National Aeronautics and Space Administration

Postdoc Research

Estimating the Unobserved: Antarctic State Estimation using the Ice-sheet and Sea-level System Model (ISSM)

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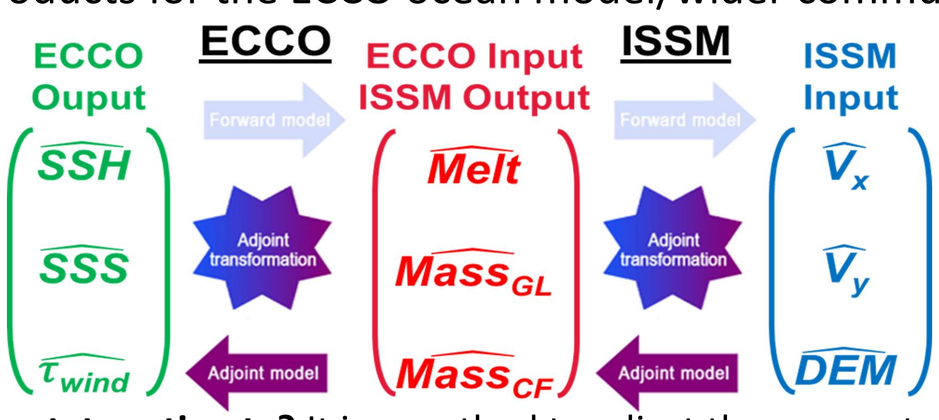
Background

Goal: We want to improve estimates of ice/ocean states to reduce sea level change uncertainty.

Question: Can we provide physically consistent estimates of unobserved data using observable datasets that are comparable with existing estimates?

Objective: Perform an Antarctic state estimation (*data assimilation*) using the ISSM ice sheet model, and provide new data products for the ECCO ocean model/wider community.

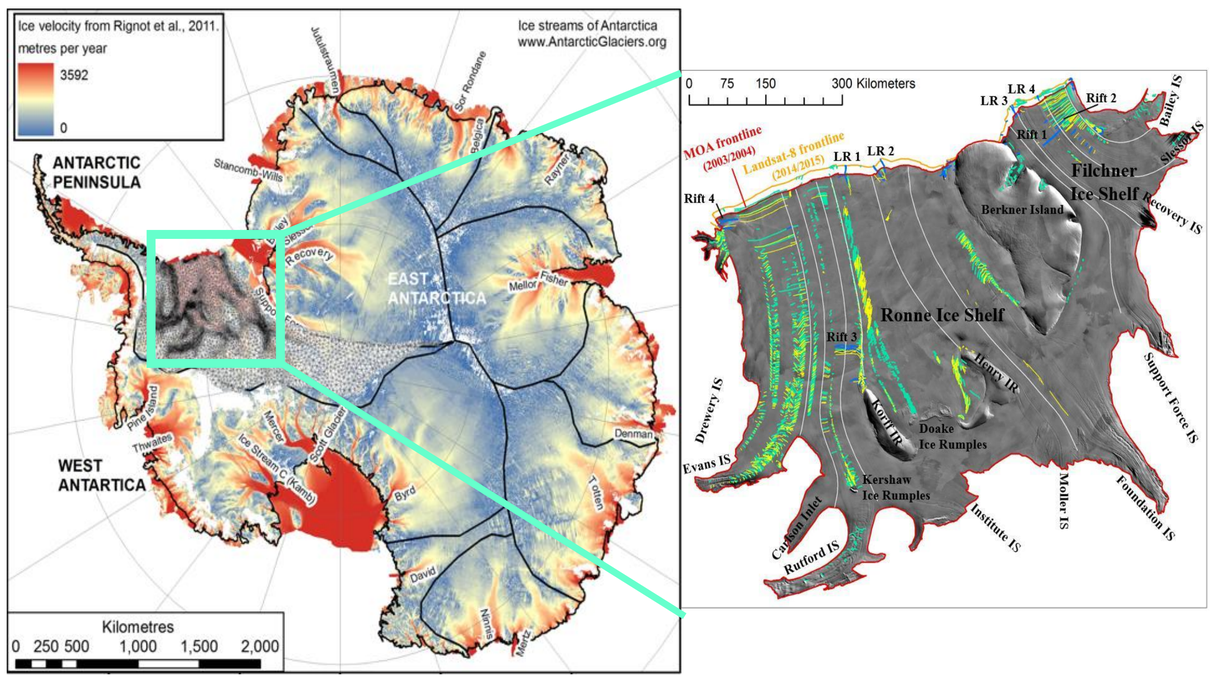


What is a state estimate? It is a method to adjust the parameters of the model such that its results are closer to observed values.

How do we perform the state estimate? We use adjoint (*inverse*) models, shown above, to understand the sensitivity of outputs (*states*) to inputs (*parameters*). These sensitivities are used to adjust the models to better match observations.

Approach

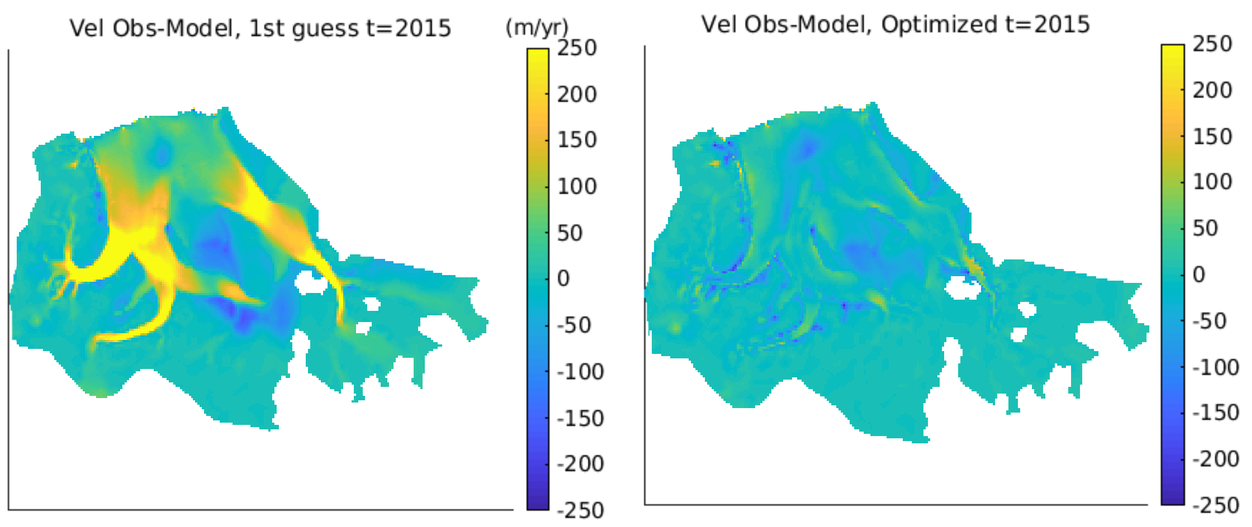
Method: We calculate the adjoint model of Ronne Ice Shelf in Antarctica (shown below) from 1995-2018 in quarterly time steps and ~1-40km spatial resolution mesh, using ISSM.



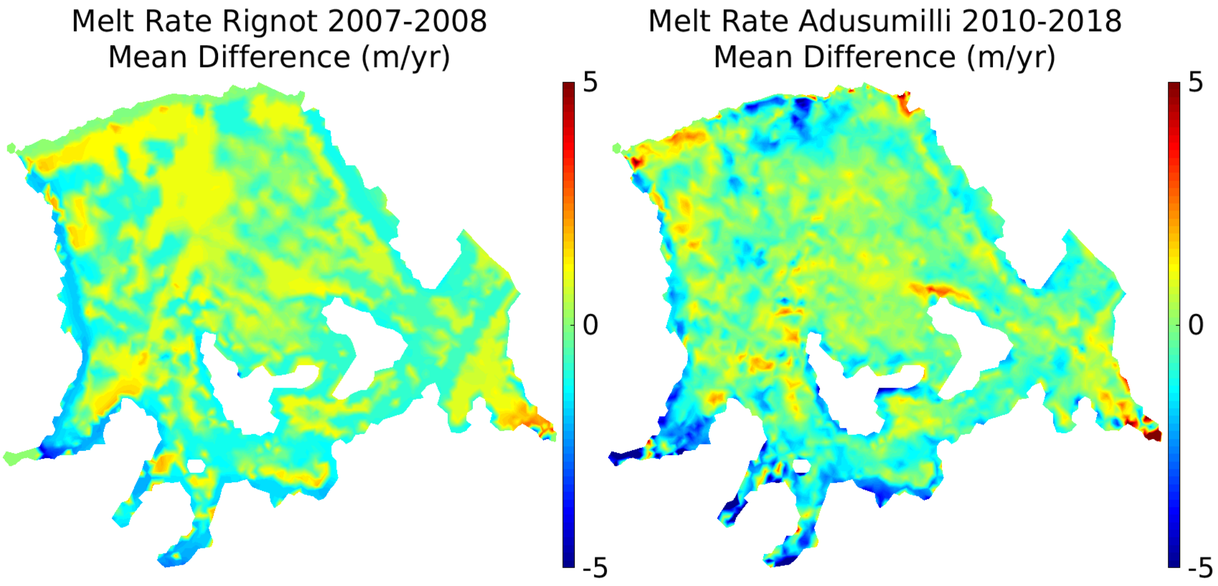
Data: includes bed geometry, elevation/DEM from BedMachine (Morlighem et al. 2020), surface mass balance (SMB) from MAR v3.6, and the observational constraints elevation and velocity change from ITS_LIVE (Gardner et al. 2018).

Results

Velocity Optimization: Differences between initial velocity state (shown below left) and optimized velocity state (shown below right). The adjoint model is shown to give parameter adjustments that correctly reduce model-data misfit.



Melt Rate Comparison: Differences between existing models (Rignot et al. 2014, shown below left) (Adusumilli et al. 2020, shown below right) and our basal melt rates of the Ronne Ice Shelf are within 1σ of expected values.



Significance of Results/Benefits to NASA/JPL

Data product generation of physically consistent, time varying unobserved states/parameters (friction, ice rigidity)

Reduces climate uncertainty sea-level change uncertainty

Calibration/validation of existing JPL/NASA melt rate, elevation, and velocity data products

Future Work

Publication of initial framework/results for Ronne Ice Shelf

Expansion to Antarctic state estimate, then Greenland

Data Release of ISSM model and data products on NSIDC

ECCO pseudo-coupling to refine the ocean/sea-level estimate

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