We would like to thank the two referees for their constructive and appropriate comments and suggestions. We believe that, based on their suggestions, the paper has sensitively improved. Below is a point-by-point answer to all referee #1 comments and requests. We are also ready to submit a revised version of the paper which addresses all points below.

Anonymous Referee #1

My recommendation is to reject the manuscript in its present form.

Results of two lidar techniques for estimating the height of the atmospheric boundary layer are presented and compared with radiosonde measurements.

The first technique uses the derivative of the elastic backscatter signal. This technique is already described in many papers and has even been extended within many studies since. Many of these references to previous work, however, are missing.

In the old version of the paper (discussion paper) we introduced several citations to previous papers describing the approach based on the use of the derivative of the elastic backscatter signal. The cited papers were not intended to be all papers published on this topic, but a selected ensemble of these covering a period of almost three decades. A variety of additional citations to papers describing this technique have now been introduced in the revised version of the paper, hopefully covering the gap of missing citations highlighted by the referee. Among others, Russell et al. 1974; Menut et al., 1999 ; Bösenberg and Linné, 2002 ; Frioud et al., 2003; Matthias et al., 2004. We also introduced references to previous papers which compare different approaches considering the elastic backscatter signal derivative. Furthermore, two additional approaches to estimate the PBL height based on the use of the elastic lidar backscatter signal have also been introduced, together with an extensive list of references describing them: these are the approaches considering the backscatter signal variance and a backscatter signal threshold value. All in all ten additional new references, now covering almost four decades of literature production, have been introduced in the revised version of the paper.

This manuscript shows nothing new in this context.

Authors are well aware that the first technique (approach 1) is not a new one, but instead it is well established and widely recognized by the lidar community. This is actually the reason why this approach is used in this paper so that it can act as a comparison and validation tool for the verification of the second approach (the one using the range-corrected rotational Raman signals), which instead is completely new and discussed for the first time in this paper.

The second lidar technique uses a range-corrected rotational Raman signal. But it remains unclear on which atmospheric characteristics this technique is based. Are gradients in the particle extinction profile identified? Or in the total extinction profile?

The referee is right is posing this question as in fact the low-quantum number rotational Raman signals are dependent on both temperature and molecular/particle extinction. However, vertical changes in molecular extinction are very smooth with limited effects on the rotational Raman signal gradients, while the sensitivity of the low-quantum number rotational Raman signals to temperature gradients is much larger than their sensitivity to particle extinction gradients. This aspect in now more explicitly specified in the text of the revised version of the paper. In this respect, we have to specify that typical temperature gradients observed at the top of the boundary layer (0,03-0,05 K/m) lead to low-quantum number rotational Raman signal gradients which are a factor of 2-5 larger than those associated with the typical particle extinction gradients observed at the top of the boundary layer (2-3x10^{-8} m^{-1}/m). Based on this consideration, we can state that this technique is primarily sensitive to temperature gradients and far less to the gradients in particle and total extinction; consequently, the approach primarily identifies temperature gradients with marginal effects from the particle or total extinction gradients. This aspect makes this approach particularly useful and effective, resulting to be successfully applicable also in the afternoon-evening decaying phase of the PBL, when the effectiveness of the approach based on the use of the elastic backscatter lidar signals may be compromised or altered by the presence of the residual layer. Additionally, this approach allows an unambiguous determination of the PBL height also in the presence of aerosol stratifications within the PBL. These aspects had already been briefly specified in the old version of the paper (discussion paper), but are even more emphasized now in the revised version of the paper we are ready to submit. Specifically, in section "Results" - where the considered approaches are described – the following new sentences have been introduced: "We need to recall at this point that, while approach 1 allows to estimate the PBL height based on the identification of the elastic lidar signal gradients associated with gradients in particle backscatter at the top of the PBL (with aerosols acting as atmospheric dynamical tracers), approach 2 allows to obtain PBL height estimates based on the identification of the rotational Raman lidar signal gradients, primarily associated with temperature gradients found at the top of the boundary layer, which characterize the transition from the convectively unstable region within the PBL to the more stable region aloft.

It is worth pointing out that either the low- and the high-quantum number rotational Raman signals are dependent on both temperature and molecular/particle extinction. However, vertical changes in molecular extinction are very smooth with limited effects on rotational Raman signal gradients, while the sensitivity of rotational Raman signals to temperature gradients is much larger than their sensitivity to particle extinction gradients. In this respect, it is to be specified that typical temperature gradients observed at the top of the boundary layer (0,03-0,05 K/m) lead to low/high-quantum number rotational Raman signal gradients which are a factor of 2-5/10-50 larger than those associated with the typical particle extinction gradients observed at the top of the boundary layer (2-3x10^{-8} m^{-1}/m). Based on this consideration, we can state that this technique is primarily sensitive to temperature gradients and far less to particle and total extinction gradients. This aspect makes the approach particularly effective and useful in the determination of the PBL height as it results to be successfully applicable also in the afternoon-evening decaying phase of the PBL, when the effectiveness of the approach based on the use of the elastic backscatter lidar signals may be compromised or altered by the presence of the residual layer. Additionally, this approach allows an unambiguous determination of the PBL height also in the presence of aerosol stratifications within the PBL."

I cannot see why this should be better than using the backscatter coefficient which is the basis for the first technique with the elastic signal.

We agree that if the technique was primarily sensitive to gradients in particle or total extinction, there would be no need for it as in fact this approach would be less effective than the one making use of the backscatter signals. However, as we already mentioned above, the technique is primarily sensitive to temperature gradients and this allows to effectively infer the PBL height as a result of the fact that temperature gradients are found to characterize the transition from the convectively unstable region within the PBL to the more stable region aloft.

Or is this rotational signal sensitive to the temperature gradient at the boundary layer top?

As already mentioned above, rotational signals are primarily sensitive to temperature gradients, this sensitivity being used to reveal temperature gradients at the boundary layer top. And again: tracking temperature gradients instead of aerosol backscatter gradients has the advantage to allow the unambiguous and accurate estimate of the boundary layer top also in the presence of a residual layer or multiple aerosol layers within the PBL.

If so, how sensitive?

Typical temperature gradients observed at the top of the boundary layer (0,03-0,05 K/m) lead to low-quantum number rotational Raman signal gradients which are a factor of 2-5 larger than those associated with the typical particle extinction gradients observed at the top of the boundary layer (2-3x10^{-8} m^{-1}/m). As already mentioned above, based on this consideration we can state that this technique is primarily sensitive to temperature gradients and far less to the gradients in particle and total extinction. Consequently, the approach primarily identifies temperature gradients with marginal effects from the particle or total extinction gradients. These aspects are now more explicitly specified in the text of the revised version of the paper. In the section "Results", where the considered approaches are described, the following paragraphs have been introduced: "We need to recall at this point that, while approach 1 allows to estimate the PBL height based on the identification of the elastic lidar signal gradients associated with gradients in particle backscatter at the top of the PBL (with aerosols acting as atmospheric dynamical tracers), approach 2 allows to obtain PBL height estimates based on the identification of the rotational Raman lidar signal gradients, primarily associated with temperature gradients found at the top of the boundary layer, which characterize the transition from the convectively unstable region within the PBL to the more stable region aloft.
It is worth pointing out that either the low- and the high-quantum number rotational Raman signals are dependent on both temperature and molecular/particle extinction. However, vertical changes in molecular extinction are very smooth with limited effects on rotational Raman signal gradients, while the sensitivity of rotational Raman signals to temperature gradients is much larger than their sensitivity to particle extinction gradients. In this respect, it is to be specified that typical temperature gradients observed at the top of the boundary layer (0,03-0,05 K/m) lead to low/high-quantum number rotational Raman signal gradients which are a factor of 2-5/10-50 larger than those associated with the typical particle extinction gradients observed at the top of the boundary layer (2-3x10^{-8} m^{-1}/m). Based on this consideration, we can state that this technique is primarily sensitive to temperature gradients and far less to particle and total extinction gradients. This aspect makes the approach particularly effective and useful in the determination of the PBL height as it results to be successfully applicable also in the afternoon-evening decaying phase of the PBL, when the effectiveness of the approach based on the use of the elastic backscatter lidar signals may be compromised or altered by the presence of the residual layer. Additionally, this approach allows an unambiguous determination of the PBL height also in the presence of aerosol stratifications within the PBL."

Now we are also considering in the text the possibility to apply approach(2) to the high- instead of the low-quantum number signals. In this respect, the corresponding paragraph in section "Results" have been changed as follows: "Both $P_{\lambda_{LoJ}}(z)$ and $P_{\lambda_{HiJ}}(z)$ are characterized by a strong sensitivity to temperature variations, the sensitivity being anyhow larger for the signal $P_{\lambda_{HiJ}}(z)$ than for $P_{\lambda_{LoJ}}(z)$. It is worth pointing out, however, that $P_{\lambda_{LoJ}}(z)$is usually affected by a smaller random uncertainty than $P_{\lambda_{HiJ}}(z)$, as a result of both the smaller cross-section of the high-quantum number rotational Raman lines and the larger bandwidth of the interference filter used for the selection of this signal. The larger random uncertainty affecting $P_{\lambda_{HiJ}}(z)$ often prevents from the possibility to obtain accurate PBL height estimates based on the application to this signal of approach(2) in the central portion of the day, when solar irradiance is higher and has larger effects on the noise level of the signal. Thus, in approach(2) of the present paper, expression (1) is applied to the rotational Raman signal $P_{\lambda_{LoJ}}(z)$. However, we tested this approach also with $P_{\lambda_{HiJ}}(z)$ and corresponding results are included in figure 4b." Further down in the section, when comment figure 4b the following text has been introduced: "The red stars in figure 4b represent the PBL height estimates obtained from approach(2) applied to the high-quantum number rotational signals $P_{\lambda_{HiJ}}(z)$, these estimates being in very good agreement with those obtained with the application of approach(2) to $P_{\lambda_{LoJ}}(z)$."

But why don't you use the measured temperature gradient itself then?

Using the measured temperature gradient is certainly a valid alternative. However, the determination of the temperature profiles and their gradients from the rotational Raman signals implies the use of a more complex analysis scheme, which requires the application of a dedicated calibration procedure. Furthermore, we wanted to verify the possibility to use for the rotational Raman signals the same simple algorithm applied to the elastic backscatter signals (identification of the minima in the derivative of the logarithm of the lidar signals), just substituting the elastic backscatter signals with the low-quantum number rotational Raman signals. These further considerations and aspects have also been introduced in the paper, where the following text is now present: "It is worth pointing out that the direct use of the lidar measurement of the temperature gradient would have certainly been a valid alternative to approach(2). However, the determination of the temperature profiles from the rotational Raman signals, and consequently their gradients, would have implied the use of a more complex analysis scheme, requiring the application of a dedicated calibration procedure. Furthermore, we wished to verify the possibility to extend to the rotational Raman signals the same simple algorithm applied to the elastic backscatter signals (identification of the minima in the derivative of the logarithm of the lidar signals)."