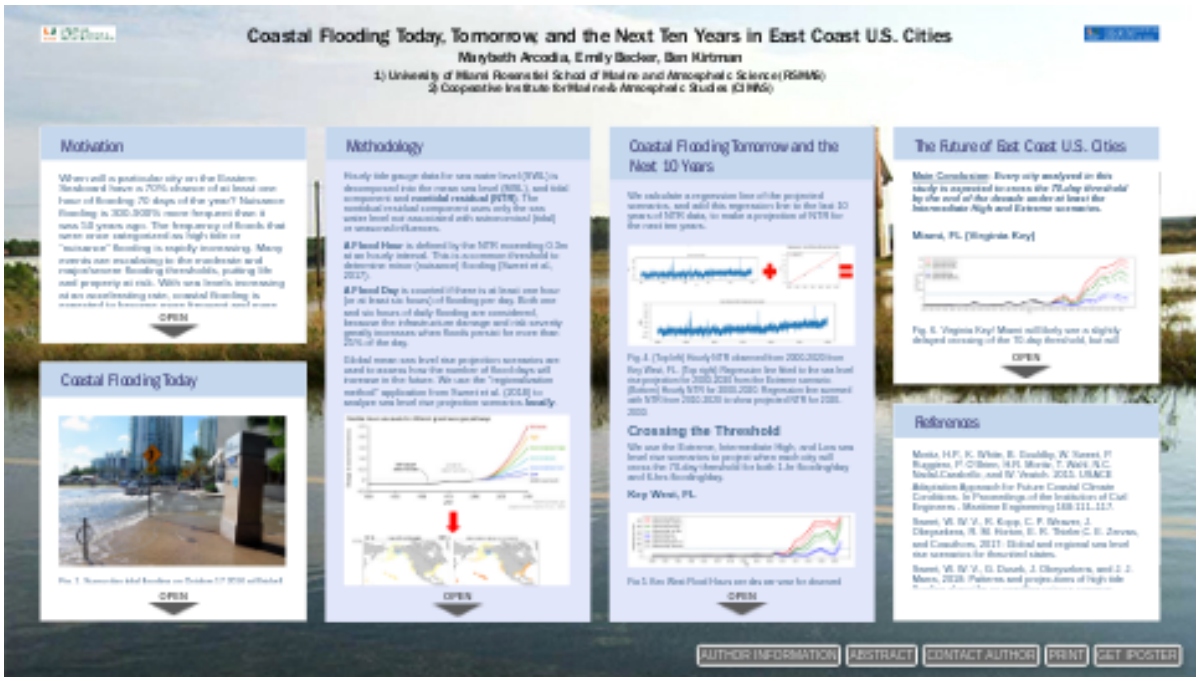
Coastal Flooding Today, Tomorrow, and the Next Ten Years in East Coast U.S. Cities



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MIAMI COOPERATIVE INSTITUTE FOR MARINE & ATMOSPHERIC STUDIES

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MOTIVATION

When will a particular city on the Eastern Seaboard have a 70% chance of at least one hour of flooding 70 days of the year? Nuisance flooding is 300-900% more frequent than it was 50 years ago, meaning that the frequency of floods that were once categorized as high tide or “nuisance” flooding is rapidly increasing. Many events are escalating to the moderate and major/severe flooding thresholds, putting life and property at risk. With sea levels increasing at an accelerating rate, coastal flooding is expected to become more frequent and more intense. This study focuses on flooding events prone to causing property damage and hazardous conditions to make flooding forecasts that are the most impactful.

COASTAL FLOODING TODAY

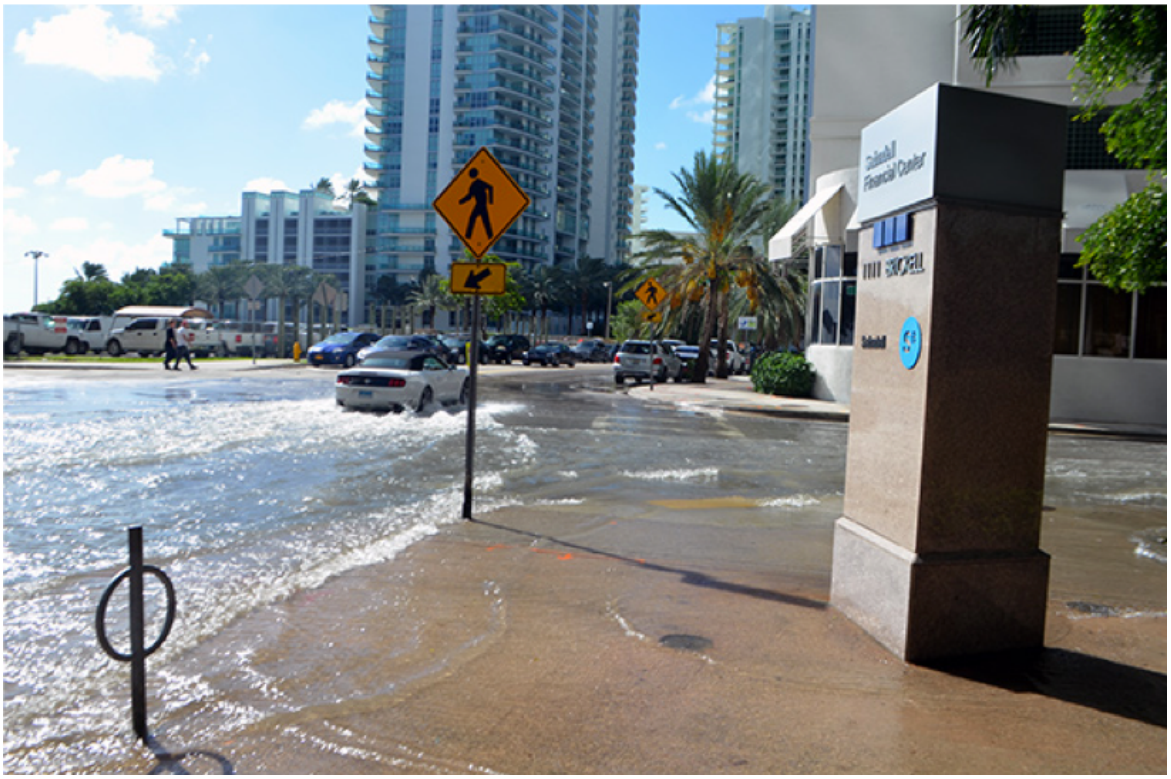

Fig. 1. Sunny day tidal flooding on October,17 2016 at Brickell Bay Drive and 12th Street in downtown Miami.

Fig. 2. Downtown Key West Duval St. Photo:Rob O'Neal/Florida Trend Magazine

METHODOLOGY

Hourly tide gauge data for sea water level (SWL) is decomposed into the mean sea level (MSL), and tidal component and **nontidal residual (NTR)**. The nontidal residual component uses only the sea water level *not* associated with astronomical (tidal) or seasonal influences.

A Flood Hour is defined by the NTR exceeding 0.3m at an hourly interval. This is a common threshold to determine minor (nuisance) flooding (Sweet et al., 2017).

A Flood Day is counted if there is at least one hour (or at least six hours) of flooding per day. Both one and six hours of daily flooding are considered, because the infrastructure damage and risk severity greatly increases when floods persist for more than 25% of the day.

Global mean sea level rise projection scenarios are used to assess how the number of flood days will increase in the future. We use the "regionalization method" application from Sweet et al. (2018) to analyze sea level rise projection scenarios ***locally***.

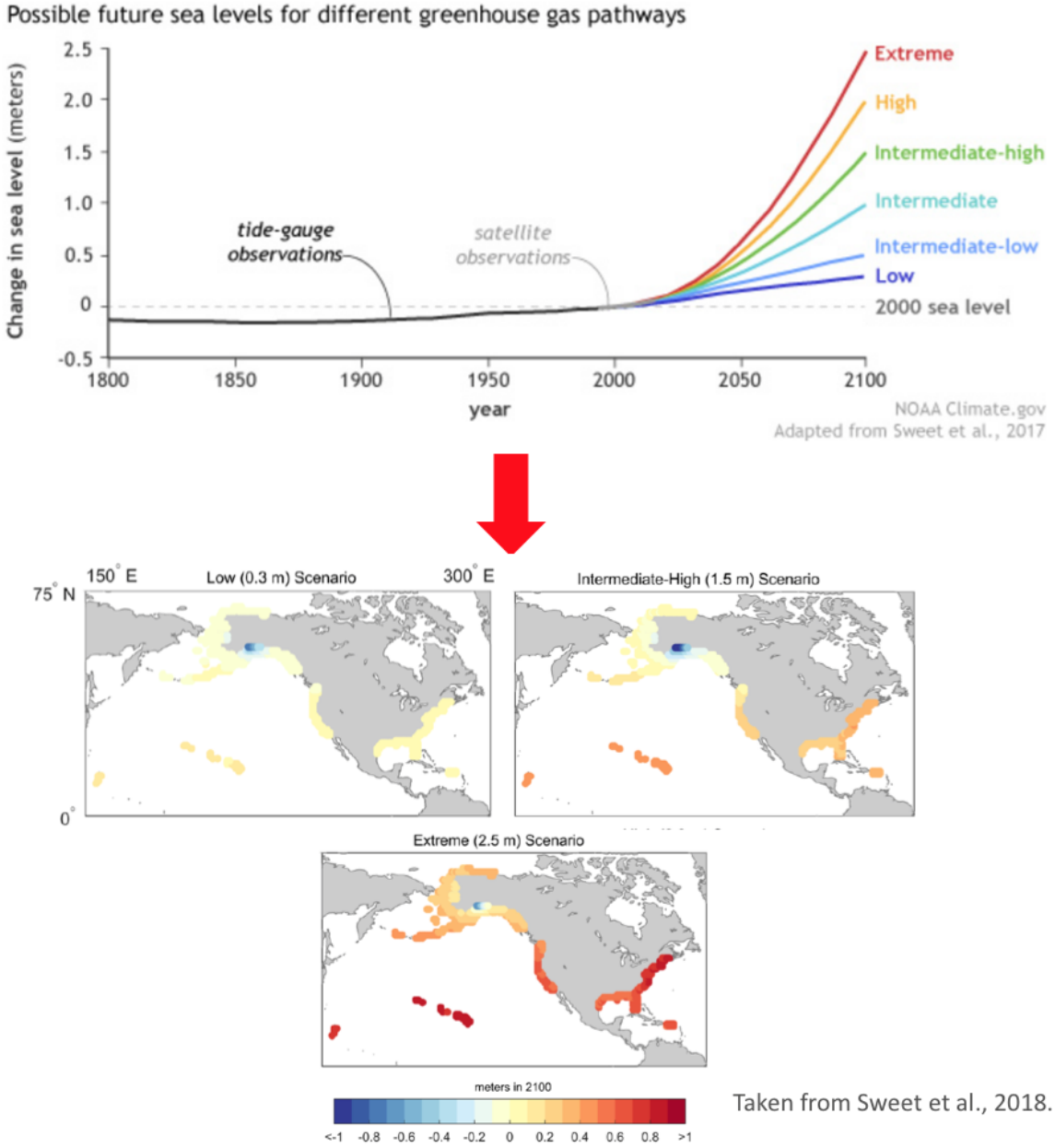

Fig. 3. (Top) Observed sea level (black) with future seal level under six possible future scenarios (colors) based on potential future rates of greenhouse gas emissions. (Bottom) Climate-related relative sea level change relative to global mean seal live rise amount for the Low, Intermediate High, and Extreme scenarios used in this study.

COASTAL FLOODING TOMORROW AND THE NEXT 10 YEARS

We calculate a regression line of the projected scenarios, and add this regression line to the last 10 years of NTR data, to make a projection of NTR for the next ten years.

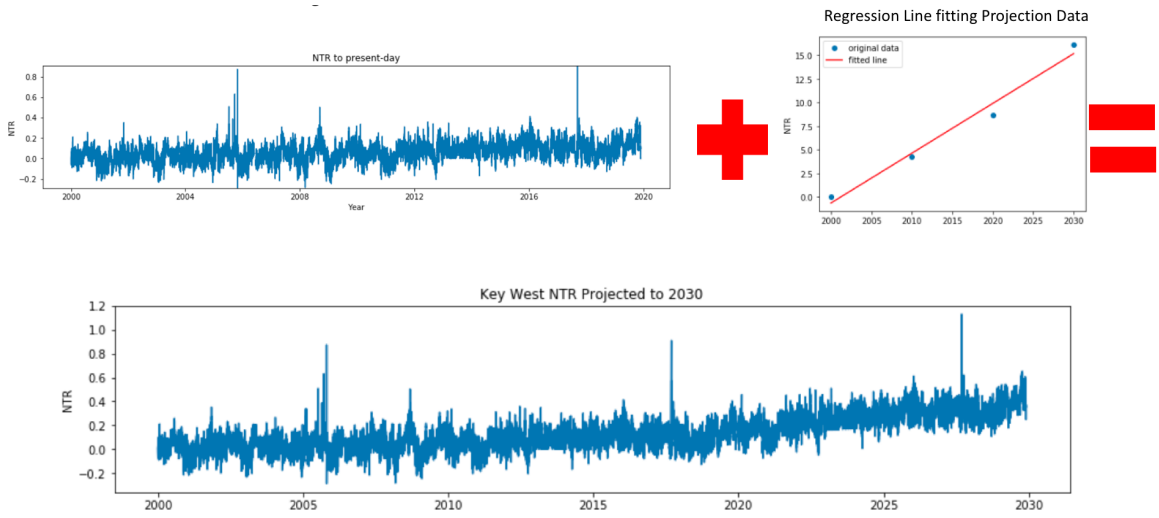

Fig. 4. (Top left) Hourly NTR observed from 2000-2020 from Key West, FL. (Top right) Regression line fitted to the sea level rise projection for 2000-2030 from the Extreme scenario. (Bottom) Hourly NTR for 2000-2020. Regression line summed with NTR from 2010-2020 to show projected NTR for 2020-2030.

Crossing the Threshold

We use the Extreme, Intermediate High, and Low sea level rise scenarios to project when each city will cross the 70-day threshold for both 1-hr flooding/day and 6-hrs flooding/day.

Key West, FL

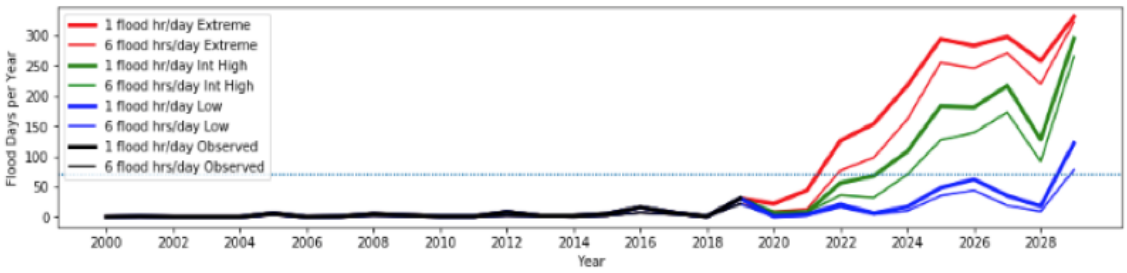

Fig 5. Key West Flood Hours per day per year for observed (black) and projected using multiple regional sea level rise projection scenarios (colors) for one hour of flooding per day (thick line) and six hours/day (thin line). Dotted blue line shows 70-days per year of flooding threshold.

By the end of the decade, Key West will experience at least an hour of flood per day more than 70 days per year.

THE FUTURE OF EAST COAST U.S. CITIES

Main Conclusion: ***Every city analyzed in this study is expected to cross the 70-day threshold by the end of the decade under at least the Intermediate High and Extreme scenarios.***

Miami, FL (Virginia Key)

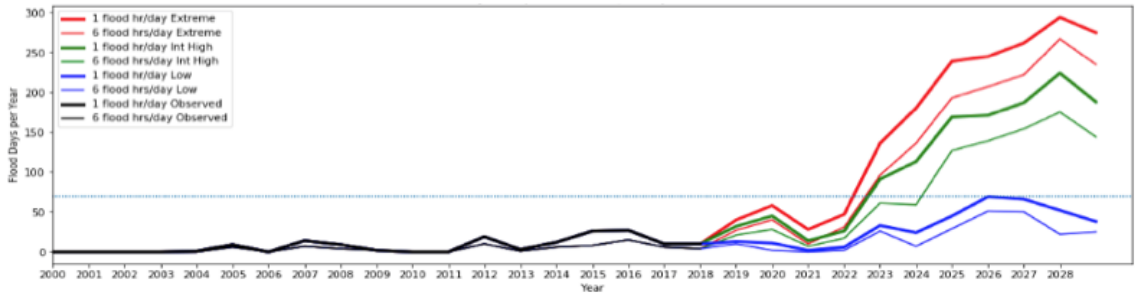

Fig. 6. Virginia Key/ Miami will likely see a slightly delayed crossing of the 70-day threshold, but will likely see >70 days/flooding annually by the end of the decade. Same description as Fig. 5 for Figs. 6-8.

Annapolis, MD

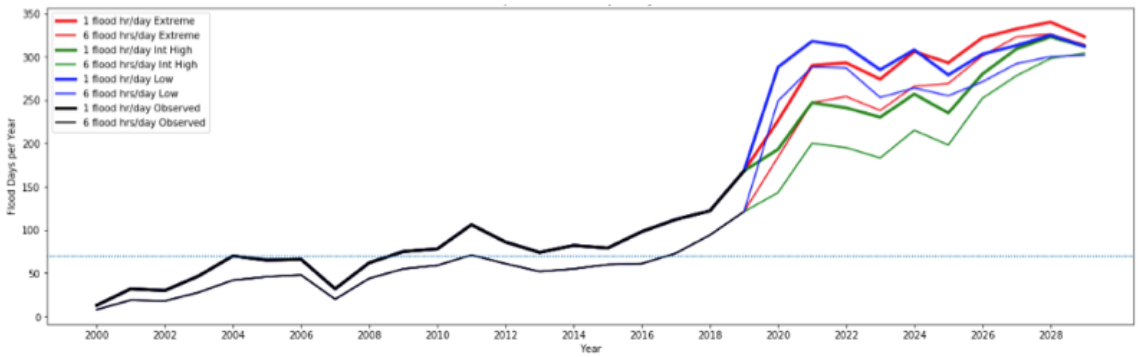

Fig. 7. Annapolis has already crossed the 70-day threshold last decade with the number of annual flood days only increasing into the future.

Charleston, SC

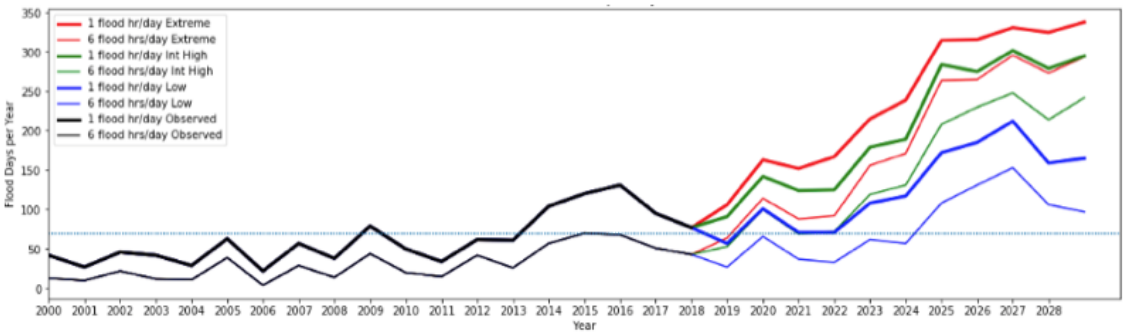

Fig. 8. Charleston has already crossed the 70-day threshold multiple years and will likely stay above the threshold for the rest of the decade.

REFERENCES

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AUTHOR INFORMATION

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ABSTRACT

When will a particular city on the Eastern Seaboard have a 70% chance of flooding at least one hour on at least 70 days of the year? This jam-packed question drives this study, as coastal flooding is becoming increasingly frequent in many East Coast U.S. cities. The frequency of floods that were once categorized as high tide or “nuisance” flooding is rapidly increasing, and many events are escalating to the moderate and major/severe flooding thresholds, putting life and property at risk. This study focuses on flooding events prone to causing property damage and hazardous conditions to make improvements for the subseasonal and seasonal outlooks that are most impactful. A number of East Coast cities are employed as case studies, such as Key West, FL, Charleston, SC, and Annapolis, MD, to analyze current and projected flooding rates. The spatial extent of flooding is considered by using high-resolution topographical data in combination with National Ocean Service tidal datums. NOAA sea level rise scenarios are used to determine the probable time period at which a portion of each city will be experiencing flooding for at least one hour per day frequently throughout the year. Additionally, tide gauge data from the case study cities is decomposed to understand which physical components are contributing to the regional coastal flooding on timescales from subseasonal to seasonal and beyond.