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The impact of surface fluxes on future regional sea level change

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Climate models predict a global mean rise of sea level due to thermal expansion during the next century. They all show large regional variations in sea level change, but disagree on the patterns. Such differences could arise from the atmosphere model, the ocean model or both. Understanding the causes of model spread will help identify which processes require attention in order to reduce uncertainty in predictions.

We investigate how changes in surface fluxes (momentum, heat and water) can explain the patterns of predicted sea level change and their differences among models. The surface fluxes can affect the uptake and distribution of heat and salinity directly or indirectly, e.g. by modifying the oceanic circulation. The resulting distribution of heat and salinity will then determine the pattern of sea level change. For this study we use the FAMOUS model, which is a low-resolution version of the HadCM3 AOGCM. The atmosphere is 7.5º longitude by 5º latitude and the ocean 3.75º longitude by 2.5º latitude with 20 levels. We prescribe anomalous surface fluxes from the CMIP3 and CMIP5 experiments with scenarios of increasing CO_2. We analyze and compare the regional sea level change patterns thus obtained to those given by the CMIP3 and CMIP5 models in order to determine which fluxes are predominant in setting the various patterns and how they impact regional sea level.

We show that the windstress change plays a dominant role in the Southern Ocean where it explains most of the meridional dipole of sea level change as well as the spread between models. In other regions such as the North-west Pacific or the Indian Oceans, other surface fluxes also have to be taken account, while in the North Atlantic the windstress change plays a relatively minor role. Here the buoyancy fluxes dominate. In particular, the penetration of heat explains most of the relatively higher sea level rise in the northern part of the North Atlantic. Although the AMOC change induced by the high latitude warming leads to higher sea level rise along the North-East coast of the US, in the rest of the North Atlantic the higher sea level rise is mostly due to thermal expansion.