National Aeronautics and Space Administration

Quantifying the role of climate variability in driving the recent acceleration of Earth's fastest glacier

Principal Investigator: Nicole-Jeanne Schlegel (329); Co-Investigators: Alexander Robel (Georgia Institute of Technology), Helene Seroussi (Dartmouth College)

Program: FY22 SURP
Strategic Focus Area: Ocean and ice

Objective:

We aim to quantify the importance of internal multi-decadal climatic variability in driving the recent speedup, ice front evolution, and mass loss of the **world's fastest glacier**: Jakobshavn Isbrae (or Sermeq Kujalleq, SK) outlet glacier in West Greenland.

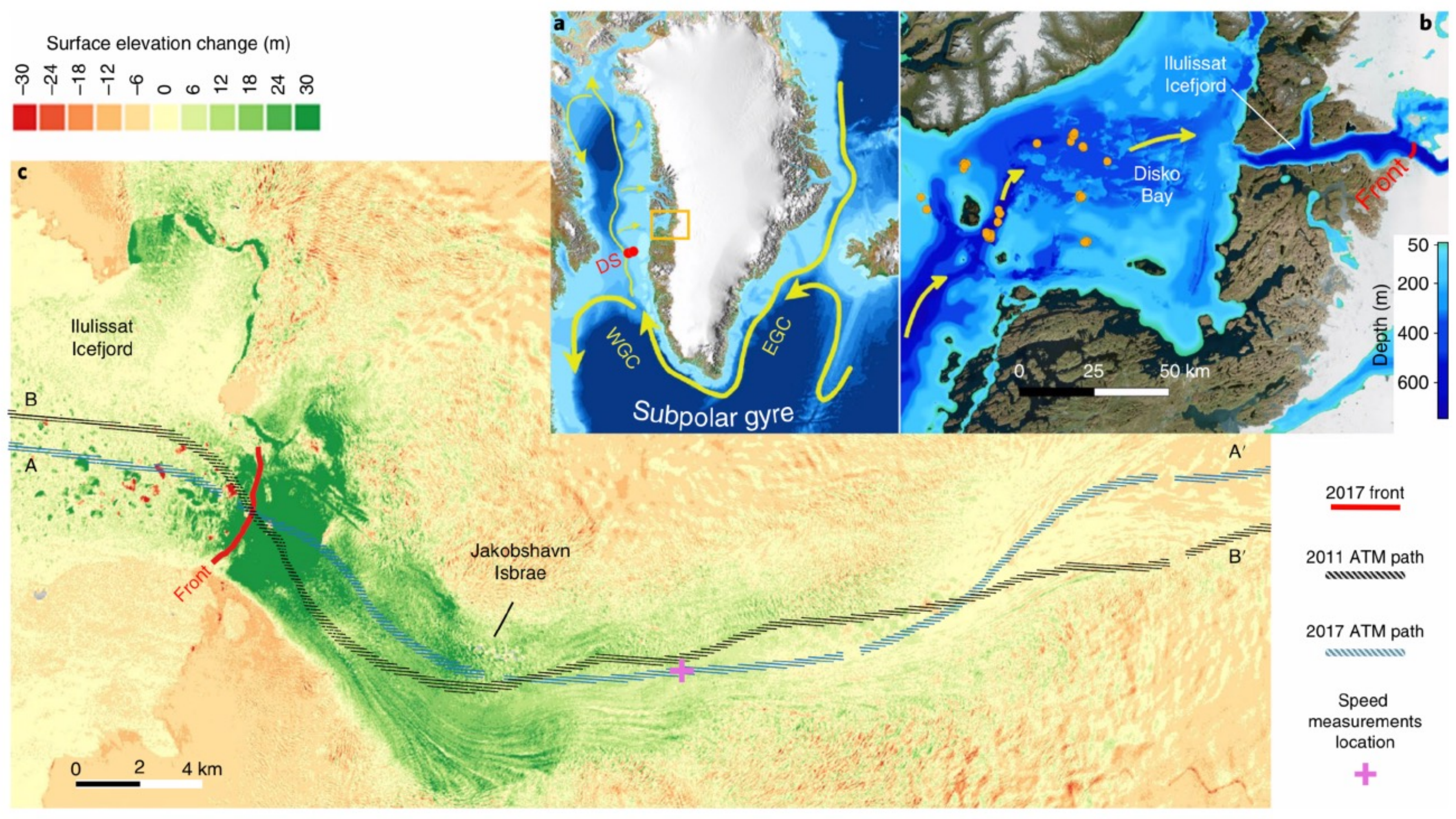

Figure 1. Ice front re-advance and ice thickening of SK in West Greenland in 2017. This glacier's fjord is connected to the subpolar gyre through the Disko Bay region.

Background:

SK, which drains a significant portion of the Greenland Ice Sheet, has undergone significant change over the last decades in response to ocean and atmospheric climate forcing:

It's ice speed has double

It's floating ice tongue has collapsed

It's ice front has retreated inland by > 20 km

It's lost > 500 Gt, or 1.5 mm of equivalent sea-level

Yet, most recently, SK has slowed in response to cooling waters in the North Atlantic Ocean. Here, we disentangle the internal climate variability to infer the anthropogenic portion of SK's historic ocean forcing. This information will allow us to investigate how sensitive this glacier is to human-induced warming historically as well as under future warming.

Approach and Results:

We use the **Ice-sheet and Sea-level System Model** to simulate the glacier dynamic response to changes in climate. We run an ensemble forced with ECCO ocean conditions, varying how the ocean is allowed to affect the glacier.

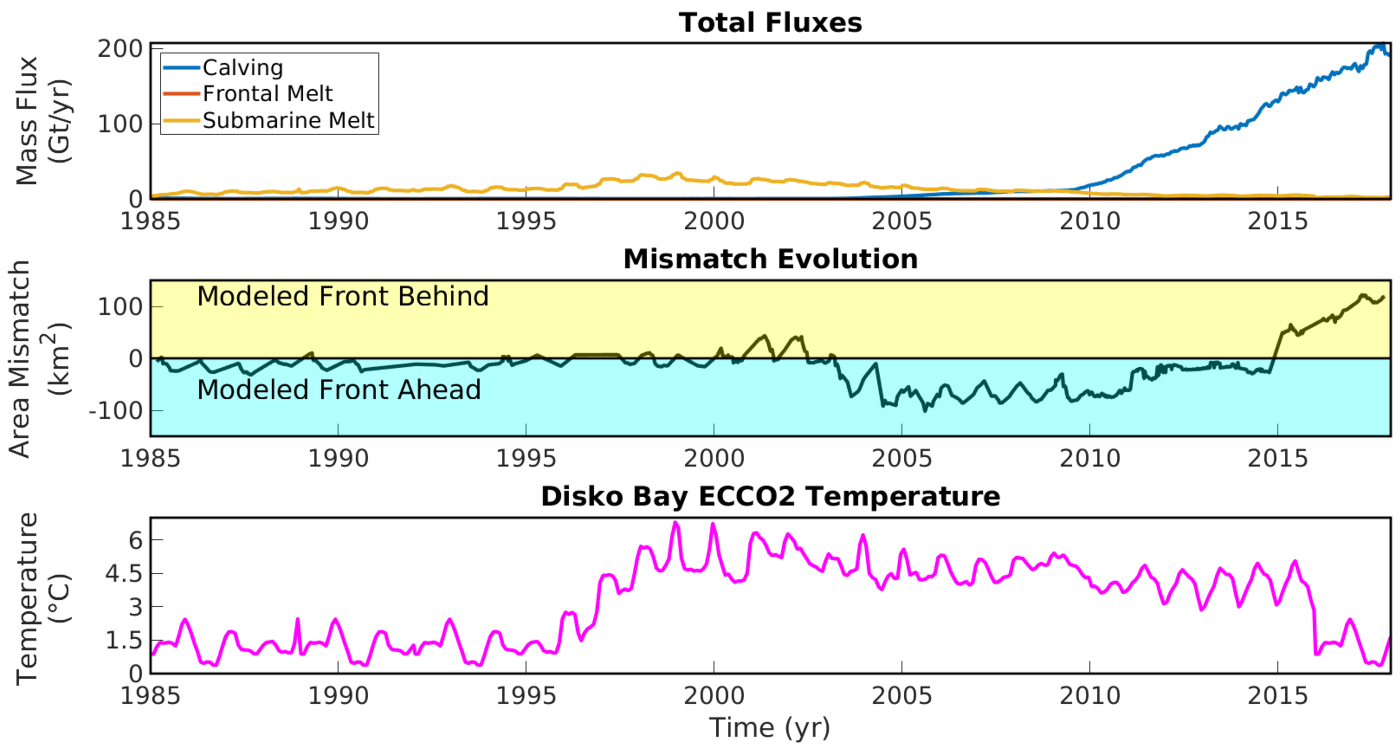

Figure 2: The best-match member (above) reproduces SK's historical behavior, and suggests that after 2007, the most important ocean forcing shifts from submarine melting to calving.

To investigate **internal climate variability**, we use a large ensemble to inform historical ocean temperatures in Disko Bay, and infer the proportion of interval variability vs. anthropogenic signal in the region.

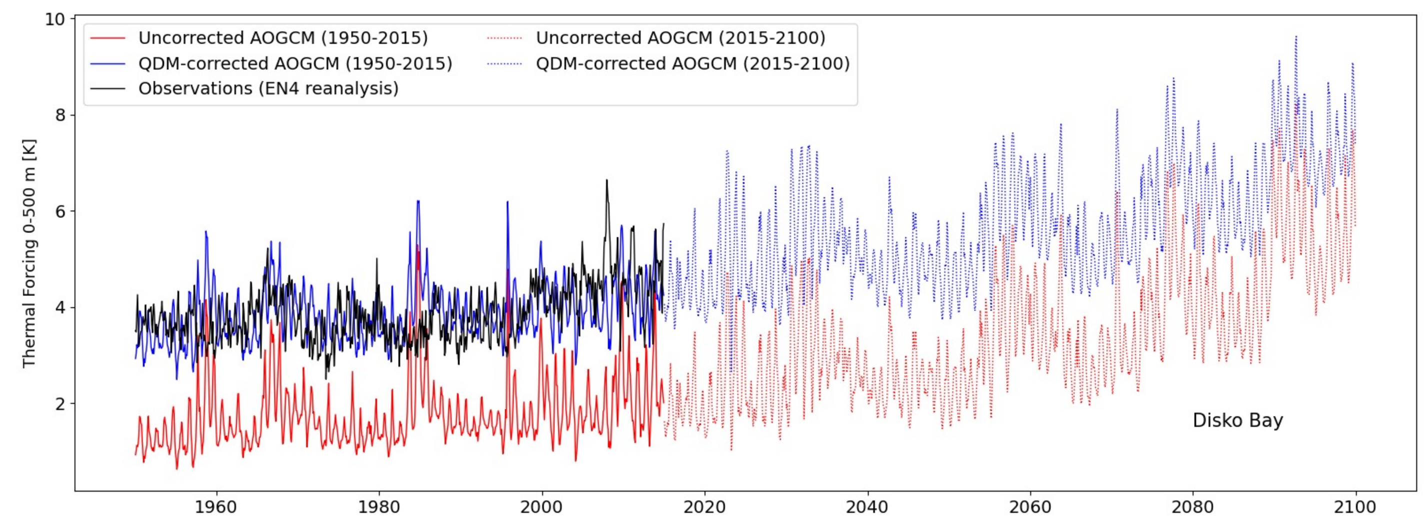

Figure 3: We use quantile mapping to bias-correct the climate model's ocean temperatures so that they reproduce ocean thermal forcing of SK within its fjord.

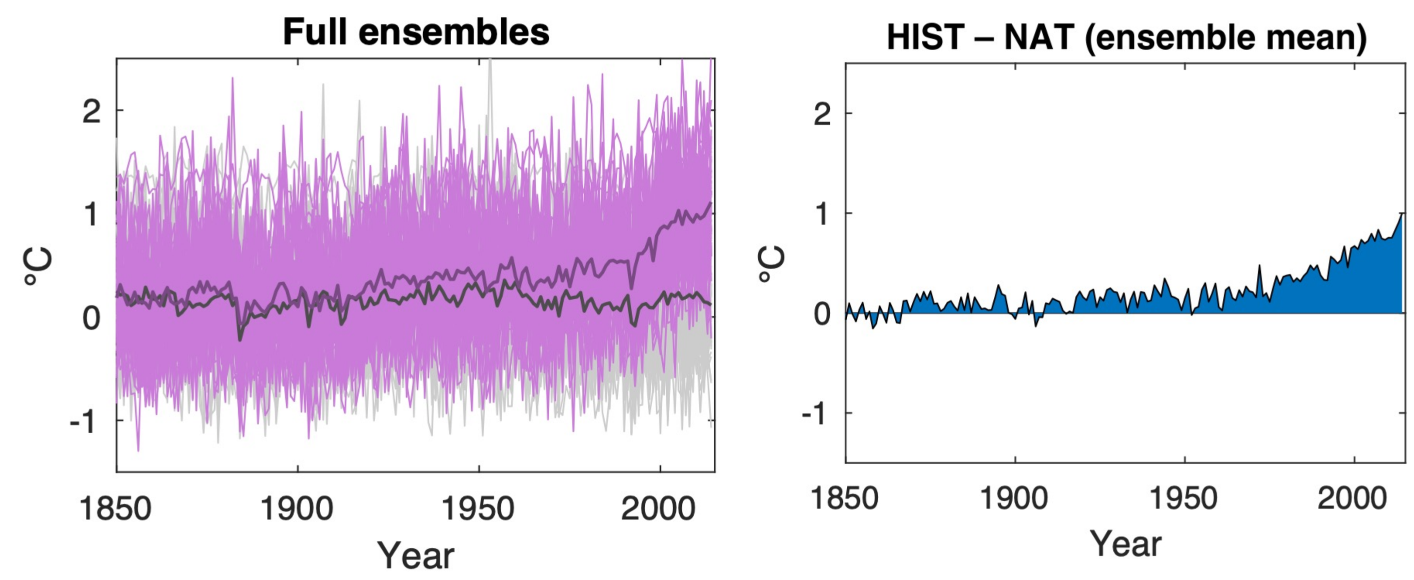

Figure 4: Internal climate variability is deduced by comparing ensembles with (purple, HIST) and without (black, NAT) anthropogenic forcing.

Significance:

Our results highlight the large climate variability in Disko Bay that is superimposed on top of a trend of warming. As SK is sensitive to shifting trends in climate forcing, we find that both natural and anthropogenic climate forcing have affected the historic evolution of Jakobshavn Isbrae's retreat. We have now created a framework to force the SK ice flow model with ocean conditions from coarser-resolution climate models, therefore allowing us to use available large ensembles to include or exclude anthropogenic forcing and study the sensitivities of ice dynamics in a changing climate. Understanding the factors that drive regional glacier change is critical for developing robust projections of Greenland sea-level contribution and for quantifying model projection uncertainty.

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

Clearance Number: CL#22-4950
Poster Number: RPC-117

Publications:

Z. Rashed, A. Robel, H. Seroussi, et al., (2022) "Disentangling the physical mechanisms linking ocean warming to the recent retreat of Sermeq Kujalleq, Greenland", Journal of Glaciology, in submission.

J.E. Christian, Z. Rashed, V. Verjans, N-J. Schlegel, G. Catania, A.A. Robel (2022) "Quantifying anthropogenic contributions to the retreat of Sermeq Kujalleq (Jakobshavn Isbrae) since 1850". Cryosphere, in prep.

PI/Task Mgr. Contact Information:

Email: Nicole-Jeanne.Schlegel@jpl.nasa.gov