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Generating Synthetic Receiver Functions Using Seismic Interferometry

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SUMMARY

Receiver functions have a wealth of crustal information and are useful to study the lithosphere. They require a powerful impulsive source like earthquakes and must be a teleseismic event from the receiver station. Such requirements does not always guarantee a good azimuthal coverage from the station which is essential to get good accurate results. Seismic interferometry is used to generate virtual impulsive sources of energy and synthesize synthetic receiver functions which provides additional azimuthal coverage. Such receiver functions can be stacked with other receiver functions having the same back azimuthal characteristics to obtain better crustal information.

Introduction

Seismic interferometry represents the crosscorrelation of receiver responses to obtain synthetic receiver responses, which are nothing but the Green's function response between the receivers. The advantage it possesses is that virtual impulsive sources of energy can be created at any point in space where receivers exist, without having any prior knowledge about the subsurface or its medium parameters, and their receiver responses can be synthesized. The scope of this source of energy can today be even extended to include seismic noise to image the subsurface as explained by Wapenaar et al., (2010).

Receiver functions are the receiver responses to teleseismic earthquakes. The large distance ensures that the seismic waves arriving at the receivers can be approximated to plane wavefronts and they reach the station almost vertically after crossing the crust-mantle boundary. Receiver functions therefore contain important crustal information, and the depth of the Mohorovičić discontinuity (Moho) which is the crust-mantle boundary can be found. Receiver function analysis has been used in the past to find the crustal thickness for (Chen et al., 2010; Srivardhan 2013) continental and oceanic crusts.

Synthetic Receiver Functions

The receiver functions for stations TARA (latitude 1.35°N and longitude 172.92°W) and BTDF (latitude 1.36°N and longitude 103.77°W) due to an earthquake at latitude 1.3388°N and longitude 85.2931° W occurring on 05-10-2009 are shown in Figure 1. (a), (b). The receiver functions were crosscorrelated to obtain a virtual impulsive source at station TARA and a synthetic receiver function for station BTDF was synthesized (Figure 1(c)). It is important to note that the latitudes for all the receiver stations and the source are almost the same or in other words the receivers and the source located at the ends or the extensions contribute most in the synthesize process (Nicolson et al., 2012).

Response Spectra of the stations

Figure 1 (a) The response spectra at station TARA. (b) The response spectra at station BTDF. (c) The response spectra of the crosscorrelated signal at station BTDF.

The synthesized receiver function is compared with the parent receiver function for station BTDF (Figure 2), and the arrival of various phases for both the signals are different. This is expected as both the functions though having the same azimuthal coverage from the station, have different back azimuth's from the source of the earthquake.

Figure 2 Comparing the crosscorrelated signal (black) with the parent signal (red) for station BTDF.

Conclusion

A methodology using seismic interferometry was proposed to synthesize synthetic receiver functions. These synthesized receiver functions provide additional azimuthal coverage to the station which may not be obtained unless there is a powerful earthquake in that direction. The synthesized receiver functions can be stacked with other receiver functions having the same back azimuthal characteristics to derive accurate crustal information.

References

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