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Turbulence-Induced Wave Attenuation in the Marginal Ice Zone

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Ocean waves can penetrate hundreds of kilometers into the sea-ice covers (a region referred to as the Marginal Ice Zone, MIZ), before the ice covers fully attenuate their energy. To improve weather and climate forecasting, the dissipation of wave energy in the MIZ needs to be accurately parameterized in spectral wave models. However, current methods to predict wave attenuation by sea-ice (such as wave scattering and visco-elastic theory) have had mixed success in their ability to replicate wave measurements in the field. In particular, the inability of these parameterizations to replicate idealized laboratory-controlled experiments seems to suggest that critical dissipation processes are currently missing. In this study, we examine whether shear-induced turbulence between the orbital wave motion of the upper ocean and the sea-ice cover can explain field observations of wave attenuation in the MIZ. We do so by using observations from the Arctic Sea State Program, where both waves and under-ice turbulence were measured simultaneously. The results show that turbulence-induced wave attenuation is in good agreement with the observed wave attenuation during the field campaign. Thus, it suggests that turbulence should be included as dissipative mechanism of wave energy in the MIZ. A simple predictive model is proposed to estimate wave attenuation using a drag coefficient. While the drag coefficient is expected to depend on a variety of sea-ice properties, the drag coefficient can be reasonably estimated by the sea-ice concentration.