Tropical Cyclone Flooding: Not Just a Coastal Storm-Surge Phenomenon

Inland riverine flooding from tropical cyclones (TCs) is responsible for significant economic losses in the United States. Yet, most hurricane loss assessment efforts are focused on coastal areas. Hurricane Irene, which struck the U.S. east coast in 2011, provides a recent and poignant example: while intense media coverage and preparation and evacuation activities focused on the projected coastal landfall locations in North Carolina and New York, ultimately, most of the losses were due to heavy rainfall and associated inland riverine flooding, not storm surge.

Working with flood modelers at the University of Iowa and at Princeton University (Willis Research Network colleagues), we developed a methodological approach to better understand the relationship between TC-related flood magnitudes and inland flood damage. We empirically demonstrate that our data-driven methodology to quantify inland flood magnitude produces a very good representation of the number of non-storm-surge flood insurance claims experienced for each impacted geographic area.

First, we apply new quantification methods of the spatial structure of TC-related flood magnitudes (flood peak data) at a regional scale. Analyzing flood impacts associated with a geographically expansive individual TC event (i.e., across an entire state or even multiple states) requires characterization of the spatial extent of flooding. We propose and implement a data-driven approach to flood hazard characterization based on discharge observations from a network of stream gaging stations. By normalizing with respect to a reference site-specific discharge value (e.g., 10-year flood peak), we can account for the drainage area dependence of flood peak measurements from different sites and develop spatially varying information about the intensity of the flood event associated with TCs. A ratio with a value of 1 indicates that the inland flood peak equal to the 10-year flood peak. Values larger (smaller) than 1 indicate flood peaks caused by Hurricane Ivan that are larger (smaller) than the 10-year flood peak. Across Ivan’s 23 impacted states there are a total of 27,790 census tracts with a quantified flood ratio. Nearly 2,000 census tracts (7%) had a flood ratio value greater than 1.

We then compare this data to claims data from the federally-run National Flood Insurance Program (NFIP) that underwrites the vast majority of residential flood insurance policies throughout the U.S., to which we have unique access. This combination of data allows us to produce a detailed characterization of homeowners’ flood claims at a given inland location and flood magnitudes that led to those claims.

For example, our analysis of the NFIP database reveals that inland riverine flooding from Hurricane Ivan — a devastating and costly hurricane that impacted 23 U.S. states — led to 19,273 claims with $800.9 million in flood damages. This represents 67% of the total residential NFIP flood insurance claims and 54% of the total residential NFIP flood damages from Hurricane Ivan.

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Finally, to explicitly determine the relationship between our NFIP inland flood insurance losses and inland flood intensities, we conducted an empirical analysis at the census tract level on the number of claims as a function of the quantified flood magnitude ratio and other relevant exposure factors. The coefficient values on the flood ratios from the estimation do in fact indicate whether a census tract has a higher probability of incurring any positive amount of claims, as well as an increasing number of claims as flood ratio values increase.

Guidance to federal, state and local authorities

In July 2012, President Obama signed the Flood Insurance Reform Act, which calls for better assessment of flood hazard. Our proposed methodology provides a foundation for TC flood risk assessment across all impacted areas, not just coastal landfall locations. For example, our inland flood risk assessment results could provide guidance to federal, state and local authorities in order to better sensitize inland residents who think that storms affect only coastal areas.

Notably, it is this type of inland risk assessment that is a priority for the National Weather Service (NWS) as evidenced by a U.S. Department of Commerce service assessment of Hurricane Irene where improvement on how the NWS “communicates the risk of inland flooding and educate[s] the public, media, and emergency managers on that risk” was the number one overarching recommendation.

Or, in the words of FEMA, “The next time you hear hurricane — think inland flooding!” (http://www.nws.noaa.gov/oh/hurricane/inland_flooding.html).

References
