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Hydrochlorofluorocarbon and hydrofluorocarbon emissions in East Asia determined by inverse modeling

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The emissions of three hydrochlorofluorocarbons, HCFC-22 ($CHClF_2$), HCFC-141b (CH_3CCl_2F) and HCFC-142b (CH_3CClF_2) and three hydrofluorocarbons, HFC-23 (CHF_3), HFC-134a (CH_2FCF_3) and HFC-152a (CH_3CHF_2) from five East Asian countries for the year 2008 are determined by inverse modeling. The inverse modeling is based on in-situ measurements of these halocarbons at the Japanese stations Cape Ochi-ishi and Hateruma, the Chinese station Shangdianzi and the South Korean station Gosan. For every station and every 3 hours, 20-day backward calculations were made with the Lagrangian particle dispersion model FLEXPART. The model output, the measurement data, bottom-up emission information and corresponding uncertainties were fed into an inversion algorithm to determine the regional emission fluxes. The model captures the observed variation of halocarbon mixing ratios very well for the two Japanese stations but has difficulties explaining the large observed variability at Shangdianzi, which is partly caused by small-scale transport from Beijing that is not adequately captured by the model. Based on HFC-23 measurements, the inversion algorithm could successfully identify the locations of factories known to produce HCFC-22 and emit HFC-23 as an unintentional byproduct. This lends substantial credibility to the inversion method and is, to our knowledge, the first time greenhouse gas emissions from point sources can be determined by inverse modeling using stations of a global network. The HFC-23 emissions thus determined will also be compared to emissions reported for some factories in the framework of Clean Development Mechanism projects. We report national emissions for China, North Korea, South Korea and Japan, as well as for the Taiwan region. Halocarbon emissions in China are much larger than the emissions in the other countries together and contribute a substantial fraction to the global emissions. Our estimates of Chinese emissions for the year 2008 are 64.9±6.5 kt/yr for HCFC-22 (17% of global emissions extrapolated from Montzka et al., 2009), 12.0±1.6 kt/yr for HCFC-141b (22%), 7.3±0.7 kt/yr for HCFC-142b (17%), 6.2±0.6 kt/yr for HFC-23 (>50%), 12.8±1.7 kt/yr for HFC-134a (9% of global emissions estimated from Velders et al., 2009) and 3.4±0.5 kt/yr for HFC-152a (7%).