COMPARISON OF WATER VAPOR MEASUREMENTS BETWEEN THE SATELLITE LIMB SOUNDER MIPAS/ENVISAT AND THE AIRBORNE MICROWAVE RADIOMETER AMSOS

Stefan C. Müller[1], **Niklaus Kämpfer**[1], **and Matthias Milz**[2]

[1] *University of Bern, Institute of Applied Physics, 3012 Bern, Switzerland*
[2] *Institut für Meteorologie und Klimaforschung, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany*

ABSTRACT

To validate our ten year middle atmospheric water vapor dataset obtained by the airborne microwave radiometer AMSOS we compared its datas to the satellite instruments MIPAS on ENVISAT and MLS on Aura. AMSOS has a dry bias of up to 15%. Beside the offset the error is in the range of $\pm$10%. Surprisingly the offset with regard to the infrared instrument MIPAS is twice as big as to the microwave instrument MLS. This fact leads us to assume a problem in the spectral parameters of the different spectral ranges.

Key words: Water vapor; middle atmosphere; AMSOS; MIPAS.

1. INTRODUCTION

Two key domains in climate research are global warming and ozone depletion. They require detailed information about the atmospheric state and their single parameters. Water vapor is involved in both topics as the most important natural greenhouse gas and as a source for polar stratospheric clouds and the radical molecule OH in the ozone depletion process. The water vapor mixing ratio has very low values in the stratosphere and a strong gradient in the troposphere. Due to the large dynamical range over multiple magnitudes in altitude it is difficult to measure and data products need to be validated between each other.

Two instruments which were designed to measure water vapor are the **M**ichelson **I**nterferometer for **P**assive **A**tmospheric **S**ounding (MIPAS) [Milz 2005] onboard the ESA satellite Envisat (fig. 1) and the **A**irborne **M**icrowave **S**tratospheric **O**bserving **S**ystem (AMSOS) carried by a Learjet of the Swiss Air Force (fig. 2) [Vasic 2005]. Both cover the stratosphere and the upper part of the troposhere. In this study we compared single profiles from both instruments for validation purposes. Suplementary a comparison to the **M**icrowave **L**imb **S**ounder MLS on NASAs satellite Aura is added.

Figure 1. Satellite ENVISAT with MIPAS (Source of image: ESA)

Figure 2. Learjet of the Swiss Air Force

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2. METHODS

2.1. Instrumental description and data product

Both instruments perform passive remote sensing detecting molecular spectral emission lines at infrared (MIPAS) and microwave (AMSOS) wavelength, respectively. We will concentrate in the following especially on water vapor. The two sensors are capable to measure in the stratosphere and in the UTLS (upper troposphere, lower stratosphere) region. The MIPAS vertical profiles cover an altitude range from about 6-68 km over the whole globe. The AMSOS instrument delivers profiles from about 13 up to 60 km [Vasic 2004]. Flight campaigns were realized over the northern hemisphere for the last ten years once a year during one week. A composition of the technical details of the measurements is given in table 1.

	MIPAS	**AMSOS**
spectral range	infrared	microwave
wavenumber, frequency	685-2410 cm^{-1}	183 GHz
observation platform	satellite ENVISAT	airborne
observation technique	limb sounding	up looking
altitude coverage	6-68 km	13-60 km
profile version	H2O_11	2
operational years	2002-2004, since 2005 in reduced mode	1998-2006

Table 1. Technical details of the water vapor measurements with MIPAS and AMSOS.

2.2. Profile comparison

The profiles to compare were selected by searching for the nearest profile within a time window of 10 hours and not more than 500 km of distance. The plot in figure 3 shows the flightpath of the Learjet in September 2002 in blue and the collocation pairs as red connected circles. The set of profile pairs consists of nine sites distributed over the northern hemisphere from subtropical to subarctical regions.

The limb sounding technique of the MIPAS generates vertical profiles with higher resolution than the ones from AMSOS. To take that into account we have to smooth out the MIPAS profile by applying the averaging kernels A of the microwave instrument as it is described in equation 1 [Tsou 1995] to get two profiles of equal altitude resolution for comparison.

$$\mathrm{MIPAS}_{\mathrm{smoothed}} = \mathrm{AMSOS}_{\mathrm{apriori}} + A * (\mathrm{MIPAS} - \mathrm{AMSOS}_{\mathrm{apriori}}) \quad (1)$$

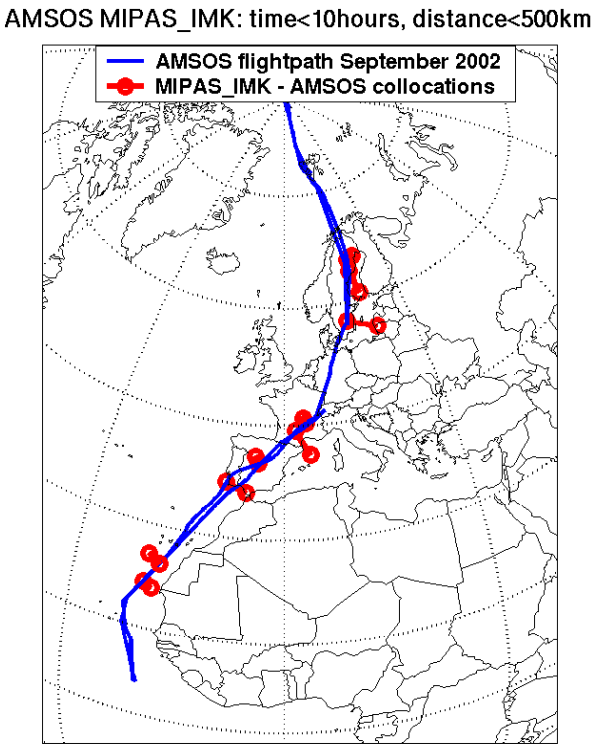

Figure 3. AMSOS flightpath and collocation sites.

As the AMSOS apriori profile is a global mean profile it does not reproduce well the location of the hygropause in every latitudinal zone. This can lead to big differences in the second term $(\mathrm{MIPAS} - \mathrm{AMSOS}_{\mathrm{apriori}})$ for the tropospheric part for several cases. A kernel function that belongs to the upper stratosphere as higlighted in figure 4 with the green thick line also has a very small contribution in the upper troposphere at 200 hPa that becomes large when its multiplied with the above mentioned difference and falsifies the folding procedure by simple mathematics. For that reason we cut the averaging kernel (see figure 5) at the hygropause level of the apriori profile and smooth only the stratospheric part. For the tropospheric part then we take the real differences.

3. RESULTS

Figure 6 shows an example of a measurement at a collocation site at mid-latitudes. The magenta profile is the smoothed version of the original green MIPAS profile at equal vertical resolution as the AMSOS by applying the averaging kernels as described in section 2.2. In this example the hygropause level is well reproduced by both and the part in the lower stratosphere agrees excellently. In the middle and upper stratosphere both show the expected water vapor maximum at the 1 hPa level but they have a bias of about 1 ppm.

The relative mean difference between profiles of the two sensors is plotted as a red curve in figure 7. We deter-

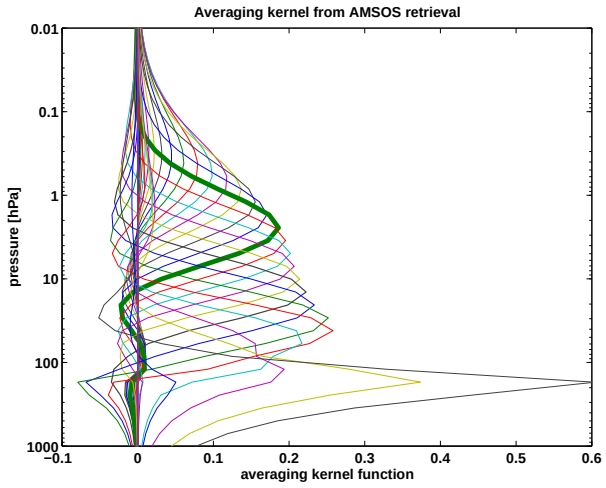

Figure 4. AMSOS averaging kernel

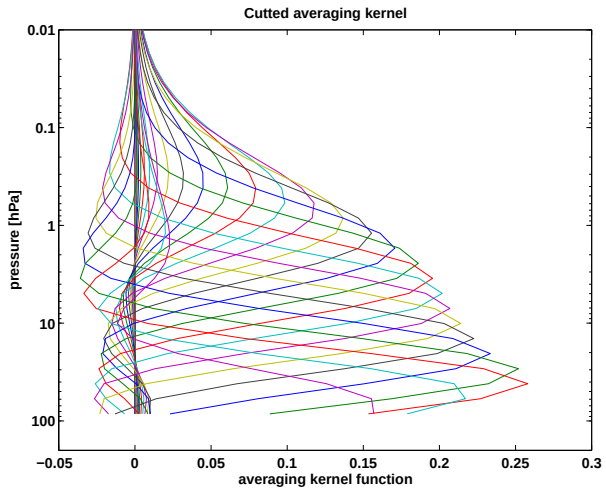

Figure 5. Cutted AMSOS averaging kernel

mined a dry bias of AMSOS with regard to MIPAS in the order of 10-15% over the whole overlap region. Beside the offset the error is less than $\pm 10\%$.

The comparison to the MLS instrument on the Aura satellite is shown in figure 8. The set of 39 collocations from November 2005 show a quasi constant mean dry bias of the AMSOS instument of 8% throughout the stratosphere. Higher up it rise to 15%.

4. DISCUSSION

Water vapor measurements are important for observations of the earth climate system. Datasets have to be validated for their significance. For that reason we compared AMSOS profiles with data from the MIPAS instrument. It has clearly been shown that the main features of the vertical water vapor profile are well reproduced, the strong gradient in the troposphere, location of the hygropause

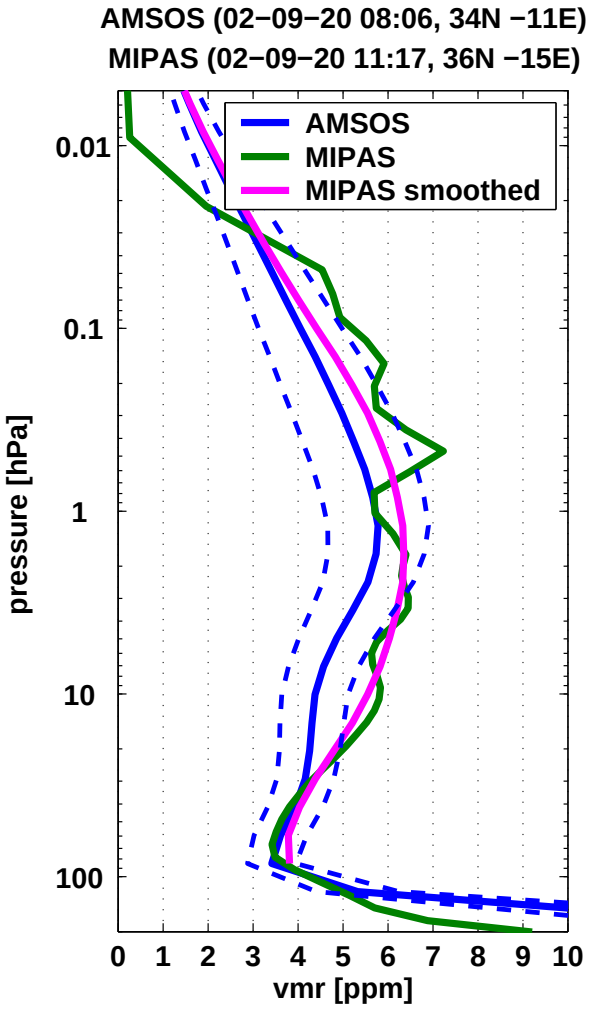

Figure 6. Vertical water vapor distribution measured by AMSOS and MIPAS.

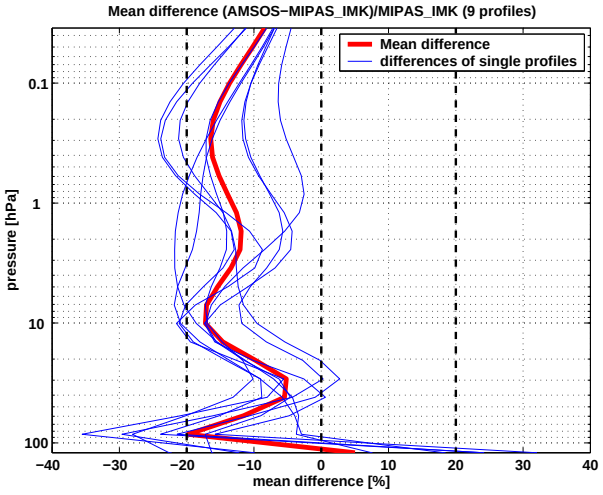

Figure 7. Mean relative difference between AMSOS and MIPAS.

and a H_2O maximum in the upper stratosphere. The

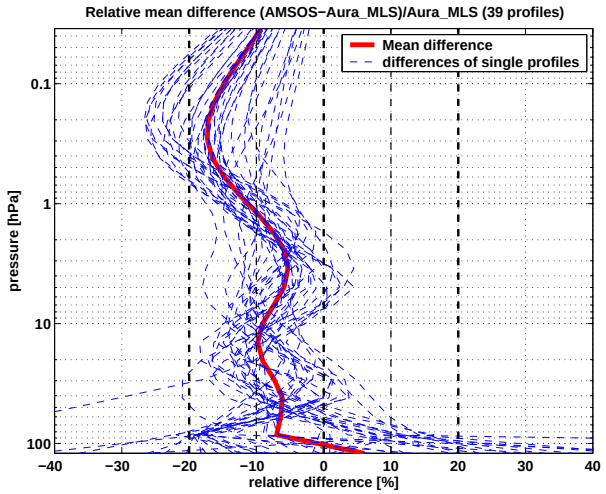

Figure 8. Mean relative difference between AMSOS and MLS on Aura.

number of collocation that fit in a certain distance and time window is rather small. Nevertheless a dry bias of the AMSOS instrument in the stratosphere of nearly 15% was determined. An explanation for this offset might be different characteristics in the spectral parameters in different wavelength region. This assumption is strengthened by the fact that the offset to the microwave instrument on the Aura satellite is smaller. However it seems that the AMSOS instrument is still too dry that might also be due to the choice of the apriori information.

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