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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Relative impact of aerosol, soil moisture and orographyperturbations on deep convection" *by* Linda Schneider et al.

Anonymous Referee #1

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The study investigates the difference between short-term cloud-resolving weather forecast type simulations that have been perturbed in their specification of aerosols, soil moisture and the underlying orography. This is done for six different cases. While three of the cases cover weak synoptic forcing, the other three address strong synoptic forcing. The difference between the simulations is quantified in terms of the 24h domain-averaged precipitation sum, the evolution in time of the domain mean precipitation rate and the Structure Amplitude and Location (SAL) parameter. The authors find that differences between the simulations are larger for weak synoptic forcing, than for strong synoptic forcing. Moreover, the soil-moisture perturbations lead to the biggest differences between the simulations, with a positive soil-moisture precipitation feedback. Perturbations to the prescribed aerosol concentrations can have an equally large

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impact on the simulated precipitation field, but a reduction or increase of aerosols can either lead to an increase or decrease of precipitation, and vice versa. Changes to the orography showed the smallest impact on the resulting precipitation.

The study addresses interesting aspects and is well written. Yet, in parts it lacks precision about the exact aims and methods to address the open questions. Thus, in my view it needs major revisions before it can be published.

General comments:

1. The authors claim to investigate the contribution of soil moisture, aerosols and orography on the predictability of deep convection. Yet, they investigate the impact of these factors on 24-hour sums of precipitation. In order to address predictability, further analysis would be needed, as e.g. the RMSE between the simulations, the growth of the RMSE over time, and the saturation of the error. I suggest removing the term “predictability“ from the manuscript. Moreover, the term “ensemble spread” is used. Yet, the different experiments are introduced as “sensitivity studies”, but not as “ensemble perturbations”.

2. Page 4, sensitivity studies: The perturbations of soil moisture are applied to the relative water content w_so, irrespective of the soil type. Dependent on the soil type this results in a different perturbation. It would be better to first compute the soil-moisture index/soil moisture range/fraction of available water (theta-theta_wp)/(theta_fc-theta_wp), to then perturb this quantity, and to convert back to relative water content, as this would yield a fairer perturbation across soil types. Is the field capacity reached in the simulations with increased soil water content?

3. The smoothing of the orography not only modifies the static stability of the atmosphere, but also the moisture content by including/excluding parts of the moisture-laden lower troposphere. CIN/CAPE is one measure to predict the amount of convection that will occur. Another measure is the amount of moisture stored in the atmosphere that can be tapped by the convection. I suggest to include a plot showing the integrated pre-

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cipitable water before the onset of convection for the different sensitivity experiments. On page 11, lines 11-12 it is stated that the total precipitable water changes. I think it is important to show these plots and to interpret the results. Page 1, line 20: “but that precipitation amount depends ...” in my opinion it is not only the strength of the trigger mechanism, but also the amount of moisture available for precipitation formation.

4. Page 4, sensitivity studies: Please describe the generation of the random patterns in more detail.

5. Page 5, lines 5-7: “we therefore conclude that ...” in my opinion this is not a valid statement as apples are compared with pears. The perturbation that is applied in the simulations with the altered soil-water content is much larger than just shifting around the soil water, but not changing its magnitude.

6. Page 8, lines 23-24: “since the structure scales ...” what does this imply for the S values in the other sensitivity tests?

7. Paragraph 3.2: within this paragraph an attempt to validate the SAL metric is mixed with results on the different perturbation techniques. This makes it hard to read the paper. The manuscript would benefit if you split the text into an evaluation part and a results part.

8. Page 9-10, section Orography: In the text the development of the grid-scale (resolved) convection is discussed. Yet, a parameterization scheme for shallow convection is active. When is sub-grid scale convection initiated in the different experiments, and how much of the instability is being eroded by the shallow convection parameterization scheme?

9. How long are the simulations run for? Are there any spinup effects? Are the differences largest during the initial phase, or does the difference saturate, or even decrease, once the model has re-adjusted after the initial perturbation?

Specific comments:

- Page 2, line 11: I suggest to replace “uncertainties” by “states” or “conditions”, as no analysis of the underlying uncertainties is given.

- Page 3, line 1: replace “barrier” by “barriers”, or include “a” before “stable”

- Page 3, lines 14-22: to my knowledge there are two papers addressing the combined effect of soil-moisture perturbations and orography: Rihani et al. (2015), and Imamovic et al (2017).

- Page 4, line 1: replace “implies” by “includes”

- Page 4, line 13: replace “coefficients are active” by “diffusion is active”

- Page 4, line 24: replace “physical” by “physically”

- Page 7, line 12: replace “dependancy” by “dependency”

- Page 7, line 13: include “a” before “heterogeneous”

- SAL technique: I suggest to use bold, italic or calligraphic letters for A, L, or S in the text.

- Page 8, line 10: replace “as” by “than”

- Page 11, line 9: replace “as” by “than”

- Page 11, Aerosols section: what about the collection processes of the falling cold hydrometeors, e.g. self-collection of graupel and hail, collection of rain by graupel or hail?

- Page 12, line 19-21: “we therefore conclude that...more important...”, more important for what? As stated earlier, I don’t think that this is a very meaningful statement.

- Page 12, line 29: either remove “to” before “precipitation”, or replace “yield” by “lead”

- Page 12, line 32: replace “forecast” by “forecasting”

- Figure 4: the symbols indicating the different sensitivity runs are very hard to read.

- Figure 6: I suggest to include the reference simulation at (0,0)

Rihani, J. F., F. K. Chow, and R. M. Maxwell. 2015. Isolating effects of terrain and soil moisture heterogeneity on the atmospheric boundary layer: Idealized simulations to diagnose land-atmosphere feedbacks. Journal of Advances in Modeling Earth Systems 7, 915-937.

Imamovic, A., L. Schlemmer, and C. Schär. 2017. Collective impacts of orography and soil moisture on the soil moisture-precipitation feedback. Geophysical Research Letters, 44, doi:10.1002/2017GL075657.

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