HYDROMETEOROLOGICAL DESIGN STUDIES CENTER

QUARTERLY PROGRESS REPORT

1 April to 30 June 2017

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

July 2017

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 mid-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.

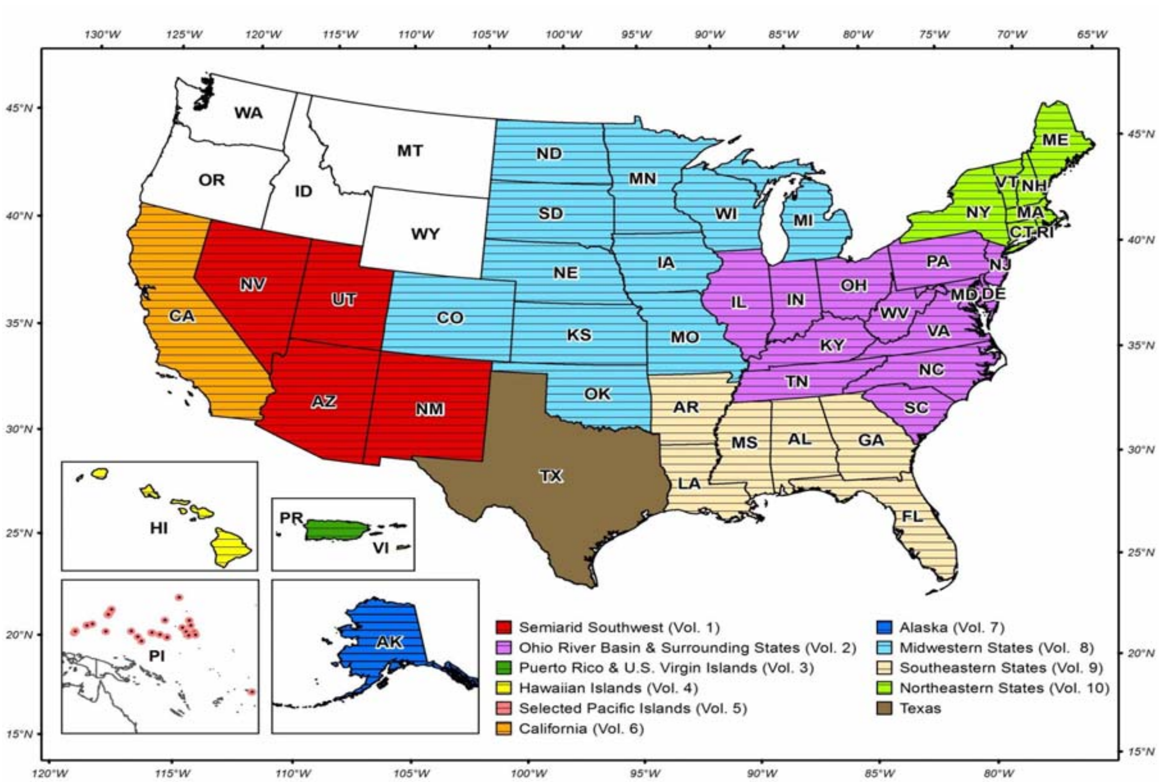

Figure 1. Current project area for Volume 11 (TX) and project areas included in published Volumes 1 to 10.

II. CURRENT PROJECTS

1. PRECIPITATION FREQUENCY PROJECT FOR THE NORTHEASTERN STATES

1.1 PROGRESS IN THIS REPORTING PERIOD (Apr - Jun 2017)

Precipitation frequency estimates for the following seven northeastern states: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont were published on September 30, 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 Precipitation Frequency Data Server (PFDS).

After restarting the work on documentation in the previous quarter, work was put on hold once more until some remaining funding issues are resolved.

1.2 PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Jul - Sep 2017)

We anticipate that the remaining funding issues will be resolved in a month or two and that we will be able to resume work on documentation.

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, and development of PFDS web pages) [Complete]

Web publication of estimates [Complete]

Web publication of Volume 10 document [TBD]

2. PRECIPITATION FREQUENCY PROJECT FOR TEXAS

2.1 PROGRESS IN THIS REPORTING PERIOD (Apr - Jun 2017)

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).

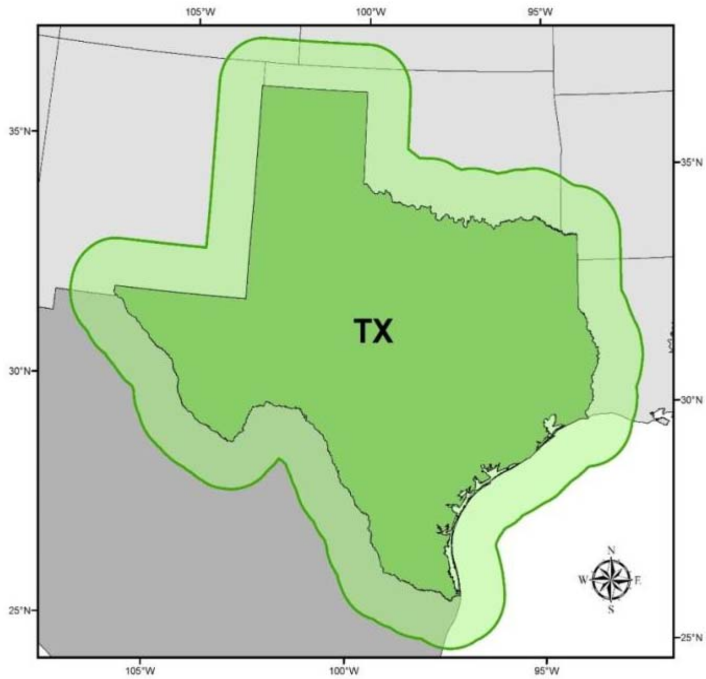

Figure 2. NOAA Atlas 14, Volume 11 extended project area.

The primary source of data for NOAA Atlas 14 Volumes is the 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. 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 inquiry and/or provided the data. We have formatted and retained data for more than 10,000 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. For more information on additional datasets that were collected but will not be used in the analysis, locations of stations that will be considered in frequency analysis, together with locations of all formatted stations per recording period please see previous report.

During this reporting period we sent at-station mean annual maximum (MAM) estimates for selected hourly and daily durations to the Oregon State University's PRISM Climate Group for high-resolution spatial interpolation using their hybrid statistical-geographical approach for mapping climate data. While we are waiting for PRISM products, we continued work on data quality control, spatial analysis of mean annual maxima for selected durations and regionalization tasks. The individual sections below describe in more detail the major tasks performed during this reporting period.

Table 1. List of formatted datasets.

Source of data: dataset/network name	**ID (first 2 digits)**	**Recording period**
NCEI: Automated Surface Observing System (ASOS)	78	1-min
NCEI: DSI 3260	03,05,14,16, 29,34,41	15-min
NCEI: DSI 3240	03,05,14,16, 29,34,41	1-hr
NCEI: Global Historical Climatology Network (GHCN)	03,05,14,16,29, 34,41,69,79,90	1-day
NCEI: Integrated Surface Data (Lite)	64	1-hr, 1-day
NCEI: Quality Controlled Local Climatological Data (QCLCD)	56	1-hr
NCEI: Unedited Local Climatological Data (ULCD)	55	1-hr
City of Austin ALERT Network	65	varying
City of Dallas ALERT Network	81	varying
Edwards Aquifer Authority	62	1-hr
Guadalupe-Blanco River Authority	77	6-min
Harris County Flood Control District's Flood Warning System	60	varying
Jefferson County Drainage District 6 ALERT Precipitation and Stream Level Network	82	varying
Lower Colorado River Authority Regional Meteorological Network	63	varying
Midwestern Regional Climate Center: CDMP 19th Century Forts and Voluntary Observers Database	52	1-day
National Atmospheric Deposition Program (NADP)	54	1-day
National Estuarine Research Reserve System (NERRS)	57	15-min, 1-hr
NWS Hydrometeorological Automated Data System	85	1-hr
Oklahoma Mesonet Observation Network	86	5-min, 1-day
San Antonio River Authority	91	varying
Sabine River Authority Precipitation Dataset	58	1-day
Servicio Meteorologico Nacional, Mexico	61	1-day
Tarrant Regional Water District (Greater Fort Worth area)/Tarrant County Urban Flood Control Network	83	15-min, 1-hr
Texas Commission on Env. Quality: Air Quality Network	75	1-hr
Texas Evapotranspiration Network	89	1-hr, 1-day
Texas Water Development Board (TWDB)	84	1-hr, 1-day
Titus County Fresh Water Supply District No. 1	53	1-day
U.S. Bureau of Reclamation: HydroMet	87	1-hr, 1-day
US Dept. of Agriculture (USDA): Agricultural Research Service (ARS)	94	varying
USDA, Forest Service: Remote Automated Weather Station (RAWS) Network	76	1-hr
USDA , National Resources Conservation Service (NRCS): Soil Climate Analysis Network (SCAN)	88	1-hr
USGS Nation Water Information System (NWIS)	59	15-min
USGS Hydrologic Data for Urban Studies in Texas	66	1-day
West Texas Mesonet	80	1-min, 15-min

2.1.1. Station cleanup

The station cleanup and merges were re-evaluated for all formatted stations. During this period we concentrated on removing shorter, less reliable records in station-dense areas.

2.1.2. Annual maximum series (AMS) quality control

AMS data identified as questionable were carefully investigated and either corrected or removed from the AMS if due to measurement errors. For more information on the AMS extraction and quality control, see previous report.

2.1.3. Spatial interpolation and analysis of mean annual maximum (MAM) data

During this reporting period we sent at-station mean annual maximum (MAM) estimates for selected hourly and daily durations to the Oregon State University's PRISM Climate Group for high-resolution spatial interpolation using their hybrid statistical-geographical approach for mapping climate data.

While we are waiting for PRISM products, we continue spatial analysis of at-station MAM estimates for 1-hour, 1-day and 10-day durations. During this analysis, MAM data for each station is reviewed for inconsistencies relative to MAMs at nearby stations. The goal is to identify locations where MAMs are affected by short periods of record or missed extreme amounts. Flagged MAMs are investigated and either adjusted or removed from the analysis. Development of final gridded MAM estimates will require several iterations with the PRISM group.

2.1.4. Regionalization

Regional approaches to frequency analysis use data from stations that are expected to have similar frequency distributions to yield more accurate estimates of extreme quantiles than approaches that use only data from a single station. The region of influence approach used in this volume defines regions such that each station has its own region with a potentially unique combination of nearby stations.

During this reporting period, we continued work on the regionalization task. Initial regions for each station are formed by grouping the closest 20 stations. Each region is then revised based on examination of stations' distances from a target station, elevation differences, inspection of their locations with respect to mountain ridges, and assessment of similarities/dissimilarities in the progression of relevant L-moment statistics across durations. During this process, some inconsistent stations are removed from the analysis, particularly in dense network areas where nearby stations have much longer records.

2.2 PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Jul - Sep 2017)

In the next reporting period we will complete the regionalization task and analysis of spatial patterns in mean annual maxima. We will derive and investigate depth-duration-frequency curves at gauged locations and interpolate estimates at a high resolution grid. We will start analysis of spatial patterns in 2-year and 100-year precipitation frequency estimates in preparation for the peer review of initial estimates that is expected to take place in October. The reviewers will be asked to provide feedback on the reasonableness of point precipitation frequency estimates, their spatial patterns, and station metadata.

2.3 PROJECT SCHEDULE

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

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) [Done]

Regionalization and frequency analysis [In progress; August 2017]

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

Peer review [October 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 of data [May 2018]

Web publication of documentation [June 2018]

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

The current NOAA Atlas 14 frequency analysis methods are based on the assumption of stationary climate in both historic and future precipitation records. As such, they may not be suitable for frequency analysis in the presence of non-stationary climate conditions. Since precipitation frequency estimates are crucial for engineering design, it is imperative that estimates are accurate, reliable, and reflect our best understanding of current and future potential risk from extreme precipitation events. It has thus become necessary to assess the potential for incorporating non-stationarity in precipitation frequency estimates.

As part of that effort, in 2015 the Federal Highway Administration (FHWA) tasked HDSC to conduct a pilot project to analyze the impacts of the stationarity assumption on precipitation magnitudes from NOAA Atlas 14. For the pilot project, we reviewed relevant literature, selected a frequency analysis method that was anticipated to be appropriate for distribution fitting under non-stationary conditions, and we performed initial analyses. Our preliminary findings were inconclusive and the pilot project ended with more questions than answers.

As a follow up to the pilot project, and with some funding provided by the FHWA, we continue to look into this issue. Our objective for this recently initiated project is to develop a modeling framework that will allow non-stationary climate effects to be integrated into the NOAA Atlas 14 process and that will also be applicable at a national scale and will produce credible precipitation frequency estimates which can be relied upon by Federal water agencies.

With that objective in mind, our goals for this project are (1) to assess, from a rigorous statistical perspective, the suitability of state of the art methodologies for non-stationary precipitation frequency analysis and to identify the most suitable method(s); (2) to test the feasibility of incorporating climate projections and to design a method to express future climate information in a format that may be applicable for use within precipitation frequency analysis; (3) to implement and test selected non-stationary precipitation frequency analysis method(s), per task 1, on a selected project area to derive precipitation frequency estimates using both historical data and future precipitation data derived from downscaled climate projections; (4) to assess the added value of new precipitation frequency estimates with respect to traditional NOAA Atlas 14 precipitation frequency estimates for the selected area and to recommend a non-stationary frequency analysis approach that will be appropriate for larger scale projects.

To meet the objective of this project, we will work in close collaboration with academia in development and value assessment of different products and methodologies.

During this reporting period, we worked on task (1) assessing the suitability of state of the art methodologies for non-stationary precipitation frequency analysis and identifying the most suitable method(s) with respect to NOAA Atlas 14. On this task we teamed up with the Penn State University team lead by Drs. Shaby and Mejia.

We also worked on the Statement of Work for task (2): testing the feasibility of incorporating climate projections in NOAA Atlas 14 precipitation frequency analysis. On this task we expect we will work in partnership with the University of Illinois, Urbana-Champaign team lead by Drs Markus, Angel and McConkey.

We anticipate reporting on this project in the next quarterly progress report.

III. OTHER

1. EXCEEDANCE PROBABILITY ANALYSIS FOR SELECTED STORM EVENTS

HDSC creates maps of annual exceedance probabilities (AEPs) for selected significant storm events for which observed precipitation amounts for at least one duration have AEP of 1/500 or less over a large area. 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 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 do not represent isohyets at any particular point in time, but rather within the whole event. The maps, usually accompanied with extra information about the storm, are available for download from the following page: AEP Storm Analysis. During this reporting period, we analyzed annual exceedance probabilities (AEPs) of the worst case rainfall covering states of Illinois, Indiana, and Missouri that occurred in late April to early May of 2017.

The heavy rains during the two week period, late April to early May, 2017, caused devastating flooding in the five states: Oklahoma, Arkansas, Illinois, Indiana, and Missouri. The high flood levels resulted in the loss of human life and destruction of private and public property, and infrastructure. HDSC analyzed annual exceedance probabilities (AEPs) for this event for a range of durations and determined that the 48-hour period (from April 28 to May 2, 2017) showed the lowest exceedance probabilities for the largest area. Areas that experienced the maximum 48-hour rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1000 (0.1%) are shown on the map in Figure 3.

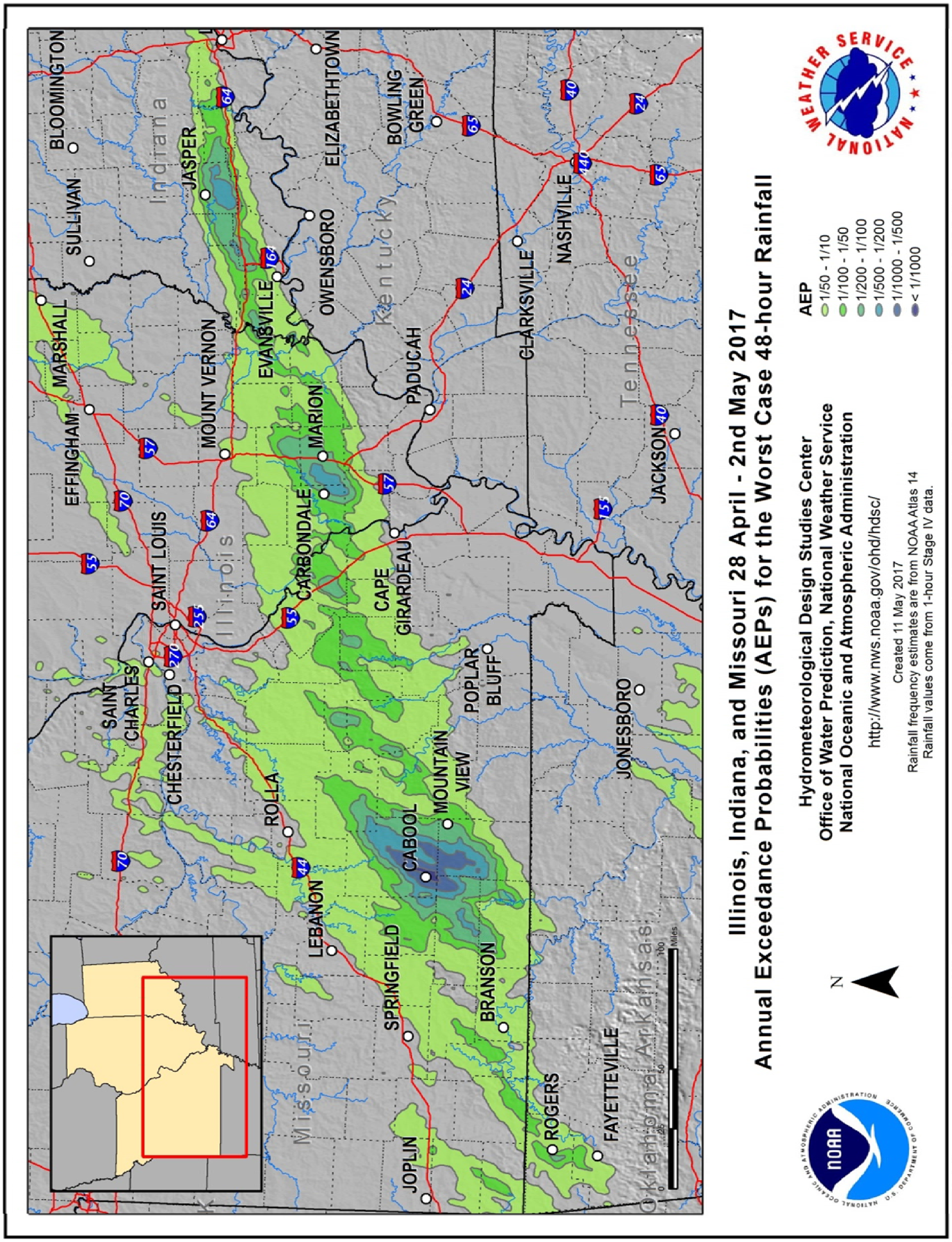

Figure 3. Annual exceedance probabilities for the worst case 48-hour rainfall between April 28 and May 2, 2017 for Illinois, Indiana, and Missouri.

2. RECENT MEETINGS AND CONFERENCES

HDSC group member Sandra Pavlovic gave a presentation titled “Improving NOAA Atlas 14 Precipitation Frequency Analysis Methods in Response to Non-Stationary Climate Conditions” at the EWRI’s World Environmental & Water Resources Congress, in Sacramento, 21-25 May 2017.

Ms. Pavlovic gave a similar presentation, titled “Impact of Non-Stationary Climate Conditions on Extreme Precipitation Frequency Estimates Needed for Engineering Design,” at the workshop on “Engineering Methods for Precipitation under a Changing Climate.” in Reston, VA on May 30th. This workshop was organized by the Subcommittee on Hydroclimatology and Engineering Adaptation (HYDEA) of the Committee on Adaptation to a Changing Climate (CACC) of the American Society of Civil Engineers (ASCE).