Response to Reviewer 2

The manuscript “Dynamics of snow and glacier cover in the Upper Karnali Basin, Nepal: An analysis of its relationship with climatic and topographic parameters” presents a significant and timely study of snow and glacier changes in the Upper Karnali Basin, Nepal. The authors have successfully analyzed snow covered area(SCA) change during 2002 and 2023, and the relationship between SCA and climate change. This work highlights SCA, as a critical, yet hitherto under-researched, component of the region’s water resource, especially when compared to glaciers. The study’s findings have important implications for understanding regional hydrology, assessing regional water security. The manuscript is well-written and the conclusions are well-supported by the data. I recommend acceptance of this manuscript after minor revisions.

Response:

Thanks for your valuable and insightful comments and suggestions. In the manuscript, while addressing the reviewers’ comments, I came across several mistakes and inconsistencies, and identified issues in text, tables, figures, and references. I have attempted to address and incorporate the comments and suggestions with sincerity and care.

General comments

1. Data sources and methods should be given much more detail. Authors mentioned that MOD10A1 was used to analyze the SCA, and also pointed out that cloud-masked snow cover data was classified into four seasons and calculated using a threshold-based binary mask. But Authors must analyze the uncertainty of SCA due to cloud-masked.

Response:

To address the issue of cloud-contaminated pixels in daily MODIS snow cover data, we also utilized the MOD10A2 8-day composite product, which applies a maximum snow extent algorithm across an 8-day window. This approach significantly reduces cloud-induced gaps by retaining the clearest observation for each pixel, thereby increasing spatial coverage and improving the reliability of seasonal snow estimates in cloudy months (Parajka and Blöschl, 2008). While it loses daily temporal resolution, the 8-day composite effectively smooths out short-lived cloud effects, offering a more stable dataset for trend analysis.

1. There are two SCA, one is derived from the resolution of MODIS products (500m). Another is derived from Landsat (30m). However, authors did not describe how to combine both SCAs. In addition, The Higher resolution from Landsat could be used to evaluate the uncertainty of MODIS products. But I do not see there is uncertainty evaluation.

Response:

I agree that the disparity in spatial resolution between MODIS (500 m) and Landsat 8 (30 m) can result in mixed pixels within MODIS data, especially in regions characterized by patchy snow cover. The uncertainty associated with MODIS-derived snow cover area (SCA) can be assessed by employing higher-resolution Landsat 8 imagery as a benchmark. The finer 30 m resolution of Landsat 8 provides more precise delineation of snow cover, particularly in heterogeneous

landscapes, rendering it an appropriate reference for evaluating the coarser 500 m MODIS product.

Sampling and Data Preparation

To facilitate comparison at a consistent spatial scale, we resampled Landsat 8 SCA maps to a 500 m resolution to match MODIS grid cells. Each Landsat scene covers an area of 185 × 180 km. From each resampled scene, 10% of the total pixels (approximately 13,320 pixels) were randomly selected as vector points using ArcGIS. These points represent snow or non-snow classes (including cloud-covered areas).

The layer of random points was overlaid on the corresponding MODIS SCE maps, and the MODIS snow classification values were extracted to the attribute table of each point. This created a composite attribute table containing snow/non-snow classifications from both Landsat 8 and MODIS for each sampled point.

Accuracy Assessment and Confusion Matrix

Accuracy assessment was conducted using a confusion matrix (Table 1) to evaluate the agreement between the two products. The analysis focused on six scenes selected based on a <7% cloud cover threshold to minimize misclassification due to cloud obstruction. Two scenes were from the Upper Karnali Basin region, and one was from eastern Nepal.

Table 1. Confusion matrix showing the matching of pixels of Snow cover extent derived from MODIS and Landsat 8 /Sentinel 2 as a measure of accuracy the processed MODIS snow product (Example).

		MODIS			
		Non snow	**Snow**	**Total**	**User's accuracy**
Landsat (30 m) resample to 500 m	**Non snow**	8950	2472	11422	**78.35**
	Snow	144	4744	4888	**97.05**
	Total	9094	7216	16310	
	Producer's accuracy	**98.4**	**65.7**		
	Overall accuracy	**83.97**			
	Bias	**0.93**			

Results

The comparison of MODIS and Landsat 8 SCA classification yielded overall accuracies (OA) ranging from 77.5% to 94.9% across the six evaluated scenes (Table 2). These findings align with previous validation studies and demonstrate that while MODIS provides a reliable estimate of snow cover at a broader scale, resolution-induced uncertainty exists and can be quantified effectively using higher-resolution data such as Landsat 8.

Table 2. Description of Landsat 8 surface reflectance data (Bands 3, 6, 5, and 9) used for validating daily MODIS Snow Cover Extent (SCE), including acquisition date, cloud cover percentage, overall classification accuracy, and bias. The last column indicates the region of the scene (MW = Mid-Western, FW = Far-Western, E = Eastern Nepal).

S.N	**Date**	**Cloud cover %**	**Overall accuracy**		**Bias**	
1	03/08/2020	6.52	83.96		0.93	MW
2	03/27/2021	4.45	94.89		0.86	MW
3	03/02/2021	5.2	86.21		0.88	FW
4	12/31/2021	2.36	77.59		0.99	FW
5	23/04/2021	6.9	97.62		0.94	E
6	21/12/2019	5.29	97.22		0.78	E

A comparative analysis was conducted between snow cover extent derived from MODIS data (spatial resolution of 500 meters) and that obtained from Landsat-8 imagery (spatial resolution of 30 meters) on a sub-scene basis to evaluate the accuracy of the datasets (Table 3) The observed discrepancies in snow cover extent ranged from approximately 1.3 to 1.6 times. The MODIS data exhibited spatial overestimation of snow cover extent, attributable to its coarser spatial resolution. Therefore, it is essential to recognize the magnitude of data discrepancies arising from differences in spatial resolution when interpreting snow cover information

Table 3. Comparison of snow-covered pixel counts and areas derived from MODIS (500 m resolution) and Landsat 8 (30 m resolution) for selected dates. The exaggeration factor represents the ratio of the MODIS-derived snow-covered area to that of Landsat 8, highlighting the potential overestimation caused by the coarser spatial resolution.

Date of scene			MODIS 500 m	Landsat (30 m)	Exaggeration factor
		Count	22878	4758571	
3/8/2020		Area (ha)	432200	571950	1.3
		Count	6587	1342895	
3/27/2021		Area (ha)	171425	120860	1.4
		Count	4736	815756	
2/3/2021		Area (ha)	118400	73418	1.6
		Count	12042	2037280	
12/31/2021		Area (ha)	301075	183355	1.6

1. GFor the land surface temperature (LST), there is difference between glacier surface temperature and other surface cover (Wu et al., 2015). I'm skeptical of the existing results.

In this investigation, snow and glacier cover are considered collectively as a unified cryospheric component due to their analogous functional roles. Moderate Resolution Imaging Spectro radiometer (MODIS) land surface temperature (LST) data at a spatial resolution of 1 km were utilized to examine temperature trends across these combined areas, rather than isolating

glacier-specific thermal measurements. Although appropriate for analyses at the basin scale, MODIS data lack the spatial granularity necessary to resolve fine-scale thermal heterogeneity on glacier surfaces. Wu et al. (2015) demonstrated that glacier surface temperatures exhibit variability influenced by factors such as albedo, shading, and surface roughness, employing a split-window algorithm with Landsat ETM+ imagery to attain enhanced accuracy (root mean square error approximately 1.2°C). Consequently, MODIS LST data are interpreted herein with respect to seasonal and elevation patterns, while recognizing their limitations for detailed assessments focused exclusively on glacier-specific temperature dynamics.

This clarification has been incorporated into the discussion section to address the reviewer's concern. And the prescribed references has been incorporated.

Specific comments

Line45 therby-thereby

Response: Corrected as 'thereby'

Line 194 P=0.00??

Response: Corrected to 0.001

Figure 6 have to mark the sub-figure as a,b,c,d, those sub-figures are also be explained in title. The same as Figure 9,11

Response: All sub-figures were marked as A,B,C)

Figure 8, The temperatures for different elevation bins were shown in Figure 8. It is very nice to show the temperature rate along with the elevation. However, I do not know where the data of temperature come?? Is it LST or ERA5?

Response: It is MODIS derived LST. Incorporated in Figure 8

Line 316 Snow cover the trend in Glacier Basins-> The snow cover trend in Glacier Basins

Response: Corrected.

Figure 11 January-march_ "delete _"

Response: Deleted "_"

Line 431 exhibits what???

Response: Corrected**. …**exhibits less snow cover.