

Interactive comment on “Storage and routing of water in the deep critical zone of a snow dominated volcanic catchment” by Alissa White et al.

Anonymous Referee #2

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This manuscript presents various data to show how critical zone “structure” influences hydrologic “function” by comparing two sites with distinct lithologies and positions within the Jemez River Basin Critical Zone Observatory. Supported by geochemical / isotopic tracers and hydrologic data, the authors found that the site with highly fractured tuff had fast responses to precipitation and contributed most of the streamflow water from its deep groundwater stores, while the site with collapse breccia included disconnected perched water table aquifer that contributed little to the stream. This study presents an impressive amount of data and analysis. However, as the manuscript is currently written, it is easy for the reader to feel a bit lost about what to focus on. I provide the following suggestions for what to clarify and potentially reorganize.

1. Clarify what is referred to as critical zone “structure” and what aspect of “structure” is the focus of the study. The abstract states the main goal of the study to be to show how critical zone “structure” controls hydrologic response, but a specific definition is not provided until Research Question 2 at the end of the Introduction – it should be stated earlier. Also, the authors alternate between “structure” and “architecture” but do not explain if these refer to the same thing or not. Finally, I am guessing that “structure” and “architecture” refer to physical properties. In the definition of “structure” in Research Question 2, the authors include “mineralogy”, but I don’t see any argument for how mineral composition affects physical flow – only how it affects water chemistry, which is used as a tracer for flow.

2. Clarify what hydrologic “functions” are the focus of the study. The authors do a good job of listing functions in their abstract (water routing, storage, mean water residence times, and hydrologic response), and these correspond to some of the subsection titles of the Results and Discussions sections. However, the research questions only seem to list the two functions of “hydrologic response” and “groundwater contributions to streams”, and not all of the subsection titles of the Results and Discussion correspond to the 4 functions listed in the abstract. One especially confusing aspect is that “storage” is highlighted in the manuscript title, but results mostly focus on different categories of groundwater stores, but not on any storage quantification.

3. Explain the broader implications of this work. The conclusions are very specific about what is occurring at JRB-CZO, and it would be good if the authors can comment on whether this understanding corroborates, challenges, or adds to what is already known about catchment behavior. One particular question I have is about the importance of the conclusions. Was it not to be expected that the fractured site would have faster response times? However, I do find it interesting that the perched water table aquifer is mostly disconnected to the stream – how commonly is this seen? What about the “structure” makes this disconnection happen?

4. I suggest that the authors either combine their Results and Discussions sections, or

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they reorganize them so that they are more distinct. Right now, with identical subsection titles, there is much repetition in places, and the reader has to keep flipping back and forth to match up results and discussion. Also, there are a lot of laborious details in the Results section – the authors could simply point to the figures (for example, no need to point out all the specific dates and discharge values in Section 3.1).

Minor points:

P4 L104-105: I'm confused. By definition, aren't springs comprised of groundwater? If it is not groundwater, then what is the water source? Also, how is this relevant to the following Research Questions.

P5, L136: Define VCNP. Fig 1 and throughout text: I suggest naming your wells in a way so that it is easier to keep track of where they are. For example, "Well 1" could be "Well T" for Tuff, and "Well 2" could be "Well B" for Breccia.

Fig 1A: Improve resolution of text.

Fig 1B: Change the color of stream line. It is not visible with the current color and transparency.

P6, L176-177: Why were different pumping methods used at the different wells?

P6, L194: For "not shown here" - either entirely omit mention of it from the paper if it does not affect your conclusions, or put in supplementary info.

P7, L223-224: how were the uncertainties associated with the background TU concentration and measured TU in samples estimated?

P8, L260: If only showing data for 2 sites, is it necessary to mention the other ones? This also applies to P9, L307.

P9, L281: Seems like Figure 4 reference precedes Figure 3 in the text.

P9, L309: What is the "node file"?

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P10, L331: Even though the water level in well 1A raises less in 2nd snowmelt event than the 1st one, and in well 2D it increases with a lower rate than the 1st snowmelt event, the discharge goes higher in La Jara stream on 4/18 relative to 3/22. Could you explain that?

Fig 3 and 4: Show the NAM time period in Figure 3 in the same way as in figure 4. Change the x-axis label to monthly intervals. Use the same scale and width for the x-axes in these two figures for easier comparison.

Fig4 , pedon 3: VWC at 65cm depth is hard to see.

P11, L361: Explain why changes in VWC are more pronounced in deeper parts. Why is the response for pedon 5 different than for pedons 1 and 6, even though they seem to have the same geology based on their locations on fig 1?

P13, L420: Could you explain why major ion concentrations are so different in wells 2A and 2B relative to 2C and 2D? If 2D is a perched aquifer with vertical connection to the wells beneath as the author mentioned in P8, L629, the temporal changes in the major ion concentrations should follow the same trend, but that is not seen in the figure.

Fig 7: It is difficult to see the trend with lines with markers. Removing markers could make it easier to read.

P13, L433: Briefly explain why Na^+ concentration increases in well 1A around June 2017 (again it would be helpful if the x-axis labels are at monthly intervals).

P14, L454: Provide discussion about the enrichment.

P14, L479-482: This sentence should be reworked. It currently implies that understanding the geochemistry is the end-goal, but actually, the geochemistry is the means for understanding the impacts of the structure and architecture. The logic in the current wording seems backwards.

P14, L497 paragraph: Is there a way to back out K values that are more relevant for

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the spatial scale of interest, which should be higher in tuff than breccia? For example, using the discharge rates and hydraulic gradients? Would the backed out K values be more consistent with literature values for high vs. less dense fractures than the slug test K results?

P15, L518: Typo: sentence ends with “and”

P16, L539: Maybe “in contrast to” instead of “however”?

P16, L546: Isn't lesser water table response to summer rains typically due to higher ET, which prevents wetting fronts to descend below the root zone?

P17, L569: delete comma after “both”

P17, L583: Seems like the correspondence of gravel and wetting patterns is major part of the paper's findings about the relationship between structure and hydrologic function. As such, the gravel data should be presented more prominently. At the very least, state what depth corresponds to the gravel-like layer. I would suggest to even further show graphically where the gravel is – either superimposed on Figure 6 or on a separate dedicated figure with similar y-axis scale.

P19, L642 paragraph: Seems out of sequence. Shouldn't this summary conceptual model come AFTER the subsequent section and old and young water?

Figure 9: The ellipses for the Summer Precip and Snow seem very approximate. Is there a more specific range?

P19, L665: Figure 10 is referenced, but it seems like a figure showing tritium results should be referenced instead. Is there supposed to be a figure showing tritium measurements?

P20, L703-704: parenthetical for “structure” includes “deep groundwater” and “longer mean residence time”, but neither of those are properties of the physical porous media. I assumed “structure” to refer to to the physical porous media.

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