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Atmospheric Measurement Techniques Discussions

Interactive comment on "Simultaneous multicopter-based air sampling and sensing of meteorological variables" *by* Caroline Brosy et al.

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The manuscripts describes first results of experiments using a multicopter UAV for wind and methane measurements. For the wind vector, only attitude and GPS data were combined in a very simple flight mechanical model of the multicopter. This approach is not new, but only few publications exist so far. In order to avoid the usual problem with small multicopter regarding very limited payload, the authors use a ground-based gas spectrometer connected by a tube to the multicopter. This allows for vertical profiles of gas data in the lowest part of the atmospheric boundary layer / surface layer / Prandtl layer.

The results are in good agreement with other measurements (EC station, tower, lidar, sodar). This analysis is a valuable contribution to measurement technology in the

surface layer, although turbulence data cannot be achieved by the presented methods. The manuscripts meets the focus of the AMT journal perfectly.

Here are my comments:

a) general: although I am not a native speaker, I think the correct word before naming an altitude is 'at', not 'in' or 'for', e.g. text below Fig. 5, lines 14 and 27 on page 7, etc.

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b) Page 5 and following: The procedure to find the relationship between tilt gamma and true airspeed TAS is based on the following assumptions:

1) TAS equals ground speed (measured using GPS) during absent wind (very calm wind, below 1 m/s)

2) TAS and gamma have a linear relation. Thus knowing gamma from attitude measurements leads directly to the TAS.

3) Since the difference between TAS and ground speed equals the wind vector, knowing the attitude / Euler angles allows the calculation of the wind vector (or at least an estimation)

First question addresses assumption #1: what is the mistake done to the TAS-gamma relationship by assuming zero wind during calm wind (1 m/s is not zero)?

Assumption #2: TAS and tilt angle gamma are not in a linear relation, but due to

Seddon, J. M., and S. Newman, 2011: Basic helicopter aerodynamics. 3rd ed., Wiley, 286 pp.,

and

Palomaki et al., 2017, Wind estimation in the lower atmosphere using multi-rotor aircraft, JTECH online: http://journals.ametsoc.org/doi/10.1175/JTECH-D-16-0177.1

(btw this article should be cited anyway), TASˆ2 = C * tan gamma

Even assuming very small gamma angles, a Taylor series expansion would lead to

TASˆ2 approx C * gamma, and not TAS approx C * gamma !

This explains why the curve in Fig. 4 is not a straight line.

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c) How was the wind direction estimated for situations with significant wind speed? Is the simple linear (or squared, see comment b) approach still valid for significant wind speed?

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d) While the relation between gamma and TAS in Fig. 4 was found for calm wind situations only, the corresponding calibration experiment (race-tracks flights) was performed without the 70 m tube that provides the methane measurements in the following. The tube adds weight and moment of inertia to the multicopter and thus changes the flight mechanics. What / how large is the influence of the tube on the relation between gamma and TAS, and finally on the wind-vector estimation? I see that this aspect is addressed in line 4 on page 9 - but there it is just a statement, not explained or proven. Of course the autopilot could handle the extra load, but this does not mean that the gamma-TAS relation remains untouched.

* Chapter 3.2: How much time did the multicopter spend at the three probing altitudes 10, 25 and 50 m?

* Chapter 3.2 / Fig. 8: The curvature of the blue temperature lines in Fig. 8 is misleading, because it does not represent the vertical temperature profile of atmosphere, but was most likely caused by (all together)

1) non-stationarity of the ABL

2) the change of the multicopter flight mechanics before climbing to the next probing level (thrust) and thus the change of the wind field around the aircraft

3) sensor inertia of the quite slow thermocouple

I suggest to use averaged temperature data at the three probing levels only, similar to the CH4 data (green)

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e) line 29 on page 7: How is the 'mean concentration of a gradient' defined?

f) line 30 on page 7: 'concentrations increased even before sunset' - how can you know? Because line 13 same page: 'starting 15 minutes after sunset'

g) line 7 on page 8: 'due to the fact that turbulence was not totally suppressed' - Well, this is more a guess rather than a fact, since turbulence was not measured.

h) line 22ff on page 9: You could visualise the mulitcopter downwash and quantify the downwash area using smoke. We did this - really easy to do and impressive.

i) section 3.2 and line 27ff on page 9: the methane data interpretation depends strongly on the accuracy of the methane concentration measurement, which is not addressed in the article. How accurate is the CRD spectrometer? See also missing error bars in Fig. 8 for additional statistical uncertainty.

j) Fig. 6 and line 13ff on page 9: it seems that the lidar wind direction at 9:00 UTC was corrupt due to very low wind speed. Same for all lidar data below 25 m. I looks like the lidar did not deliver reliable data at all under these conditions, and that this has nothing to do with horizontal separation from the sodar etc. This should be mentioned.

k) Fig. 7: for most data points the error bars are missing (since data points are a result of averaging it should be easy to add error bars)

l) Fig. 8: Since the data points (at least the CH4 concentration) are a result of averaging it would be easy to add error bars. This would give better confidence, or rather would help to see the significance of the concentration gradient described in the text, respectively.

m) Fig. 9: How were the errors calculated? What do the small circles represent?

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