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Preferences for Modeling Scenarios and Parameters: The Perspective of Planners and Emergency Managers (Risk Communication and Public Engagement in Sea Level Rise Resilience Research Series, Paper No. 1)

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RISK COMMUNICATION AND PUBLIC ENGAGEMENT IN SEA LEVEL RISE RESILIENCE RESEARCH SERIES

PAPER NO. 1

PREFERENCES FOR MODELING SCENARIOS AND PARAMETERS: THE PERSPECTIVE OF PLANNERS AND EMERGENCY MANAGERS

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COMMONWEALTH CENTER FOR RECURRENT FLOODING RESILIENCY

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ABOUT THE RISK COMMUNICATION AND PUBLIC ENGAGEMENT IN SEA LEVEL RISE RESILIENCE RESEARCH SERIES

Improving risk communication is key to building resilience in areas at risk to all types of flooding. The National Research Council has defined risk communication as an interactive process of exchange of information and perspectives among individuals, groups and institutions[1]. Risk communication is a two-way dialogue that requires communicators to understand their audience in order to deliver the correct messages at appropriate times in order to achieve the desired outcome. Key to producing useful and actionable risk communications products is understanding audience risk perceptions, information needs and ability to respond to messages.

The goal is to examine key elements of risk communication necessary for effectively delivering impactful information about flooding, adaptation, and resilience.

Likewise, public engagement is a best practice in many fields of resilience including planning, preparedness, policy and decision-making. Public engagement leads to more informed residents; better actions, impacts and outcomes; more community buy-in and support; faster implementation and more trust in local government[2]. Since meaningful stakeholder engagement efforts require having informed and educated stakeholders and are based on effective communication of critical information, these two areas are closely linked together.

This research series focuses on communicating and engaging with stakeholders regarding vulnerabilities, risks, preparedness, and adaptation. The goal is to examine key elements of risk communication necessary for effectively delivering impactful information about flooding, adaptation, and resilience. The efficacy of information supply hinges on user adoption and having the correct communication technologies and mechanisms in place. The studies in this research series focus on the factors driving use of information and specific approaches for communicating information and educating, and encouraging action. This research series include studies of modeling and visualization, adaptation preferences, information seeking, gamification, and social learning.

Studies in the Risk Communication and Public Engagement in Sea Level Rise Resilience Research Series are led by interdisciplinary faculty of the ODU Resilience Collaborative, a consortium of leading scholars actively engaged in research, education, and outreach on critical issues for resilience at the community, regional, national, and global levels.

This project, Preferences for Modeling Scenarios and Parameters: The Perspective of Planners and Emergency Managers, was funded by the Commonwealth Center for Recurrent Flooding Resiliency.

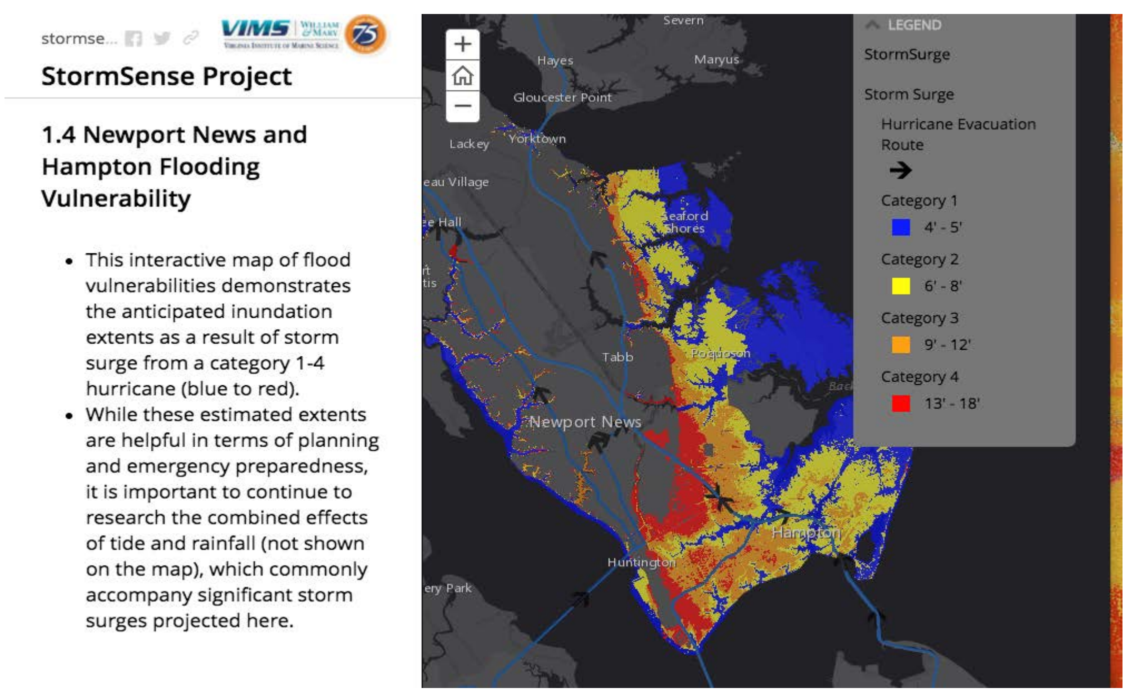
1. National Research Council. 1989. *Improving Risk Communication.* Washington, DC: The National Academies Press. https://doi.org/10.17226/1189.

2. National Research Council. 2008. *Public Participation in Environmental Assessment and Decision Making.* Washington, DC: The National Academies Press. https://doi.org/10.17226/12434.

OVERVIEW

Hampton Roads is experiencing one of the highest rates of sea level rise on the east coast, resulting in an increase in flooding and a greater need for forecast inundation modeling at a very localized scale. This study is a joint project involving researchers from both the ODU Resilience Collaborative and the Virginia Institute for Marine Science (VIMS).

The purpose of this study is to better inform research and practice in flood modeling by obtaining input from key end users on preferences for modeling approaches and model parameters, usability of flood models, and how information from flood models fit into decision making processes. We conducted a survey of stakeholders and end-users in the planning arena to identify their preferences for flood modeling scenarios and parameters. We also conducted a focus group with local emergency managers to understand how they would use predictive flood modeling for emergency management and planning.



SURVEY OF MODELING SCENARIOS AND PARAMETERS

An increasing number of hazards, disasters and extreme weather events (such as flooding, more severe storms, etc.) highlights the need for businesses to adapt to a changing environment. A significant part of adaptation includes increasing resilience to coastal hazards, disasters, and extreme events. Resilience for businesses is the (1) ability to adequately prepare for both regularly occurring events (such as flooding), and infrequent disasters and extreme events, (2) maintain operations during those events, and (3) resume operations after the events have occurred, which is often referred to as business continuity. Resilient businesses sustain less damage and fewer financial losses.

A significant part of adaptation includes increasing resilience to coastal hazards, disasters, and extreme events.

The July 2016 Hampton Roads Adaptation Forum was focused on the topic of sea level rise and flooding science. Dr. Derek Loftis, of the VIMS flood modeling team, made a presentation to the Adaptation Forum participants on his flood modeling approach. In the same presentation he described the three inundation flood modeling paradigms[3] shown in Figure 1 below. Participants were asked to answer a short survey regarding their preferences for the three paradigms, which use locally-familiar historic storms to contrast different inundation modeling paradigms, and for different modeling parameters.

3. Dr. Loftis' presentation to the Hampton Roads Adaptation Forum is available at: https://sites.wp.odu.edu/HRAdaptationForum/the-latest-in-sea-level-rise-and-flooding-science/

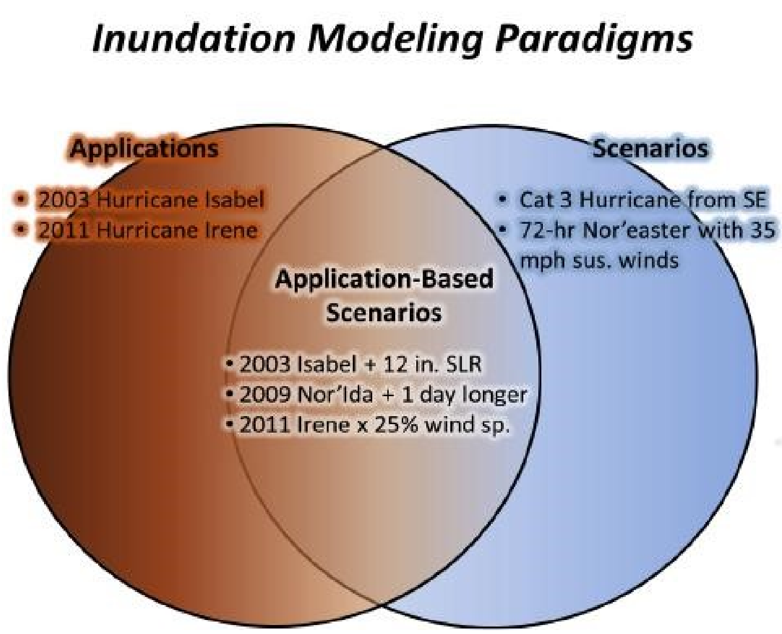
After the Hampton Roads Sea Level Rise and Flooding Adaptation Forum on July 29, 2016 a link to the web survey was disseminated via the Adaptation Forum listserv in August and October 2016 (see Appendix for the survey instrument). The listserv has 357 members made up of local government staff, academic researchers, private sector engineers, non-profit and non-governmental organization staff, and others engaged in sea level rise and flood resilience. Twenty-four complete survey responses were collected. Survey respondents fell into the following professional positions:

- Planner (21%)
- Emergency manager (17%)
- Engineer (13%)
- Academic researcher/scientist (25%)
- NGO staff (8%)
- Other governmnet staff (8%)
- Other

The first survey question was: ***To guide flood preparation efforts preparation efforts in Hampton Roads, what type of inundation modeling paradigm would you like to see used?*** Fifty percent of respondents preferred the application-based scenarios and 25% preferred scenarios. The remaining respondents were split between applications (13%) and 'I don't know' (12%).

Once respondents identify their preferred type of inundation modeling, they were asked: ***What Saffir-Simpson Hurricane Scale storm categories should be used for planning via scenario modeling?*** For this question, respondents could choose multiple answers. While there was not a majority selection in the response to this question, the most popular responses were Category 2 (46%), Category 3 (46%), and Category 1 (38%).

FIGURE 1



Similarly, respondents were asked: ***Which of the following historic storms would you like to see modeled with sea level rise?*** For this question, respondents could also choose multiple answers. There was less consensus on preferences regarding historic storms. Forty-six percent of respondents chose Hurricane Isabel (2003), 38% chose Hurricane Irene (2011), 29% chose Norida (2009), 25% chose Super Storm Sandy (2012), and 17% chose the Hurricane of 1933.

Then respondents were asked a follow-up question: ***Considering the historical storm you just selected, what additional scenario should be modeled?*** The majority (54%) chose increased wind speed by 25%, while 40% had no opinion.

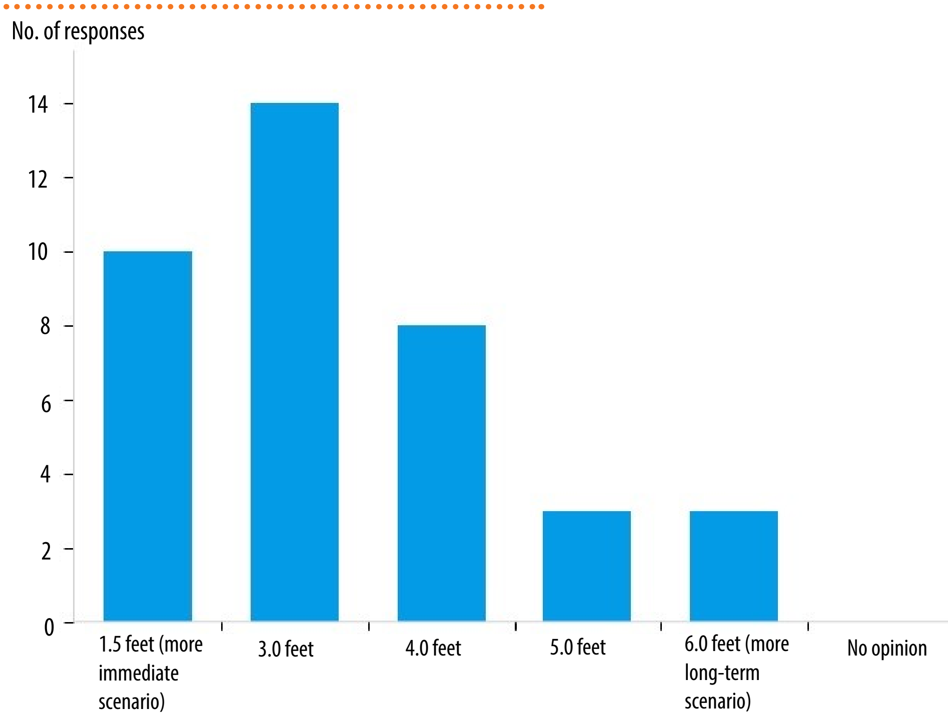
Respondents were asked: ***What wind speed should be used for extra-tropical storm scenarios?*** Of those who expressed an opinion, 33% selected 45 mph, and 8% selected each of the other choices of 25, 35 and 55 mph. Forty-six percent had no opinion.

Respondents were asked: ***Nor'easters can span several days. What length of storm should be a priority to guide the duration of winds for early scenario planning?*** Respondents clearly preferred 3 days (58% of respondents), while 21% preferred 4 days and 8% selected 2 days.

Respondents were asked: ***What direction should the prevailing winds be from?*** The Northeast direction was the most popular choice at 66%, while 21% had no opinion. Respondents were also asked: ***To guide planning scenarios, what amount of sea level rise would you like modeled?*** For this question, respondents could choose multiple answers.

All respondents answered this question, with the majority (63%) choosing the more immediate sea level rise (SLR) scenarios of 1.5 and 3.0 feet. Twenty-six percent of respondents chose 1.5 feet of SLR, 37% chose 3 feet of SLR, 21% chose 4 feet of SLR, and 8% chose each of the other choices 5 feet of SLR and 6 feet of SLR. See Figure 2 below.

FIGURE 2



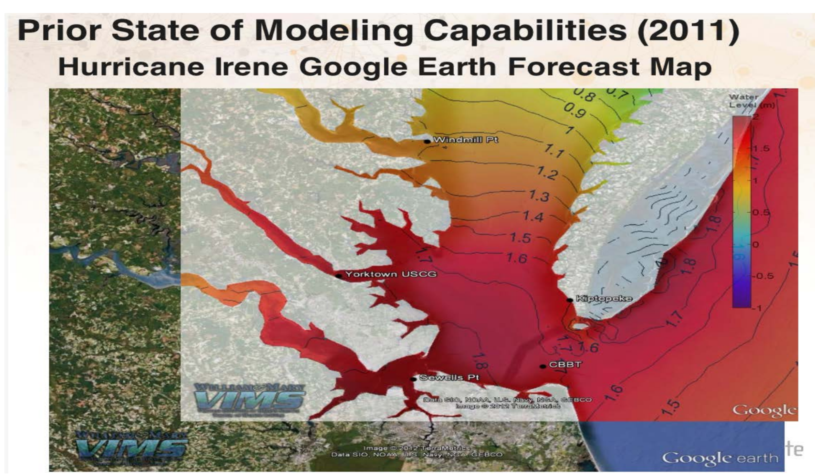
FOCUS GROUP OF EMERGENCY MANAGERS

Following the survey, Dr. Loftis created three sample flood models and a focus group was conducted with local emergency managers to understand how they would use the predicted flood modeling for emergency management and planning. The purpose of the focus group was to identify the usefulness of the information provided by the flood models, how far in advance such information would be needed, how it would fit into decision making, how often information would need to be updated, and how the model information should be communicated.

Focus group questions included:

1. How useful is the information provided by the model?
2. How far in advance would you need information from a model such as this for it to be useful in emergency management planning prior to an event?
3. How would this type of flood modeling for forecasted events fit into your decision-making processes for the purpose of emergency preparedness and/or response?
4. How often do you update your storm data information (intervals of 3 hours, 6 hours)?
5. How should this model information be communicated to stakeholders?

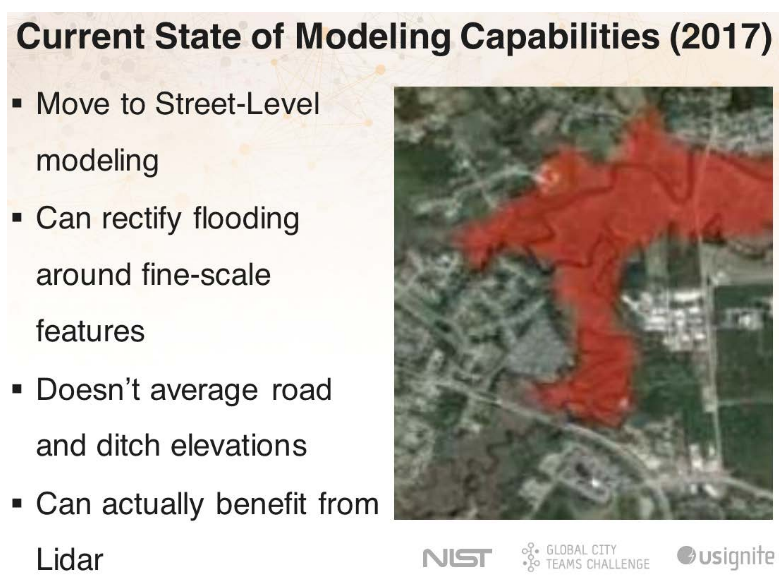
The focus group was convened on May 15, 2017 at Old Dominion University with five local emergency managers in attendance. Dr. Loftis presented his most recent flood modeling efforts, followed by structured discussion facilitated by Dr. Michelle Covi.



Dr. Loftis' presentation outlined the tandem utility of two models employed by VIMS to predict inundation timing, extent, and depths. The first is the SCHISM model developed by Dr. Joseph Zhang, and the second is the UnTRIM model, which has been custom-tailored for street-level modeling applications. Dr. Loftis described his own experiences working with the VIMS Estuarine Coastal Modeling Group led by Dr. Harry Wang during the real-time forecasting of 2011 Hurricane Irene to outline both models' inputs. This also served as a functional anecdotal opportunity to describe to the local emergency managers the overall time investment needed to reliably produce viable outputs for updates to the National Weather Service (NWS) Wakefield Office in 6-hour intervals from the new SCHISM model simulations. Dr. Loftis explained that the atmospheric inputs (wind speed and direction, and atmospheric pressure, both at 9 km resolution) used to drive the SCHISM model are updated for the Global Forecast System, and North American Mesoscale Model every 6 hours at 00:00, 06:00, 12:00, 18:00 UTC. The SCHISM model (during Irene) was set to run for 30-hr. overlapping forecast simulations.

Each simulation took approximately 2 hours to run using 128 CPU cores on William & Mary's High-Performance Computing platform, Sciclone. This estimate includes post-processing of binary results into geospatial outputs, with 6-min. water levels being extracted for key points throughout Hampton Roads and the grid covering the US-Eastern Seaboard for comparison with NOAA water level sensors.

Dr. Loftis explained that at one of the key points adjacent to the mouth of the Elizabeth River, water levels from SCHISM were used to drive the UnTRIM street-level model throughout the Cities of Norfolk and parts of Chesapeake at 5 m spatial resolution. Dr. Loftis stated that the street-level model used water levels predicted from SCHISM at 6-min. intervals, with wind and pressure inputs extracted from SCHISM for a grid cell near the center of the cities.

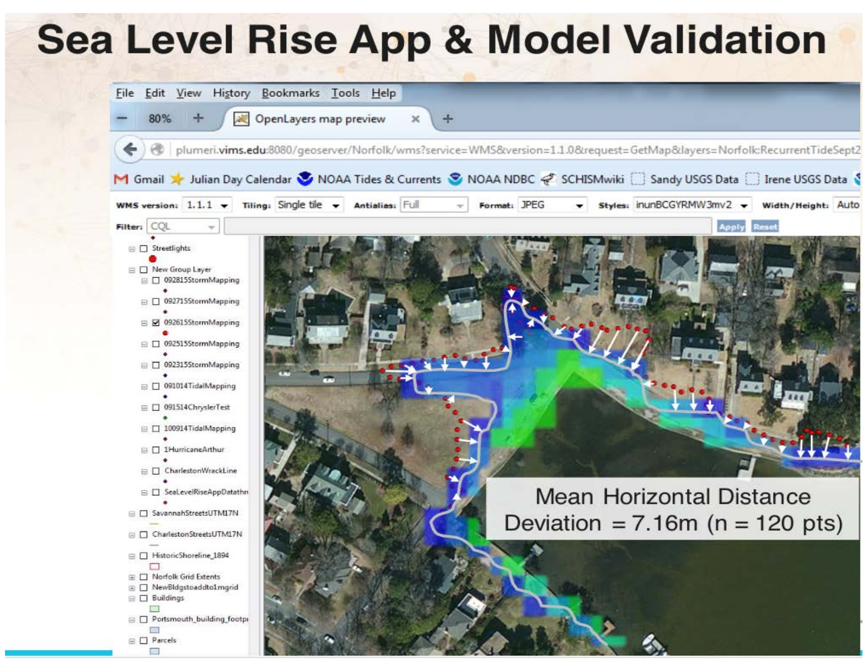


The only unique inputs for the street-level model were the inclusion of forecasted rainfall predicted by the NWS using hourly forecasts for Hampton Roads as a uniform time-varying input, and soil infiltration, which was estimated using land cover data as a spatial-varying sink to simulate percolation and groundwater recharge based upon defined hydraulic conductivity values reported in hydrology and soil drainage textbooks, as ascertained in laboratory experiments. Dr. Loftis then presented the final geospatial GIS time-aware layer outputs from the street-level model in Norfolk and Chesapeake during 2011 Hurricane Irene along with results from more recent flooding events in fall 2016, including Hurricanes Matthew and Hermine, after which, Dr. Loftis and Dr. Covi fielded questions from the emergency managers.

Focus group participants asked several questions about the flood models that were related to how they might best use the models to plan and communicate flood risk.

They asked about the flood modeling datum and noted that the most useful datum for communicating risk was feet (not meters) above ground level, which is the current standard for the NWS P-Surge products. The group expressed dislike in how various federal agencies – such as the Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA) and NWS – use many different datums. The emergency managers were very interested in models that coupled rainfall and surge forecast, which is what the model presented demonstrated.

Dr. Loftis answered questions about the real-time collection of flood inundation by sensors and citizen science observations through the Sea Level Rise phone app. The emergency managers asked if the type of event observed was documented by the app. While the answer to that question is that it was not, the data collected is time stamped and by putting the data into a model, weather observations at nearby locations can be correlated with the inundation observation.

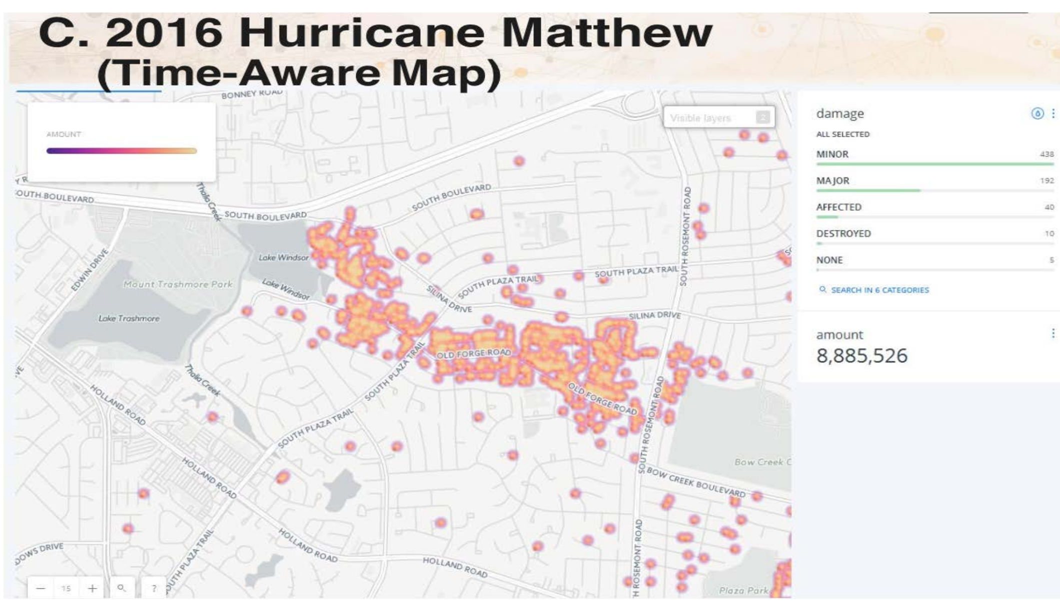


When asked if emergency managers might use the modeling and mapping before an event, focus group participants responded in the affirmative and said they could use it up to 36 hours before an event as part of an event response. This is the point at which regional emergency managers have a conference call to review the forecasts and accuracy is important. The calls actually start 5 days out from an event at 1 call per day, but increases to a couple of calls if the impact is expected locally. Participants said that their official source of forecast information is the NWS, but that they also use Fleet Weather Service and would use academic models if they were available. They want to make the best decision and believe that multiple sources of data are most helpful.

The group engaged in an in-depth discussion about how often flood models should be updated based on changing storm conditions during an event. Emergency managers currently receive this information through updates from the National Weather Service and the National Hurricane Center.

The Emergency Operations Center (EOC) lines up planning for hurricanes with updates at 5 am, 8am, 11am, 2pm, 5pm, 8pm, 11pm and suggested that VIMS updates should align with this schedule. One scenario explored was that NWS Wakefield calls are after Hurricane Center update, P-Surge takes 1 hour, and they could then follow up with VIMS.

Focus group participants thought that the most valuable part of what was shown in the presentation was the visualization. These maps of the model allow emergency managers to demonstrate why evacuations are needed. The slide showing the hindsight of storm impacts is also useful and it is valuable to know what happened after the storm to communicate losses. It is important for the emergency managers to be able to zoom in and have the most accuracy. They would like to be able to show a city manager how high water goes into a building and what the depth of the water looks like on the exterior of the building. They liked the looping graphic as the water comes in and the fly in model that visualizes what a flooded street would look like.



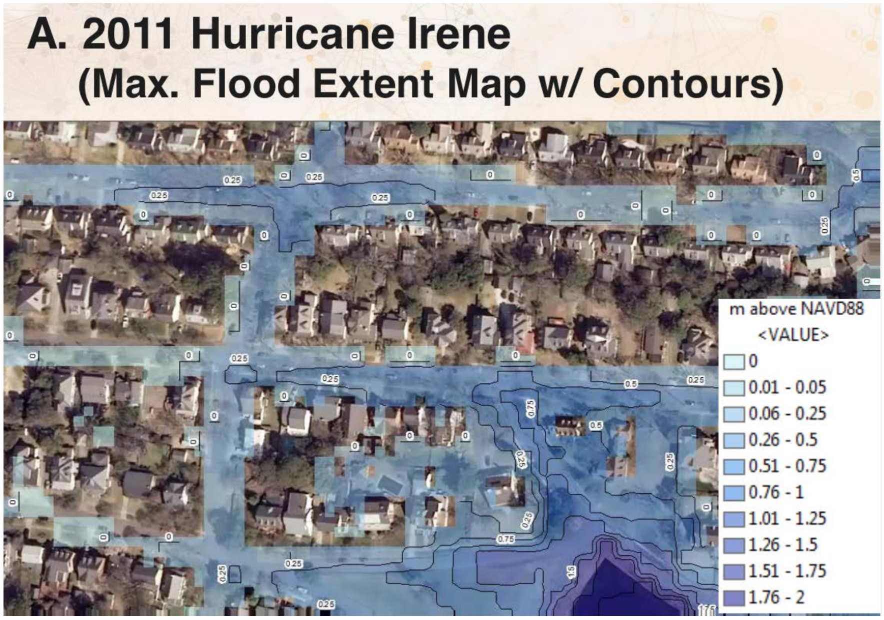
The emergency managers felt that the rainbow colors were easiest to see and that everyone understands that red is the worst situation. Participants indicated that contour lines were not needed. One of the group members said: "This information would be good for stormwater project budget support – actually showing what the problems are and how the installation of one more drainage device could have a positive impact on the problem."

When asked about platforms that the modeling could use to best integrate with the cities, the emergency managers responded that they all use ArcGIS and ideally they would like to overlay critical infrastructure with the flood model data on the map. Focus group participants would also prefer being able to display the model runs in their GIS systems that include data on critical infrastructure.

The group noted that planning maps are very useful as well, especially those using the most recent storms. When asked what scenarios would be most help with planning, they said the three factors that are most critical are forward speed of storm, strength and direction (or angle of approach).

They would also like to use ground saturation as a complicating factor. For planning, the group said, 3 or 4 scenarios at a granular level would be most useful. They already use NOAA's SLOSH model, but it does not incorporate rainfall. The inclusion of rainfall and ground saturation data would be especially useful.

The emergency managers present asked if there were ways that they could help advance the flood modeling work being conducted. They offered drone videos of the extent of flooding after a storm, noting that all the cities are using drones to assess damages and that these tools are GIS-specific. Overall, the focus group highlighted the need for locally-specific flood modeling visualizations that take into account both rainfall and surge for both planning and communication of storm risk.



SUMMARY & CONCLUSIONS

The purpose of this study is to better inform research and practice in flood modeling by obtaining input from key end users on preferences. Both surveys and focus groups were used to obtain preferences of participants.

The survey respondents did not demonstrate a strong preference for particular modeling paradigms, however, half preferred application-based scenario products. When asked about preference for particular storm scenarios, most respondents did not express a strong preference, but a slight preference for 1, 2, and 3 category tropical storms, most would like to see nor'easter storms that last for 3 days modeled.

Emergency managers that participated in the focus group were very interested in models that coupled storm surge and rainfall. They are particularly interested in using weather forecasting 36 hours ahead of a storm to anticipate impacts and plan response. The visualization tools were particularly useful to the managers and would help them to better communicate risk to the decision-makers and potentially the public as part of storm preparedness.

The models and visualization tools also have a significant utility to planning and flood mitigation, especially those based on recent storms.

Emergency managers offered to partner with flood modelers to assist in improving risk communication, risk mitigation and recovery efforts. Collaboration efforts could include sharing of drone videos documenting extent of flooding, visualization of expected flooding and visualization to support stormwater project planning.

APPENDIX

Flood Modeling Preferences Survey

1. To guide flood preparation efforts in Hampton Roads, what type of inundation modeling paradigm would you prefer to see used? (see Figure 1 on pg. 7)
   - ☐ Applications
   - ☐ Scenarios
   - ☐ Application-based scenarios
   - ☐ No opinion

2. To guide planning scenarios, what amount of sea level rise would you like to be modeled?
   - ☐ 1.5 feet (more immediate scenario)
   - ☐ 3.0 feet
   - ☐ 4.0 feet
   - ☐ 5.0 feet
   - ☐ 6.0 feet (more long-term scenario)
   - ☐ No opinion

3. What Saffir-Simpson Hurricane Scale storm categories should be used for planning?
   - ☐ Category 1
   - ☐ Category 2
   - ☐ Category 3
   - ☐ Category 4
   - ☐ Category 5
   - ☐ No opinion

4. Which of the following storms would you like to see modeled with sea level rise?
   - ☐ Hurricane of 1933
   - ☐ Hurricane Isabel 2003
   - ☐ Norida 2009
   - ☐ Hurricane Irene 2011
   - ☐ Super Storm Sandy 2012
   - ☐ No opinion
   - ☐ Other

5. Considering the historical storm you just selected, what **additional** scenario should be modeled?
    - ☐ Increased wind speed by 25%
    - ☐ Decreased wind speed by 25%
    - ☐ Increased movement speed by 25%
    - ☐ Decreased movement speed by 25%
    - ☐ No opinion

6. What wind speed should be used for Extra-Tropical Storm Scenarios?
    - ☐ 15 mph
    - ☐ 25mph
    - ☐ 35 mph
    - ☐ 45 mph
    - ☐ 55 mph
    - ☐ No opinion

7. Nor'easters can span several days. What length of storm should be a priority to guide the duration of winds for early scenario planning?
    - ☐ 1 day
    - ☐ 2 days
    - ☐ 3 days
    - ☐ 4 days
    - ☐ 5 days
    - ☐ No opinion

8. What direction should the prevailing winds be from?
    - ☐ North
    - ☐ Northeast
    - ☐ East
    - ☐ Southeast
    - ☐ Northwest
    - ☐ No opinion

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