The requested changes are as follows:

**Page 1, lines 3-5 (TS1):**

Please change the sentence

“Many watershed-scale models represent hydrological processes but lack the representation of multi-component reactive transport processes.”

To

“Many watershed-scale models represent hydrological processes but not biogeochemical reactive transport processes.”

Explanation: We tried to make the sentence more succinct.

**P. 1, l. 5-8 (TS2):**

Please change the sentence

“This has limited our capability to understand and predict solute export, water chemistry, and Earth system response to changing climate and anthropogenic

conditions.”

To

“This has limited our capability to understand and predict solute export, water chemistry and quality, and Earth system response to changing climate and anthropogenic conditions.”

Explanation: The addition of "and quality" is to emphasize the environmental significance.

**P. 1, l. 13-18 (TS3, 4):**

Please change the sentence

“It enables the simulation of (1) shallow and deep-water partitioning to represent surface water, shallow soil water, and deeper groundwater and of (2) biotic processes including plant uptake, soil respiration, and microbially mediated reactions such as nutrient transformation.”

To

“It enables the simulation of (1) shallow and deep-water partitioning to represent surface runoff, shallow soil water, and deeper groundwater, and of (2) biotic processes including plant uptake, soil respiration, and nutrient transformation.”

Explanation: - "Surface runoff" is more accurate here.

* The phrase "microbially mediated reactions" is repeated with the previous "biotic processes"

**P. 1, l. 38 (TS5):**

Please add the following sentence:

The model can be used to mechanistically understand coupled hydrological and biogeochemical processes under gradients of climate, vegetation, geology, and land use conditions.

Explanation: We wanted to add a summary sentence for the board significance of the developed model.

**P. 1, l. 50 (TS6), 55 (TS7):**

- Remove “Grathwohl et al., 2013” and add “Benettin et al., 2020; Adler et al., 2021”

- Remove “van der Velde et al., 2014; Miller et al., 2020; Han et al., 2019“

Explanation: The original references are too many and some are redundant information. The deleted ones are all redundant references with similar info with others in the list. Even after the remove of these references, there are still more than 100 references there, which are extensive for a non-review paper.

**P. 3, caption of Figure 1 (TS9, 10):**

- Change sentence

“Land-surface interactions include processes such as energy balance, solar radiation, and evapotranspiration; hydrological processes partition water between surface runoff, shallow soil water, and deeper water entering the stream.”

To

"Land-surface interactions include processes such as energy balance, solar radiation, and evapotranspiration; hydrological processes partition water between surface runoff, shallow soil water, and deeper water."

Explanation: The deletion of "entering the stream" make the sentence more accurate.

- Change sentence

“Soil biogeochemical reactions include abiotic reactions such as weathering (e.g., mineral dissolution and precipitation, ion exchange, surface complexations) and biotic processes such as plant uptake of nutrients, soil respiration, and other microbe-mediated reactions.”

To

“Soil biogeochemical reactions include abiotic reactions such as weathering (e.g., mineral dissolution and precipitation, ion exchange, surface complexations) and biotic processes such as plant uptake and leaching of nutrients, soil respiration, and other microbe-mediated reactions.”

Explanation: The addition of "and leaching" corresponds to our later nitrate leaching example.

**P. 6, l. 15 (TS12), l. 19-20 (TS13):**

- Remove “Friedlingstein et al., 2006; Hararuk et al., 2015“

- Remove “Davidson and Janssens, 2006“

Explanation: The original references are too many and some are redundant information. The deleted ones are all redundant references with similar info with others in the list. Even after the remove of these references, there are still more than 100 references there, which are extensive for a non-review paper.

**P. 6, l. 34 (TS14) (for information):**

In the former proof-reading, the sentence

“The Q\_{10} value can be specified in the input file.”

Should be removed. This is not the case anymore.

**P. 7, l. 15 (TS15):**

Remove “Neitsch et al., 2011; Porporato et al., 2003;”

Explanation: The original references are too many and some are redundant information. The deleted ones are all redundant references with similar info with others in the list.

**P. 8, l. 48-49 (TS16) (for information):**

In the former proof-reading, the sentence

“The model outputs include aqueous and solid concentrations of shallow and

deep zone and stream water.”

Should be altered. This is not the case anymore.

**P. 8, title of Section 5.2.1 (l. 50, TS17):**

“Domain setup: from simple, spatially lumped to complex, spatially distributed domains”

Should be

“Domain setup: from spatially lumped to spatially distributed domains”

Explanation: The subsection heading was changed to "Domain setup: from spatially lumped to spatially distributed domains", the words "simple" and "complex" were removed as they are vague.

**P. 8, l. 51-53 (TS18) (for information):**

In the former proof-reading, the first sentence in this subsubsection should be altered. This is not the case anymore.

**P. 10, l. 25-26 (TS20):**

Change the sentence

“This example focuses on nitrate (NO\_{3}^{-}), a dominant dissolved N form in water (https://criticalzone.org/shale-hills/data/datasets/) (Weitzman and Kaye, 2018).”

To

“This example focuses on nitrate (NO\_{3}^{-}), a dominant dissolved N form in water (Weitzman and Kaye, 2018).”

Explanation: The URL has been deleted because it is in the "Data availability" section.

Note: In the former proof-reading, more changes had been requested for this sentence. This is not the case anymore.

**P. 10, l. 34-35 (TS21):**

Change

“The soil N leaching process was represented using a lumped reaction that generates NO\_{3}^{-} .”

To

“The soil N leaching process was represented using a lumped reaction.”

Explanation: This information "that generates NO3-" is repeated with the following sentence "that generates NO3-". So we deleted it for reducing redundance.

**P. 10, l. 44-46 (TS22):**  
  
Change

“… surface area that represents the contact area between substrates

and N-transforming microbe and f(T) and f(S\_{w}) are soil temperature (Eq. 8) and soil moisture (Eq. 9) functions, respectively.”

To

“… surface area that represents the contact area between substrates

and N-transforming microbe.

Explanation: This information here is redundant. We have introduced f(T) and f(Sw) earlier in the section of 3.3.2 Reaction kinetics in natural soils.

**P. 10, l. 52-53 (TS23):**

Remove “(Di Capua et al., 2019)”

Explanation: The original references are too many and some are redundant information. The deleted ones are all redundant references with similar info with others in the list

**P. 14, caption of Fig. 11 (TS26):**

Change

“… uplands, resulting in a dilution C–Q pattern (modified from Wen et al., 2020).”

To

“… uplands, resulting in a dilution C–Q pattern at high discharge (modified from Wen et al., 2020).”

Explanation: It is a more accurate description.