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Climate Impacts along the Central California Coast

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United States Geological Survey

Pacific Coastal and Marine Science Center

Santa Cruz, CA

CoSMoS Coastal Storm Modeling System USGS

Collaborators and funders:

California's Fourth Climate Change Assessment

Point Blue

OSU Oregon State University

California natural resources agency

Scripps Institution of Oceanography UCSD

21st Century Projections California

State SLR Guidance for 2100

-Likely range of 30-110 cm
-3.05 m upper bound

Waves

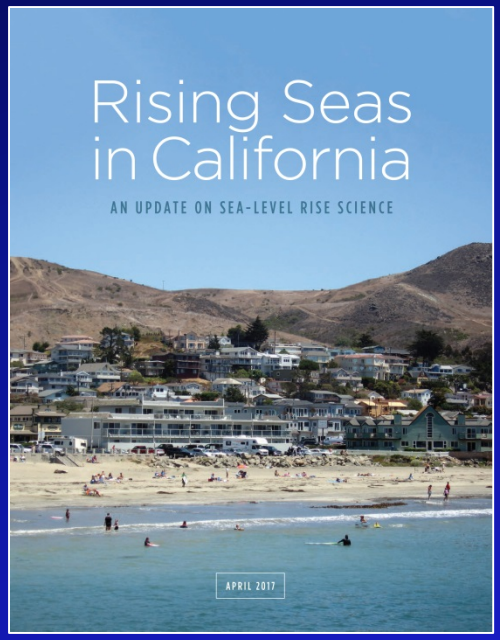
-No significant changes in wave height
-More southerly wave directions

El Niño

-More frequent extreme events
-Doubling of winter erosion
-Wave energy increase by 30%

Net effect

-Today's 100-year coastal water level event is projected to occur every 1-5 years by 2050 for much of California AND every daily high tide by 2100
-Greatest impacts on low-lying coastal areas



San Francisco (http://california.kingtides.net/)

Sunset Beach, Sean Hiller

Sunset Beach, Allan J. Schaben


Sunset Beach, Mark Rightmire


Ventura Pier, December 2015 (Ricky Staub)

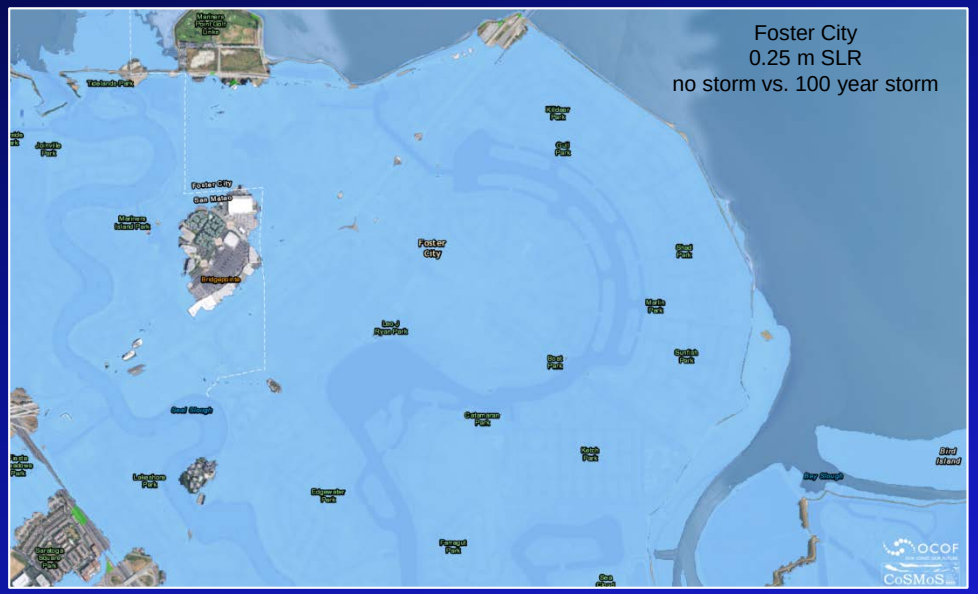
Santa Cruz, January 2017

Capitola, March 2014 (Sabine Dukes)

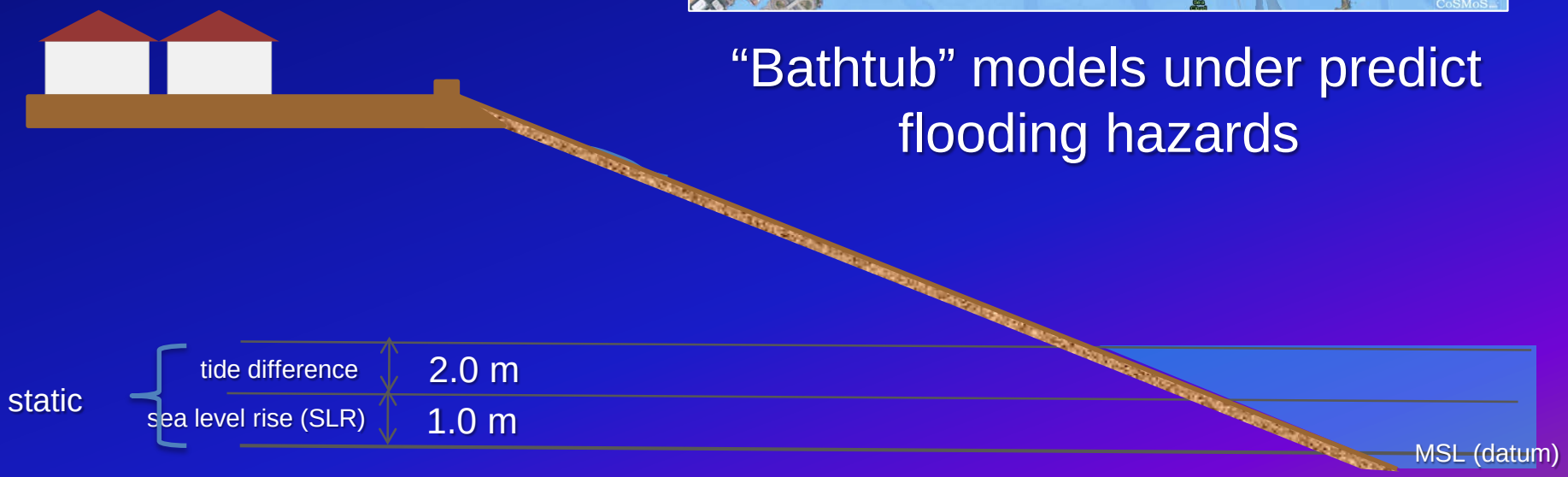
Coastal Vulnerability Approaches

Static

- Passive model, hydrological connectivity
- Tides only
- '1st order screening tool'



"Bathtub" models under predict flooding hazards



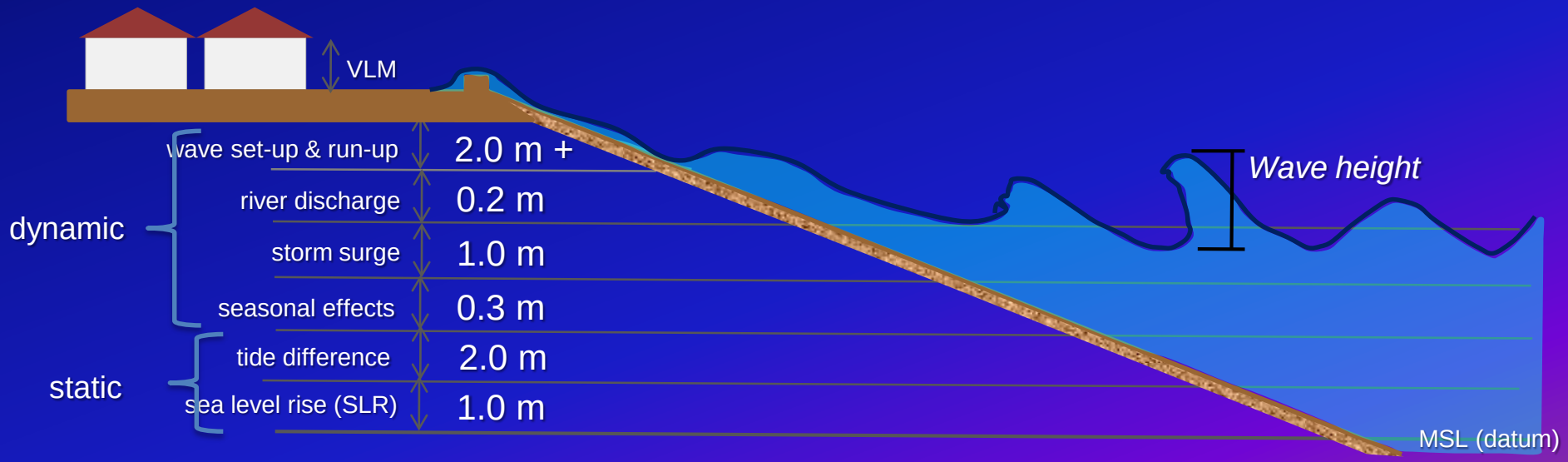
Coastal Vulnerability Approaches

Static

- Passive model, hydrological connectivity
- Tides only
- '1st order screening tool'

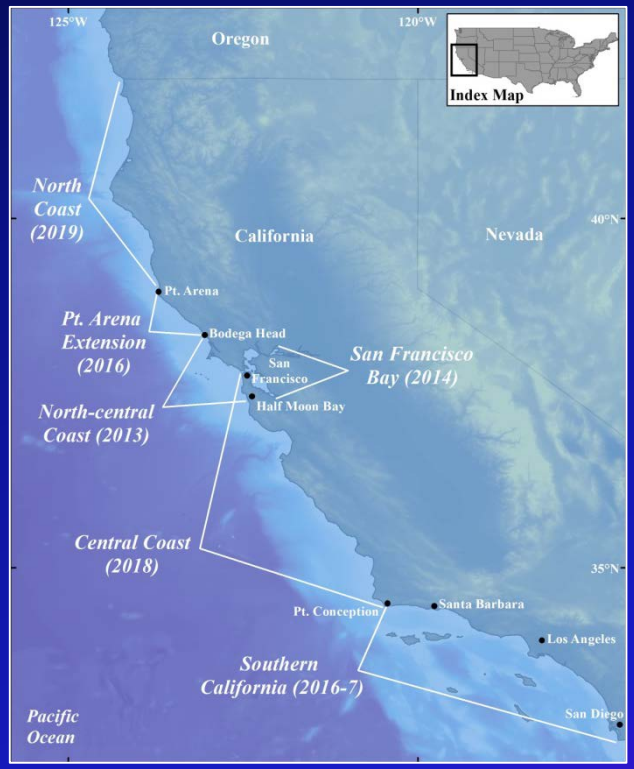
Dynamic: USGS-CoSMoS

- All physics modeled
- Forced by Global Climate Models
- Includes wind, waves, atmospheric pressure, shoreline change
- Range of SLR and storm scenarios



Coastal Storm Modeling System (CoSMoS)

- Physics-based numerical modeling system for assessing coastal hazards due to climate change
- Predicts coastal hazards for the full range of sea level rise (0-5 m) and storm possibilities (up to 100 yr storm) using sophisticated global climate and ocean modeling tools
- Developing coastal vulnerability tools in collaboration with federal, state, and city governments to meet their planning and adaptation needs



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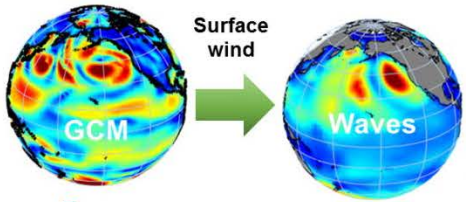
CoSMoS Framework

Global Scale

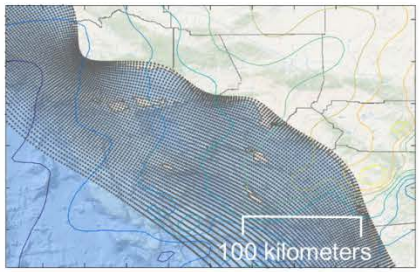
Deep water wave generation and propagation using climate change influenced future winds.



Downscaled winds and atmospheric pressures

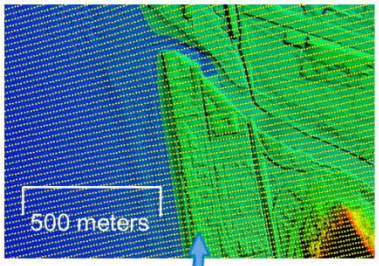
Regional Scale

Swell propagation, wave generation, storm surge, and astronomic tides.



Local Scale

High-resolution hydrodynamics: nearshore waves, wave setup and runup, storm surge, tides, overland flow, fluvial discharge.



Long-term cliff recession and shoreline change

Web-based tools for data visualization and analysis

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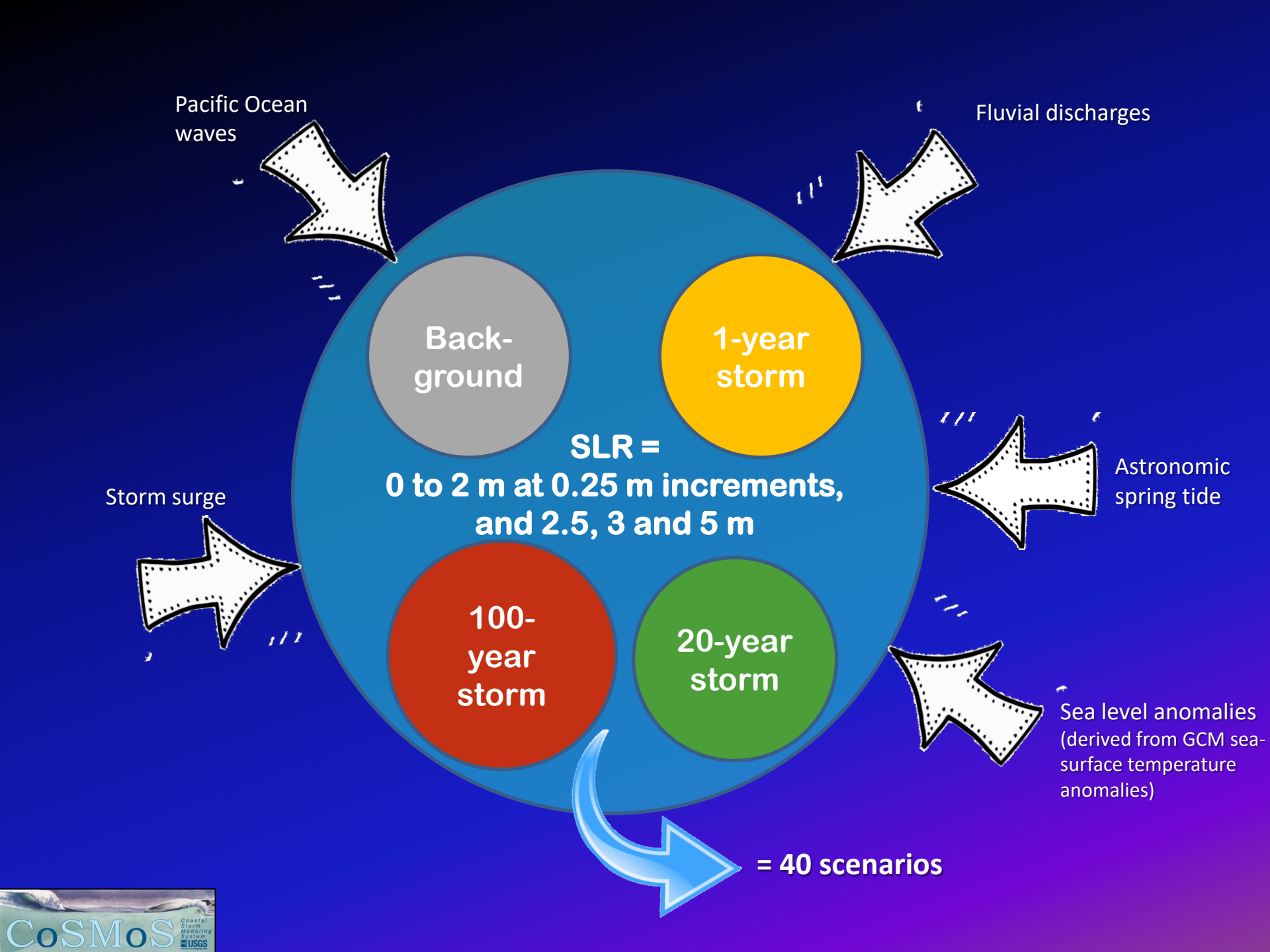
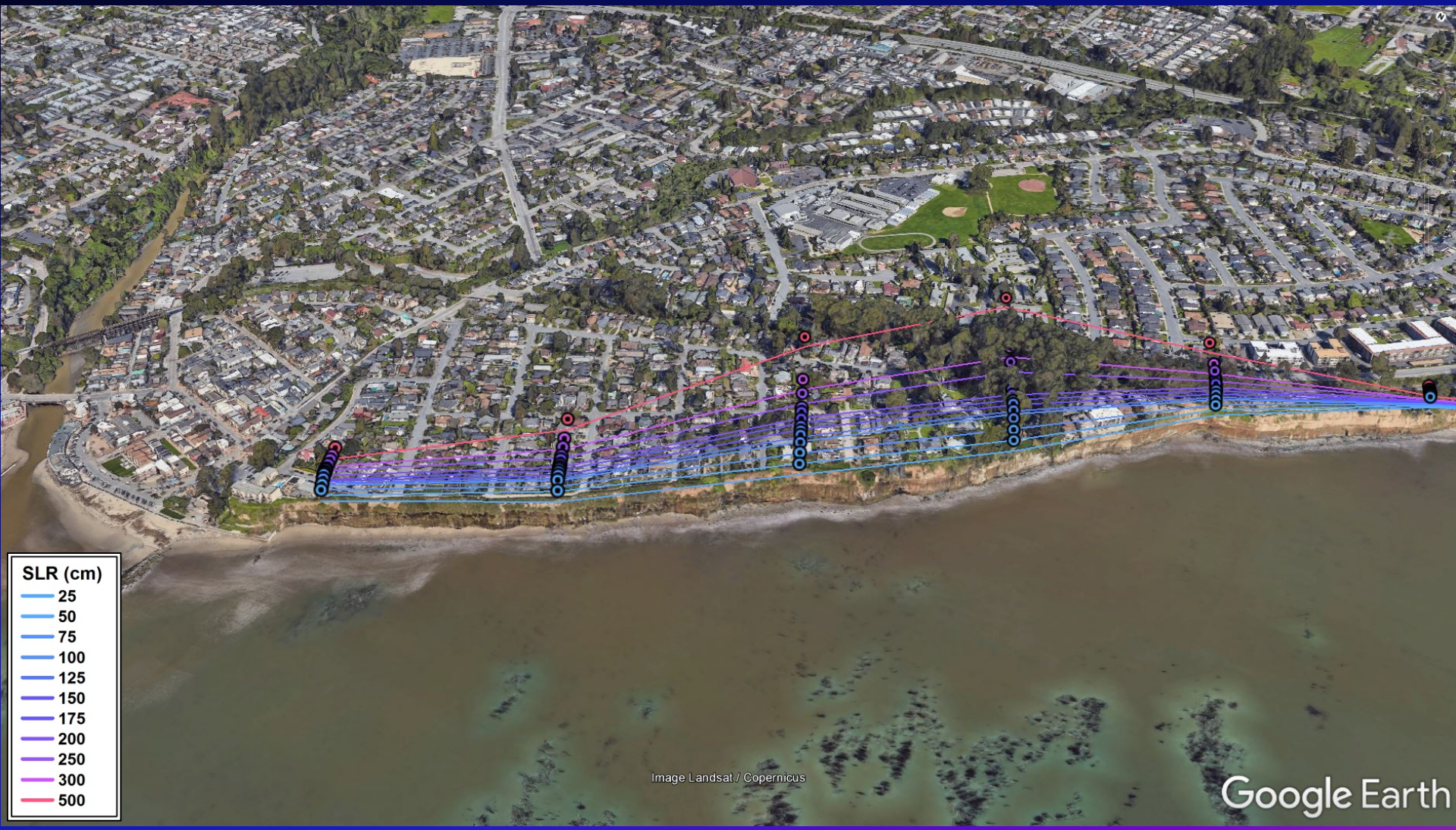
***USGS CoSMoS for Central Coast to be completed in early 2019

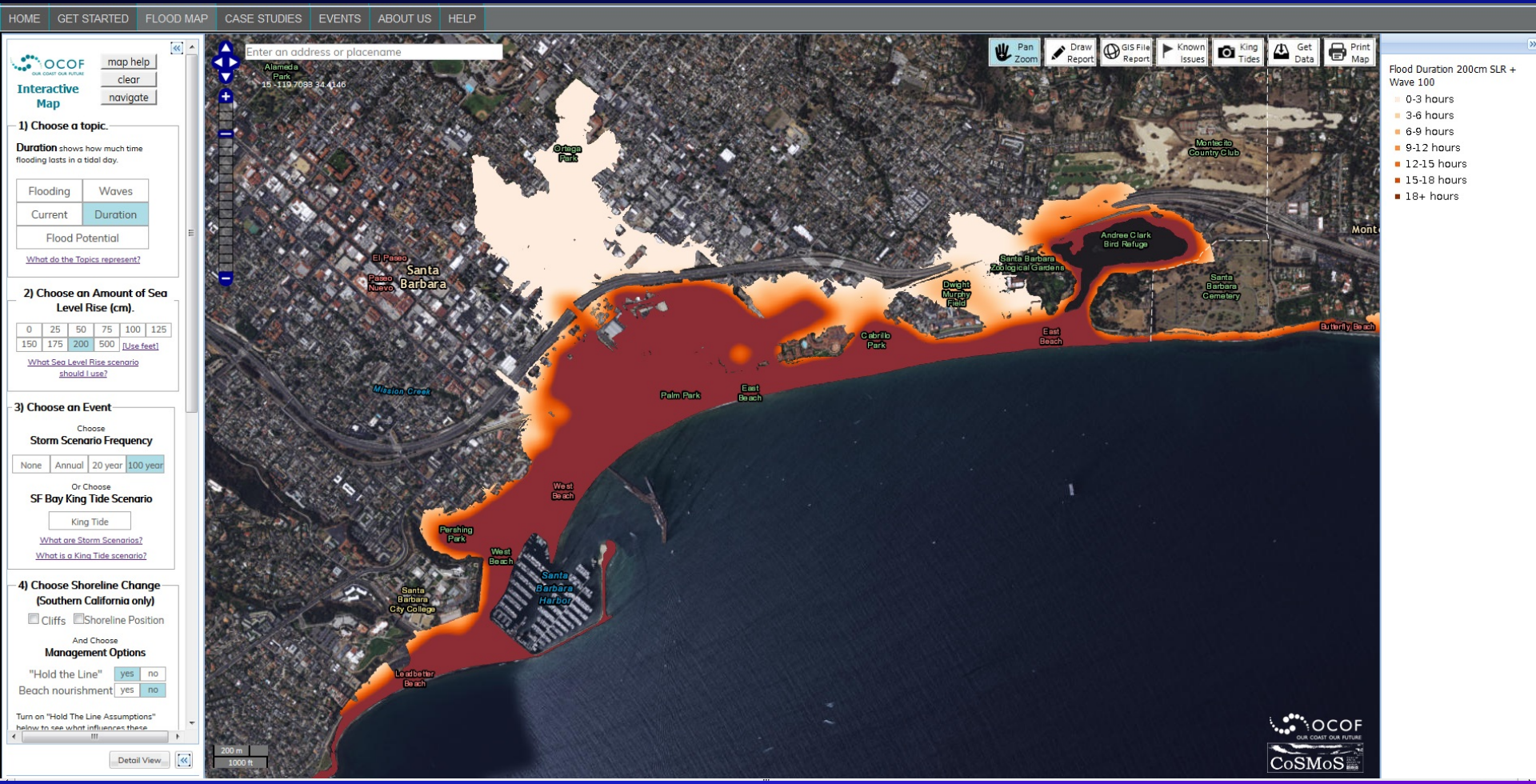

Pacific Ocean waves
Fluvial discharges
Back-ground
1-year storm
SLR =
0 to 2 m at 0.25 m increments,
and 2.5, 3 and 5 m
Storm surge
Astronomic spring tide
100-year storm
20-year storm
Sea level anomalies
(derived from GCM sea-surface temperature anomalies)
= 40 scenarios
CoSMoS
Coastal Storm Modeling System
USGS

Shoreline Projections - Monterey

Cliff Retreat - Capitola



Web Tool – Flooding



Our Coast, Our Future tool: *www.ourcoastourfuture.org*

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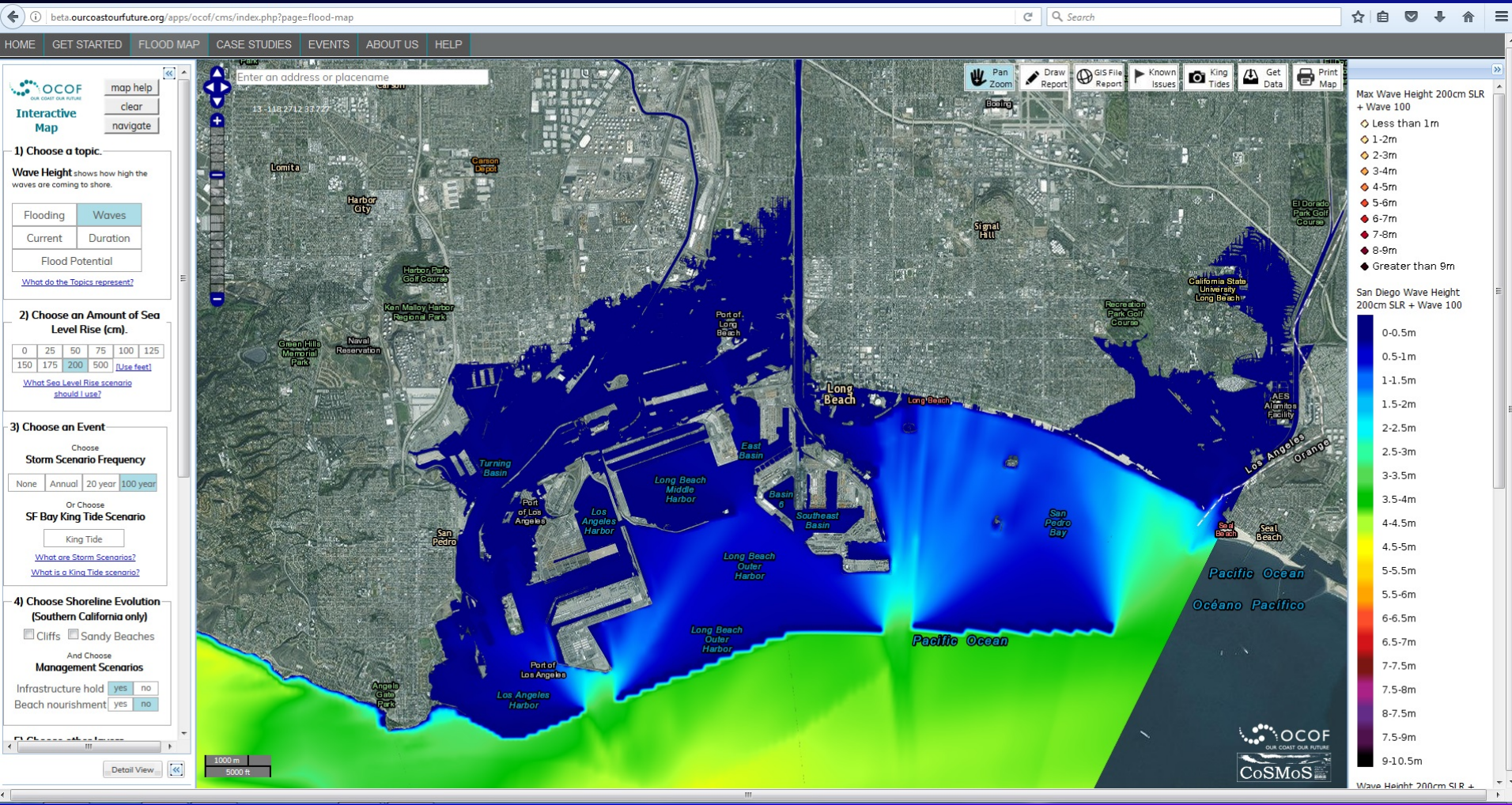
Web Tool - Waves and Currents



Our Coast, Our Future tool: *www.ourcoastourfuture.org*

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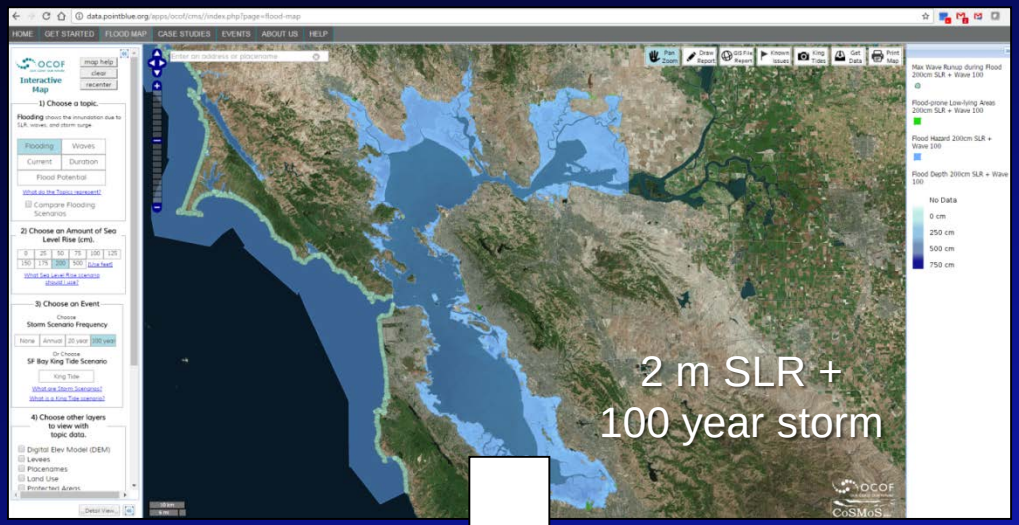
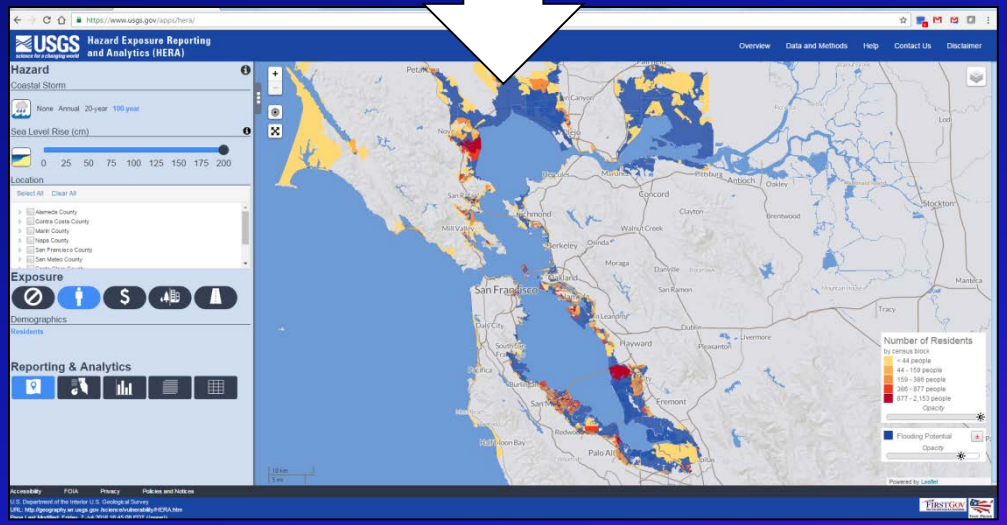
Coastal Climate Impacts by 2100





California

- 600,000+ residents
- $150 billion in property
- 4,700 km of roads
- 350 critical facilities (e.g., schools, police stations, hospitals)

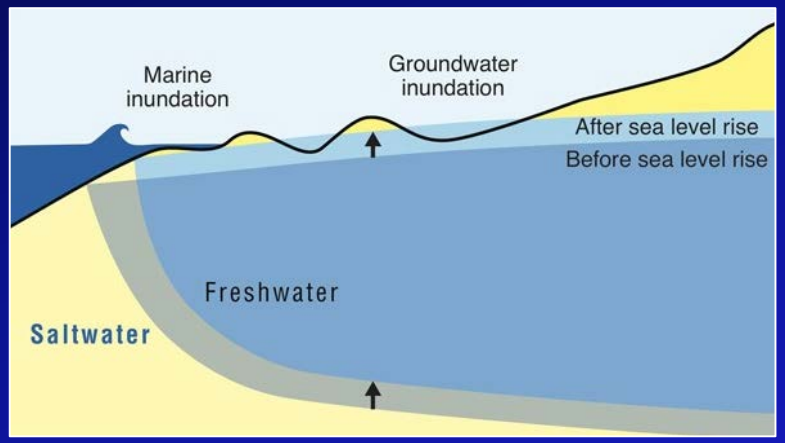
USGS

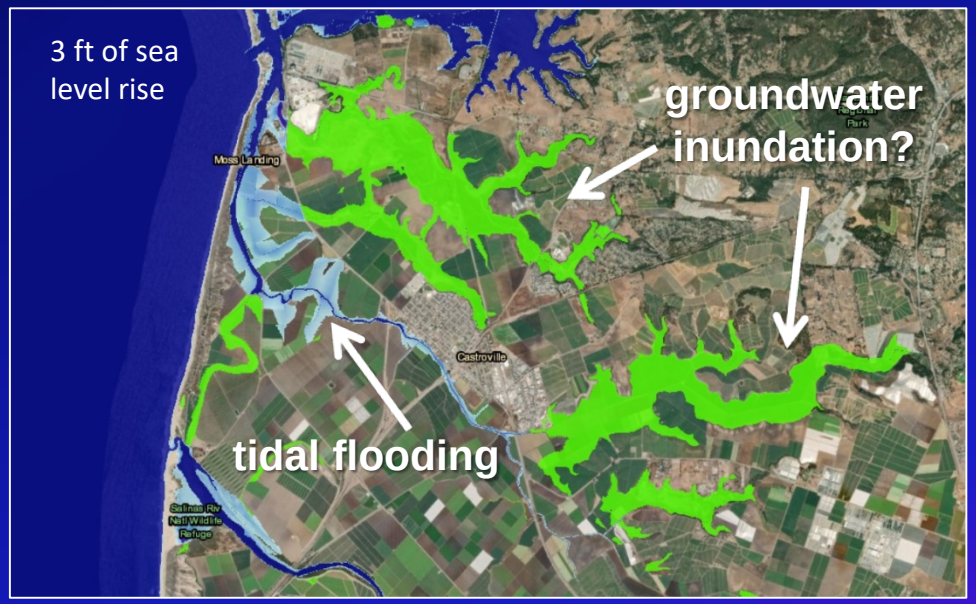
Hazards Exposure Reporting and Analytics (HERA)
www.usgs.gov/apps/hera

CoSMoS Coastal Storm Modeling System USGS

Coastal Groundwater Response to SLR

- **Major issues**
  - **Emergence/Inundation**
  - **Shallower coastal groundwater**
  - **Saltwater intrusion, major hazard for agriculture**





- **Inundation may exceed overland flooding and happen much sooner**
- **May impact infrastructure with no warning**
- **Low-lying areas most vulnerable**

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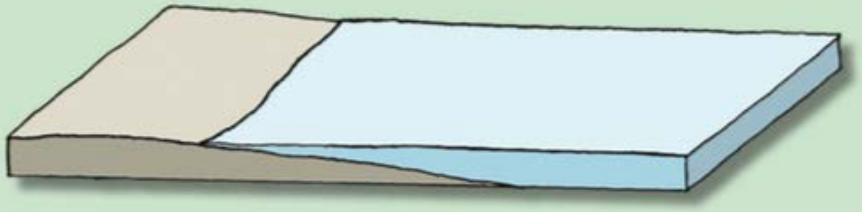
***USGS groundwater hazard assessment to be completed in 2018

SLR mitigation

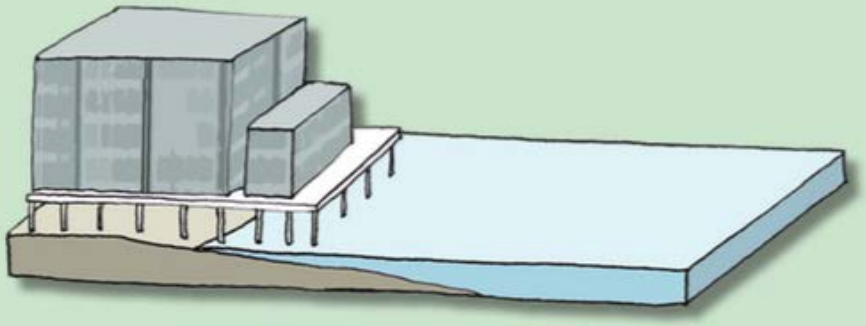
Retreat!



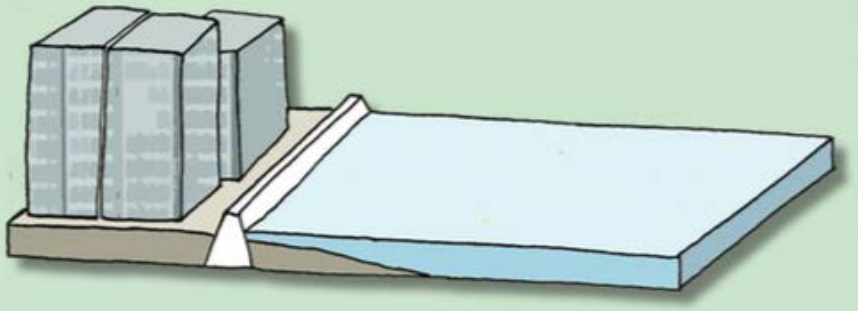
What about groundwater?

Will these strategies work inland?

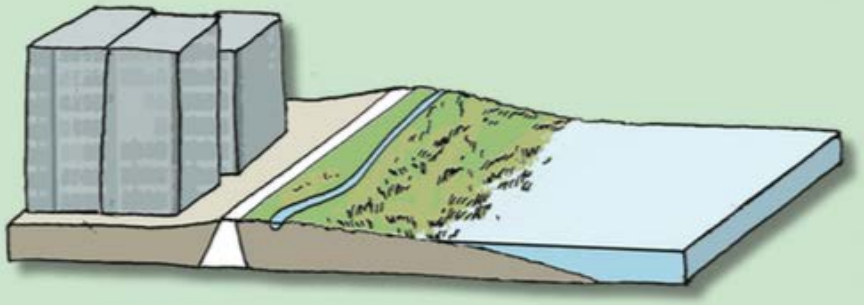
Elevate



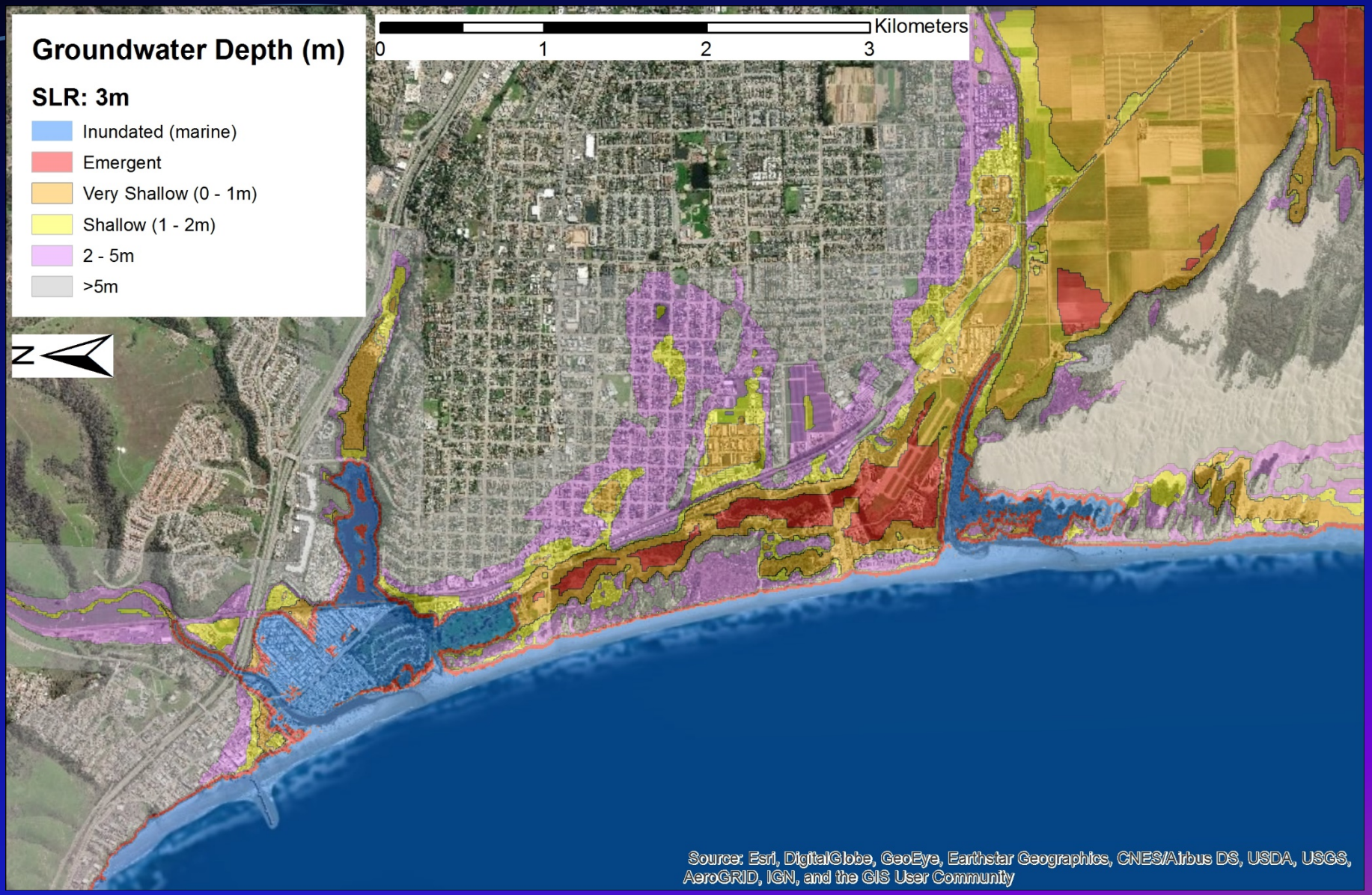
Block



Restore+



Pismo Beach Groundwater



Who uses CoSMoS?

Federal

- National Park Service
- NOAA Gulf of Farallones National Marine Sanctuary
- NOAA Office for Coastal Management
- National Estuarine Research Reserve (NOAA)

State

- California Coastal Commission
- California Coastal Conservancy
- California Department of Emergency Services (CalOES)
- California Department of Fish & Wildlife
- California Department of Transportation (Caltrans)
- California Energy Commission
- California Natural Resources Agency
- California Ocean Protection Council

County

- Sonoma County
- Marin County
- San Mateo County
- Santa Clara County
- Santa Barbara County
- Los Angeles County
  - Office of Emergency Management
  - Department of Beaches and Harbors
- San Diego County

CoSMoS Coastal Storm Modeling System USGS

Who uses CoSMoS?

City

- City of San Francisco
- City of Pacifica
- City of San Jose
- City of Santa Cruz
- City of Santa Barbara
- City of Los Angeles
- City of Santa Monica
- City of Hermosa Beach
- City of Long Beach
- City of Huntington Beach
- City of Imperial Beach
- City of Oceanside
- City of Encinitas
- City of Carlsbad
- City of San Diego
- City of Imperial Beach

Regional Scale

- AdaptLA: Coastal Impacts Planning for the LA Region
- California Climate Science Alliance
- Coastal Ecosystem Vulnerability Assessment (CEVA, Santa Barbara)
- LA Regional Collaborative on Climate Action and Sustainability (LARC)
- Regional Water Quality Control Board for LA and Ventura Counties
- San Diego Regional Climate Collaborative
- Southern California Coastal Water Research Project (SCCWRP)
- Wetlands Recovery Projects (San Diego - Orange County region & LA - Ventura - Santa Barbara region)


*For more information, contact Patrick Barnard: pbarnard@usgs.gov
and Juliette Hart: jfinzihart@usgs.gov
USGS CoSMoS data:
http://walrus.wr.usgs.gov/coastal_processes/cosmos/
Our Coast - Our Future tool: www.ourcoastourfuture.org
HERA Tool: www.usgs.gov/apps/hera
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USGS

CoSMoS USGS

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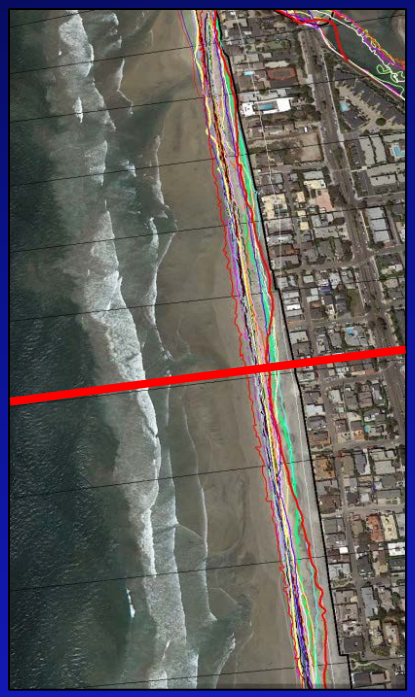
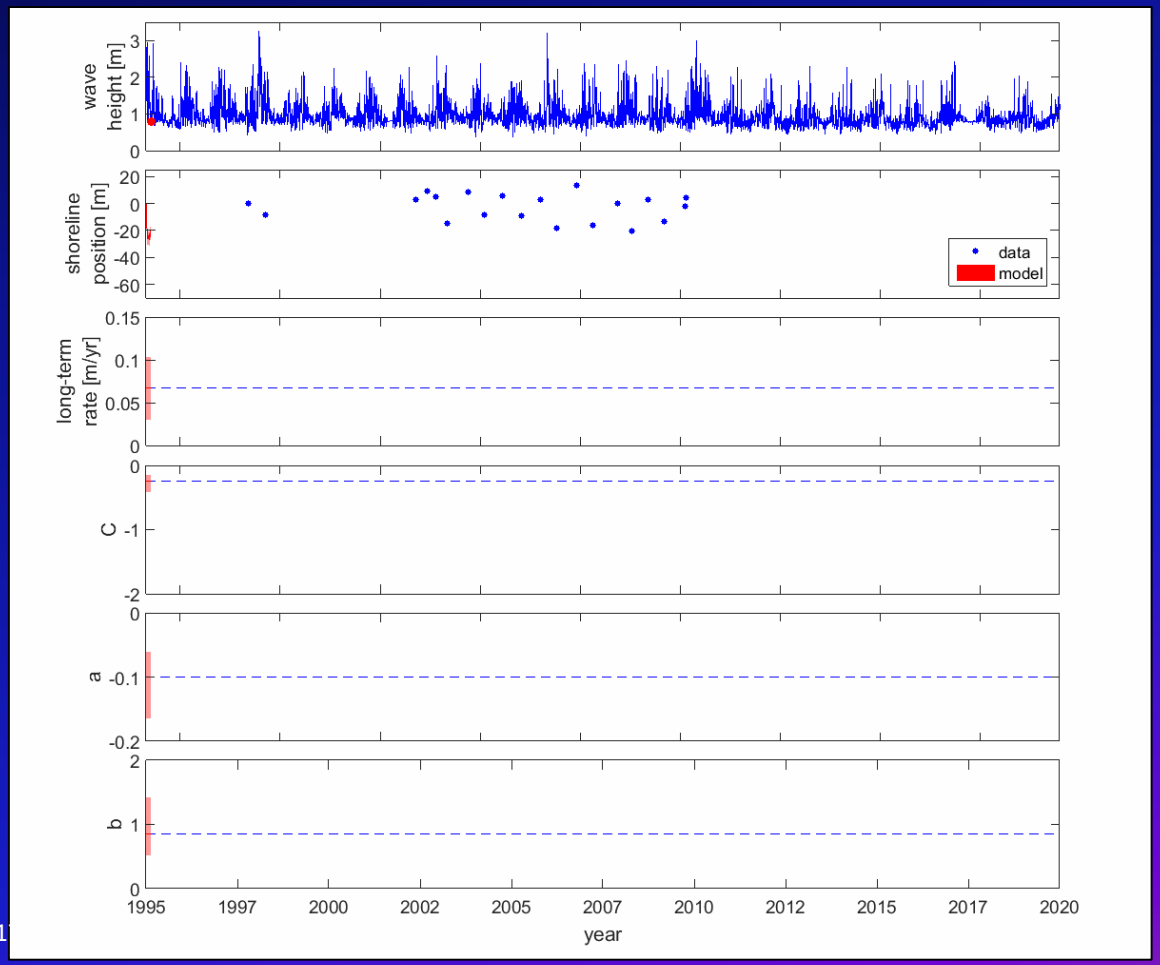
CoSMoS USGS

CoSMoS-COAST: Coastal One-line Assimilated Simulation Tool

- A (hybrid) numerical model to simulate long-term shoreline evolution
- Modeled processes include:
  - Longshore transport
  - Cross-shore transport
  - Effects of sea-level rise
  - Sediment supply by natural & anthropogenic sources





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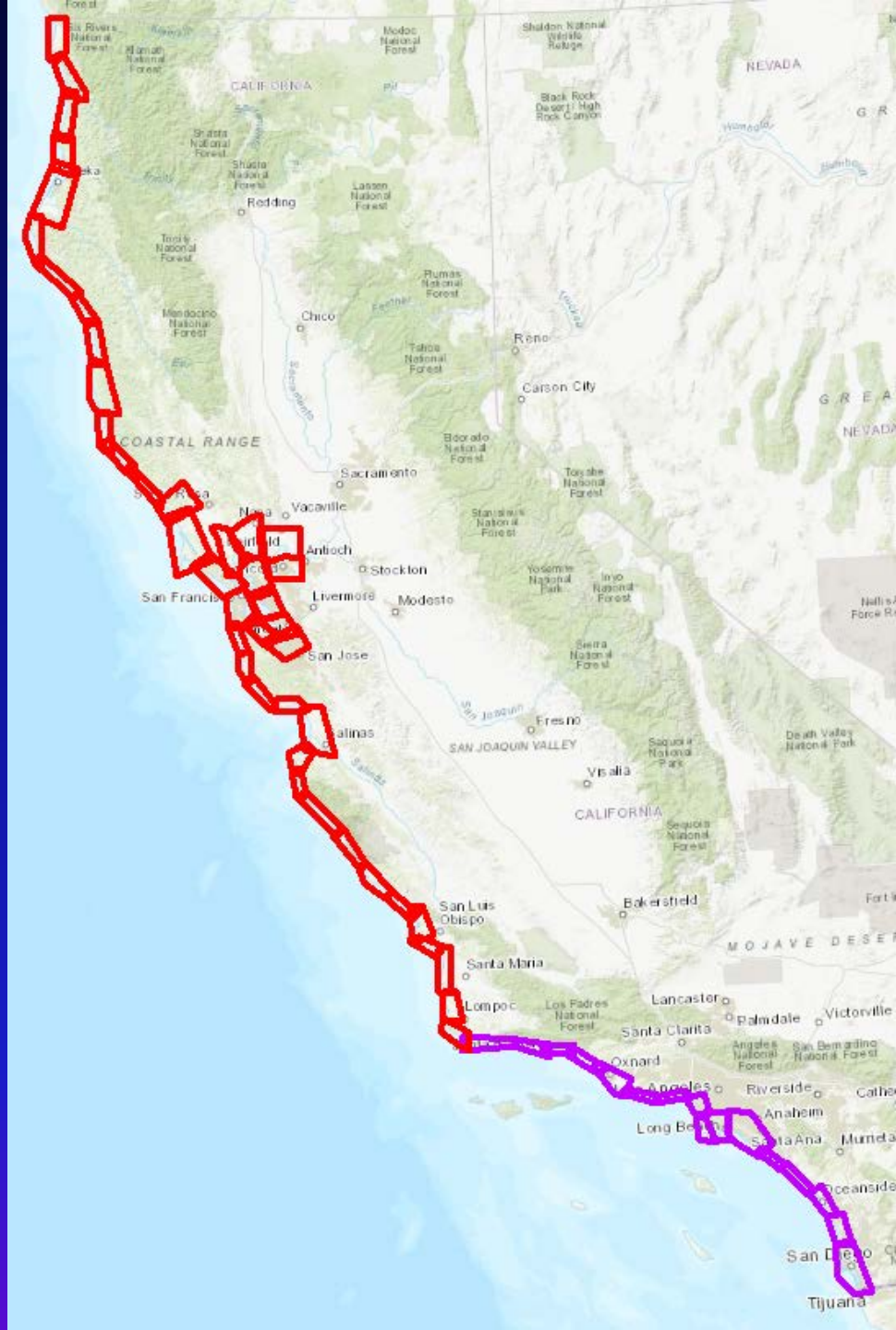
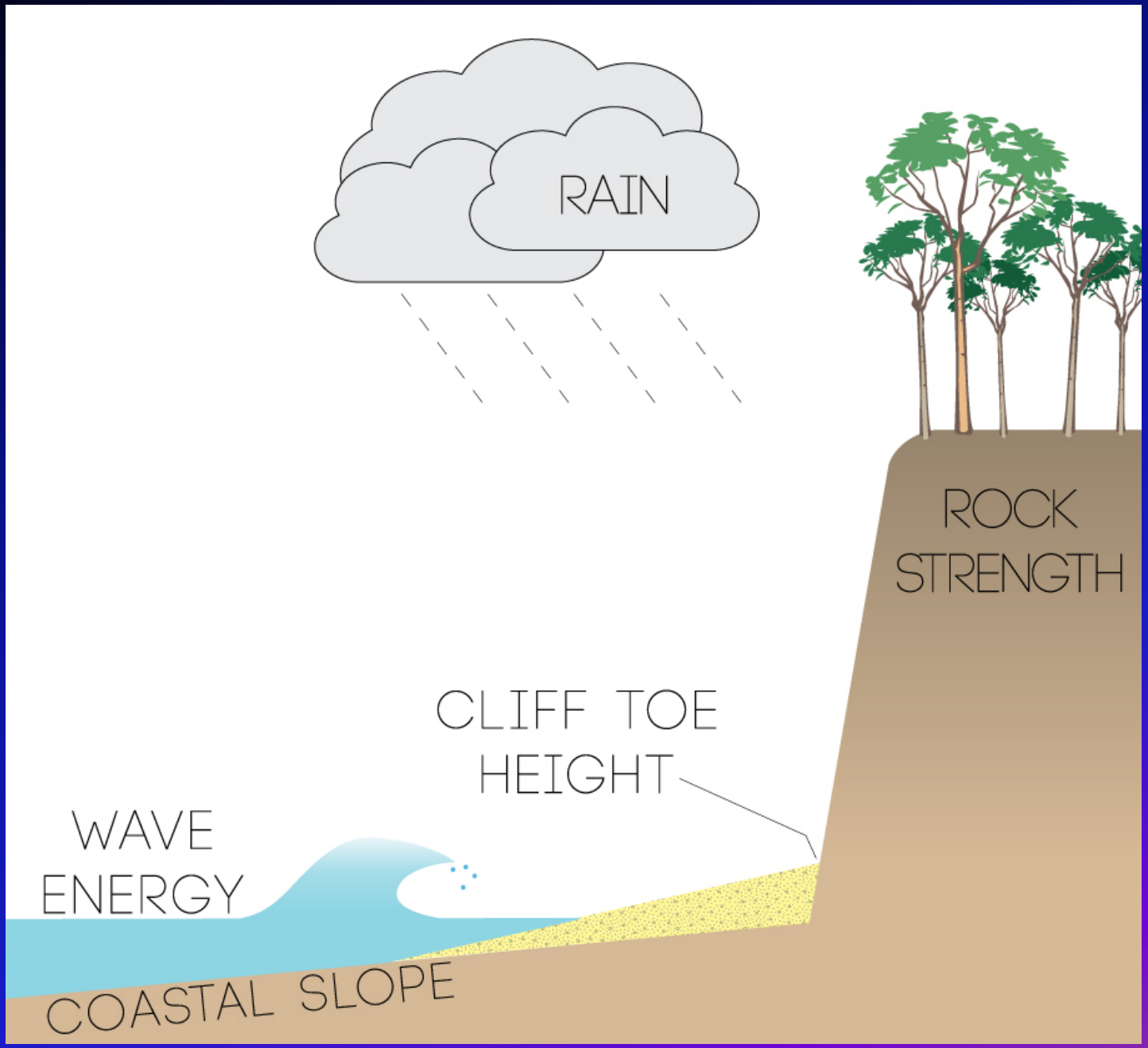
Groundwater flow model

- CA coastline into 57 overlapping models
- Inland to ~10 m elevation contour
- 10 m x 10 m grid resolution
- Uniform permeability to -50 m NAVD
- Kh/Kv = 10 (anisotropy)
- Salinity (i.e., density) changed for seawater
- Sea level set to MHHW from interpolated tide gauges
- Run to equilibrium (i.e., steady-state) for each of 12 sea level rise scenarios



Cliff Retreat



Cliff Retreat

1-D model ensemble- Limber et al. (2018)