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ECOMAN: a new open source software for Exploring the Consequences of Mechanical Anisotropy in the maNtle

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Coupling large-scale geodynamic and seismological modelling appears to be a promising methodology for better understanding the Earth's recent dynamics and present-day structure. So far, the two types of modelling have been mainly conducted separately, and a code capable of linking these two investigation methodologies is still lacking.

In this contribution we introduce ECOMAN, a new open source software that allows modelling the strain-induced mantle fabrics and related elastic anisotropy, and for performing different seismological synthetics, such as SKS splitting measurements and P- and S-wave isotropic and anisotropic inversions (Faccenda et al., in preparation).

As an input, the software requires the velocity, pressure, temperature (and additionally the fraction of deformation accommodated by dislocation creep) fields (averaged each 100 kyr for typical mantle strain rates) outputted by the large-scale mantle flow models.

The strain-induced mantle fabrics are then modelled with D-Rex (Kaminski et al., 2004, GJI), an open source code that has been parallelized and modified to account for fast computation, combined diffusion-dislocation creep (Faccenda and Capitanio, 2012a, GRL; 2013, Gcubed), LPO of transition zone and lower mantle polycrystalline aggregates, P-T dependence of single crystal elastic tensors (Faccenda, 2014, PEPI), advection and non-steady-state deformation of crystal aggregates in 2D/3D cartesian/spherical grids with basic/staggered velocity nodes (Hu et al., 2017, EPSL). The new version of D-Rex can solve for the LPO evolution of 100.000s polycrystalline aggregates of the whole mantle in a few hours, outputting the full elastic tensor of poly-crystalline aggregates as a function of each single crystal orientation, volume fraction and P-T scaled elastic moduli.

Extrinsic elastic anisotropy due to grain- or rock-scale fabrics or fluid-filled cracks can also be estimated with the Differential Effective Medium (DEM) (Ferreira et al., Nat. Geo; Sturgeon et al., Gcubed, 2019). Similarly, extrinsic viscous anisotropy can be modelled yielding viscous tensors to be used in large-scale mantle flow simulations (de Montserrat et al., in preparation).

The crystal aggregates can then be interpolated in a tomographic grid for (i) visual inspection of the mantle elastic properties (such as Vp and Vs isotropic anomalies; radial, azimuthal, Vp and Vs anisotropies; reflected/refracted energy at discontinuities for different incidence angles as imaged by receiver function studies;), (ii) generating input files for large-scale synthetic waveform modelling (e.g., SPECFEM3D format; FSTRACK format to calculate SKS splitting (Becker et al., 2006, GJI)), or to perform teleseismic P- and S-wave isotropic and anisotropic inversions with the method developed recently by (VanderBeek and Faccenda, 2021, in review).