Orange County Regional
SLR & Coastal Impacts Planning Workshop

Overview of CoSMoS and Sea Level Rise Models & Tools

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Overview of Presentation

- Sea Level Rise 101
- Models 101
- About the Coastal Storms Modeling System
- Overview of other local modeling efforts
- Questions and Discussion

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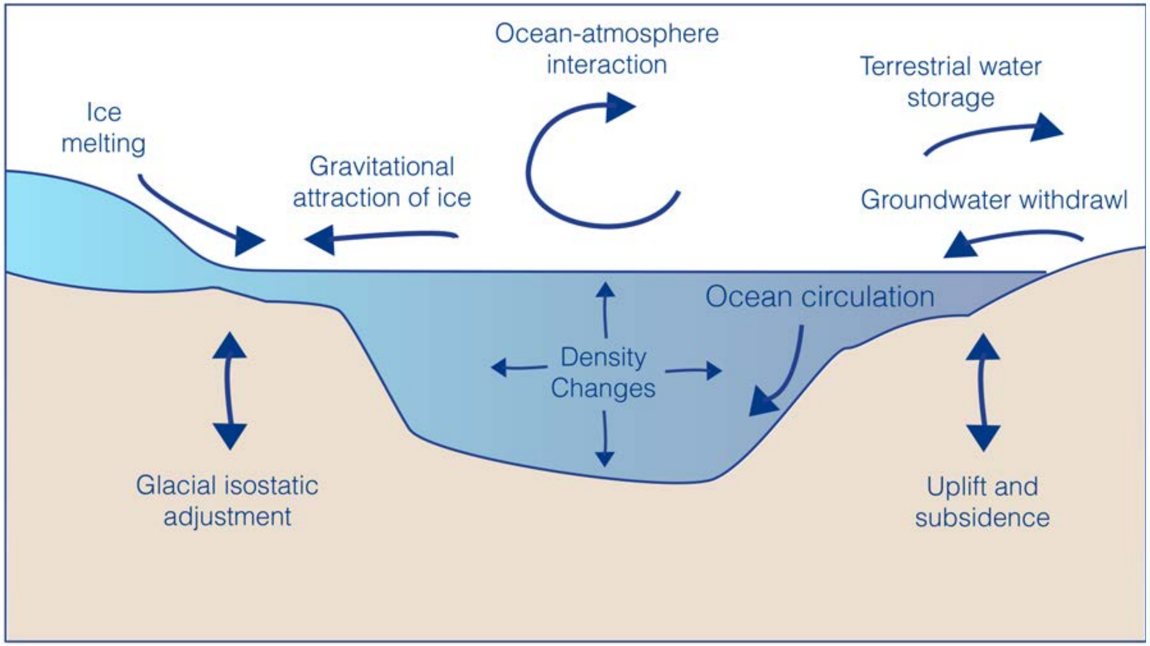
about sea level rise

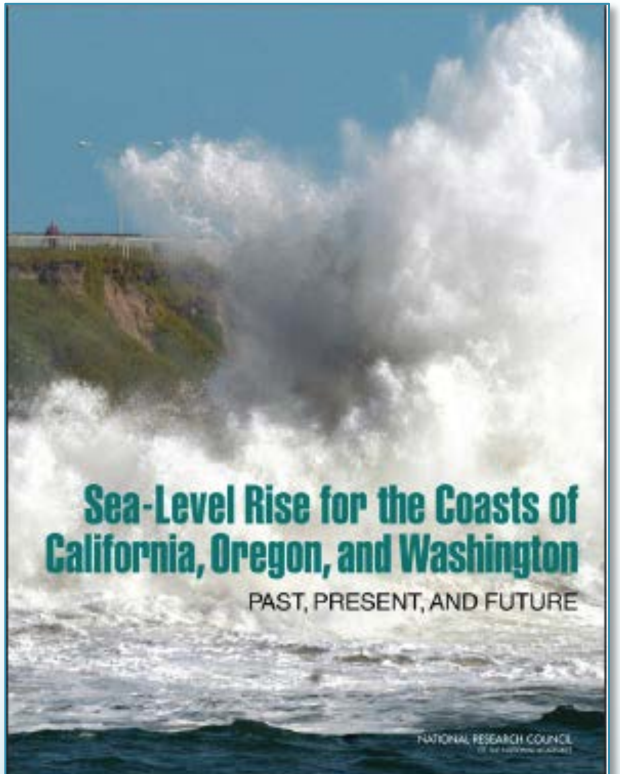
Sea Level Rise 101



- Thermal expansion
- Melting of Glaciers & Ice Sheets
- Terrestrial Water Storage
- Tectonic Activity

http://www.nap.edu/catalog.php?record_id=13389

NRC slide



Time Period	North of Cape Mendocino	South of Cape Mendocino
2000 - 2030	- 2 – 9 in.	2 – 12 in.
2000 - 2050	- 1 – 19 in.	5 – 24 in.
2000 - 2100	4 – 56 in.	17 – 66 in.

http://www.nap.edu/catalog.php?record_id=13389

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Coastal Storms

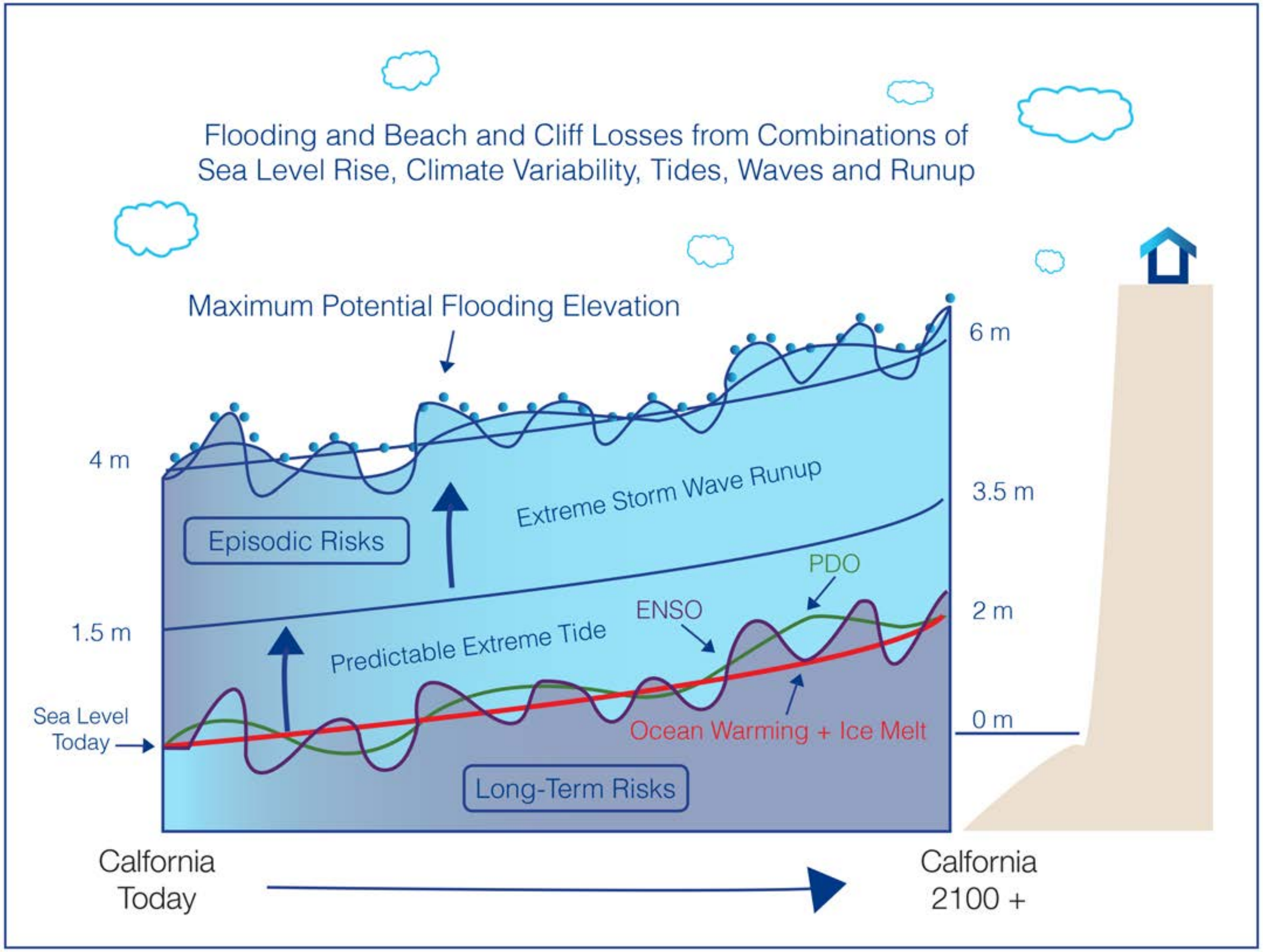

Image adapted from illustration by Dr. Bill O'Reilly (UCSD)

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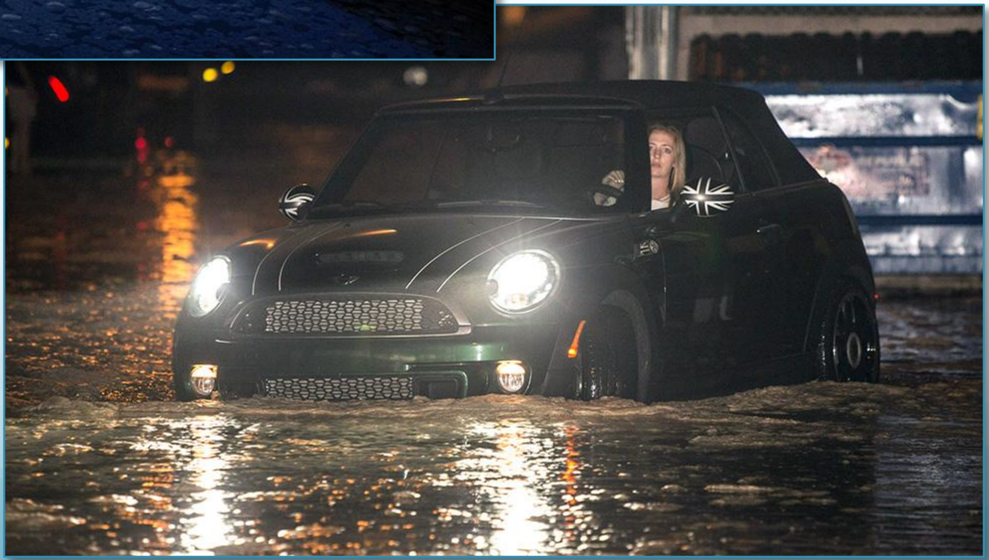
Hurricane Marie Impacts – Seal Beach



Images from:
NBC News & Weather Channel

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Coastal Storms

"Today's storm is tomorrow's high tide…"

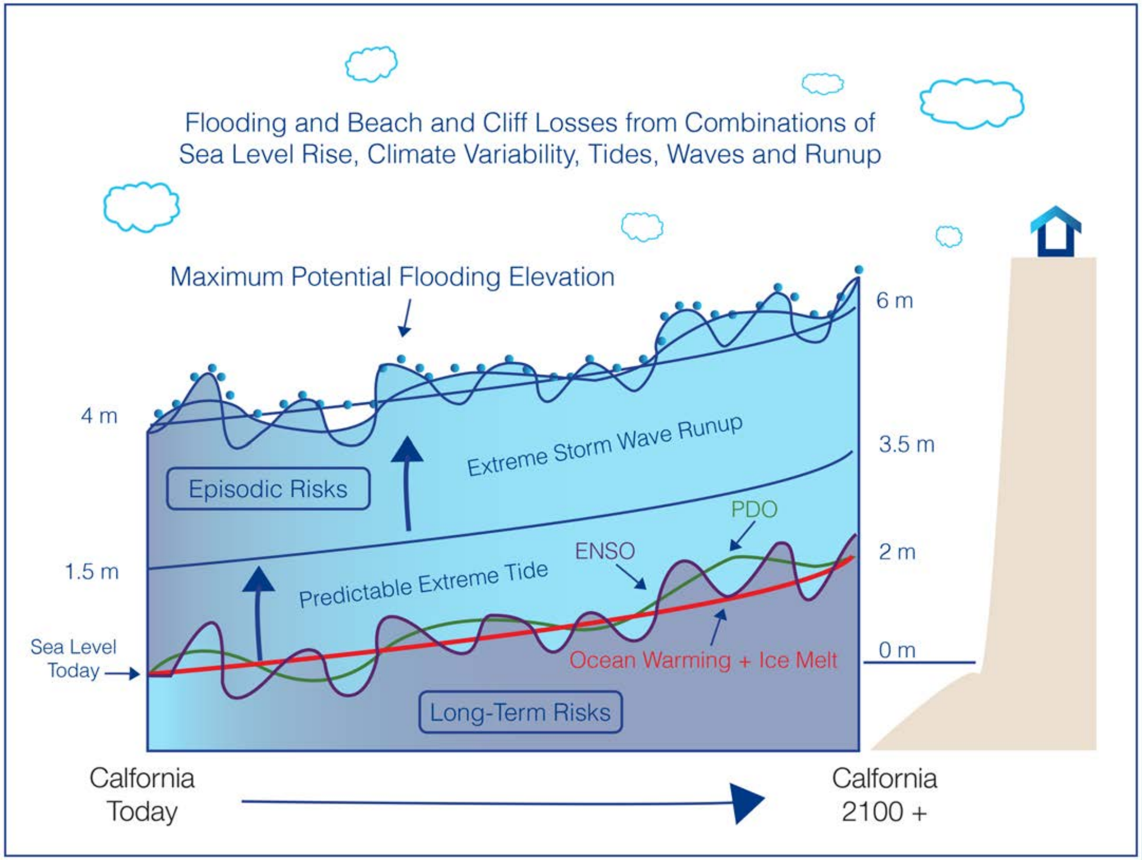

Image adapted from illustration by Dr. Bill O'Reilly (UCSD)

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Expected Impacts from SLR and Storms

- Accelerated beach erosion rates
- Greater incidence of cliff failures
- Landwards translation of coastal flooding & inundation
- Dangerous navigation conditions
- Beach/shore safety compromised
- Saltwater intrusion into coastal aquifers

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about models

All models are wrong;
some models are useful.

- statistician George Box

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What is a model?

Data → Code → Output

What is a model?

Data → Code → Output

Information that sets the boundary conditions for a model

- bathymetry and topography
- wind data
- pressure fields
- river flow rates
- grid

What is a model?

Data → Code → Output

mathematical equations or
numerical approximation

- Xbeach
- Delft 3D
- SWAN
- ADCIRC

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"The Model"

Slide format adapted from Dr. John Atkinson, Aracadis U.S. Inc

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What is a model?

Data → Code → Output

Flood projections
Storm projections
Uncertainty

Variations on a theme

Data → Code → Output

Data

Information that sets the boundary conditions for a model

- bathymetry and topography
- wind data
- river flow rates

Code

mathematical equations or numerical approximation

- Xbeach
- Delft 3D
- SWAN
- ADCIRC

Output

Flood projections
Storm projections
Uncertainty

Static vs. Dynamic Models

Static ("bathtub")

- A stationary model that floods based on a given elevation, no physics involved
- Instantaneous fill
- Output: topographic vulnerability
- Examples for O.C. area
    - NOAA SLR Viewer, Surging Seas, Pacific Institute

Dynamic

- Physical modeling of processes that affect water levels – tides, surge & wave-driven processes (set up and run up)
- Temporal variability
- Output: aereal extent, depth & velocity
- Examples for O.C. area
    - CoSMoS 3.0 (coming)
    - BreZo (currently available for Newport)

Slide adapted from Dr. Timu Gallien

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about CoSMoS

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Coastal Storms Modeling System (CoSMoS)

- Dynamic - Physics-based numerical modeling system for assessing coastal hazards on West Coast
- Predicts coastal hazards for:
  - Full range of SLR scenarios (0 – 2 m & 5 m)
  - Annual, 10 yr, 20 yr and 100 yr storms
- Developing decision support tools to meet local adaptation planning needs

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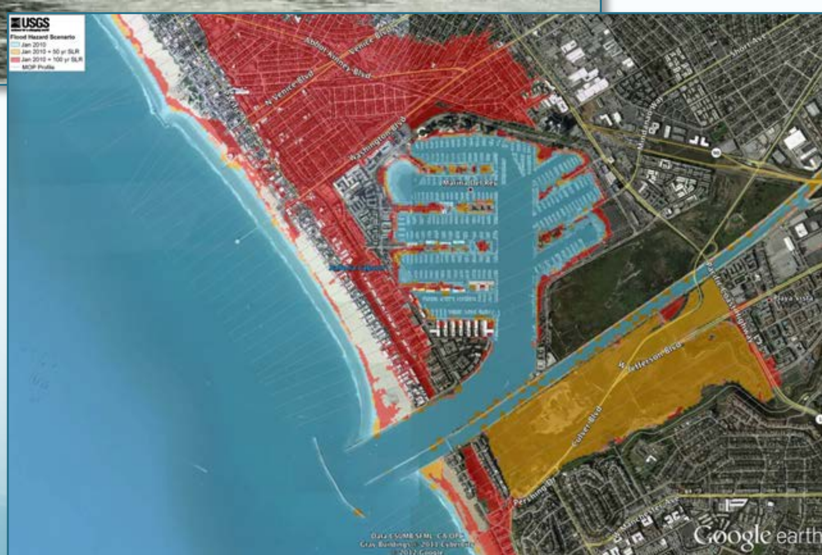
CoSMoS 1.0 – Pilot Study



- Dr. Patrick Barnard & colleagues, USGS
- Pilot Study (2010)
  - Hindcasts Jan. 2010 storm (~10 yr storm)
  - Forecasts 10 yr storm @ current, 0.5 m & 1.4 m SLR
- Outer coast focus (protected bays not explicitly modeled)
- Flooding based on maximum wave runup

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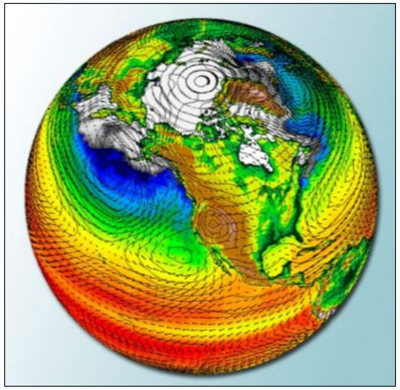
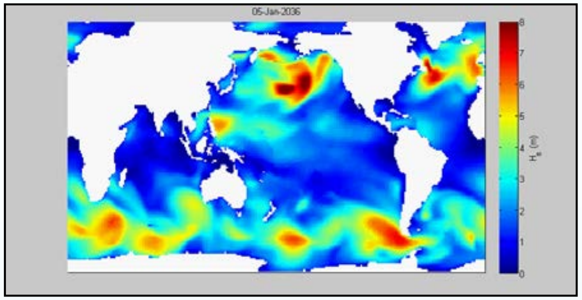
CoSMoS 2.0



Global forcing using the latest climate models



Drives global and regional wave models

Scaled down to local hazard projections

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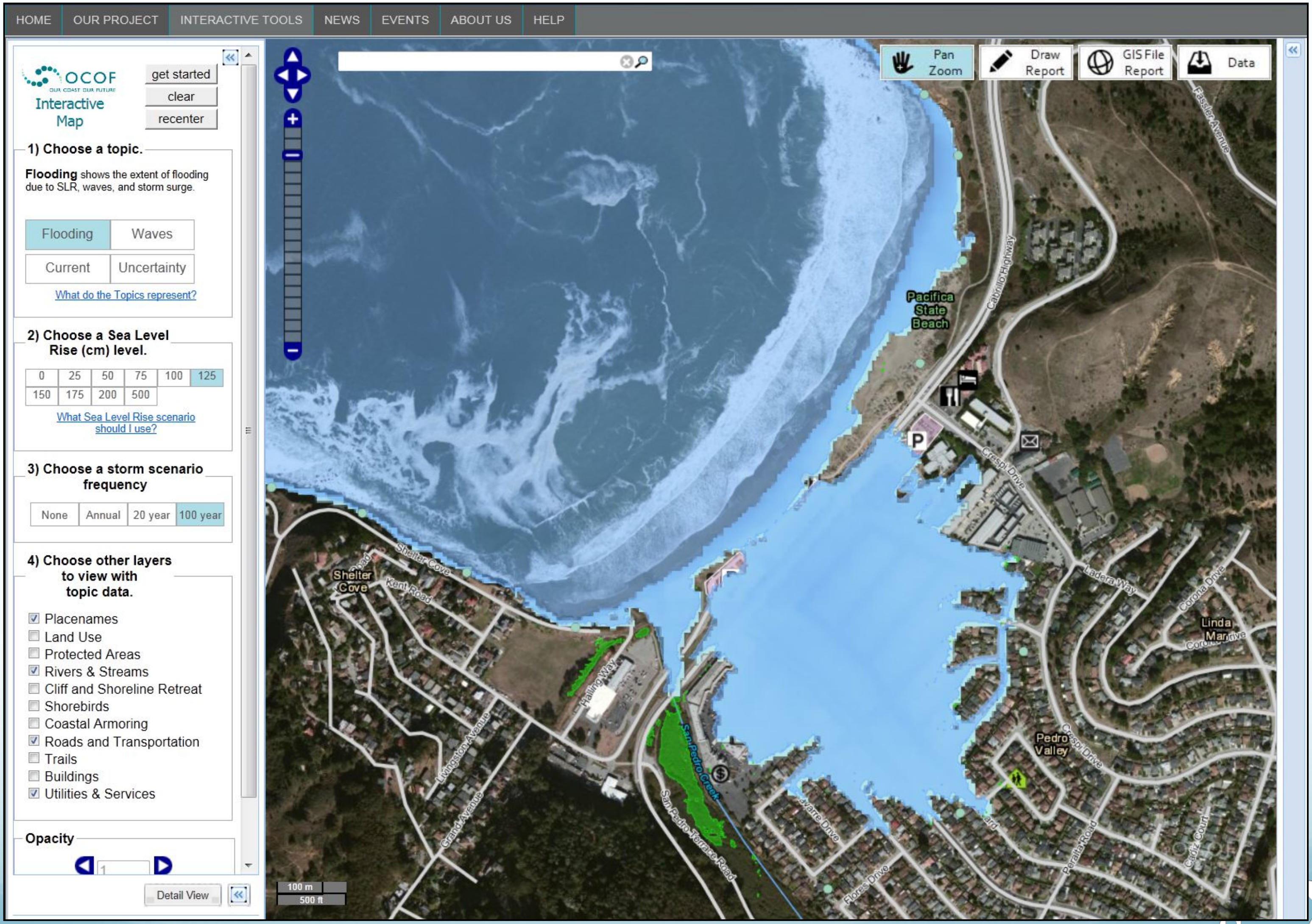
Extreme Event Impacts



http://www.pointblue.org/ocof

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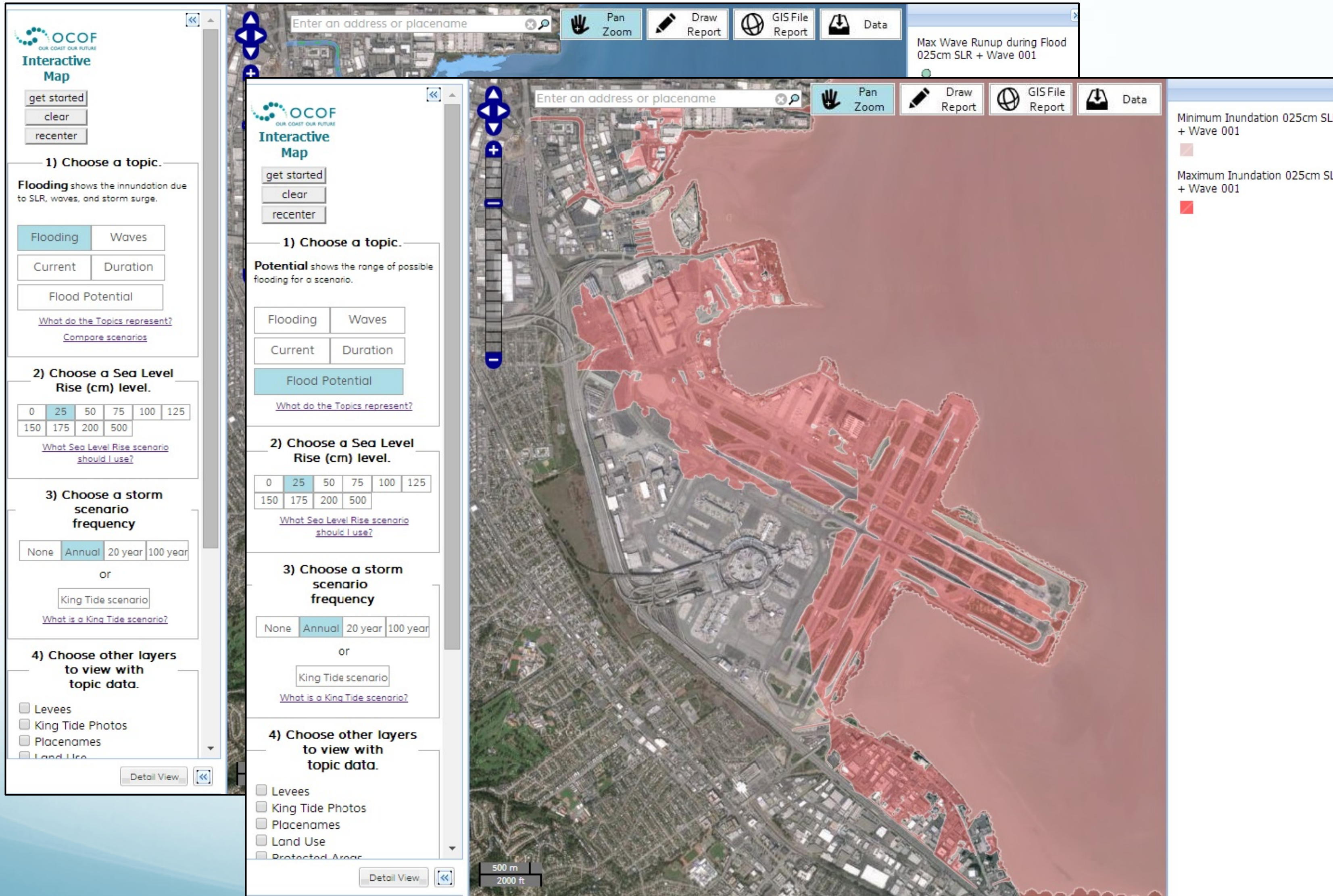
Uncertainty



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CoSMoS 3.0 – Southern California

- Downscaled winds from GCMs to get locally-generated seas and surge
- Long-term coastal evolution modeled, including sandy beaches and cliffs
- Discharge from rivers for event response and long-term sediment supply
- Multi-agency collaboration featuring coastal and climate scientists from Scripps, Oregon State University & USGS

USGS science for a changing world

Coastal Conservancy

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

COASTAL TRAINING PROGRAM Tijuana River National Estuarine Research Reserve

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CoSMoS 3.0 Timeline

- Study is underway…
- First set of limited scenarios next September 2015
- Full suite of 40 SLR and storm scenarios June 2016

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other regional OC models

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An embarrassment of riches…

CA & O.C.-focused tools

- CoSMoS 3.0
- Pacific Institute SLR Report
- BreZo (Dr. Brett Sanders and Dr. Timu Gallien)

National tools

- NOAA Sea Level Rise Viewer
- Climate Central's Surging Seas 2.0

…And likely many more to come in the future…

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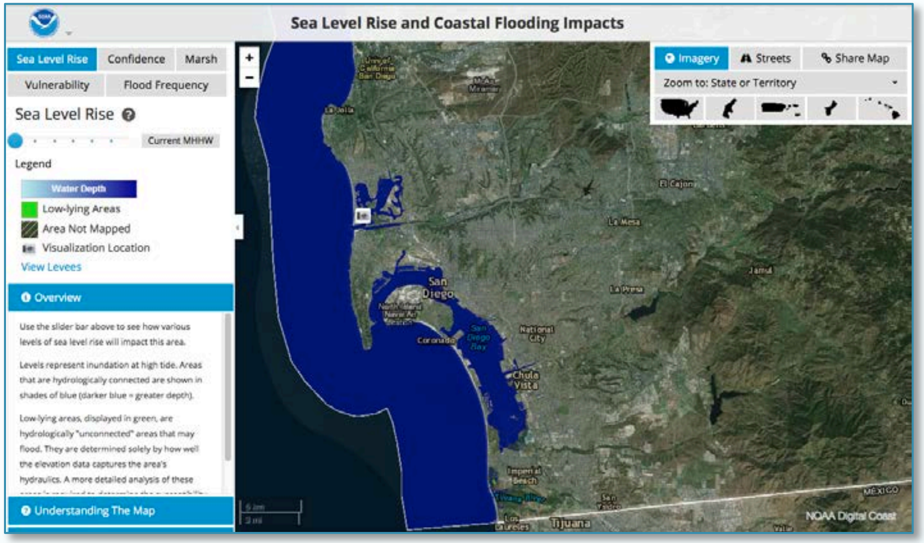
NOAA Sea Level Rise Viewer

- Static Model (“Modified bathtub”)
- Doesn’t include storms, only tides
- Sliding scale of SLR scenarios



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

- Great for “1st order screening”

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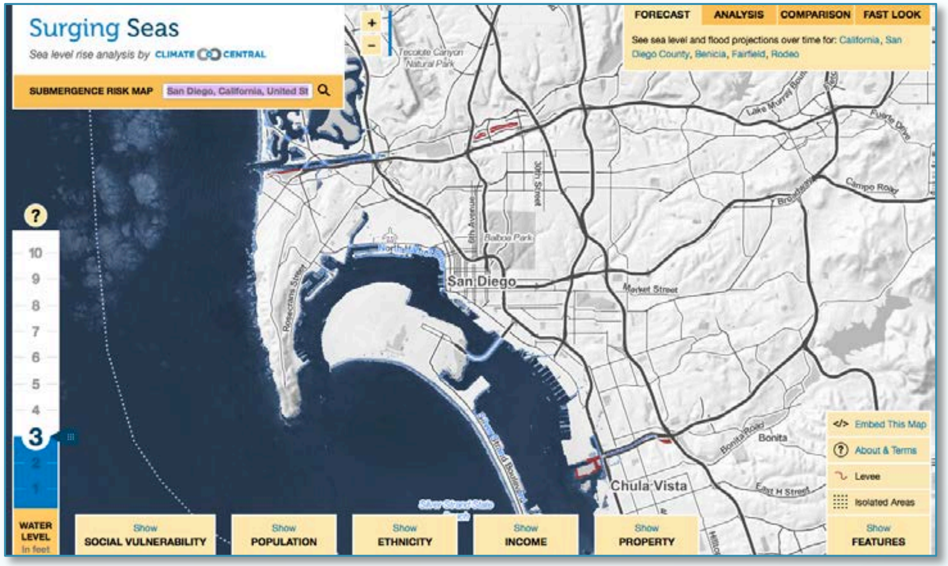
Climate Central Surging Seas

- Static Model ("Modified Bathtub")
  - Back-end data exactly the same as NOAA SLR Viewer Data
- Includes social vulnerability
- Another good "1st order screening"



http://sealevel.climatecentral.org/ssrf/california

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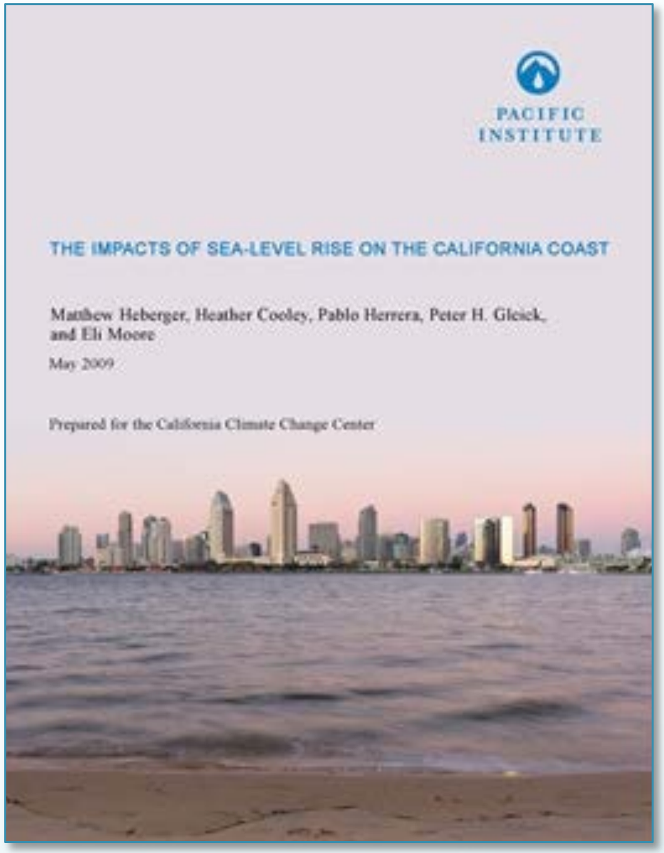
Pacific Institute

- Modeled by PWA
- "Hybrid" Static Model
  - Empirical relationships – no physics
  - included 100-yr storm event
  - two SLR scenarios (0.5 m and 1.5 m)
- Didn't include Scripps area
- Available on Cal-Adapt



http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/

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Other Regional Efforts

- FloodRISE
  - Richard Matthew & Brett Sanders, UC Irvine
- Seal Beach Sediment Augmentation Project
  - Kirk Gilligan, US Fish & Wildlife
- Assessing SLR Vulnerability for Coastal Wetlands
  - Steve Steinberg, Southern California Coastal Water Research Project

Questions?

http://news.nationalgeographic.com/news/2014/01/140130-king-tides-high-tides-sea-level-rise-science/

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Extra Slides

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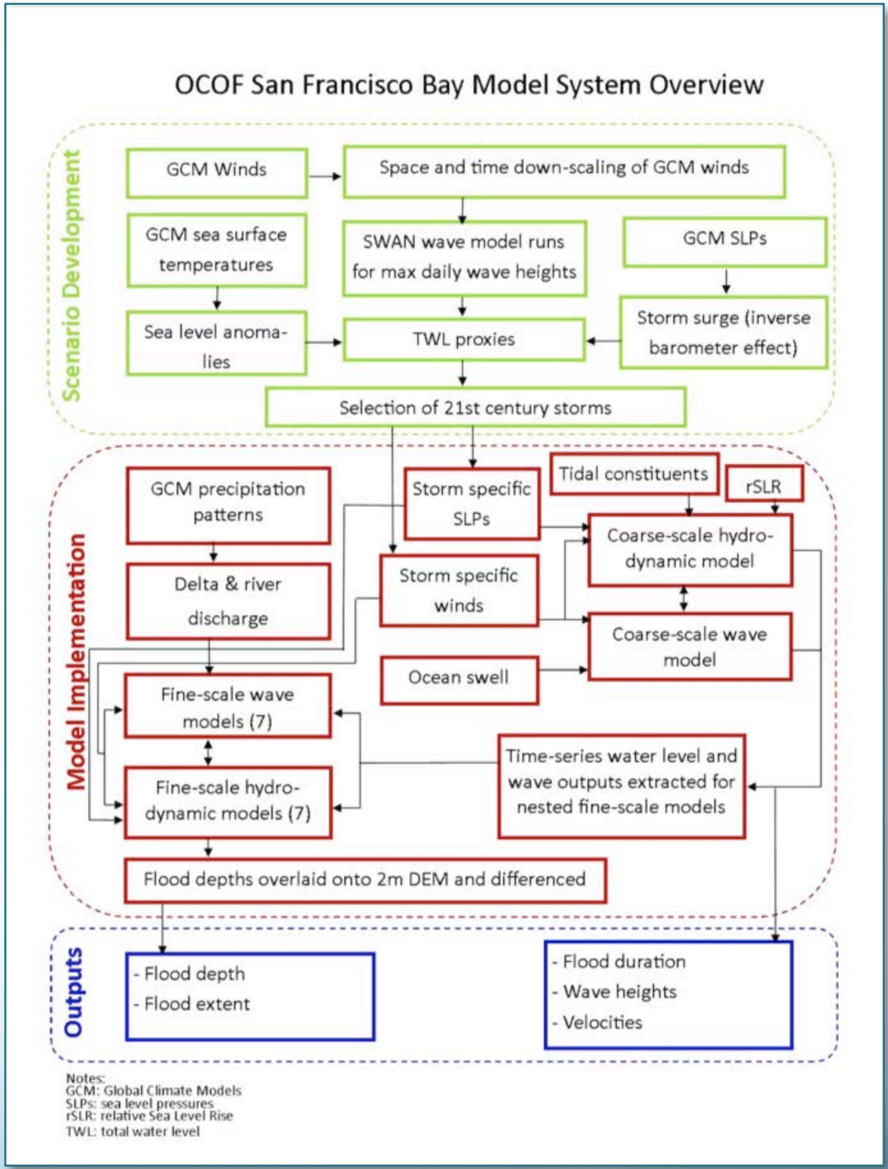
CoSMoS 2.0

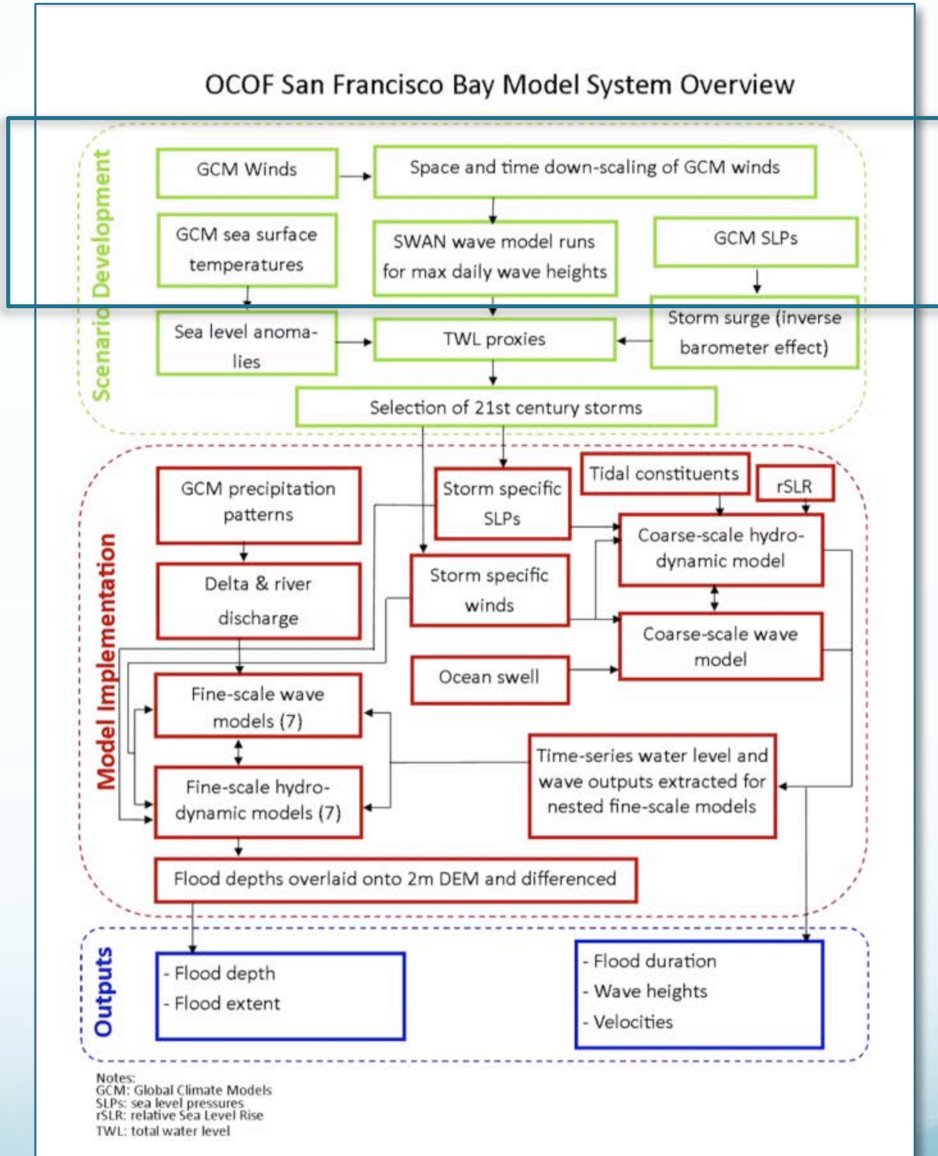


OCOF San Francisco Bay Model System Overview
Scenario Development
GCM Winds
Space and time down-scaling of GCM winds
GCM sea surface temperatures
SWAN wave model runs for max daily wave heights
GCM SLPs
Sea level anoma-lies
TWL proxies
Storm surge (inverse barometer effect)
Selection of 21st century storms
Model Implementation
GCM precipitation patterns
Storm specific SLPs
Tidal constituents
rSLR
Coarse-scale hydro-dynamic model
Delta & river discharge
Storm specific winds
Coarse-scale wave model
Ocean swell
Fine-scale wave models (7)
Fine-scale hydro-dynamic models (7)
Time-series water level and wave outputs extracted for nested fine-scale models
Flood depths overlaid onto 2m DEM and differenced
Outputs
- Flood depth
- Flood extent
- Flood duration
- Wave heights
- Velocities
Notes:
GCM: Global Climate Models
SLPs: sea level pressures
rSLR: relative Sea Level Rise
TWL: total water level

CoSMoS 2.0

The DATA

- Global Climate Models provide winds, sea surface temps, pressure



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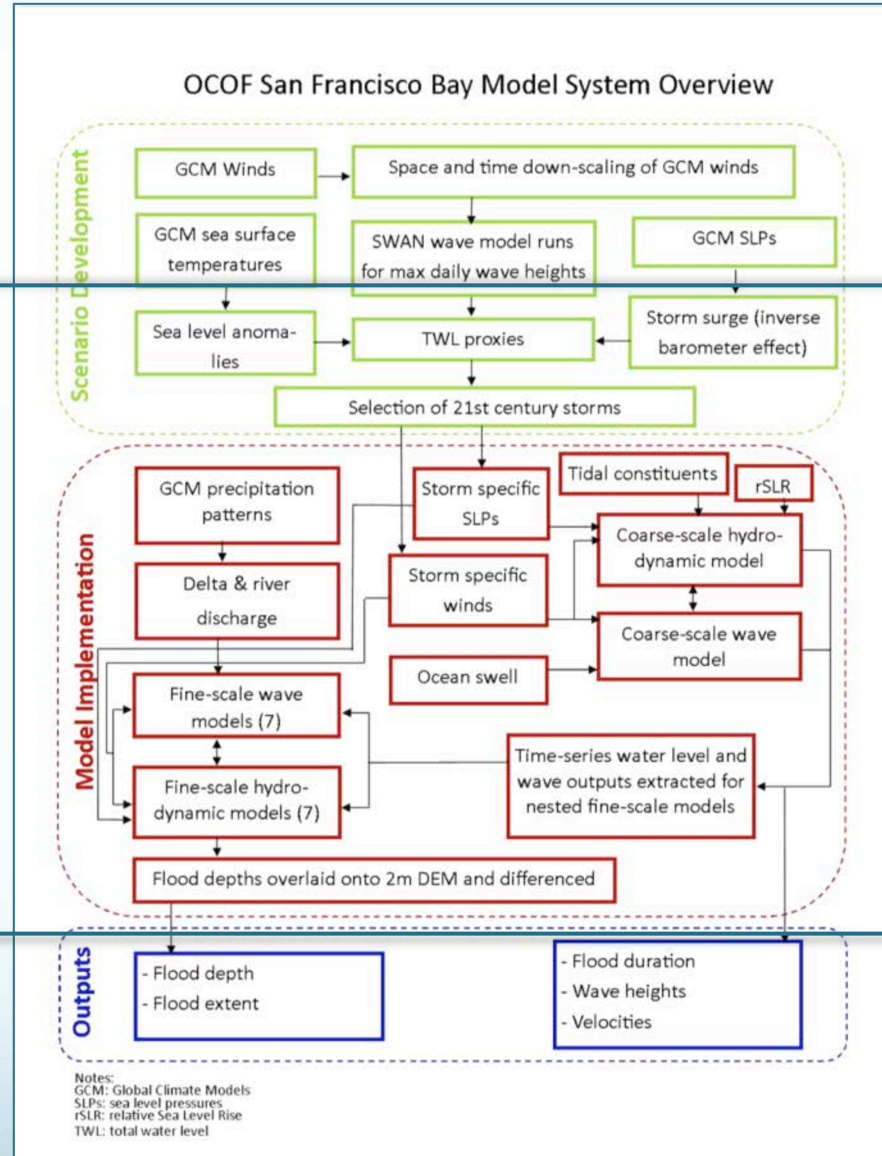
CoSMoS 2.0

The CODE

- Utilizes SWAN wave model to downscale waves and Xbeach to bring waves on shore
- Total Water Levels
  - SLR, tides, waves, SLA, storm surge, river discharge



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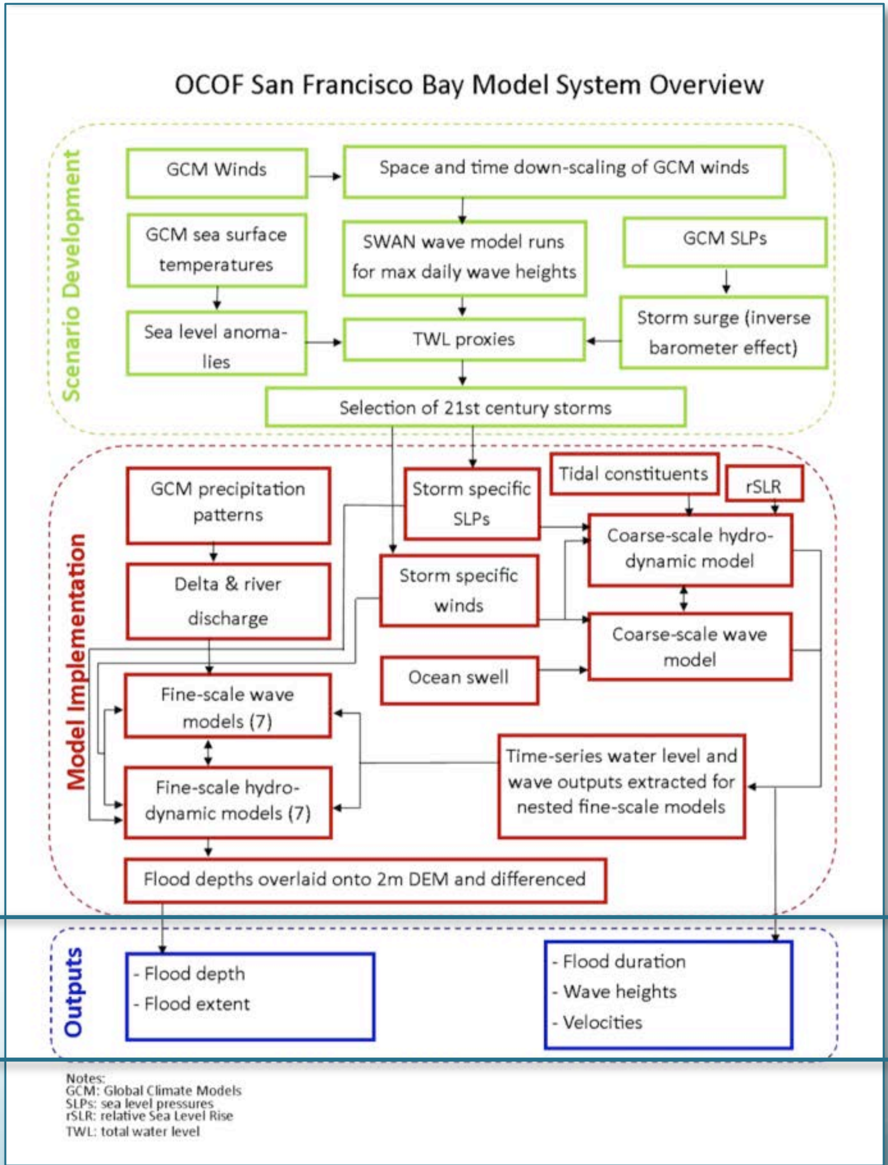
CoSMoS 2.0

The OUTPUTS

- 40 SLR and storm scenarios, plus King Tide scenario for SF Bay using CoSMoS
- Flood depth, extent, duration
- Wave heights & velocities



BreZo & FloodRISE

- Dynamic model
- Overland flow model
- Sub-meter resolution
- Completed project for Newport Beach, includes validation data set

BreZo & CoSMoS

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- Overland flow model
- Sub-meter resolution
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Main Differences –

- DATA
  - Unstructured grid (triangular vs. rectangular)
- CODE
  - Different overfland flow model (based on civil engineering)
- OUTPUT
  - Sub-meter resolution
  - Fine-scale model validation at Newport

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- Dynamic model
- Overland flow model
- Sub-meter resolution
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Previous collaboration between Brett, Timu & Patrick

- Gallien et al. (2013) Journal of Coastal Research 29(3): 642-656

Discussion of future collaboration

- CoSMoS provides total water levels to force BreZo

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