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Linking geodynamics and geophysical inversion with multiobservable probabilistic tomography

Juan Carlos Afonso (1,2), Nicholas Rawlinson (3), Yingjie Yang (1), Sergio Zlotnik (4), and Olga Ortega (4)

(1) Department of Earth and Planetary Sciences, Macquarie University, Sydney, Australia (juan.afonso@mq.edu.au), (2) CEED, University of Oslo, Norway, (3) Department of Earth Sciences, University of Cambridge, UK, (4) Laboratory of Numerical Computations, UPC, Barcelona, Spain

Our recent work (Afonso et al., 2013a,b; 2016) has demonstrated that multiobservable probabilistic tomography offers a sound method to characterize the thermochemical structure of the lithosphere and upper mantle and opens exiting new opportunities for deep-Earth imaging. In this method, all physical and chemical parameters defining an Earth model are linked together by fundamental thermodynamic relations, rather than by ad hoc empirical assumptions. This allows us to directly invert for the fundamental variables defining the physical state of the Earth's interior, namely, temperature, pressure, and major-element composition using a multitude of data sets with complementary strengths: body wave teleseismic data, surface wave phase dispersion data, gravity anomalies, long-wavelength gravity gradients, geoid height, receiver functions, absolute elevation, and surface heat flow data. In this probabilistic inversion scheme, traditional tomographic images of physical parameters such as 3-D seismic velocity become a "free" by-product. However, our tomographic images are, by design, also thermodynamically compatible with all the other inverted observables instead of satisfying one type of data set only. This is important, as any model deemed representative of the real physical state of the Earth's interior should pass the test of explaining other geophysical data sets as well.

Inverting for "geodynamic" parameters such as viscosity or convection-related topography in 3D within this multiobservable probabilistic inverse framework is a major challenge, mainly due to the computational cost of solving the Stokes equations; we are not aware of previous attempts to do so with a probabilistic approach. However, recent advances on Reduced Order Modelling and Proper Generalized Decompositions have allowed us to overcome the traditional difficulties and create a probabilistic inversion framework that not only inverts for the physical state of the mantle but also for dynamic variables in full 3D. In this talk we will present this new method and discuss its strengths and limitations for generating present-day and evolutionary models of the Earth's interior.

References:
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