New Maximum Tsunami Inundation Maps for Use by Local Emergency Planners in the State of California, USA

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**ABSTRACT**

A consortium of tsunami modelers, geologic hazard mapping specialists, and emergency planning scientists is producing maximum tsunami inundation maps for California, covering most residents and transient populated areas along the state’s coastlines. The new tsunami inundation maps will be an upgrade over the existing maps for the state, improving on the resolution, accuracy, and coverage of the most anticipated tsunami inundation line. Thirty-three separate map areas covering nearly one-half of California’s coast were selected for tsunami modeling using the MOST (Method of Splitting Tsunami) model (FIGURE 1). Based on a preliminary evaluation of over fifty local and distant tsunami source scenarios, those with the maximum expected hazard for a particular area were input to MOST. The MOST model was run with a near-shore bathymetric grid resolution varying from three arc-seconds (30m) and one arc-seconds (10m), depending on availability. Maximum tsunami “flow-depth” and inundation layers were created by combining all modeled scenarios for each area. A method was developed to better define the location of the maximum inundation line using higher resolution digital shoreline topographic data from intertidal radar sources. The final inundation line for each map area was validated using previously recorded (seismic and submarine landslide) as well as comparison to the location of recorded paleotsunami deposits. Local governmental agencies will use these new maximum tsunami inundation lines to assist in the development of their evacuation routes and emergency response plans.

**SOURCE DEVELOPMENT AND SELECTION:**

- To help protect its nearly one-million coastal residents and seaports vital to the US economy, the California Tsunami Program is developing statewide tsunami inundation maps that improve on the resolution, accuracy, and coverage of the existing maps for the state.
- California’s coast is vulnerable to tsunami sources that are distant, Pacific Rim subduction events and local, submarine seismic and landslide events. The Cascadia Subduction Zone is also a local source for the northern part of the state.
- Over 50 potential “worst-case” scenarios representing both local and distant tsunami sources were considered for 33 coastal populated areas (Borrego Springs, 2008). Figure 1 shows each coastal population area mapped. FIGURE 2 shows distant source areas considered, and TABLE 1 shows the relative impact (incomning tsunami height/ethanoh1) of different source regions on each coastal area, these results address directivity effects from distant sources.
- The source scenarios showing the greatest impact for each coastal section were selected for hydrodynamic tsunami modeling.

**MODELING AND MAXIMUM WAVE ELEVATION CREATION**

- The Tsunami Research Center at USC ran each scenario through the MOST hydrodynamic model program (Tsunami Synolakis, 1997), propagating the tsunami through nested, lower-resolution bathymetric grids resulting in output grids of one arc-second (~30m) for three source and three arc-seconds (~10m) resolution for rest of California. Figure 2 shows results from two landslide scenarios near the subsurface Goleta landslide.
- For each source scenario run for a particular area, three output grids are available for use: the initial bathymetric grid, a tsunami flow-depth grid, and a tsunami inundation grid.
- Through simple grid manipulation and processing, these three grids are used to create individual wave elevation, or runup grids for each scenario analysis.
- As shown in the FIGURE 4, the wave elevation grids for each source are combined into a single, maximum wave elevation grid.
- The maximum wave elevation grid represents the worst of all the scenarios for each individual grid cell.

**FUTURE MAPPING WORK BY THE STATE TSUNAMI PROGRAM**

- Existing paleotsunami deposit information (FIGURE 5) will be entered into a database, compatible with the National Geophysical Data Center Global Tsunami Deposits Database, and used to verify the results of the hydrodynamic tsunami models.
- A tsunami source scenario database and discussion forum will be created to allow geoscientists and hydrodynamic modelers to discuss and validate tsunami sources that could impact California.
- Tsunamigenic landslides (like FIGURE 10 showing the submarine Goleta Landslide), a potential tsunamigenic source for Santa Barbara; from Greene et al., 2008) and offshore faults will be inventoried and hazard potential maps produced for improving tsunami mitigation efforts.
- To fulfill mandates by the National Tsunami Hazard Mitigation Program and the State Scientific Hazard Mapping Act of 1990, two Pilot Studies will be developed to produce tsunami hazard information and/or maps (showing inundation, flow-depth, and flow velocity) to assist local jurisdictions in making land-use planning decisions.

**LOCAL EMERGENCY RESPONSE PLANNING APPLICATIONS**

- Draft inundation maps are checked in the field with emergency planners from local jurisdictions (FIGURE 6).
- Post-field draft tsunami inundation maps are sent to the local agencies for review and comments are collected and considered.
- Final inundation maps are sent to the local lead agencies and posted on state tsunami program websites (FIGURE 7).
- Workshops are held by state tsunami program representatives and local agency personnel to discuss how to best use the new inundation maps and what other needs local agencies might have.
- The state tsunami program may assist local leads in development of new emergency and/or evacuation plans and placement of signage (FIGURE 8).
- Regional tsunami “working groups” similar to the Redwood Coast Tsunami Working Group in the north part of the state composed of state, local, and academic representatives will be initiated to maintain community-based tsunami hazard mitigation and outreach efforts.

**MAXIMUM TSUNAMI INUNDATION LINE PRODUCTION**

- High resolution digital elevation models (DEMs) are used to enhance the location of the maximum inundation line.
- The maximum wave elevation grid is extended onshore and transferred from the coarse grid onto the USGS 10m DEMs (grain) and interferometric 3m DEMs (blue) to show were flooding from the tsunami might occur (FIGURE 5).
- A draft inundation line is digitized (also FIGURE 5). Because the topography used to create the USGS DEMs is out-of-date and the more up-to-date (2000) interferometric radar 3m DEMs show structures or vegetation, careful consideration is given to these problems with both high-resolution DEMs.
- The inundation line is checked in the field and adjusted where appropriate.