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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Using a global network of temperature lidars to identify temperature biases in the upper stratosphere in ECMWF reanalyses" *by* Graeme Marlton et al.

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Response to Anonymous reviewer 1:

We thank the reviewer for their comments, our responses and proposed amendments to the manuscript are below marked with AR

General Comments: Archived stratospheric temperature measurement data were compared with the ECMWF reanalysis data (ERA). The more recent ERA-5 version is shown to have better agreement with the measurements than the ERA-Interim version. This is useful for the ongoing development of the ERA reanalysis, but there are

no specific scientific questions addressed in the manuscript. I understand that the perspective of the paper is centred on comparing ERA with independent measurements. There is also a difference between the lidar and MLS measurements that is implicit in the results, as the lidar and MLS measurements have different offsets from ERA. Why not add a figure with a comparison between the lidar and the corresponding MLS measurements at each location, and provide some brief consideration of any significant differences? As the work has already been done to match the measurements in time and location, I assume the comparison of lidar and MLS measurements would not require a lot of additional work. It would be a unique contribution to have a comparison between lidar and MLS within the context of ERA. The paper would be more significant and interesting, at least to the lidar and MLS communities.

AR: A Lidar-MLS comparison plot can easily be added and described in the revised manuscript. In response to the reviewers comment "there are no specific scientific questions addressed". The questions addressed in this paper are: What is the temperature bias inferred in the ERA-interim and ERA-5 reanalysis data by an independent measurement technology; ground based temperature lidar. An additional question is how does this bias change in ERA5 over time with the addition of other observations streams into the reanalysis. The introduction and conclusions will be rephrased to emphasise this more.

Specific Comments

A) In describing the various sources of uncertainty in the measurements, there should be stronger distinction between random error and bias. The difference is important when assessing the averaged differences between the measurements and the model. For example, the uncertainty associated with the correction for non-linear photon counting detection in lidar measurements is a bias, and this is quite different from the random uncertainty associated with the statistics of photon counting detection. The random uncertainty is reduced by averaging, but the bias remains.

AR: We will check the manuscript for all mentions of uncertainty and ensure we are correctly referring to random error and bias, an offset between either two measurement technologies or models are referred to correctly. In response to the more specific comments regarding uncertainty surrounding the corrections in the lidars. From a metrology point anything that is not signal measured by the lidar is noise. This noise can be split into a random components in the form of photon detection, which becomes negligible when averaging, and a systematic component or bias such as level of sky light etc, which can be budgeted and corrections applied for e.g. (Leblanc et al 2016). The text in section 2 of the revised manuscript will be changed appropriately.

B) The description of “background noise” is not very well defined since “noise” is usually associated with random uncertainty. For example, the term “background noise extraction” at page 3, line 25. The constant background signal due to ambient light was subtracted. The “noise” in the background due to the photon counting statistics (Poisson distribution with variance equal to number of counts) cannot be extracted. It remained after the constant background was subtracted. Another example at page4, line 10: “background noise correction uncertainty”. Background is subtracted, but random noise is not corrected.

AR: Following discussion above this will be reworded to emphasise that background noise which is systematic can be extracted and removed where random noise from photon counting cannot be corrected.

C) In this reviewer’s opinion, phrases with the words “could be”, “likely”, “do hint at”,“may be” etc. are not appropriate for a scientific publication.

AR: The manuscript will undergo a thorough proofreading to replace these phrases with more appropriate ones.

D) The conclusion is not substantial. E.g. page 10, line 4: “...should be accounted for.” How should it be accounted for and what are the scientific implications?

AR: Studies such as Shangguan et al (2019) and Bohlinger et al (2014) use both ERA5 and ERA-interim to assess long term and short term stratospheric temperature variability in the stratosphere. In future works exploring stratospheric temperature trends changes in temperature bias presented here in this work, will need consideration when analysing results. This will be added to the conclusions in the revised manuscript

Corrections in addition to the recent edit of the manuscript Page 3, line 21:...laser light scattering FROM molecules and particles. Page 5, line 4: One such “travelling standard” Figure 4 caption: ERA-5 rather than ERA-interim

AR: These will be amended in the revised manuscript

References: Bohlinger, P., Sinnhuber, B.M., Ruhnke, R. and Kirner, O., 2014. Radiative and dynamical contributions to past and future Arctic stratospheric temperature trends. Atmospheric Chemistry & Physics Discussions, 14(3).

Leblanc, T., Sica, R.J., van Gijsel, J.A., Haefele, A., Payen, G. and Liberti, G., 2016. Proposed standardized definitions for vertical resolution and uncertainty in the NDACC lidar ozone and temperature algorithms-Part 3: Temperature uncertainty budget. Atmospheric Measurement Techniques, 9(8).

Shangguan, M., Wang, W. and Jin, S., 2019. Variability of temperature and ozone in the upper troposphere and lower stratosphere from multi-satellite observations and reanalysis data. Atmospheric Chemistry and Physics, 19(10), pp.6659-6679.

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