RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

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Bottom Line

This research project investigated the statistically likely moisture sources and pathways for extreme flooding events and how they vary seasonally and spatially.

Better, Faster, Cheaper

Understanding extreme flooding events is key to designing and planning infrastructure to withstand floods and operate safely. Research results will help inform in modeling, simulating, and predicting extremes in space and time and, consequently, for resource management. This research addresses identified needs in climate research—Long-term user needs document gap 4.03, "Method and basis for estimating extreme hydrologic event possibilities in a changing climate."

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Forecasting Extreme Flooding Events

Understanding the causes of extreme floods to predict floods in a season and through many decades

Problem

Floods and heavy rainfall pose a terrifying reality for the Western United States. Yet the average timing and magnitude of extreme events vary widely by season and location in the West. How often will extreme events occur? Will a changing climate mean more frequent flooding? If so, where and how? Understanding the atmospheric and hydrologic mechanisms behind extreme events can help Reclamation and others plan by providing decadal estimates of risk and seasonal forecasting. These answers are crucial for Reclamation's design and planning to ensure its existing infrastructure can meet its future needs, as well as efficient operation and maintenance from season to season.

The San AcaciaDiversion Dam peaked the morning of September 16, 2013, at more than 7,000 cubic feet per second. The dam is on the Rio Grande River in San Acacia, 15 miles north of Soccoro, New Mexico.

Solution

This Reclamation Science and Technology Program research project helped answer the following questions about extreme events in the Western United States:

1. Can Reclamation objectively define regions in which extremes behave similarly, and how many regions are appropriate?
2. What are the dominant moisture sources and pathways for extreme precipitation in each season for these regions?
3. How do seasonal moisture sources and pathways change under El Niño-Southern Oscillation (ENSO) regimes?

Applications

To examine how extreme events behave and vary, both by season and location, researchers:

- Obtained daily observed precipitation data
- Computed back trajectories (air pathways that arrive at a location during an extreme event—see figure)

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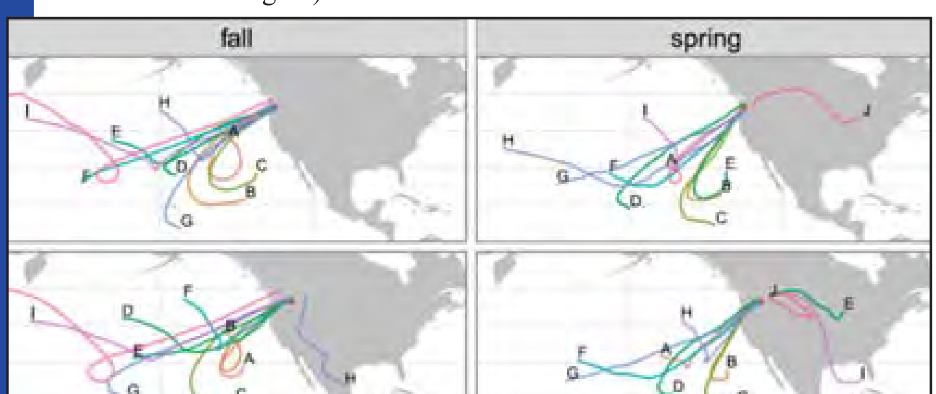

Computed back trajectories.

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- Identified seasonally coherent regions for extreme events using an improved extreme value clustering method
- Determined moisture sources
- Investigated ENSO influence on moisture sources, pathways, and extreme event frequency

Results

Based on storm back trajectory analysis, researchers were able to demonstrate unique moisture sources and dominant moisture pathways for each spatial region. Findings concluded that:

- ENSO does not strongly affect moisture source locations, but it does affect the frequency of extreme events.
- Winter and summer extremes display distinct patterns of moisture delivery, timing, and magnitude throughout the Western United States. Winter extremes behave mostly uniform across the West, while summer extremes are much more variable, and fall and spring are transitions between these seasons.
- Moisture sources include:
  - ◊ Inland regions in fall, spring, and summer: the Pacific Ocean (including the Gulf of California) and the Gulf of Mexico.
  - ◊ Northeastern regions (mostly Wyoming and Montana): land surface.
  - ◊ Coastal regions (including Northern California, Oregon, and Washington): the Pacific Ocean.
  - ◊ Southwest regions (including Southern California, Arizona, New Mexico, and western Colorado) in the summer: the Gulf of Mexico, Gulf of California, and the Pacific Ocean.

Future Plans

This analysis opens the door to many new applications, such as short-term projections similar to those made for storm tracks. These back trajectory projections could be coupled with spatial extreme models to produce maps of extreme precipitation and hydrologic extremes for resource management planning.

Future research could:

- Identify higher resolution features (e.g., specific pathways through mountains). Using newer and shorter duration datasets could also provide more detailed examinations of pathways.
- Resample back trajectories to produce physically based simulations of extreme precipitation.
- Investigate the climatic conditions in moisture source regions that favor the production of extremes, potentially to develop statistical forecast models.
- Compare the relative contribution of the land surface and open water bodies as a moisture source for extreme precipitation.

"Understanding the dynamics behind extreme flood events will help Reclamation answer questions such as: Will floods become more severe and threaten flood infrastructure under climate change? Is Reclamation's infrastructure adequately designed to perform under any increased risk due to climate change?"

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More information

www.usbr.gov/research/projects/detail.cfm?id=1916

Bracken, C., B. Rajagopalan, M. Alexander, and S. Gangopadhyay. 2015. "Spatial variability of seasonal extreme precipitation in the Western United States." Journal of Geophysical Research: Atmospheres. 10.1002/2015JD023205