Interactive comment on “Joint Analysis of Convective Structure from the APR-2 Precipitation Radar and the DAWN Doppler Wind Lidar During the 2017 Convective Processes Experiment (CPEX)” *by* F. Joseph Turk et al.

Anonymous Referee #1

Received and published: 17 April 2020

The paper presents some very interesting measurements collected during the CPEX experiment by joint Doppler Aerosol Wind Lidar and dual frequency Doppler radar observations. The paper is very important because lays the foundation on how to integrate these two different Doppler observing systems. The paper is generally very well written. I am looking forward seeing the data used for a better understanding of the linking between 3-D air motion and cloud structure in a peer-reviewed journal.

I have mainly some comments to improve the layout and to add the information content of some of the figures. Also, Sect 4 could be improved.

Line 140: “any developed” ==> developed

Fixed.

Fig.4: it is very difficult to read this figure. In particular the overlapping of the image colour and the coloured dots is particularly troublesome. Why not shifting the dots upwards by 0.5 degree latitude (properly commenting on that in the caption) ?

We agree, in fact since Fig 5 is the figure that is supposed to represent the DAWN LOS sampling, we just removed these dots from this figure and the color scales represents the Ku and Ka-band reflectivity. In Figures 6 and 7, which zooms in to the various LOS profiles, the second colorbar for the lowest level is reinstated.

Fig5: Maybe it is worth saying that no image colour is present if no clouds with reflectivity above radar sensitivity are present in the layer.

We have added this (no image color= no clouds present that are above the APR-2 radar sensitivity).

Fig7: colour-scale is in dBZ not dB, right? (also line 223 and through the document)

Yes, that’s correct. We have fixed this terminology throughout.

Fig8: red box: If the red box represents the blind zone it should follow the aircraft flight level and go oblique before scan 500. “above 6-km (where the SNR is highest), and below 3-km (where the aerosol content is higher)” it is a little bit misleading because I think in both cases the SNR is high, in the first case because of the shorter range, in the second for the higher backscattering. In general, it is not clear to me why between 1000 and 1500 (there is not a clear range dependence in the upper part, is the lower part structure related to aerosol in the first two km?) the black dots are distributed like they are. Maybe over-plotting lidar SNR contour levels could help. Same applies to Fig.10-12-14. Also isn’t in all such figures a lost opportunity? Why not showing for some of the black dots the wind direction? We could actually appreciate wind shear in proximity of convective clouds.

One reason for the “lower part structure” referred to is likely due to clouds that may be present, but below the APR-2 detectability, so we have no “proof” that they are really there. Some of these clouds are “thin” enough that DAWN can penetrate and still have sufficient dynamic range (see the reply to the comment below with an example figure of this situation), others penetrate only partially. Or some profiles occurred during slightly different aerosol concentration in the lower 1-2 km than did other nearby profiles.

The 2-km and 8-km wind barbs are plotted on Figure 4, which corresponds with Figure 7. In other words the flight segment shown in Figure 4 maps one-to-one with the x-axis on Figure 7. If I add anything more to Figure 7, it will clutter it up.

But your comment is a very good one which gave me an idea to present the wind hodographs for each of the four one-hour time segments. From these, the directional wind shear (if present) is more obvious. These are now included in the paper. I did this for the 2-vs-8 km levels and the 2-vs-6 km levels (Figure 7, similarly for other segments). Which show very interesting shear, especially in the 1830-1930 period. Furthermore, I separated the hodographs into quadrants (NE, SE, SW, NW) relative to the approximate center (25.2N 73W) of the flight box on this date. This shows the sustained 2-8 km shear in the area SW of the area of interest, that flips sign by about 90-deg when compared to the 2-6 km shear.

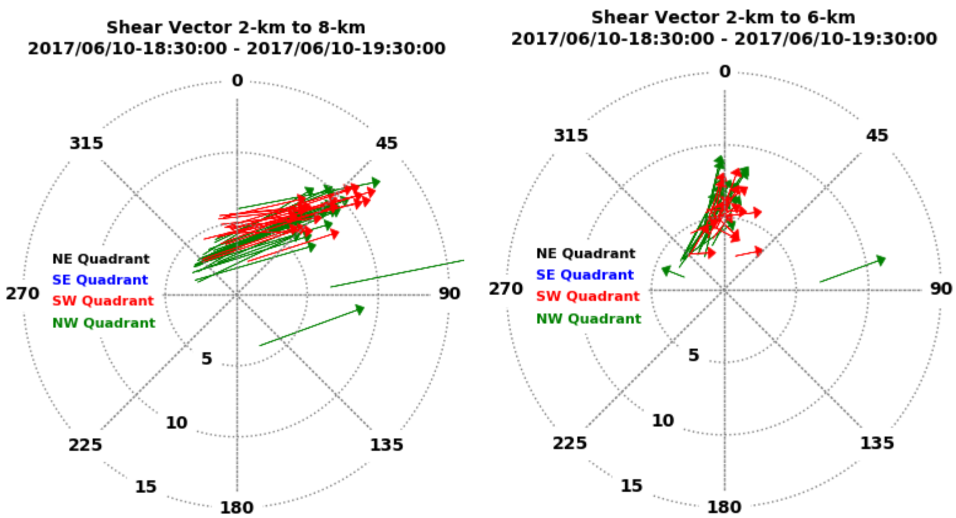
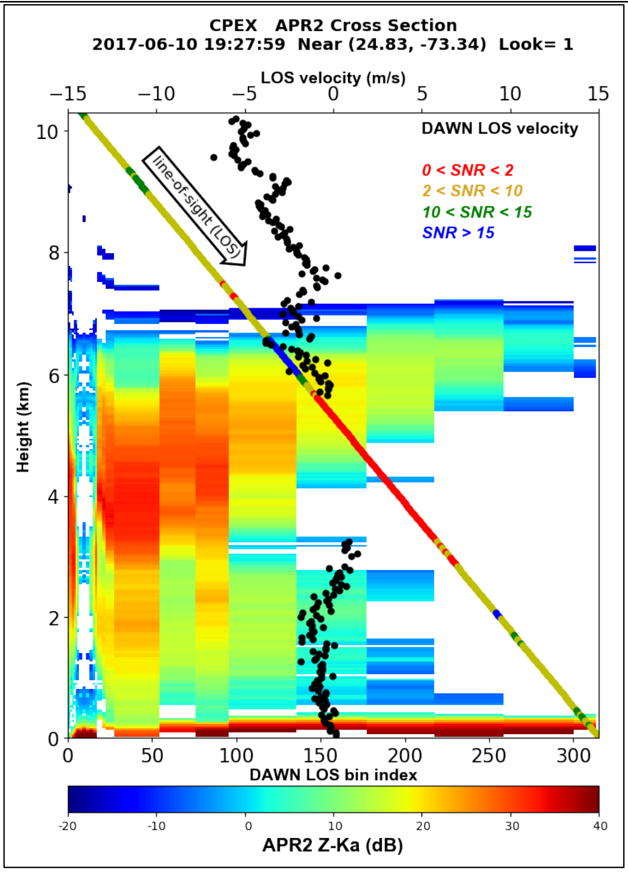


Fig.8: about the "continuous "impenetrable" cloud structures" comment obviously the lidar will see through the 3D structure, no question. I am a little bit skeptical about the profile at 192746 UTC; I cannot imagine that the lidar signals goes through the black dots as currently drawn; are we guessing here that there is basically no cloud liquid for that specific path and light will go through rain and ice? otherwise couldn't we argue that the path maybe a little bit different from the one currently drawn (you have pointing uncertainties to account for, haven't you?)?

The black dots in Figure 8 (in the revised paper) indicate the DAWN (u,v) *wind profile* vertical locations. The wind profile in turn is created by merging all five LOS beams, each with a different relative viewing direction. These are combined in an optimal way (the ASIA processing referred to in Section 2), and the resulting vertical profile is "placed" at the geographical centroid location from all five beams. Owing to the DAWN conically-located LOS locations, the "location" of the final profile is somewhat arbitrary, but if there are two beams each on either side of the DC-8 flight track, then this location will be somewhere along the aircraft subtrack, but not directly under the DC-8. It represents an aggregation or combination of five different views from different angles, so it really represents some sort of average wind from the air sampled collectively from all five beams. In other words, bin-by-bin comparisons with the APR-2 nadir reflectivity as in Figures 8 needs to take the instrument scan characteristics into account. We have added wording to this effect in the discussion of Figure 8 and the others similar to it.



As for the question on DAWN penetration through clouds. This is something that applies to each of the LOS beams. The radar and lidar systems scan and "stare" very differently. Each DAWN LOS profile is pointed off-nadir 30 degrees at different azimuth angles (Figure 1), where is "stares" over a longer integration time than the APR2 radar (APR2 collects 24 rays as it scans across track in about 1.2 seconds). So, indeed you are absolutely right that DAWN LOS and APR-2 beam matching has bin/beam matching uncertainties associated with it. We did not show this in the manuscript. When each DAWN LOS bin (about 30-m) is mapped to APR2, you end up with a very coarse interpolation. See the figure to the left, which I did not include in the manuscript. Here you can envision the DAWN LOS beam (LOS bin index 1 is the first bin below the DC-8 and bin 320 is the bin at the surface) like a pencil pointing through the APR-2 scanning "volume" covered by its cross-track swath as the DC-8 moves forward. Now imagine the APR-2 cross section along this LOS cross section. Notice how many APR-2 beams are "replicated" (no interpolation was done) owing to the different scan modes of the two instruments. In this case, this LOS beam penetrated an upper cloud portion between 7- and 4-km height, that was sufficiently optically thin enough that DAWN could penetrate it (SNR fell to below 2), but still had dynamic range to capture winds below it (SNR was near 10 near the surface). But, another of the other four LOS beams (of the five total) was unable to penetrate to the near-surface (example not shown). This would be reflected in the quality of the ASIA wind profile processing when it had only four LOS beams to work with. If there were even more cloudy conditions, even less LOS beams are available to retrieve the wind profile. Nonetheless, this picture gives an example of where (in the vertical) the cloud layers are, and how far DAWN could penetrate though the cloud before losing its signal for good.

Sect.4: I understand that the retrieval of wind must be done in the aircraft reference frame for the interpretation it is much better to go back to the usual system (E-W and N-S winds). Since the DC-8 heading is known this is a simple conversion. By so doing you will get rid of all the discussion about the heading and we will actually see the "real winds" (which are the relevant ones for the study of "dynamical processes"). Also the u,v notation is confusing since it is typically used for E-W and N-S winds.

Exactly right. For this example, we intentionally chose the June 11 case since the DC-8 flight bearings were (fortuitously) along E-W and N-S (or vice versa) directions, so this conversion was not necessary. We changed the notation as suggested in the text and Figure 20 (in the revised manuscript). But in general, yes, the aircraft cross-track winds are some mixture of u and v, so the DAWN winds could be transformed (rotated at each level) into the aircraft frame of reference. We think that this June 11 case made the DAWN-APR2 cross-track wind comparison easier to understand.