Review of the manuscript

"Development of a high-resolution coupled SHiELD-MOM6-LM4 model– Part 2: Model overview, coupling technique, and evaluation of hydrological extremes during Hurricane Helene"

By Mouallem et al.

This manuscript presents a valuable contribution to Earth system and weather modeling by integrating and coupling the NOAA-GFDL land model (LM4) into the SHiELD atmospheric model. The key element of the work is the transition from a simple explicit representation of the land surface to a more sophisticated, fully implicitly coupled land-atmosphere-ocean system to enhance the representation of physical processes and hydrological capabilities. The authors demonstrate the success of this architecture through a realistic simulation of Hurricane Helene in the Southeastern US. The manuscript is well-structured and clearly written, and the results of the simulation show a physically reasonable hydrological response.

However, several aspects of the research warrant a deeper discussion, work contextualization among the published literature, and some comparative validation (or model-model comparison) prior to publication.

Major comments

1) The Introduction section reads more like a narrative of the GFDL models rather than a scientific motivation and contextualization of the work. The authors may perhaps strengthen it by motivating the critical role of land surface processes and land-atmosphere feedbacks in predicting extreme weather events and advancing Earth system modeling. The authors also need to contextualize their development within the broader modeling community. For instance, how does their coupling strategy and design choices compare to other approaches utilized in operational and research models (e.g., ECMWF, UFS, or NCAR/UCAR models).

2) Page 8, Line 136: The temperature and moisture fluxes are themselves physically coupled to the momentum flux (or friction velocity scale u_*) in the Monin-Obukhov Similarity Theory (MOST) scheme, so the authors need to address whether excluding the momentum flux computation from the implicit solver loop influences the consistency, partitioning, or magnitude of the sensible and latent heat fluxes. A physical discussion justifying this design choice is needed.

3) While the discussion of the results is rigorous, the manuscript does not show any model-observation or model-model comparisons. I think the manuscript would be much strengthened and impactful if a comparison of at least few results between this LM4-SHiELD configuration and the previous version (or explicit, uncoupled version) is

conducted. This can highlight the strengths and/or weaknesses of the new coupling strategy and drive future research.

Minor comments

1) Page 14, Line 238: The description of the initial conditions for LM4 used for the experiments needs to be expanded. Was LM4 spun up for a specific period to get ICs? What was the rationale?
2) Page 2, Line 28: correct the typo “withing”.
3) Page 4, Line 98: “hereafter” instead of “thereafter”
4) Page 7, Line 116: series of “vertical” layers indexed by k?
5) Page 7, Line 129: remove one “the”
6) In several instances (e.g., Line 222, Page 13 but others too), “latter” is written as “later”.
7) Caption of Figure 9: Correct “Vertical dashed vertical …”
8) Page 19, last line: remove “XXXX”