Synthetic ambient seismic noise dataset for testing ambient-noise methods

Authors: Claudia Finger (1), Erik H. Saenger (1,2,3)
Affilitations: 1: Fraunhofer IEG, Fraunhofer Institute for Energyinfrastructures and Geothermal Energy, Bochum
2: Bochum University of Applied Sciences
3: Ruhr-University Bochum
Contact: claudia.finger@ieg.fraunhofer.de

We present a continuous seimic waveform dataset created with the rotated staggered-grid finite-difference simulator HeidimodX (*Saenger et al., 2000*). The aim of the dataset is to recreate the random nature of ambient seismic noise using numerous synthetic point sources with arbitrary source parameters and locations. Three-component waveforms are recorded at the free surface of a three-dimensional model with two different velocity structures. This dataset can be used to benchmark and test robustness of different methodologies typically applied to ambient noise data.

Simulation parameters to create three-component synthetic waveform dataset

Model dimensions

model size in x direction: 60 km
model size in y direction: 60 km
model size in z direction: 30 km
grid spacing (equidistant in all directions): 50 m
time interval spacing: 0.005 s
sampling rate: 200 Hz
length of continuous time series: 1540 s

Receivers

Total Number: 441
Network shape: equidistant square
Minimum inter-receiver spacing: 500 m
Maximum aperture: 14142 m

Sources

Total Number: 8000
Random origin time throughout the whole time (except first 2.5 s)
Random location inside the following bounds:
- Minimum radius (distance) from center: 17.67 km (2.5 * aperture/2 after *Wathelet et al. 2008*)
- Maximum radius (distance) from center: 30 km (0.5 size of model in horizontal direction)
- Minimum depth: 0 km
- Maximum depth: 30 km

Source wavelet: Ricker waveform
random frequency and source mechanism inside the following bounds:
- Minimum dominant frequency: 0.01 Hz
- Maximum dominant frequency: 2 Hz
- Source mechanism type: random moment tensor component scaling

Velocity structure 1
2-layer model with horizontal layer boundary
Horizontally homogeneous layers
Depth of layer boundary: 1 km
P-wave velocity of shallow layer: 3598 m/s
S-wave velocity of shallow layer: 1500 m/s
Density of shallow layer: 1800 kg/m^3
P-wave velocity of deep layer: 7621 m/s
S-wave velocity of deep layer: 4400 m/s
Density of deep layer: 2500 kg/m^3

Velocity structure 2
2-layer model with inclined layer boundary
Horizontally homogeneous layers
Inclined layer boundary with function: z[m] = (0.148148*x[m]/50-67)*50
P-wave velocity of shallow layer: 3598 m/s
S-wave velocity of shallow layer: 1500 m/s
Density of shallow layer: 1800 kg/m^3
P-wave velocity of deep layer: 7621 m/s
S-wave velocity of deep layer: 4400 m/s
Density of deep layer: 2500 kg/m^3

Data format

The continuous waveform data are published as big-endian binary files and can be opened using the numpy package in python with the following commands:

```
import numpy as np
[your_waveforms]=np.memmap([your_filename],dtype='>f4',mode='r',shape=(441,
308000),order='F')
```

The data created with velocity structure 1 can be found in the following files:

- vel1_arbxseis_nreceivers441_308000samples (displacement in x-direction at receiver locations)
- vel1_arbyseis_nreceivers441_308000samples (displacement in y-direction at receiver locations)
- vel1_arbzseis_nreceivers441_308000samples (displacement in z-direction at receiver locations)
- vel1_receiver_locations.txt (in meters from model origin)
- vel1_source_locations.txt (in meters from model origin)

The data created with velocity structure 2 can be found in the following files:

- vel2_arbxseis_nreceivers441_308000samples (displacement in x-direction at receiver locations)
- vel2_arbyseis_nreceivers441_308000samples (displacement in y-direction at receiver locations)
- vel2_arbzseis_nreceivers441_308000samples (displacement in z-direction at receiver locations)
- vel2_receiver_locations.txt (in meters from model origin)

- vel2_source_locations.txt (in meters from model origin)

References:

Saenger, E.H., Gold, N., and Shapiro, S.A. (2000), Modeling the propagation of elastic waves using a modified finite-difference grid, Wave Motion, 31, 77-92.

Wathelet, M., Dongmans, D., Ohrnberger, M., and Bonnefoy-Claudet, S. (2008), Array performances for ambient vibrations on a shallow structure and consequences over Vs inversion, J Seismol, 12:1-19.