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The Impact of Thermal Sea Level Rise on Earth Orientation Variability

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We present a mechanism by which thermal (or steric) sea level rise through ocean warming leads to changes of the Earth's orientation parameters, e.g., polar motion (PM) and length-of-day (LOD) on decadal to centennial timescales. Steric sea level change is commonly considered negligible for the excitation of Earth orientation variations. With a simple conceptual model, however, we show that thermal sea level rise leads to a horizontal mass redistribution within ocean basins that alters Earth's inertia tensor, thereby leading to considerable changes of Earth orientation parameters. The projected changes of the orientation parameters for the 21st and 22nd century from this process are derived from climate simulations with the numerical Earth system models ECHAM5/MPI-OM and GFDL-CM2.1. The net effect is a small additional LOD signal of about -0.002 ms per 10 millimeter of steric sea level rise. For polar motion, ocean warming leads to a considerable excitation of about 1.7 milli-arcseconds per 10 millimeter of steric sea level rise (or about 0.47 mas/year for mid-range IPCC climate-change scenarios), nearly linearly polarized towards 150 West. As ocean warming and steric sea level rise are expected to accelerate in the decades to come, we conjecture that this mechanism could contribute increasingly more to Earth orientation variations in the near future. The implications of this results are two-fold: firstly, this process should be accounted for when Earth orientation observations are inverted to deduce geophysical parameters and mass redistribution processes; secondly, Earth orientation observations, in particular polar motion, can provide an independent constraint on global steric sea level change.

F. W. Landerer, J. H. Jungclaus and J. Marotzke, 2009: A new excitation mechanism for long-term polar motion: ocean thermal expansion, submitted.

F. W. Landerer, J. H. Jungclaus and J. Marotzke, 2007: Ocean Bottom Pressure Changes Lead to a Decreasing Length-of-Day in a Warming Climate, Geophys. Res. Lett., Vol. 34, L06307, doi:10.1029/2006GL029106.