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Modeling the impact of contemporary ocean stratification changes on the global M_2 tide

Lana Opel and Michael Schindelegger
University of Bonn, Institute of Geodesy and Geoinformation, Germany (opel@igg.uni-bonn.de)

Low-frequency non-astronomical changes of tides are among the most puzzling signals in the world ocean. Although the relevance of these signals in the order of a few cm is gradually being appreciated in the context of coastal flooding or de-aliasing of satellite gravimetry observations, a detailed quantitative understanding of the causative mechanisms has been lacking. Among the suspected forcing factors are fluctuations and trends in relative sea level, basin geometry (associated with, e.g., melting Antarctic ice-shelves), bed roughness, and ocean stratification. Here, we use a high-resolution general circulation model to spatially map the influence of stratification changes on the global M_2 tide, on time scales from years out to decades. We conduct global tidal simulations in annually changing density structures, as drawn from hydrographic profiles and other external datasets (e.g., an eddying ocean reanalysis) from 1993 to present day. We perform internal-tide permitting simulations (1/12° horizontal grid spacing, 50 vertical layers) to resolve the relevant physics, particularly low-mode barotropic-to-baroclinic energy conversion at topographic features and vertical mixing in shallow water. Atmospheric forcing is omitted to constrain the model's density distribution to the prescribed initial hydrography. We validate the resulting annual M_2 amplitude changes against estimates from harmonically analyzed tide gauge series, distributed across the globe. Particular emphasis in our analysis is given to the tropical Pacific and the South China Sea, where the seesawing of stratification between positive and negative phases of ENSO (El Niño-Southern Oscillation) is expected to introduce spatially coherent amplitude modulations of ±1 cm on interannual time scales.