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Onset of convection in an anisotropic viscous fluid and implications for geophysical flows

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The dynamics of planetary bodies is strongly dependent on the rheological properties of polycrystalline aggregates. The deformation process, specifically dislocation creep, that occurs in ice or olivine leads to the formation of a texture, yielding to anisotropic properties of the material. Until now, anisotropic viscosity has received little attention when related to complex geophysical flow, mostly because of the mathematical complexity of the description of the physical properties.

In this study, we propose to use an original mathematical technique derived from anisotropic elasticity to explore the range of effects we can expect when considering the onset of convection in an anisotropic viscous fluid. Using linear stability analysis, we determine the potential effect of anisotropic viscosity on the critical parameters for the onset : the critical Rayleigh number Ra_c and the critical wave number a_c, and the most unstable roll direction α_c which is specific to anisotropic convection.

Consequences for the dynamics of icy satellites and small-scale convection beneath the oceanic lithosphere will be discussed.