Tropical Cyclone Induced Storm Surge and Relative Sea Level Rise Modeling in the Lower Mississippi River Industrial Corridor

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Overview
State and federal management laws play a significant role in the vulnerability of coastal communities to sea level rise and subsidence. Subsidence is a perpetual coastal and geological process amplified by the impacts of eustatic sea level rise, flooding, and erosion in coastal ecosystems. The combination of eustatic sea level rise and local subsidence is defined as relative sea level rise (RSLR). Meteorological events, such as tropical cyclones, further intensify the impacts of RSLR. While hazard mitigation planning has become more common in communities throughout Louisiana following Hurricane Katrina, the impacts of RSLR on tropical cyclone storm surge are not always addressed. However, the state of Louisiana Hazard Mitigation Plan and the Louisiana Coastal Protection and Restoration Authority’s Coastal Master Plan have laid the groundwork for various modeling methods to predict future potential economic losses caused by RSLR.

The coastal areas of Louisiana have experienced significant destruction in recent years because of tropical cyclone events. The costliest natural disaster and currently third ranked most intense tropical cyclone to ever make landfall in the United States is Hurricane Katrina in 2005. The fourth most intense Atlantic hurricane to make landfall was Hurricane Rita, which made landfall shortly after Hurricane Katrina. Following the intense 2005 United States hurricane season, it was found that the open water area of coastal Louisiana increased by approximately 562 km$^2$. In 2008, Louisiana was impacted by Hurricane Gustav, which was the second-most destructive storm of the 2008 Atlantic hurricane season. While Hurricane Gustav was far less severe than Hurricanes Katrina and Rita, it did have a devastating storm surge, with heights approximately 4 m. Each of these storms had a significant impact on coastal Louisiana, and they served as the baseline events for determining how RSLR could influence future events.

Abstract
The coastal areas of Louisiana have experienced significant destruction in recent years because of tropical cyclone events. These events, coupled with relative sea level rise, are major threats to the Lower Mississippi River Industrial Corridor and the approximately 120 industrial complexes located within the corridor. Empirical Bayesian kriging interpolation methods were applied to the 2004 National Oceanic and Atmospheric Administration (NOAA) Technical Report #50 dataset to create digital elevation models for the study area for 2020, 2045, and 2070 by incorporating estimated subsidence rates for the respective years. The Federal Emergency Management Agency’s Hazus economic loss modeling program was utilized along with the newly created digital elevation models to conduct a reanalysis of Hurricanes Gustav, Katrina, and Rita for present-day sea level, as well as for the years 2020, 2045, and 2070 sea level rise projections using the Grand Isle and Lake Canal tidal station data to project sea level rise for the given years. Eight of the 122 industrial complexes within the Lower Mississippi River Industrial Corridor were projected to be inundated by modeled Hurricane Katrina storm surge using Grand Isle and New Canal sea level rise trends by 2020; two industrial complexes were projected to be inundated by modeled Hurricane Rita storm surge by 2070, and six industrial complexes were projected to be inundated by modeled Hurricane Gustav storm surge by 2020.

Hazus Results
Sea level rise projections were created for the models using the rate of sea level rise reported for each tidal station location. The New Canal tidal station has a rate of sea level rise calculated at 0.005 m yr$^{-1}$ and estimates of total sea level rise are 0.053 m over 10 years, 0.333 m over 25 years, and 0.266 m over 50 years. The Grand Isle tidal station has a rate of sea level rise calculated at 0.009 m yr$^{-1}$ and estimates of total sea level rise are 0.091 m over 10 years, 0.227 m over 25 years, and 0.454 m over 50 years. Below are the Hazus results for Gustav, Rita, and Katrina based on the above sea level rise projections and previously created digital elevation models based on the NOAA Technical Report NOS/NGS 50 subsidence rates.

Conclusions
Storm surge models for three historical storms were examined using digital elevation models created using projected subsidence rates and from sea level rise trends from two tidal stations (Grand Isle and New Canal). Industrial complexes which could potentially be impacted by storm surge for the years 2020, 2045, and 2070 were identified within the LMRIC. This study concludes that:

1) RSLR would have a direct impact on storm surge depth and extent. Each historical modeled storm experienced an increase in both storm surge depth and inundation using both the Grand Isle and New Canal sea level trend estimates.
2) Most industrial complexes are built on higher ground along the banks of the Mississippi River, which affords the complexes additional protection from RSLR and storm surge inundation. However, eight facilities in the LMRIC would be inundated by storm surge in a modeled Hurricane Katrina event, six in a modeled Hurricane Gustav event, and two in a Hurricane Rita modeled event.