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# Explaining the spread of CMIP5 climate models in global-mean thermosteric sea level rise over the $20^{th}$ and $21^{st}$ centuries

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The ocean stores more than 90% of the energy excess associated with anthropogenic climate warming. The resulting warming and thermal expansion of the ocean is a leading contributor to sea level rise. Confidence in projections of global mean sea level rise therefore depends on the ability of climate models to reproduce ocean warming and induced global mean thermosteric sea level (GMTSL) over the $20^{th}$ century. This study aims at explaining and trying to reduce the spread of GMTSL across climate models of the Coupled Models Intercomparison Project Phase 5 (CMIP5) over the $20^{th}$ and $21^{st}$ centuries.

We first show that the GMTSL rise computed from climate models is approximately proportional to the radiative forcing. The constant of proportionality mostly depends on the climate feedback parameter and the ocean heat uptake efficiency. From that linear relationship, we show that the spread in the net top-of-atmosphere radiative flux (N) explains most of the spread in projections of the GMTSL. The inter-model spread of N is itself mostly explained by the spread in the radiative forcing changes while the spread in climate feedback parameter and ocean heat uptake efficiency play a smaller role.

We then compare GMTSL from climate models to observational estimates over the 1961-2005 period. Although the model-ensemble mean is within the uncertainty of observations, a significant number of models consistently overestimate or underestimate the observed GMTSL rise. The contribution of the deep ocean (below 700 m depth) to GMTSL is largely spread among climate models ($33 \pm 28\%$ over 1900-2005). Selecting the sub-ensemble of models that conserve the energy in the climate system and are within the observational estimates of GMTSL reduces that spread and leads to a contribution of $35 \pm 10\%$.

The uncertainty in projected GMTSL in 2100 can also be reduced with a selection of climate models based on the comparison of the climate feedback parameters, ocean heat uptake efficiencies and 20th century radiative forcings of the sub-ensemble of climate models that best reproduce the observed GMTSL over 1961-2005.