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Orange County CoSMoS Results

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U.S. Department of the Interior
U.S. Geological Survey

Huntington Beach Pier, January 1983
(H. Lorren Au Jr., Orange County Register)

Support for CoSMoS SoCal

- State Coastal Conservancy
- City of Imperial Beach
- Tijuana River National Estuarine Research Reserve
- California Department of Fish & Wildlife
- California's Fourth Climate Change Assessment (California Natural Resources Agency)

USGS

Projections for Southern California

<u>SLR for Los Angeles (NRC, 2012)</u>
-28 cm of sea level rise by 2050 (range 13-61 cm)
-93 cm of sea level rise by 2100 (range 44-167 cm)
-includes global and regional effects (e.g., wind and circulation patterns, sea level fingerprint, glacial isostatic adjustment, tectonics)

<u>Storms for Southern California (Bromirski et al., 2012; Erikson et al., 2015)</u>
-No significant changes in wave height
-Extreme events approach from ~10-15 degrees further south

<u>El Niño for 21st Century (Cai et al., 2015, Barnard et al., 2015)</u>
-More frequent extreme events
-Doubling of winter erosion
-Wave energy increase by 30%

<u>Orange County 21st Century Vulnerability (Pacific Institute, 2009)</u>
-110,000 people at risk
-$17 billion in property

Sunset Beach, Sean Hiller


The Wedge


Seal Beach, Frederic J. Brown

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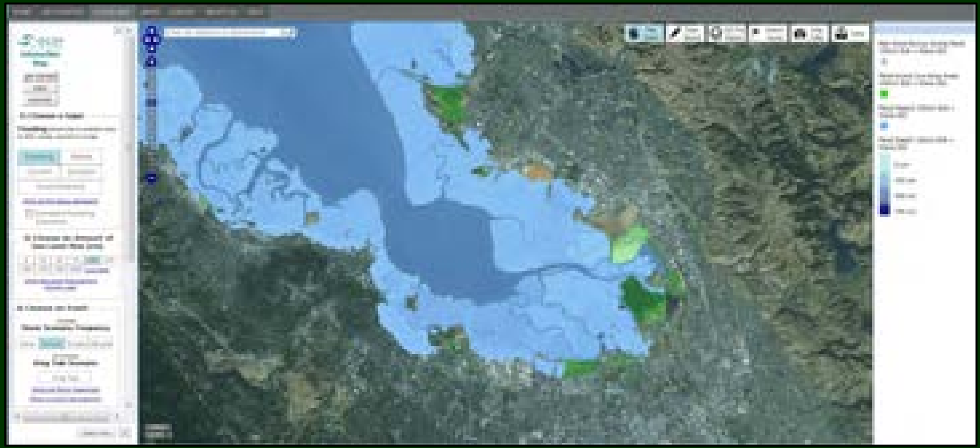
Coastal Vulnerability Approaches

- **<u>STATIC</u>: NOAA SLR Viewer**
  - –Passive model, hydrological connectivity
  - –Tides only (MHHW)
  - –Excellent elevation data, datum control
  - –Wetland migration model, socioeconomic impacts
  - –'1st order screening tool'

http://www.coast.noaa.gov/slr/

- **<u>DYNAMIC</u>: CoSMoS**
  - –GCM ensemble forcing
  - –Includes wind, waves, sediment transport, fluvial discharge, and vertical land movement rates
  - –Range of SLR and storm scenarios
  - –Flooding extent explicitly modeled, hydrological connectivity



Our Coast Our Future: *www.prbo.org/ocof*

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CoSMoS: A Tool for Coastal Resilience

- **Physics-based numerical modeling system for assessing coastal hazards due to climate change**

- **Predicts coastal hazards for the full range of sea level rise (0-2, 5 m) and storm possibilities (up to 100 yr storm) using sophisticated global climate and ocean modeling tools**

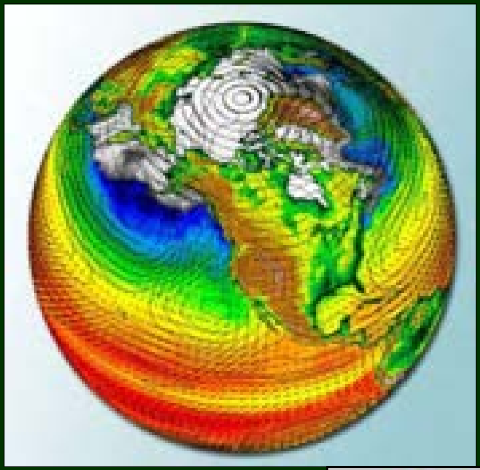
- **Developing coastal vulnerability tools in collaboration with federal, state, and city governments to meet their planning and adaptation needs**

- **Emphasis on directly supporting federal and state-supported climate change guidance (e.g., Coastal Commission) and vulnerability assessments (e.g., LCP updates, OPC/Coastal Conservancy grants)**

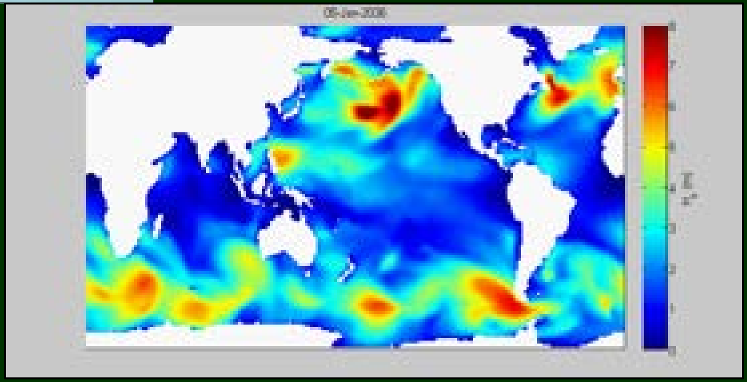
Sunset Beach, Allan J. Schaben


Sunset Beach, Mark Rightmire

Identifying Future Risk with CoSMoS



1. Global forcing using the latest climate models



2. Drives global and regional wind/wave models

3. Scaled down to local hazards projections

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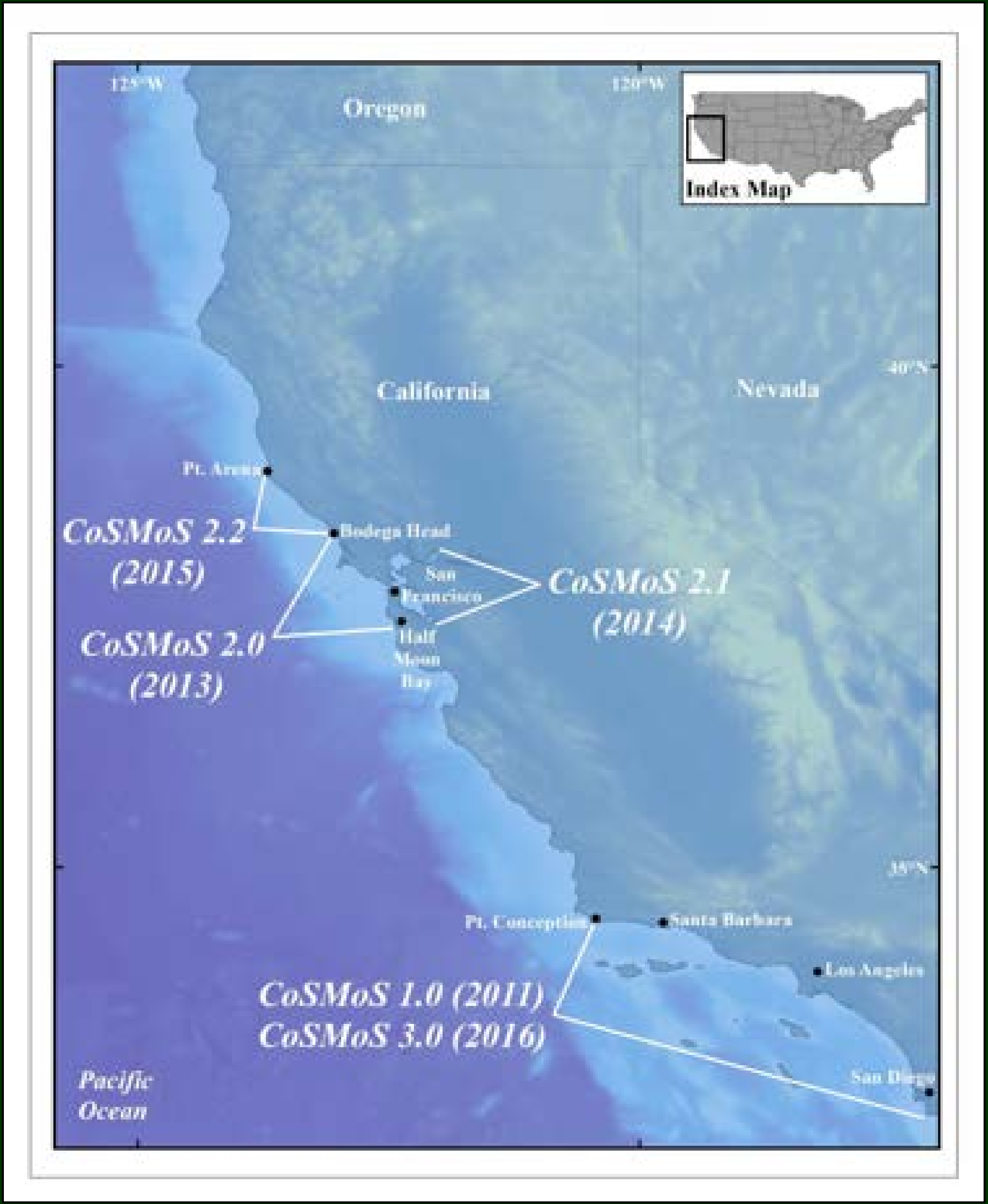
CoSMoS Version Summary



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CoSMoS Version Summary

CoSMoS 1.0

- So Cal, 470 km coastline (Pt. Conception -> Mexico border)
- Historical storms, 2 SLRs
- Global & regional parts continue to run operationally

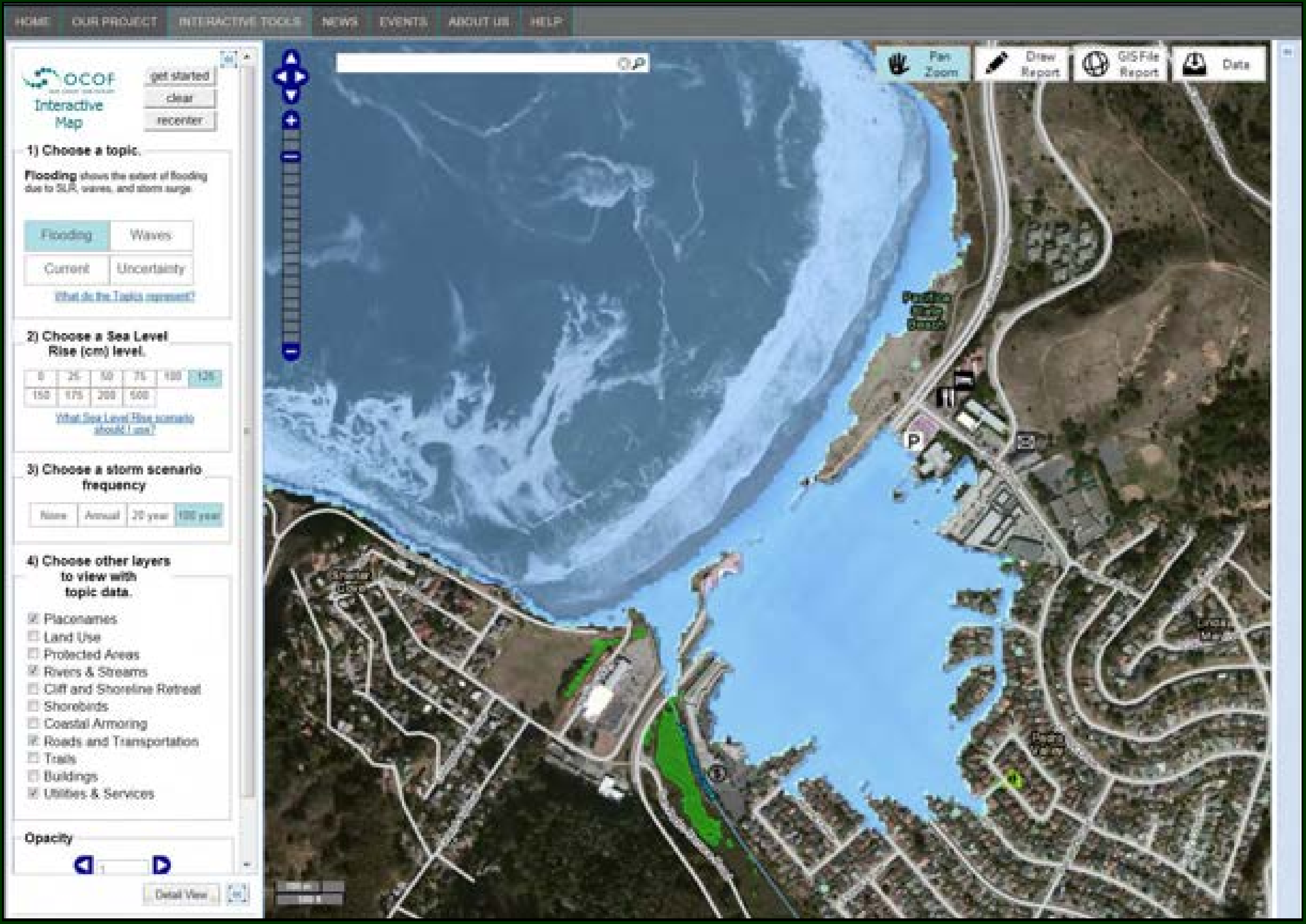
CoSMoS 2.0

- North-Central CA coast, 170 km, (Bodega Head to Half Moon Bay)
- 21st century winds & waves
- High resolution grids of lagoons and protected areas
- Annual, 1 yr, 20 yr, 100 yr storm events in combination with SLR 0 m to 5 m at 0.25 m increments +5 m
- Web-based tool

CoSMoS 2.1

- San Francisco Bay
- Spatial- & time-downscaled climate scenario winds
- Fluvial discharges
- Vertical land motion
- Marsh accretion

CoSMoS 2.0- CenCal/NorCal



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www.prbo.org/ocof (Our Coast - Our Future)

Highlights of CoSMoS 3.0

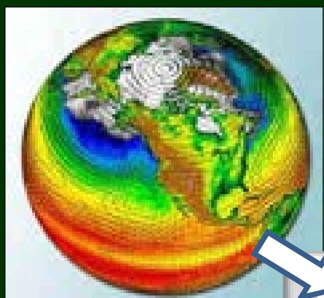
- Multi-agency collaboration featuring top coastal and climate scientists from Scripps, Oregon State University, private sector, and USGS
- Long-term coastal evolution modeled, including sandy beaches and cliffs
- Downscaled winds from GCMs to get locally-generated seas and surge
- Discharge from rivers for event response
- 100 yr storm events in combination with SLR 0 m to 1.5 m in 0.5 m increments delivered Fall 2015

USGS

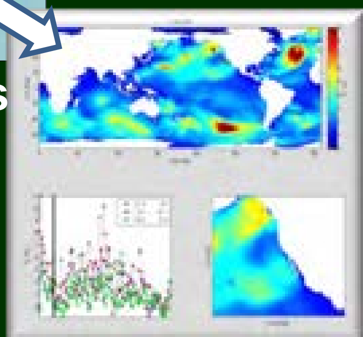
CoSMoS 3.0 Southern California

Global

Global conditions of future climate scenarios



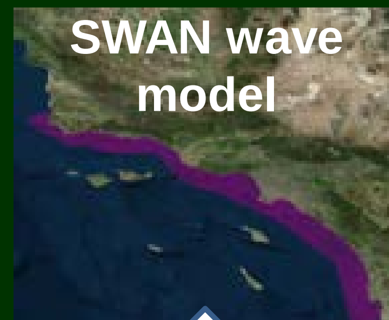
GCM winds



WW3 wave model

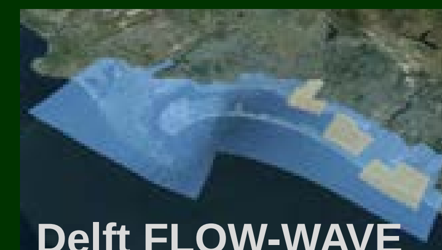
Regional

Tides, water levels, and regional forcing

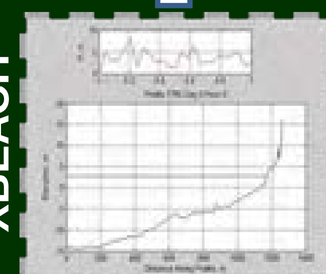


Local

High resolution hydrodynamics and



XBEACH



Open coast

Fluvial discharge
VLM
Coastal change

results projected onto hi-res DEM

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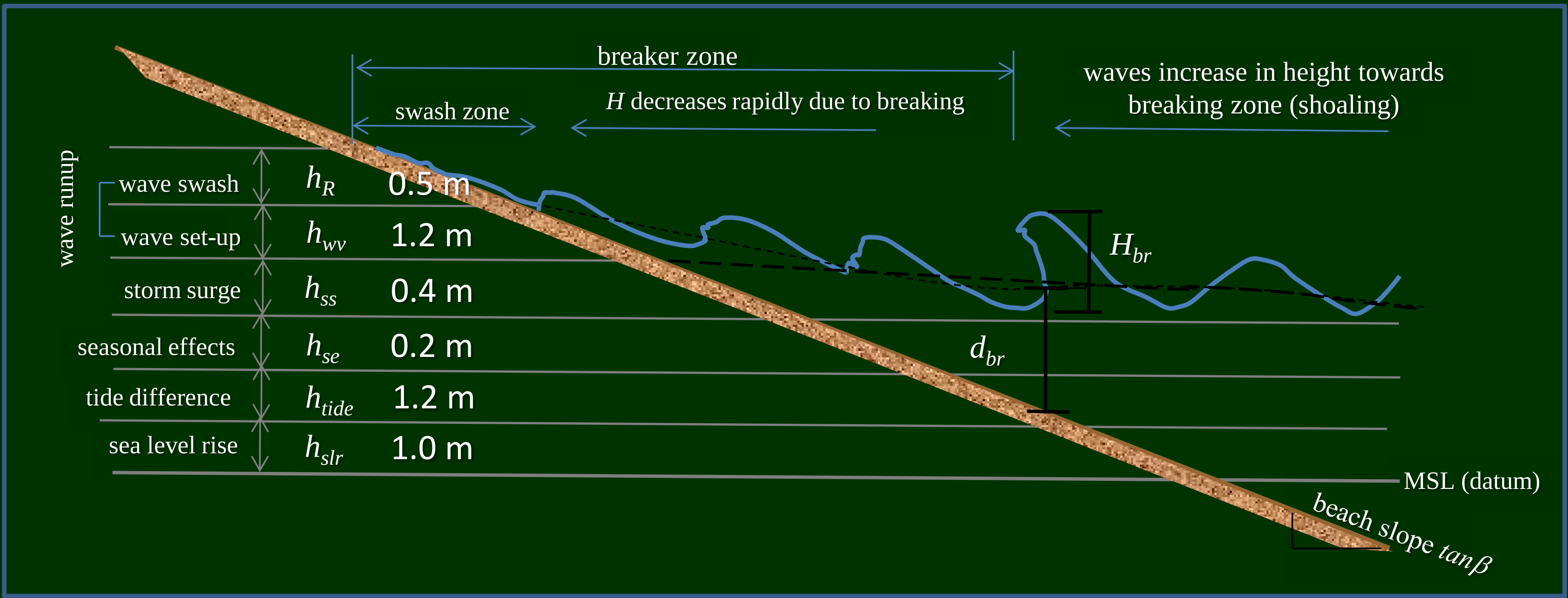
CoSMoS

Overview of Processes Included in CoSMoS



flood level is the combination of

$$rSLR + tides + seasonal\ effects + storm\ surge + wave\ setup + wave\ runup + fluvial\ discharge\ backflow$$

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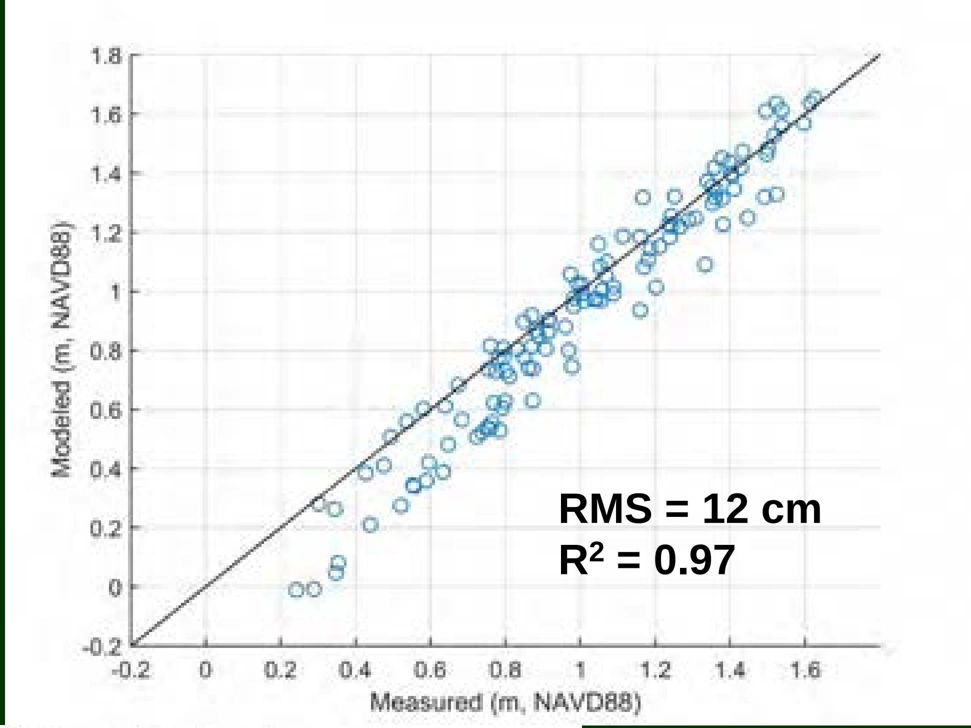
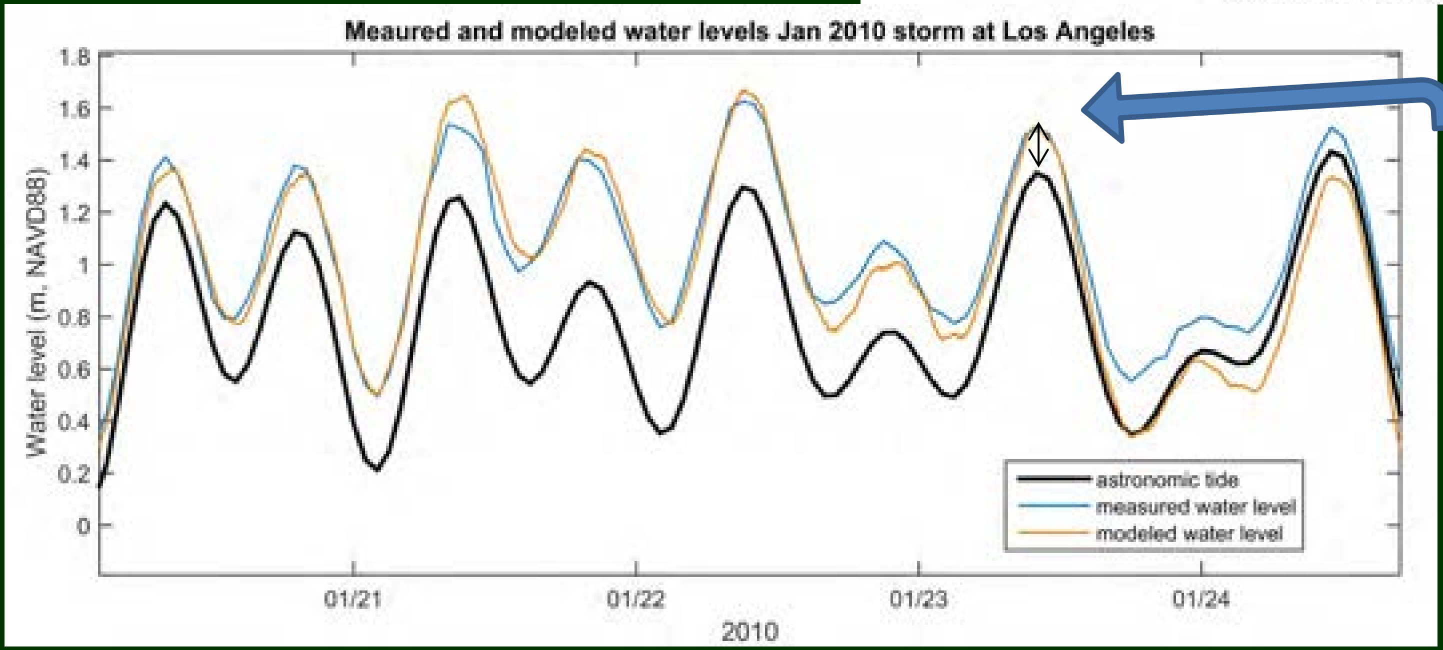
CoSMoS validated with January 2010 Storm

Los Angeles tide gauge



RMS = 12 cm
R^2 = 0.97

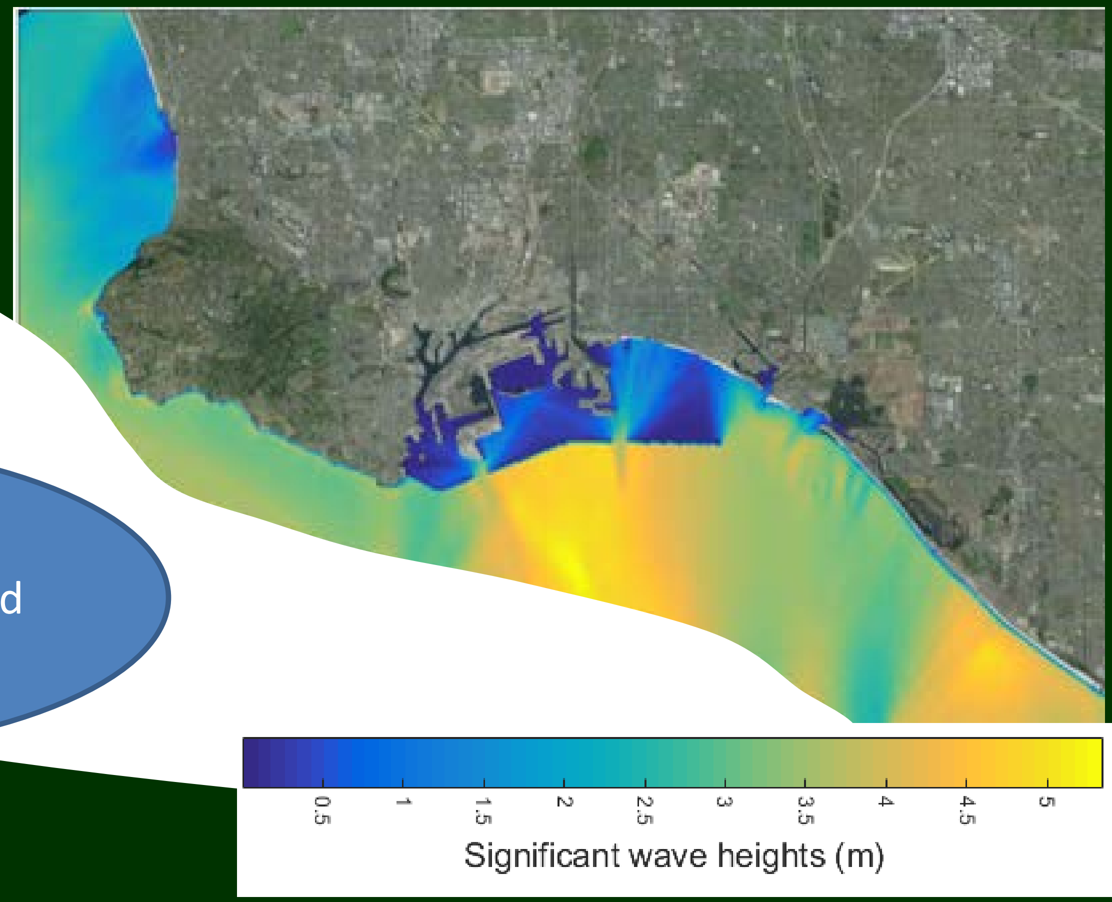


Predicted and observed/modeled water levels differ by 6 to 52 cm

Products- Wave and Currents

- Delft3D model results from all local SWAN and FLOW runs are used to…

To generate maps of maximum wave heights and maximum currents



Products- Flood Maps

- Delft3D model results from high resolution grids (inlets, harbors, etc.)
- Combined with open coast XBeach results
- Overlain and differenced from the 2 m resolution DEM

To generate maps of flood extents, duration, and depth

High resolution model results

XBeach results along open coast

Flood map

CoSMoS Fall 2015 Product Release

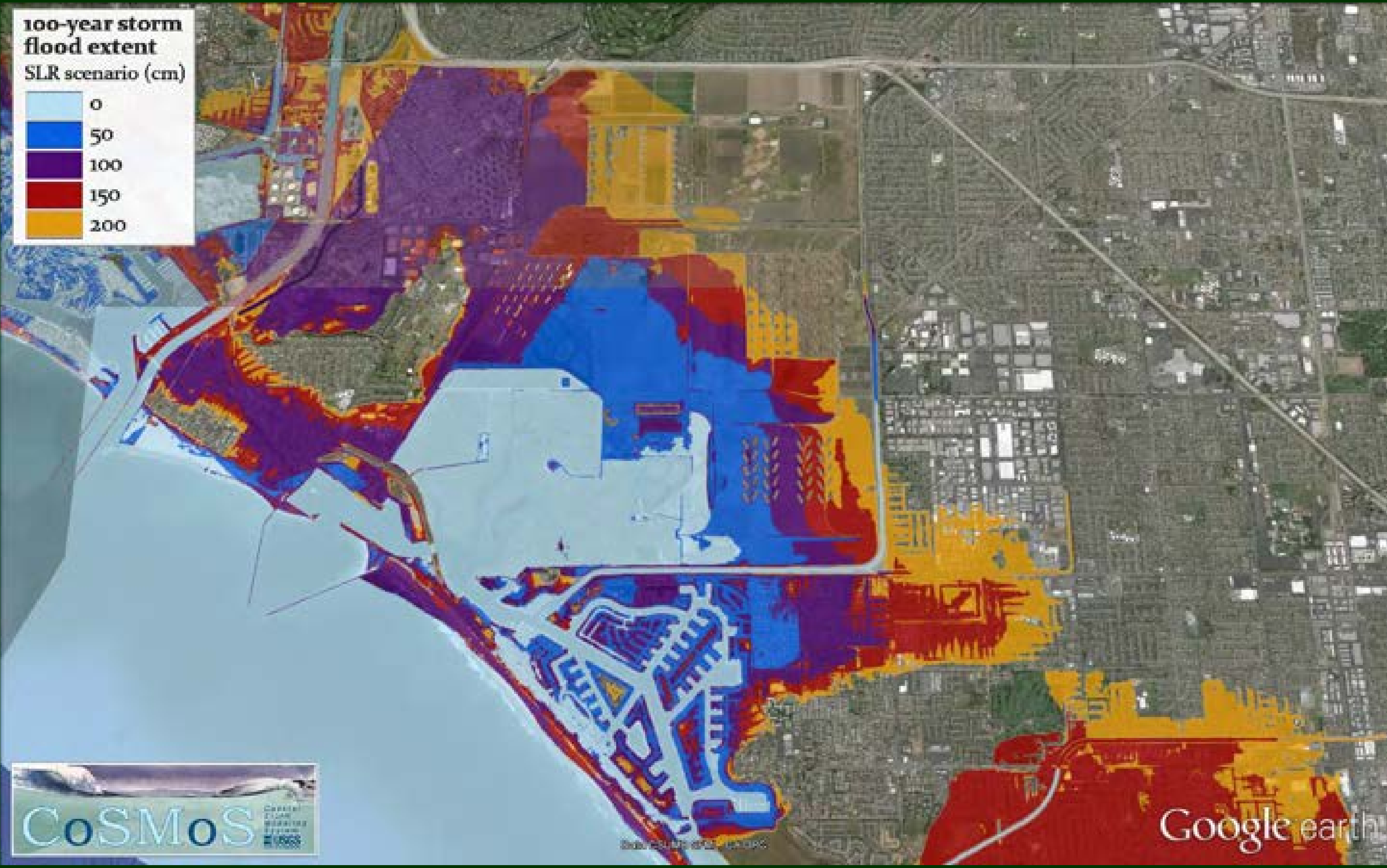
- 5 scenarios, 100 year storm + 0, 0.5, 1.0, 1.5 and 2.0 m SLR
- Available now: KMZs and shapefiles of flood extent, shoreline projections and cliff retreat
- Next summer: all 40 scenarios, integrated coastal change with coastal flooding
  - Coastal hazards data served up in Our Coast Our Future web tool
  - Socioeconomic data served up in USGS web tool

http://walrus.wr.usgs.gov/coastal_processes/cosmos/socal3.0/index.html

Flooding – Orange County Overview

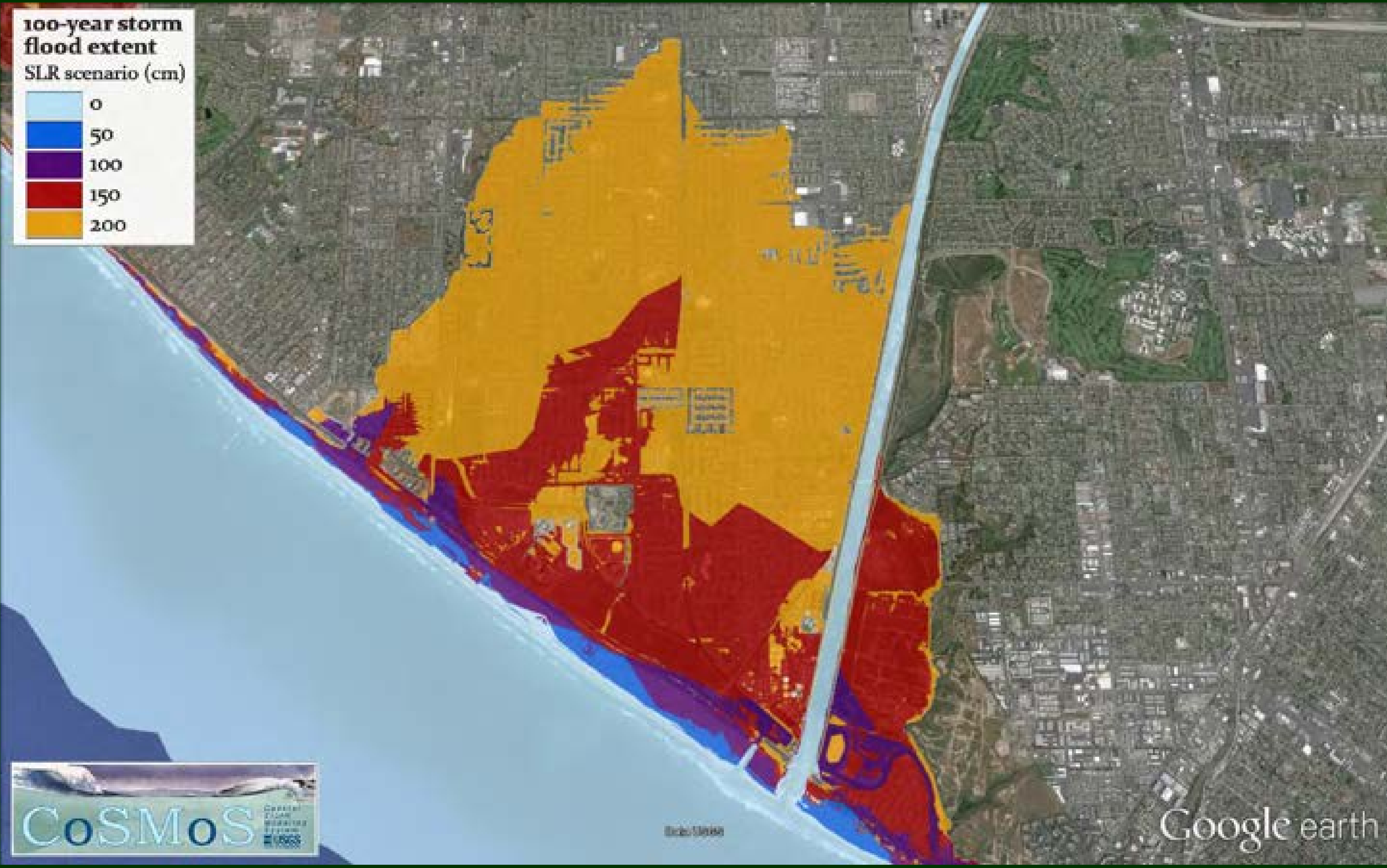
http://walrus.wr.usgs.gov/coastal_processes/cosmos/socal3.0/index.html

Flooding – Seal Beach/ Sunset Beach

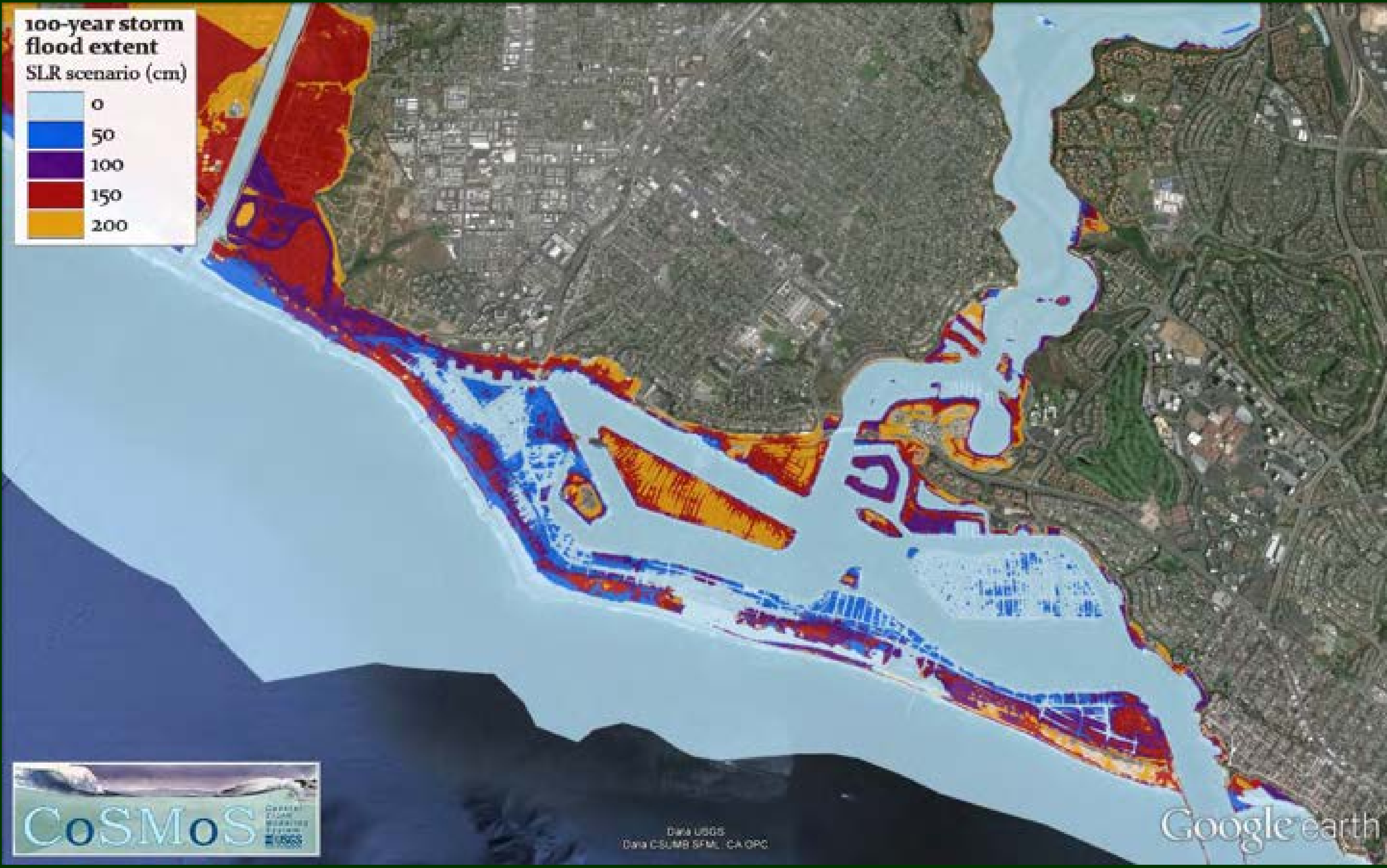


Flooding – Bolsa Chica

Flooding – Huntington Beach



Flooding – Newport Beach



Flooding – Corona del Mar

Flooding – Laguna

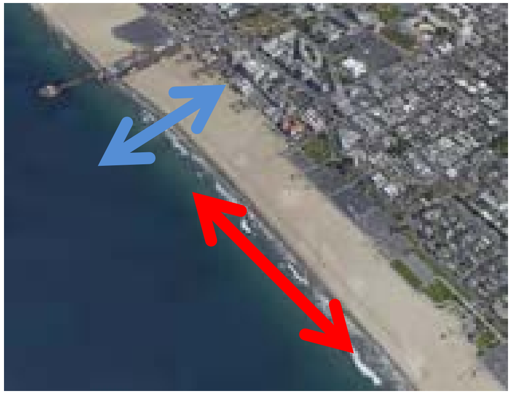
Flooding – Dana Point

CoSMoS-COAST: Coastal One-line Assimilated Simulation Tool

- **A (hybrid) numerical model to simulate long-term shoreline evolution**
  - coastline is represented by shore-perpendicular transects:

- **Two current assumptions: hold the line at urban interface and projection of historical rates**

- **Modeled processes include:**
  - Longshore sediment transport
  - Cross-shore sediment transport
  - Effects of sea-level rise
  - Sediment supply by natural & anthropogenic sources



- **Synthesized from models in scientific literature (with several improvements):**
  - Longshore transport: Pelnard-Considere 1956, Larson et al. 1997, Vitousek & Barnard 2015
  - Equilibrium shoreline change models: Miller & Dean 2004, Yates et al. 2009, Long & Plant 2012
  - Cross-shore transport due to sea-level rise: Bruun 1954, Davidson-Arnot 2005, Anderson et al. 2015

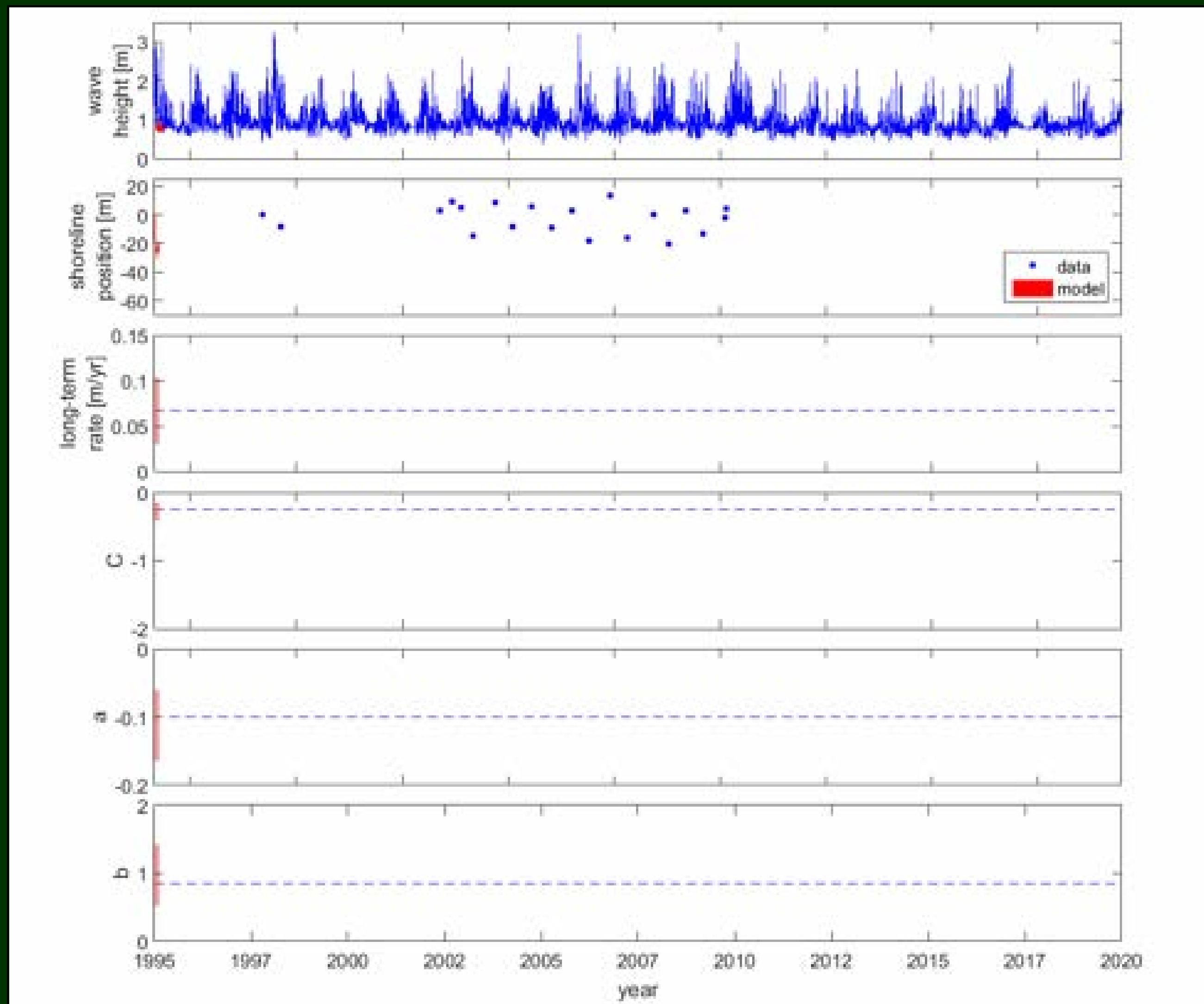
- **Uses data assimilation (Extended Kalman Filter) to improve model skill**

Data Assimilation

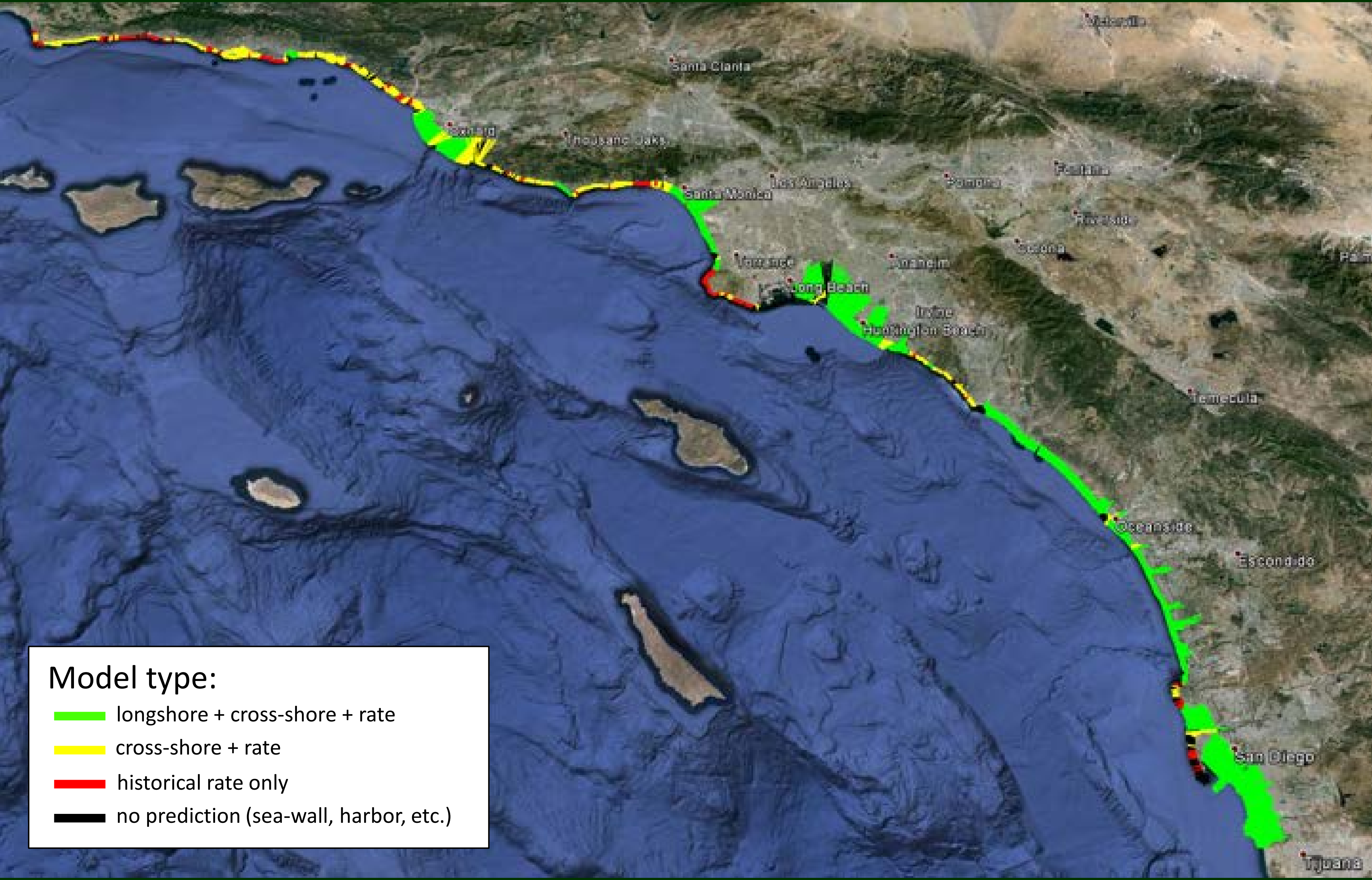
We use the *extended Kalman filter method* of Long & Plant 2012

- Auto-tunes model parameters for each transect to best fit the historical shoreline data
- We improved the method to handle sparse shoreline data and ensure that parameters are positive or negative.

Simulation output for a single transect at Del Mar Beach:



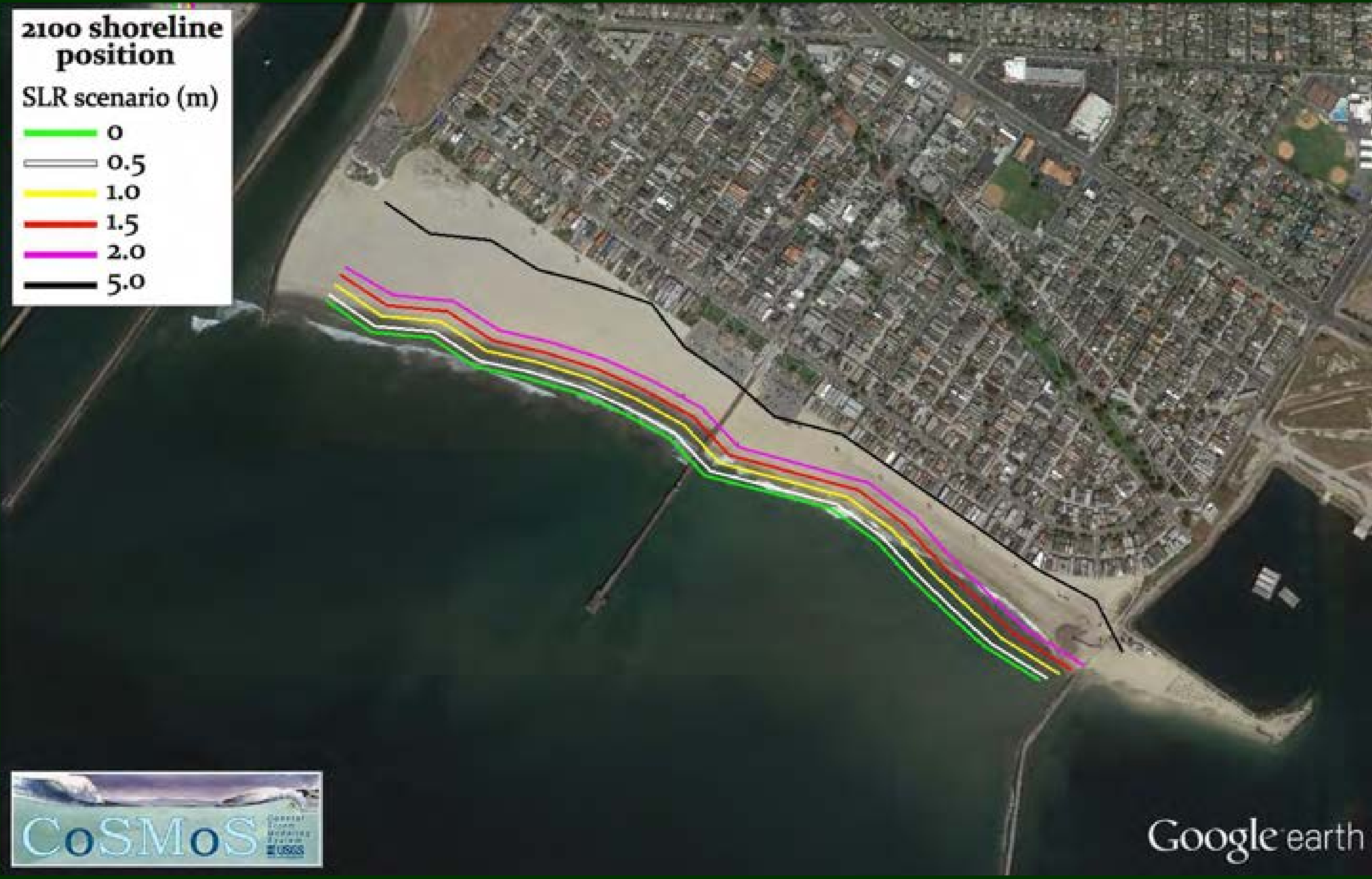
Model has ~4800 transects with ~100 m grid spacing



Shoreline Change Considerations

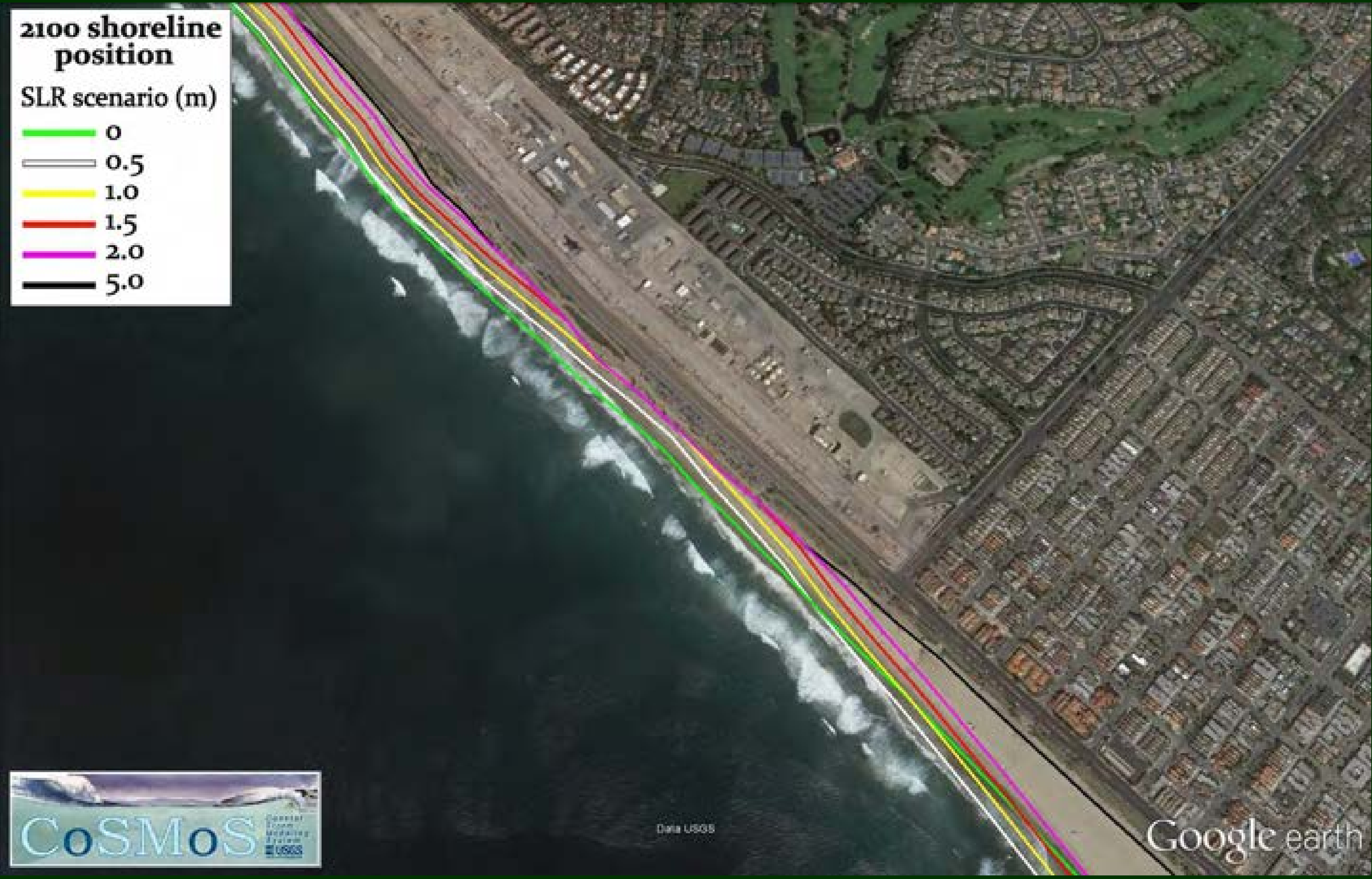
- 2 key coastal management assumptions
  - No erosion beyond urban infrastructure (‘hold the line’)
  - Incorporate historical rates of change in future projections (e.g., nourishment)
- Current assumptions result in potential underestimation of future beach erosion, especially in areas where significant nourishment has taken place
- Solution: run 4 different shoreline change scenarios
  - Hold the line + nourishment
  - *Hold the line + no nourishment
  - Do not hold the line + nourishment
  - Do not hold the line + no nourishment

Shoreline Projections – Seal Beach

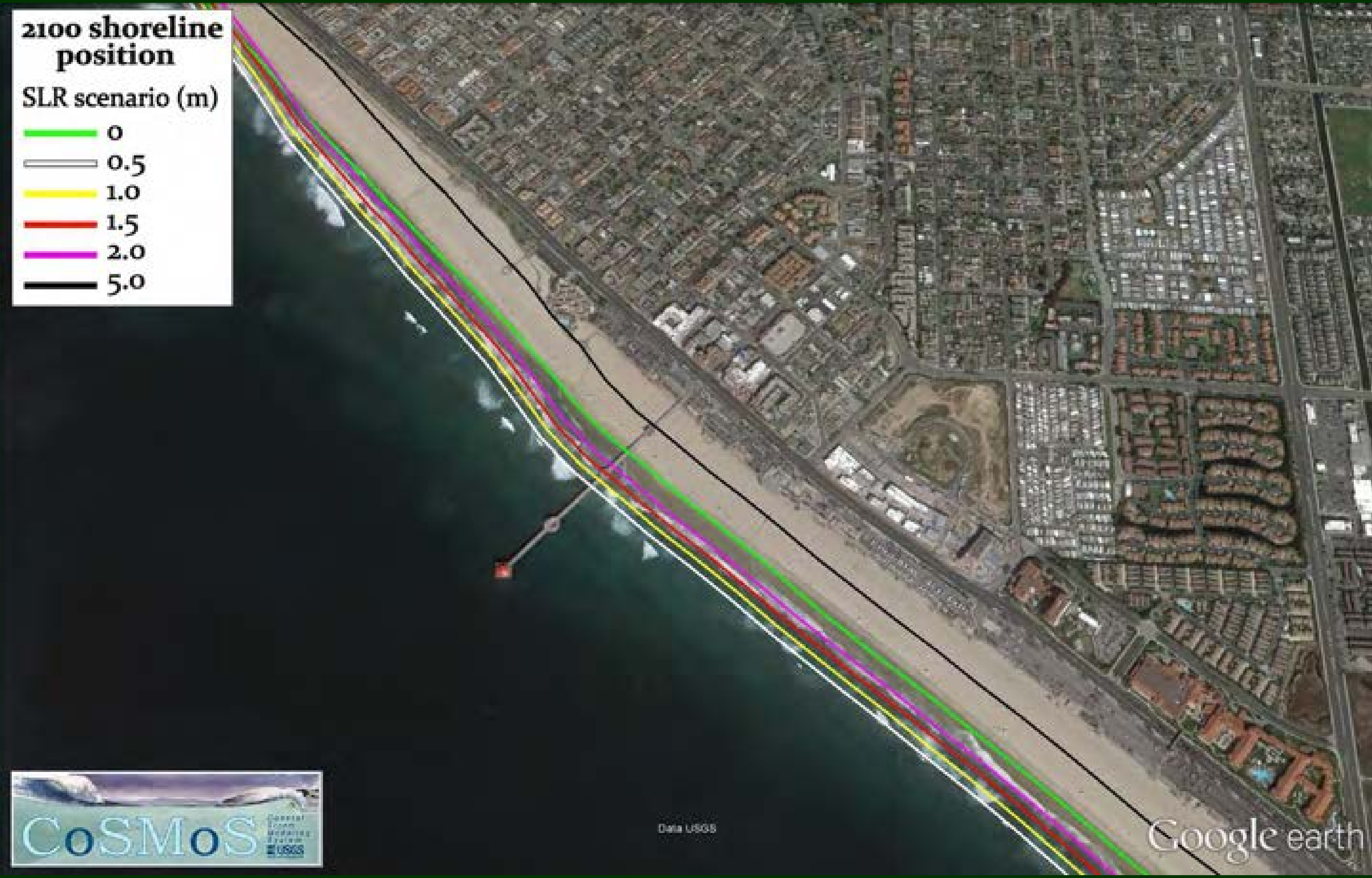


Shoreline Projections – Sunset Beach

Shoreline Projections – Bolsa Chica



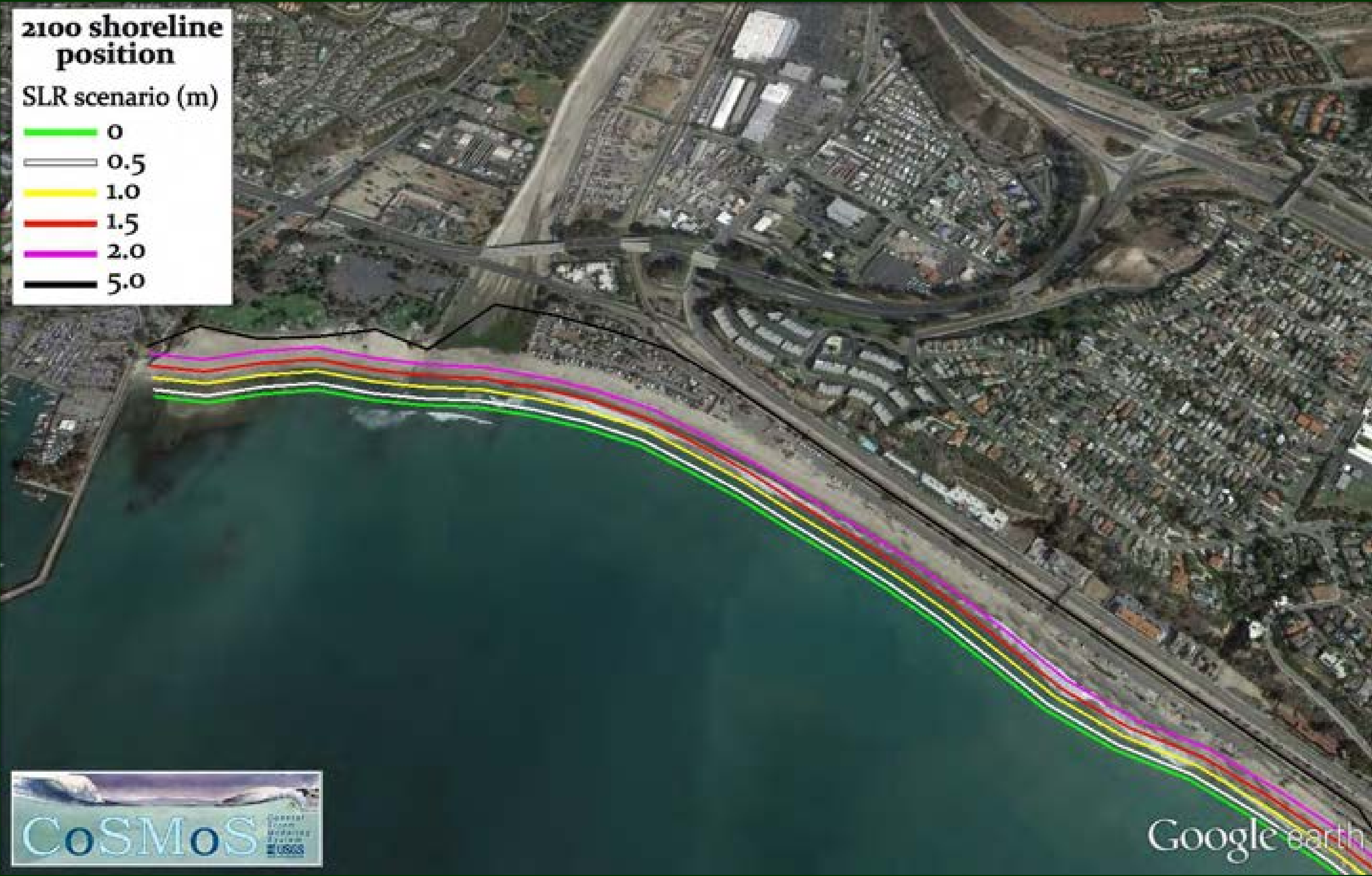
Shoreline Projections – Huntington Beach



Shoreline Projections – Newport Beach

Shoreline Projections – Laguna

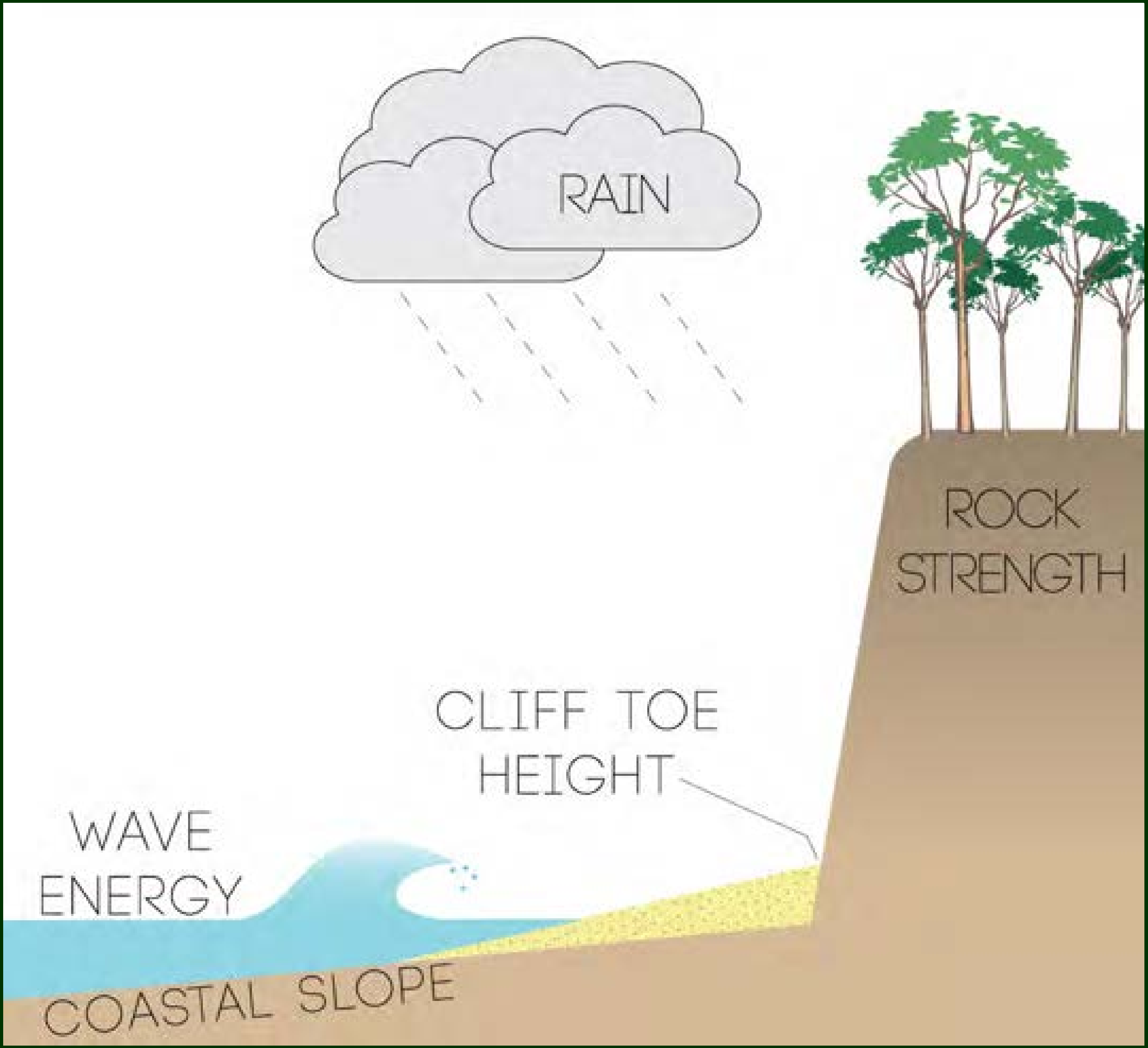
Shoreline Projections – Dana Point



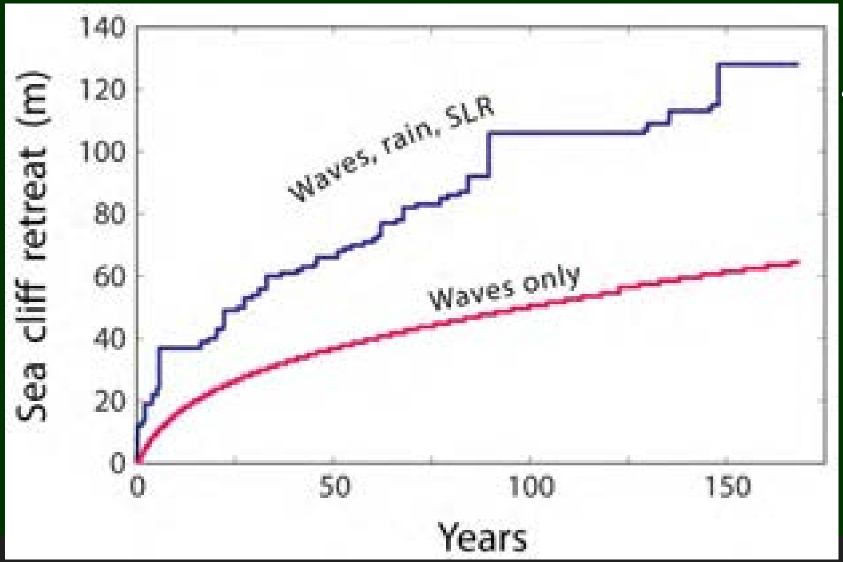
Shoreline Projections – Capistrano Beach

Shoreline Projections – San Clemente

Factors Driving Sea Cliff Erosion & Retreat

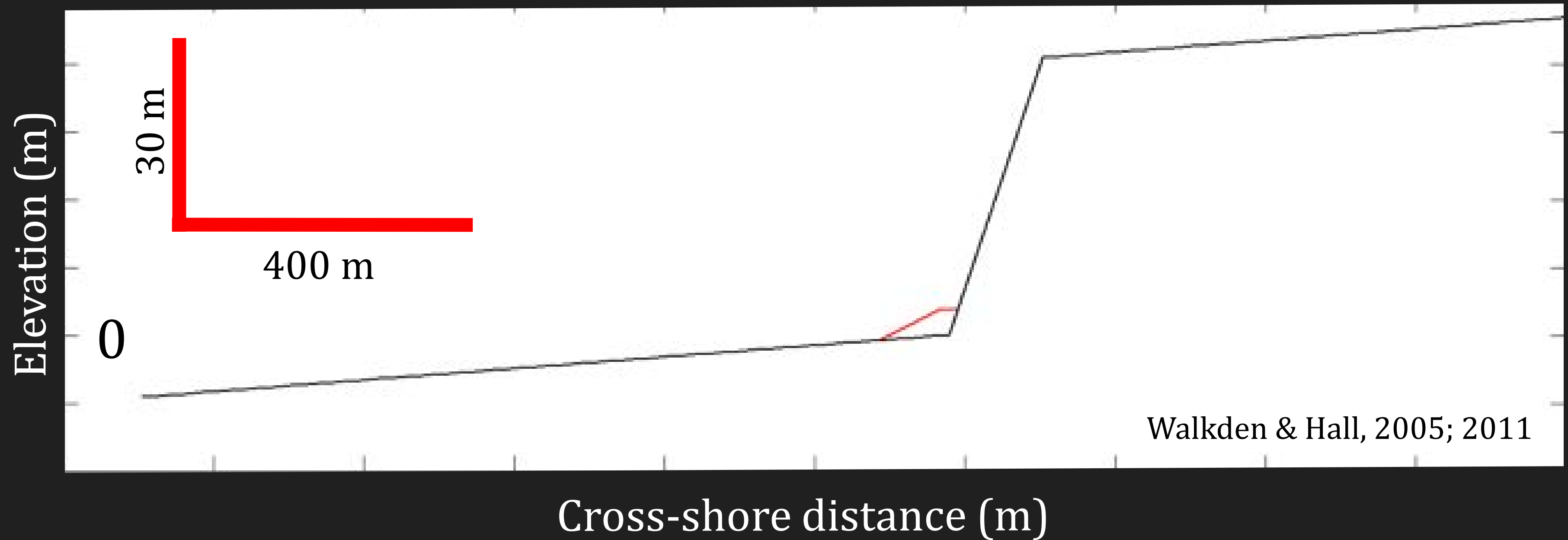


Multi-decadal Models of Sea Cliff Erosion & Retreat

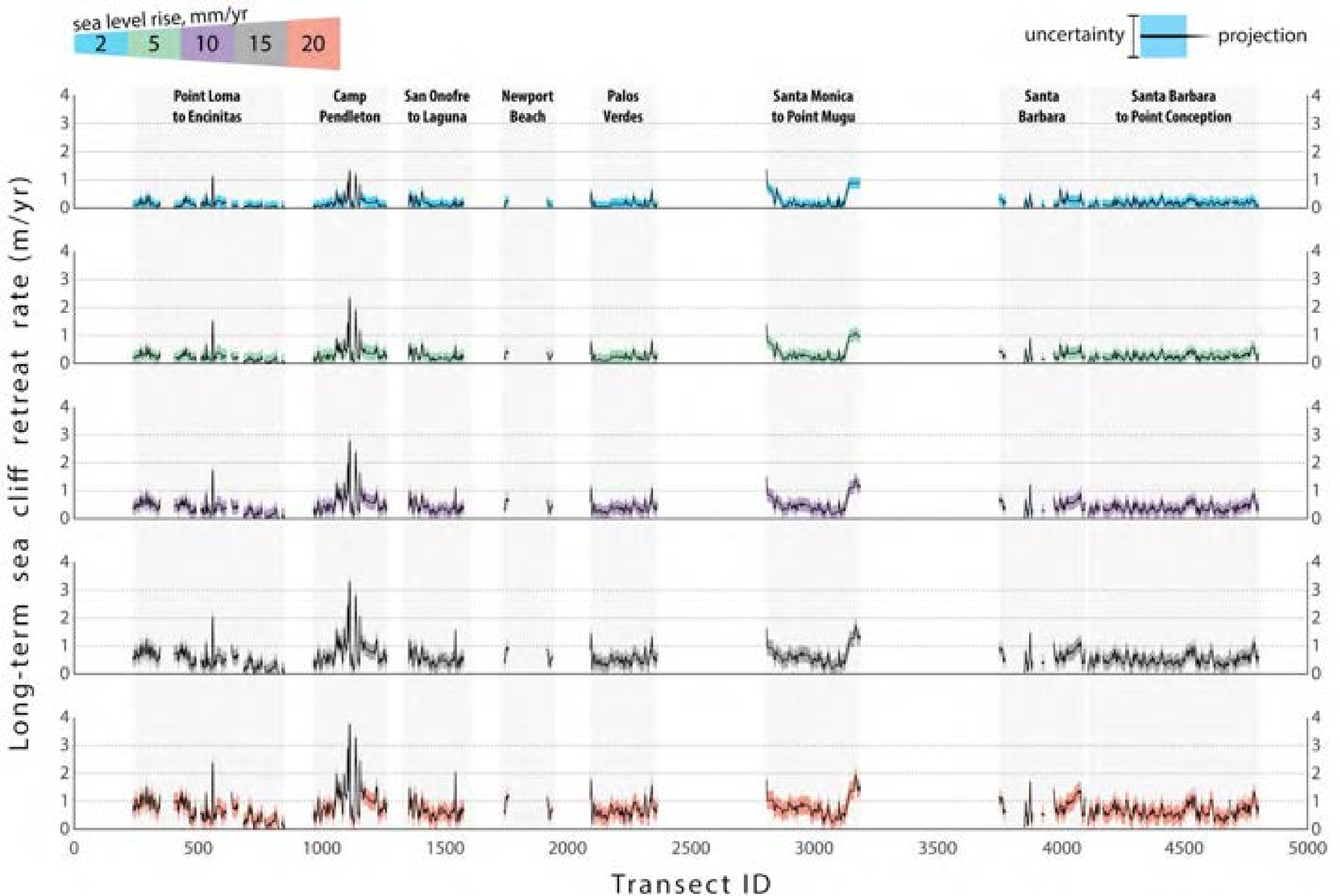


Rain, SLR cause more cliff retreat

(rain effects are in beta mode)



Results

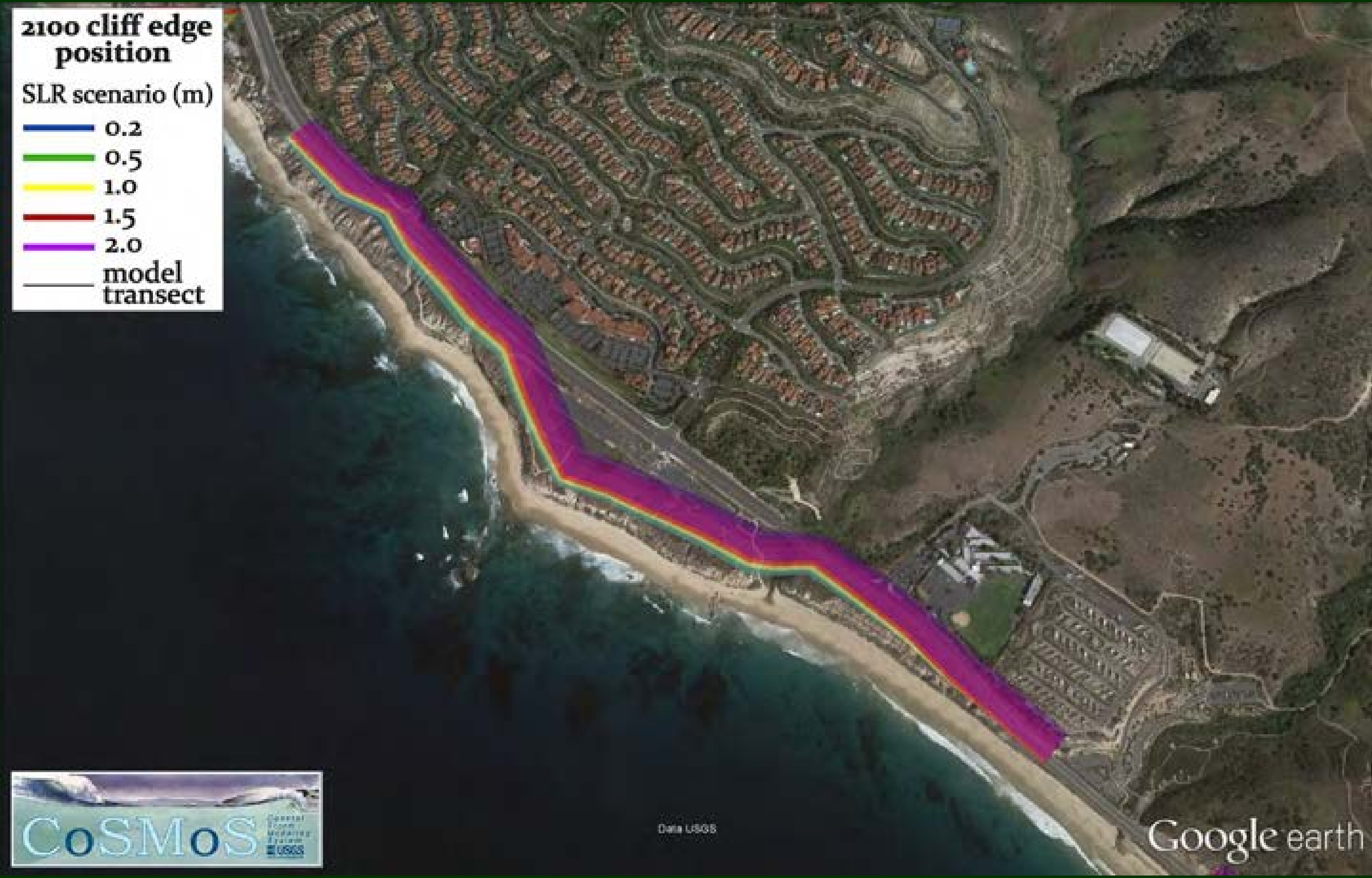


sea level rise, mm/yr
2
5
10
15
20
uncertainty
projection
Point Loma to Encinitas
Camp Pendleton
San Onofre to Laguna
Newport Beach
Palos Verdes
Santa Monica to Point Mugu
Santa Barbara
Santa Barbara to Point Conception
Long-term sea cliff retreat rate (m/yr)
Transect ID
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

Cliff Retreat Projections – Huntington Beach

Cliff Retreat Projections – Corona del Mar

Cliff Retreat Projections – Crystal Cove

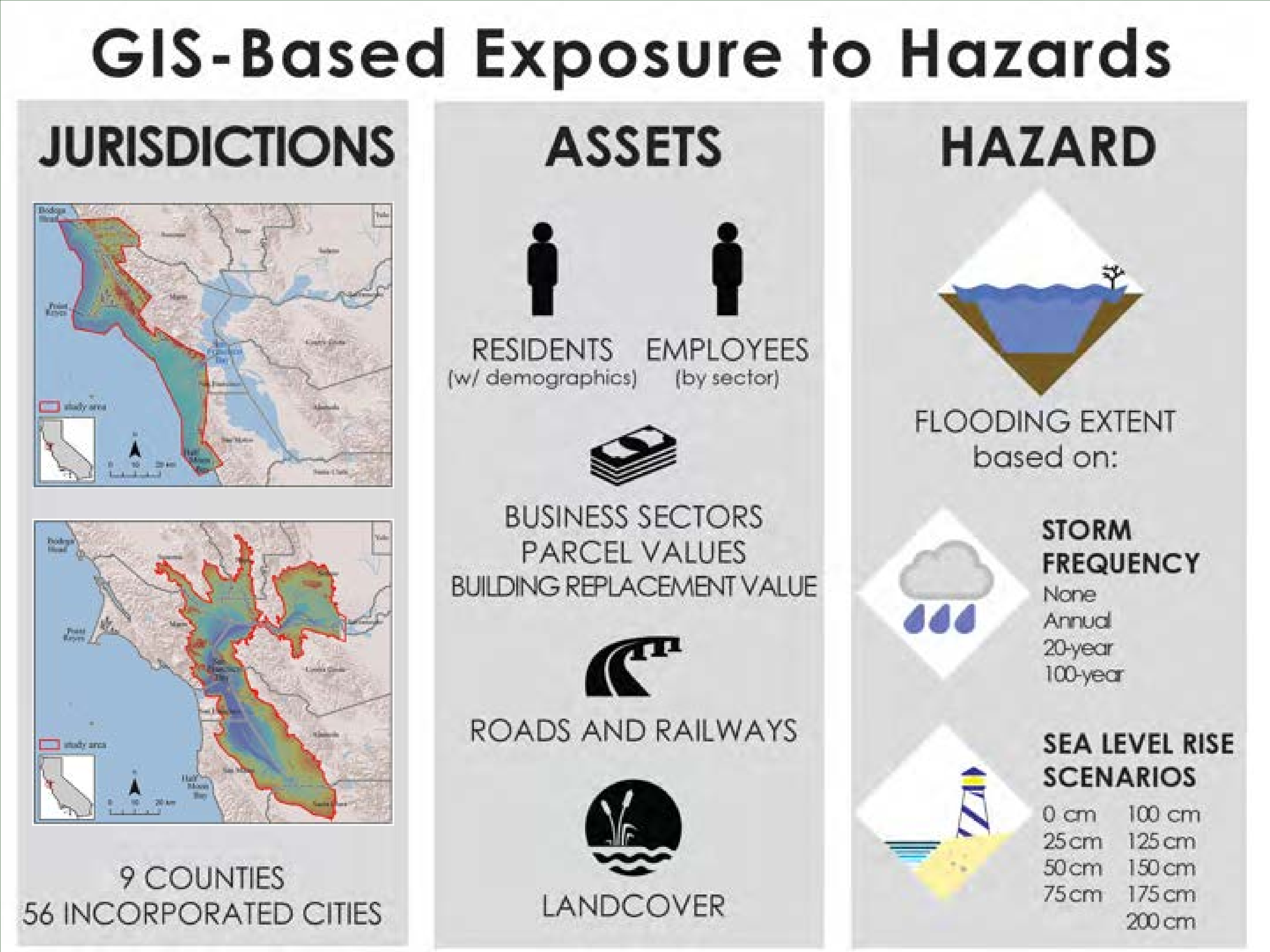


Cliff Retreat Projections – Laguna

Cliff Retreat Projections – Dana Point

Cliff Retreat Projections – N. San Clemente

Cliff Retreat Projections – S. San Clemente


GIS-Based Exposure to Hazards
JURISDICTIONS
9 COUNTIES
56 INCORPORATED CITIES
ASSETS
RESIDENTS
(w/ demographics)
EMPLOYEES
(by sector)
BUSINESS SECTORS
PARCEL VALUES
BUILDING REPLACEMENT VALUE
ROADS AND RAILWAYS
LANDCOVER
HAZARD
FLOODING EXTENT
based on:
STORM
FREQUENCY
None
Annual
20-year
100-year
SEA LEVEL RISE
SCENARIOS
0 cm
25 cm
50 cm
75 cm
100 cm
125 cm
150 cm
175 cm
200 cm

What’s Coming Summer 2016

- **40 scenarios of SLR + storms**
- **Long-term coastal evolution integrated into flood mapping**
- **Our Coast Our Future (OCOF) web tool**
- **Socioeconomic impacts and web tool**
- **Groundwater, hurricane impact pilots**

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

USGS CoSMoS data: ***http://walrus.wr.usgs.gov/coastal_processes/cosmos/socal3.0/index.html***

Our Coast- Our Future tool: ***www.prbo.org/ocof***

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CoSMoS USGS