Santa Barbara and Ventura County CoSMoS Results

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Ventura Pier, December 2015
(Ricky Staub)
Santa Barbara Littoral Cell Coastal Processes Study (2005-present)

Scientific Objective: Gain a fundamental understanding of coastal change at a range of spatial and temporal scales, including climate change response

Data Collection:
- Beach and bathymetric change
- Regional survey (BEACON) lines
- Modeled sediment transport potential

Key Funding Partners: BEACON, CA Boating and Waterways, City of Carpinteria, and USACE
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)
Projections for Southern California

SLR for Los Angeles (NRC, 2012)
- 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)

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

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

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

**DYNAMIC:** CoSMoS (also TNC, FEMA)
- 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

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

Our Coast Our Future: www.prbo.org/ocof
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)
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
CoSMoS Version Summary
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
- Daily, annual, 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 1.0- Historical Storms and Climate Change

[Map showing flood hazard scenarios with USGS logo]
CoSMoS 2.0 - CenCal/NorCal

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
CoSMoS 3.0 Southern California

Global conditions of future climate scenarios

Local high resolution hydrodynamics and

Regionalized storm response to 20-year storm return

Regional tides, water levels, and regional forcing

Open coast phenomena

Fluvial discharge results projected onto hi-res DEM

High resolution hydrodynamics and waves

GCM winds project onto hi-res DEM

XBEACH

WW3 wave model

Coastal change

Delft FLOW-WAVE

VLM

CoSMoS science for a changing world
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
CoSMoS validated with January 2010 Storm

Los Angeles tide gauge

RMS = 12 cm
$R^2 = 0.97$

Predicted and observed/modelled 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
- Overlaid and differenced from the 2 m resolution DEM

To generate maps of flood extents, duration, and depth
CoSMoS Winter 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, grids for flood depth, max. waves and currents

- 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

Flooding – Regional Overview

Flooding – Santa Barbara

Flooding – Carpinteria

Flooding – Ventura River Mouth
Flooding – Santa Clara Alluvial Plain

[Map showing 100-year storm flood extent with SLR scenarios (cm): 0, 50, 100, 150, 200]

Flooding – Pierpont/Ventura Harbor

Flooding – Santa Clara River Mouth

Flooding – Channel Islands Harbor

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):

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

Model type:
- longshore + cross-shore + rate
- cross-shore + rate
- historical rate only
- no prediction (sea-wall, harbor, etc.)
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 – Gaviota
Shoreline Projections – Goleta
Shoreline Projections – East Beach
Shoreline Projections – Ventura Pier
Shoreline Projections – Pierpont
Shoreline Projections – Santa Clara River
Shoreline Projections – Mugu
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)*

Walkden & Hall, 2005; 2011
Results
Cliff Retreat Projections – Gaviota
Cliff Retreat Projections – El Cap
Cliff Retreat Projections – Mesa
Cliff Retreat Projections – Summerland
Cliff Retreat Projections – Carpinteria
Cliff Retreat Projections – South Ventura Co.
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: 100 cm
    - 25 cm: 125 cm
    - 50 cm: 150 cm
    - 75 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

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