Atlantic Tsunami sources used for tsunami hazard assessment and Inundation mapping along the US East Coast

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NTHMP-16

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NTHMP East Cpast Mapped areas FY10-15

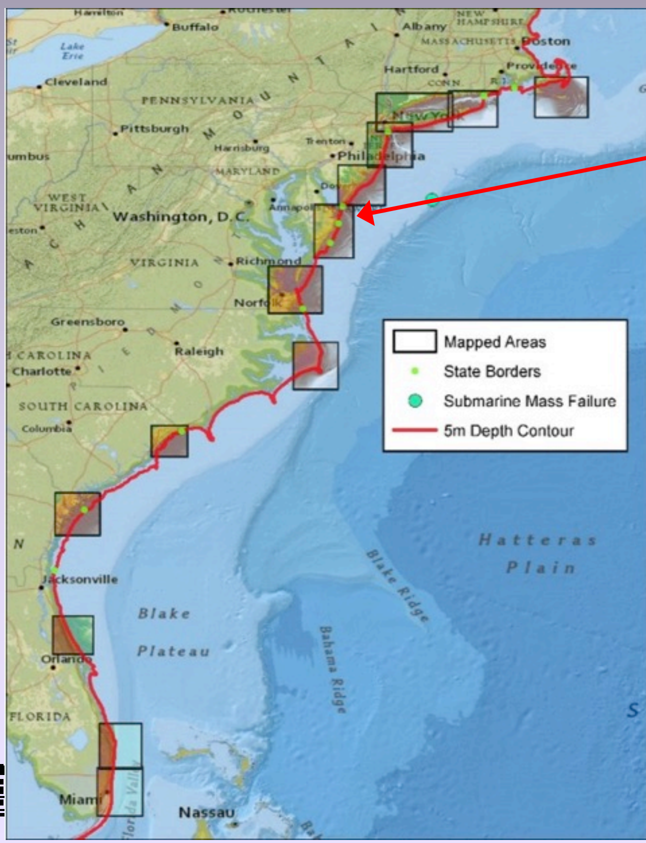
-> First generation maps based on Probable Maximum Tsunami (PMT) sources in the Atlantic Ocean Basin

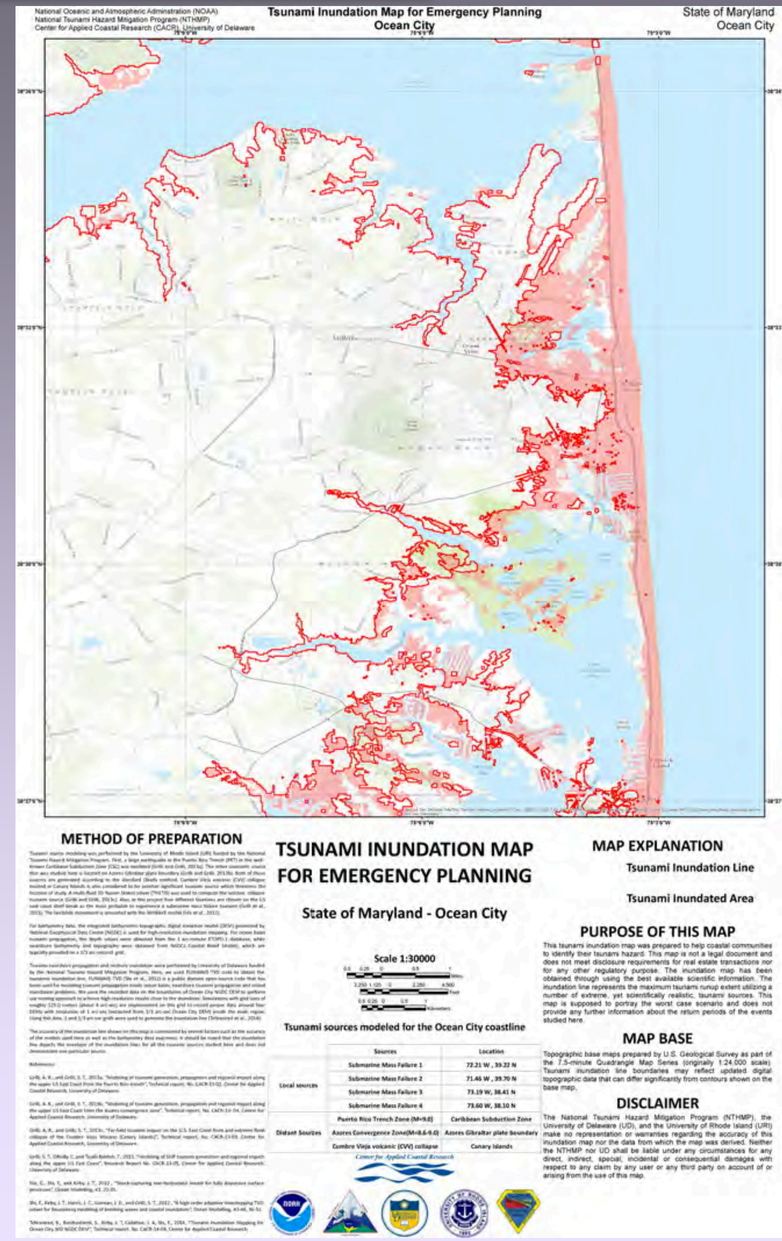
=> not a probabilistic study; envelope maps

=> variety of models (not discussed here)

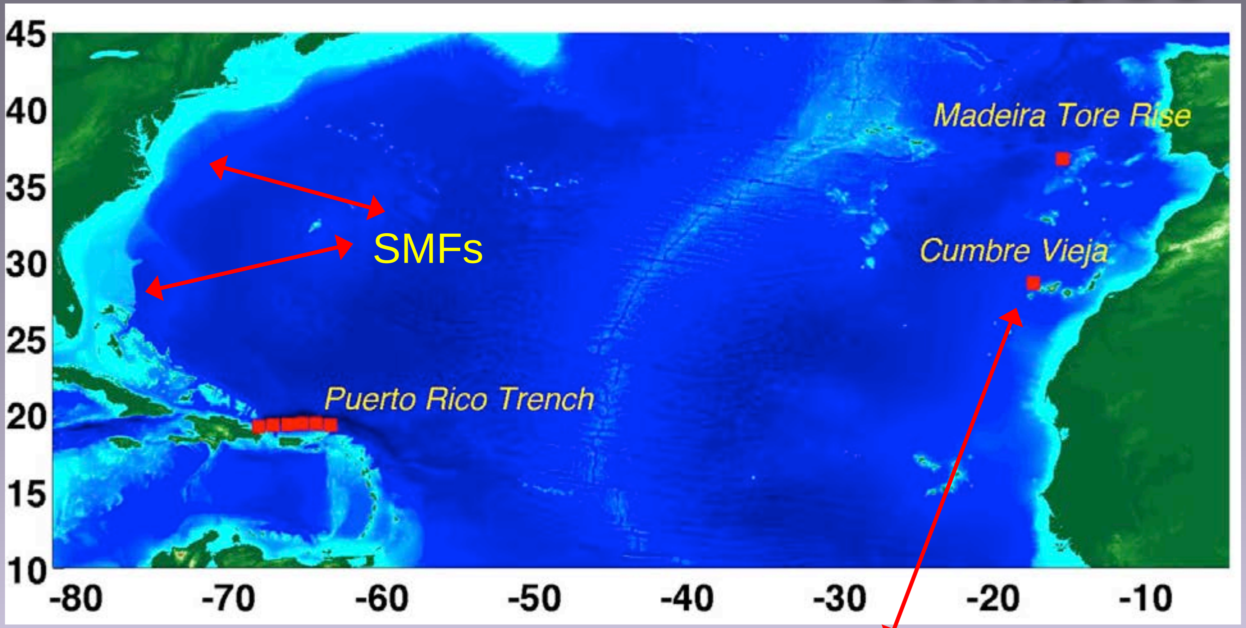
-> Locations of Maps, East Coast (2010-2015) :

www.udel.edu/kirby/nthmp_protect.html





Tsunami sources: SMFs, seismic, volcano collapse

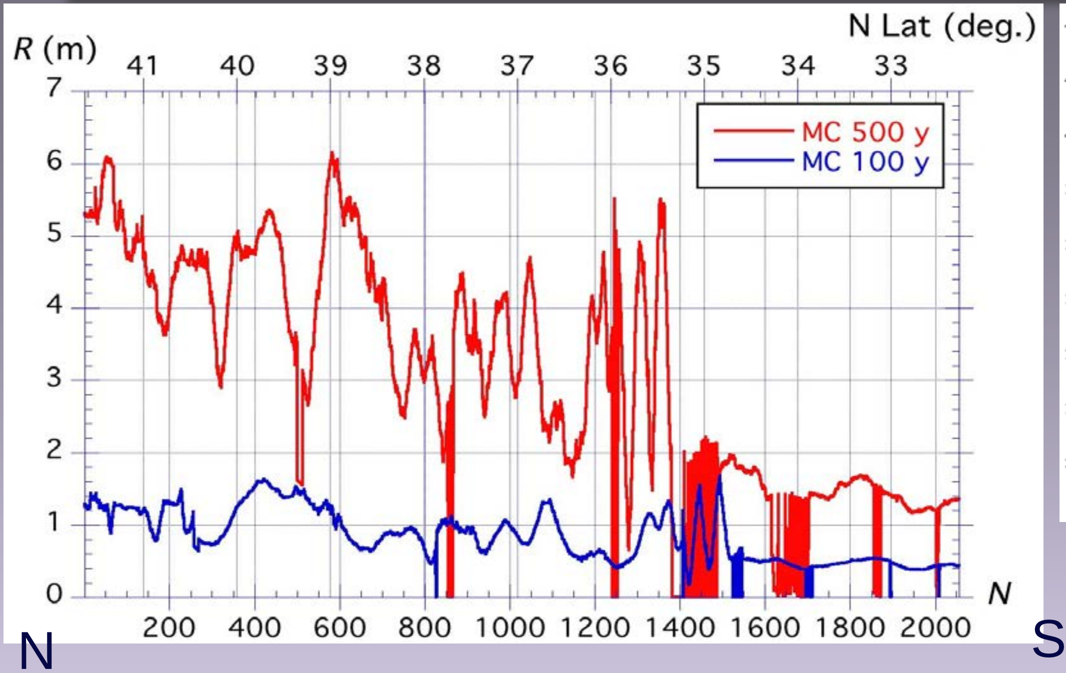


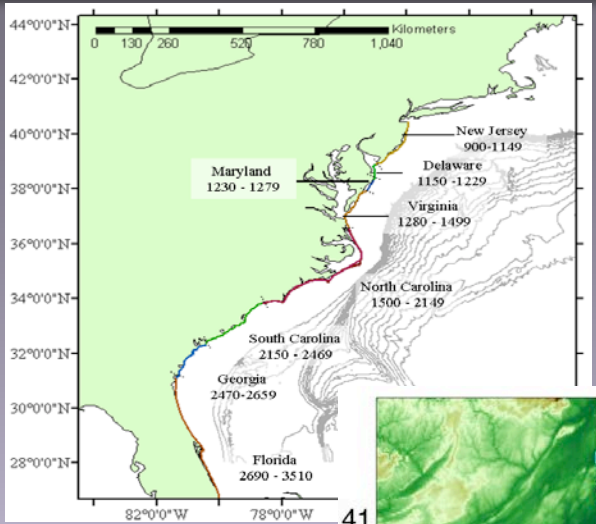
-> M9 far-field seismic source in MTR: repeat of Lisbon 1755 (multiple sources, various strike angl.) (Barkan et al., 2008)

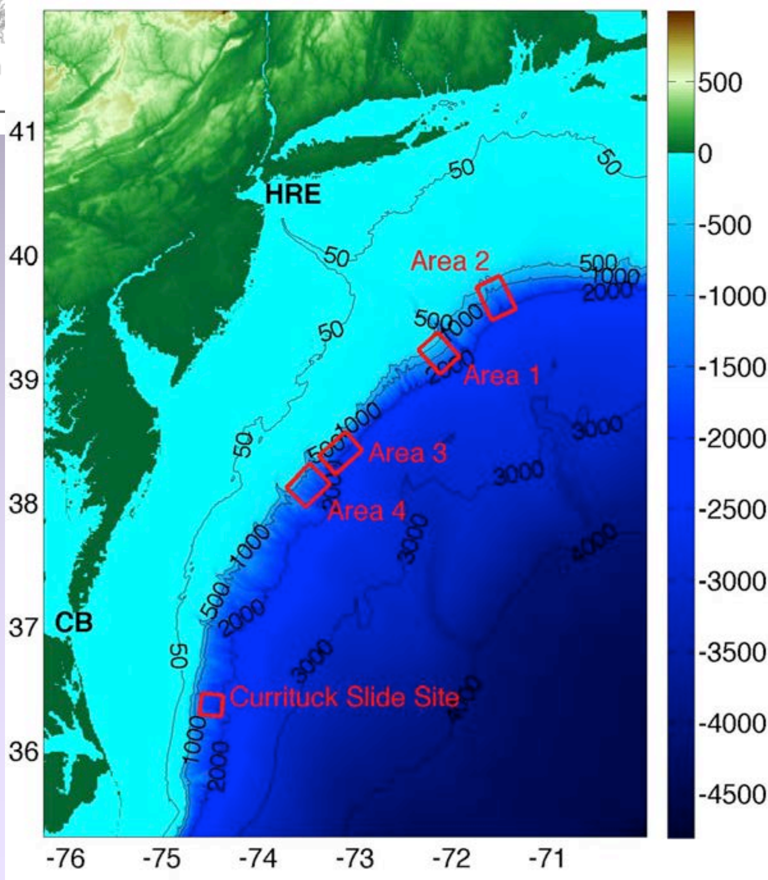
-> M9 far-field seismic source in PRT: designed as extreme event, 600x150 km (12 SIFT sources), 12 m slip (600 yrs of convergence) (Knight, 2006; Grilli et al., 2010; NHESS)

-> Far-field flank collapse of CVV (Ward and Day, 2001; Abadie et al., 2012, JGR; Tehranirad et al., 2015, PAGEOH), with 80 or 450 m^3 volume (extreme and most extreme events), with return period (?) perhaps 1,000-100,000 yrs.

Near-field SMF sources: Monte Carlo + proxies

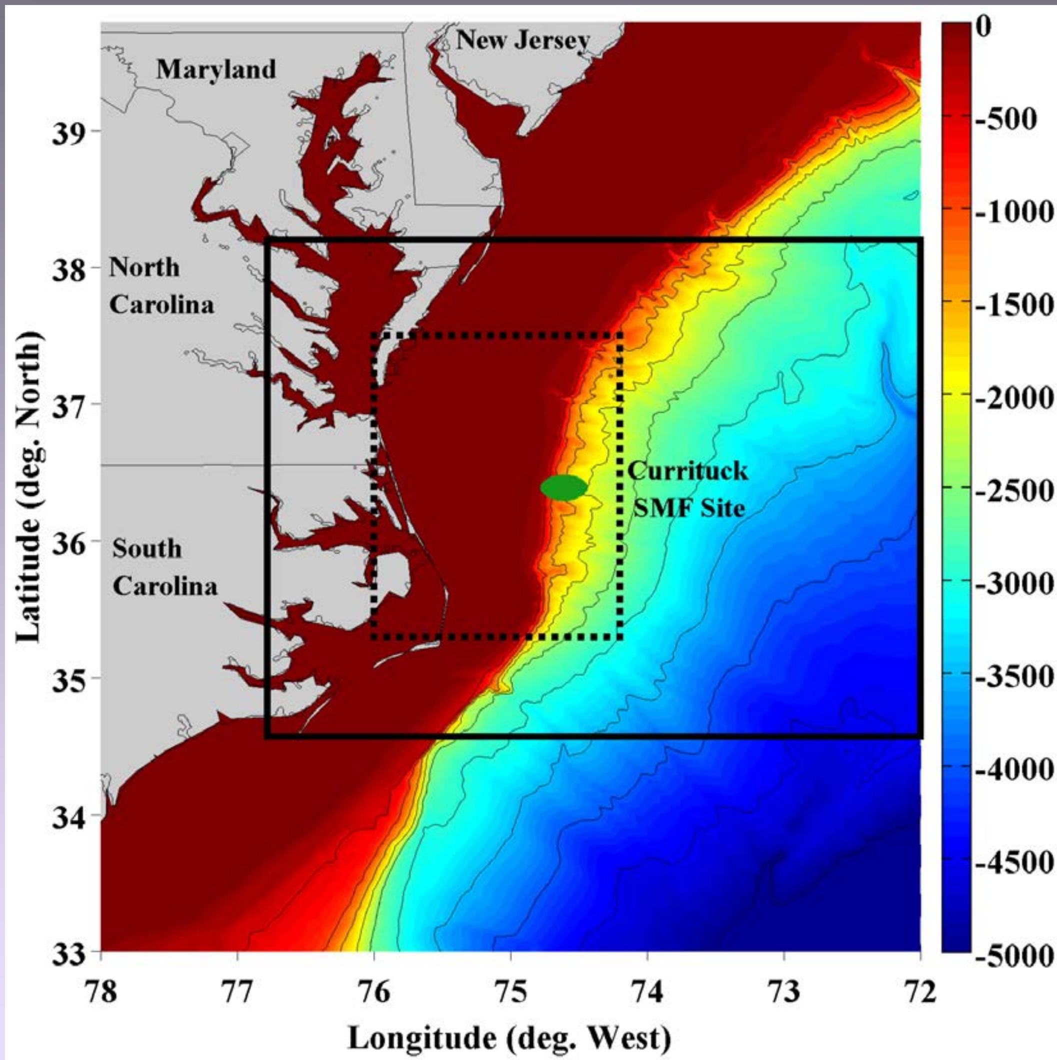


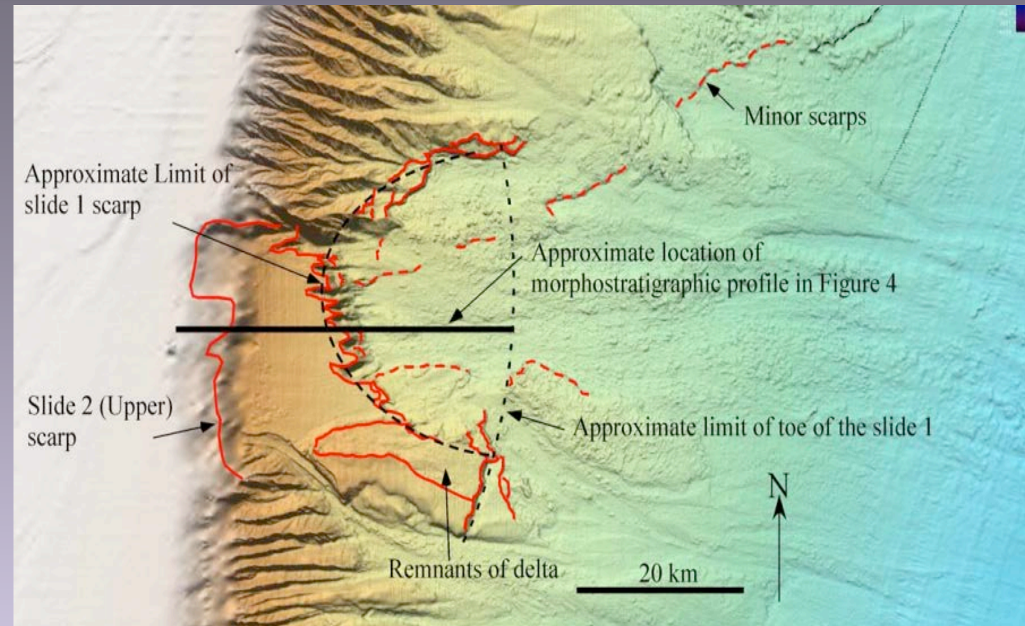


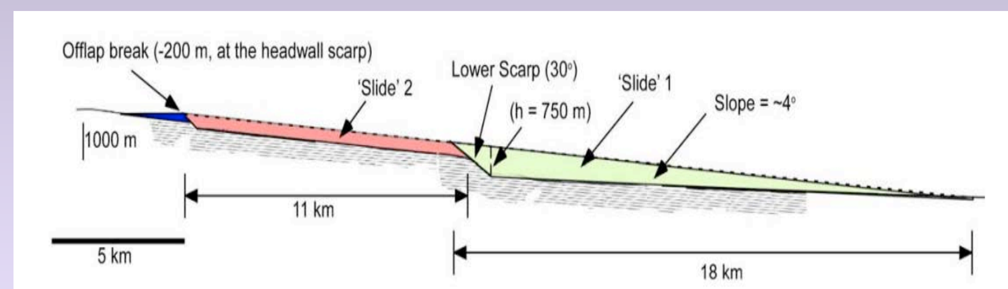


- -> Grilli et al.'s (2009, MG) Monte Carlo slope stability analyses along transects, for a
  => areas of estimated (100-500 year) runup
- -> Sediment availability/geology
  => Areas 1 to 4: Currituck SMF proxies
  (Grilli et al., 2015; NH)

Case study of US East Coast SMF: Currituck

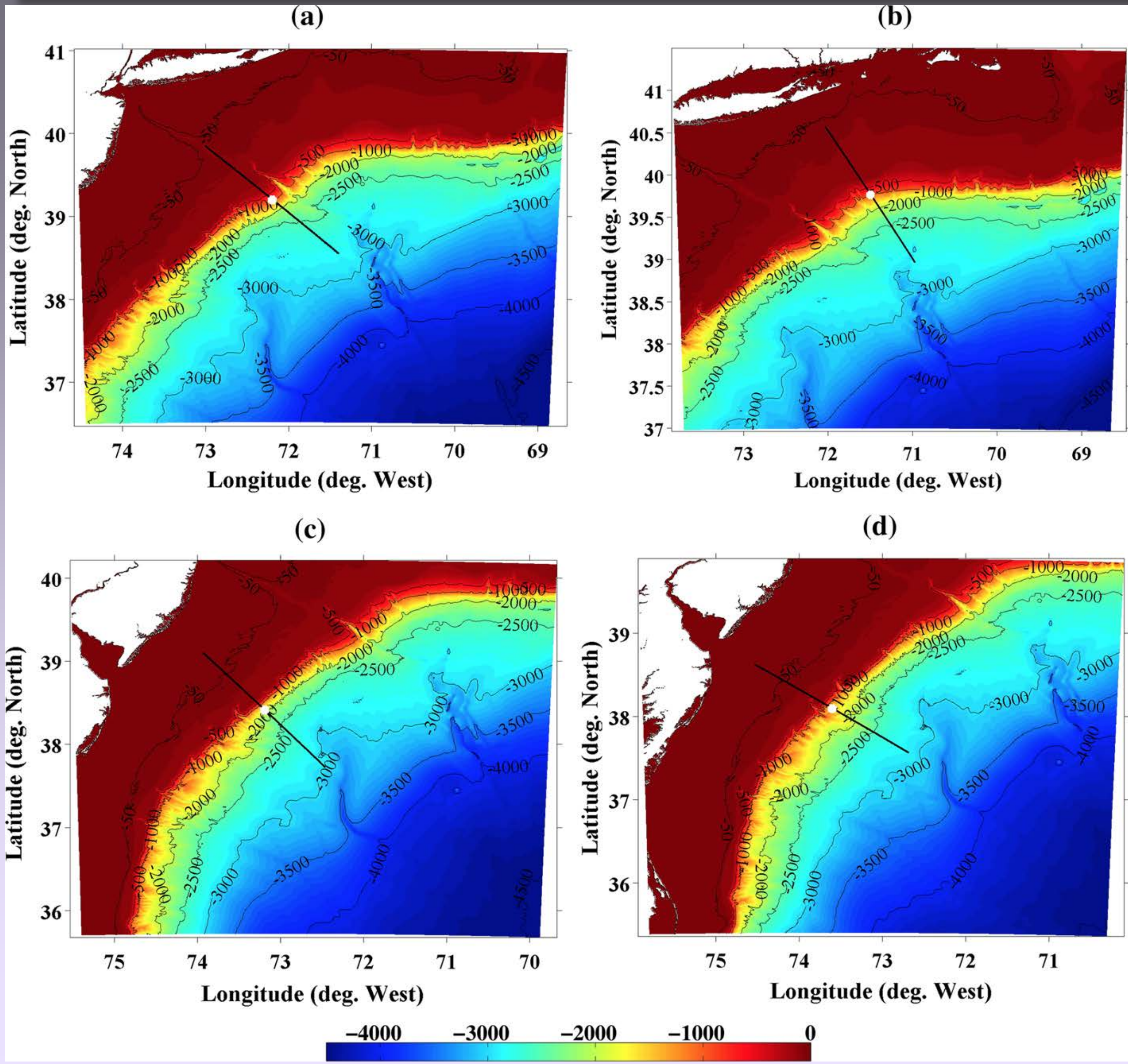




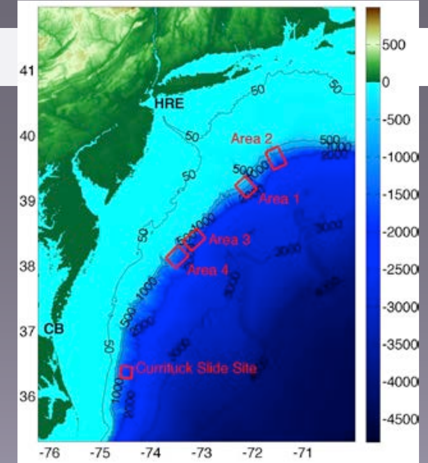


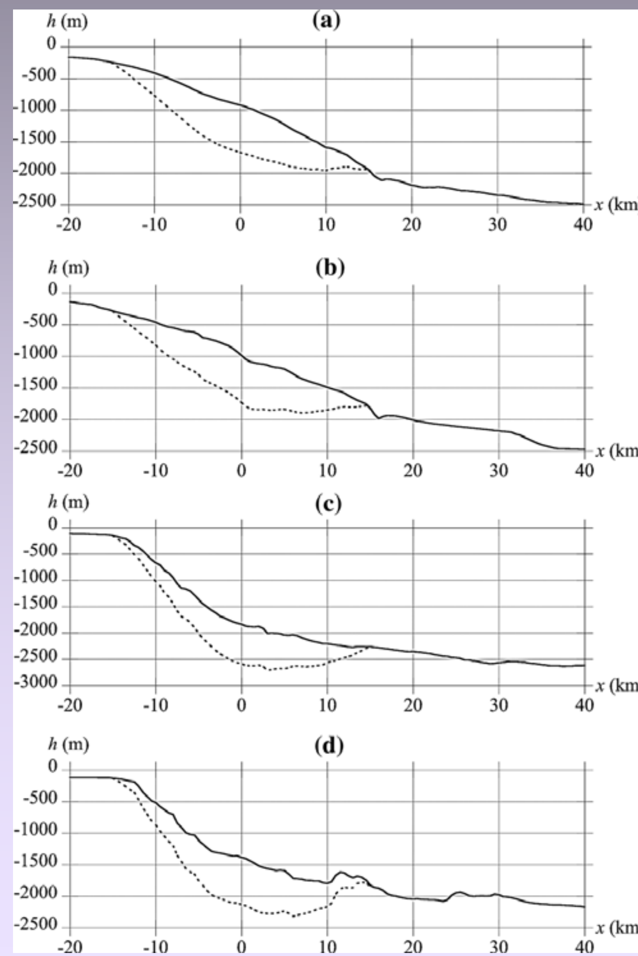
[Grilli et al., 2015 (Nat. Haz.)]

Currituck SMF proxies in areas 1 to 4

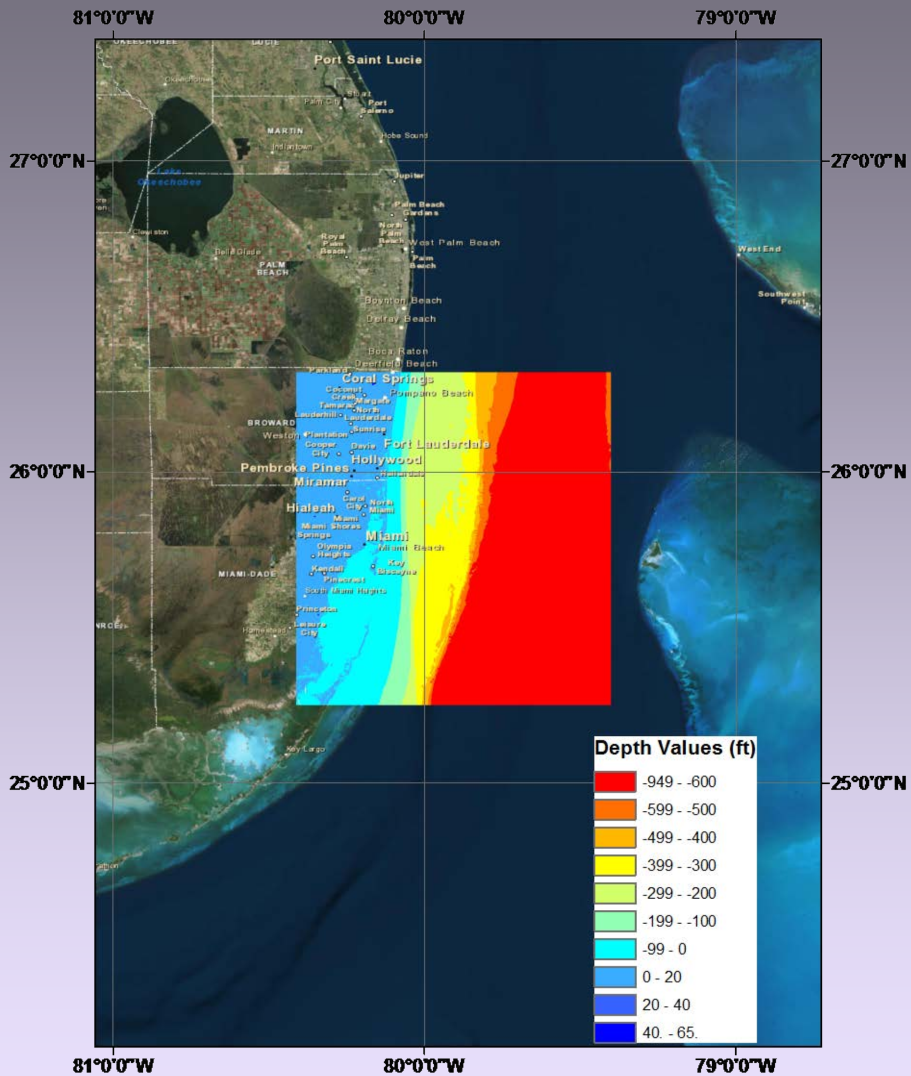


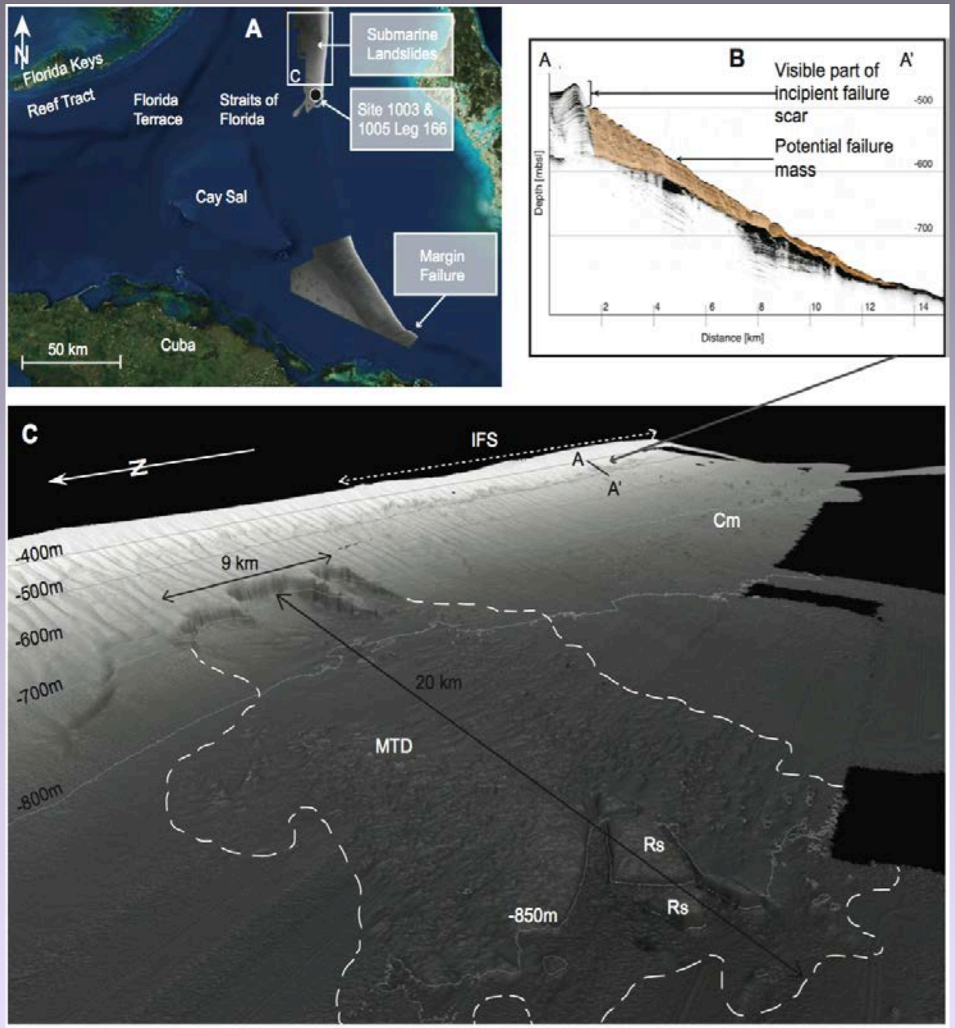
SMFs: 165 km^3 rigid slumps





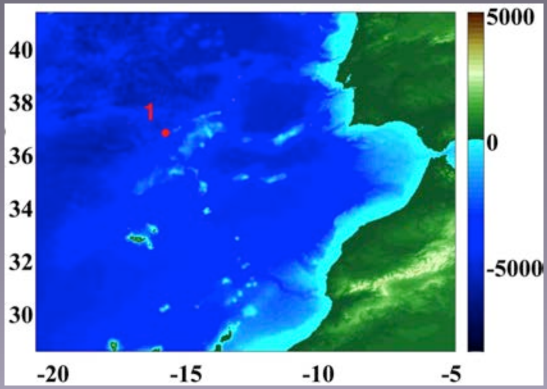
Near-field SMF sources: West Bahamas Banks

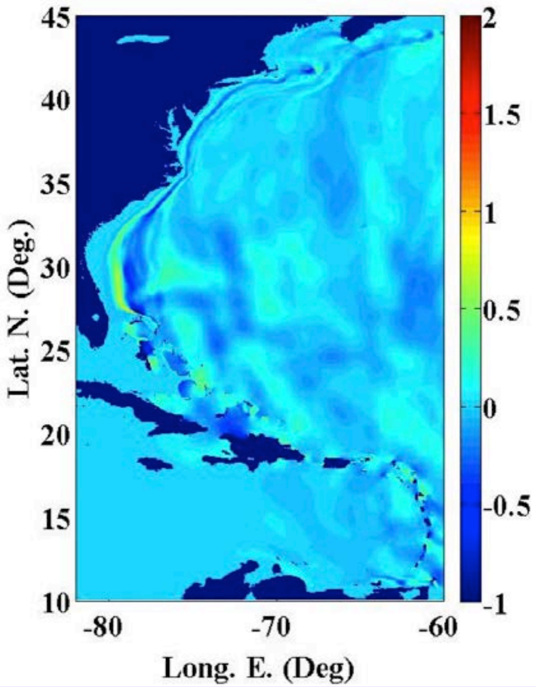


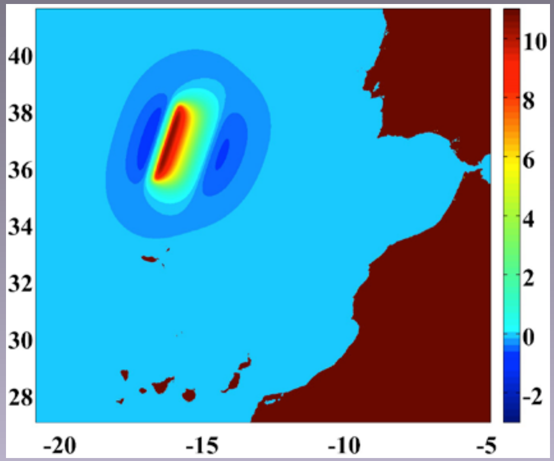


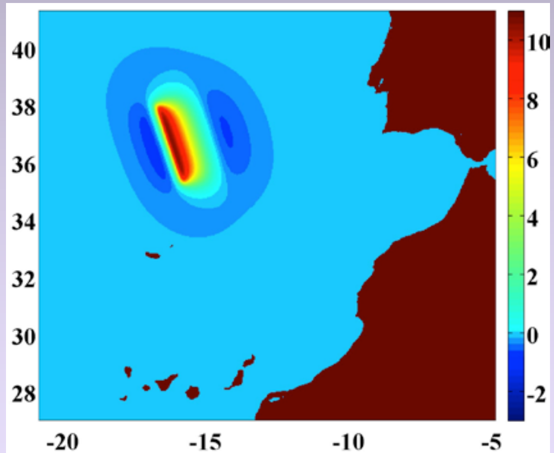
(Schnyder et al., 2013)

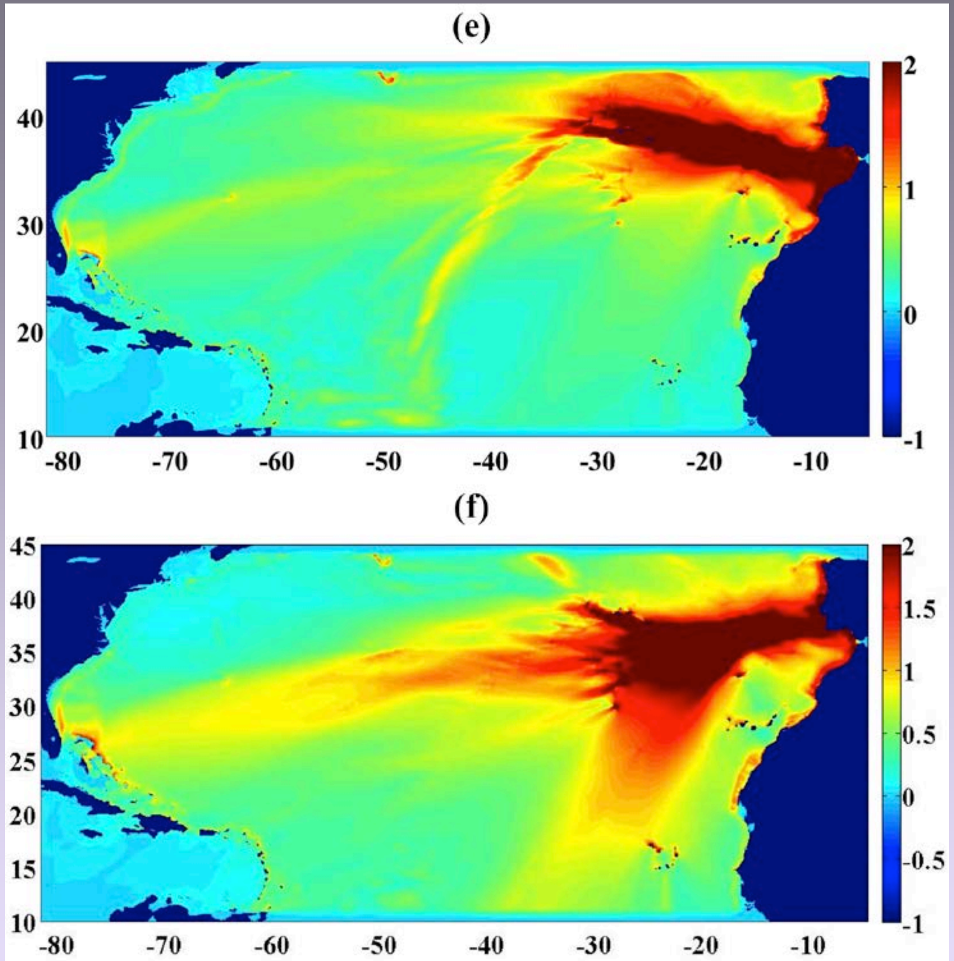
Far-field source modeling : M9 MTR





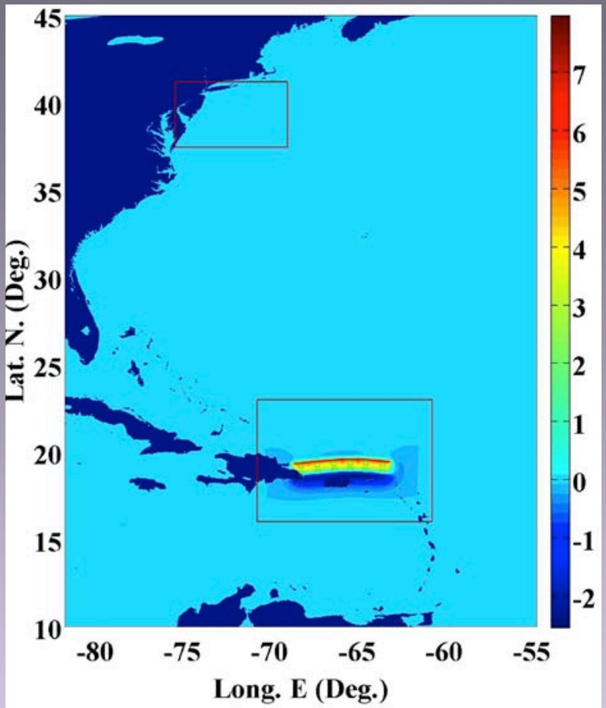


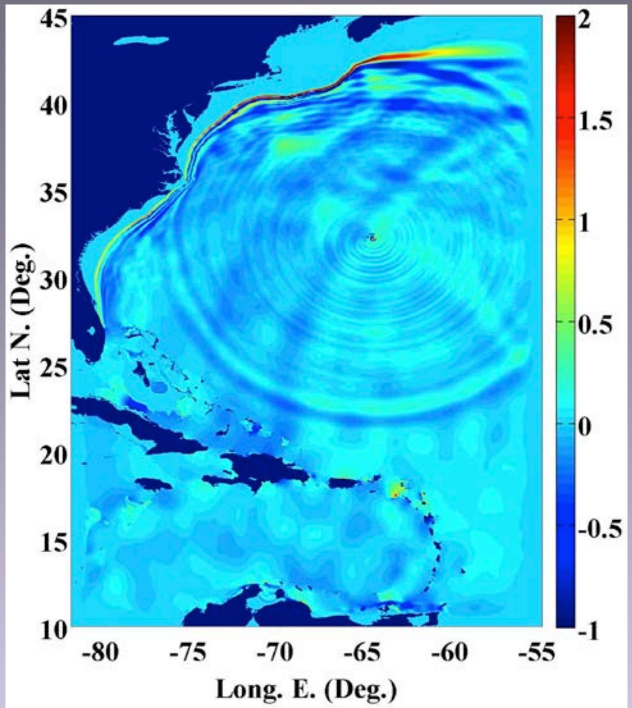


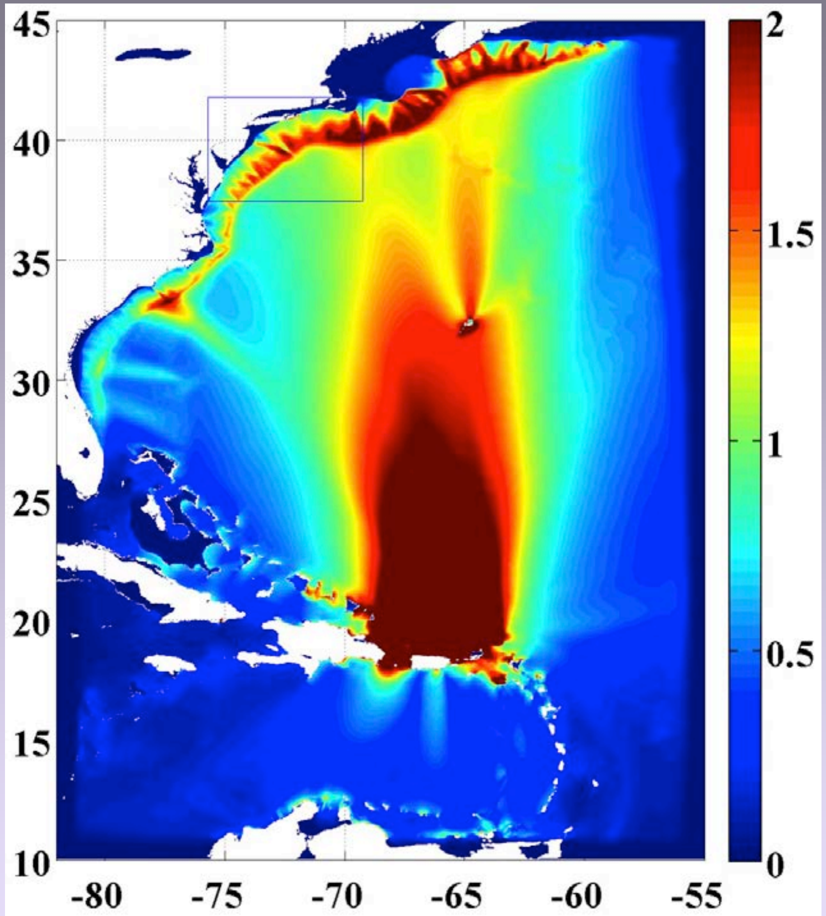


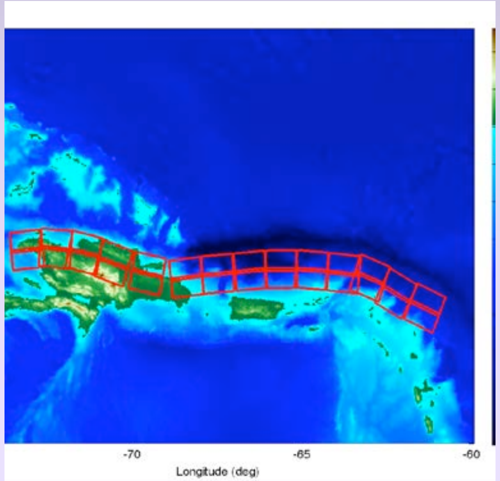
-> Order 1 m runup/inundation, not dominant

Far-field source modeling : M9 PRT







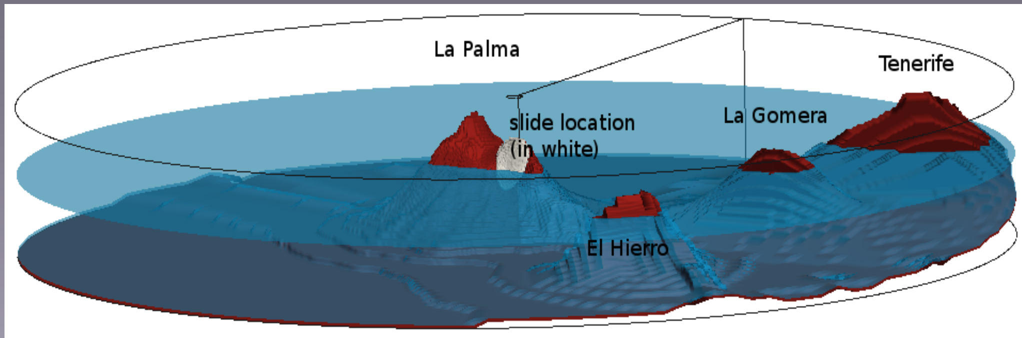


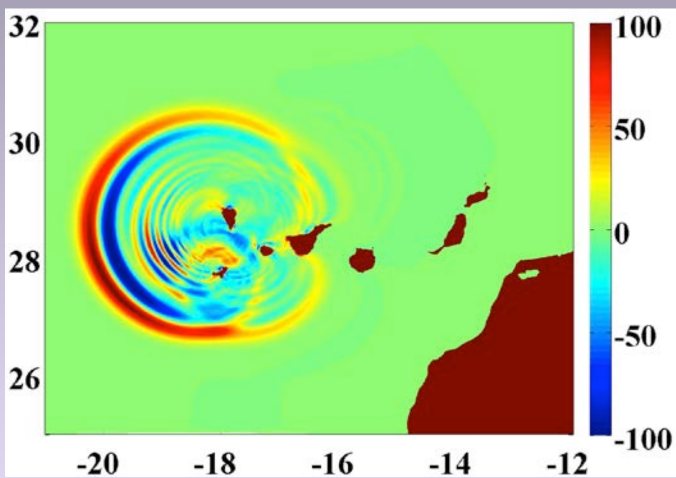
"SIFT" sources

Fault planes, in the area

-> Order 2 m runup/inundation

CVV Flank Collapse source (450 km^3)





-> Surface elevation (meter) after 20 min

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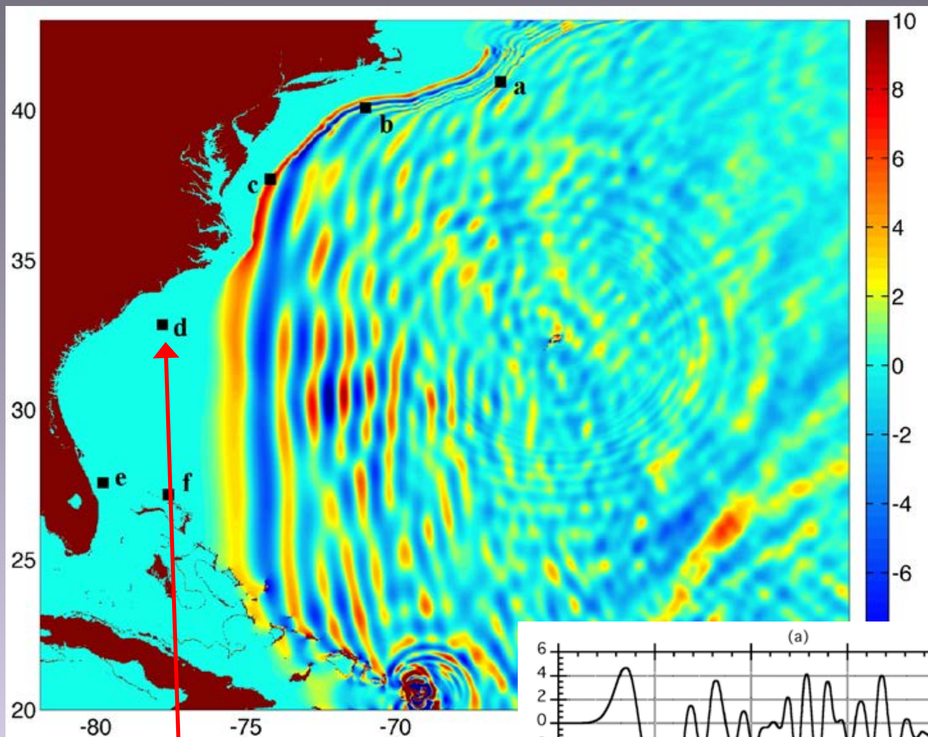
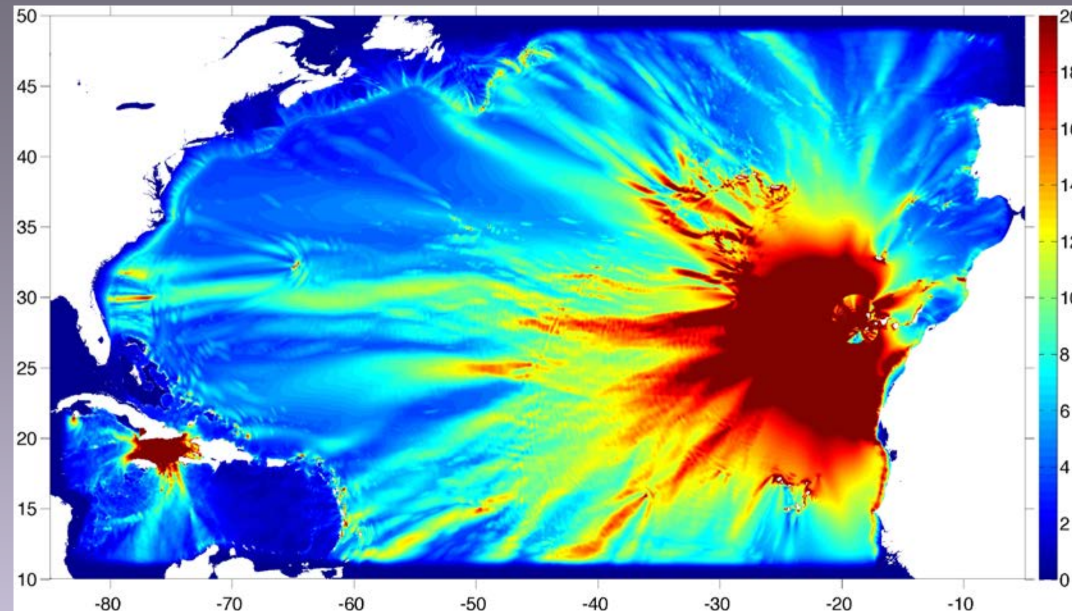
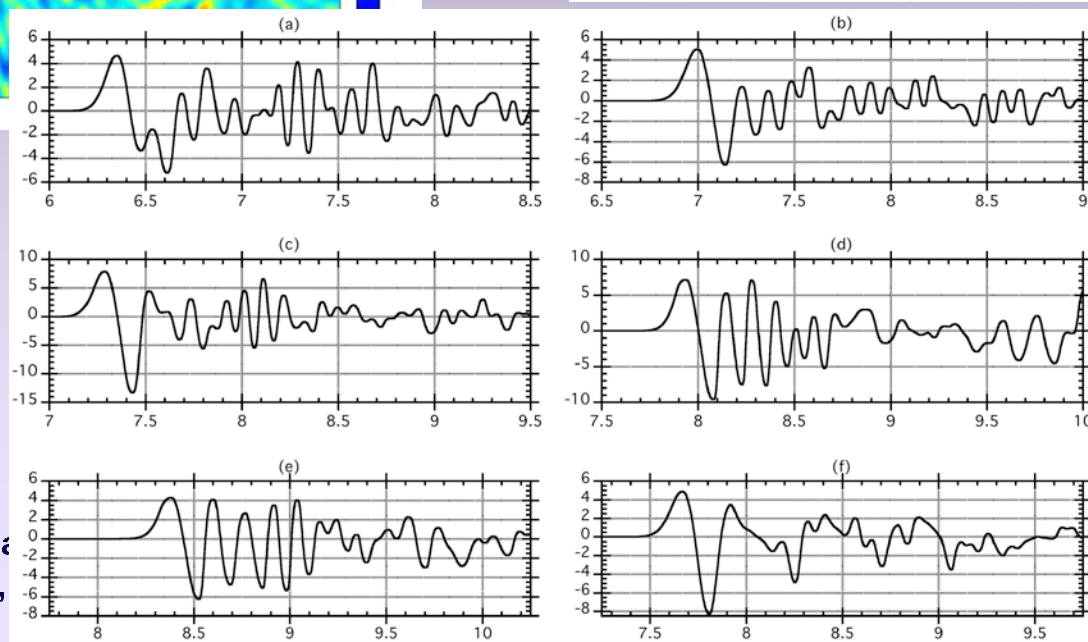
CVV Flank Collapse source (450 km^3)





-> Dispersive trains of large waves, 9-12 min period



-> 450 km^3:

Up to 5-6 m runup/inundation

-> 80 km^3:

Up to 2-2.5 m runup/inundation

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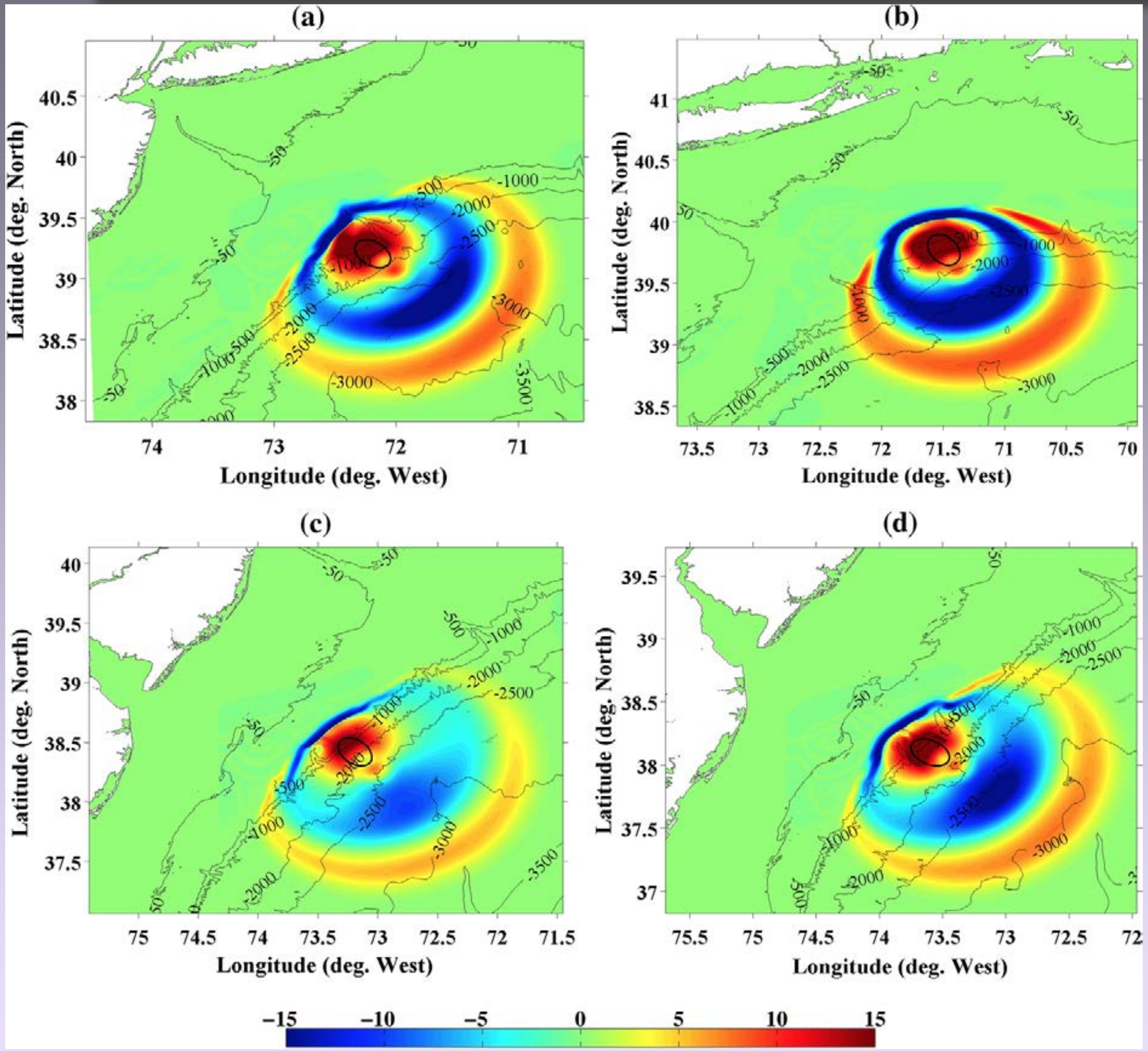
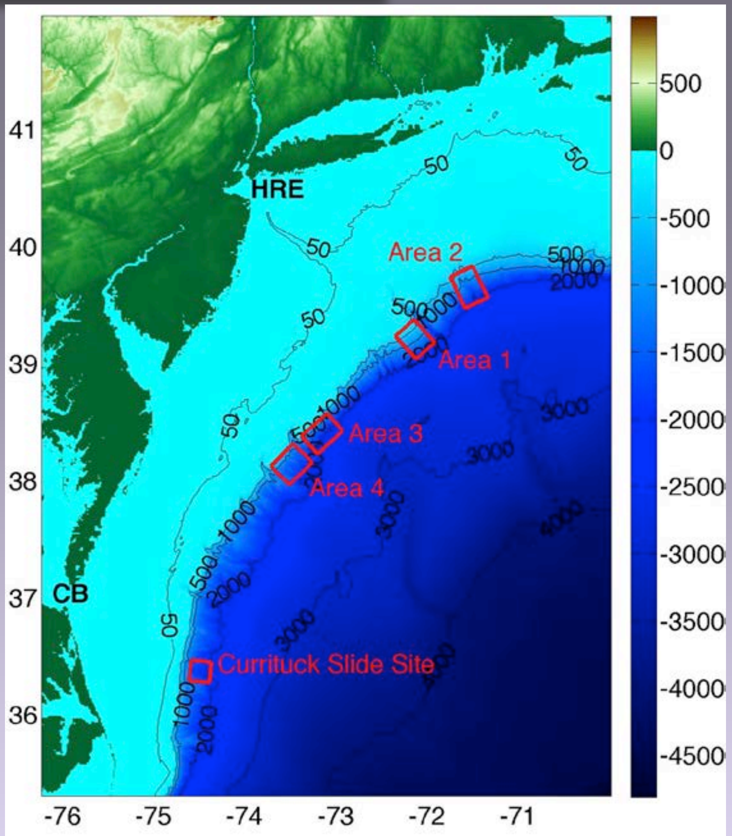
Curritick SMF proxies in areas 1 to 4

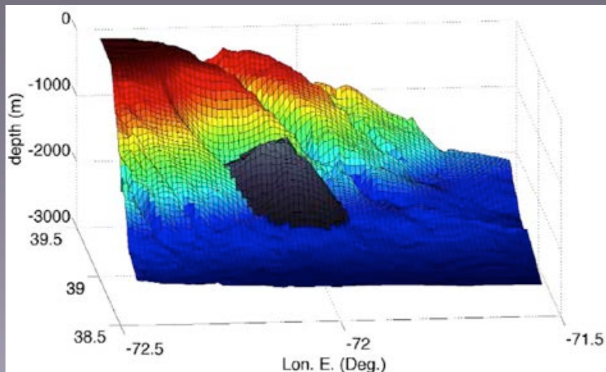


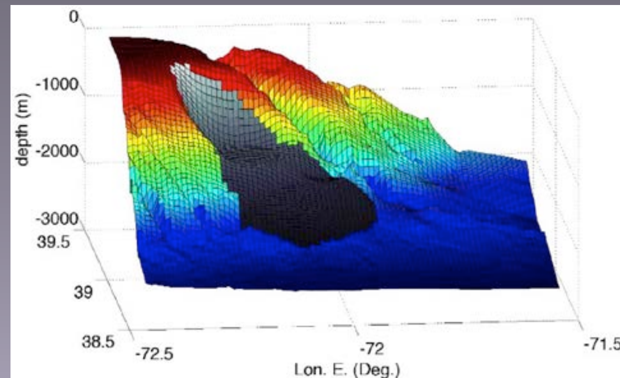


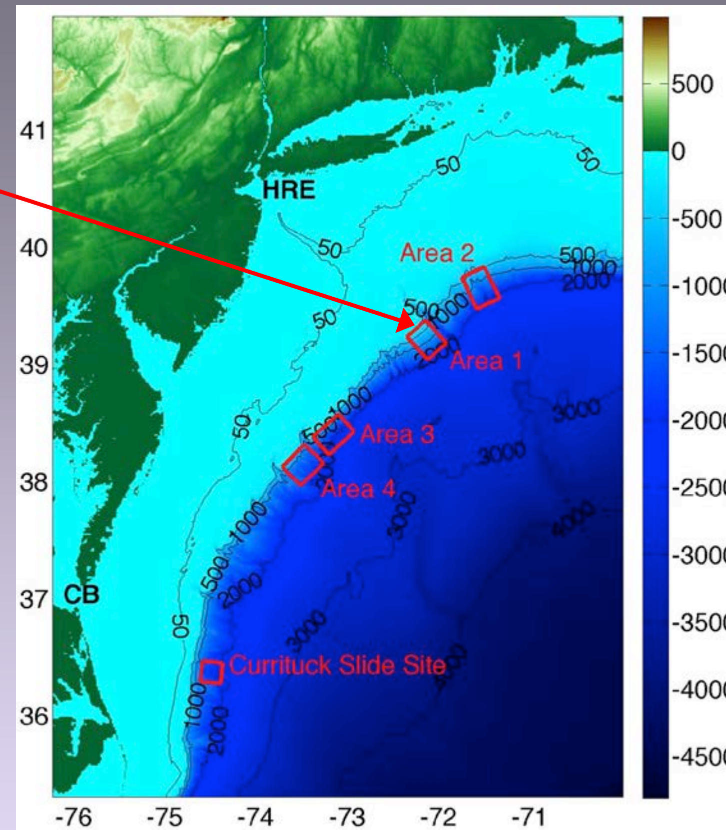
- Modeled as rigid slumps (surface elevations after 13.3 min)

  [Details in Grilli et al. (2015) NH]
- Deformation is being studied

Currituck SMF proxies 1: rheology effect

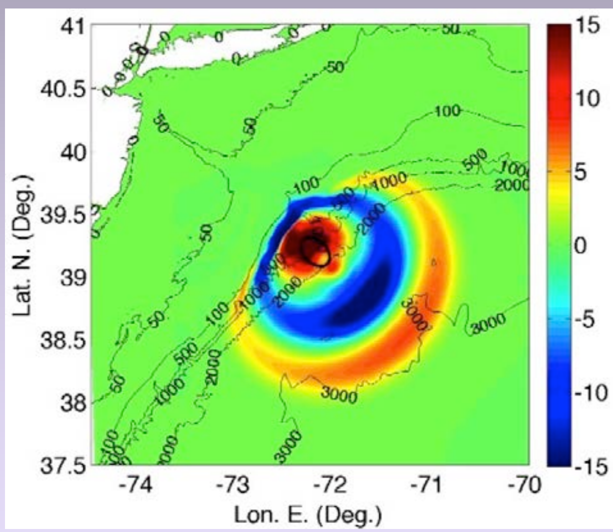


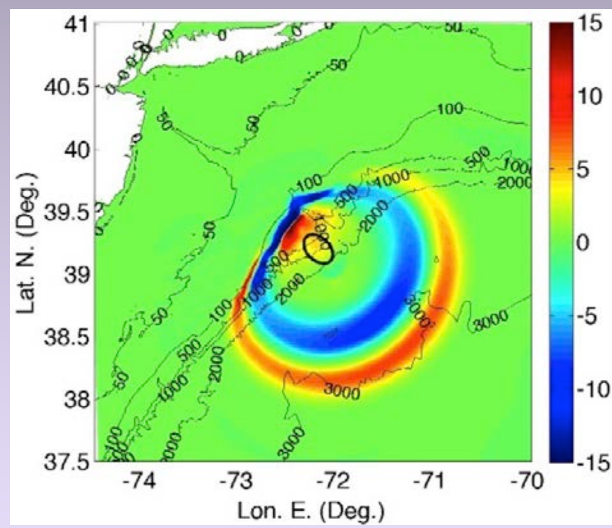




Rigid slump

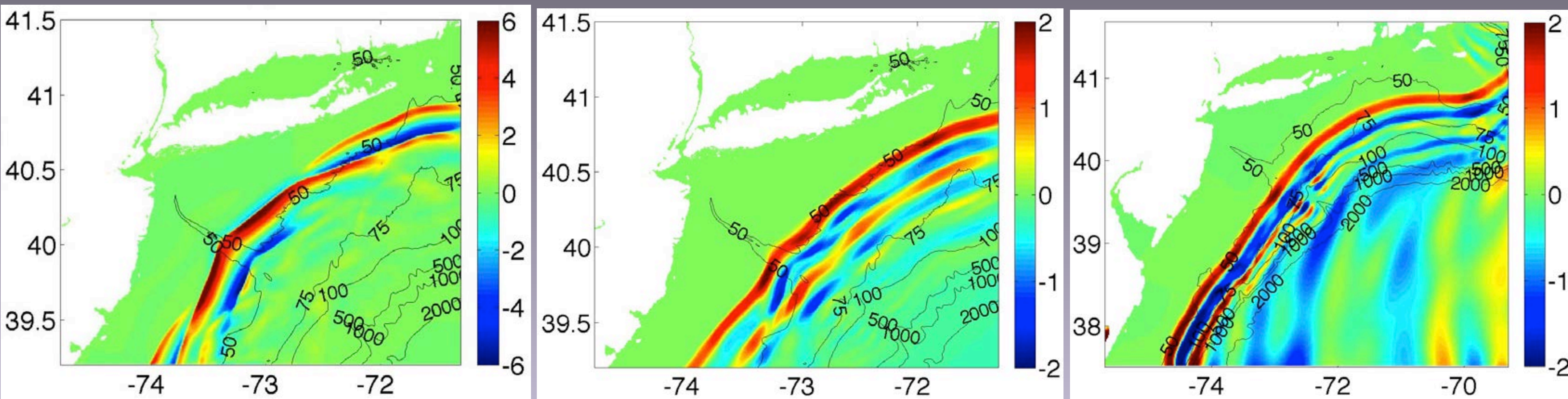
Deforming slide





Surface elevation after 13.3 min (slump stops at 12 min; same runout)

Comparing coastal impact CVV/SMF/PRT

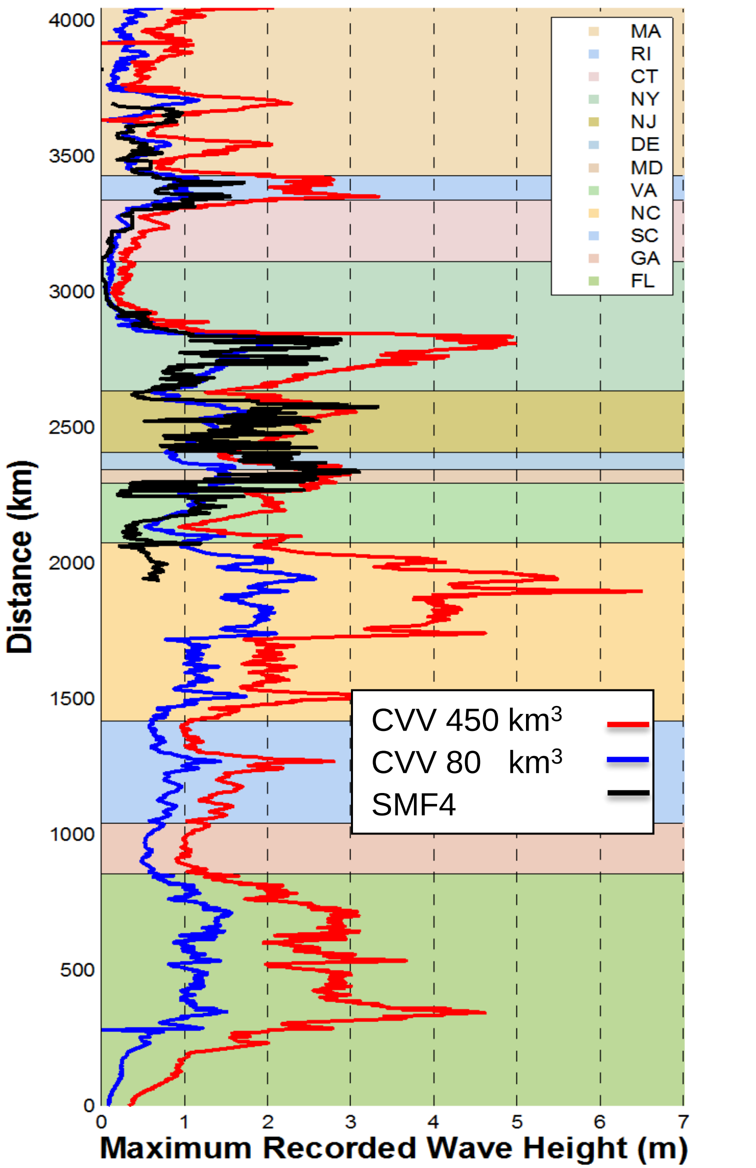


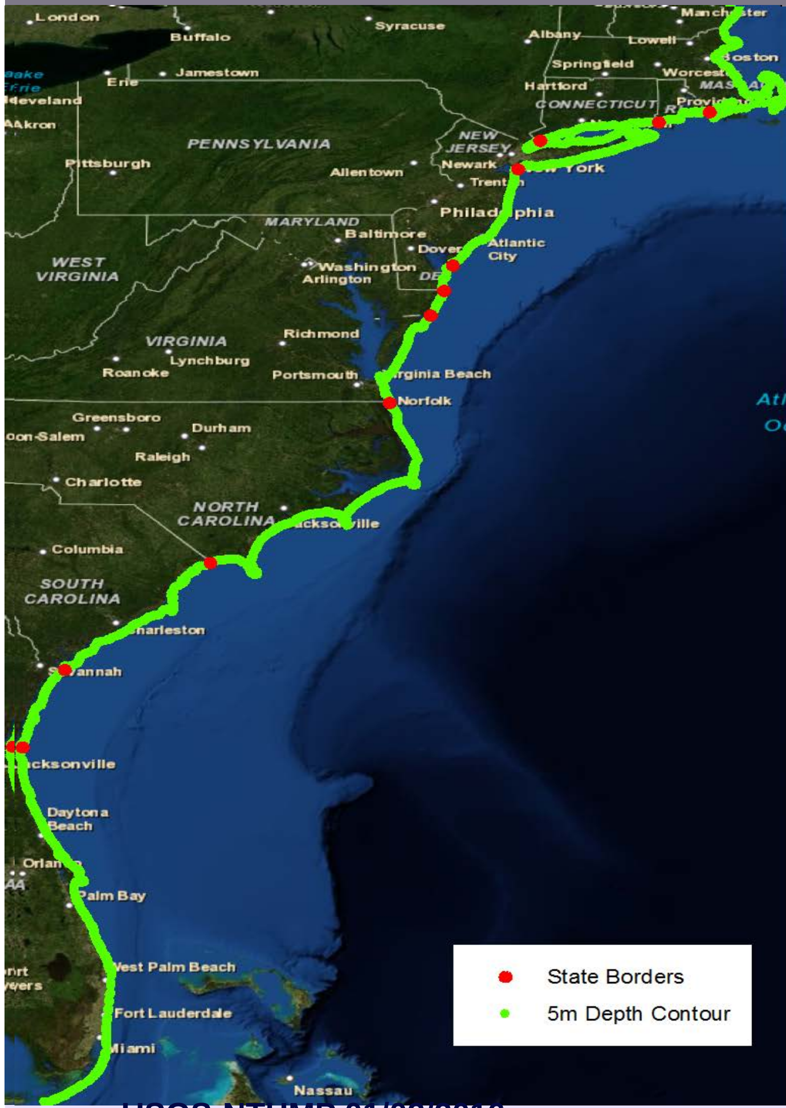
SMF-1 (rigid slump) 1h18’ PRT (4h) CVV (80 km^3) (8h)

-> Similar patterns of nearshore waves are observed for all sources

-> Coastal wave height distribution suggest tsunami coastal hazard is controlled by nearshore bathymetry, particularly that of a wide shelf.

Comparing coastal impact CVV/SMF1-4/PRT





- -> A similar wave height distribution pattern is observed for all of the sources simulated in this study.
- -> Wave height distribution and tsunami propagation control by nearshore bathymetry,

Discussion – East Coast Risk

1) First generation maps are based on extreme sources/PMTs, with no consideration for return periods of LSB, PRT, CVV, SMFs.

=> Return periods are needed for coastal managers to assess risk and for future work on PTHA

=> Last major PRT earthquake was in 1787 (M8.1); is a 200-300 year return period possible for a 600 year M9-PRT event ?

Discussion during USGS workshop

- No landslide has been found that is more recent than 10,000 years
- Main trigger for landsides is seismicity => slope stability analysis with peak horizontal earthquake acceleration (Approach in Grilli et al.'s, 2009 MC work)
- Maximum event in PRT is linked to whether plates are coupled or uncoupled

=> No apparent consensus at USGS on this (100s to 1,000s of years) and need for more paleo-tsunami work in the PRT area to help decide.

Discussion – East Coast Risk

2) Size and likelihood of CVV failure (e.g., 80, 450 km^3; single/multiple)

=> might dominate east coast hazard for most extreme case, or not ?

(see Cape Verde mega-tsunami 73ka ago; Ramalho et al., 2015)

Discussion during USGS workshop

- No guidance from USGS as they are not funded to study these volcano failures

3) SMF siting and rheological properties have major influence on coastal hazard

=> Need for geological/geotechnical data, siting, … for east coast SMFs

Discussion during USGS workshop

- USGS (Chaytor's group) will provide data based on recent field survey
- This can be fed into more accurate MC studies of east coast landside tsunamis

4) Geist et al. (2014,2015) study of 2013 EC meteotsunami => 1-2 m runup can be expected on a 100-200 year time scale -> similar risk

Thank you