Geophysical Research Abstracts
Vol. 13, EGU2011-2999-1, 2011
EGU General Assembly 2011

Seismic tomography: recent developments and new perspectives

Guust Nolet, Christophe Zaroli, Jean Charlety, and Diego Mercerat
Geoazur, Sophia Antipolis, France (nolet@geoazur.unice.fr)

Though onset times satisfy by definition the equations of ray theory, modern broadband instrumentation allows for more and more accurate information to be extracted from seismograms than given by only one or just a few arrival times. Cross-correlation techniques are now generally used to measure travel times. These are more accurate than onset times, but have a fundamentally different meaning, since they incorparate information from the later part of the waveform.

In case a body wave arrival is not dispersive, this observation allows us to put a minimum size on the heterogeneities that cause the delay if we apply finite-frequency theory. In fact, evidence that body waves are dispersive is rapidly accumulating, and the measurement of this dispersion significantly increases the resolving power for smaller size anomalies that give rise to wavefront healing.

Sensitivity kernels for distinct body wave phases can be computed very efficiently using ray theory, but the rapid development of fast and accurate computational tools for the calculation of wavefields in 3D media now makes it possible to include arbitrary windows from the seismogram in the interpretation. It remains advantageous, however, to observe delay times by cross-correlation rather than invert for waveforms directly; the latter approach quickly turns highly non-linear unless the starting model is very close to the real Earth. By measuring the dispersion of delays, the waveform information is still taken into account in tomographic inversions. As for amplitudes, early results are encouraging, but show that focusing dominates over attenuation in perturbing body wave amplitudes.

These developments are new, and several challenges still remain to make them work without complications. Dispersion is not only caused by diffraction, but also by attenuation, multipathing, ghost signals or reverberations due to rather trivial structure such as the ocean bathymetry or thick sediment. This may be especially troublesome for phases like PP and SS that reflect in the oceanic domain, but early results to model sediment reverberations in local studies give reason for optimism. To make full use of the complicated sensitivity offered by finite-frequency theory, a dense parameterization is required, but this leads to very large, highly underdetermined inverse problems. Progress is made by solving these using a gradient search in the model domain ("adjoint inversion") or using new regularisation techniques in wavelet space ("compressed sensing"). However, the spectral element method, which is usually the method of choice for adjoint inversion, is not (yet) able to handle the full seismic spectrum for body waves.