Hydrometeorological Design Studies Center
Progress Report for Period
1 January to 31 March 2025

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

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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.

The 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.

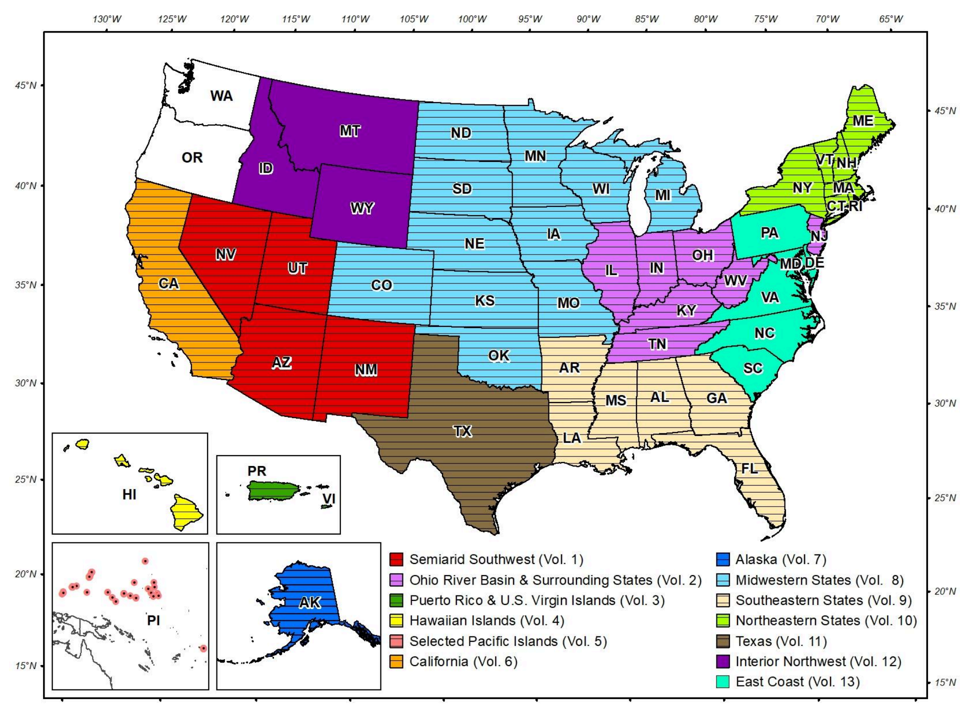

Figure 1. States or territories associated with each of the volumes of the Atlas.

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 March 31, 2026, subject to change based on the availability of funds and personnel to support the development.

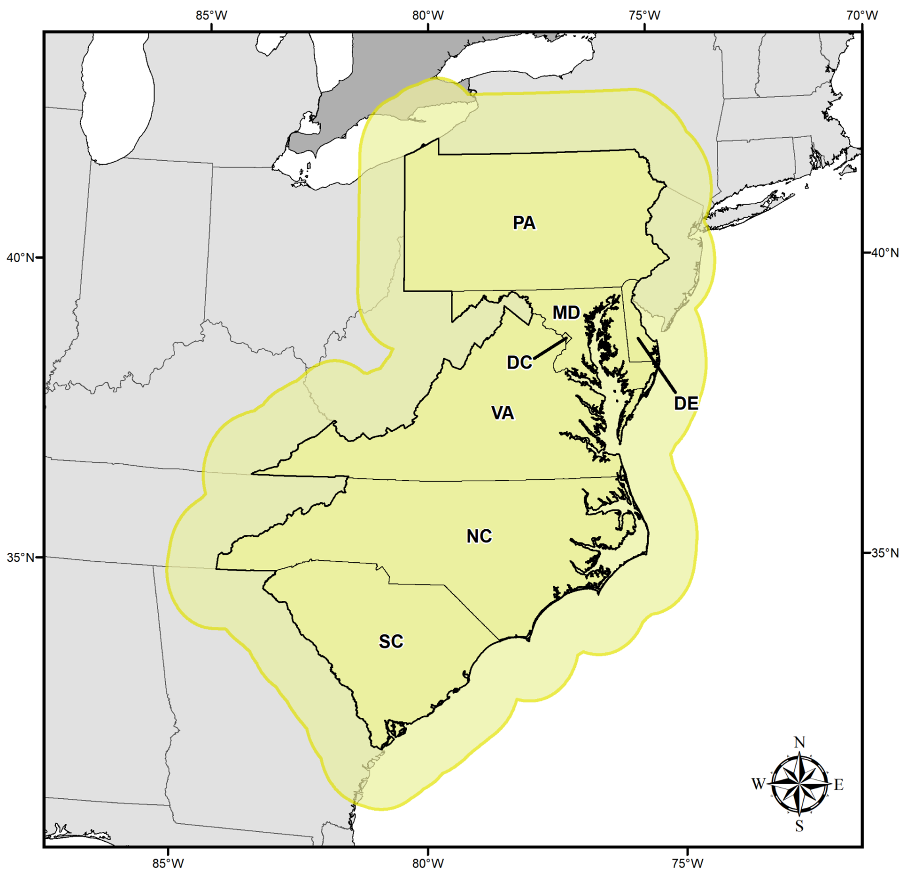

Figure 2. NOAA Atlas 14, Volume 13 extended project area (shown in yellow).

1.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2025)

In the reporting period of Jan 1 to March 31, 2025, we completed conversion factors and we continue to work on development and evaluation of the rainy season and mean annual maxima grids. In addition, we continue quality controlling the station metadata and high outlier checks.

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.

Table 1. 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	Duplicate
13	Hampton Roads Sanitation District		HRSD	Received
14	Midwestern Regional Climate Center (MRCC)	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	Formatted
16	National Oceanic and Atmospheric Administration (NOAA)	National Estuarine Research Reserve	NERRS	Formatted
17	National Atmospheric Deposition Program (NADP)	National Trends Network	NTN	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
20	U.S. Dept of Agriculture (USDA), Forest Service	Remote Automated Weather Station Network	RAWS	Formatted
21	U.S. Dept of Agriculture (USDA), Natural Resources Conservation Service (NRCS)	Soil Climate Analysis Network	SCAN	Formatted
22	U.S. Geological Survey (USGS) National Water Information System (NWIS)	Charlotte-Mecklenburg Hydrologic Network	CMHN	Investigating
23	University of Albany	New York State Mesonet	NYS	Formatted
24	University of Delaware, Center for Environmental Monitoring & Analysis	Delaware Environmental Observing System	DEOS	Formatted
25	University of Georgia	Georgia Weather Network	GWN	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, Mid-Atlantic River Forecast Center Integrated Flood Observing and Warning System (IFLOWS), Pennsylvania State University Environmental Monitoring Network, USDA ARS, USGS NWIS (CHMN is being investigated) WeatherSTEM, and Western Kentucky University Kentucky Mesonet.

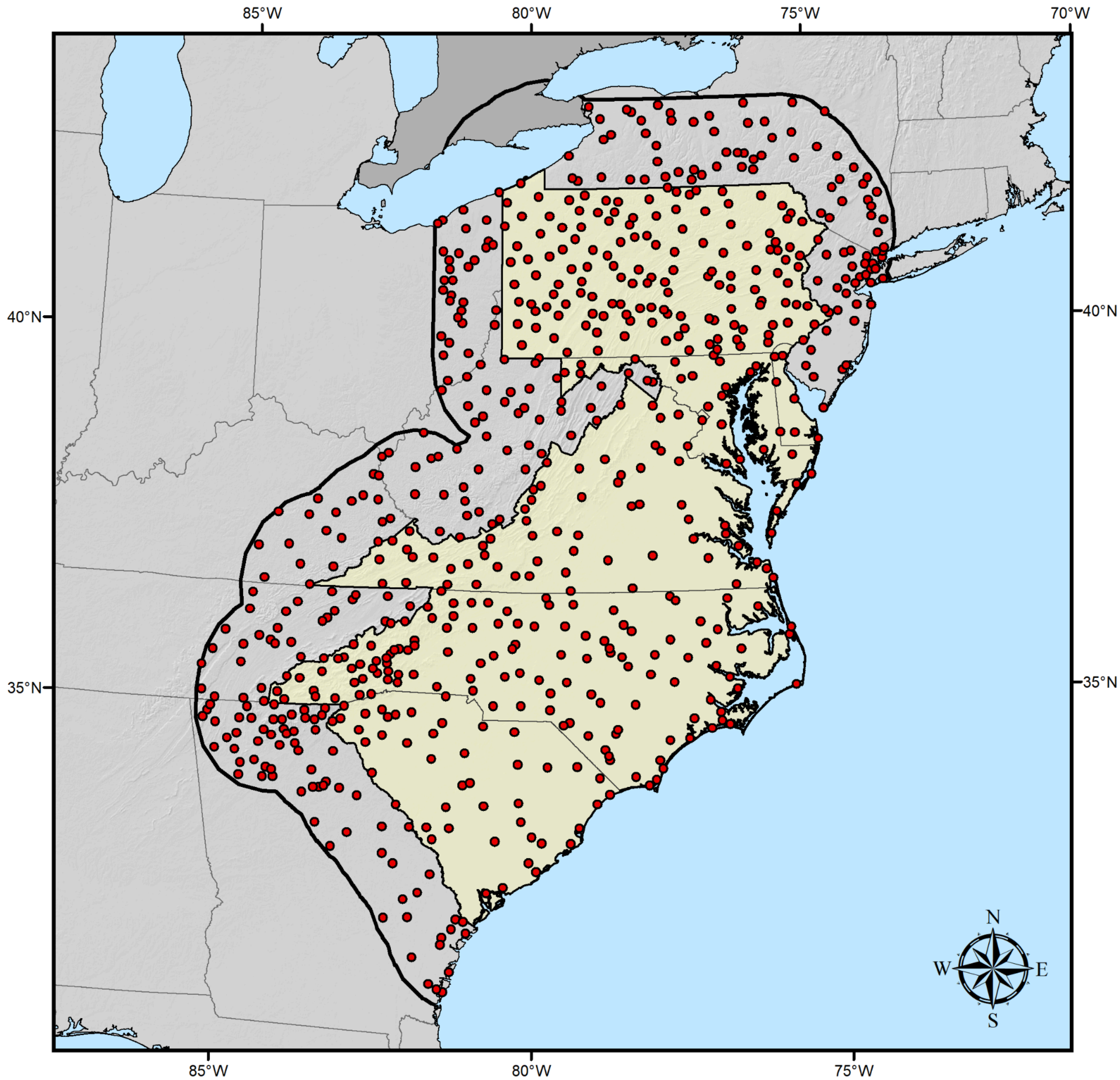

Figure 3. Merged stations at hourly durations with 20 or more years of record.

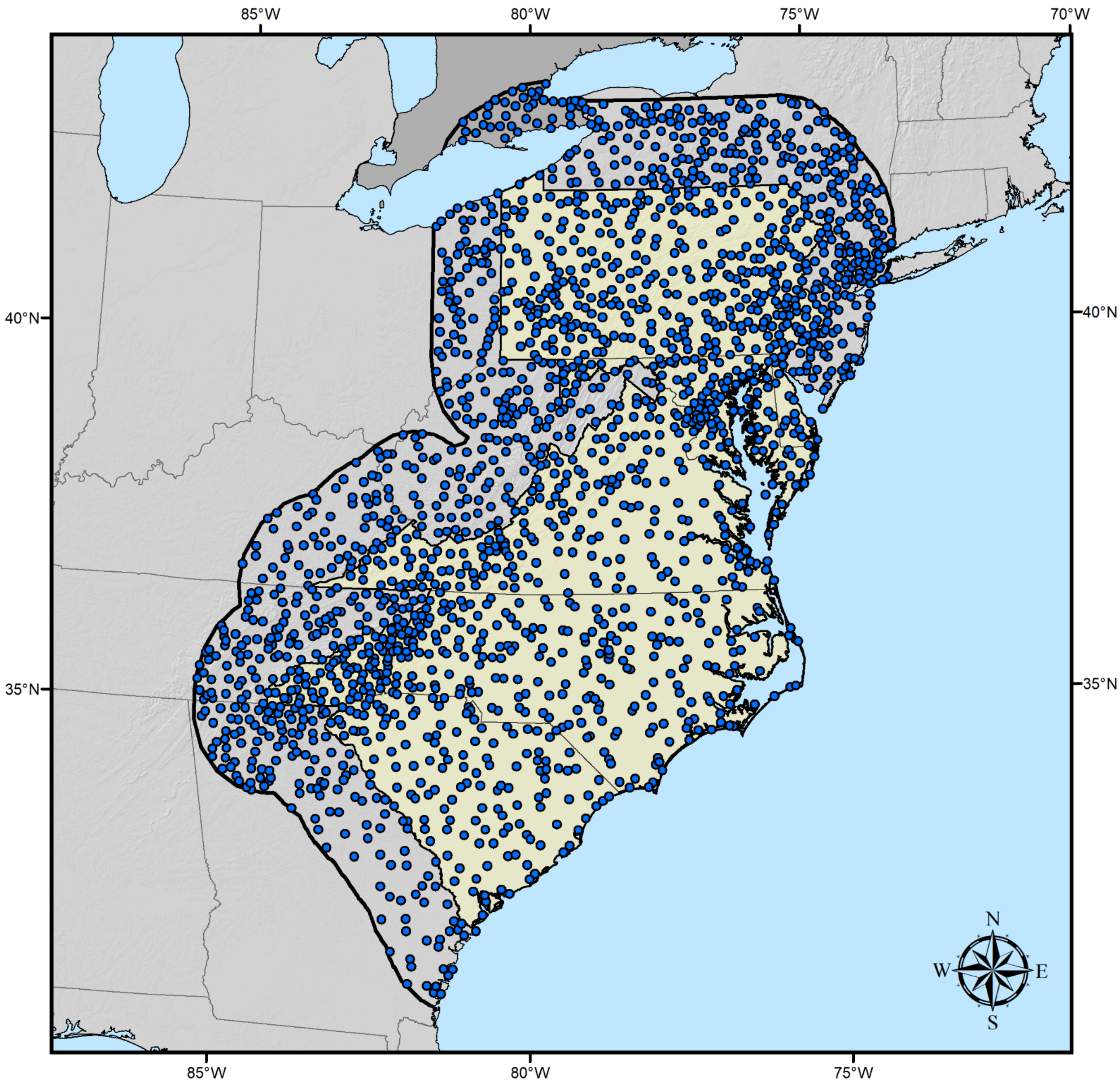

Figure 4. Merged stations at daily durations with 20 or more years of record.

1.1.2. Station metadata screening

In this reporting period, we continue to perform manual metadata inspection for datasets formatted (Table 1), and thus far completed the 95% of the metadata checks for all networks. See previous report on methodology here: [January - March, 2024 QPR Report].

1.1.3. Station cleanup

In this reporting period, we continue to perform station cleanup. See previous report on methodology here: [January - March, 2024 QPR Report].

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

In this reporting period, we evaluated two in-house approaches (Spatial regression and modified PRISM-based method) to develop mean annual maximum (MAM) precipitation grids. These two methods were assessed over the past couple of months using the same evaluation criteria, and their performance was similar. In support of and alignment with the Atlas 15 methodology, we will move forward with the PRISM-based method for this project area.

- Spatial regression method — This step-wise multiple regression model utilizes spatial covariates such as elevation, slope, aspect, latitude, longitude, distance to coast, height above local terrain, and nearby surface water proportion, a.k.a. "lake effect index," and MAM derived from NCAR's CONUS404. This method has been described in more detail in previous quarterly progress reports, such as the January—March 2024 QPR Report.
- Modified PRISM-based method — This method utilizes regional regression through a moving window approach with an adaptable radius, where regional stations are weighted based on geographical and meteorological covariates, including the mean annual precipitation (MAP).

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

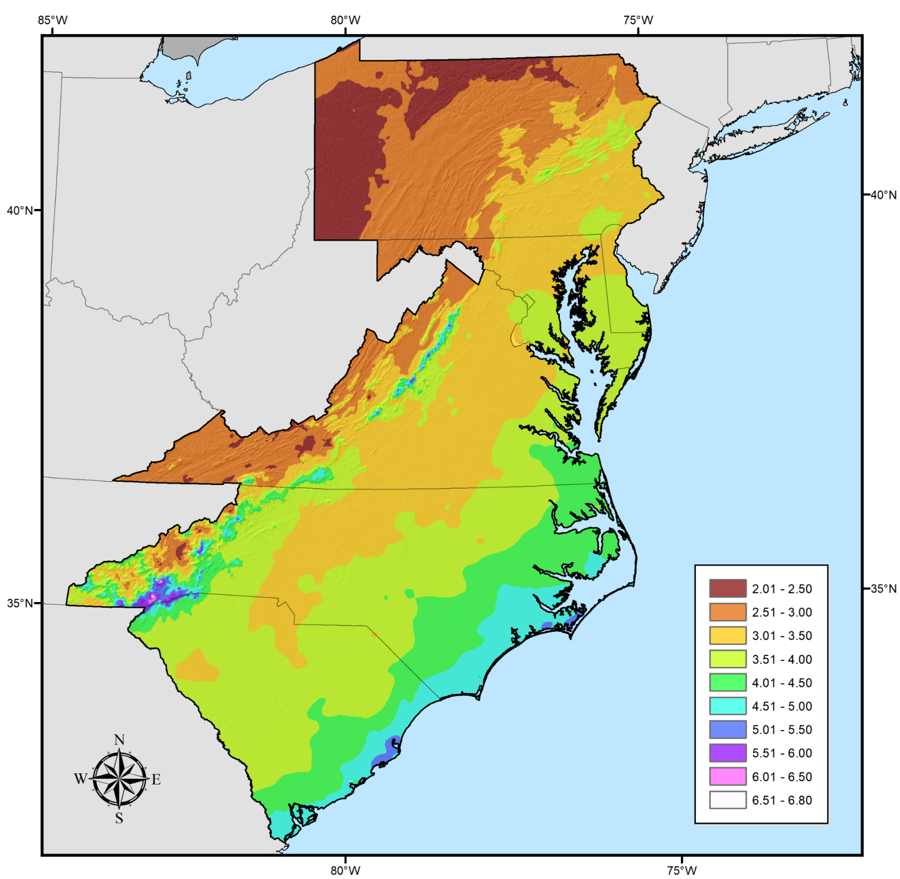

Figure 5. 1-day PRISM-based method mean annual maximum

1.1.5 Analysis of the Rainy Season

During this reporting period, the rainy season Python code was rerun on NCEI merged data with stations with at least 20 years. Stations are spatially analyzed by rainy season beginning month, end month, duration, and a combination of begin and end month for 1-hour and 1-day AMS. Since the rainy season calculation is based on when ⅔ of the AMS are occurring, durations of 8 months or higher indicate an all-year rainy season. Preliminary results show a distinction between the northern and southern Appalachian regions and also the coastal plain. This can be seen in the begin month (Figure 6), end month (Figure 7) and the duration (Figure 8) for daily stations. Hourly rainy season results show much less regional variability and mostly occur during the late spring to early fall.

During the next reporting period, final climate regions will be delineated based on spatial variations in the rainy season across the project area.

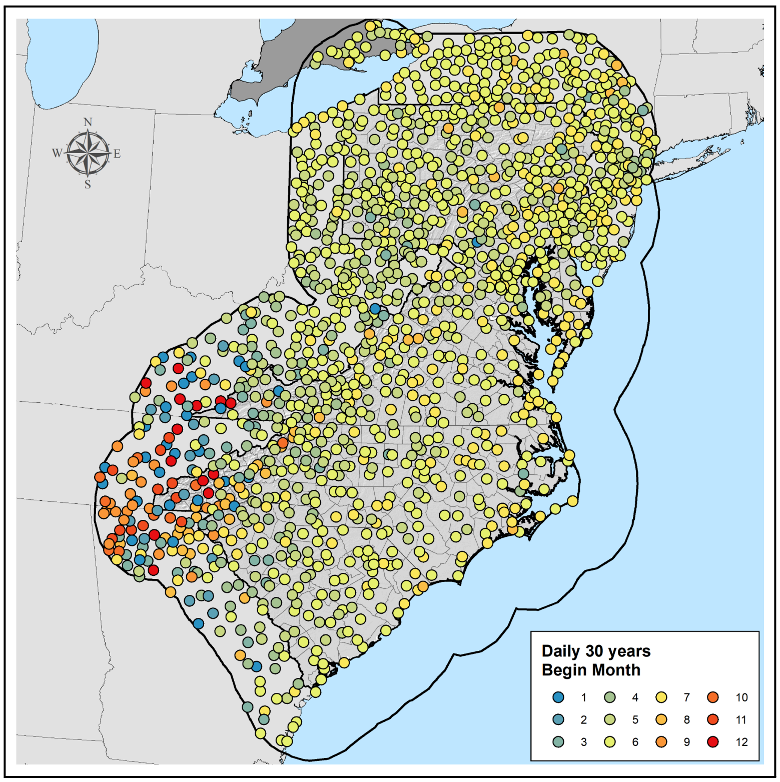

Figure 6. Begin month of the rainy season for daily stations with 30 years or more of data.

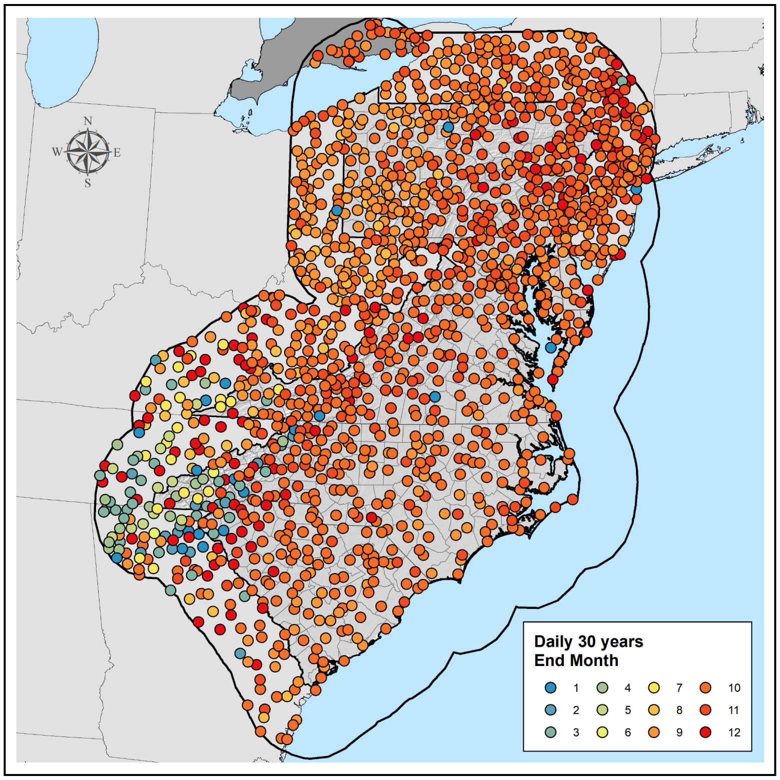

Figure 7. End month of the rainy season for daily stations with 30 years or more of data.

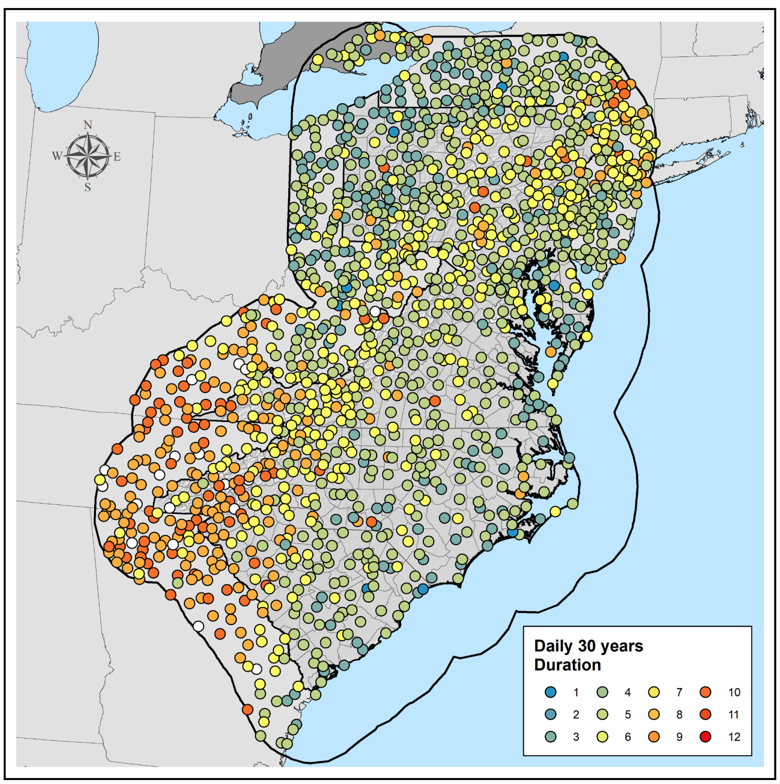

Figure 8. Duration of the rainy season for daily stations with 30 years or more of data.

1.1.6 Extraction and quality control of annual maximum series outliers

During the previous reporting period, data was appended for many datasets (e.g. all NCEI-related datasets, RAWS, etc) through the end of 2024. During this reporting period, quality control was completed on this appended data and 1300 erroneous values and/or data periods were corrected.

1.1.7 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. This method is a stationary analogue to the methods described in Section 4.3 of the Atlas 15 Pilot Technical Report. The stationary GEV probability distribution function applied to Atlas 14 is defined as:

$$f(x) \; = \; \frac{1}{\sigma(x)}\left\{1 \; - \; \xi(x)\frac{x-\mu(x)}{\sigma(x)}\right\}^{\left(\frac{1}{\xi(x)}-1\right)} \exp\left(- \; 1\left\{\xi(x)\frac{x-\mu(x)}{\sigma(x)}\right\}^{\frac{1}{\xi(x)}}\right)$$

where μ, σ, and ξ are location, scale, and shape parameters, respectively, and x is a spatial coordinate. For each region, the parameters are defined as:

Location: $\mu(x) \; = \; a_1 \times MAM(x)$

Scale: $\sigma(x) \; = \; b_1 \times MAM(x)$

Shape: $\xi(x) \; = \; c_0$

The location and scale parameters vary with a spatial covariate (MAM). Because of sensitivity to outliers, the shape coefficient is held constant to avoid generation of unreasonable values. Additionally, a lower bound is enforced on the scale parameter to ensure a non-negative result. The resulting parameters define a unique GEV distribution at each station's region.

1.1.8 Conversion factors

Daily durations. The majority of AMS data used in this project came from daily stations at which readings were taken once per day (usually around 8am local time, but this can vary over the course of a station's record and from station to station). Due to the fixed beginning and ending of observation times at daily stations, the true 24-hour (unconstrained) annual maximum could be up to 100 percent larger than the corresponding 1-day (constrained) value extracted from the daily records. Correction factors were applied to each annual maximum to account for the likely failure of capturing the true unconstrained values. In previous Atlas 14 volumes, the correction factor for each daily duration was estimated by using the same pool of sub-daily data to calculate unconstrained (e.g. 24-hour) and constrained (e.g. 1-day 8am-8am) annual maximum independently. This leads to one ratio per duration to be used for all stations in the entire region.

For Volume 13, this has been updated to a rolling-region method, where conversion factors are estimated on a gridpoint-by-gridpoint basis. This allows for slowly-varying changes in the conversion factors over large areas (Figure 9).

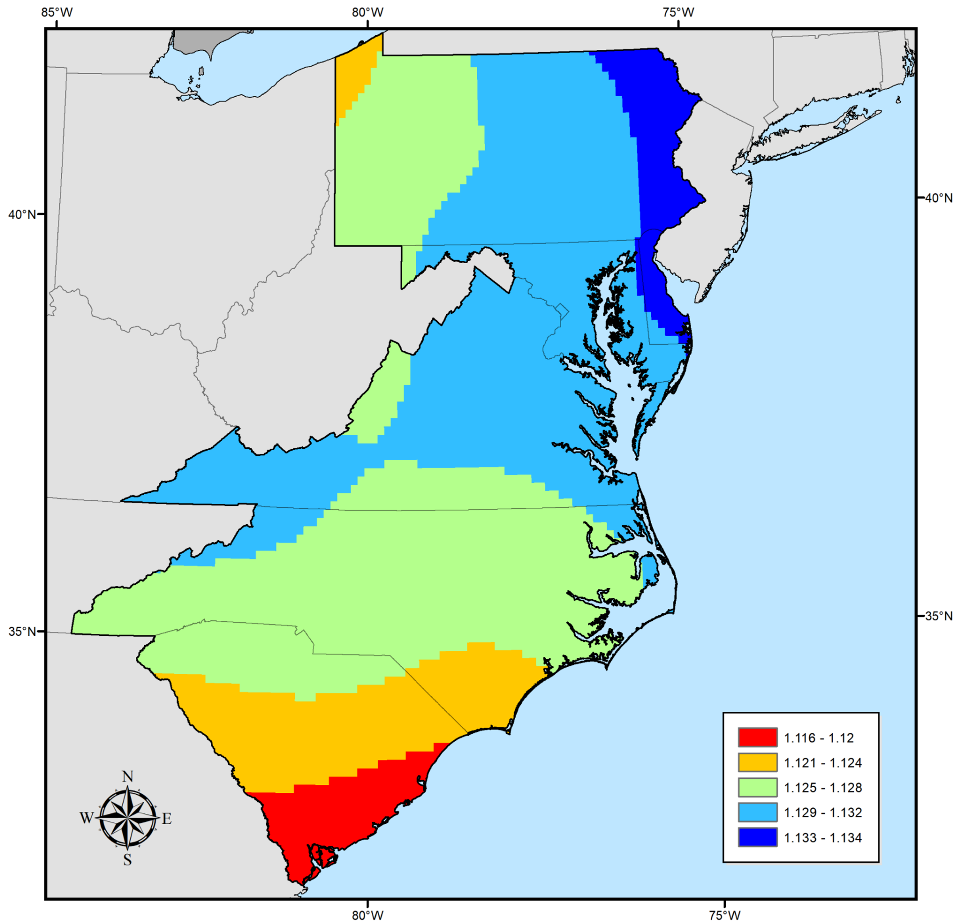

Figure 9. Preliminary conversion factors to convert from constrained to unconstrained 24-hour annual maxima. The average factor is 1.127, and the region varies from 1.116 to 1.134.

Hourly durations. While significant underestimations due to constrained observations are commonly seen for daily stations, ‘clock-hour’ observations also affect hourly measurements at stations recording at 1-hour intervals. Hourly conversion factor grids were produced using a similar method as the daily method, except with using a sub-hourly pool of data to calculate unconstrained (e.g. 60-minute from 1-minute data) to constrained (1-hour data from clock-hour aggregated 1-minute data) ratios (Figure 10).

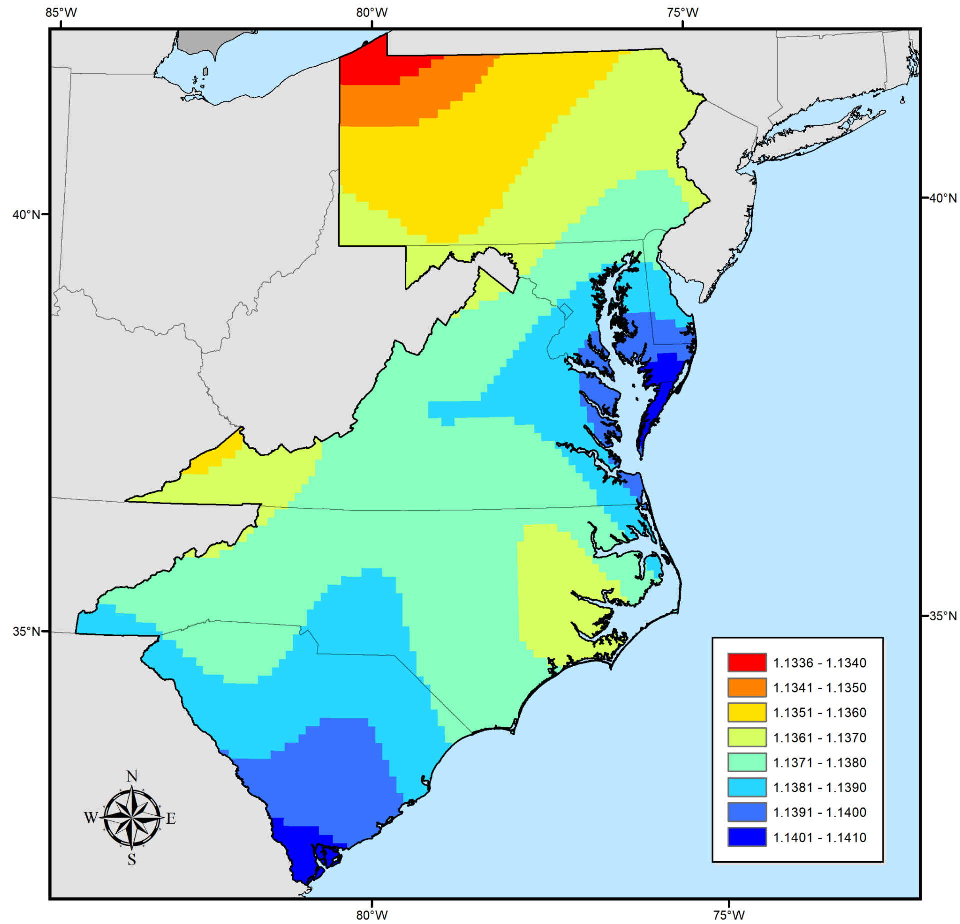

Figure 10. Preliminary conversion factors to convert from constrained to unconstrained 60-minute annual maxima. The average factor is 1.137, and the region varies from 1.134 to 1.141.

1.1.9 Regionalization

In this reporting period, we continue to work on regionalization attribute bounds for the weights, derived in the Section 2.1.8 Regionalization of the [October - December, 2024 QPR Report](#).

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2025)

We will finish data collection, reformatting, and quality control on data received for 2024, which includes data from Helene. In parallel, we will finish developing MAM grids for base durations for the development of the preliminary estimates over this domain. We will review 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.

1.3. 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; In Progress]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [FY Q3 2025; In Progress]
- Peer review [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 [Revised: FY Q2 2026]

III. ATLAS 15: PRECIPITATION FREQUENCY STANDARD UPDATE

With funding support from the Bipartisan Infrastructure Law (BIL), 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 the Atlas 15 Pilot data and web dissemination strategy, OWP released the NOAA Atlas 15 Pilot data 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 the CONUS and oCONUS, respectively. 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.

In this reporting period, we started compiling and addressing the feedback received, and translating that feedback into the development of both data and web functionalities.

In parallel, during this reporting period, the Atlas 15 technical contract team initiated expansion of the Pilot framework over CONUS, and continues to collect, format and quality control observed extreme time series data and develop and evaluate historical and projected precipitation frequency estimates. Under the grant support, our grantees continue to support the research activities associated with the precipitation frequency analysis. The next Atlas 15 development milestone will be the publication of the CONUS preliminary estimates in 2025.

For technical questions, please contact atlas15.info@noaa.gov. For all other inquiries, including those related to schedule and the availability of funding for NOAA Atlas 15, please contact NWS Public Affairs at nws.pa@noaa.gov.

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. WORKSHOPS AND CONFERENCES

During this reporting period, we completed significant outreach with stakeholders to share the outcomes of the NOAA Atlas 15 Pilot Project over the state of Montana and encouraged feedback, in partnership with the NOAA NCEI stakeholder engagement team. As part of the engagement effort, Janel Hanrahan and Dale Unruh gave a virtual webinar on the science and web services associated with the NOAA Atlas 15 Pilot release.

In addition, Austin Jordan, Greg Fall, Debbie Martin, Ken Kunkel and Sandra Pavlovic gave five presentations at the 105th American Meteorological Society Annual Meeting on January 15, 2025 in New Orleans, Louisiana. Janel Hanrahan and Lynne Trabachino presented Atlas 15 development virtually to the American Institute of Hydrology webinar series on January 23, 2025.