Responses to the reviewers

Impacts of combined microphysical and land-surface uncertainties on convective clouds and precipitation in different weather regimes

by C. Barthlott, A. Zarboo, T. Matsunobu, and C. Keil August 17, 2022

We thank both reviewers for reading the revised manuscript again. We have carefully considered all remaining comments and changed the manuscript accordingly. Please find below our responses in blue.

Reviewer 1

The authors have responded satisfactorily to most of my previous comments, except for major comments #2 and 4 (i.e., Why choose the shape parameter to represent microphysical uncertainties?). The way it was written in the text gives the reader the impression that the selection of microphysical parameters is arbitrary. My main point is whether the uncertainty associated with the shape factor is substantially significant compared to other microphysical uncertainties (in producing spreads). I suggest the authors at least provide a reference indicating that the uncertainty associated with the shape parameter for cloud drop size distribution is sufficiently representative.

We tried to justify the choice of the shape parameter in the introduction as the width of the CDSD is not well constrained by measurements and a wide range of values (between 0–14) based on cloud type and environmental conditions were reported. We also mentioned variables that are directly and indirectly affected by the shape parameter together with references to idealized (Igel and van den Heever, 2017) and realistic simulations (Barthlott et al., 2022). In these papers, the potentially large impact of the shape parameter on the simulation results is documented. E.g. Barthlott et al. (2022) found that the increase in the shape parameter can produce almost as large a variation in precipitation as a CCN increase from maritime to polluted conditions. Furthermore, in the widely used Thompson-Eidhammer cloud microphyics scheme, the shape parameter is one of the stochastically perturbed parameters. We included references to two recent papers and hope that our choice to simultaneously perturb the shape parameter together with CCN concentrations and soil moisture is sufficiently motivated now.

"Furthermore, the shape parameter is one of the stochastically perturbed parameters in the widely used Thompson-Eidhammer cloud microphyics scheme and recent model results indicate a suitability of this parameter for generating ensembles at the convective scale (Griffin et al., 2020; Thompson et al., 2021)."

An additional comment: The precipitation response to soil moisture may depend on whether the cloud formation location is energy-limited or moisture-limited for the particular cases. I suggest describing where the studied conditions (including the perturbed soil moistures) are placed on the Budyko-curve plot (i.e., do they stay mostly in one of the regimes or spread widely across them?). This will give the readers an indication of the applicability of the results for different regions. Also, it might help explain the nonlinearity exhibited in the precipitation response to soil moisture shown in various figures.

We agree with the reviewer that such an analyses might be helpful, but unfortunately the evapotranspiration was not part of the model output as we focussed more on microphysical process rates. Thus, we cannot generate a Budyko-curve plot for our cases. However, we already mentioned the mean relative water content at initial time for the runs with reference CCN concentration and shape parameter in section 3.1. As suggested by the reviewer, we now added the values of the runs with perturbed soil moisture as well. Instead of mentioning them in the text, we now added these values to Tab. 2 with the overview of the cases. We believe that the inclusion of the RWC to that table will help to characterize our cases with respect to soil moisture initialization. The table now reads:

Table 1: List of cases with convective adjustment time scale τ *and mean initial relative water content RWC for the three soil moisture scenarios*.

Synoptic-scale forcing	Date	τ (h)	*RWC (DRY/REF/WET) (%)*
weak	5 June 2016	5.22	*55/73/86*
weak	9 June 2018	4.65	*28/37/46*
strong	10 June 2019	0.17	*24/33/41*
strong	17 August 2020	1.09	*25/37/42*

Reviewer 2

I appreciate the authors' efforts to address reviewers' comments and questions. One minor thing to note is Author's response on pages 12–13, item 3. There is this recent paper besides Grant and van den Heever (2014) and Baur et al. (2022). Please find this: https://acp.copernicus.org/preprints/acp-2021-693/

Thank you for pointing that out, we added this reference to our manuscript. It now reads:

To our knowledge, only Grant and Heever (2014), *Park and van den Heever (2021)* and Baur et al. (2022) studied synergistic effects of aerosols and soil moisture so far. Grant and Heever (2014) conducted idealized cloud-resolving simulations of tropical sea breeze convection and found precipitation reductions by over 40% and 50% for the most extreme perturbations. *Park and van den Heever (2021) have performed two large idealized 130-member ensembles that represent different initial conditions typical of tropical sea breeze environments in which they simultaneously perturbed six atmospheric and four surface parameters. Comparisons of the clean and polluted ensembles demonstrated that aerosol direct effects reduce the incoming shortwave radiation, as well as the outgoing longwave radiation, within the polluted ensemble and that enhanced aerosol loading results in a weakening of the convection initiated along the sea breeze front.* The realistic convection-resolving simulations of Baur et al. (2022) ...