

AR Science, Natural Hazards Risk Reduction and ARkStorm

Dale A. Cox
Program Manager
U. S. Geological Survey
Science Application for Risk Reduction (SAFRR) Project






USGS Mission

The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.






The SAFRR Project

SAFRR: Science Application for Risk Reduction

The mission of SAFRR is to innovate the application of hazard science for the safety, security, and economic well-being of the nation.






The SAFRR Scenarios

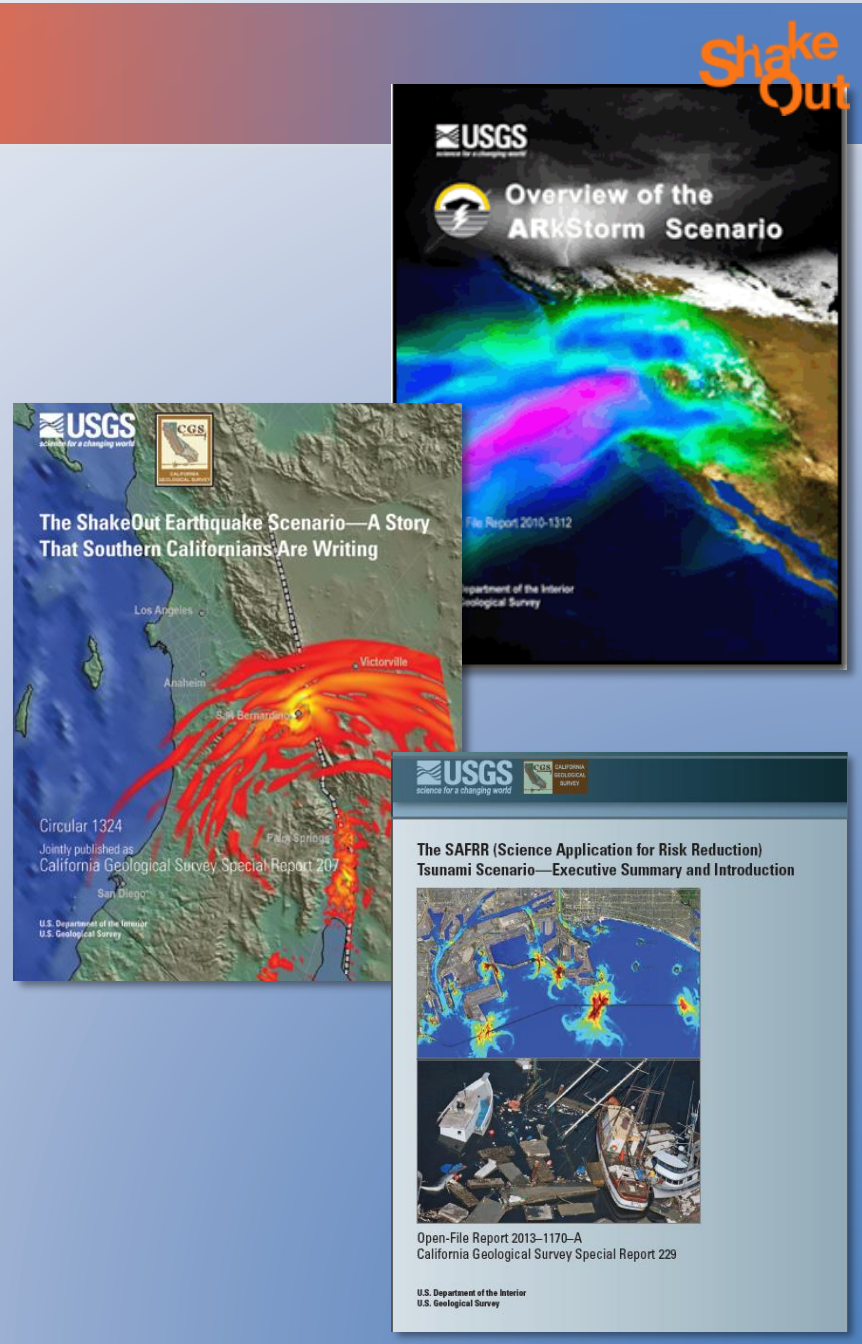
ShakeOut: San Andreas fault (southern California) earthquake scenario (2008)

ARkStorm: winter storm scenario impacting U.S. West Coast (2010)

Tsunami Scenario: tsunami generated by an Alaskan earthquake and impacting the U.S. West Coast (2013)

HayWired: Hayward fault (northern California) earthquake scenario (in progress)

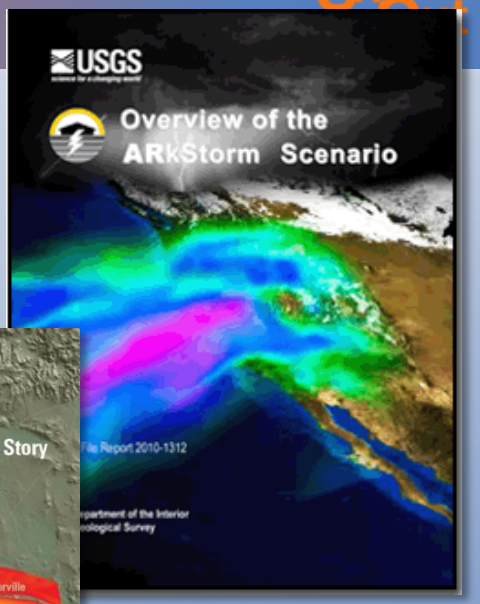
Hawaii Tsunami Scenario: tsunami scenario affecting Hawaii, Pacific islands, and the U.S. mainland (in initiation stage)

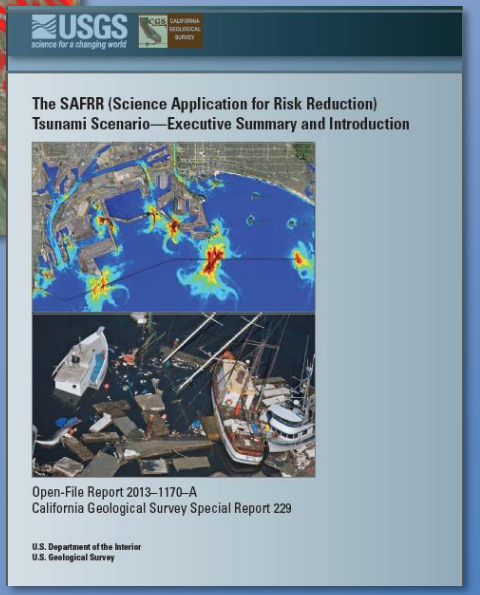


Principles of a Scenario

1. A single, large but plausible event (realistic but not worst case)
2. An event we need to be ready for
3. Integrate across many disciplines
4. Consensus among leading experts
5. Create study together with community partners
6. Results presented in products that fit the user, not the scientist

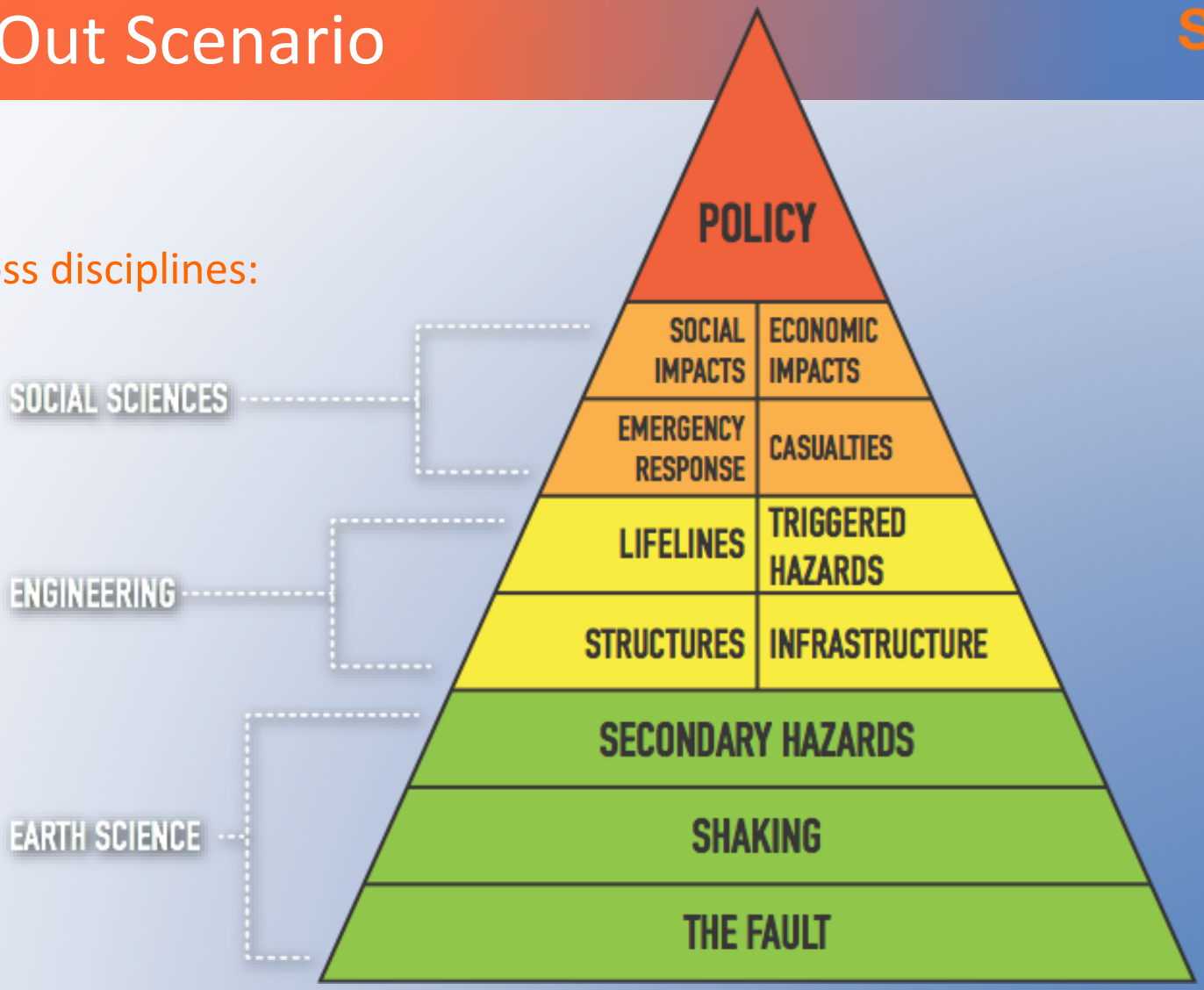
…A tool to help visualize, plan, & prepare.





The ShakeOut Scenario

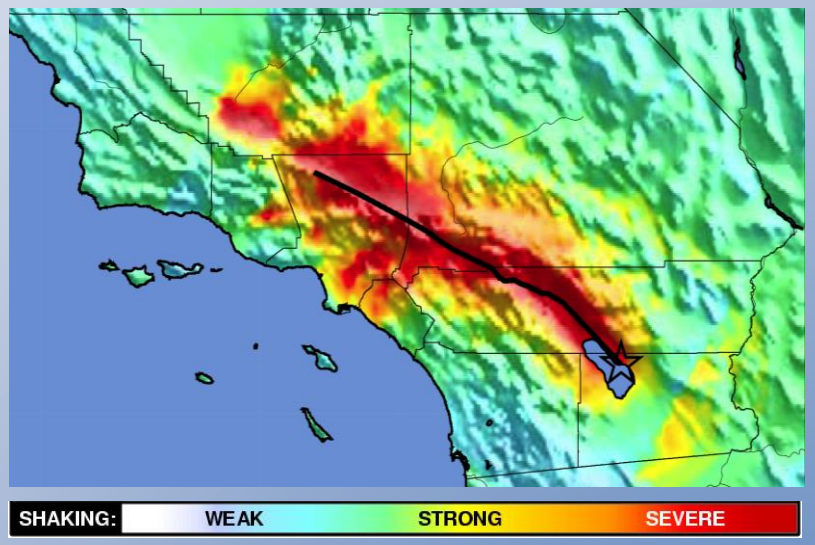
Integrating across disciplines:



Building the ShakeOut Scenario

The ShakeOut Scenario

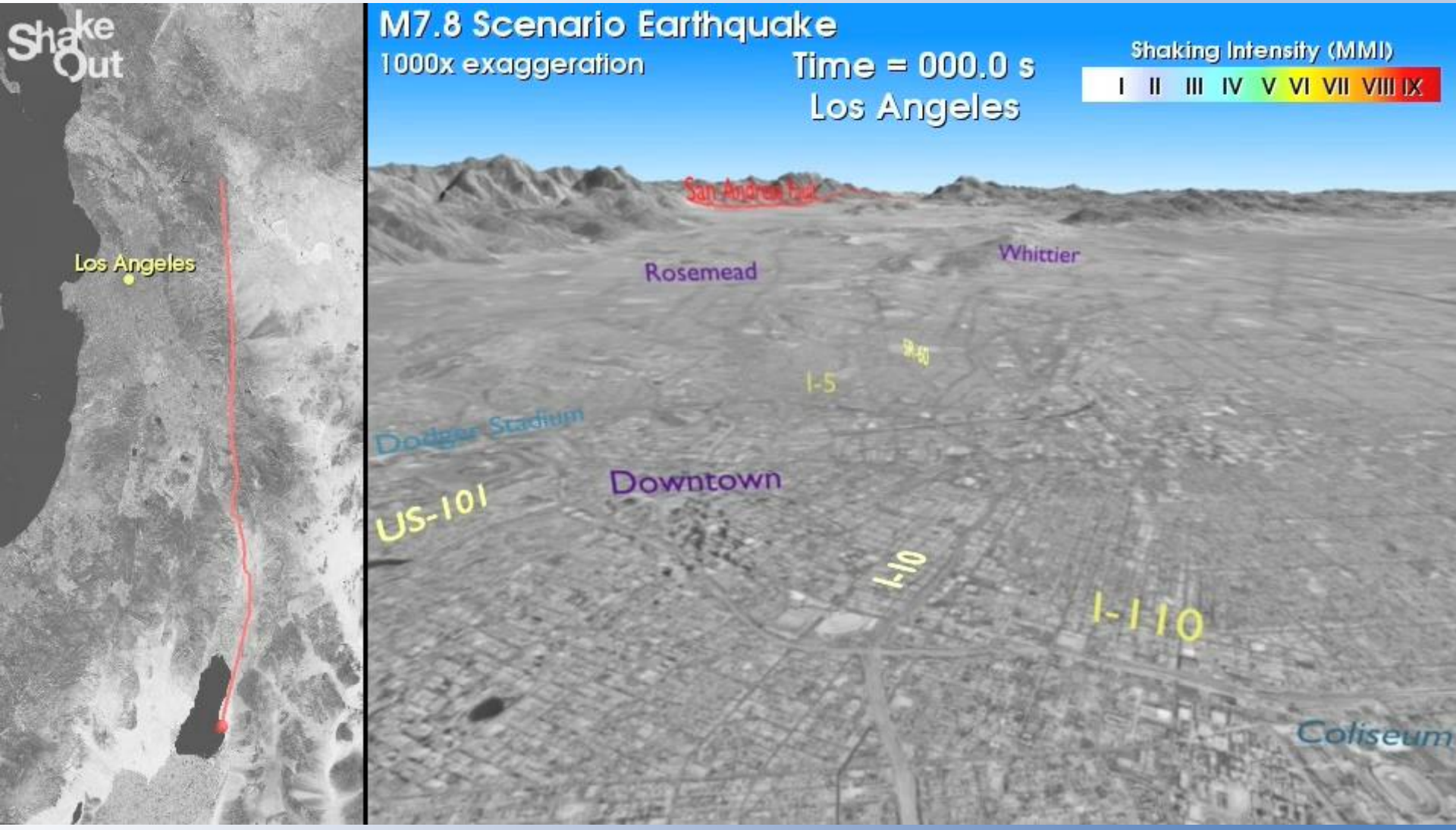
- The possible “Big One:”
  an earthquake on the southernmost section of the San Andreas Fault
- SAFRR led a group of scientists, engineers, and others to create a realistic scenario of what could happen.
- 180 mile rupture
- Magnitude 7.8
- 100 seconds of fault rupture
- Shaking for over 2 minutes in many places



Full Report details
http://pubs.usgs.gov/of/2008/1150/

Resources: www.shakeout.org

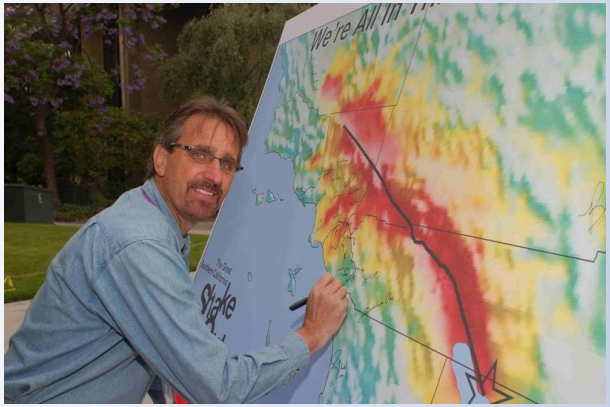
ShakeOut Simulation: Los Angeles



"The Great ShakeOut"

- 45 million people worldwide participate in the ShakeOut Drill (see: http://www.shakeout.org)

- School, Business, & Community Organization recruitment efforts help "spread the word" and promote participation in the ShakeOut



- Helps shift the culture in southern California toward improved earthquake awareness:
  - We must all take greater responsibility for readiness
  - We all need to talk about earthquakes and preparedness more often

- Significant increase in earthquake readiness at all levels

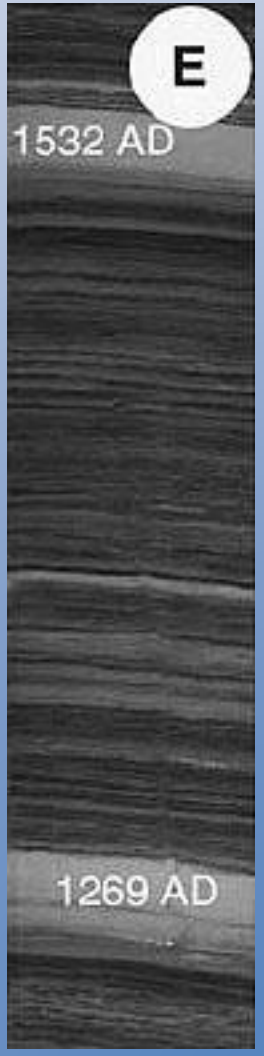
The ARkStorm Scenario

Prehistoric Megafloods

Revised dating of the laminated sediment in the Santa Barbara Basin (SBB) by Arndt Schimmelmann et al. (2013) indicates the occurrence of megafloods around BC 107, AD 53, AD 263, AD 735, AD 1269 and AD 1532.

"Exceptionally large regional flood events in the SBB area have occurred every few hundred years in prehistoric times."

"The past rate of recurrence makes severe flooding in the future a likely possibility, especially in a warming global climate."



Schimmelmann, A., Hendy, I.L., Dunn, L., Pak, D.K. & Lange, C.B., 2013: Revised , ~2000-year chronostratigraphy of partially varved marine sediment in Santa Barbara Basin, California. GFF, 2013

The ARkStorm Scenario

Historical Floods: 1861 – 1862

The “Great Flood of 1862”

The State of California went bankrupt.

200,000 cattle drowned…

…caused the state’s economy to shift from ranching to farming.

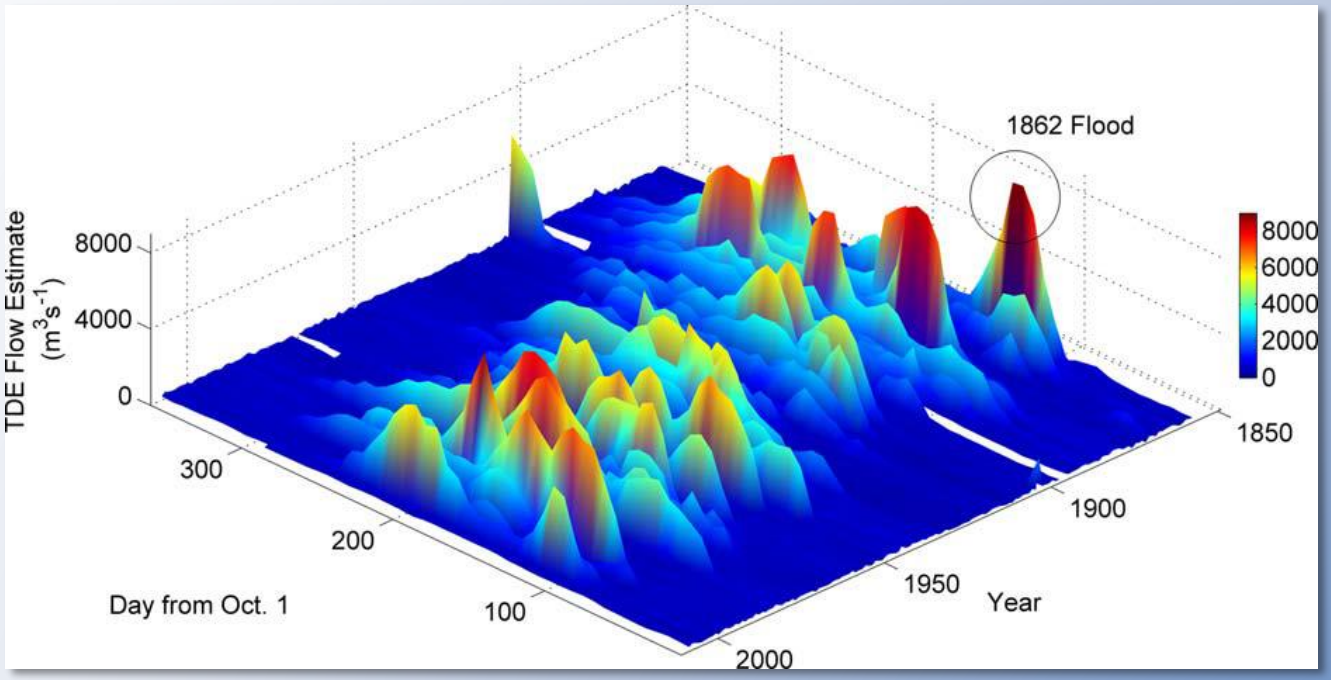
The ARkStorm Scenario

Historical Floods: 1861 – 1862

- **Central Valley: flooding over about 300 miles long, 12 – 60 miles wide**
- **LA Basin: reported as "generally inundated"**
- **San Gabriel & San Diego Rivers: cut new paths to sea**
- **Agua Mansa: the largest community between Los Angeles and New Mexico – obliterated.**
- **Two Storms: 12 days separated the flood crest in Sacramento from the crest in Los Angeles.**

The ARkStorm Scenario

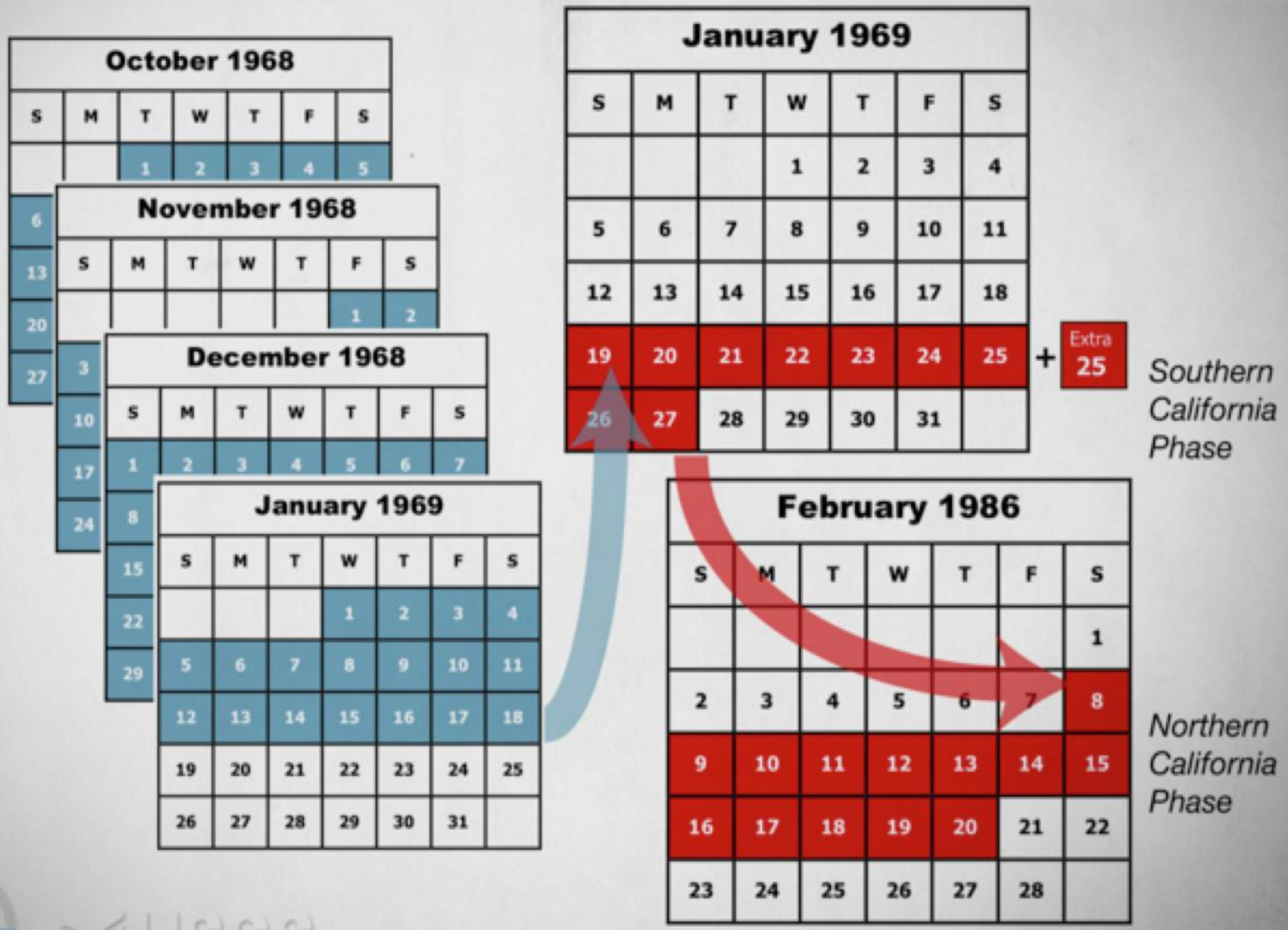
Historical Floods: 1861 – 1862



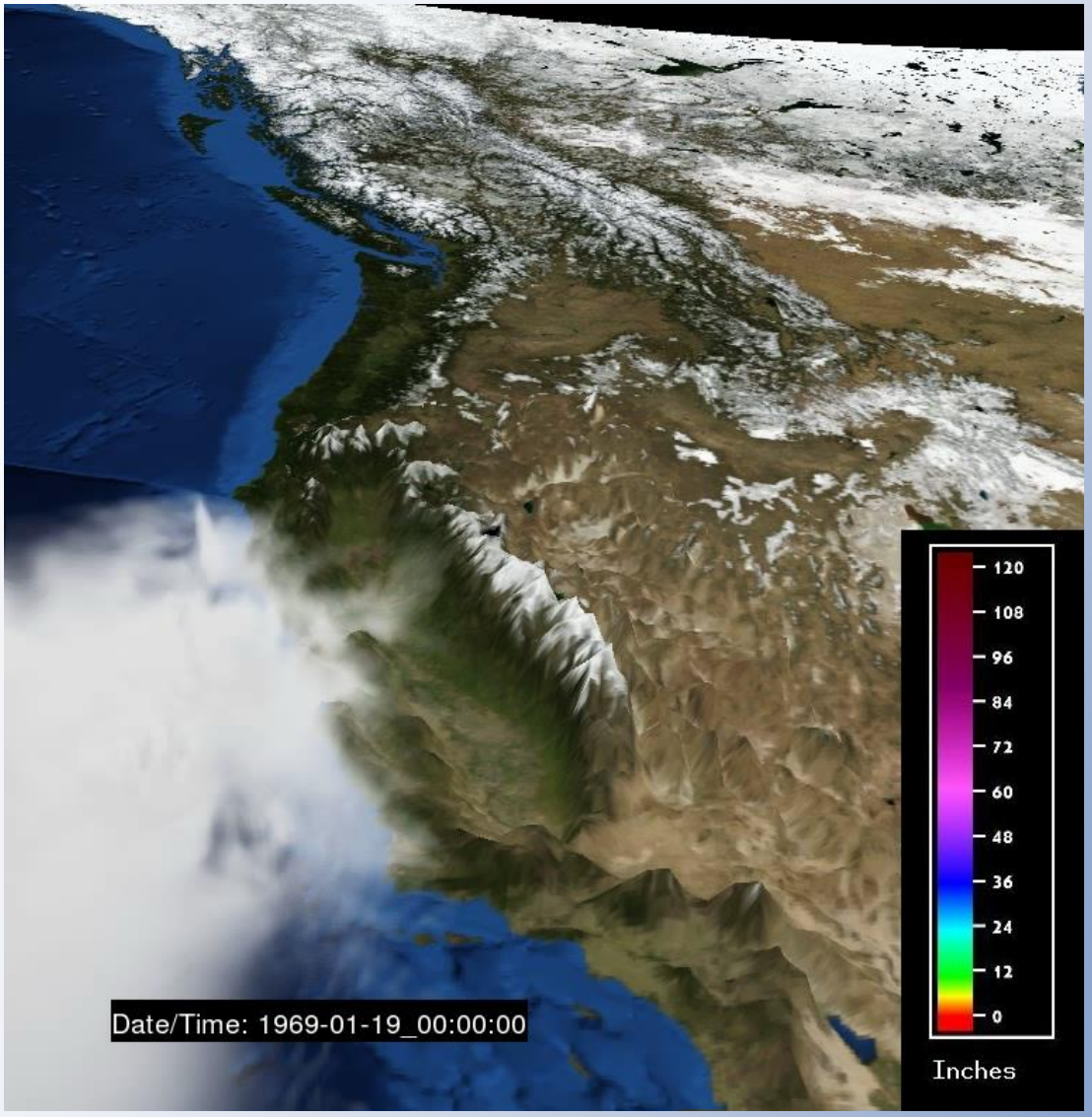
The 1862 flood is the largest flow event of the last 150 years….about 25% larger than the 1997 flood.

Moftakhari, H. R., D. A. Jay, S. A. Talke, T. Kukulka, and P. D. Bromirski (2013), A novel approach to flow estimation in tidal rivers, Water Resour. Res., 49, 4817–4832, doi:10.1002/wrcr.20363.

The ARkStorm Scenario

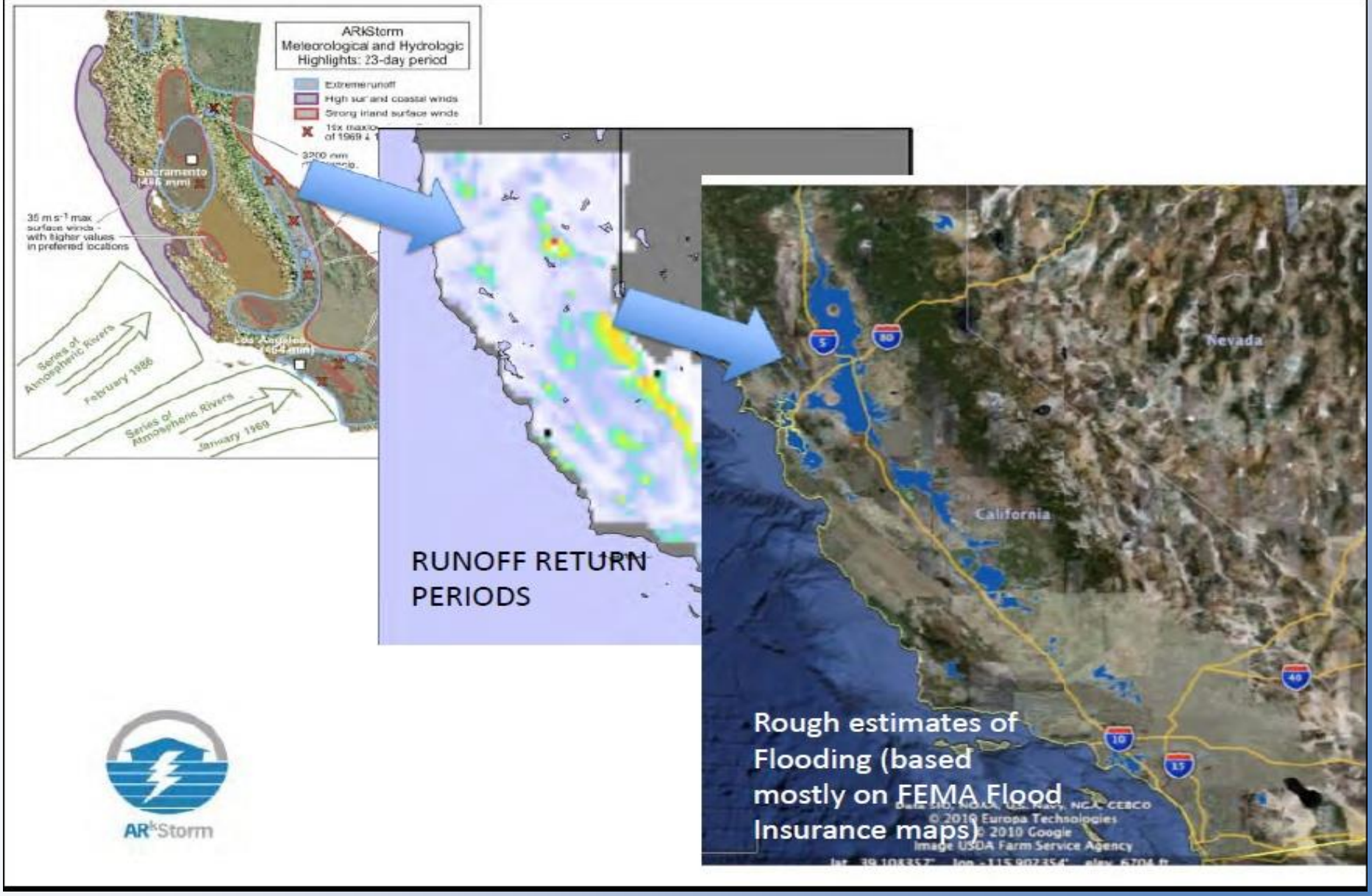


The ARkStorm Scenario

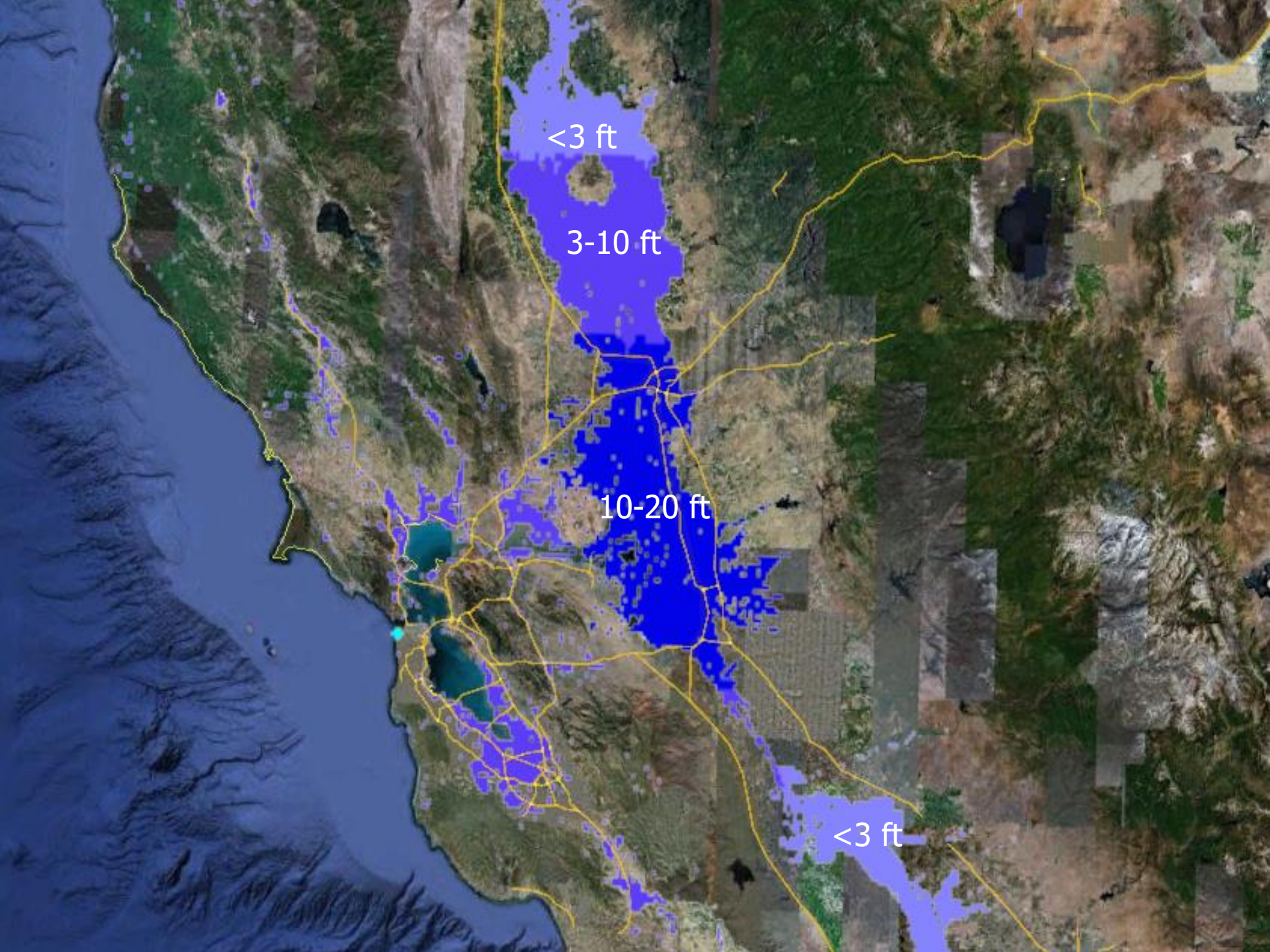


- James Done, NCAR
  Earth System Laboratory (NESL), Mesoscale and Microscale Meteorology Division (MMM), Regional Climate Research (RCR)

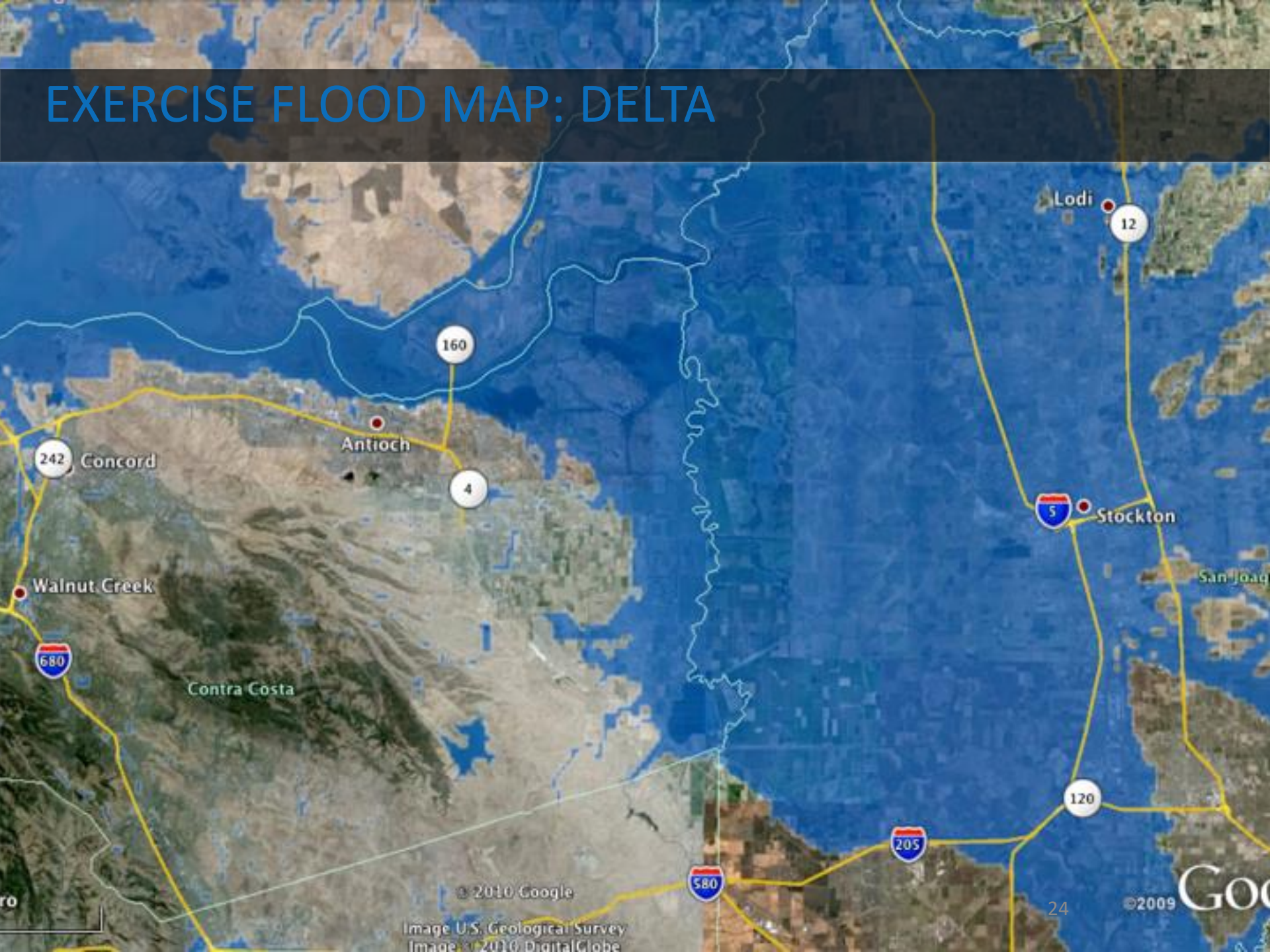
The ARkStorm Scenario



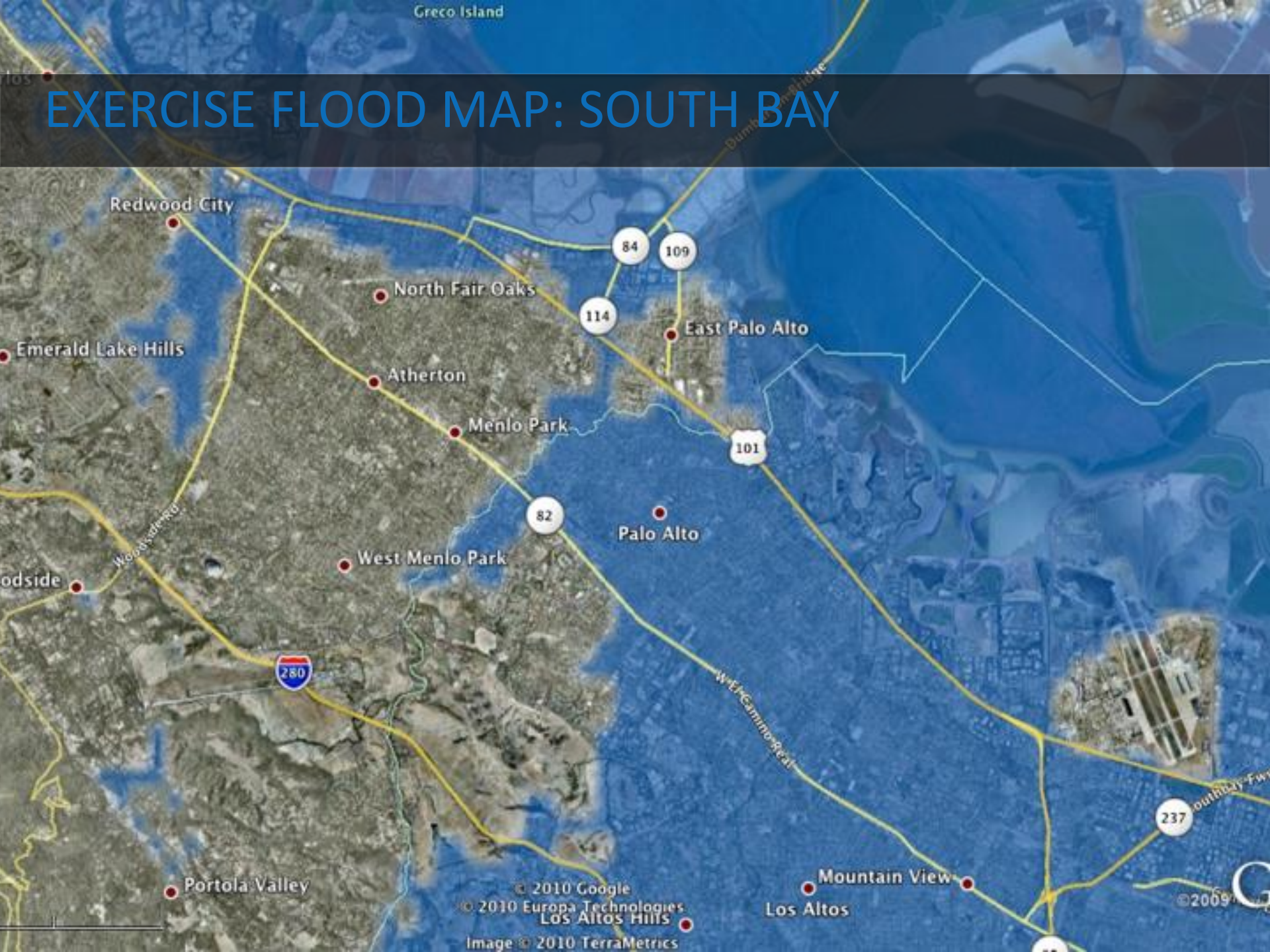

80
San Francisco
San Jose
California
Nevada
40


<3 ft
3-10 ft
10-20 ft
<3 ft

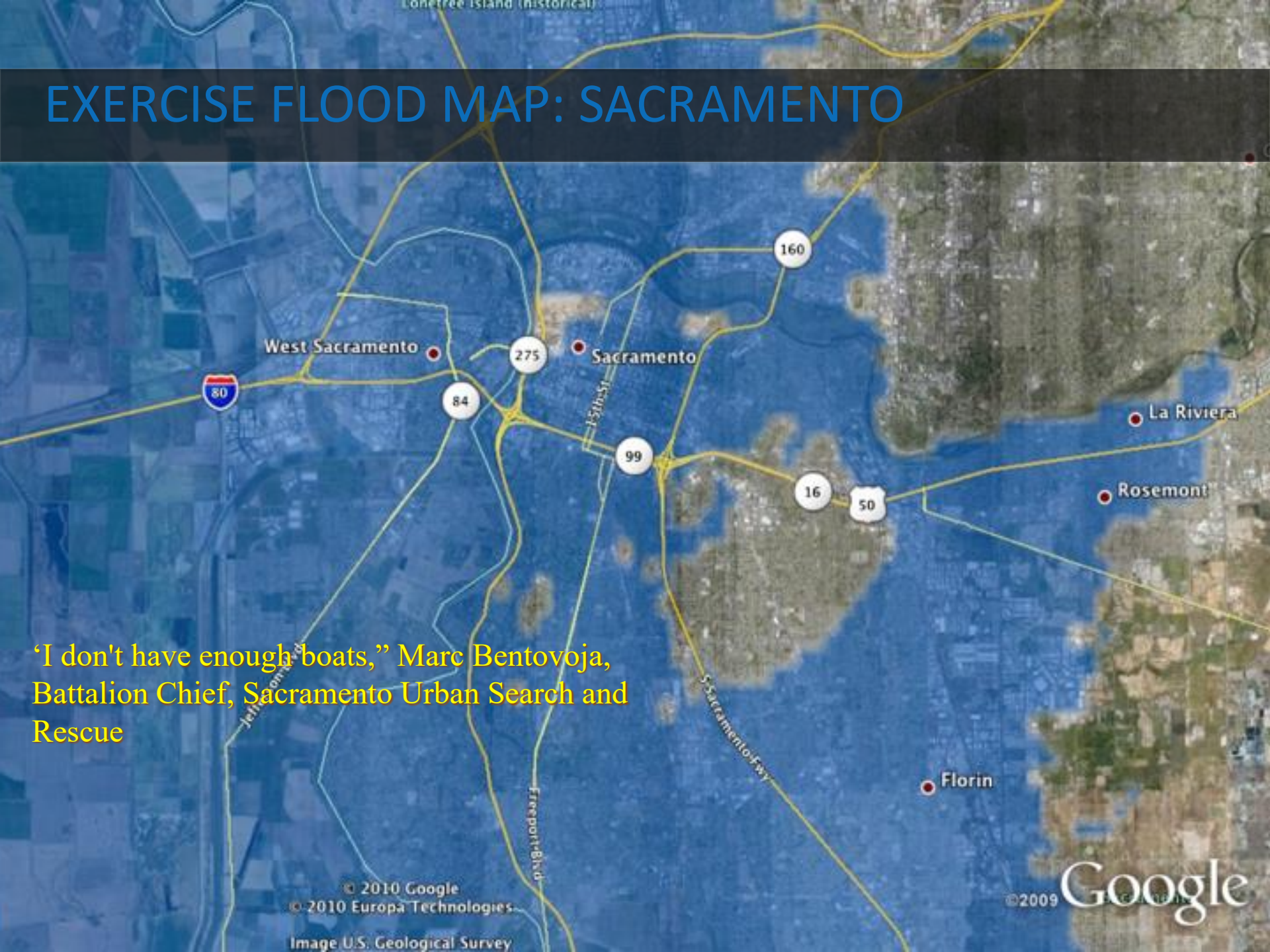
EXERCISE FLOOD MAP: DELTA



EXERCISE FLOOD MAP: SOUTH BAY



EXERCISE FLOOD MAP: SACRAMENTO



'I don't have enough boats," Marc Bentovoja, Battalion Chief, Sacramento Urban Search and Rescue

EXERCISE COASTAL INUNDATION: SAN DIEGO

CoSMoS-estimated coastal inundation at Mission Bay, San Diego

(CoSMoS = Coastal Storm Modeling System)

The ARkStorm Scenario

Flood Protection System: Extensive flooding overwhelms the state's flood-protection system, designed to resist 100- to 200-year runoffs.

Flooding: The Central Valley experiences hypothetical flooding 300 miles long and 20 or more miles wide. Depths in some areas could reach 10-20 feet.

Wind: Wind speeds in some places reach 125 miles per hour, hurricane-force winds. Across wider areas of the state, winds reach 60 miles per hour.

Landslides: Hundreds of landslides damage roads, highways, and homes.

Figure 8. Blue areas indicate ARkStorm flooding as projected by models used in the scenario.

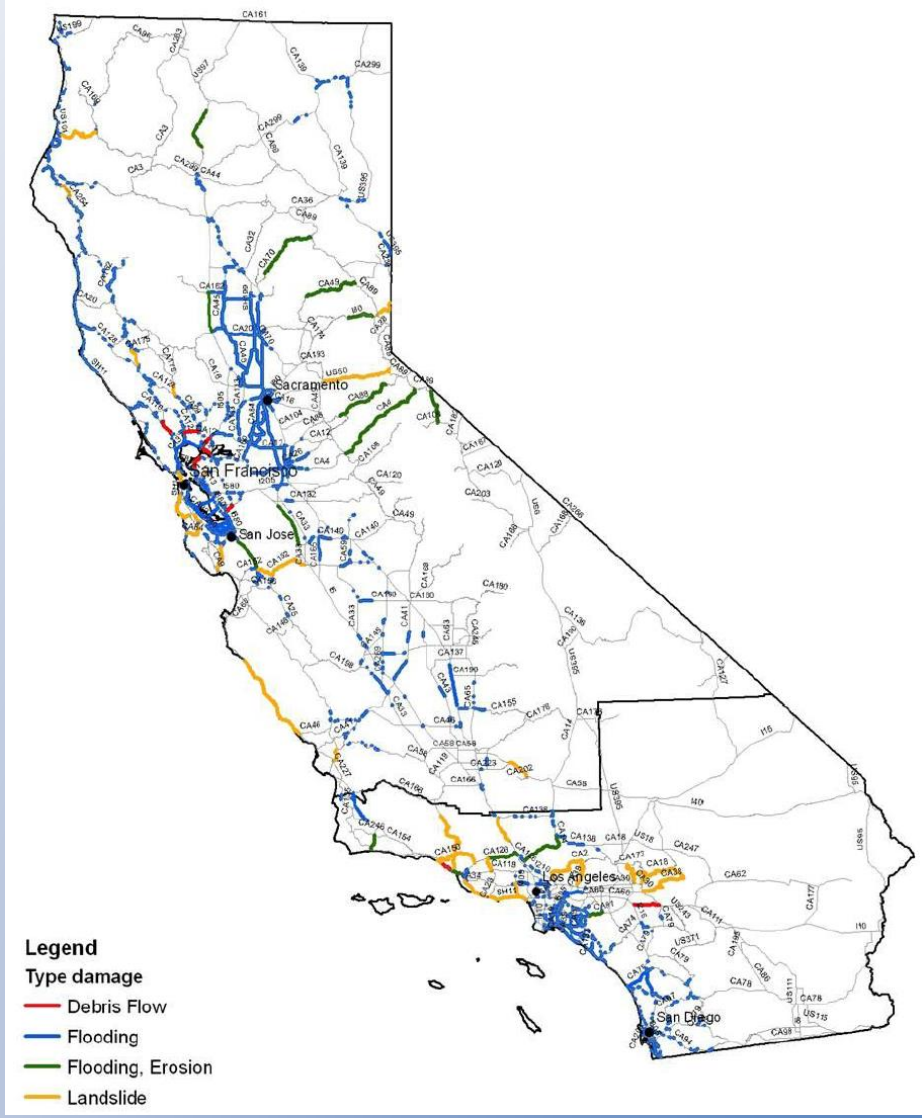
The ARkStorm Scenario: Impacts

Highway Damage

Primary perils to highways:

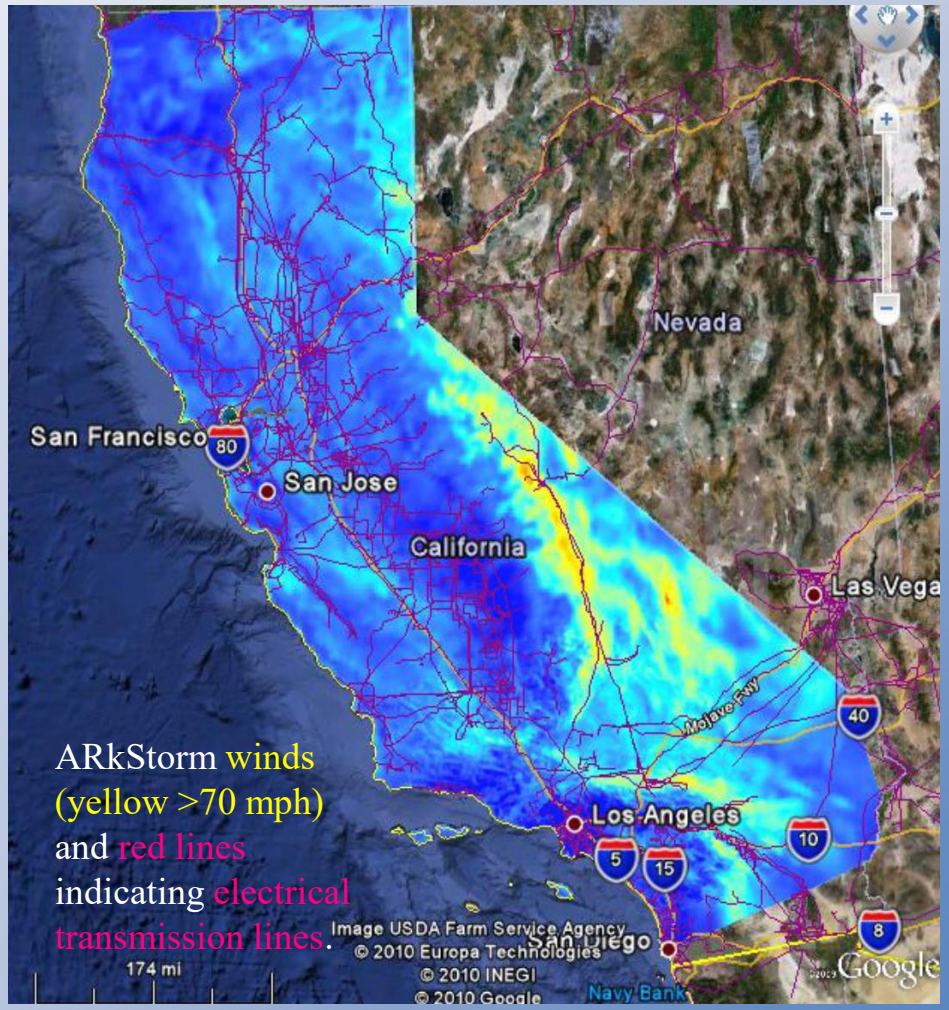
- Landslides (burying or undermining)
- Floods (inundating)
- Clogged culverts (causing flooding and erosion where water washes over roadway)

Estimations of restoration times



The ARkStorm Scenario: Impacts

- Power Facilities & Sources of Damages
  - Wind (& windborne debris) damage to utility poles, transformer, transmission lines/towers/poles



The ARkStorm Scenario: Impacts

Evacuation

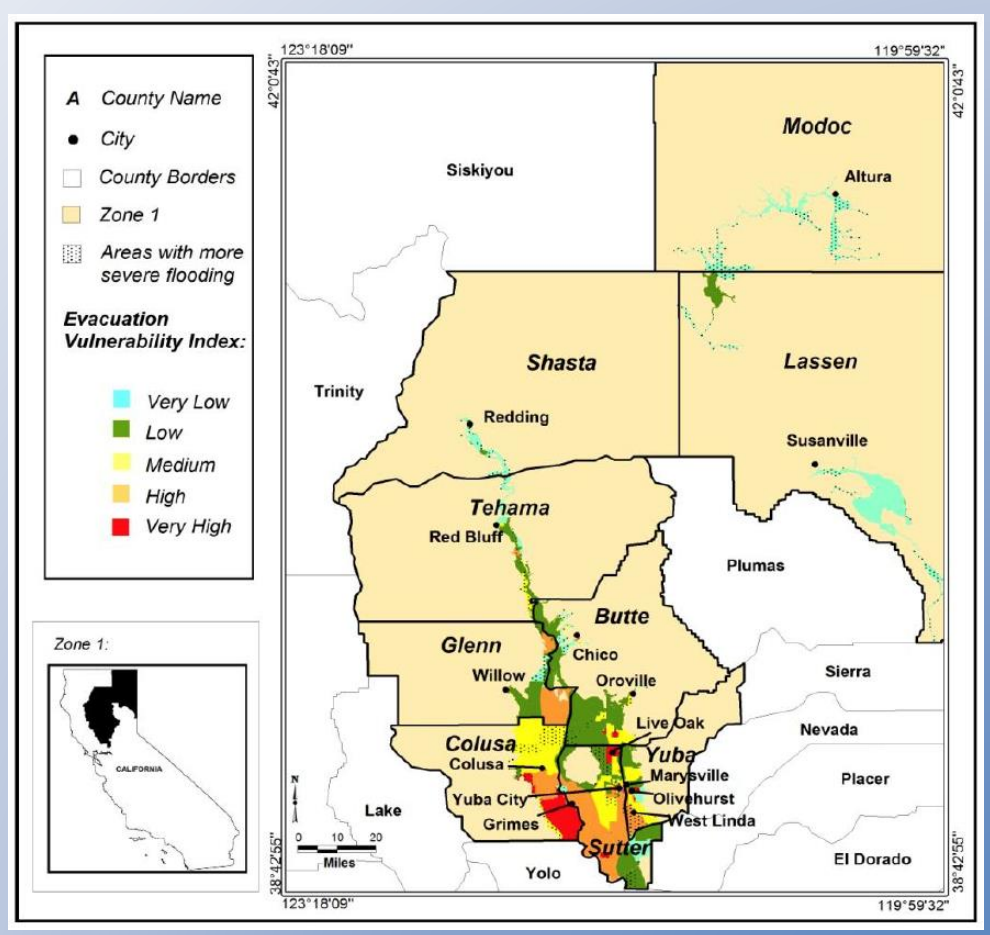
Population Living in Flooded Areas

Social Indicators (ability to evacuate)

- Population (coordination, traffic, special needs, shelter, transport)
- Age (physical self-sufficiency)
- Income (mobility)
- Population density (high density often concentrated poverty & need more assistance)
- Diversity (studies suggest minorities less likely to evacuate)
- Language (barriers, need translation)

Shelter Requirements

- Estimate #s needing temporary shelter



The ARkStorm Scenario

- **Property Damage:** Exceeds $300 billion, most from flooding.
- **Demand Surge:** Labor rates and repair costs could increase property losses by 20 percent.
- **Damage and Losses:** Agricultural losses and costs to repair lifelines, drain flooded islands, and repair damage from landslides brings total to $400 billion.
- **Lifeline Damage:** Power, water, sewer, and other lifelines experience damage that takes weeks or months to restore.
- **Business Interruption:** Costs reach $325 billion in addition to the earlier $400 billion.
- **Total:** ARkStorm could cost on the order of $725 billion, which is nearly three times the loss deemed to be realistic by the ShakeOut authors.

ARkStorm compared to Katrina

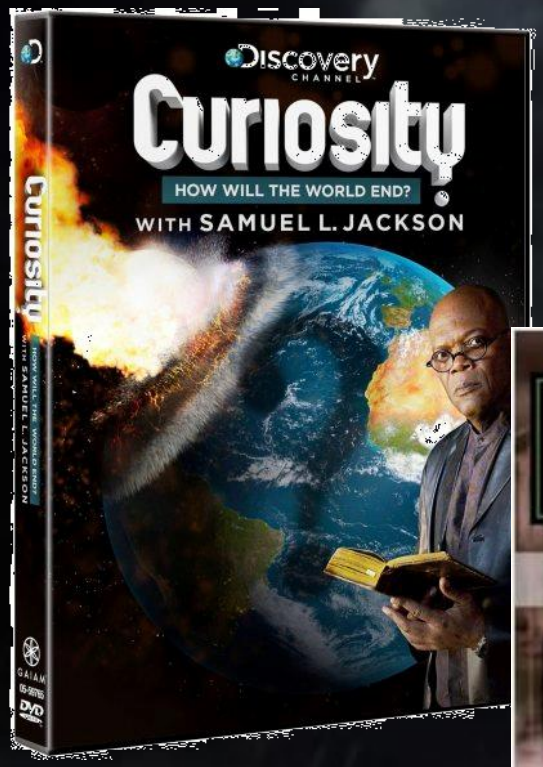
	Gross State Product	Direct Damage (%GSP)	Total Losses
Katrina (Louisiana)	$168.2 bn (2005)	>$70 bn (42)%	>$100 bn (60%)
ARkStorm (California)	$1,891.4 bn (2009)	$400 bn (21%)	$1000 bn (53%)

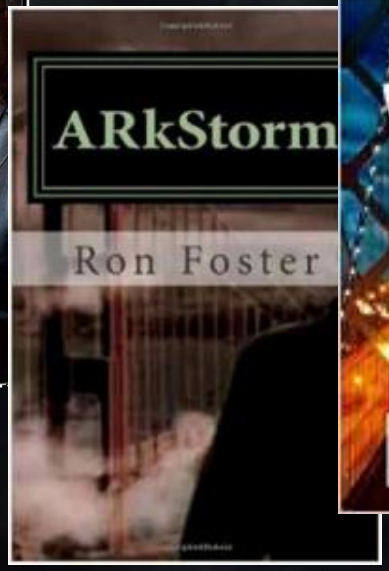
ARkStorm Exceeds California Earthquake Scenarios

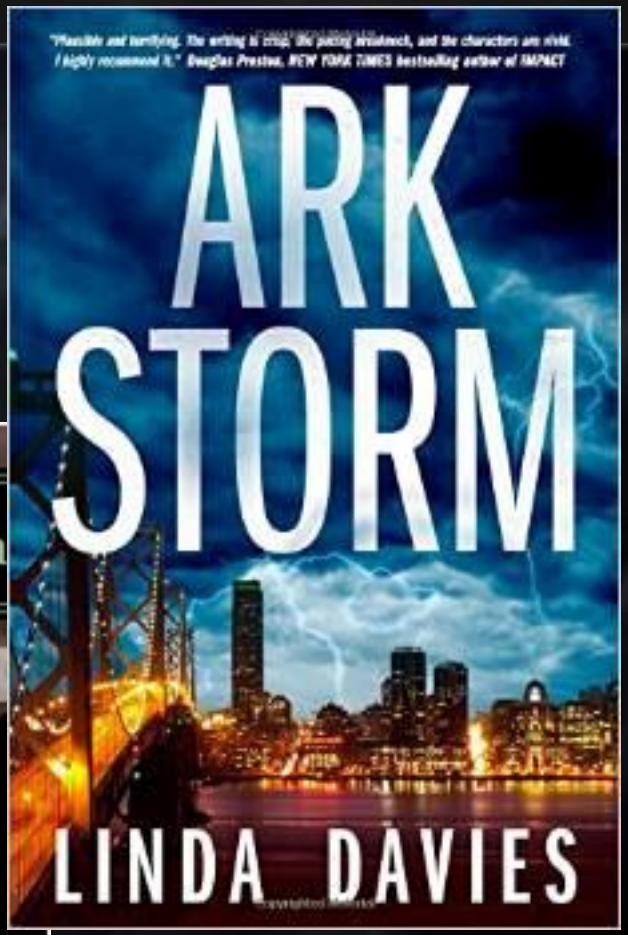
Region	Last Major Earthquake	Mean Recurrence Interval (yr)	Economic Losses	Insured Losses
Southern California	1690 – S San Andreas	300[1]	>$200 bn[1]	$30 bn[2]
	1857 – C-S San Andreas	140[1]	>$150 bn[3]	$40 bn[3]
Northern California	1868 – Hayward	140[4]	>$165 bn[4]	<$30 bn[5]
	1906 – N San Andreas	>200[6]	>$150 bn[6]	>$50 bn[7]

1 “Shakeout Scenario” USGS, 2008
2 “CatUpdate for ‘Shakeout’ Earthquake Scenario Mw7.8” RMS, 2008
3 “1857 Fort Tejon Earthquake: 150-Year Retrospective” RMS, 2007
4 1868 Hayward Alliance, EERI, 2008
5 “1868 Hayward Earthquake: 140-year Retrospective” RMS, 2008
6 “Repeat of the 1906 Earthquake,” EERI 2006
7 AIR Worldwide, 2006; RMS, 2006

ARkStorm: Popular Culture





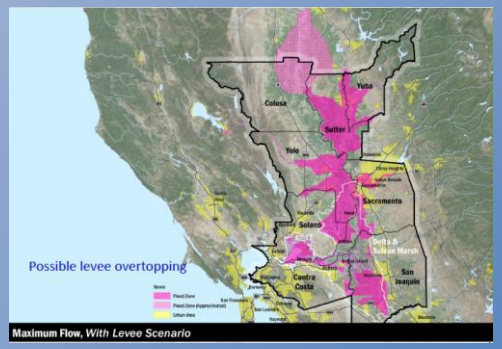


ARkStorm

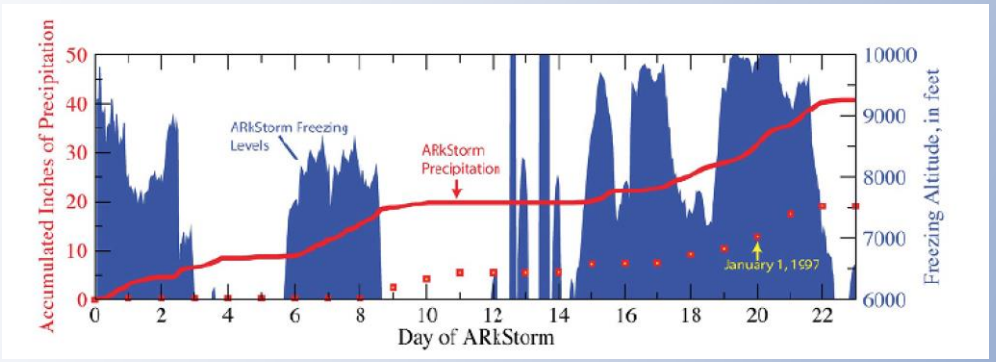
USGS
science for a changing world

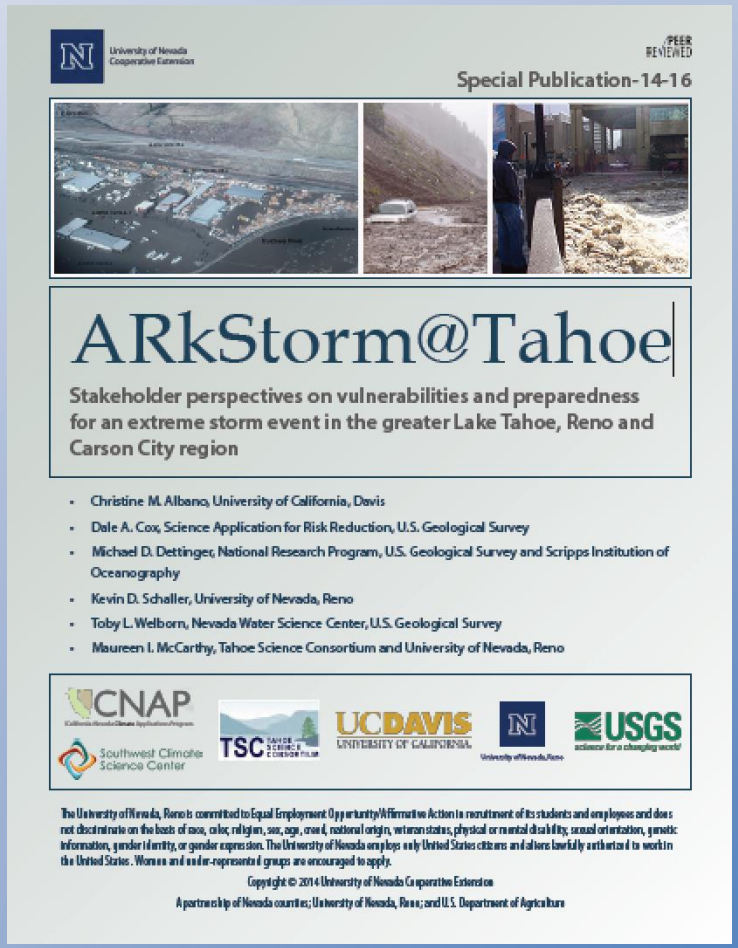
The ARkStorm Scenario: Community Interaction

- **US Navy and NASA: 2011**
- **Ventura & San Diego County: 2012**
- **CalOES NorCal Cat Flood Plan: Summer 2013**



The ARkStorm Scenario: Community Interaction





University of Nevada Cooperative Extension

PEER REVIEWED

Special Publication-14-16

ARkStorm@Tahoe

Stakeholder perspectives on vulnerabilities and preparedness for an extreme storm event in the greater Lake Tahoe, Reno and Carson City region

- Christine M. Albano, University of California, Davis
- Dale A. Cox, Science Application for Risk Reduction, U.S. Geological Survey
- Michael D. Dettinger, National Research Program, U.S. Geological Survey and Scripps Institution of Oceanography
- Kevin D. Schaller, University of Nevada, Reno
- Toby L. Welborn, Nevada Water Science Center, U.S. Geological Survey
- Maureen I. McCarthy, Tahoe Science Consortium and University of Nevada, Reno

CNAP

Southwest Climate Science Center

TSC

UCDAVIS UNIVERSITY OF CALIFORNIA

USGS

A partnership of Nevada counties; University of Nevada, Reno; and U.S. Department of Agriculture

Climate Change Projections

"The likelihoods of increasing flood risks appear to be quite real."

“In the Northern Sierra, the 50-year flood flows increase (relative to simulated historical values) by 30–90%; in the Southern Sierra, by 50–100%. These changes would be large enough to pose important challenges in terms of infrastructure and flood management."

- Das, T., Maurer, E., Pierce, D., Dettinger, M. Cayan, D. 2013, Increases in flood magnitudes in California under warming climates: Journal of Hydrology, 501 (2013) 101 - 110

Southwest Climate Extremes Scenario

- **Create scientifically plausible meteorological and hydrological drought scenarios to examine how water supply is stressed in the Southwest.**

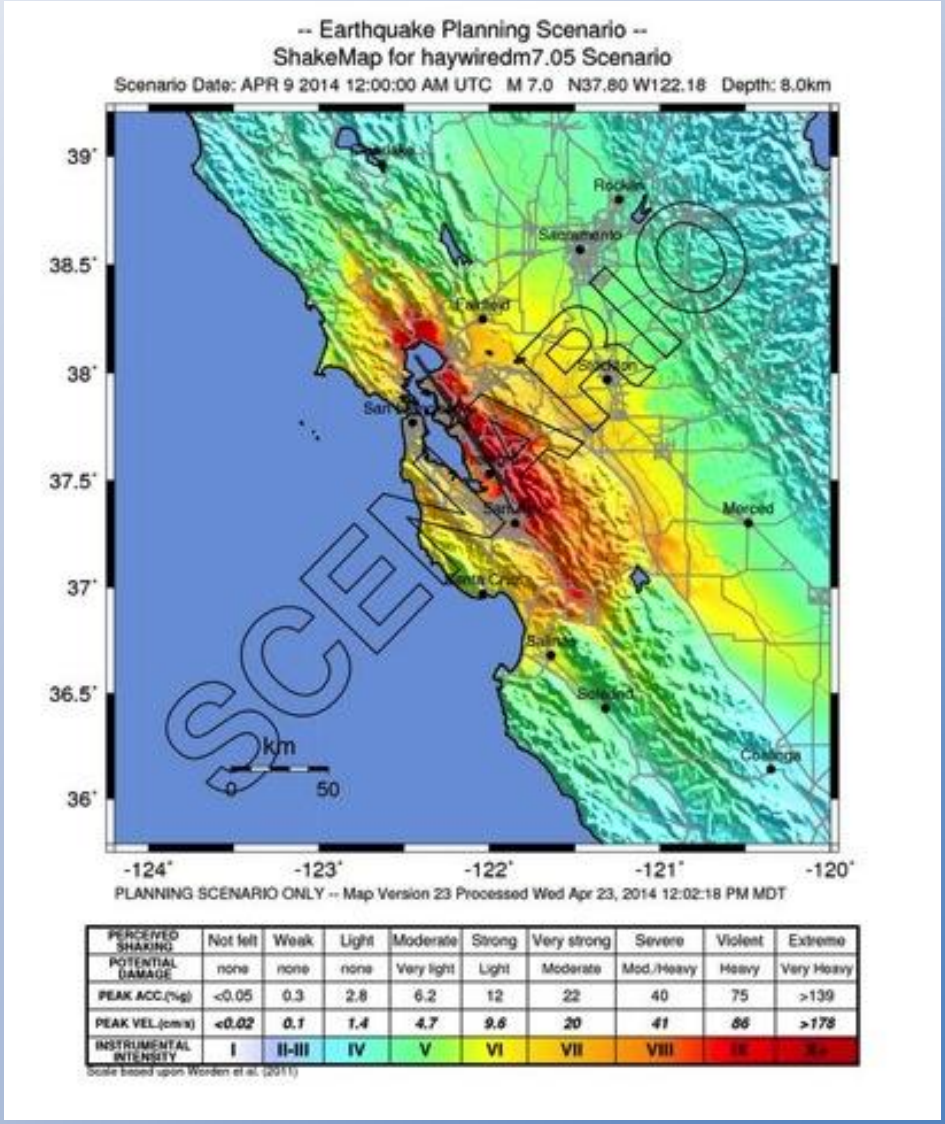
- **Assess how cascading impacts, like forest fires, landslides, and more extreme storms, might play out in non-water-supply sectors.**

- **Assess how they could effect resilience to other natural hazards like earthquakes.**

- **Inform federal, state and local climate adaptation strategies, plans and exercises.**

HayWired Scenario (In Progress)

- M7.05 on Hayward Fault
- Parallel with FEMA/CalOES Planning
- Examination of vulnerable lifeline interactions
  - Water
  - Electric
  - Gas
  - Telecommunications
  - Roads
  - Special Focus: Internet and Internet Economy, Outmigration



Questions?

Dale A. Cox, dacox@usgs.gov

Questions?

- Resources (scenarios, videos, reports):

http://www.usgs.gov/natural_hazards/safrr/

- Contact: safrr@usgs.gov