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Coherent modes of coastal sea level variability from altimetry and tide gauge observations

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Sea level dynamics in the coastal zone can differ significantly from that in the open ocean. The presence of the continental slope, shallow waters and the coastlines give rise to a variety of processes that mediate the response of coastal sea level to open-ocean changes and produce distinct spatiotemporal sea level patterns. Yet how exactly this interplay occurs and, more importantly, the extent to what coastal sea level variations differ from open-ocean variability remain poorly understood. In this work, we use coastal altimetry observations in combination with tide gauge data to determine patterns of coherent coastal sea level variations and the degree of decoupling between such variations and open-ocean changes.

In a first step, we apply Bayesian mixture models to identify clusters of correlated tide gauge observations that explain a significant fraction of the coastal sea level variability. Using altimetry data, we find high regional coherency of along-shore coastal sea level variations, indicating common underlying mechanisms that cause these correlations.

In light of previous research, we confirm that the correlation structures of these coherent patterns are often confined to the continental slopes, particularly in extratropical regions. In regions like the northeastern US continental shelf, correlations decrease with increasing water depth, indicating a decoupling of shelf sea and open-ocean variability. We investigate how these differences between coastal and open ocean sea level variations change as a function of time scale, i.e., from monthly or interannual variations to long-term trends, and validate these results against tide gauge observations. We derive across-shore correlation length scales that provide insights into the space scales of coastal sea level dynamics and are useful to understand how well gridded products can resolve such processes.

We discuss possible causes of the coherent sea level fluctuations, such as wind forcing, coastally

trapped waves, and large scale climate modes. The results motivate further research to better understand the driving mechanisms behind these coherent sea level variations, as well as the pathways linking remote forcing to coastal changes.