Hydrometeorological Design Studies Center

Progress Report for Period
1 July 2021 to 31 September 2021

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

October 20, 2021

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 recently commenced work on a new NOAA Atlas 14 Volume 12 for a full precipitation frequency analysis covering the states of Idaho and Montana. The NOAA Atlas 14 Volume 12 precipitation frequency estimates are expected to be published by December 2023. No funding is available to extend NOAA Atlas 14 Volume 12 coverage to the remaining three northwestern states: Oregon, Washington and Wyoming. Figure 1 shows the new project area as well as updated project areas included in NOAA Atlas 14, Volumes 1 to 12. For any inquiries regarding NOAA Atlas 14, please send an email to hdsc.questions@noaa.gov.

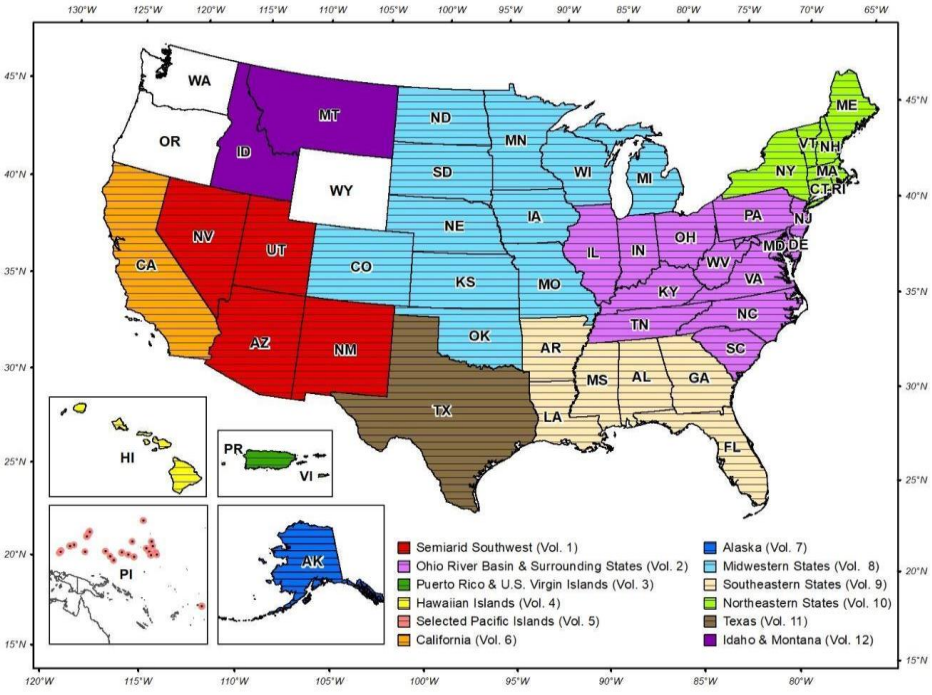

Figure 1. States or territories associated with each of the volumes of the Atlas.

II. CURRENT NOAA ATLAS 14 PROJECTS

1. VOLUME 12: IDAHO AND MONTANA STATES

On May 26, 2021, the HDSC commenced work on a new NOAA Atlas 14 Volume 12. The precipitation frequency estimates for this volume includes the states of Montana and Idaho and approximately a 1-degree buffer around these two states (Figure 2). This project's planned completion date is December of 2023.

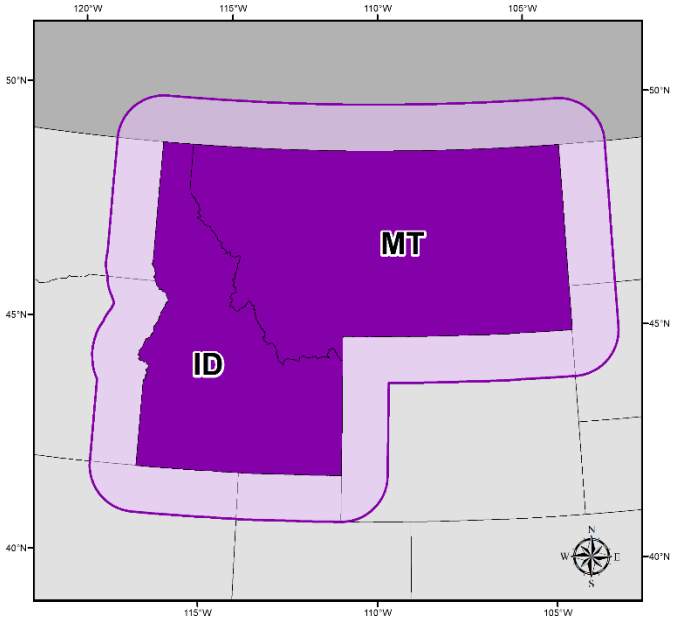

Figure 2. NOAA Atlas 14, Volume 12 extended project area (shown in purple).

In the period between July, 1, 2021 and September, 31 2021, we collected and re-formatted additional datasets and completed related station screening and quality control tasks. The individual sections below describe in more detail the major tasks performed during this reporting period.

1.1 PROGRESS IN THIS REPORTING PERIOD (July - Sep 2021)

1.1.1. Data collection and data screening

The primary source of NOAA Atlas 14 Volumes 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.

For this project area, we are interested in collecting all available precipitation datasets (daily, hourly, 5-minute, etc.) for stations in Idaho and Montana, as well as in adjacent portions of neighboring states (Nevada, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming) and also in Canada.

In this reporting period, we continued to download and format the 15-minute, hourly and daily datasets we received, and we continued to contact data providers of the newly identified datasets. Table 1 lists all sources of data collected so far and the current status of the data formatting task.

Table 1. Sources of datasets considered, contacted, downloaded or formatted for the precipitation frequency analysis for NOAA Atlas 14 Volume 12.

FID	Data Provider	Dataset name	Abbr.	Base Duration	Status
1	National Centers for Environmental Information (NCEI)	Automated Surface Observing System	ASOS	1M	formatted
2		DSI 3240, DSI 3260	DSI 3240, DSI 3260	15M, HLY	formatted
3		Global Historical Climatology Network	GHCN-DAILY	DLY	formatted
4		Environment Canada	GHCN-DAILY	DLY	formatted
5		Integrated Surface Data (Lite)	ISD_LITE	HLY, DLY	formatted
6		Quality Controlled Local Climatology	QCLCD	HLY	formatted
7		Unedited Local Climatological Data	ULCD	HLY	formatted
8		Hourly Precipitation Data (HPD) v1.0 Beta and v2.0 Beta	HPDv1, HPDv2	HLY,15M	formatted
9		United States CoCORAHS	GHCN-DAILY	DLY	formatted
10		Canada CoCORAHS	GHCN-DAILY	DLY	formatted
11		Snow Telemetry	GHCN-DAILY	DLY	formatted
12		Weather Bureau Army Navy (WBAN)	GHCN-DAILY	DLY	formatted
13	Ada County Highway District	Precipitation Gauge Network	AC	DLY, HLY, VARYING	received
14	Benton County	Benton County Gauging Dam Data	BC	HLY	received
15	City of Caldwell	City of Caldwell	CC	DLY	received
16	Environment Canada (EC)		EC	DLY, HLY, 15M	formatted
17	High Plains Regional Climate Center (HPRCC)	Automated Weather Data Network (AWDN)-CoAgMet, NDAWN, and WACNet	AWDN	DLY, HLY, 15M	received
18	Idaho National Laboratory (INL)	Air Resources Laboratory (ARL) Mesonet	INL_ARL	DLY, 5M	received
19	Midwestern Regional Climate Center (MRCC)	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	DLY	received
20	Montana Department of Transportation (MDT)	Engineering Division, Highways Bureau, Hydraulics Section Precipitation Study	MT_DOT	HLY	duplicate of NCEI
21	Montana Department of Transportation (MDT)	Road Weather Information System (RWIS)	RWIS	5M	considering
22	National Atmospheric Deposition Program (NADP)		NADP	DLY	contacted

FID	Data Provider	Dataset name	Abbr.	Base Duration	Status
23	National Centers for Environmental Prediction (NCEP)	Meteorological Assimilation Data Ingest System (MADIS)	MADIS	DLY, HLY, VARYING	considering
24	National Weather Service (NWS)	Hydrometeorological Automated Data System	HADS	HLY	received
25	National Weather Service (NWS)	Snowpack Telemetry (SNOTEL) Network	SNOTEL	DLY, HLY	received
26	North Dakota Atmospheric Resource Board	Cooperative Observer Network (ARBCON)	ARBCON	DLY	received
27	The Northwest Watershed Research Center (NWRC)		NWRC	DLY, HLY	received
28	Snow Telemetry		SNOTEL	DLY, HLY	received
29	U.S. Bureau of Reclamation (USBR)	HydroMet	HYDROMET	DLY, HLY	received
30	U.S. Bureau of Reclamation (USBR)	Agricultural Weather Networks (AgriMet)	AGRIMET	DLY, 15M	received
31	U.S. Geological Survey (USGS)	Nation Water Information System (NWIS) dataset	NWIS	15M	not used
32	University of Montana	Mesonet	UM_MESONET	DLY	received
33	University of Utah Synoptic Data	MesoWest	UT_MESONET	DLY, HLY, VARYING	downloading
34	U.S. Dept of Agriculture (USDA), Natural Resources Conservation Service (NRCS)	Soil Climate Analysis Network (SCAN)	SCAN	DLY, HLY	received
35	U.S. Dept of Agriculture (USDA), Forest Service	Remote Automated Weather Station Network (RAWS)	RAWS	HLY	downloading

Locations of formatted NCEI daily, hourly and 15-minutes stations are shown in Figure 3. Daily stations are shown as blue circles, hourly as red, and 15-minutes as green circles. Only stations with at least 30 years of useful daily data and at least 20 years of useful hourly and sub-hourly data will be considered for the development of NOAA Atlas 14 estimates. However, these stations will be filtered after all the additional datasets have been added and the quality control and cleanup procedures (described in the sections below) are completed.

At the start of this project, we also contacted our network of users and stakeholders to help us identify the data sources in the project area. We would like to thank all of those who responded to our inquiry and/or provided the data. 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.

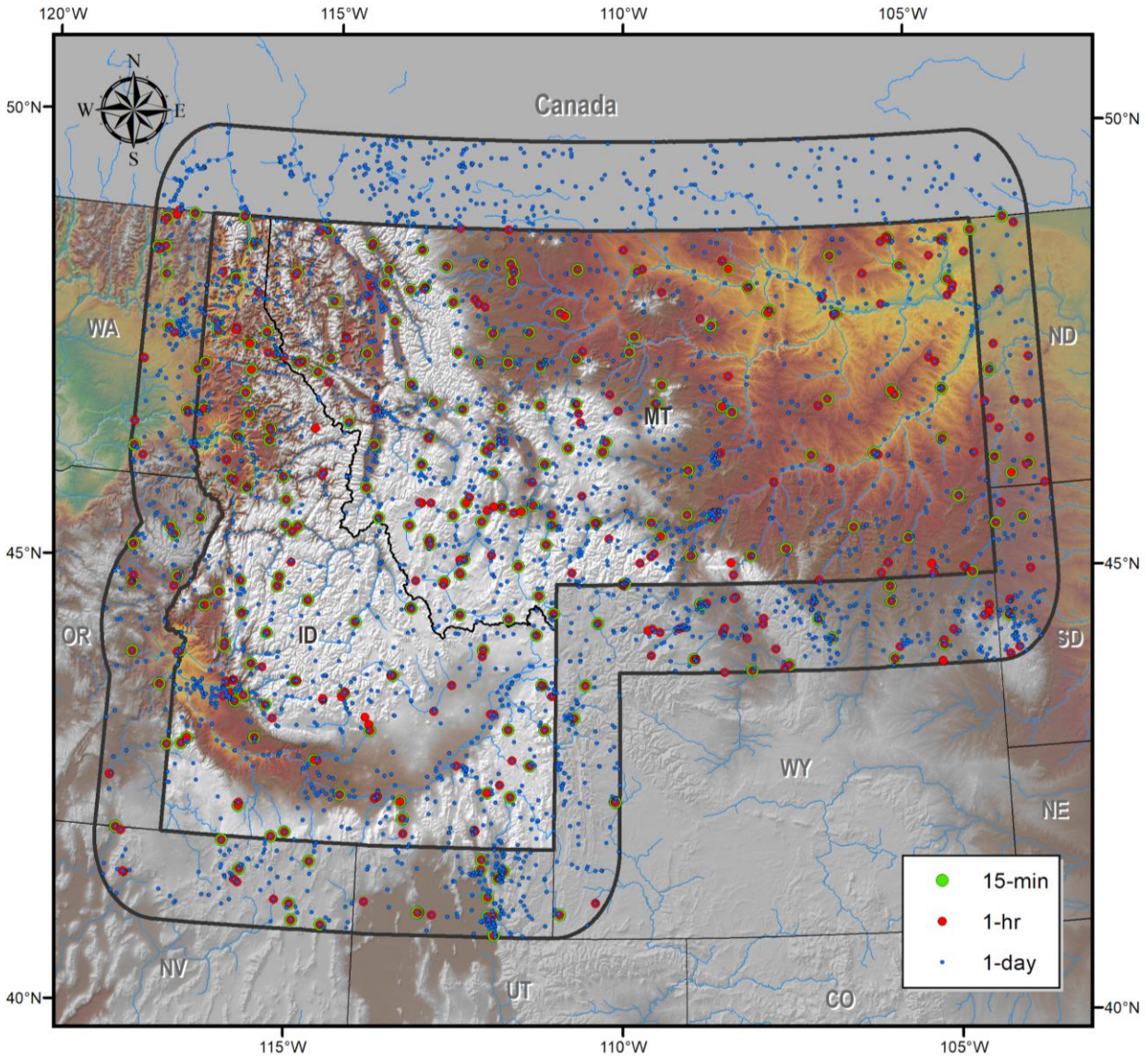

Figure 3. Map showing 3,204 formatted stations recording at 1-day interval, 562 at hourly and 368 at 15-minutes.

1.1.2. Metadata quality control

We continue screening stations' metadata for errors. In this reporting period, we screened the metadata information from additional datasets considered: SCAN, SNOTEL, MESONET, HYDROMET, and AGRIMET. In this task, stations with potential errors were identified by reviewing published coordinates and elevations for large changes over the course of the station's lifetime. Stations with assigned elevations that were more than 10% different from elevations extracted from a 1 arcsecond (approx 30 meters) digital elevation model (DEM) are being investigated. Such stations may be relocated based on inspection of satellite images, maps and records of the station's history. Misplacements were typically the result of latitude and longitude data having inadequate precision. Original and revised coordinates for all stations used in the analysis will be provided in Appendix 1 of the accompanying NOAA Atlas 14 Volume 12 document. Stations with no elevation information were assigned DEM elevations and also investigated for possible location errors.

1.1.3. Colocated cleanup

In this reporting period, we completed the station colocated cleanup for the NCEI's stations' (which make up the majority of the data for the project). During this task we performed the following:

- screening for duplicate records at collocated stations,
- extending records at longer-duration stations using data from collocated stations,
- investigating large differences in annual maximum series (AMS) at collocated stations at critical durations such as 1-hour and 1-day
- implementing data corrections to ensure co-located data consistency across multiple gauges

Figure 4 shows an example of the station cleanup task done for the NCEI's station 10-1956 (Coeur d'Alene, ID) that has three co-located gauges that observe precipitation at the 15-min, hourly, and daily time intervals. This station also has additional 15-min data under the ID 54-0016, which is duplicate hourly precipitation data of 10-1956 15-min but contains new data beginning in 2014. For this check, all annual maximum series (AMS) are plotted and compared at multiple durations including 1-hour, 12-hour, and 1-day. Large discrepancies are thoroughly investigated and data corrections implemented if the differences are due to data quality issues.

For this particular station, multiple data issues were identified and fixed. The unreasonably large 1-hour value of 10.02 inches in 1964 was confirmed to be .02 in the Hourly Precipitation Data publication for Idaho in 1964. In 1997, 2 inches in 1-hour was measured by the 15-min gauge compared to only 0.4 inches in the hourly gauge. This particular value was already quality-controlled and removed from the hourly record by NCEI, but kept the event in the 15-min data. It was confirmed to be erroneous after reviewing the time distribution of 15-min data and because it conflicted with the co-located COOP daily station which measured only .25 inches for the day. Afterwards, it was then removed from the 15-min data to be consistent with the hourly data. Quality control was also done on the 1-hour value of 1-inch on 1/31/2012, which is too high for the winter and conflicts with the daily gauge which measured no precipitation. We also fixed high 1-hr values in 2014/2015 from the new 15M data, 1.49 on 9/4/2014 and 1.49 on 10/21/2015, as both appear unreliable and conflict with the daily COOP gauge. From the 12-hour AMS plot, the following 15-min data conflict with both the hourly and daily COOP data and thus have been removed from the record: 5.3 inches on 7/16/1999 and 1.8 inches on 7/19/1998.

On the 1-day plot, the daily COOP station is being plotted in addition to the hourly and 15-min data. Of significance is the discrepancy in 1982 where the daily gauge measured 2.1 inches in a single day compared to the hourly/15-min data which had precipitation over a longer period than a single day. The original COOP observer form confirms that this was not a single-day event as the event was noted to be a 2-day accumulation. Large precipitation daily values in 1997 and 1998, including 4.5 inches on 12/21/1997 and 3.5 inches on 1/4/1998, both of which conflict with the hourly/15-min data, are likely snowfall that was not correctly observed as snow water equivalent after review of the COOP forms. Large values that have this data issue appear to be exclusive to the period of October 1997 - January 1998 and have been fixed.

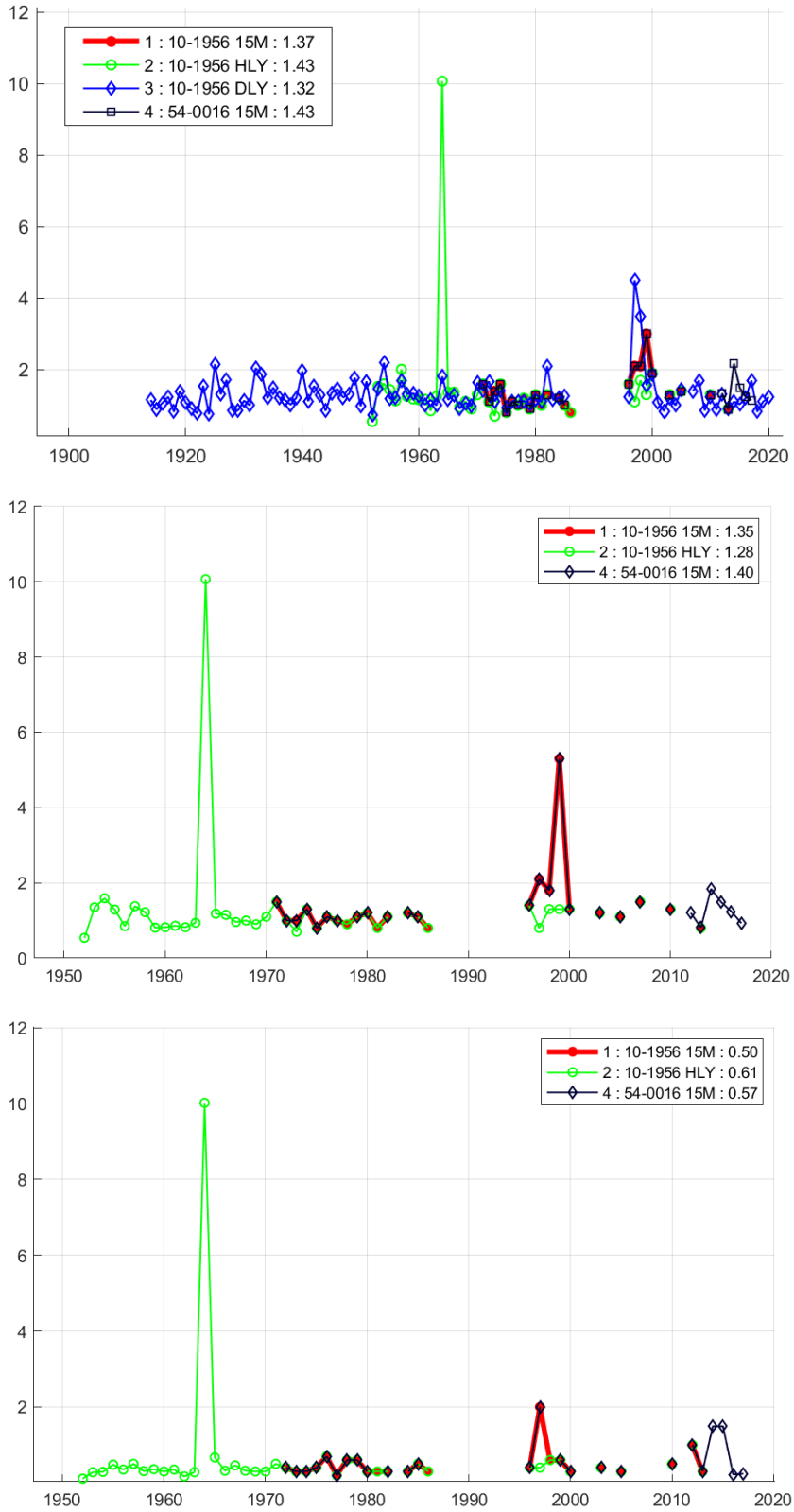

Figure 4. The colocated cleanup task for the NCEI's station 10-1956 (Coeur d'Alene, ID) using annual maximum series (AMS), for a) 1-day b) 12-hour,and c) 1-hour duration.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2021)

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

The large portion of the work in the next reporting period will be on non-NCEI dataset reformatting and co-located station cleanup, and NCEI station cleanup.

1.3. PROJECT SCHEDULE

- Data collection, formatting, and initial quality control [March 2022]
- 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) [May 2022]
- Regionalization and frequency analysis [August 2022]
- Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [November 2022]
- Peer review [January 2023]
- Revision of PF estimates [March 2023]
- Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [September 2023]
- Web publication [December 2023]

III. OTHER

1. ANALYSIS OF IMPACTS OF NON-STATIONARY CLIMATE ON NOAA ATLAS 14 ESTIMATES

The work on the project to assess the impact of a non-stationary climate on the NOAA Atlas 14 method was put on hold from May 2020 until May 2021. In late May 2021, the HDSC resumed the work on the non-stationary project and worked on an assessment report that summarizes the work performed by the academic partners in the two project phases. A draft analysis and assessment report by OWP has been completed, which includes the final reports from the university research teams. It has been shared with the DOT-FHWA and is being reviewed. We plan to have to share the assessment report in December 2021 or January 2022.

2. 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.

2.1. West Central Tennessee, 20-22 August 2021

During this reporting period, we analyzed data from the extreme rainfall event that took place in West Central Tennessee from 20-22 August 2021. A stalled frontal boundary west of Nashville, TN led to training thunderstorms during the early morning hours of August 21st which led to up to 15 inches of rainfall in about a 6-hour period. A rain gauge operated by the Tennessee Valley River Authority in the town of McEwen recorded 17.02 inches (43.2 cm) of rain, setting a new daily record rainfall for the state. This flooding event which was a result of such extreme rainfall was associated with 20 casualties and over 270 homes being completely destroyed. More information about the event can be found here.

For this event, we looked at a range of durations and selected the 12-hour duration to analyze. Areas that experienced the maximum 12-hour rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the map in Figure 4. Precipitation frequency estimates from NOAA Atlas 14 Volume 2 were used in the analysis. The underlying observed rainfall data came from 1-hour Stage IV multi-sensor precipitation estimates.

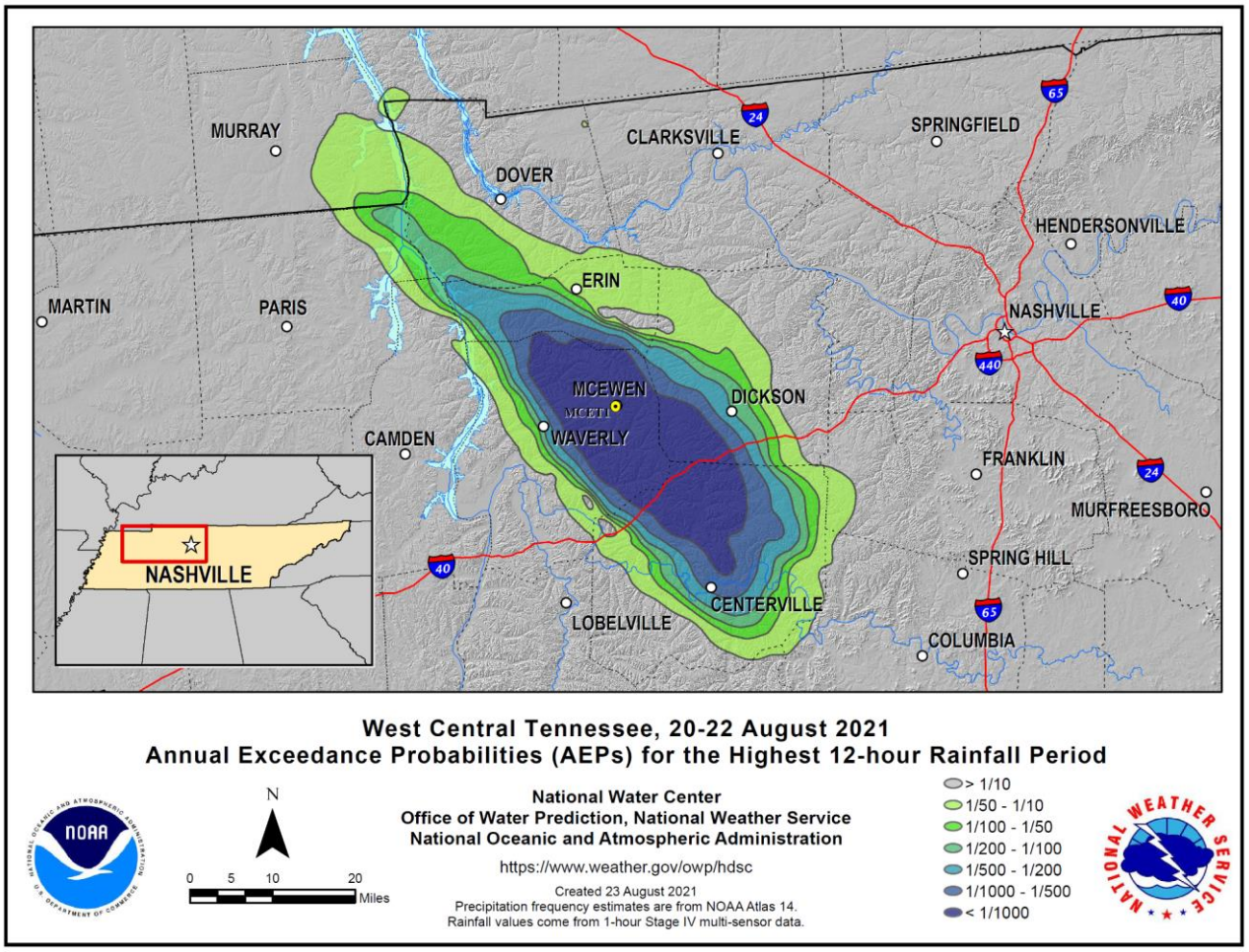

Figure 4. Annual exceedance probabilities for the worst case 12-hour rainfall during the West Central, TN event.

2.2. Post-Tropical Depression Ida, Northeast, 31 August - 2 September 2021

Major Hurricane Ida made landfall on the Louisiana coast on August 29th as a Category 4 hurricane. After causing devastating damage to parts of Louisiana, the remnants of Hurricane Ida pushed northeast over the next two days and transitioned into a post-tropical cyclone on September 1. This post-tropical cyclone brought torrential rain, tropical-storm-force winds and several tornadoes to the Northeastern United States. The flooding from this storm caused around 43 casualties across New York, Connecticut, New Jersey and Pennsylvania. A summary of the event can be found here.

During this reporting period, we also analyzed data from post-tropical Ida over the Northeastern U.S. from 31 August - 2 September 2021. We looked at a range of durations and selected the 3-hour duration to analyze. Areas that experienced the maximum 3-hour rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the map in Figure 5. Precipitation frequency estimates from NOAA Atlas 14 Volume 2 and Volume 10 were used in the analysis. The underlying observed rainfall data came from 1-hour Stage IV multi-sensor precipitation estimates.

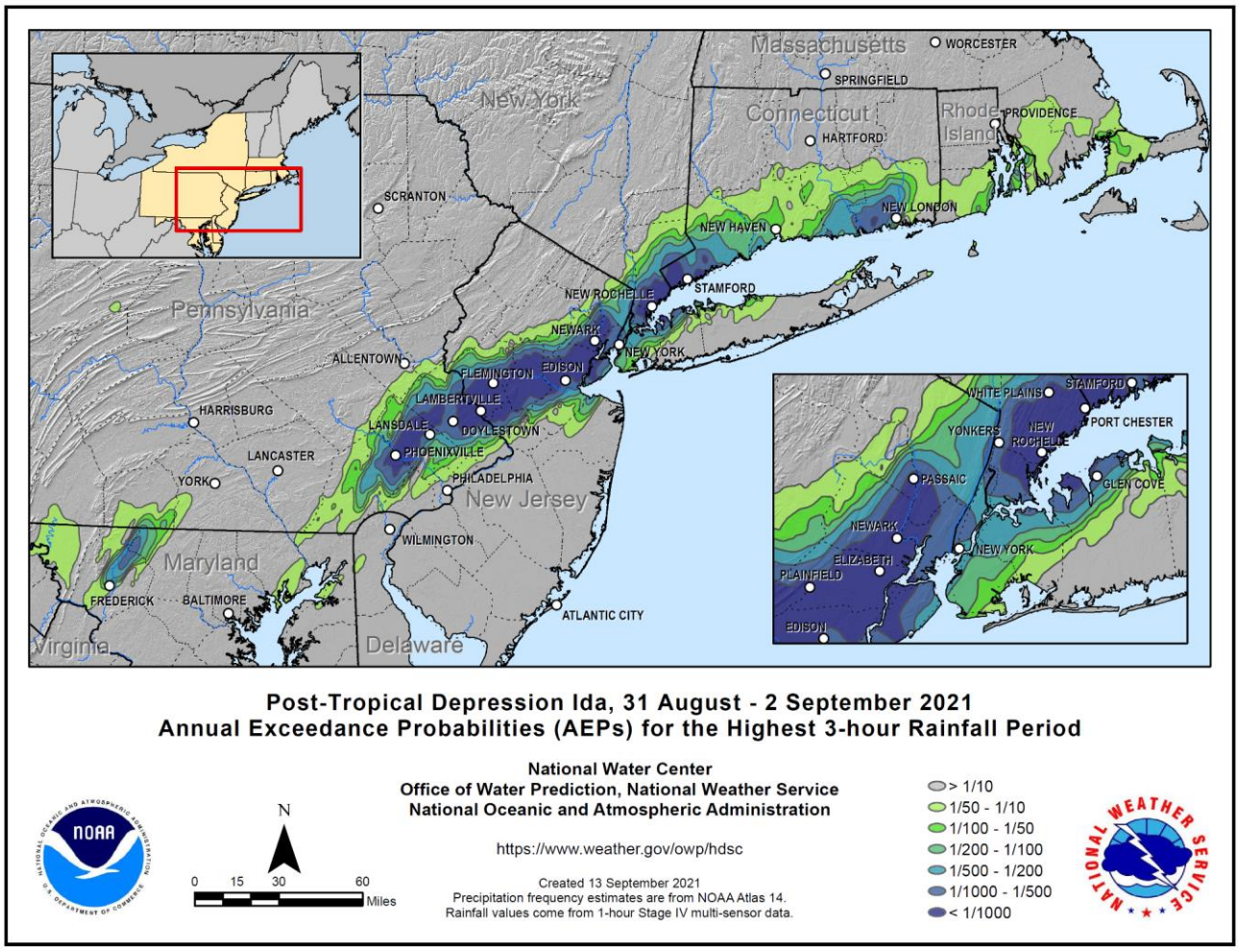

Figure 5. Annual exceedance probabilities for the worst case 3-hour rainfall during the Post-tropical Depression Ida event.

3. CONFERENCES, MEETINGS

On Wednesday September 9, HDSC's Acting Technical Director Sandra Pavlovic gave a presentation for the Iowa Flood Center Virtual Meeting titled: "NOAA Atlas 14: Current and Future Developments."

On Tuesday October 5, HDSC Mission Lead Mark Glaudemans gave a presentation at the NOAA/WRF Webinar series: Our Changing Precipitation: A Conversation on the Science of Precipitation and Planning for the Future for Local Planners Session 5 titled: "NOAA Precipitation Frequency Estimation - Atlas 14 and Beyond", and participated in the panel discussion relevant to the topic of the webinar series.