Review of manuscript with number: acp-2019-289
Towards continuous monitoring of aerosol hygroscopicity by Raman lidar measurements at the EARLINET station of Payerne

April 30, 2019

Summary
The manuscript describes the retrieval of aerosol hygroscopicity from Raman lidar measurements. Also included is a comparison of mixing ratio, temperature and relative humidity profiles from lidar with those from radiosondes. This is a comprehensive paper of, in my opinion, very high interest to the atmospheric remote sensing community. Therefore, I recommend this work to be published in ACP. However, there are some minor points that need to be addressed before publication. My comments and corrections are given below.

General comments
Most importantly, I'm missing a discussion of uncertainties in the part of this study about the impact of hygroscopicity of aerosols on the radiative budget.

Another aspect to correct is the consistency within this manuscript. Generally it is recommended to use present tense describing established knowledge and previously published work, and for presentation of results (Figure 1 shows …), and to use past tense describing methods and results, and for referencing (Author X reported …). I have added comments in appropriate places throughout the manuscript, but it would be helpful to give the finished manuscript to a native English speaker to check the language. There are also inconsistencies in some units, especially altitude measures are given in m and km, and in date formats. In figure captions alone, there are many different date formats (8 of September 2017, 7th September 2017, 3 September 2017, 07 September 2017), please homogenise these throughout the text and captions.

Specific comments

Page 1
Title
You do not highlight the automatization of the detection of hygroscopicity. Shown are case studies from automatic and continuous measurements, but the hygroscopicity retrieval was done "manually", as far as I understood. You could crop the title to "Aerosol hygroscopicity from Raman lidar measurements at the EARLINET station of Payerne".

Abstract
Line 7
"whole troposphere" is only valid for nighttime retrievals. Please rephrase.

Line 11
"rural aerosol": You only mention a mix of "local" and smoke particles once in the main text, and once in the conclusion. Elsewhere you only refer to smoke. You could update smoke references in the text to "smoky mix" or similar.

Line 17
Please see my comment on the use of "significant" in the main text (page 13, line 20).

Page 8
Line 2, Figure 1
Use either "r" or "mixing ratio", and either "T" or "temperature" in the text. After introducing "r" on page 5, line 12, you keep using "mixing ratio". When discussing the results you sometimes use "r", and sometimes "mixing ratio". It should be consistent throughout. Please update occurrences of "r"/"mixing ratio" in the text.
T is first used on page 6, line 8, but is not introduced as meaning temperature, nor used in other parts of the text.

Line 31-32
Am I correct that you averaged the mean bias below 2.1 km asl, where it was positive? In that case, please replace "was +2.0" with "was on average +2.0", and "was -4" with "was on average -4".

Page 9
Line 3
You are using different altitude ranges to average mean bias (2.1 km asl) and standard deviation (2.0 km asl) of the RH nighttime comparison, and yet different when looking at temperature and RH daytime (5 km asl). The only reason I can see, is that the mean bias of RH changes from positive to negative at 2.1 km asl. Please provide justifications for your choice of altitudes in the other two cases.

Line 6
You refer here to "errors". What are the errors/uncertainties of RS and lidar profiles? It is not specified. Or do you mean the difference between the profiles?

Line 30
Please explain NAAPS and add reference.

Line 32
I don't think that the lowest trajectory (arriving at 566 m agl, red) indicates air mass origin. It is too close to the ground throughout its journey to allow any conclusion on air mass origin.

Page 10
Figure 5
You show, but do not discuss PM10. Either remove this panel from the figure, or discuss what is shown.

Line 22
Why are potential temperature and mixing ratio auxiliary information? Besides, you sometimes use "temperature" and sometimes "potential temperature". Please be clear and specific, when which is used.

Line 34-35
Referring to "indicating a lower sensitivity of this wavelength to the aerosol hygroscopic growth": Do you mean this applies to this case? Or generally? Would it depend on the aerosol type?

Page 11
Line 2
Please rephrase the sentence starting with "This parameter …". I don't understand, especially the last part "observed in the aerosol property".

Line 6
What do you mean with "consistent"? The trend is the same (lower at longer wavelength), but the values are different. How large is uncertainty or variability of the Hänel parameter? This information would help to judge, what falls into the "consistent" range.

Line 21
You write that backscatter is sensitive to wavelength and particle size, **as expected**. This contradicts somewhat the first sentence of this paragraph. Please explain, or rephrase.

Line 22
You write, Mie scattering regime is expected for x≈1. However, x is as large as 7.1 in figure 8d. Please discuss how representative or applicable your Mie simulations are in such conditions, especially for wavelength 355 nm.

Page 12
Line 10
Out of curiosity, did you also look at dehydration along the vertical?

Page 13
Line 12
Did you try this on night-time measurements using directly the Raman lidar extinction profiles? Please briefly discuss here or below, what impact the choice of LR has on AOD, ARE and FE.

Line 15
Is AOD in table 1 columnar AOD from the full integrated lidar extinction profiles (which height range?), or just layer AOD? As the only change (according to figure 13) occurs in one layer per case, it would also be useful to see these values for the layers only. Please discuss if it is reasonable, that there is no hygroscopicity in other altitude regions. (See my comment on figure 13)

Line 17
You wrote it in the table title. Please also add here a short remark that the relative values are relative to dry values.

Line 20
It is hard to judge significance, if no uncertainties are provided. Please specify what you mean with "significant".

Table 1
Please provide an estimate of uncertainties, either in the table or in the text.

Line 31
Please add a reason, why you chose to optimise solar zenith angle for Case 1 rather than Case 2. I assume it's because the hygroscopic effect was stronger in Case 1, but it is not mentioned.

Page 14
Line 10
Does this not contradict the previous sentence? It sounds to me, that it would not be necessary. As long as AOD and ARE are right, FE is not sensitive to hygroscopicity. Please elaborate, I cannot follow this statement.

Page 23
Figure 3 (and figure 11 a)
Please consider using a different colour map, for reasons outlined here among other sources:
https://www.mathworks.com/tagteam/81137_92238v00_RainbowColorMap_57312.pdf (see page 3
for a brief overview). I find cubehelix a good replacement (or the reversed version of cubehelix, from
light to dark colour).

Page 26
Figure 7
Did you use instantaneous lidar measurements here, or again the average from 15:00 to 15:30?
Please specify.

Page 27
Figure 8
Is the size parameter x a result of the simulations, or was it an input?

Page 29
Figure 11
Show plot a) as separate figure.
Increase font size in plot b). Did you create plot 11b? If not, add source. Possibly like: "Adapted from
[source]". If you plotted the model output, please keep style consistent with other figures in this
manuscript.
Remove legend in plot c), or add meaningful label.
In the caption, replace "Quicklook of r, RH and backscatter coefficient at 355 nm from Ralmo
measurements on" with "Same as figure 3, on". Avoid "quicklook", it's too specific to the lidar
community.

Page 30
Figure 13
Those profiles suggest that there was no hygroscopic growth in other regions along the profile. How
realistic is that? I think it would be better to, for example, plot the full wet profile as faint line, the
wet profile within the studied layer as bold line, and the dry profile within the layer as dashed line,
but without connecting it to the wet profile.

Technical corrections

Page 1
Line 14   replace "is" with "was"
Line 16   be specific about "this type of aerosol"
Page 2
Line 4   remove "altering also in this way", and rephrase the following part of this sentence to
             "also altering the global radiative budget (indirect effects)(…) in this way."
Line 9   replace "has been" with "was";
             remove "in order"
Line 10   replace "kind" with "kinds"
Line 12   replace "as" with "like"
Lines 15-16 keep either "still" or "yet", remove one of them
Line 17   replace "RH" with "relative humidity (RH)";
             add comma after "water"

Line 32	rephrase sentence: "remote sensing [...] since it", or "remote sensors [...] since they", or "remote sensing techniques [...] since they"
Line 33	it is not clear what "this technique" refers to
Page 3	
Line 3	replace "RS" with "radiosondes (RS)"
Line 10	please explain what "r" is
Line 29	replace "telescope" with "telescopes"
Page 4	
Line 4	replace "to" with "into"
Line 11	replace "have been" with "were"
Line 13	"temperature" appears twice
Page 5	no comments
Page 6	
Line 23	replace "the particle" with "particles"
Line 28	replace "defined" with "fixed / constant"
Line 29	replace "are" with "were"
Line 30	replace "need" with "needed"
Page 7	
Line 1	remove "the"; add comma after "that"
Line 3	replace "use" with "used"; replace "the profiles" with "profiles of"
Line 4	replace "are" with "were"
Line 6	replace "have been" with "were"
Line 11	replace "An other" with "Another"
Line 12	remove "have"
Line 25	duplication of "of"
Line 30	add comma after "critical"
Page 8	
Line 1	replace "RSs" with "RS"; replace "allows" with "allowed"
Line 10	add comma after "retrievals"; replace "has been" with "was"
Line 12	replace "has been" with "was"; replace "treated" with "discussed"; change format of citation to "(Martucci et al., in preparation)"
Line 13	add comma after "UTC)"
Line 19	add comma after "UTC)"
Page 9	
Line 1	remove "the"
Lines 7-10	I find this difficult to follow. Please rephrase. Commas are your (and your readers') friends! For example: "In any case it is important to point out the good accomplishment of Ralmo in retrieving RH information. This can be concluded from this intercomparison, in which Ralmo showed very small biases and standard deviations (below 9%RH), which are indicative of accuracy and precision, respectively, of our measurements."
Line 12	add comma after "studies"
Line 15	add comma after "2017"; rephrase the rest of the sentence, for example: "...with smoke particles present during one, and mineral dust during the other."
Line 16	replace "in" with "of"

Line 18	replace "pannel" with "panel"
Line 19	replace "planetary" with "atmospheric"
Line 20	replace "PBL" with "ABL", and change throughout the manuscript
Line 21	replace "pattern" with "development";
	replace "along" with "during"
Line 24	replace "is" with "was";
	replace "pannel" with "panel"
Line 25	replace "for" with "during" or "in"
Line 31	add "(blue colour map)" after "concentrations";
	replace "over" with "at" (you refer to surface concentration)
Line 32	replace "from ground to 3 km asl" with "from 1 to 3 km asl"
Page 10	
Line 2	replace "for" with "in"
Line 10	remove "burning", this is already covered by "combustion"
Line 12	Please specify "that days" (or rather "those days"). Do you mean "in the period from 6th to 8th September"?
Line 14	replace "concentrations" with "concentration";
	replace "were" with "was";
	remove "than"
Line 15	replace "took place" with "occurred"
Line 16	add comma after (AAE)
Line 20	replace "of" with "over"
Line 24	replace "is" with "was"
Lines 24-25	remove either "Simultaneously to this increase," or "for the same layer";
	remove "that there is also";
	replace "can observe" with "observed";
	replace "moving" with "increasing"
Line 28	add comma after "respectively)";
	replace "is" with "was"
Line 30	replace "have been" with "were"
Line 31	add comma after "RH";
	remove "what is"
Line 34	replace "respect its" with "with respect to its"
Page 11	
Line 1	replace "took a value of" with "was"
Line 11	replace "have been" with "was"
Line 13	remove "have"
Line 21	replace "how" with "that";
	remove 2nd "the";
	replace 2nd "and" with comma
Line 22	add: "where D is particle diameter" after the equation
Line 29	remove "totally"
Line 32	add comma after "cases";
	remove "also means that we"
Line 33	replace "the theory of Mie" with "Mie theory";
	replace "," with ".";
	replace "so" with "Hence," (start new sentence)
Page 12	
Line 2	replace "For" with "In";
	replace "we can observe that r (Fig.9, top) is quite constant (…)" with "we can observe that r was quite constant (…, Fig. 9, top)"

Line 4	remove "The"
Line 6	remove "again"
Line 9	remove "very"
Line 10	replace "suffered by this aerosol" with "that occurred within this aerosol layer"
Line 12	remove "very";
	remove "either"
Lines 14-15	it sounds like you used a hygroscopic parameter of 0.4 for the later period (16:00 to 23:30); please rephrase;
	remove "also" in line 15
Line 21	replace "pannel" with "panel"
Line 22	explain acronyms "NMMB" and "BSC"
Line 23	add comma after "Europe"
Line 24	replace "in" with "for" or "above"
Line 27	replace "in our station" with "at our station"
Line 29	replace "along" with "throughout"
Line 30	replace "along" with "during" or "throughout"
Line 31	remove parentheses and include as full sentence
Line 32	replace "is" with "was";
	add comma after "measurements";
	replace "analyze" with "analyzed"
Line 33	replace "observe" with "observed"

Page 13

Lines 5-6	put parenthesis and dot on same line as 0.24 (remove space?)
Lines 6-7	rephrase, for example:
	As in case 1, we found the opposite spectral dependency compared to Lv et al. (2017). However, we considered a wider spectral range.
Line 10	remove "also";
	remove "the"
Line 11	remove "the", twice in front of "AOD"
Line 13	remove first "the"
Line 18	replace "16.6" with "15.6" (check if table 1 or text is correct);
	remove first "the"
Line 23	remove "the"
Line 24	remove first occurrence of "model"
Line 28	add "and relative" after "absolute"
Line 31	remove "the one of"

Page 14

Line 13	replace "monitor" with "observe" or "detect"; "monitor" sounds more like an automated process
Line 14	replace "in almost a continuous way" with "almost continuously"
Line 16	remove "the";
	replace "the particle" with "particles"
Line 17	add comma after "growth";
	replace "have been" with "were"
Line 21	replace "along" with "throughout"
Line 27	replace "in the full" with "throughout the"
Line 33	swap order of sentence: "…in the lower troposphere (…) were very similar to the ones obtained during nighttime."

Page 15

Line 14	add: "as well as the study of Haarig et al. (2017)"
Line 20	remove "very"

Line 21	add comma after "2017)";
	add comma after "particles"
Lines 26-27	remove first "the";
	remove "It";
	move "was also remarkable" to the end of the sentence
Line 28	replace "has been" with "was"
Line 30	remove first "the"
Line 31	add "and relative" after "absolute"
Line 32	please see specific comment for page 13, line 20
Line 33	replace "was not" with "not having been";
	add comma after "Therefore"
Line 34	replace "have" with "has"

Page 16

Line 6	replace "AA" with "AH"?

Page 21

Table 1	replace "layer width" with "layer depth"

Page 22

Figure 1	start caption with: "Mixing ratio (r), temperature (T) and relative humidity (RH) [...]"
Figure 2	add date after "UTC"

Page 23

Figure 3	replace "of" with "of vertical profiles of";
	In the caption "r" is called "water vapour mixing ratio", and in the figure "WVPR". Please amend figure and caption to "mixing ratio" and "r" to keep it consistent throughout the manuscript and to avoid confusion.

Page 24

Figure 4	replace "Total Optical Depth" with "total optical depth from sulfate (orange/red scale), dust (green/yellow scale), and smoke (blue scale)";
	possibly replace "1500, 2500, 3500 m asl" with "1000, 2000, 3000 m asl"; Payerne being roughly at 500 m asl. 3500 m asl is not consistent with the text either (page 9, line 32).

Page 26

Figure 6	explain in caption what the grey shaded area means;
	add "temperature" after "potential"

Page 27

Figure 8	increase font size in legends

Page 28

Figure 9	add "of" after "Evolution"
Figure 10	replace "Hannel" with "Hänel" in figure legends

Page 29

Figure 12	replace "pannel" with "panel" (3 times in this caption);
	increase size of the three panels on the left; font sizes in left and right plot should be the same