HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
QUARTERLY PROGRESS REPORT

1 January to 31 March 2018

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 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) has been updating precipitation frequency estimates for various parts of the United States and affiliated territories. Updated precipitation frequency estimates, accompanied by additional relevant information, are published in NOAA Atlas 14. All NOAA Atlas 14 products and documents 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, we have updated precipitation frequency estimates 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), and CT, MA, ME, NH, NY, RI, VT (Volume 10, 2015). Since May 2015, HDSC has been working on updating precipitation frequency estimates for the state of Texas. We expect to publish them in late 2018 in NOAA Atlas 14 Volume 11. OWP has been working with FHWA and several Northwestern state agencies on securing funding to extend NOAA Atlas 14 coverage to the remaining five northwestern states: ID, MT, OR, WA, WY in Volume 12. For any inquiries regarding the status of this effort, please send an email to HDSC.questions@noaa.gov.

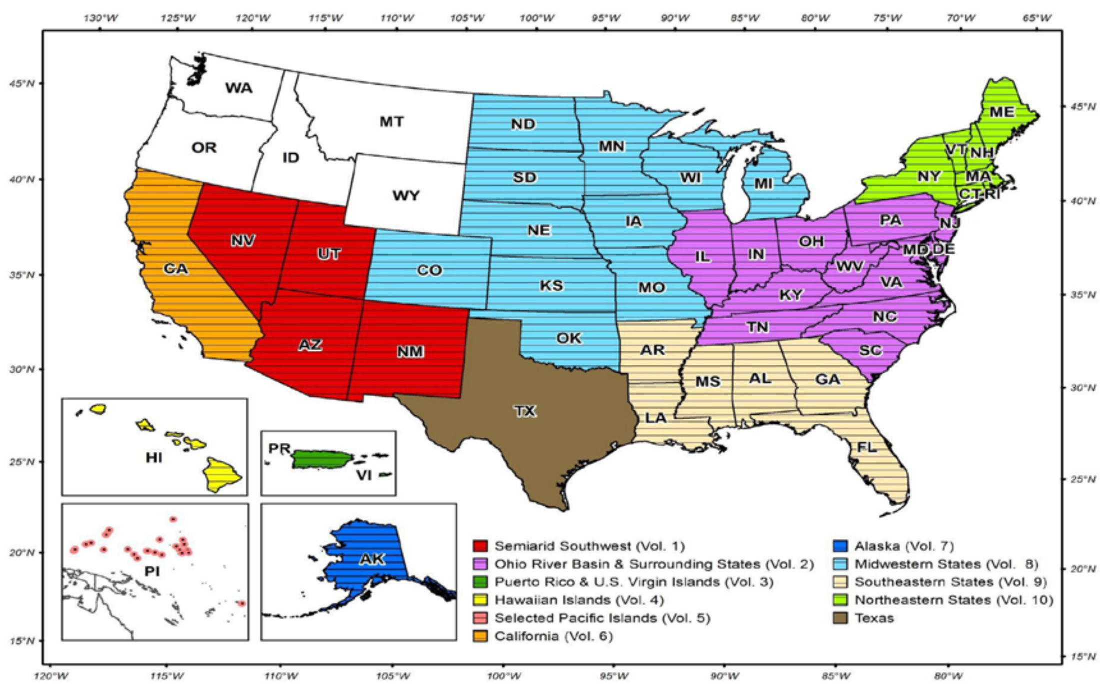

Figure 1. Current project area for Volume 11 (TX) and project areas included in published Volumes 1 to 10.

II. CURRENT PROJECTS

1. NOAA ATLAS 14 VOLUME 10: NORTHEASTERN STATES

Precipitation frequency estimates for the following seven northeastern states: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont were published in September 2015 as NOAA Atlas 14 Volume 10. The estimates for any location in the project area, along with all related products except documentation, are available for download in a variety of formats through the PFDS. Work on documentation describing the station metadata, data and project methodology was delayed by funding issues, which are now resolved. Our estimate for the publication of NOAA Atlas 14 Volume 10 documentation is December 2018.

2. NOAA ATLAS 14 VOLUME 11: TEXAS

The extended project area for the NOAA Atlas 14 Volume 11 precipitation frequency project includes the state of Texas and approximately a 1-degree buffer around the state (Figure 2).

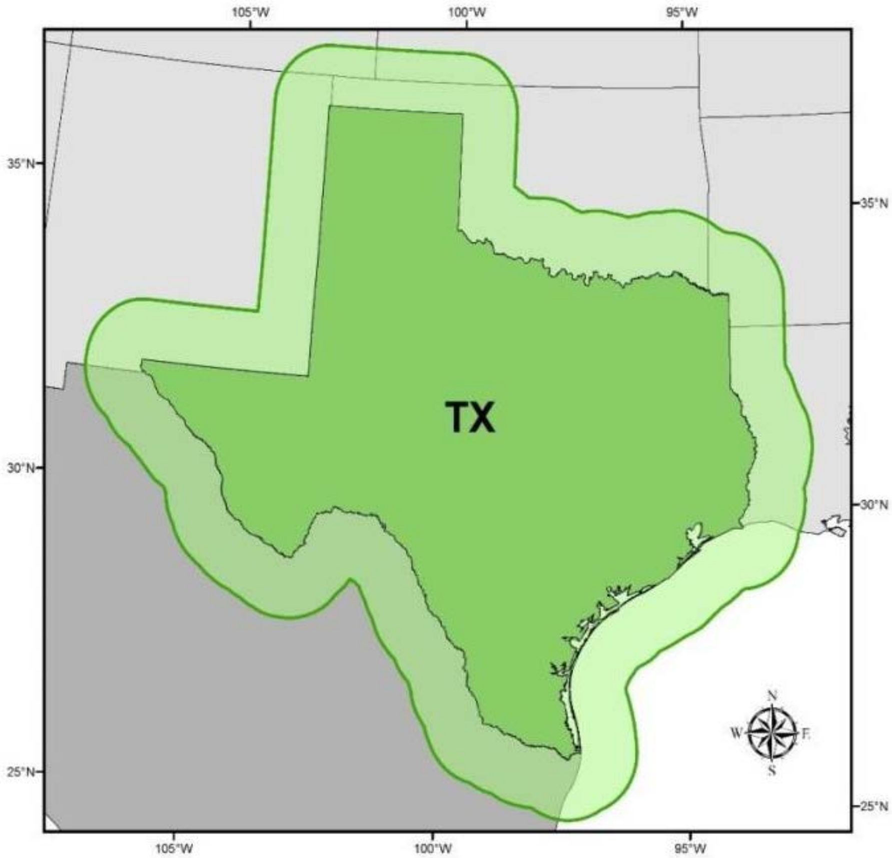

Figure 2. NOAA Atlas 14, Volume 11 extended project area.

The primary source of data for NOAA Atlas 14 Volumes is NOAA's National Centers for Environmental Information (NCEI). In addition to the NCEI's data, we gathered precipitation data collected by other Federal, State and local agencies for stations in Texas, as well as in adjacent portions of neighboring states (Arkansas, Louisiana, New Mexico, and Oklahoma) and also in Mexico to assist in data quality control and regionalization tasks. Since we started this project, we have contacted numerous agencies for assistance with the data and would like to thank all of those who responded to our inquiries and/or provided the data.

We have formatted data for almost 12,000 stations from 34 datasets listed in Table 1. Each formatted station was assigned a unique 6-digit identification number (ID), where the first 2 digits of the ID indicate the dataset. Stations were then screened for duplicate records, potential merges and for sufficient number of years with usable data. Stations with shorter or less reliable records in station dense areas were removed from the database. After all the screenings, approximately 2,000 stations were retained for frequency analysis. Until documentation for Volumes 10 and 11 is published in December, please see Volume 9 document for more information on Atlas 14 methods and products.

Table 1. List of formatted datasets.

Data provider	Dataset name	Abbr.	Station IDs (common digits)	Base duration
National Centers for Environmental Information (NCEI)	Automated Surface Observing System	NCEI	78	15M
	DSI 3240, DSI 3260		03,05,14,16, 29,34,41*	15M, HLY
	Digitized data		99	HLY, DLY
	Global Historical Climatology Network (GHCN)		03,05,14,16,29, 34,41,69,79,90*	DLY
	Integrated Surface Data (Lite)		64	HLY, DLY
	Quality Controlled Local Climatol. Data		56	HLY
	Raw sub-daily precipitation data		66	15M
	Unedited Local Climatological Data		55	HLY
City of Austin	ALERT Network	COA	65	15M
City of Dallas	ALERT Network	COD	81	15M
Edwards Aquifer Authority		EAA	62	HLY
Guadalupe-Blanco River Authority		GBRA	77	15M
Harris County Flood Control District	Flood Warning System	HCFCD	60	15M
Jefferson County Drainage District 6	ALERT Precipitation and Stream Level Network	DD6	82	15M
Lower Colorado River Authority	Regional Meteorological Network	LCRA	63	15M
Midwestern Regional Climate Center	CDMP 19th Century Forts and Voluntary Observers Database	FORTS	52	DLY
Illinois State Water Survey	National Atmospheric Deposition Program	NADP	54	DLY
National Estuarine Research Reserve System		NERRS	57	15M, HLY
National Weather Service	Hydromet. Automated Data System	HADS	85	HLY
Oklahoma Climatological Survey	Oklahoma Mesonet	OKM	86	15M, DLY
San Antonio River Authority		SARA	91	15M
Sabine River Authority		SRA	58	DLY
Servicio Meteorologico Nacional, Mexico		SMN	61	DLY
Tarrant Regional Water District (Greater Fort Worth area)	Tarrant County Urban Flood Control Network	TRWD	83	15M, HLY
Texas Commission on Env. Quality	Air Quality Network	TCEQ	75	HLY
Texas Evapotranspiration Network		TEN	89	HLY, DLY
Texas Water Development Board		TWDB	84	HLY, DLY
Titus County Fresh Water Supply District No. 1		TCWS	53	DLY
U.S. Bureau of Reclamation	HydroMet	USBR	87	HLY, DLY
US Dept. of Agriculture (USDA)	Agricultural Research Service	USDA	94	15M
USDA, Forest Service	Remote Automated Weather Station Network	RAWS	76	HLY
USDA, National Resources Conservation Service	Soil Climate Analysis Network	SCAN	88	HLY
U.S. Geological Survey	National Water Information System	NWIS	59	15M
West Texas Mesonet		WTM	80	15M

*03 - Arkansas, 05 - Colorado, 14 - Kansas, 16 - Louisiana, 29 - New Mexico, 34 - Oklahoma, 41 - Texas (DLY, HLY)
69 - GHCN CoCoRaHS, 79 - GHCN, 90 - GHCN Mexico (DLY)

2.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2018)

2.1.1. Peer review

From 20 November 2017 to 19 January 2018, HDSC conducted a peer review of preliminary precipitation frequency estimates for Texas. The following information was prepared and distributed for the review:

- metadata for stations whose data were used in precipitation frequency analysis;
- metadata for stations whose data were collected, but not used in the analysis;
- at-station depth-duration-frequency (DDF) curves for 60-minute to 10-day durations and for 2-year to 100-year average recurrence intervals (ARIs);
- maps of spatially-interpolated precipitation frequency estimates for 60-minute, 6-hour, 24-hour and 10-day durations and for 2-year and 100-year average recurrence intervals (ARIs).

The request for review was sent via email to over 750 subscribers to the HDSC list-server, as well as funding agencies and others who expressed interest in participating in the review. Potential reviewers were asked to evaluate the accuracy of station metadata and the reasonableness of point precipitation frequency estimates in addition to their spatial patterns.

We received comments from more than 30 reviewers. During this reporting period, we consolidated all comments, reviewed them and we started to address them accordingly and to respond to reviewers. The (anonymous) reviewers' comments with our responses and resulting actions will be published as an Appendix 4 in the Volume 11 document.

We first addressed reviewers' comments pertaining to station metadata and additional potential stations' merges, extensions and deletions. We extended records for all stations used in analysis through December 2017, where available, quality controlled the newly added data and extracted annual maximum series across applicable durations.

Some reviewers commented on contour lines (bullseyes) and inconsistencies relative to expected spatial patterns especially along the coast for 100-year precipitation frequency estimates at sub-daily durations. During this reporting period, we investigated the causes and ways to mitigate this effect for the final grids. We reviewed information at co-located daily and hourly stations with shorter records and re-examined AMS data at selected stations in station-dense areas. Follow-up decisions about stations' exclusions or revisions were done on a case by case basis.

The majority of bullseyes were the result of small differences in corresponding estimates at nearby stations and selected mapping contour intervals. Some were a result of mean annual maximum (MAM) patterns developed using PRISM hybrid statistical-geographic interpolation approach that serves as the basis for deriving gridded precipitation frequency estimates at different frequencies and durations. As an alternative to changing the PRISM method, we adjusted a dynamic filter that we use in development of 2-year grids from MAM grids. Parameters of the filter, which control the amount of smoothing, are a function of elevation gradients and proximity to the coastline. We adjusted the filter's parameters such that the amount of smoothing in coastal areas somewhat increased relative to the pre-peer review version; we applied maximum smoothing in flat terrain, and no smoothing in the mountains, and ensured gradual transition from one region to another. The resulting smoothed 2-year grids served as the basis for the derivation of grids for all other recurrence intervals.

Since we use regional frequency analysis approach to support estimation of the frequencies of rare events by using data from several stations to calculate estimates at one station, we also revisited regions defined before the peer review to accommodate the addition and deletion of stations and to investigate if additional modifications were needed to improve the spatial smoothness and reliability of estimates in coastal regions.

2.1.2. Temporal distributions

The Natural Resources Conservation Service has developed curves that are commonly used in engineering design to describe the temporal distribution of rainfall. For NOAA Atlas 14, NWS has adopted a technique for describing the many potential temporal distributions of natural rainfall in probabilistic terms; the technique is described in more detail in Appendix 5 of Volume 9 document.

Temporal distributions of precipitation amounts exceeding precipitation frequency estimates for the 2-year ARI have been calculated for 6-hour, 12-hour, 24-hour, and 96-hour durations for three climate regions delineated for this project area based on characteristics of heavy precipitation. They will be expressed in probability terms as cumulative percentages of precipitation totals and will be provided as charts and in tabular format.

2.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2018)

During the next reporting period, we'll share Appendix 4 and revised cartographic maps of precipitation frequency estimates for selected base durations and frequencies with those who provided comments during the peer review. We will create gridded AMS-based and partial duration series (PDS)-based estimates, as well as gridded upper and lower confidence limits for 90% confidence interval for all durations and frequencies.

2.3. PROJECT SCHEDULE

Data collection, formatting, and initial quality control [Done]
AMS extraction, additional quality control and data reliability tests [Done]
Regionalization and frequency analysis [Done]
Spatial interpolation of precipitation frequency (PF) estimates [Done]
Peer review [Done]
Revision of PF estimates [April 2018]
Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions) [July 2018]
Web publication of data [October 2018]
Web publication of documentation [December 2018]

3. ANALYSIS OF IMPACTS OF NON-STATIONARY CLIMATE ON PRECIPITATION FREQUENCY ESTIMATES

The current approach used in NOAA Atlas 14 to calculate precipitation magnitude-frequency relationships assumes stationarity in the annual maximum series (AMS) data used for frequency distribution selection and fitting. We use several parametric and non-parametric statistical tests to detect trends in the AMS, but so far, tests have shown very little geographically consistent temporal change in these data (for more information, see Volume 9 document).

There has been a growing concern among users of NOAA Atlas 14 products that they have been developed from the AMS data using stationary frequency analysis methods and as such may not appropriate in presence of non-stationary climate. For example, AMS-based approaches consider only a single highest precipitation amount for a given duration per year, and consequently are not sensitive to changes in the rate of extreme events not accompanied with a significant change in magnitudes. That suggests the need to replace the current stationary AMS-based approach with a non-stationary partial duration series (PDS)-based approach.

In an effort to understand the potential impact of non-stationary climate conditions on precipitation frequency estimates, the Federal Highway Administration tasked HDSC to conduct a pilot project to look into this issue, but preliminary findings were inconclusive. Despite the significant effort we put into this task, we did not have a definite answer to whether non-stationary methods are advantageous in practice.

With help from academia, HDSC continues this investigation with the ultimate goal of developing a modeling framework that will allow non-stationary climate effects to be integrated into the NOAA Atlas 14 process, and will produce credible precipitation frequency estimates which can be relied upon by Federal water agencies.

Since 2016, HDSC has been working together with the Penn State University team led by Drs. Shaby and Mejia on assessing the suitability of different non-stationary frequency analysis methods with respect to NOAA Atlas 14. As part of this effort, we have been evaluating estimates from various types of non-stationary models against the current NOAA Atlas 14 stationary model and investigating a number of related issues, such as performance of the AMS and PDS models in terms of the uncertainty of precipitation frequency estimators, effects of different de-clustering techniques and threshold selection mechanisms for the PDS model, effects of distribution parameterization techniques, etc. We have been also exploring if other covariates in addition to time may improve estimates. The details of methods tested and major findings will be shared in a report that will be published on the PFDS website in late-2018.

Work on testing the feasibility of incorporating future climate projections into precipitation frequency analysis is scheduled to start in May 2018. On this task we will collaborate with a team of researchers from the University of Illinois at Urbana-Champaign.