CHS13-01

Assessing climate change impact on rainfall-runoff at the event and seasonal scales in the Apalachicola River Basin

Alizad, K., Chen, X., Hagen, S. C. and Wang, D.

Corresponding Author: Karim Alizad, University of Central Florida (kalizad@knights.ucf.edu)

Poster Presenter: Karim Alizad, University of Central Florida (kalizad@knights.ucf.edu)

One of the most effective tools for water resources planning and studying coastal ecosystem dynamics is modeling rainfall-runoff under various scenarios. These scenarios may represent projected future climate change or anthropogenic changes to the basin. Climate change affecting the hydrologic cycle, and in turn impacting water resources, is a major concern as it may impact the rainfall patterns. In this study, two hydrologic models for the Apalachicola River Basin (ARB) are developed to investigate the potential change in the flow characteristics at different time scales.

The Apalachicola River is formed by the confluence of Chattahoochee and Flint Rivers and has the largest discharge in Florida. This river is home to a variety of plant and animal species. Altered water level in future climate change scenarios could cause disconnects between the channel and floodplain, decreasing the available habitat for the regions species.

Assessment of the climate change impact on rainfall intensity-duration-frequency (IDF) curves was performed by the method of sequential monthly bias correction and maximum intensity percentile-based bias correction method. Rainfall data for present and future years (30-year periods) was acquired from the North American Regional Climate Change Assessment Program (NARCCAP), where the A2 emission scenario was used. The primary driving force for the event simulation is varied design storms derived from IDF curves.

For the event scale, assessment of extreme rainfall events under climate change scenarios utilizing rainfall IDF curves is carried out using the WASH2D (WaterShed system of 2-D overland regime) numerical model. It is derived from WASH123D and can model surface flow in a watershed system using three approaches: kinematic, diffusive, and dynamic wave models. A two-dimensional mesh for the ARB is developed and rainfall-runoff is simulated under several events within the mesh. Predicted future IDF curves are implemented to forecast future river flow. Results from the WASH2D numerical model using future IDF curves are examined to gain insight into the flow and watershed responses to potential storms.

For a seasonal scale study, a seasonal water balance model is developed based on Budyko's framework and the curve number method. Unlike long-term water balance models of mean-annual scale, this monthly scale model considers the impact of storage, which is normally assumed to be negligible at longer time scales. The model is applied to a tributary of the Apalachicola River, i.e., the Chipola River, for projecting future water balance patterns based on historical data and future projections of climate change.

CHS13-02

Sea-level rise impact on the salt marshes of the South Atlantic Bight

Bacopoulos, P., Hagen, S. C., Morris, J. T. and Weishampel, J. F.

Corresponding Author: Peter Bacopoulos, University of North Florida (peter.bacopoulos@unf.edu)

Poster Presenter: Peter Bacopoulos, University of North Florida (peter.bacopoulos@unf.edu)

The impact of sea-level rise on salt marsh sustainability is examined for the South Atlantic Bight. A two-dimensional hydrodynamic model, forced by tides and sea-level rise, is coupled with a zero-dimensional marsh model to estimate the level of biomass productivity of Spartina alterniflora across the salt marsh landscape for present-day and anticipated future conditions, i.e., when subjected to sea-level rise. One major factor expected to influence salt marsh sustainability into the future is that the tidal datums of mean low water (MLW) and mean high water (MHW) increase nonlinearly and spatially non-uniform with sea-level rise. Another major factor expected to influence salt marsh sustainability into the future is that the salt marsh naturally accretes based on its biomass productivity. The goal of the research is to develop an integrated model of hydrodynamics and salt marsh productivity that captures the feedback between hydrodynamics and salt marsh productivity in a time marching basis considering sea-level rise. Ultimately, the integrated model can be adopted as a coastal hazards predictive tool to consider future conditions of salt marsh productivity in the face of sea-level rise.

CHS13-03

Sea level assessments of storm surge: A case study using Hurricane Katrina

Bilskie, M. V., Medeiros, S. and Hagen, S. C.

Corresponding Author: Matt Bilskie, University of Central Florida (Matt.bilskie@gmail.com)

Poster Presenter: Matt Bilskie, University of Central Florida (Matt.bilskie@gmail.com)

Major hurricanes have a high probability of impacting the northern Gulf of Mexico, especially coastal Mississippi. Due to the wide and flat continental shelf, this area provides near-perfect geometry for high water levels under tropical cyclonic conditions. Further, it is generally agreed that global sea levels due to climate change will rise anywhere from 18 to 100 cm by the year 2100, with some projections even higher. Further, it is recognized that coastal Mississippi is highly susceptible to a retreating shoreline from sea level rise coupled with predictions for less frequent, more intense tropical storms from an increase in sea surface temperature (SST).

An ADCIRC+SWAN hydrodynamic model of coastal Mississippi was utilized to simulate Hurricane Katrina with present day sea level conditions. Using present day as a base scenario, past and future sea level changes were simulated. A regression analysis was performed at local tide gauges to estimate past and project future sea levels. Also, surface roughness (i.e. Manning's n and wind reduction factors) was adjusted to reflect past and future landcover conditions.

Here, past, present and future sea level scenarios are modeled using a dynamic approach, along with Hurricane Katrina, and compared to present dynamic responses to sea level rise. The dynamic results will be compared and contrasted with a simpler static rise model approach. It will be demonstrated that water levels do not change linearly with modeled sea level cases (i.e. a 50 cm rise in sea level will not result in an additional 50 cm of water level at a given location) and are highly variable due to local conditions (e.g. topography, bathymetry, and surface roughness). Further, nearshore wind-wave conditions are affected by changes in local sea level due to the changes in momentum transfer from the waves to the water column. The results will be used to gain insight into possible morphological changes given several sea level scenarios coupled with an intense tropical cyclone.

CHS13-04

Using virtual appliances to communicate coastal hazard risk

Davis, J. R., Paramygin, V. A., Vogiatzis, C., Figueiredo, R. J., Sheng, Y. P. and Pardalos, P. M.

Corresponding Author: Justin R. Davis, University of Florida (davis@coastal.ufl.edu)

Poster Presenter: Justin R. Davis, University of Florida (davis@coastal.ufl.edu)

Communicating the risks of coastal hazards simultaneously to government agencies, researchers and coastal communities is especially challenging due to the wide variety of technical understanding among these diverse stakeholder groups. A typical approach to deal with this challenge is through the development of online web tools, such as Surging Seas: Sea Level Rise Analysis (Climate Central) or the Sea Level Rise and Coastal Flooding Impacts Viewer (NOAA Coastal Services Center,) or offline tools such as Hazus. While providing useful features, the online products typically use simplified approaches which cannot be modified / enhanced by the user, and offline approaches require potentially expensive software and / or are limited in their capabilities by the extent of local computational resources. To meet the challenge of developing a more adaptable education and outreach tool, the Coastal Science Educational Virtual Appliance (CSEVA) was developed. This unique tool supports interdisciplinary coastal science education and outreach activities, enabling active, hands-on, numerical modeling experiments by researchers, stakeholders and the general public. Using a newly developed application focusing on the transportation network in the Northeast Florida Regional Planning Model subject to the impact of a tropical storm under present and future climates, the capability of this system to communicate coastal hazard risk is highlighted.

CHS13-05

Modeling storm surge risk in a changing climate

Dill, N. and Bosma, K.

Corresponding Author: Nathan Dill, Woods Hole Group, Inc. (ndill@whgrp.com)

Poster Presenter: Nathan Dill, Woods Hole Group, Inc. (ndill@whgrp.com)

In many coastal areas the adverse impacts of climate change and sea-level rise may be reduced by a careful response to the increased threat of storm induced flood damage. The identification of appropriate adaptive actions (e.g. abandonment, retreat, elevation, protection, and engineering approaches) depends largely on an understanding of the present and future surge-induced flood risk. In particular, an accurate and precise assessment of the exceedance probability of tropical cyclone induced storm surge, provided at high spatial resolution, will help decision makers identify areas of existing vulnerability requiring immediate action, as well as, areas that benefit from present planning for future vulnerability. This poster gives an overview of a novel approach to generating this information by combining recent methodology for wind damage risk assessment with state of the practice hydrodynamic modeling of hurricane storm surge. Multiple large statistically robust sets of synthetic hurricanes, simulated using coupled atmospheric-oceanic models for present and future climate scenarios are used to create empirical Cumulative probability Distribution Functions (CDFs) for the Hurricane Surge Index (HSI). Subsets of these storms are then used to drive an ADvanced CIRCulation (ADCIRC) model which simulates the dynamic inundation processes over a high resolution topography/bathymetry. In turn, the maximum surge levels from the ADCIRC simulations are combined with the HSI statistics and a spatially variable Track Surge Index (TSI), and then used to develop CDFs of the storm surge still water levels at a high degree of spatial precision.

CHS13-06

The application of statistically modeled storm dataset on coastal hazard risk assessment

Feng, X., Sheng, Y. P., Condon, A. J., Paramygin, V. A. and Hall, T. M.

Corresponding Author: Xi Feng, University of Florida (feng@coastal.ufl.edu)

Poster Presenter: Xi Feng, University of Florida (feng@coastal.ufl.edu)

During the last two decades, North Atlantic hurricane activities have become more frequent and intense along U.S. Atlantic and Gulf coasts. Coastal inundation from hurricane-induced storm surges have caused catastrophic damage to lives and property, as evidenced by Hurricanes Katrina (2005), Ike (2008), and Sandy (2012). Current probabilistic coastal inundation hazard analysis usually makes use of the Base Flood Elevation (BFE) map.

BFE (Base Flood Elevation) map is used by FEMA (Federal Emergency Management Agency) to quantify the inundation hazard induced by hurricane storm surges. A recently developed very efficient method, JPM-OS (Joint Probability Method with Optimal Sampling), for determining storm response and inundation return frequencies was applied to BFE maps generation along the Southwest FL, US coast. The end result is an ensemble of a few hundred (197) optimal storms and inundations which are simulated using a dynamically coupled storm surge / wave modeling system CH3D-SSMS, from which the surge response is generated. The available historical dataset (28 storms across 1940-2012), however, is rather sparse for developing probabilistic characterizations of key storm parameters (pressure deficit, radius to maximum winds, forward speed, heading, and landfall location). The sparse historical storm data con-strains the accuracy of the PDFs (Probability Density Functions) of the hurricane characteristics and hence the accuracy of the BFE calculated.

To offset the deficiency of the sparse historical storm dataset, this study presents a different method for producing coastal inundation maps. Instead of using the historical storm data, here we adopt 10,062 tracks that can represent the storm climatology in North Atlantic Basin and West Florida Coasts. This large quantity of hurricane tracks is generated from a new statistical model which has been used for tropical cyclone (TC) genesis in the Western North Pacific (WNP) as well as the North Atlantic. The introduction of these tracks rectifies the shortage of the historical samples and allows for more reliable PDFs required for implementation of JPM-OS. Using the 10,062 tracks and JPM-OS, a new optimal storm ensemble is determined.

This study aims to: (1) Re-establish the feasibility of the newly developed JPM-OS method for BFE generation; (2) Compare the BFEs generated by the new tracks vs. the historical tracks; and (3) Determine the feasibility of statistically modeled storm dataset for generation of BFE.

CHS13-07

Three adaptation planning projects led by the University of Florida's College of Design, Construction, and Planning

Frank, K., Reiss, S. and Hoctor, T.

Corresponding Author: Kathryn Frank, Urban and Regional Planning, University of Florida (kifrank@ufl.edu)

Poster Presenter: Sean Reiss, Urban and Regional Planning, University of Florida (seanareiss@ufl.edu)

The College of Design, Construction, and Planning (DCP) is rapidly becoming a leader in the area of sea level rise and climate change adaptation planning. Building on existing and previous University of Florida research, three sea level rise adaptation planning projects are currently being led by DCP faculty. Research on global systems suggests that coastal communities and regions are becoming increasingly vulnerable to sea level rise and climate change. As a result, researchers and practitioners are developing processes, tools and strategies for adapting to future impacts. The poster will provide a short description and contact information for each of the following projects: (1) Planning for Sea Level Rise in the Matanzas Basin: Piloting an Adaptive Conservation Design Process for the National Estuarine Research Reserve System; (2) Planning for Coastal Change in Levy County: Piloting a Scoping and Engagement Process for Florida's Big Bend; (3) Predicting and Mitigating the Effects of Sea Level Rise and Land Use Changes on Imperiled Species and Natural Communities in Florida.

CHS13-08

The value of meteorological and oceanographic observations to operational marine weather forecasting in the Florida Keys

Kasper, K. B

Corresponding Author: Kennard Kasper, NOAA/National Weather Service (kennard.kasper@noaa.gov)

Poster Presenter: Kennard Kasper, NOAA/National Weather Service (kennard.kasper@noaa.gov)

The Florida Keys are home to a vast, diverse, and vulnerable marine community. Every day, members of this community participate in weather-sensitive, and inherently high-risk operations across the spectrum of maritime activities. These operations involve weather-related decisions that consider human safety, environmental protection, and economic interests. The primary meteorological hazards in the Florida Keys and the adjacent coastal waters include gale-force winds, thunderstorms, waterspouts, and hurricanes. These hazards pose a significant threat to life and property and require well-executed local emergency activities which necessarily consider marine weather information from the National Weather Service. In addition, Florida Keys National Weather Service meteorologists generate routine forecasts of wave height for an area greater than 22,000 square miles covering the Straits of Florida, Hawk Channel, and extreme southeastern Gulf of Mexico. Therefore, the daily operational marine weather forecasting mission at the Florida Keys National Weather Service relies heavily on both meteorological and oceanographic observations. Such observations directly support short-range marine weather forecasting and warning operations and contribute to development of climatologies, case studies, and warning and forecast verification efforts. Marine meteorological and oceanographic observations are especially important in providing decision support to core partners like the U.S. Coast Guard, NOAA/Florida Keys National Marine Sanctuary, and other Federal, State, and local partners. Moreover, the observations are used directly by many marine weather customers in the conduct of their daily activities. Several examples will be presented which will highlight the value of marine meteorological and oceanographic observations to the National Weather Service marine weather warning and forecast mission, with specific reference to the complex coastal environment in the Florida Keys.

CHS13-09

Quantifying the dissipation of storm surge by coastal vegetation

Lapetina, A. J. and Sheng, Y. P.

Corresponding Author: Andrew Lapetina, University of Florida (lapetina@ufl.edu)

Poster Presenter: Andrew Lapetina, University of Florida (lapetina@ufl.edu)

Vegetation such as tidal marshes and mangroves can significantly affect the risk associated with coastal hazards such as storm surge by affecting water levels, wave processes, and turbulent mixing. This study makes use of a one-dimensional turbulent kinetic energy (TKE) model and validated with data from several flume experiments. The model is incorporated into a three-dimensional coupled circulation-wave model, CH3D-SWAN, to simulate the influence of coastal wetlands on storm surge and inundation at the regional scale. In many two-dimensional storm surge models, the effects of vegetation are included through an enhanced Manning coefficient, but the modeling system presented here is a significant improvement, because it realistically models vertical velocity profiles in flow through vegetation.

To quantify the influence of coastal vegetation on coastal hazards, two experiments utilizing this three-dimensional vegetation-resolving storm surge model are presented. The first investigates the influence of vegetation canopies of varying sizes on the same storm, and the second examines how the dissipation of storm surge by given vegetation is affected by a storm's forward speed and intensity. Three variables describing vegetation canopies are considered (canopy density, canopy height, canopy width) and two variables describing storm conditions are considered (forward speed and storm intensity). Clear trends on the influence of various parameters emerge, and will prove valuable to evaluating coastal hazards.

CHS13-10

Modulation of North Atlantic tropical cyclones in the mid to late 21st century

LaRow, T. and Stefanova, L.

Corresponding Author: Timothy LaRow, Florida State University (tlarow@fsu.edu)

Poster Presenter: Timothy LaRow, Florida State University (tlarow@fsu.edu)

The controversy regarding the response of tropical cyclones to greenhouse gas emissions within a future warming climate has dominated the peer reviewed literature in the past few decades. This study uses the Florida State University/Center for Ocean Atmospheric Prediction Studies (FSU/COAPS) global spectral model to examine tropical cyclone activity in the mid-to-late 21st century using two climate model projections of sea surface temperatures (SSTs) from the CMIP5 RCP4.5 experiment. The Canadian Climate Centre Model and the Community Climate System Model SSTs were selected for this study. The SSTs are modified in the North Atlantic to include the observed positive and negative phases of the Atlantic Multi-decadal Oscillation (AMO). Two 20-year time periods were simulated (2020-2039 and 2080-2099) using the modified SSTs, resulting in over 160 unique simulations. Changes in tropical cyclone frequency, intensity and precipitation for the mid and late 21st century compared to historical 20th century simulations are presented.

CHS13-11

Simulation of storm surge, wave and coastal inundation in the Outer Banks and Chesapeake Bay during Hurricane Isabel (2003), Earl (2010) and Irene (2011)

Liu, T. and Sheng, Y. P.

Corresponding Author: Tianyi Liu, University of Florida (liutianyi@coastal.ufl.edu)

Poster Presenter: Tianyi Liu, University of Florida (liutianyi@coastal.ufl.edu)

Storm surge, wave and coastal inundation in the Outer Banks and Chesapeake Bay during three recent hurricanes – Isabel (2003), Earl (2010) and Irene (2011), have been successfully simulated using the storm surge modeling system CH3D-SSMS, which includes coupled coastal and basin-scale storm surge and wave models. Hurricane Isabel, which made landfall at the Outer Banks area, generated high waves up to 20 m offshore, while lower wave heights were created by Earl (9.5 m) and Irene (14 m), and the maximum surges generated by Isabel, Earl and Irene were 3 m, 2 m and 2.5 m, respectively. The inundation maps obtained by the simulation show that the area around Pamlico Sound was flooded during all three different hurricanes and had higher inundation risk than other areas. The peak surges in the Pamlico Sound were significantly enhanced by wave setup: up to 40-50 cm (20%-30% of the peak surge level) during Isabel and Irene, and about 10-20 cm (~10% of the peak surge) during Earl, which increased the inundation risk around this area. The Pamlico Sound, which is highly susceptible to high wave conditions, is closed basin and a shallow body of water with depth less than 10 m, and waves generated by hurricane wind can easily break and create significant wave setup that could lead to inundation, as well as the breaching of a barrier island and inlet opening as during Isabel.

CHS13-12

Interdisciplinary applications of remotely sensed data in coastal and estuarine models

Medeiros, S. C. and Hagen, S. C.

Corresponding Author: Stephen Medeiros, University of Central Florida (Stephen.Medeiros@ucf.edu)

Poster Presenter: Stephen Medeiros, University of Central Florida (Stephen.Medeiros@ucf.edu)

As models increase in geographic scale, it becomes more difficult to accurately parameterize them due to the high variability of terrain and surface roughness conditions. Furthermore, in the case of hurricane storm surge models, it is often difficult to validate results due to a lack of during and post-storm data. Tide gauges and other measurement devices often malfunction or are destroyed during these catastrophic events. In order to remedy these problems, scientists and engineers often turn to remotely sensed data from aircraft or satellites. At the University of Central Florida (UCF), we are currently utilizing remotely sensed data within this context in four ways: digital terrain model (DTM) development, inundation detection, surface roughness parameterization and biomass estimation.

First, UCF is developing cutting edge DTMs by employing scalable and optimized cell averaging schemes that factor in mesh resolution when constructing the DTM. We are also employing vertical feature extraction to ensure that hydraulically significant features and included in the mesh.

Second, we are fusing Synthetic Aperture Radar (SAR) imagery, aerial photography, Landsat 7 ETM+ imagery and digital elevation data to detect inundated areas at a specific point in history. We then simulate the hydrodynamics at that same point in time by hindcasting the tides and weather conditions. The predicted inundation area is compared to the satellite-detected inundation area to generate geographically targeted error metrics that inform model refinement.

Third, since it has been proven that land use / land cover (LULC) data are insufficient to parameterize bottom friction (Manning's n) and aerodynamic roughness (z0) on their own, we are using 3-dimensional LiDAR point cloud data to enhance this parameterization. By integrating spatial statistics derived from the point clouds, our preliminary tests show dramatic error reductions in Manning's n parameterization on the order of 75%.

Last, in order to assess the changes in coastal ecosystems due to sea level rise, researchers must have a means to assess the condition of existing vegetation and monitor any changes as time progresses. In salt marsh systems, the communities tend to cover vast swaths of land that are difficult to access and nearly impossible to survey in their entirety. Therefore, we are developing a method to fuse LiDAR and ASTER data to predict above-ground biomass (AGBM) in these areas. After a model selection process using multiple regression, preliminary tests indicate that we can predict AGBM with an R-squared value above 0.70.

CHS13-13

A 24/7 high resolution forecasting system for the Florida Coast

Paramygin, V. A., Sheng, Y. P. and Davis, J. R.

Corresponding Author: Vladimir A. Paramygin, University of Florida (pva@coastal.ufl.edu)

Poster Presenter: Vladimir A. Paramygin, University of Florida (pva@coastal.ufl.edu)

A 24/7 high-resolution forecasting system for storm surge, coastal inundation, and baroclinic circulation is being developed for Florida using the CH3D Storm Surge Modeling System (CH3D-SSMS). It is based on the CH3D hydrodynamic model coupled to a coastal wave model SWAN and basin scale surge and wave models. CH3D-SSMS has been verified with surge, wave, and circulation data from several recent hurricanes in the U.S.: Isabel (2003); Charley, Dennis and Ivan (2004); Katrina and Wilma (2005); Ike and Fay (2008); and Irene (2011), as well as typhoons in the Pacific: Fanapi (2010) and Nanmadol (2011). The effects of tropical cyclones on flow and salinity distribution in estuarine and coastal waters has been simulated for Apalachicola Bay as well as Guana-Tolomato-Matanzas Estuary. CH3D-SSMS successfully reproduced different physical phenomena including large waves during Ivan that damaged I-10 Bridges, a large alongshore wave and coastal flooding during Wilma, salinity drop during Fay, and flooding in Taiwan as a result of combined surge and rain effect during Fanapi. It can be used to simulate 3D baroclinic circulation thus addressing other types of environmental hazards, such as damage to fisheries due to drastic changes in salinity and/or temperature. It's been used to estimate the effects of changes in the controlled flow of the Apalachicola River on oysters in the Apalachicola Bay.

The system uses four domains that cover entire Florida coastline: West, which covers the Florida panhandle and Tampa Bay; Southwest spans from Florida Keys to Charlotte Harbor; Southeast, covering Biscayne Bay and Miami and East, which continues north to the Florida/Georgia border. The system has a data acquisition and processing module that is used to collect data for model runs (e.g. wind, river flow, precipitation). Depending on the domain, forecasts runs can take ~1-18 hours to complete on a single CPU (8-core) system (1-2 hrs for 2D setup and up to 18 hrs for a 3D setup) with 4 forecasts generated per day. All data is archived / catalogued and model forecast skill is continuously being evaluated. In addition to the baseline forecasts, additional forecasts are being perform using various options for wind forcing (GFS, GFDL, WRF, and parametric hurricane models), model configurations (2D/ 3D), and open boundary conditions by coupling with large scale models (ROMS, NCOM, HYCOM), as well as incorporating real-time and forecast river flow and precipitation data to better understand how to improve model skill. Real time data such as water level and salinity gauges can be used for model verification and estimating model skill. Recently HF Radar surface currents data has been used for model result validation.

In addition, new forecast products (e.g. more informative inundation maps) are being developed to targeted stakeholders. To support modern data standards, the CH3D-SSMS results are available online via a THREDDS server in CF-Compliant NetCDF format as well as other stakeholder-friendly (e.g. GIS) formats. The SECOORA website provides visualization of the model via a GODIVA-THREDDS interface.

CHS13-14

Impacts of sea level rise on shoreline changes: A Bruun Rule application

Passeri, D. and Hagen, S. C.

Corresponding Author: Davina Passeri, University of Central Florida (dpasseri@knights.ucf.edu)

Poster Presenter: Davina Passeri, University of Central Florida (dpasseri@knights.ucf.edu)

Historic gage and satellite altimetry data demonstrate that sea levels have been rising largely due to glacial melt and thermal expansion from increasing mean sea surface temperatures. As sea levels rise, offshore and onshore sediment transport can cause unprotected shorelines to migrate landward. Shoreline retreat is a not only an ecological threat, but also a socio-economic threat due to the massive growth of coastal communities and billions of dollars in infrastructure along coastlines.

This study utilizes the Bruun Rule, a straight-forward method based on nearshore mass conservation, to predict the landward and upward displacement of the cross-shore beach profile in response to a rise in mean sea level. Through use of digital elevation models constructed from topographic and bathymetric data, in conjunction with existing wave data, the Bruun Rule is applied to areas with large stretches of sandy beach. Transects of beach profiles are analyzed, resulting in a spatial illustration of recessing shorelines and the resulting new beach profiles. Two applications of the Bruun Rule are demonstrated: a case study in the Northern Gulf of Mexico, which lays the groundwork for more substantial dynamic future assessments, including the incorporation of tide and storm surge studies of sea level rise, and a case study in the South Atlantic Bight region to determine shoreline recession from Miami, FL to Cape Hatteras, NC. In areas populated by complex coastal ecosystems and a growing population, prediction of shoreline recession is imperative for understanding the effects of sea level rise.

CHS13-15

A Regional Testbed for Storm Surge and Coastal Inundation Models

Sheng, Y. P., Davis, J. R., Figueiredo, R., Liu, B., Liu, H., Luettich, R., Paramygin, V. A., Weaver, R., Weisberg, R., Xie, L., and Zheng, L.

Corresponding Author: Y. Peter Sheng, University of Florida (pete@coastal.ufl.edu)

Poster Presenter: Y. Peter Sheng, University of Florida (pete@coastal.ufl.edu)

Since 2008, a Regional Testbed has been comparing storm surge models in terms of historical storm simulations and coastal inundation maps, e.g., Flood Insurance Rate Maps and Surge Atlas. The models include two structured grid (CH3D and POM) and two unstructured grid (ADCIRC and FVCOM) models. During 2008, the storm surge and coastal inundation in the Chesapeake Bay and the Outer Banks of North Carolina during Hurricane Isabel was simulated and the results compared in an independent but non-interoperable effort by partners. In 2009-2010, an additional model SLOSH was added, and all five models were used to simulate the storm surge and coastal inundation in southwest Florida during Hurricane Charley and the results compared. Model inputs and outputs were designed in an interoperable fashion, using common model input data, parameterization and coefficients, common model output formats using a common model data grid. Thirty scenarios were developed to test the sensitivity of the models to bathymetry, storm forcing, wind drag coefficient, bottom friction, Coriolis, 2D vs. 3D formulation, etc. Various types of model products, including time series of storm surge and maximum inundation over the entire model domain, were compared to each other and measured data. The detailed model simulations and comparisons required considerable computational and analysis time, but resulted in the discovery of how model features affected the model accuracy, leading to an overall improvement of all the models used. Testbed results showed differences in storm surge elevation and coastal inundation during both Isabel and Charley. While the simulated water level at the observed stations generally did not differ by more than 20% and no model appears to be consistently superior / inferior to any other model, there are more significant differences in the produced inundation maps. The computational efficiency differs considerably among the various models. Additional simulations of a large number (40+) of storms and domains are needed to better define the relative importance of different model parameters and to sort out the causes for subtle differences among the model results.

CHS13-16

Incorporating climate change effects into next-generation coastal inundation Decision Support Systems: An integrated community-based approach

Sheng, Y. P., Davis, J. R., Paramygin, V. A., LaRow, T., Chassignet, E., Stefanova, L., Lu, J., Xie, L., Montalvo, S., Liu, P. and Liu, B.

Corresponding Author: Y. Peter Sheng, University of Florida (pete@coastal.ufl.edu)

Poster Presenter: Y. Peter Sheng, University of Florida (pete@coastal.ufl.edu)

Coastal inundation during hurricanes and storms poses a major threat to the 75% of the U. S. population who live within 100 miles 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 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. 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, FEMA, USACE, DOT, and 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.

The goal of this project is to develop the next generation Decision Support System (DSS), by incorporating the projected impact of climate change on hurricanes and SLR.

CHS13-17

Sea level rise along the Southeast US coast: Using historical measurements to inform the downscaling of CMIP5 projections

Stefanova, L., Lu, J. and LaRow, T.

Corresponding Author: Lydia Stefanova, Florida State University (lstefanova@fsu.edu)

Poster Presenter: Lydia Stefanova, Florida State University (lstefanova@fsu.edu)

The local sea surface heights from eight CMIP5 models have been extracted for the historical and RCP4.5 scenarios. A wide range of the simulated local surface heights above the geoid is seen in both the historical and RCP4.5 simulations, even between models produced within the same modeling center. All eight CMIP5 models considered here project a steady rise of global average thermosteric sea level change throughout the 21st century. This increase ranges from just over 10 cm to slightly over 20 cm, with a multi-model ensemble mean of about 20 cm, over the period 2006-2100.

Since it is impossible to determine a “best” model from the CMIP5 data set, we are adopting a multi-model ensemble approach to describe the uncertainty of projected SLR trends. The CMIP5 models produce local sea level rise (SLR) values at a coarse resolution, on the order of 1° latitude/longitude. However, calculation of local inundation levels requires high-resolution sea level information. Long-term sea level measurements are available at a relatively small number of stations spaced wide apart. A high-resolution satellite-derived data set (AVISO) is available for a relatively short period of time (1993-present). A handful of tidal gauges along the Southeast US coast provide long-term historical record of SLR.

To downscale the CMIP5 projections to a high resolution it is necessary to establish the models’ historical bias at that resolution using a long-term record. Here, we demonstrate the procedure that we have adopted to downscale CMIP5 projected SLR to a high resolution grid over the coast line of the Southeastern United States.

Analysis of the AVISO data for the region illustrates the relative uniformity and smooth variability of SLR along the coastline of interest. Given this high degree of spatial consistency, it is possible to interpolate the long-term historical tidal gauge SLR data to a regular high-resolution grid. The downscaling process involves (a) subdividing the coastline into grid boxes at the desired resolution (e.g. 10 km); (b) using these boxes' coordinates to interpolate the historical SLR trends at existing long-term tidal gauge stations to the high resolution grid; (c) interpolating model trends for the historical period to the high resolution grid; (d) from (b) and (c) creating and solving a regression equation relating the historical model data to the interpolated observations; (e) repeating (c) for the 21st century data; and, finally, using the regression coefficients derived from the historical period to create the bias-corrected high-resolution estimate of the future SLR trends.

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2011 Japan tsunami hydrographs, currents, and inundation flow velocities based on video and LiDAR measurements

Fritz, H. M., Phillips, D. A., Okayasu, A., Shimozono, T., Liu, H., Takeda, S., Mohammed, F., Skanavis, V., Synolakis, C. E. and Takahashi, T.

Corresponding Author: Hermann M. Fritz, Georgia Institute of Technology (fritz@gatech.edu)

Poster Presenter: Hermann M. Fritz, Georgia Institute of Technology (fritz@gatech.edu)

The March 11, 2011, magnitude Mw 9.0 earthquake off the Tohoku coast of Japan caused catastrophic damage and loss of life to a tsunami aware population. The mid-afternoon tsunami arrival combined with survivors equipped with cameras on top of vertical evacuation buildings provided fragmented spatially and temporally resolved inundation recordings. This report focuses on the surveys at 9 tsunami eyewitness video recording locations in Myako, Kamaishi, Kesennuma and Yoriisohama along Japan's Sanriku coast and the subsequent video image calibration, processing, tsunami hydrograph and flow velocity analysis. Selected tsunami video recording sites were explored, eyewitnesses interviewed and some ground control points recorded during the initial tsunami reconnaissance in April, 2011. A follow-up survey in June, 2011 focused on terrestrial laser scanning (TLS) at locations with high quality eyewitness videos. We acquired precise topographic data using TLS at the video sites producing a 3-dimensional "point cloud" dataset. A camera mounted on the Riegl VZ-400 scanner yields photorealistic 3D images. Integrated GPS measurements allow accurate georeferencing. The original video recordings were recovered from eyewitnesses and the Japanese Coast Guard (JCG). The analysis of the tsunami videos follows an adapted four step procedure originally developed for the analysis of 2004 Indian Ocean tsunami videos at Banda Aceh, Indonesia. The first step requires the calibration of the sector of view present in the eyewitness video recording based on ground control points measured in the LiDAR data. In a second step the video image motion induced by the panning of the video camera was determined from subsequent images by particle image velocimetry (PIV) applied to fixed objects. The third step involves the transformation of the raw tsunami video images from image coordinates to world coordinates with a direct linear transformation (DLT) procedure. Finally, the instantaneous tsunami surface current and flooding velocity vector maps are determined by applying the digital PIV analysis method to the rectified tsunami video images with floating debris clusters. Tsunami currents up to 11 m/s were measured in Kesennuma Bay making navigation impossible. Tsunami hydrographs are derived from the videos based on water surface elevations at surface piercing objects identified in the acquired topographic TLS data. Apart from a dominant tsunami crest the hydrograph at Kamaishi also reveals a subsequent draw down to minus 10 m exposing the harbor bottom. In some cases ship moorings resist the main tsunami crest only to be broken by the extreme draw down and setting vessels a drift for hours. Further we discuss the complex effects of coastal structures on inundation and outflow hydrographs and flow velocities. Lastly a perspective on the recovery and reconstruction process is provided based on numerous revisits of identical sites between April 2011 and July 2012.