Incorporating Climate Change Effects into Next-Generation Coastal Inundation Decision Support Systems

An Integrated and Community-Based Approach

The Interdisciplinary Team

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Project Highlights

- A Coastal Inundation and Decision Support System
- Climate Change Impacts on Hurricanes
- Downscaling from the Global to Regional Scale
- Sea Level Rise (SLR)

Summary

This project will develop the next generation Coastal Inundation Decision Support System (CIDSS), by incorporating the projected impact of climate change on hurricanes and SLR in the next 20-30 years and the next 80-100 years. This project will first assemble a wide spectrum of stakeholders to find out how they are using the current available coastal inundation maps, and what they would like to have to mitigate coastal inundation risk in the 21st century. This project will use a new methodology developed by the UF Coastal & Oceanographic Program to produce highly accurate coastal inundation maps for FL and NC, considering current climatology. Concurrently, atmospheric and climate scientists will use the FSU Center for Ocean Atmospheric Prediction Studies global climate model and NCSU regional atmospheric model to develop hurricane ensembles during 2020-2040 and 2080-2100 for FL and NC, using the International Panel on Climate Change (IPCC) CMIP5 (Sea Surface Temperature) generated from the RCP8.5, RCP4.5, and RCP2.6 scenarios as lower boundary conditions. Experts in SLR at NCSU and FSU will analyze historical sea level data and conduct numerical modeling to estimate the SLR at the coastal boundaries of FL and NC for the same IPCC scenarios. UF and NCSU will use the hurricane ensembles and the SLR scenarios provided by FSU and NCSU as input to storm surge and coastal inundation models to produce high resolution coastal inundation maps which include climate change effects. These climate-enhanced coastal inundation maps, along with existing inundation maps, will be

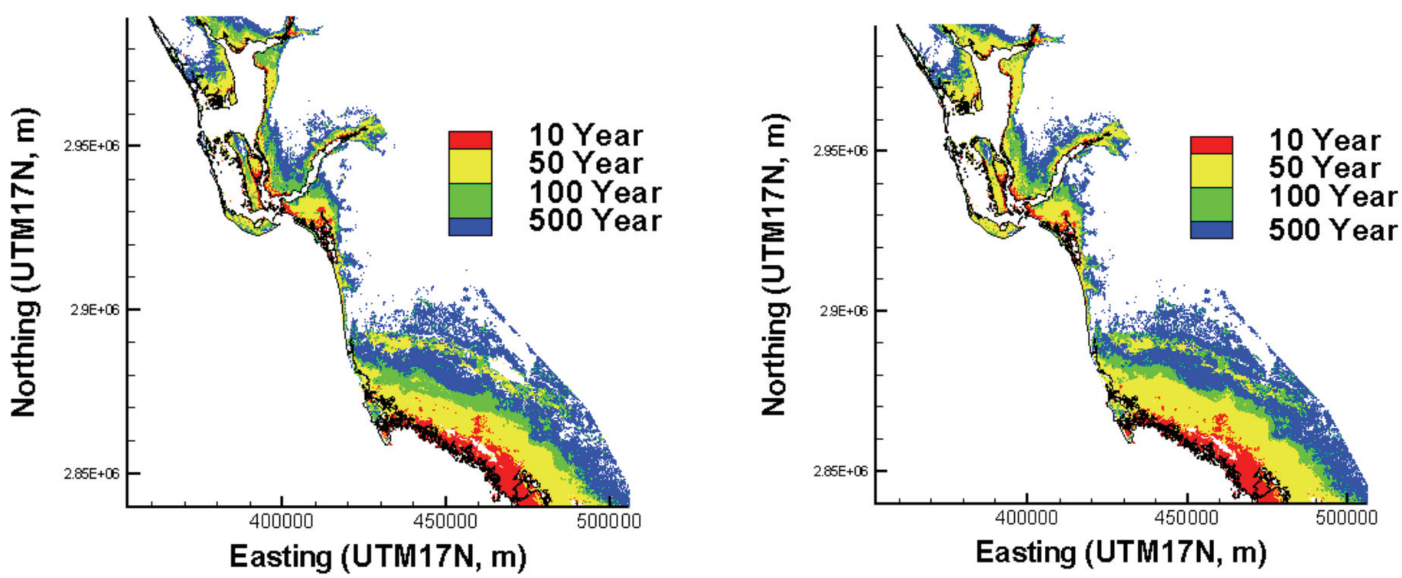
communicated to the end users for their comments and feedback, which will be the basis for further improvement of the maps, via a web-based Content Management System (CMS). The Coastal Inundation DSS, which will include the CMS and the inundation maps, will allow continual input from the end users as new products (various inundation maps) are developed and will facilitate discussions on the products so that user needs can be identified and met. The next generation coastal inundation maps will have much less uncertainty than the current ones and hence greatly improve the ability of stakeholders to mitigate future coastal inundation risk.

A Coastal Inundation and Decision Support System

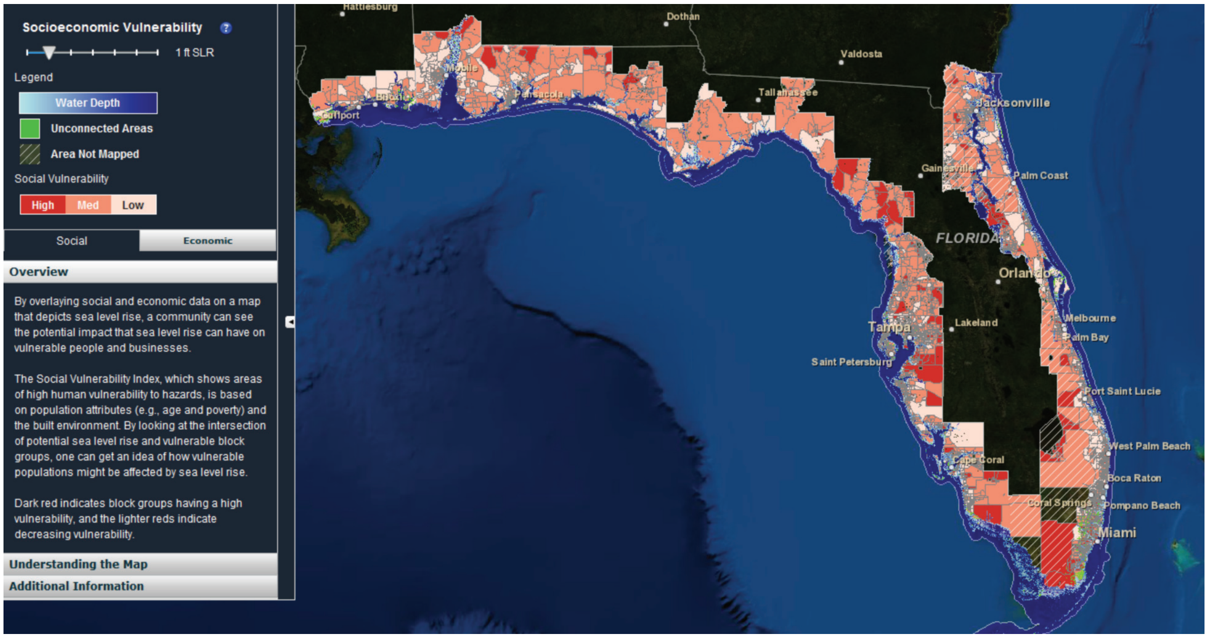
Coastal inundation during hurricanes and storms poses a major threat to the 75% of the U. S. population who live within 100 mi of the coast. With continued population growth and the impacts of climate change on hurricane intensity and frequency as well as sea level rise (SLR), coastal zones are faced with increasing risk of coastal inundation. This problem is most severe in Florida (FL) where hurricane frequency is the highest in the U.S. and SLR is expected to inundate most of Miami and many coastal highways. Coastal inundation risk is also high in North Carolina (NC) where hurricanes are much more frequent than South Carolina and Georgia. Mitigation of the increasing inundation risk is of primary concern to many entities including coastal communities, planning agencies, military facilities, water management districts, utility industries, state and county emergency management departments, the Federal Emergency Management Agency (FEMA), the Army Corps of Engineers, federal and state Dept. of Transportation, and the National Oceanic and Atmospheric Administration (NOAA). For mitigation of coastal inundation risks, various agencies have used coastal inundation Decision Support Systems (DSS) which include such inundation maps as: MOM (Maximum of Maximum), which is the maximum inundation level in a coastal zone produced by a storm surge model (e.g., SLOSH) for an ensemble of hurricanes, and FIRM (Flood Insurance Rate Map), which includes the Base Flood Elevation (BFE) for hurricanes with a 1% annual chance of occurrence, also produced by storm surge and wave models for an ensemble of hurricanes. Both MOM and FIRM are widely used for the preparation, mitigation, planning, and response of hurricane and inundation hazards; however, these maps do not include any effect of climate change on hurricanes and inundation maps, hence contain considerable uncertainties. This project will produce new generation coastal inundation maps by incorporating the climate change impacts on hurricanes and sea level rise.

Climate Change Impact on Hurricanes

The consensus from the most recent study of climate model projections for global tropical cyclone activity by the end of the 21st century is for a shift towards stronger storms with an average intensity increase between +2 to +11% while the global average frequency decreases between -6 to -34%. However, there is still large uncertainty in the projections of tropical cyclone activity in the North Atlantic basin by the end of the 21st century. Frequency projections of tropical cyclone activity in the North Atlantic by the end of the 21st century range from +62% to -61%. Despite this variability, the models agree that the average wind speeds of tropical cyclones in the North Atlantic will increase, although the percent increases were not statistically significant. Our objective is to project the frequency distribution of North Atlantic hurricanes and tropical cyclone landfalls under 21st century climate scenarios using the most recent climate model projections for the Intergovernmental Panel on Climate Change. We will determine the level of North Atlantic hurricane activity and its associated landfall potential statistics during the remainder of the 21st century associated with both anthropogenic and natural low frequency sea surface temperatures changes using the FSU Center for Ocean Atmospheric Prediction Studies global climate model. This climate model has shown very high skill in reproducing the observed year-to-year variability in hurricane activity in the North Atlantic. This research will focus



Spatial extents for the 10, 50, 100, and 500 year inundation events for present day climate (left) and future climate (right) conditions. Preliminary model results obtained without downscaling of climate and SLR models.



Social vulnerability due to sea level rise as presented by the NOAA Coastal Service's Center Sea Level Rise and Coastal Flooding Impacts Viewer

on two future periods: early-to-mid 21st century (2020-2040) and late 21st century (2080-2100). These represent short- and long-term time frames that encompass the planning horizons for interests such as natural resource management and urban/environmental planning. The output from the FSU climate model will be used as input to the higher resolution regional atmospheric model used at North Carolina State University. This 'downscaling' approach will allow for higher tropical cyclone intensity changes not permitted by the global climate model on account of its resolution. The surface wind fields from the regional model will then be used as inputs to the coastal inundation models used at UF and NCSU.

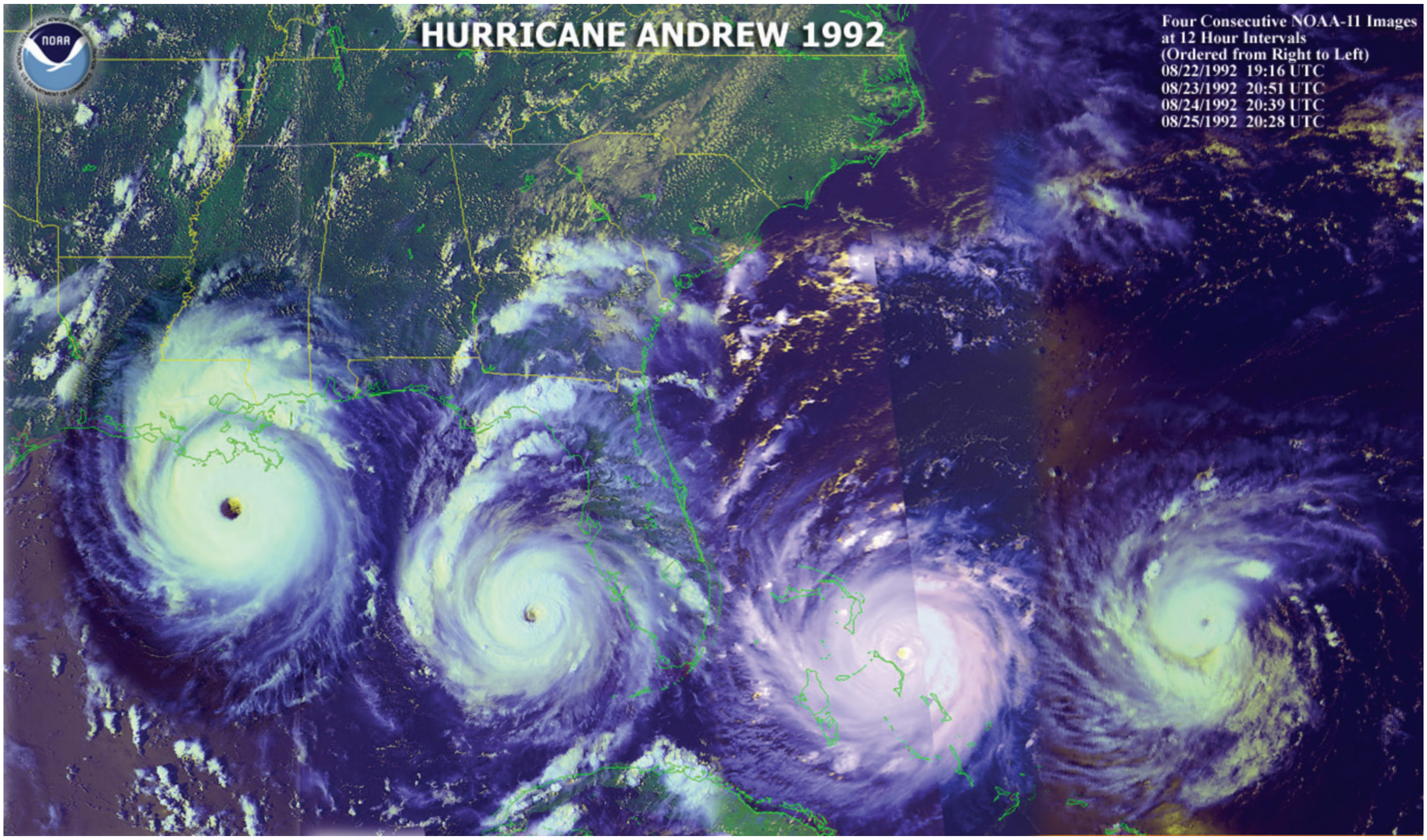
Downscaling from the Global to Regional Scale

Most of the studies on the impact of climate change on the coastal zone have been based on global climate model projections derived from IPCC assessment reports. However, global climate models are too coarse to project the level of spatial details in the climate data required for coastal inundation mapping. This study utilizes a regional climate model to downscale intensity changes of hurricanes at the coasts of Florida and the Carolinas. This will allow policy-makers to understand the risks at the local level that are contained in hurricanes in a future climate. Our downscaling technique will take the large-scale flows determined by the FSU global climate model and project smaller scale circulation near the Southeast US Coast.

Sea Level Rise

Another aspect of our research is to evaluate the projected global mean sea level rise from the models used in the latest Intergovernmental Panel on Climate Change. This will be done using a statistical relationship between global temperatures and mean sea level height and to combine these projections with the projected local regional sea level anomalies along the FL and NC coasts. These anomalies, initially available at 1° resolution, will be further downscaled to the resolution of available historical observations (tidal gauges and satellite observations).

As the global atmosphere warms, ocean waters warm and expand. This plus the melting glaciers and ice sheets in Greenland and Antarctica drive sea levels higher over the long term. Satellites as well as water level gauges have been measuring remarkably steady rise of the global ocean for the past decades. However, every once in a while, sea level rise hits a speed bump. From 2010 to 2011, global sea level actually fell by about half a centimeter. Climate scientist at NASA's Jet Propulsion Laboratory says you can blame it on the cycle of EL Nino and La Nina in the Pacific. While there was a sizable EL Nino at the beginning of 2010, it was replaced by one of the strongest La Ninas in recent history, causing massive flooding in Australia and Brazil, yet severe drought in southern U.S. The water in Australia and Brazil came from the evaporation of ocean water, causing temporary drop in sea level. However, these extra water will eventually flow back into the ocean, causing sea level rise again.



With 175 mph winds, Hurricane Andrew (1992) was the last major Category 5 storm to hit the U.S. (NOAA).

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Active Stakeholders

Florida Climate Institute

Guana Tolomato Matanzas National Estuarine Research Reserve

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