Introduction

With the widespread adoption of ambient noise tomography, and the increasing number of local earthquakes recorded worldwide due to dense seismic networks and many very dense temporary experiments, we consider it worthwhile to evaluate alternative methods to measure surface wave group velocity dispersions curves. Moreover, the increased computing power of even a simple desktop computer makes it feasible to routinely use methods other than the typically employed multiple filtering technique (MFT). MFT is a robust technique and thus often a good choice to measure dispersion. However, it involves a certain amount of averaging across frequencies. The measured dispersion curve may therefore be too smooth, or span across a too broad frequency range. While frequencies. The measured dispersion curve may therefore be inverted for velocity structure. As implied by its name, the method requires filtering the same trace multiple times. Typically these filters are Gaussian shaped, and centered at the frequency for which group velocity is measured. After filtering, the arrival time of the maximum of the envelope is picked and used together with epicentral distance to calculate group velocity at the respective period. Doing this with several filters, each centered at different periods, allows determining dispersion curves.

MFT

The Multiple Filter Technique (MFT) was introduced by Bouser et al. in 1994, as a way to measure surface wave group velocities. Countless studies have used MFT to determine group velocity dispersion curves of surface waves, which can be inverted for velocity structure. As implied by its name, the method requires filtering the same trace multiple times. Typically these filters are Gaussian shaped, and centered at the frequency for which group velocity is measured. After filtering, the arrival time of the maximum of the envelope is picked and used together with epicentral distance to calculate group velocity at the respective period. Doing this with several filters, each centered at different periods, allows determining dispersion curves.

Wigner-Ville vs MFT

We first compare MFT to Wigner-Ville (WV) on an observed teleseismic event. The measured dispersion is similar for both methods. However, WV produces a sharper picture. WV may introduce some artifacts, which can be reduced by smoothing (across time and frequency). Even after smoothing the dispersion curve as outlined by the contour is still sharper than using MFT. To test the performance of WV we proceed using synthetic waveforms.

Station Noise

The noise spectrum at seismic stations is not flat, and the amplitudes can thus vary significantly. We simulate best/worst case scenarios using Peterson’s (1993) noise models obtained from global ambient noise. The synthetic noise has the same amplitude spectrum as Peterson’s (1993) b and line noise models. Randomness is obtained from arbitrary phases assigned to each frequency (right).

Analysing Synthetic Seismograms

To compare MFT and WV with each other we compute a synthetic seismogram and measure the dispersion curve using both methods. The wave form is the vertical component of a Mw=3.2, 45° dip slip earthquake at 200 km distance using the PREM Earth model. We add random, but non-white noise to the synthetic seismogram with the amplitude spectra of the Peterson’s (1993) NLNM and NHNM. The resulting waveforms are shown on the right. We omit showing the noise-free case in the dispersion measurements (below), as it is very close to the low noise model case. Similarly to the teleseismic case, both methods produce comparable dispersion curves. However, in the case where high noise is added to the synthetic waveform, the noise itself is more visible in the MFT plots than WV.

Conclusions

- Both multiple filtering and Wigner-Ville yield similar results when measuring group velocity dispersion.
- MFT appears more robust over a wider frequency range.
- Wigner-Ville is more sensitive and better constrains dispersion measurements.
- The two methods may complement each other, whereby Multiple Filtering allows measuring dispersion over a wider frequency range and Wigner-Ville tells us about the true quality of the measurements.
- Random noise is better suppressed in WV, potentially allowing better detection of events.