CO_2 dynamics and related air-ice-sea gas transfer in spring pack and land fast sea ice

Delille B. [1*], V. Schoemann [2], C. Lancelot [2], D. Lannuzel [3], J.T.M. de Jong [3], B. Tilbrook [4,5], D. Delille [6], A.V. Borges [1], J.-L. Tison [7]

[1] *Chemical Oceanography Unit, Université de Liège, Belgium*
[2] *Ecologie des Systèmes Aquatiques, Université Libre de Bruxelles, Belgium*
[3] *Océanographie Chimique et Géochimie des Eaux, Université Libre de Bruxelles, Belgium*
[4] *CSIRO Marine Research, Australia*
[5] *ACE CRC and Antarctic Division, University of Tasmania, Australia*
[6] *Observatoire Océanologique de Banyuls, Université P. et M. Curie, France*
[7] *Glaciology Unit, Université Libre de Bruxelles, Belgium*

There are growing observations that sea ice exchange CO_2 directly with the atmosphere. To explore the relationships between sea ice-specific biogeochemical processes and fluxes of CO_2 at the air-ice interface, we carried out three surveys which addressed spring and summer CO_2 dynamics in Antarctic land fast sea ice, and first year and multiyear pack ice.
Spring and summer pCO_2 patterns are consistent between the three surveys and mainly result from physical processes (temperature increase and related melting, convection of brines,…) while the under-saturation observed in summer is the signature of chemical (dissolution of carbonate minerals) and biological processes within sea ice. Exchanges of CO_2 at the air-ice interface are unsurprisingly driven by the evolution of pCO_2 within sea ice, yet modulated by sea ice permeability.
Cold ice is generally not permeable either to gas or water transfer. As temperature crosses the threshold value of about -5°C, sea ice becomes permeable to gas, and sea ice begins to release CO_2 to the atmosphere at a rate up to 1.9 $mmol.m^{-2}.d^{-1}$. However, as the ice continues to warm up, pCO_2 decreases dramatically to reach under-saturation of CO_2 (pCO_2 down to 30 ppmV). and sea ice turns into a CO_2 sink with CO_2 fluxes ranging up to -6 $mmol.m^{-2}.d^{-1}$. First tentative, and probably underestimated, budgets of air-ice CO_2 fluxes point out that Antarctic sea ice edge would represents an additional CO_2 sink of 6 to 9 % to the current estimate of the uptake of the Southern Ocean south of 50°S. We assessed how realistic could be such CO_2 fluxes by estimating the potential CO_2 fluxes driven by each main sea ice biogeochemical processes. This independent assessment is consistent with estimates derived from air-sea CO_2 fluxes measurements and point out the significance of abiotic sea ice-specific biogeochemical processes.

* Bruno.Delille@ulg.ac.be