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Spatial patterns in nonlinear sea-level dynamics inferred from global satellite altimetry data

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Since the advent of the satellite era, global sea-level altimetry data sets are available. To study complex oceanographic processes and their coupling to atmospheric dynamics it is necessary to advance beyond analyzing global mean sea-level rise or local trends. We apply a wide range of methods from linear and nonlinear time series analysis for investigating the complex dynamics of observed sea-level altimetry time series at different locations around the globe. Employing this toolkit, linear and nonlinear autodependencies (autocorrelation and auto-mutual information functions), deterministic structure (recurrence quantification and recurrence network analysis), time-reversibility characteristics (visibility graph analysis) and the relative importance of stochastic vs. deterministic dynamics (complexity-entropy plane) are studied.

Combining the complimentary information from all metrics, consistent spatial patterns of sea-level dynamics are detected. Classical statistical properties such as variance, skewness and Shannon entropy of the probability distribution of sea-level reveal the special importance of western boundary currents as well as parts of the Antarctic Circumpolar Current as regions of particularly complex sea-level dynamics. In turn, the nonlinear dynamics characteristics present a somewhat different pattern exhibiting particularly high complexity in the tropics as well as the Gulf Stream and Kuroshio regions. Notably, these are also the areas where missing values due to atmospheric processes are most prominent. Further research is required to fully disentangle the dynamic complexity of sea-level from potential artifacts in the underlying altimetry data.