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2.5D real waveform and real noise simulation of receiver functions in 3D models

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There are several reasons why a real-data receiver function differs from the theoretical receiver function in a 1D model representing the stratification under the seismometer. Main reasons are ambient noise, spectral deficiencies in the impinging P-waveform, and wavefield propagation in laterally varying velocity variations.
We present a rapid "2.5D" modelling approach which takes these aspects into account, so that a given 3D velocity model of the crust and uppermost mantle can be tested more realistically against observed recordings from seismometer arrays.
Each recorded event at each seismometer is simulated individually through the following steps:
A 2D section is extracted from the 3D model along the direction towards the hypocentre. A properly slanted plane or curved impulsive wavefront is propagated through this 2D section, resulting in noise free and spectrally complete synthetic seismometer data. The real vertical component signal is taken as a proxy of the real impingent wavefield, so by convolution and subsequent addition of real ambient noise recorded just before the P-arrival we get synthetic vertical and horizontal component data which very closely match the spectral signal content and signal to noise ratio of this specific recording.
When these realistic synthetic data undergo exactly the same receiver function estimation and subsequent graphical display we get a much more realistic image to compare to the real-data receiver functions.
We applied this approach to the Central Fjord area in East Greenland (Schiffer et al., 2013), where a 3D velocity model of crust and uppermost mantle was adjusted to receiver functions from 2 years of seismometer recordings and wide angle crustal profiles (Schlindwein and Jokat, 1999; Voss and Jokat, 2007).
Computationally this substitutes tens or hundreds of heavy 3D computations with hundreds or thousands of single-core 2D computations which parallelize very efficiently on common multicore systems. In perspective, the comparison can even be made quantitative, and an iterative inverse 3D model updating would be possible. Furthermore the "2.5D" modelling approach of the in reality 3D problem must be investigated in terms of accuracy of the approximation, in particular with focus on highly 3D structures and multiple phases.

References:
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