DOCKETED

Docket Number:	15-AFC-01
Project Title:	Puente Power Project
TN #:	220878
Document Title:	Presented portions of USGS_CoSMoS_Presentation_July_2017
Description:	Portions of TN220369 that were actually shown during the July 26, 2017 Evidentiary Hearing. Curated by Hearing Officer Kramer as agreed by the parties (July 27, 2017, Transcript, pp. 318 - 320).
Filer:	Paul Kramer
Organization:	Energy Commission Hearing Office
Submitter Role:	Committee
Submission Date:	8/24/2017 6:41:22 PM
Docketed Date:	8/25/2017

USGS
science for a changing world

Coastal Vulnerability in Ventura County using CoSMoS

Patrick Barnard, Li Erikson, Juliette Finzi Hart, Amy Foxgrover, Liv Herdman, Patrick Limber, Andy O'Neill, Sean Vitousek, and Jonathan Warrick

Pacific Coastal and Marine Science Center, Santa Cruz, CA

U.S. Department of the Interior
U.S. Geological Survey

CoSMoS Coastal Storm Modeling System USGS

Collaborators and funders:

State of California Ocean Protection Council

Tijuana River National Estuarine Research Reserve

Resources Agency California Department Fish & Game

NOAA

OSU Oregon State University

Sea Grant

Scripps Institution of Oceanography UCSD

Coastal Conservancy

California natural resources agency

City of Imperial Beach

Point Blue

What is CoSMoS?

- **Physics-based numerical modeling system for assessing coastal hazards due to climate change**
- **Ongoing development for the last decade**
- **Utilizes models that have been developed over the past several decades**
- **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**
- **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)**
- **Designed for community-scale planning**

Ventura Pier, December 2015
(Ricky Staub)

What makes CoSMoS unique?

- Explicit, high-resolution, dynamic modeling of waves, currents, storm surge, flooding, and beach change
- Considers the future evolution of storm patterns based on the latest Global Climate Models
- Uses state-of-the-art projections of (dynamically-downscaled) winds and waves to calculate surge and seas
- Extensively tested, calibrated, and validated with local, historic data on waves, water levels and coastal change
- Flood projections are based on dynamic wave set-up, i.e., any area that is wet for at least 1 minute during a storm scenario
- Flooding is determined by the dynamic interaction of the evolving profile and ocean conditions during the storm event, including dune erosion and overtopping, and also the preceding long-term evolution of the coast
- Coastal change projections are based on a series of strenuously tested, peer-reviewed models, and calibrated by the local behavior of the coast
- Predicts the horizontal and vertical evolution of the entire beach profile through time

The CoSMoS Team*- who are we?

Research Director
Patrick Barnard, Ph.D.

Modeling Director
Li Erikson, Ph.D.

CoSMoS Manager
Andy O’Neill, M.S.

Hydrodynamic Modeling
Liv Herdman, Ph.D.
Rose Martyr, Ph.D.
Jessica Lovering, Ph.D.

Global Wave Modeling
Christie Hegermiller, Ph.D. candidate

GIS
Amy Foxgrover, M.S.

Cliff Modeling
Pat Limber, Ph.D.

Shoreline Modeling
Sean Vitousek, Ph.D.

Field Work
Dan Hoover, Ph.D.
Alex Snyder. M.S.

Director of Outreach
Juliette Hart, Ph.D.

***collectively over 150 years of experience in numerical modeling, oceanography, civil engineering, atmospheric science, and coastal geology**

The CoSMoS Team- who are we?

DEMs
Jeff Danielson, Dean Tyler (USGS EROS Data Center)

Socioeconomics
Nate Wood, Jeanne Jones, Matt Jamieson (USGS Western Geographic Science Center)

Our Coast – Our Future Web Tool
Michael Fitzgibbon, Maya Haden, Sam Veloz, Grant Ballard, Julian Wood (Point Blue)

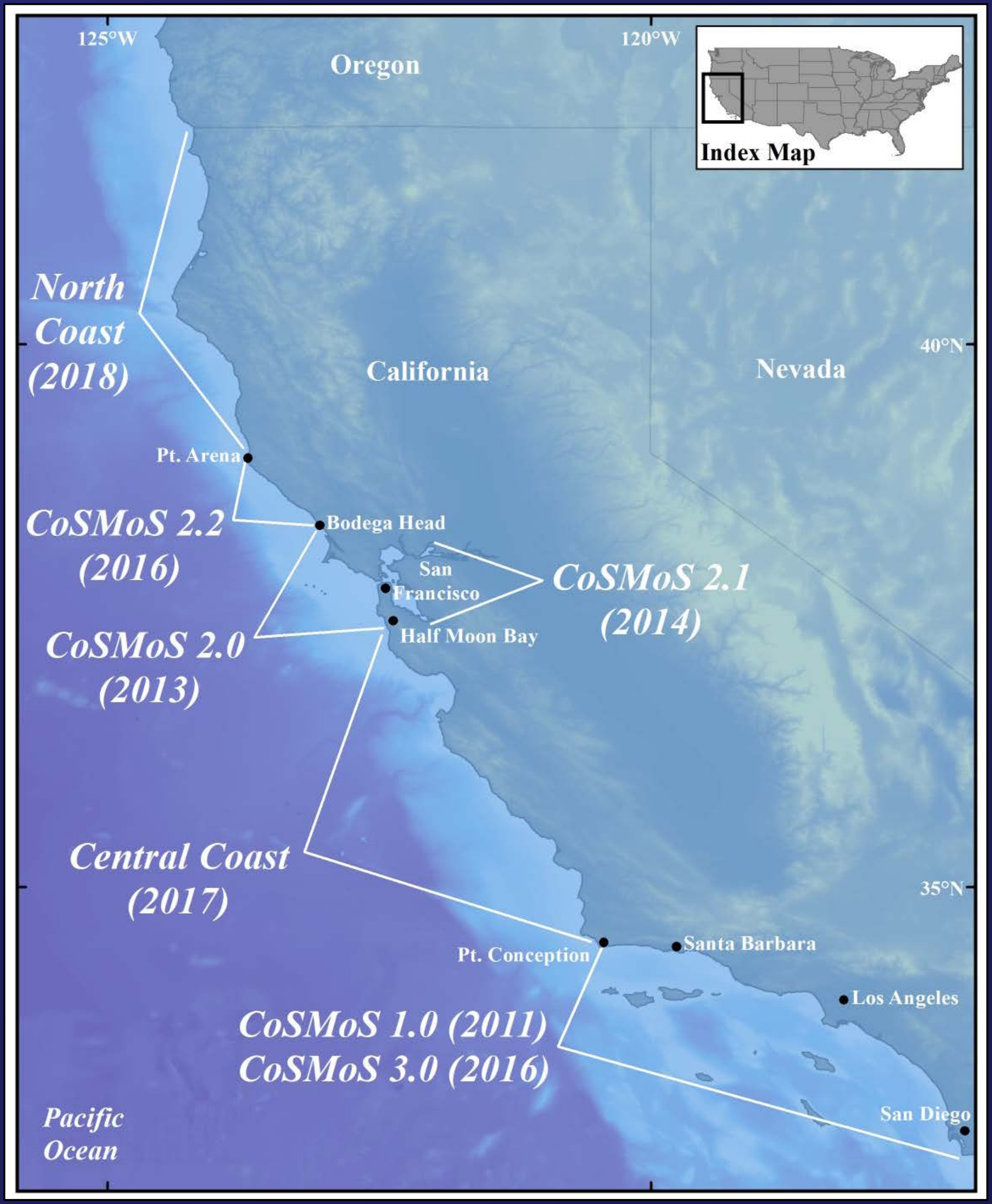
Modeling Support
Maarten van Ormondt, Edwin Elias (Deltares)

Dynamical Downscaling
Dan Cayan, David Pierce (Scripps)

Statistical Downscaling
Fernando Mendez (U. of Cantabria)

Additional Collaborations
Oregon State University (Ruggiero), U. of Hawaii (Fletcher), UC Berkeley (Stacey)

Where has CoSMoS been applied?



CoSMoS Coastal Storm Modeling System USGS

Who uses CoSMoS?

County

- Sonoma County
- Marin County
- Santa Mateo County
- Santa Clara County
- Santa Barbara County
- Los Angeles County
    - Office of Emergency Management
    - Department of Beaches and Harbors
- San Diego County

State

- California Coastal Commission
- California Coastal Conservancy
- California Department of Emergency Services (CalOES)
- California Department of Fish & Wildlife
- California Department of Transportation (CalTrans)
- California Energy Commission
- California Natural Resources Agency
- California Ocean Protection Council

Federal

- National Park Service
- NOAA Gulf of Farallones National Marine Sanctuary
- NOAA Office for Coastal Management
- National Estuarine Research Reserve (NOAA)

Who uses CoSMoS?

City

- City of San Francisco
- City of Pacifica
- City of San Jose
- City of Santa Barbara
- City of Los Angeles
- City of Santa Monica
- City of Hermosa Beach
- City of Long Beach
- City of Huntington Beach
- City of Imperial Beach
- City of Oceanside
- City of Encinitas
- City of Carlsbad
- City of San Diego
- City of Imperial Beach

Regional Scale

- AdaptLA: Coastal Impacts Planning for the LA Region
- California Climate Science Alliance
- Coastal Ecosystem Vulnerability Assessment (CEVA, Santa Barbara)
- LA Regional Collaborative on Climate Action and Sustainability (LARC)
- Regional Water Quality Control Board for LA and Ventura Counties
- San Diego Regional Climate Collaborative
- Southern California Coastal Water Research Project (SCCWRP)
- Wetlands Recovery Projects (San Diego - Orange County region & LA - Ventura - Santa Barbara region)

Where can I get more information?

USGS CoSMoS website:

http://walrus.wr.usgs.gov/coastal_processes/cosmos/

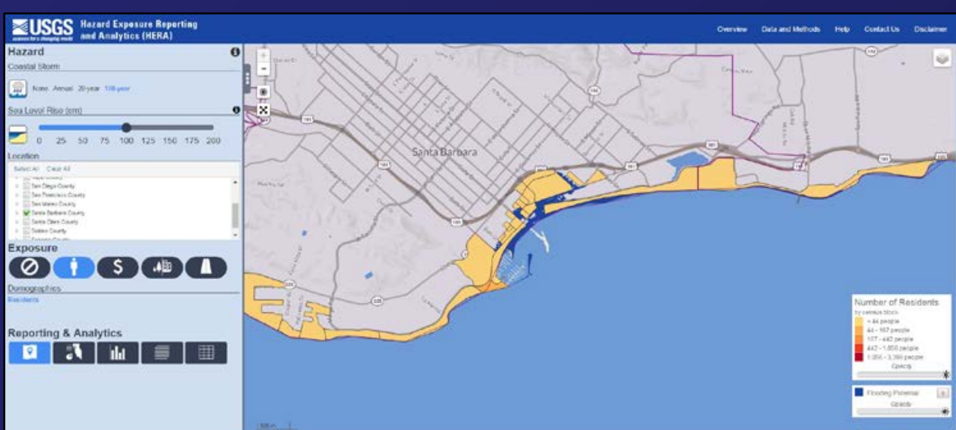
Data and detailed technical report:

https://www.sciencebase.gov/catalog/item/5633fea2e4b048076347f1cf

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

http://beta.ourcoastourfuture.org

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



Supporting References
(peer-reviewed)

Barnard, P.L., van Ormondt, M., Erikson, L.H., Eshleman, J., Hapke, C., Ruggiero, P., Adams, P.N. and Foxgrover, A.C., 2014. Development of the Coastal Storm Modeling System (CoSMoS) for predicting the impact of storms on high-energy, active-margin coasts. *Natural Hazards*, Volume 74 (2), p. 1095-1125, http://dx.doi.org/10.1007/s11069-014-1236-y

Erikson, L.H., Hegermiller, C.A., Barnard, P.L., Ruggiero, P. and van Ormondt, M., 2015. Projected wave conditions in the Eastern North Pacific under the influence of two CMIP5 climate scenarios. *Ocean Modeling*, Volume 96, p. 171-185, http://dx.doi.org/10.1016/j.ocemod.2015.07.004

Limber, P., Barnard, P.L. and Hapke, C., 2015. Towards projecting the retreat of California's coastal cliffs during the 21st Century. In: P. Wang, J.D. Rosati and J. Cheng (Eds.), *Coastal Sediments 2015 Conference Proceedings*, World Scientific, 14 pp., http://dx.doi.org/10.1142/9789814689977_0245

Vitousek, S. and Barnard, P.L., 2015. A non-linear, implicit one-line model to predict long-term shoreline change. In: P. Wang, J.D. Rosati and J. Cheng (Eds.), *Coastal Sediments 2015 Conference Proceedings*, World Scientific, 14 pp., http://dx.doi.org/10.1142/9789814689977_0215

Hegermiller, C.A., Antolinez, J.A.A., Rueda, A.C., Camus. P., Perez, J., Erikson, L.H., Barnard, P.L. and Mendez, F.J., 2016. A multimodal wave spectrum-based approach for statistical downscaling of local wave climate. *Journal of Physical Oceanography*, http://dx.doi.org/10.1175/JPO-D-16-0191.1

Hoover, D.J., Odigie, K.O., Swarzenski, P.W. and Barnard, P.L., 2016. Sea level rise and coastal groundwater inundation and shoaling at select sites in California. *Journal of Hydrology: Regional Studies*, 16 pp., http://dx.doi.org/10.1016/j.ejrh.2015.12.055

Danielson, J.J., Poppenga, S.K., Brock, J.C., Evans, G.A., Tyler, D.J., Gesch, D.B., Thatcher, C.A., and Barras, J.A., 2016, Topobathymetric elevation model development using a new methodology—Coastal National Elevation Database: Journal of Coastal Research, SI no. 76, p. 75–89, at http://dx.doi.org/10.2112/SI76-008

Palaseanu-Lovejoy, M., Danielson, J., Thatcher, C., Foxgrover, A., Barnard, P.L., Brock, J. and Young, A., 2016. Automatic delineation of seacliff limits using Lidar-derived high-resolution DEMs in Southern California. *Journal of Coastal Research*, Special Issue Volume 76, p. 162-173, http://dx.doi.org/10.2112/SI76-014

Thatcher, C.A., Brock, J.C., Danielson, J.J., Poppenga, S.K., Gesch, D.B., Palaseanu-Lovejoy, M.E., Barras, J.A., Evans, G.A., and Gibbs, A.E., 2016, Creating a Coastal National Elevation Database (CoNED) for science and conservation applications: Journal of Coastal Research, SI no. 76, p. 64–74, at http://dx.doi.org/10.2112/SI76-007

Vitousek, S., Barnard, P.L., Limber, P., Erikson, L.H. and Cole, B., in press. A model integrating longshore and cross-shore processes for predicting long-term shoreline response to climate change. *Journal of Geophysical Research-Earth Surface,* http://dx.doi.org/10.1002/2016JF004065

CoSMoS Coastal Storm Modeling System USGS

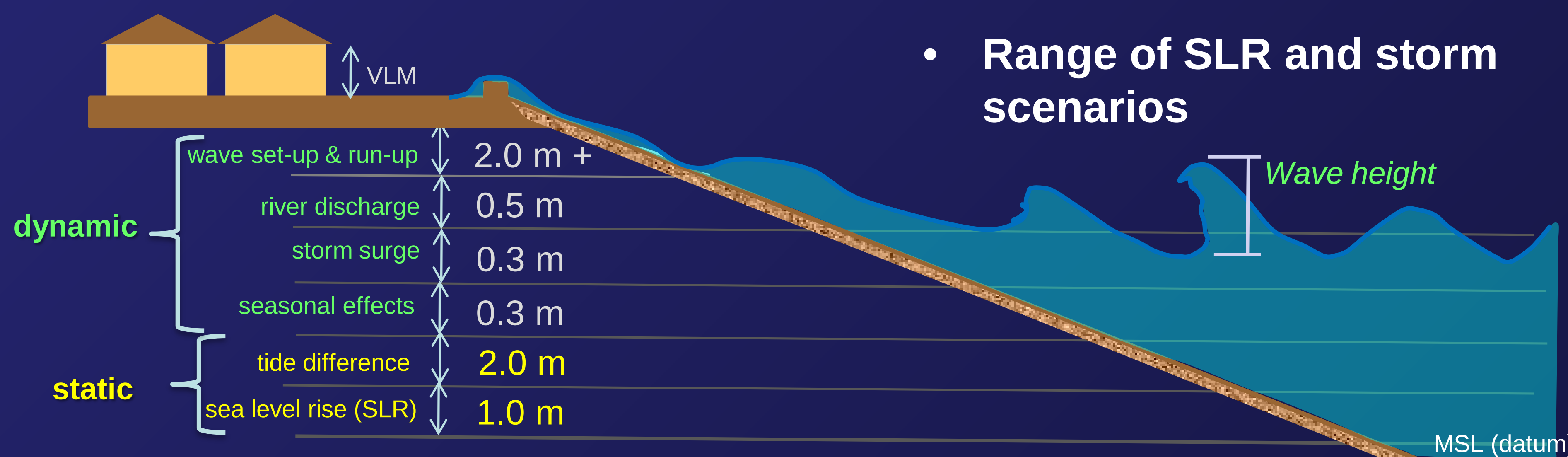
What's included in CoSMoS approach?

Static: SLR Viewer ("bathtub")

- Passive model, hydrological connectivity
- Tides only
- '1st order screening tool'

Dynamic: USGS CoSMoS

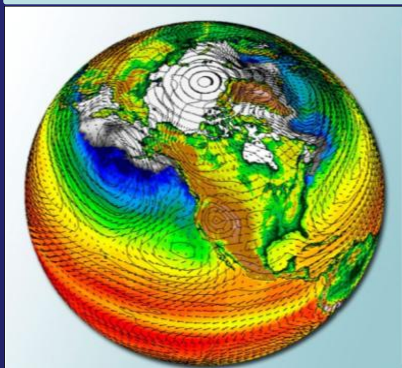
- All physics modeled
- Forced by Global Climate Models
- Includes wind, waves, atmospheric pressure, shoreline change
- Range of SLR and storm scenarios



CoSMoS Method

Global Scale

Deep water waves computed with WW3 and GCM winds



Regional Scale

Swell propagation, wave generation, storm surge, astronomic tides, and downscaled SIO winds/SLPs

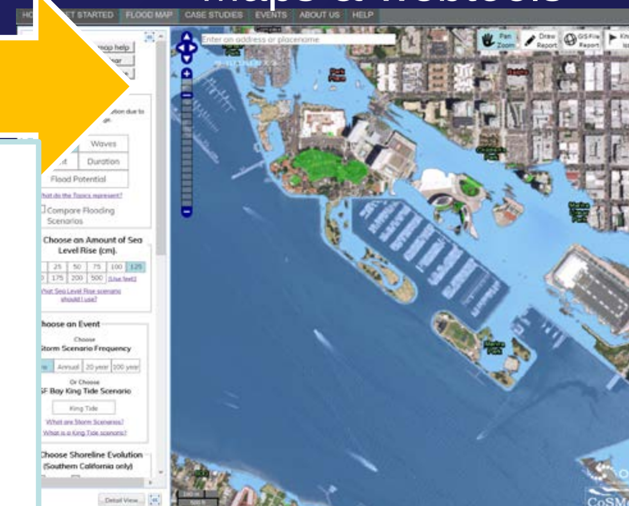
(Delft3D+SWAN)

Local Scale

Nearshore waves, wave setup and runup, storm surge, tides, overland flow, fluvial discharge, long-term topo-bathy change

(Delft3D+SWAN + XBEACH)

Maps & webtools



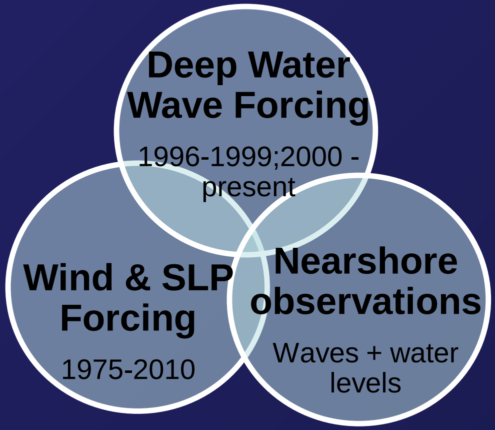
2m resolution DEMs

CoSMoS validation

CoSMoS model components and performance validated :

- **Extensive historical data including storms**
  Nov/Dec 1982
  Dec 2005
  Jan 2010

Storm events:

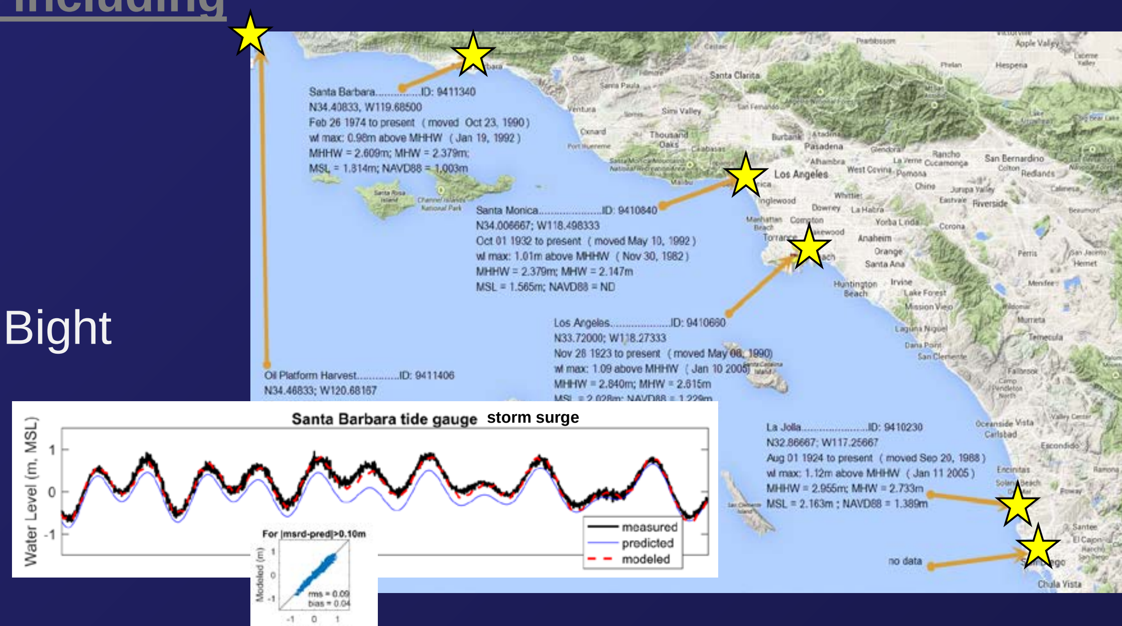


- **Water levels** – across the Bight
- **Waves** – buoys
- Wave runup
- **Storm-driven morphodynamic change** – XBeach
- **Long-term shoreline change** – CoSMoS Coast

CoSMoS validation

CoSMoS model components and performance validated :

- Extensive historical data including storms
  - Nov/Dec 1982
  - Dec 2005
  - Jan 2010
- **Water levels** – across the Bight
- Waves – buoys
- Wave runup
- Storm-driven morphodynamic change – XBeach
- Long-term shoreline change – CoSMoS Coast



CoSMoS validation

CoSMoS model components and performance validated :

- **Extensive historical data including storms**
  - Nov/Dec 1982
  - Dec 2005
  - Jan 2010

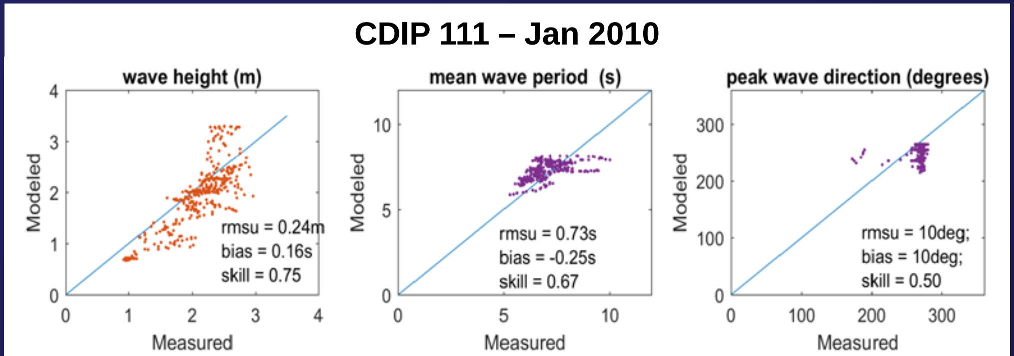
- **Water levels** – across the Bight

- **Waves** – buoys

- Wave runup

- **Storm-driven morphodynamic change** – XBeach

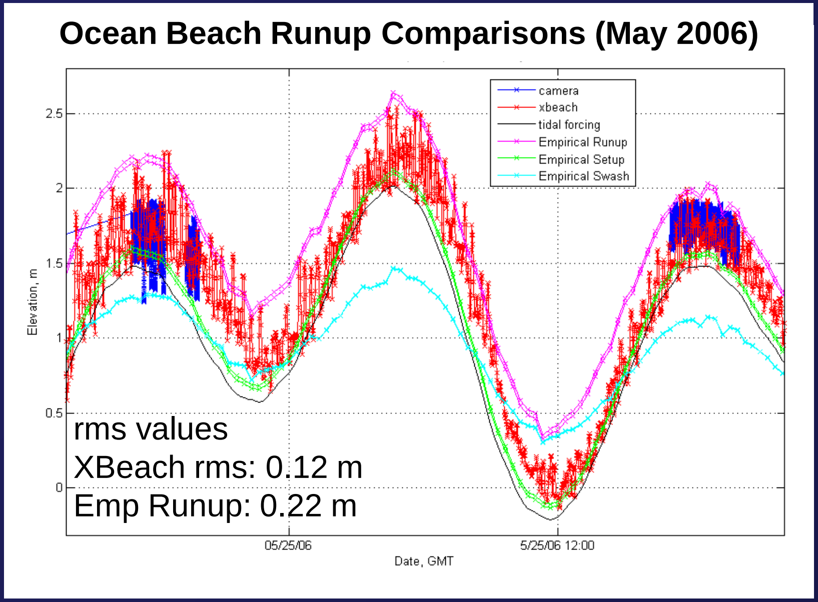
- **Long-term shoreline change** – CoSMoS Coast



CoSMoS validation

CoSMoS model components and performance validated :

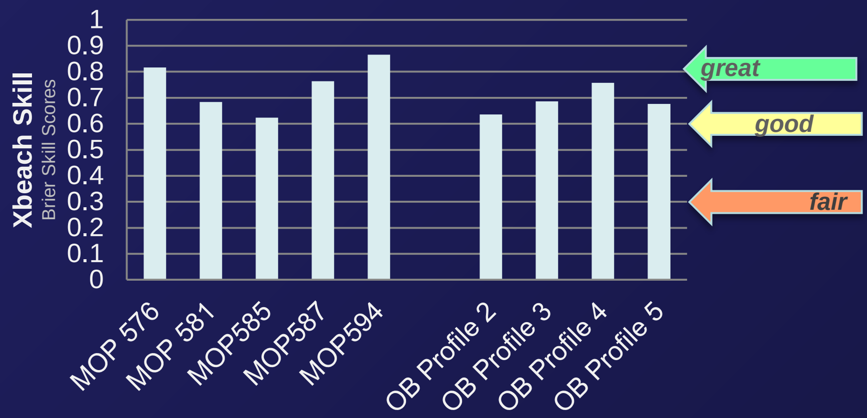
- **Extensive historical data including storms**
  - Nov/Dec 1982
  - Dec 2005
  - Jan 2010
- **Water levels** – across the Bight
- **Waves** – buoys
- **Wave runup**
- **Storm-driven morphodynamic change** – XBeach
- **Long-term shoreline change** – CoSMoS Coast



CoSMoS validation

CoSMoS model components and performance validated :

- **Extensive historical data including storms**
  - Nov/Dec 1982
  - Dec 2005
  - Jan 2010
- **Water levels** – across the Bight
- **Waves** – buoys
- **Wave runup**
- **Storm-driven morphodynamic change** – XBeach
- **Long-term shoreline change** – CoSMoS Coast



CoSMoS validation

CoSMoS model components and performance validated :

- Extensive historical data including storms
  Nov/Dec 1982
  Dec 2005
  Jan 2010

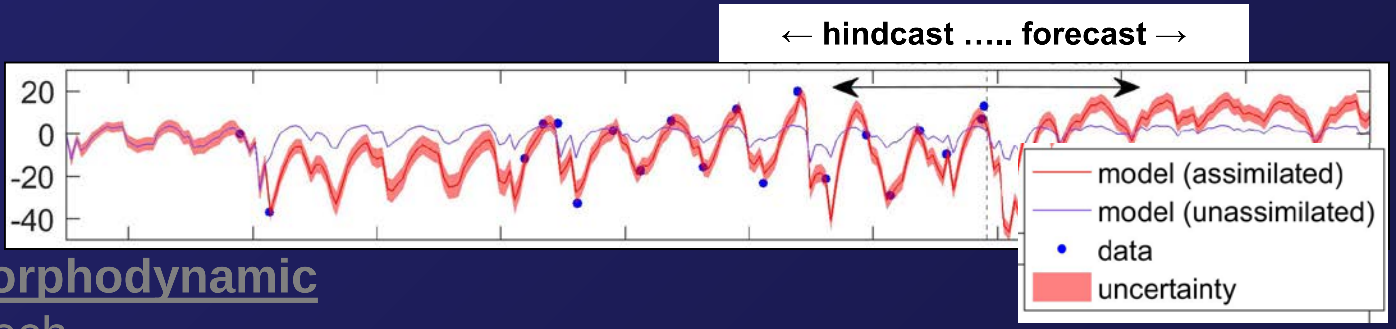
- Water levels – across the Bight

- Waves – buoys

- Wave runup

- Storm-driven morphodynamic change – XBeach

- Long-term shoreline change – CoSMoS Coast

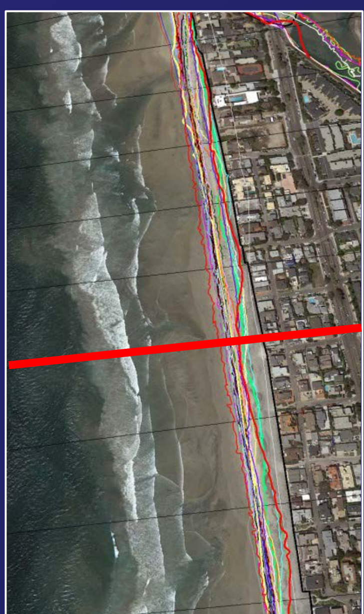


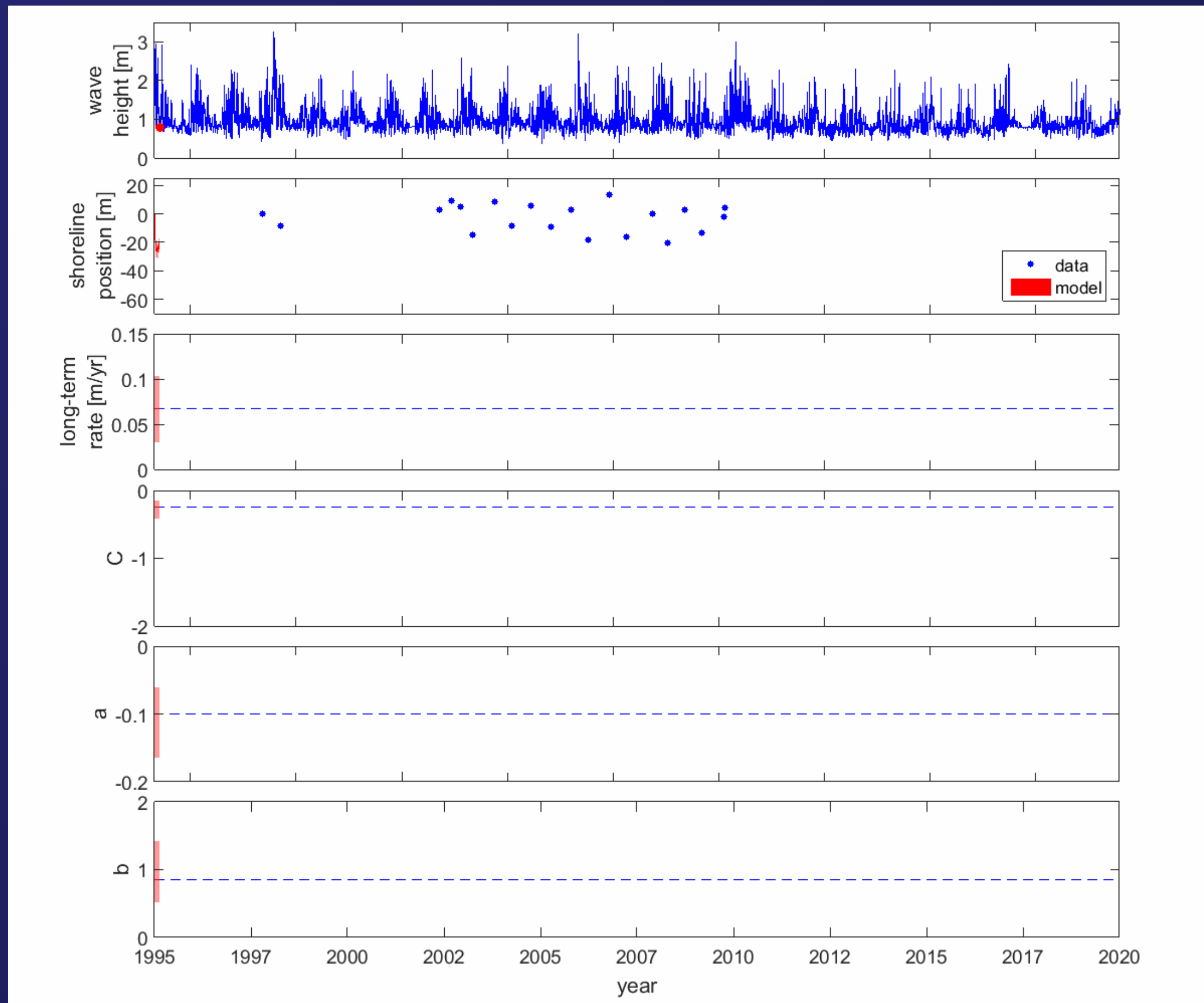
Data Assimilation

We use the *extended Kalman filter method* of Long & Plant 2012

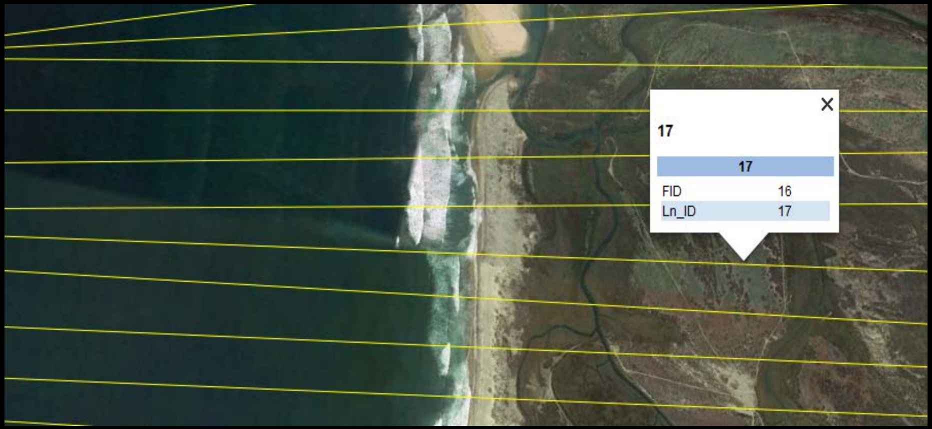
- Auto-tunes model parameters for each transect to best fit the historical shoreline data
- We improved the method to handle sparse shoreline data and ensure that parameters are positive or negative.

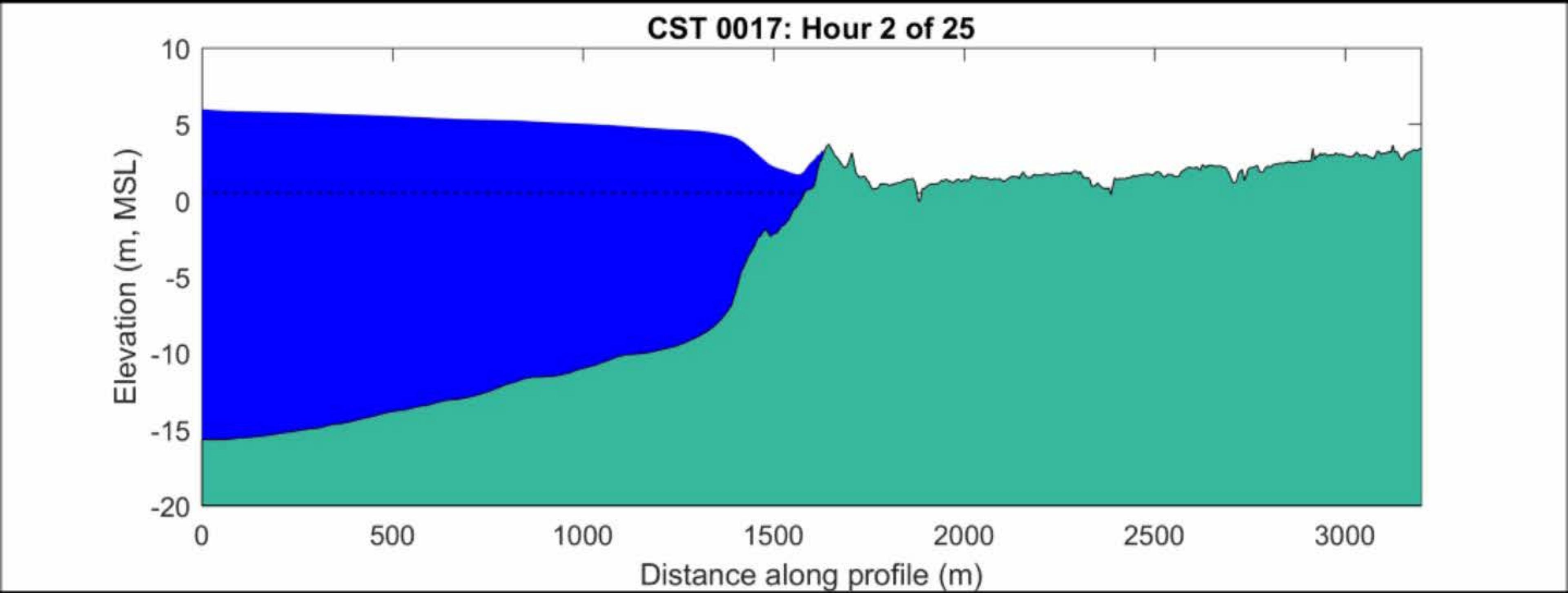
Simulation output for a single transect at Del Mar Beach:



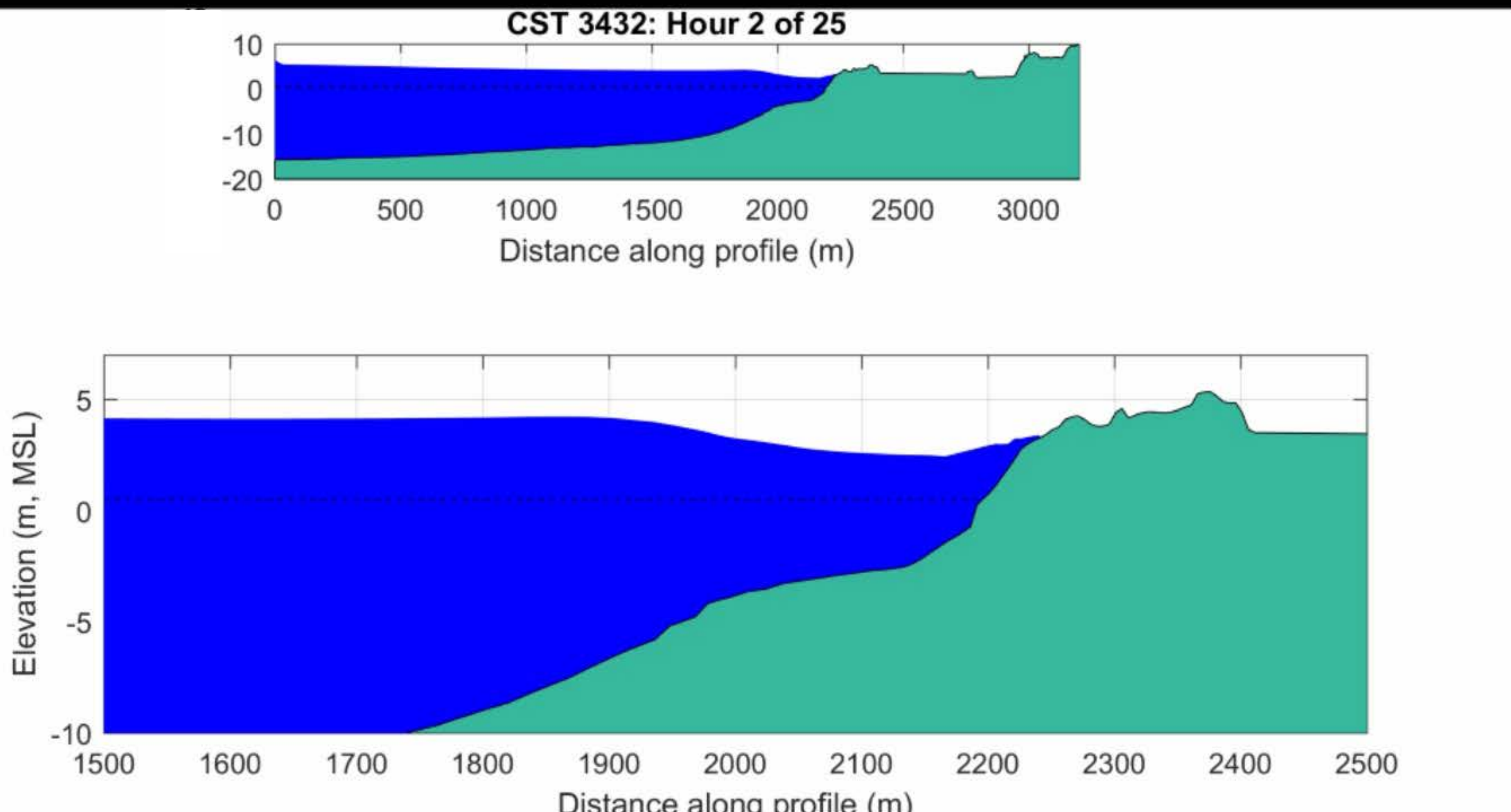


Dune field near Tijuana Estuary - XBeach simulation

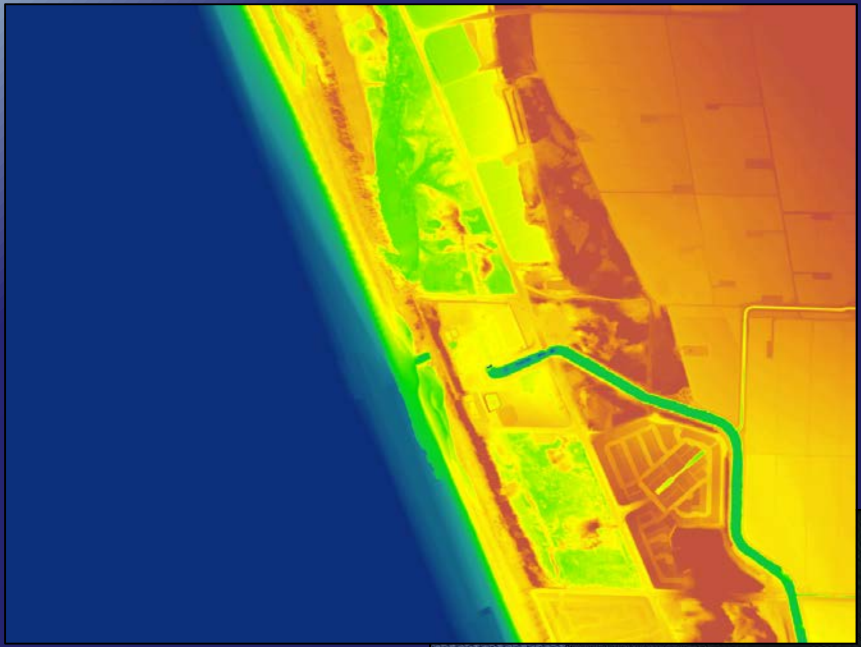





McGrath Lake
3433
3433
FID 3411
Ln_ID 3433


CST 3432: Hour 2 of 25
10
0
-10
-20
0
500
1000
1500
2000
2500
3000
Distance along profile (m)
Elevation (m, MSL)
5
0
-5
-10
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
Distance along profile (m)

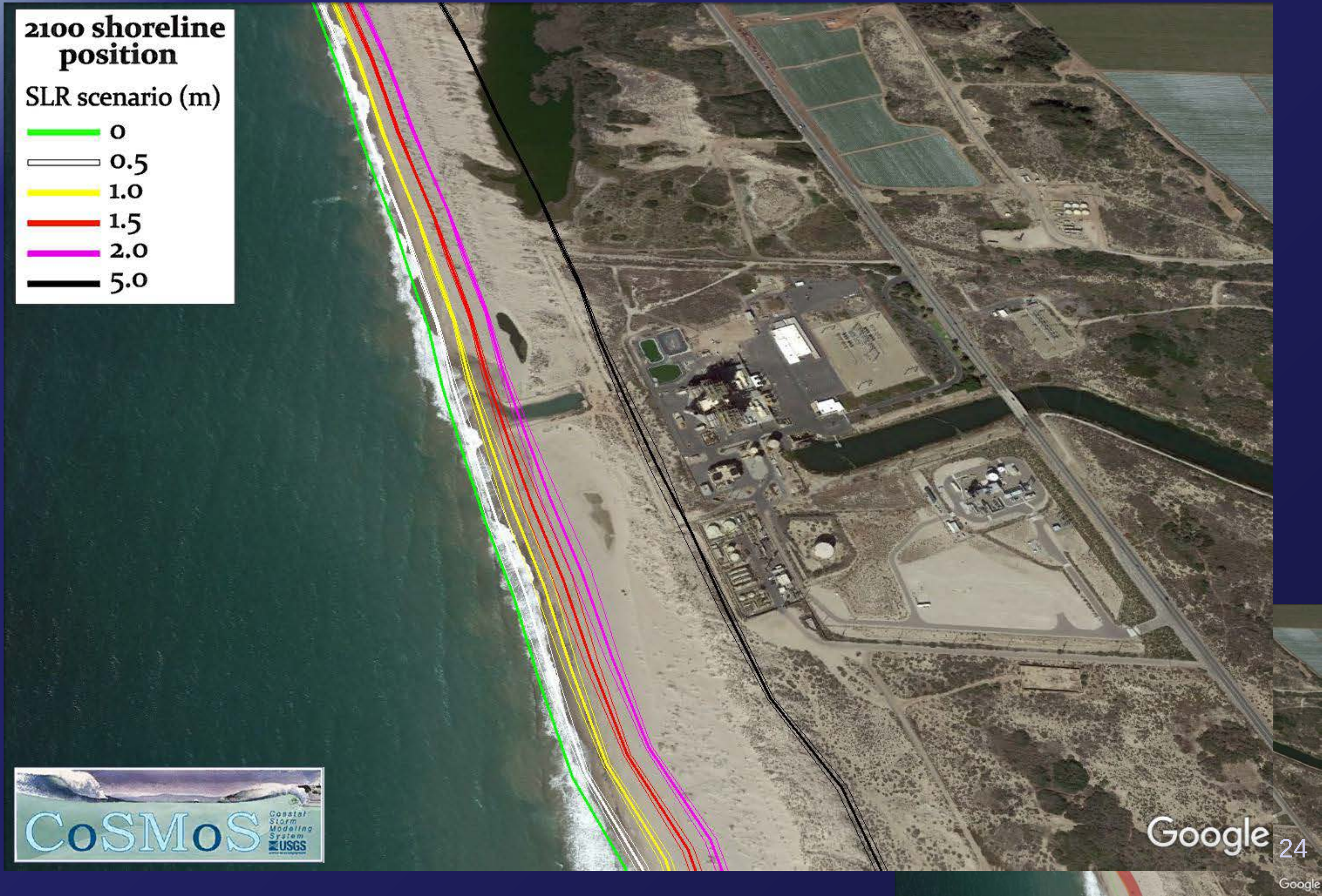
DEM and Computational Grids



DEM: 2 m horizontal resolution

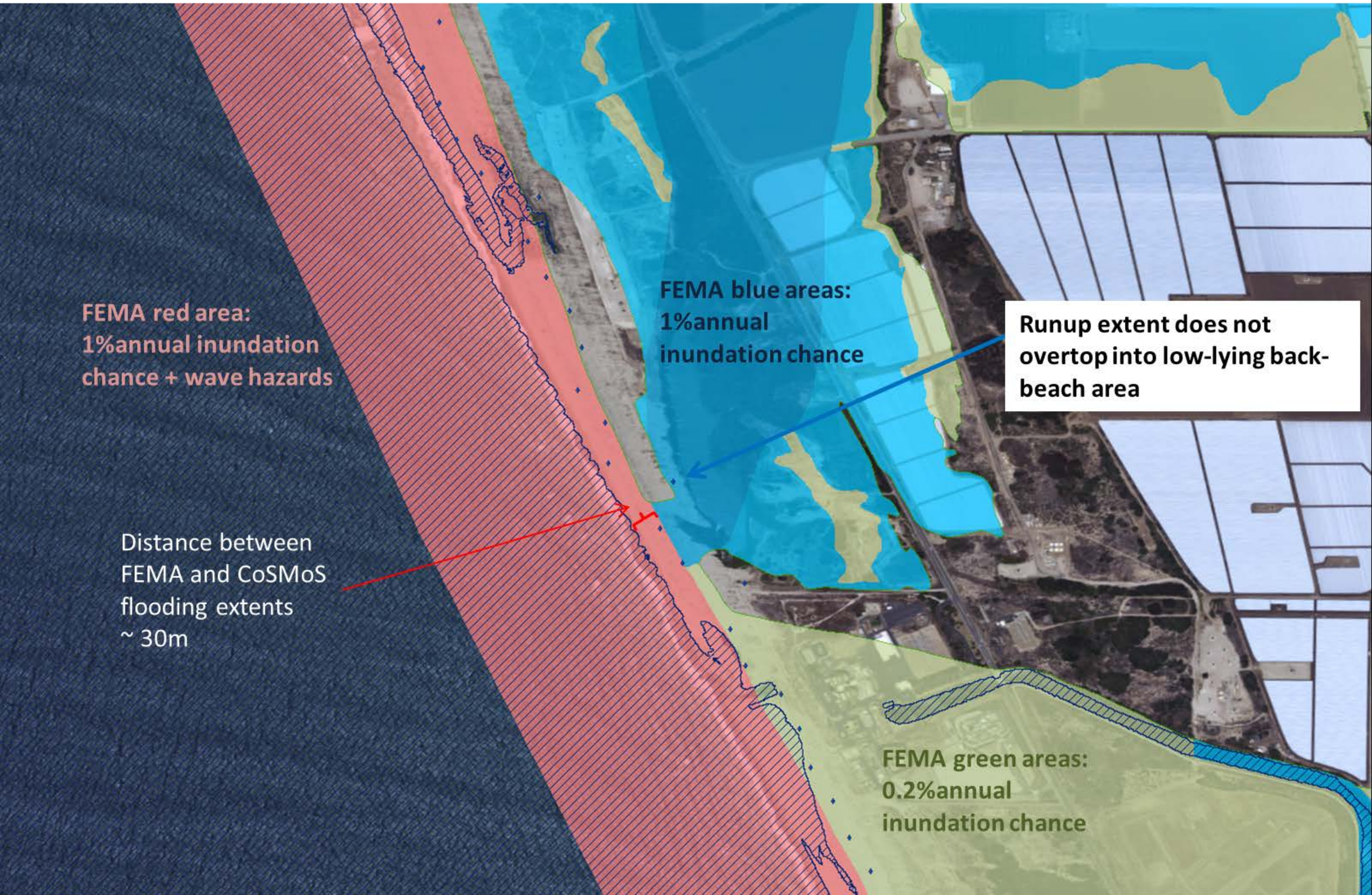
Hydrodynamic grids: 20 x 40 m

Shoreline Projections for 2050 + 100 year storm



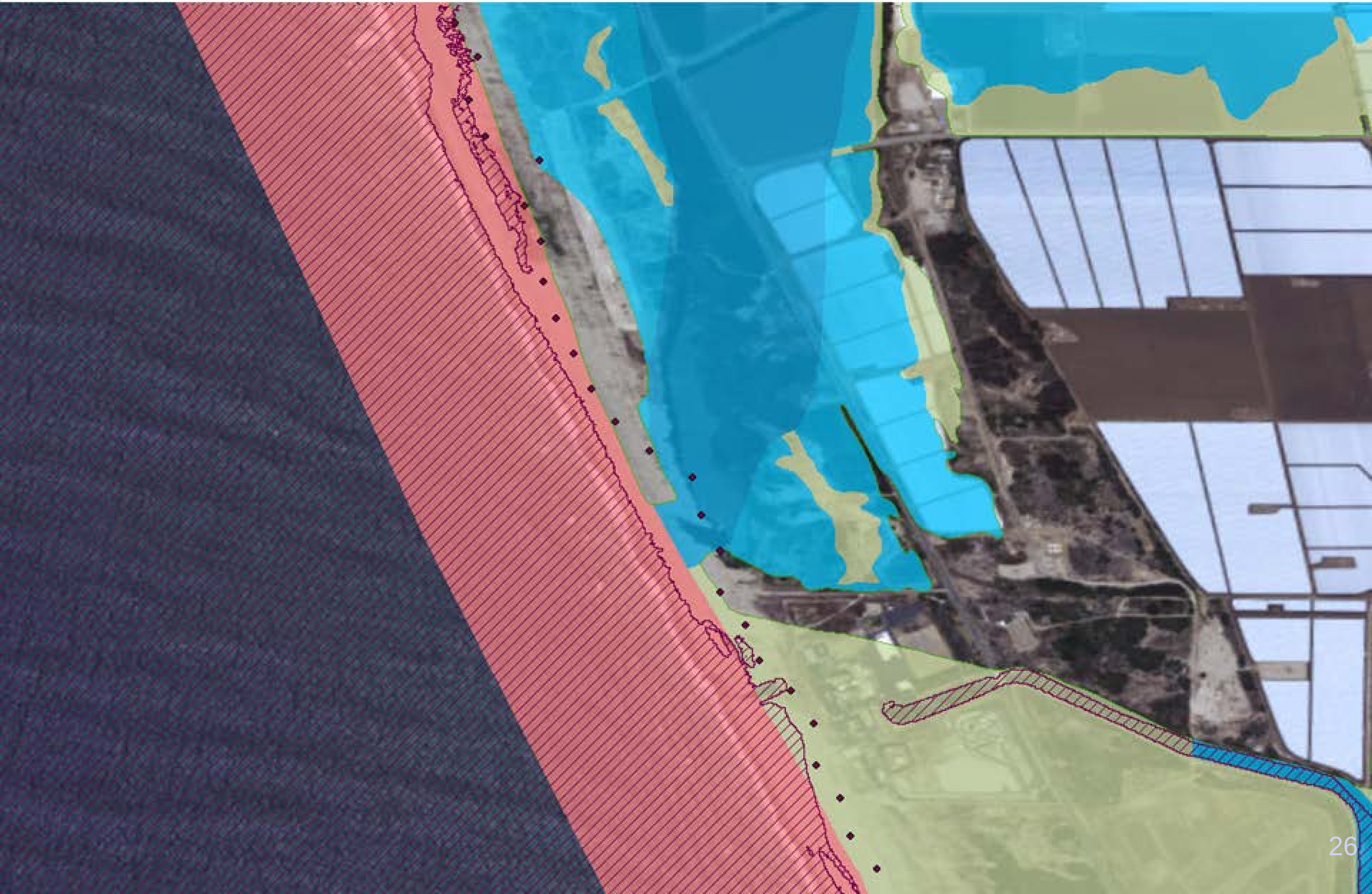
FEMA FIRM +

CoSMoS: SLR 0cm 100 yr (flood extent + runup)

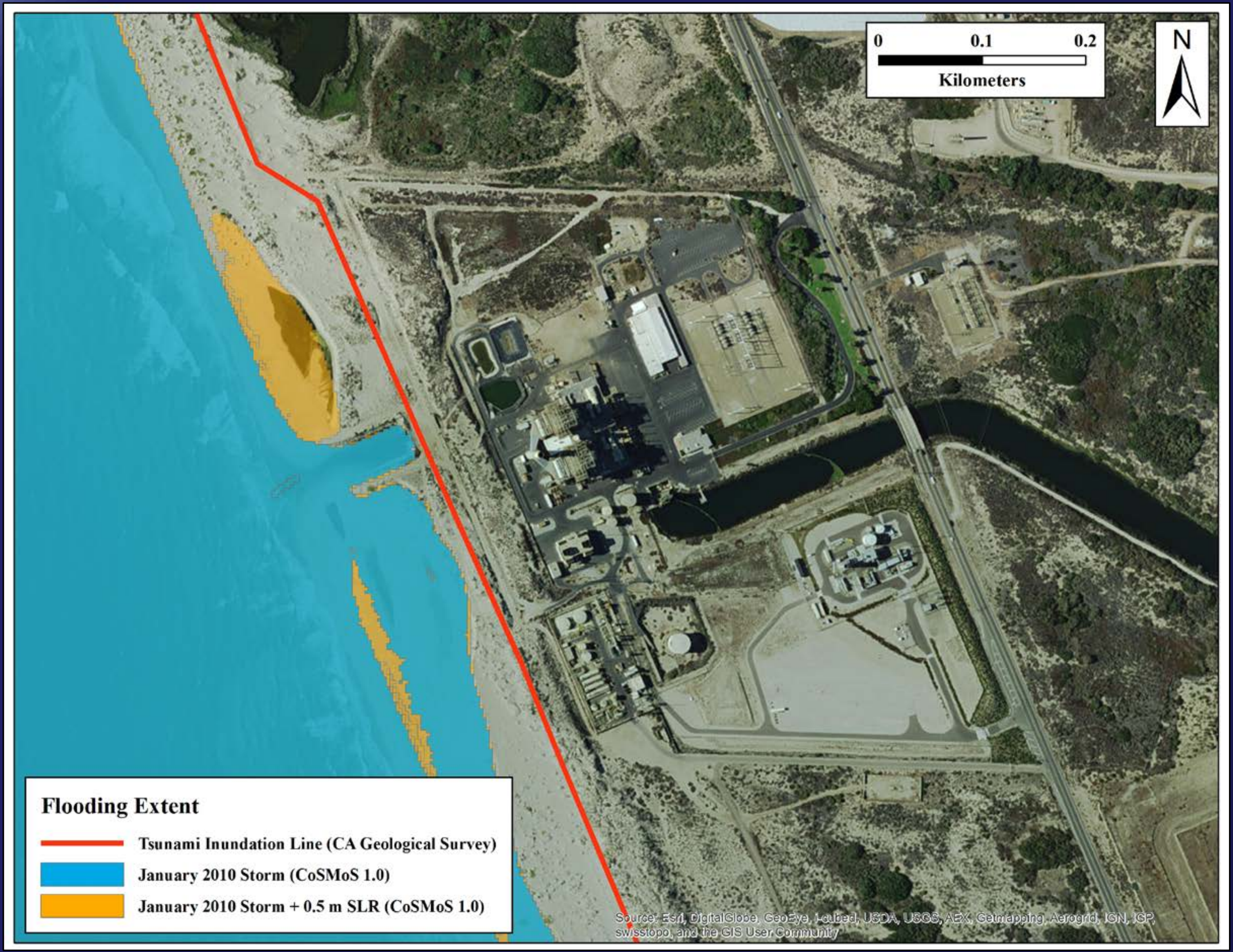


FEMA FIRM +

CoSMoS: SLR 50 cm 100 yr (flood extent + runup)



Tsunami Risk



Future Conditions

<u>SLR for Los Angeles (National Research Council)</u>
- -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

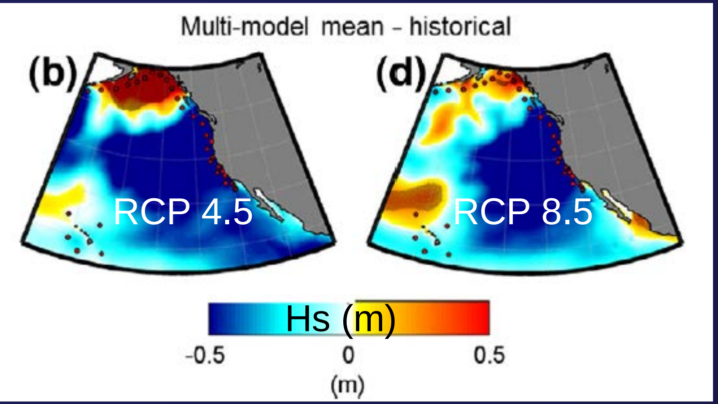
<u>Pending State SLR Guidance for 2100</u>
- -20 cm to 52 cm of sea level rise by 2050
- -74 cm to 287 cm of sea level rise by 2100

<u>Waves</u>
- -No significant changes in wave height, possible decrease
- -More south swell influence

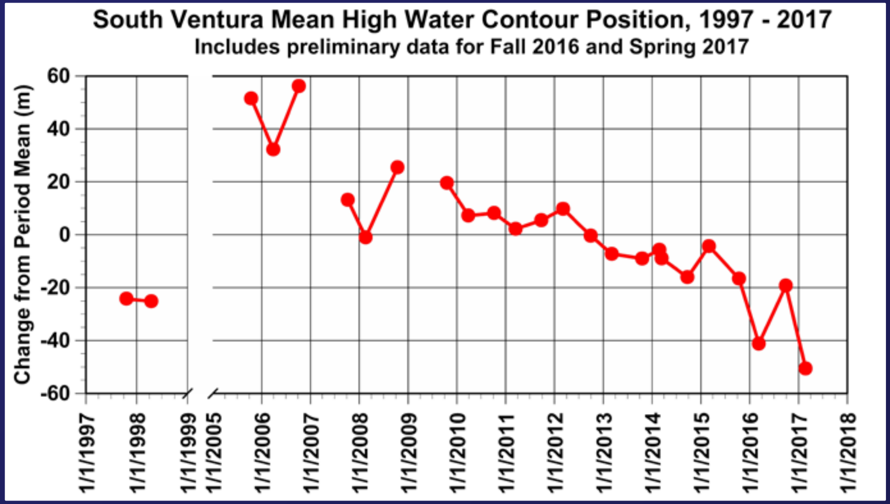
<u>Atmospheric Patterns</u>
- -Potential for more extreme El Niño events
- -Storm tracks possibly moving north

<u>Sediment Inputs</u>
- -Episodic (normal)
- -Longer droughts but higher intensity rainfall events

Projected change in wave heights



Erikson et al. 2015



CoSMoS Highlights

- **Extensively tested and validated** for waves, extreme water levels and coastal change, including with local historic storm events
- **40 plausible future scenarios**
- **Downscaled winds** from Global Climate Models (GCMs) (SIO)
- **Downscaled waves** from GCMs (dynamically, not statistically downscaled)
- **High resolution grids** of lagoons, protected areas, and high-interest areas
- **Long-term coastal evolution** (CoSMoS-COAST)
- **Short-term beach and dune response** (XBeach)
- **Long- and short-term coastal change** (i.e., beaches, dunes and cliffs) **integrated into coastal flooding projections**
- **Discharge from rivers** for event response
- **Vertical land motion** factored into flood potential layer
- **Web-based tool** that includes data visualization and download and socio-economic summaries

Conclusions

- **All phases of CoSMoS results show no significant risk of flooding to project site for 100 yr storm event at ~2050 (50 cm SLR) or for decades after**
- **Models developed are state-of-the-art**
- **Dune fields are dynamic**
- **Multiple lines of evidence from models and observations should be used to assess risk**

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

USGS CoSMoS data: ***http://walrus.wr.usgs.gov/coastal_processes/cosmos/socal3.0/index.html***

Our Coast - Our Future tool: ***www.ourcoastourfuture.org, http://beta.ourcoastourfuture.org***

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