**Synthetic Parameter Tests for Ambient Noise Tomography**

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**Introduction**

Ambient noise tomography has rapidly become a powerful tool with which seismologists throughout the world study the velocity structure of the crust and uppermost mantle using ambient seismic noise instead of earthquake recordings. Typically, the noise is recorded at periods ranging from 4 to 10 seconds, as the amplitudes are highest in that range. It is called the range is called the microseismic band, and contains the noise generated by ocean waves interacting with the coast and the sea floor. It is also well suited because the noise sources are well distributed, and the methodology actually requires randomly distributed sources. Newer studies are now also using shorter periods (see figures to the right). However, these studies only go as far as determining the dispersion curves or inverting for phase or group velocity maps. We are therefore curious to extend ambient noise recording between 0.5 and 3 seconds period. These can be used to determine surface wave dispersion curves. That end we present sensitivities and synthetic tests in the period range of 0.1 to 4 seconds, and compare them with the typically used 4 to 10 seconds band.

**Synthetic Waveforms**

The sources of ambient noise recorded by seismometers are most likely generated at the surface. Hence we calculate synthetic seismograms assuming a vertical force acting on the free surface, recorded on the vertical component of seismic station at a distance of 75 km. The full waveform is obtained by model summation.

However, a comparison of just the fundamental mode with the first 30 modes (including the fundamental) reveals that major differences exist only for the body waves arriving earlier. The surface waves are near identical so we proceed by just using the fundamental mode.

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**Sensitivity Kernels**

We calculate fundamental mode Rayleigh wave phase velocity sensitivities to illustrate the dependence of measured phase velocities to S-velocities at depth. At short periods (0.1 to 1 second) phase velocity depends only on the top few hundred meters. For longer periods the phase velocity rapidly becomes more sensitive to the S-velocities of the mid- to lower crust. Therefore we must use the short periods if we want to investigate the velocity structure of the uppermost crust.

**Conclusions**

The main conclusions of this study are quite straightforward: (1) in order to seismically investigate the shallow structure of the crust using surface waves we must use high frequency data. By this we mean periods significantly shorter than the microseismic band of 4-10 seconds. The Rayleigh wave group velocity dispersion curve measured between 0.1 and 4 seconds is relatively simple; the dispersion curve reveals two Ainy phases (slope ~ 0). However, the curve itself is easily measured.

Using a simple starting model with a constant velocity in the upper crust the true structure is not recovered as well. Importantly though, the slow velocities in the uppermost layers are seen in the inverted model.

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**Inversion of Synthetic Data**

With a real data set, crustal structure would be obtained by first measuring the surface wave group and/or phase velocities. The dispersion curve shows the frequency dependence of the surface wave velocities, and is then inverted for crustal structure at depth. The inversion of these data requires a suitable background model serving as a starting point for the inversion. This model should be similar to the real velocity structure of the study region for the inversion algorithm to yield a realistic image of the subsurface. It is important to note that the suitability of the background model also is a function of the depth region we are interested in and the frequencies used. We show this by simulating a real world scenario using the synthetic waveforms calculated previously and as if they were real data.

We first invert the measured dispersion curve using the same model used to calculate the synthetic waveforms as a starting model. Not surprisingly the true structure is well recovered by the inversion.

The longer periods also recover the crustal structure very well. The differences between the inverted model and the true structure are a bit larger than for the shorter periods, however.

At a first glance the recovered model looks similar to the one obtained at shorter periods. However the inversion does not yield the shallow low velocities.

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**References**