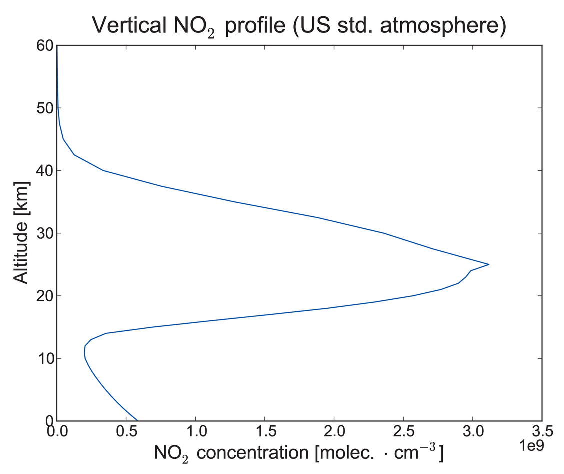
Intercomparison of different stratospheric correction schemes for the retrieval of tropospheric nitrogen dioxide columns from satellite

Andreas Hilboll (hilboll@iup.physik.uni-bremen.de), Andreas Richter, and John P. Burrows
Institute of Environmental Physics / Remote Sensing, University of Bremen, FB 1, P.O. Box 330440, D-28334 Bremen

Introduction

The retrieval of tropospheric NO_2 from satellite

- measures a combined signal from both stratosphere and troposphere.
- For investigating tropospheric NO_2 (e.g. to estimate emissions), the stratospheric contribution must be taken into account.

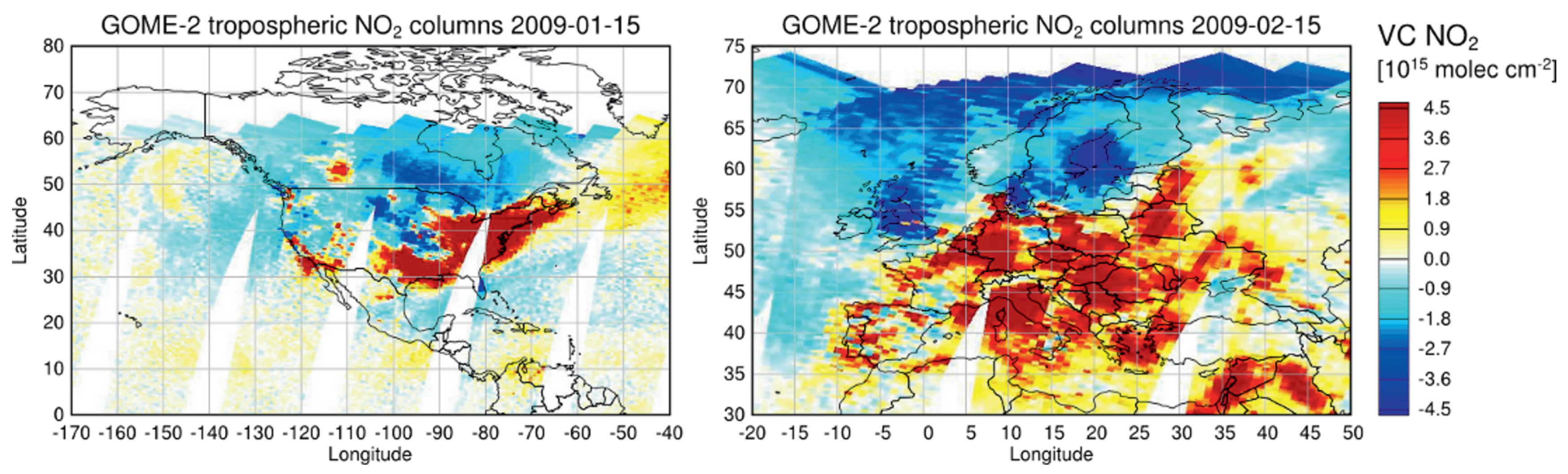


The reference sector method

- is the most simple method to account for this stratospheric signal.
- assumes that
  - the signal measured over the Pacific Ocean (180W - 150W) originates from the stratosphere only.
  - there are no longitudinal changes in stratospheric NO_2.
- shows reasonable results over many areas.

However

- both assumptions are not entirely correct.
- This leads, inter alia, to negative tropospheric NO_2 in many areas.



Stratospheric NO_2 from model data

Bremen 3d Chemistry and transport model (B3dCTM)

- model of stratospheric chemistry
- driven by ECMWF ERA Interim meteorological data
- runs on 28 isentropic surfaces from 330 to 3402 K (about 10 to 65 km)
- horizontal resolution 2.5° x 3.75°
- vertical resolution from ~ 1km (lower stratosphere) to ~ 4km (at ~ 60km)
- timestep 30 minutes
- described in *B.-M. Sinnhuber et al.* (2003) and *M. Sinnhuber et al.* (2003)

Accounting for stratospheric NO_2 using B3dCTM data

- For each latitude bin, calculate average satellite total slant column over the reference sector
- For each satellite pixel:
  - interpolate model data in space and time
  - apply stratospheric air mass factor to derive stratospheric slant column
- For each latitude bin, calculate additive offset of model minus satellite over the reference sector
- For each satellite pixel, subtract the appropriate offset from the model data

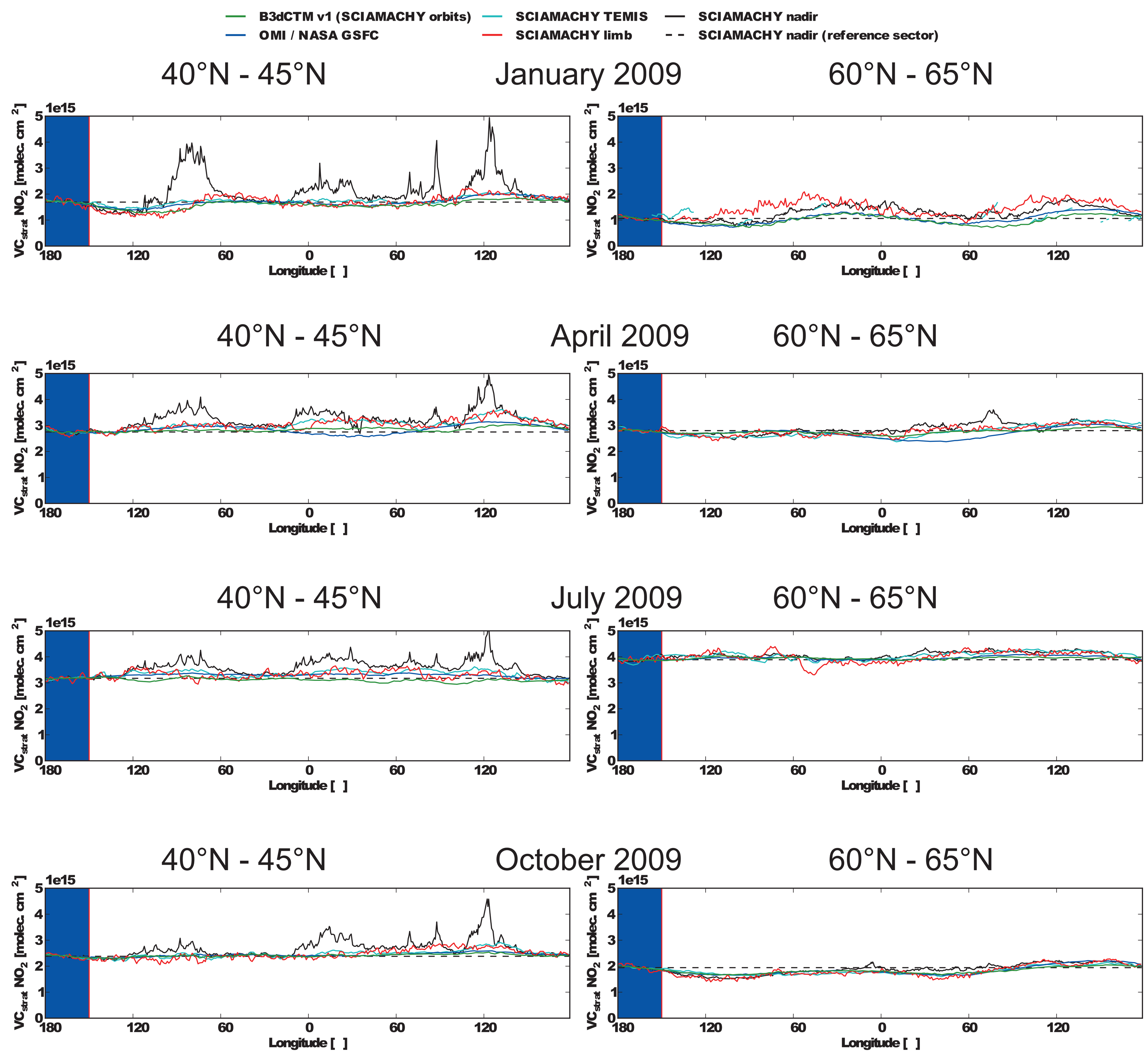
SCIAMACHY limb measurements

- SCIAMACHY limb measurements are the best measurement of stratospheric NO_2 available (tangent height 12km to 46km).
- Relatively low coverage (small pixel sizes, only few measurements per orbit) leads to difficulties in deriving global fields.
- In this study:
  - assign a LOS to each of four limb states
  - for each nadir pixel, interpolate to the correct latitude along each state
  - for each nadir pixel, interpolate to the correct LOS
  - scale limb columns to nadir columns using laitude-dependent additive offset
- Slant columns calculated with CDI retrieval from Rozanov et al. (2005)

Longitudinal variability

Comparison of different correction schemes

Scaled to IUP/Uni-HB SCIAMACHY slant columns at reference sector.



Results / Conclusions

- Results for southern hemisphere are comparable to northern hemisphere (not shown)
- Especially in winter, stratospheric NO_2 varies strongly (+/- 20%) with longitude.
- In comparison to both B3dCTM and SCIAMACHY limb data, using the reference sector method neglects many features found in stratospheric NO_2 data, leading to large errors in the tropospheric vertical columns, especially over rural regions.
- Stratospheric products derived from model data alone (B3dCTM, NASA GSFC) show smallest longitudinal variability.
- Best agreement with SCIAMACHY limb data achieved by SCIAMACHY nadir (TEMIS)
- Variability in SCIAMACHY limb data is quite high, probably due to sampling.
- In winter at high latitudes, SCIAMACHY limb columns can be higher than nadir columns, indicating possible problems with the nadir retrieval (snow, sampling).

References

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