

# Propagation and source localization of microseism in the North Atlantic Ocean: a numerical study

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## Introduction

### About microseism

- Microseism is a faint tremor generated by pressure fluctuation on ocean floor due to water waves and propagates predominantly in the form of Rayleigh waves

### Motivation

- Characterising the propagation process of microseism from the North Atlantic Ocean
- Locating the noise source of microseism with seismic data recorded by on-land stations

### Methodology

- Building a 3D seismic model from crustal density dataset
- Simulating full seismic wave propagation with a spectral-element method based open-source package SPECFEM3D [Tromp et al., 2008]
- Imaging microseismic noise sources with a time reversal mirror [Fink, 2002]

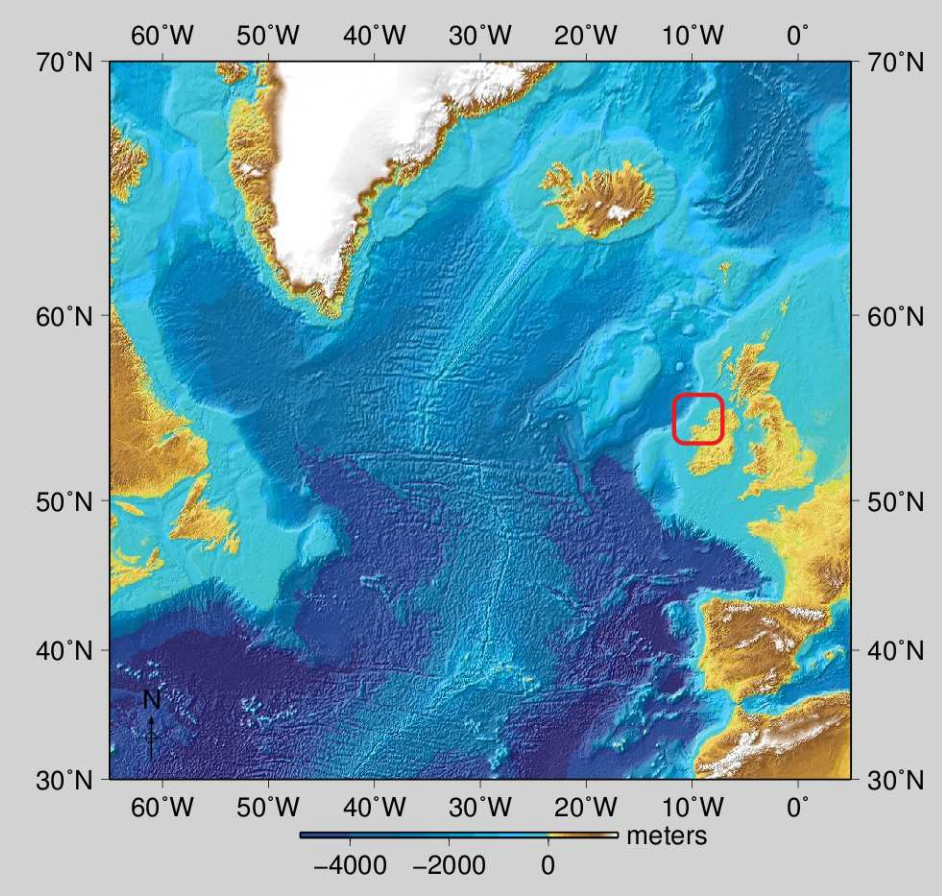


Fig. 1: North Atlantic Ocean

## Source localization algorithm – time reversal technique

### Procedures to locate microseismic noise source

- Pick-up seismic traces at stations on land
- Reverse the traces in the time order
- Send back traces where they were received into a numerical model
- Take the focal spot as the original source position

## Scaled numerical investigation

### A simplified case is first investigated with

- A homogeneous medium & flat topography
- A vertical force with 40 Hz Ricker wavelet is inputted on the model surface
- A 9-element linear array acts as a time reversal mirror

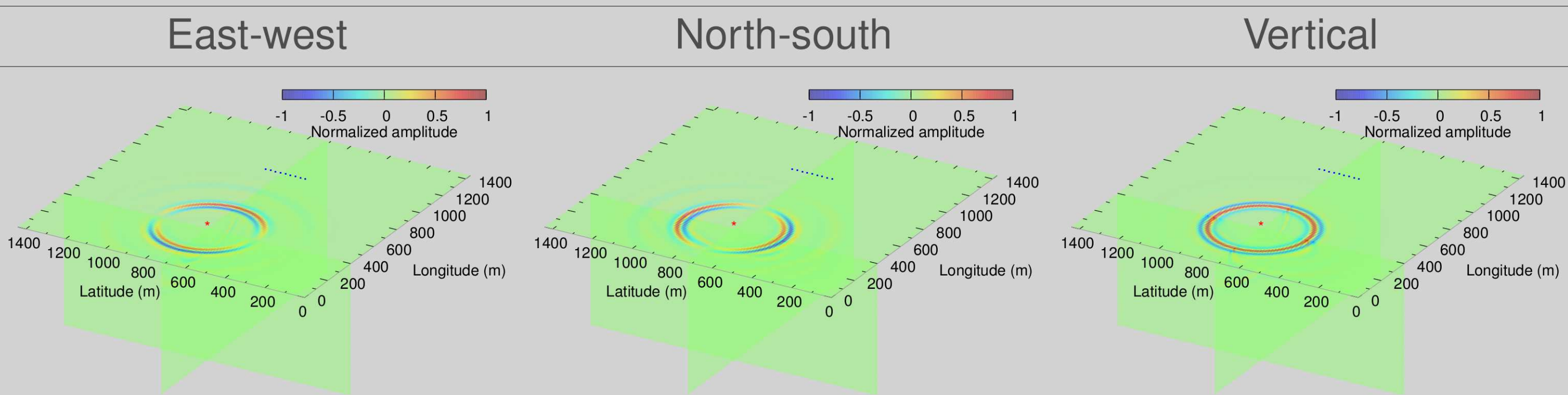


Fig. 2: 3D snapshots of forward displacement wavefields

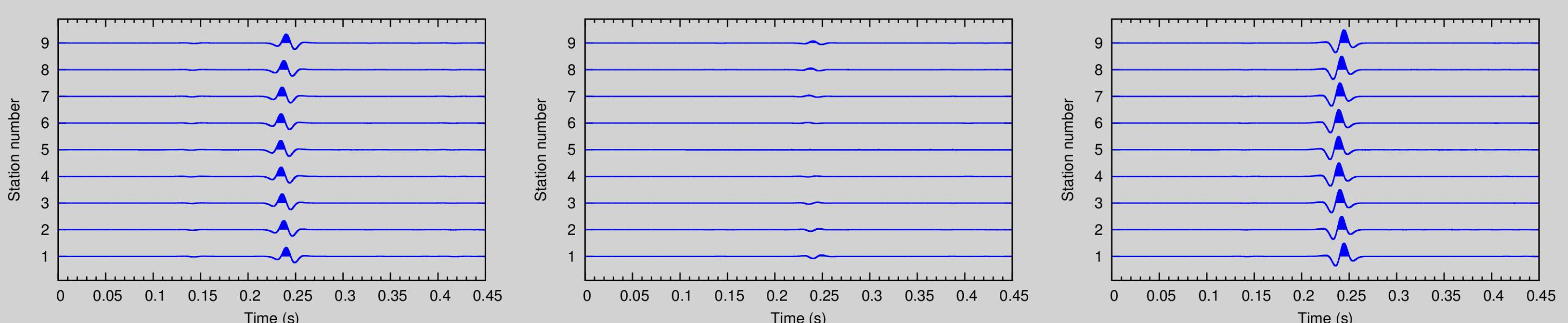


Fig. 3: Displacement traces

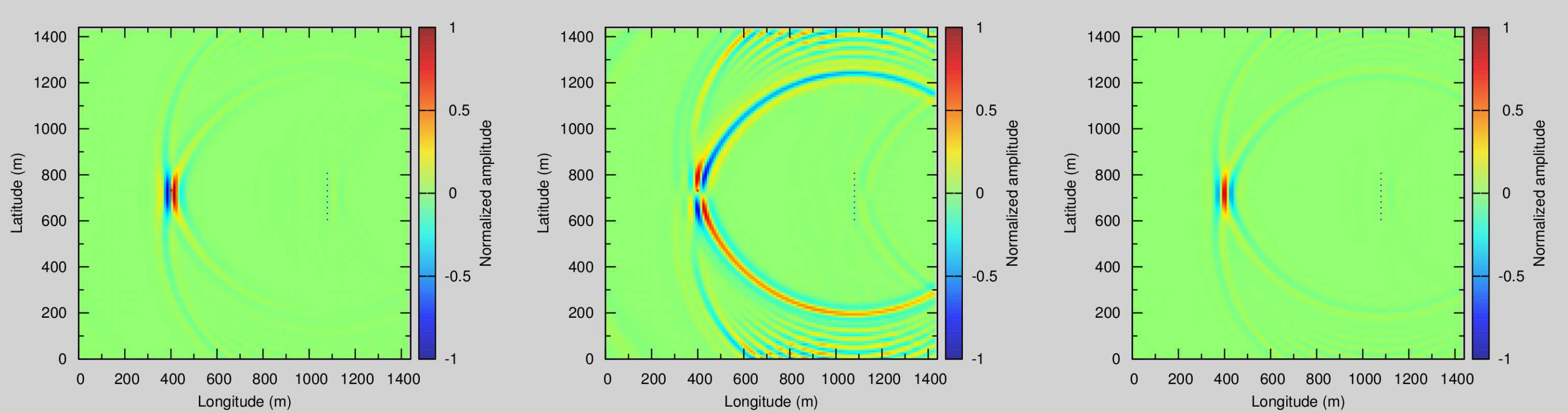


Fig. 4: Surface snapshots of backward displacement wavefields at focusing time

## Reference

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## 3D seismic model of the North Atlantic Ocean offshore Ireland

### To build the 3D seismic model

- A vertical force with 0.1 Hz Ricker wavelet located on the ocean floor simulates microseismic source
- 6 seismic stations are deployed near the west coast of Ireland
- The crustal density structure above the depth of 35 km of the computational domain is determined from the free air gravity data [Welford et al., 2010]
- The P&S-wave velocity structures are derived from density dataset using empirical relationships [Brocher, 2005]
- An Oceanic Parametric Earth Model (PEM-O) layer [Dziewonski et al., 1975] is appended from the depth of 35 km to 200 km

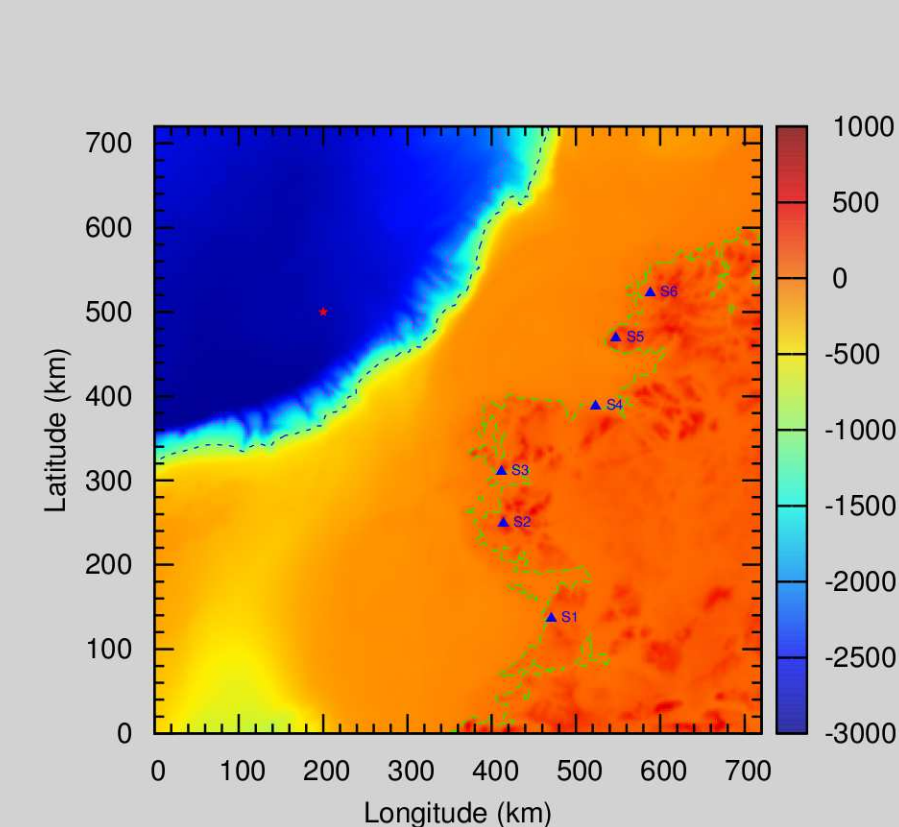


Fig. 5: Deployment

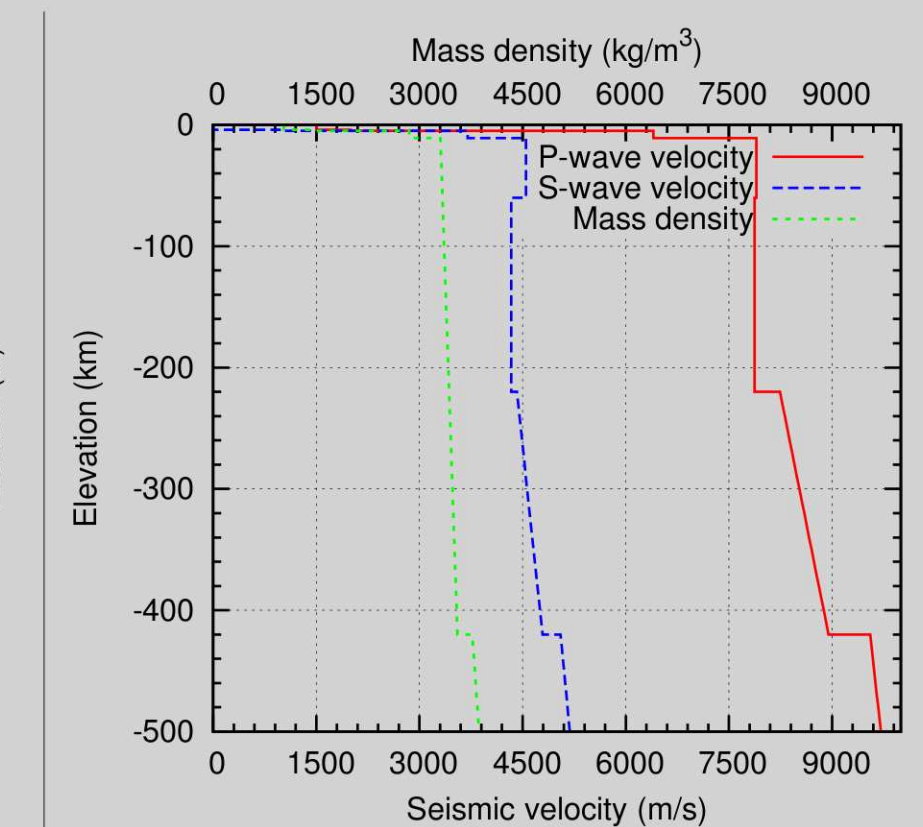


Fig. 6: PEM-O model

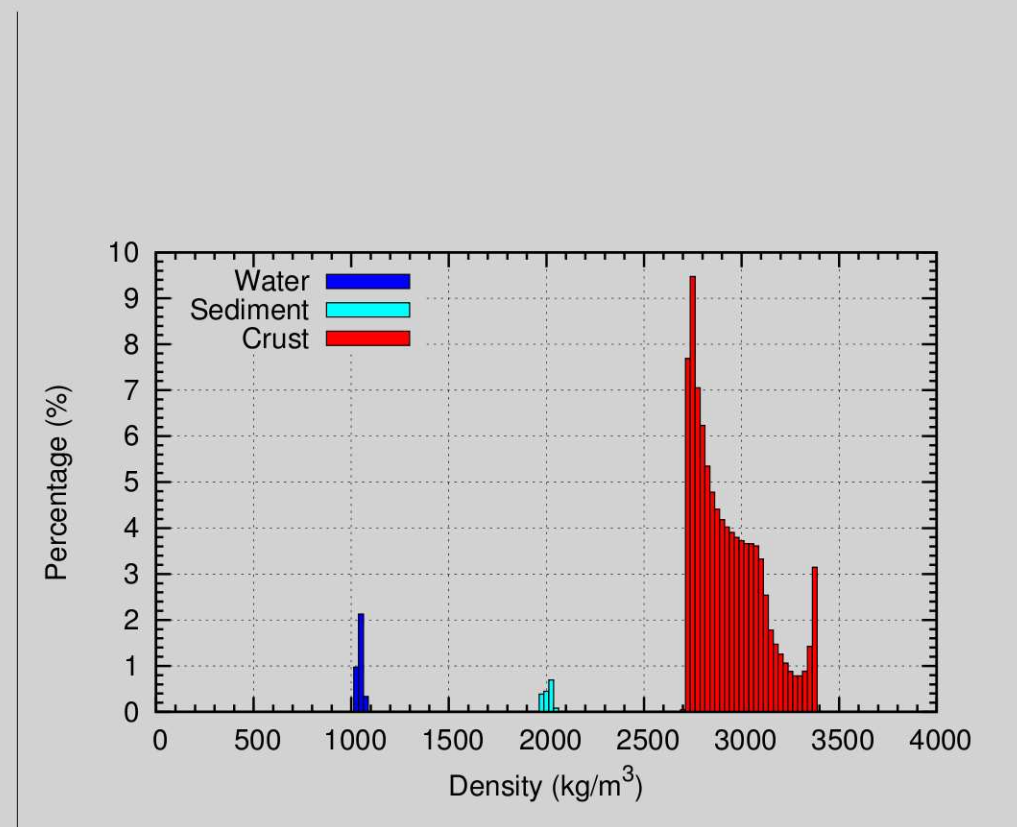


Fig. 7: Density distribution

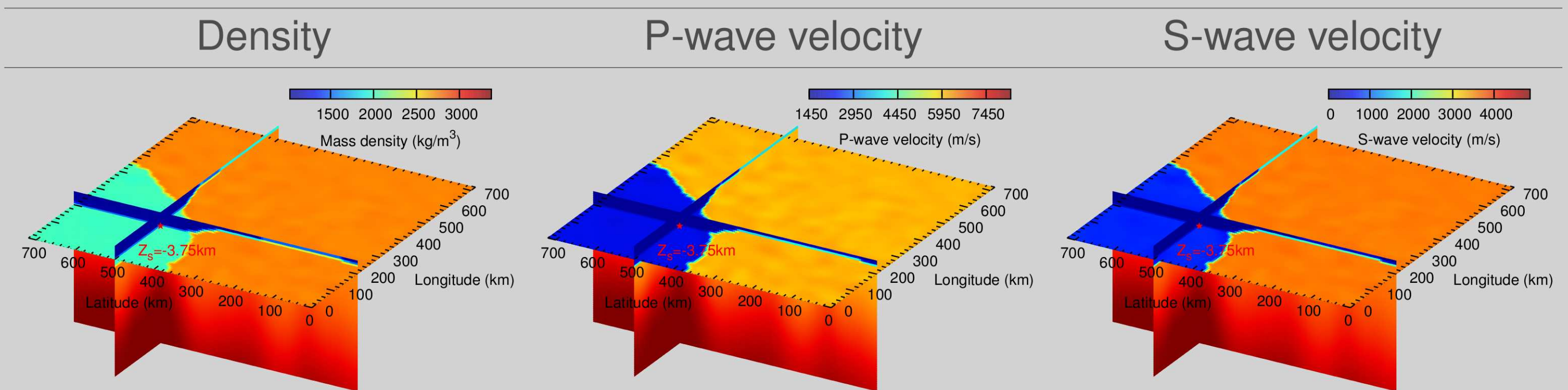


Fig. 8: 3D seismic model above the depth of 35 km

## Numerical results in real setting

### East-west North-south Vertical

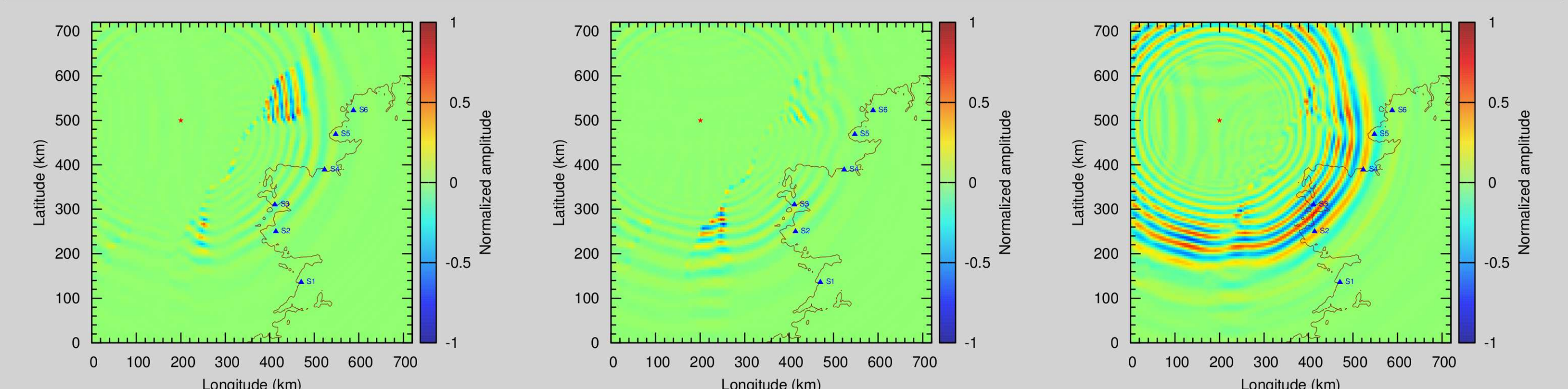


Fig. 9: Ocean-floor snapshots of forward displacement wavefields

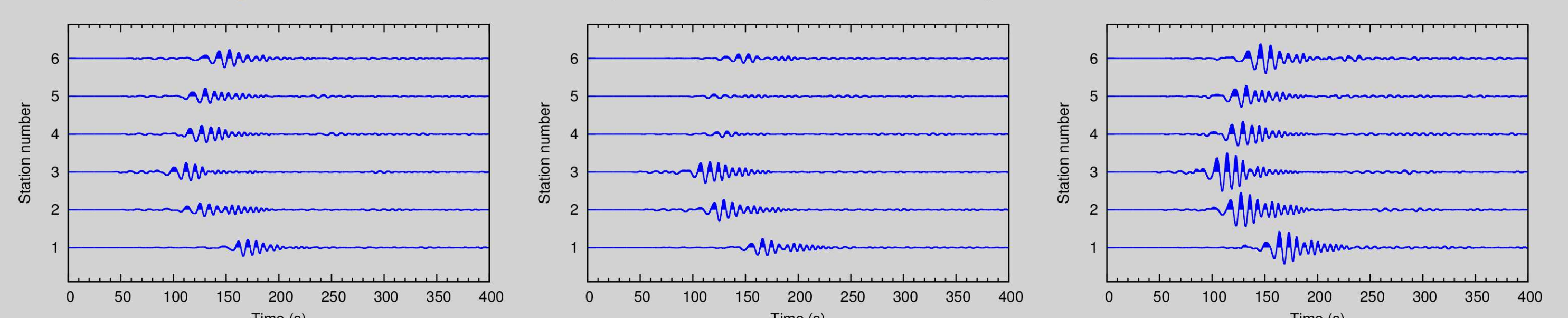


Fig. 10: Dispersed displacement traces

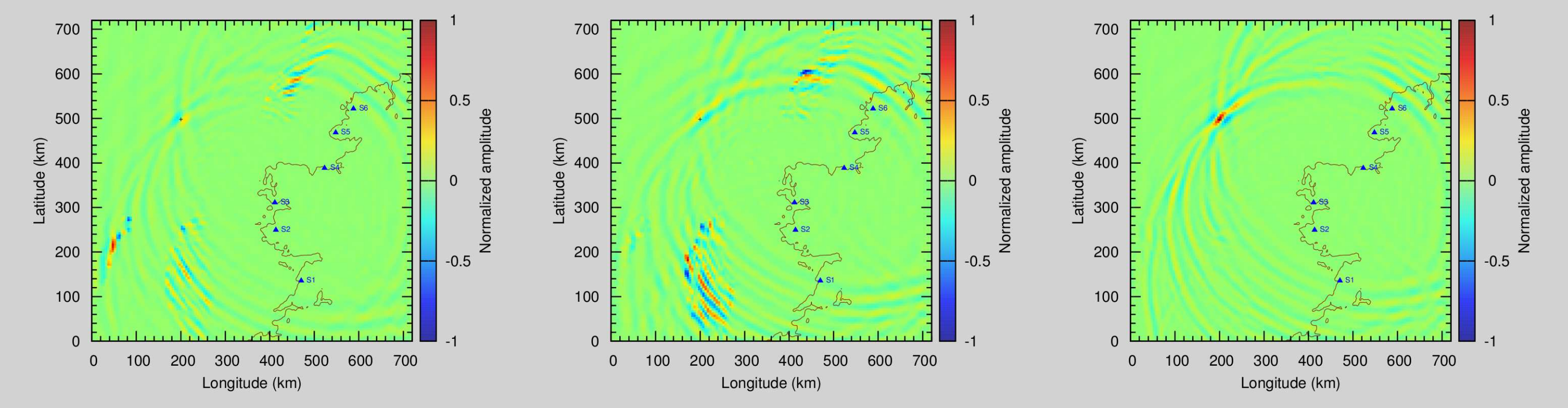


Fig. 11: Ocean-floor snapshots of backward displacement wavefields at focusing time

Note: the focal spot of the vertical displacement wavefield is at the source position

## Summary

- Microseismic noise source can be located with a time reversal mirror by utilising full-waveform simulations & crustal information

## Future work

- Test sensitivity of locating to crustal model
- Apply to real data

## Acknowledgments

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