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Interannual stratification changes affect tides in the Gulf of Maine

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Analyses of water level measurements in the Gulf of Maine and Bay of Fundy suggest interannual changes in the tidal M_2 amplitude of significant size (≈1–5 cm) and remarkable spatial coherence. These signals are of unknown origin and cannot be caused by the observed sea-level fluctuations of less than 10 cm. Here we use a regional ocean model setup to link interannual M_2 variations to changes in stratification, which may alter the surface tide through processes of turbulent mixing and baroclinic wave scattering as the tide propagates into and across the gulf. We run short (20-day) simulations at 1/30° horizontal resolution, omit atmospheric forcing, and prescribe background temperature and salinity fields at annual intervals starting in 1993. Tidal velocities are introduced along with geostrophic currents at open boundaries and are not varied in between runs. M_2 amplitudes inferred from these experiments exhibit a year-to-year variability of 1–2 cm throughout the Gulf of Maine, mostly reflecting the sign (but not always the magnitude) of measured amplitude changes at tide gauges Boston, Portland, and Eastport. In particular, we are able to reproduce the 3-cm drop in the M_2 time series from 1993 to 1998 and the subsequent increase by 1.5 cm until the year 2000. Over the period 1993–2013 and at all three stations, our simulations explain 22–29% of the locally observed M_2 variance, with linear correlations ranging from 50 to 56%. Although model sensitivities and the exact mechanisms underlying these signals are yet to be worked out, our study provides appreciable evidence that varying stratification may indeed be a significant driver for the gulf's tidal changes on interannual and perhaps secular time scales.

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