Geophysical Research Abstracts
Vol. 14, EGU2012-9006, 2012
EGU General Assembly 2012

Using Radiative Transfer Theory to model six-component seismogram envelopes

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Recent measurements of rotational motions of the seismic wave field have shown a significant amount of rotational energy also in the coda of seismic events. In particular the rotational motion in the P-wave coda bears interesting information as it can only be excited by scattering of the wave-field at 3D heterogeneities. This rotational motion clearly indicates the conversion from P to S energy in the Earth's subsurface and subsequently the scattering of high-frequency seismic waves.

A suitable method to describe this phenomena is the Radiative Transfer Theory (RTT). RTT describes the spatial and temporal distribution of seismic energy emitted from a seismic source. It considers scattering and mode conversions between P, SV and SH polarizations. It also includes the angular dependent

scattering pattern derived from the Born approximation. The RTT approach implements Monte Carlo (MC) solutions to the radiative transfer equation. Since the RTT does not contain any phase information of the seismic waves, the energy of superimposing waves can be considered additive and no interferences between the seismic signals are treated. This makes the RTT a very useful tool for the description of scattered waves.

It has recently been shown that the RTT is a powerful method to compute seismogram envelopes for the three translational components of the seismic wave-field.

In this study we additionally compute the three rotational components and therefore extend the capabilities of the method to model six-component seismogram envelopes in an elastic medium with randomly distributed velocity and density perturbations.

The three additional rotational components can provide independent information about the Earth's structure and the seismic source. For instance they can be used to further constrain scattering properties and thus help to discriminate between intrinsic and scattering attenuation.

The results of the MC simulations are verified by comparison with 3D full wave-field finite difference simulations. Six-component seismogram envelopes from the two different approaches are compared. A reasonable agreement for the translational components as well as for the rotational energy is obtained.

In conclusion, the RTT is a useful approach to model the six-component seismogram envelopes of high-frequency wave-fields from the initial onset of the direct P-wave to the later part of the S-wave coda in random elastic media.