Temporal and Spatial Variations of Tropospheric Carbon Monoxide over Japan

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Long-term systematic observations of the atmospheric CO concentration have been performed over Japan since February 1990. Air samples were collected using a chartered light aircraft (-4km) and commercial jet airliners (4-11km) once per month. Their CO concentrations were determined against our gravimetrically prepared standard gases using gas chromatographs with FID or HgO reduction detectors. The average CO concentration for the period covered by this observation is 200 ppbv at the lowest altitude of 0.5 km and 100 ppbv at the highest altitude of 10.5 km. A clear seasonal CO cycle is seen at all altitudes, and its amplitude is large at lower altitudes, mainly due to CO from anthropogenic sources in the Eurasian Continent. The CO in this region is extremely decreased in summer, due to its destruction enhanced, as well as to transport of maritime air associated with Asian monsoon. The vertical gradient of the CO concentration is largest in spring and diminishes greatly in summer. The influence of biomass burning in Siberia is clearly observed on both seasonal cycle and interannual variations of CO, especially at 3 km. CO emitted in India and South China is transported to the free troposphere over Japan through strong vertical convection, and affects the seasonal CO cycle. Emissions of CO from huge biomass burning in Siberia in 1996, 1998 and 2002/2003 have a significant influence on the interannual variations not only in the boundary layer but also in the free troposphere over Japan. We compared our observational results with those from model simulations by the Chemical AGCM for Study of atmospheric Environment and Radiative forcing (CHASER). The model reproduces the vertical profile and seasonal cycle of the CO concentration over Japan fairly well, but underestimates their values. The interannual CO variations calculated by the model are also smaller than the observed. Possible causes of these discrepancies are that the inventory scenario used in this study underestimates CO emission and/or overestimates the OH concentration by NO_X emission in Europe, as well as that CO emissions from biomass burning are underestimated and/or heights to which CO emitted by biomass burning is supplied are inappropriately represented in the model. The tagged CO tracer experiment reveals that CO produced by oxidation of CH_4 and NMHCs distributes uniformly at all heights, and that its seasonal variation is small. The CO tracers emitted in North America and Europe in winter are transported over a long distance and clearly observable over Japan. The contribution of CO from India and North Africa is also found in the upper troposphere over Japan.