Using GOME-2 measurements to extend the GOME/SCIAMACHY tropospheric NO_2 record

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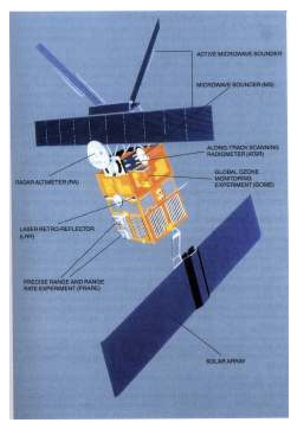
Project Summary

The overall objective is to create a consistent tropospheric NO_2 time series. The approach taken is

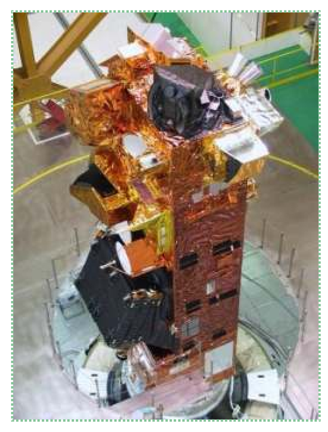
1. to use GOME-2 lv1 radiances and irradiances to derive a tropospheric NO_2 product in exactly the same way as is already done for GOME-1 and SCIAMACHY
2. to compare the results with those from SCIAMACHY, GOME-1 (if still operating) and from OMI and to evaluate the consistency
3. to investigate the possible use of operational GOME-2 NO_2 lv2-data as starting point for tropospheric NO_2 analysis
4. to analyse the results in view of possible calibration problems in the lv1 data and at the same time perform an algorithm validation for the GOME-2 NO_2 retrieval
5. to use the combined NO_2 fields from several instruments for the investigation of the effects of clouds, spatial resolution and time of measurement on the NO_2
6. to use the created long-term record to study the inter-annual variability and long-term development of the tropospheric NO_2 burden.

Instruments



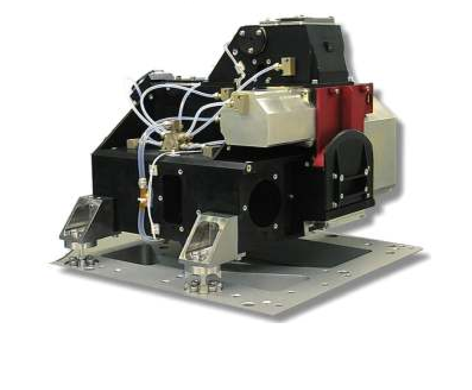
GOME

launch: April 1995
equator crossing: 10:30 LT
global coverage: 3 days
spatial resolution: 320 x 40 km^2



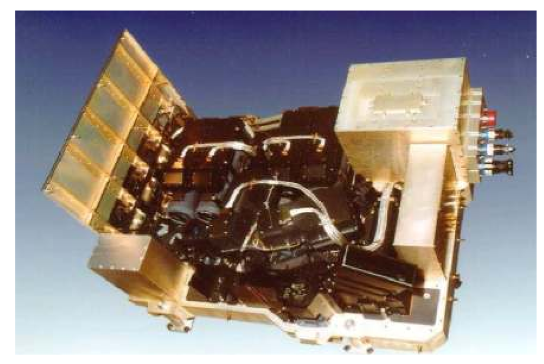
SCIAMACHY

launch: March 2002
equator crossing: 10:00 LT
global coverage: 6 days
spatial resolution: 60 x 30 km^2



OMI

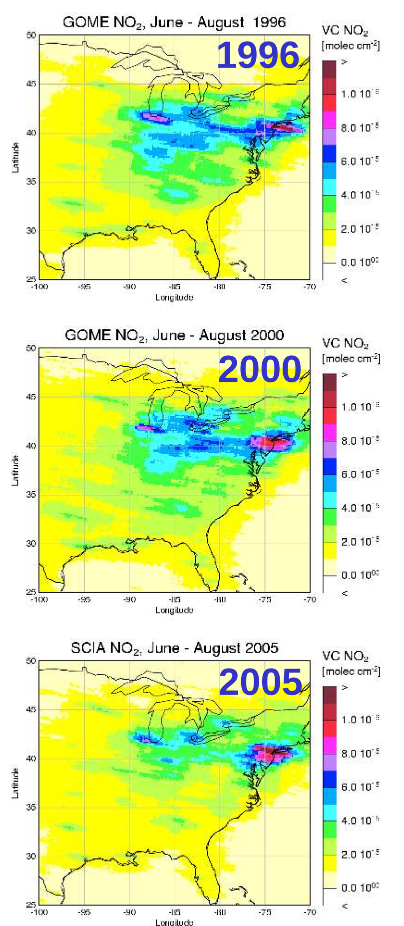
launch: June 2004
equator crossing: 13:38 LT
global coverage: 1 day
spatial resolution: up to 13 x 24 km^2

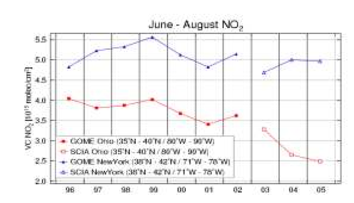


GOME-2

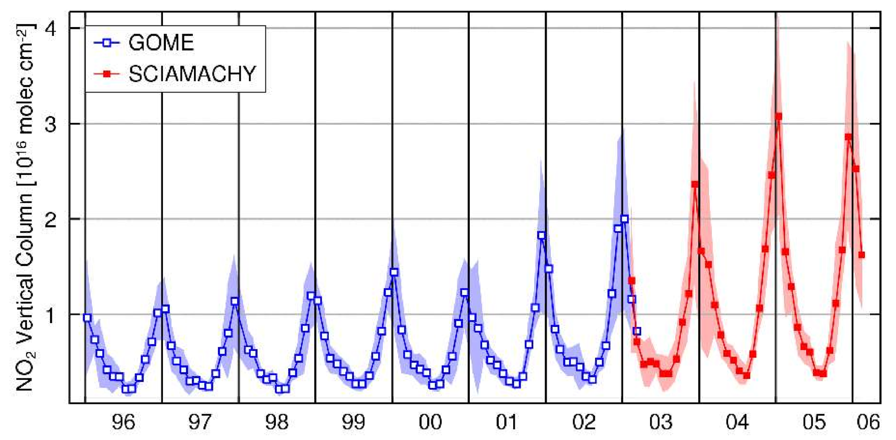
launch: June 2006
equator crossing: 9:30 LT
global coverage: 1 day
spatial resolution: 80 x 40 km^2

Extending the GOME Time Series





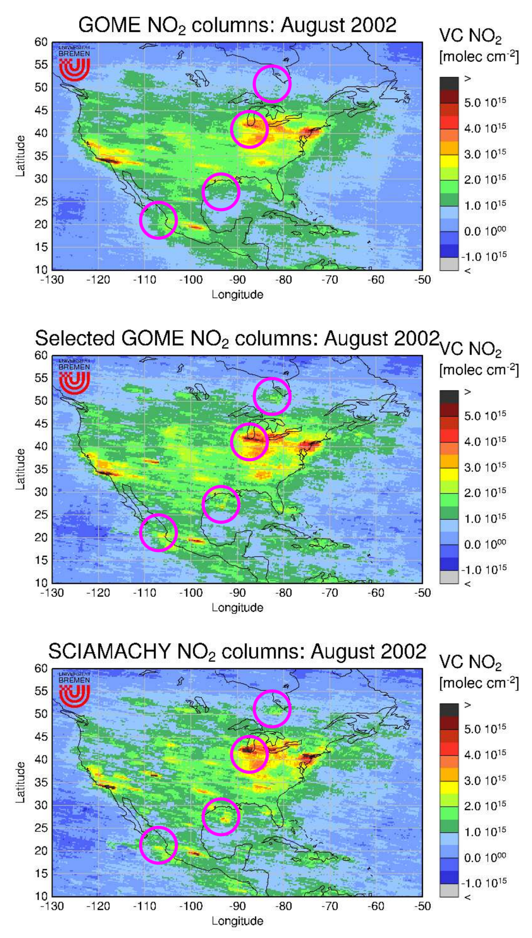
Figures: GOME and SCIAMACHY NO_2 above East Central China (right) and the US (left). The increase in NO_2 columns over China is related to the rapid economic development and increasing use of fossil fules; decreasing NO_2 columns in the US are the effect of summer time denoxification of power plants.



With the GOME time series starting in 1995, a first global long-term data set of tropospheric NO_2 has been created. By extending this time series with SCIAMACHY, OMI and GOME-2 data, more than two decades of continuous and consistent measurements will become available. However, to fully exploit the potential of these measurements, care must be taken to assure high data quality and homogeneity of the time series (see discussion in the other parts of this poster).

Applications of the combined data set will be NO_x emission source assignment, trend analysis and validation of chemical transport models. Two examples of such applications using GOME and SCIAMACHY data are shown in the figures. In the top plot, the NO_2 column development over East Central China is shown, highlighting the strong increase in NO_x emissions. To the left, the effect of recent denoxification legislation on US power plant emissions is illustrated.

Effects of Sampling



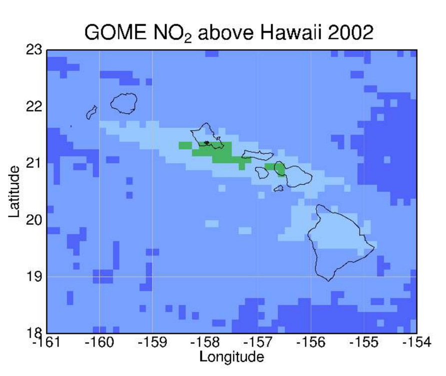
Figures: Effect of comparing GOME and SCIAMACHY measurements with and without selection for SCIAMACHY sampling.

One of the main problems of GOME and in particular SCIAMACHY measurements is the low frequency of measurements over one particular location. This not only limits the applicability of the measurements for pollution monitoring, but also has systematic effects on averages determined from the data. This is illustrated in the figures to the left, where a SCIAMACHY monthly average is compared to a GOME monthly average of all data (top) and to a monthly average using only those data with corresponding SCIAMACHY pixels. Clearly, the agreement is much better when the data are sampled in a similar way. This has a number of implications:

- for comparison with model results or other data sources, proper sampling must be applied
- the significance of monthly and even annual averages is less than one would expect
- as sampling is strongly determined by clouds, a systematic bias exists in the data to clear sky situations, and for example transport events linked to frontal systems might be strongly underestimated by the satellite measurements

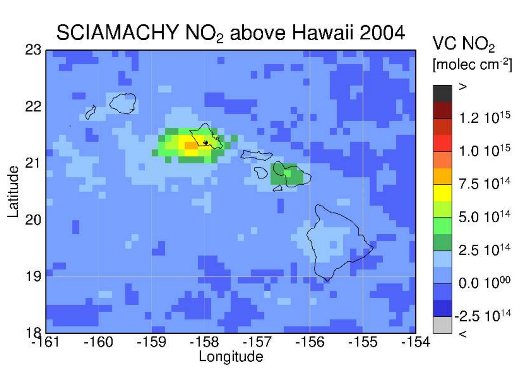
By comparison of SCIAMACHY with GOME-2 (and OMI) data, this effect will be studied and quantified.

Effects of Spatial Resolution



The spatial resolution of the satellite measurements is relevant for several aspects:

- it determines the spatial resolution of emission estimates
- it impacts on the detection limit for localised sources
- it influences the cloud statistics and thus the number of useful tropospheric measurements
- when combining data with different spatial resolution, long term trends might be biased



The figures illustrate the effect for the example of Hawaii. While GOME measurements for 2002 see a slight enhancement that has the typical shape of a GOME ground-pixel, SCIAMACHY measurements (2004) can resolve the plume off Honolulu and also the enhancement over the other islands. While the average over the whole area is similar for both measurements, SCIAMACHY data reveal much higher values locally.

Effect of Time of Measurement

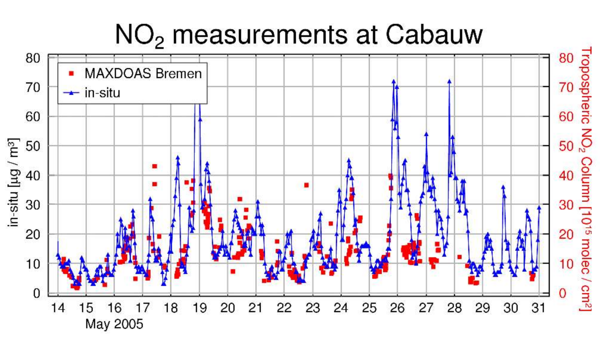


Figure: NO_2 measurements in Cabauw, The Netherlands during the DANDELIONS campaign. The data illustrate the large day to day variability and the strong diurnal variation on some days which impacts the combined use of instruments in different orbits. NO_2 in-situ measurements courtesy of KNMI.

One difference between the instruments used for this project is the local time of overpass. While GOME, SCIAMACHY and GOME-2 are all in morning orbits (overpass between 9:30 and 10:30 LT), OMI is in an afternoon orbit. This implies, that the troposphere is probed under different situations:

- the daytime boundary layer evolves over the morning and in many places is not yet fully developed at GOME-2 overpass
- emissions of NO_x are time dependent (rush hours) and as a result NO2 columns vary over the day
- lightning activity over the continents has a morning minimum and is thus much less relevant for GOME and SCIAMACHY measurements than for OMI
- cloud statistics differ in the morning and afternoon, and instruments in a morning orbit systematically probe different areas than OMI

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see also: www.iup.physik.uni-bremen.de/doas