スヴァールバル諸島ニーオルスンにおける酸素／窒素比および大気ポテンシャル酸素の高精度連続観測

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High-precision continuous measurements of the atmospheric oxygen/nitrogen ratio and atmospheric potential oxygen at Ny-Ålesund, Svalbard

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Simultaneous observations of atmospheric O_2 (defined as O_2/N_2 ratio) and CO_2 concentrations provide valuable information for understanding the global carbon cycle. Atmospheric Potential Oxygen (APO) defined as $APO=O_2+1.1\times CO_2$ (O_2 and CO_2 represent the O_2/N_2 ratio and the CO_2 concentration, respectively), which is conservative for land biospheric activities but variable by ocean-atmosphere O_2 exchange, can also be used to evaluate the air-sea O_2 flux. Therefore, several laboratories have developed precise measurement systems for the O_2/N_2 ratio and carried out systematic observations since the early 1990s. To elucidate the role of the Arctic region in the global carbon cycle in terms of atmospheric O_2, we developed a continuous measurement system using a differential fuel-cell O_2 analyzer, and initiated systematic observation at Ny-Ålesund (78˚55'N, 11˚56'E), Svalbard in November 2012 for the first continuous operation in the Arctic region. We report the results obtained from the first two years of measurement.

The O_2/N_2 ratio observed at Ny-Ålesund shows a clear seasonal cycle with peak-to-peak amplitude of about 140 per meg, which reaches a minimum in late March to early April and a maximum in August. The CO_2 concentration also varies seasonally, showing the amplitude of 17 ppm, but the phase is opposite to the O_2/N_2 ratio. APO shows the clear seasonal cycle similar to the O_2/N_2 ratio, and the amplitude is 55 per meg. In addition to the seasonal cycle, short-term variations on a timescale of several hours to several days are clearly observed. In spring and early summer, the O_2/N_2 ratio shows irregular fluctuations with the amplitude of 30–70 per meg (approximately corresponding to 6–15 ppm in mole fraction). Similar fluctuations are also found for the CO_2 concentration, but the phase is opposite to the O_2/N_2 ratio, and their amplitudes are 5 ppm at most. Irregular fluctuations of APO indicate the amplitude to be 20–50 per meg. From the comparison of backward trajectories of air parcels, as well as of the results of the tagged-tracer experiments using an atmospheric transport model, with the distribution of marine biological net primary production (NPP), it is suggested that such fluctuations of APO are closely related to O_2 emissions due to marine biological activities in the Norwegian Sea, the Greenland Sea and/or the Barents Sea. Sea-to-air O_2 flux is roughly estimated to be 1.4×10^5 μmol m^{-2} day^{-1} based on a fluctuation event of APO observed on June 17–19, 2013. The net community production (NCP) expected from the estimated O_2 flux is estimated to be 1.2×10^3 mgC m^{-2} day^{-1}, which is in good agreement with satellite-derived NPP within an order of magnitude. This suggests that in-situ continuous observation of APO at Ny-Ålesund is useful for estimating NCP and/or for validating the satellite-derived NPP data.

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