Ice Sheet Modeling for the Prediction of Sea Level Rise

Stephen Price, William Lipscomb, Todd Ringler, John Dukowicz, T-3; Antony Payne, Bristol Glaciology Centre, University of Bristol, Bristol, UK

The Antarctic and Greenland ice sheets are losing mass at rates that contribute a total of ~0.35 mm a^{-1} to global sea level rise [1]. This contribution is expected to increase in the future but, as noted in the recent IPCC report [2], current ice sheet models are too crude, in their representation of both ice sheet dynamics and fundamental physical processes, to provide a best estimate, or even an upper bound, for 21st century sea level rise due to changes occurring on ice sheets. At the same time, observations and modeling indicate that atmospheric and oceanic forcing are responsible for mass loss on both the Greenland and Antarctic ice sheets [3,4]. Coupling of ice sheet models and other climate model components will be necessary in order to make accurate predictions of future sea level rise.

The Climate Ocean and Sea Ice Modeling (COSIM) project has recently begun building an ice sheet model with improved dynamics and physics. The initial model is based on the model of Payne and Price [5,6], which includes an improved treatment of dynamics and physics. Advances to this model will follow from a new formulation [7] that will ultimately allow for efficient large-scale, high-resolution simulations on massively parallel architectures. The model will be coupled to COSIM's existing world-class sea ice and ocean circulation models to investigate a wide range of possible feedbacks among these climate components.

The model is currently being used to estimate how ocean-forced perturbations at the calving fronts of Greenland's outlet glaciers [3] translate to mass loss within the larger ice sheet (Fig. 1). We are also working on coupled ice sheet and ocean circulation experiments as part of the new DOE Investigation of the Magnitudes and Probabilities of Abrupt Climate Transitions (IMPACTS) initiative. These experiments will assess the likelihood that intrusions of warm seawater beneath ice shelves could trigger rapid retreat of the West Antarctic ice sheet during the next several decades.

For further information contact Stephen Price at sprice@lanl.gov.

[1] A. Shepherd, D. Wingham, *Science* **315,** 1529-1532 (2007).
[2] S. Solomon et al., *Climate change 2007: the physical science basis,* Cambridge University Press (2007).
[3] D.M. Holland et al., *Nature Geosc.* **1,** 659–664 (2008).
[4] M. Thoma et al., *Geophys. Res. Lett.* **35,** doi:10.1029/2008GL034939 (2008).
[5] A.J. Payne, S.F. Price, "A three-dimensional, first-order model of ice flow." In preparation.
[6] S.F. Price, A.J. Payne, A.J. Shepherd, *EOS Trans. AGU* **88(52),** Fall Meet. Suppl., Abstract C43A-06 (2007).
[7] J.K. Dukowicz, S.F. Price, W.H. Lipscomb, "Consistent Approximations for Ice Sheet Dynamics from a Principle of Least Action." In preparation.

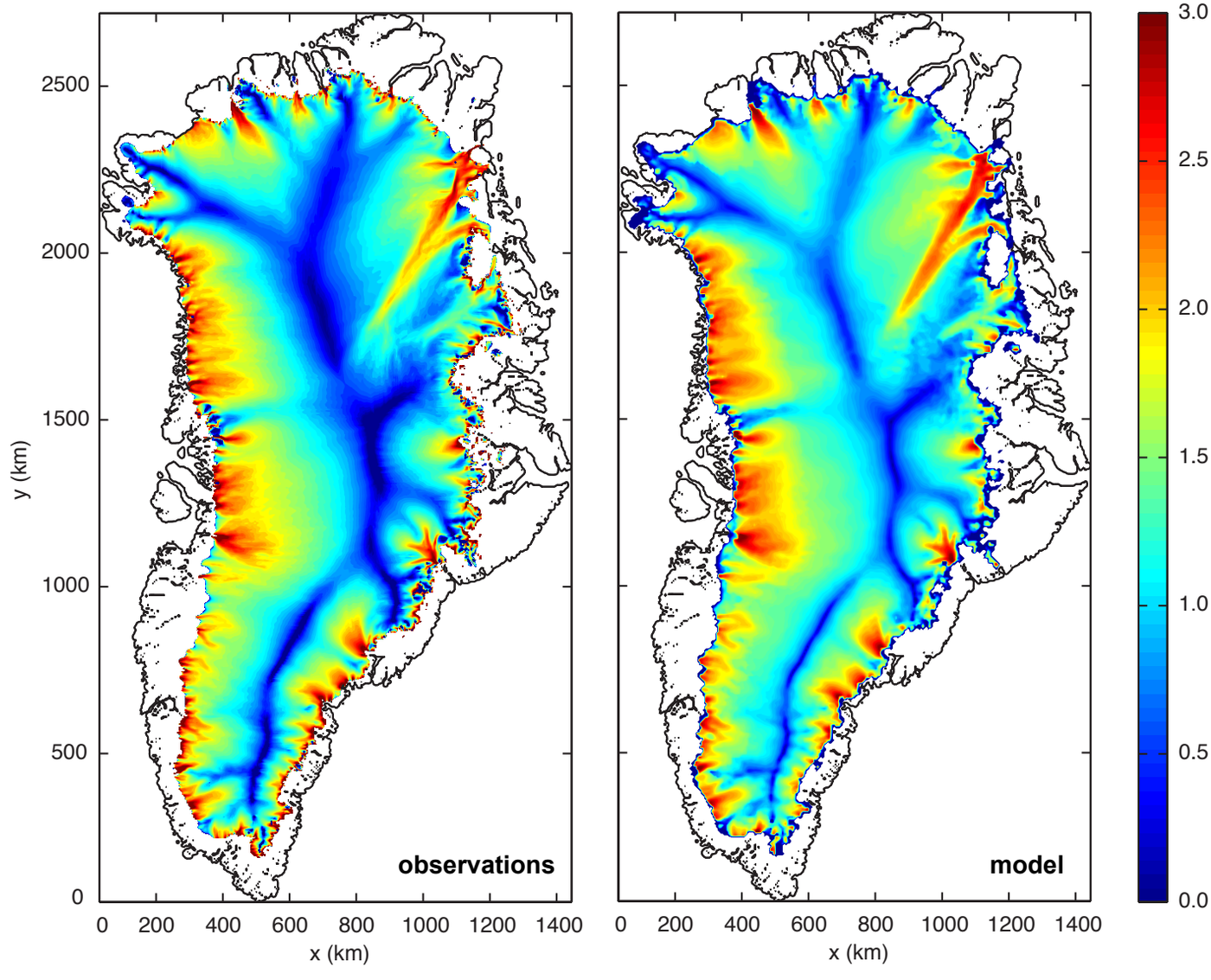

Fig. 1. Steady-state velocity field (log 10 scale) for the Greenland ice sheet based on modern-day observations of geometry and surface mass balance (left panel), and modeled velocity field with basal sliding tuned to match the velocity field inferred from observations (right panel). The model results are being used as initial and boundary conditions for high-resolution experiments to examine the susceptibility of particular outlet glaciers to dynamic mass loss induced by perturbations at their marine calving fronts.

Funding Acknowledgments

- DOE, Office of Biological and Environmental Research Climate Change Prediction Program
- DOE, Office of Science, Scientific Discovery through Advanced Computing Program
- LANL Postdoctoral Fellowship Program