



Sea Level Rise, Storms, and Extreme Coastal Water Levels: Future Impacts for the California Coast

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Coastal Impact of Projected Climate Trends

- Accelerated beach erosion rates
- Greater incidence of cliff failures
- Landward translation of coastal flooding and inundation
- More dangerous navigation conditions
- Beach/shore safety more often compromised
- Saltwater intrusion into coastal aquifers



L.A. City Lifeguards

How vulnerable are we?



Newport Beach



Malibu



Stinson Beach



Critical Infrastructure



Critical Infrastructure



What is the problem?

- 480,000 people and \$100 billion in property are at risk of flooding along the California coast over the next century (*Pacific Institute Report*)
- California beaches support 883,000 jobs and contribute \$73 billion to the national economy (*King, 1999*)
- 1982-83 El Niño storms caused more than \$200 million in damage to California

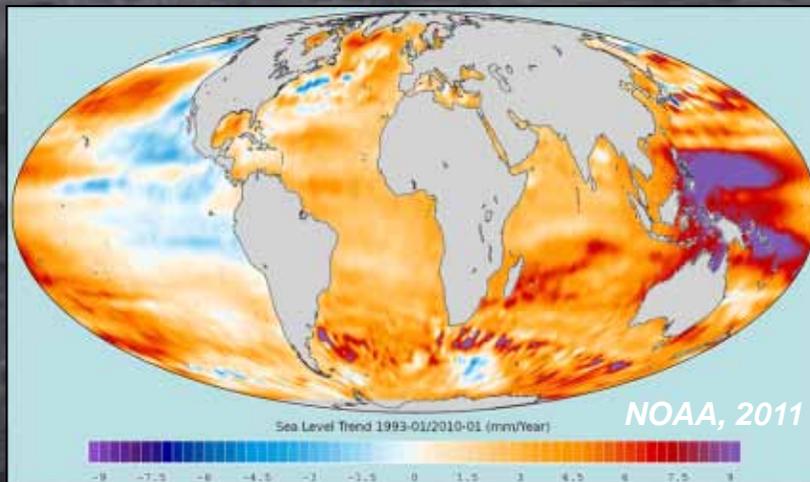


Shore & Beach, 1989

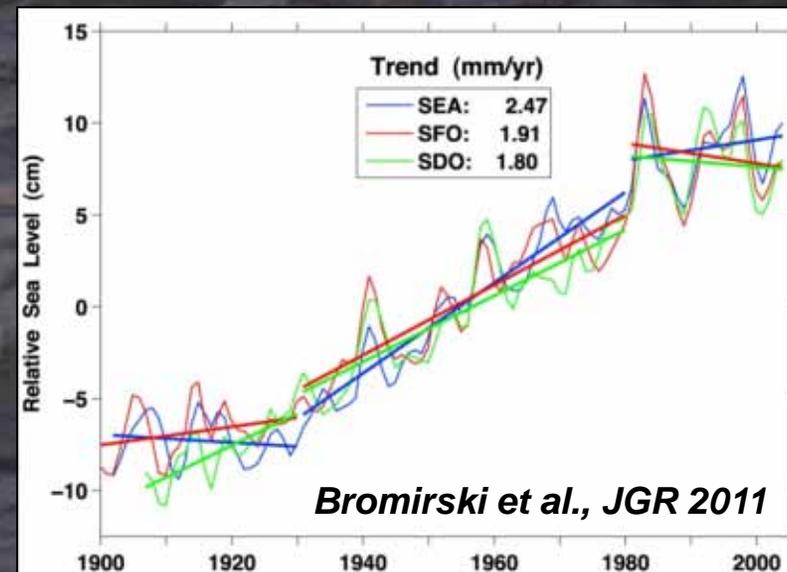


Sea Level Rise

- Rate of global SLR has increased by 50% over last two decades
- The global sea level rise signal is NOT spatially uniform due to variations in prevailing wind patterns, ocean temperature and salinity ('steric effect'), and gravitational forces



- West Coast sea level rise has been suppressed for the last thirty years due to prevailing wind patterns in the Eastern Pacific



- The current cold phase of the PDO may continue to suppress sea levels for a decade or more, but then rates may become extremely high

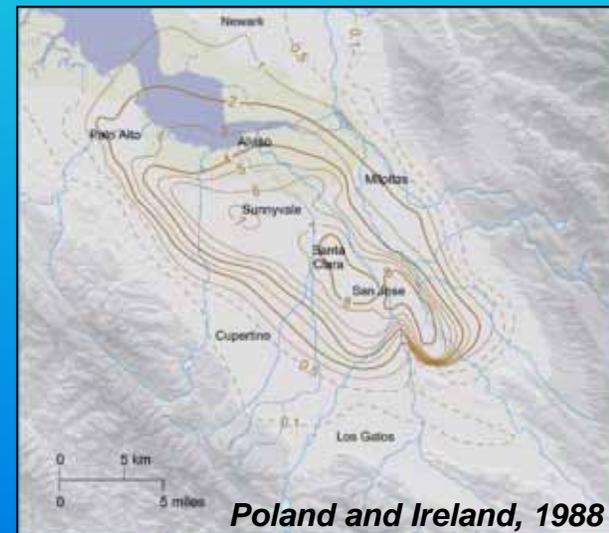
Coastal Water Level Factors for California

•Regional:

- Ocean circulation and wind patterns
- Storminess*
- Tectonics (large-scale)

•Local:

- Subsidence
- Local tectonic deformation
- Fluvial discharge AND sediment supply changes

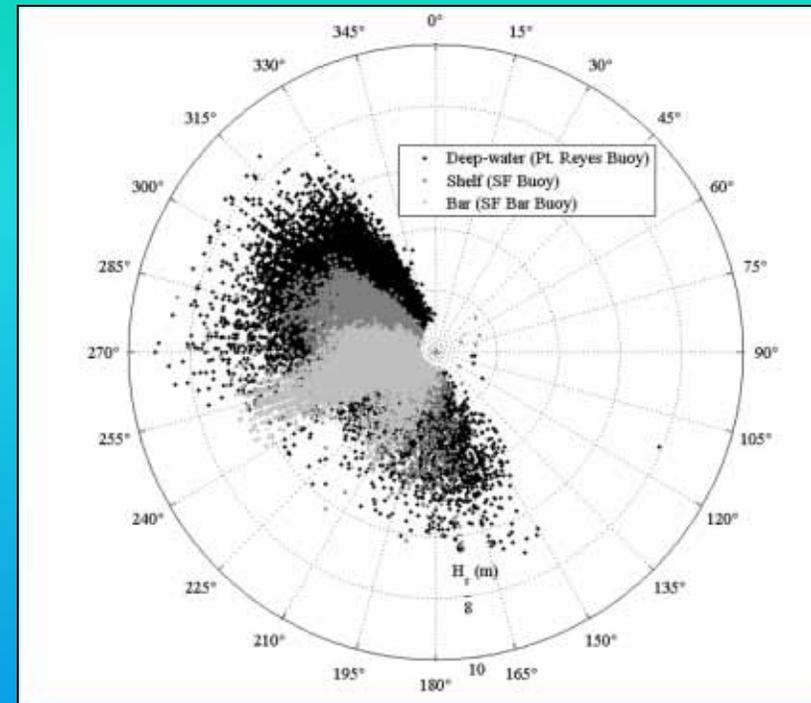


Subsidence in San Jose (1933-1969)

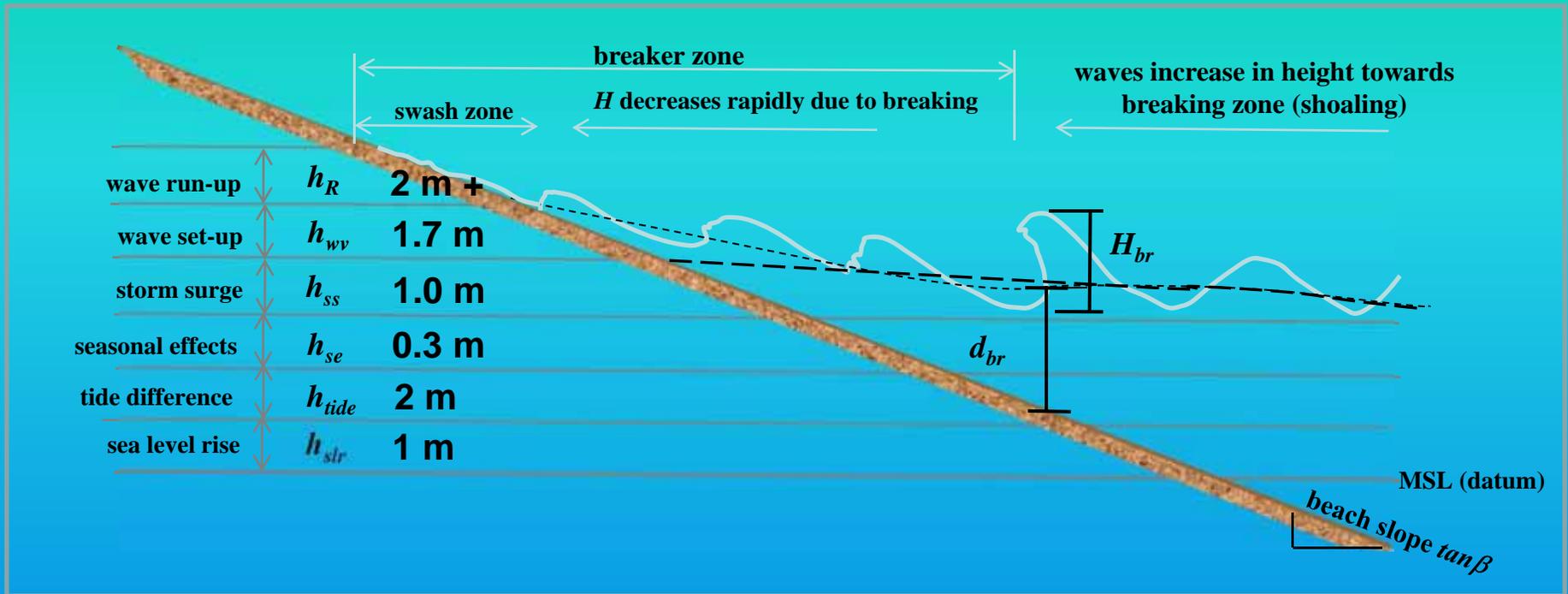
National Research Council study provides guidance on West Coast SLR, including relative land movement, ocean circulation, and storminess.

What is an extreme storm?

- Difficult to define
 - Wave height/energy
 - Wind speed/direction
 - Atmospheric pressure
 - Wave direction
 - Storm duration
 - Beach state
 - Water level
- Largest waves = ~10 m
(mean of the highest 1/3, 1 in 100 = ~15 m)



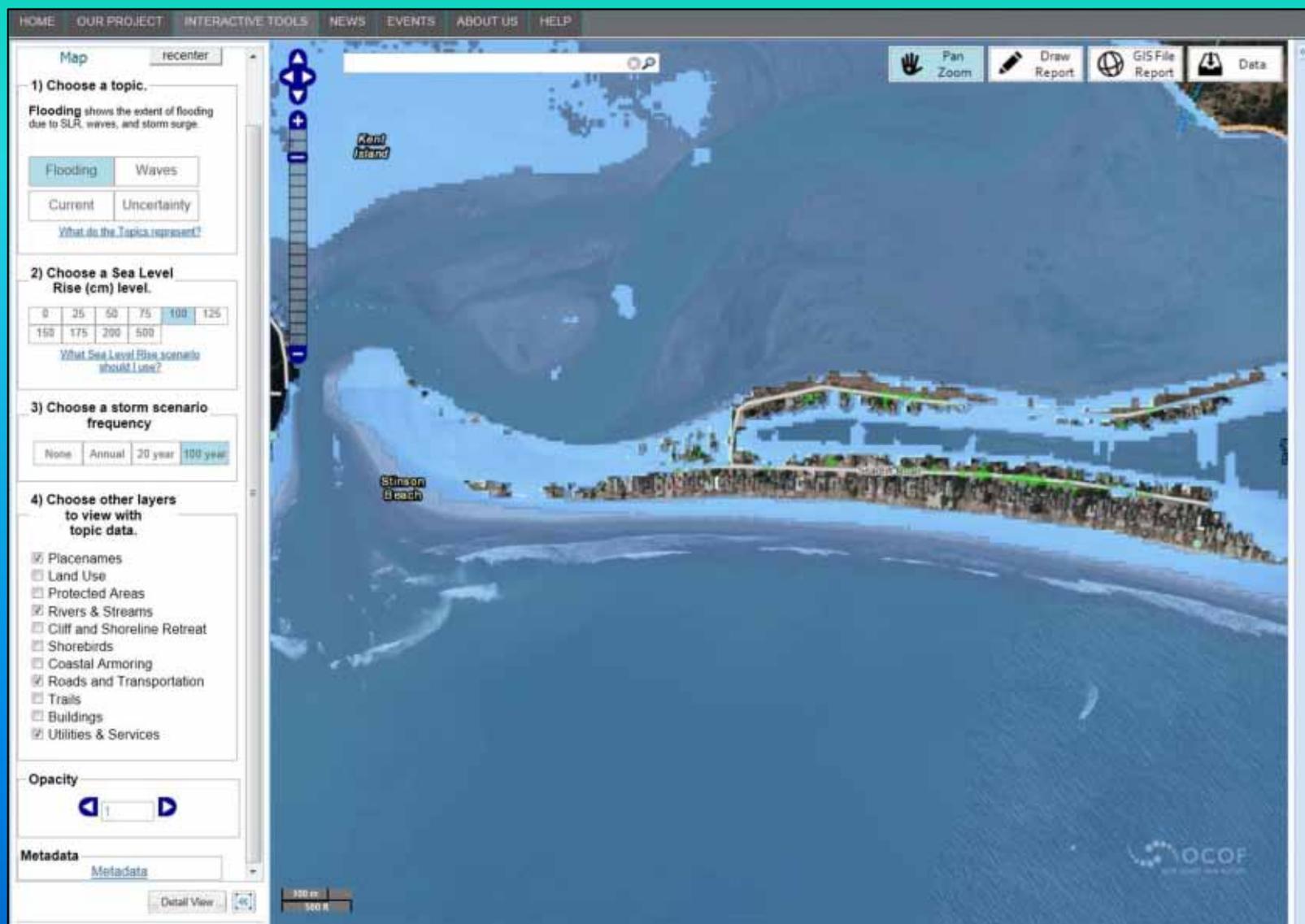
Components of Total Water Level Predictions



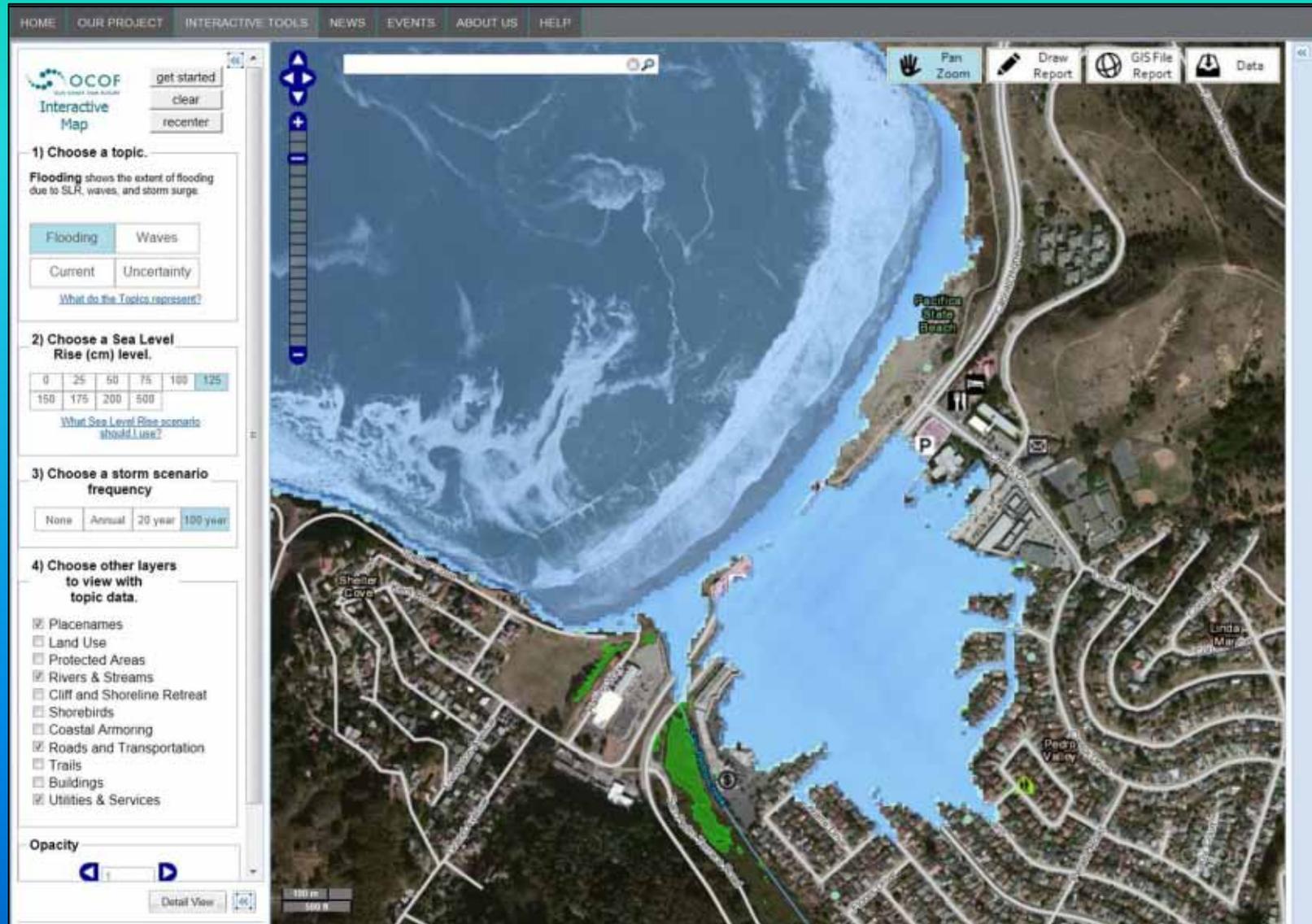
Stinson Beach
50 cm SLR



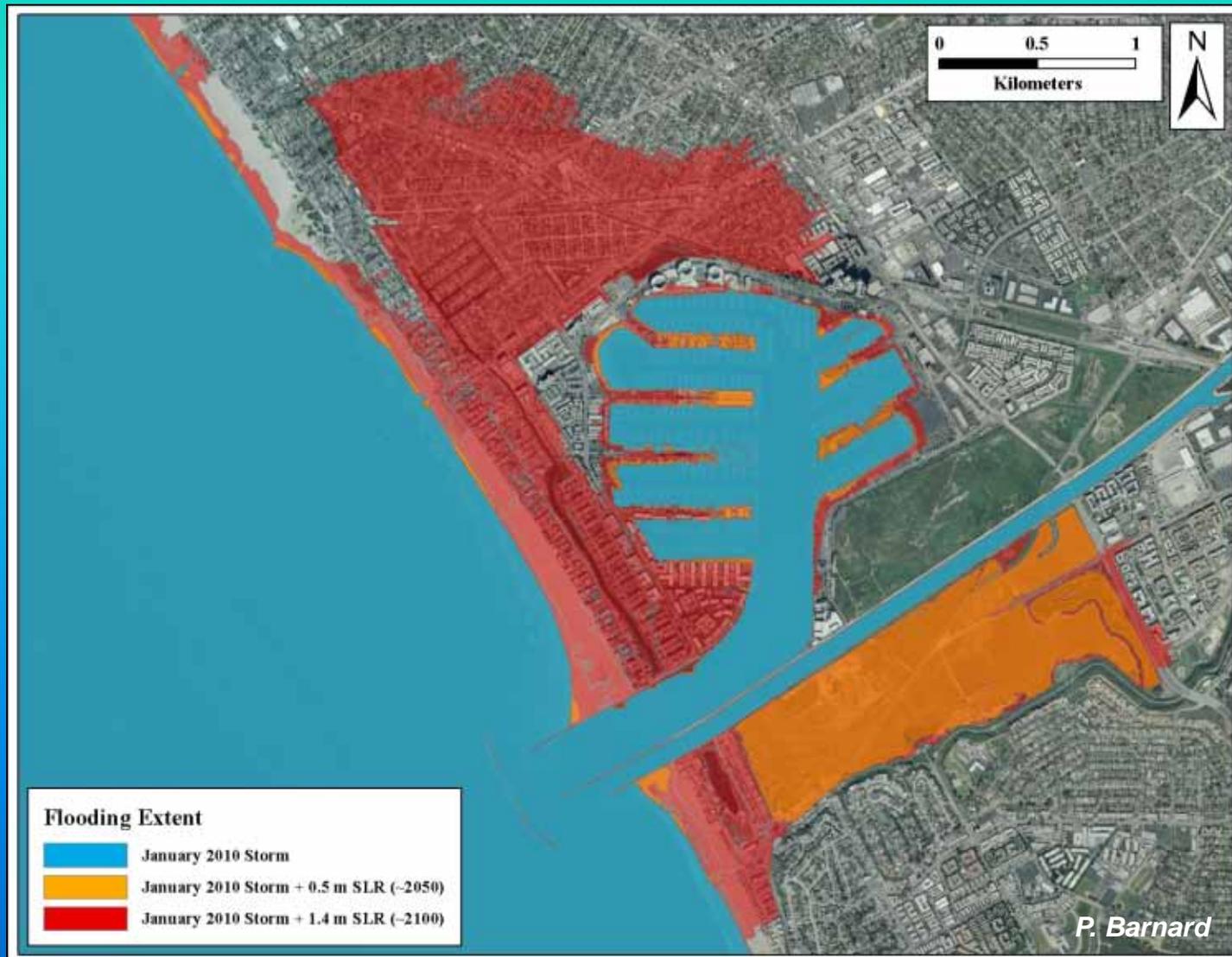
Extreme Event Impacts - Stinson Beach



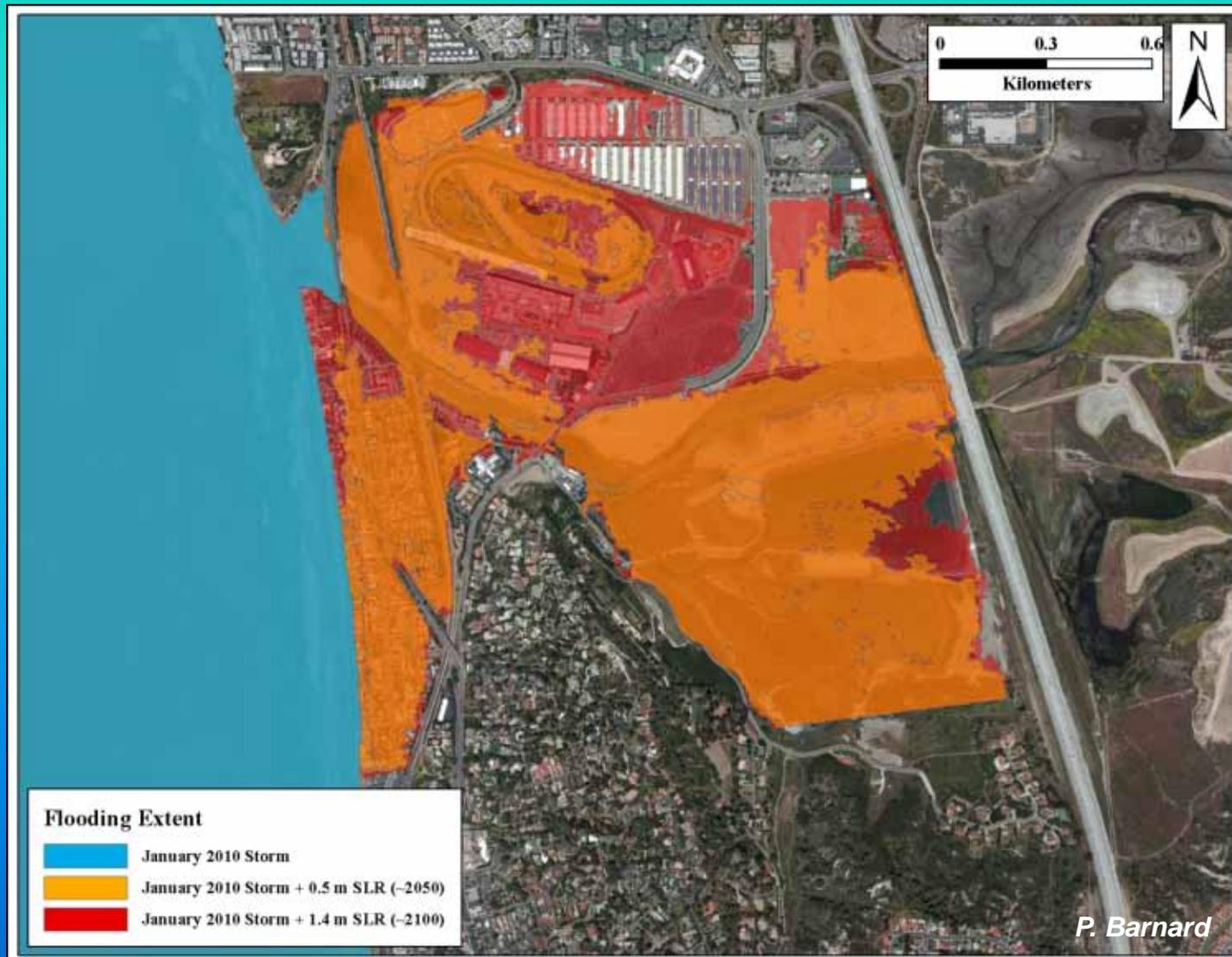
Extreme Event Impacts - Pacifica



Critical Thresholds- Marina Del Rey/Venice



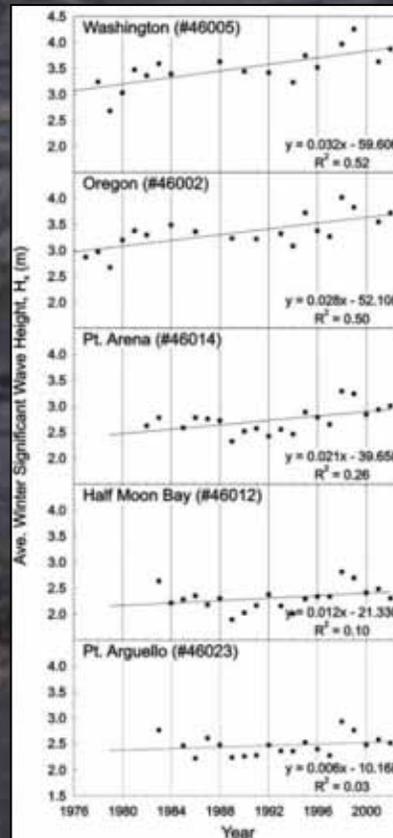
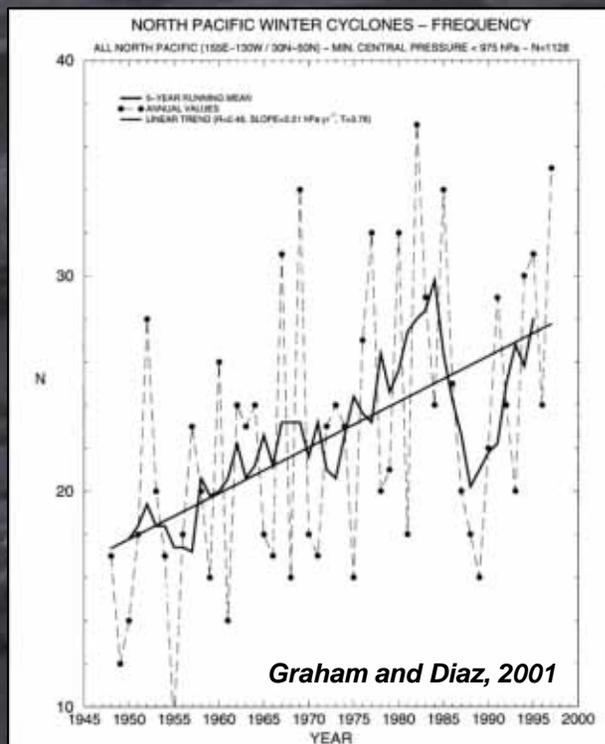
Critical Thresholds - Del Mar



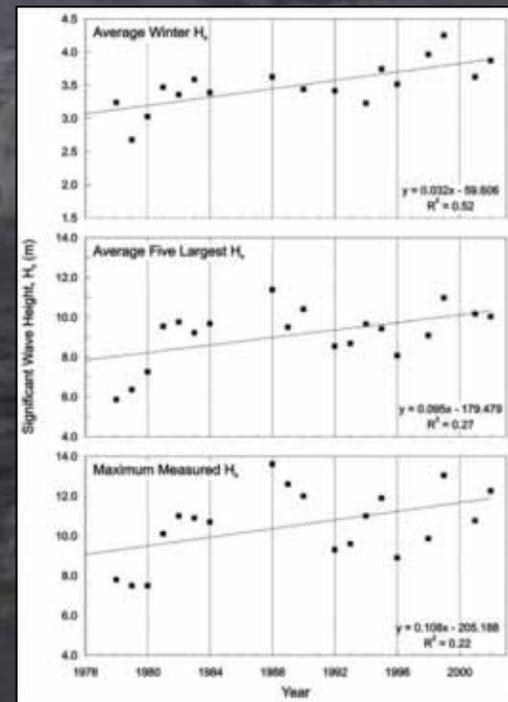
Historical Trends in Storminess

- The frequency and intensity of extreme storms in the North Pacific increased over the latter half of the 20th century

- Trends of increased average, winter and extreme wave energy for much of U.S. West Coast

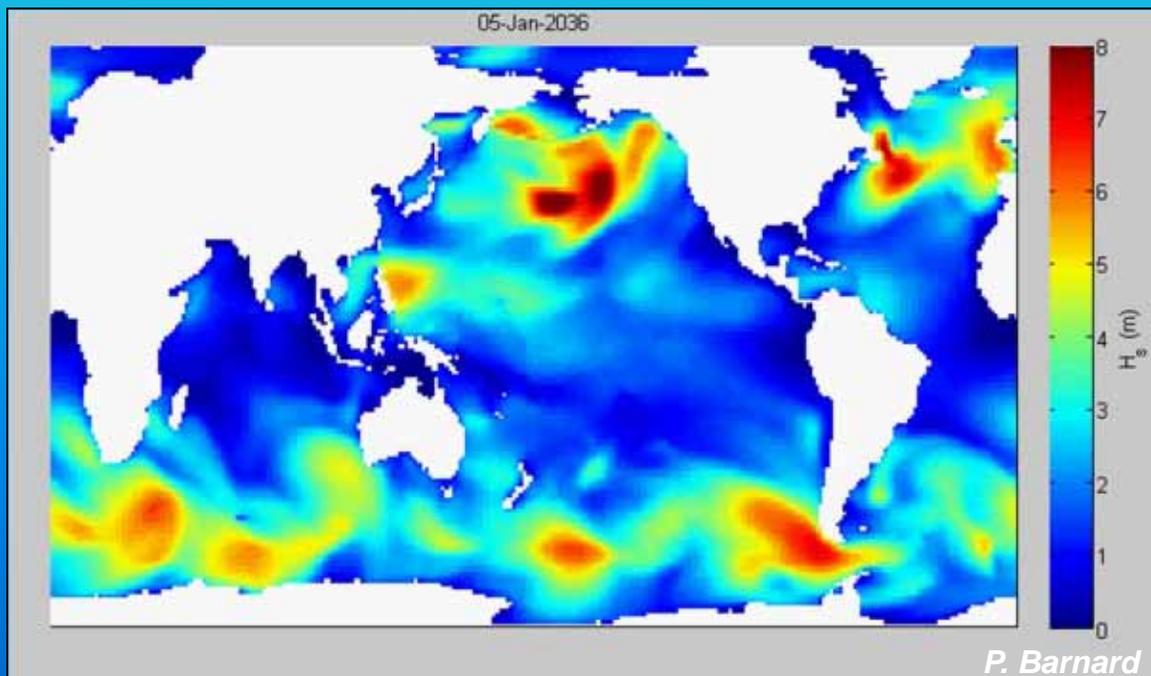


Allan and Komar, JCR 2006

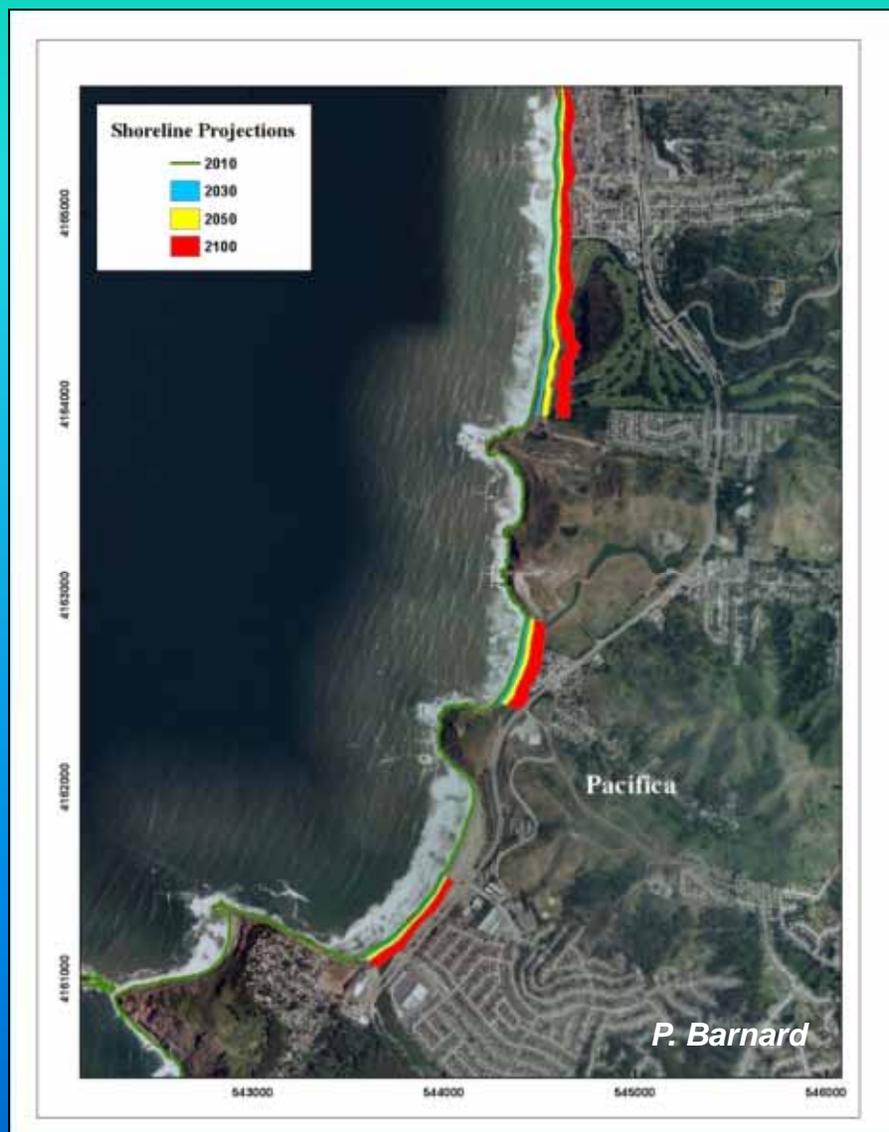


Future Storms and Wave Direction

- Intergovernmental Panel on Climate Change (IPCC) recently confirmed link between climate change and the intensity and frequency of extreme storms
- However, recent Scripps and USGS studies indicate no significant change in wave height through 2100 for most of California
- BUT extreme waves projected to come more from the south by 10-15°
- Change in wave direction will expose more south-facing beaches to hazardous conditions



Future Shoreline Change



- Rising sea level will drive shorelines further inland, increasing physical and economic impacts
- Reduced sediment supply from dams, dredging, aggregate mining, etc., likely to further exacerbate the problem
- Shoreline south of San Francisco is the most rapidly eroding section of coast in the state despite minimal SLR in the last 20 years

Assessing California's Coastal Vulnerability to Climate Change (SLR + Storms)

- Process-based models that account for all aspects of future coastal water levels, especially due to extreme storms
- Models driven by output from the latest Global Climate Models
- Inclusion of regional and local sea level rise factors that affect coastal vulnerability
- State-wide, systematic approach to assess the impact of climate change, including sea level rise AND storms
- Accuracy of models is dependent on observations
 - Monitoring of waves and water levels is adequate
 - Coastal change is poorly constrained (only ~50 km of 1340 km of the CA coast is regularly mapped)

*For more information, contact Patrick Barnard: pbarnard@usgs.gov

