Computational challenges in ice sheet modeling

Mauro Perego[1]

Joint collaboration with

Alessandro Barone[2], Luca Bertagna[1], John D. Jakeman[1], Matt Hoffman[3], Stephen Price[3], Andrew Salinger[1], Georg Stadler[4], Irina K. Tezaur[1], Ray Tuminaro[1], Jerry Watkins[1]

[1]Sandia National Laboratories, NM, USA,
[2]Emory University, GA, USA
[3]Los Alamos National Laboratory, NM, USA
[4]Courant Institute, NY, USA

Large ice sheets such as Greenland or Antarctica play a significant role in climatology and, in particular, in sea level rise. Ice sheets behave like very viscous nonlinear fluids and can be modeled with highly nonlinear Stokes equations. The nonlinearities of the model, the large extension and complexity of the geometries, the free boundary nature of the problem, the lack of data, the coupling with other climate components make the problem very challenging from a mathematical and computational point of view.

In order to simulate the evolution of the ice sheets and have an accurate prediction of the sea level rise, it is mandatory to estimate the current thermomechanical state (initial condition) of the system. Plenty of data about the current state of the ice sheet on the surface (ice velocity, temperature, snow accumulation etc.) are available (e.g. from satellites). However, little is known about the thermomechanical state of the ice in the interior of the ice sheet or at the interface between the ice sheet and the bedrock. Moreover it is important to quantify the uncertainty on the prediction of sea level rise. This is currently a formidable task due to the high dimension of the parameter space.

In this talk, I will give an overview of mathematical modeling of ice sheets and present some of the current challenges. Then, I will present in more detail the inference problem of estimating the parameters and the initial state of the ice sheet performed using a large-scale PDE constrained optimization approach.