USGS Coastal Storm Modeling System
Southern California Region (CoSMoS 3.0)
Frequently Asked Questions

What is CoSMoS?

The Coastal Storm Modeling System (CoSMoS) is a modeling approach that projects coastal flooding and shoreline change (sandy beach change and cliff retreat) due to both sea-level rise and coastal storms driven by climate change. CoSMoS was designed to understand the present-day and future vulnerability of the Southern California coast in support of federal and state climate change guidance, local vulnerability assessments, and emergency response.

What geographic area does the Southern California CoSMoS 3.0 Model cover?

The model covers the coast from Point Conception to the U.S. / Mexico Border, including all harbors, embayments, wetlands, and estuaries. Earlier versions covered the North-central California coast from Half Moon Bay to Pt. Arena, including inside San Francisco Bay. The model is currently being expanded to cover the Central California Coast, from Pt. Conception to Half Moon Bay, and later Pt. Arena to the Oregon border.

What is a "coastal storm"?

In the context of CoSMoS modeling, a coastal storm is defined as a high water-level event that impacts the outer coast, embayments, wetlands and estuaries. In CoSMoS the storm elements include:

- **Sea-Level Anomalies**: seasonal anomalies including those processes driven by El Niño, such as thermal expansion (steric effect) and coastally-trapped waves
- **Waves**: rise in coastal water levels due to breaking waves, i.e., set-up and run-up
- **Storm Surge:** rise in water levels during storms due to winds and low-atmospheric pressures
- **River Discharge:** discharges creating backflow at the river-ocean interface, locally increasing flood elevations

How does CoSMoS generate its coastal storm scenarios?

Because historic storms may not be an accurate predictor of storms under a changing climate, CoSMoS simulates future storms based on the latest global climate model projections of wind, pressure, and sea surface temperature over the next century. Using this information, CoSMoS is able to model the oceanic conditions for future storms and then determine storm-driven water levels along the coast through 2100, including the effects of waves, storm surge, and seasonal water level anomalies. Based on these projections the storm return intervals are determined, and then the storms are fully simulated for a spring tidal cycle.

What projections does CoSMoS 3.0 provide to users?

We provide 10 sea level rise scenarios to choose from: 0 – 2 meters (m) at 0.25 m increments, and an extreme 5 m scenario. These can be combined with 4 possible storm scenarios: average conditions; 1-year return; 20-

year return; and 100-year return intervals. This provides 40 possible scenario combinations that allow stakeholders to visualize the flooding extent, depth, duration, and elevation, as well as waves, currents, shoreline change and cliff erosion. We also provide the uncertainty associated with each scenario. Results can be overlain with GIS information on ecology, land use, and infrastructure attributes in the Our Coast, Our Future web tool (OCOF: http://ourcoastourfuture.org) and with socioeconomic exposure in the Hazard Exposure Reporting and Analytics web tool (HERA: www.usgs.gov/apps/hera).

What components are included in the CoSMoS flood projections?

CoSMoS 3.0 uses the following components to produce coastal storm flooding projections:

- **Sea Level Rise:** 0 – 2 meters (m), at 0.25 m increments, and an extreme 5 m scenario
- **Tides:** astronomical spring tide fluctuation
- **"Storm" Elements:** storm characteristics that can episodically raise coastal water levels and increase flood risk (sea-level anomalies, waves, storm surge and river discharge, see above for definitions of each)

Does CoSMoS show non-storm conditions?

Yes, non-storm conditions can be explored on the Our Coast, Our Future viewer by selecting "none" under "Choose Storm Frequency." By looking at various amounts of sea-level rise in the non-storm condition, you can see what the coast may look like in future, everyday conditions.

What is the source of the elevation data?

The digital elevation model used by CoSMoS is based primarily on the coastal LiDAR and multibeam data collected as part of state- and federally-funded projects from 2009-2011. High resolution coastal LiDAR data can be accessed at: http://www.opc.ca.gov/2012/03/coastal-mapping-lidar-data-available/. For inclusion in CoSMoS, this DEM was further refined in protected embayments and harbors, where data coverage was often minimal or absent. This updated DEM will be released shortly.

What is the source of the data for the shoreline change and cliff retreat models?

The historical data that was used to support the sandy beach and cliff evolution models were derived from numerous sources, including coastal LiDAR flights, USGS topographic surveys, topographic sheets and aerial photography that were utilized to generate historical rates of change for the USGS National Assessment of Shoreline Change (https://coastal.er.usgs.gov/shoreline-change/). The shoreline MHW data sets used from Santa Barbara to Mexico are listed in Appendix 1.

Specifically, the current application of the sandy beach evolution model combines the three most recent LiDAR-derived mean high water (MHW) shorelines (1997, 1998 and 2009) of the USGS National Assessment of Shoreline Change (Hapke et al. 2006), 20 MHW shorelines derived from Scripps-led coastal LIDAR surveys (2002-2009; many of which only cover the southern half of the study area, that is, south of Long Beach harbor: https://coast.noaa.gov/dataviewer/#/lidar/search/), and 20 MHW shorelines derived from bi-annual (2005-2015) GPS surveys by the USGS in the Santa Barbara Littoral Cell (Barnard et al., 2009). The cliff retreat model is based on historical retreat rates derived from a 2010 LiDAR data set along with a 1930s cliff edge derived for the USGS National Assessment (https://pubs.usgs.gov/of/2007/1112/).

How does CoSMoS consider different types of shorelines such as bluffs/cliffs vs. sandy beaches?

Sandy Beach Projections

The sandy coast shoreline change model - CoSMoS-COAST (Coastal One-line Assimilated Simulation Tool) - incorporates historical shoreline behavior, a data assimilation algorithm, and three process-based models that compute both alongshore and cross-shore transport on sandy shores due to waves and sea-level rise. The shoreline model was used to project the movement of the mean high water (MHW) line for nine SLR scenarios (0.25 m to 2 m, at 0.25 m increments, and 5 m). (On OCOF, these layers can be found here: "Box 4 – Choose Shoreline Evolution," then select "Sandy Beaches.")

Cliff Retreat Projections

The cliff retreat model employs a suite of models, including 2-D process-based soft rock (loosely consolidated sediment deposits) and hard rock (indurated lithologies such as sandstone or granite) models, and six empirical 1-D models that relate wave impacts and water-level variations (for example, storm surges and sea-level anomalies) directly to cliff edge retreat through time. Cliff retreat was projected for the same nine SLR scenarios. (On OCOF, these layers can be found here: "Box 4 – Choose Shoreline Evolution," then select "Cliffs.")

How does CoSMoS account for current coastal protection measures?

The future behavior of highly engineered shorelines such as those affected by rock revetments, seawalls, and extensive beach nourishment is difficult to predict, owing to vast uncertainties in structure life, human behavior to protect the coast and maintain existing structures, and changes in coastal policy. Similarly, it's highly uncertain if the rates of historical sand nourishment will be sustained and/or even possible in the future.

In order to provide a broad suite of planning scenarios regarding future beach behavior, four coastal management options are considered in CoSMoS-COAST that account for various coastal infrastructure maintenance and beach nourishment scenarios:

1. **Existing urban infrastructure[1] maintained with inclusion of future nourishment:** Shoreline erosion is not permitted to continue beyond existing urban infrastructure ('hold the line') + inclusion of historical rates of sand nourishment in future projections.
2. **Ignore existing urban infrastructure with inclusion of future nourishment:** Shoreline erosion is UNRESTRAINED by urban infrastructure + inclusion of historical rates of sand nourishment.
3. **Existing urban infrastructure maintained with no inclusion of future nourishment:** Shoreline erosion is not permitted to continue beyond existing urban infrastructure + NO historical rates of sand nourishment. (Note: This was the scenario integrated into the coastal flooding projections as discussed below.)
4. **Ignore existing urban infrastructure with no inclusion of future nourishment:** Shoreline erosion is UNRESTRAINED by urban infrastructure + NO historical rates of sand nourishment.

The cliff erosion model assumes that cliffs will erode and fail as they are undermined and impacted by wave action. Sediment supply from this cliff erosion is not accounted for in the shoreline change scenarios because

[1] For the purposes of the sandy beach modeling, we define urban infrastructure to include anything that is made of hardened material that cannot easily be eroded. This can range from traditional armoring structures such as seawalls or revetments, to parking lots, roadways and home foundations.

there is not enough data on cliff composition (how much sandy material is in the cliff lithology) to make confident estimates. We do, however, provide two cliff retreat projection options assuming:

1. Existing **coastal armoring** continues to exist and prohibit cliff retreat (Note: this was the scenario integrated into the coastal flooding projections as described below; existing coastal armoring is derived from several sources including the California Coastal Commission and the City of Encinitas, as well as aerial photography.)
2. NO **coastal armoring** exists in the future.

For the management options in which existing urban infrastructure and coastal armoring are maintained, it is important to note that flooding is allowed to transgress past this infrastructure.

A major challenge in coastal flood risk mapping is obtaining data describing features that are not captured by aerial LiDAR surveys. In some areas, sea walls are narrower than the resolution of the LiDAR data set (~ 1 m) and therefore poorly represented or completely absent in LiDAR-derived digital elevation models (DEMs). This is a challenge faced by CoSMoS and the majority of other flood modeling studies, except those that are conducted at the site-specific scale where on-the-ground survey work might be able to resolve these features. To address this, aerial imagery was reviewed in an attempt to capture key missing flood protection features wherever possible, and the DEMs were updated accordingly. We do note, however, that in areas with sub-meter scale coastal protection structures, CoSMoS may over-predict flooding as these fine-scale features may not all be included, or are assumed to fail during a flood event.

How does the modeling account for the sand nourishment projects throughout Southern California?

We used all available shoreline data to determine historical shoreline change rates[2], which include the effects of nourishments and other human activities, as well as natural processes (e.g., fluvial inputs, longshore transport, cross-shore transport). However, in our shoreline change scenarios we assume that any positive rates of change is solely attributed to beach nourishment activities, although positive rates could also be influenced by other factors.

Is shoreline evolution included in the flood projections?

Long-term shoreline change for sandy beaches and cliff retreat are incorporated in the final CoSMoS flood projections for all sea-level rise and storm scenarios. Based on user needs and state guidance, we selected the cliff retreat and shoreline change scenario in which sandy beach change is confined by current coastal armoring and urban infrastructure, cliff retreat is limited by existing coastal armoring, and NO historical rates of nourishment are included for sandy beach change projections. The DEM is evolved to reflect the modeled long-term changes to the beaches and cliffs, with feedback from cliff erosion distributed across the active beach profile. For more information on DEM evolution, see Erikson et al. (2017A and B).

What type of planning is the CoSMoS model most suited for?

The goal of CoSMoS is to provide information for community planning level decision-making to support federal and state-supported climate change guidance, local and regional level vulnerability assessments, and

[2] The shoreline change rates were derived from historical data from ~1997 – 2015. Derived rates are available from our Science Base website here: https://www.sciencebase.gov/catalog/item/57f426b9e4b0bc0bec033fad (viewed in KMZ files by clicking on a profile)

emergency response. For example, CoSMoS is currently being used to support numerous LCP updates and other regional climate impacts assessments, as well as statewide assessments for Caltrans and the California Office of Emergency Services (Cal OES). We provide examples of case studies on the Our Coast, Our Future (http://ourcoastourfuture.org) that demonstrates how other coastal communities have utilized the CoSMoS results for their planning.

CoSMoS was not developed to support site-specific engineering projects (e.g., site design) and is not necessarily compatible with engineering design codes and guidance. CoSMoS was designed to assess community-scale vulnerabilities and for broadly identifying where more detailed geo-technical engineering studies may be required.

Is CoSMoS designed to assess the risk of coastal river/watershed flooding?

No, CoSMoS should not be used to assess the potential exposure to river flooding. Our determination of coastal flood scenarios (e.g., the 100-year event) is based on the atmospheric and oceanographic conditions that result in elevated total water levels along the open coast, not within local watersheds. River discharge is included in CoSMoS as a likely discharge given the atmospheric conditions driving the coastal storm being simulated. That is, in the case of the 100-year event, we are not modeling the 100-year river flooding event, but rather a likely river discharge during the 100-year coastal high water-level event. There are likely storms with different characteristics than the ones simulated with CoSMoS that produce higher river discharge (for instance, atmospheric rivers and slow-moving systems with heavy rainfall) and thus would be far more damaging along river corridors than in CoSMoS scenarios.

Does CoSMoS consider vertical land motion?

Yes, vertical land motion (VLM) is included in the uncertainty projections (found on OCOF in the flood potential layer), incorporating regional tectonic and non-tectonic related movement. We used estimates of VLM across Southern California from a recent paper published in *Nature Geoscience* (Howell et al., 2016: http://www.nature.com/ngeo/journal/v9/n8/full/ngeo2741.html). These estimates are based on over 1000 GPS stations straddling the North American Plate boundary, as well as advanced physical and statistical tectonic models. Maximum rates of VLM are generally less than ±2 mm/yr, largely within the noise of our modeling work, especially as we reach higher rates of sea level rise projected for the latter half of the 21st century. That being said, the VLM approach is regional with 1 km resolution, and thus poorly resolves local VLM, where, for example, subsidence due to fluid withdrawal may be important in some coastal areas.

Is it possible to get shoreline positions (MHW lines and cliff top retreat) for select years assuming various SLR scenarios by 2100?

For SLR scenarios of 1 m or more, shoreline and cliff positions are available for the year 2100 only. However, intermediate SLR scenarios are assumed to happen before 2100. Using the NRC 21st century sea-level projection of 0.93 m by 2100 for Southern California (the mid-range projection associated with a moderate emissions reduction future), sea levels projections of the 0.25, 0.5, and 0.75 m occur at approximately 2044, 2069, and 2088, respectively. Shoreline and cliff positions are available for those dates. For the sandy shoreline modeling results, we also provide outputs for 2025, 2050, 2075 and 2100. Please contact the CoSMoS team if you need beach change or cliff retreat projections for dates other than those available on OCOF.

Which are the best scenarios to use from the CoSMoS results?

CoSMoS serves as a baseline for understanding vulnerabilities and determining what types of scenarios/worst-case storm events for which our region's cities and agencies might want to collectively agree to plan.

Cities and agencies will have to decide which scenario(s) will best suit their planning needs based on their specific planning horizon and degree of risk tolerance. For example, emergency responders may choose to focus on present-day hazards, such as the 100-year storm with no sea-level rise, while the mangers of semi-permanent infrastructure, such as airports and sewage treatment plants, might also consider the upper-end SLR scenarios. The CA Coastal Commission Sea Level Rise Guidance (https://www.coastal.ca.gov/climate/slrguidance.html) also recommends considering how long certain development and infrastructure are intended to be in place and determine the amount of sea level rise likely to take place over that time period.

How can the CoSMoS data be interpreted in the context of NRC projections and CA State Guidance?

Below is a table demonstrating how the current CoSMoS SLR scenarios align with the NRC scenarios for Southern California (based on projections for Los Angeles), which has been adopted as the current best available science by the state of California, as detailed in the State of California Sea Level Rise Guidance Document (http://www.opc.ca.gov/2013/04/update-to-the-sea-level-rise-guidance-document/) as well as the CA Coastal Commission Adopted Sea Level Rise Policy Guidance (https://www.coastal.ca.gov/climate/slrguidance.html).

Year	Mid-Range NRC SLR Scenarios			High-Range NRC SLR Scenarios		
	NRC Scenario	CoSMoS Scenario	Difference in scenarios (NRC - CoSMoS)	NRC Scenario	CoSMoS Scenario	Difference in scenarios (NRC - CoSMoS)
2050	0.28 m (0.92 ft)	0.25 m (0.82 ft)	(+) 0.03 m (0.10 ft)	0.61 m (2.00 ft)	0.5 m (1.64 ft)	(+) 0.11 m (0.36 ft)
2100	0.93 m (3.05 ft)	1 m (3.28 ft)	(-) 0.07 m (0.23 ft)	1.67 m (5.48 ft)	1.75 m (5.74 ft)	(-) 0.08 m (0.26 ft)

The State guidance is currently being updated and it is expected that new recommended scenarios will be provided in late 2018. We will update this table accordingly at that point.

How is this model different from past sea level rise modeling done in the Southern California region?

The CoSMoS 3.0 model represents an evolution from simple forecasts of static flooding due to tides and sea level to a more complex and detailed hydrodynamic coastal storm modeling approach that predicts how coastal storms and other relevant physical processes in combination with sea-level rise will cause flooding of coastal areas along with the long-term evolution of the coast. Specifically, across the entire Southern California region, this new model includes:

- A wide spectrum of future scenarios combining the full range of possible 21st century sea level rise scenarios (0-2 m at 0.25 m increments and a 5 m worst case scenario) combined with 4 possible future coastal storm conditions (daily conditions during spring tides, annual storm, 20 year storm, and 100 year storm)

- Long-term coastal evolution projections for sandy beaches and cliffs produced from a collection of state-of-the-art models and incorporating extensive historical data
- Flooding projections using future sea-level rise elevations as opposed to time horizons, so scenarios will not become obsolete when sea-level rise guidance changes
- Improved system methodology for more accurate flood projections in embayments, harbors and estuaries
- Discharge from rivers during coastal storm events
- Twenty-first century wave and storm conditions determined from the Global Climate Models (GCMs) developed for the Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC)
- Locally-generated seas and surge computed with downscaled winds and pressures from one GCM, developed by Scripps Institution of Oceanography
- An improved baseline digital elevation model (DEM) that incorporates recent LiDAR and multibeam bathymetric surveys, including the latest data from protected embayments
- High spatial flooding resolution (2 m)

How do CoSMoS flood maps differ from FEMA coastal flood maps?

FEMA provides projections of the 100 year-water level event for current conditions and does not provide these projections for sea level rise. They map the 100-year water level event on a transect by transect basis using winds, sea-level pressures and deep water waves to compute a 50-year hind-cast (1960-2009) of total water levels at individual transects along the shore. The 1% exceedance limit is calculated at each transect and water levels projected onshore using wave run-up as the mapped flood extent. CoSMoS uses dynamic set-up, or maximum sustained flooding, as the mapped flood extent (wave run-up projections are also provided), so mapped flood extents will tend be lower than FEMA for similar scenarios. Further, CoSMoS uses winds, sea-level pressures and sea surface temperatures from Global Climate Models to compute 90-year long time-series (2010-2100) of total water levels at points along the coast. Similar to FEMA, the 1% percent exceedance level at each point is computed, but these are then used to identify the dates of specific storms. The storms are then simulated in detail to account for wave-current interactions and the influence of sea level and tidally-induced depth changes on waves breaking near the shore.

Existing FEMA maps are currently being updated and released in a phased regional roll-out which began in summer 2016. USGS is partnering with FEMA, NOAA, California Coastal Commission, California State Coastal Conservancy, and USC Sea Grant in county-scale resilience workshops which address the potential overlap and/or alignment of modeling methodologies and policy/regulatory guidance and projects (such as LCP and LHMP updates). For more information about these workshops, please contact Juliette Hart (jfinzihart@usgs.gov).

How does CoSMoS differ from the NOAA Sea Level Rise Viewer?

The NOAA Sea-Level Rise Viewer (https://coast.noaa.gov/digitalcoast/tools/slr) maps inundation starting at high tide (MHHW, the average highest tide each day) combined with sea level rise up to 6 ft in 1 ft increments, effectively mapping the everyday impacts of future sea levels. It uses much of the same elevation data as CoSMoS, and similarly incorporates hydraulic connectivity (that is, an area is only flooded if it is directly connected to the ocean). The NOAA Sea Level Rise Viewer has other features as well, including mapping nuisance flooding areas. The primary difference is that CoSMoS considers the dynamic physical processes that affect the coast during a storm (i.e., waves, storm surge, tides, river discharge, sea level anomalies) and over the long-term (climate driven changes in storm patterns and shoreline evolution).

Uncertainty & known issues

Through our CoSMoS modeling, we have incorporated the most current and advanced coastal modeling approaches available, as well as our own scientific judgment, to develop as robust and effective a planning tool as possible. As with all models, there is uncertainty associated with our modeling results and we provide the range of minimum and maximum uncertainty for all of our flooding projections in the “Flood Potential” topic area. We explicitly consider uncertainty related to elevation data, model error, and vertical land motion. These are available as shapefiles and through the OCOF web tool. When working with local communities, including uncertainty in the projections will help provide a more comprehensive view of the vulnerabilities.

Similarly, as we have conducted our own internal quality control reviews, and have collected feedback from end-users, we have developed a list of “known issues.” For the Bay Area and outer coast, these are listed by region on the Our Coast, Our Future website here: http://data.pointblue.org/apps/ocof/cms/index.php?page=known-issues. A similar list for Southern California is being developed and will be available once all the model results are released. We welcome comments and feedback as community members, consultants and engineers continue to use CoSMoS for their planning projects.

Who funded it?

Funding for the most recent modeling (CoSMoS 3.0) was provided by the California State Coastal Conservancy, the California Natural Resources Agency, the City of Imperial Beach, California Department of Fish and Wildlife, the Tijuana River National Estuarine Reserve, and the United States Geological Survey (USGS). The model development was led by USGS in collaboration with Deltares and coastal and climate scientists from Scripps Institution of Oceanography, Oregon State University, and the University of Hawaii.

Is there a technical methods document?

Yes, we have developed a technical document (Erikson et al, 2017A: http://dx.doi.org/10.5066/F7T151Q4) that describes all of our methods and a list of all of our associated peer-reviewed literature can be found at the end of this report. The list of peer-reviewed literature is continuously being updated as these become available.

Where can I access the results?

GIS shapefiles and KMZ files (and associated metadata) for CoSMoS results can be downloaded from the USGS Data Repository site, *ScienceBase-Catalog*: https://www.sciencebase.gov/catalog/item/57f1d4f3e4b0bc0bebfee139

Information available on this site includes the following projections:

- Flood extent and depth (also viewable in “Box 1 – Flooding” on OCOF)
- Flood duration (also viewable in “Box 1 – Duration” on OCOF)
- Water level elevations
- Wave heights (also viewable in “Box 1 – Waves” on OCOF)
- Ocean currents (also viewable in “Box 1 – Currents” on OCOF)
- Sandy Beach Shoreline Evolution (also viewable in “Box 4 – Sandy Beaches” on OCOF)

- Cliff retreat (also viewable in “Box 4 – Cliffs” on OCOF)

Our Coast, Our Future (OCOF):
CoSMoS projections for Southern California, as well as the San Francisco Bay Area and outer coast, are also available through the Our Coast, Our Future website: http://ourcoastourfuture.org. OCOF is a collaborative, user-driven project focused on providing coastal California resource managers and land use planners locally relevant, online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea-level rise and storms. The OCOF website also provides a number of case studies of how CoSMoS has been utilized by communities throughout California. For more information on OCOF, please contact Maya Hayden (mhayden@pointblue.org).

Hazards Exposure Reporting and Analytics (HERA):
Socioeconomic exposure for each of the CoSMoS scenarios is reported through a dynamic web tool the USGS developed known as HERA: https://www.usgs.gov/apps/hera/. The HERA application was developed to provide users with insight on potential population, economic, land cover, and infrastructure exposure to a given hazard zone. Interactive maps and graphics allow users to examine exposure for individual communities, to compare the exposure of multiple communities, and to explore changes in community exposure given multiple hazard scenarios. For more information on HERA contact Nate Wood (nwood@usgs.gov).

Webinars, presentations and other local information on CoSMoS 3.0 can also be found on the following websites:

- **USGS CoSMoS website**
  https://walrus.wr.usgs.gov/coastal_processes/cosmos/

- **Resilient Coastlines Project of Greater San Diego:**
  http://www.resilientcoastlines.org/

- **USC Sea Grant Southern California Coastal Impacts Project:**
  http://dornsife.usc.edu/uscseagrant/sccip/

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Appendix 1: Information on CoSMoS Data Inputs

DIGITAL ELEVATION MODEL (DEM) INFORMATION

- For open coast: 2009-2011 CA Coastal California TopoBathy Merged Project DEM (available for download here: https://coast.noaa.gov/dataviewer/). This is a compilation of data sets including topographic LiDAR (Oct 2009-Aug 2011), bathymetric LiDAR (2009-2010), and acoustic bathymetry (1996-2011).

- For harbors and or near shore zones where high-resolution lidar or multibeam was unavailable, the above DEM used interpolations. Therefore, for San Diego Bay, Mission Bay, and Oceanside, USGS used bathymetric data from the 10 m resolution NGDC tsunami inundation grids (http://www.ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html).

- For a few of the wider near shore zones that were interpolated in the topobathy DEM (namely offshore of Tijuana Estuary, USGS also used the above NGDC grids (http://www.ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html).

- The final DEM used in CoSMoS should be published and available for download with the final CoSMoS model results.

LIDAR INFORMATION

- Scripps LiDAR MHW shorelines (Long Beach Harbor to Mexican Border):
  - May 2002
  - Sept 2002
  - Dec 2002
  - Mar 2003
  - Oct 2003
  - Apr 2004
  - Sept 2004
  - Apr 2005
  - Oct 2005
  - Oct 2006
  - Apr 2007
  - Dec 2007
  - Apr 2008
  - Sept 2008
  - Mar 2009

- USGS National Assessment LiDAR MHW shorelines (whole coast):
  - Fall 1997
  - Spring 1998
  - Fall 2009
  - Fall 2010 (cliffs only)

USGS LOCAL BEACH SURVEYS (Santa Barbara Littoral Cell)

- Fall and Spring 2005-2015 MHW shorelines