

MS Title: The role of land-surface interactions for surface climate in the EC-Earth3 earth system model

Author: Wilhelm May

General comment

The manuscript entitled “The role of land-surface interactions for surface climate in the EC-Earth3 earth system model” by Wilhelm May evaluates two simulations against multiple reference data sets. For the first simulation, EC-Earth3 is forced offline with reanalysis data. For the second simulation, the land surface and atmosphere are dynamically coupled, but land surface characteristics are prescribed from the offline run. Comparing offline and constrained online simulations shows to what extent biases are related to the land surface component versus the coupling of the atmosphere. The first simulation has an overall warm and dry bias with some regional differences, a negative bias in net radiation and sensible heat flux, and a positive bias for latent heat flux. Dynamic coupling leads to stronger biases, and the sign of those biases can differ from the ones in the offline run. The study describes regional differences using multiple reference data sets in great detail. The author concludes that atmospheric coupling has a large impact on temperature, net radiation and sensible heat flux, and a modest impact on soil moisture and latent heat flux. The study concludes that further model development is required for reducing model biases.

The manuscript is very well written and I expect that the results are of much value to EC-Earth3 model developers. However, the manuscript also remains very descriptive. The Discussion section elaborates only on the study’s limitations. It remains unclear how well the results compare to previous studies, the relevance of the findings for the broader land surface modelling community, and possible venues for model improvements. I, therefore, recommend that the manuscript may be considered for publication in ESD after major revision. Please find my detailed comments below.

Detailed Comments

L 7 The effect of the land surface on the *global* climate system is not limited to CO₂ alone. The ice and snow albedo feedback for instance affects the global climate as well. Please rewrite.

L 65 The description of how changes in latent heat flux can potentially affect precipitation is vague, please rewrite.

L 76 Please add references.

L 88 Typo, replace *ad* with *and*.

L 176 Explain why you use prescribed data from the offline simulation in your coupled simulation.

L 222 So your offline simulation is based on a spinup that was driven with GSWP3 and a historical run that uses ERA5 data? Why did you not use ERA5 data for both, the historical and the the spinup? Please justify.

- L 246 Replace *merged* with *spatially upscaled*.
- L 297 Please gather all results under a *Results* section.
- L 307 Please add the value of the global mean bias in the text.
- L 370 The equation applies to the upwelling, not downwelling LW radiation. Please adjust the direction of the arrow accordingly.
- L 371 Add that ground heat flux is close to zero when averaged over longer periods, such as a month, which is why you may omit it in your equation.
- L 358-377 This paragraph provides very basic information that you can expect the reader to know. I think you can skip this part.
- L 402 Provide the definition of evaporative fraction further up where you first use the term.
- L 587 This paragraph explains why you focus on JJA. Please provide this justification earlier in the methods section.
- L 570 The Discussion section only elaborates on the study's limitation. Please also elaborate on how well your results compare to previous studies, the relevance of your findings for the wider land surface modeling community, and possible venues for model improvements.
- L 605 I would omit subsections in the Summary and conclusions section
- Code and Data availability: You write that code and data can be made available by the author on request. I don't think this approach satisfies the ESD data policy, which states that data and other information underpinning the research findings are findable, accessible, interoperable, and reusable (FAIR) not only for humans but also for machines.

Figures

- Figures 1a, 3a, 5a, 7a, and 9a: Please replace the divergent with a continuous color legend, as you are not showing the difference but the absolute values. Also, please ensure all legends include their units.
- Figures that show seasonal biases: Please denote where biases are statistically significant.
- Figure 15: Please add a map that identifies the different IPCC regions.
- The text includes 17 Figures, of which not all are discussed in great detail. I recommend to remove figures that are not discussed in more detail, such that the total number of figures does not exceed ten.