Author response to Referee #1 comments:

This manuscript describes a novel spatially distributed ecohydrologic model ECOTWIN. This model links hydrology with nutrient and isotopic modules. The capability has great potential to improve our understand the terrestrial and aquifer ecosystem interactions. Although similar capability has been attempted in several other studies with different focus such as dissolved organic carbon (DOC), the inclusion of lateral flow with nutrient and carbon cycle is still a challenge in most spatially distributed (eco)hydrological models.

There are some missing information in the current manuscript, such as (1) groundwater level; (2) resolution for evaluation; (3) chemical reaction. See details below. The presentation of some information can be improved, especially some figures are too small to be read.

Dear Dr. Chang Liao,

Thank you for the positive feedback! All comments will be addressed accordingly.

Best regards,
Songjun, on behalf of all co-authors

Distributed, do you mean spatially distributed?

** Yes, spatially distributed is the more rigorous term. I assume that the review is suggesting Line 33-34 ("*The development of ecohydrological models has been accelerating in the recent decades towards frameworks that are more distributed*"). This will be correlated.

Line 40: Sentence stoped abruptly without giving reasons.

** The challenges originate from the uncertainty in model inference, which is introduced in next paragraph. But yes, we agree that more explicit statements should be used to link the two paragraphs. This will be implemented.

Line 43: What is "somehow"

** Here we mean "to some extent". This will be addressed.

Line 44: Where is 81% come from? Reference needed

** The number originates from a review of water quality modelling in recent decades (Wellen et al., 2015) where statement "Only 19% of studies in our database calibrated to more than one location in space" was made. It is also cited at the end of the sentence.

Wellen, C., Kamran-Disfani, A.-R., & Arhonditsis, G. (2015). Evaluation of the Current State of Distributed Watershed Nutrient Water Quality Modeling. Environmental Science & Technology, 49. https://doi.org/10.1021/es5049557

Line 82: On disk/memory change to online and offline coupling

** Agreed. We will use “via online in-memory coupling (instead of offline on-disk coupling).”

Figure 1. Is soil zone part of vadose zone?

** This storage is separated from soil. We realised the ambiguity to call it “vadose zone”. Therefore, it will be changed to unsaturated zone (like conceptualized in many hydrological models like HBV, mHM, etc.). The term will be corrected through text and plots.

Line 192: What if the water table is above the last soil layer?

** No, the vertical distribution of water is represented in a few numbers of soil layers, an unsaturated storage, and a groundwater storage. Water table can be explicitly calculated but this is not included in EcoTWIN v1.0. We are also considering to include the water table calculation into v2.0 as it is a commonly used observation in hydrological modelling (especially in regions without river networks).

Equation 16: If the pond is not next to the river channel, why or how it contribute to the channel flow?

** Only grid cells with river channels contribute to channel flow. Otherwise, all available ponding storage routes to the ponding storage in downstream grid cells (until reaching the channel grids). This is the most used flow routing conceptualistion in spatially distributed models (e.g., mHM, EcH2o) though the channel contribution might need to be expanded in high-resolution modelling (e.g., in a few meters). The statements will be updated to avoid ambiguity.

Similarly, in equation 18, if the terrestrial grid cell is far away from the river channel, how does the vadose zone contribute to the channel flow?

** The same rules also apply to the relationship between geographic location and channel contribution from unsaturated storage. The corresponding description will be updated accordingly.

Figure 2: Does not have coordinates. Such as longitude and latitude information.

** Thank you for suggestions. Longitude and latitude will be added.

What are the particular reason why these 17 watersheds were chosen.

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

Line 346: Does the model need spin-up to reach steady state?

** Yes, the first two years were used for spin-up. This will be added in method section.

Line 399: How do you consider the upstream - downstream dependency in discharge, some watersheds are connected based on Figure 2.

** All the watersheds in Figure 2 are exorheic basin, which ultimately drain to the sea. Therefore, there is no interaction or connection between watersheds.

Figure 4: Show line/color meaning in the Figure as well. Also missing time step information.

The subfigures are too small to read. Maybe move some into SI and only show a few here.

** Yes, Agreed. We will add legends for line/color and remove some subplots to reduce the image size. The main message will remain unchanged.

Figure 5. Is the time series watershed averaged? If so, the caption should mention that.

** Agreed. The captions will be revised for Figure 5, 6, and 7.

Figure 6: The GRACE datasets resolution might be too coarse for comparison; there need to be some justification somewhere. Check other spatial products as well, maybe a table listing all produce with original and resample resolution for reference.

** Yes, we also agree that the coarse resolution of GRACE might be the reason for poor performance in validation. This will be discussed in section 5.1.3.

Line 534: Integrated C++ framework: C++ is a programming language, not a framework.

** Agreed. It will be revised to “an integrated framework in C++”.