In-situ basal melt rate distribution of the floating tongue of 79°N Glacier, Greenland

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LOCATION

The 79°N Glacier (79NG) is located in north-east Greenland. It is one of the three main outlet glaciers of the North-East Greenland Ice Stream (NEGIS).

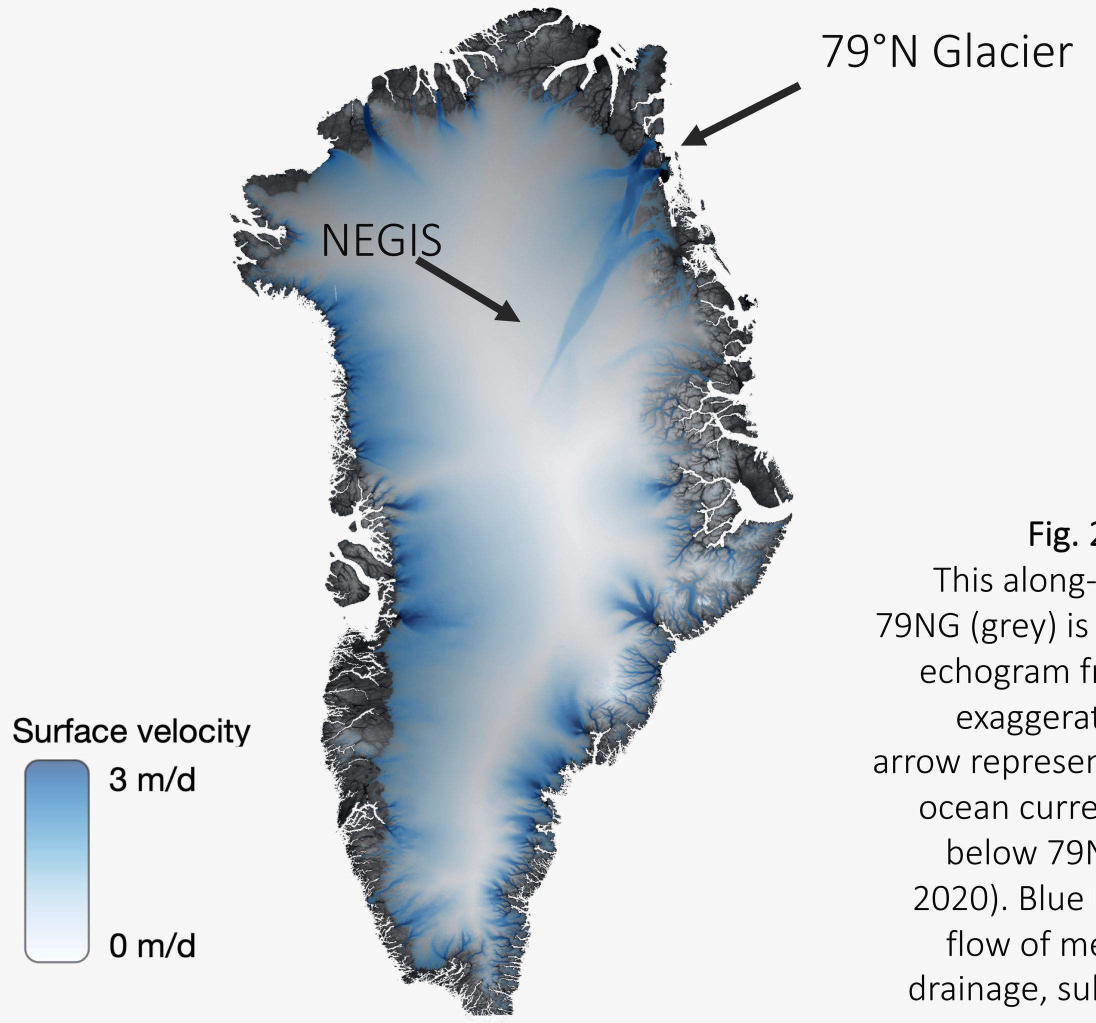

Fig. 1: Map of Greenland Ice Sheet. Colours represent the surface velocity (Joughin et al., 2017).

MOTIVATION

The 79NG is one of the last remaining glaciers in Greenland with a floating ice tongue. The extent of the 20 km wide and 70 km long ice tongue has remained stable over the past few decades. Remote-sensing studies indicate high basal melt rates (50 - 60 m a^{-1}) near the grounding line (Wilson et al., 2017). However, these methods are limited in the hinge zone where the floating ice is not in hydrostatic equilibrium. Therefore, the amount of basal melting near the grounding line is still unknown.

MEASUREMENTS

We have performed a dense grid of repeated measurements with a phase-sensitive radio echo sounder (pRES) in 2017 and 2018 to estimate basal melt rates focusing on the hinge zone of 79NG. These Lagrangian measurements were accompanied with autonomous pRES (ApRES) stations to derive time series of basal melt rates. Furthermore, a flight campaign with AWI's ultra-wideband (UWB) airborne radar installed on the AWI Polar6 aircraft was executed to map the 79NG geometry. Details of the pRES system was published by Nicholls et al. (2015) and of the UWB by Hale et al. (2016). For (A)pRES data processing, we followed methods described by Brennan et al. (2014) and Stewart et al. (2019).

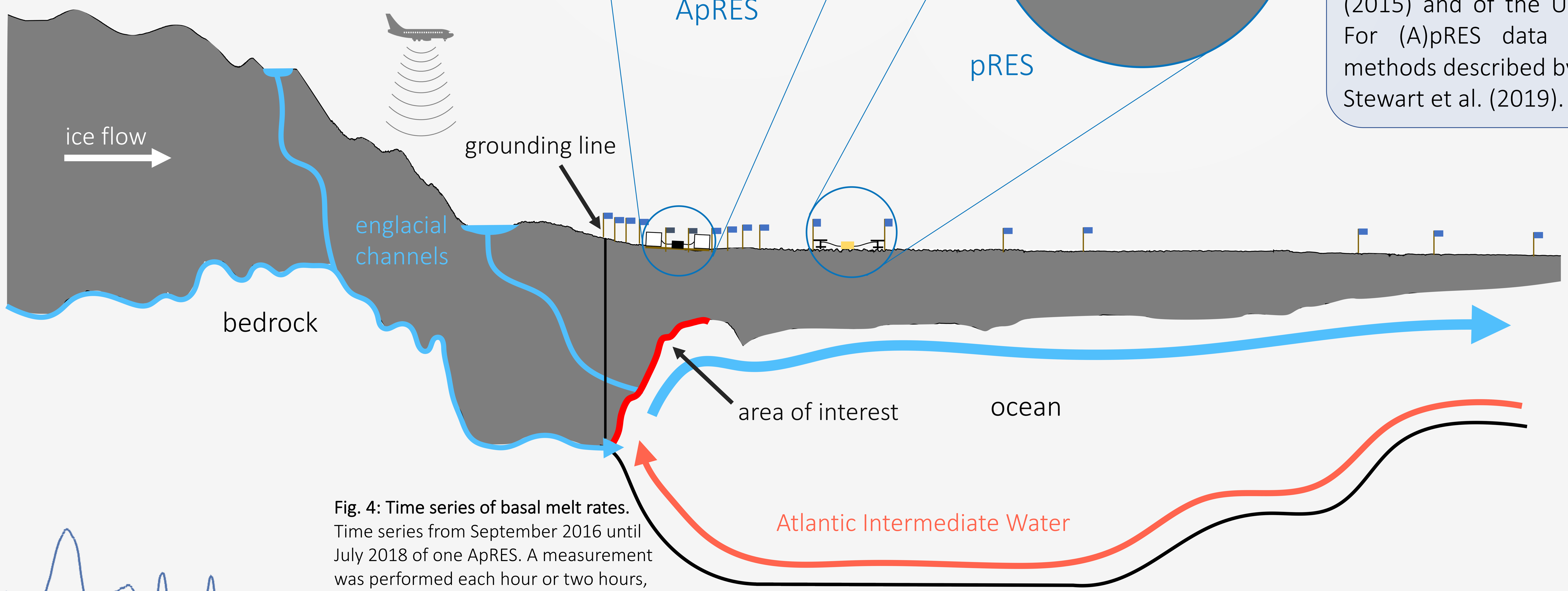

Fig. 2: Profile of 79NG. This along-flow profile of the 79NG (grey) is based on an UWB echogram from 2018 (vertical exaggeration: x20). The red arrow represents inflow of warm ocean currents into the cavity below 79NG (Schaffer et al., 2020). Blue lines/arrows show flow of melt water (e.g. lake drainage, subglacial discharge, melt plume)

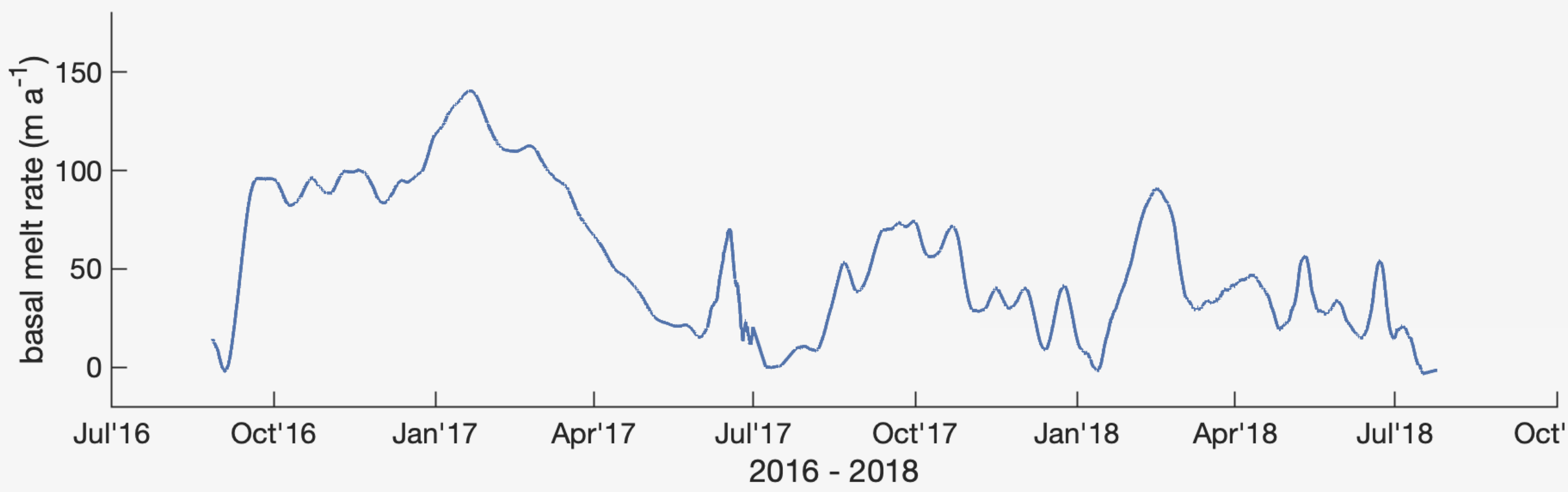

Fig. 4: Time series of basal melt rates. Time series from September 2016 until July 2018 of one ApRES. A measurement was performed each hour or two hours, respectively. Results show strong variability of melt rates between ~0 m a^{-1} to > 150 m a^{-1}.

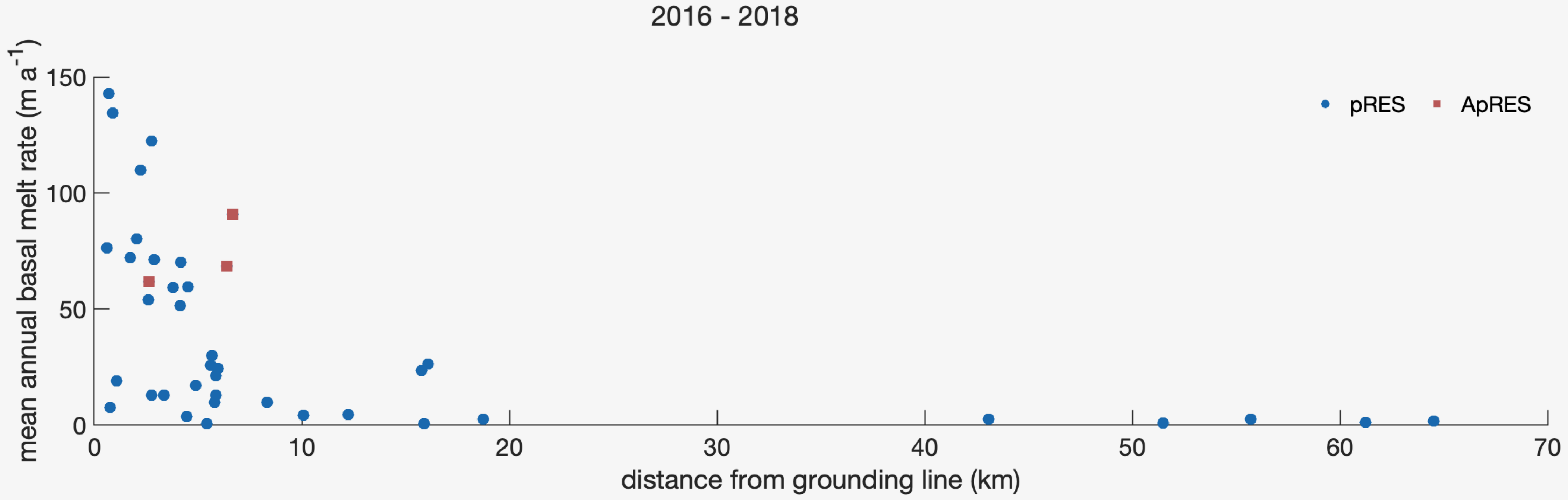

Fig. 3: Spatial distribution of basal melt rates. Spatial distribution of all pRES and ApRES measurements from July 2017 to July 2018 as function of distance to grounding line. Vertical strain rates could not be derived from pRES measurements to subtract from change in ice thickness. An assessment based on ApRES measurements revealed small values.

KEY FINDINGS

1. Within the first kilometre downstream the grounding line, UWB echograms reveal an averaged thinning of >100 m km^{-1} where surface velocities reach 1.1 km a^{-1}. Thinning rates decrease significantly after 3 to 5 km and remain low to the calving front (Fig. 2).
2. We found mean annual basal melt rates >110 m a^{-1} at four locations next to the grounding line with a maximum of 143 m a^{-1}, measured within 2 km from the grounding line (Fig. 3).
3. Melt rates strongly decrease with increasing distance from the grounding line, reaching mean annual melt rates <30 m a^{-1} (except two) at 5-8 km downstream the grounding line. The observations show low basal melt rates of 1.0 - 2.5 m a^{-1} within 25 km to the calving front (Fig. 3).
4. The time series of basal melt rates show a strong variability of basal melt rates but indicate no seasonal or tidal variation (Fig. 4).

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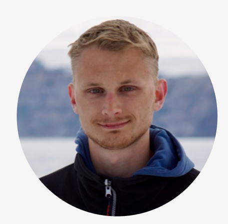

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