

San Diego Regional SLR & Coastal Impacts Planning Workshop

Overview of CoSMoS and Sea Level Rise Models & Tools

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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

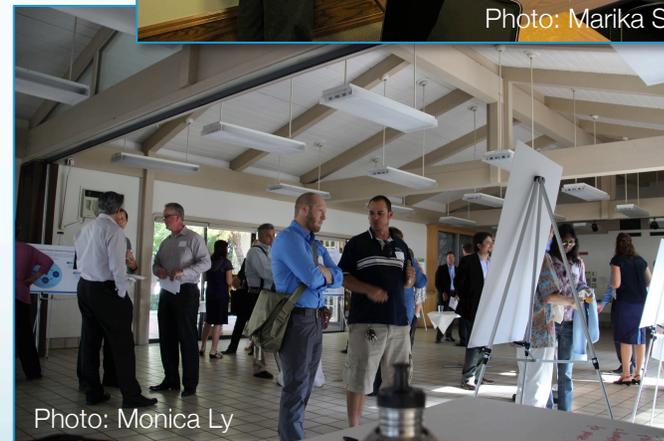
10 Million by the Sea...

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

Southern California Coastal Impacts Project



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

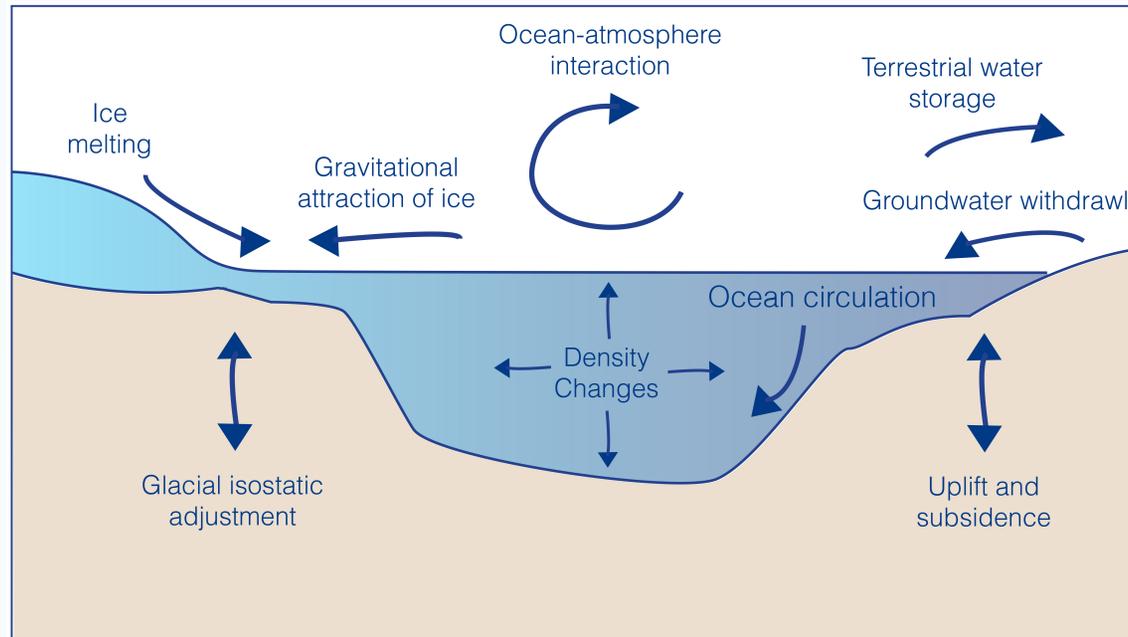


Overview of Presentation

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

about sea level rise

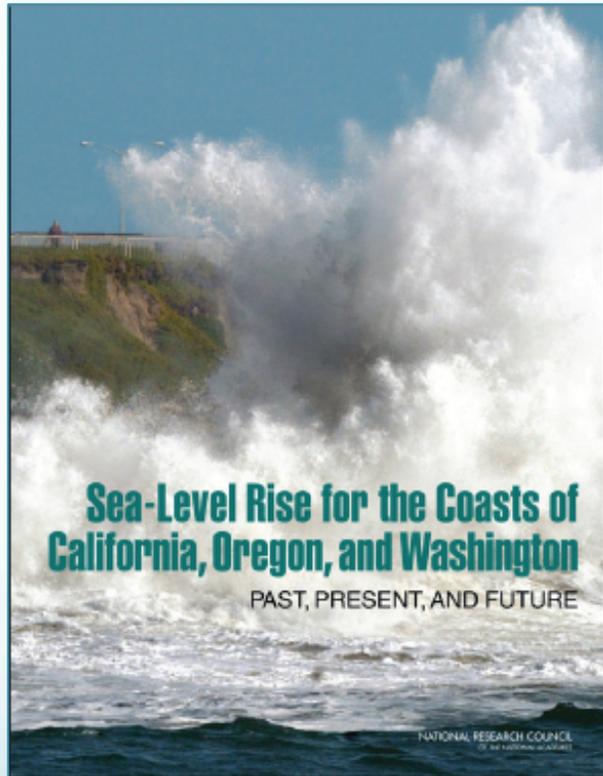
Sea Level Rise 101



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

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

NRC slide



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

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.

Coastal Storms

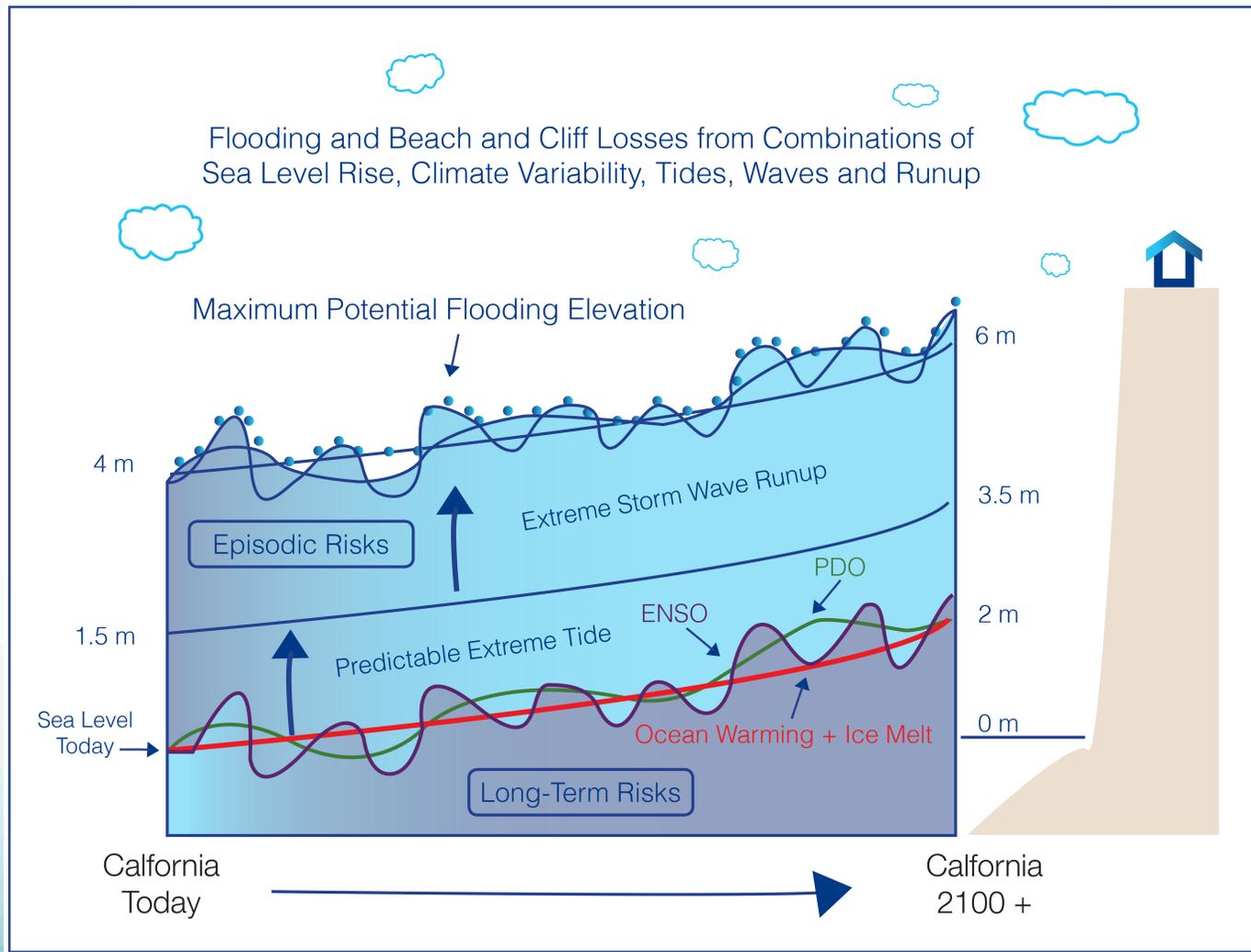
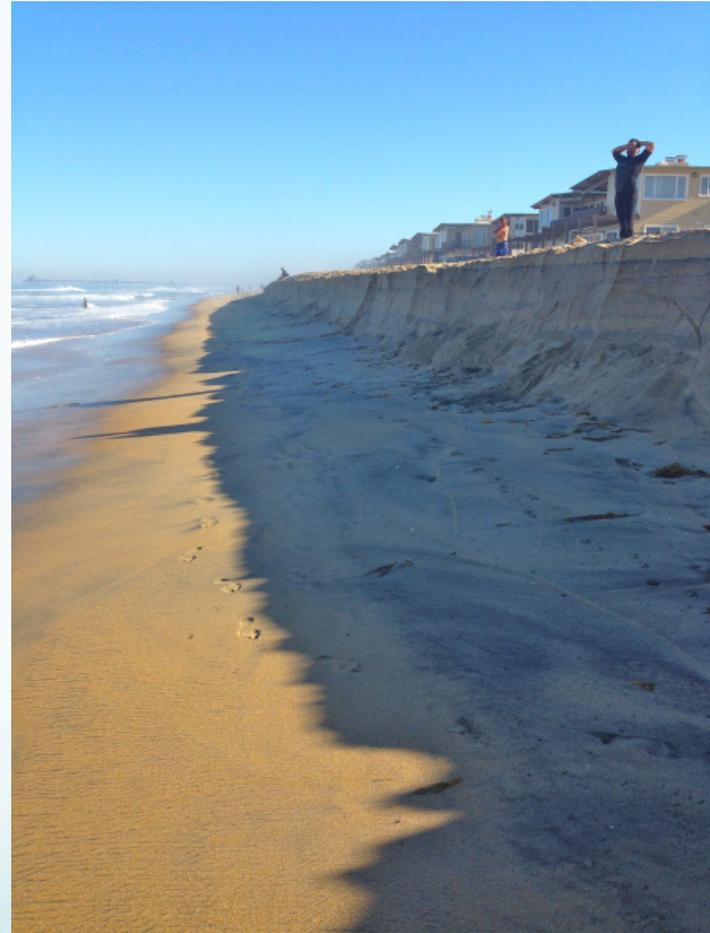


Image adapted from illustration by Dr. Bill O'Reilly (UCSD)

Hurricane Marie Impacts – Imperial Beach



Coastal Storms

“Today’s storm is tomorrow’s high tide...”

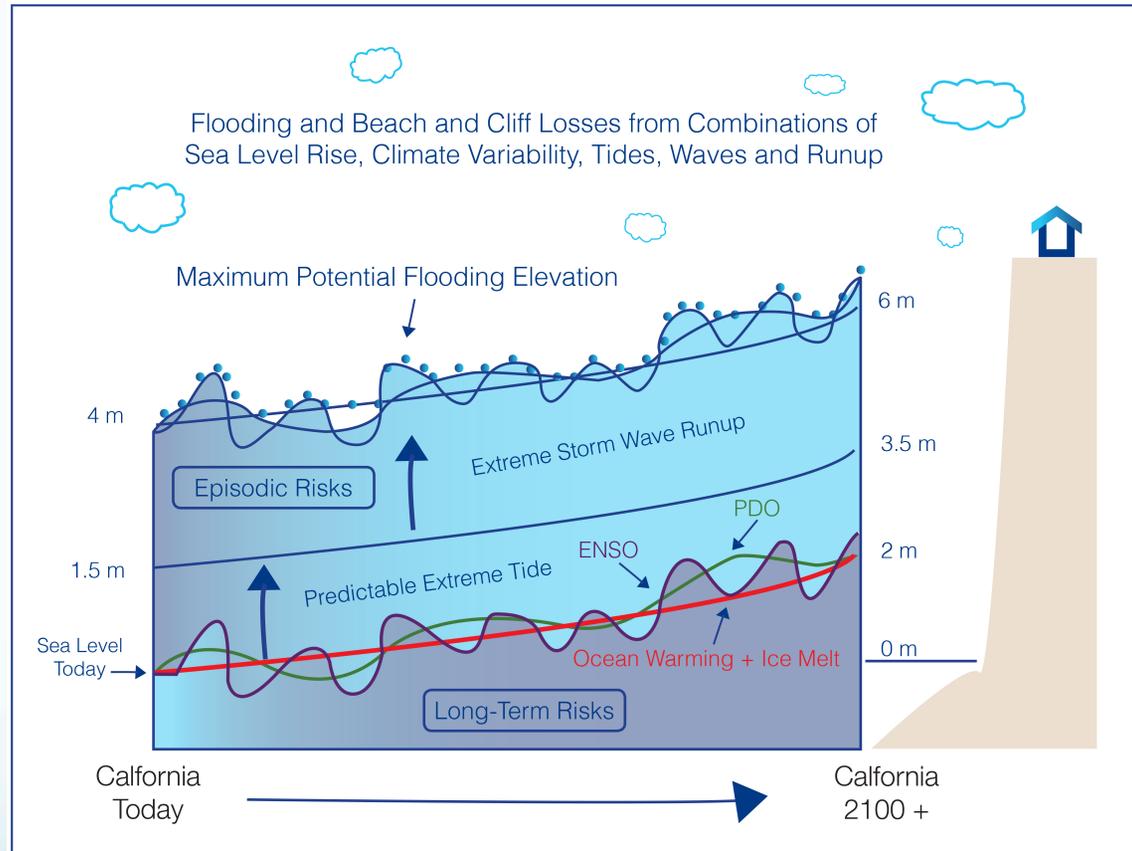


Image adapted from illustration by Dr. Bill O'Reilly (UCSD)

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

about models

All models are wrong;
some models are useful.

- *statistician George Box*

What is a model?



What is a model?



Information that sets the boundary conditions for a model

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

What is a model?



mathematical equations or
numerical approximation

- Xbeach
- Delft 3D
- SWAN
- ADCIRC

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

mathematical equations or numerical approximation

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“The Model”

What is a model?



Flood projections
Storm projections
Uncertainty

Variations on a theme



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

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

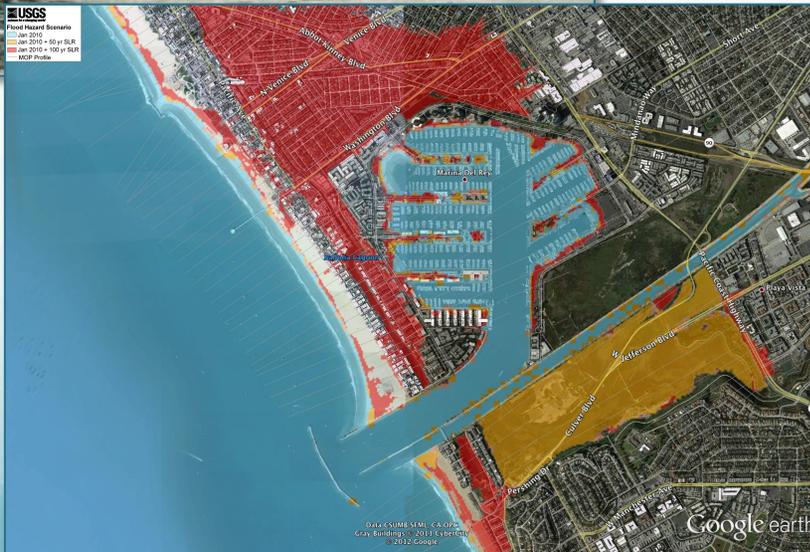
- Physical modeling of processes that affect water levels – tides, surge & wave-driven processes (set up and run up)
- Based on time scale of storms
- Examples from S.D. area
 - CoSMoS 3.0
 - SPAWAR
 - BreZo

about CoSMoS

Coastal Storms Modeling System (CoSMoS)

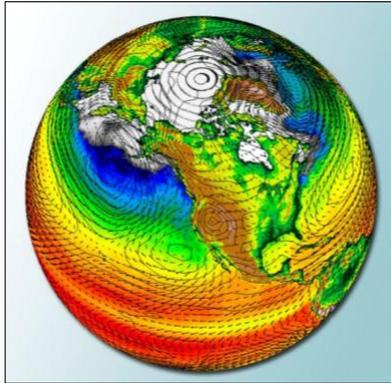
- Dynamic - Physics-based numerical modeling system for assessing coastal hazards on West Coast
- Predicts coastal hazards for:
 - Full range of SLR scenarios (0 – 2 m & 5 m)
 - Annual, 10 yr, 20 yr and 100 yr storms
- Developing decision support tools to meet local adaptation planning needs

CoSMoS 1.0 – Pilot Study

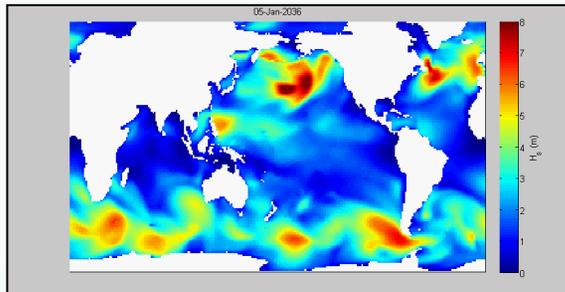


- Dr. Patrick Barnard & colleagues, USGS
- Pilot Study (2010)
 - Hindcasts Jan. 2010 storm (~10 yr storm)
 - Forecasts 10 yr storm @ current, 0.5 m & 1.4 m SLR
- Outer coast focus (protected bays not explicitly modeled)
- Flooding based on maximum wave runup

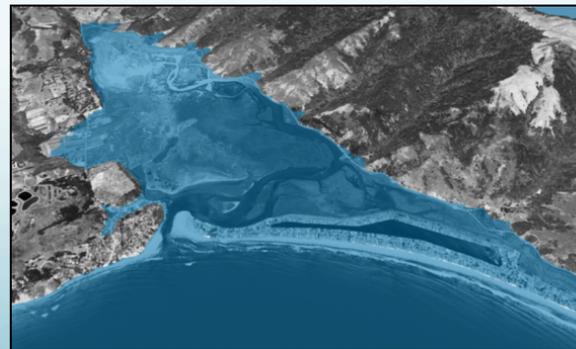
CoSMoS 2.0



Global forcing using the latest climate models

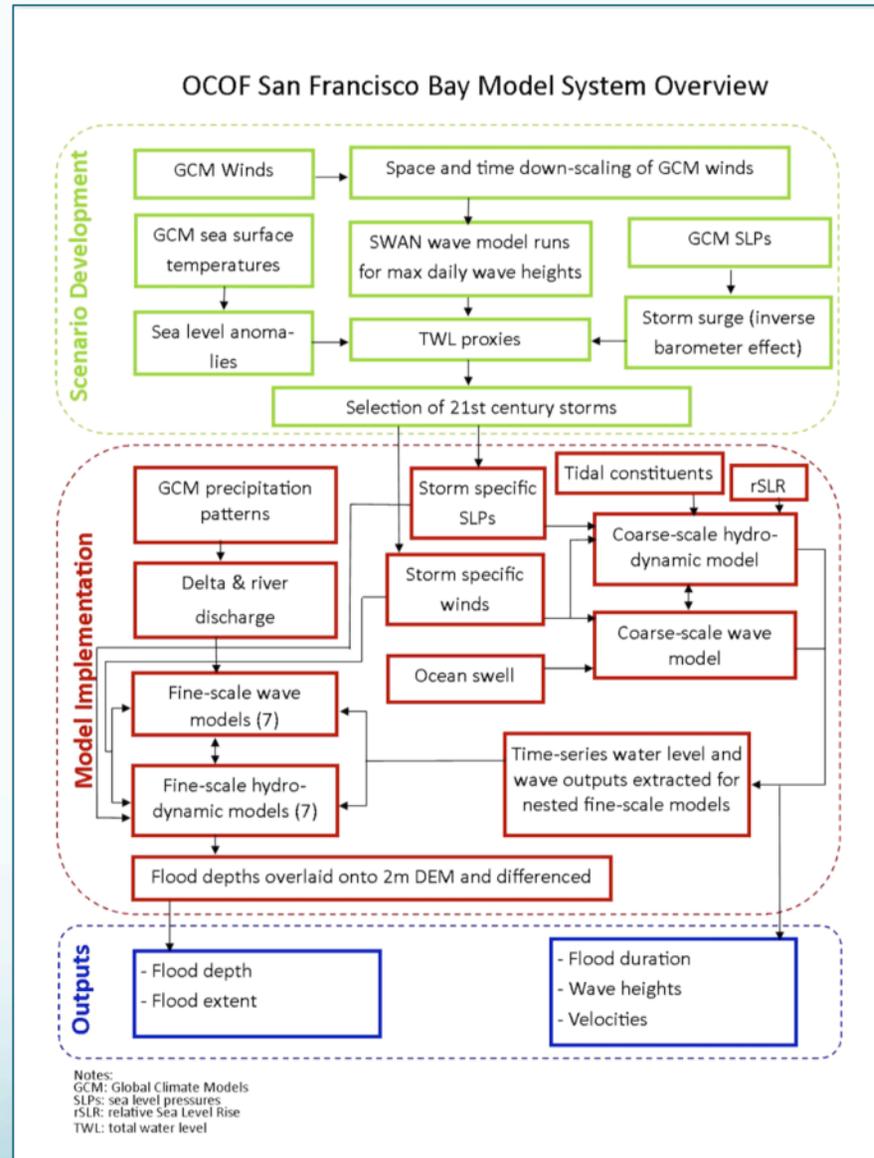


Drives global and regional wave models



Scaled down to local hazard projections

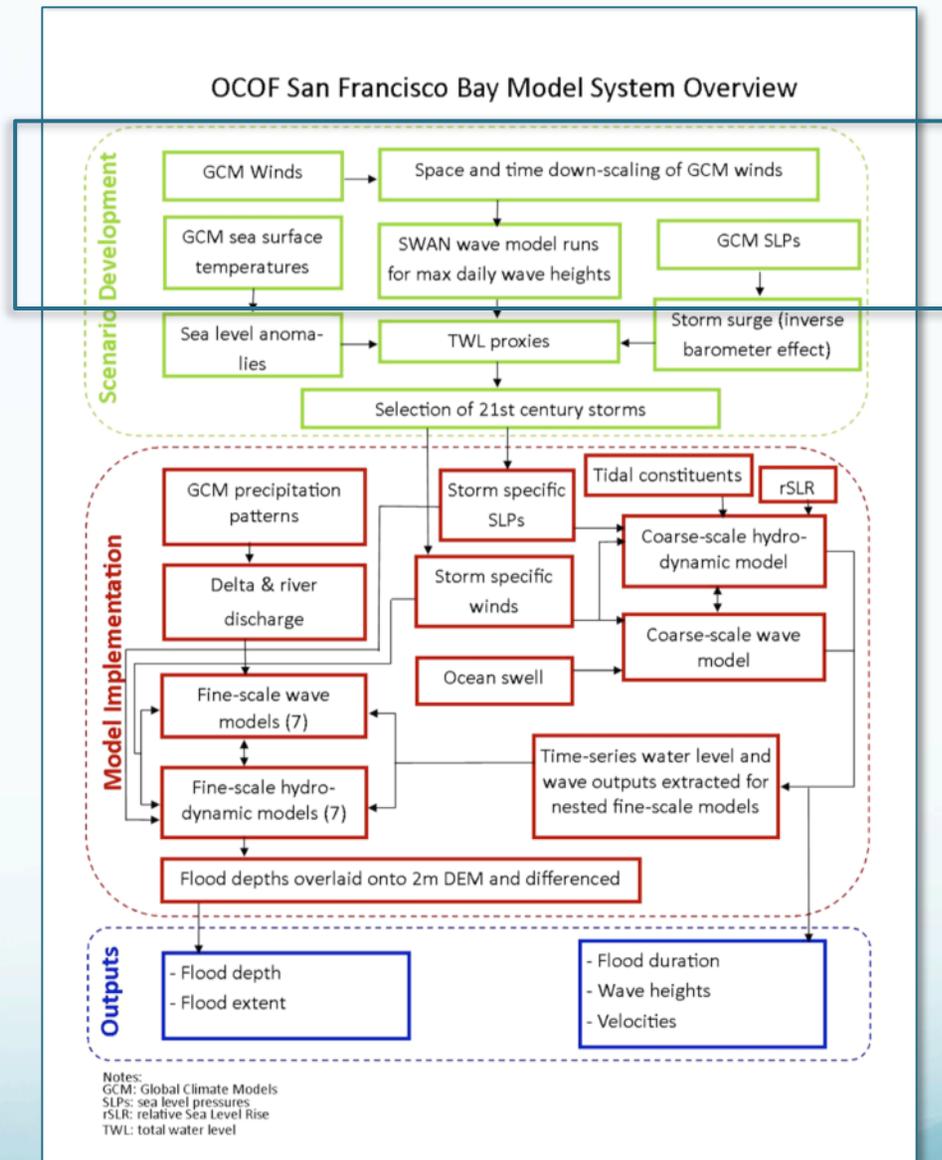
CoSMoS 2.0



CoSMoS 2.0

The DATA

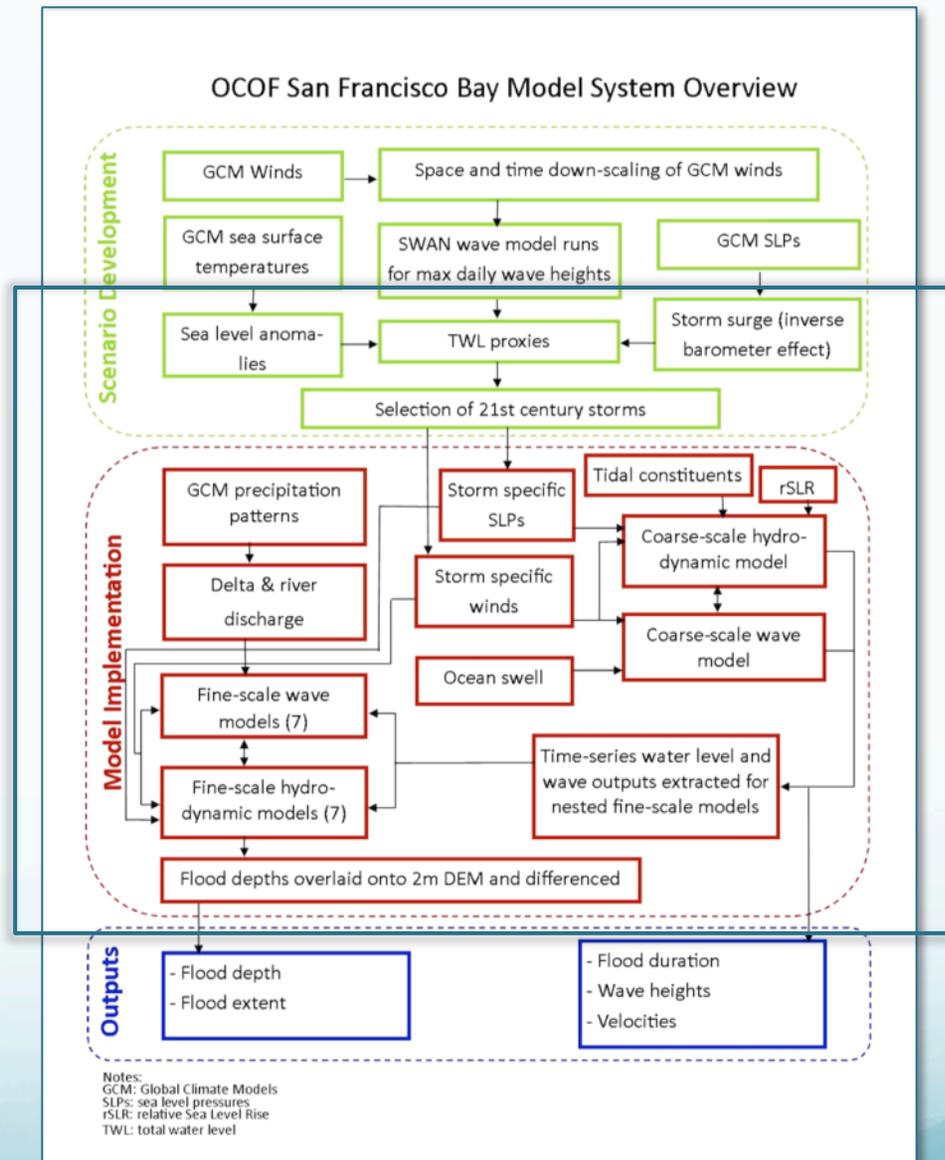
- Global Climate Models provide winds, sea surface temps, pressure



CoSMoS 2.0

The CODE

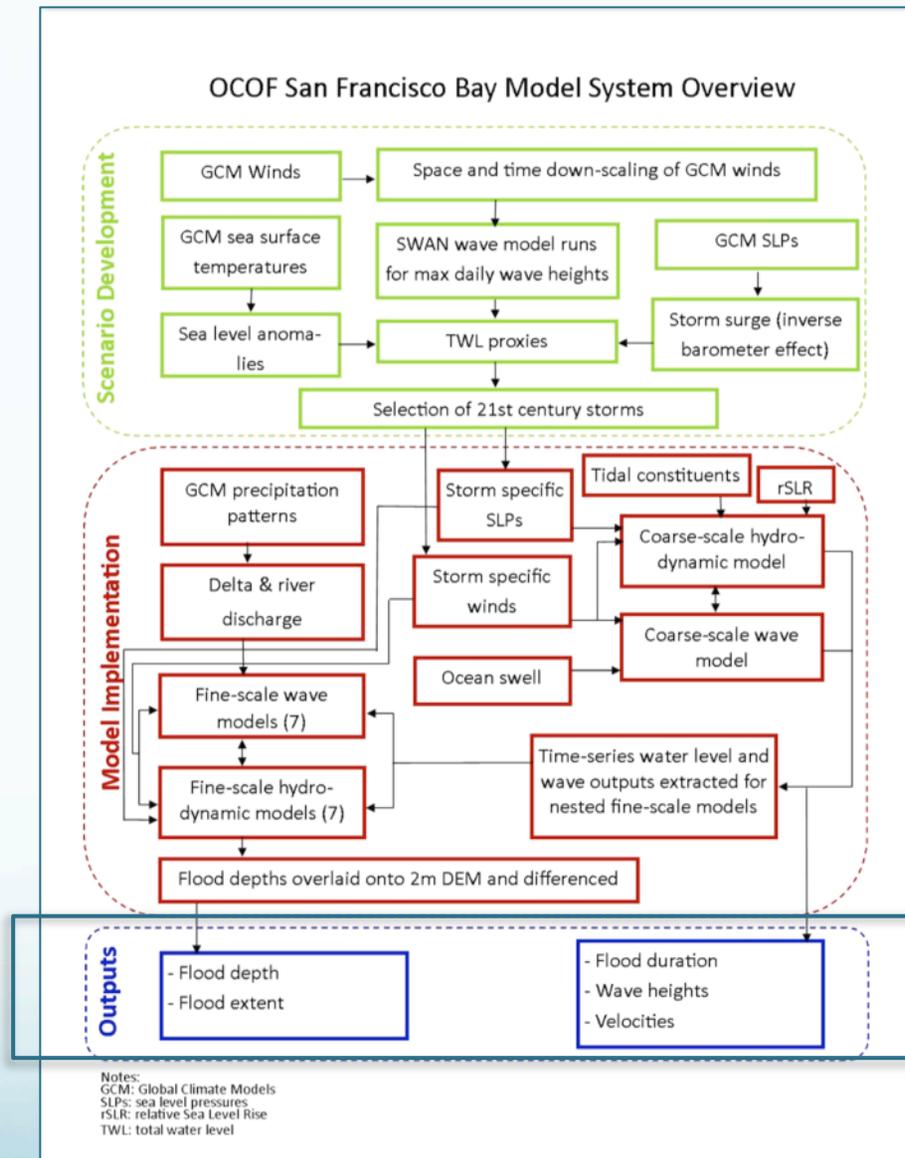
- Utilizes SWAN wave model to downscale waves and Xbeach to bring waves on shore
- Total Water Levels
 - SLR, tides, waves, SLA, storm surge, river discharge



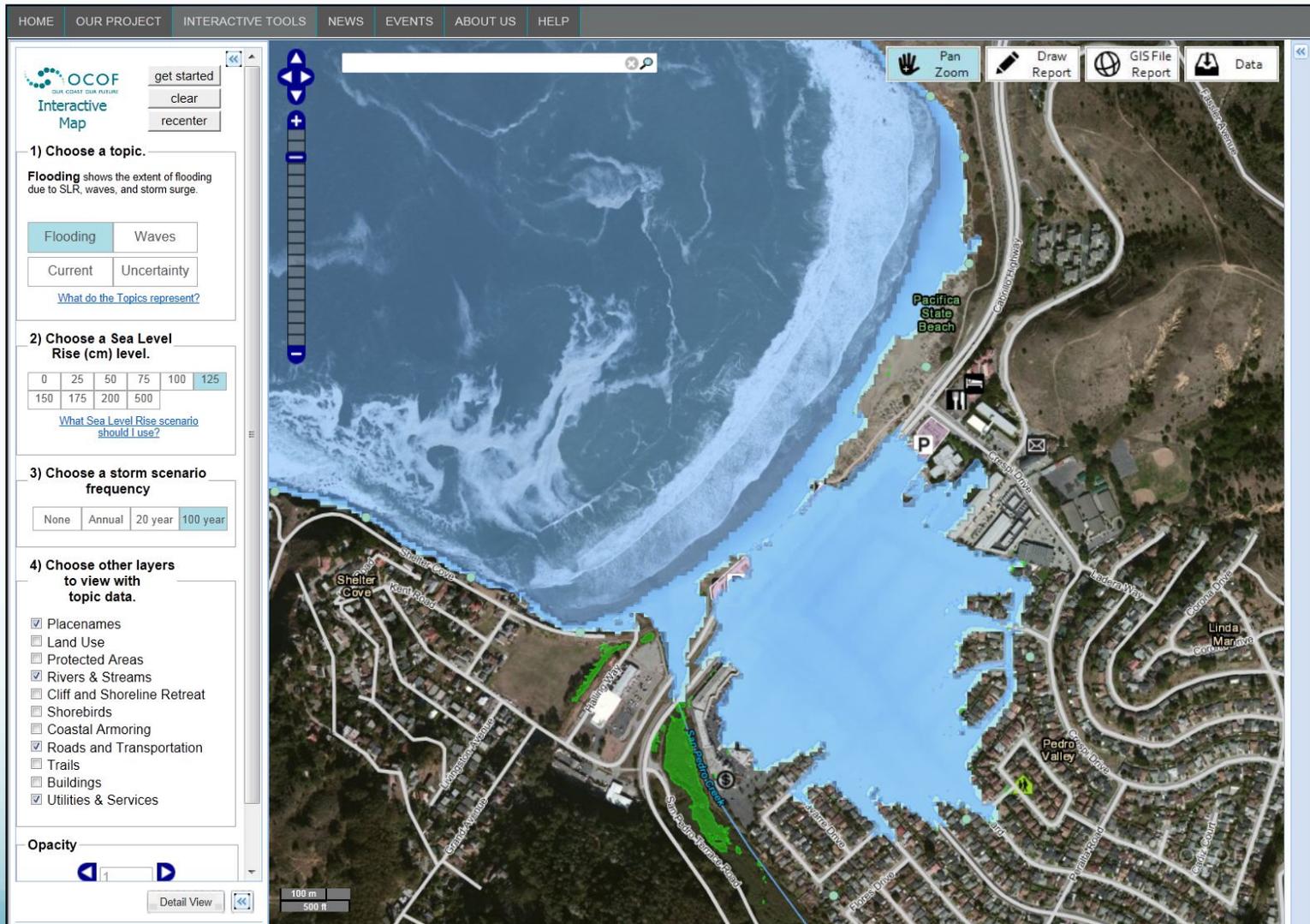
CoSMoS 2.0

The OUTPUTS

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



Extreme Event Impacts



<http://www.pointblue.org/ocof>

Uncertainty

The image displays two instances of the OCOF Interactive Map interface. The left instance shows the 'Flooding' topic selected, while the right instance shows the 'Potential' topic selected. Both instances show a map of a coastal city with red overlays indicating inundation. The right instance's legend shows 'Minimum Inundation 025cm SLR + Wave 01' in light red and 'Maximum Inundation 025cm SLR + Wave 01' in dark red. The interface includes search bars, navigation tools, and a data panel on the right.

<http://www.pointblue.org/ocof>

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

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



other regional SD models

An embarrassment of riches...

CA & S.D.-focused tools

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

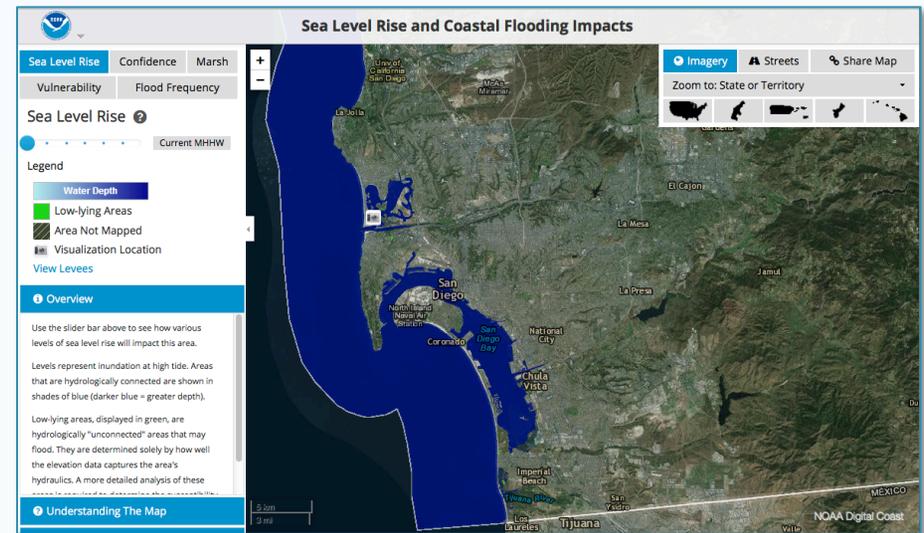
National tools

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

...And likely many more to come in the future...

NOAA Sea Level Rise Viewer

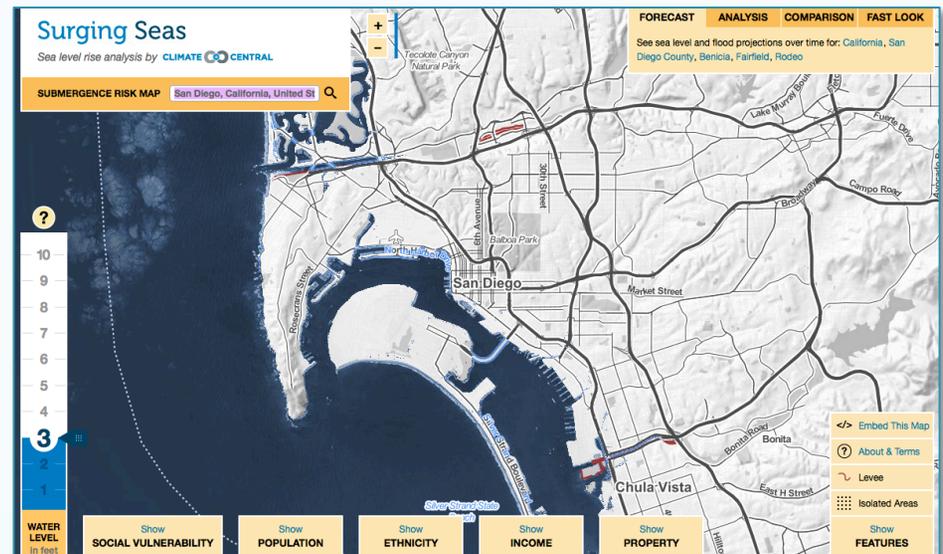
- Static Model (“Modified bathtub”)
- Doesn’t include storms, only tides
- Sliding scale of SLR scenarios
- Great for “1st order screening”



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

Climate Central Surging Seas

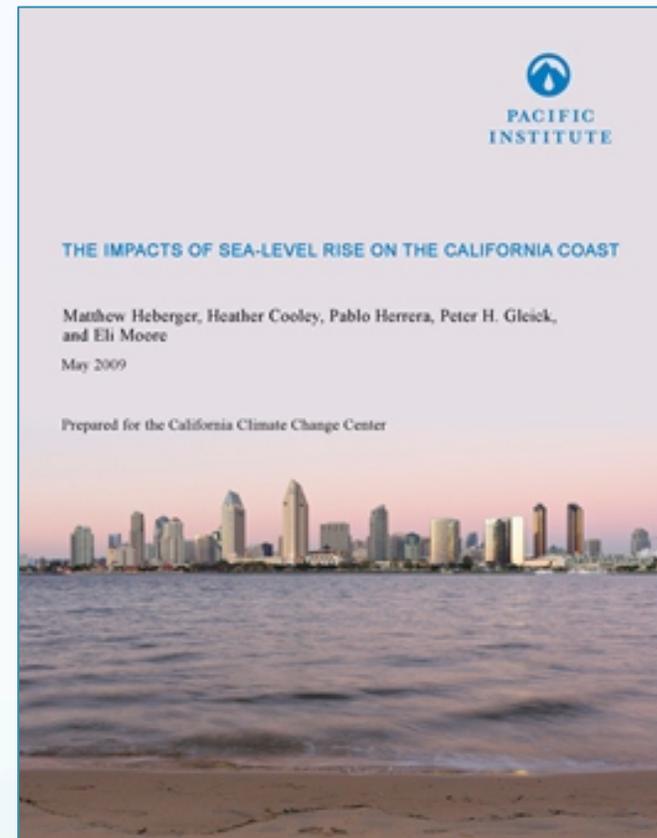
- Static Model (“Modified Bathtub”)
 - Back-end data exactly the same as NOAA SLR Viewer Data
- Includes social vulnerability
- Another good “1st order screening”



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

Pacific Institute

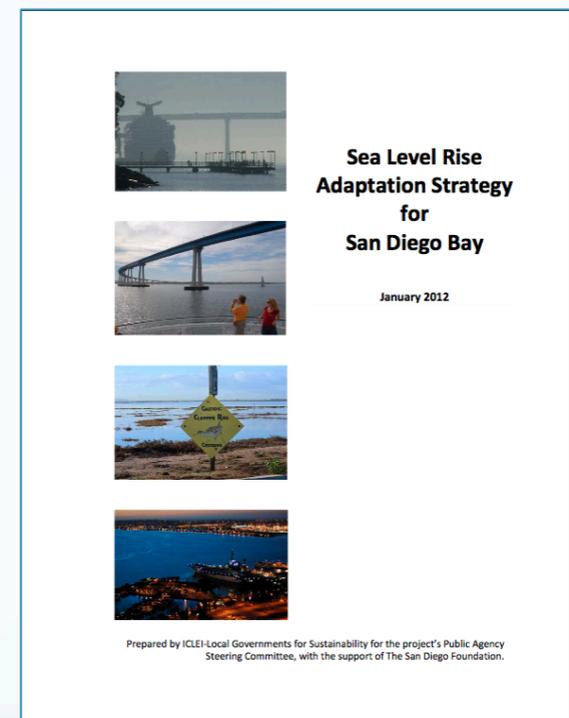
- Modeled by PWA
- “Hybrid” Static Model
 - Empirical relationships – no physics
 - included 100-yr storm event
 - two SLR scenarios (0.5 m and 1.5 m)
- Didn't include Scripps area
- Available on Cal-Adapt



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

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

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



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

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



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 overland flow model (based on civil engineering)
- OUTPUT
 - Sub-meter resolution
 - Fine-scale model validation at Newport

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

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

Questions?

