

Assessing and Communicating Storm and Sea Level Rise Impacts

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Societal Relevance of Coastal Hazards

- Climate change, including sea level rise, changing wave climates, and storms will place additional stresses on coastal systems worldwide
- Over 1 billion people are expected to live in the coastal zone by the end of the 21st century
- Sustainability of nations are at risk
- U.S. coastal counties generate \$6.7 trillion to the GDP
- In CA by 2100, over 2 million people and over ~\$1 trillion dollars (~5% of CA GDP) at risk



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- In CA by 2100, over 2 million people and over ~\$1 trillion dollars (~5% of CA GDP) at risk
- **Hazards assessments are limited to impacts of SLR alone, and do not include waves, storms, coastal change or groundwater impacts**



How vulnerable are we?

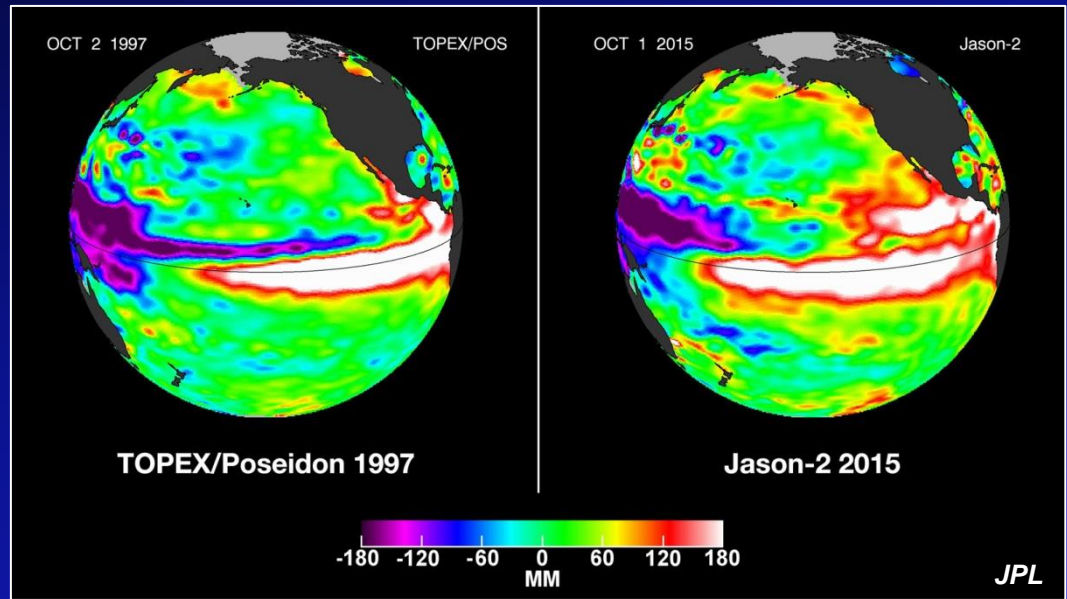


Critical Infrastructure



El Niño

- El Niño-Southern Oscillation (ENSO) is the dominant mode of climate variability across the Pacific Ocean basin
- The end-members of this cycle, El Niño and La Niña, are linked to elevated coastal hazards risk across the region (Barnard et al., 2015, *Nature Geoscience*)
- In California El Niño = elevated seasonal water levels (30 cm), wave energy (50%), coastal erosion (70%), flooding and damages (\$ billions)



NORTH

1

NO LEFT
TURN

Newport Blvd
Balboa, Peninsula →





Huntington Beach Pier, January 1983
(H. Loren AB Jr., Orange County Register)



Capitola, January 2008

2015-16 El Niño Impacts

- The 2015-16 El Niño was one of the most powerful events of the last 150 years
- Winter wave energy equaled or exceeded observed maxima across the entire U.S. West Coast
- Winter beach erosion was the highest ever recorded
- Drought and low El Niño precip is limiting beach recovery in California



Barnard, P.L., Hoover, D.J., Hubbard, D.M., Snyder, A., Ludka, B.C., Allan, J., Kaminsky, G.M., Ruggiero, P., Gallien, T.W., Gabel, L., McCandless, D., Weiner, H.M., Cohn, N., Anderson, D.L. and Serafin, K.A., 2017. Extreme oceanographic forcing and coastal response due to the 2015-2016 El Niño. *Nature Communications*, Volume 8 (14365), 8 pp., <http://dx.doi.org/10.1038/ncomms14365>

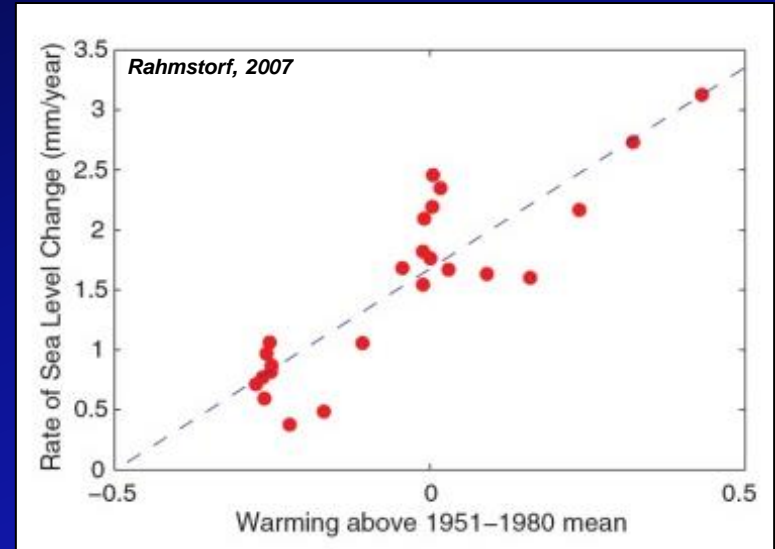
Santa Cruz, CA
February 13, 2016
(Christie Hegermiller)

Climate Change and Sea Level Rise

- Global temperature increases are linked to sea level rise

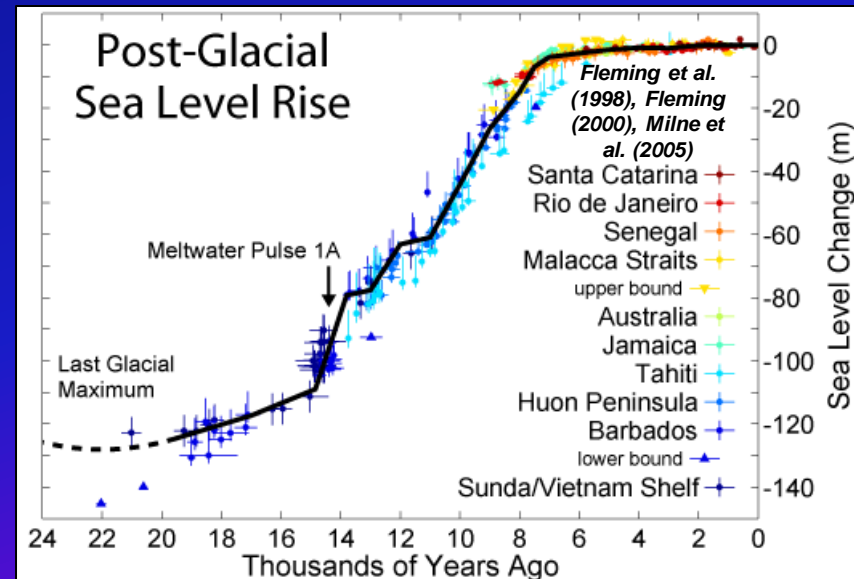
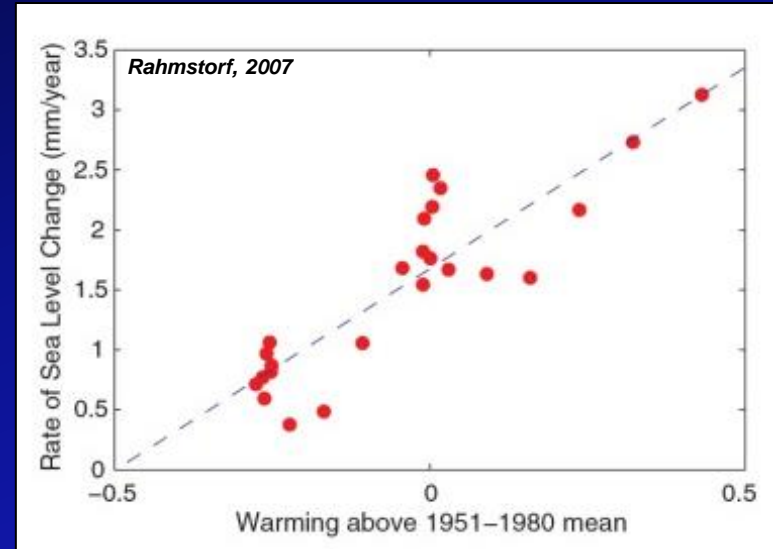
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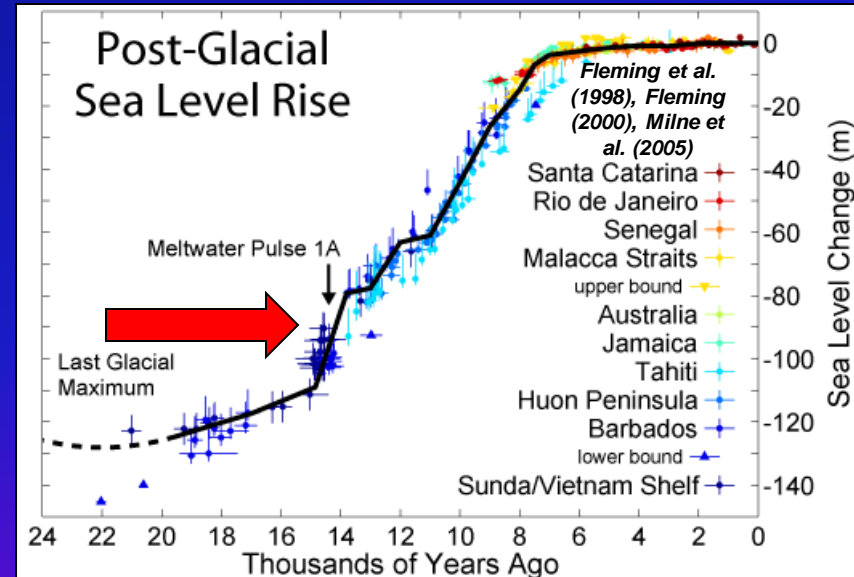
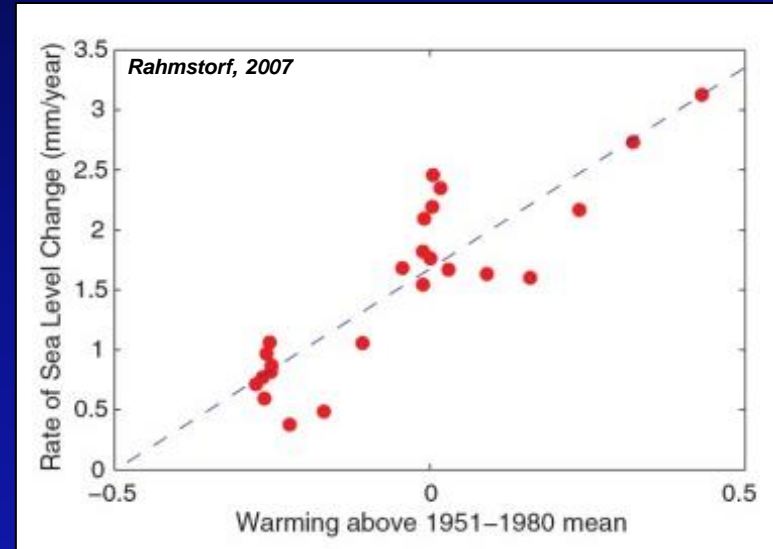
Climate Change and Sea Level Rise

- Global temperature increases are linked to sea level rise
- Sea level rise lags temperature increases due to long timescale of ice-sheet response
- 125,000 years ago global temperature was $\sim 2^\circ$ warmer but sea level was 8 m higher
- 14,000 years ago sea level rose 20 m in 4 centuries



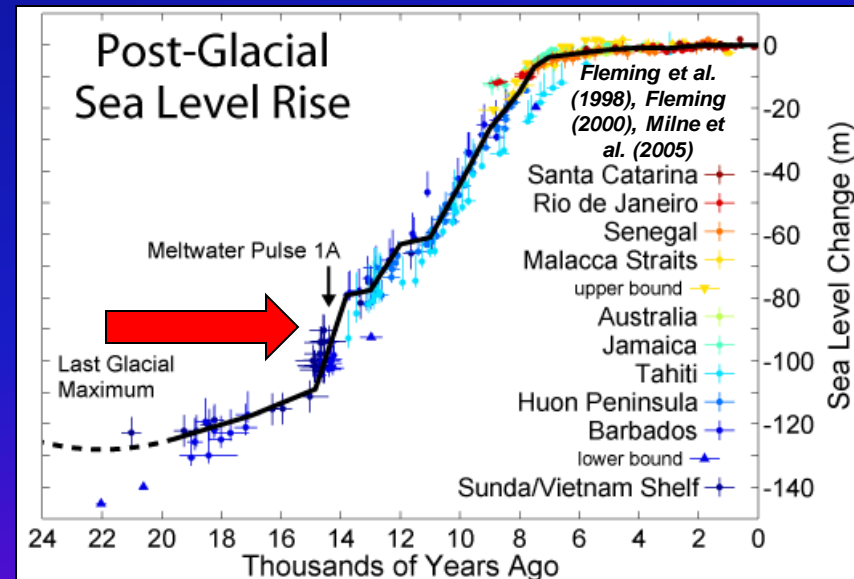
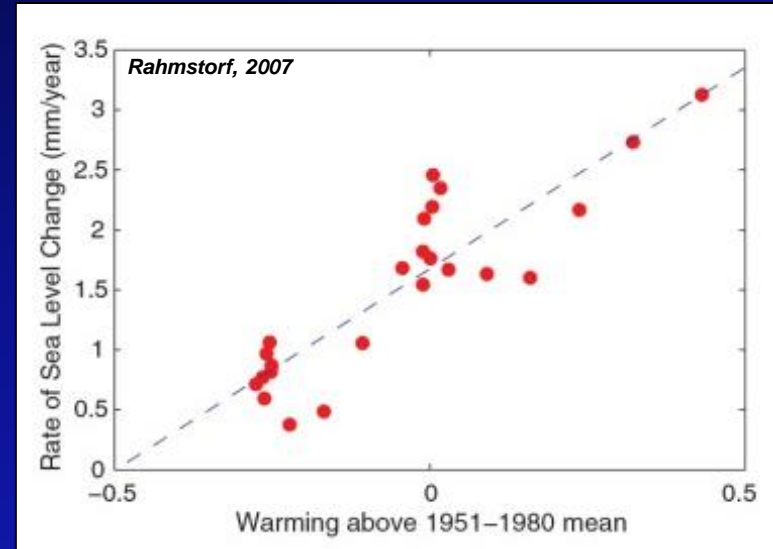
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- 125,000 years ago global temperature was $\sim 2^\circ$ warmer but sea level was 8 m higher
- 14,000 years ago sea level rose 20 m in 4 centuries
- With net zero future emissions we are committed to 1.7 m of SLR
- Same carbon emissions in 21st century will commit us to 9 m more of SLR





2015. 11. 25 9:0

Imperial Beach, November 25, 2015 (Chris Helmer)





Santa Cruz, Winter 2017 (Nick Moless)

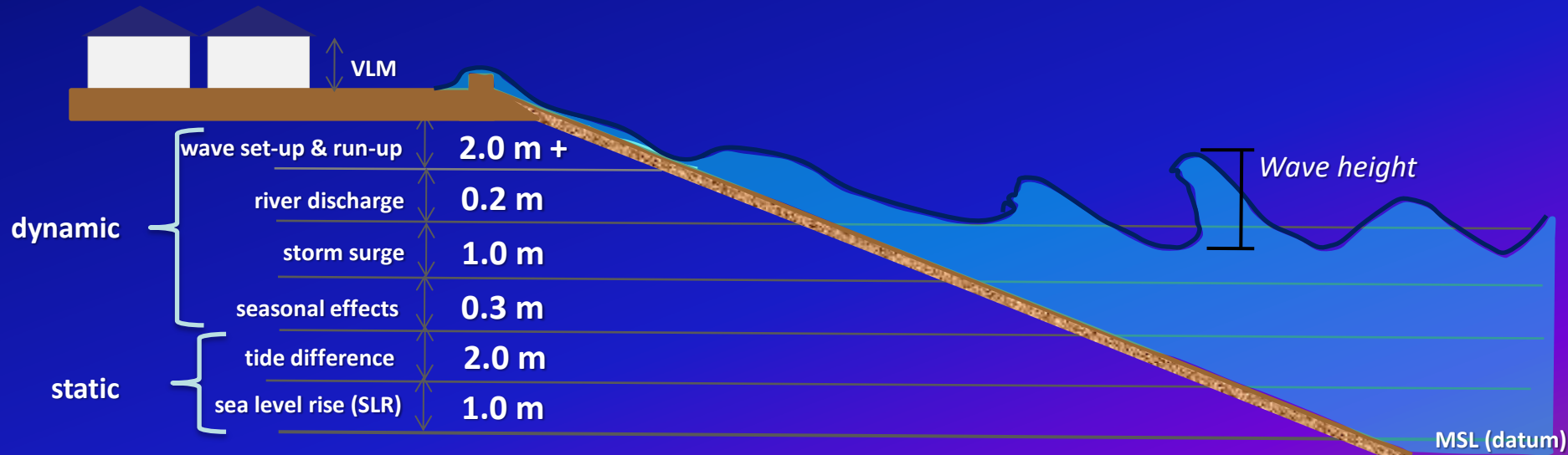
Coastal Vulnerability Approaches

Static: NOAA SLR Viewer

- Passive model, hydrological connectivity
- Tides only
- Excellent '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

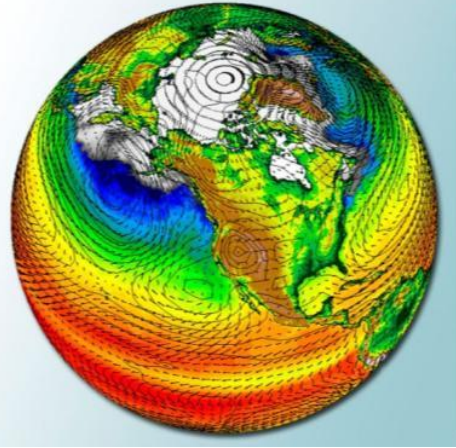


CoSMoS: A Tool for Coastal Resilience

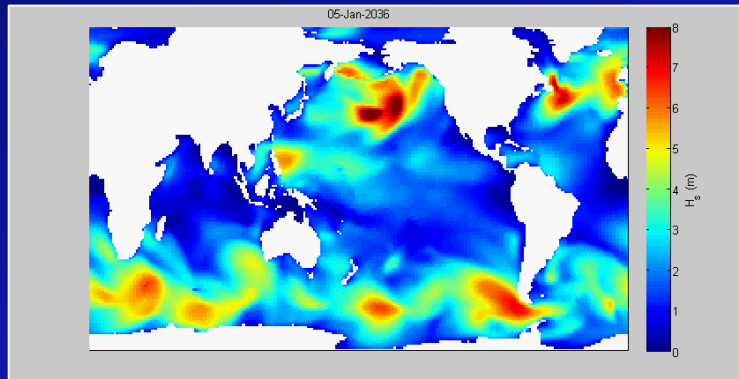
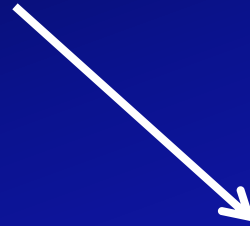
- **Physics-based numerical modeling system for assessing coastal hazards due to climate change**
- **Predicts coastal hazards for the full range of sea level rise (0-2, 5 m) and storm possibilities (up to 100 yr storm) using sophisticated global climate and ocean modeling tools**
- **Developing coastal vulnerability tools in collaboration with federal, state, and city governments to meet their planning and adaptation needs**



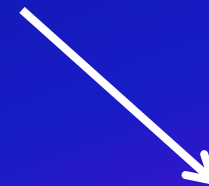
Identifying Future Risk with CoSMoS



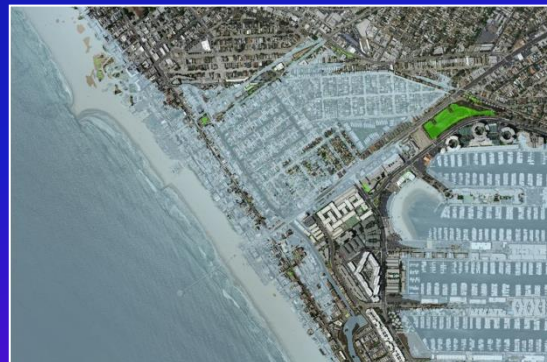
1. Global forcing using the latest climate models



2. Drives global and regional wind/wave models



3. Scaled down to local hazards projections



Web Tool - Flooding

HOME GET STARTED FLOOD MAP CASE STUDIES EVENTS ABOUT US HELP

OCOF OUR COAST OUR FUTURE
Interactive Map
map help
clear
navigate

1) Choose a topic.
Flooding shows the inundation due to SLR, waves, and storm surge.

Flooding	Waves
Current	Duration

Flood Potential

What do the Topics represent?

Compare Flooding Scenarios

2) Choose an Amount of Sea Level Rise (cm).

0	25	50	75	100	125
150	175	200	500	[Use feet]	

What Sea Level Rise scenario should I use?

3) Choose an Event

Choose Storm Scenario Frequency

None Annual 20 year 100 year

Or Choose SF Bay King Tide Scenario

King Tide

What are Storm Scenarios?
What is a King Tide scenario?

4) Choose Shoreline Change (Southern California only)

Cliffs Shoreline Position

And Choose Management Options

"Hold the Line" yes no
Beach nourishment yes no

200 m
1000 ft

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CoSMoS

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

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Web Tool - Flooding

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Choose
Storm Scenario Frequency

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Or Choose
SF Bay King Tide Scenario

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[What is a King Tide scenario?](#)

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200 m / 1000 ft

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Flood Potential
Flooding Waves
Current Duration
What do the Topics represent?
 Compare Flooding Scenarios

2) Choose an Amount of Sea Level Rise (cm).
0 25 50 75 100 125
150 175 200 500 Use feet!
What Sea Level Rise scenario should I use?

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Enter an address or placename
Alameda Park
15 -119.6739 34.4299

Map controls: Pan Zoom, Draw Report, GIS File Report, Known Issues, King Tides, Get Data, Print Map

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Web Tool - Flooding

HOME GET STARTED FLOOD MAP CASE STUDIES EVENTS ABOUT US HELP

OCOF OUR COAST OUR FUTURE map help
Interactive Map clear navigate

1) Choose a topic.
Flood Potential shows the range of possible flooding for a scenario.

Flooding	Waves
Current	Duration
Flood Potential	

[What do the Topics represent?](#)

2) Choose an Amount of Sea Level Rise (cm).

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King Tide

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Cliffs Shoreline Position

And Choose Management Options

"Hold the Line" yes no
Beach nourishment yes no

Turn on "Hold The Line Assumptions" below to see what influences these

Detail View

Enter an address or placename

Alameda Park
15 -119.7124 34.1165

Map Tools: Pan Zoom, Draw Report, GIS File Report, Known Issues, King Tides, Get Data, Print Map

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CoSMoS

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Web Tool - Flooding

HOME GET STARTED FLOOD MAP CASE STUDIES EVENTS ABOUT US HELP

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Interactive Map

map help
clear
navigate

1) Choose a topic.
Duration shows how much time flooding lasts in a tidal day.

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Alameda Park
15-119-7059 34.4146

Alameda Park
Galega Park
Santa Barbara
El Paseo
Pablo Murphy
Mission Creek
Palm Park
East Beach
West Beach
Pershing Park
Santa Barbara Harbor
Santa Barbara City College
Los Alamos Beach

Montecito Country Club
Santa Barbara Zoological Gardens
Dwight Murphy Field
Santa Barbara Cemetery
Andree Clark Bird Refuge
Santa Barbara
Cabrillo Park
East Beach
Butterfly Beach

Pan Zoom
Draw Report
GIS File Report
Known Issues
King Tides
Get Data
Print Map

Flood Duration 200cm SLR + Wave 100

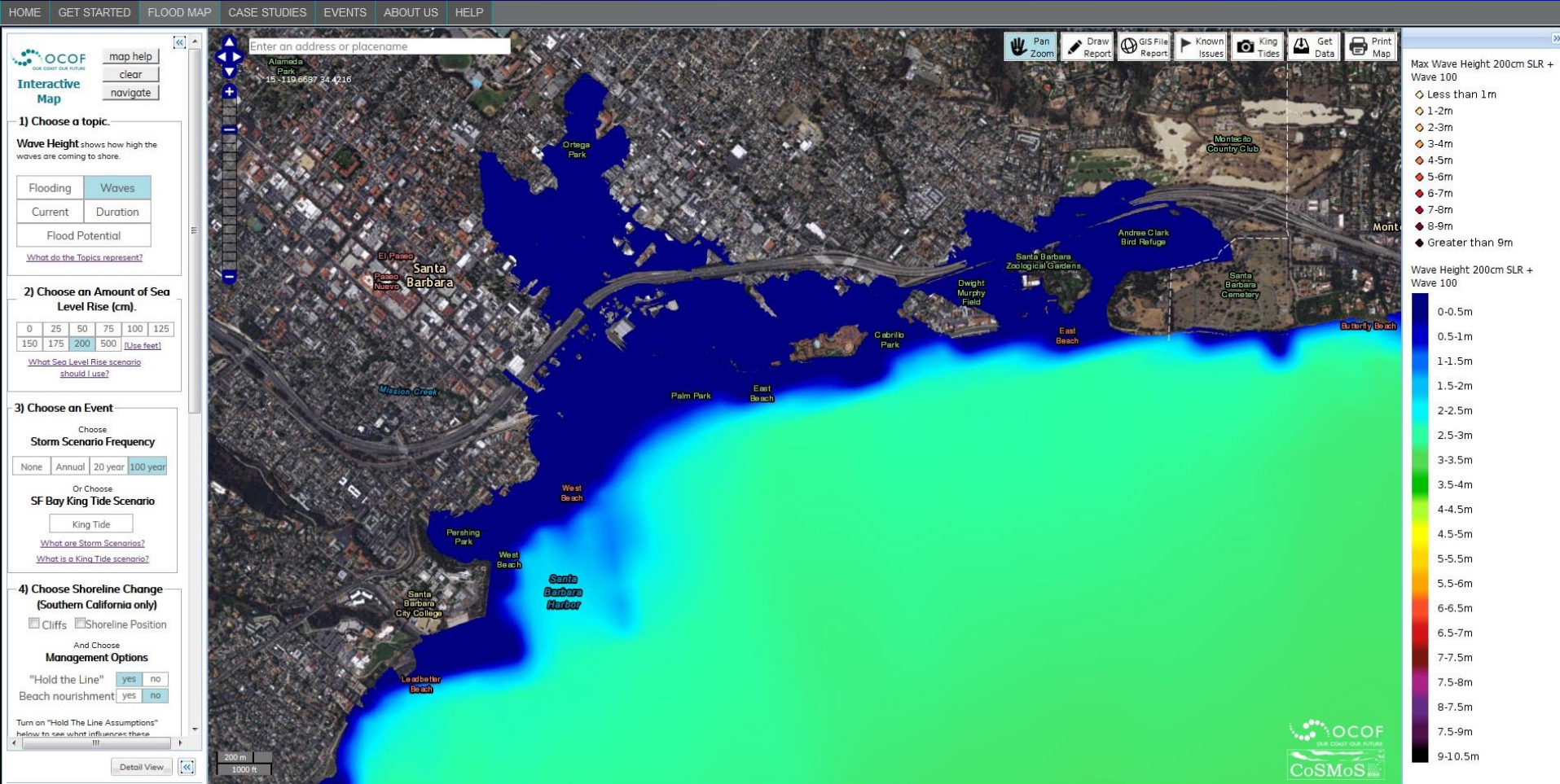
- 0-3 hours
- 3-6 hours
- 6-9 hours
- 9-12 hours
- 12-15 hours
- 15-18 hours
- 18+ hours

200 m
1000 ft

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CoSMoS

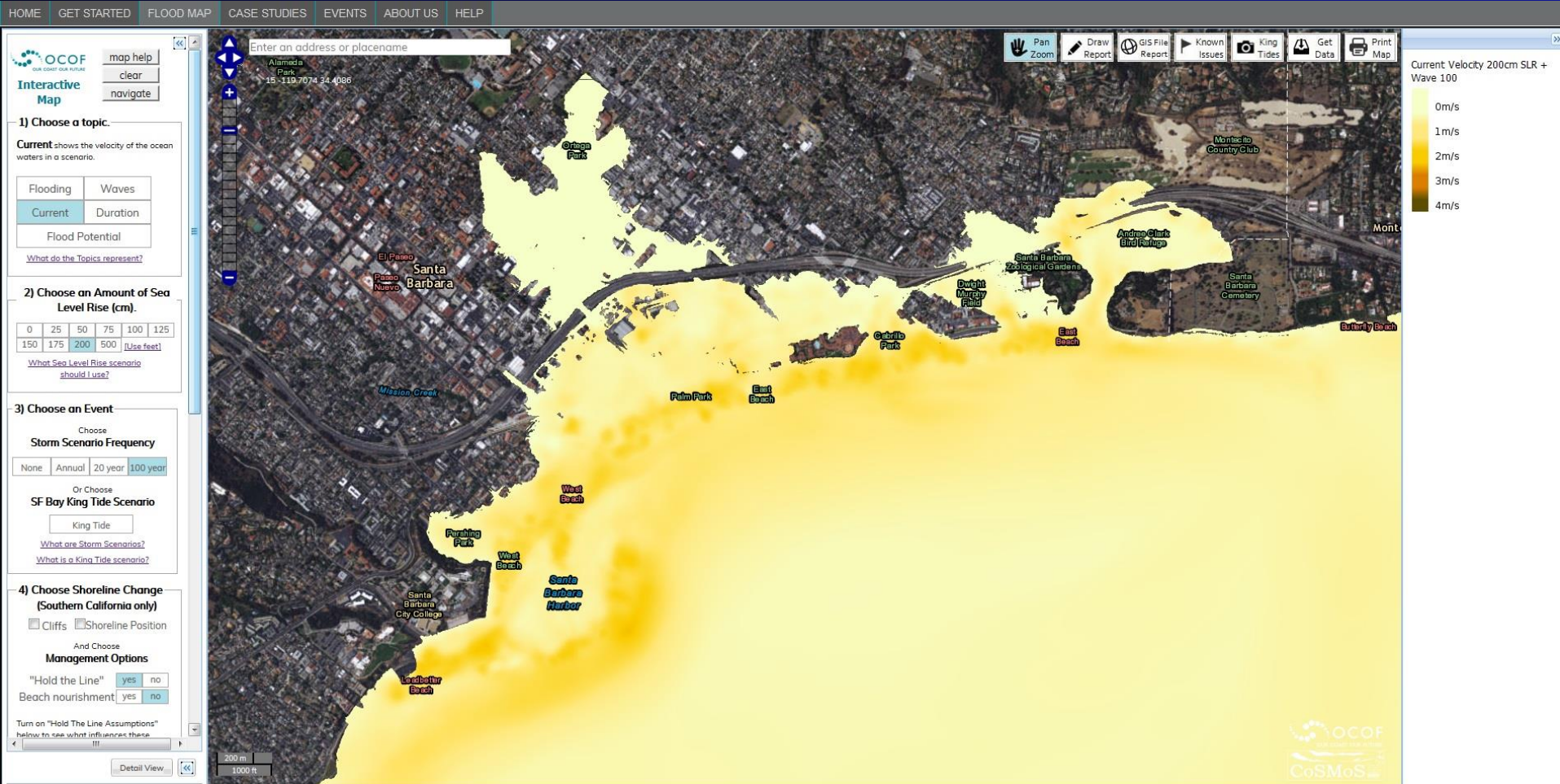
Our Coast, Our Future tool: www.ourcoastourfuture.org

Web Tool - Waves and Currents



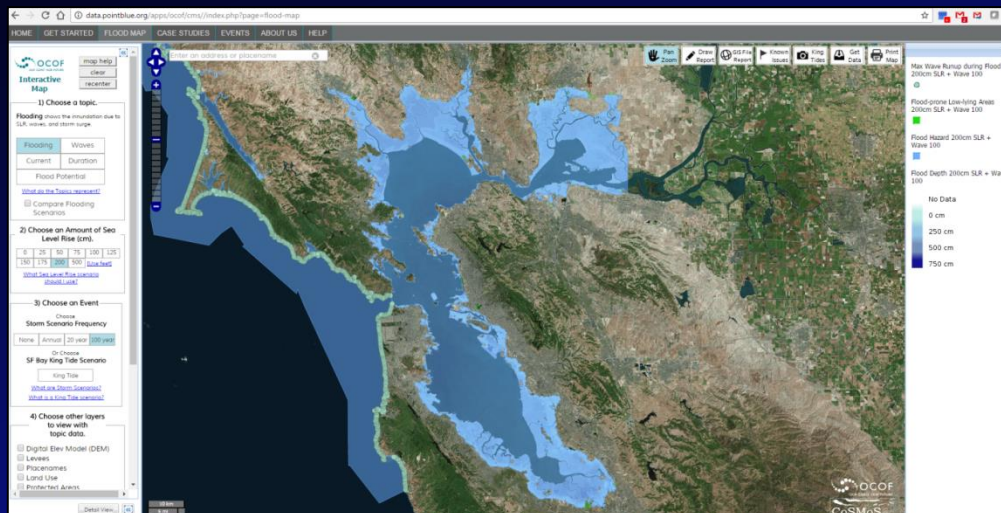
Our Coast, Our Future tool: www.ourcoastourfuture.org

Web Tool - Waves and Currents



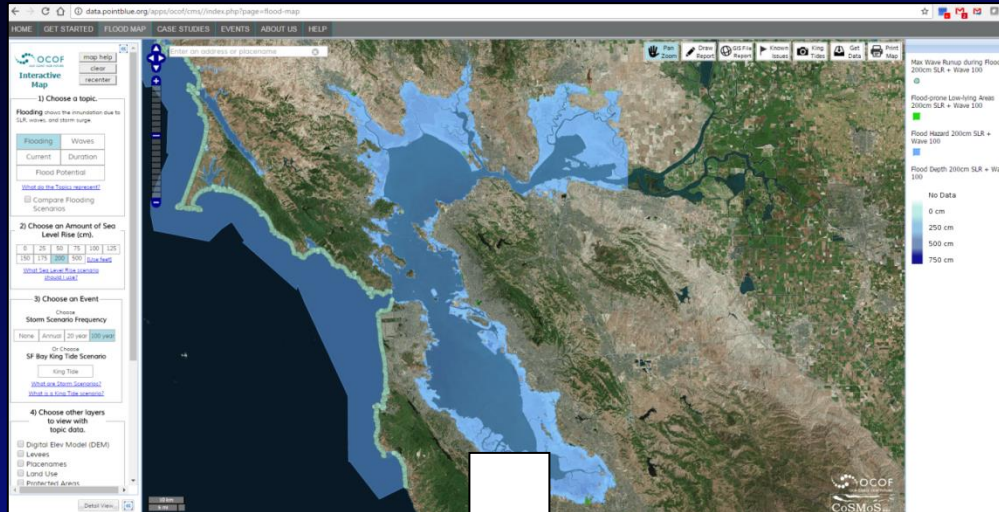
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Socioeconomic Impacts

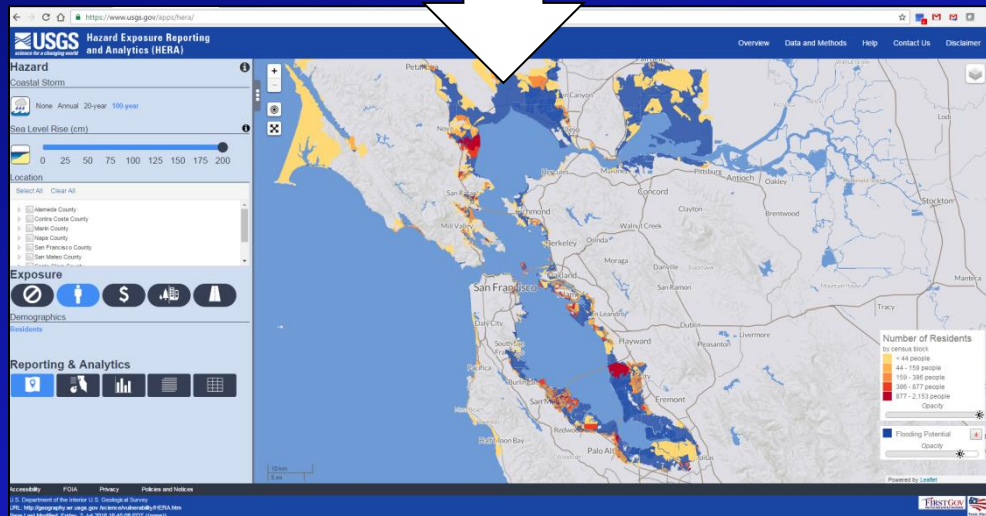


2 m SLR +
100 year storm

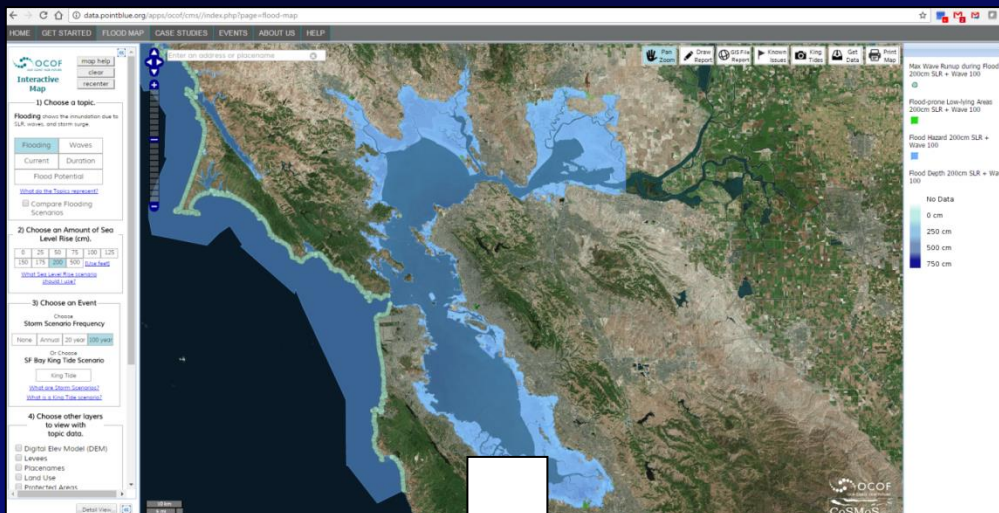
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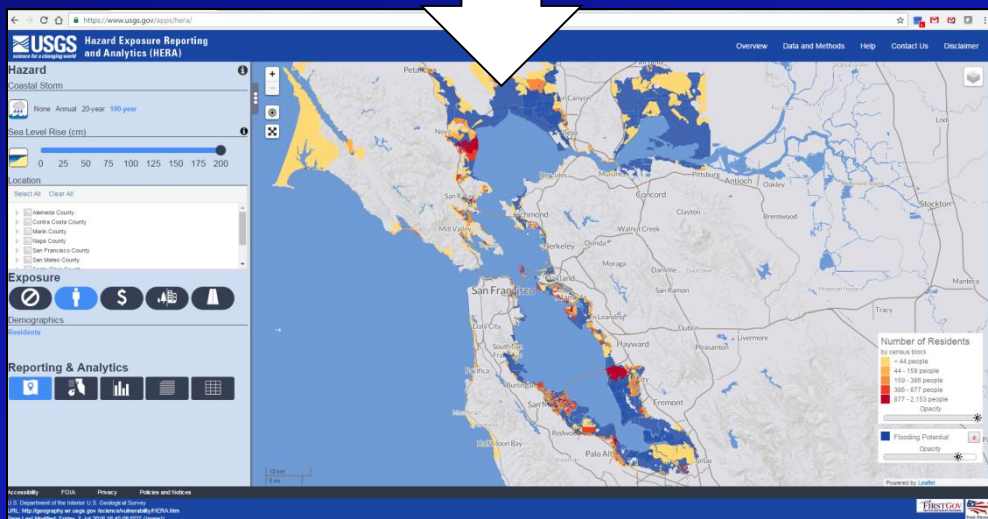
Socioeconomic Impacts



2 m SLR +
100 year storm

Hazard Exposure Reporting and Analytics (HERA)

- 355,000 residents
- \$102 billion in property
- 1,941 miles of roads
- 278 critical facilities



Future Coastal Flooding and Erosion

- Today's 100-year coastal water level event is projected to occur every 1-5 years by 2050
- Up to 2/3 of beaches will be completely eroded by 2100, due to SLR and urbanized coast
- Cliffs will erode up to 3 times faster than present



Outreach- Santa Monica Owl



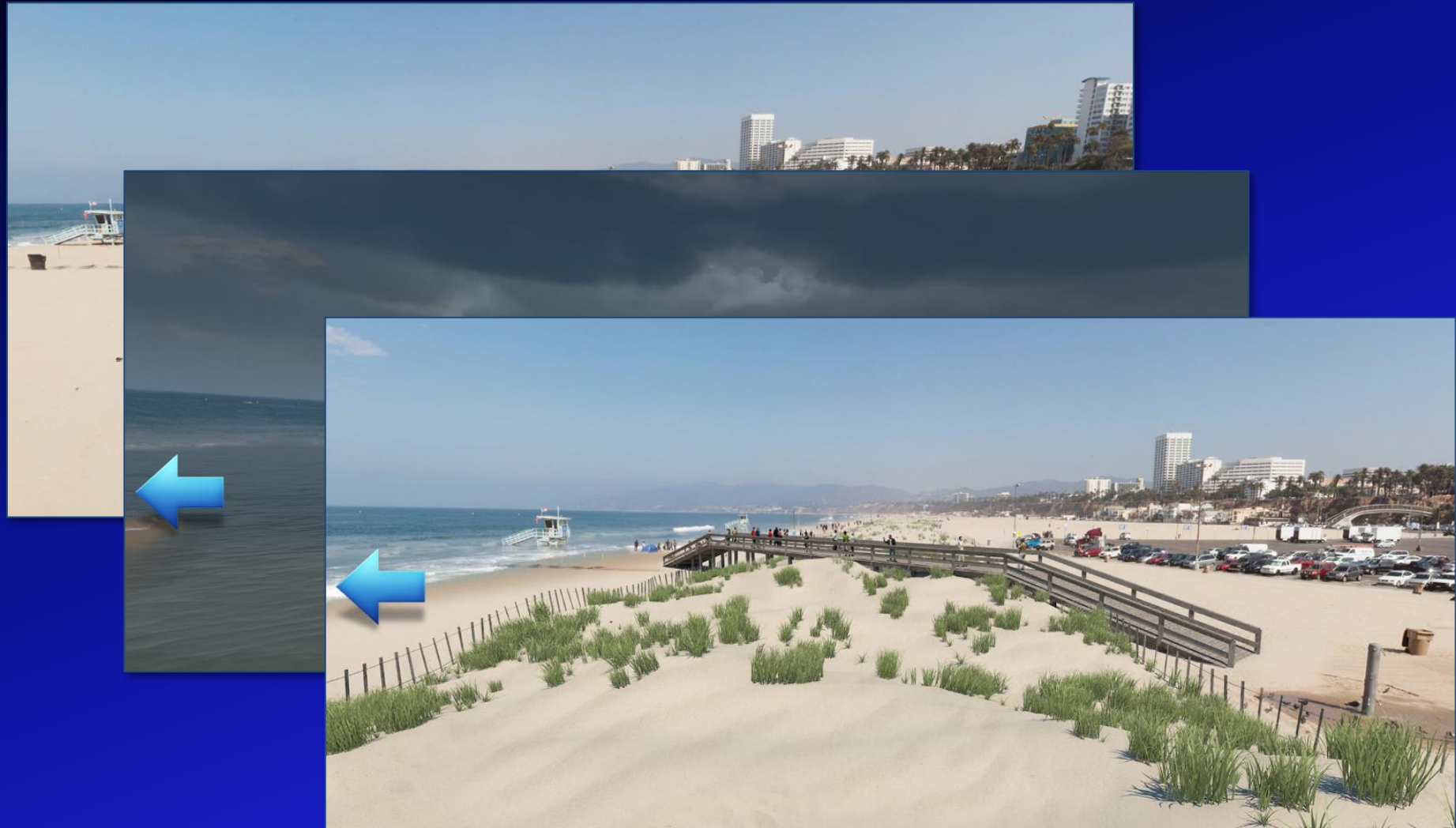
Outreach- Santa Monica Owl



Outreach- Santa Monica Owl



Outreach- Santa Monica Owl



Critical Needs

- Policy decisions made in the next few years to decades will have profound impacts on global climate, ecosystems and human societies for millennia
- Nation-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
 - Annual/seasonal mapping of coastal change

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

USGS CoSMoS website: http://walrus.wr.usgs.gov/coastal_processes/cosmos/

Our Coast - Our Future tool: www.ourcoastourfuture.org

HER Tool: www.usgs.gov/apps/hera

