Spatial and temporal variations in atmospheric nitrous oxide concentration over the Pacific

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Atmospheric nitrous oxide (N_2O) concentration was observed in the Pacific for the period 1991-2006, using commercial container ships sailing between Japan and North America and between Japan and Australia or New Zealand. The N_2O concentration showed a secular increase and interannual variations at all sampling locations, but a seasonal cycle was detectable only at northern high latitudes. The annual mean N_2O concentration distributed longitudinally evenly within +-0.3 ppb in the northern Pacific, but showed a clear north-south gradient with the northern hemispheric values higher by about 0.8 ppb than the southern hemispheric values. The annual mean N_2O concentration also showed especially high values at 30 degrees north due to strong local N_2O emissions and a steep latitudinal decrease from the equator to 20 degrees south due to the suppression of exchange of both hemispheric air by South Pacific Convergence Zone. The N_2O growth rate varied interannually with periods of about 3 years, showing high values in 1999 and 2000, and its phase tended to delay going eastward and toward high latitude in the northern and western Pacific, respectively. The interannual variations of the N_2O growth rate showed a good correlation with those of soil water, suggesting that N_2O emission from soils plays an important role in interannually varying N_2O concentration observed in the area covered by this measurement. The multivariate ENSO index varies almost opposite in phase with the N_2O growth rate in both hemispheres, indicating that ENSO-related changes in oceanic N_2O emission and atmospheric transport are also important for the atmospheric N_2O concentration variations.

These observation results were analyzed by using AGCM (Atmospheric General Circulation Model) nudged with NCEP/DOE AMIP-II Reanalysis meteorological data. The model results were used to examine the effects of atmospheric transport on longitudinal/latitudinal distributions and interannual/seasonal variations of atmospheric N_2O concentration. EDGAR-based surface emission, which was mainly used in our modeling, showed reasonable performance for the spatial distribution, although it is indicated that present emission inventories probably underestimated land emissions at northern high latitudes. Temporal analyses indicated the possibility that atmospheric transport, including the stratospheric influences, could explain up-to about 50% of interannual and seasonal variations in atmospheric N_2O concentration.