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NOx emission trends in megacities derived from satellite measurements

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The effects of air pollutant emissions on both local air quality in megacities and composition of the atmosphere on regional and global scales are currently an important issue of atmospheric researches. In order to properly evaluate these effects, atmospheric models should be provided with accurate information on emissions of major air pollutants. However, such information is frequently very uncertain, as it is documented in literature. The quantification of emissions and related effects is an especially difficult task in the case of developing countries. Recently, it has been demonstrated that satellite measurements of nitrogen dioxide (NO2) can be used as a source of independent information on NOx emissions. In particular, the satellite measurements were used in our earlier studies to improve spatial allocation of NOx emissions, to estimate multi-annual changes of NOx emissions on regional scales and to validate data of traditional emission inventories (see Ref. 1, 2).

The goals of the present study are (1) developing an efficient method for estimation of NOx emissions trend in megacity regions by using satellite measurements and an inverse modeling technique and (2) obtaining independent estimates of NOx emission trends in several megacities in Europe and the Middle East in the period from 1996 to 2008. The study is based on the synergetic use of the data for tropospheric NO2 column amounts derived from the long-term GOME and SCIAMACHY measurements and simulations performed by the CHIMERE chemistry transport model. We performed the analysis involving methods of different complexity ranging from estimation of linear trends in the tropospheric NO2 columns retrieved from satellite measurements to evaluation of nonlinear trends in NOx emission estimates obtained with the inverse modeling approach, which, in the given case, involves only very simple and transparent formulations.

The most challenging part of the study is the nonlinear trend estimation, which is performed by means of an original algorithm enabling filtering out noisy fluctuations caused by measurement and model errors from the retrieved time series of the NOx emission estimates. Our algorithm does not require any a priori knowledge of uncertainties in the satellite measurements and in the model results or of a character of the nonlinearity; it uses artificial neural networks for fitting the trend and the probabilistic approach along with the cross validation technique for estimation of their optimal parameters. As a result, statistically significant nonlinearities of the NOx emission trends are revealed in 5 megacities (Barcelona, Madrid, Milan, Moscow and Paris) out of 12 megacities considered.

Our NOx emission trend estimates are compared with the corresponding data of the EMEP emission inventory. This comparison confirmed that the emission control measures have been efficient for most of Western Europe, but indicated also possible inaccuracies of the EMEP data for some megacity regions.

Results of model runs using the obtained estimates of emission changes are found to be consistent with data of independent near-surface measurements of nitrogen oxides in London, Madrid, Milan and Paris. Moreover, it is found that the nonlinear trends of NOx emissions (where they are revealed) are more consistent with near surface measurements than the linear trends.

References

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