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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "High-resolution atmospheric water vapor measurements with a scanning differential absorption lidar" *by* F. Späth et al.

Anonymous Referee #3

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The paper presents some technical aspects of a water vapor DIAL and some examples of measurements that have been taken during the HOPE campaign. Further, a discussion of the effect of temperature, pressure and humidity on the water vapor cross section is given and the calculations of the optimal online wavelengths are presented.

As explained in detail below, I cannot recommend the paper for publication in its current form. In a major revision the scope of the paper needs to be better defined, missing information and scientific justification of crucial assumptions need to be provided, the coherence between the Sections needs to be improved, errors and inconsistencies need to be removed and the conclusions need to be enhanced.

General Comments

The purpose of the presented paper is not clear. While the title is very general, the abstract promises the presentation of the design of the instrument and an illustration of the performance. However, the paper does not contain enough technical details to be an instrumental paper (telescope FOV, overlap, saturation, background, operation mode, alignment, temperature stability), not a nearly complete discussion of the measurement uncertainties and a methodically and scientifically relatively poor validation part.

The paper further fails to give important information and explanations in several parts and is based on assumptions that are not justified or seem to be too simple. The authors give an estimation of the "total uncertainty of the WV DIAL data analysis procedure" while only aspects of the effective cross section have been discussed. Background correction and perhaps saturation correction, which are part of the analysis procedure, are not even mentioned. Other instrumental effects like uncertainties in pointing and laser frequency do not appear in the uncertainty discussion. It is not possible to find out from the text, what type or kind of radiosonde has been used in the validation and the "overall bias", which is a main part of the summary, is not defined.

Finally, clarity and precision of the language are insufficient in several parts.

Specific Comments

2.1 Therory P29061, l18: It is incorrect to say that they cancel. Better say "can be neglected", as it is done a few lines lower down.

2.3 Sensitivity analyses P29065, l15: Actually, Fig. 4 shows sigma_wv. Please resolve the inconsistency (see comment for Fig. 45).

P29065, l19: This paragraph says that temperature profiles from RRL CAN be used, or that iterative retrievals CAN be made to reduce uncertainty due to humidity changes. The authors have to be more specific what actually IS done in the presented processing and what the uncertainties associated to the temperature profile are for the different data sources.

P29066, l3: The authors must justify in the text their assumptions for the pressure and temperature uncertainties. Second, it is very misleading to say, that the "total uncertainty of the WV DIAL data analysis procedure" is smaller than 1.4%. It obviously only refers to the uncertainty in derived water vapor due to the uncertainty in pressure and temperature used in the calculation of sigma_eff. The obtained value of 1.4% should be put in relation with uncertainties in sigma_eff due to uncertainties in beam elevation and laser frequency.

2.4 Wavelength selection P29066, l19: Give a number for the uncertainty in laser frequency (see comment above).

P29067, l1: no "." after sigma_on.

P29067, l3: "More accurate ... optimum signal to noise ratio" this paragraph is not clear.

P29067, l9: This assumption seems to be too simple given the high changes in water vapor with altitude. The authors need to justify this assumption to convince the reader that the following estimations are useful, in particular for R>3.3 km.

P29067, l26: The authors should explain here what scheme is used to change the laser wavelength in order to minimize the measurement error.

3 Setup P29069, l9: Since the laser wavelength is changing, it would be more sensible to give the center frequency of the IF directly.

4.1 Vertical measurements

P29071, l4: Please indicate in the text what polynomial degree has been used in the SaGo filter.

P29071, l6: It is not clear from the text if "DIAL data" refers to retrieved water vapor

profiles or to raw data. Please clarify.

P29071, l16: There is an inconsistency in Fig. 9 between absolute and relative error, suggesting that either one or the other presentations is wrong by a factor of 100 (see comment for Fig. 9). Please resolve this issue and correct the text and the conclusions if necessary.

P29072, l5: It is explained nowhere in the text, what radiosonde type (not even what physical principle) has been used. The Behrendt et al. references are certainly not the correct ones for the RS data.

P29072, equation 14: Is the "2" in the numerator correct? The bias is normally estimated with the arithmetic mean. Please justify or correct.

P29072, l13: What is the "overall bias". Please give the equation in the text. Given the small values for the "overall bias", I do have the impression it is the average over all profiles and all heights. If so, then this is a highly questionable metric. The DIAL could have a 100% negative bias below 1500 m and a 100% positive bias above and the "overall bias" would still be approx. zero.

4.2 Scanning measurements P29073, l10: What is the pointing uncertainty for the different scan speeds?

Figures and Tables

Table 1: It would be easier to understand if the conventions of the text were kept, hence sigma_on rather than sigma_wv and N_wv rather than N. It seems that the fourth column should be in 10ˆ26 mˆ-2.

Figure 4: The figures are too small. In the caption, I guess it should not be sigma_wv but sigma_eff, as explained in the text P29065, l15. Why do the authors conclude, that the sigma_eff is most sensitive to temperature changes? A close look at the panels shows that a 10% change in pressure leads to a larger change in sigma_eff than a 10% change in temperature at all altitudes.

Figure 9: The relative error at 1000 m is around 0.01 % and the corresponding absolute error is 0.05 g/mˆ3. This yields a humidity of 500 g/mˆ3, which is off by a factor of 100.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 29057, 2014.