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Managing Water in the West

Methodology and Data for Quantifying Extreme Precipitation Events in a Changing Climate

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Science and Technology Research Meeting, October 3, 2012

U.S. Department of the Interior
Bureau of Reclamation

Outline

- Collaborators and Related Projects – see one-page description
- Research Questions and Context – Infrastructure and Floods
- Project Overview
  - Research Goals, Strategy and Tasks
  - Needs and Benefits – *Why do We Care?*
- Progress to Date
- Ongoing Work/Directions

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Infrastructure and Floods

Individual Events Causing Failures:

Truckee Canal, Fernley, Nevada January 2008

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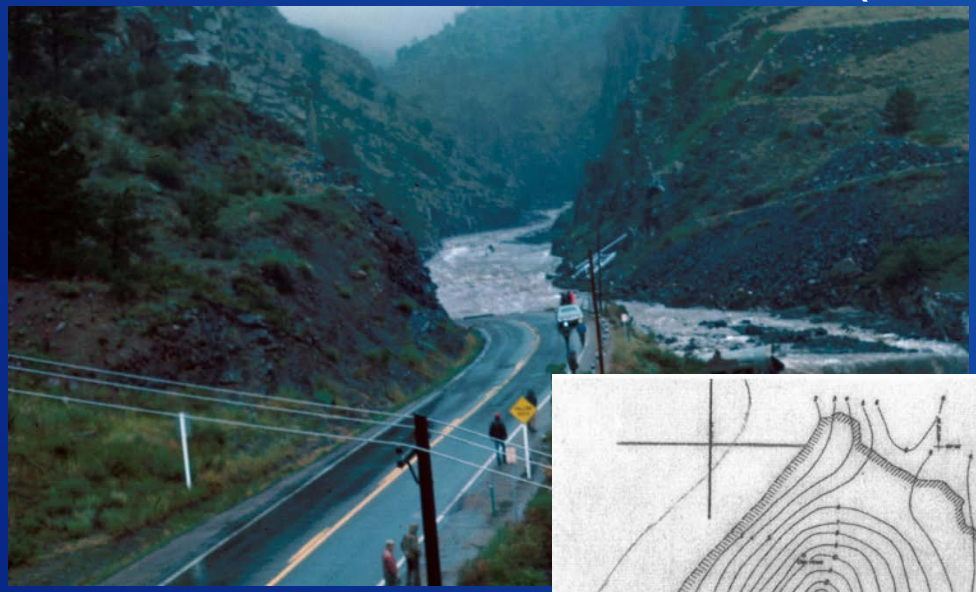
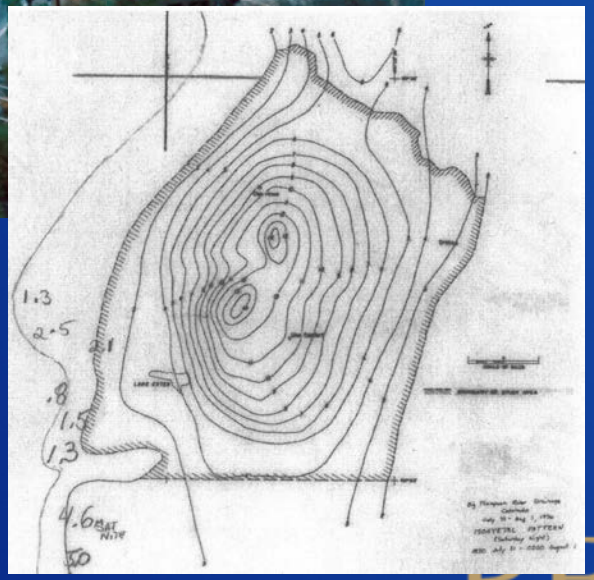
Research Questions

- What are the spatial and temporal characteristics of individual recent extreme precipitation storm events in orographic regions that have occurred since data used for Probable Maximum Precipitation (PMP) estimates were last collected (1970s -1986)?





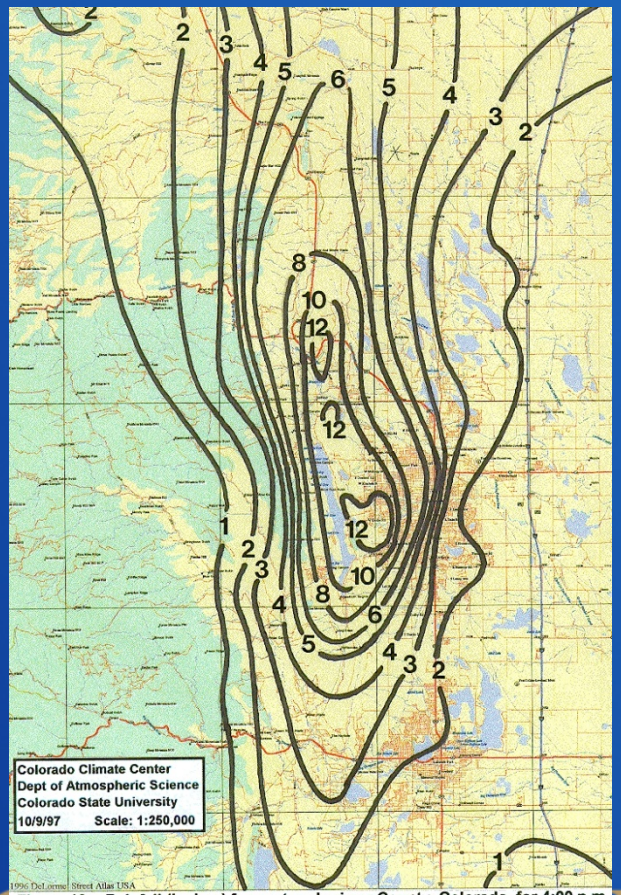


Figure 10. Rainfall (inches) for eastern Larimer County, Colorado, for 4:00 p.m. MDT July 27, 1997 through 11:00 p.m. MDT for July 28, 1997

July 31, 1976
Big Thompson, CO
(HMR 55A)
July 27, 1997
Fort Collins, CO
(post-HMR)

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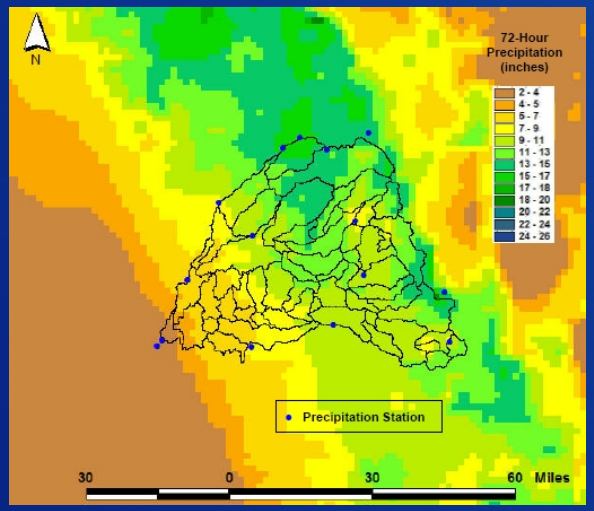
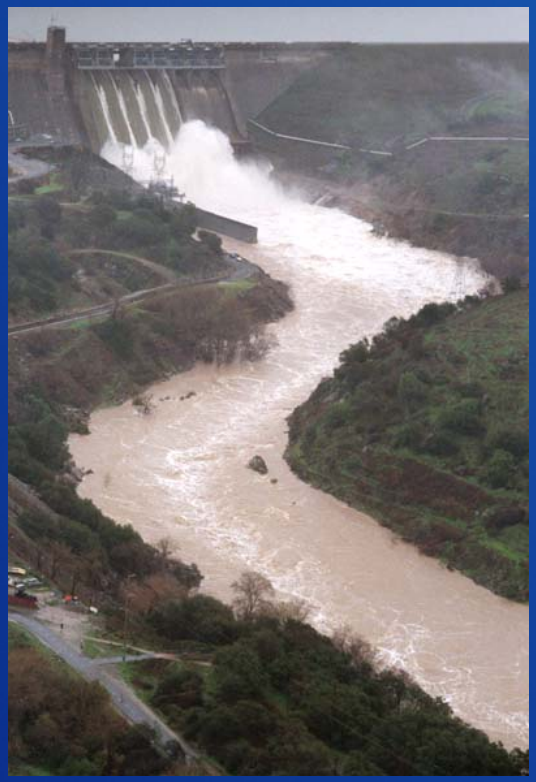
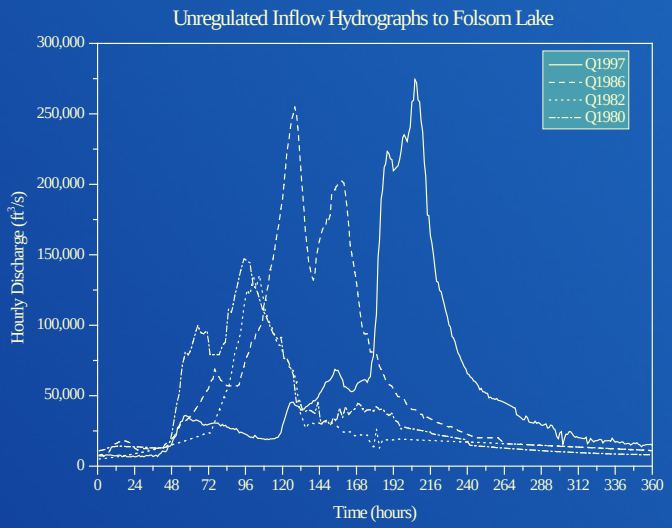
Research Questions

- Are recent individual extreme storms characteristics, including rainfall rates and spatial distributions at fine temporal and spatial scales, larger (areal extent, intensity) than those past events used in PMP estimates?







Folsom Dam, CA January 1997 Flood

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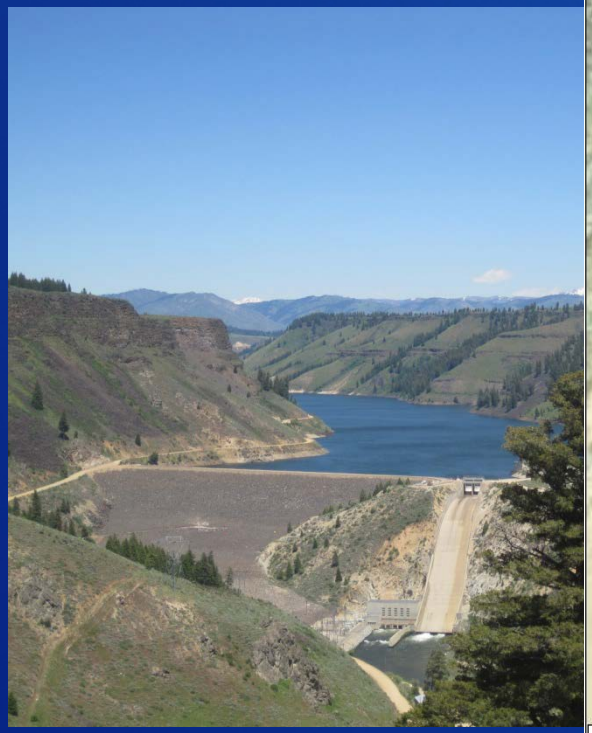
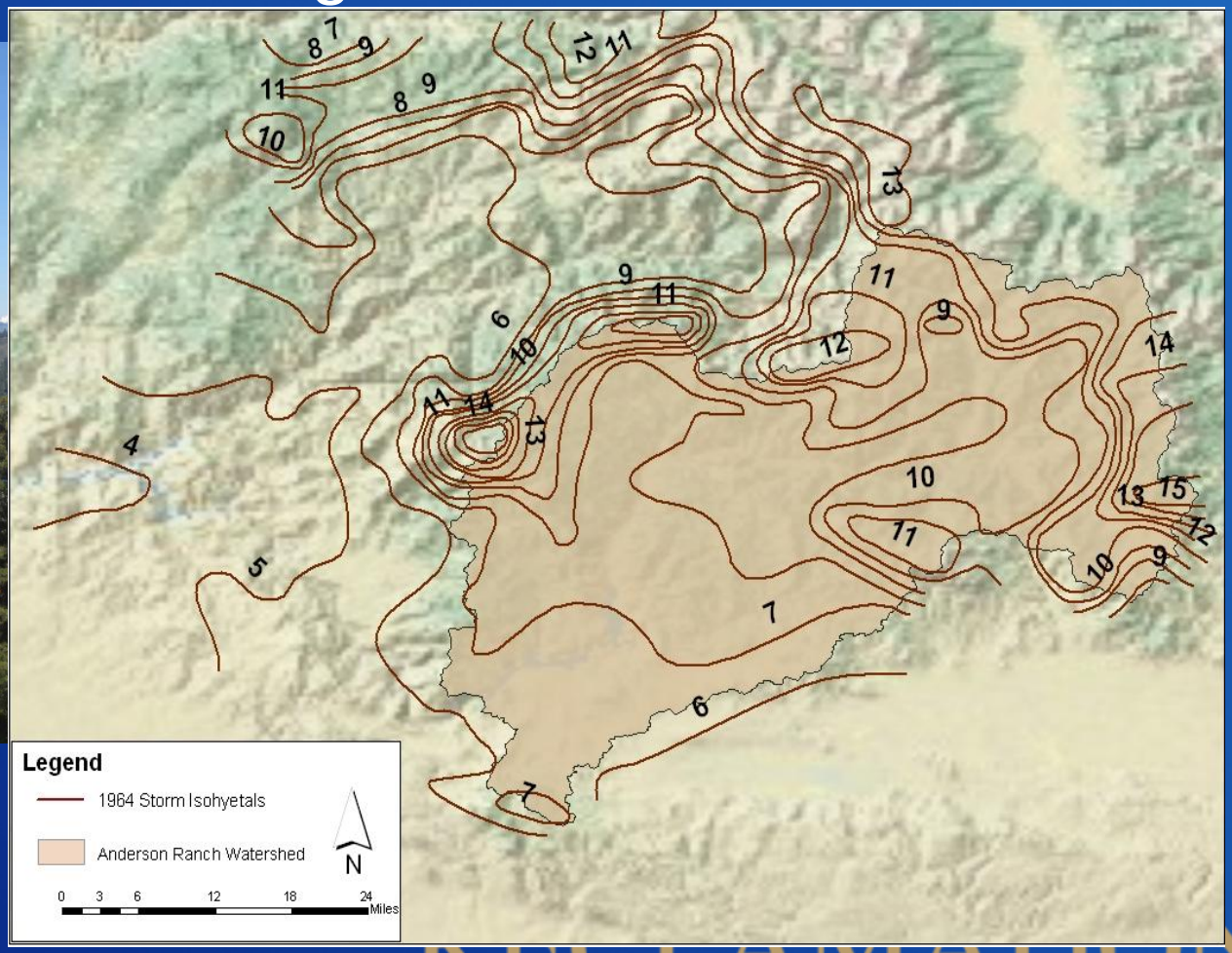
Research Questions (continued)

- How can future climate projection information be used to adjust the recent and past individual extreme storms underlying PMP in orographic regions (such as Big Thompson)?
- Do future climate projections affect storm maximization ratios and influence PMP?
- How would past extreme precipitation events, adjusted based on future climate projections, increase in intensity? Could potential increases in extreme precipitation depths over areas be assessed?

Adjusting Past Events?

December 1964 near Boise, ID: would pattern be different in future? Magnitudes increase?





January 1997?
Extreme storms in future climates?

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Some Research Goals

- Develop a methodology and initial data set of individual extreme precipitation events, in the form of gridded data sets at fine temporal and spatial scales (~hourly, 4 km) based on gage, radar data, and other modern data sets.

- Address in-part High Priority Gap No. 3.06 “Method and basis for estimating extreme meteorological event possibilities, deterministically or probabilistically, in a changing climate”

  Reclamation-USACE (2011) “Addressing Climate Change in Long-Term Water Resources Planning and Management: User Needs for Improving Tools and Information” report

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Research Strategy, Tasks, Progress

Ongoing

1. ***Recipe -*** analyze individual extreme precipitation events;
2. ***Data Base -*** quantify individual extreme events over fine spatial (e.g. 1 km to 4 km) and temporal (hourly) scales.
3. ***Spatial Interpolation -*** assess alternative strategies for spatial interpolation of ~hourly storm rainfall fields.

Future

4. ***Climate Projections and PMP -*** assess changes to regional and local in-place precipitable water storm maximization ratios/factors from climate projection information.
5. ***QPE Tool Testing -*** Examine existing probabilistic QPE tools for estimating probabilities and uncertainties of individual extreme events in complex terrain.

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Need and Benefit: Why do We Care?

What is needed?

- Temporal patterns of recent extreme storm events, with associated
- Gridded spatial patterns.
- To review PMP concepts with new research

Why?

- The storm database is 40 years old, and
- The database is not being updated.
- The concepts to formulate PMP were created before the age of computers
- PMP has the potential to be exceeded

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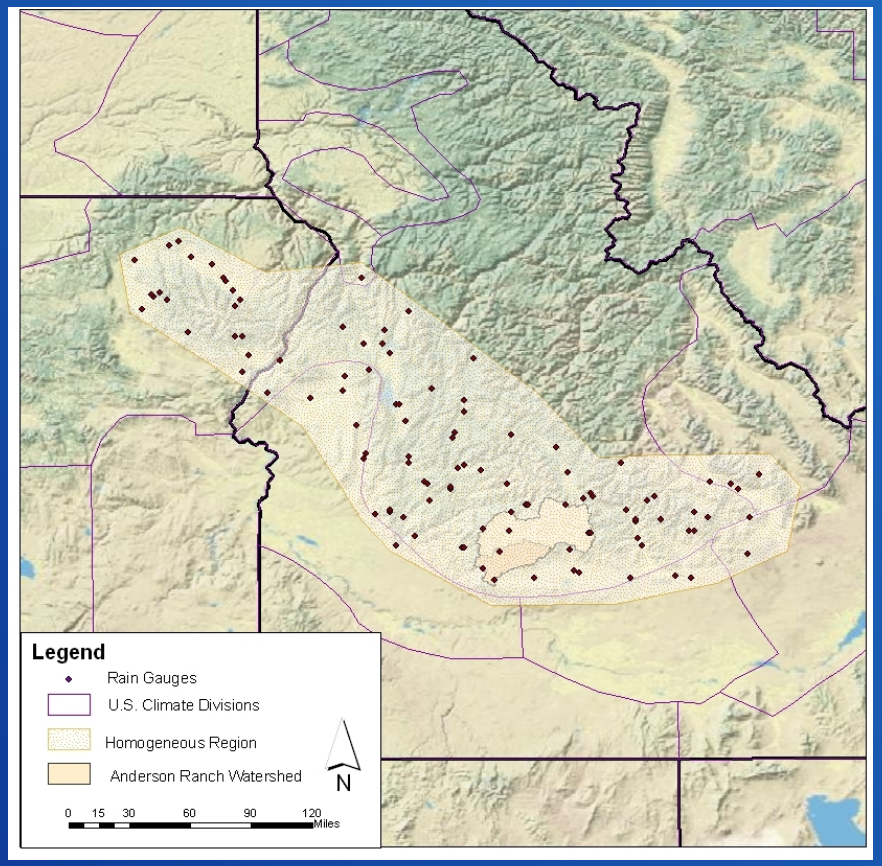
Extreme Storms and Regional Precipitation Frequency Analysis

Current Engineering Hydrology Paradigm

- Regional precipitation frequency with L-Moments
- Stochastic storm transposition

- Storm Spatial and Temporal patterns are key inputs to these statistical methods and runoff models
- Point and Basin-average extreme statistics



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Methodology and Data

- Methodology for grid-based data processing
  - Precipitation gage only cases
  - Gridded data processing
- Data considered *to date*
  - Radar products (gridded): MPR, MPE, Q2
    - ***National archive radar reanalysis in flux…***
  - Point data sets: NCDC GHCN (daily); ISD-lite (hourly)
  - Reanalysis: NARR, CFS-R,
  - SSTs – ICOADS (monthly, daily)
  - Precipitable Water (PW) and Specific Humidity: NCEP/NCAR Reanalysis
  - Climate projections: Bias Corrected and Downscaled WCRP CMIP3 (P,T)

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Individual Event Analysis - Progress to Date

- Initial data analysis – gridding of individual events
  - NC/SC: 10 events (1996-2010) MPR (prior work)
  - Oklahoma: 16 events (1975-2007), gage-only
    - Investigation of Aug 2007 TS Erin
  - Central California: 8 events (1950-2002), gage-only
    - CFS-R comparisons (Precip, Temp, Freezing Levels): 3 events
  - Idaho: 2 historical events (1955, 1964); beginning event collection
- USACE parallel efforts
  - Missouri River Basin historical events

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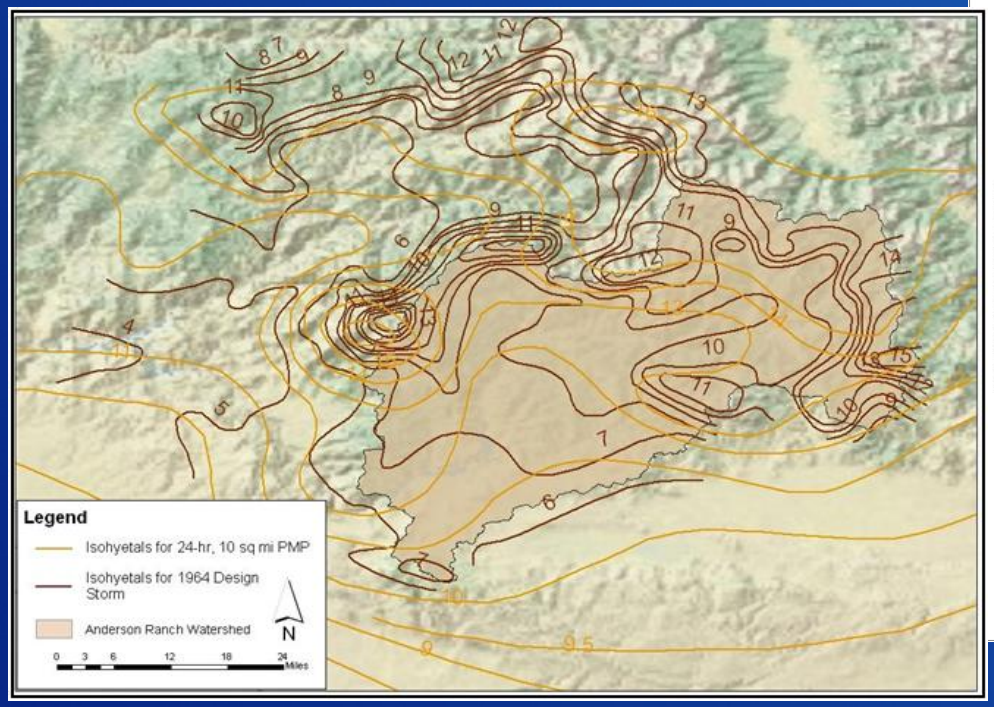
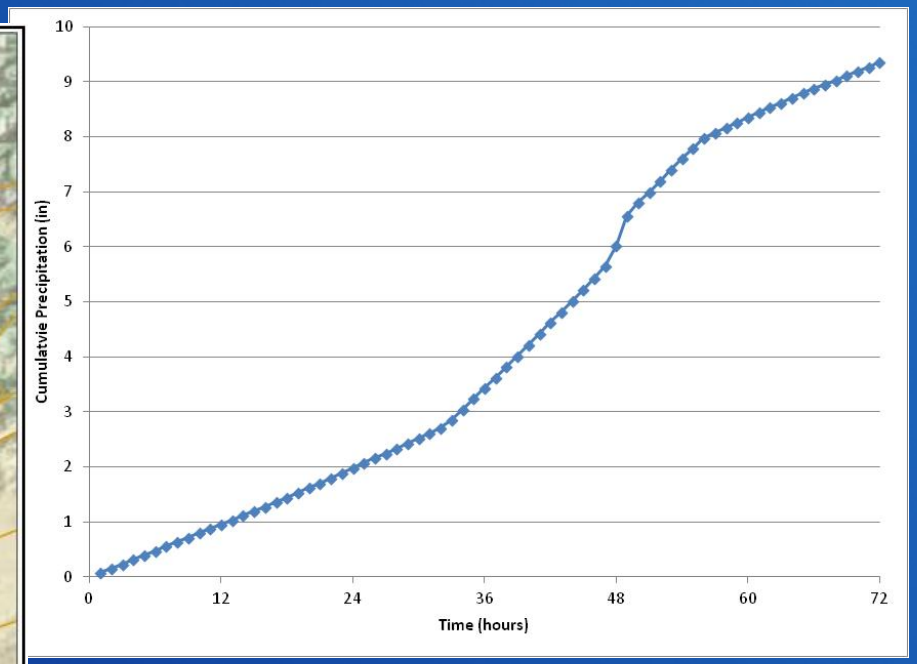
Example Historical Spatial/Temporal Pattern - December 1964





Spatial pattern of the 1964 design storm to the 10 mi^2, 24-hour PMP (HMR 57). Is pattern like climatology?

December 1964 design storm basin-average temporal pattern

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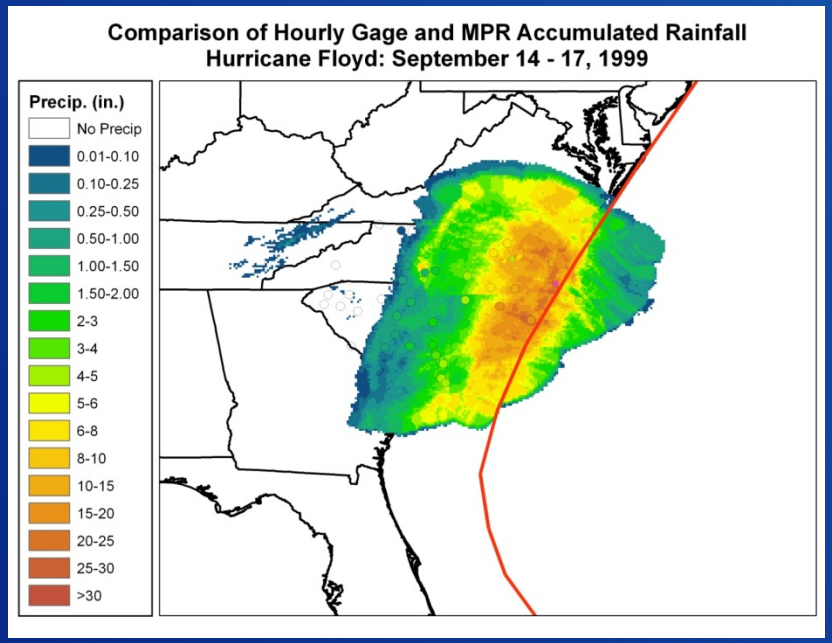
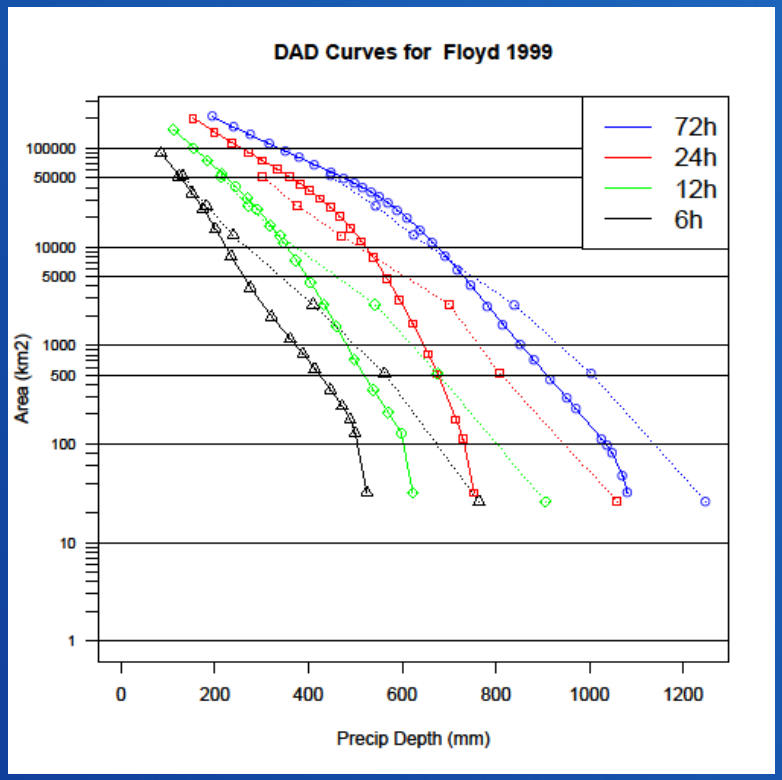
“Current” Methods/Data
D-A-D Analysis



MPR Data



Comparison of DADx curves from MPR (solid) and HMR51 (dashed).

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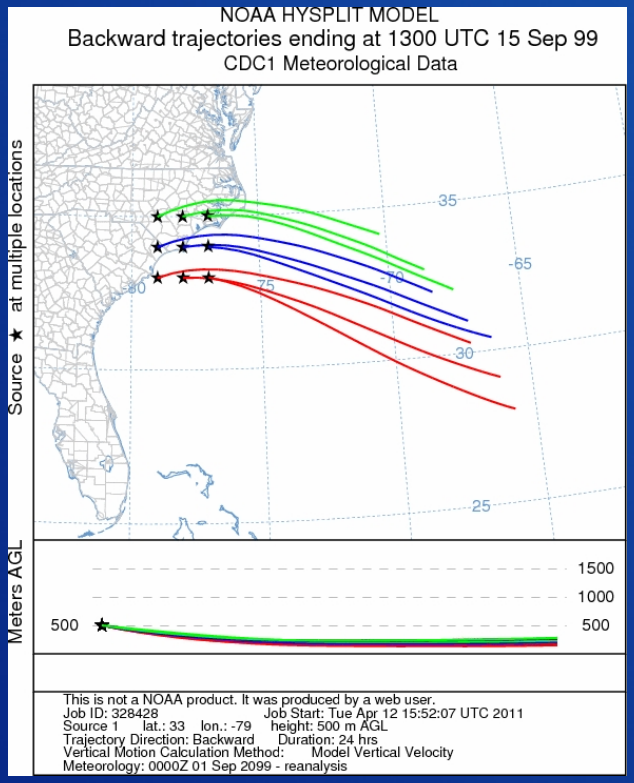
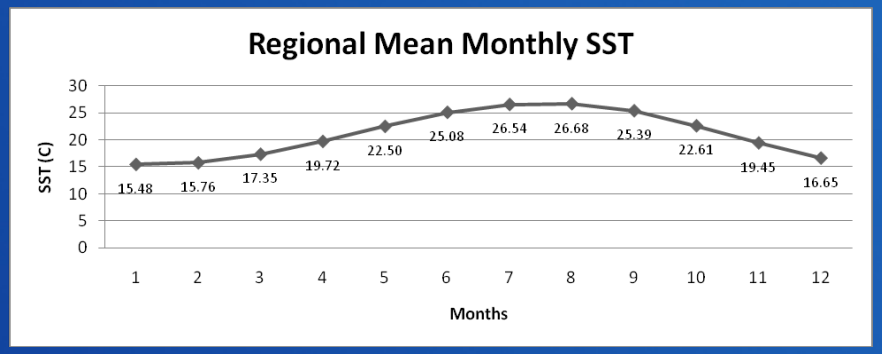
“Current” Methods/Data
Storm Maximization





Monthly average SST estimated from NCEP/NCAR (also consider ICOADS)

$$P_a = P_o \frac{W_{p,a}}{W_{p,o}}$$

Individual Storm SST source location ID
NOAA Hysplit back-trajectory model

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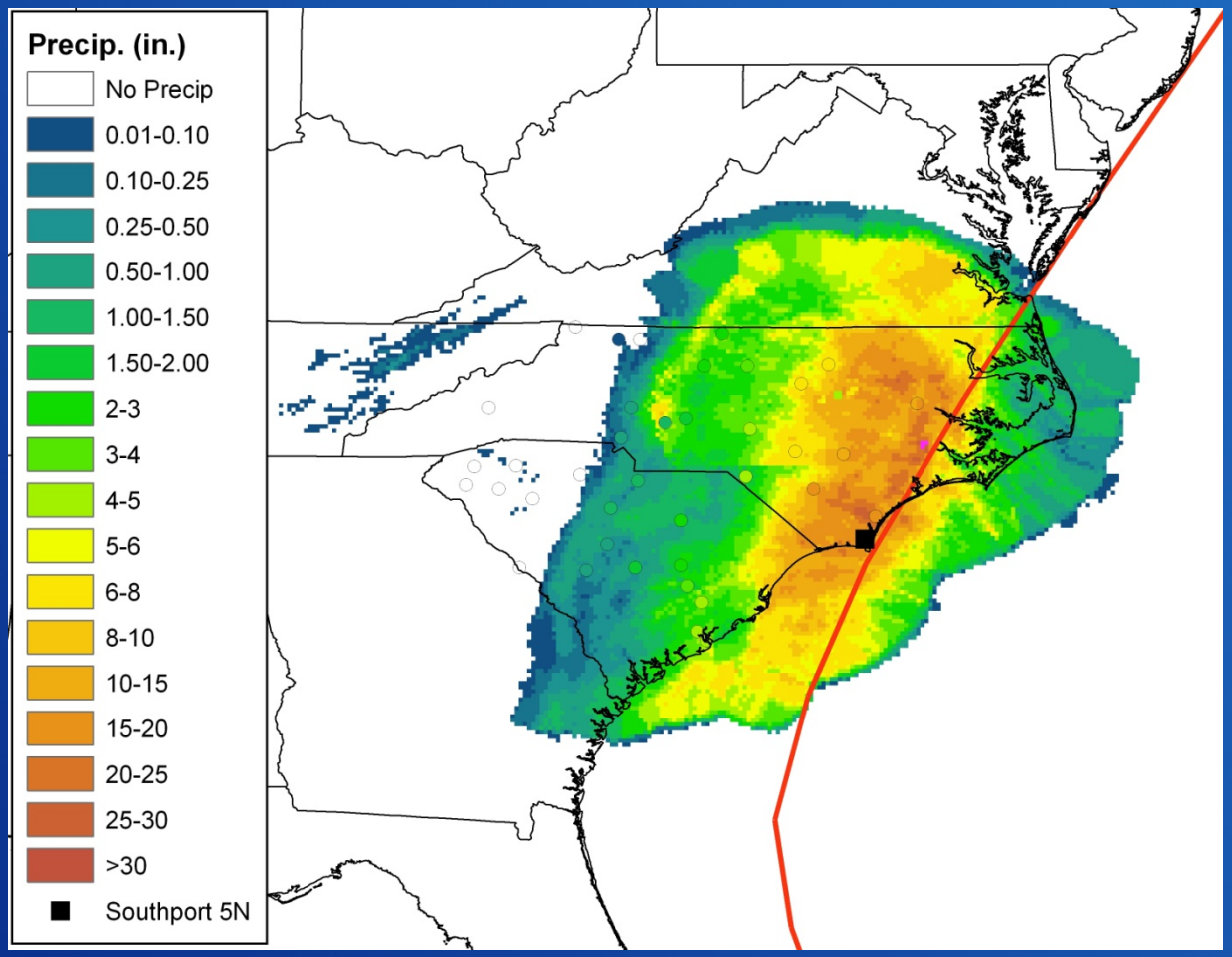
Recent Storms Exceed HMR 51 PMP Southeast US

Hurricanes Floyd (1999) and Fran (1996) based on MPR and in-place maximization

suggest ***HMR 51 PMP values too low*** for durations > 12 hrs and area sizes > 5,000 mi^2 along coastal Carolinas



Newer Data Sources and Impacts?

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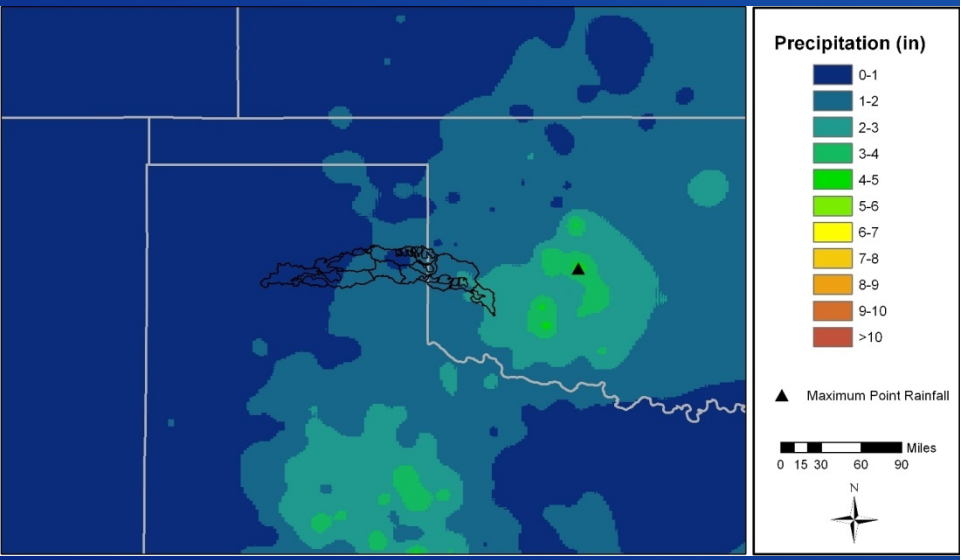
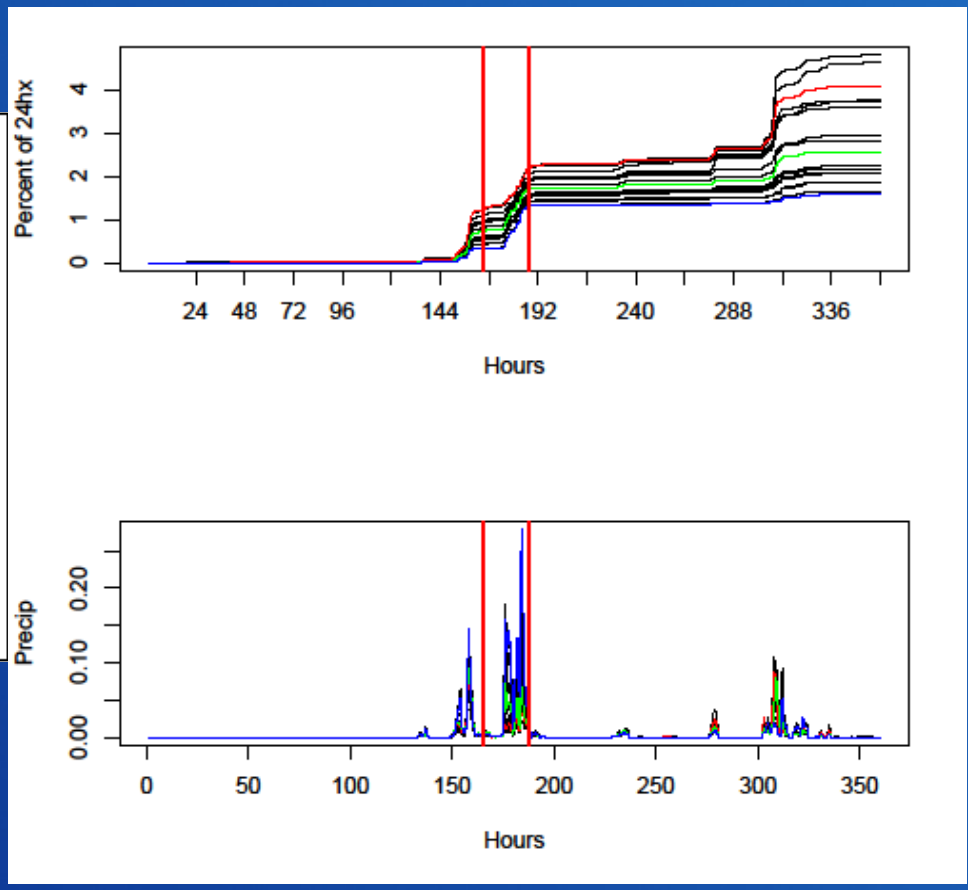
Gridded Point Analysis Spatial/Temporal Pattern – August 2007





Accumulated in-place precipitation from the 15-day period centered on August 19, 2007

Dimensionless mass curves and hyetographs (% 24-hour max precip) for each subbasin

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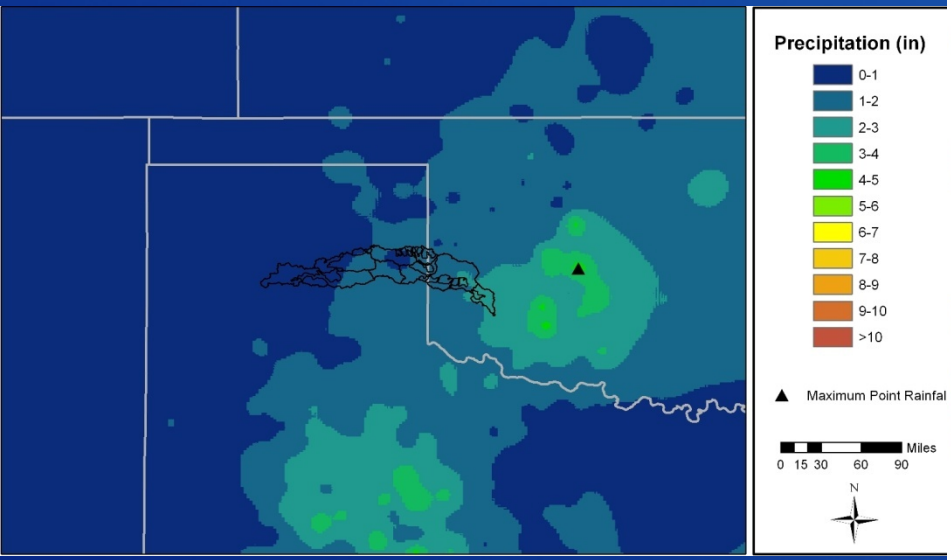
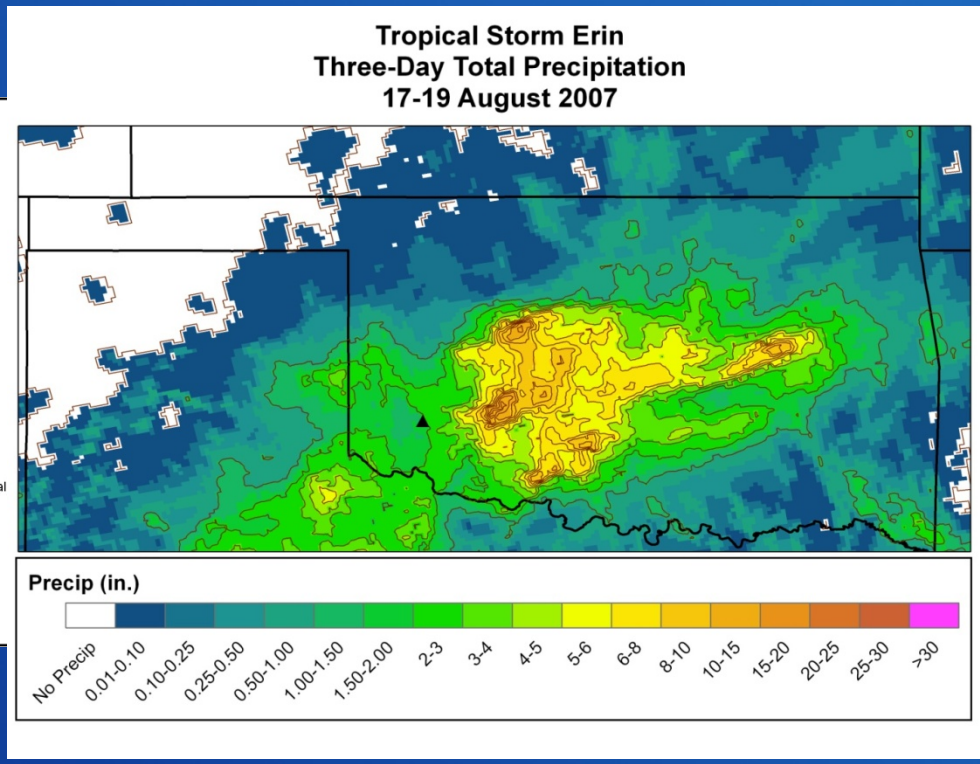
Data, Gridding and Spatial Pattern – August 2007





Gage-only accumulated in-place precipitation from the 15-day period centered on August 19, 2007

Storm total/72-hour accumulated ***MPE*** over Oklahoma from TS Erin (00 UTC 17 August to 23 UTC 19 August). One-inch isohyets (brown) are shown

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CFS-R Comparisons – Central CA

3 storms:

- Model precipitation amounts are roughly ½ of the observed precipitation amounts
- Approximately 30% of the bias is coming from areal reduction considerations
  - Friant (~1,700 sq mi); Region of Consideration (~23,000 sq mi)
- Remaining under-prediction likely due to model issues
  - Topographic smoothing
  - Parameterization schemes
- HOWEVER, the mass curves are reasonably consistent with observations
- In addition, freezing level heights and 1000hPa temperatures also agree quite well

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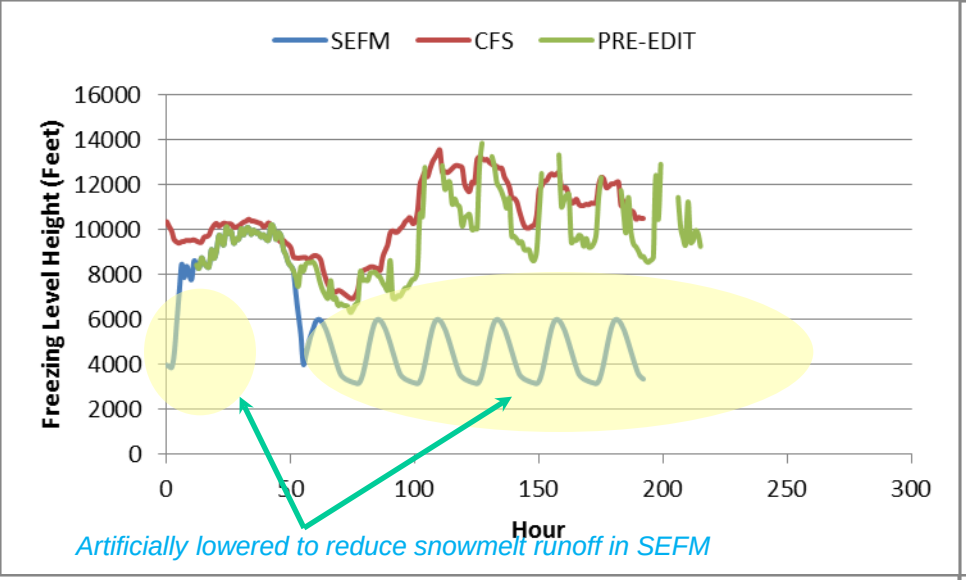

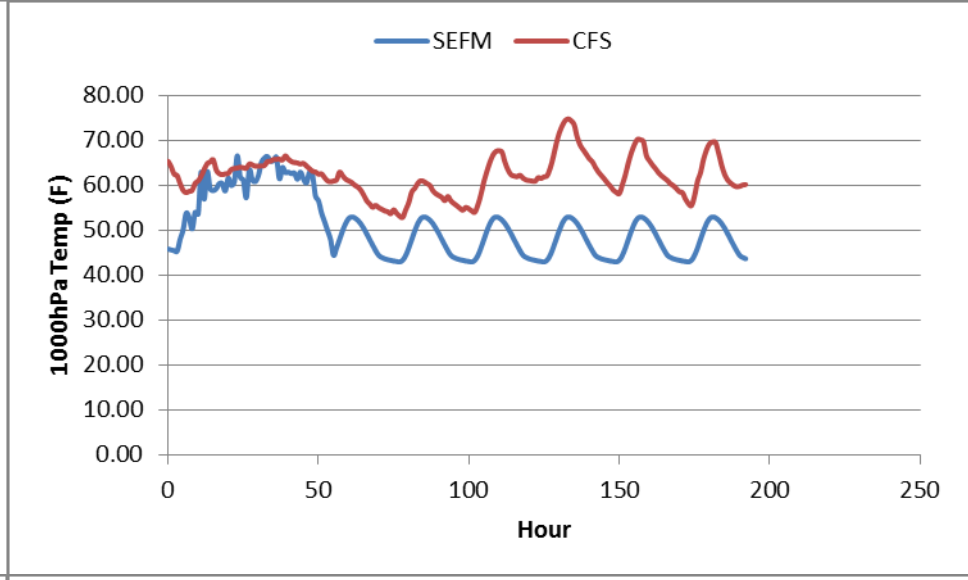

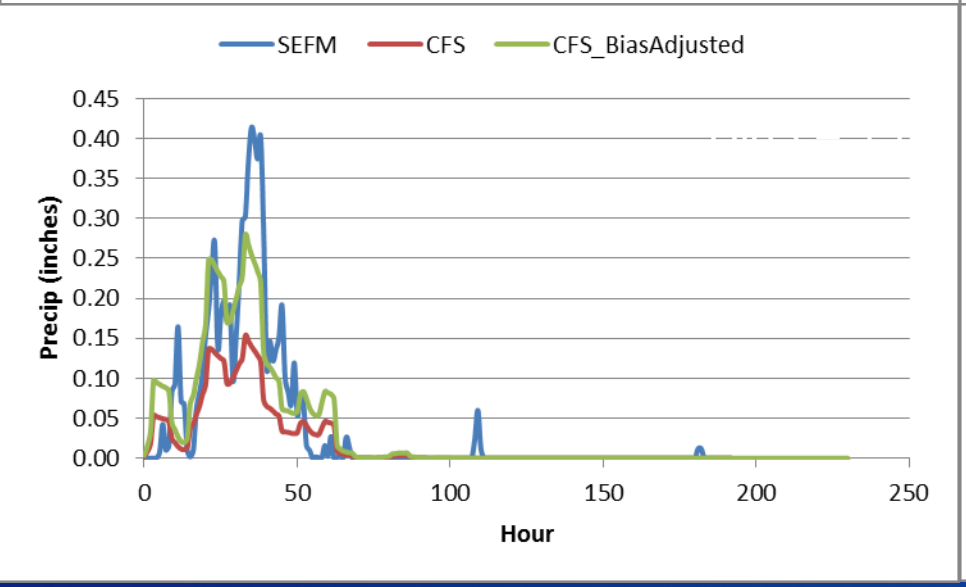

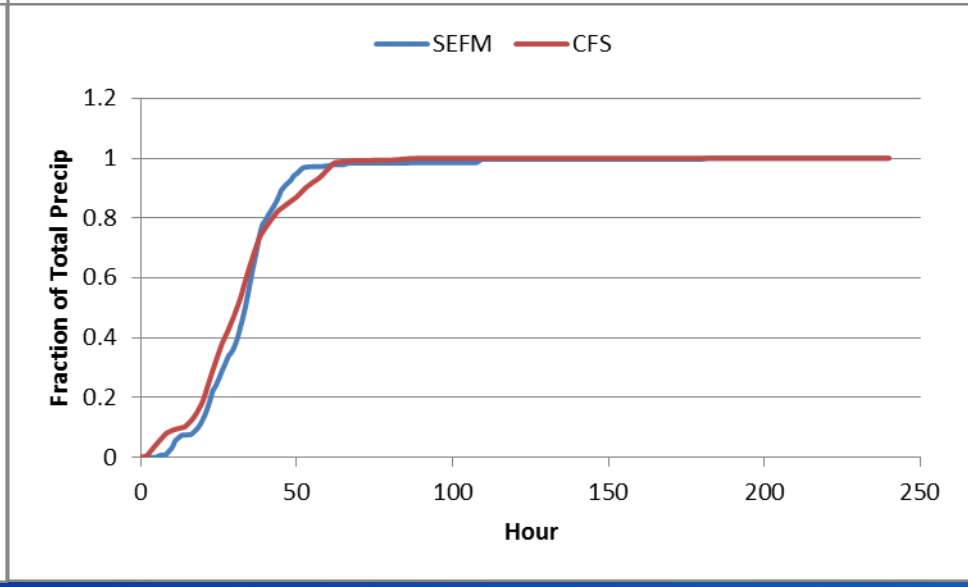

November 7 – November 16, 1997

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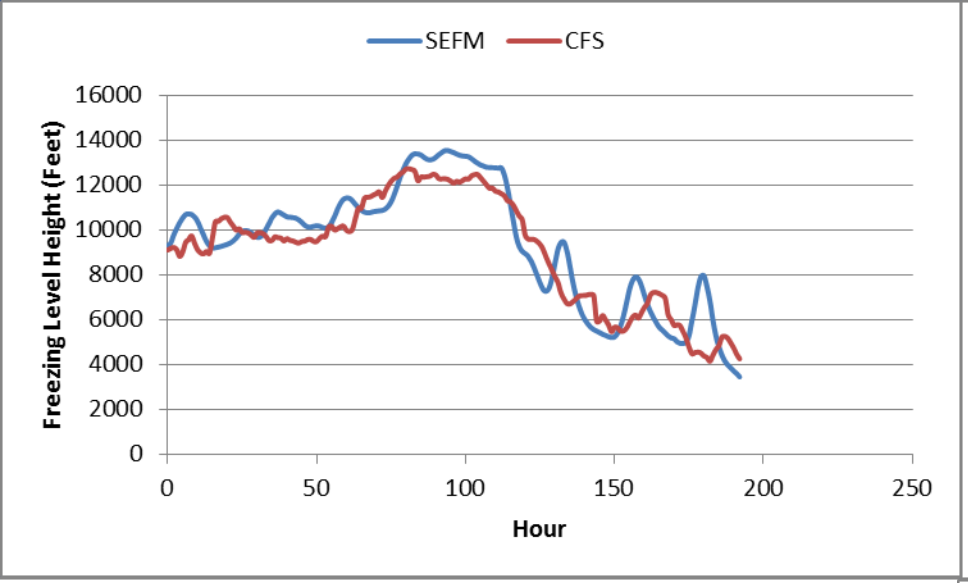

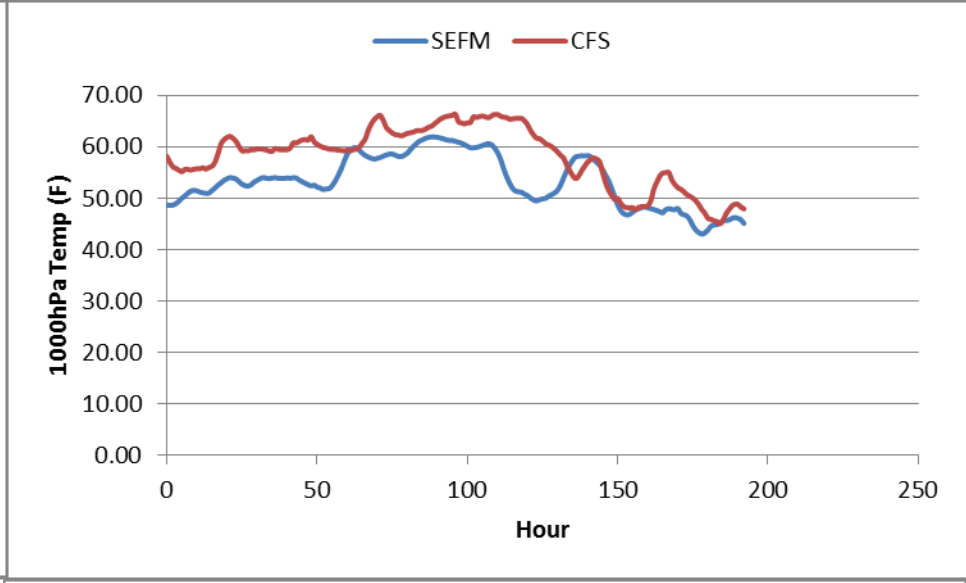

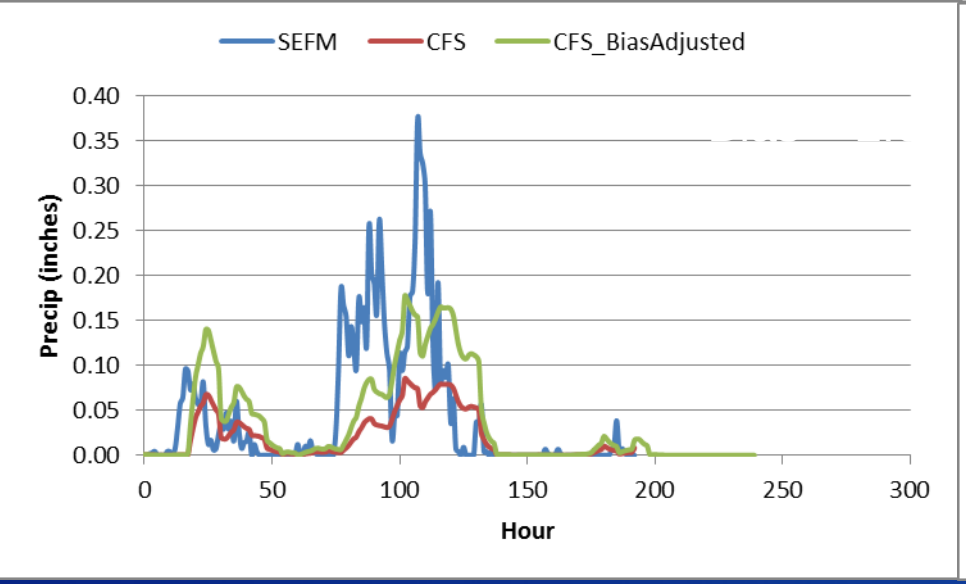

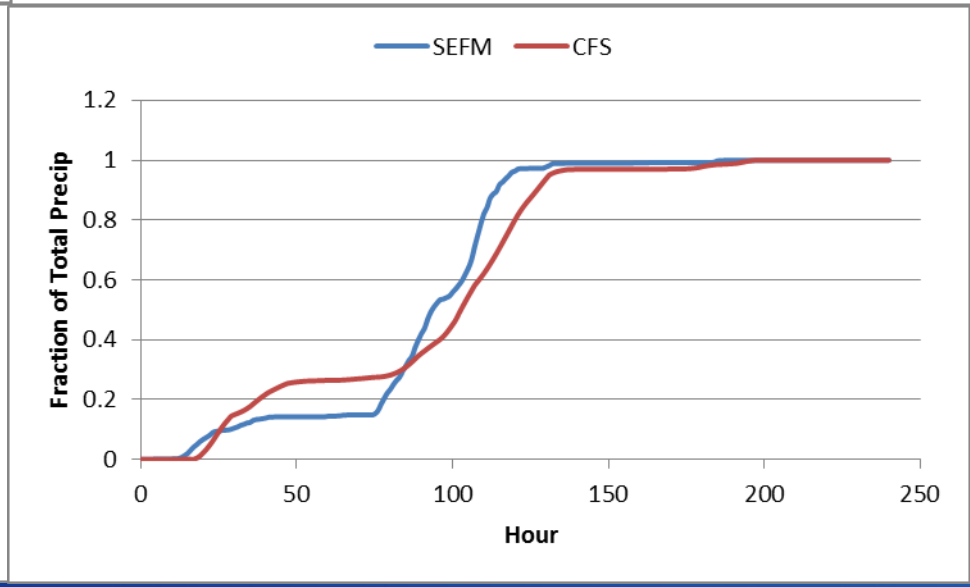

December 29, 1996 – January 7, 1997

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Ongoing Work/Directions

- Individual storm data processing and gridding
- CFS-R investigations/comparisons
- Climate Projection recipe development
- Storm transposition and Trajectories tie-in

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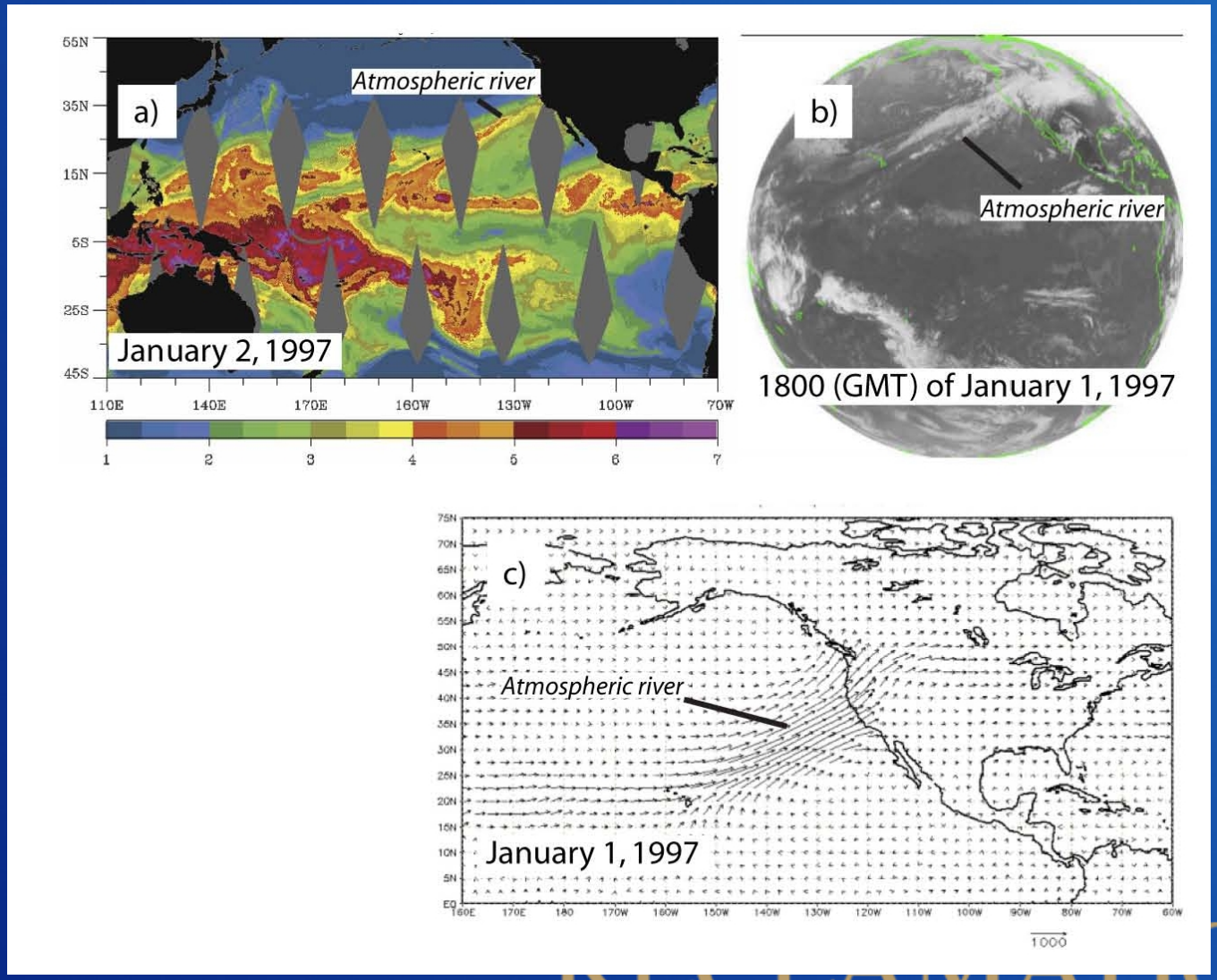
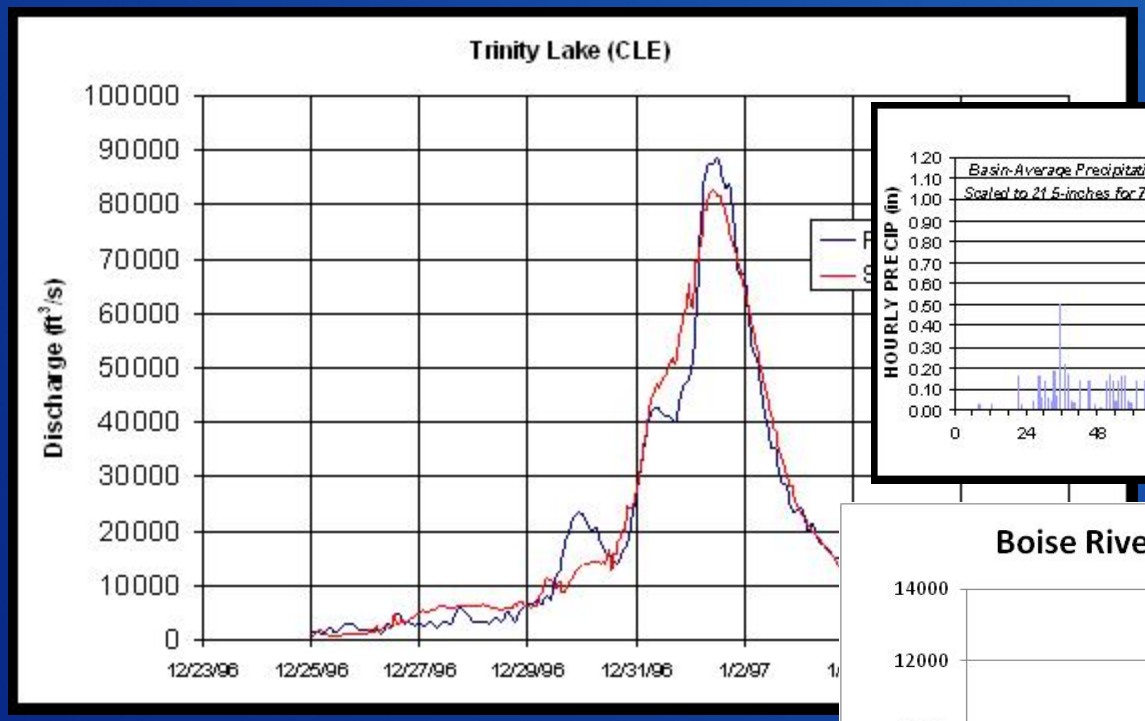
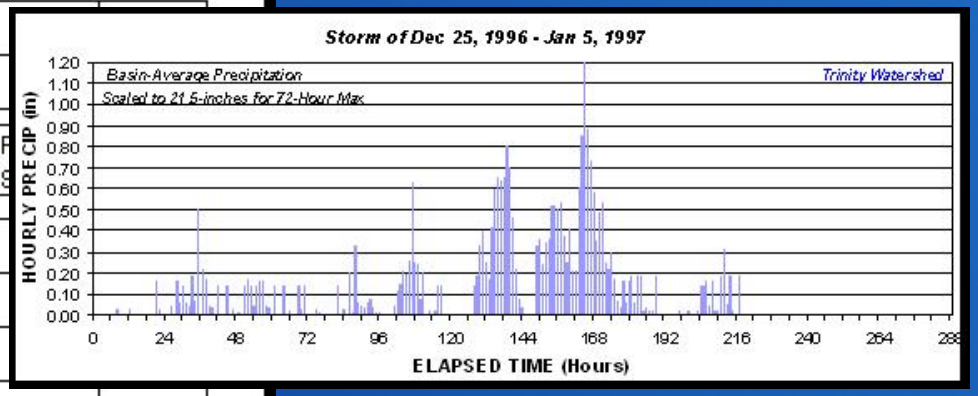
Northern California Storms: Pineapple Express and Atmospheric Rivers (e.g. Folsom, Trinity, Friant)- January 1997

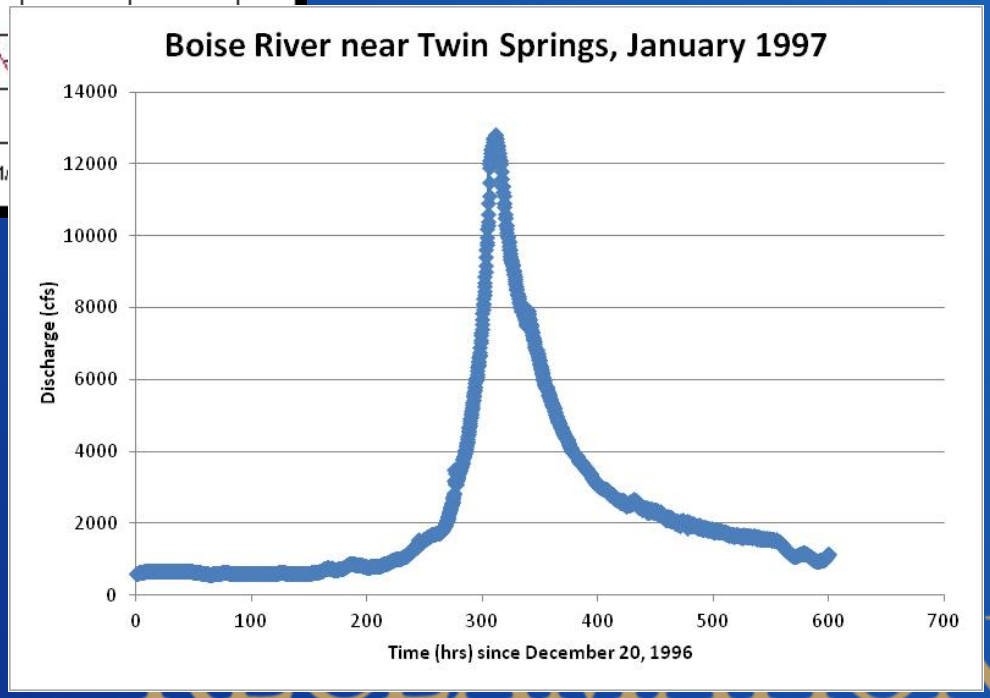


courtesy M. Dettinger (USGS) et al., Water Intl 2011

Atmospheric Rivers – Trajectories Connections January 1997: Trinity River, CA and Boise River, ID



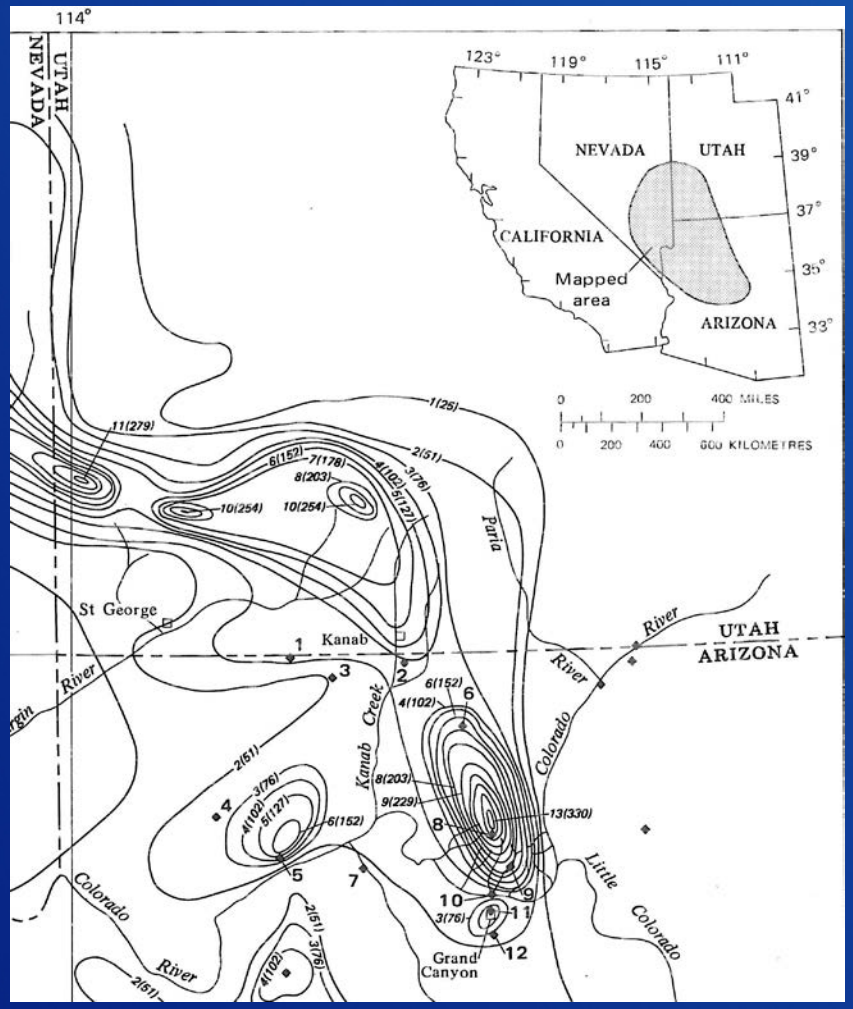




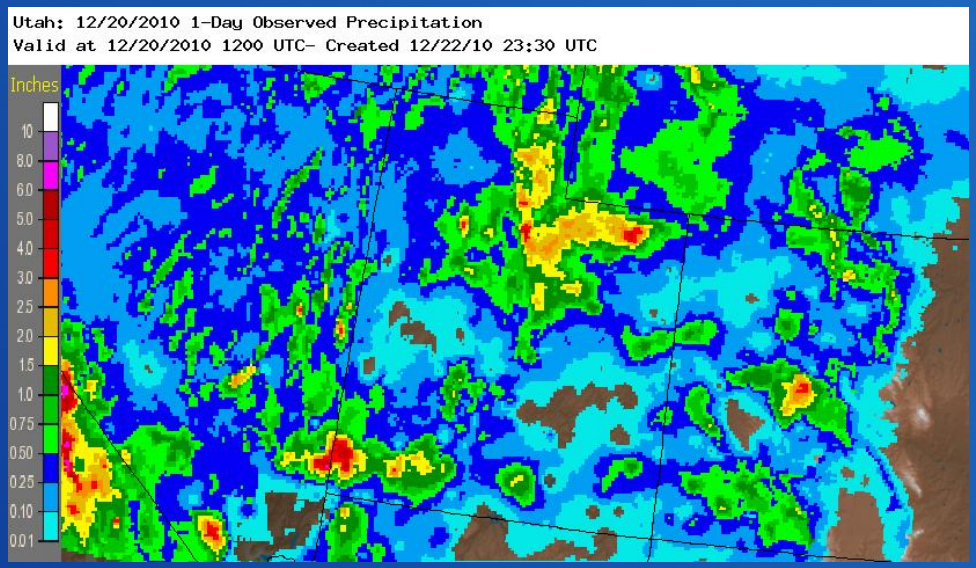
AR Strength? Deeper Penetration into ID/MT? Future Climates?

Precipitation Estimates for Boise River 1997 – Future Work…

Questions/Comments?



December 3-6, 1966 rainfall/flood (14+ in)
Grand Canyon NP; St George, UT



December 20-21, 2010 rainfall/flood
St George, UT (MPE-AHPS) (10+ in)

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