An Approach to Computing Discrete Adjoints for MPI-Parallelized Models Applied to the Ice Sheet System Model 4.11

Larour, E., J. Utke, A. Bovin, M. Morlighem and G. Perez

Main points:

- NASA/JPL's Ice Sheet System Model now capable of computing gradients of any diagnostics (ex: best-fit to observations) with respect to any model input (ex: ice thickness, surface mass balance).

- Relies on automatic differentiation: exact gradients are computed within machine precision.

- Enables data assimilation of spatio-temporally variable datasets: altimetry, InSAR, GPS, etc … (as opposed to steady-state assimilation, which was the state of the art prior to this publication.)

- ISSM is now ready to assimilate surface altimetry from ICESat-2 and surface displacements from NISAR as soon as data is available! Will lead to instantaneous improvements on projections of sea-level rise contributed by Antarctica and Greenland.
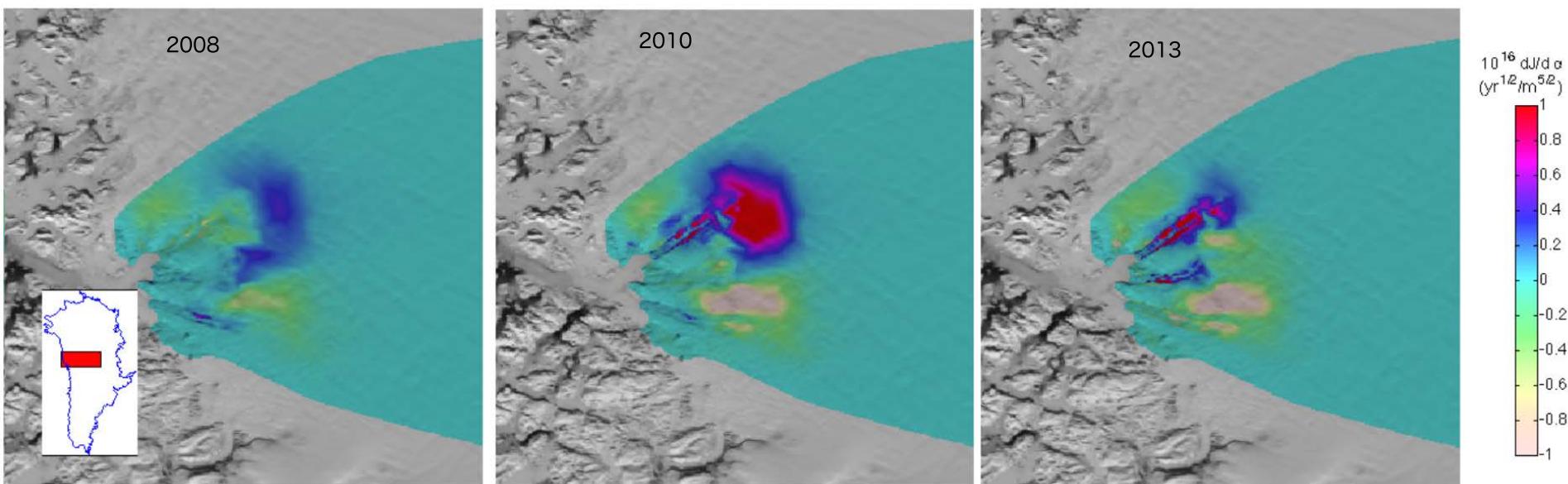
Spatio-temporally resolved gradient of the best-fit between modeled and observed surface velocities with respect to basal friction for Upernavik Glacier, Greenland. The time series spans 2008 to 2013, at a 2-week time step (only 3 snap-shots are provided for 2008, 2010 and 2013).