On behalf of all the co-authors, I would like to thank the reviewer, Anonymous Referee #1, for his thoughtful and constructive comments which helped us to improve our study. We have responded to comments as follows:

NOTE

Anonymous Referee #1 Comments (Black font)

Authors Responses (Red font)

Specific changes that were made in the manuscript (Blue italic)

1. The manuscript deals with the compilation of a glacier inventory in the Karakoram region. The topic is of high interest to the scientific community, and not only. The manuscript is well written (there are a few typos to check, e.g. line 248), but there are some issues to be solved before its publication. First of all, authors need to describe all the, employed, data at the beginning of Section2; currently, ancillary data, which constitute an important part of the processed ones, are progressively introduced during the description of the various elaboration.

Response: Thank you for your valuable suggestions. We have made modifications according to your suggestions, including adding a section (Sec. 2.1) to introduce all the data used in this study, and described the data in detail in Table 1.

"*2.1 Datasets* ***(Partial content)***

This subsection lists all data sets covering the Karakoram that are used to produce and assist in the analysis of the multi-temporal glacier inventory, including optical images from different satellite sensor, digital elevation model (DEM), four previous glacier inventories, three supraglacial debris extents, two surge-type glacier inventories, two modelled ice thickness data, hydrological basins and river networks. Table 1 summarizes their key characteristics, presenting their sources, date, application in this study and access link.

At least 12 Landsat images are required ……

Table 1 Lists of data sets covering the Karakoram mountain that are used in this study. (***Partial content)***

Data Name	Sources	Date	Access
Satellite images	Landsat TM, ETM and OLI +30-m/ 15-m images	1990, 1991, 1993, 1994; 2000, 2001; 2009, 2010; 2018, 2019, 2020 (details see Table S1)	GEE asset or https://earthexplorer.usgs.gov/
	Sentinel-2 10-m images	2020-08-25, 2020-08-23	GEE asset or https://scihub.copernicus.eu/
	Planet 3-m images	2019-05-29	Ordered and download via Planet's APIs
DEM	30-m ASTER GDEM V3	2000-2013	https://e4ftl01.cr.usgs.gov/ASTT/ASTGTM.003
…	…	…	…

"

2. Concerning subsection 2.6, to improve readers' comprehension, a figure, like Fig. 4, should be added. Moreover, if applied to debris-covered glaciers, the discrepancies between the two methods highlight their proneness to errors in their mapping.

Response: Thank you for your suggestions. We added a figure (Fig. 5) and rephrased the text.

Among the feasible methods to determine accuracy and precision of glacier outlines(Paul et al., 2017), the buffer method (most used) and multiple digitizing (including area difference) are the most commonly used and effective methods (Mölg et al., 2018; Paul et al., 2020; Paul et al., 2017; Guo et al., 2015)(Mölg et al., 2018; Paul et al., 2020; Paul et al., 2017; Guo et al., 2015). The buffer method provides a minimum/maximum estimate of precision that scales with glacier size. Its overall value will thus vary with the size distribution of the selected sample. Due to the mapping uncertainty of the debris-covered glaciers is usually greater than clean ice, a 30m buffer was used to evaluate the uncertainty of the debris-covered part in this study, as in previous studies, it is also treated differently (e.g., ±2% for clean ice, ±5% for debris-covered, or±5%) (Paul et al., 2017; Mölg et al., 2018).

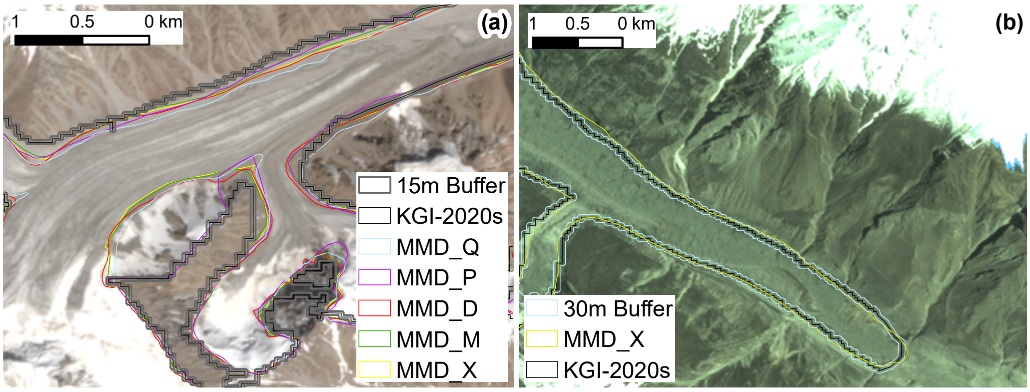

*Fig. 5. Overlaying of a 15m buffer (**a**) from the KGI-2020s glacier extent and a 30m buffer (**b**) from the supraglacial debris extent with MMD outlines on the base map of Sentinel-2 and Planet image*.

3. In Section 4, the authors should immediately state that due to the different approaches, data sources and methods cannot be compared without a high level of uncertainty and maybe, only qualitatively. Subsection 4.3 should be shortened and merged with the previous one.

Response: Thank you for your suggestions. We have stated this situation at the beginning of section 4.1. Subsection 4.3 has been shortened and merged into subsection 4.1 and subsection 4.2.

*"**However, due to the different approaches, data sources and methods among different glacier inventories, cannot be compared without a high level of uncertainty, so this is only a qualitative comparison.** The Karakoram boundary …".*

Shortened subsection 4.3:

"Moreover, referring to the suggestions of Braithwaite and Raper (2009) and (Sakai et al., 2015), we assume that median glacier elevation could act as a proxy for long-term equilibrium line altitude, which

is correlated with the glacier mass balance budget, that can be used to describe the state and fate of glaciers (Fujita and Nuimura, 2011). Among the five sub-basins in the Karakoram, as shown in Table S6, the median elevations of glaciers in the three basins with increasing glacier coverage decreased, while the altitudes increased in the basins with decreasing glacier area. Spatially, as pointed out by Bolch et al. (2012), the median elevations increase with the distance from the moisture source (Fig. S5). The glaciers in the northwest exposed to the westerlies and heavily debris-covered have a relatively low median elevation, while the glaciers north or northeast of the main ridge of the Karakoram have a clearly higher median elevation. On the whole, the median elevation of the Karakoram glaciers showed an increasing trend during 1990-2020, indicating that glacier melting likely is becoming more intense, with runoff moving towards peak water (Huss and Hock, 2018; Nie et al., 2021). Especially in the melt-dominated Tarim and Indus basins, accelerated glacier melt is the main contributor to rising 21st century streamflow, which increases before peak water, then declines (Huss and Hock, 2018; Rounce et al., 2020; Nie et al., 2021).

Multi-temporal glacier inventories are an important data source for either basic glacier outlies or as a validation set when computing glacier mass changes and associated runoff from projection models. Based on published ice thickness data, we calculated the ice volume in Karakoram is 2.03 ± 0.52 $\times 10^3$ km^3 (Farinotti et al., 2019) or 2.81 ± 1.08 $\times 10^3$ (Millan et al., 2022), which has a potential contribution to sea-level rise of 4.88 ± 1.27 mm or 7.11 ± 3.07 mm. Taking into account different glacier extents in different periods, these projections will produce a variable error of 0.36 ~ 0.49%. "

4. Conclusions should mention that the processing is carried out by semiautomatically processing Landsat images and ancillary data.

Response: Thank you for your suggestion. We have stated in the conclusion.

*"In this study, first we generated inventories which allowed us to systematically detect glacier change patterns in the Karakoram range over the past three decades by using 186 Landsat scenes **and ancillary data** through a semi-automatic method based on the Google Earth Engine cloud-based platform."*

5. Additionally, some parts need rephrasing as they are unclear to the reader:

Response: Thanks. We rephrased the two sentences.

- Lines 174-181;

"A similar threshold was also used for generating glacier inventories for large regions elsewhere (e.g. Ke et al. (2016)). Second, since many pixels outside of the glacier extent are considered to be supraglacial debris in the initial debris-covered data, glacier outlines from previous glacier inventories were used as a mask to eliminate them, as suggested in similar studies (Bolch et al., 2010; Scherler et al., 2018; Baumann et al., 2020). We combined two earlier glacier inventories (90% CCI + 10% GGI18, to fully cover Karakoram glaciers) as the mask layer for KGI-1990s, and the

subsequent KGI-2000s, KGI-2010s, and KGI-2020s rely on the earlier revision of the glacier inventory (KGI-1990s, KGI-2000s and KGI-2010s in that order).”

- Lines 292-307.

“*As a second measure of uncertainty, we applied the buffer method (Bolch et al., 2010; Granshaw and G. Fountain, 2006) on the contiguous glacier polygons. Accordingly, a buffer of ± 1/2 pixel (i.e., 15 m) for the KGI outlines (Fig. 5a) were generated and the area difference between the area of the KGI buffer and the KGI was used as the uncertainty measure. The uncertainty for the four periods KGI data are ± 5.31%, ± 5.18%, ± 5.12% and ±5.21%, with an average of ±5.21%. In terms of the debris-covered areas, generally, a buffer of ± 1 or 2 pixels (30 or 60 m) buffer was suggested in previous research (Mölg et al., 2018; Paul et al., 2020). The uncertainty of the debris portion in this study was evaluated through the ratio of the glacier area to the debris cover area multiplied by the uncertainty of ± 1 pixel (30m) buffer (Fig. 5b), resulting in uncertainty of ±27.89%, ±29.39%, ±28.20%, and ±29.76% for the four periods, with a mean value of ± 28.81%.*

For the whole glacier, the mapping uncertainty based on the “round robin” experiment is within the estimation range based on the buffer method, indicating that the ‘round robin’ value can be used as a reasonable estimation of the uncertainty. Hence, we used this value ($\sigma = \pm$ 3.68%) as the uncertainty value for all KGI data in this study. The area change uncertainty (σ_Δ) was estimated according to the standard error propagation, as root sum square of the uncertainty for outlines mapped from different periods, but only consider the glacier parts which showed change in the 1990s and 2020s (ΔA_{1990s} and ΔA_{2020s}) (Bhambri et al., 2011; Zhang et al., 2018; Li et al., 2022), calculated as : $\sigma_\Delta = \sqrt{(\Delta A_{1990s} * \sigma)^2 + (\Delta A_{2020s} * \sigma)^2}$.”

6. In the data repository, the uncertainty statement is different from the one cited in the paper [±5.03% ≠ ±3.68%], please clarify.

Response: Thank you for pointing out the mistake. Due to the manuscript was revised twice according to the editor's suggestions before the interactive discussion, the uncertainty evaluation result changed. We neglected to synchronize the description of data assets. It has been revised now, and we will update all the information of the data assets when the revision of the manuscript is finished.

There are also minor comments as follows:

7. Subsection 2.5 is written in the wrong format;

Response: Thank you. We have revised it.

8. Line 485, please mention rockfalls in addition to avalanches;

Response: Thank you for your advice. The influence of rockfalls have been mentioned in this sentence.

“Increased snow avalanche activity and ***rockfalls*** *at high altitudes may have brought more debris to the glacier (Hewitt, 2005), thus…”*

9. when regression or correlation analyses are cited statistical significance (p value) and the correct parameter should be cited;

Response: Thank you for your suggestion. Correct and reasonable parameters (including correlation coefficient r and p value for evaluating significance) are updated and used for correlation and regression analysis in the revised manuscript. And the involved figures have been redrawn.

10. Maps should be improved by removing the north arrow and scale (the coordinates in the outline give the same information) or by placing them in the same area of the legend (i.e. unique white background).

Response: Thank you. According to your suggestion, we have improved all the figures (including supplementary figures) in the manuscript.

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