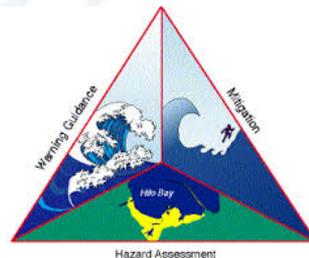




East Coast Progress Report

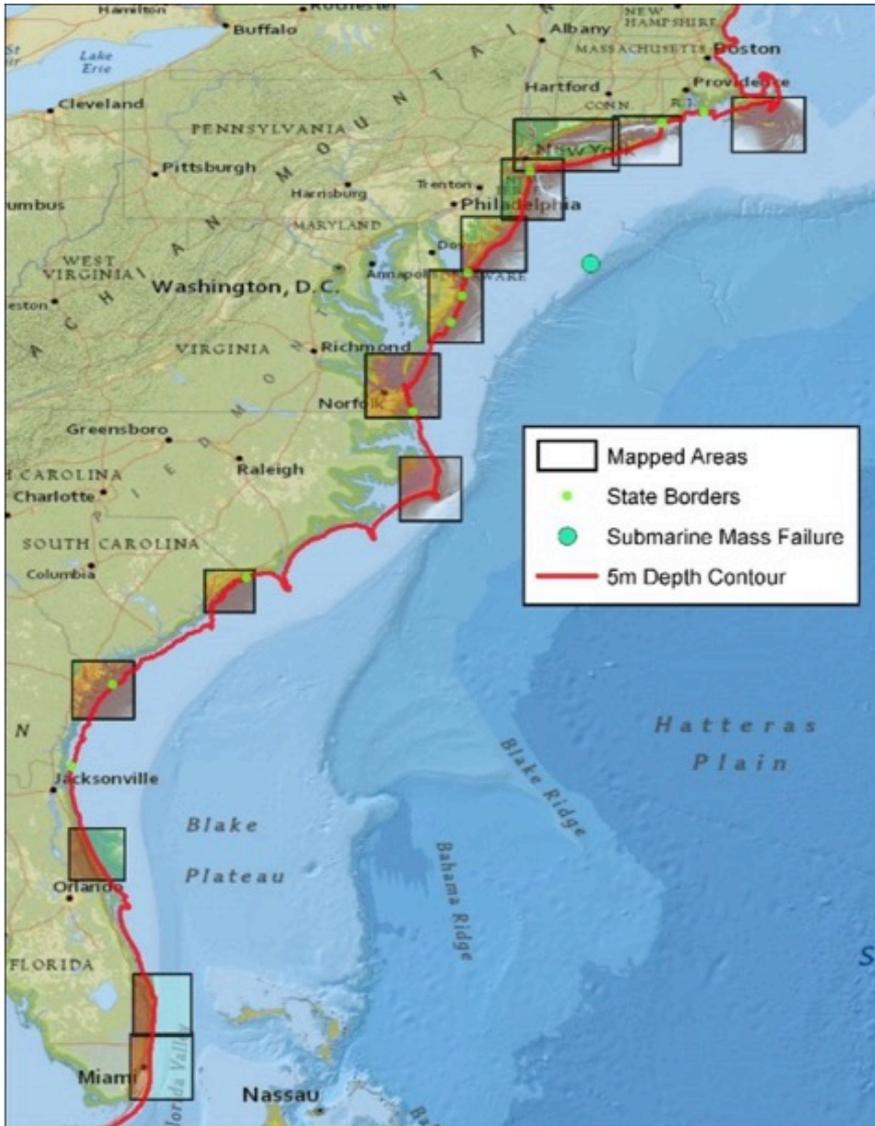
Jim Kirby, University of Delaware
Stephan Grilli, University of Rhode Island

NTHMP Annual Meeting, February 4, 2016





Overview of Map Products, FY10-12, 13, 14



Reporting:

1. Source reports

- Organized by event or class of event.

2. Inundation reports

- Organized by DEM
- Provide:
 - Information on sources for each region
 - Arrival time information
 - Description of maps
 - Description of additional products (mainly maritime, momentum flux estimates on land)
 - ArcGIS information.

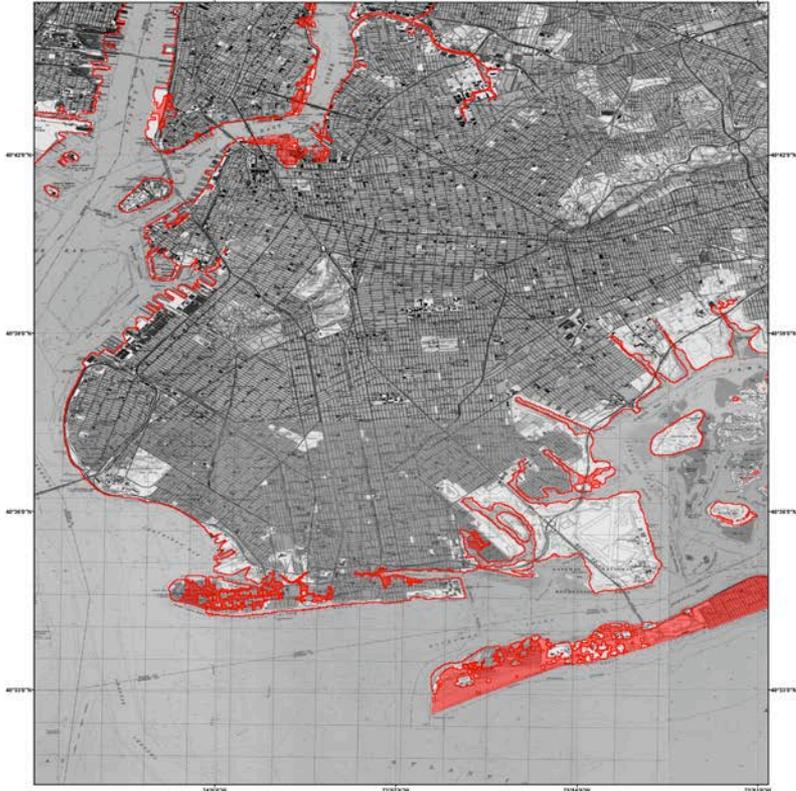
3. Draft maps available to partners for evaluation at www.udel.edu/kirby/nthmp_protect.html



National Oceanic and Atmospheric Administration (NOAA)
National Tsunami Hazard Mitigation Plan (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware

Tsunami Inundation Map for Emergency Planning Brooklyn

State of New York
Brooklyn



METHOD OF PREPARATION

This map was prepared by the University of Delaware Center for Applied Coastal Research (CACR) for the National Oceanic and Atmospheric Administration (NOAA) as part of the National Tsunami Hazard Mitigation Plan (NTHMP). The map was prepared using the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC) Coastal Vulnerability Model (CVM) and the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC) Coastal Vulnerability Model (CVM)...

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING States of New York Brooklyn

February 1, 2015
Scale 1:40,000



Tsunami sources modeled for the Ocean City coastline

Source	Location
Submarine Mass Failure 1	73.21 W, 39.22 N
Submarine Mass Failure 2	73.46 W, 39.70 N
Submarine Mass Failure 3	73.53 W, 38.81 N
Submarine Mass Failure 4	73.60 W, 38.81 N
Puerto Rico Trench Zone (M-0-1)	Caribbean Subduction Zone
Antarctic Convergence Zone (M-0-2)	Antarctic Subduction Zone
Caribbean Sea	Caribbean Sea

MAP EXPLANATION

- Tsunami Inundation Line
- Tsunami Inundated Area

PURPOSE OF THIS MAP

This tsunami inundation map was prepared to help coastal communities to identify their tsunami hazards. This map is not a legal document and does not meet disclosure requirements for real estate transactions nor for any other regulatory purpose. The inundation map has been obtained through using the best available scientific information. The inundation line represents the maximum tsunami runup extent within a number of kilometers, yet scientifically realistic, tsunami sources. This map is supposed to portray the worst case scenario and does not provide any further information about the return periods of the events modeled here.

MAP BASE

Topographic base maps prepared by U.S. Geological Survey as part of the 7.5-minute Quadrangle Map Series (originally 1:24,000 scale). Tsunami inundation line boundaries have been updated using digital topographic data that can differ slightly from contours shown on the base map.

DISCLAIMER

The National Tsunami Hazard Mitigation Program (NTHMP), the University of Delaware (UD), and the University of Rhode Island (URI) make no representation or warranty regarding the accuracy of this inundation map nor the data from which the map was derived. Neither the NTHMP nor URI shall be liable under any circumstances for any direct, indirect, special, incidental or consequential damages with respect to any claim by any user or any third party on account of or arising from the use of this map.

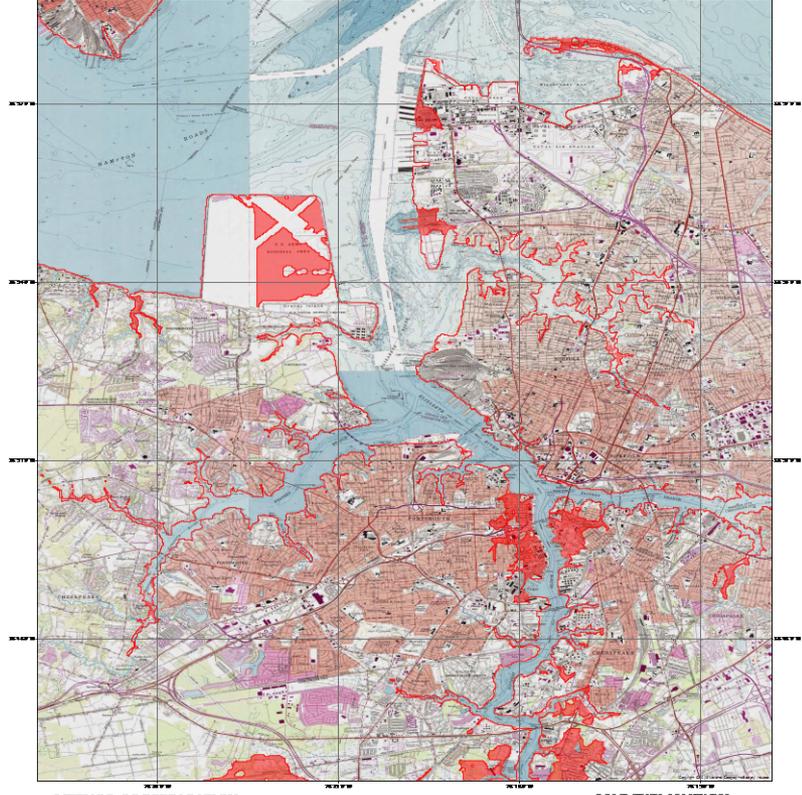


Shawanda B. Nockels, D. Kelly T. Collier, L. M. M. 2014. "Tsunami Hazard Mitigation Plan for the State of New York." Technical report, No. CACR 14-01. Center for Applied Coastal Research, University of Delaware.

National Oceanic and Atmospheric Administration (NOAA)
National Tsunami Hazard Mitigation Plan (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware

Tsunami Inundation Map for Emergency Planning Norfolk

State of Virginia
Norfolk

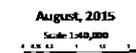


METHOD OF PREPARATION

This tsunami inundation map for the State of Virginia was prepared by the National Oceanic and Atmospheric Administration (NOAA) as part of the National Tsunami Hazard Mitigation Plan (NTHMP). The map was prepared using the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC) Coastal Vulnerability Model (CVM) and the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center (CSC) Coastal Vulnerability Model (CVM)...

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING State of Virginia Norfolk

August, 2015
Scale 1:40,000



Tsunami sources modeled for Virginia Beach, NDCS DEM

Source	Location	Arrival Time (hr)
Cape Fear Slide	76.00 W, 33.33 N	2.0
Puerto Rico Trench Zone (M-0-1)	Caribbean Subduction Zone	6.5
Antarctic Convergence Zone (M-0-2)	Antarctic Subduction Zone	6.0
Caribbean Sea	Caribbean Sea	6.0

MAP EXPLANATION

- Tsunami Inundation Line
- Tsunami Inundated Area

PURPOSE OF THIS MAP

This tsunami inundation map was prepared to help coastal communities to identify their tsunami hazards. This map is not a legal document and does not meet disclosure requirements for real estate transactions nor for any other regulatory purpose. The inundation map has been obtained through using the best available scientific information. The inundation line represents the maximum tsunami runup extent within a number of kilometers, yet scientifically realistic, tsunami sources. This map is supposed to portray the worst case scenario and does not provide any further information about the return periods of the events modeled here.

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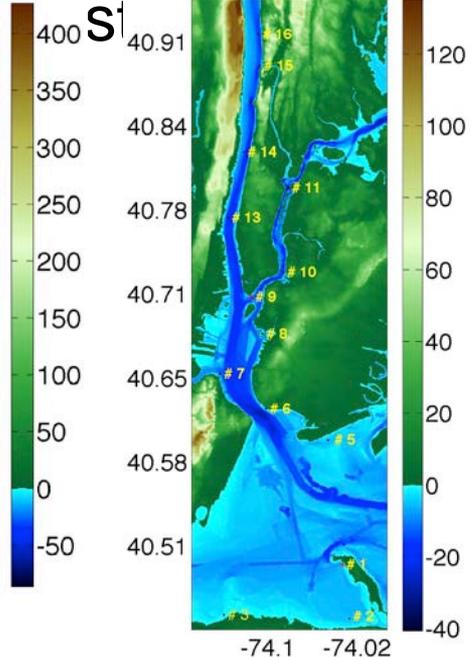
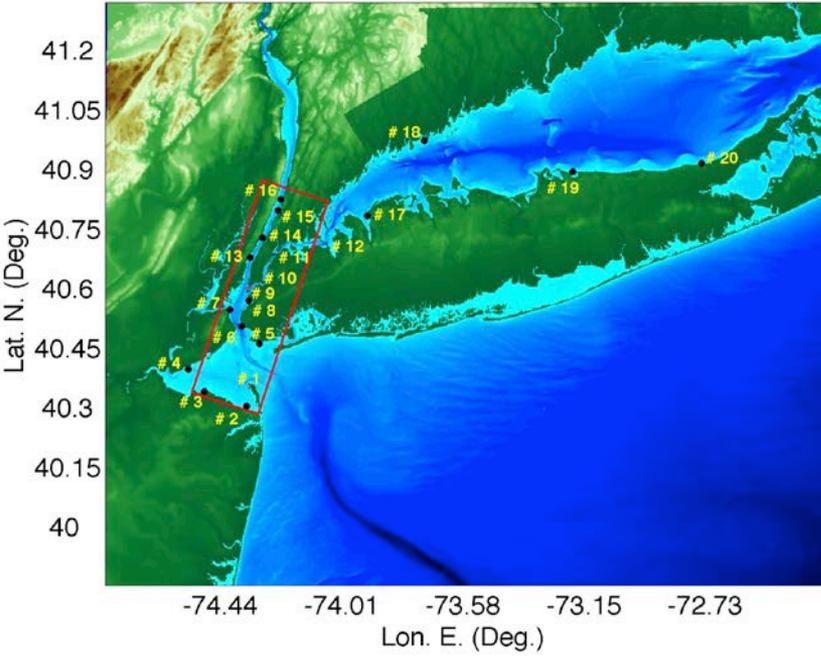


FY14: Task 1: Tsunami-Tide Interactions in East Coast Estuaries and River Entrances

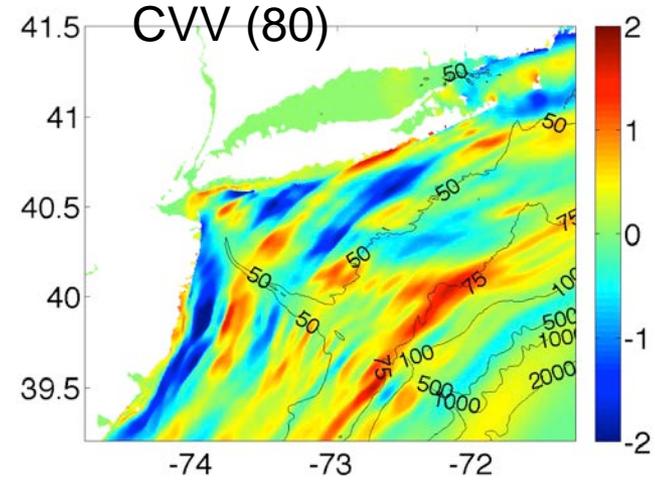
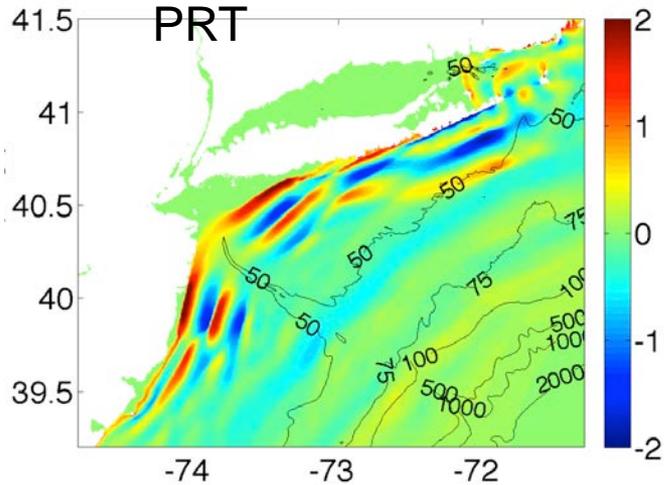
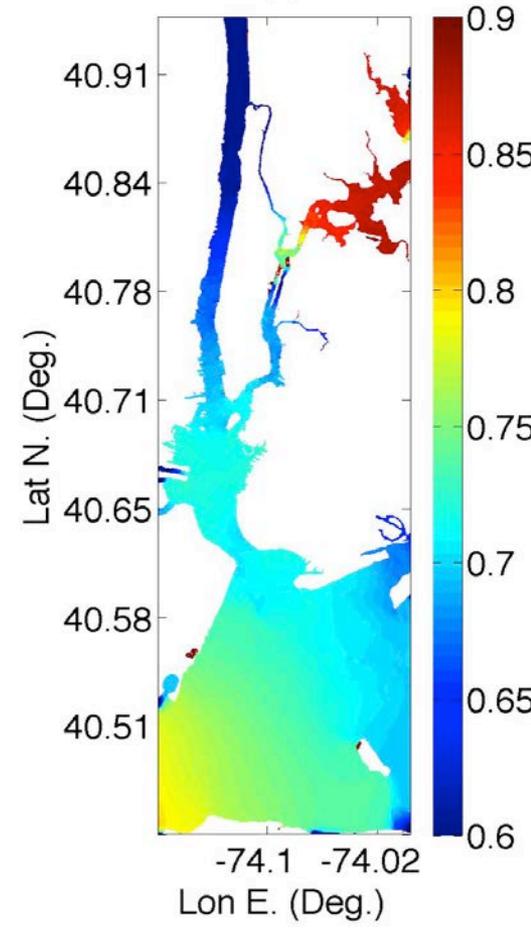
- In **large estuaries and Bays** (e.g., Chesapeake Bay and Hudson River/New York Harbor on the USEC), with **strong tidal flow**, the **nonlinear combination of tides and tsunamis may create more hazardous conditions and larger inundations**.
- The arrival of the tsunami at **different phases of the tide** may both influence this nonlinear combination and the resulting inundation.
- Tide and tsunami are nearly linear long waves in deep water; hence their elevation and current are **linearly combined along an offshore boundary** of the model to perform combined tide-tsunami simulations; also initial ramp-up with the calibrated tide.
- **Chesapeake Bay** : simulations for M2 (10% exceedance) tide (based on NOAA tide gage data) plus extreme tsunami sources (LSB, PRT, CVV and CRT), for 8 different phases of the tide => **small differences** (Report, Tajelli-Baksh et al., 2015)
- **Hudson River/New York harbor** : MHW tide simulations were done and combined tide-tsunami simulations were done extreme tsunami sources (PRT, CVV and CRT-proxy 1), for 4 phases of the tide => **causes up to 0.2-0.8 m more in inundation** (Report and PAGEOH paper (in revision); Shelby et al., 2015)



FY14: Task 1: Tide-tsunami simulations in Hudson River



Calibrated tide (MHW)





U





FY15: Task 1: Landslide Benchmark Workshop

Importance of landslides for NTHMP inundation mapping

- Many NTHMP “states” (regions) have **significant tsunami hazard** resulting from potential “**landslide tsunamis**” (this includes SMFs, subaerial slides, and volcano collapse/volcanic eruption):
 - > Alaska/Aleutian (historical Lituya Bay, Skagway, Kitimat, Unimak, Valdez,...)
 - > Oregon/Washington (Cascadia-induced SMFs)
 - > California (Goleta, Big Sur,...)
 - > Hawai (Kalapana, Kilauea,...)
 - > Gulf of Mexico (Many sites, including off of the Mississippi Delta)
 - > Puerto Rico (Mona Passage,...)
 - > East Coast (Currituck and many others, West Bahamas, Grand Bank,...)
- **Many mechanisms** => Many types of models are required in simulations
 - => **Need for model benchmarking**



FY15: Task 1: Landslide Benchmark

Workshop Goals

-> Following **earlier NTHMP model benchmarking workshops** for *long wave model runup* (Galveston, 2011) and *long wave velocity* (Portland, 2015)

=> **similar approach and goals** for this workshop

-> **Outcomes:**

1. A set of **community accepted benchmark tests** for validating models for landslide tsunami generation (different classes)
2. A first set of **comparison of results of state-of-the-art landslide tsunami generation models** with the set of benchmarks
=> Develop acceptable accuracy thresholds
3. Recommendations for **future model/tests development** and NTHMP
=> **Set of criteria for acceptable landslide tsunami models**



FY15: Task 1: Landslide Benchmark Workshop

Work done

- A set of possible benchmark tests have been selected for inclusion in workshop:
 - Experiment: submarine/subaerial slides using solid objects
 - Experiment: submarine/subaerial slides using discrete particles (spheres, irregular shapes)
 - Field observations: (Papua New Guinea 1998, Grand Banks 1929 , Valdez 1964)
- Benchmark candidates are being modeled to assess available data and appropriateness for workshop.
- Workshop schedule delayed due to invitational travel restrictions.
=> Tentative dates Nov./Dec. 2016 or Jan. 2017



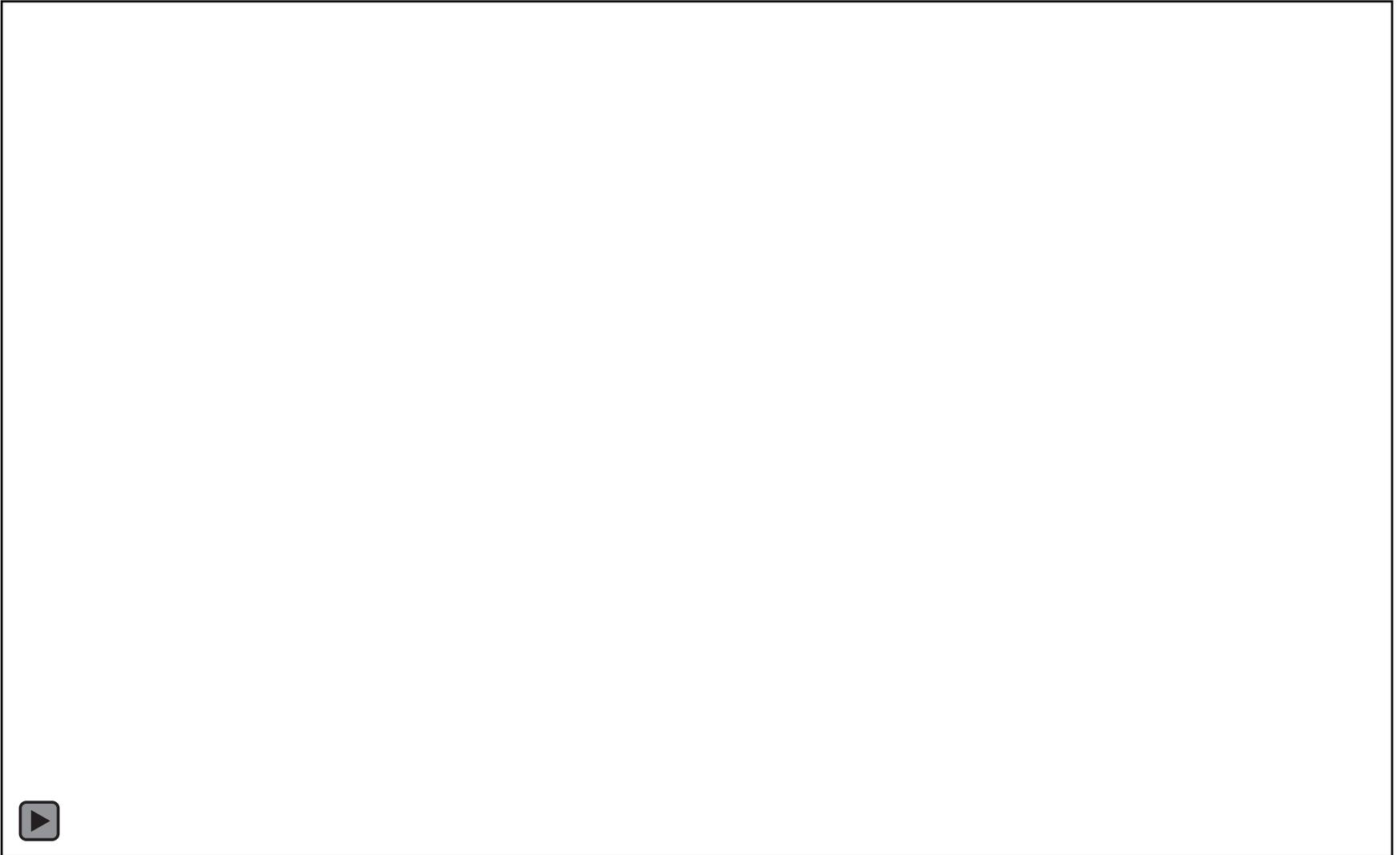
FY15: Task 1: Landslide Benchmark Workshop

Work done

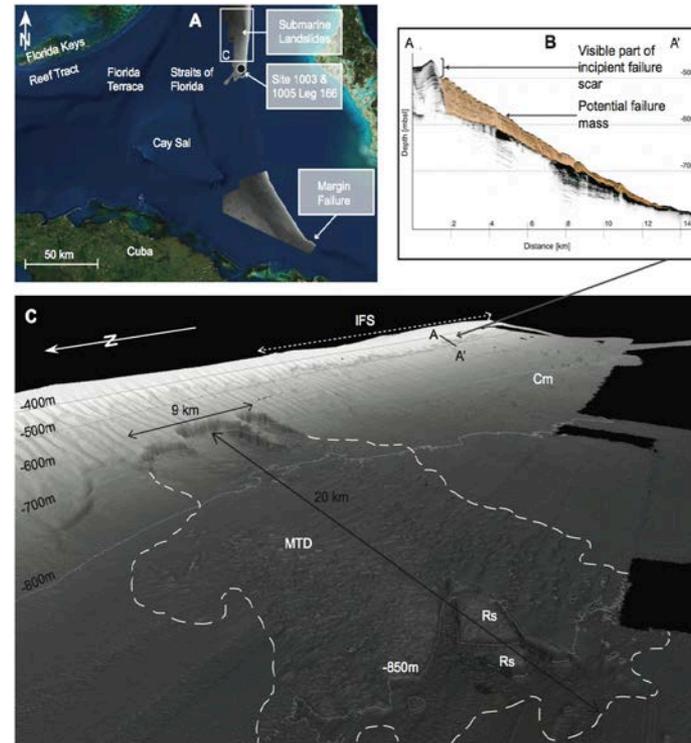
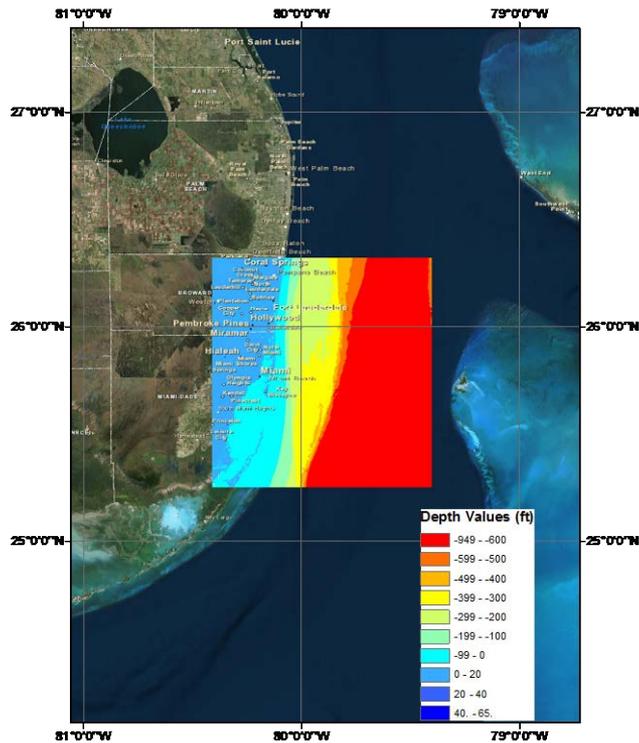
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FY15: Task 1: Landslide Benchmark Workshop

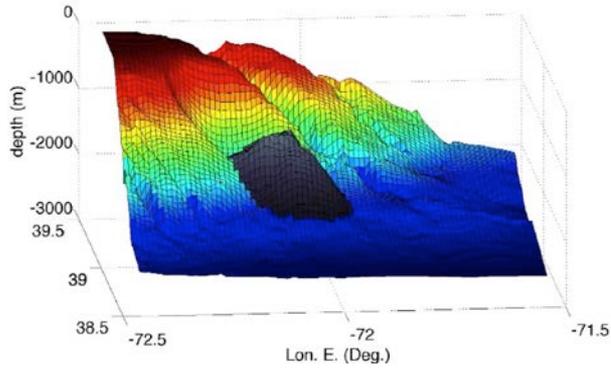


FY15: Task 2.1: Development of new SMF sources (siting/modeling)

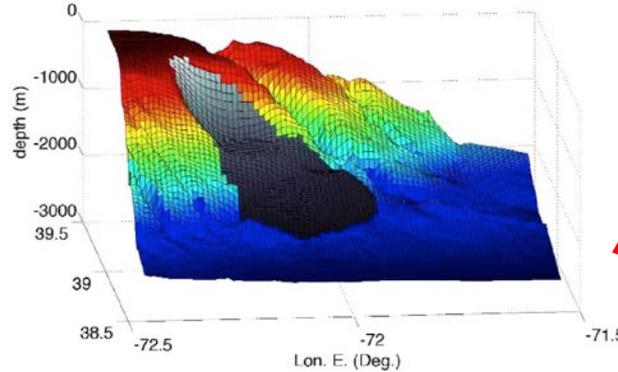


- New source being developed for use in Florida mapping, based on Bahamas Banks SMF events, in collaboration with Eberli's group at U. Miami (Schnyder et al., 2013)

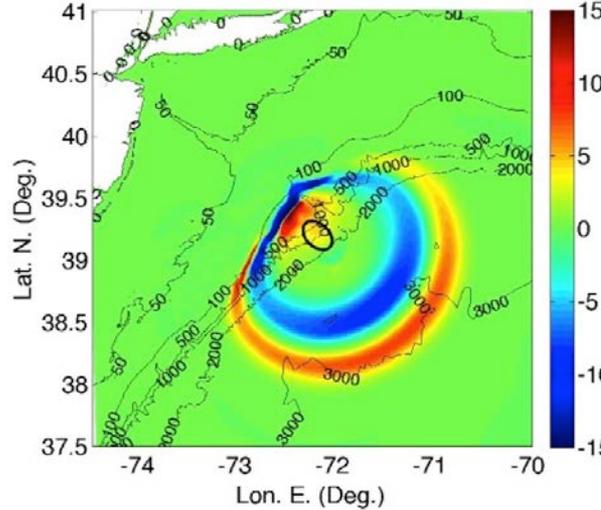
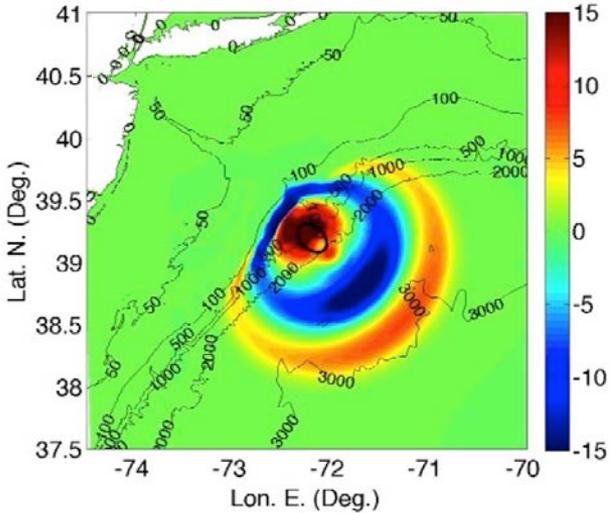
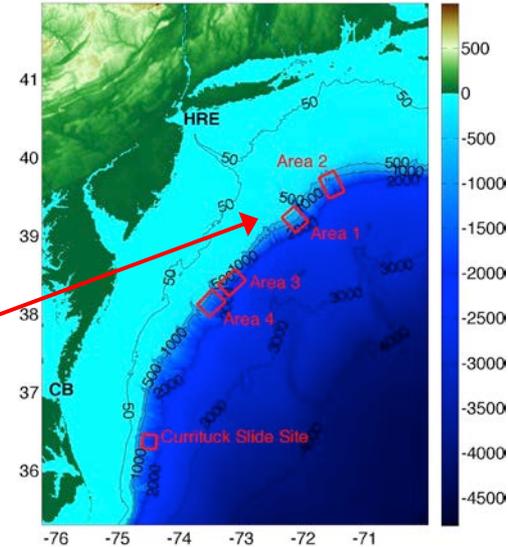
FY15: Task 2.1: Development of SMF sources (modeling)



Rigid slump



Deforming slide



- Hudson River canyon SMF
- Surface elevation after 13.3 min

- Rigid slump (as for SMF proxies) vs. deformable slides with same runout at 12 min (when slumps stops) => **Reduces wave generation**



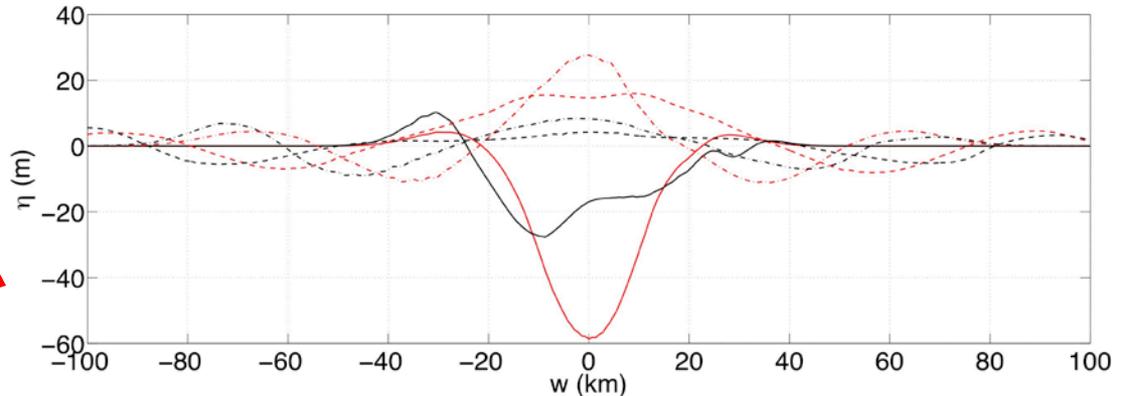
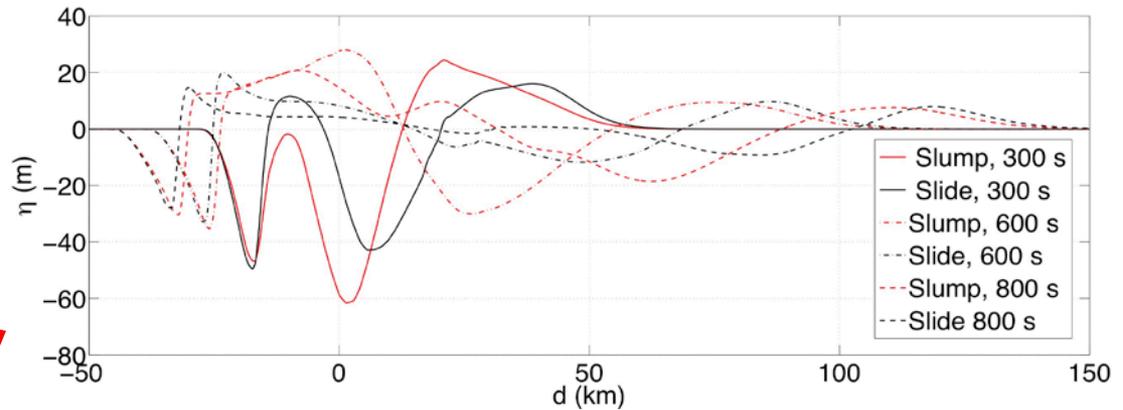
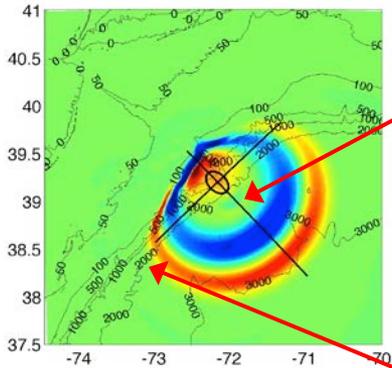
FY15: Task 2.1: Development of SMF sources (deforming slide modeling)





FY15: Task 2.1: Development of SMF sources (modeling)

Transects in rigid slump and deforming slide waves

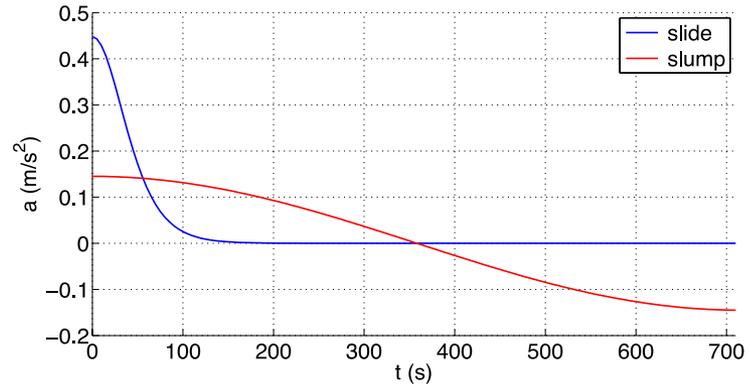
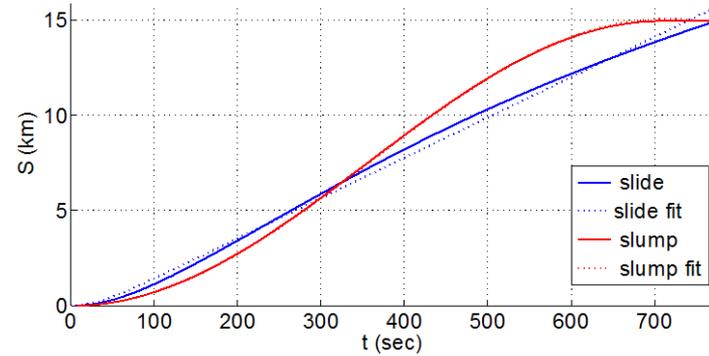
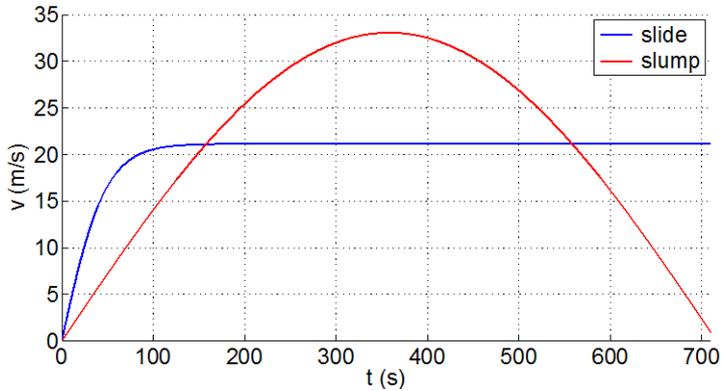


- Rigid slump **generates larger tsunamis** (mostly for the onshore moving waves) than deformable slides
- Waves from deforming slide are asymmetric as slide follows terrain
=> **Risk is function of rheology (need for USGS guidance/collaboration)**⁴



FY15: Task 2.1: Development of SMF sources (modeling)

Kinematics of rigid slump and Deforming slide (center of mass)

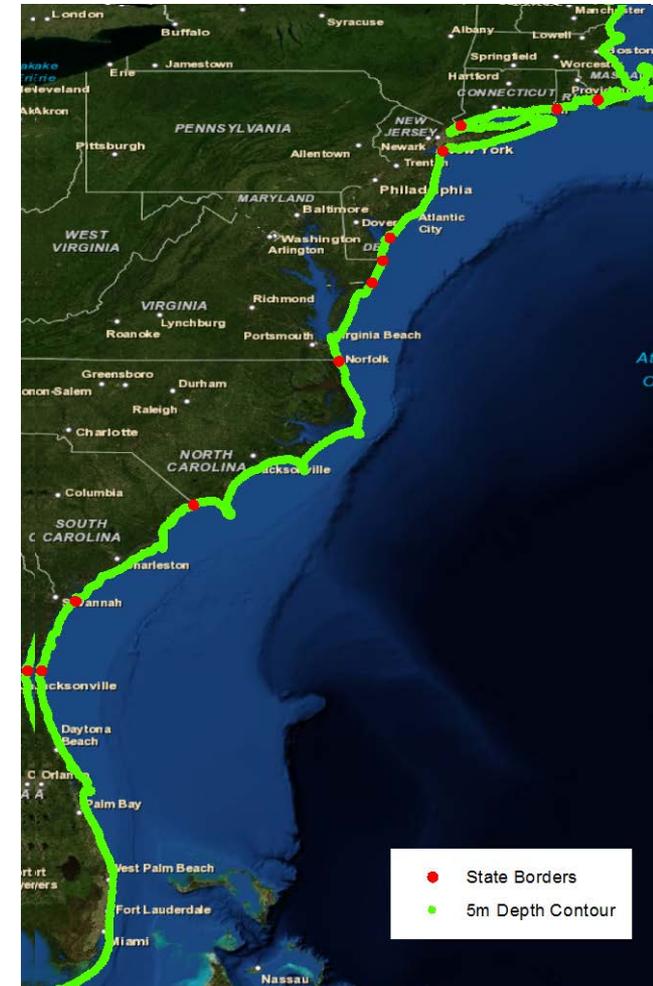
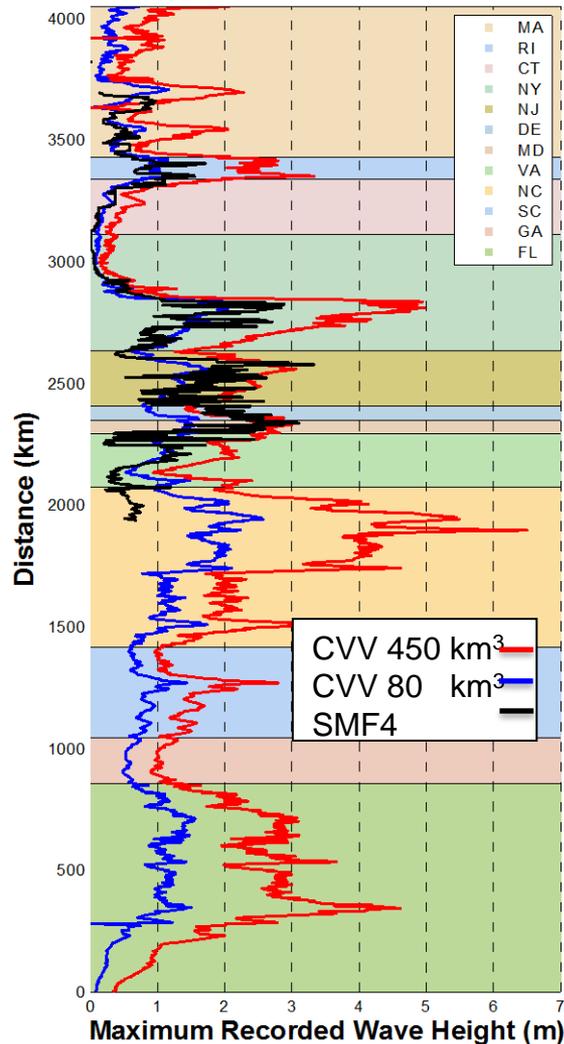


- Deformable slide **has larger initial acceleration** causing larger initial waves
 - Rigid slump then reaches a larger velocity and makes larger waves
- => SMF rheology is very important to assess coastal tsunami hazard**



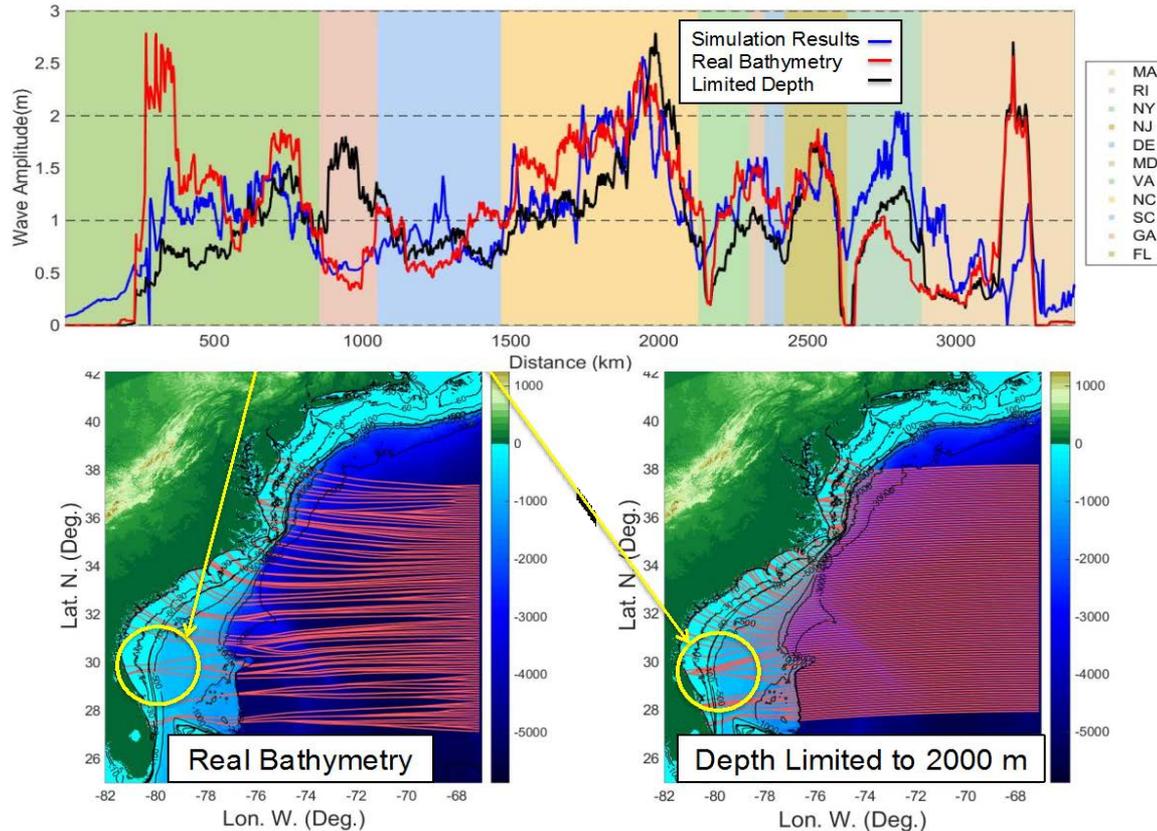
FY15: Task 2.4: Cumbre Vieja Reanalysis

- Mapping for East Coast sites has now been conducted using a smaller, 80 km³ SMF volume for CVV.
- All existing draft maps covered by funding from FY10-14 now reflect this change.
- Comparison of inundation at 5 m contour line for all selected sources
- SMFs dominate hazard at many locations





FY15 Task 3: Tsunami Hazard Assessment for unmodeled East Coast Sites



- Extensive ray analysis conducted for entire east Coast to determine spatial patterns and variability for the range of sources used in map development.
=> Results point out **dominance of wide shelf in determining vulnerability** of different regions to tsunami attack (see previous slide). **Very different from West Coast !**



FY15 Task 3: Tsunami Hazard Assessment for unmodeled East Coast Sites

- **Inundation lines** in mapped areas are being compared to **Cat 1-5 hurricane storm surge** maps in order to **develop guidelines for tsunami evacuation**.
- In unmapped areas, **hurricane surges need to be scaled** according to sites' position along the coastline (**using amplification factor from ray analysis**)
- -> **validation using full tsunami model results**
- Tsunami inundation show a **different dependence on inland cross-shore distance** than seen in surge maps:
 - > **inland** less severe than CAT 1 (time factor; bathtub filling)
 - > **at the shore** more severe (barrier is overwashed; more areas inundated)

