Vertical profiles and temporal variations of greenhouse gases in the stratosphere over Syowa Station, Antarctica

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To understand the vertical distributions and temporal variations in CO_2, CH_4, N_2O, and SF_6 mole fractions in the Antarctic stratosphere, we collected air samples over Syowa Station in the austral summers of 1997/98, 2003/04, 2007/08, and 2012/13 using balloon-borne cryogenic air samplers (Honda et al. 1996) and newly developed compact cryogenic air samplers (J-T sampler) (Morimoto et al., 2009). Each air sampler was launched using a scientific plastic balloon, and landed on the sea ice using a parachute after collecting the stratospheric air at assigned altitudes between 10 and 30 km. After recovering the samplers, the respective constituents of air samples were analyzed. The vertical profiles of CO_2 and SF_6 mole fractions showed high values in the lower stratosphere, decreasing gradually with altitude, and then becoming almost constant at altitudes above 18 km. Stratospheric CO_2 and SF_6 over Antarctica increased secularly at respective average rates of 1.82 ± 0.31 ppm yr^{-1} and 0.26 ± 0.01 ppt yr^{-1} during the study period, but were delayed a few years compared to the troposphere. By comparing the average mole fractions of CO_2 and SF_6 above 18 km over Syowa with tropospheric data from Mauna Loa, the lag time in secular increase was estimated as 4.5 ± 0.5 years for CO_2 and 5.6 ± 0.2 years for SF_6. These results indicate that the stratospheric air over Syowa was older by about 4–6 years than the tropical tropospheric air. The CH_4 and N_2O mole fractions decreased with increasing altitude due to chemical reactions and photodissociation in the stratosphere, and a compact positive correlation between CH_4 and N_2O was found in their vertical profiles. By taking into account the N_2O depletion during transport of air from the tropical troposphere to the Antarctic stratosphere, the secular increase in stratospheric CH_4 was detected from measured values.

References

Honda, H., S. Aoki, T. Nakazawa, S. Morimoto, and N. Yajima, Cryogenic air sampling system for measurements of the concentrations of stratospheric trace gases and their isotopic ratios over Antarctica, *J. Geomagn. Geoelectr.*, **48**, 1145–1155. doi:10.5636/jgg.48.1145, 1996.

Morimoto, S., T. Yamanouchi, H. Honda, I. Iijima, T. Yoshida, S. Aoki, T. Nakazawa, S. Ishidoya, and S. Sugawara, A New Compact Cryogenic Air Sampler and Its Application in Stratospheric Greenhouse Gas Observation at Syowa Station, Antarctica. *J. Atmos. Oceanic Technol.*, **26**, 2182–2191, doi: 10.1175/2009JTECHA1283.1, 2009.