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Modelling salinity in a sea ice thickness distribution model

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The theory of sea ice thickness distribution is generalized to include sea ice salinity distribution. The formulation of the thermodynamic changes in ice salinity is done through a parameterization of brine entrapment and drainage, which is validated against a more complex sea-ice halodynamic module in a 1-D test case. The salinity distribution is included in LIM3, a 3D dynamic-thermodynamic model including ice thickness, enthalpy and age distributions as well as a description of the impact of ice salinity on ice growth and decay. LIM3 is coupled to the ocean model OPA9 and run over 1970-2006, forced by a combination of daily NCEP/NCAR reanalysis data and various climatologies. The seasonal cycle of the simulated sea ice salinity averaged over thickness categories agrees well with historical ice core salinity data. The simulated Arctic salinity distribution follows the salinity-thickness relations of Cox and Weeks (1974). Due to hemispherical differences in the forcings, the model simulates Arctic and Antarctic salinity fields that differ significantly. The simulated large-scale sea ice mass balance is found quite sensitive to the model representation of ice salinity. In the Arctic, including an in interactive salinity distribution enhances ice growth / melt rates through a direct impact on ice thermodynamics. Around Antarctica, the effect of an interactive salinity distribution is even larger. But, in contrast to the Arctic, the role of ice-ocean interaction is dominant: using a variable salinity enables to maintain significant ice growth with relatively small salt fluxes to the ocean, which in turn further reduces oceanic heat fluxes and enhances ice growth. Given the importance of salinity on the simulated sea ice characteristics, the salinity distribution should be included in assessments of the response of the high-latitude oceans to ongoing and

future climate change.