Global Inventory of Nitrogen Oxide Emissions Constrained by Space-based Observations of NO_2 Columns

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Abstract

We use tropospheric NO_2 columns from the Global Ozone Monitoring Experiment (GOME) satellite instrument to derive top-down constraints on emissions of nitrogen oxides (NO_x = NO + NO_2), and combine these with a priori information from a bottom-up emission inventory (with error weighting) to achieve an optimized a posteriori estimate of the global distribution of surface NO_x emissions. Our GOME NO_2 retrieval improves on previous work by accounting for scattering and absorption of radiation by aerosols; the effect on the air mass factor (AMF) ranges from +10% to -40% depending on the region. Our AMF also includes local information on relative vertical profiles (shape factors) of NO_2 from a global 3-D model of tropospheric chemistry (GEOS-CHEM); assumption of a globally uniform shape factor, as in most previous retrievals, would introduce regional biases of up to 40% over industrial regions and a factor of 2 over remote regions. We derive a top-down NO_x emission inventory from the GOME data by using the local GEOS-CHEM relationship between NO_2 columns and NO_x emissions. The derived NO_x emissions for industrial regions are aseasonal, despite large seasonal variations in NO_2 columns, providing confidence in the method. Top-down errors in monthly NO_x emissions are about 50%, comparable to bottom-up errors over source regions. Annual global a posteriori errors are half of a priori errors. Our global a posteriori estimate for annual land surface NO_x emissions (37.7 Tg N yr^{-1}) agrees closely with the GEIA-based a priori (36.4) and with an independent bottom-up inventory (EDGAR 3.0) (36.6), but there are significant regional differences. A posteriori NO_x emissions are higher by 50-100% in the Po Valley, Tehran, and Riyadh urban areas, and by 25-35% in Japan and South Africa. Biomass burning emissions from India, central Africa, and Brazil are lower by up to 50%; soil NO_x emissions are appreciably higher in the western United States, the Sahel, and southern Europe.