RESPONSE TO TOPIC EDITOR FOR GEOSCIENTIFIC MODEL DEVELOPMENT: MANUSCRIPT EGUSPHERE-2025-713

We thank the Topic Editor for the thorough evaluation, constructive guidance, and recognition of the manuscript's contribution when framed as an intra-model sensitivity analysis within CLM5. Below, we provide a point-by-point response to each editorial request. The corresponding revisions have been implemented throughout the manuscript, including the Abstract, Introduction, Methods, Results, figure captions, and Conclusions. Our responses to the suggestions are detailed below (in blue).

1. ERA5-Land framing and terminology

   Editor Comment: Recast ERA5-Land as a model product used for pattern comparison, not as "observations" or ground truth; avoid "performance/validation" language.

   Response: We thank the Topic Editor for this essential clarification. We have implemented the requested reframing throughout. We now describe ERA5-Land as a spatially complete, model-based reference used only for pattern consistency (not validation of absolute levels). We explicitly state that ERA5-Land does not assimilate land/soil-moisture observations, is not ground truth, and is not a validation target. Instances of "observational benchmark," "validation," "performance," or "observed" have been replaced with phrasing such as "similarity/differences relative to ERA5-Land patterns." We chose the term *"model-based reference"* rather than *"benchmark"* to emphasize that ERA5-Land is another model product, not a standard of truth. This more cautious terminology avoids overstating its authority while maintaining its role as a consistent point of comparison for spatiotemporal pattern analysis.

2. Forcing/structure mismatch is stated prominently

   Editor Comment: Note the forcing mismatch (CLM5 forced by GSWP3 vs. ERA5-Land forced by ERA5) and structural differences (CLM5 vs. HTESSEL); differences should not be attributed to parameter effects alone.

   Response: We thank the Topic Editor for highlighting this distinction. We have added an explicit statement in *Methods* and reiterated it in *Results* and *Conclusions/Limitations* that differences between CLM5 and ERA5-Land can arise from both forcing differences (GSWP3 vs. ERA5) and model structural contrasts (CLM5 vs. HTESSEL), in addition to parameter effects. We emphasize this to avoid over-attribution of discrepancies to soil parameterization alone and to ensure that model-to-model and forcing mismatches are clearly recognized as contributing factors.

3. Study the positioning and placement of objectives

   Editor Comment: Present plainly as an intra-model sensitivity analysis within CLM5, not a validation exercise; move objectives into the Introduction.

Response: We thank the Topic Editor for this guidance. We now state explicitly in both the *Abstract* and *Introduction* that this work is an intra-model sensitivity analysis within CLM5, not a validation exercise. ERA5-Land is framed only as a model-based reference for assessing pattern similarity. The two study objectives have been moved from the *Conclusion and Recommendation* to the end of the *Introduction* and reworded to align with the Methods framing. This restructuring ensures that readers understand from the outset that our focus is on documenting how soil parameterizations propagate into simulated variability within CLM5, rather than on validation against external products.

4. Results wording and figure captions

Editor Comment: Where ERA5-Land had been used to assert 'better/worse performance' or 'validation,' rephrase as 'greater/lesser similarity to ERA5-Land patterns' or 'pattern differences.

Response: We thank the Topic Editor for the specific wording direction. We have systematically replaced "performance/validation" language with pattern-based phrasing across the Results and all figure captions, e.g., "greater/lesser similarity to ERA5-Land patterns," "pattern differences," or "pattern consistency."

5. Compact experiment summary table; clarify Exp. 1 vs. Exp. 4a–d; fix cross-references

Editor Comment: "Include a compact experiment summary table; make Exp. 1 (single uniform parameter set) vs Exp. 4a–d (separate uniform texture-class sets, run individually) unambiguous. Correct figure/table cross-references."

Response: We thank the Topic Editor for this practical suggestion. We have added a concise experiment summary table listing EXP1 and EXP4a–d, including soil input, parameter settings, and purposes for each experiment. We clarify that EXP1 uses a single uniform parameter set globally, whereas EXP4a–d are four separate globally uniform "design-soil" runs (loamy sand, loam, clay, silt), each executed individually. We also state plainly that the analysis utilizes root-zone (0–1m) soil moisture data from 1980 to 2010. All figure/table cross-references have been corrected.

6. Irrigation: explicit statement and reader caution

Editor Comment: State plainly that neither CLM5 nor ERA5-Land includes irrigation; caution readers regarding agricultural hotspots.

Response: We thank the Topic Editor for this important caveat. We now explicitly state that irrigation is not represented in our CLM5 simulations (rainfed/naturalized) and is not included in ERA5-Land. We caution readers not to over-interpret agricultural hotspots for this reason. This clarification appears where the datasets are introduced and is reiterated in the Results and Conclusions.

7. Brief Limitations paragraph (scope and proportionality)

   Editor Comment: Include a short Limitations paragraph acknowledging model-to-model comparison, forcing mismatch, and structural differences; keep conclusions proportionate.

   Response: We thank the Topic Editor for emphasizing proportional conclusions. We added a concise Limitations paragraph in the Conclusions that: (i) reiterates the model-to-model, pattern-based scope of all comparisons (ERA5-Land used only as a model product for pattern comparison, not ground truth), (ii) notes the forcing and structural mismatches (GSWP3/CLM5 vs. ERA5/HTESSEL), and (iii) flags that neither dataset includes irrigation, so agricultural hotspots should be interpreted cautiously. We also state that parameter effects cannot be fully separated from forcing/structural differences, and results should be interpreted accordingly.

8. Positive core and disciplined claims

   Editor Comment: The value lies in documenting, within CLM5, how parameter datasets propagate into regional patterns/variability and where parameter uncertainty most strongly affects simulated soil moisture, provided the claims are disciplined.

   Response: We thank the Topic Editor for articulating the paper's positive core. We revised the Abstract and Conclusions to foreground the CLM5-internal contribution: documenting how soil parameter choices propagate into regional patterns and variability, and identifying regions/seasons where parameter uncertainty most strongly affects simulated soil moisture. Claims are now explicitly discipline-appropriate and proportionate, aligned with the pattern-comparison framing.

9. Reviewer-specific technical points

   Editor comment: Please also address the specific technical points raised by Reviewer #3.

   Response: We thank the Topic Editor for this reminder. We have prepared a separate, point-by-point response to Reviewer #3, and all technical comments are addressed in detail within it. Corresponding manuscript edits are implemented and cross-referenced as needed.

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RESPONSE TO REVIEWER #3 FOR GEOSCIENTIFIC MODEL DEVELOPMENT: MANUSCRIPT EGUSPHERE-2025-713

We thank Reviewer #3 for the careful reading and constructive suggestions, which have improved the clarity, proportionality, and utility of the manuscript.

1. Lines 125–131 — Introduce only datasets; move parameter derivation to Sec. 2.2.1

   Reviewer Comment: Introduce datasets only in Data Description; explain parameter derivation later.

   Response: We thank the reviewer for this request for clarification. Implemented. The Data Description now introduces only the datasets (SP-MIP/CLM5 output and ERA5-Land) with domain, resolution, and period. All parameter-derivation details and the experiment setup are consolidated in Sec. 2.2.1 "Experimental Designs."

2. Line 127 — Table reference

   Reviewer Comment: Should this refer to Table 2?

   Response: Yes, the Brooks–Corey (Clapp–Hornberger) reference now points to Table 2.

3. Line 142 — Remove irrigated cropland

   Reviewer Comment: Recommend removing irrigated cropland from analysis.

   Response: We appreciate the reviewer's attention to this issue. We retain the full CONUS domain to preserve comparability across experiments and avoid introducing a non-standard mask; however, we now (i) state explicitly that irrigation is not represented in our CLM5 configuration and not included in ERA5-Land, and (ii) caution readers against over-interpreting agricultural hotspots. We flag this as a limitation and a priority for future work (e.g., using irrigation-aware datasets/masks).

4. Line 155 — Add a summary table of all experiments

   Reviewer Comment: Please add a table summarizing experiments, datasets, and purposes.

   Response: Implemented. We added a concise experiment summary table (EXP1–EXP4a–d) listing for each experiment the soil input, parameter setting, purpose, and the analysis period (0–1 m root-zone soil moisture, 1980–2010)

5. Line 156 — Clarify Exp. 1 vs. Exp. 4

   Reviewer Comment: Both have uniform parameters—what is the distinction?

Response: Implemented. EXP1 applies one single uniform parameter set globally; EXP4a–d comprise four separate globally uniform "design-soil" runs (loamy sand, loam, clay, silt), each executed individually.

6. Line 316 — Figure cross-reference

   Reviewer Comment: Should this be Figure 4d?

   Response: Corrected. The cross-reference now points to Figure 4d; nearby figure/table references were re-checked for consistency.

7. Line 379 — Conclusions given ERA5-Land biases

   Reviewer comment. If ERA5-Land has documented biases, what meaningful conclusions can be drawn from CLM5–ERA5-Land comparisons?

   Response: We thank the reviewer for prompting a clearer interpretive scope. We now explicitly frame all CLM5–ERA5-Land comparisons as pattern-based, rather than as validation of absolute levels. We state that ERA5-Land is a model product without land/soil-moisture assimilation, and that CLM5–ERA5-Land differences reflect forcing (GSWP3 vs ERA5) and structural contrasts (CLM5 vs HTESSEL) in addition to parameter effects. Thus, our conclusions concern pattern consistency and parameter-sensitive regions, rather than errors in magnitude. We note that future extensions will incorporate observational products (e.g., SMAP, GLEAM, SMERGE, MERRA-2) to enable targeted calibration and broader evaluation.