ESSReS-R1

Observation of Megacity pollution from space

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Background

Using measurements from satellite based spectrometers, the spatial distribution and the temporal evolution of nitrogen dioxide (NO_2), an important ozone precursor, can be determined. These measurements can be applied to validate results of chemistry transport models such as MOZART and also combined with these to assess the impact of pollution from large cities on the atmosphere and to estimate future developments.
In this PhD project, data from the GOME, SCIAMACHY and GOME-2 satellite instruments will be used to derive a consistent dataset of tropospheric columns of NO_2, to study their evolution and the importance of megacities on their global budgets.

Constructing a consistent dataset of tropospheric NO_2 from 1996-2009

GOME and SCIAMACHY pixel sizes

While the older GOME instrument collects data for ground pixels of 40 x 320 km, the newer SCIAMACHY instrument has a considerably improved resolution of 30 x 60 km.

	GOME	SCIAMACHY
Ground pixels		
Pixels per forward scan:	3	16
Pixel data		
Width:	320 km	60 km
Height:	40 km	30 km
Scan duration:	1.5 s	0.25 s

Previous studies ignored this considerably different pixel sizes, because usually analysis is done on gridded data. However, it seems advisable to account for this difference by either

- averaging over 5 SCIAMACHY pixels to yield an effective size of 30 x 300 km

or

- finding a way to include finer spatial structure into the large GOME pixels.

Deconvolution of GOME data

In order to yield comparable pixel sizes of GOME and SCIAMACHY measurements, a new set of GOME data will be constructed by superimposing the finer spatial structure of SCIAMACHY data on the original GOME measurements (see *Konovalov et al., 2006*).
For each point on the global 0.0625° x 0.0625° grid of monthly means, artificially convoluted SCIAMACHY slant columns will be calculated:

$$c_{i(dc)}^{GOME} = \frac{c_i^{SCIA}}{c_{i(c)}^{SCIA}} \cdot c_i^{GOME}$$

From these convoluted SCIAMACHY columns, we will then in a second step and for each gridpoint calculate the deconvoluted GOME slant column monthly mean values by

$$c_{i(c)}^{SCIA} := \frac{1}{m\sqrt{\pi}} \sum_{j=-m}^{m} c_{i+j}^{SCIA} e^{-\frac{(j+m)^2}{m^2}}$$

m is chosen such that the summation includes all gridpoints which would lie inside the GOME pixel centered at the current grid point.

Future work

Technical improvements to tropospheric NO_2 retrieval

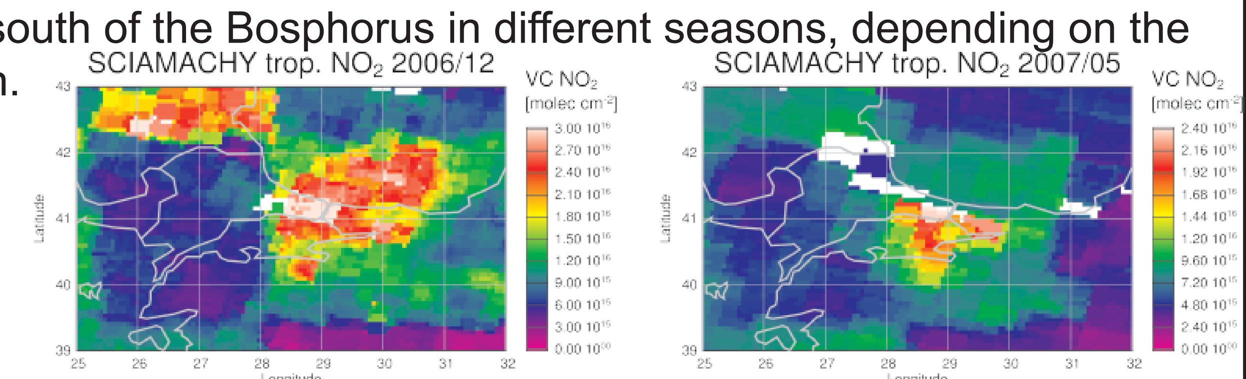
Recalculate the AMF database, using updated, improved and higher resolved input data and account for the temperature dependance of NO_2 absorption cross-section.

Decadal changes in tropospheric NO_2 over megacities

A first application of the new consistent dataset will be the investigation of decadal trends over megacities in the Middle East and Mediterranean. Studies using SCIAMACHY data only have shown annual trends of as much as 10% over Teheran and Baghdad for 2003-2008. Combining these data with older GOME data will for the first time give insight into longer trends over these pollution hot spots.

Export of NO_2 from megacities

Due to their short lifetime, the transport of megacities' tropospheric NO_2 plumes can be investigated using the new high resolution dataset. As an example, the plume of Istanbul can be observed north or south of the Bosphorus in different seasons, depending on the predominant wind direction.

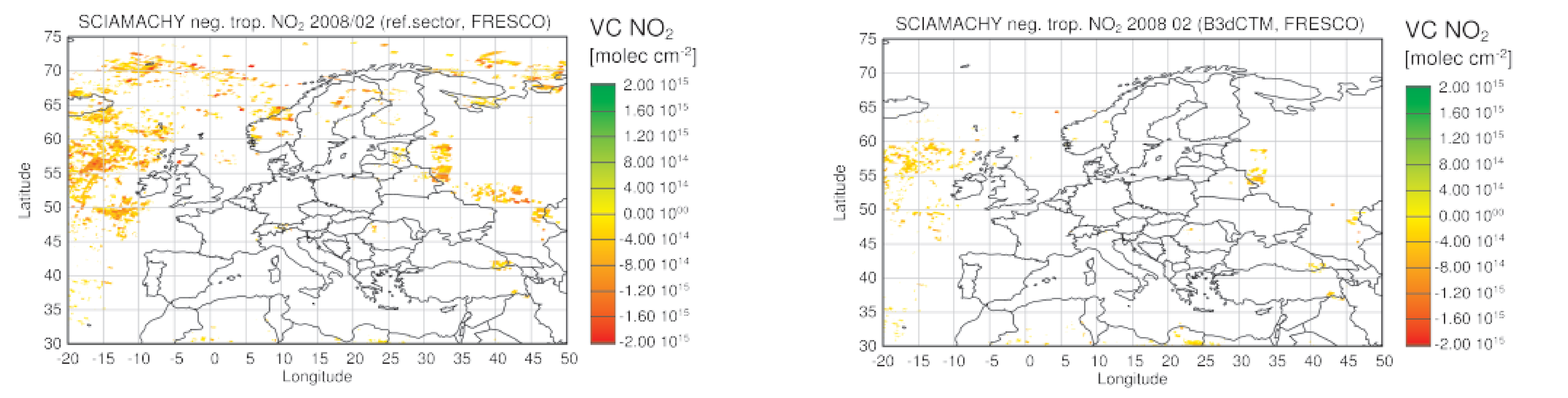


Stratospheric correction

In order to derive tropospheric trace gas column abundances from satellite measurements, one needs to seperate the tropospheric from the stratospheric signal. Traditionally, this has been done using the so-called reference sector method, in which the measured quantities over the Pacific Ocean are subtracted globally from all other measurements (see *Richter and Burrows, 2002*). This is based on the following two assumptions:

- There is no tropospheric NO_2 over the reference sector.
- The distribution of NO_2 in the stratosphere is constant with longitude.

Since especially the second assumption is not correct, this has traditionally resulted in a high number of negative tropospheric column abundances.
In our improved treatment of the stratospheric contribution to total column abundances, the Bremen 3d chemistry and transport model (B3dCTM) is used. First evaluations show a considerable reduction of negative tropospheric values, indicating an improved overall quality of the tropospheric data product (see *Hilboll et al., 2009*):



Air mass factor database

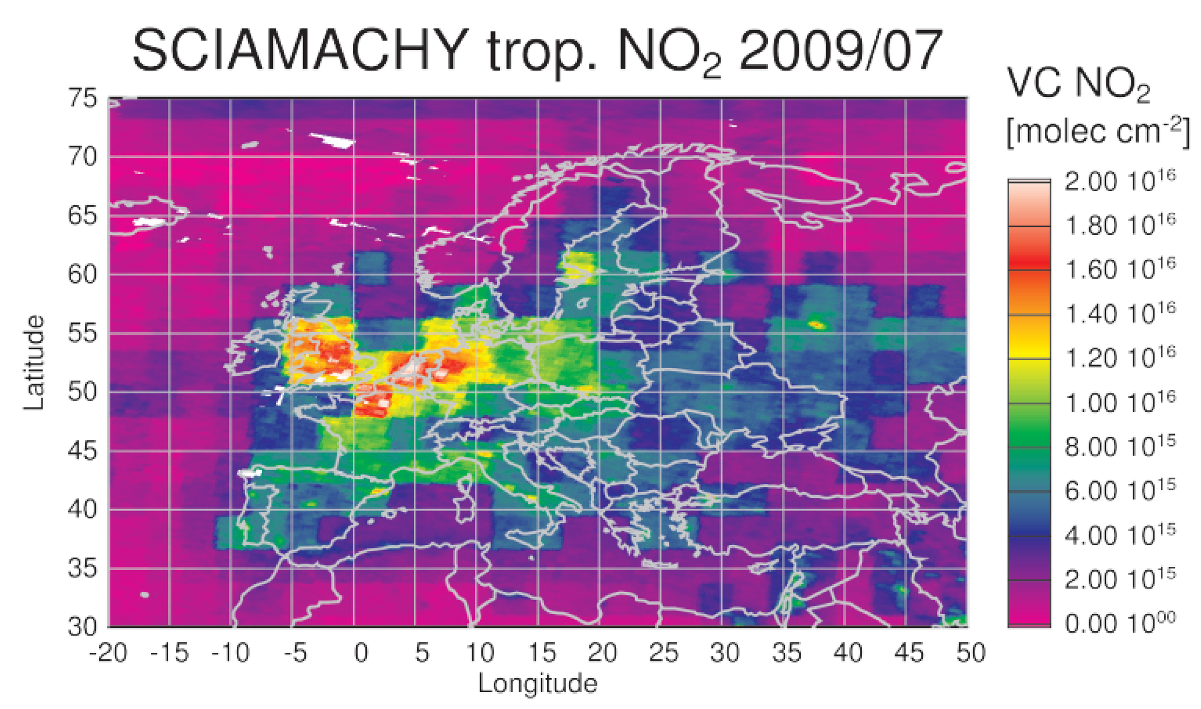
Conversion of measured slant columns (SC) to vertical columns (VC) depends on the radiative transport (RT) in the atmosphere. This is done using an air mass factor (AMF), which describes the relation between sland and vertical columns as

$$\mathrm{AMF} = \frac{\mathrm{SC}}{\mathrm{VC}}$$

Using the following variables, the AMF is calculated for a set of possible solar zenith angles (SZA) using the RT model SCIATRAN:

Parameter	Spatial resolution	Temporal resolution
Surface elevation	2.8125° x 2.8125°	constant
Surface albedo	1° x 1°	1 / month
Aerosol load	2.8125° x 2.8125°	constant (3 aerosol types)
Vertical trace gas profile	2.8125° x 2.8125°	1 / month

In a first step towards an improvement of the AMF database used, the currently used values will be interpolated in space and time using cubic splines and linear interpolation, respectively. This will eliminate the sharp changes in tropospheric NO_2 values currently seen at the model box boundaries:



Selected References

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