

Package ‘hurricaneexposure’

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Type Package

Title Explore and Map County-Level Hurricane Exposure in the United States

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Description Allows users to create time series of tropical storm exposure histories for chosen counties for a number of hazard metrics (wind, rain, distance from the storm, etc.). This package interacts with data available through the 'hurricaneexposedata' package, which is available in a 'drat' repository. To access this data package, run 'install.packages("`hurricaneexposedata", repos = "`https://geanders.github.io/drat/", type = "`source")'. The size of the 'hurricaneexposedata' package is approximately 25 MB. This work was supported in part by grants from the National Institute of Environmental Health Sciences (R00ES022631), the National Science Foundation (1331399), and a NASA Applied Sciences Program/Public Health Program Grant (NNX09AV81G).

URL <https://github.com/geanders/hurricaneexposure>

BugReports <https://github.com/geanders/hurricaneexposure/issues>

License GPL-2

LazyData TRUE

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Author Brooke Anderson [aut, cre],
 Meilin Yan [aut],
 Joshua Ferreri [aut],
 William Crosson [ctb],
 Mohammad Al-Hamdan [ctb],
 Andrea Schumacher [ctb],
 Dirk Eddelbuettel [ctb]

Maintainer Brooke Anderson <brooke.anderson@colostate.edu>

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county_distance	<i>Hurricane exposure by distance for counties</i>
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Description

This function takes a list of US counties, based on their 5-digit Federal Information Processing Standard (FIPS) codes, boundaries on the range of years to be considered, and thresholds for distance between each county and the storm track for the county to be considered "exposed" to the storm. Based on these inputs, the function returns a dataframe with the subset of Atlantic basin storms meeting those criteria for each of the listed counties.

Usage

```
county_distance(counties, start_year, end_year, dist_limit)
```

Arguments

counties	Character vector of the five-digit Federal Information Processing Standard (FIPS) codes for counties for which the user wants to determine storm exposure.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
dist_limit	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.

Details

For more information on how distances between counties and storm tracks are calculated for this function, see the documentation for the `closest_dist` dataset that comes with this package.

Value

Returns a dataframe with a row for each county-storm pair and with columns for:

- `storm_id`: Unique storm identifier with the storm name and year, separated by a hyphen (e.g., "Alberto-1988", "Katrina-2005")
- `fips`: County's 5-digit Federal Information Processing Standard (FIPS) code
- `closest_date`: Date (based on local time) of the closest approach of the storm to the county's population mean center.
- `storm_dist`: Minimum distance (in kilometers) between the storm's track and the county's population mean center.
- `local_time`: Local time of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.
- `closest_time_utc`: Time, in UTC, of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.

Note

Only counties in states in the eastern half of the United States can be processed by this function.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposedata", quietly = TRUE)) {

  county_distance(counties = c("22071", "51700"),
                  start_year = 1995, end_year = 2005,
                  dist_limit = 75)

}
```

 county_events

Find events for storms by county

Description

Takes a list of US counties, based on their 5-digit Federal Information Processing Standard (FIPS) codes, boundaries on the range of years to be considered, and the type of event (e.g., "flood", "tornado") and returns a list of all storms with listings for that type of event for the counties. This output is based on listings in the NOAA Storm Events database. See the help documentation for the storm_events dataset for more information and references on the data source used by this function.

Usage

```
county_events(counties, start_year, end_year, event_type)
```

Arguments

counties	Character vector of the five-digit Federal Information Processing Standard (FIPS) codes for counties for which the user wants to determine storm exposure.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
event_type	Character string with the type of event to use to identify county exposures. Options include "flood", "tornado", "wind", and "tropical storm".

Note

Of the event types that this function can pull, only "tornado" and "wind" are available for years before 1996. Therefore, this function will pull listed tornado events or wind events for all years, but for any other event type, you should not use a start year prior to 1996, as events of other types were not recorded in the database before 1996.

#' @return Returns a dataframe with a row for each county-storm pair and with columns for:

- fips: County's 5-digit Federal Information Processing Standard (FIPS) code
- storm_id: Unique storm identifier with the storm name and year, separated by a hyphen(e.g., "Alberto-1988", "Katrina-2005")

- `closest_time_utc`: Time, in UTC, of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.
- `storm_dist`: Minimum distance (in kilometers) between the storm's track and the county's population mean center.
- `local_time`: Local time of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.
- `closest_date`: Date (based on local time) of the closest approach of the storm to the county's population mean center.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  county_events(counties = c("37031", "37053", "37055"),
                start_year = 1996, end_year = 2015,
                event_type = "flood")
}
```

county_rain

Hurricane exposure by rain for counties

Description

This function takes a list of US counties, based on their 5-digit Federal Information Processing Standard (FIPS) codes, boundaries on the range of years to be considered, thresholds for distance between each county and the storm track, as well as minimum rainfall over a certain time window for the county to be considered "exposed" to the storm. Based on these inputs, the function returns a dataframe with the subset of Atlantic basin storms meeting those criteria for each of the listed counties.

Usage

```
county_rain(counties, start_year, end_year, rain_limit, dist_limit,
            days_included = c(-2, -1, 0, 1))
```

Arguments

<code>counties</code>	Character vector of the five-digit Federal Information Processing Standard (FIPS) codes for counties for which the user wants to determine storm exposure.
<code>start_year</code>	Four-digit integer with first year to consider.
<code>end_year</code>	Four-digit integer with last year to consider.
<code>rain_limit</code>	Minimum of rainfall, in millimeters, summed across the days selected to be included (<code>days_included</code>), that must fall in a county for the county to be classified as "exposed" to the storm.

<code>dist_limit</code>	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.
<code>days_included</code>	A numeric vector listing the days to include when calculating total precipitation. Negative numbers are days before the closest date of the storm to a county. For example, <code>c(-1, 0, 1)</code> would calculate rain for a county as the sum of the rainfall for the day before, the day of, and the day after the date when the storm center was closest to the county center. Values can range from -5 to 3 (i.e., at most, you can calculate the total rainfall from five days to three days after the day when the storm is closest to the county).

Value

Returns a dataframe with a row for each county-storm pair and with columns for:

- `storm_id`: Unique storm identifier with the storm name and year, separated by a hyphen (e.g., "Alberto-1988", "Katrina-2005")
- `fips`: County's 5-digit Federal Information Processing Standard (FIPS) code
- `closest_date`: Date (based on local time) of the closest approach of the storm to the county's population mean center.
- `storm_dist`: Minimum distance (in kilometers) between the storm's track and the county's population mean center.
- `tot_precip`: Cumulative rainfall, in millimeters, in the county for the days selected using the `days_included` option.
- `local_time`: Local time of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.
- `closest_time_utc`: Time, in UTC, of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.

References

Al-Hamdan MZ, Crosson WL, Economou SA, Estes MG, Estes SM, Hemmings SN, Kent ST, Puckette M, Quattrochi DA, Rickman DL, Wade GM, McClure LA, 2014. Environmental public health applications using remotely sensed data. *Geocarto International* 29(1):85-98.

North America Land Data Assimilation System (NLDAS) Daily Precipitation years 1979-2011 on CDC WONDER Online Database, released 2012. <http://wonder.cdc.gov/wonder/help/Precipitation.html>

Rui H, Mocko D, 2014. README Document for North America Land Data Assimilation System Phase 2 (NLDAS-2) Products. Goddard Earth Sciences Data and Information Services Center.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {
```

```

county_rain(counties = c("22071", "51700"),
            start_year = 1995, end_year = 2005,
            rain_limit = 100, dist_limit = 100)
}

```

county_wind

Hurricane exposure by wind for counties

Description

This function takes a list of US counties, based on their 5-digit Federal Information Processing Standard (FIPS) codes, boundaries on the range of years to be considered, and thresholds for wind speed (in meters per second) (or, alternatively, duration of winds at or above 20 m / s in minutes) for each county to be considered "exposed" to the storm. Based on these inputs, the function returns a dataframe with the subset of Atlantic basin storms meeting those criteria for each of the listed counties.

Usage

```

county_wind(counties, start_year, end_year, wind_limit,
            wind_var = "vmax_sust", wind_source = "modeled")

```

Arguments

counties	Character vector of the five-digit Federal Information Processing Standard (FIPS) codes for counties for which the user wants to determine storm exposure.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
wind_limit	A numeric vector of length one giving the minimum wind speed (in meters per second) or duration of winds of 20 m / s or more (in minutes) to use in the filter. The units of this variable will depend on the user's choice for the wind_var parameter. If the Extended Best Tracks wind radii are used as the source of the wind data, the sustained winds will only be available for cutpoints of 34 knots, 50 knots, and 64 knots, so these values should be used (e.g., to get all counties with winds of 34 knots or higher, you could use wind_limit = 17.4, with the limit given as a value just below 34 knots in the units meters per second).
wind_var	A character string giving the wind variable to use. Choices are "vmax_sust" (maximum sustained winds; default), "vmax_gust" (maximum gust winds), "sust_dur" (minutes of sustained winds of 20 m / s or higher) and "gust_dur" (minutes of gust winds of 20 m / s or higher). If the Extended Best Tracks wind radii are used as the source of wind data, the "gust_dur" option cannot be selected.
wind_source	A character string specifying the source to use for the winds. Options are "modeled", for estimates based on running a wind model from Best Tracks data inputs, and "ext_tracks", for estimates based on the wind radii in the Extended Best Tracks data. See the help files for the datasets storm_winds and

ext_tracks_wind in the hurricaneexposuredata package for more details on each of these sources for wind estimates. For the gust wind estimates, these are based on applying a gust factor of 1.49 to the sustained wind estimates in both wind data sources.

Details

For more information on how wind speeds are modeled in this data, see the documentation for the stormwindmodel R package.

Value

Returns a dataframe with a row for each county-storm pair and with columns for:

- storm_id: Unique storm identifier with the storm name and year, separated by a hyphen(e.g., "Alberto-1988", "Katrina-2005")
- fips: County's 5-digit Federal Information Processing Standard (FIPS) code
- max_sust: Maximum sustained wind speed (in m / s)
- max_gust: Maximum gust wind speed (in m / s)
- sust_dur: Minutes sustained wind speed was 20 m / s or higher
- gust_dur: Minutes gust wind speed was 20 m / s or higher (only returned if the modeled winds are requested using wind_source)

Note

Only counties in states in the eastern half of the United States can be processed by this function. Winds are modeled at 15-minute increments, so all duration estimates (sust_dur and gust_dur in the output) will be divisible by 15.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  county_wind(counties = c("22071", "51700"),
              start_year = 1988, end_year = 2005,
              wind_limit = 20, wind_var = "vmax_sust")
}
```

`default_map`*Create a default map with eastern US states*

Description

Creates a ggplot object with the underlying map of all states in the eastern section of the US that might be prone to hurricane-related exposure. Other lines and points can be added to the output using ggplot2 plotting functions.

Usage

```
default_map()
```

Details

Only states in the eastern half of the United States (i.e., ones prone to exposure to Atlantic basin tropical storms) are included on this map.

Value

A ggplot object that maps the states of the Eastern United States

Examples

```
default_map()
```

`distance_exposure`*Write storm distance exposure files*

Description

This function takes an input of locations (either a vector of county FIPS or a dataframe of multi-county FIPS, with all FIPS listed for each county) and creates a dataframe with storm listings and dates that can be merged with time series of health or other outcomes, giving the dates and exposures for all storms meeting the given storm distance criteria.

Usage

```
distance_exposure(locations, start_year, end_year, dist_limit, out_dir,  
  out_type = "csv")
```

Arguments

locations	Either a vector of FIPS county codes, for county-level output, or a dataframe with columns for community identifier (commun) and associated FIPS codes (fips), for multi-county community output. See the examples for the proper format for this argument.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
dist_limit	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.
out_dir	Character string giving the pathname of the directory in which to write output. This directory should already exist on your computer.
out_type	Character string giving the type of output files you'd like. Options are "csv" (default) and "rds".

Value

Writes out a directory with rain exposure files for each county or community indicated. For more on the columns in this output, see the documentation for [county_rain](#) and [multi_county_rain](#).

Examples

```
## Not run:
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

# By county
distance_exposure(locations = c("22071", "51700"),
                  start_year = 1995, end_year = 2005,
                  dist_limit = 75,
                  out_dir = "~/tmp/storms")

# For multi-county communities
communities <- data.frame(commun = c(rep("ny", 6), "no", "new"),
                          fips = c("36005", "36047", "36061",
                                    "36085", "36081", "36119",
                                    "22071", "51700"))
distance_exposure(locations = communities,
                  start_year = 1995, end_year = 2005,
                  dist_limit = 75,
                  out_dir = "~/tmp/storms")
}

## End(Not run)
```

filter_storm_data	<i>Filter hurricane datasets</i>
-------------------	----------------------------------

Description

This function is a helper function for many of the the other functions in this package that measure exposure.

Usage

```
filter_storm_data(counties = NULL, storm = NULL, year_range = NULL,
  distance_limit = NULL, rain_limit = NULL, include_rain = FALSE,
  days_included = NULL, output_vars = c("fips"))
```

Arguments

counties	A character vector listing all 5-digit county FIPS codes for a subset of counties.
storm	A character string giving the storm ID (e.g., "Floyd-1999")
year_range	A numeric vector of length two with the starting and ending year to subset to.
distance_limit	A numeric vector of length one giving the maximum distance (in kilometers) to use in the filter
rain_limit	A numeric vector of length one giving the minimum rain (in millimeters) to use in the filter
include_rain	A logical specifying whether to pull in rain data to use in the filter or give as output (default is FALSE)
days_included	A numeric vector giving the lag numbers for days to include when calculating the total rain over the storm period (e.g., c(-1, 0, 1, 2) would calculate the rain from the day before the storm until two days after the storm). Values in this vector cannot be lower than -3 or higher than 3.
output_vars	A character vector listing all the columns to include in the output.

Value

A dataframe with storms filtered based on the input criteria to the function. Columns in the output will vary depending on the user's selections for the output_vars argument.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposedata", quietly = TRUE)) {

  filter_storm_data(counties = c("22071", "51700"), year_range = c(1988, 2011),
    distance_limit = 250, rain_limit = 150,
    include_rain = TRUE, days_included = c(-1, 0, 1),
```

```

        output_vars = c("fips", "storm_id", "closest_date",
                        "storm_dist", "tot_precip"))
filter_storm_data(storm = "Floyd-1999", include_rain = TRUE,
                  days_included = c(-1, 0, 1),
                  output_vars = c("fips", "tot_precip"))
}

```

filter_wind_data *Filter hurricane wind dataset*

Description

This function is a helper function for many of the other functions in this package that measure wind exposure.

Usage

```

filter_wind_data(counties = NULL, storm = NULL, year_range = NULL,
                 wind_limit = NULL, output_vars = "fips", wind_var = "vmax_sust",
                 wind_source = "modeled")

```

Arguments

counties	A character vector listing all 5-digit county FIPS codes for a subset of counties.
storm	A character string giving the storm ID (e.g., "Floyd-1999")
year_range	A numeric vector of length two with the starting and ending year to subset to.
wind_limit	A numeric vector of length one giving the minimum wind speed (in meters per second) or duration of winds of 20 m / s or more (in minutes) to use in the filter. The units of this variable will depend on the user's choice for the wind_var parameter. If the Extended Best Tracks wind radii are used as the source of the wind data, the sustained winds will only be available for cutpoints of 34 knots, 50 knots, and 64 knots, so these values should be used (e.g., to get all counties with winds of 34 knots or higher, you could use wind_limit = 17.4, with the limit given as a value just below 34 knots in the units meters per second).
output_vars	A character vector listing all the columns to include in the output.
wind_var	A character string giving the wind variable to use. Choices are "vmax_sust" (maximum sustained winds; default), "vmax_gust" (maximum gust winds), "sust_dur" (minutes of sustained winds of 20 m / s or higher) and "gust_dur" (minutes of gust winds of 20 m / s or higher). If the Extended Best Tracks wind radii are used as the source of wind data, the "gust_dur" option cannot be selected.
wind_source	A character string specifying the source to use for the winds. Options are "modeled", for estimates based on running a wind model from Best Tracks data inputs, and "ext_tracks", for estimates based on the wind radii in the Extended Best Tracks data. See the help files for the datasets storm_winds and ext_tracks_wind in the hurricaneexposedata package for more details on

each of these sources for wind estimates. For the gust wind estimates, these are based on applying a gust factor of 1.49 to the sustained wind estimates in both wind data sources.

Value

A dataframe with storms filtered based on the input criteria to the function. Columns in the output will vary depending on the user's selections for the `output_vars` argument.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposure", quietly = TRUE)) {

  filter_wind_data(counties = c("22071", "51700"), year_range = c(1988, 2011),
                  wind_limit = 20,
                  output_vars = c("fips", "storm_id", "vmax_sust"))
}
```

get_eastern_map	<i>Get map data for eastern US states</i>
-----------------	---

Description

Get map data for eastern US states

Usage

```
get_eastern_map(map = "county")
```

Arguments

`map` A character string giving the map database from which to pull

Value

A dataframe with map data pulled using the `map_data` function in `ggplot2`, filtered to states in the eastern half of the United States.

hurr_choropleth *Create a map customized for this package*

Description

Creates a county choropleth map customized for displaying hurricane exposure. This function is used as a helper function within other mapping functions in the package.

Usage

```
hurr_choropleth(map_data, metric = "distance", wind_var = "vmax_sust",
  wind_source = "modeled")
```

Arguments

map_data	A dataframe with columns with FIPS numbers (in numeric class) for all counties in the eastern US (region) and the exposure value (value)
metric	Character string giving the metric to plot. Current options are "distance", "wind", and "rainfall". These options are used to customize the color palette and scale of the choropleth map produced by this function.
wind_var	A character string giving the wind variable to use. Choices are "vmax_sust" (maximum sustained winds; default), "vmax_gust" (maximum gust winds), "sust_dur" (minutes of sustained winds of 20 m / s or higher) and "gust_dur" (minutes of gust winds of 20 m / s or higher). If the Extended Best Tracks wind radii are used as the source of wind data, the "gust_dur" option cannot be selected.
wind_source	A character string specifying the source to use for the winds. Options are "modeled", for estimates based on running a wind model from Best Tracks data inputs, and "ext_tracks", for estimates based on the wind radii in the Extended Best Tracks data. See the help files for the datasets storm_winds and ext_tracks_wind in the hurricaneexposedata package for more details on each of these sources for wind estimates. For the gust wind estimates, these are based on applying a gust factor of 1.49 to the sustained wind estimates in both wind data sources.

Details

The function only maps counties in states likely to be exposed to Atlantic basin tropical storms.

Value

A ggplot object with a map of hurricane exposure in eastern US counties

interp_track	<i>Interpolate a storm track</i>
--------------	----------------------------------

Description

This function takes a wider-spaced storm track (e.g., every 6 hours) and interpolates to a finer interval (e.g., every 15 minutes). To do this, it fits GLMs of latitude and longitude regressed on natural cubic splines of date-time, and then predicts these splines to new intervals. These splines use degrees of freedom equal to the number of original observations divided by two.

Usage

```
interp_track(track, tint = 0.25)
```

Arguments

track	A dataframe with hurricane track data for a single storm
tint	A numeric vector giving the time interval to impute to, in units of hours (e.g., 0.25, the default, interpolates to 15 minute-intervals).

Value

A dataframe with hurricane track data for a single storm, interpolated to the interval specified by tint.

map_counties	<i>Map counties</i>
--------------	---------------------

Description

Map counties

Usage

```
map_counties(storm, metric = "distance", wind_var = "vmax_sust",  
             days_included = c(-2, -1, 0, 1), add_track = TRUE,  
             wind_source = "modeled")
```

Arguments

storm	Character string giving the name of the storm to plot (e.g., "Floyd-1999")
metric	Character string giving the metric to plot. Current options are "distance", "wind", and "rainfall". These options are used to customize the color palette and scale of the choropleth map produced by this function.
wind_var	A character string giving the wind variable to use. Choices are "vmax_sust" (maximum sustained winds; default), "vmax_gust" (maximum gust winds), "sust_dur" (minutes of sustained winds of 20 m / s or higher) and "gust_dur" (minutes of gust winds of 20 m / s or higher). If the Extended Best Tracks wind radii are used as the source of wind data, the "gust_dur" option cannot be selected.
days_included	A numeric vector listing the days to include when calculating total precipitation. Negative numbers are days before the closest date of the storm to a county. For example, c(-1, 0, 1) would calculate rain for a county as the sum of the rainfall for the day before, the day of, and the day after the date when the storm center was closest to the county center. Values can range from -5 to 3 (i.e., at most, you can calculate the total rainfall from five days to three days after the day when the storm is closest to the county).
add_track	TRUE / FALSE of whether to add the storm's track to the map. The default is TRUE.
wind_source	A character string specifying the source to use for the winds. Options are "modeled", for estimates based on running a wind model from Best Tracks data inputs, and "ext_tracks", for estimates based on the wind radii in the Extended Best Tracks data. See the help files for the datasets storm_winds and ext_tracks_wind in the hurricaneexposedata package for more details on each of these sources for wind estimates. For the gust wind estimates, these are based on applying a gust factor of 1.49 to the sustained wind estimates in both wind data sources.

Value

This function creates a choropleth map of counties in the eastern part of the United States, showing distance from a storm track, maximum wind speed (or duration of winds at or above 20 m / s), or total rainfall over a given window of one or more days near the date of the storm's closest approach.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposedata", quietly = TRUE)) {

  map_counties("Floyd-1999", metric = "rainfall", days_included = c(-2, -1, 0, 1))

  map_counties("Katrina-2005", metric = "wind")
  map_counties("Katrina-2005", metric = "wind", wind_var = "vmax_gust")
  map_counties("Katrina-2005", metric = "wind", wind_var = "sust_dur")
  map_counties("Katrina-2005", metric = "wind", wind_source = "ext_tracks")
}
```

```
}
```

map_distance_exposure *Map counties with distance exposure*

Description

Map counties as "exposed" or "unexposed" based on the criterion that the storm came within a given distance (specified by `dist_limit`) of the county's population mean center.

Usage

```
map_distance_exposure(storm, dist_limit, add_track = TRUE)
```

Arguments

<code>storm</code>	Character string giving the name of the storm to plot (e.g., "Floyd-1999")
<code>dist_limit</code>	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.
<code>add_track</code>	TRUE / FALSE of whether to add the storm's track to the map. The default is TRUE.

Value

Plots a map showing whether eastern US counties were exposed or unexposed to a specific storm based on a distance criterion.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  floyd_map <- map_distance_exposure(storm = "Floyd-1999", dist_limit = 75)
  floyd_map

  allison_map <- map_distance_exposure(storm = "Allison-2001",
                                       dist_limit = 75)
  map_tracks("Allison-2001", plot_points = FALSE, plot_object = allison_map)
}
```

map_event_exposure *Map county-level exposure based on reported events*

Description

Map counties as "exposed" or "unexposed" based on the criterion that the county had an event listing of a specified type in the NOAA Storm Events database. For more information on the underlying data, see the helpfile for the storm_events dataset.

Usage

```
map_event_exposure(storm_id, event_type, add_track = TRUE)
```

Arguments

storm_id	Character vector with the storm for which to map events (e.g., "Katrina-2005")
event_type	Character string with the type of event to use to identify county exposures. Options include "flood", "tornado", "wind", and "tropical storm".
add_track	TRUE / FALSE of whether to add the storm's track to the map. The default is TRUE.

Value

A map showing whether eastern US counties were exposed or unexposed to a specific storm based on event listings.

Note

Note that flood events are not available for any year before 1996.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  map_event_exposure(storm_id = "Floyd-1999", event_type = "flood")
  map_event_exposure(storm_id = "Floyd-1999", event_type = "tornado")
  map_event_exposure(storm_id = "Floyd-1999", event_type = "wind")
  map_event_exposure(storm_id = "Floyd-1999", event_type = "tropical_storm")
}
```

map_rain_exposure	<i>Map counties with rain exposure</i>
-------------------	--

Description

Map counties as "exposed" or "unexposed" based on the criteria that the storm came within a given distance (specified by `dist_limit`) of the county's population mean center and a certain amount of rain `rain_limit` fell during a specified window of days (`days_included`).

Usage

```
map_rain_exposure(storm, rain_limit, dist_limit, days_included = c(-2, -1, 0,
  1), add_track = TRUE)
```

Arguments

<code>storm</code>	Character string giving the name of the storm to plot (e.g., "Floyd-1999")
<code>rain_limit</code>	Minimum of rainfall, in millimeters, summed across the days selected to be included (<code>days_included</code>), that must fall in a county for the county to be classified as "exposed" to the storm.
<code>dist_limit</code>	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.
<code>days_included</code>	A numeric vector listing the days to include when calculating total precipitation. Negative numbers are days before the closest date of the storm to a county. For example, <code>c(-1, 0, 1)</code> would calculate rain for a county as the sum of the rainfall for the day before, the day of, and the day after the date when the storm center was closest to the county center. Values can range from -5 to 3 (i.e., at most, you can calculate the total rainfall from five days to three days after the day when the storm is closest to the county).
<code>add_track</code>	TRUE / FALSE of whether to add the storm's track to the map. The default is TRUE.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  map_rain_exposure(storm = "Floyd-1999", rain_limit = 50, dist_limit = 100)

  # Example of customizing track appearance
  allison_map <- map_rain_exposure(storm = "Allison-2001", rain_limit = 125,
    dist_limit = 100, days_included = -5:3,
    add_track = FALSE)
  map_tracks("Allison-2001", plot_object = allison_map, plot_points = TRUE)
}
```

map_tracks

*Plot Atlantic basin hurricane tracks***Description**

Plot the tracks of any selected storms in the hurricane tracking dataset for the Atlantic basin. This function allows you to plot a new map or add the tracks to an existing ggplot object.

Usage

```
map_tracks(storms, plot_object = NULL, padding = 2, plot_points = FALSE,
           alpha = 1, color = "firebrick")
```

Arguments

storms	Character vector with the names of all storms to plot. This parameter must use the unique storm identifiers from the 'storm_id' column of the 'hurr_tracks' dataframe.
plot_object	NULL or the name of a ggplot object to use as the underlying plot object. If NULL, the function will generate a new map of the eastern US states using 'default_map'.
padding	Numerical value giving the number of degrees to add to the outer limits of the plot object (or default map if 'plot_object' is left as NULL) when cropping hurricane tracks.
plot_points	TRUE / FALSE indicator of whether to include points, as well as lines, when plotting the hurricane tracks. These points show the times for which observations were recorded in the hurricane track data.
alpha	Numerical value designating the amount of transparency to use for plotting tracks.
color	Character string giving the color to use to plot the tracks.

Value

Returns a ggplot object with plotting data for the storm tracks of the selected storms. This object can be printed directly or added to with other ggplot2 commands.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the 'hurricaneexposure' package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposedata", quietly = TRUE)) {

  map_tracks(storms = "Sandy-2012")
  map_tracks(storms = "Floyd-1999", plot_points = TRUE)
  map_tracks(storms = c("Sandy-2012", "Floyd-1999"))
}
```

```

a <- map_tracks(storms = "Sandy-2012", color = "blue", alpha = 0.3)
b <- map_tracks(storms = "Floyd-1999", plot_object = a)
b
}

```

map_wind_exposure *Map counties with wind exposure*

Description

Map counties as "exposed" or "unexposed" based on the criterion that the storm had a certain wind speed (specified by `wind_limit`, in meters per second).

Usage

```

map_wind_exposure(storm, wind_var = "vmax_sust", wind_limit,
  add_track = TRUE, wind_source = "modeled")

```

Arguments

<code>storm</code>	A character string giving the storm ID (e.g., "Floyd-1999")
<code>wind_var</code>	A character string giving the wind variable to use. Choices are "vmax_sust" (maximum sustained winds; default), "vmax_gust" (maximum gust winds), "sust_dur" (minutes of sustained winds of 20 m / s or higher) and "gust_dur" (minutes of gust winds of 20 m / s or higher). If the Extended Best Tracks wind radii are used as the source of wind data, the "gust_dur" option cannot be selected.
<code>wind_limit</code>	A numeric vector of length one giving the minimum wind speed (in meters per second) or duration of winds of 20 m / s or more (in minutes) to use in the filter. The units of this variable will depend on the user's choice for the <code>wind_var</code> parameter. If the Extended Best Tracks wind radii are used as the source of the wind data, the sustained winds will only be available for cutpoints of 34 knots, 50 knots, and 64 knots, so these values should be used (e.g., to get all counties with winds of 34 knots or higher, you could use <code>wind_limit = 17.4</code> , with the limit given as a value just below 34 knots in the units meters per second).
<code>add_track</code>	TRUE / FALSE of whether to add the storm's track to the map. The default is TRUE.
<code>wind_source</code>	A character string specifying the source to use for the winds. Options are "modeled", for estimates based on running a wind model from Best Tracks data inputs, and "ext_tracks", for estimates based on the wind radii in the Extended Best Tracks data. See the help files for the datasets <code>storm_winds</code> and <code>ext_tracks_wind</code> in the <code>hurricaneexposedata</code> package for more details on each of these sources for wind estimates. For the gust wind estimates, these are based on applying a gust factor of 1.49 to the sustained wind estimates in both wind data sources.

Value

Plots a map showing whether eastern US counties were exposed or unexposed to a specific storm based on a wind criterion.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  map_wind_exposure(storm = "Beryl-1988", wind_limit = 15)
}
```

multi_county_distance *Hurricane exposure by distance for communities*

Description

This function takes a dataframe with multi-county communities and returns a community-level dataframe of "exposed" storms, based on the shortest distance between the storm's track and the population-based centers of each county in the community.

Usage

```
multi_county_distance(communities, start_year, end_year, dist_limit)
```

Arguments

communities	A dataframe with the FIPS codes for all counties within each community. It must include columns with a column identifier (<i>commun</i>) and with the FIPS codes of counties included in each community (<i>fips</i>). See the example code.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
dist_limit	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.

Value

Returns the same type dataframe as *county_distance*, but with storms listed by community instead of county.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

  communities <- data.frame(commun = c(rep("ny", 6), "no", "new"),
                            fips = c("36005", "36047", "36061",
                                      "36085", "36081", "36119",
                                      "22071", "51700"))

  distance_df <- multi_county_distance(communities = communities,
                                       start_year = 1995, end_year = 2005,
                                       dist_limit = 75)

}
```

multi_county_rain *Hurricane exposure by rain for communities*

Description

This function takes a dataframe with multi-county communities (see example for the proper format) and returns a community-level dataframe of storms to which the community was exposed, based on the average distance between the storm's track and the population-based centers of each county in the community and the given threshold of rainfall, summed over the days included in the rainfall measurement.

Usage

```
multi_county_rain(communities, start_year, end_year, rain_limit, dist_limit,
                  days_included = c(-2, -1, 0, 1))
```

Arguments

communities	A dataframe with the FIPS codes for all counties within each community. It must include columns with a column identifier (commun) and with the FIPS codes of counties included in each community (fips). See the example code.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
rain_limit	Minimum of rainfall, in millimeters, summed across the days selected to be included (days_included), that must fall in a county for the county to be classified as "exposed" to the storm.
dist_limit	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.

`days_included` A numeric vector listing the days to include when calculating total precipitation. Negative numbers are days before the closest date of the storm to a county. For example, `c(-1, 0, 1)` would calculate rain for a county as the sum of the rainfall for the day before, the day of, and the day after the date when the storm center was closest to the county center. Values can range from -5 to 3 (i.e., at most, you can calculate the total rainfall from five days to three days after the day when the storm is closest to the county).

Value

Returns a dataframe with a row for each county-storm pair and with columns for:

- `commun`: Each community's unique id
- `storm_id`: Unique storm identifier with the storm name and year, separated by a hyphen (e.g., "Alberto-1988", "Katrina-2005")
- `closest_date`: Date (based on local time) of the closest approach of the storm to the county's population mean center.
- `local_time`: Local time of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.
- `closest_time_utc`: Time, in UTC, of the closest approach of the storm to the county's population mean center, based on storm tracks linearly interpolated to 15-minute increments.
- `mean_dist`: Average of the minimum distance (in kilometers) between the storm's track and the population mean centers of all the counties in the community.
- `mean_rain`: Average of cumulative rainfall, in millimeters, in the counties in the community for the days selected using the `days_included` option.
- `min_dist`: The smallest minimum distance (in kilometers) between the storm's track and the population mean centers of any of the counties in the community.
- `max_rain`: The maximum cumulative rainfall, in millimeters, in any of the counties in the community for the days selected using the `days_included` option.

References

Al-Hamdan MZ, Crosson WL, Economou SA, Estes MG, Estes SM, Hemmings SN, Kent ST, Puckette M, Quattrochi DA, Rickman DL, Wade GM, McClure LA, 2014. Environmental public health applications using remotely sensed data. *Geocarto International* 29(1):85-98.

North America Land Data Assimilation System (NLDAS) Daily Precipitation years 1979-2011 on CDC WONDER Online Database, released 2012. <http://wonder.cdc.gov/wonder/help/Precipitation.html>

Rui H, Mocko D, 2014. README Document for North America Land Data Assimilation System Phase 2 (NLDAS-2) Products. Goddard Earth Sciences Data and Information Services Center.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {
```

```

communities <- data.frame(commun = c(rep("ny", 6), "no", "new"),
                          fips = c("36005", "36047", "36061",
                                    "36085", "36081", "36119",
                                    "22071", "51700"))
rain_storm_df <- multi_county_rain(communities = communities,
                                  start_year = 1995, end_year = 2005,
                                  rain_limit = 100, dist_limit = 100)
}

```

multi_county_wind *Hurricane exposure by wind for communities*

Description

This function takes a dataframe with multi-county communities and returns a community-level dataframe of "exposed" storms, based on the highest of the maximum sustained wind speed for each county in the community.

Usage

```
multi_county_wind(communities, start_year, end_year, wind_limit)
```

Arguments

communities	A dataframe with the FIPS codes for all counties within each community. It must include columns with a column identifier (commun) and with the FIPS codes of counties included in each community (fips). See the example code.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
wind_limit	A numeric vector of length one giving the minimum wind speed (in meters per second) or duration of winds of 20 m / s or more (in minutes) to use in the filter. The units of this variable will depend on the user's choice for the wind_var parameter. If the Extended Best Tracks wind radii are used as the source of the wind data, the sustained winds will only be available for cutpoints of 34 knots, 50 knots, and 64 knots, so these values should be used (e.g., to get all counties with winds of 34 knots or higher, you could use wind_limit = 17.4, with the limit given as a value just below 34 knots in the units meters per second).

Value

Returns the same type dataframe as county_rain, but with storms listed by community instead of county.

Note

This function currently will only input a threshold for the sustained wind metric. If you would like to use gust winds or duration of winds, you will need to use the county_wind function to pull storms and aggregate to the multi-county community level yourself.

Examples

```
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposedata", quietly = TRUE)) {

  communities <- data.frame(commun = c(rep("ny", 6), "no", "new"),
                            fips = c("36005", "36047", "36061",
                                      "36085", "36081", "36119",
                                      "22071", "51700"))

  wind_df <- multi_county_wind(communities = communities,
                              start_year = 1988, end_year = 2005,
                              wind_limit = 20)

}
```

rain_exposure

Write storm rain exposure files

Description

This function takes an input of locations (either a vector of county FIPS or a dataframe of multi-county FIPS, with all FIPS listed for each county; see examples) and creates time series dataframes with the dates and exposures for all storms meeting the given rainfall and storm distance criteria. These exposure time series can then be merged with other time series (e.g., community-specific daily counts of health outcomes).

Usage

```
rain_exposure(locations, start_year, end_year, rain_limit, dist_limit,
              days_included = c(-2, -1, 0, 1), out_dir, out_type = "csv")
```

Arguments

locations	Either a vector of FIPS county codes, for county-level output, or a dataframe with columns for community identifier (commun) and associated FIPS codes (fips), for multi-county community output. See the examples for the proper format for this argument.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
rain_limit	Minimum of rainfall, in millimeters, summed across the days selected to be included (days_included), that must fall in a county for the county to be classified as "exposed" to the storm.
dist_limit	Maximum distance, in kilometers, of how close the storm track must come to the county's population mean center to classify the county as "exposed" to the storm.

- `days_included` A numeric vector listing the days to include when calculating total precipitation. Negative numbers are days before the closest date of the storm to a county. For example, `c(-1, 0, 1)` would calculate rain for a county as the sum of the rainfall for the day before, the day of, and the day after the date when the storm center was closest to the county center. Values can range from -5 to 3 (i.e., at most, you can calculate the total rainfall from five days to three days after the day when the storm is closest to the county).
- `out_dir` Character string giving the pathname of the directory in which to write output. This directory should already exist on your computer.
- `out_type` Character string giving the type of output files you'd like. Options are "csv" (default) and "rds".

Value

This function writes out rain exposure files for each county or community indicated to the specified output directory (`out_dir`). For more details on the columns in the output files, see the documentation for [county_rain](#) and [multi_county_rain](#).

Examples

```
## Not run:
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

# By county
rain_exposure(locations = c("22071", "51700"),
              start_year = 1995, end_year = 2005,
              rain_limit = 100, dist_limit = 100,
              out_dir = "~/tmp/storms")

# For multi-county communities
communities <- data.frame(commun = c(rep("ny", 6), "no", "new"),
                          fips = c("36005", "36047", "36061",
                                   "36085", "36081", "36119",
                                   "22071", "51700"))
rain_exposure(locations = communities,
              start_year = 1995, end_year = 2005,
              rain_limit = 100, dist_limit = 100,
              out_dir = "~/tmp/storms")
}

## End(Not run)
```

Description

This function takes an input of locations (either a vector of county FIPS or a dataframe of multi-county FIPS, with all FIPS listed for each county) and creates time series dataframes that can be merged with health time series, giving the dates and exposures for all storms meeting the given storm wind criteria.

Usage

```
wind_exposure(locations, start_year, end_year, wind_limit, wind_var, out_dir,
              out_type = "csv")
```

Arguments

locations	Either a vector of FIPS county codes, for county-level output, or a dataframe with columns for community identifier (commun) and associated FIPS codes (fips), for multi-county community output. See the examples for the proper format for this argument.
start_year	Four-digit integer with first year to consider.
end_year	Four-digit integer with last year to consider.
wind_limit	Vector giving the wind speed (in m / s) to use as a threshold for classifying a county as "exposed" to a specific storm.
wind_var	A character string giving the wind variable to use. Choices are "vmax_sust" (maximum sustained winds; default), "vmax_gust" (maximum gust winds), "sust_dur" (minutes of sustained winds of 20 m / s or higher) and "gust_dur" (minutes of gust winds of 20 m / s or higher). If the Extended Best Tracks wind radii are used as the source of wind data, the "gust_dur" option cannot be selected.
out_dir	Character string giving the pathname of the directory in which to write output. This directory should already exist on your computer.
out_type	Character string giving the type of output files you'd like. Options are "csv" (default) and "rds".

Value

Writes out a directory with rain exposure files for each county or community indicated. For more on the columns in this output, see the documentation for [county_wind](#) and [multi_county_wind](#).

Note

This function allows you to use different wind variables (sustained winds, which is the default; gust winds; duration of sustained winds; duration of gust winds) when pulling exposures by county. However, if pulling multi-county communities, currently only the sustained winds metric can be used with this function.

Examples

```
## Not run:
# Ensure that data package is available before running the example.
# If it is not, see the `hurricaneexposure` package vignette for details
# on installing the required data package.
if (requireNamespace("hurricaneexposuredata", quietly = TRUE)) {

# By county
wind_exposure(locations = c("22071", "51700"),
              start_year = 1988, end_year = 2005,
              wind_limit = 10,
              out_dir = "~/tmp/storms")

# For multi-county communities
communities <- data.frame(commun = c(rep("ny", 6), "no", "new"),
                          fips = c("36005", "36047", "36061",
                                    "36085", "36081", "36119",
                                    "22071", "51700"))
wind_exposure(locations = communities,
              start_year = 1988, end_year = 2005,
              wind_limit = 10,
              out_dir = "~/tmp/storms")
}

## End(Not run)
```

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