Observed and modeled firn properties on the Greenland Ice Sheet

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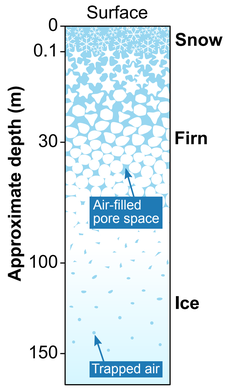
BACKGROUND

The Greenland Ice Sheet's porous firn layer stores meltwater generated at the surface



A thick layer of compacted snow, called "firn," covers the surface of the Greenland Ice Sheet. The **firn is porous and acts as a sponge** that stores meltwater produced at the ice-sheet surface, thus buffering Greenland's contribution to sea level rise in a warming climate.

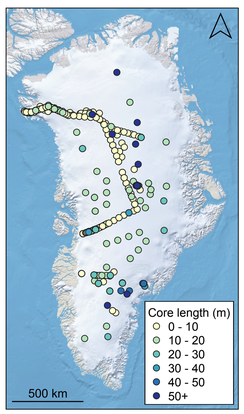
Measurements of firn density provide an estimate of the air-filled pore space (called, "firn air content") within the firn. However, in Greenland, these observations are spatially and temporally limited. Firn models forced by climate data provide a mechanism to investigate the **atmospheric drivers responsible for variations in firn properties** across the entire ice sheet.

Key objective: Use observations to evaluate firn models, and examine atmospheric controls on firn properties across the entire Greenland Ice Sheet

DATA & MODELS

Observations: SUMup Dataset[1]

Collection of firn density observations reaching depths of up to 350 m on both ice sheets. In Greenland, 700 unique observations are included in SUMup.



Locations of observations

Firn model: SNOWPACK[2,3]

Physics-based, single-column, multi-layered snow and firn model that uses atmospheric input data and simulates firn processes.

Firn model: CFM[4]

Semi-empirical snow and firn model that uses atmospheric input data and simulates firn processes. "Community Firn Model"

Atmospheric input: MERRA-2[5]

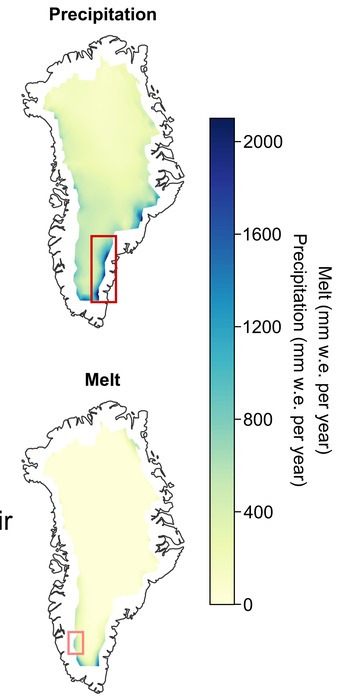
Hourly global atmospheric reanalysis spanning 1980 to present day with a spatial resolution of ½° latitude by ⅝° longitude.

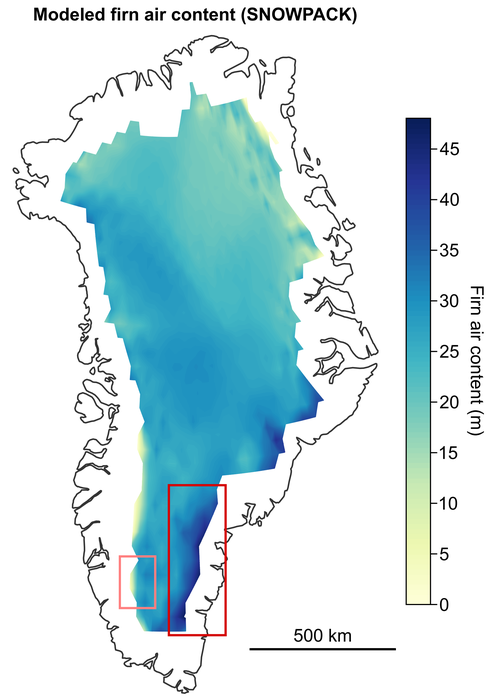
We use two firn models to simulate firn processes across the entire ice sheet and evaluate results with observations from a large dataset

RESULTS: Atmospheric effects on firn properties

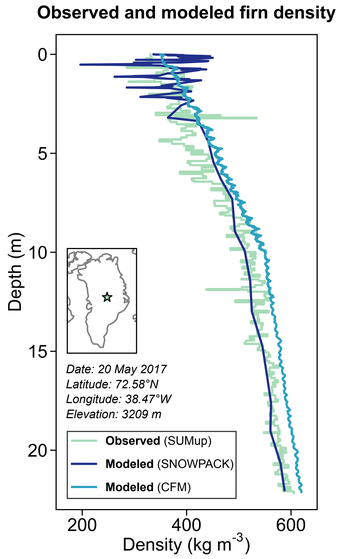
Areas with high precipitation have high firn air content

Areas with low firn air content experience relatively high melt

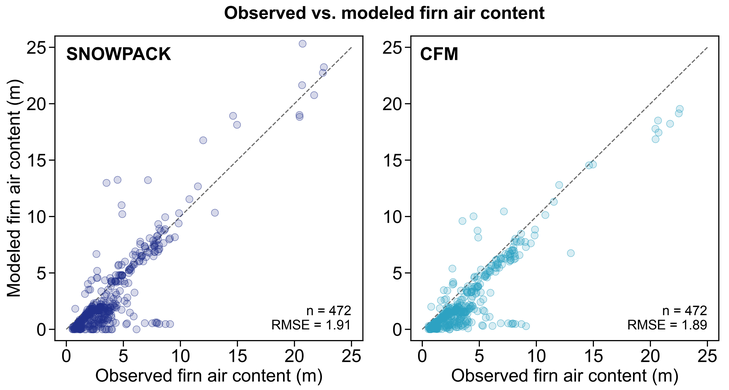




RESULTS: Observed and modeled firn properties



Both models simulate realistic values of firn density and firn air content, and generally show very good agreement when compared with observations



CONCLUSIONS

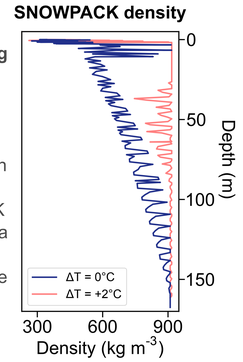
Firn density and firn air content modeled by SNOWPACK and CFM closely match observations from the SUMup dataset. Additionally, we confirm that some firn properties are dependent on surface mass balance components like precipitation and melt. We note that modeled results may be limited by the accuracy and spatial resolution of the atmospheric forcing. We conclude that these **firn models perform well in Greenland**, and we can use them to (1) simulate firn properties across the full ice sheet, and (2) predict how firn properties may evolve in a warming climate.

Key finding: Models overcome the spatial and temporal limitations of observations by simulating realistic firn properties across the entire ice sheet

FUTURE WORK

Future work will focus on **investigating evolving firn properties in the context of climate change**. We will use future climate scenarios to predict changes in firn density and air content.

An example of the expected outcome is shown in the figure to the right. When we increase the input air temperature by 2°C (pink), SNOWPACK produces a much denser firn layer compared to a firn layer produced with no temperature change (blue). We expect the firn layer to densify and the firn air content to be depleted in the future.



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