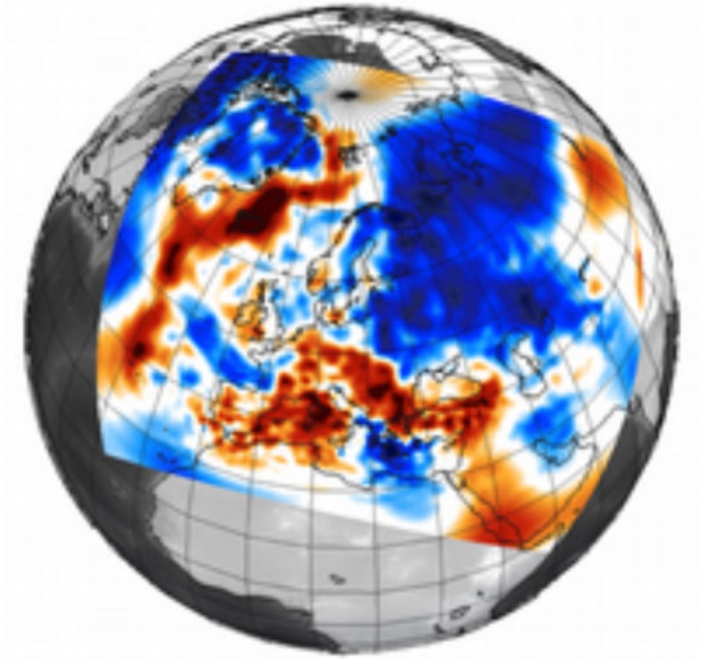
Towards Full-Waveform Inversion with Distributed Acoustic Sensing

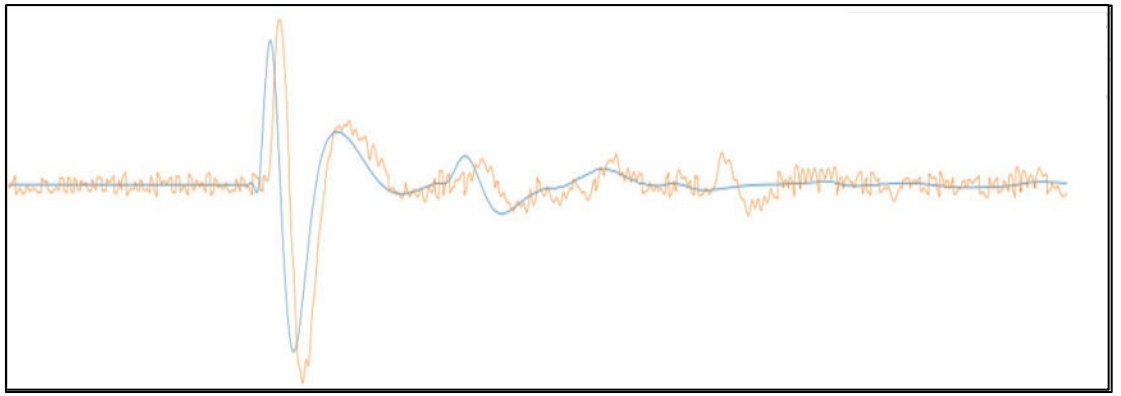
Sebastian Noe, Sara Klaasen, Lars Gebraad and Andreas Fichtner

ETH Zurich

Seismology and Wave Physics Group

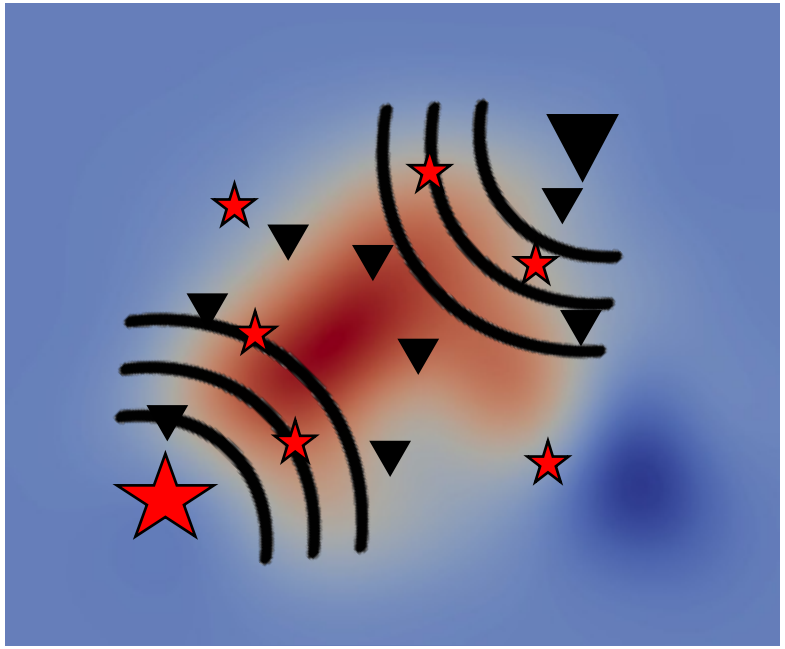


Full-waveform Inversion

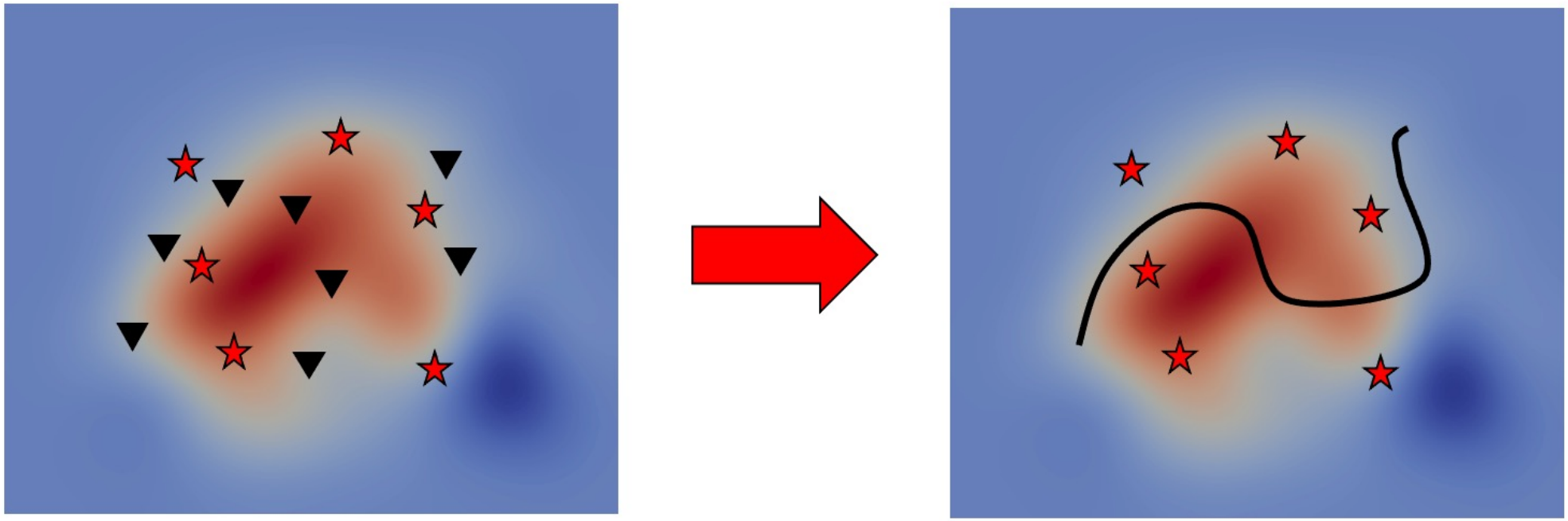


Invert for subsurface model

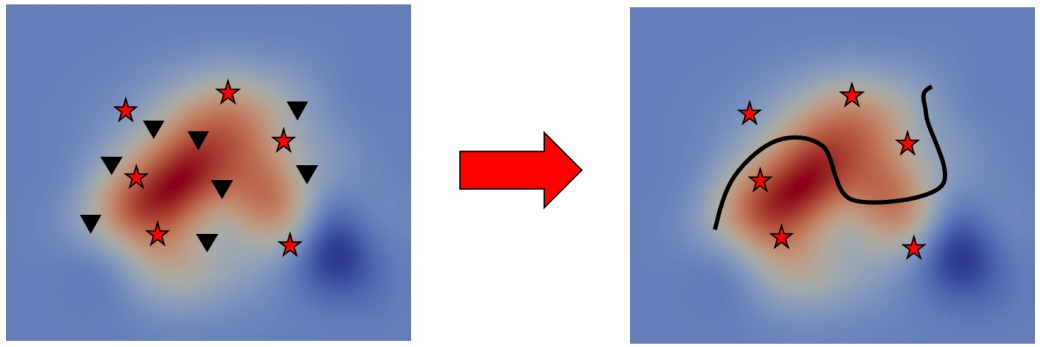
- Start with initial model
- Forward Simulation → Synthetic Measurements
- Compare to observations
- Adjoint simulation
- Model gradient (combination of forward & adjoint fields)
- Iterative



Moving away from traditional seismology …



Moving away from traditional seismology …

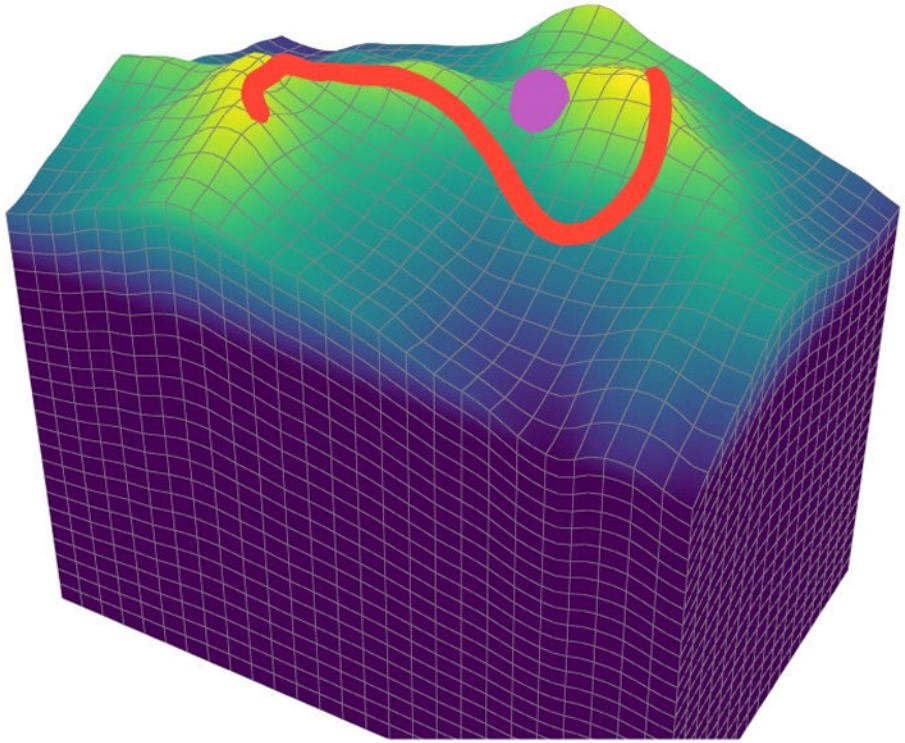


Ground displacement	Strain
3D measurements	1D measurement
Isolated Receivers	Receivers along line

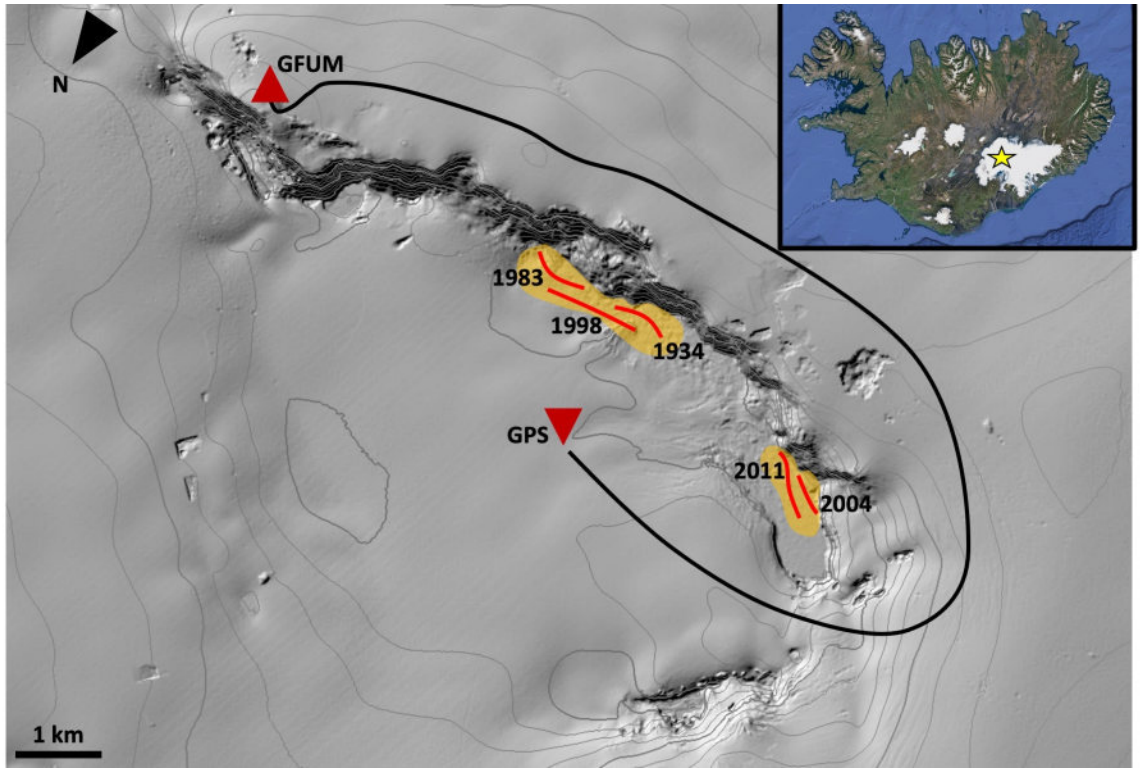
Simulations crucial for success of FWI

Simulations

- DAS package for SALVUS
- DAS line at the surface of the mesh
- Topography
- Extraction of strain rates along the line from the wavefield



Grimsvötn, Iceland

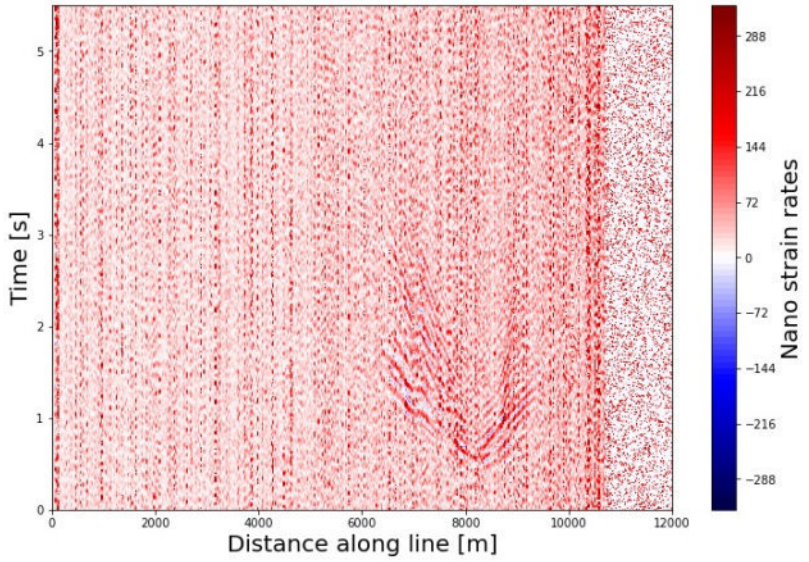


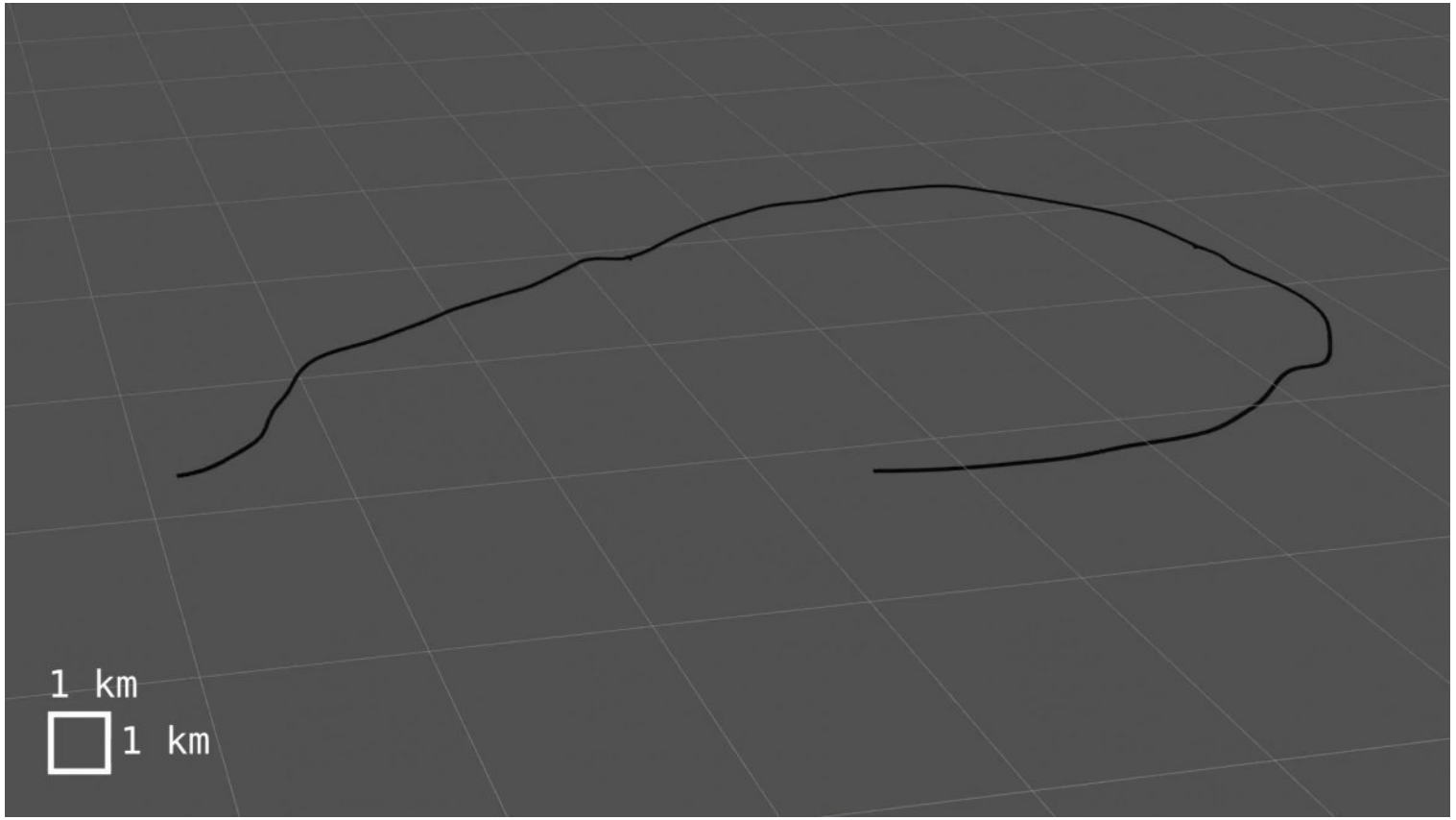
- Active volcano covered by ice
- Experiment in Spring 2021
- 12 km fibre-optic cable
- 1 month

Source localizations

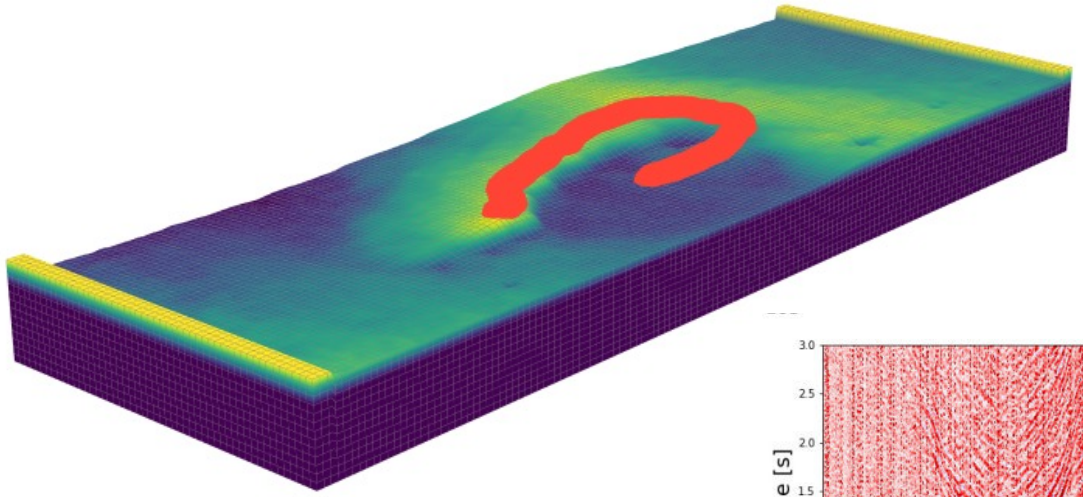
Probabilistic Matched Field Processing approach based on Hamiltonian Monte Carlo

1700 events detected



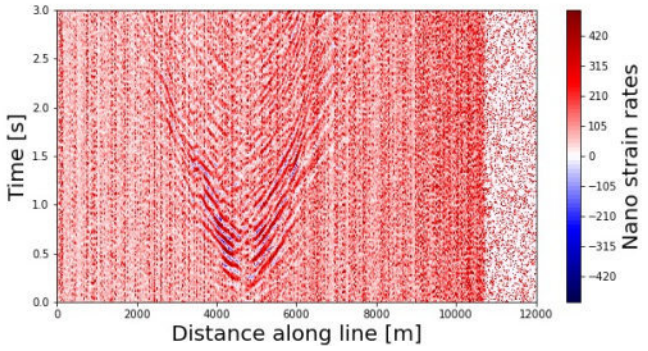


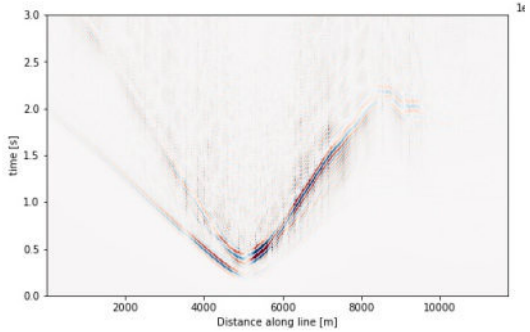
Forward Simulations

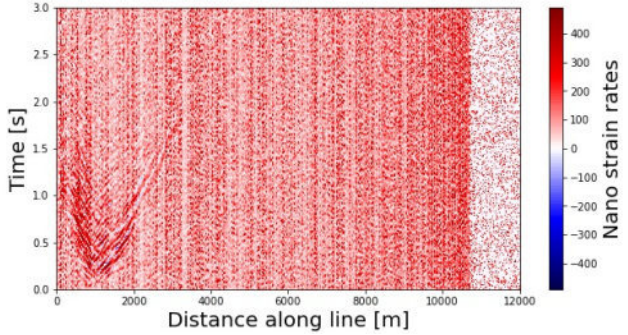


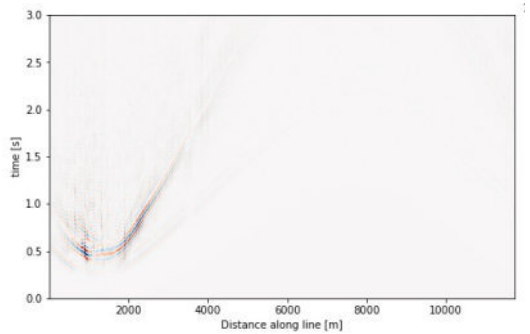
Initial Models:

1. Homogeneous volcanic rock
2. Covered by constant ice sheet
3. Account for ice thickness



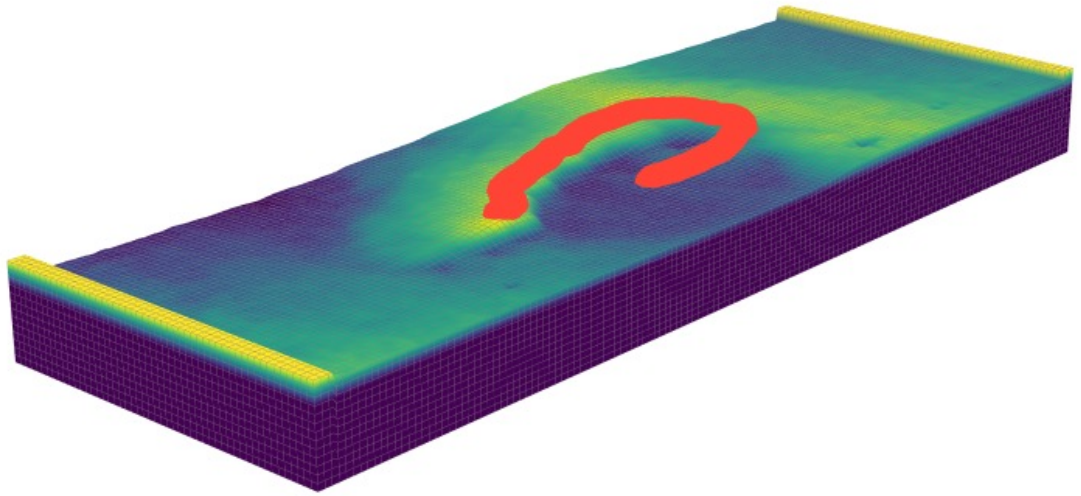






Summary and Outlook

We want to formulate a general full-waveform inversion tool for DAS and use it to image Grimsvötn volcano.



- Define proper misfit function
- Incorporate adjoint sources
- Joint inversion for sources and model
- How to include array data?
- Choose initial model for Grimsvötn
- Find adequate optimizer
- Continuously push to higher frequencies until convergence
- Also apply to other volcanic settings (e.g. Tenerife)