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Atmospheric Measurement Techniques Discussions

Interactive comment on "Meteorological profiling of the lower troposphere using the research UAV "M²AV Carolo"" *by* S. Martin et al.

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Report #3 (Referee #2 full paper review) and response by the authors:

General comments In this paper, vertical temperature and wind profiles (orientation and speed) are obtained from an unmanned research aircraft automatically operated in the lower troposphere. The primary aim of this new technique is to investigate the turbulent fluxes occurring within the atmospheric boundary layer. A first evaluation of the M^2AV performances could be performed during the LITFASS-2009 campaign and results are presented in this paper. As already mentioned in the first quick review, the presented paper shows a good and clear overall structure which does not require any major correction. The use of state-of-the-art aircraft technology is also well explained

in the paper. However, in the following section, several remarks / advises are presented in order to further improve the coherency and scientific quality of the paper, in concordance with the AMT evaluation criteria. In particular, some current interpretations presented in the comparison sections are still lacking or insufficient to correctly reflect what is actually seen on Figures 4 to 7 and 9 to 10 (see next sections for more details). A quantitative (rather than qualitative) comparison based on the rms error of the different measurement would also be appreciated in Sections 3.4 and 3.5 (see again the next section for more details). The last section finally deals with few technical corrections related to the use of English and readability of the different sections of the paper.

Specific comments I would recommend the authors to pay a particular attention to this section concerning the scientific evaluation of the paper.

First of all, some clarifications should be provided for the following parts:

- Lines 197-199: the authors mention that 70% of the sodar data availability is constrained between 360 and 480 m for the wind. However most of the wind comparisons provided in the paper are performed below 360 m with the sodar.

Further details regarding the sodar, its operation and performance are included: Wind and temperature proïňĄles from 40 m up to a few hundred meters above ground are measured with a sodar/RASS DSDPA.90-64 (METEK) operated at the GM Falkenberg. The sodar operating frequency is 1598 Hz, vertical resolution of the proïňĄles is 20 m. 70% data availability is achieved at heights between 360 m to 480 m for wind, and 180 m to 240 m for temperature, respectively (for further details see Engelbart et al., 1999). The measurement range is often reduced during the morning and evening transition periods when thermal turbulence and stratiïňĄcation are weak and the sodar signal-to-noise ratio might be relatively low. The latter may also reduce the accuracy of the derived meteorological parameters. Temperate proïňĄles derived from the RASS measurements of this system are corrected by adjustment of the constants and for the inïňĆuence of the vertical wind according to Görsdorf and Lehmann (2000).

- Could it be a plausible explanation for the wind orientation discrepancy observed in Figures 6 and 7?

The sodar data were rechecked and an inaccurate time assignment was found. All figures that include sodar data are replotted. Now the systems are in higher agreement concerning wind and temperature data. Here, only Figures 6 and 7 are presented. In the manuscript all figures will be replaced.

- For clarification, Figure 8 should be introduced earlier within Section 3.2 (where all instruments are presented) in order to correctly apprehend the comparisons between the devices.

Done

- Lines 273-277: 'The meteorological profiles... for virtual temperature' – this section might be shifted to Section 3.2 where the vertical resolution of each instrument is also presented.

Done

- Lines 278-280: 'During the morning transition... expected in the ML' – these sentences might be misplaced and shall be shifted at the end of Line 284, where temperature discrepancies in the ML are described.

Done: During the morning transition of the ABL, fast temporal changes occur in the developing mixed layer. Therefore, differences between the M^2AV data, which are not averaged and the averaged data of the ground-based systems are expected.

- Lines 293-294: The sentence 'This may indicate... morning hours' is not grammatically correct – Is part of the sentence missing?

Done: Nevertheless, the three maxima of the M^2AV humidity proïňĄles are also found in the radiosonde proïňĄle. This may indicate a high degree of stationarity in the lower

free atmosphere above the stable boundary layer and the early morning mixing layer.

- Lines 303-304: place this one sentence paragraph at the end of the previous paragraph (related to the same topic – based on humidity profile comparison). Done

- Lines 332-338: On the one hand, the authors mention that the differences between aircraft and sodar measurements are smaller in the afternoon than in the morning flight within the Mixed Layer. On the other hand, the authors indicate in the next line that poor sodar performances are known to occur in the late afternoon, implying fewer differences in the morning than in the afternoon flight. Therefore, these two sentences are quite conflicting and should be better explained. Also, because of poor performances in the afternoon, the use of the sodar during the afternoon for comparison purpose might be reconsidered.

The sodar data were rechecked and an inaccurate time assignment was found. All figures that include sodar data are replotted. Now the systems are in higher agreement concerning wind and temperature data. The discussion by the authors is revised according to the new results.

- Line 362: At the end of the paragraph, it would be worth mentioning that such fast temporal changes are not detected by current standard observation sensors, which makes the use of this aircraft so unique.

Done: Such fast temporal changes are not detected by current standard observation sensors, which makes the use of this aircraft so unique.

Secondly, some qualitative information of the observation and comparison of the aircraft data with other instruments are still lacking in the paper:

- Lines 142-143: how accurate is the wind vector retrieved using the GPS and the IMU?

Changes in the manuscript: An analysis of error propagation resulted in an accuracy of 0.8 m/s for wind speed and an accuracy of 15° for wind direction.

- Lines 143-144: How slow is the Vaisala HMP 50. It is suggested to remove ‘rather slow’ in the sentence if no figures can be provided.

Changes in the manuscript: The Vaisala HMP 50 provides air humidity measurements (Vaisala Humicap) with an accuracy of $\pm$ 2% relative humidity in a measurement range of 0 to 98%. The sensor also measures the air temperature (resistance thermometer) with an accuracy of $\pm$ 0.6 K. During flight the sensor has a response time of about 1 s. Spectral analysis has shown that humidity and temperature fluctuations down to 1 Hz can be resolved.

- In Section 3.4 and 3.5: Some qualitative information (root mean square errors between the different sensors) on how much the measurements agree in Figures 6-7 and 9-10 would be highly appreciated in order to correctly assess this comparison.

We did not provide rmsd values to quantify the differences between the aircraft data and the other systems considering the different sampling strategies and averaging methods. It was our aim to demonstrate consistency between the different profiling methods including the M^2AV which becomes, to our opinion, obvious from the profiles presented. The calculation of rmsd values would require the application of different averaging rules to the aircraft data for comparison with each of the other profiling systems before determining quantitative error measures, this goes beyond the scope of the present manuscript.

Finally, some further explanations would be appreciated for the following statements:

- Line 267: what does a negative sensible heat flux during the afternoon flight imply? (Either explain or remove)

Removed

- Lines 268-270: ‘By comparing. . . wind speed decreased’ – how do you interpret this observation in terms of mixed layer evolution?

Changes in the manuscript: By comparing ascent and descent it can be seen that in

the ML the fast fluctuations in wind direction and speed increased as this layer evolved.

- Lines 270-271: how are remnants of a nocturnal low-level jet represented in figure 6?

Removed

- Line 309: why is there better agreement when the ABL is more turbulent?

Removed

- Lines 309-311: the very good agreement found between the M2AV, the sodar and tower are quite remarkable knowing the difference in the sampling and averaging strategies taken into account for each instruments. Do you also find the same type of results for other measurements not shown in this paper?

Removed

Technical corrections The technical corrections are presented in order of appearance in the paper:

- Title: wrong quotation mark before ‘M^2AV. If written in Latex, you should use the following symbol ‘ instead of ‘. The quotation marks are preset by the journal.

-Line 60: The acronym RASS is not previously defined in the paper. Done

- Line 88: ‘Experimental’ shall be replaced by ‘Experiment’ or ‘Experimental setup’. Done

- Lines 81, 85, 154, 229, 263, 345, 347 and 361. The word ‘instantaneous’ might be misused in this paper since you need quite some minutes in order to actually get one profile in the Boundary layer (compared to ‘instantaneous’ profiles obtained from tower-based and active remote-sensing devices).

Instantaneous is changed to: snapshot-like, momentary and profiles result from instantaneous local measurements at different points in space and time along the flight track

- Line 164: you shall replace ‘reliable’ by ‘accurately’. Done

- Line 166: you shall replace ‘a component of’ by ‘part of’. Done

- Line 175: ‘combines’ shall be replaced by ‘combined’ Done

- Line 229: same than for the title The quotation marks are preset by the journal.

- Line 235: ‘Vertical profiles during the morning transition’ Done

- Line 262: The value at 50. . .Done

- Line 277: The time indicated in. . . marks . . .Done

- Line 281: For ascent and descent, . . .Done

- Line 299: ‘Being a passive remote sensing instrument, the MWRP is not able. . .Done

- Line 319: ‘Vertical profiles during the afternoon transition’ Done

- Line 323: fluxes measured at 50 and . . .Done

- Line 331: It is advised to rewrite the sentence in Line 331 as follows: The tower provides measurement down to 10 m agl where the stably stratified layer was observed. Done

- Line 359: The data were obtained. . .Done

This paper is considered to satisfy the AMT criteria as long as the comments mentioned above are correctly taken into account and could, therefore, be accepted for publication.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 5179, 2010.

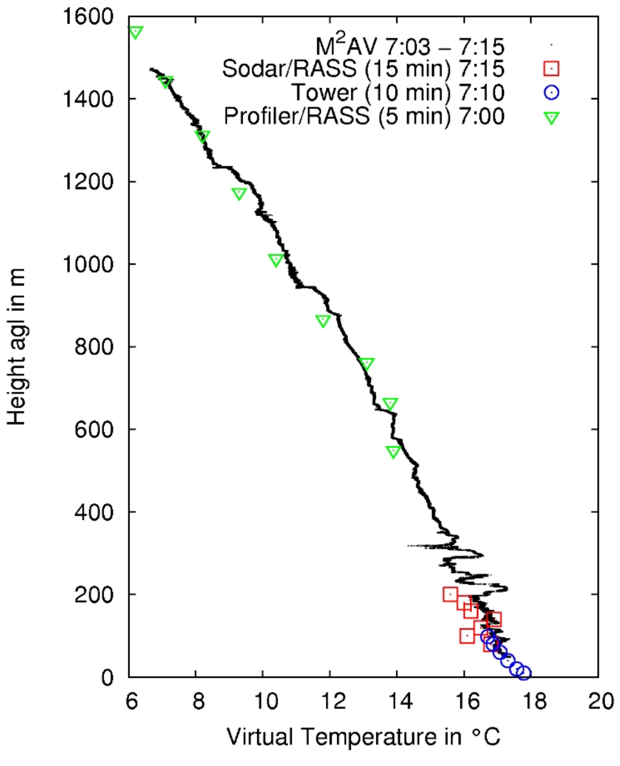

Fig. 1. first flight, ascent, virtual temperature

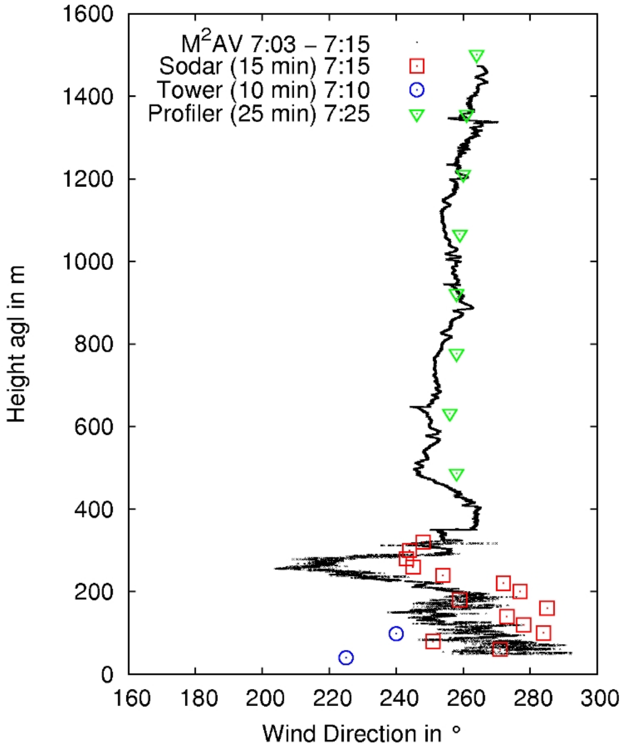

Fig. 2. first flight, ascent, wind direction

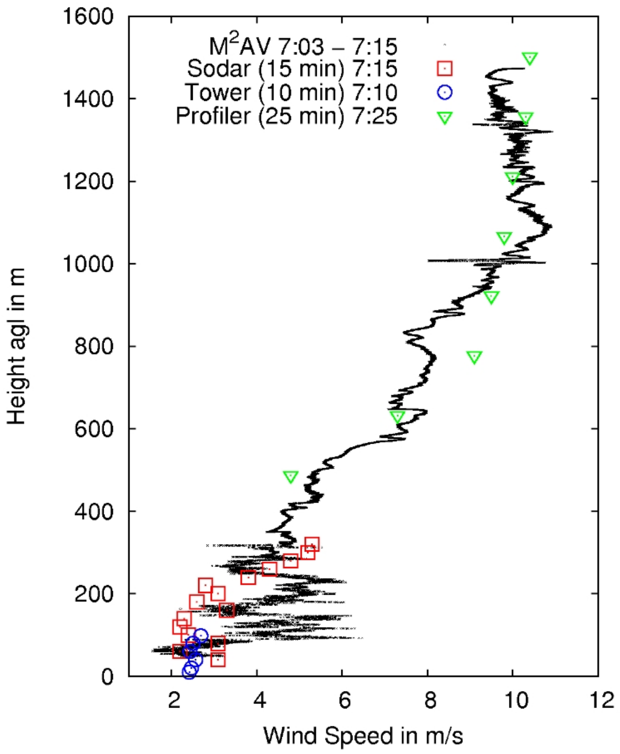

Fig. 3. first flight, ascent, wind speed

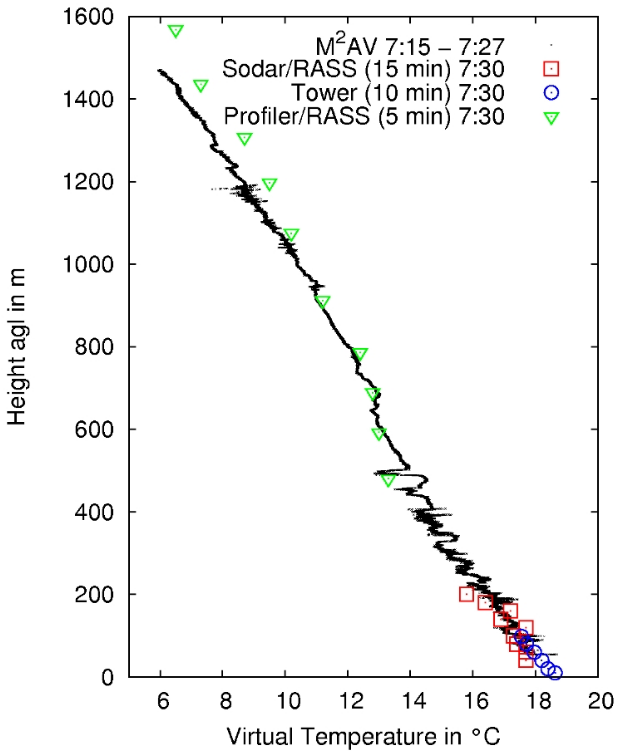

Fig. 4. first flight, desscent, virtual temperature

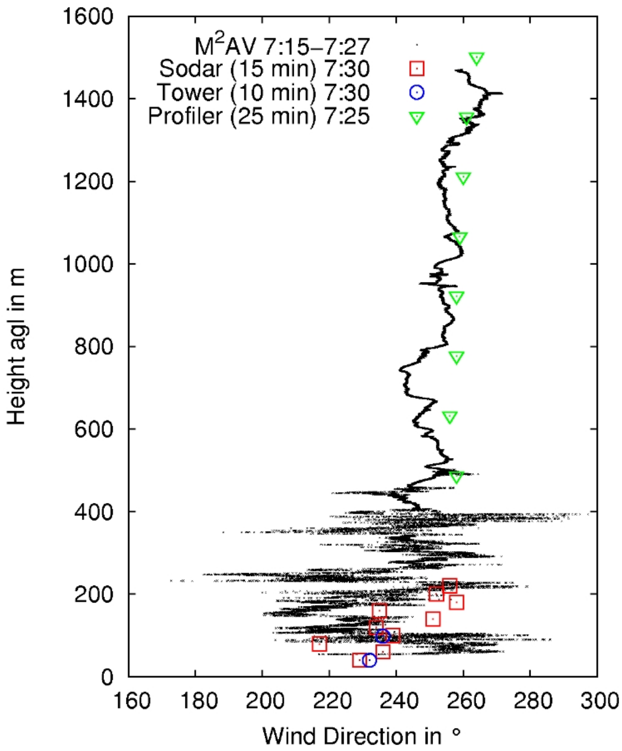

Fig. 5. first flight, descent, wind direction

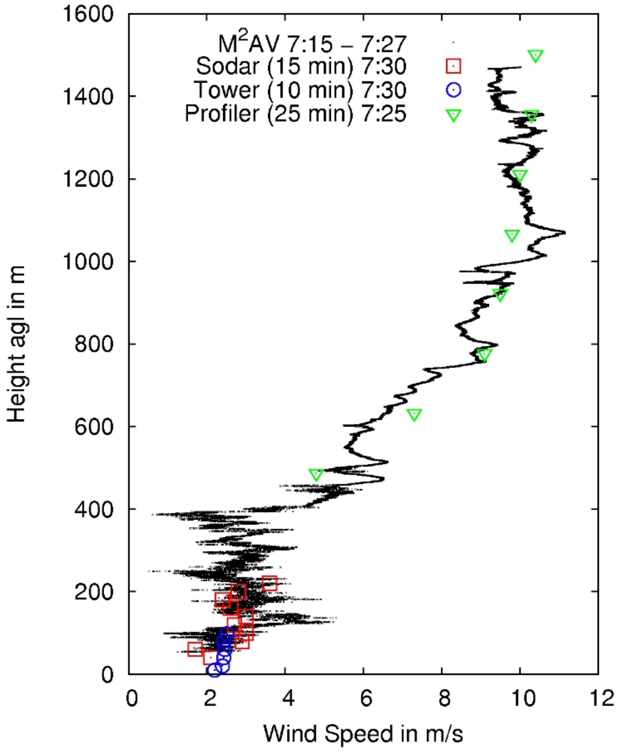

Fig. 6. first flight, descent, wind speed