COMBINED EFFECT OF STORM SURGE AND OVERLAND FLOW ON FLOODING IN A COASTAL URBAN AREA

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INTRODUCTION
The coastal regions in the U.S. East Coast and the Gulf of Mexico are under the risk of storm surge and precipitation-driven flooding. The adverse impacts of climate change including sea level rise (SLR), potential increase in intensity and frequency of extreme storms, and increase in precipitation intensity increases the vulnerability of coastal communities to flooding. The common practice for flood hazard assessment in urban coastal areas can result in some errors as the effect of storm surge and overland flow are not considered simultaneously. In this study, we combine the results of two hydrodynamic models, one for overland flow and the other for storm surge inundation, to develop an improved approach for flood hazard assessment.

STUDY AREA
The study region is Hampton Roads located in southeast Virginia. This region is critical in economical and national security aspects. It is comprised of 10 cities, the 34th most populated metropolitan area in the U.S., and the 38th economy in the U.S. Furthermore, the Port of Virginia, the second largest port in the U.S. East Coast, and the largest naval base in the world are located in the region. Storm surge and recurrent flooding are common in this low-lying highly urbanized region. Nuisance flooding has wide spread adverse impacts in the region. Of particular importance is the flooding of the transportation network. Among numerous adverse impacts, storm surge and recurrent flooding disrupts access to Norfolk General Hospital (NGH) which houses the only level 1 trauma center in the region. In this study, we focus on a watershed in the vicinity of NGH that includes the entire city of Norfolk and parts of the cities of Virginia Beach, Chesapeake, and Portsmouth.

METHODOLOGY
In this study, we utilize a hydrodynamic+wave model to simulate storm surge inundation in the area of interest. The model is developed using the Delft3D modelling suite. A nested model approach is utilized in which a low-resolution model computes water level and velocities over a large domain and provides the boundary condition for a nested high resolution model that covers a subset of the first model around the area of interest. The model captures superelevation of water over mean sea level due to storm surge, including wave setup, and high tides. Water elevation at the coastal margin is used as the boundary condition in a hydrodynamic model for overland flooding. The model is based on the model TUFLOW and uses precipitation, soil type, and surface roughness data, as well as the location of outfalls to simulate overland flow. Therefore, the approach captures direct and indirect contribution of storm surge to flooding at the coastal boundary as well as precipitation-driven flooding.

RESULTS
Two recent hurricanes, hurricanes Irene (2011) and Mathew (2016) that caused significant precipitation-driven and storm surge flooding were selected to test the approach. The results for the extent of flooding during hurricane Irene were compared with flood report data to obtain a qualitative validation. A more accurate comparison was made with the extent of flooding during hurricane Mathew as observed with synthetic aperture radar satellite data. Both comparisons are satisfactory.