Scattering effects in surface wave tomography by membrane waves

Summary: In order to conduct seismic tomography, one might use the most adequate description of wave propagation; thus, far, almost all tomographic models rely on ray theory, a high-frequency approximation. Particularly for surface waves, Born theory, a single-scattering theory, improves it by taking first order scattering effects into account. The resulting sensitivity kernels are typically derived from analytical far-field Green’s tensors, which lead to singularities at source and receiver locations; numerical derivation of kernels in contrast can avoid this, but full numerical integration of the equations of motion in 3D is expensive. For surface waves, the membrane wave method restricts the propagation to two dimensions; it allows thus to compute numerical sensitivity kernels in a shorter time. We investigate the potential of the membrane wave method to produce a kernel library for tomographic algorithms and compare our results with linear approximation theories.

Meshing of the Earth’s surface
Discretization takes advantage of geodesic grids initially found for meteorological flow modelling.

Numerical vs. analytical kernels

Algorithm’s performance

References

Acknowledgments

Figure captions:

- Error of the (a) unfiltered and (b) filtered numerical solution for different levels of grid refinement, compared with the analytical solution (see Fig. 1) in terms of arrival phase delay. Filtering is done around the corner frequency for Love waves at 150 s. Notice that the numerical displacements are more kinked (geographic delay) compared to the analytical ones.

- Meshing of the Earth’s surface

- Benchmarking of the code for Love waves at 150 s period with a propagation time of ~40 min.

- Scattering effects for lateral heterogeneities (blue circles) depending on their location between sources located at (0ºN,0ºE) and (0ºN,90ºE).

- A single-scattering theory, improves it by taking first order scattering effects into account. The resulting sensitivity kernels are typically derived from analytical far-field Green’s tensors, which lead to singularities at source and receiver locations; numerical derivation of kernels in contrast can avoid this, but full numerical integration of the equations of motion in 3D is expensive. For surface waves, the membrane wave method restricts the propagation to two dimensions; it allows thus to compute numerical sensitivity kernels in a shorter time. We investigate the potential of the membrane wave method to produce a kernel library for tomographic algorithms and compare our results with linear approximation theories.

- Discretization takes advantage of geodesic grids initially found for meteorological flow modelling.

- Numerical vs. analytical kernels

- Numerical sensitivity functions

- Membrane waves

- Algorithm’s performance

- References

- Acknowledgments

- Figure captions: