COASTAL RESILIENCE CENTER
A U.S. Department of Homeland Security Center of Excellence

Coastal Resilience Center of Excellence
Research Lead

based at

The University of North Carolina at Chapel Hill

YEAR 4 ANNUAL REPORT

Reporting Period:
July 1, 2018 – June 30, 2019
Award Number 2015-ST-061-ND0001-01

submitted to:

The Office of University Programs
Science & Technology Directorate
U.S. Department of Homeland Security

Coastal Resilience Center of Excellence
100 Europa Drive, Suite 540
Campus Box 7581
Chapel Hill, NC 27517
coastalresiliencecenter.org

August 2019
Revised March 2020

US Department of Homeland Security
Coastal Resilience Center of Excellence – Research Lead
Based at the University of North Carolina at Chapel Hill
Award Number 2015-ST-061-ND0001-01
YEAR 4 ANNUAL REPORT
(Reporting period: July 1, 2018 – June 30, 2019)

Theme 4: Education and Workforce Development

Appendices

DHS S&T Coastal Resilience Center of Excellence
based at
The University of North Carolina at Chapel Hill
Year 4 Annual Report
July 1, 2018 – June 30, 2019

I. INTRODUCTION AND CENTER OVERVIEW

This report provides a description of the activities and accomplishments of the Coastal Resilience Center of Excellence (CRC) that occurred during Year 4 of the Center's operations, covering the reporting period July 1, 2018, to June 30, 2019.

Report Structure

The first section of this annual performance report summarizes the administrative/management structure of the CRC, followed by a description of selected activities that were undertaken at the Center level during Year 4, including summaries of supplemental studies carried out by the CRC, a description of ongoing program activity, and activities taken in support of the DHS S&T Centers of Excellence network.

Following the summary is a section containing individual progress reports from each of the CRC PIs. The CRC provided a template to assist PIs describe in detail their research and education activities; progress in achieving project milestones; efforts towards transition of project outputs; interactions with end-users and stakeholders; and student activity. In addition, the template included a customized chart for each PI to report on project metrics for Years 1-4. These metrics are reported in the aggregate to DHS OUP each calendar year.

Finally, this report includes three appendices: Appendix A contains a report submitted by the CRC student recipient of the DHS S&T funded Science and Engineering Workforce Development Grant; Appendix B contains a list of journal articles, conference papers, and other documents produced by PIs with support from CRC; and Appendix C contains material that supplements the reports of a few individual PIs.

CRC Project Composition

During Year 4 CRC managed a total of 15 projects carried out by partners from 15 universities and colleges and three private-sector firms located in eight U.S. states and one U.S. territory. Five projects focused on enhancing and institutionalizing education and workforce development programs at partner institutions; of these partners, four are classified as Minority Serving Institutions (MSIs). The remaining CRC projects focused primarily on research in coastal hazards modeling, planning, and social and behavioral sciences.

Delays in receiving full funding for Year 4 impacted the ability of several projects to make as much progress as had been proposed, resulting in some milestones not being met on schedule. In particular, 50% of the funding slated for ADCIRC-related projects was restricted by DHS until CRC met the condition of developing a plan to integrate all the ADCIRC projects into one portfolio. The plan was developed and submitted to DHS, however, administrative issues compounded the delay in issuing these funds.

Summary Statistics

Despite funding delays, CRC PI's made steady progress on their projects as demonstrated by the following aggregated figures:

- PI's reported teaching **46 courses** to **453 students** across six campuses, including class offerings in multiple categories, such as majors, minors, concentrations, certificate programs, seminars, and electives.

- Students were involved in **23 internships** related to Homeland Security.

- **36** students received **Homeland Security-related degrees**, nearly half of whom were at the graduate level.

- **12** students secured **employment in Homeland Security**-related fields.

- **49** journal articles were submitted and/or published.

- PIs gave more than **200** project-related **presentations** in a variety of settings, including professional conferences, visiting lecture series, panel discussions and outreach events, among others.

- Center partners reported **more than $2.7 million in non-OUP funding**. Funding came from a variety of sources, such as government agencies, foundations and internal institutional programs. Note: the definition of non-OUP funding was changed from the definition used in previous years to ensure more accurate funding amounts and greater consistency among PI reporting methods.

CRC Administration and Management

The structure and associated roles and responsibilities of the CRC were altered at the mid-way point in Year 4 with the departure of the Director, Gavin Smith, as well as the conclusion of the Hurricane Matthew Resilience and Recovery Initiative. The following two organizational charts depict the changes made to the CRC management structure during Year 4.

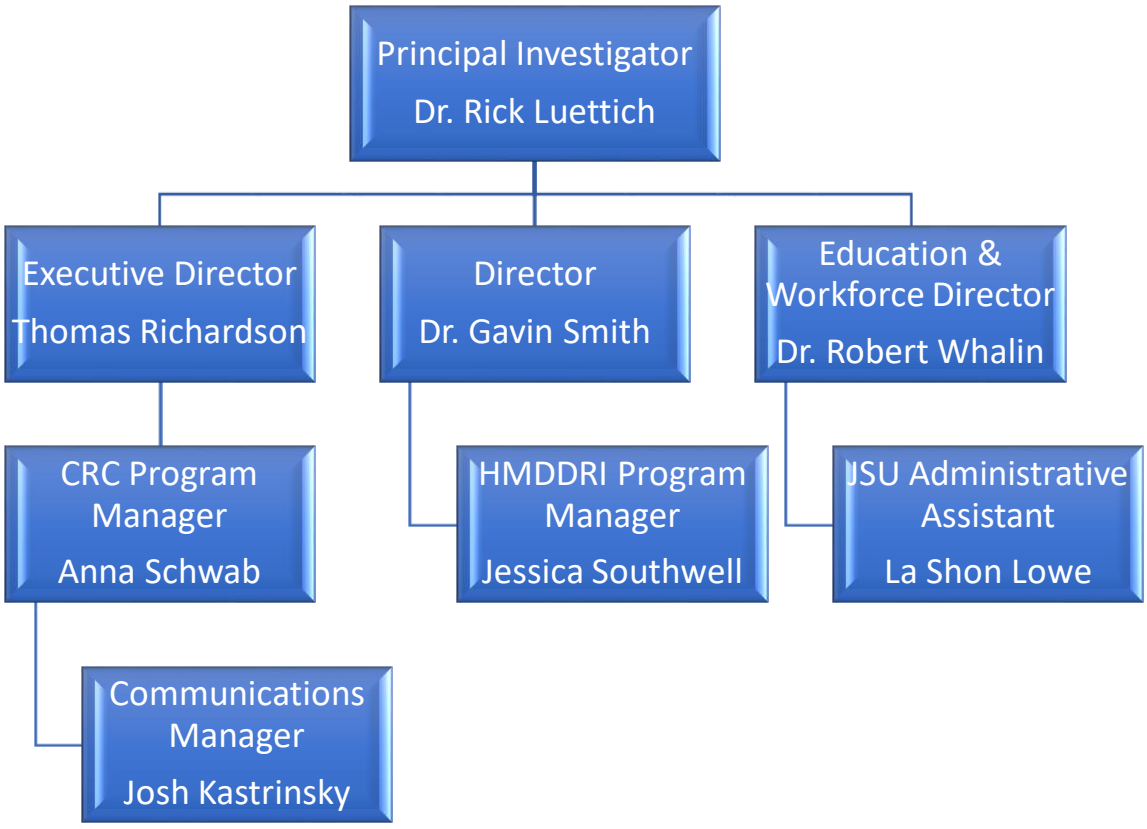


Figure 1: CRC organizational chart, July 1, 2018 – January 1, 2019

Figure 2: CRC organizational chart, January 1, 2019 – June 30, 2019

Internal Communications

Frequent communication continued to be an essential mechanism for ensuring coordination among members of the CRC management team during Year 4. As in prior years, weekly meetings were held every Monday morning with Center management and staff. A running chronological narrative for each issue and task was captured, listed, and assigned to a member of Center management for implementation. Monthly Center conference calls with PIs and Advisory Board members continue to be used to discuss business matters, plans and upcoming events, and to address questions and concerns. The CRC email listserv was used throughout Year 4 to send messages regarding important management issues, as well as information of general interest such as funding announcements, job postings, and student opportunities. Subscribers to the CRC listserv included PIs, Center management, and the DHS Program Manager. A separate listserv was used to communicate with Advisory Board members.

External Communications

Led by the CRC Communications Manager, Josh Kastrinsky, CRC communicated information about its projects, events, successes and interactions with end users, stakeholders and the general public through the following media:

- News posts placed on the CRC website

- An informational website about the ADCIRC Prediction System™ (APS)
- Electronic newsletters issued 10 times a year
- Social media (Twitter and Facebook)
- Videos produced by CRC and in partnership with other groups, posted on YouTube
- Media interviews about CRC projects and expertise regarding current hazard events

Social media posts reach an audience of about 2,250 users across Twitter and Facebook, totaling about 50,000 impressions per month. The CRC website receives an average of about 1,900 unique visitors per month, while the CRC newsletter has about 1,500 recipients.

In November 2018 CRC hired Chris Johns to fill a part-time Visual Communications/Digital Media Specialist position to help guide, support, and execute the development and implementation of the CRC's graphic identity and visual media products. Mr. Johns has begun creating and deploying print, digital and multimedia graphic products that tell the story of CRC work and that communicate the impacts and capabilities of Center products. In addition, Mr. Johns develops web graphics, informational graphics for projects, multimedia designs, animation, and videography.

Unified Business Center

Essential support functions during Year 4 were provided by the Renaissance Computing Institute's Unified Business Center (UBC), including: assistance with grant management, financial administration, human resources, travel, event planning, purchasing, and other administrative functions. The UBC also continued to provide pre- and post-award administrative services, including developing, executing, and managing subcontracts.

CRC Advisory Board

Many members of the CRC Advisory Board who served during Years 1-3 continued to be involved in the Center through Year 4 as well. Board members have helped the Center by reviewing and providing feedback on overall Center activities, evaluating current projects, and helping to place graduate students in internships and careers. Board members also help to identify transition partners, and to serve as subject matter experts as needed.

The primary mechanism for transmitting Board recommendations is the closed-door session immediately following the Center's Annual Meeting, as well as through communications with individual Board members.

The following members served on the CRC Advisory Board during Year 4:

- **Norma Anderson,** Founder, The William Averette Anderson Fund (BAF) for Hazard & Disaster Mitigation Education and Research
- **Doug Bellomo,** Institute for Water Resources, US Army Corps of Engineers
- **Chad Berginnis**, Executive Director, Association of State Floodplain Managers
- **Dr. John Cooper, Jr.,** Associate Professor of Practice, Landscape Architecture and Urban Planning Department, Texas A&M University

- **Dr. William Hooke,** Senior Policy Fellow and Director of Policy Programs, American Meteorological Society
- **Dr. Jae Park**, Recovery and Hazard Mitigation, AECOM
- **Dr. John Pine**, Director, Research Institute for Environment, Energy & Economics, Appalachian State University
- **Anthony Pratt,** Shoreline and Waterway Administrator, State of Delaware
- **Dr. Linda Rimer**, Region IV Liaison for Climate Resilience, U.S. Environmental Protection Agency
- **Ellis Stanley**, Executive Vice President, Hammerman & Gainer International and former General Manager, City of Los Angeles Emergency Preparedness Department
- **Dr. Lee Weishar,** Senior Scientist, Woods Hole Group, Inc.

II. CENTER-LEVEL ACTIVITIES

Over the course of Year 4, the CRC administrative and management team carried out multiple activities on behalf of the Center, as summarized below. Additional information is found on the CRC website.

CRC Annual Meeting

The fourth annual CRC meeting was held March 27-28, 2019, at the Center's main offices in Chapel Hill, NC. Fifty-seven attendees participated in the event, including the CRC management and support team; 22 Principal Investigators; 6 CRC Advisory Board members; 5 students (UNC-CH); and 18 DHS personnel, OUP support staff, and Federal Board of Directors.

Over the course of the two-day meeting, each research PI made a detailed presentation about their project, including a summary of research methodology and findings, outcomes to date, milestone accomplishments, as well as an update on engagement with the project's end users. Education PIs focused on how their projects' course content is kept current, their level of engagement with HSE professionals, and plans for courses to continue post-CRC funding. The Federal Board of Directors prepared evaluations of each presentation. Results of these evaluations were received by the CRC and will be incorporated into project workplans during Year 5. Updates about Center-level activities were also presented at the Annual Meeting, including the Floyd-Matthew Study (Flood Apex Project), the Floodplain Management Regulations Compliance Study; and Resilient Design Education in the United States.

ADCIRC Prediction System™

During Year 4, the CRC created a Year 5 workplan to develop a business plan for making the ADCIRC Prediction System™ (APS) self-sustaining. As part of the planning for this effort, the CRC invited Nancy Maron of BlueSky to BluePrint, LLC to make a presentation at the Year 4 annual meeting on transitioning from research products to a commercial enterprise. The CRC also began the process of applying for a Federally registered trademark for APS and an associated logo, which was still under development at the end of Year 4.

2018 Hurricane Season

The 2018 hurricane season was highlighted by Hurricanes Florence and Michael. CRC Lead PI Rick Luettich and PI Jason Fleming provided guidance based on the ADCIRC Prediction System™ to federal, state and local officials in North Carolina during the storm, including:

- APS predictions helped to inform US Coast Guard operations at the National USCG Command Center, Atlantic Area, District Five and Sector North Carolina before landfall.
- FEMA used APS results for storm damage assessments.
- North Carolina Division of Emergency Management used APS predictions for storm damage assessments and storm response.

Over the course of the season, CRC researchers appeared in more than 50 publications, including The Guardian, Washington Post, Forbes, The Wall Street Journal, The New York Times, PBS News Hour, CNN, Nature and The Weather Channel.

DHS Flood Apex Program

Research Review Board

The multidisciplinary Flood Apex Research Review Board was established formally in November 2015 by the CRC with 13 members from academia, DHS subject matter experts (e.g., FEMA), other federal, regional, state and local experts, professional organizations, and the private sector. The Research Review Board serves as an expert panel whose responsibilities include:

- Help the DHS Flood Apex Program Manager refine the concept, requirements, and target users of the Program;
- Provide input on existing and developing systems, methods, and data sources;
- Provide advice on gaps in knowledge, data, and technology;
- Review draft products and publications;
- Identify transition pathways to help ensure end-products are useable for target users, particularly as they may have differing levels of capability and capacity

The Board first met informally via webinar in September 2015. Through Year 4, it has met 13 times (7 via webinar and 6 in person). During Year 4, the CRC organized and managed the following meetings:

- August 27-28, 2018 – in-person meeting, Washington, DC
- December 13, 2018 – virtual meeting by webinar
- April 23-24, 2019 – in-person meeting, Washington, DC

Floyd/Matthew Study

In March 2019, the CRC released the results of a Flood Apex study by AECOM that compared the impacts of the two storms on eastern North Carolina and the improvements made by the state after Hurricane Floyd that mitigated the impacts of Hurricane Matthew. Led by Dr. Jae Park, the

AECOM team studied 17 theoretical indicators of resilience in six eastern North Carolina counties after Hurricane Matthew: Bertie, Columbus, Edgecombe, Lenoir, Robeson and Wayne. Indicators were divided into social, economic, physical and disaster management categories, and ranged from home ownership rate and availability of parks to unemployment and flood insurance coverage. The report can be found on the CRC website here.

ADCIRC Users Group Meeting and Boot Camp 2019

More than 50 people gathered at the US Army Engineer Research and Development Center's Coastal and Hydraulics Laboratory (ERDC CHL) in Vicksburg, Miss., from May 20-21, 2019, for the 23rd ADCIRC Users Group Meeting. Federal, academic and private-sector users of ADCIRC met to discuss their work using and building capacity for the coastal surge inundation model. The event was co-organized by CRC PI Jason Fleming of Seahorse Coastal Consulting, along with ERDC personnel.

Boot Camp Events

Because of high user demand, two sessions of the ADCIRC Boot Camp were offered this year to provide hands-on training for new users. Texas ADCIRC Week was held April 8-12, 2019, at the University of Texas-Austin. It was co-hosted by Gordon Wells (UT-Austin), CRC researcher Clint Dawson, and Jason Fleming of Seahorse Coastal Consulting. Thirty-eight participants attended sessions covering everything from "ADCIRC Fundamentals" to "Mapping for Risk Communication." Attendees came from 14 US academic institutions, 7 private-sector groups, 3 federal agencies, and one international research institution.

The second ADCIRC Week event, focused on Florida, is scheduled to be held in November 2019.

RETALK

The Research Talk program, or *RETALK*, began in Year 1, and involves research PIs delivering an in-person talk to students at a CRC education partner. The talk may be a lecture, seminar or other type of presentation where visiting PI's discuss the details of their research projects as they relate to courses taught at the host institution. Guest speakers may also engage the students in new and different ways of thinking about resilience issues by exposing them to expanded scientific or technical concepts. During Year 4, the following RETALK activities took place:

- Research in Coastal Engineering at UPRM, Dr. Dan Cox, and 2 others from Oregon State University, Dr. Jamie Padgett from Rice University, and Drs. Miguel Canals and Sylvia Rodriguez from UPRM gave 6 lectures to students, professors and general public at UPRM, December 6, 2018.
- Profs Ismael Pagán and Ricardo López of UPRM made 2 presentations in Dr. Gavin Smith's courses at UNC and NCSU, February 27, 2019.
- Dr. Gavin Smith visited UPRM and gave the presentation "Relocation of Coastal Communities", at UPRM, attended by a good mixture of students, professors and general public including officials from local and federal government, on April 26, 2019. He also visited coastal areas affected by Hurricane María.

SUMREX: Summer Research Experience

Every summer since the CRC began operations, select students have benefited from participation in the CRC's summer exchange program. The SUMmer Research EXperience, known as SUMREX, is a unique program developed by the CRC. Student support is provided through the project budgets of individual Research PIs.

Through the program, students enrolled in CRC-supported courses at partner universities are hosted by CRC research PIs for several weeks in the summer, where the students receive intensive training, research experience, and mentoring in their chosen fields of study.

During the summer of 2018, student exchanges included:

- Rising senior Ihan J. Acevedo Gonzalez and rising junior Robert Ethan Lewis from University of Puerto Rico–Mayaguez visited Oregon State University to participate in research led by Dr. Dan Cox. This marks the fourth consecutive year of exchange between these two CRC partner institutions.
- Senior student Courtney Thomas, a sociology and social work major, and junior Madison Bibbs, a psychology major, both enrolled at Tougaloo College, spent the summer with Old Dominion University researcher Wie Yusuf.

Stories of SUMREX and other CRC-supported students narrated in their own words are shared in the CRC News section and on the Students page of the CRC website.

DHS Summer Research Team Program for Minority Serving Institutions

During Year 4, CRC hosted two teams of faculty and students through the DHS S&T Summer Research Team (SRT) Program for Minority Serving Institutions.

Researchers at North Carolina State University, led by CRC PI Gavin Smith, hosted Dr. Michelle Dovil and students Tenesha Washington and Tia Maxwell from Florida A&M University. Their collaborative research was titled "The Place We Call Home: The Risk Perceptions and Place Attachments of Coastal Communities at Risk for Sea Level Rise in NC."

Researchers at Old Dominion University, led by Dr. Wie Yusuf, hosted Dr. Kulwinder Kaur and students Jaida Ellis and Genesis McClain from Elizabeth City State University (NC) on a project titled "An Examination of Mental Health Effects of Hurricanes on Vulnerable Populations in Coastal NC and Implications for Resilience."

More information about the MSI Summer Research Team experience can be found on the CRC website.

Career Development and Workforce Development Grants

With funding from the DHS Office of University Programs, CRC and its predecessor, the CHC, have sponsored a total of five fellowships at UNC-CH through the DHS Career Development Grant (CDG) and the Science and Engineering Workforce Development Grant (WFD). The following update shows where these former students are now.

The first CDG recipient, Lea Sabbag, graduated with a Master's in City and Regional Planning from UNC-CH in Spring 2016. Following graduation, she served at the NC Division of Emergency Management (NCEM) as the Housing Operations Manager for NCEM's Recovery Section for Hurricane Matthew. She then went on to work as the Housing Manager for the Community Development Block Grant - Disaster Recovery (CDBG-DR). She continues to be employed full-time at the NC Division of Emergency Management.

Ms. Ashton Rohmer completed the requirements for the CDG program upon graduating from UNC-CH with a Master's in City and Regional Planning in the Spring of 2017. After working with ASI Government as a consultant in support of the National Flood Insurance Program, Ms. Rohmer now works at AECOM Consulting under Dr. Jae Park, a CRC Advisory Board member.

With funding from the DHS OUP Science and Engineering Workforce Development grant, two students from UNC-CH - Colleen Durfee and Darien Williams – graduated with master's degrees in City and Regional Planning in Spring, 2018, while a third student – Jessamin Straub – graduated in August of 2019 with a degree in Marine Science.

Mr. Williams is continuing his resilience studies by pursuing a Ph. D in Urban Studies and Planning at the Massachusetts Institute of Technology. After working as the Planning and Zoning Administrator for the City of University City, Missouri for a year, Ms. Durfee has secured a position as Planner II for Lochmueller Group, where she performs transportation planning studies focused on improving the reliability and resilience of the city's transit systems and infrastructure. She also participates in multi-disciplinary teams involved in comprehensive planning, economic resilience planning, community equity, and sustainability.

Jessamin Straub was awarded a 2020 Knauss Fellowship, a highly prestigious appointment conferred through Sea Grant. The program provides a year of funding and job placement for graduate students working in areas focusing on national ocean and coastal policies. Ms. Straub's final report is included in Appendix A.

NSF PIRE Program

During Year 4, CRC partners continued to be engaged in the National Science Foundation (NSF) Partnerships for International Research and Education program (PIRE) through an award made to Texas A&M University at Galveston. The program provided a rich summer research experience for Akil Muhammad, a master's student in coastal engineering at Jackson State University, and Sofia N. Rivera Soto, a senior undergraduate chemical engineering student at the University of Puerto Rico, Mayaguez. Both students had the opportunity to travel to The Netherlands where they spent two weeks collecting data, interviewing practicing engineers, and touring coastal flood mitigation structures. Akil's PIRE research study is "Comparing Dredging and Disposal Methods in Galveston Bay and the Western Scheldt Estuary." Sofia's project is titled "Assessing Changes in pH, Temperature, and Salinity in the Eastern Scheldt Estuary."

COE Summit

For the second consecutive year, staff at CRC engaged in intense planning, organizing and coordinating to ensure a successful CoE Summit, scheduled for July 31-August 1, 2019. This annual event is held at George Mason University in Arlington, VA, home of the CINA CoE. The theme of the second annual Summit was "Homeland Security Challenges: Evolving Threats and Dynamic Solutions." During Year 4 CRC's role in preparing for the Summit included coordinating a panel led by CRC Executive Director Tom Richardson titled "Community, Collaboration and Homeland Security Research - Maximizing Impacts and Outcomes." Other planned activities included a technology showcase to demonstrate CoEs' recent research products. CRC demonstrated the ADCIRC Prediction System™ as well as the Plan Integration for Resilience Scorecard tool. Summit planning also included multiple student activities, including a judged poster session, a "Grand Challenge" event, a student breakfast with human capital specialists from DHS component agencies, and other opportunities for CoE students to network with federal agency personnel and with each other.

While planning activities in preparation for the 2019 Summit occurred during Year 4, the event took place during Year 5. Details about CRC participation and Summit results will be described in the Year 5 report.

HMDRRI Year 4 Wrap-Up

Starting in 2016 the Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI) involved faculty and students as well as professional planning and design experts to address community and state-level needs associated with recovery from Hurricane Matthew. HMDRRI focused on the needs of six hard-hit communities in eastern North Carolina, including Fair Bluff, Seven Springs, Windsor, Kinston, Lumberton and Princeville.

During Year 4 the Initiative finalized studies, assessments and plans for each of the six communities. Documents produced by the HMDRRI team included flood retrofit studies of downtown Fair Bluff, Windsor and Seven Springs; land suitability analyses, analysis of policies and projects to make the communities and neighborhoods more resilient to future flood events. More information about the Initiative, including community-specific plans and documents, can be found on the **CRC website**.

III. PROJECT REPORTS

The CRC research portfolio spans three research themes: 1) The Coastal Infrastructure Resilience project focuses on ways to improve damage prediction and loss estimates due to coastal hazards and develop a framework for new design methodologies for near-coast structures; 2) Projects in the Building Resilient Communities theme focus on: developing tools to help communities integrate hazard resilience into local planning efforts; developing effective ways to communicate risk to motivate individuals to take preparedness action; and developing ways to integrate flood exposure and damage modeling techniques to improve planning in coastal communities. 3) The Coastal Hazards Modeling-themed projects emphasize advancing computer modeling capabilities for predicting storm surge, waves, and flooding associated with

severe weather events along the U.S. East and Gulf Coasts and communicating the results of these predictions to improve coastal resilience.

Through the fourth theme, CRC addresses education and workforce development by formulating and delivering resilience-oriented undergraduate and graduate courses, concentrations, minors, certificates, and training, with strong emphasis on Minority Serving Institutions. Focus areas in education include coastal and computational engineering, computer science and engineering, social science, coastal infrastructure, disaster science, and natural hazards resilience.

Performance reports for each CRC project are in the section that follows, organized by theme. All of the PIs were encouraged to take a retrospective look back to activities undertaken and milestones achieved during Year 4, with a focus on the cumulative progress made to date. A list of the projects by theme is below:

Theme: Coastal Infrastructure Resilience

Cox; van de Lindt: *Experimental and Numerical Study to Improve Damage and Loss Estimation due to Overland Wave and Surge Hazards on Near-Coast Structures*

Theme: Building Resilient Communities

Berke: *Application of the Plan Integration for Resilience Scorecard (PIRS) to Practice*

Prochaska: *Communicating risk to motivate individual action*

Twilley: *Integrating CERA-Planning Software to support DHS Modeling and Planning Efforts for more Resilient Communities*

Theme: Disaster Dynamics

Luettich: *ADCIRC Prediction System™ Development Coordination and Improved Connectivity with Hydrologic Models*

Fleming: *The ADCIRC Surge Guidance System as a Conduit for Innovation*

Blanton: *Operational Awareness Dashboard for ADCIRC Surge Guidance System*

Dietrich/Dawson: *Improving the Efficiency of Flooding Predictions via Adaptive Mesh Resolution*

Hagen/Medeiros/Bilskie: *Development of an optimized tide and hurricane storm surge model for the west coast of FL for use with the ADCIRC Surge Guidance System*

Ginis/Huang: *Modeling the combined coastal and inland hazards from high-impact hurricanes*

Resio: *Development and Validation of Efficient and Accurate Methods for Coupling ADCIRC to Hydrologic Models*

Theme: Education

Faik: *Preparing Tomorrow's Minority Task Force in Coastal Resilience through Interdisciplinary Education, Research, and Curriculum Development*

Laiju: *Multidisciplinary Certificate: Disaster and Coastal Studies (DCS)*

Pagan-Trinidad: *Education for Improving Resiliency of Coastal Infrastructure*

Smith: *Continuation of the Natural Hazards Resilience Certificate Program and Assistance to FEMA*

Whalin: *PhD in Engineering (Coastal/Computational) at an HBCU - Jackson State University*

Theme 1

Coastal Infrastructure Resilience

Dan Cox, OSU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:

Experimental and Numerical Study to Improve Damage and Loss Estimation due to Overland Wave and Surge Hazards on Near-Coast Structures

Principal Investigators:
Dr. Daniel Cox, (PI) Professor, Oregon State University
Dr. John van de Lindt (Co-PI), Professor, Colorado State University

Other Partners/Institutions:
FEMA DHS

Short Project Description ("elevator speech")

This project applies the wave-surge fragility method developed in years 1-3 of the project to determine damage to several additional building types. A HAZUS analysis over a region of the New Jersey shoreline will be conducted using (1) the existing HAZUS methodology, and (2) the new fragilities developed herein. This will require utilizing the ADCIRC work of others within the Center of Excellence as input. The investigators will work with DHS FEMA HAZUS developers to lay out the steps needed to implement the new fragility types in HAZUS, including any additional validation steps needed.

1. Introduction and project overview:

Hurricanes Sandy in 2012, Ike in 2008, and Katrina and Rita in 2005 have underscored the significant and growing risk to coastal communities due to surge and wave hazards. Hurricane-induced economic losses in the United States have increased steadily over the past 60 years and are now $35.8 billion annually. Approximately 50 percent of the U.S. population lives within 50 miles of a coastline, and the physical infrastructure to support this population was estimated in the 1990s to be over $3trillion in the Gulf and Atlantic regions. These problems are compounded by global climate change resulting in increased sea levels and increases in the intensity and frequency of extreme windstorms. The overall vision for this project is to support the broader vision of the CRC to increase the resilience of near-coast structures to coastal hazards. Resilience is the ability of a system to absorb and recover from a sudden disturbance.

Our project is linked to "Mission 5: Ensuring Resilience to Disasters" as listed in the DHS Strategic Plan Fiscal Years 2012 – 2016. Goal 5.1 is to Mitigate Hazards by "strengthening the capacity at all levels of society to withstand threats and hazards." Moreover, Objective 5.1.2 Mitigate Risk To Communities will "improve community capacity to withstand disasters by mitigating known and anticipated threads and hazards." Our project will link directly to Goal 5.1 and Objective 5.1.2 by understanding the damage to the built environment as a result of coastal

hazards produced by hurricanes and other coastal windstorms. The overall aim of the DHS CRC is to improve the Nation's ability to safeguard people, infrastructure and economies from catastrophic coastal disasters. By improving FEMA's (HAZUS-MH) ability to predict damage and loss estimates due to waves and surge and developing a framework for new design methodologies for near-coast structures, this project will enhance the resilience of the Nation's coastal infrastructure to hurricane and other coastal hazards. By improving the predictions of damage and loss, we will be better positioned to anticipate and manage cascading consequences and interactions between infrastructure and hazards. This project will help reduce losses from hurricanes in the United States. and will assist FEMA's mission in the National Windstorm Impact Reduction Program and the National Flood Insurance Program by improving damage and loss assessment tools consistent with FEMA's program for HAZUS modernization.

2. Results:

Do, T, JW van de Lindt, DT Cox (2019) "Hurricane Surge-Wave Building Fragility Methodology for Use in Damage, Loss, and Resilience Analysis," J. Structural Engineering (accepted).

ABSTRACT: Physics-based fragility for damage, loss, and resilience analysis are needed to model a community to loading by earthquakes, hurricane wind, tornado, or flood. Currently, most building flood fragilities such as those available in assessment tools such as HAZUS-MH do not account for the hydro-dynamic forces caused by surge and waves, only the depth of a flood. In this paper, a methodology to evaluate forces on all building components including windows, doors, walls and floor systems for elevated coastal buildings under a combination of hurricane surge and waves is proposed. The model was validated by comparing vertical and horizontal forces from existing laboratory test results of a one-tenth scale elevated structure under wave loading. A full-scale wood-frame residential building was then modeled as an example to illustrate the method and is intended to be representative of an elevated coastal structure in a typical coastal region of the United States. The hurricane was modeled as a combination of two intensity parameters, namely significant wave height and surge level at the building location and is better able to represent the loading condition and thus damage to the structure than static flood alone. Fragility surfaces for four damage states for the building as a whole were generated as a damage combination of all damageable building components. Finally, a comparison of the loss estimated using the fragility surfaces versus the current loss model in HAZUS-MH is provided to illustrate the effect on loss estimates when including wave height in predicting damage for near-coast buildings under hurricane wave and surge. By calibrating the physics-based fragilities with empirical data, the surface fragilities developed in this paper are ready to use in HAZUS-MH or other loss and resilience-focused analysis at the community level for coastal communities subjected to both waves and storm surge during hurricanes.

Tomiczek, T, A Wyman, H Park, DT Cox (2019) "Modified Goda Equations to Predict Pressure Distribution and Horizontal Forces for Design of Elevated Coastal Structures," J. Waterway Port Coastal and Ocean Engineering (accepted).

ABSTRACT: A 1:10 scale physical model was constructed to measure horizontal and vertical pressures and forces on an elevated structure under nonbreaking, impulsive breaking, and broken wave conditions. Regular wave trials with varying wave heights and periods were used to

diagnose phase-averaged horizontal pressure distributions at the time of the maximum horizontal force for a range of structural air gap conditions. Measured pressures were then compared with those predicted ASCE 7-16 (2016) design equations and modifications to the Goda (2010) equations for wave pressures on a vertical caisson breakwater modified by Wiebe et al. (2014) for near-coast structures. The modified Goda equations showed good agreement with measured pressures and total horizontal force per unit width for nonbreaking wave conditions over a range of structural elevations from at grade to 0.28 m above the still water level. While generally conservative for nonbreaking, breaking, and broken waves, the modified Goda equations were more accurate than the ASCE 7-16 (2016) equations, which significantly over-predicted pressures and forces in nearly all cases. Results suggest that the modified Goda equations may be used to improve design guidance for at grade or elevated coastal structures.

3. **End users:**
   Primary end users are at FEMA.

4. Transition:

HAZUS - Coastal Resilience Center (CRC) Workshop. June 10 and 11, 2019. FEMA HQ in Washington DC.

Attendees:

- Doug Bausch, NiyamIT, CDS
- Ryan Blanton, University of North Carolina (UNC), Chapel Hill
- Suman Biswas, NiyamIT
- Jordan Burns, NiyamIT, CDS
- Dan Cox, Oregon State University (OSU)
- Andrew Ditmore, IBM, CDS
- Daniel Eglovitch, NiyamIT, CDS
- Andrea Jackman, IBM, CDS
- Katie Jones, LSU
- Carola Kaiser, Louisiana State University (LSU)
- End user, FEMA
- End user, FEMA
- Rick Luettich, UNC Chapel Hill
- End user, FEMA
- Alexis Richmond, Nodi Solutions, PM Team
- End user, FEMA
- End user, FEMA
- End user, DHS
- Robert Twilley, LSU
- Nikolay Todorov, NiyamIT, CDS
- Ujvala Sharma, NiyamIT, CDS
- John van de Lindt, Colorado State University
- Stephen Veith, Nodi Solutions, PM Team

Agenda:

- Coastal Damage Functions Brief
- Coastal Preliminary Flood Risk Assessment (PFRA) Brief
- Interdependent Networked Community Resilience Modeling Environment (IN-CORE) Brief
- Advanced Circulation (ADCIRC) storm surge model Brief
- Coastal Emergency Risk Assessment (CERA) Visualization Tool Presentation / Discussion
- Reducing Repetitive Loss Post-Storm Project

Summary: van de Lindt and Cox to be involved in FEMA-MH hindcast study for Bolivar Peninsula for Hurricane Ike (2008) damage and loss prediction. Hindcast will show the relative merits of physics-based fragility functions.

5. Project Impact:

The improved fragilities are the first fragilities developed using experimental data and then validated using FEMA community-level inspections following a storm. Thus, the project results can be used for better risk-informed decision-making and loss avoidance calculations for hazard mitigation due to hurricane wave and surge on coastal residential structures. Further, HAZUS currently does not have fragilities for flood, but uses stage-damage functions, and therefore is unable to propagate uncertainty.

6. Unanticipated Problems:

There were no unanticipated problems.

7. Student Involvement and Awards:

We included the following students in Year 4.

- Jason Burke (MS, Oregon State University; currently USN-NAVFAC)
- Matt Karney (MS, Oregon State University; currently USN-NAVFAC)
- Bryan Acevedo (SUMREX, UPRM; currently enrolled at UPRM)
- Jorge Santiago (SUMREX, UPRM; currently grad student at UF)
- Ana Lopez (REU Cal Poly SLO; currently applying to graduate school)

Student Demographics

- 1 (out of 5) female
- 3 (out of 5) from underrepresented group
- 3 (out of 5) undergraduate

Degrees Attained

- MS Civil Engineering, 2018 (Burke)
- MS Civil Engineering, 2018 (Karney)

8. Interactions with education projects:

- 2 SUMREX students from UPRM (Acevedo; Santiago)

9. Publications:

Journal Papers

- Park, H., Tomiczek, T., **Cox, D.T., van de Lindt, J.W.**, Lomonaco, P. (2017) "Experimental Modeling of Horizontal and Vertical Wave Forces on an Elevated Coastal Structure," *Coastal Engineering*, 128, 58-74. DOI: 10.1016/j.coastaleng.2017.08.001
- Do, Trung, **van de Lindt, J., Cox, D.T.** (2016) "Performance-Based Design Methodology for Inundated Elevated Coastal Structures Subjected to Wave Load Engineering Structures," *Engineering Structures*, 117, 250 – 262. DOI: 10.1016/j.engstruct.2016.02.046
- Park, H., Do, T., Tomiczek, T., Cox, D.T., van de Lindt, J.W. (2018) "Numerical Modeling of Non-breaking, Impulsive Breaking, and Broken Wave Interaction with Elevated Coastal Structures: Laboratory Validation and Inter-Model Comparisons," *Ocean Engineering*, 158, 15, 78-98. DOI: 10.1016/j.oceaneng.2018.03.088
- Tomiczek, T, A Wyman, H Park, DT Cox (2019) "Modified Goda Equations to Predict Pressure Distribution and Horizontal Forces for Design of Elevated Coastal Structures," *J. Waterway Port Coastal and Ocean Engineering* (accepted).
- Do, T, JW van de Lindt, DT Cox (2019) "Hurricane Surge-Wave Building Fragility Methodology for Use in Damage, Loss, and Resilience Analysis," *J. Structural Engineering* (In Press).

Conference Papers

- Do, T., Tomiczek, T., **van de Lindt, J. Cox, D.** (2017) "Development of Physics-Based Building Fragility Surfaces for Near-Coast Community Modeling," *International Conference on Coastal and Ocean Engineering*, Osaka, Japan.
- Lomonaco, P., P. Arduino, A. Barbosa, D. Cox, T. Do, M. Eberhard, M. Motley, K. Shekhar, T. Tomiczek, H. Park, J. W. van de Lindt, A. Winter (2018) "Experimental Modeling of Wave Forces and Hydrodynamics on Elevated Coastal Structures Subject to Waves, Surge or Tsunamis: The Effect of Breaking, Shielding and Debris, *International Conference on Coastal Engineering*, ASCE.
- Park, H., Do, T., Tomiczek, T., **Cox, D., van de Lindt, J.W.** (2018) "Laboratory Validation and Inter-Model Comparisons of Non-breaking, Impulsive Breaking, and Broken Wave Interaction with Elevated Coastal Structures using IHFOAM and FLUENT," *International Conference on Coastal Engineering*, ASCE.
- Tomiczek, T., Wyman, A., Park, H., **Cox, D.T.** (2018) "Application and modification of Goda Formulae for Non-impulsive Wave Forces on Elevated Coastal Structures," *International Conference on Coastal Engineering*, ASCE.

- Tomiczek, T., Park, H., **Cox, D.T.**, Lomonaco, P., **van de Lindt, J.W.** (2018) "Application and modification of Design Formulae for Impulsive Wave Forces on Elevated Coastal Structures," *International Conference on the Application of Physical Modelling in Coastal and Port Engineering and Science (Coastlab18)*, IAHR.
- Do, T, JW van de Lindt W, DT Cox (2018) "Physic-Based Component Fragility Model for Near-Coast Residential Wood Building Subjected to Hurricane Wave and Surge" Engineering Mechanics Institute Conference 2018, Cambridge MA.

Thesis/Dissertation and Reports

- Trung Q. Do. *Fragility Approach for Performance-Based Design in Fluid-Structure Interaction Problems, Part I: Wind and Wind Turbines; Part II: Waves and Elevated Coastal Structures*, (2016), Ph.D. Dissertation, Colorado State University.
- William Short. *A laboratory study of horizontal and vertical regular wave forces on an elevated structure*. (2016). MS Thesis, Oregon State University.
- Benjamin Hunter. *Exceedance Probabilities of Hurricane Wave Forces on Elevated Structures*. (2016). MS Thesis, Oregon State University.
- Jason Burke. *Design and Structural Testing of a 1:6 Scaled, Light-frame Construction, Near-coastal, Residential Structure*. (2018). MS Thesis, Oregon State University.
- Matt Karney. *Hydrodynamic Testing on a 1:6 Scale, Wood Framed Near-Coast Residential Structure*. (2018). MS Thesis, Oregon State University.

10. <u>Year 4 Research Activities and Milestone Achievements:</u>

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
RA1: Development of fragilities for two additional building types for combined surge and waves; these are in the form of fragility surfaces. Within this technical task, the research team will conduct scale-model tests to validate the global forces and subcomponent damages predicted by the numerical model and will test the overall applicability of the fragility functions.	3/31/2019	100%	
RA2: HAZUS-MH analysis of 4 to 6 blocks of New Jersey shoreline	4/30/2019	0%	Decide to work with FEMA Hazus team to identify appropriate hindcast area. Determined Bolivar Peninsula, TX, is better
Research Milestone			
RM1: Documentation of RA1 as a journal paper submission (J. of Structural Engineering)	3/31/2019	100%	
Documentation of RA2 as a journal paper submission to peer reviewed journals such as the *Journal of Ports, Waterways, Coast and Ocean Engineering and Natural Hazards*, etc.	4/30/2019	100%	

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
TA1: In-person meeting with FEMA HAZUS-MH in Denver to discuss timeline transition, hindcast study location, building archetypes, and FEMA data	11/1/2018	100%	Note: HAZUS-MH meeting held June 10 and 11, 2019. Date determined by FEMA.
TA2: Webex meeting: Establish periodic webex meetings with project team and end users for project update and feedback	Held every other month	50%	Discussions are continuing following June Hazus meeting
Transition Milestone			
TM1: Timeline for work plan agreement between project team and HAZUS-MH Technical staff	12/1/2018	50%	Progressing since June 2019 Hazus meeting

12. Tables:

Table 1: Research Project Product Delivery

Product Name	Product Type (e.g., software, guidance document, knowledge product)	Delivery Date	Recipient or End User(s)
HAZUS-MH Hindcast	Knowledge product to demonstrate the value of new fragilities for coastal residential structures subjected to hurricane surge and waves	End of Year 5	FEMA Hazus Development Team

Table 2: Performance Metrics:
COX/van de LINDT PERFORMANCE METRICS

Metric	**Year 1** (7/1/15-6/30/16)	**Year 2** (7/1/16-6/30/17)	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)				
Undergraduates provided tuition/fee support (number)	0	0	0	0
Undergraduate students provided stipends (number)	0	0	0	0
Graduate students provided tuition/fee support (number)	2	2	2	1
Graduate students provided stipends (number)	0	2	2	1
Undergraduates who received HS-related degrees (number)	0	0	0	0
Graduate students who received HS-related degrees (number)	0	0	0	0
Graduates who obtained HS-related employment (number)	0	0	0	0
SUMREX program students hosted (number)	2	2	2	2
Lectures/presentations/seminars at Center partners (number)	0	3	0	1
DHS MSI Summer Research Teams hosted (number)	0	0	0	0
Journal articles submitted (number)	0	2	2	2
Journal articles published (number)	0	2	0	2
Conference presentations made (number)	0	1	2	2
Other presentations, interviews, etc. (number)	0	0	2	2
Patent applications filed (number)	0	0	0	0
Patents awarded (number)	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies (number)	0	0	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0	0	0
Dollar amount of external funding	$355,000	$355,000	$0	0
Total milestones for reporting	4	5	4	4
Accomplished fully (research activity/milestone)	0	2	3	2
Accomplished partially (research activity/milestone)	4	3	1	1
Not accomplished (research activity/milestone)	0	0	0	1

Theme 2

Building Resilient Communities

Phil Berke, TAMU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Application of the Plan Integration for Resilience Scorecard (PIRS) to Practice

Principal Investigator Name/Institution:
Philip Berke, PI / TAMU

Other Partners/Institutions:
Jaimie Masterson, Investigator

Short Project Description ("elevator speech"):

We develop the *Plan Integration for Resilience Scorecard* (PIRS) to assist local practitioners assess the degree to which networks of plans are coordinated in risk mitigation and target geographic areas most prone to hazards. Our research tested PIRS in six coastal communities and found that plans are not fully consistent and do not always address the areas in a community most vulnerable to floods or sea level risks; moreover, some plans actually increase physical and social vulnerability to hazards. For this project, our primary objectives are: to document experiences of communities that have applied PIRS (City of Norfolk, VA and City of Nashua, NH); and to initiate new partnerships in applying PIRS with the City of Rockport, TX and the Port of Corpus Christi Authority. Results from the documentation will be used to refine the PIRS guidebook, training materials and plan scoring tool to ensure that they meet needs and requirements of different types of communities that vary in capacity to anticipate and plan for future risks. The documentation will be based on a participatory action research methodology. A top priority throughout the project is to continue our ongoing collaboration with federal agencies (FEMA, NIST), state agencies (New York Rising, Texas Sea Grant), and professional practice organizations, especially the American Planning Association, to demonstrate how PIRS can best support their local resilience planning programs.

1. Introduction and project overview:

Communities adopt multiple interdependent plans that significantly affect future community vulnerability to hazards. The plans are almost always independently prepared by distinct government agencies and interest groups. It is not surprising that the plans are often in conflict and can actually increase physical and social vulnerability to hazards. We develop a resilience scorecard that allows local planners, emergency managers and other officials to assess the degree to which the network of local plans integrate mitigation and recognize and respond to the physical and social vulnerabilities of geographic areas most prone to hazards. The information generated by the Resilience Scorecard is used to create strategies to resolve conflicts across plans and missed opportunities to improve community resilience.

A notable success story in applying the Resilience Scorecard to practice occurred in the City of Norfolk, VA. The city's planning department used scorecard results to help develop a fact base for a proposal to the National Disaster Resilience Competition that targeted a poor and underserved neighborhood that received low scores based on the scorecard evaluation. In 2018, the city received a $112 million award to invest in a resilience project in the Ohio Creek watershed (figure 1), known as Chesterfield Heights area. Design work will be measured against several goals, such as improving amenities in the form of a park, enhancing economic development, and strengthening infrastructure and the built environment in vulnerable neighborhoods.

Figure 1: Norfolk Resilience Park as part of Ohio Creek Watershed Initiative

Another success story occurred in the City of Nashua, NH. The emergency manager, Justin Kates, led an effort that used both the Resilience Scorecard and the NIST Resiliency Planning Guidebook to create a comprehensive and integrated resilience planning framework for the city (figures 2 and 3). In collaboration with the Texas A&M and NIST teams, Kates created a crosswalk that demonstrates how to apply the Resilience Scorecard and Planning Guidebook to develop an Integrative Framework for Community Resilience (Nashua city staff indicate that the finalized version of the crosswalk will be complete in August 2019).

Figure 2: Nashua community members discussing the scoring and geographic placement of a policy as part of a *Plan Integration for Resilience Scorecard* activity.

Figure 3: Nashua city staff (Emergency Manager, Justin Kates, far left; Community Resilience Coordinator, Anna McGinty, far right; and City Planner, second from right) and Texas A&M team members (Jaimie Masterson, second from left; Matt Malecha, center, facing away; Siyu Yu, not pictured) discuss the process of policy evaluation described in the *Plan Integration for Resilience Scorecard Guidebook*, Nashua City Hall.

2. **Results:**

See comments above (Section 1: Introduction and project overview) about two examples of applications that took place in Norfolk and Nashua.

- Two published peer reviewed papers (see attachments).
- Revised second version of the guidebook for local practitioners based on our work with two demonstration cities, *Plan Integration for Resilience Guidebook 2.0* [mitigationguide.org, go to link Scorecard Guidebook]
- Completed a report on lessons learned and outcomes 18-months after the Norfolk demonstration effort was completed (see attachment).
- Initiated three additional pilot projects in Texas.
    - A community-based organization (Charity Productions) is partnering with poor minority neighborhoods in Houston in applying the scorecard. The objective is to track how well county, city and neighborhood plans

(stormwater, housing, recovery, transportation, mitigation) to meet neighborhood needs after Hurricane Harvey.
    - The Port of Corpus Christi Authority is collaborating with communities that experience growth related to port expansion in applying the resilience scorecard in order to better coordinate plans to reduce hazard vulnerability.
    - Rockport is applying the scorecard to guide preparation of the city's new comprehensive plan to assure alignment of multiple post-Harvey recovery initiatives in the city with the vision and strategies included in the plan.
- Conducted a series of trainings:
    - Masterson, Jaimie and Justin Kates, emergency manager for City of Nashua, NH. May 23, 2019. Conducted a two-hour intensive workshop at the 2019 National Conference of Association of State Floodplain Managers (ASFPM). Twelve participants from public and private sector were in attendance.
    - Masterson, Jaimie and Philp Berke. December 11, 2018. Conducted introductory webinar for state and local pracitioners, New York Rising.
    - Berke, Phil and Jaimie Masterson. February 8, 2019. NYS Pilot Scoping call. Discussed the opportunity of using PIRS in preparation for hazard mitigation plans and the state resilience initiative, New York Rising.
    - Masterson, Jaimie. October 15, 2019. State Chapter Conference of Texas Chapter of American Planning Association (TXAPA) Plenary. Moderated the opening plenary on Hurricane Harvey recovery and discussed the value of planning and plan integration with the PIRS tool.
    - Masterson, Jaimie and Matt Malecha. February 1, 2019. Texas Sea Grant Program. Conducted a second 2-hour workshop with planning extension agents on PIRS.
    - Malecha, Matthew and Jaimie Masterson. 11/29/2018. Texas Sea Grant / Community Resilience Collaborative. 'Train-the-trainers' session with Sea Grant Planning Specialist and administrative staff.
    - Malecha, Matthew and Siyu Yu. 06/18/2019. City of Rockport, TX. Plan Integration for Resilience Scorecard *for Disaster Recovery*. Training and discussion of preliminary scorecard results and future analysis.
    - Malecha, Matthew and Siyu Yu. 06/19/2019. Port of Corpus Christi, Corpus Christi Bay region, TX. Plan Integration for Resilience Scorecard *for Disaster Recovery*. Preliminary training and discussion of scorecard evaluation parameters in a new context (Port of Corpus Christi and neighboring jurisdictions).

Research Findings

Two sets of findings are revealed by two papers published in peer reviewed journals.

Findings from Berke et al. 2019

We examined the relationship between policies in local networks of plans with level of social vulnerability in neighborhoods of six cities along the Atlantic and Gulf coasts. The policies are designed to stimulate redevelopment in primarily poor and minority neighborhoods that are exposed to flood and sea level rise hazards. Findings reveal a "development paradox": policy scores in plans intended to stimulate development in socially vulnerable neighborhoods could

increase risk, which, in turn, escalates the potential for greater losses that could wipe out progress in development by failing to give attention to reducing risk.

This dynamic raised by the paradox is not new, nor is it unique to the communities included in this study. Planning efforts for major neighborhood improvement projects are often overtly designed to achieve wider development objectives in impoverished areas in high hazard locations, and this pattern is shaping urban areas in many parts of the world. Yet, development policy responses to achieve risk reduction and human development goals are undertaken independently and have been piecemeal or, at worst, conflicting.

Findings from Newman, et al. 2019
This paper offers a novel Geodesign procedure for creating master plans at the site scale that support neighborhood resilience. The procedure integrates a proactive plan evaluation using the Resilience Scorecard with landscape performance indicators. The Resilience Scorecard is used to evaluate the degree to which local networks of plans are coordinated (or in conflict) in support of neighborhood resilience. Landscape performance indicators are used to measure the projected impact of alternative design strategies that could be integrated into the plans. The indicators measure differences in outcomes of alternative strategies, including future stormwater runoff, groundwater replenishment, carbon sequestration, and energy use, as well as costs and economic benefits. In collaboration with neighborhood residents, design strategies were created that best support neighborhood resilience. Projections of impacts based on landscape performance indicators of each alternative were used as a guide to develop a resilient master plan for League City, Texas.

Products

- Revision of PIRS Guidebook 2.0 for local practitioners, updated software tool
- 2 published peer reviewed articles
- Lessons learned report on Norfolk's experience in applying the Resilience Scorecard (see attachment)
- 2 PhD dissertations completed at Texas A&M
- Developed training materials for local practitioners and tested with Texas Sea Grant and at ASFPM workshop.

3. End users:

- Charity Productions: In spring 2019, we initiated a partnership with this community-based organization (CBO) to apply the scorecard in three poor minority neighborhoods in Houston that experienced significant damages from Hurricane Harvey. This CBO represents neighborhoods internal to the city with little or no formal power, but with intimate knowledge about how their neighborhoods are affected by hazards and the appropriateness of risk mitigation policy interventions that reflect the needs of socially vulnerable groups.
- Texas Sea Grant, Texas A&M: We trained four coastal planning specialists employed by Sea Grant. They are currently working in collaboration with our group in three Texas communities, including Rockport, Corpus Christi and Houston.

- National Institute for Science and Technology (NIST): We are partnering with NIST in assisting staff of the City of Nashua, NH in attempting to integrate the Resilience Scorecard and NIST Resilience Planning Guide.
- FEMA: End user at FEMA has assisted NIST and the Texas A&M group in facilitating potential work with NY Rising. While the project has not been initiated to date, we have had numerous contacts with FEMA and especially appreciate their efforts.
- Port of Corpus Christi Authority, TX: We initiated a new project with the port staff in May 2019, expected completion date about February 2020.
- Nashua, NH: Over the past year we have been in continual contact and regularly provide technical assistance to city staff in applying the Resilience Scorecard. Nashua is expected to complete application of the scorecard in September 2019.
- City of Norfolk, VA: We completed our project with Norfolk, VA in Spring 2018, and have been collaborating with city staff in to prepare the lessons learned report (see attachment).
- Rockport, TX: We initiated a new project with the Rockport staff in January 2019, expected completion date about September 2019. Rockport is devastated by Hurricane Harvey.
- Association of State Floodplain Managers: Jaimie Masterson collaborated with Justin Kates of Nashua, NH (leads city team in applying the scorecard) is giving a training session on how to apply the Resilience scorecard at the 43rd ASFPM National Conference, Cleveland, Ohio, May 2019.

4. Transition:

- We have had numerous discussions with senior staff at the American Planning Association. We focused on how we might co-develop communication, outreach and training programs. We hope to translate the scorecard to practice in working with APA through utilization of its extensive resources and outreach to 44,000 members.
- Completed demonstration project in Norfolk, VA and produced a lesson learned report (see attachment).
- Continued working with emergency management, GIS, resilience office staff in Nashua, NH in applying the Resilience Scorecard.
- Initiated three new community demonstration projects in Texas: poor minority neighborhoods in Houston, Port Corpus Christi Authority, and Rockport.
- Revised *Plan Integration for Resilience Guidebook 2*.

5. Project Impact:

- Raise Awareness/Knowledge. Risk mitigation practitioners in local governments and civic-based organization are using the scorecard to identify when and where local plans are in conflict and whether they focus on the local areas most vulnerable to specific hazards. With the information gathered using the scorecard, the officials inform the public and decision makers about conflicts and missed opportunities to improve local hazard mitigation planning.
- Changes Made by Local Governments. The demonstration communities (Norfolk and Nashua) indicate that the information produced by the scorecard influenced

changes and innovations in plans, development regulations and infrastructure investments. The changes include a range of impacts:

- steer new development and public infrastructure investments away from hazard areas;
- protect ecosystem (e.g., wetlands) that support hazard mitigation;
- avoid reproducing many pre-existing physical and social vulnerabilities during disaster recovery; and
- provide a fact base that supports change in development policies that create inequality and increase the uneven impacts of hazards on poor minority populations.

6. Unanticipated Problems:

NY Rising has not progressed as initially anticipated during discussions with FEMA and NIST. With NIST staff we conducted a webinar training for local officials in NY state, and had multiple conversations with state agency staff (Emergency Management and Department of State). We are appreciative of FEMA staff who worked to enable initiation of projects in two counties. We remain in contact with NY Rising staff and hope a project will evolve.

7. Student Involvement and Awards:

- Two doctoral students were supported: Siyu Yu and Matt Malecha, Urban & Regional Science, Texas A&M.

- A Landscape Architecture studio class (about 15 students) taught by Dr. Galen Newman applied the scorecard in Houston.

No minority students were involved. **However**, we did training and actively engaged poor minority neighborhoods. Specifically, in May 2019, we trained an early career African American planning practitioner based in Houston [Steven Washington of Texas Sea Grant; http://texasseagrant.org/staff/steven-c.-washington/]. He will be participating on a collaborative partnership to apply the scorecard in three poor minority neighborhoods in Houston that experienced significant damages from Hurricane Harvey during 2019-20. The partnership includes a highly regarded community-based organization -- Charity Productions, plus Mr. Washington and the Texas A&M team. The aim is to apply the scorecard to track how well county, city and neighborhood recovery plans (stormwater, housing, transportation, mitigation) are meeting neighborhood needs after Hurricane Harvey.

Degrees:
- You Jung Kim. 2019. PhD in Urban & Regional Science, Texas A&M
- Siyu Yu. 2019. PhD in Urban & Regional Science, Texas A&M

Awards:
2018 "TX-ASLA Award of Excellence," American Society of Landscape Architects, Texas Chapter (TX-ASLA). "*Resilience through Regeneration.*" Planning and Analysis Category, Graduate. Student Team: Xu qi Song & Rui Zhu

8. Interactions with education projects:

None

9. Publications:

Two New Publications Year-4:

Newman, Galen, Malecha, Matt, Yu, Si, Qipao, Z., Horney, Jen, Lee, Daemyung, Kim, Young., Lee, R.J., & **Berke, Philip.** 2019. Integrating a Resilience Scorecard and Landscape Performance Tools into a Geodesign Process. *Landscape Research*. DOI: 10.1080/01426397.2019.1569219

Berke, Philip, Siyu Yu, Matt Malecha, John Cooper. 2019. Plans that Disrupt Development: Equity Policies and Social Vulnerability in Six Coastal Cities. *Journal of Planning Education and Research*. (forthcoming).

Publications Prior to Year-4

Berke, P., Lee, J., **Newman, G.**, Combs, T. Kolosna, C., Salvesen, D. 2015. Evaluation of Networks of Plans and Vulnerability to Hazards and Climate Change: A Resilience Scorecard, *Journal of the American Planning Association* 81(4): 287-302. DOI: 1080/01944363.2015.1093954

Berke P., Malecha M., Yu S., Lee J., **Masterson J.** (2018). Plan Integration Scorecard for Resilience: Evaluating Networks of Plans in Six US Coastal Cities, Journal of Environmental Planning and Management, DOI:10.1080/09640568.2018.1453354.

Malecha, M., Brand, A., & **Berke, P.** (2018). Spatially evaluating a network of plans and flood vulnerability using a Plan Integration for Resilience Scorecard: A case study in Feijenoord District, Rotterdam, the Netherlands. Land Use Policy, 78, 147-157. DOI: 10.1016/j.landusepol.201

Masterson, J., Berke, P., Malecha, M., Yu, S., Lee, J., & Thapa, J. (2017) Plan integration for resilience scorecard: How to spatially evaluate networks of plans to reduce hazard vulnerability. College Station, Texas: Institute for Sustainable Communities, College of Architecture, Texas A&M. http://mitigationguide.org/wpcontent/uploads/2013/01/Scorecard_3Oct2017.pdf

Student theses and dissertations completed up through Year 4.

Su Yu. *The Influence of Plan Integration on Community Vulnerability and Ecological Resilience to Natural Hazards*. 2019. Landscape architecture and Urban Planning, Primary Advisor: Phil Berke

You Jung Kim. *Advancing Scenario Planning to Prepare for Uncertain Climate Change: Future Urban Growth Prediction and Flood Vulnerability*. 2019. Landscape architecture and Urban Planning, Primary Advisor: Dr. Galen Newman, Committee Member, Phil Berke

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Document the process in which PIRS is applied to the communities that combine the NIST resilience planning guide and the PIRS guidelines, and that are planning for post-disaster recovery. The process includes recording the results of local official evaluations of plans, actual changes in plans as a result of the self-evaluations, and actual changes in local development ordinances and infrastructure spending priorities.	5/15/2019	50%	Documentation of the process was completed for Norfolk, but not Nashua. Nashua fell behind schedule since GIS staff person left. Nashua plans to complete GIS mapping of scorecard results by August 2019. Documentation for Nashua should be complete by October 2019.
Conduct analysis of field notes of local officials' reactions to using the PIRS and documentation of outcomes due to PIRS.	5/30/2019	60%	Interviews completed in Norfolk, and initiated in Nashua. We plan to complete Nashua by November 2019.
Complete analysis of consistency between networks of plans and land use regulations in reducing vulnerability in Tampa, Florida.	5/30/2019	90%	All research has been completed. We are now writing the report with expected completion date August 2019.
Research Milestone			
Produce a 3-page research summary that concisely describes findings from applying PIRS for each community to a professional audience. Each research summary will include illustrations and concise explanations of each community's experiences, lessons learned and outcomes from the PIRS application process. The PI (Berke) has	6/30/2019	50%	Summary report based on documentation of changes and interviews is

found that research summaries are effective for conveying the results of research to mitigation practitioners and policy makers.			completed for Norfolk, and will be completed for Nashua by December 2019. We could not complete summery report for Nashua because city is behind schedule due to loss of GIS staff person.
Submit a paper for peer review that focuses on developing a user-friendly evaluation procedure to determine the degree to which land use regulatory ordinances (i.e., zoning) are consistent with networks of plans.	6/30/2019	20%	Need to complete research summaries for more demonstration communities.

11. Year 4 **Transition** Activities and Milestone Achievements

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Continue working with Nashua, NH to apply the PIRS tool and integrate PIRS with NIST resilience planning guide.	3/30/2019	80%	We have worked extensively with Nashua for past year, and now waiting for the city to complete its application of the scorecard.
Continue working with New York Rising to undertake a community demonstrate project to show how PIRS could be applied in State of NY.	6/30/2019	0%	As noted, to date we have not initiated a project with a community in NY state.
Partner with 1-2 communities recovering in Texas from Hurricane Harvey to apply PIRS with recovery planning.	8/30/2019	100%	We have partnered with 3 communities in Texas.
Conduct at least two training webinars; one for FEMA, one or more for each of the following professional organizations NADO, ASFPM, APA. In addition, State Sea Grant or a state agency (planning, emergency management).	6/30/2019	100%	We have completed 3 training seminars for the Association of State Floodplain Managers, Texas Sea Grant, State of New York Rising and FEMA Region 2. Plus, one at State Chapter

			Conference of Texas Chapter of American Planning Association, 3 for local governments, and the Port of Corpus Christi.
Transition Milestone			
Update PIRS guidebook and related training materials. Updates will be based on applications of the guidebook working in partnership with a range of communities with different levels of capacity to plan for resilience. Investigators will document the strengths and weaknesses of each element in the guidebook based on end-user comprehension of concepts, recommendations on how best to organize local staff into work teams (mapping, policy, engagement), and capacity to undertake technical analyses (e.g., GIS mapping of hazards and evaluation of plans and basic vulnerability data). Knowledge gained in working with different types of communities (e.g., low and high capacity) in pre-disaster and post-disaster recovery settings will be used to improve the guidebook in ways that encourage use of PIRS by local officials (planners, emergency managers, county and city managers, and others). The focus will be making revisions that enable local officials: 1) to better comprehend how resilience planning concepts can be translated to practice; 2) to draw on experience of other communities in assigning tasks and organizing staff in applying the scorecard; 3) to more clearly identify readily available sources of mapped hazards, vulnerability, and plan policy data; 4) to facilitate use of the plan evaluation spreadsheet software scoring tool; and 5) to better understand how to use information generated by real world applications of PIRS to create solutions for improving integration of resilience across multiple sectors of urban planning, and land use and development regulations and investments.	6/30/2019	100%	
Update website that will house PIRS (mitigationguide.org). The investigators will work with engagement staff at the Institute for Sustainable Communities (PI Berke is Director) who are trained in website development to incorporate the updates of the guidebook and training materials that supplement use of the guidebook. Knowledge generated by application of PIRS with partner communities during year-4 will provide the basis for creating the updates. The updated website will significantly facilitate use by end-users by incorporating more information about real world applications of the guidebook and plan evaluation tool.	6/30/2019	100%	
Present the most up-to-date version of PIRS and local experiences in applying PIRS at one national conference linked to associations that represent professional practice that deal with mitigation (e.g., APA conference, ICMA conference, ASFM conference, National Hurricane Center Conference) or at a workshop organized by FEMA.	6/30/2019	100%	

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
Plan Integration for Resilience Guidebook 2.0 (2nd edition)	Guidebook and associated spreadsheet software	6/30/2019	Practitioners from the fields of urban planning, landscape architecture, urban design, emergency management, and community resilience, community-based civic groups active in mitigation and disaster recovery.
Application of Plan Integration for Resilience Scorecard: Lessons Learned from the City of Norfolk, VA	Lessons learned research summary report: Norfolk	4/30/2019	Practitioners from the fields of urban planning, landscape architecture, urban design, emergency management, and community resilience, community-based civic groups active in mitigation and disaster recovery.
Training Course	Draft for two-hour training course materials based on ASFPM workshop: ppt slides, Guidebook, case study to support in-class assignment involving review of plans.	5/23/2019	Practitioners from the fields of urban planning, landscape architecture, urban design, emergency management, and community resilience, community-based civic groups active in mitigation and disaster recovery.

TABLE 2: BERKE PERFORMANCE METRICS

Metric	Year 1 (1/1/16 – 6/30/16)	Year 2 (7/1/16 – 6/30/17)	Year 3 (7/1/17-6/30/18)	Year 4 (7/1/17-6/30/18)
HS-related internships (number)	0	0	0	0
Undergraduates provided tuition/fee support (number)	0	0	0	0
Undergraduate students provided stipends (number)	0	0	0	0
Graduate students provided tuition/fee support (number)	2	2	2	2
Graduate students provided stipends (number)	3	3	3	0
Undergraduates who received HS-related degrees (number)	0	0	0	0
Graduate students who received HS-related degrees (number)	0		0	2
Graduates who obtained HS-related employment (number)	0		0	1
SUMREX program students hosted (number)	0	0	0	0
Lectures/presentations/seminars at Center partners (number)	0	3		8
DHS MSI Summer Research Teams hosted (number)	0	0		0
Journal articles submitted (number)	0	2	2	2
Journal articles published (number)	0	0	2	2
Conference presentations made (number)	3	5	2	4
Other presentations, interviews, etc. (number), webinars	1	6	2	1
Patent applications filed (number)	0	0	0	0
Patents awarded (number)	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies (number) (FEMA, NIST)	0	1	2	2
Requests for assistance/advice from other agencies or governments (number)	0	9	3	8
Dollar amount of external funding	$200,000	$250,000	$2,490,000	0
Total milestones for reporting period (number)	2	2		5
Accomplished fully (number)	2	1	4	3
Accomplished partially (number)		1	1	2
Not accomplished (number)	0	0	0	0

PROCHASKA, URI
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Communicating risks to motivate individual action

Principal Investigator Name/Institution:
James O. Prochaska, Ph. D. University of Rhode Island

Other Partners/Institutions:
Andrea L. Paiva, Ph.D., Pam Rubinoff, and Karin Oatley, University of Rhode Island

Short Project Description ("elevator speech")

Our research path will complete the validation or Proof of Concept (initiated in year 3) for changing storm preparedness behavior (Get a Kit, Make a Plan, Be Informed), using our Transtheoretical Model (TTM). This TTM tailored online approach with complementary texting; recruitment and intervention will use a census-balanced sample of 700 at-risk participants over a 10-month period. Our targeted end-user transition path includes outreach, needs assessment, recruitment, and implementation with organization(s); protocol development addresses the key elements including participant time demands, organizational costs, intellectual property issues and supporting technologies for program delivery. Our end-user recruitment plan targets organizations that are committed to having their employee or customer populations be adequately prepared for natural disasters.

1. **Introduction and project overview:**

This project has supported DHS in improving its national mission to safeguard people, infrastructure, and economies from catastrophic coastal natural disasters. This research met DHS priorities by strengthening national preparedness and improving the resilience of coastal communities in the face of coastal storm hazards; consistent with NOAA's coastal missions and programs as well. As such, this research addresses Presidential Policy Directive 8, which calls for increasing our level of National Preparedness by preventing, mitigating, responding to, and recovering from the hazards that pose the greatest risk. This project is specifically tied to strategic priority 1 of the 2014-2018 DHS strategic plan. More specifically we are responding to objective 1.3 aimed at increasing disaster awareness and action. Additionally, this project addresses QHSR Mission 5 (Strengthen National Preparedness and Resilience), which helps develop tools to enhance citizen preparedness, specifically Goal 5.1, Enhance National Preparedness supports efforts to "Empower individuals and communities to strengthen and sustain their own preparedness…build a collective understanding of their risks, the resources available to assist their preparations, and their roles and responsibilities in the event of a disaster." Hurricanes account for 10 of the top 15 most expensive natural disasters in the United States, including the top 3 (NOAA, 2014).

2. **Results:**

Our team has had enormous success in reaching out to end-users in Y04 and engaging them to participate in our program. As mentioned in the workplan, we considered completing the Proof of Concept validation research in Year 4 with a transition partner (e.g. health-related organization) instead of the new survey company. However, our previous experience recruiting such organizations for longitudinal intervention research took at least 12 months just to complete recruitment. For this project, this has not been the case at all. In fact, every organization that we have reached out to has shown enormous interest and have been working with us to figure out how we can implement our program with their employees, some of which have over 14,000 employees.

3. **End users:**

The following end-user organizations have been engaged during Y04:

- Major Health Retail Organization (2/25/2019) - Preliminary meeting with the Enterprise Response and Resiliency manager led to a request for a presentation at their national corporate headquarters. During this second meeting our team's feedback was requested in creating tailored in-store messages pertaining to emergency preparedness to be aired in over 9,000 stores. Our team provided feedback to their development team as requested. Currently, communication is ongoing regarding future presentations to be made to a larger scope of the administrative team regarding future utilization of the computer-tailored intervention program (CTI) with possible end-users being their employees and customers.
- Rhode Island Flood Mitigation Annual Conference (4/30/19)– In a collaborative roundtable format, participants were invited to share their agency/ organization's successes and barriers encountered when implementing outreach strategies regarding the reduction of property-related climate risk. Information regarding organizations, businesses, municipalities and state agencies' efforts to educate and disseminate information on this topic. The session concluded with ideas and suggestions regarding next steps for positive outcomes, one being our CTI program.
- Rhode Island Emergency Management Agency (5/13/19) – Presentation given to the director and members of the administrative staff as well as the Rhode Island representative for FEMA. High enthusiasm from all members with unanimous agreement that the program would be a good fit. FEMA representative requested we present to the regional team in Boston. Planning for next steps is process.
- Rhode Island Department of Health (RIDOH) (5/1/19 & 8/20/19) – Our initial presentation led to request for a meeting to discuss questions and potential timeline for implementation of our CTI program in a feasibility study to run concurrently with the pilot study. The RIDOH has requested the employees of the following agencies be recruited by the agencies list-serve to participate in our CTI:
- Bradley Hospital
- Butler Hospital
- Eleanor Slater Hospital
- Kent Hospital

- Fatima Hospital
- Landmark Medical Center
- The Miriam Hospital
- Newport Hospital
- Providence Veterans Affairs Medical Center
- Rhode Island Hospital
- Roger Williams Medical Center
- South County Hospital
- Westerly Hospital
- Women & Infants Hospital
- Health centers
- Nursing homes
- Assisted living communities
- EMS agencies
- Home health/hospice agencies
- Dialysis centers
- CEPR/HCRI

Lifespan hospitals account for only four out of the fourteen hospitals listed. Lifespan is largest employer in the state of RI accounting for over 14,000 potential participants. Since the scale of this trail would be enormous, we are in the process of assessing what would be required in terms of additional staff effort and financial support for launching this large-scale trial simultaneously with our currently funded study.

4. Transition:

The above-mentioned end-user organizations received in-person presentations detailing the history of our work on this project, including preliminary trial results, an overview of the evidence regarding the efficacy of the Transtheoretical Model of behavior change, its applicability to the process of change in becoming better prepared for weather-related emergencies and the computer tailored intervention program designed to provide individualized feedback interventions to each user based on their own personal stage of readiness.
A Frequently Asked Questions handout was developed and provided to all we met with.
Two promotional videos are in the process of being produced by film and media students at URI's Harrington School of Communication. One video is being developed to augment our power-point presentation designed for engaging interest among end-user *organizations*. A shorter version is designed to inform and encourage potential end-user/*participants* to agree to utilization of the program to help them better prepare. Since these videos provide testimonials from climate impact leaders and various experts in areas related to preparedness and extreme weather as well as show evidence of recent changes in weather and its impact on communities it advances our current presentation modality with a more dynamic experience for the viewer considering our program. We expect future presentations utilizing these promotional videos will lead to an increase in the likelihood of end-user engagement. Our hope is that higher end-user engagement with our CTI will lead to a more informed and prepared general citizenry, savings in money and/or property, increases in the operational efficiency of business communities as well as greater resiliency in communities as a whole.

5. Project Impact:

In year 4 our outreach to end users far surpassed our expectations and our goals. After two presentations of our digital program for helping participants progress through the stages of change to become prepared for severe storms, the chief of the center for emergency preparedness and response (CEPR) at the RI Department of Health enthusiastically wants to offer our preparedness program to employees of its following organizations: 1. All 14 hospitals Rhode Island; 2. All federally funded health centers; 3. All nursing homes; 4. Assisted living communities; 5. EMS agencies; 6. Home/Hospice agencies; 7. Dialysis centers and 8. CEPR/HCRI. These agencies serve a broad range of diverse and vulnerable populations whose lives would be at increased risk if they could not receive this health services that are needed.

We had similar enthusiastic response from the Director of Emergency Preparedness for one of the nation's largest multi-tiered health companies. The goal would be to provide our program to the 300,000 employees of this company and potentially to the 5,000,000 customers they serve each day. Similarly, the Directors Preparedness programs for the US Naval instillation in Rhode Island want s our programs to be delivered to Navy personnel.
The Challenge is that our grant does not have the resources to deliver our preparedness programs to so many organizations and populations. In year five we are planning to serve as many organizations and populations as we can and to work to discover how funding can be found for organization s to serve their key personnel and their vulnerable populations to reduce their risks and to protect the health and lives of the populations they serve.

6. Unanticipated Problems:

Our legal team at URI has been working diligently with the survey company since the notice of Y04 funding in January 2019 to secure a contract to recruit our 700 baseline participants for our proof of concept trial. We are 90% of the way there and plan to recruit our baseline sample as soon as that is signed. Due to the later notice of award and more communication between URI's legal department and the survey company, this is happening later than anticipated but we remain hopeful that this will materialize in the next few weeks and we will be able to start recruitment.

7. Student Involvement and Awards:

Lauren Hanna, a URI graduate student in environmental management, was funded by leveraged sources in the second half of year 4. Her role was to support the tram in developing messaging for texts related to preparedness. Additionally, she has been assisting on video development and outreach to end users.

In addition, two undergraduate film and media majors have been completing an internship to develop short videos for outreach to end users. Sarah Angeloni and Joshua Hastings have done extensive work to prepare for and shoot these videos with experts in the field. In addition, they recently attended Prep Con (Rhode Island's Annual Rhode Island Preparedness Conference)

8. Interactions with education projects:
None

9. Publications:

- Mundorf, N., Redding, C.A., **Prochaska, J.O., Paiva, A.L.**, & **Rubinoff, P.** (2017). TResilience and Thriving in spite of Disasters: A Stages of Change Approach. In A. Fekete & Fiedrich, F. *Urban Disaster, Resilience and Security.* Berlin: Springer.

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Proof of Concept - Review/revise text messages sent to participants with FEMA/RIEMA colleagues	3/1/2019	100%	
Proof of Concept - Contract with Survey Company for Time 1 (baseline) and T2 (follow up); implement T1 assessment; begin sending text intervention	3/1/2019	90%	Contract is in negotiations with URI's legal team and the survey company.
Proof of Concept - Analyze baseline assessment	5/1/2019	0%	Contract with survey company is not yet signed.
Proof of Concept - Text messages sent to participants for 10 months	1/1/2020 (outside the reporting period)		
Proof of Concept - Reassess participants for longitudinal study	1/15/2020 (outside reporting period)		
Proof of Concept - Analyze follow-up data	1/31/2020 (outside reporting period)		
Research Milestone			

Proof of Concept - Baseline assessment completed	4/1/2019	0%	Contract with survey company is not yet signed.
Written quarterly progress update delivered to DHS	10/1/18; 1/1/19; 4/1/19; 6/30/19	100%	
Proof of Concept - Text messages completed and longitudinal assessment implemented	1/15/2020 (outside reporting period)		
Proof of Concept – Analysis completed; reported to/discussed with to CRC/DHS; webinar #2	1/31/2020 (outside reporting period)		

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Summarize the sample that was collected at T1including region, demographics, stage of change, time spent on the program/assessment, and how many participants opt into the text messaging feature. This summary will indicate that we were able to recruit the sample needed for our proof of concept.	3/1/2019	0%	Contract with survey company is not yet signed.
Engage end-users in series of Webinars to share research findings, and market use to end- user organizations. • Preliminary outcome and new baseline for proof of concept. • Preliminary outcomes and opportunities and benefits of adoption.	4/1/19; 8/1/19 (outside reporting period)	100%	Have presented preliminary outcomes and benefits of adoption to many potential end-user organizations.
Identify and meet with 3 potential end-user organizational partners (quarter2), no less than 6 candidates, located in RI and Nationally (face-to-face or teleconference). Understanding the organizational facilitators and barriers to using this tool and identifying options to reduce barriers as part of protocols.	8/31/2019 (outside reporting period)	100%	Have surpassed original requirements for this activity. We have met extensively with 6+ potential end-user organizations all expressing interest in utilizing the program.

Demonstrate online program to potential end-users such as FEMA, RIEMA, and companies that might be interested in adopting this program for their employees. Walk potential end-users through the program and explain impacts that it can have on the participants. This walk-through will demonstrate the interactive nature of the assessment and tailored feedback as well as the short duration of the program	8/2019 (outside reporting period)	50%	
Compiling proposed Protocol components for transition end-users such as costs, time, and training.	11/2019 (outside reporting period)	75%	This has been completed with the exception of estimated cost.
Transition Milestone			
Develop and share a fact sheet with potential end users that will contain components related to demands on participants, costs to sponsoring organizations, intellectual property issues and supporting technologies for delivering the program.	8/31/2019 (outside reporting period)	100%	
Summarize progress for program adoption and organizational facilitators and barriers to using this tool and identifying options to reduce barriers.	12/31/2019 (outside reporting period)		
Close on at least one Letter of Agreement with an end user to move onto the next end user	4/20 (outside reporting period)		
Draft Protocol related to demands on participants, costs to sponsoring organizations, intellectual property issues and supporting technologies for delivering the program.	3/2019	100%	

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	Delivery Date	**Recipient or End User(s)**
End-user Organization FAQ Handout	Guidance document	4/20 (outside reporting period)	• RIEMA • RI Department of Health and affiliated agencies • Major Healthcare Retail Organization

Table 2: PROCHASKA PERFORMANCE METRICS

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)				
Undergraduates provided tuition/fee support (number)				
Undergraduate students provided stipends (number)				
Graduate students provided tuition/fee support (number)	1			
Graduate students provided stipends (number)				
Undergraduates who received HS-related degrees (number)				
Graduate students who received HS-related degrees (number)				
Graduates who obtained HS-related employment (number)				
SUMREX program students hosted (number)				
Lectures/presentations/seminars at Center partners (number)	2	2		
DHS MSI Summer Research Teams hosted (number)				
Journal articles submitted (number)				
Journal articles published (number)				
Conference presentations made (number)				
Other presentations, interviews, etc. (number)				
Patent applications filed (number)				
Patents awarded (number)				
Trademarks/copyrights filed (number)				
Requests for assistance/advice from DHS agencies (number)	2	2		
Requests for assistance/advice from other agencies or governments (number)				
Dollar amount of external funding	$0	$100,000	$100,000	
Total milestones for reporting period (number)	4	5		3
Accomplished fully (number)	4	3		3
Accomplished partially (number)	4	2		0
Not accomplished (number)				1

TWILLEY, LSU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Integrating CERA-Planning Software to support DHS Modeling and Planning Efforts for more Resilient Communities

Principal Investigator Name/Institution:
Robert R. Twilley, Louisiana Sea Grant/Oceanography & Coastal Science, Louisiana State University

Other Research Partners/Institutions:

- Traci Birch, Coastal Sustainability Studio, LSU
- Carola Kaiser, Center for Computation and Technology (CCT)
- LSU Brant Mitchell, Stephenson Disaster Management Institute (SDMI), LSU

Short Project Description ("elevator speech"):

We propose to investigate how some of the skills developed within CERA-Planning can be integrated into some of the flood exposure and damage modeling techniques that have been developed to evaluate impact of natural hazards to improve planning. The approach is to test whether some of the skills that have been developed within CERA/ASGS and incorporated into CERA-Planning to describe flood exposure and impacts can contribute to the existing flood consequence modeling within FEMA and NIST.

1. Introduction and project overview:

We propose that the CERA-Planning tool, as a next step innovation to CERA/ASGS, can provide additional skills to existing community resilience tools within NIST and DHS sectors such as HAZUS FLOOD. The high scale resolution of flood exposure presented in an innovative communication platform may prove to be a valuable tool to innovate design/planning approaches. Communities need clear guidance on exactly which vulnerable infrastructure and populations may be threatened and/or protected (pre-disaster planning and rapid response), and accurate post-event impact to make crucial land use and redevelopment decisions during initial stages of recovery. The ability to leverage this type of community-specific data along with fine-scale modeling of flood exposure (in a universal communication platform) provides the opportunity to avoid loss and rebuild for maximum future risk reduction. The proposed LSU partnership with DHS sectors using CERA-Planning builds on the strengths of existing flood hazard and community planning approaches with the innovation of flood modeling developed

with CRC. The transformational products proposed will allow vulnerable communities to actively address improved flood prediction, protection, and response. We will incorporate established modeling outputs into existing consequence models (HAZUS FLOOD) and community resilience guidelines (NIST Community Resilience Program) showing how flood risk (both from storms and SLR) will impact people, industry, and infrastructure. This much needed information will be used to enhance pre- and post-disaster planning efforts. The products will be tested with communities in the Gulf region that have experienced repetitive losses to flood events. Community engagement with end users directly in the development process will be leveraged using university-based design studio projects and design/outreach activities (such as those within Sea Grant Community Resilience focus area).

These enhancements will focus on the ability of consequence modeling platforms to enable vulnerable communities to plan in areas facing repetitive disturbance. The goals of the program are to migrate technologies developed in the CRC to enhance flood prediction and emergency management to modeling tools and planning toolkits that are designed to protect vulnerable infrastructure and populations, and to reduce repetitive loss by providing accurate potential impact data to community planners. This program focuses on significant reduction in risk with the use of high-fidelity storm surge data and impact scenario viewers useful to post-disaster recovery planning. Together this group will test what skill sets in the CERA/ASGS modeling platform may enhance the following: (1) planning tools that are being developed by NIST Community Resilience program that may help to visualize aggregated risks to include hurricane force winds, storm surge, and inland flooding along with vulnerable populations based on socio-economic status; (2) test and migrate modeling and visualization tools to communicate flood risks during a tropical cyclone event to HAZUS FLOOD to assist in identifying vulnerable populations and structures that are susceptible to storm surge; (3) run comparative tests of CERA-Planning with HAZUS FLOOD over test beds associated with Hurricanes Matthew and Irma in the Gulf of Mexico region; (4) work with Texas A&M and NIST collaborators in testing planning guidance tools to improve resilience based on CERA-Planning tool. The CERA-Planning tool will work with NIST and HAZUS FLOOD group to integrate data sets and scenario analysis to inform consequence model results.

2. Results:

The original intent for CERA was to present results to emergency managers, and that was the focus of benefits with initial developments in consequence modeling. In the last year, our focus has been to impact the thinking and actions of existing hazard and resilience planning tools within NIST and other DHS sectors (HAZUS, FEMA). Our efforts have focused on how our experience in building integrated modeling information for future hazard mitigation decisions can be used to promote programs within NIST and FEMA (Fig. 1). The proposed project utilized discussions with DHS and CRC leadership to determine how outcomes of the CERA-Planning tool can be integrated into existing federal systems and training opportunities to improve planning actions creating more resilient communities. We held a series of videoconference and attended workshops to integrate CERA-Planning with existing tools currently used or developed by DHS partners to expand the utility of previous investments by DHS to ASGS-CERA capacity.

Collaborating with NIST and FEMA groups has been extremely helpful to our project and we have contacts with individuals involved with these efforts. We report on possibilities to integrate the results of this project with existing tools currently used or developed by DHS. The products of CERA also help to inform other tool development programs on what specific information may be most effective in changing the perspective of planning process (see discussion at HAZUS workshop held in June 2019). Thus, CERA-Planning is not another tool as much as CERA-Planning is a tool that is testing a variety of techniques to be more effective in communicating the risk of flooding on planning analyses and decisions. Discussions are reported with the NIST Community Resilient program to see how information from CERA-Planning may be used in the guidance documents that are being developed for communities. CERA-Planning (and CERA/ASGS) can provide scenario analyses for NIST to test different capabilities of guidance documents. This expansion in model capability has been identified as having parallel training efforts at the state, regional and national level in coordination with present APA training efforts (see specifics outlined below).

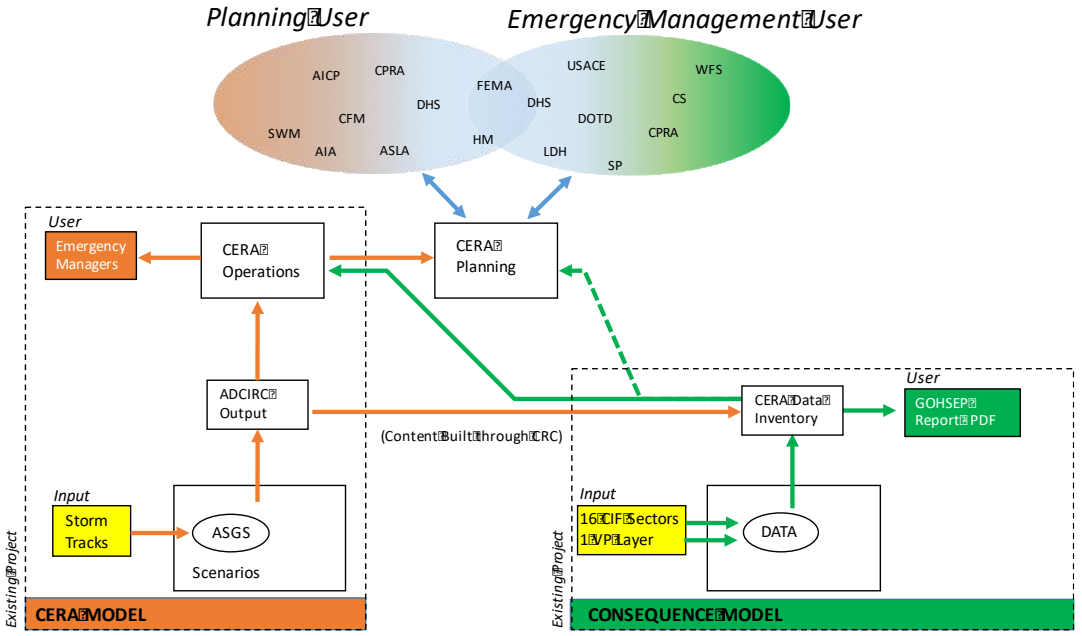


Figure 1. Diagram that demonstrates the development of the CERA model originally for emergency managers (CERA Operations) to the proposed CERA for planners (CERA Planning); and the linkages to the Consequence Modeling.

Activities over the last year have been involved with developing greater utility in CERA-Planning to help neighborhood, city, regional planners determine future land-use planning decisions based on future risk scenarios and flood vulnerabilities using the needs of programs and models developed within NIST and FEMA.

- Conference calls and webinar with NIST was organized during spring and summer 2018 to initiate the utility of CERA Planning into those techniques and guidelines. In addition, efforts have been initiated, at the request of FEMA, to test the application of CERA Planning with the mitigation planning guidelines that are being developed at Texas A&M by Dr. Phil Burke. Both of these efforts are in the stage of identifying coastal communities in Louisiana to apply the NIST and TAMU techniques, and test the application of CERA Planning to those case studies.
- Continue develop CERA-Planning Model to capture the diversity of coastal infrastructure and assets for scenarios of Hurricanes Matthew and Irma
- Held technical workshop with Hazus-FLOOD modelers and developers to identify how CERA-Planning tool can provide additional high-resolution input data on flood conditions during an event on June 9-10, 2019. Participants that focused on the use of CERA-Planning and ADCIRC with Hazus capability included the following: Rick Luettich (University of North Carolina), Brian Blanton (University of North Carolina), Carola Kaiser (Louisiana State University), Robert Twilley (Louisiana State University), Hazus developer, FEMA developer, Hazus lead, Hazus program integration. Plans for YEAR 5 to link CERA-Planning and Hazus include the following:
    - ADCIRC team will make both wind and flood hazard data from Michael available on the THREDDS server for Hazus experimentation
    - Hazus will experiment with data formatting options for unstructured ADCIRC grids – NetCDF, GeoTIFF, etc.
    - Hazus will determine path forward for dynamic integration of ADCIRC data – THREDDS server vs. CERA website
    - Hazus will work with ADCIRC team as next Hazus release is developed to test ADCIRC data integration functionality
    - Hazus will develop messaging for user community on new ADCIRC hazard data applications
    - ADCIRC team will send along any useful documentation/publications on the development of ADCIRC data
- On site visits at UT Austin (July 2018 and April 2019) to meet with Gordon Wells, Texas SOC for potential further improvement of the CERA tool, e.g., the use of satellite imagery and oil pipelines following the impacts of Hurricane Harvey in the TX Houston area
- Conducted a CERA tutorial session at the ADCIRC Bootcamp week 2019 (April 2019, Austin). Attendees included
  - Heath E. Jones (Director of Operations for the New Orleans District of the US Army Corps of Engineers, New Orleans)
  - US Coast Guard Incident Management Sector Chief
  - Katie Breland (Texas Task Force 1 swift water rescue)

- Gordon Wells (Texas State Operations Center and Program Manager at the Center for Space Research at the University of Texas at Austin)
- Phillipe Tissot (Research Professor at the Texas A&M University-Corpus Christi, teaching a course in Environmental Forecasting)

- Technical improvements of the CERA tool including the complete migration from Python version 2 to Python 3 and the Django web framework version 1 to version 2
- New CERA feature for hurricane season 2019: Implementation of real-time wind level stations as direct response of user feedback after hurricane Harvey
- Training of a Louisiana based ASGS operator in collaboration with CRC PI Dr. Jason Fleming; training of a CERA backup operator (in progress) for hurricane season 2019

3. <u>End users:</u>

- Research Engineer, Community Resilience Group, NIST, Section Chief, Infrastructure Development and Recovery at National Protection and Programs Directorate; Lead contact to establish integration of CERA-Planning into NIST Community Resilience Guidelines
- We engaged the Capital Region Planning Commission (CRPC; Kim Marousek, Director of Planning) to select community to utilize the NIST Community Resilience Guidelines and the CERA-Planning tool as envisioned from the design class as part of the LSU Coastal Sustainability Studio.
- NOAA Gulf of Mexico Regional Team (GoMRT) to incorporate NOAA tools into the Community Resilience Index that has been program supported by the Gulf of Mexico Alliance. The discussions have been centered around interest in using NOAA tools to support the Gulf of Mexico Community Resilience Index community engagements. CERA-Planning is working to be part of the hurricane scenario discussions that initiate the community engagement process.
- As of July 1, 2019, the CERA tool has 426 subscribed users including clients from DHS, FEMA, NOAA, USACE, USCG, USMC, TXSOC, CPRA, NWS, insurance companies, and the research community, among others.
- Collaboration with NOAA to integrate ESTOFS (Extratropical Surge and Tide Operational Forecast System) into CERA. ESTOFS has interest to use CERA platform at NOAA for disseminating model guidance to benefit NOAA and raise visibility of operational data already available.
- On-site visits at UT Austin (July 2018 and April 2019) to meet with Gordon Wells, TX SOC for potential further improvement of the CERA tool, e.g., the use of satellite imagery and oil pipelines following the impacts of hurricane Harvey in the TX Houston area
- CERA presentation at National Tropical Weather conference (April, 2019) engaged end users such as the following:
  - Director of the National Hurricane Center
  - Team lead of the NHC Storm Surge Unit
  - Lead Warning Coordination Meteorologist at the National Weather Service in Corpus Christi
  - Chief Forecast Operations, US Department of Commerce, NOAA
  - Several local emergency managers from Texas and media participants

4. Transition:

- The LSU CERA/ASGS team have been working with NIST to define how CERA-Planning can create test case scenarios of previous storms in selected locations to test the capacity of these new tools and guidelines in achieving the goals of the NIST
- Webinars with NIST have been held to define how CERA-Planning may be used in the presentation format used by NIST in community engagement to utilize the Community Resilience Planning Guide.
- The development of CERA-Planning took has focused around the use of Hurricane Isaac and flood prone region of Northshore of Lake Pontchartrain to build an integrated system for community resilience.
- Presentation of the CERA tool at the ASBPA conference, Nov 2018 and the ESIP Winter Meeting. Introduction of CERA as a potential tool for the "Operational Readiness Level" that the ESIP Disaster Lifecycle Cluster is trying to establish in the community
- Presentations that describe the utility of CERA as communications tool continue to help provide utility of the ADCIRC Prediction System such as at the National Tropical Weather conference (April, 2019) that included National Hurricane Center, National Weather Service in Corpus Christie, Chief Forecast Operations of NOAA, and several local emergency managers from Texas and media participants.

5. Project Impact:

- Held technical workshop with Hazus-FLOOD modelers and developers to identify how CERA-Planning tool can provide additional high-resolution input data on flood conditions during an event on June 9-10, 2019.
- A contact to the HAZUS senior developer (Riskmap CDS), Ujvala Sharma with niyamIT, has been established at the FEMA Hazus workshop (June 2019). Access to the Hazus infrastructure database has been granted to the CERA team. The data will be evaluated for potential use in the CERA-Planning tool.
- CERA statistics for Hurricane Florence for the date range 8-15 September 2018 represents the growing impact of ADCIRC Prediction System (APS) during hurricane events. This project, along with support from Louisiana Sea Grant, continues to support the operations of APS during major events.
    - 154 new users requested a login during this time. Please see attached the screenshot "CERA_new-login_Florence_8-15Sep2018.png" for a breakdown.
    - 54,577 unique users have accessed the CERA website that is free for the public. They viewed a total of 152,905 CERA map displays. The peak was on Sep 11 with 17,609 unique users.
    - 368 CERA users with a login used the CERA website during the storm with a total of 6389 map views.

6. Unanticipated Problems:

There was a problem in making final links and implementation plans between the NIST Community Resilience Planning Guide and CERA-Planning. The plan was to engage a community resilient studio focused on how CERA-Planning could be implemented in community planning and use the NIST planning guide as tool to suggest tool augmentation in the

planning process. That studio was not finalized; and is planned again for fall semester 2019. The process lacks tool development skills needed to program CERA-Planning with data acquisition and visualization that is needed by the planning process; and clarity in how tools such as CERA-Planning can help develop scenarios that augment the resilient community planning process. Two solutions have been implemented to resolve these problems. First, a graduate student has been recruited that has undergraduate degree in civil engineering with interest in pursuing a graduate degree working on the CERA-Planning tool to augment planning process. The student has background and interest in regional planning and models that simulate flood risks. The student began working on the project in June 2019 and attended the Hazus workshop held in Washington DC. Second, contact was initiated with the Gulf Community Resilience Index team that has been focused on integrating NOAA tools to augment community resilience planning. This discussion, along with recent collaborations with Hazus development team, may help to define clarity in what information in hurricane scenarios would help the planning process to help communities reduce competitive losses. The new graduate student hired on this project will work on programming CERA-Planning using access to information in Hazus and working closely with the Gulf Community Resilience Index team to define what scenarios will help communities define needs for resilience planning.

7. Student Involvement and Awards:

- Nick Robles completed the requirements for a Masters of Science
- Undergraduate interns were supported in the LSU Coastal Sustainability Studio to assist with collecting and organizing GIS information on the 2016 Louisiana Flood.
- New graduate student, Katherine Jones, has been hired to program CERA-Planning to augment regional planning for community resilience

8. Interactions with education projects:

N/A

9. Publications:

N/A

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Continue to develop CERA-Planning Model to capture damage to diverse coastal infrastructure and community assets associated with Hurricane Isaac	12/2018	70%	Need to implement studio on community resilience planning
Conduct analysis of hurricane impact scenarios from Hurricane Isaac to capture the diversity of recovery and adaptation needs for community planning to augment workshop activities with partner community planned in 2019.	12/2018	50%	Need to implement studio on community resilience planning
Determine available data to be used in building CERA-Planning based upon Hurricane Isaac that provide technical assistance in use of NIST Community Resilience Program guidelines.	06/2019	50%	Need to implement studio on community resilience planning and connect to NIST program
Research Milestone			
Identified scenarios using Hurricane Isaac that provide flooding outcomes and consequences that would be useful in workshop planning exercise using NIST guidance tools that augment technical quality of partner community planning process.	12/2018	70%	Need to implement studio on community resilience planning and connect to NIST program
Finalize compiling the data sets required to build CERA-Planning based upon Hurricane Isaac data sets and monitoring reports.	06/2019	50%	Need to implement studio on community resilience planning and connect to NIST program

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Based upon discussions with NIST, determine process to engage CERA-Planning into process development of Community Resilience Program.	12/2018	80%	Discussions with NIST have identified process but need to simulate community augmentation with studio
Link CERA-Planning with NIST Community Resilience program using Hurricane Isaac as example of how flood modeling can improve community impact using present community planning guidelines	12/2018	50%	Discussions with NIST have identified process but need to simulate community augmentation with studio
Meet with Capital and/or New Orleans Regional Planning Commission staff to discuss candidate partner communities to augment planning process using CERA-Planning and NIST Community Resilience Program guidelines.	03/2019	50%	Discussions with NIST and Capital Regional Planning Commission have been initiated; but need to define tools to augment process, which is planned with fall 2019 studio
Transition Milestone			
Select a partner community to test benefit of CERA-Planning/NIST Community Resilience program based on present protocols and criteria that exist in community planning effort	12/2018	50%	Discussions with NIST and Capital Regional Planning Commission have been initiated; but need to define tools to augment process, which is planned with fall 2019 studio
Execute a workshop with selected community partner demonstrating value added of the CERA-Planning with NIST Community Resilience Program to augment technical assistance in planning efforts.	06/2019	25%	Discussions with NIST and Capital Regional Planning Commission have been initiated; but need to define tools to augment process, which is planned with fall 2019 studio

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
Open DAP Server	OpenDap is a webserver technology that runs on dedicated servers at CCT/LSU and RENCI/UNC. It is used to store ADCIRC simulation results produced by the ASGS in a data archive on those servers. The data files provided on the OpenDap servers will be downloaded and consumed by CERA to visualize ADCIRC simulations with the goal to present the maps on the CERA website.	December 2018	Customers using CERA on line products
Updates to CERA software	Complete migration from Python version 2 to Python 3 and the Django web framework version 1 to version 2	December 2018	Customers using CERA on line products

Table 2: TWILLEY Performance Metrics:

Metric	Year 1 (1/1/16 – 6/30/16)	Year 2 (7/1/16 – 6/30/17)	Year 3 (7/1/17-6/30/18)	Year 4 (7/1/18-6/30/19)
HS-related internships (number)				
Undergraduates provided tuition/fee support (number)				
Undergraduate students provided stipends (number)	1	1	1	0
Graduate students provided tuition/fee support (number)	1	1	1	1
Graduate students provided stipends (number)	1	1	1	1
Undergraduates who received HS-related degrees (number)				
Graduate students who received HS-related degrees (number)				
Graduates who obtained HS-related employment (number)				
SUMREX program students hosted (number)				
Lectures/presentations/seminars at Center partners (number)	1	2	3	3
DHS MSI Summer Research Teams hosted (number)				
Journal articles submitted (number)				
Journal articles published (number)				
Conference presentations made (number)	5	3	3	4
Other presentations, interviews, etc. (number)	6	2	3	2
Patent applications filed (number)				
Patents awarded (number)				
Trademarks/copyrights filed (number)				
Requests for assistance/advice from DHS agencies (number)	7	6	11	18
Requests for assistance/advice from other Federal agencies or state/local governments (number)	5	4	3	55,000*
Dollar amount of external funding	$650,243	$800,243	$575,243	$575,243
Total milestones for reporting period (number)	8			
Accomplished fully (number)	3			
Accomplished partially (number)	5			
Not accomplished (number)	0			

* See discussion on users for CERA during 2018 hurricane season

Theme 3

Coastal Hazards Modeling

LUETTICH, UNC-CH
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:

ADCIRC Prediction System Development Coordination and Improved Connectivity with Hydrologic Models

Principal Investigator Name/Institution:
Rick Luettich, Professor, University of North Carolina at Chapel Hill

Other Research Partners/Institutions:

Brian Blanton, Jason Fleming, Casey Dietrich, Clint Dawson, Scott Hagen, Isaac Ginis, Don Resio

Short Project Description ("elevator speech"):

A substantial portion of the Coastal Resilience Center's research portfolio involves the development and application of new capabilities for the ADCIRC Prediction System (APS) which is comprised of ADCIRC, the ADCIRC Surge Guidance System (ASGS) and the Coastal Emergency Risks Assessment (CERA) web portal. Included in these activities is the development of:

- higher resolution regional grids for the US East and Gulf coasts that integrate with our current national scale Hurricane Surge on demand Forecast System (HSOFS) grid (with Dietrich, Dawson, Hagen, Ginis);
- software to efficiently track and manage multiple ADCIRC runs across different computer platforms including "the cloud" (with Blanton, Fleming);
- additional improvements in the wind model that is included in ADCIRC (with Ginis);
- better coupling to hydrology models that track the movement of fresh water across the land, into streams and rivers until it interacts with coastal waters (with Resio, Ginis, Huang); and
- continued operation and maintenance of the ASGS and CERA to provide access to ADCIRC predicted water levels and flooding during major storm events and water velocities 24x7x365 for US Coast Guard search and rescue operations (with Blanton, Fleming and Kaiser).

This proposed project will contribute to and coordinate the suite of projects providing enhancements to the APS to increase the accuracy and power of this system; provide interpretation of APS results during major storm surge events to maximize the value of these results for end users; and develop improved documentation and testing via an updated website, wiki and test cases to better enable its use by the broader ADCIRC user community.

1. Introduction and project overview:

Significant development work has been and continues to be done to enhance the ADCIRC modeling system. This project is designed to direct and integrate this work for the benefit of ADCIRC-based forecasting system that comprises the ADCIRC Prediction System (APS). In addition, this project supports the expansion of ADCIRC information and documentation available to the user community and the development of improved couplings between inland and coastal flooding.

2. Results:

Results are further detailed in the milestone tables below. Preeminent results include extensive forecasting efforts for 2018 hurricanes Florence and Michael (and 2019 hurricane Barry), progress toward enhancing the APS capabilities, the growth of a group of individuals who are capable of operating the APS and cloud-based high-performance computing to execute the APS. Especially successful was the development of the ASGS monitoring portal by Blanton.

Substantial transition progress was accomplished as documented below.

3. End users:

USCG information consumption
Louisiana Coastal Protection and Restoration Authority identify information desired for future events.

4. Transition:

- Wrote the APS business plan scope of work
- Organized APS planning workshop at LSU
- Attended NOAA sponsored Coastal Coupling Community of Practice (CCCoP) Workshop at the National Water Center, agree to join the CCCoP steering committee
- multiple times daily communications with potential end users during 2018 hurricanes
- led design of ADCIRC Wikipedia and ADCIRC wiki, new ADCIRC branding activities
- worked on manuscript for bias correction
- communication with other CRC ADCIRC project PIs regarding efforts to support APS.

5. Project Impact:

This project is intended to provide significant progress in the development and implementation of the ADCIRC Prediction System (APS). Evidence of the success was the extensive use of the APS during hurricanes Florence and Michael in the fall of 2018 and the considerable impact it had during hurricane Barry in 2019. In the latter case our APS results were extensively used to assist decision making by the U.S. Army Corps of Engineers and the State of Louisiana.

6. Unanticipated Problems:

This project built from past CRC work, principally coordination and transition of important findings into the operational ADCIRC Prediction System and also initiated new research in coastal – inland model coupling. The former work was successfully accomplished during the project year. The latter was not initiated due to the delayed funding and the resulting inability to hire a post-doctoral associated to perform this work. It will be reinitiated during Year 5.

7. Student Involvement and Awards:

Research

PhD Student Jie Gao was supported by other funds but worked on research directly related to this project over her time as a UNC graduate student. She completed her dissertation and was awarded a PhD in December 2018.

PhD Student Taylor Asher received primary support for his work on storm surge uncertainty from other sources. However, he received partial support from this project for his work on the bias correction, the ADCIRC Wikipedia page and the ADCIRC wiki.

Student Demographics

Jie Gao – Asian, foreign national, graduate

Taylor Asher – US, graduate

Degrees Attained

none

Student Awards

Taylor Asher – ADCIRC User meeting, most significant male contributor of 2018-19

8. Interactions with education projects:

n/a

9. Publications:

Gao, J., 2018. On the Surface Wind Stress for Storm Surge Modeling, PhD Dissertation UNC Chapel Hill, 12/2018.

Asher, T.G, Luettich, R.A. Jr., Fleming, J.G, Blanton, B.O., in review, Dynamic Water Level Correction in Storm Surge Models Using Data Assimilation, Ocean Modelling

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Evaluate feasibility of using URI HBL wind model improvements in APS	06/2019	0	Funding not available to hire necessary personnel. Will be pursued in Year 5
Test new approach for representing rivers to link ADCIRC with hydrology models	06/2019	0	Funding not available to hire necessary personnel. Will be pursued in Year 5.
Research Milestone			
Presentation of findings from research activities at ADCIRC Week	06/2019	100	Presented keynote talk on the ADCIRC Prediction System at the ADCIRC Users group meeting

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Process to include dynamic offset capability into ASGS using the recently developed data assimilation scheme to account for un-modeled processes such as antecedent meteorology, large-scale ocean currents (e.g., the Gulf Stream) and other factors that can introduce bias into ADCIRC water levels	06/2019	50	Review of a manuscript covering the dynamic offset capability provided suggestions for improving the methodology. We have been investigating this prior to full implementation in ADCIRC. In the meantime we have implemented an interim capability that was used extensively during 2018

			hurricanes Florence and Michael.
Transfer of high resolution regional grids being developed by Dietrich, Ginis, Hagen projects into APS to provide more accurate storm surge results than possible with the HSOFS grid.	06/2019	20	One grid has been transferred, the Northern Gulf of Mexico (NGOM) grid developed by Hagen. This was used extensively during 2018 Hurricane Michael.
Test capabilities of ADCIRC run monitoring portal	06/2019	100	ADCIRC run monitoring portal has been thoroughly evaluated with many improvements recommended and implemented during the project performance period. The portal performed without a hitch and proved **INVALUABLE** during Hurricane Barry. Based on the recent experience we expect to continue to recommend enhancements for the porta.
Revise ADCIRC website and update ADCIRC online documentation at adcirc.org to provide more a more current look and feel and easier access to content for the benefit of the ADCIRC user community.	06/2019	50	Efforts have been focused on developing a Wikipedia page for ADCIRC (targeted at broad audiences) and an ADCIRC wiki (wiki.adcirc.org) to provide more user friendly ADCIRC documentation and community input. Both have been created, substantially populated with information and will continue to be expanded in Year 5.
Transition Milestone			
Dynamic offset capability included in ASGS	06/2019	50	Interim version implemented. Working on improvements to methodology prior to full inclusion

Version 1 of high resolution grids included in APS	06/2019	20	One grid included, waiting on the delivery of other grids from partners.
Version 1 of ADCIRC / ASGS run monitoring portal is operational	06/2019	100	Fully achieved and highly successful! (Technical work accomplished by Blanton's project.)
Version 1 of revised ADCIRC website and documentation available online	06/2019	100	Wikipedia page and ADCIRC wiki online and populated.

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
ADCIRC Wikipedia page	Online information	6/30/2019	
ADCIRC wiki	Online documentation	6/30/2019	
ASGS run portal	Software	6/30/2019	ADCIRC Prediction System team

Table 2: Performance Metrics
(N/A)

RESIO, UNF
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 201

Project Title:
Development and Validation of Efficient and Accurate Methods for Coupling ADCIRC to Hydrologic Models

Principal Investigator Name/Institution:
Don Resio, University of North Florida

Other Partners/Institutions:
John Atkinson, Arcadis

Short Project Description ("elevator speech"):

Today, the ability of coastal communities to sustain health and prosperity is being threatened by rising sea level and increased development in areas vulnerable to flooding. Recent storms such as Isaac, Harvey, and Irma have shown that a somewhat previously overlooked threat, the combination of storm surges and hydrologic (i.e. combined rainfall, runoff, and river flow) flooding, is contributing to a serious problem of under-predicted flood risk. This project will develop methods to couple hydrologic and surge models for evaluating flood risk from predictions of potential flooding for real-time evacuation planning, supporting long-term resiliency planning, and hazard level prediction in coastal areas. Products derived from this research mission will be of immediate utility to DHS and their mission to define existing risk and proposed risk reduction activities for United States coastal communities. The project will also develop a set of metrics that include accuracy, computer resource requirements (primarily execution time) and the flexibility of the system to function effectively in a range of conditions.

1. Introduction and project overview:

Our research project is focused on comparisons of accuracies obtainable using different approaches to solve for compound flooding events. Our test site is the St Johns River and water levels and flooding produced by Hurricane Irma, which flooded a substantial portion of downtown Jacksonville, FL. Our approach to improve flood prediction has been to couple the ADCIRC storm surge model and a time-stepping solution to the Gradually Varied Flow (GVF) equation to account for additional flooding from the watershed. Research is ongoing to evaluate efficiency and accuracy of several model coupling methodologies. The outcome of this research will assist planners and government agencies (FEMA and USACE in particular) in quantifying the inundation probabilities in terms of Annual Exceedance Probabilities (AEP's). It will also examine the computational costs of obtaining these results via different methods, which is extremely important to planning groups due to the impact of computational burdens on such projects

2. Results:

Work on this project has been impacted by funding restrictions. To date we have only received $37.5k for this project; however, the Taylor Engineering Research Institute (TERI) at UNF has provided sufficient additional funding to maintain student funding and reasonable research progress on this project. Our main research finding is that the upriver levels appear to be very reasonably captured in our 1D model. Although it is possible to add wind effects parametrically, in a 1D model, this has not yet been done yet. The watershed model being applied here is a basin-scale model; however, we have kept the form of the model general to allow it to couple with any hydrologic models for watersheds in an efficient manner. We are also investigating the rainfall patterns in hurricanes relative to different parametric models that can be applied both within ADCIRC and inland hydrologic models. This will ensure that we can maintain consistency between surges at the coast and inland rainfall for simulated events. The ADCIRC code has been modified to accept rainfall volumes as increased nodal water surface elevations. In addition, the ADCIRC meshes have been modified to allow for a mass influx as an internal point source within the model domain. This allows for a linkage between the 2D surge model and the 1D flood routing model. Testing for optimal boundary location is ongoing.

3. End users:

Florida Department of Emergency Management is having Dr. Resio work with a team from Florida Atlantic University on a template for coupling surges and hydrologic models for the entire state. This state funding is already in place and the overall project will begin next February. This is a very substantial project (approximately $20M) and will help integrate state hydrologic groups and hydrologists within a system that can be adapted to their area and their own hydrologic models.

4. Transition:

The current state plan is to transition this system to the entire state of Florida in 2020. Given the importance of compound surge-inland flooding events coupled with sea level rise in many coastal areas of Florida, this represents a major step toward the application of the methodology developed under DHS and TERI funding to a real-world problem.

5. Project Impact:

This advance in the ability to efficiently handle compound flooding events should result in an operational system that opens the surge-hydrologic computational system to a range of approaches with different classes of hydrologic models, ranging from detailed models of urban and other highly developed regions to rural areas, where the hydrologic system is much more natural and contains far less detail. This will likely produce a system that is more flexible to meet local needs, since hydrologic models in most states are not standardized. In turn, this should allow more planning options to be investigated in more detail, which should

yield improved ability to couple these results with economic, social and land-use metrics, which should help reduce adverse consequences of coastal inundation.

6. Unanticipated Problems:

Funding delays have not had a large role within UNF, since we have several fully funded graduate assistants who are not assigned to specific problems. The student chosen for this project is Paul Chilton, who is currently also a part-time employee of Taylor Engineering (working on the revised New York City flood mapping). However, these delays have had a serious impact on the Arcadis portion of this work.

7. Student Involvement and Awards:

a) As noted above, it is difficult to fund students under a project in which the funding is not provided on a regular basis; however, Paul Chilton (a Master's Degree student) is presently funded full time under TERI funding and is dedicated to the compound flooding effort at UNF.

b) Student Demographics

Our overall graduate student population remains 50% male and 50% female. We have about 30% minority students within the program.

c) Degrees Attained

Amanda Tritinger was funded for 4 years on this project. She just earned her PhD from the University of Florida and has accepted a job at the USACE Engineering Research & Development Center (ERDC).

d) Student Awards

n/a

8. Interactions with education projects:

n/a

9. Publications:

- **Resio, D.T.**, Asher, T.G., and J.I. Irish, 2017: The effects of natural structure on estimated tropical cyclone surge extremes, J. Nat. Haz., currently available online, Nat Hazards, DOI: 10.1007/s11069-017-2935-y
- Irish, J.L., Weiss, R. and **D.T. Resio**, "Physical Characteristics of Coastal Hazards and Risks", Chapter 25, Springer Handbook of Ocean Engineering, Springer Dordrecht Heidelberg London New York, M. Dhanak and N. Xiros (Eds.), 549–562.
- **Resio, D.T.**, Tumeo, M.A., and J.L. Irish, "Statistical Characterization of Hazards and Risk in Coastal Areas," Chapter 26, Springer Handbook of Ocean Engineering, Springer Dordrecht Heidelberg London New York, M. Dhanak and N. Xiros (Eds.), 567–593.

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Assemble observational data sets for coastal, riverine, tributaries and peripheral areas for model calibration and performance evaluation	10/2018	95% (we might need more data depending on the tests needed for the state of Florida project.)	It is completed for what we need now; but if we move on to other areas we could need more.
Enhance existing ADCIRC grid for Jacksonville along the river banks of the St Johns River near selected areas that underwent flooding	10/2018	100%	
Build hydrologic grids for coupling hydrologic models for coupling with ADCIRC in IRMA and Matthew testing in northeast Florida.	2/2018 (date precedes the reporting period)	70%	We have not received sufficient funding to get this work completed.
Test different combinations of hydrologic models with ADCIRC, along with boundary types and locations	6/2019	50%	Funding delays
Research Milestone			
Preliminary modeling system based on Hurricanes Matthew and Irma, since these two storms affected the same area and had very different outcomes in different areas. They also have very good pre- and post-storm information for model testing and validation.	6/2019	50%	Funding delays

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Prototype map of Jacksonville flooding hazards and vulnerabilities related to tropical cyclones	2/2019	50%	We are expanding to a statewide focus, which has delayed the initial Jacksonville focus.
Meetings with City and County (and state) officials to convey information on the areal distribution of flood-prone parts of the city and to discuss potential assistance available for future planning	6/2019	50%	Funding delays in producing products for review
Transition Milestone			
Prototype modeling system for tropical cyclones, surge, and rainfall flooding affecting the Jacksonville areas and its vicinity	6/2019	100%	Now being tested.
Report on prototype system capabilities and preliminary report on the development of model interaction guidelines for placement of boundaries between models and methods used to couple models across these boundaries, along with metrics for accuracies of the effects of different options	6/2019	50%	Funding delays.

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
n/a			

Table 2: Performance Metrics

RESIO Performance Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)				
Undergraduates provided tuition/fee support (number)				2
Undergraduate students provided stipends (number)				
Graduate students provided tuition/fee support (number)	1			1
Graduate students provided stipends (number)	1	2	1	
Undergraduates who received HS-related degrees (number)				
Graduate students who received HS-related degrees (number)				1
Graduates who obtained HS-related employment (number)	2			1
SUMREX program students hosted (number)		1		
Lectures/presentations/seminars at Center partners (number)	1	1	1	
DHS MSI Summer Research Teams hosted (number)				
Journal articles submitted (number)	1	1	1	1
Journal articles published and Book Chapters (number)	1	1		
Conference presentations made (number)		1	1	
Other presentations, interviews, etc. (number)	1		1	
Patent applications filed (number)				
Patents awarded (number)				
Trademarks/copyrights filed (number)				
Requests for assistance/advice from DHS agencies (number)	1	1		1
Requests for assistance/advice from other agencies or governments (number)	1	1		2
Dollar amount of external funding	$40,000	$187,000	$150,000	$125,000
Total milestones for reporting period (number)	3	2	2	7
Accomplished fully (number)	1	5	1	2
Accomplished partially (number)	2	6	1	5
Not accomplished (number)				

BLANTON: UNC-CH
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Operational Awareness Dashboard for ADCIRC Surge Guidance System

Principal Investigator Name/Institution:
Brian Blanton (RENCI)

Other Partners/Institutions:
Lisa Stillwell (RENCI), Phil Owen (RENCI)

Short Project Description ("elevator speech"):

This project will design, develop, and deploy a web-based "operational awareness dashboard" for monitoring ADCIRC Surge Guidance System (ASGS) prediction activities being conducted at several HPC sites. This dashboard will provide a real-time view of ASGS simulations during tropical cyclone events, and will be capable of displaying multiple, concurrent ASGS instances on different HPC resources. This new capability will elevate ADCIRC/ASGS prediction activities to a new level of robustness, reliability, confidence and availability by showing all ASGS activities in one web-based application. This new capability also advances ASGS/ADCIRC operational activities as we position for long-term sustainability through continued federal support and industry/commercial subscription services.

1. Introduction and project overview:

Recent tropical cyclones (TC) that threatened the eastern United States and Gulf of Mexico coasts have demonstrated that storm surge and wave predictions from the ADCIRC Prediction System (APS) have substantial demand and value to end-users, such as emergency managers, the US Coast Guard, NOAA, and DHS/FEMA. To meet this demand, the core APS operations community (DHS/CRC, RENCI, UT, NCSU, Seahorse Coastal Consulting, etc) relies on High Performance Computing (HPC) assets to compute and deliver real-time storm surge guidance information to end-users. While the primary APS components, ADCIRC and ASGS, have proven to be robust, efficient, and accurate, it remains challenging for APS operators to have an awareness of the entire suite of activities and simulations being conducted during a TC event, since each ASGS instance is run independently of each other, and potentially with different human operators. This presents a significant challenge when it is critical for operators and real-time guidance experts to know what is being computed, in what stage is any given simulation, and (particularly) when updated results can be expected. At the start of year 4, we proposed to ***develop an operational awareness dashboard (OAD)*** that monitors multiple, concurrent ASGS instances on different HPC resources and provides a real-time, web-based visualization of the ASGS workflow, progress, and status. This was achieved during year 4.

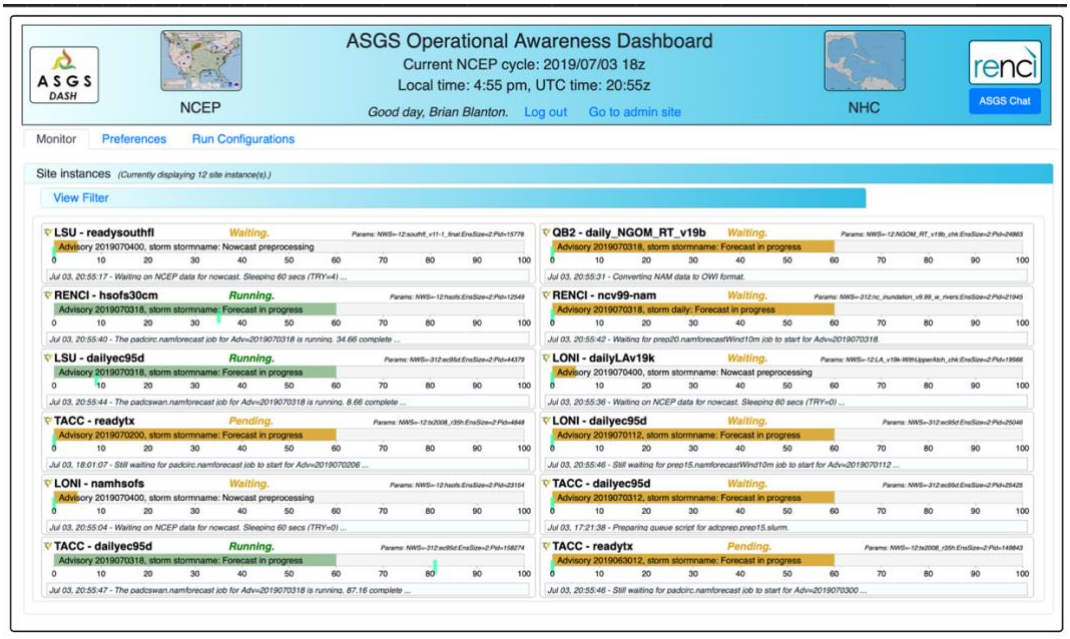
The resulting OAD alerts APS operators to runtime warning and errors that occur, substantially decreasing downtime and facilitating debugging of ASGS input/output and operational issues. This level of awareness has been critical for APS operators as we headed into the 2019 Atlantic hurricane season. This functionality and awareness will be essential to presenting the APS operational activities as robust and reliable to end-users as we position for long-term sustainability through continued federal support and industry/commercial subscription services.

2. Results:

During year 4, the first year of this specific OAD project, we designed, implemented, tested, and deployed the OAD. Development of the infrastructure was rapid, due to the expertise of the project's software engineering personnel (L. Stillwell and P. Owen).

The current version of the OAD website is shown in the figure below. At the time this figure was taken (4:55pm EST on 3 July, 2019), there were 12 different instances of ASGS running on 5 different HPC resources (LSU, LONI, QB2, TACC, and RENCI). Nine of the instances are waiting on upstream information to become available, and three instances are computing forecasts. All of these instances are driven by the daily weather model output from NWS/NCEP. I.e., these are not tropical/hurricane driven simulations because there was no active tropical cyclone threatening the Atlantic/Gulf coast at this time. During an active/threatening tropical event, many of these NWS/NCEP driven instances would be suspended so that the HPC resources could be used for more critical simulations.

The OAD also shows important information in the top-level banner. From left to right, the NCEP inset graphic shows the continental-scale synoptic weather (clicking on the thumbnail brings up a larger version); the current NCEP cycle date/time and local time, and the current tropical situation from NHC.



3. End users:

End users of the APS OAD are the APS operators and those communicating directly with end-users. As noted above, the OAD does not provide the actual APS prediction/simulation output (that functionality resides with the CERA website), but rather on simulation status information.

4. Transition:

Current APS operators and product communicators include: Jason Fleming (Seahorse Coastal Consulting), Rick Luettich, Brian Blanton, Matt Bilskie (LSU), and Nathan Dill (Ransom Consulting). Carola Kaiser has been using the OAD to better understand the full spectrum of APS activities, and how they might impact CERA. This group of users must maintain an "operational awareness" of all concurrent ASGS computing activities in a fast and easily understandable format, in order to optimally communicate hazard information to their respective end-users and "clients", anticipate delivery of new information, and react to system warnings and errors that delay product computation and delivery.

5. Project Impact:

During tests of the messaging system and web infrastructure, prior to the 2019 Atlantic hurricane season, we got feedback from ASGS operators (i.e., OAD end-users). They all expressed that the OAD definitely provides a systematic view of all of the ASGS activities, enabling operators to more quickly identify and trouble-shoot run-time problems. Although occurring after this reporting period, tropical storm Barry provided a real-time opportunity to qualitatively evaluate the OAD effectiveness. During that event, operators were able to see the overall ASGS situation/activities, and we were able to better anticipate computer resource constraints and bottlenecks and thereby move higher priority simulations to less burdened HPC resources. This significantly increased availability of APS results to the broader end-user community.

6. Unanticipated Problems:

There have been no unanticipated problems, due to the expertise of the software development/engineering personnel on the project. The design, implementation, and maintenance of the OAD has been efficient, streamlined, and rapid.

7. Student Involvement and Awards:

No students were involved in this project, because of the need for robustness, on-time delivery, and deep understanding of web technologies.

8. Interactions with education projects:

There have been no interactions with education projects due to the need for robustness, on-time delivery, and deep understanding of web technologies and the functioning of ASGS in real-time operations.

9. Publications:

None to date. We will likely publish a technical report describing the software architecture and implementation, as well as publish the code in GitHub (as a transition element).

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Implement/configure the RabbitMQ messaging system server	9/1/2018	100	
Develop message data structure/content and "sender" code	9/30/2018	100	
Initial end-user dashboard requirements gathering	9/30/2018	100	
Instrument ASGS with RabbitMQ messaging	11/30/2018	100	
Web dashboard design, development, deployment	1/31/2019	100	
Assess OAD functionality during pre-season ASGS test simulations	3/31/2019	100	
Research Milestone			
Publish message-enabled ASGS to GitHub repository so that other ASGS users can begin to test it.	11/30/2018	100	
Achieve basic functionality for the OAD	2/28/2019	100	
Maintenance and updating of OAD infrastructure. This includes addressing software bugs and failures and updating the required software components on the computers that host the RabbitMQ messaging system, the message database, and the website itself. Any substantial software update will be documented. Without maintenance of the software system,	6/30/2019	100	

existing functionality may be degraded and new features impossible to implement.			

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Deploy (make available) current OAD proof-of-concept website to ASGS operators and communicators. This involves putting the proof-of-concept website on a public-facing (and password protected) web server so that operators can access, test, and critique the OAD. This activity explicitly names this as a goal/objective/activity/etc./	9/31/2018	100	
Document ASGS messaging implementation and messaging configuration setup for real-time messaging.	12/31/2018	100	
Deploy (make available) revised OAD for 2019 Atlantic hurricane season testing. This revision to OAD is based on the information gathered from the first activity above.	3/31/2019	100	
Transition Milestone			
Successful access by end users to the OAD proof-of-concept website, with initial feedback on OAD interface and information content provided by operators to project team.	9/31/2019	100	
Host a virtual meeting with ASGS operators and communicators to train them on OAD website functionality and information content.	4/15/2019	50	Training / communication has largely taken place via the ASGS2019 Slack channel and related conference calls.

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
OAD website	software	5/1/2019	APS/ASGS operators

Table 2: Performance Metrics

Metric	Year 1 (1/1/16 –	Year 2 (7/1/16 –	Year 3 (7/1/17-6/30/18)	Year 4 (7/1/18-6/30/19)
HS-related internships (number)	0	0	0	0
Undergraduates provided tuition/fee support	0	0	0	0
Undergraduate students provided stipends	0	0	0	0
Graduate students provided tuition/fee support	1	1	1	0
Graduate students provided stipends (number)	1	1	1	0
Undergraduates who received HS-related	0	0	0	0
Graduate students who received HS-related	0	0	1	0
Graduates who obtained HS-related	0	0	0	0
SUMREX program students hosted (number)	0	1	0	0
Lectures/presentations/seminars at Center	1	0	1	0
DHS MSI Summer Research Teams hosted	1	0	0	0
Journal articles submitted (number)	0	0	0	0
Journal articles published (number)	0	0	0	0
Conference presentations made (number)	2	2	2	0
Other presentations, interviews, etc. (number)	0	2	4	0
Patent applications filed (number)	0	0	0	0
Patents awarded (number)	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS	0	0	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0	0	0
Dollar amount of external funding	0	0	$935,000	0
Total milestones for reporting period (number)	7	7	5	5
Accomplished fully (number)	2	2	5	4
Accomplished partially (number)	3	3	0	1
Not accomplished (number)	2	2	0	0

HAGEN - LSU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Development of an optimized tide and hurricane storm surge model for the west coast of FL for use with the ADCIRC Surge Guidance System.

Principal Investigator Name/Institution:
Scott C. Hagen, Professor - Louisiana State University, Department of Civil & Environmental Engineering / Center for Computation & Technology, Director - Center for Coastal Resiliency

Other Research Partners/Institutions:

Stephen C. Medeiros, Lecturer, University of Central Florida, Department of Civil, Environmental & Construction Engineering / Institute for Simulation and Training.
Matthew V. Bilskie, Research Scientist, Louisiana State University, Center for Coastal Resiliency.

Short Project Description ("elevator speech"):

This project will simplify an existing high-definition research-grade tide, wind-wave, and hurricane storm surge model of the west coast of Florida for use in the ADCIRC (Advanced Circulation) Surge Guidance System (ASGS). The goal is to enable the model to complete a 5-day simulation forecast in less than 1 hour, while retaining water surface elevations that are within 10-percent of the original research-grade model. Achieving this goal reduces model run times (from several hours to 1 hour) so that end-users will have model forecast guidance in a timelier fashion.

1. Introduction and project overview:

The research need that this project is addressing is a means to develop a computationally efficient hurricane storm surge model with sufficient detail across the coastal floodplain. Storm surge simulations will be generated in near real-time during an impending tropical cyclone event in order to provide surge guidance to emergency managers and stakeholders.

2. Results:

Outcomes of Year 4:

- Full production (transition – see Item 4 below) of the real-time grade northern Gulf of Mexico ADCIRC mesh and model (NGOM-RT) for the 2018 hurricane season, which includes Subtropical Storm Alberto, Tropical Storm Gordon, and Hurricane Michael. This outcome is a combination of a product (NGOM-RT storm surge model) and its application in real-time. The deployment of this model was a huge success. Results generated by this model were the default view on the Coastal Emergency Risks

Assessment (CERA) visualization website (cera.coastalrisk.live) during Hurricane Michael.

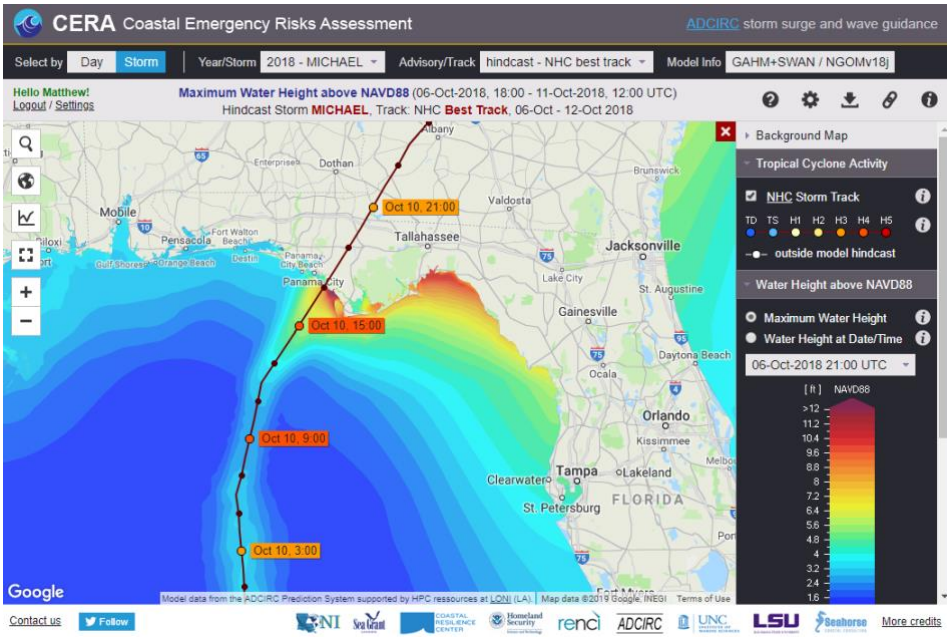


Figure 1. Hurricane Michael results generated by the NGOM-RT model as shown by CERA.

- Preliminary hindcast and error quantification of Hurricane Michael using the NGOM-RT ADCIRC model (research findings). A manuscript is currently being written on this topic (see Item 9 below).
- Initial development of a forecast-grade ADCIRC model for the west coast of Florida (product).

3. End users:

Dr. Medeiros conducted a 90-minute workshop on CERA to FDOT District 5 on June 18, 2019. The workshop focused on the key features of CERA that would be relevant to FDOT's needs. All participants provided valuable feedback on adaptations to CERA that would make the tool more useful to their operations. This workshop was attended by:

- John Hatfield
  - District Maintenance Engineer / District Emergency Coordinator
- Doni Laney
  - District Safety and Health Manager
- Dennis Kirk
  - Deputy District Maintenance Administrator, Assistant District Emergency Coordinator
- Ed Kestory
  - District Structures Maintenance Engineer
- Jonathan Jastremsky
  - Engineering Section Manager – Structures Maintenance

4. Transition:

The transition of results was outlined in Item 2 with respect to the transition of the developed NGOM-RT model to production, particularly with Hurricane Michael.

There have not been any transition activities at this time in regard to the west Florida storm surge model.

5. Project Impact:

The capability to provide high fidelity storm surge forecasts, as shown through the production of advanced technology developed as part of this project, via increased operational efficiency in real-time has a direct real-world impact. There is no doubt that the forecasts provided by the NGOM-RT model during Hurricane Michael played a role in saving lives, money, and property.

6. Unanticipated Problems:

The delay and splitting of Year 4 funds substantially impacted the progress of this project. To overcome this, Dr. Medeiros used faculty accounts to cover the shortcoming for the undergraduate student's stipend (See Section 7).

7. Student Involvement and Awards:

Dr. Medeiros used project funds to support Makayla Maduro. She assisted with literature review and various other research related tasks. She is also interested in building hurricane storm surge models of one or more Caribbean islands.

Student demographics: Ms. Maduro is a West Indian female undergraduate student at UCF with a dual major in Civil and Construction Engineering.

Degrees attained:

NA

Student Awards.

NA

8. Interactions with education projects:

NA

9. Publications:

- Santiago-Collazo, F.L., Bilskie, M.V., Hagen, S.C. (2019) "A comprehensive review of compound inundation models," *Environmental Modelling & Software,* Accepted June 17.

- Bilskie, M.V., Asher, T.G., Fleming, J.G., Hagen, S.C., Kaiser, C., Luettich Ur., R.A., Twilley, R. (2019) "Real-time storm surge predictions during Hurricane Michael," *Geophysical Research Letters*, In Progress (Previously submitted and being revised).
- Bilskie, M.V., Hagen, S.C., Medeiros, S.C. (2019) "Unstructured finite element mesh development for real-time hurricane storm surge forecasting," *Coastal Engineering*, In Preparation.

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Obtain FEMA Flood Map Modernization Model for FL West Coast	10/31/2018	100%	
Optimize FEMA Flood Map Modernization Model for FL West Coast. The result will be a forecast-grade, real-time, model of the FL West coast. This will provide timelier model forecasts without reducing model error.	3/31/2019	25%	Funding Delay
Perform test simulations and model validation of the real-time model of the FL West coast within the ADCIRC Surge Guidance System (ASGS) modeling framework on the LSU and LONI HPC systems. This will enable identifying potential model errors or bugs prior to full implementation during the active hurricane season.	4/30/2019	0%	Funding Delay / Audacious Year 4 Activity
Test the real-time model of the West FL coast on the UCF STOKES HPC system. This will ensure that a redundant back-up is available on a separate HPC platform in the case that a failure or shut-down occurs on the LSU or LONI systems.	5/31/2019	0%	Funding Delay/ Audacious Year 4 Activity
Research Milestone			
The real-time FL West Coast model will be fully connected to CERA. Model testing, evaluation, and validation will be complete.	6/1/2019	0%	Funding Delay/ Audacious Year 4 Milestone
Submission of manuscript on the development and validation of FL west coast model to a peer-reviewed journal.	6/30/2019	0%	Funding Delay/ Audacious Year 4 Milestone

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Develop a 1 – 2 hour training program for introducing CERA to new end users. Training will focus, but not be limited, to new end-users and partners along the west coast of Florida. Stephen Medeiros will lead the identification of end users.	12/31/2018	100%	
Share the CERA training materials with the CERA team and request feedback in order to finalize the training materials. Feedback from the CERA research team will be incorporated into the final set of training materials.	3/31/2019	50%	Shared with script for FDOT workshop with CERA team
CERA Training Complete for 5/10 the identified end users. End users will be proficient in operating the CERA online platform.	6/01/2019	100%	Workshop for 5 end users at FDOT conducted on June 18, 2019
Transition Milestone			
CERA Training Complete for 5/10 of the identified end users. End users will be proficient in operating the CERA online platform.	6/01/2019	100%	
Integration of minimally modified real-time forecast-grade FL West Coast model into the ASGS. During an impending tropical cyclone event with potential impacts to the region results from the ASGS will be delivered to the CERA online visualization platform.	6/01/2019	0%	Funding Delay

12. Tables

Table 1: Research Project Product Delivery

N/A

Table 2: Performance Metrics

HAGEN-MEDEIROS-BILSKIE Performance Metrics

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)				
Undergraduates provided tuition/fee support (number)				
Undergraduate students provided stipends (number)		1	1	1
Graduate students provided tuition/fee support (number)	1	1		
Graduate students provided stipends (number)	1	1		
Undergraduates who received HS-related degrees (number)				
Graduate students who received HS-related degrees (number)				
Graduates who obtained HS-related employment (number)				
SUMREX program students hosted (number)	1	2		
Lectures/presentations/seminars at Center partners (number)				
DHS MSI Summer Research Teams hosted (number)				
Journal articles submitted (number)				2
Journal articles published (number)	1	1		1
Conference presentations made (number)			1	1
Other presentations, interviews, etc. (number)	8	10	1	3
Patent applications filed (number)				
Patents awarded (number)				
Trademarks/copyrights filed (number)				
Requests for assistance/advice from DHS agencies (number)		1		
Requests for assistance/advice from other agencies or governments (number)		2		1
Dollar amount of external funding	$0	$0	$0	
Total milestones for reporting period (number)	3	4		4
Accomplished fully (number)	0	5	3	1
Accomplished partially (number)	3	2	3	1
Not accomplished (number)	0			2

DIETRICH - NCSU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:

Improving the Efficiency of Flooding Predictions via Adaptive Mesh Resolution

Principal Investigator Name/Institution:

Casey Dietrich, Assistant Professor, North Carolina State University

Other Research Partners/Institutions:

Clint Dawson, Professor, The University of Texas at Austin

Short Project Description:

Coastal communities rely on predictions of flooding caused by storms. Computational models are essential for making these predictions, but a typical prediction can require hundreds or even thousands of computational cores in a supercomputer and several hours of wall-clock time. In this project, we will improve the performance and accuracy of a widely-used, predictive model for coastal flooding. Its representation of the coastal environment will adapt during the storm, to better utilize the computing resources and ultimately provide a faster prediction.

1. Introduction and Project Overview:

The goal of this research project is to speed up the ADvanced CIRCulation (ADCIRC) modeling system, which is used extensively by DHS and its constituent agencies for the prediction of storm-induced flooding. We are improving the efficiency of the modeling system, and thus reducing its computational cost. This work is relevant to the DHS mission to ensure resilience to disasters, as articulated in its Strategic Plan and Quadrennial Review, specifically its Goals 5.1 (Objectives 5.1.1 and 5.1.2) to reduce vulnerability and mitigate risks associated with natural hazards, and its Goal 5.3 (Objective 5.3.1) to provide timely and accurate information during a storm event. The efficiency improvements in this project will allow for more model simulations in ensemble-based design applications, which will increase the accuracy of flood risk products used in building design and the establishment of flood insurance rates, and thus lessen the impact of a disaster. The efficiency improvements in this project will also allow for faster simulations in time-sensitive applications such as operational forecasting, and thus improve the communication and understanding of potential hazards.

This project will benefit DHS and the Homeland Security Enterprise in two ways: a more-efficient ADCIRC model will allow for more model runs in ensemble-based design application, and for faster simulations in time-sensitive applications such as operational forecasting. In its development of Flood Insurance Rate Maps (FIRMs), FEMA will benefit because the probabilistic framework requires a large number of simulations, which will now require fewer

computational resources, and thus the studies can be completed in a shorter time and/or consider a larger suite of storms. We are working with FEMA engineers, with whom we are sharing research progress and receiving feedback on future directions. In their use of flood predictions provided in real-time by the ADCIRC community, state-level emergency managers will benefit because by now having more time to consider the forecast guidance in their decision-making. We are working with partners at the Texas State Operations Center and NC Emergency Management. We also have partners in the USACE, NOAA, and academia, as described below.

2. Results:

During Year 4, our research was focused on three related topics: (A) the continued development and testing of technologies for a coarse-grain mesh adaptivity, (B) the continued development and testing of dynamic load balancing, and (C) the refinement of techniques for downscaling and visualizing the forecast guidance as a post-processing step. We discuss our results for each of these topics:

Adaptive mesh techniques: The idea behind this approach is simple on the surface: use a less refined mesh when the storm is still far from land and/or the track is still uncertain, then, at some intermediate point of the calculation, stop the run, interpolate the solution onto a higher resolution mesh, and finish the simulation on this mesh. The outcomes of the research include the software ADCIRpolate, which uses many of the interpolation routines in the open-source Earth System Modeling Framework (ESMF). ADCIRpolate reads an ADCIRC hotstart file generated on one mesh (call it Mesh 1) and interpolates it onto another mesh (call it Mesh 2). If Mesh 1 and Mesh 2 cover the exact same domains, this process is straightforward. The difficulty in our project is that Mesh 1 and Mesh 2 may differ substantially, especially in floodplain areas. This required developing some extensions of the ESMF software to handle extrapolation and wetting and drying, and to make some modifications to the hotstart capability of ADCIRC, which historically has been based on simply hot-starting a calculation on the same mesh/domain. We also note that ESMF operates in parallel, thus the interpolation from one mesh to the next can be done very efficiently.

During Year 4, we made significant progress on hardening these technologies, so that they can be used for a variety of meshes and storms. This hardening required an extensive testing by the project teams at both institutions. At UT Austin, the tests have been for hurricanes that impacted the Texas coast, such as Ike (2008) and Harvey (2017). These storms had tracks that were shore-perpendicular, and so they are amenable to the adaptive meshing technologies. The simulation can be started on a low-resolution mesh with limited coverage of the floodplains while the storm is located offshore, and then it can be switched onto a higher-resolution mesh as the storm approaches the coast. We have shown that, if the switch is performed early so the model can adjust to the additional resolution and coverage, then the results can be nearly identical to a full simulation on the higher-resolution mesh. For example, in the figure below, we show the maximum water levels predicted for Harvey, both with a full, high-resolution simulation (on the left) and for an adaptive simulation (on the right). In this simulation, the calculation was started on the NOAA Hurricane Surge On-Demand Forecast System (HSOFS) ADCIRC mesh, which is used in operational mode by NOAA and has coverage of the entire eastern U.S. and Gulf of Mexico coasts. After 1 day of simulation, we interpolated the results onto a higher-resolution mesh developed specifically for the Texas coast, that has improved representation of inland

channels and flood plains (the same mesh used in the left half of the figure below). The results are nearly identical, thus indicating that there is no loss in accuracy, even while gaining an improvement in efficiency. The adaptive simulation is faster but gives the same flooding predictions.

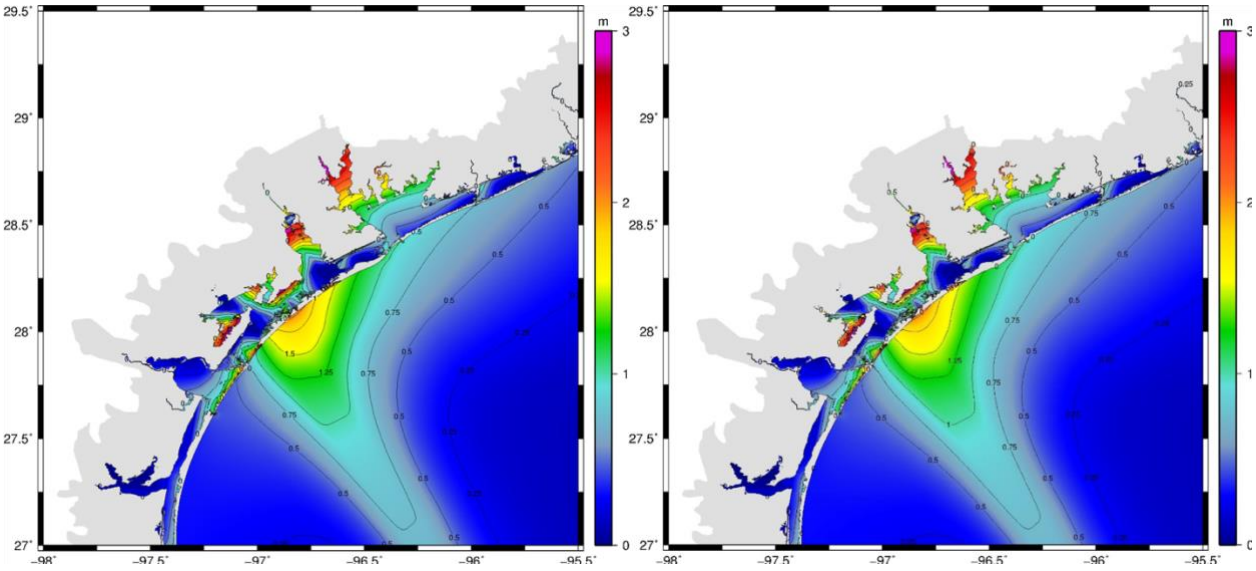


Figure: Maximum water levels (m) predicted for Hurricane Harvey (2017): (left) for a full simulation on a high-resolution mesh, and (right) for an adaptive simulation in which the mesh was changed. The results are nearly identical.

At NC State, the tests have been for Hurricane Matthew (2016), which had a shore-parallel track along the southeast U.S. coast. The storm stayed offshore of Florida and Georgia, made a brief landfall in South Carolina, and then tracked past North Carolina and into the Atlantic Ocean. This storm has been our focus for several years, and PhD student Ajimon Thomas just published a manuscript about how the storm interacted with the tides over several days as it moved offshore. Matthew is a perfect test for the adaptive meshing technologies, because they allow for higher-resolution floodplains to be excluded as the storm is far away, included as the storm passes, and then removed again as the storm moves away.

For example, we have tested the adaptive meshing technologies for a simulation of Matthew with six meshes. It starts on a coarsely-resolved mesh with coverage only in open water (so no floodplains), and then it slowly adds and subtracts the following higher-resolution components as the storm moves northward:

- 4.50 days: open-water
- 0.75 days: add Florida
- 0.75 days: add Georgia and South Carolina
- 0.75 days: add North Carolina
- 0.75 days: subtract Florida
- 1.5 days: subtract Georgia and South Carolina

Thus, we include the full coastline (with higher-resolution floodplains for all four states) only during the 0.75 days when the storm is affecting them. At other points in the simulation (both before and after), we include only the floodplains that are affected, and we exclude everything else. The adaptive meshing technologies were able to map the interim solution from mesh to mesh without any problems, and the final results were nearly identical to a full simulation on the higher-resolution mesh (similar to the findings above from Harvey).

We have been working to develop a mesh for this same region (the southeast U.S. coast), but with much higher resolution to give a more-accurate representation of the coastal features and surge response. This mesh has been developed by combining the FEMA meshes for floodplain mapping studies in this region. The overall mesh (shown below) has about 5.6 million vertices and provides coverage from south Florida through North Carolina. We are doing preliminary tests on this mesh to confirm stability and accuracy, and then we will use it to continue hardening and testing the adaptive meshing techniques.

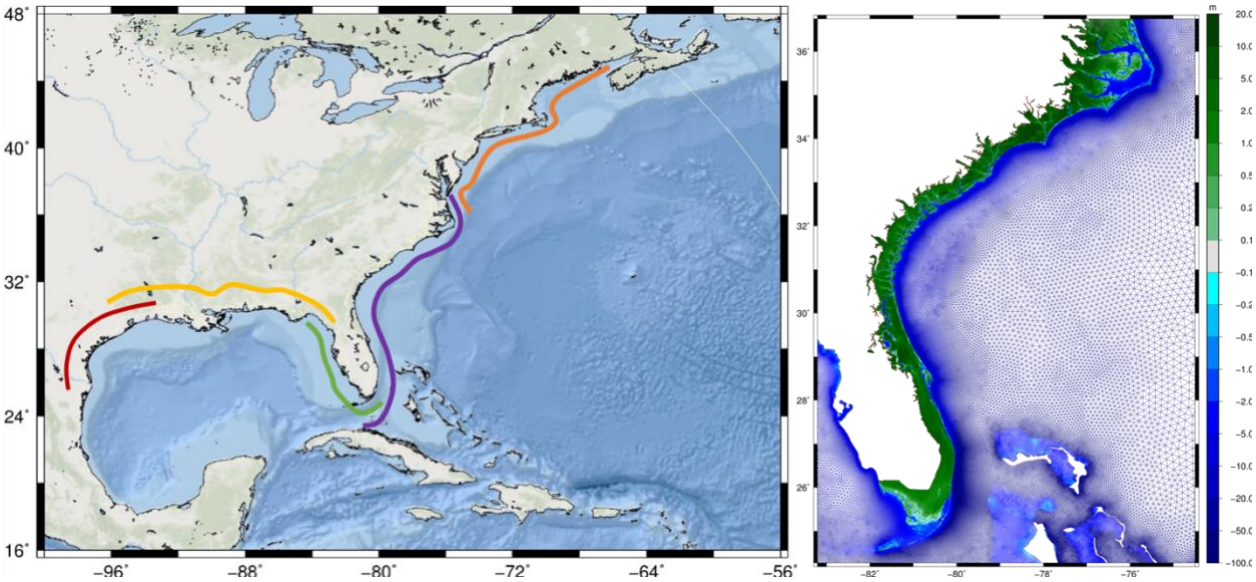


Figure: (left) schematic of higher-resolution meshes with coverage of floodplains along the U.S. coast from Texas through Maine, and (right) early version of the higher-resolution mesh for the southeast U.S. coast.

Dynamic load balancing: The other component of this research project has been the treatment of dry regions within our high-resolution meshes. The idea behind this research is to better distribute the dry regions, so that they are contained on only a few cores. Then more of the cores will be available to compute the flooding in wet regions. This technology will adapt during the storm, as regions become wet and then dry again. By better distributing the workload over the cores, ADCIRC will become more efficient for simulations of flooding into overland regions. Working with collaborators at Notre Dame, we rewrote the dynamic load balancing routine to use the Zoltan library for adaptive domain decomposition. This library can control how computational points are migrated between neighboring sub-domains, instead of starting each decomposition from scratch. This implementation has provided further speed-ups in the wall-clock time.

During Year 4, we continued to harden and test this routine on a variety of idealized and realistic simulations of coastal flooding. By using an idealized domain with a controlled flooding, we evaluated the performance and scalability of the routine over a range of parallel configurations. We have shown the routine can provide near-theoretical speed-ups, where the theoretical speed-up is when the dry vertices do not have any cost. The routine can scale to hundreds of CPUs at the same rate as if the dry vertices are excluded entirely from the mesh. We continue to harden the routine by streamlining the migration of information between CPUs, so it uses fewer steps and handles better the memory and libraries. We have also extended the migration to include station data, nodal attributes, and levee information.

For storms on realistic domains, the dynamic load balancing is allowing for significant speed-ups over a base simulation. In the figure below, we show a typical workload for a simulation on a higher-resolution mesh. The red lines are the boundaries between the sub-meshes sent to the CPUs; these sub-meshes can be redistributed at checkpoints during the simulation. For a simulation of Hurricane Florence (2018), the speed-up is about 20 percent, with no change in the solution. Thus, the dynamic load balancing is providing a benefit in wall-clock times with no trade-off in the model accuracy. We are continuing to work on documenting this feature so it can be released to the model community.

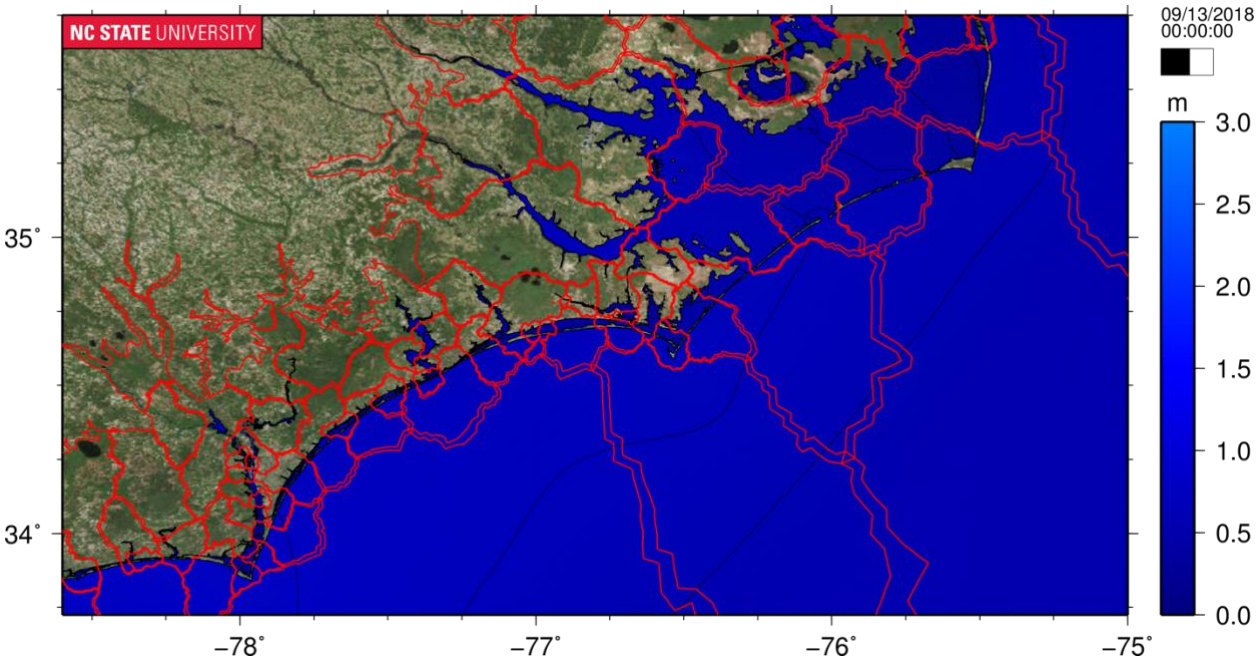


Figure: Example of load balancing for a simulation of Hurricane Florence (2018) in North Carolina. The red lines show the boundaries between the sub-meshes sent to each CPU; these sub-meshes are redistributed at checkpoints during the simulation to maintain an even workload among the CPUs. For this simulation, the overall speed-up was about 20 percent.

Downscaling and visualization of forecast guidance: When the flooding forecast guidance is shared with stakeholders, it is shared typically in an online mapping system (CERA) or via GIS shapefiles. The advantage of the GIS shapefiles is that they can then be integrated within the workflows of our stakeholders, who may want to combine them with other datasets for flooding forecasts or critical infrastructure. Although the GIS shapefiles have infinite resolution, in the

sense that they are vector-based representations of the ADCIRC results, they are still limited by the mesh resolution used by ADCIRC. This mesh resolution may vary downward to 10-20 m in specific small-scale channels, but more typically the mesh resolution is 100-500 m throughout the coastal zone. This resolution can prevent the representation by ADCIRC of smaller-scale infrastructure, including roadways and buildings, which are critical for decision-makers. We have developed a technology to downscale ADCIRC guidance to a finer resolution in a DEM, and then extrapolate the water levels to where they should intersect with the topography.

During Year 4, we extended this technology so it can be used for any ADCIRC flooding predictions in any geographical region. The user can specify a high-resolution digital elevation model (DEM) from any source, and the technology will downscale the ADCIRC water levels onto that data set. We have tested extensively for storms along the U.S. Gulf and Atlantic coasts. In the figure below, we show the difference between the maximum water levels from an ADCIRC simulation and from the downscaling process. The ADCIRC resolution is too coarse to allow the water to push far into the estuaries, but the downscaling does extend the water surface until it intersects with the topography. This process will provide a better depiction of the flooding extents.

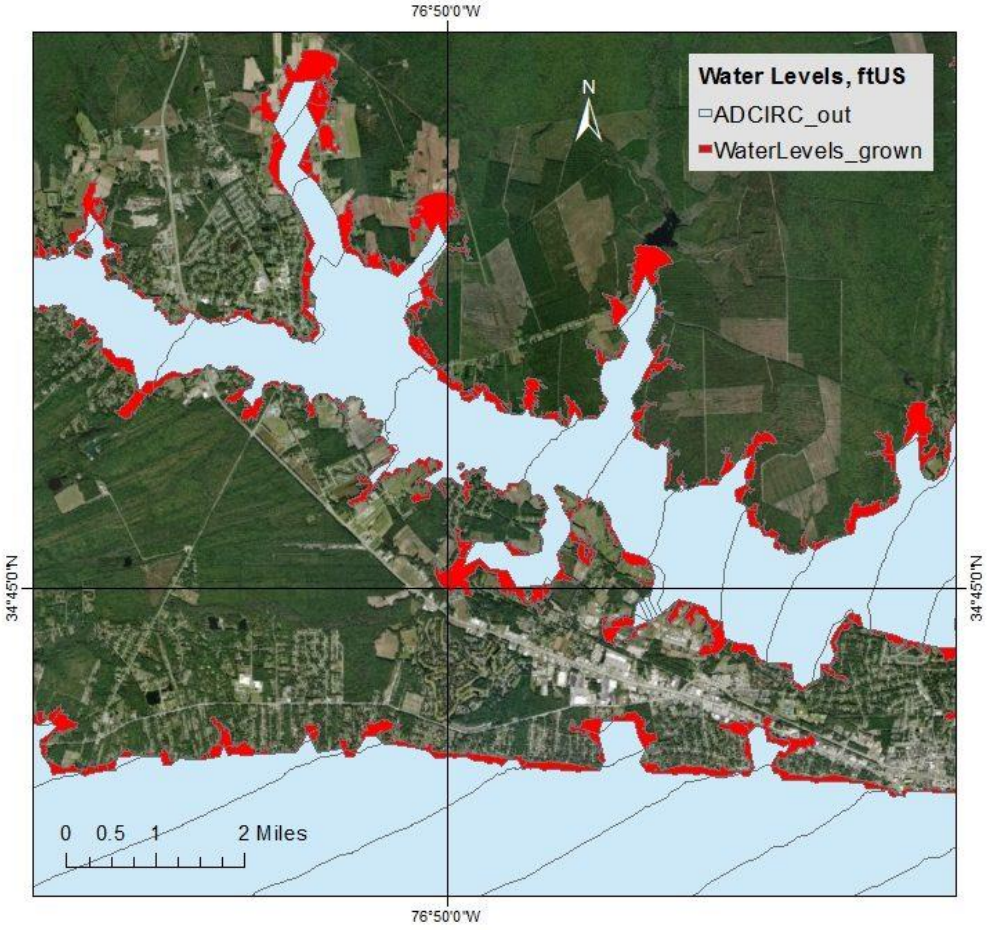


Figure: ADCIRC vs. extrapolated water levels, plan view. This image shows the difference in prediction of flooding extents, with the pale blue portion representing the original ADCIRC flooding extents and red representing the extrapolated extents.

3. End users:

The proposed enhancements to efficiency will benefit all model users, including several DHS agencies with missions related to coastal flooding. In its development of Flood Insurance Rate Maps (FIRMs), FEMA will benefit because the probabilistic guidance requires a large number of deterministic simulations, and the approach described in this project will require fewer computational resources. For example, if a flood mapping study would see an efficiency gain of, say, 10 percent, then the study could be completed in a shorter time. Alternatively, that efficiency gain could be reinvested into increasing the mesh resolution and/or considering a larger suite of storms, and thus increasing the accuracy of the model results. At FEMA, several end users are participating as transition partners. The project will also help to speed the delivery of projected flood inundation levels associated with coastal storms, thereby assisting FEMA as well as state and local emergency managers to plan for coastal evacuations and deployment of resources and personnel. In addition, the Coast Guard will benefit from faster guidance about waves and surge and therefore be able to make operational decisions about the possible relocation of assets in advance of an oncoming storm. The project personnel will continue to work with the transition team to identify additional end-users in these and other DHS constituent agencies.

With the Texas State Operations Center, the project personnel are working with **Gordon Wells** to transition the analysis products that are used for guidance by the emergency management leadership. Dr. Wells has worked with forecast guidance for the Texas coastline in previous seasons and is supportive of the proposed work. This partnership is important because it connects the products with end users at the state and local levels.

The proposed work will also benefit ADCIRC model users at other federal agencies. With the USACE Engineer Research and Development Center, with the NOAA NCEP, and with the NOAA West Gulf River Forecast Center, multiple end users are participating as transition partners. For partners who are focused on operational modeling with ADCIRC, these activities are taking the form of guidance about development with the goal of transitioning products to their work in the long term.

The project personnel also work closely to transition the project outcomes to the ADCIRC modeling community. These transition activities are connected with **Jason Fleming** and **Carola Kaiser**, who are key members of the Coastal Emergency Risks Assessment (CERA) group. They operate the forecasting systems for regions along the U.S. Gulf and Atlantic coasts, and they visualize and communicate the forecast guidance via a Google Maps application. Dr. Fleming also manages the software repository for the development of ADCIRC. The project personnel are working with these partners to ensure that the new modeling technologies can be incorporated within the forecasting system and the release version of ADCIRC.

4. Transition:

The project team has transitioned the research results, both in real-time during storm events, as well as in activities to benefit the community in the longer-term.

During storms, the project team continues to support the ADCIRC real-time forecasting activities, which have a direct benefit to DHS constituent agencies and other emergency managers. At UT Austin, the team continued to work with Jason Fleming and Carola Kaiser to update the ASGS on supercomputers at the Texas Advanced Computing Center (TACC) and provide support for the CERA and the Texas State Operations Center during the 2018 hurricane season. TACC facilities were utilized during Hurricanes Florence and Matthew. We are currently preparing for the 2019 hurricane season. The UT Austin team will be working with Jason Fleming and Brett Estrade to provide operational ASGS support for storms that threaten the Texas coast.

At NC State, the project team also supported real-time forecasting during Florence, specifically by using the downscaling technologies to provide guidance products to collaborators at FEMA and NC Emergency Management (NCEM). For every forecast advisory, we sent products to NCEM to show the maximum water levels at higher-resolution in coastal NC. On Wednesday, September 8, 2018, or less than 2 days before Florence made landfall, we received the following feedback from Tom Langan, the engineering supervisor for the North Carolina Floodplain Mapping Program:

> *Forecasts have been working great. Really appreciate you running script. We are using for coastal flood damage estimates with our building footprints and comparing to a similar analysis with P-surge.*

After the storm, we also shared products with partners at FEMA, who were interested to see our best-available hindcast. The maximum water levels from ADCIRC were downscaled onto a higher-resolution DEM, and then provided as a geo-referenced TIFF to help with their post-storm work.

The project team has also worked to transition our results in more-general ways outside of hurricane season. The UT Austin team and our end user Gordon Wells worked with Jason Fleming in setting up the "ADCIRC Texas Week," an ADCIRC boot-camp specifically targeted to the Texas ADCIRC user base. This event was held on the University of Texas campus the week of April 8-12, 2019.

At NC State, we have released the downscaling technologies as open-source software with a full documentation. They can be downloaded from this site:

- https://ccht.ccee.ncsu.edu/downscaling-flooding-inundation-extents-using-kalpana/

which provides examples for using the technology, including input files and commands. These technologies have already been adopted by partners in the ADCIRC community, including at George Mason University and Taylor Engineering.

5. Project Impact:

This project is developing technologies to improve the efficiencies of the ADCIRC modeling system in parallel computing environments. It is developing automated routines for an adaptive,

multi-resolution approach to employ high-resolution, unstructured meshes for storm surge applications, and it is developing automated routines for the efficient re-balancing of the computational workload via parallelized domain decomposition.

The initial motivation for adaptive mesh refinement was to speed up the forecast capabilities of ADCIRC and improve the ASGS. We are working with Jason Fleming and other ASGS developers to incorporate ADCIRpolate into the ASGS as a beta version. The adaptive capability has also motivated future ADCIRC-related projects within the CRC. We are working to develop capability to interpolate HSOFS results onto a number of ADCIRC models of Texas, the Northern Gulf, the Carolinas, and the Northeast/New England. In addition, there are extensions of this work beyond hurricane forecasting. We are speeding up post-storm analysis and scenario analysis by allowing for the use of high-resolution meshes targeted to specific regions and specific locations, but also allowing for pre-storm tidal spin-up and storm initiation to be executed on a coarser mesh.

The capability for dynamic load balancing has the potential to benefit all ADCIRC simulations, including the real-time forecasting in the ASGS. These routines better utilize the available computing resources by ensuring that every core is busy during the entire simulation. One benefit of these new routines is that they will be blind to the user; the workload will be rebalanced automatically, without requiring input from the user. Thus it will not be necessary for users to know Zoltan or the other mechanics of the domain decomposition. The efficiency gains will be shared by all users. These new routines are being shared (with extensive documentation and examples) with the ADCIRC modeling community, including the ASGS.

6. Unanticipated Problems:

During Year 4, the only unanticipated problem was a delay in funding for the ADCIRC-related projects in the CRC. We received the first half of our Year 4 funding during Dec/Jan, or about halfway through the project year. As of June, we have not received the second half of our Year 4 funding. These delays have made it necessary to use other funding sources to support partially our students, who then cannot focus entirely on this CRC project. These delays have also hindered our ability to collaborate with the other ADCIRC-related projects on the implementation of our project technologies. We are hopeful that the remaining Year 4 funds will be received early in Year 5 (along with the entirety of the Year 5 funds), so that we can finish strong.

7. Student Involvement and Awards

CRC Supported Students

At UT Austin, this project supported:

- Graduate student **Mark Loveland**. Mark worked primarily on the implementation of the dynamic mesh software ADCIRpolate and the testing of the software on Hurricane Harvey. He worked with NCSU students to train them on the use and installation of the software and the ESMF library.

At NC State, this project supported:

- Graduate student **Ajimon Thomas**, who worked primarily on testing the ADCIRpolate software for Hurricane Florence, as well as developing a mesh for the southeast U.S. coast.
- Graduate student **Carter Rucker**, who worked primarily on generalizing the downscaling technologies, including their release as open-source software with extensive documentation.
- Undergraduate student **Chloe Stokes**, who assisted Ajimon with mesh editing.
- Undergraduate student **Carter Howe**, who assisted with programming improvements for visualization software to support the project.

Student Demographics:

During Year 4, three graduate (Mark, Ajimon, Carter R.) and two undergraduate (Chloe, Carter H.) students were supported on this project. One undergraduate student (Chloe) is a member of an under-represented group (women) in engineering.

Degrees Attained:

During Year 4, no degrees were obtained by our students. However, Ajimon passed his PhD proposal defense, and both Ajimon and Carter R. are on track for graduation during Year 5.

Awards

During Year 4, no awards were achieved by our student.

8. Interactions with Education Projects:

Fourteen students (and four faculty members) in CRC's JCSU Summer Research Program visited the Department of Civil, Construction, and Environmental Engineering at NC State on Thu Jun 13. The students shared presentations about their research projects, and then learned about computing- and resilience-related opportunities at NC State. Here is the full agenda.

The JCSU students shared three presentations about summer research on topics like traffic contraflow, disease outbreaks, and tornado characteristics, and on methods including fuzzy inference systems and data mining. About 30 students and faculty from NC State attended the presentations, noted the connections with their ongoing research, and asked questions about how the summer projects can be continued into the future.

Then three NC State faculty members shared presentations about their research, ranging from agent-based models of environmental systems, to computer vision techniques to inform construction, to predictive models for coastal flooding. There was a lot of student engagement, especially because most of the NC State research was presented by graduate students, who also interacted informally with the visitors during their visit.

Figure: Casey Dietrich (at far left) posing with Ahmed Faik and faculty and students from Johnson C. Smith University during their visit to NC State on Thu Jun 13.

9. Publications:

- A Gharagozlou*, JC Dietrich, A Karanci, RA Luettich, MF Overton. "Storm-Driven Erosion and Inundation of Barrier Islands from Dune- to Region-Scales." *Coastal Engineering*, in review.
- A Thomas*, JC Dietrich, TG Asher, M Bell, BO Blanton, JH Copeland, AT Cox, CN Dawson, JG Fleming, RA Luettich (2019). "Influence of Storm Timing and Forward Speed on Tide-Surge Interactions during Hurricane Matthew." *Ocean Modelling*, 137, 1-19, DOI: 10.1016/j.ocemod.2019.03.004.
- R Cyriac*, JC Dietrich, JG Fleming, BO Blanton, C Kaiser, CN Dawson, RA Luettich (2018). "Variability in Coastal Flooding Predictions due to Forecast Errors during Hurricane Arthur." *Coastal Engineering*, 137(1), 59-78. DOI: 10.1016/j.coastaleng.2018.02.008.

Student theses and dissertations

None to report.

10. Year 4 Research Activities and Milestone Achievements:

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not completed
Development of coarse-resolution, base mesh	08/2018	100	
Extension of enhanced-resolution technique to entire U.S.	02/2019	100	
Development of fine-resolution, target meshes: • Western Gulf • Northern Gulf • Eastern Gulf • Southern Atlantic • Central Atlantic • Northern Atlantic	 03/2019 06/2019 03/2019 03/2019 03/2019 06/2019	50	Delay in funds. We are working on the meshes for the southeast Atlantic and western Gulf, and collaborating with partners in the other CRC projects on the other meshes.
Operationalization of interpolation routines. These routines allow for the downscaling and extrapolation of forecast guidance, so it can be shared at higher-resolution to stakeholders. These routines are run currently as a post-processing step at NCSU, but they will be operationalized to be included in the ASGS workflows at UNC, LSU, UT, etc.	06/2019	50	Delay in funds. These routines have been released as open-source software, and we will work with our partners to operationalize them.
Research Milestone			
Presentation at ADCIRC Week	04/2019	100	
Submission of peer-reviewed manuscript	06/2019	25	Delay in funds.

about adaptive approach			

11. Year 4 Transition Activities and Milestone Achievements:

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Sharing of geoTIFF forecast guidance with FEMA. The forecast guidance for maximum water levels during Florence was shared as high-resolution shapefiles to stakeholders during Florence, including to FEMA. These shapefiles contain the downscaled and extrapolated guidance as described below in the research technical description. Then, after the storm, this guidance was converted into raster format as geo-referenced TIFF (geoTIFF) images, which contain the same information but at a constant resolution. These geoTiff guidance products were used by FEMA as part of its post-Florence analyses.	09/2018	100	
Transfer of mesh adaptivity technology into official ASGS. This technology will allow for the continuation of a simulation on a different ADCIRC mesh, and thus for forecasts to start on a coarse mesh and then continue on a finer mesh with higher-resolution coverage at the expected landfall location. This technology is the key component of our project and is described below in the research technical description.	06/2019	50	Delay in funds. We will work with our partners to operationalize these technologies.
Transition Milestone			
Sharing of forecast guidance with G Wells, T Howard, who work at the Texas State Operations Center Division of Emergency Management. They communicate the guidance to stakeholders and decision-makers to support emergency activities	08/2018	100	

during storms, including during Harvey in 2017. Dawson has a long relationship with them and has passed guidance to them for at least 10 years, and so we include this ongoing transition as a milestone.			
Quarterly progress updates, feedback from transition partners. These updates are provided as videoconferences, in which Dietrich and Dawson share their research progress as short presentations, with an emphasis on what is novel since the previous update. Most of the update is a discussion about ongoing and future research directions, and we are careful to solicit feedback and suggestions from our partners. This feedback is then used to improve the utility of our technologies as we develop them during the project.	09/2018 12/2018 03/2019 06/2019	50	Delay in funds. We are sharing research progress with our partners as it becomes mature and ready for feedback.

12. Tables:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
Downscaled forecast guidance during Florence	Shapefiles	09/2018	Tom Langan, NC Emergency Management
Downscaled hindcast guidance after Florence	Shapefiles and geo-referenced TIFFs	09/2018	FEMA

Table 2: Performance Metrics

Metric	**Year 1** (1/1/16 –	**Year 2** (7/1/16 –	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)	0	0	0	0
Undergraduates provided tuition/fee support	0	0	0	0
Undergraduate students provided stipends (number)	0	0	0	2
Graduate students provided tuition/fee support	3	2	2	3
Graduate students provided stipends (number)	3	2	2	3
Undergraduates who received HS-related degrees	0	0	0	0
Graduate students who received HS-related degrees	0	0	1	0
Graduates who obtained HS-related employment	0	0	0	0
SUMREX program students hosted (number)	1	0	0	0
Lectures/presentations/seminars at Center partners	1	1	0	0
DHS MSI Summer Research Teams hosted	0	1	0	1
Journal articles submitted (number)	0	0	1	1
Journal articles published (number)	0	0	1	1
Conference presentations made (number)	2	4	3	3
Other presentations, interviews, etc. (number)	1	4	11	5
Patent applications filed (number)	0	0	0	0
Patents awarded (number)	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies	0	1	0	2
Requests for assistance/advice from other agencies or governments (number)	0	1	3	2
Dollar amount of external funding	$0	$0	$0	$0
Total milestones for reporting period (number)	6	7	8	10
Accomplished fully (number)	6	3	3	5
Accomplished partially (number)	0	2	5	5
Not accomplished (number)	0	2	0	0

GINIS, URI
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Modeling the combined coastal and inland hazards from high-impact hurricanes

Principal Investigator Name/Institution:
PI: Isaac Ginis, University of Rhode Island, Professor
Co-PIs:

- Tetsu Hara, University of Rhode Island, Professor
- David Ullman, University of Rhode Island, Marine Research Scientist
- Pam Rubinoff, University of Rhode Island, Coastal Resilience Specialist
- Austin Becker, University of Rhode Island, Assistant Professor

Other Research Partners/Institutions:
Wenrui Huang, Florida State University, Professor

Short Project Description ("elevator speech)

This project advances modeling capabilities that assess the potential impacts of landfalling hurricanes on critical infrastructure and communities. The primary focus is on hurricanes in the Northeastern United States, combining multiple hazard impacts, including coastal flooding due to storm surge and inland flooding due to rainfall.

This project will expand outreach to the Northeast region previously not a focus of the models and allow DHS and other agencies to better understand the consequences of coastal and inland hazards associated with extreme high-impact landfalling hurricanes in specific regions and to better prepare coastal communities for future risks.

1. Introduction and project overview:

The major goal of this project is to comprehensively investigate hazards and impacts in the focus regions using the most advanced coupled hurricane, coastal ocean circulation/storm surge, wave, and hydrological models and transition the developed new modeling capabilities to the real-time ADCIRC-Surge Guidance System (ASGS) and Coastal Emergency Risks Assessment (CERA). To attain this goal, the following specific tasks will be accomplished: 1) Advancing the ADCIRC modeling system in the Northeast; 2) Expanding coupled inland and coastal flood modeling to all of Southern New England; 3) Expanding the URI Hurricane Boundary Layer model application to any location in the U.S. coastal region; 4) Implementation of hazard impact modeling into the real-time ASGS and CERA; and 5) Expanding end-user outreach to New England stakeholders.

2. Results:

Our research activities in Year 4 focus on advancing the capabilities and forecast skill of the ADCIRC modeling system in the Northeast and add new capabilities, such as improved surface wind modeling during hurricane landfall, coupling of storm surge and waves, inland flooding from rainfall. Details of the main activities and research findings are provided in Year 4 Report Appendix.

3. End users:

This project will contribute to improving the real-time ADCIRC-Surge Guidance System (ASGS) and Coastal Emergency Risks Assessment (CERA) to meet the requirements of their main users within federal agencies, including users within FEMA, USACE and NOAA NWS, and decision makers at state and municipal levels in New England.

Focus to date has been to engage end-users to define and advise on pilot application in Providence, Rhode Island. The Rhode Island Emergency Management Agency, RI Department of Health Emergency Preparedness Center, and the Providence Emergency Management Agency are our prime partners to help scope and implement the effort, as they are the ones targeted to use the product for real time applications. In efforts to plan and implement focus groups and gather information, there is a Steering Committee, made up of other key state, municipal, and private sector partners. These include: US Coast Guard, RI Department of Environmental Management, RI Department of Transportation, Lifespan Health Care, Narragansett Bay Commission (wastewater), City of Providence Police and Fire, Providence Port Authority and National Grid (energy).

4. Transition:

To date, the primary focus on the end-user transition has been on the Rhode Island emergency management community, with the goal of getting their input and buy-in to 1) develop a pilot project that shows the capability of modeling storms and impacts; 2) gather critical infrastructure information to use in the model; 3) Identify ways to share information for real time use at the Emergency Operations Center; 4) Get feedback on visualizations, platforms, and modeling approaches that will be rolled out to New England stakeholders for the enhanced ADCIRC modeling initiative.

The team has successfully engaged key project partners - Rhode Island Emergency Management Agency, the Rhode Island Department of Health Emergency Preparedness Center and the Providence Emergency Management Agency. Providence is the capital city of Rhode Island, where much of the state leadership is housed as well as the largest population in the state. With these groups, we confirmed that we would target our pilot project for Providence, Rhode Island to develop and demonstrate real time hazard and impact prediction system for hurricanes and

nor'easters in Southern New England. The system includes an assessment of cascading consequences of extreme weather impacting critical infrastructure.

In efforts to collect critical infrastructure information, thresholds, and concerns, we received Internal Review Board approval to conduct key informant interviews and focus groups of key infrastructure sector experts. We had a project kickoff meeting (25 stakeholders), and established a Steering Committee with 15 end-user organization/agency participants. The Steering Committee helped to refine the list of ten critical infrastructure and key resources (CIKR) sectors for which we will conduct focus group and/or key informant interviews. The CIKR was preferred by the emergency managers, as opposed to critical infrastructure communities, as it would be more functional within the Emergency Operations Center, with the Emergency Support Functions already functioning in Rhode Island. Efforts are underway to plan for 7-10 focus groups during the summer 2019.

Additional details on the transition activities are provided in Year 4 Report Appendix.

5. Project Impact:

By establishing a partnership with statewide emergency managers, and the capital city's emergency management agency in the development and implementation of the pilot project, it helps to ensure that the project, framework, information, and the technologies will build upon existing knowledge and be applicable to them as the products are rolled out. It provides the team with a real-world application, and a committed end user, who will be able to use this for real world applications, in addition to training exercises. This real time critical infrastructure impact information will build upon and enhance their knowledge base and strategies for preparation, response and recovery.

We further advanced the capabilities the ADCIRC modeling system in the Northeast and added new capabilities, such as improved surface wind modeling during hurricane landfall, highly refined its computational grid in Southern New England, improved wave coupling physics and the coupling with hydrological models. Specific examples are provided in the Year 4 Project Appendix.

6. Unanticipated Problems:

This project received 50% of annual budget in Year 4. As a result, some of the tasks have partially completed. The graduate students involved in the projects received partial support through a Dean's pledge provided by the URI's Graduate School of Oceanography.

7. Student Involvement and Awards:

1) Xuanyu Chen, a PhD student at the Graduate School of Oceanography, focused her work on evaluation and improvements of the wave models WW3 and SWAN in hurricane conditions

and investigated the sea state dependent drag coefficient in shallow waters during hurricane landfall.

2) Mansur Ali Jisan, a PhD student at the Graduate School of Oceanography, focused his work on advancing modeling of surface winds during hurricane landfall for predicting storm impacts.
3) Robert Witkop, a MS student at the Department of Marine Affairs, developed a methodology to collect qualitative data from emergency managers in a format that could then be integrated with the drivers that can be modeled (e.g., wind, wave, surge, flooding). He served as an intern in RIEMA's critical infrastructure program intern and conducted storm vulnerability analysis for 11 critical facilities in Westerly, RI.
4) For the transition component, three students have been hired to work 20 hours per week, two at URI, Noah Hallisey and Samantha Radov. One of the graduate students, Joyce Park, has been leveraged through our partnership with the RI Department of Health and Brown Public Health program. The primary responsibility of these students is to work with PIs and end-user partners to collect data on critical infrastructure.

Student demographics: Three female, and two males. Four graduate students and one undergraduate.

Degrees attained

- Bobby Witkop, Master's thesis in Marine Affairs
- Peter Stempel, Ph.D. Dissertation in Marine Affairs

8. Interactions with education projects:

N/A

9. Publications:

Publications (Student authors are marked with an asterisk)

- *Liu, Q.*, L. M. Rothstein, and Y. Luo, 2017. A periodic freshwater patch detachment process from the Block Island Sound estuarine plume. J. Geophys. Res. Oceans, 122, 570–586, DOI:10.1002/2015JC011546
- Gao, K., I. Ginis, J.D. Doyle, Y. Jin, 2017: Effect of boundary layer roll vortices on the development of the axisymmetric tropical cyclone *J. Atmos. Sci*. DOI: 10.1175/JAS-D-16-0222.1
- Whitney, M. M., D. S. Ullman, and D. L. Codiga, 2016. Subtidal Exchange in Eastern Long Island Sound, . *J. Phys. Oceanogr*. 46, 2351-2371. DOI: 1175/JPO-D-15-0107.1
- Gao, K. and I. Ginis, 2016: On the equilibrium-state roll vortices and their effect in the hurricane boundary layer. *J. Atmos. Sci.*, 1205- 1222. https://doi.org/10.1175/JAS-D-15-0089.1
- Liu, Q., L. M. Rothstein, Y. Luo, D. S. Ullman, and D. L. Codiga, 2016. Dynamics of the periphery current in Rhode Island Sound, *Ocean Modelling*, 105, 13-24. DOI: 10.1016/j.ocemod.2016.07.001
- Liu, Q., L. Rothstein, and Y. Luo, 2016. Dynamics of the Block Island Sound estuarine plume. J. Phys. Ocean., Accepted for publication. DOI: 10.1175/JPO-D-15-0099.1

- Reichl, B. G, D. Wang, T. Hara, I. Ginis, T. Kukulka, 2016: Langmuir turbulence parameterization in tropical cyclone conditions. *J. Phys. Oceanogr.*, 46, 863-886. DOI: 10.1175/JPO-D-15-0106.1
- Reichl, B. G., I. Ginis, T. Hara, B, Thomas, T. Kukulka, and D. Wang, 2016: Impact of sea-state dependent Langmuir turbulence of the ocean response to a tropical cyclone, *Mon. Wea. Rev*. DOI: 10.1175/MWR-D-16-0074.1
- Sun, Y., C. Chen, R. C. Beardsley, D. Ullman, B. Butman, and H. Lin, 2016. Surface Circulation in Block Island Sound and Adjacent Coastal and Shelf Regions: A FVCOM-CODAR comparison, *Progress in Oceanography*, 143, 26-45. DOI: 10.1016/j.pocean.2016.02.005
- Spaulding, M. L., Grilli, A., Damon, C., Crean, T., Fugate, G., Oakley, B., & Stempel, P.*, (2016). "Stormtools: Coastal Environmental Risk Index (CERI)." *Journal of Marine Science and Engineering*, 4(3). DOI: 10.3390/jmse4030054
- Fei, T., W. Huang, I. Ginis, Y. Cai, 2016. Characteristics of River Flood and Storm Surge Interactions in a Tidal River in Rhode Island, USA. Proceeding of IUTAM Symposium on Storm Surge Modelling and Forecasting, Oct 17-19, 2016, Shanghai, China

New Publications:

- Gao K, and I. Ginis, 2018: On the characteristics of roll vortices under a moving hurricane boundary layer, *J. Atmos. Sci*., 75, 2589-2598. https://doi.org/10.1175/JAS-D-17-0363.1
- Chen*, X., I. Ginis, and T. Hara, 2018: Sensitivity of offshore tropical cyclone wave simulations to spatial resolution in wave models. J. Mar. Sci. Eng., 6, 116. http://www.mdpi.com/2077-1312/6/4/116/
- Jisan, M. A. *, Bao, S., & Pietrafesa, L. J. (2018). Ensemble projection of the sea level rise impact on storm surge and inundation at the coast of Bangladesh. Natural Hazards and Earth System Sciences, 18(1), 351. https://doi.org/10.5194/nhess-18-351-2018
- Stempel, P.*, Ginis, I., Ullman, D., Becker, A., Witkop, R. (2018). Real-Time Chronological Hazard Impact Modeling. Journal of Marine Science and Engineering, Vol. 6, no. 134. doi:10.3390/jmse6040134.
- Teng, F., W. Huang, and I. Ginis, 2018. Hydrological modeling of storm-induced runoff and snowmelt in Taunton River Basin. Journal of Natural Hazards, 91, 179-199, https://doi.org/10.1007/s11069-017-3121-y
- Ullman D.S., I. Ginis, W. Huang, C. Nowakowski*, X. Chen*, and P. Stempel, 2019: Assessing the Multiple Impacts of Extreme Hurricanes in Southern New England, USA, Geosciences 2019, 9(6), 265; https://doi.org/10.3390/geosciences9060265
- Witkop, R., Becker, A., Stempel, P.*, Ginis, I. (2019). Developing Consequence Thresholds for Storm Models through Participatory Processes: Case Study of Westerly Rhode Island. Frontiers in Earth Science: Geohazards and Georisks.Vol. 7. Doi: 10.3389/feart.2019.00133.

Conference papers, presentations:

New presentations:

- Stempel, P.*, Becker, A. (2018), "Effects of localization on perceptions of storm surge risk depicted in model driven semi-realistic visualizations." International Conference on Sustainable Development, NY, NY. September 26-28, 2018.
- Ginis, I., D. Ullman, T. Hara, W. Huang, A. Becker, and R. Luettich (2018): Developing a Coastal and Inland Hazard and Impact Prediction System for Extreme Weather Events in the Northeastern United States, AGU Fall Meeting, December 14, https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/409069
- Ginis I. (2019): Advancing modeling capabilities to improve prediction of extreme weather events in the Northeastern United States, NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, April 11.
- Ginis I. (2019): Improving Prediction of Extreme Weather and Its Impact in New England, RI Emergency Management Agency, Cranston RI, March 7.
- Ginis I. (2019): Modeling Combined Coastal and Inland Impacts from Extreme Storms, RI Department of Health, Providence RI, March 8.
- Ginis I. (2018): Advances in Predicting Hurricane Path and Intensity, Jamestown Philomenian Library, Jamestown RI, September 24.
- Ginis I. (2018): The 1938 Great New England Hurricane Looking to the Past to Understand Today's Risk, East Greenwich Historic Preservation Society, East Greenwich, RI, September 15.
- Becker, A, (2019). "Overcoming Barriers to Long-term Climate Adaptation," Lecture of Opportunity, US Naval War College, Newport, RI, April 29.
- Becker, A., (2019). "Climate risk adaptation for ports: Research for transformational thinking." UNCTAD Ad Hoc Expert Meeting on Climate Change Adaptation for International Transport: Preparing for the Future , Geneva, Switzerland, April 16-17.
- Stempel, P., Becker., A., Ginis, I., Ullman, D., Rubinoff., P., Overstrom, N. (2019). "Rethinking model-driven realistic storm-surge graphics." Rhode Island Coastal Ecology, Assessment, Innovation, and Modeling (RI C-AIM) Research Symposium 2019, Kingston RI. April 10.
- Becker, A, Stempel, P., Menendez, J. (2019). "Visualizing Risk: Dynamic 3d Models of Storm Impacts on Coastal Structures In Rhode Island." Poster presentation at the Infrastructure Climate Network Meeting, Portsmouth, NH, April 4-5.
- Becker, A. (2018). "Stimulating Transformational Thinking for Long-Term Climate Resilience." University of Rhode Island Coastal Resiliency Symposium, Oct. 16, Narragansett, RI. (I)
- Huang, W., F Teng, I. Ginis, and D. Ullman. 2019. Rainfall Runoff and Flood Simulations for Hurricane Impacts on Woonasquatucket River, USA. ICCEN 2019. Accepted by 8th International Conference on Civil Engineering (ICCEN 2019), November 19-20, Paris, France, 2019

Previous publications

- Chen, X. *, I. Ginis and T. Hara (2018). "Sea-State Dependent Drag Coefficient in Shallow Waters Under Tropical Cyclones", 21st Conference on Air-Sea Interaction, June 18 https://ams.confex.com/ams/23BLT21ASI/meetingapp.cgi/Paper/345222

- Chen, X.*, T. Hara, and I. Ginis (2018). “Sea-state dependent air-sea momentum flux in a shallow water under a tropical cyclone”, Ocean Sciences Meeting, February 14 https://agu.confex.com/agu/os18/meetingapp.cgi/Paper/303041
- Ginis, I., C. Nowakowski*, and K. Gao (2018). “A Hurricane Boundary Layer Model for Simulating Surface Winds during Hurricane Landfall”, 33rd Conference on Hurricanes and Tropical Meteorology, April 18, https://ams.confex.com/ams/33HURRICANE/webprogram/Paper339799.html
- Ginis, I., D. Ullman, T. Hara, C. Kincaid, K. Rosa*, X. Chen*, B. Thomas, A. Becker, P. Stempel*, R. Witkop*, P. Rubinoff, W. Huang, M. Orr, R. Thomas, R. Thompson, M. Belk, P. Morey, and S. Conard (2018). “Advancing Modeling Capabilities and Impact Analysis Tools to Improve Preparedness for Major Hurricane Hazard Events”, 98th AMS Annual Meeting, January 11, https://ams.confex.com/ams/98Annual/webprogram/Paper336049.html
- Nowakowski, C.* and Ginis I. (2018): Advancing modeling of surface winds during hurricane landfall for predicting storm impacts, DHS Centers of Excellence Summit, May 30-31, 2018 https://cina.gmu.edu/coe-summit-2018/
- Witkop, R.*, Becker, A., Stempel, P.*, (2018). “Incorporating facility manager knowledge into storm impact models: A case study of critical facilities in Westerly, Rhode Island,” Rhode Island Floodplain Managers Association, Smithfield, RI, April 5.
- Rosa, K.*, Kincaid, **C.** (2018). “Transporting Nutrients Northward from Rhode Island Sound Bottom Water to the Upper Narragansett Bay Euphotic Zone”, RI C-AIM/RI NSF EPSCoR Symposium. Kingston, RI, April 9.
- Rosa, K., Kincaid, C., Ullman, D., and Ginis, I. (2017). Hurricane Rhody: How does Rhode Island Fare Against Hypothetical Superstorm? URI Graduate Conference. Kingston, RI. 8 April.
- Rosa, K. *, Kincaid, C., Ullman, D., and Ginis, I. (2017). “Baroclinic Model of Narragansett Bay Post-Storm Shelf-Estuary Exchange”, Estuary Research Workshop: Limiting Factors Beyond Nitrogen. Narragansett, RI. September 13.
- Ginis, I., D. Ullman, T. Hara, C. Kincaid, L. Rothstein, W. Hwang, B. Thomas, X. Chen*, K. Rosa*, A. Becker, P. Stempel*, R. Witkop*, P. Rubinoff (2017). “Developing a mul.-model ensemble system for assessing hurricane hazards and impacts”, URI Coastal Resilience Science and Engineering Workshop, December 4.
- Ullman, D., I. Ginis, W. Hwang, P. Stempel*, T. Hara, C. Kincaid, L. Rothstein, P. Rubinoff, B. Thomas, X. Chen*, K. Rosa* (2017). “Assessing the Mul-ple Impacts of Extreme Hurricanes in Southern New England”, URI Coastal Resilience Science and Engineering Workshop, December 4.
- Witkop, R.*, Stempel, P.*, **Becker, A.**, (2017). “Coupling local scale, high resolution, qualitative data to interface with numerical storm models”, American Geophysical Union Annual Conference, New Orleans, LA. Dec. 12.
- Stempel, P.* (2016). “Data Driven Visualization”, Estuarine and Coastal Modeling Conference 2016, Narragansett, RI, June 14-15.

Student Theses/Dissertations

- Bobby Witkop Master’s thesis in Marine Affairs “Developing Consequence Thresholds for Storm Impact Models: Case Study of Westerly, Rhode Island”, 2018, Primary advisor: Dr. Austin Becker, Committee member: Dr. Isaac Ginis

- Peter Stempel Ph.D. Dissertation in Marine Affairs: “Depicting consequences of storm surge, opportunities and ethics.” 2018, Primary advisor: Dr. Austin Becker, Committee member: Dr. Isaac Ginis

10. Year 4 Research Activities and Milestone Achievements:

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Modify the ADCIRC mesh to provide higher spatial resolution in the open ocean region south of New England in order to enable more accurate wave forecasts near the coast during hurricanes.	12/31/2018	100%	
Modify the ADCIRC mesh to increase the spatial resolution to approximately 30 m along the entire southern New England coast from western Connecticut to northern Massachusetts.	06/30/2019	100%	
Modify the ADCIRC mesh to facilitate the implementation of riverine inflows from the major New England rivers at the upland boundary of the mesh.	06/30/2019	80%	Delay due to receipt of funding.
Evaluate and implement the sea state dependent drag coefficient into ADCIRC.	06/30/2019	80%	Delay due to receipt of funding.
Implement the Precipitation-Runoff Modeling System (PRMS) to simulate rainfall runoff in Connecticut.	06/30/2019	60%	Delay due to receipt of funding.
Expand the operation of the hurricane boundary layer model to more locations in the U.S. coastal region and develop a more efficient and user-friendly software to run the HBL model.	06/30/2019	100%	
Integrate hazard impact tools into the real-time ADCIRC-Surge Guidance System (ASGS). Besides the storm surge prediction, this new capability will provide information on disaster consequence thresholds for critical facilities such as wastewater treatment facilities, seaports, substations, roads and communication facilities.	06/30/2019	10%	Delay due to receipt of funding.
Configure inputs and outputs of the hazard impact tools to conform to the existing ASGS formats and computational framework.	06/30/2019	40%	Delay due to receipt of funding.
Research Milestone			
Complete the modification of a high resolution ADCIRC mesh along the entire southern New England coast from western Connecticut to northern Massachusetts including the implementation of riverine inflows from the major New England rivers at the upland boundary of the mesh.	06/30/2019	80%	Delay due to receipt of funding.

Implemented of the sea state dependent drag coefficient into ADCIRC.	06/30/2019	80%	Delay due to receipt of funding.
Implemented the Precipitation-Runoff Modeling System (PRMS) to simulate rainfall runoff in Connecticut.	06/30/2019	60%	Delay due to receipt of funding.
Extend the URI hurricane boundary layer model to additional locations in the U.S. coastal region with a more efficient and user-friendly software to run the HBL model.	06/30/2019	100%	
Completed integration of the URI hazard impact model into the real-time ADCIRC-Surge Guidance System (ASGS).	06/30/2019	10%	Delay due to receipt of funding.
Publish research results in peer-reviewed journal and conduct presentations at national and regional conferences and workshops. We anticipate delivering 14-15 presentations each year.	06/30/2019	90%	Delay due to receipt of funding.

11. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Coordinate transition efforts with UNC/CRC on ADCIRC/CERA.	6/30/2019	30%	Delay due to receipt of funding.
Identify, contact, and meet with core end-users, Federal and State Emergency Managers in the five states of NE, to discuss the project and strategy for engagement and outreach.	6/30/2019	60%	Given the delay in ADCIRC team funding, this has been initiated in RI, but not in the other states.
Assist the model developers in their efforts to enlist local emergency managers in the development a database that includes the concerns of specific facility managers as quantifiable thresholds that tie these concerns back to the hazard models.	6/30/2019	30%	Delay due to receipt of funding.
Develop and/or adapt ADCIRC and CERA outreach materials for Northeast users.	6/30/2019	30%	Delay due to receipt of funding.

Participate and contribute to annual ADCIRC training courses for end users.	6/30/2019	20%	Delay due to receipt of funding.
Conduct questionnaires at the end of each training and workshop activity to determine progress and assess effectiveness of the developed hazard model improvements and impact output capabilities in improving risk assessment and emergency response.	6/30/2019	30%	Delay due to receipt of funding.
Transition Milestone			
Transition the URI hazard impact analysis tools into the ADCIRC-Surge Guidance System (ASGS).	6/30/2019	10%	Delay due to receipt of funding.
Disseminate ADCIRC and CERA outreach materials to-Northeast end-users.	6/30/2019	60%	Delay due to receipt of funding.

12. Tables:

Table 1: Research Project Product Delivery

N/A

Table 2:

GINIS – HUANG Performance Metrics

Metric	Year 1 (1/1/16 – 6/30/16)	Year 2 (7/1/16 – 6/30/17)	Year 3 (7/1/17-6/30/18)	Year 4 (7/1/18-6/30/19)
HS-related internships (number)	0	0	0	0
Undergraduates provided tuition/fee support (number)	0	0	0	0
Undergraduate students provided stipends (number)	0	0	0	1
Graduate students provided tuition/fee support (number)	2	3	3	3
Graduate students provided stipends (number)	2	3	3	3
Undergraduates who received HS-related degrees (number)	0	0	0	0
Graduate students who received HS-related degrees (number)	0	0	0	0
Graduates who obtained HS-related employment (number)	0	0	0	0
SUMREX program students hosted (number)	0	2	2	0
Lectures/presentations/seminars at Center partners (number)	1	3	2	1
DHS MSI Summer Research Teams hosted (number)	0	0	0	0
Journal articles submitted (number)	2	7	6	3
Journal articles published (number)	7	8	9	7
Conference presentations made (number)	15	14	15	8
Other presentations, interviews, etc. (number)	12	22	17	23
Patent applications filed (number)	0	0	0	0
Patents awarded (number)	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies (number)	0	3	5	3
Requests for assistance/advice from other agencies or governments (number)	5	13	12	11
Dollar amount of external funding	$3,921,000	$3,660,000	$3,660,000	
Total milestones for reporting period (number)	11	21	19	8
Accomplished fully (number)	9	17	19	1
Accomplished partially (number)	2	4	0	7
Not accomplished (number)	0	0	0	0

FLEMING: SEAHORSE COASTAL CONSULTING
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
The ADCIRC Surge Guidance System as a Conduit for Innovation

Principal Investigator Name/Institution:
Jason G. Fleming, Seahorse Coastal Consulting

Other Partners/Institutions:

Short Project Description ("elevator speech)

We are positioning our ADCIRC Surge Guidance System software as a real time 24/7 delivery vehicle for the innovations developed at the CRC that have the best value proposition for our key stakeholders. We are also researching asset database driven products beyond storm surge that are more directly relevant to the needs of our transition targets. Finally, we are setting up outreach and training activities that will benefit new users as well as generate sales leads for sustainable funding going forward.

1. Introduction and project overview:

The ADCIRC Surge Guidance System (ASGS) automates the production of ADCIRC model guidance in real time for decision support. Whenever new hurricane forecast/advisories are issued, it takes care of collecting all up-to-date wind and water level input data, creating input files for ADCIRC, running the model, producing graphics output including contour plots and PowerPoint slides, and posting results for further use by our clients and stakeholders. We are continuously improving this system according pure research drivers from agencies like NOAA as well as responding to direct and personal feedback from Operations personnel ranging from FEMA, FIMA, the Texas State Operations Center (SOC), the US Coast Guard, the Louisiana Coastal Protection and Restoration Authority, AECOM, Dewberry, and many others. Our technology development paradigm places equal weight on Research-to-Operations (R2O) and Operations-to-Research (O2R).

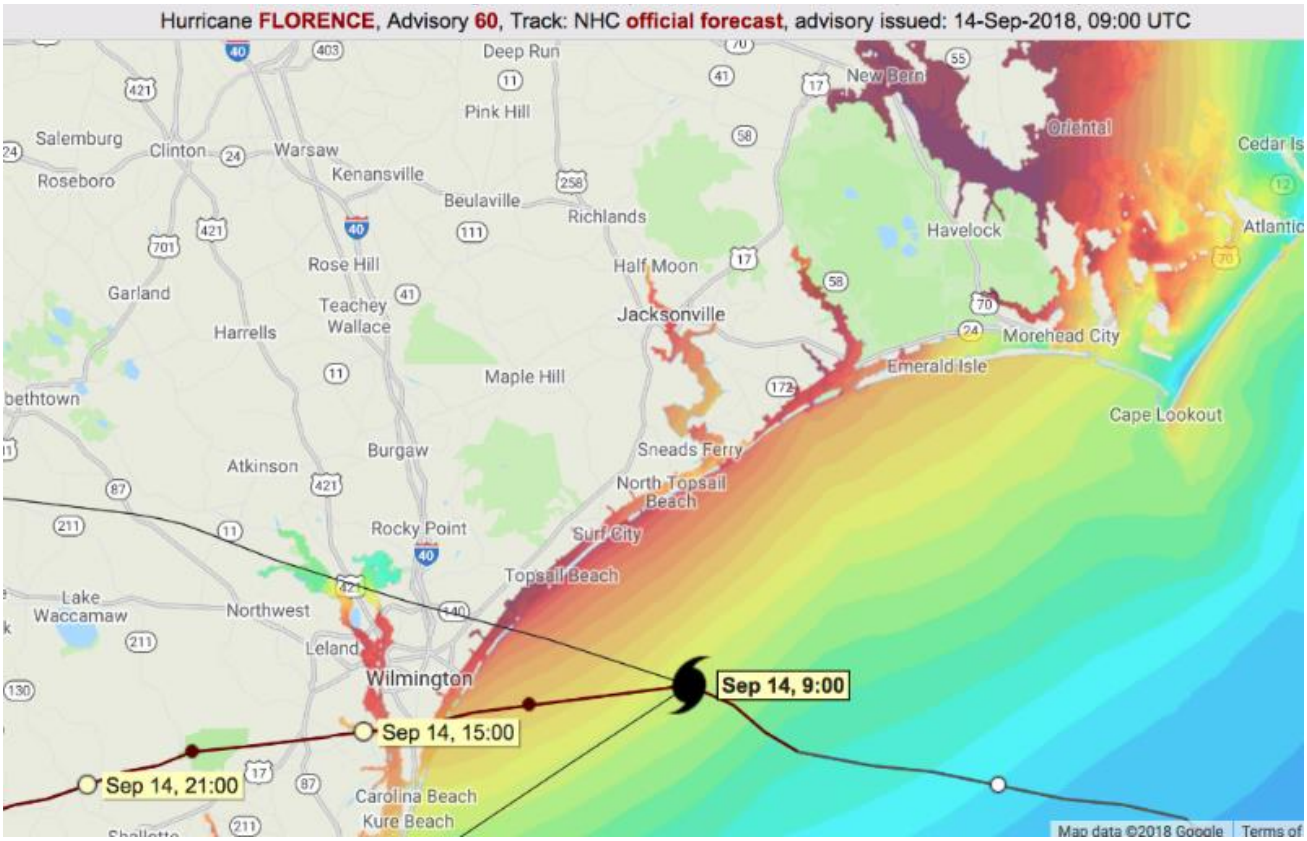
2. Results:

We provided real time model guidance for every significant tropical cyclone (including Tropical Storm Gordon, Hurricane Florence, and Hurricane Michael) to official decision makers. We also provided search-and-rescue data 24/7/365 for US Coast Guard SAROPS at their request. We made outreach and training visits to clients and stakeholders in Texas, Louisiana, Mississippi, and Florida. We produced training events (2019 Texas ADCIRC Week) and ADCIRC community organization events (2019 ADCIRC Users Group Meeting). We also developed and deployed new technologies for our ASGS, including water level bias correction (to eliminate the last remaining centimeters of error in our real time ADCIRC guidance) and inland wind

production for real time situations (to extend our wind model guidance beyond the coastal zone). These two technology deliverables (bias correction and inland wind guidance) were the direct result of requests that came out of debriefs with Operations personnel based on their experiences in the field.

Additional details are available in focused writeups in CRC News items:

Hurricane Florence Special Edition: https://mailchi.mp/03d85395e634/coastal-resilience-center-april-2017-newsletter-3340013?e=e2f14bd7a6



2019 ADCIRC Users Group Meeting, organized by PI Fleming: https://coastalresiliencecenter.unc.edu/2019/06/23rd-adcirc-users-group-meeting-gathers-modeling-community-to-discuss-latest-improvements/

3. End users:

We have hundreds of documented/registered decision making officials using our products as well as tens of thousands of public users because we partner with the Coastal Emergency Risks Assessment (CERA) web mapper project (https://cera.coastalrisk.live). We also distribute our numerical data directly to the public in raw format (e.g., multiple redundant THREDDS servers hosted at the Renaissance Computing Institute in North Carolina as well as the Center for Computation and Technology at LSU and the Texas Advanced Computing Center at UT Austin). We have made a conscious decision to not try to silo end users under our project; we actively maintain an extremely close and mutually beneficial collaborative relationships with several other CRC teams, particularly Carola Kaiser, Robert Twilley, Brian Blanton, Clint Dawson, and Casey Dietrich. As a result, we share end users with those other CRC team members.

4. Transition:

Our strategy for transition is continuous integration according to a pattern known as DevOps that has been developed over the past decade in the private sector technology industry. DevOps is a technique that combines design, development, deployment, and support personnel within a single team to accelerate technology release cycles thereby reducing lead times for new capabilities from years to weeks. Our ASGS workflow for producing real time model guidance runs 24/7/365 on multiple redundant supercomputers in cooperation with our academic HPC partners; we continuously insert new technology improvements, catching and correcting issues, and making the latest features available to our clients and stakeholders.

5. Project Impact:

Include information about how your project's outcomes advanced current technologies or capabilities, especially with regard to DHS component agencies (e.g., saves lives, saves money and/or property, increases operational efficiency). In Year 4 our project continued its tradition of significant impacts for real time decision makers with too many anecdotes and instances to list effectively in this report. However, we would like to offer the following as a small sample. During Hurricane Florence, Texas Task Force 1 used our ADCIRC model guidance via the CERA site (in partnership with our CRC colleagues Carola Kaiser and Robert Twilley) to make decisions about swift water rescue deployments in New Bern, North Carolina. During Tropical Storm Gordon, the mayor of Slidell, Louisiana successfully used ADCIRC model guidance to avoid expensive emergency deployments even when the news media made that mild storm seem more dangerous than it was. During and after Category 5 Hurricane Michael FEMA used our guidance to get rapid damage estimates for insurance claims after the storm made landfall but before it had even dissipated. Throughout the year, we produce water current velocity data 24/7/365 for the US Coast Guard in Pamlico Sound for search-and-rescue operations, which they had accessed over 700 times at last count. Our guidance is provided to such a wide variety of stakeholders, there are undoubtedly many use cases and decisions that have been made we are not aware of. We continue to collect feedback and decision support scenarios to continuously improve and add value for official decision makers.

6. Unanticipated Problems:

We had three unanticipated challenges that arose during Year 4: (1) delays in ADCIRC-related funding; (2) inadequacies in datum conversion capabilities via NOAA VDatum, and (3) impacts from Hurricane Florence. The delays in ADCIRC funding were easily handled by deferring certain priorities and deliverables until after Year 4. Most of these deferred deliverables were related to commercialization and customer service, and the delay will only change the timing of delivery (as opposed to quality or completeness). The inadequacies in datum conversion capabilities falls under the unanticipated issues category and really results from the nature of the VDatum project (from NOAA) as a work-in-progress. It does not yet fully cover the regions of interest that are covered by our ADCIRC meshes and are in demand during Operations. One of the reasons for this demand is the need for decision support during floods, regardless of the cause (riverine or coastal surge or a combination). The terrestrial and marine vertical datums have been developed independently historically and the process of integrating them has not yet reached the reliability and coverage required in Operations, particularly in the case where coastal rivers are impacted by storm surge far enough inland that mean sea level becomes difficult to reconcile with terrestrial datums. As a result, additional effort will be required to determine suitable areas for the use of these datum tools before they can be employed with confidence. Finally, the impacts related to Hurricane Florence were the most significant, as this storm forced us to reassign a significant portion of our calendar time from Research to Operations, as well as affecting the PI (Jason Fleming) since the storm had personal impacts for him. However, recovery is ongoing and we expect the delayed deliverable (far field winds) to be delivered with the other ADCIRC milestones during Year 5.

7. Student Involvement and Awards:

PI Jason Fleming conceived and organizes the annual ADCIRC Community Awards each year, with the nominations announced and awards given out at the annual ADCIRC Users Group Meeting. Students are often nominated, both CRC and non-CRC affiliated. The rationale for the Awards is that a software model like ADCIRC requires many supporting technologies and efforts: documentation, community-maintained analysis codes and utilities, code maintenance and refactoring, formal and informal mentoring of new users, etc. These efforts are not typically directly funded by any Federal Agency or other research sponsor but are required for the model to continue to attract new followers and to be sustainable. As a result, PI Jason Fleming created the ADCIRC Community Awards to incentivize and recognize these pro-social behaviors to enhance efficiency and productivity of the community as a whole.

Figure 2 Ashley Kauppila of Taylor Engineering (ADCIRC mesh developers for FEMA) was voted ADCIRC Community Woman of the Year. Taylor Asher (graduate student with CRC Director Rick Luettich) was voted ADCIRC Community Man of the Year.

8. Interactions with education projects:

We had strong graduate student participation in the 2019 Texas ADCIRC Week which was conceived, organized, and co-instructed by PI Fleming along with a host of topic instructors

including CRC researchers Clint Dawson and Carola Kaiser. Additional instructors from the private sector included Ashley Kauppila, P.E., Project Engineer with Taylor Engineering; Michelle Terry, Floodplain Risk Analyst and Coastal GIS Specialist with of AECOM; and Alan Zundel, President and Lead Developer for SMS, with Aquaveo, LLC.

The CRC declined to provide the approximately $5000 in financial sponsorship this year for student participation as it had in past ADCIRC Boot Camp events. However, we were been able to compensate successfully by taking advantage of strong demand to raise registration prices and keep the event's finances in the black. Furthermore, we took a risk this year in growing the Boot Camp from 3 days to a full week and setting it up as a standalone training event (i.e., beyond its traditional colocation and outside its traditional association with the ADCIRC Users Group Meeting). With these ambitious goals and new partnerships we were able to generate one of the strongest turnouts we've had in the history of the ADCIRC Boot Camp series.

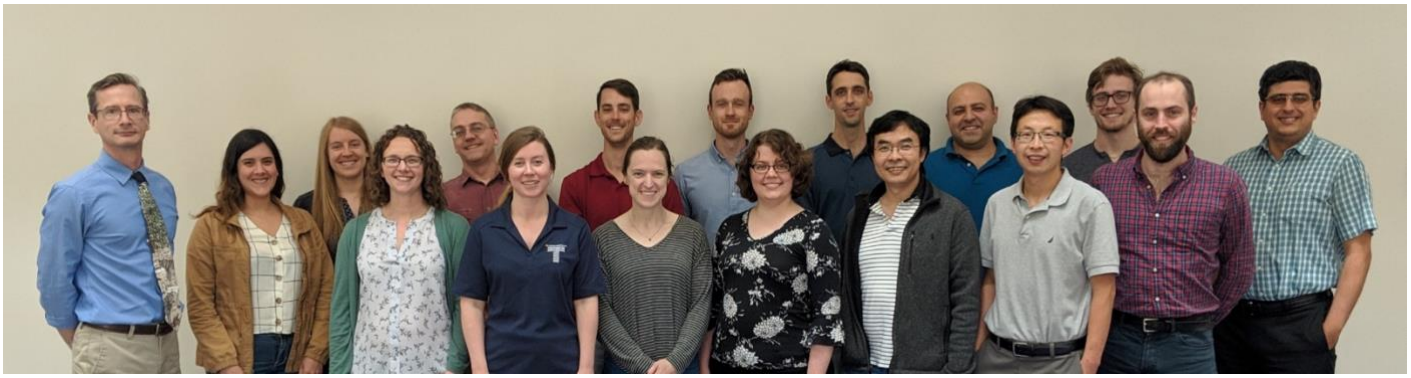
Our registration numbers at the 2019 Texas ADCIRC Week included the following:

ADCIRC 101 Fundamentals: 21 registered
ADCIRC 102 Modelling with SMS: 12 registered
ADCIRC 104 CERA for Emergency Response: 11 registered
ADCIRC 202 ArcGIS Integration: 9 registered
ADCIRC 203 Mapping for Risk Communication: 4 registered
ADCIRC 305 ASGS: 5 registered

There were 38 unique participants total. The list of institutional affiliations is as follows:

AECOM
CDM Smith
ERT/NOAA
Kunsan National University
Louisiana State University
Mott MacDonald
Korea National Disaster Management Research Institute
North Carolina State University
Oden institute, the University of Texas at Austin
Risk Management Solutions
Rutgers University
TACC
Taylor Engineering, Inc.
Texas A&M Task Force 1 Operations
Texas A&M University-Corpus Christi, Conrad Blucher Institute
The University of Texas at Austin
University Corporation for Atmospheric Research
USACE - New Orleans District
USCG Atlantic Area (35IM)

UT Arlington
UT Center for Space Research



We also had a notable success story in terms of workforce development: our Texas ADCIRC Week participant from Risk Management Solutions (RMS) in California, Dr. Shuangcai Li, is also their lead developer for natural hazards modelling. He took the opportunity to advertise several open positions to the participants at 2019 Texas ADCIRC Week. I forwarded that information to one of our past ADCIRC Boot Camp participants, PhD student Peyman Taeb of Florida Institute of Technology, who immediately applied and was hired! Here is his subsequent email to me (along with his stated interest in continuing to participate as a professional in future ADCIRC Boot Camp events):

> *Dr. Fleming: I applied to the open positions at RMS that you sent me in April. I got the position as "Tropical Cyclone Wind Hazard Modeler". I will be starting in August. I wanted to deeply thank you for informing me of these openings. I still look forward to working with you on Florida ADCIRC boot camp this year, if it is still on the table.*
>
> *I wouldn't get the job if you haven't sent me the job opening. So thank you! RMS wants me to actively perform research, publish papers, get involved in research activities like ADCIRC boot camp. A dream job. If you need me for Florida ADCIRC workshop I will talk to RMS and will take a week off. Again, thanks for forwarding this job opening, also for everything that I learned from you and your ASGS scripts.*

We are very proud of our work with students at the ADCIRC Boot Camp event series, and we are looking forward to even bigger and better future events.

9. Publications:

- "Dynamic Water Level Correction in Storm Surge Models Using Data Assimilation." Authors: Taylor G. Asher, Richard A. Luettich Jr. and Jason G. Fleming. Submitted to Ocean Modelling. In revision.
- "Influence of storm timing and forward speed on tides and storm surge during Hurricane Matthew." Authors: Ajimon Thomas, JC Dietrich, TG Asher, M Bell,

BO Blanton, JH Copeland, AT Cox, CN Dawson, JG Fleming, RA Luettich. Ocean Modelling. Published. https://doi.org/10.1016/j.ocemod.2019.03.004

- "Forecasting Model, Forecast Advisories and Best Track in a Wind Model, and Observed Data – Case Study Hurricane Rita." Authors: Abram Musinguzi, Muhammad Akbar, Jason G. Fleming, Samuel K. Hargrove. Journal of Marine Science and Engineering. Published. J. Mar. Sci. Eng. 2019, 7(3), 77; https://doi.org/10.3390/jmse7030077
- Media coverage of the 2019 Texas ADCIRC Week training event that PI Jason Fleming organized: "DesignSafe ADCIRC Provides Storm Surge Simulators for Natural Hazards Community" (picked up and republished by HPCWire): https://www.hpcwire.com/off-the-wire/designsafe-adcirc-provide-storm-surge-simulators-for-natural-hazards-community/
- CRC Coverage of 2019 ADCIRC Users Group Meeting event that PI Jason Fleming organized: https://www.flickr.com/photos/133219410@N05/albums/72157709249042136

Figure 3 PI Jason Fleming maintains cross-cutting collaborations with many other CRC Researchers, such as Clint Dawson pictured here during his training session at 2019 Texas ADCIRC Week. PI Jason Fleming conceived and organized Texas ADCIRC Week.

10. Year 4 Research Activities and Milestone Achievements

Year 4 Research Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Evaluate blended far field winds in ASGS	12/31/2018	0%	Hurricane Florence.
Integrate water level bias correction workflow into ASGS.	6/30/2019	100%	
Provide support for vertical datum options in ASGS.	6/30/2019	0%	Suitable datum surfaces not available from any source.
Investigate inland winds production in ASGS	6/30/2019	100%	
Research Milestone			
Finalize operational implementation of far field winds in ASGS.	6/30/2019	0%	Hurricane Florence.
Deliver real time data assimilated results with ASGS	6/30/2019	100%	
Make ASGS data-ready for vertical datum relation surfaces for input and output.	6/30/2019	0%	
Implement inland winds in Texas, Louisiana, Florida, and North Carolina in production.	6/30/2019	100%	Suitable datum surfaces not available from any source

11. Year 4 Transition Activities and Milestone Achievements

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Developer, stakeholder, and institutional coordination for all transition activities	6/30/2019	100%	

Improve handling of support requests related to decision support services.	6/30/2019	0%	Delayed ADCIRC funding.
Gather technical requirements and feedback and establish business relationships with clients	6/30/2019	100%	
Planning and organizing 2019 ADCIRC Boot Camp for graduate students, postdocs, faculty members, and practicing professionals to learn the details of running the ADCIRC model.	4/30/2019	100%	
Provide operational support for existing ADCIRC Surge Guidance System for all clients and stakeholders.	6/30/2019	100%	
Conduct onboarding training and coordination for backup Developer/Operator	6/1/2019	50%	Delayed ADCIRC funding.
Conduct monthly readiness exercises	6/30/2019	100%	
Design and develop e-commerce infrastructure including ADCIRC products portal	6/30/2019	0%	Delayed ADCIRC funding.
Complete improvements to the ASGS status monitoring across sites	6/30/2019	100%	
Travel to technical, business, and scientific meetings as described in the planned travel schedule below.	6/30/2019	100%	
Transition Milestone			
Successful delivery of Year 4 deliverables assigned to transition project participants as described above.	6/30/2019	100%	
Deliver a fully functioning support ticketing system for client and stakeholder inquiries	6/30/2019	0%	Delayed ADCIRC funding.
Delivering 2019 ADCIRC Boot Camp for graduate students, postdocs, faculty members, and practicing professionals to learn the details of running the ADCIRC model	4/30/2019	100%	
Complete onboarding of the new backup ASGS Developer/Operator	6/30/2019	50%	Delayed ADCIRC funding.
Produce a prototype e-commerce portal and make available for review.	6/30/2019	0%	Delayed ADCIRC funding.
ASGS status monitoring infrastructure functioning at all HPC sites.	6/30/2019	100%	

12. Table:

Table 1: Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document, knowledge product)	**Delivery Date**	**Recipient or End User(s)**
ADCIRC Surge Guidance System (ASGS)	Software	Continuous	Distributed publicly, actively used by HPC partners (RENCI, LSU, TACC) as well as NOAA and private sector (Ransom Consulting, WorldWinds, Inc) et al, to produce ADCIRC model guidance.
Real Time ADCIRC Model Guidance	Knowledge Products	During active storm situations	FEMA, US Coast Guard, Texas Task Force 1 Swift Water Rescue, Texas State Operations Center, Louisiana Coastal Protection and Restoration Authority, and many others.

Table 2: Performance Metrics:
n/a

Theme 4

Education and Workforce Development

WHALIN, JSU
DHS COASTAL RESILIENCE CENTER
EDUCATION PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
PhD in Engineering (Coastal Engineering and Computational Engineering) at an HBCU.

Principal Investigator Name/Institution:
Robert W. Whalin, Ph.D., P.E., D. CE; Professor of Civil Engineering and Education Director, Coastal Resilience Center of Excellence, Jackson State University (JSU).

Other Partners/Institutions:
US Army Engineer Research and Development Center (ERDC), Vicksburg, MS and Texas A&M University at Galveston

Short Project Description ("elevator speech"):

This project focuses on strengthening the establishment and institutionalization of the PhD in Engineering (Coastal Engineering and Computational Engineering concentrations) accomplished during years 1 to 3 of this CRC education project. A steady output of MS and PhD Engineering degree graduates with Coastal Engineering or Computational Engineering concentrations focused on coastal natural disasters is projected to be established and to help increase workforce diversity in the greater Homeland Security enterprise.

1. Introduction and project overview:
This project directly addresses the education need for graduate engineering programs focused on coastal natural disasters to provide engineers that can help mitigate the ever-increasing cost of damages, especially those from tropical storms and hurricanes that DHS is confronted with through FEMA missions. Almost no graduate coastal engineering programs are focused on coastal natural disasters and none are located at an HBCU where a large percentage of African American engineers matriculate. Jackson State University has an African American student body exceeding 80% which will directly support the DHS Strategic Plan Goal to Enhance the DHS Workforce, especially the Objective to increase Workforce Diversity and Priority Goal 3 to Enhance Resilience to Disasters. Leverage of federal assets is assured by the Education Partnership Agreement (authorized by Public Law) between the Engineer Research and Development Center and Jackson State University. The Agreement facilitates ERDC providing Adjunct Faculty, student internships and potential use of ERDC experimental and computational facilities for graduate research. An excellent record of DHS End User involvement and transition of graduates to end users continued throughout year four of the Coastal Resilience Center of Excellence. Research staff and graduate students had direct participation in a CRC research project, and in highly relevant hurricane barrier projects nationwide (funded by others) including the Ike Dike concept for protecting Galveston Island and the greater Houston metropolitan area from devastating, albeit low probability, hurricane surges. Coastal Engineering education programs nationwide have been on a decline for the past two decades and United States

leadership in the coastal engineering profession has declined relative to other nations. This project will help ameliorate the trend while increasing the supply of minority coastal and computational graduate level engineers focused on the field of coastal natural disasters.

2. End users:

A list of end-users that participated in this project during Year 4 follows. Their project role is included focusing on facilitating transitions to these end users as appropriate. Discussions were held with each at either the CRC Annual Meeting, at ERDC, at MS Engineering Society Meetings, during classes or on other professional occasions.

Table 1: End-User Involvement

End-User	Agency/Employer	Project Role (Year 4)
	FEMA Region IV	Transition, potential employer
BG (Ret) Robert Crear Chairman, Free Flow Power Development, LLC	Free Flow Power	Collaborator (guest lecturer), Transition (assists with student internships/employment).
Mr. Mark Sanders GIS Specialist	MEMA	Collaborator, Transition (potential employer of graduates)
Branch Chief, MVX	USACE Vicksburg District	Transition (potential employer): Sponsored student Society of American Military Engineers. Discussed engineer government careers, employer of graduates.
Mr. John T. Weeks, PE Vice President	SDW	Transition (potential employer)
Research Engineer	ERDC	Collaborator, research advisor for a PhD student: discussed dissertation research several times during Year 4.
Research Engineer	USACE ERDC	Collaborator, Leveraged Project from TAMUG
Director	ERDC	Transition, signatory for Education Partnership Agreements; had several discussions during Year 4.
Director, Geotechnical and Structures Lab	ERDC	Transition; GSL employs graduates. Held discussions.
Research Engineer	ERDC	Adjunct Professor, graduate courses; served on two graduate committees.
Research Engineer	ERDC	Adjunct Prof., graduate courses; served on two graduate committees.

There is a very small number of end-users in FEMA, Corps of Engineers Districts, Emergency Management Agencies and private industry contractors who have engineers with graduate Coastal Engineering education (most especially African American and Hispanic American engineers). This project will help ameliorate this critical deficiency in widespread expertise (over 80% of JSU students are minorities, mostly African American). The immense cost to the taxpayers of rescue and recovery from Hurricane inundation, coastal and estuarine flooding from intensified precipitation events and tsunami inundation drives the need for additional engineers with graduate education focused on coastal natural disasters.

3. Unanticipated Problems:

None. A very good year.

4. Students and recent graduates:

The demographics of students enrolled in Year 4 project core courses for whom I served on their graduate committees Year 4 is shown in Table 1 below:

	Undergraduate	Graduate	
		Full Time	Part Time
Enrolled	0	8	7
Graduated	0	2 PhD	1 MS

Student Demographics for Year 4

The PI advises all students enrolled in Coastal Engineering concentration core courses. He served on the PhD committee of both the PhD Engineering graduates (both Asian) who were in the Transportation Engineering concentration and was Chair of the MS Oral Exam Committee for the MS Engineering graduate (female, African American) who was in the Coastal Engineering concentration.

Former students from Years 1-3 who graduated with a MS Engineering (Coastal Engineering concentration) degree numbered five (two female and two male African American and one Caucasian) and four of the five are employed in the greater homeland security enterprise (two are employed by the US Army Corps of Engineers, two by private industry and we have lost contact with the fifth. Five other former students advised who enrolled in core coastal engineering concentration courses are in academia as post docs (4 Asian PhD) related to the HSE, and a fifth (Asian PhD) is employed by TXDOT specifically to assist during hurricane evacuations. Approximately four additional MS graduates (3 male and 1 female African Americans) are employed in HSE related positions and two were enrolled in homeland security graduate level programs related to resilience during year four.

5. Project Impact:

This project impacted workforce capabilities during year four by graduating an additional MS (coastal engineering concentration student), as scheduled, that was a working professional in

private industry. She was African American. It also added two PhD Engineering graduates, who enrolled in coastal engineering courses, to the greater homeland security academic\ enterprise in post-doctoral teaching and research positions. Two additional MS Engineering graduate students completed a year of graduate studies and are scheduled to graduate in May 2020 (one African American and one Caucasian). Additional, two graduate students were recruited to begin Coastal Engineering concentration studies in Fall 2019. Courses are revised every time taught by adding relevant new literature content. Most commonly from publications in the International Conferences on Coastal Engineering (ICCE), Journal of Coastal Engineering and the ASCE Coastal, Oceans, Ports and Rivers Institute journal. It is a responsibility of all faculty professors to update course content each time taught.

6. Institutionalization:

This education was formally institutionalized by Jackson State University during Year 3 when the PhD Engineering (Coastal Engineering concentration was approved for award and publication in the graduate catalog. This approval was contained in the Year 3 Annual Report last year. This approval makes the students eligible to compete for graduate assistantship awarded by the universities. The degree program is offered in the Department of Civil and Environmental Engineering where the MS Engineering (Coastal Engineering concentration degree) is housed. The Education Partnership Agreement (EPA) with the U.S. Army Corps of Engineers Engineer Research and Development Center is expected to continue. The EPA facilitates joint research projects with ERDC, facilitates ERDC researchers to teach mutually agreeable graduate courses and facilitates use and or loan of research equipment. The PI led the institutionalization of the PhD program with direct involvement of the Department Chair, Department Curriculum Committees, Associate Dean, College of Science, Engineering, and Technology (CSET); the College Curriculum Committee, the Dean CSET, University Curriculum Committee and the Provost and Vice President for Academic Affairs.

7. Interactions with research projects:

Year four interactions with research projects were focused mostly on research projects of the JSU CRC group out of necessity. Two of the three active PhD students passed their Qualifying Examinations during year four and are now PhD Candidates, they are both completely involved with their dissertation research and are unable to participate in SUMREX which is more appropriate for undergraduate and early MS students. The third active PhD student is preparing to take her PhD Qualifying Examination near the end of July. Of three active MS students, one is a full time working professional that cannot participate in SUMREX experience, a second is on a summer tour with the Olympic baseball team and the third is a part time working professional who is enrolled in a three semester hour Independent Research course to participate in The Netherlands research experience as part of our research subcontract from Texas A&M University at Galveston. JSU is a partner in their NSF Partnership for International Research and Education (PIRE) entitled Coastal Flood Risk Reduction. The PIRE student group made their two-week research trip to The Netherlands during the last two weeks of May. One of our PhD students spent two weeks during July 2018 collaborating on research with a TAMUG professor who accompanied her on The Netherlands research experience during 2018. The other PhD student attended the ADCIRC users group meeting held at ERDC this year. He is a knowledgeable ADCIRC user and it is an integral part of his dissertation research. This keeps

him abreast of the latest advancements to the ADCIRC Modeling System. ERDC researchers gave a lecture in each of my two courses during the year (one fall, one spring).

Year four was a highly productive year for our graduate students relative to interactions with some of the most outstanding coastal engineering researchers worldwide (Delft Technical University, The Netherlands; Texas A&M University, Galveston; Rice University; Texas A&M University, College Station and the Engineer Research and Development Center).

8. Publications:

An updated list of publications appears below. The first two were published during Year 4 and another publication has been accepted (not listed) for Year 5 at the 11th Texas Hurricane Conference.

- **Whalin, Robert W**., "A PhD in Engineering Degree: Coastal Engineering Emphasis Area," Proceedings, 126th ASEE Conference, Tampa Bay, FL, June 2019.
- **Ebersole, Bruce; Richardson, Thomas W.; Whalin, Robert W.,** "Suppression of Hurricane Surge Forerunner and Peak Surge in Galveston and West Bays Achieved with a Western Segment of the Coastal Spine," 10th Texas Hurricane Conference, University of Houston, Houston, TX; Aug. 3, 2018.
- "NSF-PIRE, Coastal Flood Risk Reduction Program, Authentic Learning and Transformative Education", Volume 1-2015-2017; Edited by Baukje "Bee" Kothius, Yoonjeong Lee and Samuel Brody, March 2018.
- **Ebersole, Bruce; Richardson, Thomas**; and **Whalin, Robert, W.**, "Surge Suppression Achieved by Different Coastal Spine (Ike Dike) Alignments", 9th Texas Hurricane Conference, University of Houston, August 4, 2017, Houston, TX.
- **Whalin RW**, Pang Q, Latham J, Lowe LN. Assessment of a Summer Bridge Program: Seven Years and Counting, 2017 ASEE National Conference Proceedings, Columbus, OH, June 24-28, 2017.
- **Whalin RW**. HBCU Engineering Faculty and Graduates: Implications for Race, Retention and Graduation Linkages, NAAAS & Affiliates 2016 National Conference Proceedings, Baton Rouge, LA, published Oct. 2016.
- **Whalin RW**, Brody SD, and Merrell WJ. The Galveston Bay Region as an International Test Bed for Flood Risk Reduction, 8th Texas Hurricane Conference, University of Houston, Houston, TX, August 5, 2016.
- **Ebersole B, Richardson TW**, and **Whalin RW**. Modeling Coastal Storms: Past, Present and Future, 8th Texas Hurricane Conference, University of Houston, Houston, TX, August 5, 2016
- **Whalin, Robert, W.; Pagan-Trinidad, Ismael**; Villanueva, Evelyn; and Pittman, David, W., "A Quarter Century of Resounding Success for a University/Federal Laboratory Partnership", ASEE 123rd Annual Conference and Exposition, New Orleans, LA, June 26, 2016.

9. Year 4 Education Activities and Milestone Achievements:

Year 4 Education Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Education Activities	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Enroll students in Coastal Engineering concentration of MS and PhD Engineering Degree Program	Continuous	100%	---
Advise MS/PhD Coastal Engineering concentration students. PI is the advisor, Records, including course enrollment and graduation information, are kept by PI.	Continuous	100%	---
Schedule PhD Qualifying Exam	Continuous	100%	---
Administer PhD Qualifying Exam	Continuous	100%	---
Education Milestones		100%	---
Enroll at least two students in Coastal Engineering concentration of PhD Engineering degree program	6/30/2019	100%	---
Schedule 1 or 2 PhD Qualifying Exams (Coastal Engineering concentration)	1/30/2019	100%	---
Administer 1 or 2 PhD Qualifying Exams (Coastal Engineering concentration)	6/30/2019	100%	---
At least one student complete minimum required PhD courses (non-research) in the Coastal Engineering concentration	6/30/2019	100%	---
Award at least one MS Engineering Degree with a Coastal Engineering concentration and track plans post-graduation.	5/30/2019	100%	---

10. Year 4 Transition Activities and Milestone Achievements:

Year 4 Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Coordinate inclusion of Approved Coastal Engineering concentration for PhD Engineering Degree in JSU Graduate Catalog	12/2018	100%	---
Advise MS and PhD Coastal Engineering Concentration students. PI is the primary advisor for Coastal Engineering Concentration students and maintains records.	Continuous	Continuous	---
Transition Milestone			
JSU online Graduate Catalog contains PhD Engineering degree (Coastal Engineering concentration)	12/2018	100%	---
Award at least one MS Engineering degree (Coastal Engineering concentration) and track placement post-graduation.	5/2019	100%	---

11. Tables:

The following Tables enumerate core courses and elective courses taught through Year 4, their enrollment and performance metrics.

Core Courses (Coastal Engineering Concentration)	
CIV 520	Advanced Engineering Analysis
CIV 538	Coastal Structure
CIV 539	Advanced Coastal Engineering Design
CIV 631	Linear Theory of Ocean Waves
CIV 632	Tides and Long Waves
CIV 636	Spectral Wave Analysis
CIV 637	Advanced Design for Breakwater Rehabilitation
CIV 698	Independent Study (4 Separate Courses)
CIV 899	Dissertation Research

Elective Courses	
CIV 535	Pavement Design
CIV 542	Advanced Design of Concrete Structures
CIV 544	Advanced Design of Steel Structures
CIV 544	Advanced Design of Hydraulic Structures
CIV 550	Engineering Hydrology
CIV 561	Chemistry for Environmental Engineering
CIV 567	Environmental Remediation
CIV 568	Land Disposal of Waste
CIV 574	Engineering Hydrogeology
CIV 640	Finite Element Method
CIV 642	Pre-Stressed Concrete Design
CIV 661	Biological Processes in Wastewater Engineering
CIV 675	Earth Dams and Slopes
CIV 899	Dissertation Research

"PhD in Engineering (Coastal Engineering and Computational Engineering) at an HBCU" Core and Elective Courses					
#CIV631	Course Title: Linear Theory of Ocean Waves	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	--	--
	Offering: Elective (E), Concentration (C), Minor (M)	C	C	--	--
	Number of Students Enrolled	6	5	--	--
#CIV637	Course Title: Advanced Design for Breakwater Rehabilitation	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	--	T	--
	Offering: Elective (E), Concentration (C), Minor (M)	C	--	C	--
	Number of Students Enrolled	3	--	7	--
#CIV642	Course Title: Pre-Stressed Concrete Design	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	--	--	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	E	--	--	E
	Number of Students Enrolled	4	--	--	5
#CIV698	Course Title: Independent Study (4 separate courses)	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T/R (4 courses)	T/R (4 courses)	T/R (3 courses)	T/R (1 course)
	Offering: Elective (E), Concentration (C), Minor (M)	C	C	C	C
	Number of Students Enrolled	1 each	1 each	1 each	1 each
#CIV538	Course title: Coastal Structures	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	--	T	--	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	--	C	--	C
	Number of Students Enrolled	--	6	--	8
#CIV636	Course title: Spectral Wave Analysis	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	--	T	T/R	--
	Offering: Elective (E), Concentration (C), Minor (M)	--	C	C	--
	Number of Students Enrolled	--	5	5	--
#CIV539	Course title: Advanced Coastal Engineering Design	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	--	T	--	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	--	C	--	C
	Number of Students Enrolled	--	6	--	7
#CIV520	Course title: Advanced Engineering Analysis	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	--	T	T/R	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	--	C	C	C
	Number of Students Enrolled	--	9	4	7
#CIV535	Course Title: Pavement Design	YR 1	YR 2	YR 3	YR 4

	Status: Developed (D), Revised (R), and/or Taught (T)	-	T	-	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	-	E	-	E
	Number of Students Enrolled	-	8	-	8
#CIV542	Course Title: Advanced Design of Concrete Structures	YR 1	YR 2	YR3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	T	--	--
	Offering: Elective (E), Concentration (C), Minor (M)	-	E	-	--
	Number of Students Enrolled	-	9	-	--
CIV544	Course Title: Advanced Design of Steel Structures	YR 1	YR 2	YR 3	YR4
	Status: Developed (D), Revised (R), and/or Taught (T)		T	--	T
	Offering: Elective (E), Concentration (C), Minor (M)	-	E	--	E
	Number of Students Enrolled	-	8	--	6
CIV544	Course Title: Advanced Design of Hydraulic Structures	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	T	-	T
	Offering: Elective (E), Concentration (C), Minor (M)	-	E	-	E
	Number of Students Enrolled	-	9	-	5
CIV632	Course Title: Tides and Long Waves	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	T/R	-
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	C	-
	Number of Students Enrolled	-	-	10	-
CIV550	Course Title: Engineering Hydrology	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	T	-
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	E	-
	Number of Students Enrolled	-	-	10	-
CIV661	Course Title: Biological Processes in Wastewater Engineering	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	T	T
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	E	E
	Number of Students Enrolled	-	-	9	6
CIV561	Course Title: Chemistry for Environmental Engineering	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	T	-
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	E	-
	Number of Students Enrolled	-	-	6	-
CIV567	Course Title: Environmental Remediation	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	T	-
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	E	-
	Number of Students Enrolled	-	-	7	-

CIV675	Course Title: Earth Dams and Slopes	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	T	-
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	E	-
	Number of Students Enrolled	-	-	9	-
CIV568	Course Title: Land Disposal of Waste	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	-	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	-	E
	Number of Students Enrolled	-	-	-	7
CIV574	Course Title: Engineering Hydrogeology	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	-	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	-	E
	Number of Students Enrolled	-	-	-	8
CIV640	Course Title: Finite Element Method	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	T	-	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	-	E	-	E
	Number of Students Enrolled	-	6	-	7
CIV681	Course Title: Excavation Support Systems and Retaining Structures	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	-	T
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	-	E
	Number of Students Enrolled	-	-	-	6
CIV899	Course Title: Dissertation Research	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	-	T/R
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	-	C
	Number of Students Enrolled	-	-	-	1
TOTALS		**17**	**69**	**70**	**82**

Table: Performance Metrics:

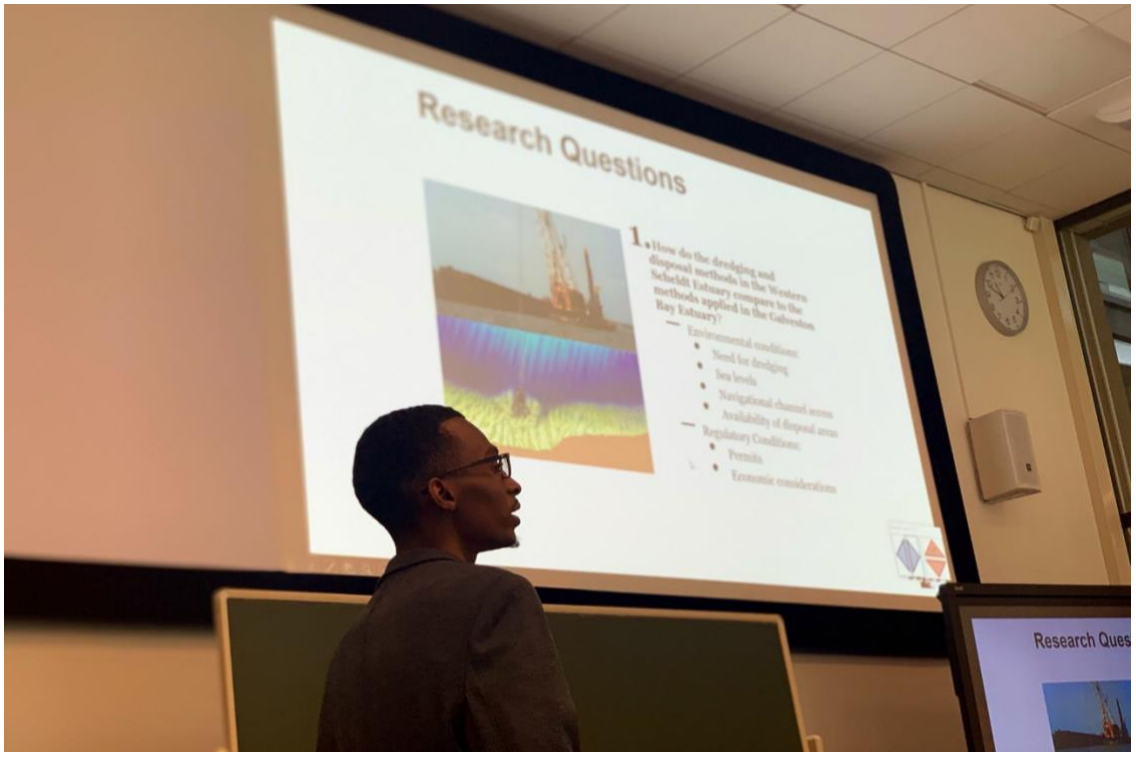
WHALIN: Performance Metrics

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)	5	4	3	3
Undergraduates provided tuition/fee support (number)	1	0	0	0
Undergraduate students provided stipends (number)	0	0	0	0
Graduate students provided tuition/fee support (number)	4	7	10	4
Graduate students provided stipends (number)	2	6	6	3
Undergraduates who received HS-related degrees (number)	2	3	3	3
Graduate students who received HS-related degrees (number)	0	4	4	5
Certificates awarded (number)	0	0	0	0
Graduates who obtained HS-related employment (number)	1	2	3	4
Lectures/presentations/seminars at Center partners (number)	1	1	1	1
DHS MSI Summer Research Teams hosted (number)	0	0	0	0
Journal articles submitted (number) (includes peer reviewed conference proceeding)	2	0	0	0
Journal articles published (number) (includes peer reviewed conference proceeding)	2	4	0	0
Conference presentations made (number)	2	4	3	2
Other presentations, interviews, etc. (number)	5	3	5	3
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies (number)	0	4	2	2
Requests for assistance/advice from other agencies or governments (number)	0	3	2	2
Dollar amount of external funding			$941,825 (YRs 1-3)	$424,854 Year 4
Total milestones for reporting period (number)	3	4	3	7
Accomplished fully (number)	2	3	3	7
Accomplished partially (number)	1	0	0	0
Not accomplished (number)	0	1	0	0

US students (14) on 2019 PIRE trip

JSU student & colleague at Netherlands Flood Control Structure

Western Scheldt Case Study Team



Mr. Akil Mohammad: Making Research Presentation in Netherlands

Half US PIRE Team on the North Sea

FAIK, JCSU
DHS COASTAL RESILIENCE CENTER
EDUCATION PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Preparing Tomorrow's Minority Task Force in Coastal Resilience through Interdisciplinary Education, Research, and Curriculum Development.

Principal Investigator Name/Institution:
PI, Dr. Ahmed Faik, Chair and Assistant Professor of the Department of Computer Science and Engineering Johnson C. Smith University

Other Partners/Institutions:
UNC-Chapel Hill, UNC-Charlotte, and Jackson State University (major partners)

Short Project Description

We focus on the integrative, interdisciplinary nature of real-world problems and strive to bridge traditional academic programs to develop solutions to coastal resilience and its related problems facing our nation. This project sustains an undergraduate education framework to prepare tomorrow's minority task force in coastal resilience (approximately 80% of JCSU students are minorities) by presenting tailored courses in coastal resilience, applied research experience, knowledge transfer activities, scientific seminars, and summer camps. The project is housed in the Department of Computer Science and Engineering of STEM College at JCSU, but collaborates across departments and programs. Project-supported courses are designed to introduce engineering, data analytics, natural science and social science topics to better understand coastal resilience. These courses are classified as "Integrated Studies, Global Studies, and Emergent Fields" general education electives, which students from all majors can take to fulfill the general education requirements. The summer camp, seminar and undergraduate research projects are also powerful tools for engaging all students and all disciplines in addressing coastal resilience issues.

1. Introduction and project overview:

Given the national need to prepare future coastal resilience professionals with educational and research experience, this proposed program supports a critical mission. Most existing coastal resilience related curriculum currently either targets graduate programs or vocational education. We developed an undergraduate education framework that meets the needs and standards for excellence in undergraduate education.

The project was designed around the following aims:

1) **Goal 1**: Develop a curriculum to prepare undergraduate students for careers in coastal resilience;
2) **Goal 2**: Create partnerships to conduct applied research in the area of coastal resilience;

3) **Goal 3**: Create ongoing opportunities for the transfer of skills, knowledge, people and ideas between JCSU and the community at large.

To help reach the above-mentioned goals, we defined the following processes:

1) **Process 1**: Develop four new courses to educate students with demonstrated interests and aptitudes in coastal resilience study;
2) **Process 2**: Design and deploy interdisciplinary coastal resilience seminar series;
3) **Process 3**: Establish and develop Faculty/Student research collaborations in coastal resilience;
4) **Process 4**: Design and offer a 1-week summer research camp to expose and increase the awareness of undergraduate students in coastal resilience study.
5) **Process 5**: Design and offer a 4-week summer research project to expose and increase the awareness of undergraduate students in coastal resilience study.

2. End users:

In the Spring of 2019 four faculty members conducted four separate DHS CRC related research projects.

Spring 2019 – Project 1

Student researchers: 4

Project title: "Data preparation for big data analysis and literature review on Infectious Disease Outbreaks following Natural Disasters."

Project description: This project is a follow-up of a research that was initiated last year that aimed to discover infectious disease outbreaks following natural disasters in the US 2014-2018. Data was analyzed and visualized in Tableau using data from the National Oceanic and Atmospheric Administration and the Center for Disease Control and Prevention. The data suggests that sexually transmitted, person to person, tick borne, waterborne and food borne infections increased in number of reported cases following a storm event. A main challenge in this project was manage a big data set, including identifying, retrieve and selecting data from big data sets and maintain responsive programs. The Spring project addresses creation of a workflow to program the download and prepare the data for analysis. Alteryx was used to download data from the Socrata API, exclude irrelevant data and prepare data for analysis. As our initial analysis was limited to data 2014-2018, only few clusters of outbreaks and natural disaster correlations were identified. In the current project we aimed at preparing data from 1998-2019 to be able to generate hypothesis about outbreaks and natural disasters. To verify that our method identified known events of natural disasters causing disease outbreaks we completed a comprehensive literature review to identify scientific papers describing natural disasters and diseases outbreaks correlations.

The DHS grant has provided the opportunity for four JCSU undergraduate students to participate in an internationally competitive research project that can have implications on disaster response policy. They have learnt essential skills to complete their SIP and for future research endeavors, including literature searches, reading scientific literature, data preparation and data visualization. The data visualizations and analysis have identified disease outbreaks which needs to be further investigated so their response can be incorporated in natural disaster emergency response plans. The data preparation workflow for big data sets created in this project can be used as a basis for

courses and projects in biology and computer science, which will improve quality and currency of education and research at the university. I will incorporate it in a the senior paper courses that I teach. I plan to apply for funding both to improve the research course offerings as well as the research environment at the university as well as to work on data analysis of the collected data.

Spring 2019 – Project 2

Student researchers: 3

Project title: “Environmental monitoring using wireless sensors network

Project description: 2018 was the most destructive year for wildfires in recent history and research indicates it will only continue to get worse. In California alone it was estimated that it would take 3 billion for cleanup – 1.3 billion more than in 2017. In late 2018, over 19,000 houses and business were lost to the massive fires that plagued both southern and northern California. Not only are wildfires dangerous to an individual, but they can be also costly – as wildfires become more prevalent insurers are will either increase prices or be less likely to payout in an event of a wildfire. The continued increase in global temperatures will lead to wildfires last longer, burn more acres and have more extreme fire behavior. The purpose of this research is to introduce a proactive monitoring solution that will mitigate the impact of wildfires by providing predictive models that determine areas of high risk. The data collected in this project will consist of moisture, humidity, and temperature with which areas of high risk will be determined. The use of real time data and predictive models will allow time to plant preventative measures, faster response time and real time monitoring. Environmental monitoring is required to protect the public and the environment from toxic contaminants and pathogens that can be released into a variety of media including air, soil, and water. Air pollutants include sulfur dioxide, carbon monoxide, nitrogen dioxide, and volatile organic compounds, which originate from sources such as vehicle emissions, power plants, refineries, and industrial and laboratory processes. Soil and water contaminants can be classified as microbiological (e.g., coliform), radioactive (e.g., tritium), inorganic (e.g., arsenic), synthetic organic (e.g., pesticides), and volatile organic compounds (e.g., benzene). Pesticide and herbicides are applied directly to plants and soils, and incidental releases of other contaminants can originate from spills, leaking pipes, underground storage tanks, waste dumps, and waste repositories. Some of these contaminants can persist for many years and migrate through large regions of soil until they reach water resources, where they may present an ecological or human-health threat. 2. ARCHITECTURE There is one small computing device called the raspberry pie 3 generation device which is a small version of a computer central processing unit. This unit has in-built sensors which can be programmed in python 3.7.2 version to work wirelessly to communicate and transport wireless messages and data across the communication channel. There are three in-built sensors - moisture measuring sensors, temperature measuring sensors and humidity sensors. The console in sublime has been programmed in such a way that it can display the current measurements values for the soil of a specific location which is extremely important because these data are very much spatial-correlated. We used one laptop where this programming interface is working continuously 24*7 for few days irrespective of the weather. Due to severe changes in regular climate at the location where this experiment has been executed. Changes in weather has left significant changes in the data receiving by these sensors and these kinds of changing data are very much helpful to build a prediction-based model which we plan to build as a continuation of this research study

Spring 2019 – Project 3

Student researchers: 3

Project title: “Data-driven Resilience and Community Disaster Mitigation.”

Project description: I held weekly research meetings with the student researchers to carry out the project implementation. First, I directed them to relevant literature about community disaster mitigation through the use of social media. Social media for disaster mitigation is especially relevant among traditional college students or those between the ages of 18 – 21. Most institutions have a crisis communication plan that includes a mix of SMS messaging, emails and automatic phone calls. However, when an emergency occurs on campus, it makes sense to also send the alert out via social media. So, we discussed the importance of using this platform for disaster management analysis, particularly among college students.

Next, I led the students through the application process to become a Twitter Developer so they could build a Twitter app to analyze disaster community tweets. All new developers must apply for a developer account to access Twitter APIs. Once approved, developers can begin to use Twitter’s standard APIs, which were needed to carry out the project activities. I taught students how to use the Twitter Developer interface and GitHub to store and manage their code. The developer portal is a self-serve user interface within developer.twitter.com where developers can manage their API access and Twitter apps. The developer portal is visible with a logged in context to developer.twitter.com and an approved developer account. Students learned to access the developer portal by clicking on the 'Dashboard' link or the @handle dropdown navigation panel in the top right-hand corner of developer.twitter.com. Also, I instructed them on how to register for a GitHub account. GitHub is a free web-based hosting service for version control using Git and is mostly used for computer code. I helped students use their GitHub website on the Twitter developer portal to create a new Twitter Application and get associated API keys and tokens.

Once the students were set up as Twitter developers, I showed them how to download and install the Anaconda distribution of Python. Anaconda is a free and open-source distribution of the Python and R programming languages for scientific computing. With Python, the students and I made a Twitter application using scripts to extract tweets from two disaster management organizations, FEMA Region 4 and Samaritan’s Purse. I showed the students how to understand a Tweet Object, and extract data from a Tweet object using Python. I showed them how to use attributes such as created at, id, text, and user.

To complete the project, I showed the students how to use sentiment analysis to assess the extracted tweets from their chosen disaster management organization. We discussed how this is made possible through Natural Language Processing (NLP). NLP is an area of growing attention due to increasing number of applications like chatbots and machine translation. In some ways, the entire revolution of intelligent machines in based on the ability to understand and interact with humans. After the tweets were extracted and stored into a CSV file, the students and I used two Python packages to measure the overall sentiment of the tweets over the last several hours and then across specific times such as during recent hurricanes. The example we used was Hurricane Florence, which hit North Carolina August 31, 2018 – September 19, 2018. Using both the Twitter application, Python, and the sentiment analysis packages, students learned how

disaster management groups could make data-driven decisions to help mitigate community disasters.

Lastly, I introduced students to several additional research opportunities where I verified that one submitted an application to graduate school and another submitted an application to complete two summer undergraduate research projects doing similar tasks. I reviewed, edited, and helped revise their project summaries at the conclusion of the research project.

Spring 2019 – Project 4

Student researchers: 4

Project title: National disasters Preparedness in NY City and Charlotte NC

Project description: Students in this research evaluated the preparedness of residents in New York City and Charlotte, NC. The coast in general is threatened by competing demands due to the diversity of resources. For example, New York's coastal area is unique as it contains a variety of natural, recreational, commercial, cultural, and energy resources of local, statewide, regional and national significance. Data for this research was collected by the students from a revised survey that asked questions of respondent's preparedness and mitigation plan, also the survey include questions such as age, lifestyle, income, own or rent and soon, the survey consists of 37 questions including six different disasters.

- Students used Data Mining for Exploration & analysis of data to discover meaningful patterns.
- Students use Data Mining analysis to test the relationship between factors such as education, gender, age, income.
- Analyze and find the natural disasters experienced in a lifetime and the number of years lived in a location and actual natural hazards to the preparedness level in the event of a natural disaster.

In the Summer of 2019 one faculty members guided 25 students through a 1-week intensive DHS CRC related research project.

Summer 2019 – 1-week Project

Student researchers: 25

Project title: Students are to define a problem, get some data analyze it and propose solutions using Tableau.

Project description: Students are divided to 5 groups each group consists of 5 students. Dr. Amin is helping the students how to search and find data about a natural disaster of their choice. Then they have to collect the data, clean the data and put it in the right format to be analyzed. Dr. Amin is introducing to the students Tableau software. For most of the students it was the first time to work with Tableau software, it was a challenge.
In this short period of time each group of students is learning the Tableau software and managing to work on a project on a natural disaster and analyze the data using. Each group of students also is preparing a report of at least10 pages about the project and a power point presentation. On the 5th day each group is presenting to STEM faculties.

These are the titles for the 5 groups.
Group 1: Comparing flood damage between states on an economic level
Group 2: Purchasing Insurance Coverage for your Property Based on the Prevalence of Major Disasters in Coastal States.
Group 3: Categorization and Preparation of Wildfires by states within the US
Group 4: Comparing global geographical earthquakes based on magnitude, damage, cost, and fatalities.
Group 5: Analyzing destruction of hurricanes in the United States with emphasis on comparing hurricane Harvey and Katrina's wind speed, pressure, and rainfall to determine the correlation between these variables and mortality rates.

In addition, during the Summer of 2019 three faculty members guided students through a 4-week intensive DHS CRC related research projects.

Summer 2019 – 4-week Project 1

Student researchers: 4

Project title: Building TORNADO Resilient Communities

Project description: Often, Tornadoes are treated with a great deal of mythos and can commonly be thought of as being as somewhat unpredictable. The research is invested in ascertaining what conditions and metrics, that are readily accessible to the public; should be analyzed in order to prepare for tornadoes, more accurately predict their outcomes, and subsequently build resilient communities. In addition, what emphasis and resources should be allocated based on a tornado's corresponding Fujita rating.

Our research was focused on Florida, Iowa, Colorado, Nebraska, Missouri, Texas, Oklahoma, Kansas, Illinois, and Alabama. We used the data mining techniques decision tree and linear discriminant analysis. Our sources were tornadohistoryproject.com, USA.com, and the USDA Forest Service. The research findings suggest that although the majority of the general public's attention is focused on catastrophic tornadoes; weaker storms over time may actually culminate in more losses.

Summer 2019 – 4-week Project 2

Student researchers: 4

Project title: Build a Practical Contraflow Model for Natural Disasters Evacuation Plans Using Fuzzy Inference System

Project description: Emergency evacuation is the immediate and urgent movement of people away from the threat or affected area of the occurrence or in this case a natural disaster. These evacuations may be carried out before or after the natural disasters such as hurricanes, floods and earthquakes etc. Emergency evacuating planning is an intricate part in evacuating people. These plans are developed to ensure the safest and most efficient evacuation time of all expected residents of a city or region. Proper planning involves the use of contraflow lanes in addition to special technologies to ensure full, fast and complete evacuation. A contraflow control lane is an emerging and developing tool that may be used to improve evacuation traffic capacity.

In this summer project, students will design, develop and build a contraflow control system with MATLAB Fuzzy Logic Toolbox (Type-1 and Interval Type-2) to provide a practical evacuation

plan model for decision makers to effectively and efficiently perform evacuation process via national highways prior the disasters coming.

The project's procedures and outcomes can be summarized as:

1. Familiar students with a powerful tool, MATLAB Fuzzy Logic Toolbox with 8 projects.
2. Design and build a contraflow system model with MATLAB Fuzzy Logic Toolbox GUI App (Type-1).
3. Develop and build a contraflow system evacuation model with MATLAB Fuzzy Logic Toolbox functions (Type-1).
4. Familiar students with Interval Type-2 Fuzzy Inference System (IT2FIS) and its related Toolbox as well as related functions.
5. Design and build a contraflow control system model with IT2FIS

The final products of this project also include:

1) Final Project Report
2) Final MS PPT Presentations
3) Final Project Poster

Summer 2019 – 4-week Project 3

Student researchers: 4

Project title: DHS Coastal Resilience Infectious Disease Outbreaks following Natural Disasters in the US 2014-2019

Project description: This project aimed to discover infectious disease outbreaks following natural disasters. Data from the National Oceanic and Atmospheric Administration and the Center for Disease Control and Prevention was used to highlight outbreaks occurring in the United States after natural disasters. Definitions for natural disasters and disease outbreaks where created based on previous studies. By analyzing the data to find events that correlated between similar time and location, according to the definitions, clusters of data points were collected. The data suggests that sexually transmitted, person to person, tick borne, waterborne and food borne infections increased in number of reported cases following a natural disaster. The study identified outbreaks of specific diseases which differed from the Center for Disease Control and Prevention's list of possible outbreaks following a natural disaster, such as Gonorrhea, Campylobacteriosis, Invasive Pneumococcal disease, Salmonellosis and Pertussis.

Floods has been linked to water-related infectious diseases, for example diarrhea, due to water contamination and damage to water systems, as wells as increasing endemic vector-borne diseases. Evidence of a relationship between storm-related events and infections mainly comes from large-scale disasters. In 2005, Louisiana and Mississippi experienced an increase in West Nile neuroinvasive disease after Hurricane Katrina, which was a category three storm. Here the objective was to identify infectious disease outbreaks following storm events of different magnitudes in the United States. Data of storm events and other significant weather phenomena was combined with weekly number of cases of infectious diseases. The Storm Events Database from the National Oceanic and Atmospheric Administration and the National Notifiable Diseases Surveillance System from the Center for Disease Control and Prevention were mined for patterns. Data sets were prepared using Alteryx and data analysis and visualizations were

performed using Tableau. Data from all states from 2014 to April 2019 were included. Here a natural disaster was defined as a storm event or weather phenomena that causes property damage over $500,000. An outbreak was defined as an occurrence of an infectious disease with at least five cases per week and the current week number of cases at least 100% higher than the average number of cases from the four previous weeks. By mining the data to find events that correlated in time and space, clusters of data points were collected. Preliminary analysis suggests that sexually transmitted, vector borne, water borne, and food borne infections increased following storm events. Impact of climate, income level and vaccination coverage on natural disasters and infectious disease outbreaks was investigated .

The DHS grant has provided the opportunity for four JCSU undergraduate students to participate in an internationally competitive research project that can have implications on disaster response policy. They have learnt essential skills to complete their senior paper and for future research endeavors, including literature searches, reading scientific literature, data analysis and data visualization. The data visualizations and analysis have identified disease outbreaks which needs to be further investigated so their response can be incorporated in natural disaster emergency response plans. The Alteryx data management software and the Tableau data visualizations created in this project can be used as a basis for courses and projects in biology and computer science, which will improve quality and currency of education and research at the university. I will incorporate Tableau in a new course in research methods with a focus on data analytics where real data will be used for course projects. I plan to apply for funding both to improve the research course offerings as well as the research environment at the university as well as to work on data analysis of the collected data.

3. Unanticipated Problems:

We did not manage to get any faculty from other collaborating institutions in our work-plan due to conflict in time and schedule. The conflict was discussed with the End users and in our next academic year we intend to plan far enough ahead of time to avoid any conflicts.

We could not track some of our graduating students. We have plans to establish Linkedin and Facebook as well as other social media accounts for the department, through which we can stay in touch with our graduating students. We also plan to work with the Institutional Planning, Assessment, Effectiveness and Research office at our university to follow up with students who have graduated in the past. In addition, we will contact CRC to identify mechanisms others have used to determine post-graduate employment/education.

4. Students and recent graduates:

- 1 student applied for graduate studies at Coastal Carolina University in the field of disaster management.
- 3 students applied for Research Experiences for Undergraduates at Coastal Carolina University.

5. Project Impact:

The courses incorporated cybersecurity, data mining, machine learning, ArcGIS and bioinformatics.

6. Institutionalization:

Sources of post-CRC support established:

S/F	Agency Name	Project Name/ Project Director	Grant Life	Original Award Date	Total Amount Awarded FY 18	Indirect Cost
F	National Science Foundation NSF: HBCU-UP	**(HBCU-UP) Historically Black Colleges and Universities Undergraduate Program - "Developing a Minor in Data Science at JCSU" Dr. Felesia Stukes**	August 1, 2018 - July 30, 2019	8/1/2018	$149,466.00	$37,650.00
F	ED- Department of Education	**(MSIEP) Minority Science and Engineering Improvement Program Grant Dr. Sabina Otienoburu**	October 1, 2018 - September 30, 2019	10/1/2017	$77,937.00	$4,681.00
F	Department of Homeland Security	**Sub-Contract with UNC-CH- Coastal Resilience Center of Excellence- Research Lead Dr. Ahmed Faik**	July 1, 2018 - June 30, 2019	7/1/2018	$90,000.00	$3,194.00
Other	Oxford University	**Worldwide Antimalarial Drug Resistance Network (The WWARN Project) Dr. Sabina Otienoburu**	August 1, 2018 - December 31, 2018	8/1/2018	$5,000.00	$0.00
Other	Oxford University	**Worldwide Antimalarial Drug Resistance Network (The Second WWARN Project) Dr. Sabina Otienoburu**	May 28, 2019 - December 31, 2019	05/28/2019	$18,159.00	$1,287.00
F	ED- Department of Education	**(MSIEP) Minority Science and Engineering Improvement Program Grant Dr. Suryadip Chakraborty**	October 1, 2018 - September 30, 2019	10/1/2018	$245,475.00	$14,979.00
F	NSF / UNCC	**"UNC Charlotte Intelligence Community Center of Academic Excellence" Amin Awatif, Bledsoe-Gardner**	09/2019-09/08/2024	06/2019	$ 195,651.00	$43,191.00
F	Department of Defense Research and Education Program for HBCUs and MSIs - Equipment/Instrumentation	**"Data Science Education and Sport: Equipping the DATA Bulls" Dr. Felesia Stukes**	4/30/2019 - 4/29/2020	06/21/2019	$173,837.00	$2,798.00
F	Department of Defense Research and Education	**"Intelligent Mobile Robot System for Designing and Implementing Nested Fuzzy Logic**	5/1/2019 - 4/30/2020	06/21/2019	$227,862.00	$13,339.00

	Program for HBCUs and MSIs - Equipment/Instrumentation	**Controllers to Reduce the Effects of Electromagnetic and Environmental Radiations on Military Robots and Manipulators" Dr. Ying Bai**				
TOTAL					987,736.00	77,928.00

Following CRC support, the project will be maintained in our STEM College. We have already added the two seminars (CSC210 Career Preparation Seminar I, and CSC211 Career Preparation Seminar II) to the curriculum and they are currently required from the students in all three of our majors.
The two courses "Risk Analysis and Management" (CSC430) and "Data Mining" (CSC432) have already been developed, taught and added to the department curriculum and the university catalogue.

The following two courses; "Introduction to Geographic Information System" and "Network Science", have been developed and taught in past semesters under generic computer science electives. They will be added to the university catalogue and the curriculum of the three majors in our department. The course "Introduction to Geographic Information System" is in the process of being added to the university catalogue as part of a new minor in our Computer Science and Engineering department.

Some of the faculty members of our Computer Science and Engineering department as well as one or two faculty members of the Natural Sciences and Mathematics (NSM) department will be involved in sustaining the project. Mostly the same faculty members who were involved in the project in the past year, plus one or two others

7. Interactions with research projects:

Fourteen of our students visited NCSU civil engineering department, which itself is one of the DHS CRC grant participants. Our students presented their findings from three different research projects. Faculty as well as several graduate students from NCSU presented their findings from their own research projects.

8. Publications:

- Ying Bai & **Hang Chen**, "Build an Optimal Evacuation Contraflow Model for Natural Disasters by Using Fuzzy Inference System", to be appeared on Proceedings of the 2018 IEEE International Conference on Fuzzy System, July 8-13, Rio de Janeiro, Brazil, 2018.
- Cody Byrd, Jean-Marie Nshimiyimana, Ehije Idehenre, **Hang Chen** (Faculty Advisor), "Data Analysis of Haiti's Resiliency Post-2010 Earthquake". Presented at the 2017

Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM).

- NyJae Dickerson, Adonis Tillman, Desmond Taylor, Awatif Amin (Faculty Advisor) "Using Data Mining to analyze Natural Disasters at 10 countries". Presented at the 2017 Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM).

9. Year 4 Education Activities and Milestone Achievements:

Education Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Education Activities	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Develop one new course on Network Science	12/31/2018	75%	It will be taught in the Spring 2020.
Host three seminars each semester. The seminars' presenters are participants in the CRC program. The topics they present are related to the CRC program. The students will benefit from the seminars		0%	due to conflict in time and schedule
Select eight students to conduct research projects, during the Spring semester. The students will be selected according to the courses the students are enrolled in, which are related to this program. The goal is to have the students apply the knowledge they gain from their courses on analyzing CRC data, and possibly present their findings in conferences and publications. 12 students were selected during the Spring 2019 semester and conducted research according to the courses the students were enrolled in.	2/28/2019	100%	
Design a one-week summer camp focused on Coastal Resilience for eight students. 25 students conducted and presented 5 different topics during the 1-week summer research camp.	6/30/2019	100%	
Select nine students and three faculty members to form the summer research teams, during the Summer session. Different students and different subjects will be covered from the Spring semester. 14 students conducted and presented 3 different research projects during the 4-week summer research camp.	6/30/2019	100%	
Education Milestones			

Approval of a new course by the College or Department	6/30/2019	100%	
Eight students complete the spring research course and research project. Students may be able to present the results of the project in conferences and STEM journals. 12 students were selected during the Spring 2019 semester and conducted research according to the courses the students were enrolled in.	6/1/2019	100%	
20 students complete the one-week summer camp. Students will be exposed to emergency management and CRC activities and apply their knowledge gained in the summer camp by using software tools to complete a project. 25 students conducted and presented 5 different topics during the 1-week summer research camp.	6/30/2019	100%	
Nine students and three faculty members complete four-week summer research projects. The end results are power point presentations and posters that can be presented in conferences. 14 students conducted and presented 3 different research projects during the 4-week summer research camp.	6/30/2019	100%	

10. Year 4 Transition Activities and Milestone Achievements:

Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Continued enrollment of students in developed courses and research projects. All of our STEM students are being targeted, which is around 250 students.	6/30/2019	100%	
Dissemination of the undergraduate education and research education framework and results. The results will be presented to practitioners in the field through conferences and publications. Other universities will benefit from the information.	6/30/2019	100%	
We established collaboration with research partners at other academic institution. Collaboration with companies are still in progress (red Ventures).	6/30/2019	50%	
Transition Milestone			

We will be targeting all 20 students, who will be participating in the summer research camp, for employment in the HS enterprise or continue to graduate studies. Our goal is to place at least two students in full-time positons in the HS enterprise and two students in graduate programs.	6/30/2019	100%	
Students will be required to present their findings in ERN (Emerging Research National) conference, STARS (Students Transitions Achievement Retention & Success), Tapia (ACM Richard Tapia Celebration of Diversity in Computing). We also plan to have some of the students' results published in peer-reviewed journals.	6/30/2019	0%	Conferences conflicted with the students' schedules.
Present at one to two conferences per year.	6/30/2019	0%	Planning to attend and present the DHS summit in July 2019

11. Tables:

Table 1: Annual Courses and Enrollments

FAIK: Annual Courses and Enrollments

Courses Developed and Taught by Johnson C Smith University under Project DHS CRC					
Course		YEAR			
Number	Title	YR 1	YR 2	YR 3	YR 4
CSC432	Course Title: Data Mining				
	Status: Developed (D); Revised (R); and/or Taught (T)	D, T	T	R, T	R, T
	Offering: Elective (E), Concentration (C), Minor (M)	E	E	E	E
	Number of students enrolled	12	8	10	10
CSE439 A	Course Title: Introduction to Geographic Information System (GIS)	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D); Revised (R); and/or Taught (T)	-	-	D, T	R, T
	Offering: Elective (E), Concentration (C), Minor (M)	-	-	E	E
	Number of students enrolled	-	-	10	10
CSE439 B	Course Title: Risk Analysis and Management	YR 1	YR 2	YR 3	YR4
	Status: Developed (D); Revised (R); and/or Taught (T)		D, T		
	Offering: Elective (E), Concentration (C), Minor (M)	E	E	E	E
	Number of students enrolled		10		
CSC210	Course Title: Career Prep I	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D); Revised (R); and/or Taught (T)		D	T	R, T
	Offering: Elective (E), Concentration (C), Minor (M)			C	C
	Number of students enrolled			16	30
CSC211	Course Title: Career Prep II	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D); Revised (R); and/or Taught (T)		D	T	R, T
	Offering: Elective (E), Concentration (C), Minor (M)			C	C
	Number of students enrolled			19	30
#	Course Title:	YR 1	YR 2	YR3	YR 4
	Status: Developed (D); Revised (R); and/or Taught (T)				
	Offering: Elective (E), Concentration (C), Minor (M)				
	Number of students enrolled				

Table 2: Performance Metrics

FAIK – JCSU-Performance Metrics

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17 – 6/30/18)	**Year 4** (7/1/18 – 6/30/19)
HS-related internships (number)	1	1	0	0
Undergraduates provided tuition/fee support (number)	0	0	0	0
Undergraduate students provided stipends (number)	37	47	40	51
Graduate students provided tuition/fee support (number)	0	0	0	0
Graduate students provided stipends (number)	0	0	0	0
Undergraduates who received HS-related degrees (number) Students who participated CBC Research	9	20	7	12
Graduate students who received HS-related degrees (number)	0	0	0	0
Certificates awarded (number)	0	0	0	0
Graduates who obtained HS-related employment (number)	3	0	0	0
Lectures/presentations/seminars at Center partners (number)	0	0	0	0
DHS MSI Summer Research Teams hosted (number)	0	0	0	0
Journal articles submitted (number)	1	1	1	0
Journal articles published (number)	0	0	1	11
Conference presentations made (number)	0	2	0	2
Other presentations, interviews, etc. (number)	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies (number)	0	0	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0	0	0
Dollar amount of external funding	$267,417	$887,917	$2,031,917	$987,736.00
Total milestones for reporting period (number)	7	6	0	7
Accomplished fully (number)	4	6	0	5
Accomplished partially (number)	3	0	0	0
Not accomplished (number)	0	0	0	2

LAIJU, TOUGALOO
DHS COASTAL RESILIENCE CENTER
EDUCATION PROJECT
YEAR 4PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Multidisciplinary Certificate: Disaster and Coastal Studies (DCS)

Principal Investigator Name/Institution:
Meherun Laiju, Ph.D.; Tougaloo College

Other Partners/Institutions:
Internal collaboration with Political Science, Psychology, Mass-Communications, Sociology Department, and Natural Science Division

Short Project Description ("elevator speech"):

Multidisciplinary Certificate: Disaster and Coastal Studies (DCS) is housed in the Sociology and Social Work Department in the Social Sciences Division at Tougaloo College, a Historically Black College (HBCU). One of the major goals of the certificate program is to diversify the Department of Homeland Security's (DHS) workforce. Other objectives included: a) train interested students in the field of disaster management for local emergency management agencies and graduate studies; and b) create neighborhood outreach training programs in collaboration with Mississippi Emergency Management Agency (MEMA) to facilitate resilient community building.

1. Introduction and project overview:

The education project, Multidisciplinary Certificate: Disaster Coastal Studies (DCS), addresses the acute underrepresentation of minorities in the Science, Technology, Engineering, and Mathematics areas (STEM). The project goal is to diversify the future DHS and S&T related workforce by training underrepresented minorities, mirroring some of the more vulnerable population impacted by disaster scenarios. The DCS curriculum allows students to develop skills and knowledge and provides an opportunity to be trained in multidisciplinary fields across academic divisions (Humanities, Natural Sciences, & Social Sciences). The curriculum helps create a pipeline of underrepresented minority students with multidisciplinary skills, incorporating a Social Science focus that is marketable in the field of disaster and emergency planning, management, response, and recovery. In addition to coursework that addresses the legal, social, and public health aspects of natural disasters, practical skills—such as student internships with emergency management agencies, Geographical Information System (GIS) training, and FEMA's Independent Study (IS) training—are incorporated into the coursework. The Project also provides students the opportunity to participate in faculty lead research in the field of community preparedness to enhance community resilience. Students present their research findings in the field of disaster preparedness and recovery at the annual, year-end symposium—attended by various stakeholders including students, faculty, staff, administration, project partners, homeland security related organizations, and community members.

Additionally, the pilot program neighborhood outreach initiative, in collaboration with MEMA, offered opportunities for community leaders and interested citizens to be trained as first responders. The neighborhood training initiative addresses Homeland Security's Post–Katrina Emergency Reform Act of 2006—building resilient communities as a part of national preparedness.

2. End users:

In year 4, we worked with Mississippi Emergency Management Agency (MEMA), American Red Cross, and Salvation Army. During Fall of 2018, Grant Director of MEMA Dr. George Humphrey, taught the DCS 320 Emergency Management course. The five students who were in DCS 400 Internship course were placed in MEMA, Red Cross, and Salvation Army. Local county management agency personal were invited to speak with DCS students, participate at Tougaloo College job fair, and attend the DCS Symposium.

Intern

Instructor DCS 320

Intern

3. Unanticipated Problems:

Year 4 is the first time I did not face any major unanticipated challenges.

4. Students and recent graduates:

Tougaloo College is a Historically Black undergraduate institution, 99% of the student body are African-American and full-time students. The Certificate program was launched in year four. Five students completed the certificate courses 3 females (graduated) and 2 males (Junior). One is currently working with Red Cross (volunteer) and 2 applied for graduate school.

DCS Faculty & Students with

5. Project Impact:

Interdisciplinary Minor Disaster Coastal Studies (DCS) was modified and changed into a multidisciplinary certificate program. In Fall 2018, the project commenced the multidisciplinary certificate Disaster Coastal Studies (DCS) program. The curriculum of the professional certificate incorporated the Interdisciplinary Minor (DCS) courses and courses from Humanities, Natural Sciences, and Social Sciences. The focus of this certificate program is to strengthen student careers in public safety, emergency management, community and research planning, and public-policy making. The goal of the certificate program is to create well-informed and socially-committed professionals able to use holistic, humane, and integrated strategies to mitigate the impact of disasters and support DHS efforts to build more resilient communities. The 12 credit hour multidisciplinary certificate in Disaster and Costal Studies (DCS) is open to degree seeking students across the institution's majors. The DCS certificate conforms to the mission and vision of Tougaloo College by emphasizing a multidisciplinary and policy-relevant approach to a major 21st century challenge that will also confer competitive career advantages to students. The certificate consists of four courses (12 credit hours) including 40 hours of practical internship experiences with local, state, federal agencies, or NGOs.

Curriculum of Certificate Program	
Core Courses	
Course Name	**Objective**
DCS/NSD 210 Introduction to Natural and Manmade Disasters	Basic Concepts and GIS Training
DCS 320 Emergency Preparedness and Response	Training as a first responder
DCS 400 Internship	Practical skills working in a Local Emergency Management Agency
Electives (Choose 1) Multidisciplinary	
Course Name	**Objective**
COP 211 Public Relations Writing	Develop writing & editing Skills along with incorporate media role in disaster management
POL 317 Public Policy and Legal Issues in Disaster Management	Understand Policy and Legal issues related to disaster
PSY 328 Health Psychology in Disaster Preparedness	Understand Health issues pertaining Disasters & Policy
SOC/SWK 331 Social Community Organization and Disaster Preparedness	Understand Organization and Community's Connectedness in Rescue and Management Policy

The multidisciplinary certificate curriculum included three DCS minor courses as core requirements and one elective course. The elective courses were adopted from participating departments. These departments modified one of their required electives to be part of the certificate program. The modified elective courses include content, assignments, and field experts as guest lecturer to address the natural disaster and building/strengthening community resilience. This curriculum also exposed students not pursuing the certificate become familiar with the field of natural disaster and resilience. Students who are pursuing the DCS certificate are guided by the instructor to conduct research in field of disaster resilience, publish, and attend national conferences to present the findings. Also, students who are pursuing the certificate shared their course related project at the DCS research Symposium (Program attached). The following are some examples of DCS certificate course content which highlights the incorporation of current literature, advances in the field, and technology:

- **POL 317 Public Policy and Legal Issues in Disaster Management:** Elective **c**ourse offered by Political Science Department and taught by Attorney Dennis Sweet who specializes in disaster management. The course presents concepts and basic

descriptive information about the public policy process in the executive and legislative branches of government and actions of the judicial branch in court cases that relate to disaster preparedness. This includes case studies to examine the Federal Emergency Management Agency's legal requirements, responsibilities, laws pertaining to emergency management, and actions based on these laws. Course content also includes analysis of public policies and understanding the procedures and requirements in emergency management.



Instructor Atty. Dennis Sweet Guest Speaker Atty. Bobby Owens Von Anderson Senior Planner

- **DCS/ NSD 201 Introduction to Natural and Man Made Disaster:** This is a required course for the DCS certification. The course has been adopted by Natural Science Division as an elective. The course content incorporates a broad overview of natural and man-made disaster and applications of modern tools like Geospatial information System (GIS) to study natural disasters. Students receive training in GIS and work on project to present at the conferences.


DCS 201 Instructor & Class

- **DCS 320 Emergency Preparedness Planning and Response:** This is also a required course for the DCS certification. Instructor of this course is Dr. George Humphrey, Director of Grant Management at MEMA. The course content helped students gain competency to terminology, policy, planning, and management issues that arise in preparing for and responding to disasters. The course includes case studies from current and past disasters events to help students develop an understanding an organization's role in assisting individuals and communities affected by disasters during both immediate and long term recovery. Students participate FEMA's online Independent Study (IS) Training which focus on disaster preparedness and rescue as part of graded assignment.

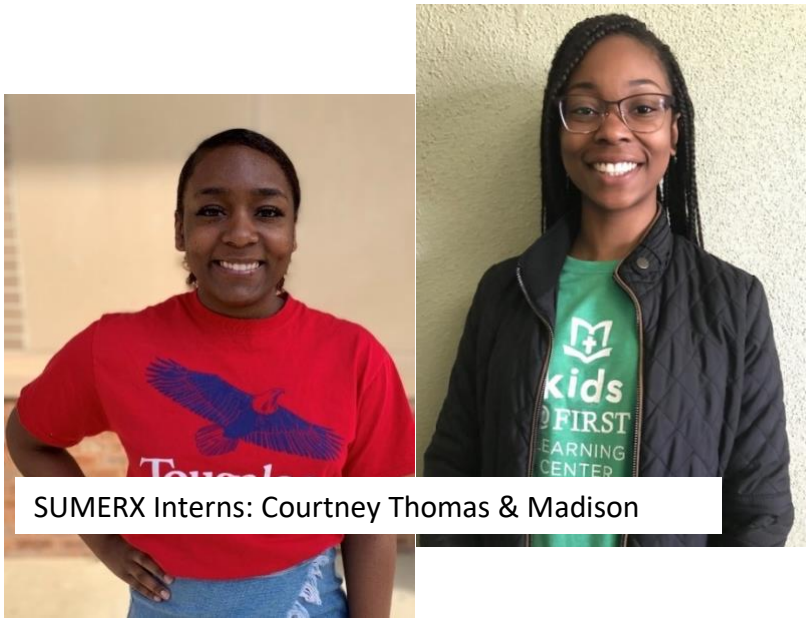
6. Institutionalization:

To institutionalize the DCS minor, past three years took steps such as collaborating with different disciplines, modifying courses, incorporating elective courses from other disciplines, and designing a self-sustaining Multidisciplinary Certificate Program. The certificate program replaced the DCS minor and was executed in Fall 2018. To be a self-sustaining program, the twelve credit-hour certification curriculum incorporates the existing elective courses from different disciplines (see Curriculum table). One of core required courses, *DCS 201: Intro to Natural Disaster,* was adopted by the Natural Science and co-listed (NSD 201) offered by the NSD division as an elective requirement. Mississippi Emergency Management Agency (MEMA) personnel currently teach another core requirement DCS *320: Emergency Preparedness and Response* as adjunct faculty. Academic Affairs agreed to pay the adjunct salary if the enrollment in the course is 8-10 students after (2020). The same holds true for the Internship course (*DCS 400).* College rolled out Bachelor of Social Work (BSW) as a degree granting program in Fall 2018 and the DCS certification is included within the BSW degree program as an option of specialization. The DCS certificate is also a part of Tougaloo College's path to career program. The project also took initiatives such as continuing with the existing end-users, establishing collaboration with FEMA and other private agencies which deal with emergency management, placing interns into private emergency management organizations, inviting personnel to class as field experts, and inviting local public and private emergency management agencies to participate in the Tougaloo College job fair to help DCS graduates'

recruitment. I am expecting that these initiatives will help strengthen and sustain the certificate program beyond 2020.

7. Interactions with research projects:

The Interdisciplinary Minor: Disaster Coastal Studies hosts a research symposium at Tougaloo College each academic year to showcase students' activities. In year 4 Ms. Mechelle B Smith, a Ph.D. student from Old Dominion University, Presented her dissertation *Social Vulnerability and Hurricane Response: Emergency Management Policy Implementation in a Social Construction Paradigm* at the symposiums. Students who are pursuing the certificate presented their class project at the symposium (Program attached). This academic year for the SUMERX program, two students, Sociology Senior Courtney Thomas, and Psychology Junior Madison Bibbs, attended Old Dominion University. Both of them are pursuing the Certificate program. Sociology graduates Alexandra Jwainat and Jessica Porter took courses in DCS and did there senior paper on Natural Disaster related topics.



SUMERX Interns: Courtney Thomas & Madison

DCS Research

8. Publications:

Mage, D. Reed, S. Hokins, A. Mangum, C. & Banerjee, S. (2018) Using Arc GIS to Map Disaster Effects on Mississippi, abstract published in *The journal of Mississippi Academy of Sciences (*ISSN 0076-9436) vol 63, 1 February edition

Bryant, J. Hill, C. Bibbs, M. Boler, D. & Khan, S. (2018) *Role of Effective Communication in Disaster Preparedness*, abstract published in *The journal of Mississippi Academy of Sciences (*ISSN 0076-9436) vol 63, 1 February edition

Ball, I &**Laiju, M.** (2017) Sociodemographic Characteristics and Natural Disaster Preparedness among Mississippi Residence, abstract published in *The journal of Mississippi Academy of Sciences (*ISSN 0076-9436) April edition.

Laiju, M. (2016) *Natural Disaster and Child Trafficking,* Mellon Fellowship

Laiju, M. (2017) *A Global Issue: Natural, Manmade Disaster, and Exploitation of Children,* Pardee RAND Faculty Leaders Fellowship, manuscript under review.

Laiju, M. & Banerjee, S. (2017) *Innovative Interdisciplinary Undergraduate Curriculum in Homeland Security at a HBCU*, Presented at the 10th Anniversary Homeland Defense & Security Education Summit on March 23, 2017

Year 4 Publications:

Long, J., Rose, S., Jwainat, A. & Hunter, F. (2019), Tougaloo Community Preparedness for Homeowners, abstract published in*Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1

Jones, T. Robinson, S. Boler, D.& Hunter, F. (2019) Disaster Preparedness: How Prepared Are They? An Assessment of Renters in Tougaloo Mississippi, abstract published in abstract published in*Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1

Kinkaid, D.,Ze'ronte, B.Sneed, H., &Banerjee, S., (2019), *Using GIS to Study Disproportionate Disaster Impact on Vulnerable Mississippi Population,* abstract published in *Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1, & Presented at 83rd Annual Meeting in Hattiesburg, MS on February 21, 2019

Laiju, M. (2019), *A Framework: Address Vulnerability of Children and Current Policy of Disaster,*
abstract published in*Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1, &presented at 83rd Annual Meeting in Hattiesburg, MS on February 21, 2019

Laiju, M. (2019) *Career Pathway: Multidisciplinary Undergraduate Curriculum in Homeland Security's Coastal Resilience at a HBCU.* Abstract published in *Southern Sociological Society* (SSS) Journal and presented atSSS Conference on April 11, 2019, at Atlanta, GA.

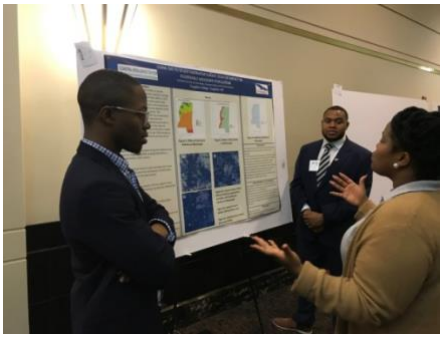
Presentation:

Laiju, M. & Hunter, F. (2018), *Transforming the Curriculum: Adding Disaster Management and Coastal Infrastructure Management to the Curriculum,* abstract accepted and presented at the Historical Black Colleges &Universities(HBCU) Faculty Development Network Conference
in Jackson, Mississippi, November 2,2018

Senior Paper:

Jwainat, A. (2019), senior paper Knowledge and Attitudes Regarding Disaster/ Emergency Preparedness

Porter, J. (2019), New Orleans Residents' Awareness of Disaster Preparedness



Students participating at MAS

9. Year 4 Education Activities and Milestone Achievements:

Education Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Education Activities	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Promote DCS certificate program & recruit 10-12 students.	ongoing		
Offer three courses in Fall Semester (NSD 201, DCS 320, & SOC/SWK 331)	08/2018	100%	
Offer four courses in spring semester (PSY 328, COP 211, POL 317, & DCS 400)	01/2019	75%	COP 211 course was not offered; Instructor was on Maternity leave
Select students for course project. Students who are interested in the program must be sophomore or higher with a minimum 2.5 GPA.	08/2019 01/2019	100%	
Place 6-7 students in internships with end-users.	01/2019	100%	
RETALK- invite guest for symposium	02/2019	100%	
Neighborhood Outreach Training planning for homeowner's associations in Jackson, Mississippi.	12/2018	0%	Due to shutdown & inclement weather
Interview – future plan of graduates with DCS certificate	05/2019	100%	
Education Milestones			
DCS Students participation in conferences (MAS, SSC, PRAM etc.)	02/03/04/2019	100%	
Neighborhood Outreach Training for homeowner's associates in Jackson, Mississippi.	03/2019	0%	Due to shutdown & inclement weather
Select and place 1-2 students in SUMREX internships.	04/2019	100%	
Host DCS Symposium to showcase DCS students' research activity, bring guest lecturers from partner institutions, and to share their research with students	04/2019	100%	

10. Year 4 Transition Activities and Milestone Achievements:

Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Recruitment for Certificate Program	ongoing		
Recruit 3 additional end-users to provide internships (course)	12/2018	0%	Did not need any additional placement
Advise and track the students pursuing the Certificate	05/2019	100%	
SUMREX- Summer Internshipand bringing guest lecturer (DCS Symposium	02/2019	100%	
Encourage the DCS certificate pursuing students to attend the job fair	02/2019	100%	
Collaborate College's career pathway sector to invite emergency management agencies to job fair	ongoing		
Transition Milestone			
Place 6-7 students into internships at end-user organizations	01/2019	100%	
Place 2 students in Summer Internship (SUMREX)	05/2019	100%	
Graduate 4-5 students from the DCS certificate program.	06/2019	100%	

12. Tables:

Table 1: Annual Courses and Enrollments
LAIJU: Annual Courses and Enrollments

Courses Developed and Taught by Tougaloo College through project titled "Multidisciplinary Certificate: Disaster and Coastal Studies(DCS)"					
Course Number	Course Title				
NSD/DCS 201	Course Title:**Introduction to Natural & Manmade Disaster**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	--	R,T	T	R/T
	Offering: Elective (E), Concentration (C), Minor (M)		M	M	CERT** CORE
	Number of Students Enrolled	*	10	10	10
	*offer in fall semester				
DCS 211	Course title:**Public Health Issues in Disaster Preparedness**	YR 1	YR 2	YR 3	
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	T,R	R
	Offering: Elective (E), Concentration (C), Minor (M)		M	M	
	Number of Students Enrolled	1**	8	11	
**Schedule to offer in fall; 2016 spring offered as an independent study for a graduating Senior with DCS minor					
DCS 301	Course title: **Political & Legal Issues in Disaster Preparedness**	YR 1	YR 2	YR 3	
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	T,R	R
	Offering: Elective (E), Concentration (C), Minor (M)	M	M	M	
	Number of Students Enrolled	14	10	8	
DCS 320	Course Title: **Emergency Preparedness Response & Planning**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	R,T	T	T
	Offering: Elective (E), Concentration (C), Minor (M)	M	M	M	CERT** CORE
	Number of Students Enrolled	16	5	11	9
DCS 314	Course title: **Economic Aspects of Disaster**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)		T	T,R	R
	Offering: Elective (E), Concentration (C), Minor (M)		E	E	-
	Number of Students Enrolled		13	7	-
DCS 311	Course title: **Psychological Dimension of Disaster**	YR 1	YR 2	YR 3	YR4
	Status: Developed (D), Revised (R), and/or Taught (T)	-	-	R	R
	Offering: Elective (E), Concentration (C), Minor (M)		E	E	-
	Number of Students Enrolled	***			-
***offer one elective in fall for each academic year					
DCS 400	Course title: **Internship**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	****	T
	Offering: Elective (E), Concentration (C), Minor (M)	M	M		CERT** CORE
	Number of Students Enrolled	7	8		5
CERT** (Certificate Program)					

	Course title: COP Public Relations Writing**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)			R	-
	Offering: Elective (E), Concentration (C), Minor (M				E
	Number of Students Enrolled				-
	Course title: SOC/SWK 331 Social, Community Organizations & Disaster Preparedness**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)			R	T
	Offering: Elective (E), Concentration (C), Minor (M				E
	Number of Students Enrolled				10
	Course title: POL 317 Public Policy & Legal Issues in Disaster Management**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)				T
	Offering: Elective (E), Concentration (C), Minor (M				E
	Number of Students Enrolled				17

	Course title: PSY 328 Health Psychology in Disaster Preparedness**	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)				T
	Offering: Elective (E), Concentration (C), Minor (M				E
	Number of Students Enrolled				14

NOTE: The certificate program started in Year 4. The red font indicates offered courses and enrollment data of this new program.

Table 2: Performance Metrics

LAIJU: Performance Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17— 6/30/18)	**Year4** (7/1/18— 6/30/19)
HS-related internships (number)	7	8	0	5
Undergraduates provided tuition/fee support (number)				
Undergraduate students provided stipends (number)	15	17	20	24
Graduate students provided tuition/fee support (number)	NA	NA	NA	NA
Graduate students provided stipends (number)	NA	NA	NA	NA
Undergraduates who received HS-related degrees (number)	3	5	4	5
Graduate students who received HS-related degrees (number)	NA	NA	NA	NA
Certificates awarded (number)	NA	NA	NA	5
Graduates who obtained HS-related employment (number)			0	1
Lectures/presentations/seminars at Center partners (number)	1	1	1	1
DHS MSI Summer Research Teams hosted (number)	0	0	0	0
Journal articles submitted (number)	0	0	0	0
Journal articles published (number)ABSTRACT	0	0	3	5
Conference presentations made (number)	1	4	6	6
Other presentations, interviews, etc. (number)Symposium Scenior	10	12	14	15
Trademarks/copyrights filed (number)	0	0	0	0
Requests for assistance/advice from DHS agencies (number)	2	1	1	1
Requests for assistance/advice from other agencies or governments (number)	5	2	2	3
Dollar amount of external funding	$12,000	--	$8,000	-
Total milestones for reporting period (number)	7	7	7	7
Accomplished fully (number)	4	5	6	6
Accomplished partially (number)	3	1	1	-
Not accomplished (number)	-	1	-	1

PAGAN, UPR-M
DHS COASTAL RESILIENCE CENTER
EDUCATION PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Education for Improving Resilience of Coastal Infrastructure

Principal Investigator Name/Institution:
Ismael Pagán-Trinidad (PI), Ricardo R. López (Co-PI)/ University of Puerto Rico - Mayagüez

Other Partners/Institutions:
ERDC-US Army Corp of Engineers; US Army Corp of Engineering PR District Office; PR Emergency Management Agency; FEMA; RAND Corporation - Dr. Isaac Porche; PR Department of Natural Resources; PR Climate Change Council (PRCCC) – Mr. Ernesto Díaz; Association of Professional Engineers of PR- Eng. Marilú de la Cruz; Aqueduct and Sewer Authority (AAA)- Eng. José Rivera, Eng. Joel Lugo and Eng. Glorimar Cortes; Integrated Añasco River Basin Management Group - Mr. Luis Villanueva; UPRM partners (Marine Science Department, PR Sea Grant Program Ruperto Chaparro; CariCOOS NOAA project; Transportation Technology Transfer Center- Dr. Benjamín Colucci; Civil Infrastructure Research Center); NOAA (National Weather Service); INESI - Dr.Cecilio Ortiz (Instituto Nacional de Energía y Sostenibilidad Isleña - "National Institute on Energy and Island Sustainability"); CRB (Community Resilient Building); Re-Imagina Puerto Rico;
Senior Personnel: Dr. Carla López del Puerto, Dept. of Civil Engineering and Surveying, UPRM; Collaborating Faculty at UPRM: Dr. Luis Aponte, Professor, Wind Engineering; Dr. José Guevara, Professor, Rehabilitation of Coastal Infrastructure; Dra. Alesandra Morales, Geotechnical Engineering; Dr. Walter Silva- Hydraulics; Dr. Ali Saffar, Structural Reliability; Dr. Raúl Zapata, Water resources; Dr. Francisco Maldonado, Construction and Cost Management; Dr. Alberto Figueroa, Resilient Transportation Systems; Dr. José Cedeño, Electrical and Power Systems

Short Project Description ("elevator speech")

This project will help educate the community by transferring state of practice knowledge to stakeholders (students, faculty, professionals, first responders, and workforce) through formal (curriculum, internships, student projects, undergraduate research) and informal (workshops, seminars, lectures, short courses, webinars) learning experiences. It will serve as a vehicle to engage the community as a whole to understand and learn its members' roles and responsibilities in providing resilient infrastructure systems to coastal and neighboring communities. The project will help the community understand better various stages in coastal infrastructure hazard prevention, preparedness, response, recovery, and mitigation. The focus will be on understanding the natural phenomenology, the engineering methodologies to address the level of risk the infrastructure is exposed to, the engineering methodologies and technology to analyze and predict the level of resistance and vulnerability the infrastructure and community is exposed to, the sustainable and resilient alternatives available at the state of practice or state of art to cope with communities' risks and vulnerabilities. The project will help motivate students, faculty,

professionals and the community leaders and will create pipelines of students and professionals into coastal resilient infrastructure (CRI) careers and practice.

1. Introduction and project overview:

The main goal of this project is to develop and offer formal and informal education through courses, workshops, seminars, lectures, and other educational means leading to advance knowledge on the state of practice on the Resiliency of Coastal Infrastructure (RCI) of the built and natural environment. This initiative aims at creating a **Certificate in Resiliency of Coastal Infrastructure**. The focus of the project is to provide students and faculty, professionals and homeland security personnel, and affected citizens with capabilities to assess the effects of natural hazards on coastal infrastructure, the conditions of existing structures, and rehabilitation alternatives to mitigate future damage and potential risks. The educational content will focus on pre-incidents, incidents and post-incidents. New courses and revisions of existing course will be evaluated in Civil Engineering and related disciplines dealing with estimates of causes and effects of coastal flooding, storm surge, ocean waves, tsunami loads, earthquake effects, and strong winds. Courses will be alternatively offered in the form of conferences, workshops, and lectures. Lecturers and experts from CRC, ERDC, FEMA, and other partners will be invited to participate. State of practice technology will be a priority, e.g., FEMA P646 publication for tsunami load estimates. The National Infrastructure Protection Plan and state infrastructure protection programs and plans will be addressed. Results of recent research work by UPRM, ERDC, and other CRC partner investigators regarding flood, wave, earthquake and tsunami, and hurricane wind effects on structures will be incorporated. Being a small and fully developed island, Puerto Rico offers the ideal setting to assess lessons learned of the effect of natural hazards on built and natural infrastructure including housing, commercial, industrial, institutional, transportation, communication systems, and others. Most recent Hurricane Irma and María experiences on the devastation over Puerto Rico will continued to be evaluated and the lessons learned will be incorporated in presentations, curriculum contents, and guidelines. The principal investigators will continue participating in various working teams, forums and meetings addressing building a resilient community in Puerto Rico for the future. At present time the PI's are involved with various initiatives, for example, Resilient Puerto Rico, Imagine Puerto Rico, and others. All communities in Puerto Rico have been left overexposed to major damages and recovery challenges which requires strong capacity building from the engineering perspective.

The Island continues to present more catastrophic settings from overdeveloped and exposed urban and rural communities, more vulnerable zones (flood prone, weak soils and landslides, hurricane wind exposure), highly concentrated and poorly planned urban communities, stressful tradeoff between urban development and natural ecosystems development and conservation, extreme economic development constraints and suboptimal first responders resources (e.g. funding, equipment, capabilities, training, and others) make the Island educational settings most challenging. All this setting will be available for first-hand assessment and evaluation from the educational and research perspective.

Puerto Rico will be in a continuous development process focusing on providing a more resilient community, infrastructure, families, and individual. The project will collect, disseminate and expose new knowledge and lessons learned from our past and expected natural events causing damages to the community.

This program has also the goal to facilitate internships at CRC universities performing research in CRI and in government agencies and industry dealing with coastal hazards. Being a minority serving institution (MSI) with a high women's participation (near one-third in Civil Engineering) it is also our goal to create and capacitate minority Hispanic students, faculty, professionals, and affected citizens to warranty up to date level of competency in Coastal Resilient Infrastructure to this part of the community. Our MSI University has been providing well qualified Hispanic engineers to the mainland United States for many years and will benefit from the opportunity to collaborate with DHS and the community it serves.

2. End users:

a. **PR Emergency Management Agency Staff - FEMA (Roles - trainees, collaborators, partners):** Provided training and tools through a partnership with administrators for coordinating near two dozen trainings, workshops, meetings and collaboration activities (see list in Section 9. Educational Activities and Milestones) based on their needs and priorities. Provide instructors for trainings, provide facilities, videotaped of activities, and issued Certificates of Participation to FEMA officials were invited and participated in all the activities sponsored by the CRC.

b. **RAND Corporation -Contactor to FEMA (Role- sponsor, trainers, and trainees):** A research service partnership was established to support RAND officials in the reconstruction efforts of Puerto Rico focusing on providing expert advice and support on cost estimation and validation of permanent reconstruction projects to be sponsored by FEMA public assistance projects. CRC recruited a team of faculties and students to continuously work on various scope of works on reconstruction projects in public infrastructure, namely: buildings, water/wastewater, dams, power and energy, transportation, communications, and others. This initiative is operated through periodic meetings, communications and meetings between officials from both parties.

c. **Municipality and state government - engineers, planners, technicians, administrators, others (Role: trainees, collaborators):** Participate as audience and certificate recipients. Share their problems and priorities. Coordinated field trips and inspections.

d. **Professional Engineers and Planners – Industry (Role – trainers and trainees):** Participated as audience, certificate of participation and recipients of continuing education certifications. They also participate as trainers in expertise areas of interest.

e. **Faculty (Roles - trainers, trainees, researchers):** Course development and supervision, research work-proposals and projects): Faculty continued engaged in resilience of coastal infrastructure either by offering training and courses and engaging in research work (proposals and projects) but also as trainees in trainings and workshops. Various professors engaged course amendments and course development in resilience topics. Some turned into leadership roles in their research teams.

f. **Students (Roles: trainees, undergraduate and graduate research**): Students participate in formal and informal education. A variety of undergraduate and graduate research and projects addressing local projects associated with civil infrastructure exposed and vulnerable to natural hazards.

g. **Community leaders and members (Roles: trainees, certificate recipients):** Community leaders and members of communities at risk participate in trainings, workshops and team building where they can share their experiences and needs.

h. **Partnership with EPA (“***As Chairman/Professor of the DHS Coastal Resilience Center of Excellence-UPRM Partner; Department of Civil Engineering & Surveying at UPR-Mayagüez, Ismael is a key partner of the EPA-led PR Healthy Buildings (Homes/Public Housing/Schools/Public Buildings) Long-Term Recovery Initiative.”* - citation from LEED-AP Indoor Air Quality Coordinator - Asthma, Mold, Radon & Radiation, Disaster Recovery HSS-RSF Co-Lead Technology, Transportation and Radiation Branch, Air and Radiation Division, US EPA Region II.

i. **Partnership with the Añasco River Watershed Management Working Group:** A basin-wide stakeholders team has been formed focusing of basin wide resilient attention to the Añasco River basin flooding and environmental problems. This imitative has been led by the *Community Planning and Capacity Building Recovery Support Function (CPCB RSF) – Aguadilla Office with the participation of many government and community stakeholders.*

j. **Collaboration Initiative with The Nuclear Alternative Project (NAP) :** The UPRM-CRC Team coordinated to participate in practical research work for evaluating the feasibility of alternative nuclear energy for the Island. A feasibility study is proposed (FEASIBILITY STUDY FOR MICRO AND SMALL MODULAR REACTORS (SMR) FOR PUERTO RICO $3.1M) by the NAP to the USA Department of Energy to evaluate the economic, safety and societal aspects of deploying micro-reactors and SMRs for Puerto Rico. Puerto Rico aspires to a clean, resilient, zero-carbon emission energy generation portfolio as the basis for a modernized, robust and dynamic economy. Based on the latest draft of the Integrated Resources Plan (IRP), for the near-term, Puerto Rico plans to replace all oil and coal plants with natural gas plants while at the same time reforming regulatory and financing tools to expedite solar and wind projects across the island.

k. **NIST Intergovernmental Personnel Act with NIST:** Dr. Aponte-Bermúdez will bring significant expertise in wind and structural engineering to the NIST team studying Hurricane Maria's impacts on Puerto Rico. Dr. Aponte-Bermúdez has extensive experience with measurements and modeling of the wind environment in Puerto Rico, as well as documentation of the performance of buildings through post-hurricane damage assessments. Dr. Aponte-Bermúdez's participation in this study will provide a synergy with his ongoing research activities. At the completion of this assignment, Dr. Aponte-Bermúdez will continue in his current position at the University of Puerto Rico at Mayagüez.

l. **Oregon State University (Dr. Dan Cox) and Rice University:** A Planning Grant was proposed and approved Led by OSU to work on a proposal for adaptation and resilience of coastal infrastructure (CARCI) was approved. Dr. Ricardo López (UPRM) is CO-PI. ORU also collaborates in the SUMREX with a total of 8 students since the CRC project began in 2016. Two team meetings were celebrated at Washington DC (George Mason University) and OSU where a number of partners collaborated in the topic of resilient coastal infrastructure.

3. Unanticipated Problems:

A significant number of students and faculty have been attracted to the CRC project however, due to the proposed budget constraints a limited number of students and faculty could be committed to the project. Some faculty have participated through extended release time whenever possible or by Ad-Hon participation. It turned out that attracting faculty and students to work Ad-Hon is not the best way of building up leadership, work force and long-term resources. Although we have not received any instruction not to transfer funding to support students and faculty, we felt we need to consult and have prior budget revision and authorization from headquarters to move on for last project year. We understand that a more effective engagement of the faculty can be obtained with appropriate funding support.

4. Students and recent graduates:

A total of 8 students registered in graduate courses. A total of 81 students registered in undergraduate courses. All of the courses focused on resilient infrastructure.

INCI 4998/ININ5996 – 16 undergraduate students
INCI 4950 – 65 undergraduate students
INCI 5996 – 1 graduate student
INCI 6995 – 1 graduate student
INCI 6066 – 2 graduate students
INCI 6065 - 1 graduate student
INCI 8999 – 3 graduate students

Other than formal courses, many of the project activities were sponsored conferences and seminars open to students, faculty and the general public. The number and distribution by sector of attendants can be seen in Figure 1 in the following.

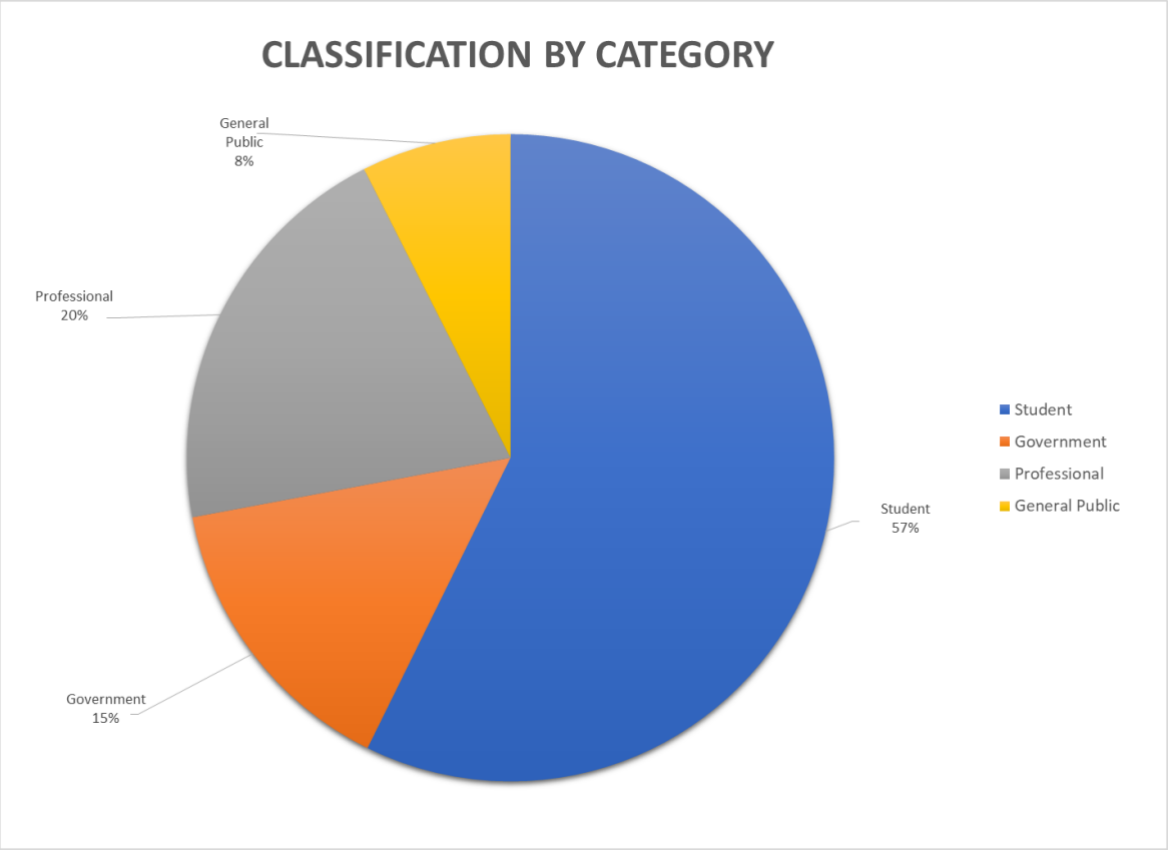


Figure 1 – Attendants by Category

5. Project Impact

The project intensively reached out to students, professors, government officials, design professionals and the general public. Many of the activities were developed in coordination with other departments and organizations to ensure ample diffusion and participation. Within the collaborators are FEMA, NOAA, US Army Corps of Engineers, Department of Natural Resources, Sea Grant, CoHemis, ReImagina, and others. A total of 17 main educational conferences and workshops have were organized during Year 4 with 893 participants (an average of 52 participants per activity) and 108 contact hours (an average of with the representation of different sectors like (Students-57%, Professionals -20%; Government 15%; and General Public-8%). Since 2017 until 2019 a total of 1823 participants attended the project activities with a total of 120 contact-hours.

The invited speakers are well recognized leaders in their fields precisely to make sure the most up to date information is given. The project has become a leader with partners in our state agenda to rebuild Puerto Rico. The project team has acquired the collaboration of students and faculty through developing leadership and reaching out for their own initiatives and sponsorship.

Although it is difficult to measure, there is a significant impact on the attitude, confidence and capacity of the participants from all sectors. It evident in our graduates who have been hired by FEMA and contractors responsible for the emergency management and the permanent

reconstruction of Puerto Rico after Hurricane María. Figure 2 shows the distribution of participants per educational activity.

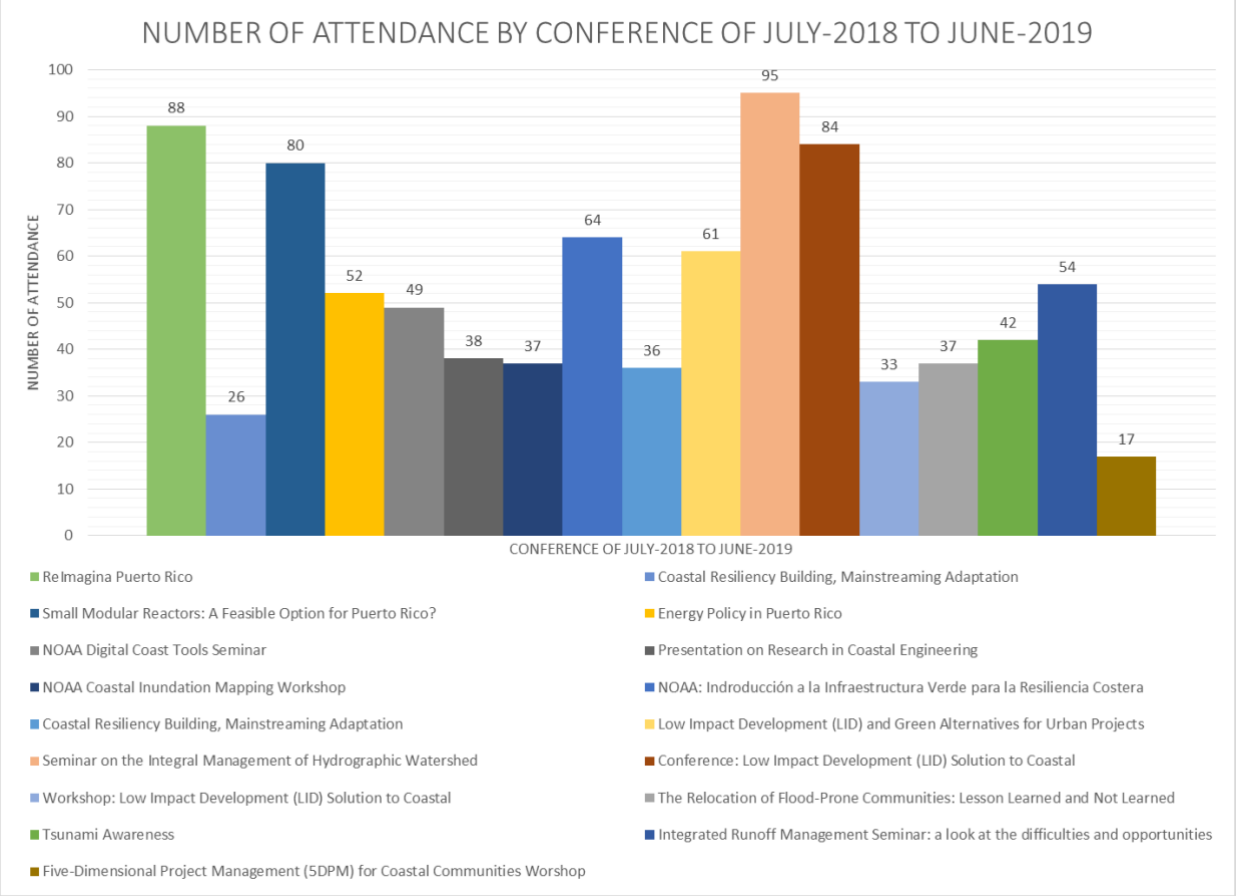


Figure 2: Distribution of Participants per Educational Activity

6. Institutionalization:

The project PI's have been very active searching for additional funding for activities related to the project. Some of the most important activities are:

- Proposal to NSF for an Engineering Research Center together with Oregon State University and Rice University. A Planning Grant for this purpose was approved to OSU with Ricardo López as CoPI. The proposed Center name is CARCI- Center for Adaptation and Resilience of Coastal Infrastructure. A request for a no cost extension of the Planning Grant has been submitted recently.
- Proposal to Rand Corporation to give advice and support on FEMA projects for the reconstruction of Puerto Rico after Hurricane María. An agreement for $500,000 was approved with the name "Expert Analysis of FEMA Cost Estimate Development Process and Validation for FEMA-4339-DR-PR". This project started February 2019 and is in progress.

- Continuation of efforts to establish an Education Certificate in Resilient Infrastructure. It is being negotiated with several Departments. Courses have been identified, two new courses have been developed, other potential courses for the certificate have been identified. The initiative has been expanded and it is ongoing to be developed by various departments, namely: Materials Science and Engineering Marine Science, and Civil Engineering. This coordination is much more complex but much more significant than being developed by only one department.
- Participation in NSF Rise-Up Project. Senior Personnel Carla López del Puerto is the PI and Ismael Pagán and Ricardo López are Co-PI's in the NSF project. The project is called "A Collaborative Undergraduate STEM Program in Resilient and Sustainable Infrastructure and started in 2018 with a duration of 5 years.
- The PI's have developed collaboration with other initiatives at UPRM which are focusing on parallel activities with similar goals hosted at the INESI, PR Sea Grant, Materials Science and Engineering, Marine Science outside the department or like NSF RISE-UP project and other faculty initiatives at the department. The resilience mission has been adopted by the College of Engineering and the whole UPRM where the PI's play a leadership role.

For the foreseeable future the main activities of the project will be housed in the Department of Civil Engineering and Surveying, (where Prof. Ismael Pagán Trinidad is the Chairman) through the Civil Infrastructure Research Center (where Dr. Ricardo López is the Center Director) at UPRM.

7. Interactions with research projects:

a. SUMREX: Civil Engineering undergraduate students Jorge Santiago and Bryan Acevedo attended OSU in Summer 2018 (July 1- August 17).
b. SUMREX: Civil Engineering undergraduate students Robert Lewis and Ihan- Jarek T. Acevedo González are attending Oregon State University during Summer 2019 (June 2019) Supervisors Dan Cox and Meagan Wengrove.)
c. UPRM-ERDC 2018 and 2019: Coastal and Hydraulic Laboratory - Engineer Research and Development Center, Vicksburg. MS (One Student Nelson Cordero)
d. UPRM-ERDC ERPA – Civil Engineering Graduate Nelson Cordero worked under BAA working at ERDC in Vicksburg from Aug 2018 to May 2019.
e. NSF – PIRE Summer Intern - One student, Sofia N. Rivera-Soto was selected to attend the internship and travel to Netherlands in Summer of 2019. Spent 2 weeks in the Netherlands in May and 10 weeks at UPRM completing her research project during Summer. She continued her work at UPR and the project is due August 30.
f. ReTalk
    - Research in Coastal Engineering at UPRM, Dr. Dan Cox, and 2 others from Oregon State University, Dr. Jamie Padgett from Rice University, and Drs. Miguel Canals and Sylvia Rodriguez from UPRM gave 6 lectures to students, professors and general public at UPRM, December 6, 2018
    - Profs Ismael Pagán and Ricardo López of UPRM made 2 presentations on Dr. Gavin Smith's courses in UNC and NCSU, February 27, 2019.

- Dr. Gavin Smith visited UPRM and gave the presentation "Relocation of Coastal Communities", at UPRM, attended by a good mixture of students, professors and general public including officials from local and federal government, on April 26, 2019. He also visited coastal areas affected by Hurricane María.

8. Publications:

Publications/Presentations:

- Pagán Trinidad, Ismael, López-Rodríguez, Ricardo and Ernesto Diaz, "Education and Building Capacity for Improving Resilience of Coastal Infrastructure", Proceedings, ASEE 126th Annual Conference & Exposition: June 16-19, 2019, Tampa FL, **Peer-reviewed.**
- Hector Colón, (SUMREX student 2017), Paper and Presentation, ASCE Coastal Engineering International Conference, "NUMERICAL MODELLING OF TSUNAMI INUNDATION CONSIDERING THE PRESENCE OF OFFSHORE ISLANDS AND BARRIER REEFS", Baltimore, MD, July 2018; **Peer-reviewed.**
- Benjamín Colucci, Alberto Figueroa and Alexander Molano, (Graduate student supported by the CRC project), Paper and Presentation, "Impacts and Lessons Learned as a Result of the Passage of Hurricane Maria on the Transportation Infrastructure of the Caribbean Island of Puerto Rico", UPADI, August 2018.
- Benjamín Colucci, Alberto Figueroa and Alexander Molano,(Graduate student supported by the CRC project), Paper and Presentation, "Lessons Learned for the Puerto Rico Transportation Infrastructure after Hurricane María", ITE, October 2018.
- Morales-Velez, A. C., and Hughes, K.S., "Comprehensive Hurricane María Mass Wasting Inventory and Improved Frequency Ratio Landslide Hazard Mapping", Revista Dimension Year 32, Vol 1, 2018. Peer-reviewed
- Aponte Bermúdez, Luis D., "Huracán María,: Sinopsis y Análisis Preliminar del Impacto en la Infraestructura de Puerto Rico", Revista Dimensión Year 32, Vol 1, 2018. Peer-reviewed.
- Martínez-Cruzado, José A. Huerta-López, Carlos I. Martínez-Pagán, Jaffet, Santana Torres, Erick X. and Hernández-Ramírez, Francisco J., "Destrozos, Recuperación, y Planes en la Red Sísmica de Movimiento Fuerte a Raíz de los Huracanes Irma y María", Revista Dimensión, Year 32, Vol 1, 2018. Peer-reviewed.
- Acosta, Felipe J, Esquilín-Mangual, Omar, Wood, Stephanie G., Long, Wendy R. and Valdés, Didier, Lessons Learned from the Evaluation of Concrete Pole Failures Following Hurricane María, Revista Dimension Year 32, Vol 1, 2018. **Peer-reviewed.**
- Ismael Pagán-Trinidad and Ricardo R. López, editors, Digital proceedings of Conference "Lessons Learned and Best Practices: Resilience of Coastal Infrastructure" , San Juan, PR, August 2017, http://engineering.uprm.edu/inci/?page_id=3522
- The following two presentations were given by Dr. Ricardo López at the World Engineering Conference on Disaster Risk Reduction. More information at

http://www.wfeo.org/events/world-engineering-conference-disaster-risk-reduction-wecdrr-2016/

- **Ismael Pagán-Trinidad, Ricardo López-Rodríguez,** Agustín Rullán, Oscar Perales-Pérez, John Fernández-Van Cleve, "THE ROLE OF UNIVERSITIES ON DISASTER RISK REDUCTION IN THE COMMUNITY: UPRM CASE STUDY", World Engineering Conference on Disaster Risk Reduction, Peruvian Association of Professional Engineers, Lima Perú, December 5-6, 2016. Presentation.
- **López-Rodríguez, Ricardo R., Pagán-Trinidad, Ismael**, "Structural Vulnerability to Natural Hazards in Puerto Rico", World Engineering Conference on Disaster Risk Reduction, Peruvian Association of Professional Engineers, Lima Perú, December 5-6, 2016.Presentation.
- **Robert W. Whalin, Ismael Pagán-Trinidad**, Evelyn Villanueva and David Pittman, "A Quarter Century of Resounding Success for a University/Federal Laboratory Partnership", Proceedings, 123rd ASEE Annual Conference and Exposition, Vol 1, presented June 27 2016 in New Orleans, LA. ISBN: 978-1-5108-3480-4. Peer-reviewed
- **Ismael Pagán-Trinidad, Ricardo López-Rodríguez**, "Education, Resilience and the Built Environment: Impacts and Some Lessons Learned on Infrastructure for Improvement of Coastal Infrastructure in PR", Symposium: Planning and Resilient Recovery in Puerto Rico, Graduate School of Planning – University of Puerto Rico – Río Piedras, May 18-19, 2018. Presentation.
- Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago, Ismael Pagán Trinidad and Didier. M Valdés Díaz. Impact of Extreme Climate in Coastal Transportation Civil Infrastructure in the Caribbean, World Engineering Forums November 26 to December 2, 2017, Rome, Italy. Presentation
- Benjamín Colucci Ríos (Presenter) and Alexander Molano Santiago, Impact of Hurricane Maria on Puerto Rico's Transportation Infrastructure: Lessons Learned, 97th Transportation Research Board Annual Meeting, AHB55 Committee, *Work Zone Traffic Control Committee Meeting*, January 9, 2018. Presentation
- Benjamín Colucci Ríos (Presenter) and Alexander Molano Santiago, Impacto del Huracán María en la infraestructura de transportación de Puerto Rico (Impact of Hurricane María in Puerto Rico's Transportation Infrastructure), 4to Conversatorio para un Puerto Rico Resiliente. February 20, 2018, Presentation.
- Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago and Joel F. Alvarado López, El impacto del Huracán María en la infraestructura de transporte de Puerto Rico:Lecciones aprendidas (The Impact of Hurricane Maria in Puerto Rico's Transportation Infrastructure: Lessons Learned), Mega Viernes Civil 2018: Resiliencia Aplicada, College of Engineers and Surveyors of Puerto Rico, San Juan, April 6, 2018. Presentation.
- Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago, Luis Sevillano García, Launelly M. Rosado Rosa and Joel F. Alvarado López, Transportation Engineering Innovation Spearheading the Economic Development of Puerto Rico after an Extreme Natural Disaster, XXX Congress of Engineering and Surveying, COINAR 2018, San Juan, April 17, 2018. Presentation.

- Re-Imagine Puerto Rico a discussion panel on solutions to rebuild PR, co-sponsored with Resilient Puerto Rico Advisory Commission, 11 speakers including Prof. Ismael Pagán, ample audience participation, UPRM, August 14, 2018, Presentations
- Coastal Resiliency Building, Mainstreaming Adaptation, Ernesto Díaz, Director, Coastal Management Program of Dept. Natural Environment Resources and of PR, offered at Capstone course, UPRM, October 4, 2018, Presentation.
- Digital Coast Tools Applications-1 day Seminar, Sponsor: PR Sea Grant, NOAA, CRC; Two NOAA instructors, UPRM, December 5, 2018, Presentations
- NOAA Coastal Inundation Mapping Workshop, Sponsors Sea Grant, NOAA, CRC; two NOAA instructors, UPRM, December 6-7, 2018, Workshop.
- Research in Coastal Engineering, Sponsors with CARCI NSF planning grant with Dr. Dan Cox, Six speakers including three from Oregon State University, one from Rice University and two from UPR Mayagüez, UPRM, December 6, 2018, Presentations
- NOAA – Introduction to Green Infrastructure for Coastal Resiliency: Co-sponsored with NOAA, PR Sea Grant Program, UPRM-CRC, December 12, 2018, Presentations
- Coastal Resiliency Building and Promoting Adaptation: Ernesto Díaz of Dept Natural Resources and Environment of PR, offered at Capstone course UPRM, January 31, 2019, Presentation.
- Low Impact Development and Green Alternatives for Urban Projects: Sponsors FEMA, CRC; Speaker Ismael Pagán Trinidad, Aguadilla FEMA Headquarters, February 8, 2019, Presentation.
- Seminar on the Integral Management of Hydrographic Watershed: Sponsors with FEMA, UPRM, March 5, 2019, Presentations.
- Small Modular Reactors: A Feasible Option for Puerto Rico?, a panel discussion, co-sponsored with Nuclear Alternative Project, UPRM, October 30, 2018, Presentations
- Public Forum: Energy Policy in Puerto Rico, What is Ongoing, Co-sponsored with INESI, UPRM, November 29, 2018, Presentations.
- Carla López del Puerto, Ismael Pagán Trinidad and Ricardo López, "Hurricane Maria in Puerto Rico: Assessment of the Damages, Reconstruction Efforts and Beyond Recovery" at ASCE Construction Summit in Atlanta, March 7 to 9, 2019, Presentation Panel.
- Ismael Pagán Trinidad and Ricardo López," Overview of Damage Caused by Hurricane Maria in PR", at Gavin Smith's Seminar at **NCSU**, February 27, 2019, Remote Presentation.
- Ismael Pagán Trinidad and Ricardo López were invited and participated in Coastal Engineering Workshop, sponsored by NSF, held in Arlington, Virginia, November 13 and 14, 2018. Similarly, a second meeting-workshop at OSU in February 4-5, 2019 with the same objective.
- Ismael Pagán Trinidad and Ricardo López, "Improving Resilience of Coastal Infrastructure through Education and Building Capacity", 2019 NLTAPA Southeast Region Meeting, April 30, 2019 San Juan PR, Presentation

- Ismael Pagán Trinidad and Ricardo López, "Education and Building Capacity for Improving Resilience of Coastal Infrastructure" at ASEE 126th Annual Conference & Exposition: June 16-19, 2019, Tampa FL, Presentation
- Ricardo López and Juan Rodríguez, "Análisis tridimensional no lineal de estructuras de concreto (Non Linear Tridimensional Analysis of Reinforced Concrete Structures)" at CIAPR –Mega Viernes Civil (Island wide meeting of Civil Engineers), April 5 2019, San Juan PR, Presentation.
- Carla López del Puerto (senior personnel) gave short course Complex Project Management for Coastal Communities presented at FEMA headquarters in Aguadilla PR for FEMA personnel on June 27, 2019.

Dissertations and Theses

- Angel Alicea (PhD Dissertation): "Dynamic Identification and Nonlinear Modeling for the Structural Health Assessment of Aged Coastal Infrastructure in Puerto Rico", PhD dissertation completed in December 2018, Department of Civil Engineering, advisor Ricardo López
- Efrain Ramos (MSCE Thesis): "Stochastic Simulation of Tropical Cyclones for Quantification of Uncertainty associated with Strong Recurrence and Intensity", July 8, 2019 (already submitted, pending final oral presentation); Dept. of Civil Engineering and Surveying; Advisor Ismael Pagán Trinidad-UPRM; Co-Advisor Norberto Nadal ERDC-UPRM.
- Kevin Cueto (MSCE Thesis): "Modeling considering Computational Fluid Dynamics of hydraulic pressure exerted on coastal structures", July 8, 2019 (already submitted, pending final oral presentation); Dept. of Civil Engineering and Surveying, Advisor-Ricardo López, UPRM.

9. Year 4 Education Activities and Milestone Achievements:

Education Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Education Activities	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Offer series of seminars / lectures / short courses (SLSc) in: Advances in Analyses / Design / Operation / Maintenance / Retrofitting of Resilient Coastal Infrastructure.	Offered from 09/2018 to 06/2019	100	
Internships: a. SUMREX: Civil Engineering undergraduate students Jorge Santiago and Bryan Acevedo attended OSU in Summer 2018 (July 1- August 17). b. SUMREX: Civil Engineering undergraduate students Robert Lewis and Ihan- Jarek T. Acevedo González are attending Oregon State	07/01/2018-08/17/2018	100 100	*-Notice that Summer internships run over two fiscal year periods.

University during Summer 2019 (June 2019) Supervisors Dan Cox and Meagan Wengrove.) c. UPRM-ERDC 2018 and 2019: Coastal and Hydraulic Laboratory - Engineer Research and Development Center, Vicksburg. MS (One Student Nelson Cordero) d. UPRM-ERDC ERPA – Civil Engineering Graduate Student - Nelson Cordero worked under BAA working at ERDC in Vicksburg from Aug 2018 to May 2019. e. NSF – PIRE Summer Intern - One student, Sofia N. Rivera-Soto was selected to attend the internship and travel to Netherlands in Summer 2019. Spent 2 weeks in the Netherlands in May and 10 weeks at UPRM completing her research project during Summer. She continued her work	06/01/2019 – 06-30-2019 06/06/2018 - 08/15/2018 and 06/01/2019 – 06/30/2019 15/08/2018 - 31/05/2019 12/05/2019-30/06/2019 (will continue until 30/08/2019)	100 100 100	
<u>Workshops/Conferences</u> Rehabilitation of Coastal Infrastructure (José Guevara) - Jan 2019 a. Re-Imagine Puerto Rico a discussion panel on solutions to rebuild PR, co-sponsored with Resilient Puerto Rico Advisory Commission, 11 speakers including Prof. Ismael Pagán, ample audience participation, UPRM, August 14, 2018 b. Small Modular Reactors: A Feasible Option for Puerto Rico?, a panel discussion, co-sponsored with Nuclear Alternative Project, UPRM, October 30, 2018 c. Public Forum: Energy Policy in Puerto Rico, What is Ongoing, Co-sponsored with INESI, UPRM, November 29, 2018. d. Reliability of Resilient Infrastructure - course to be video recorded (Ali Saffar)- Recording modules (Module 1 Dec 2018, Module 2 May 2019, Module 3 Summer 2019) e. Community Resilience Building (Adam Welchel) Dec 2018 f. Riverine and Coastal Flood Hazards (Walter Silva) October 2018 g. Complex Coastal Construction Projects (Carla López del Puerto) June 2019 **<u>Others - depending on availability of instructors</u>** h. Coastal Resiliency Building, Mainstreaming	08/2018— 06/2018	100*	*-The objective of Educational Activities was completed well beyond expectations and over 100% of the proposed work. Only two activities were not offered but many others were added. Many more activities were incorporated and some of the planned activities were substituted. Some limited adjustments were done as follows: 1. Activity d. began and significant recording was done, however, the quality of the recording is not convincing for the PI's and the author. It has been agreed to re do it. New appropriate digital equipment has been in the process of

Adaptation, Ernesto Diaz, Director, Coastal Management Program of Dept. Natural Environment Resources and of PR, offered at Capstone course, UPRM, October 4, 2018 i. Digital Coast Tools Applications- 1-day Seminar, Sponsor: PR Sea Grant, NOAA, CRC; Two NOAA instructors, UPRM, December 5, 2018 j. NOAA Coastal Inundation Mapping Workshop, Sponsors Sea Grant, NOAA, CRC; two NOAA instructors, UPRM, December 6-7, 2018 k. Research in Coastal Engineering, Sponsors with CARCI NSF planning grant with Dr. Dan Cox, Six speakers including three from Oregon State University, one from Rice University and two from UPR Mayagüez, UPRM, December 6, 2018 l. NOAA – Introduction to Green Infrastructure for Coastal Resiliency: Co-sponsored with NOAA, PR Sea Grant Program, UPRM-CRC, December 12, 2018 m. Coastal Resiliency Building and Promoting Adaptation: Ernesto Diaz of Dept. Natural Resources and Environment of PR, offered at Capstone course UPRM, January 31, 2019 n. Low Impact Development and Green Alternatives for Urban Projects: Sponsors FEMA, CRC; Speaker Ismael Pagán Trinidad, Aguadilla FEMA Headquarters, February 8, 2019 o. Seminar on the Integral Management of Hydrographic Watershed: Sponsors with FEMA, UPRM, March 5, 2019ReImagina Stormwater Management Workshop: 'Comprehensive Stormwater Management Seminar: A look at the difficulties and opportunities"; cosponsored with ReImagine Puerto Rico Initiative; Ten expert speakers on stromwater management issues. Participants from FEMA, Municipal Staff, Academia and Private Sector. June 19, 2019. p. Five-Dimensional Project Management (5DPM) for Coastal Communities Workshop, Speaker-Dr. Carla López del Puerto (UPRM CRC Senior Personnel), offered to FEMA and PR COR3 staff at Aguadilla Branch, June 27, 2019.			being acquired. This task has been rescheduled for year 5 work plan. 2. Activity e. was cancelled pending the possibility of rescheduling for Year 5. 3. Activity f. was incorporated with the Re-Imagine Puerto Rico Storm Water Management Workshop from June 19, 2019.
<u>Establish or Continue Formal Courses</u> a. Theses (various ongoing): Kevin Cueto, Jorge Romeu, Angel Alicea, Johnny Rosario, Efrain Ramos, Nelson Cordero, Juan Rodríguez, Oscar Vélez b. Undergraduate Research and Problems: various INCI 4998 (13 students IPT), INCI 6995 (2) , ININ 4996 (1) c. Appropriate courses will be offered based on demand: INCI 4950 Twice (32, 33)	07/2018—06/2019	100	
<u>Develop and Institutionalize Curriculum Sequence for CRI</u>	05/2019	75**	**-Courses have been identified, two new

a. Design a Curriculum Sequence leading to an Educational Certificate in Resilient Infrastructure b. Identify potential courses c. Design new courses as required d. Certificate will be promoted and announced e. Orientations will be programmed			courses have been developed, other potential course for the certificate have been identified. The initiative has been expanded and it is ongoing to be developed by various departments, namely: Materials Science and Engineering Marine Science, and Civil Engineering. This coordination is much more complex but much more significant than being developed by only one department.
Website: Electronic repository of digital documentation, sites, educational resources, videos, photos, webinars, experiential testimonies, etc. will continue to develop and advertise.	12/2018	80***	***-This initiative is continuous. The site has been developed. It continues to be populated.
Publications in peer review sources by participants as faculty, students, and researchers from UPRM and partner institutions are and will continue to be motivated and supported by the project.	05/2019	100	
Education Milestones			
Advance the state of knowledge of various constituencies through technology transfer, training, and teaching Purpose: To provide education and formation of the participants in RCI Goal: Build up capacity and better trained professionals and students.	08/2018 – 06/2019	100	
Provide alternative learning, motivation and incentives to students through research and experiential work in interns. Introduce students into a pipeline toward HSE advanced graduate education and research careers and jobs Purpose: Attract and orient students into RCI to pursue graduate studies and related carriers; and attract, orient and support students to pursue HSE jobs. Goal: Provide work and research experiences to students to become motivated to pursue graduate studies, education and research careers, and HSE jobs.	Summer 2018 Summer 2019	100	
Host at least two workshops to increase accessibility and hands on experiences of best available technology to the audience with special emphasis to practitioners, faculty	12/2018, 06/2019	100	

and students. Purpose: Help provide accessibility and hands on experiences of best available technology to the audience with special emphasis to practitioners, faculty and students. Goal: Build up capacity on the best available technologies for professionals involved or motivated to be involved in HSE.			
Strengthen and update the contents of the civil engineering curriculum and faculty expertise on HSE priorities for RCI Goal: Help provide a better educated new generation of civil engineers and professionals in related disciplines.	12/2018 – 06/2019	100	
Facilitate end-users updated and state of practice references, tools, and guideline son RCI. Goal: Better educated and informed professionals, government employees, faculty and students on RCI.	06/2019	100	

10. Year 4 Transition Activities and Milestone Achievements:

Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Curricular Sequence-Certificate (Impact on the curriculum): A curricular sequence is proposed that enhances the informal Certificate implemented the first three years will provide opportunities to incorporate infrastructure resilience into the formal curricular options. Appropriate courses will be identified which will accumulate credits towards obtaining the Certificate.	05/2019	75**	**-Courses have been identified, two new courses have been developed, other potential courses for the certificate have been identified. The initiative has been expanded and it is ongoing to be developed by various departments, namely: Materials Science and Engineering Marine Science, and Civil Engineering. This coordination is much more complex but much more significant than being developed by only one department.
Host a series of seminars/lectures/short courses (SLSc) called “Advances in Analyses /Design/ Operation / Maintenance / Retrofitting of	06/2019	100	

Resilient Coastal Infrastructure" will be designed, institutionalized and managed through the Civil Infrastructure Research Center (CIRC) at the department of Civil Engineering and Surveying. List of priority topics to be selected from include: Water/Wastewater; Transportation (bridges, roads, etc.); Flood/Drainage; Buildings (Housing/Commercial/Industrial/ Hospitals/Schools, etc.); Airports/Seaports Pending); Communication/Power; Geotechnical Structures/Landslides/ Liquefaction; Coastal Protection Infrastructure (Partners from ERDC, CRC, others to be invited); Green Protective Infrastructure (Partners from ERDC, CRC,); Extreme Climate Adaptation. It is expected to be offered on the average at least one per month. It will depend on the availability of resources, suitability of the activity for supplying the audience needs and particular enquiries from our constituents.			
Alternative Learning Initiatives (ALI): Alternatives to learning other than the one obtained through formal courses required in the curriculum in RCI will be institutionalized and offered through internships, undergraduate research, special projects, professional practice, community service and any other available option. Workshops, conferences, and seminars will also help develop informally a desirable body of knowledge on RCI. Alternative learning mode bring students and practitioners the opportunity of: (a) learning by doing, participate in experiential learning, (b) engage in new state of practice advances in the field of resilience engineering, (c) expand breadth and depth of curriculum contents, (d) be exposed to experts from abroad, (e) and start new journeys either academically or professionally in the resilience agenda of the homeland security enterprise, among others	06/2019	100	
Technology Transfer on RCI: Access to the state of practice and experiential infrastructure resilience will be made available through trainings, divulgation, and digital literature at the project site or a family of web links**.** This web site is intended to be a repository of literature on RCI. Divulgation of knowledge and literature through this project is aimed through various available modes, namely: website, conference presentations, class and reports, class notes, guidelines, theses, and conference proceedings, and journal papers, Publications of new materials in peer reviewed conferences or journal will be sought based on opportunities and availability.	06/2019	80 ****	**** This initiative is continuous. The site has been developed. It continues to be populated.
Transition Milestone			
Curricular Alternative Offering in Civil Engineering/Surveying: Formalize the curricular exposure	06/2019	100	

of students through RCI curriculum by offering a variety of learning alternatives. New formal courses will be proposed and existing course will be updated including the resilience of coastal infrastructure and resilience theme (in general) topics. At least three new courses are expected to be submitted for approval during year 4-5 period. Various others continue to be updated to include the RCI topics.			
Technology Transfer: Establish a continuous technology transfer mechanisms on RCI to civil engineering/surveying students through training or access to the state of practice literature and educational resources. On the average, one activity per month is expected. Although our target student audience is the junior, senior, and graduate student audience, students from other disciplines will be also welcome. At least 30 students are targeted to be directly exposed to formal or informal technology transfer activities.	06/2019	100	
Enhance the Students' Study or Work Options and Opportunities in HSE: Provide civil and surveying students the opportunity to expand their opportunities to study and work in the HSE business and be a part of a pipeline for its national labor force team by means of alternative learning experiences.	06/2019	100	
Engage Faculty Leaders: Engage civil engineering and surveying faculty as leaders in the RCI field which help seek new opportunities in resilience of coastal infrastructure education, research and practice	05/2019	100	

11. Tables:

Table 1: Annual Courses and Enrollments

Table 1: Annual Courses and Enrollments

Courses Developed and Taught by University of Puerto Rico Mayaguez under Project **Education for Improving Resiliency of Coastal Infrastructure**					
Course Number	Course Title	Project Year			
INCI6997 INCI5995	Course Title: *"Rehabilitation of Coastal Structures (under development)"*- Guevara [Dual codes for graduate and undergraduate]	YR 1	YR 2	YR 3	YR 4
Status: Developed (D), Revised (R), and or Taught (T)			D	T	
Offering: Elective (E), Concentration (C), Minor (M)		-	E	E	
Enrollment		-	-	7	
INCI6XXX INCI5XXX	Course Title: *"Resilience and Reliability of Coastal Infrastructures (under development)"*- Saffar	YR 1	YR 2	YR 3	YR 4
Status: Developed (D), Revised (R), and or Taught (T)			D	R	R
Offering: Elective (E), Concentration (C), Minor (M)		-	E	E	
Enrollment		-	-	-	

INCI6995	Course Title: *"CE Special Problems"* (Graduate) Status: Developed (D), Revised (R), and or Taught (T) ● *"A Novel Boussinesq -Type Numerical Wave Model Development" – IPT* ● *"Stochastic Simulation of Tropical Cyclones for the Quantification of Uncertainty Associated with Storm Recurrence and Intensity: Phase II" – IPT* ● *"Analysis of a Ring Levee Breach Using Adaptive Hydraulic" – IPT* ● *"US Army Improved Ribbon Bridge" – IPT* ● *Feasibility of Using the Weather Research and Forecasting Model (WRF) as forcing to the Advanced Circulation Model (ADCIRC) – IPT* ● *"Assessment of Existing Tropical Cyclone Vortex Models for the Development of Wind and Pressure Profiles and Fields"* ● *Vulnerability of Rubble Mound Structures*	YR1 T T T	YR2 T T T T T	YR3 T	YR4 T
	Offering: Elective (E), Concentration (C), Minor (M)	E/C	E/C	C	C
	Enrollment	3	5	1	1
INCI5996	Course Title: *"Special Problems (Undergraduate Project)"* Status: Developed (D), Revised (R), and or Taught (T) ● *"Impact of Projected Sea Water Rise on Coastal Infrastructures" - IPT* *"Ship Simulation Study"- IPT* ● *"Utilities and Building Inventory For Resiliency Analyses at the Mayagüez Municipality Coastal Zone" - Dr. Ricardo Ramos* ● Assessment of Hurricane Vortex Models and Boundary Layer Models for the Development of Wind and Pressure Profiles and Fields - IPT	YR 1 T	YR 2 T T	YR 3	YR 4 T
	Offering: Elective (E), Concentration (C), Minor (M)	E	E		E
	Enrollment	1	4		1
INCI6066	Course Title: *MS-Thesis*	YR1	YR 2	YR 3	YR 4

	Status: Developed (D), Revised (R), and or Taught (T) ● *"Structural Effects of Tsunami Loads on Coastal Infrastructure," by Kevin Cueto (Ricardo Lopez)* ● *"Computation of Gradually Varied Flow in Channel Networks with Hydraulic Structures" by Felix Santiago (Walter Silva)* ● *"Cost analysis of the alternatives to mitigate damage to the infrastructure in Rincon" by Francisco Villafañe (Luis Aponte)* ● *"Stochastic Simulation of Tropical Cyclones for Quantification of Uncertainty Associated with Storm Recurrence and Intensity" by Efrain Ramos (Ismael Pagán-Trinidad and Norberto Nadal)*	D	D D T T	T T T T	T T
	Offering: Elective (E), Concentration (C), Minor (M)		C	C	C
	Enrollment	1	4	4	2
INCI6065	Course Title*: Master of Engineering Project* Status: Developed (D), Revised (R), and or Taught (T) *Structural Analysis of Common Coastal Structures found on the West Coast of Puerto Rico using FEMA P-646 by Jorge Romeu (Ricardo López)*	YR1	YR2 D	YR3 T	YR4 T
	Offering: Elective (E), Concentration (C), Minor (M)		C	C	C
	Enrollment		1	1	1
INCI8999	Course Title*: PhD Dissertation* Status: Developed (D), Revised (R), and or Taught (T) ● *"Resistencia a Cargas de Tsunami de Estructuras Críticas en el Norte de Puerto Rico" (Resistance to Tsunami Loads of Critical Structures in the North of PR) by Johnny Rosario* ● *"Variation of the nonlinear dynamic response of three-dimensional buildings of reinforced concrete considering the directionality of seismic accelerations" by Juan Rodríguez* ● *"Dynamic Identification and Nonlinear Modeling for the Structural Health Assessment*	YR 1 D	YR 2 D D T	YR 3 T T T	YR 4 T T T

	of Aged Coastal Infrastructure in Puerto Rico" by Angel Alicea				
Offering: Elective (E), Concentration (C), Minor (M)			C	C	C
Enrollment			3	3	3
INCI4950	Course Title: *Civil Engineering Integrated Design Project - Capstone Course*	YR 1	YR 2	YR 3	YR 4
Status: Developed (D), Revised (R), and or Taught (T)			T	T	T
Offering: Elective (E), Concentration (C), Minor (M)			C	C	C
Enrollment			45	43	65
CIMA8999	Course Title: *Marine Science PhD Dissertation*	YR 1	YR 2	YR 3	YR 4
Status: Developed (D), Revised (R), and or Taught (T)			D	D	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			1	1	
CIMA6999	Course Title: *Marine Science Master Thesis*	YR 1	YR 2	YR 3	YR 4
Status: Developed (D), Revised (R), and or Taught (T)			D	D	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			1	1	
INCI4998	Course Title: *Civil Engineering Undergraduate Research*	YR 1	YR 2	YR 3	YR 4
Status: Developed (D), Revised (R), and or Taught (T)			T	T	T
Offering: Elective (E), Concentration (C), Minor (M)			C	C	E
Enrollment			1	1	16
	Course Title:	YR 1	YR 2	YR 3	YR
Status: Developed (D), Revised (R), and or Taught (T)					
Offering: Elective (E), Concentration (C), Minor (M)					
Enrollment					

Table 2: Performance Metrics

PAGAN: Performance Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17— 6/30/18)	**Year 4** (7/1/18— 6/30/19)
HS-related internships (number)	10	16	9	9
Undergraduates provided tuition/fee support (number)		1	2 - ERDC	5
Undergraduate students provided stipends (number)		2	1	9
Graduate students provided tuition/fee support (number)	5	9	5	7
Graduate students provided stipends (number)	6	9	4	7
Undergraduates who received HS-related degrees (number)		N/A	2	3
Graduate students who received HS-related degrees (number)		N/A	2	1
Certificates awarded (number)		245	800	893
Graduates who obtained HS-related employment (number)		2	1	1
Lectures/presentations/seminars at Center partners (number)		1	2	2
DHS MSI Summer Research Teams hosted (number)		N/A	N/A	N/A
Journal articles submitted (number) *- ASEE, ASCE, ITE	1	0	4	3*
Journal articles published (number) *- ASEE, ASCE, ITE	1	0	4	3*
Conference presentations made (number) **-All kind of conferences, Seminars, and panels	2	31	23	62
Other presentations, interviews, etc. (number)	2	8	5	6
Trademarks/copyrights filed (number)		0	0	0
Requests for assistance/advice from DHS agencies (number)				10
Requests for assistance/advice from other Federal agencies or state/local governments (number)	5		4	9
Dollar amount of external funding	$95,760	$58,000	$110,534	$550K
Total milestones for reporting period (number)		2	7	9
Accomplished fully (number)	2	2	7	9
Accomplished partially (number)		N/A	N/A	N/A
Not accomplished (number)		N/A	N/A	N/A

SMITH, UNC-CH
DHS COASTAL RESILIENCE CENTER
EDUCATION PROJECT
YEAR 4 PROGRESS REPORT
July 1, 2018 – June 30, 2019

Project Title:
Continuation of the Natural Hazards Resilience Certificate Program and Assistance to FEMA

Principal Investigator Name/Institution:
Gavin Smith, UNC-CH Department of City and Regional Planning and Director, Coastal Resilience Center of Excellence (7/1/2018 – 12/31/2018); NCSU Department of Landscape Architecture, School of Design (1/1/2019 – 6/30/2020)

Other Partners/Institutions:

- Principal Investigator Gavin Smith joined the faculty at NC State University effective January 1, 2019. During Year 4, he taught one course in the Fall 2018 semester, and one course in the Spring 2019 semester at UNC-CH with CRC support.
- Other faculty at UNC-CH will continue to play a role in the UNCCH Graduate Certificate in Natural Hazards Resilience, pending internal departmental or institutional funding.
- Wei Mei, Assistant Professor, Department of Marine Sciences

Short Project Description ("elevator speech"):
The Graduate Certificate in Natural Hazards Resilience program at UNC-CH started in the Fall of 2015, with a focus on the nexus between the physical science underlying natural hazards phenomena and the policies, programs, and plans needed to help societies manage hazards and increase resilience. The program grew to incorporate direct student, faculty, and practitioner engagement as a way to enrich the student experience. The educational deliverables include classroom lectures and discussions, field trips to hazard-impacted communities, and the Natural Hazards Speaker Series Seminar, in which students learn about the field of hazards and disasters from guest speakers, including practitioners, academics, government agency officials, and local community members, among others. Students are also required to take at least one elective course in a related discipline. The delivery of these courses allows students enrolled in the program to earn the credits needed to graduate with the certificate notation stamped on their diplomas within two years, thereby increasing their marketability when seeking resilient-related employment in the HSE.

In addition to the educational deliverables, during Year 4 the PI developed a Scope of Work for Year 5 to provide assistance to FEMA in implementation of the Disaster Recovery Reform Act and to create a new Graduate Certificate in Disaster Resilient Policy, Engineering and Design, to include the development of a new 3-hour core course entitled Disaster Resilient Policy, Engineering and Design. The CRC will provide travel funds for Dr. Smith to meet with appropriate FEMA personnel to develop this Scope of Work.

1. Introduction and project overview:

This project has enabled the continued operation of the Graduate Certificate Program in Natural Hazards Resilience, which provides a platform to educate the next generation of natural hazards and disaster researchers and practitioners. The growing demand for students with an education in natural hazards resilience is evidenced by the hiring of all graduates in the field upon graduation. Graduates of this program have gone on to work in a number of areas including FEMA, consulting firms, regional planning organizations and state and local government agencies, and to continue their education as PhD candidates.

2. End users:

Primary end users of the educational component of this project include students at UNC-CH and other universities (e.g., NCSU, Duke) who participate in the Natural Hazards Resilience Certificate program. The education and training opportunities made available to students provide a unique combination of theory and practice, thereby better positioning them to serve as the next generation of natural hazards and disaster scholars and practitioners. Upon entering the workforce, these students have gone on to provide direct benefit to the agencies and organizations that have hired them to assist with issues tied to disaster recovery, mitigation, and hazards resilience. Employers have included emergency management and planning officials at federal, state, and local levels of government; regional planning organizations, design professionals involved in disaster resilient design, and private consulting firms engaged in hazard mitigation and recovery planning. In addition, some graduates have gone on to pursue PhD's, where they are focused on becoming faculty members focused on the study of natural hazards, disasters and climate change adaptation.

End users of the FEMA assistance component of this project include officials at FEMA who are directly engaged in the implementation of the Disaster Recovery Reform Act. In particular, the PI will advise the agency about policies and best practices to allocate disaster mitigation funding, as well other provisions in the act. In addition, research will be conducted on the role of states in fostering local capacity to implement the intent of the Disaster Recovery Reform Act.

3. Unanticipated Problems:

Unanticipated problems surrounded my move from UNCCH to NCSU in the Spring of 2019 which meant the Graduate Certificate Program might be discontinued. In the interim, I agreed to teach the required 1-credit hour Speaker Series course at UNCCH in the Spring of 2019 even though I was now employed full time at North Carolina State University. UNCCH has hired an adjunct faculty member to teach the required coursework in the Fall of 2019 and is exploring a range of alternatives to ensure the continuation of the program.

4. Students and recent graduates:

Student demographics were comprised of mainly master's students from UNCCH (14) and to a lesser extent Duke University (1). In addition, three UNCCH PhD students were enrolled in the program. In addition, a significant number of students enrolled in my classes that were not

members of the certificate cohort. For instance, my Fall 2018 course was comprised of 26 students. All graduates of the certificate program received jobs in the field, which totaled approximately 8 students, including 1 master's student who chose to pursue a PhD at MIT focused on natural hazards, disasters and climate change adaptation.

5. Project Impact:

The certificate was explicitly designed to educate and train graduates to work in the field as either practitioners or scholars. This was accomplished through a range of actions, including: 1) grounding coursework in the latest research findings and technical reports, 2) inviting internationally-renowned speakers to come to class to share with students their research and field-based professional experiences, including tips associated with what it takes to work in this profession; 3) conducting field trips to areas where students can observe how research and practice based readings, lecture material and conversations with others is relevant to activities happening on the ground; and 4) in prior years, certificate program students were involved in deep community engagement through efforts like the Hurricane Matthew Disaster Recovery and Resilience Initiative, which sought to assist 6 hard-hit communities with a range of planning and policy-related issues that are not typically addressed by federal and state agencies. This effort lasted for 1 and ½ years and provided a very unique and rich learning environment for 10 students enrolled in the certificate program.

6. Institutionalization:

The UNC Department of City and Regional Planning has expressed a commitment to continue the Certificate in Natural Hazards Resilience by creating a permanent faculty position to assume this task. At this time, an adjunct position has been created to teach the certificate classes beginning in the Fall of 2019. In addition, the UNCCH's Department of City and Regional Planning has hired a junior faculty member who is focused on natural hazards resilient research. The position is well aligned with a new initiative titled Environment, Ecology, and Energy Program at UNC-CH. The stated priorities of the emerging program include coastal and hazards resilience, enhanced experiential education, and developing stronger alliances with the Department of City and Regional Planning through graduate certificates.

7. Interactions with research projects:

Interactions with SUMREX involved lectures provided by Dr. Ismael Pagan and Dr. Ricardo Lopez from the University of Puerto Rico at Mayaguez during my Spring Speaker Series class as well as a trip I took to UPRM to conduct a class lecture and explore future collaborative opportunities with Dr. Pagan, Dr. Lopez and other UPRM faculty. Lectures conducted by Dr. Pagan and Lopez were tied to their ongoing research and used to inform students participating in the UNCCH graduate certificate program. My lecture informed UPRM students working with Dr. Pagan and Dr. Lopez as part of their educational initiative.

8. Publications:

Journal Articles

Horney, Jennifer, Carolina Dwyer, Bhagath Chirra, Kerry McCarthy, Jennifer Shafer and **Gavin Smith**. 2018. Measuring Successful Disaster Recovery, International Journal of Mass Emergencies and Disasters 36(1): 1-22.

Gavin Smith, Lea Sabbag and Ashton Rohmer. 2018. A Comparative Analysis of the Roles Governors Play in Disaster Recovery, Risk, Hazards & Crisis in Public Policy. 9(2): 205-243. DOI: 10.1002/rhc3.12133.

Smith, Gavin. 2016. Remembrances of the Past, Concerns for the Future, and the Potential Resilience of a Small Coastal Town, Southern Cultures. Summer: 64-87.

Horney, Jennifer, Caroline Dwyer, Meghan Aminto, Phil Berke and **Gavin Smith**. 2016. Developing Indicators to Measure Post-Disaster Community Recovery, Disasters 41(1): 124-149.

Lyles, Ward, Philip Berke and **Gavin Smith**. 2015. Local Plan Implementation: Assessing Conformance and Influence of Local Plans in the United States, Environment and Planning B: Planning and Design.

Smith, Gavin. 2014 (Autumn). Involving Land Use Planners in Pre-Event Planning for Post-Disaster Recovery. Planner's Note, Journal of the American Planning Association. 80(4): 306-307. Special Issue, Planning for Disaster Recovery.

Berke, Philip, Ward Lyles, and **Gavin Smith**. 2014. Impacts of Federal and State Mitigation Policies on Local Land Use Policy, Journal of the Planning Education and Research. 34(1): 60-76.

Lyles, Ward, Phil Berke and **Gavin Smith**. 2014. A Comparison of Local Hazard Mitigation Plan Quality in Six States, USA, Landscape and Urban Planning 122 (February): 89-99.

Lyles, Ward, Phil Berke and Gavin Smith. 2014. Do Planners Matter? Examining Factors Driving Incorporation of Land Use Approaches into Hazard Mitigation Plans, Journal of Environmental Planning and Management 57(2):792-811.

Sandler, Dylan and **Gavin Smith**. 2013. Assessing the Quality of State Disaster Recovery Plans: Implications for Policy and Practice, Journal of Emergency Management 11(4):281-291.

Smith, Gavin, Ward Lyles, Philip Berke. 2013. The Role of the State in Building Local Capacity and Commitment for Hazard Mitigation Planning, International Journal of Mass Emergencies and Disasters 31(2): 178-203.

Smith, Gavin, Dylan Sandler and Mikey Goralnik. 2013. Assessing State Policy Linking Disaster Recovery, Smart Growth and Resilience in Vermont Following Tropical Storm Irene, Vermont Journal of Environmental Law 15: 67-102.

Berke, Philip, **Gavin Smith**, Ward Lyles. 2012. Planning for Resiliency: Evaluation of State Hazard Mitigation Plans Under the Disaster Mitigation Act, Natural Hazards Review 13(2): 139-150.

Smith, Gavin and Tom Birkland. 2012. Building a Theory of Recovery: Institutional Dimensions. Special Edition on Developing a Theory of Disaster Recovery. International Journal of Mass Emergencies and Disasters 30(2): 147-170.

Smith, Gavin. 2010. Disaster Recovery Planning in the United States: Lessons for the Australasian Audience Australasian Journal of Disaster and Trauma Studies. Natural Hazards Planning in Australasia. ISSN: 1174-4707, Volume 2010-1.

Books

Glavovic, Bruce and **Gavin Smith**. 2014. *Adapting to Climate Change: Lessons from Natural Hazards Planning*. New York: Springer.

Smith, Gavin. 2011. *Planning for Post-Disaster Recovery: A Review of the United States Disaster Assistance Framework*. Washington, D.C.: Island Press.

Book Chapters

Smith, Gavin. "The Role of States in Disaster Recovery: An Analysis of Engagement, Collaboration, and Capacity Building." 2019. In *Building Community Resilience to Disasters: The Handbook of Planning for Disaster Resilience*, Routledge Press.

Smith, Gavin, Amanda Martin and Dennis Wenger. "Disaster Recovery in an Era of Climate Change: The Unrealized Promise of Institutional Resilience." 2017. In *Handbook of Disaster Research*, Second Edition, Eds. Havidan Rodriguez, Joseph Trainor and William Donner. New York: Springer.

Smith, Gavin. "Pre- and Post-Disaster Conditions, their Implications, and the Role of Planning for Housing Recovery." 2017. Chapter 18, pp. 277-292. In *Coming Home After Disaster: Multiple Dimensions of Housing Recovery*, Eds. Ann-Margaret Esnard and Alka Sapat. Boca Raton, Florida" CRC Press.

Smith, Gavin. "Planning for Sustainable and Disaster Resilient Communities." 2015. Chapter 9, pp. 249-279. In Hazards Analysis: Reducing the Impact of Disasters, Ed. John Pine (2nd edition). Boca Raton, Florida: CRC Press.

Smith, Gavin. "Creating Disaster Resilient Communities: A New Hazards Risk

Management Framework." 2015. Chapter 10, pp. 281-308. In Hazards Analysis: Reducing the Impact of Disasters, Ed. John Pine. (2nd edition). Boca Raton, Florida: CRC Press.

Smith, Gavin. "Applying Hurricane Recovery Lessons in the U.S. to Climate Change Adaptation: Hurricanes Fran and Floyd in North Carolina, USA." 2014. Chapter 9, pp. 193-229. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Bruce Glavovic and **Gavin Smith**. "Introduction: Learning from Natural Hazards Experience to Adapt to Climate Change." 2014. Chapter 1, pp. 1-38. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Smith, Gavin. "Disaster Recovery in Coastal Mississippi (USA): Lesson Drawing from Hurricanes Camille and Katrina." 2014. Chapter 14, pp. 339-368. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Smith, Gavin and Bruce Glavovic. "Conclusions, Recommendations, and Next Steps: Integrating Planning for Natural Hazards and Climate Change Adaptation." 2014. Chapter 16, pp. 405-450. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Smith, Gavin. "Catastrophic Disaster Recovery: An Institutional Network Perspective." 2013. Chapter 12, pp. 281-300. In *Preparedness and Response to Catastrophic Disasters*, Ed. Richard A. Bissell. Boca Raton, Florida: CRC Press.

Smith, Gavin. 2009. "Planning for Sustainable and Disaster Resilient Communities." Chapter 9, pp. 221-247. In *Natural Hazards Analysis: Reducing the Impact of Disasters*, Ed. John Pine. Boca Raton, Florida: CRC Press.

Smith, Gavin. 2009. "Disaster Resilient Communities: A New Hazards Risk Management Framework." Chapter 10, pp. 249-267. In *Natural Hazards Analysis: Reducing the Impact of Disasters*, Ed. John Pine. Boca Raton, Florida: CRC Press.

Smith, Gavin. 2009. "A Review of the United States Disaster Assistance Framework: Planning for Recovery." Chapter 7, pp. 99-111. In *Emergency Management in Higher Education: Current Practices and Conversations*, Ed. Jessica Hubbard. Fairfax, Virginia: Public Entity Risk Institute.

Smith, Gavin. 2009. "Recovery and Reconstruction." Session 10, pp. 1-32. In *Catastrophe Readiness and Response*, Ed. Richard Bissell. Emmitsburg, Maryland: FEMA Emergency Management Institute, Higher Education Project.

Accessed at: http://training.fema.gov/EMIWeb/edu/catastrophe.asp.

Berke, Phil and **Gavin Smith**. 2009. "Hazard Mitigation, Planning and Disaster Resiliency: Challenges and Strategic Choices for the 21st Century." Chapter 1, pp. 1-20. *Building Safer Communities: Risk, Governance, Spatial Planning and Responses to Natural Hazards*, Ed. Urbano Fra Paleo. NATO Science for Peace and Security Series, E, Human and Societal Dynamics, Volume 58. Amsterdam: ISO Press.

Technical Reports

Smith, Gavin, Mai Thi Nguyen, Colleen Durfee, Darien Williams, Ashton Rohmer. September, 2018. *Resilient Design Education in the United States*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Resilience Center of Excellence.

Smith, Gavin, Barry Hokanson, Link Walther, Jessica Southwell. 2017. *Hurricane Matthew Disaster Recovery and Resilience Initiative. A Project of the North Carolina Policy Collaboratory*. Chapel Hill, North Carolina: Hurricane Matthew Recovery and Resilience Initiative.

Smith, Gavin, Lea Sabbag, Ashton Rohmer. *Role of States in Recovery Video Training Guide*. March, 2016. Chapel Hill, North Carolina: Department of Homeland Security, Coastal Resilience Center of Excellence.

Horney, Jennifer and Gavin Smith. September, 2015. *Measuring Successful Recovery: A Case Study of Six Communities in Texas.* Tysons, Virginia: LMI Research Institute.

Tuckson, Reed V., et. al 2015. Healthy, Resilient, and Sustainable Communities After Disasters: Strategies, Opportunities, and Planning for Recovery. Washington, D.C.: National Academies Press (consultant).

Smith, Gavin. *Disaster Recovery Funding: Achieving a Resilient Future?* National Academy of Science, Institute of Medicine. June, 2014. Commissioned by the National Academy of Science, Committee on Post-Disaster Recovery of a Community's Public Health, Medical and Social Services.

Smith, Gavin, David Perkes, Andy Rumbach, Darrin Punchard. September, 2014. Community Planning Assistance Team Report. *Lyons, Colorado: Designing a More Resilient Future*. Chicago, Illinois: American Planning Association.

Smith, Gavin, John Whitehead, Nikhil Kaza, Jae Park, John Pine, Randy Kolar. December, 2013. *Aggregate Flood Hazard Risk Reduction Scoping Project*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazards Center of Excellence.

Smith, Gavin, Dylan Sandler, Mikey Goralnik. October, 2013. *Vermont State Agency Policy Options. Smart Growth Implementation Assistance Program: Disaster Recovery and*

Long-Term Resilience Planning in Vermont. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazards Center of Excellence.

Smith, Gavin and Dylan Sandler. July, 2012. *State Disaster Recovery Guide*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazards Center of Excellence.

Lyles, Ward, Philip Berke and Gavin Smith. July, 2012. *Evaluation of Local Hazard Mitigation Plan Quality.* Center for Sustainable Community Design and the Coastal Hazards Center. Chapel Hill, North Carolina: University of North Carolina at Chapel Hill.

Burkett, V.R. and Davidson, M.A. 2012. *Coastal Impacts, Adaptation, and Vulnerability: A Technical Input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment.* Contributing author. Washington, D.C.: Island Press.

Berke, Philip, Gavin Smith and Sara Reynolds. 2011. *Community Rating System: Plan Evaluation & Model Practices.* Federal Emergency Management Agency. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazard Center of Excellence.

Berke, Philip, Gavin Smith, Dave Salvesen, Ward Lyles, and Dylan Sandler. December, 2011. *An Evaluation of Floodplain Management Planning Under the Community Rating System.* Final Report for the Federal Emergency Management Agency. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazard Center of Excellence.

Smith, Gavin and Victor Flatt. 2011. *Assessing the Disaster Recovery Planning Capacity of the State of North Carolina.* Research Brief. Durham, North Carolina. Institute for Homeland Security Solutions.

Berke, Philip, Gavin Smith, and Ward Lyles. August, 2009. *State Hazard Mitigation Plan Evaluation and Model Practices. Analysis of Federal Mitigation Policy in the U.S.: Mitigation Plans, Expenditures, Civic Engagement, and Local Capability.* Report to the Department of Homeland Security Center of Excellence – Disasters, Coastal Infrastructure and Emergency Management, University of North Carolina at Chapel Hill, Chapel Hill, NC.

Student Theses and Dissertations completed

Master's Project Committee, Master's Candidate. Margaret Keener. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2017-2019.

Department of Homeland Security, Workforce Development Grant Recipient. Master's Candidate. Jessamin Straub. Department of Marine Science. University of North Carolina at Chapel Hill. 2018-2019.
Master's Project Committee, Master's Candidate. Chair. Christian Kamrath. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Chair. Meredith Burns. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Chair. Estefany Noria. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2017.

Master's Project Committee, Master's Candidate. Kevin Fish. Sanford School of Public Policy. Duke University. 2017.
Master's Project Committee, Master's Candidate. Chair. Darien Williams. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Colleen Durfee. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Chair. Ashton Rohmer. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2017.

Master's Project Committee, Master's Candidate. Chair. Abby Moore. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2017.

Master's Project Committee, Master's Candidate. Chair. Jamar Nixon. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2017.
Dissertation Committee, Doctoral Candidate. Sierra Woodruff. Curriculum for the Environment and Ecology, University of North Carolina at Chapel Hill. Local Climate Change Adaptation Plan Quality and Content in the United States. 2012-2017.

Master's Project Committee, Master's Candidate. Chair. Lea Sabbag. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2016.

Master's Project Committee, Master's Candidate. Chair. Christina Hurley. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2016.

Dissertation Committee, Doctoral Candidate (external committee member). Alex Greer. Disaster Science and Management, University of Delaware. Resettlement After Disaster: Case Studies following Hurricane Sandy. 2013-2015.

Master's Project Committee, Master's Candidate. Chair. Caroline Dwyer. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Building Back Better? A Comparison of Intergovernmental Cooperation Frameworks Influencing Post-Sandy Recovery and Rebuilding in Coastal New Jersey and New York. 2013-2014.
Master's Project Committee, Master's Candidate. Chair. Fayola Jacobs. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Hazard Mitigation Planning and Policy in the Caribbean. 2013-2014.

Master's Project Committee, Master's Candidate. Capstone Committee Member. Rachel Meyerson. Department of Public Administration, University of North Carolina at Chapel Hill. A Tool for Evaluating Plan Quality of Local Government Response Plans. 2011-2012.

Master's Project Committee, Master's Candidate. Chair. Rachel Meyerson. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Assessing the Quality of Disaster Response Plans. 2011-2012.

Dissertation Committee, Doctoral Candidate. Ward Lyles. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Stakeholder Network Influences on Local-Level Hazard Mitigation Planning Outputs. 2010-2012.

Master's Project Committee, Master's Candidate. Co-Chair. Dylan Sandler. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Assessing the Quality of Disaster Recovery Plans. 2011.
Dissertation Committee, Doctoral Candidate (external committee member). Wendy Saunders. Department of Resource and Environmental Planning, Massey University, Manawatu, New Zealand. Innovative Land-Use Planning for Natural Hazard Risk Reduction in New Zealand. 2011.

9. Year 4 Education Activities and Milestone Achievements:

Education Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Education Activities	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed / Other comments
Teach one required certificate course in Fall semester 2018 (PLAN 755: Planning for Natural Hazards and Climate Change Adaptation (3 hours)	12/2018	100%	
Teach one required certificate course in Spring semester 2019 (PLAN 754: Natural Hazards Resilience Speaker Series Seminar (1 hour)	05/2019	100+%	In addition, taught same class at NCSU as part of new Graduate Program in Disaster Resilient Policy, Engineering and Design
Education Milestones			
Conduct one Certificate course-related field trip for students	12/2018	100%	Location: Charlotte, NC to see nationally-recognized floodplain management program
Teach 1 required certificate course in Fall semester 2018	12/2018	100%	

10. Year 4 Transition Activities and Milestone Achievements:

Transition Activities and Milestones: Status as of 6/30/2019

Reporting Period 7/1/2018 – 6/30/2019			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Create faculty position at UNCCH to continue leading UNCCH Certificate Program in Natural Hazards Resilience, pending institutional support	Spring 2019	100%	
Recruit for permanent faculty member to lead UNCCH Graduate Certificate Program	Spring 2019	100%	
Transition Milestone			
--			

11. Tables:

Table 1: Annual Courses and Enrollments

Table 1: Annual Courses and Enrollments

Courses Developed and Taught by University of North Carolina under Project Expanding Coastal Resilience Education at UNC					
PLAN 755	Course Title: Planning for Natural Hazards and Climate Change Adaptation	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	T	T
	Offering: Elective (E), Concentration (C), Minor (M)	C	C	C	C
	Enrollment	8	20	40	26
PLAN 754	Course Title: Speaker Series	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	T	T
	Offering: Elective (E), Concentration (C), Minor (M)	C	C	C	C
	Enrollment	14	31	28	32;22*
PLAN 756	Course Title: Survey of Natural Hazards and Disasters	YR 1	YR 2	YR 3	YR 4
	Status: Developed (D), Revised (R), and/or Taught (T)	T	T	T	NA
	Offering: Elective (E), Concentration (C), Minor (M)	C	C	C	
	Enrollment	9	15	26	

*Taught 32 UNCCH students and 22 NCSU students in the Fall of 2019.

Table 2: Performance Metrics

SMITH: Performance Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)	**Year 3** (7/1/17-6/30/18)	**Year 4** (7/1/18-6/30/19)
HS-related internships (number)	2	14		4
Undergraduates provided tuition/fee support (number)				
Undergraduate students provided stipends (number)		1		
Graduate students provided tuition/fee support (number)	2	2	2	
Graduate students provided stipends (number)		13	23	
Undergraduates who received HS-related degrees (number)				
Graduate students who received HS-related degrees (number)		3	5	4
Certificates awarded (number)	1	3	5	4
Graduates who obtained HS-related employment (number)	1	3	5	4
Lectures/presentations/seminars at Center partners (number)	3	3	4	3
DHS MSI Summer Research Teams hosted (number)				1
Journal articles submitted (number)	1	1	2	3
Journal articles published (number)		2	2	
Conference presentations made (number)	6	12	29	22
Other presentations, **interviews**, etc. (number)		11	14	17
Trademarks/copyrights filed (number)				
Requests for assistance/advice from DHS agencies (number)		1	5	2
Requests for assistance/advice from other agencies or governments (number)		4	2	6
Dollar amount of external funding	--	$614,966	$1,204,382	$54,329
Total milestones for reporting period (number)	10	11	11	3
Accomplished fully (number)	9	11	11	3
Accomplished partially (number)	1			
Not accomplished (number)				

Appendices

COASTAL RESILIENCE CENTER
A U.S. Department of Homeland Security Center of Excellence

DHS Workforce Development Grant
Jessamin Straub: Student Final Performance Report

1) Jessamin Straub, Department of Marine Sciences, University of North Carolina at Chapel Hill

2) Master of Marine Sciences, 2019

3) The relevant courses that I took while a WFDG student include:
   - Natural Hazards & Climate Change (PLAN 755)
   - Natural Hazards and Disasters (PLAN 756)
   - Natural Hazards Speaker Series (PLAN 754)
   - Advanced Coastal Environmental Change (GEOL 710)
   - Science and Public Policy (PLCY 575)
   - Physical Oceanography (MASC 506)
   - Introduction to GIS (GEOG 591)
   - Advanced GIS (GEOG 591)

4) My co-advisors for my Marine Sciences degree are Dr. Antonio Rodriguez and Dr. Rick Luettich. My UNC Chapel Hill faculty mentor for the Workforce Development Grant is Dr. Gavin Smith.

5) The title of my master's research thesis is *predicting dune erosion at dissipative, intermediate, and reflective beaches*.

6) Research Project Abstract:

Coastal communities commonly expend resources on the conservation and restoration of dunes, because dunes help protect infrastructure from storm waves and flooding. Predicting dune erosion is increasingly important for making management decisions related to flood-hazard mitigation as sandy beaches continue to erode, coastal populations increase, sea-level rises, and storms become more powerful. The information necessary to implement a dune erosion forecasting model includes the elevation of the dune toe, beach slope, and total water elevation (tide + storm surge + wave runup). Contemporary beach morphology data is important for predicting dune

erosion because the elevation of the dune toe is the water level threshold for erosion, and the beach slope is needed for calculating wave runup. Beach morphology is commonly dynamic, limiting the duration over which these data are useful and forcing models to be parameterized with beach morphology data that does not reflect current conditions. We used hindcast water level and wave information from the coupled ADCIRC + SWAN (ADvanced CIRCulation + Simulating WAves Nearshore) model in combination with recent beach morphology data to predict collision events at three barrier island sites in North Carolina: Core Banks (dissipative), Shackleford Banks (intermediate), and Onslow Beach (reflective). Predictions were compared with continuous observations of water level and time-lapse beach photography to assess accuracy. This work emphasizes the importance of constraining beach slope, especially at intermediate and reflective beaches to accurately predict dune erosion. The beach slope of dissipative beaches is stable, while intermediate and reflective beaches are variable, requiring frequent assessment of beach morphology. This information is useful for identifying shorelines that require more resources for beach surveying to maximize predictive power of the storm impact scaling model.

7) Relevance to Homeland Security:
    - This research is important as coastal communities often spend money and resources to protect coastal dunes from flooding and erosion. Being able to forecast when coastal communities will experience erosion can provide tools to assist in pre and post storm resources and limit building in highly vulnerable areas, and ultimately help coastal communities become more resilient.

8) Research accomplishments and contributions:
    - This research project has shown using the ADCIRC + SWAN model along with recent beach morphology data, can provide a tool to accurately predict dune erosion at different types of beach environments. The research is built on previous work in this field, and I hope this project will contribute to future work. In addition to publishing this work as my master's research with the UNC Graduate school, this research will be submitted as a manuscript to a peer-reviewed journal.

9) New skills and/or knowledge:
    - The WFDG has allowed me to develop my scientific skills as a marine scientist while building a strong understanding of coastal hazards and resilience. Through the Natural Hazards and Resilience Certificate Program I have been exposed to the human dimension of coastal hazards and experienced first-hand resilient coastal communities. The WFDG program has allowed me to expand my knowledge beyond

the UNC Marine Sciences program, such as learning about socially vulnerable populations and the connections to coastal hazards and resilience.

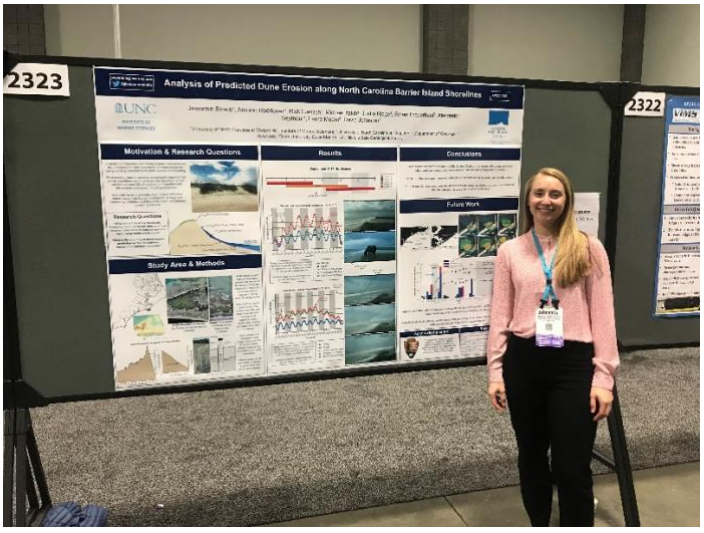
- Additionally, the WFDG program has exposed me to multiple disciplines and has helped me develop communication skills when addressing interdisciplinary problems.

10) Relevant conferences, seminars and/or lectures:

- American Geophysical Union Fall Meeting (Hazards and Resilience Sections)
- UNC Climate Change and Resilience Symposium
- UNC Graduate Research and Policy Expo
- In addition to conferences and lectures that I was able to attend, I also greatly benefited from field trips through the Natural Hazards and Resilience Certificate Program. The below pictures are from our class trip to Mecklenburg County where we learned first-hand about planning for future flood hazards and storm water management.

11) Presentations, poster sessions:

- UNC Institute of Marine Sciences- Research Applied to Managing the Coast Symposium (RAMCS)- oral presentation
- UNC Graduate Research and Policy Expo- poster presentation
- American Geophysical Union Fall Meeting- poster presentation (pictured below)



12) Internships & Experiences:

- During my time as a WFDG student and through the Natural Hazards and Resilience Certificate Program I was selected as a participant for the American Meteorological Society's Summer Policy Colloquium. The policy colloquium occurred in June 2018 in Washington D.C. The program provided me with the opportunity to understand the federal budget and policy process, create unique professional connections, and critically evaluate legislation such as the Weather Act. Following the Colloquium, I eagerly communicated the importance of science-based decision making to my peers through postings on the UNC Marine Sciences student blog. This experience enhanced my belief that science and policy are connected and most successful when accomplished together. The photos below show pictures from the experience.

13) Personal Reflection:

- My time as a WFDG recipient has impacted me personally by allowing me to gain the skills and knowledge to be successful within a career of coastal hazards and resilience. The program exposed me to all different types of career paths and

opportunities that are exciting and interesting to me. Through the program I've been able to hone my interests as well as get a broad understanding of the interdisciplinary work within the hazards and resilience field.

- The program exceeded my expectations, and I think puts me in a qualified and unique position for my career goals.
- The program has provided me with unique skills and experiences to foster collaboration between the spheres of science, public policy, and communication. My career goal is to bring relevant coastal science research to communities while making the research relatable, accessible, and beneficial to crafting effective policy. The WFDG program prepared me for my long-term goals by broadening my knowledge across disciplines, providing me the platform to engage with diverse stakeholders, and develop a passion for coastal hazards science, public planning and policy, and risk communication.

14) Post-Graduation Employment:

- I have been selected as a John A. Knauss Marine Policy Fellowship Finalist through Sea Grant. The Fellowship is a unique educational and professional experience in ocean, coastal, and Great Lakes resources and in national policy and management decisions related to those resources. The Fellowship matches graduate students with "hosts" in the legislative and executive branches of government located in the Washington, D.C. area, for a one-year paid fellowship.
- This Fellowship relates to increasing resilience by offering direct experience working on the latest issues in ocean and coastal management, research, and policy. A lot of the fellowship is centered around communicating issues, working collaboratively together with diverse groups, and working towards management and policy decisions that help communities become more resilient.
- Details regarding my fellowship are forthcoming following placement week in October 2019.

15) Contact information:

On file

Appendix B – CRC PI Publications
2015-2019

RESEARCH PROJECTS

Cox:

- Park, H., Tomiczek, T., **Cox, D.T., van de Lindt, J.W.**, Lomonaco, P. (2017) "Experimental Modeling of Horizontal and Vertical Wave Forces on an Elevated Coastal Structure," *Coastal Engineering*, 128, 58-74. DOI: 10.1016/j.coastaleng.2017.08.001
- Do, Trung, **van de Lindt, J., Cox, D.T.** (2016) "Performance-Based Design Methodology for Inundated Elevated Coastal Structures Subjected to Wave Load Engineering Structures," *Engineering Structures*, 117, 250 – 262. DOI: 10.1016/j.engstruct.2016.02.046
- Park, H., Do, T., Tomiczek, T., Cox, D.T., van de Lindt, J.W. (2018) "Numerical Modeling of Non-breaking, Impulsive Breaking, and Broken Wave Interaction with Elevated Coastal Structures: Laboratory Validation and Inter-Model Comparisons," *Ocean Engineering*, 158, 15, 78-98. DOI: 10.1016/j.oceaneng.2018.03.088
- Tomiczek, T, A Wyman, H Park, **DT Cox** (2019) "Modified Goda Equations to Predict Pressure Distribution and Horizontal Forces for Design of Elevated Coastal Structures," *J. Waterway Port Coastal and Ocean Engineering (*accepted).
- Do, T, **JW van de Lindt, DT Cox** (2019) "Hurricane Surge-Wave Building Fragility Methodology for Use in Damage, Loss, and Resilience Analysis," *J. Structural Engineering* (In Press).

Conference Papers

- Do, T., Tomiczek, T., **van de Lindt, J. Cox, D.** (2017) "Development of Physics-Based Building Fragility Surfaces for Near-Coast Community Modeling," *International Conference on Coastal and Ocean Engineering*, Osaka, Japan.
- Lomonaco, P., P. Arduino, A. Barbosa, D. Cox, T. Do, M. Eberhard, M. Motley, K. Shekhar, T. Tomiczek, H. Park, J. W. van de Lindt, A. Winter (2018) "Experimental Modeling of Wave Forces and Hydrodynamics on Elevated Coastal Structures Subject to Waves, Surge or Tsunamis: The Effect of Breaking, Shielding and Debris, *International Conference on Coastal Engineering*, ASCE.
- Park, H., Do, T., Tomiczek, T., **Cox, D., van de Lindt, J.W.** (2018) "Laboratory Validation and Inter-Model Comparisons of Non-breaking, Impulsive Breaking, and Broken Wave Interaction with Elevated Coastal Structures using IHFOAM and FLUENT," *International Conference on Coastal Engineering*, ASCE.
- Tomiczek, T., Wyman, A., Park, H., **Cox, D.T.** (2018) "Application and modification of Goda Formulae for Non-impulsive Wave Forces on Elevated Coastal Structures," *international Conference on Coastal Engineering*, ASCE.
- Tomiczek, T., Park, H., **Cox, D.T.**, Lomonaco, P., **van de Lindt, J.W.** (2018) "Application and modification of Design Formulae for Impulsive Wave Forces on Elevated Coastal Structures,"

International Conference on the Application of Physical Modelling in Coastal and Port Engineering and Science (Coastlab18), IAHR.

- Do, T, JW van de Lindt W, DT Cox (2018) "Physic-Based Component Fragility Model for Near-Coast Residential Wood Building Subjected to Hurricane Wave and Surge" Engineering Mechanics Institute Conference 2018, Cambridge MA.

Thesis/Dissertation and Reports

- Trung Q. Do. *Fragility Approach for Performance-Based Design in Fluid-Structure Interaction Problems, Part I: Wind and Wind Turbines; Part II: Waves and Elevated Coastal Structures*, (2016), Ph.D. Dissertation, Colorado State University.
- William Short. *A laboratory study of horizontal and vertical regular wave forces on an elevated structure*. (2016). MS Thesis, Oregon State University.
- Benjamin Hunter. *Exceedance Probabilities of Hurricane Wave Forces on Elevated Structures*. (2016). MS Thesis, Oregon State University.
- Jason Burke. *Design and Structural Testing of a 1:6 Scaled, Light-frame Construction, Near-coastal, Residential Structure*. (2018). MS Thesis, Oregon State University.
- Matt Karney. *Hydrodynamic Testing on a 1:6 Scale, Wood Framed Near-Coast Residential Structure*. (2018). MS Thesis, Oregon State University.

Berke:

- Newman, Galen, Malecha, Matt, Yu, Si, Qipao, Z., Horney, Jen, Lee, Daemyung, Kim, Young., Lee, R.J., & Berke, Philip. 2019. Integrating a Resilience Scorecard and Landscape Performance Tools into a Geodesign Process. Landscape Research. DOI: 10.1080/01426397.2019.1569219

- Berke, Philip, Siyu Yu, Matt Malecha, John Cooper. 2019. Plans that Disrupt Development: Equity Policies and Social Vulnerability in Six Coastal Cities. Journal of Planning Education and Research. (forthcoming).

Prochaska:

- Mundorf, N., Redding, C.A., **Prochaska, J.O.,** **Paiva, A.L.**, & **Rubinoff, P.** (2017). Resilience and Thriving in spite of Disasters: A Stages of Change Approach. In A. Fekete & Fiedrich, F. *Urban Disaster, Resilience and Security.* Berlin: Springer.

Twilley:

N/A

Blanton:

N/A

Luettich

Gao, J., 2018. On the Surface Wind Stress for Storm Surge Modeling, PhD Dissertation UNC Chapel Hill, 12/2018.

Asher, T.G, Luettich, R.A. Jr., Fleming, J.G, Blanton, B.O., in review, Dynamic Water Level Correction in Storm Surge Models Using Data Assimilation, Ocean Modelling

Hagen:

- Santiago-Collazo, F.L., Bilskie, M.V., Hagen, S.C. (2019) "A comprehensive review of compound inundation models," *Environmental Modelling & Software*, Accepted June 17.
- Bilskie, M.V., Asher, T.G., Fleming, J.G., Hagen, S.C., Kaiser, C., Luettich Ur., R.A., Twilley, R. (2019) "Real-time storm surge predictions during Hurricane Michael," *Geophysical Research Letters*, In Progress (Previously submitted and being revised).
- Bilskie, M.V., Hagen, S.C., Medeiros, S.C. (2019) "Unstructured finite element mesh development for real-time hurricane storm surge forecasting," *Coastal Engineering*, In Preparation.

Dietrich:

- A Gharagozlou*, JC Dietrich, A Karanci, RA Luettich, MF Overton. "Storm-Driven Erosion and Inundation of Barrier Islands from Dune- to Region-Scales." Coastal Engineering, in review.
- A Thomas*, JC Dietrich, TG Asher, M Bell, BO Blanton, JH Copeland, AT Cox, CN Dawson, JG Fleming, RA Luettich (2019). "Influence of Storm Timing and Forward Speed on Tide-Surge Interactions during Hurricane Matthew." Ocean Modelling, 137, 1-19, DOI: 10.1016/j.ocemod.2019.03.004.
- R Cyriac*, JC Dietrich, JG Fleming, BO Blanton, C Kaiser, CN Dawson, RA Luettich (2018). "Variability in Coastal Flooding Predictions due to Forecast Errors during Hurricane Arthur." Coastal Engineering, 137(1), 59-78. DOI: 10.1016/j.coastaleng.2018.02.008.

Resio:

- **Resio, D.T.**, Asher, T.G., and J.I. Irish, 2017: The effects of natural structure on estimated tropical cyclone surge extremes, J. Nat. Haz., currently available online, Nat Hazards, DOI: 10.1007/s11069-017-2935-y
- Irish, J.L., Weiss, R. and **D.T. Resio**, "Physical Characteristics of Coastal Hazards and Risks", Chapter 25, Springer Handbook of Ocean Engineering, Springer Dordrecht Heidelberg London New York, M. Dhanak and N. Xiros (Eds.), 549–562.
- **Resio, D.T.**, Tumeo, M.A., and J.L. Irish, "Statistical Characterization of Hazards and Risk in Coastal Areas," Chapter 26, Springer Handbook of Ocean Engineering, Springer Dordrecht Heidelberg London New York, M. Dhanak and N. Xiros (Eds.), 567–593.

- "Dynamic Water Level Correction in Storm Surge Models Using Data Assimilation." Authors: Taylor G. Asher, Richard A. Luettich Jr. and Jason G. Fleming. Submitted to Ocean Modelling. In revision.
- "Influence of storm timing and forward speed on tides and storm surge during Hurricane Matthew." Authors: Ajimon Thomas, JC Dietrich, TG Asher, M Bell, BO Blanton, JH Copeland, AT Cox, CN Dawson, JG Fleming, RA Luettich. Ocean Modelling. Published. https://doi.org/10.1016/j.ocemod.2019.03.004

- "Forecasting Model, Forecast Advisories and Best Track in a Wind Model, and Observed Data – Case Study Hurricane Rita." Authors: Abram Musinguzi, Muhammad Akbar, Jason G. Fleming, Samuel K. Hargrove. Journal of Marine Science and Engineering. Published. J. Mar. Sci. Eng. 2019, 7(3), 77; https://doi.org/10.3390/jmse7030077
- Media coverage of the 2019 Texas ADCIRC Week training event that PI Jason Fleming organized: "DesignSafe ADCIRC Provides Storm Surge Simulators for Natural Hazards Community" (picked up and republished by HPCWire): https://www.hpcwire.com/off-the-wire/designsafe-adcirc-provide-storm-surge-simulators-for-natural-hazards-community/
- CRC Coverage of 2019 ADCIRC Users Group Meeting event that PI Jason Fleming organized: https://www.flickr.com/photos/133219410@N05/albums/72157709249042136

Ginis:

- Gao K, and I. Ginis, 2018: On the characteristics of roll vortices under a moving hurricane boundary layer, *J. Atmos. Sci*., 75, 2589-2598. https://doi.org/10.1175/JAS-D-17-0363.1
- Chen*, X., I. Ginis, and T. Hara, 2018: Sensitivity of offshore tropical cyclone wave simulations to spatial resolution in wave models. J. Mar. Sci. Eng., 6, 116. http://www.mdpi.com/2077-1312/6/4/116/
- Jisan, M. A. *, Bao, S., & Pietrafesa, L. J. (2018). Ensemble projection of the sea level rise impact on storm surge and inundation at the coast of Bangladesh. Natural Hazards and Earth System Sciences, 18(1), 351. https://doi.org/10.5194/nhess-18-351-2018
- Stempel, P.*, Ginis, I., Ullman, D., Becker, A., Witkop, R. (2018). Real-Time Chronological Hazard Impact Modeling. Journal of Marine Science and Engineering, Vol. 6, no. 134. doi:10.3390/jmse6040134.
- Teng, F., W. Huang, and I. Ginis, 2018. Hydrological modeling of storm-induced runoff and snowmelt in Taunton River Basin. Journal of Natural Hazards, 91, 179-199, https://doi.org/10.1007/s11069-017-3121-y
- Ullman D.S., I. Ginis, W. Huang, C. Nowakowski*, X. Chen*, and P. Stempel, 2019: Assessing the Multiple Impacts of Extreme Hurricanes in Southern New England, USA, Geosciences 2019, 9(6), 265; https://doi.org/10.3390/geosciences9060265
- Witkop, R., Becker, A., Stempel, P.*, Ginis, I. (2019). Developing Consequence Thresholds for Storm Models through Participatory Processes: Case Study of Westerly Rhode Island. Frontiers in Earth Science: Geohazards and Georisks.Vol. 7. Doi: 10.3389/feart.2019.00133.

***Conference papers, presentations*:**

- Stempel, P.*, Becker, A. (2018), "Effects of localization on perceptions of storm surge risk depicted in model driven semi-realistic visualizations." International Conference on Sustainable Development, NY, NY. September 26-28, 2018.
- Ginis, I., D. Ullman, T. Hara, W. Huang, A. Becker, and R. Luettich (2018): Developing a Coastal and Inland Hazard and Impact Prediction System for Extreme Weather Events in the Northeastern United States, AGU Fall Meeting, December 14, https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/409069

- Ginis I. (2019): Advancing modeling capabilities to improve prediction of extreme weather events in the Northeastern United States, NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, April 11.
- Ginis I. (2019): Improving Prediction of Extreme Weather and Its Impact in New England, RI Emergency Management Agency, Cranston RI, March 7.
- Ginis I. (2019): Modeling Combined Coastal and Inland Impacts from Extreme Storms, RI Department of Health, Providence RI, March 8.
- Ginis I. (2018): Advances in Predicting Hurricane Path and Intensity, Jamestown Philomenian Library, Jamestown RI, September 24.
- Ginis I. (2018): The 1938 Great New England Hurricane Looking to the Past to Understand Today's Risk, East Greenwich Historic Preservation Society, East Greenwich, RI, September 15.
- Becker, A, (2019). "Overcoming Barriers to Long-term Climate Adaptation," Lecture of Opportunity, US Naval War College, Newport, RI, April 29.
- Becker, A., (2019). "Climate risk adaptation for ports: Research for transformational thinking." UNCTAD Ad Hoc Expert Meeting on Climate Change Adaptation for International Transport: Preparing for the Future , Geneva, Switzerland, April 16-17.
- Stempel, P., Becker., A., Ginis, I., Ullman, D., Rubinoff., P., Overstrom, N. (2019). "Rethinking model-driven realistic storm-surge graphics." Rhode Island Coastal Ecology, Assessment, Innovation, and Modeling (RI C-AIM) Research Symposium 2019, Kingston RI. April 10.
- Becker, A, Stempel, P., Menendez, J. (2019). "Visualizing Risk: Dynamic 3d Models of Storm Impacts on Coastal Structures In Rhode Island." Poster presentation at the Infrastructure Climate Network Meeting, Portsmouth, NH, April 4-5.
- Becker, A. (2018). "Stimulating Transformational Thinking for Long-Term Climate Resilience." University of Rhode Island Coastal Resiliency Symposium, Oct. 16, Narragansett, RI. (I)
- Huang, W., F Teng, I. Ginis, and D. Ullman. 2019. Rainfall Runoff and Flood Simulations for Hurricane Impacts on Woonasquatucket River, USA. ICCEN 2019. Accepted by 8th International Conference on Civil Engineering (ICCEN 2019), November 19-20, Paris, France, 2019

Student Theses/Dissertations:

- Bobby Witkop Master's thesis in Marine Affairs "Developing Consequence Thresholds for Storm Impact Models: Case Study of Westerly, Rhode Island", 2018, Primary advisor: Dr. Austin Becker, Committee member: Dr. Isaac Ginis

- Peter Stempel Ph.D. Dissertation in Marine Affairs: "Depicting consequences of storm surge, opportunities and ethics." 2018, Primary advisor: Dr. Austin Becker, Committee member: Dr. Isaac Ginis

Fleming

- "Dynamic Water Level Correction in Storm Surge Models Using Data Assimilation." Authors: Taylor G. Asher, Richard A. Luettich Jr. and Jason G. Fleming. Submitted to Ocean Modelling. In revision.
- "Influence of storm timing and forward speed on tides and storm surge during Hurricane Matthew." Authors: Ajimon Thomas, JC Dietrich, TG Asher, M Bell,

BO Blanton, JH Copeland, AT Cox, CN Dawson, JG Fleming, RA Luettich. Ocean Modelling. Published. https://doi.org/10.1016/j.ocemod.2019.03.004

- "Forecasting Model, Forecast Advisories and Best Track in a Wind Model, and Observed Data – Case Study Hurricane Rita." Authors: Abram Musinguzi, Muhammad Akbar, Jason G. Fleming, Samuel K. Hargrove. Journal of Marine Science and Engineering. Published. J. Mar. Sci. Eng. 2019, 7(3), 77; https://doi.org/10.3390/jmse7030077
- Media coverage of the 2019 Texas ADCIRC Week training event that PI Jason Fleming organized: "DesignSafe ADCIRC Provides Storm Surge Simulators for Natural Hazards Community" (picked up and republished by HPCWire): https://www.hpcwire.com/off-the-wire/designsafe-adcirc-provide-storm-surge-simulators-for-natural-hazards-community/
- CRC Coverage of 2019 ADCIRC Users Group Meeting event that PI Jason Fleming organized: https://www.flickr.com/photos/133219410@N05/albums/72157709249042136

EDUCATION PROJECTS

Whalin:

An updated list of publications appears below. The first two were published during Year 4 and another publication has been accepted (not listed) for Year 5 at the 11th Texas Hurricane Conference.

- **Whalin, Robert W**., "A PhD in Engineering Degree: Coastal Engineering Emphasis Area," Proceedings, 126th ASEE Conference, Tampa Bay, FL, June 2019.
- **Ebersole, Bruce; Richardson, Thomas W.; Whalin, Robert W.,** "Suppression of Hurricane Surge Forerunner and Peak Surge in Galveston and West Bays Achieved with a Western Segment of the Coastal Spine," 10th Texas Hurricane Conference, University of Houston, Houston, TX; Aug. 3, 2018.
- "NSF-PIRE, Coastal Flood Risk Reduction Program, Authentic Learning and Transformative Education", Volume 1-2015-2017; Edited by Baukje "Bee" Kothius, Yoonjeong Lee and Samuel Brody, March 2018.
- **Ebersole, Bruce; Richardson, Thomas**; and **Whalin, Robert, W.**, "Surge Suppression Achieved by Different Coastal Spine (Ike Dike) Alignments", 9th Texas Hurricane Conference, University of Houston, August 4, 2017, Houston, TX.
- **Whalin RW**, Pang Q, Latham J, Lowe LN. Assessment of a Summer Bridge Program: Seven Years and Counting, 2017 ASEE National Conference Proceedings, Columbus, OH, June 24-28, 2017.

- **Whalin RW**. HBCU Engineering Faculty and Graduates: Implications for Race, Retention and Graduation Linkages, NAAAS & Affiliates 2016 National Conference Proceedings, Baton Rouge, LA, published Oct. 2016.
- **Whalin RW**, Brody SD, and Merrell WJ. The Galveston Bay Region as an International Test Bed for Flood Risk Reduction, 8th Texas Hurricane Conference, University of Houston, Houston, TX, August 5, 2016.
- **Ebersole B, Richardson TW**, and **Whalin RW**. Modeling Coastal Storms: Past, Present and Future, 8th Texas Hurricane Conference, University of Houston, Houston, TX, August 5, 2016
- **Whalin, Robert, W.; Pagan-Trinidad, Ismael**; Villanueva, Evelyn; and Pittman, David, W., "A Quarter Century of Resounding Success for a University/Federal Laboratory Partnership", ASEE 123rd Annual Conference and Exposition, New Orleans, LA, June 26, 2016.

Faik:

- Ying Bai & **Hang Chen**, "Build an Optimal Evacuation Contraflow Model for Natural Disasters by Using Fuzzy Inference System", to be appeared on Proceedings of the 2018 IEEE International Conference on Fuzzy System, July 8-13, Rio de Janeiro, Brazil, 2018.
- Cody Byrd, Jean-Marie Nshimiyimana, Ehije Idehenre, **Hang Chen** (Faculty Advisor), "Data Analysis of Haiti's Resiliency Post-2010 Earthquake". Presented at the 2017 Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM).
- NyJae Dickerson, Adonis Tillman, Desmond Taylor, Awatif Amin (Faculty Advisor) "Using Data Mining to analyze Natural Disasters at 10 countries". Presented at the 2017 Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM).

Laiju:

- Long, J., Rose, S., Jwainat, A. & Hunter, F. (2019), Tougaloo Community Preparedness for Homeowners*,* abstract published in *Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1
- Jones, T. Robinson, S. Boler, D.& Hunter, F. (2019) Disaster Preparedness: How Prepared Are They? An Assessment of Renters in Tougaloo Mississippi*,* abstract published in abstract published in *Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1
- Kinkaid, D.,Ze'ronte, B.Sneed, H., &Banerjee, S., (2019), *Using GIS to Study Disproportionate Disaster Impact on Vulnerable Mississippi Population,* abstract published in *Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1, & Presented at 83rd Annual Meeting in Hattiesburg, MS on February 21, 2019
- Laiju, M. (2019), *A Framework: Address Vulnerability of Children and Current Policy of Disaster,* abstract published in *Mississippi Academy of Sciences (MAS)* ISSN 0076 – 9436, Vol 64 # 1, &presented at 83rd Annual Meeting in Hattiesburg, MS on February 21, 2019

- Laiju, M. (2019) *Career Pathway: Multidisciplinary Undergraduate Curriculum in Homeland Security's Coastal Resilience at a HBCU.* Abstract published in *Southern Sociological Society* (SSS) Journal and presented at SSS Conference on April 11, 2019, at Atlanta, GA.

Presentation:

- Laiju, M. & Hunter, F. (2018), *Transforming the Curriculum: Adding Disaster Management and Coastal Infrastructure Management to the Curriculum,* abstract accepted and presented at the Historical Black Colleges &Universities (HBCU) Faculty Development Network Conference in Jackson, Mississippi, November 2,2018

Senior Paper:

- Jwainat, A. (2019), senior paper Knowledge and Attitudes Regarding Disaster/ Emergency Preparedness Porter, J. (2019), New Orleans Residents' Awareness of Disaster Preparedness

Pagan-Trinidad:

- Pagán Trinidad, Ismael, López-Rodríguez, Ricardo and Ernesto Diaz, "Education and Building Capacity for Improving Resilience of Coastal Infrastructure", Proceedings, ASEE 126th Annual Conference & Exposition: June 16-19, 2019, Tampa FL, **Peer-reviewed.**
- Hector Colón, (SUMREX student 2017), Paper and Presentation, ASCE Coastal Engineering International Conference, "NUMERICAL MODELLING OF TSUNAMI INUNDATION CONSIDERING THE PRESENCE OF OFFSHORE ISLANDS AND BARRIER REEFS", Baltimore, MD, July 2018; **Peer-reviewed.**
- Benjamín Colucci, Alberto Figueroa and Alexander Molano, (Graduate student supported by the CRC project), Paper and Presentation, "Impacts and Lessons Learned as a Result of the Passage of Hurricane Maria on the Transportation Infrastructure of the Caribbean Island of Puerto Rico", UPADI, August 2018.
- Benjamín Colucci, Alberto Figueroa and Alexander Molano,(Graduate student supported by the CRC project), Paper and Presentation, "Lessons Learned for the Puerto Rico Transportation Infrastructure after Hurricane María", ITE, October 2018.
- Morales-Velez, A. C., and Hughes, K.S., "Comprehensive Hurricane María Mass Wasting Inventory and Improved Frequency Ratio Landslide Hazard Mapping", Revista Dimension Year 32, Vol 1, 2018. Peer-reviewed
- Aponte Bermúdez, Luis D., "Huracán María,: Sinopsis y Análisis Preliminar del Impacto en la Infraestructura de Puerto Rico", Revista Dimensión Year 32, Vol 1, 2018. Peer-reviewed.
- Martínez-Cruzado, José A. Huerta-López, Carlos I. Martínez-Pagán, Jaffet, Santana Torres, Erick X,and Hernández-Ramírez, Francisco J., "Destrozos, Recuperación, y Planes en la Red Sísmica de Movimiento Fuerte a Raíz de los Huracanes Irma y María", Revista Dimensión, Year 32, Vol 1, 2018. Peer-reviewed.

- Acosta, Felipe J, Esquilín-Mangual, Omar, Wood, Stephanie G., Long, Wendy R. and Valdés, Didier, Lessons Learned from the Evaluation of Concrete Pole Failures Following Hurricane María, Revista Dimension Year 32, Vol 1, 2018. **Peer-reviewed.**
- Ismael Pagán-Trinidad and Ricardo R. López, editors, Digital proceedings of Conference "Lessons Learned and Best Practices: Resilience of Coastal Infrastructure" , San Juan, PR, August 2017, http://engineering.uprm.edu/inci/?page_id=3522

  The following two presentations were given by Dr. Ricardo López at the World Engineering Conference on Disaster Risk Reduction. More information at http://www.wfeo.org/events/world-engineering-conference-disaster-risk-reduction-wecdrr-2016/

- **Ismael Pagán-Trinidad, Ricardo López-Rodríguez,** Agustín Rullán, Oscar Perales-Pérez, John Fernández-Van Cleve, "THE ROLE OF UNIVERSITIES ON DISASTER RISK REDUCTION IN THE COMMUNITY: UPRM CASE STUDY", World Engineering Conference on Disaster Risk Reduction, Peruvian Association of Professional Engineers, Lima Perú, December 5-6, 2016. Presentation.
- **López-Rodríguez, Ricardo R., Pagán-Trinidad, Ismael**, "Structural Vulnerability to Natural Hazards in Puerto Rico", World Engineering Conference on Disaster Risk Reduction, Peruvian Association of Professional Engineers, Lima Perú, December 5-6, 2016.Presentation.
  Robert W. Whalin, Ismael Pagán-Trinidad, Evelyn Villanueva and David Pittman, "A Quarter Century of Resounding Success for a University/Federal Laboratory Partnership", Proceedings, 123rd ASEE Annual Conference and Exposition, Vol 1, presented June 27 2016 in New Orleans, LA. ISBN: 978-1-5108-3480-4. Peer-reviewed
- **Ismael Pagán-Trinidad, Ricardo López-Rodríguez**, "Education, Resilience and the Built Environment: Impacts and Some Lessons Learned on Infrastructure for Improvement of Coastal Infrastructure in PR", Symposium: Planning and Resilient Recovery in Puerto Rico, Graduate School of Planning – University of Puerto Rico – Río Piedras, May 18-19, 2018. Presentation.
- Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago, Ismael Pagán Trinidad and Didier. M Valdés Díaz. Impact of Extreme Climate in Coastal Transportation Civil Infrastructure in the Caribbean, World Engineering Forums November 26 to December 2, 2017, Rome, Italy. Presentation
- Benjamín Colucci Ríos (Presenter) and Alexander Molano Santiago, Impact of Hurricane Maria on Puerto Rico's Transportation Infrastructure: Lessons Learned, 97th Transportation Research Board Annual Meeting, AHB55 Committee, *Work Zone Traffic Control Committee Meeting,* January 9, 2018. Presentation
- Benjamín Colucci Ríos (Presenter) and Alexander Molano Santiago, Impacto del Huracán María en la infraestructura de transportación de Puerto Rico (Impact of

Hurricane María in Puerto Rico's Transportation Infrastructure), 4to Conversatorio para un Puerto Rico Resiliente. February 20, 2018, Presentation.

- Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago and Joel F. Alvarado López, El impacto del Huracán María en la infraestructura de transporte de Puerto Rico:Lecciones aprendidas (The Impact of Hurricane Maria in Puerto Rico's Transportation Infrastructure: Lessons Learned), Mega Viernes Civil 2018: Resiliencia Aplicada, College of Engineers and Surveyors of Puerto Rico, San Juan, April 6, 2018. Presentation.
- Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago, Luis Sevillano García, Launelly M. Rosado Rosa and Joel F. Alvarado López, Transportation Engineering Innovation Spearheading the Economic Development of Puerto Rico after an Extreme Natural Disaster, XXX Congress of Engineering and Surveying, COINAR 2018, San Juan, April 17, 2018. Presentation.
- Re-Imagine Puerto Rico a discussion panel on solutions to rebuild PR, co-sponsored with Resilient Puerto Rico Advisory Commission, 11 speakers including Prof. Ismael Pagán, ample audience participation, UPRM, August 14, 2018, Presentations
- Coastal Resiliency Building, Mainstreaming Adaptation, Ernesto Díaz, Director, Coastal Management Program of Dept. Natural Environment Resources and of PR, offered at Capstone course, UPRM, October 4, 2018, Presentation.
- Digital Coast Tools Applications-1 day Seminar, Sponsor: PR Sea Grant, NOAA, CRC; Two NOAA instructors, UPRM, December 5, 2018, Presentations
- NOAA Coastal Inundation Mapping Workshop, Sponsors Sea Grant, NOAA, CRC; two NOAA instructors, UPRM, December 6-7, 2018, Workshop.
- Research in Coastal Engineering, Sponsors with CARCI NSF planning grant with Dr. Dan Cox, Six speakers including three from Oregon State University, one from Rice University and two from UPR Mayagüez, UPRM, December 6, 2018, Presentations
- NOAA – Introduction to Green Infrastructure for Coastal Resiliency: Co-sponsored with NOAA, PR Sea Grant Program, UPRM-CRC, December 12, 2018, Presentations
- Coastal Resiliency Building and Promoting Adaptation: Ernesto Díaz of Dept Natural Resources and Environment of PR, offered at Capstone course UPRM, January 31, 2019, Presentation.
- Low Impact Development and Green Alternatives for Urban Projects: Sponsors FEMA, CRC; Speaker Ismael Pagán Trinidad, Aguadilla FEMA Headquarters, February 8, 2019, Presentation.
- Seminar on the Integral Management of Hydrographic Watershed: Sponsors with FEMA, UPRM, March 5, 2019, Presentations.
- Small Modular Reactors: A Feasible Option for Puerto Rico?, a panel discussion, co-sponsored with Nuclear Alternative Project, UPRM, October 30, 2018, Presentations
- Public Forum: Energy Policy in Puerto Rico, What is Ongoing, Co-sponsored with INESI, UPRM, November 29, 2018, Presentations.

- Carla López del Puerto, Ismael Pagán Trinidad and Ricardo López, "Hurricane Maria in Puerto Rico: Assessment of the Damages, Reconstruction Efforts and Beyond Recovery" at ASCE Construction Summit in Atlanta, March 7 to 9, 2019, Presentation Panel.
- Ismael Pagán Trinidad and Ricardo López, "Overview of Damage Caused by Hurricane Maria in PR at Gavin Smith's Seminar at **UNC**, February 27, 2019, Remote Presentation
- Ismael Pagán Trinidad and Ricardo López," Overview of Damage Caused by Hurricane Maria in PR", at Gavin Smith's Seminar at **NCSU**, February 27, 2019, Remote Presentation.
- Ismael Pagán Trinidad and Ricardo López were invited and participated in Coastal Engineering Workshop, sponsored by NSF, held in Arlington, Virginia, November 13 and 14, 2018. Similarly, a second meeting-workshop at OSU in February 4-5, 2019 with the same objective.
- Ismael Pagán Trinidad and Ricardo López, "Improving Resilience of Coastal Infrastructure through Education and Building Capacity", 2019 NLTAPA Southeast Region Meeting, April 30, 2019 San Juan PR, Presentation
- Ismael Pagán Trinidad and Ricardo López, "Education and Building Capacity for Improving Resilience of Coastal Infrastructure" at ASEE 126th Annual Conference & Exposition: June 16-19, 2019, Tampa FL, Presentation
- Ricardo López and Juan Rodríguez, "Análisis tridimensional no lineal
- de estructuras de concreto (Non Linear Tridimensional Analysis of Reinforced Concrete Structures)" at CIAPR –Mega Viernes Civil (Island wide meeting of Civil Engineers), April 5 2019, San Juan PR, Presentation.
- Carla López del Puerto (senior personnel) gave short course Complex Project Management for Coastal Communities presented at FEMA headquarters in Aguadilla PR for FEMA personnel on June 27, 2019.

Dissertations and Theses:

- Angel Alicea (PhD Dissertation): "Dynamic Identification and Nonlinear Modeling for the Structural Health Assessment of Aged Coastal Infrastructure in Puerto Rico", PhD dissertation completed in December 2018, Department of Civil Engineering, advisor Ricardo López
- Efrain Ramos (MSCE Thesis): "Stochastic Simulation of Tropical Cyclones for Quantification of Uncertainty associated with Strong Recurrence and Intensity", July 8, 2019 (already submitted, pending final oral presentation); Dept. of Civil Engineering and Surveying; Advisor Ismael Pagán Trinidad-UPRM; Co-Advisor Norberto Nadal ERDC-UPRM.
- Kevin Cueto (MSCE Thesis): "Modeling considering Computational Fluid Dynamics of hydraulic pressure exerted on coastal structures", July 8, 2019 (already submitted, pending final oral presentation); Dept. of Civil Engineering and Surveying, Advisor-Ricardo López, UPRM.

Smith:

Horney, Jennifer, Carolina Dwyer, Bhagath Chirra, Kerry McCarthy, Jennifer Shafer and **Gavin Smith**. 2018. Measuring Successful Disaster Recovery, International Journal of Mass Emergencies and Disasters 36(1): 1-22.

Gavin Smith, Lea Sabbag and Ashton Rohmer. 2018. A Comparative Analysis of the Roles Governors Play in Disaster Recovery, Risk, Hazards & Crisis in Public Policy. 9(2): 205-243. DOI: 10.1002/rhc3.12133.

Smith, Gavin. 2016. Remembrances of the Past, Concerns for the Future, and the Potential Resilience of a Small Coastal Town, Southern Cultures. Summer: 64-87.

Horney, Jennifer, Caroline Dwyer, Meghan Aminto, Phil Berke and **Gavin Smith**. 2016. Developing Indicators to Measure Post-Disaster Community Recovery, Disasters 41(1): 124-149.

Lyles, Ward, Philip Berke and **Gavin Smith**. 2015. Local Plan Implementation: Assessing Conformance and Influence of Local Plans in the United States, Environment and Planning B: Planning and Design.

Smith, Gavin. 2014 (Autumn). Involving Land Use Planners in Pre-Event Planning for Post-Disaster Recovery. Planner's Note, Journal of the American Planning Association. 80(4): 306-307. Special Issue, Planning for Disaster Recovery.

Berke, Philip, Ward Lyles, and **Gavin Smith**. 2014. Impacts of Federal and State Mitigation Policies on Local Land Use Policy, Journal of the Planning Education and Research. 34(1): 60-76.

Lyles, Ward, Phil Berke and **Gavin Smith**. 2014. A Comparison of Local Hazard Mitigation Plan Quality in Six States, USA, Landscape and Urban Planning 122 (February): 89-99.

Lyles, Ward, Phil Berke and Gavin Smith. 2014. Do Planners Matter? Examining Factors Driving Incorporation of Land Use Approaches into Hazard Mitigation Plans, Journal of Environmental Planning and Management 57(2):792-811.

Sandler, Dylan and **Gavin Smith**. 2013. Assessing the Quality of State Disaster Recovery Plans: Implications for Policy and Practice, Journal of Emergency Management 11(4):281-291.

Smith, Gavin, Ward Lyles, Philip Berke. 2013. The Role of the State in Building Local Capacity and Commitment for Hazard Mitigation Planning, International Journal of Mass Emergencies and Disasters 31(2): 178-203.

Smith, Gavin, Dylan Sandler and Mikey Goralnik. 2013. Assessing State Policy Linking Disaster Recovery, Smart Growth and Resilience in Vermont Following Tropical Storm Irene, Vermont Journal of Environmental Law 15: 67-102.

Berke, Philip, **Gavin Smith**, Ward Lyles. 2012. Planning for Resiliency: Evaluation of State Hazard Mitigation Plans Under the Disaster Mitigation Act, Natural Hazards Review 13(2): 139-150.

Smith, Gavin and Tom Birkland. 2012. Building a Theory of Recovery: Institutional Dimensions. Special Edition on Developing a Theory of Disaster Recovery. International Journal of Mass Emergencies and Disasters 30(2): 147-170.

Smith, Gavin. 2010. Disaster Recovery Planning in the United States: Lessons for the Australasian Audience Australasian Journal of Disaster and Trauma Studies. Natural Hazards Planning in Australasia. ISSN: 1174-4707, Volume 2010-1.

Books

Glavovic, Bruce and **Gavin Smith**. 2014. *Adapting to Climate Change: Lessons from Natural Hazards Planning*. New York: Springer.

Smith, Gavin. 2011. *Planning for Post-Disaster Recovery: A Review of the United States Disaster Assistance Framework*. Washington, D.C.: Island Press.

Book Chapters

Smith, Gavin. "The Role of States in Disaster Recovery: An Analysis of Engagement, Collaboration, and Capacity Building." 2019. In *Building Community Resilience to Disasters: The Handbook of Planning for Disaster Resilience*, Routledge Press.

Smith, Gavin, Amanda Martin and Dennis Wenger. "Disaster Recovery in an Era of Climate Change: The Unrealized Promise of Institutional Resilience." 2017. In *Handbook of Disaster Research*, Second Edition, Eds. Havidan Rodriguez, Joseph Trainor and William Donner. New York: Springer.

Smith, Gavin. "Pre- and Post-Disaster Conditions, their Implications, and the Role of Planning for Housing Recovery." 2017. Chapter 18, pp. 277-292. In *Coming Home After Disaster: Multiple Dimensions of Housing Recovery*, Eds. Ann-Margaret Esnard and Alka Sapat. Boca Raton, Florida" CRC Press.

Smith, Gavin. "Planning for Sustainable and Disaster Resilient Communities." 2015. Chapter 9, pp. 249-279. In Hazards Analysis: Reducing the Impact of Disasters, Ed. John Pine (2nd edition). Boca Raton, Florida: CRC Press.

Smith, Gavin. "Creating Disaster Resilient Communities: A New Hazards Risk Management Framework." 2015. Chapter 10, pp. 281-308. In Hazards Analysis: Reducing the Impact of Disasters, Ed. John Pine. (2nd edition). Boca Raton, Florida: CRC Press.

Smith, Gavin. "Applying Hurricane Recovery Lessons in the U.S. to Climate Change Adaptation: Hurricanes Fran and Floyd in North Carolina, USA." 2014. Chapter 9, pp. 193-229. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Bruce Glavovic and **Gavin Smith**. "Introduction: Learning from Natural Hazards Experience to Adapt to Climate Change." 2014. Chapter 1, pp. 1-38. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Smith, Gavin. "Disaster Recovery in Coastal Mississippi (USA): Lesson Drawing from Hurricanes Camille and Katrina." 2014. Chapter 14, pp. 339-368. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Smith, Gavin and Bruce Glavovic. "Conclusions, Recommendations, and Next Steps: Integrating Planning for Natural Hazards and Climate Change Adaptation." 2014. Chapter 16, pp. 405-450. In *Adapting to Climate Change: Lessons from Natural Hazards Planning*, Eds. Bruce Glavovic and Gavin Smith. New York: Springer.

Smith, Gavin. "Catastrophic Disaster Recovery: An Institutional Network Perspective." 2013. Chapter 12, pp. 281-300. In *Preparedness and Response to Catastrophic Disasters*, Ed. Richard A. Bissell. Boca Raton, Florida: CRC Press.

Smith, Gavin. 2009. "Planning for Sustainable and Disaster Resilient Communities." Chapter 9, pp. 221-247. In *Natural Hazards Analysis: Reducing the Impact of Disasters*, Ed. John Pine. Boca Raton, Florida: CRC Press.

Smith, Gavin. 2009. "Disaster Resilient Communities: A New Hazards Risk Management Framework." Chapter 10, pp. 249-267. In *Natural Hazards Analysis: Reducing the Impact of Disasters*, Ed. John Pine. Boca Raton, Florida: CRC Press.

Smith, Gavin. 2009. "A Review of the United States Disaster Assistance Framework: Planning for Recovery." Chapter 7, pp. 99-111. In *Emergency Management in Higher Education: Current Practices and Conversations*, Ed. Jessica Hubbard. Fairfax, Virginia: Public Entity Risk Institute.

Smith, Gavin. 2009. "Recovery and Reconstruction." Session 10, pp. 1-32. In *Catastrophe Readiness and Response*, Ed. Richard Bissell. Emmitsburg, Maryland: FEMA Emergency Management Institute, Higher Education Project. Accessed at: http://training.fema.gov/EMIWeb/edu/catastrophe.asp.

Berke, Phil and **Gavin Smith**. 2009. "Hazard Mitigation, Planning and Disaster Resiliency: Challenges and Strategic Choices for the 21st Century." Chapter 1, pp. 1-20. *Building Safer Communities: Risk, Governance, Spatial Planning and Responses to Natural Hazards*, Ed. Urbano Fra Paleo. NATO Science for Peace and Security Series, E, Human and Societal Dynamics, Volume 58. Amsterdam: ISO Press.

Technical Reports

Smith, Gavin, Mai Thi Nguyen, Colleen Durfee, Darien Williams, Ashton Rohmer. September, 2018. *Resilient Design Education in the United States*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Resilience Center of Excellence.

Smith, Gavin, Barry Hokanson, Link Walther, Jessica Southwell. 2017. *Hurricane Matthew Disaster Recovery and Resilience Initiative. A Project of the North Carolina Policy Collaboratory*. Chapel Hill, North Carolina: Hurricane Matthew Recovery and

Resilience Initiative.
Smith, Gavin, Lea Sabbag, Ashton Rohmer. *Role of States in Recovery Video Training Guide*. March, 2016. Chapel Hill, North Carolina: Department of Homeland Security, Coastal Resilience Center of Excellence.
Horney, Jennifer and Gavin Smith. September, 2015. *Measuring Successful Recovery: A Case Study of Six Communities in Texas.* Tysons, Virginia: LMI Research Institute.

Tuckson, Reed V., et. al 2015. Healthy, Resilient, and Sustainable Communities After Disasters: Strategies, Opportunities, and Planning for Recovery. Washington, D.C.: National Academies Press (consultant).
Smith, Gavin. *Disaster Recovery Funding: Achieving a Resilient Future?* National Academy of Science, Institute of Medicine. June, 2014. Commissioned by the National Academy of Science, Committee on Post-Disaster Recovery of a Community's Public Health, Medical and Social Services.
Smith, Gavin, David Perkes, Andy Rumbach, Darrin Punchard. September, 2014. Community Planning Assistance Team Report. *Lyons, Colorado: Designing a More Resilient Future*. Chicago, Illinois: American Planning Association.
Smith, Gavin, John Whitehead, Nikhil Kaza, Jae Park, John Pine, Randy Kolar. December, 2013. *Aggregate Flood Hazard Risk Reduction Scoping Project*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazards Center of Excellence.
Smith, Gavin, Dylan Sandler, Mikey Goralnik. October, 2013. *Vermont State Agency Policy Options. Smart Growth Implementation Assistance Program: Disaster Recovery and Long-Term Resilience Planning in Vermont*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazards Center of Excellence.
Smith, Gavin and Dylan Sandler. July, 2012. *State Disaster Recovery Guide*. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazards Center of Excellence.
Lyles, Ward, Philip Berke and Gavin Smith. July, 2012. *Evaluation of Local Hazard Mitigation Plan Quality.* Center for Sustainable Community Design and the Coastal Hazards Center. Chapel Hill, North Carolina: University of North Carolina at Chapel Hill.
Burkett, V.R. and Davidson, M.A. 2012. *Coastal Impacts, Adaptation, and Vulnerability: A Technical Input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment.* Contributing author. Washington, D.C.: Island Press.
Berke, Philip, Gavin Smith and Sara Reynolds. 2011. *Community Rating System: Plan Evaluation & Model Practices.* Federal Emergency Management Agency. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazard Center of Excellence.
Berke, Philip, Gavin Smith, Dave Salvesen, Ward Lyles, and Dylan Sandler. December, 2011. *An Evaluation of Floodplain Management Planning Under the Community Rating System.* Final Report for the Federal Emergency Management Agency. Chapel Hill, North Carolina: Department of Homeland Security Coastal Hazard Center of Excellence.
Smith, Gavin and Victor Flatt. 2011. *Assessing the Disaster Recovery Planning Capacity of the State of North Carolina.* Research Brief. Durham, North Carolina. Institute for Homeland Security Solutions.
Berke, Philip, Gavin Smith, and Ward Lyles. August, 2009. *State Hazard Mitigation Plan Evaluation and Model Practices. Analysis of Federal Mitigation Policy in the U.S.: Mitigation Plans, Expenditures, Civic Engagement, and Local Capability.* Report to the Department of Homeland Security Center of Excellence – Disasters, Coastal Infrastructure

and Emergency Management, University of North Carolina at Chapel Hill, Chapel Hill, NC.

Student Theses and Dissertations

Master's Project Committee, Master's Candidate. Margaret Keener. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2017-2019.

Department of Homeland Security, Workforce Development Grant Recipient. Master's Candidate. Jessamin Straub. Department of Marine Science. University of North Carolina at Chapel Hill. 2018-2019.

Master's Project Committee, Master's Candidate. Chair. Christian Kamrath. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Chair. Meredith Burns. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Chair. Estefany Noria. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2017.

Master's Project Committee, Master's Candidate. Kevin Fish. Sanford School of Public Policy. Duke University. 2017.

Master's Project Committee, Master's Candidate. Chair. Darien Williams. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Colleen Durfee. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2018.

Master's Project Committee, Master's Candidate. Chair. Ashton Rohmer. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2017.

Master's Project Committee, Master's Candidate. Chair. Abby Moore. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2017.

Master's Project Committee, Master's Candidate. Chair. Jamar Nixon. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2016-2017.

Dissertation Committee, Doctoral Candidate. Sierra Woodruff. Curriculum for the Environment and Ecology, University of North Carolina at Chapel Hill. Local Climate Change Adaptation Plan Quality and Content in the United States. 2012-2017.

Master's Project Committee, Master's Candidate. Chair. Lea Sabbag. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2016.

Master's Project Committee, Master's Candidate. Chair. Christina Hurley. Department of City and Regional Planning, University of North Carolina at Chapel Hill. 2015-2016.

Dissertation Committee, Doctoral Candidate (external committee member). Alex Greer. Disaster Science and Management, University of Delaware. Resettlement After Disaster: Case Studies following Hurricane Sandy. 2013-2015.

Master's Project Committee, Master's Candidate. Chair. Caroline Dwyer. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Building Back Better? A Comparison of Intergovernmental Cooperation Frameworks Influencing Post-Sandy Recovery and Rebuilding in Coastal New Jersey and New York. 2013-2014.
Master's Project Committee, Master's Candidate. Chair. Fayola Jacobs. Department of City and Regional Planning, University of North Carolina at Chapel Hill. Hazard Mitigation Planning and Policy in the Caribbean. 2013-2014.

Master's Project Committee, Master's Candidate. Capstone Committee Member. Rachel Meyerson. Department of Public Administration, University of North Carolina at Chapel Hill. A Tool for Evaluating Plan Quality of Local Government Response Plans. 2011-2012.