EGU2020-5526
https://doi.org/10.5194/egusphere-egu2020-5526
EGU General Assembly 2020
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Antarctic Uncertainty: Learning more about past ice sheet shapes with Bayesian methods

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Understanding the effect warming has on ice sheets is vital for accurate projections of climate change. A better understanding of how the Antarctic ice sheets have changed size and shape in the past would allow us to improve our predictions of how they may adapt in the future; this is of particular relevance in predicting future global sea level changes. This research makes use of previous reconstructions of the ice sheets, ice core data and Bayesian methods to create a model of the Antarctic ice sheet at the Last Glacial Maximum (LGM). We do this by finding the relationship between the ice sheet shape and water isotope values.

We developed a prior model which describes the variation between a set of ice sheet reconstructions at the LGM. A set of ice sheet shapes formed using this model was determined by a consultation with experts and run through the general circulation model HadCM3, providing us with paired data sets of ice sheet shapes and water isotope estimates. The relationship between ice sheet shape and water isotopes is explored using a Gaussian process emulator of HadCM3, building a statistical distribution describing the shape of the ice sheets given the isotope values outputted by the climate model. We then use MCMC to sample from the posterior distribution of the ice sheet shape and attempt to find a shape that creates isotopic values matching as closely as possible to the observations collected from ice cores. This allows us to quantify the uncertainty in the shape and incorporate expert beliefs about the Antarctic ice sheet during this time period. Our results suggests that there may have been a thicker West Antarctic ice sheet at the LGM than previously estimated.