THE EFFECT OF HARBOR DEVELOPMENTS ON HIGH-TIDE FLOODING IN MIAMI (FL)

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We develop and validate a tidal-inference based methodology that leverages estimates of historical tidal ranges to obtain historical tidal predictions and constituents. Next, the method is applied to a case study in Miami (Florida), where mean tidal range has more than doubled since 1900, from 0.32 m to 0.66 m today. Water level predictions that represent historical and modern water level variations are projected forward in time using different sea level rise (SLR) scenarios, to see how the historical increase in tidal range affects the occurrence of present-day and future high-tide flooding. To this end, we apply the method of Li et al., (2021), which implies to remove tidal oscillations from present-day water levels and replace them with constant tidal prediction, obtained with tidal constituents representing historic conditions. This creates a synthetic time series that approximates what water levels would have been, had tides not evolved. Possible future water levels are estimated for each SLR scenario for (a) a “tide-only” scenario, using tidal oscillation on top of SLR and accounting for average seasonal cycle of mean sea level (MSL); and (b) a “total water level” approach that includes SLR, non-tidal fluctuations and seasonal sea level. While the first approach neglects relevant forcing (e.g., inter-annual to decadal MSL variability, river discharge, storm surge), it enables us to isolate the contribution of tides to HTF and provides useful metrics for quantifying the effects that tides and SLR have on coastal flooding. Results show that the total integrated number of days with high-tide floods in the 2020-2100 period will be approximately 10^3 more under present day tides compared to pre-development conditions (see for example Figure 1 for high SLR).

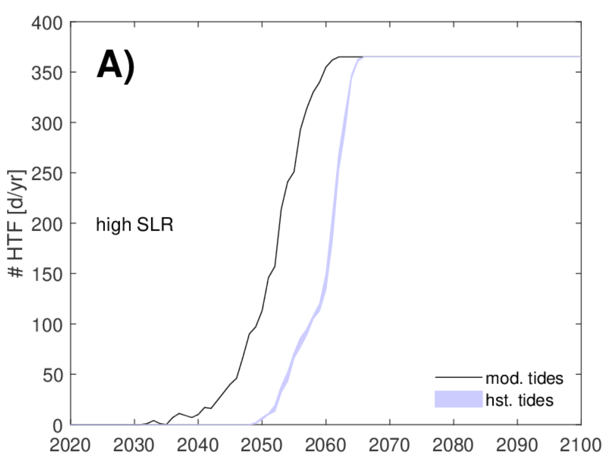

Figure 1 - Yearly HTF days at Miami under different tidal conditions and high SLR.

A likely cause for the sharp increase in the mean tidal range in Miami is the dredging of a ≈15 m deep, 150 m wide harbor entrance channel beginning in the early 20th century (the Government Cut), which changed northern Biscayne Bay from a chocked inlet to one with a tidal range close to coastal conditions. To investigate whether increased tidal exchange has amplified tides, we digitize and geo-rectify two coast charts from 1895 and 2017. Next, we compute a composite choking number (*P*; Hill, 1994) for both historical and modern landscapes, by considering that tidal exchange occurred through 3 channels in the 19th century and occurs today through 5 channels. Results show that, during the past century, extensive land reclamation and navigational development occurred in the area (Figure 2), and that *P* has increased from ≈3.3 (1895) to ≈15.3 (2017). This increase is consistent with the bay moving from a choked condition historically to an unimpeded system today and opens the door to improving out understanding of other heavily-altered systems.

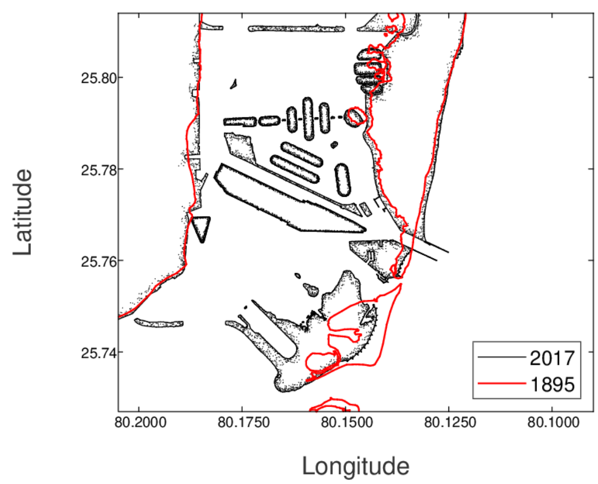

Figure 2 - Comparison between 1895 landscape and 2017 landscape in the Northern Biscayne Bay (note that Virginia Key island is shifted due to uncertainties in the reference system for the historical map).

REFERENCES

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