Atmos. Meas. Tech. Discuss., 6, C939–C945, 2013
www.atmos-meas-tech-discuss.net/6/C939/2013/

Atmospheric Measurement Techniques Discussions

AMTD

6, C939–C945, 2013

Interactive Comment

Interactive comment on "Validation of middle atmospheric campaign-based water vapour measured by the ground-based microwave radiometer MIAWARA-C" *by* B. Tschanz et al.

B. Tschanz et al.

brigitte.tschanz@iap.unibe.ch

Received and published: 17 May 2013

Dear Referee #2, your constructive comments and suggestions are highly appreciated. Pointing out imprecise formulations helps to improve the quality of the paper. We thank you for your time and the motivating suggestions for future studies. In the following we answer your comments and indicate how we are planning to change the manuscript. We summarise the main points of your general comments in bold and present the response.

Stimulated by the comments of both referees we will add an additional data set (Sodankylä 2011-2013, with new receiver) and divided the Zimmerwald campaign into two comparison periods; the first one with the old and the second one with the new receiver set-up. In addition, it turned out that at Zimmerwald we often get interference from some external signals that disturb small parts of the measured spectrum. The affected parts are now excluded from the spectrum for the retrieval.

Instrument has been changed, data sets used do not offer sufficient evidences to claim travelling standard:

We agree with both referees, the campaign-based data sets used up to now might not be sufficient to decide whether MIAWARA-C can be called travelling standard. In the revised version of the paper, we conclude that MIAWARA-C is a reliable instrument for campaign-based measurements and has the potential of becoming a travelling standard in the future. The validation efforts are continuing and as suggested by the referee, further comparisons to MIAWARA are planned.

For a better characterisation of the new receiver and of the differences caused by the upgrade we plan to include a new data set obtained with the new receiver. MIAWARA-C has been measuring in Sodankylä from June 2011 to March 2013. In total we have now results from three campaigns: LAPBIAT (old receiver, Sodankylä), Zimmerwald (first old, then new receiver) and Sodankylä (new receiver). We split the Zimmerwald campaign into two periods, the first with the old and the second with the new receiver. With these data sets we can obtain a better estimation of the data quality with the different receiver types and give first indications about the stability of MIAWARA-C's measurement between different campaigns. The comparison to Aura MLS v3.3 using all data sets is shown in Fig. 1.

Incorrect assumption: negligible systematic errors of reference instruments: We are aware of the problems resulting from neglecting the systematic errors of the reference instruments. The systematic errors of the satellites can change over time and can depend on the location making it difficult to impossible to give realistic systematic error estimates. Therefore, we are going to stick to the assumption of negligible systematic errors of the reference instruments as described in Sect. 4.2 (P1328 L12-17). Possible consequences of this assumptions are mentioned in Sect. 4.2 and repeated in the summary (P1324 L22-26), in the conclusion we state the systematic error of MIAWARA-C's v1.1 is an upper limit.

Following an advice of referee 1 *negligible* is going to be replaced by *not considered*.

P1312L13: As the measurements contain many other error sources than thermal noise, the two polarisations do not give independent "measurements". For example, errors due to so called baseline ripple are probably more or less the same between the polarisations. Hence, systematic error should be highly correlated.

We agree with the referee and thank for pointing out that the measurements of the two polarisations are not independent as the same retrieval set-up is used for both polarisations. The baseline ripples seem to have both correlated and uncorrelated contributions. For the revised version we change P1312 L11-13 to:

MIAWARA-C measures two polarisations of the incident radiation in separate receiver channels and can therefore provide two measurements of the same air mass with independent instrumental noise.

Related to this is the assumption in Sec 2.3 that the only random error source is thermal noise. At least, the temperature profile and calibration contain also

AMTD
6, C939–C945, 2013

terms of random character.

We agree with the referee. Considering thermal noise as the only random error source was chosen for consistency with previous studies (Straub et al. (2010), Wachter et al. (2010), Haefele et al. (2009)). For the revised version we change the approach used for the error estimation. The systematic error remains as in the discussion version except that the uncertainty in the temperature profile is changed from 5 K to 8 K (see also response to referee 1). Contribution from random uncertainties in the calibration and in the temperature profile are added to the thermal noise to obtain a random error estimate. The random error of the temperature profile is assumed to be 3 K and the random error of the calibration factor is estimated as 5%.

P1316L13: Is the value 0.014K considering tropospheric attenuation? (That is required to reach the stated goal.) and

P1316L15: The answer is maybe in this sentence, but then not expressed clearly. Please remove these obvious remarks and instead explain the approach taken for this particular work. We change P1316 L3-18 to:

The difference measurements, line minus reference, are calibrated and corrected for tropospheric attenuation resulting in spectra ***y*** *as seen from the tropopause in zenith direction. For the profile retrieval a number of measured spectra need to be averaged in order to achieve a sufficiently high signal to noise ratio. For MIAWARA-C spectra are averaged until a noise level of 0.014 K is reached. Averaging to a fixed noise level results in data covering an almost constant altitude range. The temporal resolution of the integrated spectra used for the profile retrieval mainly depends on the tropospheric opacity and on the observation geometry (Straub et al., 2011).*

The two signals measured by the two receiver chains of the dual-polarisation receiver are calibrated separately. The two measurements, $\vec{y}_1$ *and* $\vec{y}_2$*, with noise levels,* σ_1 *and* σ_2*, share the same optical system and can therefore be either regarded as two*

AMTD

6, C939–C945, 2013

independent measurements of the same airmass or they can be combined into one spectrum which has the advantage of lower measurement noise. Both polarised spectra are weighted according to their noise levels to obtain the combined spectrum, $\vec{y}$:

$$\vec{y} = \frac{\sigma_2^2 \vec{y}_1 + \sigma_1^2 \vec{y}_2}{\sigma_1^2 + \sigma_2^2}. \quad (1)$$

P1317L6: Is this statement really correct considering the low noise of the cWASPAM set of instruments?
See http://www.atmos-chem-phys.net/12/3753/2012/acp-12-3753-2012.html
Of course, similar 22 GHz instruments achieve comparable temporal resolution and instruments with cooled front-ends like cWASPAM have higher signal to noise ratio. The temporal resolution is only special compared to satellites. We changed P1317 L6 to: *The good temporal resolution and its reliability are the major benefits of MIAWARA-C.*

P1328L9: Please clarify what is meant by "standard error of the bias".
For clarification we insert:

$$\sigma_{i,bias} = \sqrt{\frac{\sum_{n=1}^{N_i} \left(x_{i,mia-c}(n) - x_{i,ref}(n) - b_i\right)^2}{N_i \left(N_i - 1\right)}} \quad (2)$$

P1329L3: Unclear sentence. Only correlation coefficients having a confidence level above 95% displayed?

AMTD
6, C939–C945, 2013

Yes. P1329L3 changed to: *All correlation coefficients displayed have a confidence level above 95%.*

Sec 5.1 A higher emphasis on this comparison is encouraged. This is the most interesting part of the article. In the comparison to MIAWARA all disturbing factors can be removed. There should be no collocation error, and the retrievals can use identical assumptions (as done fully, or just in part?). Hence, this comparison could reveal the instrument specific problems. How are the differences of 5-10 % explained? By baseline issues? And then in which of the instruments? In fact, this comparison can be used to show how a "travelling standard" instrument could be applied to analyse the performance of another ground-based microwave radiometer.

The retrievals of both MIAWARA-C and MIAWARA use identical assumptions except the baseline fitting is slightly different. In the revised paper we highlight the importance of this comparison. Analysing the periods with the two receivers of MIAWARA-C separately (as mentioned above) will result in a more thorough discussion than in the discussion paper. We agree with the referee that further comparisons to MIAWARA are crucial for the assessment of MIAWARA-C's data quality and potential as a travelling standard and will be covered in future studies.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 1311, 2013.

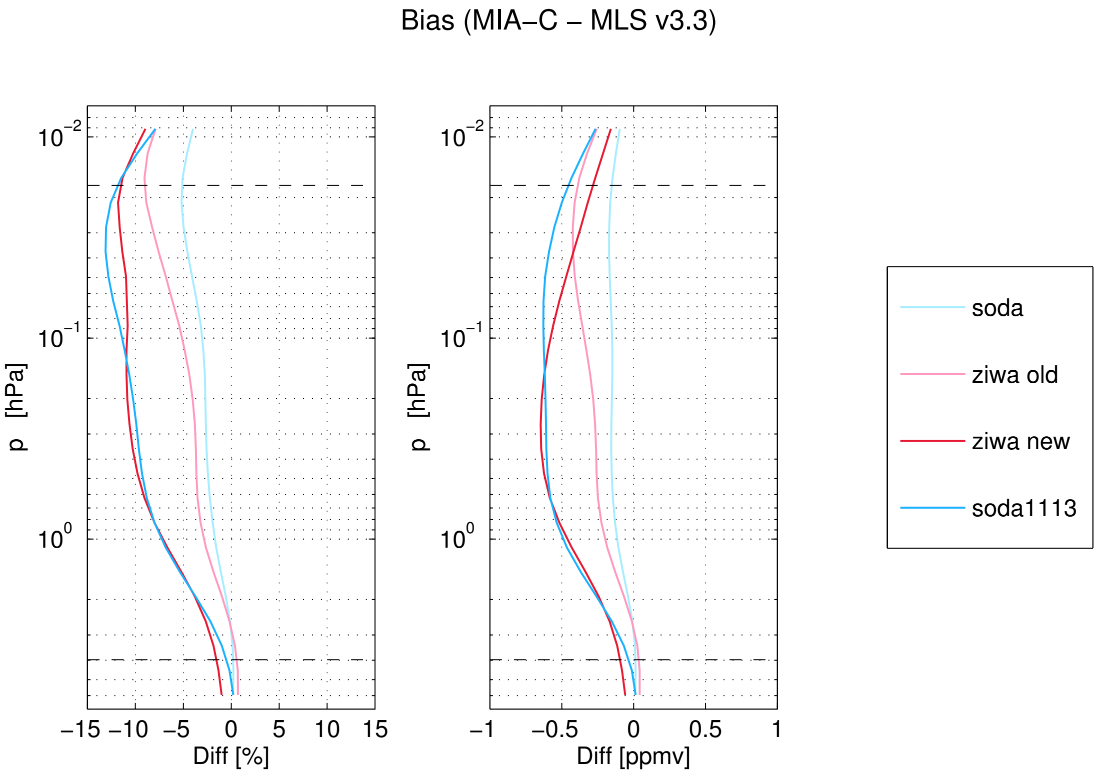

Fig. 1. Relative and absolute bias compared to MLS v3.3 for all campaigns. Soda (green) and ziwa old (cyan) data are obtained with the old receiver and ziwa new (blue) and soda1113 (red) with the new receiver

AMTD

6, C939–C945, 2013