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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Validation of temperature data from the RAman Lidar for Meteorological Observations (RALMO) at Payerne. An application to liquid cloud supersaturation" *by* Giovanni Martucci et al.

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[a4paper,14pt]extarticle

etoolbox mathptmx [11pt]moresize blindtext, xfrac xcolor geometry a4paper, total=170mm,257mm, left=20mm, top=20mm, graphicx caption

1 Answer to Referee's general comment

We thank the Referee for the detailed and constructive review provided. We can see that our article is improved by implementing your suggestions.
We appreciate your suggestion to remove the part on cloud supersaturation and to rather put it in a separated publication. We understand that the paper is already long and, even without the supersaturation study, presents already all useful results needed to validate thoroughly the temperature product. Even if the application to a real case of liquid cloud supersaturation is important and provides a direct tool to validate a product that is largely undersampled currently across the scientific community, we agree to remove the chapter on supersaturation. This part will be integrated in a separate publication and submitted as new scientific article.

2 Answer to Referee's specific comments

Sect.1, The last two paragraphs should be combined to avoid repetition.
Done.
Sect.3, Page7, Line 8: If only 2 of the 4 telescopes are used for temperature and humidity measurements, what are the other 2 telescopes for?
all four telescopes collect the backscattered signal and transmit it through the REF to the H_2O polychromator. Two mirrors reflects the collected backscattered signal onto the REF and transmit it to the temperature polychromator.
Sect.3, P7, L7: The tilted ïňĄlter induces polarization effects. Have polarization issues been studied?
Yes. There is a full study that has been conducted, because we are in the process to implement a new depolarization channel. The REF at 9° induces only a negligible depolarisation s. The figure 1 below shows that all signals $(p+s)$ are reflected by the REF without modification.

Sect.3, P8, L6: Please name type and manufacturer of the PMTs.
Done.
Sect.4, P12, L16: Probably, the step width is 0.01 ns?
Indeed!! Corrected, thanks!
Sect.4, P12, L26: The dead times differ signiïňĄcantly. Do you have an explanation? Do you use different PMTs?
Yes each channel has a a dedicated PMT. In principle, the dead-time is provided as a specification of the acquisition card (in this case the FastCom P7888), but the PMT, from which the acquisition card gets the number of photons can modify the deadtime significantly.
Sect. 4, P13, L4ff.: Why is this so? At 50-60 km, the 'weaker' (as you say) J_{high} signal should contain only background photons, and so, in theory, background subtraction should be OK.
Yes, "it should", and that is why the standard procedure takes the far range averaged signal and subtract it from the entire signal. However, from a computational point of view, the operation of calculating a mean value (MATLAB in our case) introduces a very small error, due to the not limitless precision of this operation. A slight overestimation or underestimation with respect to the true value generates fractions of percentage-error after subtraction that then cause the temperature to have up to 1 K or 2 K bias.
Sect. 4, P15, Fig. 9 (and others): The temperature proïňĄles are presented starting at 500 (or 600)m. Given the fact that Payerne is at about 450 m asl, this is quite close to the ground and probably within the region of incomplete overlap. At what altitude does RALMO reach full overlap? Do you have instances where an incomplete overlap may have caused measurement errors?
Payerne station is at 491 m a.s.l., RALMO's full overlap occurs at an altitude of $\approx$ 4000 m. However, the temperature measurement is not really affected by the incomplete overlap in the region 500-4000 m a.s.l. as it is proportional to the ratio $J_{low}(z)/J_{high}(z)$ and both $J_{low}(z)$ and $J_{high}(z)$ have the same overlap function.

REF_depol.jpg

Fig. 1. Reflectance for two tilt angles (angle of incidence, AOI) of $9°$ and $20°$; the half-angle cone of the reflected light is $8.5°$. The data are computed by the manufacturer's on-line simulation tool

Sect. 5, P17, L1ff.: Exclusion of measurements within clouds from the statistics are justiïňĄed by the attenuation of the signals and the subsequent increase in SNR. Because of the proximity of the elastic line, however, blocking might be an issue as well. Have the authors attempted to measure PRR temperatures in clouds? How well does the double-polychromator setup suppress elastic light in the PRR signals? Up to which backscatter ratio (BSR) can the PRR temperature be considered unaffected by particle scattering? Are there any polarization effects? "

This is a very interesting point. The double-stage temperature polychromator has an almost 100% efficiency in removing the stray light from the elastic signal. However the extinction coefficient of the PRR signal backscattered from a cloudy volume is so high to impede the transmission of the PRR signal through the cloud and back to the telescope as soon as the cloudy volume is one optical depth above the cloud base $(BSR \approx 5)$.

Sect. 6, P25, L20: The 'clouds' presented are actually extremely thin. Even if the stratus were broken, to obtain a mean BSR of only 4 would mean that most of the integration time there was no cloud at all, or only swollen aerosols were present. ProïňĄles of the cloud optical properties [backscatter coefïňĄcient, extinction coefïňĄcient, lidar ratio (, and depolarization ratio; but probably not available)] plus RALMO humidity and PRR temperatures would make it possible to assess the measurement situation and the RALMO performance much better. Co-location of maximum RH and BSR sounds a bit suspicious, s. blocking comment above. As already mentioned in the summary, the reviewer recommends to discard this section.

The studied clouds (both cases) are indeed thin liquid stratus (15 Nov 2017) and fair weather cumulus (20 May 2018) clouds. In both cases, the colocated ceilometer detected a cloud base. An opaque cloud detected by the ceilometer starts at about BSR>2. Both cases showed:

1. Pre-cloud formation, with fast growing higroscopicity as a precursor of cloud.

2. Already formed cloud.

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Discussion paper

3. blocking by fully-developed cloud

The second stage is the one when supersaturation has its onset at the cloud base. All profiles (backscatter, extinction, humidity...) are available and could be added as ancillary information. However, we have decided as mentioned in the general comment to drop the section on supersaturation as suggested by the Referee. This part will hopefully converge into a cloud microphysics dedicated paper.

Math, equations and running text (all):

1. All variables must be in italic. Done

2. If not a variable, text must not be italic,e.g.: O_2,N_2,high,low,Stokes,AntiStokes, ïňĄt, sig, SB, TD, season, max, ss, ... Done, apart for ss that is a variable.

Figures:

1. Fig. 4: There is no wavelength scale as stated in the caption.
   corrected

2. Fig. 5: Is there a 'degree' symbol after 'to Aerosol & T'?
   Yes.

3. Fig. 5: The depiction of the water vapor spectrum would be more realistic if the steep slope was on the blue shoulder.
   Thanks for noticing it, we have corrected the WV spectrum.

4. Fig. 6: There are many more holes in the blocks (at the edges) than explained in the running text. What are they for?
   The holes surrounding the fiber's block are not active, are available holders for other potential input/output cables. A full description has been added to the figure's caption.

5. Figs. 10, 11: Use same style for panels left and right. Use same x range for STD in both ïňĄgures.
   Axis $x - y$ of the panels in figures 10-11 have been harmonized.

6. Figs. 14, 16: Harmonize x ranges as much as possible. For instance, use 0-120 for availability in all panels, 0-1 for STD.
   Done

Tables:

1. Tab. 2: There are entries missing down in the third column.
   Thanks for noticing it! We have added the efficiencies for lines 9 and 10

Typos:

1. P3, L5: '. Our'
   done

2. P3, L13: '. Moreover,'
   done

3. P3, L19: ‘possible causes’
   done

4. P4, L7: ‘2018)
   done

5. Caption Fig. 2: ‘2b).
   done

6. Caption Fig. 3: ‘ïňĄgures.’
   done

7. P6, L30: ‘transceiver’
   done

8. P7, L2: ‘of the signal’
   done

9. Caption Fig. 6: This is not the correct text (has been copied from Fig. 5).
   the caption has been properly adapted.

10. P11, L11: ‘is used to’
    done

11. P17, L16: ‘are the metric’
    done

12. Caption Fig. 10: Explain ‘STD’.
    done

13. Caption Fig. 11: Explain ‘STD’.
    done

14. Caption Fig. 12: ‘Differences between RALMO and COSMO temperatures’
    done

15. Caption Fig. 12: Include date of sunrise and sunset plotted.
    done

16. P20, L2: ‘November;’
    done

17. P20,L20: ‘Like spring’
    done

18. Heading, Tab. 6: Explain ‘TD’.
    done

19. P21, L8: ‘from the instrument’
    We replaced with, "from the lidar’s telescope"

20. Heading, Tab. 7: Explain ‘TD’.
    done

21. P25, L24: DeïňĄne ‘ss’.
    The chapter has been removed.