Hydrometeorological Design Studies Center
Progress Report for Period
1 July to 30 September 2024

Office of Water Prediction
National Weather Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Silver Spring, Maryland

October 28, 2024

DISCLAIMER

The data and information presented in this report are provided only to demonstrate current progress on the various tasks associated with these projects. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any other purpose does so at their own risk.

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I. INTRODUCTION

The Hydrometeorological Design Studies Center (HDSC) within the Office of Water Prediction (OWP) of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) updates precipitation frequency estimates for parts of the United States and affiliated territories, in coordination with stakeholder requests. Updated precipitation frequency estimates, accompanied by additional relevant information, are published as NOAA Atlas 14 and are available for download from the Precipitation Frequency Data Server (PFDS).

NOAA Atlas 14 is divided into volumes based on geographic sections of the country and affiliated territories. Figure 1 shows the states or territories associated with each of the volumes of the Atlas. To date, precipitation frequency estimates have been updated for AZ, NV, NM, UT (Volume 1, 2004), DC, DE, IL, IN, KY, MD, NC, NJ, OH, PA, SC, TN, VA, WV (Volume 2, 2004), PR and U.S. Virgin Islands (Volume 3, 2006), HI (Volume 4, 2009), Selected Pacific Islands (Volume 5, 2009), CA (Volume 6, 2011), AK (Volume 7, 2011), CO, IA, KS, MI, MN, MO, ND, NE, OK, SD, WI (Volume 8, 2013), AL, AR, FL, GA, LA, MS (Volume 9, 2013), CT, MA, ME, NH, NY, RI, VT (Volume 10, 2015), and TX (Volume 11, 2018).

HDSC is currently working on two NOAA Atlas 14 Volumes: Volume 12 and Volume 13, and initiated Atlas 15 development. The Volume 12 project area covers the states of Idaho, Montana and Wyoming, while the Volume 13 project area covers the states of Delaware, Maryland, North Carolina, Pennsylvania, South Carolina, Virginia and Washington D.C. and approximately a 1-degree buffer around these states.

Figure 1 shows the new and updated project areas included in NOAA Atlas 14, Volumes 1 to 13. The proposed schedules for the two projects are contingent on funding and a timely hiring process. For any inquiries regarding NOAA Atlas 14, please email hdsc.questions@noaa.gov.

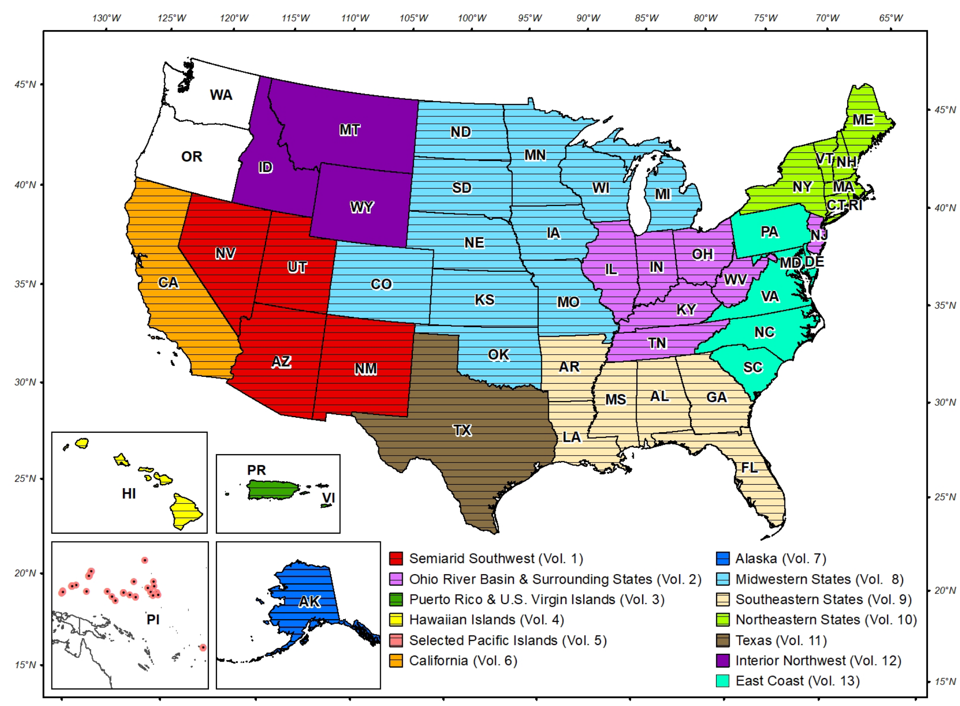

Figure 1. States or territories associated with each of the volumes of the Atlas.

II. CURRENT NOAA ATLAS 14 PROJECTS

1. VOLUME 12: INTERIOR NORTHWEST

On September 19, 2024, the HDSC published the NOAA Atlas 14 Volume 12 estimates for Idaho, Montana, and Wyoming. The development of this volume was initiated on May 26, 2021, and the project development area included the aforementioned states with an approximately 1-degree buffer around these states (Figure 2).

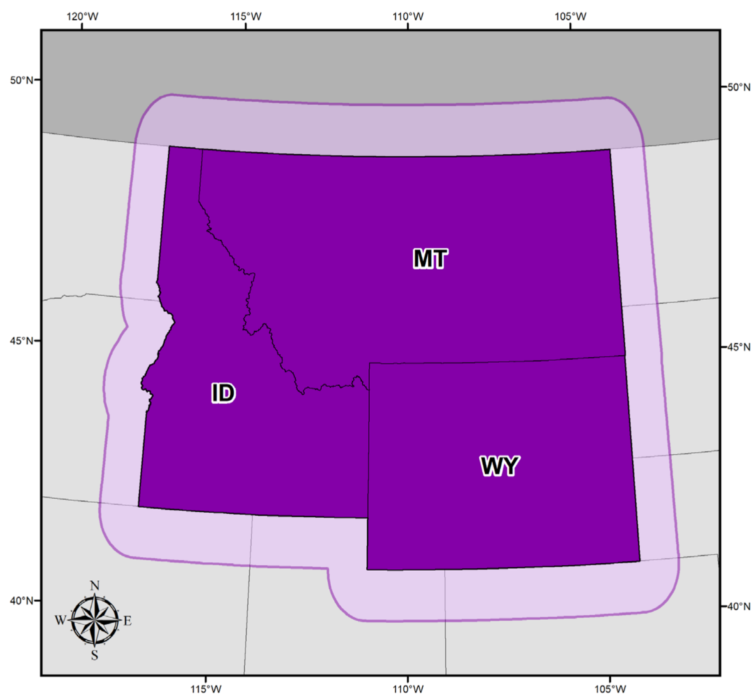

Figure 2. NOAA Atlas 14, Volume 12 extended project area (shown in purple).

In the reporting period of July 1 to Sep 30, 2024, we finalized estimates across all durations, 1-day through 60-day, after extensively reviewing the spatial patterns and corresponding depth-duration-frequency (DDF) curves. Once the review of estimates was complete, we finalized development of the supplementary information, such as trend analysis, temporal analysis and confidence intervals, and documentation. For more information on how the supplementary information tasks, please refer to January - March, 2024 Progress Report.

1.1. PROGRESS IN THIS REPORTING PERIOD (July- Sep 2024)

For the sources of datasets considered, contacted, downloaded or formatted for the precipitation frequency analysis for NOAA Atlas 14 Volume 12, please see July - Sept, 2022 Progress Report.

1.1.1. Finalization of spatially interpolated precipitation frequency estimates

In NOAA Atlas 14, the grids of mean annual maxima (MAM) at 30 arc-sec resolution, together with at-station precipitation frequency estimates, are the basis for calculation of gridded annual maximum series (AMS)-based and partial duration series (PDS)-based precipitation frequency estimates and corresponding upper and lower bounds of the 90% confidence interval. Mean annual maximum grids serve as the basis for calculation of the precipitation frequency estimates for the 2-year average recurrence interval (ARI), which are then used to calculate gridded 5-year estimates and so on. More information on this method will be provided in the Volume 12 document, which will be available for download from the PFDS web page in September 2024.

During this reporting period we finalized spatial patterns for the 2-year, 100-year and 1000-year grids across all durations, and revisited and improved at-station and regional estimates where needed. Corresponding depth-duration frequency curves were adjusted to ensure consistent transition between durations and return periods. The resulting adjustments were then carried through to other recurrence intervals in an iterative process. Typically, several iterations are required to ensure realistic spatial patterns and consistency in gridded estimates for 13 selected durations from 1 hour to 60 days (1-hr, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, 2-day, 4-day, 7-day, 20-day, 30-day, 45-day and 60-day).

To ensure consistency in grid cell values across all durations and frequencies (e.g., a 24-hour estimate has to be at least equal to the corresponding 12-hour estimate), we also conducted duration-based internal consistency checks across durations and frequencies.

1.1.2. Development of rainfall frequency estimates

For rainfall frequency analysis, annual maxima from the precipitation and rainfall-only time series using at least 20 years of station data were used. At-station precipitation and rainfall frequency estimates were produced using L-moment statistics with a GEV distribution on each annual maximum series (e.g. the station in Figure 3). Ratios of rainfall/precipitation frequency estimates at various average recurrence intervals from 1-year to 1000-year were calculated at each station. Multiple linear regression of these ratios for each average recurrence interval, with various combinations of independent variables such as latitude, longitude and elevation were used to form a relationship. For more common return periods (e.g. 1-year), there was statistical significance with elevation (p value < 0.05), with increasing elevation correlating with decreasing rain/precipitation ratios. At rarer recurrence intervals there was no statistical significance, where rain/precipitation ratios approached 1.0.

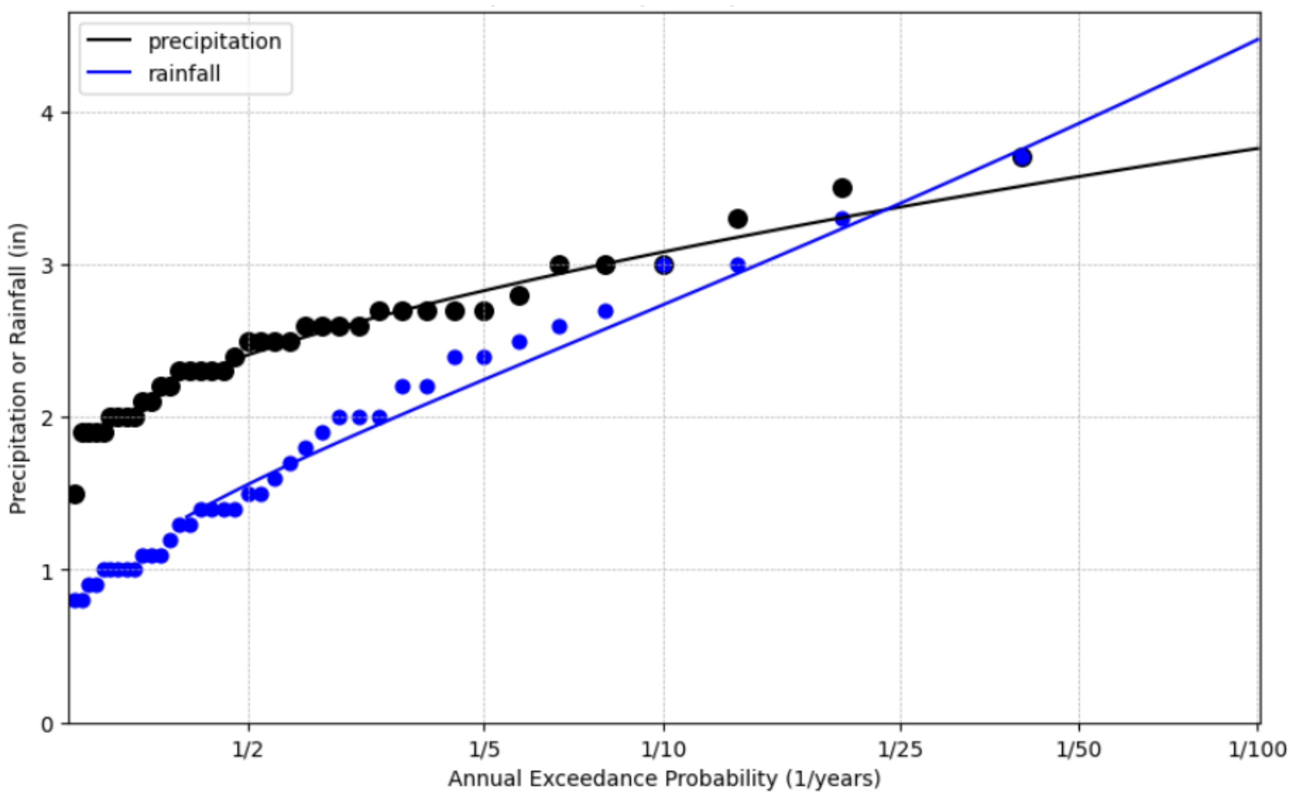

Figure 3: 24-hour precipitation (black) versus rainfall (blue) annual maxima, with GEV distributions fitted. Station is SNOTEL Site number 411 - Cool Creek at 1,914 meters. Precipitation and rainfall show differences at frequent AEPs, but converge at rarer AEPs.

To further investigate the statistical significance of elevation, stations used for the 24-hour rainfall frequency analysis with both concurrent precipitation and rainfall-only time AMS were collected in 500-meter bins. For each bin and recurrence interval, the mean rain/precipitation ratio was calculated. The resulting “binned” ratios show a similar pattern as the multiple linear regression, where ratios are smaller for higher elevations and for more common average recurrence intervals. This is physically consistent with snowfall having a larger impact at higher elevations and rainfall being more dominant at larger/rarer average recurrence intervals. These rarer events need higher precipitable water values, which are directly correlated with higher temperatures.

Similar to the 24-hour analysis, annual maximum series for precipitation and rainfall are compared using elevation bins at different recurrence intervals and durations using only stations that measure at sub-daily (hourly or shorter) intervals, and mean ratios are calculated. Lastly, these sub-daily ratios were combined with the ratios from the 24-hour analysis. Ratios for all ARIs/AEPs from 1-year to 1000-year were interpolated using Piecewise Cubic Hermite Interpolating Polynomial (PCHIP) and log-transformed durations as the independent variables. Additional optimization was used to constrain ratios to a maximum of 1.00, and also enforce consistency (eg. ratio for 1-hr > 2-hr > 3-hr > 6-hr > 12-hr > 24-hr). Ratio consistency was typically only necessary for average recurrence intervals above 100-year. Some manual adjustments were needed at sub-daily for the highest two elevation bins, where only 8 and 2 stations existed, respectively. Results show higher ratios (more liquid contribution) for the shorter durations and rarer average recurrence intervals, consistent with warm season convection at short durations. Section 4.7 in Atlas 14 Volume 12 documentation includes a table with the rainfall / precipitation ratios for various elevation bins and average recurrence intervals for durations 1-hour through 24-hour.

These ratios are multiplied with relevant precipitation frequency gridded information (e.g. 100-year 24-hour) to create a rainfall-only equivalent frequency grid. The same ratios were used to estimate confidence limits by multiplying with the relevant lower or upper precipitation frequency grid. Due to applying these ratios directly to the precipitation frequency confidence limits, it is important to note that the rainfall confidence limits do not incorporate the added uncertainty with respect to the precipitation-to-rainfall conversion process itself.

1.1.3. Documentation

During this reporting period, we completed work on the NOAA Atlas 14 Volume 12 Version 2 documentation which is available for download here: https://www.weather.gov/media/owp/oh/hdsc/docs/Atlas14_Volume12.pdf.

The documentation is similar in layout, coverage and depth to documentation prepared for previous NOAA Atlas 14 volumes. It describes all aspects of the development of each artifact in sufficient depth to allow the knowledgeable user to understand the basis of the estimates and their scope and applicability. It also includes information on the comments received during the peer review process and HDSC follow-up actions (see Appendix 5), and relates current NOAA Atlas 14 estimates with corresponding estimates from superseded NOAA publications (Section 7).

1.1.4. Web Publication

Precipitation frequency estimates for the Interior Northwest with supplementary products were published as NOAA Atlas 14 Volume 12 Version 2 on September 19, 2024.

All NOAA Atlas 14 Volume 12 products are available for download from the PFDS page for the Interior Northwest, shown in Figure 4. Section 5 of the NOAA Atlas 14 documentation provides additional information on the underlying data and functioning of the PFDS. Section 5 will be updated over the next reporting period.

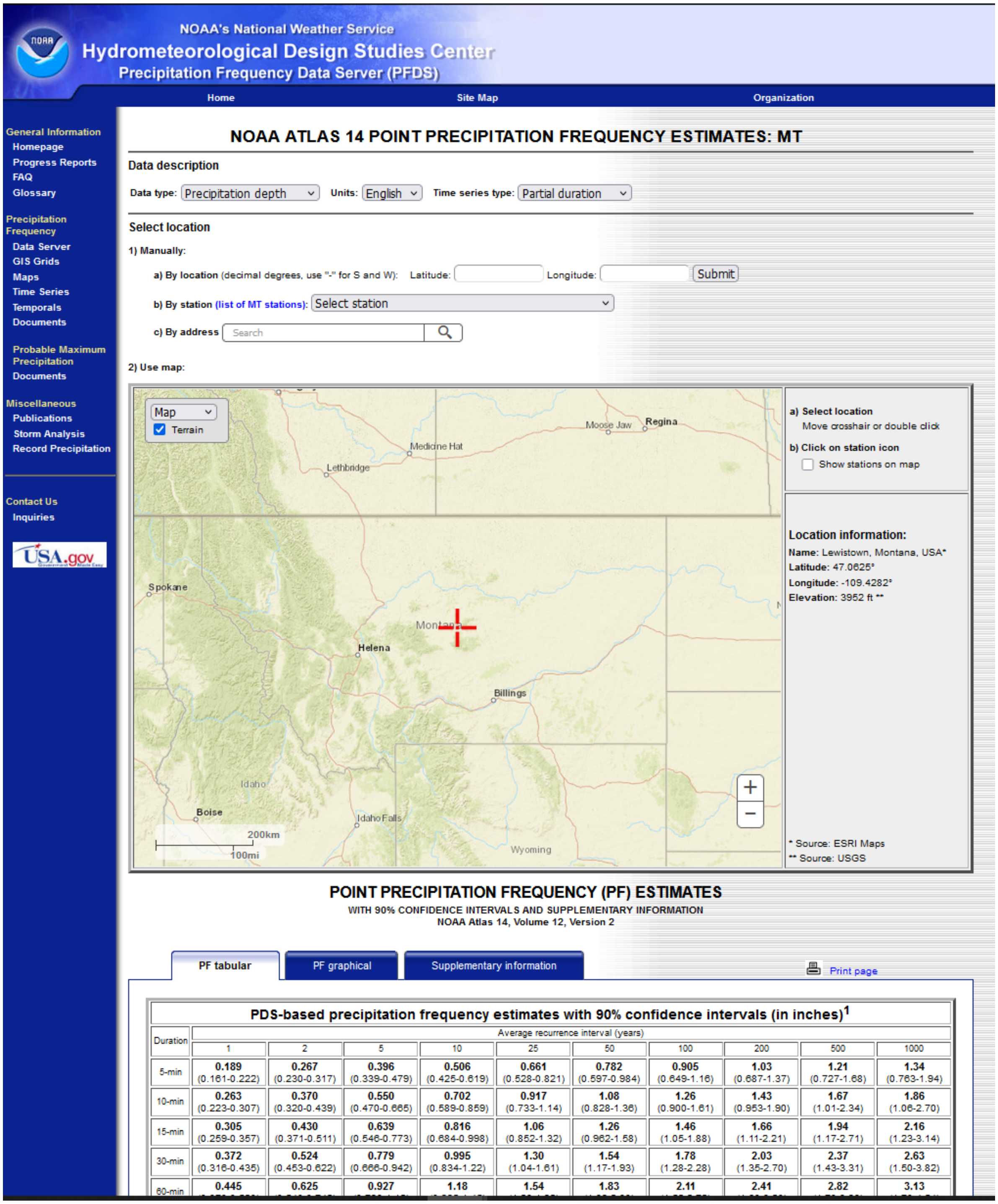

Figure 4. PFDS page for Volume 12.

When information is needed only for a specific location, it can be retrieved manually by entering the location's address or coordinates in decimal degrees (negative numbers should be entered for longitudes). It can also be retrieved from the map by dragging the red cursor on the map to the selected location or by double-clicking anywhere on the map. For gaged locations, a selection can also be made by choosing a station name from a pull-down list or clicking on an observing station on the map (after selecting “Show stations on map” and zooming in).

From the menu at the top of the page, a user can request partial duration series (PDS)-based or annual maximum series (AMS)-based precipitation frequency (PF) estimates to be displayed as precipitation depths or intensities in English or SI (metric) units. By default, PDS-based precipitation frequency depths in English units are shown. After a location is selected, all precipitation frequency and confidence limit estimates are displayed directly below the map in three separate tabs: “PF tabular” (displayed by default), “PF graphical” and “Supplementary information.”

The side menu under the “Precipitation Frequency” tag is used to download various products applicable across the entire state, such as:

- GIS grids - ASCII grids of spatially interpolated PDS-based and AMS-based precipitation frequency estimates and accompanying bounds of a 90% confidence interval for durations from 5 minutes up to 60 days and for average recurrence intervals (ARIs) up to 1000 years can be downloaded via pull-down menu, via web browser, or by anonymous FTP. Grid metadata files, in Federal Geographic Data Committee compliant XML format, are automatically downloaded with corresponding grids.
- Maps - NOAA Atlas 14 cartographic maps of precipitation frequency estimates for selected ARIs and durations show contour lines created from gridded PDS-based precipitation frequency estimates for selected average recurrence intervals and durations. Figure 4 shows, as an example, isopluvials for 100-yr 24-hr estimates from Volume 12. Maps were created to serve as visual aids and are not recommended for interpolating estimates.
- Time Series - AMS data for Texas stations whose data were used in frequency analysis are published for consistency as constrained values, even if they captured true interval maximum amounts, so correction factors have to be applied to obtain unconstrained values. More information on conversion from constrained to unconstrained amounts across durations will be available from Section 4.5 of the NOAA Atlas 14 Volume 12 document.
- Temporals - Temporal distributions of precipitation amounts exceeding 2-yr estimates are provided for 6-hr, 12-hr, 24-hr, and 4-day durations for four temporal distribution regions delineated for Volume 12 project area (Figure 5). The temporal distributions for the duration are expressed in probability terms as cumulative percentages of precipitation totals. To provide detailed information on the varying temporal distributions, separate temporal distributions are also derived for four precipitation cases defined by the duration quartile in which the greatest

percentage of the total precipitation occurred. More details on the derivation of temporal distribution curves will be provided in the Volume 12 document.

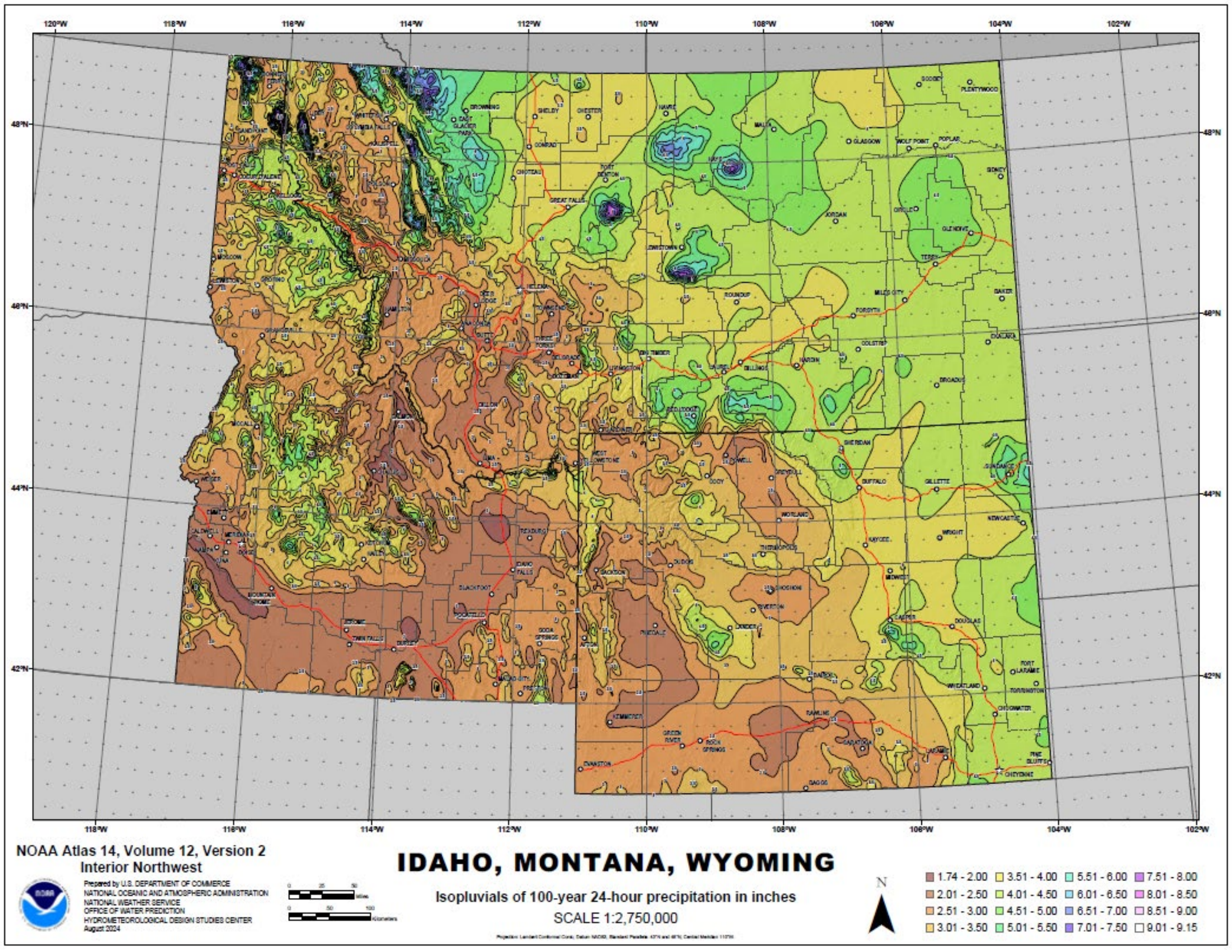

Figure 5. Isopluvials for 100-yr 24-hr estimates from Volume 12.

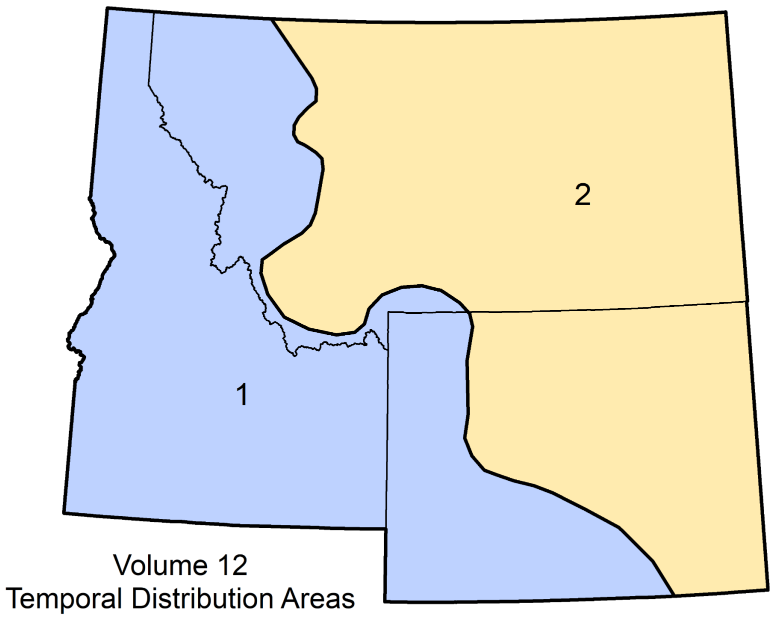

Figure 6. Temporal distribution areas for Volume 12.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2024)

Section 5 of documentation will be updated and published.

1.3. PROJECT SCHEDULE

- Data collection, formatting, and initial quality control [Completed]
- Extraction of annual maximum series (AMS); additional quality control and data reliability tests (e.g., outliers, independence, consistency across durations, duplicate stations, candidates for merging)] [Completed]
- Regionalization and frequency analysis [Completed]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [Completed]
- Peer review [Completed]
- Revision of PF estimates [Completed]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [Completed]
- Web publication [Completed]

2. VOLUME 13: EAST COAST STATES UPDATE

On July 28, 2022, the NOAA Atlas 14 Volume 13 kickoff meeting was held to commence work on a new NOAA Atlas 14 Volume 13. The precipitation frequency estimates for this volume include the states of Delaware, Maryland, North Carolina, Pennsylvania, South Carolina, Virginia and Washington D.C. and approximately a 1-degree buffer around these states (Figure 7). This project's expected completion date is December 2025, subject to change based on the availability of funds and personnel to support the development of two volume

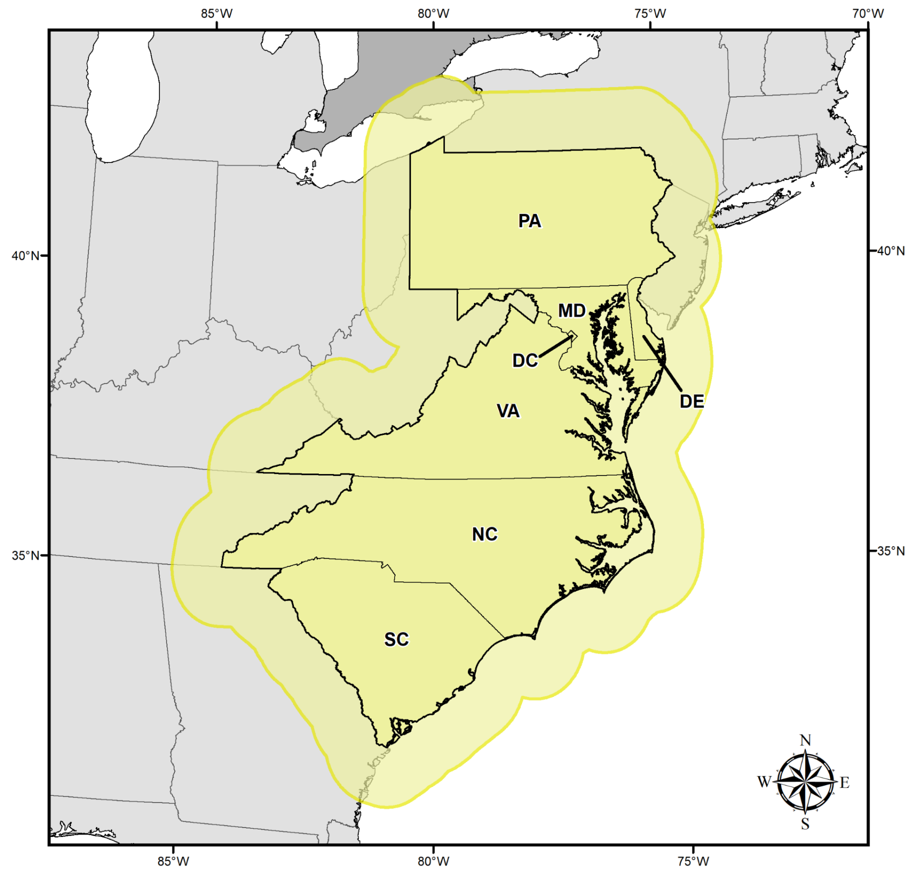

Figure 7. NOAA Atlas 14, Volume 13 extended project area (shown in yellow).

2.1. PROGRESS IN THIS REPORTING PERIOD (July- Sep 2024)

In the reporting period of July to Sep 30, 2024, we completed the modernization of the station cleanup software and initiated the manual station cleanup for the co-located NCEI networks. In addition, we continue quality controlling the station metadata and high outlier checks. Finally, we continue investigating the development of the mean annual maxima grids for this project area.

2.1.1. Data collection and screening

We continue to quality control the identified precipitation networks that are considered for the development of the Atlas 14 Volume 13 estimates. As with all NOAA Atlas 14 Volumes, the primary source of data is the NOAA's National Centers for Environmental Information (NCEI). The NCEI is the most reliable data source network in the United States. The NCEI's precipitation data alone may not be sufficient to support the objectives of NOAA Atlas 14. Since the NOAA Atlas 14 estimates are based on the statistical analysis of the historical record of the observed precipitation data, denser spatial coverage may be needed to compute the robust and reliable precipitation frequency estimates. Therefore, for each project area, we also collect digitized data measured at 1-day or shorter reporting intervals from other Federal, State and local agencies.

Table 2. Sources of datasets considered, contacted, downloaded or formatted for the precipitation frequency analysis for NOAA Atlas 14 Volume 13.

FID	Data Provider	Dataset name	Abbr.	Status
1	National Centers for Environmental Information (NCEI)	Automated Surface Observing System	ASOS	Formatted
2		DSI 3240, DSI 3260	DSI 3240 DSI 3260	Formatted
3		Global Historical Climatology Network	GHCNd	Formatted
4		Environment Canada	GHCNd	Formatted
5		Integrated Surface Data (Lite)	ISD_LITE	Formatted
6		Local Climatological Data	LCD	Formatted
7		Coop Hourly	GHCNh	Formatted
8		United States CoCORAHS	GHCNd	Formatted
9		Canada CoCORAHS	GHCNd	Formatted
10		Weather Bureau Army Navy (WBAN)	GHCNd	Formatted
11		U.S. Climate Reference Network	USCM	Formatted
12	Aberdeen Proving Ground	Phillips Airfield Weather Station	PAWS	Formatted
13	Hampton Roads Sanitation District		HRSD	Received
14	Midwestern Regional Climate Center (MRCC)	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	Formatted
15	National Weather Service (NWS) Mid-Atlantic River Forecast Center (MARFC)	Integrated Flood Observing and Warning System	IFLOWS	Formatted
16	National Oceanic and Atmospheric Administration (NOAA)	National Estuarine Research Reserve	NERRS	Formatted
17	National Atmospheric Deposition Program (NADP)	National Trends Network	NADP	Formatted
18	North Carolina State University, State Climate Office (NCSU)	North Carolina Environment & Climate Observing Network	ECONet	Formatted
19	Tennessee Valley Authority (TVA)	Rainfall Gauge Data	TVA	Formatted
21	U.S. Dept of Agriculture (USDA), Forest Service	Remote Automated Weather Station Network	RAWS	Formatted
22	U.S. Dept of Agriculture (USDA), Natural Resources Conservation Service (NRCS)	Soil Climate Analysis Network	SCAN	Formatted
24	University of Albany	New York State Mesonet	NYS	Formatted
25	University of Delaware, Center for Environmental Monitoring & Analysis	Delaware Environmental Observing System	DEOS	Formatted
26	University of Georgia	Georgia Weather Network	GWN	Formatted
27	Western Kentucky University	Kentucky Mesonet	KYM	Formatted

The following datasets were not used after investigation and review of periods of record and data quality: Automatic Position Reporting System WX NET/Citizen Weather Observer Program, Synoptic Weather, Maryland Department of Transportation Road Weather Network, Pennsylvania State University Environmental Monitoring Network, and WeatherSTEM.

2.1.2. Station metadata screening

In this reporting period, we continue to perform manual metadata inspection for datasets formatted (Table 2), and thus far completed the 95% of the metadata checks for all networks. See previous report on methodology here: January - March, 2024 QPR Report.

2.1.3. Station cleanup

The station cleanup effort is performed to:

- screen for duplicate records
- extend records at longer-duration stations using data from nearby stations,
- investigate large differences in annual maximum series (AMS) at collocated stations at critical
- durations such as 1-hour and 1-day
- implement data corrections to ensure data consistency across multiple gauges
- determining if overall datasets are of good quality and should be used in the analysis

In this reporting period, we investigated ways on how we could automate station cleanup procedures to screen stations with a short period of record prior manual cleanup and quality control process. We started testing on the Global Historical Climatology Network daily (GHCN-daily), specifically merging the CoCoRaHS stations into longer-record GHCN-daily stations, such as from the Cooperative Observer Network (COOP). Though the Community Collaborative Rain, Hail and Snow (CoCoRAHS) Network is relatively new, with shorter record lengths (Figure 8b), they are very valuable for filling the gap of steadily decreasing station counts in the COOP network (Figure 8a). We are investigating rules for auto-merging this information, such as:

- Auto-merging stations with no overlap within a small radius (eg. 3-5 km)
- Auto-merging stations with overlapping records within a small radius, with a check on the correlation of the overlapping annual maximum series.
- Considering short-record CoCoRaHS that received a significant precipitation event in the context of nearby stations.
- Deleting duplicate, or near-duplicate data in data-dense areas

Stations failing correlation checks, or having significantly different statistics will still be considered for merging in a manual round of cleanup. Rules for auto-merging stations will be finalized and applied in the next reporting period.

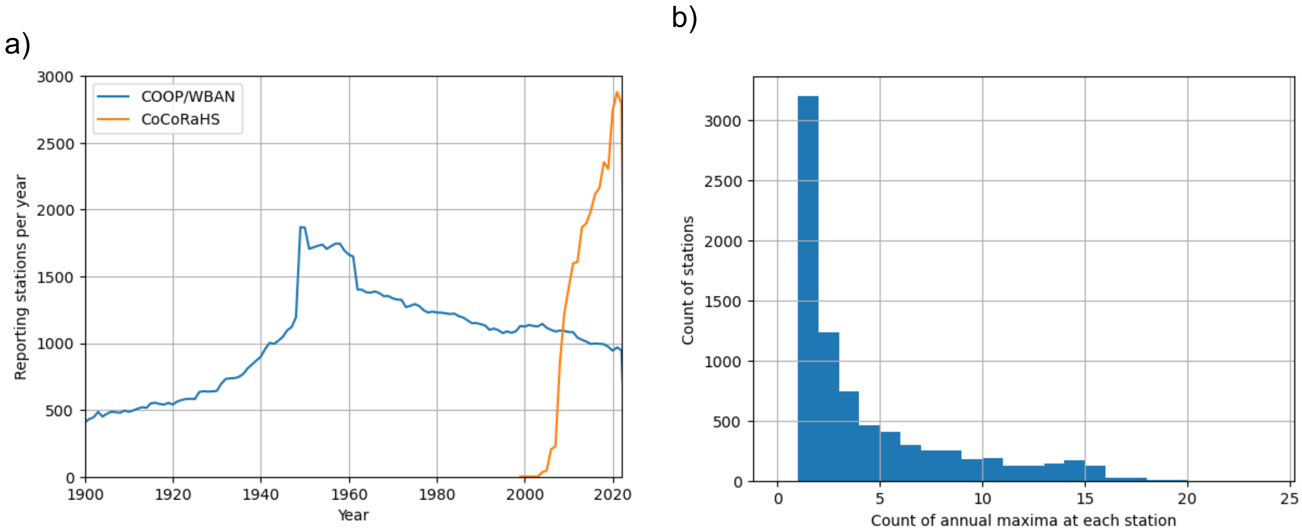

Figure 8. a) Station counts from the GHCN-daily archive, divided into COOP/WBAN and CoCoRaHS for the NOAA Atlas 14, Volume 13 extended project area. b) Histogram of annual maxima counts for CoCoRAHS stations in the same project area.

2.1.4. Mean Annual Maxima (MAM) grids for base durations

During this reporting period, we continued to explore in-house development of mean annual maxima (MAM) precipitation grids for this project area. By comparing skill metrics such as mean squared error and R^2, we have identified the most critical covariates to include in stepwise multiple regressions to generate background MAM analyses. We have developed an ordinary kriging process to correct errors correlated over large spatial scales (typically 100-200 km) in that background, and demonstrated, via leave-one-out cross validation, that the combination of stepwise multiple regression and ordinary kriging produces error metrics that are similar, and at times slightly improved, relative to the PRISM-based framework of previous Atlas 14 Volumes. We have evolved the code so different configurations can be stored and executed repeatedly using YAML configuration files, and maintained this code in a GitHub repository to benefit collaboration.

For the next quarter, we will generate configurations to produce MAM analyses for several durations (1 hour, 6 hours, 24 hours, and 10 days). We will also implement a third analysis (to follow the ordinary kriging step) which will adjust small-scale (50-100 km) residual errors in the analysis to better match station values. The MAM grids produced by that final step can then be used to interpolate at-station regional precipitation frequency estimates to 30 arc-sec grids, following the NOAA Atlas 14 interpolation process. We will continue using cross-validation methods to optimize configurations and evaluate the results of our MAM analyses, and will continue managing the code produced for this effort (mostly Python) on GitHub.

2.1.5 Extraction and quality control of annual maximum series outliers

During this reporting period, the NCEP/EMC 4KM Gridded Data (GRIB) Stage IV Data was used to aid in discovery of “dry” hourly periods in the station precipitation data, in areas of sufficient radar coverage for approximately years 2005-present. This was tested on the COOP hourly dataset, in which 399 unflagged values >= 1.00”/hour were identified as likely invalid in the Volume 13 project area.

During the next reporting period, we will confirm the validity of these values, possibly identify more events through additional criteria, and expand the analysis to other sub-daily datasets.

2.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2024)

We will continue with data collection, reformatting, and data quality checks for NCEI stations. In parallel, we will continue to evaluate the spatial covariates, and will start investigating the regionalization approach for this project area.

2.3. PROJECT SCHEDULE

- Data collection, formatting, and initial quality control [Revised to FY Q2 2025; In Progress]
- Extraction of annual maximum series (AMS); additional quality control and data reliability tests (e.g., outliers, independence, consistency across durations, duplicate stations, candidates for merging)] [Revised to FY Q2 2025; In Progress]
- Regionalization and frequency analysis [Revised to FY Q2 2025; In Progress]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [Revised to FY Q3 2025; In Progress]
- Peer review [Revised to FY Q3 2025; In Progress]
- Revision of PF estimates [FY Q3 2025]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [FY Q1 2026]
- Web publication [FY Q1 2026]

III. ATLAS 15: PRECIPITATION FREQUENCY STANDARD UPDATE

On September 26, 2024, the NOAA Office of Water Prediction (OWP) released the NOAA Atlas 15 Pilot dataset covering the state of Montana, which provides an early first look at the future of the NOAA Precipitation Frequency Atlas of the United States. The NOAA Atlas 15 development effort represents a shift from a stationary climate assumption (NOAA Atlas 14) to a nonstationary assumption by incorporating climate model outputs and nonstationary statistical methods into the analysis. For more information on the initiation and timeline for the Atlas 15 development, please refer to the July - Sept, 2023 Progress Report.

The pilot data are available for review through the National Weather Service's gateway to all water information, the National Water Prediction Service (NWPS), at water.noaa.gov/about/atlas15 (Figure 1). The yellow box at the top of the page offers quick links to the pilot data visualization page, a scientific report describing the data and methodology used, a quick start video on navigating the NA15 pilot pages, and a survey for providing feedback on the pilot data and web dissemination strategy.

As with all NOAA Atlas 14 volumes, public involvement through the peer review and feedback process is highly valued. We encourage everyone to complete the survey, available here, as this is the most effective way for us to gather and evaluate feedback consistently. As part of the engagement efforts, the National Weather Service also released the NWS Public Notification Statement (PNS), which is available at: https://www.weather.gov/media/notification/pdf_2023_24/pns24-61atlas15_montana.pdf.

National Water Prediction Service

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Welcome to the NOAA Atlas 15 Informational Page

NOAA ATLAS 15:
Update to the National Precipitation Frequency Standard

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- What happens after the NOAA Atlas 15 Pilot?
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RELATED LINKS

NOAA Atlas 14/15 Updates
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Atlas 14
NOAA Atlas 14, Volume 12 data can be found on the NOAA National Weather Service Precipitation Frequency Data Server (PFDS)

Probable Maximum Precipitation Estimation
Updating national PMP estimates through specialized research to improve the safe design, operation, and

News: The NOAA Atlas 15 Pilot over Montana is now available for early feedback, HERE. Click to explore the pilot data and how the NOAA Atlas 15 framework differs from NOAA Atlas 14. Feedback can be submitted through this survey. A Quick Start Video is available. See the NOAA Atlas 15 Pilot Technical Report for more information.

What is NOAA Atlas 15?

NOAA Atlas 15 is the new authoritative, spatially continuous and climate-informed National Precipitation Frequency Atlas of the United States, currently under development by the NOAA National Weather Service (NWS) Office of Water Prediction (OWP). As with previous Precipitation Frequency Atlases, NOAA Atlas 15 will provide spatially independent estimates of expected precipitation depth (or intensity) for a specified storm duration (e.g., 6 hours), at a particular location of interest (e.g., Tulsa, Oklahoma). The statistically expected precipitation estimates will be presented as exceedance probabilities ranging from 50% average annual exceedance to 0.1%, and will cover storm durations ranging from 5 minutes to 60 days. As an example, a NOAA Atlas 15 precipitation estimate with a 20% average annual exceedance probability has a 20% chance of being exceeded in the year of interest (see table below for a range of examples).

	Annual Exceedance Probability (%)					
Duration	50%	20%	10%	4%	2%	1%
60 minutes	0.499 (0.446 - 0.549)	0.729 (0.64 - 0.818)	0.919 (0.793 - 1.05)	1.21 (1.02 - 1.41)	1.48 (1.22 - 1.75)	1.79 (1.45 - 2.16)
120 minutes	0.619 (0.563 - 0.675)	0.841 (0.747 - 0.937)	1.01 (0.888 - 1.15)	1.3 (1.11 - 1.51)	1.56 (1.31 - 1.84)	1.86 (1.53 - 2.24)
3 hours	0.71 (0.649 - 0.771)	0.951 (0.851 - 1.06)	1.14 (1 - 1.28)	1.43 (1.23 - 1.64)	1.68 (1.42 - 1.96)	1.97 (1.64 - 2.35)
6 hours	0.89 (0.817 - 0.966)	1.18 (1.07 - 1.31)	1.4 (1.25 - 1.57)	1.71 (1.5 - 1.95)	1.96 (1.69 - 2.26)	2.23 (1.9 - 2.62)

In contrast to NOAA Atlas 14, NOAA Atlas 15 will provide spatially continuous coverage over the entire United States and, for the first time, will also account for future climate variability (through the year 2100). When published, NOAA Atlas 15 will be the authoritative source for precipitation frequency information across the United States. The current standard, NOAA Atlas 14, is referenced in many engineering design standards and floodplain regulations, published by entities outside of NOAA, and engineers and other practitioners use those standards and regulations to make local decisions (designs for drainage infrastructure, city and regional planning, etc.) Among the civil engineering community, precipitation frequency estimates for various durations are often referred to as Depth-Duration-Frequency (DDF) or Intensity-Duration-Frequency (IDF) curves.

Why is NOAA Atlas 15 Important?

NOAA Atlas 15 can help communities nationwide become more climate-resilient when planning for and designing new infrastructure. This objective will be supported by (1) the delivery of spatially continuous precipitation frequency estimates that cover the entire United States and (2) the incorporation of

Figure 9. NOAA Atlas 15 Informational Page, added to the National Weather Service's gateway to all water information.

The NOAA Atlas 15 Pilot visualization page provides a user-friendly interface for the pilot data. As part of the feedback process, we ask the public and our users to provide feedback on the pilot website and web dissemination strategy. The NOAA Atlas 15 Pilot data is presented in two volumes and offers spatially continuous and independent present-day estimates of expected precipitation depth or intensity for a specified duration, at a particular location of interest (See top left map on Figure 10 for Volume 1: Current Estimates as of 2023), and estimates of future conditions leveraging outputs from multiple climate models, and is presented for future periods within two distinct frameworks, one based on Global Warming Levels, the other on emission scenarios (See top right map on Figure 10 for Volume 2: Projected Estimates).

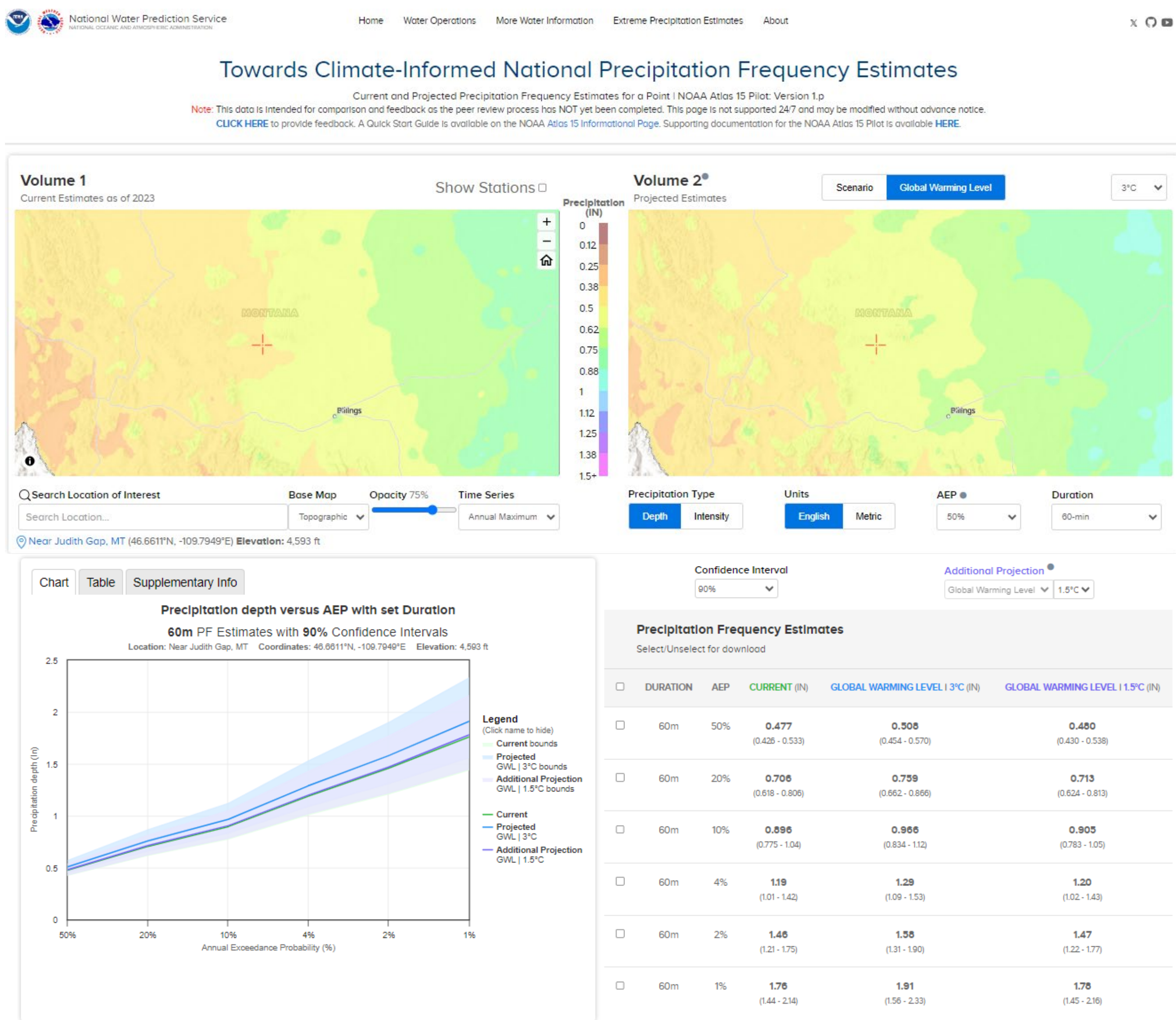

Figure 10. NOAA Atlas 15 Informational Page, added to the National Weather Service's gateway to all water information.

The Volume 1 and Volume 2 maps display the gridded estimates for the selected duration and annual exceedance probability that can be selected through the drop-down menus below the maps. For the pilot study the time series is the annual maximum series. Precipitation type defaults to depth, but intensity can also be chosen. The units default to English (inches), but Metric units in millimeters can also be selected. Both maps currently default to 50% annual exceedance probability and 60-minute duration, but users can change these options, and both maps will update accordingly.

Finally, the user can select a location of interest by double clicking the left mouse button on the map or by typing in a specific address, town or city, or latitude/longitude information in decimal degrees (with a comma separating the latitude information) in the location search bar under the left map. By selecting the location, the precipitation frequency estimates for that location will be displayed in the table and graph chart under two maps. For more detailed information on how to navigate the website and all the functionalities, please visit a quick start video.

The pilot precipitation estimates for both volumes include a subset of storm durations, from 1-hour to 10-days, and average annual exceedance probabilities from 50 percent to 1 percent. The entire range of durations and annual exceedance probabilities, currently available in the NOAA Atlas 14 volumes, will be available upon the final publication of the NOAA Atlas 15.

NOTE: The release of Atlas 15 pilot data is intended for comparison and feedback purposes as it has not completed the peer review process. The Atlas 14 Volume 12 data released on September 19, 2024, is the authoritative source and standard for Montana.

IV. OTHER

4.1. FREQUENCY ANALYSIS OF RECENT HISTORICAL STORM EVENTS

HDSC creates maps of annual exceedance probabilities (AEPs) for selected significant storm events for which observed precipitation amounts have AEP of 1/500 or less over a large area for at least one duration. AEP is the probability of exceeding a given amount of rainfall for a given duration at least once in any given year at a given location. It is an indicator of the rarity of rainfall amounts and is used as the basis of hydrologic design. For the AEP analysis, we look at a range of durations and select one or two critical durations to analyze which show the lowest exceedance probabilities for the largest area, i.e., the “worst case(s).” Since, for a given event, the beginning and end of the worst case period are not necessarily the same for all locations, the AEP maps represent isohyets within the whole event. The maps, occasionally accompanied with extra information about the storm, are available for download from the AEP Storm Analysis page. During this reporting period, we analyzed the following event:

- Helene, 23-28 September 2024

4.1.1 Helene

Catastrophic flooding occurred in southern Appalachia due to the remnants of hurricane Helene. Some of the heaviest rainfall totals can be found in the following summary document from NWS Greenville-Spartanburg Weather Forecast Office.

We analyzed AEPs for this event for several durations and decided to create AEP maps for 3-day. Areas that experienced the maximum rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the map in Figures 11. Precipitation frequency estimates used in the analysis were from NOAA Atlas 14 Volumes 2 and 9. The underlying observed data came from the NCEI's multi-sensor [Stage IV QPE Product.](#)

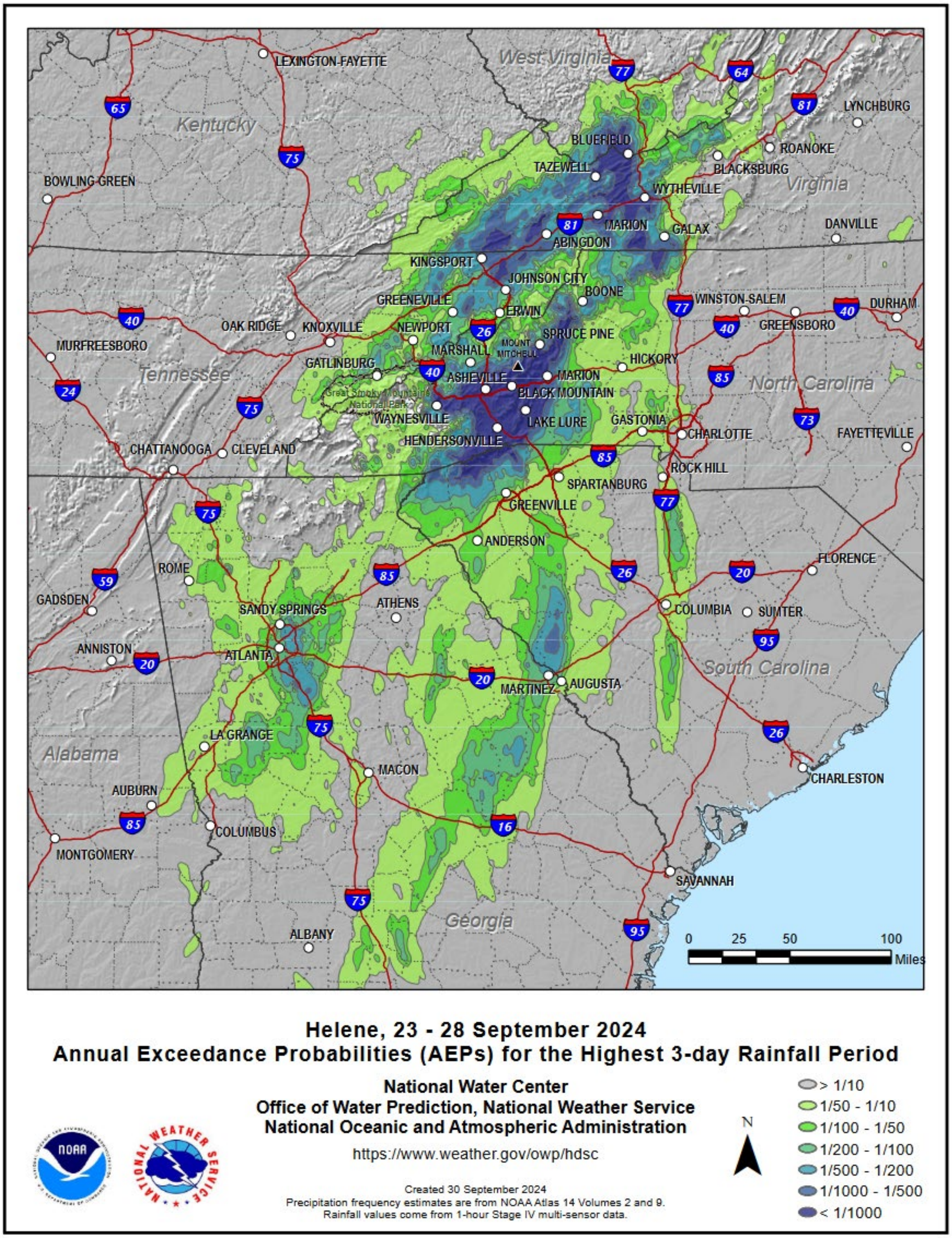

Figure 11. Annual exceedance probabilities for the worst case 3-day rainfall during Helene.

4.2. WORKSHOPS AND CONFERENCES

On August 14, 2024, the NOAA Office of Water Prediction hosted a follow-up technical workshop for federal partners that included subject matter experts and participants from 10 federal agencies (EPA, FERC, FEMA, FHWA, NASA, NOAA, NRC, USACE, USBR, USDA, and USGS). The agenda included presentations by Dr. Janel Hanrahan and Dr. Ken Kunkel on Volume 1 and 2 pilot data, respectively, followed by a panel session with Dr. Janel Hanrahan, Dr. Ken Kunkel, Dr. Sanja Perica, Dr. Xia Sun, and Dr. Marcelo Lago as panelists. Joe Krolak, P.E. Principal Hydraulic Engineer from the U.S. Department of Transportation's, Federal Highway Administration Office of Bridges and Structures, moderated the panel sessions.