Package ‘hurricaneexposure’

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Type Package

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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 ‘hurricaneexposuredata’ package, which is available in a ‘drat’ repository. To access this data package, see the instructions at <https://github.com/geanders/hurricaneexposure>. The size of the ‘hurricaneexposuredata’ package is approximately 20 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)

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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

\[ \text{county_distance(} \text{counties, start\_year, end\_year, dist\_limit) } \]

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

```r
# 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_distance(counties = c("22071", "51700"),
                  start_year = 1995, end_year = 2005,
                  dist_limit = 75)
}
```

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

```r
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".

Value

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")
• `usa_atcf_id`: United States Automated Tropical Cyclone Forecasting storm identifier
• `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.

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.

Examples

```r
# 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 = 2018,
                event_type = "flood")
  county_events(counties = c("37055"),
                start_year = 1996, end_year = 2018,
                event_type = "tropical_storm")
}
```

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

```r
county_rain(
  counties,  # Character vector of the five-digit Federal Information Processing Standard (FIPS)
  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
  dist_limit,  # Maximum distance, in kilometers, of how close the storm track must come to
  days_included = c(-2, -1, 0, 1)  # 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 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 closest day when the storm is closest to the county).
)
```

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.
- **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 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 closest 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


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 `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

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`)
• usa_atcf_id: United States Automated Tropical Cyclone Forecasting storm identifier
• 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.

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

```r
# 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")
}
```

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

```r
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”.
events_exposure

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

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

  # For these examples to work, you will need to have a directory called "tmp"
  # as a subdirectory of your home directory. These examples will create new
  # directories with exposure output to that "tmp" directory.

  # 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(community_name = 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)
```

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 events criteria.

Usage

```r
events_exposure(
    locations, 
```
events_exposure

```r
start_year,
end_year,
event_type,
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.

event_type Character string with the type of event to use to identify county exposures. Options include "flood", "tornado", "wind", and "tropical_storm".

out_dir Character string with the filepath to the directory where the data will be saved

out_type Character string with the type of file to save to. Options are "csv" for a comma-separated file (default) and "rds" for an R object file.

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

```r
## 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)) {

  # To run this example, you will need to have a directory named "tmp"
  # as a subdirectory of your home directory.

  # By county
  events_exposure(locations = c("22071", "51700"),
                   start_year = 1995, end_year = 2005,
                   event_type = "flood",
                   out_dir = "~/tmp/storms")
}
```
filter_storm_data  

Filter hurricane datasets

Description
This function is a helper function for many of 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("hurricaneexposuredata", 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("hurricaneexposedata", 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  Get map data for eastern US states

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.

**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**

```r
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 `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

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

### Interpolate a storm track

#### Description

This function takes a wider-spaced storm track (e.g., every 6 hours) and interpolates to every 15 minutes. To do this, it uses natural cubic spline interpolation using the 'spline' function from the 'stats' package. The track is only interpolated if there are three or more observations on the central location of the storm (this is almost always the case for storms tracked in the HURDAT2 dataset).

#### Usage

```r
interp_track(track)
```

#### Arguments

- `track` A dataframe with hurricane track data for a single storm

#### Value

A dataframe with hurricane track data for a single storm, interpolated to 15-minute intervals.

---

 map_counties

### Map counties

#### Description

Map counties

#### Usage

```r
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.
daysIncluded  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 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.

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("hurricaneexposuredata", quietly = TRUE)) {
  map_counties("Floyd-1999", metric = "rainfall", daysIncluded = 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

storm Character string giving the name of the storm to plot (e.g., "Floyd-1999")
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.
add_track 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.counties("Michael-2018", metric = "wind")
map_counties("Michael-2018", metric = "wind", wind_var = "vmax_gust")
map_counties("Michael-2018", metric = "wind", wind_source = "ext_tracks")
}
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("hurricaneexposedata", 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_event_exposure(storm_id = "Florence-2018", event_type = "flood")
  map_event_exposure(storm_id = "Florence-2018", event_type = "tropical_storm")
  map_event_exposure(storm_id = "Michael-2018", event_type = "wind")
  map_event_exposure(storm_id = "Michael-2018", event_type = "tropical_storm")
}
Map counties with rain exposure

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

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

Arguments

`storm`  
Character string giving the name of the storm to plot (e.g., "Floyd-1999")

`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).

`add_track`  
TRUE / FALSE of whether to add the storm’s track to the map. The default is TRUE.

Examples

```r
# 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_wind_exposure

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
if (requireNamespace("hurricaneexposuredata", 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

storm  A character string giving the storm ID (e.g., "Floyd-1999")
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_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).

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 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.

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)
}

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)
multi_county_events

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.

  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(community_name = 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_events  Hurricane exposure by events for communities

Description

  This function takes a dataframe with multi-county communities and returns a community-level dataframe of "exposed" storms, based on the type of the event.

Usage

  multi_county_events(communities, start_year, end_year, event_type)
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.

date

date

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".

Value

Returns the same type dataframe as county_events, 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("hurricaneexposedata", quietly = TRUE)) {
  communities <- data.frame(community_name = c(rep("ny", 6), "no", "new"),
                           fips = c("36005", "36047", "36061",
                                    "36085", "36081", "36119",
                                    "22071", "51700"))
  distance_df <- multi_county_events(communities = communities,
                                      start_year = 1995, end_year = 2005,
                                      event_type = "flood")
}

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,
multi_county_rain

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


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(community_name = 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**

```r
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 (`community_name`) 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

```r
# 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(community_name = 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)
}
```

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

```r
rain_exposure(
  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 = c(-2, -1, 0, 1),  # 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 = "csv"  # Character string giving the type of output files you'd like. Options are "csv" (default) and "rds".
)
```

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)) {

# For these examples, you need to have a directory in your home
# directory called "tmp".

# 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(community_name = 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)

wind_exposure  Write storm wind 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 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

```r
## 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)) {

  # You will need a directory named "tmp" in your home directory to
  # run these examples.

  # 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

```r
communities <- data.frame(community_name = 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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