General Comments

The paper presents an innovative framework for mapping wet snow in the Karakoram region using SAR and topographic data. The integration of the Gaussian Mixture Model (GMM) to determine the Wet Snow Index (WSI) and the calculation of the Topographic Snow Index (TSI) significantly improve the accuracy of snow mapping in complex terrains. And I do appreciate the extensive data sources used by the authors, including Sentinel-1 SAR imagery, Digital Elevation Models (DEM), and Sentinel-2 Level-2A imagery, which ensure robust and detailed mapping of seasonal snow melting. The continuous analysis of Wet Snow Extent and Snow Melting Duration provides valuable insights into the temporal and spatial dynamics of snow melting in the Karakoram region, offering excellent references for water resource management and hydrological modeling, especially in glacial and high mountain areas with complex terrain.

However, I have several concerns regarding the complexity of the methodology and the unclear use of data, as well as the lack of quantified uncertainty analysis. Therefore, I recommend that the paper undergo revisions before it can be considered for publication.

Here are my detailed comments:

Line 47, should be “includes”

Line 96, Please specify the spatial resolution of the DEM.

Line 109, Please specify the Sentinel-2 spectral bands used to calculate the LIS in the paper.

Line 122, It is unclear which corrections and preprocessing methods were adopted in the GAMMA software for SAR image processing. Did you apply terrain correction or geometric correction?

Line 131, The focus season of the paper is summer. Why was a multi-year winter value chosen for the reference γ, Does the reference γ have a spatial pattern climatology or a single value for each basin?

Line 146, In the GMM model, which covariance structure did you choose? Were other parameters set by default?

Line 175, I am a little confused about the SI definition. From my understanding, is the WSI first scaled by the TSI, meaning SI = WSI/ TSI? Then you have an SI map, and to further differentiate the wet snow, a threshold of 3.5 is selected. Is this threshold basin-dependent or applied across the entire Karakoram? How do you determine that 3.5 is the optimal threshold, and how do you quantify the uncertainty resulting from this coefficient?

Eq. 7, should be “ρ_B”?

Line 184, It would be better if you could clarify the exact thresholds used in the S2 snow cover detection. Currently, the flowchart for S2 is unclear. Specifically: (1) First step to meet the condition NDSI >0.4 and ρ_B>0.2; (2) the dark cloud region only defined by ρ_B>0.3? Can you explain what is bi-linearly down-sampled red band, from which resolution to which resolution?; (3) and then calculate the snow cover fraction (SCF) at which resolution? (4)

Line 196, is this for dark cloud pixels above the snowline? Based on your description, above snow line, 'no-snow' is defined by NDSI >0.15 and ρ_B>0.04 and ρ_B<=0.1, and dark cloud is defined by NDSI >0.15 and ρ_B>0.1? How consistent are these relaxed thresholds compared to the strict threshold ρ_B>0.3 mentioned in 191? Generally, if you are strictly following Gascoin et al. (2019), you can briefly refer to their method, but any changes should be clearly mentioned; otherwise, restate the algorithm clearly and concisely.

Line 203, When you mention summer, which months are included?

Line 204, I am curious about the accuracy in S2 classification, and is it possible to estimate its uncertainty? Generally, in which confidence (and at what elevation) can S2 snow mostly be considered melt snow during summer, given that the accuracy matrix is calculated by comparing snow-free or snow from S2 with no-or-dry snow or melt snow from SI?

Figure 6, How do you explain the remaining mismatch in the ice and melt categories between SI/Rc and S2 detection in the Hunza region?

Figure 7, How do you explain the steeper slope of the snow coverage profile in the SI method compared to the flatter slope in the Rc method?

Line 243, when calculating the SWE and SMD, do you also include the area where a.s.l. over 5500m? Then how to make sure the accuracy above 5500m, given that these areas were excluded in the S2 validation?

Line 256, what level of precipitation and temperature are adopted here, surface or pressure level?

Line 269, does it mean that each pixel you have the wet snow days in total in terms of the whole summer season, then I don't know the purpose of rescale it into 365 days since I guess most of the melting is in summer? It is not appropriate to extend the summer research into the annual. You could just use real wet duration instead.

Line 290, It may not be suitable to use words like "greatly" to describe the improvement if the new classification's improvement is around 5%.