NTHMP FY14 Grant Project Narrative

Project Name/Title:	Modeling Tsunami Inundation and Hazard for the U. S. East Coast (Phase 3)
Project Dates:	September 1, 2014 – August 31, 2015
Recipient Institution:	University of Delaware
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Executive Summary

In contrast to the long history of tsunami hazard assessment on the US West coast and Hawaii, tsunami hazard assessment along the eastern US coastline 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 trench (PRT) or near Leeward Islands, or a flank collapse of the Cumbre Vieja Volcano (CVV) in the Canary Islands). Moreover, considerable geologic 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.

In FY10-12, we began the process of hazard analysis and inundation map development for the U. S. East Coast. Simulating tsunami sources from the PRT, CVV and Azores-Gibraltar convergence zone, together with a number of relevant near-field SMFs, we concentrated on developing tsunami inundation maps (maximum envelope) for continuous coastal areas located North of Ocean City, MD to Cape Cod, MA, plus Myrtle Beach, SC (excluding major bays or estuaries such as Chesapeake Bay, Delaware Bay, Hudson River, Long Island Sound and Narragansett Bay). In FY13, we are extending the range of this mapping effort southward to include the communities of Virginia Beach, VA, Savannah, GA, and Miami Beach, FL. Work done in this area will provide detailed tsunami hazard mapping inputs for a number of the larger east coast coastal communities, and the overall modeling effort should provide an indication of possible additional communities needing attention as well as a sufficient background for providing guidance on determining hazard levels for non-modeled communities. The work to date provides

a reasonably comprehensive coverage of the Northeast, as indicated in Figure 1. More work would need to be done to provide complete coverage of the Southeast, beyond the level of coverage in the present effort.

We propose to address several important issues in FY14, and provide a set of three prioritized tasks.The Priority 1 task is to begin an investigation of dynamic tidal effects on tsunami behavior. Several high population locations on the East Coast are located in regions, which are strongly affected by estuarine tidal flows, with prominent examples being New York, NY and Norfolk, VA. Both of these areas have been or are presently being modeled as part of FY10-12 or FY13 work, but these investigations do not take into account any potential effects of the tidal conditions. In the work proposed here, we would model the combined effects of tidal phase and current magnitude on the evolution of tsunami waves, in order to gain an understanding of nature of the combination. In particular, we would assess whether the resulting scenario could be treated as a simple linear combination of tide and tsunami, or whether there are significant nonlinearities in the superposition that potentially lead to more hazardous conditions than would be expected from linear superposition alone. At the same time, we would use this extended modeling effort to examine maritime hazard conditions, and assess whether guidelines adopted for the West Coast are appropriate to East Coast sites. (In particular, we wish to examine whether existing guidance for safe water depths, obtained by examining modeled conditions on the West Coast, are appropriate guidance for the East Coast, where water depths increase much more slowly offshore.)

Our second priority item is to further refine our set of sources used for east coast modeling, mainly by (1) extending the suite of candidate continental margin SMF sources to include a broader set of cases from the geological record, (2) performing a broader range of simulations for the CVV volcanic cone collapse based on events which are less extreme than the presently utilized 450 km^3 slide volume, and (3) examine the role of our modeling approach in determining the hazard associated with each event. We would use this broader range of source conditions as a basis for reexamining several of the most-impacted communities identified in FY10-12 and FY13 work, with the goal of redoing detailed mapping of two communities in FY14. Finally, we would collaborate with a multi-state group led by California, which is working towards the development of improved capabilities in the area of landslide-generated tsunamis, particularly regarding model benchmarking and the development of warning and detection capabilities for landslide events. This collaboration is spelled out in a multi-state priority submitted by California.

Our third priority task is to conduct a comparison of our previously developed inundation lines with published FEMA hurricane flood maps for selected areas we have directly modeled. The goal is to determine whether there is sufficient agreement between the two families of results to allow using the FEMA maps as proxies in areas where tsunami inundation maps have not yet been developed. A positive result here would have two potential outcomes: first, an agreement between the map products would reduce the urgency for producing independent tsunami hazard maps in all communities (particularly those believed to be less affected) and would allow local communities to start making determinations on hazard conditions and evacuation strategies based on the more familiar FEMA products. Secondly, a positive outcome would allow us to use FEMA products as the fundamental resource for providing guidance in areas which are not likely to be covered by a detailed NHTMP modeling effort. We will also approach this problem by comparing low resolution model predictions offshore, which are available for the entire coastline, to high resolution inundation results onshore, which are available for our areas mapped in FY10-13. Development of guidance based on these approaches will be closely coordinated with the Gulf States, who will be working with the same basic information.

Similar to our earlier work during FY 10-12, and FY13, modeling in this project will be carried out using a set of models developed at the University of Delaware, including FUNWAVE-TVD, a Boussinesq model for tsunami propagation and inundation simulations, in Cartesian or spherical coordinates (Shi et al., 2012; Kirby et al., 2013) and NHWAVE, a RANS three-dimensional, sigma-coordinate model for simulating fully non-hydrostatic short wave response to large scale ground motion (Ma et al., 2012, 2013; Kirby et al, 2014). FUNWAVE and NHWAVE are open source, publically available models, which have been benchmarked according to NTHMP standards (Tehranirad et al, 2011, 2012; Shi et al, 2012b) for use in NTHMP-sponsored work. Both codes are efficiently parallelized using MPI and use a one-way coupling methodology, allowing for large scale computations of tsunami propagation and coastal impact to be performed in a series of nested grids of increasingly finer resolution. Both models deal with breaking dissipation via a TVD algorithm and also implement bottom friction. As in previous work, we will use NHWAVE to compute the initial tsunami waves generated from SMF sources (both translational slides and rotational slumps) and, once the tsunamigenic part of the SMF is complete, we will continue simulating tsunami propagation in FUNWAVE. While we have been so far only considering rigid SMFs in our work, which are believed to yield worst case scenario SMF tsunamis, the most recent version of NHWAVE makes it possible to simulate deforming slides (Ma et al., 2013; Kirby et al, 2014). We will begin to assemble a set of model results based on deforming slide calculations, pending anticipated parallel efforts towards benchmarking the codes for NTHMP work.

The three tasks indicated here are primarily intended to support the MMS outcome "Tsunami hazard assessment that supports informed decision making in tsunami-threatened communities."
Task 1 addresses the MMS strategy to "Develop new tsunami hazard products to assist the maritime community and meet emergency management and other NTHMP customer requirements". Task 3 addresses the specific MMS strategy to "Develop expected inundation limits for communities which are not provided with high resolution inundation maps". Finally, Task 2 work aimed at furthering the multi-state collaboration on landslides is aimed at supporting the Warning Coordination outcome "Understandable and effective warning center products".

Background

The proposing team of Kirby and Shi (UD) and S. Grilli and A. Grilli (URI) has been conducting NTHMP-funded work starting in FY10 (A. Grilli since FY12) and continuing to the present. Work to date has been entirely in the area of modeling inundation resulting from potential coseismic, submarine mass failure and volcanic cone failure events, in support of the goal of developing tsunami inundation maps for coastal communities. FY10-12 project work centered on development of an initial set of tsunami sources and high resolution mapping of DEM's stretching from Ocean City, MD to Cape Cod. FY13 work is aimed at additional modeling of regions further to the south, including Virginia Beach VA, Savannah, GA, and Myrtle Beach, SC using existing sources, and Miami FL and vicinity using a SMF source based on the West Bahama Banks. This last study leverages a collaboration with U. Miami, who have performed the initial analysis and modeling of the source. Project work on sources has been documented in a series of reports, which are available at http://chinacat.coastal.udel.edu/nthmp.html. Inundation reports for each regional DEM are being developed. These reports provide guidance on accessing modeling results, stored as raster based data sets in ArcGIS format. Tabulated results include inundation limits, inundation depths, maximum velocities and maximum momentum fluxes for initially dry areas, and maximum elevation, velocity and vorticity for initially submerged areas. Draft versions of annotated inundation maps, following NTHMP guidelines, will be provided for evaluation and approval by individual state agencies.

The PIs have extensive experience in tsunami model development and application to ocean scale propagation, submarine mass failure generation mechanisms, and inundation modeling. Kirby and Grilli developed the first fully-nonlinear Boussinesq model, and this theory served as the basis for the first open source, publically available version of such a model, FUNWAVE. FUNWAVE has recently been extensively revised in order to improve its accuracy in performing simulations of tsunami runup and inundation (Shi et al., 2012), and it has been extended to include a spherical coordinate system, with Coriolis effects, for use at ocean scale (Kirby et al., 2013). The model has been fully documented and benchmarked (Shi et al., 2011a; Tehranirad et al., 2011) according to NTHMP standards (Synolakis et al, 2007). The PIs have also been instrumentally involved in the development of methods for performing simulations of either solid or deforming submarine mass failures (SMF) using Navier-Stokes solvers, with either high resolution VOF modeling (Abadie et al., 2010, 2012), or a more efficient, lower resolution surface and terrain following model (Ma et al., 2012, 2013). This latter model, NHWAVE, is being used for ongoing SMF simulations in the FY10-12 and FY13 work, and has been benchmarked for NTHMP use (Tehranirad et al., 2012). The PIs have made a number of significant contributions to the understanding of wave generation by SMFs, and the group has carried out highly accurate simulations of near and farfield response to seismic tsunami events including the 2004 Indian Ocean event (Grilli et al, 2007; Ioualalen et al, 2007) and the 2011 Tohoku event (Grilli et al, 2013; Kirby et al, 2013).

In this box, provide the title of each task, listed in order of priority.

The tasks listed should reflect priorities for sustainment of current activity and participation in NTHMP supported projects and should be consistent with the NTHMP Strategic Plan.

Explain carefully how this new grant will not overlap or duplicate any work under current NOAA grants which, with no-cost extensions, could overlap in time periods for execution.

Priority 1: Tidal effects on tsunami inundation at estuarine and river entrances.

Priority 2: Refinement and extension of potential SMF sources and source modeling techniques for tsunami activity in the North Atlantic.

Priority 3: Developing guidelines for tsunami hazard estimation in non-modeled U. S. East Coast areas.

Each of these proposed tasks is distinct from work undertaken in FY10-12 and FY13.

Modeling and mapping in FY10-13 has been carried out without consideration of the dynamic influence of tides on nearshore wave characteristics. The effort proposed in Priority 1 reconsiders two of our previously mapped areas, but addresses the question of whether strong tidal flows could alter the magnitude of shoreline inundation in a manner that needs to be addressed in final map products. The effort in Priority 1 would utilize existing model codes for tidal motions. No code development is required.

Work in Priority 2 could lead to revision of final inundation lines and other tabulated results that have been assembled to date for modeled areas. These revisions would likely occur before effort is expended at state level to complete tsunami inundation or evacuation maps.

Work in Priority 3 will hopefully indicate whether existing model results will be sufficient for providing guidance for hazard assessment for the remainder of the coast that is not modeled yet at a high resolution, or whether there are additional areas that are likely to be in need of high resolution modeling.

Task Project Narratives

Priority 1: Tidal effects on tsunami inundation at estuarine and river entrances.

The primary goal of this task is to utilize a combined model of tidal circulation and tsunami behavior to assess the effect of tidal stage and currents on shoreline inundation. A secondary goal is to examine the combined effect of tidal and tsunami-driven currents on increased maritime hazards in areas with strong tidal flows to start with.

To date, the interaction between tides and potential tsunami waves have only rarely been studied. Tolkova (2012) simulated such a tsunami-tide interaction for the Columbia River, where the East Japan Tohoku tsunami of March 11th, 2011 propagated more than 100 km upstream (see also Grilli et al., 2012a and Kirby et al., 2013). Tolkova found that the tsunami waves propagated further on a rising tide in the lower portion of the river; however, upstream the tsunami propagated further at the maximum high tide. The simulations performed also showed potential amplification of the tsunami waves directly after the high tide. Tolkova concluded that the interaction of the two waves is completely dependent on the specific environment in which the interaction occurs. To evaluate the effects of tide-tsunami interactions, here, for the largest tides at the site, we will perform simulations where incoming tsunami wave elevation and velocities and tidal forcing will be superimposed at an offshore boundary. To do so, it will be assumed that in sufficiently deep water and far offshore, both waves (i.e., tsunami and tide) can be linearly superimposed to define the boundary condition. Tide forcing will be limited to the strongest semi-diurnal component and will be obtained from a tide simulation model.

Modeling will be based on an accepted model for tidal circulation, such as NearCoM (Shi et al, 2011), ADCIRC or Delft3D, used together with the Boussinesq model FUNWAVE for shorter, more dispersive tsunami motions. The modeling team has experience utilizing the models for tidal circulation mentioned, and have developed the FUNWAVE and NearCoM codes in house.

Dispersive tsunami wave trains can cover time periods on the order of a tidal cycle in length, and hence, in order to obtain a complete picture of the potential for increased hazard in a tidally modulated event, it will necessary to perform a number of simulations encompassing a range of lag times (for example, hours between high tide at a reference point and arrival of the tsunami at that point).

In FY14, we will apply this technique to DEM's for New York Harbor and Virginia Beach/Norfolk, which have been or are presently being studied without consideration of tides in FY10-12 and FY13 work, respectively. Model grids for computing tidal motion in Chesapeake Bay and the Hudson River regions will be obtained from separate oceanographic studies or will be developed specifically for this work.

List all NTHMP Strategic Plan Outcome and Strategies that this task addresses.

1. Tsunami hazard assessment that supports informed decision making in tsunami-threatened communities (MMS)

2. Develop inundation maps for all communities with high tsunami hazard as defined by state tsunami programs
   Milestone: Test in a high-hazard rated selected community the importance of updating previously computed inundation maps based on new tsunami source information, improved digital-elevation models, and/or improved modeling technology by the end of 2014.
3. Develop new tsunami hazard products to assist the maritime community and meet emergency management and other NTHMP customer requirements

Is there a task in this Priority that is shared in its execution with another NTHMP partner? _x_ No ____ Yes. If so, state which partner(s):	
	FY14: A procedure for modeling shoreline inundation for combined tidal and tsunami processes, and application to two major, ocean-exposed East Coast sites with heavy ship utilization. Multi-year, application to two sites by 8/31/15
	FY14 Cost: $100,012

Priority 2: Refinement and extension of potential SMF sources and source modeling techniques for tsunami activity in the North Atlantic:

Sources used in initial mapping efforts for the East Coast consist of seismic sources (Puerto Rico, Azores), volcanic cone collapse (Cumbre Vieja, CVV) and several SMF sources on the US continental margin. To date, FY10-12 work, mainly confined to the Northeast, has used a family of Currituck-like sources as SMF proxies with various source locations dictated by the presence of an adequate sediment supply to support the size of the event. FY13 work further to the south utilizes a Cape Fear-like slide proxy with a probable maximum size, and an event located on the West Bahamas Bank carbonate platform. All slide modeling to date has been based on a solid slide model developed in house by Ma et al (2012) and benchmarked against a solid slide experiment by Enet and Grilli (2007). We would like to put in effort to:

1. Extend the number and distribution of size of our slide sources in order to obtain a more nuanced set of input to hazard mapping results, particularly near the northern and southern edges of our study area,
2. Perform a broader range of simulations for the CVV volcanic cone collapse based on events which are less extreme than the presently utilized 450 km^3 slide volume (Abadie et al., 2012).
3. Examine the role of modeling approach in determining the hazard associated with each event.

For each of the slide sources considered here, we propose to perform simulations for both solid slides, and for a slide model based on a depth-integrated, deformable slide layer lying below the usual NHWAVE perfect fluid layer (Kirby et al, 2014). The purpose of this exercise is to determine whether solid slide modeling provides an overly conservative view of resulting tsunami events, as discussed further below.

The results for the increased range of slide events, and for the choice of deforming vs.

solid slides, would be used to re-examine the hazard mapping results for two heavily impacted communities, to be determined later.

As part of this task, we would take part in the initial phase of a multistate project "Improving tsunami warning for landslide tsunamis" proposed by California. Landslide tsunamis play a dominant role in the hazard estimates for the East Coast, and we are concerned both with the warning technology (with warning times being much smaller for SMF tsunamis) and with the impact of choice of modeling technique on the resulting size of modeled events. In particular, we would like to provide a comparison of events for our chosen sources (as well as other sources of generic nature or in specific geographic locations) based on using solid translating slides vs. arbitrarily deforming slides. Results in hand from other related projects indicate that simulations based on solid, nondeforming slides can be dramatically over-conservative. There is also a need for establishing benchmark tests for the deformable slide cases, as this modeling approach plays a strong part in several state and region NTHMP modeling efforts.

Echoing the description of a multi-state effort proposed through the State of California's NTHMP FY14 proposal, we would coordinate with CA and additional partners to:

- Evaluate and improve the criteria used by the Tsunami Warning Centers for minor-moderate earthquake and landslide sources. This warning criteria issue is a major concern along the highly populated, central and southern California coastlines. California is working closely with Alaska, Puerto Rico, and the East and Gulf Coast states, which face a similar hazard, to develop tsunamigenic landslide benchmarks and hold a model validation workshop by 2015.
- Work with other entities to evaluate appropriate locations for undersea landslide investigations to compare with the above analysis and use toward eventual WCS recommendation of protocol development by the tsunami warning centers; these other entities include states/territories with similar local source issues: Alaska, Puerto Rico, East Coast, and Gulf Coast. Part of this analysis will also lead to the creation of new benchmarks for tsunamigenic landslide modeling through the NTHMP and ultimately to a model benchmark workshop. The PIs have experience in such an activity, as they co-organized the first workshop on SMF tsunami modeling in 2003, which was sponsored by the National Sciences Foundation.

List all NTHMP Strategic Plan Outcome and Strategies that this task addresses.

1. Tsunami hazard assessment the supports informed decision making in tsunami-threatened communities (MMS)
2. Provide guidance to refine TWC products
3. Develop inundation maps for all communities with high tsunami hazard as defined by state tsunami programs

   Milestone: Test in a high-hazard rated selected community the importance of updating previously computed inundation maps based on new tsunami source information, improved digital-elevation models, and/or improved modeling technology by the end of 2014.

4. Understandable and effective Tsunami Warning Center Products
5. Provide guidance to refine TWC products
   Milestone: Conduct an annual review of TWC products at the annual WCS meeting and update products accordingly.

Is there a task in this Priority that is shared in its execution with another NTHMP partner?
__ No _X__ Yes. If so, state which partner(s): California, Alaska, Puerto Rico, Gulf Coast.

	FY14: A more detailed examination and probabilistic analysis of a wider range of Atlantic tsunami sources for use in hazard mapping. Multiyear, two remapped communities by 8/31/15. Eventual development of protocol for appropriate magnitude of earthquake for assisting warning centers with issuing appropriate information.
	FY14 Cost: $44,993

Priority 3: Examining the correspondence between tsunami and storm surge inundation estimates for use as the basis for mapping tsunami hazards in non-modeled U.S. East Coast areas:

The U.S. East and Gulf Coasts are frequently impacted by large storm systems such as tropical cyclones and Nor'easters, and as a result there has been extensive effort made to develop probabilistic inundation maps for storm-driven coastal flooding. These maps cover the same areas under consideration in NTHMP modeling and mapping efforts, and are already extensively developed for the entire region, with extensive efforts either ongoing or recently completed to update the modeling database and resulting maps in several FEMA regions. (These studies have also been the source for high resolution DEM's in several areas not covered by the NGDC tsunami DEM's, such as New York City and adjacent areas in New Jersey and Long Island (NY)). FEMA flooding maps will be collected for the entire East Coast and then systematically compared to existing NTHMP modeling efforts. The task is expected to not be entirely straightforward, as estuaries and other types of embayments can be resonators of low frequency storm surge responses, leading to increasing surge with distance from ocean entrances, whereas they typically serve as filters for tsunami motions, attenuating the tsunami signal over these same distances. Our strategy would likely be to examine the correspondence between FEMA and NTHMP results on directly exposed ocean shorelines, and then account for likely tsunami attenuation effects further up rivers or estuaries using medium resolution modeling.

In addition, geometric features of shelf geometry are known to lead to focusing effects in incident tsunami waves, leading to alongshore variations in tsunami response that are not likely to be mirrored by surge responses to traveling storm systems. To address this, we will examine the correspondence between low resolution model results offshore and detailed model results onshore in mapped areas in order to provide an additional baseline for unmapped areas.

In order to provide a test of the resulting methodology, we will use a training set and test set approach. Guidelines will be developed based on a set of about 50% of our total set of modeled DEM's (the training set), and then the guidelines will be applied to the remaining set of modeled DEM's and compared to model results there (the test set). In the event that the test produces accurate results (as indicated by a to-be-determined criterion), the methodology will then be suggested for use as the regular NTHMP guidance for hazard determination in unmodeled East Coast areas. A "learning machine algorithm" approach could be evaluated to help identifying similar patterns in both types of maps and defining a relevant criterion to do so. We will coordinate closely with the Gulf Coast region in developing the methodology, as that region has undergone the same detailed analysis for hurricane storm surge and is affected by similar types of potential tsunami events. No formal multi-state proposal exists on this topic to date.
List all NTHMP Strategic Plan Outcome and Strategies that this task addresses. 1. Tsunami hazard assessment to support informed decision making in tsunami-threatened communities (MMS) 2. Develop expected inundation limits for communities, which are not provided with high-resolution inundation maps. (MMS)
Is there a task in this Priority that is shared in its execution with another NTHMP partner? _X_ No ___ Yes. If so, state which partner(s):

	FY14: Guidelines for using FEMA storm surge maps and/or low resolution model results as a basis for determining NTHMP guidelines in unmapped areas. 8/31/15
	FY14 Cost: $29,994

Summary of Task Plan

FY14 Milestone Schedule (September 1, 2014 – August 31, 2015)

Task	Key Milestone	Expected Month/Year of Completion	Requested Funding
Priority 1: Tidal effects on tsunami inundation at estuarine and river entrances.			
	Operating tide/tsunami simulation for general application	**12/14**	
	Simulations of NY, Norfolk	**8/15**	
		Subtotal Priority 1:	**$100,012**
Priority 2: Refinement and extension of potential SMF sources and source modeling techniques for tsunami activity in the North Atlantic			
	Determining additional sources (slides and CVV)	**2/15**	

	Comparison of solid vs deformable slides as tsunami sources	**5/15**	
	Remapping two heavily impacted areas	**8/15**	
		Subtotal Priority 2:	**$44,993**
Priority 3: Examining the correspondence between tsunami and storm surge inundation estimates for use as the basis for mapping tsunami hazards in unmodeled U. S. East Coast areas.			
	Comparison of NTHMP and FEMA inundation maps for NTHMP mapped areas	**2/15**	
	Objective testing of methodology against previous modeled results	**8/15**	
		Subtotal Priority 3:	**$29,994**
		Total FY2014 Grant Request:	$174,999

Grand Total of Award Request: $174,999

BIOGRAPHICAL SKETCH

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A. Professional Preparation

Brown University	Engineering	Sc. B., 1975
Brown University	Engineering	Sc. M., 1976
University of Delaware	Civil Engineering	Ph. D., 1983

B. Appointments

Edward C. Davis Professor of Civil Engineering, University of Delaware, 2003 to present.
Professor, Department of Civil and Environmental Engineering, University of Delaware, 1994 to 2003.
Joint appointment in College of Earth, Ocean and the Environment, 1994 to present.
Visiting Professor, Grupo de Dinamica de Flujos Ambientales, Universidad de Granada, 2010, 2012.
Associate Professor, Department of Civil and Environmental Engineering, University of Delaware, 1989 to 1994.
Associate Professor, Department of Coastal and Oceanographic Engineering, University of Florida, 1988 to 1989.
Assistant Professor, Department of Coastal and Oceanographic Engineering, University of Florida, 1984 to 1988.
Assistant Professor, Marine Sciences Research Center, SUNY Stony Brook, 1983 to 1984.

C. Products

1. Kirby, J. T., Shi, F., Tehranirad, B., Harris, J. C. and Grilli, S. T., 2013, “Dispersive tsunami waves in the ocean: model equations and sensitivity to dispersion and Coriolis effects”, *Ocean Modelling*, **62**, 39-55.
2. Grilli, S. T., Harris, J. C., Tajalibakhsh, T., Masterlark, T. L., Kyriakopoulus, C., Kirby, J. T. and Shi, F., 2013, “Numerical simulation of the 2011 Tohoku tsunami based on a new transient FEM co-seismic source", *Pure and Applied Geophysics*, **170**, 1333-1359.
3. Ma, G., Kirby, J. T. and Shi, F., 2013, "Numerical simulation of tsunami waves generated by deformable submarine landslides", *Ocean Modelling*, **69**, 146-165.
4. Ma, G., Shi, F. and Kirby, J. T., 2012, "Shock-capturing non-hydrostatic model for fully dispersive surface wave processes", *Ocean Modelling*, **43-44**, 22-35.
5. Shi, F., Kirby, J. T., Harris, J. C., Geiman, J. D. and Grilli, S. T., 2012, "A high-order adaptive time-stepping TVD solver for Boussinesq modeling of breaking waves and coastal inundation", *Ocean Modelling*, **43-44**, 36-51.

Other Products

1. Sawyer, A. H., Shi, F., Kirby, J. T. and Michael, H. A., 2013, "Dynamic response of surface water-groundwater exchange to currents, tides and waves in a shallow estuary", *Journal of Geophysical Research - Oceans*, **118**, 1749-1758.

2. Ma, G., Kirby, J T., Su, S. F., Figlus, J. and Shi, F., 2013, "Numerical study of turbulence and wave damping induced by vegetation canopies", *Coastal Engineering*, **80**, 68-78.
3. Shi, F., Cai, F., Kirby, J. T. and Zheng, J., 2013, "Morphological modeling of a nourished bayside beach with a low tide terrace", *Coastal Engineering*, **78**, 23-34.
4. Geiman, J. D. and Kirby, J. T., 2013, "Unforced oscillation of rip-current vortex cells", *J. Phys. Oceanogr.*, **43**, 477-497.
5. Geiman, J. D., Kirby, J. T., Reniers, A. J. H. M. and MacMahan, J. H., 2011, “Effects of wave-averaging on estimates of fluid mixing in the surfzone”, *J. Geophys. Res.*, 116, C04006, doi:10.1029/2010JC006678

D. Synergistic Activities

1. Editorial service including Associate Editor, Journal of Engineering Mechanics (1994-1995), Editor, Journal of Waterway, Port, Coastal and Ocean Engineering (1996-2000), Editor, Journal of Geophysical Research – Oceans (2003-2006) and Editor-in-Chief, Journal of Geophysical Research – Oceans (2006-2009).
2. Member, Coordinating Committee and Mapping and Modeling Subcommittee of the National Tsunami Hazard Mitigation Program (2008-present).
3. Member, Board of Directors, American Institute of Physics (2011-2013).
4. Lead developer of a number of widely used public domain models for surface wave processes, including the surface wave transformation programs REF/DIF and FUNWAVE, the nearshore community model NearCoM for wave-driven circulation, and the recently developed surface and terrain following nonhydrostatic model NHWAVE.
5. Developer of course content for several University of Delaware graduate level courses including CIEG 672 Ocean wave mechanics, CIEG 872 Advanced ocean wave mechanics (textbook under development), CIEG 681 Ocean wave spectra (textbook under development), and CIEG 684 Introduction to nearshore modeling techniques (new course)

E. Collaborators and Other Affiliations

Collaborators and Co-Editors (48 months)
P. Barnard (USGS), Chris Baxter (URI), Tim J. Campbell (NRL), Yeon Chang, Bruce Cornuelle (SIO), K. P. Das (U. Calcutta), S. Debsarma (U. Calcutta), T. Duman (U AR), Kasey Edwards (NRL), L. Erickson (USGS), J. Eshleman (USGS), Katja Fennel (Dalhousie), W. Fox, David Froehlich (NOAA), W. Rockwell Geyer (WHOI), Stephan Grilli URI), Merrick Haller (OSU), Daniel Hanes (St. Louis U), Jeffrey L. Hanson (USGS), Jeffrey C. Harris (U. Rhode Island), Ruoying He, Bill Hodgkiss (SIO), H. R. Albert Jagers, James M. Kaihatu (Texas A&M), Michael Kemp (UMd), Bill Kuperman (SIO), Ming Li (UMD), Jamie MacMahan (NPS), Tim Masterlark (ND School of Mines), H. Tuba Özkan-Haller (OSU), John Proakis (UCSD), Ad Reniers (U Miami), D. Rouseff (U Wash), Audrey Sawyer (U. Kentucky), Jerry Smith (SIO), Tim Stanton (NPS), Ed Thornton (NPS), Jay Veeramony (NRL).

Ph.D. Thesis Advisor: Robert A. Dalrymple, Dept. of Civil Engineering, Johns Hopkins University.

Graduate and Postgraduate Advisees (41 total graduate advisees)
Dongming Liu (2008-2009); James Kaihatu (1994, Texas A&M), Changhoon Lee (1994, Sejong Univ.), Ge Wei (1997, unknown), H. Tuba Özkan-Haller (1997, Oregon St U), Mauricio Gobbi (1998, Fed. Univ. Parana), Arun Chawla (1999, NWS), Shubhra Misra (2005, Chevron), Wen Long (2006, U MD), Joseph Geiman (2011, Johns Hopkins ARL), Gangfeng Ma (2012, Old Dominion U), Zhifei Dong (expected 2014), Babak Tehranirad (expected 2015), Morteza Derakhti (expected 2015), Ryan Mieras (expected 2015), Saeideh Banihashemi (expected 2016).

Biographical Sketch for Stephan Grilli

Name: Stephan T. Grilli Title: Distinguished Professor
http: www.oce.uri.edu/_grilli Address: Dpt. Ocean Engng., URI, Narragansett, RI 02882
Tel./Fax.: (401) 874-6636/-6837 Email: grilli@oce.uri.edu

A. Professional Preparation :
M.S. (1980, Civil Engineering); Registered Professional Civil Engineer (1980); M.S. (1983, Physical Oceanography); Ph.D (1985, Ocean Engng.; advisor Prof. A. Lejeune), all from Univ. of Liège (Belgium) (all *summa cum laude*). Post-doctoral work (1985-87), Univ. of Liège (Belgium)

B. Permanent positions :
2011-present, *Professor* (joint appointment), U. of Rhode Island, Grad. School of Oceanography
2002-2008, *Chairman*, University of Rhode Island, Dept. of Ocean Engng.
1998-present, *Distinguished Professor*, University of Rhode Island, Dept. of Ocean Engng.
1996-1998, *Distinguished Assoc. Professor*, University of Rhode Island, Dept. of Ocean Engng.
1993-1996, *Associate Professor*, University of Rhode Island, Dept. of Ocean Engineering.
1991-1993, *Assistant Professor*, University of Rhode Island, Dept. of Ocean Engineering.
1987-1991, *Research Assistant Professor*, University of Delaware, Dept. of Civil Engineering.
1985-1987, *Research Associate* (F.N.R.S.), University of Liège (Belgium).

C. Visiting positions :
2007, 2014, *Research Director*, C.N.R.S., University of Toulon, LSEET, France (Spring 07, 14).
2005, *Invited Professor*, U. of Braunschweig, Institute for Civil Engng., Germany (January 05).
1999, *Visiting Senior Scientist*, University of Nice, Institut Nonlin´eaire, France (Spring 99).
1998-present, *Visiting/Invited Prof.*, Univ. of Toulon, LSEET Laboratory, France (1-3 m./year).
1996, *Visiting Professor*, University of Nantes, Ecole Centrale, France (January 06).
1991, *Visiting Scholar*, U. of Cantabria, Dept. of Water Science and Tech., Spain (April/June 91).

D. Selected Recent Publications : (see http://www.oce.uri.edu/ grilli/resume.html; h-index: 33)

1. Grilli, S.T., Ioualalen, M, Asavanant, J., Shi, F., Kirby, J. and Watts, P. (2007). Source Constraints and Model Simulation of the 12/26/04 Indian Ocean Tsunami. *J. Waterw. Port Coast. Ocean Engng.*, **133**(6), 414-428.
2. Ioualalen, M. , Asavanant, J., Kaewbanjak, N., Grilli, S.T., Kirby, J.T. and P. Watts (2007). Modeling the 12/26/04 Indian Ocean tsunami: Case study of impact in Thailand. *J. Geoph. Res.*, **112**, C07024.
3. Tappin, D.R., Watts, P., Grilli, S.T. (2008). The Papua New Guinea tsunami of 1998: anatomy of a catastrophic event. *Natural Hazard and Earth System Sc.*, **8**, 243-266.
4. Grilli, S.T., Taylor, O.-D. S., Baxter, D.P. 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, doi:10.1016/j.margeo.2009.02.010.
5. Grilli, S.T., S. Dubosq, N. Pophet, Y. P´erignon, 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. *Natural Hazards and Earth System Sciences*, **10**, 2109-2125.
6. Abadie, S., J.C. Harris, S.T. Grilli and R. Fabre (2012). 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.*, **117**, C05030.
7. Harris, J.C., S.T. Grilli, S. Abadie and T. Tajalibakhsh (2012). Near- and far-field tsunami hazard from the potential flank collapse of the Cumbre Vieja Volcano. In *Proc. 22nd Offshore and Polar Engng. Conf.* (ISOPE12, Rodos, Greece, June 17-22, 2012), Intl. Society of Offshore

and Polar Engng., 242-249.
8. Grilli, S.T., Harris, J.C., Tajali Bakhsh, T.S., Masterlark, T.L., Kyriakopoulos, C., Kirby, J.T. and and Shi, F. (2013). Numerical simulation of the 2011 Tohoku tsunami based on a new transient FEM co-seismic source: Comparison to far- and near-field observations. *Pure and Appl. Geophys.*, **170**, 1333-1359, doi:10.1007/s00024-012-0528-y .
9. Kirby, J.T., Shi, F., Tehranirad, B., Harris, J.C. and Grilli, S.T (2013). Dispersive tsunami waves in the ocean: Model equations and sensitivity to dispersion and Coriolis effects. *Ocean Modell.*, **62**, 39-55, doi:10.1016/j.ocemod.2012.11.009.
10. Grilli, S.T., J.C. Harris, J.T. Kirby, F. Shi, and G. Ma, T. Masterlark, D.R. Tappin and T.S. Tajali-Bakhsh (2013). Modeling of the Tohoku-Oki 2011 tsunami generation, far-field and coastal impact: a mixed coseismic and SMF source. In *Proc. 7th Intl. Conf. on Coastal Dynamics* (Arcachon, France, June 2013) (ed. P. Bonneton), paper 068, 749-758.
11. Grilli, S.T., Harris, J., F. Shi, J.T. Kirby, T.S. Tajalli Bakhsh, E. Estibals and B. Tehranirad (2013). Numerical modeling of coastal tsunami dissipation and impact. In *Proc. 33rd Intl. Coastal Engng. Conf.* (J. Mc Kee Smith, ed.) (ICCE12, Santander, Spain, July, 2012), 12 pps. World Sci. Pub. Co. Pte. Ltd.
12. Morra G., R. Geller, S.T. Grilli, S.-I. Karato, S. King, S.-M. Lee, P. Tackley, and D. Yuen (2013). Growing Understanding of Subduction Dynamics Indicates Need to Rethink Seismic Hazards. *EOS Trans. American Geophys. Union* **94**(13), 125-126, doi:10.1002/2013EO130008.

E. Synergistic Activities:
1. Various tsunami hazard assessment projects for critical coastal infrastructures (e.g., nuclear powerplant as and maritime facilities). Proprietary studies.
2. Appointed member of the US *National Research Council Marine Board* (2010-); East Coast co-representative on the US *National Tsunami Hazard Mitigation Program* mapping and modeling committee (2010-2013).

F. Current collaborators: Prof. M. Benoit (Univ. Paris East, France); Profs. C.A. Gu´erin, F. Nougquier, M. Saillard and Ph. Fraunie (Univ. of Toulon, France); Prof. S. Abadie (Univ. of Pau et Pays de l'Adour, France); Prof. M. Benoit (Lab. St Venant; Univ. Paris East); Prof. F. Dias (Ecole Normale Sup´eriqure, Paris, France); Prof. J.T. Kirby (Univ. of Delaware); Professor T.L. Masterlark South Dakota School of Mines); Prof. D. Tappin (British Geological Survey, UK); Prof. Krafczyk (Tech. U.. Braunschweig, Germany).

G. Media outreach: Featured on local, national, and international media (TV, radio, newspaper science sections) regarding extreme waves and tsunamis (e.g., Discovery channel, PBS-National Geographics Intl., US Weather Channel, BBC-TV/radio, ABC/NBC, CNN International, History Channel, DE-NPR,. . .).

I. Thesis advisor and postgraduate-scholar sponsor: (past 5 years : 2 post-doc, 20 graduate students) : Taylor Asher (MS, URI), Amir Banari (current PhD student, URI); Benjamin Biausser (PhD; Technip, France), Myriam El Bettah (current PhD student, URI), Kevyn Bollinger (MS, URI), Sara Dubosq (current PhD student, U. of Toulon, France), Yann Drouin (MS; Ecole Centrale, Nantes, France), Francois Enet (PhD, URI; Alkyon Inc., Holland), Christophe Fochesato (PhD; Ecole Normale Sup´erieure, France), Nate Greene (MS, URI; Raytheon, RI), Richard Gilbert (MS; McLaren Inc., NY), Philippe Guyenne (PhD; U. of Delaware, DE), Jeff Harris (PhD, URI; Laboratoire St Venant, Paris), Stefan Maretzki (MS, URI; Germany), Kristy Moore (MS, URI; NUWC, RI), Yves Perignon (MS; PhD, ECN, Nantes, France) Matt Schultz (MS, URI; Woods Hall Engineering Inc.), Tayebeh S. Tajali-Bakhsh (current PhD student, URI).

Professional Societies : AGU, ASCE, ISOPE, MTS; 7 scient. awards in Belgium, France and US

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C. Professional Preparation

Wuhan University of Science and Technology, Physics, Sc. B., 1984
Ocean University of Qingdao, Physical Oceanography, Sc. M., 1991
Ocean University of Qingdao, Environmental and Physical Oceanography, Ph. D., 1995
University of Delaware, Center for Applied Coastal Research, Postdoc, 1999-2003

D. Appointments

Research Associate Professor, Department of Civil and Environmental Engineering & Center for Applied Coastal Research, University of Delaware, 2012 - present
Research Assistant Professor, Department of Civil and Environmental Engineering & Center for Applied Coastal Research, University of Delaware, 2007 - 2012
Associate Scientist, Center for Applied Coastal Research, University of Delaware, 2004 – 2007
Associate Professor, Institute of Estuarine and Coastal Research, East China Normal University, 1997 – 1998

E. Publications

(i) Five most closely related to the proposed project

- Ma, G., Kirby, J. T. and Shi, F., 2013, ``Numerical simulation of tsunami waves generated by deformable submarine landslides", *Ocean Modelling*, 69, 146-165.

- Kirby, J. T., Shi, F. Harris, J. C., and Grilli, S. T., 2013, "Sensitivity analysis of trans-oceanic tsunami propagation to dispersive and Coriolis effects", *Ocean Modeling* , 62, 39-55.

- Grilli, S. T., Harris, J. C., Tajalibakhsh, T., Masterlark, T. L., Kyriakopoulus, C., Kirby, J. T. and Shi, F., 2012, ``Numerical simulation of the 2011 Tohoku tsunami based on a new transient FEM co-seismic source", *Pure and Applied Geophysics*, doi:10.1007/s00024-012-0528-y

- Shi, F., Kirby, J. T., Harris, J. C., Geiman, J. D. and Grilli, S. T., 2012, "A high-order adaptive time-stepping TVD solver for Boussinesq modeling of breaking waves and coastal inundation", *Ocean Modelling*, 43-44, 36-51.

- Ma, G., Shi, F. and Kirby, J. T., 2012, "Shock-capturing non-hydrostatic model for fully dispersive surface wave processes", *Ocean Modelling*, 43-44, 22-35.

(ii) Five other recent publications

- Ma, G., Kirby, J T., Su, S. F., Figlus, J. and Shi, F., 2013, "Numerical study of turbulence and wave damping induced by vegetation canopies", *Coastal Engineering*, 80, 68-78.
- Shi, F., Cai, F., Kirby, J. T. and Zheng, J., 2013, ``Morphological modeling of a nourished bayside beach with a low tide terrace", *Coastal Engineering*, 78, 23-34.
- Sawyer, A. H., Shi, F., Kirby, J. T. and Michael, H. A., 2013, ``Dynamic response of surface water-groundwater exchange to currents, tides and waves in a shallow estuary", *J. Geophys. Res.*, 118, doi:10.1002/jgrc.20154.
- Ma, G., Shi, F., and Kirby, J. T., 2011, A polydisperse two-fluid model for surfzone bubble simulation, *J. Geophys. Res.* , doi:10.1029/2010JC006667.
- Shi, F., Kirby, J. T., and Ma, G., 2010, Modeling quisecent phase transport of air bubbles induced by breaking waves, *Ocean Modelling* , 35, 105-117.

D. Synergistic Activities

Convener and chair of session of nearshore processes at AGU 2008 Fall Meeting
Session chair of 32nd international conference of coastal engineering, 2010
Editorial board of the scientific world journal - oceanography

F. Collaborators and Other Affiliations

(i) Collaborators

Patrick Barnard(USGS), Chris Chickadel(UW), Steve Elgar(WHOI), Li Erikson(USGS), Jody Eshleman(NPS), Stephan Grilli(URI), Merrick Haller(OSU), Daniel Hanes(SLU), Jeffrey L. Hanson(ASACE), Rob Holman (OSU), Raleigh Hood (U. Maryland), Evamaria Koch(U. Maryland), Jamie MacMahan(NPS), Tim Masterlark(U. Alabama), Natalie Perlin(OSU), Roger Newll(U. Maryland), Elizabeth North(U. Maryland), Ad Reniers(UM), Larry Sanford (U. Maryland), Chris Sherwood(USGS), Richard P. Signell(USGS), John C. Warner(USGS), Phil Watts(App. Fluid Engr.), Chris Waythomas(USGS)

(ii) Graduate and Postgraduate Advisees

Master graduate student: Yunfeng Chen (graduated 2010, Educational Testing Service, co-advise with Kirby)

PhD students: Jialin Chen (co-advise with Hus), Mohammad Keshtpoor (co-advise with Puleo)

Post-doc: Wenzhou Zhang (Xiamen University)

(iii) Ph.D. Thesis Advisor:

Shizuo Feng, Department of Physical Oceanography, Ocean University of Qingdao.

Annette R. Grilli

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Education

University of Delaware, USA, 2000, Ph.D. in Climatology
University of Liège, Belgium, 1984, M.S. in Oceanography
University of Liège, Belgium, 1983, B.S. in Geography and B.S. in Education (summa cum laude)

Experience

2006–present: Asst. Research Professor, Department of Ocean Engineering, University of Rhode Island (URI) ; 2004-2005: Research Scientist, OCE-URI.
2003-2005 : Independent Consultant in Environmental Engng., Narragansett, RI.
2002-2003 : Research Scientist, Applied Sciences Associates, Narragansett, RI.
2000-2002 : Post Doctoral researcher, OCE-URI.
1993-2000 : Independent Consultant, Narragansett, Rhode Island.
1988-1991 : Research Assistant in Climatology, University of Delaware.
1984-1987: Research/Teaching Assistant/Lecturer in regional planning. Department of Geography, University of Liège (Belgium).

Professional Societies/Honors

2010-2012: Appointed member of the National Research Council (NRC) "Marine and Hydrokinetic Energy Technology Assessment" committee, of the National Academies.
2010-: Member of the "American Geophysical Union".
2007-: Member of the "International Society for Offshore and Polar Engineers".
1992-98: Member of the "American Geographical Society".
1988-1989 : Lefranc Foundation Travel/Research scholarship, University of Liège (Belgium).

Book

Marine and Hydrokinetic Energy Technology Assessment Committee, 2013. National Research Council. *An Evaluation of the U.S. Department of Energy's Marine and Hydrokinetic Resource Assessments*. Washington, DC: The National Academies Press, 154 pages, 978-0-309-26999-5, http://www.nap.edu/catalog.php?record_id=18278.

Selected Recent Journal and refereed Proceedings Articles

Grilli, A.R. and M.L. Spaulding 2013. Offshore wind resource assessment in Rhode Island waters. *Wind Engineering,* **37**(6), 579-594, doi:10.1260/0309-524X.37.6.579.

O'Reilly C., Grilli A. and G. Potty 2013. Micrositing Optimization of the Block Island Wind Farm, RI, USA. In *Proc. Intl. Conf. Ocean, Offshore and Arctic Engineering* (OMAE 2013, Nantes 6/9-14/13), paper OMAE2013-10191, pp. V008T09A009; 9 pps., doi: 10.1115/ OMAE2013-10191.

Gemme, D.A., Bastien, S.P., Sepe R.B., Montgomery J., Grilli S.T. and Grilli A.R. 2013. Experimental Testing and Model Validation for Ocean Wave Energy Harvesting Buoys. In *Proc. IEEE Energy Conversion Congress and Exposition* (ECCE13, Denver CO, September, 2013), paper 1407, 337-343

Grilli, A.R., Lado, T., and M. Spaulding 2012. A protocol to include ecosystem services in a wind farm cost model. *J. Environmental Engineering* **139**(2), 176-186, doi:10.1061/(ASCE)EE. 1943-7870.0000599.

Grilli, A.R., Lado, T. and M.L Spaulding 2011. Ecosystem services typology: a wind farm siting tool. In *Proc. 21th Offshore and Polar Engng. Conf.* (ISOPE11, Maui, HI June 19-24, 2011), 525-532, Intl. Society of Offshore and Polar Engng.

Grilli, S.T., Grilli, A.R., Bastien, S.P., Sepe, Jr., R.B., and M.L. Spaulding 2011. Small Buoys for Energy Harvesting: Experimental and Numerical Modeling Studies. In *Proc. 21st Offshore and Polar Engng. Conf.* (ISOPE11, Maui, HI, USA, June 19-24, 2011), 598-605, Intl. Society of Offshore and Polar Engng.

Grilli, A.R., Spaulding, M.L. and C. Damon 2010. Methods for Wind Farm Siting Optimization: New England Case Study. In *Proc. 20th Offshore and Polar Engng. Conf.* (ISOPE10, Beijing, China, June 20-25, 2010), 727-734, Intl. Society of Offshore and Polar Engng.

Spaulding, M.L., Grilli, A.R., and C. Damon 2010. Application of technology development index and principal component analysis and cluster methods to ocean renewable energy facility siting. *J. Marine technology Soc.*, **44**(1), 8-23.

Bastien, S.P., Sepe, R.B., Grilli, A.R., Grilli S.T., and M.L. Spaulding 2009. Ocean Wave Energy Harvesting Buoy for Sensors. In *Proc. IEEE Energy Conversion Congress and Exposition* (ECCE09, San Jose CA, September, 2009), **3**,718-3,725, doi: 978-1-4244-2893-9/09/.

Selected Recent Research reports

Grilli A.R. and S.T. Grilli, 2013. Modeling of tsunami generation, propagation and regional impact along the U.S. East Coast from the Azores Convergence Zone. *Research Report no.* **CACR-13-04**. NTHMP Award, #NA10NWS4670010, US National Weather Service Program Office, 20 pp.

Grilli A.R. and S.T. Grilli, 2013. Far-Field tsunami impact on the U.S. East Coast from an extreme flank collapse of the Cumbre Vieja Volcano (Canary Island). *Research Report no.* **CACR-13-13**. NTHMP Award, #NA10NWS4670010, US National Weather Service Program Office, 13 pp.

Grilli A.R. and S.T. Grilli, 2013. Modeling of tsunami generation, propagation and regional impact along the upper U.S East coast from the Puerto Rico trench. *Research Report no.* **CACR-13-02**. NTHMP Award, #NA10NWS4670010, US National Weather Service Program Office, 18 pp.

Grilli S.T., Tajalli-Bakhsh, T.S., Grilli, A.R. and J. Harris 2012. Fine grid simulations of tsunami hazard along the Mozambique coast. *Technical Report for Phase III.* Ocean Engineering, University of Rhode Island, 52 pps.

Grilli, A.R. and T. Asher 2011. Development of an Integrated Design Tool for Wave Energy Conversion Devices used to Power Coastal Surveillance Systems. *Final Technical Report* for DOE-MREC grant. Ocean Engineering, University of Rhode Island, 44 pps.

Grilli, A.R., M.L. Spaulding, A. Crosby and R. Sharma 2010. Evaluation of Wind Statistics and Energy Resources in Southern RI Coastal Waters for the Rhode Island Ocean Special Area Management Plan 2010. *State of RI Ocean Special Area Management Plan* (SAMP) *Technical Report*, University of Rhode Island, 51 pps.

Grilli, A.R., M.L. Spaulding, Chris Damon, and Ravi Sharma 2010. High Resolution Application of the Technology Development Index (TDI) in State Waters South of Block Island. *State of RI Ocean Special Area Management Plan* (SAMP) *Technical Report*, University of Rhode Island, 14 pps.

Grilli, A.R. and T. Lado 2010. Ecological and Service Valuation, a Principal Component and Cluster Analysis Approach: An Ecological and Service Typology in the Ocean SAMP area. *State of RI Ocean Special Area Management Plan* (SAMP) *Technical Report*, Ocean Engineering, University of Rhode Island, 49 pps.

SUPPLEMENTAL MATERIAL

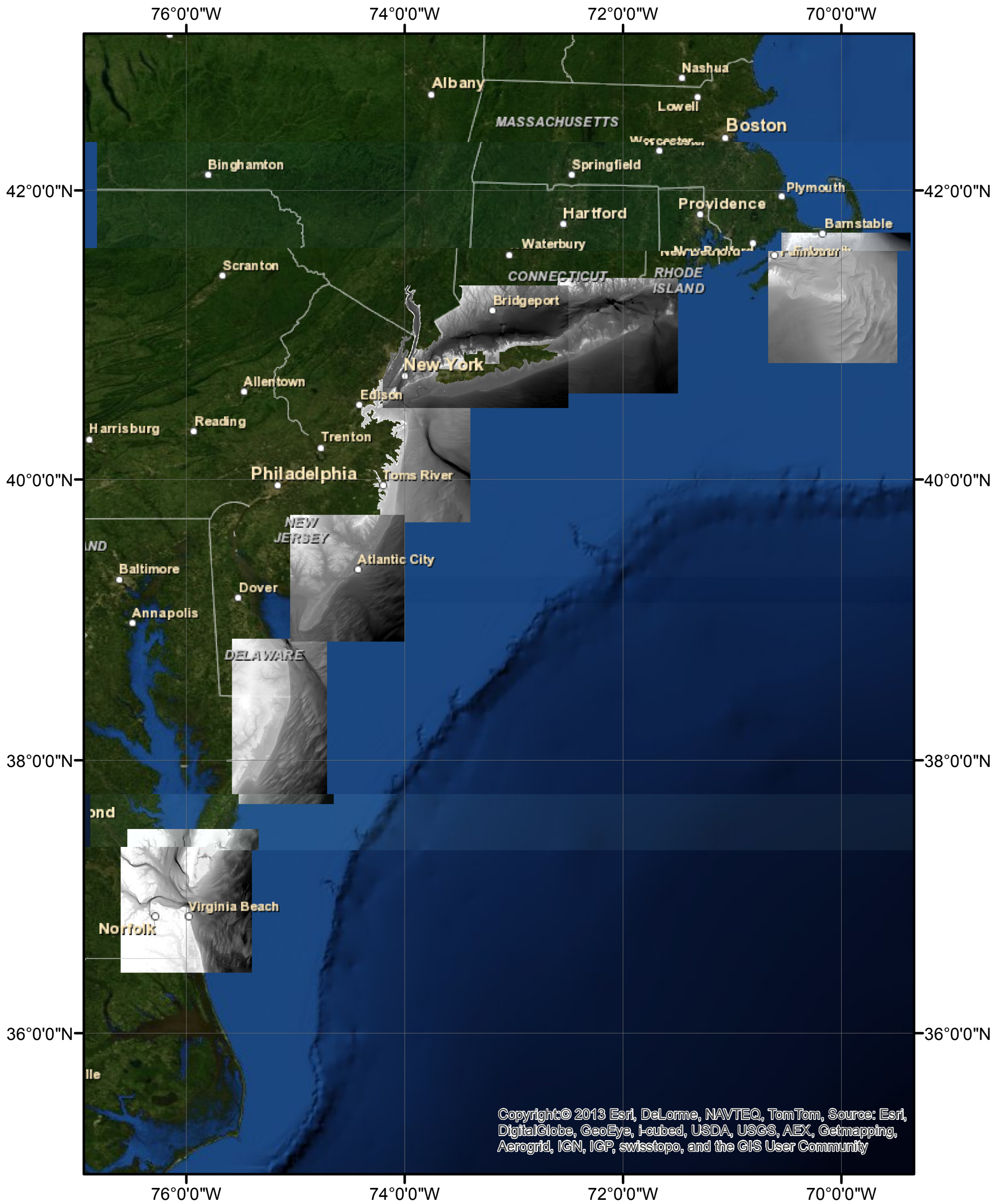

Figure 1. Northeast US DEM coverage for FY10-12 (Ocean City, MD; Atlantic City, NJ, Northern New Jersey, New York City and Western Long Island, Montauk (Eastern Long Island) and Martha's Vineyard/Nantucket) and FY13 (Virginia Beach). All DEM's are NGDC Tsunami DEM's except for Northern New Jersey, New York and Western Long Island, which are derived from FEMA Region 2 DEM's.

REFERENCES

Abadie, S., Morichon, D., Grilli, S.T. and Glockner, S. 2010. Numerical simulation of waves generated by landslides using a multiple-fluid Navier-Stokes model. *Coastal Engineering*, **57**, 779-794, doi:10.1016/j.coastaleng.2010.03.003.

Abadie, S., J.C. Harris, S.T. Grilli and R. Fabre 2012. 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.*, **117**, C05030, doi:10.1029/2011JC007646.

Chen, J.-L., Shi, F., Hsu, T. J. and Kirby, J. T., 2013, "NearCoM-TVD - a quasi-3D nearshore circulation and sediment transport model", submitted to *Coastal Engineering*, October.

Friday, D.Z., L.A. Taylor, B.W. Eakins, R.R. Warnken, K.S. Carignan, R.J. Caldwell, E. Lim and P.R. Grothe, 2012. Digital Elevation Models of Palm Beach, Florida: Procedures, Data Sources and Analysis, NOAA Technical Memorandum NESDIS NGDC-54, U.S. Dept. of Commerce, Boulder, CO, 34 pp.

Grilli, A. and Grilli, S. T., 2013a. Far-field tsunami impact on the US East Coast from an extreme flank collapse of the Cumbre Vieja volcano (Canary Islands), Research Report No. CACR-13-03, Center for Applied Coastal Research, University of Delaware.

Grilli, A and Grilli, S. T., 2013b. Modeling of tsunami generation, propagation and regional impact along the upper US East Coast from the Puerto Rico Trench. Research Report No. CACR-13-02, Center for Applied Coastal Research, University of Delaware.

Grilli, A. and Grilli, S. T. 2013c. Modeling of tsunami generation, propagation and regional impact along the upper US East Coast from the Azores convergence zone. Research Report No. CACR-13-04, Center for Applied Coastal Research, University of Delaware.

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**, 283-297.

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 Engng.*, **133**, 414-428.

Grilli, S. T., Harris, J. C., Tajalli Bakhsh, T., Masterlark, T. L., Kyriakopoulus, C., Kirby, J. T. and Shi, F., 2013a. Numerical simulation of the 2011 Tohoku tsunami based on a new transient FEM co-seismic source: Comparison to far- and near-field observation. *Pure and Applied Geophysics*, **170**, 1333-1359.

Grilli, S. T., O'Reilly, C. and Tajalli Bakhsh, T., 2013b. Modeling of SMF tsunami generation and regional impact along the upper US East Coast. Research Report No. CACR-13-05, Center for Applied Coastal Research, University of Delaware.

Grilli, S. T., O'Reilly, C., Harris, J. C., Tajalli Bakhsh, T., Baxter, C. D. P., Eggeling, T., Tehranirad, B., Kirby, J. T., Banihashemi, S. and Shi, F., 2014. Modeling of SMF tsunami hazard along the upper U.S. East Coast. In preparation for *Nat. Haz. Earth Sys. Sci.*

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

Kirby J.T., Shi F., Tehranirad, B., Harris J.C. and Grilli, S. T. 2013. Dispersive tsunami waves in the ocean: Model equations and sensitivity to dispersion and Coriolis effects. *Ocean Modelling*, **62**, 39-55.

Kirby, J. T., Nicolsky, D., Hsu, T. J., Shi, F., Schnyder, J. S. D. and Ma, G., 2014, Landslide generated tsunamis. Submitted for *34th Int. Conf. Coastal Engineering*, Seoul, June 15-20.

Locat, J., H. Lee, U. S. ten Brink, D. Twichell, E. Geist, and M. Sansoucy. 2009. Geomorphology, stability and mobility of the Currituck slide. *Marine Geology*. **264**, 28-40.

Lynett, P. J., Borrero, J. C., Weiss, R., Son, S., Greer, D. and Renteria, W., 2012, Observations and modeling of tsunami-induced currents in ports and harbors, *Earth and Planetary Science Letters,* **327-328**, 68-74.

Ma G., Shi F. and Kirby J.T. 2012. Shock-capturing non-hydrostatic model for fully dispersive surface wave processes. *Ocean Modelling*, **43-44**, 22-35.

Ma, G., Kirby, J. T. and Shi, F., 2013, Numerical simulation of tsunami waves generated by deformable submarine landslides, *Ocean Modelling*, , **69**, 146-165.

Mulder T., E. Ducassou , G.P. Eberli, V. Hanquiez , E. Gonthier , P. Kindler, M. Principaud , F. Fournier, P. Léonide, I. Billeaud, B. Marsset, J.J.G. Reijmer, C. Bondu , R. Joussiaume, and M. Pakiades. 2012, New insights into the morphology and sedimentary processes along the western slope of Great Bahama Bank, *Geology,* **40**(7), 603–606.

Shi, F., Kirby, J. T. and Hanes, D. M., 2007. An efficient mode-splitting method for a curvilinear nearshore circulation model, *Coastal Engineering*, **54**, 811-824.

Shi, F., Kirby, J. T., Tehranirad, B., Harris, J. C. and Grilli, S. T., 2011a. FUNWAVE-TVD, Fully nonlinear Boussinesq wave model with TVD solver, documentation and user's manual (Version 2.0). Research Report No, CACR-11-04, Center for Applied Coastal Research, Univ. of Delaware, Newark.

Shi, F., Hanes, D. M., Kirby, J. T., Erikson, L., Barnard, P. and Eshleman, J., 2011b. Pressure gradient-dominated nearshore circulation on a beach influenced by an adjacent large inlet. *J. Geophys. Res.*, **116**, C04020, doi:10.1029/2010JC006788.

Shi, F., J.T. Kirby, J.C. Harris, J.D. Geiman and S.T. Grilli 2012a. A high-order adaptive time-Stepping TVD solver for Boussinesq modeling of breaking waves and coastal inundation. *Ocean Modelling*, **43-44**: 36-51.

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