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).

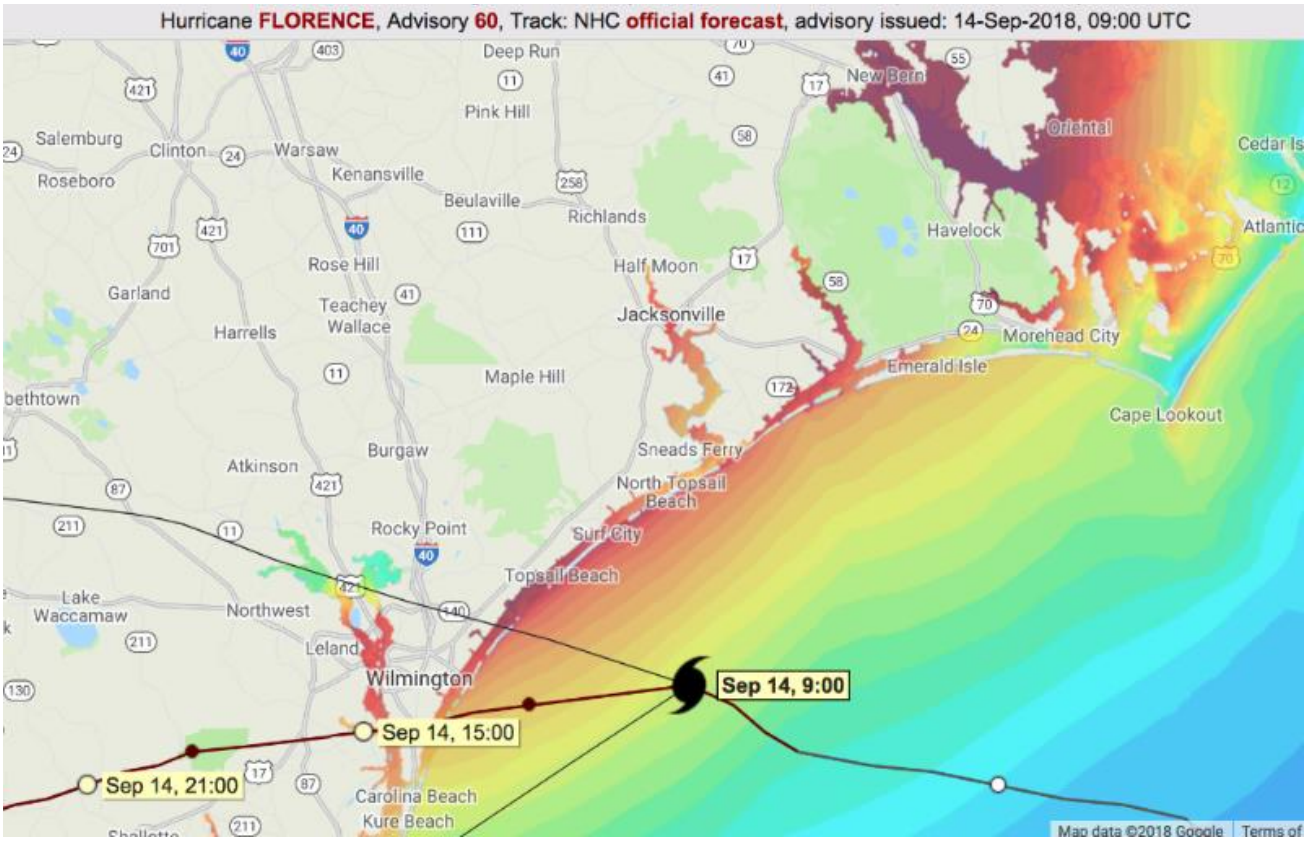
2. Results:

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 1 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.

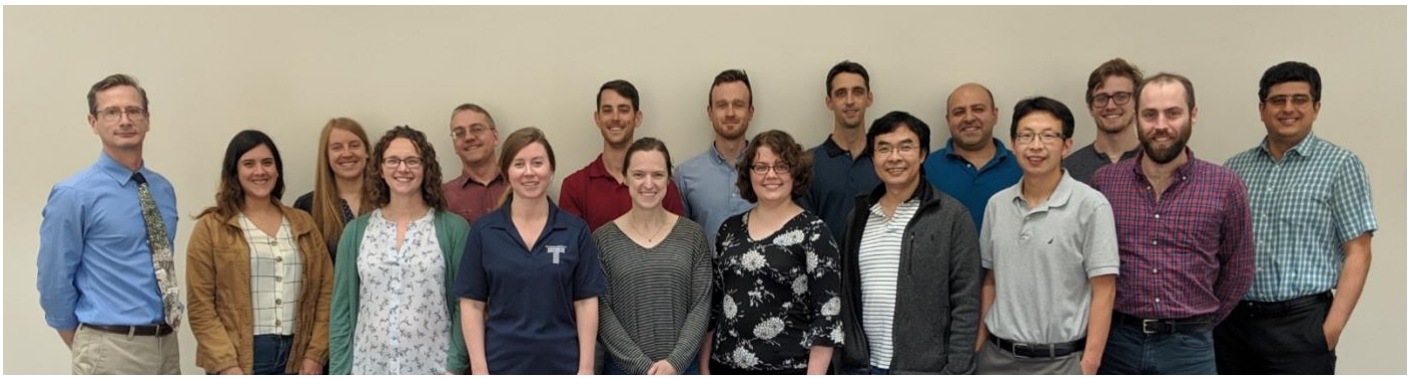
Our registration numbers at the 2019 Texas ADCIRC Week included the following:

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 2 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