SDSU Coastal Engineering Lab

Department of Civil, Construction and Environmental Engineering

San Diego State University

Who we are? The new Coastal Engineering Lab at San Diego State University studies the most relevant natural hazards in the coastal environment and the engineering solutions to mitigate them. Want to be a member?

Why? About 40% of the world's population lives within 100 kilometers of the coast. Past engineering solutions are becoming obsolete due to climate change and other changes due to anthropogenic activities. The world urgently needs a new generation of Coastal Engineers and Scientist. Want to be part of the new generation?

What we do? We currently address three research fields as explain below. New fields will be also explored (tsunamigenic earthquake modeling, Wave/storm surge Simulation, tidal simulation and Citizen Science). What ideas do you have?

Interested on being a Master or PhD student? Let's talk

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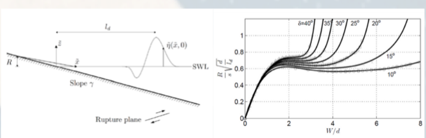
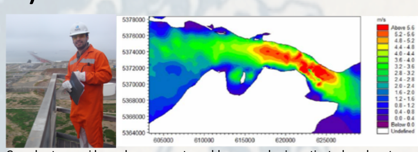
TSUNAMI SCIENCE

Tsunamis are the most powerful hazard striking coastal communities. Our work includes the improvement of tsunami propagation models and runup estimations, the improvement of tsunami generation models and the study of tsunami interaction with other physical processes (e.g. tides and sea level rise).



We proposed a closed-form expression to estimate the runup of tsunami waves (R), in terms of the characteristics of the tsunamigenic earthquake (dip δ, slip s, depth d). The closed-form expressions can be used for tsunami early-warning provided that earthquake fault parameters are known. We also proposed a closed form expression for a wave breaking criterion. Paper published in Journal of Coastal Engineering.

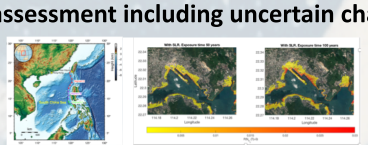


Complex tsunami hazard assessments problems are also investigated, such as tsunami hazard assessments for LNG ports (left) or tsunami-tide hazard models for Civil Engineering projects in the marine environment (right). The study of tsunami hazards relies on numerical models, commonly based on the shallow water wave equations (a simplification of Navier-Stokes equations).

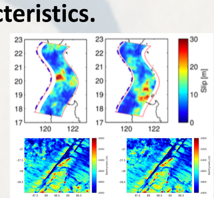
Our knowledge of the tsunami physics is imperfect and the information of past tsunamis is incomplete. The introduction of new tsunami science advancements requires the investigation of recent tsunamis (e.g. by post-tsunami surveys, left figure), the collection of data from past tsunamis (e.g. information from the 1960 tsunami, middle figure) and numerical models to validate hypotheses (e.g. the model of 1960 tsunami in the pacific ocean). We do all of this!.

PROBABILISTIC HAZARD ASSESSMENTS

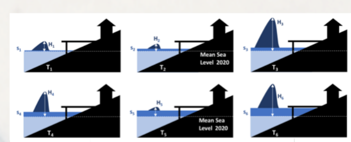
Tsunamis and earthquake occur randomly in time. To quantify the likelihood that a city is affected by such natural hazards, we need to adopt a probabilistic approach. Natural hazards, once occurring, are further uncertain because their governing processes have random properties and/or are not well known. Our lab adopts stochastic approaches to design new formulations for probabilistic hazard assessment including uncertain characteristics.



Probabilistic tsunami hazard assessments (PTHA) aim to provide probability estimates of having a tsunami with intensity greater than a certain value within an interval of time (e.g. the lifetime of a port). We have conducted several PTHA in the Chilean coast and the South China Sea.



In our group, we employ stochastic approaches to model the uncertainty of geophysical variables such as the earthquake slip and the seafloor topography. **Top samples:** Earthquakes have uncertain characteristics. One important uncertain variable is the slip distribution (or dislocation between two converging tectonic plates). We model the slip as a random field calibrated with past earthquakes. **Bottom samples:** One of the most important input data for wave models, including tsunami models, is the seafloor topography (bathymetry). Bathymetry surveys are scarce with a significant uncertainty. We model such uncertainty.



$$P(N_{hc} > 0) = 1 - e^{-\bar{\lambda}_N T}$$

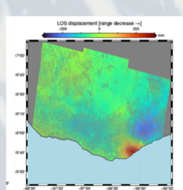
$$\bar{\lambda}_{N(T)} = \sum_i \lambda_i \frac{1}{T} \int_0^T P(H > h_c | E_i, s(t)) dt$$

Future tsunamis are expected to cause greater impacts because they will propagate over a significantly higher sea level due to climate change. The statistics of tsunamis, therefore, will be non-stationary. The changes of tsunami statistics and their impact of probabilistic tsunami hazard assessments is addressed in our lab.

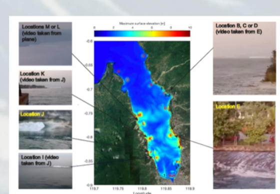
SENSING TECHNOLOGIES

One of the main challenges in coastal engineering is the collection of coastal data. Cheap and robust technologies need to work in remote locations and survive extreme conditions such as big waves, high wind and sediment transport. Our lab aims to exploit remote sensing technologies to increase coastal data. We are also prompted to include citizens in the collection process.

GPS and other navigation systems (GNSS is the system including all the constellations) are massively used. Additional applications have been discovered for these systems, such as the GNSS Interferometric Reflectometry (GNSS-IR) with study signals reflecting from surfaces close to the antenna. Our experiments measure water levels and wave height (left, Scripps Pier). The technique can also use geodetic stations (right, Mehuin-Chile) and cellphones (middle, Bermuda Island)!.



The deformation of the earth's crust is relevant for many application, including seismology and tsunami science. The earthquake co-seismic deformation may provide relevant information about earthquake fault mechanism. Interferometric Synthetic Aperture Radars (InSAR) provides information about earth surface deformation by comparing shots from different epochs (e.g. before and after an earthquake). This type of information is relevant to understand the mechanism of past earthquakes and tsunamis.



Sensing technologies are sometimes not available everywhere. This is especially true in underserved communities affected by great coastal hazards. We have developed new computational tools to take full advantage of the information which can be extracted from citizen videos obtained from social media. An example was the tsunamigenic source identification using videos recorded for the 2018 Palu tsunami in Sulawesi Island, Indonesia.