Review of "Score-based Filtering for Land Data Assimilation"

Fan et al. develop LandSF by incorporating SDEdit and MMPS into score-based filtering and applying the method to land data assimilation with CoLM using SMAP satellite observations. The study involves substantial work in method development, numerical experiments, and online model coupling, and addresses an important topic for improving land-state estimation and supporting weather and climate forecasting. Overall, the manuscript is well written, and the proposed methodological improvements and results are promising. I recommend **Moderate Revision**, with several comments that may help improve the clarity and reproducibility of the manuscript.

1. **Section 2.2.4 and Appendix A.** Appendix A establishes the connection to the Kalman analysis under linear-Gaussian assumptions, while the implemented LandSF uses SDEdit initialization at an intermediate diffusion step (Equations 30–31). Could the authors clarify whether the theoretical equivalence also applies to this sampling procedure or only to the analytical score formulation?
2. **Figure 9 and Section 2.3.** Figure 9 shows LandSF curves with $\gamma = 0.5$, 1, and 2, while the text states that LandSF does not require an additional tunable guidance parameter. Could the authors clarify what γ represents and which setting was used in the main experiments?
3. **Section 3.2 and Supplement Text S1.** Could the authors clarify how the ascending and descending SMAP observation times are matched to the hourly CoLM time steps? In particular, is assimilation performed at each available satellite overpass or at fixed intervals?
4. **Sections 2.2.3 and 3.2.** The score network operates on standardized forecast states, while the assimilation uses soil moisture anomalies and a prescribed observation-error covariance. Please clarify how these transformations are handled consistently in the MMPS likelihood-score calculation, particularly whether the observation-error covariance is adjusted when working in standardized space.
5. **Section 3.2 and Supplement Text S1.** The manuscript states that grid cells outside the observation influence area retain their forecast values. Could the authors clarify how this area is defined and whether the observation mask is applied during reverse diffusion or after the analysis samples are generated?
6. **Figure 8.** The B24−OL and LandSF−OL differences are described as analysis increments. Could the authors clarify whether these represent the immediate analysis increments at each assimilation time or differences from the open-loop simulation that also include the effects of previous assimilation cycles?
7. **Code and Data Availability.** The LandSF Zenodo link includes an access token. It would be helpful to provide a stable public DOI or direct archive link to the code version used in this study.
8. **Supplement Text S1.** Could the authors briefly clarify how the soil-water storage changes introduced by the analysis increments are handled when the updated states are returned to

CoLM, particularly when physical bounds are applied? This would help readers understand how water balance is maintained during the coupling.

9. **Section 3.2 and Supplement Tables S3–S5.** Could the authors specify the spatial correlation scales used for the atmospheric forcing perturbations and clarify whether the soil moisture state perturbations are applied only during ensemble initialization or repeatedly during model integration?
10. **Section 3.2, Lines 357–370.** Could the authors specify the measurement depths of the in situ soil moisture observations used for validation and explain how these depths are matched to the CoLM soil layers? It would also be helpful to clarify whether the modeled and observed daily means are evaluated using the same valid dates.

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