General Comments:

This paper focuses on 12 major pan-Arctic basins and constructs a unified empirical reconstruction framework to generate monthly terrestrial water storage (TWS) and runoff series for 1952–2025. The overall rationale and ideas of the paper are good, and there are notable innovations in the model experimental design. However, I still have some questions about the paper. The specific questions are listed below. My recommendation is major revision.

Major Comments:

1. This study calibrates the parameters using the eight years from 2003 to 2010 and then extrapolates them to 1952–2002. The problem, however, is that these eight years represent only the climate conditions within the calibration period, whereas studies have shown that the Arctic has experienced pronounced climate change (Rantanen et al., 2024). It is therefore difficult to argue that the climate conditions during the calibration period and the reconstruction period are consistent, and the existing validation and results in the paper are insufficient to support the transferability of the parameters. Both the training period (2003–2010) and the testing period (2011–2025) fall within a pronounced warming period. In the sensitivity experiments in Section 5.1, the windows of different lengths overlap considerably with one another. Moreover, although in Section 5.2 the authors conduct relatively comprehensive model simplification experiments to test the necessity of the parameters, they lack a test of climate dependence. I think it is difficult to demonstrate that the model parameters are transferable. This part needs to be explained in detail by the authors or supported by additional experiments.
2. In the discussion, the authors provide a detailed discussion of parameter calibration, model structure, and anthropogenic disturbances, but they lack a discussion of the accuracy of the forcing data. This content should be added to improve the discussion of the model results.
3. Figure 12 C in Section 5.4 shows that the model exhibits certain biases in some basins during approximately the Northern Hemisphere summer period. I am quite interested in what might have caused such biases.

4. The authors' description of the procedure for separating the seasonal cycle and the non-seasonal component is too brief. I suggest that the authors describe in detail in the Methods how the seasonal cycle and the non-seasonal component are separated.
5. The content in Section 5.1, “Sensitivity to the parameter-estimation period,” should be split into two parts: the design of the windows should be placed in the Methods, and the results of the sensitivity experiments would be more appropriately placed in the Results.

Minor Comments:

In Line 316, the formatting of “T o” should be “To”.

Reference:

Rantanen, M., Karpechko, A. Yu., Lipponen, A., Nordling, K., Hyvärinen, O., Ruosteenoja, K., Vihma, T., & Laaksonen, A. (2022). The Arctic has warmed nearly four times faster than the globe since 1979. *Communications Earth & Environment, 3*(1), 168. https://doi.org/10.1038/s43247-022-00498-3