VARIATIONS OF OCEANIC PCO_2 AND AIR-SEA CO_2 FLUX IN THE GREENLAND SEA AND THE BARENTS SEA

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ABSTRACT

In order to elucidate seasonal and interannual variations of oceanic CO_2 uptake in the Greenland Sea and the Barents Sea, partial pressures of CO_2 in the surface ocean (pCO_2^{sea}) were measured from 1992 to 2001. The values of pCO_2^{sea} were lower than the partial CO_2 pressures in the atmosphere (pCO_2^{air}) throughout the year, and the annual net air-sea CO_2 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 CO_2 uptake of 0.050 ± 0.030 GtC yr^{-1}. We also found that the annual mean CO_2 uptake was positively correlated with the North Atlantic Oscillation Index (NAOI) via wind strength, but was negatively correlated with ΔpCO_2 (pCO_2^{air}-pCO_2^{sea}) 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 CO_2 uptake, with ΔpCO_2 playing a minor role.

INTRODUCTION

The Greenland Sea and the Barents Sea are thought to absorb a considerable amount of CO_2, since deep/intermediate waters are formed in these seas [e.g. *Schlosser et al*., 1990]. It is therefore crucial for a better understanding of the global carbon cycle to elucidate temporal and spatial variations of CO_2 uptake by these seas. We measured pCO_2^{sea} in the two seas for the period 1992-2001. Based on the results of measurements, we show variations of pCO_2^{sea} and air-sea CO_2 flux in the Greenland Sea and the Barents Sea.

OBSERVATIONS

Measurements of pCO_2^{sea} were made 9 times covering four seasons mainly in middle Greenland Sea (73˚-75˚N, 15˚W-5E˚) 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 CO_2 concentrations of air samples were determined against our air-based CO_2 standard gases with a precision of ± 0.5 ppmv using a gas chromatograph. The atmospheric CO_2 data at Ny-Ålesund in Svarbard Islands (79°N, 12°E) were used to calculate pCO_2^{air}.

RESULTS AND DISCUSSION

The observed values of pCO_2^{sea} ranged between 200 and 350 μatm, which are lower than those of pCO_2^{air}. This suggests that the Greenland Sea and the Barents Sea take up CO_2 from the atmosphere through the year. The observed pCO_2^{sea} values also showed a positive correlation with SST, except in May and June when the negative pCO_2^{sea}-SST relationship was found in the western Greenland Sea due to CO_2 drawdown by biological activities. In addition, our pCO_2^{sea} 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 pCO_2^{sea} has increased at the same rate as pCO_2^{air}, we derived a set of seasonally-varying pCO_2^{sea}-SST relationships for the Greenland Sea and the Barents Sea to estimate the pCO_2^{sea} values in 1995 using the SST data from the NCEP/NCAR reanalysis. The calculated pCO_2^{sea} 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 pCO_2^{sea} in the western edge of the Barents Sea varied largely on a time scale of a few months (Fig. 1).

The air-sea CO_2 fluxes were calculated using gas transfer coefficient, wind speed, and ΔpCO_2 derived from the pCO_2^{sea}–SST relationships, SST and pCO_2^{air} at Ny-Ålesund. The air-sea CO_2 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 CO_2 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 CO_2 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 CO_2 uptake to the gas transfer coefficient as a function of wind speed, ΔpCO_2 and the sea ice area (Fig. 2). The results showed that both the wind field and ΔpCO_2 were especially important for the seasonal variation in the CO_2 uptake. The interannual variability was estimated to be ± 18 % of the oceanic CO_2 uptake. The wind speed anomaly showed a positive correlation with the NAOI, while the anomalies of ΔpCO_2 and the sea ice area were negatively correlated with the index. The CO_2 uptake anomaly showed temporal variations similar to the NAOI. It was also found that the interannual variability of the CO_2 uptake was noticeably influenced by the wind speed (13 %) and the sea ice area (15 %), while the contribution of ΔpCO_2 was relatively little (4 %).

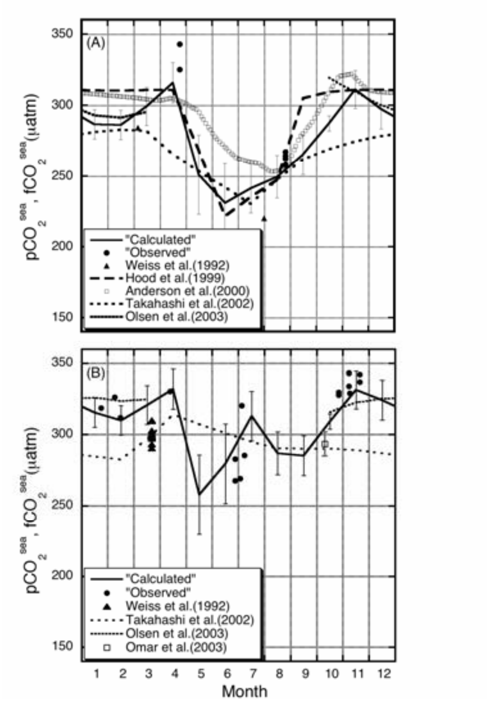

Fig. 1. Seasonal variations of pCO_2^{sea} and fCO_2^{sea} in the central Greenland Sea (75˚N, 0˚, panel A) and the western Barents Sea (74˚N 18˚E, panel B).

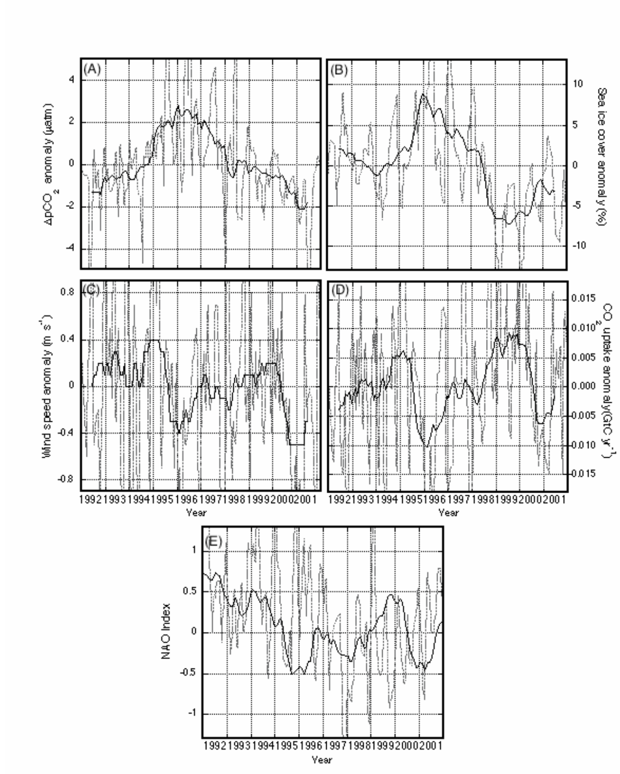

Fig. 2. Anomalies of ΔpCO_2 (A), the sea ice cover (B), the wind speed (C), and the CO_2 uptake (D) in the Greenland Sea and the Barents Sea, and the North Atlantic Oscillation Index (E).

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