Short-term variations in atmospheric potential oxygen at Ny-Ålesund, Svalbard

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Oxygen in the atmosphere undergoes variations and changes in response to biospheric activities, ocean–atmosphere exchange, and fossil fuel combustion. To contribute to a better understanding of the global carbon cycle and air–sea O_2 exchange, continuous measurements of atmospheric O_2 (defined as $\delta(O_2/N_2)$) and CO_2 were started at the Japanese station in Ny-Ålesund in November 2012. This instrument setup is controlled remotely, as a first trial in the Arctic region, serviced annually by the personnel from Tohoku University and NIPR. Atmospheric potential oxygen (APO) calculated from the measured $\delta(O_2/N_2)$ and CO_2 show a clear seasonal cycle with a peak-to-peak amplitude of approximately 50 per meg. We also performed numerical simulations of APO using an atmospheric transport model (the JAMSTEC's ACTM) with prescribed oceanic O_2, N_2, and CO_2 fluxes. The seasonal cycle of APO simulated using the ACTM is in excellent agreement with the observed APO. However, in spring and early summer, high values of APO are observed irregularly on a timescale of hours to days. By comparing backward trajectories of air parcels released from the site with distributions of marine net primary production (NPP), and tagged tracer experiments made using the ACTM for APO, it is found that these high APO fluctuations are primarily attributable to O_2 emissions from the Greenland Sea, the Norwegian Sea, and the Barents Sea, due to marine biological productivity. Marine net community production (NCP), estimated based on the sea-to-air O_2 flux derived from observed APO fluctuations, agrees with NPP obtained from satellite observations within an order of magnitude. The results obtained in this study have still some uncertainties, but our continuous observations of atmospheric $\delta(O_2/N_2)$ and CO_2 mole fraction at Ny-Ålesund can play an important role in detecting possible changes in the carbon cycle in the near future.