Seismic Full Waveform Inversion: Feasibility to Recover Firn Properties

eeevep@leeds.ac.uk
@emm_pearce

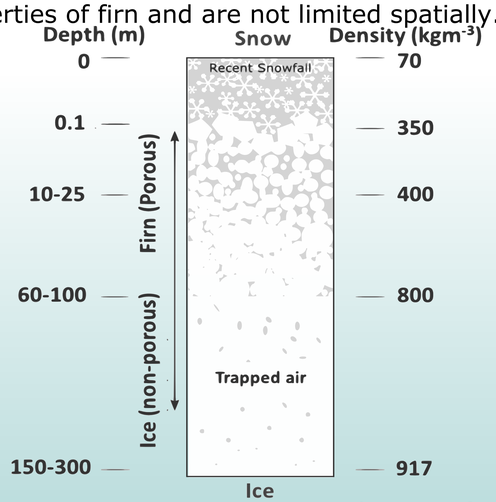
Emma Pearce[1*], Adam Booth[1], Ian Jones[2], Bryn Hubbard[3], Graham Stuart[1], Paul Sava[4]

1. University of Leeds 2. ION Geophysical 3. Aberystwyth University 4.Colorado School of Mines

UNIVERSITY OF LEEDS

1. Introduction & Rationale

- Firn gives insight into past and present climate conditions.
- Due to changes in density with depth, geophysics can be used to recover the firn profile.
- Seismic surveys are a popular technique. They are able to recover both physical and mechanical properties of firn and are not limited spatially.

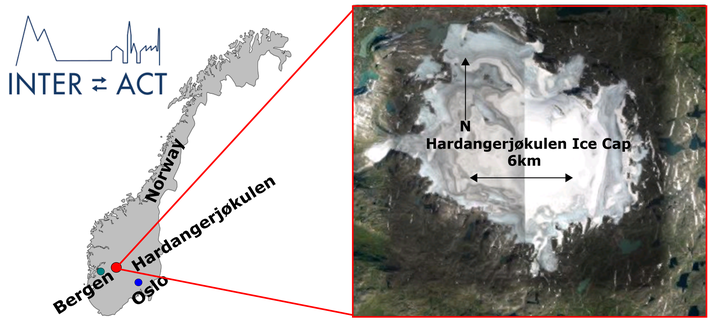


- Current Seismic inversion techniques (Herglotz Wiechert) are limited by the assumption of simple physics.
- **Full Waveform Inversion (FWI)** can mitigate these limitations and improve our understanding of firn.

The ability of FWI to recover firn was tested on data acquired from Hardangerjøkulen Ice Cap

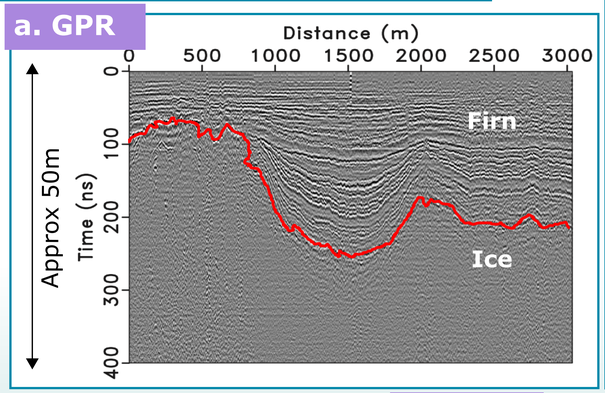
2. Hardangerjøkulen, Norway

- An Ice Cap situated on the western flank of the Hardangervidda mountain plateau
- Chosen as the site for seismic acquisition due to easy accessibility from the UK and areas of known firn coverage

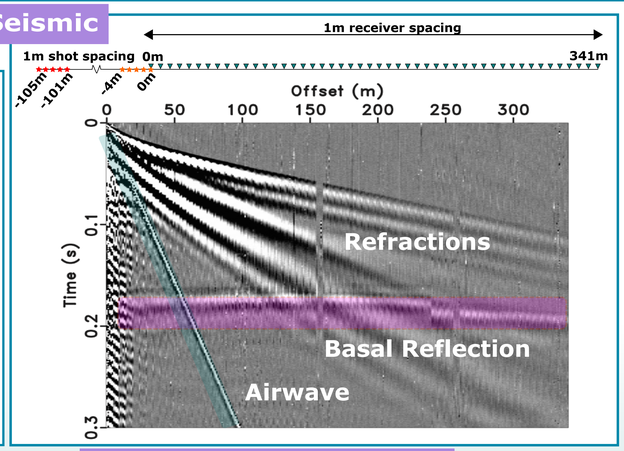


3. Field Acquisition

a. GPR



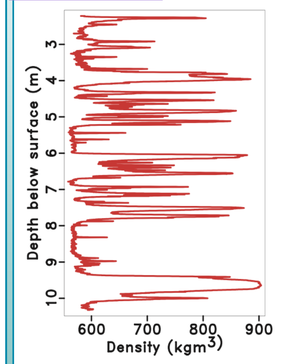
b. Seismic



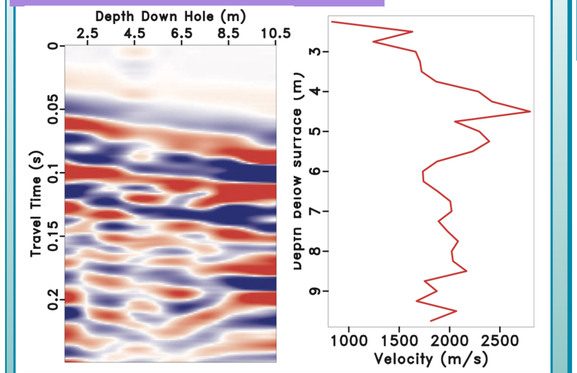
Acquisition Parameters

Surface Seismic
1m Geophone Spacing
Hammer source
Min offset = 0m
Max offset = 341m
Number Receivers = 48
Vertical Seismic Profile
Depth of borehole = 11m
6 Receivers up to 1.5m from borehole
Density
OPTV every 0.1m

c. Density

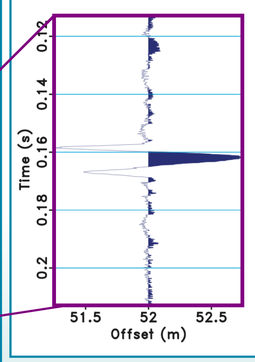


d. Vertical Seismic Profile

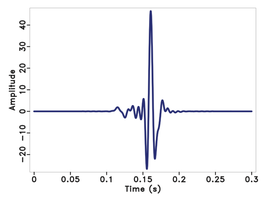


4. FWI methodology

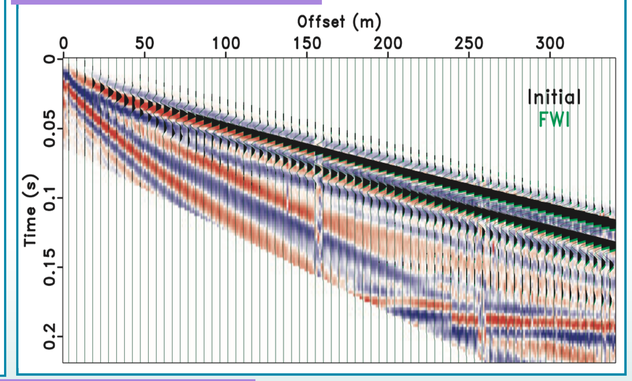
b. Wavelet Extraction

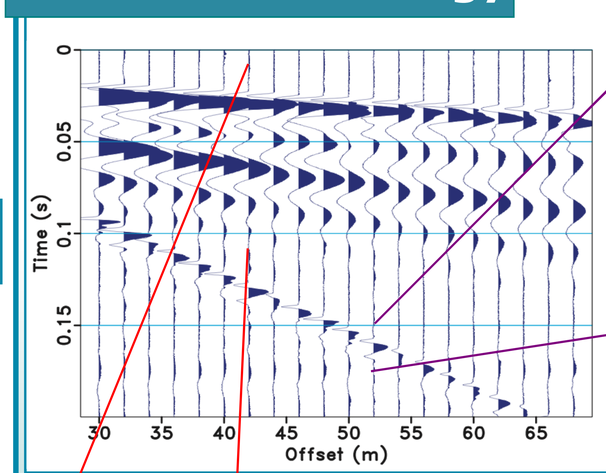


Flatten Airwave: LMO
Residual shift
Stack traces
Shift data by 0.154s

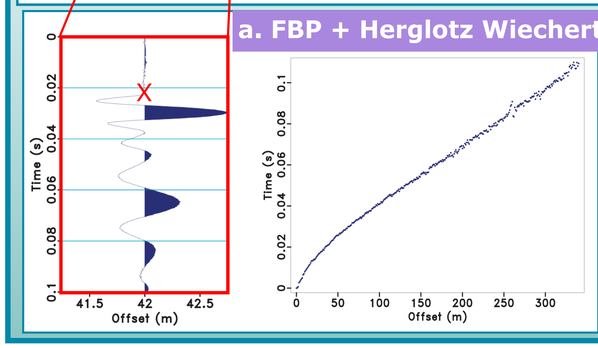


d. FWI Data Match

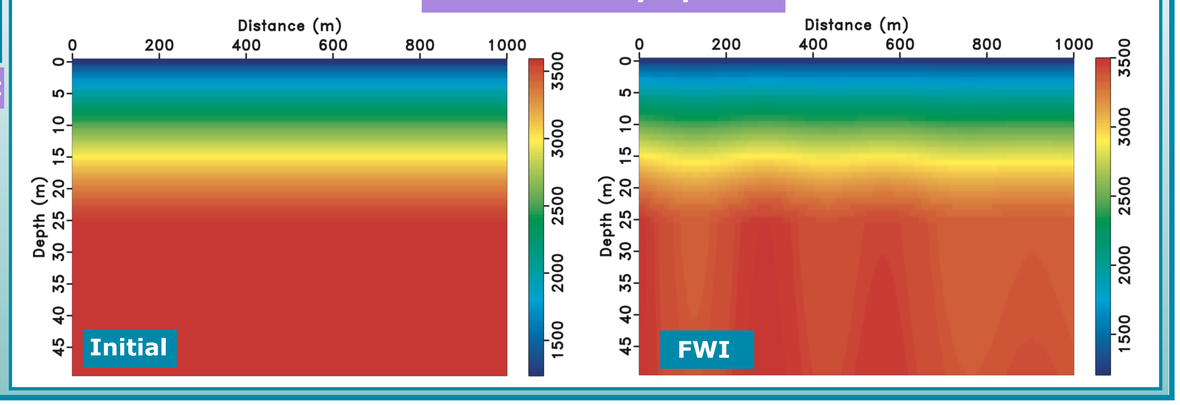




a. FBP + Herglotz Wiechert



c. FWI Velocity Update



5. Conclusions

- Data is not cycle skipped and updates in the right direction
- Replicating single shot allows uniform update
- Starting model is too simple to model full coda of the refractions

6. Recommendations

- Constrain update with GPR firn depth information
- Incorporate density and VSP into starting model

Acknowledgements

Thanks go to INTERACT TA for funding this field work, along with Bryn Hubbard and Katie Miles for collecting and processing the OPTV density data.