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Global sea-level change during the next 10,000 years: the end of an icehouse?

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Because of the long life-time of atmospheric CO_2, any realized future warming is likely to persist for many centuries to millennia. As a consequence, sea-level rise will continue on a multi-millennial timescale, especially from the slower components such as oceanic thermal expansion and above all, from melting of the Greenland and Antarctic ice sheets. The two polar ice sheets have the potential to produce a global eustatic sea-level rise of about 65 m, at least an order of magnitude larger than thermal expansion under extreme forcing scenarios. Other components contributing to sea-level change are the melting of glaciers and ice caps and haline contraction of the ocean from fresh water delivery from land ice, but are less important.

We have made projections of future sea-level rise over the next 10,000 years with the Earth System Model of Intermediate Complexity LOVECLIM, which includes high resolution models of the Greenland and Antarctic ice sheets. Four different model parameter sets are considered to explore the model uncertainty. The climate forcing is based on prolonged Radiative Concentration Pathway (RCP) scenarios with an assumed exponential falloff for carbon dioxide concentrations according to global carbon cycle simulations. Six different forcing scenarios are constructed where the highest scenario includes a positive feedback due to the destabilization of methane hydrates and the subsequent emission of methane.

By far the largest contribution in the global sea-level projections arises from the polar ice sheets. For the Greenland ice sheet, the ablation is larger than the accumulation for all forcing scenarios shortly after the start of the experiments. The ice sheet continuously melts and nearly disappears in all cases. The Antarctic ice sheet grows during the first decades under low to intermediate forcing scenarios due to increased accumulation. However, the spread between the different scenarios is very large. Under the highest prolonged RCP scenario (and in case methane hydrate starts to destabilize), the model uncertainty does not exclude melting of the entire Antarctic ice sheet after 10,000 years. This would mark the end of the present icehouse, which has existed for about 34 Myr, and would raise global sea-level by up to 70 m from all contributions combined.