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)				