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Atmospheric Measurement Techniques Discussions

Interactive comment on "Compact and Lightweight Mid-IR Laser Spectrometer for Balloon-borne Water Vapor Measurements in the UTLS" *by* Manuel Graf et al.

Anonymous Referee #1

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The paper "Compact and Lightweight Mid-IR Laser Spectrometer for Balloon-borne Water Vapor Measurements in the UTLS" of Graf et al. describes the development, characterization and test of a new lightweight balloon-borne instrument for water vapour measurements in the UTLS region. The compact instrument employs mid-IR absorption spectroscopy as operating principle, with a quantum cascade laser as a light source and a segmented circular multipass absorption cell for path length augmentation.

New developments of lightweight and balloon borne instruments for the challenging measurements of water vapour in the UTLS region are interesting, in particular if they

have the potential to establish SI traceability and do not rely on cryogens that are threatened by phase out such as CHF_3, on which current frost point hygrometers depend.

The paper is thus highly significant and it fits very well with the scientific scope of AMT. The discussion is clear, scientifically sound, and well argumented. The overall presentation is also clear, with only a few Figures requiring slight adjustments to enhance the readability.

There are only two minor remarks that apply to the paper in its current form, which should be published after minor corrections. First, the capability of measuring at high temporal resolution is pointed out at several instances all over the paper and in the abstract. However, apart from the better than 1 Hz requirement and the capability to measure at 1 s time resolution, no clear number is given with respect to the time resolution reached by the final instrument. I would suggest putting such a number (or a qualifier such as sub-Hz) in the abstract and the conclusion to make things clear.

Second, an uncertainty budget (L301+) for the water vapour measurements is provided, but the discussion does not include any of the systematic biases that were discusssed in the previous paragraphs. While degassing from the balloon seems to be an unwanted effect that can be overcome using a longer rope or by measuring in descent, the problem of degassing into the 9 mm interior optical path has not yet been overcome by the present design. According to Fig. 7, this problem is apparent in the > 13 km altitude range, where a correction is applied that brings the water mixing ratio to constant values. What is the uncertainty of the measurements in this altitude range ? Then, there is (another ?) apparent offset (> 10 %) between QCLAS and CFH in the 11 to 13.5 km range. Where does this come from ? I could not find an adequate discussion, but obviously the proposed degassing correction does not account for the discrepancy. This systematic bias also warrants discussion in the text and a corresponding number should appear in the uncertainty budget.

L45 "these are yet itself ..." → "these are yet themselves ..."

L46 Mention the Kigali (2016) amendment to the Montreal Protocol.

L66 - 67 "The tunability of the laser allows to record entire transmission spectra at fast scanning rates, from which the number of molecules can be deduced." An entire rovibrational spectrum of $\sim 100\,cm^{-1}$ is hardly accessible for a conventional high-resolution laser. The sentence should be rephrased accordingly.

L109 "while the absorption signal can be optimized by the selection a wavelength range with strong" → "while the absorption signal can be optimized by the selection of a wavelength range with strong" or "while the absorption signal can be optimized by selecting a wavelength range with strong"

L112 "due to the (a)symmetric stretching mode (ν_1 and ν_3) ... ". Use of singular is confusing here. Better write, "due to the symmetric (ν_1) and asymmetric (ν_3) stretching modes ..."

L119 "According to the HITRAN-database, the absorption parameters for this line, especially the intensity, are known with an accuracy better than 2 %." While the reference to HITRAN is correct, the authors should also cite the original work that has led to the entry in HITRAN. Otherwise, the people who did the (spectroscopy) work don't get the credit.

L211 The SI recommended µmol / mol is to be preferred over ppmv, especially because SI recommended abundance (mixing) ratios are used elsewhere in the article (e.g. Figure 6).

L218 "mixing ratios is" → "mixing ratio is"

L233 - 235 "Numerous additional tests ... A detailed discussion of these experiments

can be fond in Graf (2020)" It is not quite clear how relevant the information is. Either the phrases should be omitted or the authors should give a very short summary/conclusion of the relevance of these tests for the current paper.

L256 - 261 "In the right panel of this figure, the relative deviation is plotted, showing a standard deviation of 13 % between 2 and 10 km altitude." The way the paragraph is organised is confusing, because the authors mention the standard deviation first and the mean deviation of 3 % only at the end. The order in which variables are presented should be reversed.

L327 "A standard deviation of 1.1 % relative to the finally chosen configuration ...". This sentence needs to be rephrased. It is not clear what "relative to" means in this context.

L335 "which are currently not available for the herein used molecular transition" → "which are currently not available for the molecular transition used here"

L336 "herein selected absorption line" → "selected absorption line"

L382 H2O - → "H_2O"

L442 H2O - → "H_2O"

L444 Camy-peyret → Camy-Peyret

Figure 6 labels are too small and hardly legible

Figure 8 Label identifies water vapour in "atmospheric." Should be "in atmosphere."

Figure 9 Graphs are too small. It is difficult to identify the different retrieved mixing ratios.

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