Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
https://doi.org/10.5194/amt-2021-50-RC2, 2021

Comment on amt-2021-50

Anonymous Referee #2

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-RC2, 2021

Review for AMT of "Physical characteristics of frozen hydrometeors inferred with parameter estimation" by Alan Geer.

Paper Summary:

Our understanding of ice clouds and ice particle characteristics globally, and especially in deep convection, is sorely lacking. The author aims to address aspects of this problem via perturbation of six parameters relevant to frozen hydrometeors in the ECMWF assimilation system, with the goal of simultaneously adjusting parameters in such a way that simulated microwave radiances agree with observed microwave radiances from F17 SSMIS (for 13 channels, extending from 19 – 183 GHz) over a 13 – 22 June 2019 test period. An output of this study is improved frozen hydrometeor assumptions to be used in version 13 of RTTOV-SCATT.

Major Issue(s) and Comments:

One major issue I had was the lack of discussion on mixed phase microphysical processes and presence of super-cooled liquid in the "frozen" tops of convective cores. A neglect of this implies that ice particle parameter settings will likely have unphysical settings or values due to scattering signatures in convective regions having to be matched by varying only ice parameter degrees of freedom. If variations in liquid (at the expense of ice) were allowed, simulated microwave Tb signatures would be substantially different since liquid would cause emission instead of scattering, thus impacting the choice of ice parameter settings (and potentially allowing graupel to occur much more frequently). We can comfortably neglect liquid at cold icy temperatures in the weak ascent regions of stratiform clouds, but since convective ice is a particular focus of this paper (which is certainly welcomed given the lack of convective ice papers), then at the least, some discussion of the role of liquid at cold temperatures in convection must be discussed.

Clearly some of the results for perturbing convective-ice related parameters signify a compensation for lack of liquid allowed in convection, and thus, parameter values decidedly returned are also likely not realistic due to this neglect. The number of studies documenting the prevalence of liquid down to minus 37.5 deg C in convection are numerous and increasing (e.g., in general, independent of aerosol effects or discussion: Kumjian et al. (2012; JAS); Dolan et al. (2013, JAMC); Xu and Zipser (2015, JGR); van Lier-Walqui et al. (2016, MWR); Fuchs et al. (2018, JGR), and within the context of aerosols: Rosenfeld and Woodley (2000; Nature); Fan et al. (2018; Science)). In short, importantly, liquid/graupel/hail is a microphysical phenomenon common in the cold tops of convection, further evidenced by the commonality of lighting in convection globally. I would not be terribly surprised if the lack of choices regarding choosing graupel/hail in this study (and others) relate to our underestimation of liquid in the upper reaches of convection. At the very least, this should be given distinct discussion within the context of the parameter settings determined.

Minor Issue(s) and Comments:

- Is noise in observed microwave radiances considered at any point?
- When it is said that mixing ratios are halved/doubled, does this mean for all altitudes equally, from above the melting level to cloud top?
- The 20K discrepancies in Fig. 4 are sort of glossed over mostly due to occurrence frequencies, but I suspect they are the convective regions (convection by frequency of occurrence is of course small relative to ice cloud in general, so this seems plausible). Would a map of the large discrepancies be correlated with deep convection patterns or no?
- Related to the issue of large fractions of liquid in convective cores, if something so simple as an effective cloud fraction (C) can be used as a parameter, could a simple factor that governs the amount of convective condensate partitioned into ice vs liquid (with the latter describe bed using a M-P DSD for simplicity) be incorporated quite easily as well? Or, even, couldn't the temperature for freezing in convection simply be modified to vary from 0 deg C to approx.. minus 37 deg C?
- Abstract, first sentence, Line 2: I recommend replacing 'models or satellite observations' with 'model grid boxes or satellite observation fields-of-view'.