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Radial models of viscosity and seismic velocity-to-density scaling from geophysical observables

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Knowledge of the Earth's mantle radial model of viscosity is of great importance to better understand Earth's mantle dynamics. During the past two decades, considerable efforts have been dedicated to recover such a model from traditional inverse techniques, appropriate viscoelastic modeling, and post-glacial rebound data. However, no consensual model could be identified. More recently, an alternate approach proposed to constrain the radial variations of viscosity from various geophysical observables, mainly gravity anomalies and seismic data. In this approach, an analytical theory of mantle flow provides geoid kernels that relate density maps and viscosity profiles to the Earth's gravity field. To a first approximation, 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. The problem is further complicated by the existence of numerous, competing tomographic models of seismic velocity, and by the way to interpret them. Growing evidences suggest that seismic velocity anomalies reflect thermal and chemical heterogeneities. Both sources of heterogeneity participate to the density variations, but unlike the effects of temperature changes, the consequences of chemical changes on seismic velocities and density are not well defined. This adds some difficulty in establishing an appropriate velocity-to-density scaling for the Earth's mantle. In the present study, we account for non-uniqueness in the inverse problem by exploring the model space of the radial profiles of viscosity and velocity-to-density scaling with a genetic algorithm. For each point of the model space explored by the genetic algorithm, we derive density models from seismic tomographic maps, and we compute synthetic gravity anomalies that we test against the gravity anomalies from GRACE.