EGU24-12970, updated on 24 May 2024
https://doi.org/10.5194/egusphere-egu24-12970
EGU General Assembly 2024

A Mushy Model of Gas Bubble Nucleation and Transport in Sea Ice

Andrew Wells[1], Joseph Fishlock[1], and Christopher MacMinn[2]
[1]Dept of Physics, University of Oxford, Oxford, United Kingdom
[2]Dept of Engineering Science, University of Oxford, Oxford, United Kingdom

Gas bubble nucleation and transport within porous sea ice is an important factor in the biogeochemistry of sea ice. Freezing concentrates dissolved gas species present in ocean water, which can subsequently exceed saturation and nucleate as bubbles. Buoyant gas bubbles can escape to the atmosphere or redissolve into the liquid inclusions. The resulting transport is a key physical uncertainty for the flux of climatically important gases between the ice and the atmosphere, as well as the chemical and optical properties of the ice.

We develop a phenomenological model for the motion of a bubble rising in porous sea ice which includes viscous drag and bubble trapping. We apply this description of bubble transport to a thermodynamic model of sea ice growth. Our model extends the traditional mushy-layer theory describing the solidification of saltwater solutions to include a gas phase. The resulting model is solved numerically to investigate idealized gas dynamics during a seasonal cycle of ice growth and melt. We find that the total gas flux to the atmosphere during a season is highly sensitive to the ratio of the bubble size to the characteristic scale of the ice pore geometry. We also extend the description of bubble transport to include a distribution of bubble sizes. We evaluate the output of different versions of the model by comparing to field observations of argon content in sea ice from a study in Barrow, Alaska.