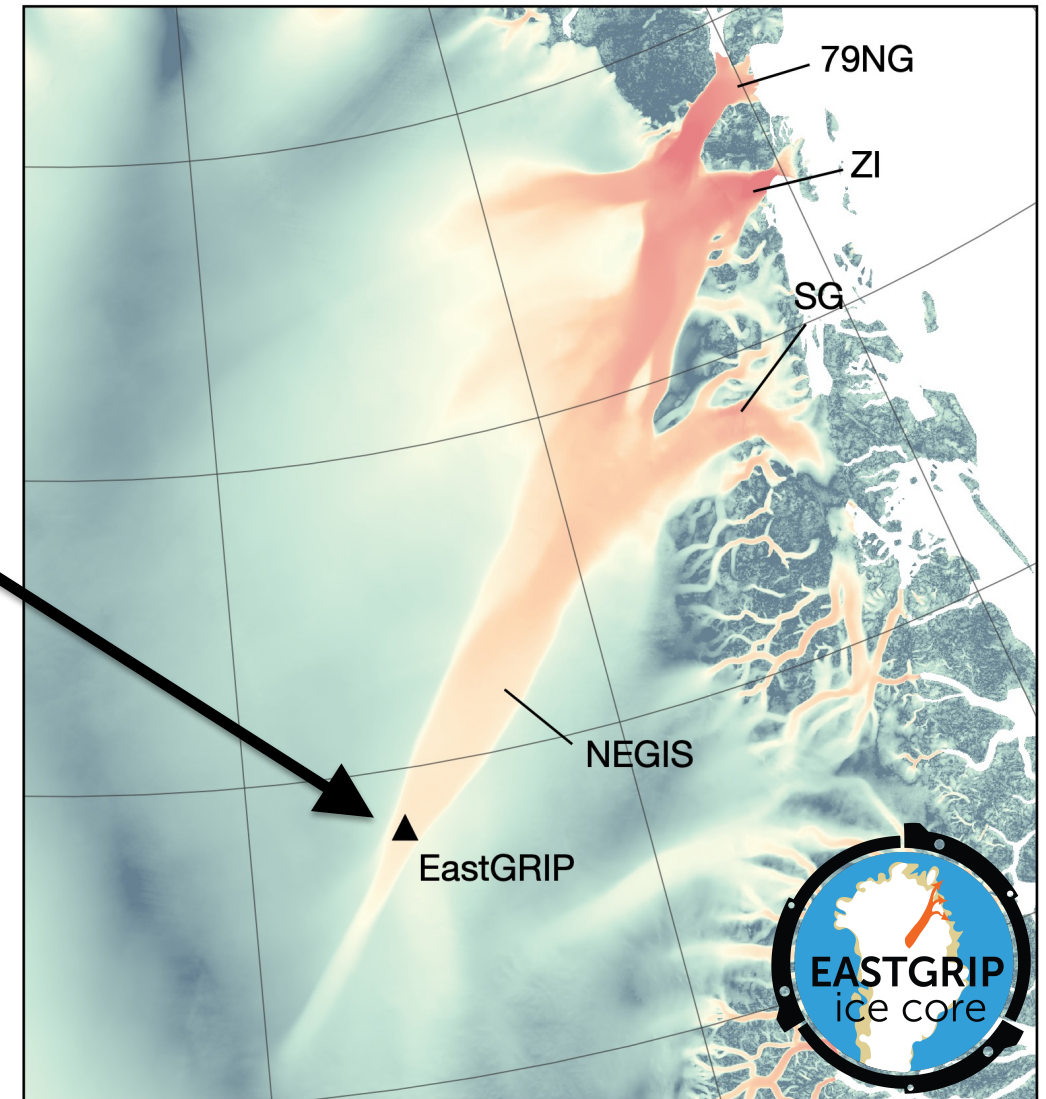


High basal melting below Greenland's largest ice stream?



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Zeising and Humbert, 2021, TCD, in review; Velocities: [Joughin et al. \(2018\)](#)

What drives the ice flow of the Northeast Greenland Ice Stream (NEGIS)?

Hypothesis

Locally increased basal melting at the onset area of the Northeast Greenland Ice Stream (NEGIS) enables and enhances basal sliding and forms a subglacial hydrological system. The coupling with basal sliding is facilitated via the water pressure, so that the sliding velocity rises with increasing water pressure.

(Further reading: e.g., [Fahnestock et al., 2001](#); [Christianson et al., 2014](#); [Beyer et al., 2018](#); [Smith-Johnsen et al., 2020](#); [Franke et al., 2021](#))

What is the magnitude of the basal melt rate at the base of NEGIS at the EastGRIP drill site?

Previous observations at NEGIS:

~0.1 m/a based on radiostratigraphy methods

([Fahnestock et al., 2001](#); [Keisling et al., 2014](#); [MacGregor et al., 2016](#))

<https://doi.org/10.5194/tc-2021-37>

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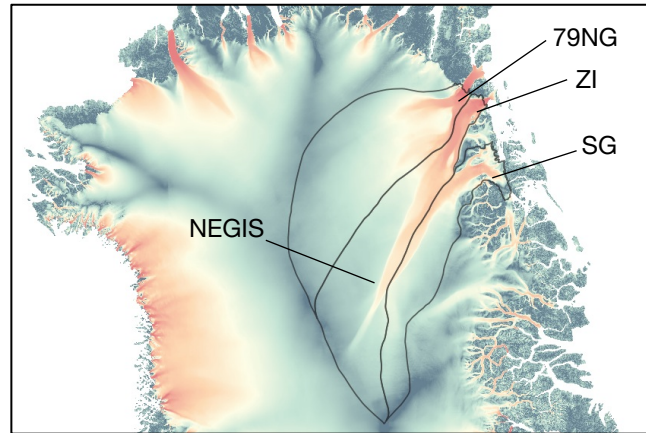
Indication of high basal melting at EastGRIP drill site on the Northeast Greenland Ice Stream

Ole Zeising^{1,2} and Angelika Humbert^{1,2}

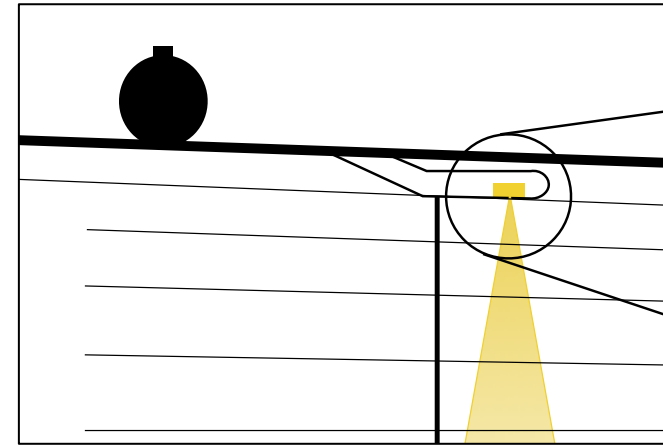
0.19 ± 0.04 m/a

basal melting indicated by **phase-sensitive radar** at EastGRIP drill site

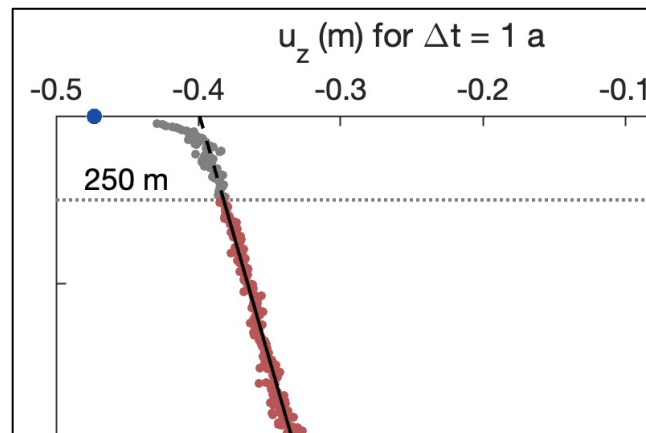
1. Glaciological Setting



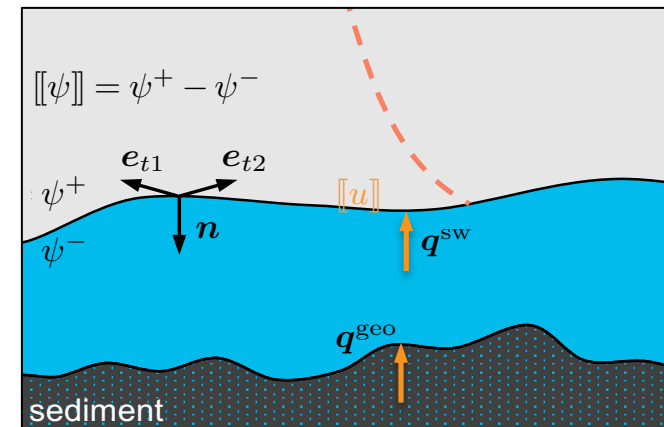
2. Measurement



3. Results



4. Discussion

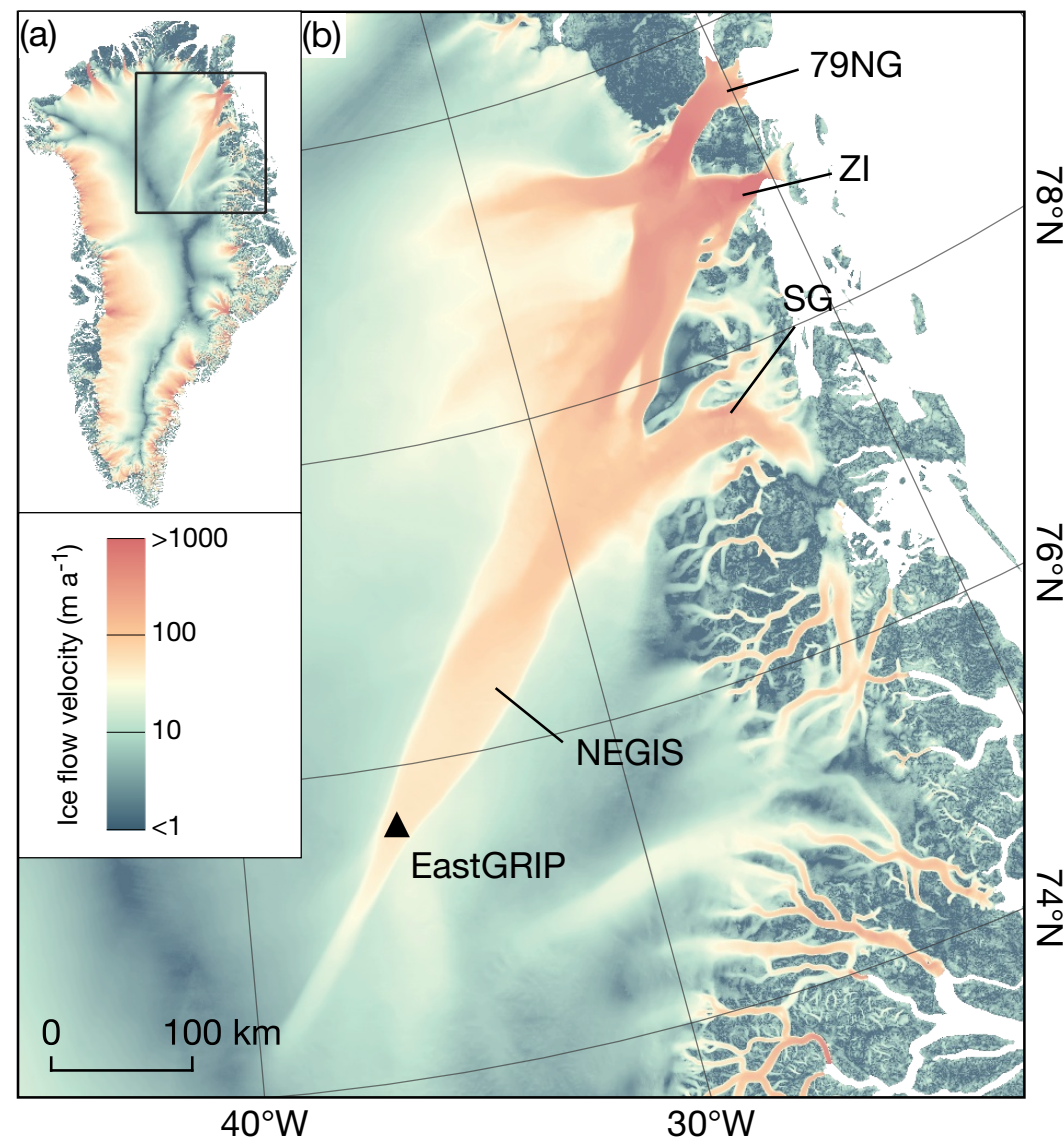


1. Glaciological Setting

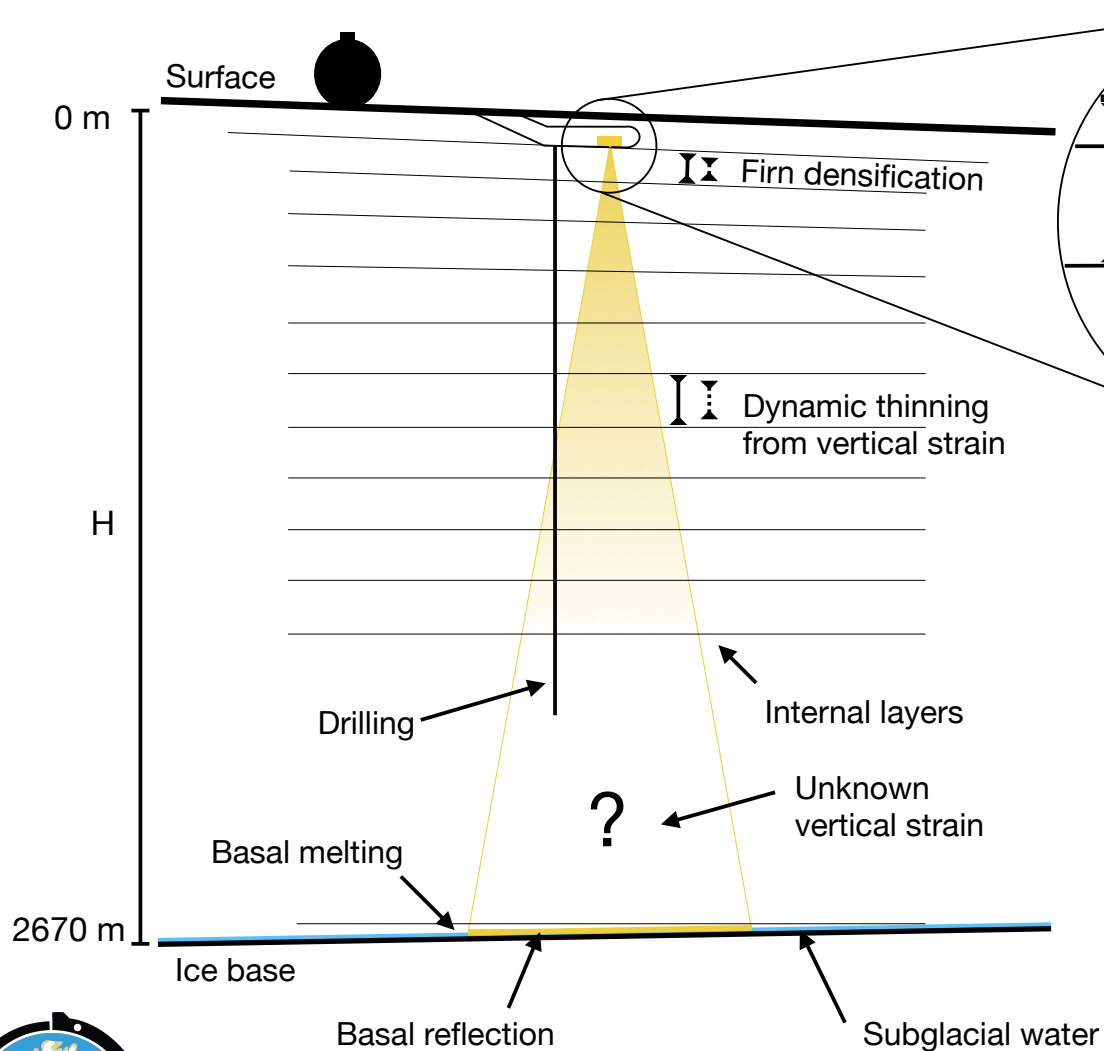
The 700 km long NEGIS is the only large ice stream in Greenland. It drains about 12 % of Greenland's ice through three major outlet glaciers Nioghalvfjerdsbrae (79NG), Zachariæ Isstrøm (ZI) and Storstrømmen Glacier (SG).

Loss of the floating tongue of ZI has already led to ice flow acceleration and increased mass loss. Consequently, it is expected and projected that NEGIS will contribute significantly to sea-level rise in the future, highlighting the importance to understand the general ice flow dynamics and its driving mechanisms.

([Fahnestock et al., 1993](#), [2001b](#); [Joughin et al., 2001](#); [Rignot and Mouginot, 2012](#); [Khan et al., 2014](#); [Mouginot et al., 2015](#))



2. Measurement



Autonomous phase-sensitive radar (ApRES) time series are used to achieve a reliable estimation of the annual mean basal melt rate.

The total change in ice thickness (ΔH) within the time period Δt is caused by firn densification (ΔH_f), dynamic thinning/thickening (ΔH_ϵ) and basal melting (a_b):

$$\frac{\Delta H}{\Delta t} = \frac{\Delta H_f}{\Delta t} + \frac{\Delta H_\epsilon}{\Delta t} - a_b.$$

The dynamic change in ice thickness is derived from the vertical strain (ϵ_{zz}):

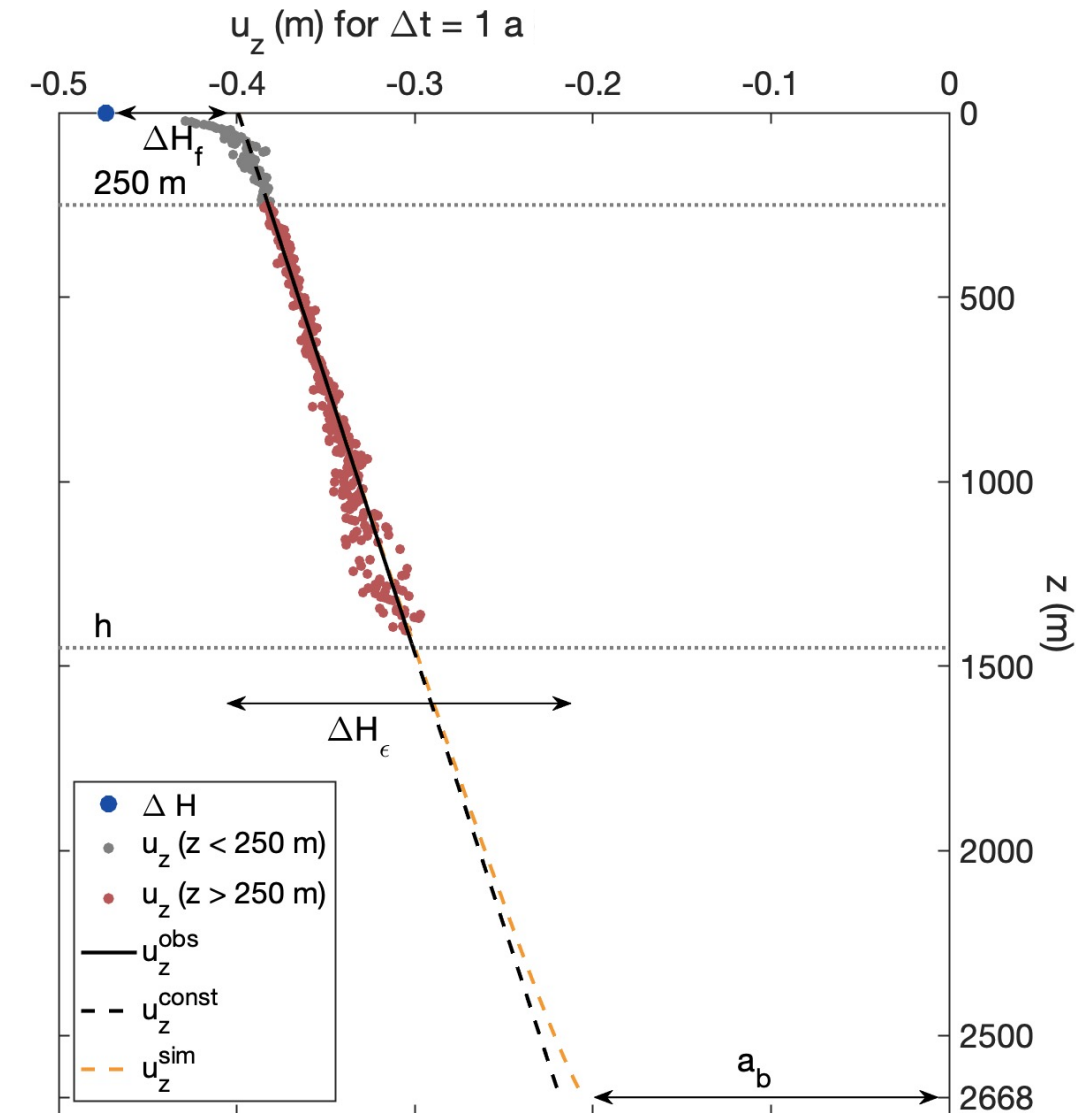
$$\frac{\Delta H_\epsilon}{\Delta t} = \frac{1}{\Delta t} \int_0^H \epsilon_{zz} dz$$

Challenge

Unknown vertical strain in lower part of ice column.

([Brennan et al., 2014](#); [Nicholls et al., 2015](#); [Stewart et al. 2019](#); [Vankova et al., 2020](#))

3. Results



Zeising and Humbert, 2021, TCD, in review (modified)

Derivation of basal melt rate is based on vertical displacements (u_z) relative to the ice base.

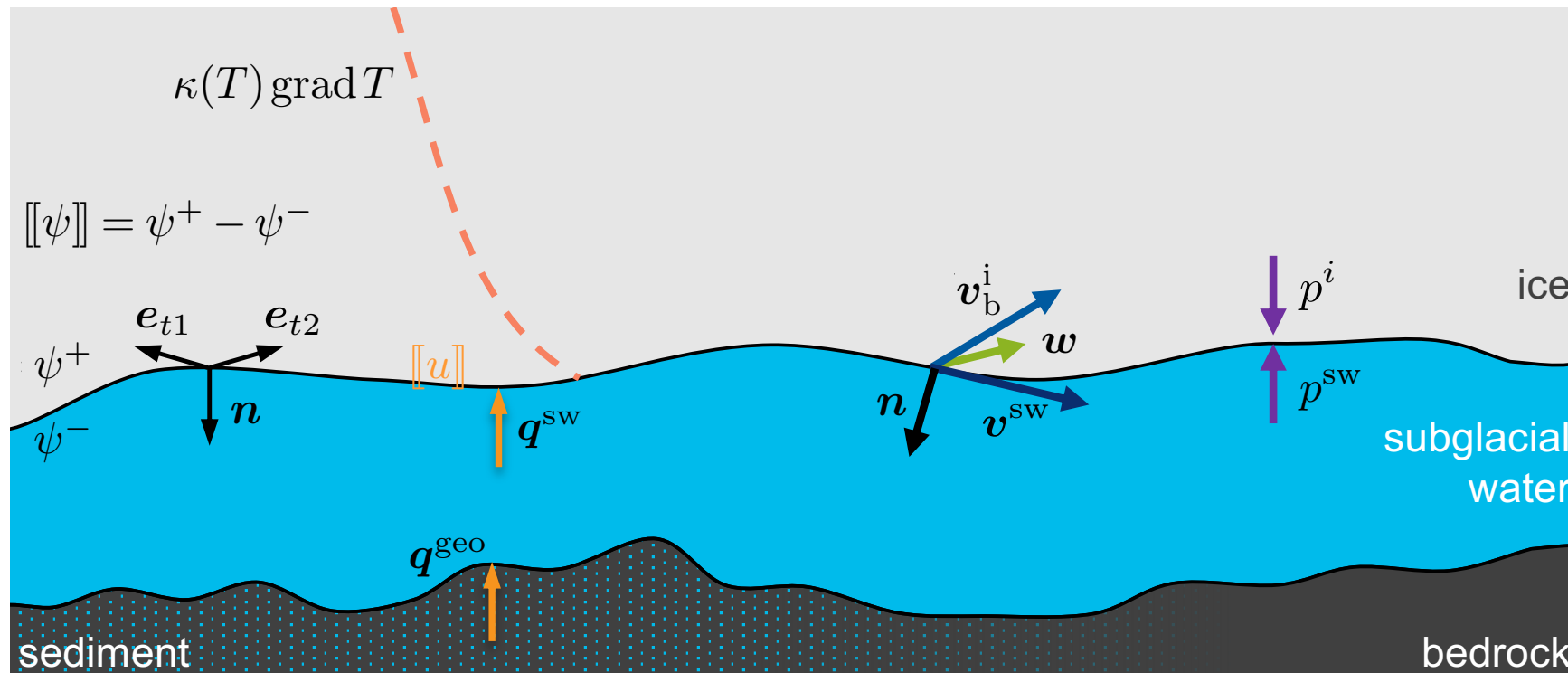
- Total change in ice thickness (distance between radar and ice base) is derived from lowering of the surface (blue dot):
 $\Delta H = -0.45 \pm 0.03$ m/a
- From internal displacements within the ice ($250 \text{ m} < z_i < 1450 \text{ m}$ to exclude effects from firn densification and noise) are used to calculate a linear fit (solid black line), the gradient of which is the vertical strain:
 $\epsilon_{zz} = (-0.068 \pm 0.001) \times 10^{-3}$
- The difference between the surface intercept of the linear fit and the derived surface displacement is the firn compaction:
 $\Delta H_f = -0.08 \pm 0.01$ m/a
- Dynamic ice thickness change is estimated from the integrated vertical strain
 1. linear extrapolated to the ice base: $\Delta H_e = -0.18 \pm 0.01$ m/a
 2. simulated vertical strain (Rückamp et al., 2020) : $\Delta H_e = -0.19 \pm 0.01$ m/a
- The resulting basal melt rate is: $a_b = 0.19 \pm 0.04$ m/a

4. Discussion

Where does the heat come from?

Heat at the ice base is supplied by geothermal heat flux and that of the subglacial water. Depending on flow speed of subglacial water and roughness of the ice base, friction has the potential to govern the heat budget.

For more details, check out our manuscript at [The Cryosphere Discussions](#)



Zeising and Humbert, 2021, TCD, in review

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