Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-596-AC1, 2020

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "The effects of cloud-aerosol-interaction complexity on simulations of presummer rainfall over southern China" *by* Kalli Furtado et al.

Kalli Furtado et al.

kalli.furtado@metoffice.gov.uk

Received and published: 7 February 2020

Author replies to anonymous Referee #3

2.) Specific comments:

1. P2-3. "illustrate the new work in this study compared to Miltenberger". Miltenberger studied relative non-extreme, small scale convective storms over a small area in the UK. There is a need to extend her analysis to a range of cases, particularly ones that can be considered truly 'extreme' in global terms. This is part of longer term effort to build-up information on the performance of bulk-microphysics scheme with two-way coupled cloud & aerosols. The aim is to create a body of evidence which will help the NWP community to assess the value of such schemes for weather forecasting, particularly heavy rainfall in complex aerosol environments (e.g., China). We've motivated this as follows on p4: "In terms of convective storms globally, Miltenberger et al considered relatively low-intensity, small-scale rainfall events. To improve understanding of the effects of aerosols on forecasts of extremes of rainfall, there is a need to test cloud-interacting models of bulk-cloud microphysics on heavier-rainfall cases. The monsoon regions present an ideal setting for doing this because of the frequent occurrence of globally significant rainfall extremes. In this paper, we apply the CASIM microphysics to a squall line over south China which, in contrast to previously studied cases, was close to 1000-km across, produced clouds over 15 km in depth, and sustained heavy rainfall rates for a period of several days."

2. P4. L42–44. Figs 2(a,b) : contours unclear. We've changed the figure from 2x2 to 2x3-panels, and put cloud/snow & ice and rain/ graupel on separate panels (each with its own color scale).

3. Cloud-droplets size plots have been added to Figure 3. In the text: "Aerosol also affects the size of the hydrometeors (Figs 3(j-l)), with the mean-size of cloud droplets becoming larger as the aerosol concentration is reduced. The rain-drop sizes (the grey contours in Figs (j-l)) show the opposite trend, with the cleaner simulations associated with smaller rain drops (see also Fig. 4)."

4. P6. L23–25. The auto-conversion parametrization in CASIM uses the "KK"-formulation (Khairoutdinov and Koga, 2000). The parametrization depends on number-concentration and cloud-water content (not on size explicitly). Now described in the Model description section (p5): "Conversion of cloud-droplets to rain is parametrized following Khairoutdinov and Kogan (2000). Other inter-species transfers of mass and number are handled as accretion processes with bulk-collection kernels determined by the fallspeeds and collision-cross sections of the sedimenting particles."

5. P6. L27–29. “please add the initial vertical profiles of aerosol”. This profile is not shown, because the initial aerosol concentrations are constant. Indeed, the depletion of aerosols near the melting level in 1s0dP is due to the mechanism that you mention (activation of droplets) .

6. The aerosol mass profile has been added to Fig.4 for the 1s0dP experiment. The panel labels have been corrected (note that two new panels have been added, in response to Review 4’s comments).

Previously, the cloud-droplet number profiles ended around 1e5 -/kg because of a mistake in the plotting! Thank you for highlighting this; it has now been corrected.

7. In the original text, the value of 1/8 is just an example value, to illustrate our points regarding dependence of rain rate on aerosol. However, it was a bit confusing, so we’ve removed this line.

8. P11. L18. “prove that lower droplet numbers is giving rise to smaller raindrops” (as opposed to a cold-rain mechanism). We’ve added rain-drop size information to the longitude-time plots (Fig.3) and vertical profile plots (Figs 4(a-d). You can see from these that rain-drop size is decreasing as the cloud-droplet number decreases. In the text (p10): “[Enhancement of warm-rain processes] also predicts the simulated tendencies for rain-drop size [shown in Figs 4(a-d)]: faster warm-rain process can lead to more numerous and smaller-sized rain drops.”

We agree with you that cold-rain effects cannot be ruled out; a remark about the possible effects of cold-rain processes (e.g., riming) on the reflectivity-factor histograms has been added on (p13); “Cold-rain processes could also influence th occurrence of small reflectivity values and rain rates. For example, changes in the rate-of-production of graupel particles of different sizes could influence the distribution of drop sizes after melting, and therefore contribute to the skewing of the reflectivity histograms towards smaller values of dBZ.”

9. Fig. 6b. “check the lower limit of surface rain rate . . . is 0.1 mm/h”. In fact, not using a lower limit of 0.1 in the model’s histograms is intentional: threshold-masking the values introduces a ‘normalization issue’ because there would be a different total number of points in each histogram, which makes it difficult to interpret the differences. Instead, we much prefer to show the ‘raw’ number of counts in each histogram bin, with the caveat that the numbers below 0.1 cannot be compared to the observations.

10. Good point! This is apparently a systematic/structural error in the simulated clouds. Added to the text(p14): “It is noteworthy that the most polluted experiment (5e8F) shows the best agreement with the observations for TOA-SW flux but has relatively poor performance for radar reflectivity and surface rainfall rate. This may be because larger cloud-droplet numbers suppress drizzle, which is beneficial for stratiform clouds, and increase ice-crystal number –which is beneficial for the SW reflected from cirrus anvils– but simultaneously increase heavy-rain production in the convective-core region.”

11./12. We now discuss these points further on p15–17. The main effect of two-way coupling is the novel ‘clean-core’ structure, as was already noted in the Conclusions. In terms of benefits for NWP: these are limited, based on the evaluations presented. We’ve added this as a conclusion as follows (p17): “However, despite the large changes in the microphysical structure of the squall line, e.g., the occurrence of a ‘clean-core’, the overall impact of coupling on model performance against the metrics considered is small, particularly when compared to the overall biases present in all the model configurations. Hence the usefulness of the additional complexity of two-way coupling for weather forecasting is still moot, and will benefit from analysis of further cases in future work.”

3.) Typing errors & citations:

Checked, and corrected (where found)

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-596,

2019.

C5