Historical Severe December-January Floods in Yosemite Valley, with implications for climate change

Michael Dettinger, USGS
NEW YEAR'S FLOODS IN YOSEMITE
MERCED RIVER AT HAPPY ISLES, Water Year 1997

Observed and Simulated Streamflows

Daily Precipitation

Observed and Simulated Streamflows

cubic meters/second

Oct-1 Nov-26 Jan-21 Mar-18 May-13 Jul-8 Sep-2

Simulated

Observed

Daily Precipitation

millimeters

Oct-1 Nov-26 Jan-21 Mar-18 May-13 Jul-8 Sep-2
The US Geological Survey's PRECIPITATION-RUNOFF MODELING SYSTEM (PRMS)

Representation at surface:

100m x 100m Hydrologic-Response Units

MERCED RIVER, YOSEMITE NATIONAL PARK

Representation at depth:

Subbasin-scale subsurface flow reservoirs (covering 500 km²)
SENSITIVITY OF NEW YEARS 1997 FLOOD AT HAPPY ISLES TO CHANGES IN PRECIPITATION AND TEMPERATURES

Precipitation, in % observed

Change in Temperatures, in degrees C

DISCHARGE, in cubic meters/second

- Observed Discharge
- With changes in Dec 28 – Jan 3 Temperatures
- With changes in Dec 1 – Dec 28 Temperatures
- with changes in Dec 28 – Jan 3 precipitation
- with changes in October 1 – Dec 27 precipitation
Daily Temperatures and Precipitation Totals
Yosemite Park Headquarters, Dec–Jan 1915–99

- Daily observations
- January 2, 1997
- Previous largest Dec–Jan floods
- Other warm–wet storms
- Cool–wet storm (January 18, 1921)
- January 30, 1963

Precipitation, in mm

Mean Temperature, in degrees C
Dec–Jan Warm–Storm Discharge Responses
Merced River at Happy Isles Bridge

Discharge, in cms

(Simulated) Antecedent Snow–water Equivalent, in mm
National Assessment 2000
HadCM2-simulated Ratios of Dec-Feb Precipitation Rates

(2090-99) / (1961-90)
Merced River, CA, above Happy Isles Bridge
20-member ensemble Annual–Flood Frequencies

- Simulated with Obs Meteorology, 1916–98
- 1980–99 Downscaled Reanalysis Forcing
- 1980–1999 Hadley GCM Forcing
- 2080–2099 Hadley GCM Forcing

Flow, in cubic meters/sec

Percent of Years Exceeded
Merced River Annual Maximum Flows vs Day of Water Year
In Historical Record, 1916–2000

Cubic meters/sec

Merced River Annual Maximum Flows vs Day of Water Year
In 20 realizations of Downscaled GCM 1980–99 Climate

Cubic meters/sec

Merced River Annual Maximum Flows vs Day of Water Year
In 20 realizations of Downscaled GCM 2080–99 Climate

Cubic meters/sec
ACPI DJF Precipitation

B06.40

B06.43

([2090 to 2099] - [2000 to 2009]) / [2000 to 2009]
Daily Temperatures and Precipitation Totals
Yosemite Park Headquarters, Current vs Future Climates

- Daily observations
- PCM B06.40 2048-99 Simulation

Precipitation, in mm

Mean Temperature, in degrees C
Comparison of Observed and Simulated Daily Streamflows
Merced River above Happy Isles

Discharge, in m$^3$/s

Exceedence Probability

- Observed Flows, 1916–96
- PCM b06.40 Flows, 2015–99
LESSONS for CLIMATE CHANGE in the SIERRA NEVADA

Historically, all of the biggest floods on the Merced at Happy Isles (representative of the highest Sierra basins) have been wintertime warm-wet storms.

The New Years 1997 Flood in this basin was a result of rainfall runoff, much more than snowmelt.

In simulation, the New Years 1997 Flood was “set up” by conditions within a few days of the event (precipitation and temperatures much earlier in the year played little role).

The winter storm that brought about the New Years 1997 Flood was among the warmest and wettest, but was not the warmest or wettest.

Similar storms have yielded floods or not, depending on storm depths and temperatures, and immediately antecedent snowpack and soil-moisture conditions.

Under projected warmer (and especially warmer & wetter) climate conditions, a whole new population of floods is simulated in the Merced River, centered in the December-January season.