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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.

Anonymous Referee #1

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General comments to amt-2012-138:

The manuscript describes a validation of a water vapour Raman lidar with other nearby instrumentation from a 12 months measurement series. Direct vertical profile intercomparisons have been carried out using radiosonde ascends, while the comparison of integrated water vapour (IWV) is additionally regarding data from GPS and a microwave radiometer. The lidar yields profiles up to 8km within 5% to 10% to radiosonde values during the darkness and up to 3 km within 3% during daytime. The intercomparisons of IWV with GPS (5.3% wet BIAS), microwave radiometer (6.4% dry

bias) and radiosondes (4.2% dry bias) show also a good agreement and correlation on a short time scale. These results are very impressive and definitely merit publication. The manuscript has some deficits and needs some revisions.

Specific comments:

P6916 L25ff: Introduction:
The state of the art of water vapour remote sensing and interrelated instrument intercomparisons needs to be discussed in more detail and cited more considerably. E.g., Intercomparison of microwave radiometer data (Bleisch et al. 2011, AMT); LUAMI Campaign 2008 (Wirth et. al, ISTP 2009, Deflt); IWV intercomparison FTIR vs Lidar (Vogelmann et al. 2011, AMT), MOHAVE Campaign (Leblanc et al. 2011, AMT).
P 6918 L24f: The state of the art of water vapour profiling in the troposphere with lidar needs to be discussed an cited more considerably. There are other full operational Raman lidars around, e.g., Lindenberg (Reichardt et al., ILRC 2010), Cabauw (Apituley et al., ILRC 2012) and also some full daytime capable DIALs with short integration times, e.g., Hamburg (Bosenberg et al., 2002, ESPR), Zugspitze (Vogelmann et al. 2008, Appl. Opt.), DLR-Falcon (Wirth et al. 2009, Appl. Phys. B). This part should be moved into the introduction.

P6919 L16:
I expect a more detailed description of the smoothing algorithm (gliding average or least square fit or other) and its vertical resolution as a function of altitude.

P6921 L22-23:
The influence of different temporal and spatial matching needs to be discussed in more detail. The work of other groups on this topic should be cited. E.g., Sussmann et al., 2009, ACP; Schneider et al., 2010, AMT; Vogelmann et al. 2011, AMT

P6922 L5:
Replace ”On the one hand” by ”First”.

P6922 L11:
Replace ”On the other hand” by ”Second”.

P6922 L16ff:
The impact of clouds, in particular of cirrus clouds, should be discussed here more detailed.

P6922 L25:
”large part” should be reduced to ”large part of the tropospheric water vapour content”

P6924 L1-2:
Could you give a quantification of the moon-light / cloud induced reduction of the altitude range? Is their a citation available?

P6923 L4-5:
replace ”are” by ”were”

P6923 L 13:
replace ”...in the form of...” by ”carried out by a comparison... just before launch.”

P6923 L20:
replace ”on the order of” by ”of the order of”.

P6923 L22:
replace ”in the order of” by ”of the order of”.

P6923 L24:
replace ”in Payerne” by ”at Payerne”.

P6924 L11ff:
The HATPRO instrument should be specified more detailed. Some information about integration time, pointing geometry, field of view would be very creditable.

P6924 L15ff:
To my knowledge, a lidar profile is presumably for the birds above the bottom edge of any cloud being hit by the laser beam at any time during the integration time because of potential signal induced noise after a signal overflow in the detection system. But it should be easy to detect this from the lidar data itself. Even clouds at higher altitudes beyond the vertical range are easily to detect with the lidar itself. Thus, it is not clear, why the author wants to distinguish between clear sky and not clear sky from an independent source. As long as there is no cloud in the field of view of the lidar detection system during the integration time it should not make any difference if there is clear sky around or not? I kindly ask the author to give an explanation and a motivation for using this clear-sky detection algorithm.

P6925 L1-3:
Distinguishing between night and day profiles makes sense but what does the author mean with ”valid assumption for more than 95%”? Are their cases where the zenith angle is greater than 95 degree and the sun is still above the horizon? Hard to believe. Please, explain this.

P6925 L13-14:
Either you refer to your example (Fig. 1), as indicated by the subsection header, or you make a general statement ”A wet layer can move...” but with citations. Fast vertically moving layers can also be very dry (stratospheric intrusion). There have been many

lidar observations of vertical dynamics in the troposphere (Stohl et al. and others). I suggest to delete the subsection header 5.1 and merge subsection 5.1 into subsection 5.2.

P6925 L21:
insert ”horizontally” before ”away”.

P6925 L14ff:
Regarding water vapour the effect of probing different volumes is definitely not negligible and should be dicussed significantly more extensive here. I see, that it is very ambitious to quantify the influence of volume mismatch which is already beyond the scope of this paper. I suggest that at least an autocorrelation plot of the lidar data should be shown in contrast to the lidar-radiosonde correlation plot.

P6925 L21-23:
Quantify the positioning errors of the radiosonde, and, if of the same order as the field of view, the jitter of the lidar. If not possible, erase the statement about relevance.

P6926 L12-13:
Explain how the altitude information from the radiosonde is retrieved. If it is retrieved by pressure, the information can be used for the calculation of relative humidity profiles from the lidar only with limits. If it is retrieved from GPS, specify the altitude uncertainty.

P6926 L15:
Write ”...the difference between ...shows negative values of 5% to 10% up to 7.5 km”.

P6925 L24ff and Fig. 7/8:
I do not see the evidence of the left plots of Fig. 7 and 8. It does not tell us anything about the precision of the lidar what is suggested by the text. I would expect that the

deviation between lidar an radiosonde is strongly influenced by different conditions (beyond day an night). Is their more information available? It would be of interest, how the deviations develop under certain conditions like ”cold and dry” ”warm and humid” and other combinations. I would prefer the profile of the standard deviation of differences between radiosonde and lidar as a curve. Same with error of mean value. Anyway, Fig. 8 or a new Fig. 8 should be cut of at 6km. Why doesn’t the number of profiles have its maximum at the bottom? I would expect a constantly falling number of profiles with ascending altitude (there are some more ripples).

P6927 L6ff:
Explain how the correlation (Fig. 9) was calculated. Was the calculation done for one certain altitude or for several altitude layers? How were the values put together into the basic ensemble of the calculation?

P6927 L10:
Typo:”These”

P6927 L28ff - P6928 L10:
Why was the IWV calculation from the radiosonde data not limited exactly to the vertical range of the lidar (range bottom to range top) for this intercomparison? This should be recalculated. For an intercomparison with the radiosonde an absolute IWV value is not necessary. For the intercomparison with GPS and the radiometer the IWV from the lidar should be completed by using the data from the radiosonde and not by extrapolating a 2m a.g.l. value which is presumably producing larger errors. Radiosonde data could also be used for altitudes above the lidar range.

P6928 L18:
The 1% difference was also observed in a recent intercomparison study (Lidar vs. FTIR, Vogelmann et al., 2011, AMT) and should be cited here.

P6928 L24ff:
As already mentioned above, I suggest a more sophisticated analysis regarding different conditions. If meaningful add one or even more plots.

P6929 L17ff:
A general explanation of the basics of measuring humidity with electronic sensors is credible, but, if doing so, I expect citations, and the error sources need to be specified in detail. Otherwise, the entire paragraph should be condensed to a subordinate clause.

P6929 L26ff:
I do not agree. In the context with the forgoing paragraph an explanation from the basics is appropriate: "The lidar's basic measurement principle is to measure backscattered light from molecules or particles as a function of time (distance, altitude). A Raman lidar or DIAL is measuring the intensity of inelastic backscatter from water molecules, or the specific absorption of (infrared) light by water molecules, respectively..."

P6930 L3:
Not so if using a DIAL. The statements should be clearly referred to the Raman technique.

P6930 L11ff:
It is questionable, if it might be better to kick the comparison with GPS data out of the manuscript. It is known, that GPS data is not really suitable for such instrument validations (Sussmann et al. 2009, ACP). At least, I expect a statement about the reliability of GPS IWV data.

P6932 L14:
The Reference list is somewhat poor. There was recently many work done by others in the field of water vapour profiling with lidar and interrelated instrument intercomparisons (Whitman, Reichardt, Behrendt, Vogelmann, Leblanc, Wirth, Calpini, Apituley and others). This should be cited more complete.

P6936 Table2:
What does the second column tell us? I suggest to specify non-clear-sky-day numbers instead.

P6941 Fig. 4:
Replace this by a histogram plot.

P6944 Fig. 7 and P6945 Fig. 8:
See above, it might be useful to plot this for different conditions including the mean horizontal distance. Standard deviation and errors of the mean value should be plotted as curve. The plot in Fig 8. should be cut of at 6km.

P6946 Fig. 9 caption:
The altitude from were the values were taken must be specified, see above.

P6947 Fig. 10:
Scale the upper one higher to get a better spread.

P6948 Fig. 11:
Split this into 3 squared plots or merge it into one squared plot.

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