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Systematic analysis of interannual and seasonal variations of model-simulated tropospheric NO₂ in Asia and comparison with GOME-satellite data

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Abstract. Systematic analyses of interannual and seasonal variations of tropospheric NO₂ vertical column densities (VCDs) based on GOME satellite data and the regional scale chemical transport model (CTM), Community Multi-scale Air Quality (CMAQ), are presented for the atmosphere over eastern Asia between 1996 and June 2003. A newly developed year-by-year emission inventory (REAS) was used in CMAQ. The horizontal distribution of annual averaged GOME NO₂ VCDs generally agrees well with the CMAQ results. However, CMAQ/REAS results underestimate the GOME retrievals with factors of 2–4 over polluted industrial regions such as Central East China (CEC), a major part of Korea, Hong Kong, and central and western Japan. The most probable reasons for the underestimation typically over the CEC are accuracy of the basic energy statistic data, emission factors, and socio-economic data used for construction of emission inventory. For the Japan region, GOME and CMAQ NO₂ data show reasonable agreement with respect to interannual variation and show no clear increasing trend. For CEC, GOME and CMAQ NO₂ data indicate a very rapid increasing trend from 2000. Analyses of the seasonal cycle of NO₂ VCDs show that GOME data have larger dips than CMAQ NO₂ during February–April and September–November. Sensitivity experiments with fixed emission intensity reveal that the detection of emission trends from satellite in fall or winter has a larger error caused by the variability of meteorology. Examination during summer time and annual averaged NO₂ VCDs are robust with respect to variability of meteorology and are therefore more suitable for analyses of emission trends. Analysis of recent trends of annual emissions in China shows that the increasing trends of 1996–1998 and 2000–2002 for GOME and CMAQ/REAS show good agreement, but the rate of increase by GOME is approximately 10–11% yr⁻¹ after 2000; it is slightly steeper than CMAQ/REAS (8–9% yr⁻¹). The greatest difference was apparent between the years 1998 and 2000:



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CMAQ/REAS only shows a few percentage points of increase, whereas GOME gives a greater than 8% yr⁻¹ increase. The exact reason remains unclear, but the most likely explanation is that the emission trend based on the Chinese emission related statistics underestimates the rapid growth of emissions.

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