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Spatio-temporal patterns in Baltic sea-level dynamics

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Recent work on sea-level change has mainly focused on long-term trends in the mean. In turn, changes in the nonlinear dynamics of sea-level variability have hardly been studied so far, even though they can provide unique information on the ocean's response to long-term changes of different atmospheric driving factors.

In this work, we study seven long-term daily tide gauge records from the Baltic Sea with a set of complementary methods of linear and nonlinear time series analysis, including discrete wavelet analysis, autocorrelation-based dimension densities, time- and scale-dependent detrended fluctuation analysis, measures of complexity based on recurrence quantification analysis and recurrence networks, as well as information-theoretic approaches.

The linear and nonlinear dynamical properties obtained for different records show consistent long-term variations, which are determined by changes in both local hydrological factors and the regional climatology. Time- and scale-resolved analyses reveal that temporal changes of nonlinear dynamic characteristics affect different temporal scales in different ways and are thus reflected differently by the individual measures evaluated at distinct scales. The corresponding analysis allows identifying and distinguishing long-term changes in sub-annual as well as annual to decadal-scale variability, which can be related to triggering factors acting at different temporal scales.

In general, the results of all applied analyses display a consistent spatial pattern with a marked latitudinal complexity gradient, with sea-level variability being most complex close to the Baltic entrance and least complex in the central Baltic Sea.