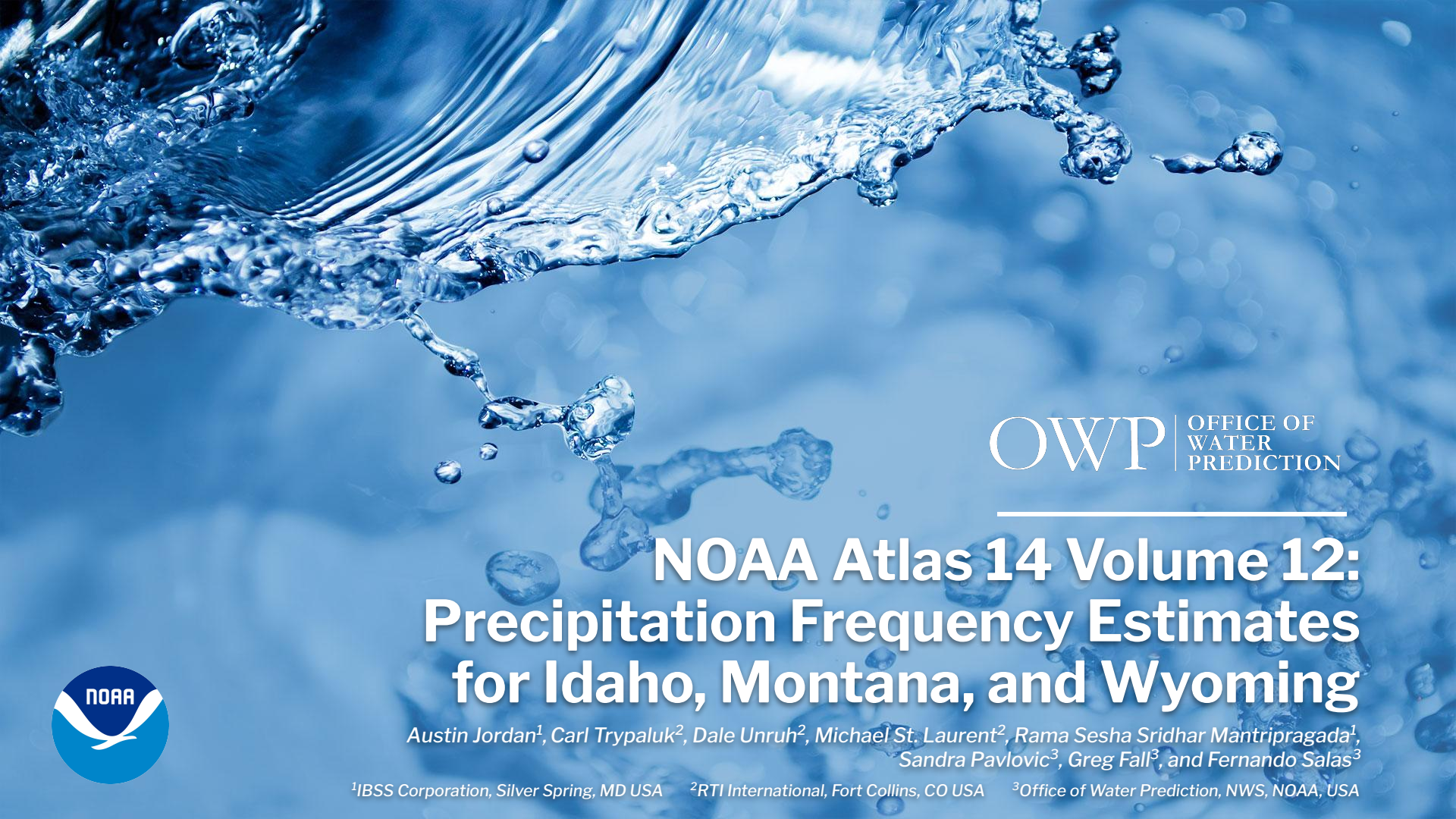


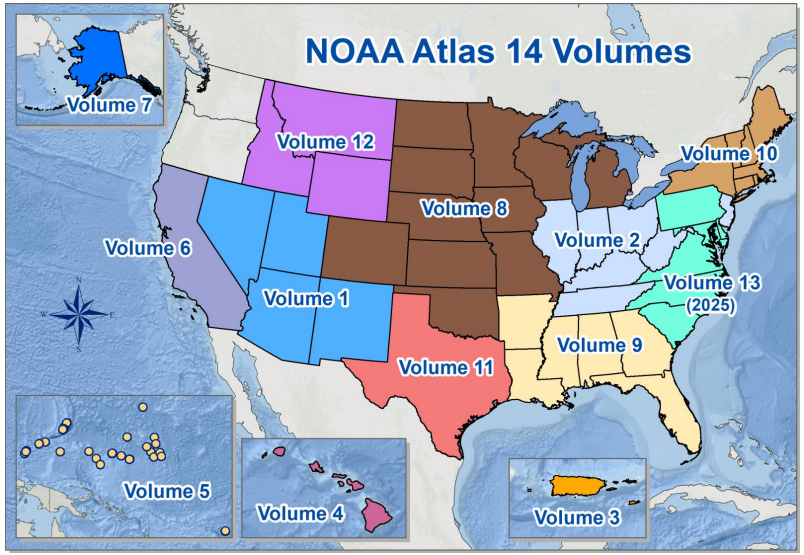
OWP | OFFICE OF WATER PREDICTION

NOAA Atlas 14 Volume 12: Precipitation Frequency Estimates for Idaho, Montana, and Wyoming

Austin Jordan[1], Carl Trypaluk[2], Dale Unruh[2], Michael St. Laurent[2], Rama Sesha Sridhar Mantripragada[1], Sandra Pavlovic[3], Greg Fall[3], and Fernando Salas[3]

[1]IBSS Corporation, Silver Spring, MD USA [2]RTI International, Fort Collins, CO USA [3]Office of Water Prediction, NWS, NOAA, USA

Overview of NOAA Atlas 14



Authoritative Regional Studies
Funded by States
Not Informed by Climate Trends

www.weather.gov/owp/hdsc

Hydrometeorological Design Studies Center (HDSC)

- Part of NOAA/NWS/Office of Water Prediction.
- Develops and updates precipitation frequency estimates for U.S. states and territories.

Majority of built infrastructure leverages precipitation frequency data for design and planning under federal, state, and local regulations.

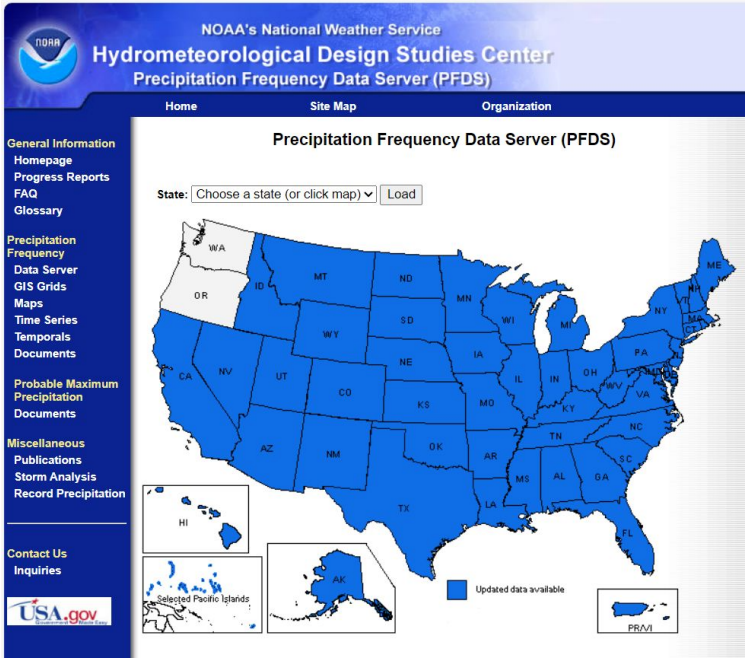
Volumes

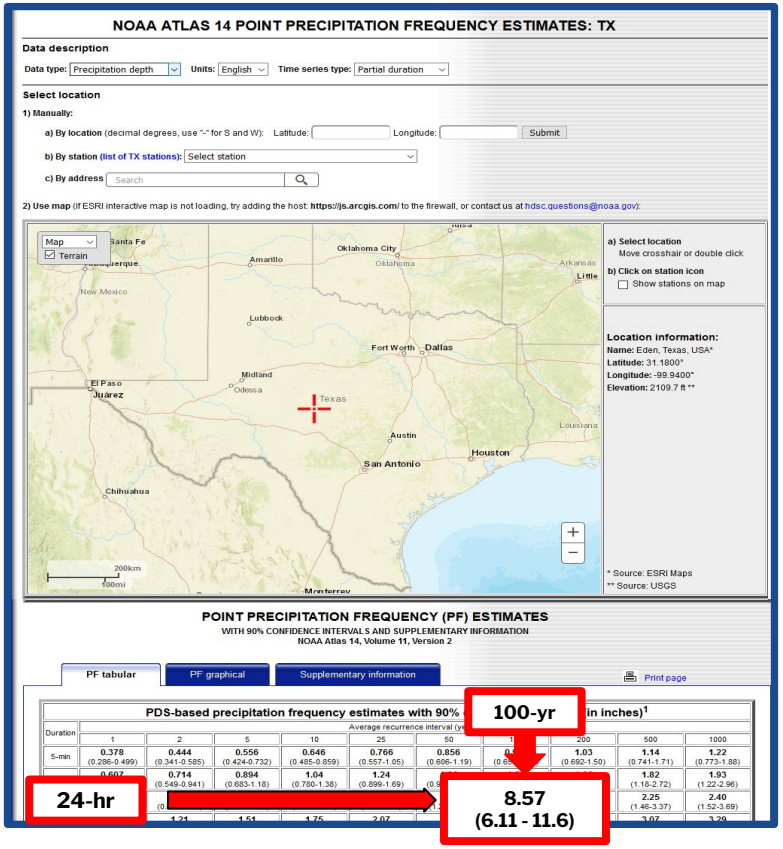
- Volume 1 (2004): Semiarid Southwest

  ....
- Volume 11 (2018): Texas
- **Volume 12 (2024) :** Idaho, Montana, and Wyoming
- **Volume 13 (2025):** Mid-Atlantic

NA14 PF Estimates

Point precipitation frequency estimates: precipitation **magnitude/intensity** at a given **point location** for a specific **duration** and **frequency**.





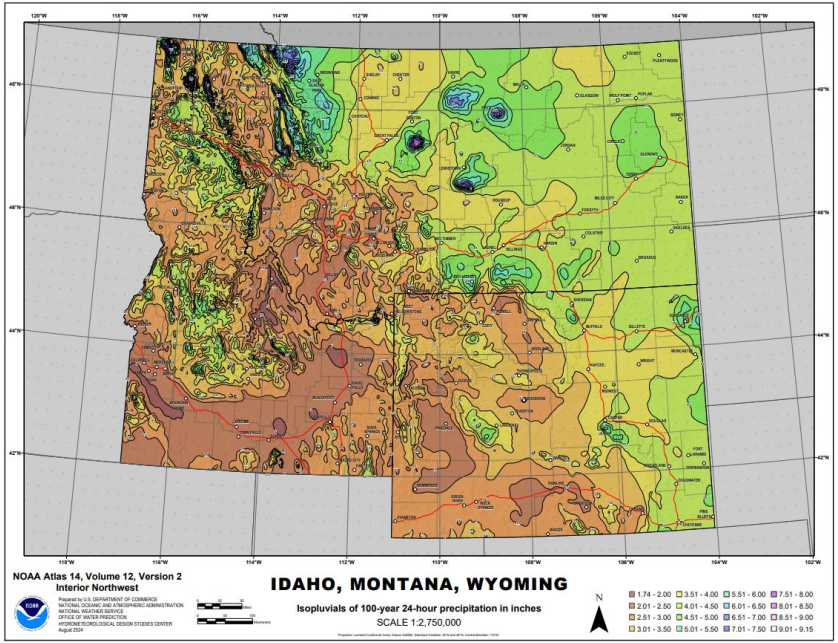
- **Durations: 5-min through 60-day**
- **ARIs: 1-yr through 1000-yr**
- **AEPs: 1/2 (50%) through 1/1000 (0.1%)**

Developing NA14 Volume 12 PF Estimates

Region-of-influence frequency analysis approach based on L-moment statistics

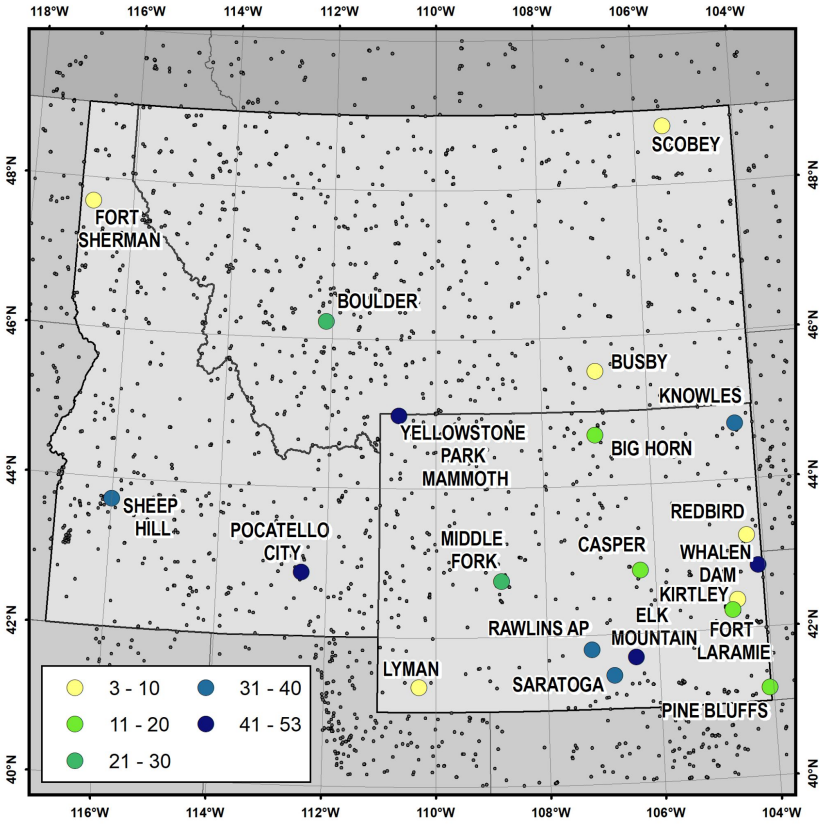
1. Data Collection
2. Quality Control
3. At-station Estimates and DDF/IDF Curves
4. Interpolation and Map Review
5. Peer Review and Revision
6. Supplementary Information
7. Results/Web Publication

Covers states of Idaho, Montana, and Wyoming.



Data Collection

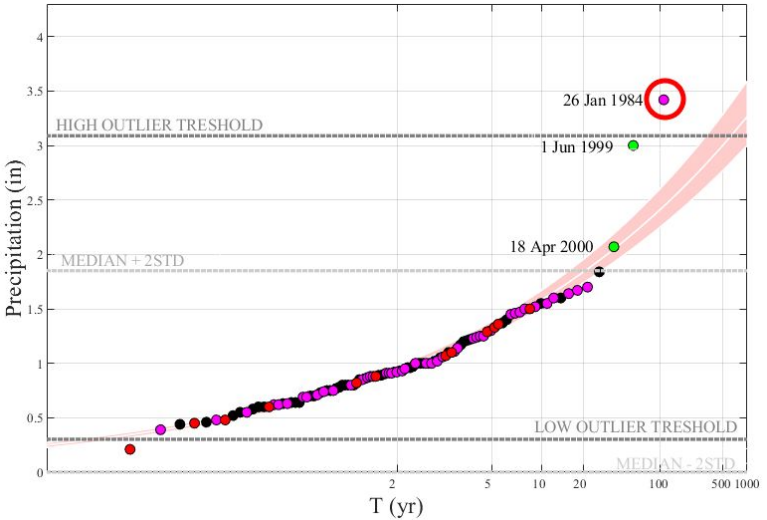
- 15,328 stations from a number of federal, state, and local gauge networks.
  - Majority maintained by the National Centers for Environmental Information (NCEI).
  - Other data providers include: U.S. Department of Agriculture (USDA), U.S. Bureau of Reclamation, Idaho National Laboratory.
- Additional data digitized to extend record lengths and include extreme events missing from provided datasets.
  - For some stations, this added up to 53 data years and some of their highest annual maximum events.



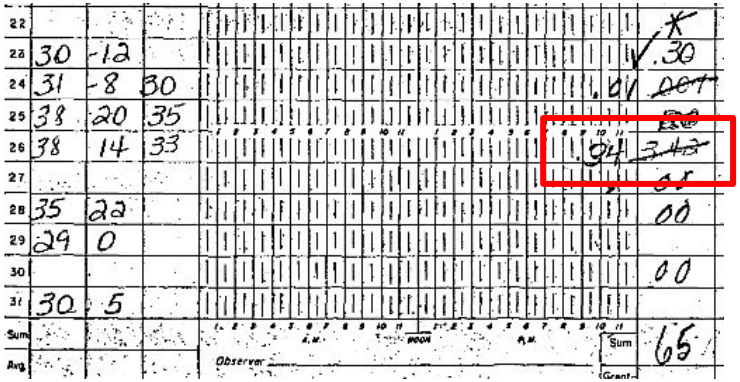
Stations used for Volume 12, with locations of 21 stations where daily records were extended through digitization. Legend indicates number of data years digitized.

Quality Control

- **Metadata review**
  - Check for discrepancies in provided location, elevation, and county/state data.
- **Station cleanup**
  - Co-locations and merges (associating or combining nearby station data for longer and more complete records)
  - Deletes (poor data quality, redundant data in dense areas, insufficient record lengths)
- **Annual Maximum Series (AMS) quality control**
  - Investigate highest AMS values, especially high outliers, to determine if they are real measurements and not an observer, digitization, or gauge error.

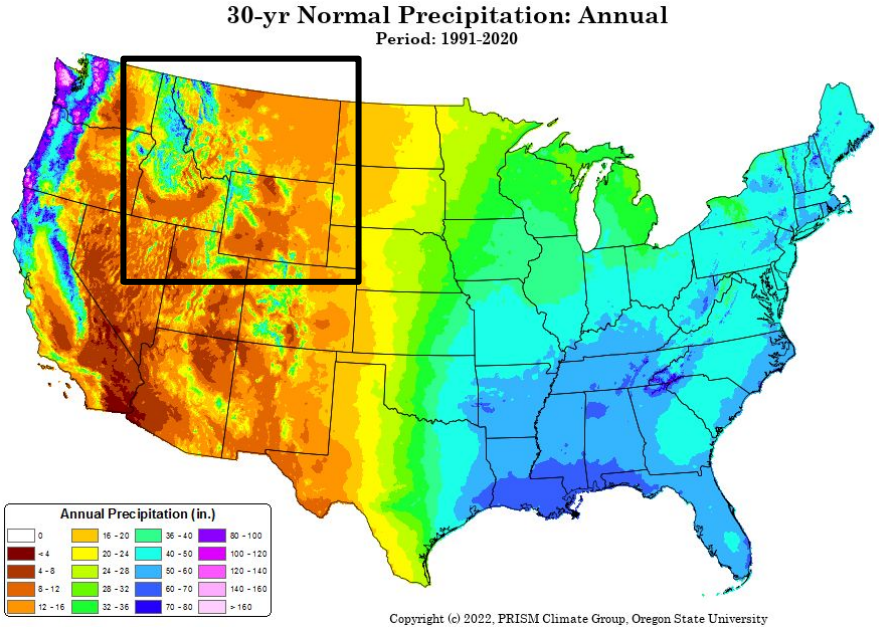


1-day AMS at Blackfoot, Idaho



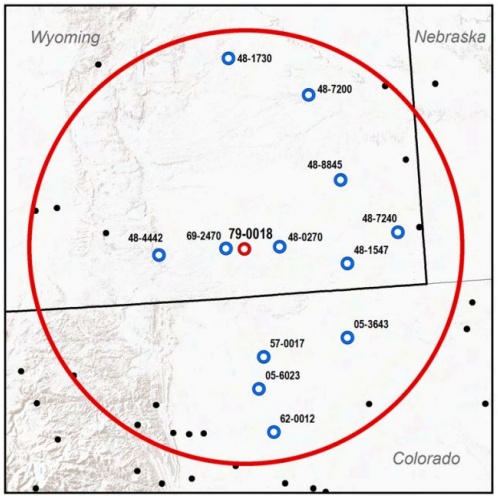
NA14 Volume 12 QC Challenges

- **Remote stations and terrain**
  - Lack of comparable nearby data and storm reports.
  - Large differences in precipitation over short distances in some areas.
- **Climate and snow**
  - Relatively dry - easier for bad data to enter AMS and impact estimates.
  - Snow events often appear in 6-hr and daily duration AMS.
  - Snow liquid equivalent often estimated or not measured by observers.
  - Many automated gauges do not accurately measure frozen precipitation.

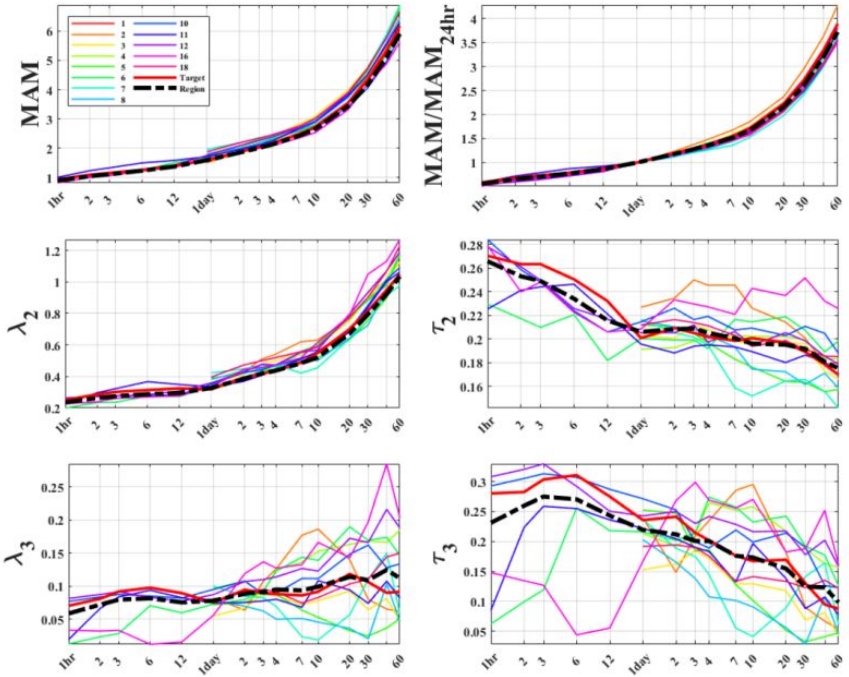


At-station Estimates and DDF/IDF Curves

- **Regionalization**
  - Distance, elevation, proximity to terrain
  - Mean annual maximum (MAM)
  - Max observed values and record length
  - L-moment statistics across durations



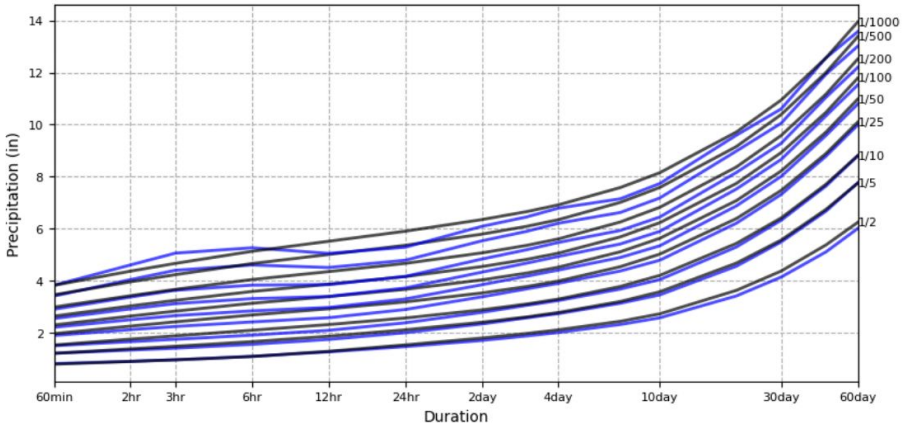
Region for Cheyenne, WY (79-0018)



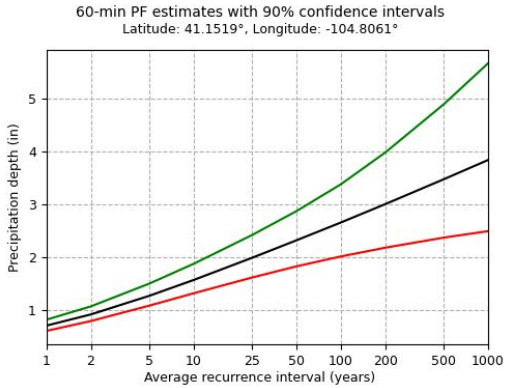
L-moments, MAM/MAM$_{24\text{-hr}}$ and L-moment ratios across hourly and daily durations for Cheyenne's region

At-station Estimates and DDF/IDF Curves

- **Derivation of estimates and confidence limits**
  - Select probability distribution (GEV).
  - Determine distribution parameters (station MAM and regionally determined higher order L-moments) and calculate PF estimates.
  - Smooth PF estimates across durations to ensure consistency.
  - Construct 90% confidence intervals via Monte Carlo simulation.

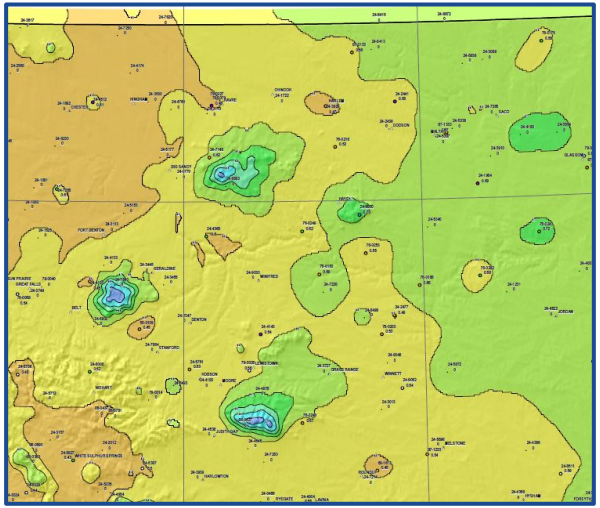


Cheyenne, WY ***unsmoothed*** *and* ***smoothed*** *depth-duration-frequency (DDF) curves (left) and final 60-min estimates with 90% confidence intervals (right)*

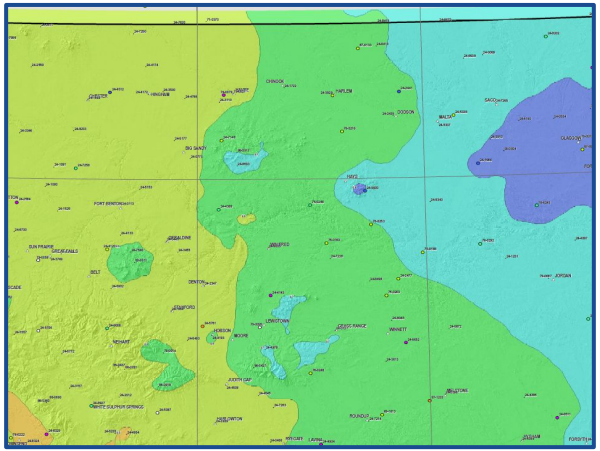


Interpolation and Map Review

- Station mean annual maximum (MAM) values interpolated using Parameter-elevation Regressions on Independent Slopes Model (PRISM) statistical-geographical approach.
- Gridded MAM maps were reviewed and several iterations made with PRISM Climate Group to ensure satisfactory MAM patterns.
  - Some station MAM estimates were adjusted slightly, excluded from MAM analysis, or deleted.
  - MAMs were estimated for some locations to anchor the spatial interpolation where complex terrain and/or a lack of station data were contributing to unexpected spatial patterns.



1-hr MAM First Round

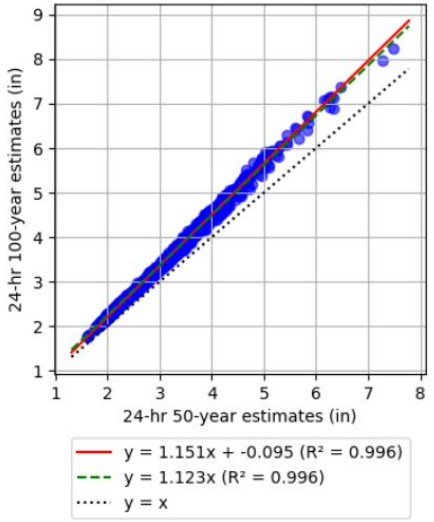


1-hr MAM Final Round

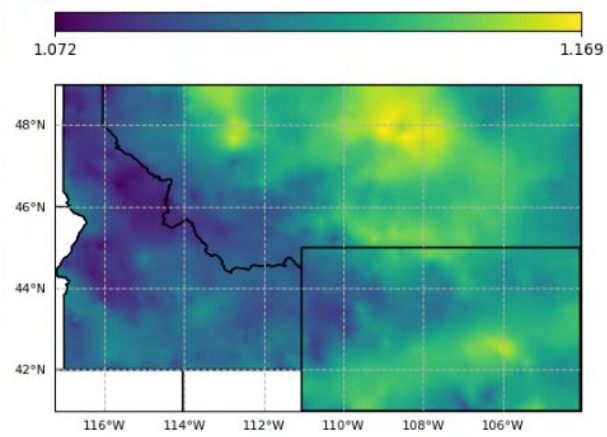
Interpolation and Map Review

PF grids are derived using strong linear relationship between MAM and 2-yr estimates, and between PF estimates at consecutive frequencies.

1. For each duration, at-station ratios between 2-yr estimates and MAM spatially interpolated via natural neighbor interpolation.
2. Gridded MAM estimates multiplied by gridded ratios to create 2-year estimate grid.
3. Ratios between 5-yr and 2-yr estimates interpolated and used to calculate 5-yr estimates. Repeat for remaining frequencies.
4. Resulting grids examined and adjusted in cases where inconsistencies occurred between durations and frequencies.



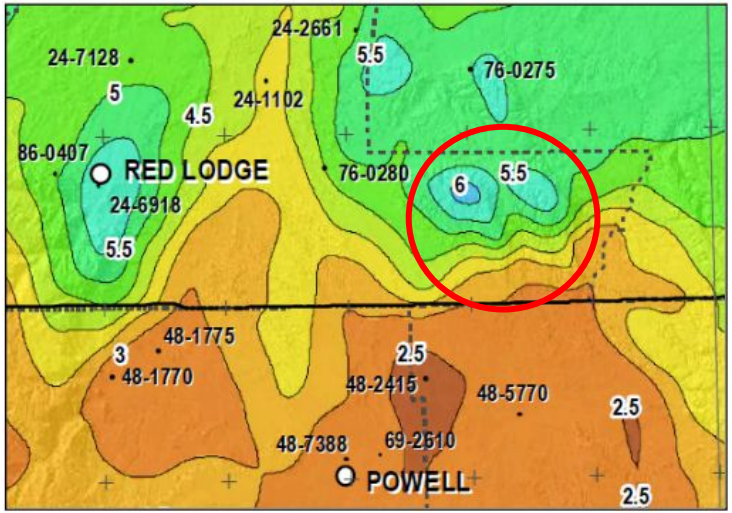
Linear relationship between 50-yr and 100-yr 24-hour PF estimates



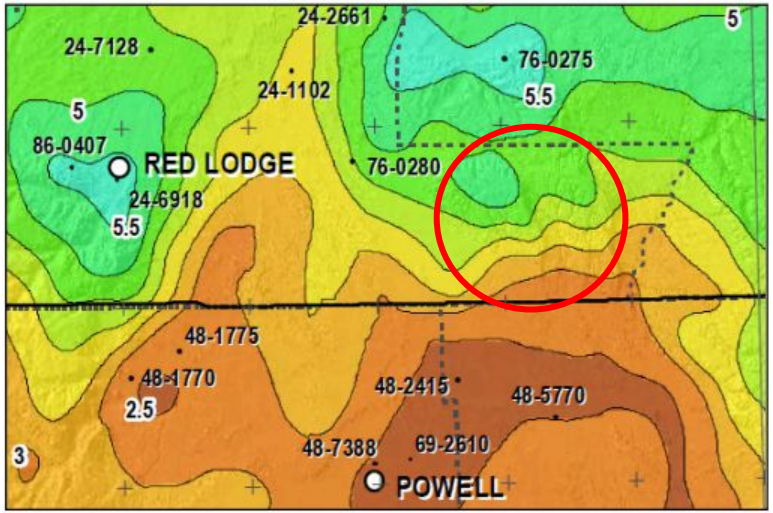
Interpolated ratios used to calculate 100-yr 24-hr PF grid from 50-yr 24-hr PF grid

Peer Review and Revision

Feedback requested from funding agencies, HDSC list-server subscribers, etc.



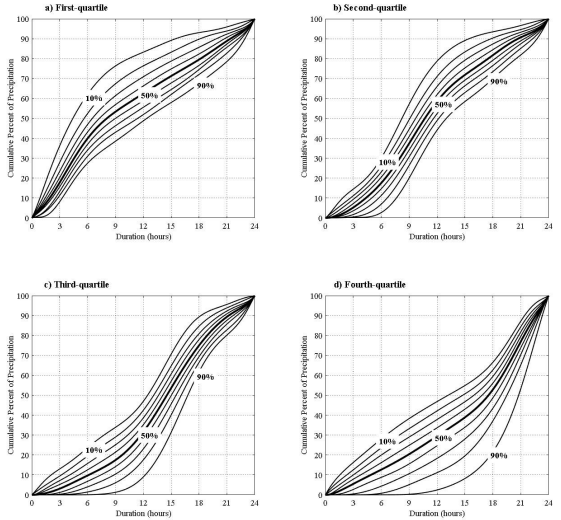
Preliminary 100-yr 24-hr

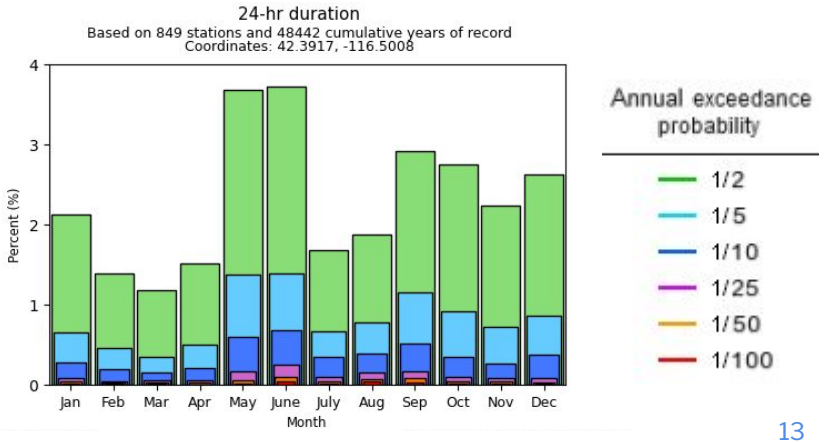


Final 100-yr 24-hr

Supplementary Information

- Documentation
- Estimate/confidence limit GIS grids
- Cartographic maps
- Final QC'd AMS for stations
- Temporal distributions
- Seasonality analysis
- Rainfall frequency estimates





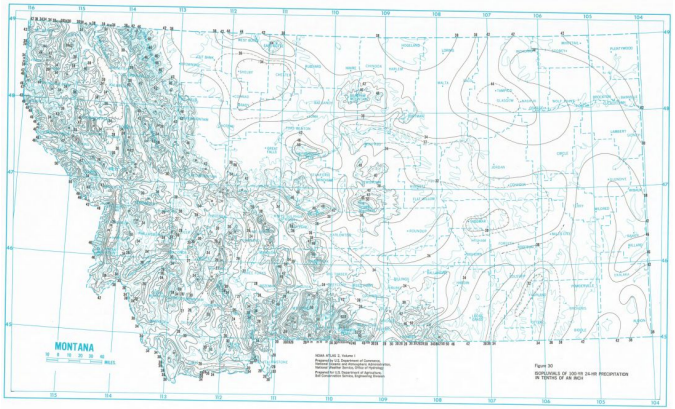
24-hr temporal distributions (top) and seasonality plot (bottom) for the Northern US Rockies climate region

Results/Web Publication

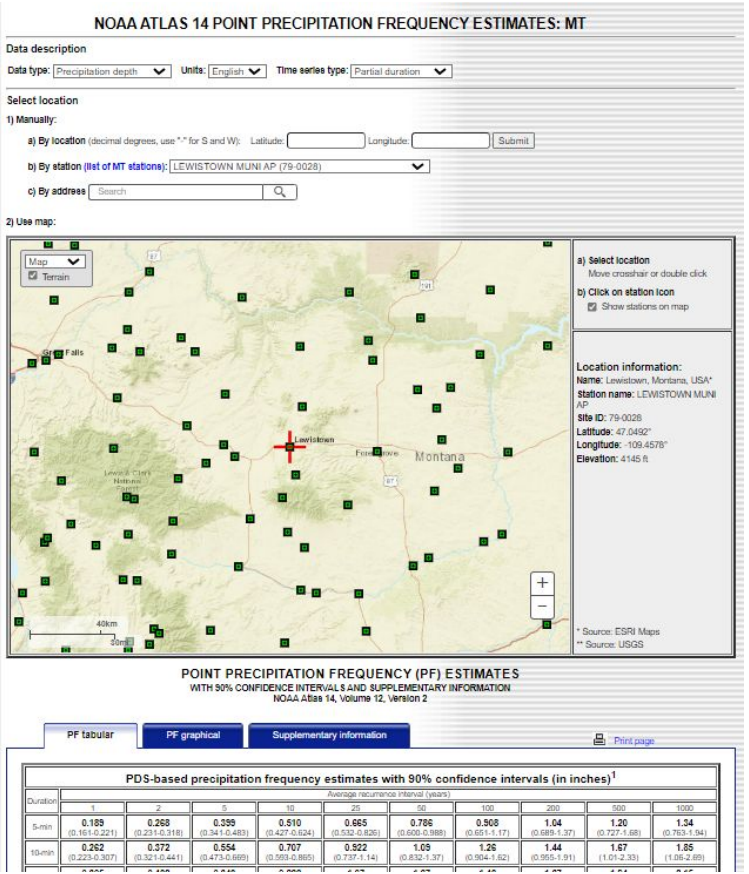
Published on September 19, 2024

Supersedes estimates generated:

- In 1964 as part of the Technical Paper No. 49.
- In 1973 as part of the NOAA Atlas 2 publication.
- In 1986 as part of the Arkell et al. publication *Short Duration Rainfall Relations for the Western United States*.

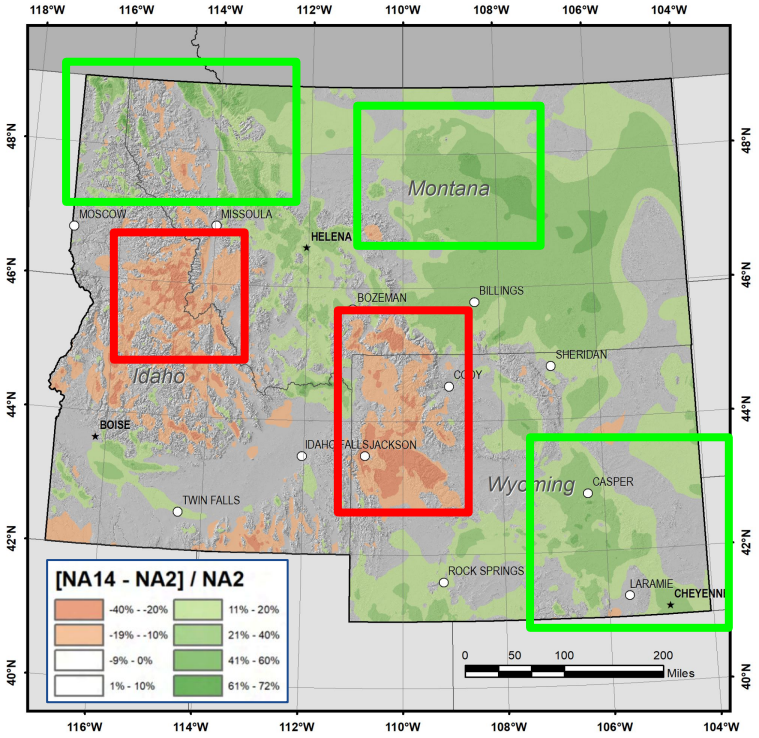


NOAA Atlas 2 (NA2), 1973; *Montana*



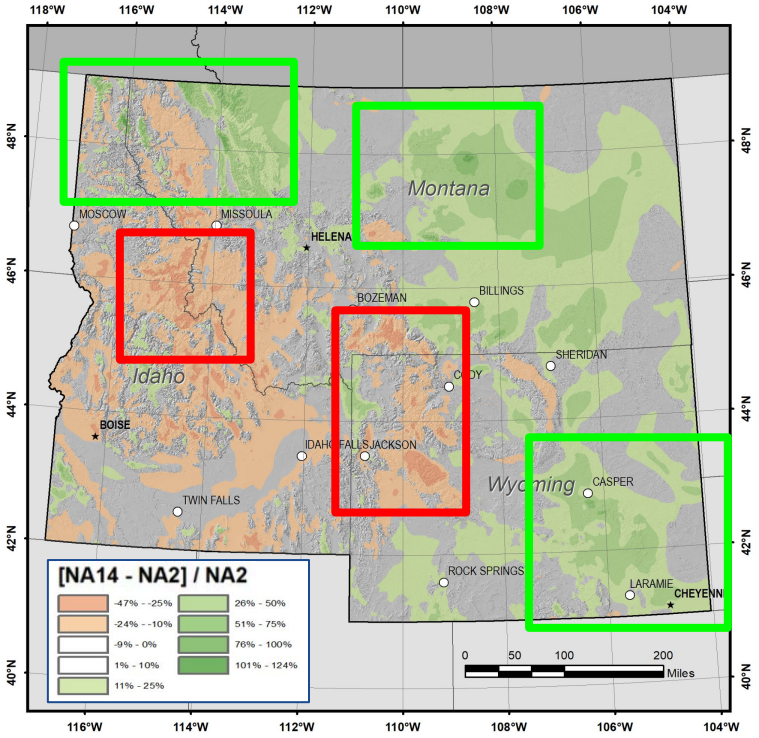
PFDS webpage with stations in Montana

Volume 12 Results: 100-yr Estimates vs NOAA Atlas 2



6-hr Percent Difference

1+in (40+%) / -0.75+in (-20+%)



24-hr Percent Difference

2+in (50+%) / -1+in (-25+%)

Acknowledgements

Carl Trypaluk[2], Dale Unruh[2], Michael St. Laurent[2], Austin Jordan[1], Rama Sesha Sridhar Mantripragada[1], Sandra Pavlovic[3], Greg Fall[3], and Fernando Salas[3]

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[2]*RTI International, Fort Collins, CO USA*
[3]*Office of Water Prediction, National Weather Service, NOAA, USA*

Many thanks to:

- Idaho Transportation Department, Montana Department of Transportation, and Federal Highway Administration
- Data Providers
- Peer Reviewers
- NOAA/NWS/OWP colleagues and website/IT/contractual support

Thank You!

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