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Effect of uncertainty in surface mass balance elevation feedback on projections of the future sea level contribution of the Greenland ice sheet

Tamsin Edwards (1), Xavier Fettweis (2), Olivier Gagliardini (3,4), Fabien Gillet-Chaulet (3), Heiko Goelzer (5), Jonathan Gregory (6,7), Matthew Hoffman (8), Philippe Huybrechts (5), Antony Payne (1), Mauro Perego (9), Stephen Price (8), Aurélien Quiquet (3), and Catherine Ritz (3)

(1) Department of Geographical Sciences, University of Bristol, Bristol BS8 1SS, UK (tamsin.edwards@bristol.ac.uk), (2) Department of Geography, University of Liege, Laboratory of Climatology (Bat. B11), Allée du 6 Août, 2, 4000 Liège, Belgium, (3) Laboratoire de Glaciologie et Géophysique de l'Environnement, UJF - Grenoble 1 / CNRS, 54, rue Molière BP 96, 38402 Saint-Martin-d'Hères Cedex, France, (4) Institut Universitaire de France, Paris, France, (5) Earth System Sciences & Departement Geografie, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium, (6) NCAS-Climate, Department of Meteorology, University of Reading, Reading, UK, (7) Met Office Hadley Centre, Exeter, UK, (8) Fluid Dynamics and Solid Mechanics Group, Los Alamos National Laboratory, T3 MS B216, Los Alamos, NM 87545, US, (9) Department of Scientific Computing, Florida State University, 400 Dirac Science Library, Tallahassee, FL 32306, US

We apply a new parameterisation of the Greenland ice sheet (GrIS) surface mass balance elevation feedback in the MAR regional climate model with five ice sheet models (ISMs) to climate projections for 2000-2199 forced by the ECHAM5 and HadCM3 global climate models (GCMs) under the SRES A1B emissions scenario. In all results, the elevation feedback is positive: the lower bounds of our 95% credibility intervals (CIs) have larger sea level contributions than the 'no feedback' cases. We compare the feedback responses for the two GCMs from three of the ISMs: without elevation feedback, the mean GrIS sea level contributions at 2100 are 58 mm (ECHAM5) and 66 mm (HadCM3); with feedback, these increase by 3 mm (5%). At 2200, the mean sea level contributions without feedback are 167 mm (ECHAM5) and 179 mm (HadCM3); the feedback contributes an additional 17 mm (10%) and 19 mm (11%) respectively.

Our projections propagate three types of model uncertainty (GCM and ISM structural uncertainties, and elevation feedback parameter uncertainty) along the causal chain from SRES scenario to sea level within a coherent experimental design and statistical framework. We find that the relative contributions to uncertainty depend on the timescale of interest. At 2100, the GCM and ISM ensemble spreads are two and half times greater than the elevation feedback parameterisation uncertainty. By 2200, the ISM spread and elevation feedback parameterisation uncertainty are larger than the difference between the two GCMs. We also perform a perturbed parameter ensemble with one ISM to estimate the shape of the projected sea level probability distribution. Our results indicates that the probability density is slightly skewed towards higher sea level contributions.

These results begin the process of determining where it is most important to focus computational resources and model development for making sea level mitigation and adaptation decisions at different timescales.