

General comments

Thank you for the opportunity to review the revised manuscript again. Compared with the previous version, the manuscript has been improved in several aspects. The overall organization around the proposed Surface Active Layer Permafrost (SAP) framework is clearer, additional conceptual figures have been included, and the discussions of active layer processes, thermokarst, and groundwater processes have been expanded. However, several points still need further clarification.

Major comments

(1) The Abstract mainly describes the topics covered under the three dimensions, but it does not clearly explain why the SAP framework is used or what conclusions are drawn from this framework.

(2) The Abstract refers to “large scale permafrost hydrology”, and Section 3.4 also uses the heading “Large scale permafrost hydrological processes”. However, the manuscript does not clearly define what “large scale” means. The authors should clarify this term and further explain whether hydrological processes at slope or headwater scales differ from hydrological responses at larger basin or regional scales.

(3) In the first paragraph of the Introduction, water tracks are highlighted, but they are not adequately addressed later in the manuscript. The paragraph describes water tracks as critical conduits for water and sediment flux across hillslopes, but their role in permafrost hydrological processes is not further discussed.

(4) In the second paragraph of the Introduction, the influence of permafrost on hydrological processes is still not sufficiently explained. The paragraph first emphasizes the importance of permafrost for hydrological processes in mountainous basins, but then focuses mainly on estimates of ground ice storage. This may suggest that the hydrological role of permafrost is mainly related to ground ice storage, rather than active layer changes, infiltration processes, and hydrological connectivity.

(5) The Method column in Table 1 is not consistently defined. It includes specific analytical methods, such as runoff partitioning based on isotopes and electrical conductivity and hydrograph separation, but also includes data sources, such as long term discharge records, and nonspecific entries, such as multiple methods. The authors should clarify the meaning of this column.

(6) The title of Section 3.3 does not fully match the content of the section. The section is titled “River channel hydrological processes”, but much of the text discusses riverbank retreat, lateral channel migration, floodplain subsidence, channel geometry, and channel morphology.

(7) In Section 4.1, the description of active layer hydrological processes appears too deterministic. The authors write that “Groundwater storage and flow capacity increase linearly with active layer depth”. The use of “linearly” implies a strong quantitative relationship. The authors should provide clear evidence for this linear relationship or revise the wording.

(8) In Section 4.1, the wording “active layer functioned as an impermeable barrier” needs clarification. During the early thaw phase, snowmelt infiltration is usually limited by frozen soil rather than by the active layer as a whole. The active layer is a seasonally freezing and thawing soil layer, so this wording may confuse the active layer with the frozen soil that limits infiltration.

(9) In Figure 2, the representation of surface soil moisture is ambiguous. The surface soil in the initial thawing stage is shown as wet, whereas the late thawing stage and completely thawed stage are marked as dry soil. However, the soil moisture versus soil depth plot below the figure shows higher surface soil moisture in the late thawing and completely thawed stages than in the initial thawing stage. The authors should check the dry soil and wet soil labels and clarify the correspondence between soil moisture and the different thawing stages.

(10) The title of Section 5.1 does not fully match the content of the section. The section is titled “Transformation relationships between surface water and groundwater in permafrost regions”, but the discussion mainly focuses on water age determination and geophysical exploration. The section currently emphasizes methods rather than the related hydrological mechanisms.

(11) In the third coupling point of Section 6, the basis and applicability of the 40% ground ice content threshold need further clarification. The authors use a volumetric ice content of approximately 40% as a key threshold affecting hydraulic conductivity, but this is a strong quantitative statement. If the authors consider this threshold applicable to other permafrost regions, they should provide additional references or further discuss its applicability across different permafrost catchments.

Detailed comments

(1) Some lines in Figures 2, 3, and 4 are not sufficiently clear. The authors should improve the figure resolution and make the arrow lines easier to distinguish.

(2) In Figure 2, the meaning of the dark blue water body is not clear. Does it represent groundwater storage? No corresponding legend is provided in the figure. In addition, from the mid thaw stage to the completely thawed stage, the dark blue water body appears to decrease. The authors should clarify whether this indicates a decrease in

groundwater with active layer deepening.

(3) The terminology in Table 1 is not fully consistent. For the same reference, the Huangheyuan station is described as “Permafrost thaw water contribution to annual runoff”, whereas the Tangnaihui station is described as “Permafrost meltwater contribution to annual runoff”. The authors should check the use of “melt” and “thaw” throughout the manuscript and standardize the related terminology.

(4) In Section 7.2, the relationship between active layer hydrological processes and suprapermafrost hydrological processes needs further clarification. The manuscript discusses active layer hydrological processes and then refers to the suprapermafrost water system. The authors should clarify whether these terms refer to the same type of process or to different processes within the active layer and the suprapermafrost water system.