RECLAMATION
Managing Water in the West

H13D-0954

EXTREME STORM ASSESSMENTS FOR NUCLEAR FACILITIES AND DAM SAFETY

John F. England, Jr.[1], Thomas J. Nicholson[2] and Rajiv Prasad[3]

[1]Bureau of Reclamation, jengland@do.usbr.gov; [2]U.S. Nuclear Regulatory Commission, Thomas.Nicholson@nrc.gov; [3]Pacific Northwest National Lab, rajiv.prasad@pnl.gov

Abstract

Extreme storm events over the last 35 years are being assessed to evaluate flood estimates for safety assessments of dams, nuclear power plants, and other high-hazard structures in the U.S. The current storm rainfall design standard for evaluating the flood potential at dams and non-coastal nuclear power plants is the Probable Maximum Precipitation (PMP). PMP methods and estimates are published in the National Weather Service generalized hydrometeorological reports (HMRs). A new Federal Interagency cooperative effort is reviewing hydrometeorologic data from large storms which have occurred in the last 20 to 40 years and were not included in the database used in the development of many of the HMRs. Extreme storm data, such as the January 1996 storm in Pennsylvania, June 2008 Iowa storms, and Hurricanes Andrew (1992), Floyd (1999), Isabel (2003), Katrina (2005), need to be systematically assembled and analyzed for use in these regional extreme storm studies. Storm maximization, transposition, envelopment, and depth-area duration procedures will incorporate recent advances in hydrometeorology, including radar precipitation data and stochastic storm techniques. We describe new cooperative efforts to develop a database of extreme storms and to examine the potential impacts of recent extreme storms on PMP estimates. These efforts will be coordinated with Federal agencies, universities, and the private sector through an *Extreme Storm Events Work Group* under the *Federal Subcommittee on Hydrology*. This work group is chartered to coordinate studies and develop databases for reviewing and improving methodologies and data collection techniques used to estimate design precipitation up to and including the PMP. The initial effort focuses on collecting and reviewing extreme storm event data in the Southeastern U.S. that have occurred since Tropical Storm Agnes (1972). Uncertainties and exceedance probability estimates of PMP are being explored. Potential effects of climate variability and change on the PMP are also under investigation.

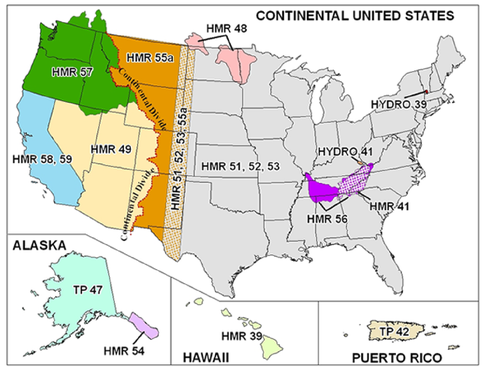
Issue, Motivation and Consequences

- Data and methods for estimating extreme storms, up to and including the Probable Maximum Precipitation (PMP), are currently insufficient.
- No current mechanisms in place within Federal Agencies to routinely collect, analyze, and archive extreme storm data for estimating extreme floods.
- No procedures in place to update storm data sets, methodology, and reports that are used to develop generalized PMP estimates.
- Improved extreme storm estimates, including exceedance probability estimates of storm properties, can be used for dam safety assessments, nuclear power plant designs and assessments, risk analysis, and understanding extreme flood processes.
- **Extreme flood design data, standards and criteria for dams and nuclear power plants outdated.**
- **Unknown risk and safety**
- **Potential costly retrofits**

Folsom Dam, CA $550M ongoing flood modifications by Reclamation and USACE

Bellefonte, AL nuclear generating station

Extreme Storm D-A-D Data and NWS HMRs



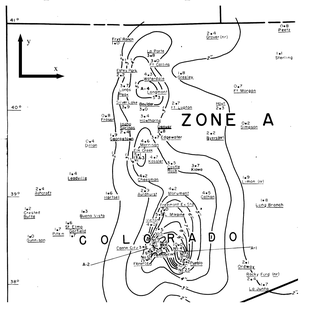
Depth-Area-Duration data and PMP methods are used to provide "generalized" PMP estimates over large regions of the United States. The PMP estimates have been published in Hydrometeorological Reports by NWS.

Key Concepts:
Storm Data Collection, D-A-D Analysis; Maximization; Transposition; Envelopment

Storm Index No. 31 — Date – 6/2–6/21 — Storm Assignment No. SW 1-23
Max. Rainfall Center: Penrose, CO — Lat. 38°27' Long. 105°04'
Moisture Adjustment 151

Maximum average depth of rainfall in inches

Area (mi²)	Duration of rainfall in hours							
	6	12	18	24	36	48	60	72
10	10.4	11.3	12.0	12.0	12.0	12.0	12.0	12.0
100	8.8	10.4	11.0	11.1	11.1	11.2	11.2	11.2
200	7.9	9.7	10.3	10.4	10.5	10.7	10.7	10.7
500	6.5	8.4	9.0	9.1	9.4	9.6	9.7	9.7
1000	5.4	7.1	7.8	7.8	8.2	8.6	8.7	8.7
2000	4.2	5.4	6.1	6.2	6.9	7.1	7.4	7.4
5000	2.7	4.0	4.3	4.4	5.6	5.7	6.0	6.2



June, 1921 Penrose, CO storm

HMR Status Summary:

Last storms collected and analyzed from 1980s in CA. Storms in eastern U.S. from 1972.

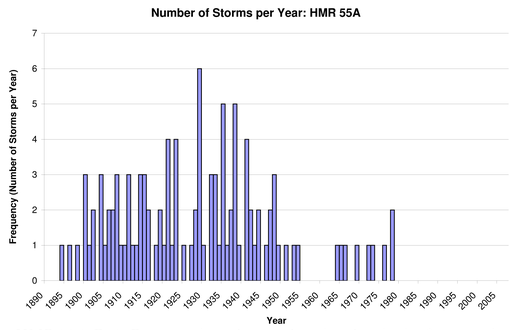
Limited data and lack new data.

Deterministic focus with no estimates of exceedance probabilities.

HMR No.	Publication Date	Latest Storm Used	Comments
49	1977	Sept. 3-7, 1970	see HMR 50 for storm info; 1983 Prescott, AZ storm exceeds PMP
51	June 1978	June 19-23, 1972	Replaced HMR 33 (1956)
55A	June 1988	Aug. 1-4, 1978	Replaced HMR 55 (1985) and TP 38 (1960)
57	October 1994	Dec. 24-26, 1980 (general) Aug. 16, 1990 (local)	Replaced HMR 43 (Nov. 1966)
59	February 1999	Feb. 14-19, 1986	Replaced HMR 36 (Oct. 1961)

Current Needs

- Update Extreme Storm Catalog
- Spatial and Temporal Storm Representations in Orographic Areas
- Integrate Site-Specific and Regional Data Sets
- Examine Recent Data Collection Advances (e.g. Radar)
- Incorporate New Extreme Storm Research
- Risk-Based Focus
- Address Potential Climate Change Effects



HMR 55A D-A-D storm data time series showing lack of storm data collected since 1980; many years only data from one storm collected.

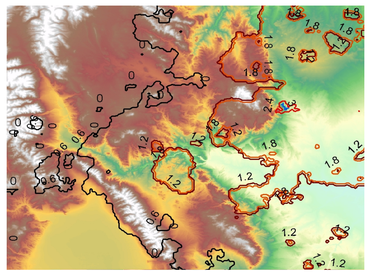
Extreme Storm Events Work Group Subcommittee on Hydrology

Purpose: Coordinate studies and databases for reviewing and improving methodologies and data collection techniques used to develop design precipitation estimates of large storm events up to and including the Probable Maximum Precipitation (PMP).
Develop detailed scope of work; determine funding needed to update the Catalog of Extreme Storms and Hydrometeorological Reports (HMR) for estimating PMP.

Current Members: Reclamation; USACE; NRC; FERC; FEMA; USGS; NHWC; NRCS

INVITATION: We Seek Collaborators and Partners

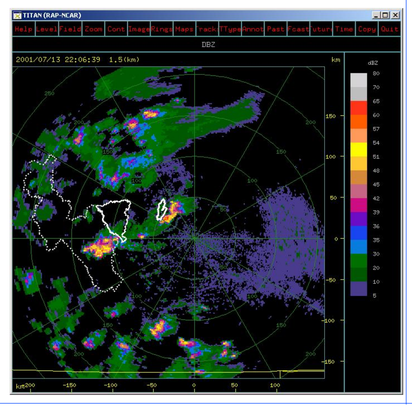
New Extreme Storm Analysis Methods



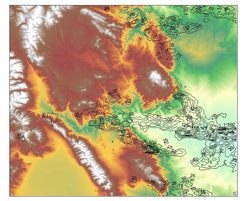
Geographical Distribution of Storm Initiation Sites and Average Storm Activity, Pueblo, CO KPUX radar catalog (1995-2003), 66 storms events. Storm activity for a radar grid cell computed as the number of hours of storms over a grid divided by the total number of stormy hours over the entire domain. Highlights regions with larger storms as they account for more time over each grid cell.

Radar-Based Analyses

- Fine Space-Time Data and Details
- Storm Tracking and Movement
- Space-Time Analysis
- Can Estimate Detailed D-A-D Data
- Probabilities and Maximization Opportunities



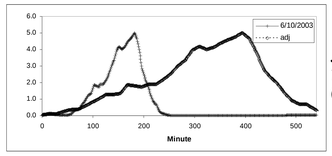
July 13, 2001 storm near Pueblo, CO



June 10, 2003 Storm from KPUX (CO) Radar

Rainfall maximization for June 10, 2003 to mimic June 1921 storm

Spatial Map of Maximized Rainfall (mm) (magnitude adjustment)



June 10, 2003 Temporal Rainfall (duration adjustment)

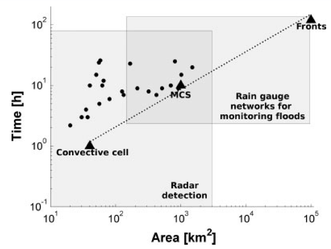
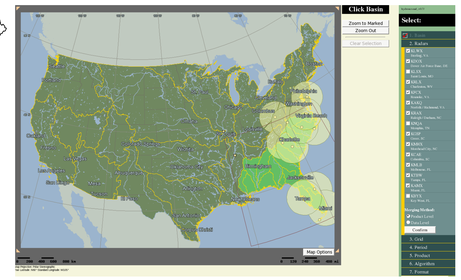


Figure 1. Schematic of flash-flood space–time scale versus monitoring capabilities of weather radar and rain-gauge networks. Dots represent time and space scales of a number of flash-flood generating storms observed in Europe in the last 15 years (Borga, 2007). Scales of convective cells, mesoscale convective systems (MCS) and fronts are taken from Orlanski (1975)

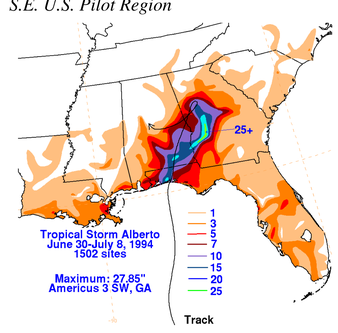
Current Data Collection/Investigation Efforts

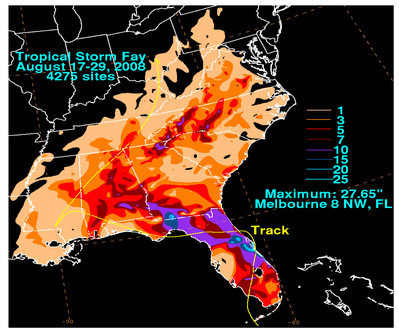
Pilot Project Area: Southeastern United States; North Carolina and South Carolina
Data Collection: focus on precipitation gages and WSR-88D Radar (Hydro-NEXRAD)
PMP Comparisons: Effects of recent storms on HMR 51 PMP estimates.

S.E. U.S. Pilot Region



Hydro-NEXRAD Data Sets (U. Iowa)





Recent Extreme Rainfalls: Alberto (1994); Floyd (1999); Fay (2008)

Summary and Ongoing Work

- Depth-Area-Duration data sets used to develop generalized PMP estimates are outdated; most storm collection efforts ceased in the 1970s.
- New extreme storm data collection and processing efforts are needed to provide the basis for:
  (1) updating generalized HMRs and PMP; and
  (2) estimating extreme storm exceedance probabilities.
- An Extreme Storm Event Work Group has been formed under Subcommittee on Hydrology. We seek collaborators and partners in this effort.
- Pilot extreme storm study commenced in Southeast U.S. for application to the design and assessment of nuclear facilities. Comparing new storms to HMR 51 PMP.
- Developing prototype for creating an electronic database for existing USACE D-A-D data (1945-1973) and for new D-A-D data.
- Examining new extreme storm developments (e.g. mesoscale models; individual storms; transposition; moisture maximization) for implications to PMP assumptions.
- Investigating potential effects of climate variability and change on D-A-D relationships and PMP-specific procedures (transposition, maximization and envelopment).