Hydrometeorological Design Studies Center
Progress Report for Period
1 January to 31 March 2023

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.

TABLE OF CONTENTS

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 supporting planning for 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.

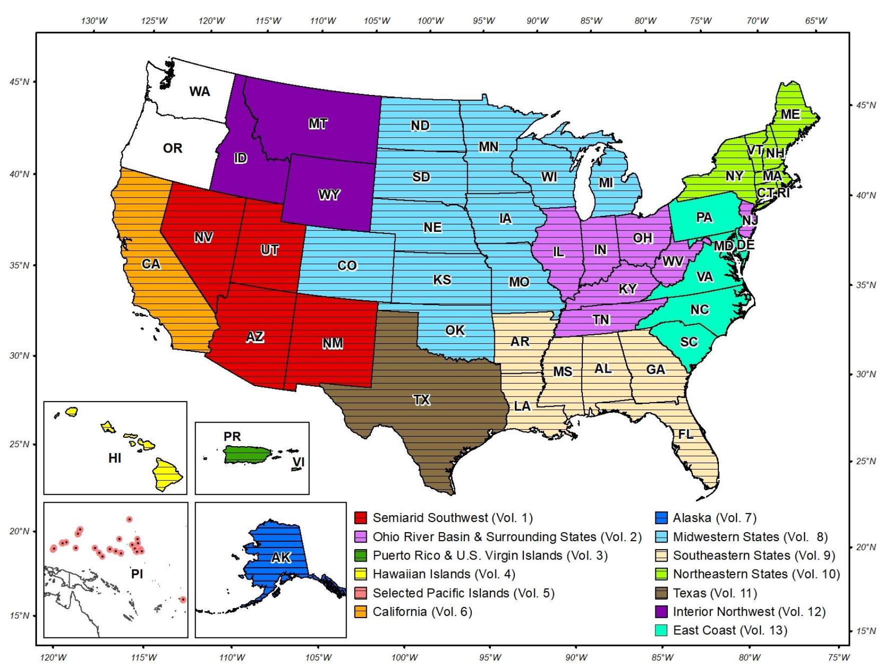

Figure 1. States or territories associated with each of the volumes of the Atlas.

II. CURRENT NOAA ATLAS 14 PROJECTS

1. VOLUME 12: INTERIOR NORTHWEST

On May 26, 2021, the HDSC commenced work on a NOAA Atlas 14 Volume 12. The precipitation frequency estimates for this volume include the states of Idaho, Montana, and Wyoming, with an approximately 1-degree buffer around these states (Figure 2). The expected project's completion date has been revised to Q2 of 2024, due to delays with availability of personnel to support the development of two volumes. In this reporting period, OWP explored contractor support as well as the new NOAA/NWS Cooperative Institute for Research to Operations in Hydrology (CIROH) for additional personnel to support the development of two Atlas volumes in parallel.

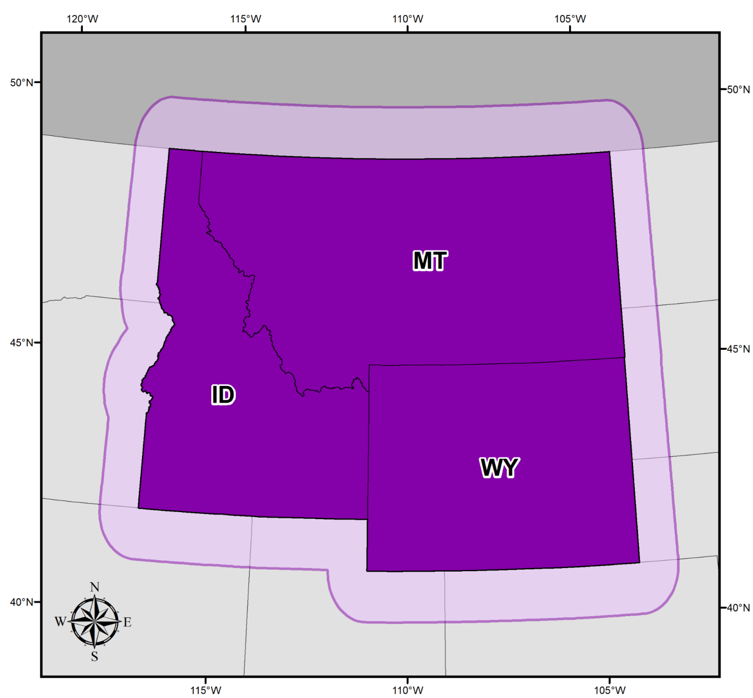

Figure 2. NOAA Atlas 14, Volume 12 extended project area (shown in purple).

In the reporting period of January 1 to March 31, 2023, we conducted quality control checks for hourly stations with a focus on base duration, analyzed conversion factors and the rainy season, and revised the initial version of the mean annual maximum. The following sections provide a more detailed account of the significant tasks accomplished during this reporting period.

1.1 PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2023)

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. AMS quality control

The precipitation frequency analysis approach we used in this project is based on AMS analysis across a range of durations. AMS for each station whose data were formatted were obtained by extracting the highest precipitation amount for a particular duration in each successive calendar year.

The AMS data at both high and low extremities can considerably affect precipitation frequency estimates, they have to be carefully investigated and either corrected or removed from the AMS if due to measurement errors. We use different statistical tests to identify high and low outliers in the distribution of at-station precipitation AMS. All identified outliers and other questionable maxima at base durations (1-hour and 1-day) are now being verified. First, they are mapped with concurrent measurements at nearby stations. If the values cannot be confirmed from similar measurements at nearby stations, they are investigated further using information from monthly climatological data publications, cooperative observation forms, and monthly storm data reports obtained primarily from the NCEI's Image and Publication System (IPS). Additional resources, such as historical storm reports and surface weather observations, are accessed through NCEI's Environmental Document Access and Display System, Version 2 (EV2). Gridded precipitation products and other NEXRAD radar products are also used in some cases to verify and help disprove events for areas with good radar coverage.

In this reporting period, we completed work on the hourly AMS quality control task for 1-h, 2-h, 3-h, 6-h and 12-h. All corrections were implemented. Overall, 1,334 outliers were looked into resulting in 1,572 total corrections. We also began work on the 15-minute AMS quality control task, which will be completed early next quarter.

1.1.2. Spatial analysis of mean annual maximum (MAM) data

We received the first iteration of mean annual maxima (MAMs) for all durations between 15-minute and 60-day from the PRISM Group at Oregon State University for high-resolution spatial interpolation using their hybrid statistical-geographical approach for mapping climate data. The mean annual maxima (MAMs) grids are created by the PRISM Group at Oregon State University by spatially interpolating at-station estimates for the base duration, 1-hour, 12-hour, 24-hour, and 10-days. In this reporting period, we started carefully reviewing for inconsistencies resulting from stations that may have had less reliable sampling (shorter record, missed winter events or missed several heavy events) relative to nearby stations or any inconsistent areas unduly influenced by the interpolation process or a lack of stations. The development of final gridded MAM estimates will require several iterations with the PRISM group. We completed 1 round of review of the largest 24-hour duration discrepancies.

1.1.3. Delineation of Climate Regions

The criteria for AMS extraction are designed to exclude maxima if there are too many missing or accumulated data during the year and during critical months when precipitation maxima are most likely to occur (wet season) in their assigned climate region. Two climate regions, as shown in Figure 5, were delineated through a spatial assessment of the periods in which two-thirds of annual maxima occurred at each station and by inspecting histograms of annual maxima for the 1-day and 1-hour durations in corresponding climate regions. In addition to the AMS extraction task, these climate regions will be used in the analysis of trends in AMS, analysis of temporal distributions, and in portraying the seasonality of annual maxima.

For this project area, two climate regions were delineated, as shown in Figure 3. The western region incorporates the higher elevations of the Northern U.S. Rocky Mountains where many of the daily stations have AMS occurring during the winter months. The eastern region encompasses the Northern Great Plains where a majority of stations have daily AMS occurring during the warm season. A majority of the hourly AMS in both regions occurs during the warm season. Due to many of the daily stations in the project area having wintertime AMS, it was decided that a water year would be used when extracting AMS instead of a calendar year.

Figure 3. Climate regions delineated during the rainy season analysis.

1.1.4. Correction Factor Analysis

In this reporting period we completed work on developing factors to convert constrained observations (e.g., 1-day) to unconstrained values (e.g., 24-hour). Quality-controlled, constrained and unconstrained annual maxima from hourly stations were used to create correction factors for daily durations, while collocated hourly (constrained) and 1-minute/5-minute/15-minute (unconstrained) concurrent annual maxima were used to develop correction factors for hourly durations. When analyzing the spatial variability of the averages at each station, we saw no distinct regions. ASOS 1-minute data was also used to develop correction factors for constrained 15-minute durations.

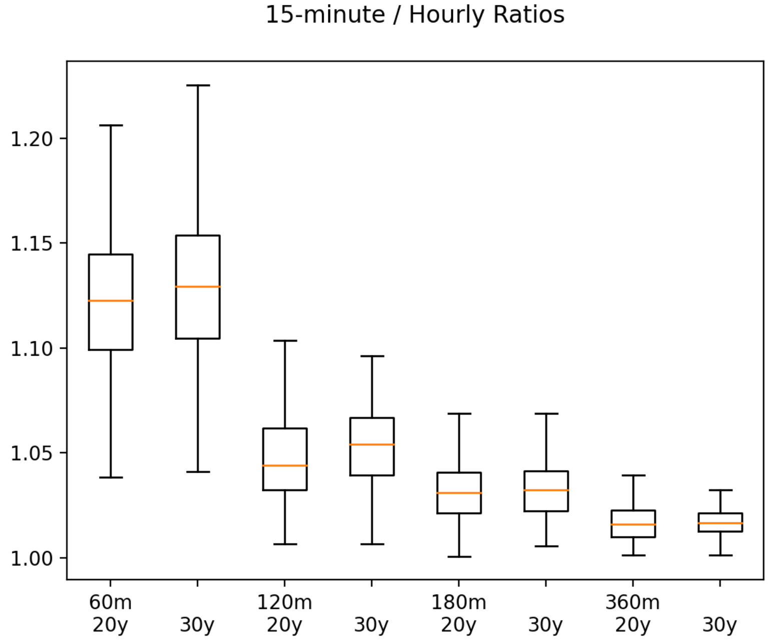

Figure 4. Box plots showing distribution of conversion factors for stations with 20-years and 30-years of data for 1-hour through 6-hour durations.

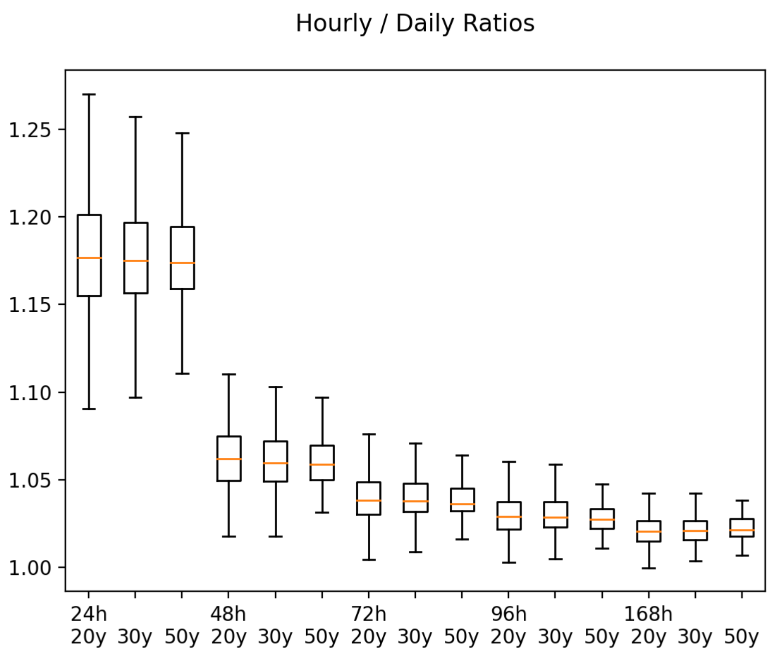

Figure 5. Box plots showing distribution of conversion factors for stations with 20-years and 30-years of data for 1-day through 7-day durations.

Table 1. Final conversion factors applied to constrained durations.

15-min	1.14		1-hr	1.13		1-day	1.17
30-min	1.04		2-hr	1.05		2-day	1.06
45-min	1.02		3-hr	1.03		3-day	1.04
60-min	1.01		6-hr	1.02		4-day	1.03
			12-hr	1.01		7-day	1.02

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2023)

A large portion of the work in the next reporting period will plan on finalizing quality control of AMS data for other durations (24-hr/48-hr, 2-day through 60-days), completing the review of the mean annual maximum grids at base durations and regionalization.

The project milestone schedule has been revised to align with the availability of funds and personnel (current and projected).

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)] [In progress; revised to Q2 2023]
- Regionalization and frequency analysis [Revised to Q2 2023]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [Revised to Q3 2023]
- Peer review [Revised to Q4 2023]
- Revision of PF estimates [Revised to Q2 2024]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [Revised to Q2 2024]
- Web publication [Q2 2024]

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 5). 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 volumes. In this reporting period, OWP explored contractor support as well as the new NOAA/NWS Cooperative Institute for Research to Operations in Hydrology (CIROH) for additional personnel to support the development of two Atlas volumes in parallel.

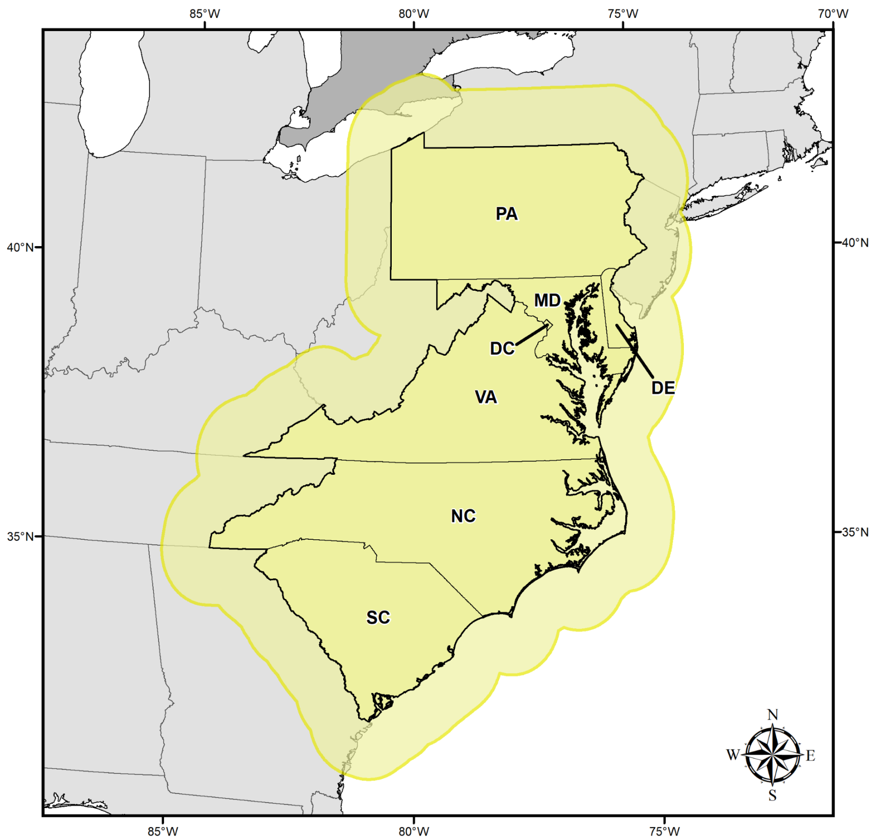

Figure 6. NOAA Atlas 14, Volume 13 extended project area (shown in yellow).

For this project area, we are interested in collecting all available precipitation datasets (daily, hourly, 5-minute, etc.) for stations in Delaware, Maryland, North Carolina, Pennsylvania, South Carolina, Virginia, and Washington D.C. as well as in adjacent portions of neighboring states (Georgia, Kentucky, New York, New Jersey, Ohio, Tennessee, West Virginia) and also in Canada. We welcome any information on the data for this project area. If you have any relevant information, please contact us at hdsc.questions@noaa.gov.

2.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2023)

2.1.1. Data collection and data screening

During the Oct, 1 to Dec, 30 2022 reporting period, we worked on searching and compiling a list of the precipitation networks that will be considered for the development of the Atlas 14 Volume 13 estimates, and formatting the NCEI datasets for this project area. 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.

As mentioned above, for this project area, we are interested in collecting all available precipitation datasets (daily, hourly, 5-minute, etc.) for stations in Delaware, Maryland, North Carolina, Pennsylvania, South Carolina, Virginia, and Washington D.C. as well as in adjacent portions of neighboring states (Georgia, Kentucky, New York, New Jersey, Ohio, Tennessee, West Virginia) and also in Canada. We welcome any information on the data for this project area. If you have any relevant information, please contact us at hdsc.questions@noaa.gov.

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	Received
2		DSI 3240, DSI 3260	DSI 3240, DSI 3260	Received
3		Global Historical Climatology Network	GHCN-DAILY	Formatted
4		Environment Canada	GHCN-DAILY	Formatted
5		Integrated Surface Data (Lite)	ISD_LITE	Received
6		Local Climatological Data	LCD	Received
7		Hourly Precipitation Data (HPD) v1.0 Beta and v2.0 Beta	HPDv1, HPDv2	Formatted
8		United States CoCORAHS	GHCN-DAILY	Formatted
9		Canada CoCORAHS	GHCN-DAILY	Formatted

FID	Data Provider	Dataset name	Abbr.	Status
11		Weather Bureau Army Navy (WBAN)	GHCN-DAILY	Formatted
12		U.S. Climate Reference Network	USCRN	Formatted
13	Midwestern Regional Climate Center (MRCC)	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	Received
14	National Weather Service (NWS) Mid-Atlantic River Forecast Center (MARFC)	Integrated Flood Observing and Warning System	IFLOWS	Contacted
15	National Oceanic and Atmospheric Administration (NOAA)	National Estuarine Research Reserve	NERRS	Received
16	National Atmospheric Deposition Program (NADP)	National Trends Network	NADP	Formatted
17	North Carolina State University, State Climate Office (NCSU)	North Carolina Environment & Climate Observing Network	ECONet	Partially Received
18	Pennsylvania State University (PSU)	Pennsylvania Environmental Monitoring Network	PEMN	Contacted
19	Tennessee Valley Authority (TVA)	Rainfall Gauge Data	TVA	Contacted
20	U.S. Department of Agriculture (USDA)	Agriculture Research Service	ARS	Received
21	U.S. Dept of Agriculture (USDA), Forest Service	Remote Automated Weather Station Network	RAWS	Received
22	U.S. Dept of Agriculture (USDA), Natural Resources Conservation Service (NRCS)	Soil Climate Analysis Network	SCAN	Received
23	University of Albany	New York State Mesonet	NYS	Received
24	University of Delaware, Center for Environmental Monitoring & Analysis	Delaware Environmental Observing System	DEOS	Received
25	University of Georgia	Georgia Weather Network	GWN	Received
26	Western Kentucky University	Kentucky Mesonet	KYM	Contacted
27	U.S. Geological Survey (USGS)	National Water Information System	NWIS	Investigating

In addition, we will consider other networks, including Aberdeen Proving Ground Network, Automatic Position Reporting System WX NET/Citizen Weather Observer Program, Synoptic Weather, Maryland Department of Transportation Road Weather Network, and WeatherSTEM.

2.1.2. Station Metadata screening

Software has been developed using Python to modernize and automate our quality control system of station metadata. DEM was extracted for all stations and then compared to the provided elevation to determine if the station was in the correct location. Stations with large differences between their elevation and the extracted DEM were analyzed with a circle test using a 400-m diameter radius to match the station location to the elevation provided. This is especially useful for stations missing seconds in their precision which can have an error of over a mile in their location. 165 stations that could not be automatically adjusted, based on the currently formatted dataset, were marked for manual checking.

2.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2023)

We will continue with data collection, reformatting, and station metadata checks for NCEI stations. All collected data will be examined and formatted into a common format, where appropriate.

2.3. PROJECT SCHEDULE

- Data collection, formatting, and initial quality control [Q2 2023; 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)] [Q2 2024]
- Regionalization and frequency analysis [Q3 2024]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [Q3 2024]
- Peer review [Q4 2024]
- Revision of PF estimates [Q3 2025]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [Q4 2025]
- Web publication [Q4 2025]

III. PROPOSED PRECIPITATION FREQUENCY STANDARD UPDATE

With support from the Bipartisan Infrastructure Law (BIL), OWP has received a one time funding opportunity to update the NOAA Atlas 14 precipitation frequency standard and fill in the existing product gaps. We anticipate this product update to be referred to as NOAA Atlas 15 and to be presented in two volumes. The first volume would account for temporal trends in historical observations, and the second volume would use future climate projections to generate adjustment factors for the first volume. These new estimates will provide critical information to design national infrastructure under a changing climate.

For more information, please refer to the Program 2-pager document, which includes a detailed timeline and additional project details.

IV. ARTICLES, CONFERENCES, MEETINGS, PERSONEL

On January 1, Gregory Fall, a physical scientist and federal employee, joined the HDSC team. Greg has over a decade of experience working with the Office of Water Prediction and was previously a software engineer at NOHRSC. His expertise lies in continental-scale model implementation, spatial analysis, and data assimilation, particularly for land surface modeling and snow analysis. Greg has been instrumental in designing and implementing the SNODAS system and the National Snow Analysis, which he continues to support, and is the primary developer and maintainer of the National Snowfall Analysis.

On January 4, HDSC also welcomed Rama (Sridhar) Mantripragada to the team. Sridhar Mantripragada has an M.S. in Atmospheric Science from North Carolina State University and a Master of Technology in Earth System Science and Technology from the Indian Institute of Technology Kharagpur. Sridhar has more than eight years of data analysis experience and has developed strong programming skills, enabling him to quickly analyze complex geophysical datasets and convert Fortran and Matlab codes to Python. He has also worked with machine learning models for over two years and co-authored a study on utilizing machine learning approaches to extract intra-seasonal variability in geophysical data. Furthermore, he has worked with global climate models such as CMIP6 and co-authored a study on the relationship between global warming and the evolution of heat waves.

On January 18, 2023, in anticipation of a 5-year Atlas 15 project, HDSC held a technical workshop to inform federal partners about the proposed update and to solicit feedback on the proposed statistical methodology and integration of climate projections. Experts from 10 federal agencies participated in the workshop, including those who use NOAA Atlas 14 or probable maximum precipitation estimates or create derivative products. The workshop's objectives were to share OWP's proposed Atlas 15 modeling framework, garner feedback, identify partnerships, and compile the information received into a workshop summary report to inform the Atlas 15 development.

Sandra Pavlovic, the HDSC Lead, and Michael St. Laurent, the Technical Director for NOAA Atlas 14 Volume 13, updated various stakeholders on the current and future activities of the HDSC. Sandra Pavlovic presented the plans for NOAA Atlas 15 to the National Weather Service Office of the Chief Learning Officer (OCLO) Webinar Series on January 26th. Meanwhile, on March 23rd, Michael St. Laurent participated in the Nuclear Regulatory Commission's 8th Annual Probabilistic Flood Hazard Assessment Research Workshop.