HYDROMETEOROLOGICAL DESIGN STUDIES CENTER QUARTERLY PROGRESS REPORT

1 January 2010 to 31 March 2010

Office of Hydrologic Development

U.S. National Weather Service

National Oceanic and Atmospheric Administration

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DISCLAIMER

The data and information presented in this report are provided only to demonstrate current progress on the various technical 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 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. Updated precipitation frequency estimates for durations from 5 minutes to 60 days and selected average recurrence intervals (1-year to 1,000-years) accompanied by additional 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 (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html).

HDSC is currently updating estimates for California, Alaska, 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. Figure 1 shows new project areas as well as project areas included in NOAA Atlas 14, Volumes 1 to 5.

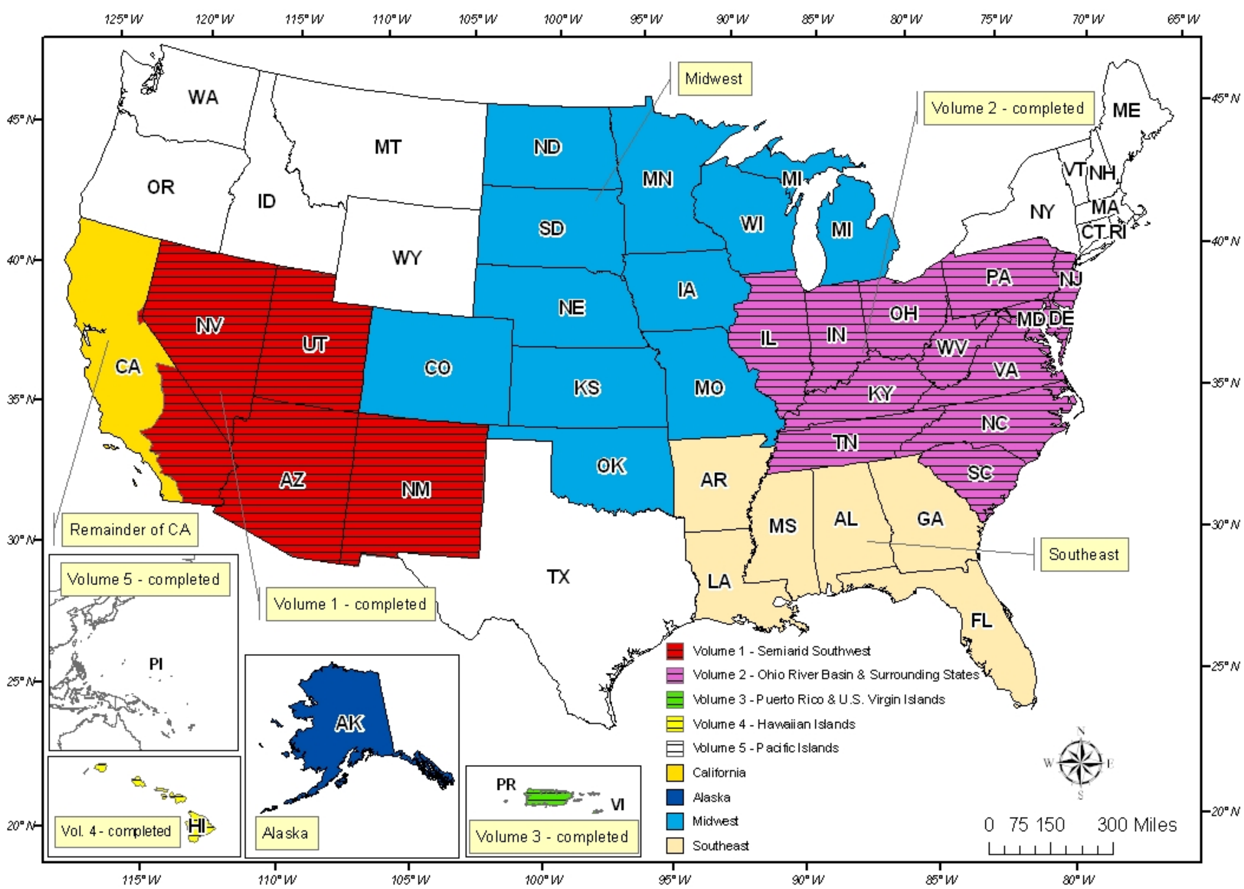

Figure 1. Map showing current project areas and project areas included in NOAA Atlas 14, Volumes 1-5.

II. CURRENT PROJECTS

1. PRECIPITATION FREQUENCY PROJECT FOR CALIFORNIA

1.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2010)

1.1.1. Change in project scope

It was decided to extend the project area to include southeastern California that was previously published in NOAA Atlas 14, Volume 1. Stations from southeastern California and 1-degree buffer area around it were added to the data set. Consequently, NOAA Atlas 14, Volume 6 will contain updated precipitation frequency estimates for the whole state of California.

As the term "precipitation frequency estimates" suggests, frequency estimates published in NOAA Atlas 14 volumes are calculated from precipitation data, where no distinction is made between different types of precipitation. Since for many engineering applications it is important to set apart snowfall and rainfall, it was decided to calculate and assess the differences in precipitation and rainfall-only frequency estimates.

1.1.2. Annual maximum series (AMS) analysis

a. AMS quality control

For all stations that were added to the project to include southeastern California, AMS were extracted and quality controlled for high and low outliers across all durations using procedures described, for example, in Section 4 of NOAA Atlas 14, Volume 5.

b. AMS correction factors for constrained observations

The majority of daily AMS data comes from daily stations at which readings were taken once every day at fixed times (constrained observations). To account for the likely failure of capturing the true-interval 24-hour maxima (unconstrained), correction factors are developed to apply to constrained AMS.

Concurrent (occurring within +/- 1 day) unconstrained and constrained annual maxima for 1, 2, 4, and 7 day durations were extracted at co-located daily and hourly stations. Slope coefficients of zero-intercept regression models were used to estimate correction factors. Similarly, concurrent constrained and unconstrained annual maxima were extracted for 1, 2, 3 and 6 hour durations and used to estimate correction factors.

c. AMS comparison at co-located stations

1-hour AMS at co-located hourly and 15-minute stations were compared for overlapping periods of record. Similarly, 1-day AMS at co-located daily, hourly, and 15-minute stations were compared for overlapping periods of record. Where corresponding AMS were significantly different, efforts were made to identify source of error and to correct erroneous observations across all durations that may be affected.

d. Station independence check

One of the assumptions in the regional frequency analysis approach is that annual maxima extracted at different stations inside a homogeneous region are independent. Inter-station dependence of AMS data for all durations was assessed by computing cross-correlation between AMS at nearby stations. During this analysis it became clear that additional station cleanup was necessary, particularly in the Los Angeles County area. We began to further screen all highly correlated stations within 5 miles distance and 300 feet elevation.

1.1.3. Analysis of at-station L-moment statistics

L-moments that are typically used in frequency analysis include 1st and 2nd order L-moments: L-location (mean annual maximum - MAM) and L-scale, and the following three L-moment ratios: L-CV, L-skewness, and L-kurtosis.

L-moment statistics were calculated from station AMS extracted at all durations. Transitions in L-moments across durations were then investigated for each station. A new optimization algorithm was developed and implemented to ensure consistency in L-moment statistics across durations and to achieve smooth, monotony increasing curves. Various degrees of smoothness and number of iterations were tested to get optimum results.

1.1.4. Spatial analysis of mean annual maxima

Mean annual maximum (MAM) estimates at 1-hour and 1-day durations were reviewed for spatial consistency. Some stations were deleted because their MAMs were inconsistent with MAMs at nearby stations and considered less reliable due to data quality or period of record. Some stations with different recording times (e.g., hourly and daily) from different datasets were designated to be treated as co-located stations. Lastly, stations with erroneous coordinates were identified and corrected.

MAMs were sent to the PRISM Group at Oregon State University for spatial interpolation. In their preliminary analysis of 1-day duration MAMs, cases were identified where at-station 1-day MAM estimates were more than 20% different than PRISM-interpolated MAMs using a jack-knife analysis. We reviewed these cases to determine if an inconsistent station should be deleted, adjusted, or retained in the analysis.

1.1.5. Rainfall versus precipitation frequency analysis

Daily observations of precipitation and rainfall-only were extracted from NCDC's DSI-3200 dataset for all stations above 3,000 feet and used to extract AMS. NCDC's DSI-3290 dataset which includes 6-hour observations of snowfall is currently being formatted.

For the 1-day duration, frequency estimates were calculated from rainfall-only AMS and from precipitation AMS using Generalized Extreme Value (GEV) distributions based on L-moment statistics. Mean annual maxima and frequency estimates for several selected frequencies were reviewed. Initial analysis indicated that differences in precipitation and rainfall-only frequency estimates were highly influenced by elevation. Stations were split based on elevation ranges. Regression analyses on various precipitation and rainfall frequency estimates for 1,000-feet elevation groups are being explored.

1.1.6. Regionalization

The combination of Wards and K-mean clustering methods was used to group stations into initial homogenous regions. Latitude, longitude and mean annual precipitation were selected as attribute variables for the initial regionalization. All variables were standardized to make their ranges comparable. After several iterations, 40 regions were delineated. 70% of the resulting regions were homogeneous with respect to annual maximum precipitation based on homogeneity tests described in NOAA Atlas 14 documentation. Those regions will be further refined or subdivided based on combined results of statistical tests and consideration of the climatology of heavy precipitation events.

An alternative method of regionalization, known as "region-of-influence," that groups together the statistics of sites that are located in close proximity to each other and which are deemed to be statistically homogeneous will also be investigated. Performance of both regionalization approaches will be assessed.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2010)

During the next quarter, regionalization work will be done. Spatial interpolation of MAMs at all durations and consistency checks of station and regional L-moment statistics will be completed. Preliminary precipitation frequency estimates will be computed and the initial spatial interpolation of precipitation frequency estimates will be developed in preparation for a peer review.

1.3. PROJECT SCHEDULE

Due to the change in project scope, the schedule for some tasks had to be revised. The project is still expected to be completed on time.

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) [January 2010; revised to April 2010]

Regionalization and frequency analysis [February 2010; revised to May 2010]

Initial spatial interpolation of PF estimates and consistency checks across durations [March 2010; revised to May 2010]

Peer review [April 2010; revised to June 2010]

Revision of PF estimates [July 2010]

Remaining tasks (e.g., development of precipitation frequency estimates for PD series, seasonality, temporal distributions, documentation) [August 2010]

Web publication [September 2010]

2. PRECIPITATION FREQUENCY PROJECT FOR THE SOUTHEASTERN STATES

2.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2010)

The project includes the states of Alabama, Arkansas, Florida, Georgia, Louisiana and Mississippi. An approximately 1-degree buffer around the core states was added to the project area to assist in the delineation of homogenous regions with respect to heavy precipitation characteristics (Figure 2).

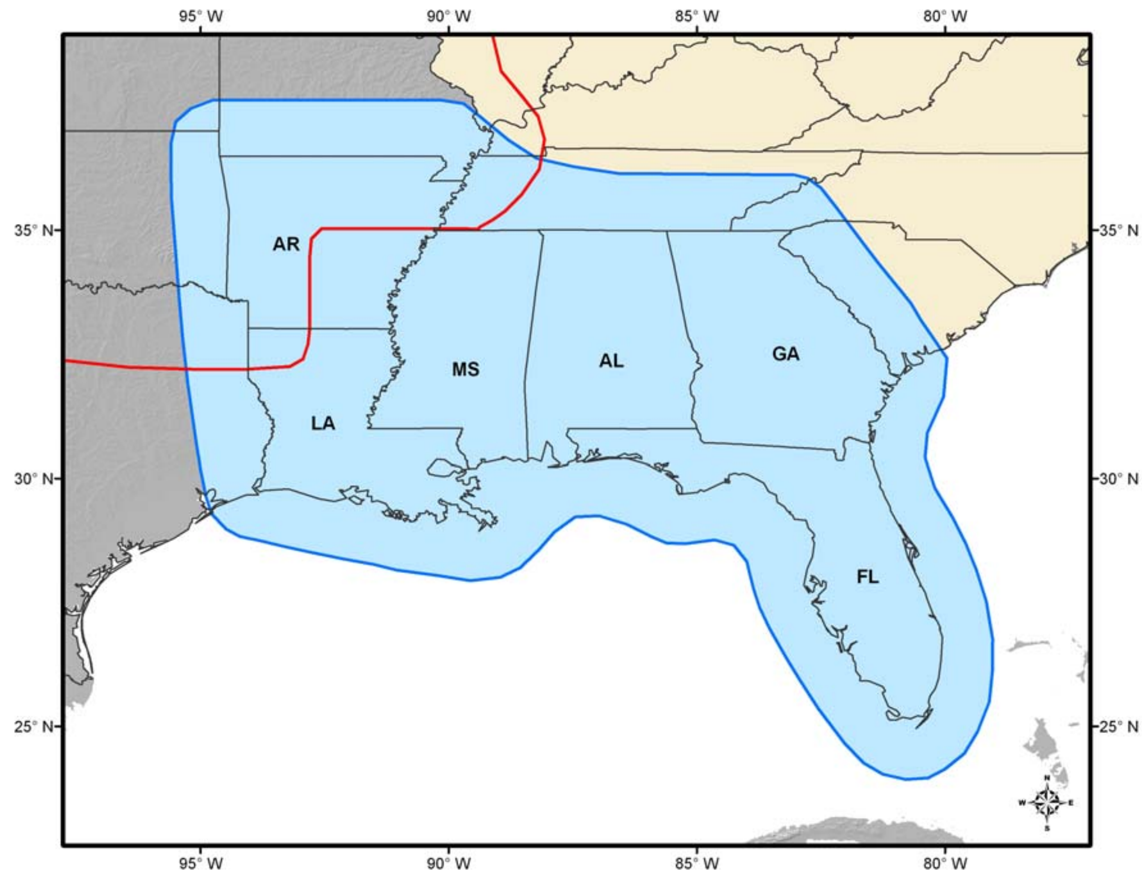

Figure 2. Southeastern precipitation frequency project area (shown in blue). Also shown is the border of the Midwestern precipitation frequency project area (red line).

The main activity in this period was focused on organizing and reformatting the numerous datasets collected. Table 1 provides a current list of potential data sets and their status.

During this reporting period, all formatted datasets were revisited to standardize formats and summarize information about each. In addition, log files were created to document data quality flags and type of precipitation as provided for each observation. This task is near completion.

Table 1. Current list of potential precipitation data sources; datasets in gray will not be used in the analysis for reasons given.

Formatting status	Source of data	Data reporting interval	Number of stations formatted or comment
Data formatted	National Climatic Data Center (NCDC)	daily	2186
		hourly	623
		15-min	343
		n-min	146
	U.S. Geological Survey	daily	710
	National Atmospheric Deposition Program	daily	32
	St. Johns River Water Management District	daily	54
	City of Vero Beach, Florida	daily	1
	Georgia Forestry Commission Weather Station Network	hourly	16
	Natural Resources Conservation Service: SCAN network	hourly	13
	Remote Automated Weather Stations (RAWS)	hourly	11
	University of Florida, Florida Automated Weather Network (FAWN)	15-min	6
		hourly	3
	NASA, TRMM Satellite Validation Office	1-min	TBD
	South Florida Water Management District	varies	831
	Southwest Florida Water Management District	15-min	53
		hourly	51
	Natural Resources Management Office, Brevard County, Florida	daily	1
Datasets that will not be used	U.S. Climate Reference Network (NCDC)	5-min	Established in 2003
	USGS, Georgia Water Science Center	daily	Same as USGS
	Road Weather Information System (RWIS) network	–	Real-time obs.; insufficient length
	Alabama Office of the State Climatologist	–	Data from NOAA
	Alabama Mesonet/NRCS Soil Climate Analysis Network (SCAN)	daily	Established in 2002
	Auburn University Mesonet	daily	Fee for data
	Cooperative Huntsville Area Rainfall Measurements (CHARM), Alabama	daily	Established in 2001
	Arkansas Red Basin River Forecast Center	daily	Same as NCDC
	Florida Climate Center	–	Same as NCDC
	Northwest Florida Water Management District	5-min	Contacted but did not receive data
	Suwannee River Water Management District	hourly	Insufficient data length
	Lake Okeechobee Lakewatch Rainfall Monitoring Program, Florida	daily	Part of SFWMD
	Capital Area Flood Warning Network, Florida	5-min	Established in 2005
	Brevard County Utility Services Department, Florida	daily	Same as Brevard County, FL
	Department of Barefoot Bay Water and	monthly	Same as Brevard

	Sewer District, Florida		County, FL
	Public Waters and Utilities Administration, City of Melbourne, Florida	daily	No metadata available
	WEAR WeatherNet, Florida	5-min	Real-time obs.; insufficient data length
	Georgia State Climatology Office	–	Same as NCDC
	Georgia Automated Environmental Monitoring Network (GAEMN)	15-min	Fee for data
	GeorgiaWx.net Mesonet System	–	Real-time obs.; insufficient data length
	Mississippi State Climatology Office	–	Same as NCDC
	Delta Research and Extension Center (DREC) Network, Mississippi	–	Data forwarded to NOAA
	Mississippi Mesonet	hourly	Established in 2004

2.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2010)

In the next reporting period, annual maximum series will be extracted, and data quality control will begin. Examination of geospatial data, and screening for duplicate stations will begin.

2.3. 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) [July 2010]

Regionalization and frequency analysis [November 2010]

Initial spatial interpolation of PF estimates and consistency checks across durations [May 2011]

Peer review [July 2011]

Revision of PF estimates [October 2011]

Remaining tasks (e.g., development of precipitation frequency estimates for PD series, seasonality, temporal distributions, documentation) [April 2012]

Web publication [May 2012]

3. PRECIPITATION FREQUENCY PROJECT FOR THE MIDWESTERN STATES

3.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2010)

The project area includes the states of Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin. An approximately 1-degree buffer around the core states was added to the project area to assist in the delineation of homogenous regions with respect to heavy precipitation characteristics (Figure 3).

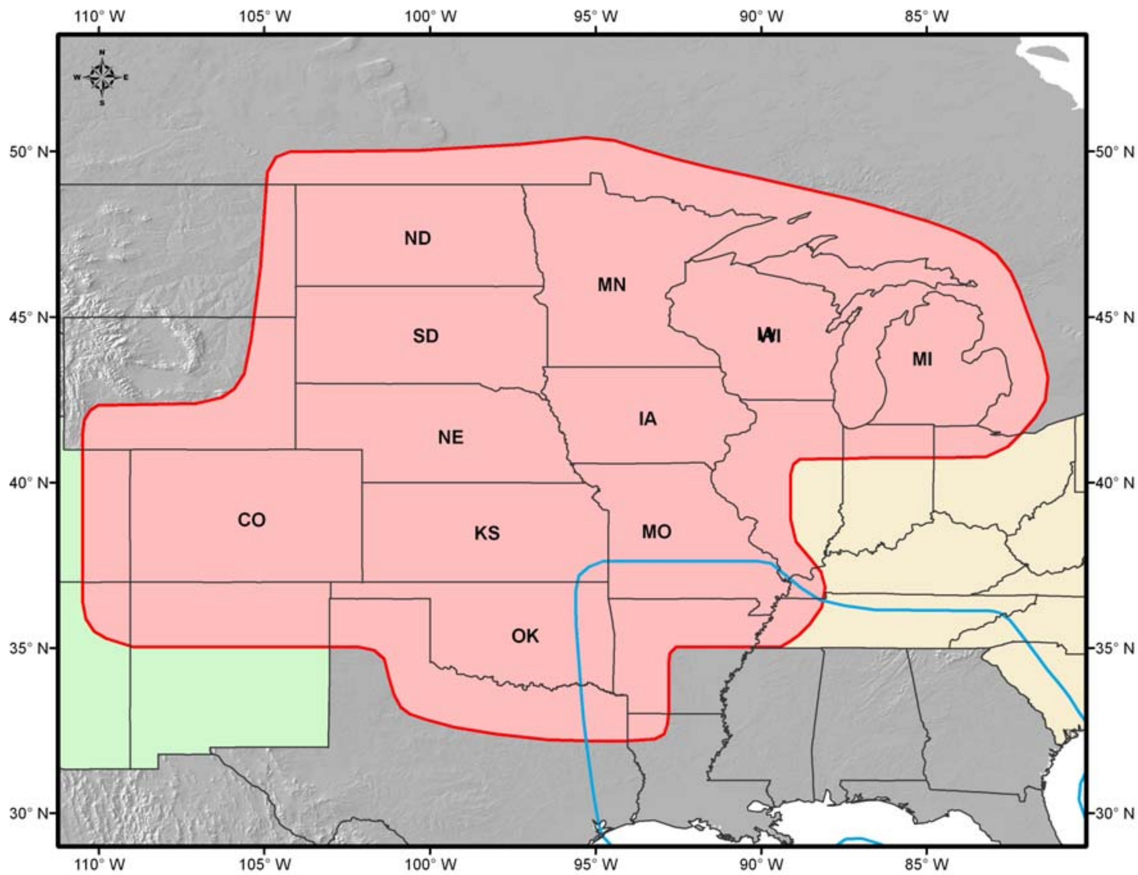

Figure 3. Midwestern precipitation frequency project area (shown in red). Also shown is the border of the Southeastern precipitation frequency project area (blue line).

The main activity in this period was focused on organizing and reformatting the numerous datasets collected. Table 2 provides a current list of potential data sets and their status.

During this reporting period, all formatted data sets were revisited to standardize formats and summarize information about each. In addition, log files were created to document data quality flags and type of precipitation as provided for each observation. This task is near completion.

Table 2. Current list of potential precipitation data sources; datasets in gray will not be used in the analysis for reasons given.

Formatting status	Source of data	Data reporting interval	Number of stations formatted or comment
Data formatted	National Climatic Data Center (NCDC)	daily	4110
		hourly	1214
		15-min	757
		n-min	185
	Environment Canada	daily	284
		hourly	35
	U.S. Geological Survey	daily	531
	National Atmospheric Deposition Program	daily	58
	Natural Resource Conservation Service: SNOTEL dataset	daily	106
		hourly	79
	Bureau of Reclamation, Colorado, Kansas, Nebraska, North Dakota and South Dakota	daily	41
	Community Collaborative Rain, Hail and Snow Network (CoCoRaHS), Colorado	daily	71
	Missouri Commercial Agriculture Weather Station (CAWS) Network	hourly	17
	North Dakota State Water Commission Precipitation Network	daily	2890
	North Dakota State University, North Dakota Agricultural Weather Network	daily	53
		hourly	49
	Minnesota State Climatology Office, Department of Natural Resources	daily	344
	Natural Resources Conservation Service: SCAN network	hourly	7
	US Army Corps of Engineers, Omaha District Office	hourly	44
	US Army Corps of Engineers, St. Louis District Office	hourly	64
	Colorado Agricultural Meteorological Network (CoAgMet)	daily	34
	CoAgMet	hourly	34
	Oklahoma Mesonet	daily	127
		hourly	13
	Atmospheric Radiation measurement (ARM) Southern Great Plains (SGP) Surface Meteorological Obs.System (SMOS) Network	1-min	21
	Colorado Springs Utilities Department Network	daily	5
	Remote Automated Weather Stations (RAWS)	hourly	86
	Northern Colorado Water Conservancy District (NCWCD) Weather Station Network	daily	14
	High Plains Regional Climate Center: Automated Weather Data Network	daily	144
		hourly	143
	Fort Collins Utilities Department: ALERT System	varies	28

	Overland Park: ALERT Precipitation Network (Kansas)	varies	58
	Urban Drainage Flood Control District (UDFCD): ALERT Weather Station Network, Denver, CO	varies	131
	Michigan Automated Weather Network (MAWN)	5-min	3
	Metropolitan Council Environmental Services, Minnesota	15-min	22
	Southeastern Wisconsin Regional Planning Commission, Milwaukee Metropolitan Sewerage District (MMSD)	hourly	21
Datasets that will not be used	Minnesota Department of Transportation	15-min	Same as MN MCES
	Meteorological Assimilation Data Ingest System (MADIS)	5-min	Established in 2001
	Road Weather Information System (RWIS) network	–	Real-time obs.; insufficient length
	Colorado Climate Center, Colorado State University	–	Fee for data; same as the CoAgMet
	MesoWest Colorado	–	Data from other data sources
	Denver Water Network	weekly	Established in 2003
	Iowa AgClimate Network	hourly	Removed the data based on manager's recommendation
	Kansas State University, State Climate Office	–	Same as NCDC
	Southwest Kansas Mesonet	hourly	Established in 2002
	Michigan State University Climatology Program	daily	Established in 2003
	Minnesota Climatology Group/High Spatial Density Precipitation Network (HIDEN)	daily	Same as MN DNR
	University of Missouri, State Climate Office	hourly	Same as CAWS

3.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2010)

In the next reporting period, annual maximum series will be extracted, and data quality control will begin. Examination of geospatial data, and screening for duplicate stations will begin.

3.3. 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) [July 2010]

Regionalization and frequency analysis [November 2010]

Initial spatial interpolation of PF estimates and consistency checks across durations [May 2011]

Peer review [July 2011]

Revision of PF estimates [October 2011]

Remaining tasks (e.g., development of precipitation frequency estimates for PD series, seasonality, temporal distributions, documentation) [April 2012]

Web publication [May 2012]

4. PRECIPITATION FREQUENCY PROJECT FOR ALASKA

4.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2010)

The University of Alaska, Fairbanks (UAF) is moving forward on the joint effort with NWS to update precipitation frequency estimates for Alaska. UAF continues with data collection, formatting, and quality control. Unfortunately, the schedule for certain tasks for this project has slipped due to issues in collecting and formatting difficult datasets (Section 4.3).

4.1.1. Data collection and formatting

UAF continues to pursue a few small outstanding datasets. The UAF datasets (WERC and ATLAS) were substantially augmented in the past reporting period to include a total of 34 stations located on Alaska's North Slope and Seward Peninsula. The Circumpolar Active Layer Monitoring (CALM) data are not in a usable form at this time and so were removed from the collection list. Table 3 provides basic information on datasets: current status of data formatting, dataset source, data reporting interval, and number of stations in each dataset. This table is subject to change as a result of the quality control process to be performed after all data are screened.

Formatted datasets underwent further review since additional inconsistencies in the raw data files and formatted data files were identified by UAF. Inconsistencies, including unrealistically large observation amounts in two datasets, were investigated and corrected. This led to a delay in the final delivery of formatted data to HDSC. Final formatted datasets were delivered to HDSC on March 26th, 2010.

Table 3. List of data sources, data reporting intervals, and number of stations in each dataset.

Formatting status	Source of data	Data reporting interval	Number of stations
Data formatted	Arctic-Long Term Ecological Research Site (LTER)	daily	3
	Environment Canada	daily	132
	Natural Resources Conservation Service (NRCS) SNOTEL (SNOwpack TELemetry)	daily	63
	Road Weather Information System (RWIS) - Alaska Department of Transportation	daily	15

Formatting status	Source of data	Data reporting interval	Number of stations
	National Climate Data Center (NCDC)	daily	606
	Bonanza Creek LTER	hourly	11
	NCDC – TD3240	hourly	92
	NCDC – Integrated Surface Hourly (ISH) Database	hourly	378
	Environment Canada	hourly	45
	Arctic-Long Term Ecological Research Site (LTER)	hourly	3
	Road Weather Information System (RWIS) - Alaska Department of Transportation	hourly	15
	Water & Environmental Research Center (WERC) - North Slope	hourly	26
	Remote Automated Weather Station (RAWS)	hourly	129
	NCDC	15-min	38
	Arctic Transitions in the Land-Atmosphere System (ATLAS)-UAF	hourly	8
Collecting data or metadata	Atmospheric Radiation Measurement (ARM) Program		2
	USGS-Benchmark Glaciers		2

4.1.2. Data bias correction

The influence of under-catch during extreme events may be mitigated by applying a bias correction to the data. In order to perform the bias correction, the presence of an alter shield at the site needs to be determined. Agencies were contacted to determine whether the gauges for their sites are equipped with alter shields. UAF is still waiting for information from NCDC on their stations. Preliminary query on precipitation equipment from the NCDC database contains many "unknowns" or simply blanks. Alternative approaches may need to be developed to accommodate a lack of information.

4.1.3. Annual maximum series extraction

Precipitation versus rainfall frequency analysis. UAF discussed with Billy Connor (head of Alaska University Transportation Center and the primary funder of UAF activities associated with this project) the issue of liquid and solid precipitation (or liquid vs. total precipitation) frequency estimation. It was concluded to look at rainfall precipitation only. This will require the development of criteria for distinguishing between snow and rain.

Range of durations for frequency analysis. Engineering designs are typically based on rainfall frequency estimates for durations between 15 minutes and 24 hours, although there are some applications that may require longer durations. It was decided to proceed with the analysis across all durations (5-minute to 60-day) since logistically the software is already in place, and then decide after the frequency analysis is done if any of the longer durations should be discarded. The dilemma here is that in southeast Alaska longer durations may make sense because of a longer season for rainfall precipitation, whereas in northern Alaska the rainfall season is relatively short, only about 120 days.

4.1.4. Annual maximum series quality control

Initial annual maximum series (AMS) were extracted by HDSC using relaxed criteria to accommodate large amounts of missing winter data at some stations. UAF has begun to assess these data for heavy precipitation seasonality, and in particular to investigate which maxima and durations are principally rainfall-only.

4.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2010)

The main focus during the next reporting period will be quality control of formatted data and subsequent AMS extraction.

4.3. PROJECT SCHEDULE

The schedule for some tasks has slipped due to technical issues in formatting difficult datasets and revised completion dates are shown. The project is still expected to be completed on time.

Data collection, formatting, and initial quality control [January 2010; revised to April 2010]

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) [February 2010; revised to July 2010]

Regionalization and frequency analysis [September 2010, revised to November 2010]

Initial spatial interpolation of PF estimates and consistency checks across durations [January 2011]

Peer review [March 2011]

Revision of PF estimates [May 2011]

Remaining tasks (e.g., development of precipitation frequency estimates for PD series, seasonality, temporal distributions, documentation) [August 2011]

Web publication [September 2011]

5. AREAL REDUCTION FACTORS

5.1. PROGRESS IN THIS REPORTING PERIOD (Jan - Mar 2010)

HDSC is developing geographically-fixed areal reduction factors that can be used to convert point precipitation frequency estimates into corresponding areal estimates in the United States. For a given average recurrence interval, rainfall duration and area size, the areal reduction factor (ARF) is defined as a ratio of average point depth and areal depth with the same recurrence interval.

HDSC is conducting a literature review and an assessment of past approaches.

5.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (Apr - Jun 2010)

HDSC will start development of ARF approach that utilizes radar-estimated precipitation.

5.3. PROJECT SCHEDULE

This project officially begins on April 1, 2010. It is expected to take 2 years to complete.

III. OTHER

1. RECENT MEETINGS

On January 5-6th, 2010, Geoff Bonnin participated in a meeting of the National Research Council Committee on Hydrologic Sciences entitled “Global Change and Extreme Hydrology: Testing Conventional Wisdom” in Washington D.C. He also gave a presentation at the workshop on “Nonstationarity, Hydrologic Frequency Analysis and Water Management” organized by Federal water agencies in Boulder, CO from January 13-15th.

On March 1-4th, Geoff Bonnin attended the 8th Annual Climate Prediction Applications Science Workshop in San Diego, CA. The integrated theme for the workshop was “Managing Water Resources and Drought in a Changing Climate.” Mr. Bonnin presented HDSC’s work, “Update on Precipitation Frequency Estimates and Questions of Stationarity”.