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Temporal trends and spatial variations of ozone-depleting substances (ODS) in the Pearl River Delta (PRD) region, southern China

Yanli Zhang (1), Xinming Wang (1), Donald Blake (2), and Isobel Simpson (2)

(1) Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, China (wangxm@gig.ac.cn), (2) Department of Chemistry, University of California, Irvine, CA, USA

Long-term observation of mixing ratios of ozone-depleting substances (ODS) in ambient air can help to assess the implementation of the Montreal Protocol and Its Amendments in regional and national scales. Here we present our measurement of ODS such as CFCs, HCFCs, halons and other halocarbons in ambient air since 2000 in the Pearl River Delta (PRD) region, one of the most densely populated and highly industrialized regions that was supposed to be a hotspot for ODS emission in China. These halocarbons in the PRD region were found to have 5-348% enhancements when compared to their global background levels. CFC-12 and CFC-11 in the region, for example, were 37-56% and 12-43%, respectively, above their global background levels. CFC replacement compounds showed even larger enhancements. In average mixing ratios of HCFC-22, HCFC-141b, and HCFC-142b were 89%, 87%, and 86% above their background levels of 148 ppt, 12.1 ppt, and 12.1 ppt in the year of 2000, respectively; and 72%, 125%, and 52% over their background levels of 205 ppt, 20.2 ppt, and 20.0 ppt in the year of 2009, respectively. During 2000-2009, CFCs in the PRD region showed decline trends with the decreasing rates of -3.0, -5.9, and -9.4 ppt/yr for CFC-12, CFC-11, and CFC-113, respectively; these rates were faster than that at the global background sites, which were -0.91, -2.12, and -0.69 ppt/yr, respectively. The CFCs substitutes HCFC-22, HCFC-141b, and HCFC-142b, however, showed increasing trends with the increasing rates of 8.0, 2.6, and 0.9 ppt/yr, respectively. HFC-134a, a refrigerant used for mobile air conditioning, showed rapid increase with a rate of 15 ppt/yr from 2000 to 2009 in the region. As for other halocarbons, methyl chloroform and carbon tetrachloride decreased with rates of 21 and 1 ppt/yr during the period. The mixing ratios of methyl chloride in the region showed unusual rapid increase at a rate of 64 ppt/yr when compared to its increasing rate of 1.3 ppt/yr at the global background sites. Spatial variations of ODS in the region were also explored with two grid-study campaigns by sampling concurrently at 84 sites. Source apportioning by PMF revealed that ODS were mainly coming from refrigerating/air-conditioning, industrial solvent use and biomass burning. Emission of these ODS in the PRD region was also estimated employing the CO-tracer method.