Seasonal enhanced melting under Ekström Ice Shelf, Antarctica

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Introduction

Ice–ocean interaction is crucial for the integrity of ice shelves and thus ice sheet stability. Warm ocean currents lead to enhanced basal melting of ice shelves, which is the dominant component of mass loss for the Antarctic Ice Sheet. Knowing the current melt rates and predicting those under future climate scenarios is thus of great importance.

Measurements

We deployed a continuously measuring ApRES (Autonomous phase-sensitive Radio-Echo Sounder) in the centre of Ekström Ice Shelf, recording an hourly time series since April 2020. In addition, we performed annual point measurements with the ApRES to determine the spatial pattern of basal melt rates between 2018/19 and 2021/22 (coloured dots in Fig. 1).

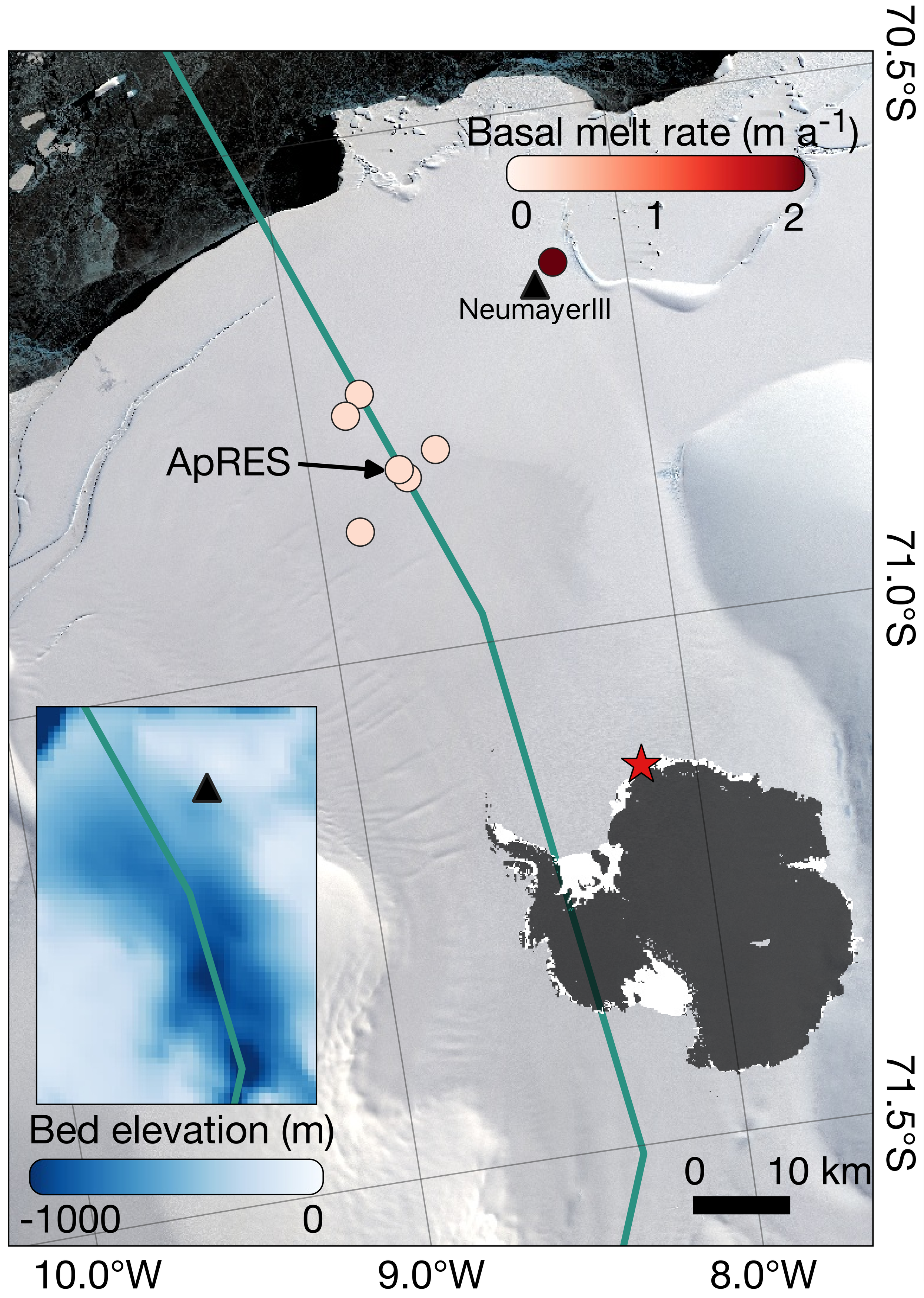

Fig. 1: Landsat Image (2018) of Ekström Ice Shelf with basal melt rates from annual point measurements. The green line shows the profile in Fig. 3. The inlet shows the bed elevation from Eisermann et al. (2020).

Seasonal enhanced melting

The continuous time series reveals a seasonal onset of enhanced melt rates, abruptly increasing from <0.5 to 2 m a^{-1} in July/August. High melt rates with around weekly to bi-weekly fluctuations last until November/December.

The majority of the point sites show yearly averaged melt rates of <0.5 m a^{-1} and at one site near Neumayer III station 2 m a^{-1}. This is in good agreement with satellite remote sensing estimates.

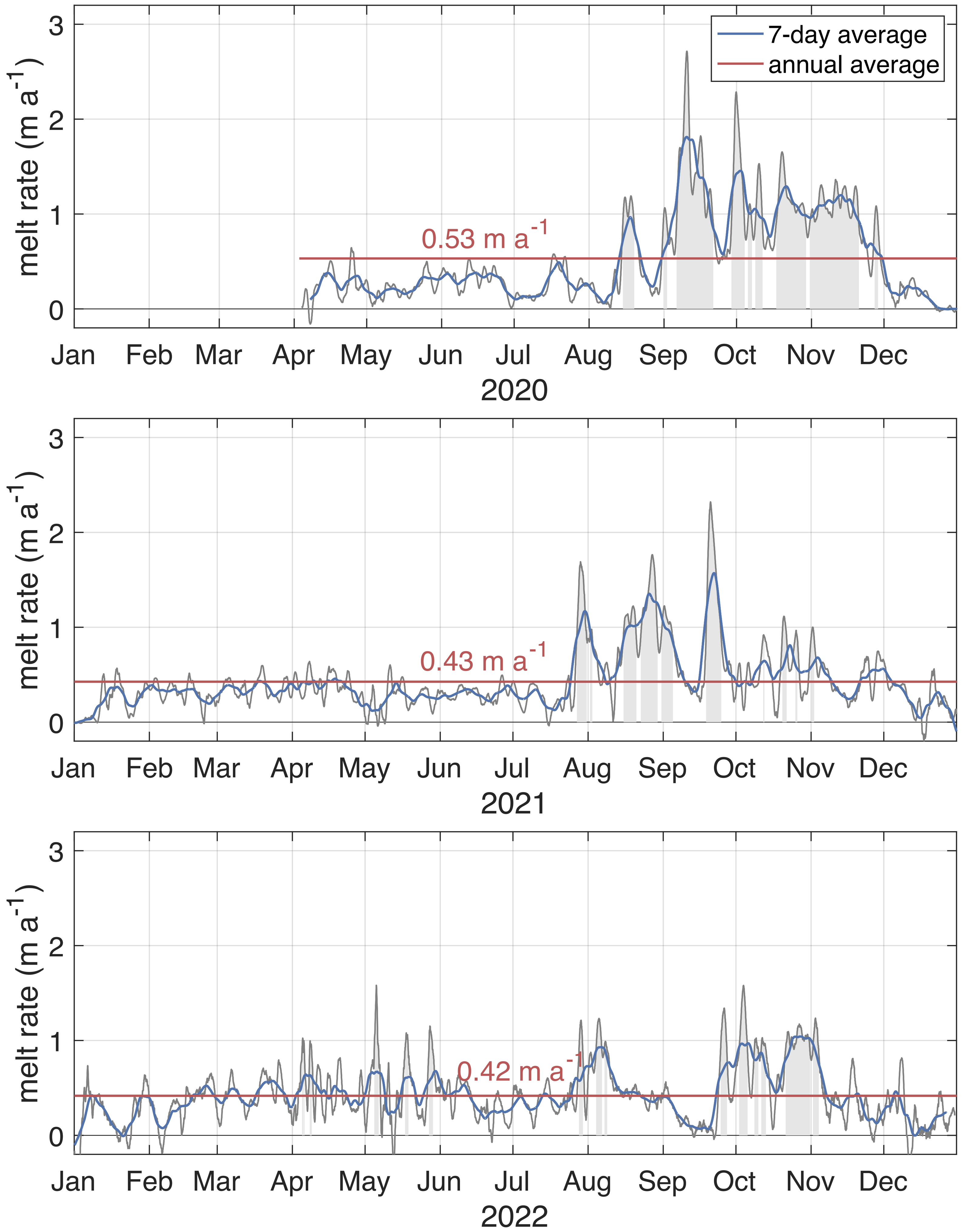

Fig. 2: Melt rate time series between 2020 and 2022 measured at ApRES location shown in Fig. 1 and 3. The red line shows the mean annual melt rate and the grey area shows melt rates above two times the multi-year mean.

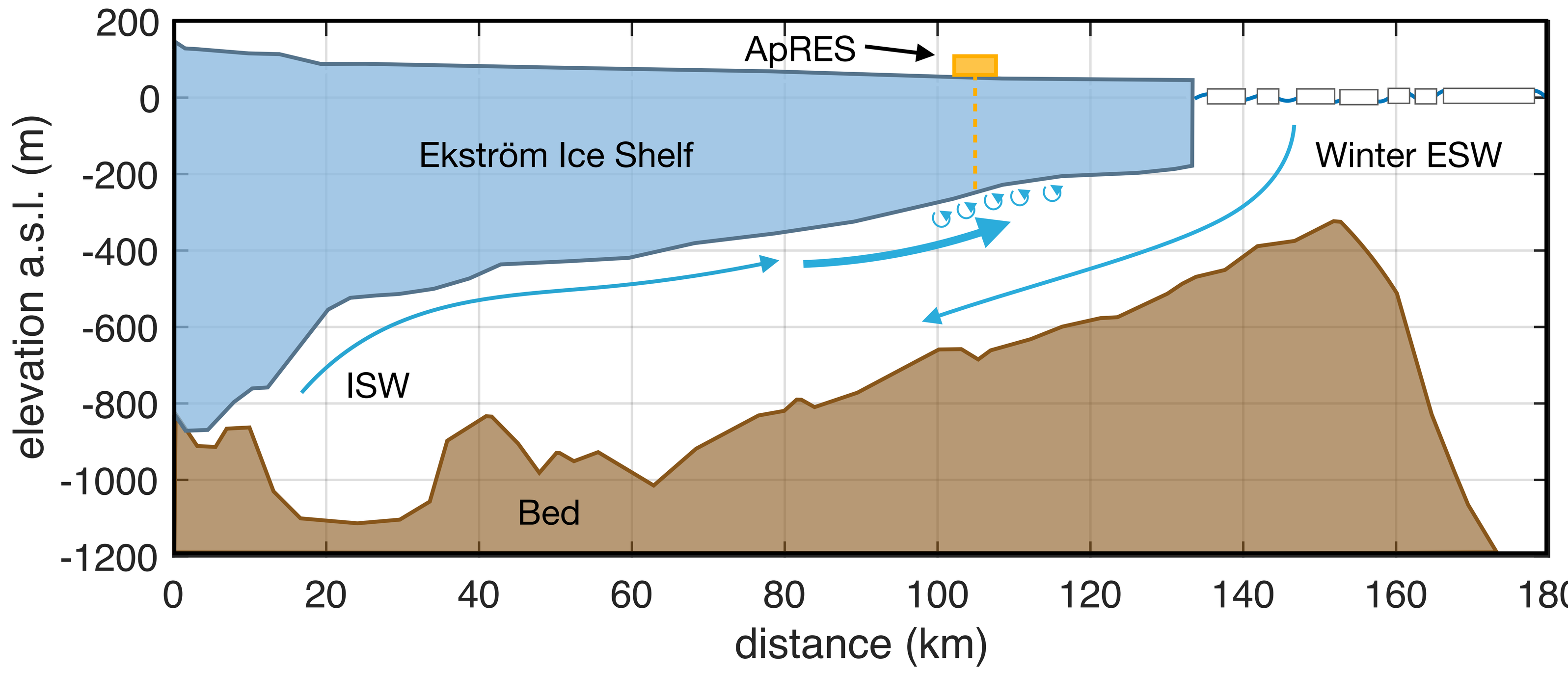

Fig. 3: Ice shelf geometry and bathymetry from BedMachine (Morlighem, 2020) and active seismic measurements (Smith et al., 2020). Arrows showing water currents in Winter.

What is driving enhanced melting in winter?

A. Jenkins' (1991) model suggests that energetic Ice Shelf Water (ISW) plumes can enhance melting during winter at this site. This process is driven by the denser Eastern Shelf Water (ESW) due to sea ice formation. Access of lighter and more stratified Antarctic Surface Water (AASW) weakens the plume and suppresses melting during summer.

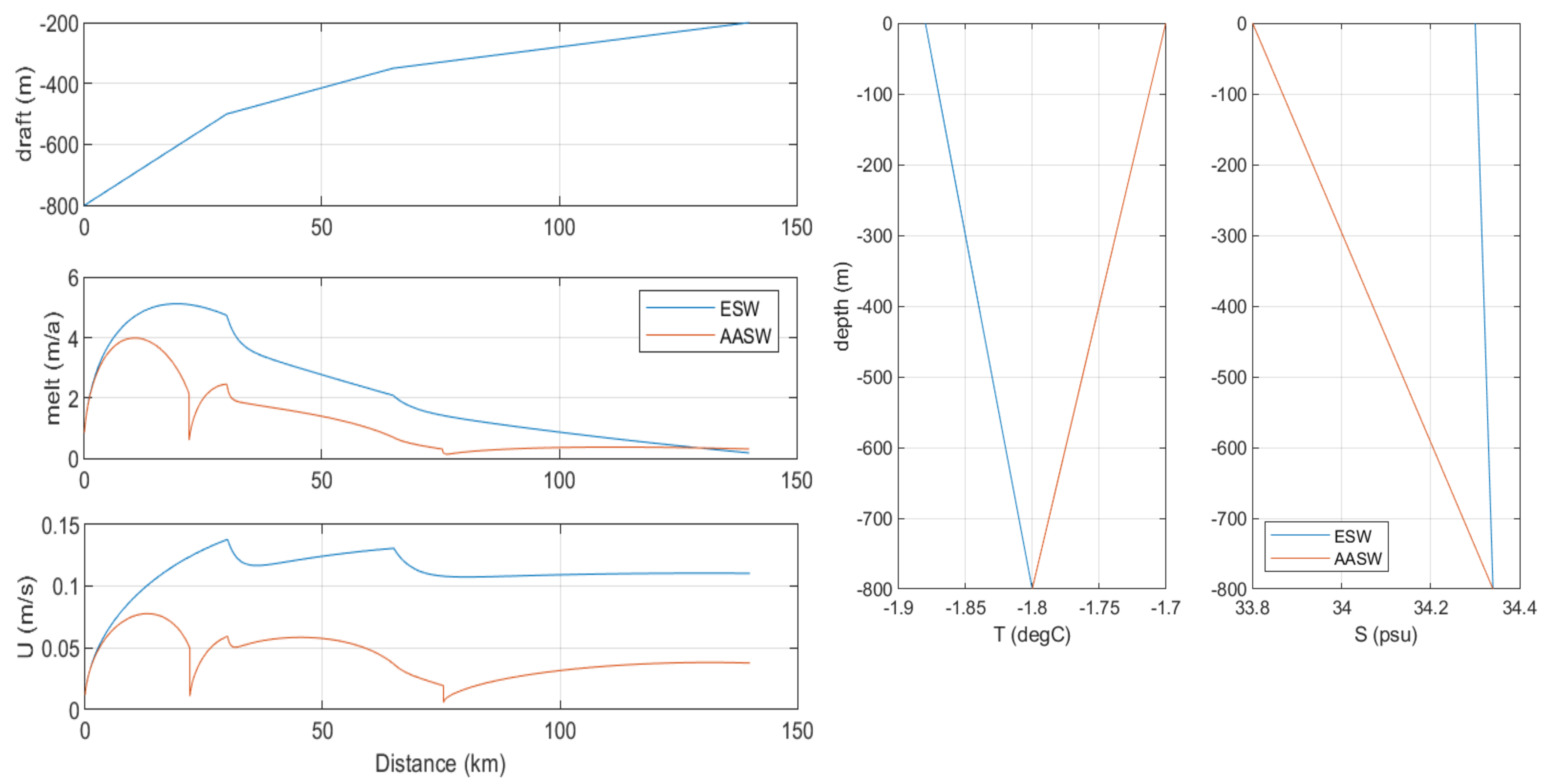

Fig. 4: Results from 1-dimensional flow model showing melt rate and plume velocity

Conclusion

- Unusual observation of enhanced basal melting in Winter
- Complex internal interplays highlight the need of distributed melt rate observations to evaluate of future ocean-simulations and satellite remote sensing estimates

References:
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