

Review of “4D-VAR assimilation of disdrometer ...” by Mercier et al.

The paper introduces a 4D-VAR assimilation technique that ingests disdrometer data at ground and vertical profiles of Doppler radar spectra to retrieve the DSD parameters and vertical air velocity. The framework presented in this paper is very promising and should allow for great progress in our understanding of rain microphysical processes. In its present form, the propagation model developed only allows for retrievals in light stratiform events. The major weakness of the paper is that there is essentially no validation of the results obtained with the technique. But there is not much the authors can do about that. The English is also not great and needs to be improved. Overall, given the great promise offered by such technique, I recommend publication provided that the following comments are addressed.

Major comment

The abstract and introduction need to be improved to clearly state that the objective of this paper is really to present a new and promising framework to better characterize rainfall microphysical processes. It is important to clearly state that the current model is quite simplistic and does not include all important microphysical processes. Even in stratiform precipitation, there is horizontal advection, evaporation and coalescence / breakup. Section 2, where the authors try to justify that they can neglect such processes, is not convincing. They should rather explicitly say they are working with a simplified model as a first step, and then discuss how this model will be improved in the future, by either introducing parameterizations of those processes or more observations to constrain them. For instance there can be a lot of horizontal wind and vertical shear of horizontal wind in stratiform precipitation. Evaporation will be controlled by the low-level ambient humidity, which is not always high; therefore evaporation in most cases cannot be neglected. Even the carefully chosen example, the vertical structure of the reflectivity field indicates that some neglected processes are actually active. It is also very important to state that you don't have independent data to validate the outputs, and that you will only discuss how realistic the outputs seem to be, leaving more validation work for other papers.

Technical comments

Overall, the English is too casual and really needs to be improved. I assume the paper will be edited later, but below I provide some suggestions (not exhaustive, by far).

- P. 12384, line 2: “(DSD) and vertical wind **profiles** ...”
- P. 12384, lines 9-10: about “ ... in which these phenomena appear negligible”. I don't think this statement is true and should be reworded. You don't really have to say such things if you change the pitch of the abstract and introduction as suggested in the major comment.
- P. 12384, lines 18-19: suggest “the algorithm is able to reproduce the observations and retrieve realistic DSD and vertical wind profiles, when compared to what ...”
- P. 12386, line 2: “either” instead of “whether”
- P. 12387, line 15: “describe” instead of “explicit”
- P. 12390, line 5: “interested in” instead of “interested by” and line 15: “the **simplified** PDE modelling ...”

- P. 12392, line 1: replace “is often supposed to be gamma” with “is well approximated by a gamma distribution (and provide references)”, also lines 22-23: “vertical wind **profile**”, “variational” instead of “variational”, and I would remove “coarsely”.
- P. 12394, line 13: replace “which are able to explain the observations” with “which minimize the cost function”. Also line 20, weird statement: “provide an admissible answer”, what do you mean ? Penalization terms are generally used to smooth out the solution, avoid multi-minima, help convergence, filter noise etc ...
- P. 12395, line 6: “radar **returned power as a function of the Doppler velocity, the so-called Doppler spectrum** (Giangrande ...”
- P. 12398, line 18: “manufacturer” instead of “maker”
- P. 12399, line 1-2: suggest replacing with “apply a minimum diameter threshold of 0.4 mm)”. We have no idea why you choose such a threshold, so you also need to explain why. Also line 14, suggest replacing “regular” with “sustained”. Also line 27, I don’t understand what the “fall height of the drops is”. You show on that plot that drops fall from a higher height than that (melting layer is much higher). Do you actually mean “top of the retrieval domain” here?
- P. 12400, lines 2-3, winds are “light” not “low”. The sentence needs to be revised. Also line 7: “for” instead of “fo”
- P. 12402, line 8: replace with “to get winds within +- 2ms-1”
- P. 12406, line 20: replace “control” with “assess” ?
- P. 12407, line 20: “subsection” instead of “paragraph”
- P. 12408, lines 1-2: sentence needs to be revised, “does less good” does not mean anything (performs less accurately, or produces less accurate results).
- P. 12409, lines 13-14, and throughout the document: you need to be careful with the word “significant” because you have no way to test the statistical significance of your results. Use “little” in this case, and please check other locations.
- P. 12410, line 9, add “assumed negligible in our propagation model” after the word “phenomena” and replace “phenomena” with “processes”. Also line 10-11, this sentence is extremely vague and is not based on an actual result proving it. You need to avoid such speculative statements. Also line 20: what do you mean by “followed” ? “well reproduced” ?
- P. 12411, line 25: “on average”
- P. 12413, line 17: “we showed that **the proposed technique** is able to ...”
- P. 12414, line 7: “For this purpose, we **plan to use dual-frequency** wind profilers ...”