Assessing the influence of land use/land cover and climate changes on inland flooding occurrence and severity following tropical cyclone events in the Southeast United States

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Introduction

Recent hurricanes, like Katrina, have been some of the worst the United States has experienced, causing record storm surges (Mousavi *et al.*, 2011). Further, tropical cyclones are expected to intensify in the near future in response to global climate warming (Frey *et al.*, 2010; Greenough *et al.*, 2001; Mousavi *et al.*, 2011). In 2007, the National Science Board published a report indicating that predicting "inland flooding from hurricanes and tropical storms" was a high priority for the United States (NSB, 2007). Approximately half of the United States population lives within only 50 miles of the coast (NSB, 2007), and, on average, areas that are prone to tropical cyclones are fives times more heavily populated than the rest of the nation (Frey *et al.*, 2010). Hurricanes are the most costly of all weather hazards (Frey *et al.*, 2010; NSB, 2007), and have caused 14,600 deaths over the last century (Greenough *et al.*, 2001).

Most past research has focused on predicting storm surge following hurricane events, while not much research has been conducted to study the effects of tropical cyclones on flooding on inland rivers in the Southeast United States, or how inland-river flooding following these events is likely to change in the near future. That is the focus of this research, which will hopefully help inform future mitigation and preparedness efforts.

Study Areas

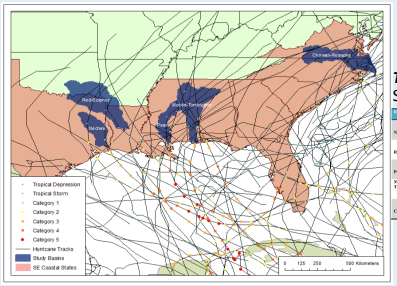

Table 1. Location of Gaging Stations in the 5 Study Basins

River Basin	River	Near	Latitude	Longitude	Basin Size
Neches	Neches River	Neches/Franklin, TX	30°25'24.95" N	96°5'10.87" W	26,041.04 km²
Red-Sulphur	Red River	Alexandria, LA	31°21'18.45" N	92°32'4.37" W	71,618.75 km²
Pearl	Pearl River	Slidell, LA	30°16'13.65" N	89°56'38.44" W	22,582.94 km²
Mobile-Tombigbee	Mobile River	Mt. Vernon, AL	31°5'11.71" N	87°58'16.92" W	56,490.07 km²
Chowan-Roanoke	Roanoke River	Williamston, NC	35°51'36.00" N	77°2'24.53" W	48,033.93 km²

Figure 1. The location of the 5 basins that will be analyzed in this study (blue). Colored dots represent points along the tracks of all tropical cyclones since 2002 that hit the SE coast, where the color/size of the dot indicates the severity of the storm at that location (see legend). (HURDAT2, NHD, ESRI)

Methodology & Initial Results

This study utilizes the Soil & Water Assessment Tool (SWAT) to assess the magnitude, duration, and frequency of floods following tropical cyclone events in the 5 study basins (***Figure 1***). The SWAT model uses data inputs, including: watershed dimensions, climate properties (e.g. temperature, precipitation), hydrologic properties (e.g. runoff, evapotranspiration), land use/land cover properties, soil properties, and channel properties, to provide simulated estimates of discharge at the mouth of a basin (Arnold *et al.*, 2012). The time period analyzed in this study will be 2002-2013, during which both sufficient tropical cyclone data and daily discharge data at the mouth of each of the 5 study basins (***Table 1***) is available.

1. Land Use/Land Cover Change (*Figure 2*)

- The A1B climate scenario will be analyzed in this study (rapid economic growth, peak in global population mid-century, development of new efficient technologies, and balanced use of fossil and non-fossil energy sources) (IPCC, 2000).
- Model scenarios will be run with 2011 land use/land cover, and predicted 2100 land use/land cover (Sohl *et al.*, 2014), given the A1B climate.

2. Climatic Change (*Figure 3*)

- Precipitation during tropical cyclone events is expected to increase by 20% by 2100 (GFDL, 2013).
- Model scenarios will be run with historical precipitation, and with a 20% increase in precipitation during tropical cyclone events (to simulate predicted 2100 climatic conditions).

3. Combined Effects (*Figure 4*)

- Another modeling scenario will be run to see what effects both the predicted A1B land use/land cover for 2100 and and a 20% increase in precipitation is likely to have on flooding conditions following tropical cyclone events in the five study basins.

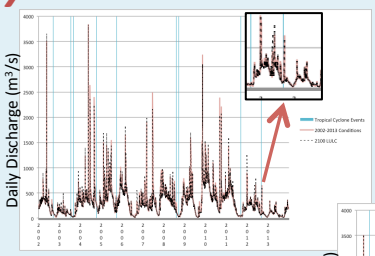

Figure 2. Modeled results of the effects of land use/land cover change on discharge at the mouth of the Neches River basin. Increased forestation appears to attenuate discharge during tropical cyclone events in this basin (see insert).

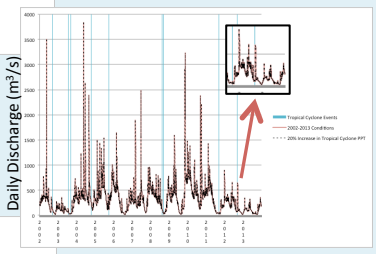

Figure 3. Modeled results of the effects of a 20% increase in tropical cyclone precipitation on discharge at the mouth of the Neches River basin. Increased precipitation appears to have little effect on discharge during tropical cyclone events in this basin (see insert).

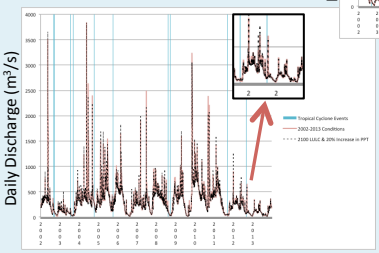

Figure 4. Modeled results of the effects of both land use/land cover change and a 20% increase in tropical cyclone precipitation on discharge at the mouth of the Neches River basin. Together these changes appear to attenuate discharge during tropical cyclone events in this basin (see insert).

Conclusions & Future Work

The preliminary results of this research indicate that flooding conditions following tropical cyclone events in this case study of the Neches River basin are likely to be less severe in the near future. These results also indicate that the timing of tropical cyclone events is a significant factor in the susceptibility of a river basin to tropical-cyclone-induced flooding. In the case of the Neches River basin, which is relatively arid, most tropical cyclone events tend to occur during low-flow times of the year. We expect the effects of tropical cyclones on inland flooding to be much higher in more humid basins, and when the tropical cyclone season coincides with high-flows. Thus, these initial results indicate that there may be both spatial and temporal drivers on basin susceptibility to tropical-cyclone-induced flooding.

The same procedure outlined above will be run on the Red River, Pearl River, Mobile River, and Roanoke River basins. Further, a sensitivity analysis will be performed using hypothetical land use/land cover scenarios in order to elucidate the influence of different land use/land cover types on inland flooding magnitude and duration following tropical cyclone events.

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