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Deep structure of the Earth : from the lower mantle to the inner core

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Normal modes of the Earth are split by the diurnal rotation, ellipticity, and lateral heterogeneity of the Earth. Splitting observations of mantle-sensitive modes are well explained by 3-D models of the mantle. Some modes, however, exhibit an anomalous splitting which is not explained by the Earth's rotation, ellipticity and mantle heterogeneity. These modes are thought to be sensitive to the properties of the inner core.
Following the observation of travel time anomalies of PKIKP waves (Poupinet et al. 1983) and the identification of anomalous split modes (Masters & Gilbert 1981), it has been proposed that anisotropy in the inner core can explain anomalous mode-splitting. Initial anisotropic models of the Earth were purely radial. With improved theory, data quality and measurement, the structure of the inner core appears to be more complex. Current structural models of the inner core now exhibit a degree one pattern and depth-dependent in anisotropy and attenuation.
Using normal modes theory, we calculate the coupling between modes in order to retrieve the odd-degree of the inner core, since self-coupling is sensitive to the even structure only. In this study, we use data collected from the 2004 Sumatra-Andaman and 2010 Chilean earthquakes, which were large enough in magnitude to excite core-sensitive modes, to determine models of anisotropy and attenuation for the deep Earth interior.
We couple the "High Order Perturbation Theory" (HOPT) package (Lognonné, 1991; Lognonné et Clévédé, 2002; Millot-Langet et al. 2003) with the "Neighborhood Algorithm" (NA) method (Sambridge, 1999a,b) and adapt them to run on the "EGEE" grid. In the HOPT package, perturbations are developed up to 3rd order in frequency and 2nd order in amplitude. This method allows us to compute synthetic seismograms in a 3-D Earth taking into account the Earth's diurnal rotation, ellipticity, and coupling between modes. The NA algorithm uses a Voronoi cell discretization. No linearization is involved, which makes the method suitable for the non-linear nature of our study. The algorithm is simple to implement, requiring only two parameters to define either an explorative or exploitative search.
This method allows us to study 3-D models of both anisotropy and attenuation from the lower mantle to the inner core. In this context, thousands of models can be generated and processed for a given set of data and parameters.