Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-1342-RC1, 2019

Atmospheric Chemistry and Physics Discussions

Interactive comment on "An emulator approach to stratocumulus susceptibility" *by* F. Glassmeier et al.

Anonymous Referee #1

Received and published: 19 February 2019

Review of "An emulator approach to stratocumulus susceptibility" by Glassmeier et al.

Overall Comment:

This work presents a strong foundation for modelling studies investigating the very complex nature of aerosol-cloud interactions. The methodology utilizes advanced computational tools that have been developed in recent years and applies them to this very challenging problem. The analysis corroborates the findings of existing literature demonstrating strong connections between cloud droplet number concentration and precipitation that are responsible for driving the liquid water path, cloud fraction and cloud radiative effect responses in aerosol-cloud interactions. The advantage of the emulator is evident in this context – it extends the analysis to a wider phase space than can be provided by sequential simulations alone. Overall, the paper is great, however,

Printer-friendly version

Discussion paper

I do have some concerns regarding the spatial and temporal scales of the training dataset simulations (described below) as it relates to the very important transitions between non-precipitating and precipitating clouds.

Minor Comments:

Pg3 L16: Spatial resolution: Is a 48 x 48 km domain big enough to simulate the largest scales of the boundary layer circulation? It is evident that this model can simulate a wide range of system-wide variables (e.g. cloud fraction) and (quite likely) mesoscale cloud types (e.g. closed vs open cells are probably being simulated here). The aspect ratios for mesoscale structures in stratocumulus can be quite large (e.g. 40:1; Wood and Hartmann, 2006) particularly for drizzling clouds. Drizzling stratocumulus require a larger LES domain in order to capture the interactions between precipitating clouds (Zhou et al. 2018, JAS). A concern, therefore, is if the emulator is constructed from poorly resolved mesoscale cloud interactions (for some of the simulations) then the inferred aerosol-cloud interaction responses will be distorted across the Latin-hypercube and the inferred responses for precipitating clouds that require a larger simulation domain would therefore bias the conclusions and interpretation of this study. Have the authors visualised the simulated cloud fields from these experiments? Adding a few representative images (possibly from each quadrant in figure 1) would be useful to the reader.

Pg 3 L16: Temporal resolution: Is 12 hours a long enough simulation period to observe transitions between non-precipitating and precipitating clouds? The reason I ask is because it is evident from the simulations shown in quadrant 1 of Figure 1 that very few of these simulations transition to a precipitating state? What is the reason for this? Could it be due to a short simulation period? Perhaps this point is mute because you have enough simulations to construct an emulator. Regardless, some justification for the chosen simulation period as it relates to this critical transition should be discussed in more detail.

Printer-friendly version

Discussion paper

Pg6 L1-15: Gaussian process emulation depends on stationary covariance functions and will perform poorly if the response surface has sharp local features, such as a discontinuity or a tall peak. I am wondering if this hypercube surface could be visualized from your analysis to both 1) convey how this rather esoteric concept works and 2) to boost confidence that Gaussian process emulation is a suitable assumption (as opposed to a non-stationary gaussian process emulation approach described here: Montagna and Tokdar, J. Uncertainty Quantification, 10.1137/141001512)

Figure 4: A recent paper (Rosenfeld et al. 2019, Science; 10.1126/science.aav0566) shows that increasing cloud droplet number concentrations increases both cloud top radiative cooling and precipitation suppression thereby causing cloud fraction to increase especially in larger thicker drizzling clouds. I would have therefore expected to see this effect in Figure 5b of your paper but the response appears somewhat flat. Why? Perhaps the differences between these papers are due to cloud diversity. For example, Rosenfeld sample a wide range of clouds between the equator and 40 South. I suspect that if the height of the inversion layer in this model is preventing the vertical development of deeper clouds (e.g. trade wind cumulus) and preventing transitions to precipitation this may be an explanation for why the relationship is dissimilar. This may also explain why the liquid water paths in this set of simulations is so much smaller than those observed from the satellite observations in Rosenfeld et al. 2019. Please discuss.

Other comments:

Pg1 L18: Warm shallow boundary layer clouds are also abundant and contribute substantially to the global aerosol indirect forcing-based estimate (e.g. Christensen et al. 2016, JGR; doi:10.1002/2016JD025245).

Pg4 L10: what is tau(500nm) >1? Is this the visible (at the 500 nm wavelength) optical depth? Please clarify.

Pg 6 L19: what does “completely random” mean?

Pg 7 L9 refers to Figure 4 but Figure 3 has not been discussed in the text yet (to this location).

Pg 7 L10: what is km () can you just spell it out?

Figure 4: “color-filled” circles; do you mean grey circles?

Pg 11 L1-3: CloudSat observations of the rainwater path contributions to total liquid water path have been shown to contribute significantly as the LWP becomes larger (Lebsock et al. 2011, JAMC, https://doi.org/10.1175/2010JAMC2494.1).

Figure 8 caption: Please include reference to where this equation was obtained.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-1342, 2019.