Modelling the response of ice sheets to environmental forcing and projecting future sea level rise within the framework of the SeaRISE community effort

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Ice sheets, ice shelves, ice caps and glaciers are active, dynamic components of the climate system of the Earth. They feature gravity-driven free surface flow ("glacial flow"), controlled by pressure, internal stresses, temperature and basal friction. Since the late 1970s, numerical modelling has become established as an important technique for the understanding of ice dynamics. Ice sheet models are particularly relevant for predicting their possible response to climate change and consequent sea level rise, and thus a number of such models have been developed over the years. Recent observations actually suggest that ice dynamics could play a crucial role in predicting future sea level rise under global warming conditions.

In this study, the ice sheet models Elmer/Ice (full Stokes force balance, finite elements) and SICOPOLIS (shallow ice/shallow shelf force balance, finite differences) are applied to the Greenland and Antarctic ice sheets. We carry out a series of scenarios 500 years into the future specified by the SeaRISE (Sea-level Response to Ice Sheet Evolution) community effort (http://tinyurl.com/srise-lanl, http://tinyurl.com/srise-umt). These scenarios comprise sensitivity experiments forced by (i) surface climate warming, (ii) accelerated basal sliding, and (iii) increased sub-ice-shelf melting, as well as a combination experiment designed to approximate ice sheet response to IPCC's RCP8.5 greenhouse gas emission scenario ("experiment R8"). In addition to the results obtained with Elmer/Ice and SICOPOLIS, we also discuss the results obtained by the other models that contributed to SeaRISE, as documented by Bindschadler and 27 others (*Journal of Glaciology,* submitted).

For both ice sheets and all scenarios, the results produced by the different models vary widely. However, a robust finding is that the Greenland ice sheet is most sensitive to atmospheric changes in temperature and precipitation (direct surface climate forcing), while the Antarctic ice sheet is most sensitive to sub-ice-shelf melting and only little sensitive to surface climate forcing. For the combination experiment R8, the simulated contribution of the Greenland ice sheet to sea level rise is 0.22 m after 100 years, 0.53 m after 200 years and 2.02 m after 500 years (ensemble mean of all participating models). The respective values for the Antarctic ice sheet are 0.07 m after 100 years, 0.21 m after 200 years and 0.93 m after 500 years, that is, a bit less than half of the values for the Greenland ice sheet. In relative terms, this means that Greenland loses as much as ~25% of its volume above floatation after 500 years, while Antarctica loses only about 1.6%.