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Non-steric sea level rise: Insights from interannual changes in Earth's dynamic oblateness (J_2)

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Recent findings regarding changes in the heat content of the upper 750 m of the global ocean (Lyman et al., 2006) have suggested that the planetary radiative balance may fluctuate and even change sign on interannual time scales. At the same time global general circulation models, and time series of altimeter-determined global sea level, do not appear to reflect the same degree of interannual variability as suggested by the heat content observations. A possible means to reconcile the observational discrepancy is through variations in the rate of non-steric sea level rise induced by transfers of water mass between land ice reservoirs and the global ocean.

In this work, we use time series of the Earth's dynamic oblateness (J_2) as an independent metric of the redistribution of mass between high and low latitudes. When properly corrected for atmospheric, oceanic and hydrological mass exchange / redistribution, the J_2 residual can provide an independent constraint on mass transfers between high latitude land ice and the global ocean (Dickey et al., 2002). We assess the uncertainties in this metric of land ice ablation and its relevance for understanding changes in the ocean's heat and mass balances during recent years; in particular, we show that time series of observed J_2 changes can be used to discriminate between scenarios in which the observed upper ocean cooling results from loss of heat to space, or from exchange of heat with layers below the 750 m level.