Ice Sheet Initialization and Uncertainty Quantification of Sea-level Rise

John Jakeman, Mauro Perego, Irina Tezaur
Sandia National Laboratories
jdjakem@sandia.gov, mperego@sandia.gov, ikalash@sandia.gov

Stephen Price
Los Alamos National Laboratory
sprice@lanl.gov

Georg Stadler
Courant Institute of Mathematical Sciences
stadler@cims.nyu.edu

Abstract

In order to produce reliable estimates of the sea level rise in next decades to centuries, it is of paramount importance to appropriately initialize Greenland and Antarctic ice sheets by estimating unkown or poorly know fileds such as the bedrock topography and the basal friction coefficient. It is also crucial to be able to quantify the uncertainty associated with such estimates.

In this talk, we present recent work towards developing a methodology for quantifying uncertainty in Greenland and Antarctica ice sheets' contribution to sea-level rise. While we focus on uncertainties associated with the optimization and calibration of the basal sliding parameter field, the methodology is largely generic and could be applied to other (or multiple) sets of uncertain model parameter fields. The first step in the workflow is the solution of a large-scale, deterministic inverse problem, which minimizes the mismatch between observed and computed surface velocities by optimizing the two-dimensional coefficient field in a friction sliding law. This step is performed using FELIX, a parallel finite element C++ code with embedded analysis tools. The inversion is performed through a PDE-constrained optimization approach. Under the Gaussian approximation, we then determine the probability distribution of the basal friction coefficient using the Hessian of the deterministic inversion. The uncertainty in the modeled sea-level rise is obtained by performing an ensemble of forward propagation runs.

The extent and complexity of the geometries, the nonlinearity of the flow equation, and the high-dimensionality of the parameter space present numerous challenges that will be addressed in the talk. We will present and discuss results obtained using different resolutions of the Greenland and Antarctic ice sheets.

References

1. M. Perego and S. Price and G. Stadler. Optimal initial conditions for coupling ice sheet models to Earth system models. J. Geophys. Res. Earth Surf., 119 (2014).