Geophysical Research Abstracts
Vol. 19, EGU2017-4147, 2017
EGU General Assembly 2017

Exploring the data constrained phase space of the last Antarctic glacial cycle

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The evolution of the Antarctic Ice Sheet over the last two glacial cycles is studied using the Glacial Systems Model (GSM). Glaciological modelling is an effective tool to generate continental-scale reconstructions over glacial cycles, but the models depend on parameterizations to account for the deficiencies (e.g., missing physics, unresolved sub-grid processes, uncertain boundary conditions) inherent in any numerical model. These parameters, considered together, form a parameter phase space from which sets of parameters can be sampled; each set corresponds to an ice sheet reconstruction. The GSM has been updated with a number of recent developments: hybrid SIA-SSA physics, Schoof grounding line parameterization, broadened degrees of freedom in the climate forcing, sub-shelf melt explicitly dependent on ocean temperatures, improved hydrofracturing, cliff failure at the margins, basal topographic uncertainties, impact of basal drag roughness and subgrid statistics, and first order geoidal corrections in the coupled glacial isostatic adjustment component. Parametric uncertainties are defined in the GSM using >36 ensemble parameters. Prior to conducting a full Bayesian calibration, one must first validate the ability of the GSM to simulate a broad range of responses. We attempt this by latin hypercube sampling of the parameter phase space and comparing the model predictions against our constraint database consisting of past elevation, extent and relative sea level observations and the present day geometry. We document the capability of the GSM to envelope the observational constraints given the parametric uncertainties and discuss the implications for the evolution of the Antarctic Ice Sheet.