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A Spectral Directors Method for Modeling the Coupled Evolution of Flow and CPO in Polycrystalline Olivine

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The crystallographic preferred orientation (CPO) of polycrystalline olivine affects both the viscous and seismic anisotropy of Earth's upper mantle with wide geodynamical implications. In this methods contribution, we present a continuous field formulation of the popular directors method for modeling the strain‐induced evolution of olivine CPOs, assuming the activation of a single preferred crystal slip system. The formulation reduces the problem of CPO evolution to a linear matrix problem that can easily be integrated alongside large‐scale geodynamical flow models, and conveniently minimizes the degrees of freedom necessary to represent CPO fields. We validate the CPO model against existing deformation experiments and naturally deformed samples, as well as the popular discrete grain model D‐Rex. A numerical model of viscoplastic thermal convection is built to illustrate how flow and CPO evolution may be two‐way coupled, suggesting that CPO‐induced viscous anisotropy does not necessarily strongly affect convection time scales, boundary (lid) stresses, and seismic anisotropy, compared to isotropic viscoplastic rheologies. As a consequence, geodynamical modeling that relies on an isotropic rheology (one‐way coupling) might suffice for predicting seismic anisotropy under some circumstances. Finally, we discuss limitations and shortcomings of our method, such as representing D‐ and E‐type fabrics or modeling flows with mixed fabric types, and potential improvements such as accounting for the effect of dynamic recrystallization.