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Formulating the ARkStorm Meteorology

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BIOGRAPHICAL SKETCH

Dr. Michael Dettinger is a research hydrologist for the U.S. Geological Survey, Branch of Western Regional Research, and a research associate of the Climate, Atmospheric Sciences and Physical Oceanography Division at Scripps Institution of Oceanography, La Jolla, California. Dettinger has monitored and researched the hydrology, climates, and water resources of the West for almost 30 years, focusing on regional surface water and groundwater resources, watershed modeling, causes of hydroclimatic variability, and climatic-change influences on western water resources. He has authored over 75 scientific articles in scholarly journals and books, 20 government reports, and another 70 articles in outreach and less formal outlets.

Among other activities, he was the physical-sciences team leader for DOI-DOD ecosystem planning in the Mojave Desert, founding member of the multi-institutional CIRMONT Western Mountain Climate Sciences Consortium, climate advisor to the CALFED Bay-Delta Restoration Program, member of the Climate Change Technical Advisory Group for California Dept. of Water Resources’ 2009 Water Plan Update and ongoing Central Valley Flood Protection Program workgroup, member of the external Science Steering Group for the federal Global Water Cycle Program, research advisor for USGS Surface-Water Discipline, and a member of the USGS Global Change Science Strategic Planning Team. He has degrees from the University of California, San Diego, Massachusetts Institute of Technology, and a Ph.D. from the University of California, Los Angeles (Atmospheric Sciences).

ABSTRACT

The USGS Multi-Hazards Project is working with numerous agencies and experts to evaluate hazards that would be associated with a scientifically plausible series of extreme winter storms in California. The scenario consists of a storm sequence that impacts both Southern and Northern California in rapid succession, and that is more severe overall than any single 20th century storm, but that may rival the extreme storms of 1861-62. The atmospheric and hydrological characteristics of the storms are quantified to provide the basis for other teams to estimate human, infrastructure, economic, and environmental impacts. The scenario will be used to design emergency preparedness and flood planning exercises by federal, state and local agencies.

Recent storm episodes were “stitched” together to describe a rapid sequence of several major storms over the state, yielding precipitation totals and runoff rates beyond any that occurred during the individual (unstitched) historical events. This stitching approach is a new strategy that allowed the scenario-design team to avoid arbitrary scalings to achieve much greater-than-historical storm and flood totals, by instead allowing for the very real occasions when storms stall over parts of the state and when extreme storms have followed each other into the state over short periods of time. The scenario—called the ARkStorm—is quantified by a dynamical (regional weather-model) downscaling of historical observations of extreme winter storms of January 1969 and February 1986 to 6-km and 2-km grids over California. The weather model outputs were used to force a hydrologic model to estimate runoff, for comparison with historical runoff. The methods used to build this scenario, and key results, could also be applied to other, nonemergency or non-California applications.
Formulating ARkSTORM Meteorology

Mike Dettinger (USGS) and Marty Ralph (NOAA)

Mimi Hughes (NOAA), Tapash Das (SIO), Paul Neiman (NOAA), Dale Cox (USGS)
• The Great Southern California Shakeout: A week-long series of events to inspire SoCalifornians to improve earthquake readiness; >6 million participants thus far

• A scientifically plausible & detailed scenario of a major southern San Andreas earthquake was designed by the USGS scientists (and collaborators) and used as basis for California Office of Homeland Security’s Golden Guardian exercises, Nov 2008, Oct 2009, Oct 2010, ...
In a new MultiHazards effort, we were tasked recently with formulating a similarly detailed & defensible scenario for an extreme-winter storm/flood episode(s) in California—eventually dubbed “ARkStorm”
THE 1861-1862 FLOODS

- December 24, 1861 through Jan 21, 1862: nearly unbroken rains
- Central Valley flooding over about 300 mi long,
  12 – 60 mi wide
- Most of LA basin reported as “generally inundated”
- San Gabriel & San Diego Rivers cut new paths to sea
- 420% of normal-January precipitation in Sacramento in Jan 1862
- 300% of normal-January precipitation in San Diego in Jan 1862
- 500% of normal-January in San Francisco
THE 1861-1862 FLOODS

• No way of knowing how intense the rains were, but they were exceptionally large in total and prolonged.

• Lesson: Prolonged storm episodes are a plausible mechanism for winter-storm disaster conditions in California

• Lesson: A combined NorCal+SoCal extreme event is plausible. 12 days separated the flood crest in Sacramento from the crest in Los Angeles in Jan 1862
AR in ARkStorm = Atmospheric River

MIMIC-TPW from CIMMS @ Univ. Wisconsin Madison
http://cimss.ssec.wisc.edu/tropic/real-time/tpw2/epac/main.html
WHICH STORMS TO STITCH, WHEN?

500 mb geopotential heights (m)

Day +1, 27 Jan 1969

Day -4, 08 Feb 1986

Day -4, 22 Dec 1996

Day 0, 26 Dec 1996

Feb 1986?

New Years, 1997?
ALL reports of precipitation > 15 in/day at sites in California, 1871-1998

Courtesy, Jim Goodridge, 2008
Weather Research & Forecasting (WRF) model’s nested grids

54-km grid
18-km grid
6-km grid
2-km grid

Mimi Hughes, NOAA/ESRL, at the helm
ARkStorm PRECIPITATION TOTALS

Total accumulated precipitation, in mm
DAILY PRECIPITATION AT THREE SITES

Preconditioning (in half-months)
1 Nov 1968–18 Jan 1969

Southern California storm
19–27 Jan 1969
Includes extra 25 Jan

Northern California storm
8–20 Feb 1986

Nor-Cal mtn site:
40.35N, 121.6W
1600 m MSL

So-Cal mtn site #1:
34.23N, 117.48W
850 m MSL

So-Cal mtn site #2:
34.23N, 117.18W
1600 m MSL

Daily precipitation, mm/day

Date (month/day)

Observed
WRF, 6–km
WRF, 2–km

“Stitched”
PERCENTAGE OF ARkStorm SEQUENCE SPENT BELOW FREEZING
Maximum 3-sec gust, in mph
Based on comparisons to WY1916-2003 historical VIC runoff simulation.
Rough estimates of Flooding (based mostly on FEMA Flood Insurance maps)