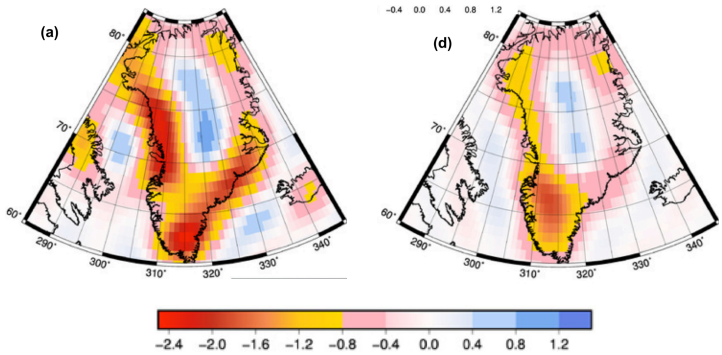
A New Ice Sheet Model Validation Framework for Greenland

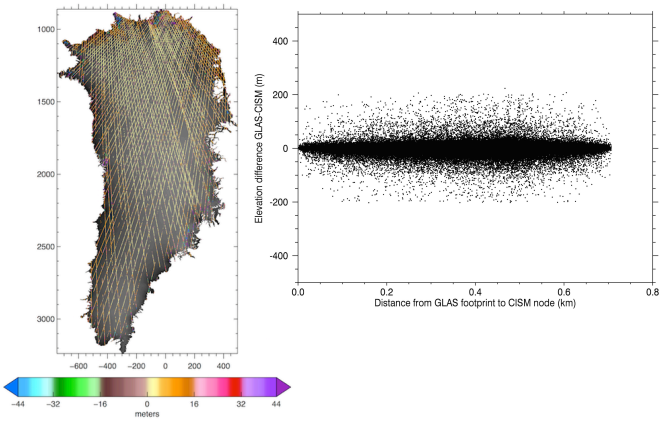
Achievement: Researchers bridge the expertise gap between modelers and observationalists by using the Cryospheric Model Comparison Tool (CmCt) to evaluate satellite-based observations of polar ice sheet change.



Map of Greenland mass trend between 2003-2013 (in m of water equiv. height) from GRACE observations (left) and from a high-resolution, *CISM-Albany* simulation (right).

Significance and Impact:

- Simulations demonstrate that quantitative metrics provided by CmCt are able to distinguish simulations of differing skill
- Modelers avoid need for expertise in processing of large, complex data sets
- Datasets can be altered or augmented remotely by relevant experts
- CmCt is extensible; new types of validation data, new metrics, and new geographic regions (e.g. Antarctica) can be added



Map of ICESat vs. model elevation differences in 2007 (left) and scatter plot of the same (right).

Research Details:

- Develop online tool to process and compare realizations of ice sheet change from models and observations
- Provide qualitative and quantitative metrics for use in assessing model skill at mimicking observed changes
- Demonstrate the tool by conducting and evaluating simulationsusing idealized and dynamic ice sheet models of increasing complexity

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Overview:

We propose a new ice sheet model validation framework – the Cryospheric Model Comparison Tool (CmCt) – that takes advantage of ice sheet altimetry and gravimetry observations collected over the past several decades and is applied here to modeling of the Greenland ice sheet. We use realistic simulations performed with the Community Ice Sheet Model (CISM) along with two idealized, non-dynamic models to demonstrate the framework and its use. Dynamic simulations with CISM are forced from 1991 to 2013, using combinations of reanalysis-based surface mass balance and observations of outlet glacier flux change. We propose and demonstrate qualitative and quantitative metrics for use in evaluating the different model simulations against the observations. We find that the altimetry observations used here are largely ambiguous in terms of their ability to distinguish one simulation from another. Based on basin-scale and whole-ice-sheet-scale metrics, we find that simulations using both idealized conceptual models and dynamic, numerical models provide an equally reasonable representation of the ice sheet surface (mean elevation differences of < 1 m). This is likely due to their short period of record, biases inherent to digital elevation models used for model initial conditions, and biases resulting from firn dynamics, which are not explicitly accounted for in the models or observations. On the other hand, we find that the gravimetry observations used here are able to unambiguously distinguish between simulations of varying complexity, and along with the CmCt, can provide a quantitative score for assessing a particular model and/or simulation. The new framework demonstrates that our proposed metrics can distinguish relatively better from relatively worse simulations and that dynamic ice sheet models, when appropriately initialized and forced with the right boundary conditions, demonstrate a predictive skill with respect to observed dynamic changes that have occurred on Greenland over the past few decades. An extensible design will allow for continued use of the CmCt as future altimetry, gravimetry, and other remotely sensed data become available for use in ice sheet model validation.