Colorcoding:

Referee comments

Authors answers

Changes in text

CC1: J. Barry McManus, 06 Feb 2024

Review for: Ort, et al., “In-flight characterization of a compact airborne quantum cascade laser absorption spectrometer”.

General comments: This is a well written and comprehensive description of the group’s new mid-IR laser spectrometer trace gas instrument for airborne measurements, named “ATTILA”, including instrument design, data processing and scientific results.

Thank you for reading and commenting on our manuscript!

The figures’ text is too small and lines are too thin, making them difficult to read.

We improved the features of the figures, so that they are easier to read.

Line 122: As is often argued, a presented advantage of WMS is that it is baseline independent. However, in discussion of results shown in Figure 5 [page 9], when the baseline contains optical interference fringes with free spectral range close to the frequency width of absorption lines, then those elements of the baseline are quite important. Some might say that fringes are not part of the laser baseline, but even if so in a narrow sense, fringes still may influence the measurement.

We apologize for the confusion. In WMS the baseline contribution due to laser intensity and background broadened absorption lines from open beam path absorption are greatly reduced. Further disturbances of the signal due to fringes still persist in WMS and are the main limitation of the described instrument, as discussed in the article.

Also, in discussion of results shown in Figure 5 [page 9], do the authors understand the source of the optical etalons, beyond what changes their phase?

Optical etalon structures are caused by interferences through any reflecting surfaces like mirrors and lenses. Their periodic frequencies, amplitudes and bandwidths can vary depending on their optical source in the setup. The optical source has not been determined with respect to their free spectral range since we have to deal with more than one etalon. Changes in temperature and pressure can cause small variations of the etalons free spectral range and their phase. This hardly can be identified.

I did not see a mention of how the frequency scale of the laser scan is determined. Is that in the supplemental material?

The frequency scale of the laser scan is determined by laser temperature and current according to the laser specifications and double checked by identification of the neighboring absorption lines. The frequency is kept stable throughout the measuring process.

What are the main sources of noise in the instrument?

The main sources of noise are optical fringe interferences, as discussed in the article. Further sources are electrical noise and pressure fluctuations. High frequency electrical noise caused by the detector is present but reduced by averaging the oversampled signal, as you can find in Line 113 in the manuscript.

Minor comments on the text:

Abstract, lines 15-16: With data uncertainties and accuracies given as percentages, it is not immediately clear what are the base amounts used to calculate the percentages.

The measurement uncertainties are given relative to the calibration gas mixing ratio. The calibration gas has a CO mixing ratio of 153 ppbv and a CH4 mixing ratio of 1990 ppbv which is close to the expected ambient concentrations. We have chosen to present our measurement uncertainties and accuracies in percentage as this covers a broader range of the data. Especially, CO has a wide range in the atmosphere and thus the absolute values of the error differ depending on the absolute values. We have added this information in the abstract.

Line 15: First dynamical characteristics and tracer distributions of CO and methane (CH4) over the Amazon rainforest can be identified with ATTILA measurements with a total measurement uncertainty of 10.1 % and 17.5 % **for calibration gas mixing ratios of 153 ppbv and 1990 ppbv** and an accuracy of the standards of 0.3 % and 5.5 % for a data acquisition frequency of 1 Hz for CO and CH4, respectively.

Line 52: Linear dimensions are given as cm^3.

We have acknowledged this comment and have changed it in the text.

Line 52: ATTILA is mounted in a 19-inch box and is small in size **(48 cm x 27 cm x 55 cm)** with a total weight of only 20.6 kg (excluding the pump).

Line 112: “Sinus” wave instead of sine or sinusoidal.

We have corrected this mistake.

Line 112: With a **sine wave** modulation frequency of 17.86 kHz, a ramp is generated with 4096 discrete steps and scanned within 28.7 ms.

Line 183: Rather than say [≈] material expansion induces etalons, perhaps: material expansion and air pressure changes phase modulate etalon fringes that are present in the optical system. That is, unless the authors mean that material thermal expansion produces misalignment that then produces etalons. That would be a worse kind of problem.

We are sorry that we have not been precise enough. The cell itself is quite robust against temperature and pressure changes. Nevertheless, the surrounding optics, which lead the laser beam into the cell can be influenced by temperature and pressure changes as there is no protection mounted. This causes a phase shift of the etalon fringes while the free spectral range stays almost constant. Those multiple etalon fringes are difficult to subtract and are our main limitation of the instrument setup, as discussed in the text.