VARIATIONS OF OCEANIC pCO₂ AND AIR-SEA CO₂ FLUX IN THE GREENLAND SEA AND THE BARENTS SEA

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ABSTRACT
In order to elucidate seasonal and interannual variations of oceanic CO₂ uptake in the Greenland Sea and the Barents Sea, partial pressures of CO₂ in the surface ocean (pCO₂sea) were measured from 1992 to 2001. The values of pCO₂sea were lower than the partial CO₂ pressures in the atmosphere (pCO₂air) throughout the year, and the annual net air-sea CO₂ fluxes in the Greenland Sea and the Barents Sea were evaluated to be 52 ± 31 and 46 ± 27 gC m⁻² yr⁻¹, respectively, yielding a total oceanic CO₂ uptake of 0.050 ± 0.030 GtC yr⁻¹. We also found that the annual mean CO₂ uptake was positively correlated with the North Atlantic Oscillation Index (NAOI) via wind strength, but was negatively correlated with ΔpCO₂ (pCO₂sea-pCO₂air) and the sea ice coverage. The results also indicate that the wind speed and sea ice coverage play a major role in determining the interannual variation of CO₂ uptake, with ΔpCO₂ playing a minor role.

INTRODUCTION
The Greenland Sea and the Barents Sea are thought to absorb a considerable amount of CO₂ since deep/intermediate waters are formed in these seas [e.g. Schloesser et al., 1990]. It is therefore crucial for a better understanding of the global carbon cycle to elucidate temporal and spatial variations of CO₂ uptake by these seas. We measured pCO₂sea in the two seas for the period 1992-2001. Based on the results of measurements, we show variations of pCO₂sea and air-sea CO₂ flux in the Greenland Sea and the Barents Sea.

OBSERVATIONS
Measurements of pCO₂sea were made 9 times covering four seasons mainly in middle Greenland Sea (73°-75°N, 15°W-5°E) and the western edge of the Barents Sea between the Scandinavian Peninsula and Svarbard Islands (70-78°N, 15°-20°E) by using a discrete flask sampling of air equilibrated with seawater. The CO₂ concentrations of air samples were determined against our air-based CO₂ standard gases with a precision of ± 0.5 ppmv using a gas chromatograph. The atmospheric CO₂ data at Ny-Ålesund in Svarbard Islands (79°N, 12°E) were used to calculate pCO₂air.

RESULTS AND DISCUSSION
The observed values of pCO₂sea ranged between 200 and 350 µatm, which are lower than those of pCO₂air. This suggests that the Greenland Sea and the Barents Sea take up CO₂ from the atmosphere through the year. The observed pCO₂sea values also showed a positive correlation with SST, except in May and June when the negative pCO₂sea-SST relationship was found in the western Greenland Sea due to CO₂ drawdown by biological activities. In addition, our pCO₂sea data suggested a long-term increase as Olsen et al. (2003) and Omar et al. (2003) recently found for the North Atlantic Ocean and the Barents Sea, respectively. Therefore, by assuming that pCO₂sea has increased at the same rate as pCO₂air, we derived a set of seasonally-varying pCO₂sea-SST relationships for the Greenland Sea and the Barents Sea to estimate the pCO₂sea values in 1995 using the SST data from the NCEP/NCAR reanalysis. The calculated pCO₂sea in the central Greenland Sea shows a seasonal variation with two maxima, one in April and another in November, and a minimum in June, while pCO₂sea in the western edge of the Barents Sea varied largely on a time scale of a few months (Fig. 1).

The air-sea CO₂ fluxes were calculated using gas transfer coefficient, wind speed, and ΔpCO₂ derived from the pCO₂sea-SST relationships, SST and pCO₂air at Ny-Ålesund. The air-sea CO₂ fluxes for the Greenland Sea ranged between 37 ± 22 gC m⁻² yr⁻¹ in summer and 72 ± 40 gC m⁻² yr⁻¹ in winter, showing an annual average of 52 ± 31 gC m⁻² yr⁻¹. On the other hand, the CO₂ fluxes for the Barents Sea were found to be 28 ± 16 gC m⁻² yr⁻¹ in spring and 63 ± 35 gC m⁻² yr⁻¹ in winter, with an annual average of 46 ± 27 gC m⁻² yr⁻¹. The total combined CO₂ uptake in the
Greenland Sea and the Barents Sea (70°-80°N, 20°W-40°E) was estimated to be 0.050 ± 0.030 GtC yr⁻¹. We also examined the sensitivity of seasonal/interannual variations of the oceanic CO₂ uptake to the gas transfer coefficient as a function of wind speed, ΔpCO₂ and the sea ice area (Fig. 2). The results showed that both the wind field and ΔpCO₂ were especially important for the seasonal variation in the CO₂ uptake. The interannual variability was estimated to be ±18% of the oceanic CO₂ uptake. The wind speed anomaly showed a positive correlation with the NAOI, while the anomalies of ΔpCO₂ and the sea ice area were negatively correlated with the index. The CO₂ uptake anomaly showed temporal variations similar to the NAOI. It was also found that the interannual variability of the CO₂ uptake was noticeably influenced by the wind speed (13%) and the sea ice area (15%), while the contribution of ΔpCO₂ was relatively little (4%).

Fig. 1. Seasonal variations of pCO₂sea and fCO₂sea in the central Greenland Sea (75°N, 0°, panel A) and the western Barents Sea (74°N 18°E, panel B).

Fig. 2. Anomalies of ΔpCO₂ (A), the sea ice cover (B), the wind speed (C), and the CO₂ uptake (D) in the Greenland Sea and the Barents Sea, and the North Atlantic Oscillation Index (E).

REFERENCES