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NTHMP Inundation Mapping for North and South Carolina and Georgia Part 1: Modeling

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July 18, 2018

Center for Applied Coastal Research

THE UNIVERSITY OF RHODE ISLAND

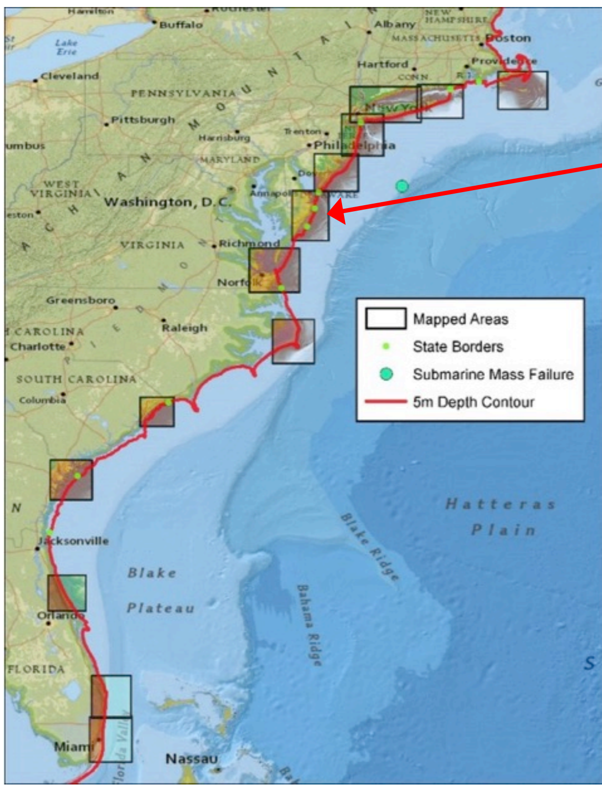
NTHMP East Coast mapped areas

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

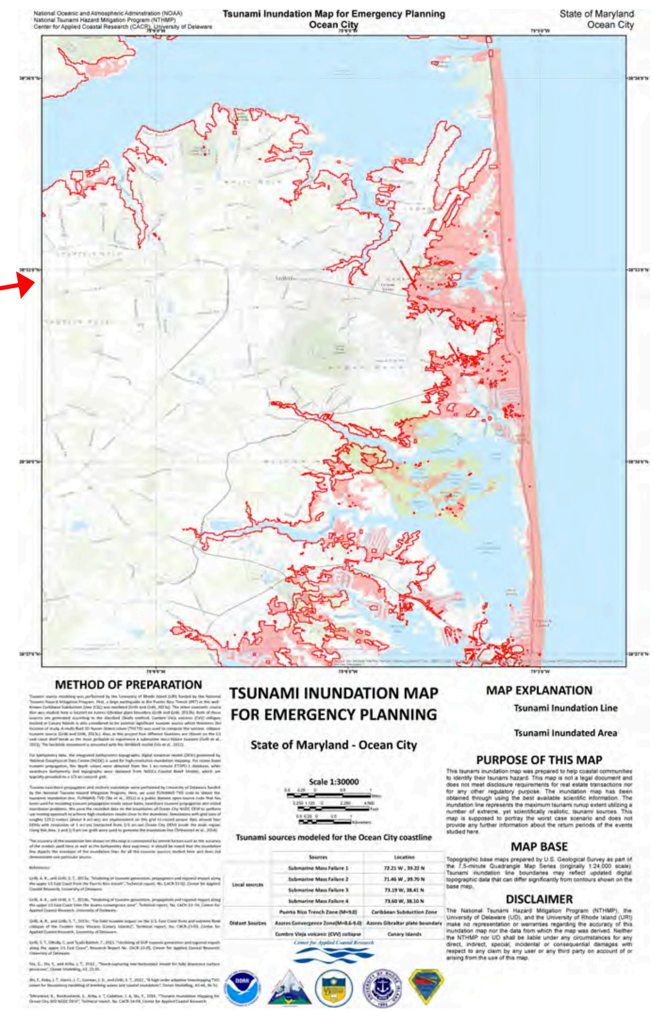
- Return periods not considered
- Maps are envelopes of worst case

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

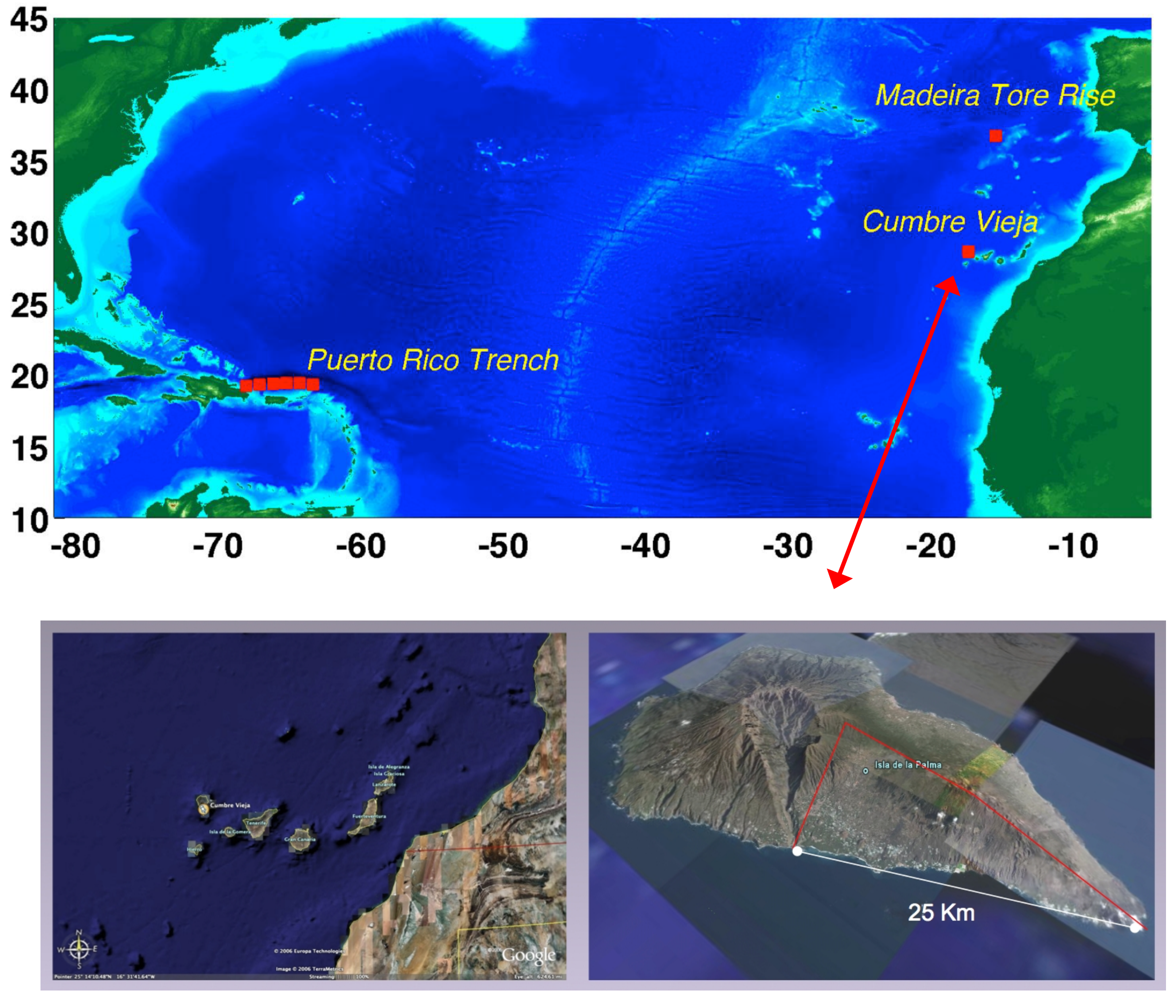
www.udel.edu/kirby/nthmp_protect.html



Regions containing detailed maps



Tsunami sources: Far-field seismic, volcano collapse



M_9 historical far-field seismic source in Azores Convergence Zone: repeat of Lisbon 1755 (multiple sources, various strike angles)

M_9 hypothetical far-field seismic source in Puerto Rico Trench: designed as extreme event, (600 yrs of full convergence)

Hypothetical far-field flank collapse of Cumbre Vieja Volcano with 80 or 450 m^3 volume (extreme and most extreme events), with return period (?) perhaps 1,000-100,000 yrs.

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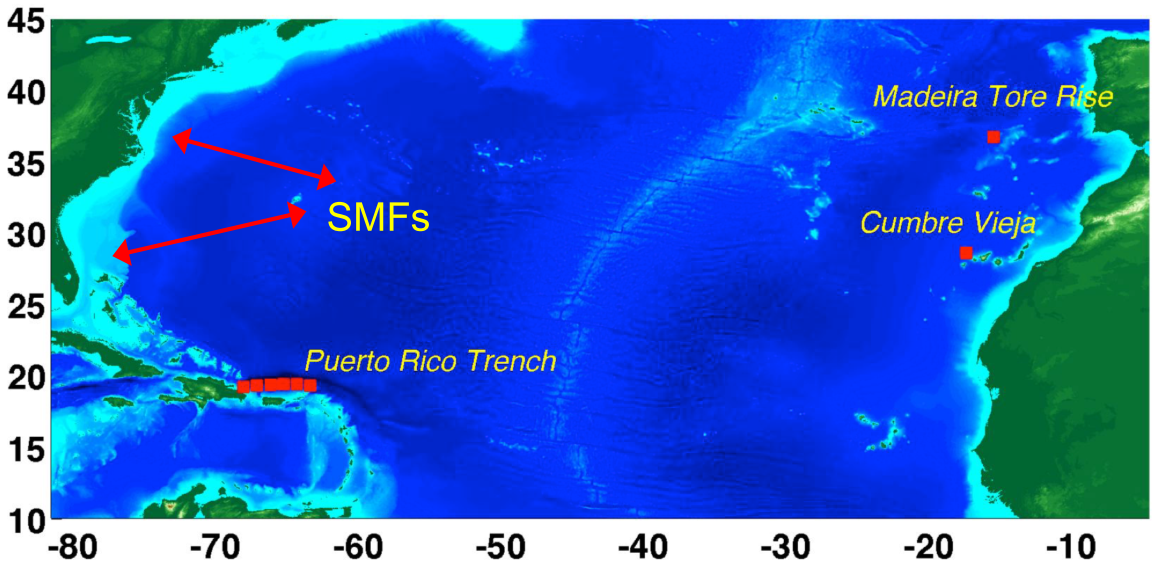
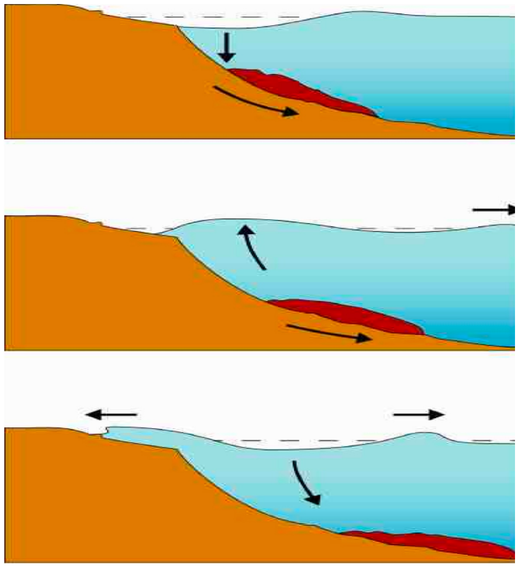
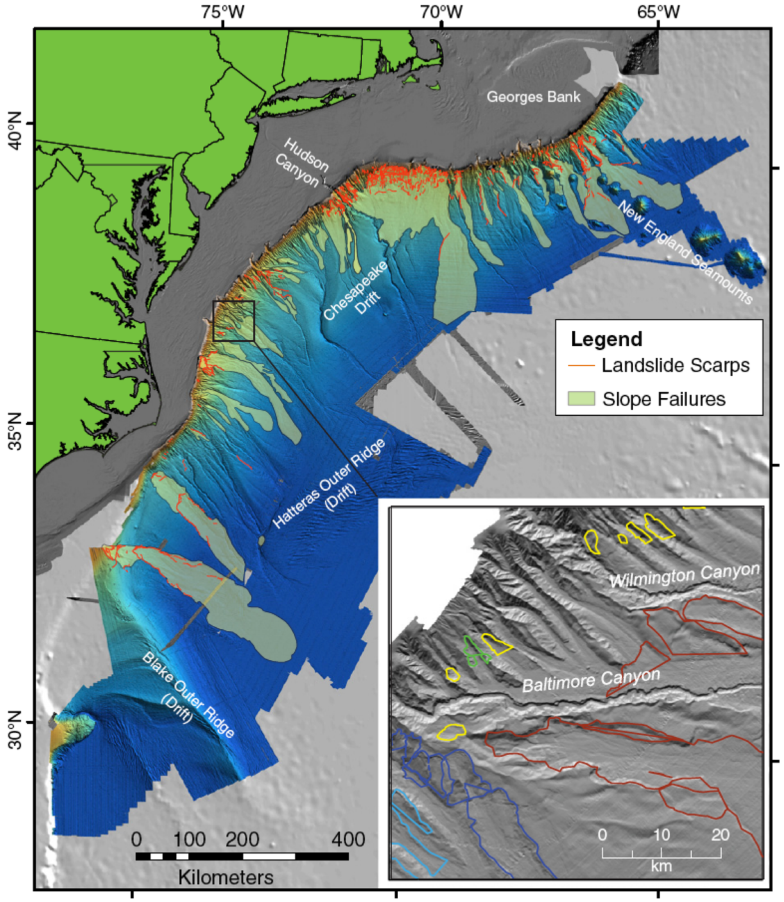
Tsunami sources: Near-field Submarine mass Failures (SMF)



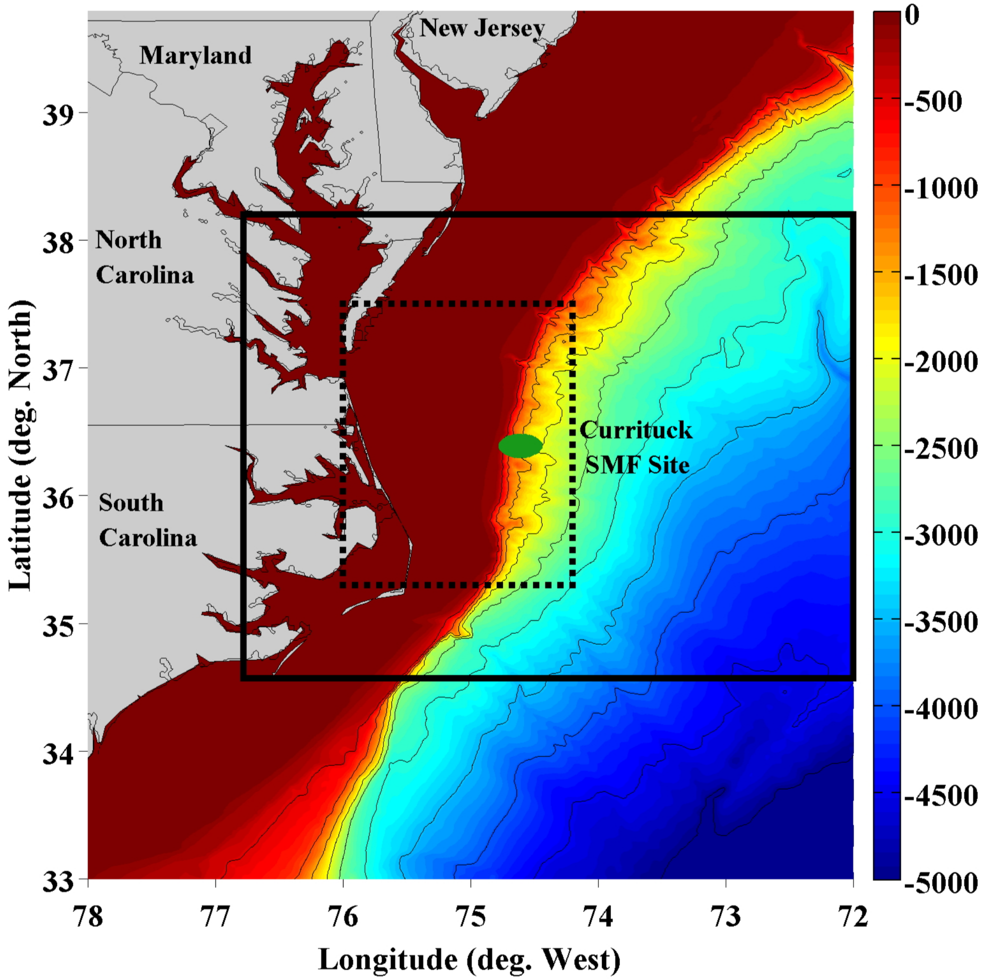


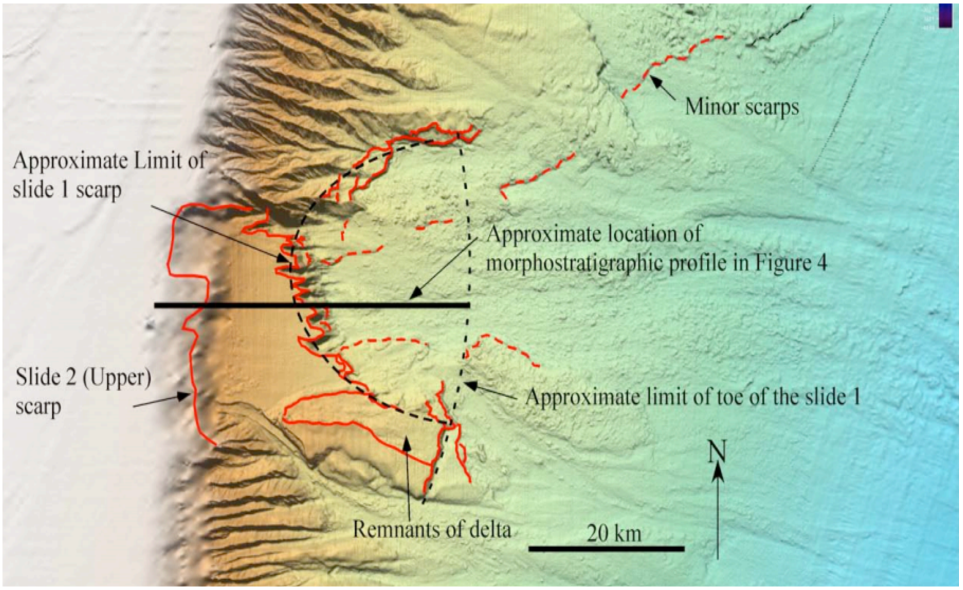


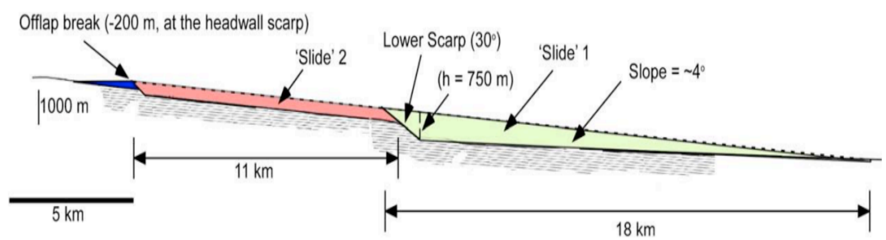
(ten Brink et al., 2014)

- SMF can generate large damaging tsunamis.
- SMF scars are widespread on US Atlantic margin, but mostly old - 1,000s of yrs. (Exception: 1929 Grand Bank SMF tsunami)

Case study of US East Coast SMF: Currituck







(Grilli et al., 2015)

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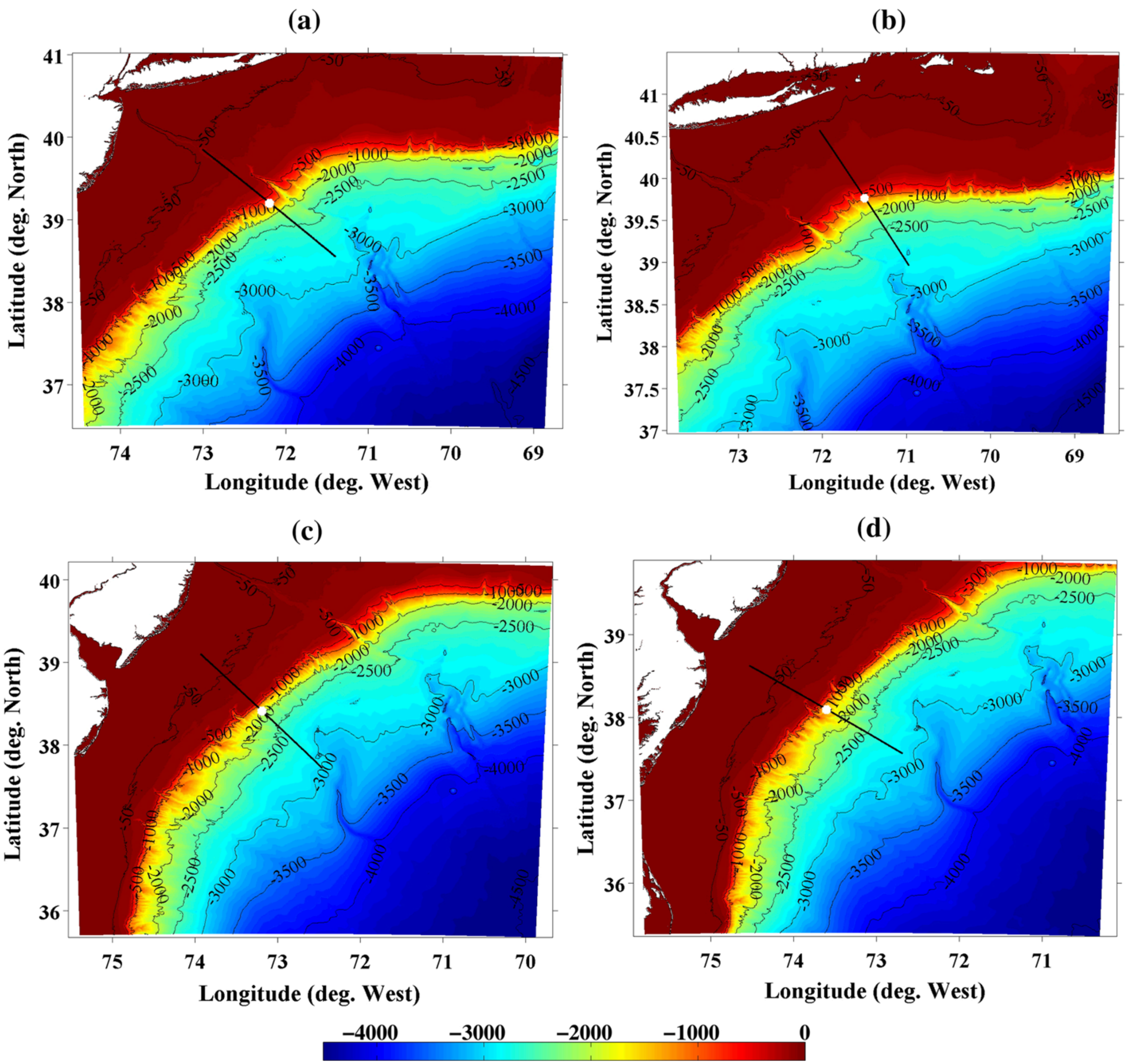
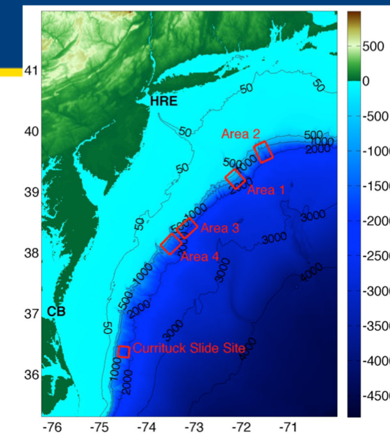
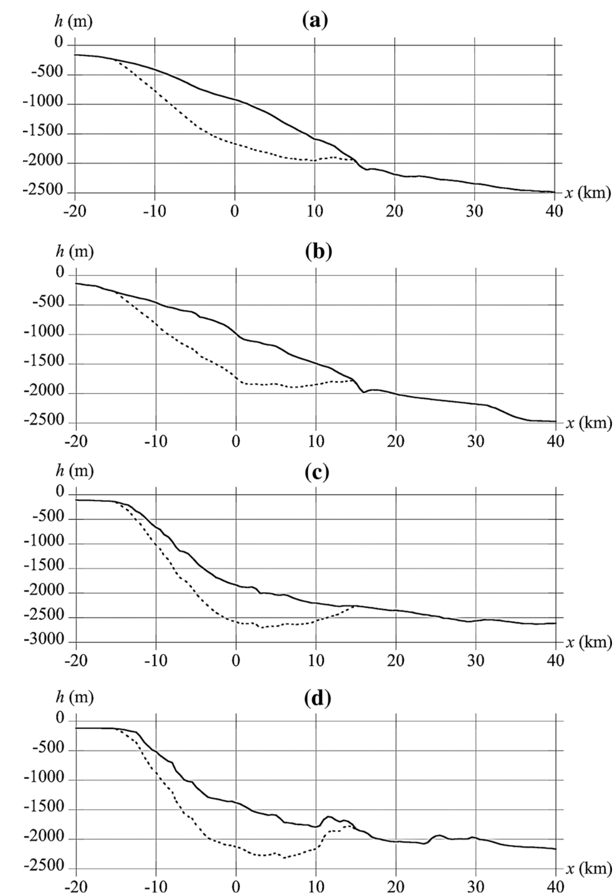
Curritiuck SMF proxies in areas 1 to 4

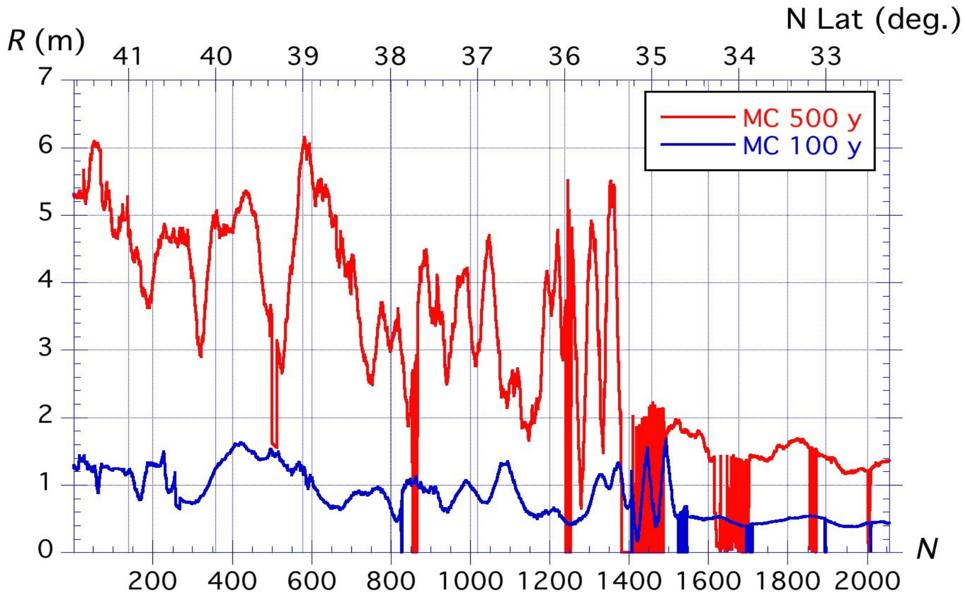


SMFs: 165 km^3 rigid slumps

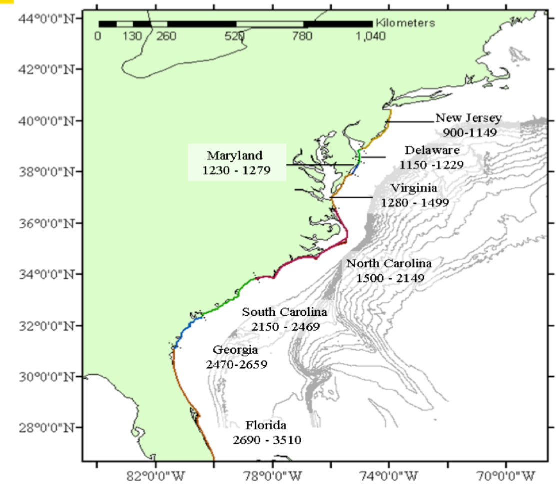


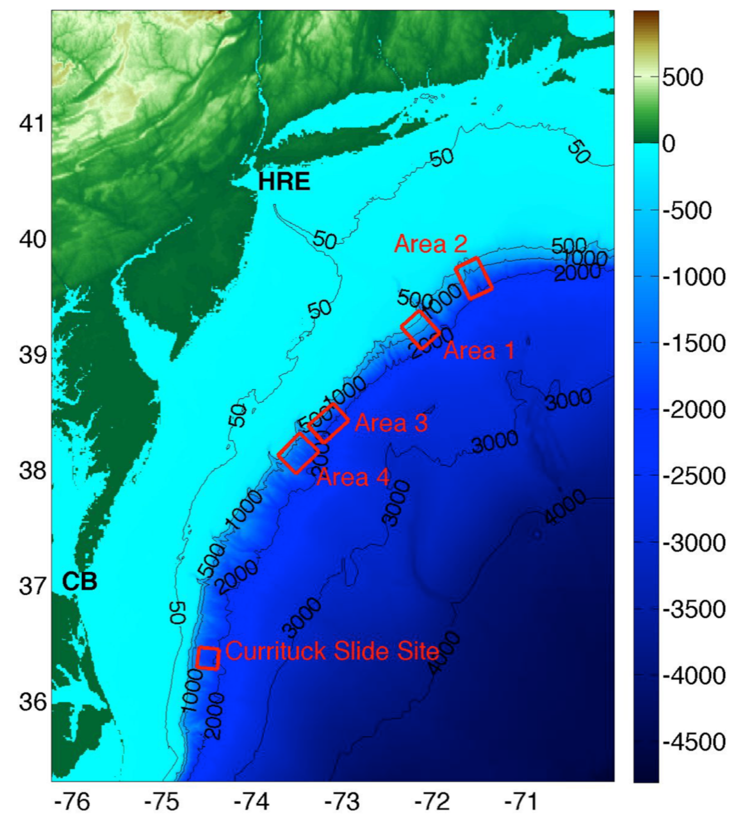


Monte Carlo estimation of tsunami hazard for Currituck-like SMF events



- Grilli et al’s (2009, MG) Simple Monte Carlo slope stability analyses along transects:
    - areas of estimated (100-500 year) runup
- Sediment availability/geology:
    - Areas 1 to 4: Currituck SMF proxies, with 165 km^3, 14,000 y old (Grilli et al., 2015)





Cape Fear slide

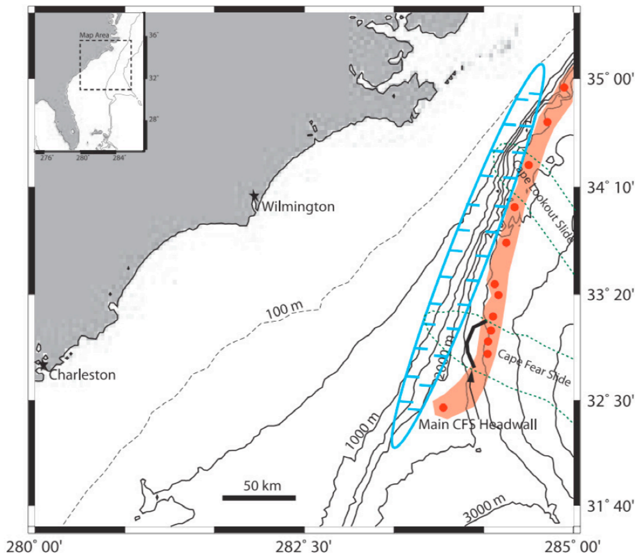


Figure 29: General location of the Cape Fear Slide (CFS) headwall and debris field (Hornbach et al., 2007). The Carolina trough is outlined in blue and the approximate location of a chain of salt diapirs is denoted by red circles.

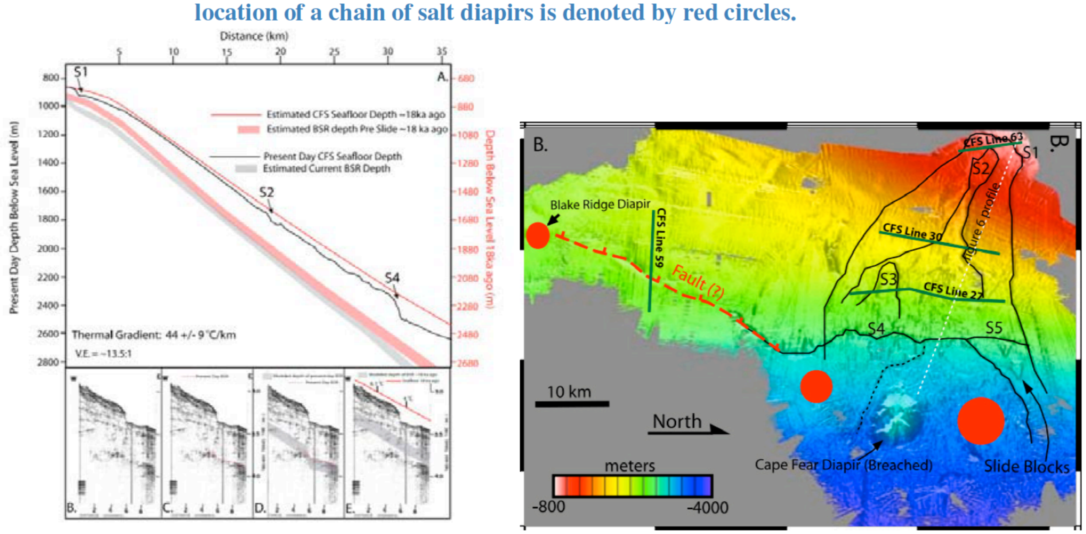
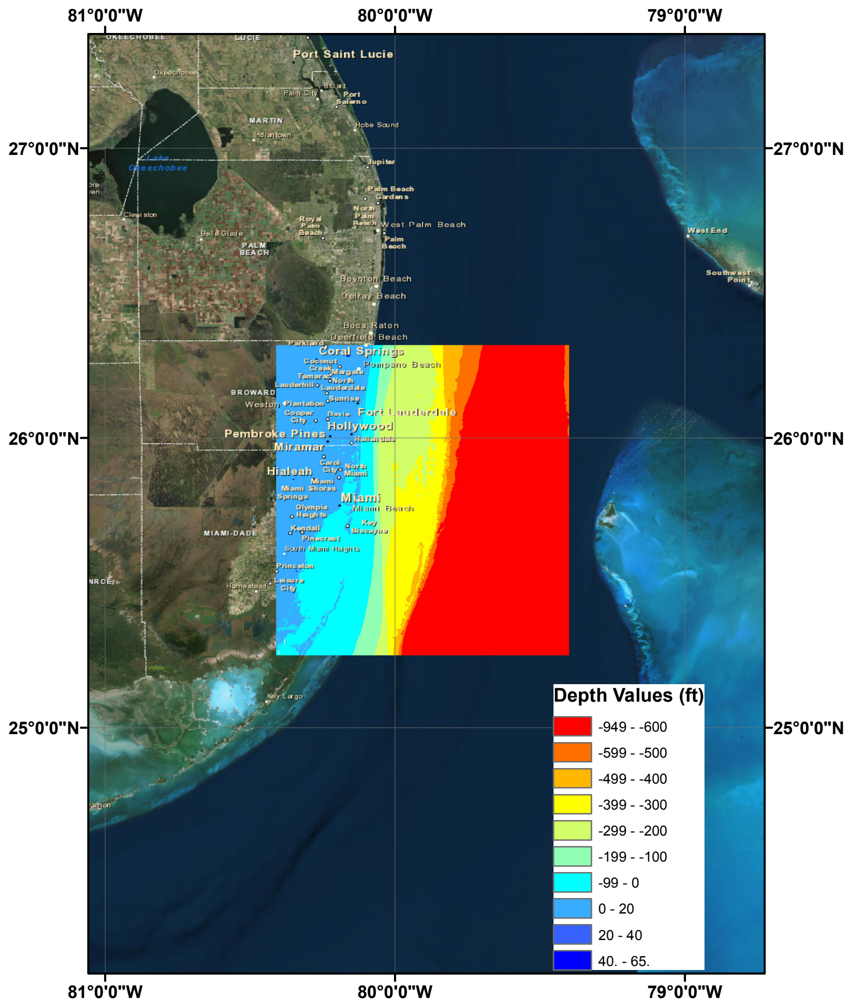
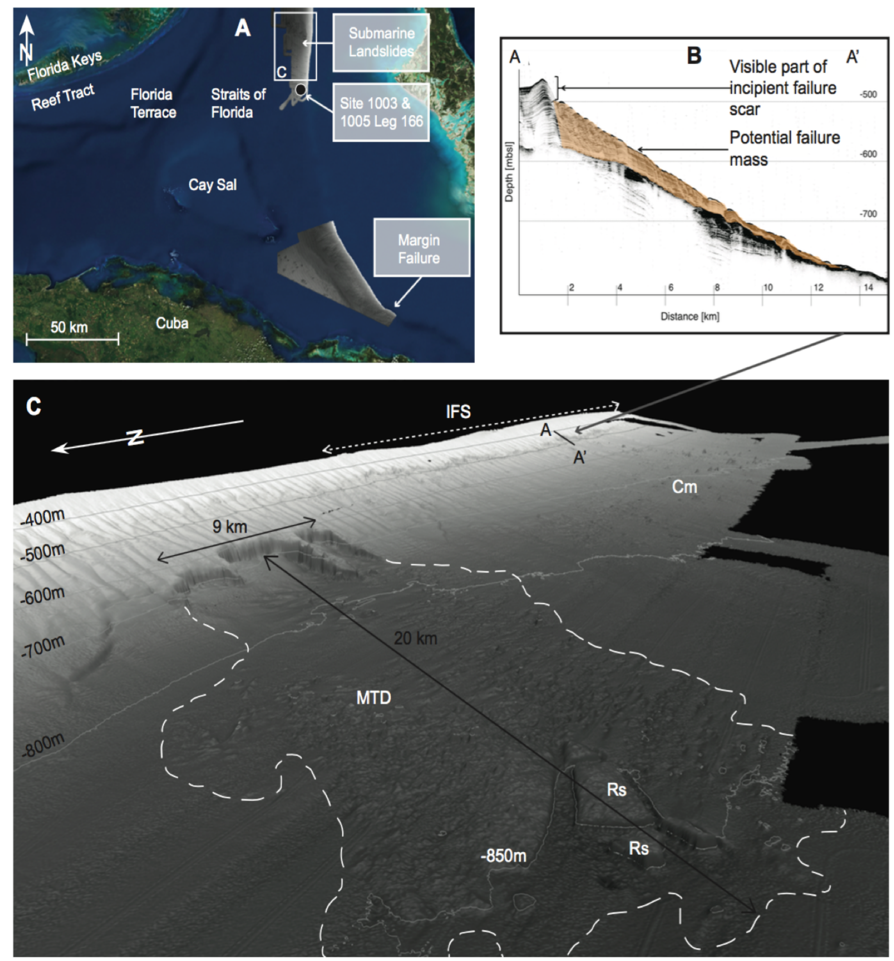


Figure 30: (a) Transect showing the current bathymetry and identified SMF failure surfaces at the CFS site. (b) Bathymetry used in tsunami simulations, with SMF and diapir locations (red dots). (Hornbach et al., 2007).

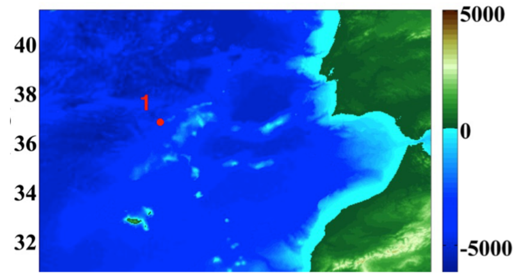
Near-field SMF sources: West Bahamas Banks



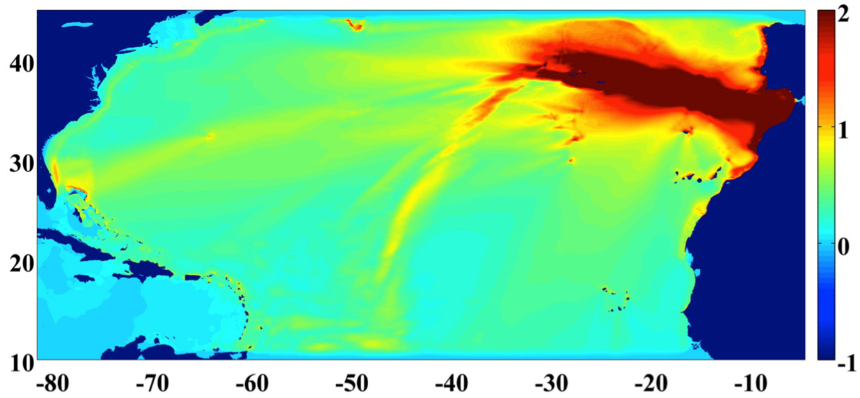


(Schnyder et al., 2013)

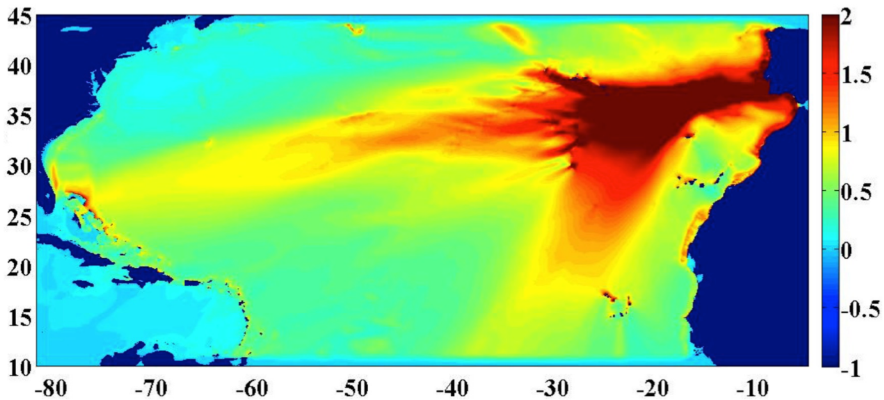
Far-field source modeling



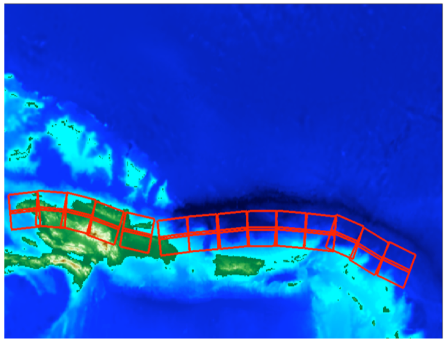
(e)

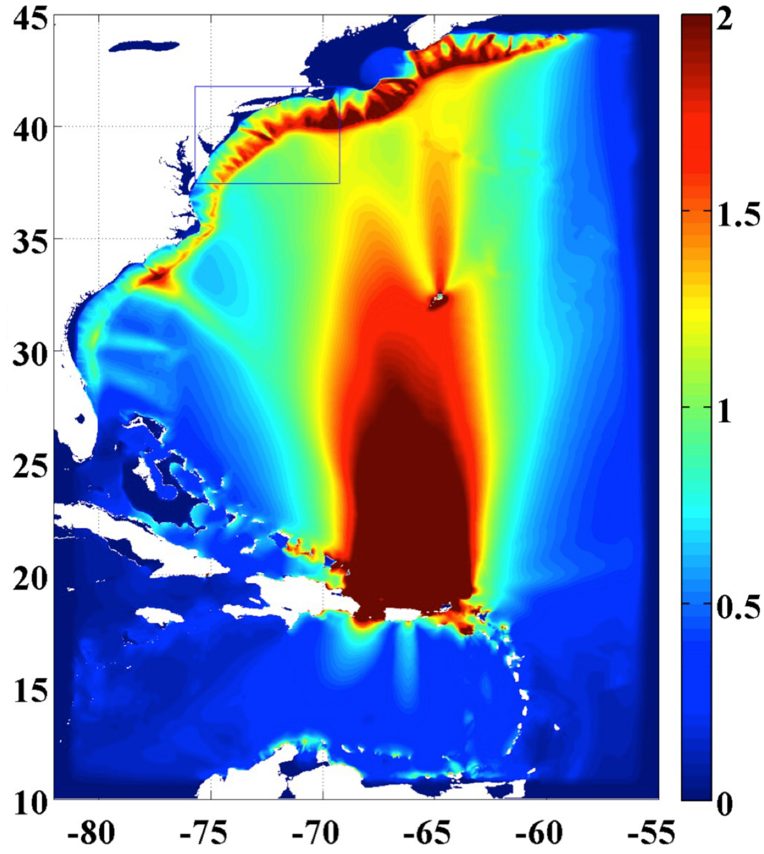


(f)



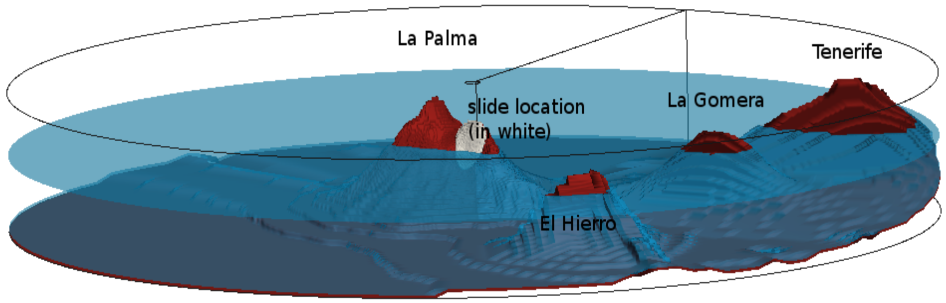
Azores Convergence Zone (Lisbon), M_9



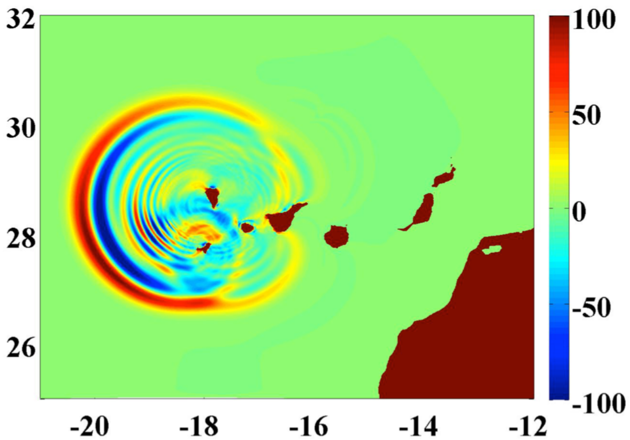


Puerto Rico Trench, M_9

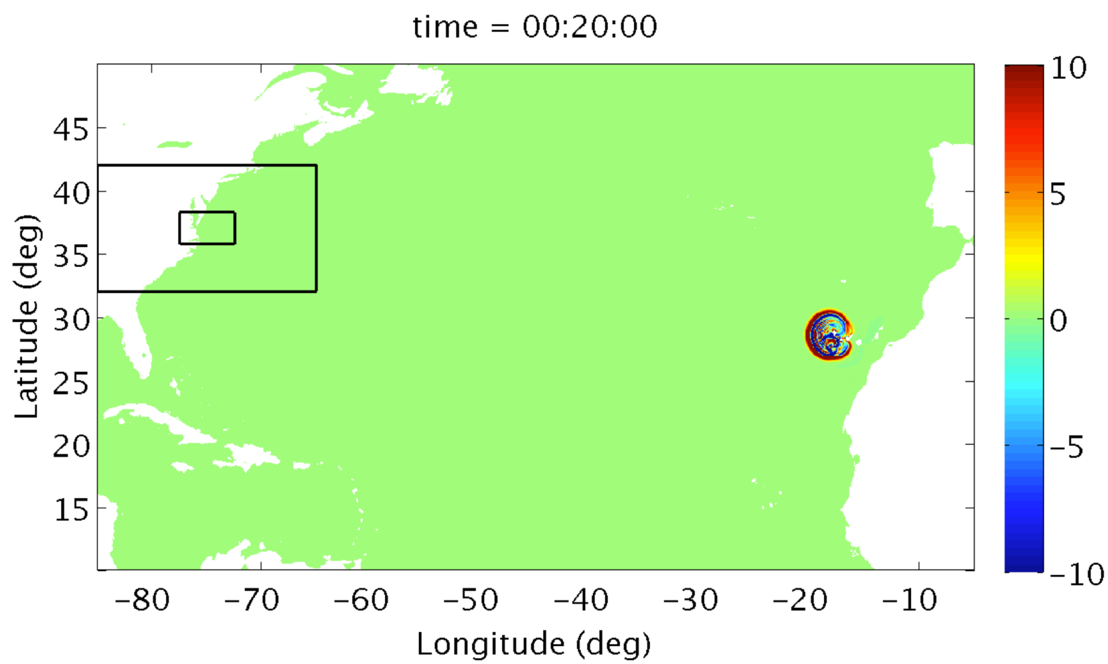
CVV Flank Collapse source (450 km^3)



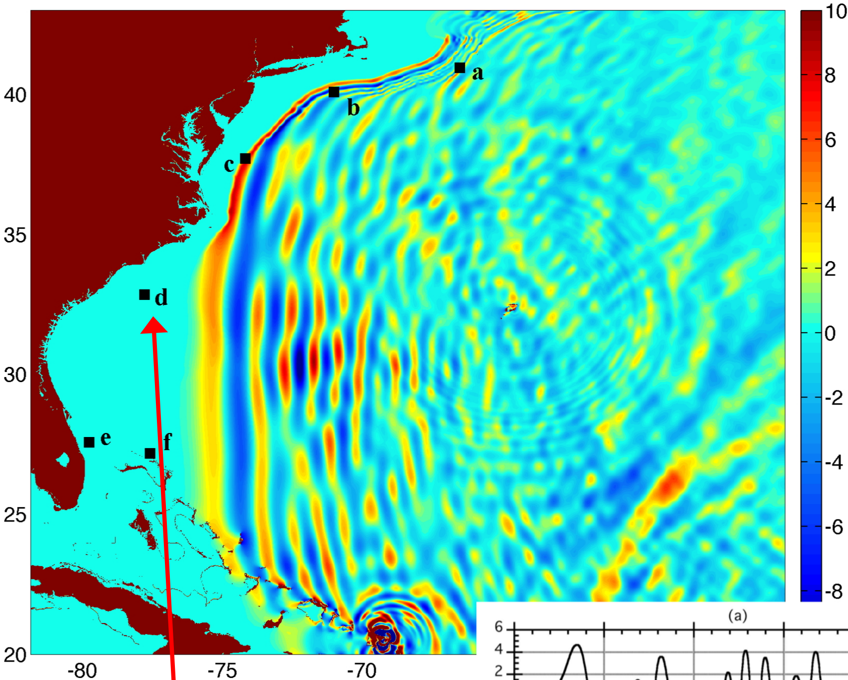
Surface elevation as a function of time (meter)

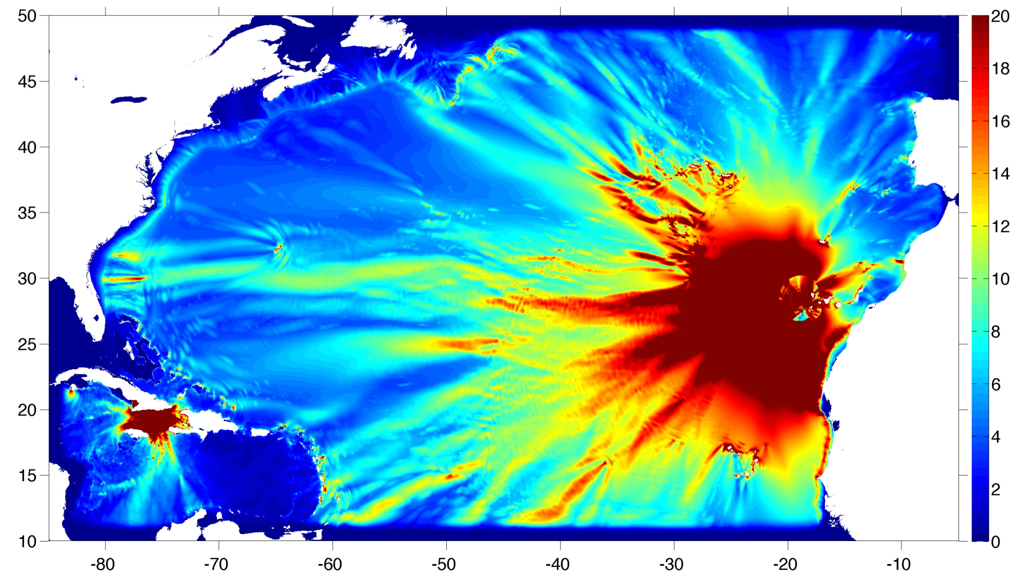


-> Surface elevation (meter) after 20 min

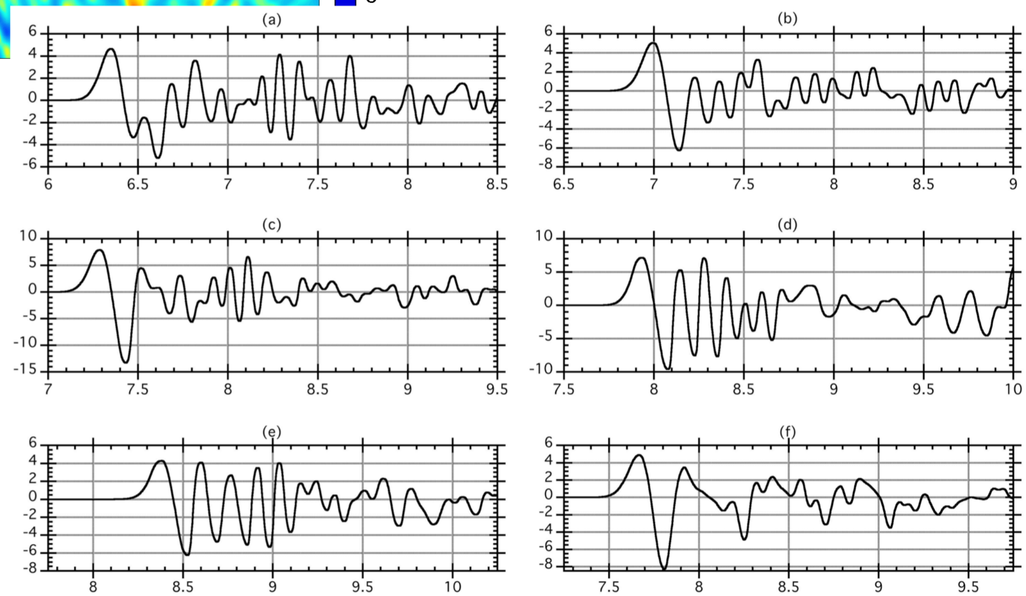


CVV Flank Collapse source (450 km^3)



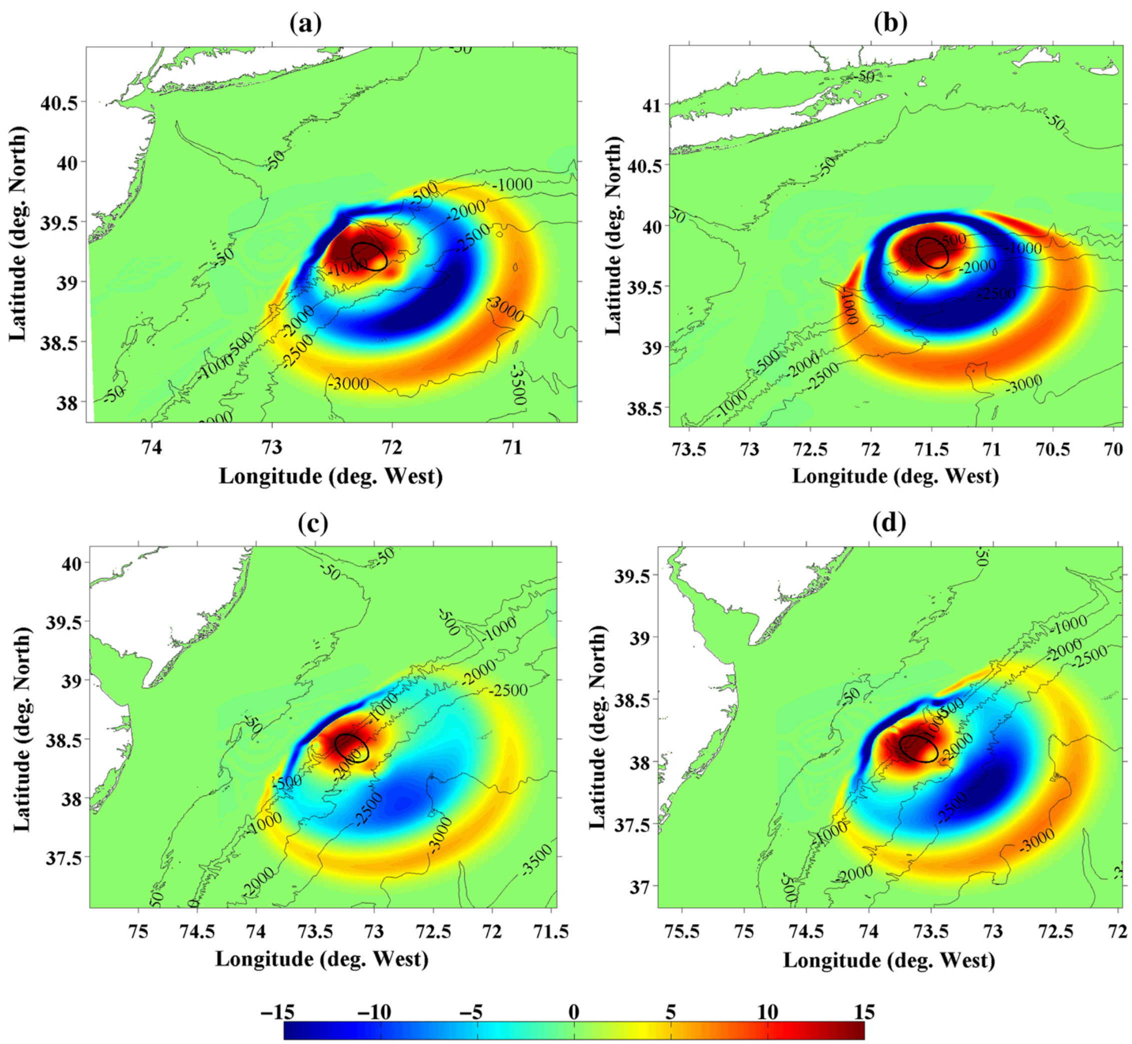


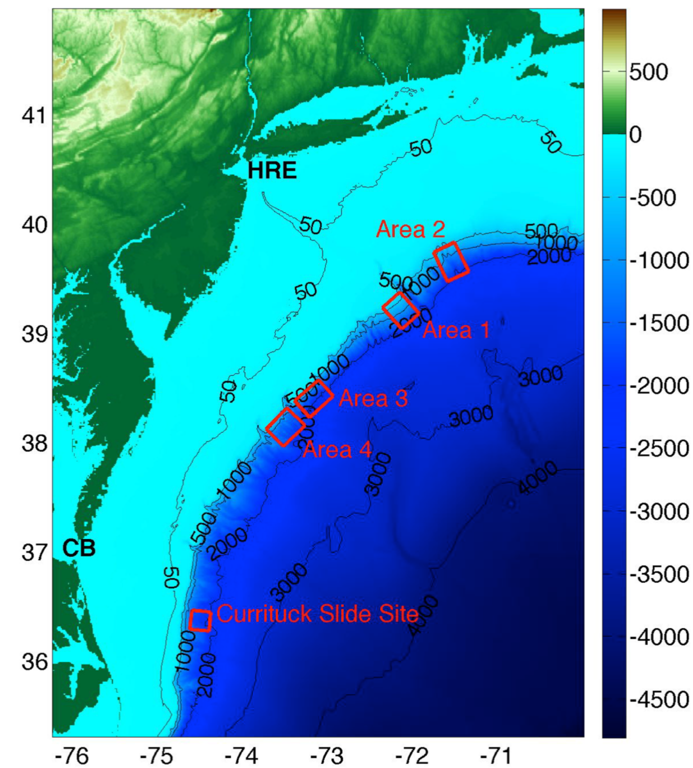
Dispersive trains of large waves, 9-12 min period



- 450 km^3: Up to 5-6 m runup/inundation
- 80 km^3: Up to 2-2.5 m runup/inundation

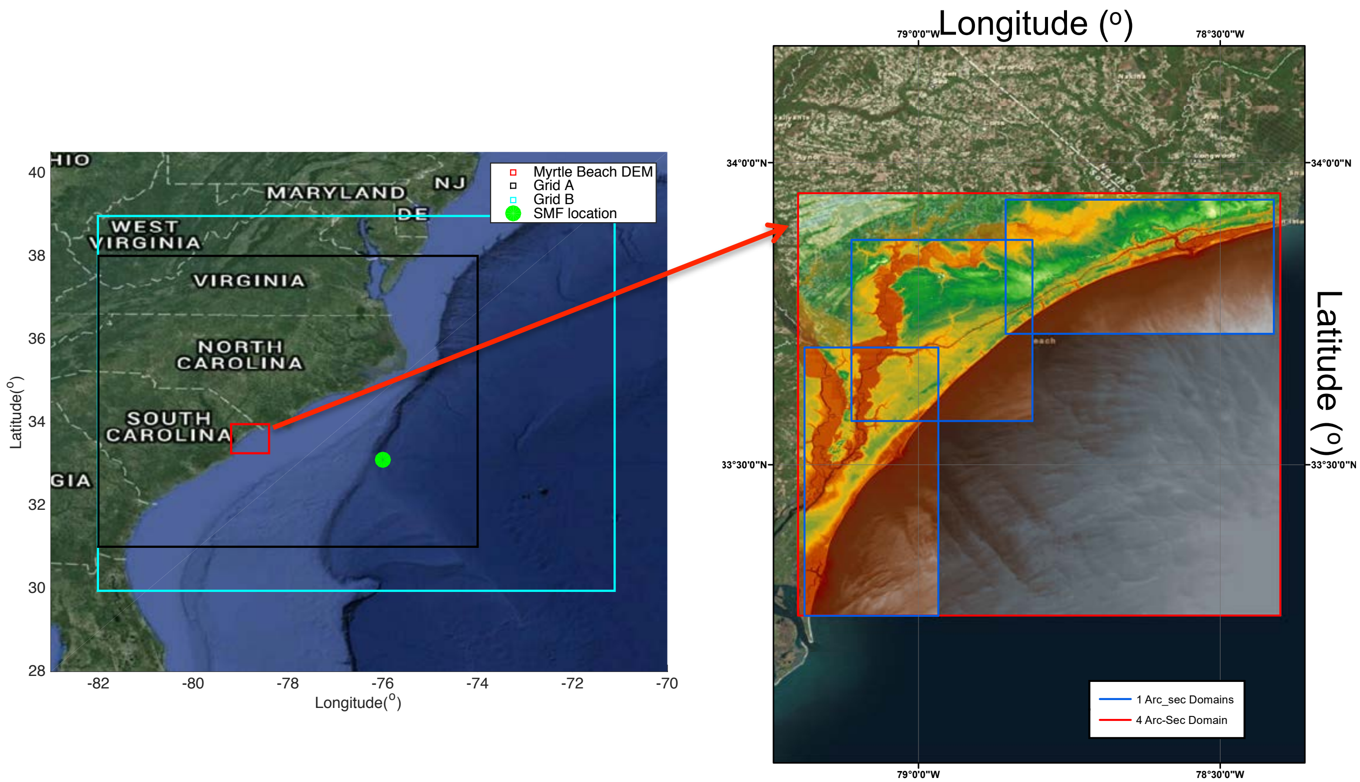
Curritruck SMF proxies in areas 1 to 4





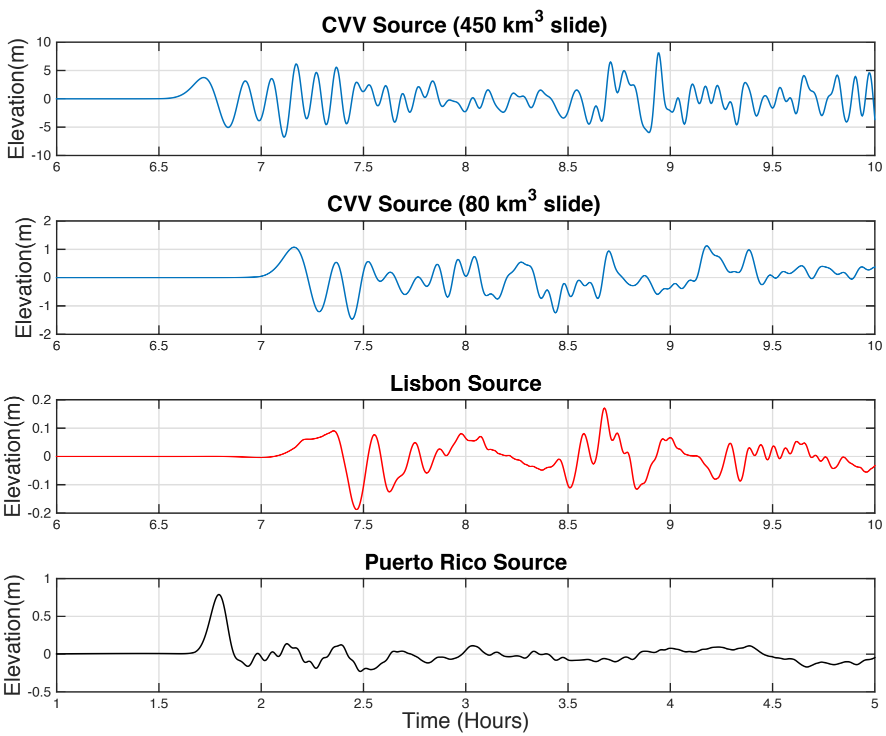
- Modeled as rigid slumps (surface elevations after 13.3 min) (Details in Grilli et al., 2015)
- Deformation is being studied

Nesting of computations from large to small scale

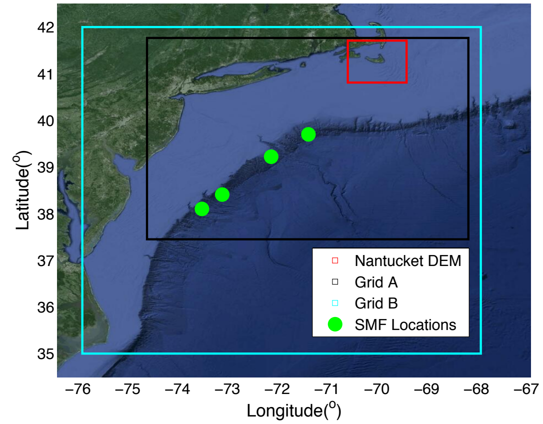


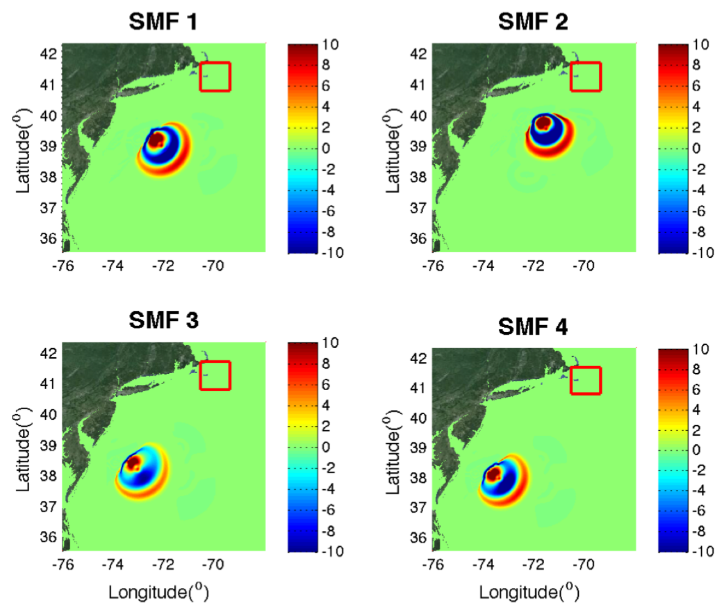
The sequence of grid nesting. The left depicts Grid A and B and the location of the Myrtle Beach DEM. The right frame shows the 1 arc-second grids.

Inputs for calculations



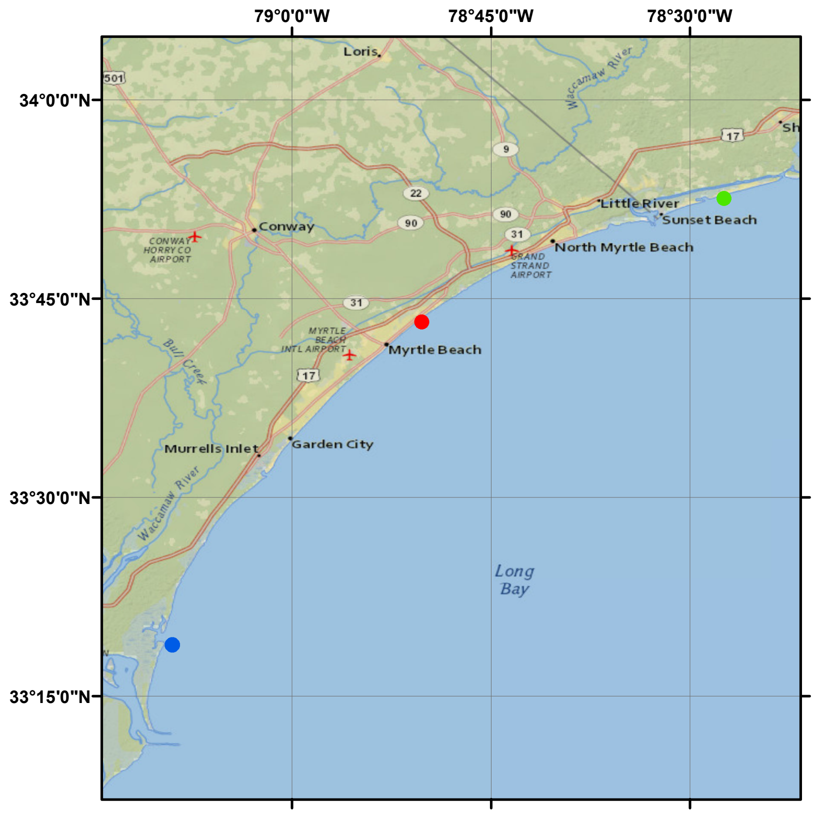
Distant sources

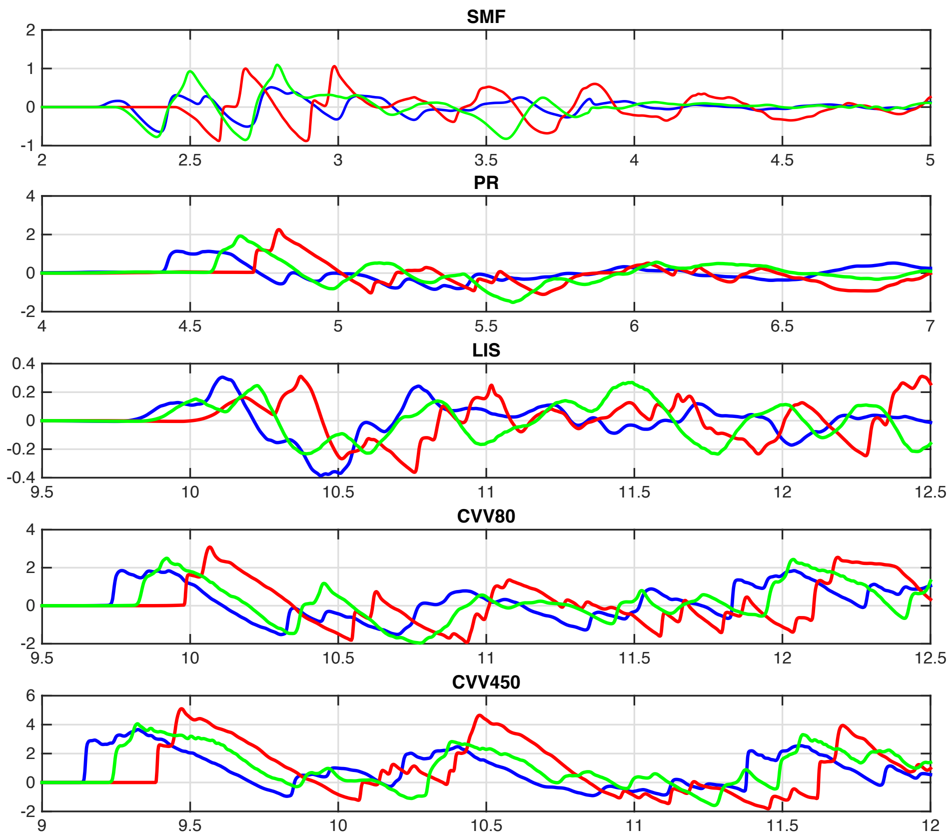




SMF sources

Arrival times after initial event: Myrtle Beach





Discussion – East Coast Risk

1) First generation maps are based on extreme sources/PMTs, with no consideration for return periods of events.
   - Return periods are needed to assess risk => future work on PTHA ?
   - Realistic SMF rheology needs to be considered => ongoing work
   - Last major PRT earthquake was in 1787 ($M_{8.1}$); is a 200-300 year return period possible for a 600 year M_9-PRT event ?

2) Discussion during USGS workshop (Boulder 2016)
   - No East Coast SMF has been found that is more recent than 10,000 years (except for Grand Banks event in 1929)
   - Main SMF trigger is seismicity => slope stability analysis with peak horizontal earthquake acceleration (Approach in Grilli et al.'s, 2009 MC work)
   - Maximum PRT event 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, 200+ m runup; Ramalho et al., 2015)
   - No guidance from USGS as they are not funded to study these volcano failures

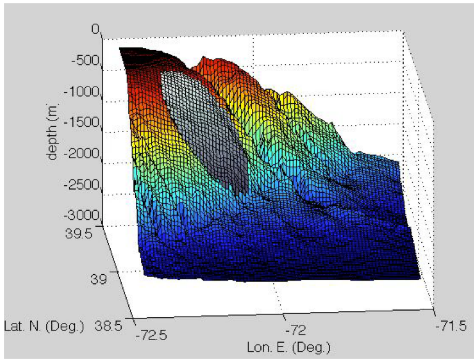
3) SMF siting and rheological properties have major influence on coastal hazard.
   - Need for geological/geotechnical data, siting, for east coast SMFs
   - USGS (Chaytor's group) will provide data based on recent field survey. This can be fed into more accurate MC studies of east coast landside tsunamis.

4. Geist et al. (2014,2015) study of 2013 East Coast meteo-tsunami
   - 1-2 m runup can be expected on a 100-200 y time scale
   - similar risk to seismic, SMF events (ongoing work)

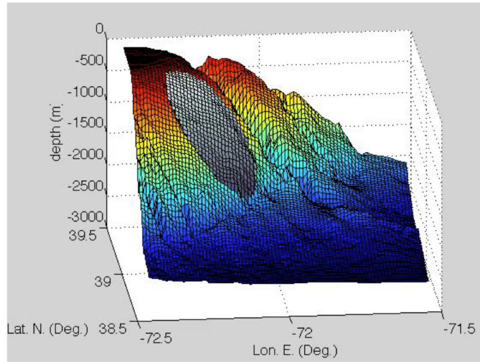
Ongoing modeling efforts

- Rheology effects on SMF behavior – solid vs deforming slides
- Meteo-tsunami events – impacts on harbors and exposed beaches
- Dynamic erosion and morphology change during events
  – increased hazard (?) and shoaling effects in navigable channels

1. Rheology effects on tsunami event simulation

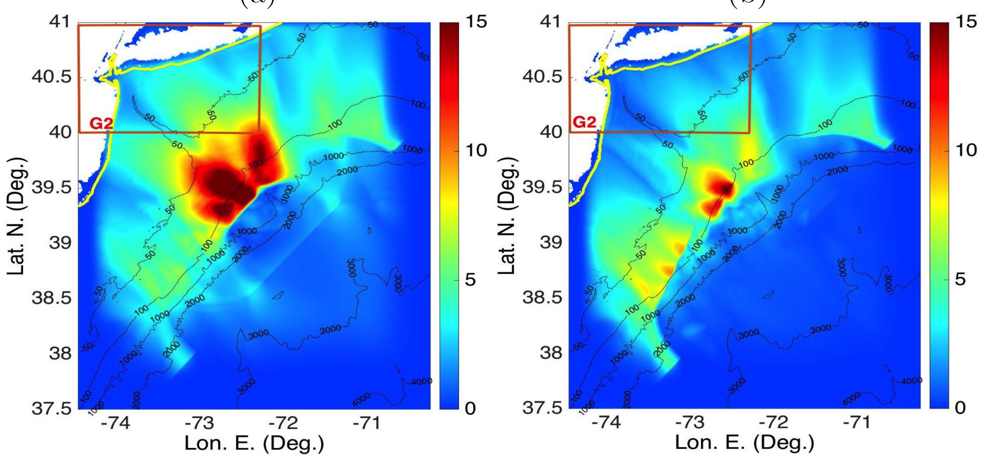


Rigid slump

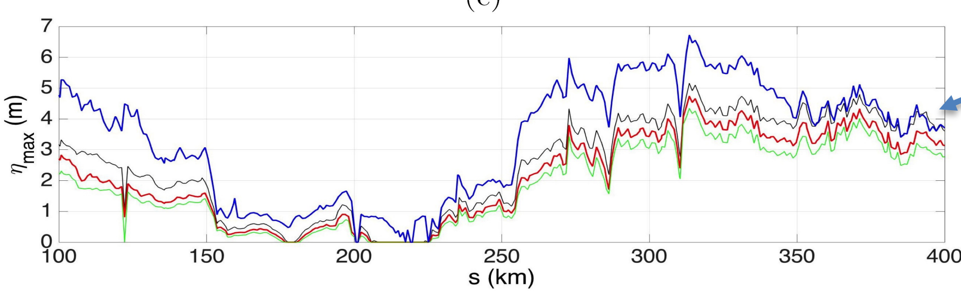


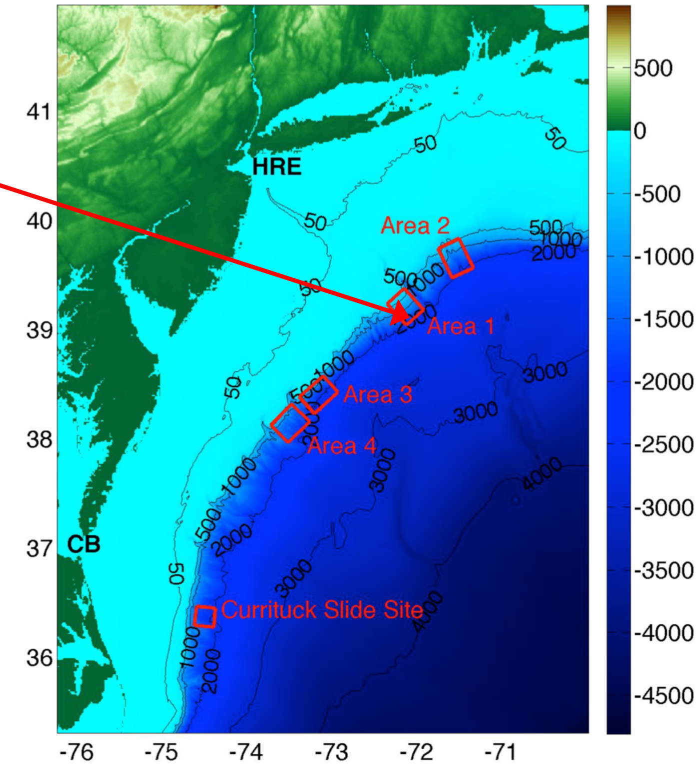
Deforming slide

(a) (b)



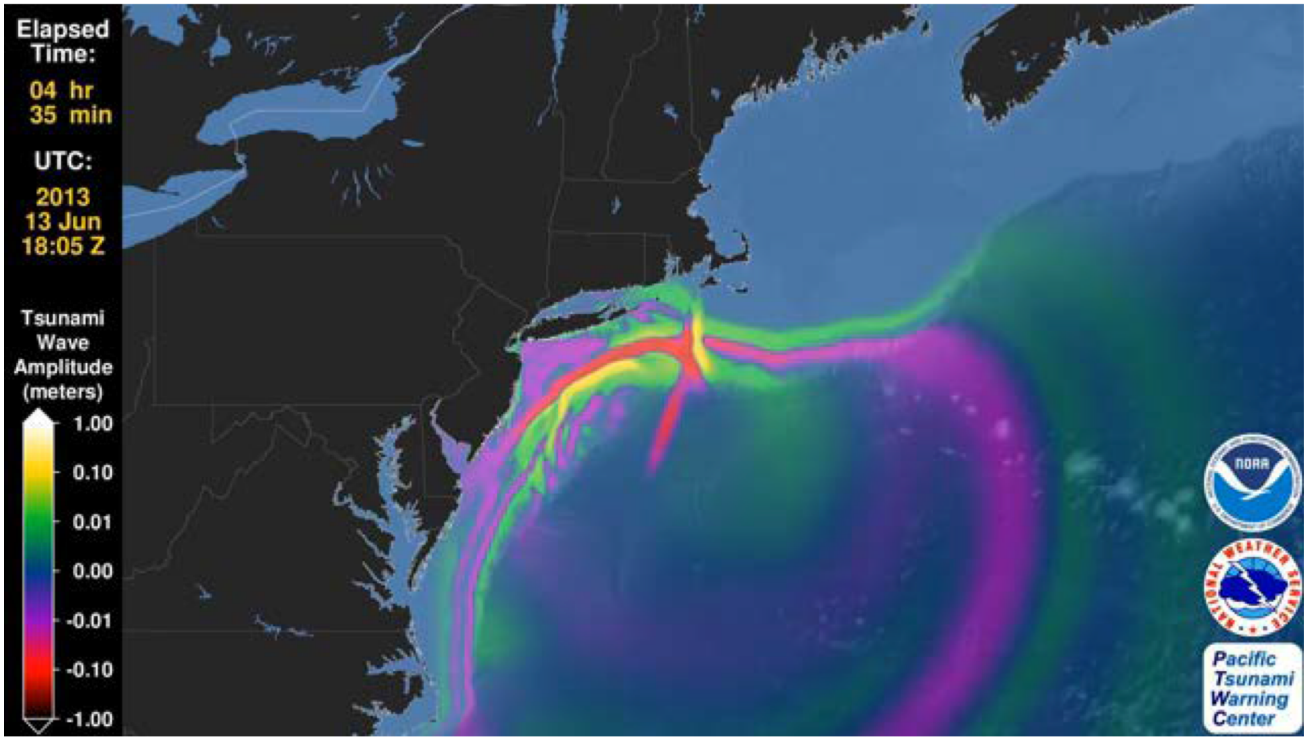
(c)





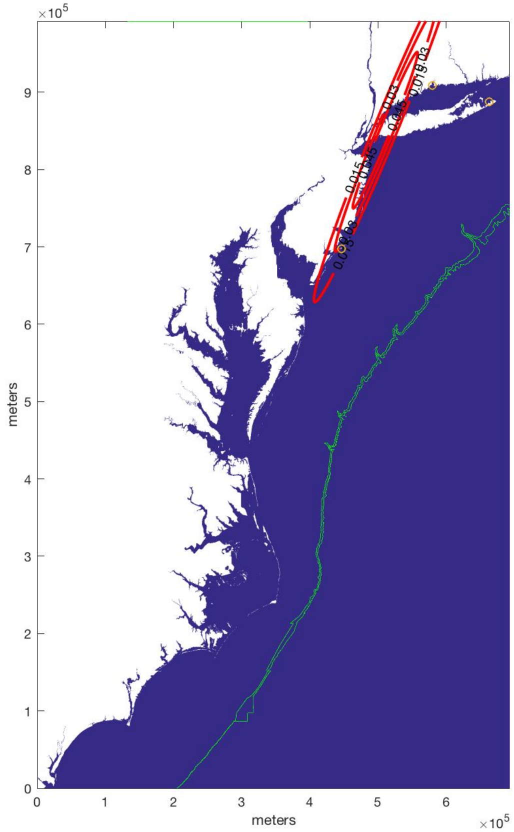
- Hudson River CRT proxy elevation at 5 m isobaths.
- Comparing rigid slump (blue) to 3 deforming slides with varying rheology (Grilli et al., 2017)
- Rheology effects are not included in 1st generation maps

2. Meteo-tsunami hazard

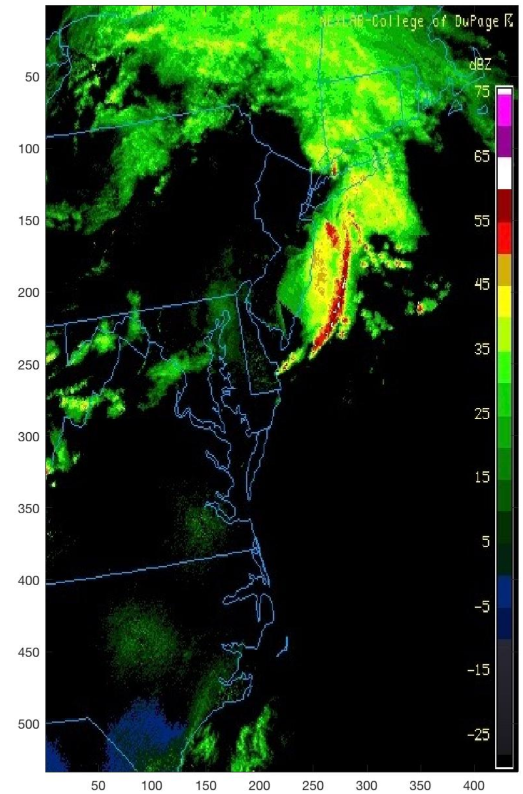


June 13, 2013 East Coast meteo-tsunami -> 2 m waves off of New Jersey

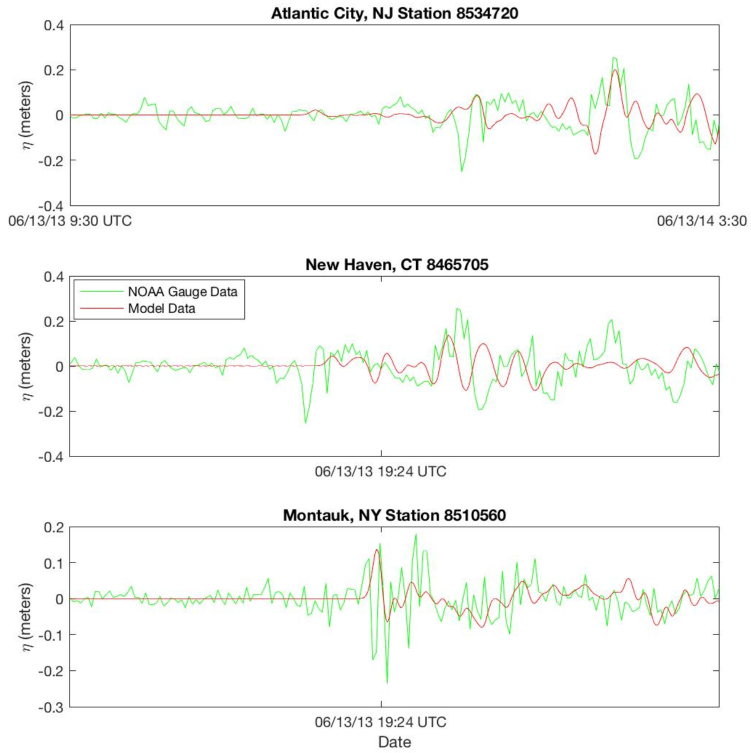
June 13, 2013 Mid-Atlantic event



Forcing in model simulation



Observed radar image

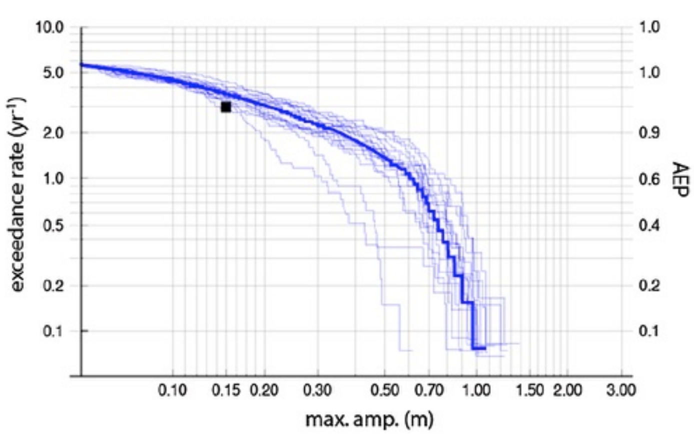


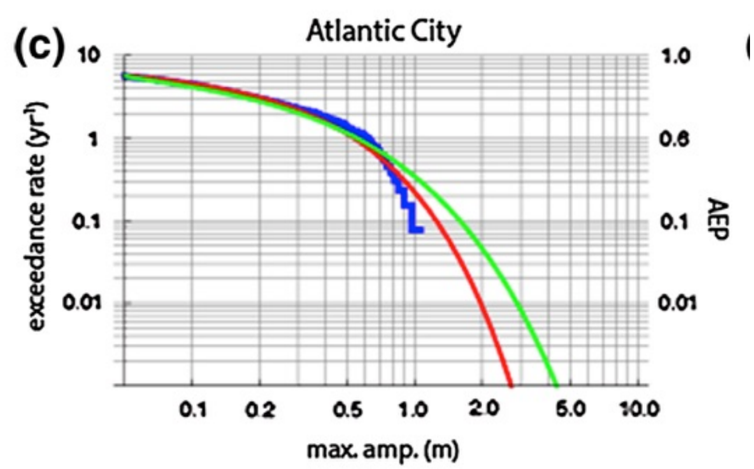
Observed and modeled tide gauge response

- Meteo-tsunami events are frequent. We are presently testing our ability to reproduce observed events in model simulations.

	Date	Max Pressure Jump (mb)	Number of Gauges	Length(kilometers)	Storm Velocity(meters/sec)	Area
1	06/13/2011	3.7	16	515	26	Mid-Atlantic Coast
2	06/30/2012	4.1	7	500	23	Mid-Atlantic Coast
3	12/08/2011	3.6	20	400	23	Mid-Atlantic Coast
4	3/02/2009	4.9	8	1042	31	East Coast
5	07/02/2012	4.5	7	900	17	South Atlantic Coast
6	04/11/2013	3.8	7	561	23	Mid-Atlantic Coast
7	02/05/2016	3.6	4	1521	29	East Coast
8	01/16/2016	3.5	5	270	22	Mid-Atlantic Coast
9	06/09/2011	3.3	6	750	22	New England
10	02/03/2015	2.5	7	514	8	East Coast

- Large data set allows for analysis of return periods for events with wave heights up to a meter or so in size (Geist et al, 2014; Dusek et al, 2017; our work)

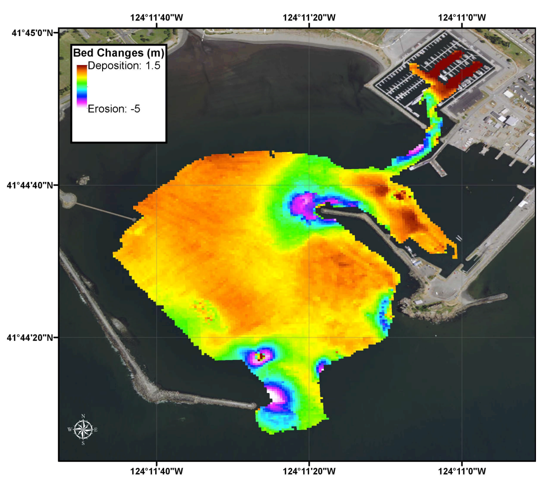




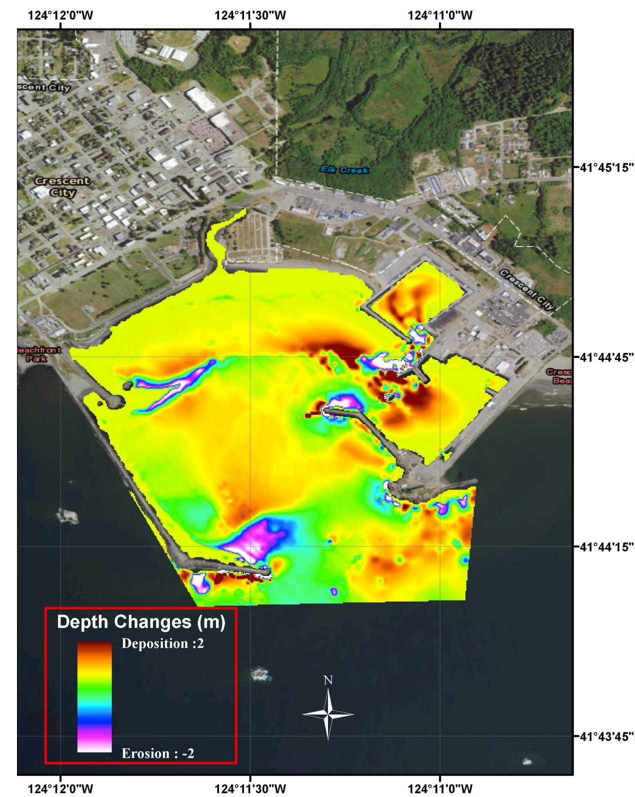
Monte-Carlo estimates of return period, and extrapolated estimates (Geist et al, 2014)

3. Erosion, deposition effects on navigation

Morphology change inside Crescent City, CA harbor during Tohoku 2011 event

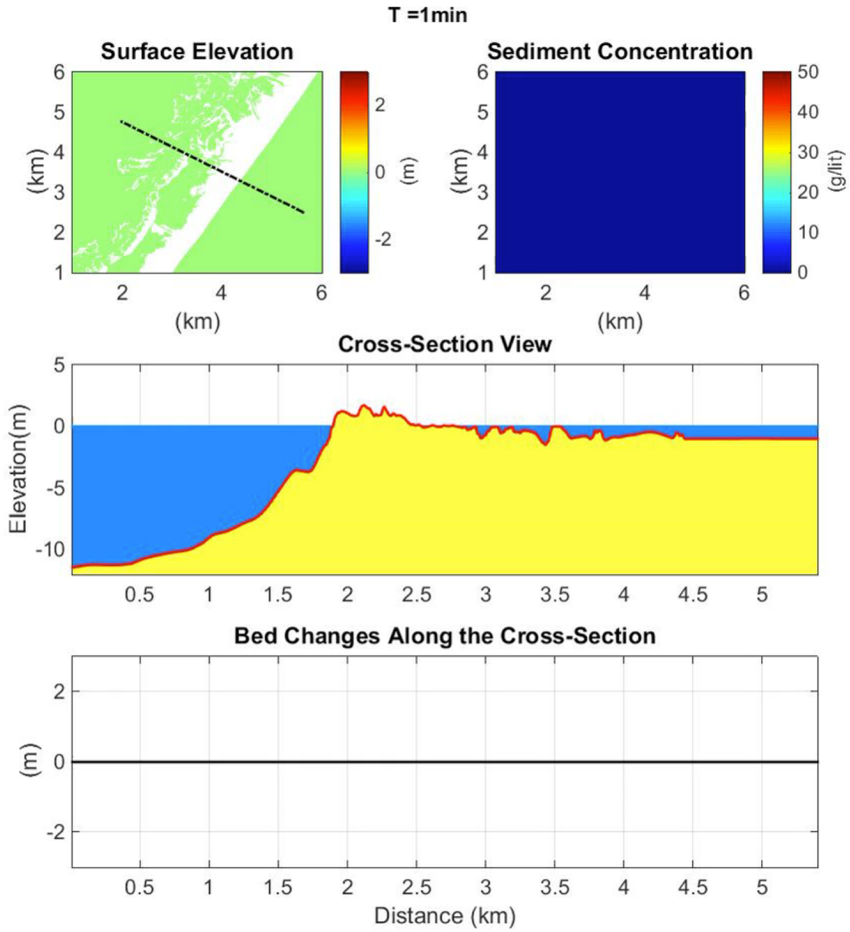


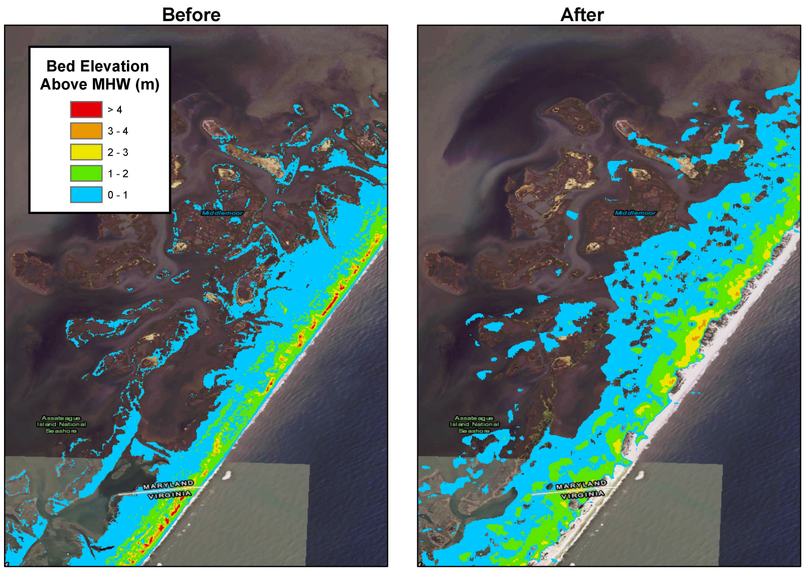
Measured (Wilson et al., 2012)



Calculated (Tehranirad et al., 2016)

And effect on barrier islands





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NTHMP Inundation Mapping for North and South Carolina and Georgia Part 2: Mapping and Available Products

Jim Kirby
University of Delaware

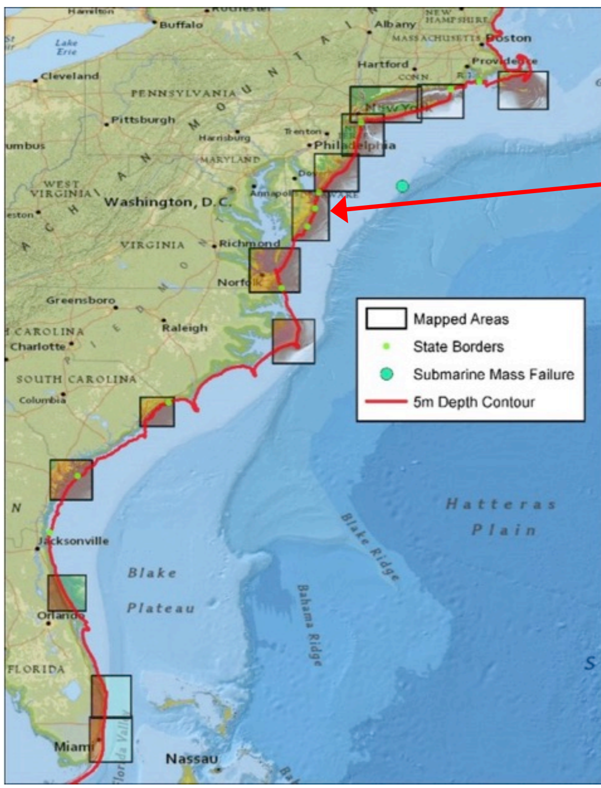
July 18, 2018

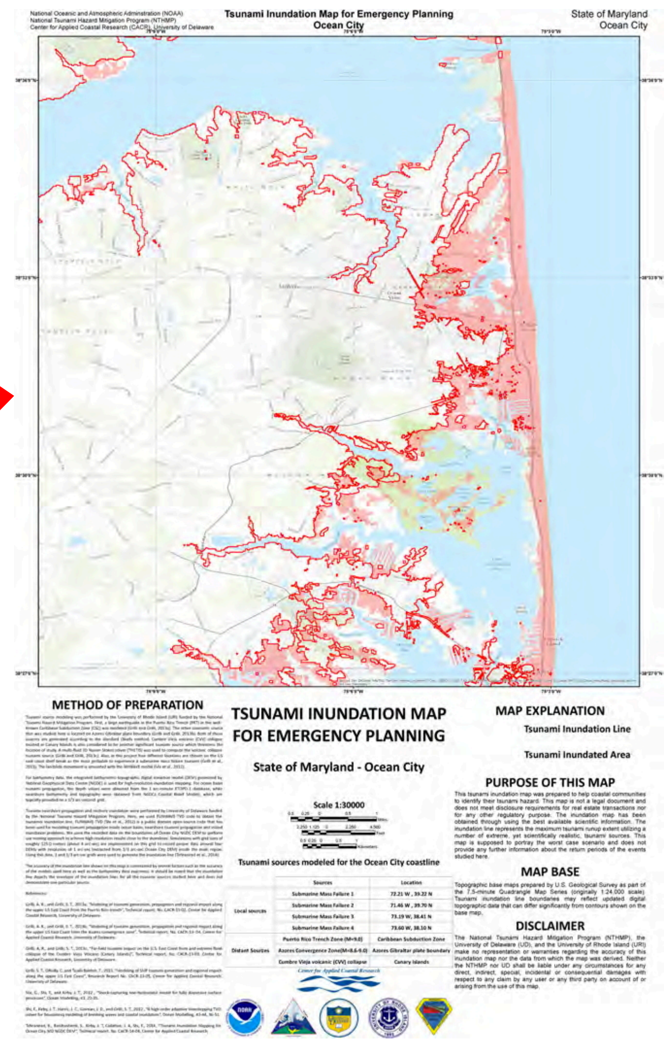
Center for Applied Coastal Research

THE UNIVERSITY OF RHODE ISLAND

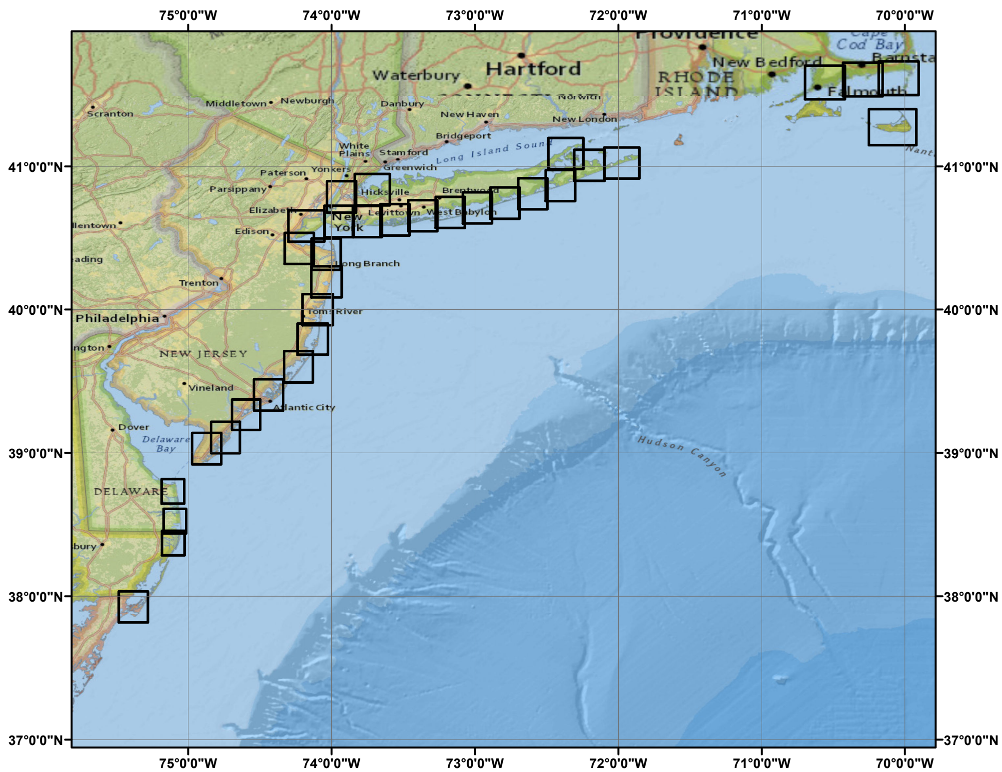
NTHMP East Coast mapped areas

- First generation maps based on Probable Maximum Tsunami (PMT) sources in the Atlantic Ocean Basin.
- Maps are envelopes of maximum inundation for the events studied.
- First generation maps may be found at www.udel.edu/kirby/nthmp_protect.html





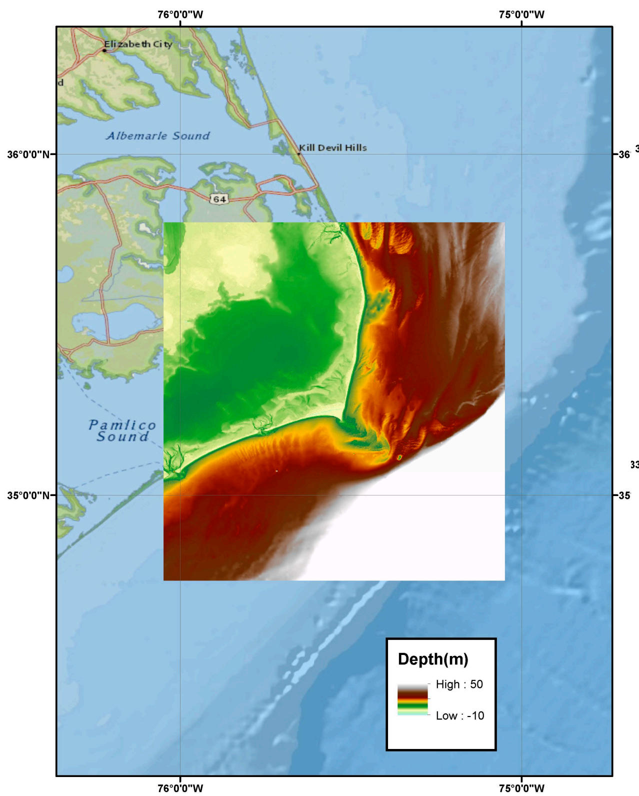
Location of Maps Generated for the Upper East Coast

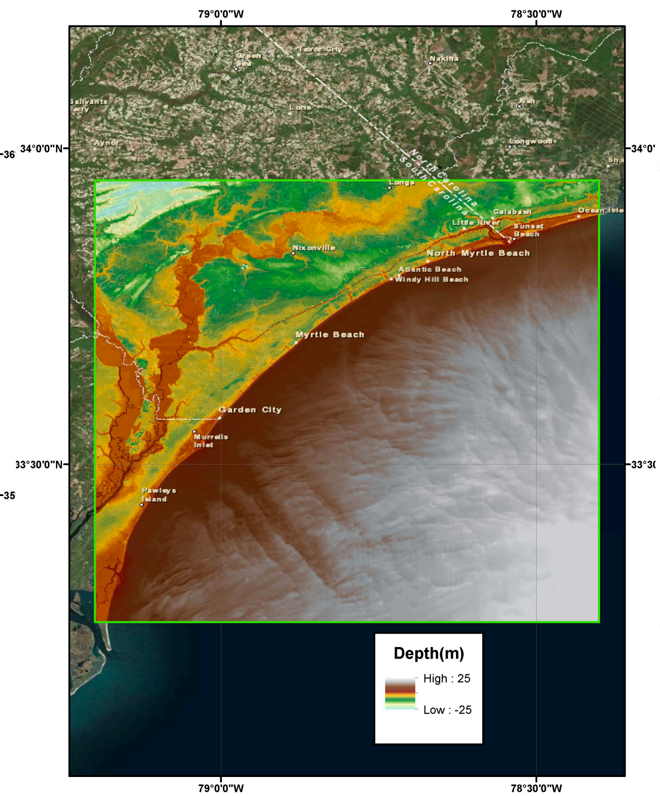


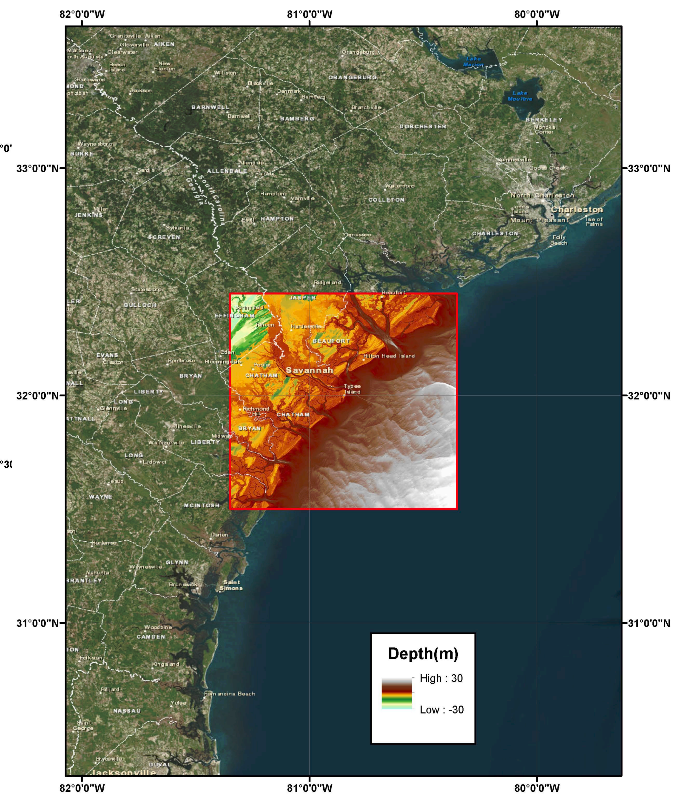
Reporting:

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. Maps

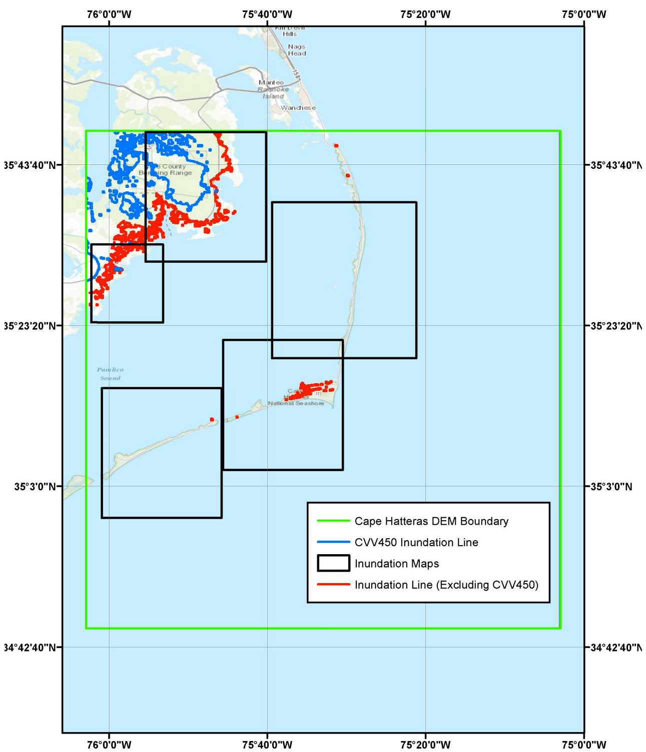
Basis for local mapping: NCEI Cape Hatteras, Myrtle Beach and Savannah DEMs

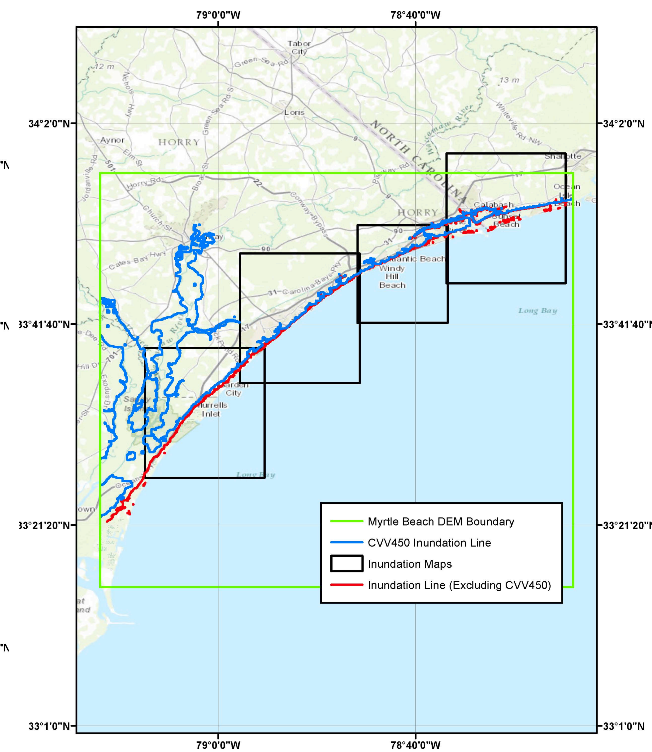


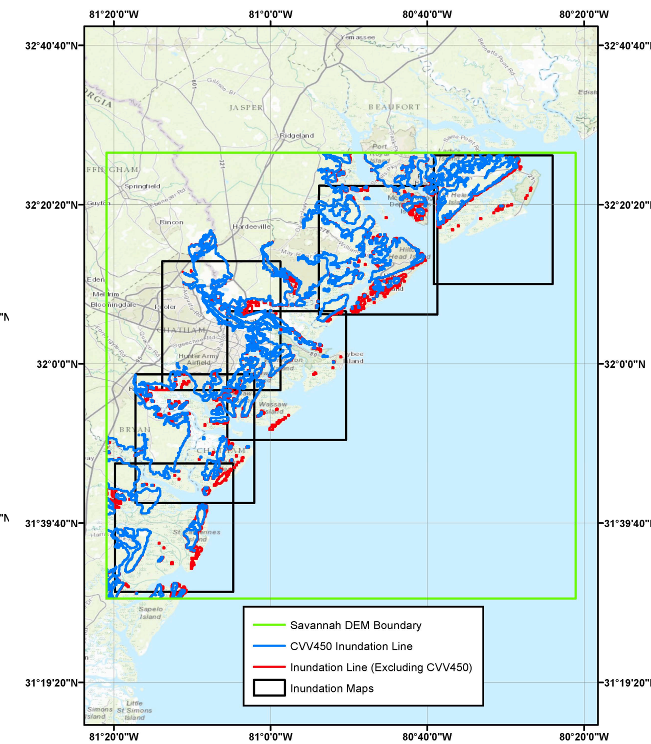




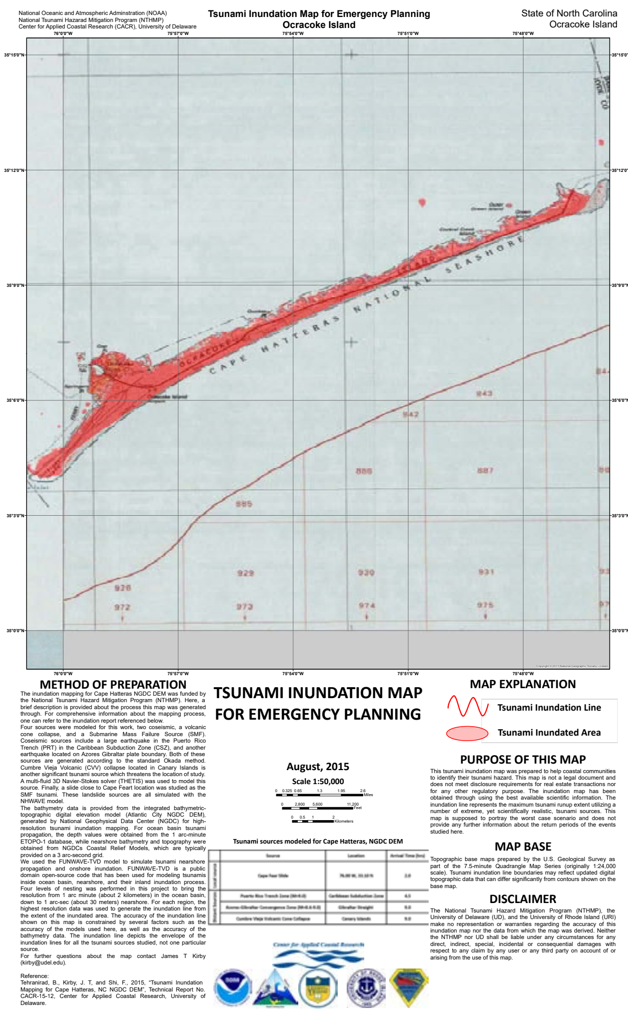
First generation mapping products: Envelope of maximum inundation

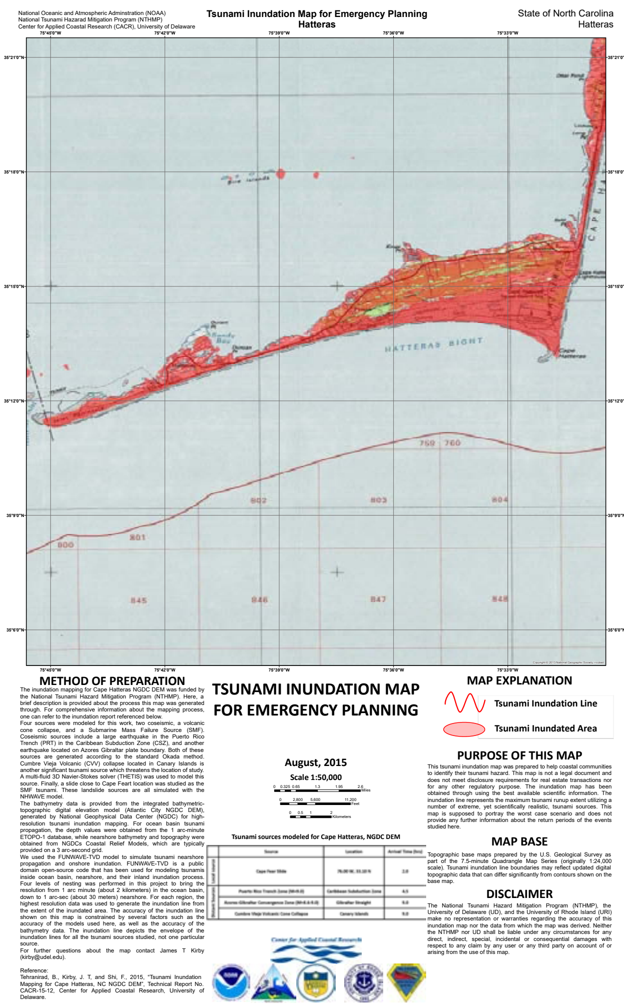


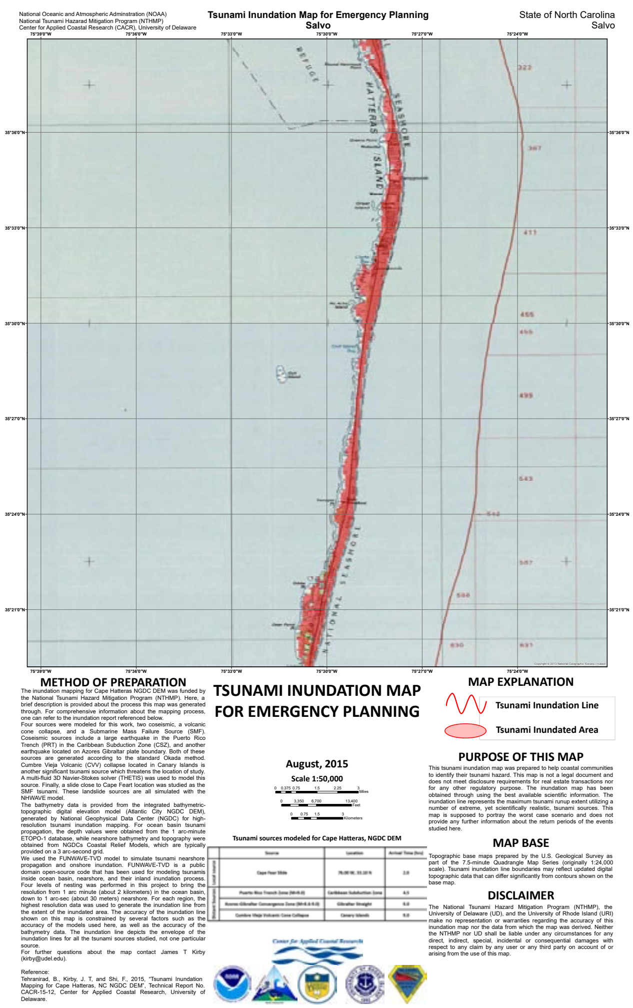




UNIVERSITY of DELAWARE



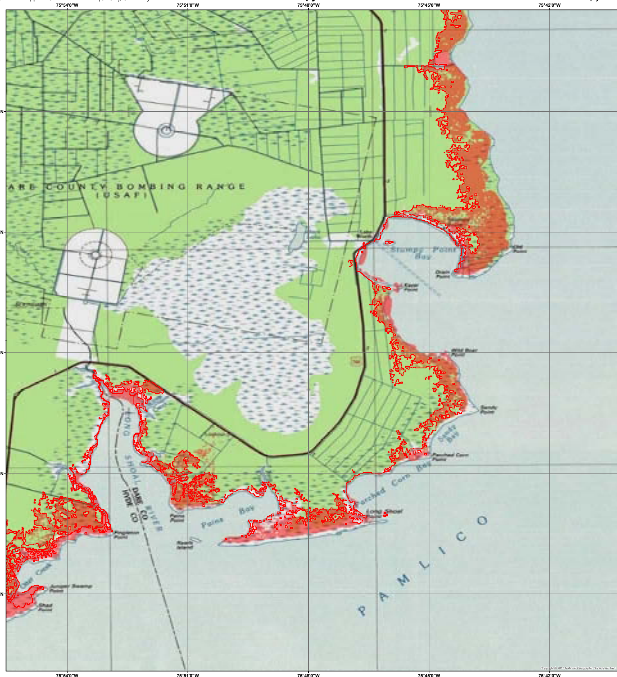




National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazarad Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware

Tsunami Inundation Map for Emergency Planning
Stumpy Point

State of North Carolina
Stumpy Point



METHOD OF PREPARATION

The inundation mapping for Cape Hatteras NGDC DEM was funded by the National Tsunami Hazard Mitigation Program (NTHMP). Here, a brief description is provided about the process this map was generated through. For comprehensive information about the mapping process, one can refer to the inundation report referenced below.

Four sources were modeled for this work, two coseismic, a volcanic cone collapse, and a Submarine Mass Failure Source (SMF). Coseismic sources include a large earthquake in the Puerto Rico Trench (PRT) in the Caribbean Subduction Zone (CSZ), and another earthquake located on Azores Gibraltar plate boundary. Both of these sources are generated according to the standard Okada method. Cumbre Vieja Volcanic (CVV) collapse located in Canary Islands is another significant tsunami source which threatens the location of study. A multi-fluid 3D Navier-Stokes solver (THETIS) was used to model this source. Finally, a slide close to Cape Feart location was studied as the SMF tsunami. These landslide sources are all simulated with the NHWAVE model.

The bathymetry data is provided from the integrated bathymetric-topographic digital elevation model (Atlantic City NGDC DEM), generated by National Geophysical Data Center (NGDC) for high-resolution tsunami inundation mapping. For ocean basin tsunami propagation, the depth values were obtained from the 1 arc-minute ETOPO-1 database, while nearshore bathymetry and topography were obtained from NGDCs Coastal Relief Models, which are typically provided on a 3 arc-second grid.

We used the FUNWAVE-TVD model to simulate tsunami nearshore propagation and onshore inundation. FUNWAVE-TVD is a public domain open-source code that has been used for modeling tsunamis inside ocean basin, nearshore, and their inland inundation process. Four levels of nesting was performed in this project to bring the resolution from 1 arc minute (about 2 kilometers) in the ocean basin, down to 1 arc-sec (about 30 meters) nearshore. For each region, the highest resolution data was used to generate the inundation line from the extent of the inundated area. The accuracy of the inundation line shown on this map is constrained by several factors such as the accuracy of the models used here, as well as the accuracy of the bathymetry data. The inundation line depicts the envelope of the inundation lines for all the tsunami sources studied, not one particular source.

For further questions about the map contact James T Kirby (kirby@udel.edu).

Reference:
Tehranirad, B., Kirby, J. T, and Shi, F., 2015, "Tsunami Inundation Mapping for Cape Hatteras, NC NGDC DEM", Technical Report No. CACR-15-12, Center for Applied Coastal Research, University of Delaware.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

August, 2015

Scale 1:50,000

0 0.325 0.65 1.3 1.95 2.6 Miles
0 2,800 5,600 11,200 Feet
0 0.5 1 2 Kilometers

Tsunami sources modeled for Cape Hatteras, NGDC DEM

	Source	Location	Arrival Time (hrs)
Local source	Cape Fear Slide	76.00 W, 33.10 N	2.0
Distant Sources	Puerto Rico Trench Zone (M=9.0)	Caribbean Subduction Zone	4.5
	Azores-Gibraltar Convergence Zone (M=8.6 9.0)	Gibraltar Straight	9.0
	Cumbre Vieja Volcanic Cone Collapse	Canary Islands	9.0

Center for Applied Coastal Research

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 hazard. 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 utilizing a number of extreme, 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 studied here.

MAP BASE

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

DISCLAIMER

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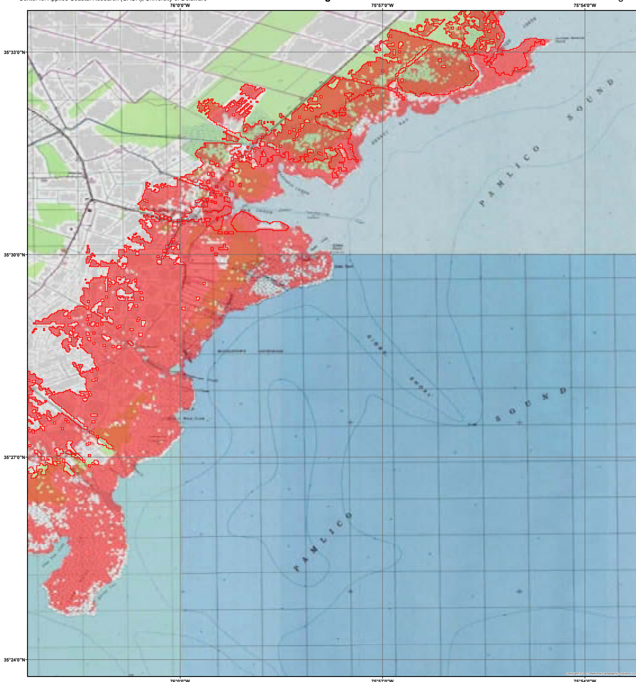
National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazarad Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware

Tsunami Inundation Map for Emergency Planning
Engelhard

State of North Carolina
Engelhard



METHOD OF PREPARATION

The inundation mapping for Cape Hatteras NGDC DEM was funded by the National Tsunami Hazard Mitigation Program (NTHMP). Here, a brief description is provided about the process this map was generated through. For comprehensive information about the mapping process, one can refer to the inundation report referenced below.

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For further questions about the map contact James T Kirby (kirby@udel.edu).

Reference:
Tehranirad, B., Kirby, J. T, and Shi, F., 2015, "Tsunami Inundation Mapping for Cape Hatteras, NC NGDC DEM", Technical Report No. CACR-15-12, Center for Applied Coastal Research, University of Delaware.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

August, 2015

Scale 1:30,000

0 0.175 0.35 0.7 1.05 1.4 Miles
0 1,650 3,300 6,600 Feet
0 0.375 0.75 1.5 Kilometers

Tsunami sources modeled for Cape Hatteras, NGDC DEM

	Source	Location	Arrival Time (hrs)
Local source	Cape Fear Slide	76.00 W, 33.10 N	2.0
Distant Sources	Puerto Rico Trench Zone (M=9.0)	Caribbean Subduction Zone	4.5
	Azores-Gibraltar Convergence Zone (M=8.6 9.0)	Gibraltar Straight	9.0
	Cumbre Vieja Volcanic Cone Collapse	Canary Islands	9.0

Center for Applied Coastal Research

MAP EXPLANATION

Tsunami Inundation Line
Tsunami Inundated Area

PURPOSE OF THIS MAP

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MAP BASE

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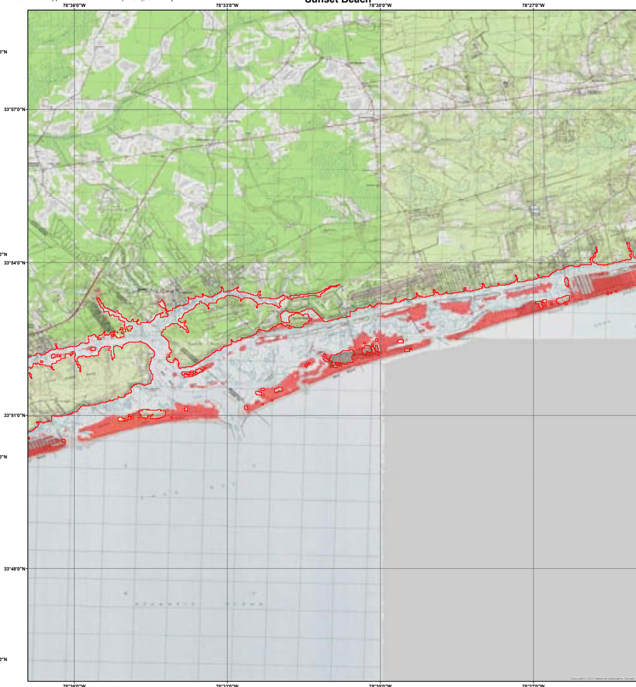
National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazarad Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware

Tsunami Inundation Map for Emergency Planning
Sunset Beach

State of North Carolina
Sunset Beach



METHOD OF PREPARATION

The inundation mapping for Myrtle Beach NGDC DEM was funded by the National Tsunami Hazard Mitigation Program (NTHMP). Here, a brief description is provided about the process this map was generated through. For comprehensive information about the mapping process, one can refer to the inundation report referenced below.

Four sources were modeled for this work, two coseismic, a volcanic cone collapse, and a Submarine Mass Failure Source (SMF). Coseismic sources include a large earthquake in the Puerto Rico Trench (PRT) in the Caribbean Subduction Zone (CSZ), and another earthquake located on Azores Gibraltar plate boundary. Both of these sources are generated according to the standard Okada method. Cumbre Vieja Volcanic (CVV) collapse located in Canary Islands is another significant tsunami source which threatens the location of study. A multi-fluid 3D Navier-Stokes solver (THETIS) was used to model this source. Finally, a slide close to Cape Feart location was studied as the SMF tsunami. These landslide sources are all simulated with the NHWAVE model.

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Reference:
Tehranirad, B., Kirby, J. T, and Shi, F., 2015, "Tsunami Inundation Mapping for Myrtle Beach, SC NGDC DEM", Technical Report No. CACR-15-13, Center for Applied Coastal Research, University of Delaware.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of North Carolina
Sunset Beach

August, 2015

Scale 1:40,000

0 0.25 0.5 1 1.5 2 Miles
0 2,250 4,500 9,000 Feet
0 0.5 1 2 Kilometers

Tsunami sources modeled for Myrtle Beach, NGDC DEM

	Source	Location	Arrival Time (hrs)
Local source	Cape Fear Slide	76.00 W, 33.10 N	2.0
Distant Sources	Puerto Rico Trench Zone (M=9.0)	Caribbean Subduction Zone	4.5
	Azores-Gibraltar Convergence Zone (M=8.6 9.0)	Gibraltar Straight	9.0
	Cumbre Vieja Volcanic Cone Collapse	Canary Islands	9.0

Center for Applied Coastal Research

MAP EXPLANATION

Tsunami Inundation Line
Tsunami Inundated Area

PURPOSE OF THIS MAP

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MAP BASE

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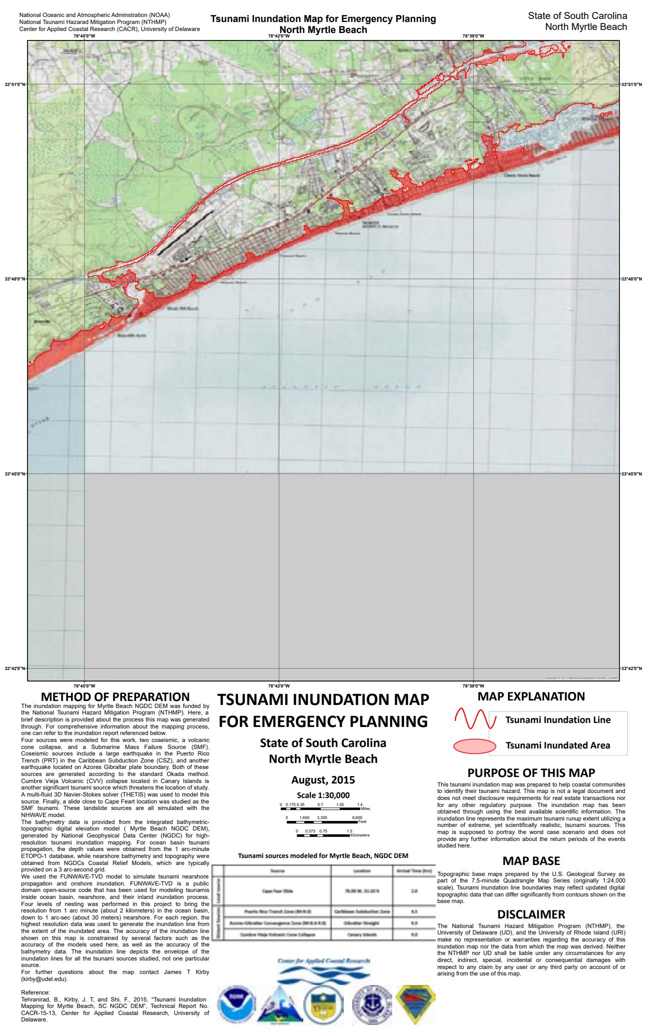
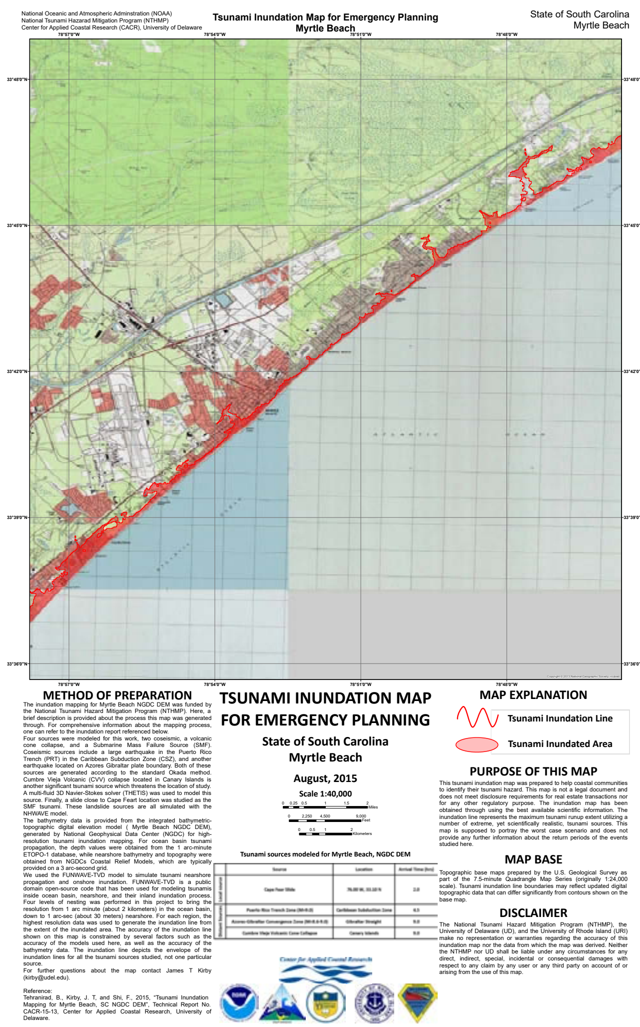
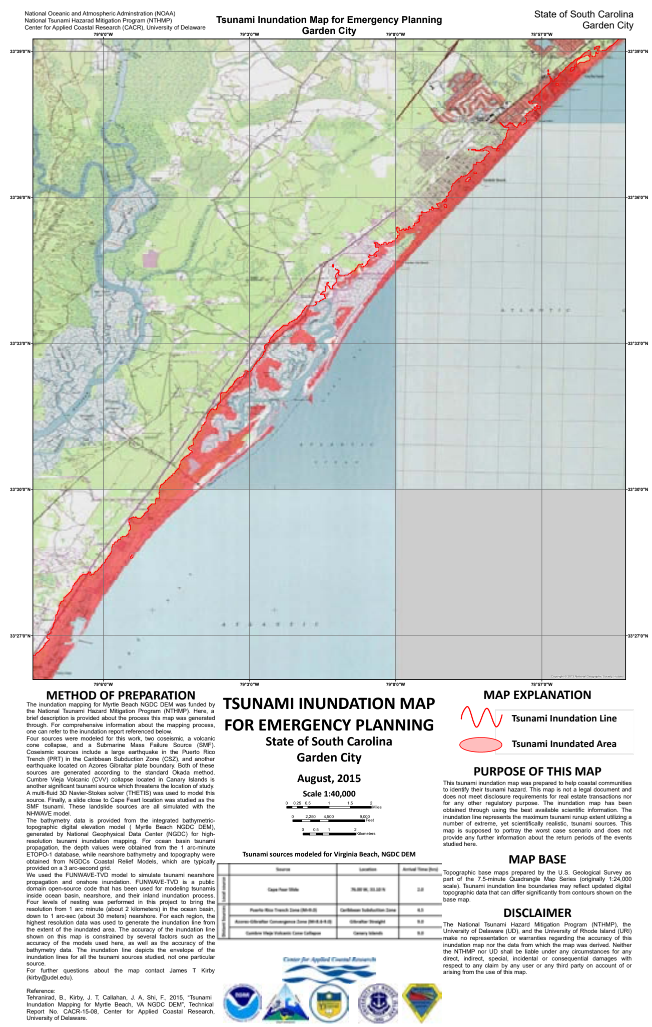
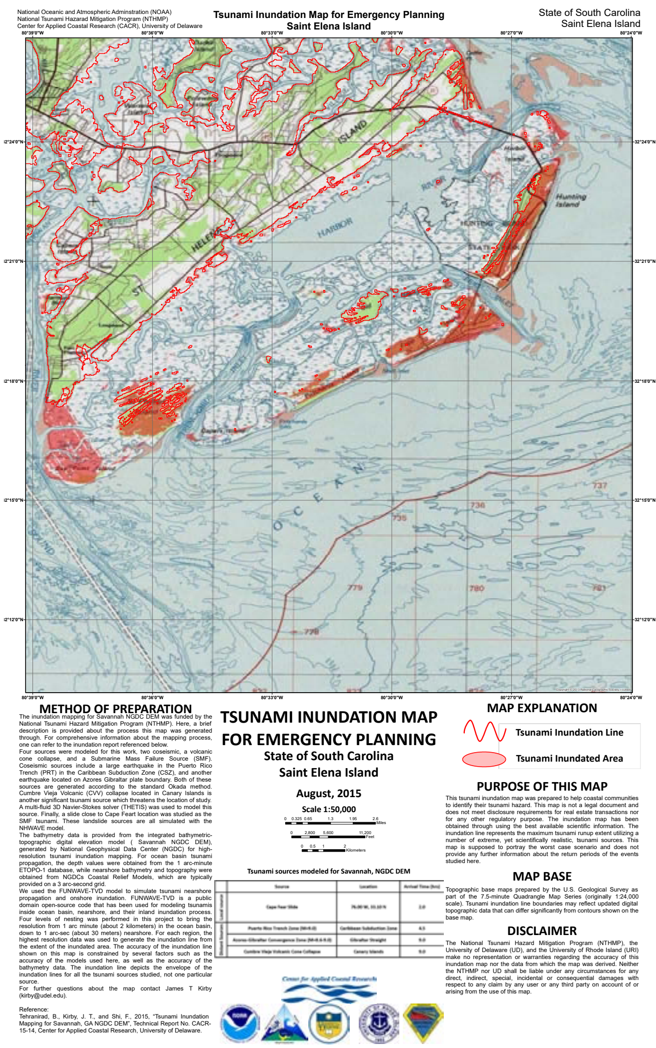
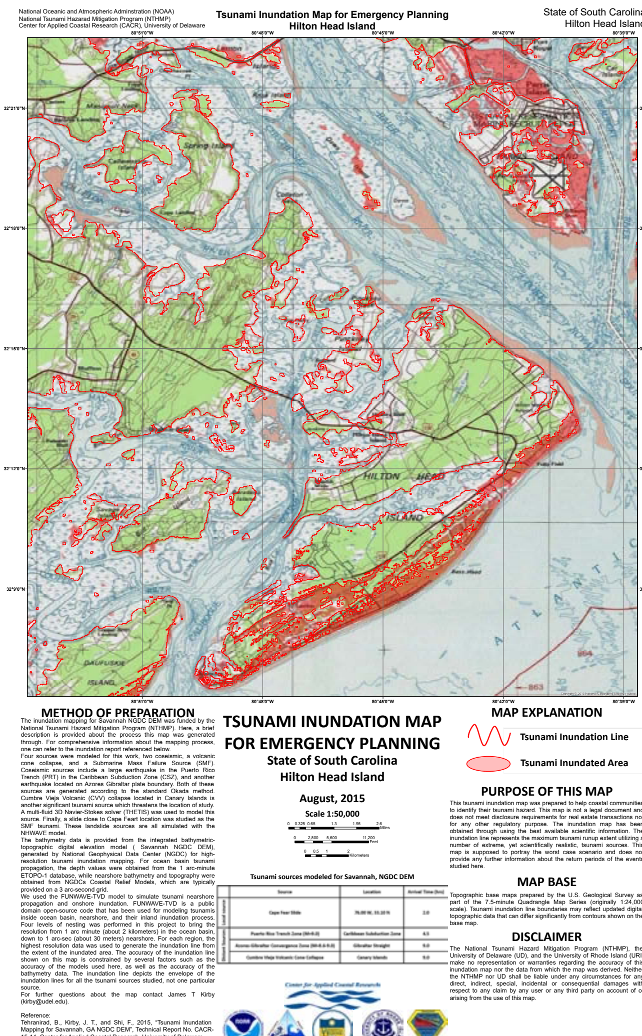
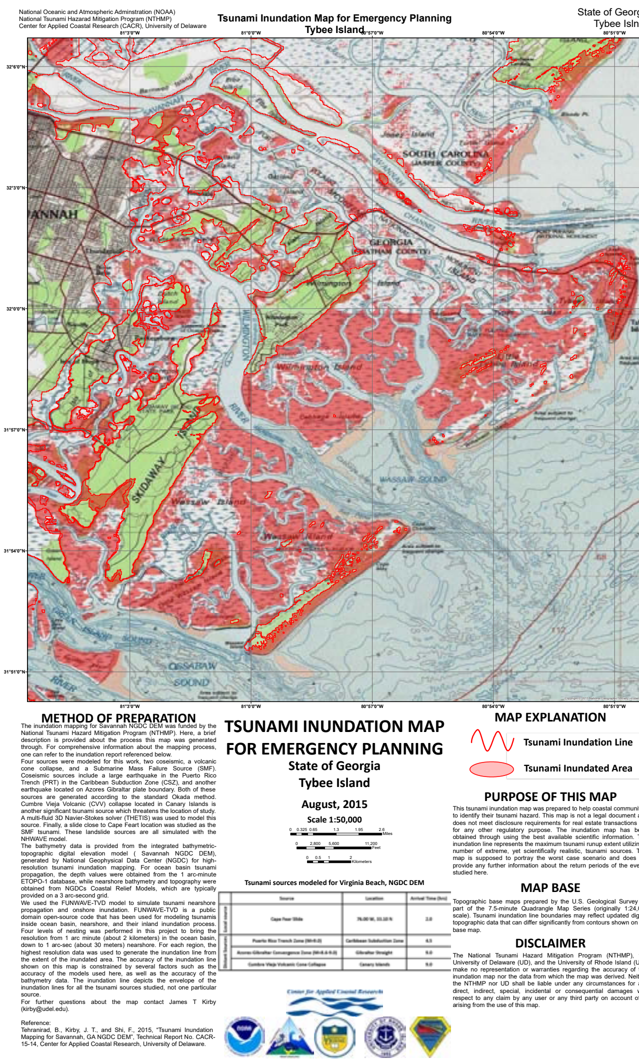

National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazardard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
North Myrtle Beach
State of South Carolina
North Myrtle Beach
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of South Carolina
North Myrtle Beach
August, 2015
Scale 1:30,000
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
Tsunami sources modeled for Myrtle Beach, NGDC DEM
MAP BASE
DISCLAIMER
Center for Applied Coastal Research

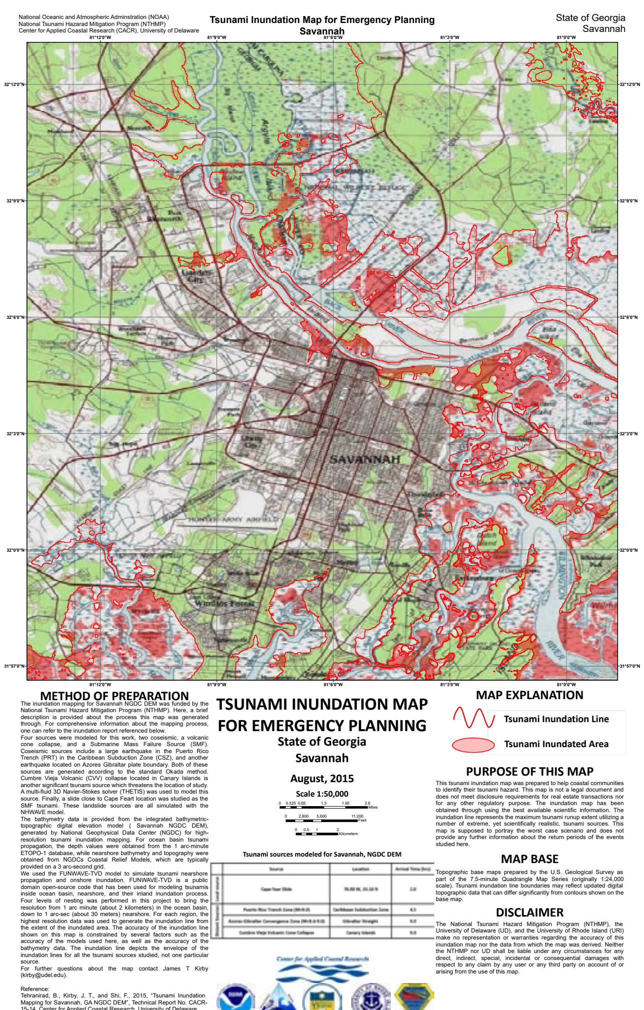

National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazardard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Myrtle Beach
State of South Carolina
Myrtle Beach
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of South Carolina
Myrtle Beach
August, 2015
Scale 1:40,000
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
Tsunami sources modeled for Myrtle Beach, NGDC DEM
MAP BASE
DISCLAIMER
Center for Applied Coastal Research

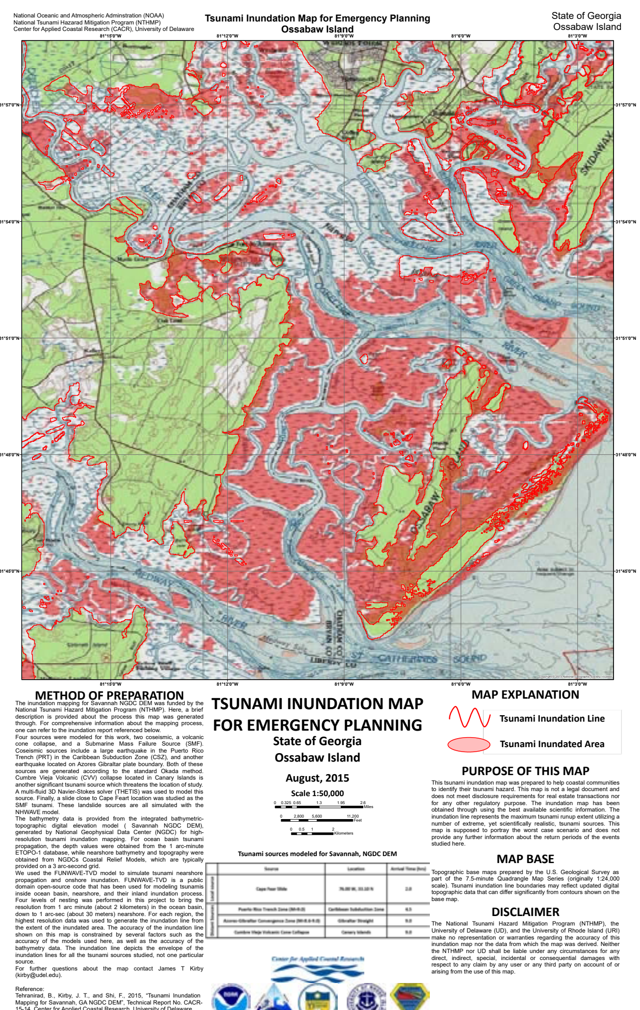

National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazardard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Garden City
State of South Carolina
Garden City
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of South Carolina
Garden City
August, 2015
Scale 1:40,000
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
Tsunami sources modeled for Virginia Beach, NGDC DEM
MAP BASE
DISCLAIMER
Center for Applied Coastal Research

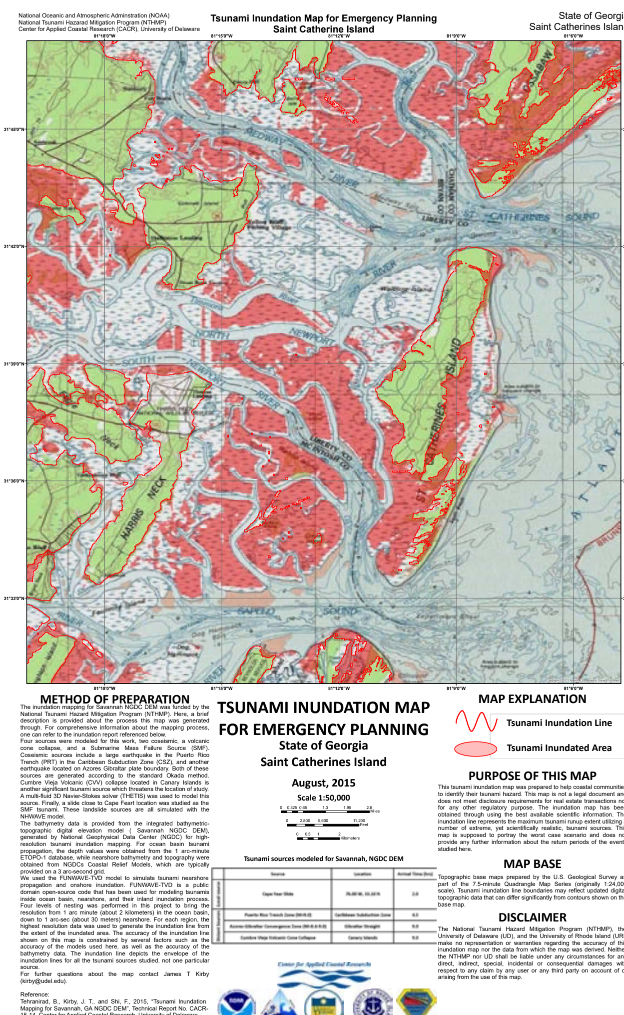

National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Saint Elena Island
State of South Carolina
Saint Elena Island
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING
State of South Carolina
Saint Elena Island
August, 2015
Scale 1:50,000
Tsunami sources modeled for Savannah, NGDC DEM
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER


National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Hilton Head Island
State of South Carolina
Hilton Head Island
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING
State of South Carolina
Hilton Head Island
August, 2015
Scale 1:50,000
Tsunami sources modeled for Savannah, NGDC DEM
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER

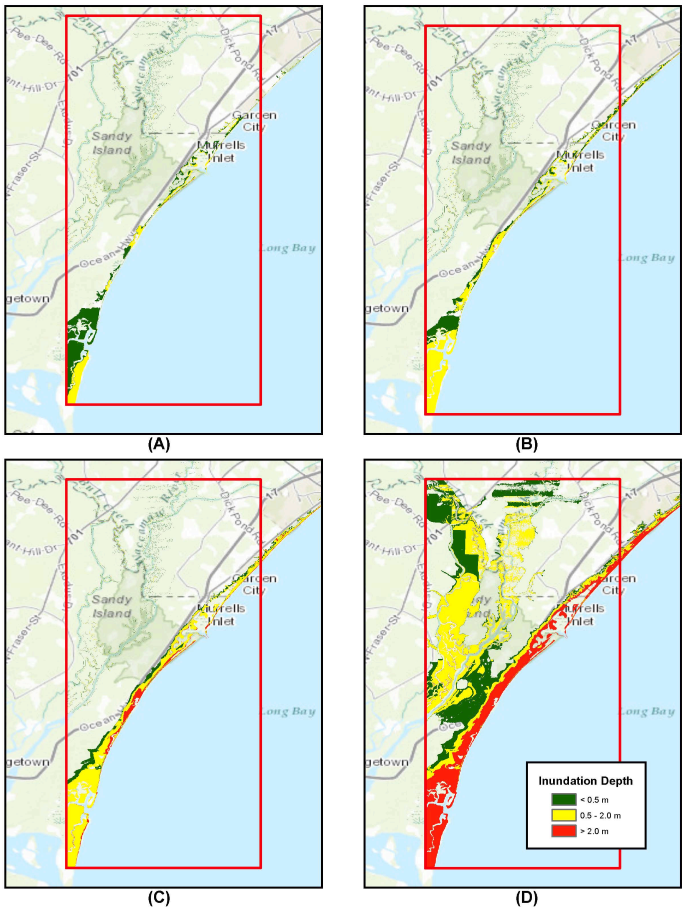

National Oceanic and Atmospheric Adminstration (NOAA)
National Tsunami Hazard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Tybee Island
State of Georgia
Tybee Islnad
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING
State of Georgia
Tybee Island
August, 2015
Scale 1:50,000
Tsunami sources modeled for Virginia Beach, NGDC DEM
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER


National Oceanic and Atmospheric Administration (NOAA)
National Tsunami Hazard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Savannah
State of Georgia
Savannah
SAVANNAH
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of Georgia
Savannah
August, 2015
Scale 1:50,000
Tsunami sources modeled for Savannah, NGDC DEM
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER

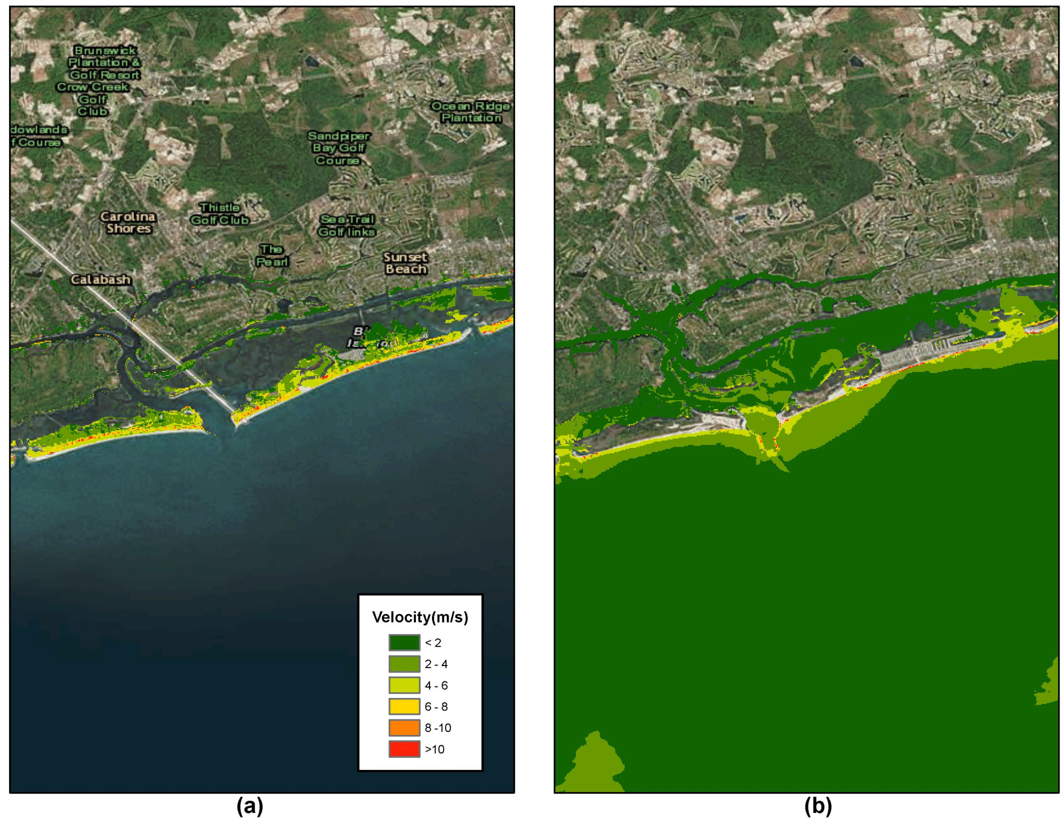

National Oceanic and Atmospheric Administration (NOAA)
National Tsunami Hazard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Ossabaw Island
State of Georgia
Ossabaw Island
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of Georgia
Ossabaw Island
August, 2015
Scale 1:50,000
Tsunami sources modeled for Savannah, NGDC DEM
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER


National Oceanic and Atmospheric Administration (NOAA)
National Tsunami Hazard Mitigation Program (NTHMP)
Center for Applied Coastal Research (CACR), University of Delaware
Tsunami Inundation Map for Emergency Planning
Saint Catherine Island
State of Georgia
Saint Catherines Island
METHOD OF PREPARATION
TSUNAMI INUNDATION MAP
FOR EMERGENCY PLANNING
State of Georgia
Saint Catherines Island
August, 2015
Scale 1:50,000
Tsunami sources modeled for Savannah, NGDC DEM
MAP EXPLANATION
Tsunami Inundation Line
Tsunami Inundated Area
PURPOSE OF THIS MAP
MAP BASE
DISCLAIMER

Additional products

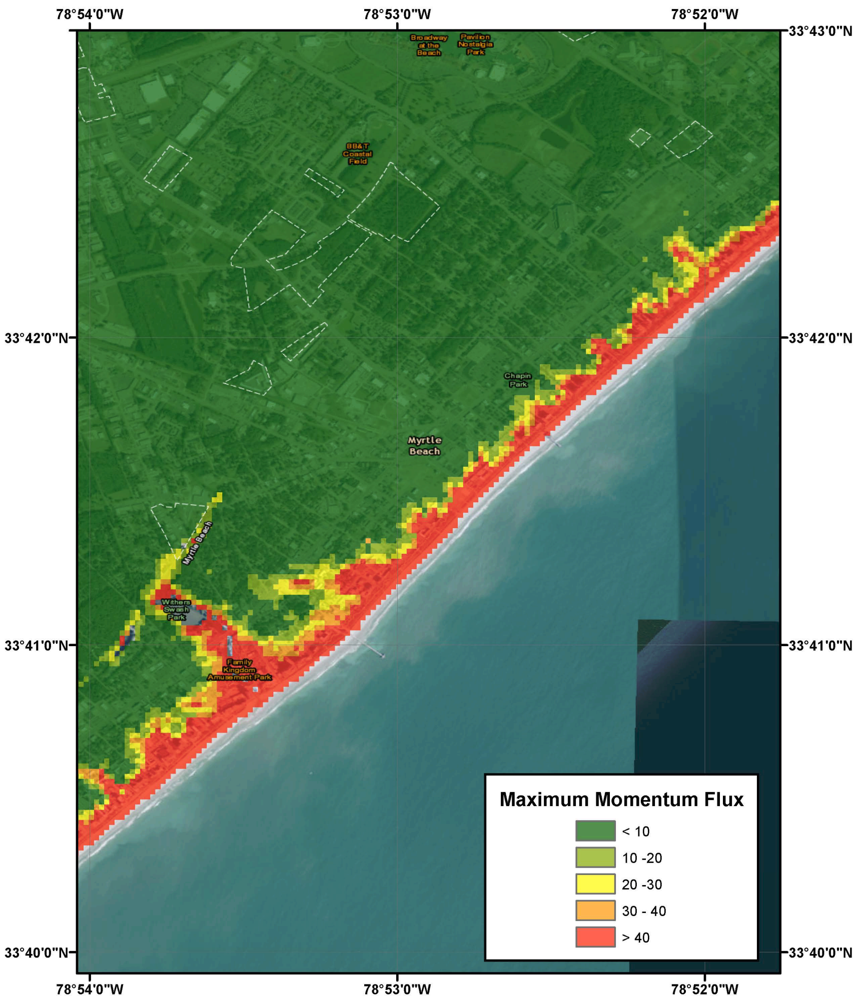


Inundation depths – composite or for individual events

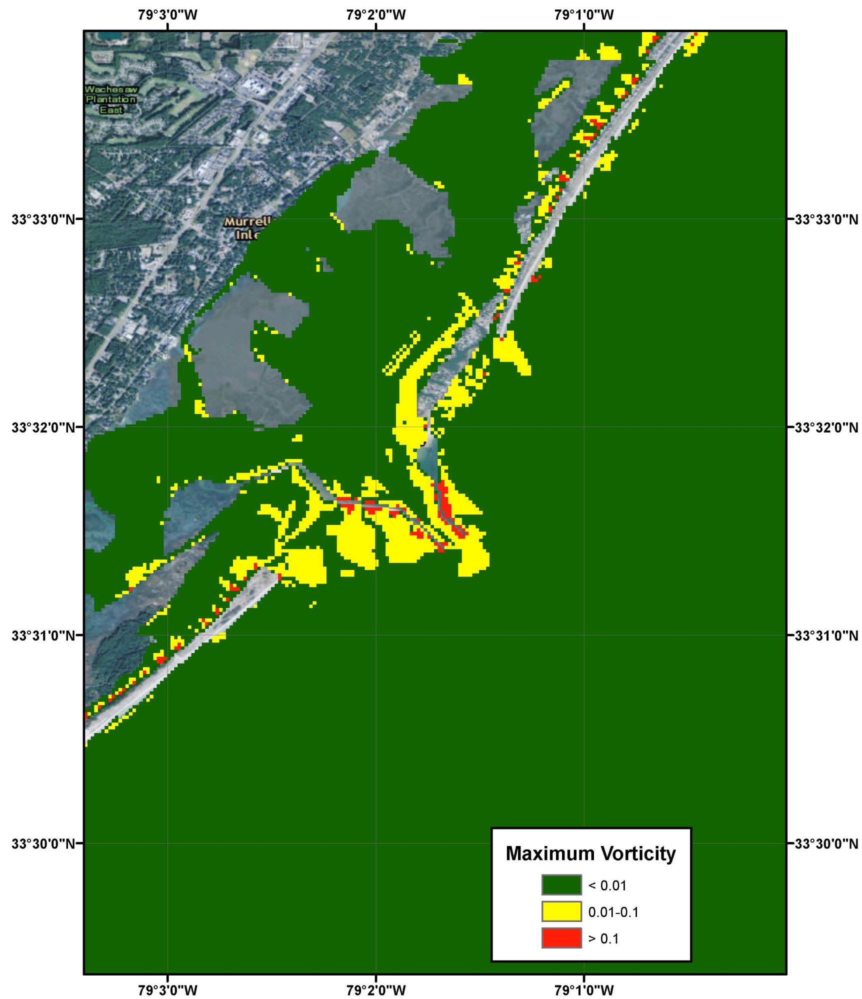


Maximum velocities – on land or marine

Additional products

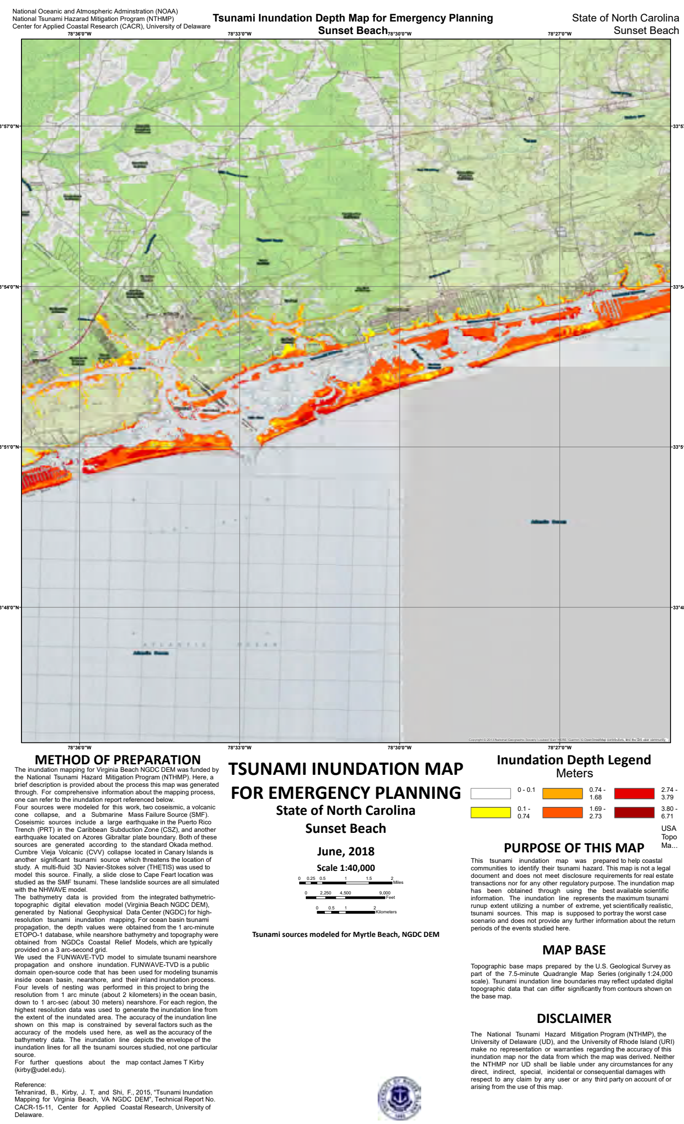


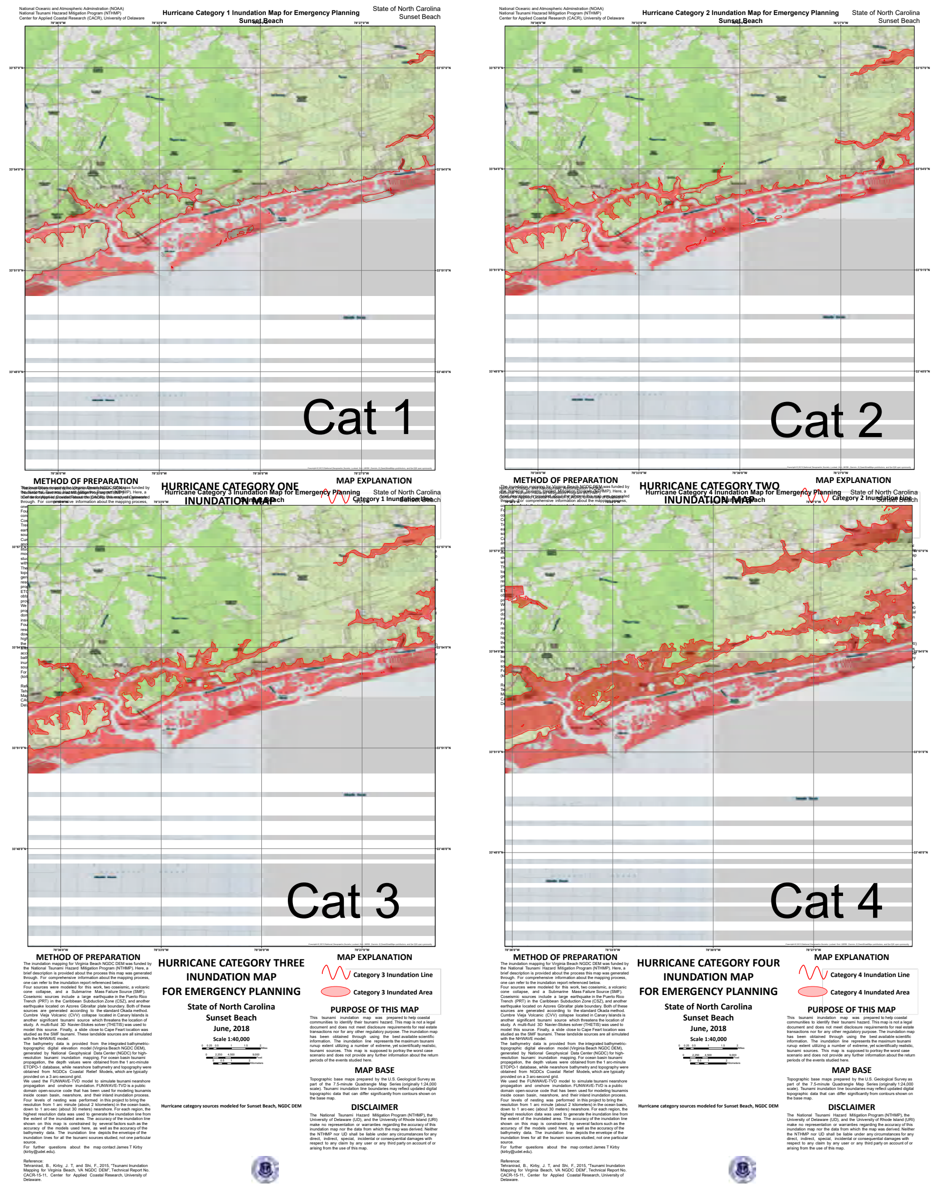
Momentum flux (structural damage)



Vorticity (related to navigation, harbor damage)

Inundation maps vs. storm surge maps





Ongoing mapping efforts

- Inundation guidelines for unmapped areas
- Dynamic erosion and morphology change during events – increased hazard levels?
- Maritime hazard assessment – guidance for boat operators after event warnings

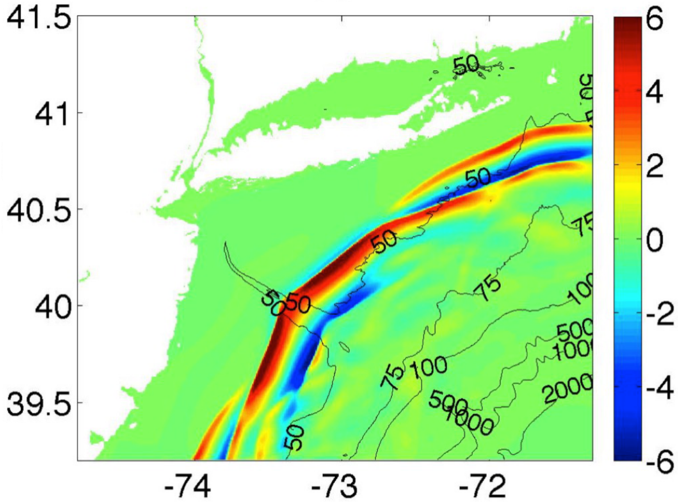
Guidance for unmapped areas

- Need for estimates of inundation extent and inundation depth, velocities, etc, for areas that have not been covered by high resolution modeling.
- Approach is to develop an algorithm based on comparison of modeled inundations to previous storm surge modeling (SLOSH results).
- Additional factors including coastline irregularity and inland distance need to be accounted for.

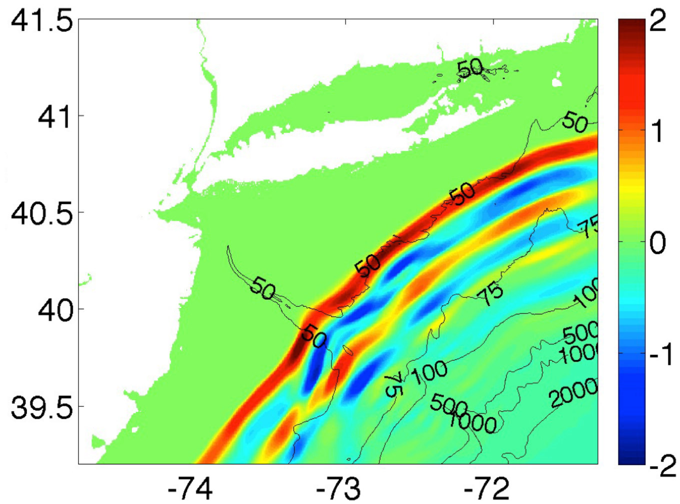
- Test algorithm using previously mapped areas not used in developing algorithm.

- Apply algorithm to unmapped areas.

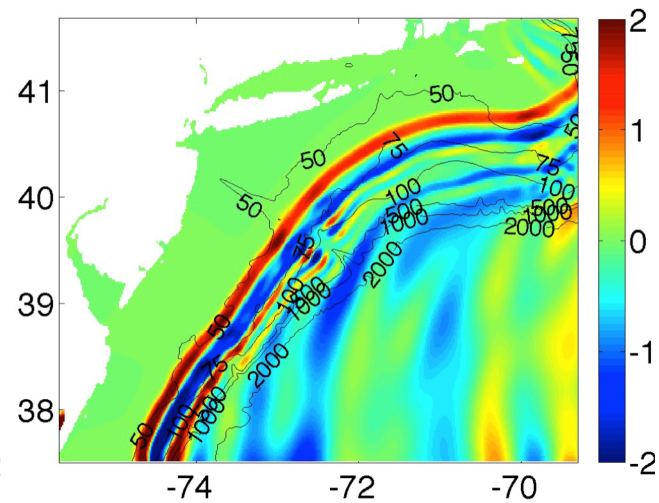
Comparing coastal impact CVV/SMF/PRT



SMF-1 (rigid slump) 1h18’



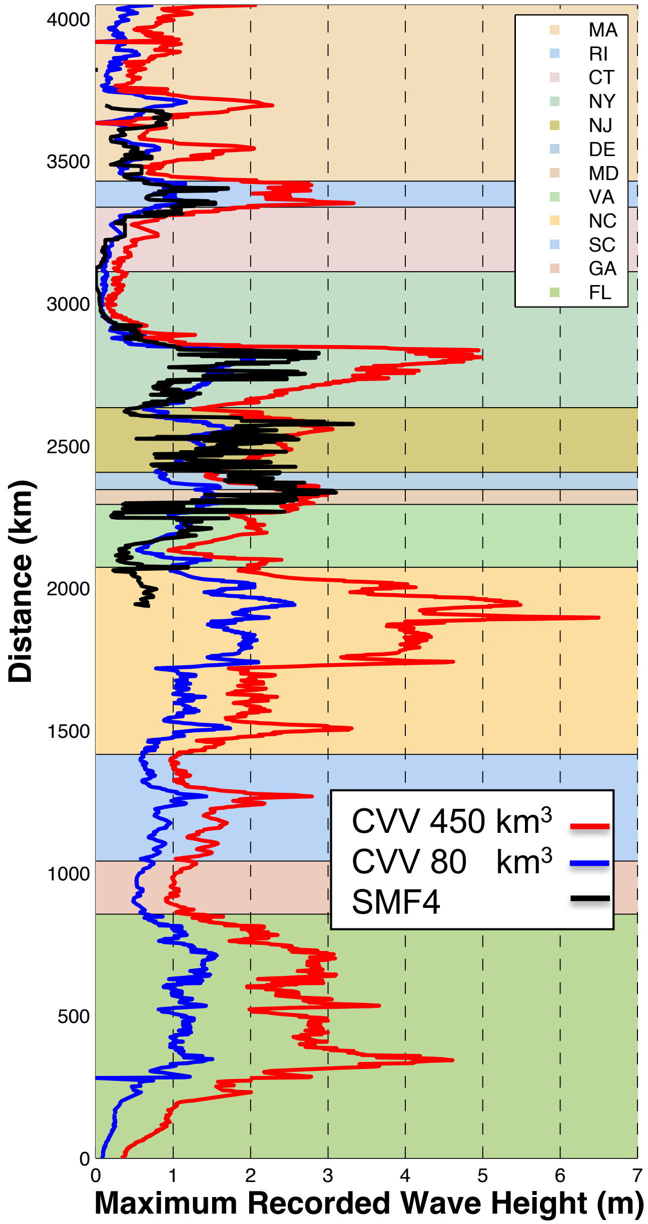
PRT (4h)

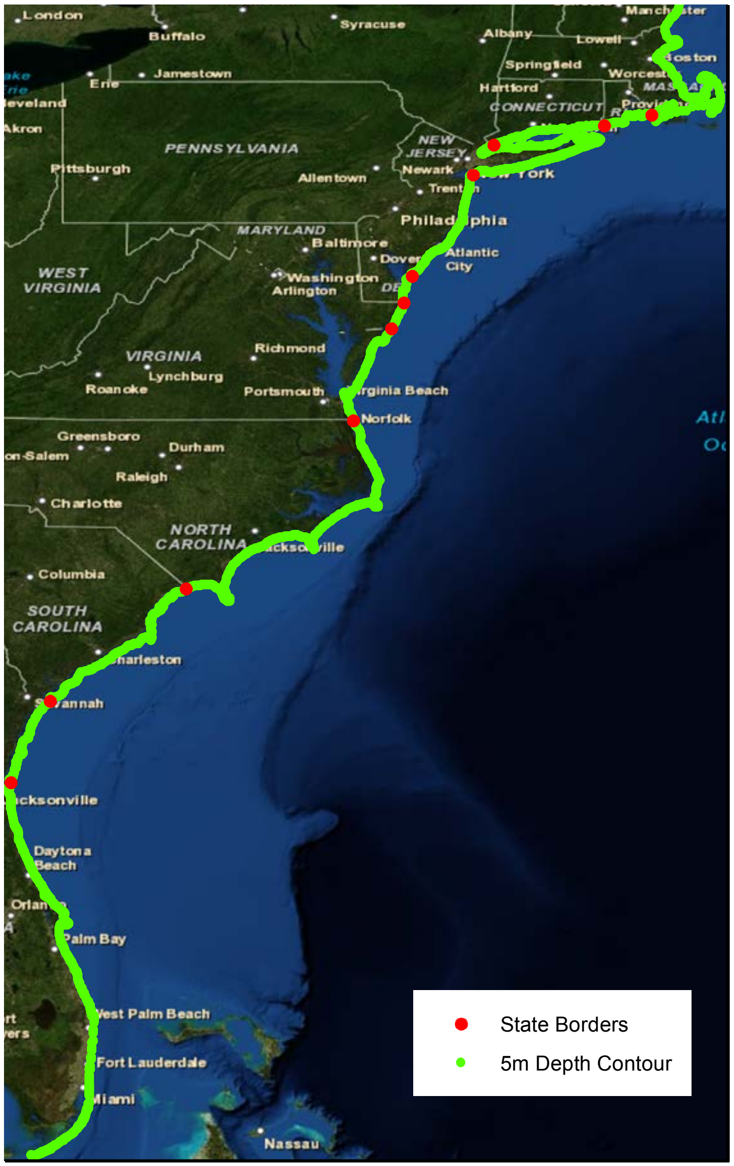


CVV (80 km^3) (8h)

- Similar patterns of nearshore waves are observed for all sources.
- Coastal wave height distribution suggest tsunami coastal hazard is controlled by shelf bathymetry and shelf-break geometry, particularly in regions with wide shelves.

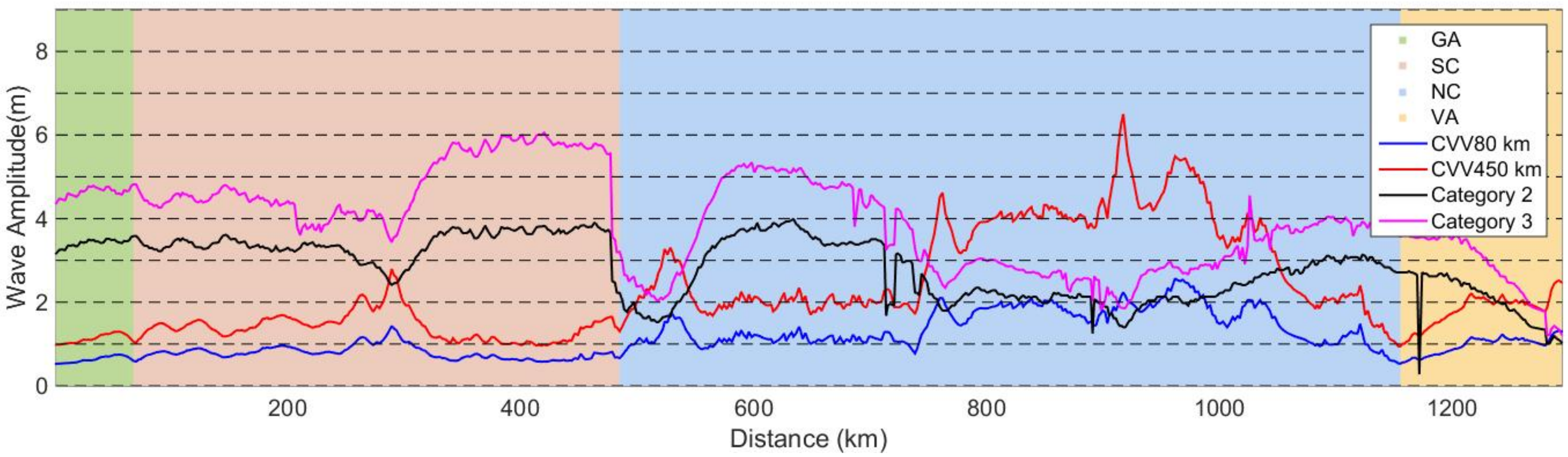
Guidance for unmodeled areas





- A similar wave height distribution pattern was observed for all of the sources simulated in this study.
- Tsunami wave height distributions along the east coast suggest that the tsunami propagation is determined by the bathymetry due to the existence of a wide shelf.

Storm surge elevations (cat 2, 3) vs CVV max crest elevations at 5m depth contour offshore of coastline



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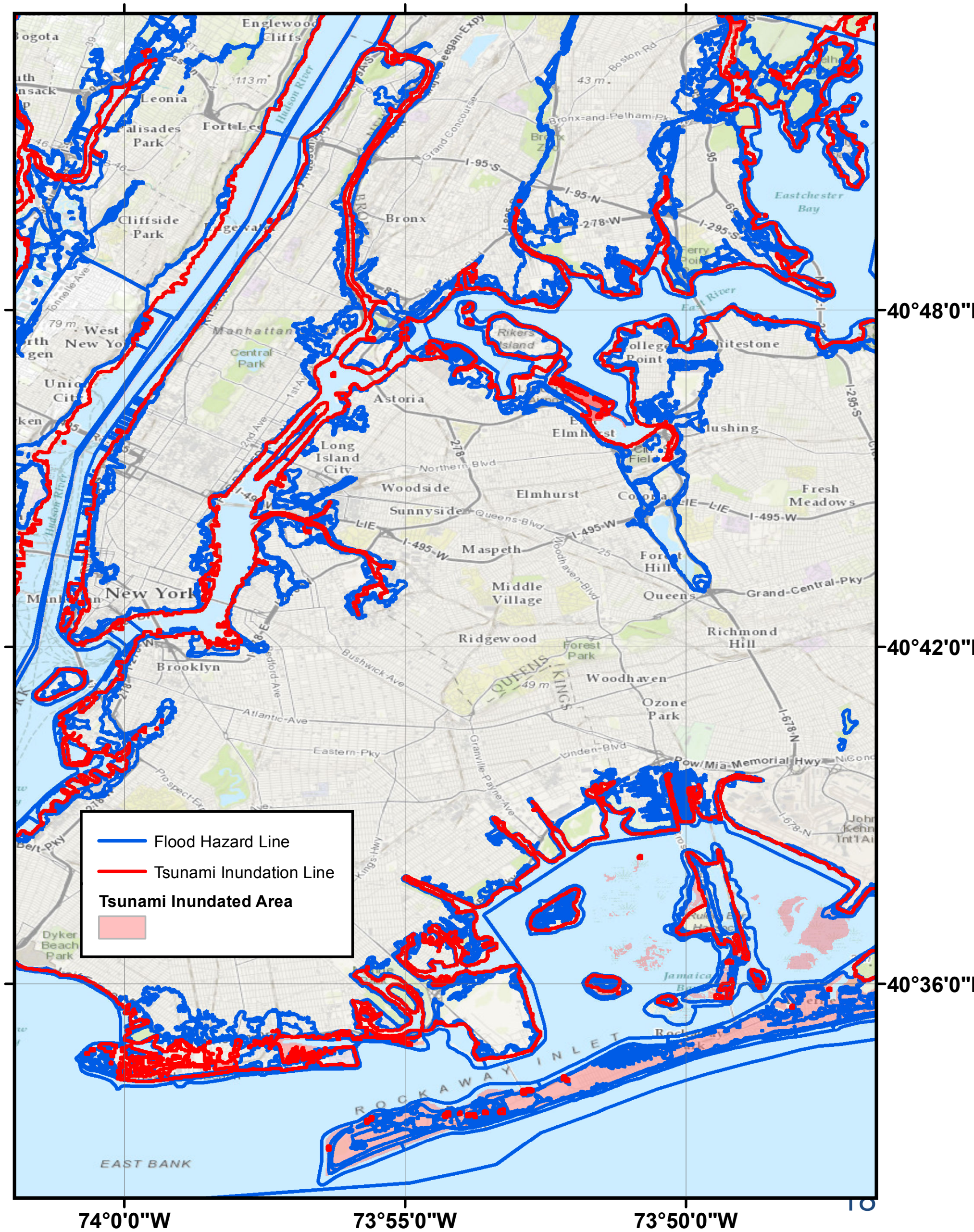
Guidance for unmodeled areas

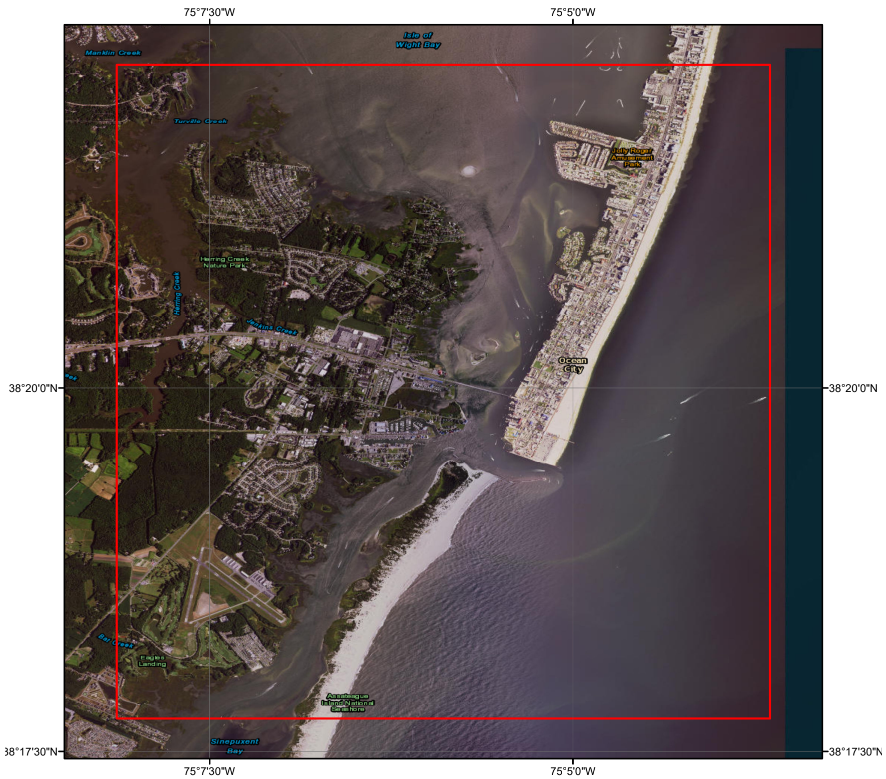
Comparison of tsunami inundation line and Storm Surge hazard maps

- Tsunami inundation is dominant in areas directly facing open water.
- In areas behind barrier islands or other protected areas, storm surge effects are dominant.

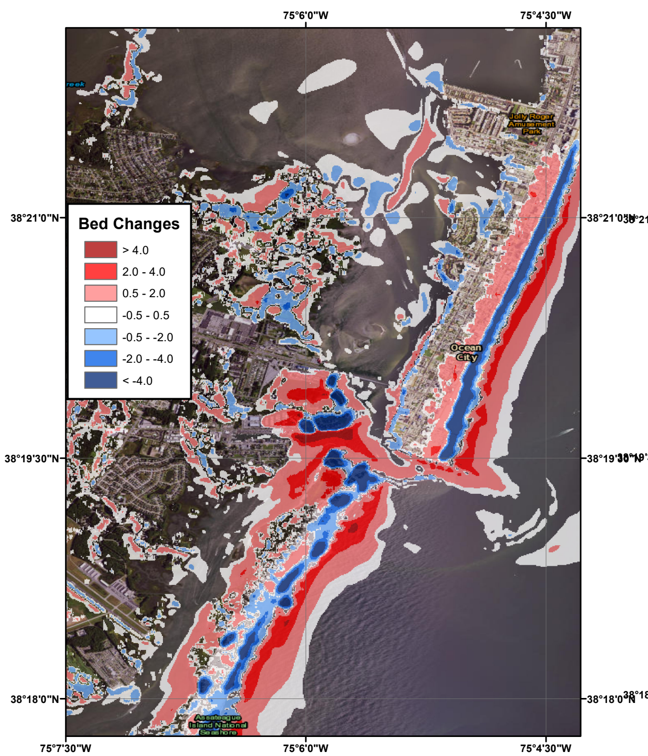


Effect of erosion on hazard levels

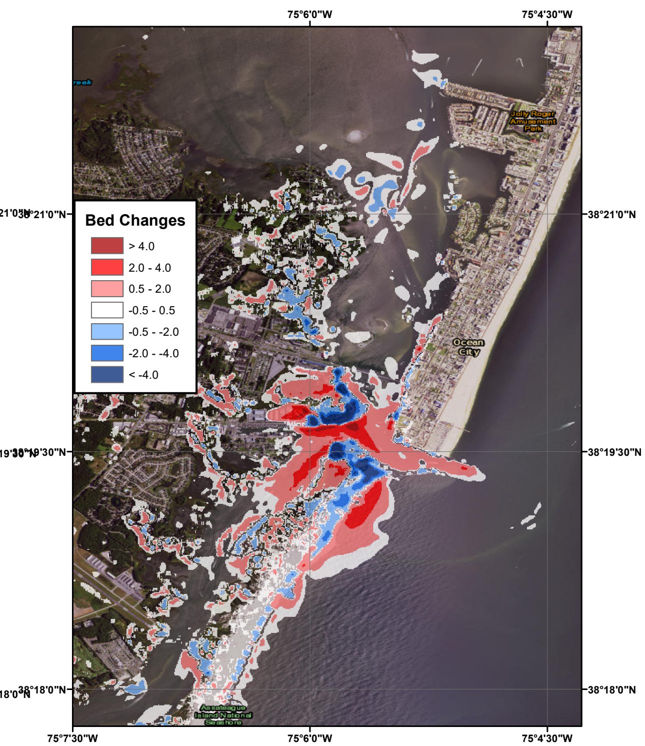
Hypothetical test case
based on Ocean City, MD



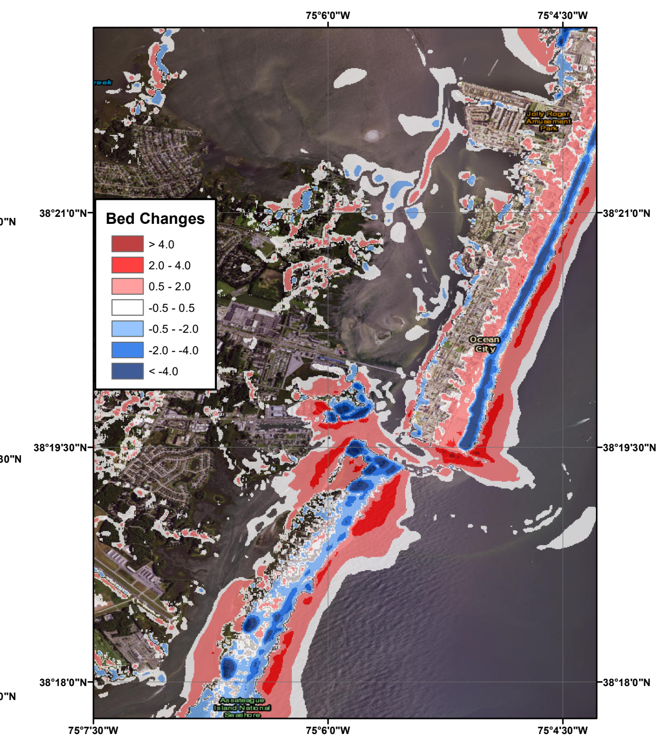
Morphology change for 3 sample events



Puerto Rico Trench



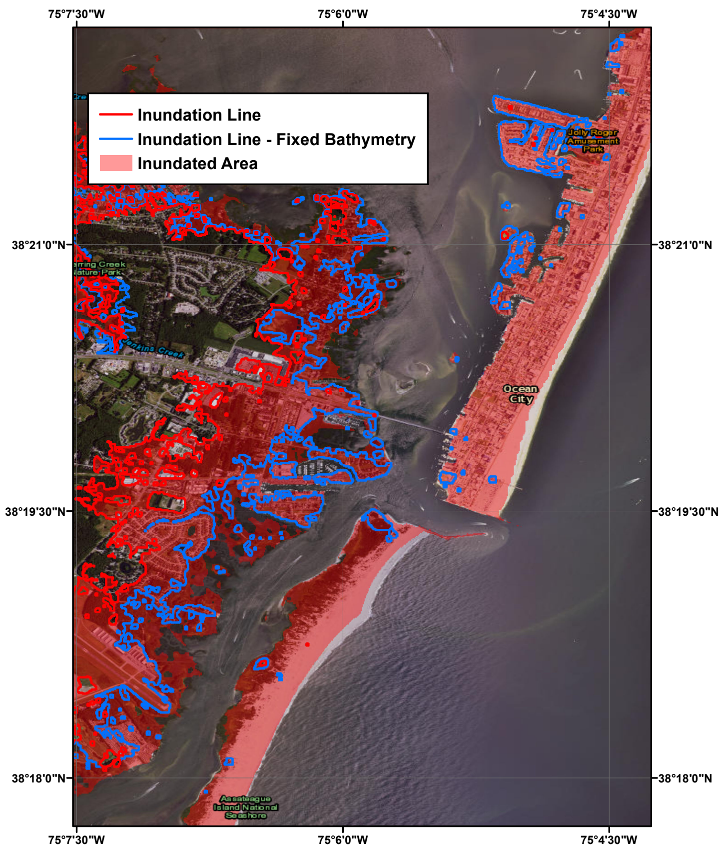
Lisbon (Azores)

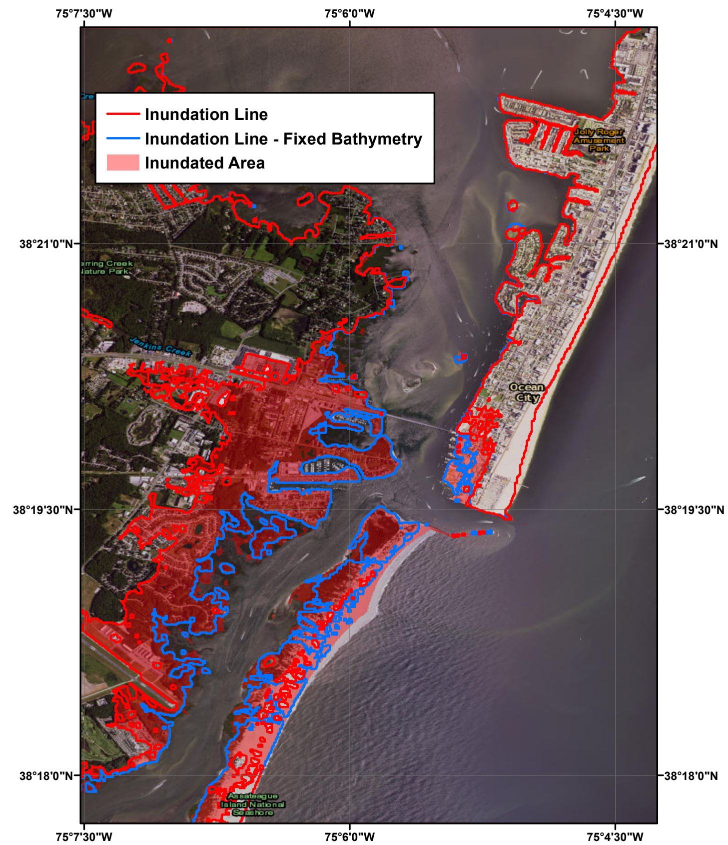


SMF event

Increased inundation area

CVV





Lisbon

Comparison between inundated area in Ocean City inlet region for static and dynamic bathymetry conditions

Tsunami	Inundated Area (Static)	Inundated Area (Dynamic)	Inundation Area Increase (%)
Puerto Rico	7.03 km^3	10.61 km^3	51
Landslide	9.46 km^3	13.43 km^3	42
Volcanic cone collapse	10.94 km^3	19.25 km^3	76
Lisbon	1.28 km^3	7.02 km^3	547

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