

# Package ‘countyfloods’

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**Type** Package

**Title** Quantify United States County-Level Flood Measurements

**Version** 0.1.0

**Description** Quantifies United States flood impacts at the county level using United States Geological Service (USGS) River Discharge data for the USGS API. This package builds on R packages from the USGS, with the goal of creating county-level time series of flood status that can be more easily joined with county-level impact measurements, including health outcomes. This work was supported in part by grants from the National Institute of Environmental Health Sciences (R00ES022631), the Colorado Water Center, and the National Science Foundation, Integrative Graduate Education and Research Traineeship (IGERT) Grant No. DGE-0966346 “I-WATER: Integrated Water, Atmosphere, Ecosystems Education and Research Program” at Colorado State University.

**License** GPL (>= 2)

**LazyData** TRUE

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construct_prob_plot	<i>Construct probability plot using the Weibull plotting method</i>
---------------------	---

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### Description

Construct probability plot using the Weibull plotting method

### Usage

```
construct_prob_plot(vals)
```

### Arguments

vals	A numeric vector of annual peak discharge values obtained from the readNWISpeak function of the dataRetrieval package.
------	--

### Details

The Weibull plotting method is commonly used in flood-frequency analysis. The basic procedure involves ranking the values from highest to lowest and calculating an exceedence probability ( $p = rank/(n + 1)$ ) where  $n$  is the total number of observations. The median annual flood (Q2) is the flow with a probability of 0.5.

**References**

Rao, A.R. and Hamed, K.H. 2000. Flood Frequency Analysis. CRC Press: Boca Raton.

---

county\_aggregates      *Get county level output*

---

**Description**

Function aggregates gage-level output into county-level output

**Usage**

```
county_aggregates(flood_stats, county_cd)
```

**Arguments**

flood\_stats      Data frame of gage-level output from flood\_analysis function.  
 county\_cd        Character vector with the county FIPS code(s)

**Value**

A data frame with the following columns:

Name	Type	Description
county	character	County name
state	character	State name
num_gage	numeric	Number of analyzed gages in county
avg_peak	numeric	Average flood ratio among county gages
max_peak	numeric	Maximum observed flood ratio
minor	numeric	Percentage of gages at or above "minor" flood class (flood ratio > 1)
moderate	numeric	Percentage of gages at or above "moderate" flood class (flood ratio > 1.5)
major	numeric	Percentage of gages at or above "major" flood class (flood ratio > 2)
extreme	numeric	Percentage of gages at or above "extreme" flood class (flood ratio > 5)
max_dur	numeric	Maximum flood duration in county
avg_dur	numeric	Average flood duration in county

If threshold = "NWS", the columns "minor", "moderate", "major", and "extreme" are replaced with two columns: "no\_flood" and "yes\_flood" which show the percentage of gages in the county with or without flooding.

**Examples**

```
## Not run:
va_counties <- get_county_cd("Virginia")
va_gages <- get_gages(va_counties, start_date = "2015-01-01",
  end_date = "2015-12-31")
va_flow_data <- get_flow_data(va_gages, start_date = "2015-01-01",
```

```

        end_date = "2015-12-31")
va_peaks <- find_q2(va_gages$site_no)
va_stats <- flood_analysis(flow_data = va_flow_data, peaks = va_peaks,
                           gages = va_gages, county_cd = va_counties, threshold = "Q2")
va_county_stats <- county_aggregates(flood_stats = va_stats)

## End(Not run)

```

---

county\_aggregates2      *Get county level output from long\_range\_flood analysis*

---

### Description

Function aggregates gage-level output into county-level output. This is the same as the county\_aggregates function but it summarizes by county and date range instead of just county.

### Usage

```
county_aggregates2(flood_stats, county_cd)
```

### Arguments

flood\_stats      Data frame of gage-level output from flood\_analysis function.  
 county\_cd        Character vector with the county FIPS code(s)

### Value

A data frame with the following columns:

Name	Type	Description
county_cd	character	FIPS code of gage county location
start_date	date	Input start date
end_date	date	Input end date
county	character	County name
state	character	State name
num_gage	numeric	Number of analyzed gages in county
max_peak	numeric	Maximum observed flood ratio
avg_peak	numeric	Average flood ratio among county gages
minor	numeric	Percentage of gages at or above "minor" flood class (flood ratio > 1)
moderate	numeric	Percentage of gages at or above "moderate" flood class (flood ratio > 1.5)
major	numeric	Percentage of gages at or above "major" flood class (flood ratio > 2)
extreme	numeric	Percentage of gages at or above "extreme" flood class (flood ratio > 5)
max_dur	numeric	Maximum flood duration in county
avg_dur	numeric	Average flood duration in county

If threshold = "NWS", the columns "minor", "moderate", "major", and "extreme" are replaced with two columns: "no\_flood" and "yes\_flood" which show the percentage of gages in the county with

or without flooding.

Internal function used within long\_term\_flood function.

---

find_nws	<i>Get National Weather Service (NWS) flood stage/discharge levels for gages.</i>
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---

### Description

Use National Weather Service designated flood stages/discharges as flood thresholds. These come in four levels: "action", "flood", "moderate", and "major".

### Usage

```
find_nws(site_no, type = "flood")
```

### Arguments

site_no	Character vector with USGS gage IDs of stream gage sites to pull.
type	Character string with the type of flood stage to be used. Can be one of four options: "action", "flood", "moderate", and "major". Defaults to "flood".

### Value

Data frame of gage IDs and the corresponding NWS flood value, if available.

### Note

Since most USGS gages do not have these values specified (or may not have all levels), using this definition of the flood threshold can severely limit the sample size of the data output.

### Examples

```
va_counties <- get_county_cd("Virginia")
va_gages <- get_gages(va_counties, start_date = "2015-01-01",
                    end_date = "2015-12-31")
va_nws <- find_nws(site_no = va_gages$site_no, type = "moderate")
```

---

find_q2	<i>Get median flood for each gage</i>
---------	---------------------------------------

---

### Description

This function will get annual maximum flow series for each USGS gage and compute median flood (Q2) to serve as flood threshold. Peak flow data is obtained using the readNWISpeak function from the dataRetrieval package.

### Usage

```
find_q2(site_no)
```

### Arguments

site\_no            Character vector with USGS gage IDs of stream gage sites to pull.

### Value

A data frame with median flood values (Q2) and the number of years of data used to compute this value.

### See Also

[readNWISpeak](#)

### Examples

```
## Not run:
miami_gages <- gage_extract("12086", start_date = "2000-01-01",
                           end_date = "2009-12-31")
miami_q2 <- find_q2(site_no = miami_gages$site_no)

va_counties <- get_county_cd("Virginia")
va_gages <- get_gages(va_counties, start_date = "2015-01-01", end_date = "2015-12-31")
va_q2 <- find_q2(va_gages$site_no)

## End(Not run)
```

---

flood_analysis	<i>Compute flood statistics</i>
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---

**Description**

Takes flow data and computes flood statistics based on selected flood threshold.

**Usage**

```
flood_analysis(flow_data, peaks, gages, county_cd, q2_val = data.frame(site_no
  = "", q2 = NA, stringsAsFactors = FALSE), threshold, weight = "Q2")
```

**Arguments**

flow_data	A data frame with discharge data for each USGS gage found for the specified data range. Output from get_flow_data function.
peaks	A data frame of USGS gage IDs and flood values obtained from either the find_Q2 or find_NWS function.
gages	A data frame of all USGS gages and metadata obtained from the get_gages function. This input is used to add lat/long and county codes to the summarized output.
county_cd	Character vector with the county FIPS code(s)
q2_val	A data frame with values of the median annual flood to be used to compare relative sizes of streams at gage locations
threshold	Character string of the flood threshold to be used in the analysis (either "Q2" or "NWS"). Used to determine which type of summary statistics to compute.
weight	Character string of variable to be used to scale by river size for weighted averages and scaling point sizes on maps. Options are median annual flood ("Q2") or drainage area ("DA"). Defaults to "Q2".

**Value**

A data frame with the following columns:

Name	Type	Description
site_no	character	USGS gage ID
county_cd	character	FIPS code of gage county location
lat	numeric	Gage latitude
long	numeric	Gage longitude
avg_peak	numeric	Mean flood ratio for date range (discharge/flood threshold)
flood_dur	numeric	Number of days in date range discharge above flood threshold
max_peak	numeric	Maximum value of flood ratio for date range (discharge/flood threshold)
num_missing	numeric	Number of days with missing discharge data from input date range
Q2	numeric	Median annual discharge (cubic feet per second)
DA	numeric	Drainage area of the gage (square miles)

size	numeric	Relative river size, logarithm of either Q2 or DA depending on user specified weight
state	character	State name
county	character	County name
flood	character	Flood magnitude category based on peak

### Examples

```
## Not run:
va_counties <- get_county_cd("Virginia")
va_gages <- get_gages(va_counties, start_date = "2015-01-01",
  end_date = "2015-12-31")
va_flow_data <- get_flow_data(va_gages, start_date = "2015-01-01",
  end_date = "2015-12-31")
va_peaks <- find_q2(va_gages$site_no)
va_stats <- flood_analysis(flow_data = va_flow_data, peaks = va_peaks,
  gages = va_gages, county_cd = va_counties, threshold = "Q2")

## End(Not run)
```

---

gage_extract	<i>Get gage meta-data for a county</i>
--------------	--

---

### Description

This function uses the `whatNWISSites` function from the `dataRetrieval` package to pull information on all stream gages within a county and then adds the county FIPS code as an additional column to the dataframe.

### Usage

```
gage_extract(county_cd, start_date, end_date)
```

### Arguments

county_cd	Character vector with the county FIPS code
start_date	Character string with the starting date, using "YYYY-MM-DD" notation.
end_date	Character string with the end date, using "YYYY-MM-DD" notation.

### Value

A dataframe with information about stream gages within a county for a specified time frame. This information typically includes each gage's site number, station name, agency code, site type code, latitude, longitude, and county code. See the `whatNWISSites` function from the `dataRetrieval` package for details.

### See Also

[whatNWISSites](#)



**Examples**

```
gage_extract("12086", start_date = "2000-01-01", end_date = "2009-12-31")
```

---

`get_county_cd`*Get all FIPS county codes within a state*

---

**Description**

This function will return all county FIPS codes for all counties within a state or states.

**Usage**

```
get_county_cd(state)
```

**Arguments**

`state` Character vector giving the name of state or states (not case sensitive) for which you would like to get county FIPS codes.

**Details**

This function uses the `county.fips` dataset from the `maps` package to pull county FIPS for a state.

**Value**

A character vector with the 5-digit FIPS codes for all counties within the specified state or states.

**Examples**

```
get_county_cd("Virginia")
get_county_cd(c("North Carolina", "South Carolina"))
```

---

`get_flow_data`*Retrieve discharge data at specified gages*

---

**Description**

Pulls all discharge data for the specified gage numbers and date range.

**Usage**

```
get_flow_data(gages_df, start_date, end_date)
```

**Arguments**

gages_df	A dataframe that includes the column <code>site_no</code> , a character vector with USGS gage IDs of stream gage sites to pull.
start_date	Character string with the starting date, using "YYYY-MM-DD" notation.
end_date	Character string with the end date, using "YYYY-MM-DD" notation.

**Value**

A dataframe with discharge data for each of the specified monitors. This is a dataframe that includes columns for the gage site number, date of each observation, and observed mean daily discharge (cubic feet per second).

**See Also**

[readNWISdv](#)

**Examples**

```
## Not run:
miami_gages <- get_gages("12086", start_date = "2000-01-01",
                        end_date = "2009-12-31")
miami_flow_data <- get_flow_data(gages_df = miami_gages,
                                start_date = "2000-01-01",
                                end_date = "2000-01-31")

# Example using piping
library(dplyr)
miami_flow_data <- get_gages("12086", start_date = "2000-01-01",
                            end_date = "2009-12-31") %>%
  get_flow_data(start_date = "2000-01-01",
                end_date = "2000-01-31")

## End(Not run)
```

---

get\_gages

*Get all gage site numbers for a county*

---

**Description**

Pulls gage numbers of all gages with discharge data within a county and within the specified date range.

**Usage**

```
get_gages(county_cd, start_date, end_date)
```

**Arguments**

county_cd	Character vector with the county FIPS code
start_date	Character string with the starting date, using "YYYY-MM-DD" notation.
end_date	Character string with the end date, using "YYYY-MM-DD" notation.

**Value**

A dataframe that gives the following variables for stream gages within the county and time range:

Name	Type	Description
agency_cd	character	Agency running the gage (typically will be the USGS)
site_no	character	USGS gage ID
station_nm	character	Name of the gage site
site_tp_cd	character	Type of gage (should always be "ST" for stream)
dec_lat_va	numeric	Latitude of the gage site, in decimal degrees
dec_long_va	numeric	Longitude of the gage site, in decimal degrees
county_cd	character	Five-digit FIPS code of gage county location
DA	numeric	Drainage area of the gage, in square miles

Note that the returned object is the same as that returned by the `whatNWISSites` function in the `dataRetrieval` package, but with county FIPS added for each gage.

**Examples**

```
## Not run:
get_gages("12086", start_date = "1988-01-01", end_date = "2015-01-01")

va_counties <- get_county_cd("Virginia")
va_gages <- get_gages(va_counties, start_date = "2015-01-01",
                     end_date = "2015-12-31")
# Equivalent with piping
library(dplyr)
va_gages <- get_county_cd("Virginia") %>%
  get_gages(start_date = "2015-01-01", end_date = "2015-12-31")

## End(Not run)
```

---

long\_term\_flood      *Return flood metrics by county codes for a data frame input*

---

**Description**

Access USGS databases to retrieve gages and flow data for the specified county FIPS codes and the specified date ranges. Flooding at these gage locations are assessed by one of two metrics. Data can be returned at the gage level or the county level. This is the same as the `run_flood` function but accepts a data frame as input with multiple county codes and date ranges for each.

**Usage**

```
long_term_flood(input_df, threshold = "Q2", flood_type = "flood",
               weight = "Q2")
```

**Arguments**

input_df	Data frame with three columns: county_cd, start_date, and end_date
threshold	Character string of the flood threshold to be used in the analysis (either "Q2" or "NWS"). Defaults to "Q2".
flood_type	Character string of the defined flood type based on NWS classifications (one of "action", "flood", "moderate", or "major")
weight	Character string of variable to be used to scale by river size for weighted averages and scaling point sizes on maps. Options are median annual flood ("Q2") or drainage area ("DA"). Defaults to "Q2"

**Value**

A list with two data frames summarizing data by gage and by county.

Gage:

Name	Type	Description
start_date	date	Input start date
end_date	date	Input end date
site_no	character	USGS gage ID
county_cd	character	FIPS code of gage county location
lat	numeric	Gage latitude
long	numeric	Gage longitude
avg_peak	numeric	Mean flood ratio for date range (discharge/flood threshold)
flood_dur	numeric	Number of days in date range discharge above flood threshold
max_peak	numeric	Maximum value of flood ratio for date range (discharge/flood threshold)
num_missing	numeric	Number of days in given date range with no discharge data at that gage
Q2	numeric	Median annual discharge (cubic feet per second)
DA	numeric	Drainage area of the gage (square miles)
size	numeric	Relative river size, logarithm of either Q2 or DA depending on user specified weight
state	character	State name
county	character	County name
flood	character	Flood magnitude category based on peak

County:

Name	Type	Description
county_cd	character	FIPS code of gage county location
start_date	date	Input start date
end_date	date	Input end date
county	character	County name
state	character	State name
num_gage	numeric	Number of analyzed gages in county

max_peak	numeric	Maximum observed flood ratio
avg_peak	numeric	Average flood ratio among county gages
minor	numeric	Percentage of gages at or above "minor" flood class (flood ratio > 1)
moderate	numeric	Percentage of gages at or above "moderate" flood class (flood ratio > 1.5)
major	numeric	Percentage of gages at or above "major" flood class (flood ratio > 2)
extreme	numeric	Percentage of gages at or above "extreme" flood class (flood ratio > 5)
max_dur	numeric	Maximum flood duration in county
avg_dur	numeric	Average flood duration in county

If threshold = "NWS", the columns "minor", "moderate", "major", and "extreme" are replaced with two columns: "no\_flood" and "yes\_flood" which show the percentage of gages in the county with or without flooding.

### Examples

```
## Not run:
#Northern VA flooding every April
county_cd <- c(rep("51013", 5), rep("51107", 5), rep("51059", 5))
start_date <- rep(c("2010-04-01", "2011-04-01", "2012-04-01", "2013-04-01", "2014-04-01"), 3)
end_date <- rep(c("2010-04-30", "2011-04-30", "2012-04-30", "2013-04-30", "2014-04-30"), 3)
input_df <- data.frame(county_cd = county_cd, start_date = start_date, end_date = end_date,
  stringsAsFactors = FALSE)

#With default values
VA_floods <- long_term_flood(input_df)

#Using NWS values
VA_floods <- long_term_flood(input_df, threshold = "NWS")

## End(Not run)
```

---

map\_county

*Maps flood data by county*

---

### Description

Creates a state level map of flood analysis output by county. Counties are color coded based on the percentage of gages in that county at or exceeding a given flood magnitude.

### Usage

```
map_county(county_stats, category = "minor", date = "")
```

### Arguments

county_stats	Data frame of flood analysis results, summarized by county.
category	Character string of the flood magnitude category to be used for mapping (one of "minor", "moderate", "major", or "extreme"). This parameter only works when mapping county-level, rather than gage-level, values.

date                    Date of data mapped to be printed at the top of the image. This argument is used by the 'time\_series\_map' function.

### Value

A map of counties color coded by percentage of gages experiencing flooding.

---

map_flood	<i>Function maps data, either by gage or by county</i>
-----------	--

---

### Description

Displays a state or multi-state map summarizing flood analysis results either by gage or county.

### Usage

```
map_flood(flood_stats, category = "minor")
```

### Arguments

flood\_stats        Either a data frame of flood analysis results, by gage or by county, or a list of both data frames.

category           Character string of the flood magnitude category to be used for mapping (one of "minor", "moderate", "major", or "extreme"). This parameter only works when mapping county-level, rather than gage-level, values.

### Value

A map of the state(s) analyzed showing counties and gages color coded based on flood magnitude, depending on the type of data in flood\_stats. Gage flood thresholds are "None" (flood\_ratio < 1), "Minor" (flood\_ratio < 1.5), "Moderate" (flood\_ratio < 2), "Major" (flood\_ratio < 5), and "Extreme" (flood\_ratio > 5). For county aggregate maps, flood exposure is assessed based on the percentage of gages in the county at or above a specified flood threshold. Exposure categories include "Low" (0 (40

### Examples

```
## Not run:
#Use Q2 as flood threshold and get gage-level output
va_floods <- run_flood(state = "Virginia", start_date = "2015-01-01",
                      end_date = "2015-12-31", threshold = "Q2", output = "gage")

#Map results by gage
map_flood(va_floods)

#Use NWS flood thresholds and get county-level output
va_floods <- run_flood(state = "Virginia", start_date = "2015-01-01",
                      end_date = "2015-12-31", threshold = "NWS", flood_type = "action",
```

```

                                output = "county")
#Map results by county
map_flood(va_floods)

## End(Not run)

```

---

map_gage	<i>Maps flood data by gage</i>
----------	--------------------------------

---

### Description

Creates a state level map of flood analysis output by USGS gage. Gages are color coded based on maximum flood magnitude (for flood threshold = "Q2"). If the flood threshold is "NWS", points are binary coded based on flood occurrence (e.g. yes/no).

### Usage

```
map_gage(flood_stats, date = "")
```

### Arguments

flood_stats	Data frame of flood analysis results, by gage.
date	Date of data mapped to be printed at the top of the image. This argument is used by the 'time_series_map' function.

### Value

A map of USGS gages color coded by maximum flood magnitude.

---

run_flood	<i>Return flood metrics by county codes or state names</i>
-----------	--

---

### Description

Access USGS databases to retrieve gages and flow data for the specified counties/states or county FIPS codes and the specified date ranges. Flooding at these gage locations are assessed by one of two metrics. Data can be returned at the gage level or the county level.

### Usage

```
run_flood(county_cd = NULL, state = NULL, start_date, end_date,
          threshold = "Q2", flood_type = "flood", output = "both",
          weight = "Q2")
```

**Arguments**

county_cd	Character vector with the county FIPS code(s)
state	Character vector of state names. Used to obtain county FIPS codes if county_cd is NULL
start_date	Character string with the starting date, using "YYYY-MM-DD" notation.
end_date	Character string with the end date, using "YYYY-MM-DD" notation.
threshold	Character string of the flood threshold to be used in the analysis (either "Q2" or "NWS"). Defaults to "Q2".
flood_type	Character string of the defined flood type based on NWS classifications (one of "action", "flood", "moderate", or "major")
output	Character string of output summary type (either "gage", "county", or "both"). Defaults to "both".
weight	Character string of variable to be used to scale by river size for weighted averages and scaling point sizes on maps. Options are median annual flood ("Q2") or drainage area ("DA"). Defaults to "Q2".

**Value**

A data frame with output at either the gage or county level, depending on the value of "output". If output = "gage" a data frame with the following columns is returned:

Name	Type	Description
site_no	character	USGS gage ID
county_cd	character	FIPS code of gage county location
lat	numeric	Gage latitude
long	numeric	Gage longitude
avg_peak	numeric	Mean flood ratio for date range (discharge/flood threshold)
flood_dur	numeric	Number of days in date range discharge above flood threshold
max_peak	numeric	Maximum value of flood ratio for date range (discharge/flood threshold)
num_missing	numeric	Number of days in given date range with no discharge data at that gage
Q2	numeric	Median annual discharge (cubic feet per second)
DA	numeric	Drainage area of the gage (square miles)
size	numeric	Relative river size, logarithm of either Q2 or DA depending on user specified weight
state	character	State name
county	character	County name
flood	character	Flood magnitude category based on peak

If output = "county" a data frame with the following columns is returned:

Name	Type	Description
county	character	County name
state	character	State name
num_gage	numeric	Number of analyzed gages in county
avg_peak	numeric	Average flood ratio among county gages
max_peak	numeric	Maximum observed flood ratio
minor	numeric	Percentage of gages at or above "minor" flood class (flood ratio > 1)



moderate	numeric	Percentage of gages at or above "moderate" flood class (flood ratio > 1.5)
major	numeric	Percentage of gages at or above "major" flood class (flood ratio > 2)
extreme	numeric	Percentage of gages at or above "extreme" flood class (flood ratio > 5)
max_dur	numeric	Maximum flood duration in county
avg_dur	numeric	Average flood duration in county

If threshold = "NWS", the columns "minor", "moderate", "major", and "extreme" are replaced with two columns: "no\_flood" and "yes\_flood" which show the percentage of gages in the county with or without flooding.

If output = "both" a list containing both data frames is returned. In both cases, if data in counties were requested but not available, these counties are included as additional rows with data values of NA.

### Examples

```
## Not run:
#Use Q2 as flood threshold and get gage-level output
va_floods <- run_flood(state = "Virginia", start_date = "2015-01-01",
                      end_date = "2015-12-31", threshold = "Q2",
                      output = "gage")

#Use NWS flood thresholds and get county-level output
va_floods <- run_flood(state = "Virginia", start_date = "2015-01-01",
                      end_date = "2015-12-31", threshold = "NWS",
                      flood_type = "action",
                      output = "county")

## End(Not run)
```

---

time\_series\_analysis *Get time series output*

---

### Description

Function takes flow data and summarizes flood occurrence through time at both the gage and county level.

### Usage

```
time_series_analysis(flow_data, peaks, gages, county_cd, q2_val, threshold,
                    weight = "Q2", Q2_magnitude = "Moderate", filter_data = TRUE)
```

### Arguments

flow_data	A data frame with discharge data for each USGS gage found for the specified data range. Output from get_flow_data function.
peaks	A data frame of USGS gage IDs and flood values obtained from either the find_Q2 or find_NWS function.

gages	A data frame of all USGS gages and metadata obtained from the <code>get_gages</code> function. This input is used to add lat/long and county codes to the summarized output.
county_cd	Character vector with the county FIPS code(s)
q2_val	A data frame with values of the median annual flood to be used to compare relative sizes of streams at gage locations (from the <code>find_Q2</code> function).
threshold	Character string of the flood threshold to be used in the analysis (either "Q2" or "NWS"). Defaults to "Q2".
weight	Character string of variable to be used to scale by river size for weighted averages and scaling point sizes on maps. Options are median annual flood ("Q2") or drainage area ("DA"). Defaults to "Q2".
Q2_magnitude	Character string of ratio of daily streamflow to Q2 used as a binary flood threshold. One of "Minor" ( $1 < \text{Flow} / \text{Q2} < 1.5$ ), "Moderate" ( $< 2$ ), "Major" ( $< 5$ ), and "Extreme" ( $> 5$ ). Defaults to "Moderate".
filter_data	Logical. If TRUE only dates with a flood occurring are returned for both gage and county-level data. If FALSE, all dates are returned.

### Value

A list with two data frames, summarizing the results by gage and by county:

Gage:

Name	Type	Description
site_no	character	USGS gage ID
date	date	Date of observation
lat	numeric	Gage latitude
long	numeric	Gage longitude
county_cd	character	FIPS code of gage county location
Q2	numeric	Median annual discharge (cubic feet per second)
DA	numeric	Drainage area of the gage (square miles)
size	numeric	Relative river size, logarithm of either Q2 or DA depending on user specified weight
discharge	numeric	Observed mean daily discharge (cubic feet per second)
flood_val	numeric	Selected threshold flood value. Either Q2 or an NWS flood threshold.
flood_ratio	numeric	Ratio of the observed discharge divided by the defined flood threshold
state	character	State name
county	character	County name
flood	character	Flood magnitude category based on peak

County:

Name	Type	Description
date	date	Date of observation
county	character	County name
state	character	State name
num_gage	numeric	Number of analyzed gages in county
max_peak	numeric	Maximum observed flood ratio

avg_peak	numeric	Average flood ratio among county gages
minor	numeric	Percentage of gages at or above "minor" flood class (flood ratio > 1)
moderate	numeric	Percentage of gages at or above "moderate" flood class (flood ratio > 1.5)
major	numeric	Percentage of gages at or above "major" flood class (flood ratio > 2)
extreme	numeric	Percentage of gages at or above "extreme" flood class (flood ratio > 5)
flood_metric	numeric	Fraction of gages in county experiencing a flood, weighted by river size (size from gage-level out

If threshold = "NWS", the columns "minor", "moderate", "major", and "extreme" are replaced with two columns: "no\_flood" and "yes\_flood" which show the percentage of gages in the county with or without flooding.

### Examples

```
## Not run:
va_counties <- get_county_cd("Virginia")
va_gages <- get_gages(va_counties, start_date = "2015-01-01",
  end_date = "2015-12-31")
va_flow_data <- get_flow_data(va_gages, start_date = "2015-01-01",
  end_date = "2015-12-31")
va_peaks <- find_q2(va_gages$site_no)
va_time_series <- time_series_analysis(flow_data = va_flow_data, peaks = va_peaks,
  gages = va_gages, county_cd = va_counties,
  q2_val = dplyr::rename_(va_peaks, .dots = list(q2 = "flood_val")),
  threshold = "Q2")

## End(Not run)
```

---

time\_series\_flood      *Return a time series of flood metrics by county codes or state names*

---

### Description

Access USGS databases to retrieve gages and flow data for the specified counties/states or county FIPS codes and the specified date ranges. Flooding at these gage locations are assessed by one of two metrics. Data on timing and magnitude of flooding will be returned at the gage level or the county level.

### Usage

```
time_series_flood(county_cd = NULL, state = NULL, start_date, end_date,
  threshold = "Q2", flood_type = "flood", weight = "Q2",
  Q2_magnitude = "Moderate", filter_data = TRUE)
```

### Arguments

county_cd	Character vector with the county FIPS code(s)
state	Character vector of state names. Used to obtain county FIPS codes if county_cd is NULL

start_date	Character string with the starting date, using "YYYY-MM-DD" notation.
end_date	Character string with the end date, using "YYYY-MM-DD" notation.
threshold	Character string of the flood threshold to be used in the analysis (either "Q2" or "NWS"). Defaults to "Q2".
flood_type	Character string of the defined flood type based on NWS classifications (one of "action", "flood", "moderate", or "major")
weight	Character string of variable to be used to scale by river size for weighted averages and scaling point sizes on maps. Options are median annual flood ("Q2") or drainage area ("DA"). Defaults to "Q2".
Q2_magnitude	Character string of ratio of daily streamflow to Q2 used as a binary flood threshold. One of "Minor" ( $1 < \text{Flow} / \text{Q2} < 1.5$ ), "Moderate" ( $< 2$ ), "Major" ( $< 5$ ), and "Extreme" ( $> 5$ ). Defaults to "Moderate".
filter_data	Logical. If TRUE only dates with a flood occurring are returned for both gage and county-level data. If FALSE, all dates are returned.

### Value

A list with two data frames, summarizing the results by gage and by county:

Gage:

Name	Type	Description
site_no	character	USGS gage ID
date	date	Date of observation
lat	numeric	Gage latitude
long	numeric	Gage longitude
county_cd	character	FIPS code of gage county location
Q2	numeric	Median annual discharge (cubic feet per second)
DA	numeric	Drainage area of the gage (square miles)
size	numeric	Relative river size, logarithm of either Q2 or DA depending on user specified weight
discharge	numeric	Observed mean daily discharge (cubic feet per second)
flood_val	numeric	Selected threshold flood value. Either Q2 or an NWS flood threshold.
flood_ratio	numeric	Ratio of the observed discharge divided by the defined flood threshold
state	character	State name
county	character	County name
flood	character	Flood magnitude category based on peak

County:

Name	Type	Description
date	date	Date of observation
county	character	County name
state	character	State name
num_gage	numeric	Number of analyzed gages in county
max_peak	numeric	Maximum observed flood ratio
avg_peak	numeric	Average flood ratio among county gages
minor	numeric	Percentage of gages at or above "minor" flood class (flood ratio $> 1$ )

moderate	numeric	Percentage of gages at or above "moderate" flood class (flood ratio > 1.5)
major	numeric	Percentage of gages at or above "major" flood class (flood ratio > 2)
extreme	numeric	Percentage of gages at or above "extreme" flood class (flood ratio > 5)
flood_metric	numeric	Fraction of gages in county experiencing a flood, weighted by river size (size from gage-level out

If threshold = "NWS", the columns "minor", "moderate", "major", and "extreme" are replaced with two columns: "no\_flood" and "yes\_flood" which show the percentage of gages in the county with or without flooding.

### Examples

```
## Not run:
#Use Q2 as flood threshold
va_time_series <- time_series_flood(state = "Virginia", start_date = "2015-01-01",
                                   end_date = "2015-12-31", threshold = "Q2")

#Use NWS flood thresholds
va_time_series <- time_series_flood(state = "Virginia", start_date = "2015-01-01",
                                   end_date = "2015-12-31", threshold = "NWS",
                                   flood_type = "action")

## End(Not run)
```

---

time_series_map	<i>Function maps time series flood data, either by gage or by county</i>
-----------------	--

---

### Description

Displays a state or multi-state map summarizing flood analysis results either by gage or county for each individual date with data.

### Usage

```
time_series_map(flood_stats, category = "minor", filename = "")
```

### Arguments

flood_stats	Either a data frame of flood analysis results, by gage or by county, or a list of both data frames.
category	Character string of the flood magnitude category to be used for mapping (one of "minor", "moderate", "major", or "extreme"). This parameter only works when mapping county-level, rather than gage-level, values.
filename	Character string of the file path and beginning of name of where to save the individual images generated. For example, "C:/Desktop/TX" would produce image files saved as "TX_Gage_Map_Date.png" or "TX_County_Map_Date.png" where "Date" is replaced by the actual date. If no filename is provided, the images aren't saved but are displayed in the plot viewer.

**Value**

For each date with data, a map of the state(s) analyzed showing counties and gages color coded based on flood magnitude, depending on the type of data in flood\_stats. Gage flood thresholds are "None" (flood\_ratio < 1), "Minor" (flood\_ratio < 1.5), "Moderate" (flood\_ratio < 2), "Major" (flood\_ratio < 5), and "Extreme" (flood\_ratio > 5). For county aggregate maps, flood exposure is assessed based on the percentage of gages in the county at or above a specified flood threshold. Exposure categories include "Low" (0 (20 (80

**Examples**

```
## Not run:
#Use the time_series_flood function with option filter_data = FALSE to get data
tx <- time_series_flood(state = "Texas", start_date = "2017-08-24", end_date =
  "2017-09-10", filter_data = FALSE)

#Returns a list of gage data and county data. Can map them individually or all at once

## End(Not run)
```

---

time_series_plot	<i>Function plots time series data by county</i>
------------------	--

---

**Description**

Displays four time series bar charts per county displaying the number of gages with flooding, maximum flood ratio, average flood ratio, and the percent of gages above a specified flood threshold.

**Usage**

```
time_series_plot(county_series, category = "moderate", start_date = NULL,
  end_date = NULL)
```

**Arguments**

county_series	Data frame of flood time series results by county, output of time_series_flood function.
category	Character string of the flood magnitude category to be used for mapping (one of "minor", "moderate", "major", or "extreme").
start_date	Character string of start date for x-axis of plots. If not specified, defaults to the earliest observed flood in the data.
end_date	Character string of end date for x-axis of plots. If not specified, defaults to the latest observed flood in the data.

**Value**

Four time series bar charts per county displaying the number of gages with flooding, maximum flood ratio, average flood ratio, and the percent of gages above a specified flood threshold.

**Examples**

```
## Not run:  
#Use Q2 as flood threshold  
va_time_series <- time_series_flood(state = "Virginia", start_date = "2015-01-01",  
                                   end_date = "2015-12-31", threshold = "Q2")  
  
#Map results  
time_series_plot(va_time_series[[2]])  
  
## End(Not run)
```

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