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Air-ice CO2 fluxes and pCO2 dynamics in the Arctic coastal area (Amundsen Gulf, Canada)

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Sea ice covers about 7% of the Earth surface at its maximum seasonal extent. For decades sea ice was assumed to be an impermeable and inert barrier for air – sea exchange of CO2 so that global climate models do not include CO2 exchange between the oceans and the atmosphere in the polar regions. However, uptake of atmospheric CO2 by sea ice cover was recently reported raising the need to further investigate pCO2 dynamics in the marine cryosphere realm and related air-ice CO2 fluxes. In addition, budget of CO2 fluxes are poorly constrained in high latitudes continental shelves [Borges et al., 2006]. We report measurements of air-ice CO2 fluxes above the Canadian continental shelf and compare them to previous measurements carried out in Antarctica.
We carried out measurements of pCO2 within brines and bulk ice, and related air-ice CO2 fluxes (chamber method) in Antarctic first year pack ice ("Sea Ice Mass Balance in Antarctica –SIMBA" drifting station experiment September – October 2007) and in Arctic first year land fast ice ("Circumpolar Flaw Lead" – CFL, April – June 2008). These 2 experiments were carried out in contrasted sites. SIMBA was carried out on sea ice in early spring while CFL was carried out in from the middle of the winter to the late spring while sea ice was melting.
Both in Arctic and Antarctic, no air-ice CO2 fluxes were detected when sea ice interface was below -10°C. Slightly above -10°C, fluxes toward the atmosphere were observed. In contrast, at -7°C fluxes from the atmosphere to the ice were significant. The pCO2 of the brine exhibits a same trend in both hemispheres with a strong decrease of the pCO2 anti-correlated with the increase of sea ice temperature. The pCO2 shifted from a large over-saturation at low temperature to a marked under-saturation at high temperature. These air-ice CO2 fluxes are partly controlled by the permeability of the air-ice interface, which depends of the temperature of this one. Moreover, air-ice CO2 fluxes are driven by the air-ice pCO2 gradient. Hence, while the temperature is a leading factor in controlling magnitude of air-ice CO2 fluxes, pCO2 of the ice controls both magnitude and direction of fluxes. However, pCO2 in Arctic is significantly higher than in Antarctica. This difference could be due to a higher level of organic matter in Arctic. The degradation of this organic matter fuel CO2 efflux from the ice to the atmosphere in early spring. We observed evidence of CaCO3 precipitation, but only at the top of the ice. Implications in term of air-ice CO2 transfer of such CaCO3 precipitation will be discussed. In addition, salt-rich snow appears to strongly affect air-ice CO2 fluxes in the arctic.

Borges, A. V., et al. (2006), Carbon dioxide in European coastal waters, Estuar. Coast. Shelf Sci., 70(3), 375-387.