Earth as a Black Box: Advances in Bayesian Inversion and Applications in Global Seismology From the Crust to the Core

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Geophysical inference is a process that underlies everything we know about the Earth's interior. Seismologists use earthquake waves in a similar way astronomers use light to infer properties of distant objects in the universe. It is by means of these waves that the information about the Earth's interior is brought to the surface. However, while we are in a stage of mapping the Earth's crust, we are still discovering what lies beneath our feet in the deeper interior of our planet. Obtaining a too simplistic (or a too complex) geophysical model is one of the consequences of utilizing a conventional geophysical inversion that requires various subjective decisions. Some of the issues of traditional techniques are inadequate parameterization of a problem and an inaccurate knowledge of data noise. A trans-dimensional Bayesian inverse method has the excellent property of treating the number of model parameters (e.g. the number of basis functions in seismic tomography, or the number of layers in receiver function inversions) as an unknown in the problem. Furthermore, in a hierarchical extension of the trans-dimensional framework, the level of data noise can be relaxed to become a free parameter in the inversion. This is critical because it effectively quantifies the usable information present in the data, and therefore determines the complexity of the solution.

In this talk, I will show the application of the Bayesian methods to problems in global observational seismology. The presentation will include application to joint inversion of receiver functions and surface wave dispersion to image crustal and lithospheric structure, application to invert for the earthquake source parameters, application to travel-time tomography of the lowermost mantle, Earth's free oscillations, and recent advances in modeling the rotational dynamics of the inner core. The obtained results have profound consequences for the interpretation of structure and dynamics of the Earth's interior.