

Review of “A new microwave spectrometer for ground-based observations of water vapour” by K. Hallgren et al.

General comments

The paper presents the description of a new ground based microwave radiometer at 22.235 GHz for middle atmospheric water vapor, cWASPAM. cWASPAM is an improved version of the WASPAM radiometer and three units are being deployed forming a small network. The instrument description is complemented by a short comparison with EOS-MLS data and a discussion of the uncertainties.

Results from the cWASPAM instruments have already been presented in Hallgren et al. 2010 (WSPC) Straub et al. 2011 (AMT) and in Hallgren and Hartogh 2012 (ACP). The presented paper adds only very little to the already published material. The authors need to explain (in response to this review or directly in the paper) what is new in this publication and what is the motivation for this publication. The paper cannot be considered as a general validation paper of cWASPAM1-3 since only data from Schneefernerhaus are shown and it has been compared to only one reference. However, to my knowledge a general validation of the three instruments is still missing and I would like to encourage the authors to expand the presented paper to a general validation considering all three instruments.

The main default of the paper is the lack of precision in terms of language. The usage of words is often misleading and sometimes wrong. Several key sentences are not clear and the author's thoughts cannot be understood. I got the impression that the paper has not been written carefully. Further, interesting aspects on short term variability of mesospheric water vapor in the validation part are not supported by the necessary illustrations and are hence not convincing.

I cannot recommend this paper for publication. Major revisions are needed to improve the language and to put the paper in proper context with other publications on this instrument highlighting the new results in this paper.

Specific comments

Abstract

Please clarify if the statement “... a time resolution of an order of magnitude better than what has been achieved by earlier instruments” refers to earlier WASPAM instruments or to ground-based radiometers in general. In the latter case, the statement does not hold: Nedoluha et al. 2012 (JGR) report integration times of 6h and Scheiben et al. 2013 (ACP) report integration times shorter than 2h.

Introduction

The structure of the introduction is rather confusing mixing up very general statements on ground based radiometry or atmospheric water vapor with very specific statements on the presented instrument. A more logic structure would be: (I) atmospheric water vapor and the need for observations with high temporal resolution, (II) ground-based radiometry followed by (III) some introductory phrases on cWASPAM and (IV) how the paper is structured.

P4678,I21: "... have been detected and..." in this phrase this sounds almost as if these gases had been discovered by microwave radiometry. If this is the message, support it with according references. If not, just leave it away.

P4679,I5: What exactly means "ground-based spectroscopy"? I assume the authors mean "ground-based observations".

P4679,I10: what follows after "molecular parameters" are the "spectroscopic parameters". Please correct that.

P4679,I18: this phrase is not well written. Water vapor plays an important role in climate through photochemistry.

P4679,I19: who is "we"? Avoid whenever possible the first person plural. Exceptions can be made when the authors refer to themselves.

P4679,I25: First, methane is not a source of water vapor, but methane oxidation. Second, "its photodissociation" in the following phrase refers grammatically to water, while the authors want to refer to methane. However, methane is exactly not photodissociated but oxidized (Remsberg et al. 1984, JAS, 41, 19).

P4680,I17: The correct reference must be Haeferle et al. 2008. Add also Scheiben et al. 2013 (ACP).

Instrument description

P4681,I7: Why is the instrument at IAP called MISI and what does the acronym mean?

P4682,I4: How does the system temperature of cWASPAM compare with the one from WASPAM?

P4682,I13: Report both channel spacing and spectral resolution (channel bandwidth) in Table 1.

P4683,I23: In the view of long term monitoring, the authors should give some more information on the maintenance requirements?

P4683,I26: What does "retrieved data" refer to? In the common terminology this would refer to the retrieved water vapor profiles.

P4684,I11: Does this mean, that the load temperatures are varied according to the atmospheric conditions?

Retrieval

P4684,I20: "initial calibration" is used the second time (first use on p4684,I15) but probably refers to a different procedure. Specify what "initial calibration" refers to and avoid any possible misunderstanding.

P4684,I21: Precision in language is missing: (1) according to common terminology, the spectra are not retrieved but measured or observed; (2) it is not the spectra that are uncorrelated, but the noise. The spectra are highly correlated since the same atmosphere is observed.

P4684,l24 and ff: It is more common to use y for the measurement vector and x for the state vector. This would also avoid any misunderstandings regarding equation (4) where x refers to the retrieved profiles.

P4685,l7: I agree that the variance is reduced by a factor of 2. But it is the standard deviation, $\sqrt{\sigma}$, which is relevant for the SNR and hence the time to obtain the same SNR using both polarizations is reduced by a factor of $\sqrt{2}$ compared to a single or unpolarized measurement.

P4685,l21: “retrieved profile” or “inverted spectrum (or line)” instead of “retrieved line”.

P4685,l23: This is not correct. The averaging kernels represent the sensitivity of the retrieved profile to changes in the true atmosphere. Each line in the averaging kernel represents the change in the retrieved profiles at all levels with respect to a change in the true atmosphere at a specific altitude. Hence, a perfect AVK is a unity matrix.

Validation of data

P4686,l9: Leave away “on the water vapour distribution”.

P4686,l12: Do the authors really refer to the spectra? Or to the profiles?

P4686,l25: Replace “The new profiles” by “The convolved profiles”

P4686,l27: explain ALL variables in this equation.

P4687,l6: given equation (4) and (5) my interpretation is that the differences have not been calculated with convolved EOS-MLS profiles. Add the necessary hats and descriptions where necessary to leave no room for interpretation.

P4687,l9: This statement is too qualitative. Use the measurement response (sum of averaging kernel function) to show the sensitivity of the retrieval as a function of altitude. Often, a threshold in the measurement response (e.g. 50%) is used to determine the upper limit of the measurement.

P4687,l11: “Although both...” this phrase is not clear.

P4687,l17: “The variability...” A vertical profile of the variability has to be shown to illustrate this statement.

P4687,l19ff: The rest of the paragraph discusses actually a very interesting episode but nothing of it is shown. The text absolutely needs to be supported by corresponding figures for illustration. Time series of the 4h and 12h integration retrievals at different pressure levels must be shown.

Error analysis

P4688,l6ff: The first two phrases of this paragraph need to be reformulated.

P4688, l13: “In general...” this is certainly not true for the MNE. Since the authors are highlighting the short integration time of cWASPAM the errors should be shown for both integration times. Having a close look at Figure 4 I somehow get the impression that the same measurement covariance matrix is used for both integration times. If this is the case, then this should be stated clearly and the motivation for this choice should be given.

P4689,l13ff: From “It is however...” to the end of this paragraph: it is not clear what point the authors want to make. A more precise language and more careful use of the different terms like error and noise may already help a lot.

Conclusions

This paragraph is very minimalistic.

P4689,l27: “As a result...” this sounds as if cWASPAM achieved the same SNR after 4h like WASPAM after 24h. However, the paper fails to show this: The dual polarization explains a reduction of integration time by a factor of $\sqrt{2}$. The receiver temperature of both instruments have not been compared. Any changes in duty cycle?

P4690,l1: “Validation of ...” this is not part of the presented paper and proper reference has to be given.

Technical corrections

P4681,l5: replace “has been” by “have been”.

P4682,l2: the abbreviation LO is not explained.

P4682,l25: explain MPS.

P4685,l5: use “sigma hat” instead of “sigma_n” in accordance with “x hat”.

P4685,l11: “involves” instead of “involve”.

P4686,l22: replace “is reduced” by “are reduced”.