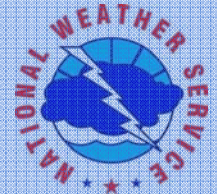


# NOAA Atlas 14: Precipitation Frequency Atlas of the United States Volume 10: Northeastern States



(Connecticut, Maine, Massachusetts, New Hampshire,  
New York, Rhode Island, Vermont)



**Authors:** Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk,  
Dale Unruh, Deborah Martin, Orlan Wilhite

**Contact:** Email: [hdsc.questions@noaa.gov](mailto:hdsc.questions@noaa.gov)  
Phone: 301-427-9552

## TOPICS

1. NA14 VOL 10 PRODUCTS
2. NA14 VOL 10 DATA AND METHODOLOGY
3. COMPARISON WITH PREVIOUS NWS STUDIES

## HDSC and NOAA Atlas 14

- ❑ Hydrometeorological Design Studies Center (**HDSC**)/National Water Center (previously Office of Hydrologic Development)/NWS/NOAA: responsible for updating precipitation frequency (PF) estimates for the U.S. states and affiliated territories.
- ❑ Since 2004, PF updates are published in Volumes of NOAA Atlas 14

- Vols 1 to 10: published
- Vol 11 (TX): mid-2018
- Vol 12 (OR,WA): mid-2019?
- Vol 13 (ID, MT, WY) : ?

- ❑ External funding

NOAA's National Weather Service  
Hydrometeorological Design Studies Center

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**NEW: Precipitation frequency estimates for CONNECTICUT, MAINE, MASSACHUSETTS, NEW HAMPSHIRE, NEW YORK, RHODE ISLAND, AND VERMONT updated on September 30, 2015**

NOAA Atlas 14 project areas

- Volumes 1 to 10 (published)
- Volume 11 (2018)

<http://nws.noaa.gov/oh/hdsc/index.html>

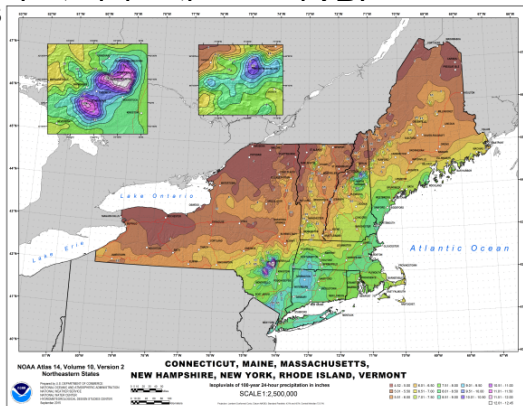
# Precipitation Frequency Data Server (PFDS)

## Whole project area

### PF Data Server

- **PF in GIS Format.** High resolution grids of AMS-based and PDS-based estimates and 90% confidence interval bounds for 5-min to 60-day durations and 1- to 1,000-year ARI (1/2 – 1/1000 AEP)

- **PF Maps.** Cartographic maps for S



- **Temporal Distr.**
- **Time Series Data**

### PF Documents

## Selected location

<http://hdsc.nws.noaa.gov/hdsc/pfds/index.html>

# PF estimates for selected location

## NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: NY

### DATA DESCRIPTION

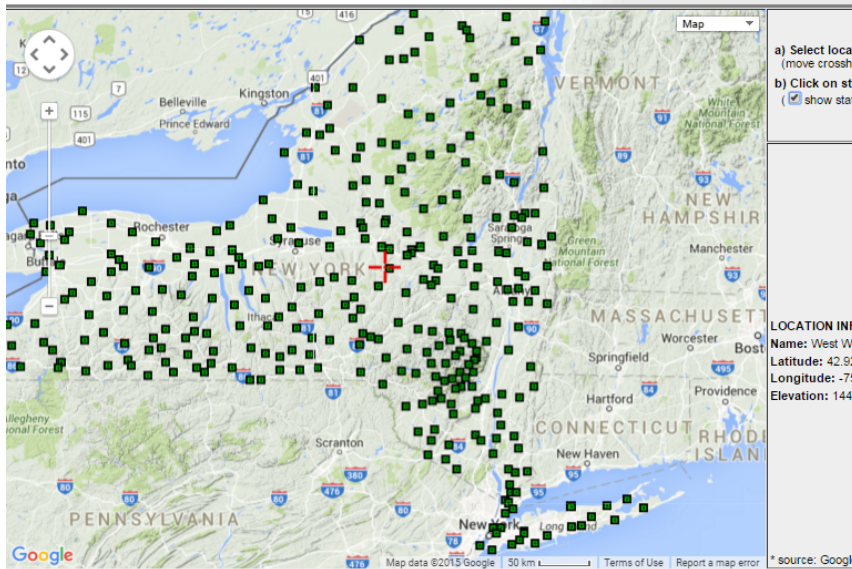
Data type: precipitation depth Units: english Time series type: partial duration

### SELECT LOCATION

#### Manually:

- a) Enter location (decimal degrees, use "-" for S and W): latitude: longitude: submit
- b) Select station (click here for a list of stations used in frequency analysis for NY): select station

#### Use map:



- a) Select location (move crosshair or double click)
- b) Click on station icon (show stations on map)

#### LOCATION INFORMATION:

Name: West W  
Latitude: 42.9  
Longitude: -72  
Elevation: 144

**POINT PRECIPITATION FREQUENCY (PF) ESTIMATES**  
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION  
NOAA Atlas 14, Volume 10, Version 2

## POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

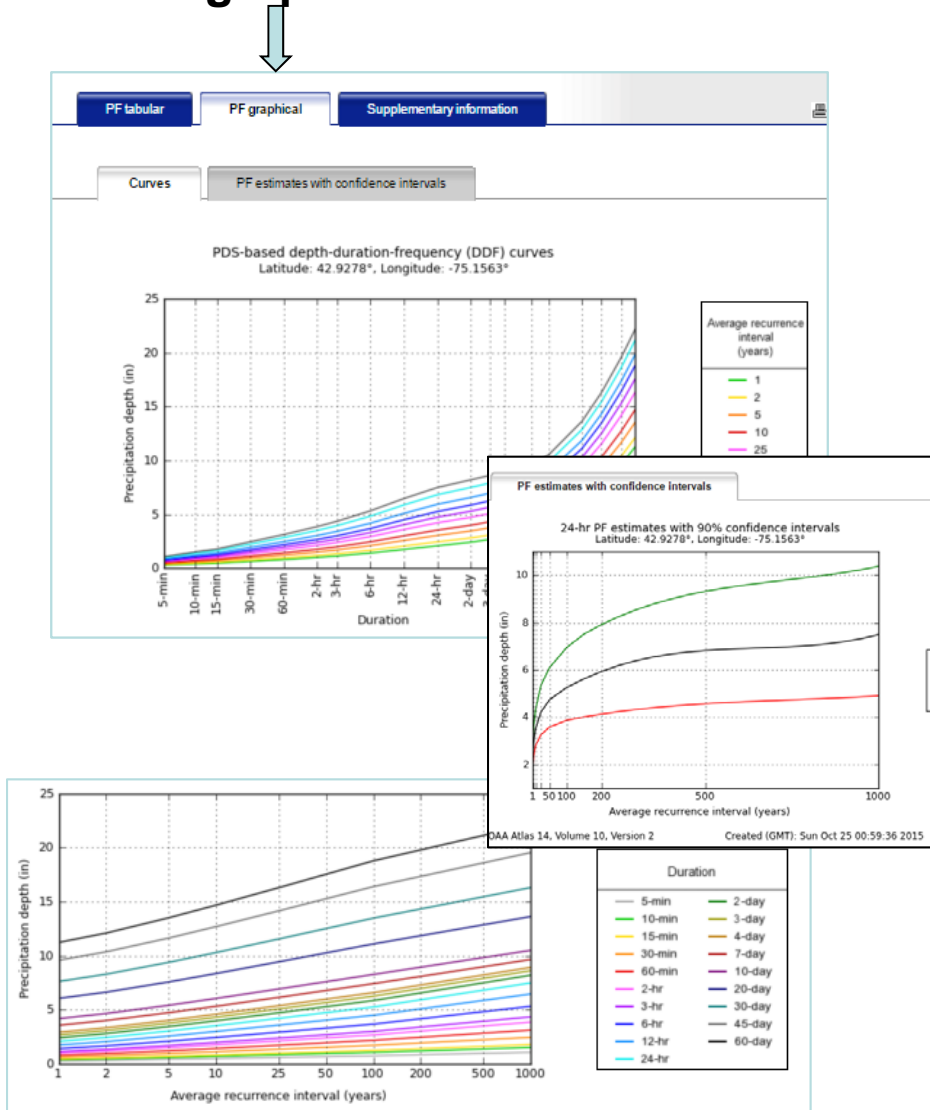
WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION  
NOAA Atlas 14, Volume 10, Version 2

PF tabular PF graphical Supplementary information [Print Page](#)

Duration	PDS-based precipitation frequency estimates with 90% confidence intervals (in inches) <sup>1</sup>									
	Average recurrence interval (y)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.275 (0.215-0.348)	0.330 (0.258-0.417)	0.419 (0.326-0.530)	0.493 (0.381-0.626)	0.594 (0.446-0.779)	0.673 (0.495-0.895)	0.773 (0.531-1.03)	0.847 (0.575-1.17)	0.974 (0.637-1.38)	1.07 (0.684-1.54)
10-min	0.390 (0.305-0.482)	0.467 (0.365-0.590)	0.593 (0.462-0.751)	0.698 (0.540-0.887)	0.842 (0.632-1.10)	0.953 (0.701-1.27)	1.07 (0.761-1.45)	1.20 (0.815-1.66)	1.38 (0.903-1.96)	1.52 (0.970-2.18)
15-min	0.459 (0.359-0.579)	0.550 (0.429-0.694)	0.698 (0.543-0.884)	0.821 (0.636-1.04)	0.991 (0.743-1.30)	1.12 (0.825-1.49)	1.27 (0.891-1.71)	1.41 (0.959-1.95)	1.62 (1.06-2.30)	1.78 (1.14-2.57)
30-min	0.627 (0.490-0.792)	0.752 (0.587-0.950)	0.956 (0.744-1.21)	1.13 (0.871-1.43)	1.36 (1.02-1.78)	1.54 (1.13-2.05)	1.73 (1.23-2.35)	1.94 (1.32-2.68)	2.23 (1.46-3.17)	2.45 (1.57-3.53)
60-min	0.796 (0.622-1.00)	0.954 (0.745-1.21)	1.21 (0.945-1.54)	1.43 (1.11-1.81)	1.73 (1.29-2.26)	1.95 (1.44-2.60)	2.21 (1.58-2.98)	2.47 (1.68-3.41)	2.84 (1.86-4.03)	3.13 (2.00-4.50)
2-hr	0.997 (0.784-1.25)	1.19 (0.934-1.49)	1.50 (1.18-1.89)	1.76 (1.37-2.23)	2.12 (1.60-2.77)	2.40 (1.78-3.17)	2.71 (1.93-3.64)	3.03 (2.07-4.17)	3.50 (2.31-4.93)	3.86 (2.48-5.51)
3-hr	1.13 (0.895-1.42)	1.35 (1.06-1.68)	1.70 (1.33-2.13)	1.99 (1.55-2.50)	2.39 (1.81-3.10)	2.70 (2.01-3.55)	3.03 (2.18-4.08)	3.41 (2.33-4.66)	3.94 (2.60-5.53)	4.35 (2.80-6.18)
6-hr	1.41 (1.12-1.75)	1.67 (1.33-2.07)	2.10 (1.66-2.60)	2.45 (1.93-3.05)	2.93 (2.24-3.78)	3.41 (2.59-4.51)	3.94 (2.83-5.34)	4.51 (3.21-6.18)	4.83 (3.20-6.71)	5.32 (3.45-7.50)
24-hr	1.74 (1.40-2.08)	2.06 (1.67-2.45)	2.57 (2.04-3.13)	3.00 (2.42-3.59)	3.59 (2.85-4.39)	4.21 (3.25-5.34)	5.26 (3.87-6.95)	6.03 (4.57-7.91)	6.46 (4.57-8.31)	7.09 (4.90-10.4)
	2.41	2.81	3.45	3.99	4.72	5.29	5.86	6.57	7.50	8.20

# PF estimates for selected location

## PF graphical



## Supplementary information

PF tabular | PF graphical | **Supplementary information** | Print Page

**I. Document**  
Click here for this volume's document.

**II. PF in GIS format**  
Spatially interpolated precipitation frequency estimates (with upper and lower bounds of the 90% confidence interval) are available in GIS compatible format (ascii file). For default download page click here.  
Select: Average recurrence interval: 2-year duration: 60-minute set: Precipitation frequency estimates Submit

**III. PF cartographic maps**  
Cartographic maps of precipitation frequency estimates were created for selected average recurrence intervals and durations. We recommend that these color maps be used as visual aids only. For default cartographic maps page click here.  
Select: Average recurrence interval: 2-year duration: 60-min Submit

**IV. Temporal distributions**  
Temporal distributions are provided for 5-hour, 10-hour, 24-hour, and 96-hour durations. The temporal distributions for the duration are expressed in probability terms as cumulative percentages of precipitation totals (see documentation for more information). To provide detailed information on the varying temporal distributions, separate temporal distributions were derived for four precipitation cases defined by the duration quartile in which the greatest percentage of the total precipitation occurred.  
Select duration: 24-hour Submit

**V. Seasonality analysis**  
The seasonality graphs show the percentage of precipitation totals for a given duration that exceeded the precipitation frequency estimates for the duration and selected annual exceedance probabilities in each month for each region. The precipitation frequency estimates were derived from annual maximum series at each station in the region (as described in documentation). Results are provided for 60-min, 24-hr, 2-day, and 10-day durations and for annual exceedance probabilities of 1/2 (or 1-in-2), 1/5, 1/10, 1/25, 1/50, and 1/100. Seasonality graphs should not be used to derive seasonal precipitation frequency estimates.

**24-hr duration**  
Based on 468 stations and 31543 cumulative years of record  
Coordinates: 42.9278, -75.1563

NOAA/NWS/OHD/HDS/C Created (GMT): Mon Oct 26 17:13:18 2015

**VI. Rainfall frequency estimates**  
NOAA Atlas 14 precipitation frequency estimates represent precipitation magnitudes regardless of the type of precipitation. For some areas, where the contribution of snowfall to the total yearly precipitation amount is significant, a separate rainfall (liquid precipitation only) frequency analysis is done for durations between 1 and 24 hours, which are of most interest to design projects relying on peak flows.  
Rainfall (liquid precipitation only) frequency estimates for NOAA Atlas 14 Volume 10 project area will be provided for durations between 1 and 24 hours in addition to precipitation frequency estimates after NOAA Atlas 14 document is completed.

**VII. Time series data**  
Annual maximum series precipitation data is available for download only for stations used in frequency analysis.

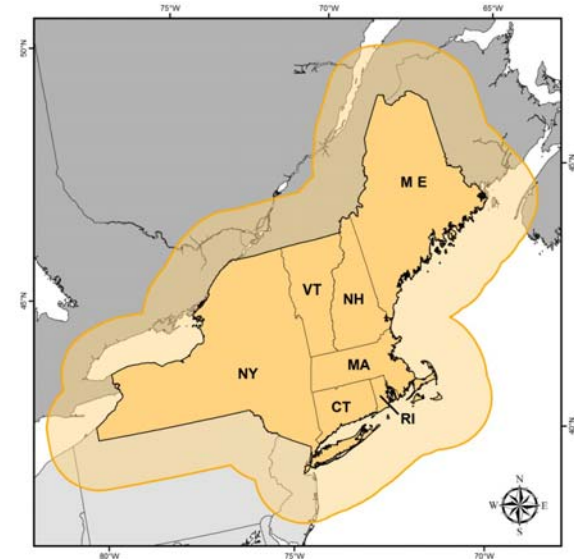
**VIII. Climate data source**  
Precipitation frequency results are based on data from a variety of sources, but largely from the National Centers for Environmental Information - NCEI (formerly National Climatic Data Center - NCDC). For more information about observing sites in the area, regardless of if their data was used in this study, please visit NCEI's Climate Data Online.  
For detailed information about the stations used in this study, please refer to NOAA Atlas 14 Document.

**IX. Watershed information**  
Click here to get the watershed information for this location from the U.S. Environmental Protection Agency's (EPA) site.

## Data sources

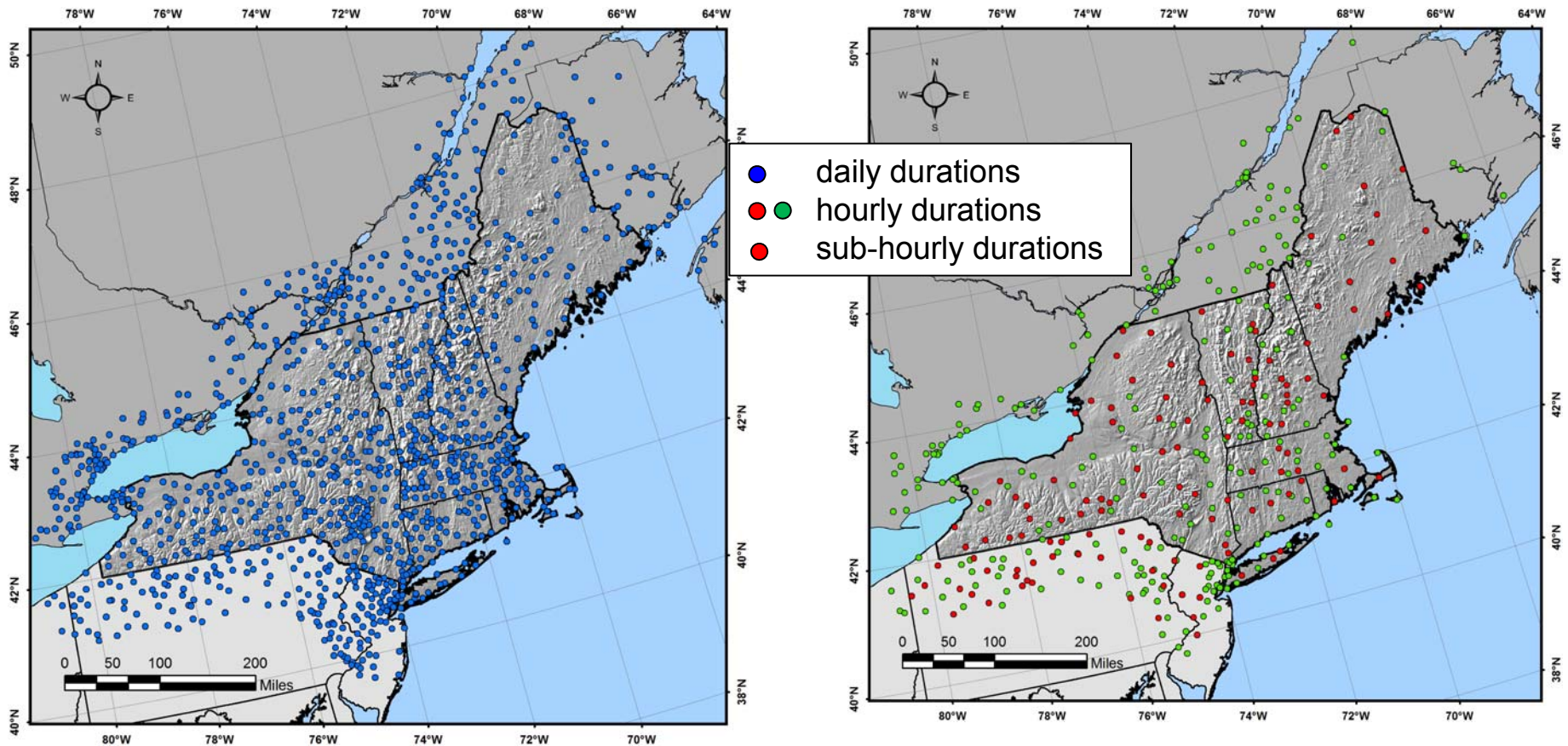
NCEI: ASOS, AWOS, COOP, GHCN, QCLCD, USCRN

- Boston Water and Sewer Commission
- Citizen Weather Observers Program
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS)
- Earth Networks
- Eastern New York Observing Network
- Environment Canada
- Illinois State Water Survey: NADP
- Lyndon State College, Lyndonville, VT
- Massachusetts Department of Conservation and Recreation
- Mid-Atlantic River Forecast Center: IFLOWS
- Midwestern Region Climate Center: 19th Century Forts and Voluntary Observers Database
- Mount Washington Observatory
- Narragansett Bay Commission
- National Resources Conservation Service: SCAN
- New Hampshire Department of Transportation
- New York City Department of Environmental Protection
- Office of the New Jersey State Climatologist at Rutgers University: NJ Mesonet & NJ SafetyNet
- Rhode Island Department of Environmental Management, Office of Water Resources
- U.S. Department of Agriculture, Agricultural Research Service
- U.S. Forest Service: RAWS
- U.S. Geological Survey: ME Water Science Center (WSC), MA-RI WSC, NH-VT WSC, NY WSC



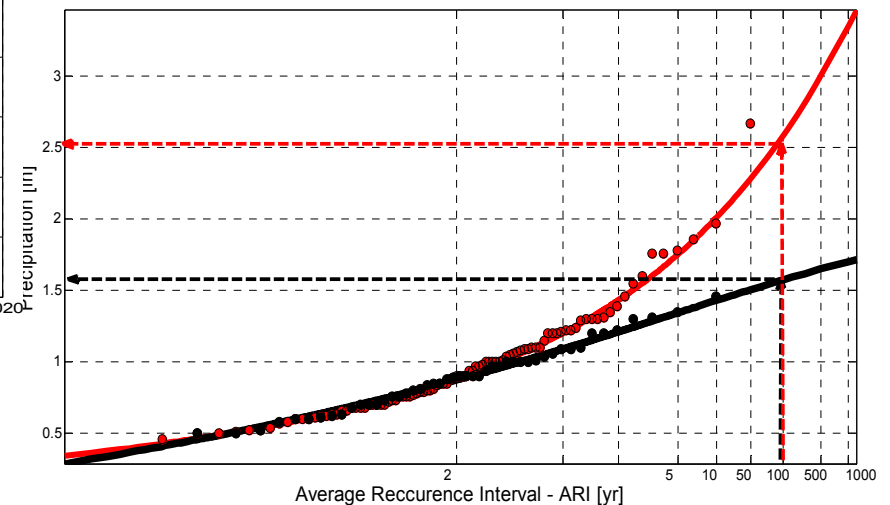
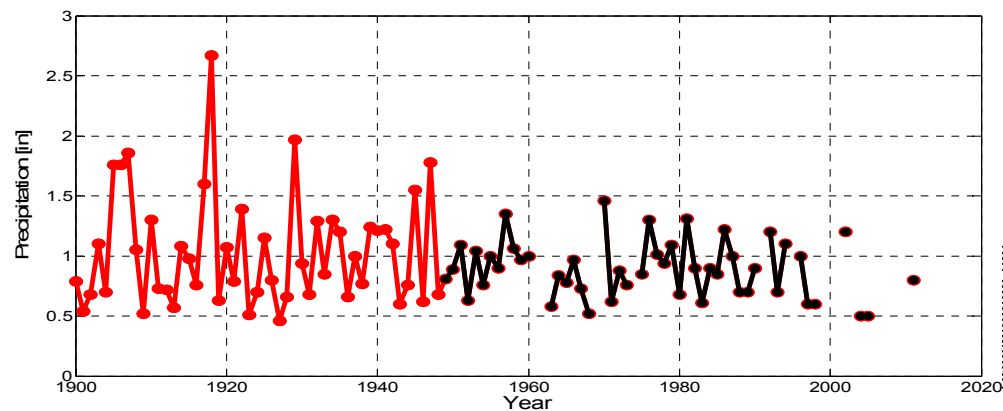
## Stations used in frequency analysis

Duration (D)	Number of stations	Record length (data years)		
		average	median	range
Daily (1-day $\leq$ D $\leq$ 60-day)	1,218	66	62	30 (9) – 173
Hourly (1-hr $\leq$ D < 24-hr)	370	42	40	30 (9) – 122
Sub-hourly (D < 60-min )	127	27	26	20 (14) – 46



## Data digitizing

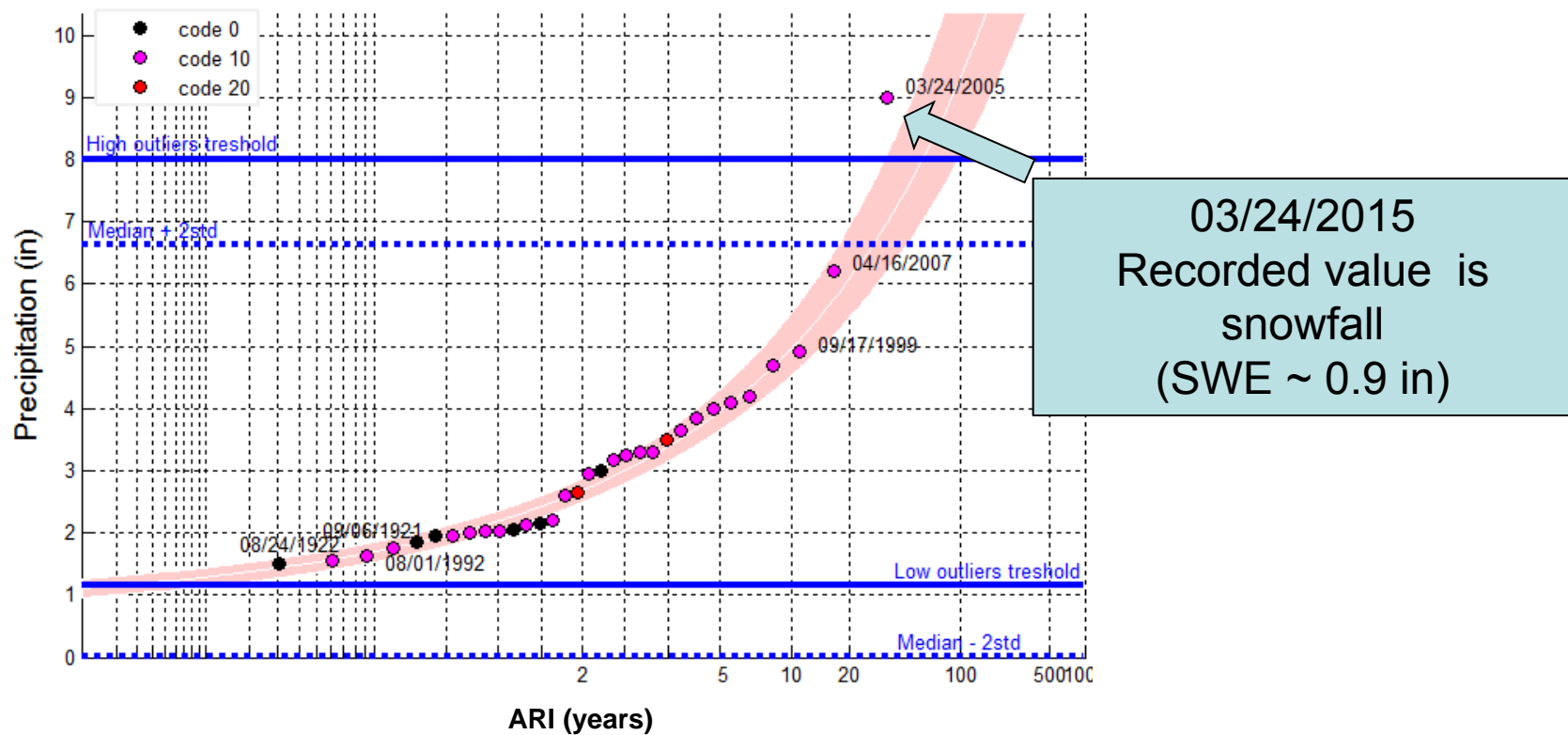
- Digitized additional data for 78 stations (on average 35 years of data) from
  - New York City Environmental Protection Bureau of Water Supply (NYCEPBWS)
  - Massachusetts Department of Conservation and Recreation (DCR)
  - NCEI's Climate Database Modernization Program (CDMP).
  
- *Example: 1hr AMS for ITHACA, NY. Hourly record extended 49 years (1900-1948).*





## AMS extraction and QC

- AMS extracted and QC-ed for 17 durations from 15-min to 60-day
- Example: *24-hr AMS for Rhinebeck 4SE, NY (30-7035)*



## AMS adjustments

- Adding missing significant events:

Station	Date	Amount	Source
Westerly, RI (37-8911)	16-17 Sep 1932	12.13 in/24hr	NCEI State Climate Extremes Committee: state record
Sanford, ME (17-7479)	21 Oct 1996	8.19 in/1day	0.19 in digitized in observer form
Barre Falls Dam, MA (19-0408)	12-22 Sep 1938	11.38 in/1day 18.71 in/10days	USGS: <i>Hurricane Floods of September 1938</i>
Brattleboro, VT (43-0841)	6-7 Aug 1856	11.80 in/2days	D. Ludlum: <i>The Vermont Weather Book</i>
Tannersville, NY (30-8403)	21 Mar 1980	7.76 in/1day	J. Thaler: <i>Catskill Weather</i>
Peekamoose, NY (30-6479)	22-24 Aug 1933	11.6 in/1day 16.0 in/3days	Corps of Engineers: <i>Storm Studies – NA 1-24</i>
Saratoga Springs, NY (30-7484)	25 Jun 1966	3.74 in/1hour	U.S Dept of Commerce: <i>Storm Data – June 1966 (8/6)</i>

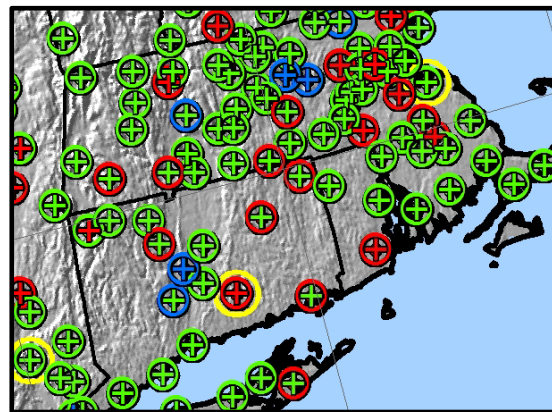
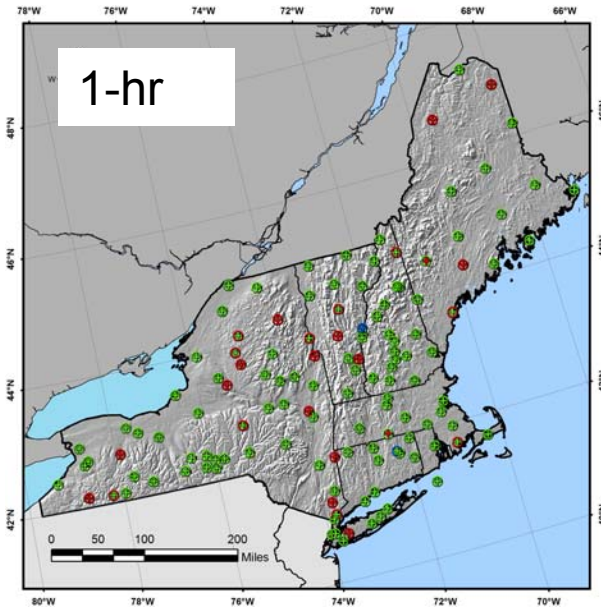
- Manually adjusting constrained AMS values:

Station	Date	Constrained (unconstrained) 1-day	Unconstrained 24-hour
East Jewett, NY (30-2366)	28-29 Aug 2011	6.70 (7.37) in/day	12.85 in/day
Rhinebeck 4 SE, NY (30-7035)	28-29 Aug 2011	4.20 (4.62) in/day	8.27 in/day
MT Mansfield, VT (43-5416)	28-29 Aug 2011	3.62 (3.98) in/day	6.84 in/day
Poughkeepsie( NY (30-6821)	11-12 Jun 1903	5.10 (5.61) in/day	8.16 in/day
NYC Central Park, NY (30-5801)	8-9 Oct 1903	7.33 (8.06) in/day	11.17 in/day
Binghamton Greater AP(30-0687)	June 17, 1960	1.50 (1.62) in/hr	2.92 in/hr

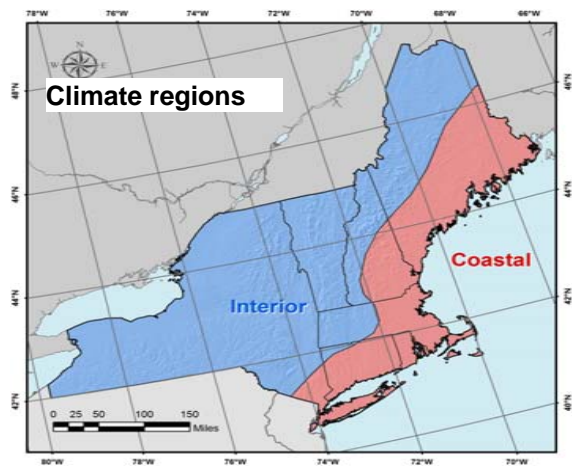
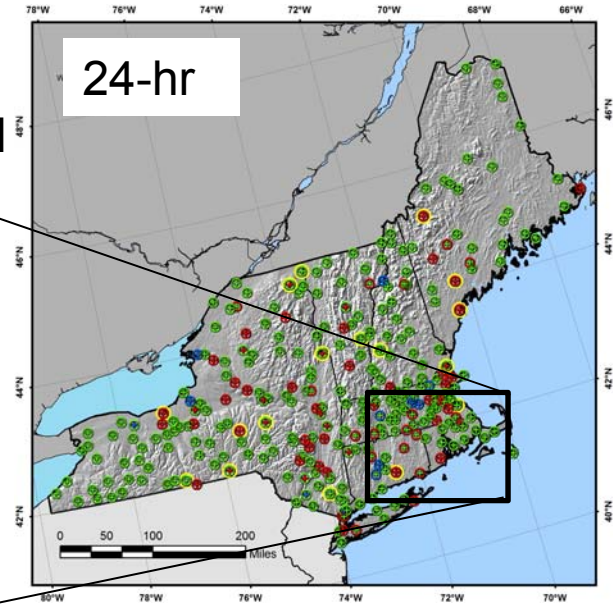
# AMS trend analysis

## At-station analysis

- Test for trends & investigate spatial patterns
- MEAN: parametric *t*-test; non-parametric Mann-Kendal
- VARIANCE: Levene test



positive trend  
negative trend  
no trend

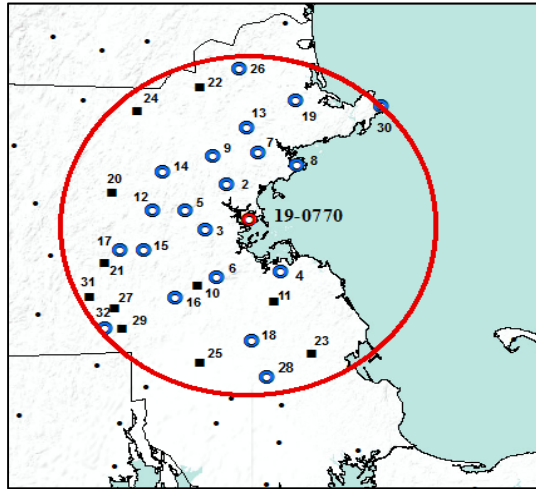


## Regional analysis:

- AMS normalized and regressed against time.
- Test  $H_0$ : no serial correlation at 5% level

# Regionalization

NA14 METHOD: Regional frequency analysis approach based on L-moment statistics.

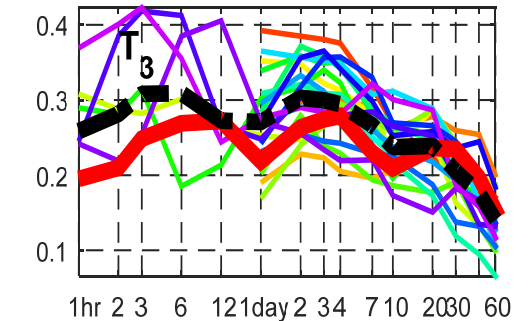
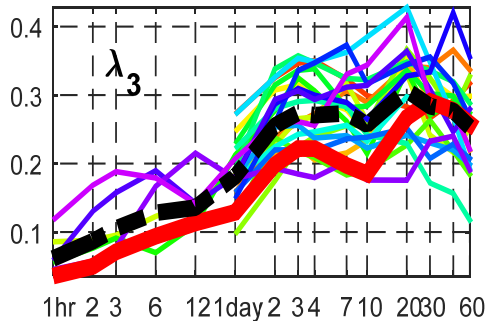
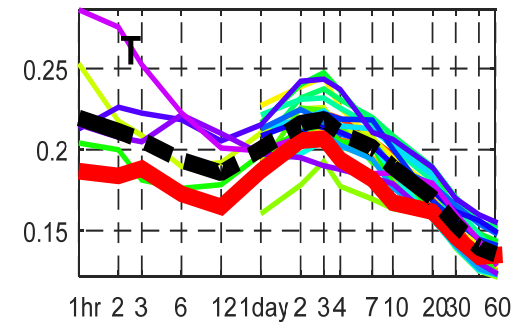
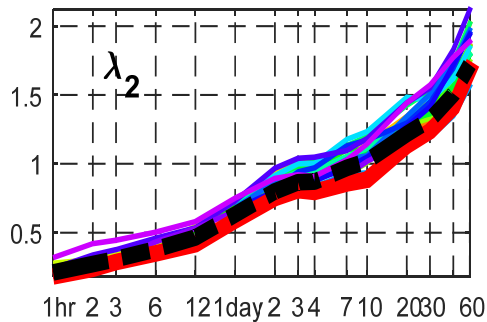
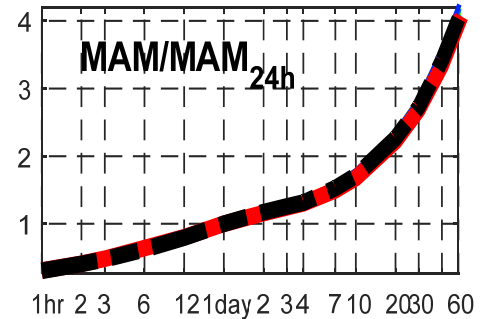
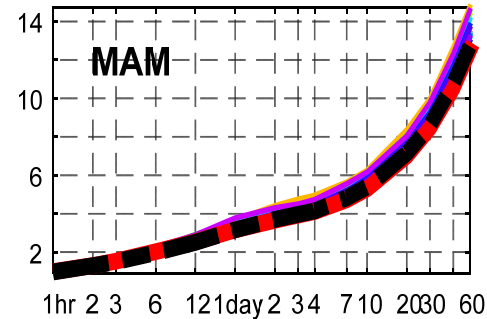


REGIONAL ANALYSIS FOR STATION 19-0770

i	ind	site_id	dist(mi)	elev	elev_diff	stddt	enddt	man24hr	man_diff	max1hr	max6hr	max2
<b>Deleted stations</b>												
31	97	19-4760	29.12	270	258	1885	2014	3.46	0.31	NaN	NaN	8.5
29	73	19-2997	28.21	250	238	1905	2014	3.96	0.21	NaN	NaN	10.7
<b>Backup stations</b>												
10	147	19-6012	14.39	50	38	1931	2014	3.23	0.07	NaN	NaN	6.8
22	90	19-4105	24.68	50	38	1893	2014	3.15	-0.00	NaN	NaN	7.7
21	52	19-0218	24.58	230	218	1893	1969	3.45	0.30	NaN	NaN	8.4
20	94	19-4580	22.60	205	193	1893	2014	2.92	-0.23	NaN	NaN	6.6
11	150	79-0028	15.07	161	149	1945	1996	3.04	-0.11	NaN	NaN	6.9
10	147	19-6012	14.39	50	38	1931	2014	3.23	0.07	NaN	NaN	6.8
<b>Selected stations</b>												
32	139	96-0003	30.33	304	292	1948	2013	3.77	0.62	3.46	6.55	10.4
30	113	19-6977	28.96	79	67	1902	2013	3.32	0.17	1.86	4.75	7.8
28	59	19-0840	28.20	40	28	1940	2014	3.39	0.24	3.30	7.37	9.1
...												
5	136	54-0129	10.57	58	46	1889	2010	3.08	-0.07	NaN	NaN	9.6
4	82	19-3624	10.51	35	23	1936	2014	3.67	0.52	NaN	NaN	8.0
3	64	19-1447	7.38	121	109	1884	2013	3.24	0.08	NaN	NaN	7.9
2	116	19-8030	7.20	171	159	1904	1977	3.30	0.15	NaN	NaN	11.0
1	143	19-0770	0.00	12	0	1851	2014	3.15	0.00	2.19	5.51	8.3

total number of years: 1879 346

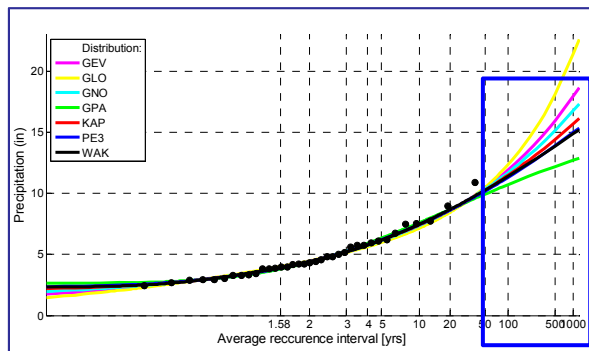
Enter index j from table for station you want to remove or add:



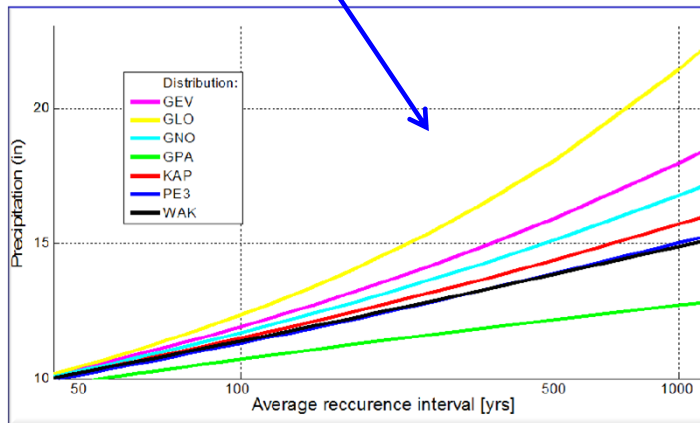
# Distribution fitting

Distributions tested for 15-min to 60-day durations:

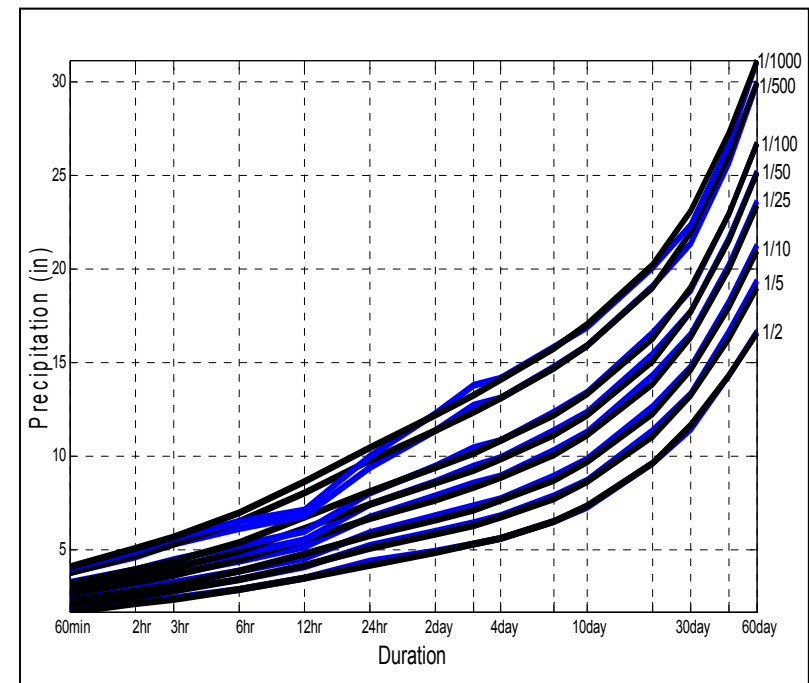
- Generalized Extreme Value (GEV)
- Generalized Normal
- Generalized Pareto
- Generalized Logistic
- Pearson Type III
- Kappa
- Wakeby



ARI (years)	Potential PF range
100	11-13 in
1000	13 -22 in
10000	14 - 38 in

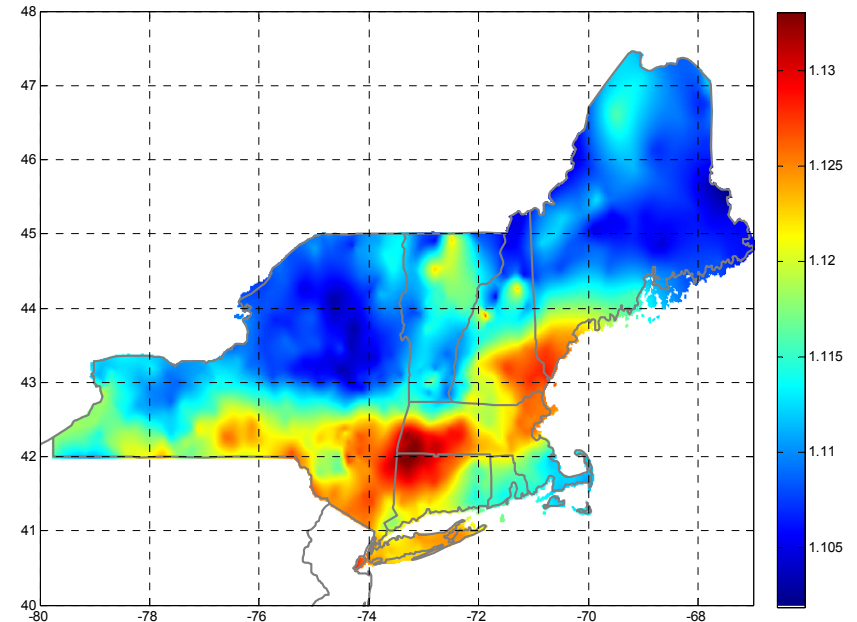
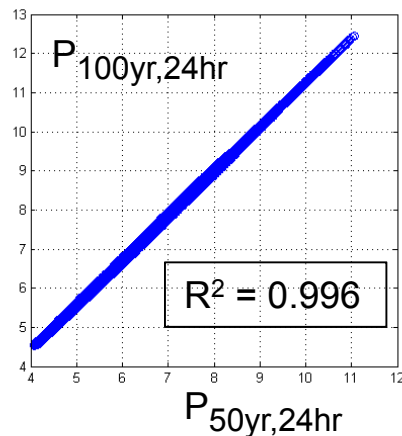


# Development of DDF curves



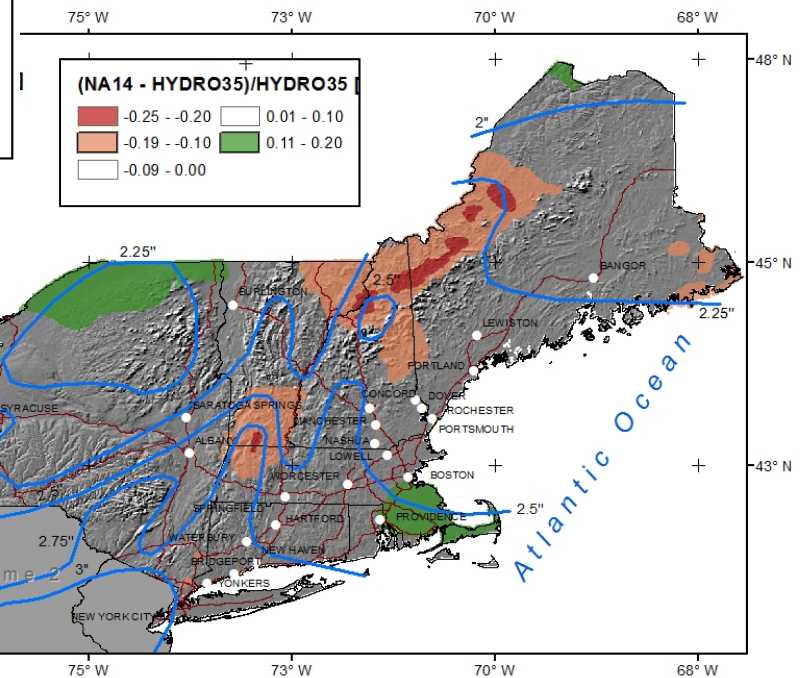
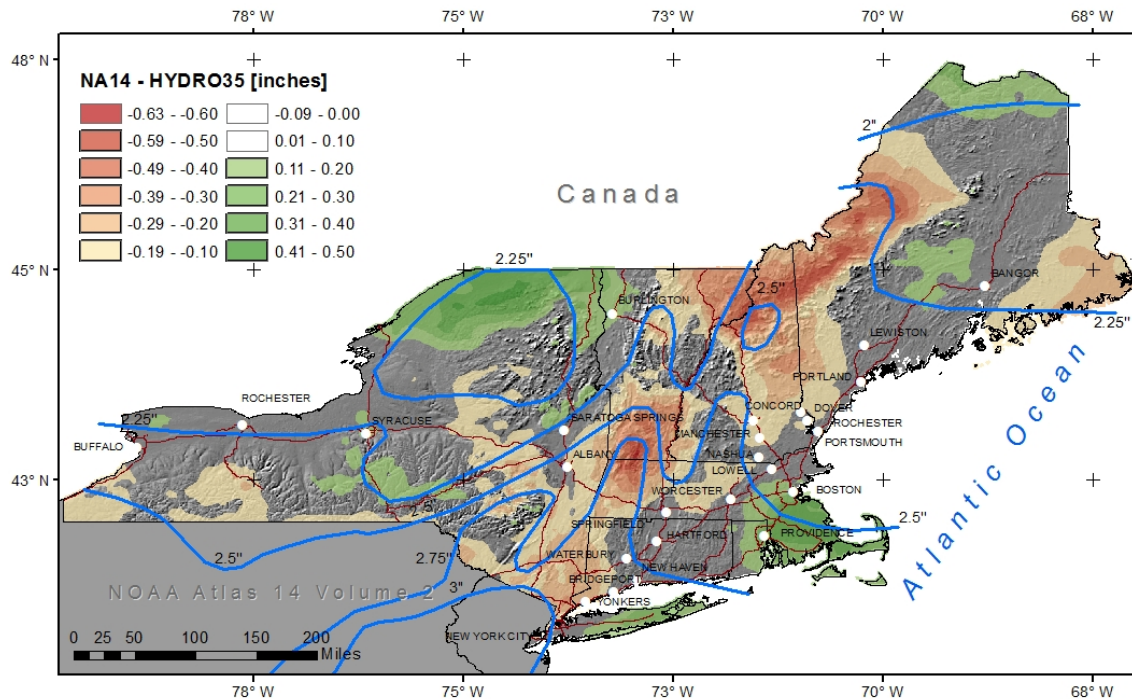
## Spatial interpolation

- ❑ Mean annual maximum (MAM) precipitation grids are basis for deriving PF grids.
- ❑ PRISM statistical-geographic approach for mapping climate data used to derive MAM grids for 15-min to 60-day durations.
- ❑ Evolution of frequency-dependent spatial patterns is independent for each duration
- ❑ 5-min and 10-min grids derived from 15-min grids
- ❑ Process utilizes spatially interpolated ratios of precipitation frequency estimates for consecutive ARIs (natural neighbor interpolation - Delauney triangulation).
- ❑ Similar method used for confidence intervals



# COMPARISON

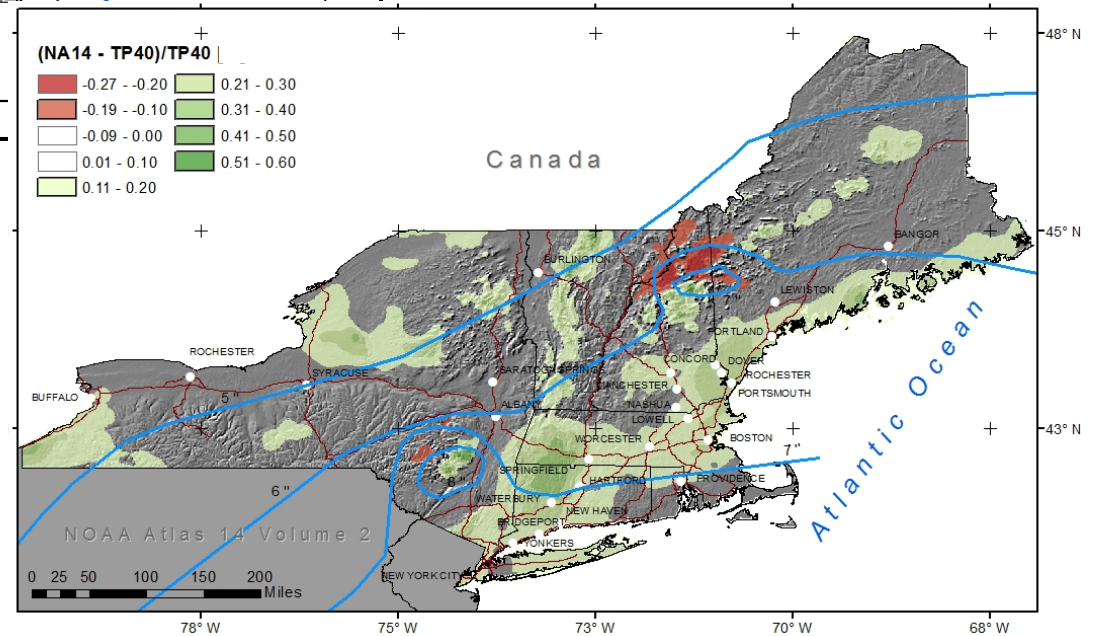
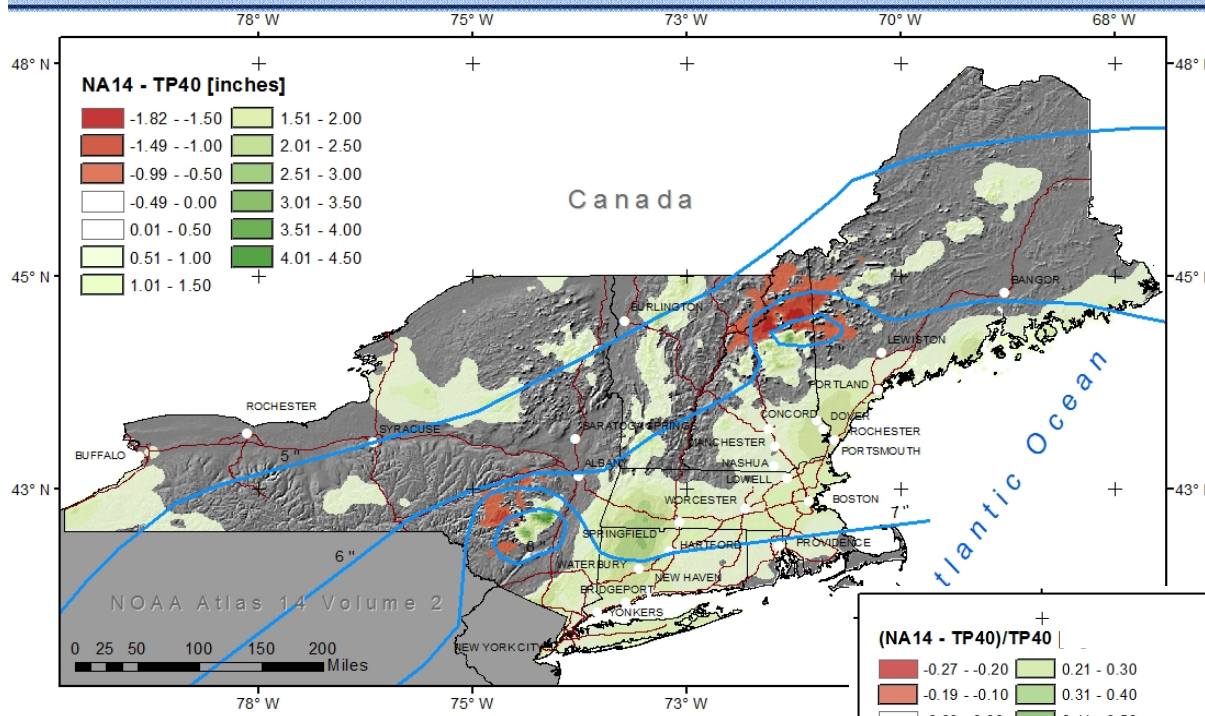
## Differences in 100-year 60-minute estimates from NA14 and HYDRO35 (1977)



Superimposed blue lines are isopluvials from HYDRO35

# COMPARISON

## Differences in 100-yr 24-hr estimates from NA14 and TP40 (1961)



Superimposed blue lines are isopluvials from TP40.