

Quantitative retrieval of polar stratospheric cloud (PSC) volume density profiles from MIPAS in comparison to CALIPSO

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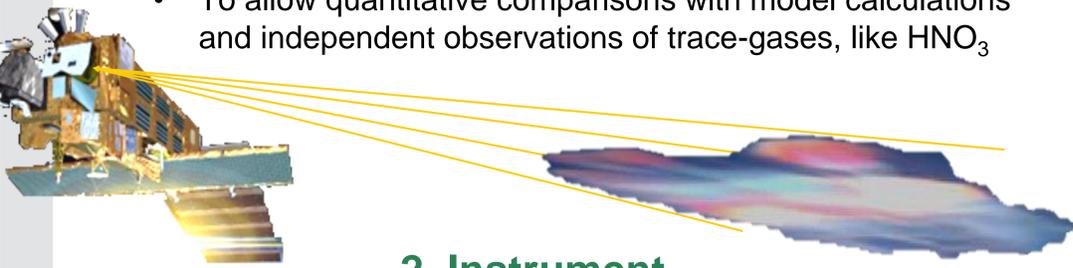
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1. Motivation

- Advantages of PSC-observations by MIPAS/Envisat:
 - Day- and night-time observations with no degradation between day and night
 - Coverage nearly up to the poles (~89°)
- Available information on PSCs from MIPAS/Envisat so far:
 - PSC existence, top height, composition [1,2,3,4]
- Goal of actual study:
 - Effective retrievals of altitude-resolved profiles of PSC volume density
 - To allow quantitative comparisons with model calculations and independent observations of trace-gases, like HNO₃



2. Instrument

Michelson Interferometer for Passive Atmospheric Sounding on Envisat (MIPAS)

- Infrared limb emission measurements with high spectral resolution
- Global observations, ~1000 profiles per day, Jun 2002–Apr 2012

3. Retrieval

Improved retrieval approach:

- Simulated test cases based on real in-situ balloon-borne observations of particle size distributions [5,6] by using the validated radiative transfer/retrieval algorithm KOPRA
- Test-retrievals for optimization of spectral intervals and refractive indices
- Resulting set of parameters:
 - Spectral window: 831-832.5 cm⁻¹
 - Refractive index: β -NAT
- Estimated retrieval error from test calculations (Fig. 1):
 - Systematic: up to 0.5-1 $\mu\text{m}^3\text{cm}^{-3}$ (STS, NAT, and STS/NAT mixed), 5 $\mu\text{m}^3\text{cm}^{-3}$ (ice)
 - Random (excluding spectral noise): up to 3 $\mu\text{m}^3\text{cm}^{-3}$, typical 1-2 $\mu\text{m}^3\text{cm}^{-3}$ (STS, NAT, and STS/NAT mixed); 10 $\mu\text{m}^3\text{cm}^{-3}$ (ice)
 - Spectral noise: 0.2-1 $\mu\text{m}^3\text{cm}^{-3}$
- Vertical resolution of the retrieval: 2.5-3.5 km

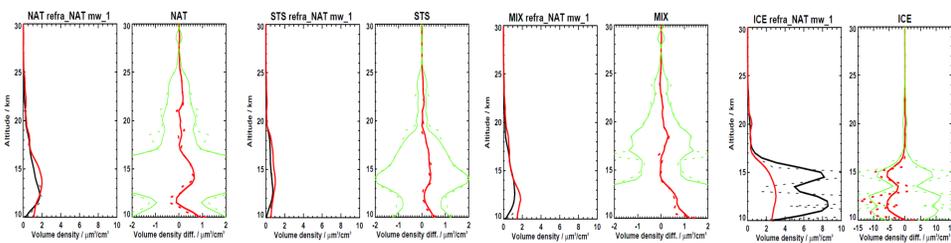


Fig. 1: Estimation of retrieval uncertainties based on in-situ test cases. Left, black: reference. Left, red: mean retrieval result. Right, red: systematic mean difference. Right, green: standard deviation of differences. Solid: compared to 3-km smoothed in-situ profiles. Dotted: compared to in-situ profiles with 0.5 km altitude resolution.

4. Application to Antarctic winter 2011

- The developed retrieval baseline has been applied to all MIPAS spectra south of 55°S between 10-May and 31-Oct 2011. Some orbital cross-sections are shown in Fig. 2.

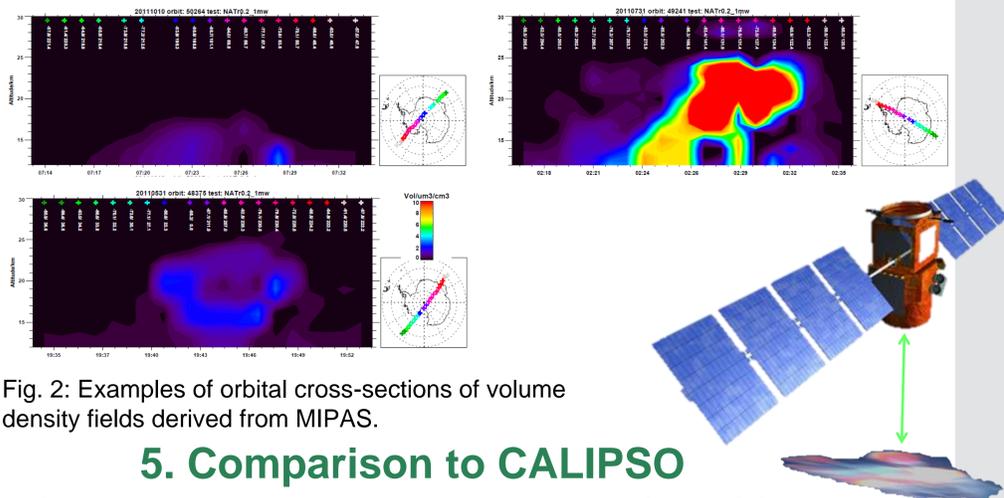


Fig. 2: Examples of orbital cross-sections of volume density fields derived from MIPAS.

5. Comparison to CALIPSO

- Calculation of volume density profiles from CALIPSO surface area densities by application of relationship derived for liquid PSC particles: $\log_{10}\text{SAD} = 0.92 + 0.667 \times \log_{10}\text{VD}$
- Selection of CALIPSO co-incidences within 200 km and 2 h of each MIPAS measurement.
- The co-incident profiles compare qualitatively well with respect to PSC detection and vertical extend taking into consideration the different vertical resolutions (3 km vs. 0.2 km).
- When CALIPSO detects mainly liquid particles, the volume density profiles compare well (Fig. 3, 1st and 2nd rows). Estimated CALIPSO volume densities for mixed and ice PSCs are smaller than MIPAS values, as expected since the CALIPSO VD/SAD relationship is for liquid PSC particles only.

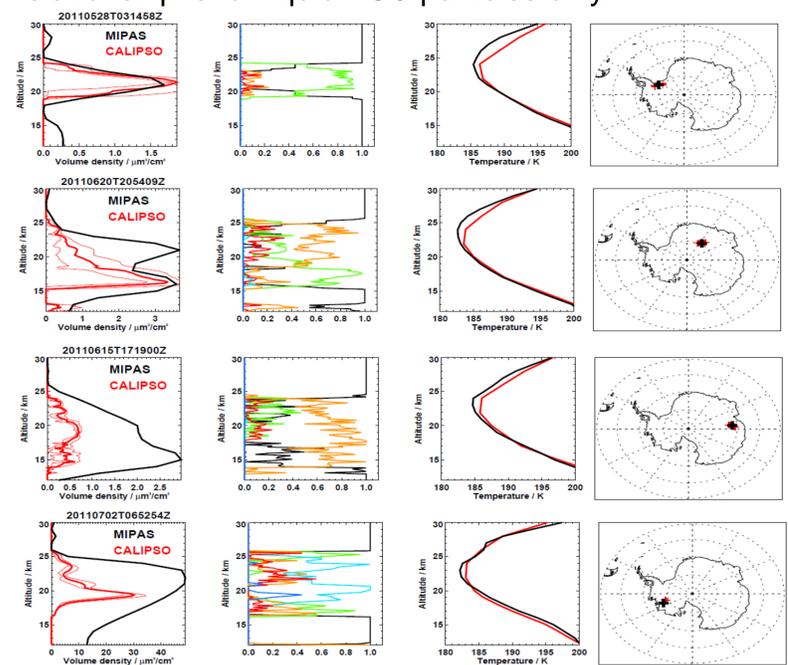


Fig. 3: Comparison between MIPAS and CALIPSO volume density profiles. Left: thick, red: average; thin, red: single CALIPSO profiles. Col 2: composition from CALIPSO. Black: no PSC, green: STS, blue: ice, red: enhanced NAT, orange: NAT mixtures. Col 3: temperatures (analyses). Col 4: profile location. Cols 1,3,4: black: MIPAS, red: CALIPSO.

References

[1]Spang et al., 2005, doi:10.5194/acp-5-679-2005. [2]Höpfner et al., 2006, doi:10.5194/acp-6-1221-2006. [3]Höpfner et al., 2009, doi:10.1029/2009JD012114. [4]Spang et al., 2016, doi:10.5194/amt-9-3619-2016. [5] http://www-das.uwoy.edu/~deshler/Data/Aer_Meas_Wy_read_me.htm. [6]Deshler et al., 2003, doi:10.1029/2003JD003479.

Acknowledgement:

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