EGU2009-7165 / AS3.15

The impact of the stratospheric correction on tropospheric NO_2 measurements from satellites

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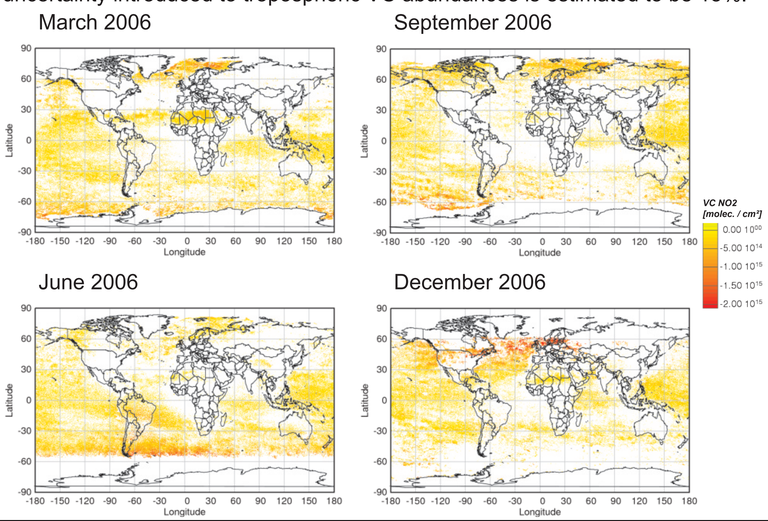
Background

Satellite measurements of atmospheric NO_2 in the UV/visible range yield the gas' total column abun-dance. One problem in using these measurements is the fact that this signal is a combination of tropospheric and stratospheric contri-butions. Since for many applications, only the tropospheric part is needed, the stratospheric column needs to be removed.

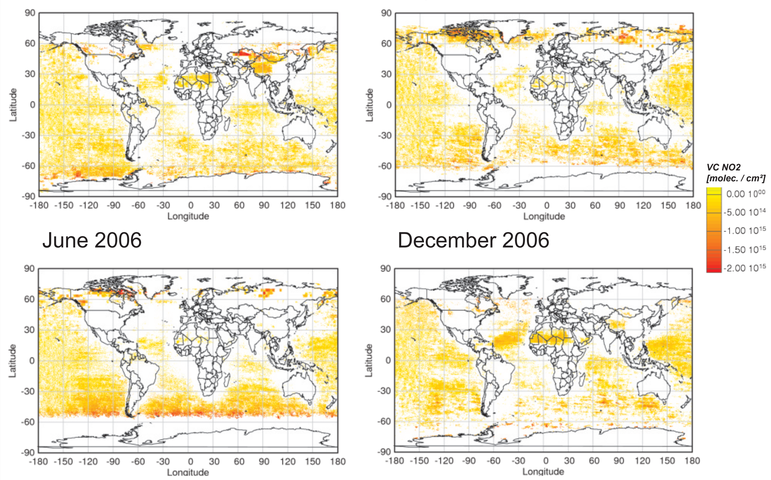
Reference Sector Method

Methods to account for the stratospheric contribution include using model data (SLIMCAT), assimilation of satellite measurements into model data and the reference sector method. In this latter method, data from a reference sector (180°-220°) which is assumed to have little or no tropospheric NO_2 is subtracted from all NO_2 total columns. If the instrument (as SCIAMACHY) is on a sun-synchronous orbit, one can assume that the NO_2 amounts only depend on latitude, not on longitude. While this assumption of longitudinal homogeneity is in general justified by the results of various validation studies, it fails to hold on a global scale. This is shown by the large number of ground pixels for which the application of this method yields negative tropospheric colums. The total uncertainty introduced to tropospheric VC abundances is estimated to be 15%.



Using the Bremen 3d CTM

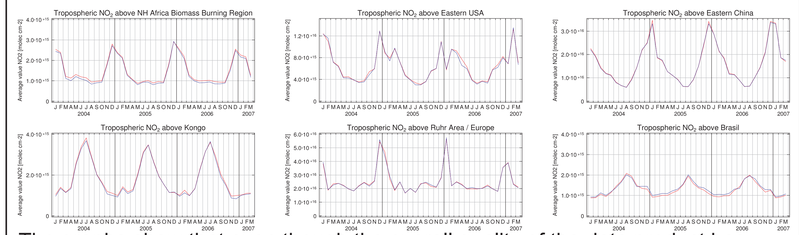
To account for the longitudinal inhomogeneity of stratospheric NO_2 columns, output from the Bremen 3d Chemical Transport Model has been used to correct for the stratospheric contribution to NO_2 total columns.
For each model pixel (2.5°x3.75°), stratospheric columns have been linearly interpolated from a 30-min.-timestep model run to SCIAMACHY overpass times. Assuming no tropospheric contribution to NO_2 total columns over the reference sector (180°-220°), the model output has been forced to the satellite measurements in this area by addition of a latitutdinally varying offset.



For most times, utilisation of Bremen 3d CTM data for correction of the strato-spheric contribution yields a significant reduction of negative tropospheric co-lumn abundances over land and for non-polar latitudes. The only exceptions are Tibet and the Sahara region, suggesting that the DOAS retrieval systematically underestimates NO_2 columns these regions. Since over Tibet, the number of ne-gative tropospheric column values is actually increased by usage of the model, it seems that the model suffers from certain inaccuracies in this region.
For high latitudes the model seems to overestimate actual stratospheric NO_2 values, which is also suggested by comparison with ground-based measure-ments in these regions (not shown).
Over sea, finally, negative tropospheric columns of low absolute value fall within the expected error range of the retrieval. Thus, no significant reduction of the number of negative values over ocean can be expected from improvements in the stratospheric correction.

Impact on Data Product

To account for the longitudinal inhomogeneity of stratospheric NO_2 columns, output from the Bremen 3d Chemical Transport Model has been used to correct for the stratospheric contribution to NO_2 total columns. Assuming no tropo-spheric contribution to NO_2 total columns over the reference sector (180°-220°), the model output has been forced to the satellite measurements in this area by addition of a latitudinally varying offset.
The following graphs compare time series of SCIAMACHY tropospheric vertical column monthly averages, corrected for the stratospheric contribution by reference sector (red) and Bremen 3d CTM data (blue).



The graphs show that even though the overall quality of the data product has increased significantly, the tropospheric column abundances over polluted regions do not change by much. One can conclude that application of Bremen 3d CTM data is a feasible approach to improve tropospheric NO_2 retrieval.

Future Work

To make use of the high temporal resolution of the model data, the stratospheric NO_2 columns will be interpolated to the satellite overpass times for each individual ground pixel. By doing so, the diurnal variation of stratospheric NO_2 abundance will be accounted for, eliminating one further shortcoming of the tropospheric data product.

Selected References

• Boersma, K. F. et al., **Error analysis for tropospheric NO_2 retrieval from space**, *JGR*, **D04311**, 2004
• Richter, A. and J.P. Burrows, **Tropospheric NO_2 from GOME Measurements**, *Adv. Space Res.*, **29(11)**, 1673-1683, 2002
• Richter, A. et al., **Increase of tropospheric nitrogen dioxide over China observed from space**, *Nature*, **437**, 6373, 2005

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