General comments

Very good research that combines surface and subsurface hydrology. The topic fits the scope of the journal. However, information is missing, and I am available to review the manuscript a second time under request of the editors. Please, address the specific comments.

We sincerely thank the reviewer for taking the time to review our manuscript and for the constructive comments, which will help us improve the clarity and overall quality of the manuscript.

Specific comments

1. Clarify the novelty of your manuscript in the introduction.

Groundwater can strongly influence land-surface water and energy processes and thereby affect land–atmosphere interactions, making its representation important in Earth system models. However, explicitly resolving three-dimensional groundwater flow at large scales remains computationally demanding, and how groundwater effects can be represented efficiently remains an open question. WTR has been proposed as a reduced-dimensional diagnostic of groundwater–climate interactions. If it can reliably distinguish regions where groundwater exerts strong or weak influences on land-surface processes, it may provide a useful basis for simplified or adaptive groundwater representation. However, this diagnostic interpretation has not been systematically examined against a three-dimensional process-based representation. The novelty of this study is therefore to identify groundwater-sensitive and groundwater-insensitive regions using paired ParFlow–CLM simulations and to examine how well WTR distinguishes between these regions, how stable this distinction is under input uncertainty, and which parameters are most strongly associated with the discrepancies. This rationale is developed in the final two paragraphs of the Introduction, but it is not summarized in a single explicit novelty statement. We will make this novelty more direct in the revised Introduction.

2. Disclose the general aim of your research at the end of the introduction.

The general aim is already stated at the end of the Introduction: “The purpose of this comparison is not to accept or reject WTR, but to examine the correspondence between the reduced-dimensional and process-based representations and to investigate the sources of their discrepancies.” The following sentence further states that the study examines WTR as a reduced-dimensional diagnostic of groundwater–land interactions using an integrated ParFlow–CLM framework. We will revise this passage so that the general aim is easier to identify.

3. Describe the multiple specific objectives of your research in the final part of your introduction.

The specific objectives are already introduced by “Specifically” in the final paragraph of the Introduction: (1) to quantify how alternative parameter estimates and parameter uncertainty affect WTR values and classification stability; (2) to compare WTR-based classifications with groundwater-sensitive regions identified from paired ParFlow–CLM simulations; and (3) to identify the parameters most strongly associated with classification discrepancies. In the revised manuscript, we will number these objectives explicitly so that they can be more readily identified.

Study area

4. What are you modelling in terms of subsurface hydrology for the geological heterogeneities? Which type of rocks?

The subsurface heterogeneity considered in this study includes spatial variations in shallow soil types and deeper-aquifer lithology. As stated in the manuscript, the soil types were obtained from GSDE, whereas the deeper-aquifer units were obtained from GLHYMPS 1.0. In the revised manuscript, we will provide a concise summary of the dominant soil types and deeper lithological units within the study area.

Methodology

5. Figure 1. Please, provide more information in the figure and main body about the boundary conditions.

We will add further information on the model boundary conditions to Figure 1 and the corresponding description in the main text.

6. Reduce the number of equations.

We will review and streamline the presentation of the equations to make the analysis easier to follow.

Results

7. Figure 1. Pay attention to the use of bold.

The Figure 1 caption will be changed from bold to regular type.

8. Figure 2. Which is the meaning in terms of heterogeneities? I ask to be more conceptual.

Here, “spatial heterogeneity” refers to the spatial variability of the estimated WTR across the study domain. We will rephrase this sentence to make its meaning clearer.

9. Figure 4. Improve the language of this caption. Some sentences are too long.

We will revise the Figure 4 caption using shorter sentences to improve its clarity.

References

10. Expand literature on subsurface flow in heterogeneous aquifers.

We will expand the relevant discussion and add references on subsurface flow in heterogeneous aquifers in the revised manuscript.