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Global Trends of Tropospheric NO_2 Observed From Space

P. Schneider (1) and R. J. van der A (2)

(1) NILU - Norwegian Institute for Air Research, Norway (ps@nilu.no), (2) Royal Netherlands Meteorological Institute, De Bilt, Netherlands

Nitrogen Dioxide (NO_2) is one of the major atmospheric pollutants and is primarily emitted by industrial activity and transport. While observations of NO_2 are frequently being carried out at air quality stations, such measurements are not able to provide a global perspective of spatial patterns in NO_2 concentrations and their associated trends due to the stations' limited spatial representativity and an extremely sparse and often completely non-existent station coverage in developing countries. Satellite observations of tropospheric NO_2 are able to overcome this issue and provide an unprecedented global view of spatial patterns in NO_2 levels and due to their homogeneity are well suited for studying trends.

Here we present results of a global trend analysis from nearly a decade of NO_2 observations made by the SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY) instrument onboard the Envisat satellite platform. Using only SCIAMACHY data allows for mapping global and regional trends at an unprecedented spatial resolution since no aggregation to the coarser resolution of other sensors is necessary. Monthly average tropospheric NO_2 column data was acquired for the period between August 2002 and August 2011. A trend analysis was subsequently performed by fitting a statistical model including a seasonal cycle and linear trend to the time series extracted at each grid cell. The linear trend component and the trend uncertainty were then mapped spatially at both regional and global scales.

The results show that spatially contiguous areas of significantly increasing NO_2 levels are found primarily in Eastern China, with absolute trends of up to 4.05 ($\pm$ 0.41) $\times$ 10^{15} molecules cm^{-2} yr^{-1} at the gridcell level and large areas showing rapid relative increases of 10-20 percent per year. In addition, many urban agglomerations in Asia and the Middle East similarly exhibit significantly increasing trends, with Dhaka in Bangladesh being the megacity with the most rapid relative increase during the study period (9.5 $\pm$ 1.7 percent per year). In contrast, significantly decreasing trends in NO_2 levels exist over large parts of Europe and the Eastern United States, with average rates of decrease in the range of 0 to -10 percent per year. The satellite-derived time series were further analysed with respect to identification of the impact of the 2008/2009 economic crisis. European trends obtained from the satellite analysis are also compared with corresponding trends computed using data of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) model, as well as with NO_2 trends calculated from station observations throughout Europe.