

Package ‘terra’

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Description Methods for spatial data analysis with raster and vector data. Raster methods allow for low-level data manipulation as well as high-level global, local, zonal, and focal computation. 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/terra/>> to get started. 'terra' is very similar to the 'raster' package; but 'terra' can do more, is easier to use, and it is faster.

License GPL (>= 3)

URL <https://rspatial.org/terra/>

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

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terra-package	<i>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 cells (pixels) and they are commonly used to represent spatially continuous phenomena, such as elevation or the weather. Satellite images also have this data structure. 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 (R 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.

These classes hold a C++ pointer to the data and they cannot be directly saved to a ".Rds" file or used in cluster computing. They cannot be recovered from a saved R session either. See [wrap](#) or [writeRaster](#) to work around that limitation.

The terra package is conceived as a replacement of the raster package. terra has a very similar, but simpler, interface, and it is faster than raster. 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> or <code>[[</code> , or <code>\$</code>	Select layers of a <code>SpatRaster</code>

<code>selectRange</code>	Select cell values from different layers using an index layer
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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>extend</code>	Enlarge 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 using the layers of a SpatRaster as variables
<code>sapp</code>	Apply a function to each layer
<code>rapp</code>	Apply a function to a spatially variable range of layers

Arithmetic, logical, and standard math methods:

<code>Arith-methods</code>	Standard arithmetic methods (+, -, *, ^, %, %/, /)
<code>Compare-methods</code>	Comparison methods for SpatRaster (==, !=, >, <, <=, >=)
<code>Logic-methods</code>	Boolean methods (!, &,)
<code>Math-methods</code>	<code>abs</code> , <code>sign</code> , <code>sqrt</code> , <code>ceiling</code> , <code>floor</code> , <code>trunc</code> , <code>cummax</code> , <code>cummin</code> , <code>cumprod</code> , <code>cumsum</code> , <code>log</code> , <code>log10</code> , <code>log2</code> , <code>log1p</code> , <code>acos</code> , <code>acosh</code> , <code>asin</code> , <code>asinh</code> , <code>atan</code> , <code>atanh</code> , <code>exp</code> , <code>expm1</code> , <code>cos</code> , <code>cosh</code> , <code>sin</code> , <code>sinh</code> , <code>tan</code> , <code>tanh</code> , <code>round</code> , <code>signif</code>
<code>Summary-methods</code>	<code>mean</code> , <code>max</code> , <code>min</code> , <code>median</code> , <code>sum</code> , <code>range</code> , <code>prod</code> , <code>any</code> , <code>all</code> , <code>stdev</code> , <code>which.min</code> , <code>which.max</code>
<code>as.bool</code>	create a Boolean (logical) SpatRaster
<code>as.int</code>	create an integer (whole numbers) SpatRaster

Other methods:

<code>approximate</code>	Compute missing values for cells by interpolation across layers
<code>cellSize</code>	Compute the area of cells
<code>classify</code>	(Re-)classify values
<code>cover</code>	First layer covers second layer except where the first layer is NA
<code>init</code>	Initialize cells with new values
<code>mask</code>	Replace values in a SpatRaster based on values in another SpatRaster
<code>subst</code>	Substitute (replace) cell values
<code>which.lyr</code>	which is the first layer that is TRUE?

IV. Zonal and global methods

<code>expand</code>	Compute the summed area of cells
<code>crosstab</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>direction</code>	Direction (azimuth) to or from cells that are not NA
<code>focal</code>	Focal (neighborhood; moving window) functions
<code>focalCpp</code>	Faster focal by using custom C++ functions
<code>focalReg</code>	Regression between layers for focal areas
<code>focalCor</code>	Correlation between layers for focal areas
<code>patches</code>	Find patches (clumps)
<code>terrain</code>	Compute slope, aspect and other terrain characteristics from elevation data
<code>shade</code>	Compute hill shade from slope and aspect layers
<code>autocor</code>	Compute global or local spatial autocorrelation

VI. Model predictions

<code>predict</code>	Predict a non-spatial model to a <code>SpatRaster</code>
<code>interpolate</code>	Predict a spatial model to a <code>SpatRaster</code>

VII. Accessing cell values

Apart from the function 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>extract</code>	Extract cell values from a <code>SpatRaster</code> (e.g., by cell, coordinates, polygon)
<code>spatSample</code>	Regular or random sample
<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
<code>extract</code>	spatial queries of a <code>SpatRaster</code> with a <code>SpatVector</code>

VIII. Getting and setting dimensions

Get or set basic parameters of `SpatRasters`. If there are values associated with a `SpatRaster` object (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>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>crs</code>	The coordinate reference system (map projection)
<code>is.lonlat</code>	Test if an object has (or may have) a longitude/latitude coordinate reference system
<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>compareGeom</code>	Compare the geometry of <code>SpatRasters</code>
<code>NAflag</code>	Set the NA value (for reading from a file with insufficient metadata)

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 row 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 from an <code>SpatVector</code> or <code>SpatExtent</code>

X. 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>writeStart</code>	Open a file for writing
<code>writeValues</code>	Write some values
<code>writeStop</code>	Close the file after writing

XI. Time related methods

<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

XII. 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>readStart</code>	Open file connections for efficient multi-chunk reading
<code>readStop</code>	Close file connections
<code>inMemory</code>	Are the cell values in memory?

SpatRasterDataSet

XIII. SpatRasterDataset

A SpatRasterDataset contains SpatRaster objects that are 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 SpatRaster objects
<code>[</code> or <code>\$</code>	Extract a SpatRaster
<code>names</code>	Get the names of the sub-datasets

SpatVector

XIV. Create SpatVector objects

<code>vect</code>	Create a <code>SpatVector</code> from a file (for example a "shapefile") or from another object
<code>rbind</code>	append <code>SpatVectors</code> of the same geometry type
<code>unique</code>	remove duplicates
<code>na.omit</code>	remove empty geometries and/or fields that are NA
<code>project</code>	Project a <code>SpatVector</code> to a different coordinate reference system
<code>writeVector</code>	Write <code>SpatVector</code> data to disk
<code>centroids</code>	Get the centroids of a <code>SpatVector</code>
<code>voronoi</code>	Voronoi diagram
<code>de-launy</code>	Delauny triangles
<code>convHull</code>	Compute the convex hull of a <code>SpatVector</code>
<code>fillHoles</code>	Remove or extract holes from polygons

XV. Properties of `SpatVector` objects

<code>geom</code>	returns the geometries as matrix or WKT
<code>crds</code>	returns the coordinates as a matrix
<code>linearUnits</code>	returns the linear units of the crs (in meter)
<code>ncol</code>	The number of columns (of the attributes)
<code>nrow</code>	The number of rows (of the geometries and attributes)
<code>names</code>	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>is.lonlat</code>	Test if an object has (or may have) a longitude/latitude coordinate reference system

XVI. 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

XVII. Geometric operations

<code>erase</code> or <code>"-"</code>	erase (parts of) geometries
<code>intersect</code> or <code>"*"</code>	intersect geometries
<code>union</code> or <code>"+"</code>	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 (<code>SpatExtent</code>) or <code>SpatVector</code>

XVIII. `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>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>values</code>	Get the attributes of a <code>SpatVector</code>
<code>values<-</code>	Set new attributes to the geometries of a <code>SpatRaster</code>

XIX. 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)

XX. 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>simplify</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

Spat* Collections

XXI. Collections

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. A `SpatVectorCollection` is a vector of `SpatVector` objects.

<code>svc</code>	create a <code>SpatRasterCollection</code> from a set of <code>SpatRaster</code> objects
<code>length</code>	how many <code>SpatRasters</code> does the <code>SpatRasterCollection</code> have?
<code>[</code>	extract a <code>SpatRaster</code>

SpatExtent

XXII. SpatExtent

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

General methods

XXIII. 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 <code>sf</code> or <code>Spatial*</code> vector data
<code>sf::st_as_sf</code>	<code>sf</code> object from SpatVector
<code>rasterize</code>	Rasterizing points, lines or polygons
<code>as.points</code>	Create points from a SpatRaster or SpatVector
<code>as.lines</code>	Create points from a SpatRaster or SpatVector
<code>as.polygons</code>	Create polygons from a SpatRaster
<code>as.contour</code>	Contour lines from a SpatRaster

XXIV. Plotting

Maps:

<code>plot</code>	Plot a SpatRaster or SpatVector. The main method to create a map
<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>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>sbar</code>	Add a scalebar to a map
<code>arrow</code>	Add a north arrow to a map
<code>inset</code>	Add a small inset (overview) map
<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>RGB2col</code>	Combine three layers (red, green, blue channels) into a single layer with a color-table

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

`density` Density plot of SpatRaster values
`pairs` Pairs plot for layers in a SpatRaster
`boxplot` Box plot of the values of a SpatRaster

Comparison with the raster package

XXV. 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

raster, brick, stack
 rasterFromXYZ
 stack, addLayer (combining Raster* objects or files)
 addLayer
 area
 approxNA
 calc
 cellFromLine, cellFromPolygon, cellsFromExtent
 cellStats
 corLocal
 coordinates
 clump
 compareRaster
 disaggregate
 drawExtent, drawPoly, drawLine
 dropLayer
 extent
 gridDistance, distanceFromPoints
 isLonLat, isGlobalLonLat, couldBeLonLat
 layerize
 layerStats
 NAvalue
 nlayers
 overlay
 projectRaster
 rasterToPoints
 rasterToPolygons
 reclassify, subs, cut
 sampleRandom, sampleRegular
 shapefile
 stackApply

terra package

rast
 rast(, type="xyz")
 c
 add<-
 cellSize
 approximate
 app
 cells
 global
 focalCor
 crds
 patches
 compareGeom
 disagg
 draw
 subset
 ext
 distance
 is.lonlat
 segregate
 layerCor
 NAflag
 nlyr
 lapp
 project
 as.points
 as.polygons
 classify
 spatSample
 vect
 tapp

stackSelect

selectRange

XXVI. 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:

as.polygons	By default, terra returns dissolved polygons
quantile	computes by cell, across layers instead of the other way around
extract	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 list=TRUE to get the results as a list
values	terra always returns a matrix. raster returns a vector for a RasterLayer
Summary-methods	With raster, mean(x, y) and mean(stack(x, y)) return the same result, a single layer with the mean of all cell values. This is also what terra returns with mean(c(x, y)), but with mean(x, y) 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 (sum, mean, median, which.min, which.max, min, max, prod, any, all, stdev), except range, which is not implemented for this case (you can use min and max instead)

Author

Except where indicated otherwise, the methods and functions in this package were written by Robert Hijmans. The configuration scripts were written by Roger Bivand for rgdal and sf. Some of the C++ code for GDAL/GEOS was adapted from code by Edzer Pebesma for sf. The progress bar code is by Karl Forner (RcppProgress). Jeroen Ooms provided the compiled GDAL and GEOS libraries for installation on windows

Acknowledgments

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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	a data.frame (ID, category) or vector with category names

Value

integer

See Also

[catalyze](#), [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

Add (in place) a SpatRaster to another SpatRaster object

Description

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

Usage

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

Arguments

x	SpatRaster
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
```

adjacent

*Adjacent cells***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)

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

Arguments

x	SpatRaster
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

<code>pairs</code>	logical. If TRUE, a two-column matrix of pairs of adjacent cells is returned. If <code>x</code> is a <code>SpatRaster</code> and <code>pairs</code> is FALSE, an <code>n*m</code> matrix is returned where the number of rows <code>n</code> is <code>length(cells)</code> and the number of columns <code>m</code> is the number of neighbors requested with <code>directions</code>
<code>include</code>	logical. Should the focal cells be included in the result? They are always included if <code>pairs=TRUE</code>
<code>type</code>	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
<code>symmetrical</code>	logical. If 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

See Also

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

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.

Or aggregate ("dissolve") a `SpatVector`.

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", ...)
```

Arguments

x	SpatRaster
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)
fun	function used to aggregate values. Either an actual function, or for the following, their name: "mean", "max", "min", "median", "sum" and "modal"
...	additional arguments passed to fun, such as na.rm=TRUE
cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created. Ignored for C++ level implemented functions "mean", "max", "min", "median", "sum" and "modal"
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster
by	character. The variable used to aggregate the geometries
dissolve	logical. Should borders between aggregated geometries be dissolved?

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 a single number. For example mean, modal, min or max.

It should also accept a na.rm argument (or ignore it as one of the 'dots' arguments).

Value

SpatRaster

See Also

[disagg](#) to disaggregate

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)

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

## 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)

```

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

*Compare two SpatRasters for equality***Description**

Compare two SpatRasters for (near) equality.

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=10000, ...)

```

Arguments

<code>target</code>	SpatRaster
<code>current</code>	SpatRaster
<code>maxcell</code>	positive integer. The size of the regular sample used to compare cell values
<code>...</code>	additional arguments passed to <code>all.equal.numeric</code> to compare cell values

Value

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

See Also[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 SpatRaster***Description**

Animate (sequentially plot) the layers of a SpatRaster to create a movie

Usage

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

Arguments

x	SpatRaster
pause	numeric. How long should be the pause be between layers?
main	title for each layer. 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
maxcell	integer > 0. Maximum number of cells to use for the plot. If maxcell < ncell(x), spatSample(type="regular") is used before plotting
n	integer > 0. Number of loops
...	Additional arguments passed to plot

Value

None

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

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

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 across SpatRasters, not across layers.

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", "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](#)

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)

## 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	<i>Estimate values for cell values that are NA by interpolating between layers</i>
-------------	--

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))

```

Description

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

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

The following methods have been implemented for `SpatExtent`:

for `(SpatExtent, SpatExtent)`: `+`, `-`, and for `(SpatExtent, numeric)`: `+`, `-`, `*`, `/`, `%%`

Value

`SpatRaster` or `SpatExtent`

seealso

[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
e
e * 2
e / 2
```

```
e + 1
e - 1
```

arrow	<i>North arrow</i>
-------	--------------------

Description

Add a (North) arrow to a map

Usage

```
arrow(xy=NULL, type=1, label="N", angle=0, d, head=0.1, xpd=TRUE, ...)
```

Arguments

xy	numeric. x and y coordinate 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"
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 scale bar or 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)
arrow()
arrow(c(178550, 332500), d=250)

## Not run:
f <- system.file("ex/elev.tif", package="terra")
```

```

r <- rast(f)
plot(r, type="interval")
sbar(15, c(6.3, 50), type="bar", below="km", label=c(0,7.5,15), cex=.8)
arrow(type=3, cex=.8)
arrow(xy=c(6.7, 49.9), type=2, angle=45, label="NE")
arrow(xy=c(6.6, 49.7), type=5, cex=1.25)
arrow(xy=c(5.5, 49.6), type=9)
arrow(d=.05, xy=c(5.5, 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
  arrow(xy=cbind(x,30), type=i)
  text(x, -20, i, xpd=TRUE)
}

## End(Not run)

```

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	<i>SpatRaster or SpatVector to data.frame</i>
---------------	---

Description

Coerce a SpatRaster or SpatVector to a data.frame or coerce a SpatVector to a list

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, na.rm=TRUE, ...)

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

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

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
xy	logical. If TRUE, the coordinates of each raster cell are included
cells	logical. If TRUE, the cell numbers of each raster cell are included
na.rm	logical. If TRUE, cells that have a NA value in at least one layer are removed
...	Additional arguments passed to the data.frame
row.names	This argument is ignored
optional	This argument is ignored

Value

data.frame

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.data.frame(v)
as.list(v)
```

as.raster	<i>Coerce to a "raster" object</i>
-----------	------------------------------------

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. Default is col=rev(terrain.colors(255)))

Value

'raster' object

Examples

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

as.spatvector *Conversion to a SpatVector, or to another SpatVector type*

Description

Conversion of a SpatRaster or SpatExtent to a SpatVector of points, lines, or polygons;
 And conversion of a SpatVector to a another SpatVector type.

Usage

```
## S4 method for signature 'SpatRaster'
as.polygons(x, trunc=TRUE, dissolve=TRUE, values=TRUE, na.rm=TRUE, extent=FALSE)

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

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

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

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

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

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

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

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

Arguments

x	SpatRaster or SpatVector
trunc	logical; truncate values to integers. Cels with the same value are merged. Therefore, if trunc=FALSE the object returned can be very large
dissolve	logical; combine cells with the same values? If TRUE only the first layer in x is processed
values	logical; include cell values as attributes? If FALSE the cells are not dissolved and the object returned can be very large

<code>multi</code>	logical. If TRUE a multipoint geometry is returned
<code>skiplast</code>	logical. If TRUE the last point of a polygon (which is the same as the first point) is not included
<code>extent</code>	logical. if TRUE, a polygon for the extent of the SpatRaster is returned. It has vertices for each grid cell, not just the four corners of the raster. This can be useful for more precise projection. In other cases it is better to do <code>as.polygons(ext(x))</code> to get a much smaller object returned that covers the same extent
<code>na.rm</code>	logical. If TRUE cells that are NA are ignored
<code>crs</code>	character. The coordinate reference system (see crs)

Value

SpatVector

Examples

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

as.points(r)
as.lines(ext(r), crs=crs(r))

if (gdal() >= "3.0.0") {
  p <- as.polygons(r)
  p
  as.lines(p)
  as.points(p)
}
```

atan2

Two argument arc-tangent

Description

For SpatRasters `x` and `y`, `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)
```

Arguments

y	SpatRaster
x	SpatRaster

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	<i>Spatial autocorrelation</i>
-----------------	--------------------------------

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)
```

Arguments

x	numeric or SpatRaster
w	Spatial weights defined by or a rectangular matrix. For a SpatRaster this matrix must the sides must have an odd length (3, 5, ...)
global	logical. If TRUE global autocorrelation is computed instead of local autocorrelation
method	character. If x is numeric or SpatRaster: "moran" for Moran's I and "geary" for Geary's C. If x 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)

# 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 a 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)
```

boundaries	<i>Detect boundaries (edges)</i>
------------	----------------------------------

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, 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>filename</code>	character. Output filename
<code>...</code>	options for writing files as in writeRaster

Value

SpatRaster. Cell values are either 1 (a border) or 0 (not a border), 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`)

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.

Usage

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

```
## S4 method for signature 'SpatVector'
buffer(x, width, quadsegs=10)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>width</code>	numeric. Unit is meter if <code>x</code> has a longitude/latitude CRS, or mapunits in other cases. Should be > 0 for <code>SpatRaster</code>
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster
<code>quadsegs</code>	positive integer. Number of line segments to use to draw a quart circle

Value

`SpatRaster`

See Also

[distance](#)

Examples

```

r <- rast(ncols=36, nrows=18)
v <- rep(NA, ncell(r))
v[500] <- 1
values(r) <- v
b <- buffer(r, width=5000000)
plot(b)

v <- vect(rbind(c(10,10), 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)

```

c

*Combine SpatRaster or SpatVector objects***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`
- 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 'SpatVector'
c(x, ...)

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

```

Arguments

x	SpatRaster, SpatVector, SpatRasterDataset or SpatVectorCollection
warn	logical. If TRUE, a warning is emitted if x is an empty SpatRaster
...	as for x (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)
```

Arguments

x	SpatVector
var	character. A variable name in x
type	character. Cartogram type, only "nc" (non-contiguous) is currently supported

Value

SpatVector

See Also

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

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$value <- 1:12
p <- cartogram(v, "value", "nc")
plot(v, col="light gray", border="gray")
lines(p, col="red", 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` transfers all categories to new layers.

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, indicating the column in <code>data.frame</code> value to be used as the category, skipping the first column with the ID. 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`

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

Get cell numbers

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)

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

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

```

Arguments

x	<code>SpatRaster</code>
y	<code>SpatVector</code> , <code>SpatExtent</code> , 2-column matrix representing points, numeric representing values to match, or missing
method	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
weights	logical. If TRUE and y has polygons, the approximate fraction of each cell that is covered is returned as well
exact	logical. If TRUE and y has polygons, the exact fraction of each cell that is covered is returned as well
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

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 particularly relevant for longitude/latitude rasters.

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 on the *actual* area, correcting for distortion. If you do not want that, you can instead use `init(x,prod(res(x)))`

Usage

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

Arguments

<code>x</code>	SpatRaster
<code>mask</code>	logical. If TRUE, cells that are NA in <code>x</code> are also NA in the output
<code>unit</code>	character. One of "m", "km", or "ha"
<code>transform</code>	logical. If TRUE, planar CRS data are transformed to lon/lat for accuracy
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

numeric. The area of each cell, expressed in square meters, square kilometers, or hectares.

See Also

[expand](#)

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, names="naive")
good <- cellSize(m, unit="km", names="corrected")
plot(c(good, bad), nc=1, mar=c(2,2,1,6))
```

centroids

Get centroids

Description

Get the centroids for the polygons of a SpatVector

Usage

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

Arguments

x SpatVector

Value

SpatVector of points

Examples

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

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. lowest value
 upper numeric. highest value
 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](#)

Examples

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

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,
         othersNA=FALSE, brackets=TRUE, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>rc1</code>	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. 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. 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. 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.
<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>	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 `right=TRUE` and `include.lowest=TRUE`

<code>othersNA</code>	logical. If TRUE, values that are not matched become NA. If FALSE, they retain their original value.
<code>brackets</code>	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)
<code>filename</code>	character. Output filename
<code>...</code>	Additional arguments for writing files as in writeRaster

Value

SpatRaster

Note

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

See Also

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

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, 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, othersNA=TRUE)
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.

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 <code>?locator</code>
<code>show</code>	logical. Print the values after each click?
<code>...</code>	additional graphics parameters used if <code>type != "n"</code> for plotting the locations. See <code>?locator</code>

Value

The value(s) of `x` at the point(s) clicked on (or touched by the box drawn).

Note

The plot only provides the coordinates for a spatial query, the values are read from the `SpatRaster` 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 at most `n` positions are determined. The identification process can be terminated 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 of a SpatRaster to a vector, matrix or array

Description

Coercion to other object types

Usage

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

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

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

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>...</code>	additional argument <code>as.matrix</code> : <code>wide</code> (logical). If <code>FALSE</code> each layer in the <code>SpatRaster</code> becomes a column in the matrix and each cell in the <code>SpatRaster</code> becomes a row. If <code>TRUE</code> each row in the <code>SpatRaster</code> becomes a row in the matrix and each column in the <code>SpatRaster</code> becomes a column in the matrix
<code>mode</code>	this argument is ignored

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)
```

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
```

Arguments

x	SpatRaster
layer	positive integer, the layer number or name
value	a vector of colors; or a three (red,green,blue) or four (alpha) column data.frame with no more than 256 rows; or NULL to remove the color table

Value

data.frame

Examples

```

r <- rast(ncols=3, nrows=2, vals=0:5)
coltb <- data.frame(t(col2rgb(rainbow(6, end=.9), alpha=TRUE)))
coltb

plot(r)
coltab(r) <- coltb
plot(r)

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

```

Compare-methods

Compare and logical methods

Description

Standard comparison and logical operators for computations with SpatRasters. Computations are local (applied on a cell by cell basis). If multiple SpatRaster objects 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`

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

The following method has been implemented for

(SpatExtent, SpatExtent): `==`

Value

SpatRaster or SpatExtent

seealso

[all.equal](#), [Arith-methods](#). See [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)

x <- is.na(r1)

```

```
!x
r1 == r2
```

```
compareGeom
```

```
Compare geometries of SpatRasters
```

Description

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

Usage

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

Arguments

x	SpatRaster
y	SpatRaster
...	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

Examples

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

## Not run:
compareGeom(r1, r3)

## End(Not run)
```

 contour

Contour plot

Description

Contour lines of a SpatRaster. Use `add=TRUE` to add the lines to the current plot. See [contour](#) for details.

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

convHull	<i>Convex hull and minimal rotated rectangle</i>
----------	--

Description

Get the convex hull or the minimal rotated rectangle of a `SpatVector`

Usage

```
## S4 method for signature 'SpatVector'  
convHull(x, by="")  
  
## S4 method for signature 'SpatVector'  
minRect(x, by="")
```

Arguments

x	<code>SpatVector</code>
by	character (variable name), to make convex hulls by group

Value

`SpatVector`

Examples

```
p <- vect(system.file("ex/lux.shp", package="terra"))  
h <- convHull(p)  
  
hh <- convHull(p, "NAME_1")  
rr <- minRect(p, "NAME_1")  
  
plot(rr, lwd=5, border="gray")  
plot(hh, "NAME_1", col=rainbow(10, alpha=.5), lwd=3, add=TRUE, plg=list(x="topright"))  
lines(aggregate(p, "NAME_1"), col="blue", lty=2, lwd=2)
```

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

Description

Replace NA or other values in `SpatRaster` `x` with the values of `SpatRaster` `y`

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 'SpatVector,SpatVector'
cover(x, y, identity=FALSE)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>y</code>	Same as <code>x</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

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)

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

Arguments

x	SpatRaster or SpatVector
df	logical. If TRUE a data.frame is returned in stead of a matrix
na.rm	logical. If TRUE cells that are NA are excluded

Value

matrix or data.frame

See Also

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

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` with a `SpatExtent`, or another object from which an extent can be obtained. With a `SpatRaster` you can only extract rectangular areas, but see [mask](#) for setting cell values within `SpatRaster` to NA.

You can crop a `SpatVector` with a rectangle, or with another vector (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.

Usage

```

## S4 method for signature 'SpatRaster'
crop(x, y, snap="near", filename="", ...)

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

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

```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>y</code>	<code>SpatRaster</code> , <code>SpatVector</code> , <code>SpatExtent</code> or other object that has a <code>SpatExtent</code> (<code>ext</code> returns a <code>SpatExtent</code>)
<code>snap</code>	character. One of "near", "in", or "out"
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

intersect

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)

# 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

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

Value

A table or data.frame

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` object.

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 replacement method for signature 'SpatRaster'
crs(x)<-value

## S4 replacement method for signature 'SpatVector'
crs(x)<-value

```

Arguments

x	SpatRaster or SpatVector
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

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. Recent changes in the PROJ library to improve transformations between datums have degraded the library's usability. The PROJ developers suggest to no longer use the proj-string notation to define a CRS, but use the WKT2 or <authority>:<code> notation instead. These alternative systems work for formally described CRSs that are in databases, but they do not cover the infinite number of CRSs that exist. It is not practical to define one's own custom CRS with WKT2. Moreover, unlike the proj-notation, these newer systems are hard to read and that leads to code that cannot be easily understood and, therefore, is more error-prone.

It is still possible to use the PROJ-string notation 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.

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 also use epsg codes
crs(r) <- "epsg:25831"
crs(r, describe=TRUE)$area
```

deecopy

Deep copy

Description

Make a deep copy of a SpatRaster or SpatVector. This is occasionally useful when wanting to use a replacement function in a shallow copy. That is a copy that was created like this: `x <- y`. If you use a replacement function to change an object, its shallow copies also change.

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)
tm <- as.Date("2001-05-03") + 1:3
time(r) <- tm
time(r)
x <- r
time(x) <- tm + 365
time(x)
time(r)

y <- deepcopy(r)
time(y) <- tm - 365
time(y)
time(r)

# or make a new object like this
z <- rast(r)
time(z) <- tm
time(z)
time(r)
```

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)
```


Arguments

x	SpatVector
interval	numeric larger than 1, specifying the desired minimum interval between nodes
equalize	logical. If TRUE, new nodes are spread at equal intervals between old nodes

Value

SpatVector

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

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

Value

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

Examples

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

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
```

Arguments

x	SpatRaster
value	numeric vector

Value

numeric

See Also

[time](#)

Examples

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

depth(s) <- 1:3
depth(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="")
```

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/programs/gdalinfo.html . Ignored if sds=TRUE
print	logical. If TRUE, print the results
open_opt	character. Driver specific open options

Value

character (invisibly, if print=FALSE)

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	<code>SpatRaster</code>
lag	postive 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)
```

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, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>filename</code>	Character. Output filename (optional)
<code>degrees</code>	Logical. If FALSE (the default) the unit of direction is radians.
<code>from</code>	Logical. Default is FALSE. If TRUE, the direction from (instead of to) the nearest cell that is not NA is returned
<code>...</code>	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.

Usage

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

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

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
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. If argument `grid=TRUE`, the distance is computed using a path that goes through the centers of the 8 neighboring cells.

If *y* is a `SpatVector`, the distance to that `SpatVector` is computed for all cells. For lines and polygons this is done after rasterization; and only the overlapping areas of the vector and raster are considered (for now).

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 object in *x* is computed. An 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.

The distance is always expressed in meter, except when the coordinate reference system is longitude/latitude AND one of the `SpatVector(s)` consists of lines or polygons. In that case the distance is in degrees, and thus not very useful (this will be fixed soon). Otherwise, results are more precise, sometimes much more precise, when using longitude/latitude rather than a planar coordinate reference system, as these distort distance.

Usage

```
## S4 method for signature 'SpatRaster,missing'
distance(x, y, grid=FALSE, filename="", ...)

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

## S4 method for signature 'SpatVector,ANY'
distance(x, y, sequential=FALSE, pairs=FALSE, symmetrical=TRUE)

## S4 method for signature 'SpatVector,SpatVector'
distance(x, y, pairwise=FALSE)

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

## S4 method for signature 'matrix,missing'
distance(x, y, lonlat, sequential=FALSE)
```

Arguments

<code>x</code>	<code>SpatRaster</code> , <code>SpatVector</code> , or two-column matrix with coordinates (x,y) or (lon,lat)
<code>y</code>	missing or <code>SpatVector</code> , or two-column matrix
<code>grid</code>	logical. If TRUE, distance is computed using a path that goes through the centers of the 8 neighboring cells
<code>filename</code>	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

Value

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

Note

The distance unit is in meters.

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

Examples

```
#lonlat
r <- rast(ncols=36, nrows=18, crs="+proj=longlat +datum=WGS84")
r[500] <- 1
d <- distance(r)
plot(d / 100000)

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

p1 <- vect(rbind(c(0,0), c(90,30), c(-90,-30)), crs="+proj=longlat +datum=WGS84")
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")
dd <- distance(p1, p2)
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)

```

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.

Usage

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

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>...</code>	additional graphics arguments for drawing

Value

`SpatVector` or `SpatExtent`

See Also

[click](#)

erase	<i>Erase parts of a SpatVector object</i>
-------	---

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)

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

Arguments

x	SpatVector
y	SpatVector or SpatExtent

Value

SpatVector or SpatExtent

See Also

[intersect](#), [crop](#). The equivalent for SpatRaster is [mask](#)

Examples

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

# 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)
```

expand

*Extend***Description**

Enlarge the spatial extent of a `SpatRaster`. See [crop](#) if you (also) want to remove rows or columns. You can also enlarge a `SpatExtent` with this method, or with algebraic notation (see examples)

Usage

```
## S4 method for signature 'SpatRaster'
extend(x, y, 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 two positive integers indicating the number of rows and columns that need to be added at each side (or a single positive integer when the number of rows and columns is equal) If <code>x</code> is a <code>SpatExtent</code> , <code>y</code> should be a numeric vector of 1, 2, or 4 elements
<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

[crop](#), [merge](#), [ext](#)

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)

# expand 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))
```

expanse	<i>Get the expanse (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) popular belief that suggest that you should use a planar coordinate reference system. This is done automatically, if `transform=TRUE`.

Usage

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

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

Arguments

x	SpatRaster or SpatVector
unit	character. One of "m", "km", or "ha"
transform	logical. If TRUE, planar CRS are transformed to lon/lat for accuracy

Value

numeric. The total area size of all cells that are not NA, expressed in square meters, square kilometers, or hectares.

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 categories.

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")

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)

### 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`, or coordinates from such an object. Or create a `SpatExtent` from a vector (length=4; order= xmin, xmax, ymin, ymax)

Usage

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

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

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

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

## S4 method for signature 'SpatExtent'
x$name
```



```
## S4 replacement method for signature 'SpatExtent'
x$name<-value
```

Arguments

x	SpatRaster
value	SpatExtent, or numeric vector of length four (xmin, xmax, ymin, ymax), or a single number with the \$ method
name	character, one of xmin, xmax, ymin, or ymax
...	if x is a single numeric value, additional numeric values for xmax, ymin, and ymax

Value

SpatExtent

Examples

```
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
```

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 matrix with (x, y) or (longitude, latitude – in that order!) coordinates, or a vector with cell numbers.

When argument y is a SpatVector, and list=FALSE, the first column has the ID (record number) of the SpatVector used.

Usage

```
## S4 method for signature 'SpatRaster,SpatVector'
extract(x, y, fun=NULL, method="simple", list=FALSE, factors=TRUE,
        cells=FALSE, xy=FALSE, weights=FALSE, exact=FALSE,
        touches=is.lines(y), layer=NULL, ...)
```

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

```
## S4 method for signature 'SpatRaster,matrix'
extract(x, y, ...)
```

```
## S4 method for signature 'SpatRaster,numeric'
extract(x, y, ...)
```

Arguments

x	SpatRaster
y	SpatVector (for points, lines, polygons), or for points, 2-column matrix or data.frame (x, y) or (lon, lat), or a vector with cell numbers
fun	function to summarize the data by geometry. If weights=TRUE or exact=TRUE only codemean, sum, min and max are accepted)
...	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)
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
list	logical. If FALSE the output is simplified to a matrix (if fun=NULL)
factors	logical. If TRUE the categories are returned as factors instead of their numerical representation. The value returned becomes a data.frame if it otherwise would have been a matrix, even if there are no factors
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. Also see xyFromCell
weights	logical. If TRUE and y has polygons, the approximate fraction of each cell that is covered is returned as well, for example to compute a weighted mean
exact	logical. If TRUE and y has polygons, the exact fraction of each cell that is covered is returned as well, for example to compute a weighted mean
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

`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)`

Value

matrix, list, or data.frame

See Also

[values](#)

Examples

```
r <- rast(ncols=5, nrows=5, xmin=0, xmax=5, ymin=0, ymax=5)
values(r) <- 1:25
xy <- rbind(c(0.5,0.5), c(2.5,2.5))
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,]
z <- rast(v, resolution=.1, names="test")
values(z) <- 1:ncell(z)

rf <- system.file("ex/elev.tif", package="terra")
x <- rast(rf)
extract(x, v, mean, na.rm=TRUE)

e <- extract(z, v)
e
tapply(e[,2], e[,1], mean, na.rm=TRUE)

ee <- extract(z, v, list=TRUE)
rapply(ee, mean)

x <- c(z, z*2, z/3)
names(x) <- letters[1:3]

e <- extract(x, v)
de <- data.frame(e)
aggregate(de[,2:4], de[,1,drop=FALSE], mean)

ee <- extract(x, v, list=TRUE)
matrix(rapply(ee, mean), ncol=nlyr(x), byrow=TRUE)

```

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)
## S4 method for signature 'SpatRaster'
hasMinMax(x)
## S4 method for signature 'SpatRaster'
setMinMax(x, force=FALSE)

```

Arguments

x	<code>SpatRaster</code>
force	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

Examples

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

factors

Categorical rasters

Description

A SpatRaster layer can be a categorical variable (factor). Like `factors`, categories are stored as indices (integers) that have an associated label. For a SpatRaster, the index starts at 0, and cannot exceed 255.

The categories can be inspected with `levels` and `cats`. With `levels<-` you can set the categories of the first layer by providing a vector of labels (the first value will be for cells with value 0, the second for 1, etc). You can also provide a `data.frame` that must have two or more columns, the first one identifying the cell values and the other column(s) providing the category labels. To set categories for multiple layers you can provide `levels<-` with a list with one element for each layer.

With `setCats` you can set it for any layer and you can also set the 'active' category if there are multiple categories.

Usage

```
## S4 method for signature 'SpatRaster'
is.factor(x)

## 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'
setCats(x, layer=1, value, index)
```

Arguments

x	SpatRaster
layer	positive integer, the layer number or name
value	a data.frame (ID, category) or vector with category names
index	positive integer, indicating the column in data.frame value to be used as the category, skipping the first column with the ID.

Value

list (levels, cats) or data.frame (cats for a single layer); logical (is.factor, setCats)

See Also

[activeCat](#), [catalyze](#)

Examples

```
set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE)
is.factor(r)

cls <- c("forest", "water", "urban")
# make the raster start at zero
x <- r - 1
levels(x) <- cls
names(x) <- "land cover"
is.factor(x)
x

plot(x, col=c("green", "blue", "light gray"))
text(x, digits=3, cex=.75, halo=TRUE)

# raster starts at 3
x <- r + 2
is.factor(x)

# approach 1
levels(x) <- c("", "", "", "forest", "water", "urban")

# approach 2, also showing the use of two categories
d <- data.frame(id=3:5, cover=cls, letters=letters[1:3], value=10:12)
levels(x) <- d
x

## switch categories
cats(x, 1)
# get current index
activeCat(x)
# set index
```

```

activeCat(x) <- 3
plot(x, col=c("green", "blue", "light gray"))
text(x, digits=3, cex=.75, halo=TRUE)

r <- as.numeric(x)
r

activeCat(x) <- 2
p <- as.polygons(x)
plot(p, "letters", col=c("green", "blue", "light gray"))

```

fillHoles

Remove holes from polygons

Description

Remove the holes in SpatVector polygons. If inverse=TRUE the holes are returned (as polygons).

Usage

```

## S4 method for signature 'SpatVector'
fillHoles(x, inverse=FALSE)

```

Arguments

x	SpatVector
inverse	logical. If TRUE the holes are returned as polygons

Value

SpatVector

Examples

```

x <- rbind(c(-10,0), 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))
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)

```

fillTime	<i>Fill time gaps in a SpatRaster</i>
----------	---------------------------------------

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 (`vertical=TRUE`) or the columns (`vertical=FALSE`).

`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)
```

focal	<i>Focal values</i>
-------	---------------------

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, 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 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 "build-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
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 with weights of zero.

Window values are typically 0 or 1, or a value between 0 and 1 if you are using a rectangular area and/or the "sum" function. They can also be NA; these are ignored in the computation. That can be useful to compute, for example, the minimum or maximum value for a non-rectangular area.

The "mean" function is a special case, as zero weights are ignored automatically.

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

See Also

[focalMat](#), [focalValues](#), [focal3D](#), [focalCor](#), [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)
```

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 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 for that)
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)
```

focalCor

*Focal function across two layers***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'
focalCor(x, w=3, fun, ..., fillvalue=NA,
filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster with at least two layers
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	A function with at least two arguments (one for each layer)
...	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](#)

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 <- focalCor(r, w=5, cor)

# suppress warning "the standard deviation is zero"
x <- focalCor(r, w=5, function(x, y) suppressWarnings(cor(x, y)))

# this does not happen when using a larger window
x <- focalCor(r, w=9, function(x, y) cor(x, y))
plot(x)
```

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, wopty=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
    for (size_t i=0; i<ni; i++) {
      // compute something for a window
      size_t start = i * nw;
      double v = 0;
      // loop over the values of a window
      for (size_t j=start; j<(start+nw); j++) {
        v += x[j];
      }
      out[i] = v * m;
    }
    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

Focal weights matrix

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 $3 \times \text{sigma}$)
<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")
```

focalReg	<i>Focal regression</i>
----------	-------------------------

Description

Calculate the coefficients for a focal ("moving window") OLS regression model.

Usage

```
## S4 method for signature 'SpatRaster'
focalReg(x, w=3, na.rm=TRUE,
fillvalue=NA, filename="", ...)
```

Arguments

x	SpatRaster with at least two layers. The first is the "Y" (dependent) variable and the remainder are the "X" (independent) variables
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
na.rm	logical. Should missing values be removed?
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[focal](#), [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	<i>Get focal values</i>
-------------	-------------------------

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)
```

freq	<i>Frequency table</i>
------	------------------------

Description

Frequency table of the values of a SpatRaster. NAs are not counted unless value=NA.

Usage

```
## S4 method for signature 'SpatRaster'
freq(x, digits=0, value=NULL, bylayer=TRUE, usenames=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

Value

matrix or data.frame with 3 columns (layer, value, count) or, if bylayer=FALSE two columns (value, count). If any of the layers of x is categorical, there is an additional column (label). A data.frame is returned if usenames=TRUE or if any of the layers of x is categorical.

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

Find gaps between polygons

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

GDAL version, supported file formats, and cache size

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.

Usage

```
gdal(warn=NA, drivers=FALSE, lib="gdal")
gdalCache(size=NA)
```

Arguments

warn	If NA and drivers=FALSE, the version of the library specified by lib 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 3
drivers	logical. If TRUE a data.frame with the raster and vector data formats that are available.
lib	character. "gdal", "proj", or "geos", or any other value to get the versions numbers of all three
size	numeric. The new cache size in MB

Value

character

See Also

[describe](#) for file-level metadata "GDALinfo"

Examples

```
gdal()
gdal(2)
head(gdal(drivers=TRUE))
```

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.

Usage

```
## S4 method for signature 'SpatVector'
geom(x, wkt=FALSE, hex=FALSE, df=FALSE)
```

Arguments

x	SpatVector
wkt	logical. If TRUE the WKT geometry is returned (unless hex is also TRUE)
hex	logical. If TRUE the hexadecimal geometry is returned
df	logical. If TRUE a data.frame is returned instead of a matrix (only for wkt=FALSE and hex=FALSE)

Value

matrix

See Also

See [xyFromCell](#) to get the coordinates of the cells of a SpatRaster

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 or the data types of the fields (attributes, variables) of a SpatVector.

Usage

```

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

## S4 method for signature 'SpatVector'
datatype(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 will fail, except when fun is one of "mean", "min", "max", "sum", "range" (min and max), "rms" (root mean square), "sd" (sample standard deviation), "sdpop" (population standard deviation), "isNA" (number of cells that are NA), "notNA" (number of cells that are not NA).

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, ...)
```

Arguments

x SpatRaster

fun function to be applied to summarize the values by zone. Either as one of these character values: "max", "min", "mean", "sum", "range", "rms" (root mean square), "sd", "std" (population sd, using n rather than n-1); or, for relatively small SpatRasters, a proper function

... additional arguments passed on to fun

weights NULL or SpatRaster

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)
```

gridDistance

Distance on a grid

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 distance is in meters if the coordinate reference system (CRS) of the SpatRaster is longitude/latitude (+proj=longlat) and in the 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.

Usage

```
## S4 method for signature 'SpatRaster'
gridDistance(x, origin, omit=NULL, chunk=FALSE, filename="", overwrite=FALSE, ...)
```

Arguments

x	SpatRaster
origin	value(s) of the cells from which the distance is calculated. If origin=NULL all cells that are not NA are origins
omit	value(s) of the cells that cannot be traversed (optional)
chunk	logical. If TRUE the data are processed in chunks. This may be necessary for large datasets, but could lead to errors in the case of complex areas that need to be omitted if they are spread over different chunks (meandering rivers, for instance).
filename	character. output filename (optional)
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments as for writeRaster

Details

If the `SpatRaster` to be processed is big, it will be processed in chunks. This may lead to errors in the case of complex objects spread over different chunks (meandering rivers, for instance).

Value

`SpatRaster`

Author(s)

Jacob van Etten and Robert J. Hijmans

See Also

See [distance](#) for "as the crow flies" distance

Examples

```
#world lon/lat raster
r <- rast(ncol=10,nrow=10, vals=1)
r[48] <- 2
r[66:68] <- 3
d <- gridDistance(r,origin=2,omit=3)
plot(d)

#UTM small area
crs(r) <- "+proj=utm +zone=15 +ellps=GRS80 +datum=NAD83 +units=m +no_defs"
d <- gridDistance(r,origin=2,omit=3)
plot(d)
```

head and tail

Show the head or tail of a `Spat` object*

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	<code>SpatRaster</code> or <code>SpatVector</code>
...	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, main, ...)
```

Arguments

x	SpatRaster
layer	integer (or character) to indicate layer number (or name). Can be used to subset the layers to plot in a multilayer SpatRaster
maxcell	integer. To regularly sample very large objects
plot	logical. Plot the histogram or only return the histogram values
main	character. Main title(s) for the plot. Default is the value of names
...	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)

```

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
<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=50000, ...)

```

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	<i>Initialize a SpatRaster with values</i>
------------	--

Description

Create a SpatRaster with values reflecting a cell property: 'x', 'y', '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 SpatRaster objects with many cells.

Usage

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

Arguments

x	SpatRaster
fun	function to be applied. This must be either a 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, row, col or cell number or a chessboard pattern (alternating 0 and 1 values)
filename	character. Output filename
...	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)
```

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, ...)
```

```
## S4 method for signature 'SpatRaster'
inset(x, e, loc="", scale=0.2, background="white",
      perimeter=TRUE, box=NULL, pper, pbox, ...)
```

```
## 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)
...	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")
```


Description

Intersect the geometries of two `SpatVectors`.

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`.

See [crop](#) for intersection of a `SpatRaster`.

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)
```

Arguments

<code>x</code>	<code>SpatVector</code> or <code>SpatExtent</code>
<code>y</code>	<code>SpatVector</code> or <code>SpatExtent</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)
```

is.bool

*Raster value types***Description**

The values in a `SpatRaster` layer are by default numeric, but they can also be logical (Boolean), integer, or categorical

Note that `as.bool` and `as.int` return a new `SpatRaster`, whereas `is.bool` and `is.int` return a logical value for each layer. For a `SpatRaster`, `isTRUE` is equivalent to `as.bool`, `isFALSE` is equivalent to `!as.bool`, `as.integer` is the same as `as.int` and `as.logical` is the same as `as.bool`

Usage

```
## 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, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>filename</code>	character. Output filename
<code>...</code>	list with named options for writing files as in writeRaster

Value

logical or `SpatRaster`

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.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 is longitude/latitude and "global" (covers all longitudes).

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)
```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
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 or when the CRS is longitude/latitude but the coordinates do not match that
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)
```

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. 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.

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, ..., usenames=FALSE, cores=1, filename="", overwrite=FALSE, wopt=list())

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

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatRasterDataset</code>
<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>usenames</code>	logical. Use the layer names to match the function arguments? If FALSE matching is by position
<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>recycle</code>	logical. Recycle layers to match the subdataset with the largest number of layers
<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`

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) }
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 usernames argument

fvi2 <- function(red, green){ (red - green) / (red + green) }
names(s)
x1 <- lapp(s[[1:2]], fvi2, usernames=TRUE)
x2 <- lapp(s[[2:1]], fvi2, usernames=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, usernames=FALSE)
x4 <- lapp(s, fvi2, usernames=TRUE)

# while this would fail because
# there are too many layers in s
# x5 <- lapp(s, fvi2, usernames=FALSE)

pairs(c(x1, x2, x3, x4))

## SpatRasterDataset
x <- sds(s, s[[1]]+50)
lapp(x, function(x, y) x/y, recycle=TRUE)
```

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, na.rm=FALSE, maxcell=Inf, ...)
```

Arguments

x	SpatRaster
fun	character. The statistic to compute: either "cov" (covariance), "weighted.cov" (weighted covariance), or "pearson" (correlation coefficient) or your own function that takes two vectors as argument to compute a single number
w	SpatRaster with the weights to compute the weighted covariance. It should have a single layer and the same geometry as x
asSample	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
na.rm	logical. Should missing values be removed?
maxcell	positive integer. The number of cells to be regularly sampled. Only used when fun is a function
...	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 two items: the correlation or (weighted) covariance matrix, and the (weighted) means.

If fun is a function, you get a 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, "pearson")

layerCor(b, "cov")

# weigh by column number
w <- init(b, fun="col")
layerCor(b, "weighted.cov", w=w)
```

linearUnits	<i>Linear units of the coordinate reference system</i>
-------------	--

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 SpatVector data to a map

Description

Add SpatVector data to a plot (map) with points, lines, or polys.

These are simpler alternatives for `plot(x, add=TRUE)`

Usage

```

## S4 method for signature 'SpatVector'
points(x, col, cex=1, pch=20, alpha=1, ...)

## 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 '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, line type. See points
alpha	number between 0 and 1 to set transparency
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
...	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

Make tiles

Description

Divide a SpatRaster into "tiles". The cell of another SpatRaster (normally with a much lower resolution) are used to define the tiles.

Usage

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

Arguments

x	SpatRaster
y	SpatRaster or SpatVector
filename	character. Output filename template. Filenames will be altered by adding the tilenumber for each tile
...	additional arguments for writing files as in writeRaster

Value

character (filenames)

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)
```

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 ".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	postive number. x resolution
yres	postive 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

mask	<i>Mask values in a SpatRaster</i>
------	------------------------------------

Description

Create a new SpatRaster that has the same values as SpatRaster *x*, except for the cells that are NA (or another maskvalue) in another SpatRaster (the 'mask'), or not covered by a SpatVector. These cells become NA (or another updatevalue).

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="", ...)
```

Arguments

<i>x</i>	SpatRaster
mask	SpatRaster
inverse	logical. If TRUE, areas on mask that are <code>_not_</code> the maskvalue are masked
maskvalues	numeric. The value(s) in mask that indicates the cells of <i>x</i> that should become updatevalue (default = NA)
updatevalue	numeric. The value that cells of <i>x</i> should become if they are not covered by mask (and 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

[crop](#)

Examples

```
r <- rast(ncols=10, nrows=10)
m <- rast(ncols=10, nrows=10)
values(r) <- 1:100
set.seed(1965)
x <- round(3 * runif(ncell(r)))
x[x==0] <- NA
values(m) <- x
mr <- mask(r, m)
```

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 SpatRaster objects. Computations are local (applied on a cell by cell basis). If multiple SpatRaster objects 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`

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)
```

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

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)
```

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)
```

```
free_RAM()
```

Arguments

x	SpatRaster
n	positive integer. The number of copies of x that are needed

Value

free_RAM returns the amount of available RAM in kilobytes

Examples

```
mem_info(rast())
```

```
free_RAM()
```

merge	<i>Merge SpatRaster or SpatExtent objects, or a SpatVector with a data.frame</i>
-------	--

Description

Merge SpatRasters to form a new SpatRaster object with a larger spatial extent. If objects overlap, the values get priority in the same order as the arguments. See [classify](#) to merge a SpatRaster and a data.frame. You can also merge SpatExtent objects.

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..

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
merge(x, y, ..., filename="", overwrite=FALSE, wopt=list())
```

```
## S4 method for signature 'SpatRasterCollection,missing'
merge(x, filename="", ...)
```

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

```
## S4 method for signature 'SpatVector,data.frame'
merge(x, y, ...)
```

Arguments

x	SpatRaster or SpatExtent
y	object of same class as x
...	if x is a SpatRaster: additional objects of the same class as x. If x is a SpatRasterCollection: options for writing files as in writeRaster . If x is a SpatVector, the same arguments as in merge
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Details

The SpatRaster objects must have the same origin and spatial resolution. In areas where the SpatRaster objects overlap, the values of the SpatRaster that is last in the sequence of arguments will be retained.

Value

SpatRaster or SpatExtent

Note

You can use `merge` with `do.call` to merge a list of SpatRasters (see example). But note that if the list is named, these names are used by `merge`. So if all elements are named, there should be one element with a SpatRaster called `x` and another one called `y`. For example with `names(x)[1:2] <- c("x" "y")`. You can also removed the names of the the first two elements (assuming these are SpatRasters) with `names(x)[1:2] <- ""`.

See Also

[mosaic](#)

Examples

```
x <- rast(xmin=-110, xmax=-80, ymin=40, ymax=70, ncols=30, nrows=30)
y <- rast(xmin=-85, xmax=-55, ymax=60, ymin=30, ncols=30, nrows=30)
z <- rast(xmin=-60, xmax=-30, ymax=50, ymin=20, ncols=30, nrows=30)
values(x) <- 1:ncell(x)
values(y) <- 1:ncell(y)
values(z) <- 1:ncell(z)

m1 <- merge(x, y, z)
m2 <- merge(z, y, x)
m3 <- merge(y, x, z)

# if you have many SpatRasters make a SpatRasterCollection from a list
rlist <- list(x, y, z)
rsrc <- src(rlist)
```



```

m <- merge(rsrc)

## 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

merge SpatRasters by timelines to create a single timeseries

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)

```

modal	<i>modal value</i>
-------	--------------------

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 writeRaster

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.

This method is similar to the simpler, but faster [merge](#) method.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'  
mosaic(x, y, ..., fun="mean", filename="", overwrite=FALSE, wopt=list())  
  
## S4 method for signature 'SpatRasterCollection,missing'  
mosaic(x, fun="mean", filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>y</code>	object of same class as <code>x</code>
<code>...</code>	additional SpatRasters
<code>fun</code>	character. One of "sum", "mean", "median", "min", "max"
<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 writeRaster

Details

The SpatRaster objects must have the same origin and spatial resolution. In areas where the SpatRaster objects overlap, the values of the SpatRaster that is last in the sequence of arguments will be retained.

Value

SpatRaster

See Also

[merge](#)

Examples

```
x <- rast(xmin=-110, xmax=-80, ymin=40, ymax=70, ncols=30, nrows=30)
y <- rast(xmin=-85, xmax=-55, ymax=60, ymin=30, ncols=30, nrows=30)
z <- rast(xmin=-60, xmax=-30, ymax=50, ymin=20, ncols=30, nrows=30)
values(x) <- 1:ncell(x)
values(y) <- 1:ncell(y)
values(z) <- 1:ncell(z)

m1 <- mosaic(x, y, z)
m2 <- mosaic(z, y, x)

# if you have many SpatRasters make a SpatRasterCollection from a list
rlist <- list(x, y, z)
rsrc <- src(rlist)

m <- mosaic(rsrc)
```

na.omit

na.omit for SpatVector

Description

Remove empty geometries and/or records that are NA from a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
na.omit(object, field=NA, geom=FALSE)
```

Arguments

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 NA flag. The file is not changed, but flagged value is set to NA when values are read from the file ("lazy evaluation"). In contrast, if the values are in memory the change is made immediately.

To change values, it is generally better to use `classify`

Usage

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

Arguments

x	<code>SpatRaster</code>
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

Names of Spat objects*

Description

Get or set the names of the layers of a SpatRaster or the attributes of a SpatVector. With longnames you can get or set the "long names" of a SpatRaster or SpatRasterDataset.

For a SpatRaster, you can also get/set a variable name or long name (one per data source)

Usage

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

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

## 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'
names(x)

## S4 replacement method for signature 'SpatRasterDataset'
names(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

## 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)

# space is not valid
names(s)[2] <- "hello world"
names(s)

# two invalid names
names(s) <- c("a", " a ", "3")
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	<i>nearby geometries</i>
---------	--------------------------

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)

## S4 method for signature 'SpatVector'
nearest(x, y, pairs=FALSE, centroids=TRUE, lines=FALSE)
```

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
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

[relate](#), [adjacent](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
nearby(v, distance=12000)
```

options

Options

Description

Class and methods for showing and setting general options for terra.

Usage

```
terraOptions(...)
```

Arguments

... option names and values (see Details). Or missing, to show the current options

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.

memmax - the maximum amount of RAM (in GB) that terra can use when processing a raster dataset. Should be less than what is detected (see [link{mem_info}](#)), and higher values are ignored. Set it to a negative number or NA to ignore this value).

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

Examples

```
terraOptions()  
terraOptions(memfrac=0.5, tempdir = "c:/temp")  
terraOptions(progress=10)  
terraOptions()
```

origin	<i>Origin</i>
--------	---------------

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	SpatRaster
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 SpatRaster
...	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]])
```

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, 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)
zeroAsNA	logical. If TRUE treat cells that are zero as if they were NA
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

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
# remove zeros manually
rr <- classify(r, cbind(0, NA))

# make layers for each value
s <- segregate(rr, keep=TRUE, other=NA)
p <- patches(s)

### 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)
```

perim	<i>Perimeter or length</i>
-------	----------------------------

Description

This method returns the length of lines or the perimeter of polygons.

When the crs is not longitude/latitude, you may get more accurate results by first un-projecting the SpatVector (you can use [project](#) to transform the crs to longitude/latitude)

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	<i>Perspective plot</i>
-------	-------------------------

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)
```

plot

Make a map

Description

Plot the values of a `SpatRaster` or `SpatVector` to make a map. See [lines](#) to add a `SpatVector` to an existing map.

Usage

```
## S4 method for signature 'SpatRaster,numeric'
plot(x, y=1, col, type, mar=NULL, legend=TRUE, axes=TRUE, plg=list(),
     pax=list(), maxcell=500000, smooth=FALSE, range=NULL, levels=NULL,
     fun=NULL, colNA=NULL, alpha=NULL, sort=FALSE, grid=FALSE, ext=NULL, reset=FALSE, ...)

## S4 method for signature 'SpatRaster,missing'
plot(x, y, maxcell=500000, main, mar=NULL, nc, nr, maxnl=16, ...)

## S4 method for signature 'SpatRaster,character'
plot(x, y, ...)

## S4 method for signature 'SpatVector,character'
plot(x, y, col, type, mar=NULL, legend=TRUE, add=FALSE, axes=!add,
     main=y, buffer=TRUE, background=NULL, grid=FALSE, ext=NULL,
     plg=list(), pax=list(), nr, nc, ...)

## S4 method for signature 'SpatVector,numeric'
plot(x, y, ...)

## S4 method for signature 'SpatVector,missing'
plot(x, y, ...)

## S4 method for signature 'SpatExtent,missing'
plot(x, y, ...)
```

Arguments

x	SpatRaster or SpatVector
y	missing or positive integer or name indicating the layer(s) to be plotted
col	character. Colors
type	character. Type of map/legend. One of "continuous", "classes", or "interval"
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. 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 draw. For example "topright" or "bottomleft". Use plg for more refined placement (SpatVector data only)
axes	logical. Draw axes?
buffer	logical. If TRUE the plotting area is slightly larger than the extent of x
background	background color. Default is no color (white)
plg	list with parameters for drawing the legend. See the arguments for legend
pax	list with parameters for drawing axes. See the arguments for axis
maxcell	positive integer. Maximum number of cells to use for the plot
smooth	logical. If TRUE the cell values are smoothed (for continuous legend)
range	numeric. minimum and maximum values to be used for the continuous legend
levels	character. labels to be used for the classes legend
fun	function to be called after plotting each SpatRaster layer to add something to each map (such as text, legend, lines). For example, with SpatVector v, you could do fun=function() lines(v). The function may have one argument, representing the the layer that is plotted (1 to the number of layers)
colNA	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
grid	logical. If TRUE grid lines are drawn. Their properties such as type and color can be set with the pax argument
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)
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. Can be use instead of xlim and ylim to set the extent of the plot

reset logical. If TRUE add the margins (see argument `mar`) are reset to what they were before calling `plot`; doing so may affect the display of additional objects that are added to the map (e.g. with `lines`)

... arguments passed to `plot("SpatRaster", "numeric")` and additional graphical arguments

See Also

[points](#), [lines](#), [polys](#), [image](#), [scatterplot](#), [sbar](#)

Examples

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

plot(r, type="interval")

e <- c(6.3, 6.35, 49.9, 50.1)
plot(r, plg=list(ext=e, title="Title\n", title.cex=1.25), pax=list(sides=1:2))

d <- classify(r, c(100,200,300,400,500,600))
plot(d, type="classes")

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", plg=list(legend=c("Mr", "Xx", "As", "Zx", "Bb"), x="bottomright"))

x <- trunc(r/200)
levels(x) <- c("earth", "wind", "fire")
plot(x, plg=list(x="topright"), mar=c(2,2,2,2))

# 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))
plot(r/2, range=c(50,600))

# as you only need one legend:
par(mfrow=c(1,2))
plot(r, range=c(50,600), mar=c(4, 3, 4, 3), plg=list(shrink=0.9, cex=.8),
pax=list(sides=1:2, cex.axis=.6))
#text(182500, 335000, "Two maps, one plot", xpd=NA)
plot(r/2, range=c(50,600), mar=c(4, 2, 4, 4), legend=FALSE,
pax=list(sides=c(1,4), cex.axis=.6))

## 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)

## vector

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

plot(v)

plot(v, 2, pax=list(sides=1:2), plg=list(x=6.2, y=50.2, cex=1.2))

plot(v, 4, pax=list(sides=1:2), plg=list(x=6.2, y=50.2, ncol=2), main="")

plot(v, 1, plg=list(x=5.9, 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, "NAME_2", col=rainbow(12), border=c("gray", "blue"), lwd=3, type="classes")

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),
      plg=list(legend=c("<200", "200-250", ">250"), cex=1,
              bty="o", x=6.4, y=50.125, 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.

Usage

```

## S4 method for signature 'SpatRaster'
plotRGB(x, r=1, g=2, b=3, a=NULL, scale, maxcell=500000, mar=0,
        stretch=NULL, ext=NULL, smooth=FALSE, colNA="white", alpha, bgamma,
        addfun=NULL, zlim=NULL, zlimcol=NULL, axes=FALSE, xlab="", ylab="",
        asp=NULL, add=FALSE, interpolate, ...)

```

Arguments

x	SpatRaster
r	integer. Index of the Red channel, between 1 and nlyr(x)
g	integer. Index of the Green channel, between 1 and nlyr(x)
b	integer. Index of the Blue channel, between 1 and nlyr(x)
a	integer. Index of the alpha (transparency) channel, between 1 and nlyr(x). 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
maxcell	integer > 0. Maximum number of pixels to use
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)
ext	An SpatExtent object to zoom in to a region of interest (see draw)
smooth	logical. If TRUE, smooth the image when drawing to get the appearance of a higher spatial resolution
colNA	color for the background (NA values)
alpha	transparency. Integer between 0 (transparent) and 255 (opaque)
bgalpha	Background transparency. Integer between 0 (transparent) and 255 (opaque)
addfun	Function to add additional items such as points or polygons to the plot (map). See plot
zlim	numeric vector of length 2. Range of values to plot (optional)
zlimcol	If NULL the values outside the range of zlim get the color of the extremes of the range. If zlimcol has any other value, the values outside the zlim range get the color of NA values (see colNA)
axes	logical. If TRUE axes are drawn (and arguments such as main="title" will be honored)
xlab	character. Label of x-axis
ylab	character. Label of y-axis
asp	numeric. Aspect (ratio of x and y. If NULL, and appropriate value is computed to match data for the longitude/latitude coordinate reference system, and 1 for planar coordinate reference systems
add	logical. If TRUE add values to current plot
interpolate	logical. Do not use, to be removed
...	graphical parameters as in plot or rasterImage

See Also

[plot](#), [RGB](#)

Examples

```

b <- rast(system.file("ex/logo.tif", package="terra"))
plotRGB(b)
plotRGB(b, mar=c(2,2,2,2))
plotRGB(b, 3, 2, 1)

b[1000:2000] <- NA
plotRGB(b, 3, 2, 1, stretch='hist')

```

predict

Spatial model predictions

Description

Make a `SpatRaster` object 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 `Raster` object 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.

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, ..., factors=NULL, const=NULL, na.rm=FALSE,
        index=NULL, cores=1, cpkgs=NULL, filename="", overwrite=FALSE, wopt=list())

```

Arguments

<code>object</code>	<code>SpatRaster</code>
<code>model</code>	fitted model of any class that has a "predict" method (or for which you can supply a similar method as <code>fun</code> argument. E.g. <code>glm</code> , <code>gam</code> , or <code>randomForest</code>)
<code>fun</code>	function. The <code>predict</code> function that takes <code>model</code> as first argument. The default value is <code>predict</code> , but can be replaced with e.g. <code>predict.se</code> (depending on the type of model), or your own custom function
<code>...</code>	additional arguments for <code>fun</code>
<code>const</code>	<code>data.frame</code> . Can be used to add a constant value as a predictor variable so that you do not need to make a <code>SpatRaster</code> layer for it
<code>factors</code>	list with levels for factor variables. The list elements should be named with names that correspond to names in <code>object</code> such that they can be matched. This argument may be omitted for standard models such as "glm" as the <code>predict</code> function will extract the levels from the <code>model</code> object, but it is necessary in some other cases (e.g. <code>cforest</code> models from the <code>party</code> package)

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
index	integer. To select subset of 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

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[,,-1]))

#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")

# use a modified function to get the probability and standard error
# from the glm model. The values returned by "predict" are in a list,
# and this list needs to be transformed to a matrix

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
# here using sampling to simulate an object too large
# to feed all its values to prcomp

sr <- values(spatSample(logo, 100, as.raster=TRUE))
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))

## End(Not run)

```

project

Change the coordinate reference system

Description

Change the coordinate reference system ("project") of a `SpatVector` or `SpatRaster`.

Usage

```

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

## S4 method for signature 'SpatRaster'
project(x, y, method, mask=FALSE, align=FALSE, gdal=TRUE, filename="", ...)

```

Arguments

x	SpatVector
y	if (x is a <code>SpatRaster</code> , the preferred approach is for y to be a <code>SpatRaster</code> as well, serving as a template for the geometry (extent and resolution) of the output <code>SpatRaster</code> . Alternatively, you can provide a coordinate reference system (crs) description. 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. If x is a <code>SpatVector</code> , you can provide a crs definition as discussed above, or any other object from which such a crs can be extracted with crs
method	character. Method used for estimating the new cell values of a <code>SpatRaster</code> . One of:

	near: nearest neighbor. This method is fast, and it can be the preferred method if the cell values represent classes. It is not a good choice for continuous values. This is used by default if the first layer of <code>x</code> is categorical.
	bilinear: bilinear interpolation. This is the default if the first layer of <code>x</code> is numeric (not categorical).
	cubic: cubic interpolation.
	cubicspline: cubic spline interpolation.
mask	logical. If TRUE, mask out areas outside the input extent (see example with Robinson projection)
align	logical. If TRUE, and <code>y</code> is a <code>SpatRaster</code> , the template is used for the spatial resolution and origin, but the extent is set such that all of the extent of <code>x</code> is included
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 near and bilinear algorithms are available for the internal algorithm
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

`SpatVector` or `SpatRaster`

Note

User beware. Sadly, the PROJ.4 notation 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 the WGS84 datum. Other datums are silently ignored.

When printing a `Spat*` object the PROJ.4 notation is shown because it is the most concise and clear format available. However, internally a WKT representation is used (see [crs](#)).

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(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 be similar to the input resolution, but there is not "correct" resolution in raster transformation; but 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](#)

Examples

```
## SpatRaster
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 <- "+proj=moll +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +datum=WGS84"
p <- project(v, crs)
p
```

 quantile

Quantiles of spatial data

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)

```

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 one or two `SpatRasters` (arguments `first` and `last`). For either `first` or `last` you can use a numeric constant instead.

See [selectRange](#) to create a new `SpatRaster` by extracting one or more values starting at a cell-varying layer.

See [app](#) or [Summary-methods](#) if you want to apply a function to all cells (not a range), perhaps after making a [subset](#) of a `SpatRaster`.

Usage

```

## S4 method for signature 'SpatRaster'
rapp(x, first, last, fun, ..., alllys=FALSE, fill=NA,
      clamp=FALSE, filename="", overwrite=FALSE, wopt=list())

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>first</code>	<code>SpatRaster</code> or positive integer between 1 and <code>nlyr(x)</code> , indicating the first layer in the range of layers to be considered
<code>last</code>	<code>SpatRaster</code> or positive integer between 1 and <code>nlyr(x)</code> , indicating the last layer in the range to be considered
<code>fun</code>	function to be applied

...	additional arguments passed to fun
allyrs	logical. Should the values of all layers be passed to fun. The values outside of the range are set to fill
fill	numeric. The fill value for the 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
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 a file, 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.

Usage

```

## S4 method for signature 'character'
rast(x, subds=0, lyrs=NULL, opts=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)

## 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)

## S4 method for signature 'SpatRasterDataset'
rast(x)

## S4 method for signature 'SpatVector'
rast(x, ...)

## S4 method for signature 'SpatExtent'
rast(x, ...)

```

Arguments

x	filename (character), missing, SpatRaster, SpatRasterDataset, SpatExtent, SpatVector, matrix, array, list of SpatRaster objects. For other types it will be attempted to create a SpatRaster via ('as(x, "SpatRaster")')
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")
opts	character. GDAL dataset open options
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. 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
keeptime	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
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 resolution (see res). If this argument is used, arguments ncol and nrow 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 not "xyz", the raster has the same number of rows and columns as the matrix. If the value is "xyz", the matrix must have 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.
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"
...	additional arguments, in some cases 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 prepending the driver name to the filename like this: `rast('NETCDF:"filename.ncdf"')`

Value

SpatRaster

See Also

[sds](#) to create a SpatRasterDataset (4 dimensions) 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)

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

# 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 vector data to a raster

Usage

```

## S4 method for signature 'SpatVector,SpatRaster'
rasterize(x, y, field="", fun, ..., background=NA, touches=FALSE,
update=FALSE, sum=FALSE, cover=FALSE, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'matrix,SpatRaster'
rasterize(x, y, values=1, fun, ..., background=NA,
update=FALSE, filename="", overwrite=FALSE, wopt=list())

```

Arguments

x	SpatVector or a two-column matrix (point coordinates)
y	SpatRaster
field	character or numeric. If field is a character, it should 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	numeric. For when x is a matrix. Normally of length 1 or nrow(x). The values will be recycled to nrow(x)
fun	function, summarizing function that returns a single number; for when there are multiple points in one cell. For example mean, length (to get a count), min or max. Only used if x consists of points
...	additional arguments passed to fun if x has point geometries
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
sum	logical. If TRUE, the values of overlapping geometries are summed instead of replaced; and background is set to zero. Only used if x does not consists of points
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)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with additional arguments for writing files as in writeRaster

Value

SpatRaster

Note

To update existing raster data use the output of rasterize as second argument in [cover](#)

See Also

[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)

```

read and write	<i>Read from, or write to, file</i>
----------------	-------------------------------------

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. When writing is done close the file with `writeStop`.

Usage

```

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

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

## S4 method for signature 'SpatRaster'
readValues(x, row=1, nrow=nrow(x), col=1, ncol=ncol(x), mat=FALSE, dataframe=FALSE, ...)

## S4 method for signature 'SpatRaster,character'
writeStart(x, filename="", overwrite=FALSE, n=4, ...)

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

## S4 method for signature 'SpatRaster,vector'
writeValues(x, v, start, nrow)

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 is 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
...	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

relate	<i>relate</i>
--------	---------------

Description

Get a matrix indicating the presence or absence of spatial relationships between geometries.

Usage

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

## S4 method for signature 'SpatVector,missing'
relate(x, y, relation, pairs=FALSE, symmetrical=FALSE)
```

Arguments

x	SpatVector or any object for which vect returns a SpatVector or else for which ext returns a SpatExtent
y	missing or as for x
relation	character. One of "intersects", "touches", "crosses", "overlaps", "within", "contains", "covers", "coveredby", "disjoint". Or a "DE-9IM" string such as "FF*FF*****". See wikipedia or geotools doc
pairs	logical. If TRUE a "from", "to" matrix is returned for the cases where the requested relation is TRUE
symmetrical	logical. If TRUE and pairs=TRUE, the relation between a pair is only included once. For example, the relation between geometry 1 and 3 is included, but the relation between 3 and 1 is not. Note that whole some relationships are symmetrical (e.g. "touches", other are not (e.g. "within"))

Value

matrix

See Also[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)")
lns <- 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

*Replace values of a SpatRaster***Description**

Replace values of a SpatRaster. These are convenience functions for smaller objects only. For larger rasters see [link{classify}](#)

Value

SpatRaster

See Also

[link{classify}](#), [values](#), [replace](#)

Examples

```
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
```

resample

*Transfer values of a SpatRaster to another one with a different geometry***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 crs 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, filename="", ...)
```

Arguments

x	SpatRaster to be resampled
y	SpatRaster with the geometry that x should be resampled to
method	character. Method used for estimating the new cell values. One of: near: nearest neighbor. This method is fast, and it can be the preferred method if the cell values represent classes. It is not a good choice for continuous values. This is used by default if the first layer of x is categorical. bilinear: bilinear interpolation. This is the default if the first layer of x is numeric (not categorical). cubic: cubic interpolation. cubicspline: cubic spline interpolation. lanczos: Lanczos windowed sinc resampling.
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")

opar <- par(no.readonly =TRUE)
par(mfrow=c(1,2))
plot(r)
plot(x)
par(opar)
```

`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

<code>x</code>	<code>SpatVector</code> or <code>SpatRaster</code>
<code>fx</code>	numeric > 0. The horizontal scaling factor
<code>fy</code>	numeric > 0. The vertical scaling factor
<code>x0</code>	numeric. x-coordinate of the center of rescaling. If missing, the center of the extent of <code>x</code> is used
<code>y0</code>	numeric. y-coordinate of the center of rescaling. If missing, the center of the extent of <code>x</code> 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")
```

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`

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)

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

## S4 method for signature 'SpatRaster'
colorize(x, to="hsv", alpha=FALSE, stretch=NULL,
grays=FALSE, filename="", overwrite=FALSE, ...)
```

Arguments

<code>x</code>	SpatRaster
<code>value</code>	vector of 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
<code>to</code>	character. The color space to transform the values to. If <code>x</code> 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 backtransform to RGB
<code>alpha</code>	logical. Should an alpha (transparency) channel be included? Only used if <code>x</code> has a color-table and <code>to="rgb"</code>
<code>stretch</code>	character. Option to stretch the values to increase contrast: "lin" (linear) or "hist" (histogram). Only used for transforming RGB to col
<code>grays</code>	logical. If TRUE, a gray-scale color-table is created. Only used for transforming RGB to col
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, filename is overwritten
<code>...</code>	additional arguments for writing files as in <code>writeRaster</code>

Examples

```

r <- rast(system.file("ex/logo.tif", package="terra"))
plot(r)
RGB(r) <- NULL
plot(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")

```

rotate

*Rotate a SpatRaster 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.

Usage

```

## S4 method for signature 'SpatRaster'
rotate(x, left=TRUE, filename="", ...)

```

Arguments

x	SpatRaster or SpatVector
left	logical. If TRUE, rotate to the left, else to the right
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

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)

```

sapp	<i>Apply a terra function that takes only a single layer to all layers</i>
------	--

Description

Apply to all layers of a `SpatRaster` a function that only takes a single layer `SpatRaster` (these are rare). in most cases you can also use `lapply` or `sapply` for this.

Usage

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

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>fun</code>	a function that takes a <code>SpatRaster</code> argument and can be applied to each layer of <code>x</code>
<code>...</code>	additional arguments to be passed to <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>

Value

`SpatRaster`

See Also

[lapp](#), [app](#), [tapp](#), [lapply](#)

Examples

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

sbar	<i>scale bar</i>
------	------------------

Description

Add a scale bar to a map

Usage

```
sbar(d, xy=NULL, type="line", divs=2, below="",
     lonlat=NULL, label, adj=c(0.5, -1), lwd=2, xpd=TRUE, ...)
```

Arguments

d	numeric. Distance covered by the scale bar or arrow. For the scale bar, it should be in the units of the coordinates of the plot (map), and in km for angular (longitude/latitude) data; see argument <code>lonlat</code> . It can also be missing
xy	numeric. x and y coordinate to place the scale bar or arrow. It can also be one of following character values: "bottomleft", "bottom", "bottomright", "topleft", "top", "topright", "left", "right", or NULL
type	for sbar: "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
label	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 or arrow can be outside the plot area
...	graphical arguments to be passed to other methods

Value

none

See Also

[arrow](#), [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=4, cex=.8)
arrow(d=250, c(178550, 332500))

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(6.65, 49.8), cex=.8, label=c(0,"km",15))
arrow(type=2)
sbar(15, c(6.65, 49.7), cex=.8, label="15 kilometer", lwd=5)
sbar(15, c(6.65, 49.6), divs=4, cex=.8, below="km")
```

scale	<i>Scale values</i>
-------	---------------------

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 <code>nlyr(x)</code>), 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 <code>nlyr(x)</code>), each layer of x is divided by the corresponding value. Scaling is done after centering.

Value

SpatRaster

See Also[scale](#)**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]

```

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, 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)
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]]))
```

sds

Create a SpatRasterDataset

Description

Methods to create a `SpatRasterDataset`. This is an object to hold "sub-datasets", each a `SpatRaster` that in most cases will have multiple layers.

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)

## 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

x	character (filename), or <code>SpatRaster</code> , or list of <code>SpatRaster</code> objects, 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>
ids	optional. vector of integer subdataset ids. Ignored if the first value is not a positive integer
crs	character. Description of the Coordinate Reference System (map projection) in PROJ.4, WKT or authority: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
extent	SpatExtent
...	additional <code>SpatRaster</code> objects

Value

SpatRasterDataset

See Also[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

*segregate***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. Classes and cell values are always truncated to integers.

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, filename="", ...)
```

Arguments

x	SpatRaster
classes	numeric. The values (classes) for which layers should be made. If NULL all classes are used
keep	logical. If TRUE, cells that are of the class represented by a layer get that value, rather than a value of 1
other	numeric. Value to assign to cells that are not of the class represented by a layer
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

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).

Usage

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

## S4 method for signature 'SpatVector'
sel(x, use="rec", draw=TRUE, col="cyan", ...)
```

Arguments

x	SpatRaster or SpatVector
use	character indicating what to draw. One of "rec" (rectangle) or "pol" (polygon)
draw	logical. If TRUE the selection is drawn on the map
col	color to be used for drawing if draw=TRUE
...	additional graphics arguments for drawing

Value

SpatRaster or SpatVector

See Also

[crop](#) and [intersect](#) to make an intersection and [click](#) and [text](#) to see cell values or geometry attributes

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

select cells with high or low values

Description

Identify *n* cells that have the highest of lowest values in the first layer of a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
selectHighest(x, n, low=FALSE)
```

Arguments

<i>x</i>	SpatRaster. Only the first layer is processed
<i>n</i>	The number of cells to select
<i>low</i>	logical. If TRUE, 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) <- 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 af 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)

```

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 `SpatRaster` objects 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, props=FALSE)

## S4 replacement method for signature 'SpatVector,ANY'
values(x)<-value

```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
value	For <code>SpatRaster</code> : matrix or numeric, the length must match the total number of cells (<code>ncell(x) * nlyr(x)</code>), or be a single value. For <code>SpatVector</code> : <code>data.frame</code> , matrix, vector, or <code>NULL</code>
values	Same as for value
keeptime	logical. If <code>TRUE</code> the time stamps are kept
keepunits	logical. If <code>FALSE</code> the units are discarded
props	logical. If <code>TRUE</code> 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="", ...)
```

Arguments

slope	SpatRaster with slope values (in radians)
aspect	SpatRaster with aspect values (in radians)
angle	The the elevation angle of the light source (sun), in degrees
direction	The direction (azimuth) angle of the light source (sun), in degrees
normalize	Logical. If TRUE, values below zero are set to zero and the results are multiplied with 255
filename	character. Output filename
...	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)
alt <- disagg(r, 10, method="bilinear")
slope <- terrain(alt, "slope", unit="radians")
aspect <- terrain(alt, "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(alt, col=rainbow(25, alpha=0.35), add=TRUE)
```

sharedPaths

Shared paths

Description

Get shared paths of line or polygon geometries

Usage

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

Arguments

x 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)
```

shift	<i>Shift</i>
-------	--------------

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

x	<code>SpatRaster</code> , <code>SpatVector</code> or <code>SpatExtent</code>
dx	numeric. The shift in horizontal direction
dy	numeric. The shift in vertical direction
filename	character. Output filename
...	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)
```

simplify

Simplify geometries

Description

Reduce the number of nodes used to represent geometries.

Usage

```
## S4 method for signature 'SpatVector'
simplify(x, tolerance=0.1)
```

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)

Value

SpatVector

See Also

[sharedPaths](#), [gaps](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
#w <- simplify(v, .02)
#e <- erase(w)
#g <- gaps(e)
#plot(e, lwd=5, border="light gray")
#polys(g, col="red", border="red")
```

sources

Data sources of a SpatRaster

Description

Get the data sources of a SpatRaster and the number of layers by source. 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 'SpatRaster'
hasValues(x)

## S4 method for signature 'SpatRaster'
inMemory(x, bylayer=FALSE)
```

Arguments

x	SpatRaster
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

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	<i>Class "SpatExtent"</i>
------------------	---------------------------

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 SpatRaster objects.

Slots

ptr: pointer to the C++ class

Methods

show display values of a SpatExtent object

Examples

```
e <- ext(-180, 180, -90, 90)
e
```

Spatial interpolation *Interpolate*

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, 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
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](#)**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 coveriate
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))
mg_sf <- 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, mg_sf, 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)

```

SpatRaster-class

SpatRaster class

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.

The underlying C++ class "Rcpp_SpatRaster" is not intended for end-users. It is for internal use within this package only.

Examples

```
rast()
```

 spatSample

Take a regular sample

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 `type="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.

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, values=TRUE,
cells=FALSE, xy=FALSE, ext=NULL, warn=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)
```

Arguments

<code>x</code>	<code>SpatRaster</code> , <code>SpatVector</code> or <code>SpatExtent</code>
<code>size</code>	numeric. The sample size. If <code>x</code> is a <code>SpatVector</code> , you can also provide a vector of the same length as <code>x</code> in which case sampling is done separately for each geometry. If <code>x</code> is a <code>SpatRaster</code> , and you are using <code>method="regular"</code> you can specify the size as two numbers (number of rows and columns)
<code>method</code>	character. Should be "regular" or "random", If <code>x</code> is a <code>SpatRaster</code> , it can also be "stratified"
<code>replace</code>	logical. If TRUE, sampling is with replacement (if <code>method="random"</code>)
<code>na.rm</code>	logical. If TRUE, codeNAs are removed. Only used with random sampling of cell values. That is with <code>method="random"</code> , <code>as.raster=FALSE</code> , <code>cells=FALSE</code>
<code>as.raster</code>	logical. If TRUE, a <code>SpatRaster</code> is returned
<code>as.df</code>	logical. If TRUE, a data.frame is returned instead of a matrix
<code>as.points</code>	logical. If TRUE, a <code>SpatVector</code> of points is returned
<code>values</code>	logical. If TRUE 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
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
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

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, 10)
spatSample(r, 10, "random")

## if you require cell numbers and/or coordinates
size <- 6
# random cells
cells <- spatSample(r, 6, "random", cells=TRUE, values=FALSE)
cells <- as.vector(cells)

v <- r[cells]
xy <- xyFromCell(r, cells)
cbind(xy, v)

# regular
cells <- spatSample(r, 6, "regular", cells=TRUE, values=FALSE)
cells <- as.vector(cells)
v <- r[cells]
xy <- xyFromCell(r, cells)
cbind(xy, v)

# 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)
plot(rr, plg=list(title="raster"))
plot(s, 1, add=TRUE, plg=list(x=185, y=1, title="points"))

## SpatExtent
e <- ext(r)
spatSample(e, 10, "random", lonlat=TRUE)

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
#sample geometries
i <- sample(nrow(v), 5)
vv <- v[i,]

```

SpatVector-class	<i>Class "SpatVector"</i>
------------------	---------------------------

Description

Objects of class SpatVector.

Objects from the Class

You can use the [vect](#) method to create SpatVector objects.

Slots

ptr: pointer to the C++ class

Methods

show display values of a SpatVector

spin	<i>spin a SpatVector</i>
------	--------------------------

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

Description

Split a SpatVector or SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'
split(x, f)

## S4 method for signature 'SpatVector'
split(x, f)
```

Arguments

x	SpatRaster or SpatVector
f	If x is a SpatVector: a field (variable) name or a vector of the same length as x. If x is a SpatRaster: a vector of the length nlyr(x)

Value

Same as x

Examples

```
v <- vect(system.file("ex/lux.shp", package="terra"))
x <- split(v, "NAME_1")

s <- rast(system.file("ex/logo.tif", package="terra"))
y <- split(s, c(1,2,1))
sds(y)
```

src

Create a SpatRasterCollection

Description

Methods to create a SpatRasterCollection. This is an object to hold a collection (list) of SpatRaster objects. 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](#)

Usage

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

```
## S4 method for signature 'list'
src(x)
```

```
## S4 method for signature 'missing'
src(x)
```

Arguments

x	SpatRaster, list with SpatRaster objects, or missing
...	additional SpatRaster objects

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 <- src(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.

Usage

```
## S4 method for signature 'SpatRaster'
stretch(x, minv=0, maxv=255, minq=0, maxq=1, smin=NA, smax=NA,
histeq=FALSE, scale=1, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>minv</code>	numeric ≥ 0 and smaller than <code>maxv</code> . lower bound of stretched value
<code>maxv</code>	numeric ≤ 255 and larger than <code>minv</code> . upper bound of stretched value
<code>minq</code>	numeric ≥ 0 and smaller than <code>maxq</code> . lower quantile bound of original value. Ignored if <code>smin</code> is supplied
<code>maxq</code>	numeric ≤ 1 and larger than <code>minq</code> . upper quantile bound of original value. Ignored if <code>smax</code> is supplied
<code>smin</code>	numeric $< smax$. user supplied lower value for the layers, to be used instead of a quantile computed by the function itself
<code>smax</code>	numeric $> smin$. user supplied upper value for the layers, to be used instead of a quantile computed by the function itself
<code>histeq</code>	logical. If TRUE histogram equalization is used instead of linear stretch
<code>scale</code>	numeric. The scale (maximum value) of the output if <code>histeq=TRUE</code>
<code>filename</code>	character. Output filename
<code>...</code>	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)
```

subset

*Subset of a SpatRaster***Description**

Select a subset of layers from a SpatRaster.

Usage

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

Arguments

x	SpatRaster
subset	integer or character. Should indicate the layers (represented as integer or by their names)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
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"]]
```

subset-vector *Subset of a SpatVector*

Description

Select a subset of variables or records from a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
subset(x, subset, drop=FALSE)
```

Arguments

x	SpatVector
subset	logical expression indicating elements or rows to keep: missing values are taken as false
drop	logical. If TRUE, the geometries will be dropped, and a data.frame is returned

Value

SpatVector or, if drop=TRUE, a data.frame.

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v[2:3,]
v[,2:3]
subset(v, v$NAME_1 == "Diekirch")
```

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, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>from</code>	numeric value(s)
<code>to</code>	numeric value(s). Normally a vector of the same length as 'from'. If <code>x</code> 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 <code>to</code>
<code>filename</code>	character. Output filename
<code>...</code>	Additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[classify](#)

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)
```

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`, `all`, `max`, `min`, `mean`, `median`, `prod`, `range`, `stdev`, `sum`, `w`. See [modal](#) to compute the mode and [app](#) to compute summary statistics that are not included here.

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'
mean(x, ..., trim=NA, na.rm=FALSE)
```

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

```
## S4 method for signature 'SpatRaster'
stdev(x, ..., pop=TRUE, na.rm=FALSE)
```

```
## S4 method for signature 'SpatRaster'
which.min(x)
```

```
## S4 method for signature 'SpatRaster'
which.max(x)
```

Arguments

x `SpatRaster`

...	additional SpatRaster objects or numeric values; and arguments 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

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)
max(r, 0.5)

y <- stdev(r)
# not the same as
yy <- app(r, sd)

z <- stdev(r, r*2)

x <- mean(r, filename=paste0(tempfile(), ".tif"))

```

summary

*summary***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

object	SpatRaster or SpatVector
size	positive integer. Size of a regular sample used for large datasets (see spatSample)
warn	logical. If TRUE a warning is given if a sample is used
...	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)
```

 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)
```

Arguments

x SpatVector, or list of a SpatVector, or missing
 ... Additional SpatVectors

Value

SpatVectorCollection

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 function used should return a single value, and the number of layers in the output SpatRaster equals the number of unique values in index.

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)).

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 object.

Usage

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

Arguments

x	SpatRaster
index	factor or numeric (integer). Vector of length <code>nlyr(x)</code> (shorter vectors are recycled) grouping the input layers
fun	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", "sd", "std", "first". To use the base-R function for say, "min", you could use something like <code>fun = \(\i) min(i)</code>
...	additional arguments passed to fun
cores	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 fun)
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](#), [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 characteristic

Description

Compute terrain characteristic 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.

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, 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
...	list. Options 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

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.

The 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 the value of its 8 surrounding cells. TPI (Topographic Position Index) 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.

Such measures can also be computed with the `focal` function:

```
f <- matrix(1, nrow=3, ncol=3)
TRI <- focal(x, w=f, fun=function(x, ...) sum(abs(x[-5]-x[5]))/8)
TPI <- focal(x, w=f, fun=function(x, ...) x[5] - mean(x[-5]))
rough <- focal(x, w=f, fun=function(x, ...) max(x) - min(x), na.rm=TRUE)
```

References

- Burrough, P., and R.A. McDonnell, 1998. Principles of Geographical Information Systems. Oxford University Press.
- Fleming, M.D. and Hoffer, R.M., 1979. Machine processing of Landsat MSS data and DMA topographic data for forest cover type mapping. LARS Technical Report 062879. Laboratory for Applications of Remote Sensing, Purdue University, West Lafayette, Indiana.
- Horn, B.K.P., 1981. Hill shading and the reflectance map. Proceedings of the IEEE 69:14-47
- Jones, K.H., 1998. A comparison of algorithms used to compute hill terrain as a property of the DEM. Computers & Geosciences 24: 315-323
- Ritter, P., 1987. A vector-based terrain and aspect generation algorithm. Photogrammetric Engineering and Remote Sensing 53: 1109-1111

Examples

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

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, ...)

## S4 method for signature 'SpatVector'
text(x, labels, halo=FALSE, ...)
```

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. If TRUE, additional arguments hc="white" and hw=0.1 can be modified to set the colour and width of the halo
...	additional arguments to pass to graphics function text

See Also

[text,plot](#)

Examples

```
r <- rast(nrows=4, ncols=4)
values(r) <- 1:ncell(r)
plot(r)
text(r)

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)
```

tighten	<i>tighten SpatRaster or SpatRasterDataset objects</i>
---------	--

Description

Combines data sources within a SpatRaster object (that are in memory, or from the same file) to allow for faster processing.

Or combine sub-datsets 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)
```

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

Description

Get or set the time of the layers of a SpatRaster.

Usage

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

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

Arguments

x	SpatRaster
value	"Date", "POSIXt", or numeric

Value

Date

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
time(s)

# POSIX (time stored as seconds)
time(s) <- as.POSIXlt(d)
time(s)

# "raw" time
time(s) <- as.numeric(d)
time(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

current	logical. If TRUE, temporary files from the current R session are included
orphan	logical. If TRUE, temporary files from the current R session that are no longer associated with a SpatRaster object (if current is TRUE these are also included)
old	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
remove	logical. If TRUE, temporary files are removed

Value

character

See Also

[terraOptions](#)

Examples

```
tmpFiles()
```

topology	<i>Vector topology methods</i>
----------	--------------------------------

Description

makeNodes create nodes on lines

mergeLines connect lines to form polygons

removeDupNodes removes duplicate nodes in geometries and optionally rounds the coordinates

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

x	SpatVector of lines or polygons
y	SpatVector of lines or polygons to snap to. If NULL snapping is to the other geometries in x
tolerance	numeric. Snapping tolerance (distance between geometries) or simplifying tolerance (distance between nodes)
digits	numeric. Number of digits used in rounding. Ignored if < 0

Value

SpatVector

See Also

[sharedPaths](#), [gaps](#), [simplify](#)

transpose

Transpose

Description

Transpose a SpatRaster

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	SpatRaster
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

Trim a SpatRaster

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	SpatRaster
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

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

Overlapping polygons (between, not within, objects) are intersected. Union for lines and points simply combines the two data sets; without any geometric intersections. This is equivalent to [c](#). Attributes are joined. See [c](#) if you want to combine polygons without intersection.

If `codex` 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>	<code>SpatVector</code> or <code>SpatExtent</code>
<code>y</code>	Same as <code>x</code> or missing

Value

`SpatVector` or `SpatExtent`

See Also

[intersect](#))

[merge](#) and [mosaic](#) to union `SpatRaster` objects.

[crop](#) and [extend](#) for the union of `SpatRaster` and `SpatExtent`.

[merge](#) for merging a `data.frame` with attributes of a `SpatVector`.

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=expansion(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 function returns the unique values in a `SpatRaster` or removes duplicates in a `SpatVector`.

Usage

```
## S4 method for signature 'SpatRaster'
unique(x, incomparables=FALSE)

## S4 method for signature 'SpatVector'
unique(x, incomparables=FALSE, ...)
```

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>...</code>	additional arguments passed on to <code>unique</code>

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)

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)
```

valid*Check or fix polygon validity*

Description

Check the validity of polygons or attempt to fix it

Usage

```
## S4 method for signature 'SpatVector'
is.valid(x, messages=FALSE, as.points=FALSE)

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

Arguments

x	SpatVector
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

Value

logical

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)
```

```
plot(w)
points(cbind(4.54, -2.72), cex=2, col="red")
```

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, `values(x, dataframe=TRUE)` and `as.data.frame(x)` the values returned match the type of each layer, and can be numeric, logical, integer, or factor.

Usage

```
## S4 method for signature 'SpatRaster'
values(x, mat=TRUE, dataframe=FALSE, row=1, nrow=nrow(x), col=1, ncol=ncol(x), ...)

## 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 data frame 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>nrow</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>ncol</code>	positive integer. How many columns? Default is the number of columns left after the start column
<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

See Also

[values<-](#), [focalValues](#)

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)
```

vect

Create SpatVector objects

Description

Methods to create a SpatVector from a filename or other R object.

A filename can be for a shapefile or any spatial file format.

You can use a data.frame 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="", extent=NULL, filter=NULL, crs="")

## S4 method for signature 'matrix'
vect(x, type="points", atts=NULL, crs="")

## S4 method for signature 'data.frame'
vect(x, geom=c("lon", "lat"), crs="")
```

```
## S4 method for signature 'list'
vect(x)
```

```
## S4 method for signature 'sf'
vect(x)
```

Arguments

x	character. A filename; or a "Well Known Text" string; or a data.frame (only to make a SpatVector of points); or a "geom" matrix to make a SpatVector of any supported geometry (see examples and geom); or a spatial vector data object defined in the sf or sp packages
layer	character. layer name to select a layer from a file (database) with multiple layers
query	character. An query to subset the dataset in the 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)
type	character. Geometry type. Must be "points", "lines", or "polygons"
atts	data.frame with the attributes. The number of rows must match the number of geometrical elements
crs	the coordinate reference system in one of the following formats: WKT/WKT2, <authority>:<code>, or PROJ-string notation (see crs)
geom	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)

Value

SpatVector

See Also

[geom](#)

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")
v

## 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-attributes *Get or replace attribute values of a SpatVector*

Description

Replace values of a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
x$name

## S4 replacement method for signature 'SpatVector'
x$name<-value
```

Arguments

x	SpatVector
name	character (field name) or numeric (column number)
value	vector of new values

Value

vector

See Also

[values](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$NAME_1
v$NAME_1[3] <- "my name"
v$ID_1 <- LETTERS[1:12]
v$new <- sample(12)
values(v)

v[2,2] <- "hello"
v[1,] <- v[10,]
v[,3] <- v[,1]
v[2, "NAME_2"] <- "terra"
head(v, 3)
```

voronoi

Voronoi diagram and Delauny triangles

Description

Get a voronoi diagram or delauny 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'  
delauny(x, tolerance=0, as.lines=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
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  
  
plot(v, lwd=2, col=rainbow(15))  
lines(x, col="gray", lwd=2)  
points(x)
```

vrt*Virtual Raster Tiles*

Description

Create a Virtual Raster Tiles (VRT) dataset from a collection of file-based raster datasets.

Usage

```
## S4 method for signature 'character'  
vrt(x, filename="", overwrite=FALSE)
```

Arguments

<code>x</code>	character. Filenames of raster "tiles". See tiles
<code>filename</code>	character. Output VRT filename
<code>overwrite</code>	logical. Should filename be overwritten if it exists?

Value

SpatRaster

See Also

[makeVRT](#) to create a .vrt file for a file without a header

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)  
head(readLines(vrtfile))  
v
```

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)
```

which.lyr *Which cells are TRUE?*

Description

This method returns a single layer SpatRaster with cell values that are the first layer in the input that has the value is not zero (FALSE), and, hence, is 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, or a multipoint whose points are identical, 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

[minRect](#)

Examples

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

window

Set a window

Description

Experimental: 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.

Currently, the window will be forced to intersect with the extent of the SpatRaster. It is envisioned that in future versions, 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 (pack) a SpatRaster or SpatVector object

Description

Wrap a SpatRaster or SpatVector object to create a Packed* object. Packed objects can be saved as an R object to disk (.rds or .RData), or passed over a connection that serializes (e.g. to nodes on a computer cluster); but with large datasets passing a filename could be more sensible in that context.

Usage

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

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


Arguments

x SpatVector or SpatRaster

Value

Packed* object

Examples

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

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

Usage

```
## S4 method for signature 'SpatRaster'
writeCDF(x, filename, varname, longname="", unit="", ...)

## S4 method for signature 'SpatRasterDataset'
writeCDF(x, filename, overwrite=FALSE, zname="time",
         prec="float", compression=NA, missval, ...)
```

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

overwrite logical. If TRUE, filename is overwritten

zname 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
...	additional arguments passed on to <code>ncvar_def</code>

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)

# for CRAN
file.remove(fname)
```

writeRaster

Write raster data to a file

Description

Write a SpatRaster object 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 for writing files. See Details

Details

In writeRaster, and in other methods that generate SpatRaster objects, 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. The following options are available:

name	description
datatype	values for datatype are "INT1U", "INT2U", "INT2S", "INT4U", "INT4S", "FLT4S", "FLT8S". The first three le
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
verbose	logical. If TRUE debugging information is printed.
steps	postive 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

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

```

library(terra)
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", "of=COG"), datatype='INT1U')

## Or with a wopt argument:

writeRaster(r, f, overwrite=TRUE, wopt= list(gdal=c("COMPRESS=NONE", "of=COG"), 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,
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> . If NULL it is attempted to guess the filetype from the filename extension
layer	character. Output layer name. If NULL the filename is used
overwrite	logical. If TRUE, filename is overwritten
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 <- tempfile()
writeVector(v, tmpf1)
x <- vect(tmpf1)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
tmpf2 <- tempfile()
writeVector(v, tmpf2)
y <- vect(tmpf2)

```

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

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 object. 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 object. row numbers start at 1 at the top, column numbers start at 1 at the left.

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'  
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)
row	integer row number(s)
x	x coordinate(s)
y	y coordinate(s)
xy	matrix of x and y coordinates

Details

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](#)).

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: 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)
```

zonal	<i>Zonal statistics</i>
-------	-------------------------

Description

Compute zonal statistics, that is summarized values of a `SpatRaster` for each "zone" defined by another `SpatRaster`.

If `fun` is a true function, `zonal` may fail for very large `SpatRaster` objects, except for the functions ("mean", "min", "max", or "sum").

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
zonal(x, z, fun=mean, ..., as.raster=FALSE, filename="", wopt=list())
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>z</code>	<code>SpatRaster</code> with values representing zones
<code>fun</code>	function to be applied to summarize the values by zone. Either as character: "mean", "min", "max", "sum", or, for relatively small <code>SpatRasters</code> , a proper function
<code>...</code>	additional arguments passed to <code>fun</code>
<code>as.raster</code>	logical. If <code>TRUE</code> , 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>wopt</code>	list with additional arguments for writing files as in writeRaster

Value

A data.frame with a value for each zone (unique value in zones)

See Also

See [global](#) for "global" statistics (i.e., all of `x` is considered a single zone), [app](#) for local statistics, and [extract](#) for summarizing values for polygons

Examples

```

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)

# 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)

```

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](#)

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