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Atmospheric Measurement Techniques Discussions

Interactive comment on "Analyzing the Atmospheric Boundary Layer by high-order moments obtained from multiwavelength lidar data: impact of wavelength choice" *by* Gregori de Arruda Moreira et al.

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We thank the anonymous reviewers for their comments, corrections and suggestions, which have helped to improve the quality of the manuscript. According to the reviewers' reports, the following changes have been performed on the original manuscript and a point-by-point response is included below.

Specific comments

Page 1, line 6-7-8. Why asserting that previous studies have shown that 1064-

nm wavelength provides an appropriate description of the turbulence field which is the reason why you consider this wavelength as a reference? Several other papers, prior and since Pal, 2010 have shown related studies for ABLH retrievals that uses different techniques and different wavelengths, including in the UV domain, applied to lidar measurements: Sawyer, et al, 2013, Detection, variations and intercomparison of the planetary boundary layer depth from radiosonde, lidar and infrared spectrometer http://dx.doi.org/10.1016/j.atmosenv.2013.07.019 Pal et al, journal of geophysical research: atmosphere, vol. 118, 9277–9295, doi:10.1002/jgrd.50710, 2013 Martucci etal, 2007, Comparison between Backscatter Lidar and Radiosonde Measurements of the Diurnal and Nocturnal Stratification in the Lower Troposphere DOI: 10.1175/JTECH2036.1 Wang et al, Atmos. Meas. Tech., 5, 1965–1972, 2012 www.atmos-meas-tech.net/5/1965/2012/ doi:10.5194/amt-5-1965-2012

We thank the Reviewer 2 for this question. In this paper, we describe the turbulence field of aerosols, so that the wavelength 1064 nm is the most convenient due to the practically null contribution of molecular signal to this channel, what enable us to perform the simplification shown in section 3 (equation 2), in agreement with results shown in Pal et al., 2010. Although others wavelengths, like as UV and 532 nm, can be applied efficiently in the ABLH detection (papers recommended by the referee), they have a higher contribution of molecular signal in comparison with 1064nm, what can increase the noise in the high-order moments as shown in section 3.2. In order to clarify this point, the text has been changed as follow:

(Page 1, Line 6-8)

"Previous studies have shown that 1064-nm wavelength, due to the predominance of particle signature in the total backscattered atmospheric signal and practically null presence of molecular signal (which can represent noise in high-order moments), provides an appropriate description of the turbulence field and thus..."

(Page 2, Line 25-26)

"...remote sensing systems (mainly lidars) become an important tool in ABLH detection (Martucci et al., 2007; Pal et al., 2010; Wang et al., 2012), as well as, in turbulence studies..."

Page 5, section 31.1 and Page 22, table A2. Detailed description of high-order moment parameters are given. However, you do not present how ABLH is retrieved from these parameters as it is shown in diagram A1 and figures A6 and A10.

We thank the Reviewer 2 for this question. At the top of the CBL there is entrainment of clear air masses coming from FT, causing fluctuations in the aerosol's concentration in this region and consequently in the RCS profile. Therefore, the height with maximum variance in the RCS profile can be used as indicator of the ABLH. This methodology is named Variance Method and has the limited applicability only for convective cases. In order to clarify this point, the text has been changed as follow:

(Page 7, Line 3-4)

"The ABLH is estimated from the Variance Method, which establish, in convective conditions, the top of CBL (ABLH) as the maximum of the variance of the RCS [σ_RCSˆ2 (z)](Baars et al., 2008)."

Page 12, line 30. Following discussion about autocorrelated function, you conclude that the profiles obtained at 355nm have a strong presence of noise and thus the skewness phenomenon are not as well retrieved at 355nm compared to those at 1064nm. I assume the authors use the term "profiles" to point out the feature of the autocorrelated function and not the one of the lidar backscatter. Nonetheless, the authors should be more precise.

We thank the reviewer#2 for this comment. We apologize due to the generalization of term "profile". Such attitude becomes some parts of the text very confusing. In order to clarify this point, the text has been changed as follow:

(Page 1, Line 12)

"...the noise associated to the high-order profiles..."

(Page 10, Line 29)

"... phenomenon presented by high-order moments profiles obtained from..."

(Page 12, Line 32-33)

"Although the high-order moments profiles obtained from the wavelength 532 nm are noisier than that one generated from..."

(Page 13, Line 8)

"Therefore the behavior observed in the high-order moments profiles generated from..."

(Page 13, Line 23-24)

"However, the same phenomena observed in the high-order moments profiles generated from the 1064 nm wavelength can be observed in that one generated from the wavelength 532 nm..."

(Page 13, Line 25-27)

"On the other hand, the high-order moments obtained from 355 nm have a strong presence of noise and, thus, from the third order moment (skewness) the phenomenon presented in the high-order moments obtained from 1064 nm wavelength cannot be observed in 355 nm high-order moments profiles. ."

Page 12, conclusion. The authors conclude that the high-order moments technique is applicable to 532nm elastic lidar measurements and shows results for ABLH retrievals C2 as well and good as for 1064nm. On the contrary, due to limited validity of the assumption of predominance of aerosol backscatter compared to molecular ones, the retrievals at 355nm are not successful due to noisier signals. The readers are left a bit curious. It would be useful for the authors to conclude weather or not the high-order

technique shows limitation for 355nm signal or if the current lidar system used for this study that could be improved or if the technique should be improved using a better assessment of molecular backscatter at 355nm.

We thank the Reviewer 2 for this comment. The proposed methodology is based on the utilization of particle signal, which is strongly present in 1064 and 532 nm wavelength. The wavelength 355 nm has a predominance of molecular signal, this is the reason of its inapplicability in the proposed methodology. However, a better assessment of the molecular backscatter at 355 can reduce the influence of the noise caused by molecular signal and improve the results obtained from the data generated from this channel. In order to clarify this point, the text has been changed as follow:

(Page 14, Line 2-5)

"On the other hand, the wavelength 355 nm does not provide satisfactory results in such methodology due to predominance of molecular signal in its composition. However, a better assessment of the molecular backscatter at 355 can reduce the influence of the noise caused by molecular signal and improve the results obtained from the data generated from this channel."

Page 25 & 29, Figure A6 and A10. I do not know why only one ABLH is retrieved since the high-order moments technique is applied for each wavelength independently? I expected to find different retrievals for each wavelength and discussion about which one should be considered as the truth.

We thank the Reviewer 2 for this comment. The two selected days have a well-defined ABL with high similarity among the RCS profiles generated from the three wavelengths, as can be observed in figures C1 and C2 of supplementary material, so that, the ABLH obtained from Variance Method to each wavelength is practically the same with difference lower than 10% as can be observed in figures A6 and A12. In order to clarify this point, the text has been changed as follow:

(Page 8, Line 32-34)

"Although the σ_355ˆ2 is nosier than another ones, there is a low difference among the ABLH estimated from the three different wavelengths (lower than 10%)."

(Page 11, Line 27-29)

"In the same way of Case I, although there are some differences among the maximum of the σ_RCSˆ2 (z), they do not influence significantly the ABLH estimation, so that, the difference among the ABLH obtained from each wavelength is lower than 10%."

Technical corrections

Page 5, line 20, equation (7). the authors should define "tf" variable. Done Page 6, Line 5: "where tf means final time."

Page 7, line 19. The authors do not define FT. I assume that it means Free Troposphere. You should precise it. Done Page 8, Line 4: ". . . of values lower than 1 in the Free Troposphere (FT), what was. . ."

Page 11, line 34. replace "taking into accounting" by "taking into account" Done

Page 20, Figure A1. The diagram indicated PBLH that should be ABLH to be coherent. In order to clarify this point the figure A1 has been redone as shown below:

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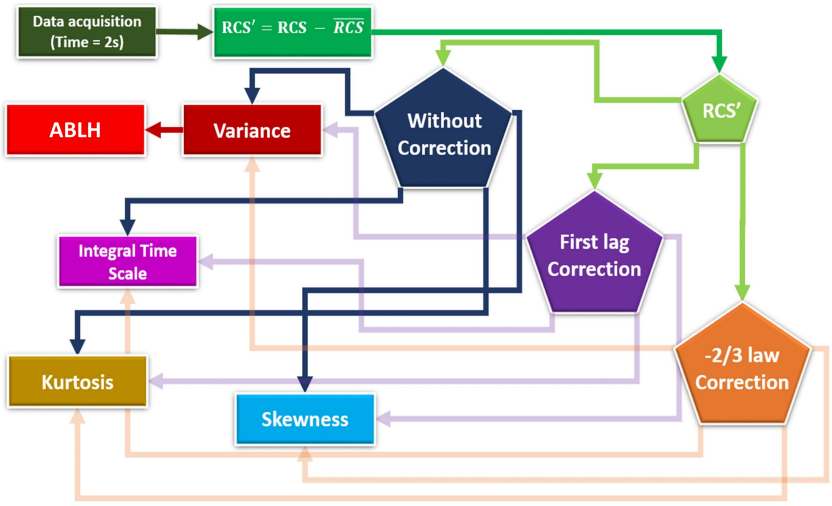
Data acquisition
(Time = 2s)
$RCS' = RCS - \overline{RCS}$
ABLH
Variance
Without
Correction
RCS'
Integral Time
Scale
First lag
Correction
-2/3 law
Correction
Kurtosis
Skewness

Fig. 1.