The impact of the stratospheric correction on tropospheric NO₂ measurements from satellites

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Background

Satellite measurements of atmospheric NO₂ in the UV/visible range yield the gas’ total column abundances. One problem in using these measurements is the fact that this signal is a combination of tropospheric and stratospheric contributions. 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 NO₂ is subtracted from all NO₂ total columns. If the instrument (as SCIAMACHY) is on a sun-synchronous orbit, one can assume that the NO₂ columns 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 grid points for which the application of this method yields negative tropospheric columns. The total uncertainty introduced to tropospheric VC abundances is estimated to be 15%.

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Using the Bremen 3d CTM

To account for the longitudinal inhomogeneity of stratospheric NO₂ columns, output from the Bremen 3d Chemical Transport Model has been used to correct for the stratospheric contribution to NO₂ total columns. For each model pixel (2.5°×3.75°), tropospheric columns have been linearly interpolated from a 30-min.-timescale model run to SCIAMACHY overpass times. Assuming no tropospheric contribution to NO₂ 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.

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Impact on Data Product

To account for the longitudinal inhomogeneity of stratospheric NO₂ columns, output from the Bremen 3d Chemical Transport Model has been used to correct for the stratospheric contribution to NO₂ total columns. Assuming no tropospheric contribution to NO₂ 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 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 NO₂ retrieval.

Future Work

To make use of the high temporal resolution of the model data, the stratospheric NO₂ columns will be interpolated to the satellite overpass times for each individual ground pixel. By doing so, the diurnal variation of stratospheric NO₂ 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 NO₂ retrieval from space, JGR, D04311, 2004
• Richter, A. et al., Increase of tropospheric nitorgen dioxide over China observed from space, Nature, 437, 6373, 2005

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