EBERHARD KARLS
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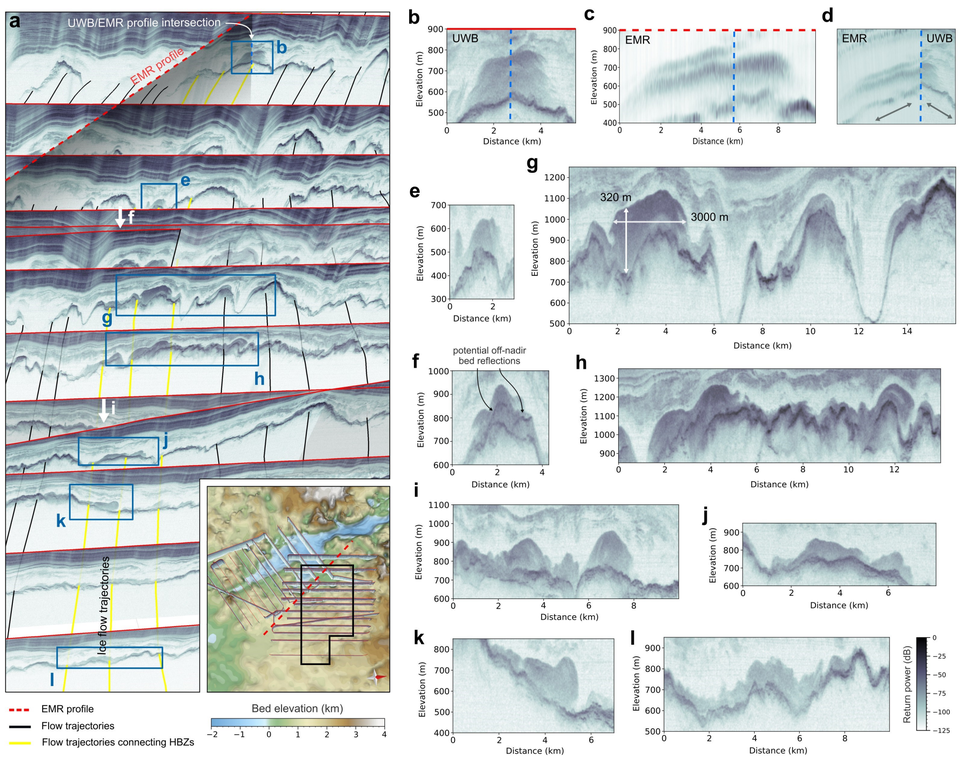

Figure 2: Observations
The basal ice in an area of ~10,000 km^2 in our survey region is composed of along-flow oriented high-scattering basal ice units connected to the basal substrate, extending up to several hundred meters thick.

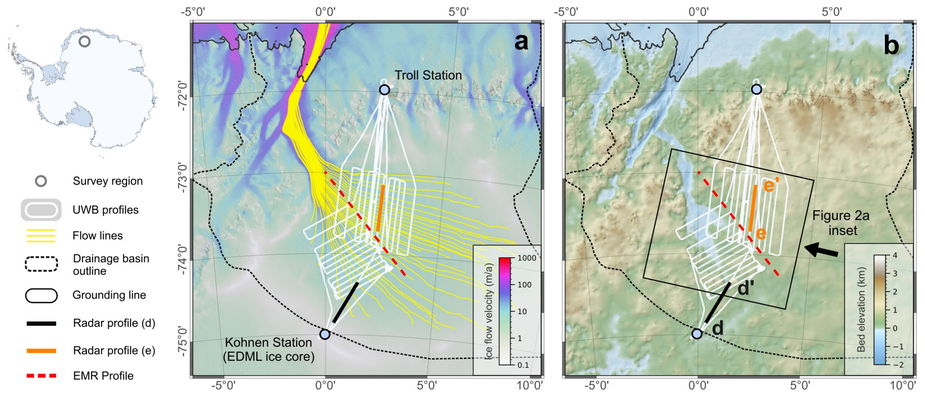

Figure 1: Study region
We employ ultra-wideband radar to map the basal ice near the glacier bed within East Antarctica's Jutulstraumen drainage basin at the onset of Jutulstraumen Glacier.

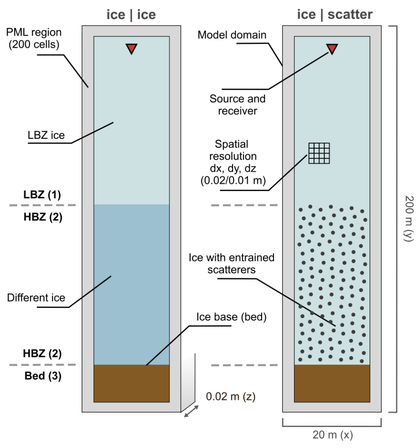

Figure 3: EM forward modeling
Radar forward modeling with gprMax suggest that these high-backscatter units are most likely composed of point reflectors with low dielectric properties (comparable dielectric properties to ice), probably entrained sediment.

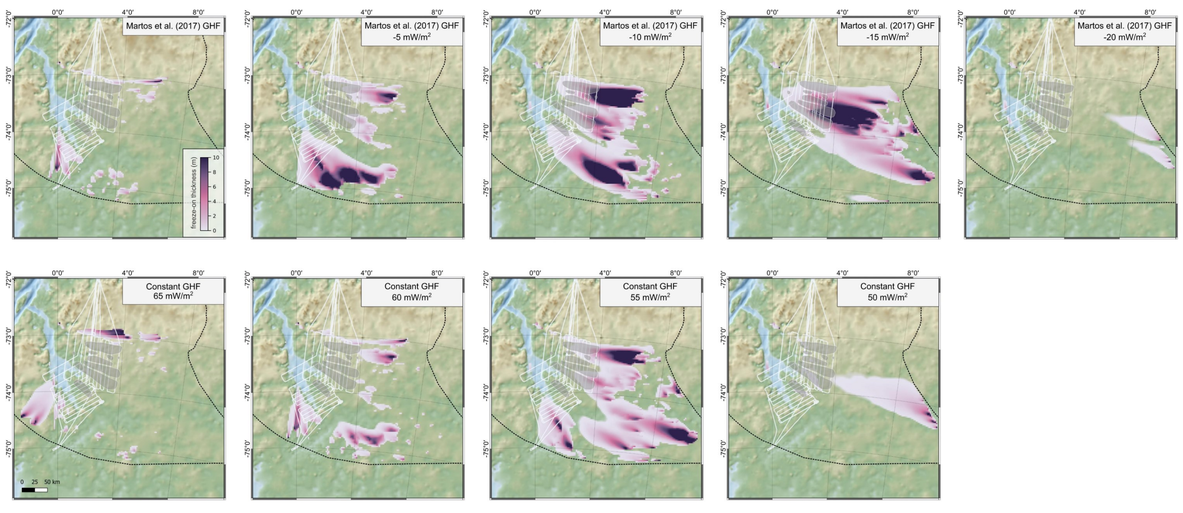

Figure 4: Thermo-mechanical modeling (basal freeze-on)
Three-dimensional thermomechanical modelling indicates that these units form via basal freeze-on of subglacial water that originated from further upstream. The freeze-on locations and thickness strongly depends on the chosen geothermal heat flux. For our study region, Martos et al., 2017 – 15 mW/m^2 provides the best fit to our observations.

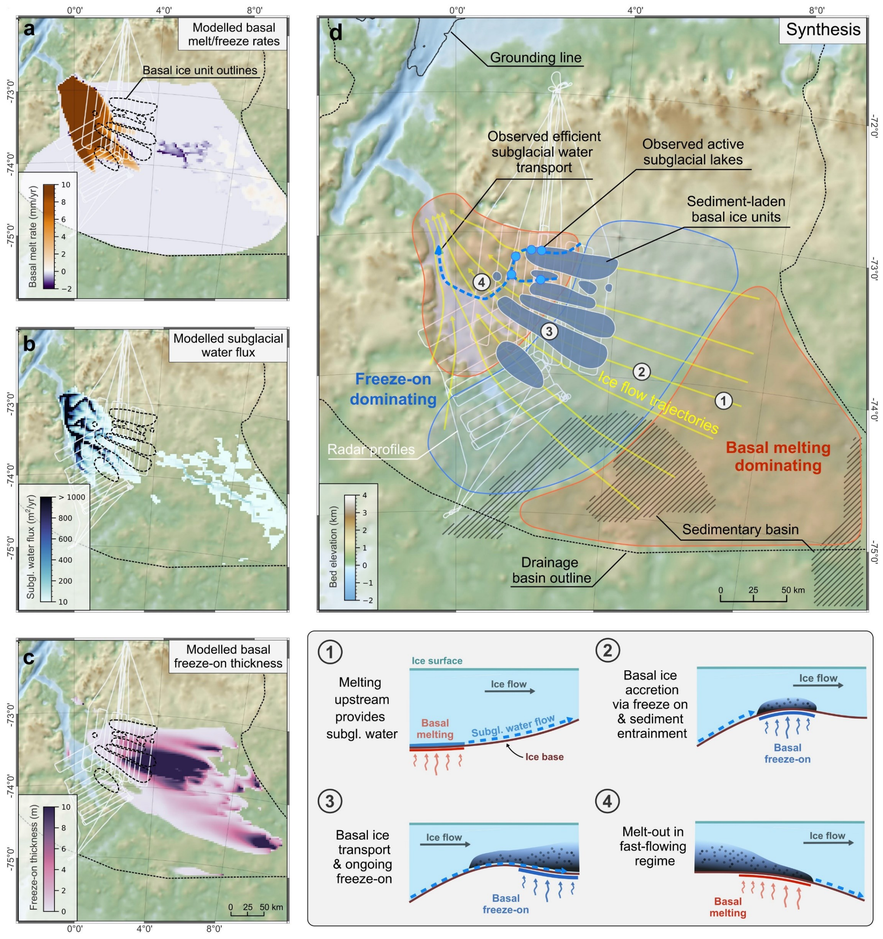

Figure 5: Synthesis
We conclude that at locations where HBZs are detected, the basal ice is composed of elongated three-dimensional ice complexes with entrained sediment, which have formed due to basal freeze-on of sub-glacial water and further amplified in thickness down-stream by other processes, such as via flow convergence or rheological mixing with meteoric ice . Notably, the basal ice units melt out in the fast-flowing regime further down-stream.

Faculty of Science, Department of Geosciences, Structural Geology Group

Sediment-laden basal ice units near the onset of a fast-flowing glacier in East Antarctica

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Key reference

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Background and motivation

Understanding the material properties and physical conditions of basal ice is crucial for a comprehensive understanding of Antarctic ice-sheet dynamics. Advancements in radar technology enable the detection of subunits within the basal ice layer exhibiting distinct units of high-backscatter (Bell et al., 2011) which imply significantly different dielectric properties.

In this study, we focus on a spatial analysis of high-backscatter zones (HBZs) detected in the basal ice environment at the onset of Jutulstraumen glacier in East Antarctica using radar data (Figure 1) to investigate their formation and link to the basal thermal conditions with a thermo-mechanical model (Wolovick et al, 2021).

Key findings

1. We have identified high-scattering basal ice in Jutulstraumen Glacier's onset region using radar, reaching several hundred meters from the bed.
2. Backscatter analysis and radar forward modeling suggests that the basal ice units contain unstratified point scatters and cause little radio-glaciological loss.
3. 3D thermo-mechanical modeling implies that freeze-on of basal meltwater generated upstream likely initially formed the basal ice units.
4. Freeze-on units are possible markers to constrain basal temperature and, thus, helpful to validate GHF maps.

Discussion and open questions

1. Modeled freeze-on thicknesses are up to 10 times smaller compared to detected basal ice thickness, hence additional mechanisms are required to amplify these ice units.
2. Type and amount of sediment is difficult to determine because the dielectric properties of the entrained material are not known.
3. Large parts of modelled basal freeze-on is indicated upstream of our survey region where no high-resolution radar data exists.

References

Bell, R. E., et al. (2011). Widespread persistent thickening of the East Antarctic Ice Sheet by freezing from the base. Science, 331(6024), 1592–1595. https://doi.org/10.1126/science.1200109

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Wolovick, et al. (2021). Joint inversion for surface accumulation rate and geothermal heat flow from ice-penetrating radar observations at Dome A, East Antarctica. Part I: Model description, data constraints, and inversion results. Journal of Geophysical Research: Earth Surface, 126(5), e2020JF005937. https://doi.org/10.1029/2020JF005937

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