Title

Predicting the Effects of Climate Change on the Size and Frequency of Floods in the Sacramento-San Joaquin Valley

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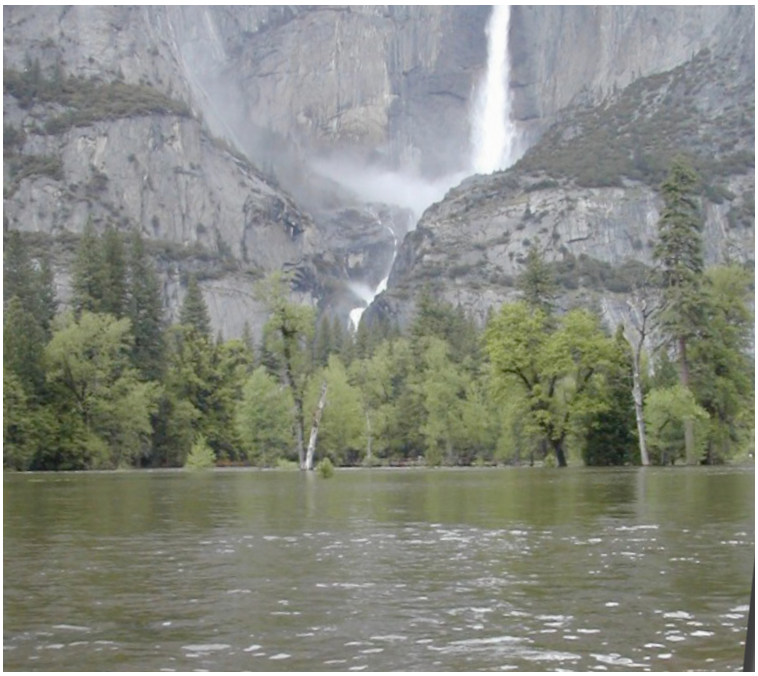

Yosemite Falls May, 16 2005. Credit: USGS

SUMMARY

How might climate change alter California's risk of floods in the future? Findings from this project suggest that flooding will become more intense in the San Joaquin and (to a lesser extent) Sacramento watersheds by the end of the century, irrespective of whether the climate becomes wetter or drier. More intense flooding appears to be a consequence of several factors—principally bigger storms, more frequent big storms and more days of precipitation falling as rain instead of snow. Moister winter soils, which may be too saturated to absorb added water, also contribute to flooding in some areas.

OBJECTIVES

The goal of this project was to investigate the possible effects of climate change on the strength and frequency of wintertime and springtime flooding in the Sacramento-San Joaquin Valley through an analysis of scenarios generated by climate and hydrological models. The following specific questions were explored:

- To what extent do simulated flood statistics mirror historical observations?
- How and why do extreme events of simulated stream flows change under different future climate scenarios?
- How sensitive are extreme-event statistics (i.e., 50-year floods) to the choice of the global climate model?

METHOD

In the first year of the project, three well-recognized General Circulation Models (GCMs) were used to simulate air temperatures and precipitation under various climate change scenarios from the present to the century's end. These simulations were "down-scaled" to produce daily forecasts of temperature and precipitation for the Western Sierra Nevada and the Sacramento-San Joaquin Valley. These projections, as well as observed measurements of temperature and precipitation from 1915 to 2003, were "fed" into a Variable-Infiltration-Capacity hydrological model to forecast flood magnitudes and frequencies, and the causes of these projected changes for each of the three GCM-derived fields.

In the project's second year, the Delta Science Fellow focused on evaluating the sensitivity of future flooding projections to the choice of GCM. To do this, 16 GCMs programmed to two future emission scenarios were used to generate an ensemble of climate projections. All the GCMs are referenced in the Intergovernmental Panel on Climate Change Fourth Assessment Report, as are the greenhouse gas scenarios.

Analyses of flood statistics were repeated on the ensemble of predictions, to examine the degree to which the apparent drivers of flood dynamics are effectively artifacts of the GCM's programming.

FINDINGS

The key findings from the analysis are:

All three of the GCMs used in the first year of the project indicate a trend toward more intense flooding for the moderate-elevation Northern Sierra Nevada and high-elevation Southern Sierra Nevada watersheds by the end of the century, regardless of whether the climate becomes wetter or drier. The increases in flooding are due to the combined effects of changing storm intensity, snowline (i.e., snowmelt) and winter soil moisture. (Flows from the Northern Sierra feed into the Sacramento Valley, while the Southern Sierra drains into the San Joaquin Valley.)

Two of the three GCMs suggest an increase in the frequency of flooding by the end of the century, while the third GCM predicts no change, or a slight decrease.

All three models also project wetter-than-average conditions for the Northern Sierra Nevada and drier-than-average conditions for the Southern Sierra Nevada by end of the century.

Fewer snowy days in the Sierra Nevada, as compared to the historical period, are also projected. This means more precipitation will fall as rain.

By 2035, the projected increases in stream flows (associated with 50-year floods) can no longer be explained by natural variability, as inferred from a 750-year control simulation.

All 16 GCMs project an increase in the magnitude of the 50-year flood by the century's end. More intense flooding appears to be the consequence of bigger storms, more frequent big storms and more days of precipitation as rain. The timing of storms and their sequence, as well as the air temperatures during and between storms and moister winter soils, may also affect flood magnitudes and frequencies. In the Northern Sierra, the increase (relative to simulated historical values) ranges from 30 to 90 percent; in the Southern Sierra, 50 to 100 percent. In terms of building infrastructure or otherwise planning for heightened flood risk, the variation in the model output is significant.

Results are a reminder that no single climatic variable dominates flood risk. It is the sum of many complex and interwoven responses to climate change expressed on the local landscape. Preparing for flood risk thus requires highly localized modeling and continued refinement for cost-effective community planning and response.

PRESENTATIONS

Das T., Dettinger M.D., Cayan D.R. and Hidalgo H.G. Potential increase in floods in California's Sierra Nevada under future climate projections. Bay-Delta Science Conference, September 2010, Sacramento, Calif.

Das T., Dettinger M.D., Cayan D.R. and Hidalgo H.G. 2010. Potential increase in floods in California's Sierra Nevada under future climate projections. CWEMF, February 2010, Asilomar, Calif.

PUBLICATIONS

Das T., Dettinger M.D., Cayan D.R. and Hidalgo H.G. Potential increase in floods in California's Sierra Nevada under future climate projections. *Climatic Change.* (In press)

Das T., Cayan D.R., Maurer E.P., Dettinger M.D. and Pierce D.W. Probabilistic forecast of change in flood characteristics in California under future climate. (In prep.)

RESEARCH MENTORS

Meteorologist Daniel Cayan and hydrologist Michael Dettinger, Scripps Institution of Oceanography, UC San Diego and U.S. Geological Survey

COMMUNITY MENTORS

Water resource engineer Michael Anderson and climate scientist John Andrew, California Department of Water Resources

Climate change is expected to exacerbate flooding in the Central Valley. Credit: USGS

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Former Delta Science Fellow Tapash Das. Credit: UCSD

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