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Mechanisms of coherent fluctuations in the sea-level annual cycle along the United States Gulf and Southeast coasts

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Several studies have reported considerable temporal variations in the amplitude of the sea-level annual cycle (SLAC) in coastal areas across the globe. These variations can significantly increase the risk of coastal flooding and alter the ecological balance of productive ecosystems. Knowing how to predict them is crucial to reducing such risks, but this requires complete understanding of their underlying mechanisms which is still lacking. Here we use a combination of sea-level observations, modelling, and Bayesian statistical methods to gain new insights into the dynamics of the SLAC along the United States Gulf and Southeast coasts. We show that the amplitude of the SLAC varies considerably over time, with decadal fluctuations reaching up to 70% of the time-mean value. Such fluctuations are coherent along the coast from the Yucatan Peninsula to Cape Hatteras, but they are decoupled from deep-ocean changes. While the mean SLAC is primarily driven by changes in surface heat fluxes, the amplitude modulation is controlled by density anomalies propagating westward as Rossby waves that generate fast boundary waves upon reaching the western boundary. These Rossby waves exhibit themselves in the upper mid-ocean transport leading to a link with the SLAC, wherein larger SLAC amplitudes coincide with enhanced transport variability. Our results will support current efforts to improve seasonal forecasts of coastal sea levels and understand the Atlantic overturning circulation.