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Large-Ensemble modeling of last deglacial and future variations of the Antarctic Ice Sheet

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Recent observations of thinning and retreat of the Pine Island and Thwaites Glaciers identify the Amundsen Sea Embayment (ASE) sector of West Antarctica as particularly vulnerable to future climate change. To date, most future modeling of these glaciers has been calibrated using recent and modern observations. As an alternate approach, we apply a hybrid 3-D ice sheet-shelf model to the last deglacial retreat of Antarctica, making use of geologic data from ∼20,000 years BP to present, focusing on the ASE but including other sectors of Antarctica.

Following several recent ice-sheet studies, we use Large-Ensemble statistical techniques, performing sets of ∼500 to 1000 runs with varying model parameters. The model is run for the last 40 kyrs on 10 to 20-km grids, both on continental domains and also on nested domains over West Antarctica. Various types of objective scores for each run are calculated using reconstructed past grounding lines, relative sea level records, measured uplift rates, and cosmogenic elevation-age data. Runs are extended into the future few millennia using RCP scenarios. The goal is to produce calibrated probabilistic ranges of model parameter values and quantified envelopes of future ice retreat.

Preliminary results are presented for Large Ensembles with (i) Latin HyperCube sampling in high-dimensional parameter space, using statistical emulators and Markov Chain Monte Carlo techniques, and (ii) dense "factorial" sampling with a smaller number of parameters. Different ways of combining the types of scores listed above are explored. One robust conclusion is that for the warmer future RCP scenarios, most reasonable parameter combinations produce retreat deep into the West Antarctic interior. Recently proposed mechanisms of hydrofracturing and ice-cliff failure accelerate future West Antarctic retreat, and later produce retreat into East Antarctic basins.