Geophysical Research Abstracts
Vol. 20, EGU2018-6493, 2018
EGU General Assembly 2018

3-d sensitivity kernels of the Rayleigh wave ellipticity

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The ellipticity of the Rayleigh wave at the surface depends on the seismic structure beneath and in the vicinity of the seismological station where it is measured and can thus be used as an independent data to constrain the structure locally. Both earthquake data and ambient noise recordings have been inverted in several studies using 1-D kernels that express how the ellipticity depends on the structure with depth. We show here how we can also obtain the 3-D kernels that describe the dependence of the ellipticity both with depth and laterally, with respect to S-wave velocity, P-wave velocity and density. Near-field terms as well as coupling to Love waves are included in the expressions. The kernels show maximum values close to the station, but with a complex pattern, even when smoothing in a finite-frequency range is used to remove the oscillatory pattern present in mono-frequency kernels. In order to follow the usual data processing flow, we also compute and analyse the kernels of the ellipticity averaged over incoming wave backazimuth. The kernels with respect to P-wave velocity have the simplest lateral variation and are in good agreement with commonly-used 1-D kernels. The kernels with respect to S-wave velocity and density are more complex and differ significantly from the 1-D kernels. Although it is clear that the ellipticity is mostly sensitive to the structure within half-a-wavelength of the station, is has a very complex sensitivity pattern and we discuss how this may affect how inversion should be performed.