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Atmospheric Measurement Techniques Discussions

Interactive comment on "4-D-VAR assimilation of disdrometer data and radar spectral reflectivities for rain drop size distribution and vertical wind retrievals" *by* F. Mercier et al.

Anonymous Referee #2

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This paper describes how 4-D-VAR assimilation can be used to estimate the raindrop size distribution and vertical air motion in the vertical column by combining surface disdrometer and 24-GHz vertically pointing radar Doppler velocity spectra data. I find this technique to be very interesting and would like to incorporate this technique into other radar retrievals.

This paper is well written and demonstrates how 4D-VAR assimilation can contribute to studying rain microphysics deduced through radar observations. After addressing a couple minor points (comments #1 through #9) and a clarification on the influence of turbulence on the assimilation procedure (comment #10), I think this paper would be a

good contribution to the journal of Atmospheric Measurement Techniques.

Specific Comments (in page order)

1. Page 12393, line 18. I'm a little confused with this sentence. Is the "last term" referring to the background term "J_b" or to "J_o" (which is the last term of equation (7))? Please clarify in the text.

2. Page 12393, line 19, equations (7) and (8). Please be explicit in the text and mention that "J_b" is dropped, or eliminated, from the cost function.

3. Page 12393, equation (8). Is the cost function evaluated for all time steps and height steps of the storm? If yes, can the manuscript clarify, or emphasize, that the cost function is evaluated for all time-height observations and not for individual radar range gates?

4. Page 12400, line 8. Please clarify in the manuscript the significance of 4900 time intervals. Specifically, are there 4900 10-second time steps, or 4900 2-minute time steps?

5. Page 12401, line 22. For the simulations, the top DSD parameters are set using the surface disdrometer observations. Thus, for the simulation, the column is bounded on the top and bottom by similar DSD parameters. For the assimilation of the real observations, are the top DSD parameters initially set using the surface disdrometer observations so that the column is bounded with similar DSD parameters? Please address in the manuscript the initial conditions of the top DSD parameters.

6. Page 12402, line 26. Understanding the influences of the convolution is very important for DSD estimation. Since the forward operator in the assimilation algorithm does not include a convolution broadening term, the assimilated DSDs will be broader than the true DSDs to account for the missing broadening effects. This is discussed in work earlier than Tridon et al 2013, in particular, include the work of Williams (2002, Radio Science, 10.1029/2000RS002603) and Gossard 1994, J. Atmos. Oceanic Technol.,

712-726) in the discussion.

7. Page 12403, equation (17) and line 5. The assimilation procedure is using the convolution in the forward model to broaden the Doppler spectra which was also used in Williams and Gage (2009, Ann. Geophys, 555-567) for DSD retrievals using vertically pointing radars.

8. Page 12405, line 16. Obtaining the result that turbulent broadening only impacts the spectral width and not the reflectivity-weighted mean downward velocity in the simulations confirms the robustness of the assimilation procedure and are expected results from prior work (Williams (2002, Radio Science) and Williams and Gage (2009, Ann. Geophys.).

9. Page 12405, line 27. I'm confused by the term "second solution". This term appears to be out-of-place and not used in other sections of the manuscript. Please clarify or correct this section of text.

10. Page 12406, lines 1-17. I don't understand how the fluctuations at the 5 s resolution (line 9) which lead to broader Doppler velocity spectra at the 2 min resolution are a result of turbulence and not a result of broader DSDs. The assimilation procedure does not include a convolution to produce Doppler velocity spectra at the 5 s resolution which would then, in a real radar system, be accumulated over a 2 minute window to produce broadened Doppler velocity spectra. From my reading of the assimilation procedure, air motion and 3-parameters of the DSD are estimated at each time-height grid box (from page 12392, lines 14-15) and are accumulated (or averaged) over the 2 minute window. Since the assimilation procedure remains in the DSD parameter domain over the 2 minute window, any increase in Doppler velocity spectrum (in the radar domain) is due to a spread of the DSD parameters. If the Doppler velocity spectra were estimated at each 5 s interval and the Doppler velocity spectra were estimated and accumulated (and averaged) over the 2 minute window, then an increased Doppler velocity spread would be due to the time-evolution of Doppler velocity spectra over the

2 minute window. As written, the conclusion that the turbulence is reproduced and the DSD is not modified needs to be clarified (see page 12406, lines 15-17 for the text that needs to be clarified). This conclusion may be true, but the logic leading to this conclusion is weak and should be addressed before publishing.

The following three pieces of text are also impacted by the 5 s to 2 minute window effects:

a. Page 12407, lines 22-24. The sentence starting with "We have seen that a 2 min . . ." needs to be consistent with the modified text.

b. Page 12408, lines 3-7. This text describes nicely how the 3 DSD parameters are adjusted to account for observed broadened Doppler velocity spectra.

c. Page 12413, lines 18-20. This concluding text needs to be modified.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 12383, 2015.