Inference of mantle viscosity from geodynamic data: a genetic algorithm inversion method

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During the past two decades, considerable efforts have been dedicated to recover radial model of mantle viscosity from traditional inverse techniques, using two main sources: data related to the glacial isostatic adjustment of the Earth, and geophysical observables linked to the convection process. Indeed, radial variations in the viscosity of the mantle can in principle be determined from gravity measurements made at the Earth's surface by means of an analytical theory of mantle flow that provides geoid kernels relating density maps and viscosity profiles to the Earth's gravity field. A scaled global tomographic map of seismic wave speeds can be used as an estimate of the Earth's density distribution. A linear inverse problem can then be set up, with gravity observations as data, and the viscosity profile as unknown. Unfortunately, the solution to this problem is strongly non-unique, and a consensual radial model of Earth's viscosity has not been identified by traditional inverse techniques. The problem is further complicated by the existence of numerous tomographic models of seismic velocity, and by the fact that both thermal and chemical heterogeneities participate to the density variations, thus adding some difficulty in establishing an appropriate velocity-to-density scaling for the mantle.
We attempt to account for non-uniqueness in the inverse problem by exploring the solution space, formed of all possible radial profiles of Earth viscosity, by means of a non-deterministic global optimization method: the genetic algorithm. For each solution (radial viscosity profile), synthetic gravity anomalies are computed and tested against the gravity anomalies from GRACE. We experiment with different density models, based on competing tomographic images of the Earth.