INCORPORATING CLIMATE CHANGE INTO COASTAL COMPOUND FLOOD RISK

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INTRODUCTION

Coastal communities are increasingly vulnerable to multi-hazard events such as storm surges, riverine flooding, and precipitation-induced runoff. Current engineering practices and risk management strategies necessitate a comprehensive assessment of these concurrent risks to effectively mitigate potential damages. Traditional methods, including those outlined in the North Atlantic Coast Comprehensive Study (NACCS) by the US Army Corps of Engineers (USACE, 2015), tend to focus on storm surge and wave contributions on coastal flooding, and less so combined effects of precipitation. Advancements in climate science suggest a shifting baseline for the frequency and intensity of these events under climate change scenarios, although associated with uncertainties. Despite these uncertainties, there is a need for tools that integrate predicted climate change impacts into coastal flooding hazard evaluations, thereby enhancing the alignment of engineering practices with applied climate and weather research.

APPROACH

This presentation introduces a framework for evaluating coastal flood risks incorporating the effects of climate change. We discuss the development of the Synthetic Tropical and Extratropical Cyclone Database (STCDB), grounded in contemporary research on storm emulation and parametric wind-pressure and rainfall models (e.g., Bloemendaal 2020, 2022; Brogli 2022) and apply it to a U.S Naval Base on the Chesapeake Bay. The STCDB comprises a collection of physically plausible storm scenarios for present and future climates. Our integrated hydrodynamic and wave modeling system employs unstructured meshes to capture flood drivers accurately and efficiently across scales—from critical infrastructure to open ocean dynamics. Validation precedes the model's use in simulating synthetic storm events under projected climate conditions. A combination of Monte Carlo simulations enables the evaluation of bivariate flood risks based on simulation outputs.

OUTCOMES

The resulting framework from this research not only encapsulates the modeling of flood risks but also incorporates infrastructure and operational vulnerability assessments. This integration yields quantifiable indicators of flood-related impacts, both economic and otherwise (Figure 1). By correlating the frequency of modeled flood events with their consequences under a range of potential future climate conditions, our methodology generates probabilistic risk assessments that capture future uncertainty and produce comparable metrics, such as expected annual losses for each inundation event. These metrics provide stakeholders a reliable dataset to inform strategic planning and mitigation investments. Crucially, the approach is applicable to various coastal environments, even when site-specific data to drive the analysis may be scarce.

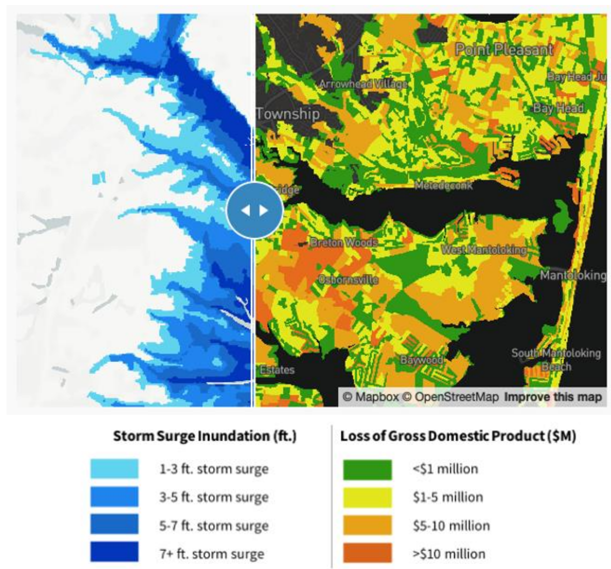

Figure 1 – Modeled storm surge impacts on inundation levels and calculated economic loss in a coastal area.

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