

Authors' Response to the Short Comments

We appreciate the comments. Below, we give detailed responses (in blue) where appropriate.

Nicolas DUMELIE (Short comment)

I think that some details and figures about the acquired spectra would be very interesting. It seems that the experimental spectra showed in figure 2 corresponds to the region of spectral interest but was it obtained using your instrument? Did you scan the same spectral range during during the UAV flights?

Yes, the spectra shown on Fig.2 was obtained with our mobile QCLAS instrument. Apparently, this point was not made clear enough. We slightly changed the text to improve this. For the flights, we were limiting the scanned region to H₂O and CH₄ absorption lines, i.e. 1276.5 – 1277 cm⁻¹. This was mainly to optimize the acquisition time and improve the duty cycle of the measurements. Furthermore, we were aiming for a large section for the baseline to make the spectral fitting more robust.

In the presented spectra of figure 2, it seems that you manage to fit the N₂O, CH₄ and H₂O absorption lines quite nicely, so why don't you also present N₂O and H₂O concentration in your results? Since the two Picarro models (G1301, G2401) used in your field experiment are able to analyse H₂O, I think that it would be very interesting to share H₂O concentration results, or even a comparison with Picarro sensors.

Our aim was to show that, in principle, the instrument has multi-species measurement capabilities, but our main target was the CH₄ concentration, for which we optimized the operation mode. For sake of completeness, it should be noted that, although the N₂O looks nice, the precision is about 1 %, i.e. about 3 ppb. For many environmental applications, this might may not be good enough. However, if one considers artificial release experiments, where N₂O is used as independent tracer, then this is attractive. The situation is similar for H₂O; we are using its absorption signal to precisely control the laser emission frequency and to easily identify the spectral region. Again, depending on the targeted application, measuring water vapor may be of interest, but for the time being we limited ourselves to CH₄.

A 1Hz raw spectra obtained during a flight would also be interesting to show as you mention baseline variations and dynamic fringes structures.

We consider that the best prove of the quality of spectra during flight is the time-series shown in Fig.7 (bottom plot). It is a zoom-in plot to illustrate the retrieved CH₄ concentrations during take-off, flight and landing. One can easily observe that there is no abrupt change in the time-series at the critical transitions. The baseline variations and dynamic fringe structures are very subtle and would be difficult to see without detailed analysis (see also our reply to Dave Nelson's comment #3).

As mentioned line 209, prior to the flight, an etalon spectrum is recorded and spectra fit is set up; is it part of your standard operation protocol? Do you always use this procedure in order to compensate a potential drift from the QCL over time?

Yes, this is our standard start-up protocol. The warm-up time of the instrument is about 20 minutes that one has to spend anyway. This time is well used to set up the fit, record a new etalon spectrum, establish communication with the host PC, mount the instrument on the drone, and make the drone ready for lift off. In our experience, the frequency drift of a state-of-the-art QCL is very small so that settings from a prior flight (that could be even weeks apart) can be readily used. In fact, we have now implemented an

automatic start-up procedure that takes care of all the initialization steps (except a new tuning curve measurement) and brings the instrument to full operation mode, without any input from the user.