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Atmospheric Measurement Techniques Discussions

Interactive comment on "A powerful lidar system capable of one-hour measurements of water vapour in the troposphere and the lower stratosphere as well as the temperature in the upper stratosphere and mesosphere" *by* Lisa Klanner et al.

Anonymous Referee #1

Received and published: 25 August 2020

This manuscript describes the development of a high-power Raman water vapor lidar deployed at a high-elevation site near Garmisch-Partenkirchen, Germany. Based on its somewhat heterogeneous content and style, the manuscript seems like the concatenation of several work efforts covering the period 2012-2019. It is long and very detailed, often too detailed, which makes it sometimes difficult to follow, and also makes the actual objectives unclear. For example, the abstract mentions an "existing" co-located DIAL (used for calibration), but this system has been out of operation since 2014. An-

other example is the multiple references to temperature measurements, including in the manuscript title. These measurements are separated from the water vapour system, as they are made with a Nd:Yag laser. They do not fit well in the present manuscript, which focuses on the high-capability water vapour measurements.

Because of the level of detail and length, I strongly suggest that many sections of the manuscript be used as "Supplementary material", and that the authors leave in the main manuscript only the critical steps that led to the instrument's current configuration. The authors should add a discussion/conclusion on expectations in terms of future measurement contributions and strategic goals.

In regards to experimental development, the technical content is very important, and for that reason, should be published, assuming that Supplementary Material can be separated from the main manuscript. I therefore recommend publication after major revisions.

Suggestions for major revisions:

1) For water vapor there are only 4 measurement nights shown (4/25/2013, 7/1/2015, 7/19/2018, and 2/5/2019), including only 1 comparison with CFH. For temperature, there is only one night shown. To my opinion, this is not enough to characterize the performance of an instrument, especially when the study period spans 7 years. I strongly suggest that the authors show more profiles and/or statistics (e.g., mean differences aggregated from all available measurement nights), and possibly a climatology. Also I strongly suggest that the authors show one or more curtain plots showing the short-term (overnight) water vapor changes as a function of time and altitude. As the authors claim in the manuscript, this is one of the strengths of lidar, yet they have not shown any examples of it.

2) Below are three sections which I believe are too detailed, and therefore fit better as "Supplementary material". They can be replaced in the main manuscript by shortened paragraphs or sentences that summarize the "take-home" message and provide

a more fluid read:

- Sections 2.2 and 2.3, and corresponding figures 2, 3, 4, 5

- Sections 3.3., 3.4, and corresponding figures 10, 11

-Section 4.4., and corresponding Fig 12 (also see my comment on this section further below)

Other major comments:

Section 4.4, and Fig 12:

This section does not bring important information to the paper, besides showing the lidar sensitivity to H2O in the UTLS. It can be removed from the manuscript. If kept in the manuscript, it should be included earlier (e.g., in the introduction) as a mean to state the problem.

Section 5 (Calibration):

Using the DIAL as a calibration source is a very interesting approach. However, it is mentioned that the DIAL has been inoperative since 2014. This section does not provide any other information on how the Raman lidar has been calibrated since then (including accuracy), and most importantly, what is the timeline to use the DIAL system again for calibration (if it will ever be used again).

Minor comments:

P3/l2, Radiosonde weakness: Outdated literature. RS92 has been replaced by RS41, with better performance in the UTLS

P3/l4, CFH: Use full instrument name Cryogenic Frost-Point Hygrometer

P3/l8, “Raman scattering is a background-free method”: this is an awkward expression. Please rephrase.

P3/l33, DIAL accuracy: Proper reference should point to HITRAN 2008. Cited ref-

erences mention 2% and 3.2%. Please clarify where the figure “1% or less” comes from.

P3/l37, “355 nm” and p4/l2: The single temperature profile shown in this manuscript comes from a Nd:Yag, not the Excimer laser described for water vapour. This distinction makes the inclusion of temperature in this manuscript somewhat off-subject.

P7/l31 and l33: Should refer to fig 7, not fig 6.

P13/l8, “multiplying the backscatter signal .... by the square of distance r”: If both the N2 and H2O detectors are triggered simultaneously, there is no need for range correction at all, which makes this sentence out of context. Please clarify or modify the sentence.

P13/l15, “the influence of ozone exactly cancels because the transmitted wavelength is the same”: This is an incorrect statement. There is a slight extinction differential associated with the returned signals (after backscatter). However, it is expected to be small for most of the troposphere because absorption at 332 and 347 nm is weak. It can however impact the measurement in the LS as ozone becomes more abundant. Please provide estimate of the ozone interference (this is quantifiable)

P13/l18, “data are collected at 51.2 ns per bin”: Is the laser pulse length 80 ns? What are the implications of such a long pulse on data sampling?

P13/l39, “The role of aerosols is limited to extinction in a Raman lidar”: Not entirely true. Fluorescence has been observed as well (e.g., Immler et al., 2005). Please modify sentence accordingly and discuss its impact. For example, a strong, widespread and sustained episode of bio-fluorescence was observed at Northern mid-latitudes during Fall 2017 after the so-called Chisolm PyroCb event. Did the IMK-IFU lidar observe it?

P14/l31, “geopotential altitudes into real ones”: Replace “real” by “geometric”

P15/l15, uncertainty equation, and p15/l19: This is a quite arbitrary estimate. There are multiple references detailing direct computation of temperature uncertainty using

the density integration technique (including Hauchecorne and Chanin, 1980 for random uncertainty; the Klett references cited, and Leblanc et al., 2016). Why not using those? Please clarify/expand.

P17 and fig 14: These results have been shown before at several occasions. The lengthy discussion is unnecessary

P18/l19,"not as reliable": What do the authors mean by "not as reliable"? What is the physical basis for such statement?

P18/l20, "We speculate that this is due to a change in sonde type from RS 92 to RS 41": RS41 is expected to be more accurate than RS92 in the LS. Please justify this statement that seems to go against current general thinking about the latest RS41 radiosondes

P19, section 6.2: The entire section, together with Fig. 21, is of poor scientific or technical interest. I would like to suggest to just remove it altogether. One of the correlative curves is extrapolated, which has no scientific value, and the apparent agreement between the lidar and correlative densities is fully expected with a figure of such aspect ratio (showing 10 orders of magnitude on the X-axis!). If any relative density comparison really must be shown, please use a ratio to the US standard atmosphere density for better visibility.

P21/l25, "The temperature measurements . . . were quite successful": Only one temperature profile is shown to support this conclusion. Please modify to mitigate this statement, or include more temperature comparisons to support it.

Syntaxing and formatting issues:

p1/l23: UTLS

p1/l33: Missing verb

p1/l36: Syntax

p2/l36:: Add "water vapor" between "ground-based" and "lidar"

p17/l38, "background signal": missing verb

p18/l24: Syntax

p27: Trickl/Wilson references misplaced

p28: Two conflicting 2020 references for Trickl 2020

Figures:

A lot of figure captions contain excessive narrative discussion. Please move those to the main text. Fig 9 caption: way too long and detailed. Most of it should be kept in the main text or put together in a table

Figure 21 caption: too long. Keep discussion in the main text.

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