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Modelling the interplay between sea ice formation and the oceanic mixed layer: limitations of simple brine rejection parameterizations

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The subtle interplay between sea ice formation and ocean vertical mixing is hardly represented in current large-scale models designed for climate studies. Convective mixing caused by the brine release when ice forms is likely to prevail in leads and thin ice areas, while it occurs in models at the much larger horizontal grid cell scale. Subgrid-scale parameterizations have hence been developed to mimic the effects of small-scale convection using a vertical distribution of the salt rejected by sea ice within the mixed layer, instead of releasing it in the top ocean layer. Such a brine rejection parameterization is included in the global ocean–sea ice model NEMO-LIM3. Impacts on the simulated mixed layers and ocean temperature and salinity profiles, along with feedbacks on the sea ice cover, are then investigated in both hemispheres. The changes are overall relatively weak, except for mixed layer depths, which are in general excessively reduced compared to observation-based estimates. While potential model biases prevent a definitive attribution of this vertical mixing underestimation to the brine rejection parameterization, it is unlikely that the latter can be applied in all conditions. In that case, salt rejections do not play any role in mixed layer deepening, which is unrealistic. Applying the parameterization only for low ice–ocean relative velocities improves model results, but introduces additional parameters that are not well constrained by observations.