(x) + .01)
plot(r, type="int", mar=c(2,2,2,2), plg=list(x="topright"))
lines(v, lwd=1.5)
lines(x, lwd=2.5)
inset(v, col=cols, loc="topleft", scale=0.15)

# a more complex one
plot(r, plg=list(title="meter\n", shrink=.2, cex=.8))
lines(v, lwd=4, col="white")
lines(v, lwd=1.5)
lines(x, lwd=2.5)
text(x, "NAME_2", cex=1.5, halo=TRUE)
sbar(6, c(6.04, 49.785), type="bar", below="km", label=c(0,3,6), cex=.8)
s <- inset(v, col=cols, box=b, scale=.2, loc="topright", background="light yellow",
          pbox=list(lwd=2, lty=5, col="blue"))

# note the returned inset SpatVector
s
lines(s, col="orange")
```

interpIDW

*Interpolate points using a moving window***Description**

Interpolate points within a moving window using inverse distance weighting. The maximum number of points used can be restricted, optionally by selecting the nearest points.

Usage

```
## S4 method for signature 'SpatRaster,SpatVector'
interpIDW(x, y, field, radius, power=2, smooth=0,
          maxPoints=Inf, minPoints=1, near=TRUE, fill=NA, filename="", ...)

## S4 method for signature 'SpatRaster,matrix'
interpIDW(x, y, radius, power=2, smooth=0,
          maxPoints=Inf, minPoints=1, near=TRUE, fill=NA, filename="", ...)
```

Arguments

x	SpatRaster
y	SpatVector or matrix with three columns (x,y,z)
field	character. field name in SpatVector y
radius	numeric. The radius of the circle (single number). If near=FALSE, it is also possible to use two or three numbers. Two numbers are interpreted as the radii of an ellipse (x and y-axis). A third number should indicated the desired, counter clockwise, rotation of the ellipse (in degrees)
power	numeric. Weighting power
smooth	numeric. Smoothing parameter
minPoints	numeric. The minimum number of points to use. If fewer points are found in a search ellipse it is considered empty and the fill value is returned
maxPoints	numeric. The maximum number of points to consider in a search area. Additional points are ignored. If fewer points are found, the fill value is returned
near	logical. Should the nearest points within the neighborhood be used if maxPoints is reached?
fill	numeric. value to use to fill empty cells
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rasterizeWin](#), [rasterize](#), [interpNear](#), [interpolate](#)

Examples

```
r <- rast(ncol=100, nrow=100, crs="local", xmin=0, xmax=50, ymin=0, ymax=50)
set.seed(100)
x <- runif(25, 5, 45)
y <- runif(25, 5, 45)
z <- sample(25)
xyz <- cbind(x,y,z)

x <- interpIDW(r, xyz, radius=5, power=1, smooth=1, maxPoints=5)
```

interpNear	<i>Nearest neighbor interpolation</i>
------------	---------------------------------------

Description

Nearest neighbor interpolation of points, using a moving window

Usage

```
## S4 method for signature 'SpatRaster,SpatVector'
interpNear(x, y, field, radius, interpolate=FALSE, fill=NA, filename="", ...)

## S4 method for signature 'SpatRaster,matrix'
interpNear(x, y, radius, interpolate=FALSE, fill=NA, filename="", ...)
```

Arguments

x	SpatRaster
y	SpatVector or matrix with three columns (x,y,z)
field	character. field name in SpatVector y
radius	numeric. The radius of the circle (single number). If interpolate=FALSE it is also possible to use two or three numbers. Two numbers are interpreted as the radii of an ellipse (x and y-axis). A third number should indicated the desired, counter clockwise, rotation of the ellipse (in degrees)
interpolate	logical. Should the nearest neighbor values be linearly interpolated between points?
fill	numeric. value to use to fill empty cells
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also[rasterizeWin](#), [rasterize](#), [interpIDW](#), [interpolate](#)**Examples**

```
r <- rast(ncol=100, nrow=100, crs="local", xmin=0, xmax=50, ymin=0, ymax=50)
set.seed(100)
x <- runif(25, 5, 45)
y <- runif(25, 5, 45)
z <- sample(25)
xyz <- cbind(x,y,z)

x <- interpNear(r, xyz, radius=5)

p <- vect(data.frame(xyz), geom=c("x", "y"))
v <- voronoi(p)

plot(x, col=rainbow(25))
lines(v)

# plot(v, col=rainbow(25)); points(p)
```

interpolation

Spatial interpolation

Description

Make a SpatRaster with interpolated values using a fitted model object of classes such as "gstat" (gstat package) or "Krige" (fields package), or any other model that has location (e.g., "x" and "y", or "longitude" and "latitude") as predictors (independent variables). If x and y are the only predictors, it is most efficient if you provide an empty (no associated data in memory or on file) SpatRaster for which you want predictions. If there are more spatial predictor variables, provide these as a SpatRaster in the first argument of the function. If you do not have x and y locations as implicit predictors in your model you should use [predict](#) instead.

Usage

```
## S4 method for signature 'SpatRaster'
interpolate(object, model, fun=predict, ..., xyNames=c("x", "y"),
            factors=NULL, const=NULL, index = NULL, cores=1, cpkgs=NULL,
            na.rm=FALSE, filename="", overwrite=FALSE, wopt=list())
```

Arguments

object	SpatRaster
model	model object
fun	function. Default value is "predict", but can be replaced with e.g. "predict.se" (depending on the class of model), or a custom function (see examples)
...	additional arguments passed to fun
xyNames	character. variable names that the model uses for the spatial coordinates. E.g., c("longitude", "latitude")
factors	list with levels for factor variables. The list elements should be named with names that correspond to names in object such that they can be matched. This argument may be omitted for some models from which the levels can be extracted from the model object
const	data.frame. Can be used to add a constant for which there is no SpatRaster for model predictions. This is particularly useful if the constant is a character-like factor value
index	positive integer or NULL. Allows for selecting of the variable returned if the model returns multiple variables
cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created and used
cpkgs	character. The package(s) that need to be loaded on the nodes to be able to run the model.predict function (see examples in predict)
na.rm	logical. If TRUE, cells with NA values in the predictors are removed from the computation. This option prevents errors with models that cannot handle NA values. In most other cases this will not affect the output. An exception is when predicting with a model that returns predicted values even if some (or all!) variables are NA
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also[predict](#), [interpIDW](#), [interpNear](#)**Examples**

```

r <- rast(system.file("ex/elev.tif", package="terra"))
ra <- aggregate(r, 10)
xy <- data.frame(xyFromCell(ra, 1:ncell(ra)))
v <- values(ra)
i <- !is.na(v)

```

```

xy <- xy[i,]
v <- v[i]

## Not run:
library(fields)
tps <- Tps(xy, v)
p <- rast(r)

# use model to predict values at all locations
p <- interpolate(p, tps)
p <- mask(p, r)
plot(p)

### change "fun" from predict to fields::predictSE to get the TPS standard error
## need to use "rast(p)" to remove the values
se <- interpolate(rast(p), tps, fun=predictSE)
se <- mask(se, r)
plot(se)

### another predictor variable, "e"
e <- (init(r, "x") * init(r, "y")) / 100000000
names(e) <- "e"

z <- as.matrix(extract(e, xy)[,-1])

## add as another independent variable
xyz <- cbind(xy, z)
tps2 <- Tps(xyz, v)
p2 <- interpolate(e, tps2, xyOnly=FALSE)

## as a linear covariate
tps3 <- Tps(xy, v, Z=z)

## Z is a separate argument in Krig.predict, so we need a new function
## Internally (in interpolate) a matrix is formed of x, y, and elev (Z)

pfun <- function(model, x, ...) {
  predict(model, x[,1:2], Z=x[,3], ...)
}
p3 <- interpolate(e, tps3, fun=pfun)

#### gstat examples
library(gstat)
library(sp)
data(meuse)

### inverse distance weighted (IDW)
r <- rast(system.file("ex/meuse.tif", package="terra"))
mg <- gstat(id = "zinc", formula = zinc~1, locations = ~x+y, data=meuse,
           nmax=7, set=list(idp = .5))
z <- interpolate(r, mg, debug.level=0, index=1)
z <- mask(z, r)

```

```

## with a model built with an `sf` object you need to provide custom function

library(sf)
sfmeuse <- st_as_sf(meuse, coords = c("x", "y"), crs=crs(r))
mgstf <- gstat(id = "zinc", formula = zinc~1, data=sfmeuse, nmax=7, set=list(idp = .5))

interpolate_gstat <- function(model, x, crs, ...) {
  v <- st_as_sf(x, coords=c("x", "y"), crs=crs)
  p <- predict(model, v, ...)
  as.data.frame(p)[,1:2]
}

zsf <- interpolate(r, mgstf, debug.level=0, fun=interpolate_gstat, crs=crs(r), index=1)
zsf <- mask(zsf, r)

### kriging

### ordinary kriging
v <- variogram(log(zinc)~1, ~x+y, data=meuse)
mv <- fit.variogram(v, vgm(1, "Sph", 300, 1))
gOK <- gstat(NULL, "log.zinc", log(zinc)~1, meuse, locations=~x+y, model=mv)
OK <- interpolate(r, gOK, debug.level=0)

## universal kriging
vu <- variogram(log(zinc)~elev, ~x+y, data=meuse)
mu <- fit.variogram(vu, vgm(1, "Sph", 300, 1))
gUK <- gstat(NULL, "log.zinc", log(zinc)~elev, meuse, locations=~x+y, model=mu)
names(r) <- "elev"
UK <- interpolate(r, gUK, debug.level=0)

## co-kriging
gCoK <- gstat(NULL, 'log.zinc', log(zinc)~1, meuse, locations=~x+y)
gCoK <- gstat(gCoK, 'elev', elev~1, meuse, locations=~x+y)
gCoK <- gstat(gCoK, 'cadmium', cadmium~1, meuse, locations=~x+y)
gCoK <- gstat(gCoK, 'copper', copper~1, meuse, locations=~x+y)
coV <- variogram(gCoK)
plot(coV, type='b', main='Co-variogram')
coV.fit <- fit.lmc(coV, gCoK, vgm(model='Sph', range=1000))
coV.fit
plot(coV, coV.fit, main='Fitted Co-variogram')
coK <- interpolate(r, coV.fit, debug.level=0)
plot(coK)

## End(Not run)

```

Description

You can intersect `SpatVectors` with each other or with a `SpatExtent`. Intersecting points with points uses the extent of `y` to get the intersection. Intersecting of points and lines is not supported because of numerical inaccuracies with that. You can use `buffer`, to create polygons from lines and use these with `intersect`.

You can also intersect two `SpatExtents`.

When intersecting two `SpatRasters` these need to be aligned (have the same origin and spatial resolution). The values of the returned `SpatRaster` are `TRUE` where both input rasters have values, `FALSE` where one has values, and `NA` in all other cells.

When intersecting a `SpatExtent` and a `SpatRaster`, the `SpatExtent` is first aligned to the raster cell boundaries.

See `crop` for the intersection of a `SpatRaster` with a `SpatExtent` (or the extent of a `SpatRaster` or `SpatVector`) if you want a `SpatRaster` (not a `SpatExtent`) as output.

See `is.related(x, y, "intersects")` to find out which geometries of a `SpatVector` intersect. You can spatially subset a `SpatVector` with another one with `x[y]`.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
intersect(x, y)
```

```
## S4 method for signature 'SpatVector,SpatExtent'
intersect(x, y)
```

```
## S4 method for signature 'SpatExtent,SpatVector'
intersect(x, y)
```

```
## S4 method for signature 'SpatExtent,SpatExtent'
intersect(x, y)
```

```
## S4 method for signature 'SpatRaster,SpatRaster'
intersect(x, y)
```

```
## S4 method for signature 'SpatRaster,SpatExtent'
intersect(x, y)
```

```
## S4 method for signature 'SpatExtent,SpatRaster'
intersect(x, y)
```

Arguments

<code>x</code>	<code>SpatVector</code> , <code>SpatExtent</code> , or <code>SpatRaster</code>
<code>y</code>	<code>SpatVector</code> , <code>SpatExtent</code> , or <code>SpatRaster</code>

Value

Same as `x`

See Also

[union](#), [crop](#), [relate](#), [\[](#)

Examples

```
e1 <- ext(-10, 10, -20, 20)
e2 <- ext(0, 20, -40, 5)
intersect(e1, e2)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
e <- ext(5.6, 6, 49.55, 49.7)
x <- intersect(v, e)

p <- vect(c("POLYGON ((5.8 49.8, 6 49.9, 6.15 49.8, 6 49.6, 5.8 49.8))",
"POLYGON ((6.3 49.9, 6.2 49.7, 6.3 49.6, 6.5 49.8, 6.3 49.9))"), crs=crs(v))
values(p) <- data.frame(pid=1:2, area=expansion(p))

y <- intersect(v, p)

r <- s <- rast(ncol=5, nrow=5, xmin=1, xmax=5, ymin=1, ymax=5)
r[5:20] <- 5:20
s[11:20] <- 11:20
rs <- intersect(r, s)

u <- shift(r, .8)
us <- intersect(u, s)
```

is.bool

Raster value types

Description

The values in a `SpatRaster` layer are by default numeric, but they can also be set to be logical (Boolean), integer, or categorical (factor).

For a `SpatRaster`, `as.logical` and `isTRUE` is equivalent to `as.bool`. `isFALSE` is equivalent to `!as.bool`, and `as.integer` is the same as `as.int`.

`as.bool` and `as.int` force the values into the correct range (e.g. whole integers) but in-memory cell values are still stored as numeric. They will behave like the assigned types, though, and will be written to files with that data type (if the file type supports it).

See [levels](#) and [cats](#) to create categorical layers by setting labels.

Usage

```
## S4 method for signature 'SpatRaster'
is.num(x)
```

```
## S4 method for signature 'SpatRaster'  
is.bool(x)  
  
## S4 method for signature 'SpatRaster'  
as.bool(x, filename, ...)  
  
## S4 method for signature 'SpatRaster'  
is.int(x)  
  
## S4 method for signature 'SpatRaster'  
as.int(x, filename, ...)  
  
## S4 method for signature 'SpatRaster'  
is.factor(x)  
  
## S4 method for signature 'SpatRaster'  
as.factor(x)
```

Arguments

x	SpatRaster
filename	character. Output filename
...	list with named options for writing files as in writeRaster

Value

The `as.*` methods return a new `SpatRaster`, whereas the `is.*` methods return a logical value for each layer in `x`.

See Also

[levels](#) and [cats](#) to create categorical layers (and set labels).

Examples

```
r <- rast(nrows=10, ncols=10, vals=1:100)  
is.bool(r)  
z <- as.bool(r)  
is.bool(z)  
  
x <- r > 25  
is.bool(x)  
  
rr <- r/2  
is.int(rr)  
is.int(round(rr))
```

is.empty	<i>Check if a SpatExtent or SpatVector is empty</i>
----------	---

Description

An empty SpatExtent has no area

An empty SpatVector has no geometries.

Usage

```
## S4 method for signature 'SpatExtent'
is.empty(x)
```

```
## S4 method for signature 'SpatVector'
is.empty(x)
```

Arguments

x SpatVector or SpatExtent

Value

logical

Examples

```
e <- ext(0,0,0,0)
is.valid(e)
is.empty(e)
```

```
v <- vect()
is.valid(v)
is.empty(v)
```

is.flipped	<i>Is a SpatRaster is flipped</i>
------------	-----------------------------------

Description

Check if a SpatRaster is "flipped" vertically, and may need to be adjusted with [flip](#) before it can be used.

Usage

```
## S4 method for signature 'SpatRaster'
is.flipped(x)
```

Arguments

x SpatRaster

Value

logical. One value for each raster data **source**

See Also

[flip](#), [is.rotated](#)

Examples

```
r <- rast(nrows=10, ncols=10)
is.flipped(r)
```

is.lonlat	<i>Check for longitude/latitude crs</i>
-----------	---

Description

Test whether a SpatRaster or SpatVector has a longitude/latitude coordinate reference system (CRS), or perhaps has one. That is, when the CRS is unknown ("") but the x coordinates are within -181 and 181 and the y coordinates are within -90.1 and 90.1. For a SpatRaster you can also test if it has a longitude/latitude CRS and it is "global" (covers all longitudes).

A warning is given if the CRS is missing or if it is specified as longitude/latitude but the coordinates do not match that.

Usage

```
## S4 method for signature 'SpatRaster'
is.lonlat(x, perhaps=FALSE, warn=TRUE, global=FALSE)
```

```
## S4 method for signature 'SpatVector'
is.lonlat(x, perhaps=FALSE, warn=TRUE)
```

```
## S4 method for signature 'character'
is.lonlat(x, perhaps=FALSE, warn=TRUE)
```

Arguments

x SpatRaster or SpatVector

perhaps logical. If TRUE and the CRS is unknown, the method returns TRUE if the coordinates are plausible for longitude/latitude

warn logical. If TRUE, a warning is given if the CRS is unknown but assumed to be lon/lat and perhaps=TRUE

global logical. If TRUE, the method tests if the raster covers all longitudes (from -180 to 180 degrees) such that the extreme columns are in fact adjacent

Value

logical or NA

Examples

```
r <- rast()
is.lonlat(r)
is.lonlat(r, global=TRUE)
```

```
crs(r) <- ""
is.lonlat(r)
is.lonlat(r, perhaps=TRUE, warn=FALSE)
```

```
crs(r) <- "+proj=lcc +lat_1=48 +lat_2=33 +lon_0=-100 +ellps=WGS84"
is.lonlat(r)
```

is.rotated

Check for rotation

Description

Check if a SpatRaster is "rotated" and needs to be rectified before it can be used

See [rectify](#)

Usage

```
## S4 method for signature 'SpatRaster'
is.rotated(x)
```

Arguments

x SpatRaster

Value

logical. One value for each raster data *source*

See Also

[rectify](#), [is.flipped](#)

Examples

```
r <- rast(nrows=10, ncols=10, vals=1:100)
is.rotated(r)
```

is.valid	<i>Check or fix polygon or extent validity</i>
----------	--

Description

Check the validity of polygons or attempt to fix it. Or check the validity of a SpatExtent.

Usage

```
## S4 method for signature 'SpatVector'
is.valid(x, messages=FALSE, as.points=FALSE)

## S4 method for signature 'SpatVector'
makeValid(x, buffer=FALSE)

## S4 method for signature 'SpatExtent'
is.valid(x)
```

Arguments

x	SpatVector or SpatExtent
messages	logical. If TRUE the error messages are returned
as.points	logical. If TRUE, it is attempted to return locations where polygons are invalid as a SpatVector or points
buffer	logical. If TRUE the zero-width buffer method is used to create valid polygons. Be careful when using this method because it may result in data loss. For example, only a single part of a self-intersecting may be preserved. See the example below

Value

logical

See Also

[topology](#)

Examples

```
w <- vect("POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")
is.valid(w)

w <- vect("POLYGON ((0 -5, 10 0, 10 -10, 4 -2, 0 -5))")
is.valid(w)
is.valid(w, TRUE)
v1 <- makeValid(w)
is.valid(v1)
```

```

v2 <- makeValid(w, buffer=TRUE)

plot(disagg(v1), col=c("light blue", "gray"))
# valid but incomplete
lines(v2, col="red", lwd=3)

plot(w)
points(cbind(4.54, -2.72), cex=2, col="red")

e <- ext(0, 1, 0, 1)
is.valid(e)

ee <- ext(0, 0, 0, 0)
is.valid(ee)

```

k_means

k_means

Description

Compute k-means clusters for a `SpatRaster`. For large `SpatRasters` (with `ncell(x) > maxcell`) this is done in two steps. First a sample of the cells is used to compute the cluster centers. Then each cell is assigned to a cluster by computing the distance to these centers.

Usage

```

## S4 method for signature 'SpatRaster'
k_means(x, centers=3, ..., maxcell=1000000, filename="", overwrite=FALSE, wopt=list())

```

Arguments

x	<code>SpatRaster</code>
centers	either the number of clusters, or a set of initial (distinct) cluster centres. If a number, a random set of (distinct) cells in x is chosen as the initial centres
...	additional arguments passed to kmeans
maxcell	positive integer. The size of the regular sample used if it is smaller than <code>ncell(x)</code>
filename	character. Output filename (ignored if <code>as.raster=FALSE</code>)
overwrite	logical. If TRUE, filename is overwritten
wopt	list with additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[kmeans](#)

Examples

```
f <- system.file("ex/logo.tif", package = "terra")
r <- rast(f)
km <- k_means(r, centers=5)
km
```

lapp

Apply a function to layers of a SpatRaster, or sub-datasets of a SpatRasterDataset

Description

Apply a function to a SpatRaster, using layers as arguments.

The number of arguments in function `fun` must match the number of layers in the SpatRaster (or the number of sub-datasets in the SpatRasterDataset). For example, if you want to multiply two layers, you could use this function: `fun=function(x,y){return(x*y)}` percentage: `fun=function(x,y){return(100 * x / y)}`. If you combine three layers you could use `fun=function(x,y,z){return((x + y) * z)}`

Before you use the function, test it to make sure that it is vectorized. That is, it should work for vectors longer than one, not only for single numbers. Or if the input SpatRaster(s) have multiple layers, it should work for a matrix (multiple cells) of input data (or matrices in the case of a SpatRasterDataSet). The function must return the same number of elements as its input vectors, or multiples of that. Also make sure that the function is NA-proof: it should return the same number of values when some or all input values are NA. And the function must return a vector or a matrix, not a data frame. To test it, run it with `do.call(fun, data)` (see examples).

Use [app](#) for summarize functions such as `sum`, that take any number of arguments; and [tapp](#) to do so for groups of layers.

Usage

```
## S4 method for signature 'SpatRaster'
lapp(x, fun, ..., usernames=FALSE, cores=1, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterDataset'
lapp(x, fun, ..., usernames=FALSE, recycle=FALSE,
     cores=1, filename="", overwrite=FALSE, wopt=list())
```

Arguments

<code>x</code>	SpatRaster or SpatRasterDataset
<code>fun</code>	a function that takes a vector and can be applied to each cell of <code>x</code>
<code>...</code>	additional arguments to be passed to <code>fun</code>
<code>usernames</code>	logical. Use the layer names (or dataset names if <code>x</code> is a SpatRasterDataset) to match the function arguments? If FALSE, argument matching is by position

cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created and used. You can also supply a cluster object. The benefit of using this option is often small, if it is even positive. Using a fast function fun can be a much more effective way to speed things up
recycle	logical. Recycle layers to match the subdataset with the largest number of layers
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

Note

Use [sapp](#) or [lapply](#) to apply a function that takes a SpatRaster as argument to each layer of a SpatRaster (that is rarely necessary).

See Also

[app](#), [tapp](#), [math](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra")) + 1
ss <- s[[2:1]]

fvi <- function(x, y){ (x - y) / (x + y) }
# test the function
data <- list(c(1:5,NA), 6:1)
do.call(fvi, data)

x <- lapp(ss, fun=fvi )

# which is the same as supplying the layers to "fun"
# in some cases this will be much faster
y <- fvi(s[[2]], s[[1]])

f2 <- function(x, y, z){ (z - y + 1) / (x + y + 1) }
p1 <- lapp(s, fun=f2 )

p2 <- lapp(s[[1:2]], f2, z=200)

# the usenames argument

fvi2 <- function(red, green){ (red - green) / (red + green) }
names(s)
x1 <- lapp(s[[1:2]], fvi2, usenames=TRUE)
x2 <- lapp(s[[2:1]], fvi2, usenames=TRUE)
# x1 and x2 are the same, despite the change in the order of the layers
```

```

# x4 is also the same, but x3 is not
x3 <- lapp(s[[2:1]], fvi2, usenames=FALSE)

# these fail because there are too many layers in s
# x4 <- lapp(s, fvi2, usenames=TRUE)
# x5 <- lapp(s, fvi2, usenames=FALSE)

pairs(c(x1, x2, x3))

## SpatRasterDataset
x <- sds(s, s[[1]]+50)
fun <- function(x, y) { x/y }

# test "fun"
data <- list(matrix(1:9, ncol=3), matrix(9:1, ncol=3))
do.call(fun, data)

lapp(x, fun, recycle=TRUE)

# the same, more concisely
z <- s / (s[[1]]+50)

```

layerCor

Correlation and (weighted) covariance

Description

Compute correlation, (weighted) covariance, or similar summary statistics that compare the values of all pairs of the layers of a `SpatRaster`.

Usage

```

## S4 method for signature 'SpatRaster'
layerCor(x, fun, w, asSample=TRUE, use="everything", maxcell=Inf, ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>fun</code>	character. The statistic to compute: either "cov" (covariance), "weighted.cov" (weighted covariance), or "cor" (pearson correlation coefficient). You can also supply your own function that takes two vectors as argument to compute a single number
<code>w</code>	<code>SpatRaster</code> with the weights to compute the weighted covariance. It should have a single layer and the same geometry as <code>x</code>
<code>asSample</code>	logical. If TRUE, the statistic for a sample (denominator is $n-1$) is computed, rather than for the population (denominator is n). Only for the standard functions

use	character. To decide how to handle missing values. This must be (an abbreviation of) one of "everything", "complete.obs", "pairwise.complete.obs", "masked.complete". With "pairwise.complete.obs", the value for a pair of layers is computed for all cells that are not NA in that pair. Therefore, it may be that the (number of) cells used varies between pairs. The benefit of this approach is that all available data is used. Use "complete.obs", if you want to only use the values from cells that are not NA in any of the layers. By using "masked.complete" you indicate that all layers have NA values in the same cells
maxcell	positive integer. The maximum number of cells to be used. If this is smaller than ncell(x), a regular sample of x is used
...	additional arguments for fun (if it is a proper function)

Value

If fun is one of the three standard statistics, you get a list with three items: the correlation or (weighted) covariance matrix, the (weighted) means, and the number of data cells in each comparison. The means are also a matrix because they may depend on the combination of layers if different cells have missing values and these are excluded from the computation. The rows of the mean matrix represent the layer whose (weighted) mean is being calculated and the columns represent the layer it is being paired with. Only cells with non-missing observations for both layers are used in the calculation of the (weighted) mean. The diagonals of the mean and n matrices are set to missing. If fun is a function, you get a single matrix.

References

For the weighted covariance:

- Canty, M.J. and A.A. Nielsen, 2008. Automatic radiometric normalization of multitemporal satellite imagery with the iteratively re-weighted MAD transformation. *Remote Sensing of Environment* 112:1025-1036.
- Nielsen, A.A., 2007. The regularized iteratively reweighted MAD method for change detection in multi- and hyperspectral data. *IEEE Transactions on Image Processing* 16(2):463-478.

See Also

[global](#), [cov.wt](#), [weighted.mean](#)

Examples

```
b <- rast(system.file("ex/logo.tif", package="terra"))
layerCor(b, "cor")

layerCor(b, "cov")

# weigh by column number
w <- init(b, fun="col")
layerCor(b, "weighted.cov", w=w)

# specify another function
layerCor(b, function(x, y) cor(x, y, method="spearman"))
```

legend_cont	<i>Add a continuous legend</i>
-------------	--------------------------------

Description

Add a continuous (color gradient) legend to an existing plot. This can be used with any base plot, not just [plot](#), [SpatRaster](#), [numeric-method](#). The legend is drawn as a color bar with tick marks and labels.

Usage

```
legend_cont(x="right", y=NULL, legend, col,
            size=NULL, title=NULL, at=NULL, digits=NULL, ...)
```

Arguments

x	character or numeric. Position of the legend. Keywords: "right", "left", "top", "bottom", "topright", "bottomright". Or a numeric x-coordinate (see y)
y	numeric. Optional y-coordinate(s) for the legend position, used when x is numeric
legend	SpatRaster or numeric vector. Used to determine the value range of the legend. If a SpatRaster, the range is taken from minmax . If numeric (e.g. <code>c(min, max)</code>), the range of the values is used
col	character. Vector of colors for the gradient. If missing, the default palette is used (<code>map.pal("viridis", 100)</code>)
size	numeric. One or two values to control the size of the legend bar. The first value scales the length (0 to 1), the second scales the width
title	character. Title to display above or beside the legend bar
at	numeric. Specific values at which to place tick marks. If NULL (the default), ticks are placed automatically with pretty
digits	non-negative integer. Number of decimal places for tick labels. If NULL (the default) an appropriate number is computed from the range
...	Additional legend parameters: <code>bg</code> (background color behind the legend, e.g. "white"), <code>cex</code> , <code>horiz</code> , <code>reverse</code> , <code>labels</code> , <code>tic</code> (or tick), <code>tic.col</code> , <code>tic.lwd</code> , <code>tic.box.col</code> , and others (see the <code>plg</code> argument in plot , SpatRaster , numeric-method for details)

Value

Invisible list with the legend parameters (can be used for further customization).

See Also

[add_legend](#), [add_box](#), [plot](#), [SpatRaster](#), [numeric-method](#)

Examples

```

# with a SpatRaster
r <- rast(ncols=40, nrows=40, xmin=0, xmax=1, ymin=0, ymax=1, vals=runif(1600))
plot(r, legend=FALSE, mar=c(3.1, 3.1, 2.1, 7.1))
legend_cont("right", legend=r)

# horizontal
plot(r, legend=FALSE, mar=c(6.1, 3.1, 2.1, 2.1))
legend_cont("bottom", legend=r, horiz=TRUE, title="values")

# on the map
plot(r, legend=FALSE, alpha=0.1)
legend_cont(0.1, legend=r)
legend_cont(0.3, c(0.5, 0.9), legend=r, bg="white")
legend_cont(c(0.4, 0.8), 0.2, horiz=TRUE, legend=r, bg="white")

# with a numeric range and custom colors
cols <- heat.colors(100)
vals <- seq(5,95,10)
par(mar=c(3.1, 3.1, 2.1, 7.1))
plot(1:10, col=cols[vals], cex=2, pch=20)
legend_cont("right", legend=c(1, 100), col=cols)

```

linearUnits

Linear units of the coordinate reference system

Description

Get the linear units of the coordinate reference system (crs) of a SpatRaster or SpatVector expressed in m. The value returned is used internally to transform area and perimeter measures to meters. The value returned for longitude/latitude crs is zero.

Usage

```

## S4 method for signature 'SpatRaster'
linearUnits(x)

## S4 method for signature 'SpatVector'
linearUnits(x)

```

Arguments

x SpatRaster or SpatVector

Value

numeric (meter)

See Also[crs](#)**Examples**

```
x <- rast()
crs(x) <- ""
linearUnits(x)

crs(x) <- "+proj=longlat +datum=WGS84"
linearUnits(x)

crs(x) <- "+proj=utm +zone=1 +units=cm"
linearUnits(x)

crs(x) <- "+proj=utm +zone=1 +units=km"
linearUnits(x)

crs(x) <- "+proj=utm +zone=1 +units=us-ft"
linearUnits(x)
```

lines*Add points, lines, or polygons to a map*

Description

Add a vector geometries to a plot (map) with points, lines, or polys.

These are simpler alternatives for [plot\(x, add=TRUE\)](#)

These methods also work for a small(!) `SpatRaster`. Only cells that are not NA in the first layer are used.

Usage

```
## S4 method for signature 'SpatVector'
points(x, col, cex=0.7, pch=16, alpha=1, jitter=0, ...)

## S4 method for signature 'SpatVector'
lines(x, y=NULL, col, lwd=1, lty=1, arrows=FALSE, alpha=1, ...)

## S4 method for signature 'SpatVector'
polys(x, col, border="black", lwd=1, lty=1, alpha=1, ...)

## S4 method for signature 'SpatRaster'
points(x, ...)

## S4 method for signature 'SpatRaster'
lines(x, mx=10000, ...)
```

```
## S4 method for signature 'SpatRaster'
polys(x, mx=10000, dissolve=TRUE, ...)

## S4 method for signature 'SpatExtent'
points(x, col="black", alpha=1, ...)

## S4 method for signature 'SpatExtent'
lines(x, col="black", alpha=1, ...)

## S4 method for signature 'SpatExtent'
polys(x, col, alpha=1, ...)
```

Arguments

x	SpatVector or SpatExtent
y	missing or SpatVector. If both x and y have point geometry and the same number of rows, lines are drawn between pairs of points
col	character. Colors
border	character. color(s) of the polygon borders. Use NULL or NA to not draw a border
cex	numeric. point size magnifier. See par
pch	positive integer, point type. See points . On some (linux) devices, the default symbol "16" is a not a very smooth circle. You can use "20" instead (it takes a bit longer to draw) or "1" for an open circle
alpha	number between 0 and 1 to set transparency
jitter	numeric. The amount of random noise used to adjust label positions, possibly avoiding overlaps. See argument 'factor' in jitter
lwd	numeric, line-width. See par
lty	positive integer, line type. See par
arrows	logical. If TRUE and y is a SpatVector, arrows are drawn instead of lines. See arrows for additional arguments
mx	positive number. If the number of cells of SpatRaster x is higher, the method will fail with an error message
dissolve	logical. Should boundaries between cells with the same value be removed?
...	additional graphical arguments such as lwd, cex and pch

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

r <- rast(v)
values(r) <- 1:ncell(r)
plot(r)
lines(v)
points(v)
```

makeTiles	<i>Make tiles or get their extents</i>
-----------	--

Description

Divide a `SpatRaster` into "tiles". The cells of another `SpatRaster` (normally with a much lower resolution) or a `SpatVector` with polygon geometry can be used to define the tiles. You can also provide one or two numbers to indicate the number of rows and columns per tile.

`getTileExtents` returns the extents of the (virtual) tiles, while `makeTiles` creates files for the tiles and returns their filenames.

Usage

```
## S4 method for signature 'SpatRaster'
makeTiles(x, y, filename="tile_.tif", extend=FALSE,
na.rm=FALSE, buffer=0, value="files", overwrite=FALSE, ...)
```

```
## S4 method for signature 'SpatRaster'
getTileExtents(x, y, extend=FALSE, buffer=0, cores=1)
```

Arguments

x	<code>SpatRaster</code>
y	<code>SpatRaster</code> or <code>SpatVector</code> defining the zones; or a positive integer specifying the number of rows and columns for each zone (or 2 numbers to differentiate the number of rows and columns). For <code>getTileExtents</code> , y may also be missing or <code>NULL</code> , in which case a tile size is computed automatically (see <i>Details</i>)
filename	character. Output filename template. Filenames will be altered by adding the tile number for each tile
extend	logical. If <code>TRUE</code> , the extent of y is expanded to assure that it covers all of x
na.rm	logical. If <code>TRUE</code> , tiles with only missing values are ignored
buffer	integer. The number of additional rows and columns added to each tile. Can be a single number, or two numbers to specify a separate number of rows and columns. This allows for creating overlapping tiles that can be used for computing spatial context dependent values with e.g. <code>focal</code> . The expansion is only inside x, no rows or columns outside of x are added
cores	integer (only used by <code>getTileExtents</code> when y is missing). The number of worker processes that will consume the tiles. Larger values lead to smaller per-worker tiles so that the concurrent peak memory stays within budget. See <i>Details</i>
value	character. The type of return value desired. Either "files" (for the filenames), "raster" (for a <code>SpatRaster</code>), or "collection" (for a <code>SpatRasterCollection</code>)
overwrite	logical. If <code>TRUE</code> , existing tiles are overwritten; otherwise they are skipped (without error or warning)
...	additional arguments for writing files as in <code>writeRaster</code>

Details

When `y` is missing in `getTileExtents`, the tile size is chosen so that

- tiles align to whole GDAL blocks of the source file(s) (as reported by `fileBlocksize`). When no source block size is reported, a default of 256 rows by 256 columns is used.
- the per-worker peak memory ($\text{cells per tile} \times \text{nlyr} \times 8 \text{ bytes} \times \text{a small ncopies factor}$) stays within cores workers' share of `terraOptions("memfrac")` of free RAM (see `free_RAM`, `terraOptions`).
- there are at least a few tiles per worker, so the work load-balances.
- the result never exceeds the raster's own dimensions.

In practice this means that for a tiled GeoTIFF / COG, tiles are an integer multiple of the file block size; for an in-memory or non-tiled raster the result is roughly square.

Value

`makeTiles` returns a character (filenames), `SpatRaster` or `SpatRasterCollection` value. `getTileExtents` returns a matrix with extents

See Also

`vrt` to create a `SpatRaster` from tiles; `crop` for sub-setting arbitrary parts of a `SpatRaster`; `divide` to divide a `SpatRaster` into parts.

Examples

```
r <- rast(ncols=100, nrows=100)
values(r) <- 1:ncell(r)
x <- rast(ncols=2, nrows=2)

getTileExtents(r, x)
getTileExtents(r, x, buffer=3)

# auto: tile size from GDAL block size and a per-worker memory budget
getTileExtents(r)      # cores = 1
getTileExtents(r, cores=4) # smaller tiles, sized for 4 concurrent workers

filename <- paste0(tempfile(), "_tif")
ff <- makeTiles(r, x, filename)
ff

vrt(ff)
```

makeVRT	<i>Make a VRT header file</i>
---------	-------------------------------

Description

Create a VRT header file for a "flat binary" raster file that needs a header file to be able to read it, but does not have it.

Usage

```
makeVRT(filename, nrow, ncol, nlyr=1, extent, xmin, ymin, xres, yres=xres, xycenter=TRUE,
        crs="+proj=longlat", lyrnms="", datatype, NAflag=NA, bandorder="BIL", byteorder="LSB",
        toptobottom=TRUE, offset=0, scale=1)
```

Arguments

filename	character. raster filename (without the ".vrt" extension)
nrow	positive integer, the number of rows
ncol	positive integer, the number of columns
nlyr	positive integer, the number of layers
extent	SpatExtent or missing
xmin	numeric. minimum x coordinate (only used if extent is missing)
ymin	numeric. minimum y coordinate (only used if extent is missing)
xres	positive number. x resolution
yres	positive number. y resolution)
xycenter	logical. If TRUE, xmin and xmax represent the coordinates of the center of the extreme cell, in stead of the coordinates of the outside corner. Only used of extent is missing
crs	character. Coordinate reference system description
lyrnms	character. Layer names
datatype	character. One of "INT2S", "INT4S", "INT1U", "INT2U", "INT4U", "FLT4S", "FLT8S". If missing, this is guessed from the file size (INT1U for 1 byte per value, INT2S for 2 bytes and FLT4S for 4 bytes per value). This may be wrong because, for example, 2 bytes per value may in fact be INT2U (with the U for unsigned) values
NAflag	numeric. The value used as the "NA flag"
bandorder	character. One of "BIL", "BIP", or "BSQ". That is Band Interleaved by Line, or by Pixel, or Band Sequential
byteorder	character. One of "LSB", "MSB". "MSB" is common for files generated on Linux systems, whereas "LSB" is common for files generated on windows
toptobottom	logical. If FALSE, the values are read bottom to top
offset	numeric. offset to be applied
scale	numeric. scale to be applied

Value

character (.VRT filename)

See Also

[vrt](#) to create a vrt for a collection of raster tiles

map.pal

color palettes for mapping

Description

Get a color palette for mapping. These palettes were copied from [GRASS](#)

Usage

map.pal(name, n=50, ...)

Arguments

name	character (name of a palette, see Details), or missing (to get the available names)
n	numeric. The number of colors
...	additional arguments that are passed to colorRamp

Details

Name	Description
aspect	aspect oriented grey colors
bcyr	blue through cyan through yellow to red
bgyr	blue through green through yellow to red
blues	white to blue
byg	blue through yellow to green
byr	blue through yellow to red
curvature	for terrain curvatures
differences	differences oriented colors
elevation	maps relative ranges of raster values to elevation color ramp
grass	GRASS GIS green (perceptually uniform)
greens	white to green
grey	grey scale
gyr	green through yellow to red
haxby	relative colors for bathymetry or topography
inferno	perceptually uniform sequential colors inferno
magma	perceptually uniform sequential colors
oranges	white to orange
plasma	perceptually uniform sequential colors

rainbow	rainbow colors
ramp	color ramp
random	random colors
reds	white to red
roygbiv	
rstcurv	terrain curvature
ryb	red through yellow to blue
ryg	red through yellow to green
sepia	yellowish-brown through to white
viridis	perceptually uniform sequential colors
water	water depth
wave	color wave

Value

none

See Also

[terrain.colors](#)

Examples

```
map.pal("elevation", 10)

r <- rast(system.file("ex/elev.tif", package="terra"))
plot(r, col=map.pal("elevation"))

map.pal()
```

map_extent

Get the coordinates of the extent of a map

Description

Helper function for creating custom map elements that are aligned with the axes of a map (base plot created with a `SpatRaster` and/or `SpatVector`). For example, you may need to know the coordinates for the upper-left corner of a map to add some information there.

Unlike the standard base plot, terra keeps the axis aligned with the data. For that reason you cannot use `par()$usr` to get these coordinates.

The coordinates returned by this function are used in, for example, [add_legend](#) such that a legend can be automatically placed in the a particular corner.

This function only returns meaningful results of the active plot (canvas) was create with a call to `plot` with a `SpatRaster` or `SpatVector` as first argument.

Usage

```
map_extent()
```

See Also

[add_legend](#), [add_grid](#), [add_box](#)

Examples

```
r <- rast(xmin=0, xmax=10, ymin=0, ymax=10, res=1, vals=1:100)
plot(r)

map_extent()
par()$usr
```

mask

Mask values in a SpatRaster or SpatVector

Description

If *x* is a SpatRaster: Create a new SpatRaster that has the same values as SpatRaster *x*, except for the cells that are NA (or other maskvalue) in another SpatRaster (the 'mask'), or the cells that are not covered by a SpatVector or SpatExtent. These cells become NA (or another updatevalue).

If *x* is a SpatVector or SpatExtent: Select geometries of *x* that intersect, or not intersect, with the geometries of *y*.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
mask(x, mask, inverse=FALSE, maskvalues=NA,
      updatevalue=NA, filename="", ...)

## S4 method for signature 'SpatRaster,SpatVector'
mask(x, mask, inverse=FALSE, updatevalue=NA,
      touches=TRUE, filename="", ...)

## S4 method for signature 'SpatRaster,SpatExtent'
mask(x, mask, inverse=FALSE, updatevalue=NA,
      touches=TRUE, filename="", ...)

## S4 method for signature 'SpatVector,SpatVector'
mask(x, mask, inverse=FALSE)

## S4 method for signature 'SpatVector,SpatExtent'
mask(x, mask, inverse=FALSE)
```

Arguments

x	SpatRaster or SpatVector
mask	SpatRaster or SpatVector
inverse	logical. If TRUE, areas on mask that are <code>_not_</code> the <code>maskvalue</code> are masked
maskvalues	numeric. The value(s) in mask that indicate which cells of x should be masked (change their value to <code>updatevalue</code> (default = NA))
updatevalue	numeric. The value that masked cells should become (if they are not NA)
touches	logical. If TRUE, all cells touched by lines or polygons will be masked, not just those on the line render path, or whose center point is within the polygon
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also[subst](#), [crop](#)**Examples**

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
msk <- ifel(r < 400, NA, 1)

m <- mask(r, msk)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)[1,]

mv1 <- mask(r, v)
mv2 <- crop(r, v, mask=TRUE)
```

`match`*Value matching for SpatRasters*

Description

`match` returns a SpatRaster with the position of the matched values. The cell values are the index of the table argument.

`%in%` returns a 0/1 (FALSE/TRUE) SpatRaster indicating if the cells values were matched or not.

Usage

```
match(x, table, nomatch = NA_integer_, incomparables = NULL)
```

```
x %in% table
```

Arguments

x	SpatRaster
table	vector of the values to be matched against
nomatch	the value to be returned in the case when no match is found. Note that it is coerced to integer
incomparables	a vector of values that cannot be matched. Any value in x matching a value in this vector is assigned the nomatch value. For historical reasons, FALSE is equivalent to NULL

Value

SpatRaster

See Also

[app](#), [match](#)

Examples

```
r <- rast(nrows=10, ncols=10)
values(r) <- 1:100
m <- match(r, c(5:10, 50:55))
n <- r %in% c(5:10, 50:55)
```

Math-methods

General mathematical methods

Description

Standard mathematical methods for computations with SpatRasters. Computations are local (applied on a cell by cell basis). If multiple SpatRasters are used, these must have the same extent and resolution. These have been implemented:

abs, sign, sqrt, ceiling, floor, trunc, cummax, cummin, cumprod, cumsum, log, log10, log2, log1p, acos, acosh, asin, asinh, atan, atanh, exp, expm1, cos, cosh, sin, sinh, tan, tanh, round, signif

Instead of directly calling these methods, you can also provide their name to the math method. This is useful if you want to provide an output filename.

The following methods have been implemented for SpatExtent: round, floor, ceiling

round has also been implemented for SpatVector, to round the coordinates of the geometries.

Usage

```
## S4 method for signature 'SpatRaster'
sqrt(x)

## S4 method for signature 'SpatRaster'
log(x, base=exp(1))

## S4 method for signature 'SpatRaster'
round(x, digits=0)

## S4 method for signature 'SpatRaster'
math(x, fun, digits=0, filename="", overwrite=FALSE, ...)

## S4 method for signature 'SpatVector'
round(x, digits=4)

## S4 method for signature 'SpatRaster'
cumsum(x)
```

Arguments

x	SpatRaster
base	a positive or complex number: the base with respect to which logarithms are computed
digits	Number of digits for rounding
fun	character. Math function name
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files as in writeRaster

Value

SpatRaster or SpatExtent

See Also

See [app](#) to use mathematical functions not implemented by the package, and [Arith-methods](#) for arithmetical operations. Use [roll](#) for rolling functions.

Examples

```
r1 <- rast(ncols=10, nrows=10)
v <- runif(ncell(r1))
v[10:20] <- NA
values(r1) <- v
r2 <- rast(r1)
values(r2) <- 1:ncell(r2) / ncell(r2)
r <- c(r1, r2)
```

```
s <- sqrt(r)
# same as
math(r, "sqrt")

round(s, 1)

cumsum(r)
```

mem

Memory available and needed

Description

`mem_info` prints the amount of RAM that is required and available to process a `SpatRaster`.

`free_RAM` returns the amount of RAM that is available

Usage

```
mem_info(x, n=1, print=TRUE)
```

```
free_RAM()
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>n</code>	positive integer. The number of copies of <code>x</code> that are needed
<code>print</code>	logical. print memory info?

Value

`free_RAM` returns the amount of available RAM in kilobytes

Examples

```
mem_info(rast())
```

```
free_RAM()
```

merge

*Merge SpatRasters, or merge a SpatVector with a data.frame***Description**

Merge multiple SpatRasters to create a new SpatRaster with a larger spatial extent. The SpatRasters should all have the same coordinate reference system. They should normally also have the same spatial origin and resolution, but automatic resampling can be done depending on the algorithm used (see argument `algo`). In areas where the SpatRasters overlap, the values of the SpatRaster that is first in the sequence of arguments (or in the SpatRasterCollection) will be retained (unless `first=FALSE`).

There is also a method for merging SpatVector with a data.frame; that is, to join the data.frame to the attribute table of the SpatVector.

See [classify](#) to merge a SpatRaster with a data.frame.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
merge(x, y, ..., first=TRUE, na.rm=TRUE, algo=1, resample=FALSE, method="",
      filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterCollection,missing'
merge(x, first=TRUE, na.rm=TRUE, algo=1, resample=FALSE, method="", filename="", ...)

## S4 method for signature 'SpatVector,data.frame'
merge(x, y, ...)
```

Arguments

<code>x</code>	SpatRaster, SpatRasterCollection, or SpatVector
<code>y</code>	missing if <code>x</code> is a SpatRasterCollection. SpatRaster if <code>x</code> is a SpatRaster. data.frame if <code>x</code> is a SpatVector
<code>...</code>	if <code>x</code> is a SpatRaster: additional objects of the same class as <code>x</code> . If <code>x</code> is a SpatRasterCollection: options for writing files as in writeRaster . If <code>x</code> is a SpatVector, the same arguments as in merge
<code>first</code>	logical. If TRUE, in areas where rasters overlap, the first value is used. Otherwise the last value is used
<code>na.rm</code>	logical. If TRUE missing values are ignored. This is only used for algo 1; the other two always ignore missing values
<code>algo</code>	integer. You can use 1, 2 or 3 to pick a merge algorithm. algo 1 is generally faster than algo 2, but it may have poorer file compression. Algo 3 creates a virtual raster (see vrt). This is very quick and can be a good approach if the merge raster is used as input to a next step in the analysis. It allows any amount of misalignment and resamples without giving a warning. Otherwise its speed is similar to that of algo 2

resample	logical. If TRUE input rasters are resampled if they do not align (same origin and resolution) with the first raster
method	character. The resampling method used (only if resample is TRUE and algo is 1 or 2). One of "nearest", "bilinear", "cubic", "cubicspline", "lanczos", "average", "mode" as in resample . If the value is "", "nearest" is used for categorical rasters and "bilinear" for other rasters
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster or SpatVector

See Also

Combining tiles with [vrt](#) may be more efficient than using merge.

See [mosaic](#) for averaging or blending the values of overlapping regions.

See [classify](#) to merge a SpatRaster and a data.frame and [union](#) to combine SpatExtent objects.

Examples

```
x <- rast(xmin=-110, xmax=-80, ymin=40, ymax=70, res=1, vals=1)
y <- rast(xmin=-85, xmax=-55, ymax=60, ymin=30, res=1, vals=2)
z <- rast(xmin=-60, xmax=-30, ymax=50, ymin=20, res=1, vals=3)

m1 <- merge(x, y, z)
m2 <- merge(z, y, x)
m3 <- merge(y, x, z)
# panel(c(m1, m2, m3))

# if you have many SpatRasters, it may be convenient
# to make a SpatRasterCollection
# s <- sprc(list(x, y, z))
s <- sprc(x, y, z)

sm1 <- merge(s, algo=1, first=FALSE)
sm2 <- merge(s, algo=2, first=FALSE)
#sm3 <- merge(s, algo=3, first=FALSE)

## SpatVector with data.frame
f <- system.file("ex/lux.shp", package="terra")
p <- vect(f)
dfr <- data.frame(District=p$NAME_1, Canton=p$NAME_2, Value=round(runif(length(p), 100, 1000)))
dfr <- dfr[1:5, ]
pm <- merge(p, dfr, all.x=TRUE, by.x=c('NAME_1', 'NAME_2'), by.y=c('District', 'Canton'))
pm
values(pm)
```

mergeTime	<i>merge SpatRasters by timelines to create a single timeseries</i>
-----------	---

Description

Combine SpatRasters with partly overlapping time-stamps to create a single time series. If there is no overlap between the SpatRasters there is no point in using this function (use `c` instead).

Also note that time gaps are not filled. You can use `fillTime` to do that.

Usage

```
## S4 method for signature 'SpatRasterDataset'  
mergeTime(x, fun=mean, filename="", ...)
```

Arguments

<code>x</code>	SpatRasterDataset
<code>fun</code>	A function that reduces a vector to a single number, such as mean or min
<code>filename</code>	character. Output filename
<code>...</code>	list with named options for writing files as in <code>writeRaster</code>

Value

SpatRaster

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))  
s1 <- c(r, r)  
time(s1) <- as.Date("2001-01-01") + 0:5  
s1 <- s1/10  
time(s1) <- as.Date("2001-01-07") + 0:5  
s2 <- s1*10  
time(s2) <- as.Date("2001-01-05") + 0:5  
x <- sds(s1, s1, s2)  
  
m <- mergeTime(x, mean)
```

meta	<i>meta</i>
------	-------------

Description

Get metadata associated with the sources or layers of a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'
meta(x, layers=FALSE)
```

Arguments

x	SpatRaster
layers	logical. Should the layer level metadata be returned?

Value

list

metags	<i>Set or get metadata</i>
--------	----------------------------

Description

You can set arbitrary metadata to (layers of) a SpatRaster using "name=value", or "domain:name=value" tags or a two (name, value) or three column (name, value, domain) matrix or data.frame.

Usage

```
## S4 replacement method for signature 'SpatRaster'
metags(x, layer=NULL, domain="")<-value

## S4 method for signature 'SpatRaster'
metags(x, layer=NULL, name=NULL)

## S4 replacement method for signature 'SpatRasterDataset'
metags(x, dataset=NULL)<-value

## S4 method for signature 'SpatRasterDataset'
metags(x, dataset=NULL, name=NULL)
```

Arguments

x	SpatRaster
layer	NULL, positive integer or character. If the value is NULL, the tags assigned or returned are for the SpatRaster. Otherwise for the layer number(s) or name(s)
domain	character. Only used if not specified by value. Use "" for the default domain. Depending on the file format used this may be the only domain supported when writing files
name	character
value	character of "name=value" or two-column (name, value) or three-column (name, value, domain) matrix or data.frame
dataset	NULL, positive integer or character. If the value is NULL, the tags assigned or returned are for the SpatRasterDataset/SpatRasterCollection. Otherwise for the dataset number(s) or name(s)

Value

SpatRaster (metags<-), or data.frame

Examples

```
r <- rast(ncol=5, nrow=5)
m <- cbind(c("one", "two", "three"), c("ABC", "123", "hello"))
metags(r) <- m
metags(r)

metags(r) <- c("another_tag=another_value", "one more=this value")
metags(r)

metags(r) <- cbind("test", "this", "mydomain")
metags(r)

metags(r, name="two")

# remove a tag
metags(r) <- cbind("one", "")
metags(r) <- "two="
metags(r)

# remove all tags
metags(r) <- NULL
metags(r)
```

Description

Compute the mode for each cell across the layers of a `SpatRaster`. The mode, or modal value, is the most frequent value in a set of values.

Usage

```
## S4 method for signature 'SpatRaster'
modal(x, ..., ties="first", na.rm=FALSE, filename="", overwrite=FALSE, wopt=list())
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>...</code>	additional argument of the same type as <code>x</code> or numeric
<code>ties</code>	character. Indicates how to treat ties. Either "random", "lowest", "highest", "first", or "NA"
<code>na.rm</code>	logical. If TRUE, NA values are ignored. If FALSE, NA is returned if <code>x</code> has any NA values
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, <code>filename</code> is overwritten
<code>wopt</code>	list with named options for writing files as in <code>writeRaster</code>

Value

`SpatRaster`

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
r <- c(r/2, r, r*2)
m <- modal(r)
```

mosaic

mosaic SpatRasters

Description

Combine adjacent and (partly) overlapping `SpatRasters` to form a single new `SpatRaster`. Values in overlapping cells are averaged (by default) or can be computed with another function.

With the "blend" function, smooth gradients in overlapping zones are created by weighting each raster's contribution by the distance from the cell to the raster's nearest edge.

The `SpatRasters` must have the same origin and spatial resolution.

If rasters do not overlap, or if their values do not need to be computed, you can use `merge` instead.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
mosaic(x, y, ..., fun="mean", resample=FALSE, method="",
       filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterCollection,missing'
mosaic(x, fun="mean", resample=FALSE, method="", filename="", ...)
```

Arguments

x	SpatRaster or SpatRasterCollection
y	SpatRaster if x is a SpatRaster, otherwise missing
...	additional SpatRasters
fun	character. One of "blend", "mean", "median", "min", "max", "modal", "sum", "first", "last"
resample	logical. If TRUE input rasters are resampled if they do not align (same origin and resolution) with the first raster
method	character. The resampling method used. One of "nearest", "bilinear", "cubic", "cubicspline", "lanczos", "average", "mode" as in resample . If NULL, "nearest" is used for categorical rasters and "bilinear" for other rasters
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[merge](#)

Examples

```
x <- rast(xmin=-110, xmax=-60, ymin=40, ymax=70, res=1, vals=1)
y <- rast(xmin=-95, xmax=-45, ymax=60, ymin=30, res=1, vals=2)
z <- rast(xmin=-80, xmax=-30, ymax=50, ymin=20, res=1, vals=3)

m1 <- mosaic(x, y, z)

m2 <- mosaic(z, y, x)

# with a SpatRasterCollection
spc <- sprc(list(x, y, z))

m <- mosaic(spc)

b <- mosaic(spc, fun="blend")
```

na.omit	<i>Find and remove geometries that are NA</i>
---------	---

Description

Find geometries that are NA; or remove geometries and/or records that are NA.

Usage

```
## S4 method for signature 'SpatVector'
is.na(x)

## S4 method for signature 'SpatVector'
na.omit(object, field=NA, geom=FALSE)
```

Arguments

x	SpatVector
object	SpatVector
field	character or NA. If NA, missing values in the attributes are ignored. Other values are either one or more field (variable) names, or "" to consider all fields
geom	logical. If TRUE empty geometries are removed

Value

SpatVector

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$test <- c(1,2,NA)
nrow(v)
x <- na.omit(v, "test")
nrow(x)
```

NAflag	<i>Set the NA flag</i>
--------	------------------------

Description

The main purpose of this method is to allow correct reading of a SpatRaster that is based on a file that has an incorrect or missing NA flag. The file is not changed, but the flagged value is set to NA when values are read from the file. In contrast, if the cell values are in memory the change is made immediately.

To change cell values, you can use [classify](#)

Usage

```
## S4 method for signature 'SpatRaster'
NAflag(x)

## S4 replacement method for signature 'SpatRaster'
NAflag(x)<-value
```

Arguments

x	SpatRaster
value	numeric. The value to be interpreted as NA; set this before reading the values from the file. This can be a single value, or multiple values, one for each data source (file / subdataset)

Value

none or numeric

See Also

[classify](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))[[1]]
NAflag(s) <- 255
plot(s)
NAflag(s)
```

names	<i>Names of Spat* objects</i>
-------	-------------------------------

Description

Get or set the names of the layers of a SpatRaster or the attributes of a SpatVector.

See [set.names](#) for in-place setting of names.

Usage

```
## S4 method for signature 'SpatRaster'
names(x)

## S4 replacement method for signature 'SpatRaster'
names(x)<-value

## S4 method for signature 'SpatRasterDataset'
names(x)
```

```
## S4 replacement method for signature 'SpatRasterDataset'
names(x) <- value

## S4 method for signature 'SpatVector'
names(x)

## S4 replacement method for signature 'SpatVector'
names(x) <- value
```

Arguments

x	SpatRaster, SpatRasterDataset, or SpatVector
value	character (vector)

Value

character

Note

terra enforces neither unique nor valid names. See [make.unique](#) to create unique names and [make.names](#) to make syntactically valid names.

Examples

```
s <- rast(ncols=5, nrows=5, nlyrs=3)
nlyr(s)
names(s)
names(s) <- c("a", "b", "c")
names(s)

# SpatVector names
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
names(v)
names(v) <- paste0(substr(names(v), 1, 2), "_", 1:ncol(v))
names(v)
```

nearest

nearby geometries

Description

Identify geometries that are near to each other. Either get the index of all geometries within a certain distance, or the k nearest neighbors, or (with nearest) get the nearest points between two geometries.

Usage

```
## S4 method for signature 'SpatVector'  
nearby(x, y=NULL, distance=0, k=1, centroids=TRUE, symmetrical=TRUE, method="geo")  
  
## S4 method for signature 'SpatVector'  
nearest(x, y, pairs=FALSE, centroids=TRUE, lines=FALSE, method="geo")
```

Arguments

x	SpatVector
y	SpatVector or NULL
distance	numeric. maximum distance
k	positive integer. number of neighbors. Ignored if distance > 0
centroids	logical. Should the centroids of polygons be used?
symmetrical	logical. If TRUE, a near pair is only included once. That is, if geometry 1 is near to geometry 3, the implied nearness between 3 and 1 is not reported. Ignored if k neighbors are returned
method	character. One of "geo", "haversine", "cosine". With "geo" the most precise but slower method of Karney (2003) is used. The other two methods are faster but less precise
pairs	logical. If TRUE pairwise nearest points are returned (only relevant when using at least one SpatVector of lines or polygons)
lines	logical. If TRUE lines between the nearest points instead of (the nearest) points

Value

matrix

See Also

[distance](#), [relate](#), [adjacent](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")  
v <- vect(f)  
nearby(v, distance=12000)
```

NIDP

Number of immediate adjacent cells flowing into each cell

Description

Compute the number of immediate adjacent cells flowing into each cell

Usage

```
## S4 method for signature 'SpatRaster'  
NIDP(x, filename="",...)
```

Arguments

x	SpatRaster with flow-direction. see terrain
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Details

NDIP is computed first to compute flow-accumulation with the algorithm by Zhou et al, 2019.

Value

SpatRaster

Author(s)

Emanuele Cordano

References

Zhou, G., Wei, H. & Fu, S. A fast and simple algorithm for calculating flow accumulation matrices from raster digital elevation. *Front. Earth Sci.* 13, 317–326 (2019). <https://doi.org/10.1007/s11707-018-0725-9> <https://link.springer.com/article/10.1007/s11707-018-0725-9>

See Also

[flowAccumulation](#)

Examples

```
elev1 <- array(NA,c(9,9))  
elev2 <- elev1  
dx <- 1  
dy <- 1  
for (r in 1:nrow(elev1)) {  
  y <- (r-5)*dx
```

```

    for (c in 1:ncol(elev1)) {
      x <- (c-5)*dy
      elev1[r,c] <- 5*(x^2+y^2)
      elev2[r,c] <- 10+5*(abs(x))-0.001*y ### 5*(x^2+y^2)
    }
  }

## Elevation Raster
elev1 <- rast(elev1)
elev2 <- rast(elev2)

t(array(elev1[],rev(dim(elev1)[1:2])))
t(array(elev2[],rev(dim(elev2)[1:2])))

plot(elev1)
plot(elev2)

## Flow Direction Raster
flowdir1<- terrain(elev1,v="flowdir")
flowdir2<- terrain(elev2,v="flowdir")

t(array(flowdir1[],rev(dim(flowdir1)[1:2])))
t(array(flowdir2[],rev(dim(flowdir2)[1:2])))

plot(flowdir1)
plot(flowdir2)

##
nidp1 <- NIDP((flowdir1))
nidp2 <- NIDP((flowdir2))

t(array(nidp1[],rev(dim(nidp1)[1:2])))
t(array(nidp2[],rev(dim(nidp2)[1:2])))

plot(nidp1)
plot(nidp2)

```

normalize.longitude *normalize vector data that crosses the dateline*

Description

Normalize the longitude of geometries, move them if they are outside of the -180 to 180 degrees range.

Usage

```
## S4 method for signature 'SpatVector'
normalize.longitude(x)
```

Arguments

x SpatVector

Value

SpatVector

See Also

[rotate](#) for SpatRaster

Examples

```
p <- vect("POLYGON ((120 10, 230 75, 230 -75, 120 10))")
normalize.longitude(p)
```

north

North arrow

Description

Add a (North) arrow to a map

Usage

```
north(xy=NULL, type=1, label="N", angle=0, d, head=0.1, xpd=TRUE, ...)
```

Arguments

xy	numeric. x and y coordinates to place the arrow. It can also be one of following character values: "bottomleft", "bottom", "bottomright", "topleft", "top", "topright", "left", "right", or NULL
type	integer between 1 and 12, or a character (unicode) representation of a right pointing arrow such as "\u27A9". You may need to install the fonts for this. See the discussion on stackoverflow
label	character, to be printed near the arrow
angle	numeric. The angle of the arrow in degrees
d	numeric. Distance covered by the arrow in plot coordinates. Only applies to type=1
head	numeric. The size of the arrow "head", for type=1
xpd	logical. If TRUE, the arrow can be outside the plot area
...	graphical arguments to be passed to other methods

Value

none

See Also

[sbar](#), [plot](#), [inset](#)

Examples

```
f <- system.file("ex/meuse.tif", package="terra")
r <- rast(f)
plot(r)
north()
north(c(178550, 332500), d=250)

## Not run:
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
plot(r, type="interval")
north(type=3, cex=.8)
north(xy=c(6.7, 49.9), type=2, angle=45, label="NE")
north(xy=c(6.6, 49.7), type=5, cex=1.25)
north(xy=c(5.65, 49.6), type=9)
north(d=.05, xy=c(5.65, 50), angle=180, label="S", lwd=2, col="blue")

## all arrows
r <- rast(res=10)
values(r) <- 1
plot(r, col="white", axes=FALSE, legend=FALSE, mar=c(0,0,0,0), reset=TRUE)
for (i in 1:12) {
  x = -200+i*30
  north(xy=cbind(x,30), type=i)
  text(x, -20, i, xpd=TRUE)
}

## End(Not run)
```

not.na

is not NA

Description

Shortcut method to avoid the two-step `!is.na(x)`

Usage

```
## S4 method for signature 'SpatRaster'
not.na(x, falseNA=FALSE, filename="", ...)
```

Arguments

x	SpatRaster
falseNA	logical. If TRUE, the output cell values are either TRUE, for cells that are not NA in x, or NA for the cells that are NA in x. Otherwise, the output values are either TRUE or FALSE
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[Compare-methods](#)

Examples

```
r <- rast(ncols=5, nrows=5, vals=1, ext=c(0,1,0,1))
r[10:20] <- NA
x <- not.na(r)
y <- not.na(r, falseNA=TRUE)
unique(values(c(x, y)))
```

nseg

Number of segments

Description

Count the number of segments in a SpatVector of lines or polygons

Usage

```
## S4 method for signature 'SpatVector'
nseg(x)
```

Arguments

x	SpatVector
---	------------

Value

numeric

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
nseg(v)
```

options	<i>Options</i>
---------	----------------

Description

Get or set general options.

Usage

```
terraOptions(..., print=TRUE)
```

Arguments

...	option names and values (see Details). Or missing, to get or show the current options
print	logical. If TRUE the option names and values are printed

Details

The following options are available.

memfrac - value between 0 and 0.9 (larger values give a warning). The fraction of RAM that may be used by the program.

memmin - if memory required is below this threshold (in GB), the memory is assumed to be available. Otherwise, terra checks if it is available.

memmax - the maximum amount of RAM (in GB) that terra is allowed to use when processing a raster dataset. Should be less than what is detected (see [mem_info](#)), and higher values are ignored. Set it to a negative number or NA to not set this option. `terraOptions` only shows the value of `memmax` if it is set.

tempdir - directory where temporary files are written. The default what is returned by `tempdir()`.

datatype - default data type. See [writeRaster](#).

todisk - logical. If TRUE write all raster data to disk (temp file if no file name is specified). For debugging.

progress - non-negative integer. A progress bar is shown if the number of chunks in which the data is processed is larger than this number. No progress bar is shown if the value is zero.

verbose - logical. If TRUE debugging info is printed for some functions.

tolerance - numeric. Difference in raster extent (expressed as the fraction of the raster resolution) that can be ignored when comparing alignment of rasters.

parallel - logical. The master switch for terra's internal parallelism. When TRUE (the default in version $\geq 1.9-21$), the C++ kernels that have been parallelized with Intel TBB (parts of `arith`, distance calculations on `SpatVector`, the fast focal path, etc.) will use multiple threads. When FALSE, all such kernels run on a single thread. Use `terra:::have_TBB()` to check whether TBB support was compiled in; without TBB, this option has no effect. The same option can be set per call as a write option, e.g. `focal(r, w=21, fun="mean", wopt=list(parallel=TRUE))`.

threads - non-negative integer. Cap on the number of threads used by parallel kernels (when `parallel=TRUE`) and by GDAL warp (in `project`, `resample`, `warp`). 0 (the default) means "no cap": TBB picks a sensible default (usually all logical CPUs) and GDAL uses `NUM_THREADS=ALL_CPUS`. A positive value caps both at that count, which is useful to leave room for other processes or to keep forked workers from each spawning hundreds of children. The value is honoured by every TBB-parallel kernel in terra through a single `tbb : task_arena`, and is forwarded to GDAL warp's `NUM_THREADS` option.

Value

list. Invisibly if `print=TRUE`

Note

It is possible to set your own default options in "etc/Rprofile.site" of your R installation like this

```
options(terra_default=list(tempdir="d:/temp", memfrac=.4))
```

But that may not be a good practice. It is clearer to set your favorite options at the beginning of each script.

Examples

```
terraOptions()
terraOptions(memfrac=0.5, tempdir = "c:/temp")
terraOptions(progress=10)
terraOptions(parallel=TRUE, threads=4) # use TBB, capped at 4 threads
terraOptions()
```

origin

Origin

Description

Get or set the coordinates of the point of origin of a `SpatRaster`. This is the point closest to (0, 0) that you could get if you moved towards that point in steps of the x and y resolution.

Usage

```
## S4 method for signature 'SpatRaster'
origin(x)

## S4 replacement method for signature 'SpatRaster'
origin(x)<-value
```

Arguments

x	<code>SpatRaster</code>
value	numeric vector of length 1 or 2

Value

A vector of two numbers (x and y coordinates)

Examples

```
r <- rast(xmin=-0.5, xmax = 9.5, ncols=10)
origin(r)
origin(r) <- c(0,0)
r
```

pairs	<i>Pairs plot (matrix of scatterplots)</i>
-------	--

Description

Pair plots of layers in a `SpatRaster`. This is a wrapper around graphics function `pairs`.

Usage

```
## S4 method for signature 'SpatRaster'
pairs(x, hist=TRUE, cor=TRUE, use="pairwise.complete.obs", maxcells=100000, ...)
```

Arguments

x	SpatRaster
hist	logical. If TRUE a histogram of the values is shown on the diagonal
cor	logical. If TRUE the correlation coefficient is shown in the upper panels
use	argument passed to the <code>cor</code> function
maxcells	integer. Number of pixels to sample from each layer of a large <code>SpatRaster</code>
...	additional arguments (graphical parameters)

See Also

[boxplot](#), [hist](#)

Examples

```
r <-rast(system.file("ex/elev.tif", package="terra"))
s <- c(r, 1/r, sqrt(r))
names(s) <- c("elevation", "inverse", "sqrt")
pairs(s)

# to make individual histograms:
hist(r)
# or scatter plots:
plot(s[[1]], s[[2]])
```

panel	<i>Map panel</i>
-------	------------------

Description

Show multiple maps that share a single legend.

Usage

```
## S4 method for signature 'SpatRaster'
panel(x, main, loc.main="topleft", nc, nr, maxnl=16,
maxcell=500000, box=FALSE, pax=list(), plg=list(), range=NULL, halo=TRUE,
type=NULL, ...)
```

Arguments

x	SpatRaster
main	character. Main plot titles (one for each layer to be plotted). You can use arguments <code>cex.main</code> , <code>font.main</code> , <code>col.main</code> to change the appearance
loc.main	numeric of character to set the location of the main title. Either two coordinates, or a character value such as "topleft")
nc	positive integer. Optional. The number of columns to divide the plotting device in (when plotting multiple layers)
nr	positive integer. Optional. The number of rows to divide the plotting device in (when plotting multiple layers)
maxnl	positive integer. Maximum number of layers to plot (for a multi-layer object)
maxcell	positive integer. Maximum number of cells to use for the plot
box	logical. Should a box be drawn around the map?
plg	see plot
pax	see plot
range	numeric. minimum and maximum values to be used for the continuous legend
halo	logical. Use a halo around main (the title)?
type	character. Type of map/legend. One of "continuous", "classes", or "interval". If not specified, the type is chosen based on the data
...	arguments passed to <code>plot("SpatRaster", "numeric")</code> and additional graphical arguments

See Also

[plot](#) and see `rasterVis::levelplot` and `tidyterra::autoplot` for more sophisticated panel plots.

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
v <- vect(system.file("ex/lux.shp", package="terra"))
x <- c(r, r/2, r*2, r)
names(x) <- paste0("(", LETTERS[1:4], ")")
panel(x)
panel(x, fun=function() lines(v), loc.main="topright")
```

patches *Detect patches (clumps) of cells*

Description

Detect patches (clumps). Patches are groups of cells that are surrounded by cells that are NA. Set zeroAsNA to TRUE to also identify patches separated by cells with values of zero.

Usage

```
## S4 method for signature 'SpatRaster'
patches(x, directions=4, values=FALSE, zeroAsNA=FALSE, allowGaps=TRUE, filename="", ...)
```

Arguments

x	SpatRaster
directions	integer indicating which cells are considered adjacent. Should be 8 (Queen's case) or 4 (Rook's case)
values	logical. If TRUE use cell values to distinguish patches. If FALSE, all cells that are not NA are considered identical
zeroAsNA	logical. If TRUE treat cells that are zero as if they were NA. Ignored if values=TRUE
allowGaps	logical. If TRUE there may be gaps in the patch IDs (e.g. you may have patch IDs 1, 2, 3 and 5, but not 4). If it is FALSE, these numbers will be recoded from 1 to the number of patches (4 in this example)
filename	character. Output filename
...	options for writing files as in writeRaster

Value

SpatRaster. Cell values are patch numbers

Author(s)

Andrew Gene Brown, Robert J. Hijmans

See Also

[focal](#), [boundaries](#)

Examples

```

r <- rast(nrows=18, ncols=36, xmin=0)
r[1:2, 5:8] <- 1
r[5:8, 2:6] <- 1
r[7:12, 22:36] <- 1
r[15:16, 18:29] <- 1
p <- patches(r)

# zero as background instead of NA
r <- rast(nrows=10, ncols=10, xmin=0, vals=0)
r[3, 3] <- 10
r[4, 4] <- 10
r[5, 5:8] <- 12
r[6, 6:9] <- 12

# treat zeros as NA

p4 <- patches(r, zeroAsNA=TRUE)
p8 <- patches(r, 8, zeroAsNA=TRUE)

### patches for different values
p <- patches(r, values=TRUE)

### patch ID values are not guaranteed to be consecutive
r <- rast(nrows=5, ncols=10, xmin=0)
set.seed(0)
values(r) <- round(runif(ncell(r))*0.7)
rp <- patches(r, directions=8, zeroAsNA=TRUE)
plot(rp, type="classes"); text(rp)

## unless you set allowGaps=FALSE
rp <- patches(r, directions=8, zeroAsNA=TRUE, allowGaps=FALSE)
plot(rp, type="classes"); text(rp)

### use zonal to remove small patches
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- classify(r, cbind(-Inf, 400, NA))
y <- patches(x)
# remove patches smaller than 100 ha
rz <- zonal(cellSize(y, unit="ha"), y, sum, as.raster=TRUE)
s <- ifel(rz < 250, NA, y)

```

perim

*Perimeter or length***Description**

This method returns the length of lines or the perimeter of polygons.

When the coordinate reference system is not longitude/latitude, you may get more accurate results by first transforming the data to longitude/latitude with [project](#)

Usage

```
## S4 method for signature 'SpatVector'
perim(x)
```

Arguments

x SpatVector

Value

numeric (m)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
perim(v)
```

persp

Perspective plot

Description

Perspective plot of a SpatRaster. This is an implementation of a generic function in the graphics package.

Usage

```
## S4 method for signature 'SpatRaster'
persp(x, maxcells=100000, ...)
```

Arguments

x SpatRaster. Only the first layer is used
maxcells integer > 0. Maximum number of cells to use for the plot. If maxpixels < ncell(x), spatSample(method="regular") is used before plotting
... Any argument that can be passed to [persp](#) (graphics package)

See Also

[persp](#), [contour](#), [plot](#)

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
persp(r)
```

pitfinder

Pit Finder in a Flow Dir SpatRaster for Watershed Extraction

Description

find pits (depressions with no outlet)

Usage

```
## S4 method for signature 'SpatRaster'  
pitfinder(x,filename="",...)
```

Arguments

x SpatRaster with flow-direction. See [terrain](#)
filename character. Output filename
... additional arguments for writing files as in [writeRaster](#)

Value

A [SpatRaster-class](#) (raster) map containing value 1 for the pits and value 0 elsewhere.

Author(s)

Emanuele Cordano

See Also

[terrain](#),[watershed](#),[flowAccumulation](#),[NIDP](#)

Examples

```
## Creation of a Digital Elevation Model  
  
elev <- array(NA,c(9,9))  
dx <- 1  
dy <- 1  
for (r in 1:nrow(elev)) {  
  x <- (r-5)*dx  
  for (c in 1:ncol(elev)) {  
  
    y <- (c-5)*dy  
    elev[r,c] <- 10+5*(x^2+y^2)  
  }  
}  
  
elev <- cbind(elev,elev,elev,elev)  
elev <- rbind(elev,elev,elev,elev)  
elev <- rast(elev)
```

```
## Flow Directions

flowdir<- terrain(elev,v="flowdir")
t(array(flowdir[],rev(dim(flowdir)[1:2])))

## Pit Detect

pits <- pitfinder(flowdir)

## Application with example DEM

elev <- rast(system.file('ex/elev.tif',package="terra"))
flowdir <- terrain(elev,"flowdir")

pits <- pitfinder(flowdir)
```

plet

Plot with leaflet

Description

Plot a `SpatRaster(Collection)` or `SpatVector(s)` to make an interactive leaflet map that is displayed in your browser.

The arguments of `plet` are similar to those of `plot`, making it easier to use leaflet (if you also use `plot`).

Usage

```
## S4 method for signature 'SpatRaster'
plet(x, y=1, col, alpha=0.8, main=names(x),
     tiles=c("Streets", "Esri.WorldImagery", "OpenTopoMap"),
     wrap=TRUE, maxcell=500000, stretch=NULL, legend="bottomright",
     shared=FALSE, panel=FALSE, collapse=TRUE, type=NULL, breaks=NULL,
     breakby="eqint", range=NULL, fill_range=FALSE, hover=FALSE, map=NULL, ...)
```

```
## S4 method for signature 'SpatRasterCollection'
plet(x, col, alpha=0.8, main=names(x),
     tiles=c("Streets", "Esri.WorldImagery", "OpenTopoMap"),
     wrap=TRUE, maxcell=500000, stretch=NULL, legend="bottomright", type=NULL,
     breaks=NULL, breakby="eqint", range=NULL, fill_range=FALSE, map=NULL, ...)
```

```
## S4 method for signature 'SpatVector'
plet(x, y="", col, main=y, cex=1,
     lwd=2, lty=NULL, border="black", alpha=c(0.3, 1), popup=TRUE, label=FALSE,
     split=FALSE, tiles=c("Streets", "Esri.WorldImagery", "OpenTopoMap"),
     wrap=TRUE, legend="bottomright", collapse=FALSE, type=NULL, breaks=NULL,
     breakby="eqint", sort=TRUE, reverse=FALSE, map=NULL, fill=NULL, ...)
```

```
## S4 method for signature 'SpatVectorCollection'
plet(x, y="", col, main=y, cex=1,
     lwd=2, lty=NULL, border="black", alpha=c(0.3, 1), popup=TRUE, label=FALSE,
     tiles=c("Streets", "Esri.WorldImagery", "OpenTopoMap"),
     wrap=TRUE, legend="bottomright", collapse=FALSE, type=NULL, breaks=NULL,
     breakby="eqint", sort=TRUE, reverse=FALSE, map=NULL, fill=NULL, ...)
```

```
## S4 method for signature 'leaflet'
lines(x, y, col, lwd=2, lty=NULL, alpha=1,
      label=NULL, popup=FALSE, ...)
```

```
## S4 method for signature 'leaflet'
points(x, y, col, border=col, cex=1, lwd=2, lty=NULL,
       alpha=c(.3, 1), label=1:nrow(y), popup=FALSE, ...)
```

```
## S4 method for signature 'leaflet'
polys(x, y, col, lwd=2, lty=NULL,
      border="black", alpha=c(0.3, 1), popup=TRUE, label=NULL, fill=NULL, ...)
```

Arguments

x	SpatRaster, SpatVector, or leaflet object
y	missing, or positive integer, or character (variable or layer name) indicating the layer(s) to be plotted. If x is a SpatRaster, you can select multiple layers
col	character. Vector of colors or a color generating function. If x is a SpatVectorCollection, you can provide a list with colors and/or functions, with one list element for each SpatVector
alpha	one or two numbers between 0 and 1 to set the transparency for lines (0 is transparent, 1 is opaque). The first number is to fill the points/lines/polygons, the second for the outline
tiles	character or NULL. Names of background tile providers
wrap	logical. if TRUE, tiles wrap around
maxcell	positive integer. Maximum number of cells to use for the plot
stretch	NULL or character ("lin" or "hist") to stretch RGB rasters. See plotRGB
legend	character to indicate the legend position ("bottomleft", "bottomright", "topleft" or "topright") or NULL to suppress the legend

main	character. Title for the legend. The length should be 1 if x is a SpatVector and length nlyr(x) if x is a SpatRaster
shared	logical. Should the legend be the same for all rasters (if multiple layers of SpatRaster x are mapped)
map	leaflet object
...	additional arguments for drawing points, lines, or polygons passed on the relevant leaflet function
border	character. Color for the polygon borders
collapse	logical. Should the layers "control" panel be collapsed?
split	logical. If TRUE a check-box is created to toggle each value in y (If x is a SpatVector)
cex	numeric. point size magnifier. See par
lwd	numeric. line-width. See par
lty	character to specify a "dash-array". For example "3 5" indicates three pixels lines with five pixel gaps
popup	logical. Should pop-ups be created?
label	logical. Should mouse-over labels be added?
panel	logical. Should SpatRaster layers be shown as a panel"
type	character. Type of map/legend. One of "classes", or "interval". If not specified, the type is chosen based on the data. Use "" to suppress the legend
breaks	numeric. Either a single number to indicate the number of breaks desired, or the actual breaks. When providing this argument, the default legend becomes "interval"
breakby	character or function. Either "eqint" for equal interval breaks, "cases" for equal quantile breaks. If a function is supplied it should take a single argument (a vector of values) and create groups
sort	logical. If TRUE legends with character values are sorted. You can also supply a vector of the unique values, in the order in which you want them to appear in the legend
range	numeric. minimum and maximum values to be used for the continuous legend. You can use NA for one of these to only set the minimum or maximum value
fill_range	logical. If TRUE, values outside of range get the colors of the extreme values; otherwise they get colored as NA
hover	logical. If TRUE, the approximate raster cell values are shown when hovering the mouse over the map. Not available for RGB rasters or panel mode
reverse	logical. If TRUE, the legends order is reversed
fill	do not use. Will be removed

See Also[plot](#)

Examples

```

## Not run:
if (require(leaflet) && (packageVersion("leaflet") > "2.1.1")) {

v <- vect(system.file("ex/lux.shp", package="terra"))
p <- spatSample(as.polygons(v, ext=T), 30)
values(p) = data.frame(id=11:40, name=sample(letters, 30, replace=TRUE))

m <- plet(v, "NAME_1", tiles="", border="blue")
m <- points(m, p, col="red", cex=2, popup=T)
lines(m, v, lwd=1, col="white")

plet(v, "NAME_1", split=TRUE, alpha=.2) |>
  points(p, col="white", border="red", cex=12, popup=TRUE, lwd=3, lty="1 4",
    clusterOptions = leaflet::markerClusterOptions())

s <- svc(v, p)
names(s) <- c("the polys", "set of points")
plet(s, col=c("red", "blue"), lwd=1)

r <- rast(system.file("ex/elev.tif", package="terra"))
plet(r, main="Hi\there", tiles=NULL) |> lines(v, lwd=1)

# hover to see raster values
plet(r, hover=TRUE)

plet(r, tiles="OpenTopoMap") |> lines(v, lwd=2, col="blue")

x <- c(r, 50*classify(r, 5))
names(x) <- c("first", "second")

# each their own legend
plet(x, 1:2, collapse=FALSE) |> lines(v, lwd=2, col="blue", lty="5,5")

# shared legend
plet(x, 1:2, shared=TRUE, collapse=FALSE) |> lines(v, lwd=2, col="blue")

}
## End(Not run)

```

plot

Make a map

Description

Plot the values of a `SpatRaster` or `SpatVector` to make a map.

See [points](#), [lines](#) or [polys](#) to add a `SpatVector` to an existing map (or use argument `add=TRUE`).

There is a separate help file for plotting a [SpatGraticule](#) or [SpatExtent](#).

Usage

```
## S4 method for signature 'SpatRaster,numeric'
plot(x, y=1, col, type=NULL, mar=NULL, legend=TRUE, axes=!add, plg=list(), pax=list(),
     maxcell=500000, smooth=FALSE, range=NULL, fill_range=FALSE, levels=NULL,
     all_levels=FALSE, breaks=NULL, breakby="eqint", fun=NULL, colNA=NULL, alpha=NULL,
     sort=FALSE, reverse=FALSE, grid=FALSE, zebra=FALSE, ext=NULL, reset=FALSE,
     add=FALSE, buffer=FALSE, background=NULL, box=axes, clip=TRUE, overview=NULL, ...)

## S4 method for signature 'SpatRaster,missing'
plot(x, y, main, mar=NULL, nc, nr, maxnl=16, maxcell=500000, add=FALSE,
     plg=list(), pax=list(), ...)

## S4 method for signature 'SpatRaster,character'
plot(x, y, ...)

## S4 method for signature 'SpatVector,character'
plot(x, y, col=NULL, type=NULL, mar=NULL, legend=TRUE, axes=!add, plg=list(), pax=list(),
     main="", range=NULL, fill_range=FALSE, breaks=NULL, breakby="eqint", fun=NULL,
     colNA=NA, alpha=NULL, grid=FALSE, zebra=FALSE, ext=NULL, sort=TRUE, reverse=FALSE,
     nr, nc, add=FALSE, buffer=TRUE, background=NULL, box=axes, clip=TRUE, ...)

## S4 method for signature 'SpatVector,numeric'
plot(x, y, ...)

## S4 method for signature 'SpatVector,missing'
plot(x, y, values=NULL, ...)

## S4 method for signature 'SpatVectorCollection,missing'
plot(x, y, main, mar=NULL, nc, nr, maxnl=16, col=NULL, ...)

## S4 method for signature 'SpatVectorCollection,numeric'
plot(x, y, main, mar=NULL, ext=NULL, ...)
```

Arguments

x	SpatRaster or SpatVector
y	missing or positive integer or name indicating the layer(s) to be plotted
col	character vector to specify the colors to use. The default is <code>map.pal("viridis", 100)</code> . The default can be changed with the <code>terra.pal</code> option. For example: <code>options(terra.pal=terrain.colors(10))</code> . If x is a SpatRaster it can also be a data.frame with two columns (value, color) for a "classes" type legend or with three columns (from, to, color) for an "interval" type legend. If x is a SpatVector it can also be a data.frame with two columns (value, color) or a named vector (value=color) for a "classes" type legend. If x is a SpatVectorCollection, a list can be provided with colors for each SpatVector
type	character. Type of map/legend. One of "continuous", "classes", or "interval". If not specified, the type is chosen based on the data

mar	numeric vector of length 4 to set the margins of the plot (to make space for the legend). The default is (3.1, 3.1, 2.1, 7.1) for a single plot with a legend and (3.1, 3.1, 2.1, 2.1) otherwise. The default for a RGB raster is 0. Use mar=NA to not set the margins
legend	logical or character. If not FALSE a legend is drawn. The character value can be used to indicate where the legend is to be drawn. For example "topright" or "bottomleft". Use plg for more refined placement. Not supported for continuous legends (the default for raster data)
axes	logical. Draw axes?
buffer	logical. If TRUE the plotting area is made slightly larger than the extent of x
background	background color. Default is no color (white)
box	logical. Should a box be drawn around the map?
clip	logical. Should the axes be clipped to the extent of x?
overview	logical. Should "overviews" be used for fast rendering? This can result in much faster plotting of raster files that have overviews (e.g. "COG" format) and are accessed over a http connection. However, these overviews generally show aggregate values, thus reducing the range of the actual values. If NULL, the argument is set to TRUE for rasters that are accessed over http and FALSE in other cases
plg	<p>list with parameters for drawing the legend. See the arguments for legend.</p> <p>A legend can be placed by specifying arguments x and y. For a continuous legend y can have two values. x can also be a SpatExtent. Furthermore, x can be a keyword such "topleft" and "bottomright" to place the legend at these locations inside the map rectangle. For a continuous legend, only the placement keywords "left", "right", "top", "bottom", "topright", "bottomright" are recognized; and when using these keywords, the legend is placed outside of the map rectangle. The placement of the legend can be altered with argument nudge that moves the location in the directions specified with one value (x direction) or two values (x, y). For a continuous legend it can also have four values (xmin, xmax, ymin, ymax). When supplying coordinates, use horiz=TRUE to get a horizontal legend.</p> <p>Additional parameters for continuous legends include:</p> <ul style="list-style-type: none"> • <code>digits</code> integer. The number of digits to print after the decimal point • <code>size</code> to change the height and/or width; the defaults are <code>c(1, 1)</code> • <code>at</code> to set the location of the tickmarks • <code>format</code> as in formatC to format the numbers. For example, you can use <code>format="g"</code> for scientific notation. The default is <code>"f"</code> • <code>tick</code> One of these partially matched values: "through", "in", "middle", "out", or "none", to choose a tickmark placement/length that is different from the default "throughout". • <code>tick.length</code> to change the tickmark length (default = 1). Only relevant when tick is "throughout" or "out". • <code>tick.col</code>, <code>tick.box.col</code> and <code>tick.lwd</code> to change the appearance of the tickmarks • <code>title</code> add a legend title

	<ul style="list-style-type: none"> • <code>title.srt</code> to rotate the legend title • <code>title.x</code> and <code>title.y</code> to place the legend title at specific coordinates • <code>bg</code> background color behind the legend (e.g. "white") for visibility when drawn on top of a map
<code>pax</code>	list with parameters for drawing axes. See the arguments for <code>axis</code> . Additional parameters include: <ul style="list-style-type: none"> • <code>side</code> numeric to indicate for which of the axes to draw a line. Default is 1:4 (only noticeable when <code>box=FALSE</code>). • <code>tick</code> numeric to indicate for which of the axes to draw tickmarks. Default is 1:2 unless <code>side</code> is changed, in which case the default is the same as <code>side</code> • <code>lab</code> numeric to indicate for which of the axes to draw labels. Default is 1:2 unless <code>side</code> is changed, in which case the default is the same as <code>side</code> • <code>xat/yat</code> numeric with the values at which tickmarks are to be drawn on the horizontal/vertical axis. • <code>xlabs/ylabs</code> this can either be a logical value specifying whether (numerical) annotations are to be made at the tickmarks, or a character or expression vector of labels to be placed at the tickmarks of the horizontal/vertical axis. • <code>retro</code> a logical value that can be set to TRUE to use a sexagesimal notation for the labels (degrees/minutes/hemisphere) instead of the standard decimal notation. For longitude/latitude data only. See <code>graticule</code> for projected data.
<code>maxcell</code>	positive integer. Maximum number of cells to use for the plot
<code>smooth</code>	logical. If TRUE the cell values are smoothed (only if a continuous legend is used)
<code>range</code>	numeric. minimum and maximum values to be used for the continuous legend. You can use NA for one of these to only set the minimum or maximum value
<code>fill_range</code>	logical. If TRUE, values outside of range get the colors of the extreme values; otherwise they get colored as NA
<code>levels</code>	character. labels for the legend when <code>type="classes"</code>
<code>all_levels</code>	logical. If TRUE, the legend shows all levels of a categorical raster, even if they are not present in the data
<code>breaks</code>	numeric. Either a single number to indicate the number of breaks desired, or the actual breaks. When providing this argument, the default legend becomes "interval"
<code>breakby</code>	character or function. Either "eqint" for equal interval breaks, "cases" for equal quantile breaks. If a function is supplied, it should take a single argument (a vector of values) and create groups
<code>fun</code>	function to be called after plotting each <code>SpatRaster</code> layer to add something to each map (such as text, legend, lines). For example, with <code>SpatVector v</code> , you could do <code>fun=function() lines(v)</code> . The function may have one argument, representing the layer that is plotted (1 to the number of layers)
<code>colNA</code>	character. color for the NA values

alpha	Either a single numeric between 0 and 1 to set the transparency for all colors (0 is transparent, 1 is opaque) or a SpatRaster with values between 0 and 1 to set the transparency by cell. To set the transparency for a given color, set it to the colors directly
sort	logical. If TRUE legends with categorical values are sorted. If x is a SpatVector you can also supply a vector of the unique values, in the order in which you want them to appear in the legend
reverse	logical. If TRUE, the legend order is reversed
grid	logical. If TRUE grid lines are drawn. Their properties such as type and color can be set with the pax argument. The grid is drawn first such that it is covered by x. See add_grid to add grid lines on top of the map
zebra	logical. If TRUE a "zebra-box" is added to the axes (ignored when add=TRUE). The width of the zebra-box can be set with additional argument <code>zebra.cex</code> . The colors can be changed with additional argument <code>zebra.col</code>
nc	positive integer. Optional. The number of columns to divide the plotting device in (when plotting multiple layers)
nr	positive integer. Optional. The number of rows to divide the plotting device in (when plotting multiple layers)
main	character. Main plot titles (one for each layer to be plotted). You can use arguments <code>cex.main</code> , <code>font.main</code> , <code>col.main</code> to change the appearance; and <code>loc.main</code> to change the location of the main title (either two coordinates, or a character value such as "topleft"). You can also use <code>sub=""</code> for a subtitle. See title
maxnl	positive integer. Maximum number of layers to plot (for a multi-layer object).
add	logical. If TRUE add the object to the current plot
ext	SpatExtent or other object for which <code>ext</code> returns one. Can be use instead of <code>xlim</code> and <code>ylim</code> to set the extent of the plot
reset	logical. If TRUE the margins (see argument <code>mar</code>) are reset to what they were before calling <code>plot</code> ; doing so may affect the display of additional objects that are added to the map (e.g. with lines)
values	Either a vector with values to be used for plotting or a two-column data.frame, where the first column matches a variable in x and the second column has the values to be plotted
...	arguments passed to <code>plot("SpatRaster", "numeric")</code> and additional graphical arguments

See Also

[points](#), [lines](#), [polys](#), [image](#)

Add map elements: [text](#), [sbar](#), [north](#), [add_legend](#), [add_box](#)

plot a [SpatGraticule](#) or [SpatExtent](#),

multiple layers: [plotRGB](#), [panel](#)

other plot types: [scatterplot](#), [hist](#), [pairs](#), [density](#), [persp](#), [contour](#), [boxplot](#), [barplot](#)

Examples

```

## SpatRaster
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
plot(r)

plot(r, type="interval")

plot(r, plg=list(x=6.35, y = c(49.9, 50.1), title="Legend\nTitle", title.cex=0.9),
pax=list(side=1:4, retro=FALSE))
north(cbind(5.8, 50.1))

d <- classify(r, c(100,200,300,400,500,600))
plot(d)

plot(d, type="interval", breaks=1:5)
plot(d, type="interval", breaks=c(1,4,5), plg=list(legend=c("1-4", "4-5")))
plot(d, type="classes", xlim=c(5.6, 6.6),
plg=list(legend=c("Mr", "Xx", "As", "Zx", "Bb"), x="bottomleft"))

x <- trunc(r/200)
levels(x) <- data.frame(id=0:2, element=c("earth", "wind", "fire"))
plot(x, plg=list(x="topright"),mar=c(2,2,2,2))

oldpar <- par(no.readonly=TRUE)

# two plots with the same legend
dev.new(width=6, height=4, noRStudioGD = TRUE)
par(mfrow=c(1,2))
plot(r, range=c(50,600), mar=c(1,1,1,4))
plot(r/2, range=c(50,600), mar=c(1,1,1,4))

# as we only need one legend (also see the "panel" method):
par(mfrow=c(1,2))
plot(r, range=c(50,600), mar=c(2, 2, 2, 2), plg=list(size=0.9, cex=.8),
pax=list(side=1:2, cex.axis=.6), box=FALSE)
#text(182500, 335000, "Two maps, one plot", xpd=NA)
plot(r/2, range=c(50,600), mar=c(2, 2, 2, 2), legend=FALSE,
pax=list(side=c(1,4), cex.axis=.6), box=FALSE)

par(oldpar)

# multi-layer with RGB
s <- rast(system.file("ex/logo.tif", package="terra"))
s
plot(s)
# remove RGB
plot(s*1)
# or use layers
plot(s, 1)
plot(s, 1:3)

```

```

# fix legend by linking values and colors

x = rast(nrows = 2, ncols = 2, vals=1)
y = rast(nrows = 2, ncols = 2, vals=c(1,2,2,1))
cols = data.frame(id=1:2, col=c("red", "blue"))
plot(c(x,y), col=cols)

r = rast(nrows=10, ncols=10, vals=1:100)
dr = data.frame(from=c(5,33,66,150), to=c(33, 66, 95,200), col=rainbow(4))
plot(r, col=dr)

### SpatVector

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

plot(v)

plot(v, "NAME_2", col=rainbow(12), border=c("gray", "blue"), lwd=3, zebra=TRUE)

plot(v, 2, pax=list(side=1:2), plg=list(x=6.16, y=50.17, cex=.8), xlim=c(5.7, 6.7))

plot(v, 4, pax=list(side=1:2), plg=list(x=6.2, y=50.2, ncol=2), main="", box=FALSE)

plot(v, 1, plg=list(x=5.8, y=49.37, horiz=TRUE, cex=1.1), main="", mar=c(5,2,0.5,0.5))

plot(v, density=1:12, angle=seq(18, 360, 20), col=rainbow(12))

plot(v, "AREA", type="interval", breaks=3, mar=c(3.1, 3.1, 2.1, 3.1),
      plg=list(x="topright"), main="")

plot(v, "AREA", type="interval", breaks=c(0,200,250,350),
      mar=c(2,2,2,2), xlim=c(5.7, 6.75),
      plg=list(legend=c("<200", "200-250", ">250"), cex=1, bty="o",
              x=6.3, y=50.15, box.lwd=2, bg="light yellow", title="My legend"))

```

plotRGB

Red-Green-Blue plot of a multi-layered SpatRaster

Description

Make a Red-Green-Blue plot based on three layers in a SpatRaster. The layers (sometimes referred to as "bands" because they may represent different bandwidths in the electromagnetic spectrum) are combined such that they represent the red, green and blue channel. This function can be used to make "true" (or "false") color images from Landsat and other multi-spectral satellite images.

Note that the margins of the plot are set to zero (no axes or titles are visible) but can be set with the `mar` argument.

An alternative way to plot RGB images is to first use [colorize](#) to create a single layer SpatRaster with a color-table and then use [plot](#).

Usage

```
## S4 method for signature 'SpatRaster'
plotRGB(x, r=1, g=2, b=3, a=NULL, scale=NULL, mar=0,
stretch=NULL, smooth=TRUE, colNA="white", alpha=NULL, bgamma=NULL,
zlim=NULL, zcol=FALSE, axes=FALSE ,...)
```

Arguments

x	SpatRaster
r	integer between 1 and nlyr(x). Layer to use as the Red channel
g	integer between 1 and nlyr(x). Layer to use as the Green channel
b	integer between 1 and nlyr(x). Layer to use as the Blue channel
a	NULL or integer between 1 and nlyr(x). Layer to use as the alpha (transparency) channel. If not NULL, argument alpha is ignored
scale	integer. Maximum (possible) value in the three channels. Defaults to 255 or to the maximum value of x if that is known and larger than 255
mar	numeric vector recycled to length 4 to set the margins of the plot. Use mar=NULL or mar=NA to not set the margins
stretch	character. Option to stretch the values to increase contrast: "lin" (linear) or "hist" (histogram). The linear stretch uses stretch with arguments minq=0.02 and maxq=0.98
smooth	logical. If TRUE, smooth the image when drawing to get the appearance of a higher spatial resolution
colNA	color. The color used for cells that have NA values
alpha	transparency. Integer between 0 (transparent) and 255 (opaque)
bgalpha	Background transparency. Integer between 0 (transparent) and 255 (opaque)
zlim	numeric vector of length 2. Range of values to plot (optional). If this is set, and stretch="lin" is used, then the values are stretched within the range of zlim. This allows creating consistent coloring between SpatRasters with different cell-value ranges, even when stretching the colors for improved contrast
zcol	logical. If TRUE the values outside the range of zlim get the color of the extremes of the range. Otherwise, the values outside the zlim range get the color of NA values (see argument "colNA")
axes	logical. If TRUE axes are drawn (and arguments such as main="title" will be honored)
...	graphical parameters as in plot <SpatRaster-method>

See Also

[plot](#), [colorize](#), [RGB](#)

Examples

```
b <- rast(system.file("ex/logo.tif", package="terra"))
plotRGB(b)
plotRGB(b, mar=2)
plotRGB(b, 3, 2, 1)

b[1000:2000] <- NA
plotRGB(b, 3, 2, 1, stretch="hist")
```

plot_extent

Plot a SpatExtent

Description

Plot a SpatExtent. Use [lines](#) to add a SpatExtent to an existing map.

See [plot](#) for plotting other object types.

Usage

```
## S4 method for signature 'SpatExtent,missing'
plot(x, y, ...)
```

Arguments

x	SpatExtent
y	missing
...	additional graphical arguments for lines

See Also

[plot](#)

Examples

```
r <- rast()
plot(ext(r))
```

plot_graticule *Plot a graticule*

Description

Plot a SpatGraticule. You can create a SpatGraticule with [graticule](#).

Usage

```
## S4 method for signature 'SpatGraticule,missing'
plot(x, y, background=NULL, col="black", mar=NULL, labels=TRUE,
     retro=FALSE, lab.loc=c(1,1), lab.lon=NULL, lab.lat=NULL, lab.cex=0.65,
     lab.col="black", off.lat=0.25, off.lon=0.25, box=FALSE, box.col="black",
     tickmarks=FALSE, add=FALSE, ...)
```

Arguments

x	SpatRaster or SpatVector
y	missing or positive integer or name indicating the layer(s) to be plotted
background	background color. If NULL, no background is drawn
mar	numeric vector of length 4 to set the margins of the plot. To make space for the legend you may use something like c(3.1, 3.1, 2.1, 7.1). To fill the plotting canvas, you can use c(0, 0, 0, 0). Use NA to not set the margins
col	character. Color for the graticule lines
labels	logical. If TRUE, show graticule labels
retro	logical. If TRUE, show "retro" instead of decimal labels with the graticule
lab.loc	numeric. The first number indicates where the longitude graticule labels should be drawn (1=bottom, 2=top, NA=not drawn, any other number=top and bottom). The second number indicates where the latitude graticule labels should be drawn (1=left, 2=right, NA=not drawn, any other number=left and right)
lab.lon	positive integers between 1 and the number of labels, indicating which longitude graticule labels should be included
lab.lat	positive integers between 1 and the number of labels, indicating which latitude graticule labels should be included
lab.cex	double. size of the label font
lab.col	character. color of the labels
off.lon	numeric. longitude labels offset
off.lat	numeric. latitude labels offset
box	logical. If TRUE, the outer lines of the graticule are drawn on top with a solid line lty=1
box.col	character. color of the outer lines of the graticule if box=TRUE
tickmarks	logical. If TRUE, tickmarks are added
add	logical. Add the graticule to the current plot?
...	additional graphical arguments passed to lines

See Also

[graticule](#), [plot](#), [points](#), [lines](#), [polys](#), [image](#), [scatterplot](#), scale bar: [sbar](#), north arrow: [north](#)

Examples

```
g <- graticule(60, 30, crs="+proj=robin")

#plot(g, background="azure", col="red", lty=2, box=TRUE)
#plot(g, background="azure", col="light gray", lab.loc=c(1,2),
# lab.lon=c(2,4,6), lab.lat=3:5, lty=3, retro=TRUE)
```

prcomp

*SpatRaster PCA with prcomp***Description**

Compute principal components for SpatRaster layers. This method may be preferred to [princomp](#) for its greater numerical accuracy. However, it is slower and for very large rasters it can only be done with a sample. This may be good enough but see [princomp](#) if you want to use all values. Unlike [princomp](#), in this method the sample variances are used with $n-1$ as the denominator.

Usage

```
## S4 method for signature 'SpatRaster'
prcomp(x, retx=TRUE, center=TRUE, scale.=FALSE,
tol=NULL, rank.=NULL, maxcell=Inf)
```

Arguments

x	SpatRaster
retx	a logical value indicating whether the rotated variables should be returned
center	a logical value indicating whether the variables should be shifted to be zero centered. Alternately, a vector of length equal the number of columns of x can be supplied. The value is passed to scale
scale.	a logical value indicating whether the variables should be scaled to have unit variance before the analysis takes place. The default is FALSE for consistency with S, but in general scaling is advisable. Alternatively, a vector of length equal the number of columns of x can be supplied. The value is passed to scale
tol	a value indicating the magnitude below which components should be omitted. (Components are omitted if their standard deviations are less than or equal to tol times the standard deviation of the first component.) With the default null setting, no components are omitted (unless rank. is specified less than $\min(\dim(x))$). Other settings for tol could be $tol = 0$ or $tol = \sqrt{.Machine\$double.eps}$, which would omit essentially constant components

rank.	optionally, a number specifying the maximal rank, i.e., maximal number of principal components to be used. Can be set as alternative or in addition to tol, useful notably when the desired rank is considerably smaller than the dimensions of the matrix
maxcell	positive integer. The maximum number of cells to be used. If this is smaller than ncell(x), a regular sample of x is used

Value

prcomp object

Note

prcomp may change the layer names if they are not valid. See [make.names](#). In that case, you will get a warning, and would need to also make the layer names of x valid before using predict. Even better would be to change them before calling prcomp.

See Also

[princomp](#), [prcomp](#)

Examples

```
f <- system.file("ex/logo.tif", package = "terra")
r <- rast(f)
pca <- prcomp(r)
x <- predict(r, pca)

# use "index" to get a subset of the components
p <- predict(r, pca, index=1:2)
```

predict

Spatial model predictions

Description

Make a SpatRaster with predictions from a fitted model object (for example, obtained with glm or randomForest). The first argument is a SpatRaster object with the predictor variables. The [names](#) in the SpatRaster should exactly match those expected by the model. Any regression like model for which a predict method has been implemented (or can be implemented) can be used.

The method should work if the model's predict function returns a vector, matrix or data.frame (or a list that can be coerced to a data.frame). In other cases it may be necessary to provide a custom "predict" function that wraps the model's predict function to return the values in the required form. See the examples.

This approach of using model predictions is commonly used in remote sensing (for the classification of satellite images) and in ecology, for species distribution modeling.

Usage

```
## S4 method for signature 'SpatRaster'
predict(object, model, fun=predict, ..., const=NULL, na.rm=FALSE,
        index=NULL, cores=1, cpkgs=NULL, filename="", overwrite=FALSE, wopt=list())
```

Arguments

object	SpatRaster
model	fitted model of any class that has a "predict" method (or for which you can supply a similar method as fun argument. E.g. glm, gam, or randomForest
fun	function. The predict function that takes model as first argument. The default value is predict, but can be replaced with e.g. predict.se (depending on the type of model), or your own custom function
...	additional arguments for fun
const	data.frame. Can be used to add a constant value as a predictor variable so that you do not need to make a SpatRaster layer for it
na.rm	logical. If TRUE, cells with NA values in the any of the layers of x are removed from the computation (even if the NA cell is in a layer that is not used as a variable in the model). This option prevents errors with models that cannot handle NA values when making predictions. In most other cases this will not affect the output. However, there are some models that return predicted values even if some (or all) variables are NA
index	integer or character. Can be used to to select a subset of the model output variables
cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created and used
cpkgs	character. The package(s) that need to be loaded on the nodes to be able to run the model.predict function (see examples)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[interpolate](#) for spatial model prediction

Examples

```
logo <- rast(system.file("ex/logo.tif", package="terra"))
names(logo) <- c("red", "green", "blue")
p <- matrix(c(48, 48, 48, 53, 50, 46, 54, 70, 84, 85, 74, 84, 95, 85,
             66, 42, 26, 4, 19, 17, 7, 14, 26, 29, 39, 45, 51, 56, 46, 38, 31,
```

```

22, 34, 60, 70, 73, 63, 46, 43, 28), ncol=2)

a <- matrix(c(22, 33, 64, 85, 92, 94, 59, 27, 30, 64, 60, 33, 31, 9,
  99, 67, 15, 5, 4, 30, 8, 37, 42, 27, 19, 69, 60, 73, 3, 5, 21,
  37, 52, 70, 74, 9, 13, 4, 17, 47), ncol=2)

xy <- rbind(cbind(1, p), cbind(0, a))

# extract predictor values for points
e <- extract(logo, xy[,2:3])

# combine with response (excluding the ID column)
v <- data.frame(cbind(pa=xy[,1], e))

#build a model, here with glm
model <- glm(formula=pa~., data=v)

#predict to a raster
r1 <- predict(logo, model)

plot(r1)
points(p, bg='blue', pch=21)
points(a, bg='red', pch=21)

# logistic regression
model <- glm(formula=pa~., data=v, family="binomial")
r1log <- predict(logo, model, type="response")

# to get the probability and standard error
r1se <- predict(logo, model, se.fit=TRUE)

# or provide a custom predict function
predfun <- function(model, data) {
  v <- predict(model, data, se.fit=TRUE)
  cbind(p=as.vector(v$fit), se=as.vector(v$se.fit))
}

r2 <- predict(logo, model, fun=predfun)

### principal components of a SpatRaster
pca <- prcomp(logo)

# or use sampling if you have a large raster
# and cannot process all cell values
sr <- spatSample(logo, 100000, "regular")
pca <- prcomp(sr)

x <- predict(logo, pca)
plot(x)

## parallelization
## Not run:

```

```

## simple case with GLM
model <- glm(formula=pa~., data=v)
p <- predict(logo, model, cores=2)

## The above does not work with a model from a contributed
## package, as the package needs to be loaded in each core.
## Below are three approaches to deal with that

library(randomForest)
rfm <- randomForest(formula=pa~., data=v)

## approach 0 (not parallel)
rp0 <- predict(logo, rfm)

## approach 1, use the "cpkgs" argument
rp1 <- predict(logo, rfm, cores=2, cpkgs="randomForest")

## approach 2, write a custom predict function that loads the package
rfun <- function(mod, dat, ...) {
  library(randomForest)
  predict(mod, dat, ...)
}
rp2 <- predict(logo, rfm, fun=rfun, cores=2)

## approach 3, write a parallelized custom predict function
rfun <- function(mod, dat, ...) {
  ncls <- length(cls)
  nr <- nrow(dat)
  s <- split(dat, rep(1:ncls, each=ceiling(nr/ncls), length.out=nr))
  unlist( parallel::clusterApply(cls, s, function(x, ...) predict(mod, x, ...)) )
}

library(parallel)
cls <- parallel::makeCluster(2)
parallel::clusterExport(cls, c("rfm", "rfun", "randomForest"))
rp3 <- predict(logo, rfm, fun=rfun)
parallel::stopCluster(cls)

plot(c(rp0, rp1, rp2, rp3))

### with two output variables (probabilities for each class)
v$pa <- as.factor(v$pa)
rfm2 <- randomForest(formula=pa~., data=v)
rpf <- predict(logo, rfm2, cores=2, type="prob", cpkgs="randomForest")

## End(Not run)

```

Description

Compute principal components for `SpatRaster` layers. This method can use all values to compute the principal components, even for very large rasters. This is because it computes the covariance matrix by processing the data in chunks, if necessary, using `layerCor`. The population covariance is used (not the sample, with $n-1$ denominator, covariance).

Alternatively, you can specify `maxcell` or sample raster values to a `data.frame` to speed up calculations for very large rasters (see the examples below).

See `prcomp` for an alternative method that has higher numerical accuracy, but is slower, and for very large rasters can only be accomplished with a sample since all values must be read into memory.

Usage

```
## S4 method for signature 'SpatRaster'
princomp(x, cor=FALSE, fix_sign=TRUE, use="pairwise.complete.obs", maxcell=Inf)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>cor</code>	logical. If <code>FALSE</code> , the covariance matrix is used. Otherwise the correlation matrix is used
<code>fix_sign</code>	logical. If <code>TRUE</code> , the signs of the loadings and scores are chosen so that the first element of each loading is non-negative
<code>use</code>	character. To decide how to handle missing values. This must be (an abbreviation of) one of the strings "everything", "complete.obs", "pairwise.complete.obs", or "masked.complete". With "pairwise.complete.obs", the covariance between a pair of layers is computed for all cells that are not NA in that pair. Therefore, it may be that the (number of) cells used varies between pairs. The benefit of this approach is that all available data is used. Use "complete.obs", if you want to only use the values from cells that are not NA in any of the layers. By using "masked.complete" you indicate that all layers have NA values in the same cells
<code>maxcell</code>	positive integer. The maximum number of cells to be used. If this is smaller than <code>ncell(x)</code> , a regular sample of <code>x</code> is used

Value

`princomp` object

Author(s)

Alex Ilich and Robert Hijmans, based on a similar method by Benjamin Leutner

See Also

[prcomp](#) [princomp](#)

Examples

```
f <- system.file("ex/logo.tif", package = "terra")
r <- rast(f)
pca <- princomp(r)
x <- predict(r, pca)

# use "index" to get a subset of the components
p <- predict(r, pca, index=1:2)

### use princomp directly
pca2 <- princomp(values(r), fix_sign = TRUE)
p2 <- predict(r, pca2)

### may need to use sampling with a large raster
### here with prcomp instead of princomp
sr <- spatSample(r, 100000, "regular")
pca3 <- prcomp(sr)
p3 <- predict(r, pca3)
```

project

Change the coordinate reference system

Description

Change the coordinate reference system ("project") of a `SpatVector`, `SpatRaster` or a matrix with coordinates.

Usage

```
## S4 method for signature 'SpatRaster'
project(x, y, method, mask=FALSE, align_only=FALSE, res=NULL,
origin=NULL, threads=FALSE, use_gdal=TRUE, by_util=FALSE, pipeline="",
AOI=NULL, desired_accuracy=-1.0, allow_approx=TRUE, filename="", ...)

## S4 method for signature 'SpatVector'
project(x, y, partial=FALSE, pipeline="", AOI=NULL,
        desired_accuracy=-1.0, allow_approx=TRUE)

## S4 method for signature 'SpatExtent'
project(x, from, to)

## S4 method for signature 'matrix'
project(x, from, to)
```

Arguments

x `SpatRaster`, `SpatVector`, `SpatExtent` or matrix (with x and y columns) whose coordinates to project

y	<p>if x is a SpatRaster, the preferred approach is for y to be a SpatRaster as well, serving as a template for the geometry (extent and resolution) of the output SpatRaster. Alternatively, you can provide a coordinate reference system (CRS) description.</p> <p>You can use the following formats to define coordinate reference systems: WKT, PROJ.4 (e.g., <code>+proj=longlat +datum=WGS84</code>), or an EPSG code (e.g., <code>"epsg:4326"</code>). But note that the PROJ.4 notation has been deprecated, and you can only use it with the WGS84/NAD83 and NAD27 datums. Other datums are silently ignored.</p> <p>If x is a SpatVector, you can provide a crs definition as discussed above, or any other object from which such a crs can be extracted with crs</p>
partial	logical. If TRUE, geometries that can only partially be represented in the output crs are included in the output
method	<p>character. Method used for estimating the new cell values of a SpatRaster. One of:</p> <p><code>bilinear</code>: bilinear interpolation (3x3 cell window). This is used by default if the first layer of x is not categorical</p> <p><code>mean</code>: This can be a good choice with continuous variables if the output cells overlap with multiple input cells.</p> <p><code>near</code>: nearest neighbor. This is used by default if the first layer of x is categorical. This method is not a good choice for continuous values.</p> <p><code>mode</code>: The modal value. This can be a good choice for categorical rasters, if the output cells overlap with multiple input cells.</p> <p><code>cubic</code>: cubic interpolation (5x5 cell window).</p> <p><code>cubicspline</code>: cubic B-spline interpolation. (5x5 cell window).</p> <p><code>lanczos</code>: Lanczos windowed sinc resampling. (7x7 cell window).</p> <p><code>sum</code>: the weighted sum of all non-NA contributing grid cells.</p> <p><code>min</code>, <code>q1</code>, <code>median</code>, <code>q3</code>, <code>max</code>: the minimum, first quartile, median, third quartile, or maximum value.</p> <p><code>rms</code>: the root-mean-square value of all non-NA contributing grid cells.</p>
mask	logical. If TRUE, mask out areas outside the input extent. For example, to avoid data wrapping around the date-line (see example with Robinson projection). To remove cells that are NA in y (if y is a SpatRaster) you can use the mask method after calling <code>project</code> (this function)
align_only	logical. If TRUE, and y is a SpatRaster, the template is used for the spatial resolution and origin, but the extent is set such that all of the extent of x is included
res	numeric. Can be used to set the resolution of the output raster if y is a CRS
origin	numeric. Can be used to set the origin of the output raster if y is a CRS
threads	logical. If TRUE multiple threads are used (faster for large files)
use_gdal	logical. If TRUE the GDAL-warp algorithm is used. Otherwise, a slower internal algorithm is used that may be more accurate if there is much variation in the cell sizes of the output raster. Only the <code>near</code> and <code>bilinear</code> algorithms are available for the internal algorithm
by_util	logical. If TRUE and <code>gdal=TRUE</code> , the GDAL warp utility is used

pipeline	character. A PROJ pipeline string to use for the coordinate transformation instead of letting GDAL select one automatically. You can use proj_pipelines to find available pipelines. When a pipeline is set, y is still used to set the output CRS
AOI	SpatExtent or object that has a SpatExtent to set the area of interest for the transformation. This is used to select the most appropriate transformation pipeline
desired_accuracy	numeric. Only use transformations with at least this accuracy (in metres). Use -1 (the default) for no constraint. Requires GDAL >= 3.3
allow_approx	logical. If FALSE, only use transformations with known accuracy (no "ballpark" transformations). Requires GDAL >= 3.3
filename	character. Output filename
...	additional arguments for writing files as in writeRaster
from	character. Coordinate reference system of x
to	character. Output coordinate reference system

Value

SpatVector or SpatRaster

Note

The PROJ.4 notation of coordinate reference systems has been partly deprecated in the GDAL/PROJ library that is used by this function. You can still use this notation, but **only** with the WGS84 datum. Other datums are silently ignored.

Transforming (projecting) raster data is fundamentally different from transforming vector data. Vector data can be transformed and back-transformed without loss in precision and without changes in the values. This is not the case with raster data. In each transformation the values for the new cells are estimated in some fashion. Therefore, if you need to match raster and vector data for analysis, you should generally transform the vector data.

When using this method with a SpatRaster, the preferable approach is to provide a template SpatRaster as argument y. The template is then another raster dataset that you want your data to align with. If you do not have a template to begin with, you can do `project(rast(x), crs)` and then manipulate the output to get the template you want. For example, where possible use whole numbers for the extent and resolution so that you do not have to worry about small differences in the future. You can use commands like `dim(z) = c(180, 360)` or `res(z) <- 100000`.

The output resolution should generally be similar to the input resolution, but there is no "correct" resolution in raster transformation. It is not obvious what this resolution is if you are using lon/lat data that spans a large North-South extent.

See Also

[crs](#), [resample](#), [warp_scale](#), [proj_pipelines](#) and [projNetwork](#) to enable or disable PROJ network access for datum grid downloads.

Examples

```
## SpatRaster
## Not run:
a <- rast(ncols=40, nrows=40, xmin=-110, xmax=-90, ymin=40, ymax=60,
          crs="+proj=longlat +datum=WGS84")
values(a) <- 1:ncell(a)
newcrs="+proj=lcc +lat_1=48 +lat_2=33 +lon_0=-100 +datum=WGS84"
b <- rast(ncols=94, nrows=124, xmin=-944881, xmax=935118, ymin=4664377, ymax=7144377, crs=newcrs)
w <- project(a, b)

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
crs(v, proj=TRUE)
cat(crs(v), "\n")

project(v, "+proj=moll")
project(v, "EPSG:2169")

## End(Not run)
```

proj_pipelines

*Find CRS transformation pipelines***Description**

Find candidate coordinate transformation pipelines between two coordinate reference systems. This can be used to examine which transformations are available, whether they require grid files, and what accuracy they provide. You can use a selected pipeline with the [project](#) methods

Usage

```
proj_pipelines(from, to, authority="", AOI=NULL, use="NONE",
              grid_availability="USED", desired_accuracy=-1.0, strict_containment=FALSE)
```

Arguments

from	character, SpatRaster, SpatVector, or any object from which <code>crs()</code> can extract a CRS
to	same types as for from
authority	character. Constrain output pipelines to those from this authority (e.g. "EPSG"). Default "" means no constraint
AOI	SpatExtent. Area of interest for the transformation in degrees. For an area of interest crossing the anti-meridian, west should be greater than east, e.g. <code>ext(150, 210, 0, 30)</code>

use	character. One of "NONE", "BOTH", "INTERSECTION", "SMALLEST", indicating how areas of interest of source and target CRS are used. Ignored when AOI is specified
grid_availability	character. One of "USED" (grid availability is used for sorting; operations with missing grids are sorted last), "DISCARD" (discard operations if a required grid is missing), "IGNORED" (ignore grid availability; results presented as if all grids were available), or "AVAILABLE" (results presented as if grids known to PROJ were available; typical when networking is enabled)
desired_accuracy	numeric. Only return pipelines with at least this accuracy (in metres). Use -1 (the default) to impose no accuracy constraint
strict_containment	logical. If FALSE (the default), permit partial matching of the area of interest. If TRUE, the area of interest must be strictly contained

Value

A data.frame with "pipelines" and the following columns:

description human-readable description

definition PROJ pipeline definition string

has_inverse logical; whether the pipeline has an inverse

accuracy accuracy in metres; -1 indicates unknown (ballpark) accuracy

grid_count number of grids required by this pipeline

instantiable logical; whether the pipeline can be used (all required grids are available)

Note

Requires PROJ >= 7.1 (inc" 3). See [projNetwork](#) to enable online grid downloading.

See Also

[crs](#), [project](#), [same.crs](#), [projNetwork](#)

Examples

```
## Not run:
# Simple case: WGS84 to UTM zone 32N
proj_pipelines("EPSG:4326", "EPSG:32632")

# Many pipelines between NAD83/Conus Albers and WGS84
pp <- proj_pipelines("EPSG:5070", "EPSG:4326")
nrow(pp)

# Only pipelines that work without downloading grids
pp_local <- proj_pipelines("EPSG:5070", "EPSG:4326", grid_availability="DISCARD")
pp_local
```

```
# Using a SpatRaster as input
r <- rast(ncols=10, nrows=10, crs="EPSG:4326")
proj_pipelines(r, "EPSG:3857")

## End(Not run)
```

quantile	<i>Quantiles of spatial data</i>
----------	----------------------------------

Description

Compute quantiles for each cell across the layers of a `SpatRaster`.

You can use `global(x, fun=quantile)` to instead compute quantiles across cells for each layer.

You can also use this method to compute quantiles of the numeric variables of a `SpatVector`.

Usage

```
## S4 method for signature 'SpatRaster'
quantile(x, probs=seq(0, 1, 0.25), na.rm=FALSE, filename="", ...)

## S4 method for signature 'SpatVector'
quantile(x, probs=seq(0, 1, 0.25), ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>probs</code>	numeric vector of probabilities with values in [0,1]
<code>na.rm</code>	logical. If TRUE, NA's are removed from <code>x</code> before the quantiles are computed
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in <code>writeRaster</code>

Value

`SpatRaster` with layers representing quantiles

See Also

[app](#)

Examples

```

r <- rast(system.file("ex/logo.tif", package="terra"))
rr <- c(r/2, r, r*2)
qr <- quantile(rr)
qr

## Not run:
# same but slower
qa <- app(rr, quantile)

## End(Not run)

#quantile by layer instead of by cell
qg <- global(r, quantile)

```

query

Query a SpatVectorProxy object

Description

Query a SpatVectorProxy to extract a subset

Usage

```

## S4 method for signature 'SpatVectorProxy'
query(x, start=1, n=nrow(x), vars=NULL, where=NULL,
      extent=NULL, filter=NULL, sql=NULL, dialect="", what="")

```

Arguments

x	SpatVectorProxy
start	positive integer. The record to start reading at
n	positive integer. The number of records requested
vars	character. Variable names. Must be a subset of names(x)
where	character. expression like "NAME_1='California' AND ID > 3" , to subset records. Note that start and n are applied after executing the where statement
extent	Spat* object. The extent of the object is used as a spatial filter to select the geometries to read. Ignored if filter is not NULL
filter	SpatVector. Used as a spatial filter to select geometries to read (the convex hull is used for lines or points)
sql	character. Arbitrary SQL statement. If used, arguments "start", "n", "vars" and "where" are ignored
what	character indicating what to read. Either "" for geometries and attributes, or "geoms" to only read the geometries, "attributes" to only read the attributes (that are returned as a data.frame)
dialect	character. The SQL dialect to use (if any). For example: "SQLite"

Value

SpatVector

See Also

[vect](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f, proxy=TRUE)
v

x <- query(v, vars=c("ID_2", "NAME_2"), start=5, n=2)
x

query(v, vars=c("ID_2", "NAME_1", "NAME_2"), where="NAME_1='Grevenmacher' AND ID_2 > 6")

## with an extent
e <- ext(5.9, 6.3, 49.9, 50)
x <- query(v, extent=e)

## with polygons
p <- as.polygons(e)
x <- query(v, filter=p)
x
```

rangeFill

Fill layers with a range

Description

Fill layers with cell-varying ranges defined by a start and end SpatRaster. The range must start at 1 and end at a user-defined maximum. Output values are either zero (not in the range) or one (in the range).

For example, for a cell with start=3, end=5 and with limit=8, the output for that cell would be 0,0,1,1,1,0,0,0

Usage

```
## S4 method for signature 'SpatRaster'
rangeFill(x, limit, circular=FALSE, filename="", ...)
```

Arguments

x	SpatRaster with at two layers. The cell values of the first layer indicate the start of the range (1 based); the cell values are indicate the end of the range
limit	numeric > 1. The range size
circular	logical. If TRUE the values are considered circular, such as the days of the year. In that case, if first > last the layers used are c(first:limit, 1:last). Otherwise, if circular=FALSE, such a range would be considered invalid and NA would be used
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rapp](#)

Examples

```
x <- y <- rast(ncol=2, nrow=2)
values(x) <- c(NA, 1:3)
values(y) <- c(NA, 4:6)

r <- rangeFill(c(x, y), 8)
```

rapp

Range-apply

Description

Apply a function to a range of the layers of a SpatRaster that varies by cell. The range is specified for each cell with one or two SpatRasters (arguments *first* and *last*). For either *first* or *last* you can use a single number instead.

You cannot use single numbers for both *first* and *last* because in that case you could use [app](#) or [Summary-methods](#), perhaps [subsetting](#) the layers of a SpatRaster.

See [selectRange](#) to create a new SpatRaster by extracting one or more values starting at a cell-varying layer.

Usage

```
## S4 method for signature 'SpatRaster'
rapp(x, first, last, fun, ..., allargs=FALSE, fill=NA,
      clamp=FALSE, circular=FALSE, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
first	SpatRaster or positive integer between 1 and nlyr(x), indicating the first layer in the range of layers to be considered
last	SpatRaster or positive integer between 1 and nlyr(x), indicating the last layer in the range to be considered
fun	function to be applied
...	additional arguments passed to fun
allyrs	logical. If TRUE, values for all layers are passed to fun but the values outside of the range are set to fill
fill	numeric. The fill value for the values outside of the range, for when allyrs=TRUE
clamp	logical. If FALSE and the specified range is outside 1:nlyr(x) all cells are considered NA. Otherwise, the invalid part of the range is ignored
circular	logical. If TRUE the values are considered circular, such as the days of the year. In that case, if first > last the layers used are c(first:nlyr(x), 1:last). Otherwise, the range would be considered invalid and NA would be returned
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also[selectRange](#), [app](#), [Summary-methods](#), [lapp](#), [tapp](#)**Examples**

```

r <- rast(ncols=9, nrows=9)
values(r) <- 1:ncell(r)
s <- c(r, r, r, r, r, r)
s <- s * 1:6
s[1:2] <- NA
start <- end <- rast(r)
start[] <- 1:3
end[] <- 4:6
a <- rapp(s, start, end, fun="mean")
b <- rapp(s, start, 2, fun="mean")

# cumsum from start to nlyr(x). return all layers
r <- rapp(s, start, nlyr(s), cumsum, allyrs=TRUE, fill=0)
# return only the final value
rr <- rapp(s, start, nlyr(s), function(i) max(cumsum(i)))

```

 rast

 Create a SpatRaster

Description

Methods to create a SpatRaster. These objects can be created from scratch, from a filename, or from another object.

A SpatRaster represents a spatially referenced surface divided into three dimensional cells (rows, columns, and layers).

When a SpatRaster is created from one or more files, it does not load the cell (pixel) values into memory (RAM). It only reads the parameters that describe the geometry of the SpatRaster, such as the number of rows and columns and the coordinate reference system. The actual values will be read when needed.

Note that there are operating system level limitations to the number of files that can be opened simultaneously. Using a SpatRaster of very many files (e.g. 10,000) may cause R to crash when you use it in a computation. In situations like that you may need to split up the task or combine data into fewer (multi-layer) files. Also note that the GTiff format used for temporary files cannot store more than 65,535 layers in a single file.

Usage

```
## S4 method for signature 'character'
rast(x, subds=0, lyrs=NULL, drivers=NULL, opts=NULL, win=NULL,
snap="near", vsi=FALSE, raw=FALSE, noflip=FALSE,
guessCRS=TRUE, domains="", md=NULL, dims=NULL)

## S4 method for signature 'missing'
rast(x, nrows=180, ncols=360, nlyrs=1, xmin=-180, xmax=180, ymin=-90,
ymax=90, crs, extent, resolution, vals, names, time, units)

## S4 method for signature 'SpatRaster'
rast(x, nlyrs=nlyr(x), names, vals, keeptime=TRUE,
keepunits=FALSE, props=FALSE, tags=FALSE)

## S4 method for signature 'matrix'
rast(x, type="", crs="", digits=6, extent=NULL)

## S4 method for signature 'data.frame'
rast(x, type="xyz", crs="", digits=6, extent=NULL)

## S4 method for signature 'array'
rast(x, crs="", extent=NULL)

## S4 method for signature 'list'
rast(x, warn=TRUE)
```

```
## S4 method for signature 'SpatRasterDataset'
rast(x)

## S4 method for signature 'SpatVector'
rast(x, type="", ...)

## S4 method for signature 'SpatExtent'
rast(x, ...)
```

Arguments

x	filename (character), missing, SpatRaster, SpatRasterDataset, SpatExtent, SpatVector, matrix, array, list of SpatRasters. For other types it will be attempted to create a SpatRaster via <code>as(x, "SpatRaster")</code>
subds	positive integer or character to select a sub-dataset. If zero or "", all sub-datasets are returned (if possible)
lyrs	positive integer or character to select a subset of layers (a.k.a. "bands"). If x has multiple filenames, the same layer numbers are selected from each of the files, unless numbers larger than the number of layers of the first data source are included
drivers	character. GDAL drivers to consider
opts	character. GDAL dataset open options
win	SpatExtent to set a window (area of interest)
snap	character. One of "near", "in", or "out", to indicate how the extent of window should be "snapped" to x
vsi	logical. If TRUE, <code>"/vsicurl/"</code> is prepended to filenames that start with "http". There are many VSI configuration options that can be set with setGDALconfig
raw	logical. If TRUE, scale and offset values are ignored. See scoff to get these parameters
noflip	logical. If TRUE, a raster (e.g. JPEG image) that is not georeferenced and that GDAL assigns a flipped extent to (<code>y_{max} < y_{min}</code>), is not considered flipped. This avoids the need to flip the raster vertically
guessCRS	logical. If TRUE and the file does not specify a CRS but has an extent that is within longitude/latitude bounds, the longitude/latitude crs is assigned to the SpatRaster
domains	character. Metadata domains to read (see metags to retrieve their values if there are any). "" is the default domain
md	logical. If TRUE, the multi-dimensional GDAL API is used for reading the file. This API can only be used for a few file formats (netCDF/HDF5) and can sometimes provide notably faster reading of data with many (time) steps in the third or higher dimension. If no subdataset is selected with subds, all usable arrays are combined into one SpatRaster (like <code>md=FALSE</code>); a warning reports how many variables and layers were combined when there is more than one variable.
dims	numeric. Specify the order of the dimensions to read atypical multidimensional files. See ar_info . Not implemented yet

nrows	positive integer. Number of rows
ncols	positive integer. Number of columns
nlyrs	positive integer. Number of layers
xmin	minimum x coordinate (left border)
xmax	maximum x coordinate (right border)
ymin	minimum y coordinate (bottom border)
ymax	maximum y coordinate (top border)
crs	character. Description of the Coordinate Reference System (map projection) in PROJ.4, WKT or authority:code notation. See crs . If this argument is missing, and the x coordinates are within -360 .. 360 and the y coordinates are within -90 .. 90, longitude/latitude is assigned
keptime	logical. If FALSE the time stamps are discarded
keepunits	logical. If FALSE the layer units are discarded
props	logical. If TRUE the properties (categories and color-table) are kept
tags	logical. If TRUE the user specified metadata tags are kept (see metags).
extent	object of class SpatExtent. If present, the arguments xmin, xmax, ymin and ymax are ignored
resolution	numeric vector of length 1 or 2 to set the spatial resolution (see res). If this argument is used, arguments ncols and nrows are ignored
vals	numeric. An optional vector with cell values (if fewer values are provided, these are recycled to reach the number of cells)
names	character. An optional vector with layer names (must match the number of layers)
time	time or date stamps for each layer
units	character. units for each layer
type	character. If the value is "xyz", x must be a SpatVector with point geometry, or a matrix or data.frame with at least two columns, the first with x (or longitude) and the second with y (or latitude) coordinates that represent the centers of raster cells. The additional columns are the values associated with the raster cells. If the value is "xyz", x must have four columns with the third representing the layer and the fourth the cell values. If the value is "", the resulting SpatRaster will have the same number of rows and columns as x.
digits	integer to set the precision for detecting whether points are on a regular grid (a low number of digits is a low precision). Only used when type="xyz"
warn	logical. If TRUE, a warning about empty rasters may be emitted
...	additional arguments passed on to the <code>rast,missing-method</code>

Details

Files are read with the GDAL library. GDAL guesses the file format from the name, and/or tries reading it with different "drivers" (see [gdal](#)) until it succeeds. In very few cases this may

cause a file to be opened with the wrong driver, and some information may be lost. For example, when a netCDF file is opened with the HDF5 driver. You can avoid that by using argument `rast("filename.ncdf", drivers="NETCDF")`

These classes hold a C++ pointer to the data "reference class" and that creates some limitations. They cannot be recovered from a saved R session either or directly passed to nodes on a computer cluster. Generally, you should use [writeRaster](#) to save `SpatRaster` objects to disk (and pass a filename or cell values to cluster nodes). Also see [wrap](#).

Value

`SpatRaster`

See Also

[sds](#) to create a `SpatRasterDataset` (`SpatRasters` with the same geometry representing different variables or higher dimension), [sprc](#) to create a `SpatRasterCollection` (to combine `SpatRasters` with different geometries), and [vect](#) for vector (points, lines, polygons) data

Examples

```
# Create a SpatRaster from scratch
x <- rast(nrows=108, ncols=21, xmin=0, xmax=10)

# Create a SpatRaster from a file
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)

# A file with multiple layers. This one is special as the layers are RGB color channels
s <- rast(system.file("ex/logo.tif", package="terra"))

# remove the color channels
#plot(s)
#RGB(s) <- NULL
#plot(s)

# Create a skeleton with no associated cell values
rast(s)

# from a matrix
m <- matrix(1:25, nrow=5, ncol=5)
rm <- rast(m)

# from a "xyz" data.frame
d <- as.data.frame(rm, xy=TRUE)
head(d)
rast(d, type="xyz")
```

rasterize

Rasterize vector data

Description

Transfer values associated with the geometries of vector data to a raster

Usage

```
## S4 method for signature 'SpatVector,SpatRaster'
rasterize(x, y, field="", fun, ..., background=NA, touches=FALSE, update=FALSE,
cover=FALSE, by=NULL, filename="", overwrite=FALSE, wopt=list())
```

```
## S4 method for signature 'matrix,SpatRaster'
rasterize(x, y, values=1, fun, ..., background=NA, update=FALSE,
by=NULL, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatVector or a two-column matrix (point coordinates) or data.frame
y	SpatRaster
field	character or numeric. If field is a character, it should be a variable name in x. If field is numeric it typically is a single number or a vector of length nrow(x). The values are recycled to nrow(x)
values	typically a numeric vector of length 1 or nrow(x). If the length is below nrow(x), the values will be recycled to nrow(x). Only used when x is a matrix. Can also be a matrix or data.frame
fun	summarizing function for when there are multiple geometries in one cell. For lines and polygons, you can only use "min", "max", "mean", "count" and "sum". For points you can use any function that returns a single number; for example mean, length (to get a count), min or max
...	additional arguments passed to fun
background	numeric. Value to put in the cells that are not covered by any of the features of x. Default is NA
touches	logical. If TRUE, all cells touched by lines or polygons are affected, not just those on the line render path, or whose center point is within the polygon. If touches=TRUE, add cannot be TRUE
update	logical. If TRUE, the values of the input SpatRaster are updated
cover	logical. If TRUE and the geometry of x is polygons, the fraction of a cell that is covered by the polygons is returned. This is estimated by determining presence/absence of the polygon in at least 100 sub-cells (more of there are very few cells)

by	character or numeric value(s) to split x into multiple groups. There will be a separate layer for each group returned. If x is a SpatVector, by can be a column number or name. If x is a matrix, by should be a vector that identifies group membership for each row in x
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rasterizeGeom](#), [rasterizeWin](#), [mask](#)

Examples

```
r <- rast(xmin=0, ncols=18, nrows=18)

# generate points
set.seed(1)
p <- spatSample(r, 1000, xy=TRUE, replace=TRUE)

# rasterize points as a matrix
x <- rasterize(p, r, fun=sum)
y <- rasterize(p, r, value=1:nrow(p), fun=max)

# rasterize points as a SpatVector
pv <- vect(p)
xv <- rasterize(pv, r, fun=sum)

# Polygons
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
r <- rast(v, ncols=75, nrows=100)
z <- rasterize(v, r, "NAME_2")
plot(z)
lines(v)
```

Description

Rasterization of geometric properties of vector data. You can get the count of the number of geometries in each cell; the area covered by polygons; the length of the lines; or the number of lines that cross the boundary of each cell. See [rasterize](#) for standard rasterization (of attribute values associated with geometries).

The area of polygons is intended for summing the area of polygons that are relatively small relative to the raster cells, and for when there may be multiple polygons per cell. See `rasterize(fun="sum")` for counting large polygons and `rasterize(cover=TRUE)` to get the fraction that is covered by larger polygons.

Usage

```
## S4 method for signature 'SpatVector,SpatRaster'
rasterizeGeom(x, y, fun="count", unit="m", filename="", ...)
```

Arguments

x	SpatVector
y	SpatRaster
fun	character. "count", "area", "length", or "crosses"
unit	character. "m" or "km"
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rasterize](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
r <- rast(v, res=.1)

# length of lines
lms <- as.lines(v)
x <- rasterizeGeom(lms, r, fun="length", "km")

# count of points
set.seed(44)
pts <- spatSample(v, 100)
y <- rasterizeGeom(pts, r)

# area of polygons
```

```
pols <- buffer(pts, 1000)
z <- rasterizeGeom(pols, r, fun="area")
```

rasterizeWin	<i>Rasterize points with a moving window</i>
--------------	--

Description

Rasterize points using a circle (or ellipse) as moving window. For each raster cell, the points (x, y) that fall within the window centered on that cell are considered. A function is used to compute a summary value (e.g. "mean") for the values (z) associated with these points.

This can result in much smoother results compared to the standard `rasterize` method.

Usage

```
## S4 method for signature 'SpatVector,SpatRaster'
rasterizeWin(x, y, field, win="circle", pars, fun, ..., cvars=FALSE,
             minPoints=1, fill=NA, filename="", wopt=list())
```

```
## S4 method for signature 'data.frame,SpatRaster'
rasterizeWin(x, y, win="circle", pars, fun, ..., cvars=FALSE,
             minPoints=1, fill=NA, filename="", wopt=list())
```

Arguments

x	SpatVector or matrix with at least three columns ((x, y) coordinates and a variable to be rasterized)
y	SpatRaster
field	character. field name in SpatVector x with the values to rasterize
win	character to choose the window type. Can be "circle", "ellipse", "rectangle", or "buffer"
pars	parameters to define the window. If win="circle" or win="buffer", a single number to set the radius of the circle or the width of the buffer. If win="ellipse", either two numbers (the x and y-axis) or three numbers the axes and a rotation (in degrees). If win="rectangle", either two (width, height) or three (width, height) and the rotation in degrees. The unit of the radius/width/height/axis parameters is that of the coordinate reference system (it is not expressed as cells). That is, if you have a lon/lat crs, there is no conversion of degrees to meters or vice-versa.
fun	function to summarize the values for each cell. If cvars=FALSE, functions must take a numeric vector and return (in all cases) one or more numbers. If cvars=TRUE, and multiple variables are used, the function must take a single argument (a data.frame with the names variables). For win="circle" and win="ellipse" there are two additional character values that can be used: "distto" (average distance to the points from the center of the cell) and "distbetween" (average distance between the points inside the window)

...	additional named arguments passed to fun
minPoints	numeric. The minimum number of points to use. If fewer points are found in a search ellipse it is considered empty and the fill value is returned
fill	numeric. value to use to fill cells with empty search areas
cvars	logical. When using multiple fields, should fun operate on all of them at once? If not, fun is applied to each variable separately
filename	character. Output filename
wopt	list with additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rasterize](#), [rasterizeGeom](#), [interpNear](#), [interpIDW](#)

Examples

```
r <- rast(ncol=100, nrow=100, crs="local", xmin=0, xmax=50, ymin=0, ymax=50)
set.seed(100)
x <- runif(50, 5, 45)
y <- runif(50, 5, 45)
z <- sample(50)
xyz <- data.frame(x,y,z)

r <- rasterizeWin(xyz, r, fun="count", pars=5)

rfuns <- c("count", "min", "max", "mean")
x <- lapply(rfun, function(f) rasterizeWin(xyz, r, fun=f, pars=5))
names(x) <- rfuns
x <- rast(x)
#plot(x)
```

rcl

Combine row, column, and layer numbers

Description

Get a matrix with the combination of row, column, and layer numbers

Usage

```
## S4 method for signature 'SpatRaster'
rcl(x, row=NULL, col=NULL, lyr=NULL)
```

Arguments

<code>x</code>	SpatRaster
<code>row</code>	positive integer that are row number(s), a list thereof, or NULL for all rows
<code>col</code>	as above for columns
<code>lyr</code>	as above for layers

Details

If a list is used for at least one of `row`, `col` or `lyr`, these are evaluated in parallel. That is combinations are made for each list element, not across list elements. If, in this case another argument is not a list it has to have either length 1 (used for all cases) or have the same length as the (longest) list, in which case the value is coerced into a list with `as.list`

If multiple arguments are a list but they have different lengths, they are recycled to the longest list.

Value

matrix

See Also

[rowColCombine](#), [cellFromRowCol](#)

Examples

```
x <- rast(ncol=5, nrow=5, nlyr=2)
values(x) <- 1:size(x)

rcl(x, 1, 2:3, 1:2)

i <- rcl(x, 1, list(1:2, 3:4), 1:2)
i

# get the values for these cells
x[i]
```

readwrite

Read from, or write to, file

Description

Methods to read from or write chunks of values to or from a file. These are low level methods for programmers. Use `writeRaster` if you want to save an entire `SpatRaster` to file in one step. It is much easier to use.

To write chunks, begin by opening a file with `writeStart`, then write values to it in chunks using the list that is returned by `writeStart`. When writing is done, close the file with `writeStop`.

`blocks` only returns chunk size information. This can be useful when reading, but not writing, raster data.

Usage

```

## S4 method for signature 'SpatRaster'
readStart(x)

## S4 method for signature 'SpatRaster'
readStop(x)

## S4 method for signature 'SpatRaster'
readValues(x, row=1, nrows=nrow(x), col=1, ncols=ncol(x), mat=FALSE, dataframe=FALSE, ...)

## S4 method for signature 'SpatRaster,character'
writeStart(x, filename="", overwrite=FALSE, n=4, sources="", ...)

## S4 method for signature 'SpatRaster'
writeStop(x)

## S4 method for signature 'SpatRaster,vector'
writeValues(x, v, start, nrows)

## S4 method for signature 'SpatRaster'
blocks(x, n=4)

fileBlocksize(x)

```

Arguments

x	SpatRaster
filename	character. Output filename
v	vector with cell values to be written
start	integer. Row number (counting starts at 1) from where to start writing v
row	positive integer. Row number to start from, should be between 1 and nrow(x)
nrows	positive integer. How many rows?
col	positive integer. Column number to start from, should be between 1 and ncol(x)
ncols	positive integer. How many columns? Default is the number of columns left after the start column
mat	logical. If TRUE, values are returned as a numeric matrix instead of as a vector, except when dataframe=TRUE. If any of the layers of x is a factor, the level index is returned, not the label. Use dataframe=TRUE to get the labels
dataframe	logical. If TRUE, values are returned as a data.frame instead of as a vector (also if matrix is TRUE)
overwrite	logical. If TRUE, filename is overwritten
n	positive integer indicating how many copies the data may be in memory at any point in time. This is used to determine how many blocks (large) datasets need to be read

sources character. Filenames that may not be overwritten because they are used as input to the function. Can be obtained with `sources(x)`

... For `writeStart`: additional arguments for writing files as in [writeRaster](#)
 For `readValues`: additional arguments for `data.frame` (and thus only relevant when `dataframe=TRUE`)

Value

`readValues` returns a vector, matrix, or `data.frame`

`writeStart` returns a list that can be used for processing the file in chunks.

The other methods invisibly return a logical value indicating whether they were successful or not. Their purpose is the side-effect of opening or closing files.

rectify *Rectify a SpatRaster*

Description

Rectify a rotated `SpatRaster` into a non-rotated object

Usage

```
## S4 method for signature 'SpatRaster'
rectify(x, method="bilinear", aoi=NULL, snap=TRUE,
        filename="", ...)
```

Arguments

x `SpatRaster` to be rectified

method character. Method used to for resampling. See [resample](#)

aoi `SpatExtent` or `SpatRaster` to crop x to a smaller area of interest; Using a `SpatRaster` allowing to set the exact output extent and output resolution

snap logical. If TRUE, the origin and resolution of the output are the same as would the case when `aoi = NULL`. Only relevant if `aoi` is a `SpatExtent`

filename character. Output filename

... additional arguments for writing files as in [writeRaster](#)

Value

`SpatRaster`

See Also

[is.rotated](#)

regress	<i>Cell level regression</i>
---------	------------------------------

Description

Run a regression model for each cell of a `SpatRaster`. The independent variable can either be defined by a vector, or another `SpatRaster` to make it spatially variable.

Usage

```
## S4 method for signature 'SpatRaster,numeric'  
regress(y, x, formula=y~x, na.rm=FALSE, cores=1, filename="", overwrite=FALSE, ...)  
  
## S4 method for signature 'SpatRaster,SpatRaster'  
regress(y, x, formula=y~x, na.rm=FALSE, cores=1, filename="", overwrite=FALSE, ...)
```

Arguments

<code>y</code>	<code>SpatRaster</code>
<code>x</code>	<code>SpatRaster</code> or numeric (of the same length as <code>nlyr(x)</code>)
<code>formula</code>	regression formula in the general form of $y \sim x$. You can add additional terms such as $I(x^2)$
<code>na.rm</code>	logical. Remove NA values?
<code>cores</code>	positive integer. If <code>cores > 1</code> , a 'parallel' package cluster with that many cores is created and used. You can also supply a cluster object.
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, filename is overwritten
<code>...</code>	list with named options for writing files as in writeRaster

Value

`SpatRaster`

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))  
x <- regress(s, 1:nlyr(s))
```

relate

Spatial relationships between geometries

Description

`relate` returns a logical matrix indicating the presence or absence of a specific spatial relationships between the geometries in `x` and `y`.

`is.related` returns a logical vector indicating the presence or absence of a specific spatial relationships between `x` and any of the geometries in `y`.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
relate(x, y, relation, pairs=FALSE, na.rm=TRUE)
```

```
## S4 method for signature 'SpatVector,missing'
relate(x, y, relation, pairs=FALSE, na.rm=TRUE)
```

```
## S4 method for signature 'SpatVector,SpatVector'
is.related(x, y, relation)
```

Arguments

<code>x</code>	SpatVector or SpatExtent
<code>y</code>	missing or as for <code>x</code>
<code>relation</code>	character. One of "intersects", "touches", "crosses", "overlaps", "within", "contains", "covers", "coveredby", "disjoint", or "equals". It can also be a "DE-9IM" string such as "FF*FF****". See Wikipedia or GeoTools doc
<code>pairs</code>	logical. If TRUE a two-column matrix is returned with the indices of the cases where the requested relation is TRUE. This is especially helpful when dealing with many geometries as the returned value is generally much smaller
<code>na.rm</code>	logical. If TRUE and <code>pairs=TRUE</code> , geometries in <code>x</code> for which there is no related geometry in <code>y</code> are omitted

Value

matrix (`relate`) or vector (`is.related`)

See Also

[compareGeom](#) to check if the geometries are identical (equivalent to the "equals" relation)
[adjacent](#), [nearby](#), [intersect](#), [crop](#)

Examples

```

# polygons
p1 <- vect("POLYGON ((0 0, 8 0, 8 9, 0 9, 0 0))")
p2 <- vect("POLYGON ((5 6, 15 6, 15 15, 5 15, 5 6))")
p3 <- vect("POLYGON ((8 2, 9 2, 9 3, 8 3, 8 2))")
p4 <- vect("POLYGON ((2 6, 3 6, 3 8, 2 8, 2 6))")
p5 <- vect("POLYGON ((2 12, 3 12, 3 13, 2 13, 2 12))")
p6 <- vect("POLYGON ((10 4, 12 4, 12 7, 11 7, 11 6, 10 6, 10 4))")

p <- rbind(p1, p2, p3, p4, p5, p6)
plot(p, col=rainbow(6, alpha=.5))
lines(p, lwd=2)
text(p)

## relate SpatVectors
relate(p1, p2, "intersects")
relate(p1, p3, "touches")
relate(p1, p5, "disjoint")
relate(rbind(p1, p2), p4, "disjoint")

## relate geometries within SpatVectors
# which are completely separated?
relate(p, relation="disjoint")

# which touch (not overlap or within)?
relate(p, relation="touches")
# which overlap (not merely touch, and not within)?
relate(p, relation="overlaps")
# which are within (not merely overlap)?
relate(p, relation="within")

# do they touch or overlap or are within?
relate(p, relation="intersects")

all(relate(p, relation="intersects") ==
     (relate(p, relation="overlaps") |
      relate(p, relation="touches") |
      relate(p, relation="within")))

#for polygons, "coveredby" is "within"
relate(p, relation="coveredby")

# polygons, lines, and points

pp <- rbind(p1, p2)
L1 <- vect("LINESTRING(1 11, 4 6, 10 6)")
L2 <- vect("LINESTRING(8 14, 12 10)")
L3 <- vect("LINESTRING(1 8, 12 14)")
lins <- rbind(L1, L2, L3)
pts <- vect(cbind(c(7,10,10), c(3,5,6)))

plot(pp, col=rainbow(2, alpha=.5))

```

```

text(pp, paste0("POL", 1:2), halo=TRUE)
lines(pp, lwd=2)
lines(lns, col=rainbow(3), lwd=4)
text(lns, paste0("L", 1:3), halo=TRUE)
points(pts, cex=1.5)
text(pts, paste0("PT", 1:3), halo=TRUE, pos=4)

relate(lns, relation="crosses")
relate(lns, pp, relation="crosses")
relate(lns, pp, relation="touches")
relate(lns, pp, relation="intersects")

relate(lns, pp, relation="within")
# polygons can contain lines or points, not the other way around
relate(lns, pp, relation="contains")
relate(pp, lns, relation="contains")
# points and lines can be covered by polygons
relate(lns, pp, relation="coveredby")

relate(pts, pp, "within")
relate(pts, pp, "touches")
relate(pts, lns, "touches")

```

rep

Replicate layers

Description

Replicate layers in a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'
rep(x, ...)
```

Arguments

x	SpatRaster
...	arguments as in rep

Value

SpatRaster

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
x <- rep(s, 2)
nlyr(x)
names(x)
x
```

replace_dollar	<i>Replace with \$<-</i>
----------------	-----------------------------

Description

Replace a layer of a SpatRaster, or an attribute variable of a SpatVector

Usage

```
## S4 replacement method for signature 'SpatRaster'
x$name <- value

## S4 replacement method for signature 'SpatVector'
x$name<-value

## S4 replacement method for signature 'SpatExtent'
x$name <- value
```

Arguments

x	SpatRaster, SpatVector or SpatExtent
name	character. If x is a SpatRaster: layer name. If x is a SpatVector: variable name. If x is a SpatExtent: "xmin", "xmax". "ymin" or "ymax"
value	if x is a SpatRaster, a SpatRaster for which this TRUE: nlyr(value) == length(i); if x is a SpatVector, a vector of new values; if x is a SpatExtent a single number

Value

Same as x

See Also

[\[\[<-](#), [\[<-](#), [\\$](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$ID_1 <- LETTERS[1:12]
v$new <- sample(12)
values(v)
```

replace_layers	<i>Replace layers or variables</i>
----------------	------------------------------------

Description

Replace the layers of `SpatRaster` with (layers from) another `SpatRaster` or replace variables of a `SpatVector`. You can also create new layers/variables with these methods.

Usage

```
## S4 replacement method for signature 'SpatRaster,numeric'
x[[i]] <- value

## S4 replacement method for signature 'SpatRaster,character'
x[[i]] <- value

## S4 replacement method for signature 'SpatVector,numeric'
x[[i]] <- value

## S4 replacement method for signature 'SpatVector,character'
x[[i]] <- value
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>i</code>	if <code>x</code> is a <code>SpatRaster</code> : layer number(s) of name(s). If <code>x</code> is a <code>SpatVector</code> : variable number(s) or name(s) (column of the attributes)
<code>value</code>	if <code>x</code> is a <code>SpatRaster</code> : <code>SpatRaster</code> for which this TRUE: <code>nlyr(value) == length(i)</code> . if <code>x</code> is a <code>SpatVector</code> : vector or <code>data.frame</code>

Value

`SpatRaster`

See Also

[\\$<-](#), [\[<-](#)

Examples

```
# raster
s <- rast(system.file("ex/logo.tif", package="terra"))
s[["red"]] <- mean(s)
s[[2]] <- sqrt(s[[1]])

# vector
v <- vect(system.file("ex/lux.shp", package="terra"))
v[["ID_1"]] <- 12:1
```

replace_values	<i>Replace values of a SpatRaster</i>
----------------	---------------------------------------

Description

Replace values of a SpatRaster. These are convenience functions for smaller objects only. For larger rasters see [link{classify}](#) or [subst](#)

Usage

```
## S4 replacement method for signature 'SpatRaster,ANY,ANY,ANY'
x[i, j, k] <- value

## S4 replacement method for signature 'SpatVector,ANY,ANY'
x[i, j] <- value

## S4 replacement method for signature 'SpatExtent,numeric,missing'
x[i, j] <- value
```

Arguments

x	SpatRaster
i	row numbers. numeric, logical, or missing for all rows. Can also be a SpatRaster or SpatVector
j	column numbers. numeric, logical or missing for all columns
k	layer number. numeric, logical or missing for all layers
value	numeric, matrix, or data.frame

Value

SpatRaster

See Also

[classify](#), [subst](#), [set.values](#), [values](#), [\[\[<-](#)

Examples

```
## SpatRaster
r <- rast(ncols=5, nrows=5, xmin=0, xmax=5, ymin=0, ymax=5)
r[] <- 1:25
r[1,] <- 5
r[,2] <- 10
r[r>10] <- NA

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
```

```
v <- vect(f)
v[2,2] <- "hello"
v[1,] <- v[10,]
v[,3] <- v[,1]
v[2, "NAME_2"] <- "terra"
head(v, 3)
```

resample	<i>Transfer values of a SpatRaster to another one with a different geometry</i>
----------	---

Description

resample transfers values between SpatRaster objects that do not align (have a different origin and/or resolution). See [project](#) to change the coordinate reference system (crs).

If the origin and extent of the input and output are the same, you should consider using these other functions instead: [aggregate](#), [disagg](#), [extend](#) or [crop](#).

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
resample(x, y, method, threads=FALSE, by_util=FALSE, filename="", ...)
```

Arguments

x	SpatRaster to be resampled
y	SpatRaster with the geometry that x should be resampled to. You can also provide one or two positive numbers to set the resolution of the output raster relative to the input raster
method	character. Method used for estimating the new cell values. One of: bilinear: bilinear interpolation (3x3 cell window). This is used by default if the first layer of x is not categorical mean: This can be a good choice with continuous variables if the output cells overlap with multiple input cells. near: nearest neighbor. This is used by default if the first layer of x is categorical. This method is not a good choice for continuous values. modal: The modal value. This can be a good choice for categorical rasters, if the output cells overlap with multiple input cells. cubic: cubic interpolation (5x5 cell window). cubicspline: cubic B-spline interpolation. (5x5 cell window). lanczos: Lanczos windowed sinc resampling. (7x7 cell window). sum: the weighted sum of all non-NA contributing grid cells. min, q1, median, q3, max: the minimum, first quartile, median, third quartile, or maximum value. rms: the root-mean-square value of all non-NA contributing grid cells.

threads	logical. If TRUE multiple threads are used (faster for large files)
by_util	logical. If TRUE the GDAL warp utility is used
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also[aggregate](#), [disagg](#), [crop](#), [project](#)**Examples**

```
r <- rast(nrows=3, ncols=3, xmin=0, xmax=10, ymin=0, ymax=10)
values(r) <- 1:ncell(r)
s <- rast(nrows=25, ncols=30, xmin=1, xmax=11, ymin=-1, ymax=11)
x <- resample(r, s, method="bilinear")
```

rescale

*rescale***Description**

Rescale a SpatVector or SpatRaster. This may be useful to make small [inset](#) maps or for georeferencing.

Usage

```
## S4 method for signature 'SpatRaster'
rescale(x, fx=0.5, fy=fx, x0, y0)
```

```
## S4 method for signature 'SpatVector'
rescale(x, fx=0.5, fy=fx, x0, y0)
```

Arguments

x	SpatVector or SpatRaster
fx	numeric > 0. The horizontal scaling factor
fy	numeric > 0. The vertical scaling factor
x0	numeric. x-coordinate of the center of rescaling. If missing, the center of the extent of x is used
y0	numeric. y-coordinate of the center of rescaling. If missing, the center of the extent of x is used

Value

Same as x

See Also

[t](#), [shift](#), [flip](#), [rotate](#), [inset](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- rescale(v, 0.2)
plot(v)
lines(w, col="red")
```

 RGB

Layers representing colors

Description

With RGB you can get or set the layers to be used as Red, Green and Blue when plotting a SpatRaster. Currently, a benefit of this is that `plot` will send the object to `plotRGB`. You can also associated the layers with another color space (HSV, HSI or HSL)

With `colorize` you can convert a three-layer RGB SpatRaster into other color spaces. You can also convert it into a single-layer SpatRaster with a color-table.

Usage

```
## S4 method for signature 'SpatRaster'
RGB(x, value=NULL, type="rgb")

## S4 replacement method for signature 'SpatRaster'
RGB(x, ..., type="rgb")<-value

## S4 method for signature 'SpatRaster'
colorize(x, to="hsv", alpha=FALSE, stretch=NULL,
grays=FALSE, NAzero=FALSE, filename="", overwrite=FALSE, ...)

## S4 method for signature 'SpatRaster'
has.RGB(x, strict=TRUE)
```

Arguments

x	SpatRaster
value	three (or four) positive integers indicating the layers that are red, green and blue (and optionally a fourth transparency layer). Or NULL to remove the RGB settings

type	character. The color space. One of "rgb" "hsv", "hsi" and "hsl"
to	character. The color space to transform the values to. If x has RGB set, you can transform these to "hsv", "hsi" and "hsl", or use "col" to create a single layer with a color table. You can also use "rgb" to back transform to RGB
alpha	logical. Should an alpha (transparency) channel be included? Only used if x has a color-table and to="rgb"
stretch	character. Option to stretch the values to increase contrast: "lin" (linear) or "hist" (histogram). Only used for transforming RGB to col
grays	logical. If TRUE, a gray-scale color-table is created. Only used for transforming RGB to col
NAzero	logical. If TRUE, NAs are treated as zeros such that a color can be returned if at least one of the three channels has a value. Only used for transforming RGB to ("col")
strict	logical. If TRUE, the function returns FALSE if a color space such as "hsv", "hsi" and "hsl" is used
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files as in writeRaster

See Also

[set.RGB](#)

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
RGB(r)
plot(r)
has.RGB(r)
RGB(r) <- NULL
has.RGB(r)
plot(r)
RGB(r) <- c(3,1,2)
# same as
# r <- RGB(r, c(3,1,2))

plot(r)

RGB(r) <- 1:3
x <- colorize(r, "col")
y <- colorize(r, "hsv")
z <- colorize(y, "rgb")
```

roll	<i>Rolling (moving) functions</i>
------	-----------------------------------

Description

Compute "rolling" or "moving" values, such as the "rolling average" for each cell in a `SpatRaster`.

See [focal](#) for spatially moving averages and similar computations. And see [cumsum](#) and other `cum*` functions to compute cumulate values.

Usage

```
## S4 method for signature 'SpatRaster'
roll(x, n, fun=mean, type="around", circular=FALSE,
na.rm=FALSE, filename="", ..., wopt=list())

## S4 method for signature 'numeric'
roll(x, n, fun=mean, type="around", circular=FALSE, na.rm=FALSE, ...)
```

Arguments

x	SpatRaster or numeric
n	integer > 1. The size of the "window", that is, the number of sequential cells to use in fun
fun	a function like mean, min, max, sum
type	character. One of "around", "to", or "from". The choice indicates which values should be used in the computation. The focal cell is always used. If type is "around", (n-1)/2 before and after the focal cell are also included. If type = "from", n-1 cells are after the focal cell are included. If type = "to", n-1 cells before the focal cell are included. For example, when using n=3 for element 5 of a vector; "around" used elements 4,5,6; "to" used elements 3,4,5, and "from" uses elements 5,6,7
circular	logical. If TRUE, the data are considered to have a circular nature (e.g. days or months of the year), such that there are no missing values before first or after the last value.
na.rm	logical. If TRUE, NA values should be ignored (by fun)
filename	character. Output filename
...	additional arguments for fun
wopt	list with named options for writing files as in writeRaster

Value

Same as x

See Also

[cumsum](#), [focal](#)

Examples

```
## numeric
roll(1:12, 3, mean)
roll(1:12, 3, mean, "to")
roll(1:12, 3, mean, circular=TRUE)

## SpatRaster
r <- rast(ncol=2, nrow=2, nlyr=10, vals=1)
r[1,2] <- 2
r[2,2] <- 4

values(roll(r, n=3, "sum", "from", na.rm=FALSE))
values(roll(r, n=3, "sum", "from", na.rm=TRUE))
values(roll(r, n=3, "sum", "from", circular=TRUE))

values(roll(r, n=3, "sum", "to", na.rm=TRUE))

values(roll(r, n=3, "sum", "around", circular=TRUE))
```

rotate

Rotate data along longitude

Description

Rotate a `SpatRaster` that has longitude coordinates from 0 to 360, to standard coordinates between -180 and 180 degrees (or vice-versa). Longitude between 0 and 360 is frequently used in global climate models.

Rotate a `SpatVector` as for a `SpatRaster` with, or with `split=FALSE` to correct for coordinates that are connected across the date line (and end up at the "other side" of the longitude scale).

Usage

```
## S4 method for signature 'SpatRaster'
rotate(x, filename="", ...)

## S4 method for signature 'SpatVector'
rotate(x, longitude=0, split=TRUE, left=TRUE, normalize=FALSE)
```

Arguments

x	SpatRaster or SpatVector
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

longitude	numeric. The longitude around which to rotate
split	logical. Should geometries be split at longitude?
left	logical. Rotate to the left or to the right?
normalize	logical. Should the output be normalized to longitudes between -180 and 180? See normalize.longitude

Value

SpatRaster

See Also[shift](#) and [spin](#)**Examples**

```
x <- rast(nrows=9, ncols=18, nl=3, xmin=0, xmax=360)
v <- rep(as.vector(t(matrix(1:ncell(x), nrow=9, ncol=18))), 3)
values(x) <- v
z <- rotate(x)

## Not run:
#SpatVector
p <- rbind(c(3847903, 1983584 ), c(3847903, 5801864), c(8301883, 5801864), c(8301883, 1983584 ))
p <- vect(p, "polygons", crs="+init=EPSG:3347")
d <- densify(p, 100000)
g <- project(d, "+proj=longlat")

x <- rotate(g, 50)
plot(g)
lines(x, col="red")

## End(Not run)

## rotate countries to 0-360 longitude
#w <- geodata::world(path=".")
#x <- rotate(w, long=0, split=TRUE, left=FALSE)
```

rowSums*row/col sums and means for SpatRaster*

Description

Sum or average values of SpatRaster layers by row or column.

Usage

```
## S4 method for signature 'SpatRaster'
rowSums(x, na.rm=FALSE, dims=1L, ...)
## S4 method for signature 'SpatRaster'
colSums(x, na.rm=FALSE, dims=1L, ...)
## S4 method for signature 'SpatRaster'
rowMeans(x, na.rm=FALSE, dims=1L, ...)
## S4 method for signature 'SpatRaster'
colMeans(x, na.rm=FALSE, dims=1L, ...)
```

Arguments

x	SpatRaster
na.rm	logical. If TRUE, NA values are ignored
dims	this argument is ignored
...	additional arguments (none implemented)

Value

matrix

See Also

See [global](#) for summing all cells values

Examples

```
r <- rast(ncols=2, nrows=5, nl=2, vals=1:20)
rowSums(r)
colSums(r)
colMeans(r)
```

same.crs

Compare coordinate reference systems

Description

The function takes two coordinate reference system descriptions and compares them for equality.

Usage

```
same.crs(x, y)
```

Arguments

x	character, SpatRaster, SpatVector, CRS, or other object that returns something intelligible with <code>crs(x)</code>
y	same types as for x

Value

logical

Examples

```
r <- rast()
same.crs(r, "+proj=longlat")

same.crs(r, "+proj=utm +zone=1")
```

sapp	<i>Apply a terra function that takes only a single layer and returns a SpatRaster to all layers of a SpatRaster</i>
------	---

Description

Apply to all layers of a SpatRaster a function that only takes a single layer SpatRaster and returns a SpatRaster (these are rare). In most cases you can also use `lapply` or `sapply` for this.

Or apply the same method to each sub-dataset (SpatRaster) in a SpatRasterDataset

Usage

```
## S4 method for signature 'SpatRaster'
sapp(x, fun, ..., filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterDataset'
sapp(x, fun, ..., filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster or SpatRasterDataset
fun	if x is a SpatRaster: a function that takes a SpatRaster argument and can be applied to each layer of x (e.g. <code>terrain</code>). if x is a SpatRasterDataset: a function that is applied to all layers of the SpatRasters in x (e.g. <code>mean</code>)
...	additional arguments to be passed to fun
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in <code>writeRaster</code>

Value

SpatRaster

See Also

[lapp](#), [app](#), [tapp](#), [lapply](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra")) + 1

#SpatRasterDataset
sd <- sds(s*2, s/2)
y <- sapp(sd, mean)
z <- sapp(sd, function(i) 2 * mean(i))
```

sbar

*scale bar***Description**

Add a scale bar to a map

Usage

```
sbar(d, xy=NULL, type="line", divs=2, below="", lonlat=NULL, labels,
adj=c(0.5, -1), lwd=2, xpd=TRUE, ticks=FALSE, scaleby=1, halo=TRUE,
col="black", fill=c("black", "white"), border="black", bg=NULL, ...)
```

Arguments

d	numeric. Distance covered by the scale bar. It should be in the units of the coordinates of the plot (map), or in km for angular (longitude/latitude) coordinates; see argument lonlat. It can also be missing
xy	numeric. x and y coordinates to place the scale bar. It can also be one of following character values: "bottomleft", "bottom", "bottomright", "topleft", "top", "topright", "left", "right", or NULL
type	one of "line" or "bar"
divs	number of divisions for a bar: 2 or 4
below	character. Text to go below the scale bar (e.g., "kilometers")
lonlat	logical or NULL. If logical, TRUE indicates if the plot is using longitude/latitude coordinates. If NULL this is guessed from the plot's coordinates
labels	vector of three numbers to label the scale bar (beginning, midpoint, end)
adj	adjustment for text placement
lwd	line width for the "line" type of the scale bar
xpd	logical. If TRUE, the scale bar can be outside the plotting area
ticks	logical or numeric. If not FALSE, tick marks are added to a "line" scale bar. The length of the tick marks can be specified
scaleby	numeric. If labels is not provided. The labels are divided by this number. For example, use 1000 to go from m to km
halo	logical. If TRUE the "line" type scale bar gets a white background

col	the font color for the labels
fill	the fill color(s) for the bar
border	the color of the border around the bar
bg	background color behind the scale bar (e.g. "white" or <code>rgb(1,1,1,0.7)</code>) for visibility on complex maps. Default is NULL (no background)
...	graphical arguments to be passed to other methods

Value

none

See Also

[north](#), [plot](#), [inset](#)

Examples

```
f <- system.file("ex/meuse.tif", package="terra")
r <- rast(f)
plot(r)
sbar()
sbar(1000, xy=c(178500, 333500), type="bar", divs=4, cex=.8)
sbar(1000, xy="bottomright", divs=3, cex=.8, ticks=TRUE)
```

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
plot(r, type="interval")
sbar(20, c(6.2, 50.1), type="bar", cex=.8, divs=4)
sbar(15, c(6.3, 50), type="bar", below="km", label=c(0,7.5,15), cex=.8)
sbar(15, c(6.6, 49.8), cex=.8, label=c(0,"km",15))
sbar(15, c(6.6, 49.7), cex=.8, label="15 kilometer", lwd=5)
sbar(15, c(6.6, 49.6), divs=4, cex=.8, below="km")
```

scale

Scale values

Description

Center and/or scale raster data. For details see [scale](#)

Usage

```
## S4 method for signature 'SpatRaster'
scale(x, center=TRUE, scale=TRUE)
```

Arguments

x	SpatRaster
center	logical or numeric. If TRUE, centering is done by subtracting the layer means (omitting NAs), and if FALSE, no centering is done. If center is a numeric vector (recycled to nlyr(x)), then each layer of x has the corresponding value from center subtracted from it.
scale	logical or numeric. If TRUE, scaling is done by dividing the (centered) layers of x by their standard deviations if center is TRUE, and the root mean square otherwise. If scale is FALSE, no scaling is done. If scale is a numeric vector (recycled to nlyr(x)), each layer of x is divided by the corresponding value. Scaling is done after centering.

Value

SpatRaster

See Also

[scale_linear](#)

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
s <- scale(r)

## the equivalent, computed in steps
m <- global(r, "mean")
rr <- r - m[,1]
rms <- global(rr, "rms")
ss <- rr / rms[,1]
```

scale_linear

Scale values linearly

Description

Linear scaling of raster cell values between a specified minimum and maximum value.

Usage

```
## S4 method for signature 'SpatRaster'
scale_linear(x, min=0, max=1, filename="", ...)
```

Arguments

x	SpatRaster
min	minimum value to scale to
max	maximum value to scale to
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[scale](#)

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
s1 <- scale_linear(r)
s2 <- scale_linear(r, 1, 10)
```

scatterplot

Scatterplot of two SpatRaster layers

Description

Scatterplot of the values of two SpatRaster layers

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
plot(x, y, maxcell=100000, warn=TRUE, nc, nr,
     maxnl=16, smooth=FALSE, gridded=FALSE, ncol=25, nrow=25, ...)
```

Arguments

x	SpatRaster
y	SpatRaster
maxcell	positive integer. Maximum number of cells to use for the plot
nc	positive integer. Optional. The number of columns to divide the plotting device in (when plotting multiple layers)
nr	positive integer. Optional. The number of rows to divide the plotting device in (when plotting multiple layers)
maxnl	positive integer. Maximum number of layers to plot (for multi-layer objects)

smooth	logical. If TRUE show a smooth scatterplot (see smoothScatter)
gridded	logical. If TRUE the scatterplot is gridded (counts by cells)
warn	boolean. Show a warning if a sample of the pixels is used (for scatterplot only)
ncol	positive integer. Number of columns for gridding
nrow	positive integer. Number of rows for gridding
...	additional graphical arguments

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
plot(s[[1]], s[[2]])
plot(s, sqrt(s[[3:1]]))
```

scoff	<i>Scale (gain) and offset</i>
-------	--------------------------------

Description

These functions can be used to get or set the scale (gain) and offset parameters used to transform values when reading raster data from a file. The parameters are applied to the raw values using the formula below:

$$\text{value} \leftarrow \text{value} * \text{scale} + \text{offset}$$

The default value for scale is 1 and for offset is 0. 'scale' is sometimes referred to as 'gain'.

Note that setting the scale and/or offset are intended to be used with values that are stored in a file. When values are memory, assigning scale or offset values will lead to the immediate computation of new values; in such cases it would be clearer to use [Arith-methods](#).

Usage

```
## S4 method for signature 'SpatRaster'
scoff(x)

## S4 replacement method for signature 'SpatRaster'
scoff(x)<-value
```

Arguments

x	SpatRaster
value	two-column matrix with scale (first column) and offset (second column) for each layer. Or NULL to remove all scale and offset values

Value

matrix or changed SpatRaster

Examples

```

r <- rast(system.file("ex/elev.tif", package="terra"))
minmax(r)
scoff(r)
r[4603]

scoff(r) <- cbind(10, 5)
minmax(r)
scoff(r)
r[4603]

```

sds

*Create a SpatRasterDataset***Description**

Methods to create a `SpatRasterDataset`. This is an object to hold "sub-datasets", each represented by a `SpatRaster` that may have multiple layers. All sub-datasets must have the same raster geometry (extent and resolution). You can use a `SpatRasterCollection` (see [sprc](#)) to combine `SpatRasters` with different geometries.

See [describe](#) for getting information about the sub-datasets present in a file.

Usage

```

## S4 method for signature 'missing'
sds(x)

## S4 method for signature 'character'
sds(x, ids=0, opts=NULL, raw=FALSE, noflip=FALSE, guessCRS=TRUE, domains="", md=FALSE)

## S4 method for signature 'SpatRaster'
sds(x, ...)

## S4 method for signature 'list'
sds(x)

## S4 method for signature 'array'
sds(x, crs="", extent=NULL)

```

Arguments

<code>x</code>	character (filename), or <code>SpatRaster</code> , or list of <code>SpatRasters</code> , or missing. If multiple filenames are provided, it is attempted to make <code>SpatRasters</code> from these, and combine them into a <code>SpatRasterDataset</code>
<code>ids</code>	optional. vector of integer subdataset ids. Ignored if the first value is not a positive integer
<code>opts</code>	character. GDAL dataset open options

<code>raw</code>	logical. If TRUE, scale and offset values are ignored
<code>noflip</code>	logical. If TRUE, a raster (e.g. JPEG image) that is not georeferenced and that GDAL assigns a flipped extent to (<code>y_{max} < y_{min}</code>), is not considered flipped. This avoids the need to flip the raster vertically
<code>guessCRS</code>	logical. If TRUE and the file does not specify a CRS but has an extent that is within longitude/latitude bounds, the longitude/latitude crs is assigned to the <code>SpatRaster</code>
<code>domains</code>	character. Metadata domains to read (see metags to retrieve their values if there are any). "" is the default domain
<code>md</code>	logical. If TRUE, the multi-dimensional GDAL API is used for reading the file. This API can only be used for a few file formats (netCDF/HDF5) and can sometimes provide notably faster reading of data with many (time) steps in the third or higher dimension. If no subdataset is selected with <code>subds</code> , all usable arrays are combined into one <code>SpatRaster</code> (like <code>md=FALSE</code>); a warning reports how many variables and layers were combined when there is more than one variable.
<code>crs</code>	character. Description of the Coordinate Reference System (map projection) in PROJ.4, WKT or <code>authority:code</code> notation. If this argument is missing, and the x coordinates are within -360 .. 360 and the y coordinates are within -90 .. 90, longitude/latitude is assigned
<code>extent</code>	SpatExtent
<code>...</code>	additional <code>SpatRaster</code> objects

Value

`SpatRasterDataset`

See Also

[sprc](#), [describe](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
x <- sds(s, s/2)
names(x) <- c("first", "second")
x
length(x)

# extract the second SpatRaster
x[2]

a <- array(1:9, c(3,3,3,3))
sds(a)
```

segregate	<i>segregate</i>
-----------	------------------

Description

Create a `SpatRaster` with a layer for each class (value, or subset of the values) in the input `SpatRaster`. For example, if the input has vegetation types, this function will create a layer (presence/absence; dummy variable) for each of these classes.

This is called "one-hot encoding" or "dummy encoding" (for a dummy encoding scheme you can remove (any) one of the output layers as it is redundant).

Usage

```
## S4 method for signature 'SpatRaster'
segregate(x, classes=NULL, keep=FALSE, other=0, round=FALSE, digits=0, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>classes</code>	numeric. The values (classes) for which layers should be made. If <code>NULL</code> all classes are used
<code>keep</code>	logical. If <code>TRUE</code> , cells that are of the class represented by a layer get that value, rather than a value of 1
<code>other</code>	numeric. Value to assign to cells that are not of the class represented by a layer
<code>round</code>	logical. Should the values be rounded first?
<code>digits</code>	integer. Number of digits to round the values to
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[split](#)

Examples

```
r <- rast(nrows=5, ncols=5)
values(r) <- rep(c(1:4, NA), each=5)
b <- segregate(r)
bb <- segregate(r, keep=TRUE, other=NA)
```

sel *Spatial selection*

Description

Geometrically subset `SpatRaster` or `SpatVector` (to be done) by drawing on a plot (map).

Note that for many installations this does to work well on the default RStudio plotting device. To work around that, you can first run `dev.new(noRStudioGD = TRUE)` which will create a separate window for plotting, then use `plot()` followed by `sel()` and click on the map. It may also help to set your RStudio "Tools/Global Options/Appearance/Zoom" to 100

Usage

```
## S4 method for signature 'SpatRaster'
sel(x, ...)

## S4 method for signature 'SpatVector'
sel(x, use="rec", show=TRUE, col="cyan", draw=TRUE, ...)
```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
use	character indicating what to draw. One of "rec" (rectangle) or "pol" (polygon)
show	logical. If TRUE the selected geometries are shown on the map
col	color to be used for drawing if draw=TRUE
draw	logical. If TRUE the area drawn to select geometries is shown on the map
...	additional graphics arguments for drawing the selected geometries

Value

`SpatRaster` or `SpatVector`

See Also

[crop](#) and [intersect](#) to make an intersection and [click](#) and [text](#) to see cell values or geometry attributes.

Use [draw](#) to draw a `SpatExtent` of `SpatVector` that you want to keep.

Examples

```
## Not run:
# select a subset of a SpatRaster
r <- rast(nrows=10, ncols=10)
values(r) <- 1:ncell(r)
plot(r)
s <- sel(r) # now click on the map twice
```

```

# plot the selection on a new canvas:
x11()
plot(s)

# vector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
plot(v)
x <- sel(v) # now click on the map twice
x

## End(Not run)

```

selectHighest	<i>select cells with high or low values</i>
---------------	---

Description

Identify *n* cells that have the highest or lowest values in the first layer of a `SpatRaster`.

Usage

```

## S4 method for signature 'SpatRaster'
selectHighest(x, n, low=FALSE)

```

Arguments

<code>x</code>	<code>SpatRaster</code> . Only the first layer is processed
<code>n</code>	The number of cells to select
<code>low</code>	logical. If <code>TRUE</code> , the lowest values are selected instead of the highest values

Value

`SpatRaster`

Examples

```

f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- selectHighest(r, 1000)
y <- selectHighest(r, 1000, TRUE)

m <- merge(y-1, x)
levels(m) <- data.frame(id=0:1, elevation=c("low", "high"))
plot(m)

```

selectRange	<i>Select the values of a range of layers, as specified by cell values in another SpatRaster</i>
-------------	--

Description

Use a single layer SpatRaster to select cell values from different layers in a multi-layer SpatRaster. The values of the SpatRaster to select layers (y) should be whole numbers between 1 and nlyr(x) (values outside this range are ignored).

See [rapp](#) for applying a function to a range of variable size.

See [extract](#) for extraction of values by cell, point, or otherwise.

Usage

```
## S4 method for signature 'SpatRaster'
selectRange(x, y, z=1, repint=0, filename="", ...)
```

Arguments

x	SpatRaster
y	SpatRaster. Cell values must be positive integers. They indicate the first layer to select for each cell
z	positive integer. The number of layers to select
repint	integer > 1 and < nlyr(x) allowing for repeated selection at a fixed interval. For example, if x has 36 layers, and the value of a cell in y=2 and repint = 12, the values for layers 2, 14 and 26 are returned
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rapp](#), [tapp](#), [extract](#)

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1
s <- c(r, r+2, r+5)
s <- c(s, s)
set.seed(1)
values(r) <- sample(3, ncell(r), replace=TRUE)
x <- selectRange(s, r)
```

```
x <- selectRange(s, r, 3)
```

serialize	<i>saveRDS and serialize for SpatVector and SpatRaster*</i>
-----------	---

Description

serialize and saveRDS for SpatVector, SpatRaster, SpatRasterDataset and SpatRasterCollection. Note that these objects will first be "packed" with [wrap](#), and after unserialize/readRDS they need to be unpacked with [rast](#) or [vect](#).

Extensive use of these functions is not recommended. Especially for SpatRaster it is generally much more efficient to use [writeRaster](#) and write, e.g., a GTiff file.

Usage

```
## S4 method for signature 'SpatRaster'
saveRDS(object, file="", ascii = FALSE, version = NULL, compress=TRUE, refhook = NULL)

## S4 method for signature 'SpatRasterDataset'
saveRDS(object, file="", ascii = FALSE, version = NULL, compress=TRUE, refhook = NULL)

## S4 method for signature 'SpatRasterCollection'
saveRDS(object, file="", ascii = FALSE, version = NULL, compress=TRUE, refhook = NULL)

## S4 method for signature 'SpatVector'
saveRDS(object, file="", ascii = FALSE, version = NULL, compress=TRUE, refhook = NULL)

## S4 method for signature 'SpatRaster'
serialize(object, connection, ascii = FALSE, xdr = TRUE, version = NULL, refhook = NULL)

## S4 method for signature 'SpatVector'
serialize(object, connection, ascii = FALSE, xdr = TRUE, version = NULL, refhook = NULL)
```

Arguments

object	SpatVector, SpatRaster, SpatRasterDataset or SpatRasterCollection
file	file name to save object to
connection	see serialize
ascii	see serialize or saveRDS
version	see serialize or saveRDS
compress	see serialize or saveRDS
refhook	see serialize or saveRDS
xdr	see serialize or saveRDS

Value

Packed* object

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
p <- serialize(v, NULL)
head(p)
x <- unserialize(p)
x
```

setValues

Set the values of raster cells or of geometry attributes

Description

Set cell values of a SpatRaster or the attributes of a SpatVector. For large SpatRasters use [init](#) instead to set values.

Usage

```
## S4 replacement method for signature 'SpatRaster,ANY'
values(x)<-value

## S4 method for signature 'SpatRaster,ANY'
setValues(x, values, keeptime=TRUE, keepunits=TRUE, keepnames=FALSE, props=FALSE)

## S4 replacement method for signature 'SpatVector,ANY'
values(x)<-value
```

Arguments

x	SpatRaster or SpatVector
value	For SpatRaster: numeric, matrix or data.frame. The length of the numeric values must match the total number of cells (<code>ncell(x) * nlyr(x)</code>), or be a single value. The number of columns of the matrix or data.frame must match the number of layers of x, and the number of rows must match the number of cells of x. It is also possible to use a matrix with the same number of rows as x and the number of columns that matches <code>ncol(x) * nlyr(x)</code> . For SpatVector: data.frame, matrix, vector, or NULL
values	Same as for value
keeptime	logical. If TRUE the time stamps are kept
keepunits	logical. If FALSE the units are discarded
keepnames	logical. If FALSE the layer names are replaced by the column names in y (if present)
props	logical. If TRUE the properties (categories and color-table) are kept

Value

The same object type as `x`

See Also

[values](#), [init](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- setValues(r, 1:ncell(r))
x
values(x) <- runif(ncell(x))
x
head(x)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
values(v) <- data.frame(ID=1:12, name=letters[1:12])
head(v)
```

shade

Hill shading

Description

Compute hill-shade from slope and aspect layers (both in radians). Slope and aspect can be computed with function [terrain](#).

A hill-shade layer is often used as a backdrop on top of which another, semi-transparent, layer is drawn.

Usage

```
shade(slope, aspect, angle=45, direction=0, normalize=FALSE,
      filename="", overwrite=FALSE, ...)
```

Arguments

<code>slope</code>	SpatRaster with slope values (in radians)
<code>aspect</code>	SpatRaster with aspect values (in radians)
<code>angle</code>	The elevation angle(s) of the light source (sun), in degrees
<code>direction</code>	The direction (azimuth) angle(s) of the light source (sun), in degrees
<code>normalize</code>	Logical. If TRUE, values below zero are set to zero and the results are multiplied with 255
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, filename is overwritten
<code>...</code>	additional arguments for writing files as in writeRaster

References

Horn, B.K.P., 1981. Hill shading and the reflectance map. Proceedings of the IEEE 69(1):14-47

See Also

[terrain](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
# disaggregating because the resolution of this raster is a bit low
# you generally should not do that with your own data
r <- disagg(r, 10, method="bilinear")

slope <- terrain(r, "slope", unit="radians")
aspect <- terrain(r, "aspect", unit="radians")
hill <- shade(slope, aspect, 40, 270)
plot(hill, col=grey(0:100/100), legend=FALSE, mar=c(2,2,1,4))
plot(r, col=rainbow(25, alpha=0.35), add=TRUE)

# A better hill shade may be achieved by combining
# different angles and directions. For example
hh <- shade(slope, aspect, angle=30, direction=c(225, 270, 315, 360))
h1 <- Reduce(mean, hh)
h2 <- mean(hh)
```

sharedPaths

Shared paths

Description

Get shared paths of line or polygon geometries. This can be for geometries in a single SpatVector, or between two SpatVectors

Usage

```
## S4 method for signature 'SpatVector'
sharedPaths(x, y=NULL)
```

Arguments

x	SpatVector of lines or polygons
y	missing or SpatVector of lines or polygons

Value

SpatVector

See Also[gaps](#), [topology](#)**Examples**

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
plot(v, col="light gray")
text(v, halo=TRUE)

x <- sharedPaths(v)
lines(x, col="red", lwd=2)
text(x, col="blue", halo=TRUE, cex=0.8)
head(x)

z <- sharedPaths(v[3,], v[12,])
```

 shift
*Shift***Description**

Shift a `SpatRaster`, `SpatVector` or `SpatExtent` to another location.

Usage

```
## S4 method for signature 'SpatRaster'
shift(x, dx=0, dy=0, filename="", ...)

## S4 method for signature 'SpatVector'
shift(x, dx=0, dy=0)

## S4 method for signature 'SpatExtent'
shift(x, dx=0, dy=0)
```

Arguments

<code>x</code>	<code>SpatRaster</code> , <code>SpatVector</code> or <code>SpatExtent</code>
<code>dx</code>	numeric. The shift in horizontal direction
<code>dy</code>	numeric. The shift in vertical direction
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

Same as `x`

See Also[flip, rotate](#)**Examples**

```
r <- rast(xmin=0, xmax=1, ymin=0, ymax=1)
r <- shift(r, dx=1, dy=-1)
```

```
e <- ext(r)
shift(e, 5, 5)
```

sieve

Sieve filter

Description

Apply a sieve filter. That is, remove "noise", by changing small clumps of cells with a value that is different from the surrounding cells, to the value of the largest neighboring clump.

Note that the numerical input values are truncated to integers.

Usage

```
## S4 method for signature 'SpatRaster'
sieve(x, threshold, directions=8, filename="", ...)
```

Arguments

x	SpatRaster, single layer with integer or categorical values
threshold	positive integer. Only clumps smaller than this threshold will be removed
directions	numeric to indicate which cells are connected. Either 4 to only consider the horizontal and vertical neighbors ("rook"), or 8 to consider the vertical, horizontal and diagonal neighbors
filename	character. Output filename
...	Options for writing files as in writeRaster

See Also[focal](#)

Examples

```
r <- rast(nrows=18, ncols=18, xmin=0, vals=0, crs="local")
r[2, 5] <- 1
r[5:8, 2:3] <- 2
r[7:12, 10:15] <- 3
r[15:16, 15:18] <- 4
freq(r, bylayer=FALSE)

x <- sieve(r, 8)
y <- sieve(r, 9)
```

simplifyGeom

simplifyGeom geometries

Description

Reduce the number of nodes used to represent geometries.

Usage

```
## S4 method for signature 'SpatVector'
simplifyGeom(x, tolerance=0.1, preserveTopology=TRUE, makeValid=TRUE)
```

Arguments

x	SpatVector of lines or polygons
tolerance	numeric. The minimum distance between nodes in units of the crs (i.e. degrees for long/lat)
preserveTopology	logical. If TRUE the topology of output geometries is preserved
makeValid	logical. If TRUE, makeValid is run after simplification to assure that the output polygons are valid

Value

SpatVector

See Also

[densify](#), [sharedPaths](#), [gaps](#), [is.valid](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- simplifyGeom(v, .02, makeValid=FALSE)
e <- erase(w)
g <- gaps(e)
plot(e, lwd=5, border="light gray")
polys(g, col="red", border="red")
```

 sort

Sort a SpatRaster or SpatVector

Description

Sort the cell values of a SpatRaster across layers. You can also compute the sorting order.

Or sort the records of SpatVector (or data.frame) by specifying the column number(s) or names(s) to sort on.

Usage

```
## S4 method for signature 'SpatRaster'
sort(x, decreasing=FALSE, order=FALSE, filename="", ...)

## S4 method for signature 'SpatVector'
sort(x, v, decreasing=FALSE)
```

Arguments

x	SpatRaster
decreasing	logical. If TRUE, sorting is in decreasing order
order	logical. If TRUE the sorting order is returned instead of the sorted values
filename	character. Output filename
...	additional arguments for writing files as in writeRaster
v	character or numeric indicating the column(s) to sort on

Value

SpatRaster

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
r <- c(r, r/2, r*2)
sort(r)

ord <- sort(r, order=TRUE)
# these two are the same
ord[[1]]
which.min(r)
```

sources

*Data sources of a SpatRaster***Description**

Get the data sources of a SpatRaster or SpatVector or related object. Sources are either files (or similar resources) or "", meaning that they are in memory. You can use hasValues to check if in-memory layers actually have cell values.

Usage

```
## S4 method for signature 'SpatRaster'
sources(x, nlyr=FALSE, bands=FALSE)

## S4 method for signature 'SpatVector'
sources(x)

## S4 method for signature 'SpatRaster'
hasValues(x)

## S4 method for signature 'SpatRaster'
inMemory(x, bylayer=FALSE)
```

Arguments

x	SpatRaster, SpatRasterCollection, SpatVector or SpatVectorProxy
nlyr	logical. If TRUE for each source, the number of layers is returned
bands	logical. If TRUE for each source, the "bands" used, that is, the layer number in the source file, are returned
bylayer	logical. If TRUE a value is returned for each layer instead of for each source

Value

A vector of filenames, or "" when there is no filename, if nlyr and bands are both FALSE. Otherwise a data.frame

See Also

[toMemory](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
s <- rast(r)
values(s) <- 1:ncell(s)
rs <- c(r,r,s,r)
sources(rs)
hasValues(r)
x <- rast()
hasValues(x)
```

SpatExtent-class

Class "SpatExtent"

Description

Objects of class `SpatExtent` are used to define the spatial extent (extremes) of objects of the `SpatRaster` class.

Objects from the Class

You can use the `ext` function to create `SpatExtent` objects, or to extract them from a `SpatRaster`, `SpatVector` or related objects.

Methods

`show` display values of a `SpatExtent` object

Examples

```
e <- ext(-180, 180, -90, 90)
e
```

SpatRaster-class	<i>SpatRaster class</i>
------------------	-------------------------

Description

A `SpatRaster` represents a rectangular part of the world that is sub-divided into rectangular cells of equal area (in terms of the units of the coordinate reference system). For each cell can have multiple values ("layers").

An object of the `SpatRaster` class can point to one or more files on disk that hold the cell values, and/or it can hold these values in memory. These objects can be created with the `rast` method.

A `SpatRasterDataset` is a collection of sub-datasets, where each is a `SpatRaster` for the same area (extent) and coordinate reference system, but possibly with a different resolution. Sub-datasets are often used to capture variables (e.g. temperature and precipitation), or a fourth dimension (e.g. height, depth or time) if the sub-datasets already have three dimensions (multiple layers).

A `SpatRasterCollection` is a collection of `SpatRasters` with no restriction in the extent or other geometric parameters.

Examples

```
rast()
```

spatSample	<i>Take a regular sample</i>
------------	------------------------------

Description

Take a spatial sample from a `SpatRaster`, `SpatVector` or `SpatExtent`. Sampling a `SpatVector` or `SpatExtent` always returns a `SpatVector` of points.

With a `SpatRaster`, you can get cell values, cell numbers (`cells=TRUE`), coordinates (`xy=TRUE`) or (when `method="regular"` and `as.raster=TRUE`) get a new `SpatRaster` with the same extent, but fewer cells.

In order to assure regularity when requesting a regular sample, the number of cells or points returned may not be exactly the same as the size requested unless you use `exact=TRUE` (and do not use `na.rm=TRUE`). Alternatively, use `method="spread"` to get an approximately regular sample for the cells that are not NA.

Usage

```
## S4 method for signature 'SpatRaster'
spatSample(x, size, method="random", replace=FALSE, na.rm=FALSE,
  as.raster=FALSE, as.df=TRUE, as.points=FALSE, as.mask=FALSE, values=hasValues(x),
  cells=FALSE, xy=FALSE, ext=NULL, warn=TRUE, weights=NULL, exp=5, exhaustive=FALSE,
  exact=FALSE, each=TRUE, ...)
```

```
## S4 method for signature 'SpatVector'
spatSample(x, size, method="random", strata=NULL, chess="")

## S4 method for signature 'SpatExtent'
spatSample(x, size, method="random", lonlat, as.points=FALSE, exact=FALSE)
```

Arguments

x	SpatRaster, SpatVector or SpatExtent
size	numeric. The sample size. If x is a SpatVector, you can also provide a vector of the same length as x in which case sampling is done separately for each geometry. If x is a SpatRaster, and you are using method="regular" you can specify the size as two numbers (number of rows and columns). Note that when using method="stratified", the sample size is returned for each stratum
method	character. Should be one of "regular", "random", or, if x is a SpatRaster, "stratified" (each value in x is a stratum), "weights" (each value in x is a probability weight), or "spread" (an approximately regular sample, using compact zones generated with k_means clustering of the raster cell locations)
replace	logical. If TRUE, sampling is with replacement (if method="random")
na.rm	logical. If TRUE, NAs are removed. Not used with method="spread" or as.raster=TRUE
as.raster	logical. If TRUE, a SpatRaster is returned
as.df	logical. If TRUE, a data.frame is returned instead of a matrix
as.points	logical. If TRUE, a SpatVector of points is returned
as.mask	logical. If TRUE x is returned, with its values "masked" by the sample. That is, only cells that are included in the sample retain their values
values	logical. If TRUE raster cell values are returned
cells	logical. If TRUE, cell numbers are returned. If method="stratified" this is always set to TRUE if xy=FALSE
xy	logical. If TRUE, cell coordinates are returned
ext	SpatExtent or NULL to restrict sampling to a subset of the area of x
warn	logical. Give a warning if the sample size returned is smaller than requested
weights	SpatRaster. Used to provide weights when method="stratified"
lonlat	logical. If TRUE, sampling of a SpatExtent is weighted by cos(latitude). For SpatRaster and SpatVector this done based on the crs , but it is ignored if as.raster=TRUE
exp	numeric >= 1. "Expansion factor" that is multiplied with size to get an initial sample used for stratified samples and random samples with na.rm=TRUE to try to get at least size samples
exhaustive	logical. If TRUE and (method=="random" and na.rm=TRUE) or method=="stratified", all cells that are not NA are determined and a sample is taken from these cells. This is useful when you are dealing with a very large raster that is sparse (most cells are NA). Otherwise, the default approach may not find enough samples. This should not be used in other cases, especially not with large rasters that mostly have values

exact	logical. If TRUE and method=="regular", the sample returned is exactly size, perhaps at the expense of some regularity. Otherwise you get at least size many samples. Ignored for lon/lat rasters
each	logical. If TRUE and method=="stratified", the sample returned is size for each stratum. Otherwise size is the total sample size
...	additional arguments passed to <code>k_means</code> when method="kmeans"
strata	if not NULL, stratified random sampling is done, taking size samples from each stratum. If x has polygon geometry, strata must be a field name (or index) in x. If x has point geometry, strata can be a SpatVector of polygons or a SpatRaster
chess	character. One of "", "white", or "black". For stratified sampling if strata is a SpatRaster. If not "", samples are only taken from alternate cells, organized like the "white" or "black" fields on a chessboard

Value

numeric matrix, data.frame, SpatRaster or SpatVector

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
s <- spatSample(r, 10, as.raster=TRUE)
spatSample(r, 5)
spatSample(r, 5, na.rm=TRUE)
spatSample(r, 5, "regular")

## if you require cell numbers and/or coordinates
size <- 6
spatSample(r, 6, "random", cells=TRUE, xy=TRUE, values=FALSE)

# regular, with values
spatSample(r, 6, "regular", cells=TRUE, xy=TRUE)

# stratified
rr <- rast(ncol=10, nrow=10, names="stratum")
set.seed(1)
values(rr) <- round(runif(ncell(rr), 1, 3))
spatSample(rr, 2, "stratified", xy=TRUE)

s <- spatSample(rr, 5, "stratified", as.points=TRUE, each=FALSE)
plot(rr, plg=list(title="raster"))
plot(s, 1, add=TRUE, plg=list(x=185, y=1, title="points"), col=rainbow(5))

# spread
s <- spatSample(r, 10, "spread", as.points=TRUE)
plot(r); points(s)

## SpatExtent
e <- ext(r)
spatSample(e, 10, "random", lonlat=TRUE)
```

```
## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

# sample the geometries
i <- sample(v, 3)

# sample points in geometries
p <- spatSample(v, 3)
```

SpatVector-class *Class "SpatVector"*

Description

SpatVector can represent points, lines or polygons.
 SpatVectorCollection can hold a collection of SpatVectors
 SpatVectorProxy is a SpatVector for which the data are on-disk in-stead of in memory.

spin *spin a SpatVector*

Description

Spin (rotate) the geometry of a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
spin(x, angle, x0, y0)
```

Arguments

x	SpatVector
angle	numeric. Angle of rotation in degrees
x0	numeric. x-coordinate of the center of rotation. If missing, the center of the extent of x is used
y0	numeric. y-coordinate of the center of rotation. If missing, the center of the extent of x is used

Value

SpatVector

See Also

[rescale](#), [t](#), [shift](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- spin(v, 180)
plot(v)
lines(w, col="red")

# lower-right corner as center
e <- as.vector(ext(v))
x <- spin(v, 45, e[1], e[3])
```

split

Split a SpatRaster or SpatVector

Description

Split a SpatRaster by layer, or a SpatVector by attributes. You can also split the geometry of a SpatVector of polygon or lines with another SpatVector of polygon or lines.

Usage

```
## S4 method for signature 'SpatRaster,ANY'
split(x, f)
```

```
## S4 method for signature 'SpatVector,ANY'
split(x, f)
```

```
## S4 method for signature 'SpatVector,SpatVector'
split(x, f, min_node_dist=10000)
```

Arguments

x	SpatRaster or SpatVector
f	If x is a SpatRaster: a vector of the length <code>nlyr(x)</code> . If x is a SpatVector: one or more variable names, or a vector of the same length as x, or a list of such vectors. If x is a SpatVector of polygons, you can also use a SpatVector of lines or polygons to split the polygon geometries
min_node_dist	positive number indicating the minimum node distance to use (in m) for longitude/latitude data. To ensure this minimum distance between nodes, additional nodes are added as needed, to improve precision. See densify

Value

list or SpatVector

See Also

[segregate](#)

Examples

```
## split layers
s <- rast(system.file("ex/logo.tif", package="terra"))
y <- split(s, c(1,2,1))
sds(y)

## split attributes
v <- vect(system.file("ex/lux.shp", package="terra"))
x <- split(v, "NAME_1")

## split geometries
v <- v[1:5,]
line <- vect(matrix(c(5.79, 6.22, 5.75, 6.1, 5.8,
50.14, 50.05, 49.88, 49.85, 49.71), ncol=2), "line")
s <- split(v, line)
```

sprc

Create a SpatRasterCollection

Description

Methods to create a SpatRasterCollection. This is an object to hold a collection (list) of SpatRasters. There are no restrictions on the similarity of the SpatRaster geometry.

They can be used to combine several SpatRasters to be used with [merge](#) or [mosaic](#)

You can create a SpatRasterCollection from a file with subdatasets.

Usage

```
## S4 method for signature 'character'
sprc(x, ids=0, opts=NULL, raw=FALSE, noflip=FALSE, guessCRS=TRUE, domains="")

## S4 method for signature 'SpatRaster'
sprc(x, ...)

## S4 method for signature 'list'
sprc(x)

## S4 method for signature 'missing'
sprc(x)
```

Arguments

<code>x</code>	SpatRaster, list with SpatRasters, missing, or filename
<code>ids</code>	optional. vector of integer subdataset ids. Ignored if the first value is not a positive integer
<code>opts</code>	character. GDAL dataset open options
<code>raw</code>	logical. If TRUE, scale and offset values are ignored
<code>noflip</code>	logical. If TRUE, a raster (e.g. JPEG image) that is not georeferenced and that GDAL assigns a flipped extent to ($y_{max} < y_{min}$), is not considered flipped. This avoids the need to flip the raster vertically
<code>guessCRS</code>	logical. If TRUE and the file does not specify a CRS but has an extent that is within longitude/latitude bounds, the longitude/latitude crs is assigned to the SpatRaster
<code>domains</code>	character. Metadata domains to read (see metags to retrieve their values if there are any. "" is the default domain
<code>...</code>	additional SpatRasters

Value

SpatRasterCollection

See Also

[sds](#)

Examples

```
x <- rast(xmin=-110, xmax=-50, ymin=40, ymax=70, ncols=60, nrows=30)
y <- rast(xmin=-80, xmax=-20, ymax=60, ymin=30)
res(y) <- res(x)
values(x) <- 1:ncell(x)
values(y) <- 1:ncell(y)

z <- sprc(x, y)
z
```

stretch

Stretch

Description

Linear or histogram equalization stretch of values in a SpatRaster.

For linear stretch, provide the desired output range ($minv$ and $maxv$) and the lower and upper bounds in the original data, either as quantiles ($minq$ and $maxq$, or as cell values ($smin$ and $smax$). If $smin$ and $smax$ are both not NA, $minq$ and $maxq$ are ignored.

For histogram equalization, these arguments are ignored, but you can provide the desired scale of the output and the maximum number of cells that is used to compute the histogram (empirical cumulative distribution function).

Usage

```
## S4 method for signature 'SpatRaster'
stretch(x, minv=0, maxv=255, minq=0, maxq=1, smin=NA, smax=NA,
histeq=FALSE, scale=1, maxcell=500000, bylayer=TRUE, filename="", ...)
```

Arguments

x	SpatRaster
minv	numeric ≥ 0 and smaller than maxv. lower bound of stretched value
maxv	numeric ≤ 255 and larger than minv. upper bound of stretched value
minq	numeric ≥ 0 and smaller than maxq. lower quantile bound of original value. Ignored if smin is supplied
maxq	numeric ≤ 1 and larger than minq. upper quantile bound of original value. Ignored if smax is supplied
smin	numeric $< smax$. user supplied lower value for the layers, to be used instead of a quantile computed by the function itself
smax	numeric $> smin$. user supplied upper value for the layers, to be used instead of a quantile computed by the function itself
histeq	logical. If TRUE histogram equalization is used instead of linear stretch
scale	numeric. The scale (maximum value) of the output if histeq=TRUE
maxcell	positive integer. The size of the regular sample used to compute the histogram or quantiles
bylayer	logical. If TRUE stretching is done for each layer individually
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
r <- rast(nc=10, nr=10)
values(r) <- rep(1:25, 4)
rs <- stretch(r)
s <- c(r, r*2)
sr <- stretch(s)
```


Examples

```

### SpatRaster
s <- rast(system.file("ex/logo.tif", package="terra"))
subset(s, 2:3)
subset(s, c(3,2,3,1))

#equivalent to
s[[ c(3,2,3,1) ]]

s[[c("red", "green")]]
s$red

# expression based (partial) matching of names with single brackets
s["re"]
s["^re"]

# not with double brackets
# s[["re"]]

### SpatVector

v <- vect(system.file("ex/lux.shp", package="terra"))

subset(v, v$NAME_1 == "Diekirch", c("NAME_1", "NAME_2"))

subset(v, NAME_1 == "Diekirch", c(NAME_1, NAME_2), NSE=TRUE)

# or like this
v[2:3,]
v[1:2, 2:3]
v[1:2, c("NAME_1", "NAME_2")]

# or by location, i.e. by spatial overlap with another object
poly <- as.polygons(ext(6, 6.4, 49.75, 50))
subset(v, poly)
v[poly]

```

subset_dollar

Subset a SpatRaster or a SpatVector

Description

Select a subset of layers from a SpatRaster or select a subset of records (row) and/or variables (columns) from a SpatVector.

Usage

```

## S4 method for signature 'SpatExtent'
x$name

```

Arguments

x	SpatRaster, SpatVector or SpatExtent
name	character. If x is a SpatRaster: layer name. If x is a SpatVector: variable name. If x is a SpatExtent: xmin, xmax, ymin or ymax

Value

if x is a SpatRaster: SpatRaster

if x is a SpatVector: SpatVector or, if drop=TRUE, a data.frame.

See Also

[subset](#), [\[](#), [\[\[](#), [extract](#)

Examples

```
### SpatRaster
s <- rast(system.file("ex/logo.tif", package="terra"))
subset(s, 2:3)
subset(s, c(3,2,3,1))
#equivalent to
s[[ c(3,2,3,1) ]]

s[[c("red", "green")]]
s$red

# expression based (partial) matching of names with single brackets
s["re"]
s["^re"]

# not with double brackets
# s[["re"]]

### SpatVector

v <- vect(system.file("ex/lux.shp", package="terra"))
v[2:3,]
v[1:2, 2:3]

subset(v, v$NAME_1 == "Diekirch", c("NAME_1", "NAME_2"))

subset(v, NAME_1 == "Diekirch", c(NAME_1, NAME_2), NSE=TRUE)
```

subset_double *Subset a SpatRaster or a SpatVector*

Description

Select a subset of layers from a SpatRaster or select a subset of records (row) and/or variables (columns) from a SpatVector.

Usage

```
## S4 method for signature 'SpatRaster,numeric,missing'
x[[i, j]]

## S4 method for signature 'SpatRasterDataset,ANY,ANY'
x[[i, j, drop=TRUE]]

## S4 method for signature 'SpatVector,numeric,missing'
x[[i, j, drop=FALSE]]
```

Arguments

x	SpatRaster or SpatVector
i	if x is a SpatRaster: integer, logical, or character to select layers if x is a SpatVector: integer, logical, or character to select variables
j	missing, or, for SpatRasterDataset only, numeric
drop	logical. If TRUE, the geometries will be dropped, and a data.frame is returned

Value

if x is a SpatRaster or SpatRasterDataset: SpatRaster
if x is a SpatVector: a data.frame.

See Also

[subset](#), [\\$](#), [\[,](#) [extract](#)

Examples

```
### SpatRaster
s <- rast(system.file("ex/logo.tif", package="terra"))
s[[ 1:2 ]]

s[[c("red", "green")]]

# expression based (partial) matching of names with single brackets
s["re"]
s["^re"]
```

```
# does not work with double brackets
# s[["re"]]

### SpatVector

v <- vect(system.file("ex/lux.shp", package="terra"))
v[[2:3]]

# to keep the geometry use
v[,2:3]
```

subset_single

Extract values from a SpatRaster, SpatVector or SpatExtent

Description

Extract values from a `SpatRaster`; a subset of records (row) and/or variables (columns) from a `SpatVector`; or a number from a `SpatExtent`.

You can use indices (row, column, layer or cell numbers) to extract. You can also use other `Spat*` objects.

Usage

```
## S4 method for signature 'SpatRaster,ANY,ANY,ANY'
x[i, j, k]

## S4 method for signature 'SpatVector,numeric,numeric'
x[i, j, drop=FALSE]

## S4 method for signature 'SpatVector,SpatVector,missing'
x[i, j]

## S4 method for signature 'SpatExtent,numeric,missing'
x[i, j]
```

Arguments

x	<code>SpatRaster</code> , <code>SpatVector</code> or <code>SpatExtent</code>
i	if x is a <code>SpatRaster</code> : numeric, logical or missing to select rows or, if j is missing, to select cells numbers. if x is a <code>SpatVector</code> : numeric or missing to select rows. if i is another <code>SpatVector</code> : get a new <code>SpatVector</code> with the geometries that intersect. if x is a <code>SpatExtent</code> : integer between 1 and 4.
j	numeric, logical, or missing to select columns

k numeric, character, or missing to select layers
 drop logical. If FALSE an object of the same class as x is returned

Value

numeric if x is a SpatExtent. Same as x if drop=FALSE. Otherwise a data.frame

See Also

[extract](#), [subset](#), [\\$](#), [\[\[](#)

Examples

```
### SpatRaster
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
r[3638]
rowColFromCell(r, 2638)
r[39, 28]
x <- r[39:40, 28:29, drop=FALSE]
as.matrix(x, wide=TRUE)

### SpatVector

v <- vect(system.file("ex/lux.shp", package="terra"))
v[2:3,]
v[1:2, 2:3]
v[1:2, 2:3, drop=TRUE]
```

subst	<i>replace cell values</i>
-------	----------------------------

Description

Substitute(replace) cell values of a SpatRaster with a new value. See [classify](#) for more complex/flexible replacement.

Usage

```
## S4 method for signature 'SpatRaster'
subst(x, from, to, others=NULL, raw=FALSE, filename="", ...)
```

Arguments

x SpatRaster

from	numeric value(s). Normally a vector of the same length as 'to'. If x has multiple layers, it can also be a matrix of numeric value(s) where <code>nrow(x) == length(to)</code> . In that case the output has a single layer, with values based on the combination of the values of the input layers. For single-layer replacement with numeric vectors, an optimized hash-based lookup is used. Floating point values are supported and are matched exactly.
to	numeric value(s). Normally a vector of the same length as 'from'. If x has a single layer, it can also be a matrix of numeric value(s) where <code>nrow(x) == length(from)</code> . In that case the output has multiple layers, one for each column in to
others	numeric. If not NULL all values that are not matched are set to this value. Otherwise they retain their original value.
raw	logical. If TRUE, the values in from and to are the raw cell values, not the categorical labels. Only relevant if <code>is.factor(x)</code>
filename	character. Output filename
...	Additional arguments for writing files as in writeRaster

Value

SpatRaster

Author(s)

Andrew Gene Brown, Robert J. Hijmans

See Also[classify](#), [clamp](#)**Examples**

```

r <- rast(ncols=5, nrows=5, xmin=0, xmax=1, ymin=0, ymax=1, crs="")
r <- init(r, 1:6)
x <- subst(r, 3, 7)
x <- subst(r, 2:3, NA)
x <- subst(x, NA, 10)

# multiple output layers
z <- subst(r, 2:3, cbind(20,30))

# multiple input layers
rr <- c(r, r+1, r+2)
m <- rbind(c(1:3), c(3:5))
zz <- subst(rr, m, c(100, 200))

```

summarize

Summarize

Description

Compute summary statistics for cells, either across layers or between layers (parallel summary).

The following summary methods are available for `SpatRaster`: `any`, `anyNA`, `all`, `allNA`, `nany`, `noNA`, `max`, `min`, `mean`, `median`, `prod`, `range`, `stdev`, `sum`, `which.min`, `which.max`. See [modal](#) to compute the mode and [app](#) to compute summary statistics that are not included here. `nany` stands for "not any" or "none" and allows to do `!all(x)` in one computation instead of two.

Because generic functions are used, the method applied is chosen based on the first argument: "x". This means that if `r` is a `SpatRaster`, `mean(r, 5)` will work, but `mean(5, r)` will not work.

The `mean` method has an argument "trim" that is ignored.

If `pop=TRUE` `stdev` computes the population standard deviation, computed as:

```
f <- function(x) sqrt(sum((x-mean(x))^2) / length(x))
```

This is different than the sample standard deviation returned by `sd` (which uses `n-1` as denominator).

Usage

```
## S4 method for signature 'SpatRaster'
min(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
max(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
range(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
prod(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
sum(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
any(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
all(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
nany(x, ..., na.rm=FALSE)

## S4 method for signature 'SpatRaster'
range(x, ..., na.rm=FALSE)
```

```

## S4 method for signature 'SpatRaster'
which.min(x)

## S4 method for signature 'SpatRaster'
which.max(x)

## S4 method for signature 'SpatRaster'
stdev(x, ..., pop=TRUE, na.rm=FALSE)

## S4 method for signature 'SpatRaster'
mean(x, ..., trim=NA, na.rm=FALSE)

## S4 method for signature 'SpatRaster'
median(x, na.rm=FALSE, ...)

## S4 method for signature 'SpatRaster'
anyNA(x)

## S4 method for signature 'SpatRaster'
countNA(x, n=0)

## S4 method for signature 'SpatRaster'
noNA(x, falseNA=FALSE)

## S4 method for signature 'SpatRaster'
allNA(x, falseNA=FALSE)

```

Arguments

x	SpatRaster
...	additional SpatRasters or numeric values; and arguments par for parallel summarization (see Details), and filename, overwrite and wopt as for writeRaster
na.rm	logical. If TRUE, NA values are ignored. If FALSE, NA is returned if x has any NA values
trim	ignored
pop	logical. If TRUE, the population standard deviation is computed. Otherwise the sample standard deviation is computed
falseNA	logical. If TRUE, cells that would otherwise be FALSE are set to NA
n	integer. If $n > 0$, cell values are TRUE if at least n of its layers are NA

Details

Additional argument par can be used for "parallel" summarizing a SpatRaster and a numeric or logical value. If a SpatRaster x has three layers, `max(x, 5)` will return a single layer (the number five is treated as a layer in which all cells have value five). In contrast `max(x, 5, par=TRUE)` returns three layers (the number five is treated as another SpatRaster with a single layer with all cells having the value five).

Value

SpatRaster

See Also

[app](#), [Math-methods](#), [modal](#), [which.lyr](#)

Examples

```
set.seed(0)
r <- rast(nrows=10, ncols=10, nlyrs=3)
values(r) <- runif(ncell(r) * nlyr(r))

x <- mean(r)
# note how this returns one layer
x <- sum(c(r, r[[2]]), 5)

# and this returns three layers
y <- sum(r, r[[2]], 5)

max(r)

## when adding a number, do you want 1 layer or all layers?
# 1 layer
max(r, 0.5)

# all layers
max(r, 0.5, par=TRUE)

y <- stdev(r)
# not the same as
yy <- app(r, sd)

z <- stdev(r, r*2)

x <- mean(r, filename=paste0(tempfile(), ".tif"))

v <- values(r)
set.seed(3)
v[sample(length(v), 50)] <- NA
values(r) <- v
is.na(r)
anyNA(r)
allNA(r)
countNA(r)
countNA(r, 2)
```

summary	<i>summary</i>
---------	----------------

Description

Compute summary statistics (min, max, mean, and quartiles) for `SpatRaster` using base [summary](#) method. A sample is used for very large files.

For single or other statistics see [Summary-methods](#), [global](#), and [quantile](#)

Usage

```
## S4 method for signature 'SpatRaster'  
summary(object, size=100000, warn=TRUE, ...)  
  
## S4 method for signature 'SpatVector'  
summary(object, ...)
```

Arguments

<code>object</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>size</code>	positive integer. Size of a regular sample used for large datasets (see spatSample)
<code>warn</code>	logical. If TRUE a warning is given if a sample is used
<code>...</code>	additional arguments passed on to the base summary method

Value

matrix with (an estimate of) the median, minimum and maximum values, the first and third quartiles, and the number of cells with NA values

See Also

[Summary-methods](#), [global](#), [quantile](#)

Examples

```
set.seed(0)  
r <- rast(nrows=10, ncols=10, nlyrs=3)  
values(r) <- runif(nlyr(r)*ncell(r))  
summary(r)
```

`surfArea`*Compute surface area from elevation data*

Description

It is often said that if Wales was flattened out it would have an area bigger than England. This function computes the surface area for a raster with elevation values, taking into account the sloping nature of the surface.

Usage

```
## S4 method for signature 'SpatRaster'  
surfArea(x, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster with elevation values. Currently the raster CRS must be planar and have the same distance units (e.g. m) as the elevation values
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

SpatRaster

Author(s)

Barry Rowlingson

References

Jenness, Jeff S., 2004. Calculating Landscape Surface Area from Digital Elevation Models. *Wildlife Society Bulletin* 32(3): 829-839

See Also

[expand](#), [cellSize](#)

Examples

```
v <- rast(volcano, crs="local")  
x <- terra::surfArea(v)
```

 svc

Create a SpatVectorCollection

Description

Methods to create a SpatVectorCollection. This is an object to hold "sub-datasets", each a SpatVector, perhaps of different geometry type.

Usage

```
## S4 method for signature 'missing'
svc(x)

## S4 method for signature 'SpatVector'
svc(x, ...)

## S4 method for signature 'list'
svc(x)

## S4 method for signature 'character'
svc(x, layer="", query="", dialect="", extent=NULL, filter=NULL)
```

Arguments

x	SpatVector, character (filename), list with SpatVectors, or missing
...	Additional SpatVectors
layer	character. layer name to select a layer from a file (database) with multiple layers
query	character. A query to subset the dataset
dialect	character. The SQL dialect to use (if any). For example: "SQLite". "" refers to the default OGR-SQL dialect
extent	Spat* object. The extent of the object is used as a spatial filter to select the geometries to read. Ignored if filter is not NULL
filter	SpatVector. Used as a spatial filter to select geometries to read (the convex hull is used for lines or points). It is guaranteed that all features that overlap with the extent of filter will be returned. It can happen that additional geometries are returned

Value

SpatVectorCollection

See Also

[sprc](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
x <- svc()
x <- svc(v, v[1:3,], as.lines(v[3:5,]), as.points(v))
length(x)
x

# extract
x[3]

# replace
x[2] <- as.lines(v[1,])
```

symdif

Symmetrical difference

Description

Symmetrical difference of polygons

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
symdif(x, y)
```

Arguments

x	SpatVector
y	SpatVector

Value

SpatVector

See Also

[erase](#)

Examples

```
p <- vect(system.file("ex/lux.shp", package="terra"))
b <- as.polygons(ext(6, 6.4, 49.75, 50))
#sd <- symdif(p, b)
#plot(sd, col=rainbow(12))
```

tapp

*Apply a function to subsets of layers of a SpatRaster***Description**

Apply a function to subsets of layers of a SpatRaster (similar to [tapply](#) and [aggregate](#)). The layers are combined based on the `index`.

The number of layers in the output SpatRaster equals the number of unique values in `index` times the number of values that the supplied function returns for a single vector of numbers.

For example, if you have a SpatRaster with 6 layers, you can use `index=c(1,1,1,2,2,2)` and `fun=sum`. This will return a SpatRaster with two layers. The first layer is the sum of the first three layers in the input SpatRaster, and the second layer is the sum of the last three layers in the input SpatRaster. Indices are recycled such that `index=c(1,2)` would also return a SpatRaster with two layers (one based on the odd layers (1,3,5), the other based on the even layers (2,4,6)).

The `index` can also be one of the following values to group by time period (if `x` has the appropriate [time](#) values): "years", "months", "yearmonths", "dekads", "yeardekads", "weeks" (the ISO 8601 week number, see [Details](#)), "yearweeks", "days", "doy" (day of the year), "7days" (seven-day periods starting at Jan 1 of each year), "10days", or "15days". It can also be a function that makes groups from time values.

See [app](#) or [Summary-methods](#) if you want to use a more efficient function that returns multiple layers based on **all** layers in the SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
tapp(x, index, fun, ..., cores=1, filename="", overwrite=FALSE, wopt=list())
```

Arguments

<code>x</code>	SpatRaster
<code>index</code>	factor or numeric (integer). Vector of length <code>nlyr(x)</code> (shorter vectors are recycled) grouping the input layers. It can also be one of the following values: "years", "months", "yearmonths", "days", "week" (ISO 8601 week number), or "doy" (day of the year)
<code>fun</code>	function to be applied. The following functions have been re-implemented in C++ for speed: "sum", "mean", "median", "modal", "which", "which.min", "which.max", "min", "max", "prod", "any", "all", "none", "sd", "std", "first". To use the base-R function for say, "min", you could use something like <code>fun = \(\i) min(i)</code>
<code>...</code>	additional arguments passed to <code>fun</code>
<code>cores</code>	positive integer. If <code>cores > 1</code> , a 'parallel' package cluster with that many cores is created and used. You can also supply a cluster object. Ignored for functions that are implemented by terra in C++ (see under <code>fun</code>)
<code>filename</code>	character. Output filename

overwrite logical. If TRUE, filename is overwritten
 wopt list with named options for writing files as in [writeRaster](#)

Details

"week" follows the ISO 8601 definition. Weeks start on Monday. If the week containing 1 January has four or more days in the new year, then it is considered week "01". Otherwise, it is the last week of the previous year (week "52" or "53", and the next week is week 1.

Value

SpatRaster

See Also

[app](#), [Summary-methods](#)

Examples

```

r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
s <- c(r, r, r, r, r, r)
s <- s * 1:6
b1 <- tapp(s, index=c(1,1,1,2,2,2), fun=sum)
b1
b2 <- tapp(s, c(1,2,3,1,2,3), fun=sum)
b2

```

terrain

terrain characteristics

Description

Compute terrain characteristics from elevation data. The elevation values should be in the same units as the map units (typically meter) for projected (planar) raster data. They should be in meter when the coordinate reference system is longitude/latitude.

For accuracy, always compute these values on the original data (do not first change the projection). Distances (needed for slope and aspect) for longitude/latitude data are computed on the WGS84 ellipsoid with Karney's algorithm.

Usage

```

## S4 method for signature 'SpatRaster'
terrain(x, v="slope", neighbors=8, unit="degrees", filename="", ...)

```

Arguments

x	SpatRaster, single layer with elevation values. Values should have the same unit as the map units, or in meters when the crs is longitude/latitude
v	character. One or more of these options: slope, aspect, TPI, TRI, TRIriley, TRIrmsd, roughness, flowdir (see Details)
unit	character. "degrees" or "radians" for the output of "slope" and "aspect"
neighbors	integer. Indicating how many neighboring cells to use to compute slope or aspect with. Either 8 (queen case) or 4 (rook case)
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Details

When `neighbors=4`, slope and aspect are computed according to Fleming and Hoffer (1979) and Ritter (1987). When `neighbors=8`, slope and aspect are computed according to Horn (1981). The Horn algorithm may be best for rough surfaces, and the Fleming and Hoffer algorithm may be better for smoother surfaces (Jones, 1997; Burrough and McDonnell, 1998).

If `slope = 0`, aspect is set to $0.5 \cdot \pi$ radians (or 90 degrees if `unit="degrees"`). When computing slope or aspect, the coordinate reference system of `x` must be known for the algorithm to differentiate between planar and longitude/latitude data.

`terrain` is not vectorized over "neighbors" or "unit" – only the first value is used.

`flowdir` returns the "flow direction" (of water), that is the direction of the greatest drop in elevation (or the smallest rise if all neighbors are higher). They are encoded as powers of 2 (0 to 7). The cell to the right of the focal cell is 1, the one below that is 2, and so on:

32	64	128
16	x	1
8	4	2

Cells without lower neighboring cells are encoded as zero.

If two cells have the same drop in elevation, a random cell is picked. That is not ideal as it may prevent the creation of connected flow networks. ArcGIS implements the approach of Greenlee (1987) and I might adopt that in the future.

Most terrain indices are according to Wilson et al. (2007), as in [gdaldem](#). TRI (Terrain Ruggedness Index) is the mean of the absolute differences between the value of a cell and its 8 surrounding cells. TPI (Topographic Position Index, or Bathymetric Position Index if on seafloor) is the difference between the value of a cell and the mean value of its 8 surrounding cells. Roughness is the difference between the maximum and the minimum value of a cell and its 8 surrounding cells.

TRIriley (TRI according to Riley et al., 2007) returns the square root of summed squared differences between the value of a cell and its 8 surrounding cells. TRIrmsd computes the square root of the mean of the squared differences between these cells.

These measures can also be computed with [focal](#) functions:

```
TRI <- focal(x, w=3, fun=\(x) sum(abs(x[-5]-x[5]))/8)
```

```
TPI <- focal(x, w=3, fun=\(x) x[5] - mean(x[-5]))
rough <- focal(x, w=3, fun=\(x) max(x) - min(x))
```

References

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- Karney, C.F.F., 2013. Algorithms for geodesics, J. Geodesy 87: 43-55. doi:10.1007/s00190-012-0578-z.
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- Ritter, P., 1987. A vector-based terrain and aspect generation algorithm. Photogrammetric Engineering and Remote Sensing 53: 1109-1111
- Wilson et al 2007, Multiscale Terrain Analysis of Multibeam Bathymetry Data for Habitat Mapping on the Continental Slope. Marine Geodesy 30:3-35

See Also

[viewshed](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- terrain(r, "slope")
```

tessellate

Create a tessellation

Description

Create a tessellation of polygons with no gaps or overlaps that cover constant area. The polygons can be hexagons or rectangles. For lon/lat coordinates it is also possible to use (Goldberg) polyhedrons with 12 pentagonal cells and $10*(n^2-1)$ hexagonal cells, of approximately equal size. Hexagons have constant area, but varying shape with lon/lat coordinates.

Usage

```
## S4 method for signature 'ANY'
tessellate(x, size, n, type="hexagon", flat_top=FALSE, align="fit", geo=NULL)
```

Arguments

<code>x</code>	SpatRaster, SpatVector or other object from which a SpatExtent can be extracted. If missing, a global lon/lat extent is used
<code>size</code>	positive number. The "across-flats" distance of a hexagon, or the center-to-center distance to the nearest neighbour in the dominant direction. The unit is the unit of the input crs, or meters for longitude/latitude data. Size is approximate for polyhedrons
<code>n</code>	positive integer. Polyhedron subdivision frequency. The output has $10*n^2 + 2$ cells in total (12 pentagons + $10*(n^2 - 1)$ hexagons). If this is supplied, argument size is ignored
<code>type</code>	character. One of "hexagons", "rectangles", or "polyhedron"
<code>flat_top</code>	logical. If TRUE, hexagons have two horizontal (flat) edges; if FALSE (the default) they have two vertical edges and a vertex pointing up and down (pointy-top)
<code>align</code>	character. rectangle alignment, one of "fit" (all rectangles fit within the extent, creating variability in size), "align" all rectangles (except perhaps the polar rectangles) have equal-area, but may stick out of the extent), or "cube" (rectangles are "cubes" in terms of naive longitude/latitude math, and may stick out of the extent)
<code>geo</code>	logical. If TRUE, and x is a SpatExtent, the coordinates of x are interpreted longitude/latitude. If it is NULL the coordinates are used to guess the CRS from the coordinates. If FALSE the CRS is set to "local" if x does not have a CRS

Value

SpatVector of polygons

See Also

[as.polygons](#)

Examples

```
# planar hexagons (exact tiling, equal Cartesian area)
e <- ext(0, 100, 0, 100)
h <- tessellate(e, size=10)
plot(h)

# flat-top hexagons over a raster's extent
r <- rast(nrows=10, ncols=10, xmin=0, xmax=100, ymin=0, ymax=80, crs="local")
h2 <- tessellate(r, size=15, flat_top=TRUE)
plot(h2)

# rectangles
r1 <- tessellate(r, size=15, type="rect", geo=FALSE)
r2 <- tessellate(ext(r), size=1000000, type="rect", geo=TRUE)
r3 <- tessellate(ext(r), size=1000000, type="rect", align="equal", geo=TRUE)
r4 <- tessellate(ext(r), size=1000000, type="rect", align="cube", geo=TRUE)
```

```
# global lon/lat equal-area hexagon tessellation
g <- tessellate(size=1000000, geo=TRUE)
g

# global polyhedron, frequency 10 -> 12 pentagons + 990 hexagons
g1 <- tessellate(n=10, type="polyhedron")
g1$size <- expanse(g1)
plot(g1, "type", col=c("tomato", "skyblue"))
plot(g1, "size")

# the truncated icosahedron ("football"): n=1, 12 pentagons + 0 hexagons
g2 <- tessellate(n=1, type="polyhedron")

# specify cell size in meters instead of frequency
g3 <- tessellate(size=1000000, type="polyhedron")
```

text

Add labels to a map

Description

Plots labels, that is a textual (rather than color) representation of values, on top an existing plot (map).

Usage

```
## S4 method for signature 'SpatRaster'
text(x, labels, digits=0, halo=FALSE, hc="white", hw=0.1, jitter=0, ...)

## S4 method for signature 'SpatVector'
text(x, labels, halo=FALSE, inside=FALSE, hc="white", hw=0.1, jitter=0, ...)
```

Arguments

x	SpatRaster or SpatVector
labels	character. Optional. Vector of labels with length(x) or a variable name from names(x)
digits	integer. How many digits should be used?
halo	logical. If TRUE a "halo" is printed around the text
hc	character. The halo color
hw	numeric. The halo width
inside	logical. Should the text always be placed inside one the sub-geometries?
jitter	numeric. The amount of random noise used to adjust label positions, possibly avoiding overlaps. See argument 'factor' in jitter
...	additional arguments to pass to graphics function text

See Also

[text](#), [plot](#), [halo](#)

Examples

```
r <- rast(nrows=4, ncols=4)
values(r) <- 1:ncell(r)

plot(r)
text(r)

set.seed(123)
text(r, jitter = 2, col = "red", halo = TRUE)

plot(r)
text(r, halo=TRUE, hc="blue", col="white", hw=0.2)

plot(r, col=rainbow(16))
text(r, col=c("black", "white"), vfont=c("sans serif", "bold"), cex=2)
```

thin

Subset geometries by minimum distance

Description

`thin` return a subset of geometries such that all remaining geometries are at least `d` apart from each other. This uses greedy spatial thinning: the first geometry is always kept, and subsequent geometries are only kept if they are at least `d` away from all previously kept geometries.

`thinNodes` reduces the number of nodes to represent line or polygon geometries

Usage

```
## S4 method for signature 'SpatVector'
thin(x, d, unit="m")

## S4 method for signature 'SpatVector'
thinNodes(x, d, unit="m", makeValid=TRUE)
```

Arguments

<code>x</code>	SpatVector
<code>d</code>	positive numeric. The minimum distance between geometries or nodes
<code>unit</code>	character. "m" (meter, the default) or "km" (kilometer)
<code>makeValid</code>	logical. If TRUE an attempt is made to assure that thinned polygon geometries are valid (e.g., not self intersecting)

Value

SpatVector

See Also[densify](#), [distance](#), [nearby](#), [nearest](#)**Examples**

```
p <- vect( matrix(c(0, .5, .6, 5, 5.5, 50), ncol=2, nrow=6), crs="lonlat")
values(p) <- data.frame(id=1:6)
nrow(p)

# points that are at least 200 km apart
p2 <- thin(p, 200000)
nrow(p2)

# same, using km
p3 <- thin(p, 200, unit="km")
nrow(p3)
```

 thresh

Thresholding

Description

Compute a threshold to divide the values of a SpatRaster into two groups, and use that threshold to classify the raster.

Usage

```
## S4 method for signature 'SpatRaster'
thresh(x, method="otsu", maxcell=1000000, combine=FALSE,
as.raster=TRUE, filename="", ...)
```

Arguments

x	SpatRaster
method	character. One of "mean", "median" or "otsu" for Otsu's method
maxcell	positive integer. Maximum number of cells to use to compute the threshold
combine	logical. If TRUE the layers of x are combined to compute a single threshold
as.raster	logical. If TRUE a classified SpatRaster is returned. Otherwise the threshold(s) are returned
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

numeric or SpatRaster

References

Otsu, N. (1979). A Threshold Selection Method from Gray-Level Histograms. *IEEE Transactions on Systems, Man, and Cybernetics*, **9**(1), 62-66. doi:10.1109/TSMC.1979.4310076

See Also

[divide](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
thresh(s, "mean", as.raster=FALSE)
thresh(s, "mean", combine=TRUE, as.raster=FALSE)

plot(thresh(s, "otsu"))
```

tighten

tighten SpatRaster or SpatRasterDataset objects

Description

Combines data sources within a SpatRaster (that are in memory, or from the same file) to allow for faster processing.

Or combine sub-datasets into a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
tighten(x)

## S4 method for signature 'SpatRasterDataset'
tighten(x)
```

Arguments

x SpatRaster or SpatRasterDataset

Value

SpatRaster

Examples

```
r <- rast(nrow=5, ncol=9, vals=1:45)
x <- c(r, r*2, r*3)
x
tighten(x)
```

tile_apply

Parallelize a SpatRaster function

Description

The function splits a `SpatRaster` into virtual tiles and applies a user supplied function to each tile, and assembles the per-tile results back into a single `SpatRaster`. The work can be distributed over a cluster of worker processes.

Usage

```
tile_apply(x, fun, cores=1, cpkgs=NULL, tiles=NULL, buffer=0, ...,
  filename="", overwrite=FALSE, wopt=list(), overlap_fun=NULL)
```

Arguments

x	SpatRaster. Preferably backed by a file so that workers can re-open it cheaply; in-memory rasters are shipped to the workers via wrap
fun	function. Takes a SpatRaster as its first argument and must return a SpatRaster. It is called once per tile, with the windowed x as the first argument and any extra ... arguments appended
cores	one of: an integer (> 1 creates a PSOCK cluster of that size, torn down at the end of the call); a cluster object created with <code>parallel::makeCluster</code> ; the string "future" (use future_lapply with the currently-active <code>future::plan</code>); or a future strategy object (e.g. <code>future::multisession()</code>), which is set as the plan for the duration of the call. The "future" and plan-object paths require the future and future.apply packages
cpkgs	character. Names of packages that must be loaded on each worker before fun is called (e.g. "randomForest")
tiles	specification of the tiles. If NULL (the default), the tile size is chosen automatically and a per-worker memory budget that depends on cores (see getTileExtents). Otherwise one of: a SpatExtent; a list of SpatExtents; a 4-column matrix of extents (xmin, xmax, ymin, ymax) as returned by getTileExtents ; a SpatRaster or SpatVector that defines the tile geometry; or one or two integers specifying the number of rows and columns <i>per tile</i> (passed on to getTileExtents)
buffer	integer. Number of additional rows and columns (one number, or two for separate row/column buffers) of x to read on each side of every tile, so that fun can compute neighbourhood-dependent values (e.g. focal) without edge artefacts. The result of fun is then cropped back to the un-buffered tile extent before it

	is written, so the per-tile outputs are non-overlapping. Only used when <code>tiles = NULL</code> ; ignored with a warning otherwise (when supplying tiles explicitly, build the overlap into the tiles yourself with <code>getTileExtents(..., buffer=)</code> and pick an <code>overlap_fun</code>)
<code>...</code>	additional arguments passed to <code>fun</code> . When <code>cores > 1</code> these are serialized and shipped to each worker; <code>SpatRaster</code> , <code>SpatVector</code> and other terra objects in <code>...</code> are automatically wrapped and unwrapped
<code>filename</code>	character. Output filename for the assembled result. When empty (the default) and <code>overlap_fun = NULL</code> , a virtual raster (VRT) is returned that references the per-tile files (see <i>Details</i>)
<code>overwrite</code>	logical. If <code>TRUE</code> , <code>filename</code> is overwritten if it exists
<code>wopt</code>	list. Writing options as in <code>writeRaster</code>
<code>overlap_fun</code>	character or <code>NULL</code> . The function name used by <code>mosaic</code> to combine overlapping cells (e.g. "mean", "min", "max", "sum", "first"). Use this when tiles was built with <code>overlap</code> (e.g. <code>getTileExtents(..., buffer=)</code>). When <code>NULL</code> (the default), tiles are assembled with <code>vrt</code> , which is correct for non-overlapping tiles (including the auto path with <code>buffer</code> , which crops away the overlap) and is essentially free

Details

Buffered tiles for focal-style operations. When `tiles = NULL` and `buffer > 0`, each tile is read on an expanded extent of (`buffer` cells on each side, clamped to `x`'s extent), `fun` is applied, and the result is cropped back to the un-buffered tile extent before it is written. This avoids the edge effects that operations like `focal` would otherwise produce at tile boundaries.

The per-tile files are then assembled into the final `SpatRaster`:

- When `overlap_fun = NULL` (the default), the assembly is a virtual raster (`vrt`). This is fast and correct as long as the tiles do not overlap. If they do, the value of the last tile in the overlapping regions is used.
- When `overlap_fun` is set (e.g. "mean"), the assembly uses `mosaic` and applies the function to the values of overlapping cells.

If `filename` is empty and a VRT is returned, the tiled data files are kept for the rest of the R session, but they are lost after the session.

Extra arguments passed via `...` must be named when `cores > 1`.

Value

A `SpatRaster`.

See Also

`getTileExtents`, `makeTiles`, `mosaic`, `vrt`, `window`, `wrap`

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)

# not parallel
# Returned object is a VRT backed by per-tile files in tempdir().
out1 <- tile_apply(r, function(x) x * 2)

# focal, use a buffer wide enough for the focal window
out3 <- tile_apply(r, function(x) focal(x, w=5, fun="mean",
na.rm=TRUE), buffer=2)

# parallel on 2 workers
## Not run:
out4 <- tile_apply(r, function(x) x * 2, cores=2)

# pass extra arguments by name; nested terra objects are auto-wrapped
out5 <- tile_apply(r, function(x, k) x * k, cores=2, tiles=50, k=10)

# use a future plan instead of a cluster
if (requireNamespace("future", quietly=TRUE) &&
    requireNamespace("future.apply", quietly=TRUE)) {
  future::plan(future::multisession, workers=2)
  out6 <- tile_apply(r, function(x) x * 2, cores="future")
  future::plan(future::sequential)
}

## End(Not run)
```

time

time of SpatRaster layers

Description

Get or set the time of the layers of a SpatRaster. Time can be stored as [POSIXlt](#) (date and time, with a resolution of seconds, and a time zone), [Date](#), "months", "years", or "yearmonths".

`timeInfo` and `has.time` are helper functions to understand what a time data a SpatRaster has.

Usage

```
## S4 method for signature 'SpatRaster'
has.time(x)

## S4 method for signature 'SpatRaster'
time(x, format="")

## S4 replacement method for signature 'SpatRaster'
```

```
time(x, timestep="")<-value

## S4 method for signature 'SpatRaster'
timeInfo(x)
```

Arguments

x	SpatRaster or SpatRasterDataset
format	One of "", "seconds" (POSIXlt), "days" (Date), "yearmonths" (decimal years), "years", "months". If "", the returned format is (based on) the format that was used to set the time
value	Date, POSIXt, yearmon (defined in package zoo), or numeric
tstep	One of "years", "months", "yearmonths". Used when value is numeric. Ignored when value is of type Date, POSIXt, or yearmon

Value

time: POSIXlt, Date, or numeric
timeInfo: data.frame with time step and time zone information
(if available) has.time: logical

See Also

[depth](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))

# Date"
d <- as.Date("2001-05-04") + 0:2
time(s) <- d
timeInfo(s)

# POSIX (date/time with a resolution of seconds)
time(s) <- as.POSIXlt(d)
timeInfo(s)

# with time zone
time(s) <- as.POSIXlt(Sys.time(), "America/New_York") + 0:2
timeInfo(s)

# years
time(s, timestep="years") <- 2000 + 0:2
s

time(s, timestep="months") <- 1:3
s
```

`tmpFiles`*Temporary files*

Description

List and optionally remove temporary files created by the terra package. These files are created when an output SpatRaster may be too large to store in memory (RAM). This can happen when no filename is provided to a function and when using functions where you cannot provide a filename.

Temporary files are automatically removed at the end of each R session that ends normally. You can use `tmpFiles` to see the files in the current sessions, including those that are orphaned (not connect to a SpatRaster object any more) and from other (perhaps old) sessions, and remove all the temporary files.

Usage

```
tmpFiles(current=TRUE, orphan=FALSE, old=FALSE, remove=FALSE)
```

Arguments

<code>current</code>	logical. If TRUE, temporary files from the current R session are included
<code>orphan</code>	logical. If TRUE, temporary files from the current R session that are no longer associated with a SpatRaster (if <code>current</code> is TRUE these are also included)
<code>old</code>	logical. If TRUE, temporary files from other "R" sessions. Unless you are running multiple instances of R at the same time, these are from old (possibly crashed) R sessions and should be removed
<code>remove</code>	logical. If TRUE, temporary files are removed

Value

character

See Also

[terraOptions](#)

Examples

```
tmpFiles()
```

toMemory	<i>Read all cell values into memory</i>
----------	---

Description

Reads all cell values of a `SpatRaster` or `SpatRasterDataset` into memory.

Using this method is discouraged as it is not necessary for processing the data and may lead to excessive memory use that will slow down your computer or worse. It cannot be used for `SpatRasters` that are based on very large files.

The method may be useful if a relatively small dataset is used repeatedly, such that efficiency gains are made because the values only need to be read from disk once.

Usage

```
## S4 method for signature 'SpatRaster'  
toMemory(x)  
  
## S4 method for signature 'SpatRasterDataset'  
toMemory(x)
```

Arguments

x `SpatRaster` or `SpatRasterDataset`

Value

Same as x

See Also

[values](#), [as.data.frame](#), [readValues](#), [inMemory](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")  
r <- rast(f)  
sources(r)  
inMemory(r)  
x <- toMemory(r)  
inMemory(x)
```

topology

*Vector topology methods***Description**

`makeNodes` create nodes on lines

`mergeLines` connect lines to form polygons

`removeDupNodes` removes duplicate nodes in geometries and optionally rounds the coordinates

`emptyGeoms` returns the indices of empty (null) geometries. `is.na` also checks if any of the coordinates is NA.

`snap` makes boundaries of geometries identical if they are very close to each other.

Usage

```
## S4 method for signature 'SpatVector'
mergeLines(x)
## S4 method for signature 'SpatVector'
snap(x, y=NULL, tolerance)
## S4 method for signature 'SpatVector'
removeDupNodes(x, digits = -1)
## S4 method for signature 'SpatVector'
makeNodes(x)
```

Arguments

<code>x</code>	SpatVector of lines or polygons
<code>y</code>	SpatVector of lines or polygons to snap to. If NULL snapping is to the other geometries in <code>x</code>
<code>tolerance</code>	numeric. Snapping tolerance (distance between geometries)
<code>digits</code>	numeric. Number of digits used in rounding. Ignored if <code>< 0</code>

Value

SpatVector

See Also

[sharedPaths](#), [gaps](#), [simplifyGeom](#), [forceCCW](#), [fillHoles](#)

Examples

```
p1 <- as.polygons(ext(0,1,0,1))
p2 <- as.polygons(ext(1.1,2,0,1))

p <- rbind(p1, p2)
```

```
y <- snap(p, tol=.15)
plot(p, lwd=3, col="light gray")
lines(y, col="red", lwd=2)
```

transpose	<i>Transpose</i>
-----------	------------------

Description

Transpose a `SpatRaster` or `SpatVector`

Usage

```
## S4 method for signature 'SpatRaster'
t(x)

## S4 method for signature 'SpatVector'
t(x)

## S4 method for signature 'SpatRaster'
trans(x, filename="", ...)
```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[flip](#), [rotate](#)

Examples

```
r <- rast(nrows=18, ncols=36)
values(r) <- 1:ncell(r)
tr1 <- t(r)
tr2 <- trans(r)
ttr <- trans(tr2)
```

trim	<i>Trim a SpatRaster</i>
------	--------------------------

Description

Trim (shrink) a `SpatRaster` by removing outer rows and columns that are NA or another value.

Usage

```
## S4 method for signature 'SpatRaster'  
trim(x, padding=0, value=NA, filename="", ...)
```

Arguments

x	<code>SpatRaster</code>
padding	integer. Number of outer rows/columns to keep
value	numeric. The value of outer rows or columns that are to be removed
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[extend](#)

Examples

```
r <- rast(ncols=10, nrows=10, xmin=0,xmax=10,ymin=0,ymax=10)  
v <- rep(NA, ncell(r))  
v[c(12,34,69)] <- 1:3  
values(r) <- v  
s <- trim(r)
```

union

Union SpatVector or SpatExtent objects

Description

If you want to append polygon SpatVectors use `rbind` instead of `union`. `union` will also intersect overlapping polygons between, not within, objects. Union for lines and points simply combines the two data sets; without any geometric intersections. This is equivalent to [rbind](#). Attributes are joined.

If `x` and `y` have a different geometry type, a `SpatVectorCollection` is returned.

If a single SpatVector is supplied, overlapping polygons are intersected. Original attributes are lost. New attributes allow for determining how many, and which, polygons overlapped.

SpatExtent: Objects are combined into their union; this is equivalent to `+`.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'  
union(x, y)
```

```
## S4 method for signature 'SpatVector,missing'  
union(x, y)
```

```
## S4 method for signature 'SpatExtent,SpatExtent'  
union(x, y)
```

Arguments

<code>x</code>	SpatVector or SpatExtent
<code>y</code>	Same as <code>x</code> or missing

Value

SpatVector or SpatExtent

See Also

[rbind](#)

[intersect](#)

[combineGeoms](#)

[merge](#) and [mosaic](#) to union SpatRasters.

[crop](#) and [extend](#) for the union of SpatRaster and SpatExtent.

[merge](#) for merging a data.frame with attributes of a SpatVector.

[aggregate](#) to dissolve SpatVector objects.

Examples

```
e1 <- ext(-10, 10, -20, 20)
e2 <- ext(0, 20, -40, 5)
union(e1, e2)

#SpatVector
v <- vect(system.file("ex/lux.shp", package="terra"))
v <- v[,3:4]
p <- vect(c("POLYGON ((5.8 49.8, 6 49.9, 6.15 49.8, 6 49.65, 5.8 49.8))",
"POLYGON ((6.3 49.9, 6.2 49.7, 6.3 49.6, 6.5 49.8, 6.3 49.9))"), crs=crs(v))
values(p) <- data.frame(pid=1:2, value=expance(p))
u <- union(v, p)
plot(u, "pid")

b <- buffer(v, 1000)

u <- union(b)
u$sum <- rowSums(as.data.frame(u))
plot(u, "sum")
```

unique

Unique values

Description

This method returns the unique values in a `SpatRaster`, or removes duplicate records (geometry and attributes) in a `SpatVector`.

Usage

```
## S4 method for signature 'SpatRaster'
unique(x, incomparables=FALSE, digits=NA, na.rm=TRUE, as.raster=FALSE)

## S4 method for signature 'SpatVector'
unique(x, incomparables=FALSE, geom=TRUE, atts=TRUE, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>incomparables</code>	logical. If <code>FALSE</code> and <code>x</code> is a <code>SpatRaster</code> : the unique values are determined for all layers together, and the result is a matrix. If <code>TRUE</code> , each layer is evaluated separately, and a list is returned. If <code>x</code> is a <code>SpatVector</code> this argument is as for a <code>data.frame</code>
<code>digits</code>	integer. The number of digits for rounding the values before finding the unique values. Use <code>NA</code> means to not do any rounding
<code>na.rm</code>	logical. If <code>TRUE</code> , <code>NaN</code> is included if there are any missing values

<code>as.raster</code>	logical. If TRUE, a single-layer categorical <code>SpatRaster</code> with the unique values is returned
<code>...</code>	additional arguments passed on to <code>unique</code> or <code>identical</code>
<code>geom</code>	logical. If TRUE the geometries are considered to determine uniqueness
<code>atts</code>	logical. If TRUE the attribute values are considered to determine uniqueness

Value

If `x` is a `SpatRaster`: `data.frame` or list (if `incomparables=FALSE`)

If `x` is a `SpatVector`: `SpatVector`

Examples

```
r <- rast(ncols=5, nrows=5)
values(r) <- rep(1:5, each=5)
unique(r)
s <- c(r, round(r/3))
unique(s)
unique(s, TRUE)

unique(s, as.raster=TRUE)

v <- vect(cbind(x=c(1:5, 1:5), y=c(5:1, 5:1)),
crs="+proj=utm +zone=1 +datum=WGS84")
nrow(v)
u <- unique(v)
nrow(u)

values(v) <- c(1:5, 1:3, 5:4)
unique(v)
```

units

units of SpatRaster or SpatRasterDataSet

Description

Get or set the units of the layers of a `SpatRaster` or the datasets in a `SpatRasterDataSet`.

Usage

```
## S4 method for signature 'SpatRaster'
units(x)

## S4 replacement method for signature 'SpatRaster'
units(x)<-value

## S4 method for signature 'SpatRasterDataset'
```

```
units(x)

## S4 replacement method for signature 'SpatRasterDataset'
units(x)<-value
```

Arguments

x	SpatRaster
value	character

Value

character

See Also

[time](#), [names](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))

units(s) <- c("m/s", "kg", "ha")
units(s)
s

units(s) <- "kg"
units(s)
```

update

Update a raster file

Description

Update metadata or cell values of a file that is the data source of a SpatRaster. This modifies the file on disk directly without reading the entire raster into memory.

BE CAREFUL with this function as you are overwriting data in an existing file.

Usage

```
## S4 method for signature 'SpatRaster'
update(object, crs=FALSE, extent=FALSE, names=FALSE,
        cells=NULL, values=NULL, layer=0)
```

Arguments

object	SpatRaster with a file source
crs	logical. Should the coordinate reference system be updated?
extent	logical. Should the extent be updated?
names	logical. Should the names be updated?
cells	numeric. Cell numbers to update (1-indexed). Must be used together with values
values	numeric. New values for the specified cells. Can be a single value (recycled), one value per cell (applied to all layers), or <code>length(cells) * length(layer)</code> values (one per cell per layer, in layer-major order)
layer	numeric or character. Layer(s) to update. Use <code>0</code> (default) to update all layers. Positive integers or layer names select specific layers

Details

The `cells` and `values` arguments allow updating specific cell values on disk without loading the raster into memory. This is useful for modifying very large rasters that cannot fit in memory. See [set.values](#) for modifying values of in-memory rasters.

Value

SpatRaster (invisibly)

Examples

```
## update metadata
s <- rast(system.file("ex/logo.tif", package="terra"))
fname <- paste0(tempfile(), ".tif")
x <- writeRaster(s*1, fname)

ext(x) <- ext(x) + 1
crs(x) <- "+proj=utm +zone=1"
names(x) <- LETTERS[1:3]

update(x, crs=TRUE, extent=TRUE, names=TRUE)

rast(fname)

## update cell values on disk
r <- rast(nrows=10, ncols=10, vals=1:100)
f <- paste0(tempfile(), ".tif")
x <- writeRaster(r, f)
x[c(1, 2, 50, 51, 100)]
update(x, cells=c(1, 50, 100), values=c(999, 888, 777))
rast(f)[c(1, 2, 50, 51, 100)]

## update specific layer only
r <- rast(nrows=5, ncols=5, nlyr=3, vals=1:75)
f <- paste0(tempfile(), ".tif")
```

```
x <- writeRaster(r, f, datatype="FLT4S")
x[c(1, 2, 25, 26)]
update(x, cells=c(1, 25), values=c(0, 0), layer=2)
rast(f)[c(1, 2, 25, 26)]
```

values

Cell values and geometry attributes

Description

Get the cell values of a `SpatRaster` or the attributes of a `SpatVector`.

By default all values returned are numeric. This is because a vector or matrix can only store one data type, and a `SpatRaster` may consist of multiple data types. However, if all layers have integer or logical values, the returned values also have that datatype.

Note that with `values(x, dataframe=TRUE)` and `as.data.frame(x)` the values returned match the type of each layer, and can be a mix of numeric, logical, integer, and factor.

Usage

```
## S4 method for signature 'SpatRaster'
values(x, mat=TRUE, dataframe=FALSE, row=1,
       nrows=nrow(x), col=1, ncols=ncol(x), na.rm=FALSE, ...)

## S4 method for signature 'SpatVector'
values(x, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>mat</code>	logical. If <code>TRUE</code> , values are returned as a matrix instead of as a vector, except when <code>dataframe</code> is <code>TRUE</code>
<code>dataframe</code>	logical. If <code>TRUE</code> , values are returned as a <code>data.frame</code> instead of as a vector (also if <code>matrix</code> is <code>TRUE</code>)
<code>row</code>	positive integer. Row number to start from, should be between 1 and <code>nrow(x)</code>
<code>nrows</code>	positive integer. How many rows?
<code>col</code>	positive integer. Column number to start from, should be between 1 and <code>ncol(x)</code>
<code>ncols</code>	positive integer. How many columns? Default is the number of columns left after the start column
<code>na.rm</code>	logical. Remove NAs?
<code>...</code>	additional arguments passed to <code>data.frame</code>

Details

If `x` is a `SpatRaster`, and `mat=FALSE`, the values are returned as a vector. In cell-order by layer. If `mat=TRUE`, a matrix is returned in which the values of each layer are represented by a column (with `ncell(x)` rows). The values per layer are in cell-order, that is, from top-left, to top-right and then down by row. Use `as.matrix(x, wide=TRUE)` for an alternative matrix representation where the number of rows and columns matches that of `x`.

Value

matrix or data.frame

Note

raster values that are NA (missing) are represented by NaN (not-a-number) unless argument `data.frame` is TRUE.

See Also

[values<-](#), [focalValues](#), [as.data.frame](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
r
x <- values(r)
x[3650:3655, ]
r[3650:3655]
```

```
ff <- system.file("ex/lux.shp", package="terra")
v <- vect(ff)
y <- values(v)
head(y)
```

varnames

variable and long variable names

Description

Set or get names for each dataset (variable) in a `SpatRasterDataset`.

Each `SpatRaster` `_data source_` can also have a variable name and a long variable name. They are set when reading a file with possibly multiple sub-datasets (e.g. netcdf or hdf5 format) into a single `SpatRaster`. Each sub-dataset is a separate "data-source" in the `SpatRaster`. Note that newly created or derived `SpatRasters` always have a single variable (data source), and therefore the variable names are lost when processing a multi-variable `SpatRaster`. Thus the variable names are mostly useful to understand a `SpatRaster` created from some files and for managing `SpatRasterDatasets`.

See `link{names}` for the more commonly used `_layer_` names.

Usage

```
## S4 method for signature 'SpatRaster'
varnames(x)

## S4 replacement method for signature 'SpatRaster'
varnames(x)<-value

## S4 method for signature 'SpatRaster'
longnames(x)

## S4 replacement method for signature 'SpatRaster'
longnames(x)<-value

## S4 method for signature 'SpatRasterDataset'
varnames(x)

## S4 replacement method for signature 'SpatRasterDataset'
varnames(x)<-value

## S4 method for signature 'SpatRasterDataset'
longnames(x)

## S4 replacement method for signature 'SpatRasterDataset'
longnames(x)<-value
```

Arguments

x	SpatRaster, SpatRasterDataset
value	character (vector)

Value

character

Note

terra enforces neither unique nor valid names. See [make.unique](#) to create unique names and {make.names} to make syntactically valid names.

Examples

```
s <- rast(ncols=5, nrows=5, nlyrs=3)
names(s) <- c("a", "b", "c")
x <- sds(s, s)
varnames(x) <- c("one", "two")
x
```

vect

*Create SpatVector objects***Description**

Methods to create a SpatVector from a filename or other R object.

A filename can be for a Shapefile, GeoPackage, GeoJSON, Keyhole Markup Language (KML) or any other spatial vector file format.

You can use a data.frame to make a SpatVector of points. If the variables to be used are not specified with argument geom, the method looks for candidate variables. If variables are found and these appear to be longitude/latitude, the "+proj=longlat" crs is assigned unless another crs is specified.

You can also use a two-column matrix to make a SpatVector of points, or a "geom" matrix to make a SpatVector of any supported geometry (see examples and [geom](#)).

You can supply a list of SpatVectors to append them into a single SpatVector.

SpatVectors can also be created from "Well Known Text", and from spatial vector data objects defined in the sf or sp packages.

Usage

```
## S4 method for signature 'character'
vect(x, layer="", query="", dialect="", extent=NULL, filter=NULL,
     crs="", proxy=FALSE, what="", opts=NULL, kml.extended=NULL)
```

```
## S4 method for signature 'matrix'
vect(x, type="points", atts=NULL, crs="")
```

```
## S4 method for signature 'data.frame'
vect(x, geom=NULL, crs=NULL, keepgeom=FALSE, quiet=FALSE)
```

```
## S4 method for signature 'list'
vect(x, type="points", crs="")
```

```
## S4 method for signature 'SpatExtent'
vect(x, crs="")
```

```
## S4 method for signature 'SpatVectorCollection'
vect(x)
```

```
## S4 method for signature 'sf'
vect(x)
```

Arguments

x character. A filename; or a "Well Known Text" or GeoJSON string; SpatExtent, data.frame (to make a SpatVector of points); a "geom" matrix to make a

	SpatVector of any supported geometry (see examples and geom); a spatial vector data object defined in the <code>sf</code> or <code>sp</code> packages; or a list with either matrices with coordinates, or raw "Well Known Binary" (WKB) blobs
<code>layer</code>	character. layer name to select a layer from a file (database) with multiple layers
<code>query</code>	character. A query to subset the dataset
<code>dialect</code>	character. The SQL dialect to use (if any). For example: "SQLite". "" refers to the default OGR-SQL dialect
<code>extent</code>	Spat* object. The extent of the object is used as a spatial filter to select the geometries to read. Ignored if <code>filter</code> is not NULL
<code>filter</code>	SpatVector. Used as a spatial filter to select geometries to read (the convex hull is used for lines or points). It is guaranteed that all features that overlap with the extent of filter will be returned. It can happen that additional geometries are returned
<code>type</code>	character. Geometry type. Must be "points", "lines", or "polygons". Ignored if <code>x</code> is a WKB list
<code>atts</code>	data.frame with the attributes. The number of rows must match the number of geometrical elements
<code>crs</code>	character. The coordinate reference system in one of the following formats: WKT/WKT2, <authority>:<code>, or PROJ-string notation (see crs). If <code>x</code> is a data.frame, <code>crs==NULL</code> , and <code>geom</code> is <code>c("lon", "lat")</code> or a variation thereof, "+proj=longlat" is assigned
<code>proxy</code>	logical. If TRUE a SpatVectorProxy is returned
<code>what</code>	character indicating what to read. Either "" for geometries and attributes, "geoms" to only read the geometries, "attributes" to only read the attributes (that are returned as a data.frame)
<code>opts</code>	character. GDAL dataset open options. For example "ENCODING=LATIN1"
<code>kml.extended</code>	logical or NULL. For .kml and .kmz files: GDAL's KML driver (common on Windows) often reads only Name and Description, while the LIBKML driver (common on Linux) may add many KML structure fields as columns (often empty). With NULL (default) or TRUE, if the suggested XML package is available, terra parses ExtendedData and replaces the attribute table when the placemark count matches the vector's feature count (same order as <Placemark> elements with geometry). For .kmz, the archive is unpacked to a temporary directory, preferring doc.kml if present. With FALSE, GDAL fields are kept. Ignored when <code>proxy=TRUE</code> or <code>what != ""</code> .
<code>geom</code>	character. The field name(s) with the geometry data. Either two names for x and y coordinates of points, or a single name for a single column with WKT geometries. If NULL the function will use <code>c("x", "y")</code> , <code>c("lon", "lat")</code> , <code>c("longitude", "latitude")</code> and a few variations thereof, if one of these pairs is in the data
<code>keepgeom</code>	logical. If TRUE the geom variable(s), e.g. spatial coordinates, is (are) also included in the attributes table
<code>quiet</code>	logical. If TRUE a warning is given when <code>x</code> is a data.frame and the values for geom and/or the crs are guessed from the data

Value

SpatVector

See Also[geom](#), [vector_layers](#)**Examples**

```

### SpatVector from file
f <- system.file("ex/lux.shp", package="terra")
f
v <- vect(f)
v

## subsetting (large) files
## with attribute query
v <- vect(f, query="SELECT NAME_1, NAME_2, ID_2 FROM lux WHERE ID_2 < 4")

## with an extent
e <- ext(5.9, 6.3, 49.9, 50)
v <- vect(f, extent=e)

## with polygons
p <- as.polygons(e)
v <- vect(f, filter=p)

### SpatVector from a geom matrix
x1 <- rbind(c(-180,-20), c(-140,55), c(10, 0), c(-140,-60))
x2 <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
x3 <- rbind(c(-125,0), c(0,60), c(40,5), c(15,-45))
hole <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))
z <- rbind(cbind(object=1, part=1, x1, hole=0), cbind(object=2, part=1, x3, hole=0),
cbind(object=3, part=1, x2, hole=0), cbind(object=3, part=1, hole, hole=1))
colnames(z)[3:4] <- c('x', 'y')

p <- vect(z, "polygons")
p

z[z[, "hole"]==1, "object"] <- 4
lns <- vect(z[,1:4], "lines")
plot(p)
lines(lns, col="red", lwd=2)

### from wkt
v <- vect("POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")

wkt <- c("MULTIPOLYGON ( ((40 40, 20 45, 45 30, 40 40)),
((20 35, 10 30, 10 10, 30 5, 45 20, 20 35),(30 20, 20 15, 20 25, 30 20)))",
"POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")
w <- vect(wkt)

```

```

# combine two SpatVectors
vw <- rbind(w, v)

# add a data.frame
d <- data.frame(id=1:2, name=c("a", "b"))
values(w) <- d

# add data.frame on creation, here from a geom matrix
g <- geom(w)
d <- data.frame(id=1:2, name=c("a", "b"))
m <- vect(g, "polygons", atts=d, crs="+proj=longlat +datum=WGS84")

### SpatVector from a data.frame
d$wkt <- wkt
x <- vect(d, geom="wkt")

d$wkt <- NULL
d$lon <- c(0,10)
d$lat <- c(0,10)
x <- vect(d, geom=c("lon", "lat"))

# SpatVector to sf
#sf::st_as_sf(x)

```

vector_layers

List or remove layers from a vector file

Description

List or remove layers from a vector file that supports layers such as GPKG

Usage

```
vector_layers(filename, delete="", return_error=FALSE)
```

Arguments

filename	character. filename
delete	character. layers to be deleted (ignored if the value is "")
return_error	logical. If TRUE, an error occurs if some layers cannot be deleted. Otherwise a warning is given

 viewshed

Compute a viewshed

Description

Use elevation data to compute the locations that can be seen, or how much higher they would have to be to be seen, from a certain position. The raster data coordinate reference system must be planar (not lon/lat), with the elevation values in the same unit as the distance unit of the coordinate reference system.

Usage

```
## S4 method for signature 'SpatRaster'
viewshed(x, loc, observer=1.80, target=0, curvcoef=6/7, output="yes/no", filename="", ...)
```

Arguments

x	SpatRaster, single layer with elevation values. Values should have the same unit as the map units
loc	location (x and y coordinates) or a cell number
observer	numeric. The height above the elevation data of the observer
target	numeric. The height above the elevation data of the targets
curvcoef	numeric. Coefficient to consider the effect of the curvature of the earth and refraction of the atmosphere. The elevation values are corrected with: $elevation = elevation - curvcoef * (distance)^2 / (earth_diameter)$. This means that with the default value of 0.85714, you lose sight of about 1 meter of elevation for each 385 m of planar distance
output	character. Can be "yes/no" to get a binary (logical) output showing what areas are visible; "land" to get the height above the current elevation that would be visible; or "sea" the elevation above sea level that would be visible
filename	character. Output filename
...	Options for writing files as in writeRaster

References

The algorithm used is by Wang et al.: https://www.asprs.org/wp-content/uploads/pers/2000journal/january/2000_jan_87-90.pdf.

See Also

[terrain](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- project(r, "EPSG:2169")
p <- cbind(70300, 96982)
v <- viewshed(x, p, 0, 0, 0.85714)
```

 voronoi

Voronoi diagram and Delaunay triangles

Description

Get a Voronoi diagram or Delaunay triangles for points, or the nodes of lines or polygons

Usage

```
## S4 method for signature 'SpatVector'
voronoi(x, bnd=NULL, tolerance=0, as.lines=FALSE, deldir=FALSE)

## S4 method for signature 'SpatVector'
delaunay(x, tolerance=0, as.lines=FALSE, constrained=FALSE)
```

Arguments

x	SpatVector
bnd	SpatVector to set the outer boundary of the voronoi diagram
tolerance	numeric ≥ 0 , snapping tolerance (0 is no snapping)
as.lines	logical. If TRUE, lines are returned without the outer boundary
constrained	logical. If TRUE, a constrained delaunay triangulation is returned
deldir	logical. If TRUE, the <code>deldir</code> is used instead of the GEOS C++ library method. It has been reported that <code>deldir</code> does not choke on very large data sets

Value

SpatVector

Examples

```
wkt <- c("MULTIPOLYGON ( ((40 40, 20 45, 45 30, 40 40)),
  ((20 35, 10 30, 10 10, 30 5, 45 20, 20 35),(30 20, 20 15, 20 25, 30 20)))",
  "POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")
x <- vect(wkt)
v <- voronoi(x)
v

d <- delaunay(x)
d
```

```
plot(v, lwd=2, col=rainbow(15))
lines(x, col="gray", lwd=2)
points(x)
```

vrt

*Virtual Raster Dataset***Description**

Create a Virtual Raster Dataset (VRT) from a collection of file-based raster datasets (tiles). See [gdalbuildvrt](#) for details.

Usage

```
## S4 method for signature 'character'
vrt(x, filename="", options=NULL, overwrite=FALSE, set_names=FALSE, return_filename=FALSE)

## S4 method for signature 'SpatRasterCollection'
vrt(x, filename="", options=NULL, overwrite=FALSE, return_filename=FALSE)
```

Arguments

x	SpatRasterCollection or character vector with filenames of raster "tiles". That is, files that have data for, typically non-overlapping, sub-regions of a raster. See makeTiles
filename	character. output VRT filename
options	character. All arguments as separate vector elements. Options as for gdalbuildvrt
overwrite	logical. Should filename be overwritten if it exists?
set_names	logical. Add the layer names of the first tile to the vrt? If options includes "-separate" the name of each source file is added, and each input goes into a separate band in the VRT dataset
return_filename	logical. If TRUE the filename is returned, otherwise a SpatRaster is returned

Value

SpatRaster

Note

A VRT can reference very many datasets. These are not all opened at the same time. The default is to open not more than 100 files. To increase performance, this maximum limit can be increased by setting the GDAL_MAX_DATASET_POOL_SIZE configuration option to a bigger value with [setGDALconfig](#). Note that a typical user process on Linux is limited to 1024 simultaneously opened files.

See Also

[makeTiles](#) to create tiles; [makeVRT](#) to create a .vrt file for a binary raster file that does not have a header file. [vrt_tiles](#) to get the filenames of the tiles in a VRT.

Examples

```
r <- rast(ncols=100, nrows=100)
values(r) <- 1:ncell(r)
x <- rast(ncols=2, nrows=2)
filename <- paste0(tempfile(), "_tif")
ff <- makeTiles(r, x, filename)
ff

#vrtfile <- paste0(tempfile(), ".vrt")
#v <- vrt(ff, vrtfile)

## output in lower resolution
#vrtfile <- paste0(tempfile(), ".vrt")
#v <- vrt(ff, vrtfile, options = c("-tr", 5, 5))
#head(readLines(vrtfile))
#v
```

vrt_tiles

filenames of VRT tiles

Description

Get the filenames of the tiles in a Virtual Raster Dataset (VRT)

Usage

```
vrt_tiles(x)
```

Arguments

x character (filename) or SpatRaster

Value

character

See Also

[vrt](#)

warp_scale	<i>Compute warp resampling scale</i>
------------	--------------------------------------

Description

Compute the ratio between source and destination pixel sizes for use with [project](#). These values correspond to the GDAL warp options XSCALE and YSCALE. By default, GDAL computes them independently for each processing chunk, which can produce visible block-boundary artifacts when the ratio varies across the raster (particularly in projections with significant deformation). Setting fixed values via `project(..., xscale=, yscale=)` eliminates these artifacts.

The function samples a grid of points in the source raster, projects them to the destination CRS, and returns summary statistics of the local resampling ratios.

Usage

```
warp_scale(x, y, n=21)
```

Arguments

x	SpatRaster. The source raster
y	SpatRaster or character. A template raster or a CRS description for the destination
n	integer. Number of sample points along each axis (the total number of sample points is n*n)

Value

A list with two named numeric vectors (`xscale` and `yscale`), each containing the quantiles (0%, 25%, 50%, 75%, 100%) of the local resampling ratio across the sampled points. The median ("50%") is typically the best choice for a global fixed scale. Values equal one for no resampling, below one for downsampling, and above one for upsampling.

See Also

[project](#)

Examples

```
## Not run:
a <- rast(ncols=360, nrows=180, xmin=-180, xmax=180, ymin=-90, ymax=90,
         crs="+proj=longlat +datum=WGS84")
values(a) <- 1:ncell(a)

sc <- warp_scale(a, "+proj=robin")
sc
# Use the median values
b <- project(a, "+proj=robin", xscale=sc$xscale["50%"], yscale=sc$yscale["50%"])
```

```
## End(Not run)
```

watershed

Catchment delineation

Description

delineate the area covered by a catchment from a `SpatRaster` with flow direction and a pour-point (catchment outlet).

Usage

```
## S4 method for signature 'SpatRaster'  
watershed(x, pourpoint, filename="",...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> with flow direction. See terrain .
<code>pourpoint</code>	matrix or <code>SpatVector</code> with the pour point location
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

Author(s)

Ezio Crestaz, Emanuele Cordano, Roman Seliger

Examples

```
elev <- rast(system.file('ex/elev_vinschgau.tif', package="terra"))  
flowdir <- terrain(elev, "flowdir")  
## pour point at Naturns  
pp <- cbind(653358.3, 5168222)  
w <- watershed(flowdir, pp)
```

weighted.mean	<i>Weighted mean of layers</i>
---------------	--------------------------------

Description

Compute the weighted mean for each cell of the layers of a `SpatRaster`. The weights can be spatially variable or not.

Usage

```
## S4 method for signature 'SpatRaster,numeric'
weighted.mean(x, w, na.rm=FALSE, filename="", ...)
```

```
## S4 method for signature 'SpatRaster,SpatRaster'
weighted.mean(x, w, na.rm=FALSE, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>w</code>	A vector of weights (one number for each layer), or for spatially variable weights, a <code>SpatRaster</code> with weights (should have the same extent, resolution and number of layers as <code>x</code>)
<code>na.rm</code>	Logical. Should missing values be removed?
<code>filename</code>	character. Output filename
<code>...</code>	options for writing files as in writeRaster

Value

`SpatRaster`

See Also

[Summary-methods](#), [weighted.mean](#)

Examples

```
b <- rast(system.file("ex/logo.tif", package="terra"))

# give least weight to first layer, most to last layer
wm1 <- weighted.mean(b, w=1:3)

# spatially varying weights
# weigh by column number
w1 <- init(b, "col")

# weigh by row number
w2 <- init(b, "row")
```

```
w <- c(w1, w2, w2)
wm2 <- weighted.mean(b, w=w)
```

where

Where are the cells with the min or max values?

Description

This method returns the cell numbers for the cells with the min or max values of each layer in a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
where.min(x, values=TRUE, list=FALSE)

## S4 method for signature 'SpatRaster'
where.max(x, values=TRUE, list=FALSE)
```

Arguments

x	SpatRaster
values	logical. If TRUE the min or max values are also returned
list	logical. If TRUE a list is returned instead of a matrix

Value

matrix or list

See Also

[which](#) and [Summary-methods](#) for `which.min` and `which.max`

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
where.min(r)
```

 which.lyr

Which cells are TRUE?

Description

This method returns a single layer SpatRaster with cell values indicating the first layer in the input that is TRUE. All numbers that are not zero (or FALSE), are considered to be TRUE.

Usage

```
## S4 method for signature 'SpatRaster'
which.lyr(x)
```

Arguments

x SpatRaster

Value

SpatRaster

See Also

[isTRUE](#), [which](#), See [Summary-methods](#) for `which.min` and `which.max`

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
x <- which.lyr(s > 100)
```

 width

SpatVector geometric properties

Description

`width` returns the minimum diameter of the geometry, defined as the smallest band that contains the geometry, where a band is a strip of the plane defined by two parallel lines. This can be thought of as the smallest hole that the geometry can be moved through, with a single rotation.

`clearance` returns the minimum clearance of a geometry. The minimum clearance is the smallest amount by which a vertex could be moved to produce an invalid polygon, a non-simple linestring, or a multipoint with repeated points. If a geometry has a minimum clearance of 'mc', it can be said that "no two distinct vertices in the geometry are separated by less than "mc". No vertex is closer than "mc" to a line segment of which it is not an endpoint".

If the minimum clearance cannot be defined for a geometry (such as with a single point), NA is returned.

Usage

```
## S4 method for signature 'SpatVector'
width(x, as.lines=FALSE)
## S4 method for signature 'SpatVector'
clearance(x, as.lines=FALSE)
```

Arguments

x SpatVector of lines or polygons
as.lines logical. If TRUE lines are returned that define the width or clearance

Value

numeric or SpatVector

See Also

[hull](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

width(v)
clearance(v)

width_lines <- width(v, as.lines=TRUE)
plot(v)
lines(width_lines, col="blue")
```

window

Set a window

Description

Assign a window (area of interest) to a SpatRaster with a SpatExtent, or set it to NULL to remove the window. This is similar to [crop](#) without actually creating a new dataset.

The window is intersect with the extent of the SpatRaster. It is envisioned that in a future version, the window may also go outside these boundaries.

Usage

```
## S4 replacement method for signature 'SpatRaster'
window(x)<-value

## S4 method for signature 'SpatRaster'
window(x)
```

Arguments

x	SpatRaster
value	SpatExtent

Value

none for window<- and logical for window

See Also

[crop](#), [extend](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
global(r, "mean", na.rm=TRUE)
e <- ext(c(5.9, 6, 49.95, 50))

window(r) <- e
global(r, "mean", na.rm=TRUE)
r

x <- rast(f)
xe <- crop(x, e)
global(xe, "mean", na.rm=TRUE)

b <- c(xe, r)
window(b)
b

window(r) <- NULL
r
```

wrap

wrap and unwrap

Description

Use wrap to pack a SpatVector or SpatRaster* to create a Packed* object. Packed objects can be passed over a connection that serializes (e.g. to nodes on a computer cluster). At the receiving end they need to be unpacked with unwrap.

Usage

```
## S4 method for signature 'SpatRaster'
wrap(x, proxy=FALSE)

## S4 method for signature 'SpatRasterDataset'
wrap(x, proxy=FALSE)

## S4 method for signature 'SpatRasterCollection'
wrap(x, proxy=FALSE)

## S4 method for signature 'SpatVector'
wrap(x)

## S4 method for signature 'ANY'
unwrap(x)
```

Arguments

x	SpatVector, SpatRaster, SpatRasterDataset or SpatRasterCollection
proxy	logical. If FALSE raster cell values are forced to memory if possible. If TRUE, a reference to source filenames is stored for data sources that are not in memory

Value

wrap: Packed* object
 unwrap: SpatVector, SpatRaster, SpatRasterCollection, SpatRasterDataset

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
p <- wrap(v)
p
vv <- vect(p)
vv
```

wrapCache

SpatRaster wrap with caching options

Description

Use wrap to pack a SpatRaster with caching options. See [wrap](#) for the general approach that is easier and better to use in most cases.

This method allows for specifying a folder, or filenames, to cache all sources of a SpatRaster in a specific location (on disk).

Usage

```
## S4 method for signature 'SpatRaster'
wrapCache(x, filename=NULL, path=NULL, overwrite=FALSE, ...)
```

Arguments

x	SpatRaster
filename	character. A single filename, or one filename per SpatRaster data source. If not NULL, the raster sources are saved in these files
path	character. If not NULL, the path where raster sources will be saved. Ignored if filenames is not NULL
overwrite	Should existing files be overwritten when files or path is not NULL? If this value is not TRUE or FALSE, only files that do not exist are created
...	Additional arguments for writeRaster. Only used for raster sources that are in memory, as other sources are cached by copying the files

Value

PackedSpatRaster

See Also

[wrap](#), [unwrap](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)

x <- wrapCache(r, path=tempdir())
x
```

writeCDF

Write raster data to a NetCDF file

Description

Write a SpatRaster or SpatRasterDataset to a NetCDF file.

When using a SpatRasterDataset, the varname, longname, and unit should be set in the object (see examples).

Always use the ".nc" or ".cdf" file extension to assure that the file can be properly read again by GDAL

You can write multiple rasters (variables) that are two (x, y), three (x, y, z or x, y, time) or four dimensional (x, y, z, time).

See [depth](#) and [time](#) for specifying the axes of the third and/or fourth dimension(s).

Usage

```
## S4 method for signature 'SpatRaster'
writeCDF(x, filename, varname, longname="", unit="", split=FALSE, ...)

## S4 method for signature 'SpatRasterDataset'
writeCDF(x, filename, overwrite=FALSE, timename="time", atts="",
         gridmap="", prec="float", compression=NA, missval, tags=FALSE, ...)
```

Arguments

x	SpatRaster or SpatRasterDataset
filename	character. Output filename
varname	character. Name of the dataset
longname	character. Long name of the dataset
unit	character. Unit of the data
split	logical. If TRUE each layer of x is treated as a sub-dataset
atts	character. A vector of additional global attributes to write. The must be formatted like c("x=a value", "y=abc")
gridmap	character. The crs is always written to the file in standard formats. With this argument you can also write the format commonly used in netcdf files. Something like c("grid_mapping_name=lambert_azimuthal_equal_area", "longitude_of_projection_origin=100", "latitude_of_projection_origin=52", "false_easting=4321000", "false_northing=3210000")
overwrite	logical. If TRUE, filename is overwritten
timename	character. The name of the "time" dimension
prec	character. One of "double", "float", "integer", "short", "byte" or "char"
compression	Can be set to an integer between 1 (least compression) and 9 (most compression)
missval	numeric, the number used to indicate missing values
tags	logical. If TRUE the value returned by metags are written to the file as attributes
...	additional arguments passed on to the SpatRasterDataset method, and from there possibly to ncvar_def

Value

SpatRaster or SpatDataSet

See Also

see [writeRaster](#) for writing other file formats

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
fname <- paste0(tempfile(), ".nc")
rr <- writeCDF(r, fname, overwrite=TRUE, varname="alt",
```

```

      longname="elevation in m above sea level", unit="m")

a <- rast(ncols=5, nrows=5, nl=50)
values(a) <- 1:prod(dim(a))
time(a) <- as.Date("2020-12-31") + 1:nlyr(a)
aa <- writeCDF(a, fname, overwrite=TRUE, varname="power",
  longname="my nice data", unit="U/Pa")

b <- sqrt(a)
s <- sds(a, b)
names(s) <- c("temp", "prec")
longnames(s) <- c("temperature (C)", "precipitation (mm)")
units(s) <- c("°C", "mm")
ss <- writeCDF(s, fname, overwrite=TRUE)

# four dimensional
r1 <- rast(nrow=5, ncol=5, vals=1:100, nlyr=4)
depth(r1) <- c(0, 2, 0, 2)
time(r1) <- c(as.Date("2012-12-12") + c(1,1,2,2))
depthName(r1) <- "angle"

r2 <- rast(nrow=5, ncol=5, vals=1:150, nlyr=6)
depth(r2) <- c(10, 10, 20, 20, 30, 30)
time(r2) <- c(as.Date("2012-12-12") + c(1:2, 1:2, 1:2))
depthName(r2) <- "height"
depthUnit(r2) <- "cm"

s <- sds(r1, r2)
names(s) <- c("TH", "DBZH")
units(s) <- c("-", "Pa")
x <- writeCDF(s, filename = fname, overwrite=TRUE)
x[1]
time(x[1])
depth(x[1])

x[2]
time(x[2])
depth(x[2])

# for CRAN
file.remove(fname)

```

writeRaster

Write raster data to a file

Description

Write a SpatRaster to a file.

Usage

```
## S4 method for signature 'SpatRaster,character'
writeRaster(x, filename, overwrite=FALSE, ...)
```

Arguments

x	SpatRaster
filename	character. Output filename. Can be a single filename, or as many filenames as nlyr(x) to write a file for each layer
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files. See Details

Details

In writeRaster, and in other methods that generate SpatRasters, options for writing raster files to disk can be provided as additional arguments or, in a few cases, as the wopt argument (a named list) if the additional arguments are already used for a different purpose. See [terraOptions](#) to get or set default values. The following options are available:

name	description
datatype	values accepted are "INT1U", "INT2U", "INT2S", "INT4U", "INT4S", "FLT4S", "FLT8S". With GDAL >= 3.5 y
filetype	file format expresses as GDAL driver names . If this argument is not supplied, the driver is derived from the filena
gdal	GDAL driver specific datasource creation options. See the GDAL documentation. For example, with the GeoTiff
tempdir	the path where temporary files are to be written to.
progress	positive integer. If the number of chunks is larger, a progress bar is shown.
memfrac	numeric between 0 and 0.9 (higher values give a warning). The fraction of available RAM that terra is allowed to
memmax	memmax - the maximum amount of RAM (in GB) that terra can use when processing a raster dataset. Should be
names	output layer names.
NAflag	numeric. value to represent missing (NA or NaN) values. See note
scale	numeric. Cell values written to disk are divided by this value (default is 1). See scoff
offset	numeric. Value that is subtracted from the cell values written to disk (default is 0). See scoff
verbose	logical. If TRUE debugging information is printed
steps	positive integers. In how many steps (chunks) do you want to process the data (for debugging)
todisk	logical. If TRUE processing operates as if the dataset is very large and needs to be written to a temporary file (for c
metadata	character, see metags<- to write metadata

Value

SpatRaster. This function is used for the side-effect of writing values to a file.

Note

GeoTiff files are, by default, written with LZW compression. If you do not want compression, use `gdal="COMPRESS=NONE"`.

When writing integer values the lowest available value (given the datatype) is used to represent NA for signed types, and the highest value is used for unsigned values. This can be a problem with byte data (between 0 and 255) as the value 255 is reserved for NA. To keep the value 255, you need to set another value as NAflag, or do not set a NAflag (with NAflag=NA)

See Also

see [writeCDF](#) for writing NetCDF files.

Examples

```
r <- rast(nrows=5, ncols=5, vals=1:25)

# create a temporary filename for the example
f <- file.path(tempdir(), "test.tif")

writeRaster(r, f, overwrite=TRUE)

writeRaster(r, f, overwrite=TRUE, gdal=c("COMPRESS=NONE", "TFW=YES"), datatype='INT1U')

## Or with a wopt argument:

writeRaster(r, f, overwrite=TRUE, wopt= list(gdal=c("COMPRESS=NONE"), datatype='INT1U'))

## remove the file
unlink(f)
```

writeVector

Write SpatVector data to a file

Description

Write a SpatVector to a file. You can choose one of many file formats.

Usage

```
## S4 method for signature 'SpatVector,character'
writeVector(x, filename, filetype=NULL, layer=NULL, insert=FALSE,
            overwrite=FALSE, options="ENCODING=UTF-8")
```

Arguments

x	SpatVector
filename	character. Output filename
filetype	character. A file format associated with a GDAL "driver" such as "ESRI Shapefile". See <code>gdal(drivers=TRUE)</code> or the GDAL docs . If NULL it is attempted to guess the filetype from the filename extension
layer	character. Output layer name. If NULL the filename is used
insert	logical. If TRUE, a new layer is inserted into the file, or an existing layer overwritten (if <code>overwrite=TRUE</code>), if the format supports it (e.g. GPKG allows that). See vector_layers to remove a layer

overwrite	logical. If TRUE and insert=FALSE, filename is overwritten if the file format and layer structure permits it. If TRUE and insert=TRUE, only the target layer is overwritten if the format supports it (e.g. GPKG).
options	character. Format specific GDAL options such as "ENCODING=UTF-8". Use NULL or "" to not use any options

Examples

```
v <- vect(cbind(1:5,1:5))
crs(v) <- "+proj=longlat +datum=WGS84"
v$id <- 1:length(v)
v$name <- letters[1:length(v)]
tmpf1 <- paste0(tempfile(), ".gpkg")
writeVector(v, tmpf1, overwrite=TRUE)
x <- vect(tmpf1)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
tmpf2 <- paste0(tempfile(), ".gpkg")
writeVector(v, tmpf2, overwrite=TRUE)
y <- vect(tmpf2)
```

xapp

Apply a function to the cells of two SpatRasters

Description

Apply a function to the values of each cell of two (multilayer) SpatRasters.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
xapp(x, y, fun, ..., filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
y	SpatRaster with the same geometry as x
fun	a function that operates on two vectors
...	additional arguments for fun. These are typically numerical constants. They should <i>never</i> be another SpatRaster
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also[app](#), [lapp](#), [tapp](#), [Math-methods](#), [roll](#)**Examples**

```
r <- rast(ncols=10, nrows=10, nlyr=5)
set.seed(1)
r <- init(r, runif)
s <- init(r, runif)
x <- xapp(r, s, fun=cor)
```

 xmin

Get or set single values of an extent

Description

Get or set single values of an extent. Values can be set for a SpatExtent or SpatRaster, but not for a SpatVector)

Usage

```
## S4 method for signature 'SpatExtent'
xmin(x)
```

```
## S4 method for signature 'SpatExtent'
xmax(x)
```

```
## S4 method for signature 'SpatExtent'
ymin(x)
```

```
## S4 method for signature 'SpatExtent'
ymax(x)
```

```
## S4 method for signature 'SpatRaster'
xmin(x)
```

```
## S4 method for signature 'SpatRaster'
xmax(x)
```

```
## S4 method for signature 'SpatRaster'
ymin(x)
```

```
## S4 method for signature 'SpatRaster'
```

```
ymax(x)

## S4 method for signature 'SpatVector'
xmin(x)

## S4 method for signature 'SpatVector'
xmax(x)

## S4 method for signature 'SpatVector'
ymin(x)

## S4 method for signature 'SpatVector'
ymax(x)

## S4 replacement method for signature 'SpatRaster,numeric'
xmin(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
xmax(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
ymin(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
ymax(x)<-value
```

Arguments

x	SpatRaster, SpatExtent, or SpatVector
value	numeric

Value

SpatExtent or numeric coordinate

See Also

[ext](#)

Examples

```
r <- rast()
ext(r)
ext(c(0, 20, 0, 20))

xmin(r)
xmin(r) <- 0
xmin(r)
```

`xyRowColCell`*Coordinates from a row, column or cell number and vice versa*

Description

Get coordinates of the center of raster cells for a row, column, or cell number of a `SpatRaster`. Or get row, column, or cell numbers from coordinates or from each other.

Cell numbers start at 1 in the upper left corner, and increase from left to right, and then from top to bottom. The last cell number equals the number of cells of the `SpatRaster` (see `ncell`). Row numbers start at 1 at the top, column numbers start at 1 at the left.

When computing row, column, or cell numbers from coordinates, and coordinates fall on the edge of two or four cells, they are assigned to the right-most and/or lowest cell. That is, in these cases of ambiguity, the highest row, column, or cell number is returned.

Usage

```
## S4 method for signature 'SpatRaster,numeric'  
xFromCol(object, col)  
  
## S4 method for signature 'SpatRaster,numeric'  
yFromRow(object, row)  
  
## S4 method for signature 'SpatRaster,numeric'  
xyFromCell(object, cell)  
  
## S4 method for signature 'SpatRaster,numeric'  
xFromCell(object, cell)  
  
## S4 method for signature 'SpatRaster,numeric'  
yFromCell(object, cell)  
  
## S4 method for signature 'SpatRaster,numeric'  
colFromX(object, x)  
  
## S4 method for signature 'SpatRaster,numeric'  
rowFromY(object, y)  
  
## S4 method for signature 'SpatRaster,numeric,numeric'  
cellFromRowCol(object, row, col)  
  
## S4 method for signature 'SpatRaster,numeric,numeric'  
cellFromRowColCombine(object, row, col)  
  
## S4 method for signature 'SpatRaster,numeric,numeric'  
rowColCombine(object, row, col)
```

```
## S4 method for signature 'SpatRaster,numeric'
rowFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
colFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
rowColFromCell(object, cell)

## S4 method for signature 'SpatRaster,matrix'
cellFromXY(object, xy)
```

Arguments

object	SpatRaster
cell	integer. cell number(s)
col	integer. column number(s) or missing (equivalent to all columns)
row	integer. row number(s) or missing (equivalent to all rows)
x	x coordinate(s)
y	y coordinate(s)
xy	matrix of x and y coordinates

Value

xFromCol, yFromCol, xFromCell, yFromCell: vector of x or y coordinates
xyFromCell: matrix(x,y) with coordinate pairs
colFromX, rowFromY, cellFromXY, cellFromRowCol, rowFromCell, colFromCell: vector of row, column, or cell numbers
rowColFromCell, rowColCombine: matrix of row and column numbers

See Also

[crds](#)

Examples

```
r <- rast()

xFromCol(r, c(1, 120, 180))
yFromRow(r, 90)
xyFromCell(r, 10000)
xyFromCell(r, c(0, 1, 32581, ncell(r), ncell(r)+1))

cellFromRowCol(r, 5, 5)
cellFromRowCol(r, 1:2, 1:2)
cellFromRowCol(r, 1, 1:3)
```

```
# all combinations
cellFromRowColCombine(r, 1:2, 1:2)

colFromX(r, 10)
rowFromY(r, 10)
xy <- cbind(lon=c(10,5), lat=c(15, 88))
cellFromXY(r, xy)

# if no row/col specified all are returned
range(xFromCol(r))
length(yFromRow(r))
```

zonal

*Zonal statistics***Description**

Compute zonal statistics, that is summarize values of a `SpatRaster` for each "zone" defined by another `SpatRaster`, or by a `SpatVector` with polygon geometry.

If `fun` is a true R function, the `<SpatRaster,SpatRaster>` method may fail when using very large `SpatRasters`, except for the functions ("mean", "min", "max", "sum", "isNA", and "notNA").

You can also summarize values of a `SpatVector` for each polygon (zone) defined by another `SpatVector`.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
zonal(x, z, fun="mean", ..., w=NULL, wide=TRUE,
as.raster=FALSE, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRaster,SpatVector'
zonal(x, z, fun="mean", na.rm=FALSE, w=NULL, weights=FALSE,
exact=FALSE, touches=FALSE, small=TRUE, as.raster=FALSE,
as.polygons=FALSE, wide=TRUE, filename="", wopt=list())

## S4 method for signature 'SpatVector,SpatVector'
zonal(x, z, fun=mean, ..., weighted=FALSE, as.polygons=FALSE)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>z</code>	<code>SpatRaster</code> with cell-values representing zones or a <code>SpatVector</code> with each polygon geometry representing a zone. <code>z</code> can have multiple layers to define intersecting zones
<code>fun</code>	function to be applied to summarize the values by zone. Either as character: "mean", "min", "max", "sum", "isNA", and "notNA" and, for relatively small <code>SpatRasters</code> , a proper function

...	additional arguments passed to fun, such as <code>na.rm=TRUE</code>
<code>w</code>	SpatRaster with weights. Should have a single-layer with non-negative values
<code>wide</code>	logical. Should the values returned in a wide format? For the <code>SpatRaster</code> , <code>SpatRaster</code> method this only affects the results when <code>nlyr(z) == 2</code> . For the <code>SpatRaster</code> , <code>SpatVector</code> method this only affects the results when <code>fun=table</code>
<code>as.raster</code>	logical. If TRUE, a <code>SpatRaster</code> is returned with the zonal statistic for each zone
<code>filename</code>	character. Output filename (ignored if <code>as.raster=FALSE</code>)
<code>overwrite</code>	logical. If TRUE, <code>filename</code> is overwritten
<code>wopt</code>	list with additional arguments for writing files as in <code>writeRaster</code>
<code>weights</code>	logical. If TRUE and <code>y</code> has polygons, the approximate fraction of each cell that is covered is returned as well, for example to compute a weighted mean
<code>exact</code>	logical. If TRUE and <code>y</code> has polygons, the exact fraction of each cell that is covered is returned as well, for example to compute a weighted mean
<code>touches</code>	logical. If TRUE, values for all cells touched by lines or polygons are extracted, not just those on the line render path, or whose center point is within the polygon. Not relevant for points; and always considered TRUE when <code>weights=TRUE</code> or <code>exact=TRUE</code>
<code>small</code>	logical. If TRUE, values for all cells in touched polygons are extracted if none of the cells center points is within the polygon; even if <code>touches=FALSE</code>
<code>weighted</code>	logical. If TRUE, a <code>weighted.mean</code> is computed and <code>fun</code> is ignored. Weights are based on the length of the lines or the area of the polygons in <code>x</code> that intersect with <code>z</code> . This argument is ignored if <code>x</code> is a <code>SpatVector</code> or points
<code>as.polygons</code>	logical. Should the zonal statistics be combined with the geometry of <code>z</code> ?
<code>na.rm</code>	logical. If TRUE, NAs are removed

Value

A data.frame with a value for each zone, or a `SpatRaster`, or `SpatVector` of polygons.

See Also

See [global](#) for "global" statistics (i.e., all of `x` is considered a single zone), [app](#) for local statistics, and [extract](#) for an alternative way to summarize values of a `SpatRaster` with a `SpatVector`. With [aggregate](#) you can compute statistics for cell blocks defined by a number of rows and columns.

Examples

```
### SpatRaster, SpatRaster
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
z <- rast(r)
values(z) <- rep(c(1:2, NA, 3:4), each=20)
names(z) <- "zone"
zonal(r, z, "sum", na.rm=TRUE)

# with weights
```

```

w <- init(r, "col")
zonal(r, z, w=w, "mean", na.rm=TRUE)

# multiple layers
r <- rast(system.file("ex/logo.tif", package = "terra"))
# zonal layer
z <- rast(r, 1)
names(z) <- "zone"
values(z) <- rep(c(1:2, NA, c(3:4)), each=ncell(r)/5, length.out=ncell(r))

zonal(r, z, "mean", na.rm = TRUE)

# raster of zonal values
zr <- zonal(r, z, "mean", na.rm = TRUE, as.raster=TRUE)

### SpatRaster, SpatVector
x <- rast(ncol=2,nrow=2, vals=1:4, xmin=0, xmax=1, ymin=0, ymax=1, crs="+proj=utm +zone=1")
p <- as.polygons(x)
pp <- shift(p, .2)
r <- disagg(x, 4)

zonal(r, p)
zonal(r, p, sum)
zonal(x, pp, exact=TRUE)
zonal(c(x, x*10), pp, w=x)

### SpatVector, SpatVector

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)[,c(2,4)]

p <- spatSample(v, 100)
values(p) <- data.frame(b2=1:100, ssep1=100:1)

zonal(p, v, mean)

```

zoom

Zoom in on a map

Description

Zoom in on a map (plot) by providing a new extent, by default this is done by clicking twice on the map.

Usage

```

## S4 method for signature 'SpatRaster'
zoom(x, e=draw(), maxcell=100000, layer=1, new=FALSE, ...)

```

```
## S4 method for signature 'SpatVector'  
zoom(x, e=draw(), new=FALSE, ...)
```

Arguments

x	SpatRaster
e	SpatExtent
maxcell	positive integer. Maximum number of cells used for the map
layer	positive integer to select the layer to be used
new	logical. If TRUE, the zoomed in map will appear on a new device (window)
...	additional arguments passed to plot

Value

SpatExtent (invisibly)

See Also

[draw](#), [plot](#)

Index

- !, SpatRaster-method (Compare-methods),
75
- * **classes**
 - options, 209
 - SpatExtent-class, 294
 - SpatRaster-class, 295
 - SpatVector-class, 298
- * **math**
 - Arith-methods, 40
 - atan2, 49
 - Compare-methods, 75
 - Math-methods, 190
 - modal, 197
- * **methods**
 - activeCat, 23
 - add_abline, 25
 - add_box, 26
 - add_grid, 26
 - add_legend, 27
 - add_mtext, 28
 - aggregate, 30
 - animate, 35
 - app, 36
 - Arith-methods, 40
 - as.data.frame, 43
 - as.list, 45
 - as.raster, 48
 - barplot, 51
 - boundaries, 54
 - cartogram, 59
 - catalyze, 60
 - cells, 61
 - cellSize, 62
 - colors, 72
 - combineGeoms, 74
 - Compare-methods, 75
 - concats, 78
 - contour, 79
 - cover, 82
 - crosstab, 86
 - datatype, 89
 - deepcopy, 90
 - densify, 91
 - diff, 95
 - disagg, 99
 - dots, 105
 - elongate, 107
 - erase, 108
 - expanse, 109
 - extract, 114
 - extractAlong, 117
 - extractRange, 118
 - extremes, 119
 - factors, 120
 - fillHoles, 122
 - fillTime, 124
 - focalValues, 137
 - gaps, 140
 - geomtype, 144
 - graticule, 146
 - headtail, 149
 - hist, 150
 - hull, 151
 - image, 154
 - impose, 155
 - inset, 159
 - interpolation, 163
 - intersect, 166
 - is.bool, 168
 - is.flipped, 170
 - is.rotated, 172
 - lapp, 175
 - legend_cont, 179
 - lines, 181
 - makeTiles, 183
 - makeVRT, 185
 - map_extent, 187
 - mask, 188

- match, 189
- Math-methods, 190
- merge, 193
- mergeTime, 195
- meta, 196
- mosaic, 198
- normalize.longitude, 205
- not.na, 207
- nseg, 208
- panel, 212
- patches, 213
- perim, 214
- persp, 215
- plet, 217
- plot, 220
- plot_extent, 228
- plot_graticule, 229
- plotRGB, 226
- predict, 231
- quantile, 241
- query, 242
- rapp, 244
- rast, 246
- readwrite, 255
- regress, 258
- relate, 259
- replace_layers, 263
- replace_values, 264
- RGB, 267
- sapp, 273
- scatterplot, 277
- scoff, 278
- sds, 279
- selectRange, 284
- serialize, 285
- setValues, 286
- sharedPaths, 288
- simplifyGeom, 291
- sources, 293
- split, 299
- sprc, 300
- summarize, 310
- summary, 313
- svc, 315
- syndif, 316
- tapp, 317
- tessellate, 320
- text, 322
- toMemory, 331
- topology, 332
- union, 335
- values, 340
- vect, 343
- vector_layers, 346
- vrt, 349
- vrt_tiles, 350
- width, 355
- window, 356
- wrap, 357
- wrapCache, 358
- writeCDF, 359
- writeRaster, 361
- writeVector, 363
- xapp, 364
- * package**
 - terra-package, 8
- * spatial**
 - activeCat, 23
 - add, 24
 - add_abline, 25
 - add_box, 26
 - add_grid, 26
 - add_legend, 27
 - add_mtext, 28
 - adjacent, 29
 - aggregate, 30
 - agitate, 32
 - align, 33
 - all.equal, 34
 - animate, 35
 - app, 36
 - approximate, 38
 - ar_info, 41
 - Arith-methods, 40
 - as.character, 42
 - as.data.frame, 43
 - as.lines, 44
 - as.list, 45
 - as.points, 46
 - as.polygons, 47
 - as.raster, 48
 - atan2, 49
 - autocorrelation, 50
 - barplot, 51
 - bestMatch, 52
 - boundaries, 54

boxplot, 55
buffer, 56
c, 57
cartogram, 59
catalyze, 60
cells, 61
cellSize, 62
centroids, 64
chunk, 65
clamp, 66
clamp_ts, 67
classify, 68
click, 70
coerce, 71
colors, 72
combineGeoms, 74
Compare-methods, 75
compareGeom, 77
concats, 78
contour, 79
costDist, 80
cover, 82
crds, 83
crop, 84
crosstab, 86
crs, 87
datatype, 89
deepcopy, 90
densify, 91
density, 92
depth, 93
describe, 94
diff, 95
dimensions, 96
direction, 98
disagg, 99
distance, 100
divide, 103
dots, 105
draw, 106
elongate, 107
erase, 108
expanse, 109
ext, 111
extend, 112
extract, 114
extractAlong, 117
extractRange, 118
extremes, 119
factors, 120
fillHoles, 122
fillTime, 124
flip, 125
flowAccumulation, 126
focal, 128
focal3D, 130
focalCpp, 132
focalMat, 134
focalPairs, 135
focalReg, 136
focalValues, 137
forceCCW, 138
freq, 138
gaps, 140
gdal, 140
geom, 143
geomtype, 144
global, 145
graticule, 146
gridDist, 147
headtail, 149
hist, 150
hull, 151
identical, 152
ifel, 153
image, 154
impose, 155
initialize, 156
inplace, 157
inset, 159
interpIDW, 161
interpNear, 162
interpolation, 163
intersect, 166
is.bool, 168
is.empty, 170
is.flipped, 170
is.lonlat, 171
is.rotated, 172
is.valid, 173
k_means, 174
lapp, 175
legend_cont, 179
linearUnits, 180
lines, 181
makeTiles, 183

makeVRT, 185
map.pal, 186
map_extent, 187
mask, 188
match, 189
Math-methods, 190
mem, 192
merge, 193
mergeTime, 195
meta, 196
metags, 196
mosaic, 198
na.omit, 200
NAflag, 200
names, 201
nearest, 202
NIDP, 204
normalize.longitude, 205
north, 206
not.na, 207
nseg, 208
options, 209
origin, 210
pairs, 211
panel, 212
patches, 213
perim, 214
persp, 215
pitfinder, 216
plet, 217
plot, 220
plot_extent, 228
plot_graticule, 229
plotRGB, 226
prcomp, 230
predict, 231
princomp, 234
proj_pipelines, 239
project, 236
quantile, 241
query, 242
rangeFill, 243
rapp, 244
rast, 246
rasterize, 250
rasterizeGeom, 251
rasterizeWin, 253
rcl, 254
readwrite, 255
rectify, 257
regress, 258
relate, 259
rep, 261
replace_dollar, 262
replace_layers, 263
replace_values, 264
resample, 265
rescale, 266
RGB, 267
roll, 269
rotate, 270
rowSums, 271
same.crs, 272
sapp, 273
sbar, 274
scale, 275
scale_linear, 276
scatterplot, 277
scoff, 278
sds, 279
segregate, 281
sel, 282
selectHighest, 283
selectRange, 284
serialize, 285
setValues, 286
shade, 287
sharedPaths, 288
shift, 289
sieve, 290
simplifyGeom, 291
sort, 292
sources, 293
SpatExtent-class, 294
SpatRaster-class, 295
spatSample, 295
SpatVector-class, 298
spin, 298
split, 299
sprc, 300
stretch, 301
subset, 303
subset_dollar, 304
subset_double, 306
subset_single, 307
subst, 308

summarize, 310
 summary, 313
 surfArea, 314
 svc, 315
 symdif, 316
 tapp, 317
 terra-package, 8
 terrain, 318
 tessellate, 320
 text, 322
 thin, 323
 thresh, 324
 tighten, 325
 tile_apply, 326
 time, 328
 tmpFiles, 330
 toMemory, 331
 topology, 332
 transpose, 333
 trim, 334
 union, 335
 unique, 336
 units, 337
 update, 338
 values, 340
 varnames, 341
 vect, 343
 vector_layers, 346
 viewshed, 347
 voronoi, 348
 vrt, 349
 vrt_tiles, 350
 warp_scale, 351
 watershed, 352
 where, 354
 which.lyr, 355
 width, 355
 window, 356
 wrap, 357
 wrapCache, 358
 writeCDF, 359
 writeRaster, 361
 writeVector, 363
 xapp, 364
 xmin, 365
 xyRowColCell, 367
 zonal, 369
 zoom, 371

* **univar**
 freq, 138
 modal, 197
 [, 16, 19, 167, 168, 303, 305, 306
 [(subset_single), 307
 [, SpatExtent, missing, missing-method
 (subset_single), 307
 [, SpatExtent, numeric, missing-method
 (subset_single), 307
 [, SpatRaster, ANY, ANY, ANY-method
 (subset_single), 307
 [, SpatRaster, ANY, ANY-method
 (subset_single), 307
 [, SpatRaster, SpatExtent, missing-method
 (subset_single), 307
 [, SpatRaster, SpatRaster, missing-method
 (subset_single), 307
 [, SpatRaster, SpatVector, missing-method
 (subset_single), 307
 [, SpatRaster, data.frame, missing-method
 (subset_single), 307
 [, SpatRaster, matrix, missing-method
 (subset_single), 307
 [, SpatRaster, missing, missing-method
 (subset_single), 307
 [, SpatRaster, missing, numeric-method
 (subset_single), 307
 [, SpatRaster, numeric, missing-method
 (subset_single), 307
 [, SpatRaster, numeric, numeric-method
 (subset_single), 307
 [, SpatRasterCollection, numeric, missing-method
 (subset_single), 307
 [, SpatRasterDataset, character, missing-method
 (subset_single), 307
 [, SpatRasterDataset, logical, missing-method
 (subset_single), 307
 [, SpatRasterDataset, missing, logical-method
 (subset_single), 307
 [, SpatRasterDataset, missing, numeric-method
 (subset_single), 307
 [, SpatRasterDataset, numeric, logical-method
 (subset_single), 307
 [, SpatRasterDataset, numeric, missing-method
 (subset_single), 307
 [, SpatRasterDataset, numeric, numeric-method
 (subset_single), 307
 [, SpatVector, SpatExtent, missing-method

- (subset_single), 307
- [, SpatVector, SpatVector, missing-method (subset_single), 307
- [, SpatVector, character, missing-method (subset_single), 307
- [, SpatVector, data.frame, ANY-method (subset_single), 307
- [, SpatVector, data.frame, missing-method (subset_single), 307
- [, SpatVector, logical, character-method (subset_single), 307
- [, SpatVector, logical, logical-method (subset_single), 307
- [, SpatVector, logical, missing-method (subset_single), 307
- [, SpatVector, logical, numeric-method (subset_single), 307
- [, SpatVector, matrix, missing-method (subset_single), 307
- [, SpatVector, missing, character-method (subset_single), 307
- [, SpatVector, missing, logical-method (subset_single), 307
- [, SpatVector, missing, missing-method (subset_single), 307
- [, SpatVector, missing, numeric-method (subset_single), 307
- [, SpatVector, numeric, character-method (subset_single), 307
- [, SpatVector, numeric, logical-method (subset_single), 307
- [, SpatVector, numeric, missing-method (subset_single), 307
- [, SpatVector, numeric, numeric-method (subset_single), 307
- [, SpatVectorCollection, numeric, missing-method (svc), 315
- [<- (replace_values), 264
- [<-, SpatExtent, numeric, missing-method (replace_values), 264
- [<-, SpatRaster, ANY, ANY, ANY-method (replace_values), 264
- [<-, SpatRaster, ANY, ANY-method (replace_values), 264
- [<-, SpatRasterDataset, numeric, missing-method (sds), 279
- [<-, SpatVector, ANY, ANY-method (replace_values), 264
- [<-, SpatVector, ANY, missing-method (replace_values), 264
- [<-, SpatVector, missing, ANY-method (replace_values), 264
- [<-, SpatVectorCollection, numeric, missing-method (svc), 315
- [[, 9, 303, 305, 308
- [[(subset_double), 306
- [[, SpatRaster, ANY, missing-method (subset_double), 306
- [[, SpatRaster, character, missing-method (subset_double), 306
- [[, SpatRaster, logical, missing-method (subset_double), 306
- [[, SpatRaster, numeric, missing-method (subset_double), 306
- [[, SpatRasterDataset, ANY, ANY-method (subset_double), 306
- [[, SpatVector, character, missing-method (subset_double), 306
- [[, SpatVector, logical, missing-method (subset_double), 306
- [[, SpatVector, numeric, missing-method (subset_double), 306
- [[, SpatVectorCollection, ANY, missing-method (subset_double), 306
- [[, SpatVectorCollection, numeric, missing-method (svc), 315
- [[<-, 9
- [[<- (replace_layers), 263
- [[<-, SpatRaster, character-method (replace_layers), 263
- [[<-, SpatRaster, numeric-method (replace_layers), 263
- [[<-, SpatVector, character-method (replace_layers), 263
- [[<-, SpatVector, numeric-method (replace_layers), 263
- \$, 9, 262, 303, 306, 308
- \$(subset_dollar), 304
- \$.SpatExtent-method (subset_dollar), 304
- \$.SpatRaster-method (subset_dollar), 304
- \$.SpatRasterDataset-method (subset_dollar), 304
- \$.SpatVector-method (subset_dollar), 304
- \$.SpatVectorCollection-method (subset_dollar), 304
- \$<-, 9

- \$<- (replace_dollar), 262
- \$<- , SpatExtent-method (replace_dollar), 262
- \$<- , SpatRaster-method (replace_dollar), 262
- \$<- , SpatVector-method (replace_dollar), 262
- %in% (match), 189
- %in% , SpatRaster-method (match), 189
- %in%, 10
- abline, 25
- activeCat, 14, 23, 60, 122
- activeCat, SpatRaster-method (activeCat), 23
- activeCat<- (activeCat), 23
- activeCat<- , SpatRaster-method (activeCat), 23
- add, 24
- add<- , 8, 22
- add<- (add), 24
- add<- , SpatRaster , SpatRaster-method (add), 24
- add<- , SpatRasterCollection, SpatRaster-method (add), 24
- add<- , SpatRasterDataset, SpatRaster-method (add), 24
- add_abline, 21, 25, 26, 27
- add_box, 21, 25, 26, 27, 28, 179, 188, 224
- add_grid, 21, 25, 26, 26, 27, 28, 188, 224
- add_legend, 21, 25–27, 27, 28, 179, 187, 188, 224
- add_mtext, 21, 25–27, 28
- addCats (factors), 120
- addCats, SpatRaster-method (factors), 120
- adjacent, 11, 17, 29, 203, 259
- adjacent, SpatRaster-method (adjacent), 29
- adjacent, SpatVector-method (adjacent), 29
- aggregate, 9, 17, 30, 74, 100, 265, 266, 317, 335, 370
- aggregate, SpatRaster-method (aggregate), 30
- aggregate, SpatVector-method (aggregate), 30
- agitate, 18, 32
- agitate, ANY-method (agitate), 32
- agitate, SpatVector-method (agitate), 32
- align, 19, 33
- align, SpatExtent, numeric-method (align), 33
- align, SpatExtent, SpatRaster-method (align), 33
- all (summarize), 310
- all, SpatRaster-method (summarize), 310
- all.equal, 10, 34, 76, 152, 153
- all.equal, SpatExtent, SpatExtent-method (all.equal), 34
- all.equal, SpatRaster, SpatRaster-method (all.equal), 34
- all.equal, SpatVector, SpatVector-method (all.equal), 34
- all.equal.numeric, 34
- allNA (summarize), 310
- allNA, SpatRaster-method (summarize), 310
- animate, 21, 35
- animate, SpatRaster-method (animate), 35
- animate, SpatVector-method (animate), 35
- animate, SpatVectorCollection-method (animate), 35
- any (summarize), 310
- any, SpatRaster-method (summarize), 310
- anyNA (summarize), 310
- anyNA, SpatRaster-method (summarize), 310
- app, 9, 22, 36, 40, 76, 146, 175, 176, 190, 191, 241, 244, 245, 273, 310, 312, 317, 318, 365, 370
- app, SpatRaster-method (app), 36
- app, SpatRasterDataset-method (app), 36
- apply, 36
- approx, 39
- approximate, 10, 22, 38, 124
- approximate, SpatRaster-method (approximate), 38
- ar_info, 15, 41, 95, 247
- area (expansion), 109
- area, SpatRaster-method (expansion), 109
- area, SpatVector-method (expansion), 109
- Arith, logical, SpatRaster-method (Arith-methods), 40
- Arith, matrix, SpatRaster-method (Arith-methods), 40
- Arith, missing, SpatRaster-method (Arith-methods), 40
- Arith, numeric, SpatExtent-method (Arith-methods), 40

- Arith, numeric, SpatRaster-method (Arith-methods), 40
- Arith, SpatExtent, numeric-method (Arith-methods), 40
- Arith, SpatExtent, SpatExtent-method (Arith-methods), 40
- Arith, SpatRaster, logical-method (Arith-methods), 40
- Arith, SpatRaster, matrix-method (Arith-methods), 40
- Arith, SpatRaster, missing-method (Arith-methods), 40
- Arith, SpatRaster, numeric-method (Arith-methods), 40
- Arith, SpatRaster, SpatRaster-method (Arith-methods), 40
- Arith, SpatVector, SpatVector-method (Arith-methods), 40
- Arith-methods, 10, 40, 76
- arrows, 182
- as.array, 12
- as.array (coerce), 71
- as.array, SpatRaster-method (coerce), 71
- as.array, SpatRasterDataset-method (coerce), 71
- as.bool, 10, 89
- as.bool (is.bool), 168
- as.bool, SpatRaster-method (is.bool), 168
- as.character, 9, 42
- as.character, SpatExtent-method (as.character), 42
- as.character, SpatRaster-method (as.character), 42
- as.contour, 20
- as.contour (contour), 79
- as.contour, SpatRaster-method (contour), 79
- as.data.frame, 12, 18, 43, 72, 331, 340, 341
- as.data.frame, SpatRaster-method (as.data.frame), 43
- as.data.frame, SpatVector-method (as.data.frame), 43
- as.factor, 14, 122
- as.factor (is.bool), 168
- as.factor, SpatRaster-method (is.bool), 168
- as.int, 10
- as.int (is.bool), 168
- as.int, SpatRaster-method (is.bool), 168
- as.integer, SpatRaster-method (is.bool), 168
- as.lines, 20, 44, 47, 48
- as.lines, matrix-method (as.lines), 44
- as.lines, SpatExtent-method (as.lines), 44
- as.lines, SpatRaster-method (as.lines), 44
- as.lines, SpatVector-method (as.lines), 44
- as.list, 18, 22, 43, 45
- as.list, SpatRaster-method (as.list), 45
- as.list, SpatRasterCollection-method (as.list), 45
- as.list, SpatRasterDataset-method (as.list), 45
- as.list, SpatVector-method (as.list), 45
- as.list, SpatVectorCollection-method (as.list), 45
- as.logical, SpatRaster-method (is.bool), 168
- as.matrix, 12, 43, 341
- as.matrix (coerce), 71
- as.matrix, SpatExtent-method (coerce), 71
- as.matrix, SpatRaster-method (coerce), 71
- as.numeric, 14
- as.numeric (catalyze), 60
- as.numeric, SpatRaster-method (catalyze), 60
- as.points, 20, 22, 44, 46, 47, 48
- as.points, SpatExtent-method (as.points), 46
- as.points, SpatRaster-method (as.points), 46
- as.points, SpatVector-method (as.points), 46
- as.polygons, 20, 22, 23, 44, 47, 72, 321
- as.polygons, SpatExtent-method (as.polygons), 47
- as.polygons, SpatRaster-method (as.polygons), 47
- as.polygons, SpatVector-method (as.polygons), 47
- as.raster, 48, 48
- as.raster, SpatRaster-method (as.raster), 48
- as.vector (coerce), 71

- as.vector, SpatExtent-method (coerce), 71
- as.vector, SpatRaster-method (coerce), 71
- atan2, 49
- atan2, SpatRaster, SpatRaster-method (atan2), 49
- atan_2 (atan2), 49
- atan_2, SpatRaster, SpatRaster-method (atan2), 49
- autocor, 11
- autocor (autocorrelation), 50
- autocor, numeric-method (autocorrelation), 50
- autocor, SpatRaster-method (autocorrelation), 50
- autocorrelation, 50
- axis, 223

- barplot, 21, 51, 52, 224
- barplot, SpatRaster-method (barplot), 51
- bestMatch, 52
- bestMatch, SpatRaster, data.frame-method (bestMatch), 52
- bestMatch, SpatRaster, matrix-method (bestMatch), 52
- bestMatch, SpatRaster, SpatVector-method (bestMatch), 52
- blocks, 14
- blocks (readwrite), 255
- blocks, SpatRaster-method (readwrite), 255
- boundaries, 11, 54, 213
- boundaries, SpatRaster-method (boundaries), 54
- box, 26
- boxplot, 21, 52, 55, 55, 150, 211, 224
- boxplot, SpatRaster-method (boxplot), 55
- buffer, 17, 56, 107, 167
- buffer, SpatRaster-method (buffer), 56
- buffer, SpatVector-method (buffer), 56
- bxp, 55

- c, 8, 22, 24, 25, 57, 195
- c, SpatRaster-method (c), 57
- c, SpatRasterCollection-method (c), 57
- c, SpatRasterDataset-method (c), 57
- c, SpatVector-method (c), 57
- c, SpatVectorCollection-method (c), 57
- cartogram, 21, 59, 105
- cartogram, SpatVector-method (cartogram), 59
- catalyze, 14, 60, 122
- catalyze, SpatRaster-method (catalyze), 60
- categories, 157
- categories (factors), 120
- categories, SpatRaster-method (factors), 120
- cats, 14, 24, 60, 78, 168, 169
- cats (factors), 120
- cats, SpatRaster-method (factors), 120
- cellFromRowCol, 13, 255
- cellFromRowCol (xyRowColCell), 367
- cellFromRowCol, SpatRaster, numeric, numeric-method (xyRowColCell), 367
- cellFromRowColCombine, 13
- cellFromRowColCombine (xyRowColCell), 367
- cellFromRowColCombine, SpatRaster, numeric, numeric-method (xyRowColCell), 367
- cellFromXY, 13
- cellFromXY (xyRowColCell), 367
- cellFromXY, SpatRaster, data.frame-method (xyRowColCell), 367
- cellFromXY, SpatRaster, matrix-method (xyRowColCell), 367
- cells, 13, 22, 61, 115
- cells, SpatRaster, missing-method (cells), 61
- cells, SpatRaster, numeric-method (cells), 61
- cells, SpatRaster, SpatExtent-method (cells), 61
- cells, SpatRaster, SpatVector-method (cells), 61
- cellSize, 10, 22, 62, 110, 314
- cellSize, SpatRaster-method (cellSize), 62
- centroids, 16, 64
- centroids, SpatRaster-method (centroids), 64
- centroids, SpatVector-method (centroids), 64
- chunk, 15, 65
- chunk, SpatRaster-method (chunk), 65
- clamp, 10, 66, 67, 69, 309
- clamp, numeric-method (clamp), 66

- clamp, SpatRaster-method (clamp), 66
- clamp_ts, 14, 67
- clamp_ts, numeric-method (clamp_ts), 67
- clamp_ts, SpatRaster-method (clamp_ts), 67
- classify, 10, 22, 66, 68, 153, 193, 194, 200, 201, 264, 308, 309
- classify, SpatRaster-method (classify), 68
- clearance, 18
- clearance (width), 355
- clearance, SpatVector-method (width), 355
- clearVSIcache (gdal), 140
- click, 18, 21, 70, 106, 282
- click, missing-method (click), 70
- click, SpatRaster-method (click), 70
- click, SpatVector-method (click), 70
- coerce, 46, 71
- colFromCell (xyRowColCell), 367
- colFromCell, SpatRaster, numeric-method (xyRowColCell), 367
- colFromX, 13
- colFromX (xyRowColCell), 367
- colFromX, SpatRaster, numeric-method (xyRowColCell), 367
- colMeans, 10
- colMeans (rowSums), 271
- colMeans, SpatRaster-method (rowSums), 271
- colorize, 21, 227
- colorize (RGB), 267
- colorize, SpatRaster-method (RGB), 267
- colorRamp, 186
- colors, 72
- colSums, 10
- colSums (rowSums), 271
- colSums, SpatRaster-method (rowSums), 271
- coltab, 21
- coltab (colors), 72
- coltab, SpatRaster-method (colors), 72
- coltab<-, 21
- coltab<- (colors), 72
- coltab<-, SpatRaster-method (colors), 72
- combineGeoms, 18, 74, 335
- combineGeoms, SpatVector, SpatVector-method (combineGeoms), 74
- combineLevels (factors), 120
- compare (Compare-methods), 75
- Compare, matrix, SpatRaster-method (Compare-methods), 75
- Compare, numeric, SpatRaster-method (Compare-methods), 75
- Compare, SpatExtent, SpatExtent-method (Compare-methods), 75
- Compare, SpatRaster, character-method (Compare-methods), 75
- Compare, SpatRaster, matrix-method (Compare-methods), 75
- Compare, SpatRaster, numeric-method (Compare-methods), 75
- Compare, SpatRaster, SpatRaster-method (Compare-methods), 75
- compare, SpatRaster-method (Compare-methods), 75
- Compare-methods, 10, 75
- compareGeom, 13, 22, 34, 77, 153, 259
- compareGeom, SpatRaster, list-method (compareGeom), 77
- compareGeom, SpatRaster, SpatRaster-method (compareGeom), 77
- compareGeom, SpatRaster, SpatRasterCollection-method (compareGeom), 77
- compareGeom, SpatRasterCollection, missing-method (compareGeom), 77
- compareGeom, SpatVector, missing-method (compareGeom), 77
- compareGeom, SpatVector, SpatVector-method (compareGeom), 77
- concats, 14, 78
- concats, SpatRaster-method (concats), 78
- contour, 21, 79, 79, 224
- contour, SpatRaster-method (contour), 79
- convHull (hull), 151
- convHull, SpatVector-method (hull), 151
- cor, 211
- costDist, 11, 80, 102, 148
- costDist, SpatRaster-method (costDist), 80
- countNA (summarize), 310
- countNA, SpatRaster-method (summarize), 310
- cov.wt, 178
- cover, 10, 17, 82, 153
- cover, SpatRaster, missing-method (cover), 82
- cover, SpatRaster, SpatRaster-method

- (cover), 82
- cover, SpatVector, SpatVector-method (cover), 82
- cppFunction, 132
- crds, 16, 22, 83, 143, 368
- crds, SpatRaster-method (crds), 83
- crds, SpatVector-method (crds), 83
- crop, 9, 16, 17, 19, 20, 84, 107, 108, 113, 167, 168, 184, 189, 259, 265, 266, 282, 335, 356, 357
- crop, SpatGraticule-method (crop), 84
- crop, SpatRaster-method (crop), 84
- crop, SpatRasterCollection-method (crop), 84
- crop, SpatRasterDataset-method (crop), 84
- crop, SpatVector-method (crop), 84
- crostab, 11, 86
- crostab, SpatRaster, missing-method (crostab), 86
- crs, 17, 19, 44, 46, 48, 87, 181, 237, 238, 240, 248, 296, 344
- crs, character-method (crs), 87
- crs, sf-method (crs), 87
- crs, SpatExtent-method (crs), 87
- crs, SpatRaster-method (crs), 87
- crs, SpatRasterDataset-method (crs), 87
- crs, SpatVector-method (crs), 87
- crs, SpatVectorCollection-method (crs), 87
- crs, SpatVectorProxy-method (crs), 87
- crs<- (crs), 87
- crs<-, SpatRaster, ANY-method (crs), 87
- crs<-, SpatRaster-method (crs), 87
- crs<-, SpatVector, ANY-method (crs), 87
- crs<-, SpatVector-method (crs), 87
- cummax, 67
- cummin, 67
- cumsum, 269, 270
- cumsum (Math-methods), 190
- cumsum, SpatRaster-method (Math-methods), 190
- cut, 52
- data.frame, 43, 257, 340
- datatype, 13, 89, 144
- datatype, SpatRaster-method (datatype), 89
- datatype, SpatVector-method (datatype), 89
- Date, 328
- deepcopy, 15, 90
- deepcopy, SpatRaster-method (deepcopy), 90
- deepcopy, SpatVector-method (deepcopy), 90
- delaunay, 16
- delaunay (voronoi), 348
- delaunay, SpatVector-method (voronoi), 348
- deldir, 348
- densify, 16, 91, 291, 299, 324
- densify, SpatVector-method (densify), 91
- density, 21, 92, 224
- density, SpatRaster-method (density), 92
- deprecated, 93
- depth, 13, 93, 329, 359
- depth, SpatRaster-method (depth), 93
- depth<- (depth), 93
- depth<- , SpatRaster-method (depth), 93
- depthName, 13
- depthName (depth), 93
- depthName, SpatRaster-method (depth), 93
- depthName<- (depth), 93
- depthName<- , SpatRaster-method (depth), 93
- depthUnit, 13
- depthUnit (depth), 93
- depthUnit, SpatRaster-method (depth), 93
- depthUnit<- (depth), 93
- depthUnit<- , SpatRaster-method (depth), 93
- describe, 15, 42, 94, 142, 279, 280
- describe, character-method (describe), 94
- describe, SpatRaster-method (describe), 94
- diff, 95
- diff, SpatRaster-method (diff), 95
- dim (dimensions), 96
- dim, SpatRaster-method (dimensions), 96
- dim, SpatRasterCollection-method (dimensions), 96
- dim, SpatRasterDataset-method (dimensions), 96
- dim, SpatVector-method (dimensions), 96
- dim, SpatVectorProxy-method (dimensions), 96
- dim<- , SpatRaster-method (dimensions), 96

- dimensions, 96
- direction, 11, 98
- direction, SpatRaster-method
(direction), 98
- disagg, 9, 17, 22, 31, 44, 84, 99, 265, 266
- disagg, SpatRaster-method (disagg), 99
- disagg, SpatVector-method (disagg), 99
- distance, 11, 22, 57, 81, 99, 100, 148, 203, 324
- distance, data.frame, data.frame-method
(distance), 100
- distance, data.frame, missing-method
(distance), 100
- distance, matrix, matrix-method
(distance), 100
- distance, matrix, missing-method
(distance), 100
- distance, SpatRaster, missing-method
(distance), 100
- distance, SpatRaster, sf-method
(distance), 100
- distance, SpatRaster, SpatVector-method
(distance), 100
- distance, SpatVector, ANY-method
(distance), 100
- distance, SpatVector, SpatVector-method
(distance), 100
- divide, 10, 17, 103, 184, 325
- divide, SpatRaster-method (divide), 103
- divide, SpatVector-method (divide), 103
- dots, 21, 105
- dots, SpatVector-method (dots), 105
- draw, 19, 21, 22, 33, 71, 106, 282, 372
- draw, character-method (draw), 106
- draw, missing-method (draw), 106
- droplevels (factors), 120
- droplevels, SpatRaster-method (factors), 120

- elongate, 18, 57, 107, 113
- elongate, SpatVector-method (elongate), 107
- emptyGeoms (topology), 332
- emptyGeoms, SpatVector-method
(topology), 332
- erase, 17, 18, 74, 107, 108, 316
- erase, SpatGraticule, SpatVector-method
(erase), 108
- erase, SpatVector, missing-method
(erase), 108
- erase, SpatVector, SpatExtent-method
(erase), 108
- erase, SpatVector, SpatVector-method
(erase), 108
- expand, 11, 17, 22, 63, 109, 314
- expand, SpatRaster-method (expand), 109
- expand, SpatVector-method (expand), 109
- ext, 13, 17, 19, 22, 33, 36, 85, 97, 111, 113, 224, 294, 366
- ext, bbox-method (ext), 111
- ext, data.frame-method (ext), 111
- ext, Extent-method (ext), 111
- ext, matrix-method (ext), 111
- ext, missing-method (ext), 111
- ext, numeric-method (ext), 111
- ext, PackedSpatExtent-method (ext), 111
- ext, Raster-method (ext), 111
- ext, sf-method (ext), 111
- ext, SpatExtent-method (ext), 111
- ext, SpatGraticule-method (ext), 111
- ext, Spatial-method (ext), 111
- ext, SpatRaster-method (ext), 111
- ext, SpatRasterCollection-method (ext), 111
- ext, SpatRasterDataset-method (ext), 111
- ext, SpatRasterGraticule-method (ext), 111
- ext, SpatVector-method (ext), 111
- ext, SpatVectorCollection-method (ext), 111
- ext, SpatVectorProxy-method (ext), 111
- ext<- (ext), 111
- ext<-, SpatRaster, numeric-method (ext), 111
- ext<-, SpatRaster, SpatExtent-method
(ext), 111
- extend, 9, 84, 85, 107, 112, 265, 334, 335, 357
- extend, SpatExtent-method (extend), 112
- extend, SpatRaster-method (extend), 112
- extract, 12, 18, 23, 114, 117–119, 146, 284, 305, 306, 308, 370
- extract, SpatRaster, data.frame-method
(extract), 114
- extract, SpatRaster, matrix-method
(extract), 114
- extract, SpatRaster, numeric-method

- (extract), 114
- extract, SpatRaster, sf-method (extract), 114
- extract, SpatRaster, SpatExtent-method (extract), 114
- extract, SpatRaster, SpatVector-method (extract), 114
- extract, SpatRasterCollection, ANY-method (extract), 114
- extract, SpatRasterDataset, ANY-method (extract), 114
- extract, SpatVector, data.frame-method (extract), 114
- extract, SpatVector, matrix-method (extract), 114
- extract, SpatVector, SpatVector-method (extract), 114
- extractAlong, 12, 116, 117
- extractRange, 10, 116, 118
- extractRange, SpatRaster, ANY-method (extractRange), 118
- extractRange, SpatRaster-method (extractRange), 118
- extremes, 119
- factor, 120
- factors, 120
- fileBlocksize, 184
- fileBlocksize (readwrite), 255
- filled.contour, 79
- fillHoles, 16, 18, 122, 140, 332
- fillHoles, SpatRaster-method (fillHoles), 122
- fillHoles, SpatVector-method (fillHoles), 122
- fillTime, 14, 40, 124, 195
- fillTime, SpatRaster-method (fillTime), 124
- flip, 9, 18, 125, 170, 171, 247, 267, 280, 290, 301, 333
- flip, SpatRaster-method (flip), 125
- flip, SpatVector-method (flip), 125
- flowAccumulation, 11, 126, 204, 216
- flowAccumulation, SpatRaster-method (flowAccumulation), 126
- focal, 11, 39, 40, 54, 65, 128, 130–137, 146, 183, 213, 269, 270, 290, 319, 326, 327
- focal, SpatRaster-method (focal), 128
- focal3D, 11, 129, 130, 135, 137
- focal3D, SpatRaster-method (focal3D), 130
- focalCor (focalPairs), 135
- focalCor, SpatRaster-method (focalPairs), 135
- focalCpp, 11, 129, 132
- focalCpp, SpatRaster-method (focalCpp), 132
- focalMat, 11, 129, 134
- focalPairs, 11, 22, 129, 135
- focalPairs, SpatRaster-method (focalPairs), 135
- focalReg, 11, 129, 135, 136
- focalReg, SpatRaster-method (focalReg), 136
- focalValues, 11, 129, 133, 137, 137, 341
- focalValues, SpatRaster-method (focalValues), 137
- forceCCW, 19, 138, 332
- forceCCW, SpatVector-method (forceCCW), 138
- formatC, 222
- free_RAM, 184
- free_RAM (mem), 192
- freq, 11, 86, 138
- freq, SpatRaster-method (freq), 138
- future_lapply, 326
- gaps, 18, 123, 140, 289, 291, 332
- gaps, SpatVector, SpatExtent-method (gaps), 140
- gaps, SpatVector-method (gaps), 140
- gdal, 15, 140, 248, 362
- gdalCache (gdal), 140
- geom, 16, 43, 46, 83, 143, 149, 343–345
- geom, SpatVector-method (geom), 143
- geomtype, 17, 144
- geomtype, Spatial-method (geomtype), 144
- geomtype, SpatVector-method (geomtype), 144
- geomtype, SpatVectorProxy-method (geomtype), 144
- getGDALconfig, 15
- getGDALconfig (gdal), 140
- getTileExtents, 65, 326, 327
- getTileExtents (makeTiles), 183
- getTileExtents, SpatRaster-method (makeTiles), 183

- global, [11](#), [22](#), [38](#), [110](#), [145](#), [178](#), [241](#), [272](#), [313](#), [370](#)
- global, SpatRaster-method (global), [145](#)
- graticule, [20](#), [25–27](#), [146](#), [223](#), [229](#), [230](#)
- grid, [26](#)
- gridDist, [11](#), [81](#), [93](#), [102](#), [147](#)
- gridDist, SpatRaster-method (gridDist), [147](#)
- gridDistance (deprecated), [93](#)
- gridDistance, SpatRaster-method (deprecated), [93](#)

- halo, [20](#), [148](#), [323](#)
- has.colors, [21](#)
- has.colors (colors), [72](#)
- has.colors, SpatRaster-method (colors), [72](#)
- has.RGB (RGB), [267](#)
- has.RGB, SpatRaster-method (RGB), [267](#)
- has.time (time), [328](#)
- has.time, SpatRaster-method (time), [328](#)
- has.time, SpatRasterDataset-method (time), [328](#)
- hasMinMax (extremes), [119](#)
- hasMinMax, SpatRaster-method (extremes), [119](#)
- hasValues (sources), [293](#)
- hasValues, SpatRaster-method (sources), [293](#)
- head (headtail), [149](#)
- head, SpatRaster-method (headtail), [149](#)
- head, SpatVector-method (headtail), [149](#)
- headtail, [149](#)
- hist, [21](#), [52](#), [55](#), [150](#), [150](#), [211](#), [224](#)
- hist, SpatRaster-method (hist), [150](#)
- hull, [16](#), [151](#), [356](#)
- hull, SpatVector-method (hull), [151](#)

- identical, [10](#), [34](#), [152](#), [337](#)
- identical, SpatExtent, SpatExtent-method (identical), [152](#)
- identical, SpatRaster, SpatRaster-method (identical), [152](#)
- identical, SpatVector, SpatVector-method (identical), [152](#)
- ifel, [40](#), [76](#), [153](#)
- ifel, SpatRaster-method (ifel), [153](#)
- ifelse, [153](#)
- image, [20](#), [154](#), [154](#), [224](#), [230](#)
- image, SpatRaster-method (image), [154](#)
- impose, [16](#), [155](#)
- impose, SpatRasterCollection-method (impose), [155](#)
- inext (inset), [159](#)
- inext, SpatVector-method (inset), [159](#)
- init, [10](#), [286](#), [287](#)
- init (initialize), [156](#)
- init, SpatRaster-method (initialize), [156](#)
- initialize, [156](#)
- inMemory, [13](#), [15](#), [331](#)
- inMemory (sources), [293](#)
- inMemory, SpatRaster-method (sources), [293](#)
- inplace, [157](#)
- inset, [21](#), [159](#), [207](#), [266](#), [267](#), [275](#)
- inset, SpatRaster-method (inset), [159](#)
- inset, SpatVector-method (inset), [159](#)
- interpIDW, [12](#), [161](#), [163](#), [164](#), [254](#)
- interpIDW, SpatRaster, matrix-method (interpIDW), [161](#)
- interpIDW, SpatRaster, SpatVector-method (interpIDW), [161](#)
- interpNear, [12](#), [162](#), [162](#), [164](#), [254](#)
- interpNear, SpatRaster, matrix-method (interpNear), [162](#)
- interpNear, SpatRaster, SpatVector-method (interpNear), [162](#)
- interpolate, [12](#), [162](#), [163](#), [232](#)
- interpolate (interpolation), [163](#)
- interpolate, SpatRaster-method (interpolation), [163](#)
- interpolation, [163](#)
- intersect, [17](#), [19](#), [74](#), [84](#), [85](#), [108](#), [166](#), [259](#), [282](#), [335](#)
- intersect, SpatExtent, SpatExtent-method (intersect), [166](#)
- intersect, SpatExtent, SpatRaster-method (intersect), [166](#)
- intersect, SpatExtent, SpatVector-method (intersect), [166](#)
- intersect, SpatRaster, SpatExtent-method (intersect), [166](#)
- intersect, SpatRaster, SpatRaster-method (intersect), [166](#)
- intersect, SpatRaster, SpatExtent-method (intersect), [166](#)
- intersect, SpatVector, SpatExtent-method (intersect), [166](#)
- intersect, SpatVector, SpatVector-method

- (intersect), [166](#)
- `is.bool`, [168](#)
- `is.bool`, `SpatRaster`-method (`is.bool`), [168](#)
- `is.empty`, [170](#)
- `is.empty`, `SpatExtent`-method (`is.empty`), [170](#)
- `is.empty`, `SpatVector`-method (`is.empty`), [170](#)
- `is.factor`, [14](#), [122](#)
- `is.factor` (`is.bool`), [168](#)
- `is.factor`, `SpatRaster`-method (`is.bool`), [168](#)
- `is.finite`, `SpatExtent`-method (`Compare-methods`), [75](#)
- `is.finite`, `SpatRaster`-method (`Compare-methods`), [75](#)
- `is.flipped`, [13](#), [170](#), [172](#)
- `is.flipped`, `SpatRaster`-method (`is.flipped`), [170](#)
- `is.infinite`, `SpatRaster`-method (`Compare-methods`), [75](#)
- `is.int` (`is.bool`), [168](#)
- `is.int`, `SpatRaster`-method (`is.bool`), [168](#)
- `is.lines`, [17](#)
- `is.lines` (`geomtype`), [144](#)
- `is.lines`, `SpatVector`-method (`geomtype`), [144](#)
- `is.lonlat`, [17](#), [19](#), [22](#), [171](#)
- `is.lonlat`, `character`-method (`is.lonlat`), [171](#)
- `is.lonlat`, `SpatRaster`-method (`is.lonlat`), [171](#)
- `is.lonlat`, `SpatVector`-method (`is.lonlat`), [171](#)
- `is.na`, [332](#)
- `is.na`, `SpatRaster`-method (`Compare-methods`), [75](#)
- `is.na`, `SpatVector`-method (`na.omit`), [200](#)
- `is.nan`, `SpatRaster`-method (`Compare-methods`), [75](#)
- `is.num` (`is.bool`), [168](#)
- `is.num`, `SpatRaster`-method (`is.bool`), [168](#)
- `is.points`, [17](#)
- `is.points` (`geomtype`), [144](#)
- `is.points`, `SpatVector`-method (`geomtype`), [144](#)
- `is.polygons`, [17](#)
- `is.polygons` (`geomtype`), [144](#)
- `is.polygons`, `SpatVector`-method (`geomtype`), [144](#)
- `is.related`, [167](#)
- `is.related` (`relate`), [259](#)
- `is.related`, `SpatExtent`, `SpatRaster`-method (`relate`), [259](#)
- `is.related`, `SpatExtent`, `SpatVector`-method (`relate`), [259](#)
- `is.related`, `SpatRaster`, `SpatExtent`-method (`relate`), [259](#)
- `is.related`, `SpatRaster`, `SpatRaster`-method (`relate`), [259](#)
- `is.related`, `SpatRaster`, `SpatVector`-method (`relate`), [259](#)
- `is.related`, `SpatVector`, `SpatExtent`-method (`relate`), [259](#)
- `is.related`, `SpatVector`, `SpatRaster`-method (`relate`), [259](#)
- `is.related`, `SpatVector`, `SpatVector`-method (`relate`), [259](#)
- `is.rotated`, [13](#), [171](#), [172](#), [257](#)
- `is.rotated`, `SpatRaster`-method (`is.rotated`), [172](#)
- `is.valid`, [18](#), [109](#), [173](#), [291](#)
- `is.valid`, `SpatExtent`-method (`is.valid`), [173](#)
- `is.valid`, `SpatVector`-method (`is.valid`), [173](#)
- `isFALSE`, `SpatRaster`-method (`is.bool`), [168](#)
- `isTRUE`, [355](#)
- `isTRUE`, `SpatRaster`-method (`is.bool`), [168](#)
- `jitter`, [32](#), [182](#), [322](#)
- `k_means`, [12](#), [174](#), [296](#), [297](#)
- `k_means`, `ANY`-method (`k_means`), [174](#)
- `k_means`, `SpatRaster`-method (`k_means`), [174](#)
- `kmeans`, [104](#), [174](#)
- `lapp`, [9](#), [22](#), [38](#), [175](#), [245](#), [273](#), [365](#)
- `lapp`, `SpatRaster`-method (`lapp`), [175](#)
- `lapp`, `SpatRasterDataset`-method (`lapp`), [175](#)
- `lapply`, [273](#)
- `layerCor`, [11](#), [22](#), [135](#), [177](#), [235](#)
- `layerCor`, `SpatRaster`-method (`layerCor`), [177](#)
- `legend`, [27](#), [222](#)
- `legend_cont`, [179](#)

- length, [16, 19](#)
- length(dimensions), [96](#)
- length, SpatRasterCollection-method
(dimensions), [96](#)
- length, SpatRasterDataset-method
(dimensions), [96](#)
- length, SpatVector-method(dimensions),
[96](#)
- length, SpatVectorCollection-method
(dimensions), [96](#)
- levels, [14, 24, 168, 169](#)
- levels(factors), [120](#)
- levels, SpatRaster-method(factors), [120](#)
- levels<- (factors), [120](#)
- levels<-, SpatRaster-method(factors),
[120](#)
- libVersion(gdal), [140](#)
- linearUnits, [17, 19, 180](#)
- linearUnits, SpatRaster-method
(linearUnits), [180](#)
- linearUnits, SpatVector-method
(linearUnits), [180](#)
- lines, [20, 26, 181, 220, 224, 228–230](#)
- lines, leaflet-method(plet), [217](#)
- lines, sf-method(lines), [181](#)
- lines, SpatExtent-method(lines), [181](#)
- lines, SpatGraticule, missing-method
(plot_graticule), [229](#)
- lines, SpatGraticule-method(lines), [181](#)
- lines, SpatRaster-method(lines), [181](#)
- lines, SpatVector-method(lines), [181](#)
- locator, [70](#)
- log(Math-methods), [190](#)
- log, SpatRaster-method(Math-methods),
[190](#)
- logic(Compare-methods), [75](#)
- Logic, logical, SpatRaster-method
(Compare-methods), [75](#)
- Logic, numeric, SpatRaster-method
(Compare-methods), [75](#)
- Logic, SpatRaster, logical-method
(Compare-methods), [75](#)
- Logic, SpatRaster, numeric-method
(Compare-methods), [75](#)
- Logic, SpatRaster, SpatRaster-method
(Compare-methods), [75](#)
- logic, SpatRaster-method
(Compare-methods), [75](#)
- Logic-methods, [10](#)
- Logic-methods(Compare-methods), [75](#)
- longnames, [12](#)
- longnames(varnames), [341](#)
- longnames, SpatRaster-method(varnames),
[341](#)
- longnames, SpatRasterDataset-method
(varnames), [341](#)
- longnames<-, [12](#)
- longnames<- (varnames), [341](#)
- longnames<-, SpatRaster-method
(varnames), [341](#)
- longnames<-, SpatRasterDataset-method
(varnames), [341](#)
- make.names, [202, 231](#)
- make.unique, [202, 342](#)
- makeNodes, [18](#)
- makeNodes(topology), [332](#)
- makeNodes, SpatVector-method(topology),
[332](#)
- makeTiles, [104, 183, 327, 349, 350](#)
- makeTiles, SpatRaster-method
(makeTiles), [183](#)
- makeValid, [18, 109, 291](#)
- makeValid(is.valid), [173](#)
- makeValid, SpatVector-method(is.valid),
[173](#)
- makeVRT, [15, 185, 350](#)
- map.pal, [20, 186](#)
- map_extent, [21, 187](#)
- mask, [10, 84, 108, 153, 188, 237, 251](#)
- mask, SpatRaster, sf-method(mask), [188](#)
- mask, SpatRaster, SpatExtent-method
(mask), [188](#)
- mask, SpatRaster, SpatRaster-method
(mask), [188](#)
- mask, SpatRaster, SpatVector-method
(mask), [188](#)
- mask, SpatVector, sf-method(mask), [188](#)
- mask, SpatVector, SpatExtent-method
(mask), [188](#)
- mask, SpatVector, SpatVector-method
(mask), [188](#)
- match, [10, 189, 190](#)
- match, SpatRaster-method(match), [189](#)
- math, [176](#)
- math(Math-methods), [190](#)

- Math, SpatExtent-method (Math-methods), 190
- Math, SpatRaster-method (Math-methods), 190
- math, SpatRaster-method (Math-methods), 190
- Math-methods, 10, 19, 190
- Math2, SpatExtent-method (Math-methods), 190
- Math2, SpatRaster-method (Math-methods), 190
- Math2, SpatVector-method (Math-methods), 190
- Math2-methods (Math-methods), 190
- max (summarize), 310
- max, SpatRaster-method (summarize), 310
- mean (summarize), 310
- mean, SpatExtent-method (summarize), 310
- mean, SpatRaster-method (summarize), 310
- mean, SpatVector-method (summarize), 310
- median (summarize), 310
- median, SpatRaster-method (summarize), 310
- median, SpatVector-method (summarize), 310
- mem, 192
- mem_info, 15, 209, 362
- mem_info (mem), 192
- merge, 9, 16, 18, 113, 121, 193, 193, 198, 199, 300, 335
- merge, SpatRaster, SpatRaster-method (merge), 193
- merge, SpatRasterCollection, missing-method (merge), 193
- merge, SpatVector, data.frame-method (merge), 193
- merge, SpatVector, SpatVector-method (merge), 193
- mergeLines, 18
- mergeLines (topology), 332
- mergeLines, SpatVector-method (topology), 332
- mergeTime, 14, 195
- mergeTime, SpatRasterDataset-method (mergeTime), 195
- meta, 15, 196
- meta, SpatRaster-method (meta), 196
- metags, 15, 196, 247, 248, 280, 301, 360
- metags, SpatRaster-method (metags), 196
- metags, SpatRasterCollection-method (metags), 196
- metags, SpatRasterDataset-method (metags), 196
- metags<-, 15, 362
- metags<- (metags), 196
- metags<-, SpatRaster-method (metags), 196
- metags<-, SpatRasterCollection-method (metags), 196
- metags<-, SpatRasterDataset-method (metags), 196
- min (summarize), 310
- min, SpatRaster-method (summarize), 310
- minmax, 12, 179
- minmax (extremes), 119
- minmax, SpatRaster-method (extremes), 119
- modal, 10, 197, 310, 312
- modal, SpatRaster-method (modal), 197
- mosaic, 9, 16, 194, 198, 300, 327, 335
- mosaic, SpatRaster, SpatRaster-method (mosaic), 198
- mosaic, SpatRasterCollection, missing-method (mosaic), 198
- mtext, 28
- na.omit, 16, 200
- na.omit, SpatVector-method (na.omit), 200
- NAflag, 13, 22, 200
- NAflag, SpatRaster-method (NAflag), 200
- NAflag<- (NAflag), 200
- NAflag<- , SpatRaster-method (NAflag), 200
- name (names), 201
- name<- (names), 201
- names, 12, 15, 16, 150, 201, 231, 338
- names, SpatRaster-method (names), 201
- names, SpatRasterCollection-method (names), 201
- names, SpatRasterDataset-method (names), 201
- names, SpatVector-method (names), 201
- names, SpatVectorCollection-method (names), 201
- names, SpatVectorProxy-method (names), 201
- names<- (names), 201
- names<- , SpatRaster-method (names), 201
- names<- , SpatRasterCollection-method (names), 201

- names<- ,SpatRasterDataset-method
(names), 201
- names<- ,SpatVector-method (names), 201
- names<- ,SpatVectorCollection-method
(names), 201
- nany (summarize), 310
- nany, ANY-method (summarize), 310
- nany, SpatRaster-method (summarize), 310
- ncell, 12, 367
- ncell (dimensions), 96
- ncell, ANY-method (dimensions), 96
- ncell, SpatRaster-method (dimensions), 96
- ncell, SpatRasterDataset-method
(dimensions), 96
- ncol, 12, 16
- ncol (dimensions), 96
- ncol, SpatRaster-method (dimensions), 96
- ncol, SpatRasterCollection-method
(dimensions), 96
- ncol, SpatRasterDataset-method
(dimensions), 96
- ncol, SpatVector-method (dimensions), 96
- ncol<- (dimensions), 96
- ncol<- ,SpatRaster, numeric-method
(dimensions), 96
- ncvar_def, 360
- nearby, 17, 30, 102, 259, 324
- nearby (nearest), 202
- nearby, SpatVector-method (nearest), 202
- nearest, 17, 30, 102, 202, 324
- nearest, SpatVector-method (nearest), 202
- NIDP, 11, 126, 204, 216
- NIDP, SpatRaster-method (NIDP), 204
- nlyr, 12, 22
- nlyr (dimensions), 96
- nlyr, SpatRaster-method (dimensions), 96
- nlyr, SpatRasterCollection-method
(dimensions), 96
- nlyr, SpatRasterDataset-method
(dimensions), 96
- nlyr<- (dimensions), 96
- nlyr<- ,SpatRaster, numeric-method
(dimensions), 96
- noNA, 75
- noNA (summarize), 310
- noNA, SpatRaster-method (summarize), 310
- normalize.longitude, 18, 205, 271
- normalize.longitude, SpatVector-method
(normalize.longitude), 205
- north, 21, 206, 224, 230, 275
- not.na, 10, 75, 207
- not.na, SpatRaster-method (not.na), 207
- nrow, 12, 16
- nrow (dimensions), 96
- nrow, SpatRaster-method (dimensions), 96
- nrow, SpatRasterCollection-method
(dimensions), 96
- nrow, SpatRasterDataset-method
(dimensions), 96
- nrow, SpatVector-method (dimensions), 96
- nrow<- (dimensions), 96
- nrow<- ,SpatRaster, numeric-method
(dimensions), 96
- nseg, 208
- nseg, SpatVector-method (nseg), 208
- nsrc (dimensions), 96
- nsrc, SpatRaster-method (dimensions), 96
- options, 209
- origin, 13, 210
- origin, SpatRaster-method (origin), 210
- origin<- (origin), 210
- origin<- ,SpatRaster-method (origin), 210
- PackedSpatRaster-class
(SpatRaster-class), 295
- PackedSpatVector-class
(SpatVector-class), 298
- pairs, 21, 55, 150, 211, 211, 224
- pairs, SpatRaster-method (pairs), 211
- panel, 20, 212, 224
- panel, SpatRaster-method (panel), 212
- par, 182, 219
- patches, 11, 22, 54, 213
- patches, SpatRaster-method (patches), 213
- perim, 17, 214
- perim, SpatVector-method (perim), 214
- perimeter (perim), 214
- perimeter, SpatVector-method (perim), 214
- persp, 21, 215, 215, 224
- persp, SpatRaster-method (persp), 215
- pitfinder, 11, 216
- pitfinder, SpatRaster-method
(pitfinder), 216
- plan, 326
- plet, 21, 217
- plet, missing-method (plet), 217

- plet, SpatRaster-method (plet), 217
- plet, SpatRasterCollection-method (plet), 217
- plet, SpatVector-method (plet), 217
- plet, SpatVectorCollection-method (plet), 217
- plot, 20, 21, 36, 59, 79, 92, 105, 148, 154, 207, 212, 217, 219, 220, 227, 228, 230, 267, 275, 323, 372
- plot, SpatExtent, missing-method (plot_extent), 228
- plot, SpatGraticule, missing-method (plot_graticule), 229
- plot, SpatRaster, character-method (plot), 220
- plot, SpatRaster, missing-method (plot), 220
- plot, SpatRaster, numeric-method (plot), 220
- plot, SpatRaster, SpatRaster-method (scatterplot), 277
- plot, SpatVector, character-method (plot), 220
- plot, SpatVector, data.frame-method (plot), 220
- plot, SpatVector, missing-method (plot), 220
- plot, SpatVector, numeric-method (plot), 220
- plot, SpatVectorCollection, missing-method (plot), 220
- plot, SpatVectorCollection, numeric-method (plot), 220
- plot, SpatVectorProxy, missing-method (plot), 220
- plot<SpatGraticule>, 20, 146
- plot_extent, 228
- plot_graticule, 229
- plotRGB, 20, 218, 224, 226, 267
- plotRGB, SpatRaster-method (plotRGB), 226
- points, 20, 105, 182, 220, 224, 230
- points (lines), 181
- points, leaflet-method (plet), 217
- points, sf-method (lines), 181
- points, SpatExtent-method (lines), 181
- points, SpatRaster-method (lines), 181
- points, SpatVector-method (lines), 181
- polys, 20, 220, 224, 230
- polys (lines), 181
- polys, leaflet-method (plet), 217
- polys, sf-method (lines), 181
- polys, SpatExtent-method (lines), 181
- polys, SpatRaster-method (lines), 181
- polys, SpatVector-method (lines), 181
- POSIXlt, 328
- prcomp, 12, 230, 231, 235
- prcomp, SpatRaster-method (prcomp), 230
- predict, 12, 69, 163, 164, 231
- predict, SpatRaster-method (predict), 231
- pretty, 179
- princomp, 12, 230, 231, 234, 235
- princomp, SpatRaster-method (princomp), 234
- prod (summarize), 310
- prod, SpatRaster-method (summarize), 310
- proj_ok (gdal), 140
- proj_pipelines, 238, 239
- project, 9, 12, 16, 22, 87, 142, 215, 236, 239, 240, 265, 266, 351
- project, matrix-method (project), 236
- project, SpatExtent-method (project), 236
- project, SpatRaster-method (project), 236
- project, SpatVector-method (project), 236
- project, SpatVectorCollection-method (project), 236
- projNetwork, 238, 240
- projNetwork (gdal), 140
- projPaths (gdal), 140
- quantile, 11, 23, 241, 313
- quantile, SpatRaster-method (quantile), 241
- quantile, SpatVector-method (quantile), 241
- query, 18, 242
- query, SpatVectorProxy-method (query), 242
- rainbow, 52
- range (summarize), 310
- range, SpatRaster-method (summarize), 310
- rangeFill, 10, 243
- rangeFill, SpatRaster-method (rangeFill), 243
- rapp, 9, 116, 244, 244, 284
- rapp, SpatRaster-method (rapp), 244
- rast, 8, 20, 22, 246, 295

- `rast`, ANY-method (`rast`), 246
- `rast`, array-method (`rast`), 246
- `rast`, character-method (`rast`), 246
- `rast`, data.frame-method (`rast`), 246
- `rast`, list-method (`rast`), 246
- `rast`, matrix-method (`rast`), 246
- `rast`, missing-method (`rast`), 246
- `rast`, PackedSpatRaster-method (`rast`), 246
- `rast`, SpatExtent-method (`rast`), 246
- `rast`, SpatRaster-method (`rast`), 246
- `rast`, SpatRasterDataset-method (`rast`), 246
- `rast`, SpatVector-method (`rast`), 246
- `rast`, stars-method (`rast`), 246
- `rast`, stars_proxy-method (`rast`), 246
- `rasterImage`, 48
- `rasterize`, 20, 114, 162, 163, 250, 252–254
- `rasterize`, data.frame, SpatRaster-method (`rasterize`), 250
- `rasterize`, matrix, SpatRaster-method (`rasterize`), 250
- `rasterize`, sf, SpatRaster-method (`rasterize`), 250
- `rasterize`, SpatVector, SpatRaster-method (`rasterize`), 250
- `rasterizeGeom`, 20, 251, 251, 254
- `rasterizeGeom`, SpatVector, SpatRaster-method (`rasterizeGeom`), 251
- `rasterizeWin`, 20, 162, 163, 251, 253
- `rasterizeWin`, data.frame, SpatRaster-method (`rasterizeWin`), 253
- `rasterizeWin`, SpatVector, SpatRaster-method (`rasterizeWin`), 253
- `RasterSource` (SpatRaster-class), 295
- `RasterSource`-class (SpatRaster-class), 295
- `rbind`, 74, 335
- `rbind` (c), 57
- `rcl`, 254
- `rcl`, SpatRaster-method (`rcl`), 254
- `Rcpp_RasterSource`-class (SpatRaster-class), 295
- `Rcpp_SpatCategories`-class (SpatRaster-class), 295
- `Rcpp_SpatExtent`-class (SpatExtent-class), 294
- `Rcpp_SpatRaster`-class (SpatRaster-class), 295
- `Rcpp_SpatVector`-class (SpatVector-class), 298
- `readRDS` (serialize), 285
- `readRDS`, character-method (serialize), 285
- `readStart`, 14
- `readStart` (readwrite), 255
- `readStart`, SpatRaster-method (readwrite), 255
- `readStart`, SpatRasterDataset-method (readwrite), 255
- `readStop`, 14
- `readStop` (readwrite), 255
- `readStop`, SpatRaster-method (readwrite), 255
- `readStop`, SpatRasterDataset-method (readwrite), 255
- `readValues`, 14, 331
- `readValues` (readwrite), 255
- `readValues`, SpatRaster-method (readwrite), 255
- `readValues`, SpatRasterDataset-method (readwrite), 255
- `readwrite`, 255
- `rectify`, 172, 257
- `rectify`, SpatRaster-method (`rectify`), 257
- `regress`, 10, 258
- `regress`, SpatRaster, numeric-method (regress), 258
- `regress`, SpatRaster, SpatRaster-method (regress), 258
- `relate`, 17, 30, 168, 203, 259
- `relate`, SpatExtent, SpatExtent-method (relate), 259
- `relate`, SpatExtent, SpatRaster-method (relate), 259
- `relate`, SpatExtent, SpatVector-method (relate), 259
- `relate`, SpatRaster, SpatExtent-method (relate), 259
- `relate`, SpatRaster, SpatRaster-method (relate), 259
- `relate`, SpatRaster, SpatVector-method (relate), 259
- `relate`, SpatVector, missing-method (relate), 259
- `relate`, SpatVector, SpatExtent-method (relate), 259

- relate, SpatVector, SpatRaster-method (relate), 259
- relate, SpatVector, SpatVector-method (relate), 259
- removeDupNodes, 18
- removeDupNodes (topology), 332
- removeDupNodes, SpatVector-method (topology), 332
- rep, 9, 261, 261
- rep, SpatRaster-method (rep), 261
- replace_dollar, 262
- replace_layers, 263
- replace_values, 264
- res, 12, 248
- res (dimensions), 96
- res, SpatRaster-method (dimensions), 96
- res, SpatRasterDataset-method (dimensions), 96
- res<- (dimensions), 96
- res<-, SpatRaster, numeric-method (dimensions), 96
- res<-, SpatRaster-method (dimensions), 96
- resample, 9, 23, 30, 31, 33, 84, 100, 113, 155, 194, 199, 238, 257, 265
- resample, SpatRaster, numeric-method (resample), 265
- resample, SpatRaster, SpatRaster-method (resample), 265
- rescale, 18, 59, 111, 160, 266, 299
- rescale, SpatRaster-method (rescale), 266
- rescale, SpatVector-method (rescale), 266
- rev (flip), 125
- rev, SpatRaster-method (flip), 125
- RGB, 227, 267
- RGB, SpatRaster-method (RGB), 267
- RGB<- (RGB), 267
- RGB<-, SpatRaster-method (RGB), 267
- roll, 10, 22, 38, 191, 269, 365
- roll, numeric-method (roll), 269
- roll, SpatRaster-method (roll), 269
- rotate, 9, 18, 125, 206, 267, 270, 290, 333
- rotate, SpatRaster-method (rotate), 270
- rotate, SpatVector-method (rotate), 270
- round, 52
- round (Math-methods), 190
- round, SpatRaster-method (Math-methods), 190
- round, SpatVector-method (Math-methods), 190
- rowColCombine, 255
- rowColCombine (xyRowColCell), 367
- rowColCombine, SpatRaster, numeric, numeric-method (xyRowColCell), 367
- rowColFromCell, 13
- rowColFromCell (xyRowColCell), 367
- rowColFromCell, SpatRaster, numeric-method (xyRowColCell), 367
- rowFromCell (xyRowColCell), 367
- rowFromCell, SpatRaster, numeric-method (xyRowColCell), 367
- rowFromY, 13
- rowFromY (xyRowColCell), 367
- rowFromY, SpatRaster, numeric-method (xyRowColCell), 367
- rowMeans, 10
- rowMeans (rowSums), 271
- rowMeans, SpatRaster-method (rowSums), 271
- rowSums, 10, 271
- rowSums, SpatRaster-method (rowSums), 271
- runif, 156
- same.crs, 15, 240, 272
- sapp, 9, 176, 273
- sapp, SpatRaster-method (sapp), 273
- sapp, SpatRasterDataset-method (sapp), 273
- saveRDS, 8, 285
- saveRDS (serialize), 285
- saveRDS, SpatExtent-method (serialize), 285
- saveRDS, SpatRaster-method (serialize), 285
- saveRDS, SpatRasterCollection-method (serialize), 285
- saveRDS, SpatRasterDataset-method (serialize), 285
- saveRDS, SpatVector-method (serialize), 285
- sbar, 20, 160, 207, 224, 230, 274
- scale, 11, 230, 275, 275, 277
- scale, SpatRaster-method (scale), 275
- scale_linear, 10, 276, 276
- scale_linear, SpatRaster-method (scale_linear), 276
- scatter plot, 21
- scatterplot, 224, 277

- scoff, [13](#), [247](#), [278](#), [362](#)
- scoff, SpatRaster-method (scoff), [278](#)
- scoff<-, [13](#)
- scoff<- (scoff), [278](#)
- scoff<-, SpatRaster-method (scoff), [278](#)
- sds, [15](#), [249](#), [279](#), [301](#)
- sds, array-method (sds), [279](#)
- sds, character-method (sds), [279](#)
- sds, list-method (sds), [279](#)
- sds, missing-method (sds), [279](#)
- sds, SpatRaster-method (sds), [279](#)
- sds, stars-method (sds), [279](#)
- sds, stars_proxy-method (sds), [279](#)
- segregate, [10](#), [22](#), [281](#), [300](#)
- segregate, SpatRaster-method (segregate), [281](#)
- sel, [18](#), [21](#), [282](#)
- sel, SpatRaster-method (sel), [282](#)
- sel, SpatVector-method (sel), [282](#)
- selectHighest, [10](#), [283](#)
- selectHighest, SpatRaster-method (selectHighest), [283](#)
- selectRange, [9](#), [22](#), [244](#), [245](#), [284](#)
- selectRange, SpatRaster-method (selectRange), [284](#)
- serialize, [285](#), [285](#)
- serialize, SpatExtent-method (serialize), [285](#)
- serialize, SpatRaster-method (serialize), [285](#)
- serialize, SpatRasterCollection-method (serialize), [285](#)
- serialize, SpatRasterDataset-method (serialize), [285](#)
- serialize, SpatVector-method (serialize), [285](#)
- set.cats, [14](#), [122](#)
- set.cats (inplace), [157](#)
- set.cats, SpatRaster-method (inplace), [157](#)
- set.crs (inplace), [157](#)
- set.crs, SpatRaster-method (inplace), [157](#)
- set.crs, SpatVector-method (inplace), [157](#)
- set.ext, [90](#), [111](#)
- set.ext (inplace), [157](#)
- set.ext, SpatRaster-method (inplace), [157](#)
- set.ext, SpatVector-method (inplace), [157](#)
- set.names, [201](#)
- set.names (inplace), [157](#)
- set.names, SpatRaster-method (inplace), [157](#)
- set.names, SpatRasterCollection-method (inplace), [157](#)
- set.names, SpatRasterDataset-method (inplace), [157](#)
- set.names, SpatVector-method (inplace), [157](#)
- set.names, SpatVectorCollection-method (inplace), [157](#)
- set.RGB, [268](#)
- set.RGB (inplace), [157](#)
- set.RGB, SpatRaster-method (inplace), [157](#)
- set.values, [264](#), [339](#)
- set.values (inplace), [157](#)
- set.values, SpatRaster-method (inplace), [157](#)
- set.values, SpatRasterDataset-method (inplace), [157](#)
- set.window (inplace), [157](#)
- set.window, SpatRaster-method (inplace), [157](#)
- setGDALconfig, [247](#), [349](#)
- setGDALconfig (gdal), [140](#)
- setMinMax, [12](#)
- setMinMax (extremes), [119](#)
- setMinMax, SpatRaster-method (extremes), [119](#)
- setValues, [12](#), [286](#)
- setValues, SpatRaster, ANY-method (setValues), [286](#)
- setValues, SpatRaster-method (setValues), [286](#)
- setValues, SpatVector, ANY-method (setValues), [286](#)
- setValues, SpatVector-method (setValues), [286](#)
- shade, [11](#), [287](#)
- sharedPaths, [18](#), [74](#), [140](#), [288](#), [291](#), [332](#)
- sharedPaths, SpatVector-method (sharedPaths), [288](#)
- shift, [9](#), [18](#), [160](#), [267](#), [271](#), [289](#), [299](#)
- shift, SpatExtent-method (shift), [289](#)
- shift, SpatRaster-method (shift), [289](#)
- shift, SpatVector-method (shift), [289](#)
- show, [149](#)
- show, SpatExtent-method

- (SpatExtent-class), 294
- show, SpatRaster-method
 - (SpatRaster-class), 295
- show, SpatVector-method
 - (SpatVector-class), 298
- sieve, 11, 290
- sieve, SpatRaster-method (sieve), 290
- simplifyGeom, 18, 91, 291, 332
- simplifyGeom, SpatVector-method
 - (simplifyGeom), 291
- simplifyLevels (factors), 120
- simplifyLevels, SpatRaster-method
 - (factors), 120
- size (dimensions), 96
- size, SpatRaster-method (dimensions), 96
- smoothScatter, 278
- snap, 18, 123
- snap (topology), 332
- snap, SpatVector-method (topology), 332
- sort, 18, 292
- sort, data.frame-method (sort), 292
- sort, SpatRaster-method (sort), 292
- sort, SpatVector-method (sort), 292
- sources, 13, 15, 293
- sources, SpatRaster-method (sources), 293
- sources, SpatRasterCollection-method
 - (sources), 293
- sources, SpatRasterDataset-method
 - (sources), 293
- sources, SpatVector-method (sources), 293
- sources, SpatVectorProxy-method
 - (sources), 293
- SpatCategories (SpatRaster-class), 295
- SpatCategories-class
 - (SpatRaster-class), 295
- SpatExtent, 112, 220, 224, 280
- SpatExtent (SpatExtent-class), 294
- SpatExtent-class, 294
- SpatGraticule, 220, 224
- SpatRaster (SpatRaster-class), 295
- SpatRaster-class, 295
- SpatRasterCollection
 - (SpatRaster-class), 295
- SpatRasterCollection-class
 - (SpatRaster-class), 295
- SpatRasterDataset (SpatRaster-class), 295
- SpatRasterDataset-class
 - (SpatRaster-class), 295
- spatSample, 12, 18, 22, 295, 313
- spatSample, SpatExtent-method
 - (spatSample), 295
- spatSample, SpatRaster-method
 - (spatSample), 295
- spatSample, SpatVector-method
 - (spatSample), 295
- SpatVector (SpatVector-class), 298
- SpatVector-class, 298
- SpatVectorCollection
 - (SpatVector-class), 298
- SpatVectorCollection-class
 - (SpatVector-class), 298
- SpatVectorProxy (SpatVector-class), 298
- SpatVectorProxy-class
 - (SpatVector-class), 298
- spin, 18, 271, 298
- spin, SpatVector-method (spin), 298
- split, 9, 16, 281, 299
- split, SpatRaster, ANY-method (split), 299
- split, SpatVector, ANY-method (split), 299
- split, SpatVector, SpatVector-method
 - (split), 299
- sprc, 16, 249, 279, 280, 300, 315
- sprc, character-method (sprc), 300
- sprc, list-method (sprc), 300
- sprc, missing-method (sprc), 300
- sprc, SpatRaster-method (sprc), 300
- sqrt (Math-methods), 190
- sqrt, SpatRaster-method (Math-methods), 190
- stdev (summarize), 310
- stdev, SpatRaster-method (summarize), 310
- stretch, 11, 227, 301
- stretch, SpatRaster-method (stretch), 301
- subset, 9, 22, 244, 303, 305, 306, 308
- subset, SpatRaster-method (subset), 303
- subset, SpatVector-method (subset), 303
- subset_dollar, 304
- subset_double, 306
- subset_single, 307
- subst, 10, 66, 69, 189, 264, 308
- subst, SpatRaster-method (subst), 308
- sum (summarize), 310
- sum, SpatRaster-method (summarize), 310
- summarize, 310
- summary, 11, 313, 313

- Summary, SpatExtent-method (summary), 313
- Summary, SpatRaster-method (summary), 313
- summary, SpatRaster-method (summary), 313
- Summary, SpatVector-method (summary), 313
- summary, SpatVector-method (summary), 313
- Summary-methods, 10, 23
- Summary-methods (summarize), 310
- surfArea, 10, 63, 110, 314
- surfArea, SpatRaster-method (surfArea), 314
- svc, 19, 315
- svc, character-method (svc), 315
- svc, list-method (svc), 315
- svc, missing-method (svc), 315
- svc, sf-method (svc), 315
- svc, SpatVector-method (svc), 315
- symdif, 17, 316
- symdif, SpatVector, SpatVector-method (symdif), 316

- t, 9, 18, 267, 299
- t (transpose), 333
- t, SpatRaster-method (transpose), 333
- t, SpatVector-method (transpose), 333
- tail (headtail), 149
- tail, SpatRaster-method (headtail), 149
- tail, SpatVector-method (headtail), 149
- tapp, 9, 22, 38, 175, 176, 245, 273, 284, 317, 365
- tapp, SpatRaster-method (tapp), 317
- tapply, 317
- terra (terra-package), 8
- terra-package, 8
- terrain, 11, 126, 204, 216, 273, 287, 288, 318, 347, 352
- terrain, SpatRaster-method (terrain), 318
- terrain.colors, 187
- terraOptions, 15, 184, 330, 362
- terraOptions (options), 209
- tessellate, 320
- tessellate, ANY-method (tessellate), 320
- text, 20, 28, 148, 224, 282, 322, 322, 323
- text, SpatRaster-method (text), 322
- text, SpatVector-method (text), 322
- thin, 17, 323
- thin, SpatVector-method (thin), 323
- thinNodes, 16, 91
- thinNodes (thin), 323
- thinNodes, SpatVector-method (thin), 323

- thresh, 10, 104, 324
- thresh, SpatRaster-method (thresh), 324
- tighten, 15, 325
- tighten, SpatRaster-method (tighten), 325
- tighten, SpatRasterDataset-method (tighten), 325
- tile_apply, 326
- time, 14, 94, 317, 328, 338, 359
- time, SpatRaster-method (time), 328
- time, SpatRasterDataset-method (time), 328
- time<- (time), 328
- time<-, SpatRaster-method (time), 328
- time<-, SpatRasterDataset-method (time), 328
- timeInfo (time), 328
- timeInfo, SpatRaster-method (time), 328
- timeInfo, SpatRasterDataset-method (time), 328
- title, 224
- tmpFiles, 15, 330
- toMemory, 13, 22, 294, 331
- toMemory, SpatRaster-method (toMemory), 331
- toMemory, SpatRasterDataset-method (toMemory), 331
- topology, 140, 173, 289, 332
- trans, 125
- trans (transpose), 333
- trans, SpatRaster-method (transpose), 333
- transpose, 333
- Trig, 49
- trim, 9, 113, 334
- trim, SpatRaster-method (trim), 334

- union, 17–19, 74, 168, 194, 335
- union, SpatExtent, SpatExtent-method (union), 335
- union, SpatVector, missing-method (union), 335
- union, SpatVector, SpatExtent-method (union), 335
- union, SpatVector, SpatVector-method (union), 335
- unique, 11, 16, 336, 337
- unique, SpatRaster, ANY-method (unique), 336
- unique, SpatRaster-method (unique), 336

- unique, SpatVector, ANY-method (unique), 336
- unique, SpatVector-method (unique), 336
- units, 13, 337
- units, SpatRaster-method (units), 337
- units, SpatRasterDataset-method (units), 337
- units<-, 13
- units<- (units), 337
- units<-, SpatRaster-method (units), 337
- units<-, SpatRasterDataset-method (units), 337
- unloadGDALdrivers (gdal), 140
- unserialize (serialize), 285
- unserialize, ANY-method (serialize), 285
- unwrap, 359
- unwrap (wrap), 357
- unwrap, ANY-method (wrap), 357
- unwrap, PackedSpatExtent-method (wrap), 357
- unwrap, PackedSpatRaster-method (wrap), 357
- unwrap, PackedSpatRasterDC-method (wrap), 357
- unwrap, PackedSpatVector-method (wrap), 357
- update, 338
- update, SpatRaster-method (update), 338
- values, 12, 18, 22, 23, 116, 264, 287, 331, 340
- values, SpatRaster-method (values), 340
- values, SpatVector-method (values), 340
- values<-, 12, 18
- values<- (setValues), 286
- values<-, SpatRaster, ANY-method (setValues), 286
- values<-, SpatVector, ANY-method (setValues), 286
- values<-, SpatVector, data.frame-method (setValues), 286
- values<-, SpatVector, matrix-method (setValues), 286
- values<-, SpatVector, NULL-method (setValues), 286
- varnames, 12, 341
- varnames, SpatRaster-method (varnames), 341
- varnames, SpatRasterDataset-method (varnames), 341
- varnames<-, 12
- varnames<- (varnames), 341
- varnames<-, SpatRaster-method (varnames), 341
- varnames<-, SpatRasterDataset-method (varnames), 341
- vect, 16, 20, 22, 243, 249, 343
- vect, character-method (vect), 343
- vect, data.frame-method (vect), 343
- vect, list-method (vect), 343
- vect, matrix-method (vect), 343
- vect, missing-method (vect), 343
- vect, PackedSpatVector-method (vect), 343
- vect, sf-method (vect), 343
- vect, sfc-method (vect), 343
- vect, SpatExtent-method (vect), 343
- vect, SpatGraticule-method (vect), 343
- vect, Spatial-method (vect), 343
- vect, SpatVector-method (vect), 343
- vect, SpatVectorCollection-method (vect), 343
- vect, XY-method (vect), 343
- vector_layers, 16, 345, 346, 363
- viewshed, 11, 320, 347
- viewshed, SpatRaster-method (viewshed), 347
- voronoi, 16, 348
- voronoi, SpatVector-method (voronoi), 348
- vrt, 15, 184, 186, 193, 194, 327, 349, 350
- vrt, character-method (vrt), 349
- vrt, SpatRasterCollection-method (vrt), 349
- vrt_tiles, 15, 350, 350
- warp_scale, 238, 351
- watershed, 11, 126, 216, 352
- watershed, SpatRaster-method (watershed), 352
- weighted.mean, 10, 178, 353, 353
- weighted.mean, SpatRaster, numeric-method (weighted.mean), 353
- weighted.mean, SpatRaster, SpatRaster-method (weighted.mean), 353
- where, 354
- where.max, 10, 120
- where.min, 10, 120
- which, 354, 355
- which.lyr, 10, 312, 355

- which.lyr, SpatRaster-method
(which.lyr), 355
- which.max (summarize), 310
- which.max, SpatRaster-method
(summarize), 310
- which.min (summarize), 310
- which.min, SpatRaster-method
(summarize), 310
- width, 18, 355
- width, SpatVector-method (width), 355
- window, 9, 247, 327, 356
- window, SpatRaster-method (window), 356
- window<-, 9
- window<- (window), 356
- window<-, SpatRaster-method (window), 356
- wrap, 8, 249, 285, 326, 327, 357, 358, 359
- wrap, SpatExtent-method (wrap), 357
- wrap, SpatRaster-method (wrap), 357
- wrap, SpatRasterCollection-method
(wrap), 357
- wrap, SpatRasterDataset-method (wrap),
357
- wrap, SpatVector-method (wrap), 357
- wrapCache, 358
- wrapCache, SpatRaster-method
(wrapCache), 358
- writeCDF, 14, 359, 363
- writeCDF, SpatRaster-method (writeCDF),
359
- writeCDF, SpatRasterDataset-method
(writeCDF), 359
- writeRaster, 8, 14, 31, 37, 39, 49, 53, 54, 57,
60, 63, 65–67, 69, 76, 78, 81, 82, 85,
89, 96, 98, 99, 101, 113, 121,
124–126, 129, 131, 132, 135, 136,
147, 153, 155, 156, 161, 162, 164,
169, 174, 176, 183, 189, 191,
193–195, 198, 199, 204, 208, 209,
213, 216, 232, 238, 241, 244, 245,
249, 251, 252, 254, 257, 258, 266,
268–270, 273, 277, 281, 284, 285,
287, 289, 290, 292, 302, 303, 309,
311, 314, 318, 319, 324, 327, 333,
334, 347, 352, 353, 360, 361, 364,
370
- writeRaster, SpatRaster, character-method
(writeRaster), 361
- writeStart, 14
- writeStart (readwrite), 255
- writeStart, SpatRaster, character-method
(readwrite), 255
- writeStop, 14
- writeStop (readwrite), 255
- writeStop, SpatRaster-method
(readwrite), 255
- writeValues, 14
- writeValues (readwrite), 255
- writeValues, SpatRaster, vector-method
(readwrite), 255
- writeVector, 16, 363
- writeVector, SpatVector, character-method
(writeVector), 363
- xapp, 9, 364
- xapp, SpatRaster, SpatRaster-method
(xapp), 364
- xFromCell, 13
- xFromCell (xyRowColCell), 367
- xFromCell, SpatRaster, numeric-method
(xyRowColCell), 367
- xFromCol, 13
- xFromCol (xyRowColCell), 367
- xFromCol, SpatRaster, missing-method
(xyRowColCell), 367
- xFromCol, SpatRaster, numeric-method
(xyRowColCell), 367
- xmax, 13, 112
- xmax (xmin), 365
- xmax, SpatExtent-method (xmin), 365
- xmax, SpatRaster-method (xmin), 365
- xmax, SpatVector-method (xmin), 365
- xmax<- (xmin), 365
- xmax<-, SpatExtent, numeric-method
(xmin), 365
- xmax<-, SpatRaster, numeric-method
(xmin), 365
- xmin, 13, 112, 365
- xmin, SpatExtent-method (xmin), 365
- xmin, SpatRaster-method (xmin), 365
- xmin, SpatVector-method (xmin), 365
- xmin<- (xmin), 365
- xmin<-, SpatExtent, numeric-method
(xmin), 365
- xmin<-, SpatRaster, numeric-method
(xmin), 365
- xres, 12
- xres (dimensions), 96

- xres, SpatRaster-method (dimensions), [96](#)
- xyFromCell, [13](#), [83](#), [115](#), [117](#), [143](#)
- xyFromCell (xyRowColCell), [367](#)
- xyFromCell, SpatRaster, numeric-method (xyRowColCell), [367](#)
- xyRowColCell, [367](#)

- yFromCell, [13](#)
- yFromCell (xyRowColCell), [367](#)
- yFromCell, SpatRaster, numeric-method (xyRowColCell), [367](#)
- yFromRow, [13](#)
- yFromRow (xyRowColCell), [367](#)
- yFromRow, SpatRaster, missing-method (xyRowColCell), [367](#)
- yFromRow, SpatRaster, numeric-method (xyRowColCell), [367](#)
- ymax, [13](#), [112](#)
- ymax (xmin), [365](#)
- ymax, SpatExtent-method (xmin), [365](#)
- ymax, SpatRaster-method (xmin), [365](#)
- ymax, SpatVector-method (xmin), [365](#)
- ymax<- (xmin), [365](#)
- ymax<-, SpatExtent, numeric-method (xmin), [365](#)
- ymax<-, SpatRaster, numeric-method (xmin), [365](#)
- ymin, [13](#), [112](#)
- ymin (xmin), [365](#)
- ymin, SpatExtent-method (xmin), [365](#)
- ymin, SpatRaster-method (xmin), [365](#)
- ymin, SpatVector-method (xmin), [365](#)
- ymin<- (xmin), [365](#)
- ymin<-, SpatExtent, numeric-method (xmin), [365](#)
- ymin<-, SpatRaster, numeric-method (xmin), [365](#)
- yes, [13](#)
- yes (dimensions), [96](#)
- yes, SpatRaster-method (dimensions), [96](#)

- zonal, [11](#), [86](#), [110](#), [114](#), [116](#), [146](#), [369](#)
- zonal, SpatRaster, SpatRaster-method (zonal), [369](#)
- zonal, SpatRaster, SpatVector-method (zonal), [369](#)
- zonal, SpatVector, SpatVector-method (zonal), [369](#)
- zoom, [21](#), [371](#)
- zoom, SpatRaster-method (zoom), [371](#)
- zoom, SpatVector-method (zoom), [371](#)