

Package Demo: rainfreq

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This vignette first provides an overview of the rainfall frequency estimates from the National Weather Service (NWS)¹ followed by some examples on how to obtain and plot the data using the *rainfreq* package.

1 Overview of Rainfall/Precipitation Frequency Estimates from NWS

Rainfall frequency estimates for the USA from the NOAA National Weather Service's (NWS) division of Hydrometeorological Design Studies Center (HDSC) are often used in the design of dams and other hydraulic structures and also in environmental planning and management. Data from NOAA NWS is available in various formats, including a user interface to extract the desired information. However, there is a lot of data and it is available in raw format as a large number of 1-km resolution GIS files.

The *rainfreq* package provides functionality to access 1-km rainfall frequency estimates in GIS format provided by the NWS' PF Data Server². The goal of the *rainfreq* package is to make the retrieval and analysis of this GIS data easier. Moreover, *rainfreq* also comes with datasets on record point rainfall measurements provided by NWS³.

2 Using *rainfreq*

After installing the package, load the package along with *RCurl* (for data extraction) and *SDMTools*, *raster* and *maps* for GIS analysis and graphics.

```
> require(rainfreq)
> require(RCurl)
> require(SDMTools)
> require(raster)
> require(maps)
```

¹Rainfall frequency estimates for the USA from the NWS Hydrometeorological Design Studies Center (HDSC) <http://hdsc.nws.noaa.gov/hdsc/pfds/index.html>

²http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_gis.html

³http://www.nws.noaa.gov/oh/hdsc/record_precip/record_precip.html

The main function provided by *rainfreq* is *extract_freq*. This could be used to extract data for any desired region. The default invocation of *extract_freq* of gets the 100-year 24-hour rainfall for the Southeast USA.

```
> x_se <- extract_freq()
> print(x_se)

class      : RasterLayer
dimensions  : 1480, 1796, 2658080  (nrow, ncol, ncell)
resolution  : 0.008333, 0.008333  (x, y)
extent      : -94.92497, -79.9589, 24.45833, 36.79117  (xmin, xmax, ymin, ymax)
coord. ref. : NA
data source : in memory
names       : layer
values      : 6596, 16976  (min, max)
```

In order to obtain the 1000-year 48-hour rainfall for the Midwest, change *region_name*, *storm_RP* and *storm_duration* arguments accordingly.

```
> x_mw <- extract_freq(region_name = "mw", storm_RP = 1000, storm_duration = "48h")
> print(x_mw)

class      : RasterLayer
dimensions  : 1934, 3239, 6264226  (nrow, ncol, ncell)
resolution  : 0.008333, 0.008333  (x, y)
extent      : -109.3667, -82.37608, 33.30833, 49.42436  (xmin, xmax, ymin, ymax)
coord. ref. : NA
data source : in memory
names       : layer
values      : 2804, 19478  (min, max)
```

Similarly, in order to obtain the 10-yr 6-hour rainfall for Hawaii, change the *region_name*, *storm_RP* and *storm_duration* arguments accordingly.

```
> x_hi <- extract_freq(region_name = "hi", storm_RP = 10, storm_duration = "6h")
> print(x_hi)

class      : RasterLayer
dimensions  : 800, 1310, 1048000  (nrow, ncol, ncell)
resolution  : 0.004166667, 0.004166667  (x, y)
extent      : -160.2625, -154.8042, 18.90833, 22.24167  (xmin, xmax, ymin, ymax)
coord. ref. : NA
data source : in memory
names       : layer
values      : 1557, 11917  (min, max)
```

One could also obtain the record storm measurements provided by NWS using *rainfreq*.

```

> data(rain_max_usa)
> head(rain_max_usa)

```

	Duration	Amount_in	Amount_mm	Location	Lat	Lon
1	1-min	1.23	31	Unionville, Maryland	38.800	-76.133
2	5-min	2.03	52	Alamogordo Creek, New Mexico	34.661	-104.387
3	15-min	3.95	100	Galveston, Texas	29.290	-94.790
4	30-min	7.00	178	Cambridge, Ohio	40.001	-81.578
5	42-min	12.00	305	Holt, Missouri	39.450	-94.333
6	1-hr	13.80	351	Burnsville 6 WNW, West Virginia	38.883	-80.770

```

  Start_Date Estimate
1 1956-07-04
2 1960-06-05
3 1871-06-04
4 1914-07-16
5 1947-06-22
6 1943-08-04      Yes

> data(rain_max_world)
> head(rain_max_world)

```

	Duration	Amount_in	Amount_mm	Location	Lat	Lon
1	1-min	1.23	31	Unionville, Maryland, USA	38.80	-76.13
2	3-min	1.75	44	Haughton Grove, Jamaica	18.33	-77.98
3	5-min	2.48	63	Porto Bello, Panama	9.55	-79.65
4	8-min	4.96	126	Fussen, Bavaria, Germany	47.87	12.17
5	15-min	7.80	198	Plumb Point, Jamaica	17.93	-76.78
6	20-min	8.10	206	Curtea-de-Arges, Romania	45.12	-24.42

```

  Start_Date Estimate
1 1956-07-04
2 1925-09-30
3 1911-11-29
4 1920-05-25
5 1916-05-12
6 1889-07-07

```

3 Graphics

The output from *extract_freq* is designed to be consistent with the "RasterLayer" class of the *SDMTools* package. This consistency enables the use of GIS functions for analysis and graphics provided by *SDMTools* and related packages.

Before plotting the data, convert the data to appropriate units. The original units are in 1000th inches, so multiply by 0.001 to get rainfall in inches.

```

> x_se <- x_se * 0.001
> x_mw <- x_mw * 0.001
> x_hi <- x_hi * 0.001

```

Here is a plot of the three rainfall estimates obtained so far. State boundaries are added for spatial reference.

```
> # southeast
> plot(x_se, breaks = c(6, 9, 12, 15, 18),
+      col = c("red", "yellow", "green", "blue"),
+      main = "100-year 24-hour Rainfall for Southeast USA (inches)")
> map('state', region = c('florida', 'arkansas', 'louisiana', 'mississippi',
+                          'alabama', 'georgia'), add = TRUE)
> # midwest
> plot(x_mw, breaks = c(2, 5, 10, 15, 20),
+      col = c("red", "yellow", "green", "blue"),
+      main = "100-year 48-hour Rainfall for Midwest USA (inches)")
> map('state', region = c('colorado', 'north dakota', 'south dakota', 'nebraska',
+                          'oklahoma', 'minnesota', 'iowa', 'missouri',
+                          'wisconsin', 'michigan'), add = TRUE)
> # hawaii
> plot(x_hi, breaks = c(1, 3, 6, 9, 12),
+      col = c("red", "yellow", "green", "blue"),
+      main = "10-year 6-hour Rainfall for Hawaii (inches)")
```

4 Future Work

The *extract_freq* function's regional selection criterion does not include US territories such as Puerto Rico and Guam. Future updates would incorporate these regions. Also, functionality could be added to extract the upper and lower limits of the confidence intervals on frequency estimates. Currently, data for Texas and Pacific Northwest is not available from NWS; when such data becomes available, *rainfreq* would be updated accordingly.

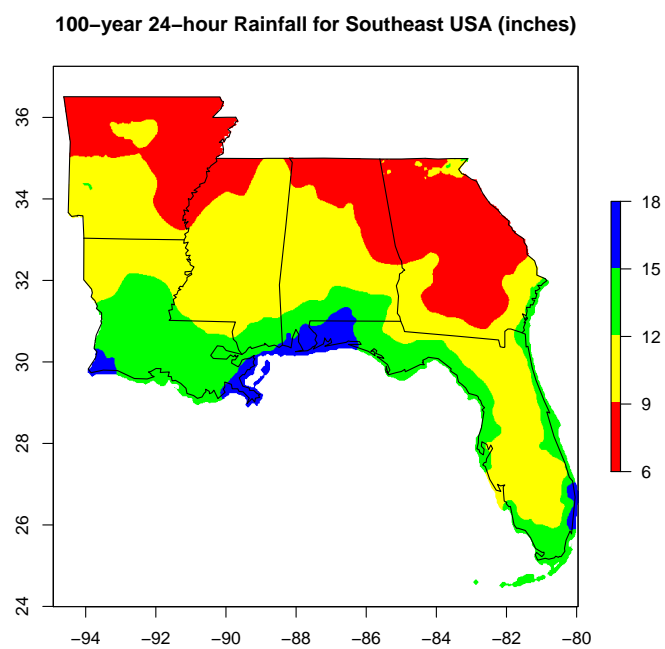


Figure 1: Rainfall amounts for selected frequency and duration periods - Southeast USA.

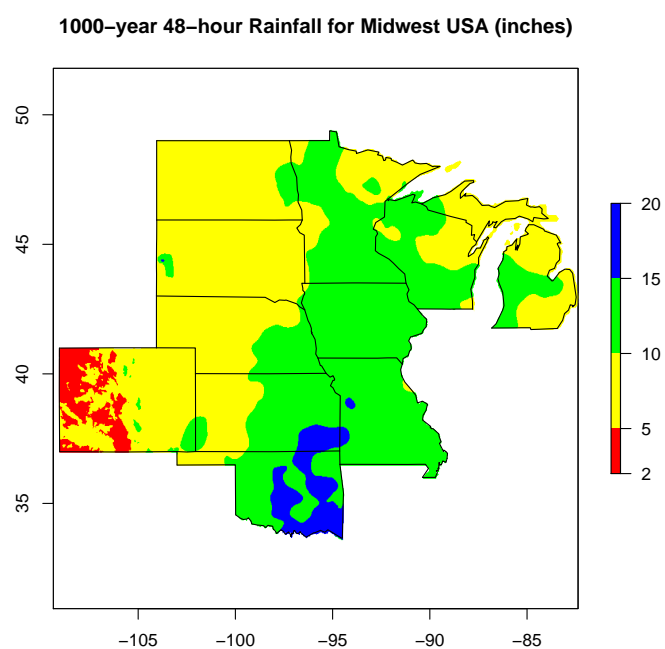


Figure 2: Rainfall amounts for selected frequency and duration periods - Midwest USA.

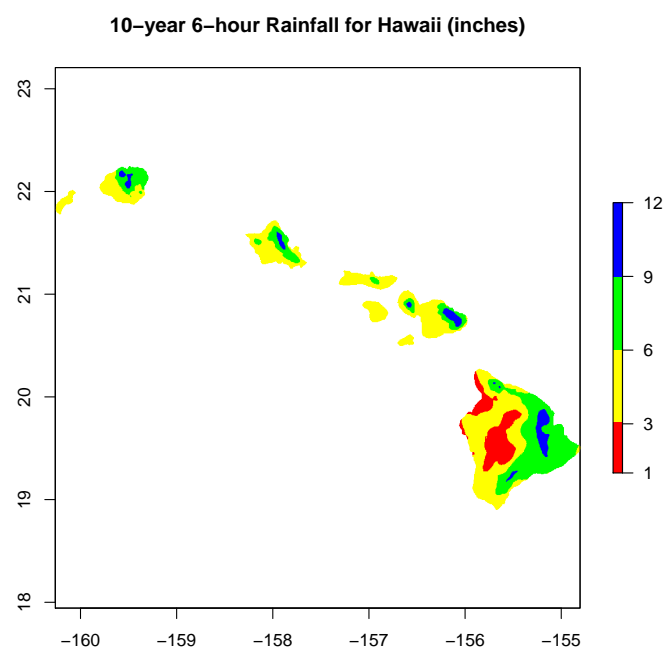


Figure 3: Rainfall amounts for selected frequency and duration periods - Hawaii.