UNIVERSITY of DELAWARE

East Coast Progress Report

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NTHMP Annual Meeting, February 4, 2016

Center for Applied Coastal Research

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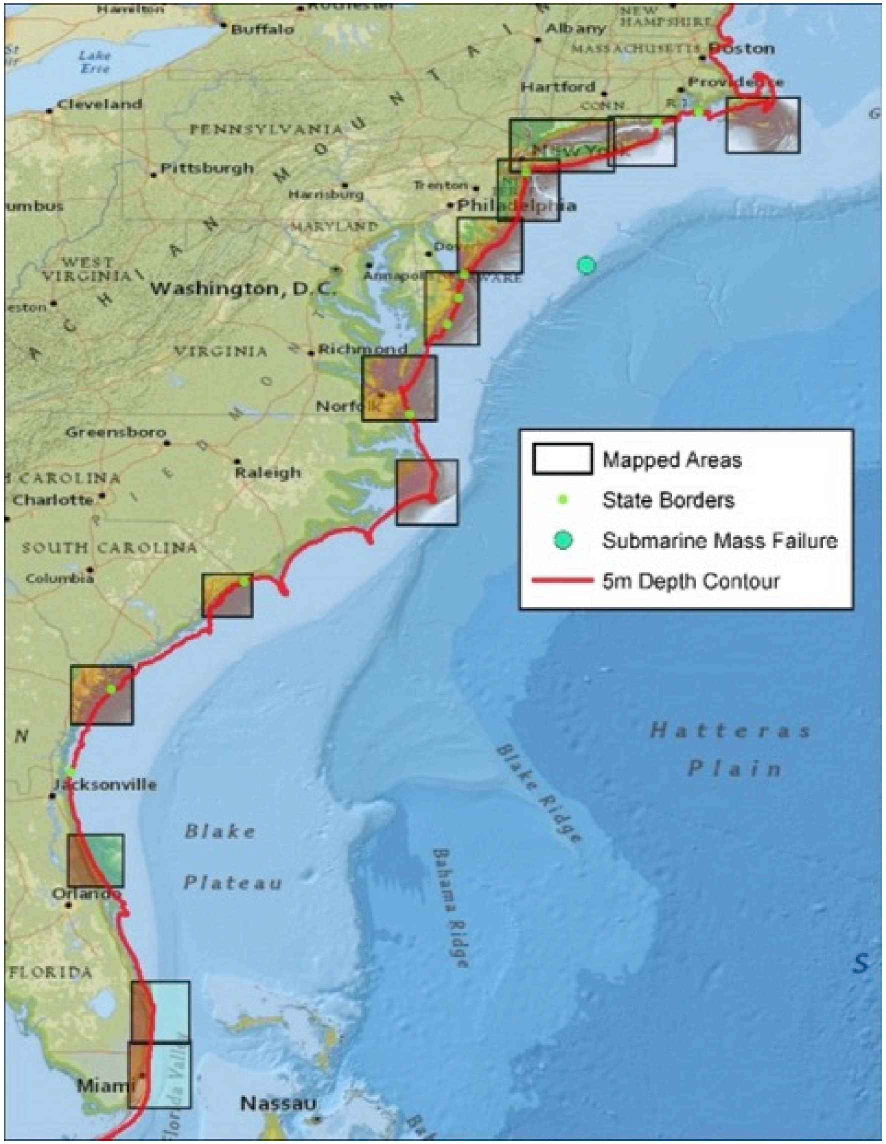
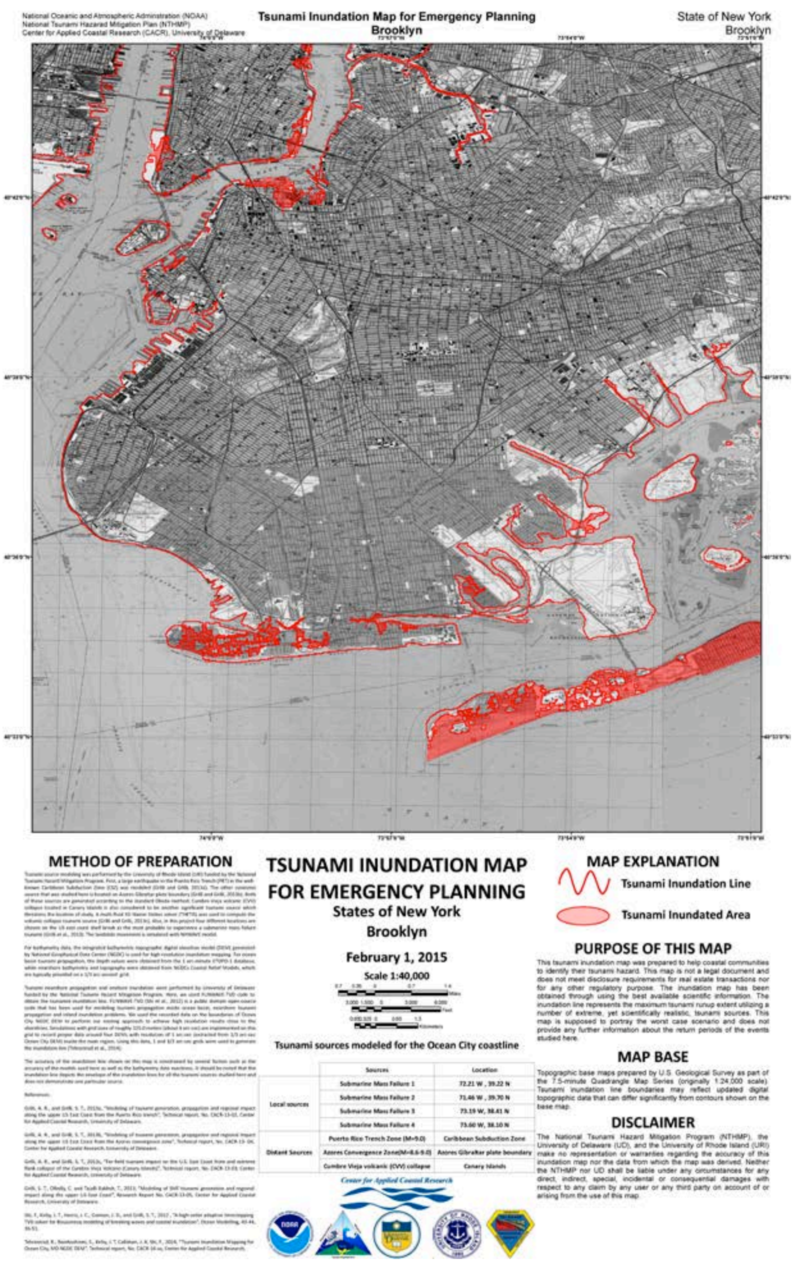
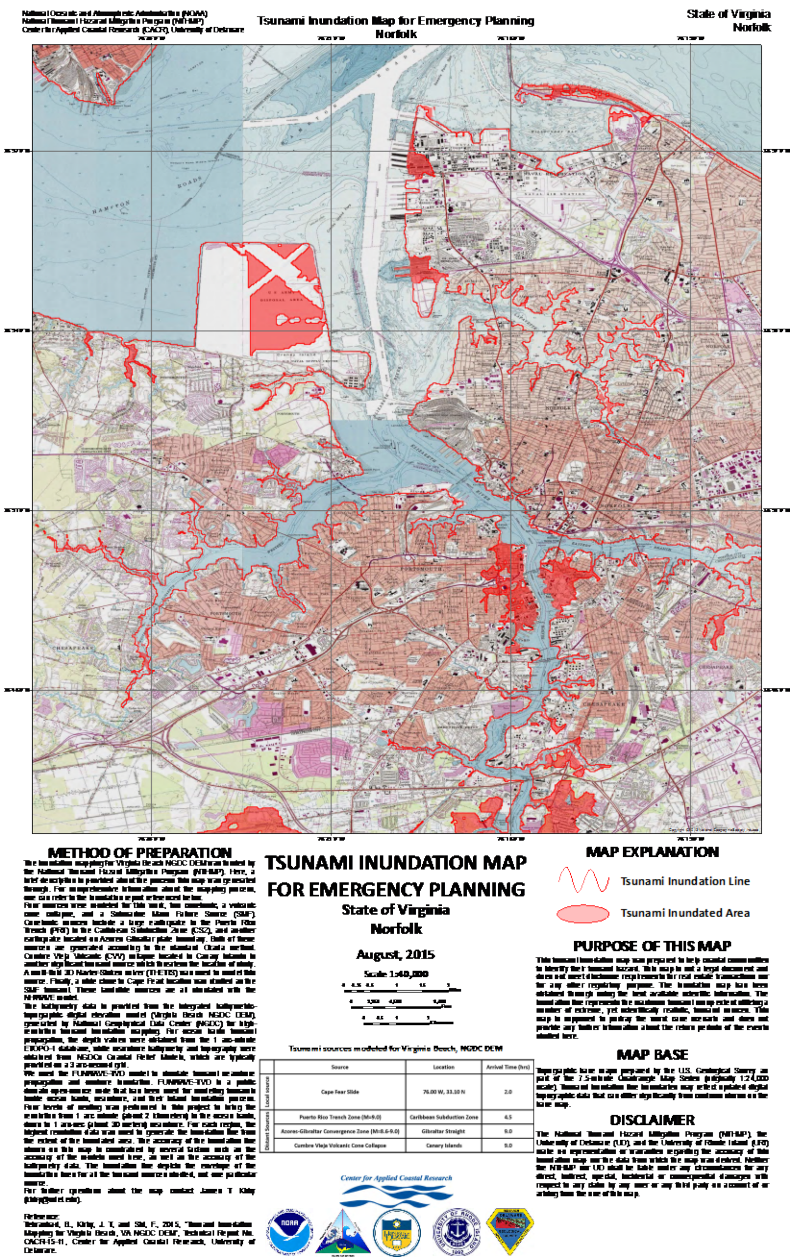
Overview of Map Products, FY10-12, 13, 14



Reporting:

1. Source reports
   - Organized by event or class of event.
2. Inundation reports
   - Organized by DEM
   - Provide:
     - o Information on sources for each region
     - o Arrival time information
     - o Description of maps
     - o Description of additional products (mainly maritime, momentum flux estimates on land)
     - o ArcGIS information.
3. Draft maps available to partners for evaluation at www.udel.edu/kirby/nthmp_protect.html


Tsunami Inundation Map for Emergency Planning
Brooklyn
State of New York
Brooklyn
METHOD OF PREPARATION
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
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER
Center for Applied Coastal Research


Tsunami Inundation Map for Emergency Planning
Norfolk
State of Virginia
Norfolk
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of Virginia
Norfolk
August, 2015
Scale 1:40,000
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
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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

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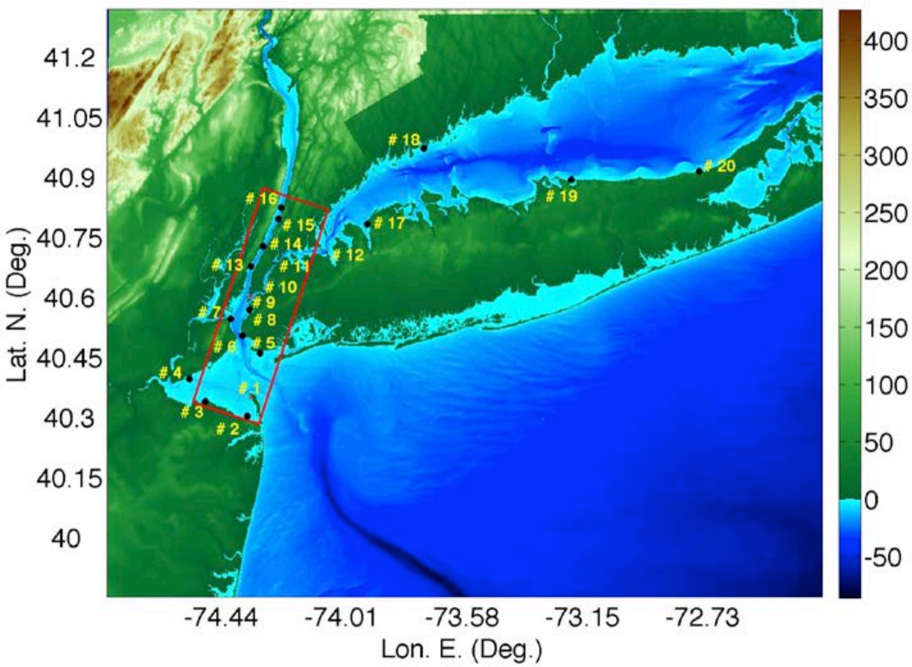
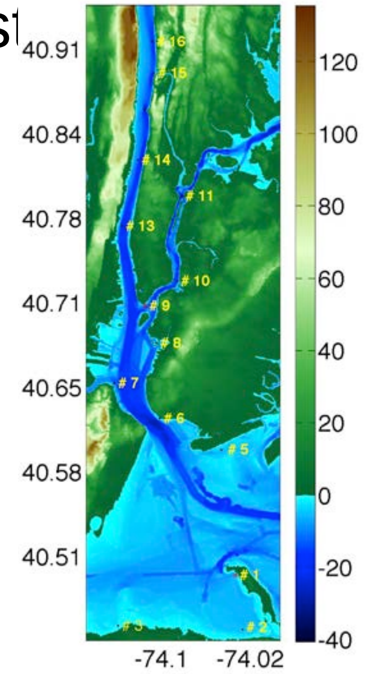
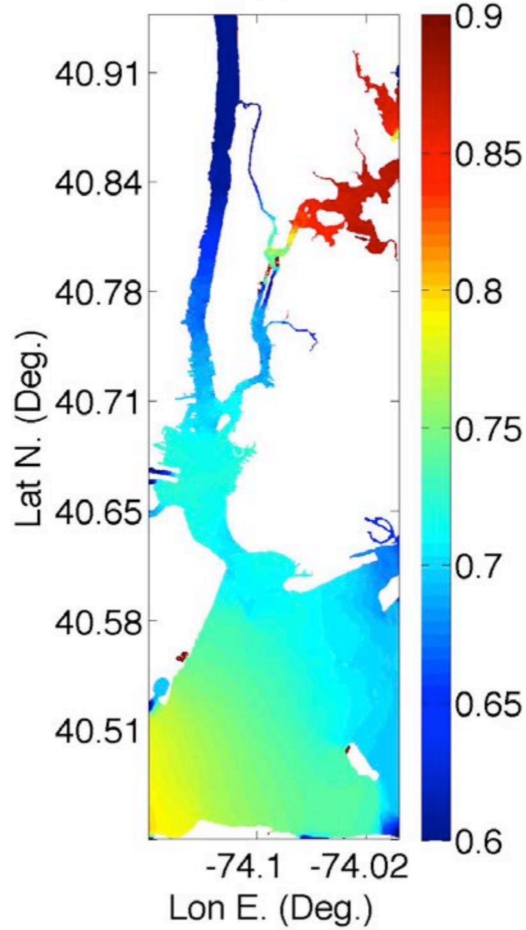
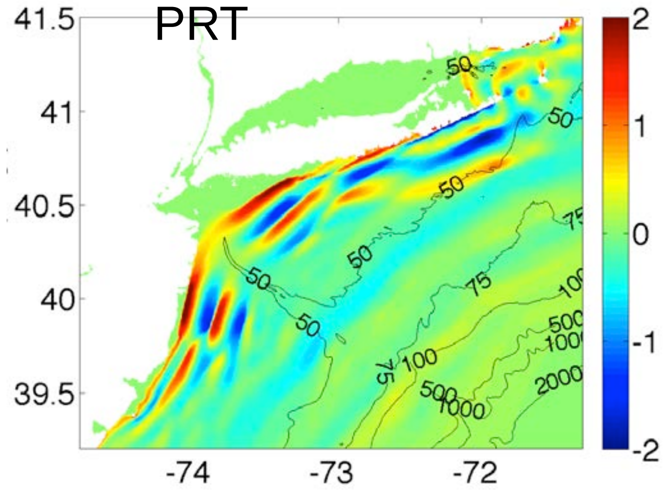




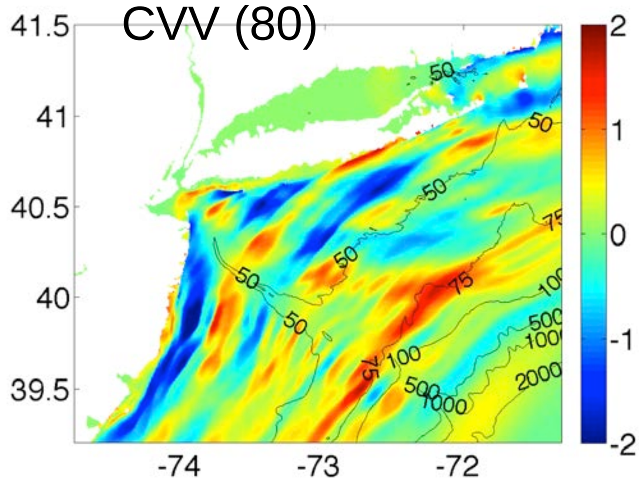
Calibrated tide (MHW)



PRT



CVV (80)



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 Mississipi 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

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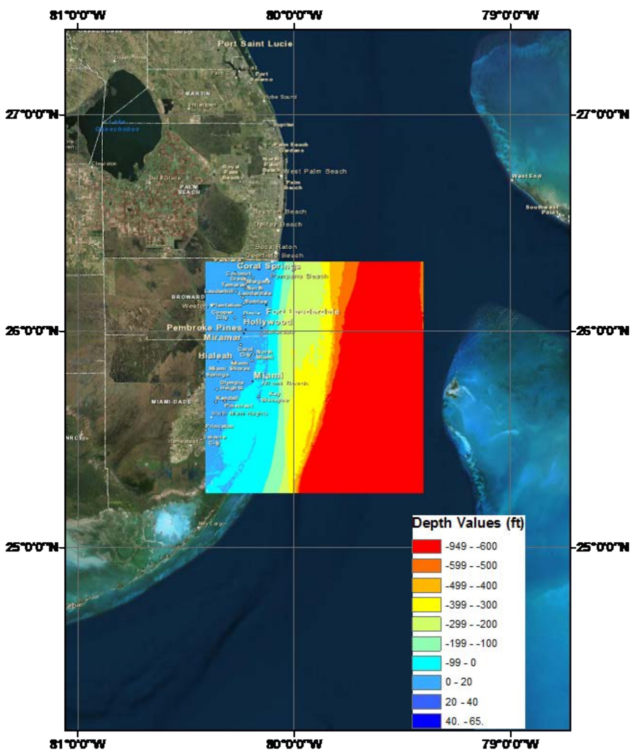
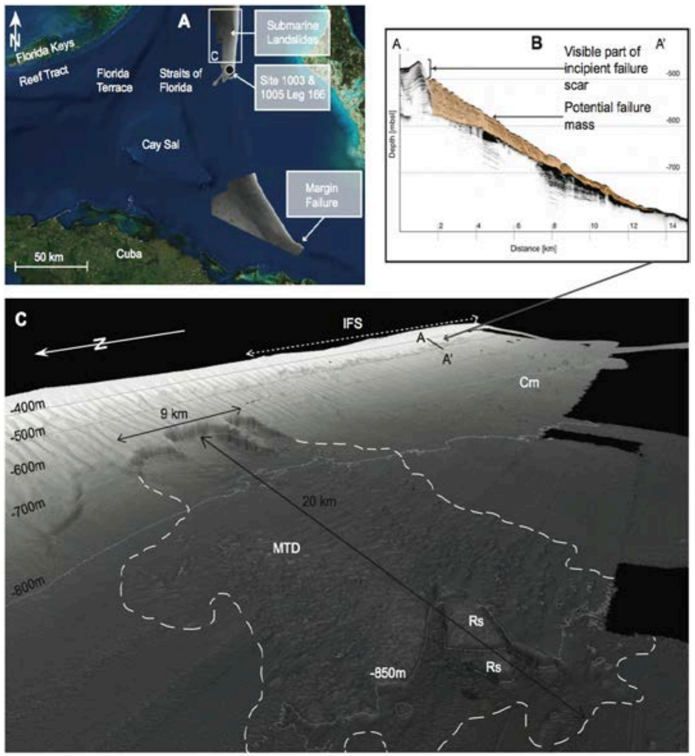
FY15: Task 1: Landslide Benchmark Workshop

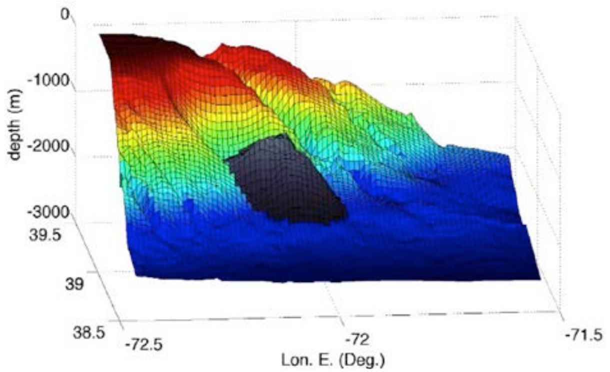
FY15: Task 2.1: Development of new SMF sources (siting/modeling)



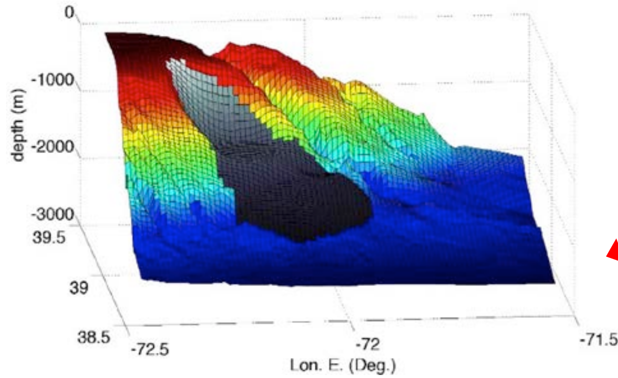


- New source being developed for use in Florida mapping, based on Bahamas Banks SMF events, in collaboration with Eberli's group at U. Miami (Schnyder et al., 2013)

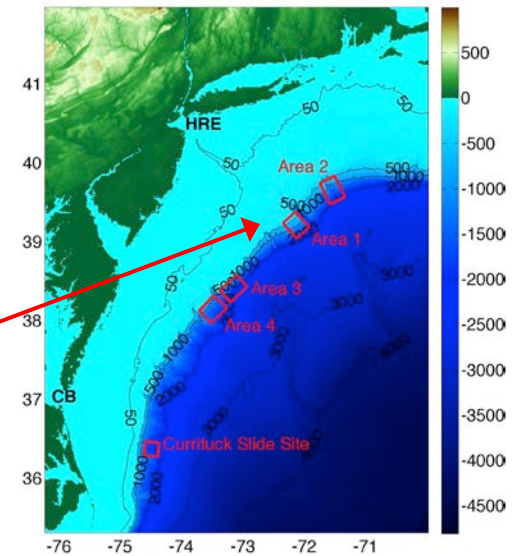
FY15: Task 2.1: Development of SMF sources (modeling)

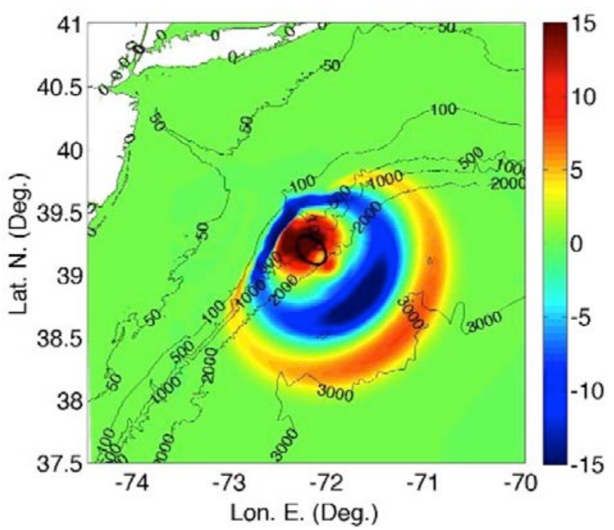


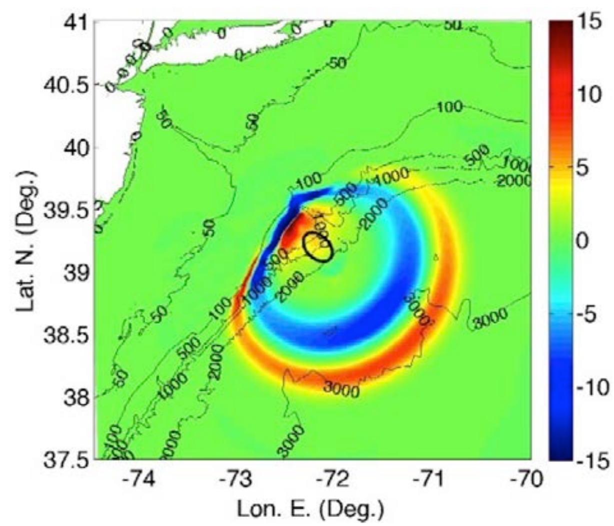
Rigid slump



Deforming slide







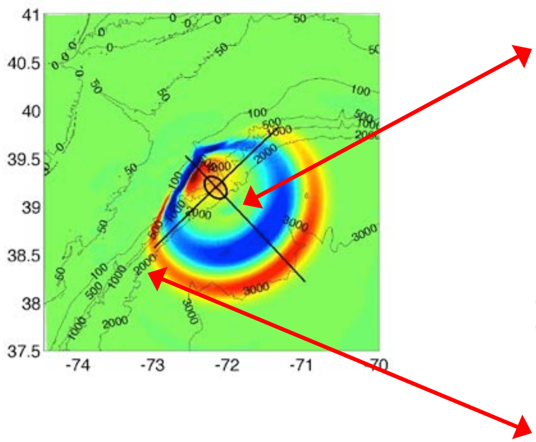
- Hudson River canyon SMF
- Surface elevation after 13.3 min

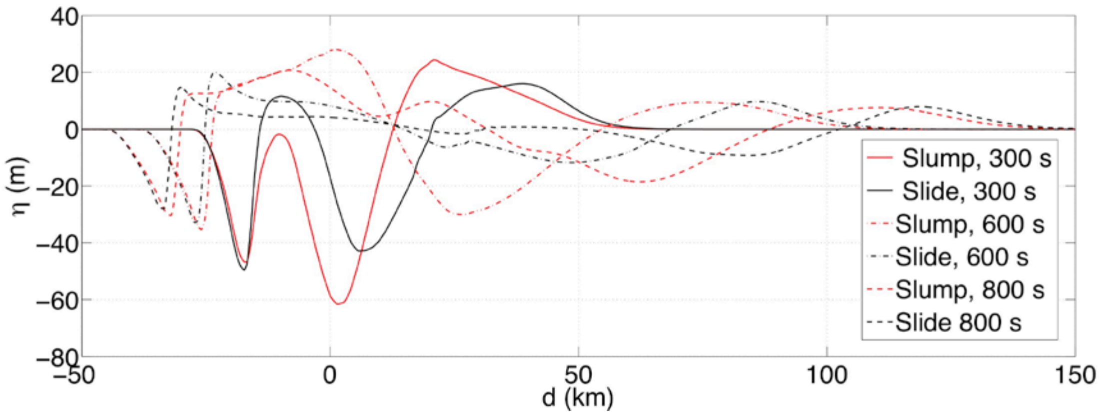
- Rigid slump (as for SMF proxies) vs. deformable slides with same runout at 12 min (when slumps stops) => Reduces wave generation

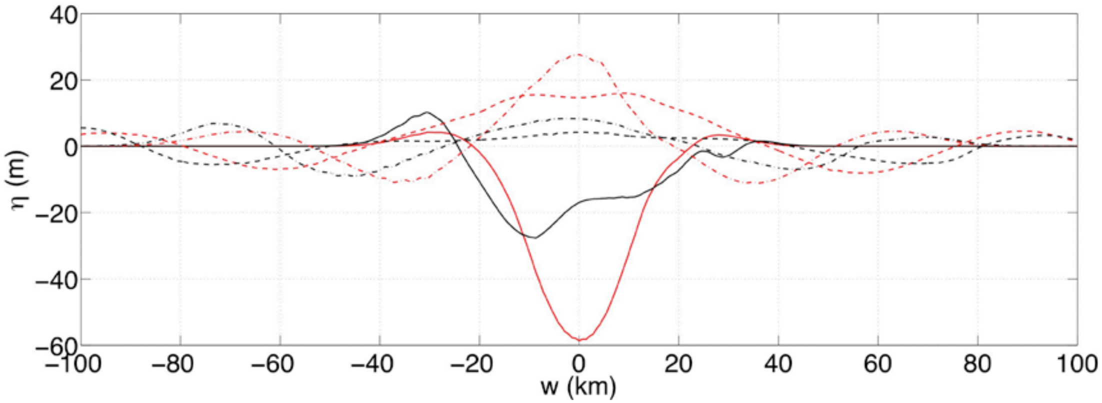
FY15: Task 2.1: Development of SMF sources (deforming slide modeling)

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

Transects in rigid slump and deforming slide waves





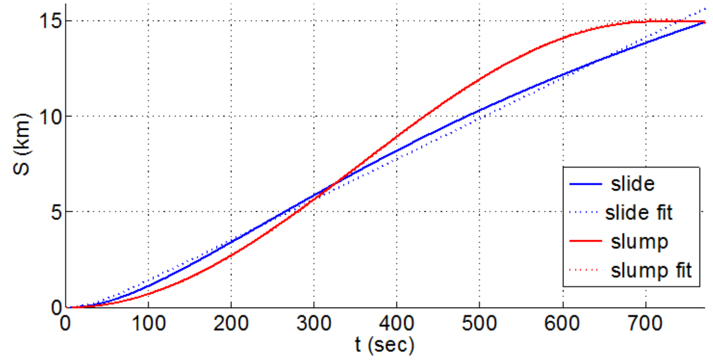


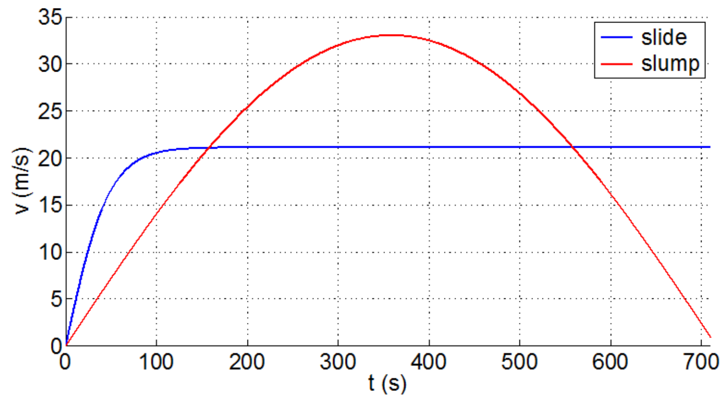
- Rigid slump generates larger tsunamis (mostly for the onshore moving waves) than deformable slides
- Waves from deforming slide are asymmetric as slide follows terrain

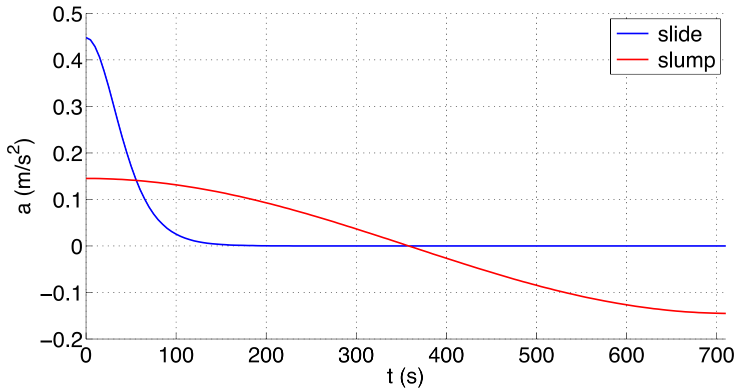
=> Risk is function of rheology (need for USGS guidance/collaboration)

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

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





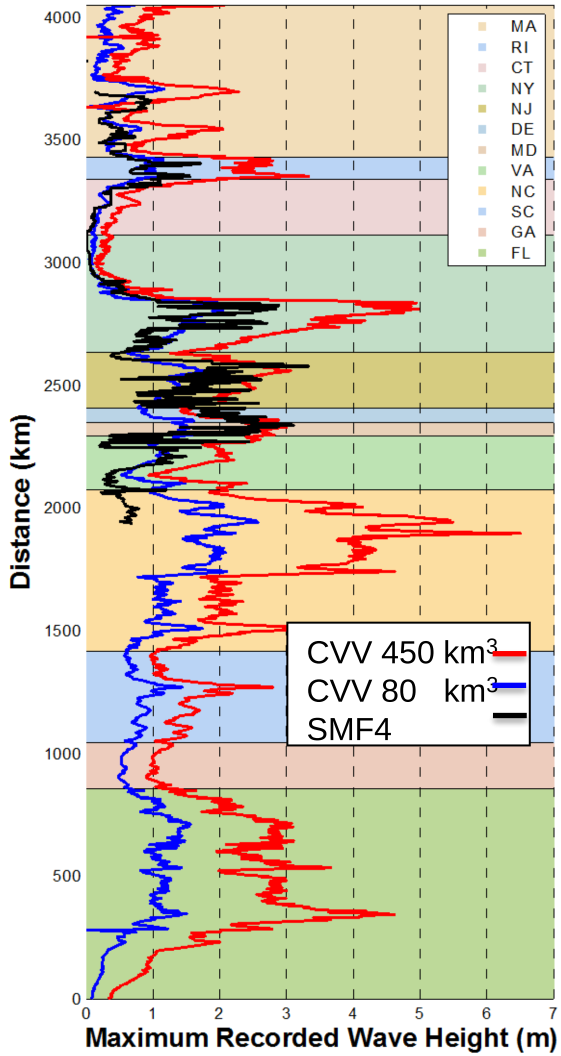


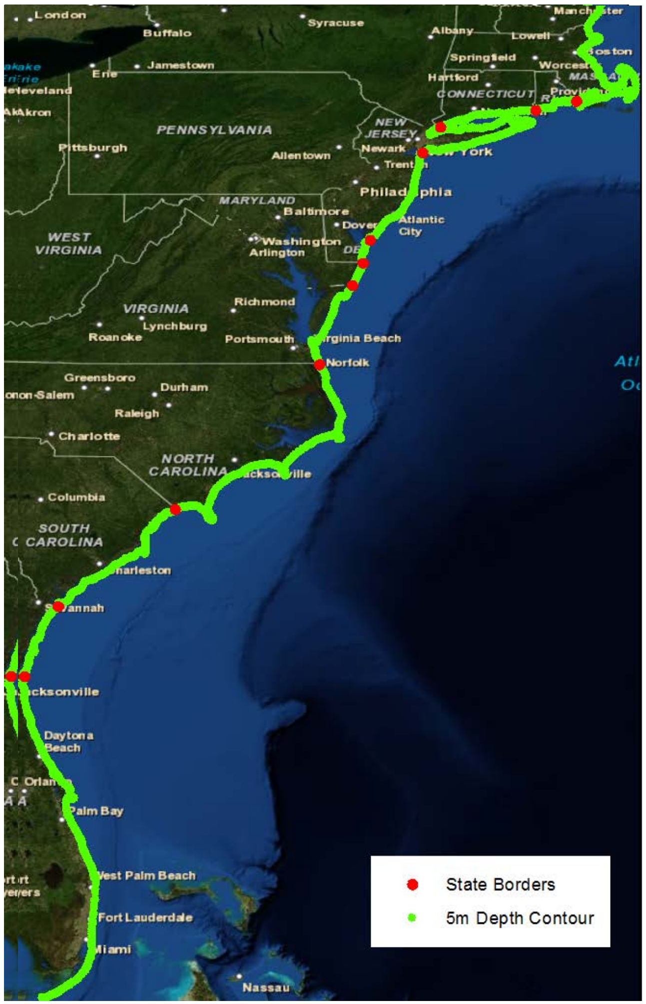
- Deformable slide has larger initial acceleration causing larger initial waves
- Rigid slump then reaches a larger velocity and makes larger waves

=> **SMF rheology is very important** to assess coastal tsunami hazard

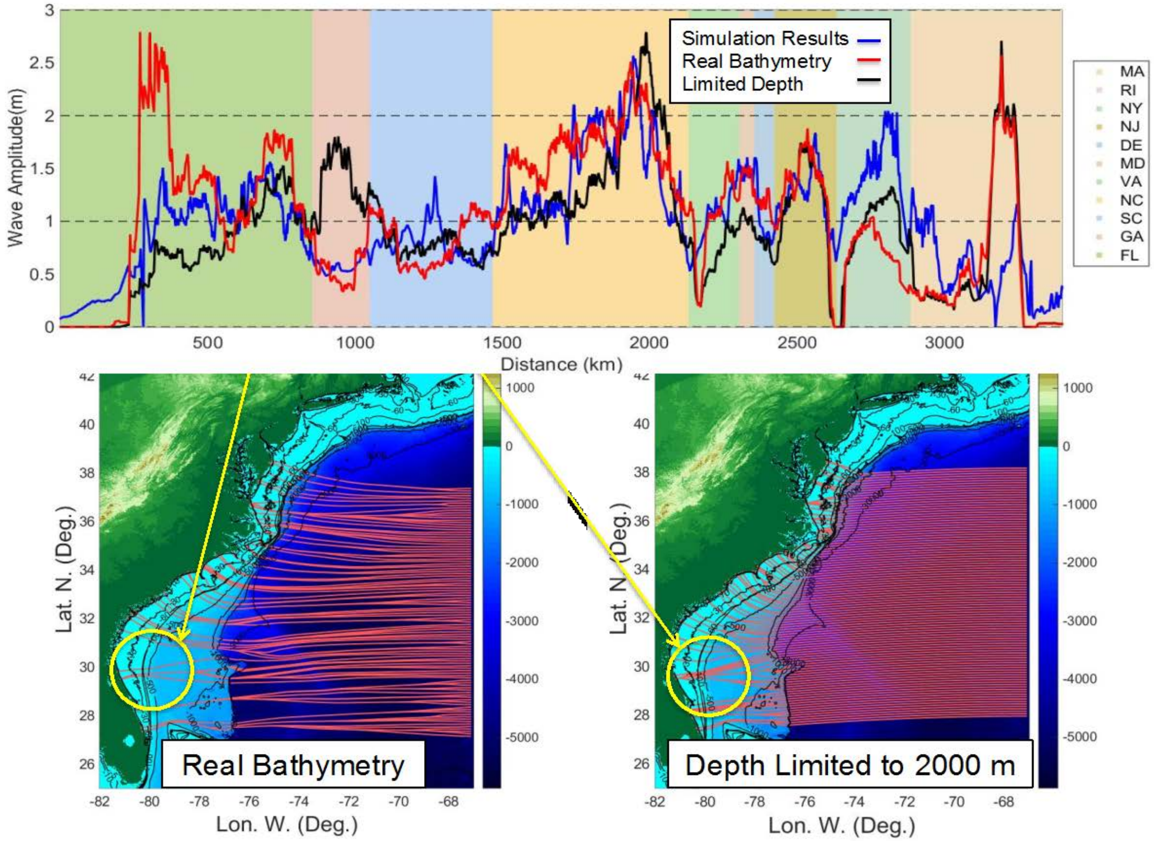
FY15: Task 2.4: Cumbre Vieja Reanalysis

- 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 overwhashed; more areas inundated)