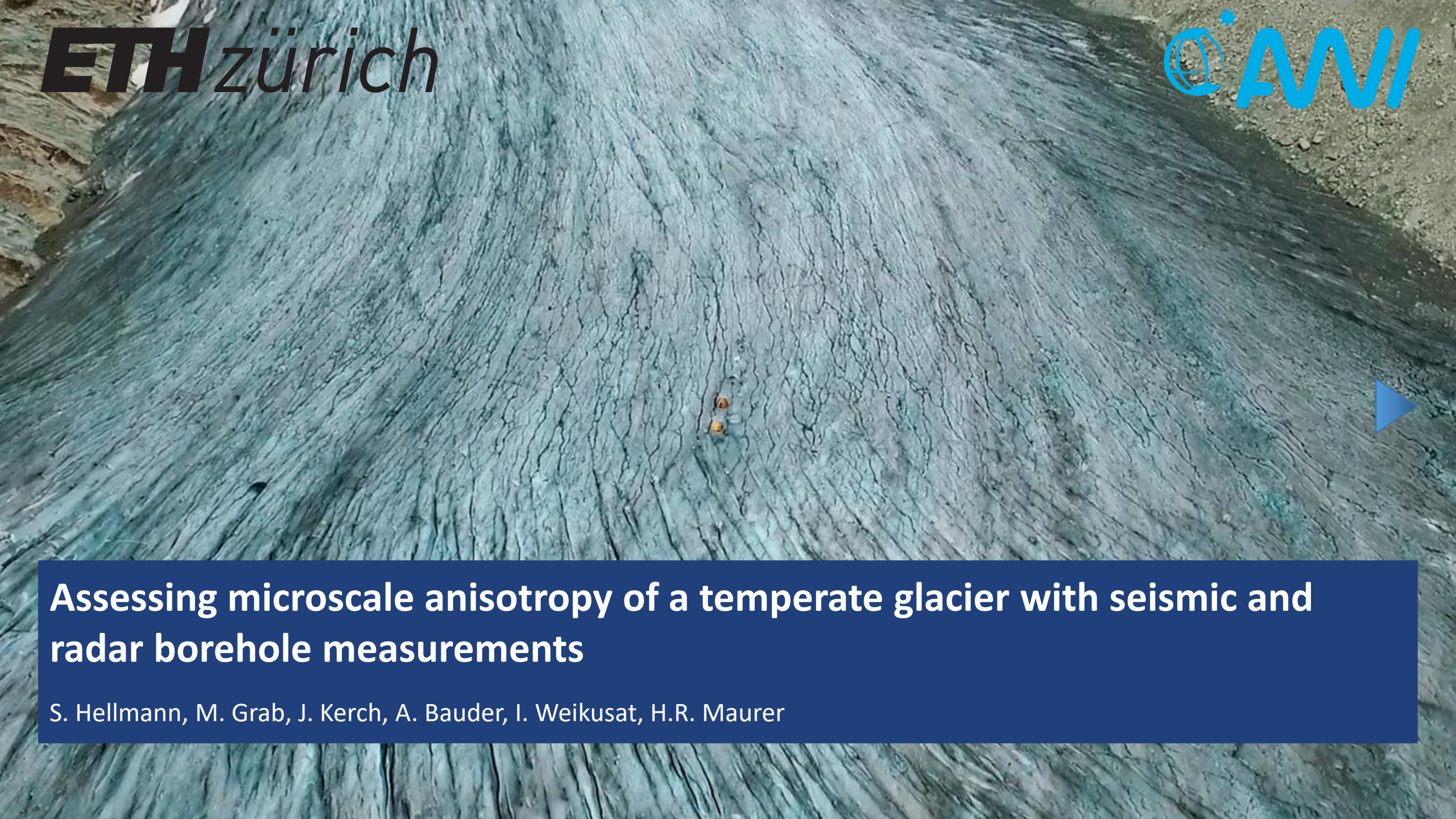
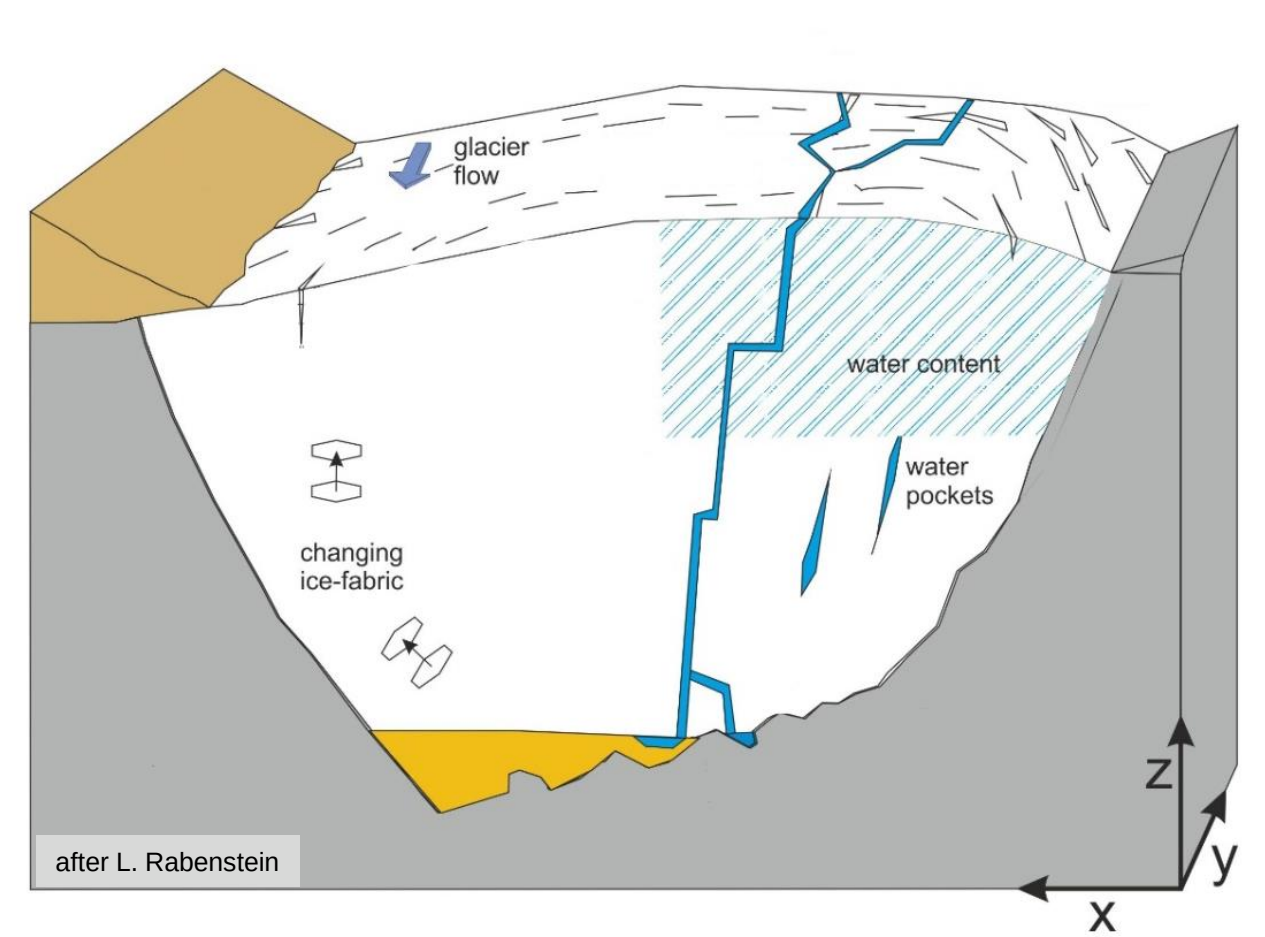


Assessing microscale anisotropy of a temperate glacier with seismic and radar borehole measurements

S. Hellmann, M. Grab, J. Kerch, A. Bauder, I. Weikusat, H.R. Maurer

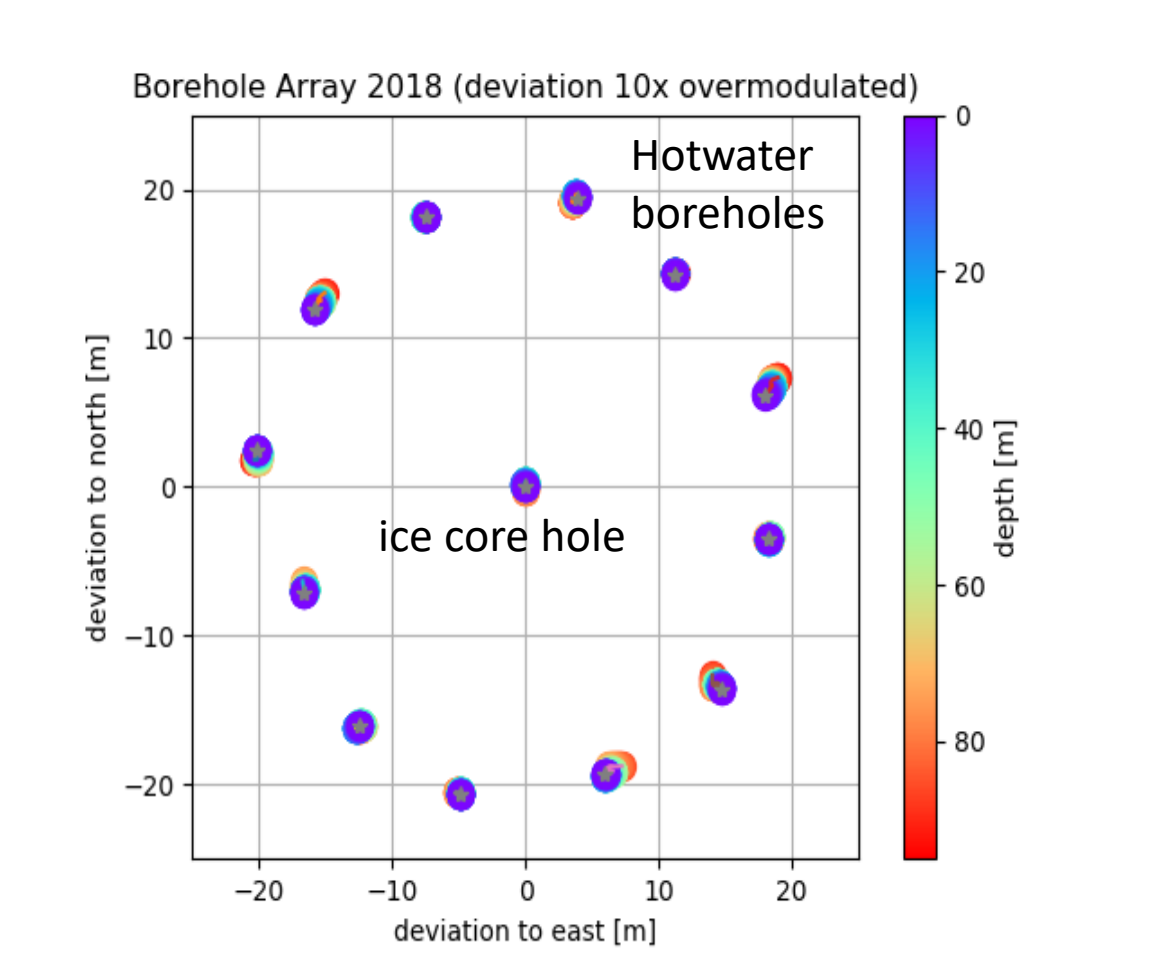
Investigating Alpine glaciers microstructure with GPR and seismics

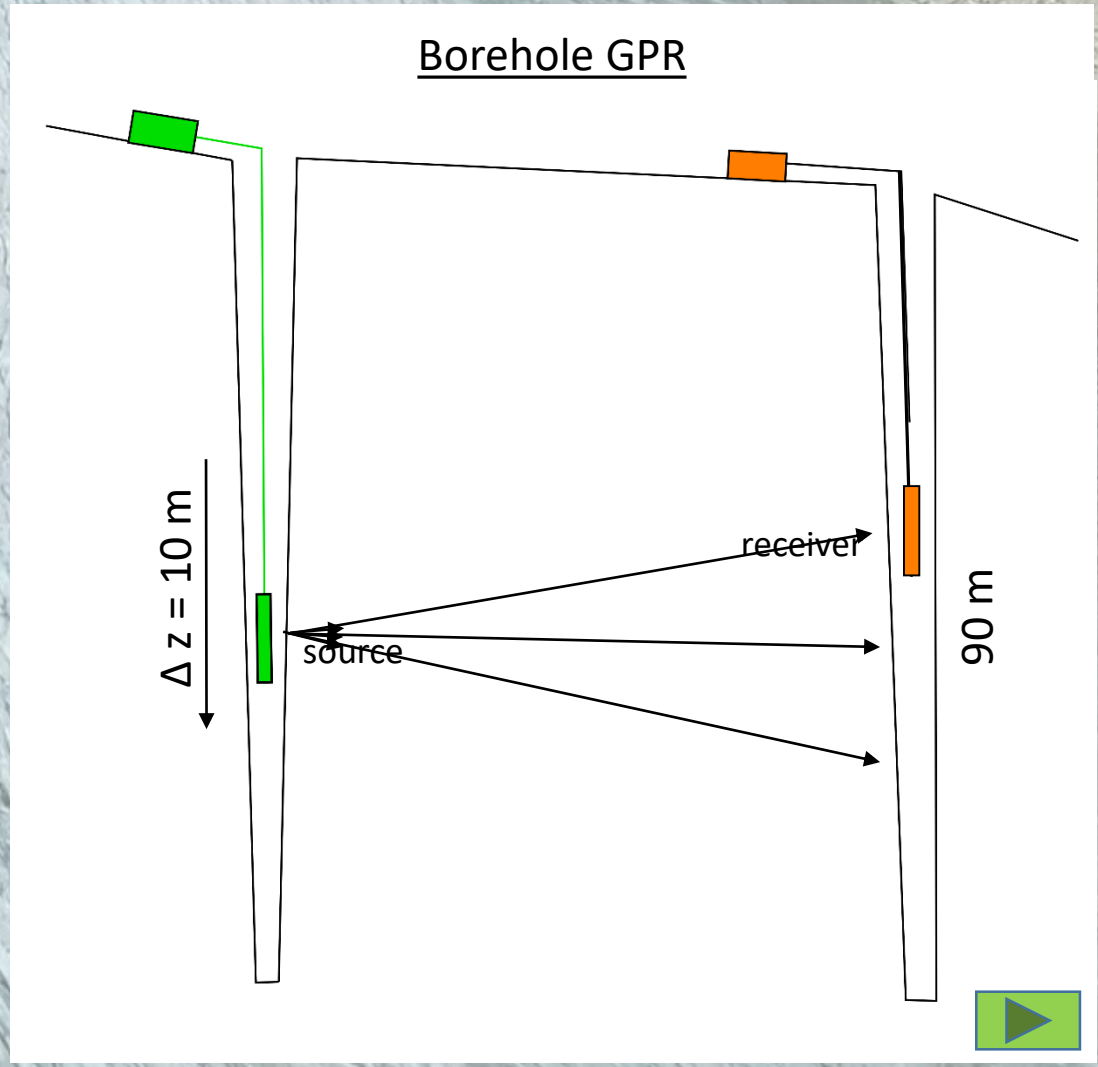


What we want to investigate:

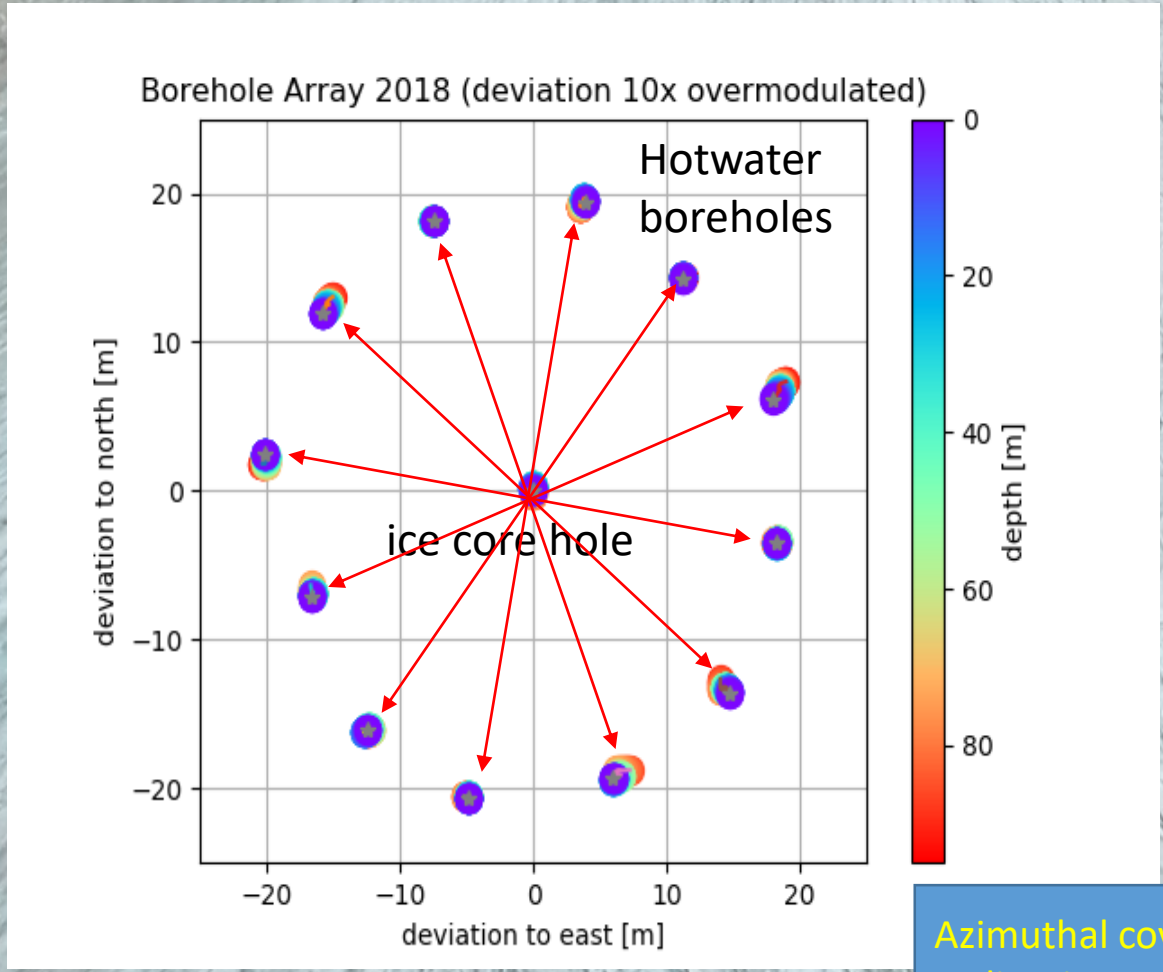
- How much does the crystal anisotropy affect the physical properties of glaciers?
- Can we assess and quantify the crystal anisotropy with combined in-situ borehole radar and seismic measurements?
- How much do the macroscopic effects (water & air content, crevasses, etc.) overlay and influence the results?
- Do we have to take the crystal anisotropy into account when modelling the flow of valley glaciers or even ice sheets?

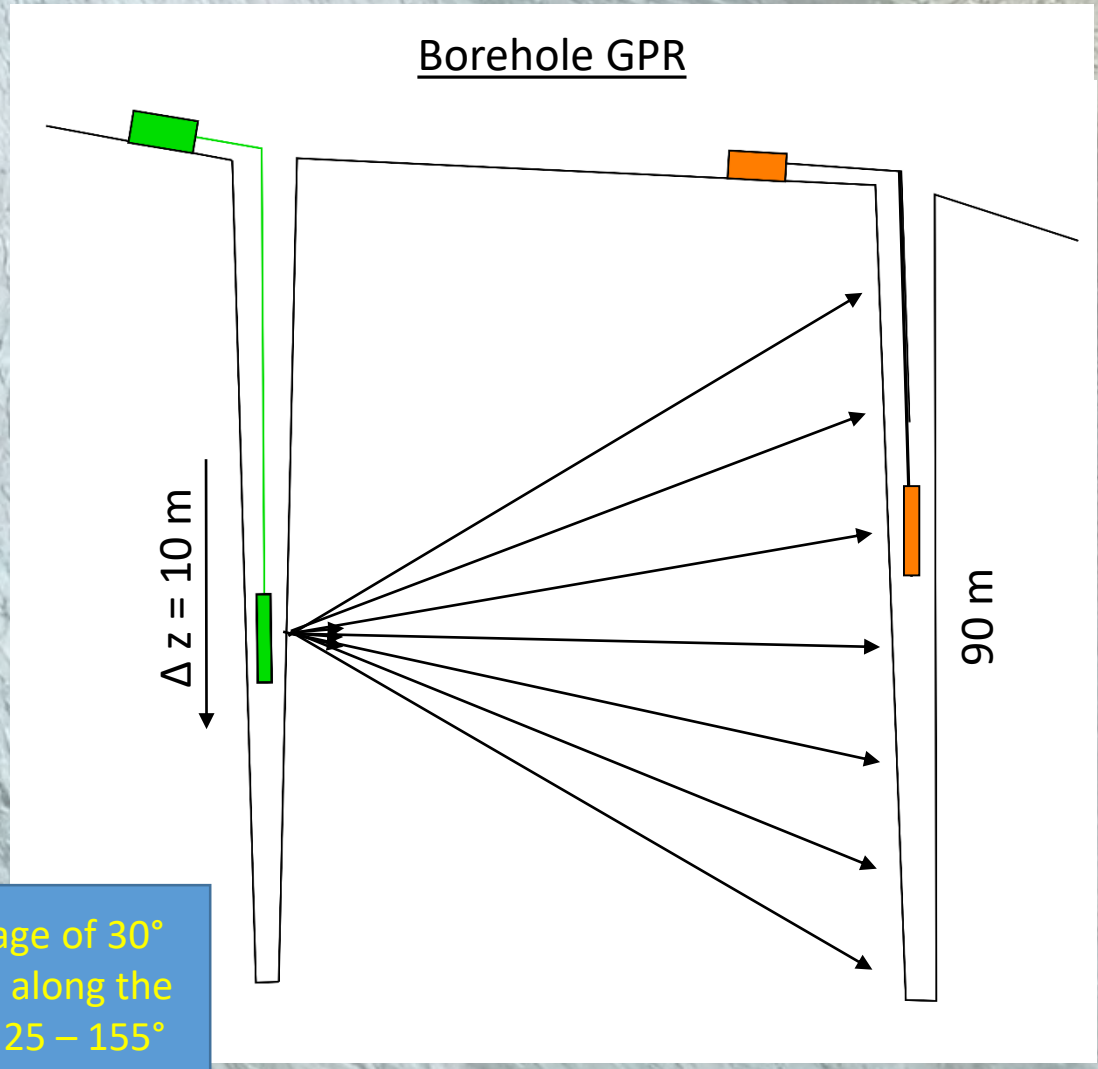
Experimental setup





Experimental setup

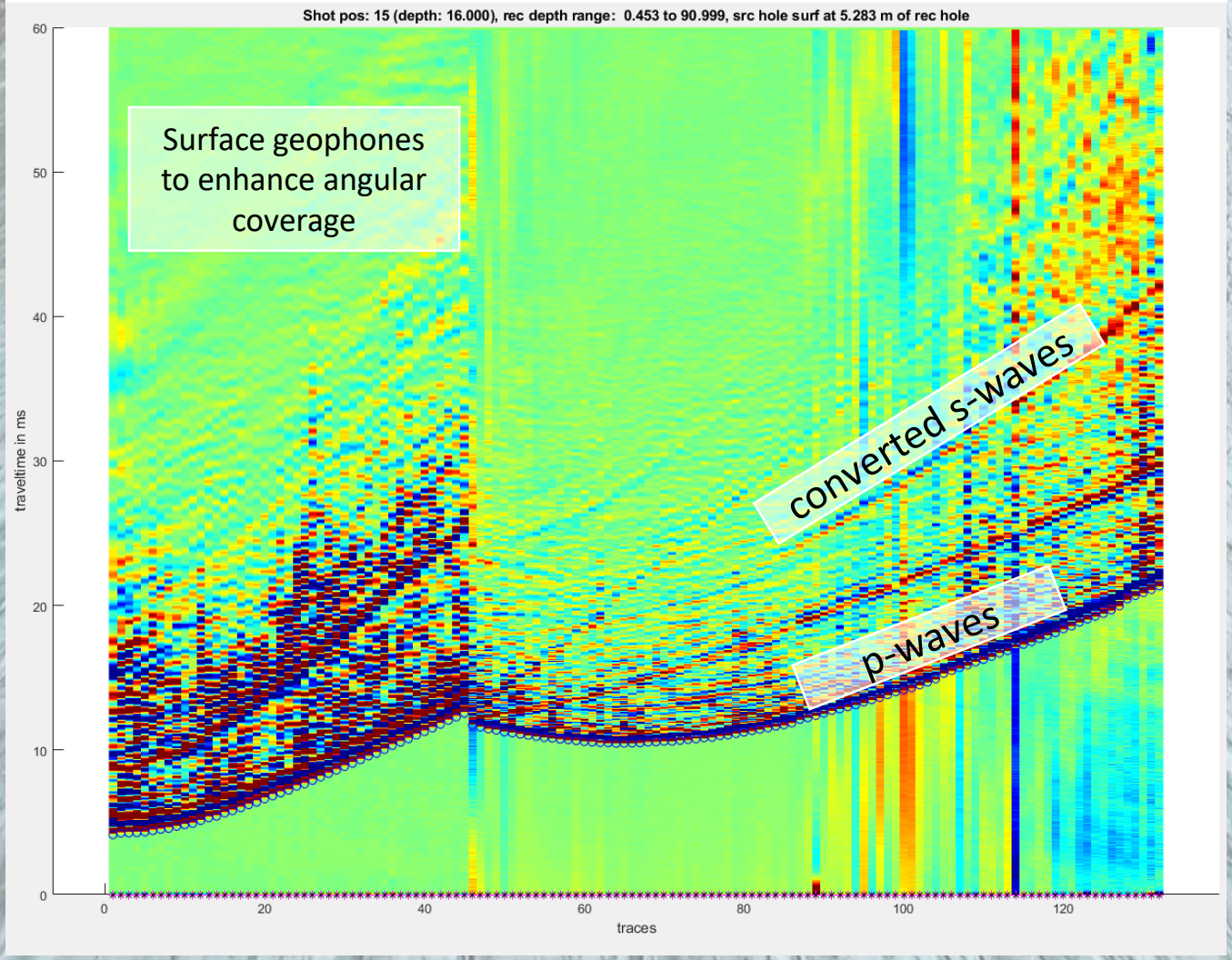




Azimuthal coverage of 30°
Inclination range along the 90 m boreholes: 25 – 155°

Introduction

Seismic cross-hole raw data (3x stacked)

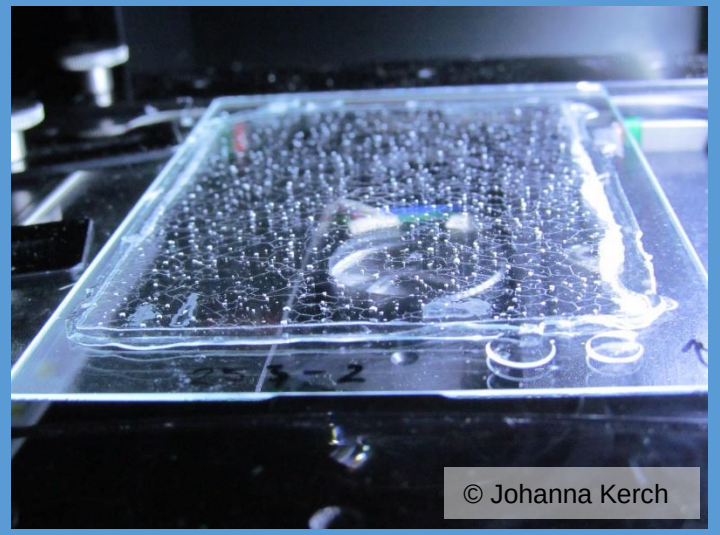


- Obtained a comprehensive crosshole **seismic** and **GPR** experiment
- Used 12 boreholes in a ring → 6 different azimuths (0/30/60/90/120/150° to ice flow)
- **Borehole length: 90 m** → Inclination range 25 to 155° (horizontal=90°)
  - For seismic experiments additional geophones at surface → inclination between 0° (vertical up) and 155°
  - An example section is shown left.
- **Good SNR** in GPR and seismic data
- **Open questions**:
  - How to split information about microstructure and macrostructure
  - Can we see azimuthally dependent changes in microstructure?

Summary and Outlook

Summary:

- Goal of the project: compare ice core and in-situ data
  Can we resolve the anisotropy induced by crystal orientation fabric with geophysical measurements?
  Can we distinguish between travel time differences induced by macroscopic structure and the crystal orientation fabric?
- Ice core data: clear change from horizontally but mostly in-flow oriented ice crystals (multi-maxima) at top towards vertical c-axis in larger depth
- Geophysical data: good Signal-to-Noise ratio
  - GPR 2D-results consistent for 3 of 4 profiles
  - Seismic data: reciprocity issue needs to be solved first



Outlook:

- GPR data → use for water content estimation → macrostructural features
- Ice core → air content estimation and ultrasonic measurements to determine vp on ice core (connection between seismics und velocity from c-axis distribution)