National Precipitation Frequency Standard

NOAA Atlas 14 and Beyond

Fernando Salas[1] and Sandra Pavlovic[2]

[1] Director, Geo-Intelligence Division | NWS Office of Water Prediction
[2] Technical Director, HDSC Team | NWS Office of Water Prediction

September 29, 2022

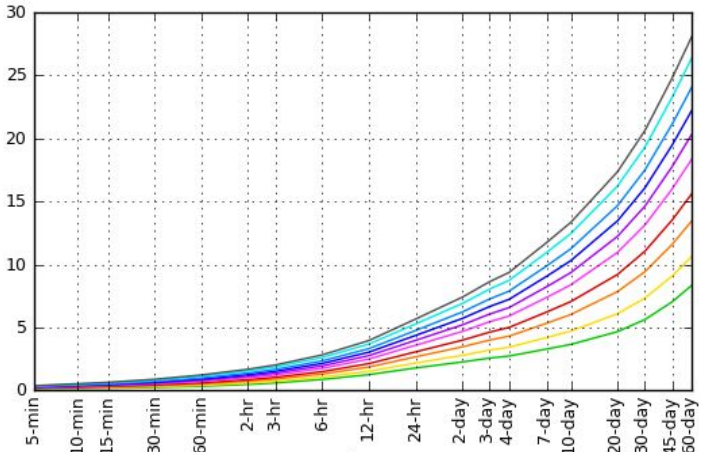
OWP | OFFICE OF WATER PREDICTION

Precipitation Frequency Estimates

- Precipitation amounts for a given duration and annual exceedance probability (or average recurrence interval).

  Example: X precipitation over 24-hour period with 1% (1/100) probability to occur in given year.

- Precipitation **D**epth (or **I**ntensity) for a given **D**uration and **F**requency (ARI or AEP)



Depth-**D**uration-**F**requency (DDF) curves

Intensity-**D**uration-**F**requency (IDF) curves

Precipitation Frequency Applications

Infrastructure design and planning under federal, state, and local regulations

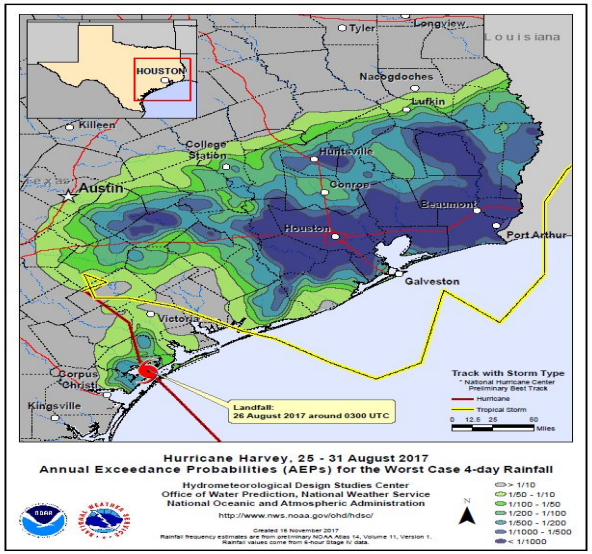
- Transportation
- Development and building codes

FEMA National Flood Insurance Program

Type of structure	Return period (years)
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	
	5–10

Comparing observed and forecasted precipitation with threshold precipitation to indicate flooding threats

Estimating severity of historic events



Precipitation Frequency Studies

Early 1950s

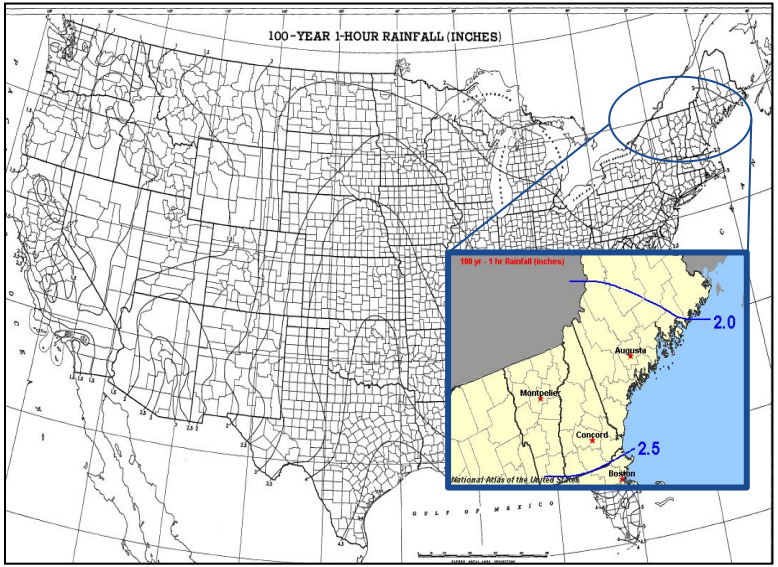
- NWS chosen to prepare IDF curves for federal government.
- NWS is independent.
- Does not regulate or design.

NWS Relevant Publications

- Technical Paper 40, 1961
- Technical Paper 49, 1964
- NOAA Atlas 2, 1973
- NOAA Atlas 14, 2004-2023

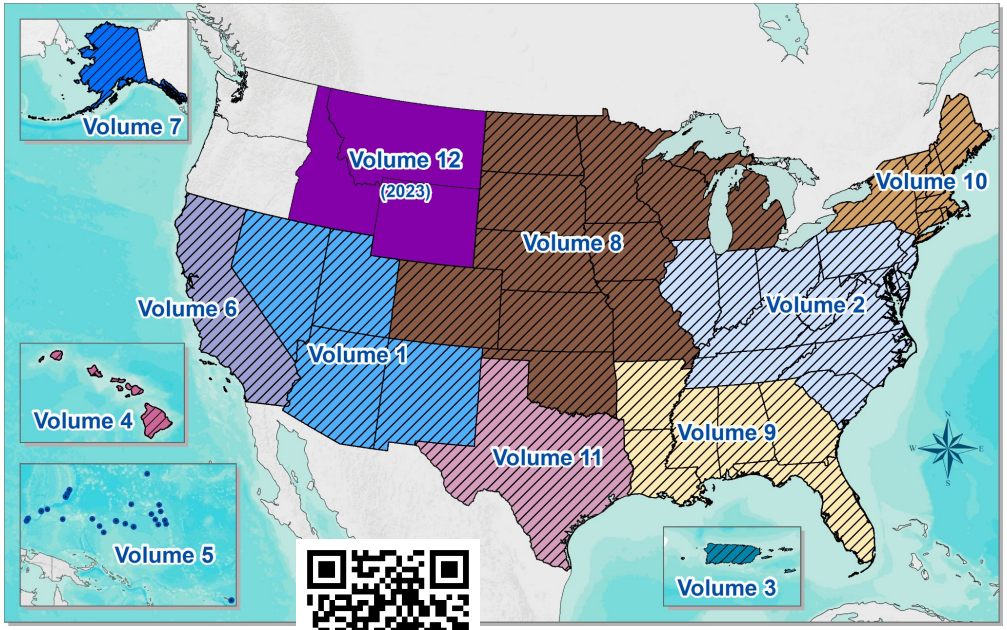
Today's De-facto National Standards

- Endorsed by federal water agencies.
- Referenced in many federal, state and local regulations.



Technical Paper 40, 1961:
https://www.weather.gov/media/owp/oh/hdsc/docs/TP40.pdf
https://www.weather.gov/gyx/TP40s.htm

NOAA Atlas 14



https://www.weather.gov/owp/hdsc

Hydrometeorological Design Studies Center (HDSC)

- Since 2003, develops and updates precipitation frequency estimates for the United States and territories
- Part of Office of Water Prediction (NWS, NOAA)

Funding Approach

- Performed At Request Of And Funded By Users - not from NWS budget

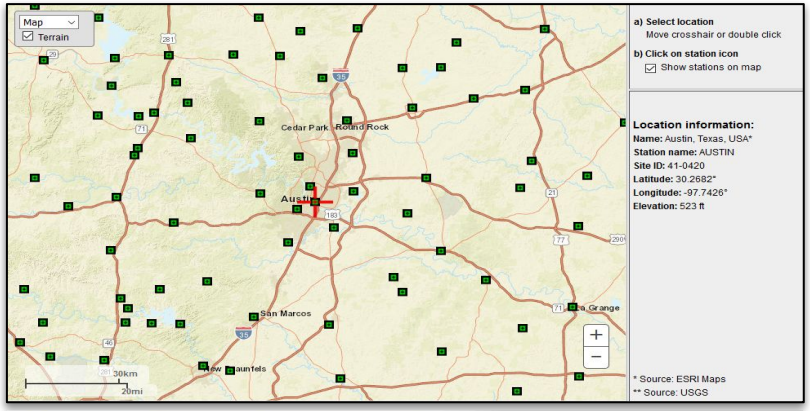
  Discontinuities at volumes' boundaries, and irregular update cycle creates issues for users

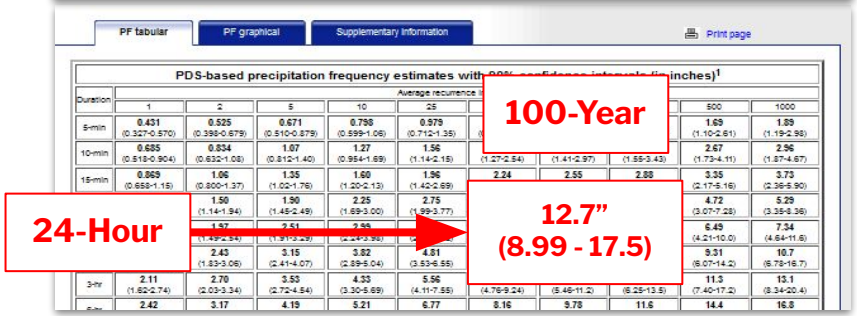
Volumes

- Volume 1 (2004): Semiarid Southwest

  ....
- Volume 11 (2018) : Texas
- Volume 12 (2023) : Montana, Idaho, and Wyoming

NOAA Atlas 14





Volume Development (and enhancement to Technical Paper 40)

- from 5 minutes to 60 days
- recurrence intervals of 1 to 1000 years.
- confidence intervals
- high spatial resolution (~800 m)
- spatial interpolation (account for terrain, coastal proximity, etc.)
- numerous internal consistency checks
- regional approach that allows for the development of rare frequency
- denser rain gauge networks with longer periods of record, and extensive quality control
- online delivery: https://hdsc.nws.noaa.gov/hdsc/pfds/

Assumptions

- Assumes stationarity in data and methodology

Sources of Error

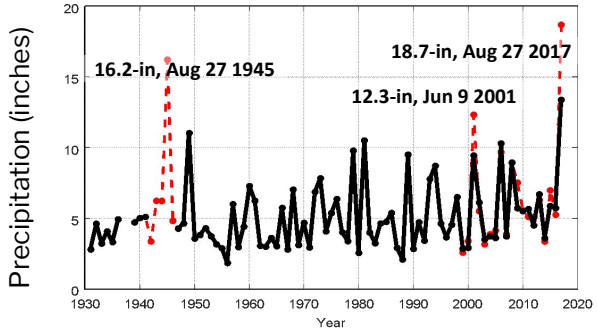
Data:

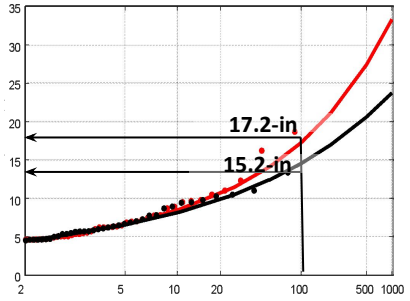
- Period of record
- Missing data
- Quality Control
- Spatial Coverage

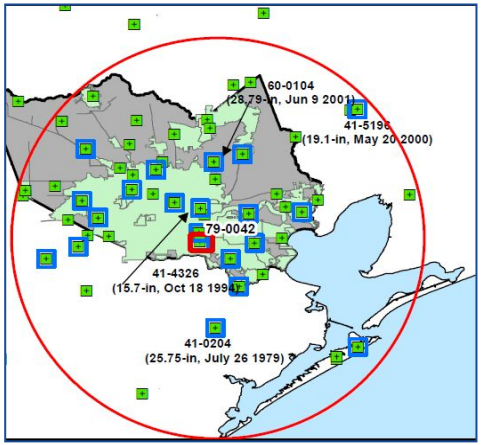
Methods:

- Distribution selection
- Parameterization method
- Stationary vs non-stationary methodology
- Regionalization
- Interpolation
- Optimization & consistency checks

Houston Hobby Airport





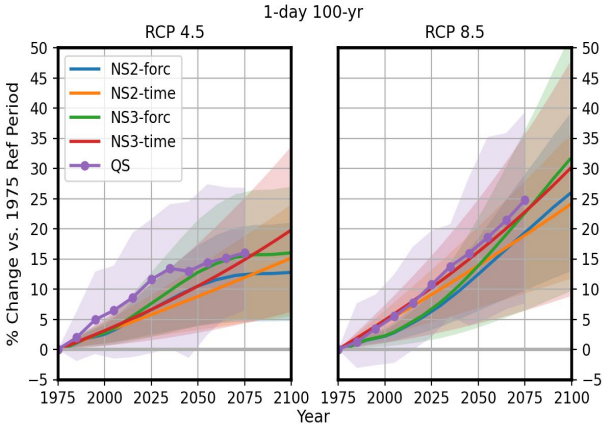


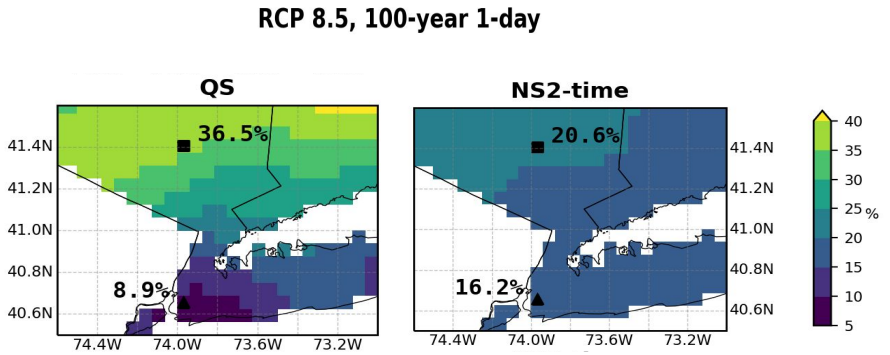
Preliminary 100-year 24-hour estimate: 17.6”

Nonstationarity Impact on NOAA Atlas 14

Proposed methodology : *"Analysis Of Impact Of Nonstationary Climate On NOAA Atlas 14 Estimates : Assessment Report"*

- Work done in collaboration with Penn State University, University of Illinois Urbana-Champaign and University of Wisconsin-Madison
- Testing done for Atlas 14 Volume 10 project area (Northeastern States)
- Funding provided by DOT FHWA

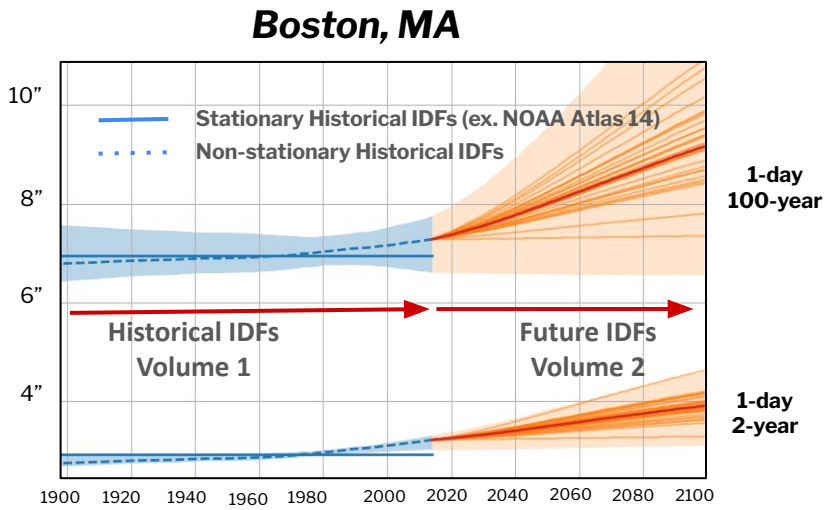




A National Analysis Accounting for Nonstationarity

Leverage support from the Bipartisan Infrastructure Law (BIL) FY22-26

- Leverage results and recommendations from the Assessment Report
- Develop a seamless spatial national analysis using a non-stationarity assumption with latest precipitation observations and climate projections
- Replaces current Atlas 14 estimates based on historical data (Historical IDFs) for durations:
  - from 5 minutes to 60 days
  - recurrence intervals of 1 to 1000 years
- Add new product features to account for the future precipitation information (Future IDFs)
- Atlas 15 to be delivered with robust web visualizations and data services



Moving Forward: NOAA Atlas 15

Volume 1: Based on historical gages and observed trends

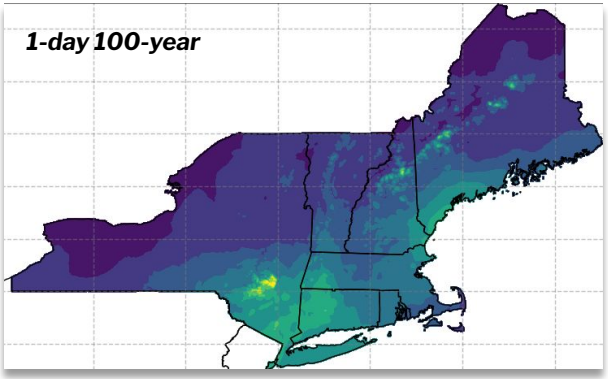
- Integrated terrain information
- Models trend in historical observations (when it exists) to account for short-term non-stationary temporal changes
  - Non-stationary trends represents a major enhancement from Atlas 14

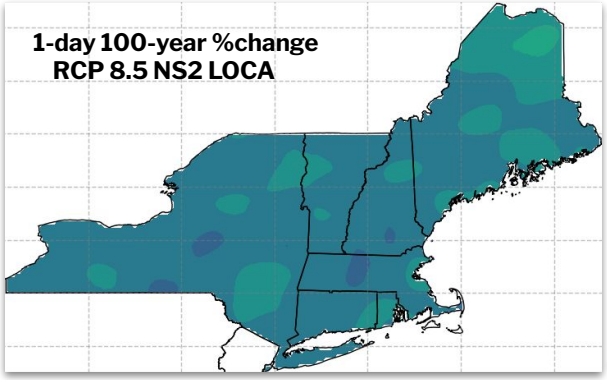
Volume 2: Incorporates climate projection adjustment factors

- Future precipitation informed by global climate models, modeled non-stationary temporal changes
- Provides adjustment factors to Volume 1 to calculate future estimates.

1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

2030 2040 2050 2060 2070 2080 2090 2100 2110 2120



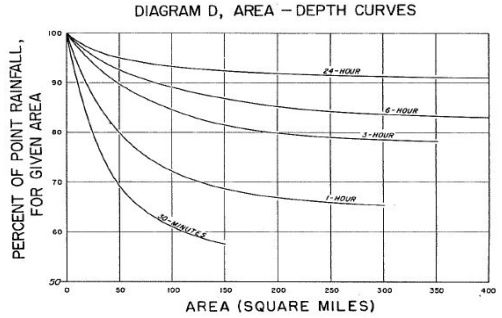


MULTI-MODELS

Additional Atlas 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.
- NEEDS: Derive regional ARFs and develop web tool to delineate watershed estimates.



Weather Bureau's ARF curves (1958)

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.
- NEEDS: Develop Atlas 15 design storm product with guidance on how to use the product.

Probable Maximum Precipitation (PMP)

- BACKGROUND: Probable Maximum Precipitation (PMP) estimates provide the maximum depth of precipitation over a given area and duration that is meteorologically possible. NWS studies done at request and funding of various federal agencies. All activities discontinued in 1999 due to lack of funding.
- NEEDS: Develop the new approach and PMP estimates in a changing climate

Thank You!

Fernando Salas and Sandra Pavlovic

fernando.salas@noaa.gov
sandra.pavlovic@noaa.gov

https://water.noaa.gov

OWP | OFFICE OF WATER PREDICTION