

Package ‘amadeus’

August 25, 2025

Title Accessing and Analyzing Large-Scale Environmental Data

Version 1.2.4.9

Maintainer Kyle Messier <kyle.messier@nih.gov>

Description Functions are designed to facilitate access to and utility with large scale, publicly available environmental data in R. The package contains functions for downloading raw data files from web URLs (`download_data()`), processing the raw data files into clean spatial objects (`process_covariates()`), and extracting values from the spatial data objects at point and polygon locations (`calculate_covariates()`). These functions call a series of source-specific functions which are tailored to each data sources/datasets particular URL structure, data format, and spatial/temporal resolution. The functions are tested, versioned, and open source and open access. For `sum_edc()` method details, see Messier, Akita, and Serre (2012) <[doi:10.1021/es203152a](https://doi.org/10.1021/es203152a)>.

Depends R (>= 4.2.0)

Imports dplyr, sf, sftime, stats, terra (>= 1.8-50), methods, data.table, httr, rvest, exactextractr, utils, stringi, testthat (>= 3.0.0), stars, tidyr, rlang, nhdplusTools, archive, collapse, Rdpack

Suggests covr, withr, knitr, rmarkdown, lwgeom, FNN, doRNG, devtools, stringr, tigris, spelling

RdMacros Rdpack

Encoding UTF-8

VignetteBuilder knitr, rmarkdown

RoxygenNote 7.3.2

Config/Needs/website tidyverse/tidytemplate

Config/testthat/edition 3

License MIT + file LICENSE

URL <https://niehs.github.io/amadeus/>

BugReports <https://github.com/NIEHS/amadeus/issues>

Language en-US

NeedsCompilation no

Author Mitchell Manware [aut, ctb] (ORCID: <https://orcid.org/0009-0003-6440-6106>),
 Insang Song [aut, ctb] (ORCID: <https://orcid.org/0000-0001-8732-3256>),
 Eva Marques [aut, ctb] (ORCID: <https://orcid.org/0000-0001-9817-6546>),
 Mariana Alifa Kassien [aut, ctb] (ORCID: <https://orcid.org/0000-0003-2295-406X>),
 Elizabeth Scholl [ctb] (ORCID: <https://orcid.org/0000-0003-2727-1954>),
 Kyle Messier [aut, cre] (ORCID: <https://orcid.org/0000-0001-9508-9623>),
 Spatiotemporal Exposures and Toxicology Group [cph]

Repository CRAN

Date/Publication 2025-08-24 23:10:18 UTC

Contents

as_mysftime	3
calculate_covariates	4
calculate_ecoregion	6
calculate_geos	7
calculate_gmted	8
calculate_gridmet	10
calculate_groads	11
calculate_hms	13
calculate_koppen_geiger	14
calculate_lagged	15
calculate_merra2	16
calculate_modis	18
calculate_narr	20
calculate_nei	22
calculate_nlcd	23
calculate_population	24
calculate_temporal_dummies	26
calculate_terraclimate	27
calculate_tri	28
download_aqs	30
download_data	31
download_ecoregion	33
download_geos	35
download_gmted	37
download_gridmet	39
download_groads	40
download_hms	42
download_koppen_geiger	43
download_merra2	45
download_modis	53
download_narr	56
download_nei	58

download_nlcd	60
download_population	62
download_terraclimate	63
download_tri	65
dt_as_mysftime	66
process_aqs	67
process_blackmarble	68
process_covariates	70
process_ecoregion	71
process_geos	72
process_gmted	73
process_gridmet	74
process_groads	75
process_hms	76
process_koppen_geiger	77
process_merra2	78
process_modis_merge	79
process_modis_sds	81
process_modis_swath	82
process_narr	83
process_nei	84
process_nlcd	85
process_population	86
process_terraclimate	87
process_tri	88
sftime_as_mysftime	89
sftime_as_sf	90
sftime_as_spatraster	91
sftime_as_spatrds	91
sftime_as_spatvector	92
sf_as_mysftime	93
spatraster_as_sftime	93
spatrds_as_sftime	94
spatvector_as_sftime	95
sum_edc	95
Index	98

as_mysftime	<i>Create an sftime object</i>
-------------	--------------------------------

Description

Create a sftime object from one of data.frame, data.table, sf, sftime, SpatRaster, SpatRasterDataset, SpatVector

Usage

```
as_mysftime(x, ...)
```

Arguments

x an object of class `data.frame`, `data.table`, `sf`, `sftime`, `SpatRaster`, `SpatRasterDataset` or `SpatVector`

... if `x` is a `data.frame` or `data.table`: `lonname`, `latname`, `timename` and `crs` arguments are required. If `x` is a `sf` or `sftime`, `timename` argument is required. If `x` is a `terra::SpatRaster`, `varname` argument is required.

Value

an `sftime` object with constrained time column name

Author(s)

Eva Marques

See Also

[check_mysftime](#), [sf_as_mysftime](#), [data.frame](#), [data.table::data.table](#), [terra::rast](#), [terra::sds](#), [terra::vect](#)

`calculate_covariates` *Calculate covariates wrapper function*

Description

The `calculate_covariates()` function extracts values at point locations from a `SpatRaster` or `SpatVector` object returned from `process_covariates()`. `calculate_covariates()` and the underlying source-specific covariate functions have been designed to operate on the processed objects. To avoid errors, **do not edit the processed `SpatRaster` or `SpatVector` objects before passing to `calculate_covariates()`.**

Usage

```
calculate_covariates(
  covariate = c("modis", "koppen-geiger", "koeppen-geiger", "koppen", "koeppen", "geos",
    "dummies", "gmted", "sedac_groads", "groads", "roads", "ecoregions", "ecoregion",
    "hms", "smoke", "gmted", "narr", "geos", "sedac_population", "population", "nlcd",
    "merra", "merra2", "gridmet", "terraclimate", "tri", "nei"),
  from,
  locs,
  locs_id = "site_id",
  ...
)
```

Arguments

covariate	character(1). Covariate type.
from	character. Single or multiple from strings.
locs	sf/SpatVector. Unique locations. Should include a unique identifier field named locs_id
locs_id	character(1). Name of unique identifier. Default is "site_id".
...	Arguments passed to each covariate calculation function.

Value

Calculated covariates as a data.frame or SpatVector object

Note

covariate argument value is converted to lowercase.

Author(s)

Insang Song

See Also

- [calculate_modis](#): "modis", "MODIS"
- [calculate_koppen_geiger](#): "koppen-geiger", "koeppen-geiger", "koppen"
- [calculate_ecoregion](#): "ecoregion", "ecoregions"
- [calculate_temporal_dummies](#): "dummies", "Dummies"
- [calculate_hms](#): "hms", "smoke", "HMS"
- [calculate_gmted](#): "gmted", "GMTED"
- [calculate_narr](#): "narr", "NARR"
- [calculate_geos](#): "geos", "geos_cf", "GEOS"
- [calculate_population](#): "population", "sedac_population"
- [calculate_groads](#): "roads", "groads", "sedac_groads"
- [calculate_nlcd](#): "nlcd", "NLCD"
- [calculate_tri](#): "tri", "TRI"
- [calculate_nei](#): "nei", "NEI"
- [calculate_merra2](#): "merra", "MERRA", "merra2", "MERRA2"
- [calculate_gridmet](#): "gridMET", "gridmet"
- [calculate_terraclimate](#): "terraclimate", "TerraClimate"

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_covariates(
  covariate = "narr",
  from = narr, # derived from process_covariates() example
  locs = loc,
  locs_id = "id",
  geom = FALSE
)

## End(Not run)
```

calculate_ecoregion	<i>Calculate ecoregions covariates</i>
---------------------	--

Description

Extract ecoregions covariates (U.S. EPA Ecoregions Level 2/3) at point locations. Returns a `data.frame` object containing `locs_id` and binary (0 = point not in ecoregion; 1 = point in ecoregion) variables for each ecoregion.

Usage

```
calculate_ecoregion(from = NULL, locs, locs_id = "site_id", geom = FALSE, ...)
```

Arguments

<code>from</code>	<code>SpatVector(1)</code> . Output of process_ecoregion .
<code>locs</code>	<code>sf/SpatVector</code> . Unique locs. Should include a unique identifier field named <code>locs_id</code>
<code>locs_id</code>	<code>character(1)</code> . Name of unique identifier.
<code>geom</code>	<code>FALSE/"sf"/"terra"</code> .. Should the function return with geometry? Default is <code>FALSE</code> , options with geometry are <code>"sf"</code> or <code>"terra"</code> . The coordinate reference system of the <code>sf</code> or <code>SpatVector</code> is that of <code>from</code> .
<code>...</code>	Placeholders.

Value

a `data.frame` or `SpatVector` object with dummy variables and attributes of:

- `attr(, "ecoregion2_code")`: Ecoregion lv.2 code and key
- `attr(, "ecoregion3_code")`: Ecoregion lv.3 code and key

Author(s)

Insang Song

See Also

[process_ecoregion](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_ecoregion(
  from = ecoregion, # derived from process_ecoregion() example
  locs = loc,
  locs_id = "id",
  geom = FALSE
)

## End(Not run)
```

calculate_geos

Calculate atmospheric composition covariates

Description

Extract atmospheric composition values at point locations. Returns a `data.frame` object containing `locs_id`, date and hour, vertical pressure level, and atmospheric composition variable. Atmospheric composition variable column name reflects variable and circular buffer radius.

Usage

```
calculate_geos(
  from,
  locs,
  locs_id = NULL,
  radius = 0,
  fun = "mean",
  geom = FALSE,
  ...
)
```

Arguments

`from` `SpatRaster(1)`. Output of `process_geos()`.
`locs` `data.frame`, character to file path, `SpatVector`, or `sf` object.

locs_id	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
radius	integer(1). Circular buffer distance around site locations. (Default = 0).
fun	character(1). Function used to summarize multiple raster cells within sites location buffer (Default = mean).
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders.

Value

a data.frame or SpatVector object

Author(s)

Mitchell Manware

See Also

[process_geos\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_geos(
  from = geos, # derived from process_geos() example
  locs = loc,
  locs_id = "id",
  radius = 0,
  fun = "mean",
  geom = FALSE
)

## End(Not run)
```

calculate_gmted	<i>Calculate elevation covariates</i>
-----------------	---------------------------------------

Description

Extract elevation values at point locations. Returns a data.frame object containing locs_id, year of release, and elevation variable. Elevation variable column name reflects the elevation statistic, spatial resolution of from, and circular buffer radius (ie. Breakline Emphasis at 7.5 arc-second resolution with 0 meter buffer: breakline_emphasis_r75_0).

Usage

```
calculate_gmted(
  from,
  locs,
  locs_id = NULL,
  radius = 0,
  fun = "mean",
  geom = FALSE,
  ...
)
```

Arguments

from	SpatRaster(1). Output from process_gmted().
locs	data.frame. character to file path, SpatVector, or sf object.
locs_id	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
radius	integer(1). Circular buffer distance around site locations. (Default = 0).
fun	character(1). Function used to summarize multiple raster cells within sites location buffer (Default = mean).
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders

Value

a data.frame or SpatVector object

Author(s)

Mitchell Manware

See Also

[process_gmted\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_gmted(
  from = gmted, # derived from process_gmted() example
  locs = loc,
  locs_id = "id",
  radius = 0,
```

```

    fun = "mean",
    geom = FALSE
  )

  ## End(Not run)

```

calculate_gridmet	<i>Calculate gridMET covariates</i>
-------------------	-------------------------------------

Description

Extract gridMET values at point locations. Returns a `data.frame` object containing `locs_id` and gridMET variable. gridMET variable column name reflects the gridMET variable and circular buffer radius.

Usage

```

calculate_gridmet(
  from,
  locs,
  locs_id = NULL,
  radius = 0,
  fun = "mean",
  geom = FALSE,
  ...
)

```

Arguments

<code>from</code>	SpatRaster(1). Output from <code>process_gridmet()</code> .
<code>locs</code>	data.frame. character to file path, SpatVector, or sf object.
<code>locs_id</code>	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
<code>radius</code>	integer(1). Circular buffer distance around site locations. (Default = 0).
<code>fun</code>	character(1). Function used to summarize multiple raster cells within sites location buffer (Default = mean).
<code>geom</code>	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
<code>...</code>	Placeholders.

Value

a data.frame or SpatVector object

Author(s)

Mitchell Manware

See Also`process_gridmet()`**Examples**

```
## NOTE: Example is wrapped in ``\dontrun{}`` as function requires a large
##      amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_gridmet(
  from = gridmet, # derived from process_gridmet() example
  locs = loc,
  locs_id = "id",
  radius = 0,
  fun = "mean",
  geom = FALSE
)

## End(Not run)
```

calculate_groads

*Calculate roads covariates***Description**

Prepared groads data is clipped with the buffer polygons of radius. The total length of the roads are calculated. Then the density of the roads is calculated by dividing the total length from the area of the buffer. `terra::linearUnits()` is used to convert the unit of length to meters.

Usage

```
calculate_groads(
  from = NULL,
  locs = NULL,
  locs_id = NULL,
  radius = 1000,
  fun = "sum",
  geom = FALSE,
  ...
)
```

Arguments

from	SpatVector(1). Output of process_groads.
locs	data.frame, character to file path, SpatVector, or sf object.
locs_id	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
radius	integer(1). Circular buffer distance around site locations. (Default = 1000).
fun	function(1). Function used to summarize the length of roads within sites location buffer (Default is sum).
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders.

Value

a data.frame or SpatVector object

Note

Unit is km / sq km. The returned data.frame object contains a \$time column to represent the temporal range covered by the dataset. For more information, see <https://data.nasa.gov/dataset/global-roads-open-access-data-set-version-1-groadsv1>.

Author(s)

Insang Song

See Also

[process_groads](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_groads(
  from = groads, # derived from process_groads() example
  locs = loc,
  locs_id = "id",
  radius = 1000,
  fun = "sum",
  geom = FALSE
)

## End(Not run)
```

calculate_hms

*Calculate wildfire smoke covariates***Description**

Extract wildfire smoke plume values at point locations. Returns a `data.frame` object containing `locs_id`, `date`, and binary variable for wildfire smoke plume density inherited from `from` (0 = point not covered by wildfire smoke plume; 1 = point covered by wildfire smoke plume).

Usage

```
calculate_hms(from, locs, locs_id = NULL, radius = 0, geom = FALSE, ...)
```

Arguments

<code>from</code>	<code>SpatVector(1)</code> . Output of <code>process_hms()</code> .
<code>locs</code>	<code>data.frame</code> , character to file path, <code>SpatVector</code> , or <code>sf</code> object.
<code>locs_id</code>	<code>character(1)</code> . Column within locations CSV file containing identifier for each unique coordinate location.
<code>radius</code>	<code>integer(1)</code> . Circular buffer distance around site locations. (Default = 0).
<code>geom</code>	<code>FALSE</code> / <code>"sf"</code> / <code>"terra"</code> .. Should the function return with geometry? Default is <code>FALSE</code> , options with geometry are <code>"sf"</code> or <code>"terra"</code> . The coordinate reference system of the <code>sf</code> or <code>SpatVector</code> is that of <code>from</code> .
<code>...</code>	Placeholders.

Value

a `data.frame` or `SpatVector` object

Author(s)

Mitchell Manware

See Also

[process_hms\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_hms(
  from = hms, # derived from process_hms() example
  locs = loc,
  locs_id = "id",
```

```

    radius = 0,
    geom = FALSE
  )

## End(Not run)

```

```
calculate_koppen_geiger
```

Calculate climate classification covariates

Description

Extract climate classification values at point locations. Returns a `data.frame` object containing `locs_id` and binary (0 = point not in climate region; 1 = point in climate region) variables for each climate classification region.

Usage

```

calculate_koppen_geiger(
  from = NULL,
  locs = NULL,
  locs_id = "site_id",
  geom = FALSE,
  ...
)

```

Arguments

<code>from</code>	<code>SpatVector(1)</code> . Output of <code>process_koppen_geiger()</code> .
<code>locs</code>	<code>sf/SpatVector</code> . Unique locs. Should include a unique identifier field named <code>locs_id</code>
<code>locs_id</code>	<code>character(1)</code> . Name of unique identifier.
<code>geom</code>	<code>FALSE/"sf"/"terra"</code> .. Should the function return with geometry? Default is <code>FALSE</code> , options with geometry are <code>"sf"</code> or <code>"terra"</code> . The coordinate reference system of the <code>sf</code> or <code>SpatVector</code> is that of <code>from</code> .
<code>...</code>	Placeholders.

Value

a `data.frame` or `SpatVector` object

Note

The returned object contains a `$description` column to represent the temporal range covered by the dataset. For more information, see <https://www.nature.com/articles/sdata2018214>.

Author(s)

Insang Song

See Also

[process_koppen_geiger](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_koppen_geiger(
  from = kg, # derived from process_koppen_geiger() example
  locs = loc,
  locs_id = "id",
  geom = FALSE
)

## End(Not run)
```

calculate_lagged

Calculate temporally lagged covariates

Description

The `calculate_lagged()` function calculates daily temporal lagged covariates from the output of `calculate_covariates()` or `calc_*()`.

Usage

```
calculate_lagged(from, date, lag, locs_id, time_id = "time", geom = FALSE)
```

Arguments

<code>from</code>	<code>data.frame(1)</code> . A <code>data.frame</code> containing calculated covariates returned from <code>calculate_covariates()</code> or <code>calc_*()</code> .
<code>date</code>	<code>character(2)</code> . Start and end dates of desired lagged covariates. Length of 10 each, format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
<code>lag</code>	<code>integer(1)</code> . Number of lag days.
<code>locs_id</code>	<code>character(1)</code> . Name of unique identifier.
<code>time_id</code>	<code>character(1)</code> . Column containing time values.
<code>geom</code>	<code>logical(1)</code> . Should the function return a <code>SpatVector</code> ? Default is <code>FALSE</code> . The coordinate reference system of the <code>SpatVector</code> is that of <code>from</code> . To return as a <code>SpatVector</code> , <code>from</code> must also be a <code>SpatVector</code> .

Value

a data.frame object

Note

In order to calculate temporally lagged covariates, from must contain at least the number of lag days before the desired start date. For example, if date = c("2024-01-01", "2024-01-31") and lag = 1, from must contain data starting at 2023-12-31. If from contains geometry features, calculate_lagged will return a column with geometry features of the same name. calculate_lagged() assumes that all columns other than time_id, locs_id, and fixed columns of "lat" and "lon", follow the genre, variable, lag, buffer radius format adopted in calc_setcolumns().

See Also

[calculate_covariates\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
terracliante_covar <- calculate_terraclimate(
  from = terraclimate, # derived from process_terraclimate() example
  locs = loc,
  locs_id = "id",
  radius = 0,
  fun = "mean",
  geom = FALSE
)
calculate_lagged(
  from = terracliante_covar,
  locs_id = "id",
  date = c("2023-01-02", "2023-01-10"),
  lag = 1,
  time_id = "time"
)

## End(Not run)
```

calculate_merra2	<i>Calculate meteorological and atmospheric covariates</i>
------------------	--

Description

Extract meteorological and atmospheric values at point locations. Returns a data.frame object containing locs_id, date and hour, vertical pressure level, and meteorological or atmospheric variable. Variable column name reflects variable and circular buffer radius.

Usage

```
calculate_merra2(
  from,
  locs,
  locs_id = NULL,
  radius = 0,
  fun = "mean",
  geom = FALSE,
  ...
)
```

Arguments

from	SpatRaster(1). Output of process_merra2().
locs	data.frame, character to file path, SpatVector, or sf object.
locs_id	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
radius	integer(1). Circular buffer distance around site locations. (Default = 0).
fun	character(1). Function used to summarize multiple raster cells within sites location buffer (Default = mean).
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders

Value

a data.frame or SpatVector object

Author(s)

Mitchell Manware

See Also

[calculate_geos\(\)](#), [process_merra2\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_merra2(
  from = merra2, # derived from process_merra2() example
  locs = loc,
  locs_id = "id",
  radius = 0,
```

```

    fun = "mean",
    geom = FALSE
)

## End(Not run)

```

calculate_modis

Calculate MODIS product covariates in multiple CPU threads

Description

calculate_modis essentially runs [calculate_modis_daily](#) function in each thread (subprocess). Based on daily resolution, each day's workload will be distributed to each thread. With product argument, the files are processed by a customized function where the unique structure and/or characteristics of the products are considered.

Usage

```

calculate_modis(
  from = NULL,
  locs = NULL,
  locs_id = "site_id",
  radius = c(0L, 1000L, 10000L, 50000L),
  preprocess = amadeus::process_modis_merge,
  name_covariates = NULL,
  subdataset = NULL,
  fun_summary = "mean",
  package_list_add = NULL,
  export_list_add = NULL,
  max_cells = 3e+07,
  geom = FALSE,
  scale = NULL,
  ...
)

```

Arguments

from	character. List of paths to MODIS/VIIRS files.
locs	sf/SpatVector object. Unique locs where covariates will be calculated.
locs_id	character(1). Site identifier. Default is "site_id"
radius	numeric. Radii to calculate covariates. Default is c(0, 1000, 10000, 50000).
preprocess	function. Function to handle HDF files.
name_covariates	character. Name header of covariates. e.g., "MOD_NDVIF_0_". The calculated covariate names will have a form of "{name_covariates}{zero-padded buffer radius in meters}", e.g., 'MOD_NDVIF_0_50000' where 50 km radius circular buffer was used to calculate mean NDVI value.

subdataset	Indices, names, or search patterns for subdatasets. Find detail usage of the argument in notes.
fun_summary	character or function. Function to summarize extracted raster values.
package_list_add	character. A vector with package names to load these in each thread. Note that sf, terra, exactextractr, doParallel, parallelly and dplyr are the default packages to be loaded.
export_list_add	character. A vector with object names to export to each thread. It should be minimized to spare memory.
max_cells	integer(1). Maximum number of cells to be read at once. Higher values will expedite processing, but will increase memory usage. Maximum possible value is $2^{31} - 1$. See exactextractr::exact_extract for details.
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
scale	character(1). Scale expression to be applied to the raw values. It is crucial that users review the technical documentation of the MODIS product they are using to ensure proper scale. An example for the MOD11A1 product's LST_Day_1km variable (land surface temperature) would be <code>scale = "* 0.02"</code> . Default is NULL, which applies no scale.
...	Arguments passed to preprocess.

Value

A data.frame or SpatVector with an attribute:

- `attr(, "dates_dropped")`: Dates with insufficient tiles. Note that the dates mean the dates with insufficient tiles, not the dates without available tiles.

Note

Overall, this function and dependent routines assume that the file system can handle concurrent access to the (network) disk by multiple processes. File system characteristics, package versions, and hardware settings and specification can affect the processing efficiency. `locs` is expected to be convertible to sf object. sf, SpatVector, and other class objects that could be converted to sf can be used. Common arguments in preprocess functions such as date and path are automatically detected and passed to the function. Please note that `locs` here and `path` in preprocess functions are assumed to have a standard naming convention of raw files from NASA. The argument `subdataset` should be in a proper format depending on preprocess function:

- `process_modis_merge()`: Regular expression pattern. e.g., `"^LST_"`
- `process_modis_swath()`: Subdataset names. e.g., `c("Cloud_Fraction_Day", "Cloud_Fraction_Night")`
- `process_blackmarble()`: Subdataset number. e.g., for VNP46A2 product, 3L. Dates with less than 80 percent of the expected number of tiles, which are determined by the mode of the number of tiles, are removed. Users will be informed of the dates with insufficient tiles. The result data.frame will have an attribute with the dates with insufficient tiles.

See Also

This function leverages the calculation of single-day MODIS covariates:

- `calculate_modis_daily()`

Also, for preprocessing, please refer to:

- `process_modis_merge()`
- `process_modis_swath()`
- `process_blackmarble()`

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
locs <- data.frame(lon = -78.8277, lat = 35.95013, id = "001")
locs <- terra::vect(locs, geom = c("lon", "lat"), crs = "EPSG:4326")
calculate_modis(
  from =
    list.files("../data", pattern = "VNP46A2.", full.names = TRUE),
  locs = locs,
  locs_id = "site_id",
  radius = c(0L, 1000L),
  preprocess = process_modis_merge,
  name_covariates = "cloud_fraction_0",
  subdataset = "Cloud_Fraction",
  fun_summary = "mean"
)

## End(Not run)
```

calculate_narr

Calculate meteorological covariates

Description

Extract meteorological values at point locations. Returns a `data.frame` object containing `locs_id`, `date`, `vertical pressure level`, and `meteorological variable`. Meteorological variable column name reflects variable and circular buffer radius.

Usage

```
calculate_narr(
  from,
  locs,
  locs_id = NULL,
  radius = 0,
```

```

    fun = "mean",
    geom = FALSE,
    ...
)

```

Arguments

from	SpatRaster(1). Output of process_narr().
locs	data.frame, character to file path, SpatVector, or sf object.
locs_id	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
radius	integer(1). Circular buffer distance around site locations. (Default = 0).
fun	character(1). Function used to summarize multiple raster cells within sites location buffer (Default = mean).
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders

Value

a data.frame or SpatVector object

Author(s)

Mitchell Manware

See Also

[process_narr](#)

Examples

```

## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_narr(
  from = narr, # derived from process_narr() example
  locs = loc,
  locs_id = "id",
  radius = 0,
  fun = "mean",
  geom = FALSE
)

## End(Not run)

```

calculate_nei	<i>Calculate road emissions covariates</i>
---------------	--

Description

Calculate road emissions covariates

Usage

```
calculate_nei(from = NULL, locs = NULL, locs_id = "site_id", geom = FALSE, ...)
```

Arguments

from	SpatVector(1). Output of process_nei().
locs	sf/SpatVector. Locations at NEI values are joined.
locs_id	character(1). Unique site identifier column name. Unused but kept for compatibility.
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders.

Value

a data.frame or SpatVector object

Author(s)

Insang Song, Ranadeep Daw

See Also

[process_nei](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_nei(
  from = nei, # derived from process_nei example
  locs = loc,
  locs_id = "id"
)

## End(Not run)
```

calculate_nlcd	<i>Calculate land cover covariates</i>
----------------	--

Description

Compute ratio of land cover class in circle buffers around points. Returns a `data.frame` object containing `locs_id`, longitude, latitude, time (year), and computed ratio for each land cover class.

Usage

```
calculate_nlcd(
  from,
  locs,
  locs_id = "site_id",
  mode = c("exact", "terra"),
  radius = 1000,
  max_cells = 5e+07,
  geom = FALSE,
  ...
)
```

Arguments

<code>from</code>	<code>SpatRaster(1)</code> . Output of <code>process_nlcd()</code> .
<code>locs</code>	<code>terra::SpatVector</code> of points geometry
<code>locs_id</code>	<code>character(1)</code> . Unique identifier of locations
<code>mode</code>	<code>character(1)</code> . One of "exact" (using <code>exactextractr::exact_extract()</code>) or "terra" (using <code>terra::freq()</code>). Ignored if <code>locs</code> are points.
<code>radius</code>	numeric (non-negative) giving the radius of buffer around points.
<code>max_cells</code>	<code>integer(1)</code> . Maximum number of cells to be read at once. Higher values may expedite processing, but will increase memory usage. Maximum possible value is $2^{31} - 1$. Only valid when <code>mode = "exact"</code> . See <code>exactextractr::exact_extract</code> for details.
<code>geom</code>	<code>FALSE/"sf"/"terra"</code> .. Should the function return with geometry? Default is <code>FALSE</code> , options with geometry are "sf" or "terra". The coordinate reference system of the <code>sf</code> or <code>SpatVector</code> is that of <code>from</code> .
<code>...</code>	Placeholders.

Value

a `data.frame` or `SpatVector` object

Note

NLCD is available in U.S. only. Users should be aware of the spatial extent of the data. The results are different depending on mode argument. The "terra" mode is less memory intensive but less accurate because it counts the number of cells intersecting with the buffer. The "exact" may be more accurate but uses more memory as it will account for the partial overlap with the buffer.

See Also

[process_nlcd](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_nlcd(
  from = nlcd, # derived from process_nlcd() example
  locs = loc,
  locs_id = "id",
  mode = "exact",
  geom = FALSE
)

## End(Not run)
```

calculate_population *Calculate population density covariates*

Description

Extract population density values at point locations. Returns a `data.frame` object containing `locs_id`, `year`, and population density variable. Population density variable column name reflects spatial resolution of `from` and circular buffer radius.

Usage

```
calculate_population(
  from,
  locs,
  locs_id = NULL,
  radius = 0,
  fun = "mean",
  geom = FALSE,
  ...
)
```

Arguments

from	SpatRaster(1). Output of process_population().
locs	data.frame, character to file path, SpatVector, or sf object.
locs_id	character(1). Column within locations CSV file containing identifier for each unique coordinate location.
radius	integer(1). Circular buffer distance around site locations. (Default = 0).
fun	character(1). Function used to summarize multiple raster cells within sites location buffer (Default = mean).
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders

Value

a data.frame or SpatVector object

Author(s)

Mitchell Manware

See Also

[process_population\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_population(
  from = pop, # derived from process_population() example
  locs = loc,
  locs_id = "id",
  radius = 0,
  fun = "mean",
  geom = FALSE
)

## End(Not run)
```

 calculate_temporal_dummies

Calculate temporal dummy covariates

Description

Calculate temporal dummy covariates at point locations. Returns a `data.frame` object with `locs_id`, year binary variable for each value in year, and month and day of week binary variables.

Usage

```
calculate_temporal_dummies(
  locs,
  locs_id = "site_id",
  year = seq(2018L, 2022L),
  geom = FALSE,
  ...
)
```

Arguments

<code>locs</code>	<code>data.frame</code> with a temporal field named "time"
<code>locs_id</code>	<code>character(1)</code> . Unique site identifier column name. Default is "site_id".
<code>year</code>	integer. Year domain to dummify. Default is <code>seq(2018L, 2022L)</code> .
<code>geom</code>	<code>FALSE</code> /"sf"/"terra".. Should the function return with geometry? Default is <code>FALSE</code> , options with geometry are "sf" or "terra". The coordinate reference system of the sf or <code>SpatVector</code> is that of from.
<code>...</code>	Placeholders.

Value

a `data.frame` or `SpatVector` object

Author(s)

Insang Song

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_temporal_dummies(
  locs = loc,
  locs_id = "id",
  year = seq(2018L, 2022L)
```

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

```
calculate_terraclimate
```

Calculate TerraClimate covariates

Description

Extract TerraClimate values at point locations. Returns a `data.frame` object containing `locs_id` and TerraClimate variable. TerraClimate variable column name reflects the TerraClimate variable and circular buffer radius. The `$time` column will contain the year and month ("YYYYMM") as TerraClimate products have monthly temporal resolution.

Usage

```
calculate_terraclimate(
  from = NULL,
  locs = NULL,
  locs_id = NULL,
  radius = 0,
  fun = "mean",
  geom = FALSE,
  ...
)
```

Arguments

<code>from</code>	<code>SpatRaster(1)</code> . Output from <code>process_terraclimate()</code> .
<code>locs</code>	<code>data.frame</code> . character to file path, <code>SpatVector</code> , or <code>sf</code> object.
<code>locs_id</code>	<code>character(1)</code> . Column within locations CSV file containing identifier for each unique coordinate location.
<code>radius</code>	<code>integer(1)</code> . Circular buffer distance around site locations. (Default = 0).
<code>fun</code>	<code>character(1)</code> . Function used to summarize multiple raster cells within sites location buffer (Default = mean).
<code>geom</code>	<code>FALSE/"sf"/"terra"</code> .. Should the function return with geometry? Default is <code>FALSE</code> , options with geometry are "sf" or "terra". The coordinate reference system of the <code>sf</code> or <code>SpatVector</code> is that of <code>from</code> .
<code>...</code>	Placeholders.

Value

a `data.frame` or `SpatVector` object

Note

TerraClimate data has monthly temporal resolution, so the `$time` column will contain the year and month in YYYYMM format (ie. January, 2018 = 201801).

Author(s)

Mitchell Manware

See Also

[process_terraclimate\(\)](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_terraclimate(
  from = terraclimate, # derived from process_terraclimate() example
  locs = loc,
  locs_id = "id",
  radius = 0,
  fun = "mean",
  geom = FALSE
)

## End(Not run)
```

calculate_tri

Calculate toxic release covariates

Description

Calculate toxic release values for polygons or isotropic buffer point locations. Returns a `data.frame` object containing `locs_id` and variables for each chemical in `from`.

Usage

```
calculate_tri(
  from = NULL,
  locs,
  locs_id = "site_id",
  radius = c(1000L, 10000L, 50000L),
  geom = FALSE,
  ...
)
```

Arguments

from	SpatVector(1). Output of process_tri().
locs	sf/SpatVector. Locations where TRI variables are calculated.
locs_id	character(1). Unique site identifier column name. Default is "site_id".
radius	Circular buffer radius. Default is c(1000, 10000, 50000) (meters)
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.
...	Placeholders.

Value

a data.frame or SpatVector object

Note

U.S. context.

Author(s)

Insang Song, Mariana Kassien

See Also

[sum_edc](#), [process_tri](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
loc <- data.frame(id = "001", lon = -78.90, lat = 35.97)
calculate_tri(
  from = tri, # derived from process_tri() example
  locs = loc,
  locs_id = "id",
  radius = c(1e3L, 1e4L, 5e4L)
)

## End(Not run)
```

download_aqs	<i>Download air quality data</i>
--------------	----------------------------------

Description

The `download_aqs()` function accesses and downloads Air Quality System (AQS) data from the [U.S. Environmental Protection Agency's \(EPA\) Pre-Generated Data Files](#).

Usage

```
download_aqs(
  parameter_code = 88101,
  resolution_temporal = "daily",
  year = c(2018, 2022),
  url_aqs_download = "https://aqs.epa.gov/aqsweb/airdata/",
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)
```

Arguments

<code>parameter_code</code>	integer(1). length of 5. EPA pollutant parameter code. For details, please refer to AQS parameter codes
<code>resolution_temporal</code>	character(1). Name of column containing POC values. Currently, no value other than "daily" works.
<code>year</code>	integer(1 or 2). length of 4. Year or start/end years for downloading data.
<code>url_aqs_download</code>	character(1). URL to the AQS pre-generated datasets.
<code>directory_to_save</code>	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped data files ("/data_files").
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands. Default is FALSE.
<code>unzip</code>	logical(1). Unzip zip files. Default TRUE.

remove_zip	logical(1). Remove zip file from directory_to_download. Default FALSE.
hash	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an `rlang::hash_file` character.
- Zip and/or data files will be downloaded and stored in `directory_to_save`.

Author(s)

Mariana Kassien, Insang Song, Mitchell Manware

References

U.S. Environmental Protection Agency (2023). “Air Quality System Data Mart [internet database].” <https://www.epa.gov/outdoor-air-quality-data>.

Examples

```
## Not run:
download_aqs(
  parameter_code = 88101,
  resolution_temporal = "daily",
  year = 2023,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_data

Download raw data wrapper function

Description

The `download_data()` function accesses and downloads atmospheric, meteorological, and environmental data from various open-access data sources.

Usage

```
download_data(
  dataset_name = c("aqs", "ecoregion", "ecoregions", "geos", "gmted", "koppen",
    "koppengeiger", "merra2", "merra", "modis", "narr", "nlcd", "noaa", "sedac_groads",
    "sedac_population", "groads", "population", "hms", "smoke", "tri", "nei", "gridmet",
    "terraclimate", "huc", "cropscape", "cdl", "prism", "edgar"),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  hash = FALSE,
  ...
)
```

Arguments

dataset_name	character(1). Dataset to download.
directory_to_save	character(1). Directory to save / unzip (if zip files are downloaded) data.
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
hash	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.
...	Arguments passed to each download function.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an `rlang::hash_file` character.
- Data files will be downloaded and stored in respective sub-directories within `directory_to_save`. File format and sub-directory names depend on data source and dataset of interest.

Note

- All download function names are in `download_*` formats

Author(s)

Insang Song

See Also

For details of each download function per dataset, Please refer to:

- [download_aqs](#): "aqs", "AQS"
- [download_ecoregion](#): "ecoregions", "ecoregion"
- [download_geos](#): "geos"
- [download_gmted](#): "gmted", "GMTED"

- `download_koppen_geiger`: "koppen", "koppengeiger"
- `download_merra2`: "merra2", "merra", "MERRA", "MERRA2"
- `download_narr`: "narr"
- `download_nlcd`: "nlcd", "NLCD"
- `download_hms`: "noaa", "smoke", "hms"
- `download_groads`: "sedac_groads", "groads"
- `download_population`: "sedac_population", "population"
- `download_modis`: "modis", "MODIS"
- `download_tri`: "tri", "TRI"
- `download_nei`: "nei", "NEI"
- `download_gridmet`: "gridMET", "gridmet"
- `download_terraclimate`: "TerraClimate", "terraclimate"
- `download_huc`: "huc"
- `download_cropscape`: "cropscape", "cdl"
- `download_prism`: "prism"
- `download_edgar`: "edgar", "EDGAR"

Examples

```
## Not run:
download_data(
  dataset_name = "narr",
  variables = "weasd",
  year = 2023,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)

## End(Not run)
```

download_ecoregion	<i>Download ecoregion data</i>
--------------------	--------------------------------

Description

The `download_ecoregion()` function accesses and downloads United States Ecoregions data from the **U.S. Environmental Protection Agency's (EPA) Ecorgions**. Level 3 data, where all pieces of information in the higher levels are included, are downloaded.

Usage

```
download_ecoregion(
  epa_certificate_path = system.file("extdata/cacert_gaftp_epa.pem", package = "amadeus"),
  certificate_url =
    "http://cacerts.digicert.com/DigiCertGlobalG2TLSRSA2562020CA1-1.crt",
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)
```

Arguments

<code>epa_certificate_path</code>	character(1). Path to the certificate file for EPA DataCommons. Default is 'ext-data/cacert_gaftp_epa.pem' under the package installation path.
<code>certificate_url</code>	character(1). URL to certificate file. See notes for details.
<code>directory_to_save</code>	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped data files ("/data_files").
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
<code>unzip</code>	logical(1). Unzip zip files. Default TRUE.
<code>remove_zip</code>	logical(1). Remove zip file from directory_to_download. Default FALSE.
<code>hash</code>	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For `hash = FALSE`, NULL
- For `hash = TRUE`, an `rlang::hash_file` character.
- Zip and/or data files will be downloaded and stored in `directory_to_save`.

Note

For EPA Data Commons certificate errors, follow the steps below:

1. Click Lock icon in the address bar at <https://gaftp.epa.gov>
2. Click Show Certificate
3. Access Details
4. Find URL with *.crt extension Currently we bundle the pre-downloaded crt and its PEM (which is accepted in wget command) file in ./inst/extdata. The instruction above is for certificate updates in the future.

Author(s)

Insang Song

References

Omernik JM, Griffith GE (2014). “Ecoregions of the Conterminous United States: Evolution of a Hierarchical Spatial Framework.” *Environmental Management*, **54**(6), 1249–1266. ISSN 0364-152X, 1432-1009, doi:[10.1007/s0026701403641](https://doi.org/10.1007/s0026701403641), <https://link.springer.com/article/10.1007/s00267-014-0364-1>.

Examples

```
## Not run:
download_ecoregion(
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_geos

Download atmospheric composition data

Description

The download_geos() function accesses and downloads various atmospheric composition collections from [NASA’s Global Earth Observing System \(GEOS\) model](#).

Usage

```
download_geos(
  collection = c("aqc_tavg_1hr_g1440x721_v1", "chm_tavg_1hr_g1440x721_v1",
    "met_tavg_1hr_g1440x721_x1", "xgc_tavg_1hr_g1440x721_x1",
    "chm_inst_1hr_g1440x721_p23", "met_inst_1hr_g1440x721_p23"),
  date = c("2018-01-01", "2018-01-01"),
  directory_to_save = NULL,
```

```

    acknowledgement = FALSE,
    download = FALSE,
    remove_command = FALSE,
    hash = FALSE
  )

```

Arguments

collection	character(1). GEOS-CF data collection file name.
date	character(1 or 2). length of 10. Date or start/end dates for downloading data. Format "YYYY-MM-DD" (ex. January 1, 2018 = "2018-01-01").
directory_to_save	character(1). Directory to save data. Sub-directories will be created within directory_to_save for each GEOS-CF collection.
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
hash	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an `rlang::hash_file` character.
- netCDF (.nc4) files will be stored in a collection-specific folder within `directory_to_save`.

Author(s)

Mitchell Manware, Insang Song

References

Keller CA, Knowland KE, Duncan BN, Liu J, Anderson DC, Das S, Lucchesi RA, Lundgren EW, Nicely JM, Nielsen E, Ott LE, Saunders E, Strode SA, Wales PA, Jacob DJ, Pawson S (2021). "Description of the NASA GEOS Composition Forecast Modeling System GEOS-CF v1.0." *Journal of Advances in Modeling Earth Systems*, **13**(4), e2020MS002413. ISSN 1942-2466, 1942-2466, [doi:10.1029/2020MS002413](https://doi.org/10.1029/2020MS002413).

Examples

```

## Not run:
download_geos(
  collection = "aqc_tavg_1hr_g1440x721_v1",
  date = "2024-01-01",

```

```

    directory_to_save = tempdir(),
    acknowledgement = TRUE,
    download = FALSE, # NOTE: download skipped for examples,
    remove_command = TRUE
  )

  ## End(Not run)

```

download_gmted	<i>Download elevation data</i>
----------------	--------------------------------

Description

The `download_gmted()` function accesses and downloads Global Multi-resolution Terrain Elevation Data (GMTED2010) from [U.S. Geological Survey and National Geospatial-Intelligence Agency](#).

Usage

```

download_gmted(
  statistic = c("Breakline Emphasis", "Systematic Subsample", "Median Statistic",
    "Minimum Statistic", "Mean Statistic", "Maximum Statistic",
    "Standard Deviation Statistic"),
  resolution = c("7.5 arc-seconds", "15 arc-seconds", "30 arc-seconds"),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)

```

Arguments

<code>statistic</code>	character(1). Available statistics include "Breakline Emphasis", "Systematic Subsample", "Median Statistic", "Minimum Statistic", "Mean Statistic", "Maximum Statistic", and "Standard Deviation Statistic".
<code>resolution</code>	character(1). Available resolutions include "7.5 arc-seconds", "15 arc-seconds", and "30 arc-seconds".
<code>directory_to_save</code>	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped data files ("/data_files").
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.

download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands. Default is FALSE.
unzip	logical(1). Unzip zip files. Default is TRUE.
remove_zip	logical(1). Remove zip file from directory_to_download. Default is FALSE.
hash	logical(1). By setting TRUE the function will return an rlang::hash_file() hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- Zip and/or data files will be downloaded and stored in directory_to_save.

Author(s)

Mitchell Manware, Insang Song

References

Danielson JJ, Gesch DB (2011). "Global multi-resolution terrain elevation data 2010 (GMTED2010)." Open-File Report 2011-1073, U.S. Geological Survey. Series: Open-File Report, <https://doi.org/10.3133/ofr20111073>.

Examples

```
## Not run:
download_gmted(
  statistic = "Breakline Emphasis",
  resolution = "7.5 arc-seconds",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_gridmet	<i>Download gridMET data</i>
------------------	------------------------------

Description

The `download_gridmet` function accesses and downloads gridded surface meteorological data from the [University of California Merced Climatology Lab's gridMET dataset](#).

Usage

```
download_gridmet(
  variables = NULL,
  year = c(2018, 2022),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  hash = FALSE
)
```

Arguments

<code>variables</code>	character(1). Variable(s) name(s). See gridMET Generate Wget File for variable names and acronym codes. (Note: variable "Burning Index" has code "bi" and variable "Energy Release Component" has code "erc").
<code>year</code>	integer(1 or 2). length of 4. Year or start/end years for downloading data.
<code>directory_to_save</code>	character(1). Directory(s) to save downloaded data files.
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
<code>hash</code>	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For `hash = FALSE`, NULL
- For `hash = TRUE`, an `rlang::hash_file` character.
- netCDF (.nc) files will be stored in a variable-specific folder within `directory_to_save`.

Author(s)

Mitchell Manware

References

Abatzoglou JT (2013). “Development of gridded surface meteorological data for ecological applications and modelling.” *International journal of climatology*, **33**(1), 121–131.

Examples

```
## Not run:
download_gridmet(
  variables = "Precipitation",
  year = 2023,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)

## End(Not run)
```

download_groads	<i>Download roads data</i>
-----------------	----------------------------

Description

The `download_groads()` function accesses and downloads roads data from [NASA's Global Roads Open Access Data Set \(gROADS\), v1 \(1980-2010\)](#).

Usage

```
download_groads(
  data_region = c("Americas", "Global", "Africa", "Asia", "Europe", "Oceania East",
    "Oceania West"),
  data_format = c("Shapefile", "Geodatabase"),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)
```

Arguments

data_region	character(1). Data can be downloaded for "Global", "Africa", "Asia", "Europe", "Americas", "Oceania East", and "Oceania West".
data_format	character(1). Data can be downloaded as "Shapefile" or "Geodatabase". (Only "Geodatabase" available for "Global" region).
directory_to_save	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped shapefiles ("/data_files").
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
unzip	logical(1). Unzip zip files. Default is TRUE.
remove_zip	logical(1). Remove zip files from directory_to_download. Default is FALSE.
hash	logical(1). By setting TRUE the function will return an rlang::hash_file() hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- Zip and/or data files will be downloaded and stored in respective sub-directories within directory_to_save.

Author(s)

Mitchell Manware, Insang Song

References

Center For International Earth Science Information Network-CIESIN-Columbia University, Information Technology Outreach Services-ITOS-University Of Georgia (2013). "Global Roads Open Access Data Set, Version 1 (gROADSv1)." doi:10.7927/H4VD6WCT, <https://data.nasa.gov/dataset/global-roads-open-access-data-set-version-1-groadsv1>.

Examples

```
## Not run:
download_groads(
  data_region = "Americas",
  data_format = "Shapefile",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
```

```

    unzip = FALSE
  )

  ## End(Not run)

```

download_hms	<i>Download wildfire smoke data</i>
--------------	-------------------------------------

Description

The `download_hms()` function accesses and downloads wildfire smoke plume coverage data from [NOAA's Hazard Mapping System Fire and Smoke Product](#).

Usage

```

download_hms(
  data_format = "Shapefile",
  date = c("2018-01-01", "2018-01-01"),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)

```

Arguments

<code>data_format</code>	character(1). "Shapefile" or "KML".
<code>date</code>	character(1 or 2). length of 10. Date or start/end dates for downloading data. Format "YYYY-MM-DD" (ex. January 1, 2018 = "2018-01-01"). NOAA HMS data is available from August 5, 2005 through present day. Data is unavailable for August 10, 2005.
<code>directory_to_save</code>	character(1). Directory to save data. If <code>data_format</code> = "Shapefile", two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped shapefiles ("/data_files"). If <code>data_format</code> = "KML", a single sub-directory ("/data_files") will be created.
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.

unzip	logical(1). Unzip zip files. Default is TRUE. (Ignored if data_format = "KML".)
remove_zip	logical(1). Remove zip files from directory_to_download. Default is FALSE. (Ignored if data_format = "KML".)
hash	logical(1). By setting TRUE the function will return an rlang::hash_file() hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- Zip and/or data files will be downloaded and stored in respective sub-directories within directory_to_save.

Author(s)

Mitchell Manware, Insang Song

References

(???). "Hazard Mapping System Fire and Smoke Product: Hazard Mapping System." <https://www.ospo.noaa.gov/products/land/hms.html#about>. <https://www.ospo.noaa.gov/products/land/hms.html#about>.

Examples

```
## Not run:
download_hms(
  data_format = "Shapefile",
  date = "2024-01-01",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_koppen_geiger

Download climate classification data

Description

The download_koppen_geiger() function accesses and downloads climate classification data from the *Present and future Köppen-Geiger climate classification maps at 1-km resolution*([link for article](#); [link for data](#)).

Usage

```
download_koppen_geiger(
  data_resolution = c("0.0083", "0.083", "0.5"),
  time_period = c("Present", "Future"),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)
```

Arguments

<code>data_resolution</code>	character(1). Available resolutions are "0.0083" degrees (approx. 1 km), "0.083" degrees (approx. 10 km), and "0.5" degrees (approx. 50 km).
<code>time_period</code>	character(1). Available times are "Present" (1980-2016) and "Future" (2071-2100). ("Future" classifications are based on scenario RCP8.5).
<code>directory_to_save</code>	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped shapefiles ("/data_files").
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
<code>unzip</code>	logical(1). Unzip zip files. Default is TRUE.
<code>remove_zip</code>	logical(1). Remove zip files from directory_to_download. Default is FALSE.
<code>hash</code>	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For `hash = FALSE`, NULL
- For `hash = TRUE`, an `rlang::hash_file` character.
- Zip and/or data files will be downloaded and stored in respective sub-directories within `directory_to_save`.

Author(s)

Mitchell Manware, Insang Song

References

Beck HE, McVicar TR, Vergopolan N, Berg A, Lutsko NJ, Dufour A, Zeng Z, Jiang X, Van Dijk AIJM, Miralles DG (2023). “High-resolution (1 km) Köppen-Geiger maps for 1901–2099 based on constrained CMIP6 projections.” *Scientific Data*, **10**(1), 724. ISSN 2052-4463, doi:10.1038/s41597023025496, <https://www.nature.com/articles/s41597-023-02549-6>.

Beck HE, Zimmermann NE, McVicar TR, Vergopolan N, Berg A, Wood EF (2018). “Present and future Köppen-Geiger climate classification maps at 1-km resolution.” *Scientific data*, **5**(1), 1–12. doi:10.1038/sdata.2018.214.

Examples

```
## Not run:
download_koppen_geiger(
  data_resolution = "0.0083",
  time_period = "Present",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_merra2

Download meteorological and atmospheric data

Description

The `download_merra2()` function accesses and downloads various meteorological and atmospheric collections from [NASA's Modern-Era Retrospective analysis for Research and Applications, Version 2 \(MERRA-2\) model](#).

Usage

```
download_merra2(
  collection = c("inst1_2d_asm_Nx", "inst1_2d_int_Nx", "inst1_2d_lfo_Nx",
    "inst3_3d_asm_Np", "inst3_3d_aer_Nv", "inst3_3d_asm_Nv", "inst3_3d_chm_Nv",
    "inst3_3d_gas_Nv", "inst3_2d_gas_Nx", "inst6_3d_ana_Np", "inst6_3d_ana_Nv",
    "statD_2d_slv_Nx", "tavg1_2d_adg_Nx", "tavg1_2d_aer_Nx", "tavg1_2d_chm_Nx",
    "tavg1_2d_csp_Nx", "tavg1_2d_flx_Nx", "tavg1_2d_int_Nx", "tavg1_2d_lfo_Nx",
    "tavg1_2d_lnd_Nx", "tavg1_2d_ocn_Nx", "tavg1_2d_rad_Nx", "tavg1_2d_slv_Nx",
    "tavg3_3d_mst_Ne", "tavg3_3d_trb_Ne", "tavg3_3d_nav_Ne", "tavg3_3d_cld_Np",
    "tavg3_3d_mst_Np", "tavg3_3d_rad_Np", "tavg3_3d_tdt_Np", "tavg3_3d_trb_Np",
    "tavg3_3d_udt_Np", "tavg3_3d_odt_Np", "tavg3_3d_qdt_Np", "tavg3_3d_asm_Nv",
    "tavg3_3d_cld_Nv", "tavg3_3d_mst_Nv", "tavg3_3d_rad_Nv", "tavg3_2d_glc_Nx"),
```

```

    date = c("2018-01-01", "2018-01-01"),
    directory_to_save = NULL,
    acknowledgement = FALSE,
    download = FALSE,
    remove_command = FALSE,
    hash = FALSE
  )

```

Arguments

collection	character(1). MERRA-2 data collection file name.
date	character(1 or 2). length of 10. Date or start/end dates for downloading data. Format "YYYY-MM-DD" (ex. January 1, 2018 = "2018-01-01").
directory_to_save	character(1). Directory to save data.
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE).
hash	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE. the text file containing download commands.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an `rlang::hash_file` character.
- netCDF (.nc4) files will be stored in a collection-specific folder within `directory_to_save`.

Author(s)

Mitchell Manware, Insang Song

References

- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 inst1_2d_asm_Nx: 2d,3-Hourly,Instantaneous,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4." doi:10.5067/3Z173KIE2TPD, https://disc.gsfc.nasa.gov/datasets/M2I1NXASM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 inst1_2d_int_Nx: 2d,1-Hourly,Instantaneous,Single-Level,Assimilation,Vertically Integrated Diagnostics V5.12.4." doi:10.5067/G0U6NGQ3BLE0, https://disc.gsfc.nasa.gov/datasets/M2I1NXINT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 inst1_2d_lfo_Nx: 2d,1-Hourly,Instantaneous,Single-Level,Assimilation,Land Surface Forcings V5.12.4." doi:10.5067/RCMZA6TL70BG, https://disc.gsfc.nasa.gov/datasets/M2I1NXLFO_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst3_3d_asm_Np: 3d,3-Hourly,Instantaneous,Pressure-Level,Assimilation,Assimilated Meteorological Fields V5.12.4.” doi:10.5067/QBZ6MG944HW0, https://disc.gsfc.nasa.gov/datasets/M2I3NPASM_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst3_3d_aer_Nv: 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Aerosol Mixing Ratio V5.12.4.” doi:10.5067/LTVB4GPCOTK2, https://disc.gsfc.nasa.gov/datasets/M2I3NVAER_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst3_3d_asm_Nv: 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Assimilated Meteorological Fields V5.12.4.” doi:10.5067/WWQSQ8IVFW8, https://disc.gsfc.nasa.gov/datasets/M2I3NVASM_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst3_3d_chm_Nv: 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Carbon Monoxide and Ozone Mixing Ratio V5.12.4.” doi:10.5067/HO9OVZWF3KW2, https://disc.gsfc.nasa.gov/datasets/M2I3NVCHM_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst3_3d_gas_Nv: 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Aerosol Mixing Ratio Analysis Increments V5.12.4.” doi:10.5067/96BUID8HGGX5, https://disc.gsfc.nasa.gov/datasets/M2I3NVGAS_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst3_2d_gas_Nx: 2d,3-Hourly,Instantaneous,Single-Level,Assimilation,Aerosol Optical Depth Analysis V5.12.4.” doi:10.5067/HNGA0EWW0R09, https://disc.gsfc.nasa.gov/datasets/M2I3NXGAS_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst6_3d_ana_Np: 3d,6-Hourly,Instantaneous,Pressure-Level,Analysis,Analyzed Meteorological Fields V5.12.4.” doi:10.5067/A7S6XP56VZWS, https://disc.gsfc.nasa.gov/datasets/M2I6NPANA_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 inst6_3d_ana_Nv: 3d,6-Hourly,Instantaneous,Model-Level,Analysis,Analyzed Meteorological Fields V5.12.4.” doi:10.5067/IUUF4WB9FT4W, https://disc.gsfc.nasa.gov/datasets/M2I6NVANA_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 statD_2d_slv_Nx: 2d,Monthly,Aggregated Statistics,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4.” doi:10.5067/KVIMOMCUO83U, https://disc.gsfc.nasa.gov/datasets/M2SMNXSLV_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 statD_2d_slv_Nx: 2d,Daily,Aggregated Statistics,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4.” doi:10.5067/9SC1VNTWGWV3, https://disc.gsfc.nasa.gov/datasets/M2SDNXSLV_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg1_2d_adg_Nx: 2d,3-Hourly,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics (extended) V5.12.4.” doi:10.5067/HM00OHQBHKTP, https://disc.gsfc.nasa.gov/datasets/M2T1NXADG_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg1_2d_aer_Nx: 2d,1-Hourly,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics V5.12.4.” doi:10.5067/KLICLTZ8EM9D, https://disc.gsfc.nasa.gov/datasets/M2T1NXAER_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg1_2d_chm_Nx: 2d,3-Hourly,Time-Averaged,Single-Level,Assimilation,Carbon Monoxide and Ozone Diagnostics V5.12.4.” doi:10.5067/3RQ5YS674DGQ, https://disc.gsfc.nasa.gov/datasets/M2T1NXCHM_5.12.4/summary.

- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_csp_Nx: 2d,1-Hourly,Time-averaged,Single-Level,Assimilation,COSP Satellite Simulator V5.12.4." doi:10.5067/H0VVAD8F6MX5, https://disc.gsfc.nasa.gov/datasets/M2T1NXCSP_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_flux_Nx: 2d,1-Hourly,Time-Averaged,Single-Level,Assimilation,Surface Flux Diagnostics V5.12.4." doi:10.5067/7MCPBJ41Y0K6, https://disc.gsfc.nasa.gov/datasets/M2T1NXFLX_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_int_Nx: 2d,1-Hourly,Time-averaged,Single-Level,Assimilation,Vertically Integrated Diagnostics V5.12.4." doi:10.5067/Q5GVUVUIVGO7, https://disc.gsfc.nasa.gov/datasets/M2T1NXINT_5.12.4/summary.
- Pawson S (2020). "MERRA-2 tavg1_2d_lfo_Nx: 2d,1-Hourly,Time-Averaged,Single-Level,Assimilation,Land Surface Forcings V5.12.4." doi:10.5067/L0T5GEG1NYFA, https://disc.gsfc.nasa.gov/datasets/M2T1NXLFO_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_lnd_Nx: 2d,1-Hourly,Time-Averaged,Single-Level,Assimilation,Land Surface Diagnostics V5.12.4." doi:10.5067/RKPHT8KCIY1T, https://disc.gsfc.nasa.gov/datasets/M2T1NXLND_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_ocn_Nx: 2d,1-Hourly,Time-Averaged,Single-Level,Assimilation,Ocean Surface Diagnostics V5.12.4." doi:10.5067/Y67YQ1L3ZZ4R, https://disc.gsfc.nasa.gov/datasets/M2T1NXOCN_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_rad_Nx: 2d,1-Hourly,Time-Averaged,Single-Level,Assimilation,Radiation Diagnostics V5.12.4." doi:10.5067/Q9QMY5PBNV1T, https://disc.gsfc.nasa.gov/datasets/M2T1NXRAD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg1_2d_slv_Nx: 2d,1-Hourly,Time-Averaged,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4." doi:10.5067/VJAFPLIICSIV, https://disc.gsfc.nasa.gov/datasets/M2T1NXSLV_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg3_3d_mst_Ne: 3d,3-Hourly,Time-Averaged,Model-Level Edge,Assimilation,Moist Processes Diagnostics V5.12.4." doi:10.5067/JRUZ3SJ3ZJ72, https://disc.gsfc.nasa.gov/datasets/M2T3NEMST_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg3_3d_trb_Ne: 3d,3-Hourly,Time-Averaged,Model-Level Edge,Assimilation,Turbulence Diagnostics V5.12.4." doi:10.5067/4I7ZI35QRH8K, https://disc.gsfc.nasa.gov/datasets/M2T3NETRB_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg3_3d_nav_Ne: 3d,3-Hourly,Time-Averaged, Vertical Coordinates V5.12.4." doi:10.5067/N5WAKNS1UYQN, https://disc.gsfc.nasa.gov/datasets/M2T3NENAV_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg3_3d_cld_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Cloud Diagnostics V5.12.4." doi:10.5067/TX10URJSKT53, https://disc.gsfc.nasa.gov/datasets/M2T3NPCLD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg3_3d_mst_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Moist Processes Diagnostics V5.12.4." doi:10.5067/0TUFO90Q2PMS, https://disc.gsfc.nasa.gov/datasets/M2T3NPMST_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavg3_3d_rad_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Radiation Diagnostics V5.12.4." doi:10.5067/3UGE8WQXZAK, https://disc.gsfc.nasa.gov/datasets/M2T3NPRAD_5.12.4/summary.

- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_tdt_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Temperature Tendencies V5.12.4.” doi:10.5067/9NCR9DDDOPFI, https://disc.gsfc.nasa.gov/datasets/M2T3NPDTDT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_trb_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Turbulence Diagnostics V5.12.4.” doi:10.5067/ZRRJPGWL8AVL, https://disc.gsfc.nasa.gov/datasets/M2T3NPTRB_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ udt_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Wind Tendencies V5.12.4.” doi:10.5067/CWV0G3PPPFW, https://disc.gsfc.nasa.gov/datasets/M2T3NPUdT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ odt_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Ozone Tendencies V5.12.4.” doi:10.5067/S0LYTK57786Z, https://disc.gsfc.nasa.gov/datasets/M2T3NP0DT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ qdt_Np: 3d,3-Hourly,Time-Averaged,Pressure-Level,Assimilation,Moist Tendencies V5.12.4.” doi:10.5067/A9KWADY78YHQ, https://disc.gsfc.nasa.gov/datasets/M2T3NPQDT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ asm_Nv: 3d,3-Hourly,Time-Averaged,Model-Level,Assimilation,Assimilated Meteorological Fields V5.12.4.” doi:10.5067/SUOQESM06LPK, https://disc.gsfc.nasa.gov/datasets/M2T3NVASM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ cld_Nv: 3d,3-Hourly,Time-Averaged,Model-Level,Assimilation,Cloud Diagnostics V5.12.4.” doi:10.5067/F9353J0FAHIH, https://disc.gsfc.nasa.gov/datasets/M2T3NVCLD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ mst_Nv: 3d,3-Hourly,Time-Averaged,Model-Level,Assimilation,Moist Processes Diagnostics V5.12.4.” doi:10.5067/ZXTJ28TQR1TR, https://disc.gsfc.nasa.gov/datasets/M2T3NVMST_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_3d_ rad_Nv: 3d,3-Hourly,Time-Averaged,Model-Level,Assimilation,Radiation Diagnostics V5.12.4.” doi:10.5067/7GFQKO1T43RW, https://disc.gsfc.nasa.gov/datasets/M2T3NVRAD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavg3_2d_ glc_Nx: 2d,3-Hourly,Time-Averaged,Single-Level,Assimilation,Land Ice Surface Diagnostics V5.12.4.” doi:10.5067/9ETB4TT5J6US, https://disc.gsfc.nasa.gov/datasets/M2T3NXGLC_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 instM_2d_ asm_Nx: 2d,Monthly mean,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4.” doi:10.5067/5ESKGQTZG7FO, https://disc.gsfc.nasa.gov/datasets/M2IMNXASM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 instM_2d_ int_Nx: 2d,Monthly mean,Instantaneous,Single-Level,Assimilation,Vertically Integrated Diagnostics V5.12.4.” doi:10.5067/KVTU1A8BWFSJ, https://disc.gsfc.nasa.gov/datasets/M2IMNXINT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 instM_2d_ lfo_Nx: 2d,Monthly mean,Instantaneous,Single-Level,Assimilation,Land Surface Forcings V5.12.4.” doi:10.5067/11F99Y6TXN99, https://disc.gsfc.nasa.gov/datasets/M2IMNXLFO_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 instM_2d_ gas_Nx: 2d,Monthly mean,Instantaneous,Single-Level,Assimilation,Aerosol Optical Depth Analysis V5.12.4.” doi:10.5067/XOGBQEPLUC5, https://disc.gsfc.nasa.gov/datasets/M2IMNXGAS_5.12.4/summary.

- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 instM_3d_ asm_ Np: 3d,Monthly mean,Instantaneous,Pressure-Level,Assimilation,Assimilated Meteorological Fields V5.12.4.” doi:10.5067/2E096JV59PK7, https://disc.gsfc.nasa.gov/datasets/M2IMNPASM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 instM_3d_ ana_ Np: 3d,Monthly mean,Instantaneous,Pressure-Level,Analysis,Analyzed Meteorological Fields V5.12.4.” doi:10.5067/V92O8XZ30XBI, https://disc.gsfc.nasa.gov/datasets/M2IMNPANA_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ adg_ Nx: 2d,Monthly mean,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics (extended) V5.12.4.” doi:10.5067/RZIK2TV7PP38, https://disc.gsfc.nasa.gov/datasets/M2TMNXADG_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ aer_ Nx: 2d,Monthly mean,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics V5.12.4.” doi:10.5067/FH9A0MLJPC7N, https://disc.gsfc.nasa.gov/datasets/M2TMNXAER_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ chm_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Carbon Monoxide and Ozone Diagnostics V5.12.4.” doi:10.5067/WMT31RKEXK8I, https://disc.gsfc.nasa.gov/datasets/M2TMNXCHM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ csp_ Nx: 2d,Monthly mean,Time-averaged,Single-Level,Assimilation,COSP Satellite Simulator V5.12.4.” doi:10.5067/BZPOTGJOQKLU, https://disc.gsfc.nasa.gov/datasets/M2TMNXCSP_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ flx_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Surface Flux Diagnostics V5.12.4.” doi:10.5067/OJRLVL8YV2Y4, https://disc.gsfc.nasa.gov/datasets/M2TMNXFLX_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ int_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Vertically Integrated Diagnostics V5.12.4.” doi:10.5067/FQPTQ4OJ22TL, https://disc.gsfc.nasa.gov/datasets/M2TMNXINT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ lfo_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Land Surface Forcings V5.12.4.” doi:10.5067/5V7K6LJD44SY, https://disc.gsfc.nasa.gov/datasets/M2TMNXLFO_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ lnd_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Land Surface Diagnostics V5.12.4.” doi:10.5067/8S35XF81C28F, https://disc.gsfc.nasa.gov/datasets/M2TMNXLND_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ ocn_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Ocean Surface Diagnostics V5.12.4.” doi:10.5067/4IASLIDL8EEC, https://disc.gsfc.nasa.gov/datasets/M2TMNXOCN_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ rad_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Radiation Diagnostics V5.12.4.” doi:10.5067/OU3HJDS973O0, https://disc.gsfc.nasa.gov/datasets/M2TMNXRAD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ slv_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4.” doi:10.5067/APIB0BA5PD2K, https://disc.gsfc.nasa.gov/datasets/M2TMNXSLV_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgM_2d_ glc_ Nx: 2d,Monthly mean,Time-Averaged,Single-Level,Assimilation,Land Ice Surface Diagnostics V5.12.4.” doi:10.5067/5W8Q3I9WUFGX, https://disc.gsfc.nasa.gov/datasets/M2TMNXGLC_5.12.4/summary.

- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_cld_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Cloud Diagnostics V5.12.4." doi:10.5067/J9R0LXGH48JR, https://disc.gsfc.nasa.gov/datasets/M2TMNPCLD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_mst_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Moist Processes Diagnostics V5.12.4." doi:10.5067/ZRZGD0DCK1CG, https://disc.gsfc.nasa.gov/datasets/M2TMNPMST_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_rad_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Radiation Diagnostics V5.12.4." doi:10.5067/H3YGROBVBGFJ, https://disc.gsfc.nasa.gov/datasets/M2TMNPRAD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_tdt_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Temperature Tendencies V5.12.4." doi:10.5067/VILT59HI2MOY, https://disc.gsfc.nasa.gov/datasets/M2TMNPDTDT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_trb_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Turbulence Diagnostics V5.12.4." doi:10.5067/2Y0IQB5C3ACN, https://disc.gsfc.nasa.gov/datasets/M2TMNPTRB_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_u dt_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Wind Tendencies V5.12.4." doi:10.5067/YSR6IA5057XX, https://disc.gsfc.nasa.gov/datasets/M2TMNPU DT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_odt_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Ozone Tendencies V5.12.4." doi:10.5067/Z2KCWAV4GPD2, https://disc.gsfc.nasa.gov/datasets/M2TMNPODT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgM_3d_qdt_Np: 3d,Monthly mean,Time-Averaged,Pressure-Level,Assimilation,Moist Tendencies V5.12.4." doi:10.5067/2ZTU87V69ATP, https://disc.gsfc.nasa.gov/datasets/M2TMNPQDT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 const_2d_asm_Nx: 2d, constants." doi:10.5067/ME5QX6Q5IGGU, https://disc.gsfc.nasa.gov/datasets/M2C0NXASM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 instU_2d_asm_Nx: 2d,Diurnal,Instantaneous,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4." doi:10.5067/BOJSTZAO2L8R, https://disc.gsfc.nasa.gov/datasets/M2IUNXASM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 instU_2d_int_Nx: 2d,Diurnal,Instantaneous,Single-Level,Assimilation,Vertically Integrated Diagnostics V5.12.4." doi:10.5067/DGAB3HFEYMLY, https://disc.gsfc.nasa.gov/datasets/M2IUNXINT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 instU_2d_lfo_Nx: 2d,Diurnal,Instantaneous,Single-Level,Assimilation,Land Surface Forcings V5.12.4." doi:10.5067/FC3BVJ88Y8A2, https://disc.gsfc.nasa.gov/datasets/M2IUNXLFO_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 instU_2d_gas_Nx: 2d,Diurnal,Instantaneous,Single-Level,Assimilation,Aerosol Optical Depth Analysis V5.12.4." doi:10.5067/TVJ4MHBED39L, https://disc.gsfc.nasa.gov/datasets/M2IUNXGAS_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 instU_3d_asm_Np: 3d,Diurnal,Instantaneous,Pressure-Level,Assimilation,Assimilated Meteorological Fields V5.12.4." doi:10.5067/6EGRBNEBMIYS, https://disc.gsfc.nasa.gov/datasets/M2IUNPASM_5.12.4/summary.

- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 instU_3d_ ana_ Np: 3d,Diurnal,Instantaneous,Pressure-Level,Analysis,Analyzed Meteorological Fields V5.12.4." doi:10.5067/TRD91YO9S6E7, https://disc.gsfc.nasa.gov/datasets/M2IUNPANA_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ adg_ Nx: 2d,Diurnal,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics (extended) V5.12.4." doi:10.5067/YZJJXZTFCX6B, https://disc.gsfc.nasa.gov/datasets/M2TUNXADG_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ aer_ Nx: 2d,Diurnal,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics V5.12.4." doi:10.5067/KPUMVXFEQLA1, https://disc.gsfc.nasa.gov/datasets/M2TUNXAER_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ chm_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Carbon Monoxide and Ozone Diagnostics V5.12.4." doi:10.5067/5KFZ6GXRHZKN, https://disc.gsfc.nasa.gov/datasets/M2TUNXCHM_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ csp_ Nx: 2d,Diurnal,Time-averaged,Single-Level,Assimilation,COSP Satellite Simulator V5.12.4." doi:10.5067/9PH5QU4CL9E8, https://disc.gsfc.nasa.gov/datasets/M2TUNXCSP_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ flx_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Surface Flux Diagnostics V5.12.4." doi:10.5067/LUHPNWAKYIO3, https://disc.gsfc.nasa.gov/datasets/M2TUNXFLX_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ int_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Vertically Integrated Diagnostics V5.12.4." doi:10.5067/R2MPVU4EOSWT, https://disc.gsfc.nasa.gov/datasets/M2TUNXINT_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ lfo_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Land Surface Forcings V5.12.4." doi:10.5067/BTSNKAJND3ME, https://disc.gsfc.nasa.gov/datasets/M2TUNXLFO_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ lnd_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Land Surface Diagnostics V5.12.4." doi:10.5067/W0J15047CF6N, https://disc.gsfc.nasa.gov/datasets/M2TUNXLND_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ ocn_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Ocean Surface Diagnostics V5.12.4." doi:10.5067/KLNAVGA7J66, https://disc.gsfc.nasa.gov/datasets/M2TUNXOCN_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ rad_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Radiation Diagnostics V5.12.4." doi:10.5067/4SDCJYK8P9QU, https://disc.gsfc.nasa.gov/datasets/M2TUNXRAD_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ slv_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Single-Level Diagnostics V5.12.4." doi:10.5067/AFOK0TPEVQEK, https://disc.gsfc.nasa.gov/datasets/M2TUNXSLV_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_2d_ glc_ Nx: 2d,Diurnal,Time-Averaged,Single-Level,Assimilation,Land Ice Surface Diagnostics V5.12.4." doi:10.5067/7VUPQC736SWX, https://disc.gsfc.nasa.gov/datasets/M2TUNXGLC_5.12.4/summary.
- Global Modeling And Assimilation Office, Pawson S (2015). "MERRA-2 tavgU_3d_ cld_ Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Cloud Diagnostics V5.12.4." doi:10.5067/EPW7T5UO0C0N, https://disc.gsfc.nasa.gov/datasets/M2TUNPCLD_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_mst_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Moist Processes Diagnostics V5.12.4.” doi:10.5067/ZRSN0JU27DK2, https://disc.gsfc.nasa.gov/datasets/M2TUNPMST_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_rad_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Radiation Diagnostics V5.12.4.” doi:10.5067/H140JMDOWB0Y, https://disc.gsfc.nasa.gov/datasets/M2TUNPRAD_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_tdt_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Temperature Tendencies V5.12.4.” doi:10.5067/QPO9E5TPZ8OF, https://disc.gsfc.nasa.gov/datasets/M2TUNPTDT_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_trb_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Turbulence Diagnostics V5.12.4.” doi:10.5067/2A99C60CG7WC, https://disc.gsfc.nasa.gov/datasets/M2TUNPTRB_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_u dt_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Wind Tendencies V5.12.4.” doi:10.5067/DO715T7T5PG8, https://disc.gsfc.nasa.gov/datasets/M2TUNPUTD_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_odt_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Ozone Tendencies V5.12.4.” doi:10.5067/M8OJ09GZP23E, https://disc.gsfc.nasa.gov/datasets/M2TUNPODT_5.12.4/summary.

Global Modeling And Assimilation Office, Pawson S (2015). “MERRA-2 tavgU_3d_qdt_Np: 3d,Diurnal,Time-Averaged,Pressure-Level,Assimilation,Moist Tendencies V5.12.4.” doi:10.5067/S8HJXIR0BFTS, https://disc.gsfc.nasa.gov/datasets/M2TUNPQDT_5.12.4/summary.

Examples

```
## Not run:
download_merra2(
  collection = "inst1_2d_int_Nx",
  date = "2024-01-01",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
)

## End(Not run)
```

download_modis

Download MODIS product files

Description

Need maintenance for the directory path change in NASA EOSDIS. This function first retrieves the all hdf download links on a certain day, then only selects the relevant tiles from the retrieved links. Download is only done at the queried horizontal-vertical tile number combinations. An exception is MOD06_L2 product, which is produced every five minutes every day.

Usage

```
download_modis(
  product = c("MOD09GA", "MYD09GA", "MOD09GQ", "MYD09GQ", "MOD09A1", "MYD09A1",
    "MOD09Q1", "MYD09Q1", "MOD11A1", "MYD11A1", "MOD11A2", "MYD11A2", "MOD11B1",
    "MYD11B1", "MOD13A1", "MYD13A1", "MOD13A2", "MYD13A2", "MOD13A3", "MYD13A3",
    "MOD06_L2", "MCD19A2", "VNP46A2"),
  version = "61",
  horizontal_tiles = c(7, 13),
  vertical_tiles = c(3, 6),
  mod06_links = NULL,
  nasa_earth_data_token = NULL,
  date = c("2023-09-01", "2023-09-01"),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  hash = FALSE
)
```

Arguments

product	character(1). One of c("MOD09GA", "MOD11A1", "MOD06_L2", "MCD19A2", "MOD13A2", "VNP46A2")
version	character(1). Default is "61", meaning v061.
horizontal_tiles	integer(2). Horizontal tile numbers c({start}, {end}). Default is c(7, 13).
vertical_tiles	integer(2). Vertical tile numbers c({start}, {end}). Default is c(3, 6).
mod06_links	character(1). CSV file path to MOD06_L2 download links from NASA LAADS MOD06_L2 . Default is NULL.
nasa_earth_data_token	character(1). Token for downloading data from NASA. Should be set before trying running the function.
date	character(1 or 2). length of 10. Date or start/end dates for downloading data. Format "YYYY-MM-DD" (ex. January 1, 2018 = "2018-01-01"). Note: ignored if product == "MOD06_L2".
directory_to_save	character(1). Directory to save data.
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). Download data or only save wget commands.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
hash	logical(1). By setting TRUE the function will return an rlang::hash_file() hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- HDF (.hdf) files will be stored in year/day_of_year sub-directories within directory_to_save.

Note

Both dates in date should be in the same year. Directory structure looks like input/modis/raw/{version}/{product}/{year}/{date}

Author(s)

Mitchell Manware, Insang Song

References

Lyapustin A, Wang Y (2022). “MODIS/Terra+Aqua Land Aerosol Optical Depth Daily L2G Global 1km SIN Grid V061.” doi:10.5067/MODIS/MCD19A2.061, <https://www.earthdata.nasa.gov/data/catalog/lpcloud-mcd19a2-061>.

MODIS Atmosphere Science Team (2017). “MODIS/Terra Clouds 5-Min L2 Swath 1km and 5km.” doi:10.5067/MODIS/MOD06_L2.061, https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/products/MOD06_L2.

Vermote E, Wolfe R (2021). “MODIS/Terra Surface Reflectance Daily L2G Global 1km and 500m SIN Grid V061.” doi:10.5067/MODIS/MOD09GA.061, <https://www.earthdata.nasa.gov/data/catalog/lpcloud-mod09ga-061>.

Wan Z, Hook S, Hulley G (2021). “MODIS/Terra Land Surface Temperature/Emissivity Daily L3 Global 1km SIN Grid V061.” doi:10.5067/MODIS/MOD11A1.061, <https://www.earthdata.nasa.gov/data/catalog/lpcloud-mod11a1-061>.

Didan K (2021). “MODIS/Terra Vegetation Indices 16-Day L3 Global 1km SIN Grid V061.” doi:10.5067/MODIS/MOD13A2.061, <https://www.earthdata.nasa.gov/data/catalog/lpcloud-mod13a2-061>.

Román MO, Wang Z, Sun Q, Kalb V, Miller SD, Molthan A, Schultz L, Bell J, Stokes EC, Pandey B, Seto KC, Hall D, Oda T, Wolfe RE, Lin G, Golpayegani N, Devadiga S, Davidson C, Sarkar S, Praderas C, Schmaltz J, Boller R, Stevens J, Ramos González OM, Padilla E, Alonso J, Detrés Y, Armstrong R, Miranda I, Conte Y, Marrero N, MacManus K, Esch T, Masuoka EJ (2018). “NASA’s Black Marble nighttime lights product suite.” *Remote Sensing of Environment*, **210**, 113–143. ISSN 00344257, doi:10.1016/j.rse.2018.03.017, <https://linkinghub.elsevier.com/retrieve/pii/S003442571830110X>.

Examples

```
## Not run:
## NOTE: Examples are wrapped in `dontrun{}` to avoid sharing sensitive
##       NASA EarthData token information.
# example with MOD09GA product
download_modis(
  product = "MOD09GA",
  version = "61",
  horizontal_tiles = c(8, 8),
```

```

vertical_tiles = c(4, 4),
date = "2024-01-01",
nasa_earth_data_token = "./pathtotoken/token.txt",
directory_to_save = tempdir(),
acknowledgement = TRUE,
download = FALSE, # NOTE: download skipped for examples,
remove_command = TRUE
)
# example with MOD06_L2 product
download_modis(
  product = "MOD06_L2",
  version = "61",
  horizontal_tiles = c(8, 8),
  vertical_tiles = c(4, 4),
  date = "2024-01-01",
  mod06_links =
    system.file(
      "extdata", "nasa", "LAADS_query.2024-08-02T12_49.csv",
      package = "amadeus"
    ),
  nasa_earth_data_token = "./pathtotoken/token.txt",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)
# example with VNP46A2 product
download_modis(
  product = "VNP46A2",
  version = "61",
  horizontal_tiles = c(8, 8),
  vertical_tiles = c(4, 4),
  date = "2024-01-01",
  nasa_earth_data_token = "./pathtotoken/token.txt",
  directory_to_save = tempdir(),
  acknowledgement = TRUE, MOD09GA
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)

## End(Not run)

```

download_narr

Download meteorological data

Description

The `download_narr` function accesses and downloads daily meteorological data from **NOAA's North American Regional Reanalysis (NARR) model**.

Usage

```
download_narr(
  variables = NULL,
  year = c(2018, 2022),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  hash = FALSE
)
```

Arguments

variables	character. Variable(s) name acronym. See List of Variables in NARR Files for variable names and acronym codes.
year	integer(1 or 2). length of 4. Year or start/end years for downloading data.
directory_to_save	character(1). Directory(s) to save downloaded data files.
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
hash	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an `rlang::hash_file` character.
- netCDF (.nc) files will be stored in `directory_to_save`.

Note

"Pressure levels" variables contain variable values at 29 atmospheric levels, ranging from 1000 hPa to 100 hPa. All pressure levels data will be downloaded for each variable.

Author(s)

Mitchell Manware, Insang Song

References

Mesinger F, DiMego G, Kalnay E, Mitchell K, Shafran PC, Ebisuzaki W, Jović D, Woollen J, Rogers E, Berbery EH, Ek MB, Fan Y, Grumbine R, Higgins W, Li H, Lin Y, Manikin G, Parrish D, Shi W (2006). “North American Regional Reanalysis.” *Bulletin of the American Meteorological Society*, **87**(3), 343–360. ISSN 0003-0007, 1520-0477, doi:[10.1175/BAMS873343](https://doi.org/10.1175/BAMS873343).

Examples

```
## Not run:
download_narr(
  variables = c("weasd", "omega"),
  year = 2023,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)

## End(Not run)
```

download_nei

Download road emissions data

Description

The `download_nei()` function accesses and downloads road emissions data from the [U.S Environmental Protection Agency’s \(EPA\) National Emissions Inventory \(NEI\)](#).

Usage

```
download_nei(
  epa_certificate_path = system.file("extdata/cacert_gaftp_epa.pem", package = "amadeus"),
  certificate_url =
    "http://cacerts.digicert.com/DigiCertGlobalG2TLSRSASHA2562020CA1-1.crt",
  year = c(2017L, 2020L),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  hash = FALSE
)
```

Arguments

`epa_certificate_path`

character(1). Path to the certificate file for EPA DataCommons. Default is 'ext-data/cacert_gaftp_epa.pem' under the package installation path.

certificate_url	character(1). URL to certificate file. See notes for details.
year	integer(1) Available years of NEI data. Default is c(2017L, 2020L).
directory_to_save	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped data files ("/data_files").
acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
unzip	logical(1). Unzip the downloaded zip files. Default is FALSE.
hash	logical(1). By setting TRUE the function will return an rlang::hash_file() hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- Zip and/or data files will be downloaded and stored in respective sub-directories within directory_to_save.

Note

For EPA Data Commons certificate errors, follow the steps below:

1. Click Lock icon in the address bar at <https://gaftp.epa.gov>
2. Click Show Certificate
3. Access Details
4. Find URL with *.crt extension Currently we bundle the pre-downloaded crt and its PEM (which is accepted in wget command) file in ./inst/extdata. The instruction above is for certificate updates in the future.

Author(s)

Ranadeep Daw, Insang Song

References

United States Environmental Protection Agency (2024). "Air Emissions Inventories." <https://www.epa.gov/air-emissions-inventories>.

Examples

```
## Not run:
download_nei(
  year = c(2017L, 2020L),
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_nlcd	<i>Download land cover data</i>
---------------	---------------------------------

Description

The download_nlcd() function accesses and downloads annual land cover data from the **Multi-Resolution Land Characteristics (MRLC) Consortium’s National Land Cover Database (NLCD) products data base**.

Usage

```
download_nlcd(
  product = "Land Cover",
  year = 2021,
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)
```

Arguments

product	character(1). "Land Cover", "Land Cover Change", "Land Cover Confidence", "Fractional Impervious Surface", "Impervious Descriptor", or "Spectral Change Day of Year ".
year	integer(1). Available years for Coterminous United States range from 1985 to 2023.
directory_to_save	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped shapefiles ("/data_files").

acknowledgement	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
download	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
remove_command	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
unzip	logical(1). Unzip zip files. Default is TRUE.
remove_zip	logical(1). Remove zip files from directory_to_download. Default is FALSE.
hash	logical(1). By setting TRUE the function will return an rlang::hash_file() hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- Zip and/or data files will be downloaded and stored in respective sub-directories within directory_to_save.

Author(s)

Mitchell Manware, Insang Song

References

Dewitz J (2023). “National Land Cover Database (NLCD) 2021 Products.” doi:[10.5066/P9JZ7AO3](https://doi.org/10.5066/P9JZ7AO3).
 Dewitz J (2024). “National Land Cover Database (NLCD) 2019 Products (ver. 3.0, February 2024).” doi:[10.5066/P9KZCM54](https://doi.org/10.5066/P9KZCM54).

Examples

```
## Not run:
download_nlcd(
  product = "Land Cover",
  year = 2021,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE # NOTE: download skipped for examples
)

## End(Not run)
```

download_population *Download population density data*

Description

The `download_population()` function accesses and downloads population density data from [NASA's UN WPP-Adjusted Population Density, v4.11](#).

Usage

```
download_population(
  data_resolution = "60 minute",
  data_format = c("GeoTIFF", "ASCII", "netCDF"),
  year = "2020",
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  unzip = TRUE,
  remove_zip = FALSE,
  hash = FALSE
)
```

Arguments

<code>data_resolution</code>	character(1). Available resolutions are 30 second (approx. 1 km), 2.5 minute (approx. 5 km), 15 minute (approx. 30 km), 30 minute (approx. 55 km), and 60 minute (approx. 110 km).
<code>data_format</code>	character(1). Individual year data can be downloaded as "ASCII" or "GeoTIFF". "all" years is downloaded as "netCDF".
<code>year</code>	character(1). Available years are 2000, 2005, 2010, 2015, and 2020, or "all" for all years.
<code>directory_to_save</code>	character(1). Directory to save data. Two sub-directories will be created for the downloaded zip files ("/zip_files") and the unzipped shapefiles ("/data_files").
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
<code>unzip</code>	logical(1). Unzip zip files. Default is TRUE.
<code>remove_zip</code>	logical(1). Remove zip files from directory_to_download. Default is FALSE.

hash logical(1). By setting TRUE the function will return an `rlang::hash_file()` hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an `rlang::hash_file` character.
- Zip and/or data files will be downloaded and stored in respective sub-directories within `directory_to_save`.

Author(s)

Mitchell Manware, Insang Song

References

Center For International Earth Science Information Network-CIESIN-Columbia University (2017). “Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11.” doi:10.7927/H49C6VHW, <https://earthdata.nasa.gov/data/catalog/sedac-ciesin-sedac-gpwv4-popdens-r11-4.11>.

Examples

```
## Not run:
download_population(
  data_resolution = "30 second",
  data_format = "GeoTIFF",
  year = "2020",
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE,
  unzip = FALSE
)

## End(Not run)
```

download_terraclimate *Download TerraClimate data*

Description

The `download_terraclimate` function accesses and downloads climate and water balance data from the [University of California Merced Climatology Lab's TerraClimate dataset](#).

Usage

```
download_terraclimate(
  variables = NULL,
  year = c(2018, 2022),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  hash = FALSE
)
```

Arguments

<code>variables</code>	character(1). Variable(s) name(s). See TerraClimate Direct Downloads for variable names and acronym codes.
<code>year</code>	integer(1 or 2). length of 4. Year or start/end years for downloading data.
<code>directory_to_save</code>	character(1). Directory(s) to save downloaded data files.
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
<code>hash</code>	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For `hash = FALSE`, NULL
- For `hash = TRUE`, an `rlang::hash_file` character.
- netCDF (.nc) files will be stored in a variable-specific folder within `directory_to_save`.

Author(s)

Mitchell Manware, Insang Song

References

Abatzoglou JT, Dobrowski SZ, Parks SA, Hegewisch KC (2018). “TerraClimate, a high-resolution global dataset of monthly climate and climatic water balance from 1958–2015.” *Scientific data*, **5**(1), 1–12.

Examples

```
## Not run:
download_terraclimate(
  variables = "Precipitation",
  year = 2023,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)

## End(Not run)
```

download_tri	<i>Download toxic release data</i>
--------------	------------------------------------

Description

The `download_tri()` function accesses and downloads toxic release data from the [U.S. Environmental Protection Agency's \(EPA\) Toxic Release Inventory \(TRI\) Program](#).

Usage

```
download_tri(
  year = c(2018L, 2022L),
  directory_to_save = NULL,
  acknowledgement = FALSE,
  download = FALSE,
  remove_command = FALSE,
  hash = FALSE
)
```

Arguments

<code>year</code>	integer(1 or 2). length of 4. Year or start/end years for downloading data.
<code>directory_to_save</code>	character(1). Directory to download files.
<code>acknowledgement</code>	logical(1). By setting TRUE the user acknowledges that the data downloaded using this function may be very large and use lots of machine storage and memory.
<code>download</code>	logical(1). FALSE will generate a *.txt file containing all download commands. By setting TRUE the function will download all of the requested data files.
<code>remove_command</code>	logical(1). Remove (TRUE) or keep (FALSE) the text file containing download commands.
<code>hash</code>	logical(1). By setting TRUE the function will return an <code>rlang::hash_file()</code> hash character corresponding to the downloaded files. Default is FALSE.

Value

- For hash = FALSE, NULL
- For hash = TRUE, an rlang::hash_file character.
- Comma-separated value (CSV) files will be stored in directory_to_save.

Author(s)

Mariana Kassien, Insang Song

References

United States Environmental Protection Agency (2024). “TRI Basic Data Files: Calendar Years 1987 – Present.” <https://www.epa.gov/toxics-release-inventory-tri-program/tri-data-action-0>.

Examples

```
## Not run:
download_tri(
  year = 2021L,
  directory_to_save = tempdir(),
  acknowledgement = TRUE,
  download = FALSE, # NOTE: download skipped for examples,
  remove_command = TRUE
)

## End(Not run)
```

dt_as_mysftime	<i>Convert a data.table to an sftime</i>
----------------	--

Description

Convert a data.table object to an sftime. x must be a data.table object with "lon", "lat", and "time" columns to describe the longitude, latitude, and time-orientation, respectively, of x.

Usage

```
dt_as_mysftime(x, lonname, latname, timename, crs)
```

Arguments

x	a data.table
lonname	character for longitude column name
latname	character for latitude column name
timename	character for time column name
crs	coordinate reference system

Value

an sf object

Author(s)

Eva Marques

process_aqs

Process U.S. EPA AQS daily CSV data

Description

The `process_aqs()` function cleans and imports raw air quality monitoring sites from pre-generated daily CSV files, returning a single `SpatVector` or `sf` object. `date` is used to filter the raw data read from csv files. Filtered rows are then processed according to `mode` argument. Some sites report multiple measurements per day with and without **exceptional events** the internal procedure of this function keeps "Included" if there are multiple event types per site-time.

Usage

```
process_aqs(
  path = NULL,
  date = c("2018-01-01", "2022-12-31"),
  mode = c("date-location", "available-data", "location"),
  data_field = "Arithmetic.Mean",
  return_format = c("terra", "sf", "data.table"),
  extent = NULL,
  ...
)
```

Arguments

<code>path</code>	character(1). Directory path to daily measurement data.
<code>date</code>	character(1 or 2). Date (1) or start and end dates (2). Should be in "YYYY-MM-DD" format and sorted.
<code>mode</code>	character(1). One of • "date-location" (all dates * all locations) • "available-data" (date-location pairs with available data) • "location" (unique locations).
<code>data_field</code>	character(1). Data field to extract.
<code>return_format</code>	character(1). "terra" or "sf" or "data.table".
<code>extent</code>	numeric(4). Spatial extent of the resulting object. The order should be <code>c(xmin, xmax, ymin, ymax)</code> . The coordinate system should be WGS84 (EPSG:4326).
<code>...</code>	Placeholders.

Value

a SpatVector, sf, or data.table object depending on the return_format

Note

Choose date and mode values with caution. The function may return a massive data.table depending on the time range, resulting in a long processing time or even a crash if data is too large for your computing environment to process.

See Also

- [download_aqs\(\)](#)
- [EPA, n.d., AQS Parameter Codes](#)

Examples

```
## NOTE: Example is wrapped in ``dontrun{}`` as function requires a large
##       amount of data which is not included in the package.
## Not run:
aqs <- process_aqs(
  path = "../data/aqs_daily_example.csv",
  date = c("2022-12-01", "2023-01-31"),
  mode = "full",
  return_format = "terra"
)

## End(Not run)
```

process_blackmarble	<i>Assign VIIRS Black Marble products corner coordinates to retrieve a merged raster</i>
---------------------	--

Description

This function will return a SpatRaster object with georeferenced h5 files of Black Marble product. Referencing corner coordinates are necessary as the original h5 data do not include such information.

Usage

```
process_blackmarble(
  path = NULL,
  date = NULL,
  tile_df = process_blackmarble_corners(),
  subdataset = 3L,
  crs = "EPSG:4326",
  ...
)
```

Arguments

path	character. Full paths of h5 files.
date	character(1). Date to query.
tile_df	data.frame. Contains four corner coordinates in fields named c("xmin", "xmax", "ymin", "ymax"). See process_blackmarble_corners to generate a valid object for this argument.
subdataset	integer(1). Subdataset number to process. Default is 3L.
crs	character(1). terra::crs compatible CRS. Default is "EPSG:4326"
...	For internal use.

Value

a SpatRaster object

Author(s)

Insang Song

References

- [Wang, Z. \(2022\). Black Marble User Guide \(Version 1.3\). NASA.](#)

See Also

- [terra::describe](#)
- [terra::merge](#)
- [process_blackmarble_corners](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
vnp46a2 <- process_blackmarble(
  path =
    list.files("./data", pattern = "VNP46A2.", full.names = TRUE),
  date = "2024-01-01",
  tile_df =
    process_blackmarble_corners(hrange = c(8, 10), vrange = c(4, 5)),
  subdataset = 3L,
  crs = "EPSG:4326"
)

## End(Not run)
```

process_covariates	<i>Process raw data wrapper function</i>
--------------------	--

Description

This function processes raw data files which have been downloaded by [download_data](#). process_covariates and the underlying source-specific processing functions have been designed to operate on the raw data files. To avoid errors, **do not edit the raw data files before passing to process_covariates**.

Usage

```
process_covariates(
  covariate = c("modis_swath", "modis_merge", "koppen-geiger", "blackmarble",
    "koeppen-geiger", "koppen", "koeppen", "geos", "dummies", "gmted", "hms", "smoke",
    "sedac_population", "population", "sedac_groads", "groads", "roads", "nlcd", "tri",
    "narr", "nei", "ecoregions", "ecoregion", "merra", "merra2", "gridmet",
    "terraclimate", "huc", "cropscape", "cdl", "prism"),
  path = NULL,
  ...
)
```

Arguments

covariate	character(1). Covariate type.
path	character(1). Directory or file path to raw data depending on covariate value.
...	Arguments passed to each raw data processing function.

Value

SpatVector, SpatRaster, sf, or character depending on covariate type and selections.

Author(s)

Insang Song

See Also

- [process_modis_swath](#): "modis_swath"
- [process_modis_merge](#): "modis_merge"
- [process_blackmarble](#): "blackmarble"
- [process_koppen_geiger](#): "koppen-geiger", "koeppen-geiger", "koppen"
- [process_ecoregion](#): "ecoregion", "ecoregions"
- [process_nlcd](#): "nlcd", "NLCD"
- [process_tri](#): "tri", "TRI"
- [process_nei](#): "nei", "NEI"

- `process_geos`: "geos", "GEOS"
- `process_gmted`: "gmted", "GMTED"
- `process_aqs`: "aqs", "AQS"
- `process_hms`: "hms", "smoke", "HMS"
- `process_narr`: "narr", "NARR"
- `process_groads`: "sedac_groads", "roads", "groads"
- `process_population`: "sedac_population", "population"
- `process_merra2`: "merra", "merra2", "MERRA2"
- `process_gridmet`: "gridmet", "gridMET"
- `process_terraclimate`: "terraclimate", "TerraClimate"
- `process_huc`: "huc", "HUC"
- `process_cropscape`: "cropscape", "cdl"
- `process_prism`: "prism", "PRISM"

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
process_covariates(
  covariate = "narr",
  date = c("2018-01-01", "2018-01-10"),
  variable = "weasd",
  path = system.file("extdata", "examples", "narr", "weasd")
)

## End(Not run)
```

process_ecoregion	<i>Process ecoregion data</i>
-------------------	-------------------------------

Description

The `process_ecoregion` function imports and cleans raw ecoregion data, returning a `SpatVector` object.

Usage

```
process_ecoregion(path = NULL, extent = NULL, ...)
```

Arguments

<code>path</code>	character(1). Path to Ecoregion Shapefiles
<code>extent</code>	numeric(4) or <code>SpatExtent</code> giving the extent of the raster if NULL (default), the entire raster is loaded
<code>...</code>	Placeholders.

Value

a SpatVector object

Note

The function will fix Tukey's bridge in Portland, ME. This fix will ensure that the EPA air quality monitoring sites will be located within the ecoregion.

Author(s)

Insang Song

Examples

```
## NOTE: Example is wrapped in ``dontrun{}`` as function requires a large
##      amount of data which is not included in the package.
## Not run:
ecoregion <- process_ecoregion(
  path = "../data/epa_ecoregion.gpkg"
)

## End(Not run)
```

process_geos

Process atmospheric composition data

Description

The process_geos() function imports and cleans raw atmospheric composition data, returning a single SpatRaster object.

Usage

```
process_geos(
  date = c("2018-01-01", "2018-01-10"),
  variable = NULL,
  path = NULL,
  extent = NULL,
  ...
)
```

Arguments

date	character(1 or 2). Date (1) or start and end dates (2). Format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
variable	character(1). GEOS-CF variable name(s).
path	character(1). Directory with downloaded netCDF (.nc4) files.

extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object;

Note

Layer names of the returned SpatRaster object contain the variable, pressure level, date, and hour.

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in ``dontrun{}`` as function requires a large
## amount of data which is not included in the package.
## Not run:
geos <- process_geos(
  date = c("2024-01-01", "2024-01-10"),
  variable = "03",
  path = "../data/aqc_tavg_1hr_g1440x721_v1"
)

## End(Not run)
```

process_gmted	<i>Process elevation data</i>
---------------	-------------------------------

Description

The process_gmted() function imports and cleans raw elevation data, returning a single SpatRaster object.

Usage

```
process_gmted(variable = NULL, path = NULL, extent = NULL, ...)
```

Arguments

variable	vector(1). Vector containing the GMTED statistic first and the resolution second. (Example: variable = c("Breakline Emphasis", "7.5 arc-seconds")). Statistic options: "Breakline Emphasis", "Systematic Subsample", "Median Statistic", "Minimum Statistic", "Mean Statistic", "Maximum Statistic", "Standard Deviation Statistic"
----------	---

	Resolution options: "30 arc-seconds", "15 arc-seconds", "7.5 arc-seconds"
path	character(1). Directory with downloaded GMTED "*_grd" folder containing .adf files.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Note

SpatRaster layer name indicates selected variable and resolution, and year of release (2010).

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
gmted <- process_gmted(
  variable = c("Breakline Emphasis", "7.5 arc-seconds"),
  path = "../data/be75_grd"
)

## End(Not run)
```

process_gridmet	<i>Process gridMET data</i>
-----------------	-----------------------------

Description

The process_gridmet() function imports and cleans raw gridded surface meteorological data, returning a single SpatRaster object.

Usage

```
process_gridmet(
  date = c("2023-09-01", "2023-09-10"),
  variable = NULL,
  path = NULL,
  extent = NULL,
  ...
)
```

Arguments

date	character(1 or 2). Date (1) or start and end dates (2). Format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
variable	character(1). Variable name or acronym code. See gridMET Generate Wget File for variable names and acronym codes. (Note: variable "Burning Index" has code "bi" and variable "Energy Release Component" has code "erc").
path	character(1). Directory with downloaded netCDF (.nc) files.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Note

Layer names of the returned SpatRaster object contain the variable acronym, and date.

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
gridmet <- process_gridmet(
  date = c("2023-01-01", "2023-01-10"),
  variable = "Precipitation",
  path = "../data/pr"
)

## End(Not run)
```

process_groads	<i>Process roads data</i>
----------------	---------------------------

Description

The process_groads() function imports and cleans raw road data, returning a single SpatVector object.

Usage

```
process_groads(path = NULL, extent = NULL, ...)
```

Arguments

path	character(1). Path to geodatabase or shapefiles.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatVector object

Note

U.S. context. The returned SpatVector object contains a \$description column to represent the temporal range covered by the dataset. For more information, see <https://data.nasa.gov/dataset/global-roads-open-access-data-set-version-1-groadsv1>.

Author(s)

Insang Song

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
groads <- process_groads(
  path = "../data/groads_example.shp"
)

## End(Not run)
```

process_hms	<i>Process wildfire smoke data</i>
-------------	------------------------------------

Description

The process_hms() function imports and cleans raw wildfire smoke plume coverage data, returning a single SpatVector object.

Usage

```
process_hms(date = "2018-01-01", path = NULL, extent = NULL, ...)
```

Arguments

date	character(1 or 2). Date (1) or start and end dates (2). Format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
path	character(1). Directory with downloaded NOAA HMS data files.
extent	numeric(4) or SpatExtent giving the extent of the output if NULL (default), the entire data is returned
...	Placeholders.

Value

a SpatVector or character object

Note

process_hms() will return a character object if there are no wildfire smoke plumes present for the selected dates and density. The returned character will contain the density value and the sequence of dates for which no wildfire smoke plumes were detected (see "Examples"). If multiple density polygons overlap, the function will return the highest density value.

Author(s)

Mitchell Manware

Examples

```
hms <- process_hms(
  date = c("2018-12-30", "2019-01-01"),
  path = "../tests/testdata/hms/"
)
```

process_koppen_geiger *Process climate classification data*

Description

The process_koppen_geiger() function imports and cleans raw climate classification data, returning a single SpatRaster object.

Usage

```
process_koppen_geiger(path = NULL, extent = NULL, ...)
```

Arguments

path	character(1). Path to Koppen-Geiger climate zone raster file
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Author(s)

Insang Song

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
kg <- process_koppen_geiger(
  path = "../data/koppen_geiger_data.tif"
)

## End(Not run)
```

process_merra2

Process meteorological and atmospheric data

Description

The process_merra2() function imports and cleans raw atmospheric composition data, returning a single SpatRaster object.

Usage

```
process_merra2(
  date = c("2018-01-01", "2018-01-10"),
  variable = NULL,
  path = NULL,
  extent = NULL,
  ...
)
```

Arguments

date	character(1 or 2). Date (1) or start and end dates (2). Format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
variable	character(1). MERRA2 variable name(s).
path	character(1). Directory with downloaded netCDF (.nc4) files.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object;

Note

Layer names of the returned SpatRaster object contain the variable, pressure level, date, and hour. Pressure level values utilized for layer names are taken directly from raw data and are not edited to retain pressure level information.

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
merra2 <- process_merra2(
  date = c("2024-01-01", "2024-01-10"),
  variable = "CPT",
  path = "../data/inst1_2d_int_Nx"
)

## End(Not run)
```

process_modis_merge	<i>Process MODIS .hdf files</i>
---------------------	---------------------------------

Description

Get mosaicked or merged raster from multiple MODIS hdf files.

Usage

```
process_modis_merge(
  path = NULL,
  date = NULL,
  subdataset = NULL,
  fun_agg = "mean",
  ...
)
```

Arguments

path	character. Full list of hdf file paths. preferably a recursive search result from base::list.files .
date	character(1). date to query. Should be in "YYYY-MM-DD" format.
subdataset	character(1). subdataset names to extract. Should conform to regular expression. See base::regex for details. Default is NULL, which will result in errors. Users should specify which subdatasets will be imported.
fun_agg	Function name or custom function to aggregate overlapping cell values. See fun description in terra::tapp for details.
...	For internal use.

Value

a SpatRaster object

Note

Curvilinear products (i.e., swaths) will not be accepted. MODIS products downloaded by functions in amadeus, **MODISTools**, and **luna** are accepted.

Author(s)

Insang Song

See Also

[download_data](#)

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
mod09ga_merge <- process_modis_merge(
  path =
    list.files("./data", pattern = "MOD09GA.", full.names = TRUE),
  date = "2024-01-01",
  subdataset = "sur_refl_b01_1",
  fun_agg = "mean"
)

## End(Not run)
```

process_modis_sds	<i>Process MODIS sub-datasets</i>
-------------------	-----------------------------------

Description

Selected MODIS sinusoidal grid product subdataset name selector. Four presets are supported. custom_sel supersedes presets of product values.

Usage

```
process_modis_sds(
  product = c("MOD11A1", "MOD13A2", "MOD09GA", "MCD19A2"),
  custom_sel = NULL,
  ...
)
```

Arguments

product	character(1). Product code.
custom_sel	character(1). Custom filter. If this value is not NULL, preset filter is overridden.
...	Placeholders.

Value

A character object that conforms to the regular expression. Details of regular expression in R can be found in [regexp](#).

Note

Preset product codes and associated variables include

- "MOD11A1" - Land surface temperature (LST)
- "MOD13A2" - Normalized Difference Vegetation Index (NDVI)
- "MOD09GA" - Surface reflectance, and
- "MCD19A2" - Aerosol optical depth (AOD).

For a full list of available MODIS product codes, see the "Short Name" column at [NASA LP DAAC Search Data Catalog](#). When utilizing a product code from this "Short Name" column, **do not include** the version number following the period. For example, if "Short Name" = MCD12C1.006, then product = "MCD12C1".

Author(s)

Insang Song

See Also

[calculate_modis](#)

Examples

```
process_modis_sds(product = "MOD09GA")
```

```
process_modis_swath    Mosaic MODIS swaths
```

Description

This function will return a `SpatRaster` object with values of selected subdatasets. Swath data include curvilinear grids, which require warping/rectifying the original curvilinear grids into rectangular grids. The function internally warps each of inputs then mosaic the warped images into one large `SpatRaster` object. Users need to select a subdataset to process. The full path looks like "HDF4_EOS:EOS_SWATH:{file_path}:mod06:subdataset", where `file_path` is the full path to the hdf file.

Usage

```
process_modis_swath(
  path = NULL,
  date = NULL,
  subdataset = NULL,
  suffix = ":mod06:",
  resolution = 0.05,
  ...
)
```

Arguments

<code>path</code>	character. Full paths of hdf files.
<code>date</code>	character(1). Date to query.
<code>subdataset</code>	character. Subdatasets to process. Unlike other preprocessing functions, this argument should specify the exact subdataset name. For example, when using MOD06_L2 product, one may specify <code>c("Cloud_Fraction", "Cloud_Optical_Thickness")</code> , etc. The subdataset names can be found in <code>terra::describe()</code> output.
<code>suffix</code>	character(1). Should be formatted <code>{product}:</code> , e.g., <code>:mod06:</code>
<code>resolution</code>	numeric(1). Resolution of output raster. Unit is degree (decimal degree in WGS84).
<code>...</code>	For internal use.

Value

- a `SpatRaster` object (`crs = "EPSG:4326"`): if `path` is a single file with full specification of subdataset.
- a `SpatRaster` object (`crs = "EPSG:4326"`): if `path` is a list of files. In this case, the returned object will have the maximal extent of multiple warped layers

Author(s)

Insang Song

See Also

- [process_modis_warp\(\)](#), [stars::read_stars\(\)](#), [stars::st_warp\(\)](#)
- [GDAL HDF4 driver documentation](#)
- [terra::describe\(\)](#): to list the full subdataset list with `sds = TRUE`
- [terra::sprc\(\)](#), [terra::rast\(\)](#)

Examples

```
## NOTE: Example is wrapped in ``dontrun{}`` as function requires a large
## amount of data which is not included in the package.
## Not run:
mod06l2_swath <- process_modis_swath(
  path = list.files(
    "./data/mod06l2",
    full.names = TRUE,
    pattern = ".hdf"
  ),
  date = "2024-01-01",
  subdataset = "Cloud_Fraction",
  suffix = ":mod06:",
  resolution = 0.05
)

## End(Not run)
```

process_narr

Process meteorological data

Description

The `process_narr()` function imports and cleans raw meteorological data, returning a single `SpatRaster` object.

Usage

```
process_narr(
  date = "2023-09-01",
  variable = NULL,
  path = NULL,
  extent = NULL,
  ...
)
```

Arguments

date	character(1 or 2). Date (1) or start and end dates (2). Format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
variable	character(1). Variable name acronym. See List of Variables in NARR Files for variable names and acronym codes.
path	character(1). Directory with downloaded netCDF (.nc) files.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Note

Layer names of the returned SpatRaster object contain the variable acronym, pressure level, and date.

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
process_narr(
  date = c("2018-01-01", "2018-01-10"),
  variable = "weasd",
  path = "../tests/testdata/narr/weasd"
)

## End(Not run)
```

process_nei	<i>Process road emissions data</i>
-------------	------------------------------------

Description

The process_nei () function imports and cleans raw road emissions data, returning a single SpatVector object.

NEI data comprises multiple csv files where emissions of 50+ pollutants are recorded at county level. With raw data files, this function will join a combined table of NEI data and county boundary, then perform a spatial join to target locations.

Usage

```
process_nei(path = NULL, county = NULL, year = c(2017, 2020), ...)
```

Arguments

path	character(1). Directory with NEI csv files.
county	SpatVector/sf. County boundaries.
year	integer(1) Year to use. Currently only 2017 or 2020 is accepted.
...	Placeholders.

Value

a SpatVector object

Note

Base files for county argument can be downloaded directly from [U.S. Census Bureau](#) or by using tigris package. This function does not reproject census boundaries. Users should be aware of the coordinate system of census boundary data for other analyses.

Author(s)

Insang Song

Examples

```
## NOTE: Example is wrapped in ``dontrun{}`` as function requires a large
## amount of data which is not included in the package.
## Not run:
nei <- process_nei(
  path = "./data",
  county = system.file("gpkg/nc.gpkg", package = "sf"),
  year = 2017
)

## End(Not run)
```

process_nlcd	<i>Process land cover data</i>
--------------	--------------------------------

Description

The process_nlcd() function imports and cleans raw land cover data, returning a single SpatRaster object.

Reads NLCD file of selected year.

Usage

```
process_nlcd(path = NULL, year = 2021, extent = NULL, ...)
```

Arguments

path	character giving nlcd data path
year	numeric giving the year of NLCD data used
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Author(s)

Eva Marques, Insang Song

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
nlcd <- process_nlcd(
  path = "../data/",
  year = 2021
)

## End(Not run)
```

process_population	<i>Process population density data</i>
--------------------	--

Description

The process_secac_population() function imports and cleans raw population density data, returning a single SpatRaster object.

Usage

```
process_population(path = NULL, extent = NULL, ...)
```

Arguments

path	character(1). Path to GeoTIFF (.tif) or netCDF (.nc) file.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
##       amount of data which is not included in the package.
## Not run:
pop <- process_population(
  path = "../data/sedac_population_example.tif"
)

## End(Not run)
```

process_terraclimate *Process TerraClimate data*

Description

The process_terraclimate() function imports and cleans climate and water balance data, returning a single SpatRaster object.

Usage

```
process_terraclimate(
  date = c("2023-09-01", "2023-09-10"),
  variable = NULL,
  path = NULL,
  extent = NULL,
  ...
)
```

Arguments

date	character(1 or 2). Date (1) or start and end dates (2). Format YYYY-MM-DD (ex. September 1, 2023 = "2023-09-01").
variable	character(1). Variable name or acronym code. See TerraClimate Direct Downloads for variable names and acronym codes.
path	character(1). Directory with downloaded netCDF (.nc) files.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatRaster object

Note

Layer names of the returned SpatRaster object contain the variable acronym, year, and month.

TerraClimate data has monthly temporal resolution, so the first day of each month is used as a placeholder temporal value.

Author(s)

Mitchell Manware

Examples

```
## NOTE: Example is wrapped in ``dontrun{}`` as function requires a large
##       amount of data which is not included in the package.
## Not run:
terraclimate <- process_terraclimate(
  date = c("2023-01-01", "2023-01-10"),
  variable = "Precipitation",
  path = "../data/ppt"
)

## End(Not run)
```

process_tri

Process toxic release data

Description

This function imports and cleans raw toxic release data, returning a single SpatVector (points) object for the selected year.

Usage

```
process_tri(
  path = NULL,
  year = 2018,
  variables = c(1, 13, 12, 14, 20, 34, 36, 47, 48, 49),
  extent = NULL,
  ...
)
```

Arguments

path	character(1). Path to the directory with TRI CSV files
year	integer(1). Single year to select.
variables	integer. Column index of TRI data.
extent	numeric(4) or SpatExtent giving the extent of the raster if NULL (default), the entire raster is loaded
...	Placeholders.

Value

a SpatVector object (points) in year year is stored in a field named "year".

Note

Visit [TRI Data and Tools](#) to view the available years and variables.

Author(s)

Insang Song, Mariana Kassien

References

<https://www.epa.gov/toxics-release-inventory-tri-program/tri-toolbox>

Examples

```
## NOTE: Example is wrapped in `dontrun{}` as function requires a large
## amount of data which is not included in the package.
## Not run:
tri <- process_tri(
  path = "./data",
  year = 2020,
  variables = c(1, 13, 12, 14, 20, 34, 36, 47, 48, 49)
)

## End(Not run)
```

sftime_as_mysftime	<i>Convert an sftime to a mysftime</i>
--------------------	--

Description

Convert an sftime object to a mysftime object. x must contain a time-defining column, identified in timename.

Usage

```
sftime_as_mysftime(x, timename)
```

Arguments

x	an sftime object
timename	character: name of time column in x

Value

an sftime object with specific format

Author(s)

Eva Marques

See Also

[check_mysftime](#)

sftime_as_sf	<i>Convert an sftime to an sf</i>
--------------	-----------------------------------

Description

Convert an sftime object to an sf object. x must contain a time-defining column, identified in timename.

Usage

```
sftime_as_sf(x, keeptime = TRUE)
```

Arguments

x	an sftime object
keeptime	boolean: TRUE if user wants to keep time column as simple column (default = TRUE)

Value

an sf object

Author(s)

Eva Marques

sftime_as_spatraster *Convert an sftime to a SpatRaster*

Description

Convert an sftime object to a SpatRaster object. Returns a SpatRaster with one layer for each time step in x.

Usage

```
sftime_as_spatraster(x, varname)
```

Arguments

x	an sftime object
varname	variable to rasterize

Value

a SpatRaster object

Note

Running sftime_as_spatraster can take a long time if x is not spatially structured.

Author(s)

Eva Marques

See Also

[terra::rast](#)

sftime_as_spatrds *Convert an sftime to a SpatRasterDataset*

Description

Convert an sftime object to a SpatRasterDataset object.

Usage

```
sftime_as_spatrds(x)
```

Arguments

x	an sftime object
---	------------------

Value

an `SpatRasterDataset` object

Note

Running `sftime_as_spatrds` can take a long time if `x` is not spatially and temporally structured.

Author(s)

Eva Marques

See Also

[terra::sds](#)

<code>sftime_as_spatvector</code>	<i>Convert an sftime to a SpatVector</i>
-----------------------------------	--

Description

Convert an `sftime` object to a `SpatVector` object.

Usage

```
sftime_as_spatvector(x)
```

Arguments

<code>x</code>	an <code>sftime</code> object
----------------	-------------------------------

Value

a `SpatVector` object

Author(s)

Eva Marques

See Also

[terra::vect](#)

sf_as_mysftime	<i>Convert an sf to an sftime</i>
----------------	-----------------------------------

Description

Convert an sf object to an sftime object. x must contain a time-defining column, identified in timename.

Usage

```
sf_as_mysftime(x, timename)
```

Arguments

x	an sf object
timename	character: name of time column in x

Value

an sftime object

Author(s)

Eva Marques

spatraster_as_sftime	<i>Convert a SpatRaster to an sftime</i>
----------------------	--

Description

Convert a SpatRaster object to an sftime object. x must contain a time-defining column, identified in timename.

Usage

```
spatraster_as_sftime(x, varname, timename = "time")
```

Arguments

x	a SpatRaster object
varname	character for variable column name in the sftime
timename	character for time column name in the sftime (default: "time")

Value

a sftime object

Author(s)

Eva Marques

See Also

[terra::rast](#)

spatrds_as_sftime	<i>Convert a SpatRasterDataset to an sftime</i>
-------------------	---

Description

Convert a SpatRasterDataset object to an sftime object. x must contain a time-defining column, identified in timename.

Usage

```
spatrds_as_sftime(x, timename = "time")
```

Arguments

x	a SpatRasterDataset object (~ list of named SpatRasters)
timename	character for time column name in the sftime (default: "time")

Value

an sftime object

Author(s)

Eva Marques

See Also

[terra::sds](#)

spatvector_as_sftime	<i>Convert a SpatVector to an sftime</i>
----------------------	--

Description

Convert a SpatVector object to an sftime object. x must contain a time-defining column, identified in timename.

Usage

```
spatvector_as_sftime(x, timename = "time")
```

Arguments

x	a SpatVector object
timename	character for time column name in x (default: "time")

Value

an sftime object

Author(s)

Eva Marques

See Also

[terra::vect](#)

sum_edc	<i>Calculate isotropic Sum of Exponentially Decaying Contributions (SEDC) covariates</i>
---------	--

Description

Calculate isotropic Sum of Exponentially Decaying Contributions (SEDC) covariates

Usage

```
sum_edc(
  from = NULL,
  locs = NULL,
  locs_id = NULL,
  sedc_bandwidth = NULL,
  target_fields = NULL,
  geom = FALSE
)
```

Arguments

from	SpatVector(1). Point locations which contain point-source covariate data.
locs	sf/SpatVector(1). Locations where the sum of exponentially decaying contributions are calculated.
locs_id	character(1). Name of the unique id field in point_to.
sedc_bandwidth	numeric(1). Distance at which the source concentration is reduced to $\exp(-3)$ (approximately -95 %)
target_fields	character(varying). Field names in characters.
geom	FALSE/"sf"/"terra".. Should the function return with geometry? Default is FALSE, options with geometry are "sf" or "terra". The coordinate reference system of the sf or SpatVector is that of from.

Value

a data.frame (tibble) or SpatVector object with input field names with a suffix "_sedc" where the sums of EDC are stored. Additional attributes are attached for the EDC information.

- 'attr(result, "sedc_bandwidth")': the bandwidth where concentration reduces to approximately five percent
- 'attr(result, "sedc_threshold")': the threshold distance at which emission source points are excluded beyond that

Note

The function is originally from **chopin**. Distance calculation is done with terra functions internally. Thus, the function internally converts sf objects in point_* arguments to terra. The threshold should be carefully chosen by users.

Author(s)

Insang Song

References

Messier KP, Akita Y, Serre ML (2012). "Integrating Address Geocoding, Land Use Regression, and Spatiotemporal Geostatistical Estimation for Groundwater Tetrachloroethylene." *Environmental Science & Technology*, **46**(5), 2772–2780. ISSN 0013-936X, doi:10.1021/es203152a.

Wiesner C (????). "Euclidean Sum of Exponentially Decaying Contributions Tutorial."

Examples

```
set.seed(101)
ncpath <- system.file("gpkg/nc.gpkg", package = "sf")
nc <- terra::vect(ncpath)
nc <- terra::project(nc, "EPSG:5070")
pnt_locs <- terra::centroids(nc, inside = TRUE)
pnt_locs <- pnt_locs[, "NAME"]
pnt_from <- terra::spatSample(nc, 10L)
```

```
pnt_from$pid <- seq(1, 10)
pnt_from <- pnt_from[, "pid"]
pnt_from$val1 <- rgamma(10L, 1, 0.05)
pnt_from$val2 <- rgamma(10L, 2, 1)

vals <- c("val1", "val2")
sum_edc(pnt_locs, pnt_from, "NAME", 1e4, vals)
```

Index

* **spacetime**

- as_mysftime, 3
- dt_as_mysftime, 66
- sf_as_mysftime, 93
- sftime_as_mysftime, 89
- sftime_as_sf, 90
- sftime_as_spatraster, 91
- sftime_as_spatrds, 91
- sftime_as_spatvector, 92
- spatraster_as_sftime, 93
- spatrds_as_sftime, 94
- spatvector_as_sftime, 95

as_mysftime, 3

base::list.files, 80

base::regex, 80

calculate_covariates, 4

calculate_covariates(), 16

calculate_ecoregion, 5, 6

calculate_geos, 5, 7

calculate_geos(), 17

calculate_gmted, 5, 8

calculate_gridmet, 5, 10

calculate_groads, 5, 11

calculate_hms, 5, 13

calculate_koppen_geiger, 5, 14

calculate_lagged, 15

calculate_merra2, 5, 16

calculate_modis, 5, 18, 81

calculate_modis_daily, 18

calculate_modis_daily(), 20

calculate_narr, 5, 20

calculate_nei, 5, 22

calculate_nlcd, 5, 23

calculate_population, 5, 24

calculate_temporal_dummies, 5, 26

calculate_terraclimate, 5, 27

calculate_tri, 5, 28

check_mysftime, 4, 90

data.frame, 4

data.table::data.table, 4

download_aqs, 30, 32

download_aqs(), 68

download_cropscape, 33

download_data, 31, 70, 80

download_ecoregion, 32, 33

download_edgar, 33

download_geos, 32, 35

download_gmted, 32, 37

download_gridmet, 33, 39

download_groads, 33, 40

download_hms, 33, 42

download_huc, 33

download_koppen_geiger, 33, 43

download_merra2, 33, 45

download_modis, 33, 53

download_narr, 33, 56

download_nei, 33, 58

download_nlcd, 33, 60

download_population, 33, 62

download_prism, 33

download_terraclimate, 33, 63

download_tri, 33, 65

dt_as_mysftime, 66

exactextractr::exact_extract, 19, 23

exactextractr::exact_extract(), 23

process_aqs, 67, 71

process_blackmarble, 68, 70

process_blackmarble(), 20

process_blackmarble_corners, 69

process_covariates, 70

process_cropscape, 71

process_ecoregion, 6, 7, 70, 71, 71

process_geos, 71, 72

process_geos(), 8

process_gmted, [71, 73](#)
process_gmted(), [9](#)
process_gridmet, [71, 74](#)
process_gridmet(), [11](#)
process_groads, [12, 71, 75](#)
process_hms, [71, 76](#)
process_hms(), [13](#)
process_huc, [71](#)
process_koppen_geiger, [15, 70, 77](#)
process_merra2, [71, 78](#)
process_merra2(), [17](#)
process_modis_merge, [70, 79](#)
process_modis_merge(), [20](#)
process_modis_sds, [81](#)
process_modis_swath, [70, 82](#)
process_modis_swath(), [20](#)
process_modis_warp(), [83](#)
process_narr, [21, 71, 83](#)
process_nei, [22, 70, 84](#)
process_nlcd, [24, 70, 85](#)
process_population, [71, 86](#)
process_population(), [25](#)
process_prism, [71](#)
process_terraclimate, [71, 87](#)
process_terraclimate(), [28](#)
process_tri, [29, 70, 88](#)

regexp, [81](#)

sf_as_mysftime, [4, 93](#)
sftime_as_mysftime, [89](#)
sftime_as_sf, [90](#)
sftime_as_spatraster, [91](#)
sftime_as_spatrds, [91](#)
sftime_as_spatvector, [92](#)
spatraster_as_sftime, [93](#)
spatrds_as_sftime, [94](#)
spatvector_as_sftime, [95](#)
stars::read_stars(), [83](#)
stars::st_warp(), [83](#)
sum_edc, [29, 95](#)

terra::describe, [69](#)
terra::describe(), [83](#)
terra::freq(), [23](#)
terra::merge, [69](#)
terra::rast, [4, 91, 94](#)
terra::rast(), [83](#)
terra::sds, [4, 92, 94](#)
terra::sprc(), [83](#)
terra::tapp, [80](#)
terra::vect, [4, 92, 95](#)