Using GOME-2 measurements to extend the GOME/SCIAMACHY tropospheric NO₂ record

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Project Summary
The overall objective is to create a consistent tropospheric NO₂ time series. The approach taken is:
1. to use GOME-2 l1 radiances and irradiances to derive a tropospheric NO₂ 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 possibility of the combined GOME-2 NO₂ l2-data as starting point for tropospheric NO₂ analysis
4. to analyse the results in view of possible calibration problems in the lv1 NO₂ retrieval
5. to use the combined NO₂ fields from several instruments for the investigation of the effects of clouds, spatial resolution and time of measurement on the NO₂ fields
6. to use the created long-term record to study the inter-annual variability and long-term development of the tropospheric NO₂ burden.

Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Launch Date</th>
<th>Equator Crossing</th>
<th>Global Coverage</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOME-2</td>
<td>April 1995</td>
<td>13:38 LT</td>
<td>1 day</td>
<td>320 x 40 km</td>
</tr>
<tr>
<td>OMI</td>
<td>June 2004</td>
<td>8:00 LT</td>
<td>1 day</td>
<td>13 x 24 km</td>
</tr>
<tr>
<td>SCIAMACHY</td>
<td>March 2002</td>
<td>09:00 LT</td>
<td>6 days</td>
<td>30 x 30 km</td>
</tr>
</tbody>
</table>

Effects of 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 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 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.

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 NO₂ 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

Effects of Time of Measurement

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Selected References

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