Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-314-RC2, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity of warm clouds to large particles in measured marine aerosol size distributions – a theoretical study" *by* Tom Dror et al.

Anonymous Referee #3

Received and published: 14 September 2020

The influence of aerosol size distribution and chemical composition on precipitation formation and intensity is still a challenging question to answer, due primarily to the sophisticated microphysical processes dealing with particles with a wide range of sizes, and also to the interplays between dynamics and microphysics. In this study, the authors choose to focus on addressing aerosol-precipitation response in a warm cloud, using a detailed bin microphysical framework for both aerosols and cloud droplets while a somewhat simplified dynamical framework (an axisymmetric model). In addition, they have also assumed a uniform chemical composition for the included aerosol population (sea salt) to limit the aerosol activation in a one-dimensional (size) parametric space. In order to address the targeted issue more realistically, they have also adopted

measured aerosol size distributions collected from locations with different atmospheric backgrounds.

An interesting finding of this study is the significant difference in aerosol-precipitation responses between a case with the so-called Atlantic-1 aerosol profile with ultra large CCNs and cases with other measured aerosol profiles without evident fraction of such giant CCNs. With a careful design of their modeling simulations, the authors have been able to define the criterion size of large aerosol particles that can create significant impacts on precipitation. Overall speaking, the paper has been relatively well organized, the research findings are well presented, and conclusions are drawn with solid science evidence.

A clear missing information in the manuscript is the cloud droplets concentrations, especially the vertical profiles of number concentration of cloud droplets and raindrops. The authors have discussed the correlation between sub-cloud evaporation and rainfall at surface. With a knowledge of sub-cloud raindrop population including total number and size distribution this would be much easier to understand. In addition, Fig. 2(d) presents a rather interesting feature in high concentration simulations using all the distributions except Atlantic 1 where collision-coalescence overwhelmed the condensation growth in a relatively early stage. However, without information of vertical distributions of cloud mass, the reader would have problem to understand (1) why the collision-coalescence increases with time but in a rather slow pace comparing to the case of Atlantic-1, and (2) the depths of layer where cloud mass grew in various cases. Note that large droplets (i.e., raindrops) can still be moved upward by updraft and both condensation and collision-coalescence can proceed in either updraft or downdraft (as far as the parcel remains saturated). Therefore, knowledge of the vertical growth tracks of precipitating particles is critical to understand how the two major growing processes evolved.

It is understood that the authors wanted to focus on the aerosol and cloud microphysical connections. Nevertheless, the feedback of dynamics, even in a rather simplified dynamical framework still plays a role in determining the growth of precipitating particles. The authors mentioned very briefly about cold downdraft and also analyzed sub-cloud evaporation. Perhaps a more in-depth analysis would provide a better understanding of the role of dynamical feedback in, e.g., leading to the results presented in Fig. 3 and 4.

Some minor comments.

Page 5, Figure 2(a) and (b): it would be helpful to provide the integration length of each simulation shown in these two figure panels in the figure caption.

Page 5, Ln 112: I understand the purpose of normalizing every distribution to match a given total concentration is for the convenience to identify the role of certain characteristics of size distribution such as shape in influencing the formation of precipitation. However, it is expected that the shift of the distributions to meet often much higher concentrations would increase the number of GCCN or even UGCCN. Could the authors provide such numbers even in the supplementary materials as a table or so? In addition, I don't remember this has been discussed in the manuscript, e.g., why the increase of GCCN still had no effect on the overall rain formation and growth for all cases including Atlantic-2 other than Atlantic-1.

Page 7, Ln 152: "bigger droplets resulted in a lower total droplets' surface area...", the sentence is somewhat ambiguous since such a result is not obvious, an explanation would be helpful here.

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