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Micrometeorological survey of air-sea ice CO2 fluxes in arctic coastal waters

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We carried out a 6 month study that aimed to robustly track CO2 exchange between land-fast sea-ice and the atmosphere during the winter and spring season. A meteorological mast equipped for eddy-covariance measurements was installed on land-fast sea-ice near Barrow (Alaska), 1 km off the coast, from the end of January 2009 to the beginning of June 2009, before ice break-up. These data were supported by continuous measurements of solar radiation, snow depth, ice thickness and temperature profile in the ice. Biogeochemical data necessary for the understanding of the CO2 dynamics in sea-ice were obtained through discrete ice coring.

Two regimes were detected for the CO2 exchanges linked with the status of the sea-ice: a winter regime and a spring summer regime.

From 27 of March onwards brine volume at the sea ice-snow interface was above the threshold of permeability for liquid according to Golden et al (1998). During this period, we observed some conspicuous CO2 fluxes events tightly linked to wind speed. The flux was directed from the sea-ice to the atmosphere and reached up to 0.6 umol m-2 s-1 (51.8 mmol m-2 d-1). This flux to the atmosphere is expected as sea-ice at the air interface is permeable during a large part of the period and brines are oversaturated compared to the atmosphere. CO2 may accumulate in the snow layer which thus acts as a buffer that is flushed under occurrence of high wind speeds and associated pressure pumping.

During the spring-summer period i.e. from 27 of April onwards, we observed a marked increase in sea ice temperature. Temperature profiles suggest that convective events occurred within the ice cover between April 27 and May 05. Within these convective events, two regimes were observed. First, for a period of 5 days, pCO2 was still above the threshold of saturation and CO2 fluxes were still mainly positive but lower than in the winter period, ranging from 0.1 to 0.2 umol m-2 s-1. This flux was only moderately controlled by windspeed perhaps due to the reduced snow cover. Further temperature increase led to a second flux regime where pCO2 of the brines were undersatured and sea ice shifted from a source to a sink of CO2 for the atmosphere, ranging from 0 to 0.1 umol m-2 s-1. These latter fluxes showed a diurnal pattern with no exchange during the night and downward fluxes during the day.

The physical and bio-chemical processes occurring within sea-ice that control these fluxes will be discussed in more depth in the presentation.