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Quantifying the future sea level rise amplification using full representation of the interactions between ice sheet dynamics and atmospheric circulation changes

Sébastien Le clec'h (1), Philippe Huybrechts (1), and Xavier Fettweis (2)

(1) Earth System Science & Departement Geografie, Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussel, Belgium (sebastien.le.clech@vub.be), (2) Laboratory of Climatology and Topoclimatology, Department of Geography, Université de Liège, 2 Alleé du 6 Août, B-4000 Liège, Belgium

The evolution of the Greenland ice sheet results from complex feedbacks between components of the Earth System. More and more studies are showing an amplification of the Greenland melting contribution to sea level rise under a future warming climate when interactions between ice sheet dynamics and atmospheric circulation are considered. The higher the complexity used to represent interactions between the Greenland ice sheet and the atmosphere component, the higher the amplification is. Using a full coupling between an ice sheet model and the MAR atmospheric regional climate model we quantified the impact of interactions over a century time scale. We first initialised the ice sheet model over a glacial-interglacial time scale and then optimised the simulated present-day ice sheet with data assimilation to fit as closely as possible the observations. From this, the regional atmospheric model is initialised with the simulated ice sheet topography over a decadal time scale before starting the fully coupled experiment. The results exhibit strong atmospheric circulation and ice dynamic changes along the ice sheet margins which propagate inwards. Increasing Greenland ice sheet surface slopes cause increasing winds impacting on the surface energy balance. This margin melting amplification contributes to a higher sea level rise compared to uncoupled model experiments. In turn, higher runoff impacts both the ice dynamics (e.g. by enhanced basal hydrology) and the atmospheric heat and water content (e.g. by surface albedo changes) to cause a further positive feedback loop.