General Comments about, "Momentum fluxes from airborne wind measurements in three cumulus cases over land," by Koning, Nuijens, and Mallaun

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General Comments

The combination of lidar and aircraft measurements to estimate wind and momentum flux is wonderful to see – the lidar really puts the momentum fluxes in context. For the Pennell/LeMone papers referenced in this paper, we had wind – but it was sampled by the aircraft taking the turbulence measurements, and there was some question as to whether the countergradient flux observed in the roll case was real, since the wind profile could have been evolving during the flight.

Something nearly equivalent was accomplished during ATOMIC/EUREC^{4}A field campaign was with dropsondes to complement aircraft flux data – something once of the co-authors (Nuijens) knows about.

But the nearly-simultaneous measurements as done here is more flexible – one need only have the two aircraft and the necessary clearances.

The one big missing item in the paper is the nature of the terrain and land-surface properties beneath the flight tracks, which *can* have strong effects on fluxes and variances. More detail is needed on the surface and the flight patterns themselves. (The tracks are helpful – but "deviations" from tracks should be described in more detail – some comments about this are in the specific comments).

I think it would be helpful to the reader to at last know the location, time, and goals of the CloudBrake campaign in the introduction. One sentence is enough.

While Fig. 1 is extremely helpful, It would be also be helpful to have a table that briefly summarize each flight, so that the unfamiliar reader can quickly flip the pages to find it, rather than hunting through the text to understand each case. This could also be the place to define "thick" and "thin" – which should be consistently used in the figures (Sometimes "east" and "west" are used instead.)

Finally, in relating momentum fluxes beneath cloudy areas to those in clear areas, it might be of interest to examine the buoyancy fluxes. This is not a requirement – but may, along with terrain and land cover, be a factor in determining horizontal distribution of fluxes.

Specific Comments

1. L31. "Convection and clouds" … since clouds are convection, not sure what this means. Are you referring to cloud- and subcloud-layer convection? Or "dry and moist" convection?

2. L42. I think you mean here Pennell and LeMone, which has profiles of momentum fluxes through the cloud layer, unless you are referring to LeMone and Pennell's Figure 5.

3. L45. Rather than small-scale – are you referring to dry-air convection? In LeMone and Pennell, Fig. 5, rolls accounted for a significant amount of the momentum transport. In this case, the clouds were extremely shallow. The linear flux dependence disappeared when clouds became significant (Case III).

4. L50, 52. Please define 'mesoscale.' km scale?

5. L77. Year? Then it doesn't need to be repeated.

6. L88. Flights adjusted to capture cumulus clouds. What does this mean … deviations from a straight line? (A zig-zag pattern? Movement of the entire track?)

7. Fig 1 and discussion.
   a) Were the flight tracks the same for the Falcon and the Cessna? (Refer to Fig. 1 on this.)
   b) I am assuming Cessna and Falcon flight legs were designed to overlap in time and space to the degree possible. Is this correct?
   c) Please describe surface conditions (terrain, significant vegetation variation) beneath the tracks
   d) Please include the typical data-collection speed of the two aircraft here, even though they are given later.
   e) Finally, you might mention that the flight legs were flown crosswind, which can have impact on the sample, particularly in stronger winds.

8. L91 (Just below Fig. 1). … "near cloud top" … above cloud top? Or just below the top of the highest clouds?

9. L102. Cruising speed? Not necessary if mentioned earlier – this is the first question I had when I saw the frequency range.

10. L129. Along-beam? (Rather than vertical?). Vertical resolution is along-beam resolution x cos (20 degrees).

11. L130. Pulse length?

12. L134. Presumably the 8 km applies to a specific vertical distance. Nearer the aircraft, the resolution would be better.

13. L145, bottom of p. 6. "turning points between legs." 180 degrees? 90 degrees? Fig 1 shows two parallel flight tracks for two of the days, and three tracks for the third. Were four levels flown by the Cessna along both flight tracks? Did the Falcon do reverse-heading legs

on the west leg and then fly east leg for reverse headings? Or did it do U or box patterns? Minor stuff – but it can affect interpretation.

14. Bottom of p. 6. "Horizontal resolution 8 km" … Is this because the width of the cone at Cessna flight level roughly 8 km? How many VAD circles are executed for each 8 km the Falcon travels? For each flight leg? I am assuming you are just getting wind vectors.

15. L154 and L155. "slightly overestimated." Not sure what this means. The variances are over different scales, aren't they? (Unless you are estimating variances using VAD as well, which doesn't seem to be the case from L133-4, and if so – aren't the scales represented still larger than what the aircraft sees?). Wouldn't it be more precise to say simply that the variance of the 8-km averaged wind is greater than the variance of the wind measured by the aircraft?

16. L157. 1-2 km is the "effective" horizontal resolution of the DWL? I thought it was 8 km! Please explain in section on lidar.

17. L160. Just out of curiosity, what sort of magnitudes do you get for mean vertical velocity from the lidar? That is such a difficult measurement – and of course you would have to know the aircraft vertical velocity as well.

18. L165. How well does the Lenschow-Stephens method work in cloud? In studies over the tropical oceans, we found that using vertical velocity alone worked better, partially because measurements of temperature and mixing ratio in cloud were not that accurate (Series of papers by LeMone and Zipser and others). Might consider trying this in the future. (Continental clouds may work better than tropical oceanic clouds – and mixing-ratio instruments could be more reliable).

19. L172-4. This makes sense. We found stronger subcloud and lower cloud-layer vertical velocity standard deviation in more cloudy conditions (Fig 11, Nicholls and LeMone, JAS, 1980), which makes sense, since associated buoyancy field and/or interaction with the shear generates pressure perturbations that can draw up air from below (LeMone et al. Mon. Wea. Rev. Feb and Oct 1988), also see Rotunno and Klemp 1982). This might be something to look at in a future paper.

20. Fig. 5. If U and V were plotted rather than direction and speed, it would be easier to relate them to the fluxes, and the wind turning on 24 May would show up in only slight changes in the wind components. (I see that they are plotted later in Figs. 6 and 7, and that the resolved winds do show strong shear – is it real?) So maybe no modification needed here.

21. L231. Skewness is not shown in Fig. 9. Delete "and skewness of"?

22. L249. "Cloudy updrafts can have vertical speeds … in both altitudes." You mean the updrafts in the subcloud layer are clearly associated with individual clouds? Or you mean updrafts

beneath cloudier areas? (Two reasons for this comment – the possible impact of terrain – though I recognize it might be unlikely, and that 600 m is in the subcloud layer).

23. L252. Same comment

24. L257, Scale contribution to flux. Near the surface, Kaimal, Wyngaard, Izumi, and Coté (1972, QJRMS) found that the cospectra of $\overline{u'w'}$ and other fluxes follow a fixed slope, with large scales more significant. Of course, things could differ from this significantly higher up, as possible in cases with quasi-two dimensional convection like clear-air roll vortices, and clouds, as is noted in this paper.

25. L268. Fig. 9 should be labeled like the others – thick and thin. Although there seems to be a "south" here as well. Are the fluxes significantly different on the "south" leg?

26. L276. Greater than 1-2 km?

27. L286. It looks like mixing ratios were higher on the cloudier day.

28. L287. Again – should specify what is meant by,"The approach cold front needed us to move to keep targeting cumulus clouds." Did the whole track get moved, or was more of a zig-zag pattern flown?

29. Figure 12. caption, line 3. "Effectively **Ex**cluding"? In the figure, you have six bars suggesting six filter scales, but in the caption, there are only four filter scales. Shouldn't these be consistent?

30. L295. Aren't the standard deviations of horizontal wind from the aircraft for much larger scales than the aircraft, which measures the standard deviation on turbulence scales? (i.e., 8 km (or a few km?) and larger vs 7 km and smaller). Could the nearby mountains contribute to this larger-scale variance in wind, e.g., though mountain related periodic waves? (as well as the distance between clouds)

31. 305. Enhancement of fluxes below clear skies? On L172-174 the opposite was stated. Or is this a different day? (Such a situation is possible, either due to enhanced heating of the ground or to the impacts of terrain or ground cover).

32. L311… "very small" … $\overline{u'w'}$ was nearly zero, but there was significant $\overline{v'w'}$ … perhaps just 'smaller'?