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Changes in OMI tropospheric NO2 columns over Europe (2004-2009) and the influence of meteorological variability

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In this study we investigate the changes in NO2 vertical tropospheric columns (VTCs) over Europe during the period 2004-2009 with a comprehensive statistical model. A high-resolution homogeneous data set was used based on observations performed by the Ozone Monitoring Instrument OMI (Zhou et al., 2009, 2010). External retrieval parameters including surface reflectance and surface pressure that largely affect the quality of the retrieved NO2 columns were improved by using high-resolution data sets. At each point of a regular grid, a Generalized Additive regression Model (GAM) with non-parametric model terms was fitted to the observed columns to describe the most relevant factors contributing to the observed variability in NO2 VTCs. These factors include seasonal cycle, day of week, wind, precipitation, retrieved cloud radiance fraction, and (linear) trend.
Significant negative trends found in areas with large anthropogenic sources over Western Europe, in particular in Western Germany, the Benelux area, Paris, and the Po Valley (mostly from -4 to -8% per year), which are in close agreement with predictions by the EMEP/CEIP expert emissions and previous trend studies. The largest decline rates were observed over the north-western part of Spain (-10 to approx. -20% per year) and the center of England (up to approx. -12% per year), which have not yet been discussed in previous trend studies. Closer inspection suggests that the sharp decrease over the energy production areas of Spain is due to the implementation of emission reduction measures for coal-fired power plants in this region. A number of other features of the temporal behavior of the time series of tropospheric NO2 over Europe were quantified, including clear seasonal and weekly cycles. Modeling the influence of wind considering both wind direction and wind speed not only improves the accuracy of the trend results, but also provides new insights into the sources of NO2 and the transport pathways of air pollutants.