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Interactive comment on "**Mean vertical velocities and flow tilt angles at a fetch-limited forest site in the context of carbon dioxide vertical advection**" *by* **E. Dellwik et al.**

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General comments:

This is a very valuable research work on the accuracy of vertical velocity measurements in a fetch-limited forest site. Measuring the vertical velocity has always been critical, whatever the platform used for it: radome or boom of an aircraft, remote sensing (radar, lidar, sodar), tower-based sonics... for all of them, it remains difficult -if not impossible- to measure an 'absolute' estimate of the vertical velocity, one that is representative of scales larger than turbulence. So it is important to address the question, even if it is only partly addressed here, in a specific complex situation and with only two kinds of

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instruments. The authors give an exhaustive and very useful review of sonic accuracy and calibration, with description of the different methods for correcting measurements for several effects due to flow distortion or error in positioning the instrument accurately. They pursue the retrieval of flow tilt angles and vertical advection above a forest edge with an interesting approach and in spite of the complexity of the issue.

I recommend publishing this article after some revision. Especially, I have the feeling of some unbalance between sonic and lidar in terms of quality and extent of the analysis, and suggest to revise the lidar part (or remove it ?, since the analysis of the lidar data seems too preliminary to help in the conclusions). The paper could also probably gain some clarity with a revision of its structure.

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Specific comments:

- Sketch of the flow (Fig. 1 and discussion lines 15 page 8174 to line 5 page 8175):

In this paper and in the refered previous works, every critical distance from the edge at which the flow is changing is expressed as a function of the canopy height. Is there any dependence on the windspeed (and any normalization by hc/U) ?

- Integral scales:

I did not understand how the integral scales were estimated (what is the displacement height 'd' in line 18 page 8175 ?). Lenschow (1994) gives a definition of the integral scale and a way to estimate it from the autocorrelation function of the vertical velocity. The authors should be able to calculate this scale directly from the vertical velocity measurement (only along wind though) or they should justify their method.

- Lidar conical scanning mode:

The method described in page 8170 is commonly called 'VAD' for 'Velocity Azimuth Display'. It is one of the earliest applications of Doppler radar. The VAD technique

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was described in details by Browning and Wexler (1968). Even if the discussion about reflectivity inhomogeneities does not apply to the lidar, there are some important issues discussed about the accuracy of the wind components retrieval, linked with the hypotheses made and the best acquisition procedure to follow.

Page 8177, lines 13-17, the authors do not specify how they fit the data to trigonometric series. A least square approach enables to statistically estimate the errors made on each term and to test the hypotheses. This is missing here, as well as a plot of the Doppler velocity measured along a circle over one round or over the three rounds made at a given height.

I am surprised that this method is used to estimate the vertical velocity. If the conical has a vertical axis like it is the case in the present study, it does not allow to measure the vertical velocity accurately, especially in case of strong vertical shear or horizontal variability. Because one cannot distinguish the first term from the second term in equation (8) (the parameter 'a', which can indeed be estimated from the VAD, is the sum of both terms).

It allows to estimate the horizontal mean wind components, along with some deformation terms linked with their variability (like divergence as mentioned), but this is only possible if the hypothesis of linear variability within the explored volume is correct. Moreover, the estimates of this variability and mean horizontal wind are representative of the scale of the circle. Usually, an estimate of the vertical velocity can be made by integrating divergence along the vertical, but it has some inaccuracy as well, is sensitive to the chosen border conditions, and again, gives an estimate which is representative of the scale of the circle. It is a useful method to estimate the mesoscale or large scale vertical velocity, but probably very difficult to apply here.

A discussion on the hypothesis on the linarity of the wind field and its variability at the scale of the conical scanning in time and space is missing in the study. With phi=30.4 degrees and h=24 to 151 m (height of focus), l=14 to 88 m (radius from the cone axis).

This is still the scale of turbulence (probably close to Lw), and the hypothesis of a linear wind field is put into question. One could think of a VAD approach, but with a turbulent field within the scanned volume rather than a linear field, especially in the situation studied here at the edged of a forest. Unless the sketch of Fig.1 leads to linear wind fields that can be observed at the proper scale with the VAD approach. If it is the case, this should be more discussed and proved, and the interest of using this approach should be emphasized convincingly.

page 8176 line 14-15: 'Without loss of validity the analysis is ignoring the fact that the QinetiQ lidar only measures the magnitude of the radial wind speed, not the sign'. This is surprising. Can you explain more ? Did you use the measurements made by the sonic to determine the sign of the radial component ?

page 8178 line 7: 'the errors on the horizontal components are independent on phi': This is also surprising and deserves more explanation.

Note that in final, only 5 lines (8 to 13) page 8188 discuss the results obtained with the conical scanning mode.

Maybe I missed a key point here, but why didn't the authors use one of the lidar to point vertically ? This would probably give the best estimate of the vertical velocity from the lidar. Averages over time at similar scale of the sonic data processing would then give estimates that could be compared to the sonic estimates, with the difference of the volume average made within the lidar beam.

- Lidar 'linear' mode

Using 'pointing horizontally' may be more appropriate for the so-called 'linear' acquisition mode.

The analysis page 8188 (par 4.5) in case of winds transverse to the edge of the forest is very interesting. It could be extended to test the hypotheses made in the VAD analysis, and in reverse, the VAD could be used to test the hypothesis made in 1d approach of

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paragraph 4.5 based on the measurements made with the lidar pointing horizontally. It would also allow the authors to check the explanation given page 8191 lines 5-6 on error made due to not measuring the transverse component.

- Flow angle dependency

page 8187, lines 1-8: We expect the authors to discuss their results and give more explanations

page 8188, lines 1-3: id.

- Paper outline:

The paper could also probably gain some clarity with a revision of its structure. For example:

* Maybe talk about 'Material and method' before explaning the VAD method and discussing the test in flat terrain ?

* Page 8178: 2.3.1 is the only subsection in 2.3

* Discuss the results as much as possible in section 4 ('Results', that is move some discussion from section 5 to 4) and keep in section 5 only further discussions that are not directly linked to the results.

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Minor comments:

p 8169, line 14: remove 'of'

p 8176: specify the referential (longitudinal/transverse the forest edge or east-north) for x, y, z line 15 and equation (4) and for the azimuth angle. Also specify that you keep phi constant, which explains why you drop it in the variables of equation (6)

Throughout the manuscript: change 'horisontal' to 'horizontal'

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page 8179, line 13: change 'Fig. 8 to 'Fig. 2'

page 8180, line 12: remove 'a' in 'with a an'

page 8180, line 13: remove 'Each height... differences' (already said in caption).

page 8187, lines 12-13: remove 'where the full line is... unstabel data' (said in Fig. caption)

page 8193, lines 4-8: this sentence is hard to follow. Maybe you could split it to help the reading.

Fig. 3: specify the x- and y- axes scales in left panel, and a scale in the right panel (indicate link between both ?)

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References:

Browning, K. A., and R. Wexler, 1968: The determination of kinematic properties of a wind field using Doppler radar. J. Appl. Meteor., 7, 105–113.

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