Geophysical Research Abstracts
Vol. 19, EGU2017-3248-1, 2017
EGU General Assembly 2017

Implications of a-priori constraints in transdimensional Bayesian inversion for continental lithospheric layering

Corinna Roy (1), Marco Calo (2), Thomas Bodin (3), Barbara Romanowicz (1,4,5)

(1) UC Berkeley, CA, United States (corinna.roy@berkeley.edu), (2) Instituto de Geofísica, UNAM,Mexico, (3) Laboratoire de Geologie de Lyon,Lyon,France, (4) IPG, Paris,France, (5) Collège de France,France

Competing hypotheses for the formation and evolution of continents are highly under debate, including the theory of underplating by hot plumes or accretion by shallow subduction in continental or arc settings. In order to support these hypotheses, documenting structural layering in the cratonic lithosphere becomes especially important.

Studies of seismic-wave receiver function data have detected a structural boundary under continental cratons at 100–140 km depths, which is too shallow to be consistent with the lithosphere–asthenosphere boundary, as inferred from seismic tomography and other geophysical studies. This leads to the conclusion that 1) the cratonic lithosphere may be thinner than expected, contradicting tomographic and other geophysical or geochemical inferences, or 2) that the receiver function studies detect a mid-lithospheric discontinuity rather than the LAB.

Recent studies (Bodin et al., 2015, Calò et al. 2016) confirmed the presence of a structural boundary under the North American craton at 100–140 km depths by taking advantage of the power of a trans-dimensional Monte Carlo Markov chain (TMCMC). They generated probabilistic 1D radially shear wave velocity profiles for selected stations in North America by jointly inverting 2 different data types (PS Receiver Functions, surface wave dispersion for Love and Rayleigh waves), which sample different volumes of the Earth and have different sensitivities to
structure. In fact, they found at least one, and in some cases several additional mid-lithospheric discontinuities (MLD) at intermediate depths in the stable part of the craton. Such discontinuities are not present in the active western part of the US.

However, in their Bayesian approach, they made two major assumptions: First, they fixed the Vp/Vs ratio to a constant, averaged value for crust and mantle. Second, they added constraints on the crustal discontinuity depths in the prior distribution of the shear wave velocity. Given these strong assumptions, the question came up whether the observed MLDs are real features or only artifacts resulting from these assumptions, in spite of the fact that the Ps converted phase constraints are included using a waveform cross-convolution approach, which should be able to handle crustal multiples, in contrast to a standard RF inversion.

We investigated these concerns by including the Vp/Vs ratio as a random variable in the Bayesian approach. By performing simulations on synthetic Earth models, we can demonstrate that a variable/fixed Vp/Vs ratio has little effect on posterior distribution of VSV, but that the imposed constraints can introduce artificial layers in depth. Nevertheless, we can confirm the overall structure found by Calò et al. 2016.

Here, we also include SKS waveforms in the joint inversion and invert for azimuthal anisotropy to verify if layering in the anisotropic structure of the stable part of the North American continent is marked by significant changes in the direction of azimuthal anisotropy as found by Yuan and Romanowicz (2010). We recently demonstrated the power of this approach in the case of two stations located in different tectonic settings (Bodin et al., 2016). Here we extend this approach to a broader range of settings within the North American continent.