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Complementing thermosteric sea level rise estimates

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Abstract. Thermal expansion of seawater has been one of the most important contributors to global sea level rise (SLR) over the past 100 years. Yet, observational estimates of this volumetric response of the world's oceans to temperature changes are sparse and mostly limited to the ocean's upper 700 m. Furthermore, only a part of the available climate model data is sufficiently diagnosed to complete our quantitative understanding of thermosteric SLR (thSLR). Here, we extend the available set of thSLR diagnostics from the Coupled Model Intercomparison Project Phase 5 (CMIP5), analyze those model results in order to complement upper-ocean observations and enable the development of surrogate techniques to project thSLR using vertical temperature profile and ocean heat uptake time series. Specifically, based on CMIP5 temperature and salinity data, we provide a compilation of thermal expansion time series that comprise 30 % more simulations than currently published within CMIP5. We find that 21st century thSLR estimates derived solely based on observational estimates from the upper 700 m (2000 m) would have to be multiplied by a factor of 1.39 (1.17) with 90 % uncertainty ranges of 1.24 to 1.58 (1.05 to 1.31) in order to account for thSLR contributions from deeper levels. Half (50 %) of the multi-model total expansion originates from depths below 490 ± 90 m, with the range indicating scenario-to-scenario variations. To support the development of surrogate methods to project thermal expansion, we calibrate two simplified parameterizations against CMIP5 estimates of thSLR: one parameterization is suitable for scenarios where hemispheric ocean temperature profiles are available, the other, where only the total ocean heat uptake is known (goodness of fit: ±5 and ±9 %, respectively).

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