北極域における大気ポテンシャル酸素と大気海洋間酸素フラックスの船舶観測

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Shipboard Observations of Atmospheric Potential Oxygen and air-sea O_2 flux in the northern North Pacific and the Arctic Ocean

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Simultaneous observations of Atmospheric Potential Oxygen (APO = O_2+1.1xCO_2) and air-sea O_2 flux were carried out onboard a research vessel MIRAI in the northern North Pacific and the Arctic Ocean in the autumns of 2012-2015. Air samples to measure the atmospheric $\delta(O_2/N_2)$ and CO_2 concentration to derive APO were collected on average once per day for the period September 5 – October 15, 2012, August 29 – October 6, 2013, September 1 – October 9, 2014 and August 27 – October 5, 2015. Dissolved oxygen concentration in the near-surface water was also measured continuously during these cruises, and converted to air-sea O_2 flux (F_{O2_obs}). The relationships of $\delta(O_2/N_2)$ and simultaneously-measured $\delta^{13}C$ with CO_2 concentration indicated that terrestrial biospheric activities and the air-sea O_2 flux are the main contributors to the observed variations in CO_2 concentration and APO, respectively. To compare the observed APO values with those simulated using the monthly air-sea O_2 flux climatology taken from the TransCom experimental protocol (F_{O2_cli}), a simulation of APO using a 3-dimensional atmospheric transport model forced by F_{O2_cli} was also carried out. The observed APO showed larger short-term variations than the simulated APO, and F_{O2_obs} also showed larger variation than F_{O2_cli}. A simple calculation indicated that the short-term variations in APO produced by using F_{O2_obs} were comparable in magnitude to the observed, and the characteristics of the temporal variations in the observed APO were relatively well reproduced by the calculated APO. These results strongly suggest that the short-term variations seen in the observed APO is attributable to the short-term variations in the air-sea O_2 flux around the observation area. The F_{O2_obs} values were systematically higher than the F_{O2_cli} values in all cruises, with an average difference of about 0.3 $\mu molm^{-2}s^{-1}$. By uniformly mixing the sea-to-air O_2 flux of 0.3 $\mu molm^{-2}s^{-1}$ from the northern hemisphere ocean into the overlying atmosphere during the fall season, it was possible to explain the discrepancy between the observed and simulated seasonal APO cycles seen at Ny-Ålesund, Svalbard and Sendai, Japan in the fall season. These findings show that simultaneous ship observations of APO and F_{O2_obs} are useful to validate regional air-sea O_2 fluxes in detail (Ishidoya et al., submitted).

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