Evaluation of global NO_2 GEMS products using IUP-Bremen SCIAMACHY measurements

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Introduction

The EU-funded **GEMS project** had as main objective the development of a modeling systems that allows for monitoring the global distributions of atmospheric constituents. The main region focus is Europe and in sub-group **GRG (Global Reactive Gases)** work is developed with global chemical transport models (CTMs) in order to provide the necessary boundary conditions to the Regional Air Quality models. The system performance of both standalone runs and coupled ECMWF mode IFS with CTMs (analysis and forecast mode) was assessed through comparison with independent observations. Here we present part of the evaluation work performed for the **modeled NO_2**, with focus on the results of the standalone runs from the latest versions of models **MOCAGE (V02), MOZART (V10) and TM5 (V10)** compared to **SCIAMACHY** satellite measurements.

SCIAMACHY flying on ENVISAT measures in UV/vis/IR and has a global coverage of the atmosphere within approx. 6 days and a spatial resolution of 60x30 km^2. The local overpass time of SCIAMACHY is at about 10:00 LT for low and mid latitudes. The NO_2 slant columns are retrieved with the DOAS technique in the wavelength region 425 – 450 nm.

Stratosphere

Satellite Product

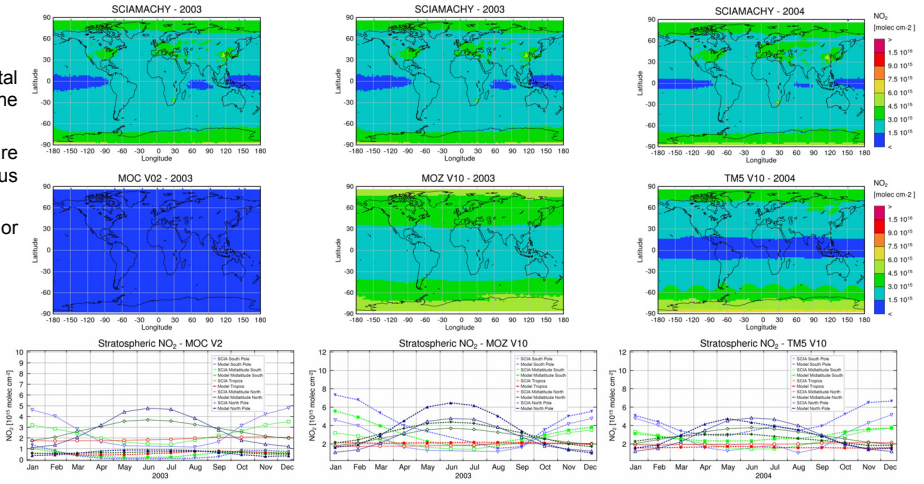
The NO_2 total vertical column is calculated by diving the total slant column measured with an airmass factor based on the US-standard atmosphere with the tropospheric part removed.

The NO_2 satellite measurements present here on the right are in fact Total Columns (not only the stratospheric) and thus representing an upper limit.

For the stratospheric values no screening for clouds or pollution is applied.

Results

- In general the MOCAGE V02 results are too low for the stratospheric NO_2.
- MOZART V10 is doing well but still slightly overestimating the stratospheric fields.
- The results of TM5 V10 are quite good overall but over the South Pole the model predicts higher NO_2 than the satellite measurements.



Troposphere

Satellite Product

The tropospheric slant columns are obtained with the subtraction, from the total column, of the average of the NO_2 slant columns measured on the same day at the same latitude over the Pacific sector (180° – 220° longitude).

Vertical tropospheric columns are then computed using airmass factors based on a MOZART run for 1997 and averaged over months.

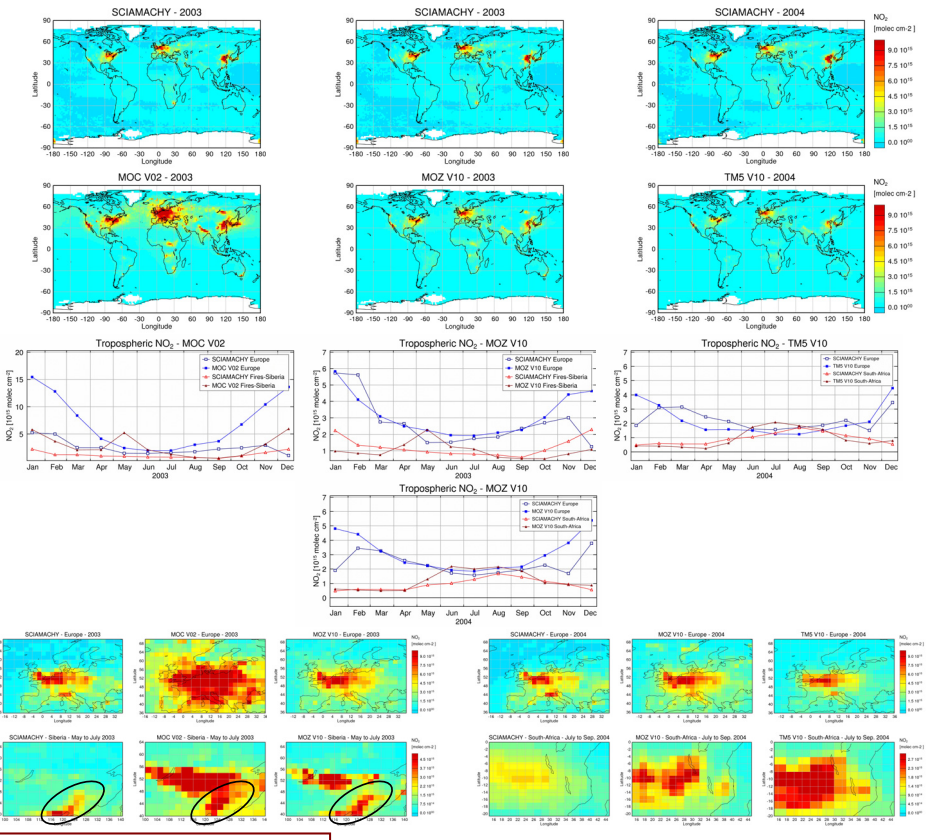
For these data, a filter for cloud fractions smaller than approx. 30% was applied.

Results

- The tropospheric NO_2 simulated by MOCAGE is in general too high.
- The other 2 models, MOZART and TM5 achieved good results. (see example of European domain)
- However, over some highly polluted areas, such as China, the results are still too low, especially in the winter months.
- In the hot-spots for biomass burning emissions, e.g. African Savannah (see example of South Africa for 2004) or boreal fires in Siberia in 2003 (see figures) and Alaska in 2004, the model values are higher than the SCIAMACHY measurements.

Note that the high values registered in the Siberia region (black circle in the figure) are not from fires but actually from China.

- In general the seasonality is well captured by all models with higher discrepancies during winter.



Conclusions

- The stratospheric NO_2 is well modeled by both standalone and coupled system MOZART-IFS, with exception of MOCAGE that presents too low values for this layer;
- The NO_2 columns are not correctly simulated over the polluted regions mostly during the winter months with, on average, an underestimation of values. This might be explained by the constant emission fields used as input in the model that have not followed the change of NOx emissions in the last years in the major urban centers. Therefore, the discrepancies of NO_2 values are even higher for the simulation of recent years by the MOZART-IFS.
- Tropospheric NO_2 values over biomass burning regions are often too high, but the seasonality is well simulated. This is an indication for a problem with the NOx/CO emission ratios used by the models.

This work was funded by the European Community through the GEMS project.
The results presented here are only a small fraction of the evaluation work developed within the GEMS project at the IUP - Bremen. The complete outcome of the continuous evaluation performed throughout the last 2 years can be found in the *GEMS GRG Comprehensive Validation Report.*

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