VALIDATION OF MIPAS OPERATIONAL LEVEL 2 PRODUCTS USING GROUND-BASED NETWORK DATA

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Structure of talk

What can be achieved as to validation of MIPAS constituent profiles, using ground-based network data
- for $O_3$?
- for other species?

- network:
  - coverage, instruments and capabilities

- from high vertical resolution to low-vertical resolution intercomparisons
  - challenges and future perspectives
Ground-based network

O₃ sounding instruments

O₃ measured by GOME on Sept. 25, 2002 (courtesy GOFAP)
UV-VIS DOAS instruments (NDSC)

Harestua
Jungfraujoch
Wealth of correlative data:

- **O₃ sondes**: (0-) 30 km range; $\Delta z \sim 100$ m
- **Lidar data**: 15 - 40 km range; $\Delta z \sim 1.5$ km → 4 km
- **Microwave radiometer (MWR) data**: 20 - 60 km range; $\Delta z \sim 10$ km

◆ High vertical resolution intercomparisons up to 40 km
Results at Payerne (46.5°N-6.6°E): MIPAS V4.53 vs 4.55

Coincidences 14/11/2002-16/12/2002

Caveat...
Relative differences for v4.53 and v4.55

\[ \text{Relative differences for v4.53 and v4.55} \]
Most appropriate instruments for $NO_2$ are UV-VIS Zenith-sky DOAS Instruments

- observations of scattered sunlight at twilight
  - $NO_2$ morning (am) and evening (pm) slant column measurements

- Recently: inversion of low resolution profiles, based on dependence of scattering height on solar zenith angle (SZA)

- Low vertical resolution intercomparisons, taking into account diurnal variation of $NO_2$ (SZA dependence)
Retrieval of vertical profile information from UV-vis observations

Based on the work of Preston et al, 1997

\[ y = F(x, b) + e_y \]

\[ b: \text{Vector of forward model parameters} \]

\[ e_y: \text{Measurements errors} \]

Retrieval method: optimal estimation [OEM, Rodgers, 2000]

\[ x_{\text{retr}} = x_a + S_a K^T (K S_a K^T + S_\epsilon)^{-1} (y - K x_a) \text{ with } x_a = \text{a priori} \]
Forward model

Stacked box photochemical model PSCBOX [Errera and Fonteyn, 2001]

• 48 species, 110 gas-phase, and 31 photolysis reactions
• Heterogeneous chemistry processes on PSCs and aerosols particles included
• Full diurnal cycle, no family and photochemical equilibrium assumptions
• Kinetic and photochemical data from JPL 2000 [Sander et al., 2000]
• Initialisation: 12h UT 3D-CTM SLIMCAT (P, T + 32 species; 18 altitude levels)

Radiative transfer model UVspec/ DISORT [Kylling, 1995]

• Discrete-ordinate, 10 streams, pseudo-spherical approximation
• Accounts for 2-D chemical variation of NO₂ profiles (incident beam)
• Accounts for multiple scattering, ground albedo and aerosol scattering
Results at Harestua

• 60°N, 10°E; NDSC complementary station, often in vortex edge

• UV-VIS DOAS zenith-sky instrument operated by BIRA-IASB

• DOAS timeseries since 1998 on a continuous basis
  • NO₂
  • O₃
  • OClO
  • BrO

Comparisons of NO₂ with MIPAS v4.57 for the period April–August 2003
Comparison conditions:

MIPAS overpasses around 9-10 and 21-22 UT, daytime SZA (~40-60°) and nighttime SZA (~95-110°) in April-Aug period

At present, model limited to ~75° to 93° SZA

→ comparisons will not be at exactly same SZA

→ To be ‘extrapolated’
‘Fit’ results

HARESTUA 22.05.03 AM

HARESTUA 20.06.03 PM

\( \text{NO}_2 \) slant column density \([\times 10^{16} \text{ molec/cm}^2]\)

- measurements
- calc. with a priori profile
- calc. with retrieved profile

\( \text{SZA}[^\circ] \)

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NO$_2$ typical evening result (20-06-2003 pm):

- UV-VIS DOAS inversion sensitive in range 15-35 km
- 2 independent information elements
$NO_2$ (typical) morning result (22-05-2003 am):
Sunrise (am) behaviour different from sunset (pm) behaviour – due to fact that photochemistry is neglected in MIPAS retrievals?

Seasonal variation of relative differences? At least in am data?
N$_2$O, HNO$_3$, CH$_4$, (O$_3$)

Only FTIR provide correlative data (except O$_3$)

- solar or lunar absorption measurements
  - daytime or nighttime vertical column measurements

- Recently: inversion of low resolution profiles, based on dependence of absorption line shape on pressure (requiring high spectral resolution), using OEM

- Low vertical resolution intercomparisons, (similar approach as for NO$_2$)
Results at Reunion Island

- 21°S, 55°E; subtropical complementary NDSC station
- FTIR measurements campaign in Sept-Oct. 2002 as a collaboration between BIRA-IASB, ULB and Univ. Reunion
  - N$_2$O
  - HNO$_3$
  - O$_3$
  - ....

Comparisons on 3 days (25, 26, 28 Oct. 2002) with MIPAS v4.53, before pointing (altitude) correction
**HNO₃ typical result (28-10-2003)**

- A priori far from real profile – still both retrievals agree well
- Essentially FTIR column retrieval!
\(N_2O\) typical result (25-10-2003)

• FTIR retrievals have 2.5 – 3 independent information elements, situated around 5, 13 and 20 km altitude; almost no sensitivity above 25 km

• Both retrievals confirm maximum of \(N_2O\) VMR profile around 22 km altitude in UT/LS where both are sensitive.
**O$_3$ typical result (25-10-2003)**

- FTIR retrievals have ~ 5 independent information elements, between 5 and 40 km altitude; vertical resolution ~5 km

- profile comparisons reflect pointing error of MIPAS before mid November 2002?
Results at other FTIR stations of network?

Most stations up to now don’t provide profile data

- Lauder and Arrival Heights provide distinct strato- and tropo- columns for $N_2O$ and $CH_4$
- Partial strato- column intercomparisons for $N_2O$ and $CH_4$
- Other stations provide total column measurements
- Total column intercomparisons for $HNO_3$, assuming tropo- column is negligible
HNO3 total columns at Arrival Heights

Courtesy:
S. Wood & D. Smale - NIWA
Partial and total column comparisons provide a quick look to the quality of the MIPAS products on a quasi-global scale;

In particular:

detection of changes in the quality of the MIPAS products with successive processor versions.

much scatter is observed –

partly due to oscillations in the MIPAS profiles

partly due to too crude co-location criteria

e.g., HNO$_3$ in winter-spring at close-to-polar locations

Partial column intercomparisons must still be corrected for different column sensitivities

has scatter increased in the versions 4.55 and 4.57?
Summary & Perspectives

Ground-based network data provide continuous support to satellite data validation, on a quasi-global scale

- NO$_2$
  
  DOAS profile inversions appear to have a significant potential for MIPAS profile validation in the altitude range where the NO$_2$ concentration peaks

  - Improve temporal colocation of intercomparisons (model evaluation extended run towards day and night)

  - Extend to Jungfraujoch – possibly other DOAS stations?
Other species ...

GB FTIR can provide useful profile data for MIPAS validation, in limited altitude ranges; for some species the (partial) column data allow an initial quality check.

- Extend work done at Reunion Island; in particular second campaign in Sept-Nov. 2004 (also for ACE and TES)

- Extend profile inversion to other stations and additional species in the UT/LS and stratosphere

- Improve co-location criteria
- Extend to validation of (additional) scientific data products
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