HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
QUARTERLY PROGRESS REPORT

1 April to 30 June 2015

National Water Center

National Weather Service

National Oceanic and Atmospheric Administration

U.S, Department of Commerce

Silver Spring, Maryland

July 2015

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 National Water Center[1] of 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 for durations from 5 minutes to 60 days and average recurrence intervals between 1- and 1,000-years, accompanied by additional relevant information (e.g., 95% confidence limits, temporal distributions, seasonality) 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. To date, precipitation frequency estimates have been updated for Arizona, Nevada, New Mexico and Utah (Volume 1, 2004), Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia (Volume 2, 2004), Puerto Rico and U.S. Virgin Islands (Volume 3, 2006), Hawaiian Islands (Volume 4, 2009), Selected Pacific Islands (Volume 5, 2009), California (Volume 6, 2011), Alaska (Volume 7, 2011), and Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin (Volume 8, 2013), Alabama, Arkansas, Florida, Georgia, Louisiana and Mississippi (Volume 9, 2013).

Currently we are finalizing updating estimates for seven northeastern states (Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont) that will be published in September 2015 as Volume 10. Work on updating precipitation frequency estimates for the state of Texas started in May 2015; those estimates are expected to be published by mid-2018 in NOAA Atlas 14, Volume 11. Figure 1 shows the states or territories associated with each of the Volumes of the Atlas.

In partnership with several federal and state agencies we have been working on securing funding to extend NOAA Atlas 14 to the remaining five northwestern states (Idaho, Montana, Oregon, Washington, Wyoming). Currently, there is an open solicitation for this project (number 1362) on the Transportation Pooled Fund Program's web page. For any inquiries regarding the status of this effort, please contact us at HDSC.questions@noaa.gov.

Due to lack of funding, in FY15 we temporarily suspended activities on the following two projects: "Analysis of potential impacts of climate change on precipitation frequency estimates" and "Development of regional areal reduction factors to accompany NOAA Atlas 14 point precipitation frequency estimates." Consequently, we omit related sections in the most current progress reports. For more details on the work accomplished so far on those two projects, please see Oct - Dec 2014 progress report.

[1] *As of April 1, 2015, the Office of Hydrologic Development reorganized into the National Water Center (NWC) with locations in Chanhassen, MN, Silver Spring MD, and Tuscaloosa, AL.*

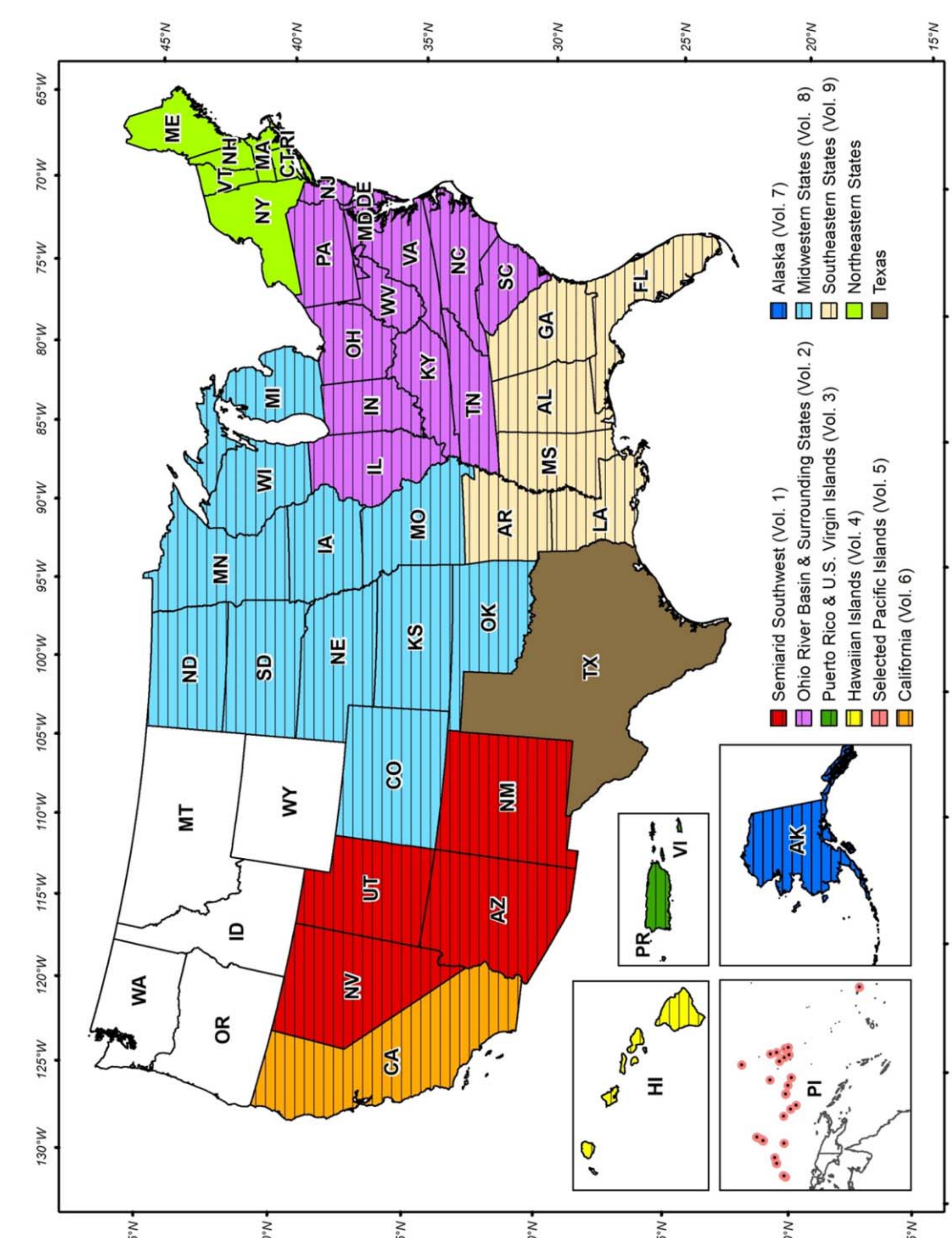

Figure 1. Current project area for Volumes 10 (Northeastern states) and 11 (Texas) and project areas included in published Volumes 1 to 9.

II. CURRENT PROJECTS

1. NOAA ATLAS 14 VOLUME 10: PRECIPITATION FREQUENCY PROJECT FOR THE NORTHEASTERN STATES

1.1 PROGRESS IN THIS REPORTING PERIOD (Apr - Jun 2015)

The project area for the Northeastern precipitation frequency project includes the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont and approximately a 1-degree buffer around these states (Figure 2).

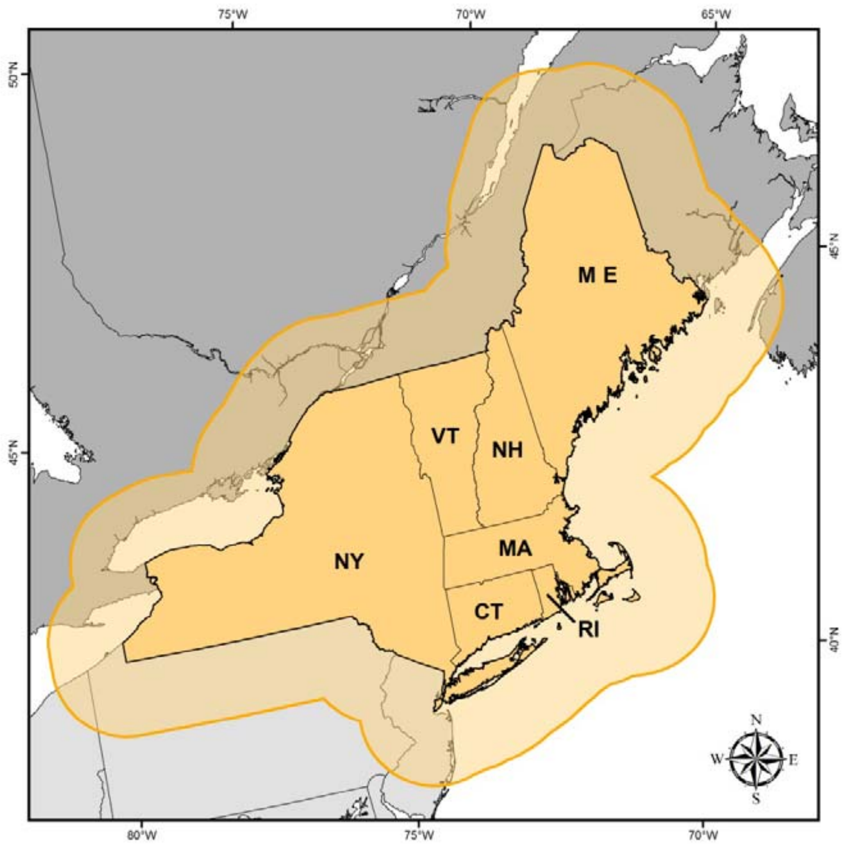

Figure 2. NOAA Atlas 14 Volume 10 project area with a 1-degree buffer zone.

1.1.1. Data collection and data screening

In this reporting period, we added hourly precipitation data, mainly between 1996-present, for hourly stations from the Quality Controlled Local Climatological Data (QCLCD) dataset. This data was used to fill in gaps in hourly AMS for Automated Weather Observing System (AWOS) and Automated Surface Observing System (ASOS) stations and to extend their records for 5-10 years.

We also digitized and formatted additional precipitation data for selected stations located in areas of high importance and scarce data from the New York City Environmental Protection Bureau of Water Supply (NYCEPBWS) and from the NCDC's Climate Database Modernization Program (CDMP) databases. The stations' names, recording intervals and periods of record digitized are shown below:

Database	Station name	Recording interval	Period digitized
NCDC CDMP	Concord, NH	1-day	1864-1884
	Concord, NH	1-hr	1903-1943
	Ithaca, NY	1-hr	1900-1948
	Northfield, VT	1-hr	1896-1948
	Portland, ME	1-hr	1894-1948
	Reading, MA	1-hr	1981-2010
NYCEPBWS	West Hurley	1-day	1918-1945
	Glenford	1-day	1945-1948
	Brown Station	1-day	1918-1948
	West Shokan	1-day	1918-1948
	Cold Brook	1-day	1918-1948
	Lake Hill	1-day	1918-1948
	Phoenicia	1-day	1918-1948
	Edgewood	1-day	1918-1948
	Slide Mountain	1-day	1918-1948
	Pine Hill	1-day	1926-1943
	Highmount	1-day	1918-1925
	Big Indian	1-day	1918-1943
	Bushnellsville	1-day	1943-1948
	West Kill	1-day	1928-1948
	Lexington	1-day	1928-1948
	Elka Park	1-day	1928-1948
	Tannersville	1-day	1928-1948
	East Jewett	1-day	1928-1948
	Windham	1-day	1928-1948
	North Settlement	1-day	1928-1948
	Manorkill	1-day	1928-1948
	Grand Gorge	1-day	1928-1948
	Prattsville	1-day	1928-1948

Figure 3 shows, as an example, updated hourly annual maximum series (AMS) data for the Ithaca, NY hourly station. For this station, the hourly record was extended for 49 years (1900-1948 period). As can be seen from the figure, several top values in the AM series come from the newly digitized data. In Figure 4 we show the effect of newly added data on at-station precipitation frequency estimates; the 100-yr estimate, for example, increased from 1.6 to 2.6 inches. Please notice that final estimates at this location may change as we apply regional frequency analysis methods and optimize quantiles to assure smooth transition across all durations. This newly digitized hourly data affected AMS at daily durations, as well; for example, 1935 and 1937 1-day AMS numbers for the Ithaca station nearly doubled and in fact 1935 value ended up being the highest 1-day AMS.

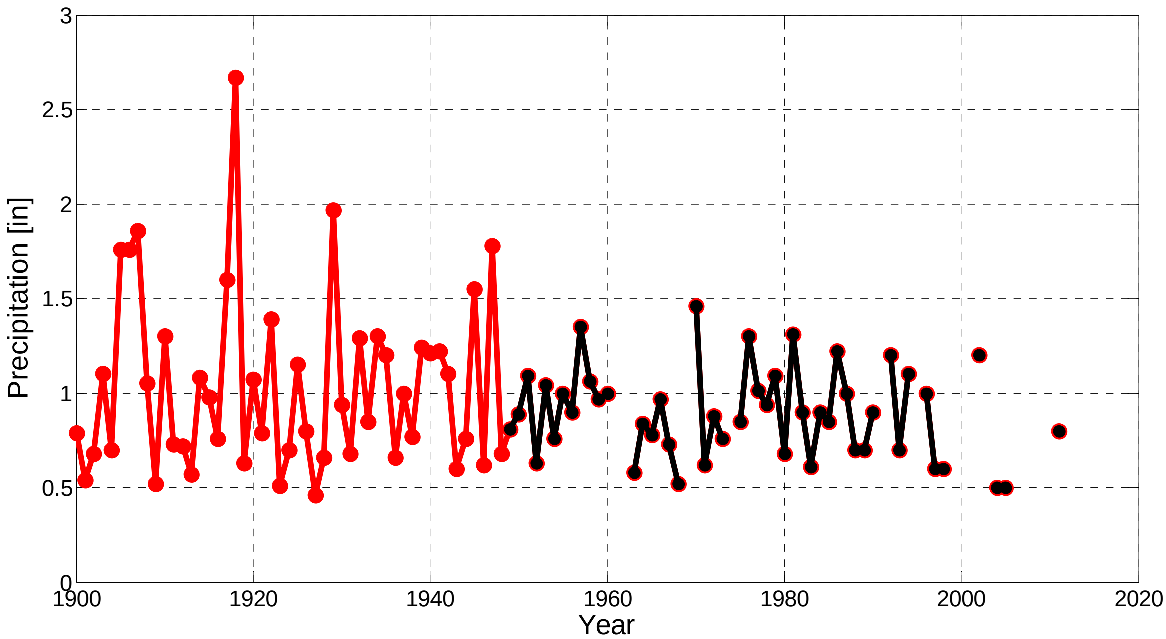

Figure 3. 1-hr AMS for the Ithaca, NY station. The left part of the time series in red represents the AMS from newly digitized data, while the time series in black is the original record.

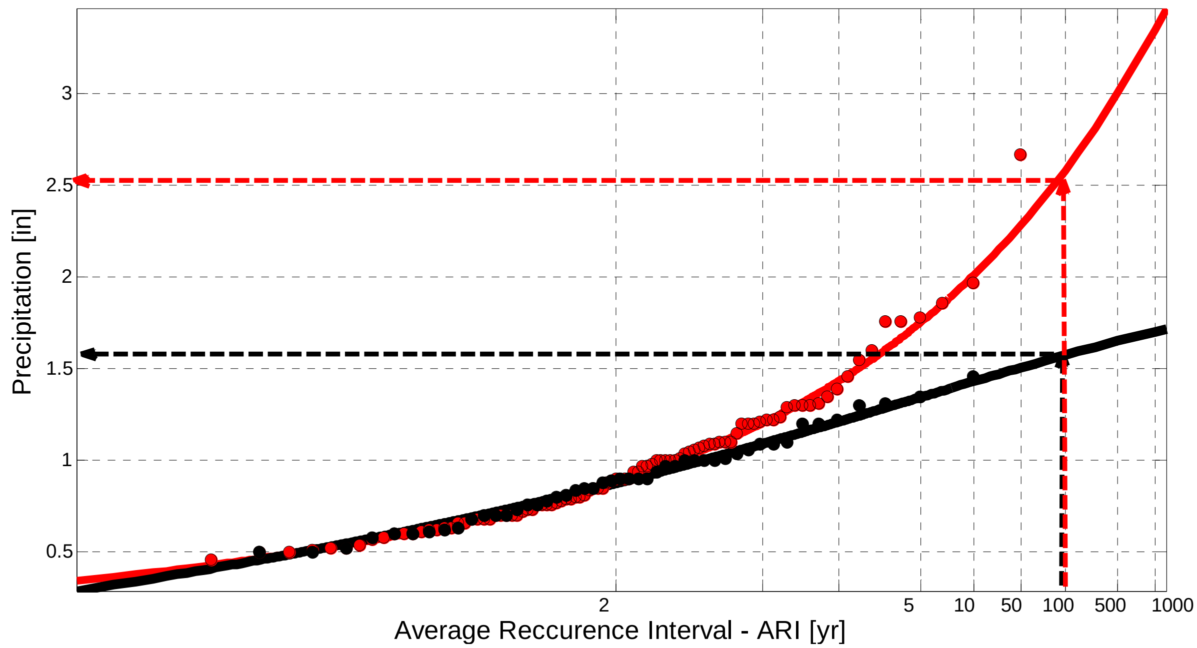

Figure 4. 1-hour precipitation frequency estimates for the Ithaca, NY station. Black curve shows estimates obtained from the original dataset, and red estimates from the AMS with the newly digitized data. Red and black dots represent corresponding AMS data.

1.1.2 Interpolation of mean annual maxima and precipitation frequency estimates

During this reporting period, we finalized mean annual maxima (MAM) grids at 30 arc-sec resolution. Grids were developed from at-station MAM values by the Oregon State University's PRISM Climate Group using their hybrid statistical-geographic approach for mapping climate data named Parameter-elevation Regressions on Independent Slopes Model (PRISM). Several iterations are typically needed to ensure realistic spatial patterns and consistency in gridded MAMs for 15 selected durations from 15 minutes to 60 days (15-min, 30-min, 1-hr, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, 2-day, 4-day, 7-day, 20-day, 30-day, 45-day and 60-day). During this reporting period, we analyzed and revised three additional versions of MAM grids, until we were satisfied with spatial patterns across all durations.

In NOAA Atlas 14, the MAM grids together with at-station precipitation frequency estimates are basis for calculation of gridded precipitation frequency estimates and corresponding upper and lower bounds of the 90% confidence interval. Development of the precipitation frequency grids from the MAM grids for each frequency utilizes the inherently strong linear relationship that exists between mean annual maxima and precipitation frequency estimates for the 2-year average recurrence interval (ARI), as well as between precipitation frequency estimates for consecutive ARIs. First, we reviewed spatial patterns for the 2-year, 100-year and 1000-year grids, and revisited and improved at-station and regional estimates where needed. The resulting adjustments were then carried through to other recurrence intervals in an iterative process.

To achieve smoother spatial results, HDSC applied a dynamic filter to precipitation frequency grids calculated from MAM grids. Parameters of the filter, which control the amount of smoothing, are a function of elevation gradients and proximity to the coastline. Parameters were selected such that maximum smoothing is applied in flat terrain, no smoothing is applied in the mountains and in coastal areas, and the transition from no smoothing to maximum smoothing is gradual. Minor adjustments were made to the parameters of the filter during this quarter. The filter was applied to grids for all ARIs. More information on this method will be provided in the Volume 10 document, which will be available for download from the PFDS web page by the end of 2015 (in the meantime, please check NOAA Atlas 14 Volume 9 document for more information on the interpolation technique).

1.1.3 Precipitation frequency estimates for sub-hourly durations

After careful investigation of 15-minute and 30-minute MAM grids developed by the PRISM Climate Group and analogous grids developed through an alternative method based on spatial interpolation of 15-min (30-min) and 60-min MAM ratios, we adopted MAM grids developed through the latter method.

Precipitation frequency grids for 15-minute (30-minute) duration were derived by assuming that relationships used to derive grids of 60-minute precipitation frequency estimates are applicable for the 15-minute (30-minute) estimates. The assumption was tested on stations that had data at sub-hourly durations and was found to be acceptable. Therefore, the ratio grids based on the 60-minute duration developed between mean annual maxima (MAMs) and precipitation frequency estimates for the 2-year ARI, as well as between precipitation frequency estimates for consecutive ARIs, were applied in the same cascading fashion to the 15-minute and 30-minute grids.

The 15-minute precipitation frequency grids were then multiplied by previously computed scaling factors to develop precipitation frequency grids for the 10-minute and 5-minute durations, respectively.

1.1.4 Temporal distributions of heavy precipitation

HDSC computed temporal distributions of precipitation amounts for 6-, 12-, 24-, and 96-hour durations exceeding corresponding magnitudes for 2-year average recurrence interval. The temporal distributions are expressed in probability terms as cumulative percentages of precipitation totals at various time steps. To provide detailed information on the varying temporal distributions, separate temporal distributions were also derived for four precipitation cases defined by the duration quartile in which the greatest percentage of the total precipitation occurred. Stations were grouped into five climate regions and separate temporal distributions were derived for each climate region. The climate regions were delineated based on extreme precipitation characteristics expressed through 24-hour MAM, mean annual precipitation (MAP) and elevation.

1.1.5 Rainfall frequency analysis

Precipitation frequency estimates represent precipitation magnitudes regardless of the type of precipitation. For some applications it may be important to differentiate total precipitation (which may include snow) frequency estimates from liquid precipitation (i.e., rainfall) only. To explore differences in total and liquid-only precipitation frequency estimates, concurrent rainfall and precipitation AMS were extracted. We conducted the rainfall frequency analysis for durations up to 24 hours, which are of most interest to design projects relying on peak flows.

Rainfall amounts for 24-hour duration were calculated for stations that have concurrent daily precipitation and snowfall measurements. Recorded snowfall amounts were first converted to snow water equivalent using the 10 to 1 rule, which assumes that the density of water is 10 times the density of snowfall. Rainfall amounts were then calculated as a difference between precipitation and snow water equivalent.

Since snow and temperature measurements were not available for hourly durations, we used daily maximum and minimum temperature measurements from co-located daily stations to classify precipitation amounts as solid or liquid. Precipitation that occurred when the daily maximum temperature was above 34^0 F was considered rainfall. Precipitation that occurred when the temperature was equal to or below that threshold was considered snowfall.

Frequency analysis was done on at-station rainfall-only AMS and on total precipitation AMS. A comparison between precipitation and rainfall frequency estimates revealed that for this project area differences between precipitation and rainfall frequency estimates are insignificant.

1.2 PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Jul - Sep 2015)

During the next reporting period, we'll develop final grids of PDS-based and AMS-based precipitation frequency estimates and corresponding bounds of 90% confidence interval. We expect to publish estimates on the PFDS around September 30th. We'll also work on the accompanying documentation, which will be published in late October.

1.3 PROJECT SCHEDULE

Data collection, formatting, and initial quality control [Complete]

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) [Complete]

Regionalization and frequency analysis [Complete]

Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [Complete]

Peer review [Complete]

Revision of PF estimates [Complete]

Remaining tasks (e.g., development of gridded precipitation frequency estimates, confidence intervals, development of PFDS web pages) [August 2015]

Web publication of estimates [around September 30th, 2015]

Web publication of Volume 10 documentation [October 2015]

2. NOAA ATLAS 14 VOLUME 11: PRECIPITATION FREQUENCY PROJECT FOR TEXAS

2.1 PROGRESS IN THIS REPORTING PERIOD (Apr - Jun 2015)

NOAA Atlas 14, Volume 11 precipitation frequency project includes the state of Texas and approximately a 1-degree buffer around this state (Figure 5). This project started in May 2015 and is expected to be completed in mid-2018.

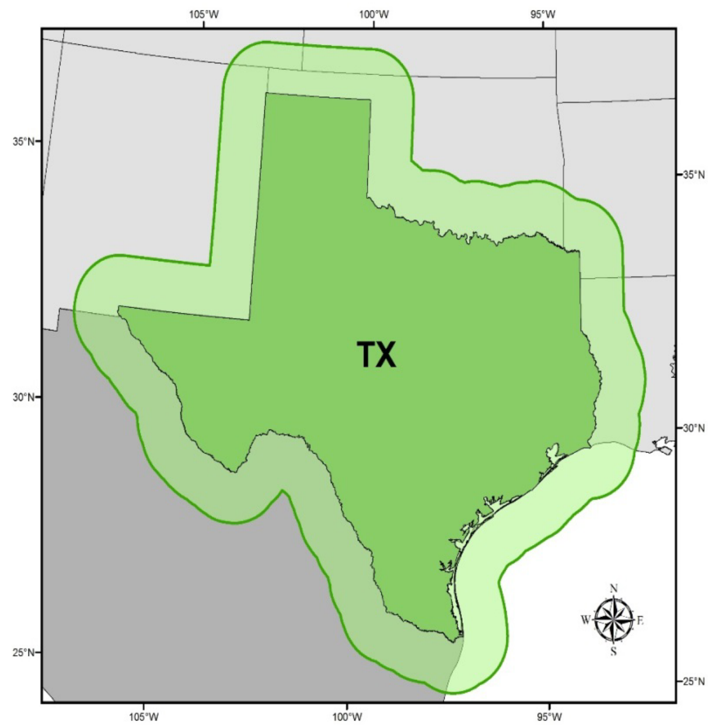

Figure 5. NOAA Atlas 14, Volume 11 project area (shown in green).

2.1.1. Data collection and data screening

In this reporting period, we started data collection process. The primary source of data for NOAA Atlas 14 Volumes is the NOAA's National Centers for Environmental Information (NCEI)[2], but it is recognized that the NCEI's precipitation data may not be sufficient to accomplish the objectives of NOAA Atlas 14. 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.) in Texas, as well as adjacent portions of neighboring USA states (Arkansas, Louisiana, New Mexico, and Oklahoma) and also in Mexico.

[2] *NOAA's former three data centers: the* National Climatic Data Center (NCDC)*, the* National Geophysical Data Center*, and the* National Oceanographic Data Center*, have merged into the National Centers for Environmental Information (NCEI).*

In early 2015, we sent an email through our list server, asking our partners for assistance with the data. So far, we received responses from the NWS Southern Region's Headquarters and several field offices, NOAA's National Severe Storms Laboratory, Oklahoma Climatological Survey, USGS Lubbock Texas Field Office and Lower Mississippi-Gulf Water Science Center, Texas Sate Climate Office, West Texas Mesonet, Trinity Watershed Management (City of Dallas), Urban Flood Control Rainfall Network (Harris, Montgomery, Travis, Bexar Counties). We are reviewing the information received and contacting other agencies which were indicated as additional sources of potentially useful data. We would like to thank all of those who responded to our inquiry. We welcome any information on the data for this project area, so if you have any relevant information, please contact us at HDSC.Questions@noaa.gov.

2.2 PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Jul - Sep 2015)

The main focus for the next period will be data collection and reformatting. All collected data will be examined and formatted in a common format, where appropriate. We'll also start work on AMS extraction and initial quality control of station metadata.

2.3 PROJECT SCHEDULE

Data collection, formatting, and initial quality control [February 2016]

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) [January 2017]

Regionalization and frequency analysis [March 2017]

Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [June 2017]

Peer review [August 2017]

Revision of PF estimates [January 2018]

Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [March 2018]

Web publication [April 2018]