We thank Dr. Chen for thoughtful and constructive suggestions. In the following, referee comments are shown in *italic fonts*, and our responses are shown in regular fonts.

*The authors investigated a remote, high-alpine catchment in the Canadian Rocky Mountains using multiple approaches, despite having very limited information at the beginning of the study. They combined hydrological, geological, hydrochemical and isotopic information to characterize the karst system, which is strongly influenced by snow and glaciers. The main outcome is a hydrogeological conceptual model that reflects the system's main hydrological and hydrogeological processes. Additionally, the authors highlight that the methods applied to this study could be transferred to other high alpine systems with similar characteristics. The manuscript is clearly structured and well written. The results seem solid. Overall, it is great work, demonstrating considerable effort in terms of fieldwork in such a remote area, as well as the combination of many different investigative methods and guidance to reach reasonable and logical interpretations, which is surely a strength of this study. However, critical discussions are missing in some places, which could be improved. I recommend considering this work as a minor revision.*

*Major comments:*

*1) Introduction / Novelties:*

*I suggest that the authors elaborate better on the novelties of this research work in the introduction. In my opinion, there are three main novelties in the current research work: 1) improvement of the process understanding about the impact of snow/ice behavior on recharge, storage, drainage and discharge in high alpine karst aquifers; 2) the combination and application of multiple investigation approaches (hydrological, hydrogeological, hydrochemical and isotopic) to a high alpine karst system to achieve a robust and coherent conceptual site model and 3) knowledge production for the local karst system (Watridge Karst Spring).*

We thank the referee for the suggestion. We will highlight these aspects of our work in the introduction of revised texts.

*2) Representativeness of weather parameters (P and T):*

*The only available weather station is located at 2260 m a.s.l. within the study area. The study area varies between 1870 (WKS) and 3406 (Mount Sir Douglas) m a.s.l. How representative are P and T measured for the entire study area, and how will the analysis and interpretation relate to the hydrological water balance and diel fluctuations of discharge and EC be influenced by these data uncertainties? It is expected that there will be spatial and temporal variation of snow/ice accumulation and melting behavior within the study area. How does this influence the diel fluctuations of discharge and EC? I suggest the authors incorporate/consider this aspect, at least for critical discussion.*

We thank the referee for pointing out the importance of elevation dependence of precipitation and air temperature. Hypsometric analysis of the effective catchment (yellow polygon in Figure 1a) indicates that 70% of the catchment is contained within an elevation range of 2100-2500m, and the median elevation of the effective catchment occurs at 2420m. Therefore, the Burstall Pass weather station (2260m) represents average precipitation and temperature of the

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catchment reasonably well. We will add a few sentences explaining this in Section 3.3 (Meteorological data), and discuss the implication in the results (Section 4.2).

*3) Artificial tracer experiments:*

*BP14(2) shows a mass recovery of 115%, which is impossible. The authors mentioned a technical issue regarding sensor calibration. How reliable are the measurements taken by the field device installed in the spring generally? Have factors such as UV, turbidity, and temperature, which can disturb the tracer measurements, been considered? To better understand the results of the tracer experiment, the breakthrough curves (BTC) should also be compared with the system input signals (e.g., precipitation, air temperature), as the shape of the BTCs differs significantly. The BTCs do not show significant tailing, but multiple peaks, which indicate the transport via multiple paths within the main karst drainage conduit network. If we assume that the measurements are reliable, how can the significant difference in mass recovery rate between BP14(2) and BP14(1) & BP11 be explained?*

We did not have high confidence in the calibration coefficient of fluorometer (Line 246-250), resulting in a large degree of uncertainty in the quantitative estimate of mass recovery. We originally thought about reporting sensor response in millivolts, instead of concentration, but we decided against the idea. We will explain this more clearly in the revised texts. We did not monitor turbidity in spring discharge. Slight increase in turbidity was visually noted in late August but we do not believe it affected the sensor performance. Water temperature was stable during the warm season when tracer tests were conducted (Figure 6b). We will add a sentence to explain these in the revised texts.

Air temperature remained mostly positive during the warm season (Figure 6a); therefore, we do not believe air temperature data are relevant to the interpretation of tracer break through curves. We will add a graph showing daily precipitation to Figure 5.

*4) Recharge area delineation*

*The uncertainty of meteorological forcing, as well as its impact on recharge area delineation and water balance calculation, should be critically discussed. In my opinion, this is one of the main sources of uncertainty when estimating the water balance of high Alpine catchments. The authors estimated that there was about 90% recharge rate (if I understood the estimation correctly) for the studied karst aquifer system. The map (Figure 1) does not show any surface drainage features (streams), so it indicates high karstification of the studied system, and precipitation or melt can easily infiltrate. The study for estimation of recharge rates for karst systems in the European Alps can be used here to support (Malard et al. 2016: A novel approach for estimating karst groundwater recharge in mountainous regions, and its application in Switzerland). To validate the recharge delineation and also the associated water balance calculation, hydrological karst modelling should be applied for future work.*

Please see our response to Comment 2 regarding the uncertainty in meteorological forcing. Relatively little surface runoff occurs within the effective catchment as pointed out by the referee (Line 95-97). We thank the referee for pointing us to Malard et al (2016). Characteristics of our study catchment (lack of vegetation, karstified surface, etc.) is similar to the study area of Malard et al. (2016). We will cite this paper in Section 4.2.

*5) Conduit flow and transport*

*In general, regarding the terms 'open channel' and 'pipe flow', I personally think that the descriptions of open and pressurized conduit flow are more accurate. Most conduits have a closed section. Depending on the water level, the conduits can be unpressurized or pressurized. The authors discussed how the existence of large pools can cause retardation during solute transport along the conduit network. In my view, there is an inconsistency or at least an open discussion point, regarding the concept of large pools when compared with dye tracer experiments. If such large pools exist in the conduit network, they should significantly impact the shape of breakthrough curves (Hauns et al. 2001: Dispersion, retardation and scale effect in tracer breakthrough curves in karst conduits; Yang et al. 2025: Effects of karst conduit structure on breakthrough curves: Experiments and modeling). Can this effect be observed or identified in the measured breakthrough curves? Additionally, the authors tried to use the concept with large pools to explain the observed increase in transport response time concurrent with the reduction in discharge. However, I think a more general reason is the change in hydraulic gradient in the groundwater level distribution in the karst aquifer during varying flow conditions. The authors used the Darcy-Weisbach equation to estimate potential flow velocity in a pressurized conduit. To my understanding, the transport time (derived from tracer experiments) and the transport response time (derived from time series analysis) should reflect the transport process through the entire aquifer (including the unsaturated and saturated parts) along fast flow paths. This is surely more than pure transport in a saturated drainage conduit. I recommend that the authors explicitly consider and discuss the role of the unsaturated part of the studied karst aquifer (e.g., the epikarst) to transport processes (transport time and transport response time). This would provide a more complete picture.*

    Similar points were made by Dr. Worthington (Community Comments 2). We will revise our conceptualization of the karst system at the Watridge site, guided by the suggestions made by Dr. Chen and Dr. Worthington. The following is an outline of our approach:

(1) We will re-examine the tracer break through curves to see if they are consistent with a system consisting of pools and open/pressurized conduits.

(2) We will re-examine the possible effects of a changing hydraulic gradient on the transport response time as a result of changing flow conditions.

(3) We will revise the estimate of gradient in the Darcy-Weisbach equation, and re-evaluate its appropriateness in the Watridge system.

(4) We will re-examine the role of vadose zone flow/transport processes and represent it more explicitly in our conceptualization.

(5) We will revise the conceptual model (Figurer 14) and completely re-write Section 5.

*Minor comments*

*1) Line 30: please remove Chen et al. 2017 and add the following references (Goldscheider 2005; Lauber & Goldscheider 2014; Lucianetti et al. 2016; Frank et al. 2019):*

    *Goldscheider 2005: Fold structure and underground drainage pattern in the alpine karst system Hochifen-Gottesacker, Eclogae geol. Helv.*

*Lauber & Goldscheider 2014: Use of artificial and natural tracers to assess groundwater transit-time distribution and flow systems in a high-alpine karst system (Wetterstein Mountains, Germany), Hydrogeol J*

*Lucianetti et al. 2016: Preliminary conceptual model of an Alpine carbonate aquifer (Pale di San Martino, Dolomites, Italy), Italian Journal of Groundwater*

*Frank et al. 2019: Sulfate variations as a natural tracer for conduit-matrix interaction in a complex karst aquifer, Hydrological Processes*

We will remove Chen et al. (2017) and add the suggested references.

*2) Figure 1: Where are the glaciers on the map? There is a legend for them, but I cannot find any in the study area.*

This was an omission. We will add glaciers on the map.

*3) Figure 14: The symbol for flow in open conduits is difficult to see. It would be useful to have a symbol for snow cover in both figures: extensive snow cover in (a) and no snow cover, only glaciers in (b). Please ensure that the saturated part in (b) is fully colored (some saturated conduits are not colored).*

We will revise Figure 14 accordingly.