Author's response

Report #1 comments

Thank you for your review and comments. We agree that these changes will improve the manuscript.

Section 4.1: First paragraph reads more as methods. No results are presented until 4.1.1.

We have rewritten the introduction to the results section to cover what we found and the importance of land use change and hydrological conditions.

Fig. 5b could go into methods (map) where you describe the use of groundwater well levels.

Added another inset map to Fig. 1, that shows the location of the study site (Balmoral) and the Canterbury region. This figure is referred to in the figure description of Fig. 5.

L568–569: "Over consecutive [...] vadose zone storage." Sentence is somewhat duplicated.

Agree. Have simplified and removed duplication in these statements.

Report #2 comments

Thank you for your review and comments. We appreciate your detailed comments and suggested changes. We agree that these changes will improve the manuscript.

The overall method introduction can be streamlined for better readability, such as the hysteresis approach and content in Line 250-258.

The methodology of calculating rainfall recharge has been simplified as suggested.

We have also removed duplicate statements in the hysteresis analysis methods.

Line 327: Add "(1)" to the right end of this equation

We have added an equation number.

Line 354: Add "(2)" to the right end of this equation

We have added an equation number.

Line 347: "This resulted in a 25 percent increase or decrease in exported nitrate-nitrogen (Table 2)". Referring to Table 2 improves readability by providing clarity on source of (± values).

Agree, have added a reference to Table 2 in this sentence.

(Fig. 5): There is no clear indication or relationship to Balmoral in the added map. Furthermore, this map appears similar to the one in the top-right corner of Fig. 1. Consider explicitly pointing out Balmoral on this map and placing it in the top-right corner of Fig. 1, instead of introducing the study area in the Results section.

We have added another inset map to Fig. 1 to show where the Balmoral study site and Canterbury region are located more clearly and earlier in the text.

We refer to Fig. 1 in the figure description of Fig. 5 for clarity.

Line 468: "There were higher intensity rainfall recharge events in 2021 and more rainfall recharge (265 mm) but the nitrate-nitrogen exported was slightly less than 2020 at 6.91 t yr-1 ." Could the causes of this observation be further elaborated in Section 5.3? Based on your previous statements, my understanding is that the lower nitrate-nitrogen export in 2021, despite higher-intensity rainfall recharge events, is due to the depletion of nitrate-nitrogen stores after the initial recharge events (i.e., larger hysteresis areas and rapid mobilization of nitrate-nitrogen). In contrast, in 2020, these stores were less depleted, resulting in higher cumulative export over the year. Please correct me if my interpretation is incorrect and consider discussing this result in Section 5.3.

We provide a more detailed explanation on why the exported loads vary between the initial years in section 5.3.

Line 515-523: this paragraph is not discussing the drivers of nitrate-nitrogen dynamics but comparing the measured/calculated nitrate-nitrogen concentrations with other literature (Table 1). For better coherence, consider merging this content with the paragraph at Line 565 to consolidate your discussion on the benefit of using high-frequency UV nitrate sensor data and integration method.

We have moved the second part of this paragraph that deals with load estimates to section 5.3. We have kept the initial sentences in this paragraph and expanded on the drivers of changing biogeochemical conditions in relation to observed nitrate-nitrogen concentrations.