GINIS, URI
HUANG - FSU
DHS COASTAL RESILIENCE CENTER
ADCIRC PROJECT
YEAR 5 PROGRESS REPORT
July 1, 2019 – June 30, 2020 (Updated 12/15/2020)

I. INTRODUCTION

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, Associate Professor

Additional Research Participants/Partners:

Research Participant: Wenrui Huang, Florida State University, Professor

Other participants: Chris Damon (URI Environmental Data Center), Peter Stempel (RI School of Design), Sam Adams (Asst. Director of URI Public Safety, President of RI Association of Emergency Managers and MAF PhD student)

Short Project Description ("elevator speech"):

This project advances modeling capabilities that assess the potential impacts of landfalling hurricanes on critical infrastructure and communities and transition the developed advanced capabilities to the real-time ADCIRC-Surge Guidance System (ASGS) and Coastal Emergency Risks Assessment (CERA). 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. We developed new capabilities for the ADCIRC modeling system, such as improved surface wind modeling during hurricane landfall, coupling of storm surge and waves, and inland flooding from rainfall. We developed a participatory methodology for capturing storm risk information in a format that is compatible for integration with high-resolution numerical storm models. Our "Consequence Threshold (CT)" approach provides end-users with real-time storm models that include a detailed understanding of a broad range of potential consequences resulting from infrastructure damage. CTs combine geospatial (location of critical facilities) and meteorological information (wind, surge, and flooding data) with qualitative storm damage information from critical facilities to model the cascading impacts of storm damage to lifeline infrastructure. CT data can then be integrated as storm model outputs and used to guide emergency response decision-making within an emergency operations center.

II. PROJECT NARRATIVE

1. Project overview:

The major goal of this project is to comprehensively investigate hazards and impacts in the focus regions through advancement of coupled hurricane, coastal ocean circulation/storm surge, wave, and hydrological models. This project contributes 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. We developed and implemented new capabilities for the ADCIRC modeling system, such as improved surface wind modeling during hurricane landfall, coupling of storm surge and waves, and inland flooding from rainfall. Emergency managers need relevant, local-scale, information about potential consequences of extreme events in advance of a storm's landfall. We develop and implement in practice an innovative hazard impact methodology for collecting actionable and nuanced storm risk information from critical facility managers that is underpinned by participatory research theory, a key tenet of which is the convergence of multiple stakeholder perspectives. This allows end-users to better understand the consequences of coastal and inland hazards associated with high impact landfalling hurricanes and to better prepare coastal communities for future risks.

2. Results:

Building on work from years 1-4, our research activities in Year 5 continued to focus on advancing the capabilities and forecast skill of the ADCIRC modeling system in the Northeast and adding new capabilities, such as improved surface wind modeling during hurricane landfall, coupling of storm surge and waves, and inland flooding from rainfall. The following specific tasks were accomplished: 1) modification of the ADCIRC mesh in coastal New England and its evaluation with river inflows during historic extreme weather events; 2) evaluation and implementation of the sea state dependent drag coefficient into ADCIRC; 3) expanding coupled inland and coastal flood modeling to many Southern New England rivers; and 4) advancing the URI Hurricane Boundary Layer model applications to any location in the U.S. coastal region. A detailed description of our modeling efforts is included in the Year 5 Report Appendix.

We also continued developing innovative hazard impact analysis and infrastructure visualization methods. A new ESRI GIS dashboard system was developed that allows end-users to filter and view the potential consequences using a simulated storm. The dashboard system integrates the "consequence thresholds database" with ADCIRC model outputs and leverages the existing technologies currently in use at the Emergency Operations Center at the Rhode Island Emergency Management Agency. The dashboard system showcases the capabilities of the system using a simulated storm and data collected for the City of Providence. We further advanced 3D Visualization infrastructure coupled with ADCIRC model outputs in Rhode Island for the towns of Newport and Portsmouth. This infrastructure has been utilized to display storm surge outputs and to create visualizations useful in conjunction with the developed elicitation methods to facilitate the expansion of the project to representing additional areas. A detailed description of our hazard impact analysis and infrastructure visualization efforts is included in

the Year 5 Report Appendix.

3. End users:

Key partners who provided regular input and guidance during Year 5 include: NOAA NWS: Hydrologist in Charge, Norton, MA; NOAA NCEP/EMC: Ocean Task Lead; US Coast Guard: Marine Transportation Recovery Specialist, Sector Southeast New England; RIEMA: Operations Section Chief/Crisis Information Management; Software Coordinator; Critical Infrastructure/Key Resources Coordinator; RI Dept of Health: Chief and Deputy Chief and Program Support Specialist, Center for Emergency Preparedness and Response; Providence Emergency Management Agency: Director and Deputy Director; Providence Department of Public Property: Public Property Coordinator; RIDEM Office of Water Resources: Engineering Manager; New England National Grid: Senior Coordinator/Community Investment & Economic Development; Providence Water Supply Board: Director of Engineering; RI Infrastructure Bank: Chief Resilience Officer; City of Providence: Division of Capital Asset Management & Maintenance. The project has established a Steering Committee with 15 end-user organization/agency participants that provides guidance on the development of training materials tailored to the needs of the critical lifeline sectors. The steering committee consists of the following partners: Rhode Island Emergency Management Agency (RIEMA), RI Department of Health (RIDOH), Providence Emergency Management Agency (PEMA), Department of Homeland Security (DHS), Providence Department of Public Property, RI Department of Environmental Management (RIDEM), Narragansett Bay Commission, US Coast Guard, North East National Grid, Providence Water Supply, RI Infrastructure Bank, and the City of Providence. "Buy-in" and trust from infrastructure facility managers is a critical component of this project, as they are the source of data that is integrated with storm model outputs. The established steering committee and key partners land the project credibility and build trust with the facility managers. We established close collaboration with the Rhode Island Association of Emergency Managers (RIAEM) which includes emergency managers (EM) from all 39 communities in the state, as well as EM from institutions, such as hospitals and universities. The collaboration with RIAEM provides an opportunity for the project team to reach out to the broader audience to get feedback on the approach and products, and build buy-in and capacity for future use of ADCIRC in real-time tool; feedback on the consequence threshold effort is also critical to determine the interest and ability to scale that effort beyond the pilot to statewide application. The president of the RIAEM (Sam Adams) also joined the team as a PhD student in Marine Affairs under the supervision of Dr. Becker.

4. Transition:

Efforts continued to engage our collaborators in the ADCIRC model development efforts. We held a meeting with the research staff and forecasters at the NOAA/NWS Northeast River Forecast Center on November 20, 2019 to discuss our work on inland and coastal flood coupled modeling in Southern New England and transitioning it to real-time forecast capabilities. We also held a meeting with the ocean and wave modeling group at the NOAA's Environmental Modeling Center in College Park, MA on January 22, 2020 to discuss our progress in developing sea-state dependent wind stress parameterization in shallow water to improve storm surge forecasting and develop plans for future collaboration with EMC scientists.

Efforts continued to engage end-users in a pilot project in Providence, Rhode Island focusing on evaluation the effectiveness of our "consequence threshold" risk analysis approach and participatory methodology for capturing storm risk information in a format that is compatible for integration with high-resolution numerical storm models. Key partners provided regular input and guidance, including direction with respect to the technical requirements of the database system and interface. RIEMA, RIDOH and PEMA 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. A full list of meetings, interviews, and site visits, as well as testimonials from these key stakeholders can be found in the Year 5 Report Appendix.

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.

Our team continued to collect critical infrastructure information, thresholds, and concerns through site visits of all critical infrastructure facilities in the floodplain of Providence, RI, key informant interviews and focus groups of key infrastructure sector experts (detailed list of all end-user interactions can be found in the Year 5 Report Appendix). In sum, we collected 321 CTs for 137 critical infrastructure assets located within the Providence floodplain. The most common assets that were identified included entrances to buildings, generators, and HVAC systems.

The project Steering Committee met in the fall of 2019 (August and September) to share an update of data collection and discuss options to fill gaps in information. The team reached out to the RI Association of Emergency Managers to provide an overview of the project, both the ADCIRC modeling as well as the consequence thresholds. There was keen interest in learning how best to use the ADCIRC as another tool for emergency response and to better understand the potential to expand the consequence threshold component statewide. The focus of end-user engagement in Fall 2019 with our partners was to discuss user interface and platforms for delivering the information. This resulted in meetings (December 2019) with FEMA Region 1 and RIEMA leaders to discuss options and collaboration.

Additional details on the transition activities are provided in Year 5 Report supplemental material.

5. Project Impact:

Significant progress was made to further advance the capabilities and forecast skill of the ADCIRC modeling system in the Northeast, including a highly refined computational grid and new capabilities, such as improved surface wind modeling during hurricane landfall, coupling of storm surge and waves, and inland flooding from rainfall. All these advancements will make an important contribution to the DHS mission, because improving the accuracy of hurricane hazard

and infrastructure impact modeling will enhance our ability to anticipate and better prepare for future hurricanes.

The new capabilities afforded by our "Consequence Threshold (CT)" approach provides end-users with real-time storm impact analysis that includes a detailed understanding of a broad range of potential consequences resulting from infrastructure damage. The CT methodology will inform emergency manager decision-making in the event of an extreme storm event to protect lives and increase operational efficiency in response to storms. Storm events are dynamic in nature and introduce economic, social, ecosystem, environmental, and supply chain impacts that vary temporally and spatially. Modeling specific impacts of critical infrastructure damage can be a time consuming and computationally intensive task for researchers. The CT approach provides a more efficient method of projecting potential storm consequences in a way that is custom tailored to the needs of the end user. The participatory nature of the process engages stakeholders and builds trust within the facility manager community.

6. Unanticipated Problems:

Because Year 5 funds arrived late in 2019 some of the tasks have been only partially completed. Engagement with end-users was severely impacted by the COVID-19 pandemic. Given that our key partners are first responders (RIEMA, RIDOH, and PEMA), it was not appropriate or feasible to engage them from March, 2020. The team continued to develop the interface for delivery of critical infrastructure consequences linked with the storm prediction models. Training material and web-based interactive software was developed for a virtual workshop in July, 2020.

On the data collection side, we faced challenges associated with the collection, handling, and dissemination of Protected Critical Infrastructure Information (PCII). We overcame this through adoption of a data sensitivity protocol built into our approach (with significant input from the steering committee), as well as by participating in PCII training for all members of the research team. Details of this are provided in Year 5 Report Appendix.

7. Student Involvement and Awards:

   a) Students involved in the research

      i. Xuanyu Chen, a PhD student at the Graduate School of Oceanography, worked 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. (Full CRC support).
      ii. Mansur Ali Jisan, a PhD student at the Graduate School of Oceanography, worked on advancing modeling of surface winds during hurricane landfall for predicting storm impacts. He also assisted in running the ADCIRC system for nor'easters. (Full CRC support).

iii. Ellis Kalaidijan, a MA student in the Department of Marine Affairs, worked with PIs and end-user partners to collect, aggregate, and synthesize data on critical infrastructure. (Partial CRC support).
iv. Noah Hallisey, a MS student in the Department of Biological and Environmental Sciences, worked with PIs and end-user partners to collect, aggregate, and synthesize data on critical infrastructure. (Partial CRC support).
v. Sam Radov, a BS student in Community Planning and Sociology, worked with PIs to collect data on critical infrastructure. (Partial CRC support).
vi. Joyce Pak, a MS student at Brown University, worked with PIs and end-user partners to collect data on critical infrastructure. Her involvement on the project was leveraged through our partnership with the RI Department of Health and Brown Public Health program. (No CRC support)
vii. Sam Adams, a PhD student at URI, is not directly assisted through CRC funding but is an active member of the team. Adams is also the Asst. Director of Public Safety for URI and president of the RIEAM. (No CRC support)
viii. Madison Russ, a MARCH student at RISD, is not directly assisted through CRC funding but is an active member of the team building visualization infrastructure for Newport. (No CRC support)
ix. Anya Drozd, a BARCH student at RISD, is not directly assisted through CRC funding but is an active member of the team building visualization infrastructure for Portsmouth. (No CRC support)

b) Student demographics

Our project involved five female and four male student researchers. Among them, seven were graduate students and two undergraduate students.

c) Student Degrees

- Peter Stempel was awarded his PhD in Marine Affairs in Y4.
- Bobby Witkop, Master's thesis in Marine Affairs in Y4.
- Xuanyu Chen, Ph.D. student is scheduled to defend her dissertation in July 2020.

d) Student Awards

- Peter Stempel was awarded the Graduate Scholarship Excellence Award in Y4.
- Xuanyu Chen was awarded the William E. Simmons Memorial Scholarship Award in Oceanography for research expected to be of real economic value in Y5 and the Marine Science Award, Thomas & Kathy J. McNiff Graduate Student Endowment in Y4.

8. Interactions with CRC education projects:

- Austin Becker gave a webinar presentation to Dan Cox's Engineering Course at Oregon State University on May 6, 2020.

III. RESEARCH ACTIVITIES AND TRANSITION MILESTONES

1. Year 5 Research Activities and Milestone Achievements:

Year 5 Research Activities and Milestones: Status as of 6/30/2020			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Implement the Precipitation-Runoff Modeling System (PRMS) to simulate rainfall runoff in Massachusetts.	06/30/2020 New target date: 6/30/2021	80%	Due to the delay in ADCIRC team funding.
Complete coupling of waves and storm surge models in ADCIRC-SWAN system to include a sea state dependent drag coefficient, air-sea flux budgets, Coriolis-Stokes interactions, Stokes-vortex forces and Langmuir turbulence.	06/30/2020 New target date: 6/30/2021	80%	Due to the delay in ADCIRC team funding.
Evaluate the ADCIRC-PRMS modeling system for simulations of historic tropical cyclones in New England, such as hurricanes Irene (2011) and Sandy (2012), and four nor'easters affected the region in March 2018.	06/30/2020 New target date: 6/30/2021	70%	Due to the delay in ADCIRC team funding.
Apply the URI Hurricane Boundary Layer (HBL) model and conduct its validation against available observations in historic hurricanes that made landfall in the U.S.	06/30/2020 New target date: 6/30/2021	80%	Due to the delay in ADCIRC team funding.
Implement the URI Hurricane Boundary Layer (HBL) model into the ADCIRC real-time prediction system and evaluate its impact on the storm prediction skill. Transition the model to the operational ADCIRC-Surge Guidance System.	06/30/2020 New target date: 6/30/2021	30%	Due to the delay in ADCIRC team funding.
In collaboration with the ASGS and CERA developers implement technical capabilities for integrating the disaster consequence thresholds into the real-time system. This will benefit coastal emergency management and provide hazard impact information to the public through CERA.	06/30/2020	60%	Due to the delay in ADCIRC team funding. In consultation with end-users and our steering committee, we altered this task to leverage the existing technology in use at RIEMA. Thus, we no longer plan to integrate the disaster consequence thresholds with CERA at this stage. Instead, we are developing an ESRI

			mapping dashboard that is similar to the systems already in use at RIEMA.
Develop and implement technical capabilities for integrating 3D hazard visualization output compatible with the ASGS and CERA computational framework.	06/30/2020	60%	In consultation with end-users and our steering committee, we altered this task to leverage the existing technology in use at RIEMA. Thus, we no longer plan to utilize the 3D visualization outputs into CERA at this stage. Instead, it will be integrated into an ESRI mapping dashboard that is similar to the systems already in use at RIEMA.
Research Milestone			
Implemented the Precipitation-Runoff Modeling System (PRMS) to simulate rainfall runoff in Massachusetts.	06/30/2020 New target date: 6/30/2021	80%	Due to the delay in ADCIRC team funding.
Implemented the sea state dependent drag coefficient and other physics upgrades in ADCIRC-SWAN system.	06/30/2020 New target date: 6/30/2021	80%	Due to the delay in ADCIRC team funding.
Completed integration of the PRMS hydrological modeling in CT, RI, and MA into ADCIRC--Surge Guidance System.	06/30/2020 New target date: 6/30/2021	70%	Due to the delay in ADCIRC team funding.
Completed integration of the URI Hurricane Boundary Layer Model into the ADCIRC-Surge Guidance System.	06/30/2020 New target date: 6/30/2021	70%	Due to the delay in ADCIRC team funding.
Completed integration of the hazard impact and 3D visualization output into the ASGS and CERA computational framework.	06/30/2020	60%	In consultation with end-users and our steering committee, we altered this task to leverage the existing technology in use at RIEMA. Thus, we no longer plan to utilize the 3D visualization outputs or to integrate with CERA at this stage. Instead, we are developing an ESRI mapping dashboard that is similar to the systems already in use at RIEMA.

2. **Year 5 Transition Activities and Milestone Achievements**:

Year 5 Transition Activities and Milestones: Status as of 6/30/2020			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not completed
Reconvene core end-user group meeting to discuss model results. Reconfirm outreach strategy to local emergency managers.	06/30/2020 New target date: 6/30/2021	50%	Due to the delay in ADCIRC team funding. Some engagements with end-users was severely impacted by the COVID-19 pandemic.
Present model capabilities to end-users at strategic meetings, such as the FEMA regional meetings, State Emergency Manager Associations or State Floodplain Manager Annual meetings.	06/30/2020 New target date: 6/30/2021	50%	Some planned engagements with end-users were impacted by the COVID-19 pandemic.
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.	06/30/2020 New target date: 6/30/2021	0%	This will be done during the workshop/webinar scheduled for July 2020. It was delayed due to the COVID-19 pandemic.
Design and conduct a webinar on model capabilities to reach out to additional end users.	06/30/2020 New target date: 6/30/2021	0%	Additional webinars will be conducted with one or more groups after the scheduled July workshop.
Participate and contribute to annual ADCIRC training courses for end-users.	06/30/2020	100%	
Transition Milestone			
Transition the completed coupling of wave and storm surge models to the operational ADCIRC-Surge Guidance System (ASGS).	06/30/2020 New target date: 6/30/2021	60%	Due to the delay in ADCIRC team funding.
Transition the completed Precipitation-Runoff Modeling System (PRMS) in CT, RI and MA to the operational ADCIRC-Surge Guidance System (ASGS).	06/30/2020 New target date: 6/30/2021	60%	Due to the delay in ADCIRC team funding.

Transition the URI Hurricane Boundary Layer Model (HBL) to the operational ADCIRC-Surge Guidance System (ASGS).	06/30/2020 New target date: 6/30/2021	70%	Due to the delay in ADCIRC team funding.
Transition the completed integration of the hazard impact and 3D visualization output into the ADCIRC-Surge Guidance System (ASGS) and the Coastal Emergency Risks Assessment (CERA).	06/30/2020	60%	In consultation with end-users and our steering committee, we altered this task to leverage the existing technology in use at RIEMA. Thus, we no longer plan to utilize the 3D visualization outputs or to integrate with CERA at this stage. Instead, we are developing an ESRI mapping dashboard that is similar to the systems already in use at RIEMA.

3. **Research Project Product Delivery.**

Table: Research Project Product Delivery

Product Name and Function	**Brief Product Description, including type** (e.g., software, algorithm, guidance document, knowledge product)	**Date Delivered** (or projected date of delivery)	**Recipient or End User(s)**
Hazard Consequence Modeling System (HCMS)	This real-time hazard and impact prediction system for hurricanes and nor'easters in Southern New England will run on existing ArcGIS systems typically in use at Emergency Operation Centers (EOCs) around the country. It integrates end-user knowledge and concerns as model inputs into the ADCIRC-Surge Guidance System. It provides predictions of cascading consequences of extreme weather (i.e., surge, wind, flooding, waves) impacting critical infrastructure (e.g., wastewater treatment facilities, sewer systems, airports, and seaports).	Demonstration product anticipated July 2020	Rhode Island Emergency Management Agency, Providence Emergency Management Agency, Rhode Island Dept. of Health, other state and federal agencies per Year 5 Report Appendix

IV. PUBLICATIONS AND METRICS

1. Publications:

Yr 4/5 Publications (Student authors are marked with an asterisk):

- Chen, X.*, T. Hara, and I. Ginis, 2020. Impact of Shoaling Ocean Surface Waves on Wind Stress and Drag Coefficient in Coastal Waters: Part I Uniform Wind, *J. Geophys. Res., In review.*
- Chen, X*., I. Ginis, and T. Hara, 2020: Impact of Shoaling Ocean Surface Waves on Wind Stress and Drag Coefficient in Coastal Waters: Part II Tropical Cyclones, *J. Geophys. Res., In press.*
- Huang, W., F Teng, I. Ginis, and D. Ullman, 2020. Rainfall Runoff and Flood Simulations for Hurricane Impacts on Woonasquatucket River, USA. ICCEN 2019. Accepted by International Journal of Structural and Civil Engineering Research (IJSCER), August V9N3.
- Stempel, P., Becker, A., 2020. Is it Scientific? Viewer perceptions of storm surge visualizations. *Cartographica (The Canadian Journal of Cartography). In Review*.
- Stempel, P., Becker, A., 2019. Visualizations out of context. Implications of using simulation-based 3d hazard visualizations. *ISPRS International Journal of Geo-Information*: Special issue on Natural Hazards and Geospatial Information. Vol 8, No 318; Doi:10.3390/ijgi8080318.
- 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*, *9*(6), 265; https://doi.org/10.3390/geosciences9060265
- Witkop R.*, A. Becker, P. Stempel*, and I. Ginis, 2019: Developing Consequence Thresholds for Storm Models Through Participatory Processes: Case Study of Westerly Rhode Island. *Front. Earth Sci.* 7:133. doi: 10.3389/feart.2019.00133
- Bender, M.A., T. Marchok, R. E. Tuleya, I. Ginis, V. Tallapragada, and S. J. Lord, 2019: Hurricane model development at GFDL, 2019: A Collaborative success story from a historical perspective., *Bull. Amer. Met. Soc.*, September, https://doi.org/10.1175/BAMS-D-18-0197.1
- Wang, D.*, T. Kukulka, B. Reichl, T. Hara, I. Ginis, and W. Perrie, 2019: Wind-wave misalignment effects on Langmuir turbulence in tropical cyclones conditions, *J. Phys. Oceanogr*., https://doi.org/10.1175/JPO-D-19-0093.1
- Torres M.J.*, M. R. Hashemi, S. Hayward, M. Spaulding, I. Ginis, and S. T. Grilli, 2019: Role of hurricane wind models in accurate simulation of storm surge and waves. *Coastal, Ocean Eng.*, 2019, 145(1): 04018039. doi: 10.1061/(ASCE)WW.1943-5460.0000496

Previous Publications (student authors are marked with an asterisk)

- 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
- *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

Conference papers, presentations:

Yr 4/5 presentations (student authors are marked with an asterisk):

- Becker, A., Rubinoff, P., Stempel, P., Ginis, I., Adams, S.*, Hallisey, N.*, Kalaidjian, E.*, (2020) Hazard Consequence Threshold Models for Emergency Management and Response Decision Making. Natural Hazards Center Researchers Meeting, Boulder, CO, July 15-16.
- Stempel, P., (2020). "Adaptation of low-lying neighborhoods in Portsmouth, RI. USA." International Geodesign Collaboration (IGC), Redlands, CA. February 22–24, 2020
- Chen, X.*, I. Ginis and T. Hara: Numerical Study of Wind Stress in Coastal Water Under a Tropical Cyclone, Ocean Sciences Meeting, Feb. 16-21, 2020, https://agu.confex.com/agu/osm20/meetingapp.cgi/Paper/644262
- Hara T., X. Chen* and I. Ginis: Impact of Shoaling Wind Waves on Drag Coefficient in Finite Depth, Ocean Sciences Meeting, Feb. 16-21, 2020, https://agu.confex.com/agu/osm20/meetingapp.cgi/Paper/646849
- Becker, A. (2019), "Coastal Hazard Impact Assessment." Climate Preparedness and Resilience Community of Practice Lead, CW Guidance Program US Army Corps of Engineers Headquarters, Washington, DC, Sept. 11.
- Becker, A. (2019), "Hazard Consequence Threshold Models for Emergency Management and Response Decision Making." CARIS (Climate Adaptation and Resilience Information Sharing Group, Sept. 13.
- Becker, A., Rubinoff, P., Ginis, I., Adams, S.* (2019) Hazard Consequence Threshold Models for Emergency Management and Response Decision Making. Presentation to FEMA Region 1, Dec. 18, Boston, MA.
- Stempel, P., (2019). "Rethinking model-driven realistic storm-surge graphics." Rhode Island Coastal Ecology, Assessment, Innovation, and Modeling (R C-AIM) Research Symposium 2019, Kingston RI. April 10.
- Ginis, I., and Il-K. Ma (2019): Impact of Warm-Core Ocean Eddies on Tropical Cyclone Intensification in the Northwest Pacific, International Workshop on Tropical Cyclone-Ocean Interaction in the Northwest Pacific, June 20, http://www.tcoi.co.kr/
- 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.
- 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, 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.

- 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 presentations (student authors are marked with an asterisk)

- Ginis I. (2018): Advances in Predicting Hurricane Path and Intensity, Jamestown Philomenian Library, Jamestown RI, September 24.
- 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
- Becker, A. (2018). "Stimulating Transformational Thinking for Long-Term Climate Resilience." University of Rhode Island Coastal Resiliency Symposium, Oct. 16, Narragansett, RI. (I)
- 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 multi-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
- Xuanyu Chen Ph.D. Dissertation in Physical Oceanography: "Impacts of Shoaling Ocean Surface Waves on Wind Stress and Storm Surge" 2020, Primary advisors: Dr. Isaac Ginis and Dr. Tetsu Hara, Committee member: Dr. David Ullman

2. Performance Metrics

Ginis 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)	Year 5 (7/1/19-6/30/20)
HS-related internships (number)	0	0	0	0	0
Undergraduates provided tuition/fee support (number)	0	0	0	0	0
Undergraduate students provided stipends (number)	0	0	0	1	1
Graduate students provided tuition/fee support (number)	2	3	3	3	3
Graduate students provided stipends (number)	2	3	3	3	3
Undergraduates who received HS-related degrees (number)	0	0	0	0	0
Graduate students who received HS-related degrees (number)	0	0	0	0	2
Graduates who obtained HS-related employment (number)	0	0	0	0	2
SUMREX program students hosted (number)	0	2	2	0	0
Lectures/presentations/seminars at Center partners (number)	1	3	2	1	2
DHS MSI Summer Research Teams hosted (number)	0	0	0	0	0
Journal articles submitted (number)	2	7	6	3	4
Journal articles published (number)	7	8	9	7	10
Conference presentations made (number)	15	14	15	8	14
Other presentations, interviews, etc. (number)	12	22	17	23	18
Patent applications filed (number)	0	0	0	0	0
Patents awarded (number)	0	0	0	0	0
Trademarks/copyrights filed (number)	0	0	0	0	0
Requests for assistance/advice from DHS agencies (number)	0	3	5	3	3
Requests for assistance/advice from other agencies or governments (number)	5	13	12	11	12
Dollar amount of external funding	$3,921,000	$3,660,000			
Total milestones for reporting period (number)	11	21	19	8	9
Accomplished fully (number)	9	17	19	1	0
Accomplished partially (number)	2	4	0	7	9
Not accomplished (number)	0	0	0	0	0