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Surface NO_2 fields derived from joint use of OMI and GOME-2A observations with EMEP model output

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Nitrogen dioxide (NO_2) is one of the most prominent air pollutants. Emitted primarily by transport and industry, NO_2 has a major impact on health and economy. In contrast to the very sparse network of air quality monitoring stations, satellite data of NO_2 is ubiquitous and allows for quantifying the NO_2 levels worldwide. However, one drawback of satellite-derived NO_2 products is that they provide solely an estimate of the entire tropospheric column, whereas what is generally needed for air quality applications are the concentrations of NO_2 near the surface.

Here we derive surface NO_2 concentration fields from OMI and GOME-2A tropospheric column products using the EMEP chemical transport model as auxiliary information. The model is used for providing information of the boundary layer contribution to the total tropospheric column.

For preparation of deriving the surface product, a comprehensive model-based analysis of the spatial and temporal patterns of the NO_2 surface-to-column ratio in Europe was carried out for the year 2011. The results from this analysis indicate that the spatial patterns of the surface-to-column ratio vary only slightly. While the highest ratio values can be found in some shipping lanes, the spatial variability of the ratio in some of the most polluted areas of Europe is not very high. Some but not all urban agglomeration shows high ratio values. Focusing on the temporal behavior, the analysis showed that the European-wide average ratio varies throughout the year. The surface-to-column ratio increases from January all the way through April when it reaches its maximum, then decreases relatively rapidly to average levels and then stays mostly constant throughout the summer. The minimum ratio is observed in December. The knowledge gained from analyzing the spatial and temporal patterns of the surface-to-column ratio was then used to produce surface NO_2 products from the daily NO_2 data for OMI and GOME-2A. This was carried out using two methods, namely using 1) hourly surface-to-column ratio at the time of the satellite overpass as well as 2) using annual average ratios thus eliminating the temporal variability and focusing solely on the spatial patterns. A validation of the resulting surface NO_2 fields was performed using station observations of NO_2 as provided by the Airbase database maintained by the European Environment Agency. First results indicate that the methodology is capable of producing surface concentration fields that reproduce the station-observed surface NO_2 levels significantly better than the model surface fields as measured by the root mean squared error. The results also show that the spatial patterns of the surface-to-column ratio are more significant than its temporal variability.

In addition to deriving satellite-based surface NO_2, we further present initial results of a geostatistical methodology for downscaling satellite products of NO_2 to spatial scales that are more relevant for applications in urban air quality. This is being carried out by applying area-to-point kriging techniques while using high-resolution (1-2 km spatial resolution) runs of a chemical transport model as a spatial proxy.

In combination, these two techniques for deriving surface NO_2 and spatially downscaling satellite-based NO_2 fields have significant potential for improving satellite-based monitoring and mapping of regional and local-scale air pollution.