Emission estimation of CFC substitutes in East Asia using a regional meteorological model and atmospheric observations

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Background: Hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs) are commonly used as substitutes for chlorofluorocarbons (CFCs) which have high ozone depletion potentials (ODP). While their ODP is zero or much lower than CFCs, they still have environmental impact via their high global warming potentials. In view of recent economic growth in East Asia, it is necessary to monitor the emissions of these halocarbons for better control. The target of this study is to estimate the size and the distribution of regional sources of these halocarbons in East Asia using observed atmospheric concentrations by combining a forward calculation to simulate the observed concentration and an inversion calculation to determine the most probable emission distribution using the result of the forward calculation.

Method: Forward calculation was conducted by the regional meteorological model RAMS (Regional Atmospheric Modeling System) developed by the Colorado state university, utilizing online-tracer function. The tagged simulation was conducted with the emission field in East Asia divided into 12-20 areas. The emission was prepared with the data provided by GEIA (Global Emissions Inventory Activity) and/or EDGAR (Emission Database for Global Atmospheric Research) and the latest publications of the annual total emission of each compounds. Horizontal resolution was 40km mesh longitude/ latitude and the number of grids was 120 both in the east-west/north-south direction. The computational domain was approximately 5000km x 4500km in the east-south and north-south direction respectively centering at 40^{o}N and 130^{o}E. The period of simulation was set from January 17th to March 31, 2005 including the spinning up period of approximately 2 weeks. The hourly observation data of halocarbons were provided by the automated online GC/MS system at Hateruma Island.

Results: For each sharp peak observed during the period, the calculated values give one or more corresponding peaks at the same timing, assuring the validity of the transport model simulation. However, when comparing the intensity of the observed and calculated peaks, the result using the initial emission was far smaller than observation, suggesting the underestimation of the inventory employed. By the inverse calculation using Bayesian statistical theory, the difference between the emission initially used in the simulation and the actual emission was estimated. Derived mean difference between calculated and observed peaks was a factor of 11(+-6) which can be converted to the annual emission of 31(+-18) Gg by multiplying the China emission used in the model. This result was consistent with the annual emission from China of 52(+-34) Gg estimated by the tracer-ratio technique using the observed concentration of HCFC-22 in 2005 [Yokouchi et al, 2006].