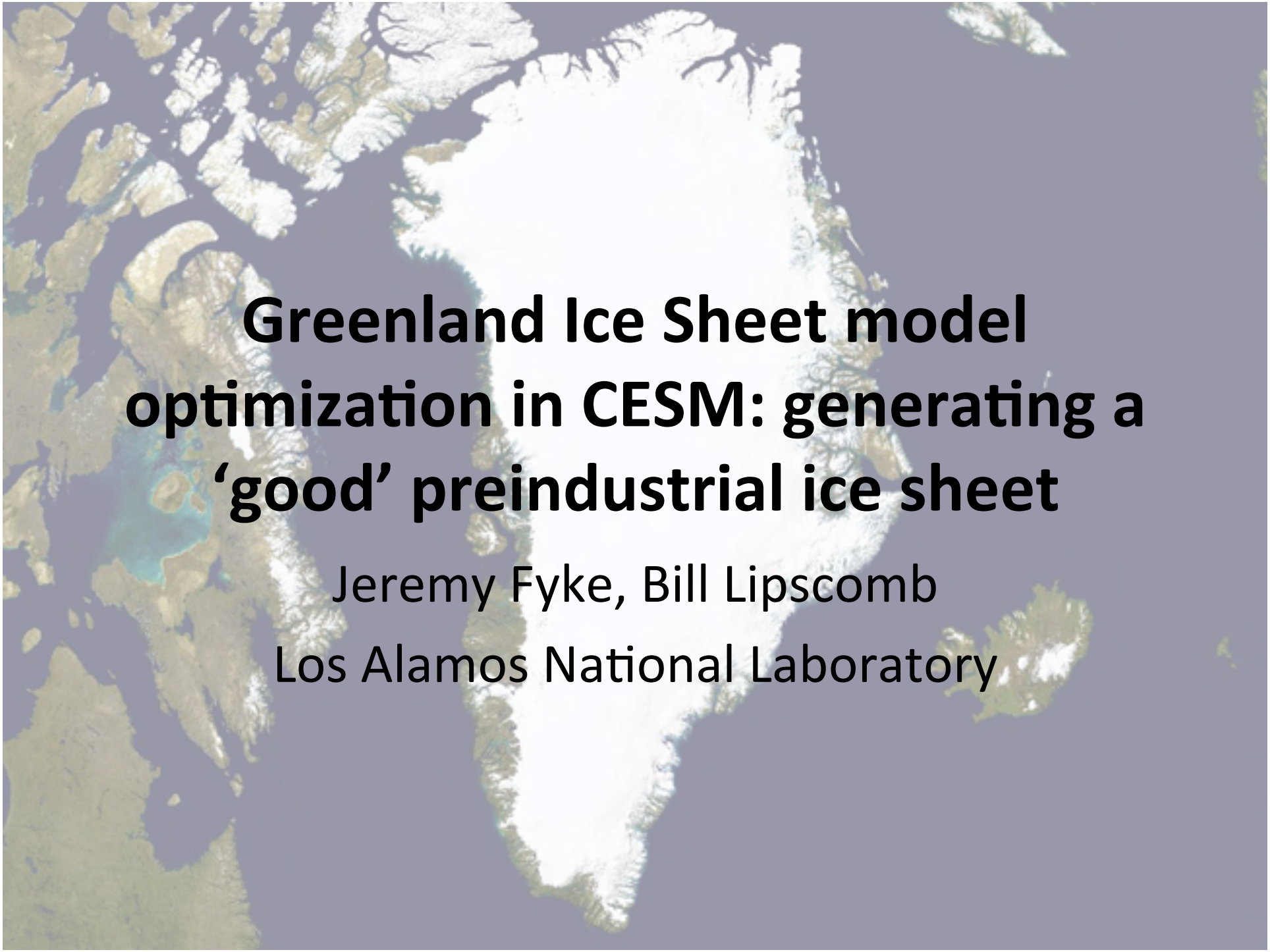


Greenland Ice Sheet model optimization in CESM: generating a 'good' preindustrial ice sheet

Jeremy Fyke, Bill Lipscomb

Los Alamos National Laboratory

Overview

- Ice sheet surface mass balance (SMB) can now be generated by CLM over Greenland Ice Sheet (GIS) (Bill Lipscomb, LANL)
- Question 1: what sort of equilibrium preindustrial Greenland Ice Sheet does this CESM-derived SMB produce?
- Question 2: how to optimize CISM using ensemble of 'perturbed physics' simulations to get reasonable preindustrial Greenland for future simulations, given climate forcing?

Modelling approach

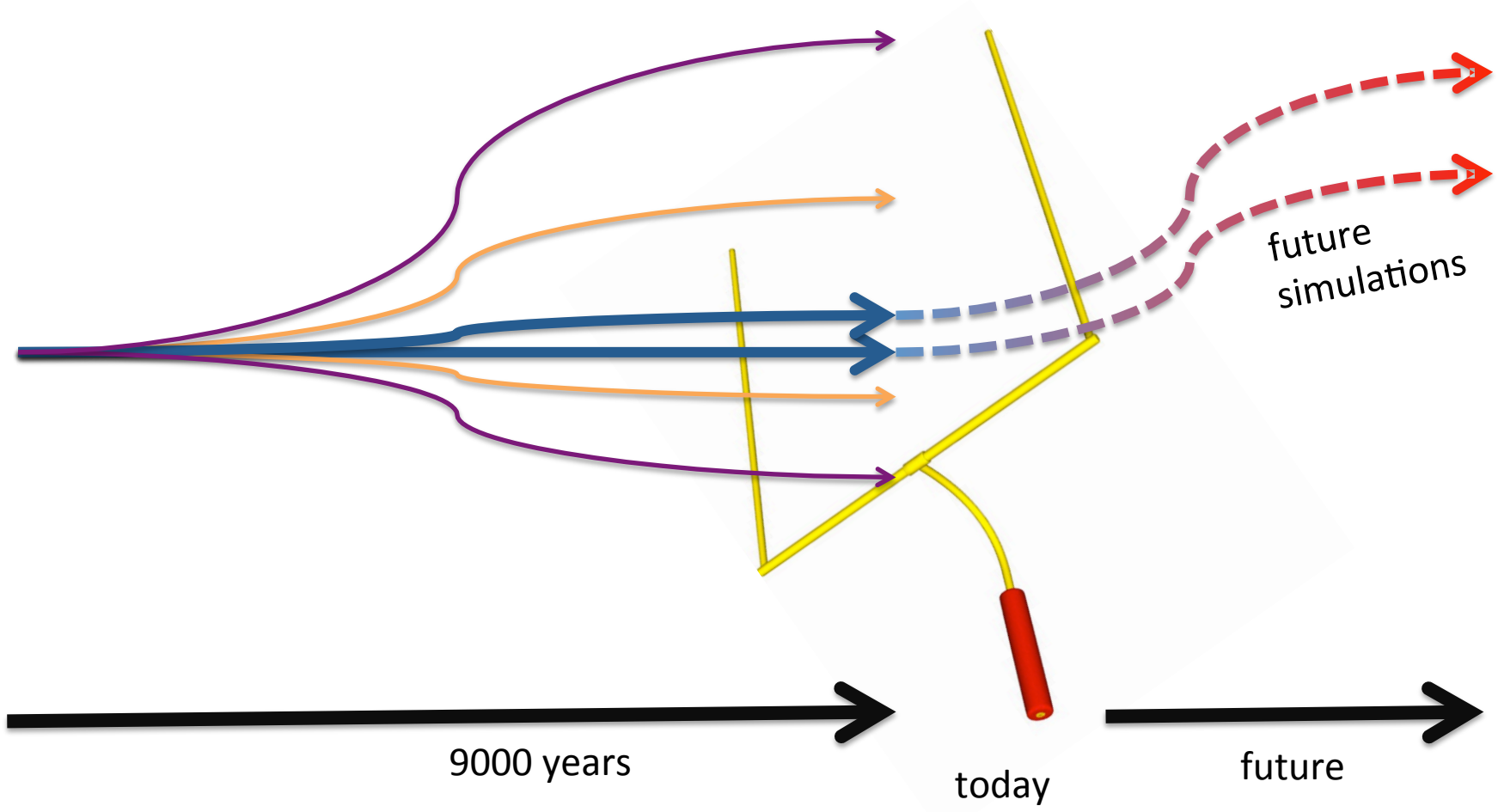
- CAM output from CCSM4 MOAR simulation used to force 300 year CLM simulation to generate SMB fields (Gail Gutowski, Texas)
- CISM initialized with present-day ice geometry, linear surface-to-bed internal temperature profile
- 100 years of post-spinup CLM SMB looped for 9000 years to provide SMB forcing for SIA CISM to evolve to ‘quasi-equilibrium’ under control forcing

Optimization approach

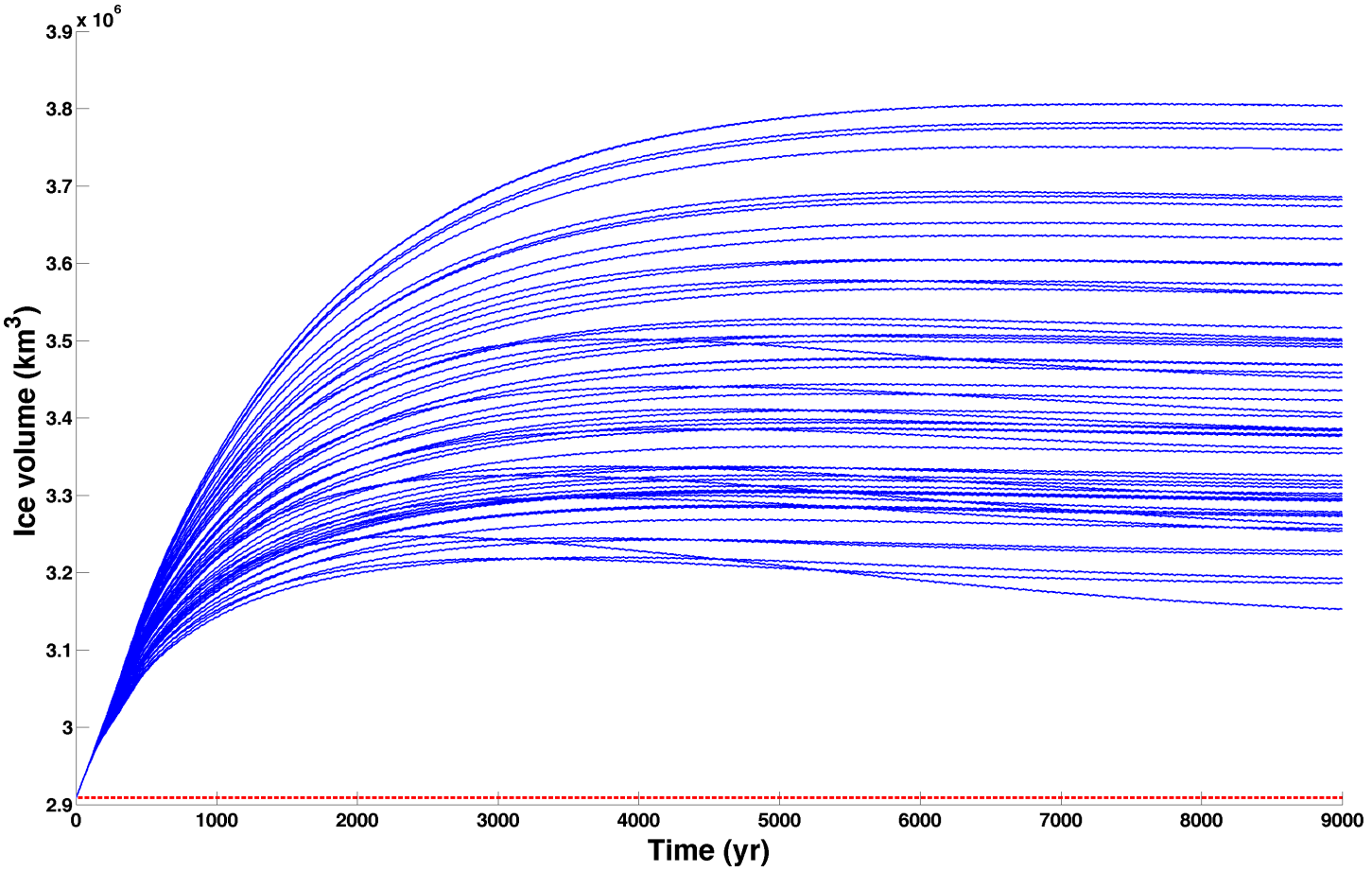
(Stone et al., 2010; Applegate et al., 2011)

- Generate 100 GIS realizations with LHS-determined random combinations of:
  - Ice sheet enhancement factor
  - Basal sliding coefficient
  - Geothermal heat flux
- Compare final states (after 9 kyr simulation) to observed GIS state for relative:
  - Ice volume errors
  - Ice area errors
  - RMSEs of ice surface elevation
  - Maximum ice elevation errors
  - Summit horizontal offset errors
- Rank models by 'worst diagnostic ranking' to get best all-around GIS realization

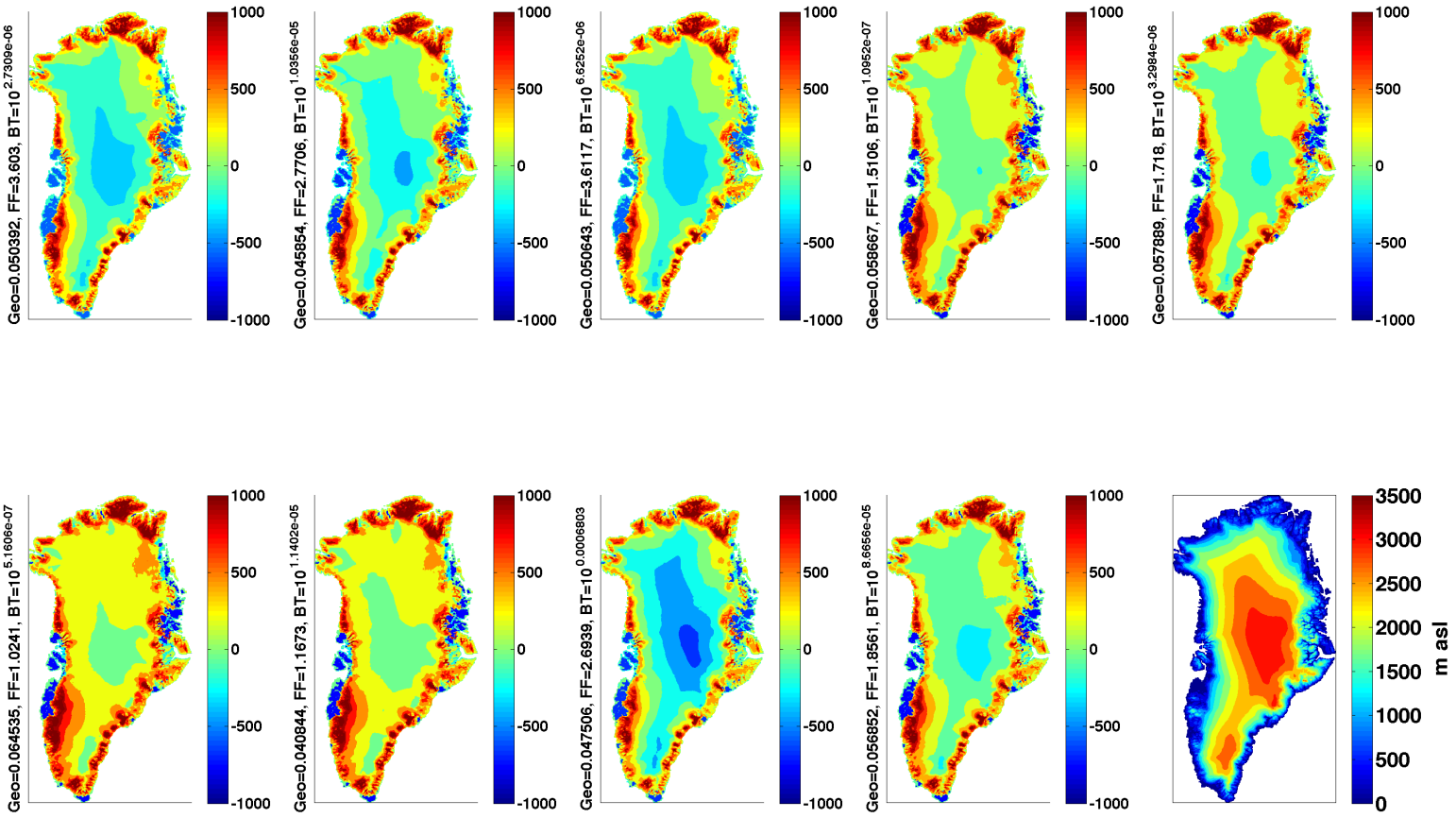
Optimization approach



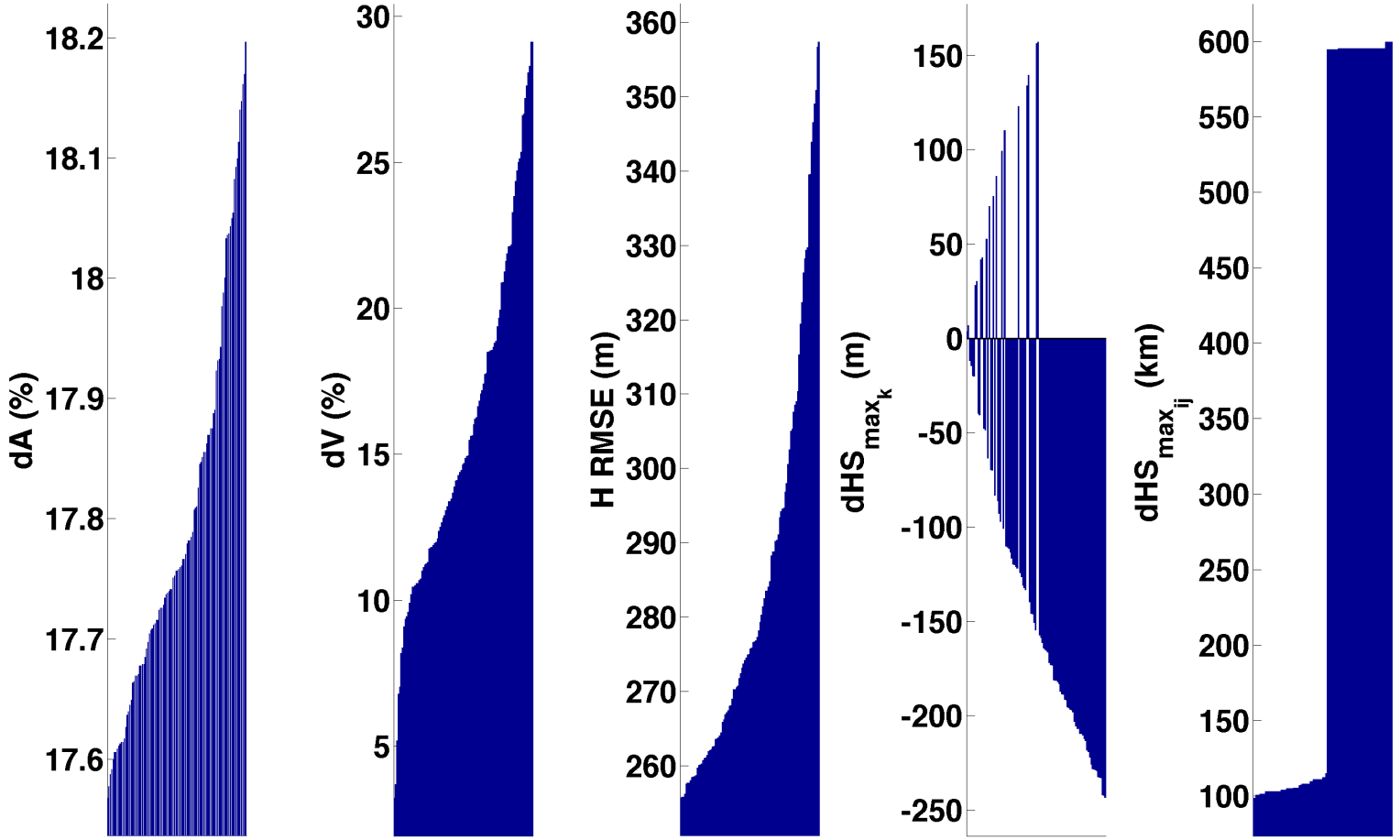
Optimization results: volume evolution



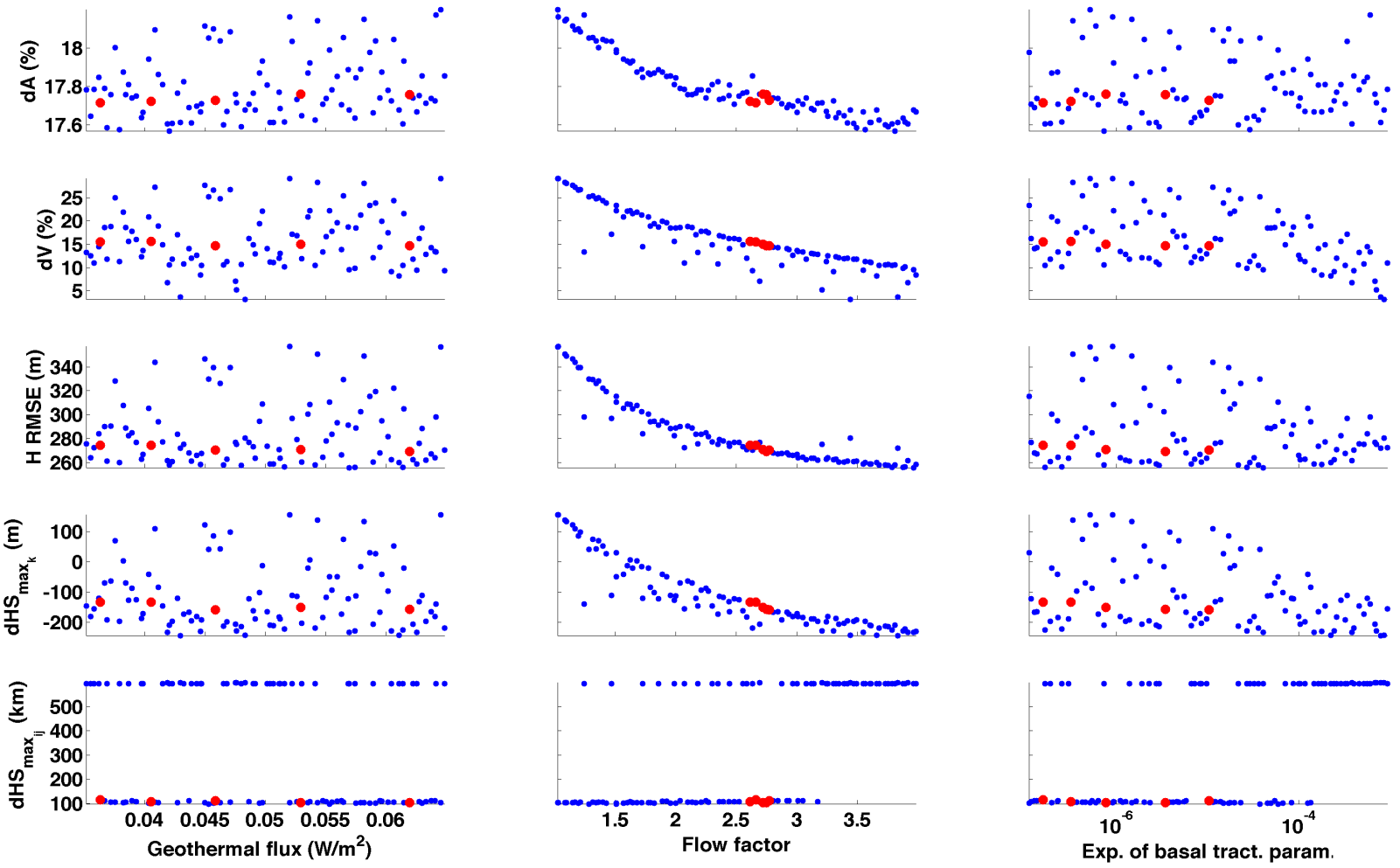
Optimization results: example GIS model-observed elevation differences



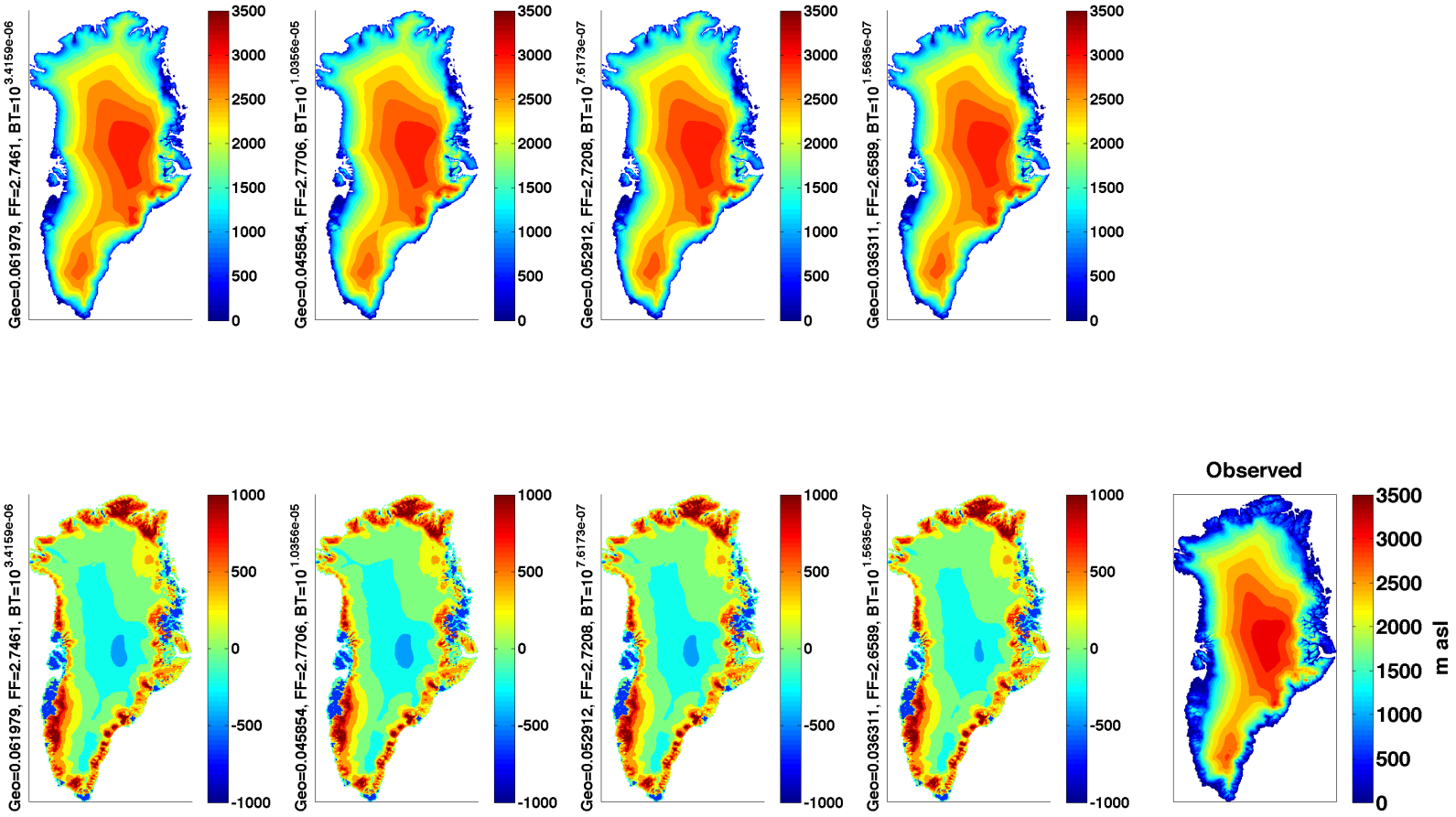
Optimization results: rankings for all diagnostics



Optimization results: dependence of diagnostics on LHS parameters



Optimization results: top-performing ice sheet model realizations



Ice sheet spinup/optimization issues

- Spinup/optimization issues to work on:
  - Thermal timescale of ice sheet (thus, ice viscosity) is 10^5 years – analogous to spinning up the deep ocean (but worse!)
  - How to spin up a GIS model, using climate model energy-balance-derived SMB forcing that is continuous between past and future, that captures transient thermal and geometric state of ice sheet?
  - LHS ensemble limited to sampling internal ice sheet parameters
  - Optimization likely compensates for CCSM-derived ice growth bias in it's choice of ice sheet parameters
  - Optimization limited to existing runs: can we make a statistical emulator to fill in unsampled parameter space?

Conclusions

- LHS sampling provides a fast way to determine optimal initial state for GIS models within CESM framework
- Flow factor parameter exerts major control on ice sheet optimization in CISM
- CESM climate-derived surface mass balance field has large role in determining long-term GIS spin up geometry
  - Spin up GIS geometry is a sensitive indicator of Arctic climate model performance
  - Spin up GIS geometry and future Arctic climate trends will influence CESM sea level rise (SLR) predictions
  - ➢ SLR(climate) means CESM SLR predictions will soon become a group-integrating coupled-model task