ASSESSING NON-LINEAR RESPONSE IN EXTREME COASTAL WATER LEVELS

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BACKGROUND
Rising sea levels and the resultant amplification of flood frequencies and magnitude has the potential to significantly change coastal flood hazards over the coming century. The Federal Emergency Management Agency (FEMA) has recognized the potential future implications of Sea Level Rise (SLR) on coastal hazards and flood insurance. However, at present, FEMA does not incorporate future conditions information in to their regulatory or non-regulatory products in the framework of their National Flood Insurance Program. Many other programs that create products to support risk recognition and resilient planning are based on "bathtub" approaches (for example NOAA's Sea Level Rise Viewer: https://coast.noaa.gov /digitalcoast/tools/slr). In order to better understand non-linear changes in coastal flood hazards, due to increased water depth and wave heights, or in the surge propagation pathway, FEMA has funded a series of pilot studies. For this study an end-of-the-century SLR condition has been imposed on storm surge simulations in West Florida to gain further understanding into how SLR may modify surge and wave effects, as well as potential techniques for approximating these via efficient approximate methods. Both the detailed non-linear methods and approximate linear approaches for developing SLR advisory information will be evaluated and compared for this study. A second, mid-century SLR condition was utilized for a shoreline change analysis to evaluate how recession due to SLR may affect coastal flood hazards.

STUDY AREA
The study area (Figure 1) includes 50 miles of shoreline located in the southeastern United States on the Gulf of Mexico coast of Florida and includes reaches in Hillsborough and Pinellas Counties. Both reaches were selected to provide representative characteristics of specific coastal environments and flood hazard elements.

SEA LEVEL RISE SCENARIO
A higher magnitude, longer-term SLR scenario of 1.3 meters (0.98 feet) was identified to provide an end-of-the-century condition for the storm surge simulations. This scenario was selected to provide a large-enough value so that a non-linear response would be detectable in extreme water levels. Numerical modeling of this conditions was expected to provide insights into where non-linear responses may manifest across the study area's diverse coastal environments.

A second, lower magnitude SLR scenario of 0.44 meters (1.44 feet) was identified to provide a mid-century condition for evaluating potential change in shoreline position due to SLR. The lower SLR scenario was used due to limitations and uncertainty in shoreline change analysis methods. Both SLR scenarios were determined based on the NOAA report by Parris et al. (2012).

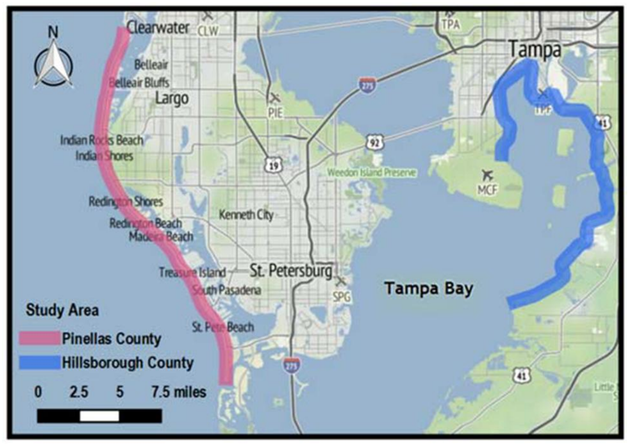

Figure 1 - Pilot study area in West Florida

FUTURE STORM SURGE CONDITIONS
The mesh used for the ADCIRC+SWAN numerical model of the West Florida FEMA Flood Insurance Study was modified to include the erosive effects on so-called stranded dune features where the rising seas would leave these areas isolated. Additionally, changes to the marshes were incorporated as changes to elevation and frictional parameters to mimic the change from vegetation to open water. The model was run using the same storm surge scenarios used for the regulatory FEMA study. The original FEMA study results were modified to add the SLR value on top of the surge results for a linear assessment of the effects of SLR on storm surge. The linear and non-linear results were compared in hopes of drawing conclusions on areas where a quickly and less-costly linear assessment may provide reasonably similar results to the more time consuming and costly non-linear analysis. Overall, this will help the coastal community better understand what environments are subject to non-linear changes in surge, and their magnitude. In turn, this will inform FEMA and others as to when numerical modeling is required to inform planning and design.

FUTURE SHORELINE POSITION
A shoreline change analysis based on the mid-century SLR scenario was evaluated using the Ashton Method and the USGS long-term shoreline change analysis data (2017). The long-term historical shoreline change rates

were used to separate changes in shoreline position due to historical SLR and due to other natural coastal processes. A mid-century shoreline position was projected based on the natural coastal processes and an estimation of future recession caused by SLR. The resulting shoreline was used to evaluate the effect on overland wave hazards in Pinellas County.

REFERENCES

Himmelstoss, Kratzman, Thieler (2017): National assessment of shoreline change - A GIS compilation of updated vector shorelines and associated shoreline change data for the Gulf of Mexico, U.S. Geological Survey data release.

Parris, Bromirski, Burkett, Cayan, Culver, Hall, Horton, Knuuti, Moss, Obeysekera, Sallenger, Weiss (2012): Global Sea Level Rise Scenarios for the United States National Climate Assessment, NOAA Technical Report OAR CPO-1, Silver Spring, MD.