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Annual and inter-annual sea-level variability from coastal altimetry and tide gauge data

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Accurate long-term measurements of coastal sea level are fundamental for understanding changes in ocean circulation and assessing the impact of low-frequency sea-level variability on, e.g., near-shore ecosystems, groundwater dynamics, and coastal flooding. However, tide gauges are sparsely distributed in space and the extent to which satellite altimetry data can be used to infer the complex patterns of sea level near the coast is a subject of debate. Here, we revisit earlier attempts of connecting tide gauge and altimetry observations of low-frequency sea-level changes across the coastal zone. Our interest lies both in short-scale spatial structures indicative of dynamic decoupling between coastal areas and the deep ocean, and in the benefits of using a reprocessed, coastal altimetry product (X-TRACK) for the analysis. The mean annual cycle is chosen as a first benchmark and more than 200 globally distributed tide gauges are examined. We compute statistics between tide gauge and along-track altimeter series within spatial radii of 20 km (“coastal”) and 134 km of the tide gauge location, and additionally split altimetry data inside the 134-km circle into “shallow” and “deep” groups relative to the 200-m isobaths. Globally averaged RMS (root-mean-square) differences in the “coastal” and “shallow” categories are 1.9 and 2.4 cm for the X-TRACK product, somewhat lower than the corresponding values from the non-optimized Integrated Multi-Mission Ocean Altimeter Data for Climate Research Version 4.2 (2.3 and 2.6 cm). Examination of inter-annual sea-level variability from 1993 to 2019 is underway, with initial focus on regions where poor correspondence between satellite and tide gauge sea-level estimates has been noted in the past (e.g., US East Coast and western South America). At most locations analyzed so far, RMS differences decrease and correlations improve as one approaches the coast along the satellite tracks. However, the X-TRACK estimates tend to become erratic within 20–30 km from the tide gauge, suggesting that the usability of classical nadir altimetry measurements for studying short-scale coastal dynamics is still limited despite ongoing reprocessing efforts.