

Response to Dr. Jasper Stroud for the manuscript entitled '1.645 μm Differential Absorption Lidar Measurements of Atmospheric Methane Using an Er:YAG Laser'

Line 83.

"The wavelength measurement alternates between the two DFBs using a fiber switch (sSWT) toggling every 10 s, thereby tracking the slow drift of each seeder locked to the laser cavity."

Line 180

"The Licel acquisition module integrates 2000 laser shots for both ON and OFF wavelengths in real time, resulting in ON and OFF profiles recorded with a temporal resolution of 4 s."

Please clarify the above two statements. Is that 4s for both, or 2 sec each? Where did 10 sec go?

As shown in Fig. 1, the setup includes two independent optical switches. Each seeder output is split into two paths by optical fiber couplers connected to the two optical fiber switches. The first switch alternates between the ON and OFF wavelengths used for seeding the laser cavity. This fast optical switch (fSWT) operates at the laser repetition rate (1 kHz), thereby alternating the laser wavelength on a shot-to-shot basis. The acquisition system accumulates the ON and OFF shots in two separate memory channels. Profile accumulation is performed over 2000 laser shots, corresponding to 4 s, since the DIAL measurement repetition rate is 500 Hz. The second optical switch is dedicated to monitoring wavelength drifts of the seeders. The switching time of this second switch is much slower, as the wavemeter requires several seconds to stabilize its measurement. A switching interval of 10 s represents a good compromise between accurate wavelength measurement and effective monitoring of the slow drift of the ON and OFF wavelengths.

To clarify this point in the manuscript, we added the following sentences:

Line 74

"This fast fibered switch alternates the wavelengths on a shot-to-shot basis at the 1 kHz laser repetition rate. Consequently, the DIAL measurements are repeated at a rate of 500 Hz."

Line 84

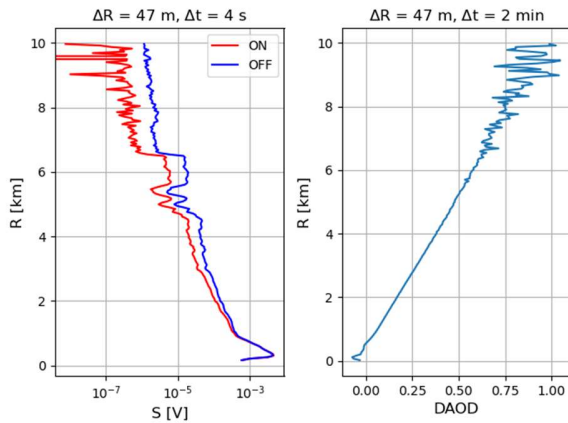
"The wavemeter requires a few seconds to stabilize its measurement, therefore, a 10 s switching interval represents a good compromise between accurate wavelength measurement and effective monitoring of the slow drift of the ON and OFF wavelengths."

Line 93

"The Licel module includes two separate memory channels that allow ON and OFF shots to be accumulated independently while the laser alternates between the two wavelengths."

Figure 3. Switching the axis of the range is confusing

Figure 3 has been modified in the manuscript



Why not match the resolution of the lidar system? Is there a limitation, or is this a choice?

The ICOS data are provided with a temporal resolution of one hour, together with a standard deviation representing the dispersion of the measurements over each hour. The precision achieved with the lidar at a temporal resolution of 20 minutes is sufficient to observe the plume dissipation. We therefore chose to retain this resolution in order to highlight the performance of the lidar.

Line 267.

“The differences in methane concentration between the ICOS measurements (at 100 m) and the lidar measurements averaged over one hour up to a range of 3.5 km remain below 50 ppb. A fire occurred at a waste sorting facility located in the city of Paris on the evening of April 7..”

Roughly how far from the point sensor (at 100 m) is the center of mass of the lidar results?

The GPS coordinates of the ICOS station are 48.7227, 2.142, those of the lidar system are 48.712034, 2.207950 and those of the measurement point shown in Fig. 6 are approximately 48.730963, 2.205855. The distances between the ICOS station and the lidar system, and between the ICOS station and the lidar measurement point, are both approximately 5 km.

The following sentence was added to the manuscript at line 259:

‘This lidar range gate is also located approximately 5 km from the ICOS station.’

Figure 6. Can you highlight the region in the left image used in the right image. The error bars and overlap is very difficult to see at the plum tail, maybe include zoomed in insert.

Figure 6 has been modified to include a zoomed view of the lidar measurements. The color bar was also modified, at the editor's request, to improve readability for visually impaired readers.

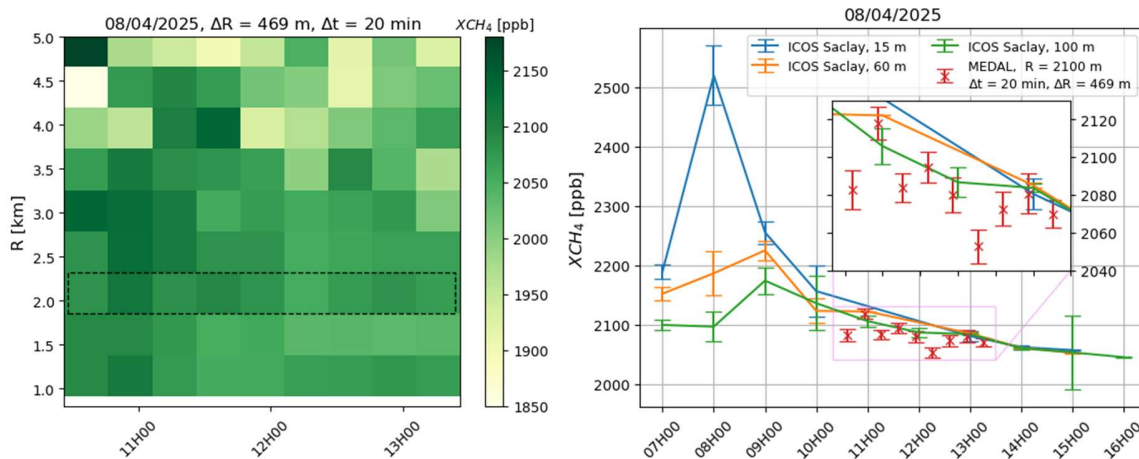


Figure 6: (Left) Time series of methane concentration profiles measured by the lidar. The time series enclosed by the dashed outline is shown in the figure on the right (Right) Comparison between ICOS tower measurements (heights: 15 m, 60 m, 100 m) and lidar measurements at 275 a range of 2100 m.

While modifying the figure, we noticed that the error bars of the lidar measurements and those of the ICOS measurements are nearly identical. The error bars of the ICOS measurements represent the dispersion over one hour of a time series of highly precise measurements (<1 ppb according to the reference Hazan et al. 2016) and therefore reflect actual variations in atmospheric methane concentrations. The lidar is thus sufficiently precise to measure these variations, and the corresponding error bars effectively represent fluctuations in methane concentration. This also explains why, in Fig. 8, the theoretical error underestimates the measured error. The sentences (line 328): ‘This discrepancy may originate from uncertainties in the parameters used in Eq. (8) (based on manufacturer datasheet values) and requires further investigation. The precision derived from the linear-fit uncertainties is also overestimated, as it includes the natural variability of atmospheric methane.’ has therefore been removed.

To complement the text, we added the following passage (line 328):

‘In Fig. 6, the error bars of the ICOS measurements and those of the lidar measurements are nearly identical. The error bars of the ICOS measurements represent the dispersion

over one hour of a time series of highly precise measurements (error < 1 ppb according to Hazan, 2016) and therefore reflect variations in atmospheric methane concentrations. At 11:00, the relative dispersion of the methane concentrations measured by ICOS is 0.4%. In Fig. 8, we observe that the methane fluctuations are larger than the theoretical lidar error. Consequently, the relative standard deviation measured by the lidar represents fluctuations in atmospheric methane concentrations.'

Hazan, L., Tarniewicz, J., Ramonet, M., Laurent, O., and Abbaris, A.: Automatic processing of atmospheric CO₂ and CH₄ mole fractions at the ICOS Atmosphere Thematic Centre, *Atmos. Meas. Tech.*, 9, 4719–4736, <https://doi.org/10.5194/amt-9-4719-2016>, 2016