Cross-evaluation of tropospheric NO_2 levels over Flanders using ground-based, airborne and TROPOMI observations and the WRF-Chem model as an intercomparison platform

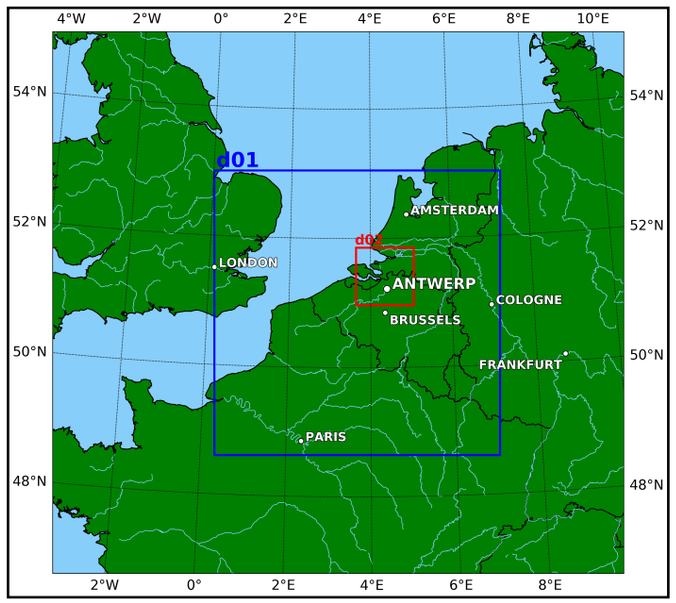
C. Poraicu[1], J.-F. Müller[1], T. Stavrakou[1], D. Fonteyn[1], F. Tack[1], N. Veldeman[2]

1. Royal Belgian Institue for Space Aeronomy, Brussels, Belgium
2. Flemish Institute for Technological Research, Mol, Belgium

Introduction + WRF-Chem

Antwerp is the most populous city in the Belgian region of Flanders. It hosts both the **second largest petrochemical cluster** in the world and the **second biggest port in Europe**. These centers lead to some of the highest NO_x emissions in Europe.

We investigated the NO_2 distribution in Flanders, recorded by ground-based concentration measurements, airborne data and remotely-sensed columns, with the help of **WRF-Chem.**



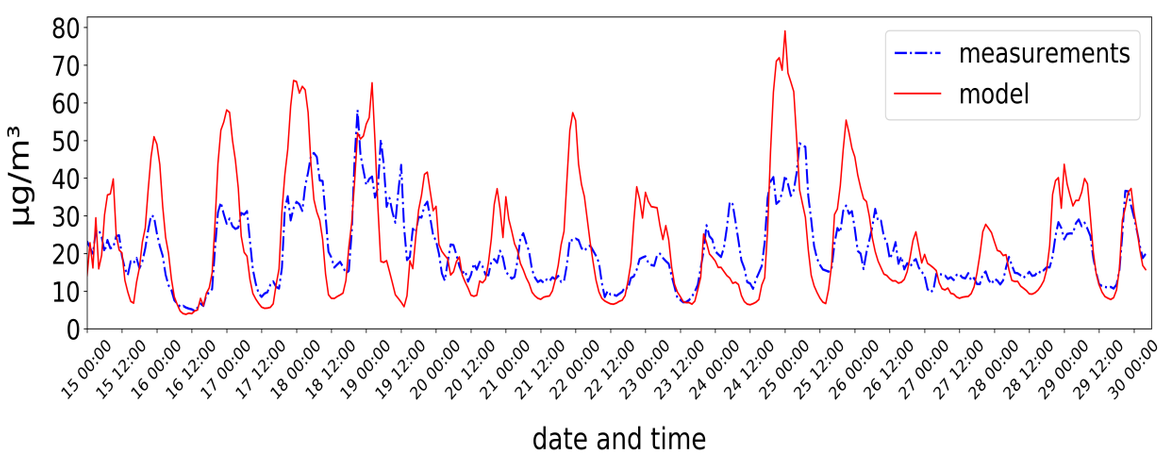
The chemical mechanism used was Carbon-Bond Mechanism by Zaveri (**CBMZ**). The emissions come from a combination of:

- 1km x 1km emissions from **VITO** (over Flanders)
- 1km x 1km emissions from **Emissieregistratie NL** (over Netherlands)
- 0.1° x 0.1° emissions from **EMEP**
- 0.1° x 0.1° emissions from **EDGAR-HTAP**
- 0.1° x 0.1° aircraft emissions from **CAMS**

The emissions were adjusted to account for diurnal, daily (depending on the day of the week) and monthly behaviour for the simulation period, in accordance with Crippa et al. (2020).

Ground-based comparisons

We compare the 15-day simulation results with NO2 concentration measurements at 30 stations hosted by the Belgian Interregional Environmental Agency (IRCEL-CELINE), all located around Antwerp. The modelled and observed NO2 concentrations averaged over the stations are plotted below. The measurements are tentatively corrected for interferences from PAN and HNO_3 following the suggestions made by Lamsal et al. 2008.



The WRF-Chem NO_2 output follows the overall diurnal shape seen by the measurements. There is clear overestimation of modelled NO_2 concentrations during the night, and an underestimation during the day.

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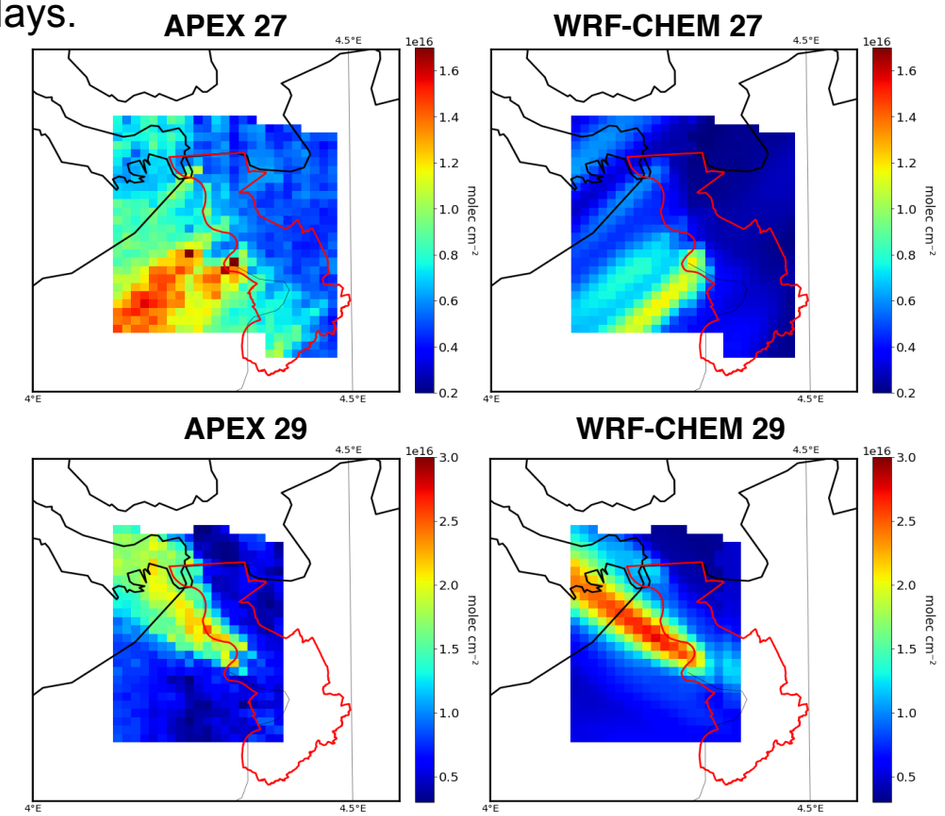
Airborne comparisons

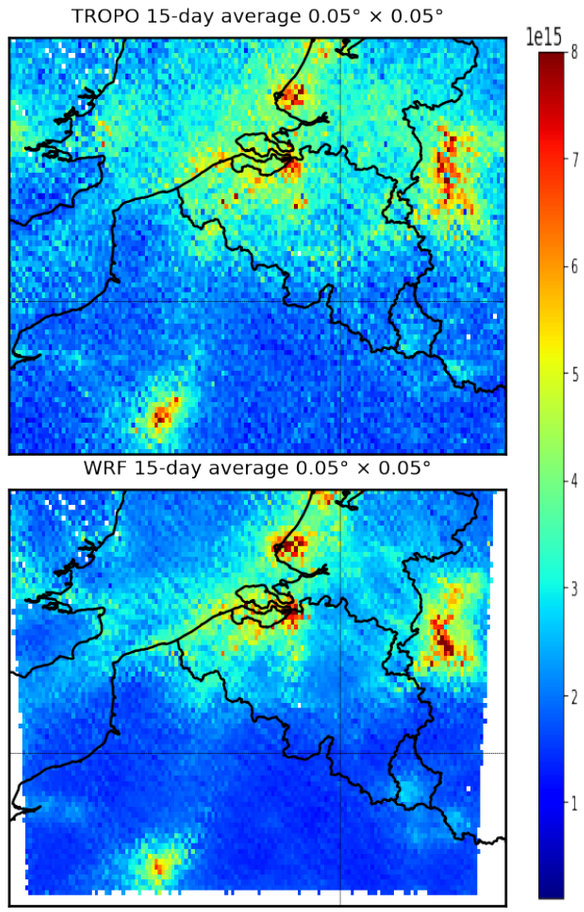
Tropospheric NO_2 vertical column densities (VCDs) are measured by the **APEX** instrument at a spatial resolution of ~75m x 120m. There were two flights over the Antwerp area in 2019, on June 27 and 29. The APEX measurements have been regridded to correspond to the WRF-Chem 1x1 km^2 grid. These can be seen in the figures below, where each plot portrays the NO_2 tropospheric column from the corresponding source (APEX or WRF-Chem) over the two days.



The NO_2 obtained from the model show similar features as the aircraft measurements, especially in the shape and direction of the plumes seen. The model performs better on the 29th than on the 27th.

TROPOMI comparisons

The model data was regridded into the TROPOMI resolution, using the latitude and longitude coordinates of the four corners of each TROPOMI cell. The WRF-Chem NO_2 columns were calculated using the TROPOMI averaging kernels. The appropriate quality filters were utilized, as described in the TROPOMI NO_2 ATBD.



WRF-Chem is mostly accurate at simulating the tropospheric NO_2 column over Western Europe, largely capturing the spatial patterns observed by TROPOMI.

However, although the ratio of the two (model/TROPOMI) shows much noise, the model displays underestimations of TROPOMI NO_2 over less polluted areas (e.g. eastern Netherlands, Ardennes, Eiffel) and overestimations at many industrial/urban areas (Ruhr, Western Netherlands).

Further analysis of the comparisons, conclusions and plans for further work can be found on the poster.