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A multi-column vertical mixing scheme to parameterize the heterogeneity of oceanic conditions under sea ice

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The heterogeneity of ocean surface conditions associated to a spatially variable sea ice cover needs to be represented in models in order to represent adequately mixed layer processes and the upper ocean density structure. This study assesses the sensitivity of the ocean-sea ice model NEMO-LIM to a subgrid-scale representation of ice-ocean interactions. The sea ice component includes an ice thickness distribution, which provides heterogeneous surface buoyancy fluxes and stresses. A multi-column ocean scheme is developed to take them explicitly into account, by computing convection and turbulent vertical mixing separately in the open water/lead fraction of grid cells and below each ice thickness category. For the first time in a three-dimensional simulation, the distinct temperature and salinity profiles of the ocean columns are allowed to be maintained over several time steps. It is shown that, if columns are laterally mixed with homogenization time scales shorter than 10 h, subgrid-scale effects exists but the model mean state is practically unaffected. For longer mixing time scales, in both hemispheres, the main impacts are reductions in under-ice mean mixed layer depths and in the summer melt of sea ice, following decreased oceanic heat flux at the ice base. Large changes in the open water temperature in summer suggest that the scheme could trigger important feedback processes in coupled simulations.