"A Review of Current Best Practices and Future Directions in Assimilating GRACE/-FO Terrestrial Water Storage Data into Numerical Models"
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General comment:

In this manuscript, the authors provide a comprehensive review of current practices and future directions in assimilating terrestrial water storage (TWS) data from the GRACE and GRACE-FO missions into hydrological and land surface models. It draws on approximately 200 references to highlight advancements in frameworks like the Ensemble Kalman Filter (EnKF) and its variants, while addressing practical issues such as scale mismatches, error correlations, and applications in drought monitoring and climate trend analysis. The emphasis on geophysical corrections (e.g., glacial isostatic adjustment) and the integration of multi-sensor data (e.g., with SMAP or SWOT) provides a cohesive narrative that bridges theoretical DA with operational hydrology. The manuscript excels in its comprehensive scope and accessibility, making it a valuable resource for early-career researchers and practitioners seeking an entry point into GRACE/-FO DA. It includes detailed tables (e.g., Table 1: models that evaluated TWS; Table 2: DA frameworks) and illustrative figures (e.g., Figure 1: TWS components scheme; Figure 3: statistics from evaluations made by models).

The manuscript is timely, given the impending launch of missions like GRACE-C (~2030) or NGGM and advancements in Earth System Modeling (ESM) frameworks. In general, this work is worth publishing in the Hydrology and Earth System Sciences journal, as it fills a gap in synthesizing post-GRACE-FO literature and could serve as a foundational reference for advancing standardized practices in hydrological DA, however some improvements are necessary, including deeper critical analysis and enhanced didactic elements. Some suggestions for revisions are included below and these points do not detract from its value; rather, they could enhance its rigor and relevance.

Moderate comments:

While the manuscript is a solid synthesis, it requires moderate revisions to elevate its critical depth and utility. As a review paper, it should compile and critically evaluate the literature, identifying inconsistencies and unresolved debates. At present, the discussion is somewhat descriptive, with limited critique of methodological limitations or comparative assessments. To ensure the article meets the standards for publication, the authors must address the following critical points:

1. Enhance your critical evaluation and gap analysis. In order to avoid a mere listing of works, I suggest to add a dedicated sub-section in Section 5 to quantify gaps. One option would be to use meta-analysis of DA performance metrics from recent studies (2020-2025).
2. Improve validation and uncertainty discussions in Section 4, since it lacks depth in metrics; mandate inclusion of quantitative benchmarks (e.g., Triple Collocation Analysis) and error propagation models. I suggest, for instance, to address how non-

Gaussianity affects DA reliability, proposing solutions to make recommendations more actionable.

3. Add didactic elements to enhance educational value, incorporate summary equations for core DA techniques in Section 3. I suggest adding schematic diagrams, such as a flowchart comparing sequential vs. smoothing DA methods, or a matrix illustrating error sources in GRACE processing.

Specific comments (Line-by-line comments):

Abstract:

- L. 1-16: The abstract is concise but could better emphasize the synthesis's novelty (e.g., "This review synthesizes over “n” studies to propose unified best practices..."). Add a sentence on key gaps identified, such as non-Gaussian challenges.

Introduction:

- Clarify the distinction between GRACE and GRACE-FO data continuity; reference Vishwakarma et al. (2021) for gap-filling techniques. I suggest to add a simple timeline figure of GRACE missions to make the historical context more didactic.

Section 2 to 7:

- Sub-section 2.3: Expand on geophysical corrections with an equation for leakage error correction.
- Sub-section 2.4: Include a recent reference (Gerdener et al., 2024) on GRACE/-FO data uncertainties. Propose a schematic diagram illustrating the GRACE processing chain from raw measurements to TWS anomalies.
- Sub-section 2.5: Although the article is a review paper on the application of data assimilation techniques, mainly from the Kalman filter family, I recommend at least adding the basic EnKF equations for accessibility.
- Sub-section 3.2: I strongly suggest a table or matrix comparing DA methods' computational costs and assumptions.
- Sub-section 6.1: Strengthen ML discussion with a hybrid DA-ML schematic (e.g., EnKF with LSTM for error modeling).

References and General:

Ensure all citations are up-to-date, specially from 2020-2025. The manuscript could benefit from an appendix with a glossary of DA terms for non-experts.