A Prediction Approach for Estimating Sea Level Contributions of West Antarctic Ice Streams via Transient Model Calibration

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Model initialization for prediction is an ongoing challenge in climate research. At the heart of the issue is the goal of finding a set of uncertain model parameters for which the inferred initial state is both close to available observations as well as free of artificial model drift when used for integrating the model forward. Ice sheet modeling in support of sea level predictions faces very similar hurdles. Current best practices are based on steady-state or snapshot inversions of flow speed and ice geometry to infer basal boundary conditions, which risks inherent drift due to incomplete data and incompatible data sets. Building on experience and practice in ocean state estimation we suggest the use of time-resolved observations to calibrate a transient ice sheet model. The optimal set of model state and parameters so obtained can reduce artificial model drift and leads to different model predictions compared to snapshot inversion. The technique has been applied to Poper, Smith and Kohler glaciers, three connected ice streams and adjacent ice shelves in West Antarctica's Amundsen Sea Embayment, to the west of Thwaites Glacier. An initial condition is inferred as a result of a decadal transient model calibration. The initial condition so obtained is used in a 30-year prediction of committed sea level change. These predictions are made without estimates of changed climate forcing and therefore should be viewed with caution; nevertheless, it is clearly demonstrated that predicted thickness evolution and grounding line migration are markedly different between these two approaches. The adjoint and Hessian models underlying these techniques can also be applied for observing system design and uncertainty characterization experiments in support of glaciological field campaigns. Sensitivities to bedrock topography, basal sliding and sub-ice shelf melt rate patterns in particular provide valuable insights of governing processes.

Keywords: West Antarctica, Ice Sheet Mass Loss, Model Initialization, Transient Calibration, Adjoint Sensitivities