Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., author comment AC3
https://doi.org/10.5194/amt-2021-132-AC3, 2021

Reply on RC2

Julien Totems et al.

Author comment on "Mitigation of bias sources for atmospheric temperature and humidity in the mobile Raman Weather and Aerosol Lidar (WALI)" by Julien Totems et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-132-AC3, 2021

Reply to report #2 by referee #1

General comments:

The study "Mitigation of bias sources for atmospheric temperature and humidity in the mobile Weather & Aerosol Raman Lidar (WALI)" by Julien Totems, Patrick Chazette and Alexandre Baron provides a thorough description of the WALI system both from the point of view of the technical characterization of the lidar transceiver and the performances in terms of bias and RMS. The article is well written, easy to read and exhaustive. All topics are described and supported by either previous literature or statistical studies performed by the authors. In Sect. 4.3, the comparison with the radiosounding, in addition to calibration purposes, brings useful information about the quality of the WVMR and temperature data. Accepting the 12 km distance between lidar and in-situ measurements, and then accepting a higher RMS due to slightly different atmosphere, it allows to use the bias and RMS values as solid evaluation of the WALI performance. There are only few technical comments/remarks that should be addressed before publication. I strongly recommend this manuscript to be published in AMT.

We thank the referee for this very encouraging review and their useful comments.

Technical comments:

Abstract: while the abstract sets the main objectives of the study within the state of the art, it does not state any quantitative result. In this way, the abstract fails to deliver to the reader a concise summary of the obtained results. The main results regarding calibrations and comparisons with radiosounding presented in section 4 should be reported in the abstract by stating the mean daytime and nighttime biases and RMS values.

We have added the following results to end of the abstract: "For temperature, the magnitude of the highlighted biases can be much larger than the targeted absolute accuracy of 1°C defined by the WMO (up to 6°C bias at low range). Measurement errors are quantified using simulations and a number of radiosoundings launched close to the laboratory. After de-biasing, the remaining mean differences are below 0.1 g/kg on water vapor, 1°C on temperature, and RMS differences are consistent with the expected error from lidar noise,

calibration uncertainty, and horizontal inhomogeneities of the atmosphere between the lidar and radiosondes."

Introduction, ln 55, 64, 71, 76: the authors mention the "sources of biases". A statistical bias is typically a systematic error, a difference between the measurement and the truth. In this sense it would be more appropriate to refer to the "sources of uncertainty" or "sources of error".

We have replaced bias by systematic error in 2 occurences, and the last by causes of bias.

Sect.2.1, Pg 4, ln 90-91: which are the "required altitude and time"?

We chose not to discuss the integration parameters here so as to reserve this section for theoretical considerations that could be applied to any lidar. These values are given in the beginning of section 4.3.

Sect.2.1, Pg 4, ln 101: "corrected for"

This has been corrected.

Sect.2.1, Pg 4, ln 106-109: have the authors actually did some simulation to assess the reliability of the 5%-impact of the differential extinction or the estimate by Whiteman 2003 is taken directly?

As stated below, we use an average atmospheric density profile to compute DeltaTau(z). Whiteman 2003 does not estimate it, but rather shows this method to be efficient, because aerosols do not interfere much with the result if their effect is approximated by the Raman-derived optical thickness and an average Angström exponent (~1).

Sect.2.1, Pg 4, ln 110-111: do the authors mean that the N2 has a constant mixing ratio through troposphere and stratosphere? The statement is not formulated in a clear way.

We have tried to clarify the sentence as suggested.

Sect.2.2, Pg 5, ln. 126-129: the authors set the requirement for successful monitoring, verification and data assimilation into models by listing noise errors and biases. If I interpret correctly what the authors mean by bias, this should not be part of the requirement as they can be efficiently removed by the calibration process.

This is an overarching yet important question. Biases can be calibrated, but it must be done using a reference, which may be imperfect, and this calibration can become obsolete if the biases vary in time. It is preferable to mitigate them in the first place, and even then monitor regularly that they are kept within acceptable bounds when the measurement is compared to an internationally recognized reference. Therefore, the size of this window, what we call requirements, around the true values, is of prime importance.

Sect. 2.3, pg 8, ln 187: "thus"

The correction has been made.

Sect. 2.3 pg 9, Figure 1b: the caption does not say what the green lines represent. One can imagine that is the return beam from the IF, but it is not clear.

We have added in the caption: "Green/red/blue lines represent rays from infinity/finite distance/offset emitted beam, respectively."

Sect. 3.3,pg 17 ln 398: what material the cage system is made of? Is the cage subject to thermal expansion?

We use the widely available 6 mm steel rod cage system distributed for instance by Thorlabs. It is indeed subject to thermal expansion, but the whole structure is thermally regulated (metal-to-metal contact with a TEC cooled plate), and enclosed in a well-adjusted 3D-printed plastic box for insulation. The temperature measured by a sensor set in one of the optical filter mount is typically kept constant within a few 10^{-1}°C in our air-conditioned laboratory.

Sect. 3.3-3.4: the authors perform a thorough analysis of the detectors' sensitivity, calibration and responses. PMT sensitivity and gain are also analysed in detail, which allows correcting for inequalities at the PMT output. As it is shown in Fig.5, each channel in the polychromator is output to an independent PMT. How the authors deal with the differential aging of the N2 and H20 PMTs? Since the ratio of the two signal is used to calculate the mixing ratio, a drift in gain or sensitivity of the PMT of one channel will not necessarily match nor correspond to a possible drift of the other PMT. This is a well-known problem in literature, and different groups apply different solutions. Could you comment on that?

Indeed we have observed this phenomenon as well, and that is why both WVMR and temperature Raman channels have to be recalibrated every time we put our system in operation. Between June 2nd and August 2nd, 2020, we have observed a 7.3% change of the water vapor calibration coefficient, and 2.1°C offset of the temperature calibration curve; however in that case a failure of the laser seeder (bi-modal behavior and central wavelength change) is mostly to blame.

In this already dense paper, we choose not to address the temporal aspect of biases, i.e. the evolution of calibration due to several causes among which PMT aging, because it is a wide subject. During the period studied here, spanning only two weeks, no such effect was consistently highlighted. We will definitely have to address it in the future, when WALI is involved in a long campaign like WaLiNeAs (2-3 months). Regular dedicated radiosondes will be launched directly from the lidar site to allow a maintained calibration.

We have added the following comments as perspectives in the conclusion: "The long-term temporal evolution of Raman channel calibration, expected due to various effects like differential PMT aging or laser seeder drift, induces biases variable in time over the time-scale of such a project (several months). It will become a focus as the community moves towards operational uses of weather Raman lidars."