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# Application of OMI tropospheric $NO_2$ for air quality monitoring in Northern Europe: shipping and land-based case studies

Iolanda Ialongo (1), Janne Hakkarainen (1), Jukka-Pekka Jalkanen (2), Lasse Johansson (2), Folkert Boersma (3), Nickolay Krotkov (4), and Johanna Tamminen (1)

(1) Finnish Meteorological Institute, Atmospheric Remote Sensing, Helsinki, Finland (iolanda.ialongo@fmi.fi), (2) Finnish Meteorological Institute, Air Quality Unit, Helsinki, Finland, (3) Royal Netherlands Meteorological Institute, Climate Observations Department, De Bilt, The Netherlands, (4) Laboratory for Atmospheric Chemistry and Dynamics, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Satellite-based data are very important for air quality applications in the Baltic Sea area, because they provide information on air pollution over sea and there where ground-based network and aircraft measurements are not available. Both the emissions from urban sites over land and ships over sea, contribute to the tropospheric $NO_2$ levels. The tropospheric $NO_2$ monitoring at high latitudes using satellite data is challenging because of the reduced light hours in winter and the snow-covered surface, which make the retrieval complex, and because of the reduced signal due to low Sun.

This work presents a detailed characterization of the tropospheric $NO_2$ columns focused on part of the Baltic Sea region using the Ozone Monitoring Instrument (OMI) tropospheric $NO_2$ standard product. Previous works have focused on larger seas and lower latitudes. The results showed that, despite the regional area of interest, it is possible to distinguish the signal from the main coastal cities and from the ships by averaging the data over a seasonal time range. The summertime $NO_2$ emission and lifetime values ($E = (1.0 \pm 0.1)\text{x}10^{28}$ molec. and $\tau = (3.0 \pm 0.5)$ h, respectively) in Helsinki were estimated from the decay of the signal with distance from the city center. The method developed for megacities was successfully applied to a smaller scale source, in both size and intensity (i.e., the city of Helsinki), which is located at high latitudes ($\sim 60^{\circ}$N). The same methodology could be applied to similar scale cities elsewhere, as far as they are relatively isolated from other sources.

The transport by the wind plays an important role in the Baltic Sea area. The $NO_2$ spatial distribution is mainly determined by the contribution of strong westerly winds, which dominate the wind patterns during summer. The comparison between the emissions from model calculations and OMI $NO_2$ tropospheric columns confirmed the applicability of satellite data for ship emission monitoring. In particular, both the emission data and the OMI observations showed similar year-to-year variability, with a drop in year 2009, corresponding to the effect of the economical crisis.