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December 28, 2011

Ms. Jane Hollingsworth
Tsunami Program Director
OCWWS/Meteorological Services Division
1325 East-West Highway, SSMC2
Silver Spring, MD 20910

Dear Ms Hollingsworth,

I am sending this request on behalf of Maryland and the states identified as the East Coast Region of the National Tsunami Hazard Mitigation Program (NTHMP). My staff has informed me the Tsunami Inundation Modeling and Mapping Project being jointly conducted by the Universities of Delaware and Rhode Island, on behalf of the East coast states and the NTHMP, has completed their reanalysis of Atlantic tsunami source regions and their potential impact on the East coast. These results indicate additional coastal segments are at a higher risk than originally determined. Funding to complete mapping of these identified coastal segments effort is not sufficient.

It has been expressed by a number of states that without more definitive evidence in hand it will be difficult to establish any level of tsunami outreach and education program. The risk analysis and supporting inundation mapping is needed to help vulnerable coastal communities prepare for, respond to, and rebound from a tsunami. Inundation mapping is essential to local emergency managers, urban planners, decision makers, and coastal resource managers to develop assessment and decision support tools for these at risk communities. A list of these coastal segments is contained in the enclosure.

At the onset of this effort East coast states believed the project would be the first step toward meeting the needs of the entire East coast and there was the expectation that reanalysis results and supporting inundation mapping would be provided before attempting to secure the needed state and local support for such an undertaking. Most felt this work was essential to hazard mitigation and community resilience efforts along the East coast and necessary to establishment of a tsunami program, thus resulting in increased participation in the TsunamiReady™ Program along the East coast.

Due to the confusion and delay in the grant notification process States found it difficult to respond on an individual basis, whereas under the initial grant this was not a requirement. To mitigate this shortfall my staff, after discussing this issue with several East coast states, has recommended supplemental funding be allocated to the Project, in lieu of requesting each state or local jurisdiction to apply for individual grants to conduct coastal inundation mapping. It is felt that this effort be viewed regionally, rather than on a state by state basis. We therefore, request the Modeling and Mapping Subcommittee (MMS) submit a specific proposal to the NTHMP requesting a funding line to complete the inundation mapping addressing the needs regionally. Cost estimates associated with completing modeling and mapping of newly identified at risk East coast segments are about $500K over the next several years.

Should you have any questions please contact Rainer Dombrowsky of my staff at 410-517-3628 or by email at rdombrowsky@mema.state.md.us, who is working with the East coast states and the project team. Thank you in advance for your consideration of our request on behalf of the East Coast Region.

Sincerely,

Richard G. Muth, Executive Director
Maryland Emergency Management Agency

cc:
Vicki Nadolski, Chair NTHMP
Rick Wilson, Chair, NTHMP MMS
Dr. James T. Kirby, PI
Dr. Stephan T. Grilli, Co-PI

Enclosure

Status of : "Modeling Tsunami Inundation and Assessing Tsunami Hazards for the U. S. East Coast"

December 10, 2012

NTHMP Award Number: **NA10NWS4670010**
National Weather Service Program Office
Project Dates: August 1, 2010 – July 31, 2013
Recipients: Univ. of Delaware (J.T. Kirby, PI); Univ. of Rhode Island (S.T. Grilli, co-PI)

BACKGROUND

Tsunami hazard assessment along the US East Coast (USEC) is still in its infancy, in part due to the lack of historical tsunami records and the uncertainty regarding the magnitude and return periods of potential large-scale events (e.g., transoceanic tsunamis caused by a large Lisbon 1755 type earthquake in the Azores-Gibraltar convergence zone, a large earthquake in the Caribbean subduction zone in the Puerto Rico (PR) trench or near Leeward Islands, or a flank collapse of the Cumbre Vieja Volcano (CVV) in the Canary Islands) (Fig. 1). Moreover, considerable geologic (e.g., Chaytor et al., 2009; Twichell et al., 2009) and some historical evidence (e.g., the 1929 Grand Bank landslide tsunami, and the Currituck slide site off North Carolina and Virginia) suggests that the most significant tsunami hazard in this region may arise from Submarine Mass Failures (SMF) triggered on the continental slope by moderate seismic activity (as low as $M_w = 6$ to the maximum expected in the region $M_w = 7.5$); such tsunamigenic landslides can potentially cause concentrated coastal damage affecting specific communities (Fig. 1).

In this project, we assess tsunami hazard from the above and other relevant tsunami sources recently studied in the literature (ten Brink et al., 2007, 2008; MG special issue, 2009), and model the corresponding tsunami inundation in affected USEC communities. Based on our past experience with a variety of tsunami sources and case studies, we model tsunami propagation, inundation, and runup using the robust and well-validated Fully Nonlinear Boussinesq Model (FNBM) FUNWAVE (Wei et al., 1995; Kennedy et al., 2000; Chen et al., 2000) in its most recent TVD and parallelized (MPI) implementation (i.e., FUNWAVE-TVD; Shi et al., 2011). Both Cartesian (Shi et al., 2011) and curvilinear grids (Kirby et al., 2009, 2011; note this implementation is only mildly nonlinear) are used, in a variety of nested computational domains at various grid scales (from the Atlantic Ocean basin scale (4' to 2') to regional (1' to 1/3') and local grid scales (3" to 1/3")). These nested domains are used to model the propagation of the various selected tsunami sources, from their initial location to that of the region of interest along the US eats coast, where impact from a particular source is deemed to be significant. The last and final nested grid where detailed inundation is computed typically corresponds to the size of a local Digital Elevation Map (DEM), for which we have bathymetric and topographic information at a very fine scale (e.g., 1/3" arc or about 10 m).

Whether frequency dispersion matters (e.g., for the SMF and other slide sources) or not (e.g., for the large co-seismic sources), our FNBM modeling framework contains all the relevant physics without need to modify the model or its equations, whether one type of tsunami source or another is used. The same goes for linear versus nonlinear effects in generated tsunami wave trains, as well as for dissipation by bottom friction or bathymetrically induced breaking (which are modeled through adequate semi-empirical terms). Finally, the spherical coordinate implementation of FUNWAVE-TVD includes Coriolis effects (Kirby et al., 2009, 2011), together with a very efficient parallel MPI and nested-domain implementation, which make FNBM transoceanic simulations possible, with typically on the order of 1h CPU time, on a multi-core desktop computer or on the cluster computing environment available at the University of Delaware (UD), Center for Applied Coastal Research.

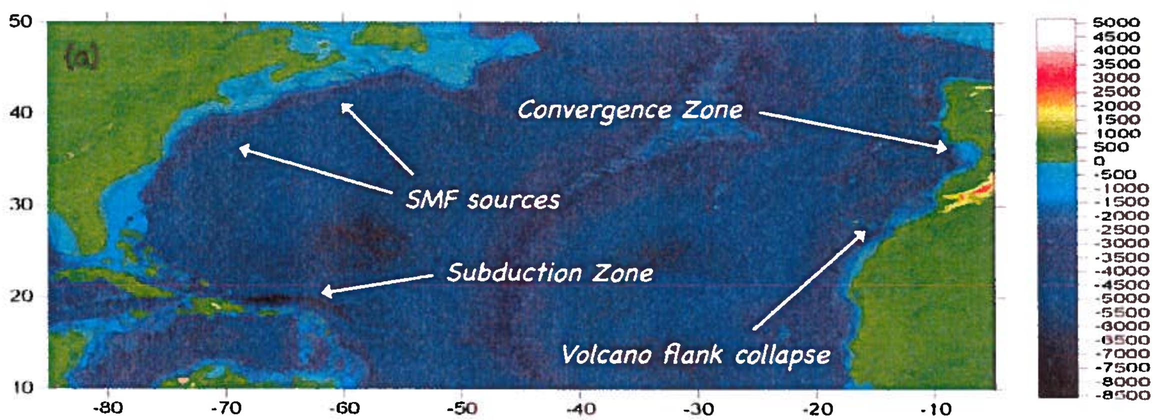


Fig. 1: Potential tsunami sources for U.S. East coast in the North Atlantic Ocean basin (ETOPO2's two second arc length ocean bathymetry is shown in the background).

TSUNAMI SOURCE SELECTION

Co-seismic sources

Following the standard procedure in tsunami hazard assessment, the large co-seismic sources (i.e., PR trench or Lisbon 1755 sources) are modeled as initial instantaneous ocean surface deformations, based on estimates of each event's size, magnitude, and geological parameters, using Okada's (1985) method. [For reference, we recently successfully conducted a case study of the 2004 Indian Ocean tsunami using FUNWAVE, following this methodology (Grilli et al., 2007; Ioualalen et al., 2007; Karlsson et al., 2009).] Co-seismic source parameters were obtained from both our past work (Grilli et al., 2010) and other recent work reported in the literature (e.g., MG special issue, 2009).

More specifically, Fig. 2 shows the locations of 16 sources used to model tsunami hazard for the Azores-Gibraltar Convergence Zone (AGCZ). Each source is run separately in the propagation model, and has the estimated magnitude and size of the M 8.5 Lisbon 1755 event and is specified at a different location based on a geological analysis (Barkan et al., 2009).

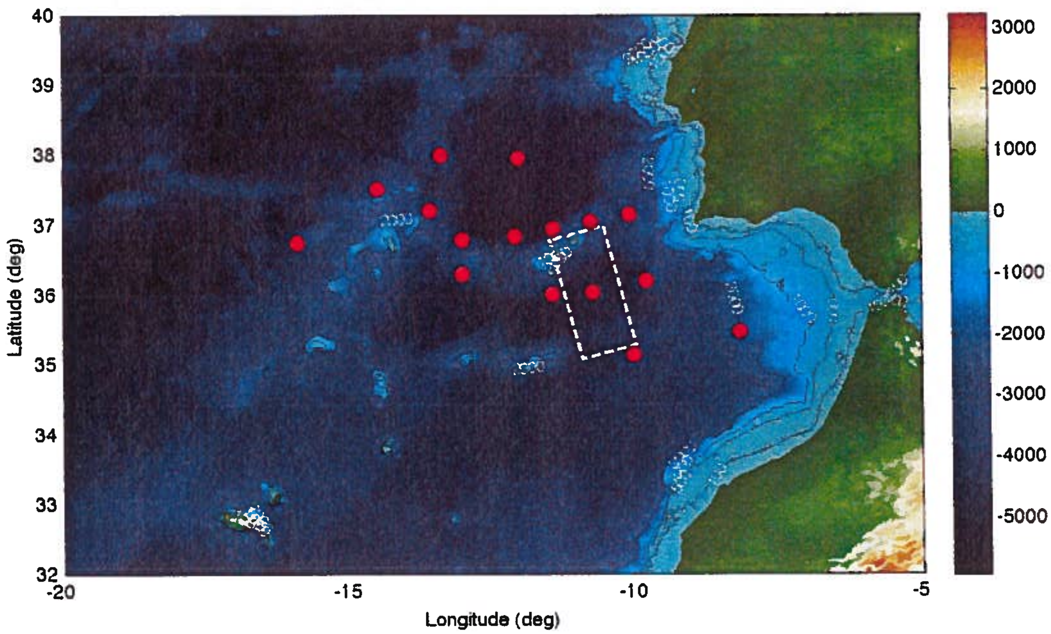


Fig. 2: Choice of potential AGCZ sources, identical to that of Barkan et al. (2009). Red dots refer to source centers; white rectangle refers to the size of the sources. These are M 8.5 sources, assuming a shear modulus of 4.2 10^{10} kg/m s^2, a slip of 13.1 m and a source area 200 km by 80 km

Fig. 3 similarly shows the location and size of 28 M 7.5 sources selected for tsunami propagation modeling in the Caribbean Subduction Zone (CSZ). These are from NOAA's SIFT database (Short-term Inundation Forecast for Tsunamis; Gica et al., 2008). The largest hazard from the CSZ would in fact be an earthquake that would rupture the entire Puerto Rico Trench (PRT). This extreme case, with an estimated M 9.0 magnitude and a 200-300 year return period, was considered in Grilli et al.'s (2010) preliminary analysis of USEC tsunami hazard. In the present work, we simulated the same M 9.0 PRT single source as in Grilli et al. (2010), but we also considered a source made of three composite sources, for a total of 28 individual sources, as shown in Fig. 3. This composite source encompasses the entire Puerto Rico, Hispaniola, and Lesser Antilles segments. Since the subduction zone is curved in the area of Puerto Rico, using these multiple Okada sources (i.e., each with constant 10 m slip) is more descriptive than using a single one, at least for such large ruptures. In the model, these 28 sources are assumed to each have a M 8 magnitude (for a total M 9 magnitude) and are simultaneously run in the propagation model, to simulate the extreme tsunami hazard on the USEC from a M 9 source in the PRT.

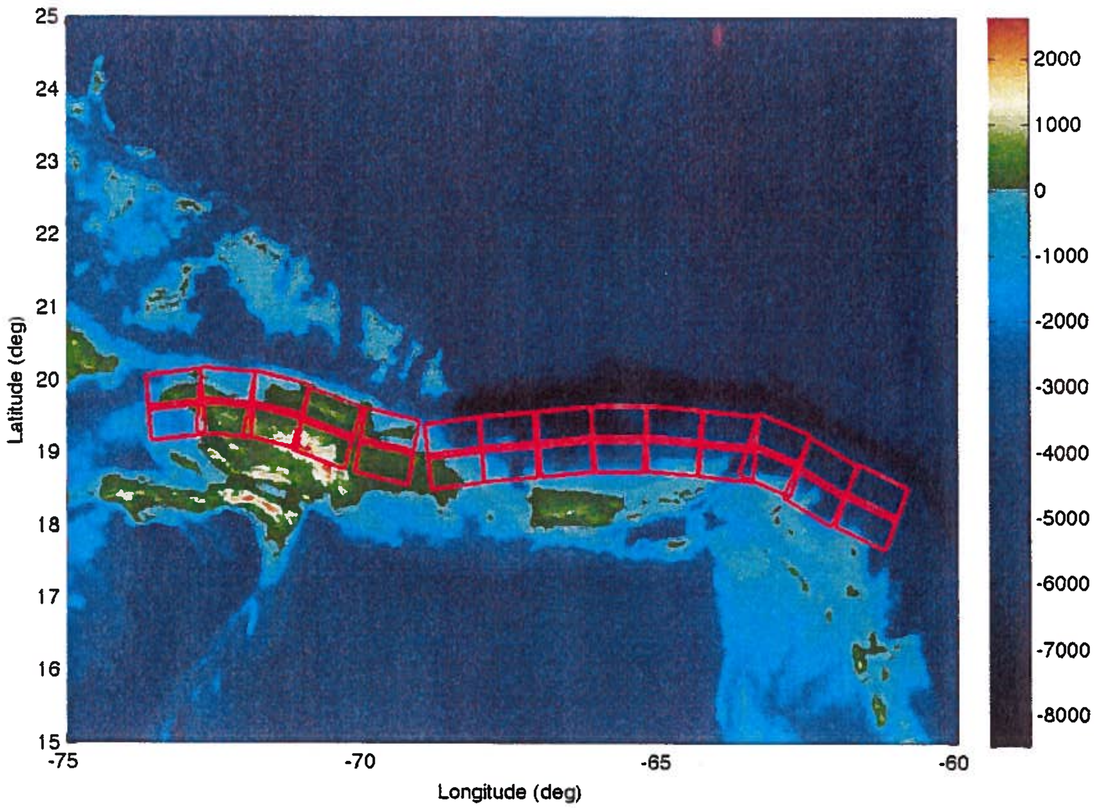


Fig. 3: SIFT sources (Gica et al. 2008) of interest in the CSZ. The 10 (5x2) sources on the left correspond roughly to the Hispaniola trench, the middle 12 (6x2) correspond to the Puerto Rico Trench (PRT), and the right 6 (3x2) sources correspond to a segment of the Lesser Antilles trench.

CVV flank collapse sources

The Cumbre Vieja Volcano (CVV) flank collapse (Fig. 4) has been identified as an extreme subaerial landslide tsunami source in the Atlantic Ocean basin, of unknown but likely very long return period, with the potential to generate very high and steep near-field and significant far-field waves along the USEC. Due to the complexity of both the source mechanism and the flow in near field waves, a 3D multi-material Navier-Stokes solver (THETIS) is used to generate the initial conditions in a fine local grid (Fig. 4). This initial source is then propagated towards the USEC in FUNWAVE-TVD in a series of nested grid, as done for the co-seismic sources. Four different scenarios were considered in the THETIS simulations, with slide volumes of 20, 40, 80, and 450 km^3.

Initial sources can be seen in Fig. 5 and details can be found in Abadie et al. (2009, 2010, 2011a,b).

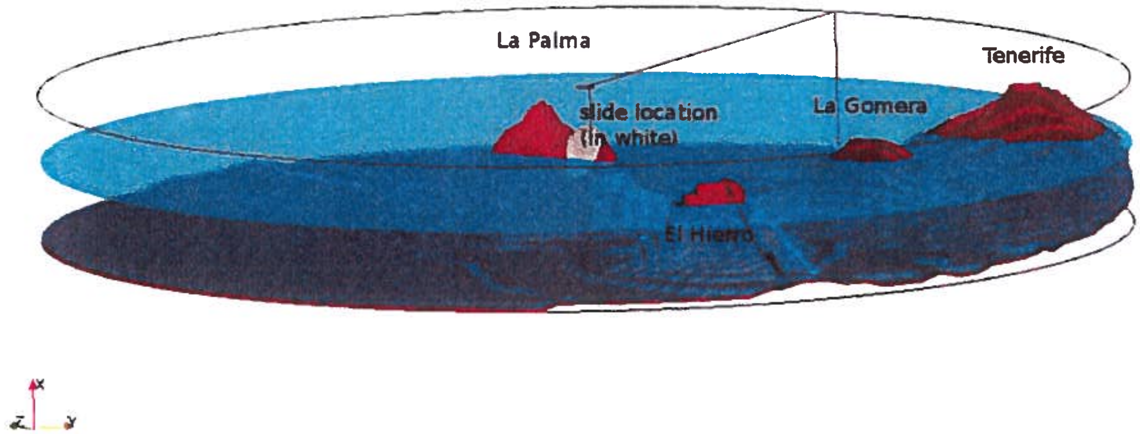


Fig. 4 : Sketch of cylindrical computational domain in THETIS model, for CVV flank collapse simulations, assuming a 80 km^3 subaerial slide case, with view of bottom bathymetry, neighboring islands, and slide location (marked in white) (Abadie et al., 2011a,b).

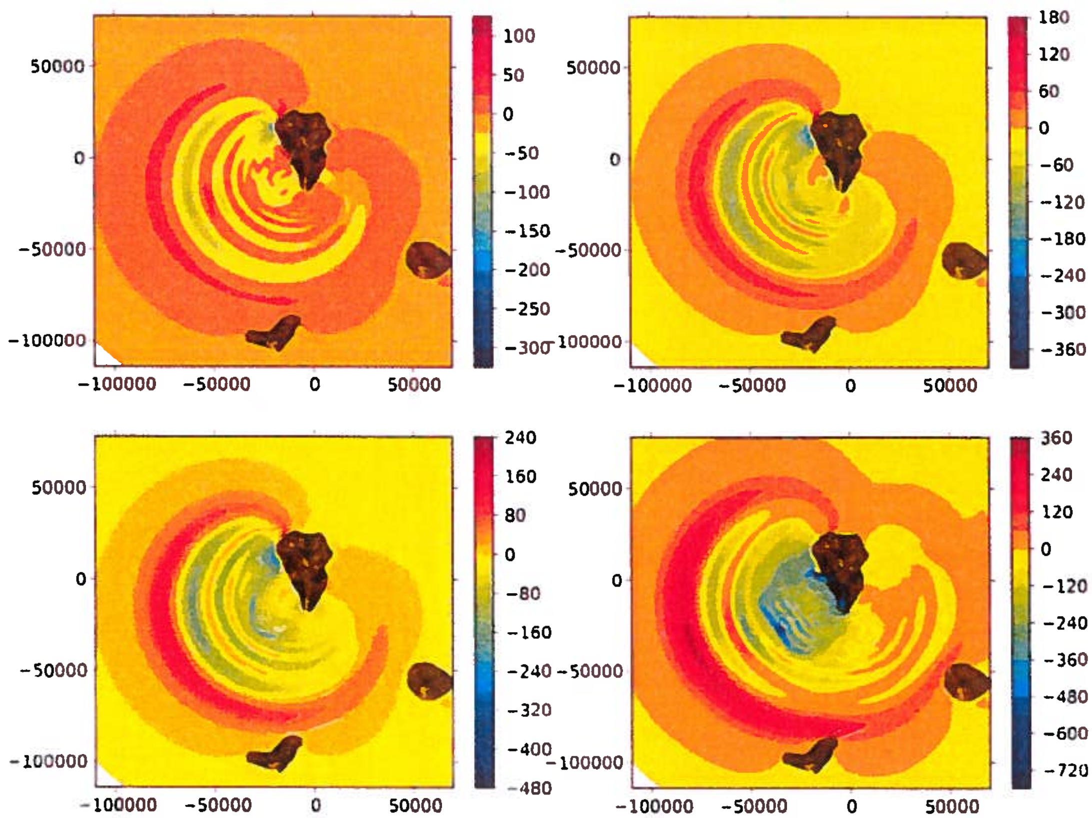


Fig. 5 : THETIS computations in geometry shown in Fig. 4. Computed free surface elevation at t = 450 s, for initial slide volume of: a) 20 km^3, b) 40 km^3 , c) 80 km^3 , d) 450 km^3. [Note the different color scales.]

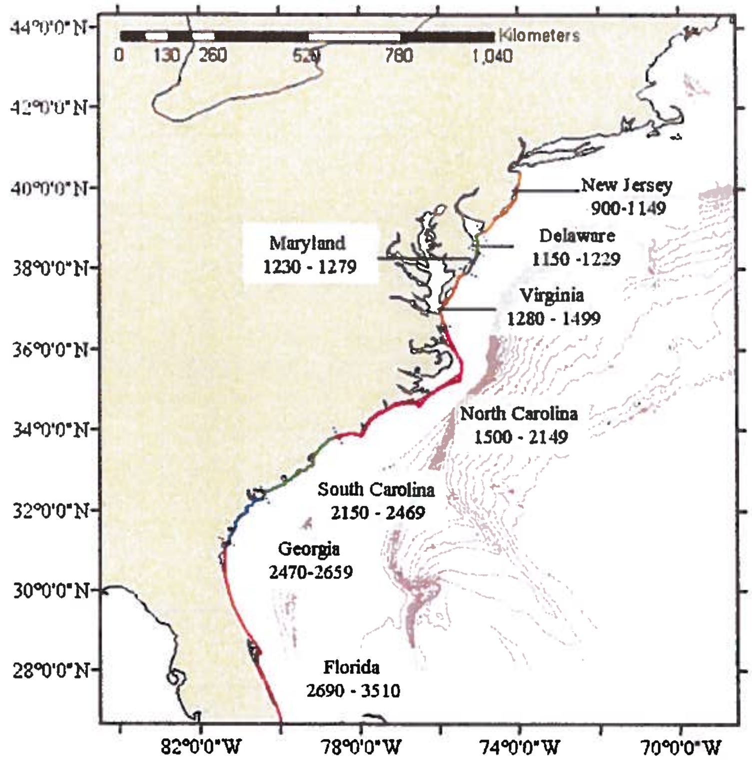


Fig. 6 : Simplified coastline with names of corresponding coastal states, ranges of indices of studied coastal points, numbered N-S (Baxter et al., 2011; Krauss, 2011). Note, coastal points 1-899 correspond to the upper East Coast already studied in Grilli et al. (2009).

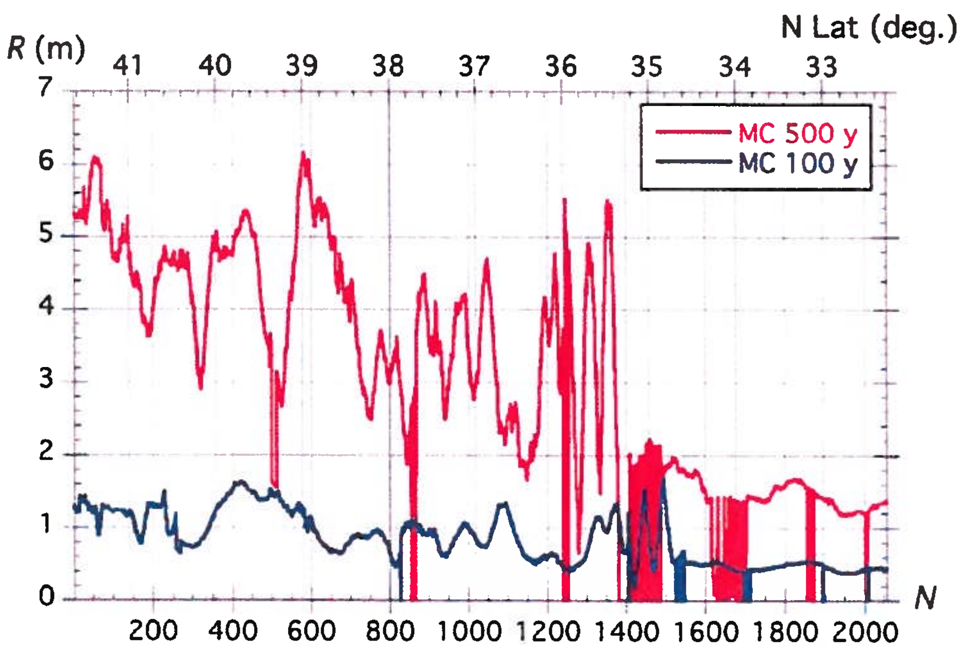


Fig. 7: Runup predicted by MC simulations of SMF tsunamis, for the USEC, for 100-yr. and 500-yr. runup events (Baxter et al., 2011; Krauss, 2011). The bottom x-axis is the index of studied coastal points, numbered N-S and the upper x-axis denotes the latitude (Fig. 6).

SMF tsunami sources

Once selected along the USEC continental slope, the SMF tsunami sources are modeled according to the methodology reported in Watts et al. (2003, 2005), Grilli and Watts (2005), and validated for a number of historical case studies (e.g., Day et al., 2005; Tappin et al., 2008). In this method, the kinematics of SMF sources is semi-empirically generated from geomechanical, geological, and geometrical parameters. Unlike in earlier simulations (e.g., Day et al., 2005; Tappin et al., 2008), however, in the present work the initial tsunami wave elevations and velocities caused by each SMF are first computed in the non-hydrostatic multi-layer model NHWAVE (Ma et al., 2011); this model was validated for SMF tsunami generation based on Enet and Grilli's (2007) experiments. Once the majority of tsunami generation has occurred, the SMF source is then propagated in nested grids in the FNBM propagation model, as discussed before.

The locations and parameters of SMF sources (other than historical) were selected by performing a probabilistic Monte Carlo (MC) analysis of SMF tsunami hazard along the USEC continental slope (Baxter et al., 2011; Krauss, 2011). This work followed and extended the methodology developed by Grilli et al. (2009), for coastal areas from New Jersey to Maine. Results of this analysis were presented in terms of 100 and 500 year runup from seismically induced tsunamigenic SMFs. In the MC model, distributions of relevant parameters (seismicity, sediment properties, type and location of slide, volume and dimensions of slide, water depth, etc.) were used to perform large numbers of stochastic stability analyses of submerged slopes (along actual transects across the shelf), based on conventional pseudo-static limit equilibrium methods for both translational and rotational failures. The distribution of predicted slope failures along the upper US East Coast was found to match published data quite well (Booth et al., 1985, 1993; Chaytor et al., 2007, 2009).

In the MC analysis, the USEC is simplified and defined by 3510 "coastal points" (Fig. 6) where runups caused by SMFs are calculated. Fig. 7, for instance shows results of the MC analysis done in the present work for the USEC from Massachusetts down to North Carolina. As also found in Grilli et al. (2009), the 500 year runup shows an elevated hazard off of Nantucket, eastern Long Island, western Long Island (Hudson River canyon) and Atlantic City. We also see elevated hazard off of Virginia and in northern North Carolina. South of the NC Outer Banks SMF tsunami hazard appears to rapidly drop.

It should be stressed that runup values in this MC screening analysis (Fig. 7) should not be taken in absolute value, as these are based on many hypotheses. Only detailed tsunami simulations can provide accurate inundation and runup values for the regions identified to have an elevated risk. To do so, based on results of the MC 500 year runup analysis, parameters of representative SMFs are being selected in areas of the USEC deemed to have elevated SMF tsunami hazard. Fig. 8 shows an example of 500 year runup SMFs selected along some transects off of areas deemed at elevated risk.

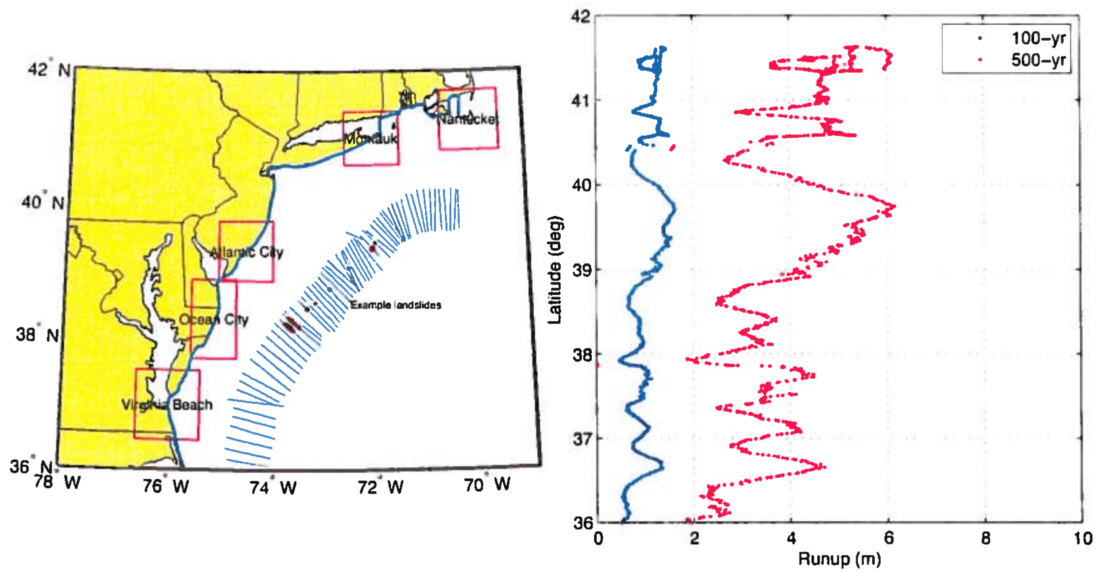


Fig. 8: Right panel: Northern part of runups shown in Fig. 7. Left panel: SMF transects (blue lines) used in MC analysis and location and size of underwater landslides causing 500 year runup (red ellipses). The solid blue line indicates the simplified coastline used in MC simulations and the red boxes mark the size and locations of DEMs currently available form NOAA-NGDC.

For each identified SMF (such as in Fig. 8), detailed deterministic tsunami generation, propagation, and inundation modeling is performed using NHWAVE and FUNWAVE-TVD, as discussed above.

TSUNAMI PROPAGATION AND COASTAL INUNDAITON MODELING

Simulations of tsunami propagations for the co-seismic and CVV sources discussed above were performed using FUNWAVE-TVD in a series of nested grids down to regional scale, along the USEC (1' grid cells or so). Similar simulations are currently being performed for the selected representative 500 year runup SMFs.

Envelopes of computed maximum surface elevations near the USEC are shown in Fig. 9 for the ACZ sources, in Fig. 10 for the M 9 Puerto Rico Trench source, and in Fig. 11 for the 80 km^3 CVV source. Fig. 12 shows results of tsunami simulations for the first SMF source shown in Fig. 8 (bottom). In this simulation, the NHwave domain was 140 km^2, with a 10 km wide sponge layer on the south and east sides, and was run for 15 min. The FUNWAVE-TVD domain was 240 km^2, in order to include the shoreline, with the same sponge layer, and was run for an additional 2.5 hours. FUNWAVE was initialized with NHwave results after 15 mins and both domains had a 500 by 500 m horizontal grids. The instantaneous wave elevation shown in Fig. 12a was computer 75 min. after the slump started moving.

Once all the SMF sources will have been simulated, results of maximum surface elevations for all the source types affecting the USEC will be combined, in order to establish the relative degree of tsunami hazard for East Coast communities. Detailed inundation studies will then be conducted for the highest-risk East Coast communities, and results of these studies will be used to construct a first-generation of tsunami inundation maps for the chosen communities. As part of this project, 4 such detailed inundation simulation and mapping studies were budgeted (2 in FY11 and 2 in FY12). Based on preliminary hazard assessments and DEM availability, the following locations/DEMS (see Figs. 9-12) were selected: (i) Montauk, Long Island, NY; (ii) Atlantic City, NJ; (iii) Ocean City, MD; and (iv) Charlestown, NC (which includes Myrtle beach).

Regarding these and other areas possibly having elevated tsunami hazard, the following observations can be drawn from Figs 7-11:

1. Nantucket, MA is mostly impacted by the PRT source and local landslide. There is a DEM for it, but it is not part of our list of currently funded areas.
2. Eastern Long Island (Montauk) is impacted by the PRT source and local landslides. There is a DEM for it, but it is not part of our list of currently funded areas.
3. Western Long Island is similarly impacted as 2., but we do not have a DEM for it and it is not on our list of currently funded areas.
4. Northern NJ from Stafford to Sandy Hook is similarly impacted as 2., but we do not have a DEM for it it is not on our list of funded areas.
5. Southern NJ from Stafford to Cape May is mostly impacted by local landslides. We have a DEM (Atlantic City) for it and it is part of our list of funded areas.
6. Eastern DELMARVA peninsula, down to Virginia beach is mostly impacted by CVV and local landslides. We have a DEM centered on Ocean City, which is part of our list of funded areas.
7. North Carolina is impacted by ACZ and CVV sources, and local landslides.
8. Further south, down to the Charlestown, SC area, whose DEM includes Myrtle Beach and the northern part of Horry and Georgetown, the landslide risk goes down and risk is driven mostly by the CVV source. We will be doing the Charlestown DEM as part of our funded work, but there will be parts not covered south and north of it where there is elevated tsunami risk as well.

In summary, regarding request for more funding from NTHMP:

1. For the state of MA, we would need funding to cover Nantucket and the surrounding region.
2. For the State of NY, we will cover the eastern long Island part in current funding, but we need additional funding to cover in detail Western Long Island (and associated barrier Islands) and the Hudson River, NY harbor areas.
3. In New Jersey, we need additional funding to cover the area north of Stafford to Sandy Hook. We will cover the area south of Stafford with current funding.
4. In Delaware/Maryland/Virginia, we will cover the area of Ocean City with current funding, but we'll need additional funding to cover the areas North and South of Ocean City, down to Virginia Beach.
5. We need funding to cover NC.
6. In South Carolina, we will cover most of the previously mentioned counties and Myrtle beach with current funding, but we need additional funding to cover some parts North and South of this area where there is also elevated hazard.

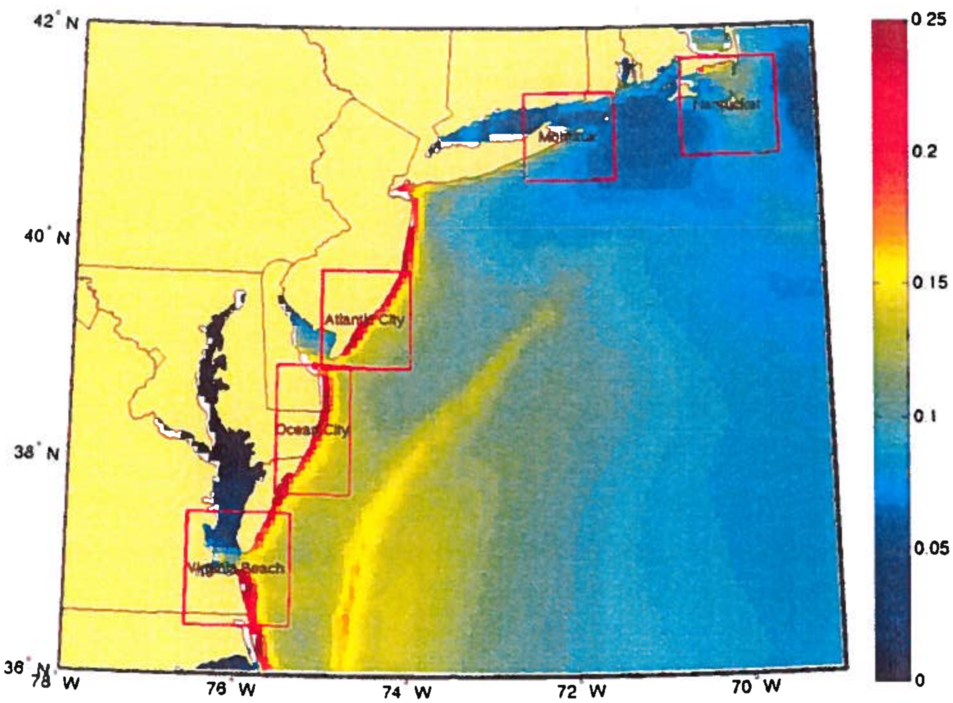


Fig. 9 : Maximum tsunami elevation in a 4' ocean grid, computed for the ACZ sources of Fig. 2.

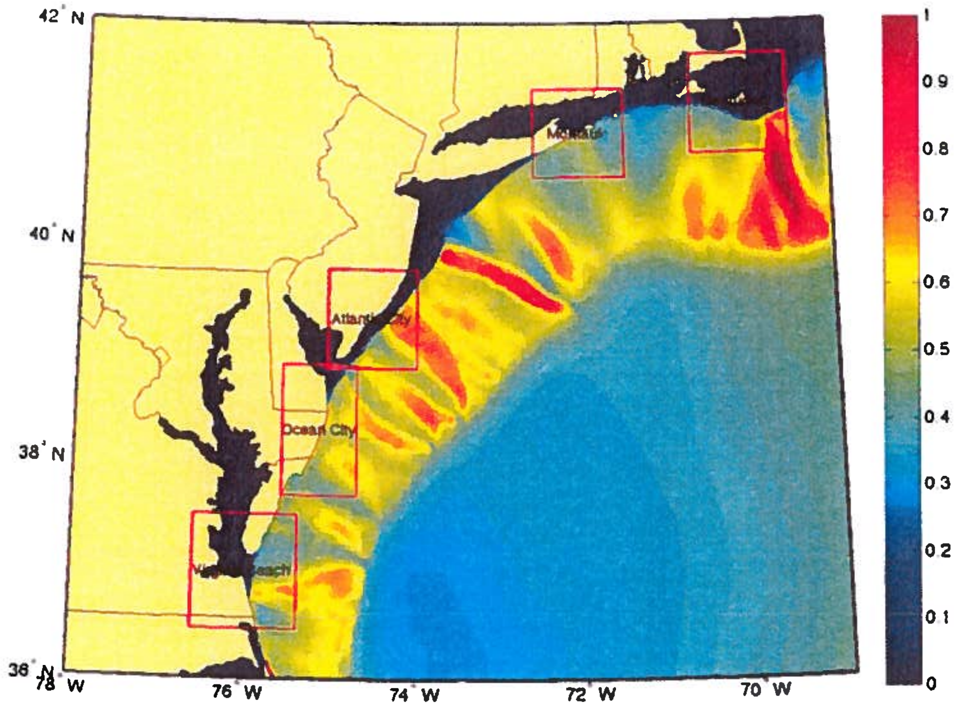


Fig. 10 : Maximum tsunami elevation in a 1' regional grid, for the M 9.0 Puerto Rico Trench source.

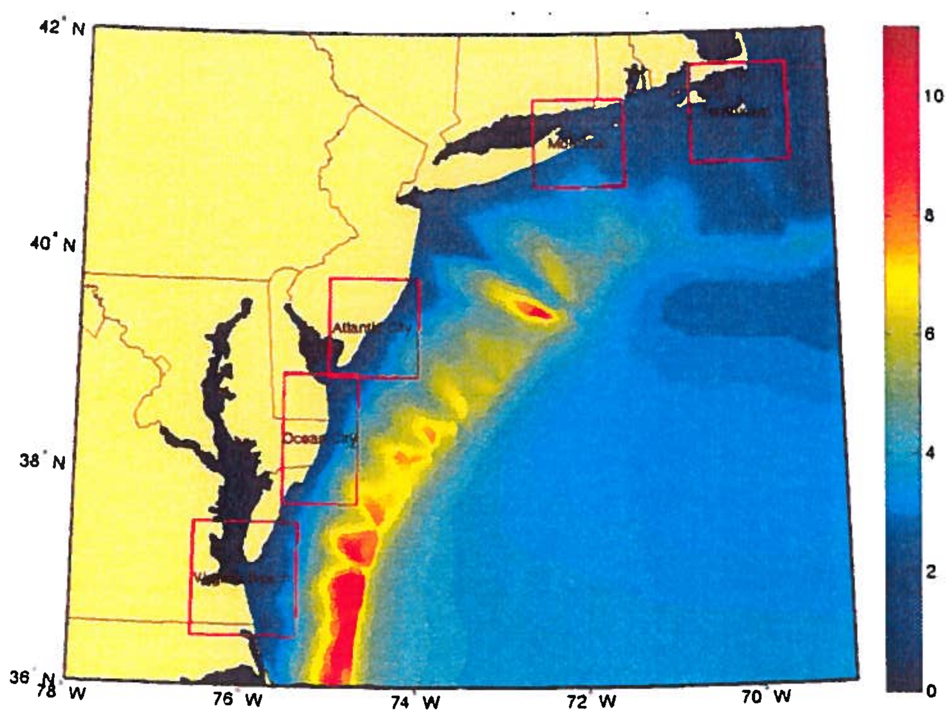
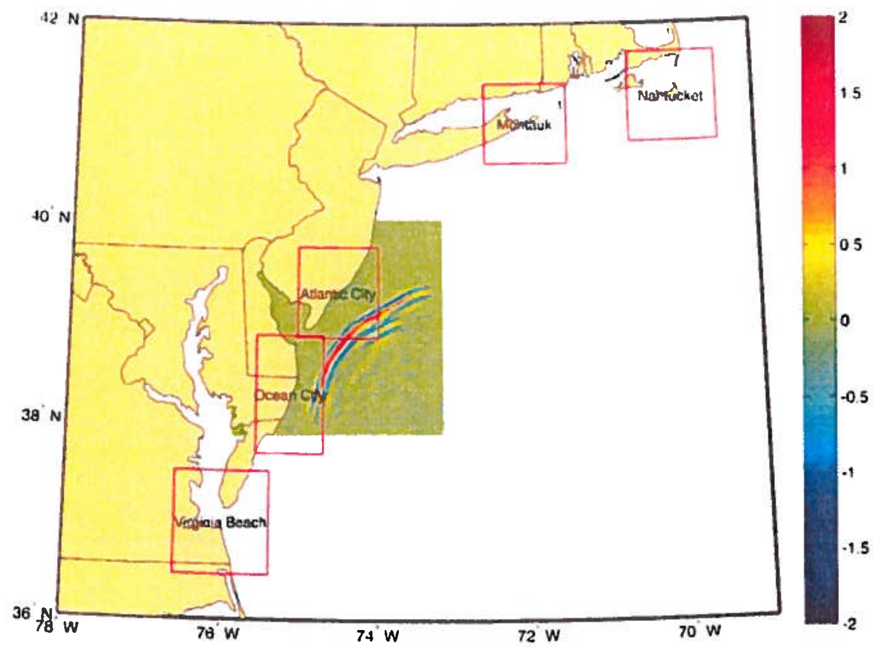


Fig. 11: Maximum tsunami elevation in a 1' regional grid, for the CVV (80 km^3) source of Fig. 5c

(a)



(b)

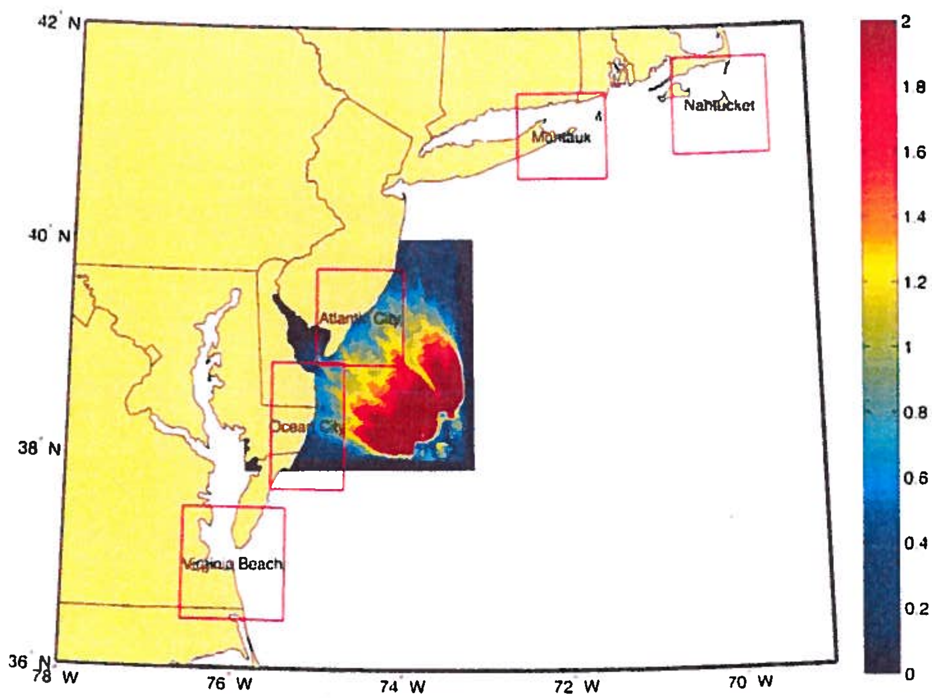


Fig. 12: Tsunami elevation computed with NHwave (up to 15 mins.) and FUNWAVE-TVD, in a 500 m regional grid, for the first SMF source shown in Fig. 8 (left; bottom source): (a) instantaneous elevation after 75 mins of propagation; (b) maximum envelope of elevation.

REFERENCES

Abadie S., C. Gandon, S. Grilli, R. Fabre, J. Riss, E. Tric, D. Morichon, and S. Glockner 2009. 3D Numerical Simulations of Waves Generated by Subaerial Mass Failures. Application to La Palma Case. In *Proc. 31st Intl. Coastal Engng. Conf.* (J. Mc Kee Smith, ed.) (ICCE08, Hamburg, Germany, September, 2008), 1,384-1,395. World Scientific Publishing Co. Pte. Ltd.

Abadie, S., Morichon, D., Grilli, S.T. and Glockner, S. 2010. A three-fluid model to simulate waves generated by subaerial landslides. *Coastal Engineering*, 57: 779-794, doi:10.1016/j.coastaleng.2010.03.003.

Abadie, S., J. Harris and S.T. Grilli 2011a. Numerical simulation of tsunami generation by the potential flank collapse of the Cumbre Vieja Volcano. In *Proc. 21st Offshore and Polar Engng. Conf.* (ISOPE11, Maui, HI, USA, June 19-24, 2011), pps. 687-694, Intl. Society of Offshore and Polar Engng.

Abadie, S., J.C. Harris, S.T. Grilli and R. Fabre 2011b. Numerical modeling of tsunami waves generated by the flank collapse of the Cumbre Vieja Volcano (La Palma, Canary Islands): tsunami source and near field effects. *J. Geophys. Res.*, 65 pps. (in revisions).

Barkan, R., U. S. ten Brink, and J. Lin. 2009. Far field tsunami simulations of the 1755 Lisbon earthquake: Implications for tsunami hazard to the U.S. East Coast and the Caribbean. *Marine Geology*. 264: 109-122.

Baxter, C., Krauss, T. and S.T. Grilli 2011. A Monte Carlo approach for estimating tsunami hazard from submarine mass failure along the U.S. East coast. *EOS Trans. AGU*, **92**(52), Fall Meet. Suppl., Abstract NH24B-06.

Booth, J.S., Circe, R.C., Dahl, A.G., 1985. Geotechnical characterization and mass movement potential of the United States North Atlantic continental slope and rise. *Tech. Rep. U.S. Geological Survey*, pp. 85–123.

Booth, J.S., O'Leary, D.W., Popenoe, P., Danforth, W.W., 1993. U.S. Atlantic continental slope landslides: their distribution, general attributes, and implications, In: Schwab, W.C., Lee, H.J., Twichell, D.C. (Eds.), *Submarine Landslides: Selected studies in the U.S. Exclusive Economic Zone*. U.S. Geological Survey Bulletin 2002, pp. 14–22.

Chaytor, J.D., Twitchell, D.C., Ten Brink, U.S., Buczkowski, B.J., Andrews, B.D., 2007. Revisiting submarine mass movements along the U.S. Atlantic continental margin: implications for tsunami hazards. *Submarine Mass Movements and their Consequences, 3rd Intl. Symp.* Springer, pp. 395–404.

Chaytor, J.D., ten Brink, U.S., Solow, A.R., Andrews, B.D., 2009. Size distribution of submarine landslides along the U.S. Atlantic margin, *Marine Geology*, 264(1-2): 16-27, doi:10.1016/j.margeo.2008.08.007.

Chen, Q., Kirby, J.T., Dalrymple, R.A., Kennedy, A.B. and Chawla, A., 2000. Boussinesq modeling of wave transformation, breaking and runup. II: Two horizontal dimensions, *J. Waterway, Port, Coastal and Ocean Engineering*, 126: 48-56.

Day, S. J., P. Watts, S. T. Grilli and Kirby J.T., 2005. Mechanical models of the 1975 Kalapana, Hawaii earthquake and tsunami, *Marine Geology*, 215(1-2): 59-92.

Enet, F. and S. T. Grilli. 2007. Experimental study of tsunami generation by three-dimensional rigid underwater landslides. *J. Waterway, Port, Coastal and Ocean Engineering*. 133: 442-454.

Gica, E., M. C. Spillane, V. V. Titov, C. D. Chamberlin, and J. C. Newman. 2008. Development of the forecast propagation database for NOAA's Short-Term Inundation Forecast for Tsunamis (SIFT). NOAA Tech. Memo. OAR PMEL-139.

Grilli. S.T., O.-D. S. Taylor, D.P. Baxter, and S. Maretzki. 2009. Probabilistic approach for determining submarine landslide tsunami hazard along the upper East Coast of the United States. *Marine Geology*. 264(1-2): 74-97.

Grilli, S.T., S. Dubosq, N. Pophet, Y. Pérignon, J.T. Kirby, and F. Shi. 2010. Numerical simulation and first-order hazard analysis of large co-seismic tsunamis generated in the Puerto Rico trench: near-field impact on the North shore of Puerto Rico and far-field impact on the US East Coast. *Nat. Hazards Earth Syst. Sci.*, 10: 2109–2125.

Grilli, S.T., Ioualalen, M, Asavanant, J., Shi, F., Kirby, J. and Watts, P. 2007. Source Constraints and Model Simulation of the December 26, 2004 Indian Ocean Tsunami. *J. Waterway, Port Coastal and Ocean Engineering*, 133(6): 414-428.

Grilli, S.T. and P. Watts. 2005. Tsunami generation by submarine mass failure Part I : Modeling, experimental validation, and sensitivity analysis. *J. Waterway Port Coastal and Ocean Engng.*, 131(6): 283-297.

Ioualalen, M. , Asavanant, J., Kaewbanjak, N., Grilli, S.T., Kirby, J.T. and P. Watts 2007. Modeling the 26th December 2004 Indian Ocean tsunami: Case study of impact in Thailand. *J. Geophys. Res.*, 112: C07024, doi:10.1029/2006JC003850

Kennedy, A. B, Chen, Q., Kirby, J. T., and Dalrymple, R. A., 2000. Boussinesq modeling of wave transformation, breaking and runup. I: One dimension, *J. Waterway, Port, Coastal and Ocean Engineering*, 126: 39-47.

Kirby, J.T., Pophet, N., Shi, F. and Grilli, S.T. 2009. Basin scale tsunami propagation modeling using Boussinesq models: Parallel implementation in spherical coordinates. In *Proc. WCCE-ECCE-TCCE Joint Conf. on Earthquake and Tsunami* (Istanbul, Turckey, June 22-24), paper 100 (published on CD).

Kirby J.T., Shi F., Harris J.C. and S.T. Grilli 2011. Sensitivity analysis of transoceanic tsunami propagation to dispersive and Coriolis effects. *Ocean Modeling*, 42 pp. (to be submitted)

Krauss, T. 2011. Probabilistic tsunami hazard assessment for the United States east coast. *MS Thesis*, University of Rhode Island, 145 pps.

Ma G., Shi F. and Kirby J.T. 2011. Shock-capturing non-hydrostatic model for fully dispersive surface wave processes. *Ocean Modeling*, 55 pps. (accepted).

Okada, Y., 1985. Surface deformation due to shear and tensile faults in a half-space, *Bull. Seis Soc. Am.*, 75(4): 1135-1154.

Tappin, D.R., Watts, P., Grilli, S.T. 2008. The Papua New Guinea tsunami of 1998: anatomy of a catastrophic event, *Natural Hazards and Earth System Sciences*, 8: 243-266.

tenBrink, U. S., D. Twichell, E. Geist, J. Chaytor, J. Locat, H. Lee, B. Buczkowski, and M. Sansoucy 2007. The Current State of Knowledge Regarding Potential Tsunami Sources Affecting U.S. Atlantic and Gulf Coasts. Report to the Nuclear Regulatory Commission. *USGS.* 166 pps.

ten Brink, U., Twichell, D., Geist, E., Chaytor, J., Locat, J., Lee, H.Buczkowski, B., Barkan, R., Solow, A., Andrews, B., Parsons, T., Lynett, P., Lin, J. and Sansoucy, M., 2008, "Evaluation of tsunami sources with the potential to impact the U. S. Atlantic and Gulf coasts – a report to the Nuclear Regulatory Commission", U.S. Geological Survey Administrative Report.

Twichell, D. C., J. D. Chaytor, U.S. ten Brink, and B. Buczkowski. 2009, Morphology of Late Quaternary Submarine Landslides along the U.S. Atlantic Continental Margin. *Marine Geology*. 264: 4-15.

Shi, F., J.T. Kirby, J.C. Harris, J.D. Geiman and S.T. Grilli 2011. A High-Order Adaptive Time-Stepping TVD Solver for Boussinesq Modeling of Breaking Waves and Coastal Inundation. *Ocean Modeling*, 60 pps. (accepted).

Watts, P., S. T. Grilli, J. T. Kirby, G. J. Fryer, and D. R. Tappin. 2003. Landslide tsunami case studies using a Boussinesq model and a fully nonlinear tsunami generation model. *Nat. Hazards Earth Syst. Sci.* 3: 391-402.

Watts, P., Grilli, S.T., Tappin D. and Fryer, G.J. 2005. Tsunami generation by submarine mass failure Part II : Predictive Equations and case studies, *J. Waterway Port Coastal and Ocean Engng.*, 131(6): 298-310.

Wei, G., Kirby, J. T., Grilli, S. T. and Subramanya, R., 1995. A fully nonlinear Boussinesq model for surface waves. I. Highly nonlinear, unsteady waves, *J. Fluid Mech.*, 294: 71-92.