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Topography of the inner core boundary: a stochastic approach

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Topography at the inner core boundary has been proposed to explain surprising seismic observations of some regional studies. Such observations are still debated, and numerical values of possible inner core topography have been proposed ranging from no topography to "inner core mountains" (10km height over length scales of 20km, as in Dai et al. 2012). The inner core boundary is a peculiar boundary, as it is the place where the iron alloy constituting the core freezes. The existence of a significant topography on such a boundary is possible, but unlikely. At thermodynamic equilibrium, no topography is expected, as any material above the equilibrium radius would have melted and any below would have frozen. However, mechanical forcing may push the system out of equilibrium. Dynamical topography could be forced by convective flows in the inner core or by outer core heterogeneities. A topography induced by outer core convection would be short-lived when compared to geodynamical processes in the bulk of the inner core ($\tau \approx 10 - 100\,$Myears), but long-lived compared to observations.

In this work, we give a geodynamical perspective over inner core topography. We constrain plausible amplitude of inner core topography, and discuss the implications for seismic observations. Any topography at the inner core boundary create an excess or loss of mass, relaxed by a viscous flow in the bulk of the inner core. The typical time scale of the relaxation is dependent on the viscosity profile of the inner core – primarily a function of the viscosity of the upper most layer of the inner core. This value is unknown, but the existence of an inner core topography would imply a high value for the viscosity (larger than $\approx 10^{19}$Pa.s) to sustain any topography on long time scale. We consider topography created by variations of growth rate on regional length scale due to outer core convection. We treat topography forcing as stochastic processes, and calculate the probability of observing a given topography. This stochastic approach allows us to calculate the stochastic properties of a topography, depending on the properties of the forcing. This can then easily be extended to different processes able to generate a topography at the inner core boundary.

Based on preliminary results, the highest proposed values for observed topography can not be interpreted as a normal behavior of inner or outer core dynamics. If confirmed, the regions are likely to be anomalous and originated from outliers in the distribution of stochastic processes.