A comprehensive, process-based modeling approach for assessing coastal flooding and inundation under extreme storm scenarios

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USGS science for a changing world

CDIP The Coastal Data Information Program Integrative Oceanography Division

SCRIPPS Institution of Oceanography

CDBW

USACE

UNIVERSITY OF FLORIDA

OSU Oregon State University

COAS College of Oceanic and Atmospheric Sciences

Deltares Enabling Delta Life

Support and Collaboration

- USGS Support
  - Multi-hazards Demonstration Project in Southern California
  - Coastal and Marine Geology Program (Erikson, Hapke, Collins)
- Academic Partners
  - Scripps (O'Reilly, Guza, Thomas)
  - University of Florida (Adams)
  - Oregon State University (Ruggiero)
  - Deltares (van Ormondt, Elias)
- Government Agencies
  - U.S. Army Corps of Engineers
  - California Department of Boating and Waterways
  - NOAA
  - National Park Service
  - Ocean Observing Systems
  - National Weather Service
  - California State Parks

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West Coast Trends

- Global sea level rise up to 79 cm by 2100
- Winter wave height increasing ~1-3 cm/yr
- Extreme wave height increasing ~10 cm/yr
- Increase in magnitude and frequency of storms

* Sources: IPCC (2007) and Allan and Komar (2006, Journal of Coastal Research)

Development of Total Water Level Time Series

Total Water Level (TWL) **= tide + surge + (runup)**

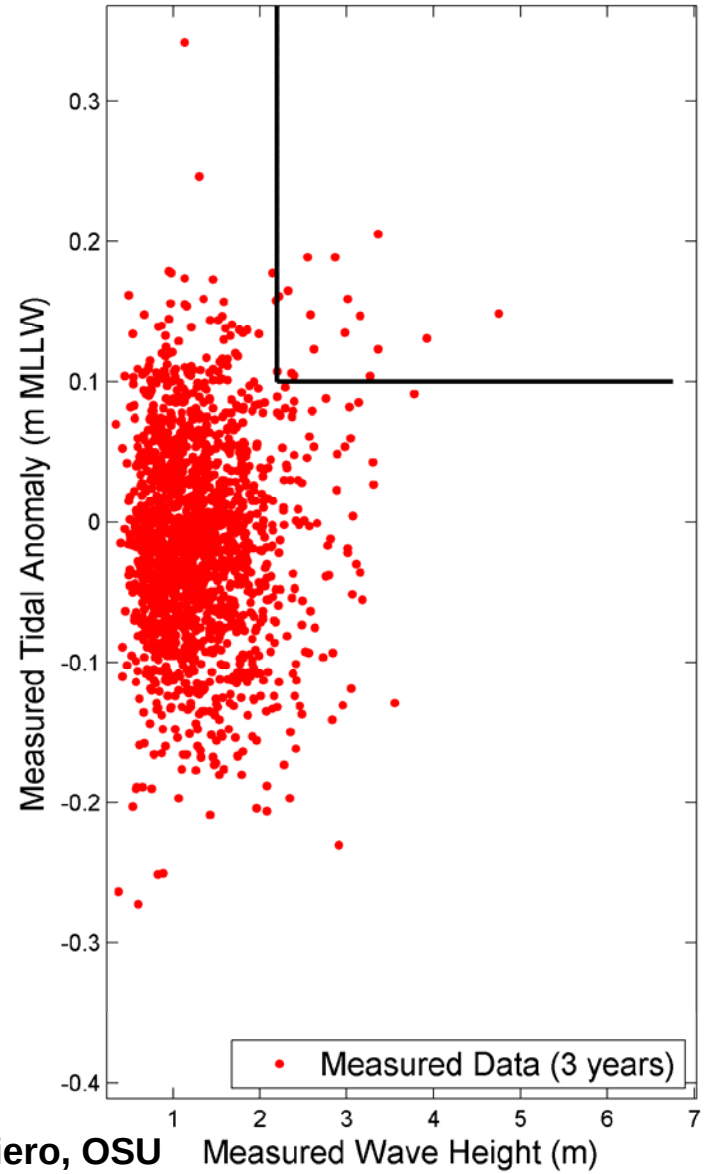
(from Ruggiero et al., 2001)

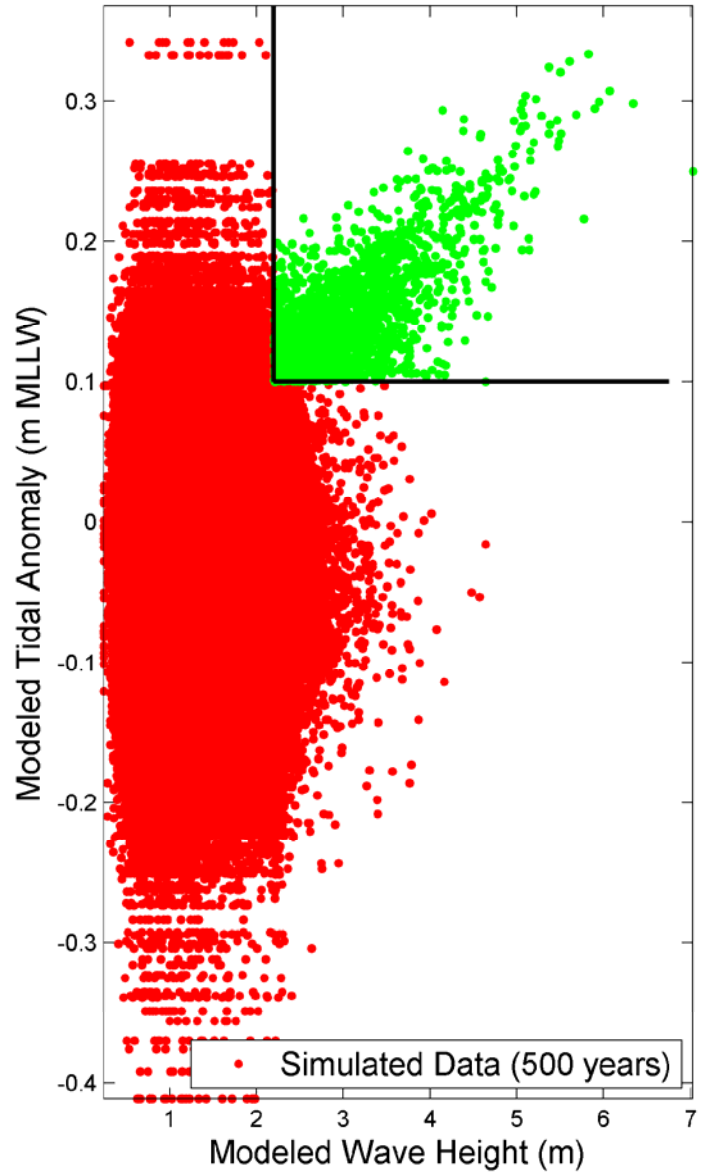
$$R_2 = 0.27(\beta_f H_0 L_0)^{1/2}$$

(from Stockdon et al., 2006)

$$R_2 = 0.35\beta_f (H_0 L_0)^{1/2} + \frac{[H_0 L_0 (0.563\beta_f^{\ 2} + 0.004)]^{1/2}}{2}$$

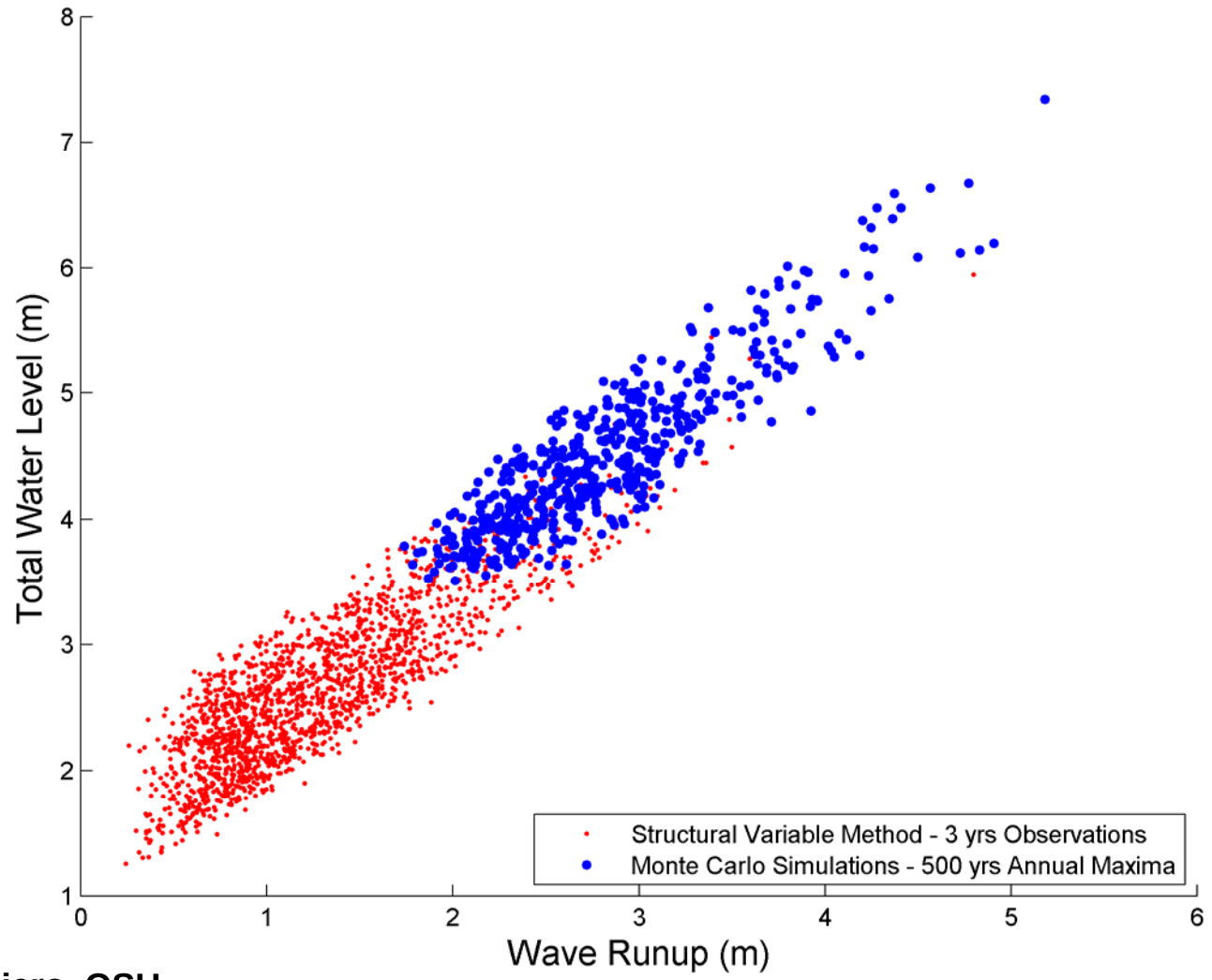
Wave Height vs Tidal Anomaly Observations vs 500 yr simulation





Ruggiero, OSU

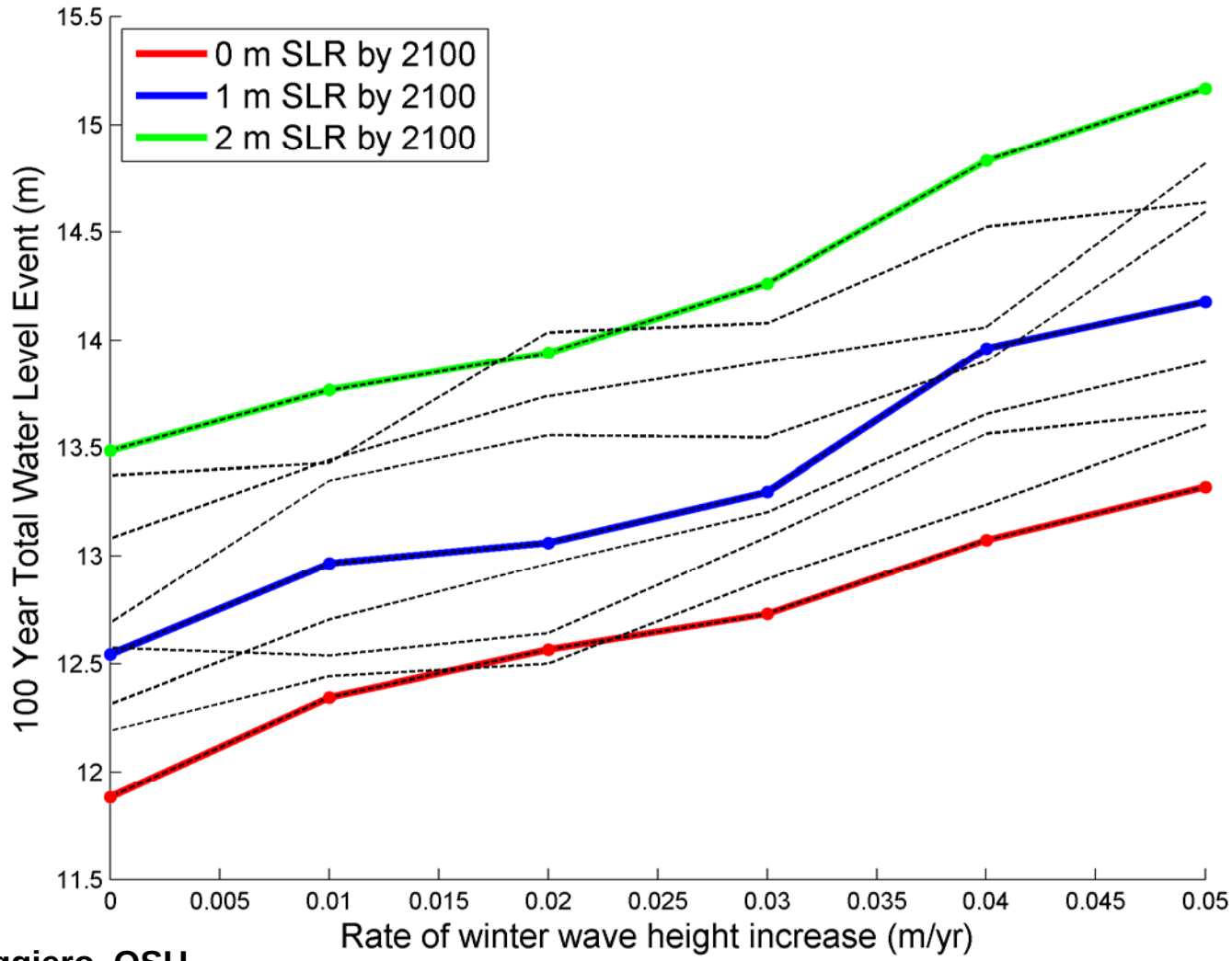
Annual Maxima Wave Runup vs Annual Maxima TWL: 500 years



Ruggiero, OSU

Impact of Various Climate Change Scenarios on 100 Year Return Level TWL Event (SWWA)

(54 500-year hourly simulations)



Ruggiero, OSU

Coastal Impact of Projected Climate Trends

- Accelerated beach erosion rates

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- **Greater incidence of cliff failures**

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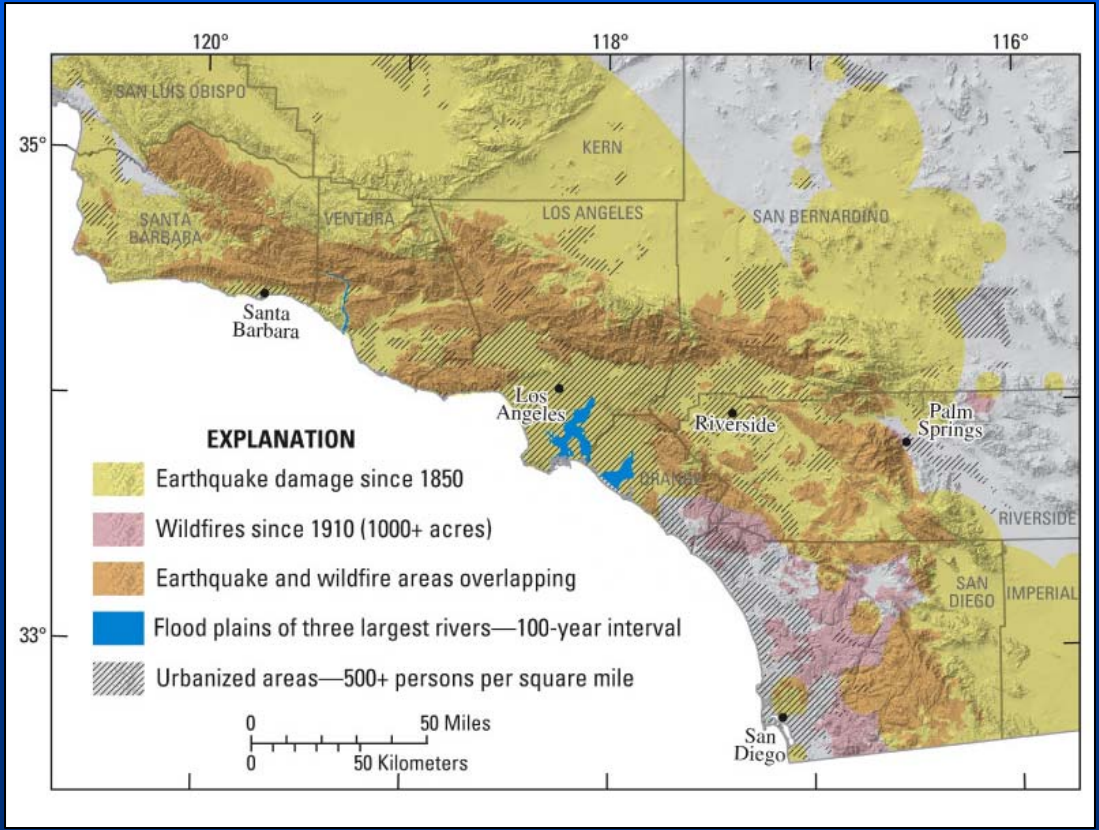
Coastal Impact of Projected Climate Trends

- 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**

Multi-hazards Demonstration Project in Southern California

Objective: Integrate multiple USGS research activities with the needs of external partners such as emergency managers and land-use planners to produce products and information that can be used to create more disaster-resilient communities

- Earthquakes
- Landslides
- Floods
- Tsunamis
- Wildfires
- **Coastal erosion**

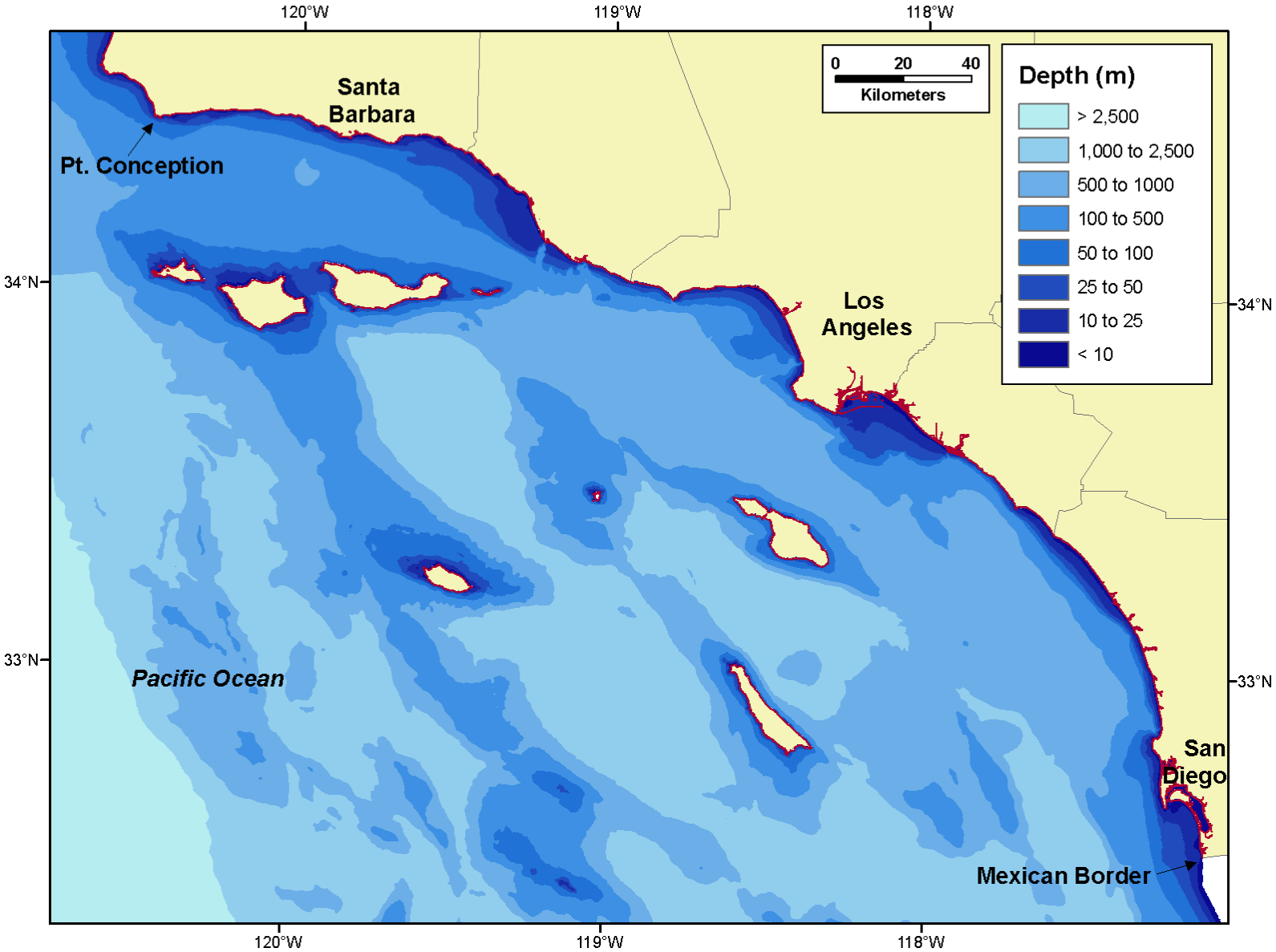


Coastal Erosion Task

Objective: To develop a real-time, state-of-the-art model for predicting coastal hazards along the Southern California coast.

- **Short-term approach: coastal vulnerability assessment using winter storm scenario, historical storms and extreme value analysis**
- **Long-term approach: real-time predictions**

Study Area


120°W
119°W
118°W
34°N
33°N
Santa Barbara
Pt. Conception
Los Angeles
San Diego
Mexican Border
Pacific Ocean
0 20 40
Kilometers
Depth (m)
> 2,500
1,000 to 2,500
500 to 1000
100 to 500
50 to 100
25 to 50
10 to 25
< 10

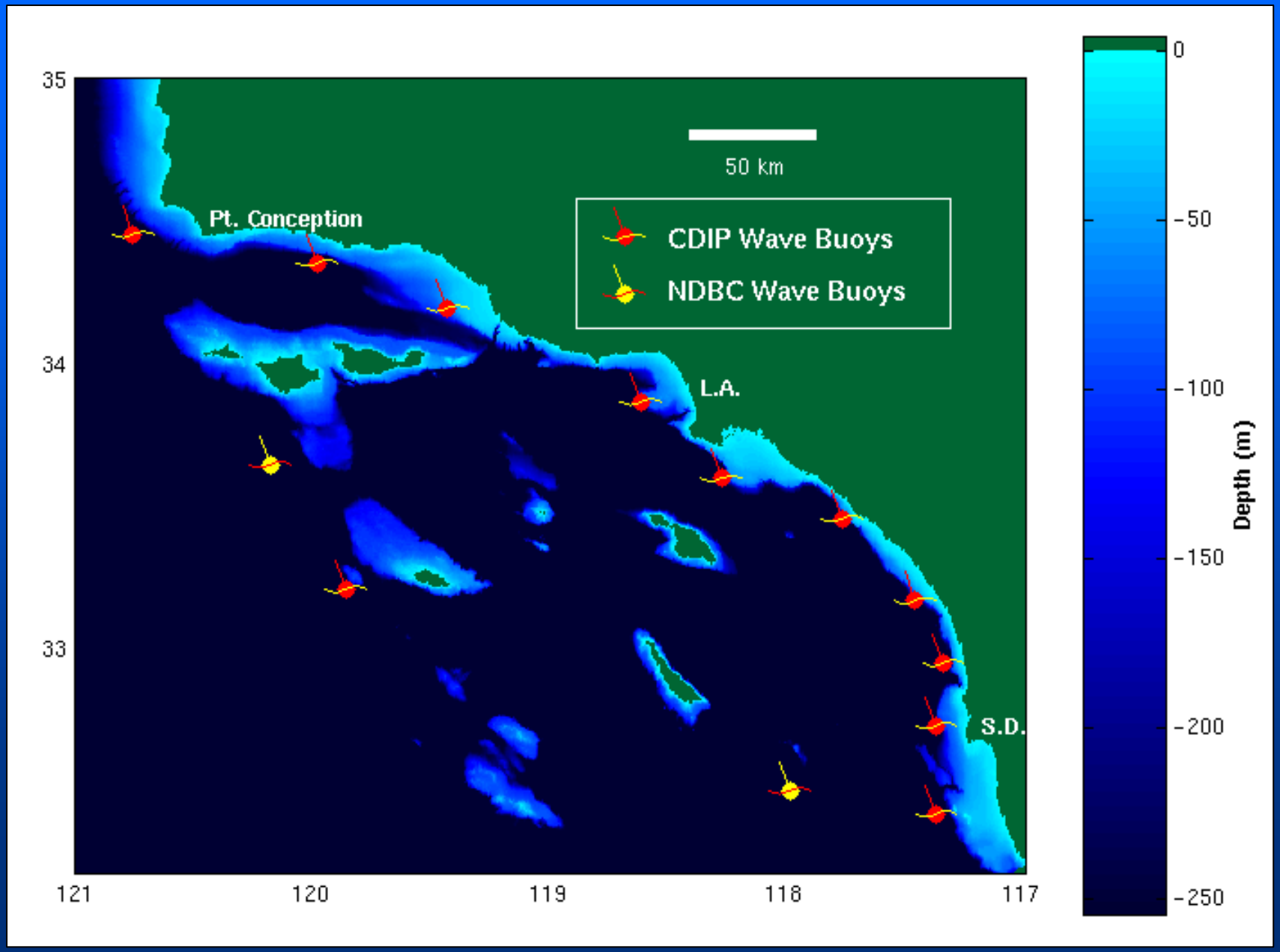
Coastal Impact of a Severe Storm – Physical Conditions

- Large waves
- Dangerous currents
- Damaging winds
- Elevated water level

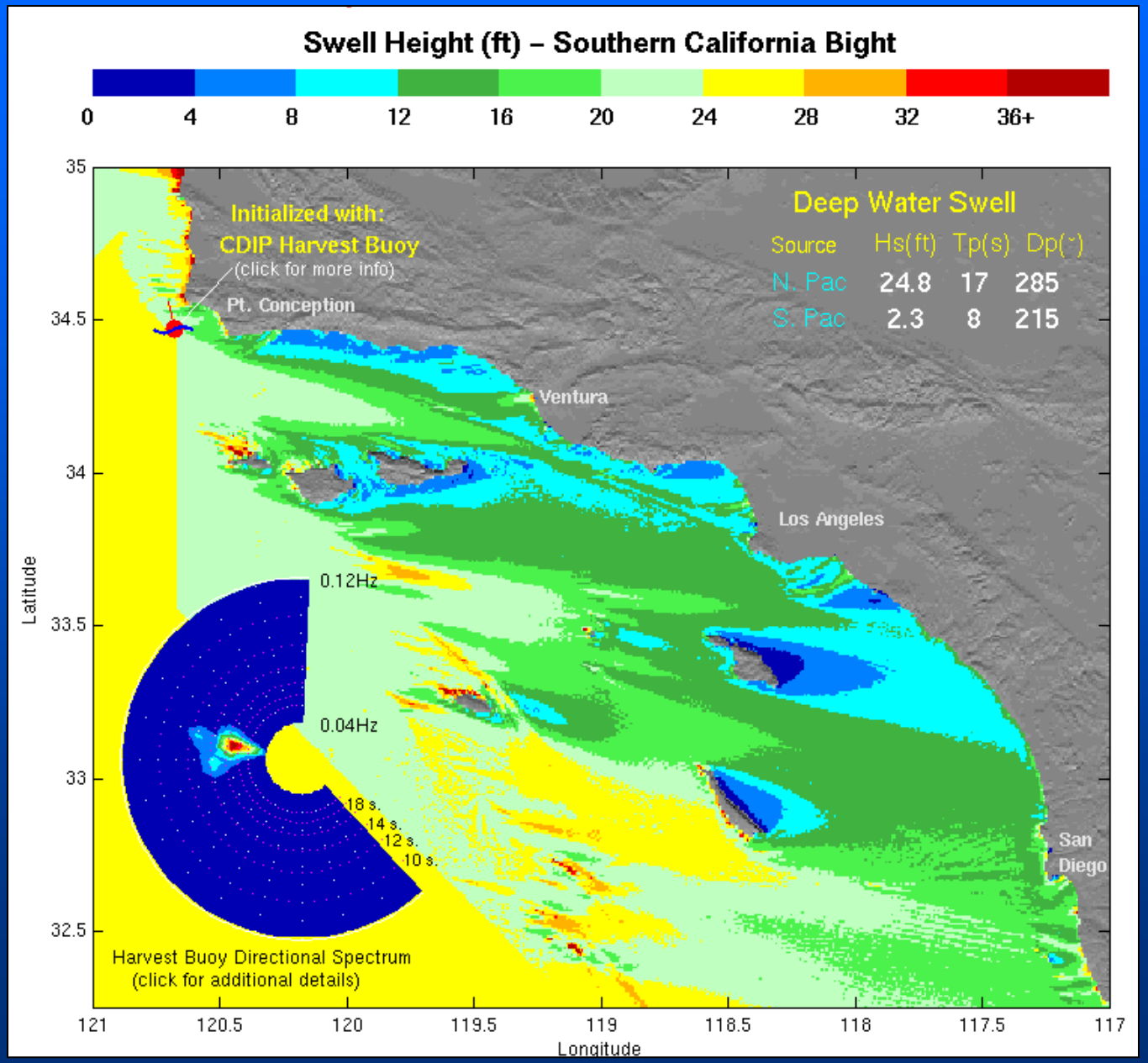
Coastal Impact of a Severe Storm – Hazards

- Beach erosion
- Flooding and inundation
- Property damage
- Cliff failure
- Threats to public safety

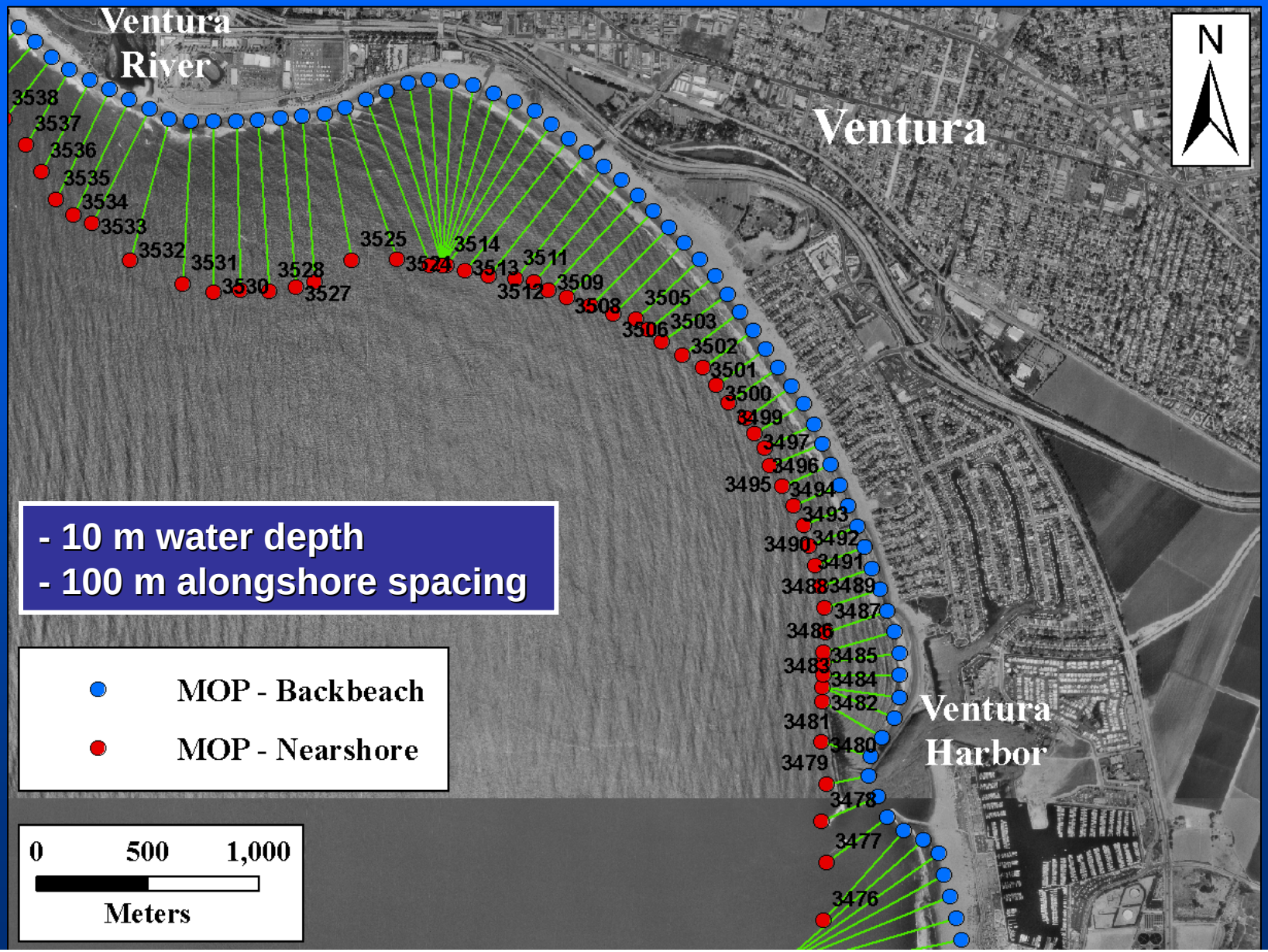
Spectral Wave Model- SIO



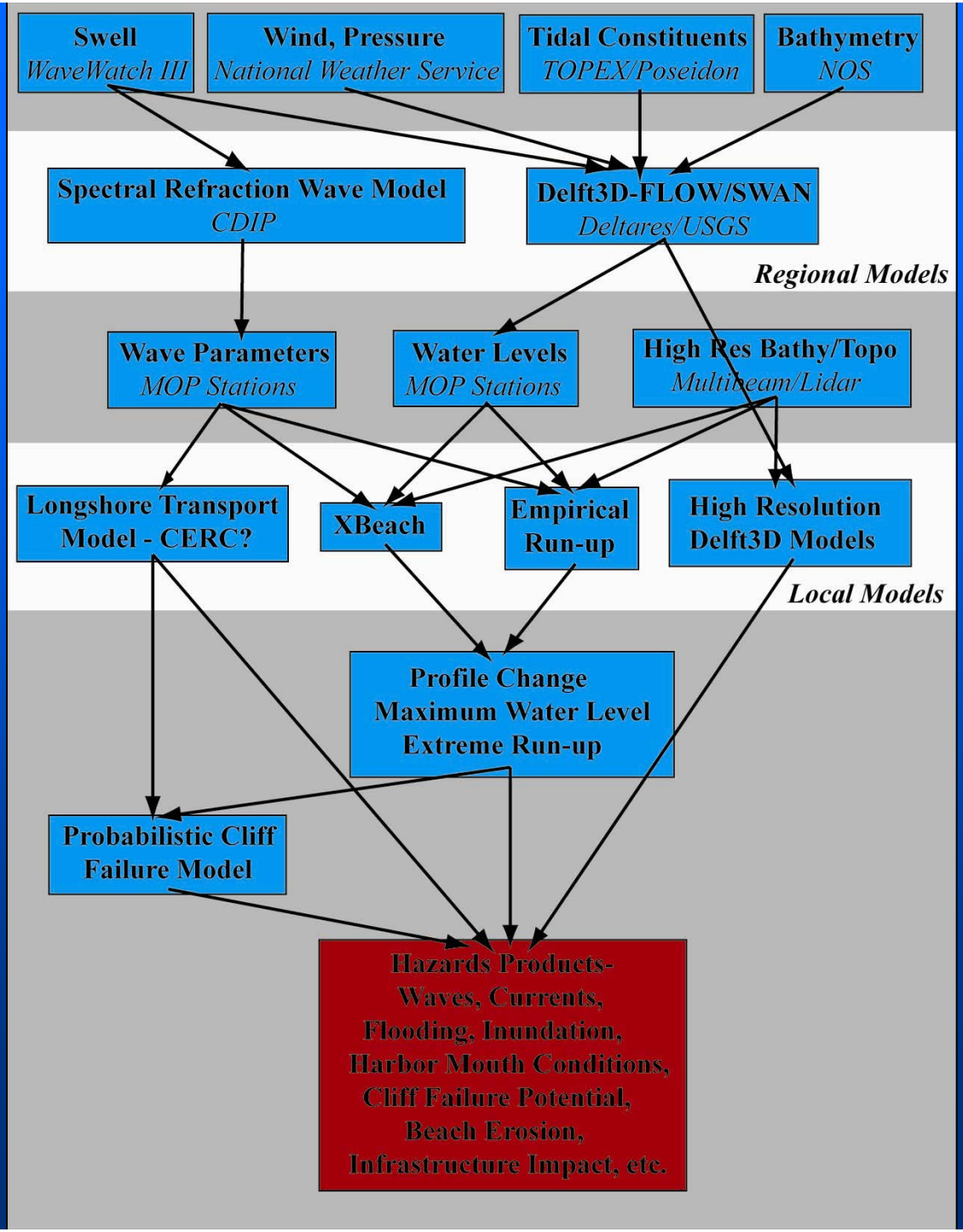
Spectral Wave Model



Alongcoast **Mo**del **P**rediction (**MOP**) Sites



Model Framework



Winter Storm Scenario with Multi-hazards Demonstration Project in Southern California

- Designed by NWS / USGS Atmospheric Scientists
- Modeled after 1862 flood – 500 yr. event
- Modeling goal is to produce "plausible results"
- Collaboration with emergency planners, structural engineers, economists, etc.

Future Directions

- Real-time model predictions
- Develop partnerships to improve model products and usage
- Analyze sea level rise and climate change impacts

http://walrus.wr.usgs.gov/coastal_processes/socalhazards/