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.

Air-ice CO$_2$ fluxes in the Arctic coastal area (Amundsen Gulf).

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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.

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.
pCO$_2$ 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$_2$.

Conclusions
pCO$_2$ of brines exhibited high temporal variability strongly related to sea ice temperature. CO$_2$ fluxes also depend 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.