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Continuous measurements of the atmospheric O2/N2 ratio at Ny-Alesund, 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 about the global carbon cycle. For a better understanding of the global carbon cycle, 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 variations of the atmospheric O_2/N_2 ratio in detail and to contribute to a better understanding of the role of Arctic region on the regional and global carbon cycle, we developed a continuous measurement system using a differential fuel-cell O_2 analyzer, and then initiated systematic observation at Ny-Ålesund, Svalbard in November 2012, which is the first continuous observation in the Arctic region. The system is equipped with NDIR analyzer to measure CO_2 concentration simultaneously. The analytical precisions of O_2/N_2 ratio and CO_2 are estimated to be $\pm$1.4 per meg and $\pm$0.03 ppmv, respectively. Here, we will present observational results of the first year.

The O_2/N_2 ratio observed at Ny-Ålesund shows a clear seasonal cycle with peak-to-peak amplitude of about 120 per meg, which reaches a minimum in late March to early April and a maximum in August. On the other hand, the CO_2 concentration varies seasonally in opposite phase with the O_2/N_2 ratio, showing the amplitude of 16 ppm. Short-term variations on time scales of several hours to several days are also clearly seen. In winter, it is often observed that the O_2/N_2 ratio sharply declines in a short time, accompanied by an increase in the CO_2 concentration, and the low values last for several hours or days. The O_2:CO_2 exchange ratio defined as the slope of a linear regression line between the measured values of O_2/N_2 ratio and CO_2 range between -1.6 and -1.5 ppm/ppm, which are close to the average O_2:CO_2 exchange ratio expected from fossil fuel burning in Europe. The results of backward trajectory analysis indicated that the air masses arrived at Ny-Ålesund during the periods when such short-term variations were observed passed near or over Scandinavian Peninsula. Therefore, such a decline in the O_2/N_2 ratio is ascribed to transport of urban air influenced by human activities in Europe. In spring to summer, irregular fluctuations of O_2/N_2 ratio are often observed. The amplitude of such fluctuations reaches 50-60 per meg (corresponding to about 10-13 ppm). Similar fluctuations of CO_2 are also found in opposite phase with O_2/N_2 ratio. However, their amplitudes are 5 ppmv at most. The comparison of backward trajectories of air parcels with the distributions of marine biotic net primary production suggests that such fluctuations of O_2/N_2 ratio are closely related to O_2 emission due to marine biological activity near Norwegian Sea.

Keywords: atmospheric O2, carbon cycle, O2:CO2 exchange ratio, air-sea O2 flux