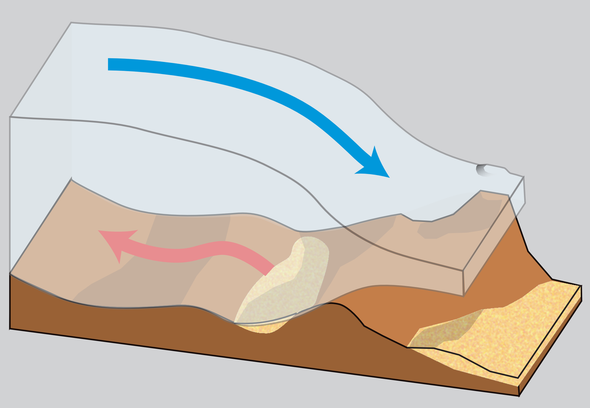
Investigating the Potential for Reconfiguration of the Antarctic and Greenland Ice Sheets

Nicholas Holschuh - Department of Geosciences

***Advisors**: Richard Alley and Sridhar Anandakrishnan*

Ice flows under its own weight, from areas where the ice surface is high to areas where the ice surface is low. The force driving ice flow is proportional to the slope of the ice surface.



In steady state, the Driving Force must be balanced by the resistive stresses, which are dominated by the Frictional Force at the bed.

In many places, the fast flowing ice in Antarctica and Greenland has a nearly flat surface, and therefore has a weak driving force. Models wouldn't naturally generate fast flow with that configuration, so to reproduce the modern ice sheet, we have to prescribe other changes in properties under the ice sheets.

Models that predict the future of the Antarctic and Greenland Ice Sheets are conditioned using modern observations.

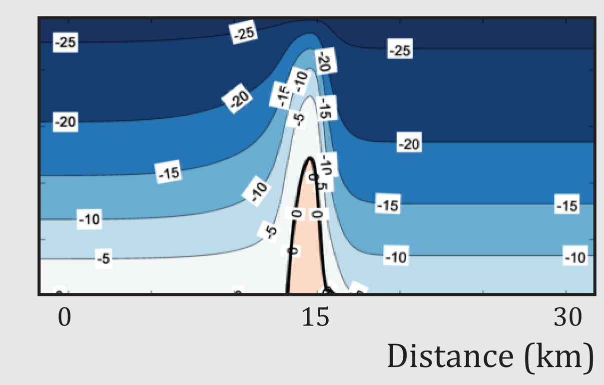
This conditioning step locks in some aspects of the ice sheet for the prediction, including the sizes and shapes of the ice streams.

By looking at the characteristics of their modern positions, we can determine which ice streams are likely to migrate, and qualify model predictions in those regions.

The Antarctic and Greenland Ice Sheets have discrete features that carry most of the ice from the interior out to the ocean, that are called "ice streams." To reproduce them, ice sheet models assume that the subglacial material is weak, and keep that assumption through the duration of the ice sheet predictions. This forces all ice routing through the modern ice streams, despite the fact that we know the number, positions, and sizes of the ice streams have changed through time.

To better predict ice behavior, we need to better determine the physics controlling the modern ice margins.

Some models, like that of Suckale et al. (2014) plotted to the right, believe that ice streams are not defined by their bed properties, but instead ice viscosity.



Topographically Controlled Margins
Shear margins with significant topographic gradients are likely long term features of the ice sheet and unlikely to change with time. This is is especially likely if strong lateral ice flow reduces the possibility of other controlling mechanisms.

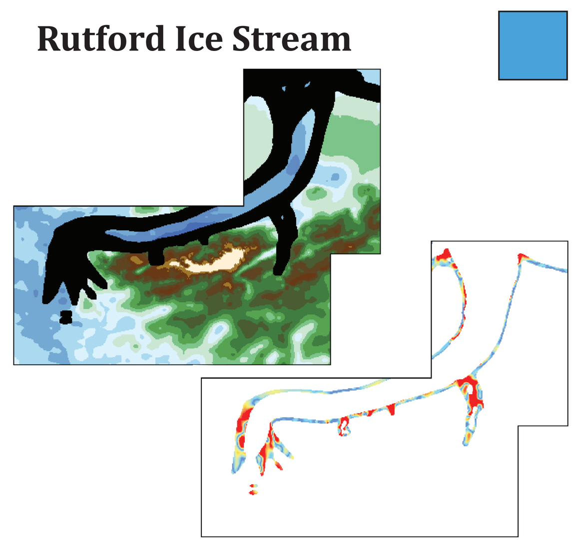
2000m
Bed Elevation
-2000m

The environments of 14 glaciers around Antarctica and Greenland

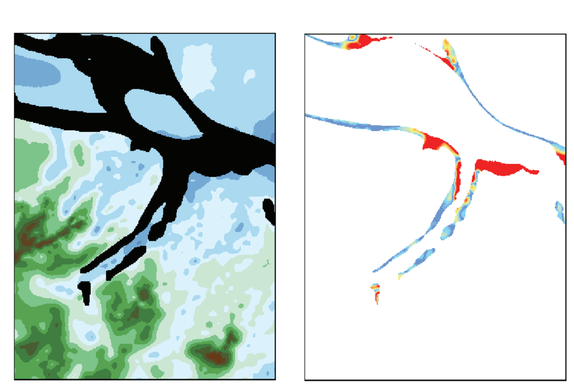
Thermally or Hydrologically Controlled Margins
Shear margins that do not have significant cross-mraginal flow accumulate heat that raises their temperature to the melting point. This warm ice is relatively weak, and likely controls the position of the modern ice streams.

50 m/a
Cross Marginal Flow
0 m/a

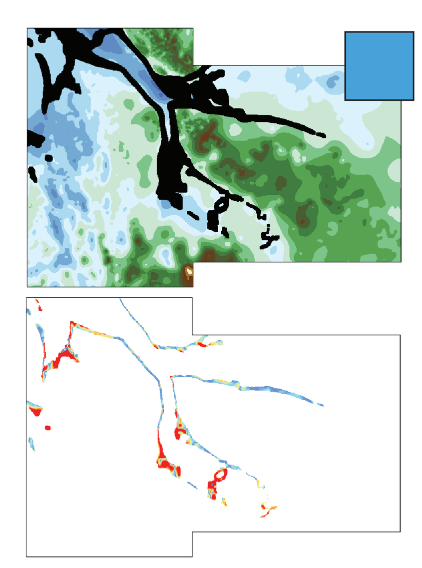
Rutford Ice Stream



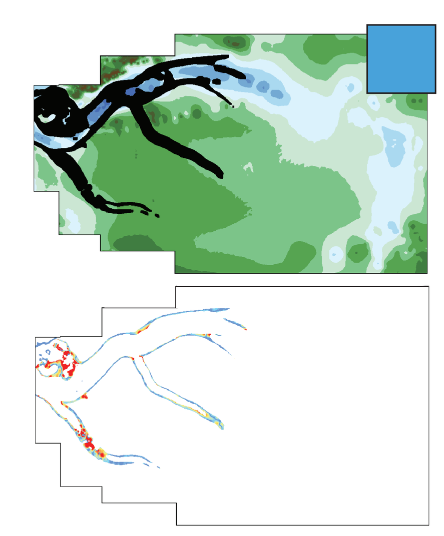
Institute Ice Stream



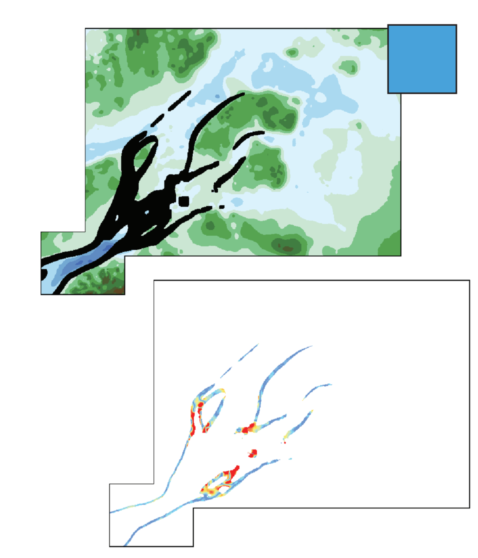
Moller and Foundation Ice Streams



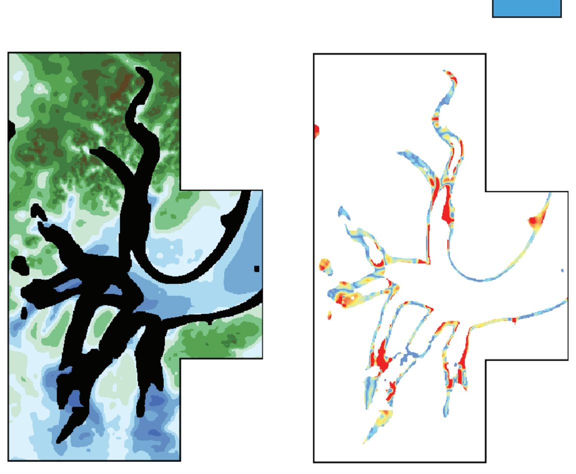
Blackwall Ice Stream and Recovery Glacier

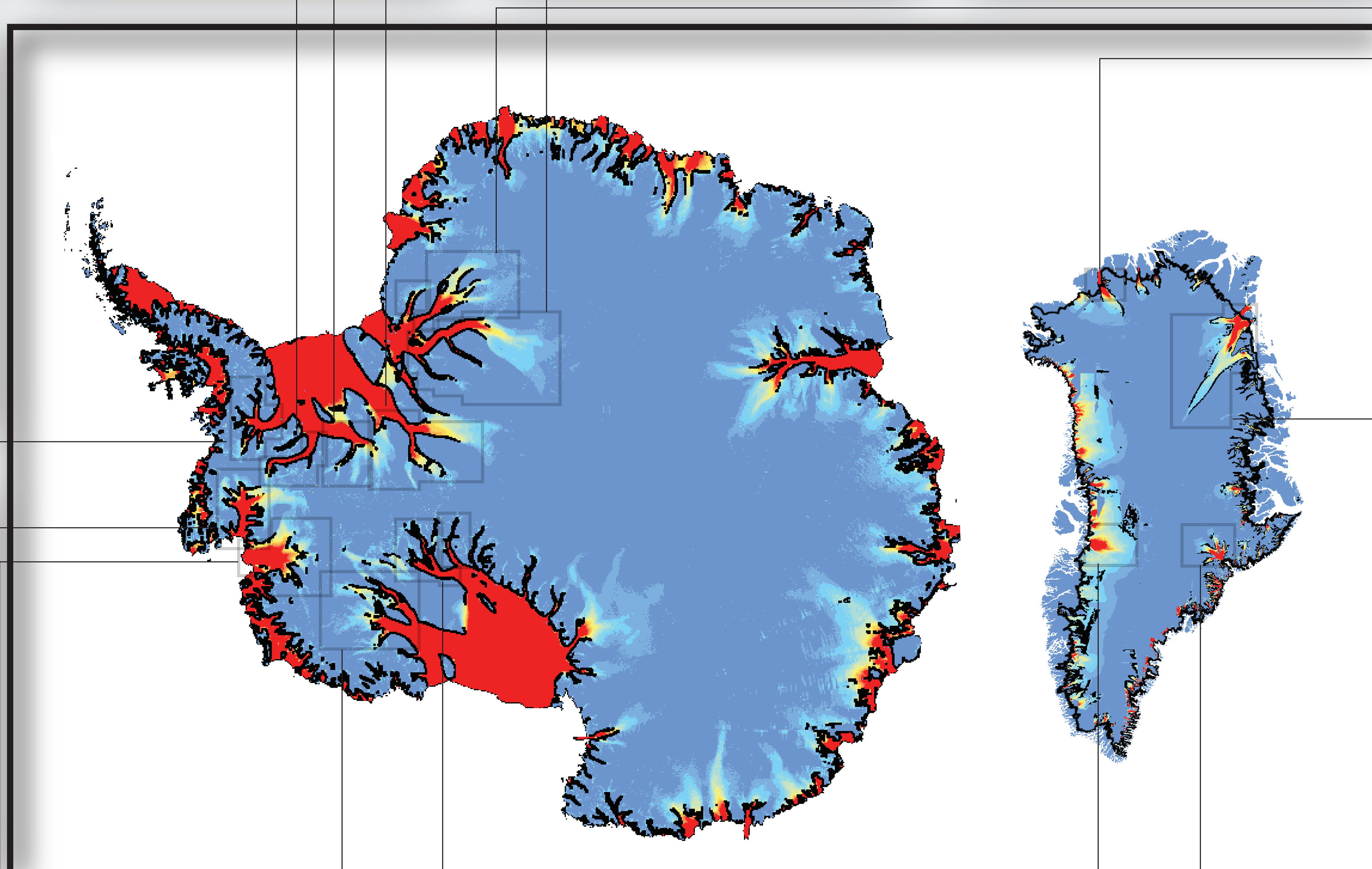


Slessor Glacier

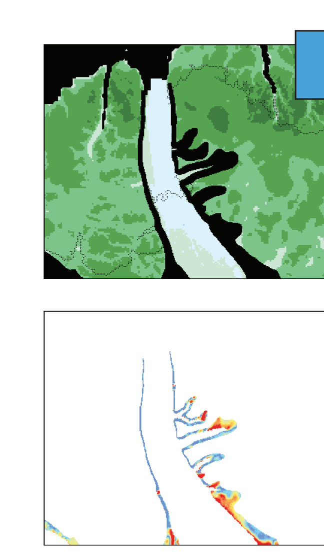


Evans Ice Stream

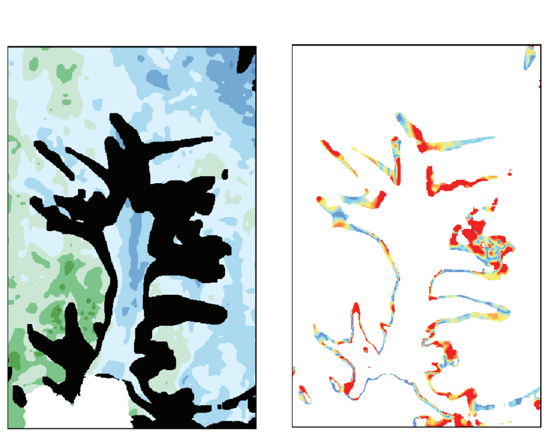




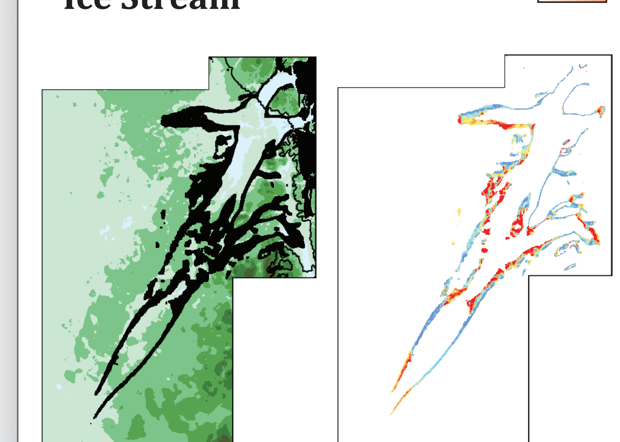
Petermann Glacier



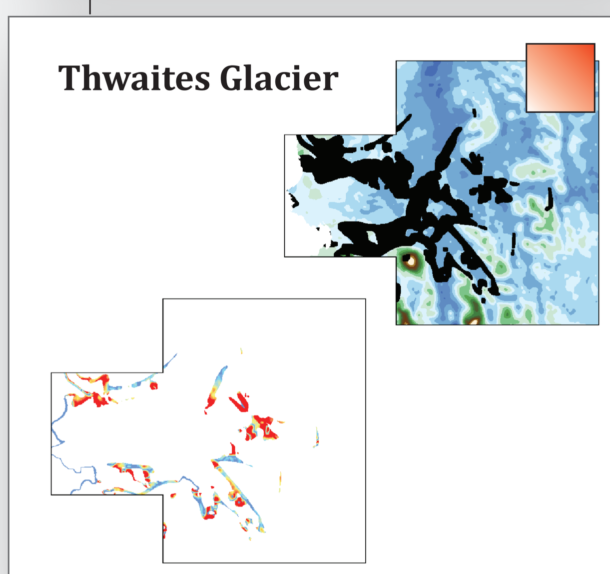
Pine Island Glacier



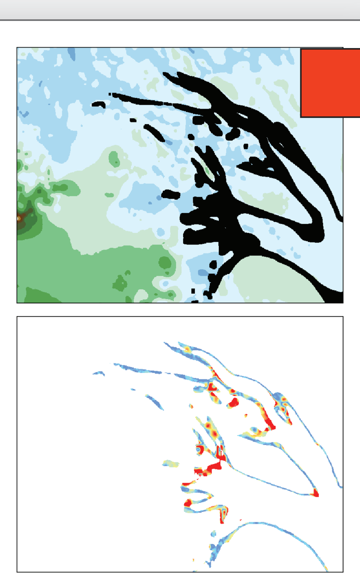
North East Greenland Ice Stream



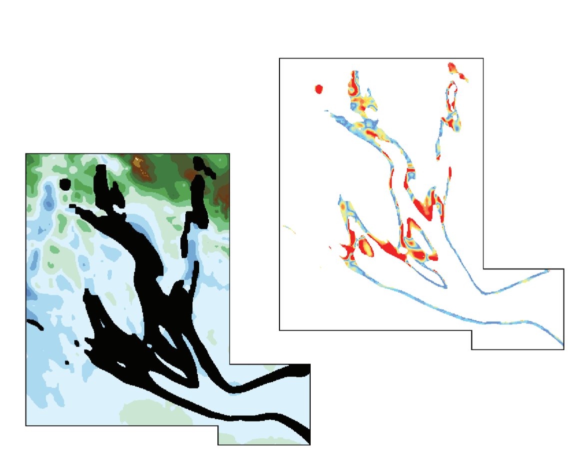
Thwaites Glacier



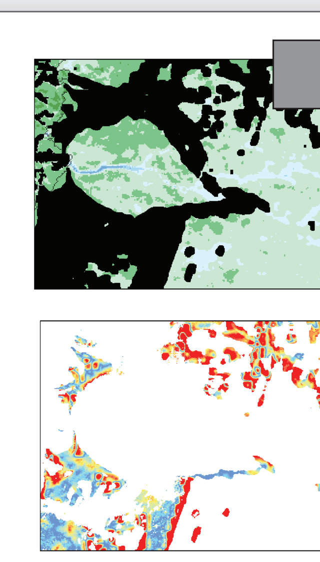
Bindschadler and MacAyeal Ice Streams



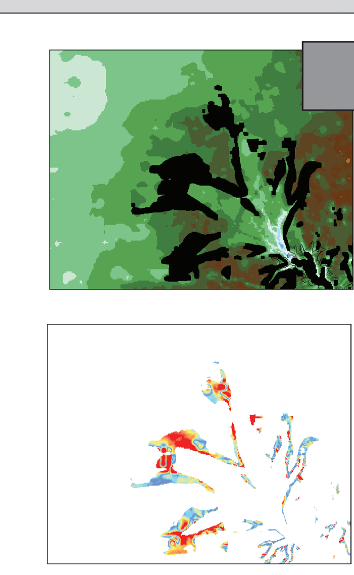
Whillans Ice Stream



Jakovshavn Glacier



Kangerlussuaq Glacier



Acknowledgements

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Data Citations: Joughin et al. (2011), Rignot et al. (2011), Fretwell et al. (2013), Bamber et al. (2013), Suckale et al. (2014)

Conclusions

Many of the ice stream gemoetries can be explained by basal topography alone (indicated with a blue marker). For those that do not have a strong topographic control, the cross marginal velocities are used to determine whether a thermal mechanism could be used to explain the boundary of fast flow, or if lateral advection of cold ice is likely to eliminate any lasting effects of thermal heating in the margin. The remaining ice streams must be hydrologically controlled, For two environments, Jakovshavn and Kangerlussuaq glaciers, more analysis is required to determine their boundary controls.