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Detecting anthropogenic footprints in sea level rise: the role of complex colored noise

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While there is scientific consensus that global mean sea level (MSL) is rising since the late 19th century, it remains unclear how much of this rise is due to natural variability or anthropogenic forcing. Uncovering the anthropogenic contribution requires profound knowledge about the persistence of natural MSL variations. This is challenging, since observational time series represent the superposition of various processes with different spectral properties. Here we statistically estimate the upper bounds of naturally forced centennial MSL trends on the basis of two separate components: a slowly varying volumetric (mass and density changes) and a more rapidly changing atmospheric component. Resting on a combination of spectral analyses of tide gauge records, ocean reanalysis data and numerical Monte-Carlo experiments, we find that in records where transient atmospheric processes dominate, the persistence of natural volumetric changes is underestimated. If each component is assessed separately, natural centennial trends are locally up to $\sim$0.5 mm/yr larger than in case of an integrated assessment. This implies that external trends in MSL rise related to anthropogenic forcing might be generally overestimated. By applying our approach to the outputs of a centennial ocean reanalysis (SODA), we estimate maximum natural trends in the order of 1 mm/yr for the global average. This value is larger than previous estimates, but consistent with recent paleo evidence from periods in which the anthropogenic contribution was absent. Comparing our estimate to the observed 20th century MSL rise of 1.7 mm/yr suggests a minimum external contribution of at least 0.7 mm/yr. We conclude that an accurate detection of anthropogenic footprints in MSL rise requires a more careful assessment of the persistence of intrinsic natural variability.