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Atmospheric Measurement Techniques Discussions

Interactive comment on "Lidar temperature series in the middle atmosphere as a reference data set. Part A: Improved retrievals and a 20 year cross-validation of two co-located French lidars" *by* Robin Wing et al.

Anonymous Referee #3

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The paper by Wing et al. is the first study to compare systematically long-term observations of two co-located Rayleigh lidar systems operating at 532 nm and 355 nm wavelengths. The author's motivation is the demonstration of the robustness and accuracy of their retrieved lidar temperatures and advertisement as a reference data set for validation of satellite measurements. The authors start with a description of both lidar systems followed by an extensive discussion of potential quality issues and data processing steps to resolve these issues, specifically electrical interference, signal induced noise, and saturation effects. Furthermore, the authors developed a robust scheme to

reject low quality lidar observations, resulting in higher signal-to-noise ratios and thus improved temperature data sets. In the last part the authors compare observations obtained by both instruments and, based on their finding of small systematic differences (<0.6 K), conclude that their lidar temperatures are accurate and thus suitable for satellite validation.

The paper is mostly well written and covers most aspects of the data processing which is typical for Rayleigh lidars. Some parts may be only relevant to older lidar systems, e.g. the detection of signal induced noise and electronic spikes, as newer systems generally do not suffer from these problems. While quality control is an important topic which is often neglected in publications, the authors also repeat basic knowledge commonly found in textbooks. I believe the manuscript can be made more concise by focusing on the important steps in data processing. Furthermore, in my opinion, differences in temperatures obtained by the two lidars should be analyzed in more detail. How do the differences (nightly menans) relate to uncertainties of the temperature profiles? E.g. are large differences visible in Figure 13 associated with large temperature uncertainties in one or both profiles? How are differences distributed?

I recommend the manuscript for revision.

Specific comments:

Please state the temporal resolution of your retrieved temperature profiles.

What does LiO3S stand for? In the paper you use different terms for the Ozone DIAL, e.g. line 86: OHP Differential Absorption Lidar, line 104: OHP DIAL, caption of Figure 2: LiO3S DIAL, line 162: LiO3S. Please use a single term to avoid confusion.

Figure 2: How are the 4 fibers combined before the chopper? Is the light coming off the four fibers coupled into a single fiber which relays the light to the receiver? What is the diameter of that fiber?

Line 153: You may add that this assumption excludes observations at mid to high latitudes in summer where NLC can occur.

Section 2.3.2: Maybe more efforts should be spent on finding and eliminating the root cause of these transients. I believe there are lidar systems in operation which do not suffer from these problems.

Line 201: "We can see that the 22nd and 46th scans are contaminated by a TES with a duration of about 0.5 μs" I can't see that. The plot you are referring to is labeled with bins rather than time. What is a "scan"?

Line 215: "The kurtosis test is done in the time dimension as well as with altitude to exclude false positives in the photon count rate skew which may be due to clouds or aerosols." Well, a cirrus cloud drifting through the lidar beam might actually look like peaks in Figure 5.

Section 3.3.3: Since you do not precisely explain what the Matlab Neural Code does and how the blue trace is derived, I suggest you remove that part and shorten this section.

Line 234: "We have shown two approaches for attempting to address the issue..." Which approaches are you referring to? Do you mean the two approaches you explain below?

Lines 244-246: "The simple reality of ground based observation means that lidar signals clearly detect changes in the viewing conditions such as moonrise, thin cirrus clouds, optically thick clouds, changing light pollution, as well as changes in signal quality." What do you mean by "changes in signal quality"? I believe all aspects you listed, e.g. cirrus clouds, impact signal quality.

Figure 7: Why did you chose a different data set and not use the same data set shown in Figure 6? In order for the reader to evaluate the different algorithms, it would be beneficial to show results based on the same data set.

Linens 267-269: What is the reason for choosing "the point where the signal to noise

equals one in the density profile"? In equation (2), which profile do you use for determining the altitude of this point, the summed profile or the individual profile?

Figure 8: I am not sure about the unit on the y-axis. Shouldn't that be just Hz?

Section 3.5.1: What is the maximum count rate at which gating (or the chopper) cuts the profile off? Have you checked the validity of equation (3) within that range? One possibility would be plotting the correction as function of count rate using equation (3) and the actual measurements (ratio of high gain and low gain channels).

Lines 318-319: You can actually check the validity of this assumption using the 532 nm and 607 nm channels.

Section 3.5.3: You should not attempt to "correct" signal induced noise. It is fundamentally impossible to characterize properly signal induced noise in lidar signals because the noise is superposed on the atmospheric signal. Determining the signal induced noise from the background signal above the lidar signal is bound to fail because you are essentially observing the noise at different times outside the period where you actually are interested in. Signal induced noise is highly non-linear and therefore it is impossible to properly correct it. The data should be regarded as corrupt and not be used in lidar analysis. Besides, significant signal induced noise (e.g. blue trace in Figure 9) indicates that detectors are operated outside safe limits or there is a general technical problem with the lidar. If you insist on using the questionable data, you should assess how the retrieved temperature profile changes when you tweak your model representing the signal induced noise (e.g. cubic versus linear). How do your retrieved profiles compare to independent observations e.g. radiosondes at lower altitudes?

Figure 10: The superadiabatic gradient at approximately 75 km altitude looks suspicious to me. I assume the upper part of the profile is dominated by noise and initialization of the retrieval should happen at lower altitudes. Are 15 km removed from the top of the profile as indicated in line 92? Which altitude was chosen for initialization? Furthermore, I would expect the temperature uncertainties to increase where the tran-

sition from the upper to the lower channels happens. Please explain why this is not the case.

Figure 11: What is the shaded area?

Line 446: What do you mean by “mis-aligned”? Please explain.

Figure 13: It is hard to estimate absolute temperature differences. I suggest you use a segmented color bar with 6-10 different colors.

Can you provide a plot showing combined temperature error estimates of both lidar data sets? There is a period in mid 2001 with distinct blue color (negative temperature differences) between 30 and 55 km altitude. Could these observations also have been affected by misalignment? A similar area can be found in right after the last marked region in 2011.

Line 441: For clarification, the observation period of one lidar could be up to 20% longer compared to the other lidar? Why not just make both observation periods equal in length by cutting the longer observation?

Line 442: What is meant by “good internal alignment”?

Figure 14: Can you please mark periods of misalignment similar to Figure 13.

Lines 459-461: “Without excluding misaligned periods the lidar temperature differences are not significant as a function of altitude or year at the 2 sigma level“. I am not sure if I understood that sentence correctly. Is the implication removal of misaligned periods causes the differences become significant intended?

Lines 462-463: “After removing comparisons between mis-aligned instruments we can calculate the ensemble median difference between the two systems.” I do not understand that sentence. What was removed? The data affected by misalignment?

Line 486: “lidar measurements are accurate” I do not think you have sufficiently backed up this claim. Maybe it depends on what we understand by “accurate”. I agree that the

long-term average (20 years) appears to be accurate, however according to Figure 13 nightly means obtained by the two co-located lidars can differ by more than 10 K. What is the reason for these large differences? Are these large differences expected from an SNR point of view, or are there other maybe unknown error sources which average out on long time scales?

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