Geophysical imaging of permafrost in the SW Sbalbard – the result of two high arctic expeditions to Spitsbergen

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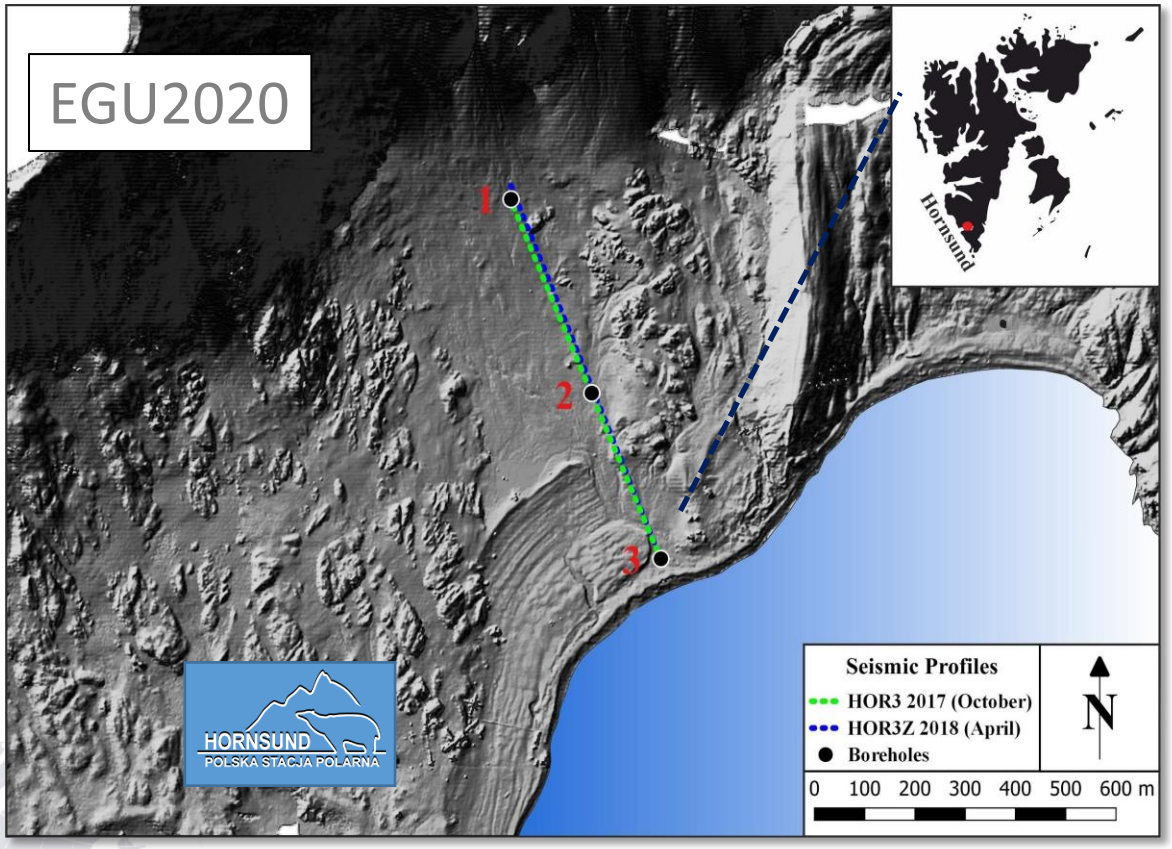
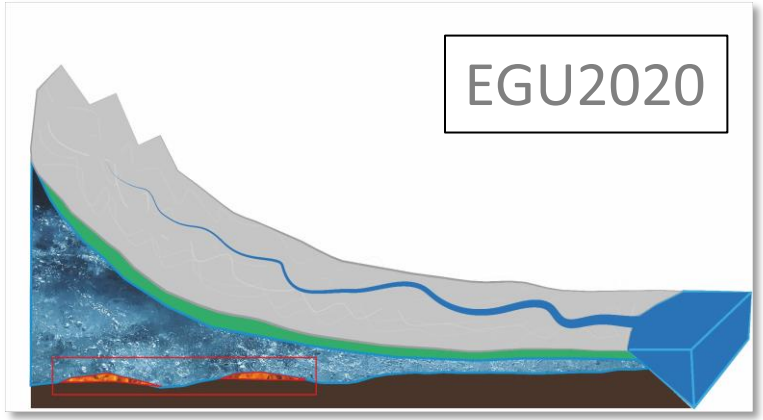
Study area – Hornsund, Spitsbergen





Questions:

Can seismic image the shape of permafrost?

What is the optimal acquisition for that?

Which seismic methods are suitable for this task?

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Fieldwork – Two Arctic Campaigns

2017 October

- 3 Seismic lines
- Parameters testing

2018 April

- 2 Seismic lines
- 6 Boreholes up to 20 meters with thermal monitoring
- GPR data on each profile with time-lapse measurements

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Seismic data acquisition & processing

Acquisition:

PEG-40 accelerated weight drop – in-house modification

GPS based timing system (by IG PAS)

60 Stand alone DATA-CUBE stations

with 4.5Hz geophones (1C & 3C)

Shot spacing – 2 m in 2017 and 2.5 m in 2018

+ 20 m extra offsets on both sides

Receiver spacing – 2 m in 2017 and 5 m in 2018

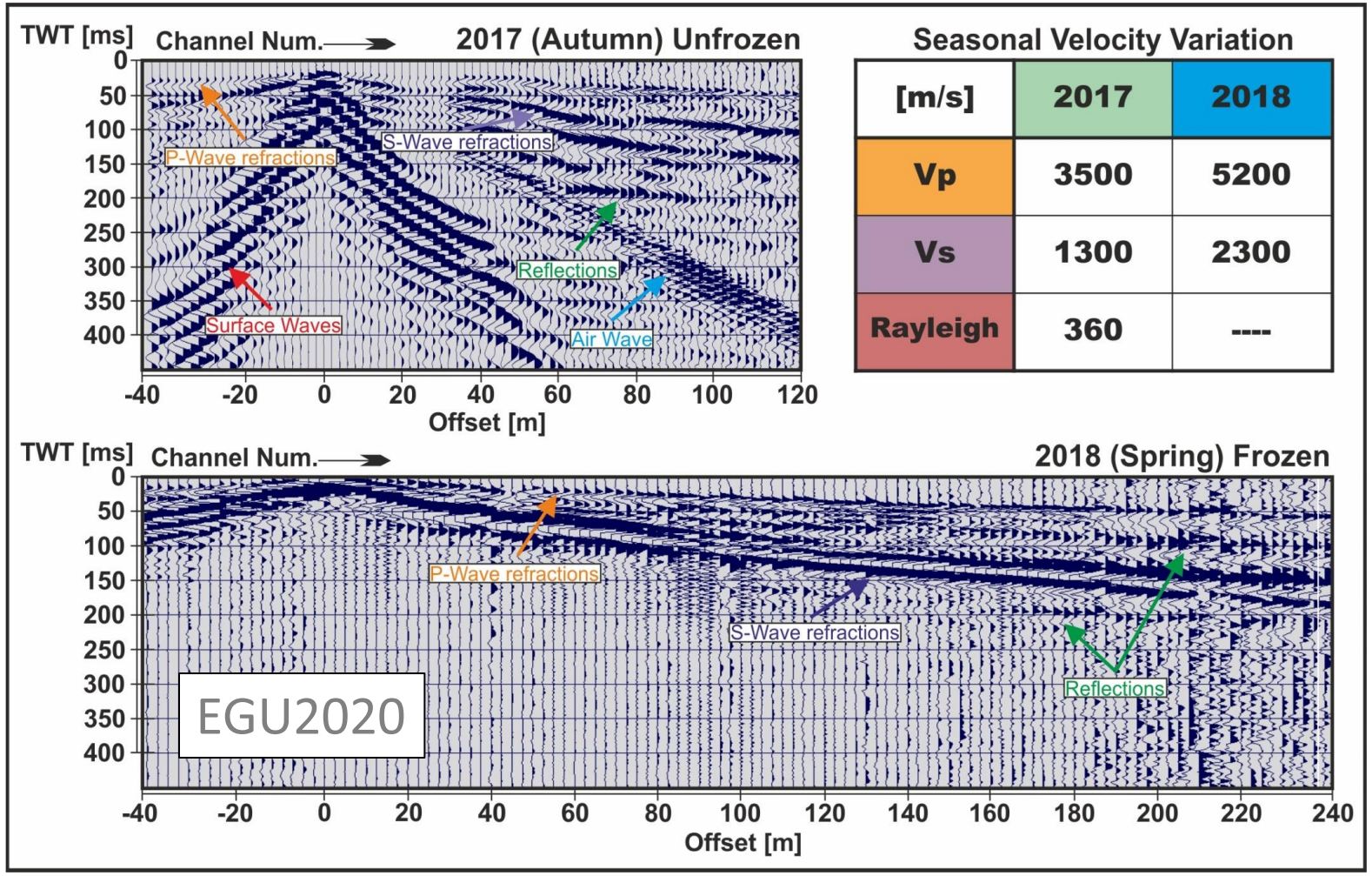
Pre-processing:

Repeated sources (4-5 times) – manual QC (removed first strike)

Manual front mute (!)

Multistep velocity analysis

Seasonal variability of seismic wavefield



Seasonal Velocity Variation

[m/s]	2017	2018
Vp	3500	5200
Vs	1300	2300
Rayleigh	360	----

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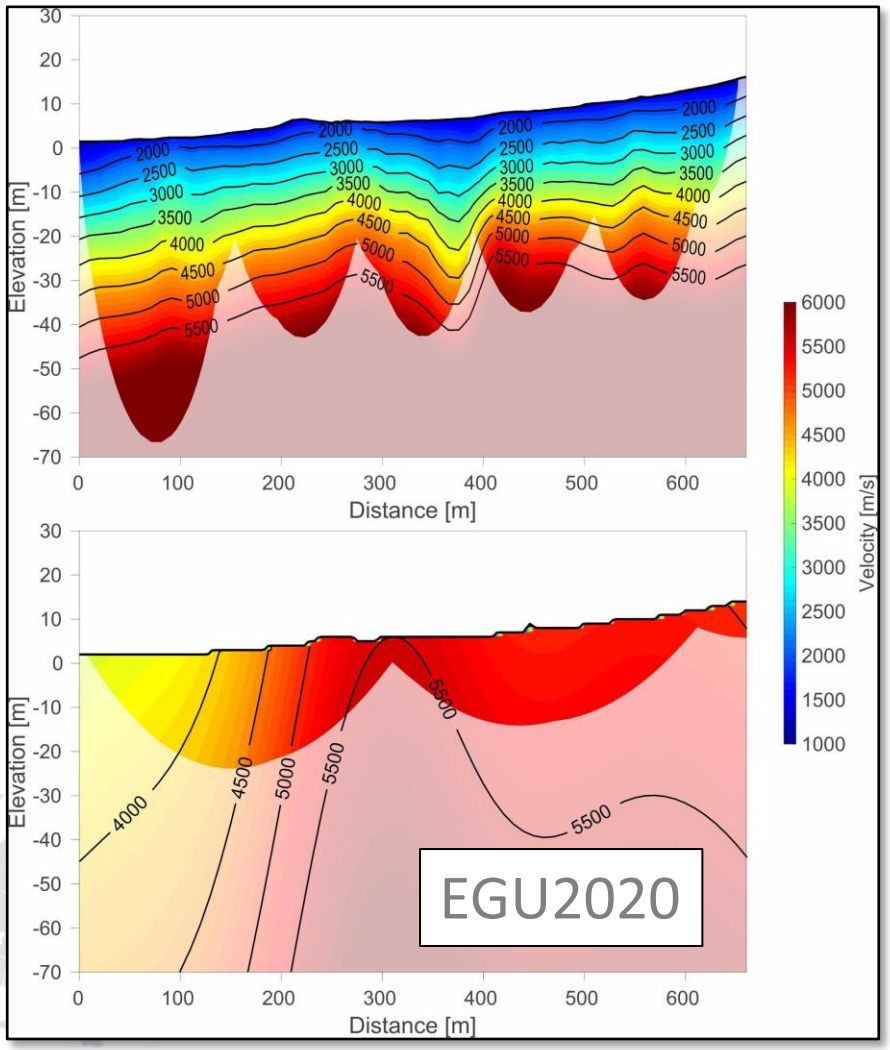
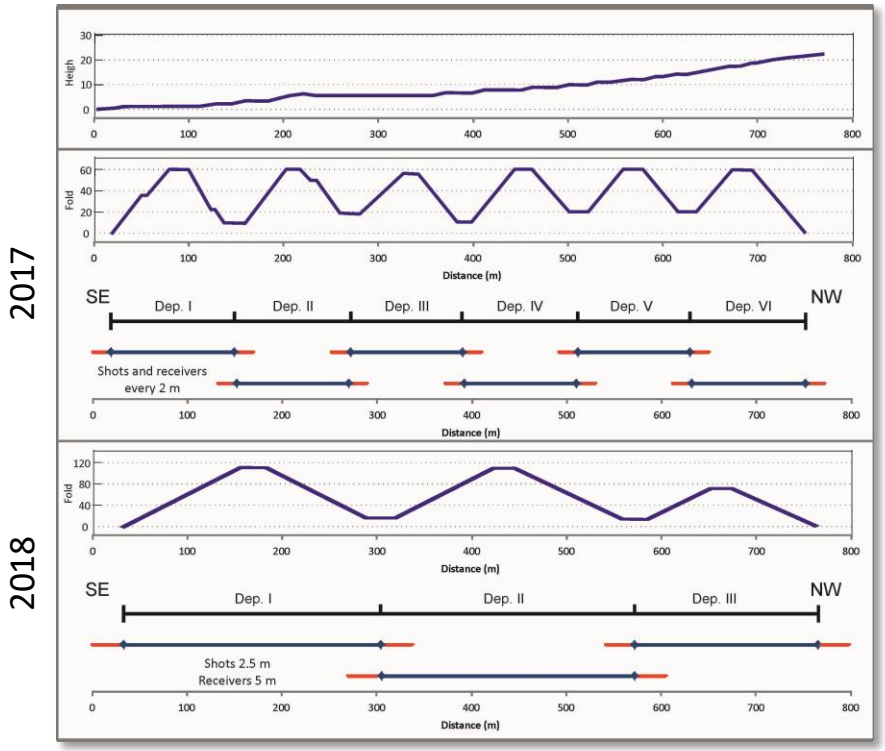
First breaks tomography





Schematic acquisition geometry
Walking deployments with extra offset shots

Significant seasonal difference in near-surface Vp values

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Conclusions

- Geophysical (seismic) imaging of the permafrost is possible and precise
- Active layer maximal thickness and its spatial variability is significantly larger than previously expected
- Seismic measurements during the winter period (frozen ground)
  - results in higher data quality,
  - are easier to process and
  - much simpler to acquire in the field

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