Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-189-RC2, 2016

Atmospheric Measurement Techniques Discussions

Interactive comment on "Tropospheric temperature retrievals using nonlinear calibration functions in the pure rotational Raman lidar technique" *by* V. V. Zuev et al.

Anonymous Referee #2

Received and published: 4 September 2016

**General comments:

The authors investigate different mathematical equations for the calibration of tropospheric (and lower stratospheric) temperature measurements with rotational Raman lidar (RRL). The topic of RRL calibration has already been discussed extensively in the literature (see references given also in the manuscript). It has been shown both within simulations and a very large set of experimental data taken with several different RRL systems that the systematic deviations between RRL measurements and collocated radiosounding data are small. Differences in individual cases can be attributed to the well-understood statistical uncertainties of the RRL measurements (which increase with range of the lidar data) or sampling of different air as well different weighting func-

tions of the data (which fluctuate and average out for a large number of comparisons). The general statement that the "commonly used calibration function" would yield significant errors of 1 K is wrong (abstract, line 14). The bias of current state-of-the-art RRL systems is only < 0.5 K (see Wulfmeyer et al. 2015 for a recent review).

The authors claim that their work goes beyond previous publications because they take the collisional broadening of the lines within the pure rotational Raman backscatter spectrum into account. While the first and second author of this manuscript have recently published simulations on this topic, the goal of this manuscript is to show experimental comparisons between RRL temperature data obtained with different calibration functions and "reference" data. Unfortunately, the study lacks such suitable reference data. The RRL measurements were taken at a site for which unfortunately no local radiosonde ascents were available. The closest radiosonde launching sites are more than 250 km away (see section 4.2). But this is clearly much too far for suitable comparisons. In addition, the authors use data of constant pressure altitude charts with low vertical resolution to overcome the large distances to the radiosonde sites but also these are certainly related to too large uncertainties for being used as reference data for investigating the small differences between the calibration functions. Also with a perfect calibration function, one could not "force" uncorrelated temperature data to agree.

It may be possible that the lidar system used by the authors is special and that for this system a more complicated calibration function is needed than for other RRL systems described in the literature. The calibration errors depend of the spectral characteristics of the lidar receiver, namely the widths, central wavelengths, shapes of the transmission functions as well as whether just the anti-Stokes or both branches of the pure rotational Raman spectrum are collected. I could imagine that especially the last point combined with narrow transmission bands may lead to larger calibration errors when using a too simple calibration function. Maybe this could explain why the commonly used calibration functions do not seem to work well for the RRL discussed here. More simulations for different types of RRL systems would be needed to verify this hypothesis – or, even better, collocated RRL measurements with different types of systems. Maybe this very interesting experiment could be realized in the future.

My suggestion is to revise the manuscript substantially and to rewrite the statements which are too general by clarifying that this study is on the data of a special/unique RRL system and comparisons with model temperature data which possess certain uncertainties. It should be made clear that the results may be used as indication (not proof) that some RRL systems may require more complicated calibration functions than the ones reported so far in the literature and that better reference data for comparisons will be useful to support this interpretation.

**Specific comments:

Title: Maybe better "Tropospheric temperature measurements with the pure rotational Raman lidar technique using nonlinear calibration functions". RRL does not "retrieve" the temperature; there is no first guess like in passive remote sensing.

Abstract, line 13 ff: This general statement is (fortunately) wrong. The calibration functions used so far lead (for all systems discussed in the literature) much smaller errors due to the calibration function itself. In addition, the error depends on the temperature range of the calibration. See general comments above. Please rewrite.

Abstract, line 15 ff: The statement that "collisional broadening. . . cannot be neglected (for) tropospheric temperature measurements" is too general. Again, this depends on the individual characteristics of the RRL system and the temperature range etc.. Please omit or clarify.

Page 2, line 4 and section 4.1: I do not like the term "smoothing" because it could include different types of filters which are not preferable and not meant. I suggest simply writing "averaging in time and range". Further averaging of the ratio should be avoided. It only complicates the effective weighting function of the resulting data while

the averaging of the raw data should anyhow be made with sufficiently large windows in order to avoid too large noise errors when taking the ratio.

Equations 1, 2, 3 and related text: The instrumental efficiency which is different for different lines is not yet included here but should be included. Otherwise, "calibration" does not make sense.

Section 4.1: What is the resolution of the raw data? As said above, further averaging of the ratio is not preferable. What is otherwise the effective weighting function of the double-averaged data?

Section 4.3: It should be made clear that the CPAC data are not a reference. Thus large differences between the RRL and CPAC data are not necessarily due to problems with the calibration function. I suggest that you show in addition the calibration plots (T_CPAC versus T_RRL with calibration function).

Appendix A: The propagation of the Poisson errors have already been discussed extensively in the literature for the calibration functions used so far – also including the contribution of the background signal which is missing here. Thus, these parts should be deleted here. Instead, references to the existing literature should be given which are currently missing.

Figure 1: Please explain also the red and blue curves and identify the laser wavelength.

Figure 2: Should be deleted as this photo does not explain any technical details. Figure 3 is enough and much better I think.

Figure 3: Which PMT is used for which signal?

**Reference:

Wulfmeyer, V., R. M. Hardesty, D. D. Turner, A. Behrendt, M. P. Cadeddu, P. Di Girolamo, P. Schlüssel, J. Van Baelen, and F. Zus, 2015: A review of the remote sensing of lower-tropospheric thermodynamic profiles and its indispensable role for the understanding and the simulation of water and energy cycles. Rev. Geophys. 53 (3), 819–895. DOI:10.1002/2014RG000476

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-189, 2016.