HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
QUARTERLY PROGRESS REPORT

1 July 2012 to 30 September 2012

Office of Hydrologic Development

National Weather Service

National Oceanic and Atmospheric Administration

U.S, Department of Commerce

Silver Spring, Maryland

October 2012

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 Hydrologic Development of National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) is 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. The Atlas is divided into volumes based on geographic sections of the country and affiliated territories. NOAA Atlas 14 is a web-based document available through the Precipitation Frequency Data Server (PFDS; http://hdsc.nws.noaa.gov/hdsc/pfds/index.html).

HDSC is currently updating estimates for the following southeastern states: Alabama, Arkansas, Georgia, Florida, Louisiana and Mississippi, and the following midwestern states: Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin. Contracts have been finalized with the Federal Highway Administration's (FHWA) Pooled Fund Program and we are also beginning work to update estimates for the following northeastern states: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. Figure 1 shows new project areas as well as updated project areas included in NOAA Atlas 14, Volumes 1 to 7.

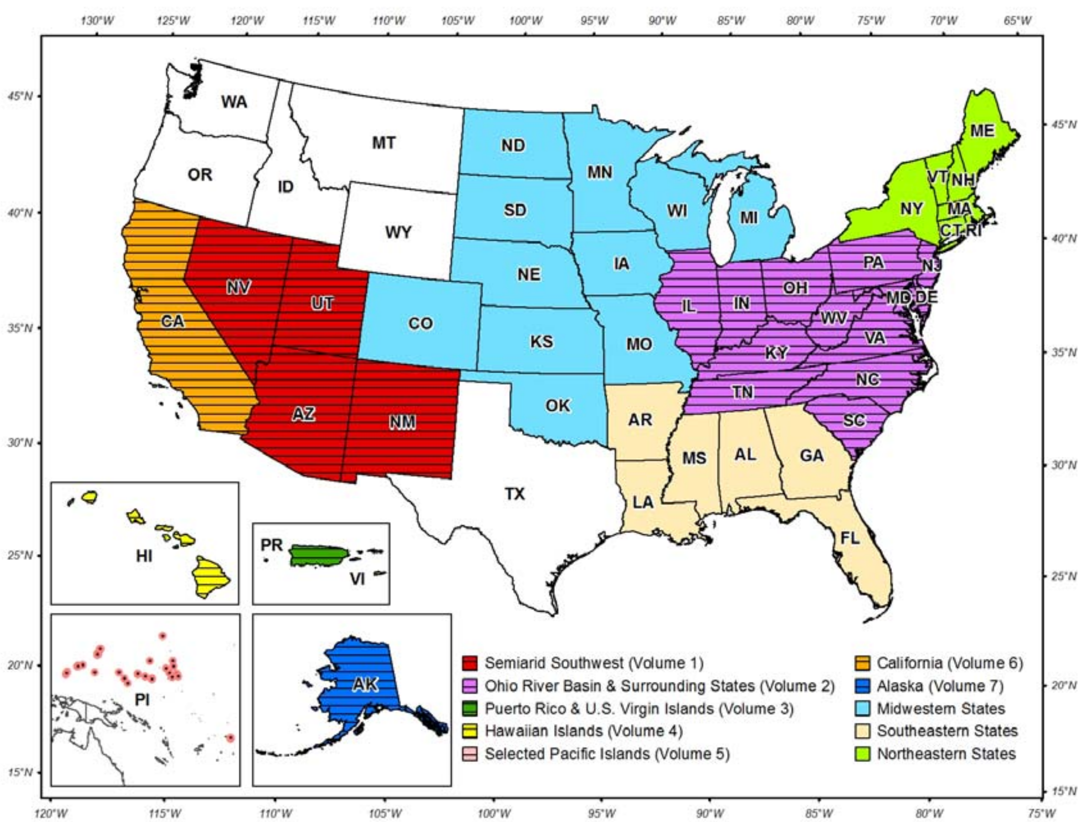

Figure 1. Current project areas and project areas included in published NOAA Atlas 14, Volumes 1-7.

II. CURRENT PROJECTS

1. PRECIPITATION FREQUENCY PROJECTS FOR THE MIDWESTERN AND SOUTHEASTERN STATES

1.1. PROGRESS IN THIS REPORTING PERIOD (Jul - Sep 2012)

To facilitate a more efficient process, the Midwestern and Southeastern precipitation frequency projects are being done simultaneously. Because of that, the results shown in this section apply for both projects. Both project areas are shown in Figure 2.

The Midwestern project area includes the states of Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin and an approximately 1-degree buffer around these core states.

The Southeastern project includes the states of Alabama, Arkansas, Florida, Georgia, Louisiana and Mississippi and an approximately 1-degree buffer around these core states.

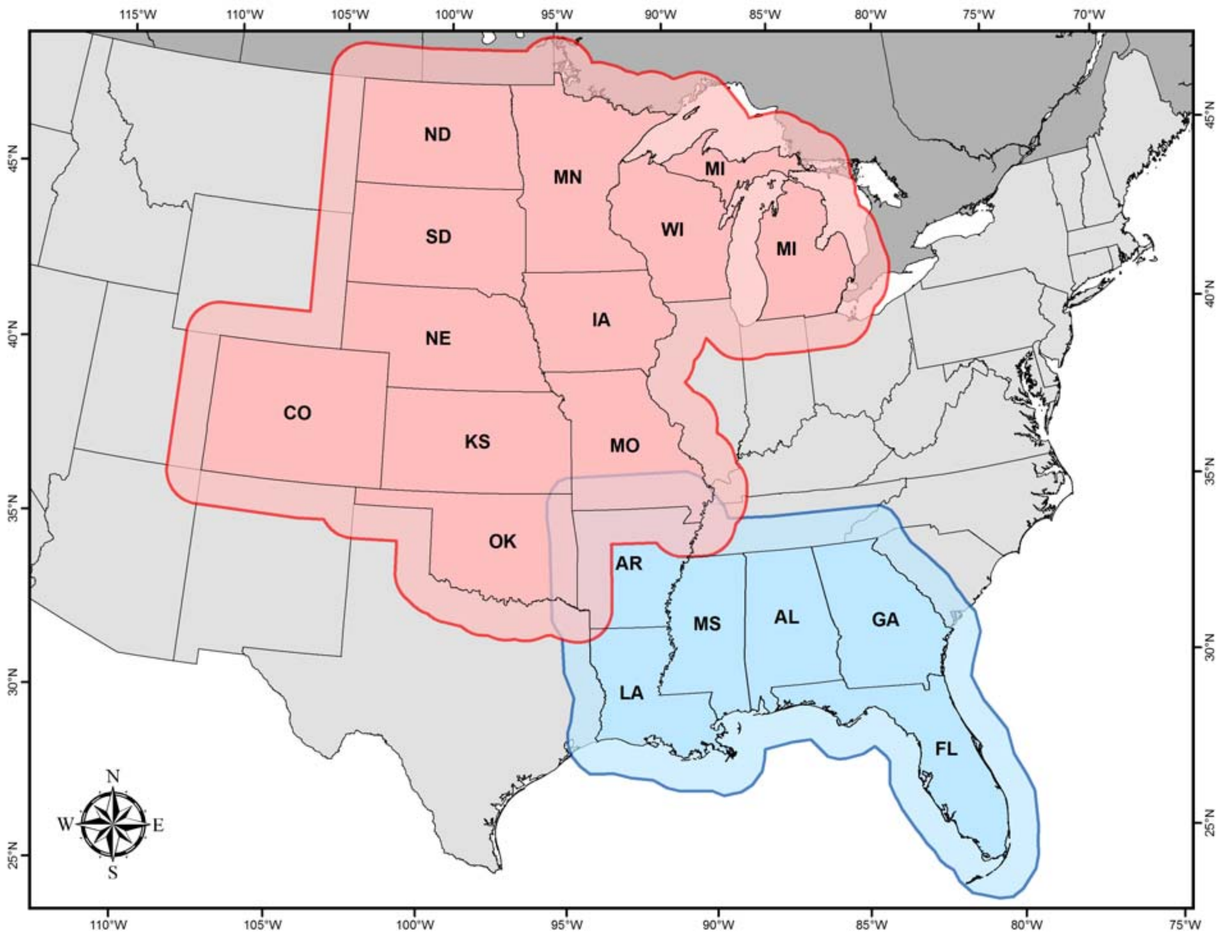

Figure 2. Midwestern precipitation frequency project areas (red) and Southeastern precipitation frequency project area (blue).

1.1.1. Peer review

A peer review of precipitation frequency estimates has begun and it will conclude on November 16th. Access to the review materials can be found at peer review page. The review includes the following items:

- Station metadata
    - *Metadata for stations whose data were used to prepare mean annual maximum precipitation maps and/or precipitation frequency estimates*. The list includes information on station name, state, source of data, assigned station ID, latitude, longitude, elevation, and period of record. It also shows if the station was merged with another station and if metadata at the station were changed;
    - *Metadata for stations whose data were collected and examined, but not used in the analysis*. This list contains basic metadata for stations that were not used and the reason why (e.g., because there was another station with a longer period of record nearby, or station data were assessed as not reliable for this specific purpose, or the station period of record was not long enough and it was not a candidate for merging with any nearby station);
- At-station depth-duration-frequency (DDF) curves
    - *DDF curves for stations used in analysis for durations between 1-hour and 10-days and for average recurrence intervals from 2-year through 100-year*;
- Cartographic maps
    - *Maps of spatially-interpolated mean annual maxima for 60-minute, 24-hour and 10-day durations;*
    - *Maps of spatially-interpolated 2-year and 100-year precipitation frequency estimates for 60-minute, 24-hour and 10-day duration.*

1.1.2. Analysis of spatial patterns of mean annual maxima

Mean annual maximum (MAM) grids serve as the basis for deriving gridded precipitation frequency estimates at different frequencies and durations. The MAM grids were developed from at-station MAM values by 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). PRISM used a grid of mean annual precipitation as the foundation for the MAM grids. Both the 1971-2000 and 1981-2010 climatology periods were reviewed for use and found to produce similar results. We decided to use the more recent climatology period for this analysis.

HDSC evaluated spatial patterns in intermediate MAM grids for the 1-hour, 1-day and 10-day durations. In particular, we investigated cases identified by the PRISM Climate Group where the at-station MAM was more than 10% different than the expected MAM determined by jackknife analysis. As a result of our review, some MAM estimates were adjusted or added to the dataset to better anchor the spatial interpolation in areas of varied terrain and/or where the lack of stations or short records unduly influenced expected spatial patterns, particularly at hourly durations. In some cases where PRISM produced a better result, stations were removed from the set of MAMs to be interpolated. We made several iterations with the PRISM Group to ensure satisfactory MAM patterns.

There were three notable changes to the MAM data set:

(1) To anchor points in the Colorado mountains, 51 daily SNOTEL stations with at least 20 years of data, which were previously deleted due to relatively short records, were added back to the dataset. Their MAM estimates were reviewed for consistency with expectations.

(2) Discussions with the United States Geological Survey (USGS) Water Science Center of South Dakota suggested that the Black Hills of South Dakota are prone to significant events. To capture this effect, HDSC first ensured that all significant precipitation events were included in the database and then added so-called pseudo-stations to anchor the interpolation in this area.

(3) Lastly, to reduce a number of station-driven "bulls' eyes" in MAM maps primarily due to differences in periods of record, it was decided to exclude daily-only stations with less than 50 years of data in areas of flat terrain and high density of stations from the MAM interpolation only.

1.1.3. Regionalization and at-station precipitation frequency analysis

As mentioned above, to help anchor the spatial interpolation of mean annual maxima and precipitation frequency estimates in the Colorado mountains, 51 daily SNOTEL stations with at least 20 years of annual maximum series (AMS) data were added back to the analysis. Originally these stations were removed for having less than 30 data years. After review, 42 of the 51 stations were retained in the database. Regions were created for each of those 42 stations (using the region-of-influence method described in the previous Quarterly Report, http://www.nws.noaa.gov/oh/hdsc/current-projects/progress/201207_HDSC_PR.pdf) for use in precipitation frequency estimation.

Precipitation frequency estimates for all 4,567 stations in the database were computed using a regional frequency analysis approach based on L-moment statistics, where statistics were weighted by record lengths. At-station MAMs were replaced with the interpolated MAMs from the PRISM grids for consistency. In most cases, the observed at-station MAMs and PRISM MAMs were the same or very similar.

1.1.4. Interpolation and analysis of spatial patterns in 100-year estimates

The spatial interpolation method first used in Volume 7 for Alaska was used to convert mean annual maximum grids into grids of precipitation frequency estimates in the Midwest and Southeast project areas for the Peer Review. The technique derives grids along the frequency dimension with station precipitation frequency estimates for different durations being separately interpolated. It uses the inherently strong (zero-intercept) linear relationship that exists between consecutive precipitation frequency estimates, as well as precipitation frequency estimates and mean annual maxima (MAM) for a given duration. Since these relationships (i.e., ratios) can show regional characteristics, spatial interpolation of the ratios can retain any regional effect.

Ratios between MAM estimates and corresponding 2-year precipitation frequency estimates, and then between precipitation frequency estimates at consecutive recurrence intervals for each station were spatially interpolated to a grid by applying MATLAB's natural neighbor interpolation scheme. Natural neighbor is a local interpolation scheme that uses a subset of input points near the target location and weights them based on the overlap of Thiessen polygons drawn around the input points and the target location. It remains true to the values at the input station locations. Gridded MAM estimates were then multiplied by corresponding gridded ratios to create a grid of precipitation frequency estimates for each average recurrence interval.

Maps of the resulting estimates for the 2-year and 100-year ARIs at the 1-hour, 1-day and 10-day durations were analyzed for inconsistencies relative to expected spatial patterns. Inconsistent estimates or patterns were resolved on a case-by-case basis in various ways: by manually adjusting the value to reflect expected patterns, omitting the station from the analysis, or by adding anchoring estimates at critical ungauged locations.

1.1.5. Rainfall frequency analysis

To explore differences in total and liquid-only precipitation frequency estimates, concurrent rainfall and precipitation AMS are being extracted at stations which have information useful for distinguishing the type of precipitation.

For daily NCDC and SNOTEL data, which contain records of precipitation and snowfall, recorded snowfall amounts were converted to snow water equivalent using the 10 to 1 rule, which assumes that the density of the snow is 1/10 of the density of water. Rainfall amounts were calculated as the difference between precipitation and snow water equivalent. Annual maximum series were extracted from resulting rainfall-only daily time series.

The ratio of precipitation to rainfall mean annual maxima were plotted on a map and reviewed for any spatial consistency. As expected, these preliminary results suggest that snowfall events are only significant in the Colorado region. The next steps will be to create 2-year and 100-year rainfall frequency estimates to compare with those of precipitation.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2012)

In the next reporting period, the peer review of precipitation frequency estimates at base durations (1-hour, 1-day and 10-day) will occur. HDSC will review and begin to address any comments received. Additionally, we will complete the following tasks: temporal distribution analysis, seasonality analysis and rainfall frequency analysis.

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, trend analysis, 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 [In progress]

Revision of PF estimates [November 2012]

Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [January 2013]

Web publication [March 2013]

2. PRECIPITATION FREQUENCY PROJECT FOR THE NORTHEASTERN STATES

2.1. PROGRESS IN THIS REPORTING PERIOD (Jul - Sep 2012)

The project area includes the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont and an approximately 1-degree buffer around these core states (Figure 3).

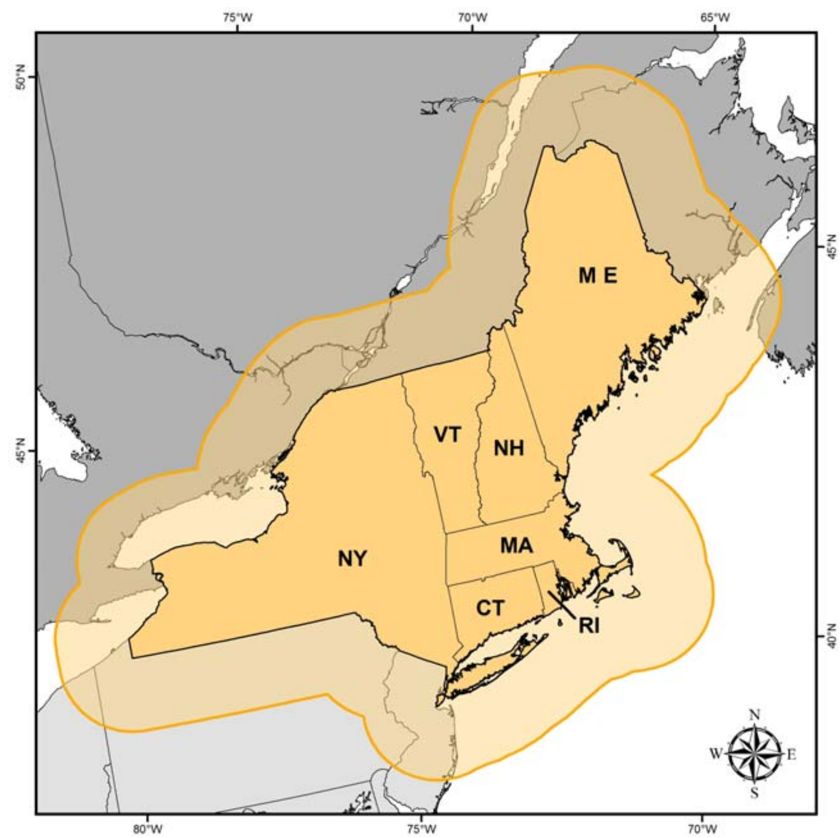

Figure 3. Northeastern precipitation frequency project area (shown in orange).

2.1.1. Data collection

The primary source of data is the National Climatic Data Center (NCDC), but digitized data measured at reporting intervals of 1-day or shorter are also being collected from known data sources. Significant progress was made collecting data during this reporting period (Table 1).

If you have any information about additional available data, please contact us at HDSC.Questions@noaa.gov.

Table 1. Sources of data for the precipitation frequency analysis and data collection progress.

Source	Reporting interval	Preliminary number of stations	Progress
Automated Surface Observing Systems (ASOS)	1-minute	42	Downloaded data from website.
Colorado Climate Center: Community Collaborative Rain, Hail and Snow Network (CoCoRaHS)	1-day	TBD	Corresponded with Center to consolidate data; data downloaded in bulk from FTP site.
Environment Canada	1-day 1-hour	TBD	Corresponded with agency; began identifying stations relevant to project area.
Global Summary of the Day (NCDC)	1-day	TBD	Downloaded data in bulk from FTP site.
Illinois State Water Survey: National Atmospheric Deposition Program (NADP) dataset	1-day	57	Downloaded data from website.
Massachusetts Department of Conservation and Recreation (DCR)	1-day	176	Received data on CD.
Mid-Atlantic River Forecast Center: Integrated Flood Observing and Warning System (IFLOWS) data	varies	TBD	Received data on DVD.
Midwestern Region Climate Center (MRCC): 19th Century Forts and Voluntary Observers Database	1-day	63	Corresponded with MRCC; downloaded data from FTP site.
National Climatic Data Center (NCDC)	1-day 1-hour 15-minute n-minute	3001 593 517 TBD	Downloaded data (except n-min) from website.
National Environmental Satellite, Data, and Information Service (NESDIS): U.S. Climate Reference Network (USCRN)	1-day 1-hour	11 11	Downloaded data from NCDC website.
National Resources Conservation Service (NRCS): Soil Climate Analysis Network (SCAN)	1-hour 1-day	6 6	Corresponded with NRCS; downloaded data from website.
Northeast Regional Climate Center (NRCC): CLimate Information for Management and Operational Decisions (CLIMOD)	1-day	TBD	No progress to report.
Rhode Island Department of Environmental Management, Office of Water Resources	1-hour	1	Received data via email.
U.S. Army Corps of Engineers	1-hour	n/a	Corresponded with USACE New England District; no suitable dataset available.
U.S. Department of Agriculture: Agricultural Research Service (ARS)	variable	23	Downloaded data from website; working to ascertain station metadata.
U.S. Forest Service: Remote Automated Weather Stations (RAWS) dataset	1-hour	TBD	Corresponded with Western Region Climate Center; currently downloading data from FTP site.
U.S. Geological Survey (USGS) Connecticut Water Science Center	1-day; 15-minute	TBD	No progress to report.
USGS Maine Water Science Center	1-day 15-minute	16 n/a	Corresponded with Center and received links; downloaded data from National Water Information System website.
USGS Massachusetts-Rhode Island Water Science Center	1-day 15-minute	11 5	Corresponded with Center; downloaded data from FTP site.
USGS New Hampshire-Vermont Water Science Center	1-day 15-minute	6 n/a	Corresponded with Center and received links; downloaded data from National Water Information System website.
USGS New York Water Science Center	1-day 15-minute	1 1	Corresponded with Center and received data via email.

2.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2012)

Data collection and formatting will continue. Quality control of the NCDC metadata will begin.

2.3. PROJECT SCHEDULE

Data collection, formatting, and initial quality control [June 2013]

Extraction of annual maximum series (AMS); additional quality control and data reliability tests (e.g., outliers, trend analysis, independence, consistency across durations, duplicate stations, candidates for merging) [December 2013]

Regionalization and frequency analysis [July 2014]

Initial spatial interpolation of precipitation frequency (PF) estimates and consistency checks across durations [December 2014]

Peer review [December 2014]

Revision of PF estimates [June 2015]

Remaining tasks (e.g., development of precipitation frequency estimates for partial duration series, seasonality, temporal distributions, documentation) [July 2015]

Web publication [September 2015]

3. AREAL REDUCTION FACTORS

3.1. PROGRESS IN THIS REPORTING PERIOD (Jul - Sep 2012)

Areal reduction factors (ARFs) are needed to convert average point precipitation frequency estimates to areal estimates with the same recurrence interval for any area of interest. HDSC is testing and comparing results from three existing ARF methods (Sivapalan and Bloschl, 1998; De Michele, Kottegoda and Rosso, 2001; Overeem et al., 2010) and a new copula-based ARF method based on Renard and Lang (2007). The methods explore using both, rain gauge and radar data.

Due to limited resources and higher priority precipitation frequency projects, during this reporting period, modest progress was made on comparing the four ARF methods using a test dataset in Oklahoma. The copula-based method was extended for hourly rain gauges and tested for use with annual maximum series data.

References:

De Michele, C., N. T. Kottegoda, and R. Rosso, 2001. The derivation of areal reduction factor of storm rainfall from its scaling properties. *Water Resources Research*, 37, 3247-3252.

Overeem, A, T.A. Buishand, I. Holleman, and R. Uijlenhoet, 2010. Extreme value modeling of areal rainfall from weather radar. *Water Resources Research, Vol. 46*.

Renard, B., and M. Lang, 2007. Use of a Gaussian copula for multivariate extreme value analysis: Some case studies in hydrology. *Advances in Water Resources*, 30, 897–912.

Rodriguez-Iturbe, I., and J. M. Mejia, 1974. On the transformation of point rainfall to areal rainfall. *Water Resources Research*, 10, 729-735.

Sivapalan M., and G. Bloschl, 1998. Transformation of point rainfall to areal rainfall: Intensity-duration-frequency curves. *Journal of Hydrology*, 204, 150-167.

3.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Oct - Dec 2012)

Limited activities are expected in the next reporting period to allow us to focus on precipitation frequency projects.

3.3. PROJECT SCHEDULE

It is expected that this project will be completed by the end of 2013.

III. OTHER

1. PERSONNEL

One member of HDSC resigned in August. Tasks have been redistributed to the remaining seven members of the group and to the Office of Hydrologic Development's Information Technology Support Group (ITSG).

2. WEBSITE UPDATES

We are redesigning some of the HDSC web pages and adding additional information.

- We have updated the record point precipitation measurements for the world and the USA pages.

- We are in the process of scanning and making available on-line all previous publications from this office. This includes all Technical Papers, Technical Memoranda, Technical Reports, and Hydrometeorological Reports dating back to 1938. We expect to have a majority of the documents from the Technical Papers series available on the HDSC web page during the next quarter.

3. STORM ANALYSIS

HDSC developed a map (Figure 4) for the NWS Cleveland Ohio Weather Forecast Office to be used in an outreach and flood awareness campaign based on the 100th anniversary of the historic Flood of 1913 in the Ohio Valley. The map shows the annual exceedance probabilities of the worst case 96-hour rainfall from that event. The flood, which occurred March 23-27, 1913 was one of the worst in Ohio's history with respect to weather-related deaths and destruction.

Rainfall amounts at 551 stations used in the analysis were obtained from the Global Historical Climatology Network (GHCN) managed by the National Climatic Data Center. It was verified that amounts provided by the NWS Forecast Office were included in the dataset. Frequency estimates were obtained from NOAA Atlas 14, Volume 2.

The worst case 96-hour period is not necessarily the same period of time at each location. As a result, this map does not represent isohyets at any particular point in time, but rather within the whole event.

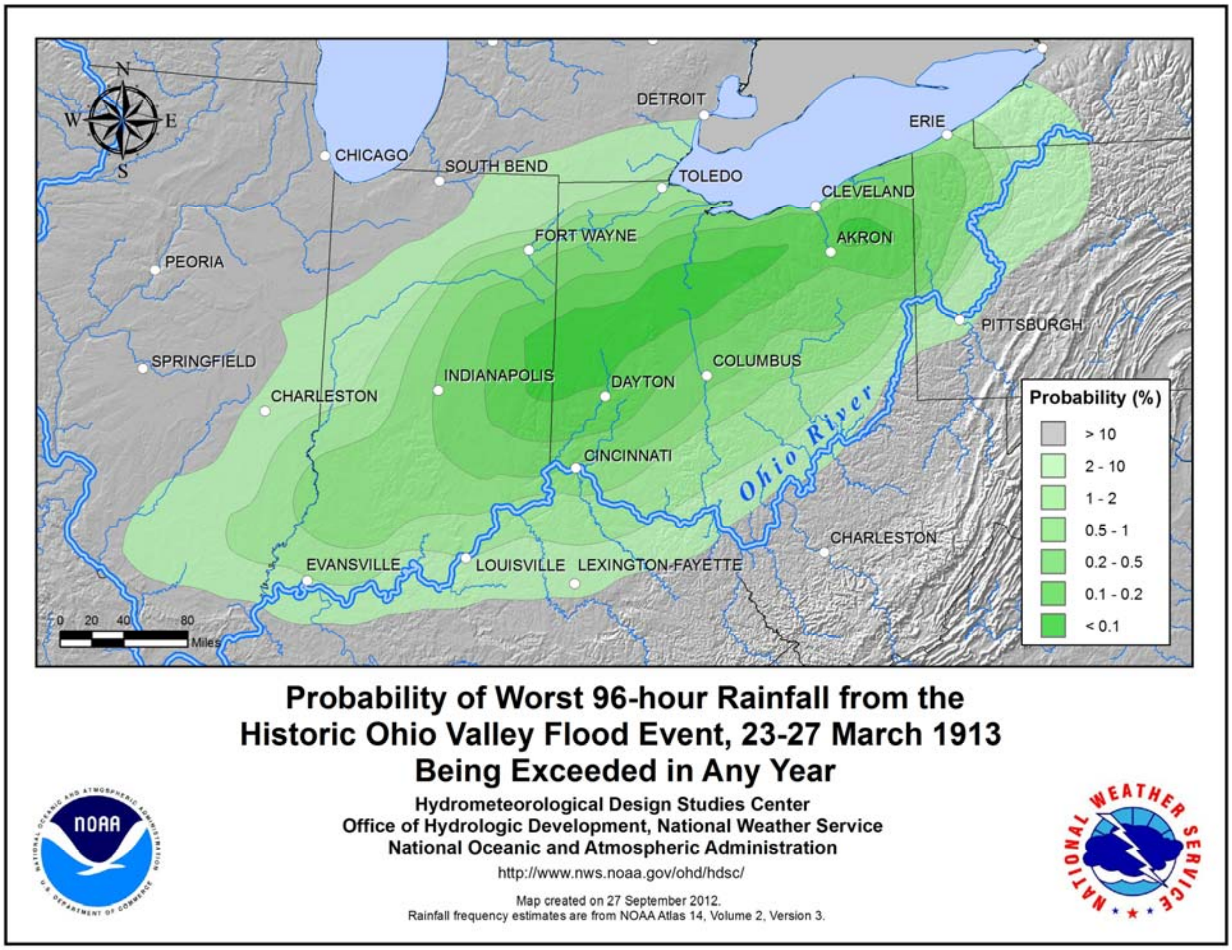

Figure 4. Annual exceedance probabilities for the worst case 96-hour rainfall from Ohio's 1913 historic flood.