Hydrometeorological Design Studies Center
Progress Report for Period
1 April to 30 June 2025

Office of Water Prediction
National Weather Service
National Oceanic and Atmospheric Administration
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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 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), TX (Volume 11, 2018), and ID, MT, WY (Volume 12, 2024).

OWP is currently working on Volume 13. The Volume 13 project area covers the states of Delaware, District of Columbia, Maryland, North Carolina, Pennsylvania, South Carolina, and Virginia with an additional approximately 1-degree buffer around these states. Figure 1 shows the new and updated project areas included in NOAA Atlas 14, Volumes 1 to 13. For any inquiries regarding NOAA Atlas 14, please email hdsc.questions@noaa.gov.

OWP is developing and implementing NOAA Atlas 15, the future authoritative source and national standard for precipitation frequency information. For more information on the NOAA Atlas 15 development, please visit the NOAA Atlas 15 Informational Page or email us at atlas15.info@noaa.gov for any inquiries regarding NOAA Atlas 15.

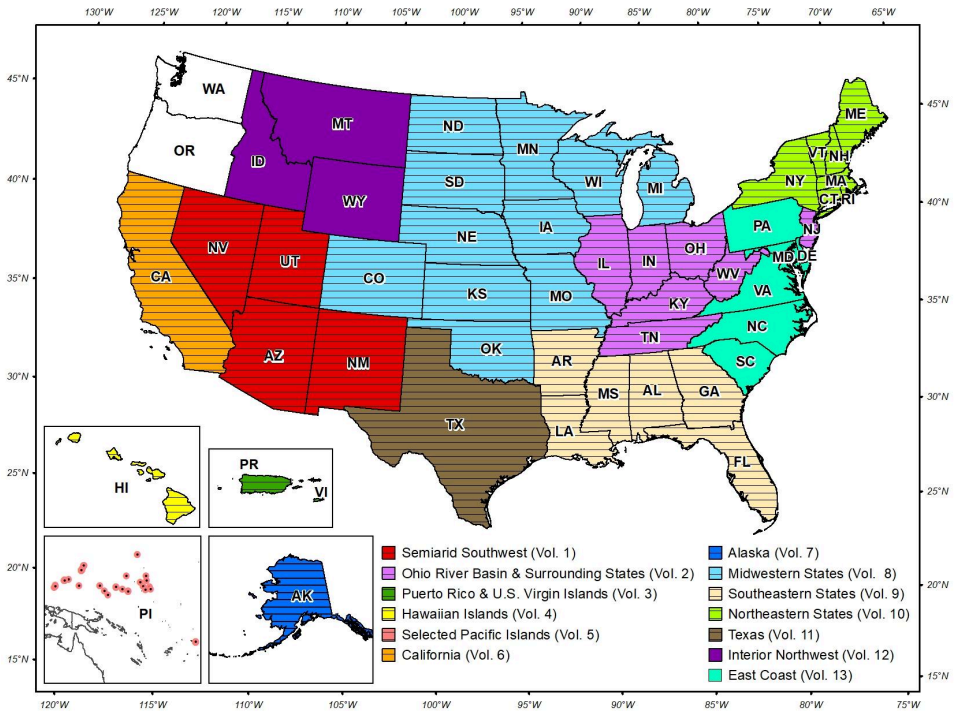

Figure 1. States or territories associated with each of the volumes of the Atlas.

II. CURRENT NOAA ATLAS 14 PROJECTS

1. VOLUME 13: EAST COAST STATES UPDATE

OWP commenced the work on the NOAA Atlas 14 Volume 13 on July 28, 2022. The precipitation frequency estimates for this volume include the states of Delaware, District of Columbia, Maryland, North Carolina, Pennsylvania, South Carolina, and Virginia and approximately a 1-degree buffer around these states (Figure 2). This project's expected completion date is the end of fiscal Q2 of 2026, subject to change based on the availability of funds and personnel to support the development.

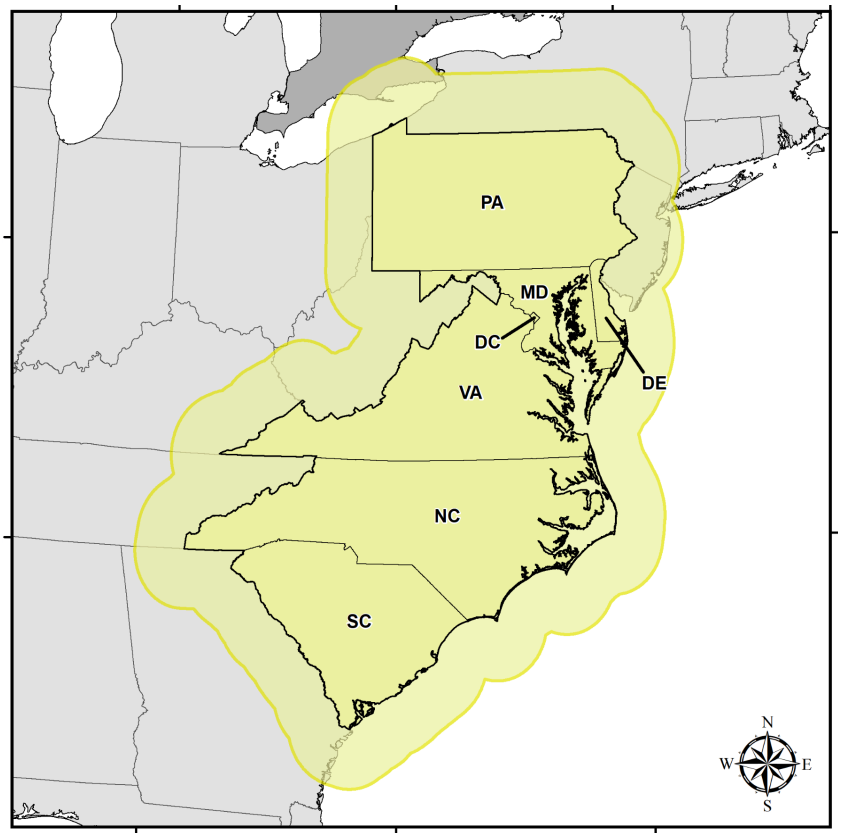

Figure 2. NOAA Atlas 14, Volume 13 extended project area (shown in yellow).

1.1. PROGRESS IN THIS REPORTING PERIOD (Apr - June 2025)

In the reporting period of Apr 1 to June 30, 2025, we completed reviewing of mean annual maximum grids for 1-hour, 6-hour, 24-hour and 10-day durations as well as precipitation frequency estimates for 2-year and 100-year return periods for the publication of the Peer Review.

1.1.1. 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.

All data were formatted to a common format (station type) at base durations: 1-minute (01M), 5-minute (05M), 15-minute (15M), 1-hour (HLY), or 1-day (DLY). Formatted datasets can be seen in Table 1. Base durations typically correspond to the original reporting periods; for stations recording at variable time steps, they were aggregated upward to the most appropriate duration. Where available, records were extended through December 2024. In areas with sparse gauge data coverage, we are currently investigating data from the U.S. Geological Survey (USGS) and various archives of the National Water Information System (NWIS). Figure 3 and figure 4 show the distribution of stations at 1-hour and 1-day respectively.

Table 1. Sources of datasets considered and formatted for the precipitation frequency analysis for NOAA Atlas 14 Volume 13, with original reporting periods.

Data provider	Dataset name	Abbr.	Base duration
National Centers for Environmental Information (NCEI)	Automated Surface Observing Systems	NCEI_ASOS_1MIN	01M
	Cooperative Observer Network	NCEI_COOP_15MIN	15M
	Cooperative Observer Network	NCEI_COOP_HOURLY	HLY
	DSI3240 Hourly Precipitation Data	NCEI_DSI3240	HLY
	DSI3260 15Minute Precipitation Data	NCEI_DSI3260	15M
	Global Historical Climatology Network daily	GHCNDAILY	DLY
	Local Climatological Data	NCEI_LCD	HLY
	U.S. Surface Climate Observing Reference Networks	NCEI_USCRN_HOURLY	HLY
	U.S. Surface Climate Observing Reference Networks	NCEI_USCRN_SUBHOURLY	05M
Hampton Roads Sanitation District		HRSD	15M
Midwestern Regional Climate Center	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	DLY
North Carolina State University	Historical Climate Data Network	NC_ECONET	01M
		NC_ECONET_HOURLY	HLY
NOAA National Estuarine Research Reserve System	System Wide Monitoring Program	SWMP	15M
Rutgers University	New Jersey Weather Network	NJWXNET_5MIN	05M
		NJWXNET_HOURLY	HLY
Tennessee Valley Authority		TVA	DLY
		TVA_HOURLY	HLY
State University of New York at Albany	New York State Mesonet	NYSM	05M
University of Delaware	Delaware Environmental Observing System	DEOS	05M

Data provider	Dataset name	Abbr.	Base duration
University of Georgia	Automated Environmental Monitoring Network	UG_AEMN	15M
University of Wisconsin	National Atmospheric Deposition Program	NTN	DLY
U.S. Department of Agriculture, Forest Service	Remote Automated Weather Stations	RAWS	HLY
U.S. Department of Agriculture, Natural Resources Conservation Service	Soil Climate Analysis Network	SCAN_DAILY	DLY
		SCAN_HOURLY	HLY
Various Archives	Data Collection Platform/Hydrometeorological Automated Data System	DCP_HADS	HLY

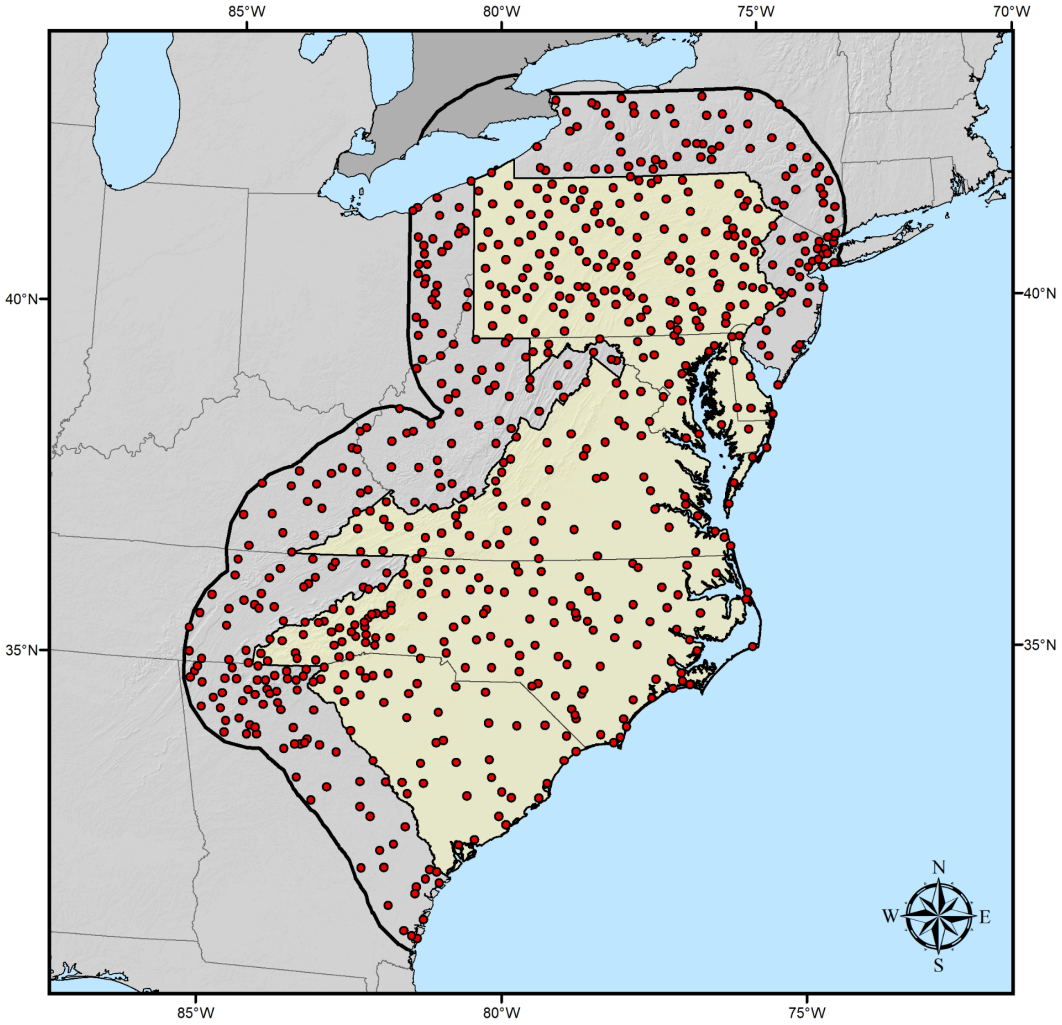

Figure 3. Merged stations at hourly durations with 20 or more years of record.

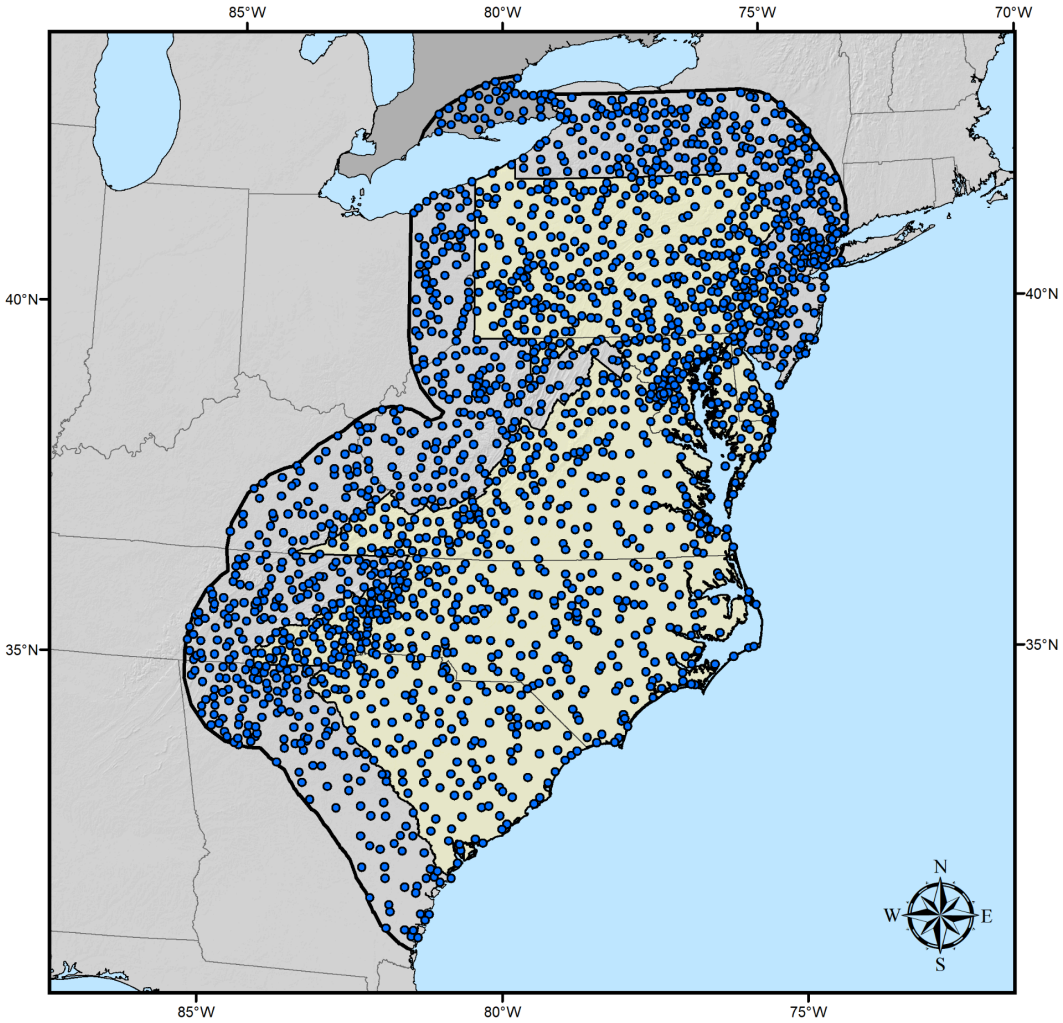

Figure 4. Merged stations at daily durations with 20 or more years of record.

1.1.2. Mean annual maxima (MAM) grids for base durations

The NOAA Atlas 14, Volume 13, mean annual maxima (MAM) grids closely follow the methodology used in previous NOAA Atlas 14 volumes (Trypaluk et al, 2024). In the past, MAM grids were developed in partnership with the Oregon State University PRISM group (Daly et al., 2002; Appendix A.3. PRISM Report of Trypaluk et al., 2024). For this study, MAM grids are developed in partnership with the NOAA Atlas 15 technical team members, who are listed in alphabetical order in the Acknowledgements of the Atlas 15 Pilot Technical Report (Perica at el., 2025). Similar to previous volumes, MAM grids at daily durations (24-hour and longer) were fitted using a relationship between the PRISM Mean Annual Precipitation and the corresponding duration for the MAM. For example, the 24-hour MAM grid was produced using the following relationship:

$$MAM24h = a + b * sqrt(MAP),$$

where “a” and “b” are fitted coefficients. This fit is performed at each gridpoint independently, and stations are weighted by distance from the gridpoint, difference in MAP from the gridpoint, obstacle height (e.g. mountain between a station and the gridpoint), and difference of the relative distance to coast between the stations and the gridpoint.

For sub-daily durations, the relationship is proportional to the 24-hour MAM grid produced. For example, for the 6-hour duration:

$$MAM6h = a * MAM24h$$

Similar to daily durations, this fit is performed independently at each gridpoint. Station weights for these durations, however, are distance from the gridpoint and difference in MAP.

In this reporting period, we have finalized the MAM grids for several durations using the modified PRISM-based in-house approach (60-minute, 6-hour, 24-hour, and 10-day). Figure 5 shows the spatial patterns using this method for 1-hour and 1-day duration.

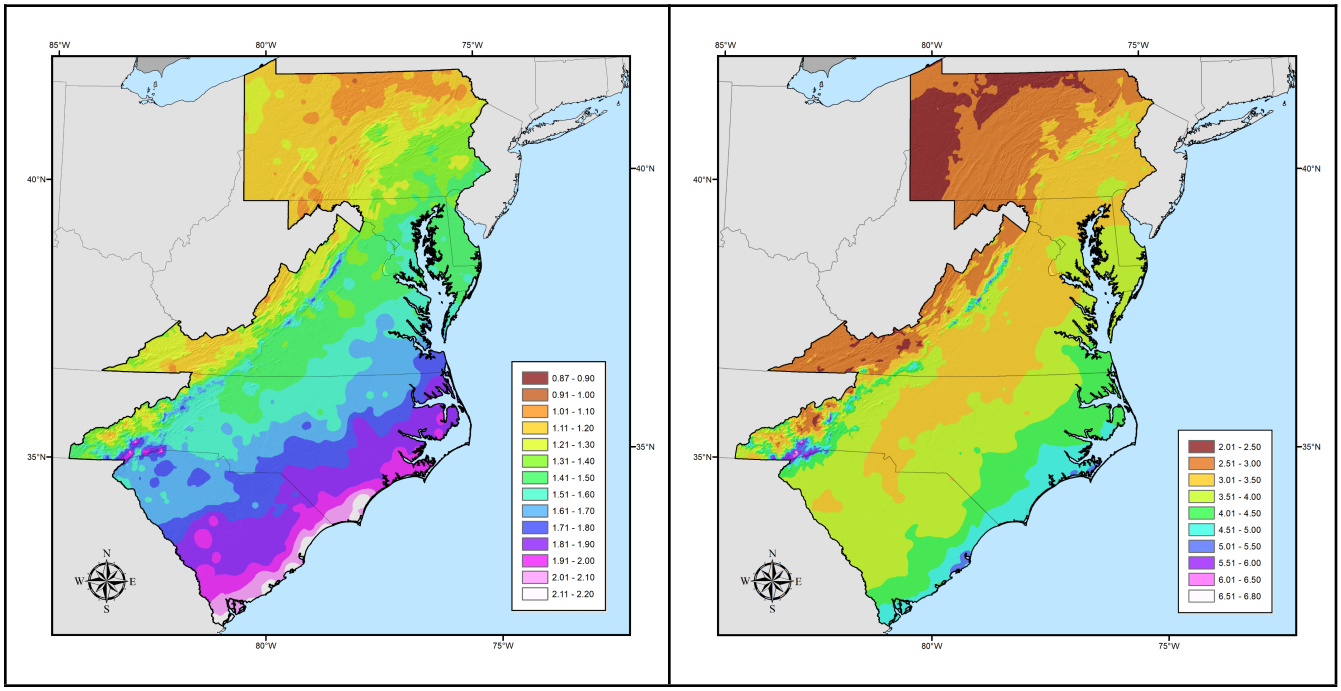

Figure 5. 1-hour (left image) and 1-day (right image) PRISM-based method mean annual maximum

In this next reporting period, we will use cross-validation methods to evaluate the results of our MAM analyses to optimize configurations and add pseudo stations where needed. We will expand the MAM analysis for additional durations including 4-day, 30-day and 60-day.

1.1.3. Development of precipitation frequency estimates

In NOAA Atlas 14, the MAM grids together with station regional precipitation frequency estimates are the basis for calculation of gridded precipitation frequency estimates and corresponding upper and lower bounds of the 90% confidence interval. For NOAA Atlas 14 Volume 13, precipitation frequency estimates are moving from L-moment statistics to a maximum likelihood approach (Wilks, 1938, Landwehr et al., 1979, Martins and Stedinger, 2000, Coles, 2001, Katz et al., 2002, El Adlouni et al., 2007, Agilan and Umamahesh, 2016, Agilan and Umamahesh, 2017)). This method is a stationary analogue to the methods described in Section 4.3 of the Atlas 15 Pilot Technical Report.

During this reporting period, estimates were generated and reviewed for 60-minute, 6-hour, 24-hour and 10-day base durations at 2-year and 100-year average recurrence intervals ARIs). Presently, we

are reviewing maps of the resulting estimates for the 2-year and 100-year ARIs. Inconsistent estimates or unreasonable patterns are resolved on a case-by-case basis in various ways: by manually adjusting the value to reflect expected patterns, omitting the station from the analysis, or by adding anchoring estimates at critical ungauged locations.

1.1.4. Development of a data and web page for the peer review

All NOAA Atlas 14 Volumes are subject to peer review which provides critical feedback on the reasonableness of DDF curves and spatial patterns in interpolated precipitation frequency estimates across durations and frequencies, and accuracy of station metadata. In August, we will send out an invitation for a review of Volume 13 preliminary estimates (Version 1) to potential reviewers suggested by funding agencies as well as subscribers to our list server. All information needed for the review will be provided via a web page that is currently being constructed specifically for that purpose. The reviewers will be asked to provide feedback on the reasonableness of point precipitation frequency estimates, their spatial patterns, and station metadata. This allows us to incorporate the reviewers' local knowledge of rainfall patterns and rain gauge networks into the final product. The peer review process will conclude on September 15, 2023. At that time, we will consolidate all comments, review and address them accordingly. We will publish all comments (anonymously) with our resulting action as Appendix 4 of Volume 13 document. The preliminary results published on the peer review pages should not be used in design since they are subject to change. The final estimates with supplementary information will be delivered via the Precipitation Frequency Data Server, and will be similar in format to previous volumes. We expect to publish the final estimates by the end of Q2 of 2026 as NOAA Atlas 14 Volume 13 Version 2.

1.1.5. Analysis of the Rainy Season

Work on development of final climate regions for the rainy season analysis is still ongoing.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (July - Sep 2025)

The peer review of NOAA Atlas 14 Volume 13 will be published. We will be adding new data from recently acquired stations from various data archives to data sparse areas in the Appalachian Mountains. MAM maps will undergo a review for all base durations from 60-minute through 60-day.

1.3. PROJECT SCHEDULE

- Data collection, formatting, and initial quality control [FY Q1 2025; 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)] [FY Q2 2025; In Progress]
- Regionalization and frequency analysis [FY Q2 2025; Completed]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [FY Q3 2025; In Progress]
- Peer review [FY Q4 2025; In Progress]
- Revision of PF estimates [FY Q4 2025]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [FY Q1 2026]
- Web publication [FY Q2 2026]

III. ATLAS 15: PRECIPITATION FREQUENCY STANDARD UPDATE

NOAA is developing and implementing NOAA Atlas 15, the future authoritative source and national standard for precipitation frequency information. When published, NOAA Atlas 15 will have nationwide coverage and account for temporal trends, and represents a shift from a stationary assumption (i.e. extreme precipitation patterns do not change over time) to a nonstationary assumption.

In order to collect feedback early in the development process on the structure of NOAA Atlas 15 and the accompanying web dissemination strategy, OWP released the NOAA Atlas 15 Pilot over the state of Montana on September 26, 2024. The data and web dissemination strategy will be revised before the final studies are published in 2026 and 2027 for CONUS and oCONUS, respectively. For more information on NOAA Atlas 15 development, please visit the NOAA Atlas 15 Informational Page or email us at atlas15.info@noaa.gov for any inquiries regarding NOAA Atlas 15.

The NOAA Atlas 15 Preliminary Estimates for CONUS are anticipated to be released in 2025 to initiate the peer review process. More information will be forthcoming and published on the NOAA Atlas 15 Informational Page.

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.

4.1.1 Middle Mississippi Valley Event

Catastrophic flooding occurred in the middle Mississippi Valley due to a strong slow-moving upper-level low pressure system which generated several rounds of thunderstorms over the first few days of April. A summary of the event can be found here from the NWS Central Region Headquarters.

We analyzed AEPs for this event for several durations and decided to create AEP maps for the 4-day period. 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 maps in Figures 4-6. Precipitation frequency estimates used in the analysis were from NOAA Atlas 14 Volumes 2, 8,and 9. The underlying observed data came from the NCEI's multi-sensor Stage IV QPE Product.

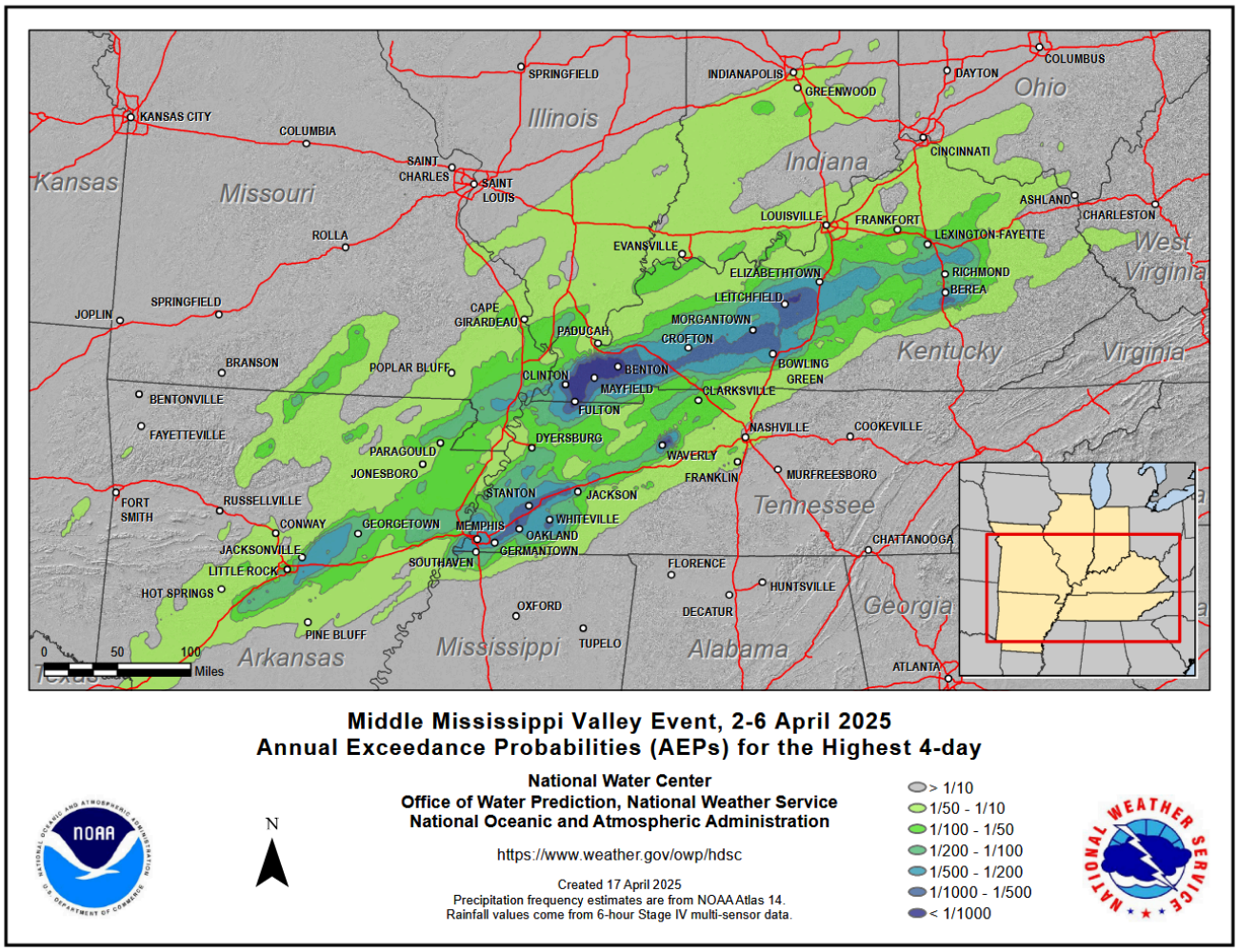

Figure 6. Annual exceedance probabilities for the worst case 4-day rainfall during the Middle Mississippi Valley event.

4.2 WORKSHOPS AND CONFERENCES

During this reporting period, Dr. Janel Hanrahan gave a presentation titled “NOAA Atlas 15 - Generating National Climate-Informed Precipitation Frequency Estimates,” at the ASCE World Environmental & Water Resources Congress - Symposium on Hydro-climate and Climate Change in Anchorage, AK on May 19, 2025.

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