

Interactive comment on “Thermal infrared laser heterodyne spectro-radiometry for solar occultation atmospheric CO₂ measurements” by Alex Hoffmann et al.

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Dear authors,

thank you for your manuscript. As a TCCON PI (Ascension Island), I have some specific comments about statements and claims that you make with respect to TCCON:

General comment on XCO₂

For TCCON, the observation of O₂ lines is essential as a proxy for airmass. Since you cannot observe O₂, how do you determine airmass? Deriving airmass from surface pressure alone is considerably less accurate and has therefore been depreciated in TCCON for years.

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Discussion paper



p. 3, l. 18-19: "Whilst TCCON currently provides the best benchmark in ground-based remote sensing of CO₂, the upfront investment in establishing a site and the subsequent running costs prevent the network from reaching a high density."

I often hear this argument - mostly from people outside the TCCON community. However, I think it is flawed because I don't see how a (potential) network of different instruments could do fundamentally different. First of all, the main limitation in the expansion of TCCON is not the cost of the FTS itself but rather the operational cost of running a site in a remote place. The not-so remote places like Europe and North America are already well covered. The typical carbon-cycle-related footprint of a total-column instrument is so large that a handful of instruments per continent are enough.

However, even in a place with good infrastructure the operational cost (excluding personnel) is in the range of 10% of the FTS acquisition cost per year. In a remote place like Ascension Island this is more like 20–25%. Main cost drivers are utilities, data transmission, spare parts and maintenance visits. If you include personnel costs in the calculation, the initial investment for the FTS would probably only account for 10–15% of the total cost for running a site for 10 years. This will not be fundamentally different for other types of instrumentation. Many TCCON instruments are built into standard 20-foot shipping containers that are easy to move to any place in the world that has road access. Despite extremely harsh environmental conditions, the Ascension Island instrument has been running up to 10 months in a row without a maintenance visit. Just by exchanging the instrument inside a lab container, the basic cost model for running a remote site would not be changed substantially. It would only be different for lightweight instruments that can run autonomously on solar power, have very limited data upload needs, run without consumables and do not require regular maintenance by qualified personnel.

BTW: just the need for cryogenic cooling for your QCL's photodiode (p. 9, l. 15) would already be a show stopper for most remote sites. So replacing it with a TEC would be very beneficial.

p. 8, l. 32: "The degrees of freedom for signal imply that 8 (or possibly more) independent pieces of information can be retrieved from a spectrum."

I find it hard to believe this number. Your instrument seems to be comparable to a TCCON instrument in spectral resolution, signal-to-noise ratio, acquisition time. It is certainly not an advantage that your bandwidth is only 0.025% of a TCCON spectrum. So I wonder why similar profile retrievals for TCCON only yield 3 degrees of freedom (Connor et al., doi:10.5194/amtd-8-12263-2015). Could it be that your OSS is assuming very idealized atmospheric and measurement conditions? I assume you are not taking into account real-world effects like horizontal atmospheric gradients, the changing airmass during the 90-sec-measurement, non-perfect instrument lineshape, non-Gaussian noise etc.?

Section 3.2: "Passive Solar Tracker"

In TCCON data, we see a lot of effects that are related to tracking accuracy - especially to the exact position on the solar disc. The Fraunhofer lines in the broadband FTS spectra can be used to correct the effects of pointing inaccuracies. However, your instrument cannot see these lines. In TCCON, the gold standard for solar tracking is camera-based tracking of the solar disc image directly on the entry aperture at high frequency. This significantly improves the measurement precision compared to quadrant-diode tracking or passive tracking (not used).

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