Package: smosr (via r-universe)

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Title Acquire and Explore BEC-SMOS L4 Soil Moisture Data in R

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Description Provides functions that automate accessing, downloading and exploring Soil Moisture and Ocean Salinity (SMOS) Level 4 (L4) data developed by Barcelona Expert Center (BEC). Particularly, it includes functions to search for, acquire, extract, and plot BEC-SMOS L4 soil moisture data downscaled to ~1 km spatial resolution. Note that SMOS is one of Earth Explorer Opportunity missions by the European Space Agency (ESA). More information about SMOS products can be found at <https://earth.esa.int/eogateway/missions/smos/data>.

License GPL-3

URL https://github.com/tshestakova/smosr

BugReports https://github.com/tshestakova/smosr/issues

Depends R (>= 4.0.0)

Imports fields, graphics, grDevices, lubridate, methods, ncdf4, RCurl, terra, tidyr, utils

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

Encoding UTF-8

LazyData TRUE

RoxygenNote 7.2.3

NeedsCompilation no

Repository https://tshestakova.r-universe.dev

RemoteUrl https://github.com/tshestakova/smosr

RemoteRef HEAD

RemoteSha 2e40707f45920765eb57a5f762b7ab5d54b33bdb

Contents

`download_smos` *Download BEC-SMOS soil moisture data*

Description

This function automates downloading of BEC-SMOS soil moisture data to a local computer via a secure FTP (SFTP) server.

Usage

```
download_smos(data, dir = NULL)
```

Arguments

`data`	a character vector as produced by `find_smos()` containing external links to the data files on the BEC server.
`dir`	a character string specifying a path to a local directory in which to save the data. Default value is `NULL` meaning that the dataset is stored in a temporary directory of the current R session.

Details

This function downloads the original BEC-SMOS soil moisture data in NetCDF format ("as is") via a secure FTP (SFTP) server. The data files are stored on the local computer in a temporary directory of the current R session (default option) if no otherwise specified by the user.

Note that the registration as a user on the Barcelona Expert Center (BEC) webpage is required to access the server. See `set_credentials()` for details.

Value

downloaded files in the specified directory

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
# to download files found with find_smos() into a temporary directory of the current R session
start_date <- as.Date("2022-01-01")
end_date <- as.Date("2022-12-31")
date_range <- seq(start_date, end_date, by = 30)
smos_data <- find_smos(freq = 3, orbit = "des", dates = date_range)
download_smos(smos_data)

## End(Not run)
```

`extract_smos` *Extract BEC-SMOS soil moisture estimates for specific geographical locations*

Description

This function facilitates reading of the original BEC-SMOS soil moisture data files and extracting relevant information for specific geographical locations by using Lat/Lon coordinates in decimal degrees.

Usage

```
extract_smos(
  data,
  lat,
  lon,
  save = FALSE,
  dir = NULL,
  filename = "smosr_output.csv"
)
```

Arguments

`data`	a character vector as produced by `list_smos()` containing links to the data files on the local computer.
`lat`	a numeric vector containing latitudes of geographical locations to extract the data from (in 'latlon' projection).
`lon`	a numeric vector containing longitudes of geographical locations to extract the data from (in 'latlon' projection).
`save`	a logical vector indicating whether the output should be saved as a CSV file. Default is `FALSE`.
`dir`	a character string specifying a path to a local directory in which to save the CSV file with the output. Default value is `NULL` meaning that the file is stored in a temporary directory of the current R session.

`filename` a character string naming the CSV file for saving the output. If `save = TRUE` and no `filename` is specified by the user, the data is saved in a file with a generic name 'smosr_output.csv'.

Details

This function reads the original BEC-SMOS soil moisture data files in NetCDF format, converts data from EASE-2 grid cells to geographic coordinates, and extracts relevant information for Lat/Lon locations specified by the user.

The data retrieved from each data file includes:

- the coordinates of spatial points (Lon and Lat) from which the data were extracted;

- frequency and SMOS orbit of each file over which the function iterated;

- date and time when the data was obtained;

- soil moisture estimate (SM);

- quality assurance (QA) flag corresponding to each SM estimate.

The output of this function could be saved as a CSV file.

Value

a data.matrix with the relevant information as described in Details.

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
# to iterate over a list of BEC-SMOS data files produced by list_smos() and
# extract soil moisture estimates for the specified geographical locations
smos_files <- list_smos()
lat <- c(40.42, 41.90, 48.86, 52.50, 59.91)
lon <- c(-3.70, 12.50, 2.35, 13.40, 10.75)
sm_estimates <- extract_smos(data = smos_files, lat = lat, lon = lon)

## End(Not run)
```

`find_smos` *Find BEC-SMOS soil moisture data on the server*

Description

This function searches for BEC-SMOS soil moisture data available on Barcelona Expert Center (BEC) server for the frequency, orbit, and dates specified by the user.

Usage

```
find_smos(freq, orbit, dates)
```

Arguments

`freq`	an integer specifying temporal frequency of the data. Possible values are: 1 - for daily data, or 3 - for 3-day moving averages. No default value is provided.
`orbit`	a character (or character string) specifying SMOS orbit corresponding to the data. Possible values are: 'a', 'asc', and 'ascending' - for an ascending pass, or 'd', 'des', or 'descending' - for a descending pass. No default value is provided.
`dates`	an object of class `Date` or a character string formatted as 'yyyy-mm-dd' (e.g. '2010-06-01') which specifies the date(s) to search through. To look for a specific date, it can be a Date object or a character vector of length 1. To iterate over various dates or a time interval, a multiple-element object of class Date or a vector should be passed (e.g. as produced by `seq.Date`).

Details

BEC-SMOS soil moisture (SM) data is a regional root zone SM product that covers Europe and Mediterranean countries. Particularly, `smosr` package works with the reprocessed SMOS Level 4 (L4) SM estimates downscaled to ~1 km spatial resolution (EASE-grid v.2). The data is computed for two time periods (argument `frequency`): daily and 3-day moving averages produced by a temporal aggregation of the daily products. Note that SMOS ascending and descending passes (argument `orbit`) are processed separately. The data is available starting from June 1st, 2010 throughout the end of 2022. The currently supported version is 6.0. For more details about the BEC-SMOS SM products, see the technical note available at https://digital.csic.es/handle/10261/303808.

Note that the registration as a user on the Barcelona Expert Center (BEC) webpage is required to access the server. See `set_credentials()` for details.

Value

a character vector containing full links to the data files on the server.

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
# to look for BEC-SMOS data on a specific date
smos_data <- find_smos(freq = 1, orbit = "a", dates = "2022-12-31")
# to search data over a date range
start_date <- as.Date("2022-01-01")
end_date <- as.Date("2022-12-31")
date_range <- seq(start_date, end_date, by = 10)
smos_data <- find_smos(freq = 3, orbit = "descending", dates = date_range)

## End(Not run)
```

`list_smos` *List BEC-SMOS data files stored on a local computer*

Description

This function returns a list of the BEC-SMOS data files previously stored on a local computer.

Usage

```
list_smos(
  freq = NULL,
  orbit = NULL,
  dates = NULL,
  dir = NULL,
  recursive = FALSE
)
```

Arguments

`freq`	an integer specifying temporal frequency of the data. Possible values are: 1 - for daily data, or 3 - for 3-day moving averages, and NULL - for cases when data frequency is irrelevant. Default value is `NULL`.
`orbit`	a character (or character string) specifying SMOS orbit corresponding to the data. Possible values are: 'a', 'asc', and 'ascending' - for an ascending pass, or 'd', 'des', or 'descending' - for a descending pass, and NULL - for cases when orbit is irrelevant. Default value is `NULL`.
`dates`	an object of class `Date` or a character string formatted as 'yyyy-mm-dd' (e.g. '2010-06-01') which specifies the date(s) to search through. To look for a specific date, it can be a Date object or a character vector of length 1. To iterate over various dates or a time interval, a multiple-element object of class Date or a vector should be passed (e.g. as produced by `seq.Date`).
`dir`	a character string specifying a path to a local directory in which to search the data for. Default value is `NULL` meaning that the dataset is looked up in a temporary directory of the current R session.

`recursive` a logical vector indicating whether the listing should recurse into directories. Default is `FALSE`.

Details

This function iterates over all files in a temporary directory of the current R session (default option) or another local folder as indicated by `dir` argument and returns a list of the BEC-SMOS data files with the `frequency`, `orbit`, and `dates` specified by the user. If no arguments are provided, all BEC-SMOS soil moisture data files found in the selected folder will be listed. A recursive option is also available.

Value

a character vector containing full links to the data files on the local computer.

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
# to list BEC-SMOS data files with the specified frequency and SMOS orbit
# stored in a temporary directory of the current R session
smos_files <- list_smos(freq = 3, orbit = "des")

## End(Not run)
```

---

missing_smos *Print the dates for which BEC-SMOS soil moisture data were not found*

Description

This function prints out the dates for which BEC-SMOS soil moisture data with specified `frequency` and `orbit` arguments were not found on the BEC server. This information is automatically generated while running `find_smos()`, but displayed only if requested by the user.

Usage

```
missing_smos()
```

Value

a character string containing dates for which the data files were not found on the server.

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
missing_smos()

## End(Not run)
```

`plot_raster_smos` *Draw a raster image of BEC-SMOS soil moisture data*

Description

This function draws a raster image of BEC-SMOS soil moisture data corresponding to a single data file and specific geographical extent.

Usage

```
plot_raster_smos(data, lat = NULL, lon = NULL, QA = NULL)
```

Arguments

`data`	a character string containing a link to a single BEC-SMOS data file stored on the local computer.
`lat`	a numeric vector of length 2 containing latitudinal bounds of the plotting region (in 'latlon' projection). Default value is `NULL` meaning that all data between min and max latitudes are drawn.
`lon`	a numeric vector of length 2 containing longitudinal bounds of the plotting region (in 'latlon' projection). Default value is `NULL` meaning that all data between min and max longitudes are drawn.
`QA`	a numeric vector specifying the desired data quality to be plotted. Possible values range from 0 (good quality data) to 15. To know the meanings of QA flags, see Details.

Details

This function reads an original BEC-SMOS soil moisture data file in NetCDF format, converts data from EASE-2 grid cells to geographic coordinates, and draws a raster image of soil moisture estimates in 'latlon' projection. The image can be drawn for a specific geographical extent if requested by the user. Otherwise, the entire dataset across Europe (between 28 and 72 degrees north and -11 and 40 degrees east) will be plotted. Note that due to high resolution of the data (~1 km), the execution of this function may take a long time to be completed depending on the amount of data to be drawn.

**** Quality assurance (QA) ****

QA flags are coded by four significant bits as described below:

Bit position	Bit value
[0]	0 - Brightness temperature not affected by sea-land contamination 1 - Brightness temperature corrected by sea-land contamination
[1]	0 - Radio Frequency Interference (RFI) not flagged in ESA L1C brightness temperature 1 - RFI flagged in ESA L1C brightness temperature
[2]	0 - L3 soil moisture with data obtained from L2 retrievals 1 - L3 soil moisture with data obtained from a linear model
[3]	0 - L4 soil moisture values within the interval [0,1] m^3/m^3 1 - L4 soil moisture values outside the interval [0,1] m^3/m^3

In case of the 3-day averaged data, each bit of the quality flag is activated if at least one soil moisture estimate during the corresponding time interval is affected.

Value

a raster image

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
# to draw a raster image of soil moisture data corresponding to the first BEC-SMOS file
# from a list produced by list_smos() and within the specified geographical bounds#'
smos_files <- list_smos()
lat <- c(35.00, 45.00)
lon <- c(-10.50, 4.50)
plot_raster_smos(data = smos_files[1], lat = lat, lon = lon)

## End(Not run)
```

`plot_temporal_smos` *Plot temporal series of BEC-SMOS soil moisture data*

Description

This function plots temporal series of BEC-SMOS soil moisture data extracted for specific geographical locations.

Usage

```
plot_temporal_smos(data, freq = NULL, orbit = NULL, dates = NULL, QA = NULL)
```

Arguments

`data`	a data.matrix containing soil moisture data as produced by `extract_smos()`.
`freq`	an integer specifying temporal frequency of the data. Possible values are: 1 - for daily data, 3 - for 3-day moving averages, and NULL - for cases when data frequency is irrelevant. Default value is `NULL`.
`orbit`	a character (or character string) specifying SMOS orbit corresponding to the data. Possible values are: 'a', 'asc', and 'ascending' - for an ascending pass, or 'd', 'des', or 'descending' - for a descending pass, and NULL - for cases when orbit is irrelevant. Default value is `NULL`.
`dates`	a object of class `Date` or a character string formatted as 'yyyy-mm-dd' (e.g. '2010-06-01') which specifies the dates to plot the data for. A multiple-element object of class Date or a vector should be passed (e.g. as produced by `seq.Date`).
`QA`	a numeric vector specifying the desired data quality to be plotted. Possible values range from 0 (good quality data) to 15. To know the meanings of QA flags, see Details.

Details

This function takes as input temporal series of BEC-SMOS soil moisture estimates extracted for specific geographical locations and plots these data as a line chart. Note that the data characterized by the same frequency and SMOS orbit can be drawn at a time. If the dataset to plot contains a mixture of temporal resolutions and/or SMOS passes, arguments `frequency` and `orbit` must be specified. In addition, the dataset can be filtered by desired data quality and specific dates to be plotted.

**** Quality assurance (QA) ****

QA flags are coded by four significant bits as described below:

Bit position	Bit value
[0]	0 - Brightness temperature not affected by sea-land contamination 1 - Brightness temperature corrected by sea-land contamination

[1]	0 - Radio Frequency Interference (RFI) not flagged in ESA L1C brightness temperature 1 - RFI flagged in ESA L1C brightness temperature
[2]	0 - L3 soil moisture with data obtained from L2 retrievals 1 - L3 soil moisture with data obtained from a linear model
[3]	0 - L4 soil moisture values within the interval [0,1] m^3/m^3 1 - L4 soil moisture values outside the interval [0,1] m^3/m^3

In case of the 3-day averaged data, each bit of the quality flag is activated if at least one soil moisture estimate during the corresponding time interval is affected.

Value

a line chart

References

Pablos M, Gonzalez-Haro C, Portal G, Piles M, Vall-llossera M, Portabella M (2022). SMOS L4 Surface Soil Moisture downscaled maps at 1 km EASE-2 (reprocessed mode) (V.6.0) [Dataset].

Examples

```
## Not run:
# to plot extracted temporal series of BEC-SMOS soil moisture data produced by extract_smos()
# with the specified frequency, SMOS orbit and QA
smos_files <- list_smos()
lat <- c(40.42, 41.90, 48.86, 52.50, 59.91)
lon <- c(-3.70, 12.50, 2.35, 13.40, 10.75)
sm_estimates <- extract_smos(data = smos_files, lat = lat, lon = lon)
plot_temporal_smos(data = sm_estimates, freq = 3, orbit = "des", QA = 0)

## End(Not run)
```

`set_credentials` *Set credentials to access Barcelona Expert Center (BEC) server*

Description

To use some functionalities of `smosr` package (e.g. access the server or download data to a local computer), the user should first register at Barcelona Expert Center (BEC) webpage. This function allows the authenticated users to set their BEC credentials (username and password) for the current R session which are used internally in `find_smos()` and `download_smos()`.

Usage

```
set_credentials(username, password)
```

Arguments

username	a character string containing BEC server username.
password	a character string containing BEC server password.

Details

If you do not have your BEC login details yet, please register on https://bec.icm.csic.es/bec-ftp-service-registration/.

Value

a character string with the inputs pasted together in the format required by `find_smos()` and `download_smos()`.

Examples

```
## Not run:
set_credentials("username", "password")

## End(Not run)
```

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