Air-ice CO_2 fluxes in the Arctic coastal area (Amundsen Gulf).

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Introduction

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 CO_2 so that global climate models do not include CO_2 exchange between the oceans and the atmosphere in the polar region. However, uptake of atmospheric CO_2 over sea ice cover has been recently reported raising the need to further investigate pCO_2 dynamics in the marine cryosphere realm and related air-ice CO_2 fluxes.

1. Methodology and sampling site

We carried out direct measurements of pCO_2 within brines and related air-ice CO_2 fluxes (chamber method, *fig.1*) of Antarctic first year pack ice (during the "Sea Ice Mass Balance in Antarctica – SIMBA drifting station experiment, Bellingshausen Sea) and of Arctic first year fast ice (during the "Circumpolar Flaw Lead" project – CFL, Amundsen Gulf region of the Beaufort Sea).

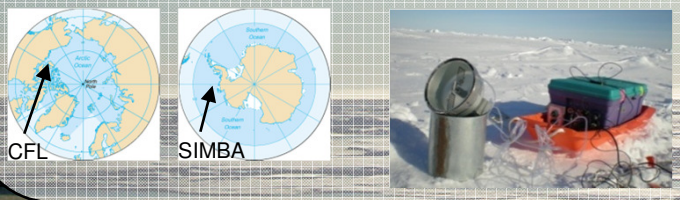

fig.1. – accumulation chamber for air-ice CO_2 fluxes measurements

2. Results (1)

Temperature exerts a strong control on pCO_2 dynamics (fig.2). As the temperature of the ice increases, the CO_2 in brines contained within the ice changes from a large over-saturation to a marked under – saturation (this shift occurs around -4°C). This trend is the same for both hemispheres. However, pCO_2 of the brines appears to be higher in Arctic than in Antarctica.

pCO2 decreases because of the dilution by decaying sea ice and related decrease of DIC. In addition, dilution allows the dissolution of the carbonate minerals that promote the decrease of pCO_2.

2. Results (2)

CO_2 fluxes at air – ice interface are not detectable or weak when the ice temperature is below -6°C (*fig.3*). As the ice warms, the permeability of the ice increases, allowing CO_2 transfer at the air – ice interface.

Air-ice CO_2 fluxes are in the same order of magnitude in both hemispheres. However, in Antarctica a flooding event induced a larger heterogeneity in the ice cover and a larger variability in the CO_2 fluxes. In Arctic, the formation of superimposed ice prevented air-ice gas transfer at temperature close to 0°C.

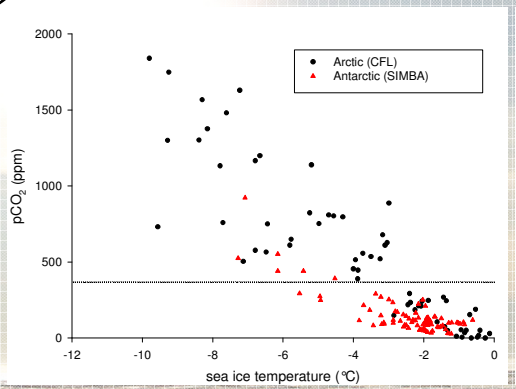

fig.2. – pCO_2 within brines versus sea ice temperature integrated over the depth of sackholes.

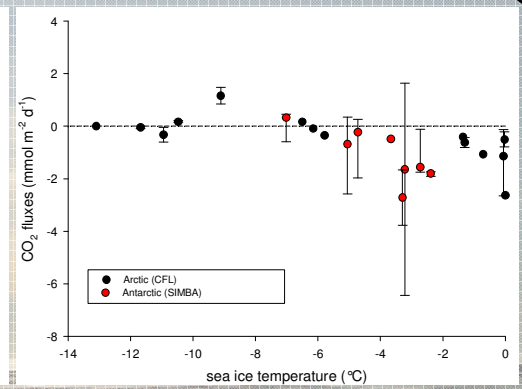

fig.3. – air-sea ice CO_2 fluxes versus sea ice temperature.

Conclusions

pCO_2 of brines exhibited high temporal variability strongly related to sea ice temperature. CO_2 fluxes also depends of the temperature of the ice for 2 reasons. First, CO_2 fluxes depend of the pCO2 of brines that is strongly related to temperature. Second, sea ice temperature controls brine channels connections and then exchanges between brines and atmosphere. In addition, physical processes, flooding, formation of superimposed ice exert a significant influence on CO_2 fluxes.

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