2020_AWI_00808

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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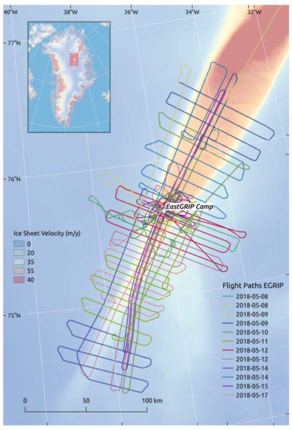
An ice stream margin as seen with high resolution radar

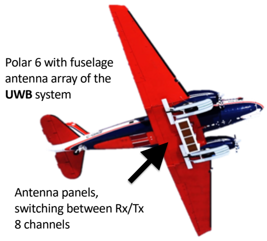


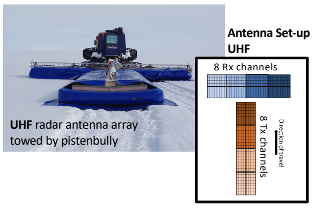
The North-East-Greenland Ice Stream (NEGIS)

The NEGIS has clear surface expression in velocity field as seen from satellites which gives a snapshot for present time and indicates the effective drainage of solid ice.

But beneath the surface the ice stream also leaves an imprint, made visible by distortion and deformation of the internal stratigraphy. These structures at depth of ice stream margins have not been investigated in detail so far, and the East-Grip Ice Core drilling project provides the possibility to do just that by extensive radar surveys

- **From the air:** using the 8-channel ultra-wide band radar on POLAR 6
- **On the ground:** with the new 8 channel UHF-Mills Cross radar and the 4 channel VHF Radar, both developed at University of Alabama



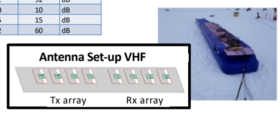


The Radar Instruments

The parameters of the different instruments are summarized in the table below

- The **VHF** radar operates at 170-230 MHz, trace distance after processing usually 2 m
- **UHF** 600-900 MHz ("Mills Cross"), trace distance is 2.5m
- The Ultra wide band (UWB) airborne radar, has been operated in narrow band mode, and thus comparable to the VHF radar frequency range 180-210 MHz, trace distance after final processing is 15m

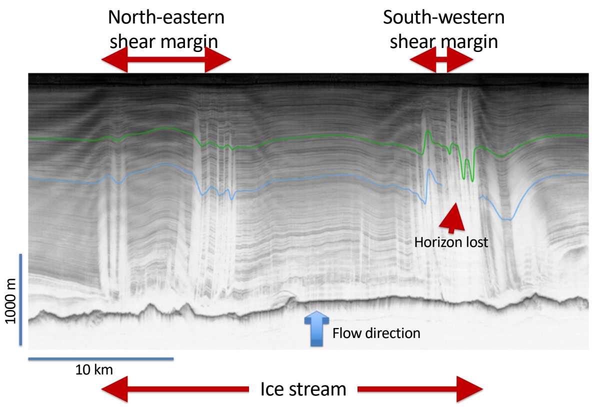
	VHF	UHF	UWB	Units
	ground	ground	airborne	
Polarization	Linear	Linear	Linear	
Frequency	200	750	195	MHz
Bandwith	60	300	30	MHz
Sweep lenght	10	10	1/3/10	µs
PRF	5	10	10	KHz
TX power	4,8	4,8	6	KW
Antenna Gain	25	60	30	dBi
Ice loss (3km -2way)	60	90	60	dB
Pulse compression gain	25	30	max 25	dB
Stacking gain	24	15	20	dB
Spreading loss (r2)	92	92	92	dB
System losses	8	10	10	dB
Processing gain	15	15	15	dB
SNR at bed	74	62	60	dB



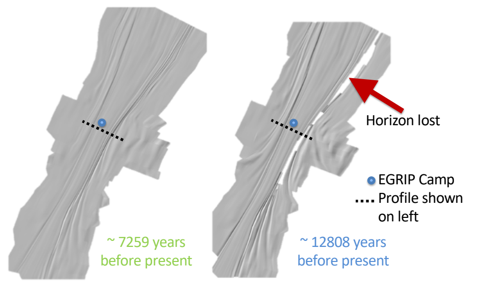
Section through the ice stream

The airborne campaign from spring 2018 covers a large region around the EGRIP drilling camp and thus provides the data to understand the impact of ice stream flow on stratigraphy on a larger scale. The profile shown to the right is located 5 km upstream of the Camp.

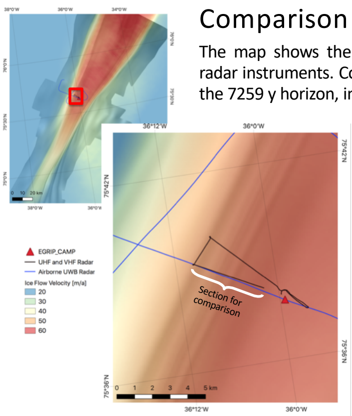
The shear margins show a distinctive pattern, which is due to the compressive stress regime the ice experiences when entering the ice stream, leading to chevron or zig-zag folding in the active margin. The folding is preserved when the ice is entering different regimes or if the stress regime is changing over time. Picking internal reflectors throughout the entire survey area and connecting them to horizons show the 3D-imprint of the ice stream at depth.



3-D Horizons from picked reflections



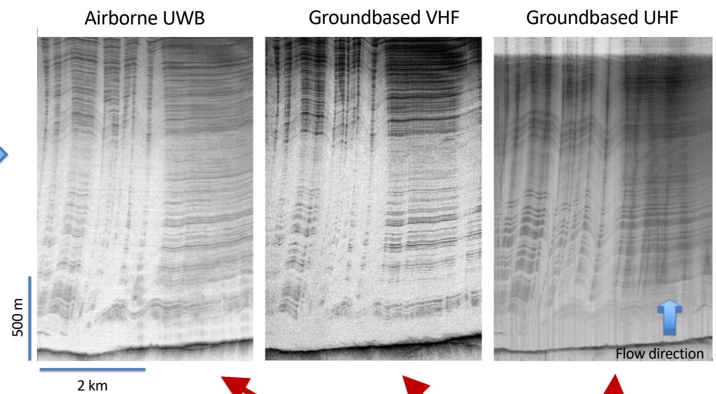
Comparison of different data sets

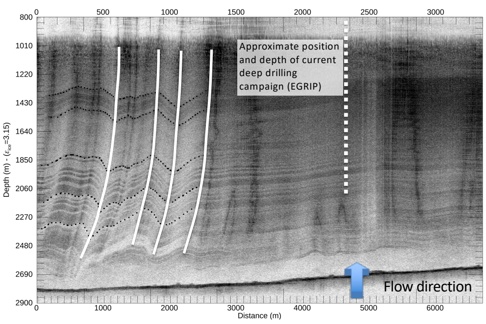


The map shows the location of the profiles measured with different radar instruments. Colour represents ice flow, and the Greyscale layer is the 7259 y horizon, indicating the position of the folds

The airborne data already gives a good representation of the folded reflectors. However, due to the slower survey speed and resulting smaller trace distance (or higher stacking rate), the ground based data from the VHF and UHF instruments resolve even the steeply dipping flanks of the folds

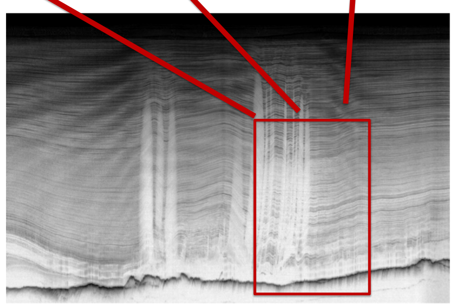
This becomes even more apparent when further reducing survey speed, as shown in the example below, with an approximate trace distance of 1 m after processing.





Summary

- Airborne radar data are essential to understanding large scale structures in ice sheet stratigraphy, and the quality of the data allows for analysing highly deformed structures, as found in the shear margins of ice streams
- In some areas the folds could not be retraced, as the steep reflectors, which are also subject t a secondary deformation process likely due to shearing (bended fold axes, see left) are lost.
- For a detailed analysis of highly deformed ice as in shear margins or in the lowermost part of the ice sheetsit is necessary to perform ground based surveys to close the gaps.



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References: Joughin et al, Franke (submitted VALLELONGA)

Acknowledgements: We would like to thank the crew of Polar 6, system engineer Lukas Kandorra, Sepp Kipfstuhl for providing the photo of Polar 6, and the EGRIP logistics team for support during the campaigns. EGRIP is directed and organized by the Center of Ice and Climate at the Niels Bohr Institute (https://eastgrip.org/). The ground-based radar Campaign was partly funded by the BeyondEPICA: Oldest Ice project (https://www.beyondepica.eu).

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