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Comment on amt-2021-299

Toshi Matsui (Referee)

Referee comment on "Evaluation of convective cloud microphysics in numerical weather prediction models with dual-wavelength polarimetric radar observations: methods and examples" by Gregor Köcher et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-299-RC1, 2021

Title: Evaluation of convective cloud microphysics in numerical weather prediction model with dual-wavelength polarimetric radar observations: methods and examples

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Summary

This study examines a series of regional storm-resolving weather forecasting with different microphysics schemes against long-term observations of dual-wavelength polarimetric radars over Munchen area. Although there are many papers inter-compare microphysics schemes available in WRF, the noble aspect of this study is to utilize polarimetric radar simulator and cell-tracking algorithm for more consistent sampling of polarimetric radar observables and dual-wavelength ratio. However, there are some major questions/suggestions related to 1) missing citations, 2) separation of convective cells, and 3) actual rain drop-size distributions, and 4) uncertainties of the forward model. By improving these issues, this manuscript could be quite powerful. Thus, my suggestion is "major revisions" in order to publish in ACP.

Major Comments/Suggestions

1) Missing citations

This study cites several microphysics evaluation papers, but it completely misses previous studies directly using forward polarimetric radar models. Here are suggested references. Please take a look and relate yours to their findings and approaches.

Jung, Y., M. Xue, and G. Zhang, 2010: Simulations of Polarimetric Radar Signatures of a Supercell Storm Using a Two-Moment Bulk Microphysics Scheme. *J. Appl. Meteor. Climatol.,* **49**, 146–163, https://doi.org/10.1175/2009JAMC2178.1

Snyder, J.C., H.B. Bluestein, D.T. Dawson II, and Y. Jung, 2017a: Simulations of Polarimetric, X-Band Radar Signatures in Supercells. Part I: Description of Experiment and Simulated ρhv Rings. *J. Appl. Meteor. Climatol.,* **56**, 1977–1999, https://doi.org/10.1175/JAMC-D-16-0138.1

Ryzhkov, A., M. Pinsky, A. Pokrovsky, and A. Khain, 2011: Polarimetric Radar Observation Operator for a Cloud Model with Spectral Microphysics. J. Appl. Meteor. Climatol., 50, 873–894. doi: http://dx.doi.org/10.1175/2010JAMC2363.1

Putnam, B.J., M. Xue, Y. Jung, G. Zhang, and F. Kong, 2017: Simulation of Polarimetric Radar Variables from 2013 CAPS Spring Experiment Storm-Scale Ensemble Forecasts and Evaluation of Microphysics Schemes. Mon. Wea. Rev., 145, 49–73, https://doi.org/10.1175/MWR-D-15-0415.1

Also a following citation is recommended for microphysics finger print from polarimetric radar signals. This Ph.D. dissertation describes various microphysics finger prints related to cloud microphysics processes.

Kumjian, M.R., 2012: The impact of precipitation physical processes on the polarimetric radar variables. PhD. Dissertation, University of Oklahoma, 327 pp.

2) separation of convective cells

One of the advantages of this paper is the large sampling volume, but it simultaneously induces ambiguity for analysis. During a long-term period, there must be various sizes of convections from shallow, congestus, and deep convective/stratiform cells. When you bundle all into a single CFAD, it tends to smear out important aspects of microphysics. Please check the following papers on how it separates cloud type and better evaluates different aspects of microphysics from long-term simulations/observations.

Matsui, T., X. Zeng, W.-K. Tao, H. Masunaga, W. Olson, and S. Lang (2009), Evaluation of long-term cloud-resolving model simulations using satellite radiance observations and multifrequency satellite simulators. *Journal of Atmospheric and Oceanic Technology,* 26, 1261-1274.

You can use echo-top height from each cell-tracked target for separation. But if this type of separation is too difficult to implement (or too much effort), please just discuss and try it in the future.

3) rain drop-size distributions

Probably the most robust finding in this study is the variability of rain-DSD related radar signals (ZDR and DWR) among different microphysics schemes as seen in Figures 5, 6, and 7. Above-melting-zone evaluations tend to have more uncertainties in the forward model (described in next). To augment your finding in radar signals and discussion, it's much better to directly examine simulated rain drop size distribution profiles (like CFAD format) from different microphysics schemes. This should not be a difficult task. (it's much better if you have disdrometer observations!)

4) uncertainties of forward model

Details and uncertainties in assumptions of the forward model (CR-SIM) are not discussed. In order to represent simulated microphysics in polarimetric observables, one must assume particle shape and orientation simultaneously in the forward model, because these are not "explicitly" simulated in most of the microphysics schemes in WRF. Following paper discusses and tests different assumptions. Please describe what kind of shape/orientation assumptions are made for each microphysics in Section 2.4 (or Appendix), and related discussions in Section 3.3.

Matsui, T., Dolan, B., Rutledge, S. A., Tao, W.â□□K., Iguchi, T., Barnum, J., & Lang, S. E. (2019). POLARRIS: A POLArimetric Radar Retrieval and Instrument Simulator. *Journal of Geophysical Research: Atmospheres*, 124. https://doi.org/10.1029/2018JD028317

Minor Comments/Suggestions

Line 25: "the huge number" -> "a large number"

Line 26: "on scales of μm to mm and" -> "on scales of mm or smaller" for consistency. In fact, microphysics processes occur less than the scale of micron, such as ice crystallization processes.

Lin 82: "with a sound statistical basis" ?? I don't understand.

Line 89: "separate the microphysical impacts from possible feedbacks." I agree. But more bottom line, I would argue whether your set of numerical weather model resolved dynamics or not with 2km horizontal grid spacinig.

Line 108: "frequency" -> "frequencies"

Line 149 and repeat the same: "a horizontal resolution of 10 km," must be replaced by "horizontal grid spacing of 10km". Numerical atmospheric model does not have 10km resolution with 10km of horizontal grid spacing. Effective dynamic resolutions are x5 ~ x10 of horizontal grid spacing in numerical dynamic core. Apply this correction elsewhere in the manuscript.

Pielke, R. A. (1991). A Recommended Specific Definition of “Resolution”, Bulletin of the American Meteorological Society, 72(12), 1914-1914. Retrieved Oct 30, 2021, from https://journals.ametsoc.org/view/journals/bams/72/12/1520-0477-72_12_1914.xml

Line 159: Please briefly describe other physics options, such as land surface, PBL, and radiation schemes.

Line 203: Did you store and use all 33bin of hydrometeor classes to calculate radar observables in CR-SIM?

Line 286: “but none of them as pronounced as in the observations.” Well, this is typical situations that relatively coarse-resolution model won’t be able to resolve tiny cells. So you are running with 2km horizontal grid, meaning that you can resolve convective features in 10km or 20km well, but never be able to resolve 2km-size of convection, which tend to have shallower echo-top heights. So, don’t blame to microphysics, but model dynamic core and grid spacing you chose.

Line 313: “Contoured frequency by altitude distributions” -> “Contoured frequency of altitude diagram”

Line 322: “image 5” -> “Figure 5”?