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Quantifying Uncertainty in the response of the Greenland Ice Sheet to future climate

Peter Fitzgerald (1), Jonathan Bamber (1), Jonathan Rougier (1), and Jeff Ridley (2)

(1) University of Bristol, School of Geographical Sciences, Bristol, United Kingdom (peter.fitzgerald@bristol.ac.uk), (2) University of Bristol, Department of Mathematics, Bristol, United Kingdom , (3) Hadley Centre for Climate Prediction and Research, Met Office, Exeter, United Kingdom

Large uncertainties exist in the response of the Greenland ice sheet (GrIS) to future climate change. These uncertainties have three broad sources: 1. The future Greenhouse Gas (GHG) concentration, 2. The climate response to a given GHG concentration, 3. The ice sheet response to a given climate. Uncertainty 2 and 3 can be further sub categorized into parametric and structural uncertainty. Parametric uncertainty is the uncertainty associated with parameter choices within the models, where as structural uncertainty is associated with the differences in model structure. Uncertainty 3 can also be split into the surface mass balance (SMB) and ice dynamic response. Here, we focus on the former using a sophisticated SMB model, which incorporates snow diagenesis and energy balance.

The main problem with making model based predictions of future SMB is the uncertainty introduced at each stage of the SMB modelling process. However Bayesian statistics provides a framework to explore many possible future states of the system and assign how certain we are about the different projections by weighting each projection based on how well the model realisation reproduces present SMB. This method of quantifying uncertainty in projections of SMB is essential for defining quantitative and rigorous bounds on the future behaviour of the ice sheet.

An Energy Balance SMB (EBSMB) model was chosen for this study because it includes the fundamental physical processes of melt within the snowpack, and as such a more comprehensive exploration of physical parameter space is possible compared to other highly parameterised SMB models. However the large parameter space is also a disadvantage in an ensemble method due to the many runs that must be carried out in order to adequately explore it. Here we carry out a systematic method to explore the parameter space in order to identify the parameters that the model response is most sensitive to when perturbed within sensible ranges. These parameters can then be taken forward to the full ensemble method with confidence that the sensitivity of the response is dominated by perturbations in these 'important' parameters.