

**RESIO, UNF**  
**DHS Coastal Resilience Center**  
**Research Project:**  
**Annual Project Performance Report**  
Covers reporting period July 1, 2016 – June 30, 2017

**1. Project Title:**

The Incorporation of Rainfall into Hazard Estimates for Improved Coastal Resiliency

**2. Principal Investigator / Institution:**

Don Resio, University of North Florida, 1 UNF Drive, Bldg 50/3204, Jacksonville, FL 32224.

**3. Other Research Participants/Partners:**

Funded Directly By the University of North Carolina:

**Jackson State University** - Tom Richardson (PI), former Director of the Coastal and Hydraulics Laboratory at ERDC and Bruce Ebersole, former Division Chief, US Army ERDC.

**ARCADIS** - Hugh Roberts (PI), hydrodynamics specialist and ADCIRC modeler and Zachary Cobell ADCIRC specialist.

**4. Short Project Description (“elevator speech”):**

Rising sea level, climate variability, and growing coastal populations increasingly threaten the immense investments in critical coastal infrastructure within the US, and could greatly impact the commercial and military value of coastal cities such as New York, New Orleans, Norfolk/Hampton Roads and many others. At the same time, natural coastal areas are essential to maintaining healthy ecosystems in these areas, since they provide much needed food and recreation and perform an important role in maintaining overall environmental stability. Decisions must be based on accurate quantification of factors which affect this balance between the natural and built environments in order to maximize resilience in these areas. A major factor known to be important in most coastal areas, interactions among rainfall, hydrologic flows and coastal surges is presently not treated within operational modeling systems. This project will develop a methodology for incorporating these interactions in a statistically and physically appropriate manner into FEMA’s operational coastal modeling systems.

**5. Abstract:**

This project will develop a method for including rainfall-runoff effects into FEMA-JPM studies, and evaluate the potential impacts of incorporating these effects into improved

estimates of flooding hazards. There are two parallel efforts the project will be undertaking: 1) an improved understanding of the statistics of river/tributary discharges in terms of both antecedent conditions and the conditional probabilities of rainfall patterns and magnitudes given a tropical cyclone in a particular area and 2) a physics-based coupling of major tributaries into the ADCIRC model, including antecedent and rainfall effects during a surge event. The goal is to develop a model that is ready to be transitioned into realistic JPM applications in areas where rainfall, hydrologic flows and surges are expected to interact strongly.

## **6. End users:**

**FEMA HQ; FEMA Region I; FEMA Region II; FEMA Region III; FEMA Region IV; and FEMA Region VI; USACE; NOAA:** One stakeholder would like to see the coordination expand to include groups within NOAA besides the National Hurricane Center. **US Coast Guard:** One stakeholder is interested in using this approach to assist in the development of scenarios during and following disasters. NGA expressed a desire to incorporate our research into their maritime mission. We will involve all of these individuals, and others as become interested, in our project to plan to maximize the utility of this effort within ongoing work on resilience by government agencies within the US. These individuals will also be key advisors on developing end-user products and product delivery mechanisms and will provide advice on methods to certify final products for widespread FEMA use and for sustaining it following project completion. A significant project partner in the private sector (Arcadis) is experienced in performing RiskMap studies for FEMA. Arcadis involvement in the project will help ensure final products are useful and understood fully by the user community and work involved in these efforts. Collaboration with end users will be sought throughout the project as noted in our annual activities and the annual Center review will be critical to guide the project. Our team members include several individuals who have worked much of their professional career as bridges to the user community. Mr. Bruce Ebersole, former division chief at ERDC, (now at JSU) will take the lead in this area and form a small team of reviewers from the general stakeholder community to solicit ideas and feedback to the project development team. Planning groups in the Norfolk/Hampton Roads area are interested in coordinating, through Old Dominion University, with the project team.

## **7. Unanticipated Problems:**

The primary unanticipated problem on this effort has been the lack of a readily available, open-source hydrologic model for routing rainfall overland and through streams into the ADCIRC model. NOAA's new National Water Center in Tuscaloosa, AL is developing a new system for this work; however, it is not ready for release at this time. In the interim, the team has tested an alternative means of incorporating the rainfall/streamflow effects and this method seems to work very well as a surrogate. Overcoming this impasse has been somewhat time consuming; however, now that we have a methodology that functions, we are proceeding with the development of efficient means to combine the new class of model runs with previous runs into a FEMA run suite.

## 8. Project Impact:

Adding the overland flow and precipitation to the surge models used in FEMA's simulations will produce significant increases along the area where the inland flooding and coastal flooding approach equal magnitudes. Flood levels in many other areas where rainfall is locally concentrated will likely also be significantly raised. These changes will increase the number of people within areas exposed to flooding. In turn, this will both increase and redistribute the flood risks in these areas.

## 9. Research Activity and Milestone Progress:

### Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
<b>Research Activity</b>	<b>Proposed Completion Date</b>	<b>% Complete</b>	<b>Explanation of why activity / milestone was not reached, and when completion is expected</b>
Obtain radar rainfall data set (from JSU source) for statistical analysis of patterns of rainfall relative to hurricane tracks and other parameters	June 2016	100%	Completed in January 2017 Delay due to delays in processing the data.
Development and test initial methodology for coupling rivers/tributaries and rainfall into ADCIRC in different geographic areas	June 2016	100%	Completed in March 2017. Delay due to delays in obtaining open-source hydrologic model.
Interaction with JSU and user groups to develop a firm framework for effective user review of project accomplishments and future directions.	June 2016	100%	Completed July 2016
Establish overarching methodology for conducting a JPM analysis which includes two new dimensions: antecedent flows and rainfall/runoff during hurricane event	August 2017	80%	Expected: December 2017
Complete analysis of rainfall probability patterns and antecedent hydrologic flows and water levels	December 2017	50%	Expected December 2017
Complete validation of modeling system and its validation at a specific site for at least one historical event and determine the impacts of coupled versus uncouple estimates of inundation	December 2017	10%	Expected December 2017

Investigate expected impact of the coupled versus uncoupled approaches to coastal inundation hazards	December 2017	30%	Expected December 2017
Completion of analysis of rainfall probability patterns and antecedent hydrologic flows and water levels	December 2017	20%	Expected December 2017
<b>Research Milestone</b>			
Report on statistical approach for rainfall patterns and combining hydrologic effects into the JPM analysis	December 2016	100%	Delays in data analysis and quantification of methodology took longer than expected
Short Report on selected methodology for hydrologic-ADCIRC model coupling	July 2017	70%	Delays in hydrologic model component made it necessary to change our technical approach, but we will still meet the overall project deadline
Final Report on coupled methodology, validation of methodology, its application, its impact on flooding, and its impact on required runs for JPM execution plus delivery of documented modeling methodology and software	December 2017	10%	We expect to reach this milestone at our estimated date.

## 10. Transition Activity and Milestone Progress:

### Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
<b>Transition Activity</b>	<b>Proposed Completion Date</b>	<b>% Complete</b>	<b>Explanation of why activity / milestone was not reached, and when completion is expected</b>
Development of technical guidelines for FEMA applications of coupled hydrologic-surge	No previous date proposed	10%	The R&D team had to concentrate on developing a strong technical basis for including rainfall and hydrologic effects into coastal surges. Now that we feel that we have achieved a methodology for this, we can begin to determine the best way to transition this methodology.
<b>Transition Milestone</b>			

Application of methodology to an area of interest	No previous date proposed	10%	The R&D team will be working with representatives of planning groups in the Norfolk/Hampton Roads area; but this is currently beyond the scope of the work that has been funded
---	---------------------------	-----	---

### 11. Interactions with education projects:

Over the two year interval to date, UNF has supported an intern from the educational component of LSU's CRC program (PhD candidate Rudy Bartels) for 6 weeks, has given two seminars at LSU, and has met with a group of 12 graduate students at LSU to advise them on technical aspects of the MS and PhD efforts.

### 12. 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\.

### 13. Tables:

**Table 1: Documenting CRC Research Project Product Delivery**

<u>Product Name</u>	<u>Product Type</u>	<u>Approx. Delivery Date</u>	<u>Recipient or Anticipated End Users</u>
Rainfall Report	WORD Document	February 2017	FEMA
Journal Publication	Publication in J. Natural Hazards	December 2016	FEMA

**Table 2: Documenting External Funding and Leveraged Support**

<u>External Funding</u>			
<u>Title</u>	<u>PI</u>	<u>Total Amount</u>	<u>Source</u>
Guidelines to Electric Power Research Institute for Application of JPM to Coastal Surges	Resio/Salisbury	\$67,000	EPRI
Development of Combined Storm Surge and Rainfall-Hydrologic modeling to the coast of Louisiana	Resio	\$120,000	State of Louisiana
<u>Leveraged Support</u>			

<u>Description</u>	<u>Estimated Annual Value</u>
Free office space	\$5,000
Free high-performance computer time	\$15,000

#### 14. Metrics:

<u>Metric</u>	<u>Year 1</u> (1/1/16 – 6/30/16)	<u>Year 2</u> (7/1/16 – 6/30/17)
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)	1	2
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Graduates who obtained HS-related employment (number)	2	
SUMREX program students hosted (number)		1
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)	1	1
Journal articles published and Book Chapters (number)	1	1
Conference presentations made (number)		
Other presentations, interviews, etc. (number)	1	
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)	1	1
Requests for assistance/advice from other agencies or governments (number)	1	1
Total milestones for reporting period (number)	3	2
Accomplished fully (number)	1	5
Accomplished partially (number)	2	6
Not accomplished (number)		