

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2021-310

Anonymous Referee #2

Referee comment on "Estimating the uncertainty of middle-atmospheric temperatures retrieved from airborne Rayleigh lidar measurements" by Stefanie Knobloch et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-310-RC2>, 2022

This manuscript aims at characterizing measurement uncertainty for an airborne Rayleigh lidar (ALIMA), looking upward towards the stratosphere and mesosphere. One of the science objectives is to observe density and/or temperature disturbances associated with the propagation and dissipation of gravity wave in the middle atmosphere. The authors use lidar signal simulation to estimate certain components of this uncertainty.

Most of the manuscript repeats what has been already published, and so my main recommendation is to re-submit after major revisions, including a re-organization of the manuscript to re-balance the weight given to each section, based on what has been already published and what has not. I recommend to refer to Leblanc et al. (2016) (citation below) who provide, for example, quantitative estimates of the uncertainty associated with molecular extinction and ozone absorption (this part should be straightforward and not exceed a paragraph or two in the revised manuscript).

Unfortunately, the manuscript suffers from a major mistake in the quantification of the temperature correction associated with ozone absorption. If I am not mistaken, their ozone optical depth and ozone absorption correction were computed using O₃ mixing ratio rather than O₃ number density, which explains why they found a maximum impact at 35 km rather than 22-24 km. Fig 7 (left) of Leblanc et al. (2016) and Figs. 4 and 5 of Sica et al. (2001) both show a maximum impact in the lower stratosphere associated with O₃ ND peaking at 23-26 km.

I also strongly recommend that the authors make a clear distinction between what is uncertainty, error, and bias, which eventually, will greatly help them re-shape the manuscript towards a well-defined objective. I believe the current objective of the authors is to assess the quality of the ALIMA measurements, and eventually provide a full uncertainty budget. Lidar simulation is not needed for most of this estimation work. Some of the figures shown in past publications can serve as guidance to present their results in the revised manuscript.

Here are suggested definitions that might help re-focusing the next manuscript:

Bias = a value, negative or positive, describing an observed, systematic (i.e., repeatable) difference between 2 observations

Error = A value, negative or positive, describing the actual (unknown) difference between the true value and the measured value

Uncertainty = A value, always positive, describing statistically the best estimate (or magnitude) of the (unknown) error arising from a specific physical effect or retrieval approach that drives the final, reported value away from its true value.

For example, "temperature uncertainty due to ozone absorption" is an estimate of the error due to the fact that the ozone absorption is not perfectly accounted for in the temperature measurement/retrieval. Unlike error and bias, uncertainty is a controlled quantity.

Minor comments:

Page 4, line 102 : sigmaray depends on wavelength. Specify the wavelength.

Page 4, lin2 109, "well mixed": Not sure what "well mixed" means here.

Page 5, line 153, "the here": missing word

Page 6, line 162, "geographic validity": this term is unclear. Did the author mean "spatial coincidence"?

Page 9, lines 118-119 "(0.25° x 0.25° x 137 levels)": Provide the model's approximate horizontal and vertical resolutions in kilometers for the geographic and vertical range

considered (this is what matters in this paragraph).

Page 11, lines 268-270: I don't understand the sentence "the on average cold bias of ≤ 1 K in the stratosphere is related to the performance of the hydrostatic integration since other uncertainties are either excluded or do not act in this altitude range". Uncertainty is a quantity provided together with a measurement and which role is to provide a statistical estimate of the measurement error.

Page 14, lines 314-321 and fig 8a: This paragraph, used together with Fig 8a, is misleading as, at a given altitude (e.g., 35 km) it is the ratio of the extinction at z and $z+dz$ that matters (the total optical depth is not the impacting variable). To really illustrate how extinction impacts the temperature measurement, the ratio of extinction at z and $z+dz$ should be plotted in fig 8a. The total optical depth only influences the magnitude of the signal (attenuated 10x between a flight at the tropopause and a flight near the ground).

Page 16, line 360, "uncertainty": Once again, this is ambiguous. I think the authors refer to the error caused by neglecting ozone absorption, which is not the same thing as uncertainty.

Leblanc et al., 2016 citation:

Leblanc, T., R. J. Sica, J. A. E. van Gijsel, A. Haefele, G. Payen, and G. Liberti (2016), Proposed standardized definitions for vertical resolution and uncertainty in the NDACC lidar ozone and temperature algorithms – Part 3: Temperature uncertainty budget, *Atmos. Meas. Tech.*, 9(8), 4079-4101.