Validation of tropospheric NO_2 from the Lotos-Euros air quality model with MAX-DOAS

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Introduction

We compared a fourteen month data set of tropospheric NO_2 column observations performed in De Bilt, the Netherlands, with the Lotos-Euros regional air quality model.

It has been demonstrated that the MAX-DOAS measurement technique can be used to retrieve tropospheric NO_2 columns with approximately 20% accuracy.

A comparison study by Huijnen et al. (ACP, 2010) has shown considerable differences in tropospheric NO_2 columns from different regional air quality models, indicating the need for further improvements and validation.
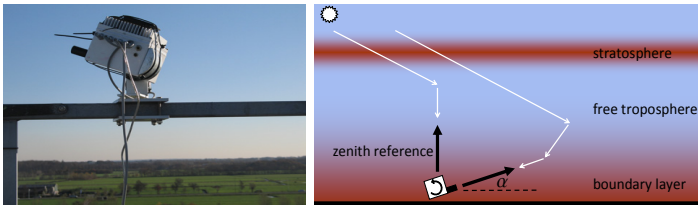
*Mini MAX-DOAS instrument and measurement technique*

MAX-DOAS

Tropospheric NO_2 columns were derived by applying the DOAS method on spectral observations (415-430 nm) of scattered sunlight in two directions: 30° elevation, and the zenith. Height dependent air mass factors were calculated with the DAK radiative transfer model for both cloud free and cloudy conditions, and combined with the Lotos-Euros NO_2 profile shape to determine a vertically integrated air mass factor.
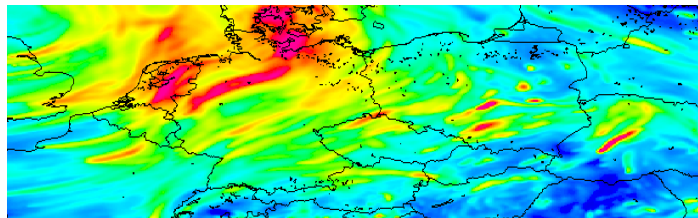
Lotos-Euros

Lotos-Euros is the Dutch national air quality model, developed by TNO, RIVM, PBL and KNMI. It is used for Dutch operational air quality forecasts, and contributes to the European air quality analyses of the MACC project, www.gmes-atmosphere.eu

The Lotos-Euros model (v1.7.001) was run on a resolution of 0.125° x0.0625° (approximately 7x7 km). The model is driven by ECMWF meteorological forecasts, available every 3 hours. Runs are based on TNO-MACC emissions for Europe, available with the same 7 km resolution.
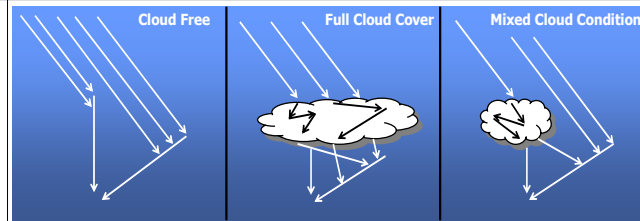
Cloud Effects

The sensitivity of the MAX-DOAS measurement technique to NO_2 rapidly decreases above the cloud bottom height. This effect was taken into account in the analysis of the measurements and in the comparison with the Lotos-Euros model:

• The cloud and its height were accounted for in the air mass factor calculation
• For the Lotos-Euros model, only the partial NO_2 column below the cloud was considered

Ground based lidar (LD40 ceilometer) observations of cloud presence and height were used to determine the cloud conditions for each half hour. Three categories were used:

• Cloud Free (0 octas)
• Full cloud cover (8 octas) and small variations in cloud bottom height
• All conditions (0-8 octas)

The uncertainty in the tropospheric NO_2 column retrieval is largest for the last category. Most results on this poster are shown for the combination of the first two categories.
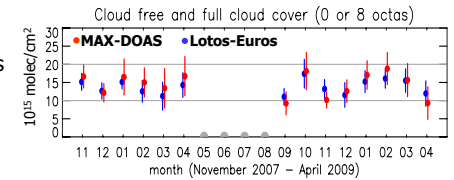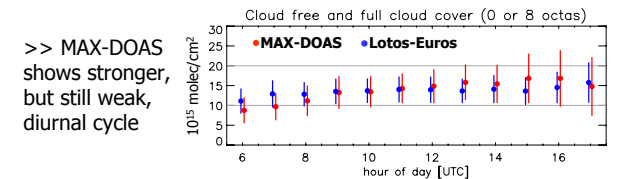
First Results
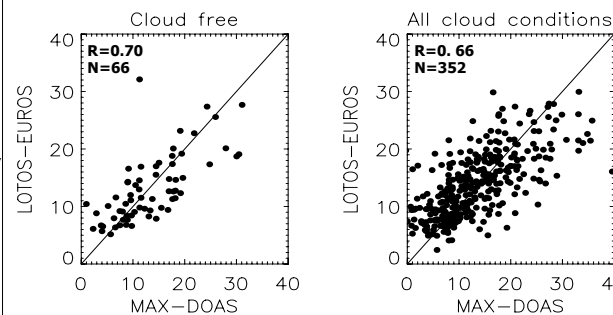
Daily averaged tropospheric NO_2 column in 10^{15} molec/cm²

Monthly averaged tropospheric NO_2 column

>> MAX-DOAS and Lotos-Euros show the same pattern

Diurnal cycle of trop. NO_2 col. averaged over all observations

>> MAX-DOAS shows stronger, but still weak, diurnal cycle

Weekly cycle of trop. NO_2 col. averaged over all observations

>> Almost no weekly cycle for Lotos-Euros

>>MAX-DOAS shows more pronounced weekly cycle
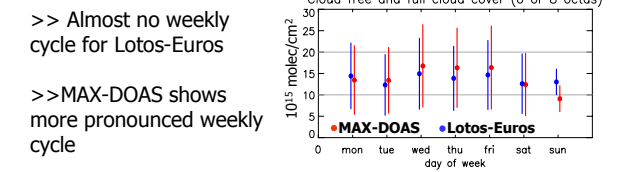
Average trop. NO_2 column for each wind direction

>>MAX-DOAS and Lotos-Euros both show that air moving in from the South West contains twice as much NO_2 as air from the North East
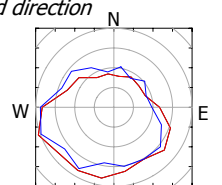
Radius of inner circle: $5x10^{15}$ molec/cm²

Conclusions

• The averaged monthly, weekly and diurnal cycle of the tropospheric NO_2 columns from MAX-DOAS and Lotos-Euros compare quite well

• The distribution over the wind directions, indicating the spatial distribution of NO_2 sources around De Bilt, compares well

• Differences can be large on a day-to-day basis