Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC1
https://doi.org/10.5194/amt-2021-50-RC1, 2021

Comment on amt-2021-50

Anonymous Referee #1

Referee comment on "Physical characteristics of frozen hydrometeors inferred with parameter estimation" by Alan J. Geer, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-50-RC1, 2021

This study develops a physically consistent means of combining NWP model simulations with a simplified radiative transfer (RT) model to estimate both the micro- and macrophysical properties of frozen atmospheric particles with the ultimate goal of improving physical constraints in operational forecasts of clouds and precipitation. I have felt for some time that such an approach would be useful in data assimilation where these physical parameters would be part of the state vector solution. However, the author has done a good job of highlighting and explaining some of the significant challenges of using parameter estimation within a DA system.

One of my main concerns with using coarse-resolution model simulations and simplified RT models is that the parameter estimation will simply reflect the NWP model biases (such as caused by sub-grid-scale parameterizations) and uncertainties in the RT model. In addition, the parameters will require continual updating based on changes to the model parameterizations and complexity of the RT model. However, the author has fully addressed these concerns in section 6.

An important conclusion of this study is the importance of utilizing a wide range of microwave frequencies to constrain the strong frequency dependence of single-scattering properties, which are sensitive to the particle size distribution, mass-size relationship, and particle density and shape. However, the author makes clear that "the particle habit itself is not being precisely identified, but rather the full 'hydrometeor model' which is controlled by the choice of particle habit in the current framework but includes also an assumed mass-size relation." This is an important clarification because there is often a misconception that particle habit is solely responsible for reducing biases in forward RT calculations at high microwave frequencies when compared to observations.

Finally, this study not only discusses the limitations of the method but also offers a way for improvement and describes how it builds on earlier work.

My only complaint is that the paper is rather long. The concern is that readers may be less inclined to read the paper in its entirety and may overlook some of the nuances and important results of the study.

In summary, the author has done an excellent job of articulating a complex problem in simple, understandable terms and in demonstrating the general applicability of the method to other NWP models and RT models.

Minor points:

Line 53: Typo: "There is also a need …"

Line 230-231: Actually, the South Dakota School of Mines and Technology T-28 storm-penetrating aircraft has, for decades, flown through convective cores to take in situ measurements of hail and graupel (e.g., Detwiler et al., 2012, Bull. American Meteorol. Soc.; Field et al., 2019, J. Appl. Meteorol. Climatol., 58, 231-245).

Line 309: "approx." should be spelled out.

Line 377: Typo: "shape of the cost function is very different"

Line 582: Typo: "If they had done that …"

Line 624: Typo: "it is important to …"

Line 635: Typo: "a little bit like …"

Line 723: Typo: "in the future …"