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Grain size evolution in convective ice shells: Application to Europa and the other icy satellites.

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On the basis of a physical model of grain size evolution, we determine the grain size spatial distribution within a convective ice shell and its effect on the convective instabilities. Our physical model is constrained from grain size measurements along ice cores on Earth's polar ice sheets and is self-consistently coupled to a 2D thermal convection code. For grain sizes ranging from 1 to 10 mm and for stresses lower than 0.01 MPa, which is typical of both convective ice shells and Earth's polar ice sheets, the deformation of ice should be governed by intracrystalline dislocation slip mainly on the basal plane and accommodated by GBM (Grain Boundary Migration) associated with normal grain growth or rotation recrystallization. In these conditions, the viscosity of ice is expected to be grain size and stress dependent, with grain size and stress exponents ranging between 1 and 2. Our simulations indicate that the grain size distribution in the convective sublayer is strongly heterogeneous with values ranging from 1 mm to several tens of centimeter. We will show how the grain size distribution and the convective instabilities are sensitive to the rheological assumptions and the presence of non-water impurities. Improving our knowledge of ice rheology from laboratory experiments and Earth field analysis in conditions similar to icy moons is required to better understanding how grain-scale processes control large-scale dynamical processes.