Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-315-AC2, 2017

Atmospheric Measurement Techniques Discussions
Open Access
EGU

Interactive comment on "Optimizing observations of drizzle onset with millimeter-wavelength radars" *by* Claudia Acquistapace et al.

Claudia Acquistapace et al.

cacquist@meteo.uni-koeln.de

Received and published: 31 January 2017

The authors would like to thank the anonymous reviewer for his/her precious comments. The following text contains the replies to each of them. The text of every comment is reported with below the specific answer. In the supplement, a pdf file containing the edited version of the paper has been provided. In it, all the words, sentences and parts of text which have been removed appear crossed out with a single line and in red. The new words, corrections and new sentences are underlined with a squiggle and colored blue.

Specific comments:

1. Page 5, line 18: It would be good to expand a little bit the description of the interpretation of skewness as this is not as simple: 0 skewness does not necessarily means

Printer-friendly version

Discussion paper

that a spectrum is Gaussian, nor that it is symmetric (since two different tails on each side can still compensate for each other).

Thank you for this comment. Our description was influenced by the large amount of nearly Gaussian Doppler spectra observed in non-drizzling conditions and hence, too case specific. We modified the text and follow the more common description as in Maahn et al, 2015: “Skewness S_k (dimensionless) provides the degree of asymmetry of a distribution and when applied to a Doppler spectrum, it describes its degree of asymmetry, namely the degree of inclination of the peak of the spectrum that represents situations in which the peak is tilted to the left or to the right. Its value is determined by the entire Doppler spectrum and it can also be affected by asymmetries in the tails of the shape. A Gaussian peak has a skewness of zero, but it should be noted that in principal also an asymmetric spectrum can have zero skewness if the two parts of the spectrum compensate each other. However, in reality this case is very rarely observed. Most of the times in drizzling/non-drizzling applications, it detects deviations from the symmetric, mostly Gaussian shape observed in non-drizzling Doppler spectra.”

2. Page 6, line 4: This is also interesting to see how the apparent thickness of the cloud seems to decrease with shorter time integration. In this regard, decreasing the integration time from 2 to 0.4 seconds seems to have a big effect. Please comment.

Thank you for carefully observing the plots and highlighting this subtle feature. We added the following comment in the text: “A decrease of the cloud thickness is mostly observed when integration time is changed from 2 s to 0.4 s. The sensitivity of the radar becomes smaller when shorter integration times are used and this has a strong impact on the cloud edge detection. The lowest cloudy range gate identified in the 2 and 10s integration time at 270 m is almost completely missed when the 0.4 seconds integration time is used.”

3. Section 3.1: this whole section is a bit messy and difficult to read (some examples

follow). It would be good to rephrase and reorder, and/or add some subsections. 3.1. Page 7, line 21: “Larger” at the beginning of the paragraph looks a bit odd. Instead, I would either not change paragraph, or start the new paragraph from line 15. On the other hand, the sentence starting with “Moreover” (line 30), is very different from what was previously discussed. This looks like a good place to start a new paragraph.

Thanks for your suggestions to improve this complex section. The text has been modified accordingly in the pdf attached.

3.2. Page 7, line 10: you explain that integration time has a larger impact on higher moments at cloud base because of wider DSD. Few lines further (line 23), you have now another explanation for Doppler velocity and spectrum width which is the “more variable vertical motions”.

Corrected. Thanks for noticing. Explanations are now provided in a more compact way. Please compare in the new pdf.

3.3 Page 8, line 23 to 29: First, you say that you will focus the analysis on integration time, second you discuss the effect of SNR, third you say that you will focus the analysis on the drizzle case and then you discuss again the effect of SNR. All these sentences seem to be just juxtaposed and it is really difficult to follow the reasoning. Please try to rephrase in order to make the reading easier.

Corrected. Rephrasing highlighted in the pdf file.

4. Page 8, line 1: Please make clear how you derive the skewness uncertainty (“derived from the skewness time series”). Do you simply calculate the standard deviation?

Yes, the uncertainty is simply calculated using the standard deviation of the time series. We added the information requested in the pdf file with the following sentence: “Assuming that skewness in these cases is close to zero, we derived the variability of skewness due to instrumental noise and dynamical effects. Standard deviations of the skewness time series in the non drizzling cloud using 2 s integration time and spectral resolutions of 256, 512 and 1024 range between 0.389 and 0.369 with a mean value over the three cases of 0.379. These values can provide a threshold to detect the drizzle onset microphysical signature from the noise caused by the fluctuations induced by the natural variability of the skewness in presence of cloud droplets only."

5. Page 10, line 20: The advantage of using simulations is that you know the truth. Why don't you show the distributions of the moments coming from the ideal Doppler spectra (without random noise and sampling effects)? On this note, it is actually not perfectly clear how you simulate the DeltaT effect: do you simulate the I/Q time series? More details are required.

Thanks for the comment which is giving us the chance to better explain the objective of the simulations in this study. We performed radar forward simulations to be able to reproduce and interpret the observed signal. The forward simulator does not directly simulate I/Q-time series but produces Doppler spectra based on the hydrometeor composition, dynamical and instrument specific effects (e.g. noise, beam width, sampling, etc.). The simulator is still very close to the real measurements because the simulations are very consistent with the radar processing except for the initial FFT to convert from I/Q-time series to individual, un-averaged spectra. The simulations reproduce the modifications which the pure microphysical signatures undergoes due to dynamics and instrumental noise. Random noise and sampling effects are included in the simulations for this reason and play a significant role in reproducing the observed signatures. We think that the discussion of ideal Doppler spectra would not add additional information in the interpretation of the measurements, because they cannot be obtained with real-world instruments. Regarding the DeltaT effect, the simulator works very similar to the radar: the final, averaged Doppler spectrum is generated by averaging an amount of spectra with different random perturbations corresponding to the desired averaging time. The following sentence regarding how DeltaT effect is obtained in the simulations has been added in the text: "The desired Delta T is obtained in the simulations by averaging the same amount of Doppler spectra as in the observations."

6. Few paragraphs starting on page 10 line 26: same as specific comment 3). For example, one page 10, line 34: You can easily simplify and make three sentences in a single one! For example: “As for the observations, the mean values of Sw increase with larger integration while the nfft has a negligible effect.

Corrected. Thanks for simplifying the text.

7. Page 11, line 11: This sentence is a bit clumsy. First, I don’t understand why it is separated from the previous paragraph, and after “Despite the missing negative Sk values in our simulations”, I would expect that you now describe some agreement with the observations. However, you are describing that the mean value of skewness distribution is changing with the integration time. This is a completely new behaviour that was not seen in the observations. Did you expect this? Why don’t we see it in the observations? Why do you need to focus on a region of coherent skewness in order to see it? More discussion is needed here.

Thanks for the comment. In the simulations, the mean value of the skewness is changing to smaller values for longer integration times. This is not the case in the observations, even if the occurrence of large values of skewness is reduced for longer integration times. In the observations, the natural variability of the skewness is so high that averaging does not help in detecting a variation of the mean value with integration time. In the simulations, the same drop size distribution is used all the time while averaging. This choice reduces the variability in the signal, showing that the mean value of the skewness is changing to smaller values for longer integration times. In fact, smoothing effects due to longer averages are expected to reduce the mean value of skewness for longer integration times in the simulations, as it is found. For longer DeltaT, more spectra are averaged together, and hence there is a high probability of averaging also spectra where the microphysical signal is hidden by noise. The resulting effect will be to reduce the total asymmetry and generate a more symmetrical spectra shape, with reduced skewness values. In order to reduce the impact of the natural variability of the skewness signal, we focus on a region of coherent skewness, selecting an area where the skewness signature appears to be induced by the microphysics only. The text in the manuscript has been modified on the basis of the text presented here.

8. Page 11, line 14: Honestly, I have real difficulties to convince myself that observations from Fig 11 confirm the behaviour of skewness in the simulation. Very few points are used to produce the pdfs of Fig 11, you need to be very cautious in your interpretations here. Can you really discuss the behaviour of the extreme when you have only 50 values in your sample (and even less for the 10 s integration time)? Even the mean value is only slightly showing the shift with time integration, with a range much smaller than in the simulations. Either you need more data, either you must be less affirmative in your conclusions.

It is true that due to the low amount of points the sentences must be less affirmative. Corrections have been implemented in this sense with the following text: " In order to reduce the impact of the natural variability of the skewness signal, we focus on a region of coherent skewness, selecting an area where the skewness signature appears to be induced by the microphysics only. If we focus the analysis to cloud regions with spatio-temporal coherent positive skewness structures as shown in Figure 11, the distributions of skewness values for the three different integration times and a spectral resolution of $nfft=256$ are shown in the upper panel of Fig. 11. Despite the reduced amount of observations contained in the selected region, a comparison with Fig. 10 seems to indicate that the range of observed skewness values now better matches the simulations. In addition, the shifting of the peak towards positive skewness with decreasing averaging time as well as a corresponding increased occurrence of positive extremes in S_k closer resembles the simulations."

9. Page 11, description of Figure 12: The interpretation of Figure 12 (skewness behaviour as function of the LWC ratio and drizzle mean size) is not easy. You need to increase the number of points for rLWC<1. Why is there no data for rLWC=0? The skewness of a cloud Doppler spectrum should be 0, so I understand that all these lines are supposed to start from 0. Then, for large drizzle radius, it is difficult to understand

why the skewness is first increasing very quickly and then decreasing again. In order to help the reader, please add a figure with some sketches of the Doppler spectra at different stages of the drizzle formation (for different rLWC) and for a drizzle radius of e.g., 10, 30 and 60 micrometers.

Thanks for the interesting suggestion of adding an additional panel with the spectra shapes corresponding to different radii of 10, 30 and 60 microns and various LWC ratios. Also the point corresponding to LWC ratio equal to zero has been added to the plot. Modifications have been implemented and now Fig. 12 is split into a)skewness is shown as a function of LWC ratios for low turbulence, b)skewness is shown as a function of LWC ratios for high turbulence, c), d), e) the spectra shapes are shown for 10, 30 and 60 microns, respectively. The following brief additional explanation of the figure has been added in the text: "a) and b): Skewness of the convoluted spectrum of cloud and drizzle drop size distributions as a function of r_LWC for different drizzle effective radii and low EDR (a)) and high EDR (b)). Simulations have been performed using 0.6 (solid line) and 0.3 (dashed line) radar beam widths. The grey bar represents the uncertainty of the skewness observations. c), d) and e): Doppler spectra corresponding to the various r_LWC obtained using drizzle effective radii of 10 microns (c)), 20 microns (d)) and 30 microns (e)).". Also, the following more detailed description of the effects of turbulence and beam width has been added: "Figures 12a) and b) show the strong dampening impact of turbulence on skewness observations, which is not compensated by the choice of adopting smaller beam widths. In fact, a smaller beam width allows the detection of only slightly higher skewness values in both turbulence conditions, compared to the larger beam width. However, the gain due to the beam width appears more evident for effective radii around 20-30 microns, underlining the importance of this parameter for the accuracy of skewness estimation when low turbulence conditions are present."

10. Page 12, line 22: Decreasing the integration time will both avoid the turbulence-induce increase of Sw and preserve large values of Sk. I don't see any compromise

Printer-friendly version

Discussion paper

here. On the other hand, there is certainly a compromise with the required sensitivity.

Corrected, thanks.

11. Figure 3 and 4: The white periods in the main time-height plots are not satisfying: it looks like you are zooming in during a period where there is no data. I understand that they correspond to the special radar operation aimed at recording the I/Q data, and that the standard output datafiles are not available for this period. But, it should be easy to process the corresponding I/Q data using the standard settings and fill in the hole in the main figures. Seeing the evolution of the cloud over the whole one-hour period would help in understanding how representative your I/Q sampling periods are.

This was also the original intention of the authors. We completely agree on the reviewer's opinion. Unfortunately, I/Q data have been collected in a discontinuous way during the time interval that appear white in the main time height plot. For this reason, each 1 min time serie cannot be made adjacent to the others, and gaps are in any case present. Therefore, we chose not to plot the 4 chunks of 1 minute IQ data in order to make it easier for the reader to understand the time period in which the observations are collected.

12. Figure 6: Since the same figure for the non-drizzle case is only shown in the supplementary material and that you are mainly describing the drizzle case, it would ease the comparison between the two cases (lines 30-32 on page 8) if you add a line on each subplot showing the non-drizzle pdf for, e.g., the 0.4 s integration time.

Very good suggestion, the plot has been added and a description in the caption has been provided: "The black dashed line represents the corresponding distribution obtained in the non drizzle case (20 November 2014) using 0.4 s averaging time (see Fig. S3 in the supplementary material)"

Technical corrections:

1. Page 2, line 27: The use of semi-colon for citation in the middle of the sentence is

inadequate. Better separate them by using “and”.

corrected

2. Page 2, line 30: “the“ appears twice.

corrected

3. Page 3, line 16 and 25: You probably want to refer to Kollias 2007b (instead of Kollias 2007a). In any case, I can’t find the discussion of nfft = 512 for ARM radars, in any of these papers. By the way, the title of Kollias 2007a is not complete.

Thanks a lot for noticing the problem. In both cases, the paper we wanted to refer to is another publication, different from Kollias et al, 2007a. The paper is Kollias et al, 2005: “The Atmospheric Radiation Measurement Program Cloud Profiling Radars: An Evaluation of Signal Processing and Sampling Strategies” and it was not included in the bibliography by mistake. Thanks a lot for the comment, the title of Kollias et al, 2007a was corrected.

4. Page 5, line 22: “to the right” does not sound very rigorous: you may better use “asymmetry towards positive velocities (e.g., to the right of the main peak in Fig. 2)”.

corrected

5. Page 6, line 32: Please correct the reference to “Kollias et al. (2014)”.

corrected

6. Page 9, line 15-to the next page: “was”, “helped”, “allowed” For clarity, I would stick to the present form.

Corrected in the whole paragraph.

7. Page 10, line 14: Either the convoluted spectrum is dominated by the cloud peak, either the contribution of the drizzle is larger than the cloud peak.

corrected

8. Page 10, line 20: For clarity, please move “into account” forward just after “take”.

corrected

9. Page 11, line 2: “address” does not seem to be right verb. “Explain” would be more sensible.

Corrected

10. Page 13, line 13: The verb is missing.

Corrected

11. Table 2: Instead of referring to Table 2 in the caption of Figure 1, it would be more readable to refer to both in the text.

corrected

12. Table 3: There is no reference to this table in the text.

Corrected

13. Comment for most of the figures: A lot of Figure labels appear blurred on screen while perfectly neat when printing.

Thanks a lot for the comment, even if it is very hard to understand which figure labels appear blurred because to all our screens all of them appear perfectly visible and readable. If the problem persists, please provide details of which figures.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/amt-2016-315/amt-2016-315-AC2-supplement.pdf

---

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-315, 2016.