The Influence of Atmospheric Rivers on Northeast Precipitation

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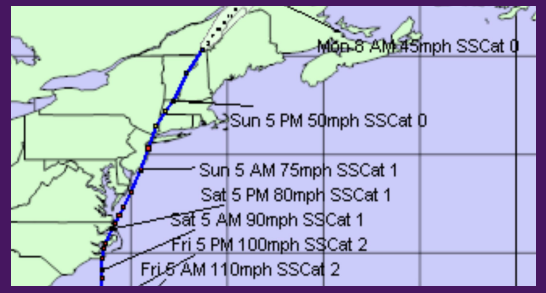
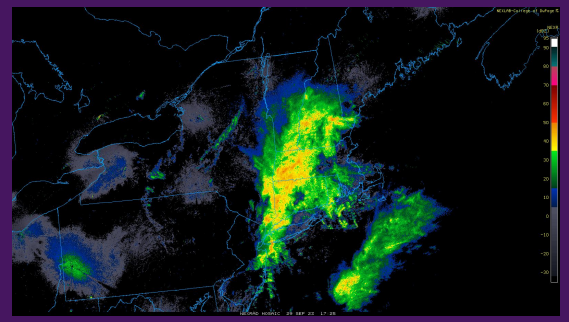
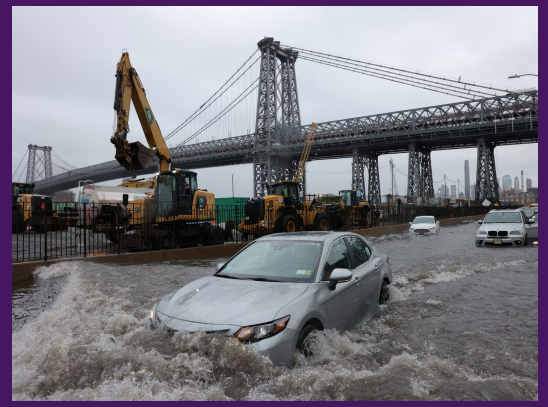
Extreme Precipitation Occurs in a Variety of Forms across the Northeast

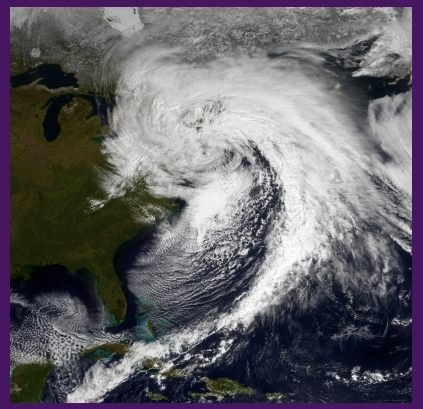


Landfalling Tropical Cyclones

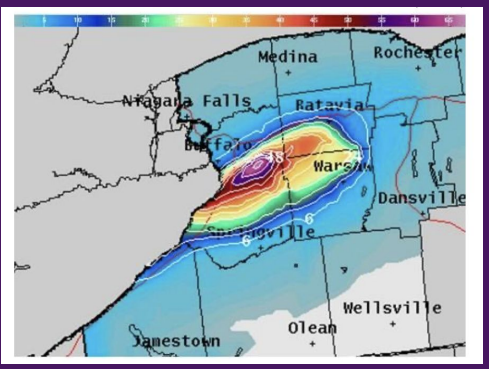




Training Convection



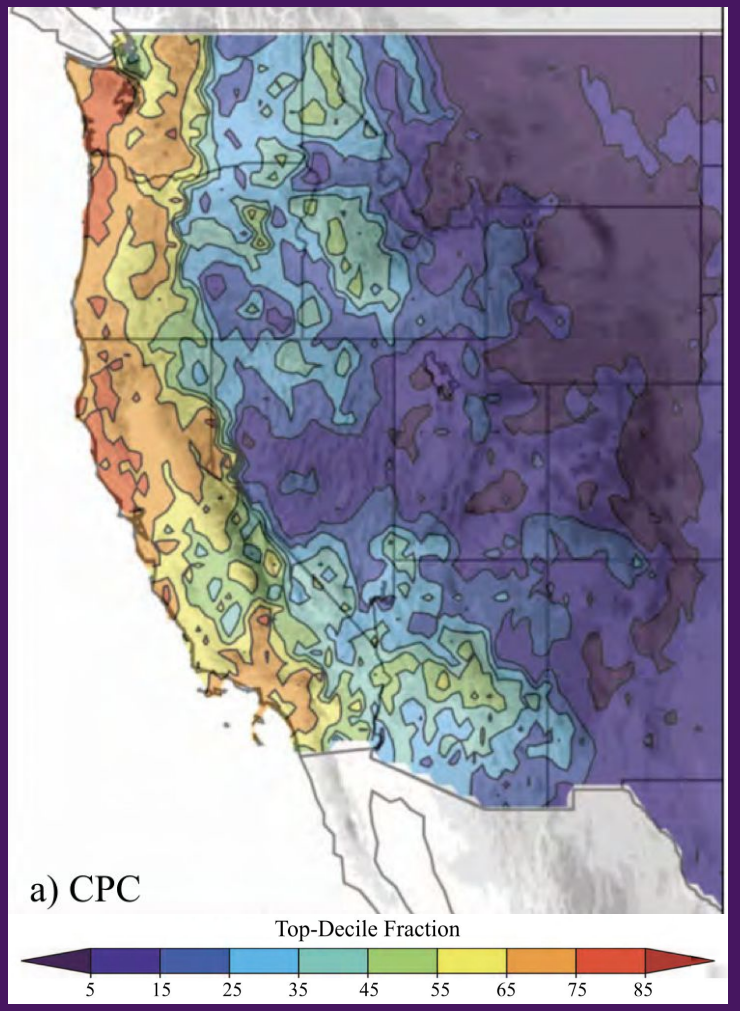
Extratropical Cyclones



Lake Effect Snow

Motivation

- Convection, extratropical cyclones, and landfalling tropical cyclones (TCs) all involve the poleward advection of moisture.
- Extent to which moisture advection is attributable to atmospheric rivers (ARs) remains uncertain.
- Extensive research on ARs in West Coast but limited on East Coast.



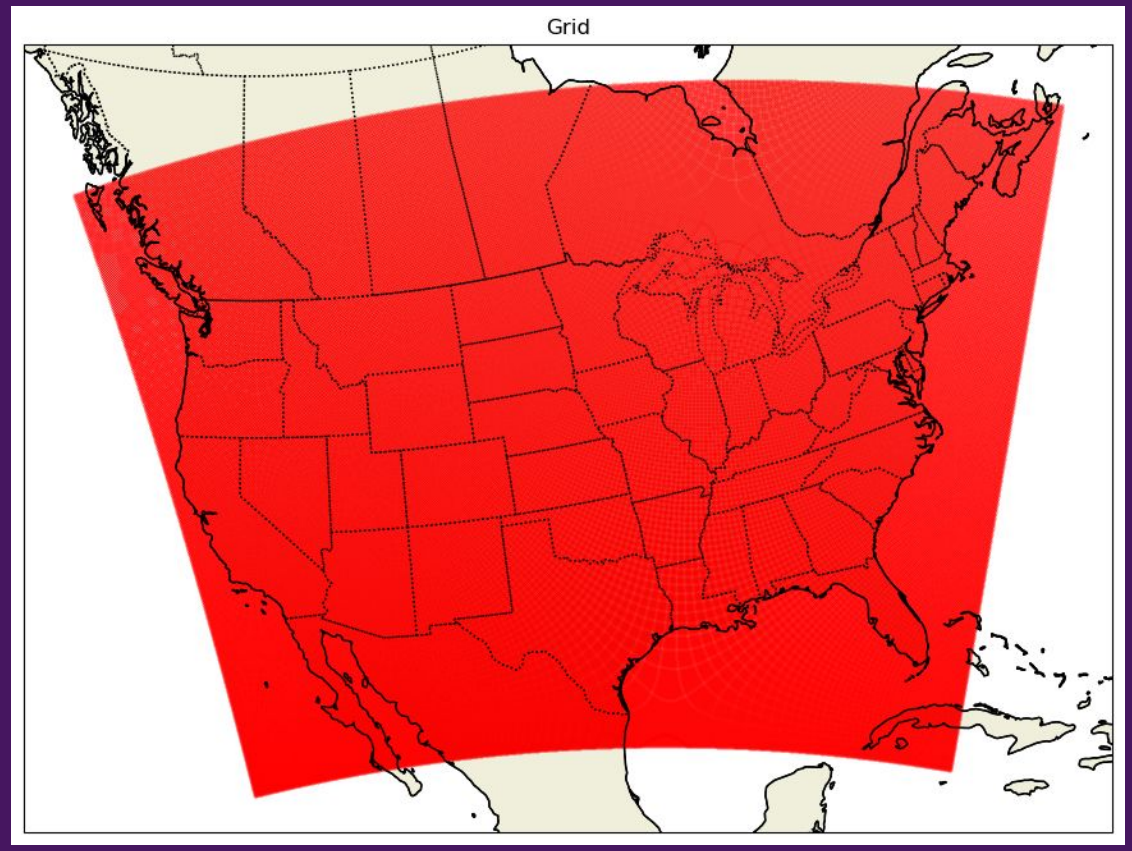
Rutz et al., 2014

Research Goals

- Sort extreme rainfall events by season, weather system (e.g., convective, tropical cyclone, extratropical cyclone), and AR presence.
- Understand seasonality and forcing mechanisms of East Coast extreme rainfall.
- Evaluate ARs' influence on heavy precipitation events in the eastern U.S.
- Improve predictability of East Coast ARs and heavy precipitation events.

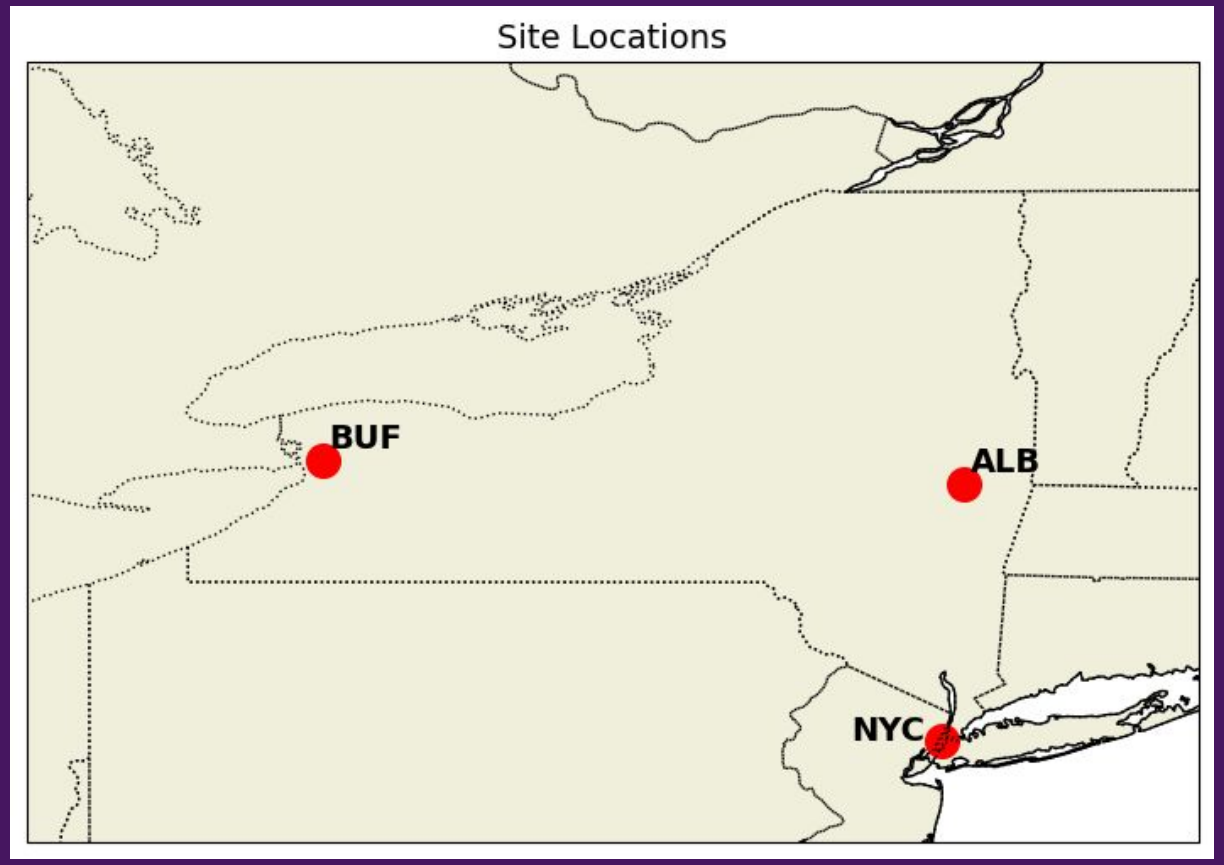
Methodology: Stage IV Precipitation

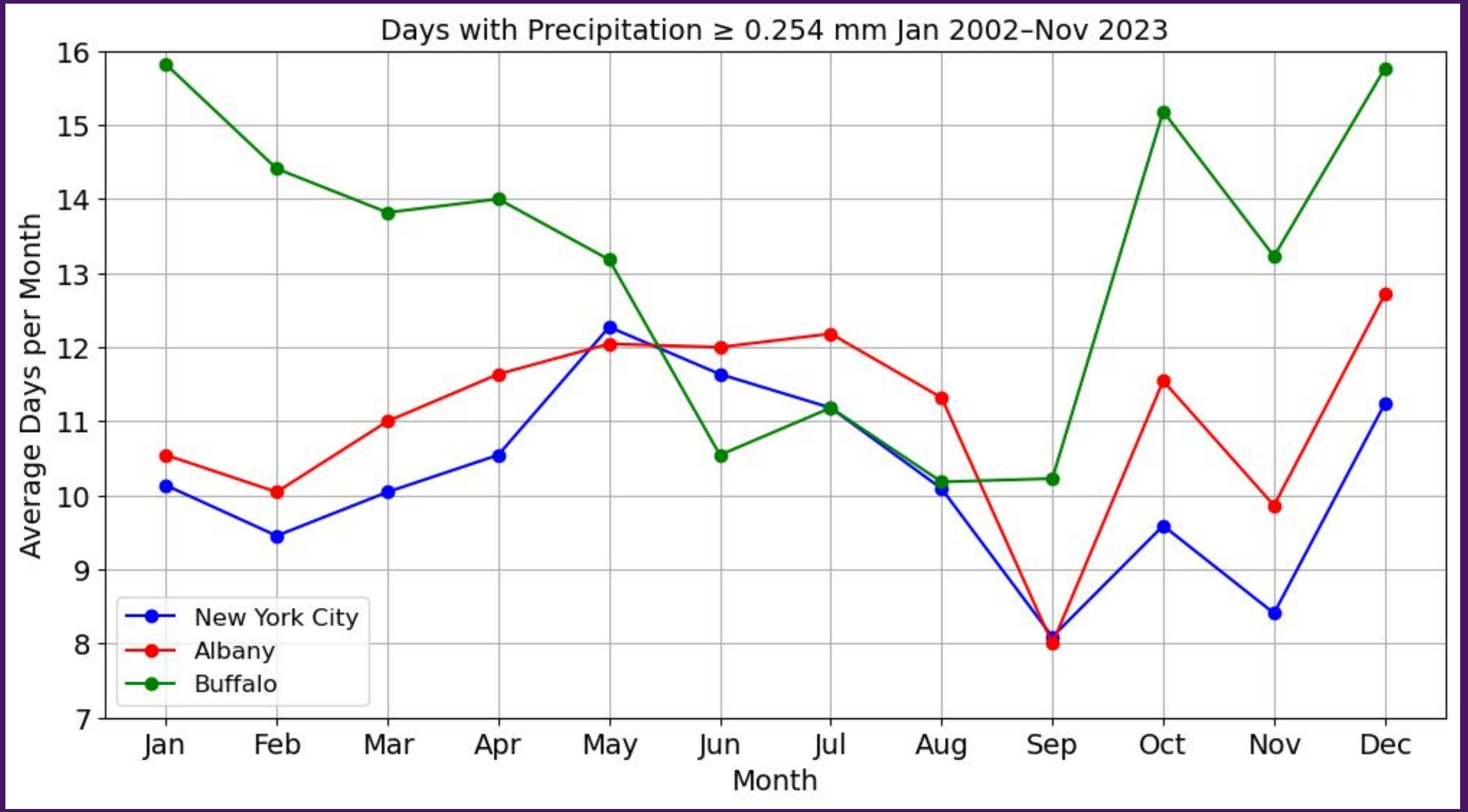
- Calibrated from hourly and six-hourly multi-sensor observations on a 4x4 km grid.
  - Rainfall gauge reports
  - Mesonet observations
  - Doppler radar estimates
- Quality controlled by the 13 National Weather Service River Forecast Centers.
- Dates back to January 2002.

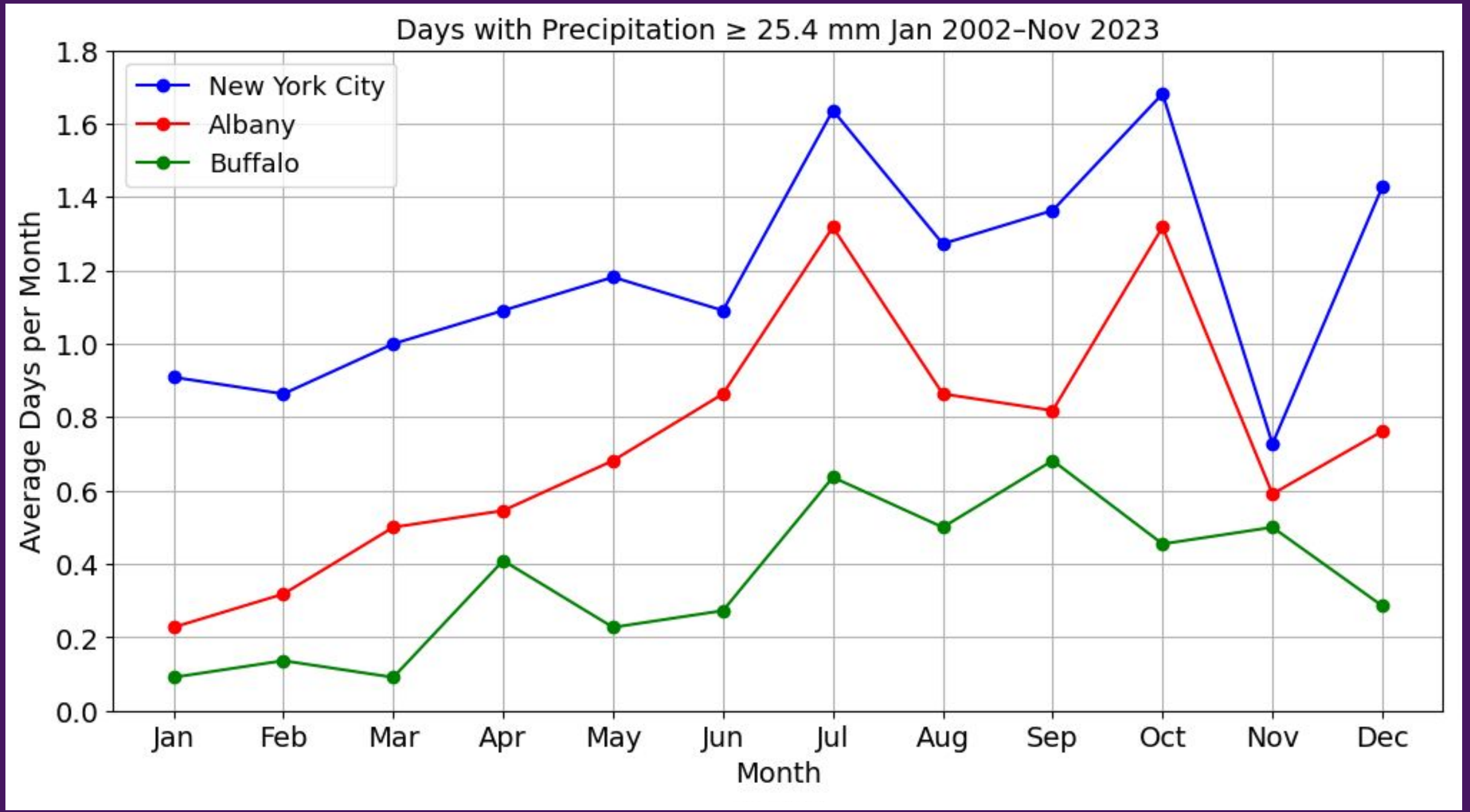


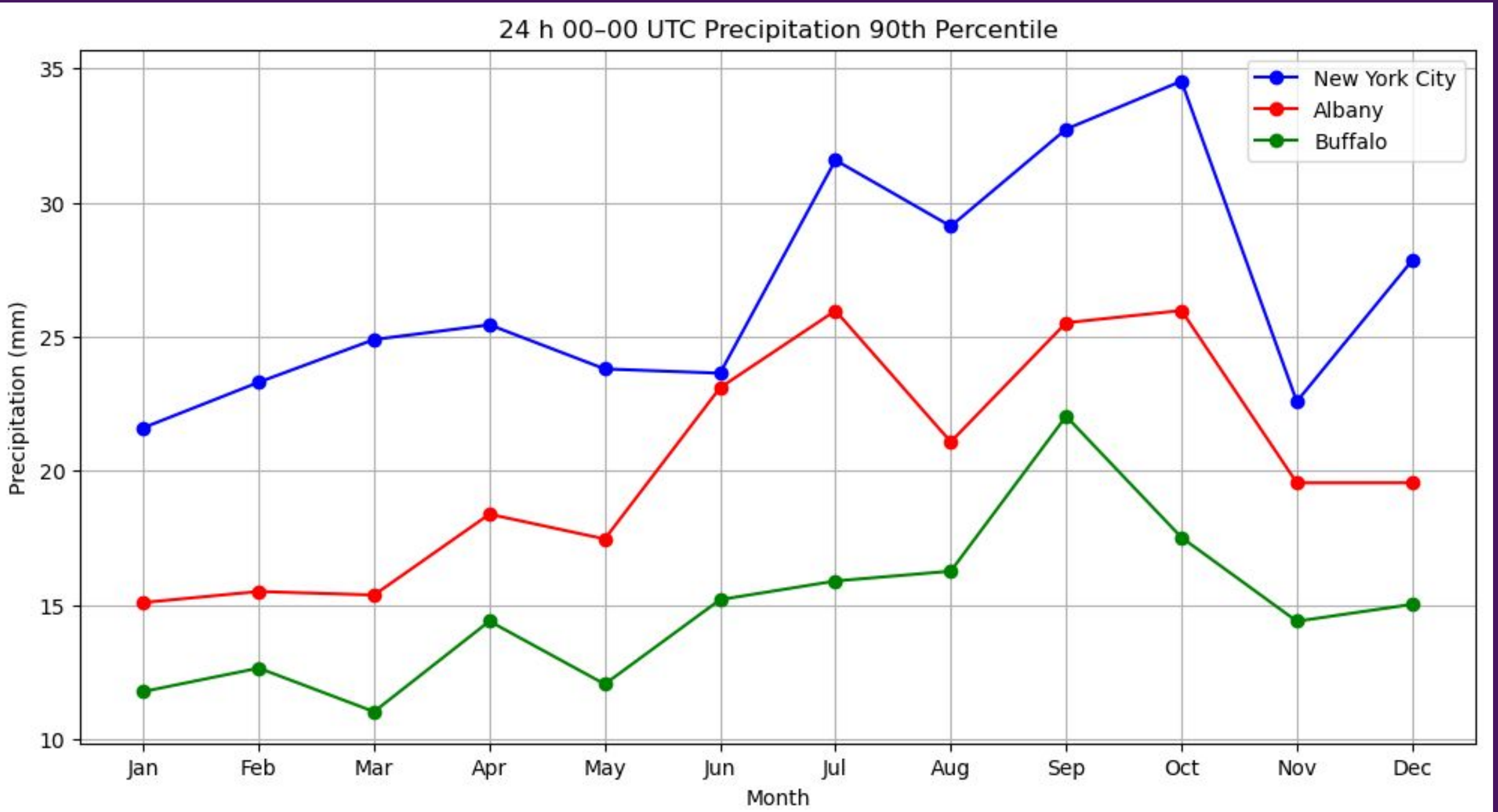
Monthly and Diurnal Cycles of Precipitation

1. Extract the Stage IV grid point closest to the location of interest.
2. Count the number of days in each month when the precipitation was ≥ 0.254 mm and ≥ 25.4 mm.
3. Evaluate the statistics of the hourly precipitation, considering only hours with measurable precipitation.




Days with Precipitation ≥ 0.254 mm Jan 2002–Nov 2023
Average Days per Month
16
15
14
13
12
11
10
9
8
7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
New York City
Albany
Buffalo


Days with Precipitation ≥ 25.4 mm Jan 2002–Nov 2023
New York City
Albany
Buffalo
Average Days per Month
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


24 h 00–00 UTC Precipitation 90th Percentile
New York City
Albany
Buffalo
Precipitation (mm)
35
30
25
20
15
10
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Case Selection

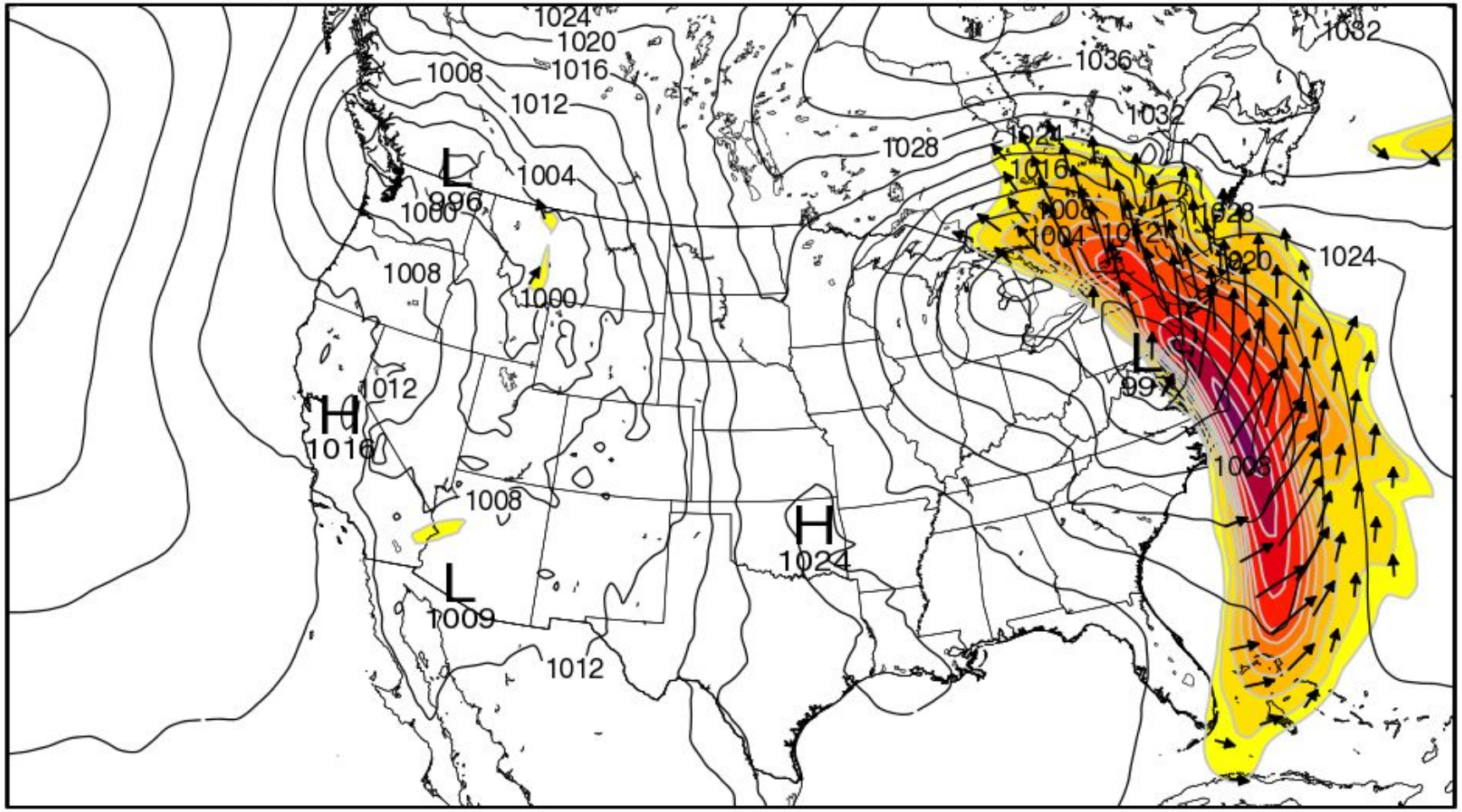
- An event is defined as the 24-hour rolling precipitation sum exceeding the 90th percentile for the corresponding month.

- Event begins the first hour with measurable precipitation after six consecutive hours of no precipitation.

- Event ends at the last hour with measurable precipitation before six consecutive hours of no precipitation.

Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)

Integrated Water Vapor Transport (IVT) and SLP (hPa)

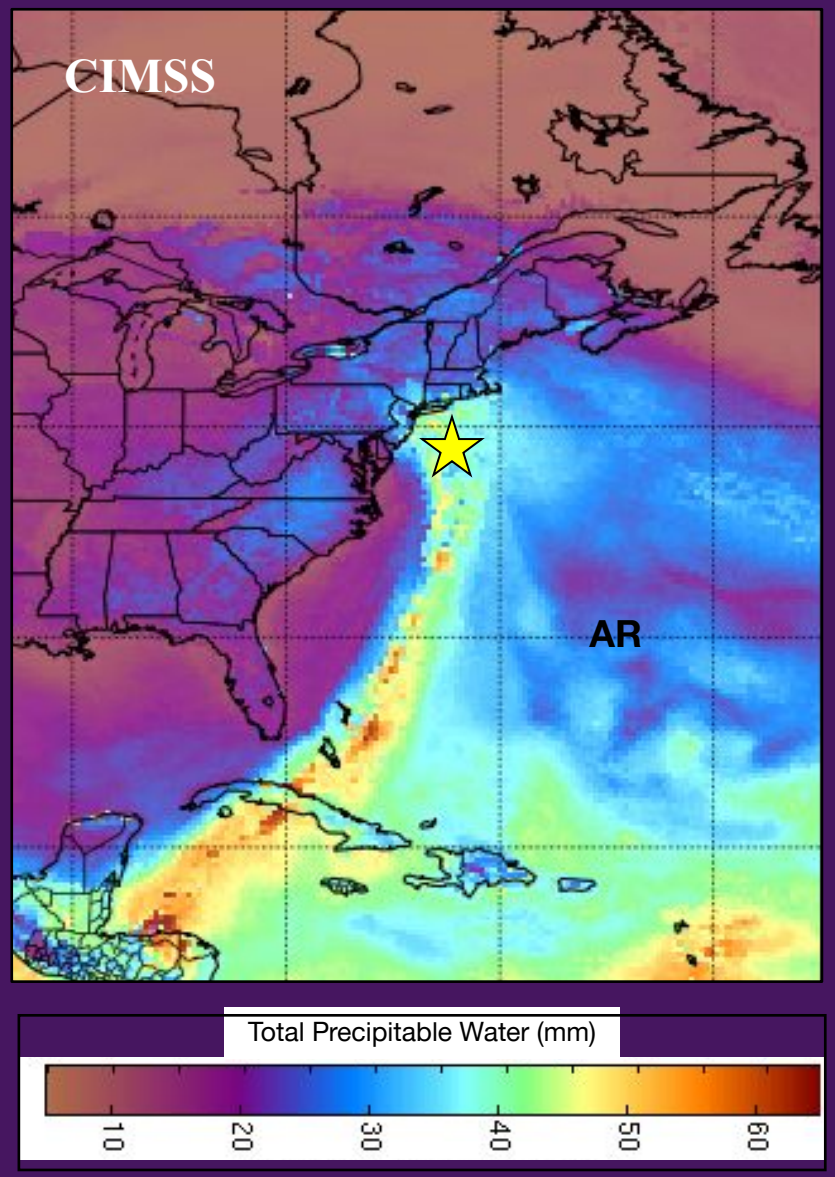


Mon 04/16/2018 12Z

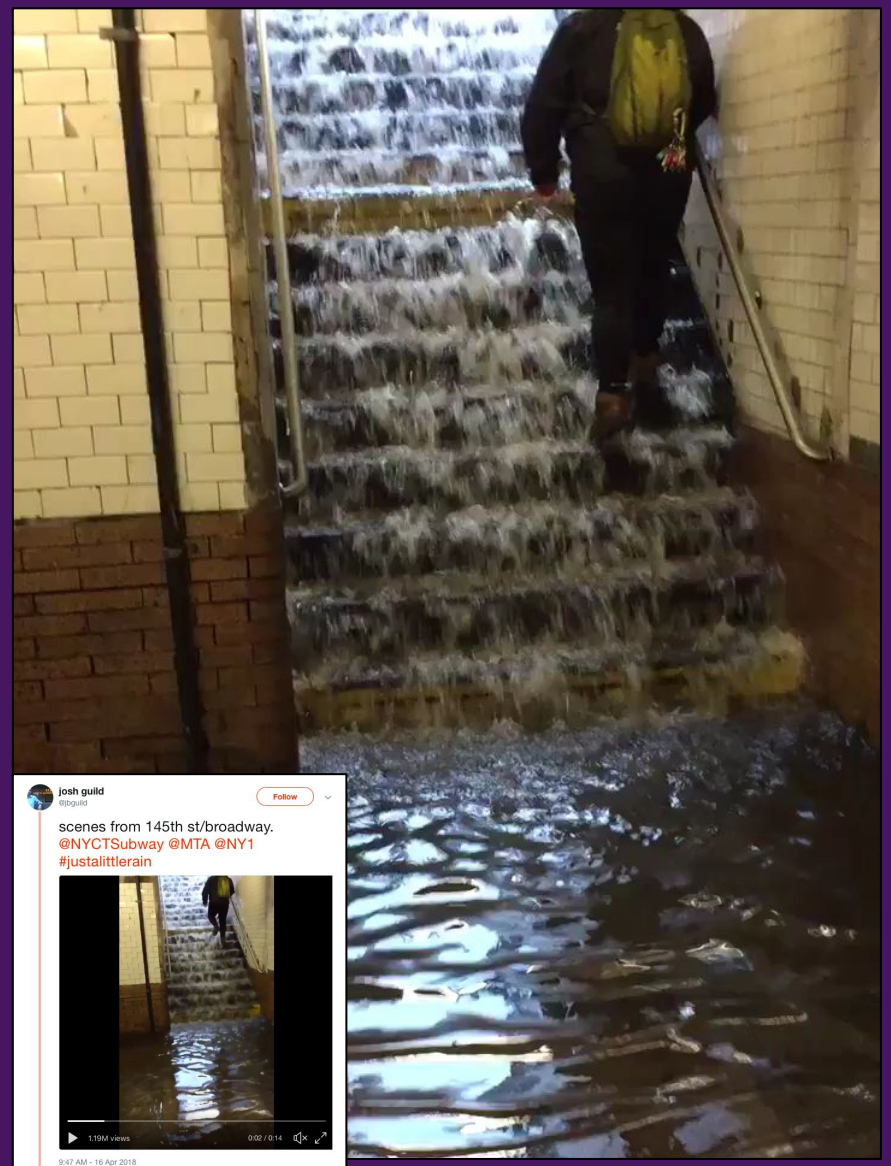
IVT [kg m^{-1} s^{-1}]

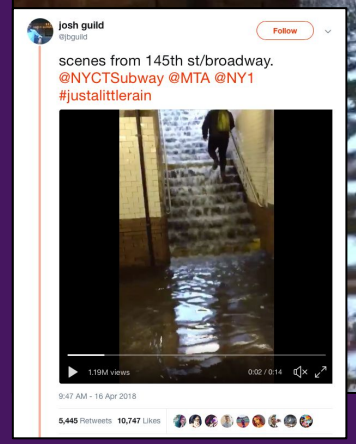
250 300 400 500 600 700 800 1000 1200 1400 1600

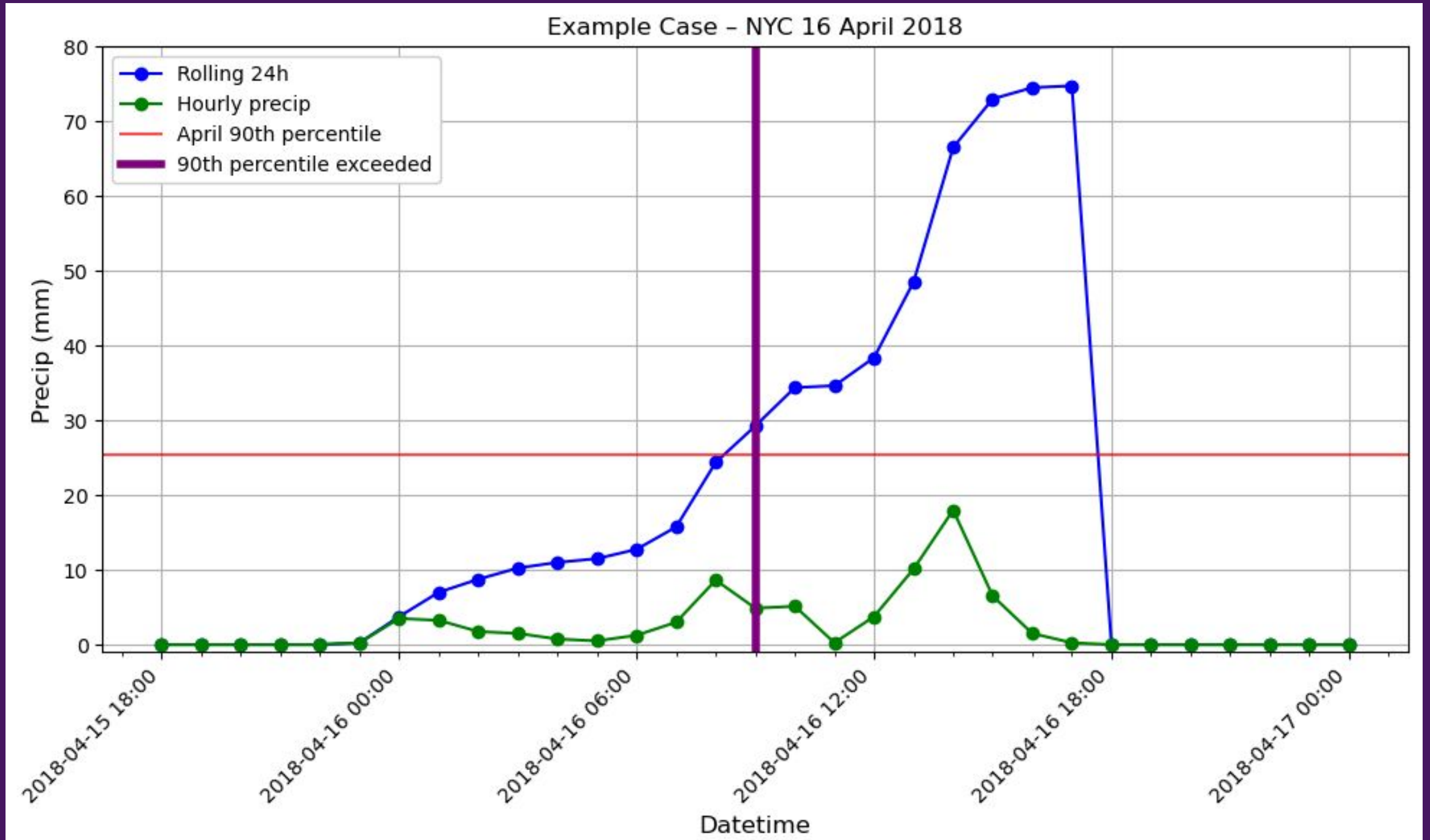
1400 UTC 16 Apr 2018
Satellite-derived Precipitable Water

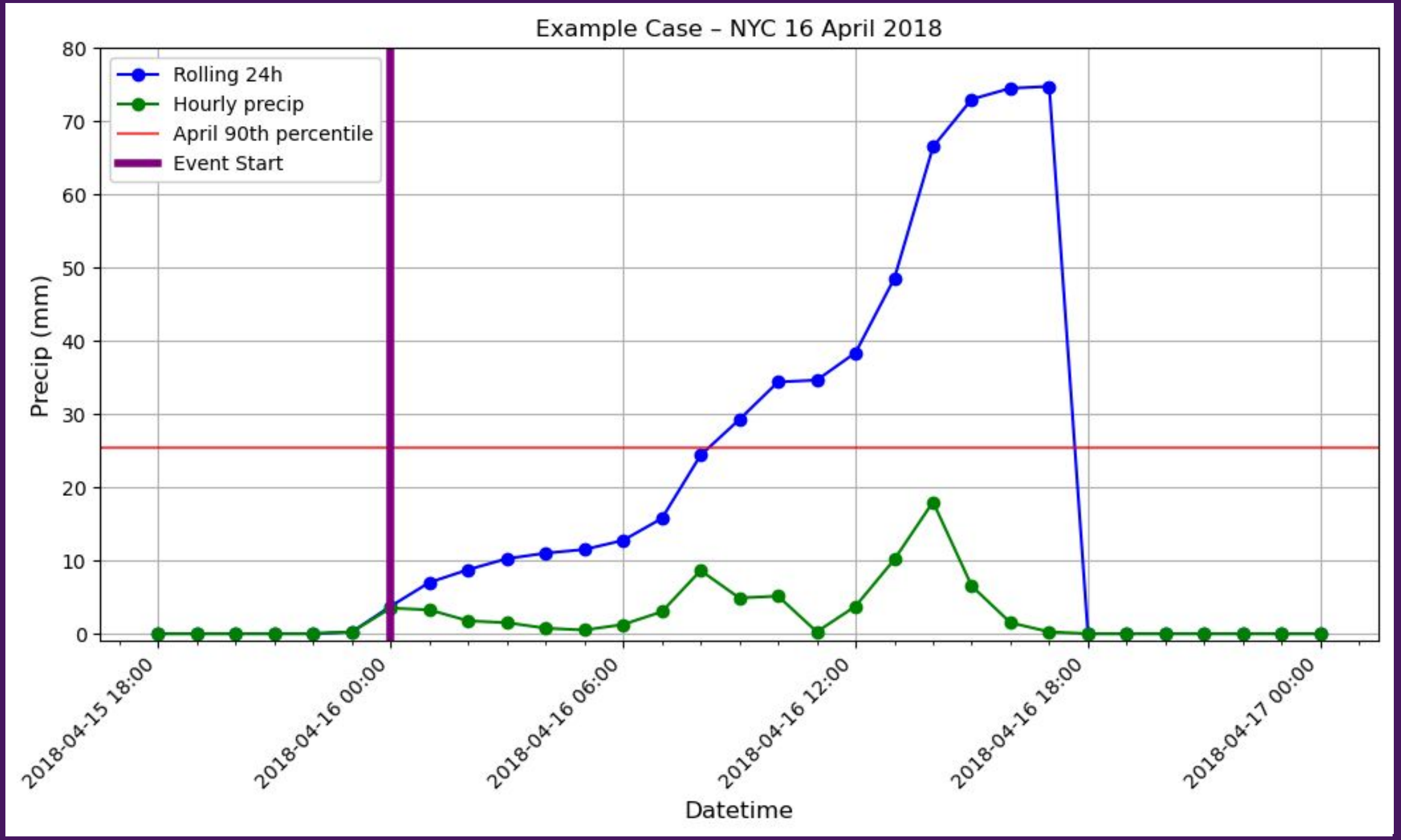


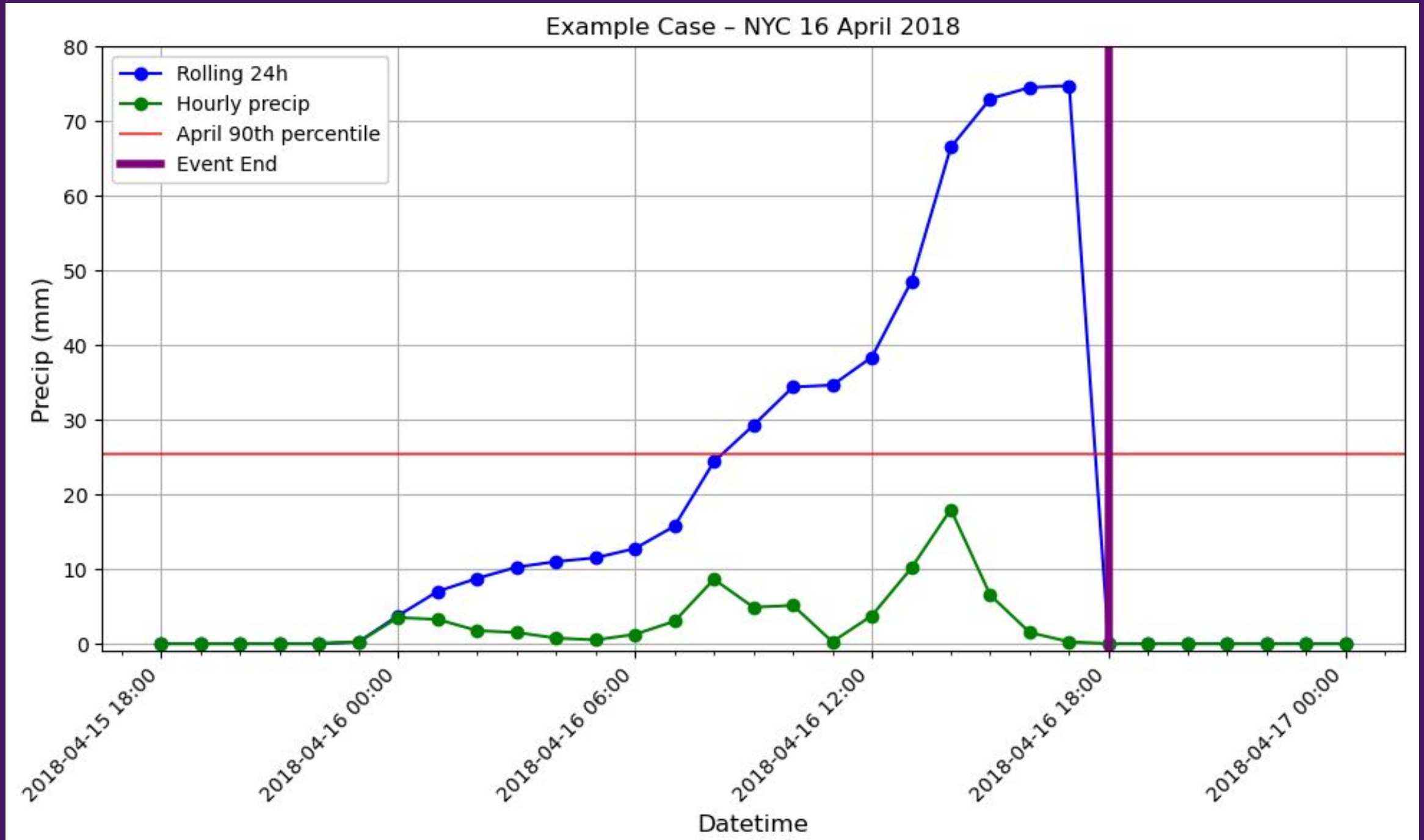
16 April 2018
@jbguild – 145th/Broadway 9:47AM

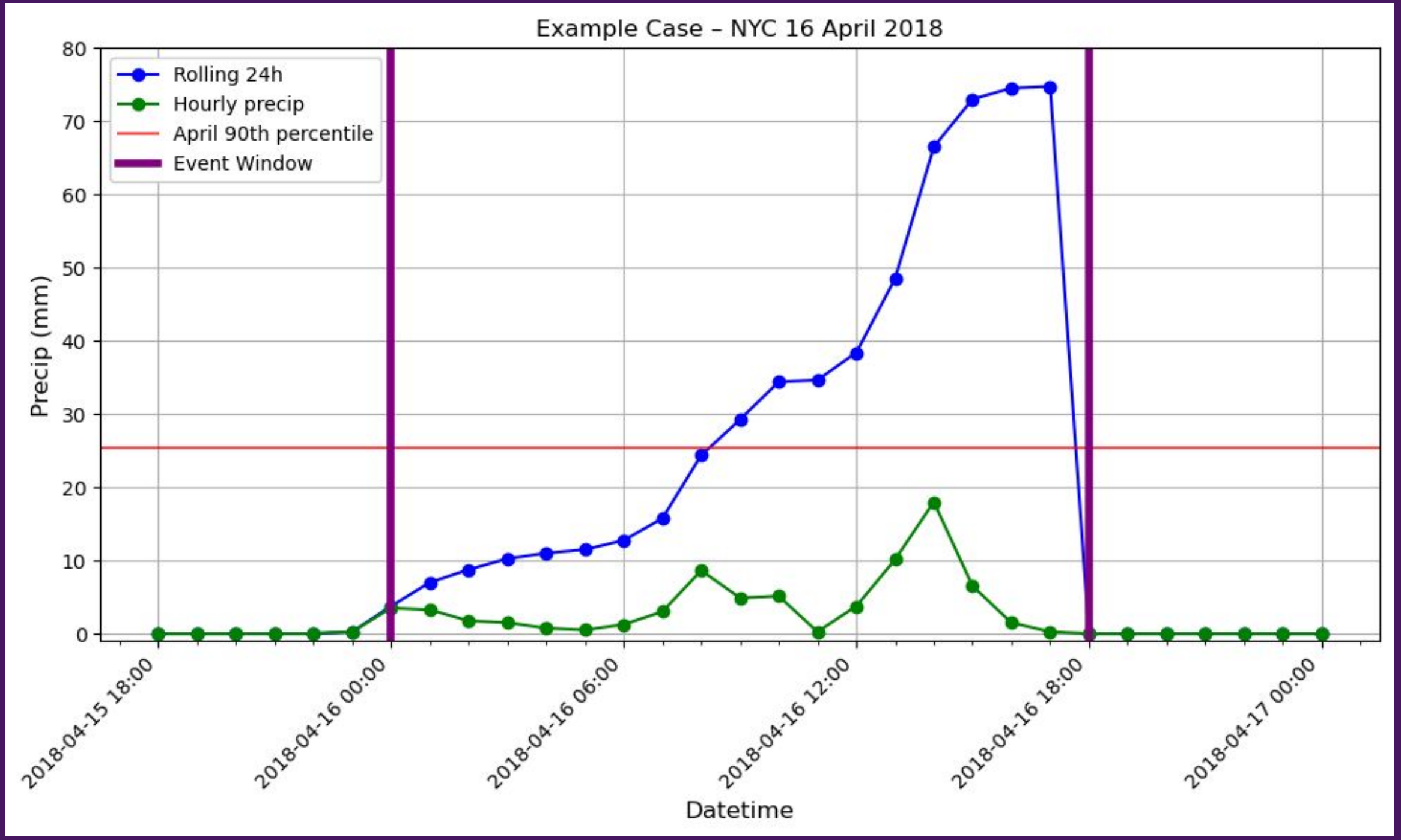





Example Case – NYC 16 April 2018
Rolling 24h
Hourly precip
April 90th percentile
90th percentile exceeded
Precip (mm)
0
10
20
30
40
50
60
70
80
2018-04-15 18:00
2018-04-16 00:00
2018-04-16 06:00
2018-04-16 12:00
2018-04-16 18:00
2018-04-17 00:00
Datetime


Example Case – NYC 16 April 2018
Rolling 24h
Hourly precip
April 90th percentile
Event Start
Precip (mm)
0
10
20
30
40
50
60
70
80
2018-04-15 18:00
2018-04-16 00:00
2018-04-16 06:00
2018-04-16 12:00
2018-04-16 18:00
2018-04-17 00:00
Datetime

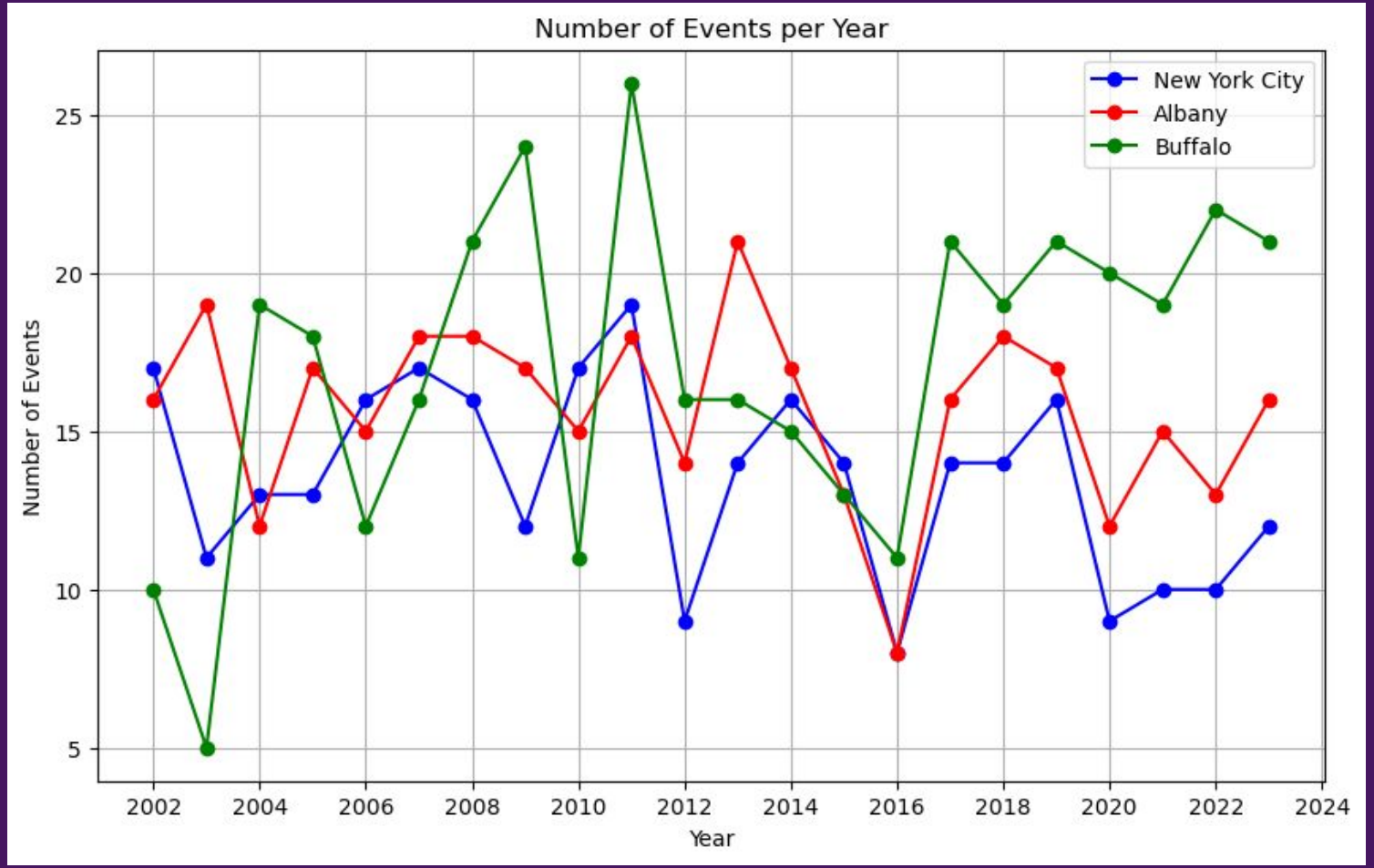

Example Case – NYC 16 April 2018
Rolling 24h
Hourly precip
April 90th percentile
Event End
Precip (mm)
0
10
20
30
40
50
60
70
80
2018-04-15 18:00
2018-04-16 00:00
2018-04-16 06:00
2018-04-16 12:00
2018-04-16 18:00
2018-04-17 00:00
Datetime

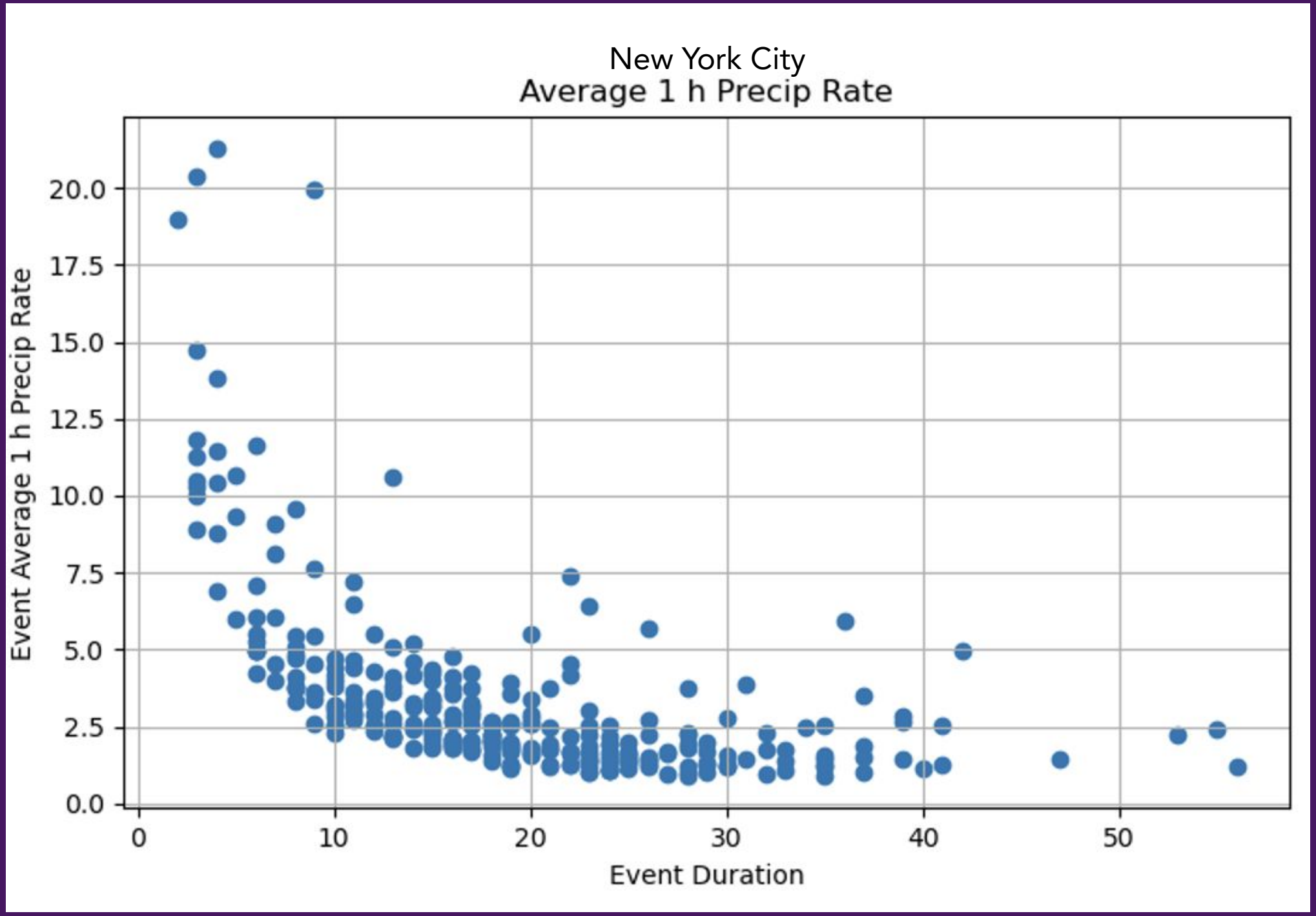

Example Case – NYC 16 April 2018
Rolling 24h
Hourly precip
April 90th percentile
Event Window
Precip (mm)
0
10
20
30
40
50
60
70
80
2018-04-15 18:00
2018-04-16 00:00
2018-04-16 06:00
2018-04-16 12:00
2018-04-16 18:00
2018-04-17 00:00
Datetime

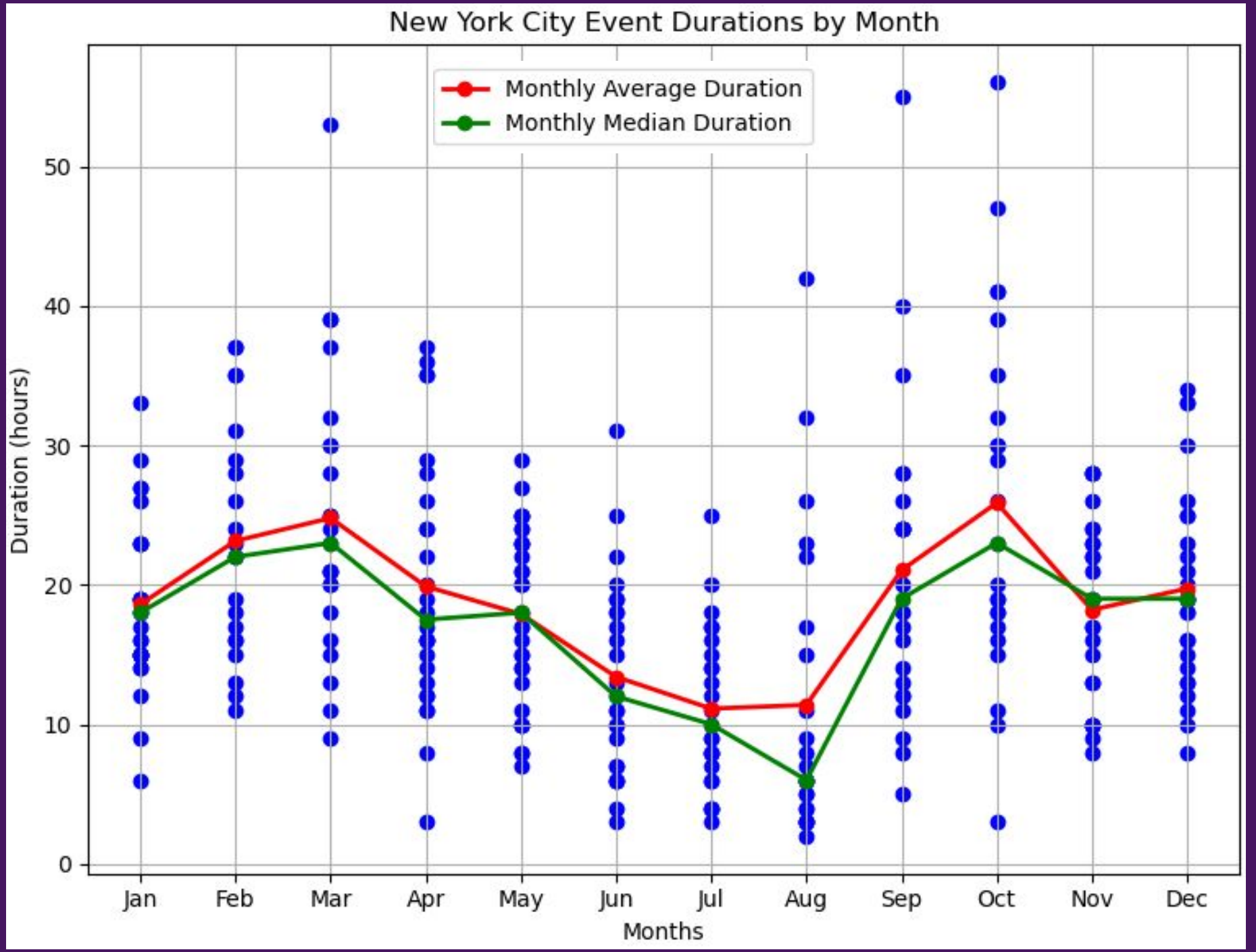
Connection to Research Goals

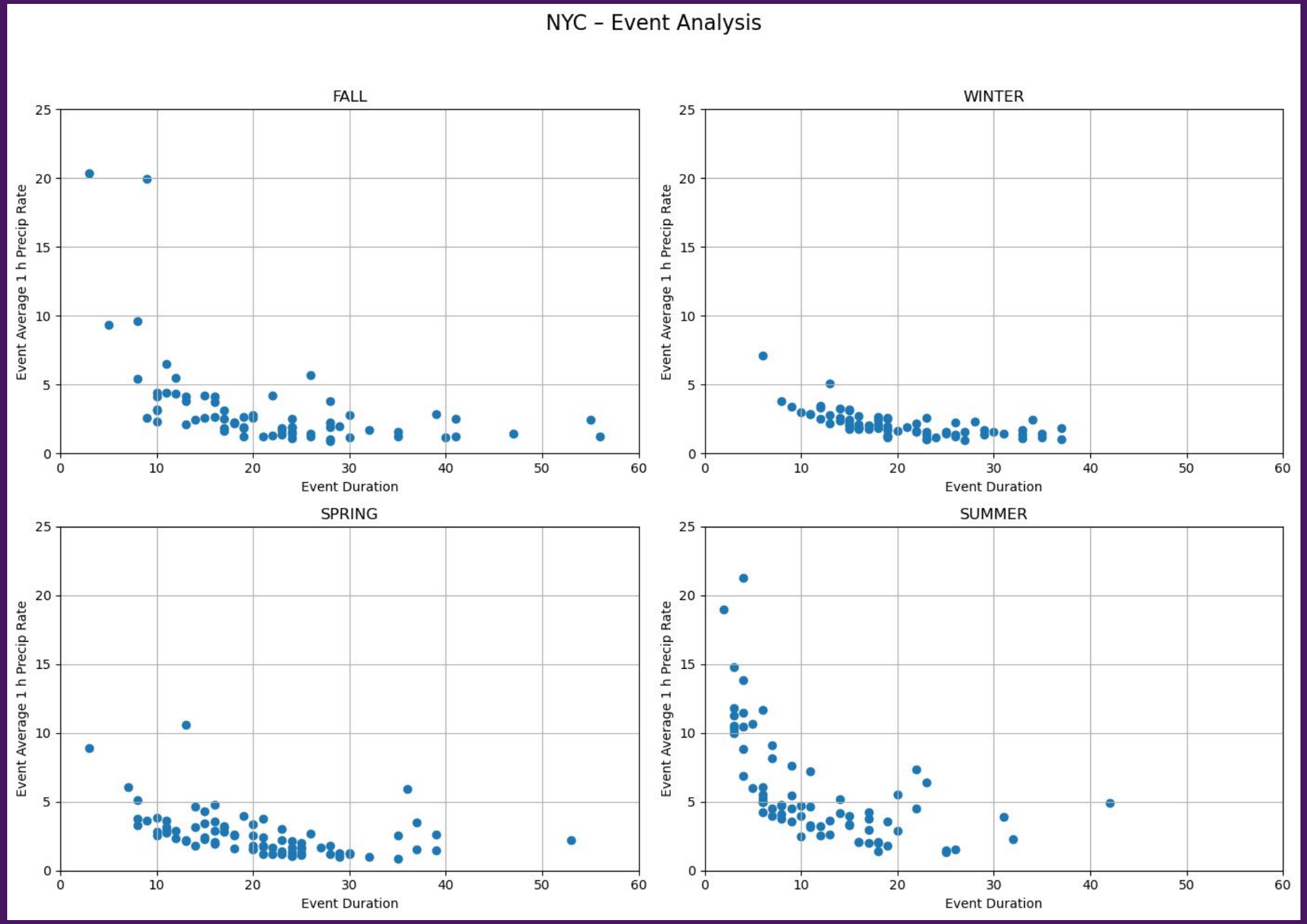
Stratify events by:

- Season
- Duration
- Intensity
- IVT




New York City
Average 1 h Precip Rate
Event Average 1 h Precip Rate
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
0
10
20
30
40
50
Event Duration


New York City Event Durations by Month
Monthly Average Duration
Monthly Median Duration
Duration (hours)
0
10
20
30
40
50
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Months


NYC – Event Analysis
FALL
WINTER
SPRING
SUMMER
Event Average 1 h Precip Rate
Event Duration
0
5
10
15
20
25
0
10
20
30
40
50
60

Conclusions

- Calculating the 90th percentile by month to account for the diurnal cycle of precipitation is essential to capture all forms of extreme events.
- The case selection methodology successfully identified a Northeast U.S. atmospheric river event.
- Summer events tend to have shorter durations but higher hourly precipitation rates, when the logarithmic distribution was most distinct.
- Fall and spring show greater variability in both event duration and rainfall rate due to the diverse range of weather systems.

Future Work

- Stratify events by additional atmospheric parameters, such as 500-hPa geopotential heights and integrated vapor transport.

- Expand the dataset to include all grid points across the Northeast U.S., enhancing the spatial analysis of these events.