San Diego Regional
SLR & Coastal Impacts Planning Workshop

Overview of CoSMoS and Sea Level Rise Models & Tools

Juliette Hart
Phyllis Grifman & Alyssa Newton Mann

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USC Sea Grant – The Urban Ocean Program


Photo: Charlotte Stevenson

- Funds research
- Community outreach & education
- Technical assistance to local/ regional government

10 Million by the Sea…

- Climate Change Science & Planning
- Coastal Ecosystem Science
- Coastal Management
- Maritime Affairs

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Southern California Coastal Impacts Project

Coastal Conservancy

- Stakeholder Engagement and Capacity Building
  - Initial Process Workshop (today)
  - Webinar series through (2015, until model results are available)
  - Technical Outreach Workshop (Summer 2016)


Photo: Marika Schulhof


Photo: Monica Ly

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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

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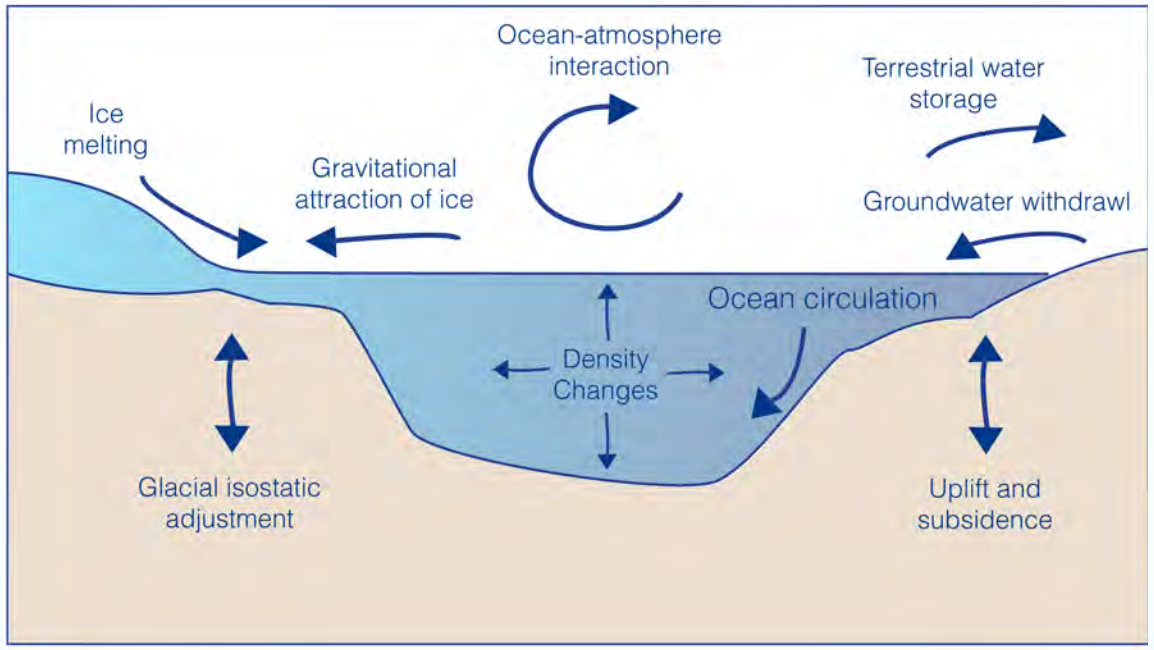
Sea Level Rise 101



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

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

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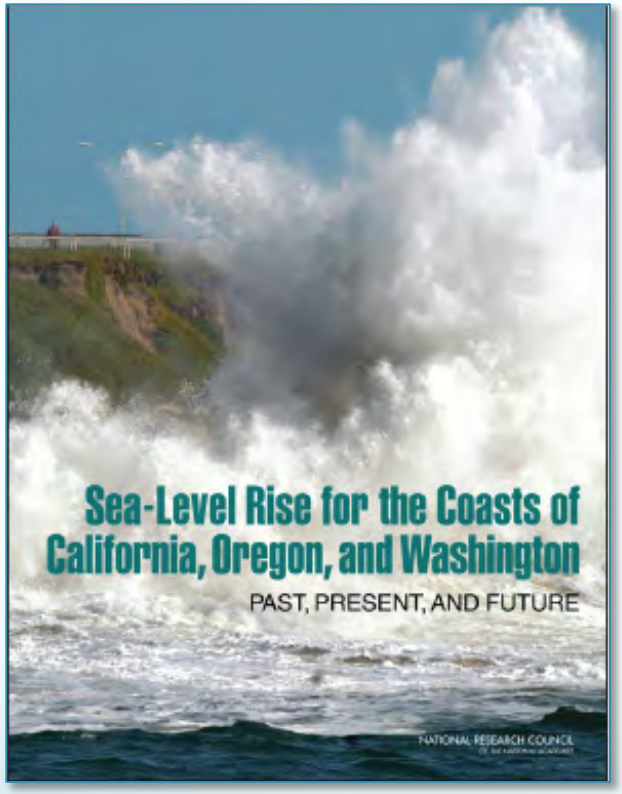
NRC slide



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

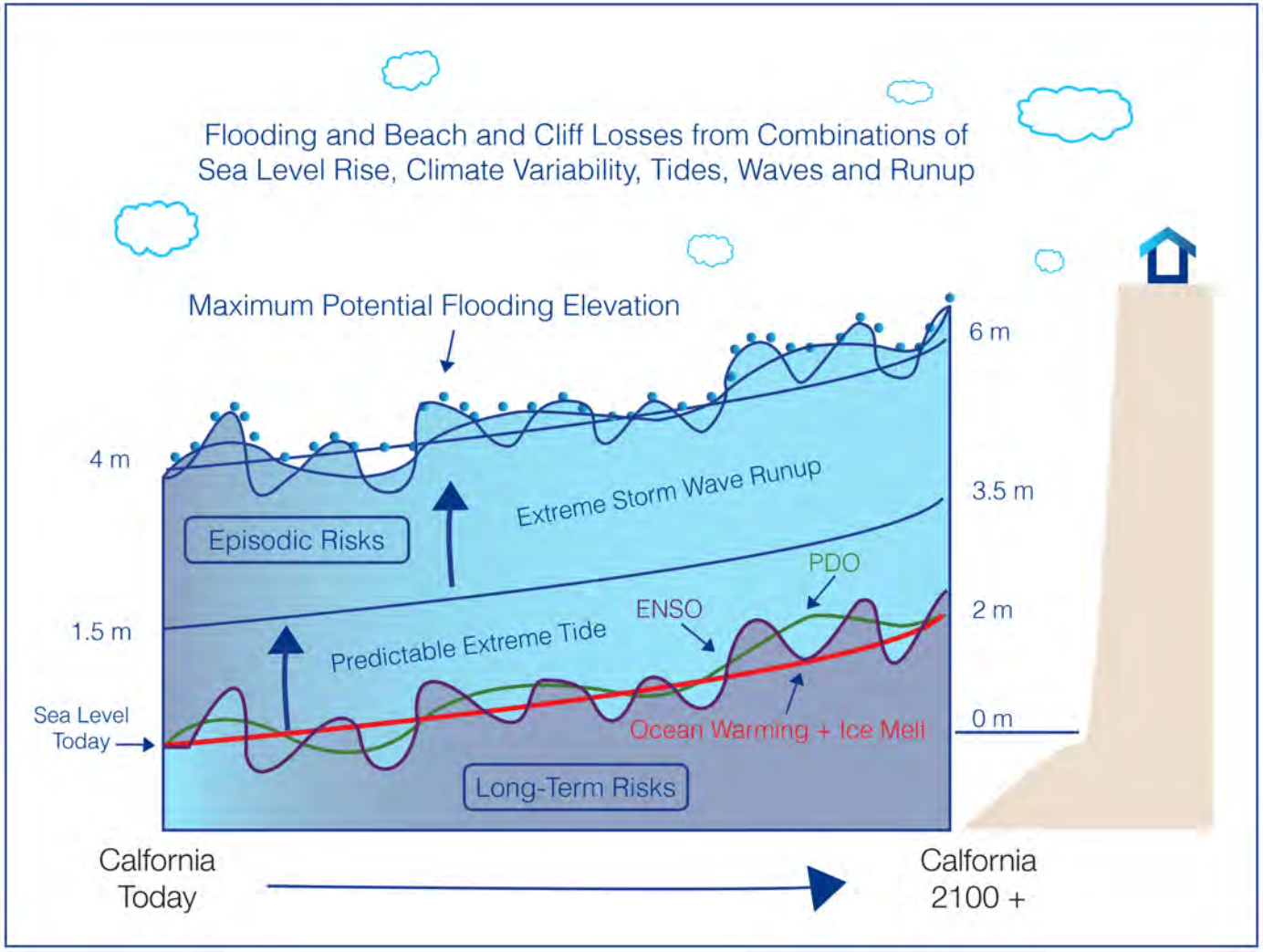

Image adapted from illustration by Dr. Bill O'Reilly (UCSD)

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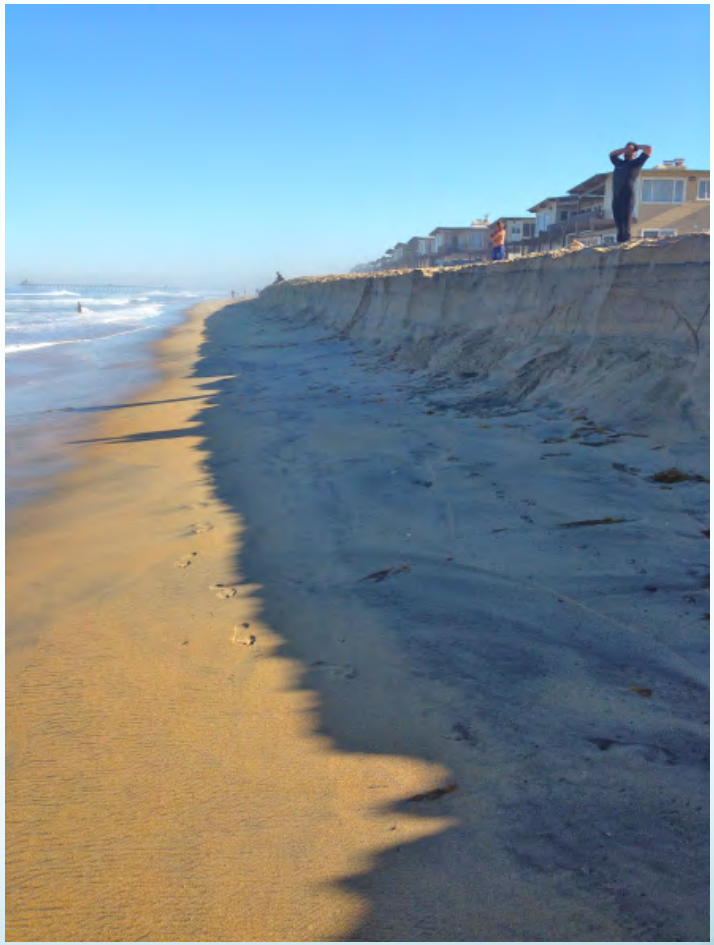
Hurricane Marie Impacts – Imperial Beach



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Coastal Storms

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

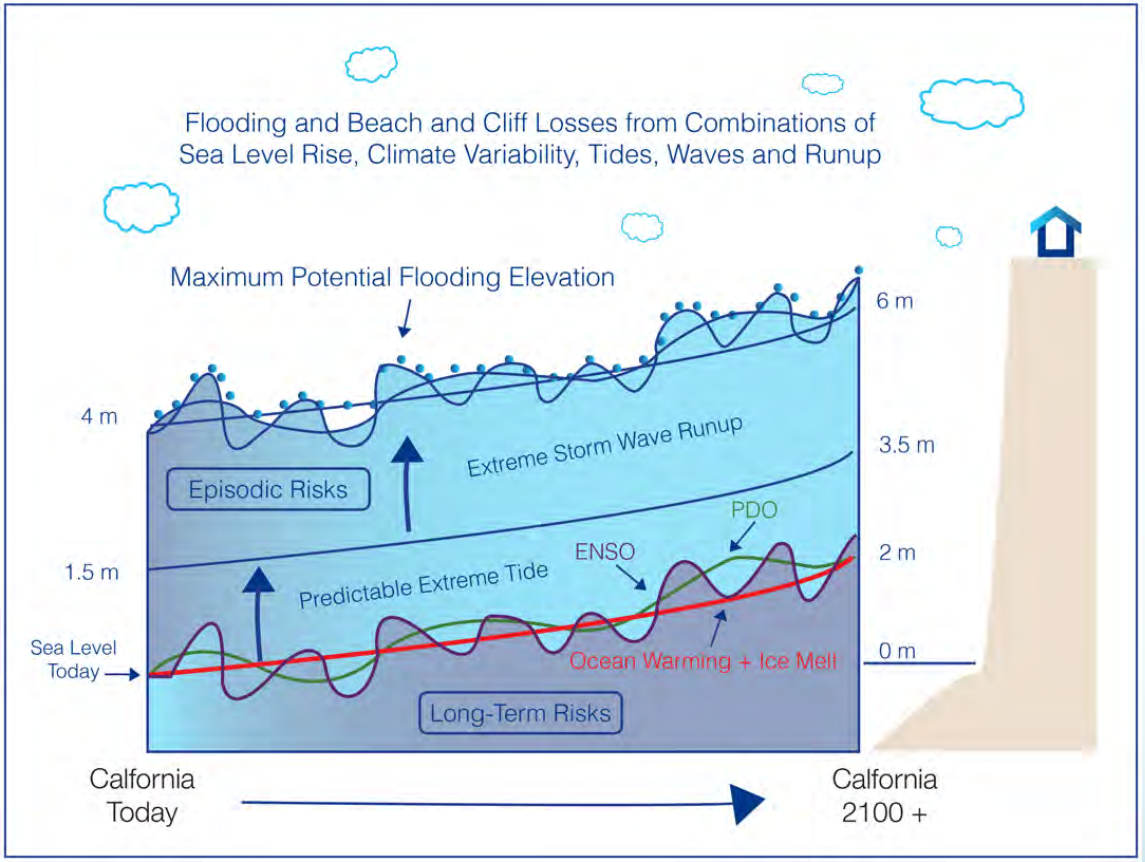

Image adapted from illustration by Dr. Bill O'Reilly (UCSD)

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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

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All models are wrong;
some models are useful.

- statistician George Box

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What is a model?

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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

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

What is a model?

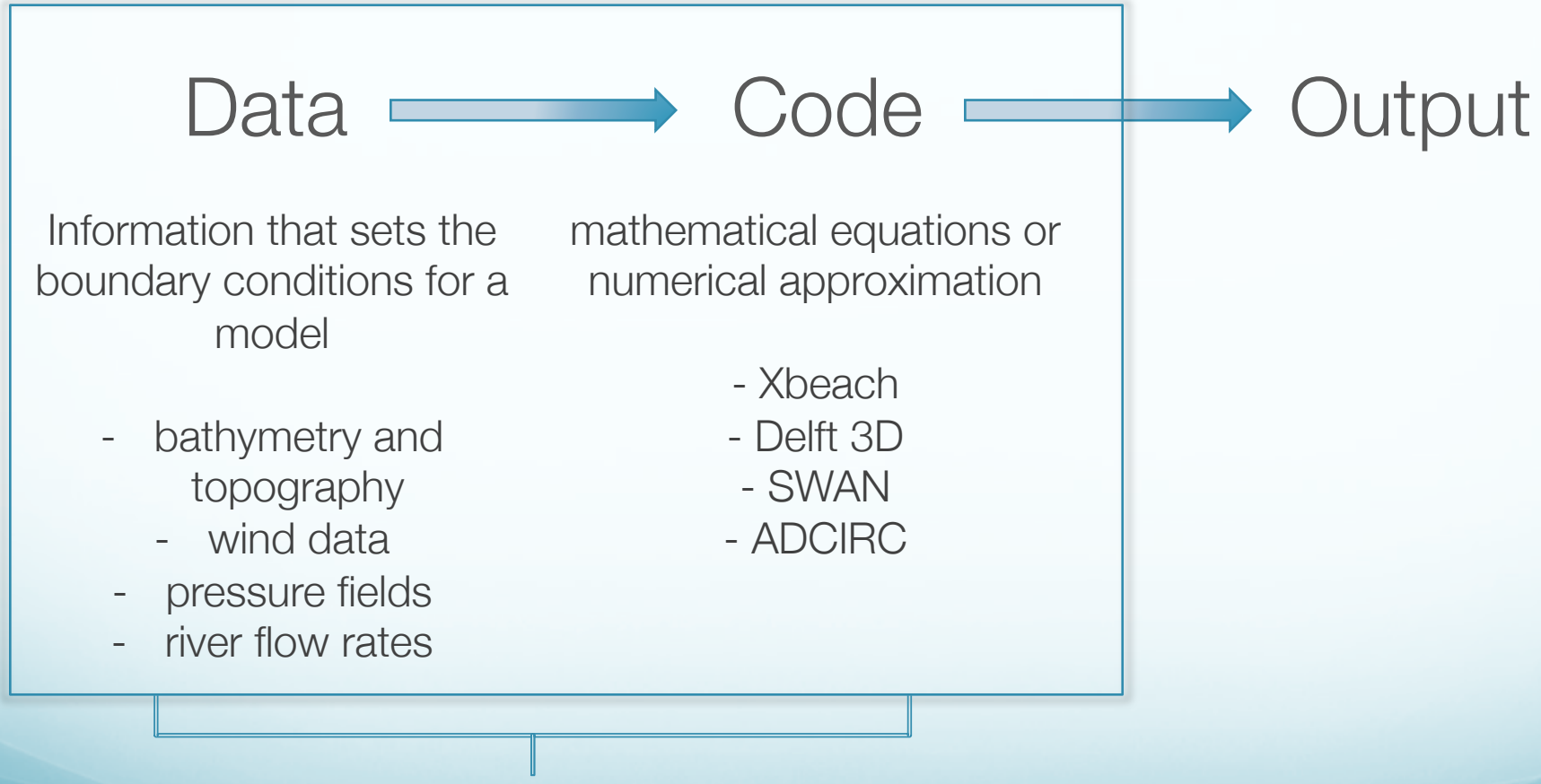
Data → Code → Output

mathematical equations or
numerical approximation

- Xbeach
- Delft 3D
- SWAN
- ADCIRC

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

What is a model?



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

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What is a model?

Flood projections
Storm projections
Uncertainty

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Variations on a theme

Data → Code → Output

Information that sets the boundary conditions for a model

- bathymetry and topography
- wind data
- river flow rates

mathematical equations or numerical approximation

- Xbeach
- Delft 3D
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Flood projections
Storm projections
Uncertainty

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Static vs. Dynamic Models

Static (“bathtub”)

- A stationary model that floods based on a given elevation, no physics involved
- Elevation (e.g. MHHW) + given amount of SLR
- Examples from S.D. area
  - San Diego Adaptation Bay Strategy SLR model
  - NOAA SLR Viewer (modified)
  - Climate Central Surging Seas (modified)
  - Pacific Institute (hybrid)

Dynamic

- Physical modeling of processes that affect water levels – tides, surge & wave-driven processes (set up and run up)
- Based on time scale of storms
- Examples from S.D. area
  - CoSMoS 3.0
  - SPAWAR
  - BreZo

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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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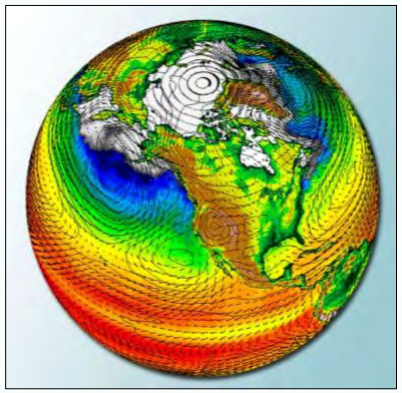
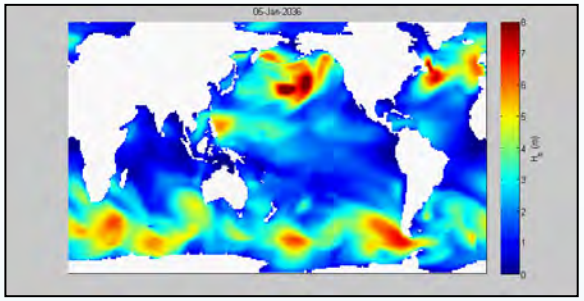
CoSMoS 2.0



Global forcing using the latest climate models



Drives global and regional wave models

Scaled down to local hazard projections

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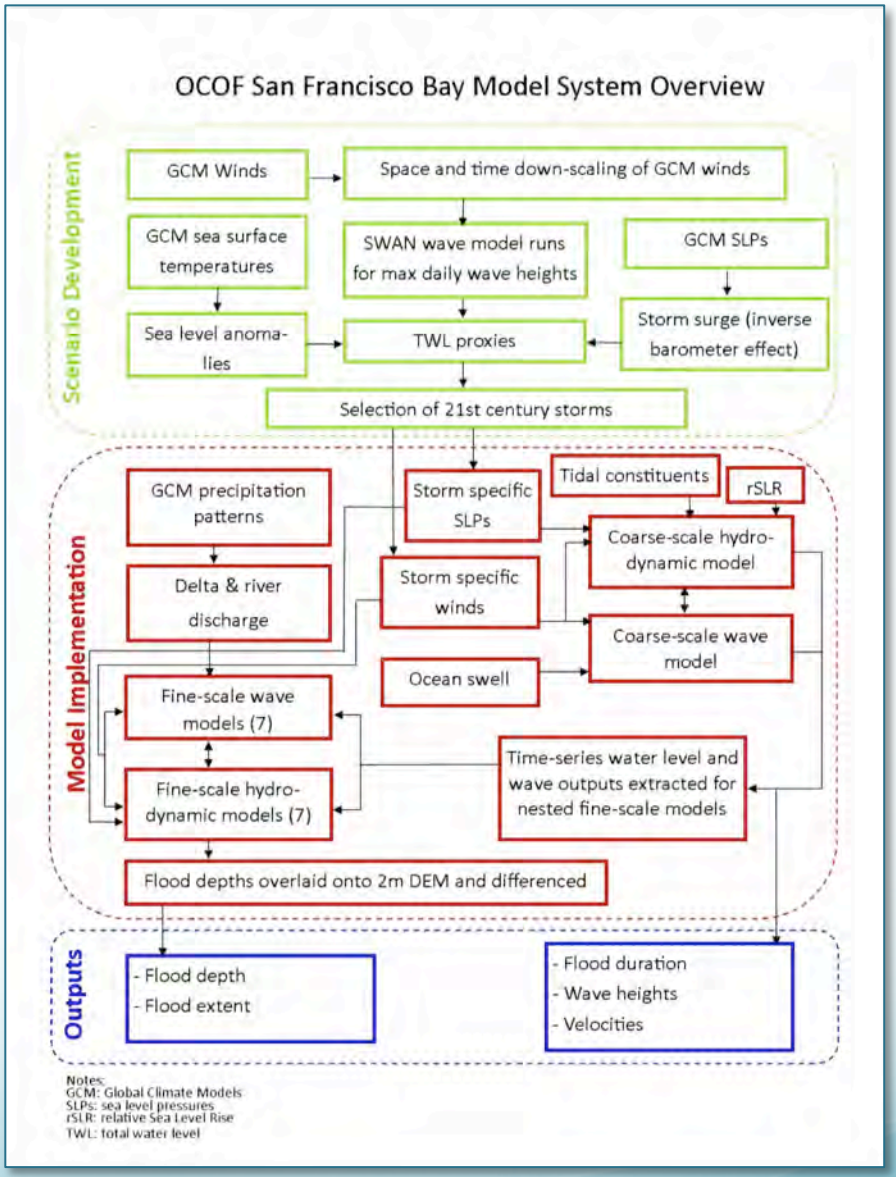
CoSMoS 2.0



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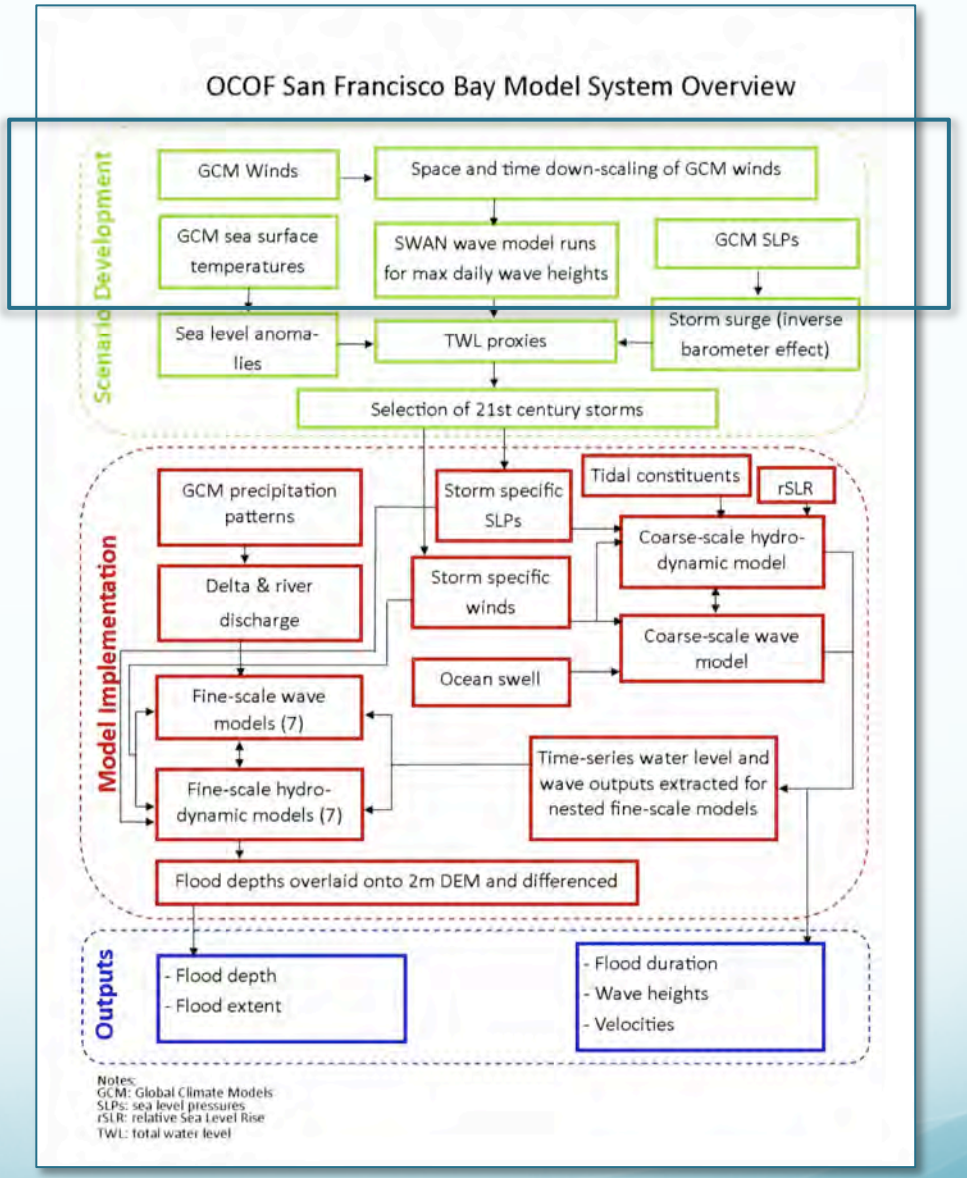
CoSMoS 2.0

The DATA

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



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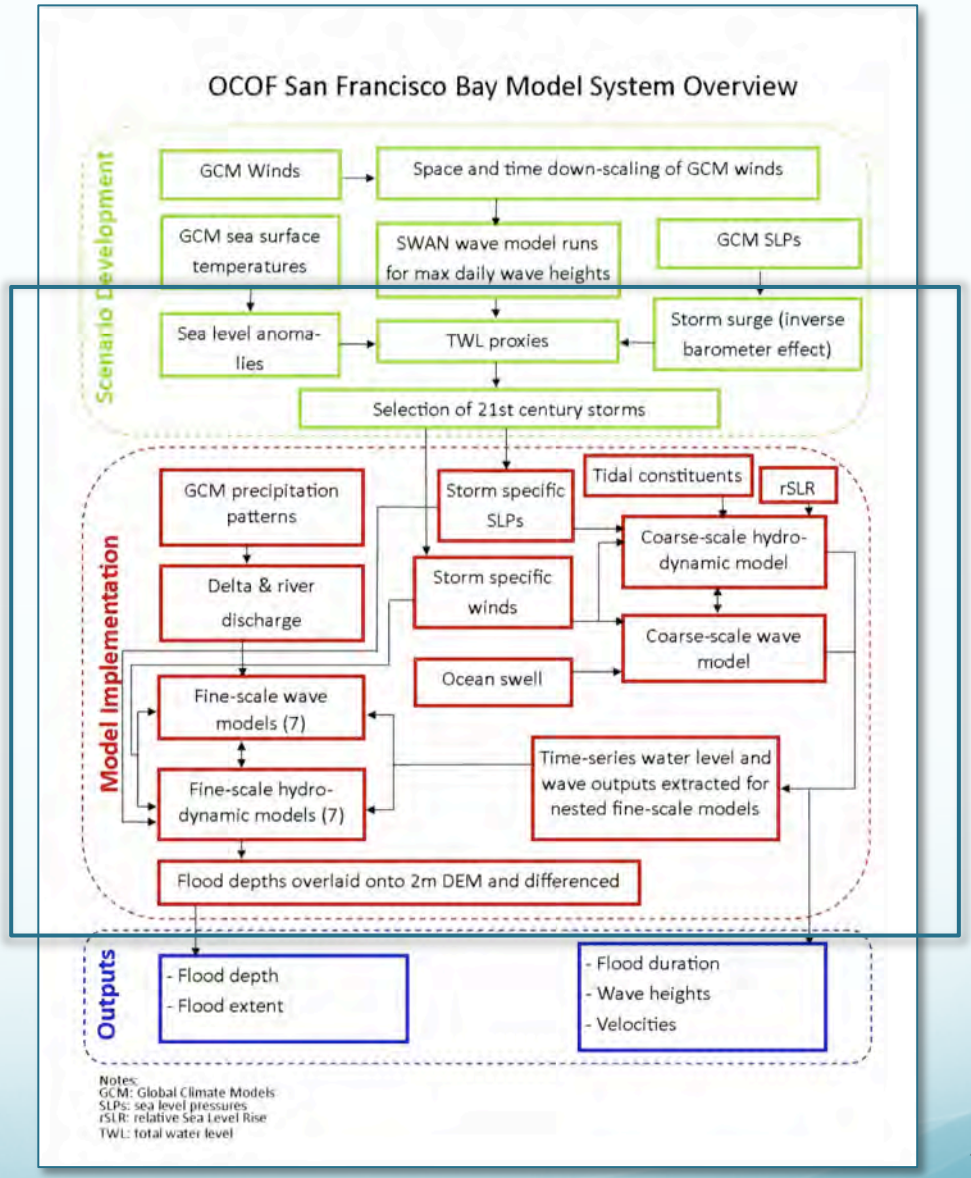
CoSMoS 2.0

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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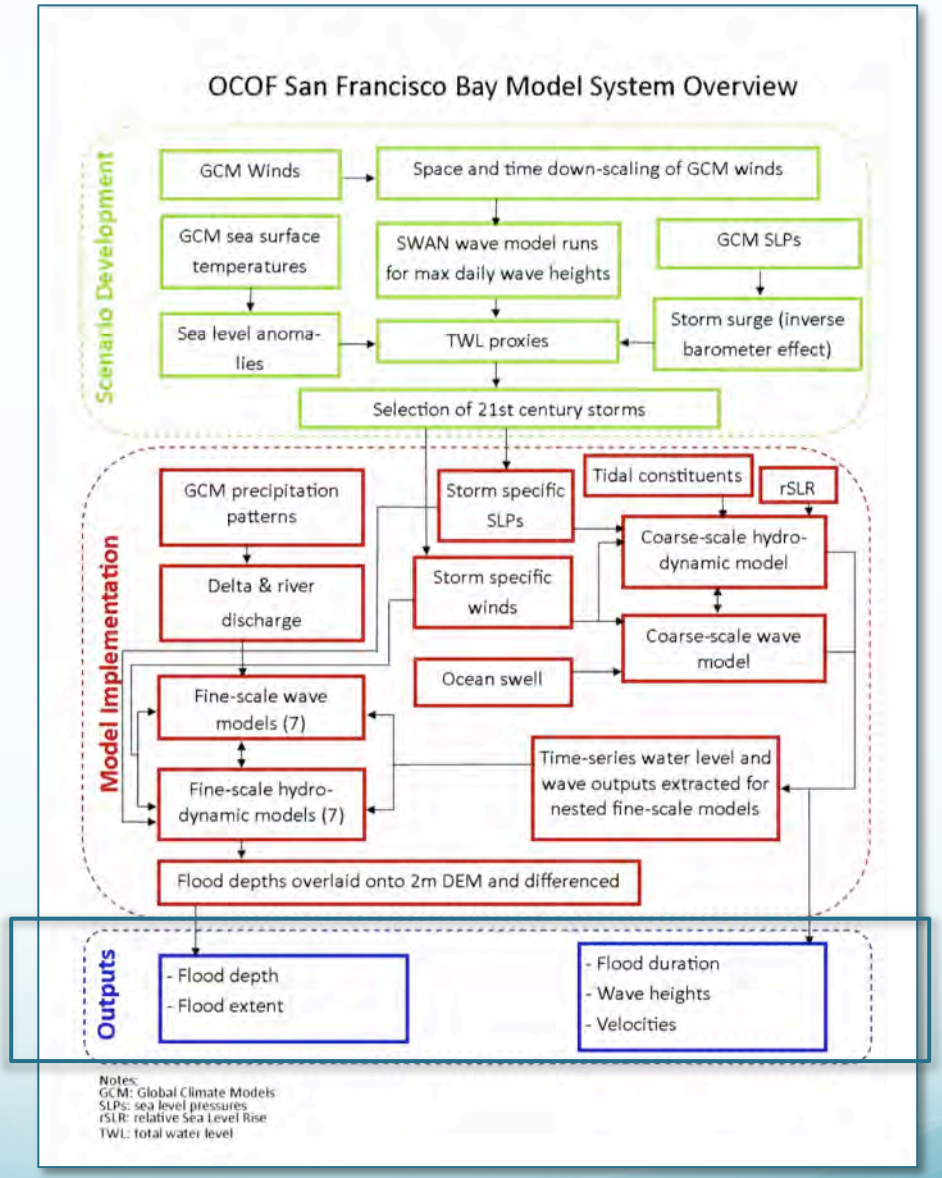
CoSMoS 2.0

The OUTPUTS

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



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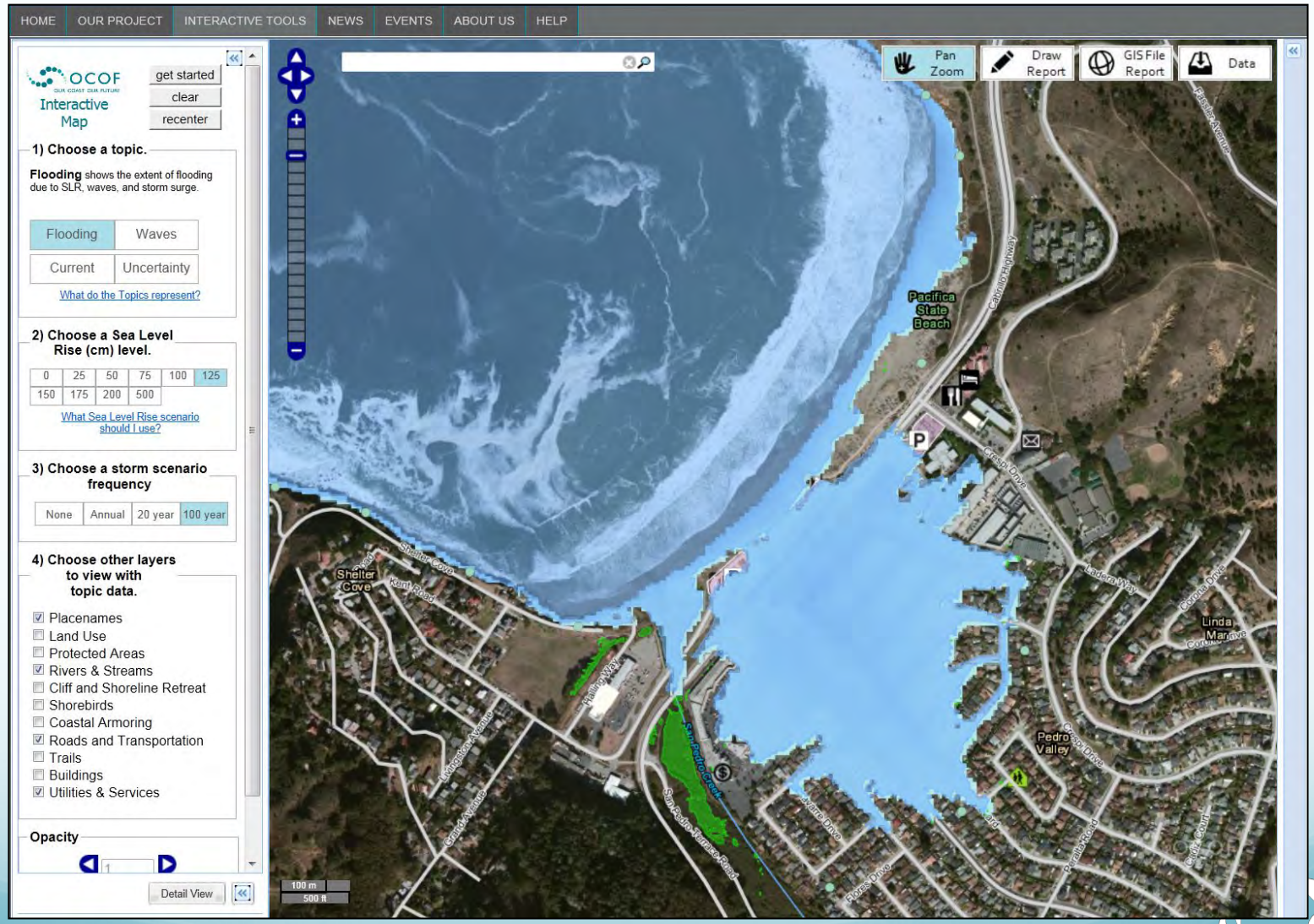
Extreme Event Impacts



http://www.pointblue.org/ocof

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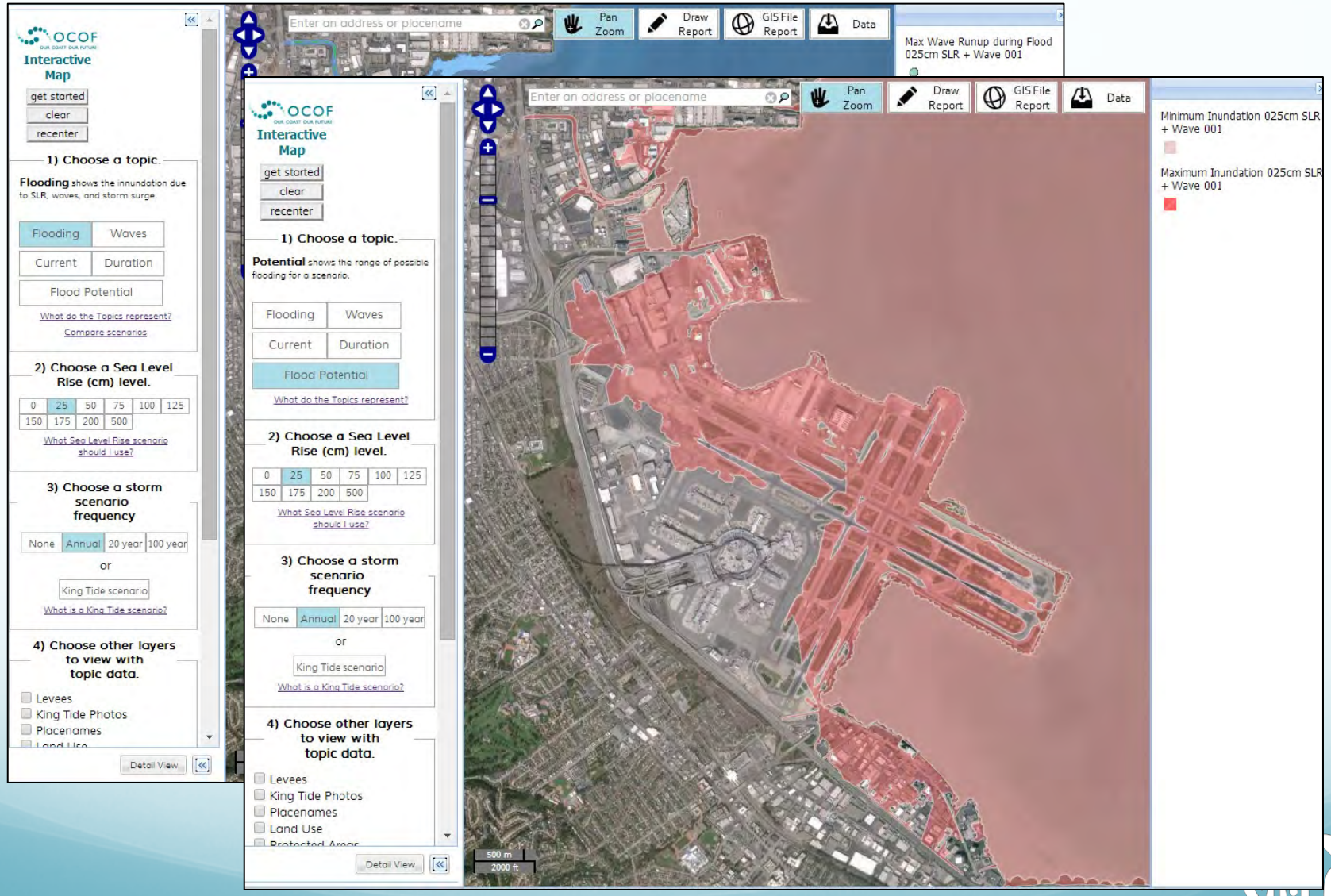
Uncertainty



http://www.pointblue.org/ocof

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CoSMoS 3.0 – Southern California

- Multi-agency collaboration featuring coastal and climate scientists from Scripps, Oregon State University 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 and long-term sediment supply

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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 SD models

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An embarrassment of riches…

CA & S.D.-focused tools

- CoSMoS 3.0
- Pacific Institute SLR Report
- SPAWAR
- San Diego Bay Adaptation Strategy

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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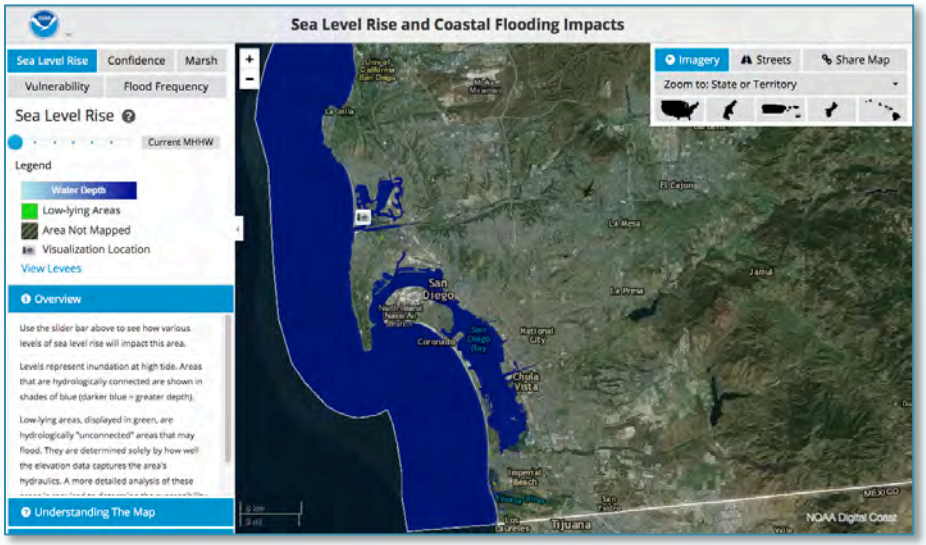
NOAA Sea Level Rise Viewer

- Static Model ("Modified bathtub")
- Doesn't include storms, only tides
- Sliding scale of SLR scenarios
- Great for "1st order screening"



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

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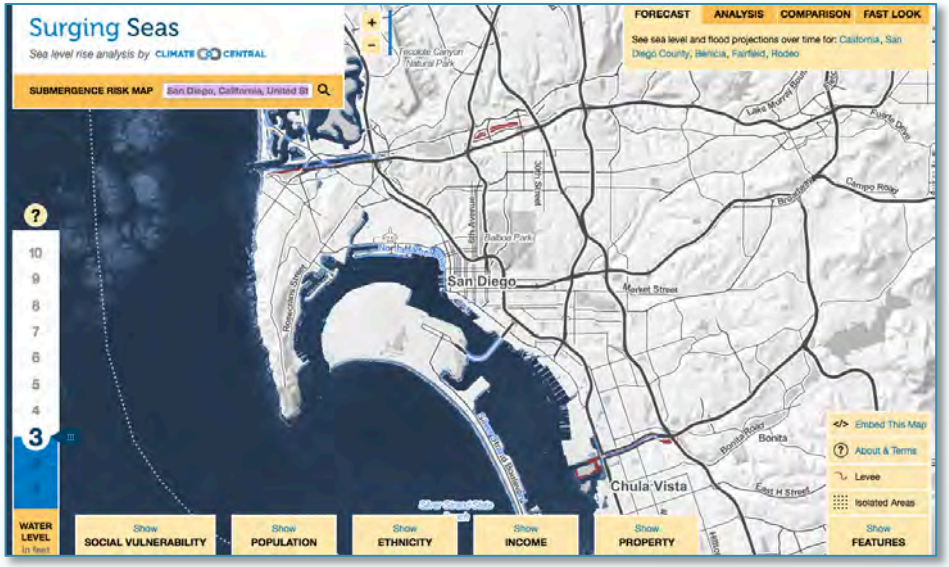
Climate Central Surging Seas

- 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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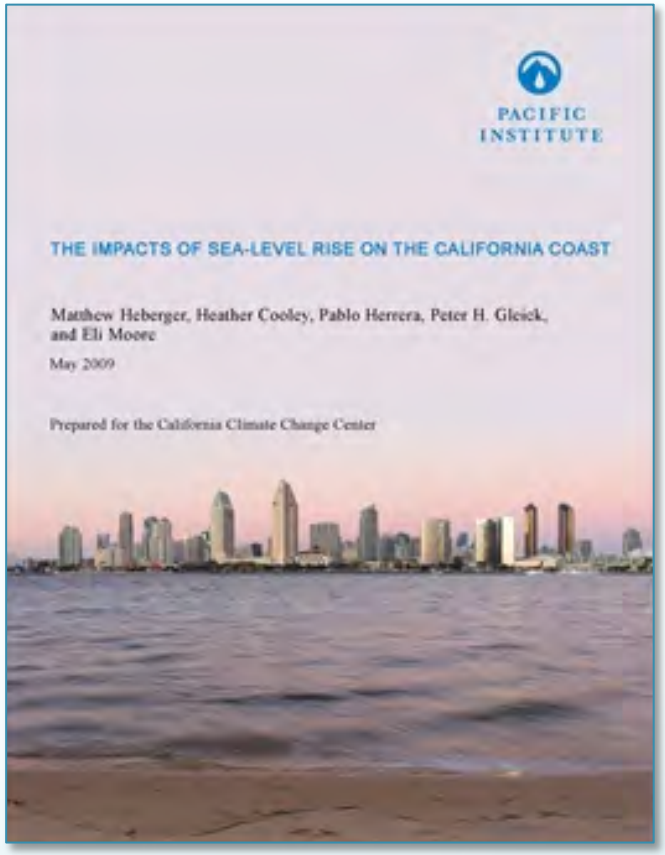
Pacific Institute

- 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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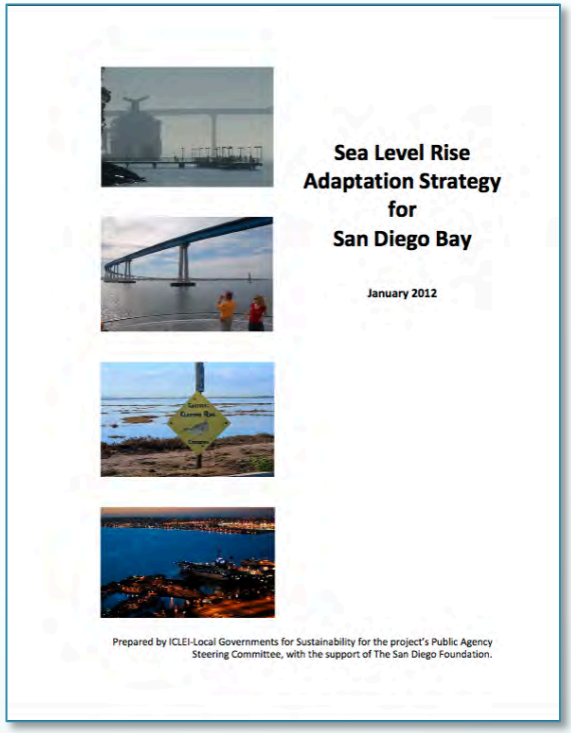
San Diego Bay Adaptation Plan Modeling Work

- Modeling by SDSU, Dr. Rick Gersberg
- Static Model
  - Included 100 yr storm event
  - Two SLR scenarios (0.5 m and 1.5 m)
- Used by San Diego Bay Adaptation Planning Team
- Modified for use by Port of San Diego by Environ



http://www.icleiusa.org/static/San_Diego_Bay_SLR_Adaptation_Strategy_Complete.pdf

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SPAWAR

- Lead: Dr. Bart Chadwick from Systems Center Pacific in collaboration with:
  - TerraCosta Consulting Group, Moffat & Nichol, USGS, UCSD San Diego Supercomputer Center
- Dynamic model w/storms
- SLR of 0 – 2 m in 0.5 m increments
- Cliff erosion & alongshore transport
- Used for Naval Base Coronado, Marine Corps Base Camp Pendleton

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SPAWAR & CoSMoS

- Lead: Dr. Bart Chadwick from Systems Center Pacific in collaboration with:
  - TerraCosta Consulting Group, Moffat & Nichol, USGS, UCSD San Diego Supercomputer Center
- Dynamic model w/storms
- SLR of 0 – 2 m in 0.5 m increments, includes
- Cliff erosion & alongshore transport
- Used for Naval Base Coronado, Marine Corps Base Camp Pendleton

Main Differences –

- DATA
  - Different GCMs
- CODE
  - SPAWAR uses CDIP, high resolution and validated wave model
  - SPAWAR uses Yates et al. Equilibrium position model, Bruun rule and Xbeach

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BreZo

- Modeling by Dr. Timu Gallien (UCI and now UCSD)
- Dynamic model
- Civil engineering overland flow model
- Sub-meter resolution
- Completed project for Newport Beach, includes validation data set
- Proposals under review for SD; UCSD funding for Imperial Beach modeling project

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BreZo & CoSMoS

- Dynamic model
- Overland flow model
- Sub-meter resolution
- Completed project for Newport Beach, includes validation data set
- Proposals in for work in SD; hindcast modeling for Imperial Beach

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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BreZo & CoSMoS

- Dynamic model
- Overland flow model
- Sub-meter resolution
- Completed project for Newport Beach, includes validation data set
- Proposals in for work in SD; hindcast modeling for Imperial Beach

Previous collaboration between 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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So, great, but which model do I use?

- Important to consider sea level rise in combination with coastal storm impacts.
- Previous efforts in SD region utilized a static model approach; several new (excellent) efforts coming online that provide dynamic models and which incorporate storms.
- CoSMoS will be open for use by all communities from Pt. Conception to the border…for free.
- SPAWAR & BreZo – both excellent options as well, but are funding-dependent and not currently available to all So Cal jurisdictions
- Potential future collaboration between Timu and Patrick as well TCG/Scripps

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Questions?

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