Hydrometeorological Design Studies Center
Quarterly Progress Report

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Office of Hydrologic Development

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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 purpose other than for what it was intended 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 accompanied by additional information (e.g., 90% confidence intervals, temporal distributions, seasonality) are published in NOAA Atlas 14. The Atlas is divided into volumes based on geographic sections of the country. Through the President`s e-gov initiative, NOAA Atlas 14 is a completely electronic document available for download from the Precipitation Frequency Data Server (http://www.nws.noaa.gov/ohd/hdsc). We are currently working on updating precipitation frequency estimates for Hawaii (NOAA Atlas 14, Volume IV) and the remainder of California (Volume 5).

In addition, HDSC is developing depth-area relationships (known also as Areal Reduction Factors - ARF) that will enable conversion of point rainfall frequency estimates to areal average frequency estimates for the same duration and same average recurrence interval. The results of this supplementary study will be applicable to all volumes of NOAA Atlas 14.

II. CURRENT PROJECTS

1. PRECIPITATION FREQUENCY FOR HAWAII

1.1. PROGRESS IN THIS REPORTING PERIOD

1.1.1. Data

a. Quality control

At some stations from National Climatic Data Center's (NCDC) TD3206 (pre-1949) daily dataset, days with zero precipitation were erroneously recorded as missing. Our automated procedure was able to detect and correct a considerable number of erroneous data, but not all of them. Recorded data were manually checked against scanned observation forms from NOAA's Web Search Store Retrieve Display (WSSRD) website. Cases where missing data were verified as zero rainfall were corrected.

We also identified twenty-three pairs of co-located stations (stations within 0.5 miles and 50 feet in elevation) from the NCDC database and stations provided by the State of Hawaii with hand-entered monthly maximum daily data. The pairs were investigated for data consistency. In each case a decision was made to retain one station over the other based on data availability and quality. In most cases, the NCDC station was retained since it enables us to calculate rainfall amounts for a range of durations. In four cases, the NCDC data could not provide 1-day maximum data due to accumulated observations and so the State data were retained as well to fill in that information. These locations were later checked for consistency in their estimates through the durations. Two pairs of stations had non-overlapping data and so were merged to form a single station with longer period of record after a statistical test confirmed that they could be considered homogeneous.

b. Annual maximum series (AMS) extraction

An evaluation of earlier extracted AMS suggested that the rules for extraction previously in place were not sufficient to accommodate Hawaii data with their significant number of precipitation data recorded as accumulations of 2 or more days and/or missing data. To ensure that only “true” maxima are extracted from the datasets, and that at the same time potentially valuable information is retained, HDSC developed new criteria for AMS extraction. The criteria were applied to extract AMS for 60-minute to 60-day durations and carefully evaluated.

Resulting AMS were screened for outliers using statistical tests and visual inspection of probability plots. Several numbers identified as potential low or high outliers were flagged and reviewed through spatial contour maps for data consistency.

c. Consistency of AMS data across durations

Due to incomplete records and because annual maxima for each duration is extracted separately, it could happen that extracted maxima for a given year for a shorter duration is greater than for a longer duration. Those inconsistencies were first investigated for data quality and missing data. Since no data quality issues were found and no additional data could be found to fill in missing information, longer duration AM were set equal to any higher value at shorter durations.

d. Intersite independence of AMS data

Work was begun to assess the intersite independence of daily AMS data. Cases where annual maxima are concurrent (overlap by +/- 1 day) at stations within 50 miles will be inspected. Pairs of stations with correlation coefficients statistically significant at the 90% confidence level will be investigated and the impact of the cross correlation on the final quantiles will be assessed.

1.1.2. Regionalization

With newly extracted AMS, a statistical measure of regional homogeneity (H1) was reviewed for all previously established regions and durations. Very high H1 values (H1 > 2.0 indicates heterogeneity) observed in several regions for longer durations prompted modifications to the regions. The most significant modifications included expanding region 10 on Oahu, and the creation of a new region (region 12) that encompasses the rest of the Kona coast on the Big Island. All modifications were carefully considered for extreme precipitation climatology and tested for the impact on other regions. The modifications were successful in reducing very high H1 measures for the longer durations while maintaining homogeneity at the 24-hour duration. Figure 1 shows the new regions and Table 1 provides the H1 measures. It is interesting to notice that newly formed regions are consistent with climate regions developed by Dr. Pao-Shin Chu, Ph.D. and Michael Nakashima from the University of Hawaii (personal communication, 2004).

Sensitivity testing is being conducted on any remaining heterogeneous regions/durations. In most of these cases, one or several stations are driving the H1 measure due to the nature of their data sampling. Omitting the offending station(s) generally decreases H1 significantly and impacts the 100-year precipitation frequency estimates and regional growth factors by 5% or less. Once identified and checked, the high H1 values in these regions will be accepted without modifying the regions themselves.

Table 1. Statistical heterogeneity measure (H1) for all daily regions and durations.

Region	Duration								
	24-hour	**2-day**	**4-day**	**7-day**	**10-day**	**20-day**	**30-day**	**45-day**	**60-day**
1	0.00	1.43	-0.37	-0.97	-0.05	0.87	1.28	1.65	2.67
2	0.01	-1.13	-0.80	-0.69	-0.17	0.30	1.18	2.17	2.45
3	0.38	-1.36	0.92	1.11	1.29	1.55	1.67	3.15	3.90
4	0.83	-0.09	0.60	1.04	2.11	2.52	2.21	1.89	2.44
5	0.94	0.06	1.50	1.68	2.08	2.81	3.58	4.90	6.76
6	-0.2	-1.18	-1.42	-0.86	-0.46	-0.82	-0.11	-0.16	0.17
7	-0.15	-0.43	0.01	-0.84	-0.42	-0.57	0.24	0.20	0.94
8	0.61	-1.01	-1.04	-1.25	-1.12	0.16	0.50	0.42	0.06
9	1.13	0.59	0.97	1.16	0.93	1.06	2.08	2.97	2.30
10	-0.68	-1.60	-1.77	-1.00	0.21	0.96	0.94	1.97	2.20
11	-0.74	-0.56	0.24	0.73	1.00	2.01	2.83	3.18	4.17
12	0.08	0.68	1.06	1.33	2.77	2.33	2.76	4.07	3.56

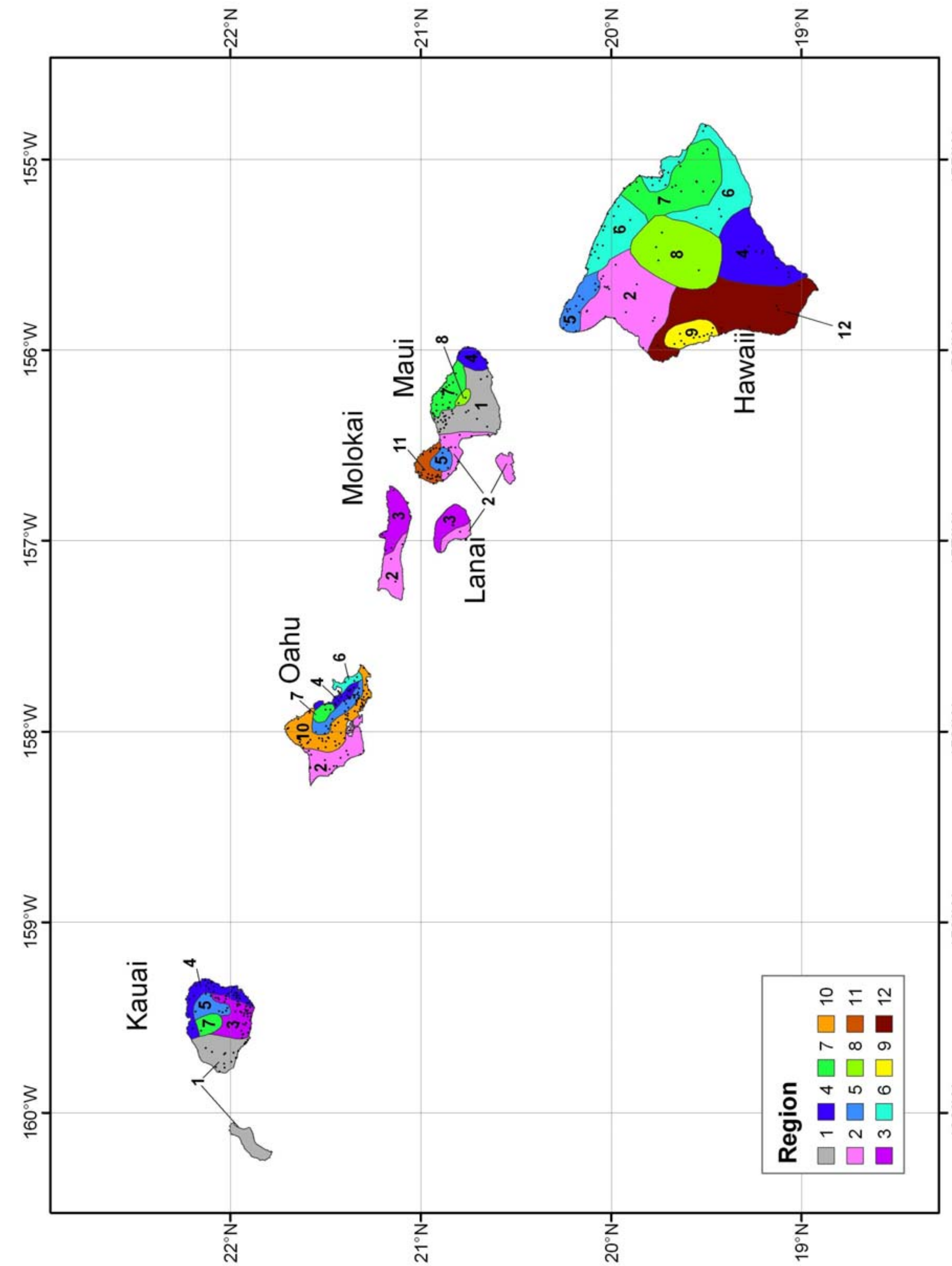

Figure 1. Twelve daily regions (applicable for durations 24-hour through 60-day).

1.1.3. Development of mean AMS for selected durations for PRISM processing

Mean annual maximum values are used as the site-specific scaling factor (the so-called "index flood") to generate precipitation frequency estimates from regional growth factors (RGFs) at locations. With the completion of the AMS extraction rules and subsequent inspection of mean annual maxima for consistency, the point mean annual maxima for 1-hour, 12-hour, 24-hour and 10-day durations were delivered to Oregon State University's PRISM Group on December 20, 2007 for spatial interpolation to 800m resolution grids. The frequency estimates for those four durations will then be subjected to a Peer Review before proceeding with frequency analysis for other durations.

The PRISM Group will use PRISM (Parameter-elevation Regressions on Independent Slopes Model), a hybrid statistical-geographic approach to mapping climate data, to spatially interpolate the HDSC-calculated mean annual maximum values for all durations by using a naturally strong relationship with mean annual precipitation. These mean annual maximum grids will be used as the "index flood" which will then be subjected to HDSC's Cascade, Residual Add-Back (CRAB) grid derivation procedure that converts mean annual maximum grids into grids of precipitation frequency estimates. We expect The PRISM Group to return the preliminary grids by March 2008.

1.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD (FY08/Q2)

1.2.1. Intersite independence of AMS data

The investigation of the intersite independence for 1-day AMS data will be completed.

1.2.2. Regionalization and distribution selection for AMS data

Regionalization will be finalized during the next quarter and evaluated for homogeneity for all durations. In addition, different frequency distributions will be evaluated for each region and for each duration.

1.2.3. Extraction of partial duration series (PDS)

Partial duration series data will be extracted for all durations.

1.2.4. Development of n-minute ratios

The 5-minute, 10-minute, 15-minute, 30-minute, and 60-minute durations are collectively called "n-minute". Because of the small number of stations with 5-minute data available to generate n-minute precipitation frequency quantiles for the whole study area, they will be estimated by applying linear scaling factors. Those factors will be developed using ratios of n-minute quantiles to 60-minute quantiles from co-located 5-minute and hourly stations.

1.2.5. Development of PRISM grids for mean annual maxima

HDSC expects the return of mean annual maximum grided estimates for 1-hour, 12-hour, 24-hour and 10-day durations from Oregon State University's PRISM Group by March 2008. Those grids will then be used to develop preliminary maps for 100-year precipitation frequency estimates that will be submitted for a Peer Review by the end of the next quarter.

1.3. PROJECTED SCHEDULE

Data quality control [Complete]

Final regionalization and frequency analysis for all AMS [March 2008]

Development of precipitation frequency grids for 1-hr, 12-hr, 24-hr, and 10-day based on PRISM deliverables [May 2008]

Peer review of estimates [June 2008]

Development of precip. frequency grids (all durations) based on PRISM deliverables [August 2008]

Development of PDS quantiles [September 2008]

Remaining tasks and web publication [December 2008]

2. PRECIPITATION FREQUENCY FOR REMAINDER OF CALIFORNIA

2.1. PROGRESS IN THIS REPORTING PERIOD

HDSC is compiling the metadata for the datasets we have collected for the California project. Table 2 lists all data types we were able to collect, data sources, current status of this task and number of stations available for each dataset processed so far. Some datasets may currently contain stations located outside the project area (the part of California not included in NOAA Atlas 14 Volume 1) and buffer areas (southwestern California, south Oregon and west Nevada). Stations with even just one year are included as they may be merged with other nearby stations if appropriate later in the project. Some stations from different sources may be duplicate data. Therefore, the total number of stations used in the study is subject to change as we review the data further.

As a general rule, only stations with at least 20 years of data are used in frequency analysis of daily data, and at least 15 years of data for hourly stations. Other stations may be kept in records to assist in spatial interpolation. Preliminary analysis of the National Climatic Data Center (NCDC) dataset for this project, for instance, indicates that daily stations have between 1 and 114 data years, with an average of 20 years.

Table 2. List of data types, data sources, current status of metadata and number of stations in each processed dataset. (ALERT data are Automated Local Evaluation in Real Time gauges that measure precipitation using tipping buckets in increments of 0.04mm.)

Type of data	Data Source	Status of Metadata	Number of Stations
Daily	NCDC	Processed	1225
	CA Department of Water Resources	Processed	411
	U.S. Army Corps of Engineers, Sacramento District	Processed	43
	Santa Barbara County Flood Control District	Processed	62
	LA County Dept. of Public Works	Processed	591
	Jim Goodridge, Retired State Climatologist	In progress	
	County of San Diego Flood Control	In progress	
	SNOTEL	In progress	
Hourly	NCDC	Processed	509
	CA Department of Water Resources	Processed	495
	U.S. Army Corps of Engineers, Sacramento District	Processed	43
	Metro Flood Control District, Fresno	Processed	8
	Jim Goodridge, Retired State Climatologist	In progress	
	County of San Diego Flood Control	In progress	
	RAWS	In progress	
15-min	Metro Flood Control District, Fresno	Processed	8
5-min	Ventura County Watershed Protection District	Processed	105
	Santa Barbara County Flood Control District	Processed	49
	LA County Dept. of Public Works	Processed	41
	County of San Diego Flood Control	In progress	
	Riverside County Flood Control District	In progress	
ALERT	California Dept. of Parks & Recreation (Orange Cnty)	Processed	109
	County of San Diego Flood Control	Processed	70
	California Nevada River Forecast Center	In progress	

2.2. PROBLEMS/CONCERNS

The formal agreement between HDSC and the California Department of Water Resources for this project is delayed. Resolution is anticipated by February 2008.

2.3. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD

HDSC will continue to compile metadata for each station and evaluate any data overlap. We will format and prepare the daily data for quality control.

2.4. PROJECTED SCHEDULE

Data quality control [September 2008]

Regionalization and frequency analysis for 1-hr and 24-hr AMS [December 2008]

Development of precipitation frequency grids for 1-hr and 24-hr durations based on PRISM deliverables [December 2008]

Peer review of estimates [February 2009]

Regionalization and frequency analysis for other durations [February 2009]

Development of precipitation frequency grids for all durations based on PRISM deliverables [April 2009]

Remaining tasks and web publication [July 2009]

3. AREAL REDUCTION FACTORS (ARFs)

3.1. PROGRESS IN THIS REPORTING PERIOD

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 (ARI), rainfall duration and area size, the areal reduction factor (ARF) is defined as a ratio of average point depth and areal depth with same ARI. Although straightforward, the method relies on accurate areal estimates (at various area sizes), which is challenging to establish without a sufficiently dense and evenly distributed network of precipitation gauging stations. Although we have identified nearly 20 networks across the U.S., many of them lack sufficient gauge density or gauge placement for any objective spatial interpolation procedure to accurately depict precipitation patterns. Based on our analysis, it appears that this limitation could potentially have a significant effect on the accuracy of areal estimates and ARFs.

To address the limitations of the gauge-based ARF analysis, the HDSC ARF team has been looking into alternative approaches that take advantage of radar data. We initiated a pilot study to evaluate the use of radar-estimated precipitation grids in the Louisville, KY area, which coincidently has a dense area rain gauge network.

In support of this study, the acquisition, decoding and reformatting of radar-estimated precipitation is complete for the continental United States from 2002 to 2007. For the Ohio River basin it is complete for the period 1997-2007. Stage IV radar-estimated precipitation grids available from 2002 through 2007 provide continental US coverage, while Stage III for years before 2001 are NWS river forecast center domains.

3.2. PROJECTED ACTIVITIES FOR THE NEXT REPORTING PERIOD

The radar-based pilot study will continue for the Louisville, KY network. The radar- and gauge-based ARFs (and associated statistics) will be evaluated and serve as the basis for making a final decision on the approach to be used to compute ARFs. It is likely that our final methodology will utilize radar data, so finalization and optimization of the computer code will take place during the next reporting period. Stage III data will be acquired, decoded and reformatted for other portions of the country. Methods will be developed to establish radar-based study areas in locations with good, uncontaminated radar data.

3.3. PROJECTED SCHEDULE

Data collection and quality control [March 2008]

Selection of the ARF computational approach [June 2008]

Calculation of geographically-fixed ARFs [September 2008]

Peer review [December 2008]

Web publication [February 2009]

III. OTHER

1. Publication of 1,000-year Estimates – User Responses

On October 15, 2007, HDSC submitted the following question to its colleagues, collaborators and other interested parties: "HDSC is considering discontinuing the publication of 1,000-year precipitation frequency estimates because of the severe uncertainty associated with computing such extreme events. We'd like to get your opinion regarding the use and understanding of 500-year and 1,000-year precipitation frequency estimates. Are these estimates being used, and if so, for what purpose?"

First, we would like to thank 122 individuals/groups who responded. Based on their responses, we decided to continue to publishing 1,000 year estimates. However, we do intend to expand upon the discussion on uncertainties of these estimates and also provide more complete statistical uncertainty information. Due to the great interest of the participants and for the outreach and education of our users, we will publish the responses (anonymously) through our Frequently Asked Questions (FAQ) web page.

2. Presentations and Meetings

On October 31, Branch Chief, Geoff Bonnin, presented a webinar to the Federal Highway Administration (FHWA) Midwestern States Hydraulic Conference on NOAA Atlas 14 and the status of efforts to update precipitation frequency estimates for Midwestern states.

On November 28, Geoff Bonnin, presented a similar webinar to interested State and Federal representatives arranged by the NWS Central region. At the time of writing, Minnesota, North and South Dakota, Nebraska, Kansas, Iowa and Missouri have either committed to the project through the FHWA Pooled Fund Program or are moving in that direction. Funds will come through State Departments of Transportation with, in some cases, participation from State Departments of Natural Resources. It is possible that Colorado, Wyoming, Montana, Wisconsin and Michigan may join the project.

On December 19, 2007, Geoff Bonnin and Sanja Perica, HDSC Director, participated in a teleconference on updating precipitation frequency estimates for Alaska. Geoff Bonnin will meet with interested parties in Alaska the week of January 21, 2008 to work out the next phase of the proposal.