Research Interests

My research mainly aims at investigating the physical properties of planetary mantles from seismic data, taking into account the non-linearity between parameters and data. These properties may be either seismic velocities and/or temperature, radial anisotropy and composition. My Ph.D work was focused on the Earth's transition zone and has been published in the Geophysical Journal International (Drilleau *et al.*, 2013).

Summary of my Ph.D

Most of the 3-D global tomographic models are based on small perturbations of 1-D global models and are secondly used to derive temperature and composition distributions. However, the degree of heterogeneity in the transition zone due to phase transitions and convective motions can be strong enough so that the concept of a 1-D reference seismic model might be addressed.

To avoid the use of any seismic reference model, I developed a Markov chain Monte Carlo algorithm to assess the distributions of temperature and radial anisotropy of the Earth's transition zone from surface wave dispersion curves, here considering a given composition of the mantle. These interpretations are based on laboratory measurements of elastic moduli and on the Birch-Murnaghan equation of state. The global philosophy was to set as few *a priori* informations as possible to let the data speak for themselves. An originality of the algorithm is its ability to explore both smoothly varying models and first-order discontinuities, using C1-Bézier curves. This parameterization is able to generate a self-adapting parameter space exploration while reducing the computing time. The inverted parameters are the control points of the Bézier curves. Thanks to a Bayesian exploration, the probability distributions are governed by uncertainties on the data set.

The method was applied to both an oceanic path (Vanuatu-California) and a continental path (China-France), using the dispersion curves of Visser et al. (2008). Considering a pyrolitic composition, a monotonous temperature distribution is found between 350 and 1000 km, below the Pacific and Eurasia. Though surface wave data are weakly sensitive to the sharpness of the mid-mantle seismic discontinuities, the interpretation of the temperature distribution is highly related to the given composition and to the modeling of mineralogical phase transformations, in particular near 660 km depth. In both paths, the retrieved anisotropy structure agrees with previous studies indicating positive uppermost mantle anisotropy. Considering few *a priori* conditions, the transition zone appears to be isotropic along the Pacific path. By contrast, a negative shear wave anisotropy ($V_{SH} < V_{SV}$) of about 2 % is found at the top of the transition zone below Eurasia (~ 450 km depth), as suggested by Montagner and Kennett (1996) and Panning and Romanowicz (2006).

Works in progress

In the framework of the forthcoming NASA/JPL InSight mission, I am participating to a research team in order to test the ability of the InSight-SEIS experiment for Mars' deep interior modeling (Panning *et al.*, submitted to Icarus). My contribution to this work consists in applying the Bayesian algorithm to constrain the shear wave velocity structure along a great-circle of the uppermost mantle of Mars from the group velocity dispersion diagram of the fundamental mode. An originality is that the non-linear behavior of the energy diagram is taken into account by directly weighting the misfit function, for a given frequency, by the associated normalized energy. An important result is that, for the synthetic data, the +/-5% intervals around the median profiles of the distributions contain the input model, which is one of the requirements of the InSight mission.

Using the same approach as for Mars, a distribution of shear wave velocity and radial anisotropy along the great-circle can be obtained for a source/receiver couple. I am currently growing a global database for numerous source/receiver couples. Finally, the study of this database will give several statistically significant constraints about the 1-D global variability of a unique model (i.e. mean, median, mode, variance...).

The results obtained during my Ph.D strongly depend on the way the dispersion curves were computed by Visser et al. (2008). The method of dispersion curves measurements developed by

Visser et al. (2007, 2008) is based on the sampling of V_S models, but depends on the PREM, which is employed to restrict the research of models in the parameter space. A work in progress is to directly adapt the algorithm to waveforms.

A current work is to perform inversions of composition in cratonic areas, using regionalized dispersion curves and assuming a typical cratonic geotherm. Given that the trade-off between temperature and composition makes difficult to decorrelate the relative contribution of the different minerals, a discrete set of mineralogical models are considered, with both equilibrium assemblages (such as pyrolite and piclogite) and mechanical mixtures.

References :

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