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Frazil ice dynamics in polynyas and leads

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The initial stage of sea ice formation in a turbulent ocean typically involves the growth of a suspension of frazil ice crystals in supercooled waters. In competition with turbulent mixing, these crystals rise buoyantly and eventually settle at the ocean surface. The resulting rapid growth of granular ice has been observed to make up a significant fraction of ice cover in certain locations. Our recent theoretical work suggests that the growth of individual frazil ice crystals may be significantly faster than had commonly been supposed. We here explore the consequences for the dynamics of a suspension of many frazil ice crystals in a well mixed layer. Frazil suspensions are affected by many processes, including the fluid dynamics of suspensions, nucleation, the collision and sintering of crystals, as well as crystal growth. These processes combine to control the evolving distribution of crystal sizes. We apply a model of the crystal size distribution in a well mixed layer to investigate the comparative importance of these mechanisms, quantify the controls on ice growth, and compare to available laboratory data. We complement our theoretical model with two-dimensional direct numerical simulations of turbulent convection with a suspension of resolved crystals, in order to elucidate the fluid dynamical coupling between ocean convection with crystal rise, and its impact on ice precipitation rates.