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Effect of atmospheric transport on seasonal and interannual variations in the atmospheric nitrous oxide concentration

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Atmospheric nitrous oxide (N_2O) concentration has dramatically increased due to anthropogenic activities from about 270 ppbv before industrialization to about 320 ppbv at the present. Recently, together with improvements of measurement precision for N_2O concentration, behaviors of shorter temporal variations such seasonal and interannual variations has been revealed more precisely than before. We extracted signals of the seasonal and interannual variations from N_2O high-precision data by AGAGE (Advanced Global Atmospheric Gases Experiment), Tohoku university and NOAA/ESRL GMD (National Oceanic and Atmospheric Administration/Earth System Research Laboratory, Global Monitoring Division). Explicit seasonal minima in summer to autumn and seasonal amplitudes of 0.7-1.0 ppbv were seen at northern mid-high latitudes, although such clear characteristics in the seasonal variations are not seen in other areas. The interannual variation at each site showed the variation period of 2-3 year, and those in the northern hemisphere showed large growth rates for the period 1999-2000. Such different time scales of variations have different causes for those. The secular trend is mainly due to the continuous anthropogenic N_2O emission, but seasonal and interannual variations are due to the variations in N_2O emissions and transport, driven by both anthropogenic activities and natural processes.

In this study, we focused on effects of the atmospheric transport on the N_2O variations. For understanding it, the atmospheric N_2O concentration was simulated us-

ing a chemistry-coupled atmospheric general circulation model (AGCM) nudged with ECMWF (European Centre for Medium-Range Weather Forecasts) and NCEP2 (NCEP-DOE Reanalysis 2) meteorological fields for the period 1980-2001. Simulations without chemistry were also performed to check the effect of the stratospheric chemical loss on the tropospheric N_2O concentration. Surface fluxes are prepared by combining 2 kinds of inventories. For simulating realistic emission trend, EDGAR (Emission Database for Global Atmospheric Research), which has no seasonal emission variation, was used, by interpolating the emissions in 1980, 1990, 1995 and 2000. GEIA (Global Emission Inventory Activity) was also used to test whether the seasonal emission now available can reasonably simulate the actual atmospheric N_2O variation and to compare with EDGAR. In those flux data, no interannual emission variations were contained.

The model results showed clear seasonal minima at the northern mid-high latitudes, and about 2-year cycle interannual variations and its large increase for 1999-2000 as well as those in the observations. The simulation with chemistry, using EDGAR fluxes and ECMWF, reproduced the observations the best, in terms of the seasonal and interannual variations. It means that the stratospheric chemistry is important for N_2O variations, and present seasonal emission data has some problems. Additionally, an analysis of zonal mean transport for N_2O was performed to understand the role of transport for N_2O variations. They indicated that N_2O advection from low latitudes with high N_2O emission via 300-500 hPa to the northern mid-high latitudes is important to decide seasonal high and low concentrations, although the stratospheric N_2O-poor air-mass also comes down. And at the areas, the interannual variations tend to propagate from upper troposphere to the surface, which means that stratospheric signal is significant to consider the cause of the interannual variation.