

Package ‘RGISTools’

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Type Package

Title Handling Multiplatform Satellite Images

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Description Downloading, customizing, and processing time series of satellite images for a region of interest. 'RGISTools' functions allow a unified access to multispectral images from Landsat, MODIS and Sentinel repositories. 'RGISTools' also offers capabilities for customizing satellite images, such as tile mosaicking, image cropping and new variables computation. Finally, 'RGISTools' covers the processing, including cloud masking, compositing and gap-filling/smoothing time series of images (Militino et al., 2018 <doi:10.3390/rs10030398> and Militino et al., 2019 <doi:10.1109/TGRS.2019.2904193>).

URL <https://github.com/spatialstatisticsupna/RGISTools#RGISTools>

BugReports <https://github.com/spatialstatisticsupna/RGISTools/issues>

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|-------------------|---|
| RGISTools-package | <i>'RGISTools': Handling Multiplatform Satellite Images</i> |
|-------------------|---|

Description

This package enables you downloading, customizing, and processing time series of satellite images from Landsat, MODIS and Sentinel in a standardized way. Some functions download and convert automatically the platform-specific file formats into GTiff, so they can be loaded in 'R'. The customization functions support tile mosaicking, cropping, and deriving new variables of interest, such as the normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), etc. Tile mosaicking is required when the region of interest extends over several tiles, so they can be combined into a single image. Cropping involves removing the pixels outside the region of interest, making any analysis more computationally and memory efficient. Processing involves cloud mosaicking, compositing and filling/smoothing satellite data. Cloud masking eliminates the pixel values corresponding to clouds. Cloud removal and (measurement or processing) errors trigger data gaps and outliers, decreasing the quality and quantity of measurements. Hence, the package includes a set of functions for filling and smoothing the satellite imagery. The combination of functions in 'RGISTools' results in a stack of satellite images ready-to-use. Due to the wide variety of procedures and sources of information being handled in 'RGISTools', the functions are divided into 7 categories, which are identified by the first 3 characters of the function names;

1. mod identifies MODIS Terra and Aqua satellite functions.
2. sen identifies Sentinel functions.
3. ls7 identifies Landsat-7 functions.
4. ls8 identifies Landsat-8 functions.
5. ls identifies both Landsat-7 and Landsat-8 functions.
6. gen identifies function for being used in any of the three platforms.
7. var identifies function for deriving variables in any of the three platforms.

Details

Below, there is a list of the most important functions grouped by satellite programs, and listed in operational order. These functions include searching, previewing, downloading, mosaicking, deriving new variables, compositing, cloud masking and filling/smoothing satellite imagery.

I. Landsat functions

The Landsat program is currently releasing imagery captured by two satellites; the Landsat-7 and Landsat-8. The functions for both satellites are separate due to discrepancies in their spectral coverage and data formats. To download Landsat imagery with the following functions, a USGS's 'EarthExplorer' account is required. Please, register [here](#).

Landsat-7:

| | |
|---------------------------------|--|
| ls7LoadMetadata | Loads the Landsat-7 metadata file |
| ls7Search | Searches a time series of Landsat-7 images |
| lsPreview | Previews Landsat satellite images |
| lsDownload | Downloads a time series of Landsat images |
| lsCloudMask | Creates clouds masks for Landsat images |
| lsMosaic | Mosaics Landsat images |
| ls7FolderToVar | Computes new variables from Landsat-7 multispectral images |
| genSaveTSRData | Saves a time series of images |

Landsat-8:

| | |
|---------------------------------|--|
| ls8LoadMetadata | Loads the Landsat-8 metadata file |
| ls8Search | Searches a time series of Landsat-8 images |
| lsPreview | Previews Landsat satellite images |
| lsDownload | Downloads a time series of Landsat images |
| lsCloudMask | Creates cloud masks for Landsat images |
| lsMosaic | Mosaics Landsat images |
| ls8FolderToVar | Computes new variables from Landsat-8 multispectral images |
| genSaveTSRData | Saves a time series of images |

II. MODIS functions

Functions in 'RGISTools' download all land products from Terra and Aqua satellites. However, the processing focuses on the multispectral images. Be aware that an 'EarthData' account is required to use NASA's web service so, please, register [here](#).

| | |
|--------------------------------|--|
| modSearch | Searches a time series of MODIS images |
| modPreview | Previews MODIS satellite images |
| modDownload | Downloads a time series of MODIS images |
| modMosaic | Mosaics MODIS images from the land products |
| modFolderToVar | Computes new variables from MODIS multispectral images |

| | |
|-----------------------------|--------------------------------------|
| <code>modCloudMask</code> | Creates cloud masks for MODIS images |
| <code>genSaveTSRData</code> | Saves a time series of images |

III. Sentinel functions

Sentinel archives provide a wide variety of products based on a 5-satellite constellation. The functions to download Sentinel images can cope with any product provided by ESA's 'SciHub' web service. However, image processing is focused on Sentinel-2 multispectral images. 'SciHub' credentials are required to download Sentinel imagery and can be obtained [here](#).

| | |
|-----------------------------|---|
| <code>senSearch</code> | Searches a time series of Sentinel images |
| <code>senPreview</code> | Previews Sentinel images |
| <code>senDownload</code> | Downloads a time series of Sentinel images |
| <code>senMosaic</code> | Mosaics Sentinel-2 images |
| <code>senCloudMask</code> | Creates cloud masks for Sentinel-2 images |
| <code>senFolderToVar</code> | Computes new variables from Sentinel-2 multispectral images |
| <code>genSaveTSRData</code> | Saves a time series of images |

IV. Important general functions

In addition to functions above, the package provides some general functions for a better data handling and processing:

| | |
|---------------------------------|---|
| <code>genCompositions</code> | Creates compositions of images from a time series of satellite images |
| <code>genSmoothingIMA</code> | Fills the gaps and smooths outliers in a time series of satellite images |
| <code>genSmoothingCovIMA</code> | Fills the gaps and smooths outliers in a time series of satellite images using covariates |
| <code>genPlotGIS</code> | Plots satellite images with a proper GIS format |
| <code>genGetDates</code> | Gets the capturing date of an image from the name of a RasterLayer |

V. Remote sensing variables

New variables can be derived from multispectral images. The most common variables in the scientific literature are pre-programmed in 'RGISTools'. They can be identified by the prefix "var".

| | |
|------------------------|---|
| <code>varEVI</code> | Calculates the enhanced vegetation index (EVI) |
| <code>varMSAVI2</code> | Calculates the modified soil-adjusted vegetation index (MSAVI2) |
| <code>varNBR</code> | Calculates the normalized burn ratio (NBR) |
| <code>varNBR2</code> | Calculates the normalized burn ratio 2 (NBR2) |
| <code>varNDMI</code> | Calculates the normalized difference moisture index (NDMI) |
| <code>varNDVI</code> | Calculates the normalized difference vegetation index (NDVI) |
| <code>varNDWI</code> | Calculates the normalized difference water index (NDWI) |
| <code>varRGB</code> | Generates a Red-Green-Blue (RGB) image |
| <code>varSAVI</code> | Calculates the soil-adjusted vegetation index (SAVI) |

 ex.dem.navarre

A Digital Elevation Model (DEM) of the region of Navarre (Spain)

Description

Geographically projected RasterStack with the digital elevation model (DEM) of the region of Navarre (Spain). The DEM was obtained from the [National Center for Geographic Information of Spain](#). The DEM is used as a covariable in the Image Mean Anomaly (IMA) algorithm ([genSmoothingCovIMA](#)).

Format

The RasterStack contains 6 layers with the same DEM, one for every image in the time series of the [genSmoothingCovIMA](#) example. The RasterStack coordinates are in the Sinusoidal projection:

name layer names contain the capturing date of the corresponding image in the format "YYYYJJJ".

size 113 rows by 105 columns and 6 layers.

ex.navarre

A polygon with the border of Navarre (Spain)

Description

Spatial feature (sf) representing the border of Navarre with coordinates in the longitude/latitude format.

ex.ndvi.navarre

A time series of NDVI of Navarre (Spain)

Description

Geographically projected RasterBrick object of the normalized difference vegetation index (NDVI) of Navarre.

Format

The RasterBrick contains 6 images, from the 2nd to the 4th of August in 2017 and 2018. The RasterBrick coordinates are in the Sinusoidal projection:

name layer names contain the date of the image in the format "YYYYJJJ".

size each layer contains 113 rows and 105 columns.

genCompositions *Create image compositions from a time series of satellite images*

Description

genCompositions combines a series of satellite images to create compositions.

Usage

```
genCompositions(rstack, by, fun, n, by.days = FALSE, verbose = FALSE,  
...)
```

Arguments

| | |
|---------|---|
| rstack | a RasterStack, where layer names contain the capturing date of an image in "YYYYJJJ" format. |
| by | character argument. Accepts "month" or "year" for creating monthly or yearly composites. Only required if n is provided. |
| fun | the function used to create the composite, such as max, min, mean, ... |
| n | number of images combined in the aggregation. Only required if by is not provided. |
| by.days | logical argument. If FALSE, n indicates the number of consecutive images being aggregated. If TRUE, the function aggregates the imagery within every n days. The aggregation requires at least one image available. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions: <ul style="list-style-type: none">• AppRoot the path where the images will be saved in the GTiff format. |

Details

The layer of the composite image takes its name from the first image used in the composition.

genCompositions reduces the number of images but improves the total quality of the time-series by removing clouds and outliers. One widespread compositing technique is the maximum value composition (MVC). This technique allocates in each pixel of the composite the maximum value (fun = max) that the pixel reaches during a time period (n, by.days = TRUE).

Value

a RasterStack with the time series of the composite images.

Examples

```

# loading NDVI images of Navarre
data("ex.ndvi.navarre")
# Plotting the images: clouds are found
genPlotGIS(ex.ndvi.navarre)
# the first composite image is made with images 1, 2 and 3,
# and the second composite image is made with images 4, 5 and 6
composite.NDVI.a <- genCompositions(rstack = ex.ndvi.navarre,
                                   n = 3,
                                   fun = max)

genPlotGIS(composite.NDVI.a)
# when by.days=TRUE, the first composite image is made with images 1, 2 and 3,
# the second with image 4, and the third with images 5 and 6.
composite.NDVI.3a <- genCompositions(rstack = ex.ndvi.navarre,
                                   n = 3,
                                   by.days = TRUE,
                                   fun = max)

# Check that the clouds were removed
genPlotGIS(composite.NDVI.3a)

```

genFilterStack

Subset a RasterStack given a range of dates

Description

genFilterStack filters the RasterLayers within a range of dates.

Usage

```
genFilterStack(r, ...)
```

Arguments

| | |
|-----|---|
| r | the RasterStack to be filtered. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • startDate a Date class object with the starting date of the study period. • endDate a Date class object with the ending date of the study period. • AppRoot the path where the RData will be saved. |

Details

This is a helper function used by other functions in this package.

Value

a RasterStack with images within the specified dates.

Examples

```
# generate random images
img <- matrix(1:16, ncol = 4, byrow = TRUE)
r <- raster(img)
r <- stack(r, r, r, r, r, r)
names(r) <- paste0("RandomImage_201803", 1:6)
# print the names and dates of the random images
print(names(r))
genGetDates(names(r))
# example of filtering the raster stack
r2 <- genFilterStack(r = r,
                    startDate = as.Date("2018-02-02", "%Y-%m-%d"),
                    endDate = as.Date("2018-02-04", "%Y-%m-%d"))
# print the names and the number of layers of the filtered stack
genGetDates(names(r2))
nlayers(r2)
```

genGetDates

Return the capturing date from the name of a raster layer

Description

genGetDates extracts the date of one or several images when the name of the layer includes the date in the "YYYYJJJ" format.

Usage

```
genGetDates(str, ...)
```

Arguments

| | |
|-----|---|
| str | character containing the date as "YYYYJJJ", where Y and J are year and julian day digits. |
| ... | arguments for nested functions: <ul style="list-style-type: none">• format the format of the date being returned. |

Details

The function reads a date from a character class object in year-julian ("YYYYJJJ") format and returns a Date class object.

Value

a Date class object with the date of the image or character class, if format argument is used.

Examples

```
img <- matrix(1:16, ncol = 4, byrow = TRUE)
r <- raster(img)
names(r) <- c("RandomImage_2018034")

splot(r)
genGetDates(names(r), format = "%Y%j")
```

genMosaicList

Mosaic a list of raster images

Description

genMosaicList makes a single mosaic from a list of raster images.

Usage

```
genMosaicList(imageList, fun = "max", verbose = TRUE)
```

Arguments

| | |
|-----------|--|
| imageList | list of RasterLayers. |
| fun | the function being applied to pixels that overlap. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |

Details

This is a helper function used by other functions in this package. It combines a list of raster images with different geolocations. If images overlap, the function applies fun to calculate the new values for the overlapping pixels. If not specified, fun = max.

Value

a raster with the mosaicked images.

Examples

```
# create simulated rasters
img <- matrix(1:16, ncol = 4, byrow = TRUE)
r1 <- raster(img)
r2 <- r1
r3 <- r1
extent(r2) <- extent(1, 2, 1, 2)
extent(r3) <- extent(1, 2, 0, 1)
imageList <- list(r1, r2, r3)
# mosaic simulated rasters
mr <- genMosaicList(imageList)
splot(mr)
```

genPlotGIS

Plot satellite images with a GIS format

Description

This function displays satellite images with the usual format in geographic information systems (GIS), i.e., adding a scale, north arrow, and the border of the region of interest (optional).

Usage

```
genPlotGIS(r, region, breaks, labels, zlim, layout, proj, nbreaks = 40,
           nlabels = 10, as.grid = TRUE, compass.rm = FALSE,
           scale.bar.rm = FALSE, ...)
```

Arguments

| | |
|--------------|--|
| r | a Raster* class object with an image or stack of images to be plotted. If r is a list of RasterStack, genPlotGIS treats the stacks as RGB images. |
| region | a Spatial*, projected raster*, or sf class object defining the area of interest. |
| breaks | a numeric vector defining the color breaks of the legend. |
| labels | a character vector defining the labels in the breaks of the legend. |
| zlim | a numeric vector defining the maximum and minimum pixel values to be mapped. |
| layout | a numeric vector defining rows and columns to divide the plotting area. |
| proj | a character or 'CRS' class object defining the coordinate reference system of the plot. |
| nbreaks | a numeric argument defining the default number of breaks. |
| nlabels | a numeric argument defining the default number of labels in the legend. |
| as.grid | a logical argument. If TRUE, removes the space between plotted layers. |
| compass.rm | a logical argument to remove the compass from the plot. FALSE by default. |
| scale.bar.rm | a logical argument to remove the scale bar from the plot. FALSE by default. |
| ... | argument for nested functions: <ul style="list-style-type: none"> • tm_layout any argument accepted by the tm_layout function. • tm_graticules any argument accepted by the tm_graticules function. The arguments are defined as tm_graticules.arg, where arg is the tm_graticules argument name. For example, the labels.size of tm_graticules is defined as tm_graticules.labels.size. • tm_compass any argument accepted by the tm_compass function. The arguments are defined as tm_compass.arg, where arg is the tm_compass argument name. For example, the type of tm_compass is defined as tm_compass.type. • tm_scale_bar any argument accepted by the tm_scale_bar function. The arguments are defined as tm_scale_bar.arg, where arg is the tm_scale_bar argument name. For example, the text.size of tm_scale_bar is defined as tm_scale_bar.text.size. |

- `tm.shape` and `tm.polygon` refer to the `region` argument. Any argument accepted by the `tm_shape` and `tm_polygon` functions. The arguments are defined as `tm.shape.region.arg` or `tm.polygon.region.arg`, where `arg` is the `tm_shape` and `tm_polygon` argument name respectively. For example, the `lwd` of `tm_polygon` is defined as `tm.polygon.region.lwd`.
- `tm.shape` and `tm.raster` refer to the `r` argument. Any argument accepted by the `tm_shape` and `tm_raster` functions. The arguments are defined as `tm.shape.r.arg` or `tm.raster.r.arg`, where `arg` is the `tm_shape` and `tm_raster` argument name respectively. For example, the `legend.reverse` of `tm_raster` is defined as `tm.raster.r.legend.reverse`.
- `tm.tmap.arrange` any argument accepted by the `tm_tmap_arrange` function. The arguments are defined as `tm.tmap.arrange.arg`, where `arg` is the `tm_tmap_arrange` argument name. For example, the `asp` of `tm_tmap_arrange` is defined as `tm.tmap.arrange.asp`. This arguments are only accepted when plotting a list of stack images to plot as RGB.

Details

This is a wrapper function of `tmap` and hence displays any `Raster*` object and accepts all of its parameters. The function adds a scale, a north arrow and a polygon in the area of interest. If necessary, the function automatically reprojects the polygon to match the projection of the raster. The projection of the map can be changed by modifying the `proj` argument. For further help on `tmap` arguments, please go the [tmap](#) reference manual.

Value

`tmap` class containing the plot.

Examples

```
## Not run:
# Simple plot of NDVI in Navarre
genPlotGIS(ex.ndvi.navarre,
           ex.navarre)

# Using tm arguments
genPlotGIS(ex.ndvi.navarre,
           ex.navarre,
           tm.compass.size=1,
           tm.compass.type="rose",
           tm.scale.bar.text.size=0.8,
           tm.polygon.region.lwd=6,
           tm.polygon.region.border.col="#000000",
           tm.raster.r.palette=rev(terrain.colors(40)),
           tm.raster.r.title="NDVI",
           as.grid = TRUE,
           tm.graticules.labels.size=1,
           tm.graticules.n.x=3,
           tm.graticules.n.y=3)

# Using the view mode of tmap for plotting the images in the viewer
tmap_mode("view")
```

```

genPlotGIS(ex.ndvi.navarre,
           ex.navarre,
           tm.raster.r.palette=rev(terrain.colors(40))+
           tm_facets(as.layers=TRUE)

# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the red, blue and NIR bands
img.mod.red <- raster(files.mod[1])
img.mod.blue <- raster(files.mod[3])
img.mod.green <- raster(files.mod[4])
img.mod.rgb<-varRGB(img.mod.red,img.mod.green,img.mod.blue)
genPlotGIS(ex.ndvi.navarre,
           ex.navarre)+
           tm_facets(as.layers = TRUE)+
genPlotGIS(list(img.mod.rgb),
           ex.navarre)

## End(Not run)

```

genSaveTSRData

Saves a time series of images as an RData

Description

genSaveTSRData imports a time series of images from a folder (GTiff format), builds a RasterStack and saves it in an RData.

Usage

```

genSaveTSRData(src, AppRoot = NULL, ts.name = "TS.Name",
               startDate = NULL, endDate = NULL, dextent = FALSE,
               recursive = FALSE)

```

Arguments

| | |
|-----------|---|
| src | path to the folder where the time series of images is located. |
| AppRoot | the path where the RData is saved. |
| ts.name | the name of the RasterStack in the RData. |
| startDate | a Date class object with the starting date of the study period. |
| endDate | a Date class object with the ending date of the study period. |
| dextent | a logical argument. If TRUE, the function expands the extent of the RasterStack to embrace the extents of all GTiff images. |
| recursive | logical argument. If TRUE, reads folders recursively, searching for GTiff images. |

Details

The function reads all the images inside the folder specified in `src`. Images files must be GTiffs. The `src` can take the path created by other functions of this package, such as `senMosaic`, `modMosaic`, `senFolderToVar`, etc. The images are imported into 'R' to build a RasterStack. The name of the RasterStack is specified in `ts.name`. The RasterStack is saved in an RData file in the AppRoot directory.

Value

a RasterStack when the AppRoot argument is not defined. The function does not return anything otherwise.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# set the download folder
s.start <- Sys.time()
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download the images
modDownSearch(product = "MOD09GA",
              startDate = as.Date("30-07-2018", "%d-%m-%Y"),
              endDate = as.Date("06-08-2018", "%d-%m-%Y"),
              username = "username",
              password = "password",
              AppRoot = wdir,
              extract.tif = TRUE,
              collection = 6,
              extent = ex.navarre)
# set folder path where MOD09GA images will be saved
wdir.mod <- file.path(wdir, "Modis", "MOD09GA")
# set the tif folder path
wdir.mod.tif <- file.path(wdir.mod, "tif")
# mosaic and cut navarre region
modMosaic(wdir.mod.tif,
          AppRoot = wdir.mod,
          out.name = "Navarre",
          extent = ex.navarre)
# change src to navarre folder
wdir.mod.navarre <- file.path(wdir.mod, "Navarre")
# calculate NDVI from navarre folder
modFolderToVar(wdir.mod.navarre,
               fun = varNDVI,
               AppRoot = dirname(wdir.mod.navarre),
               overwrite = TRUE)
# change src TS_sample
wdir.mod.ndvi <- file.path(dirname(wdir.mod.navarre), "NDVI")
# create the Rdata
tiles.mod.ndvi <- genSaveTSRData(wdir.mod.ndvi, ts.name = "ModisNDVI")
```

```

# remove values out of 0-1 range
tiles.mod.ndvi.lim <- clamp(tiles.mod.ndvi,lower=0,upper=1)
# plot the ndvi images
spplot(tiles.mod.ndvi.lim)
s.end <- Sys.time()
s.end - s.start

## End(Not run)

```

genSmoothingCovIMA *Fill data gaps and smooth outliers in a time series of satellite images using covariates*

Description

genSmoothingCovIMA runs the image mean anomaly (IMA) algorithm with covariates (Militino et al. 2018).

Usage

```

genSmoothingCovIMA(rStack, cStack, Img2Process = NULL, nDays = 3,
  nYears = 1, fact = 5, fun = mean, aFilter = c(0.05, 0.95),
  snow.mode = FALSE, out.name = "out", ...)

```

Arguments

| | |
|-------------|--|
| rStack | a RasterStack class argument containing a time series of satellite images. Layer names should contain the date of the image in "YYYYJJJ" format. |
| cStack | a RasterStack class argument containing a time series of covariates. |
| Img2Process | a vector class argument defining the images to be filled/smoothed. |
| nDays | a numeric argument with the number of previous and subsequent days that define the temporal neighborhood. |
| nYears | a numeric argument with the number of previous and subsequent years that define the temporal neighborhood. |
| fact | a numeric argument with an aggregation factor of the anomalies carried out before the interpolation. |
| fun | a function used to aggregate the image of anomalies. Both mean(default) or median are accepted. |
| aFilter | a vector with the lower and upper quantiles that define the outliers of the anomalies. Ex. c(0.05,0.95). |
| snow.mode | logical argument. If TRUE, the filling process will be parallelized using the 'raster' package. |
| out.name | the name of the folder containing the filled/smoothed images when saved in the Hard Disk Drive (HDD). |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • AppRoot the path where the filled/smoothed time series of images are saved as GTiff. |

Details

This filling/smoothing method was developed by Militino et al. (2018). This technique decomposes a time series of images into a new series of mean and anomaly images. The procedure applies the filling/smoothing algorithm with covariates over the anomaly images. The procedure requires a proper definition of a temporal neighbourhood for the target image and aggregation factor.

Value

a RasterStack with the filled/smoothed images.

References

Militino AF, Ugarte MD, Perez-Goya U (2018). “Improving the Quality of Satellite Imagery Based on Ground-Truth Data from Rain Gauge Stations.” *Remote Sensing. (Open-Access)*, **10**(398), 1–16. <http://dx.doi.org/10.3390/rs10030398>.

Examples

```
set.seed(0)
# load example ndvi and dem data of Navarre
data(ex.ndvi.navarre)
data(ex.dem.navarre)
# plot example data
genPlotGIS(ex.ndvi.navarre)
genPlotGIS(ex.dem.navarre)

# distorts 5% of the original ndvi data by
# altering 50% its values
for(x in c(2,5)){
  aux <- sampleRandom(ex.ndvi.navarre[[x]],
                      ncell(ex.ndvi.navarre) * 0.05,
                      cells = TRUE,
                      na.rm = TRUE)
  ex.ndvi.navarre[[x]][aux[,1]] <- aux[,2] * 1.5
}
genPlotGIS(ex.ndvi.navarre)

# smoothing the image using the DEM as covariate
smth.ndvi <- genSmoothingCovIMA(rStack = ex.ndvi.navarre,
                               cStack = ex.dem.navarre,
                               Img2Process = c(2,5))

# plot the distorted 1, smoothed 1,
# distorted 5, smoothed 5 images
plot(stack(ex.ndvi.navarre[[2]],
          smth.ndvi[[1]],
          ex.ndvi.navarre[[5]],
          smth.ndvi[[2]]))
```

genSmoothingIMA *Fill data gaps and smooth outliers in a time series of satellite images*

Description

genSmoothingIMA is the implementation of a spatio temporal method called image mean anomaly (IMA) for gap filling and smoothing satellite data (Militino et al. 2019).

Usage

```
genSmoothingIMA(rStack, Img2Fill = NULL, nDays = 3, nYears = 1,
  fact = 5, fun = mean, aFilter = c(0.05, 0.95), factSE = 8,
  predictSE = FALSE, snow.mode = FALSE, out.name = "outname", ...)
```

Arguments

| | |
|-----------|---|
| rStack | a RasterStack class argument containing a time series of satellite images. Layer names should contain the date of the image in "YYYYJJJ" format. |
| Img2Fill | a vector class argument defining the images to be filled/smoothed. |
| nDays | a numeric argument with the number of previous and subsequent days that define the temporal neighborhood. |
| nYears | a numeric argument with the number of previous and subsequent years that define the temporal neighborhood. |
| fact | a numeric argument with an aggregation factor of the anomalies before the interpolation. |
| fun | a function used to aggregate the image of anomalies. Both mean (default) or median are accepted. |
| aFilter | a vector with the lower and upper quantiles that define the outliers of the anomalies. Ex. c(0.05,0.95). |
| factSE | the fact used in the standard error prediction. |
| predictSE | calculate the standard error instead the prediction. |
| snow.mode | logical argument. If TRUE, the filling process will be parallelized using the 'raster' package. |
| out.name | the name of the folder containing the smoothed/filled images when saved in the Hard Disk Device (HDD). |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • AppRoot the path where the filled/smoothed time series of images will be saved in GTiff format. |

Details

This filling/smoothing method was developed by Militino et al. (2019). This technique decomposes a time series of images into a new series of mean and anomaly images. The procedure applies the smoothing algorithm over the anomaly images. The procedure requires a proper definition of a temporal neighbourhood for the target image and aggregation factor.

Value

a RasterStack with the filled/smoothed images.

References

Militino AF, Ugarte MD, Perez-Goya U, Genton MG (2019). “Interpolation of the Mean Anomalies for Cloud-Filling in Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI).” *IEEE Transactions on Geoscience and Remote Sensing*. (Open-Access). <http://dx.doi.org/10.1109/TGRS.2019.2904193>.

Examples

```
# load an example of NDVI time series in Navarre
data(ex.ndvi.navarre)
# the 2 images to be filled and the neighbourhood
genPlotGIS(ex.ndvi.navarre)

# filled images
tiles.mod.ndvi.filled <- genSmoothingIMA(ex.ndvi.navarre,
                                         Img2Fill = c(1,2))
# show the filled images
genPlotGIS(tiles.mod.ndvi.filled)
# plot comparison of the cloud and the filled images
tiles.mod.ndvi.comp <- stack(ex.ndvi.navarre[[1]], tiles.mod.ndvi.filled[[1]],
                             ex.ndvi.navarre[[2]], tiles.mod.ndvi.filled[[2]])
genPlotGIS(tiles.mod.ndvi.comp, layout=c(2, 2))
```

getRGISToolsOpt

Get the default value of an RGISTools option

Description

getRGISToolsOpt gets the current value of an ‘RGISTools’ configuration variable. This function can be jointly used with [setRGISToolsOpt](#) and [showRGISToolsOpt](#).

Usage

```
getRGISToolsOpt(opt, env = optEnv)
```

Arguments

opt a character with the name of the option.
 env the environment where the ‘RGISTools’ option are saved.

Value

an option of ‘RGISTools’ configuration variable.

Examples

```
# list available options names
showRGISToolsOpt()
# list the Sentinel-2 bands
getRGISToolsOpt("SEN2BANDS")
# list the Landsat-8 bands
getRGISToolsOpt("LS8BANDS")
# list the MODIS09 bands
getRGISToolsOpt("MOD09BANDS")
```

| | |
|----------------|--|
| ls7FolderToVar | <i>Compute a remote sensing index from a time series of Landsat-7 images</i> |
|----------------|--|

Description

[ls7FolderToVar](#) computes a remote sensing index from the spectral bands of a time series of Landsat-7 images. The images are specified by the path to the folder that stores the imagery (resulting from the [lsMosaic](#) function). The function returns a RasterStack with the time series of images of the remote sensing index.

Usage

```
ls7FolderToVar(src, fun, AppRoot, getStack = FALSE, overwrite = FALSE,
  verbose = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| src | the path to the folder with the Landsat-7 multispectral imagery. |
| fun | a function that computes the remote sensing index. |
| AppRoot | the directory of the outcoming time series. |
| getStack | logical argument. If TRUE, returns the time series as a RasterStack, otherwise the images are saved in the Hard Drive Device (HDD). |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The function requires the definition of the src and fun arguments. The src is usually the path resulting from [lsMosaic](#). The fun argument can be any function from this package beginning with “var” ([varNDVI](#), [varEVI](#), etc.). Custom functions can also be implemented.

Value

this function does not return anything, unless `getStack = TRUE` which then returns a `RasterStack` with the time series of with the index.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download Landsat-7 images
lsDownSearch(satellite = "ls7",
             username = "username",
             password = "password",
             startDate = as.Date("01-01-2018", "%d-%m-%Y"),
             endDate = as.Date("20-01-2018", "%d-%m-%Y"),
             extent = ex.navarre,
             untar = TRUE,
             AppRoot = wdir)
# folder with the Landsat-7 untared images
wdir.ls7 <- file.path(wdir, "Landsat7")
wdir.ls7.untar <- file.path(wdir.ls7, "untar")
# mosaic the Landsat-7 images
lsMosaic(wdir.ls7.untar,
         AppRoot = wdir.ls7,
         out.name = "Navarre",
         extent = ex.navarre,
         gutils = TRUE)
# folder with the mosaicked images
wdir.ls7.navarre <- file.path(wdir.ls7, "Navarre")
# generate NDVI images of Navarre
wdir.ls7.var <- file.path(wdir.ls7, "Navarre_Variables")
dir.create(wdir.ls7.var)
ls7FolderToVar(wdir.ls7.navarre,
              fun = varNDVI,
              AppRoot = wdir.ls7.var,
              overwrite = TRUE)

files.ls7.ndvi <- list.files(file.path(wdir.ls7.var, "NDVI"),
                           pattern = "\\*.tif$",
                           full.names = TRUE,
                           recursive = TRUE)
img.ls7.ndvi <- raster(files.ls7.ndvi[1])
spplot(img.ls7.ndvi)

## End(Not run)
```

| | |
|-----------------|---|
| ls7LoadMetadata | <i>Load or update the Landsat-7 metadata file</i> |
|-----------------|---|

Description

ls7LoadMetadata loads a data.frame called ".LS7MD" with the names of the Landsat-7 images and their metadata. The metadata provides auxiliary information, such as image quality, acquisition date, cloud cover, etc. You can find a description of the metadata on the [USGS's website](#).

Usage

```
ls7LoadMetadata(AppRoot, update = FALSE, verbose = TRUE,
  omit.question = TRUE, ...)
```

Arguments

| | |
|---------------|--|
| AppRoot | the directory where the metadata file should be located. |
| update | logical argument. If TRUE, updates the metadata file. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| omit.question | logical argument. If TRUE, the question about loading the metadata is omitted. |
| ... | arguments for nested functions. |

Details

All captures done by Landsat-7 are catalogued and documented in a unique csv file. The size of the file could be larger than 360MB. The function downloads and imports the metadata into 'R', which may take several minutes (roughly 15 minutes in a Intel Core i7-4790, 16Gb of RAM and Hard Drive Device). The function creates an RData file with the csv metadata. Thus, every time ls7LoadMetadata is called, this function loads the existing RData from the AppRoot directory, which aims to reduce the loading time of the metadata in the future.

Value

this function does not return anything, but loads the ".LS7MD" data.frame on the environment of the 'RGISTools' package.

Examples

```
## Not run:
# creates a MetaData folder and downloads the csv in the "Path_for_downloading_folder" directory
ls7LoadMetadata(AppRoot = file.path(tempdir(), "Path_for_downloading_folder"))

# update the metadata file
ls7LoadMetadata(AppRoot = file.path(tempdir(), "Path_for_downloading_folder"), update = TRUE)

# get metadata data frame
LS7MD <- getRGISToolsOpt("LS7METADATA")
```

```
head(LS7MD)

## End(Not run)
```

| | |
|-----------|--------------------------------|
| ls7Search | <i>Search Landsat-7 images</i> |
|-----------|--------------------------------|

Description

ls7Search searches Landsat-7 images in the Landsat repository concerning a particular location and date interval. The function returns a `data.frame` with the names of the images and their metadata.

Usage

```
ls7Search(AppRoot, verbose = FALSE, precise = FALSE, ...)
```

Arguments

| | |
|---------|---|
| AppRoot | directory of the metadata file. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| precise | logical argument. If TRUE, conducts a thorough search, tile by tile (slower). |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • <code>dates</code> a vector with the capturing dates being searched. This argument is mandatory if <code>startDate</code> and <code>endDate</code> are not defined. • <code>startDate</code> a Date class object with the starting date of the study period. This argument is mandatory if <code>dates</code> is not defined. • <code>endDate</code> a Date class object with the ending date of the study period. This argument is mandatory if <code>dates</code> is not defined. • <code>region</code> a <code>Spatial*</code>, <code>projected raster*</code>, or <code>rsf</code> class object defining the area of interest. This argument is mandatory if <code>pathrow</code>, <code>extent</code>, or <code>lonlat</code> are not defined. • <code>pathrow</code> a list of vectors with the path and row numbers of the tiles concerning the region of interest. This argument is mandatory if <code>region</code>, <code>extent</code> or <code>lonlat</code> are not provided. Ex. <code>list(c(200,31),c(200,30))</code>. • <code>lonlat</code> a vector with the longitude/latitude coordinates of the point of interest. Ex. <code>c(-1.64323,42.81687)</code>. This argument is mandatory if <code>region</code>, <code>pathrow</code>, or <code>lonlat</code> are not defined. • <code>extent</code> an <code>extent</code>, <code>Raster*</code>, or <code>Spatial*</code> object representing the region of interest with longitude/latitude coordinates. This argument is mandatory if <code>region</code>, <code>pathrow</code> or <code>lonlat</code> are not defined. • <code>column names</code> in the <code>.LS7MD data.frame</code> and their values. |

Details

ls7Search searches images in the metadata file. If the metadata was downloaded before to the current directory, ls7Search will use this metadata by default. In case the metadata was not downloaded before, ls7Search will make that call for you. The function creates the following subfolders "Landsat-8/metadata", where the metadata file is located.

Landsat images are organized by tiles, which have a unique path and row numbers according to the [Worldwide Reference System](#). The fastest way to search an image in the metadata file is by path and row (pathrow). This method requires to know in advance the path and row numbers of the tile that is relevant for your region of interest. From the user's standpoint, the simplest way to search a time series of Landsat-7 images is by region, extent, or lonlat, since they do not require any prior knowledge about the tiles.

The function can screen the results by any other attribute in the metadata. For instance, to filter the imagery with an available preview, the browseAvaliable="Y" must be added as an argument of the function (see the examples).

Value

a data.frame with the name of the images and their metadata.

Examples

```
## Not run:
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
# search by path and row numbers of a tile
sres <- ls7Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 pathrow = list(c(200,31),c(200,30)),
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# search by point coordinates (long/lat coordinates)
sres <- ls7Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 lonlat = c(-1.64323,42.81687),
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# search by extent (long/lat coordinates)
# load a spatial polygon object of Navarre
data(ex.navarre)
sres <- ls7Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 extent = ex.navarre,
                 precise = TRUE,
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# search by extent (fast mode)
sres <- ls7Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
```

```

        extent = ex.navarre,
        precise = FALSE,
        browseAvaliable = "Y",
        AppRoot = wdir)
# remove metadata to free memory space
lsRemoveMetadata()

## End(Not run)

```

| | |
|----------------|--|
| ls8FolderToVar | <i>Compute a remote sensing index from a time series of Landsat-8 images</i> |
|----------------|--|

Description

ls8FolderToVar computes a remote sensing index from the spectral bands of a time series of Landsat-8 images. The images are specified by the path to the folder that stores the imagery (resulting from the `lsMosaic` function). The function returns a RasterStack with a time series of images of the remote sensing index.

Usage

```
ls8FolderToVar(src, fun, AppRoot, getStack = FALSE, overwrite = FALSE,
  verbose = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| src | path to the folder with the Landsat-8 multispectral image. |
| fun | a function that computes the remote sensing index. |
| AppRoot | the directory of the outcoming time series. |
| getStack | logical argument. If TRUE, returns the time series of images as a RasterStack, otherwise the images are saved in the Hard Drive Device (HDD). |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The function requires the definition of the `src` and `fun` arguments. The `src` is usually the path resulting from `lsMosaic`. The `fun` argument can be any function from this package beginning with “var” (`varNDVI`, `varEVI`, etc.). Custom functions can also be implemented. If `fun = varRGB`, then the argument `getStack` must be equal to `FALSE` and the red-green-blue (RGB) images must be imported afterwards.

Value

this function does not return anything, unless `getStack = TRUE` which then returns a `RasterStack` with the time series of with the index.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download Landsat-8 images
lsDownSearch(satellite = "ls8",
             username = "username",
             password = "password",
             startDate = as.Date("01-01-2018", "%d-%m-%Y"),
             endDate = as.Date("18-01-2018", "%d-%m-%Y"),
             pathrow = list(c(200, 31), c(200, 30)),
             untar = TRUE,
             AppRoot = wdir)
# folder with the Landsat-8 untared images
src.ls8 <- file.path(wdir, "Landsat8")
src.ls8.untar <- file.path(src.ls8, "untar")
# mosaic the Landsat-8 images
lsMosaic(src = src.ls8.untar,
        AppRoot = src.ls8,
        out.name = "Navarre",
        extent = ex.navarre,
        gutils = TRUE)
# path to the folder with mosaicked images
src.ls8.navarre <- file.path(src.ls8, "Navarre")
# generate NDVI images of Navarre
src.ls8.var <- file.path(src.ls8, "Navarre_Variables")
dir.create(src.ls8.var)
ls8FolderToVar(src.ls8.navarre,
              fun = varNDVI,
              AppRoot = src.ls8.var,
              overwrite = TRUE)

files.ls8.ndvi <- list.files(file.path(src.ls8.var, "NDVI"),
                          pattern = "\\*.tif$",
                          full.names = TRUE,
                          recursive = TRUE)

img.ls8.ndvi <- raster(files.ls8.ndvi[1])
splot(img.ls8.ndvi)

## End(Not run)
```

| | |
|-----------------|---|
| ls8LoadMetadata | <i>Load or update the Landsat-8 metadata file</i> |
|-----------------|---|

Description

ls8LoadMetadata loads a data.frame called ".LS8MD" with the names of the Landsat-8 images and their metadata. The metadata provides auxiliary information, such as image quality, acquisition date, cloud cover, etc. You can find a description of the metadata on the [USGS's website](#).

Usage

```
ls8LoadMetadata(AppRoot, update = FALSE, verbose = TRUE,
  omit.question = FALSE, ...)
```

Arguments

| | |
|---------------|--|
| AppRoot | the directory where the metadata file should be located. |
| update | logical argument. If TRUE, updates the metadata file. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| omit.question | logical argument. If TRUE, the question about loading the metadata is omitted. |
| ... | arguments for nested functions. |

Details

All captures done by Landsat-8 are catalogued and documented in a unique csv file. The size of the file could be larger than 210MB. The function downloads and imports the metadata into 'R', which may take several minutes (roughly 7 minutes in a Intel Core i7-4790, 16Gb of RAM and Hard Drive Device). The function creates an RData file with the csv metadata. Thus, every time ls8LoadMetadata is called, this function loads the existing RData from the AppRoot directory, which aims to reduce the loading time of the metadata in the future.

Value

this function does not return anything, but loads the ".LS8MD" data.frame on the 'RGISTools' package.

Examples

```
## Not run:

# creates a MetaData folder and downloads the csv in the "Path_for_downloading_folder" directory
ls8LoadMetadata(AppRoot = file.path(tempdir(), "Path_for_downloading_folder"))

# update the metadata file
ls8LoadMetadata(AppRoot = file.path(tempdir(), "Path_for_downloading_folder"), update = TRUE)

# get metadata data frame
```

```

LS8MD <- getRGISToolsOpt("LS8METADATA")
head(LS8MD)

## End(Not run)

```

Is8Search

Search Landsat-8 images

Description

ls8Search searches Landsat-8 images in the Landsat repository concerning a particular location and date interval. The function returns a `data.frame` with the names of the images and their metadata.

Usage

```
ls8Search(AppRoot, verbose = FALSE, precise = FALSE, ...)
```

Arguments

| | |
|---------|---|
| AppRoot | directory of the metadata file. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| precise | logical argument. If TRUE, conducts a thorough search, tile by tile (slower). |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • <code>dates</code> a vector with the capturing dates being searched. This argument is mandatory if <code>startDate</code> and <code>endDate</code> are not defined. • <code>startDate</code> a Date class object with the starting date of the study period. This argument is mandatory if <code>dates</code> is not defined. • <code>endDate</code> a Date class object with the ending date of the study period. This argument is mandatory if <code>dates</code> is not defined. • <code>region</code> a <code>Spatial*</code>, <code>projected raster*</code>, or <code>sf</code> class object defining the area of interest. This argument is mandatory if <code>pathrow</code>, <code>extent</code>, or <code>lonlat</code> are not defined. • <code>pathrow</code> a list of vectors with the path and row numbers of the tiles concerning the region of interest. This argument is mandatory if <code>region</code>, <code>extent</code>, or <code>lonlat</code> are not provided. Ex. <code>list(c(200, 31), c(200, 30))</code>. • <code>lonlat</code> a vector with the longitude/latitude coordinates of the point of interest. Ex. <code>c(-1.64323, 42.81687)</code>. • <code>extent</code> an <code>extent</code>, <code>Raster*</code>, or <code>Spatial*</code> object representing the region of interest with longitude/latitude coordinates. This argument is mandatory if <code>region</code>, <code>pathrow</code>, or <code>lonlat</code> are not defined. • column names in the <code>.LS8MD</code> <code>data.frame</code> and their values. |

Details

ls8Search searches images in the metadata file. If the metadata was downloaded before to the current directory, ls8Search will use this metadata by default. In case the metadata was not downloaded yet, ls8Search will make that call for you. The function creates the following subfolders "Landsat-8/metadata", where the metadata file is located.

Landsat images are organized by tiles, which have a unique path and row numbers according to the [Worldwide Reference System](#). The fastest way to search an image in the metadata file is by path and row (pathrow). This method requires to know in advance the path and row number of the tile that is relevant for your region of interest. From the user's standpoint, the simplest way to search a time series of Landsat-7 images is by region, extent, or lonlat since they do not require any prior knowledge about tiles.

The function can screen the results by any other attribute in the metadata. For instance, to filter the imagery with an available preview, the browseAvaliable="Y" must be added as an argument of the function (see the examples).

Value

a data.frame with the name of the images and their metadata.

Examples

```
## Not run:
# search by path and row numbers of a tile
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
sres <- ls8Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 pathrow = list(c(200, 31), c(200, 30)),
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# search by extent (long/lat coordinates)
# load a spatial polygon object of Navarre
data(ex.navarre)
sres <- ls8Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 extent = ex.navarre,
                 precise = TRUE,
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# search by extent (fast mode)
sres <- ls8Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 extent = ex.navarre,
                 precise = FALSE,
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# remove metadata to free memory space
lsRemoveMetadata()
```

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

| | |
|-------------|--|
| lsCloudMask | <i>Create cloud masks for Landsat images</i> |
|-------------|--|

Description

lsCloudMask creates a cloud mask derived from the band for quality assurance (BQA) from Landsat-7 or Landsat-8 time series. The function is applied to untarred images, such as those resulting from [lsDownload](#) or [lsDownSearch](#). The result is a new image band, called cloud (CLD), that is saved as separate GoeTiffs.

Usage

```
lsCloudMask(src, AppRoot, out.name, sensitivity = 28000,
  overwrite = FALSE, verbose = FALSE, ...)
```

Arguments

| | |
|-------------|---|
| src | the path to the folder with the untarred images from Landsat-7 or Landsat-8. |
| AppRoot | the directory where the cloud masks are saved. |
| out.name | the name of the folder that stores the outputs. If the arguemnt is not defined the folder will be named as "CloudMask". |
| sensitivity | numeric argument. Defines the sensitivity of the cloud detection method. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector with the dates being considered for creating cloud masks. This argument is optional. |

Details

The valid range for the `sensitivity` threshold is 0-80000. By default, the argument is set to 28000. We recommend 6000 and 28000 for Landsat-7 and Landsat-8 respectively. The NA and 1 values of the mask represent cloudy and clear-sky pixels pixels respectively.

Value

this function does not return anything. It saves the cloud masks (CLD) as GTiff files in the AppRoot directory.

Examples

```

## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
wdir <- file.path(tempdir(),"Path_for_downloading_folder")
print(wdir)

# search and download images from Landsat-8 between
# 01-01-2018 and 20-01-2018 for the region of Navarre
lsDownSearch(satellite = "ls8",
             username = "username",
             password = "password",
             startDate = as.Date("01-01-2018", "%d-%m-%Y"),
             endDate = as.Date("20-01-2018", "%d-%m-%Y"),
             pathrow = list(c(200, 31), c(200, 30)),
             untar = TRUE,
             AppRoot = wdir)

# define the path where the GTiff images are located
wdir.ls8 <- file.path(wdir,"Landsat8")
wdir.ls8.untar <- file.path(wdir.ls8,"untar")

# mosaic and crop the imagery
lsMosaic(src = wdir.ls8.untar,
         AppRoot = wdir.ls8,
         out.name = "Navarre",
         extent = ex.navarre,
         gutils = TRUE, # using gdalUtils
         overwrite = TRUE) # overwrite

# generate the path where mosaicked images are located
wdir.ls8.navarre <- file.path(wdir.ls8, "Navarre")

# calculate the cloud mask from QC layer
lsCloudMask(src=wdir.ls8.navarre,
            overwrite=TRUE)

# load the B1 layer and calculate the CLD layer
files.ls8.navarre.path <- list.files(wdir.ls8.navarre,
                                   full.names = TRUE,
                                   recursive = TRUE,
                                   pattern = "\\\\.tif$")
tiles.ls8.cld <- files.ls8.navarre.path[grepl("CLD",files.ls8.navarre.path)]
tiles.ls8.b1 <- files.ls8.navarre.path[grepl("B1.tif",files.ls8.navarre.path)]
img.ls8.cld <- lapply(tiles.ls8.cld,raster)
img.ls8.b1 <- lapply(tiles.ls8.b1,raster)

# calculate cloud free b1 layers
img.ls8.b1.cloud.free <- img.ls8.b1[[1]] * img.ls8.cld[[1]]
spplot(img.ls8.b1.cloud.free)

## End(Not run)

```

| | |
|------------|--|
| IsDownload | <i>Download Landsat-7 or Landsat-8 images from a search list</i> |
|------------|--|

Description

IsDownload downloads the results from [ls7Search](#) and [ls8Search](#) functions. The images are saved as GTiff files in the AppRoot directory.

Usage

```
IsDownload(searchchres, username = NULL, password = NULL, AppRoot,
           lvl = 1, product = c("sr", "source_metadata"), verbose = FALSE,
           raw.rm = FALSE, untar = FALSE, overwrite = FALSE, nattempts = 5,
           l2rqname, ...)
```

Arguments

| | |
|-------------|--|
| searchchres | the results from ls7Search or ls8Search . |
| username | USGS's 'EarthExplorer' username. |
| password | USGS's 'EarthExplorer' password. |
| AppRoot | the download directory. |
| lvl | a number specifying the processing level. Default value, 1. |
| product | character vector with the requested Level-2 products. By default c("sr", "source_metadata"). |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| raw.rm | logical argument. If TRUE, removes the raw images. |
| untar | logical argument. If TRUE, untars downloaded images. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| nattempts | the number of attempts to download an image in case it becomes corrupted. |
| l2rqname | character argument defining the name of the order for level 2 products. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • <code>dates</code> a vector with the capturing dates being considered for downloading. • <code>bFilter</code> a vector with the bands to be extracted when <code>untar=TRUE</code>. If not supplied, all bands are extracted. |

Details

IsDownSearch downloads the list of URLs provided by [ls7Search](#) or [ls8Search](#) as a `data.frame`. The function requires an USGS's 'EarthExplorer' account, which can be obtained [here](#).

The files from 'EarthExplorer' are compressed as 'tar.gz'. IsDownload decompresses the images and obtains the corresponding GTiffs. The GTiff files are saved in the AppRoot directory. To change this option, provide `AppRoot = "full path"`. When `untar = TRUE`, the function decompresses the imagery. When only a subset of bands is required, band names can be provided through the `bFilter` argument. The band names are specified by string "band" and the band number (e.g., "band1"). Image decompression duplicates the information due to the presence of both, compressed and decompressed images. Set `raw.rm = TRUE` to remove former ones.

Value

this function does not return anything. It saves the imagery as 'tar.gz' (and GTiff files) in a folder called 'raw' ('untar') in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)

wdir <- file.path(tempdir(),"Path_for_downloading_folder")
print(wdir)

# search and download the images from Landsat-8 between
# 2011 and 2013 in the region of Navarre
sres <- ls8Search(startDate = as.Date("01-01-2018", "%d-%m-%Y"),
                 endDate = as.Date("20-01-2018", "%d-%m-%Y"),
                 extent = ex.navarre,
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# download 1 image
lsDownload(searchres = sres[1,],
           username = "username",
           password = "password",
           AppRoot = wdir,
           untar = TRUE)

# download 4 images
lsDownload(searchres = sres[1:4,],
           username = "username",
           password = "password",
           AppRoot = wdir,
           untar = TRUE)

# download all the images
lsDownload(searchres = sres,
           username = "username",
           password = "password",
           AppRoot = wdir,
           untar = TRUE)

# search and download the images from Landsat-7 between
# 2011 and 2013 in the region of Navarre
wdir <- file.path(tempdir(),"Path_for_downloading_folder")
print(wdir)
sres <- ls7Search(startDate = as.Date("01-01-2018", "%d-%m-%Y"),
                 endDate = as.Date("20-01-2018", "%d-%m-%Y"),
                 extent = ex.navarre,
                 browseAvaliable = "Y",
                 AppRoot = wdir)

# download 1 image
lsDownload(searchres = sres[1,],
           username = "username",
```



```

        password = "password",
        untar = TRUE,
        AppRoot = wdir)
# download 4 images
lsDownload(searchres = sres[1:4,],
            username = "username",
            password = "password",
            untar = TRUE,
            AppRoot = wdir)
# download all the images
lsDownload(searchres = sres,
            username = "username",
            password = "password",
            untar = TRUE,
            AppRoot = wdir)

# removes the metadata to free memory space
lsRemoveMetadata()

# select Landsat-7 RGB bands
wdir.ls7 <- file.path(wdir, "Landsat7")
files.ls7 <- list.files(wdir.ls7,
                       pattern = "\\..TIF$",
                       full.names = TRUE,
                       recursive = TRUE)[c(6,5,4)]
files.ls7.rgb <- stack(files.ls7)
qrangle <- c(0.001, 0.999)
img.ls7.rgb <- varRGB(files.ls7.rgb[[1]],
                     files.ls7.rgb[[2]],
                     files.ls7.rgb[[3]],
                     qrangle)

plotRGB(img.ls7.rgb)

## End(Not run)

```

IsDownSearch

Search and download Landsat-7 or Landsat-8 images

Description

IsDownSearch searches and downloads Landsat-7 or Landsat-8 images concerning a particular location and time interval from the **‘EarthExplorer’ repository**. Images are saved as GTiff files in the AppRoot directory.

Usage

```

lsDownSearch(satellite, username, password, AppRoot, lvl = 1,
             product = c("sr", "source_metadata"), verbose = FALSE,
             untar = TRUE, raw.rm = FALSE, ...)

```

Arguments

| | |
|-----------|--|
| satellite | string containing the type of satellite ("ls7" or "ls8"). |
| username | USGS's 'EarthExplorer' username. |
| password | USGS's 'EarthExplorer' password. |
| AppRoot | the download directory. |
| lvl | a number specifying the processing level. Default value, 1. |
| product | a character vector with the requested Level-2 products. By default c("sr", "source_metadata"). |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| untar | logical argument. If TRUE, untars downloaded images. |
| raw.rm | logical argument. If TRUE, removes the raw images. |
| ... | argumentns for nested functions: <ul style="list-style-type: none"> • dates a vector with the capturing dates being searched. This argument is mandatory if startDate and endDate are not defined. • startDate a Date class object with the starting date of the study period. This argument is mandatory if dates is not defined. • endDate a Date class object with the ending date of the study period. This argument is mandatory if dates is not defined. • region a Spatial*, projected raster*, or sf* class object defining the area of interest. • any argument for ls8Search/ls7Search or lsDownload. |

Details

lsDownSearch is a wrapper function of [ls7Search](#), [ls8Search](#), and [lsDownload](#) to search and download images in a single step. The function requires USGS's 'EarthExplorer' credentials, which can be obtained [here](#).

The files from 'EarthExplorer' are compressed as 'tar.gz'. lsDownSearch decompresses the images and obtains the corresponding GTiffs. The GTiffs are saved in the AppRoot directory. To change this option, provide AppRoot = "full path". When untar=TRUE, the function untars the imagery in this location. Image decompression duplicates the information due to the presence of both, compressed and decompressed images. Set raw.rm = TRUE to remove the former ones.

Value

this function does not return anything. It saves the imagery as 'tar.gz' (and GTiff files) in a folder called 'raw' ('untar') in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)

wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
```

```

# search and download the images from Landsat-8 between
# 01-01-2018 and 20-01-2018 for the region of Navarre
lsDownSearch(satellite = "ls8",
             username = "username",
             password = "password",
             startDate = as.Date("01-01-2018", "%d-%m-%Y"),
             endDate = as.Date("20-01-2018", "%d-%m-%Y"),
             extent = ex.navarre,
             AppRoot = wdir)

# remove metadata to free memory space
lsRemoveMetadata()

## End(Not run)

```

lsEspaDownloadOrders *Downloads the images that have been pre-processed by ESPA*

Description

lsEspaDownloadOrders downloads a set of images processed by the EROS Centre Science Processing Architecture (ESPA) through its application programming interface (API).

Usage

```

lsEspaDownloadOrders(orders, AppRoot, username = NULL, password = NULL,
                    c.handle = NULL, verbose = FALSE, overwrite = FALSE,
                    n.attempts = 5, untar = FALSE, ...)

```

Arguments

| | |
|------------|---|
| orders | a list of the requested images as returned by lsEspaGetOrderImages . |
| AppRoot | the download directory. |
| username | USGS's 'EarthExplorer' username. |
| password | USGS's 'EarthExplorer' password. |
| c.handle | a curl handler created with the package 'curl' to stablish a connection with a preset password and username. This argument is mandatory if username and password are not defined. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| n.attempts | the number of attempts to download an image in case it becomes corrupted files. |
| untar | logical argument. If TRUE, untars the downloaded images. |
| ... | argument for nested functions |

Details

This function is part of a group of functions used to pre-process Landsat level-1 images. The pre-processing is carried out by ESPA on demand. [lsEspaDownloadOrders](#) downloads the images whose processing was completed according to [lsEspaUpdateOrders](#). The function downloads and saves the imagery under the AppRoot directory. The function automatically creates two folders, called "raw" and "untar", to save the compressed and decompressed images respectively. The imagery is only decompressed when untar = TRUE.

Value

this function does not return anything. It saves the imagery as 'tar.gz' (and GTiff files) in a folder called 'raw' ('untar') in the AppRoot directory.

Examples

```
## Not run:
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# search Landsat-7 level-1
sres <- ls7Search(startDate = as.Date("01-01-2017", "%d-%m-%Y"),
                 endDate = as.Date("15-01-2017", "%d-%m-%Y"),
                 lonlat = c(-1.64323, 42.81687),
                 AppRoot = wdir)
# request to ESPA the preprocessing of level-1 images to get the surface reflectance
order <- lsEspaOrderImages(search.res = sres,
                          username = "username",
                          password = "password",
                          product = 'sr',
                          verbose = FALSE)
# get an ID for our request
orders <- lsEspaGetOrderImages(username = "username",
                              password = "password")
# follow up the status of the request
orders <- lsEspaUpdateOrders(orders = orders,
                            username = "username",
                            password = "password")
# saving directory
wdir.ls7.ESPA <- file.path(wdir, "Landsat7", "ESPA")
dir.create(wdir.ls7.ESPA, recursive = TRUE)
# download when status says: complete
lsEspaDownloadOrders(orders = orders,
                    username = "username",
                    password = "password",
                    untar = TRUE,
                    AppRoot = wdir.ls7.ESPA)

## End(Not run)
```

lsEspaGetOrderImages *Gets a first response from ESPA regarding a recent request*

Description

lsEspaGetOrderImages obtains the identification number and the status of the request from the EROS Centre Science Processing Architecture (ESPA).

Usage

```
lsEspaGetOrderImages(username = NULL, password = NULL,  
  c.handle = NULL, order.list = NULL, verbose = TRUE)
```

Arguments

| | |
|------------|--|
| username | USGS's 'EarthExplorer' username. |
| password | USGS's 'EarthExplorer' password. |
| c.handle | a curl handler created with the package 'curl' to establish a connection with a preset password and username. This argument is mandatory if username and password are not defined. |
| order.list | a list of orders from lsEspaOrderImages |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |

Details

This function is part of a group of functions used to pre-process Landsat level-1 images. The pre-processing is carried out by ESPA on demand. lsEspaGetOrderImages takes the identification (ID) number of a request carried out by [lsEspaOrderImages](#). This ID is used to follow up the processing status with [lsEspaUpdateOrders](#). All the status messages and their interpretation can be found in the ESPA's [API User Guide](#).

Examples

```
## Not run:  
wdir <- file.path(tempdir(), "Path_for_downloading_folder")  
# search Landsat 7 level-2  
sres <- ls7Search(startDate = as.Date("01-01-2017", "%d-%m-%Y"),  
  endDate = as.Date("07-01-2017", "%d-%m-%Y"),  
  lonlat = c(-1.64323, 42.81687),  
  AppRoot = wdir)  
# request to ESPA the pre-processing of level-2 images to  
# get the surface reflectance  
order <- lsEspaOrderImages(search.res = sres,  
  username = "username",  
  password = "password",  
  product = 'sr',  
  verbose = FALSE)
```

```
# get an ID for our request
lsEspaGetOrderImages(username = "username",
                      password = "password")

## End(Not run)
```

lsEspaOrderImages *Make a request to ESPA for pre-processing Landsat images*

Description

lsEspaOrder makes a request to the EROS Centre Science Processing Architecture (ESPA) to further process level-1 Landsat scenes.

Usage

```
lsEspaOrderImages(search.res, username, password, product = c("sr",
                    "source_metadata"), verbose = FALSE)
```

Arguments

| | |
|------------|--|
| search.res | the results from ls7Search or ls8Search . |
| username | USGS's 'EarthExplorer' username. |
| password | USGS's 'EarthExplorer' password. |
| product | the acronym of the requested product (see the details). |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |

Details

Landsat Level-1 images are pre-processed on demand by the EROS Centre Science Processing Architecture (ESPA). An order is placed to ESPA with the level-1 images that must be pre-processed (search.res and the requested final product (product)). The products are identified by the following short-names:

- toa: for top of atmosphere reflectance.
- bt: for brightness temperature (thermal band TOA processing).
- sr: for surface reflectance.
- sr_ndvi: the normalized difference vegetation index from surface reflectance imagery.
- sr_evi: the enhanced vegetation index from surface reflectance imagery.
- sr_savi: the soil adjusted vegetation index from surface reflectance imagery.
- sr_msavi: the modified soil adjusted vegetation index from surface reflectance imagery.
- sr_ndmi: the normalized difference moisture index from surface reflectance imagery.
- sr_nbr: the normalized burn ratio from surface reflectance imagery.
- sr_nbr2: the normalized burn ratio 2 index from surface reflectance imagery.
- pixel_qa: for pixel quality assurance.

Value

this function does not return anything. It makes a petition to process level-1 images before doing the download.

Examples

```
## Not run:
wdir <- file.path(tempdir(),"Path_for_downloading_folder")
# search Landsat 7 level-1
sres <- ls7Search(startDate = as.Date("01-01-2017", "%d-%m-%Y"),
                 endDate = as.Date("07-01-2017", "%d-%m-%Y"),
                 lonlat = c(-1.64323, 42.81687),
                 AppRoot = wdir)
# request to ESPA the pre-pocessing of level-1 images
# to get the surface reflectance
order <- lsEspaOrderImages(search.res = sres,
                          username = "username",
                          password = "password",
                          product = 'sr',
                          verbose = FALSE)

## End(Not run)
```

| | |
|--------------------|---|
| lsEspaUpdateOrders | <i>Updates the status of a request made to ESPA</i> |
|--------------------|---|

Description

lsEspaUpdateOrders checks the current status of a request made to EROS Centre Science Processing Architecture (ESPA) to pre-process Landsat level-1 images

Usage

```
lsEspaUpdateOrders(orders, username = NULL, password = NULL,
                  c.handle = NULL, verbose = FALSE)
```

Arguments

| | |
|----------|---|
| orders | a list of the requested orders as returned by lsEspaGetOrderImages . |
| username | USGS's 'EarthExplorer' username. |
| password | USGS's 'EarthExplorer' password. |
| c.handle | a curl handler created with the package 'curl' to stablish a connection with a preset password and username. This argument is mandatory if username and password are not defined. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |

Details

This function is part of a group of functions used to pre-process Landsat level 1 images. The pre-processing is carried out by ESPA on demand. `lsEspaUpdateOrders` uses the ID numbers gathered by `lsEspaGetOrderImages` regarding previous order requests to check the processing status. The function has to be run repeatedly until the status message states “complete”. All the status messages and their interpretation can be found in the ESPA’s API [User Guide](#).

Value

this function returns a dataframe with the updated order information from ESPA.

Examples

```
## Not run:
src <- file.path(tempdir(), "Path_for_downloading_folder")
# search Landsat 7 level-1
search.res <- ls7Search(startDate = as.Date("01-01-2017", "%d-%m-%Y"),
                        endDate = as.Date("15-01-2017", "%d-%m-%Y"),
                        lonlat = c(-1.64323, 42.81687),
                        AppRoot = src)
# request to ESPA the preprocessing of level-1 images to get the surface reflectance
orders <- lsEspaOrderImages(search.res = search.res,
                            username = "username",
                            password = "password",
                            product = 'sr',
                            verbose = FALSE)
# get an ID for our request
orders <- lsEspaGetOrderImages(username = "username",
                              password = "password")
# follow up the status of the request
orders <- lsEspaUpdateOrders(orders = orders,
                            username = "username",
                            password = "password")

## End(Not run)
```

lsGetDates

Return the capturing dates of Landsat-7 or Landsat-8 images

Description

`lsGetDates` reads the official name of a Landsat-7 or Landsat-8 image and returns the capturing date, as a Date class object.

Usage

```
lsGetDates(str, ...)
```


Arguments

- `str` the full path(s) or official name(s) of the Landsat-7 or Landsat-8 images from which the capturing date is retrieved.
- `...` arguments for nested functions:
- format the format of the date being returned.

Details

The function works with file names (or their paths) regardless of their extension. The function accepts more than one file path, which can be passed as a vector of characters. Dates are returned as 'YYYY-mm-dd' by default. If another format is required, it can be modified through the argument `format`.

Value

a Date class object with the date of the Landsat image or character class, if the `format` argument is used.

Examples

```
# getting the capturing date from the name of a Landsat-8 image
file.ls8 <- "LC82000312017010LGN01.tar.gz"
date.ls8 <- lsGetDates(file.ls8)
print(date.ls8)
print(format(date.ls8, "%Yj"))

# getting the capturing date from the name of a Landsat-7 and a Landsat-8
# image
file.ls7 <- c("LE72330822017009ASN01")
date.ls7 <- lsGetDates(file.ls7)
print(date.ls7)
```

lsGetPathRow
Return the pathrow of a tile of Landsat-7 or Landsat-8 images

Description

`lsGetPathRow` reads the official name of a Landsat-7 or Landsat-8 image and returns the tile's path and row number, in "PPPRRR" format (Landsat naming convention).

Usage

```
lsGetPathRow(str)
```

Arguments

- `str` the full path(s) or official name(s) of the Landsat-7 or Landsat-8 images from which the tile's path and row numbers are retrieved.

Value

a string with the path and row in "PPRRR" format.

Examples

```
# example of getting date from Landsat-8 image name
str <- c("LE72000302011066ASN00",
        "LE72000302011066ASN00")
pr <- lsGetPathRow(str)
print(pr)
```

lsMosaic

Mosaic a set of Landsat-7 or Landsat-8 images

Description

lsMosaic merges the Landsat-7 or Landsat-8 imagery that covers a region of interest on the same dates.

Usage

```
lsMosaic(src, AppRoot, region, out.name = "outfile", verbose = FALSE,
         gutils = TRUE, overwrite = FALSE, ...)
```

Arguments

| | |
|-----------|---|
| src | the path to the folder with the Landsat-7 or Landsat-8 images in GTiff format. |
| AppRoot | the directory to save the mosaicked images. |
| region | a Spatial*, projected raster*, or sf class object defining the area of interest. |
| out.name | the name of the folder that stores the outputs. By default, "outfile" is assigned. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| gutils | logical argument. If TRUE, the function uses 'GDAL' utilities for mosaicking. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • pathrow a list of vectors with the path and row numbers of the tiles concerning the region of interest. This argument is mandatory if region is not provided. • bFilter a vector with the bands to be mosaicked. If not supplied, all bands are mosaicked. • dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The function mosaics the imagery in the `src` folder. The folder can hold GTiff images from several tiles, dates and bands. When only a subset of dates has to be mosaicked, the dates should be provided through the argument `dateFilter`. The dates must be provided as a Date class objects. For further details about the `bFilter` argument go to [lsDownload](#). Once mosaicked, the images can be cropped to fit the extent (optional). The extent can be defined in any coordinate reference system, since `lsMosaic` automatically reprojects the extent to match the projection of the image. The outputs are placed in the `AppRoot` directory, under the folder named as `out.name`. If no name is provided, the folder isn named “outfile”. To use ‘`gutils = TRUE`’, a proper installation of ‘GDAL’ and the ‘`gdalUtils`’ library is required. This method is faster than native ‘R’ functions.

Value

this function does not return anything. It saves the imagery in the `AppRoot` directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download Landsat-8 images
lsDownSearch(satellite = "ls8",
             username = "username",
             password = "password",
             startDate = as.Date("01-01-2018", "%d-%m-%Y"),
             endDate = as.Date("20-01-2018", "%d-%m-%Y"),
             extent = ex.navarre,
             untar = TRUE,
             AppRoot = wdir)
# folder with the Landsat-8 untared images
wdir.ls8 <- file.path(wdir, "Landsat8")
tif.src <- file.path(wdir.ls8, "untar")
# mosaic the Landsat-8 images
lsMosaic(src = tif.src,
        AppRoot = wdir.ls8,
        out.name = "Navarre",
        extent = ex.navarre,
        gutils = TRUE, # using gdalUtils
        overwrite = TRUE) # overwrite

## End(Not run)
```

Description

IsPreview shows a preview of the n-th image from a set of search results on an interactive map.

Usage

```
IsPreview(searchres, n, dates, lpos = c(3, 2, 1), add.Layer = FALSE,
  verbose = FALSE, ...)
```

Arguments

| | |
|-----------|---|
| searchres | a data.frame with the results from ls7Search or ls8Search . |
| n | a numeric argument identifying the location of the image in searchres. |
| dates | a vector of Dates being considered for previewing. This argument is mandatory if n is not defined. |
| lpos | vector argument. Defines the position of the red-green-blue layers to enable false color visualization. |
| add.Layer | logical argument. If TRUE, the function plots the image on an existing map. Allows combinations of images on a map using senPreview and modPreview functions. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> arguments allowed by the viewRGB function from the mapview packages are valid arguments. |

Details

The function shows a preview of the n-th output image from a search in the Landsat archives ([ls7Search](#) or [ls8Search](#), with browseAvailable = "Y"). The preview is downloaded from [USGS Bulk Metadata Service](#). Please, be aware that only some images may have a preview.

Value

this function does not return anything. It displays a preview of one of the search results.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
# retrieve jpg images covering Navarre between 2011 and 2013
sres <- ls7Search(startDate = as.Date("01-01-2011", "%d-%m-%Y"),
  endDate = as.Date("31-12-2013", "%d-%m-%Y"),
  extent = ex.navarre,
  precise = TRUE,
  browseAvaliable = "Y",
  AppRoot = wdir)
IsPreview(sres, 1)
```

```
# filter the images with less than 1% pixels covered by clouds
sres.cloud.free = subset(sres, sres$cloudCover < 1)
lsPreview(sres.cloud.free, 1)
lsPreview(sres.cloud.free, 2,add.Layer = TRUE)
# plot all the images in one date
lsPreview(sres.cloud.free,dates=as.Date("2013-09-04"))

## End(Not run)
```

IsRemoveMetadata *Remove the Landsat-7 or Lansat-8 metadata from the environment*

Description

IsRemoveMetadata removes Landsat-7 and/or Landsat-8 (.LS7MD/ .LS8MD) metadata from the environment in 'R'.

Usage

```
IsRemoveMetadata()
```

Details

The metadata file is loaded in 'R' with [ls7Search](#), [ls8Search](#) and [lsDownSearch](#). IsRemoveMetadata removes the metadata and frees up valuable RAM.

Examples

```
## Not run:
# creates a MetaData folder and downloads the csv file
# in the current working directory
wdir <- file.path(tempdir(),"Path_for_downloading_folder")
print(wdir)
ls8LoadMetadata(AppRoot = wdir)
IsRemoveMetadata()

## End(Not run)
```

modCloudMask *Create cloud masks for MODIS images*

Description

modCloudMask creates cloud masks derived from the State Quality Assurance (State QA) band.

Usage

```
modCloudMask(src, AppRoot, out.name, overwrite = FALSE, ...)
```

Arguments

| | |
|-----------|---|
| src | the path to the folder with the MODIS with state_1km images. |
| AppRoot | the directory where cloud masks are saved. |
| out.name | the name of the folder that stores the outputs. If the arguemnt is not defined the folder will be named as "CloudMask". |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector of dates being considered for creating cloud masks. This argument is optional. |

Details

This function, interprets the State Quality Assurance (State QA) band to create cloud masks. The NA and 1 values of the mask represent cloudy and clear-sky pixels pixels respectively.

Value

this function does not return anything. It saves the cloud masks (CLD) as GTiff files in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)

# search and download images from MODIS between
# 01-01-2018 and 03-01-2018 for the region of Navarre
modDownSearch(product = "MOD09GA",
               startDate = as.Date("01-01-2017", "%d-%m-%Y"),
               endDate = as.Date("03-01-2017", "%d-%m-%Y"),
               username = "username",
               password = "password",
               AppRoot = wdir,
               extract.tif = TRUE,
               collection = 6,
               extent = ex.navarre)

# assign src1 as the output folder for modMosaic
wdir.mod <- file.path(wdir, "Modis")
wdir.mod.tiles <- file.path(wdir.mod, "MOD09GA")
wdir.mod.tif <- file.path(wdir.mod.tiles, "tif")
# mosaic the MODIS images
modMosaic(wdir.mod.tif, # the input folder
          AppRoot = wdir.mod.tiles, # the output folder
          out.name = "Navarre", # creates Navarre folder in AppRoot
          gutils = TRUE,
```

```

        extent = ex.navarre)

wdir.mod.navarre <- file.path(wdir.mod.tiles, "Navarre")
# generate the cloud masks
modCloudMask(src = wdir.mod.navarre,
             AppRoot = wdir.mod.tiles,
             overwrite = TRUE)

files.mod.cld <- file.path(wdir.mod.tiles,"CloudMask")
img.mod.cld <- stack(list.files(files.mod.cld, full.names=TRUE, pattern="CLD"))

# select b01
img.mod.navarre <- stack(list.files(wdir.mod.navarre,
                                 full.names=TRUE,
                                 recursive = TRUE,
                                 pattern="b01_1"))

# project to 500m
img.mod.cld.500 <- projectRaster(img.mod.cld,img.mod.navarre)

# plot the cloud free b01 layer
splot(img.mod.navarre*img.mod.cld.500)

## End(Not run)

```

modDownload

Download MODIS images from a search list

Description

modDownload downloads the images from a list of uniform resource locators (URLs) generated by the [modSearch](#) function from NASA's 'EarthData' platform. The images are saved as GTiff files in the AppRoot directory.

Usage

```

modDownload(searchres, AppRoot, username = NULL, password = NULL,
            n attempts = 5, verbose = FALSE, extract.tif = FALSE,
            overwrite = FALSE, raw.rm = FALSE, ...)

```

Arguments

| | |
|------------|---|
| searchres | the output from the modSearch function. |
| AppRoot | the directory where the images will be saved. |
| username | NASA's 'EarthData' username. |
| password | NASA's 'EarthData' password. |
| n attempts | the number of attempts to download an image in case it becomes corrupted. |

| | |
|-------------|--|
| verbose | logical argument. If TRUE, the function prints running stages and warnings. |
| extract.tif | logical argument. If TRUE, extracts all the layers from hdf files and saves them as GTiff. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| raw.rm | logical argument. If TRUE, removes the raw images. |
| ... | argument for nested functions: <ul style="list-style-type: none"> • dates a vector with the capturing dates being considered for downloading. • bFilter a vector with the bands to be extracted when extract.tif=TRUE. If not supplied, all bands are extracted. |

Details

modDownload is able to download MODIS Terra and Aqua products. These products are published in the **'EarthData' Platform**. The platform is supported by the Earth Observing System Data and Information System (EODIS) and managed NASA's Earth Science Data Systems (ESDS). modDownload requires credentials from an 'EarthData' account to access the NASA's web data service, which can be obtained [here](#).

When extract.tif = TRUE, the function decompresses the imagery. If only a subset of bands is required, band names can be provided through the bFilter argument. The band names are specified by "B" and the two-digit band number (e.g., "B01"). Image decompression duplicates the information due to the presence of both, compressed and decompressed images. Set raw.rm = TRUE to remove former ones.

Value

this function does not return anything. It saves the imagery as 'hdf' (and GTiff files) in a folder called 'raw' ('tif') in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
sres <- modSearch(product = "MYD13A2",
                 startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 collection = 6,
                 extent = ex.navarre)

head(sres)
# download the first image in sres
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
wdir.mod <- file.path(wdir, "Modis", "MYD13A2")
wdir.mod.hdf <- file.path(wdir.mod, "hdf")
modDownload(mList[1],
            username = "username",
            password = "password",
            AppRoot = wdir.mod.hdf)
# download all images in mList
```



```

modDownload(sres,
            username = "username",
            password = "password",
            AppRoot = wdir.mod.hdf)

## End(Not run)

```

modDownSearch

Search and download MODIS images

Description

modDownSearch searches and downloads MODIS images concerning a particular location and time interval from the ‘EarthData’ repository. Images are saved as GTiff files in the AppRoot directory.

Usage

```

modDownSearch(product, username, password, AppRoot, collection = 6,
              nattempts = 5, verbose = FALSE, extract.tif = FALSE, ...)

```

Arguments

| | |
|-------------|---|
| product | a character argument with the short name of the MODIS product. |
| username | NASA’s ‘EarthData’ username. |
| password | NASA’s ‘EarthData’ password. |
| AppRoot | the directory to save the outcoming time series. |
| collection | MODIS collection, by default 6. |
| nattempts | the number of attempts to download an image in case it becomes corrupted. |
| verbose | logical argument. If TRUE, the function prints running stages and warnings. |
| extract.tif | logical argument. If TRUE, extracts all the layers from hdf files and saves them as GTiff. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • dates a vector with the capturing dates being searched. This argument is mandatory if startDate and endDate are not defined. • startDate a Date class object with the starting date of the study period. This argument is mandatory if dates is not defined. • endDate a Date class object with the ending date of the study period. This argument is mandatory if dates is not defined. • lonlat a vector with the longitude/latitude coordinates of the point of interest. This argument is mandatory if region or extent are not defined. • extent an sf, Raster*, or Spatial* object representing the region of interest with longitude/latitude coordinates. This argument is mandatory if polygon or lonlat are not defined. • region A list of vectors defining the points of a polygon in longitude/latitude format. This argument is mandatory if lonlat or extent are not defined. • Any argument in <code>modExtractHDF</code> function. Ex. <code>bFilter="b01_1"</code>. |

Details

modDownSearch searches via [NASA's Common Metadata Repository](#) and downloads the imagery from the ['EarthData' web service](#) to download the imagery. The catalogue of MODIS products can be found [here](#). The catalogue shows detailed information about the products and their short names. By the time 'RGISTools' is released, NASA carries out the maintenance of its website on Wednesdays, which may cause an error when connecting to their server. You can get your 'EarthData' credentials [here](#).

Value

this function does not return anything. It saves the imagery as 'tar.gz' (and GTiff files) in a folder called 'raw' ('tif') in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(src)
modDownSearch(product = "MOD09GA",
              startDate = as.Date("01-01-2018", "%d-%m-%Y"),
              endDate = as.Date("03-01-2018", "%d-%m-%Y"),
              username = "username",
              password = "password",
              AppRoot = wdir,
              extract.tif = TRUE,
              collection = 6,
              extent = ex.navarre)

wdir.mod.tif <- file.path(wdir, "Modis", "MOD09GA", "tif")
files.mod <- list.files(wdir.mod.tif,
                      pattern = "\\\\.tif$",
                      full.names = TRUE,
                      recursive = TRUE)[c(16,19,18)]

img.mod <- stack(files.mod)
qrangle <- c(0.001, 0.999)
img.mod.rgb <- varRGB(img.mod[[1]],
                    img.mod[[2]],
                    img.mod[[3]],
                    qrangle)

plotRGB(img.mod.rgb)

## End(Not run)
```

Description

modExtractHDF converts the original format of MODIS images (hierarchical data format or HDF) into GTiffs (one file for each layer).

Usage

```
modExtractHDF(filesHDF, AppRoot, overwrite = FALSE, bFilter = NULL,
              rm.band = NULL, region = NULL, verbose = FALSE, ...)
```

Arguments

| | |
|-----------|---|
| filesHDF | the full path where the HDF files are located. |
| AppRoot | the directory where the extracted images are saved. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| bFilter | a vector containing the names of the bands to extract. |
| rm.band | a vector containing the names of the bands excluded from the extraction. |
| region | a Spatial*, projected raster*, or sf* class object defining the area of interest for image masking. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector with the capturing dates being considered for downloading. |

Details

HDF files cannot be directly loaded into 'R', so they must be converted into GTiffs. To accomplish this task, the function modExtractHDF borrows the gdalwarp and gdal_translate functions from the 'gdalUtils' package. Further details about these functions can be found in the corresponding package manual. 'GDAL' and 'gdalUtils' must be properly installed to use modExtractHDF. GTiffs can be loaded in 'R' using the 'raster' package.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)

wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
wdir.mod <- file.path(wdir, "Modis", "MOD11A1")
sres <- modSearch(product = "MOD11A1",
                 startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 collection = 6,
                 extent = ex.navarre)

# download the images of the list
wdir.mod <- file.path(wdir, "Modis", "MOD11A1")
modDownload(searchres = sres,
```

```

        username = "username",
        password = "password",
        AppRoot = wdir.mod)

wdir.mod.tif<-file.path(wdir.mod,"tif")
wdir.mod.hdf <- file.path(wdir.mod, "hdf")

# extract the first image
files.mod.hdf <- list.files(wdir.mod.hdf,
                           full.names = TRUE,
                           pattern = "\\\\.hdf$")
files.mod.hdf.1 <- files.mod.hdf[1]
modExtractHDF(filesHDF = files.mod.hdf.1,
              AppRoot = wdir.mod.tif)

## End(Not run)

```

| | |
|----------------|---|
| modFolderToVar | <i>Compute a remote sensing index from a time series of MODIS multi-spectral images</i> |
|----------------|---|

Description

modFolderToVar computes a remote sensing index from the spectral bands of a time series of MODIS images. The images are specified by the path to the folder that stores the imagery (resulting from the [modMosaic](#) function). The function returns a RasterStack with a time series of images of the remote sensing index.

Usage

```
modFolderToVar(src, AppRoot, fun, getStack = FALSE, overwrite = FALSE,
              verbose = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| src | path to the folder with the MODIS multispectral images. |
| AppRoot | the directory of the outcoming time series. |
| fun | a function that computes the remote sensing index. |
| getStack | logical argument. If TRUE, returns the time series of images as a RasterStack, otherwise the images are saved in the Hard Drive Device (HDD). |
| overwrite | logical argument. If TRUE, it overwrites the existing images with the same name. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The function requires the definition of the `src` and `fun` arguments. The `src` is usually the path resulting from `modMosaic`. The `fun` argument can be any function from this package beginning with “var” (`varNDVI`, `varEVI`, etc.). Custom functions can also be implemented. If `fun = varRGB`, then the argument `getStack` must be equal to `FALSE` and the red-gree-blue (RGB) images must be imported afterwards.

Value

this function does not return anything, unless `getStack = TRUE` which then returns a `RasterStack` with the time series of with the index.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download MOD09 images
modDownSearch(product = "MOD09GA",
              startDate = as.Date("01-01-2018", "%d-%m-%Y"),
              endDate = as.Date("03-01-2018", "%d-%m-%Y"),
              username = "username",
              password = "password",
              AppRoot = wdir, # output folder for tif images
              extract.tif = TRUE,
              collection = 6,
              extent = ex.navarre)
# assign wdir.mod as the output folder from modMosaic
wdir.mod <- file.path(wdir, "Modis", "MOD09GA") # output directory
wdir.mod.tif <- file.path(wdir.mod, "tif") # input directory
# mosaic the MODIS images
modMosaic(wdir.mod.tif,
          AppRoot = wdir.mod,
          out.name = "Navarre")
# path to the folder with the mosaicked images
wdir.mod.navarre <- file.path(wdir.mod, "Navarre")
# generate NDVI images of Navarre
wdir.mod.var <- file.path(wdir.mod, "Variables")
dir.create(wdir.mod.var)
modFolderToVar(src = wdir.mod.navarre,
              fun = varEVI,
              scfun = getRGISToolsOpt("MOD09SCL"),
              AppRoot = wdir.mod.var,
              overwrite = TRUE)
# import mosaicked images (.tif) to the environment in `R`
files.mod.evi <- list.files(file.path(wdir.mod.var, "EVI"),
                          pattern = "\\\\.tif$",
                          full.names = TRUE,
```

```

recursive = TRUE)

img.mod.evi <- lapply(files.mod.evi,raster)
spplot(img.mod.evi[[1]],at=seq(-1,2.5))

## End(Not run)

```

modGetDates

Return the capturing dates of MODIS images

Description

modGetDates reads the official name of MODIS images and returns its capturing date, as Date class object.

Usage

```
modGetDates(str, ...)
```

Arguments

| | |
|-----|---|
| str | the full path(s) or official name(s) of MODIS images from which the capturing date is retrieved. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • format the format of the date being returned. |

Details

The function works with file names (or their paths) regardless of their extension. The function accepts more than one file path, which can be passed as a list of characters. Dates are returned as 'YYYY-mm-dd' by default. If another format is required, it can be modified through the argument format.

Value

a Date class object with the date of the MODIS image or character class, if format argument is used.

Examples

```

# getting the capturing date from the name of a MODIS image
file.mod <- 'MYD13A2.A2016361.h17v04.006.2017285133407.hdf'
modGetDates(file.mod)

# a list of the full file paths of MODIS images, mixing .hdf and .tif files
file.mod<-list('MYD13A2.A2013297.h17v04.006.2015269230726.hdf',
              'MYD13A2.A2013313.h17v04.006.2015271071143.tif')
modGetDates(file.mod, format = "%Y%j")

```

| | |
|---------------|---|
| modGetPathRow | <i>Return the pathrow of a tile of MODIS images</i> |
|---------------|---|

Description

modGetPathRow reads the official name of a MODIS image and returns the tile's path and row number, in 'hXXvYY' format (MODIS naming convention).

Usage

```
modGetPathRow(str)
```

Arguments

| | |
|-----|--|
| str | the full path(s) or official name(s) of the MODIS images from which the tile's path and row numbers are retrieved. |
|-----|--|

Value

a string with the path and row in "hXXvYY" format.

Examples

```
# getting the path and row number of the tile of a Landsat-8 image
files.mod <- "MYD09GA.A2003136.h17v04.005.2008324054225"
pr.mod <- modGetPathRow(files.mod)
print(pr.mod)
```

| | |
|-----------|-------------------------------------|
| modMosaic | <i>Mosaic a set of MODIS images</i> |
|-----------|-------------------------------------|

Description

modMosaic merges the MODIS imagery that covers a region of interest on the same dates.

Usage

```
modMosaic(src, AppRoot, region = NULL, out.name = "outfile",
  verbose = FALSE, gutils = TRUE, overwrite = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| src | the path of the folder with the MODIS images in GTiff format. |
| AppRoot | the directory where the mosaicked images are saved. |
| region | a Spatial*, projected raster*, or sf class object defining the area of interest. |
| out.name | the name of the folder that stores the outputs. By default, “outfile” is assigned. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| gutils | logical argument. If TRUE, the function uses ‘GDAL’ utilities for mosaicking. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • pathrow a vector of character with the path and row numbers of the tiles concerning the region of interest in ‘hXXvYY’ format. This argument is mandatory if region is not provided. • bFilter a vector with the bands to be mosaicked. If not supplied, all bands are mosaicked. • dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The function mosaics the imagery in the `src` folder. The folder can hold GTiff images from several tiles, dates and bands. When only a subset dates has to be mosaicked, the dates should be provided through the argument `dates`. The dates must be provided as a Date class objects. For further details about the `bFilter` argument, go to the [modDownload](#) function. Once mosaicked, the images can be cropped to fit the region (optional). The region can be defined in any coordinate reference system, since `modMosaic` automatically reproject the extent to match the projection of the image. The outputs will be placed in the `AppRoot` directory, under the folder named as `out.name`. If no name is provided, the folder is named “outfile”.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download MODIS images
modDownSearch(product = "MOD09GA",
              startDate = as.Date("01-01-2018", "%d-%m-%Y"),
              endDate = as.Date("03-01-2018", "%d-%m-%Y"),
              username = "username",
              password = "password",
              AppRoot = wdir,
              extract.tif = TRUE,
              collection = 6,
              extent = ex.navarre)
# folder with the MODIS images extracted
```



```
wdir.mod <- file.path(wdir, "Modis", "MOD09GA")
wdir.mod.tif <- file.path(wdir.mod, "tif")
# mosaic the MODIS images
modMosaic(wdir.mod.tif,
          AppRoot = wdir.mod,
          out.name = "Navarre",
          gutils = TRUE,
          overwrite = TRUE,
          region = ex.navarre)

## End(Not run)
```

modPreview

Preview MODIS satellite images

Description

modPreview shows a preview of the n-th image from a set of search results on an interactive map.

Usage

```
modPreview(searchres, n, dates, lpos = c(3, 2, 1), add.Layer = FALSE,
           verbose = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| searchres | a vector with the results from modSearch . |
| n | a numeric argument identifying the location of the image in searchres. |
| dates | a vector with the dates being considered for previewing. This argument is mandatory if n is not defined. |
| lpos | vector argument. Defines the position of the red-green-blue layers to enable false color visualization. |
| add.Layer | logical argument. If TRUE, the function plots the image on an existing map. Allows combinations of images on a map using lsPreview and senPreview functions. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> arguments allowed by the viewRGB function from mapview packages are valid arguments. |

Details

The function shows a preview of the n-th output image from a search in the MODIS archives ([modSearch](#), with `resType = "broweur1"`). The preview is downloaded from the [‘EarthData’ Platform](#). Please, be aware that only some images may have a preview.

Value

this function does not return anything. It displays a preview of one of the search results.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# retrieve jpg images covering Navarre region between 2011 and 2013
sres <- modSearch(product = "MOD09GA",
                  startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                  endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                  collection = 6,
                  resType = "browseurl",
                  extent = ex.navarre)

modPreview(sres,n=1)
modPreview(sres,2,add.Layer=T)

## End(Not run)
```

modSearch

Search MODIS images

Description

modSearch searches MODIS images in the [NASA Common Metadata Repository](#) (CMR) concerning a particular location and date interval. The function returns a character vector with the names of the images and their uniform resource locators (URLs)

Usage

```
modSearch(product, collection = 6, resType = "url", verbose = FALSE,
          ...)
```

Arguments

| | |
|------------|--|
| product | the short name of the MODIS product. |
| collection | MODIS collection. By default, 6. |
| resType | response type of the query (browseurl or url). |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • <code>dates</code> a vector with the capturing dates being searched. This argument is mandatory if <code>startDate</code> and <code>endDate</code> are not defined. • <code>startDate</code> a Date class object with the starting date of the study period. This argument is mandatory if <code>dates</code> is not defined. |

- `endDate` a Date class object with the ending date of the study period. This argument is mandatory if `dates` is not defined.
- `region` a Spatial*, projected raster*, or sf class object defining the area of interest. This argument is mandatory if `extent` or `lonlat` are not defined.
- `lonlat` a vector with the longitude/latitude coordinates of the point of interest. This argument is mandatory if `region` or `extent` are not defined.
- `extent` an extent, Raster*, or Spatial* object representing the region of interest with longitude/latitude coordinates. This argument is mandatory if `region` or `lonlat` are not defined.

Details

`modSearch` uses the [NASA Common Metadata Repository](#) (CMR) powered API. The catalogue of MODIS products can be found [here](#). The catalogue shows the product short names and provides detailed information about the product. By the time 'RGISTools' is released, NASA carries out the maintenance of its website on Wednesdays, which may cause an error when connecting to their server. You can get your 'EarthData' credentials [here](#).

The function can be used to retrieve the web address of the preview (`resType = "browserurl"`) or the actual image (`resType = "url"`). By default, the URL points towards the actual image.

Value

a vector with the url for image downloading.

Examples

```
## Not run:
# load a spatial polygon object of Navarre with longitude/latitude coordinates
data(ex.navarre)
# searching MODIS MYD13A2 images between 2011 and 2013 by longitude/latitude
# using a polygon class variable
sres <- modSearch(product = "MYD13A2",
                 startDate = as.Date("01-01-2011", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2013", "%d-%m-%Y"),
                 collection = 6,
                 extent = ex.navarre)
# region of interest: defined based on longitude/latitude extent
# searching MODIS MYD13A2 images in 2010 by longitude/latitude
# using a extent class variable defined by the user
aoi = extent(c(-2.49, -0.72, 41.91, 43.31))
sres <- modSearch(product = "MYD13A2",
                 startDate = as.Date("01-01-2010", "%d-%m-%Y"),
                 endDate = as.Date("31-12-2010", "%d-%m-%Y"),
                 collection = 6,
                 extent = aoi)

head(sres)

## End(Not run)
```

senCloudMask *Create cloud masks for Sentinel-2 images*

Description

senCloudMask creates cloud masks derived from the cloud probability band (CLDPRB) band from the "S2MSI2A" product.

Usage

```
senCloudMask(src, AppRoot, out.name, resbands, sensitivity = 50,
             overwrite = FALSE, ...)
```

Arguments

| | |
|-------------|--|
| src | the path to the folder with the "S2MSI2A" images. |
| AppRoot | the directory where the cloud masks are saved. |
| out.name | the name of the folder that stores the outputs. If the argument is not defined the folder will be named as "CloudMask". |
| resbands | a character vector argument. Defines the band resolution used to create the cloud mask. Ex "20m" or "60m". |
| sensitivity | a numeric argument. Defines the sensitivity of the cloud detection method. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The valid threshold range for sensitivity is 0-100. By default, the argument is set to 50.

Value

this function does not return anything. It saves the cloud masks (CLD) as GTiff files in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# Download S2MSI1C products sensed by Sentinel-2
# between the julian days 210 and 218, 2018
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
senDownSearch(startDate = as.Date("2018210", "%Y%j"),
```

```
        endDate = as.Date("2018218", "%Y%j"),
        platform = "Sentinel-2",
        extent = ex.navarre,
        product = "S2MSI2A",
        pathrow = c("R094"),
        username = "username",
        password = "password",
        AppRoot = wdir)
# define the paths to the Sentinel-2 images and the
# folder with the unzipped images
wdir.sen <- file.path(wdir, "Sentinel-2")
wdir.sen.unzip <- file.path(wdir.sen, "unzip")
# mosaic the Sentinel-2 images
senMosaic(wdir.sen.unzip,
          AppRoot = wdir.sen,
          gutils = TRUE,
          out.name = "Navarre")

# calculate the cloud mask
wdir.sen.navarre <- file.path(wdir.sen, "Navarre")
senCloudMask(src = wdir.sen.navarre,
             resbands = "60m",
             overwrite = TRUE,
             sensitivity = 98,
             AppRoot = wdir.sen)

# define the path for the Sentinel-2 cloud mask
wdir.sen.cloud <- file.path(wdir.sen, "CloudMask")

# select B02 images of 60 meters
tiles.sen.navarre <- list.files(wdir.sen.navarre,
                              full.names = TRUE,
                              recursive = TRUE,
                              pattern = "\\\\.tif$")
tiles.sen.navarre.b2 <- tiles.sen.navarre[grepl("B02", tiles.sen.navarre)]
tiles.sen.navarre.b2 <- tiles.sen.navarre.b2[grepl("60m", tiles.sen.navarre.b2)]

# generate a 60-meter resolution cloud mask
tiles.sen.cloud <- list.files(wdir.sen.cloud,
                              full.names = TRUE,
                              pattern = "\\\\.tif$")
tiles.sen.cloud.60 <- tiles.sen.cloud[grepl("60m", tiles.sen.cloud)]

# remove the cloud mask from b02 tiles
img.sen.navarre.b2 <- stack(tiles.sen.navarre.b2)
img.sen.cloud.60 <- stack(tiles.sen.cloud.60)
img.sen.navarre.b2.cloud.free <- img.sen.navarre.b2*img.sen.cloud.60
# plot b2 cloud free layers
spplot(img.sen.navarre.b2.cloud.free)

## End(Not run)
```

senDownload *Download Sentinel images from a search list*

Description

senDownload downloads the images from a list of uniform resource locators (URLs) generated by the [senSearch](#) function from ESA's 'SciHub' web service. The images are saved as GTiff files in the AppRoot directory.

Usage

```
senDownload(searchres, AppRoot, username = NULL, password = NULL,
             nattempts = 5, unzip = FALSE, overwrite = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| searchres | the output from the senSearch function. |
| AppRoot | the directory where the outcoming time series are saved. |
| username | ESA's 'SciHub' username. |
| password | ESA's 'SciHub' password. |
| nattempts | the number of attempts to download an image in case it becomes corrupted. |
| unzip | logical argument. If TRUE, unzips the images. |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| ... | arguments for nested functions. <ul style="list-style-type: none"> • <code>dates</code> a vector with the capturing dates being considered for downloading. • <code>bFilter</code> a vector with the bands to be extracted when <code>unzip=TRUE</code>. If not supplied, all bands are extracted. |

Details

senDownload downloads the list of URLs provided by [senSearch](#). In case the process is interrupted, the image file could be corrupted. The function detects the corrupted files and restarts the process. To prevent the computer from crashing, there is a maximum number of attempts to try to download the image (`nattempts`). The default number of attempts is set to 3. The function requires an ESA's 'SciHub' account, which can be obtained [here](#).

When `unzip = TRUE`, the function decompresses the imagery. If only a subset of bands is required, band names can be provided through the `bFilter` argument. The band names are specified by "B", followed by the two-digit band number, and the resolution of the band (either 10m, 20m, or 60m) (e.g, "B01_10m"). Image decompression duplicates the information due to the presence of both, compressed and decompressed images. Set `raw.rm = TRUE` to remove former ones.

Value

this function does not return anything. It saves the imagery as 'zip' (and JP2 files) in a folder called 'raw' ('unzip') in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# download S2MSI1C products sensed by Sentinel-2
# in July-August 2018
sres <- senSearch(startDate = as.Date("2018-07-29", "%Y-%m-%d"),
                  endDate = as.Date("2018-08-06", "%Y-%m-%d"),
                  platform = "Sentinel-2",
                  extent = ex.navarre,
                  product = "S2MSI1C",
                  username = "username",
                  password = "password")

# filtering the path R094 where Navarre is located
names(sres)
sres.sen.R094 <- sres[grepl("R094", names(sres))]
names(sres.sen.R094)
# list the dates in sres
senGetDates(names(sres.sen.R094), format="%Y%j")
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
# download the imagery
senDownload(searchres = sres.sen.R094,
            username = "username",
            password = "password",
            AppRoot = wdir,
            unzip = TRUE)
wdir.sen.unzip <- file.path(wdir, "Sentinel", "unzip")
files.sen.unzip <- list.files(wdir.sen.unzip,
                             pattern = "\\TCI.jp2$",
                             full.names = TRUE,
                             recursive = TRUE)
img.sen.rgb <- stack(files.sen.unzip[1])
plotRGB(img.sen.rgb)

## End(Not run)
```

senDownSearch

Search and download Sentinel images

Description

senDownSearch searches and downloads Sentinel images concerning a particular location and time interval from ‘SciHub’s’ repository.

Usage

```
senDownSearch(username, password, AppRoot, verbose = FALSE, ...)
```

Arguments

| | |
|----------|---|
| username | ESA's 'SciHub' username. |
| password | ESA's 'SciHub' password. |
| AppRoot | the directory where the images are saved. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • product the type of Sentinel product. Ex. "S2MSI1C", "S2MSI2A", "S2MSI2Ap", ... • startDate a Date class object with the starting date of the study period. This argument is mandatory if dates is not defined. • endDate a Date class object with the ending date of the study period. This argument is mandatory if dates is not defined. • dates a vector with the capturing dates being considered for searching. This argument is mandatory if startDate and endDate are not defined. • region a Spatial*, projected raster*, or sf class object defining the area of interest. • extent an extent, Raster*, or Spatial* object representing the region of interest with longitude/latitude coordinates. This argument is mandatory when region is not defined. • platform the name of the Sentinel mission ("Sentinel-1", "Sentinel-2", ...). • nAttempts the number of attempts to download an image in case it becomes corrupted. • unzip logical argument. If TRUE, unzips the images. • verbose logical argument. If TRUE, the function prints the running steps and warnings. |

Details

senDownSearch is a wrapper function of [senSearch](#) and [senDownload](#) to search and download images in a single step. The function requires ESA's 'SciHub' credentials, which can be obtained [here](#).

Value

this function does not return anything. It saves the imagery as 'zip' (and JP2 files) in a folder called 'raw' ('unzip') in the AppRoot directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# Download S2MSI1C products sensed by Sentinel-2
# between the julian dates 210 and 218, 2018
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
```



```

senDownSearch(startDate = as.Date("2018210", "%Y%j"),
              endDate = as.Date("2018218", "%Y%j"),
              platform = "Sentinel-2",
              extent = ex.navarre,
              product = "S2MSI1C",
              pathrow = c("R094"),
              username = "username",
              password = "password",
              AppRoot = wdir)

wdir.sen <- file.path(wdir, "Sentinel-2")
wdir.sen.unzip <- file.path(wdir.sen, "unzip")

files.sen.unzip <- list.files(wdir.sen.unzip,
                             pattern = "\\TCI.jp2$",
                             full.names = TRUE,
                             recursive = TRUE)

img.sen.rgb <- stack(files.sen.unzip[1])
plotRGB(img.sen.rgb)

## End(Not run)

```

| | |
|----------------|---|
| senFolderToVar | <i>Compute a remote sensing index from a time series of Sentinel-2 images</i> |
|----------------|---|

Description

senFolderToVar computes a remote sensing index from the spectral bands of a time series of Sentinel-2 images. The images are specified by the path to the folder that stores the imagery (resulting from the [senMosaic](#) function). The function returns a RasterStack with a time series of images of the remote sensing index.

Usage

```
senFolderToVar(src, AppRoot, fun, getStack = FALSE, overwrite = FALSE,
              verbose = FALSE, resbands = c("10m", "20m", "60m"), ...)
```

Arguments

| | |
|-----------|---|
| src | the path to the folder with the Sentinel-2 multispectral images. |
| AppRoot | directory where the outcoming time series is saved. |
| fun | a function that computes the remote sensing index. |
| getStack | logical argument. If TRUE, returns the time series of images as a RasterStack, otherwise the images are saved in the Hard Drive Device (HDD). |
| overwrite | logical argument. If TRUE, overwrites the existing images with the same name. |
| verbose | logical argument. If TRUE, the function prints the running steps and warnings. |

resbands the resolution of the image being used to compute index, when the imagery comes from the Sentinel-2 "S2MSI2A" product. By default, all resolutions (10m, 20m, and 60m) are used.

... arguments for nested functions.

- dates a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked.

Details

The function requires the definition of the `src` and `fun` arguments. The `src` is usually the path resulting from `senMosaic`. The `fun` argument can be any function from this package beginning with "var" (`varNDVI`, `varEVI`, etc.). Custom functions can also be implemented. If `fun = varRGB`, then the argument `getStack` must be equal to `FALSE` and the red-green-blue (RGB) images must be imported afterwards.

Value

this function does not return anything, unless `getStack = TRUE` which then returns a `RasterStack` with the time series of with the index.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download Sentinel-2 images
senDownSearch(startDate = as.Date("2018210", "%Y%j"),
               endDate = as.Date("2018218", "%Y%j"),
               platform = "Sentinel-2",
               extent = ex.navarre,
               product = "S2MSI1C",
               pathrow = c("R094"),
               username = "username",
               password = "password",
               AppRoot = wdir)
# folder with the unzipped images from Sentinel-2
wdir.sen <- file.path(wdir, "Sentinel-2")
wdir.sen.unzip <- file.path(wdir.sen, "unzip")
# mosaic the Sentinel-2 images
senMosaic(wdir.sen.unzip,
          AppRoot = wdir.sen,
          gutils = TRUE,
          out.name = "Navarre")
# path to the folder with the mosaicked images
wdir.sen.navarre <- file.path(wdir.sen, "Navarre")
wdir.sen.var <- file.path(wdir.sen.navarre, "Navarre_Variables")
dir.create(wdir.sen.var)
# generate EVI images of Navarre
```

```
senFolderToVar(wdir.sen.navarre,
               fun = varEVI,
               resbands = c("60m"),
               AppRoot = wdir.sen.var)

files.sen.evi <- list.files(file.path(wdir.sen.var,"EVI"),
                           pattern = "\\\\.tif$",
                           full.names = TRUE,
                           recursive = TRUE)

img.sen.evi <- lapply(files.sen.evi, raster)
splot(img.sen.evi[[1]])

## End(Not run)
```

senGetDates

Return the capturing dates of Sentinel-2 images

Description

senGetDates reads the official name of a Sentinel-2 image and returns the capturing date, as a Date class object.

Usage

```
senGetDates(str, ...)
```

Arguments

| | |
|-----|---|
| str | the full path(s) or official name(s) of the Sentinel images from which the capturing date is retrieved. |
| ... | arguments for nested functions: <ul style="list-style-type: none">• format the format of the date being returned. |

Details

The function works with file names (or their paths) regardless of their extension. The function accepts more than one file path, which can be passed as a vector of characters. Dates are returned as 'YYYY-mm-dd' by default. If another format is required, it can be modified through the argument format.

Value

a Date class object with the date of the Sentinel image or character class, if the format argument is used.

Examples

```
# getting the capturing date from the name of Sentinel-2 images
file сен <- c("S2A_MSIL1C_20170102T111442_N0204_R137_T30TWN_20170102T111441.SAFE",
             "S2A_OPER_PRD_MSIL1C_PDMC_20160308T090616_R094_V20160305T110109_20160305T110109")
date сен <- senGetDates(file сен)
print(date сен)
print(format(date сен, "%Y%j"))
senGetDates(file сен, format = "%Y%j")
```

senGetOrbit

Return the relative orbit of the Sentinel-2 satellite

Description

senGetOrbit reads the official name of a Sentinel image and returns relative orbit, in "NXXXX_RYYY" or "RYYY" format (Sentinel naming convention).

Usage

```
senGetOrbit(str)
```

Arguments

`str` the full path(s) or official name(s) of the Sentinel images from which the orbits are retrieved.

Details

Get information about the relative orbits [here](#).

Value

an string with the relative orbit of the image in "NXXXX_RYYY" or "RYYY" format, depending on the version of name convention.

Examples

```
#example of getting date from Sentinel2 image name
files сен <- c("S2A_MSIL1C_20170102T111442_N0204_R137_T30TWN_20170102T111441.SAFE",
             "S2A_OPER_PRD_MSIL1C_PDMC_20160308T090616_R094_V20160305T110109_20160305T110109")
tile сен <- senGetOrbit(files сен)
print(tile сен)
```

| | |
|------------|--|
| senGetTile | <i>Return the pathrow of a tile from Sentinel-2 images</i> |
|------------|--|

Description

senGetTile reads the official name of a Sentinel-2 image and returns the tile's path and row number, in "TTTSSS" format (Sentinel naming convention).

Usage

```
senGetTile(str)
```

Arguments

| | |
|-----|---|
| str | the full path(s) or official name(s) of the Sentinel-2 images from which the tile's path and row numbers are retrieved. |
|-----|---|

Details

Find more details about the Sentinel tiling system [here](#).

Value

a string with the path and row in "TTTSSS" format.

Examples

```
# getting path and row numbers from a couple of Sentinel-2 images
files.sen <- c("S2A_MSIL1C_20170102T111442_N0204_R137_T30TWN_20170102T111441.SAFE",
              "S2A_OPER_PRD_MSIL1C_PDMC_20160308T090616_R094_V20160305T110109_20160305T110109")
pr.sen <- senGetTile(files.sen)
print(pr.sen)
```

| | |
|-----------|--|
| senMosaic | <i>Mosaic a set of Sentinel-2 images</i> |
|-----------|--|

Description

senMosaic merges the Sentinel-2 imagery that covers a region of interest on the same dates.

Usage

```
senMosaic(src, AppRoot, region = NULL, out.name = "outfile",
          verbose = FALSE, gutils = TRUE, overwrite = FALSE, ...)
```

Arguments

| | |
|------------------------|--|
| <code>src</code> | the path of the folder with the Sentinel images in GTiff format. |
| <code>AppRoot</code> | the directory to save the mosaicked images. |
| <code>region</code> | a <code>Spatial*</code> , <code>projected raster*</code> , or <code>sf</code> class object defining the area of interest. |
| <code>out.name</code> | the name of the folder that stores the outputs. By default, “outfile” is assigned. |
| <code>verbose</code> | logical argument. If TRUE, the function prints the running steps and warnings. |
| <code>gutils</code> | logical argument. If TRUE, the function uses ‘GDAL’ utilities for mosaicking. |
| <code>overwrite</code> | logical argument. If TRUE, overwrites the existing images with the same name. |
| <code>...</code> | arguments for nested functions: <ul style="list-style-type: none"> • <code>pathrow</code> a list of vectors with the path and row numbers of the tiles concerning the region of interest. This argument is mandatory if <code>region</code> is not defined. • <code>bFilter</code> a vector with the bands to be mosaicked. If not supplied, all bands are mosaicked. • <code>dates</code> a vector with the capturing dates being considered for mosaicking. If not supplied, all dates are mosaicked. |

Details

The function mosaics the imagery in the `src` folder. The folder can hold GTiff images from several tiles, dates and bands. When only a subset dates has to be mosaicked, the dates should be provided through the argument `dates`. The dates must be provided as a `Date` class object. For further details about the `bFilter` argument, go to the [senDownload](#) function. Once mosaicked, the images can be cropped to fit the region (optional). The region can be defined in any coordinate reference system, since `senMosaic` automatically reproject the extent to match the projection of the image. The outputs will be placed in the `AppRoot` directory, under the folder named as `out.name`. If no name is provided, the folder is named “outfile”.

Value

this function does not return anything. It saves the imagery in the `AppRoot` directory.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# main output directory
wdir <- file.path(tempdir(), "Path_for_downloading_folder")
print(wdir)
# download Sentinel-2 images
senDownSearch(startDate = as.Date("2018210", "%Y%j"),
              endDate = as.Date("2018218", "%Y%j"),
              platform = "Sentinel-2",
              extent = ex.navarre,
              product = "S2MSI1C",
              pathrow = c("R094"),
```

```

        username = "username",
        password = "password",
        AppRoot = wdir)
# folder with the unzipped images
wdir.sen <- file.path(wdir, "Sentinel-2")
wdir.sen.unzip <- file.path(wdir.sen, "unzip")
# mosaic the Sentinel-2 images
senMosaic(wdir.sen.unzip,
          AppRoot = wdir.sen,
          gutils = TRUE,
          out.name = "Navarre")

wdir.sen <- file.path(wdir.sen,"Navarre")
# load and plot a Sentinel-2 image
files.sen <- list.files(wdir.sen, pattern = "\\..tif$", full.names = TRUE ,recursive = TRUE)
# print Sentinel-2 bands
getRGISToolsOpt("SEN2BANDS")
file.sen.rgb <- stack(files.sen[grepl("TCI",files.sen)][1])
plotRGB(file.sen.rgb)

## End(Not run)

```

senPreview

Preview Sentinel-2 satellite images

Description

senPreview shows a preview of the n-th image from a set of search results on an interactive map.

Usage

```
senPreview(searchres, username, password, n, dates, lpos = c(3, 2, 1),
          add.Layer = FALSE, verbose = FALSE, ...)
```

Arguments

| | |
|-----------|--|
| searchres | a vector with the results from senSearch . |
| username | ESA's 'SciHub' username. |
| password | ESA's 'SciHub' password. |
| n | a numeric argument identifying the row of the image in searchres. |
| dates | a vector with the dates being considered for previewing. This argument is mandatory if n is not defined. |
| lpos | vector argument. Defines the position of the red-green-blue layers to enable false color visualization. |
| add.Layer | logical argument. If TRUE, the function plots the image on an existing map. Allows combinations of images on a map using lsPreview and modPreview functions. |

verbose logical argument. If TRUE, the function prints the running steps and warnings.
 ... arguments for nested functions:

- arguments allowed by the viewRGB function from mapview packages are valid arguments

Details

The function shows a preview of the n-th output image from a search in Sentinel archives ([modSearch](#)). The preview is downloaded from ‘SciHub’s’ website. Please, be aware that only some images may have a preview. Credentials from an ESA’s ‘SciHub’ account are needed, which can be obtained [here](#).

Value

this function does not return anything. It displays a preview of one of the search results.

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
# perform the search query
sres <- senSearch(startDate = as.Date("2018210", "%Y%j"),
                  endDate = as.Date("2018218", "%Y%j"),
                  platform = "Sentinel-2",
                  extent = ex.navarre,
                  product = "S2MSI1C",
                  username = "username",
                  password = "password")

# preview some images
senPreview(sres, username = "username", password = "password", n=1)
senPreview(sres, username = "username", password = "password", n=3, add.Layer =TRUE)

# show the dates in julian days
senGetDates(names(sres), format="%Y%j")

senPreview(sres,
           username = "username",
           password = "password",
           dates = senGetDates(names(sres[3])))

## End(Not run)
```


Description

senSearch searches Sentinel images through ESA's powered application programming interface (API), called 'SciHub', that concern a particular location and date interval. The function returns a `data.frame` with the names of the images and their uniform resource locators (URLs).

Usage

```
senSearch(username, password, ...)
```

Arguments

| | |
|----------|--|
| username | ESA's 'SciHub' username. |
| password | ESA's 'SciHub' password. |
| ... | arguments for nested functions: <ul style="list-style-type: none"> • product the type of Sentinel product. Ex. "S2MSI1C", "S2MSI2A", "S2MSI2Ap", ... • dates a vector with the capturing dates being searched. This argument is mandatory if <code>startDate</code> and <code>endDate</code> are not defined. • startDate a Date class object with the starting date of the study period. This argument is mandatory if <code>dates</code> is not defined. • endDate a Date class object with the ending date of the study period. This argument is mandatory if <code>dates</code> is not defined. • region a <code>Spatial*</code>, <code>projected raster*</code>, or <code>sf</code> class object defining the area of interest. This argument is mandatory if <code>extent</code> or <code>lonlat</code> are not defined. • extent an <code>extent</code>, <code>Raster*</code>, or <code>Spatial*</code> object representing the region of interest with longitude/latitude coordinates. This argument is mandatory if <code>region</code> or <code>lonlat</code> are not defined. • lonlat a vector with the longitude/latitude coordinates of the point of interest. This argument is mandatory if <code>region</code> or <code>extent</code> are not defined. • platform the name of the Sentinel mission ("Sentinel-1", "Sentinel-2", ...). • qformat the format of the response. • verbose logical argument. If TRUE, the function prints the running steps and warnings. |

Details

senSearch uses the [ESA's powered API](#) ('SciHub'). The catalogue of Sentinel-2 products can be found [here](#). The function explores the images available for a specific location and time-span. Dates must be provided as Date class objects. Credentials from ESA's 'SciHub' are needed and they can be obtained [here](#).

Examples

```
## Not run:
# load a spatial polygon object of Navarre
data(ex.navarre)
```

```

# perform the search query
sres <- senSearch(startDate = as.Date("2018210", "%Y%j"),
                  endDate = as.Date("2018218", "%Y%j"),
                  platform = "Sentinel-2",
                  extent = ex.navarre,
                  product = "S2MSI1C",
                  username = "username",
                  password = "password")

head(sres)

## End(Not run)

```

| | |
|-----------------|--|
| setRGISToolsOpt | <i>Change the default value of an RGISTools option</i> |
|-----------------|--|

Description

setRGISToolsOpt changes the default value of an ‘RGISTools’ configuration variable. This function can be jointly used with [showRGISToolsOpt](#) and [getRGISToolsOpt](#).

Usage

```
setRGISToolsOpt(opt, value, env = optEnv)
```

Arguments

| | |
|-------|--|
| opt | a character with the name of the option. |
| value | the new value of the selected option. |
| env | the environment where the ‘RGISTools’ option is saved. |

Value

this function does not return anything.

Examples

```

# list available options names
showRGISToolsOpt()
# list the URL where the Landsat-7 metadata is located
getRGISToolsOpt("LS7META.dir")
# change the URL where the Landsat-7 metadata is located
setRGISToolsOpt("LS7META.dir", "NewMtdir")
# list the URL where the Landsat-7 metadata is located
getRGISToolsOpt("LS7META.dir")

```

| | |
|------------------|--|
| showRGISToolsOpt | <i>Print the name of all RGISTools configuration variables</i> |
|------------------|--|

Description

showRGISToolsOpt prints the name of all options in the 'RGISTools' package. This function can be jointly used with [setRGISToolsOpt](#) and [getRGISToolsOpt](#).

Usage

```
showRGISToolsOpt(env = optEnv)
```

Arguments

env the environment where the 'RGISTools' option are saved.

Value

a character vector with the names of the configuration variables.

Examples

```
showRGISToolsOpt()
```

| | |
|--------|--|
| varEVI | <i>Calculate the enhanced vegetation index (EVI)</i> |
|--------|--|

Description

varEVI computes the enhanced vegetation index (EVI) from the blue, near-infrared (NIR) and red bands.

Usage

```
varEVI(blue, red, nir, scfun = function(r) { r })
```

Arguments

blue a raster with the blue band of the capture.
red a raster with the red band of the capture.
nir a raster with the NIR band of the capture.
scfun a function to re-scale the original pixel values into reflectance (0-1).

Details

The enhanced vegetation index (EVI) is a vegetation indicator that improves the sensitivity towards high biomass densities compared to NDVI (Huete et al. 2002) (See [varNDVI](#)). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

An EVI image in raster format.

References

Huete A, Didan K, Miura T, Rodriguez EP, Gao X, Ferreira LG (2002). "Overview of the radiometric and biophysical performance of the MODIS vegetation indices." *Remote sensing of environment*, **83**(1-2), 195–213.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern = "\\..tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")
scale.factor <- 0.0001

# select the red, blue and nir bands
img.mod.red <- raster(files.mod[1]) * scale.factor
img.mod.blue <- raster(files.mod[3]) * scale.factor
img.mod.nir <- raster(files.mod[2]) * scale.factor
# calculate the EVI without scale
img.mod.evi <- varEVI(img.mod.blue, img.mod.red, img.mod.nir)
# calculate the EVI scaling 0-1
img.mod.evi.2 <- varEVI(img.mod.blue, img.mod.red, img.mod.nir, scfun=getRGISToolsOpt("MOD09SCL"))
img.mod.evi.12 <- stack(img.mod.evi, img.mod.evi.2)
# plot the image
spplot(img.mod.evi.12, col.regions=rev(terrain.colors(20)), at = c(seq(0,1,0.05)))
```

varMSAVI2

Calculate the modified soil-adjusted vegetation index (MSAVI2)

Description

varMSAVI2 computes the modified soil-adjusted vegetation index 2 (MSAVI2) from the near-infrared (NIR) and red bands.

Usage

```
varMSAVI2(red, nir)
```

Arguments

red a raster with the red band of the capture.
nir a raster with the NIR band of the capture.

Details

The modified soil adjusted vegetation index 2 (MSAVI2) is a vegetation indicator that removes the effect from background variations (Qi et al. 1994). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A MSAVI2 image in raster format.

References

Qi J, Chehbouni A, Huerte A, Kerr Y, Sorooshian S (1994). "A modified soil adjusted vegetation index." *Remote Sensing Environment*, **48**, 119–126.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")
# select the red and NIR bands
img.mod.red <- raster(files.mod[1])
img.mod.nir <- raster(files.mod[2])
# calculate the MSAVI2 image
img.mod.msavi2 <- varMSAVI2(img.mod.red, img.mod.nir)
# plot the image
spplot(img.mod.msavi2, col.regions=rev(topo.colors(20)))
```

varNBR

Calculate the normalized burn ratio (NBR)

Description

varNBR computes the normalized burn ratio (NBR) from the near-infrared (NIR) and shortwave-infrared 2 (SWIR2) bands.

Usage

```
varNBR(nir, swir2)
```

Arguments

nir a raster with the NIR band of the capture.
 swir2 a raster with the SWIR2 band of the capture.

Details

The normalized burn ratio (NBR) is an index that identifies burned areas by comparing its value before and after the fire event. It is calculated using the NIR and SWIR2 bands (Garcia and Caselles 1991). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A NBR image in raster format.

References

Garcia ML, Caselles V (1991). "Mapping burns and natural reforestation using Thematic Mapper data." *Geocarto International*, **6**(1), 31–37.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the NIR and SWIR2 bands
files.mod.nir <- raster(files.mod[2])
files.mod.swir2 <- raster(files.mod[7])
# calculate the NBR image
files.mod.nbr <- varNBR(files.mod.nir, files.mod.swir2)
# plot the image
spplot(files.mod.nbr, col.regions=rev(heat.colors(20)))
```

varNBR2

Calculate the normalized burn ratio 2 (NBR2)

Description

varNBR2 computes the NBR2 index from the shortwave infrared 1 (SWIR1) and shortwave infrared 2 (SWIR2).

Usage

```
varNBR2(swir1, swir2)
```

Arguments

swir1 a raster with the the SWIR1 band of the capture.
 swir2 a raster with the the SWIR2 band of the capture.

Details

The normalized burn ratio 2 (NBR2) is an index to identify burned areas. In contrast to NBR, NBR2 highlights the sensitivity to water in vegetation (Lutes et al. 2006). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A NBR2 image in raster format.

References

Lutes DC, Keane RE, Caratti JF, Key CH, Benson NC, Sutherland S, Gangi LJ (2006). "FIREMON: Fire effects monitoring and inventory system." *Gen. Tech. Rep. RMRS-GTR-164. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 1 CD., 164.*

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the SWIR1 and SWIR2 bands
img.mod.swir1 <- raster(files.mod[6])
img.mod.swir2 <- raster(files.mod[7])
# calculate the NBR2 image
img.mod.nbr2 <- varNBR2(img.mod.swir1, img.mod.swir2)
# plot the image
spplot(img.mod.nbr2, col.regions=rev(heat.colors(20)))
```

varNDMI

Calculate the normalized difference moisture (water) index (NDMI)

Description

varNDMI computes the normalized difference moisture index (NDMI) from the near-infrared (NIR) and shortwave-infrared 1 (SWIR1) bands.

Usage

```
varNDMI(nir, swir1)
```

Arguments

nir a raster with the nir band of the capture.
 swir1 a raster with the swir1 band of the capture.

Details

The normalized difference moisture index (NDMI) is an index that represents the water stress levels of the canopy, using the NIR and SWIR (Gao 1995). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A NDMI image in raster format.

References

Gao B (1995). “Normalized difference water index for remote sensing of vegetation liquid water from space.” In *Imaging Spectrometry*, volume 2480, 225–237. International Society for Optics and Photonics.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the NIR and SWIR1 bands
img.mod.nir <- raster(files.mod[2])
img.mod.swir1 <- raster(files.mod[6])
# calculate the NDMI image
img.mod.ndmi <- varNDMI(img.mod.nir, img.mod.swir1)
# plot the image
spplot(img.mod.ndmi)
```

varNDVI

Calculate the normalized difference vegetation index (NDVI)

Description

varNDVI computes the normalized difference vegetation index (NDVI) from the red and near-infrared (NIR) bands.

Usage

```
varNDVI(red, nir)
```


Arguments

red a raster with the red band of the capture.
nir a raster with the NIR band of the capture.

Details

The normalized difference vegetation index (NDVI) is the most widely used index for monitoring vegetation dynamics. The NDVI reflects the vegetation vigour and it is closely related to the amount of photosynthetically active radiation absorbed (Rouse Jr 1972). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A NDVI image in raster format.

References

Rouse Jr JW (1972). "Monitoring the vernal advancement and retrogradation (green wave effect) of natural vegetation." *NASA technical Reports Server*. <https://ntrs.nasa.gov/search.jsp?R=19730009607>.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the red and NIR bands
img.mod.red <- raster(files.mod[1])
img.mod.nir <- raster(files.mod[2])
# calculate the NDVI image
img.mod.ndvi <- varNDVI(img.mod.red, img.mod.nir)
# plot the image
splot(img.mod.ndvi, col.regions=rev(terrain.colors(20)))
```

varNDWI

Calculates the normalized difference water index (NDWI)

Description

varNDWI Calculate the normalized difference water index (NDWI) from the green and near-infrared (NIR) bands.

Usage

```
varNDWI(green, nir)
```

Arguments

green a raster with the green band of the capture.
nir a raster with the NIR band of the capture.

Details

The normalized difference water index (NDWI) is a ratio between the green and near-infrared bands of the spectrum that was developed to detect open water areas and minimize the influence of the soil and vegetation variations (McFeeters 1996). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A NDWI image in raster format.

References

McFeeters SK (1996). "The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features." *International journal of remote sensing*, **17**(7), 1425–1432.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the green and NIR bands
img.mod.green <- raster(files.mod[4])
img.mod.nir <- raster(files.mod[2])
# calculate the NDWI image
img.mod.ndwi <- varNDWI(img.mod.green, img.mod.nir)
# plot the image
spplot(img.mod.ndwi, col.regions=rev(rainbow(20)))
```

varRGB

Generate an RGB image from 3 spectral bands

Description

varRGB creates red-green-blue (RGB) images as a RasterStack by scaling the pixel values to 0-255 color range.

Usage

```
varRGB(red, green, blue, q.range = c(), rPath = NULL, region = NULL)
```

Arguments

| | |
|---------|---|
| red | a raster with the red band of the capture. |
| green | a raster with the green band of the capture. |
| blue | a raster with the blue band of the capture. |
| q.range | a vector with the minimum and maximum reflectance quantiles being considered. |
| rPath | the file path where the resulting RGB image is saved. |
| region | a <code>Spatial*</code> , <code>projected raster*</code> , or <code>sf</code> class object defining the area of interest for image masking. |

Details

The function rescales the original reflectance values to a range of 0-255. The function re-arranges the RGB bands to create a stack ready to visualize with `plotRGB`. Bands may contain outliers which cause the image to look dark. Use the `q.range` argument to remove the outliers and get a better-looking image.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the red, blue and NIR bands
img.mod.red <- raster(files.mod[1])
img.mod.blue <- raster(files.mod[3])
img.mod.green <- raster(files.mod[4])

q.range=c(0.001,0.999)
img.mod.rgb<-varRGB(img.mod.red,img.mod.green,img.mod.blue,q.range)
print(plotRGB(img.mod.rgb))
```

varSAVI

Calculates the soil-adjusted vegetation index (SAVI)

Description

varSAVI Calculate the soil-adjusted vegetation index (SAVI) from the red and near-infrared (NIR) bands.

Usage

```
varSAVI(red, nir, L = 0.5, scfun = function(r) { r })
```

Arguments

| | |
|-------|---|
| red | a raster with the red band of the capture. |
| nir | a raster with the NIR band of the capture. |
| L | a constant to remove soil background effect. A value of 0.5 is recommended in the literature. |
| scfun | a function to re-scale the original pixel values into reflectance (0-1). |

Details

The soil adjusted vegetation index (SAVI) is an indicator engineered to remove the influence of the soil background effect (Huete 1988). This function is used within [ls7FolderToVar](#), [ls8FolderToVar](#), [modFolderToVar](#) and [senFolderToVar](#).

Value

A SAVI image in raster format.

References

Huete AR (1988). "A soil-adjusted vegetation index (SAVI)." *Remote sensing of environment*, **25**(3), 295–309.

Examples

```
# path to the cropped and cutted MODIS images for the region of Navarre
wdir <- system.file("ExNavarreVar", package = "RGISTools")
# list all the tif files
files.mod <- list.files(wdir, pattern="\\.tif$", recursive = TRUE, full.names = TRUE)
# print the MOD09 bands
getRGISToolsOpt("MOD09BANDS")

# select the red and NIR bands
img.mod.red <- raster(files.mod[1])
img.mod.nir <- raster(files.mod[2])
# calculate the SAVI image
img.mod.savi <- varSAVI(img.mod.red, img.mod.nir, scfun=getRGISToolsOpt("MOD09SCL"))
# plot the image
splot(img.mod.savi, col.regions=rev(topo.colors(20)))
```

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