General comments

Good modelling hydrological research. Please, follow my suggestion to improve the final version of your manuscript.

We sincerely thank the commenter for the positive assessment and constructive suggestions, which will help improve the clarity and accessibility of the manuscript.

Specific comments

Lines 32-34. Insert recent review papers that discuss challenges to resolve 3D groundwater flow at the regional and continental scales due to geological heterogeneities, and hydrological uncertainties:

- Condon, L. E., Kollet, S., Bierkens, M. F., Fogg, G. E., Maxwell, R. M., Hill, M. C., ... & Abesser, C. 2021. Global groundwater modeling and monitoring: Opportunities and challenges. Water Resources Research, 57(12), e2020WR029500.

- Lupi, F., Agbotui, P. Y., Medici, G. 2026. Hydraulic Conductivity in the Mesozoic units of the Umbria-Marche succession (Italy); insights towards a sustainable management of carbonate aquifers worldwide. Sustainability, 18, 9297; https://doi.org/10.3390/su18189297.

The primary focus of this study is not the challenge of resolving geological heterogeneity in three-dimensional groundwater simulations. Rather, we examine whether a reduced-dimensional groundwater representation can capture groundwater–land interactions identified by a three-dimensional process-based model. Nevertheless, our results identify hydraulic conductivity as the dominant source of WTR uncertainty and classification discrepancy, directly linking WTR performance to the simplified representation of subsurface heterogeneity. We will therefore incorporate Condon et al. (2021) into the broader discussion of large-scale groundwater modeling and discuss both suggested studies when interpreting the roles of hydraulic-conductivity uncertainty and geological heterogeneity.

Line 128. Clarify the general goal of your research at the end of the discussion.

Line 128 is located in the final paragraph of the Introduction, where the general aim is already stated: “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 explains 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 more immediately identifiable.

Line 128. Describe the 3 to 4 specific objectives of your research by using numbers (e.g., i, ii, and iii).

The specific objectives are already introduced by “Specifically” in the final paragraph of the Introduction: (i) to quantify how alternative parameter estimates and parameter uncertainty affect WTR values and classification stability; (ii) to compare WTR-based classifications with groundwater-sensitive regions identified from paired ParFlow–CLM simulations; and (iii) 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.

Lines 132-186. Please, provide basic information on climate of the study area.

We will add a brief description of the study area’s climate in the revised manuscript.

Lines 132-185. Insert basic information on the geology/hydro-stratigraphy of the study area.

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.

Lines 189-onwards. Provide more information on the physical principles underneath ParFlow.

We will add the governing equations used by ParFlow, together with a brief explanation of their physical basis, in the revised manuscript.

Line 147 “Deeper aquifer”. How deep? Please, be more quantitative.

The total modeled subsurface thickness of 492 m is already stated at Lines 138–139. Here, “deeper aquifer” refers to the model layers beneath the shallow soil column and extending to the base of the 492 m subsurface domain. We will make this depth range explicit near Line 147 in the revised manuscript.

Line 271. There are several equations. They should have a number associated.

We will number the equations in the revised manuscript.

Line 271. There are several equations. Can you reduce the numbers of equations? That's to be more conceptual towards the audience.

We will streamline the presentation of these equations and add a concise explanation of their physical meaning and analytical purpose, including how the elasticity analysis supports the identification of parameters associated with classification discrepancies in Section 5.3.

Line 302. Do you need to provide details for water viscosity and density values used for the conversion?

We will provide the water viscosity and density values used to convert intrinsic permeability to hydraulic conductivity in the revised manuscript.

Line 643. Do you need a separate discussion where you engage the international community?

As noted in our response to the comment on Lines 32–34, we will broaden the Discussion to engage more directly with the international literature on large-scale groundwater modeling, subsurface heterogeneity, and uncertainty.

Lines 694-701. I suggest highlighting the novelty of your research.

The novelty of the study is already developed in the final two paragraphs of the Introduction. In the revised manuscript, we will state it more explicitly in the Introduction and reiterate it at Lines 694–701.

Figures and tables

Lines 539-544. This caption is too long. Part of the text should be moved to the result section.

We will shorten the caption and move the relevant explanatory text to the Results section.