

Author response to Referee #2 comments:

Reviewing of the manuscript open for discussion 'EcoTWIN 1.0: A Fully Distributed Tracer-Aided Ecohydrological Model Tracking Water, Isotopes, and Nutrients' by Songjun Wu et al. submitted to Geoscientific Model Development (Manuscript ID: egusphere-2025-3941).

The authors have developed/improved and ecohydrological model with advanced traits, tracking water, isotopic and nutrient fluxes. The reviewer considers that this model development work is worthwhile and beneficial to the modeling community and fall within well with the journal topic. There are a couple of issues that the reviewer suggests for the authors to refer, and they are listed in detail as follows

**** We appreciate the positive evaluation by the reviewer. All comments will be addressed accordingly.**

Almost all figures need to be replotted. Here I give some examples. Fig. 1: The texts are too small to read, and the subtitles need add some explanations for the figure, so that the reader is easy to follow it; Fig. 2: the coordinates need to be added, and some important landmarks or rivers information should better be added; the texts are too small to be identified; Fig. 3: the color for the color should be more identifiable, rather than orange and blue two colors; Fig. 4: the time series figures give no information to the reviewer; similar issues also for Fig. 5-7, and the reviewer will NOT list all issues for the figures. The authors should check them carefully and revise them all.

**** Thank you for suggestions. We will revise the figures accordingly. The revision plan is listed below:**

Fig. 1: Irrelevant text will be removed from the inset plot. We will also increase the size of remaining text and improve the captions.

Fig. 2: The coordinates will be added, and text size will be increased. However, we are hesitated to add river information for two reasons: (1) the figure is already crowded, and (2) adding only major rivers will potentially mislead readers on the actual dense network in our distributed modelling.

Fig. 3: We will adjust the scale of color code to make data points more identifiable.

Fig. 4: We respectfully argue that the time series gives readers intuitive impressions of the model performance. But we will reduce the number of subplots for simplicity.

Fig. 5-7: The spatial plots show model performance in each grid cell compared to three remote sensing products. These are important validations for the ability of a hydrological model to reproduce uncalibrated hydrological fluxes, or namely the physical consistency. Therefore, we will keep three figures. The ambiguity may originate from the misleading color codes of the spatial map, which will be changed to "cool-warm" to differentiate from the inset subplots.

The structure of this manuscript may be adjusted. Part 4.1 and 4.2 may be moved under the section of 3 Model calibration and validation? This should be one section to discuss the model advantages of accuracy compared with previous models? For example, providing specific skill metrics values.

** Yes, we agree that merging section 4.1 and 4.2 to model calibration and validation section fits better to main streamline. Meanwhile, the water age section 4.3 will be an independent result section 4. These will be implemented.

Provide some explanations for the reason why these 17 catchments are selected for this study.

** The watersheds were selected due to data availability, particularly in-stream isotopes and nitrate with sparse distribution across Europe. Clarification will be added.

What is the difference between model calibration and validation? The reviewer could not quite understand herein, it seems the difference is defined by the different variables that are choose for the model-to-data comparison. Please explain it.

** Like most hydrological and water quality models, we calibrated EcoTWIN with spatially distributed point observations, including discharge, in-stream isotopes, and nitrate. However, this does not guarantee the physical consistency of uncalibrated internal fluxes (e.g., snow melt/accumulation, evapotranspiration, percolation, etc.). Therefore, additional validation was applied for those uncalibrated states/fluxes. Three remote sensing products were used to test or informally validate EcoTWIN's ability of reproducing snow depth, evapotranspiration, and total water storage without direct calibration (against these variables). This will be clearly clarified in text.

More skill metrics should be defined and used for model performance. For example, Root Mean Square Error, Correlation Coefficient, Mean Value Difference etc. to evaluate the model performance. Then, give the statistics and compare them with previous other models.

** We agree that the benefits of including more metrics. A new Table 2 will be added with statistics of different metrics (Kling–Gupta efficiency, root mean square error, Pearson correlation coefficient, percent bias). A brief comparison with literature will also be added to section 3.3.

Some small mistakes or errors. Table 1, the table better not crossing two pages. Line 378, add the equation number and the meaning of it (e.g., what does I mean in the left of the equation). Be consistent use KEG or KGE, and define it and explain it (e.g., what are the value ranges, and the corresponding performance, excellent, good, normal, poor etc.)

** Thank you for suggestions. All tables will be moved to an independent section to avoid page crossing. The equation will be labeled with explicit description of L (likelihood). KEG is the typo of KGE (Kling-Gupta efficiency). This will be corrected through text.

Line 451: ERA5 reanalysis products equal to observations? Please double check it.

** We compare the daily snow depth from ERA5 reanalysis products. This will be clarified.

Line 531-532: 'However, it increases severely increase the'. Delete one of the 'increases'.

** Thank you for pointing out. This will be corrected.

Line 694: the first letter of the word 'mediterranean' should be initialized.

** Mediterranean will be capitalised through text.