Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-1045-RC1, 2020

Atmospheric Chemistry and Physics Discussions
Open Access

Interactive comment on "Microphysical Processes Producing High Ice Water Contents (HIWCs) in Tropical Convective Clouds during the HAIC-HIWC Field Campaign: Evaluation of Simulations Using Bulk Microphysical Schemes" *by* Yongjie Huang et al.

Anonymous Referee #3

Received and published: 8 December 2020

The authors propose a study where they compare the ability of 4 different parametrisations of clouds microphysics in WRF, to simulate an extreme weather event during the campaign HAIC-HIWC over Cayenne in May 2015. Attention is focused on the capacity of the 4 schemes to simulate the High Ice Water Content (HIWC) for IWC > 0.1g/m3 with their associated particle size distributions (PSD). Before the presentation of their study, the authors provide a short review of results from former studies on simulation of HIWC and analysis of the HAIC-HIWC dataset. Hence, they highlight

Printer-friendly version

Discussion paper

that median mass diameter (MMD) for IWC>1g.m3 increase with the temperature and decrease with increasing total water content (TWC); meaning that HIWC at high altitude are made with small ice crystals. Also, it was showed that X-band radar do not have sensitivity to detect HIWC, but it can be countered using polarimetric parameters such specific differential phase (Kdp) and differential radar reflectivity ratio (Zdr) instead of radar reflectivity factors (Z) only. More importantly, the secondary ice production (SIP) process must have greater contribution in HIWC, than ice nucleating particle to explain their high number concentration of ice particles. A new process of “freezing-drop-shattering” has been recently proposed by Korolev et al. 2020. Simulations with single and double moment microphysical schemes of extreme weather event, explored during HAIC-HIWC in Darwin, showed overestimation of Z in C-band. Also, it showed overestimation of MMD for TWC> 1g/m3. Another simulation of an event during HAIC-HIWC in Cayenne, failed to represent observed IWC and PSD, suggesting a lack of the representation of SIP processes. In the presented study, there is no new parametrisation of clouds microphysics tested. But, two parametrisations are tested for the first time to simulate HIWC, where the density of the ice is predicted for one or two ice species (called in the study P3-1ICE and P3-2ICE). The other microphysical scheme are a single moment with 6 species of hydrometeors (WSM6) and a double moment with 5 hydrometeors types (MORR). Quality of simulated HIWC and PSD is tested for each scheme, through the comparison with observed Brightness temperature (Tb) of the channel 4 of GOES-13, the observed radar reflectivity factors (Z) in the X-band and the observed PSD. The authors conclude a good prediction in average of temperature, dew point and winds fields, where prediction with MORR are closer to observations. The comparison of observed brightness temperature with the simulations shows better results with the scheme P3-2ICE. However, simulated Z with the four microphysical scheme are larger than the Z observed. The four microphysical schemes give bad representation of particle size distributions when compared with the observations. Usually, total concentration of ice crystals are underestimated except for P3-1ICE at -30°C and -45°C. In the prediction, mixed-phased at -10°C processes lead to an overestimation of LWC.

Major Comments: In this study, it is difficult to see the link between HIWC and their associated microphysical processes. Main of the figures and conclusion are built on figures that includes IWC>0.1g/m3, while the authors give the definition of HIWC such IWC>1g/m3. The comparison of size distribution is made for average PSD and for IWC > 0.1g/m3, which is a large spread. This study should at least separate the results with on one side figures and comment for 0.1g/m3<IWC<1g/m3 and in the other side for IWC>1g/m3. In the introduction, the authors bring the attention on what HIWC at high altitudes are made with small ice crystals (~300-400μm) and that X band are not suited for detection of HIWC. But in the present study, the authors still use the X-band radar to evaluate the distribution of IWC in their simulations, while a look in the former publication that dedicated studies on HAIC-HIWC dataset cited in the introduction, give the information that a cloud radar was on board with the microphysical probes. Knowing the size of ice crystals that made mainly HIWC and the strong relationship demonstrated between Z, IWC and T, cloud radar is more suited to evaluate the distribution of IWC. Comparison of Z in X-band only allows to study aggregates densities and their distribution, thus aggregation process and precipitation. As Z at these frequencies (~10GHz) are more sensitive to the concentrations of large hydrometeors and not the total water content itself (see Drigeard et al., 2015). Overall, the conclusions are mainly known, overestimation of Z in C/X-bands, overestimation of LWC and then too much riming (see cited publications in the introduction; C and X bands differs from their radar constant and attenuation, but their response with regards to the hydrometeors are similar) and mainly underestimation of total concentrations due to a lack of SIP processes in convective clouds. However, the fact that P3-1ICE and P3-2ICE can produce high concentration of ice crystals is interesting. What SIP these two schemes take into account? The authors mentioned in the introduction a companion paper more dedicated to the schemes P3. I suggest that the actual paper is withdrawn and will be re-submitted in the same time than its companion paper, including in their titles “part 1” and “part 2”.

Minor comments: Page 2, line 43-49: Does this IWC-Z-T relationship is in X or C band? How does it compares with the one of Protat et al., 2016 cited in line 35 of the same page? Same for the methodology from Nguyen et al. 2019, how does it compared with the one of Protat et al. 2016, mean bias, rms of both methods? Moreover, authors do not use X-band polarized parameters as it seems to be suggested by Nguyen et al. 2019 in order to study IWC, why? Page 5-6, Section 3.2: It would help to add a description of main microphysical process and the SIP that are taken into account by each schemes. It will helps later, to discuss why P3 schemes have such high concentrations at high altitudes (Figure 11b)? Page 6, section 3.3: As commented in the major comment, evaluation of only Z in X-band can only help to study aggregation and precipitation processes. W-band is more suited for the topic of this study. Page 7, lines 187-215: Is there a relation between cloud top temperature and the IR brightness temperature? Does it means that the 4 schemes have a good predictions of the height of the convective clouds? What are cloud top heights that the radar estimate with regards to the co-located Tb? Page 8, lines 216-253: Does the same range of IWC in observations and predictions give the same range of Z, for the same T. It may need to be completed with cloud radar observations and comparison? Page 9, section 4.2: from figure 11a, it seems that range of IWC are not exactly the same with similar distributions as function of microphysical schemes and observations. The radar comparison shows a large variability of Z and a distribution of Z different between observation and prediction. Does it make sense to compare PSD over all IWC? I suggest a comparison of PSD as function of IWC range? The overestimation of concentrations of large hydrometeors can explain the figure 7. The four scheme could predict similar density as in observation, but the fact that the prediction of concentration of large hydrometeors are larger than in the observations is enough to understand the overestimation of Z ? What is the impact of IWC in the overestimation of Z? Note that P3-1ICE at -30°C and -45°C predict similar concentrations, or more exactly share a similar range of concentration with observations for large hydrometeors and that predicted Z are closer with the one observed (figure 7) than the other predicted Z. Page 14, line 417: Is this a new results?

Page 16, equation A2 + Figure 11b: Does the total concentration presented in Figure 11 from WRF prediction are calculated with this equation too ? Th comparison would not be fair if it is.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-1045, 2020.