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Protecting Lives and Property for 150 Years

NOAA Atlas 14 Precipitation Frequency Atlas of the United States

■ **Presenter: Michael St. Laurent**

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Office of Water Prediction (OWP), NWS, NOAA

² University Corporation for Atmospheric Research

What is NOAA Atlas 14?

- ❑ Since early 2000s HDSC has been updating precipitation frequency estimates for various parts of the United States and affiliated territories.
- ❑ Updated estimates with relevant supplementary information are published in NOAA Atlas 14 “Precipitation-Frequency Atlas of the United States.”
- ❑ Funding model dictates that Atlas 14 updates are done in stages based on state boundaries.

2004: Vols 1 & 2 (19 states)

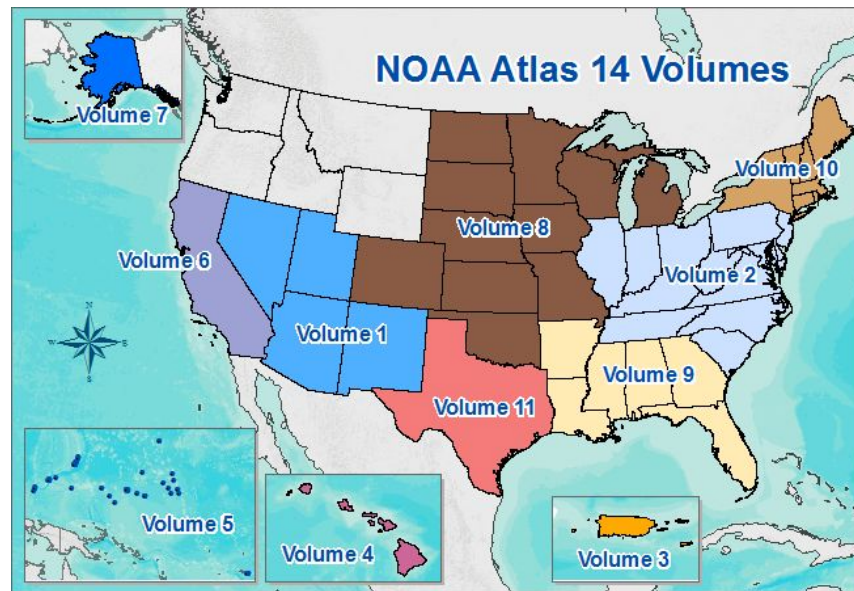
...

2013: Vols 8 & 9 (17 states)

2015: Vol 10 (7 states)

2018: Vol 11 (TX)

????: Vol 12 (ID, MT, OR, WA, WY).



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What are Precipitation Frequency Estimates?

❑ **Precipitation Frequency Estimate (at a given location):**
Precipitation **D**epth (or **I**ntensity) for a specific **D**uration that has a certain **F**requency of occurring.

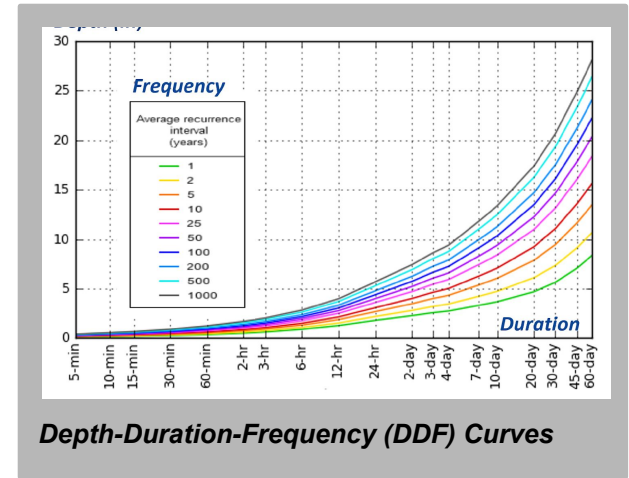
❑ **Frequency:**

Annual Exceedance Probability (“1-in-N event”)

- Probability associated with exceeding a given amount of precipitation for a specified duration at least once in any given year.
- Ex. AEP of 1-in-100 equates to a 1% chance of the amount being exceeded at least once in any year.

Average Recurrence Interval, Return Period (“N-year event”)

- Average time between precipitation events exceeding particular magnitude for a specified duration.
- Ex. 100-year amount on average occurs every 100 years.

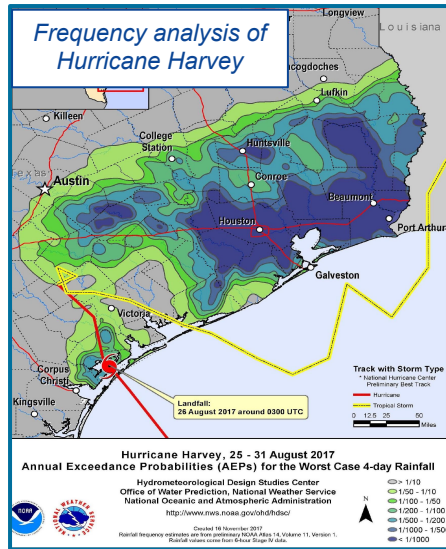


Where are Atlas 14 Estimates Used? – Storm Analysis

- ❑ NWS uses Atlas 14 estimates for monitoring observed/forecasted rain to indicate flooding threats.
- ❑ Widely used to estimate severity of historic events.

HDSC analysis of selected historic events

Event
Imelda, 16-20 September 2019
Remnants of Barry, Arkansas, 15-16 July 2019
South-Central Nebraska, 8 July 2019
Arkansas River Basin, April - May 2019
Hurricane Florence, 13-18 September 2018
Michigan and Wisconsin, 14-18 June 2018
Ellicott City, Maryland, 27 May 2018
Hurricane Maria, 20 September 2017
Hurricane Harvey, 25-31 August 2017
Missouri, 28 April - 2 May 2017
Hurricane Matthew, 6-10 October 2016
Louisiana, 11-13 August 2016
Ellicott City, Maryland, 30 July 2016
Northern Wisconsin, 11-12 July 2016
West Virginia, 23-24 June 2016
Lower Mississippi River Valley, 8-12 March 2016
Corsicana, Texas, 24-25 October 2015
Austin, Texas, 30 October 2015
South Carolina, 2 - 4 October 2015
Central Texas, 23-24 May 2015
Oklahoma, April - June 2015
Phoenix, Arizona, 19 August 2014
Islip, New York, 13 August 2014
Pensacola, Florida, 29-30 April 2014
New Mexico, 9-16 September 2013
Colorado, 9-16 September 2013
Southern Missouri, 29 July - 8 August 2013
San Antonio, Texas, 25 May 2013
Oklahoma City region, 31 May 1 June 2013
Tropical storm Debby, 24-27 June 2012
Duluth, Minnesota, 19-20 June 2012
Tennessee, 1-2 May 2010
Southeastern New England, March 2010
Southeastern United States, September 2009
Ohio Valley, 23 - 27 March 1913



http://www.nws.noaa.gov/oh/hdsc/aep_storm_analysis/index.html

Media

Forbes The Rainfall In Texas Is Changing And Here Is Proof

The Washington Post
Democracy Dies in Darkness
Houston is experiencing its third '500-year' flood in 3 years. How is that possible?

HOUSTON CHRONICLE
LOCAL / HOUSTON POLITICS
NOAA may reclassify '100-year storm' definition because Houston storms have been so bad

USA TODAY
Ellicott City rainstorm confirmed as 1-in-1,000 event — the second in two years

4 NBC WASHINGTON

HOME NEWS VIDEO WEATHER ENTERTAINMENT THE SCENE ON AIR

BROADCAST MAPS & RADAR SEVERE WEATHER ALERTS SCHOOL CLOSING ALERTS WEATHER STORIES

HOME > WEATHER > STORIES

1000-Year Rainfall in Ft. Belvoir



Where are Atlas 14 Estimates Used? - Infrastructure Design

- ❑ NOAA precipitation frequency estimates serve as the de-facto standards for designing, building and operating infrastructure to withstand the forces of heavy precipitation and floods:
 - municipal stormwater management systems, sediment control measures on construction sites, culverts, roadways and bridges, wastewater treatment plants, etc.
- ❑ Design criteria are governed by cities, municipalities, local or state governments and depend on an acceptable risk of failure.
 - smaller structures are designed to frequent events,
 - extremely rare estimates are used to assist in design and planning of dams and nuclear power plants.
- ❑ Also used for floodplain mapping and regulation of development in floodplains (National Flood Insurance Program).

Highway culverts	
Low traffic	5-10
Intermediate traffic	10-25
High traffic	50-100
Highway bridges	
Secondary system	10-50
Primary system	50-100
Farm drainage	
Culverts	5-50
Ditches	5-50
Urban drainage	
Storm sewers in small cities	2-25
Storm sewers in large cities	25-50
Airfields	
Low traffic	5-10
Intermediate traffic	10-25
High traffic	50-100
Levees	
On farms	2-50
Around cities	50-200
Dams with no likelihood of loss of life (low hazard)	
Small dams	50-100
Intermediate dams	100+
Large dams	--
Dams with probable loss of life (significant hazard)	
Small dams	100+

*Generalized design criteria for water-control structures.
From Chow, Applied Hydrology*



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Why Is It Important for Regulatory Authorities to Reference the Most Recent Estimates?

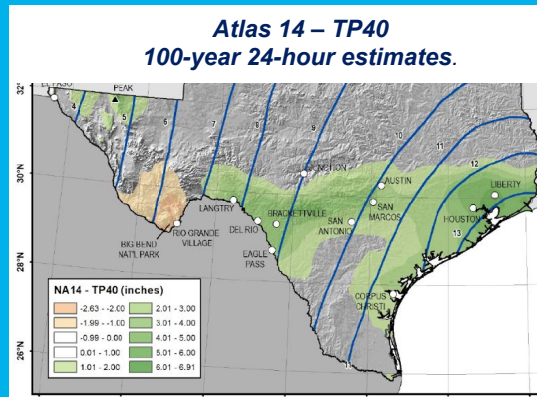
- ❑ Over-estimated precipitation frequency estimates can cause unnecessary cost to taxpayers or developers; under-estimated can result in destruction of property and loss of human life.
- ❑ Atlas 14 supersedes NOAA publications HYDRO35, TP40, TP49 and Atlas 2 published in 1950s to 1970s.
- ❑ New estimates are superior to superseded NOAA estimates in terms of accuracy, reliability, and resolution.

Example from Volume 11 (TX): City of Austin analysis (Colorado River floodplain excluded)

500-year floodplain is now 100-year floodplain

100-year floodplain increased ~25%

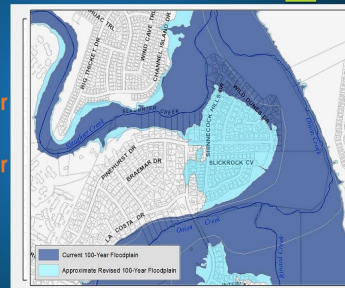
number of buildings in floodplain increased
from ~3700 to ~6500



Revise floodplain definitions

16

- ▶ 100-year = current 500-year
- ▶ 25-year = current 100-year



<http://www.austintexas.gov/edims/document.cfm?id=302092>



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Where to Find Atlas 14 Estimates?

- ❑ NOAA Atlas 14 products can be downloaded from **Precipitation Frequency Data Server (PFDS)** (hdsc.nws.noaa.gov/hdsc/pfds/index.html)
- ❑ **Estimates for a specific location** can be retrieved by clicking on appropriate state on the map or selecting the state name from the drop-down menu
- ❑ **Estimates applicable across states in each volume** Can be retrieved from side menu under “Precipitation Frequency” tag

NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)

Home Site Map News Organization

Precipitation Frequency Data Server (PFDS)

State: Choose a state (or click map) Load

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Updated data available

PFDS homepage



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Atlas 14 Products for Selected Location

- DFD estimates with confidence limits
- Available in tabular and graphical format.

Supplementary information

- Documentation
- GIS grids
- Maps
- Temporal distributions
- Seasonality charts
- Data
- Rainfall estimates
- Information on nearby NCEI climate stations and watershed (EPA).

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NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: NY

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

SELECT LOCATION
 1. 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

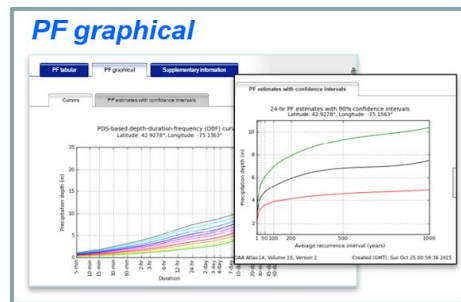
2. Use map:
 a) Select location (move crosshair or double click)
 b) Click on station icon
 c) Show stations on map

LOCATION INFORMATION
 Name: Point (KING), New York, US*
 Latitude: 42.5278°
 Longitude: -75.1563°
 Elevation: 144 ft

PF tabular | PF graphical | Supplementary information

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	500	1000	
5min	0.275 (0.215-0.348)	0.330 (0.258-0.417)	0.419 (0.328-0.530)	0.493 (0.381-0.626)	0.594 (0.446-0.779)	0.719 (0.546-0.927)	1.00 (0.751-1.27)	1.41 (1.01-1.94)	1.82 (1.31-2.41)	2.29 (1.65-3.08)
10min	0.390 (0.305-0.482)	0.467 (0.365-0.600)	0.593 (0.462-0.751)	0.698 (0.546-0.887)	0.842 (0.643-1.09)	1.03 (0.781-1.35)	1.41 (1.01-1.94)	1.78 (1.31-2.31)	2.29 (1.65-3.08)	2.83 (2.00-3.90)
15min	0.459 (0.359-0.579)	0.559 (0.428-0.729)	0.699 (0.540-0.894)	0.821 (0.643-1.04)	0.991 (0.761-1.27)	1.21 (0.91-1.59)	1.61 (1.19-2.11)	2.02 (1.48-2.73)	2.53 (1.83-3.41)	3.13 (2.24-4.23)
30min	0.627 (0.490-0.792)	0.752 (0.587-0.950)	0.959 (0.744-1.21)	1.13 (0.871-1.43)	1.36 (1.02-1.78)	1.64 (1.23-2.05)	2.14 (1.59-2.81)	2.64 (1.93-3.53)	3.29 (2.40-4.37)	4.01 (2.90-5.33)
60min	0.796 (0.621-1.00)	0.954 (0.745-1.21)	1.21 (0.915-1.54)	1.43 (1.11-1.83)	1.72 (1.29-2.20)	2.12 (1.64-2.65)	2.69 (2.00-3.53)	3.29 (2.40-4.37)	4.01 (2.90-5.33)	4.83 (3.53-6.41)
2hr	0.997 (0.764-1.25)	1.19 (0.934-1.49)	1.56 (1.18-1.99)	1.76 (1.37-2.23)	2.12 (1.62-2.77)	2.59 (1.99-3.31)	3.29 (2.40-4.37)	4.01 (2.90-5.33)	4.83 (3.53-6.41)	5.72 (4.23-7.61)
3hr	1.13 (0.895-1.42)	1.35 (1.06-1.65)	1.76 (1.32-2.13)	1.99 (1.51-2.50)	2.32 (1.71-3.10)	2.79 (2.12-3.53)	3.41 (2.53-4.46)	4.13 (3.00-5.43)	4.93 (3.60-6.41)	5.83 (4.37-7.61)
6hr	1.41 (1.12-1.75)	1.67 (1.33-2.07)	2.13 (1.60-2.80)	2.43 (1.83-3.05)	2.83 (2.18-3.71)	3.31 (2.53-4.23)	4.01 (3.00-5.33)	4.83 (3.60-6.41)	5.72 (4.23-7.61)	6.61 (4.93-8.71)
24-hr	1.74 (1.40-2.14)	2.06 (1.60-2.54)	2.57 (2.00-3.20)	2.91 (2.24-3.71)	3.39 (2.53-4.46)	3.91 (3.00-5.13)	4.61 (3.41-6.13)	5.43 (4.01-7.21)	6.31 (4.61-8.41)	7.21 (5.33-9.53)
	2.01	2.44	3.04	3.53	4.12	4.72	5.26 (3.87-6.95)	5.83	6.41	6.99



Supplementary information

I. Document
 Click here to view this document.

II. PF in GIS format
 Download the GIS data for this location. The GIS data is available in two formats: ArcView (shapefile) and ArcGIS (geodatabase). The GIS data is available for download from the NOAA Atlas 14 website.

III. PF cartographic maps
 Cartographic maps of precipitation frequency estimates are available for selected locations and durations. The information for these maps can be used to create maps for your own use.

IV. Temporal distributions
 Temporal distributions of precipitation frequency estimates are available for selected locations and durations. The information for these distributions can be used to create charts for your own use.

V. Seasonality analysis
 Seasonality analysis of precipitation frequency estimates is available for selected locations and durations. The information for this analysis can be used to create charts for your own use.

VI. Rainfall frequency information
 Rainfall frequency information is available for selected locations and durations. The information for this information can be used to create charts for your own use.

VII. Climate data source
 Climate data source information is available for selected locations and durations. The information for this information can be used to create charts for your own use.

VIII. Watershed information
 Watershed information is available for selected locations and durations. The information for this information can be used to create charts for your own use.

Atlas 14 Products Covering Whole Area within Each Volume

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DOWNLOAD GIS DATA:

The files can either be downloaded 1) via pull-down menu, 2) by anonymous ftp or 3) via web browser. Ftp is recommended for multiple-file downloads. To obtain precipitation frequency estimates without downloading files, please visit the PFDS interface.

1) Via pull-down menu:

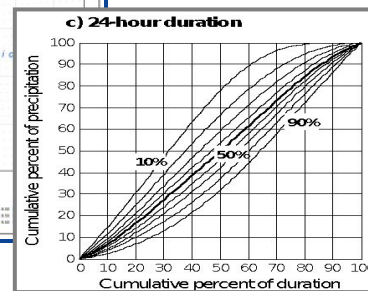
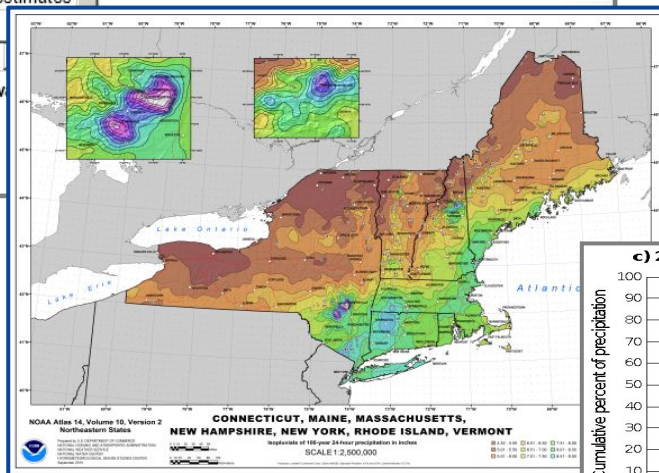
Region:
NOAA Atlas 14 Volume 7 (Alaska)

Type:
Precipitation frequency estimates

Series:
Partial duration series

Average recurrence interval:
2-year

Duration:
5-minute



- ❑ 30 arc-sec GIS precipitation frequency grids with 95% confidence limits for 5-min to 60-day durations and up to 1,000-year ARI.
- ❑ Cartographic maps for selected durations and ARI
- ❑ Time series data used in analysis
- ❑ Temporals
- ❑ Documentation

NOAA Atlas 14
Precipitation-Frequency Atlas of the United States

Volume 11 Version 2.0: Texas

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypanak, Dale Urunk, Crisn White

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service

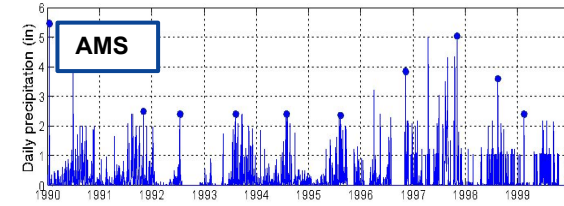
Silver Spring, Maryland, 2018



How are the Estimates Calculated?

1. Data collection, Annual Maximum Series (AMS) extraction and QC

- Data collection, digitization, formatting
- Examination of geospatial data and station cleanup
- AMS extraction for 17 durations and quality control



2. At-station DDF/IDF curves

- Regionalization
- Derivation of estimates and confidence limits

3. Interpolation to 30 arc-sec grid

- PRISM statistical-geographic approach

4. Peer review

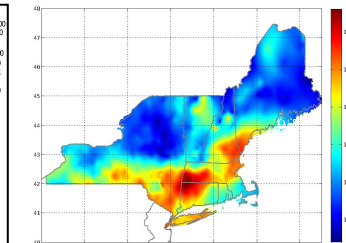
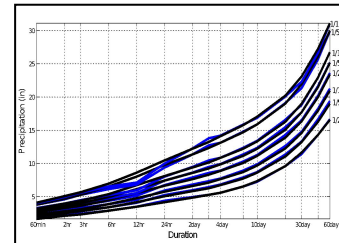
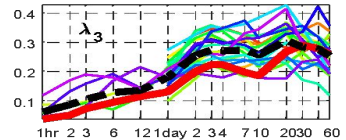
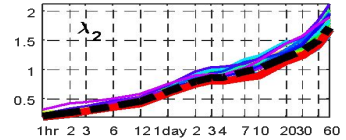
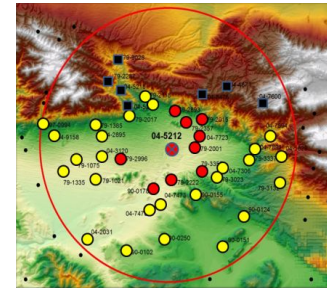
- Funding agencies, HDSC list-server subscribers, others

5. Revision (back to steps 1 to 3)

6. Supplementary information

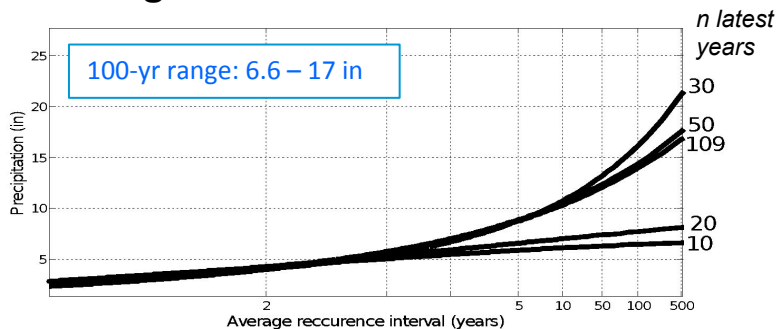
- Documentation, confidence intervals, cartographic maps, etc.

7. Web publication

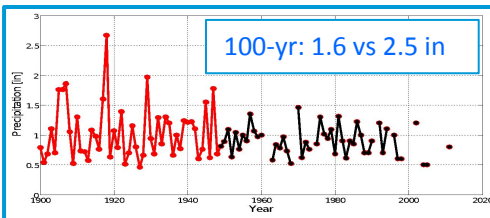


What are Major Sources of Error? - Data!

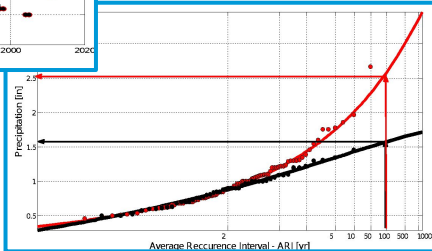
Record length



Missing data

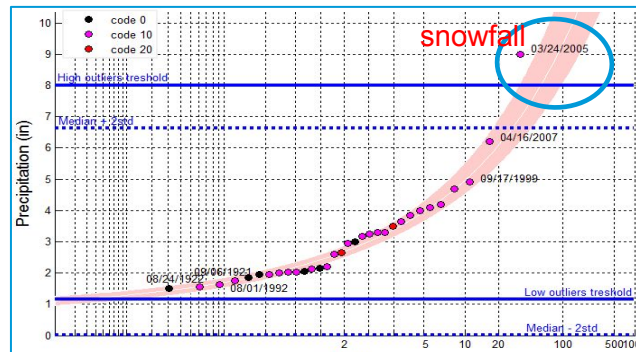


ITHACA, NY. Hourly record extended 49 years (pre-1948) through digitization

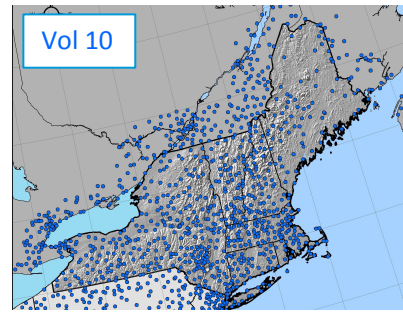
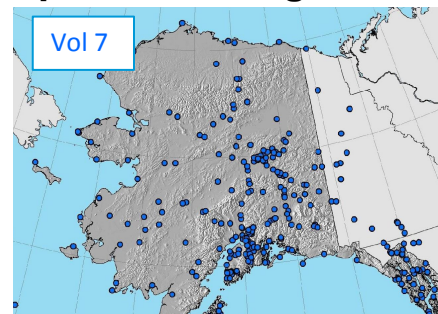


Quality control

Rhinebeck 4SE, NY
9 in of snowfall in 2005 archived as 9.00 in of liquid precipitation



Spatial coverage



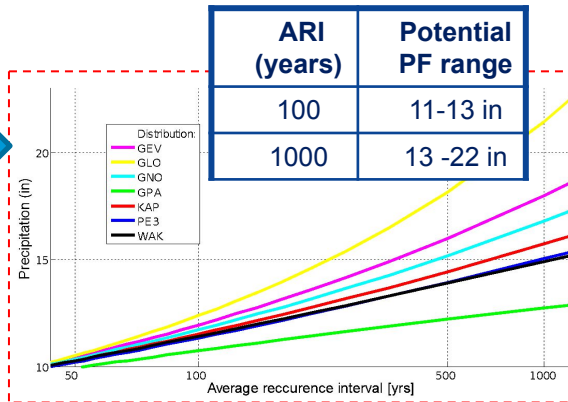
What are Other Major Sources of Uncertainty? Methods

Distribution fitting

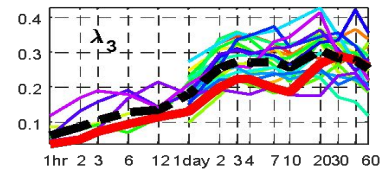
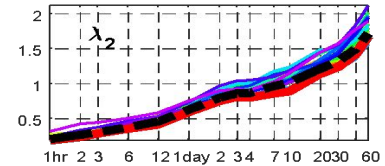
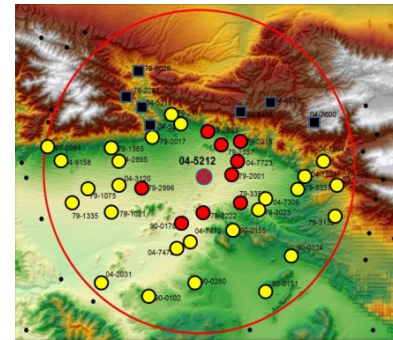
Distribution selection

Parameterization method

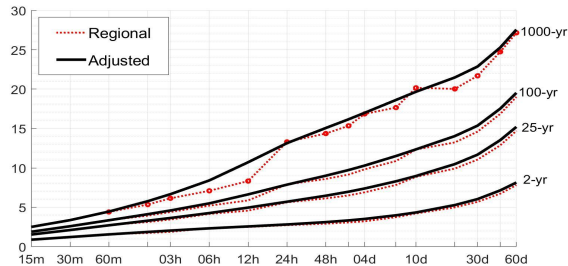
Stationary vs non-stationary



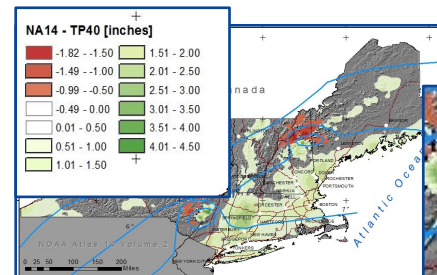
Regionalization



Optimization & consistency checks



Interpolation



Atlas 14-TP40



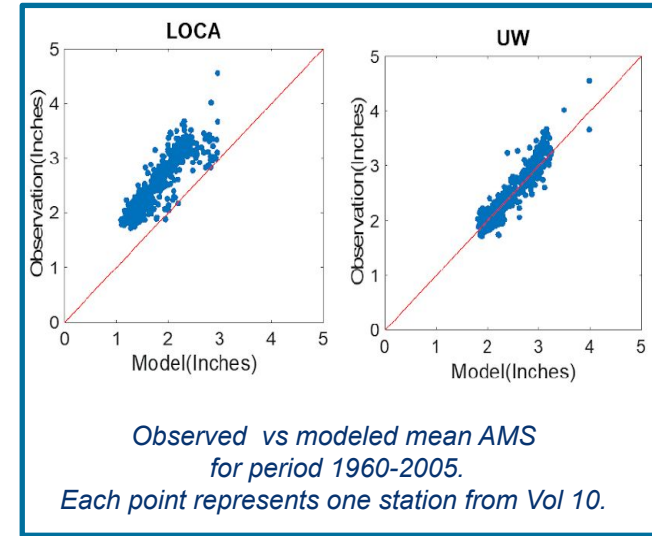
Atlas 14 Proposed Upgrades and Updates - Methodology Changes

❑ Current

- Atlas 14 approach, developed in 1990s is based on assumption that extreme precipitation characteristics do not change in time.

❑ Future

- Stationary Atlas 14 method will be replaced with non-stationary approach that can efficiently translate future climate scenarios into a product useful for NOAA Atlas 14.
- Outputs from two downscaled data sets from CMIP5 (LOCA, University of Wisconsin -UW) will be used (instead of time) to produce projected estimates under RCP4.5 and RCP8.5 emission scenarios.



⁽¹⁾ Datasets evaluated relative to Atlas 14: BCCAv2, LOCA, NA-CORDEX, UW.

⁽²⁾ Development was done in collaboration with Penn State University, University of Illinois at Urbana-Champaign and University of Wisconsin-Madison.



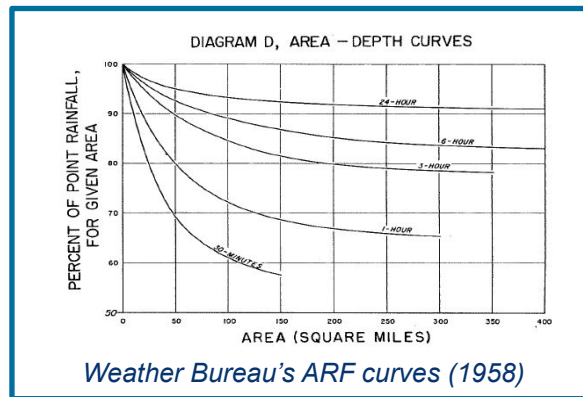
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Atlas 14 Proposed Upgrades and Updates - Additional Products

□ Areal Precipitation Frequency Estimates

- **BACKGROUND:** Atlas 14 estimates are point estimates. ARFs are used to convert point precipitation to average precipitation over a watershed. Many ARF methods have been proposed, but Weather Bureau's ARF curves from 1958 are still commonly used.
- **PROPOSED:** Derive regional ARFs and develop web tool to delineate watershed estimates.



□ Atlas 14 Design Storm

- **BACKGROUND:** Atlas 14 provides precipitation frequency estimates for a given duration, but designers often need information on how precipitation is distributed in time and not just the total amount.
- **PROPOSED:** Develop Atlas 14 design storm product with guidance on how to use the product.

□ Confidence Intervals

- **BACKGROUND:** Atlas 14 provides only bounds of 90% confidence interval
- **PROPOSED:** Development of confidence intervals of variable width



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Web: www.nws.noaa.gov/oh/hdsc

Email: HDSC.questions@noaa.gov

