Carbon dioxide dynamics in Antarctic pack ice and related air-ice CO₂ fluxes

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There is increasing evidence that sea ice can exchange directly CO₂ with the atmosphere. These exchanges are driven by the evolution of the partial pressure of CO₂ (pCO₂) within sea ice and controlled by its permeability. Both these CO₂ fluctuations and permeability are linked to peculiar physical and biogeochemical processes such as sea ice temperature and texture, biological activity or precipitation of calcium carbonate minerals (CaCO₃). Among them, sea ice temperature was suggested as one of the main physical control of the pCO₂ dynamics and CO₂ transfer. Highest oversaturation of CO₂ (pCO₂ up to 915 ppmV) were encountered in coldest ice and result from winter processes (increased brine salinities, calcium carbonate precipitation, bacterial remineralization). However, cold ice is generally not permeable either to gas or water transfer. As the temperature crosses the threshold of about -5°C, sea ice become permeable to gas, and sea ice begins to release CO₂ to the atmosphere (up to 1.9 mmol.m⁻².d⁻¹). However, at the same time brine convection develops bottom-up in the sea ice cover and by fuelling microalgae primary production in nutrients, triggers strong undersaturation of CO₂ (pCO₂ down to 30 ppmV). Sea ice therefore turns into a CO₂ sink with CO₂ fluxes ranging from 0 to -6 mmol.m⁻².d⁻¹ depending, among other parameters, on the ice texture. On the whole, spring and summer Antarctic pack ice appears to act as a CO₂ sink which magnitude could be of significant importance in the budgets of air-sea CO₂ fluxes over the Southern Ocean.