

## Gas (CO<sub>2</sub>) exchange through the sea ice

### Aims and introductory comments:

The aim of this module is to provide you with a brief introduction into measurements of CO<sub>2</sub> flux between the sea ice and atmosphere. The sea ice has been recently considered to play an important role in the carbon cycle in ice-covered waters, because the CO<sub>2</sub> exchanges through the sea ice as a permeable medium for gases. In this module, you will learn how to measure the CO<sub>2</sub> flux between the atmosphere and sea ice by using a chamber technique (see Figure 1) during the field course. You will also examine the exchange process through the sea ice structure as measuring physical properties of sea ice (i.e., temperature and salinity of sea ice), the brine content in sea ice collected by the sack hole method and the partial pressure of CO<sub>2</sub> (pCO<sub>2</sub>) in the brine and sea ice.



Figure 1. A picture showing the technique for measurements of the CO<sub>2</sub> flux by using a chamber technique at Saroma-ko lagoon, connecting to the Sea of Okhotsk, on the northern coast of Hokkaido, Japan.

### Reading material:

- 1) Course textbook: Chapter 9 (Section 9.2-9.3)
- 2) Gleitz, M., Loeff, M. R., Tomas, D. N., Dieckmann, G. S. and Millero, F. J., 1995. Comparison of summer and winter inorganic carbon, oxygen and nutrient concentrations in Antarctic sea ice brine. *Mar. Chem.* **51**, 81-89.
- 3) Nomura, D., Inoue-Yoshikawa, H. and Toyota, T., 2006. The effect of sea-ice growth on CO<sub>2</sub> exchange between the seawater and overlying air on the basis of tank experiments. *Tellus B*, **58B**, 418-426.
- 4) Semiletov, I.P., Makshtas, A. and Akasofu, S., 2004. Atmospheric CO<sub>2</sub> balance: The role of Arctic sea ice. *Geophys. Res. Lett.*, **31**, doi: 10.1029/2003GL017996.

### Instrumentation and measurements:

#### Equipment needed on the ice:

- 1) CO<sub>2</sub> measurement system
- 2) Stainless chamber to measure the CO<sub>2</sub> flux
- 3) Glass vials for transport of brine and under-ice water
- 4) Plastic syringe to collect the brine
- 5) Water sampler to collect under-ice water
- 6) Ice coring devices (generator, power head, ice corer)
- 7) Temperature sensor
- 8) Handheld drills to make holes in the ice core for measurements of temperature
- 9) Plastic containers for transport of ice cores
- 10) Snow and ice thickness measuring devices
- 11) A generator to operate the CO<sub>2</sub> measurement system

#### Equipment needed in the lab:

- 1) Salinometer to measure salinity of brine and under-ice water
- 2) PC to export the data from the logger and for analysis

#### Analysis and writing report:

- 1) Salinity measurement
- 2) Calculation of CO<sub>2</sub> flux:  
The CO<sub>2</sub> flux can be calculated from the changes in the CO<sub>2</sub> concentration in the chamber during the elapsed time.
- 3) The pCO<sub>2</sub> in the brine and under-ice water will be calculated from the dissolved inorganic carbon (DIC) and total alkalinity (TA) in the brine and under-ice water. The collected samples will be delivered to Hokkaido University, Japan for further analysis by a specially designed device. Analyzed data will be provided to prepare for writing the report.