OVERVIEW ON VALIDATION OF MIPAS H_2O VAPOUR BY COMPARISON WITH INDEPENDENT SATELLITE MEASUREMENTS

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ABSTRACT

The water vapour operational data products from MIPAS (V4.61) have been validated by comparison with independent satellite measurements from HALOE (Version 19), SAGE II (Version 6.2), and POAM III (V2). Availability of MIPAS data were limited to the validation reference data set from July 2002 to December 2002. Between 100 hPa and 10 hPa (15-30 km) good agreement between MIPAS and the three satellite instruments to within the combined error of 15 (POAM III) to 25(HALOE) has been found. Above 30 km (below 10 hPa) a positive bias of up to 20% with respect to the other satellites has been observed. In the lowermost stratosphere root-mean-squared scatter of the observed differences increases dramatically (above 100 hPa with HALOE and POAM, and above 50 hPa with SAGE II).

1 INTRODUCTION

Stratospheric water vapour is an important radiatively active trace gas and its potential long-term change due to tropospheric CH_4 increases makes it a sensible parameter to climate change (Chapter 4 in [1]). From model studies it can be shown that a 1% per year increase of stratospheric water vapour as locally observed above Boulder [2] may contribute to a stratospheric cooling trend that is comparable in magnitude to that from ozone changes [3]. However, there is a large uncertainty on the observed magnitude and sign of the stratospheric water vapour trend on global scale [4]. Global water vapour measurements from space in the coming decades are therefore of extreme importance to further our understanding of the role of (stratospheric) water vapour in our climate and in the UT/LS (upper troposphere/lower stratosphere) chemistry.

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is part of the atmospheric instrumentation on the Environmental Satellite (ENVISAT) launched in March 2002. MIPAS measures the atmospheric limb emission spectra from 685-2410 cm^{-1} (14.5 to 4.1 µm) over the altitude range from 6 to 68 km. Water vapour retrieval is done in a micro-window near 6.1µm. In this paper we summarise the water vapour profile validation from comparison with three space borne solar occultation instruments SAGE II, HALOE, and POAM III. The Halogen Occultation Experiment (HALOE) is operating since 1992 aboard the Upper Atmosphere Research satellite (UARS) and operates in the infrared between 2.45 and 10.0 µm [5]. The Stratospheric Aerosol and Gas Experiment II (SAGE II) measures since 1984 onboard ERBS and its radiometer records seven discrete UV-VIS-NIR wavelengths between 0.385 and 1.02 µm (e.g. [6]). POAM III has nine spectral windows spread from 353 nm to 1018 nm and has a similar spectral coverage than SAGE II [7,8,9]. POAM III observations are limited to polar regions near 65°N and between 60°S and 80°S, while SAGE II and HALOE also cover tropical regions.

Other satellite instruments that have been recently launched have not yet been compared to ENVISAT. They are SMR/ODIN an SAGE III/METEOR-3 (both launched in 2001) and SABER/TIMED (launched in 2002). Additional water vapour profile measurements from space are to be expected from several instruments aboard AURA, i.e. MLS, TES, and HRDLS, to be launched this year. All three atmospheric chemistry experiments aboard ENVISAT (SCIAMACHY, GOMOS, and MIPAS) measure water vapour, but inter-comparison results are not presented.

The complete MIPAS data sets from the validation reference set (data from 2002/07/18–2002/12/27) have been searched for coincident satellite measurements. The coincidence criterion was a distance of less than 250 km between tangent points of HALOE/SAGE II and MIPAS and that collocated measurements were from the same day. Similar criteria applied to collocated POAM III measurements except that the maximum allowable tangent point distance was 600 km.

During the time period of the validation reference data set altitude errors up to 3 km due to an ENVISAT pointing problem have been observed. For this reason the comparison with SAGE and HALOE was done on pressure levels that could be directly retrieved from CO2 MIPAS measurements.

For validation the following data version were used: Version 19 of HALOE, Version 6.2 of SAGE II [10], and Version 2 from POAM III [8,11].

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2 VALIDATION WITH SAGE II

For the H_2O profile comparisons with SAGE II a total of 137 collocations were found most of them from northern latitudes (96 profiles). Examples of individual collocated water vapour profiles are shown by Bracher et al. [12]. In Fig. 1 the mean of all 137 water vapour profiles for both instruments are shown. The statistical results from these comparisons (Fig. 2) show a positive bias of MIPAS to SAGE II of 4 to 12% with an RMS of 10 to 25% between 2.5 and 50 hPa. The SAGE II profiles show rather large oscillations at pressures lower than about 2.5 hPa and the comparison is not meaningful above this pressure level. Below the 50 hPa level the RMS scatter in the differences increases to more than 50%.

The accuracy of the SAGE II profiles are about 10%-15% (random) and 20%-30% (systematic) in V5.96 [6,11]. The water vapour profile retrieval has significantly improved with V6.2 as the aerosol correction in the water channel (935 nm) has been improved and a spectral shift applied (Thomason et al. 2004). It can be concluded that the agreement between MIPAS and SAGE II is excellent for the altitude range between 2.5hPa and 50 hPa.

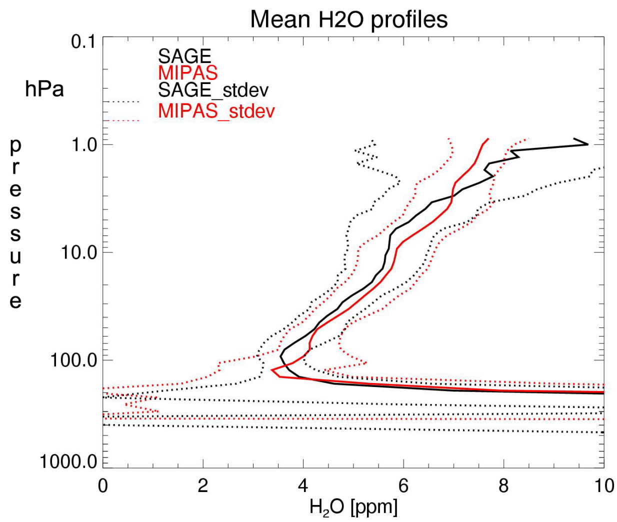

Fig. 1. Mean H_2O water vapour profiles from the collocated MIPAS (red) and SAGE II (black) profiles. Dotted lines are the 1σ root-mean-squared differences to the mean profiles for both instruments. The mean and rms scatter were calculated from 137 profiles of which 96 profiles were from northern middle (28) and polar latitudes (66).

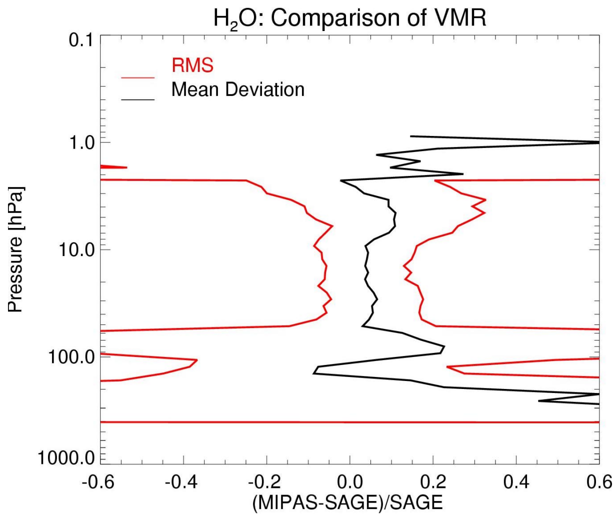

Fig. 2. Relative mean deviation of MIPAS minus SAGE profiles (black) and 1σ RMS scatter of the relative differences (red).

3 VALIDATION WITH HALOE

For the H_2O profile comparisons with HALOE, 100 collocations were found in the reference data set.. There were 49 collocation pairs between 30°N and 60°N, 31 between 60°N to 90°N, eight in the tropics, and only 12 in the middle and high southern latitudes. Comparison between individual profiles are shown by Bracher et al. [12]. Fig. 3 shows the mean H_2O profiles from MIPAS and HALOE. The statistics from these comparisons (Fig. 4) show a positive bias of MIPAS to HALOE of 1 to 15% with an RMS of 6 to 12% between 1 and 60 hPa. In the upper stratosphere MIPAS is clearly higher than HALOE by up to 20%.

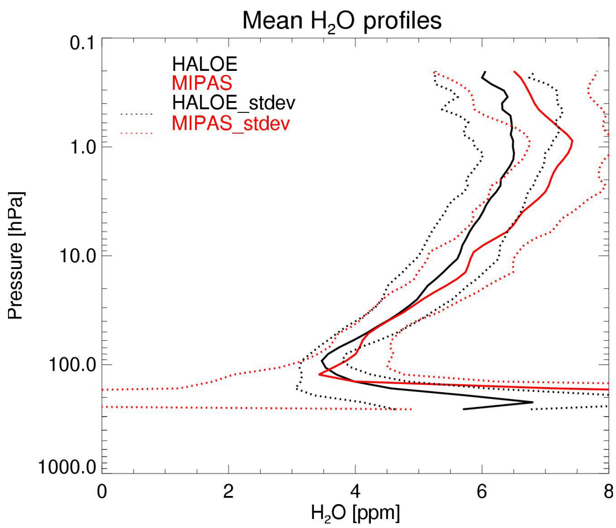

Fig. 2. Mean H_2O water vapour profiles from the collocated MIPAS (red) and SAGE II (black) profiles. Dotted lines are the 1σ root-mean-squared differences to the mean profiles for both instruments. The mean and rms scatter were calculated from 100 collocated profiles.

From the individual comparison it is evident that the MIPAS profile show oscillations that are not seen in the HALOE profiles [7]. This could point at the insufficient vertical sampling of the profiles (every 3 km) that lead to this artifact in the MIPAS retrieved profiles .

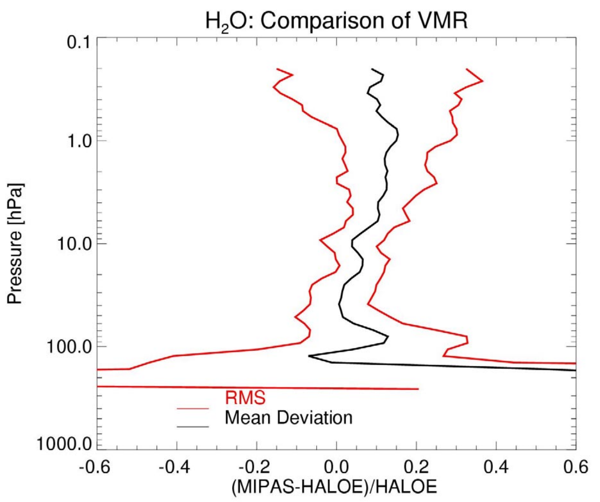

Fig. 4. Relative mean deviation of MIPAS minus HALOE profiles (black) and 1σ RMS scatter of the relative differences (red).

Sytematic (random) errors for HALOE water vapour retrieval are up to 19% (13%) in the 15-30 km and up to 15% (7%) in the 30-50 km altitude range for Version 18 [13]. Similar numbers apply to Version 19 [11]. The observed bias between MIPAS and HALOE are generally within these uncertainties but a positive bias by MIPAS is apparent.

4 VALIDATION WITH POAM III

Using a more relaxed collocation radius of 600 km between tangent points of POAM III and MIPAS a total of 616 matches was found in the 60°N-70°N latitude band. The mean water vapour profiles are displayed in Fig. 5. Compared to the HALOE and SAGE mean profiles, the mean profiles in that particular latitude band show little variability. The mean difference between MIPAS and POAM III is ranging from –5% to 5% between 15 and 35 km (Fig. 6). Above 35 km the MIPAS bias is increasing to +40% near 50 km altitude. That confirms the positive bias of MIPAS already seen in the HALOE comparisons.

POAM III retrieves water vapour in the 940 nm channel like SAGE II does [7,8]. The POAM III retrieval accuracy is reduced above 40 km that possibly explains the large difference observed [11]. The precison of the water vapour retrieval is 5% from 5 to 40 km [11]. It can be concluded that between 14 and 35 km the agreement between MIPAS and POAM III is to within the uncertainty of both satellite measurements. More details on the water vapour validation using POAM III data can be found in Bazureau et al. [14].

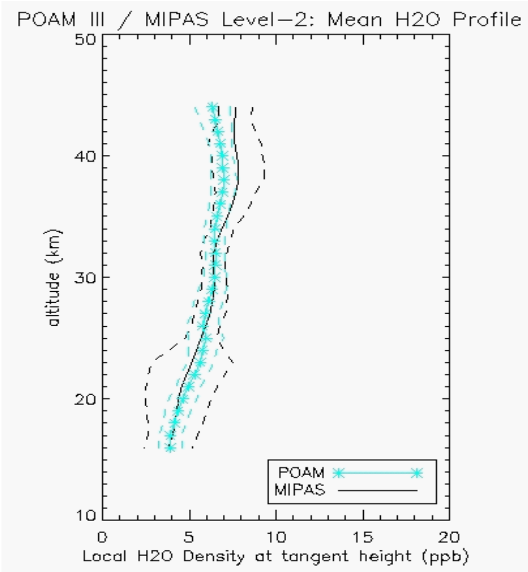

Fig. 5. Mean H_2O water vapour profiles from collocated MIPAS (black) and POAM III (blue) profiles. Dashed lines are the 1σ root-mean-squared differences to the mean profiles for both instruments. The mean and rms scatter were calculated from 616 collocated profiles in the 60°N-70°N latitude band.

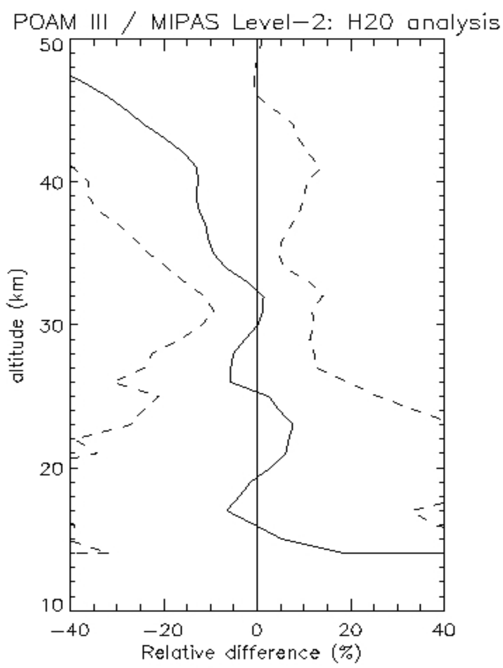

Fig. 6. Relative mean deviation of POAM III minus MIPAS profiles (solid) in percent and 1σ RMS scatter of the relative differences (dashed).

5 CONCLUSIONS

The new data version 4.61 of the MIPAS operational H_2O vapour data product have been validated with independent satellite measurements from SAGE II, HALOE, and POAM III. All three comparisons have shown that agreement of MIPAS with these instruments is to within the instrumental uncertainties of all validation instruments for the altitude range between 15 and 30 km (10-100hPa). Below 15 km altitude the RMS scatter in the differences between MIPAS and other satellites drastically increase. Most likely explanation is the limitation of solar occultation instruments at lower tangent height (increasing extinction) but may be also be caused in parts by the lower altitude boundary set for the MIPAS retrieval.

The current vertical sampling of 3 km is too coarse and possibly causes the oscillatory structures seen in the MIPAS profiles. A vertical sampling of about 1.5 km and better is recommended if feasible.

Currently a spectral window near 1650 cm^{-1} is used in the MIPAS retrieval and saturation of the water line at low pressures may be affecting upper stratospheric water vapour retrieval. By selecting alternative retrieval windows may help improving the retrieval in this atmospheric region.

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