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Atmospheric Measurement Techniques Discussions

Interactive comment on "Raman Lidar for Meteorological Observations, RALMO – Part 2: Validation of water vapor measurements" *by* E. Brocard et al.

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We would first like to thank Anonymous Referee #2 for carefully reading the manuscript and providing constructive comments. They have helped raising the quality of the manuscript. The point-by-point answers (A) are provided below.

Specific comments:

Introduction. I agree with the first reviewer: the introduction lacks of a discussion about the state of art of operational water vapor profiling in the troposphere. During the last years many efforts inside the lidar community have been done to have Raman or Dial

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lidar systems able to routinely monitor atmospheric water vapor. This topic as well as some results of interrelated instrument intercomparisons should be addressed with the appropriate references.

(A) Discussion and references have been added to the introduction.

P6917 lines 17-19: Please renumber the sections (section 3 is absent) and add some details on the description of each part of the paper.

(A) Done

Section 2. P6918 line 7: Add the diameter of the four telescopes.

(A) Done

Section 3. P6918 lines 22-23: You say: 'for normal conditions at Payerne the effect of differential extinction due to aerosols is small and is neglected'. Even if, as written in the companion paper, 'error in water vapor concentration due to aerosol extinction is below 10% even for hazy conditions (Whiteman et al. 1992, 2001)', this term could significantly affect the inter-comparison results. Arguments need to be provided to justify this assumption.

(A) 10% is an upper limit of the error under hazy conditions. Under normal conditions, in the free atmosphere, the influence can be neglected.

P6919 lines 2-8: Calibration methodology needs to be more described (adding a plot if necessary) and discussed. In particular do you use the same calibration coefficient for nighttime and daytime? What about the PMT efficiency during these two different measurement conditions? Please clarify these arguments.

(A) An illustration of the calibration is shown in the companion paper on P6912. The determination of the calibration constant is fairly simple and we feel, that the text as it is together with a reference to the companion paper on P6919, L19 contains all the relevant information.

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The same calibration constant is used for day and night. First, the narrow field of view and narrow bandwidth design of the lidar minimizes the solar background and second, analog detection is used for the water vapor channel in the lower altitudes to improve the linearity. This is described in more detail in the companion paper.

P6919 line 17: Delete the repetitive sentence 'in order to maintain a statistical error lower than 10%'. Section 4.

(A) Done

P6921 line 5ff: The presence of the outliers in Fig. 3 could affect the calculated mean monthly bias. Do you find the same trends using the median instead of the mean? If you separate daytime from nighttime measurements do you find different trends?

(A) In order to avoid having obvious outliers impacting the trend, data that are more than 3 standard deviation away from the mean have been removed (This concerns just a few points at each level). Therefore, using mean or median yield fairly similar trends. Daytime and nighttime measurements also yield similar trends at the lower altitude levels. Higher up, trend calculations using only daytime measurements would make no sense since there are too little data.

P6921 lines 23-25: I do not understand the meaning of the whole sentence ('Therefore, the characterization... as a monthly average'). Please rephrase it.

(A) This sentence is ambiguous. It has been removed.

P6923 lines 1-2: Please consider that 'limiting conditions' may include also presence of aerosol layers (see the comment P6918 lines 22-23).

(A) This has been mentioned in the paper: "It is noted that additional profile height limiting conditions may include scattered clouds, full moon nights, low laser power or cirrus clouds or aerosol layers due to the clear-sky selection algorithm"

Section 5.1. P6925 lines 17-23: Please discuss more extensively the effect of the

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different space-time collocation that is certainly relevant when comparing profiles from lidar and rds. In particular, the paper of Dionisi et al. (JAOT, 2010), which describes a methodology to calibrate a Raman lidar through non-collocated radiosoundings, shows that the main source of calibration coefficient variability (approximately 10%) appears to be caused by the different sampling between lidar and rds. This term is significant also in case of collocated instruments, because the rds drifts with the wind. This work should be cited.

(A) This work has been cited, together with the literature suggested by Reviewer 1.

Furthermore, although it is beyond the aim of the paper, an evaluation of this term could be provided by plotting, for some atmospheric layers, the dependence of the relative difference betweenlidar and rds in function of their reciprocal distance.

(A) We did some preliminary experiments on the relative difference between lidar and radiosondes as a function of their reciprocal distance but did not find any conclusive evidence. This would need further investigation, which is indeed beyond the scope of this paper.

Section 5.2. The results between daytime and nighttime should be completed with the calculation of the median to verify that the outliers do not affect the statistics. Furthermore, as suggested by the first referee, also the analysis under specific conditions (at least dry and humid) should be added to better characterize the differences between lidar and rds measurements.

(A) Please refer to the answer to Reviewer 1 (P6925 L24ff and Fig. 7/8)

P6926 line 9ff: The left plot of figure 7-8 does not provide significant elements in the discussion and should be eliminated. Figure 8 should be cut at 6 km.

(A) Here, we think it is relevant to the reader to have these plots.

(A) Figure 8 has been cut at 6km

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P6927 lines 6-9: Please add more details on the correlation procedure (vertical range, number of points used, etc.).

(A) The following has been added to the legend of Fig. 9: "for all altitude levels (day: 2239 points, night: 6887 points)"

Section 6.1. P6929 lines 5-7: One of the critical issues of a Raman lidar is to minimize the different system performances between daytime, where PMTs are subjected to the strong solar short-wave radiation, and nighttime. Although the methodology of the profile retrieval is well described in the companion paper (and it should be cited here), I suggest to add more information about the use of AD channel (how do you scale the AD signal to PhC signal?) and maybe to move this description to Section 5.2. Please also specify if you use the same AD-PhC merged profile for night and day and at which altitude the two channels are merged.

(A) A summary of the data treatment is given in Section 3 and we added some information on the use of PC and AD signals on p6919, L15 . Proper reference to the companion paper, where the use of AD and PC signals is explained in detail, is made at the end of Section 3.

(A) Here, we want to point out, that, at a fixed altitude, the SNR is generally lower during day than during night and that the background correction has more impact during day than during night. Hence, the overall uncertainty is bigger during day.

P6929 lines 9-12: Please be more specific about the behavior of SRS-C34 and RS92 during night and day (add some results).

(A) It is beyond the scope of this paper to study the behavior of the SRS-C34 radiosonde compared to other radiosondes. The last WMO radiosonde intercomparison shall provide enough substance for the interested reader. It is also ongoing research in Payerne. Here, we wanted to stress that not only the lidar has a different behavior during the night that it has during the day. In this sense, it is difficult to conclude which

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system performs best, as stated in Chapt. 6.1.

P6929 lines 21-25: Please specify the error sources and add references.

(A) A reference to the WMO Guide has been added. This guide provides an extensive discussion on the uncertainties.

Figures.

P6940 Fig. 3: Please add, If relevant, median-derived trends and separate trends for daytime and nighttime conditions.

(A) Please refer to the answer P6921 line 5ff:

P6944-45 Figs 7 and 8: Please consider modifying the figures as proposed in comment P6926 line 9ff. Furthermore the caption is a bit confusing: replace 'Top' with left and Bottom' with right and index the subplots.

(A) Plots in Fig. 8 have been cut to 6 km. The issue with the caption is just due to the way the paper is edited (A5, but it was submitted as portrait A4).

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 6915, 2012.