Dear *Prof.* Simon Mudd,

We submit a revised version of our manuscript entitled "Drainage rearrangement in an intra-continental mountain belt: A case study from the central South Tian Shan, Kyrgyzstan " for consideration for publication in *Earth Surface Dynamics*. We would like to thank two referees for their insightful reviews, which helped us improve the overall quality of the manuscript.

Both referees have requested a more statistical analysis of the transient knickpoints pattern in our case study, which we now have added to the manuscript. Following referee #2's suggestion, we simulated a 1-D river profile model incorporating quantified incision and knickpoint migration to compare with the empirical study, with the assistance of *Dr.* Fergus M^{c}Nab. Therefore, we propose to include him to the co-author list as well.

Please find attached our detailed responses to the referee #1, with edits in red, and to the referee #2, with edits in blue. We have also added unprompted edits in purple to specify the background knowledge of transient knickpoints, modelling setup, as well as acknowledgement. We hope that our manuscript is now more suitable for publication. We look forward to your thoughts!

Yours sincerely,

Lingxiao Gong (on behalf of all authors)

RC1: 'Comment on egusphere-2023-2651', Anonymous Referee #1, 14 Mar 2024

The paper entitled “Drainage rearrangement in an intra-continental mountain belt: A case study from the central South Tian Shan, Kyrgyzstan” by Gong and co-authors, presents a geomorphic analyze of the Saryjaz drainage basin localized in the Kyrgyz Tianshan. Based on a topographic analyze and the measurement of various geomorphic metrics, the authors identify knickpoints of different origins. They found several transient kick points in tributaries downstream of 180° direction change of the Saryjaz river. Authors argue these transient knickpoints were created by a large river capture which occurred 1.5-4.4 Ma ago and was driven by the overfill of a large intermontane basin.

Reconstructing the drainage evolution of a given river basin through time is often challenging because rivers, being very active and mostly destructive in intramountain area, leave few remains of their past. To tackle this issue, this study presents an interesting geomorphic approach which combine various measurements of several metrics mainly to identify knickpoints along river profiles. The main results of the paper, ie the identification of the transient knickpoints, is mostly robust. However, (1) the general motivation of the study is unclear, (2) the interpretation on the origin of the transient knickpoints (i.e river capture) should be better supported by a robust (statistical?) analysis, and (3) the scenario proposed to explain this supposed river capture (i.e. basin overfill and inverse river flowing) is speculative since not supported by any robust observations/data. More observations, analyses and quantifications are needed to better support this story.

These 3 main issues should be better addressed before final publication.

We thank the reviewer for their detailed and constructive comments, which have shown us where clarifications in the text were needed and helped us to strengthen several of our arguments. We have also considered an alternative to the final capture scenario that addresses inconsistencies that the reviewer identified. To try to address these points, we made the following modifications to the manuscript (***bold, italic text*** is new):

Motivation and goal of this study

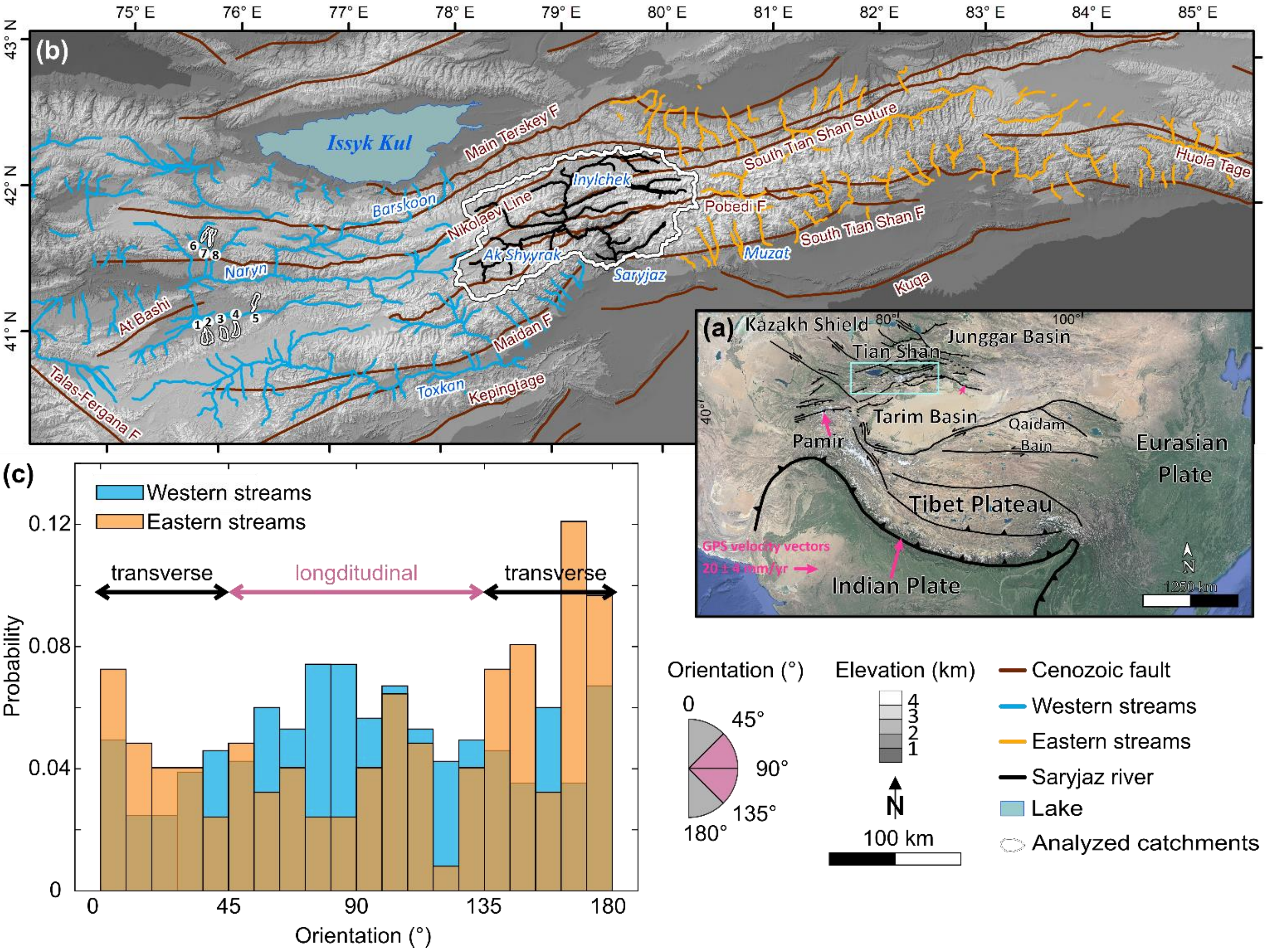
The general motivation of this work and why authors have decided to study the Saryjaz drainage basin is unclear and based on a subjective assertion. It is said lines 52-54 “Within this tectonic and climatic context, the South Tian Shan exhibits a significant contrast between a longitudinal drainage pattern in the west and transverse drainage in the east (Fig. 1).”

Also L83-85: “Drainage basins in the east are mostly characterized by transverse streams, whereas to the west, they show longitudinal patterns. The transition zone between these two drainage patterns hosts both the highest topography and the Saryjaz River catchment (Figs. 1, 2).”

So, as far as I understood, the starting point of this study is a supposed contrast in river drainage pattern between East and West of the South Tianshan and the fact that the Saryjaz basin is located at the transition zone and is, therefore, of particular interest. **First, what means East and West ? With respect of what? Longitudes should be given.**

We added the longitudinal ranges of the 'eastern' and 'western' streams in the South Tian Shan to the text: Drainage basins in the east ***(between 80-85°E, see streams colored in orange in Fig. 1b)*** are mostly characterized by transverse streams, whereas to the west, they show longitudinal patterns ***(between 74-78°E, see streams colored in blue in Fig. 1b)***.

We also updated ***Fig. 1b*** (see below) which now shows the 'eastern streams' and 'western streams' in different colours, as well as the Saryjaz river in black to provide a direct comparison of the two sides.



More importantly, this assertion of a contrasted drainage pattern is qualitative and may not be supported by the data. Indeed, the only argument presented by the authors is a rapid interpretation of Fig. 1 which displays the main rivers around the Saryjaz basin. Yet, on this figure several large longitudinal rivers are also present to the East of the Saryjaz basin as well as transverse rivers to the West. Moreover, why focusing only on this part of the South Tianshan? This range is much larger. Farther East (longitude >E83° which is the limit of Fig.1) the range is dissected by a long longitudinal river that goes down to the Bayanbulak intramountainous basin.

In conclusion, the statement that the drainage pattern of the South Tianshan exhibits a longitudinal contrast is rather vague, subjective though important for the study. This needs to be strengthened for instance using a more quantitative approach. Below is a suggestion of a quantitative analyze of the flowing directions of rivers in the South Tianshan (see screen shot in Fig. A that show the region that I have selected). This analyze could likely be refined/improved.

Using GIS and 90m SRTM DEM I extracted the flow directions of each cells of the main rivers (defining an arbitrary accumulation threshold). The figure B shows the frequency distributions of the NS, EW, NW-SE and NE-SW directions along longitudes. The frequency values are normalized to the total number of cells found for each bins of the histograms. We see from this figure that the change of East-West flowing directions in South Tianshan is tenuous. May be, it increases a little from E79° to E77° of longitude?

NB: I restricted my analyze to the main reliefs and excluded the large Tarim flat foreland basins

This is a very good point. The plots from the reviewer nicely show the normalized frequency of flow orientation along strike. To highlight the differences in drainage patterns to the west and east of the Saryjaz drainage, we now include a histogram of flow directions for these two sets of rivers in ***Fig. 1*** (see previous page).

The procedure we followed to create this histogram is the following: by using MATLAB, Topotoolbox 2 and the Copernicus GLO-90 Digital Elevation Model, we define a base-level elevation at 1500 m (piedmont elevation to the Tarim basin), extract the main rivers (accumulation threshold = 10 km) flowing through the South Tian Shan (excluding basins such as Tarim and Issyk Kul). We extract the flow orientation of rivers following cardinal directions; 0: N-S, 45°: NE-SW, 90° E-W, 135° NW-SE, and 180°: S-N. We also plotted the normalized frequency of river orientation from the 'eastern' (in orange) and 'western' (in blue) in a histogram (bin = 9°).

Considering that the strike direction of the South Tian Shan is mostly W-E, the orientation of streams in the directional ranges [0, 45º] and [135º, 180º] can be classified as mostly transverse, while those oriented between [45º, 135º] are longitudinal. The histogram shows that the majority of the 'eastern streams' have an orientation between [0, 45º] or between [135º, 180º] (i.e., transverse), while the 'western streams' are more variably oriented but show a maximum around 90º (i.e., longitudinal). Please see our updated ***Fig. 1*** for complete information.

The flow accumulation threshold should be better defined as the limit between the hillslope and fluvial processes (log plot of slope vs. drainage area).

On a regional scale, it is impractical to define the flow accumulation threshold for fluvial processes in each drainage, given that functions that operate on a DEM to define the flow accumulation network take the argument of a single minimum drainage area. Instead, we follow a fairly standard approach of choosing a minimum drainage area of 1 km^2 to initially define our drainage networks. We found that this value was sufficient to remove portions of the catchment dominated by hillslope processes, both by examining k_{sn} maps (no systematic lowering of ksn in the uppermost reaches) and chi plots (no systematic lowering of slopes in the uppermost reaches).

We modify the sentence in the main text that mentions the cut-off to the following: "Streams used for longitudinal profile and χ analysis were extracted with a minimum drainage area of 10^6 m^{2,} ***which we found was sufficient to exclude portions of the basin dominated by hillslope processes***."

Also, the strike of the range is not purely E-W while the flow directions were calculated based on cardinal points.

We agree with the reviewer that the strike of the South Tian Shan is not purely W-E, from around ENE-SWS between 73-83°E, to ESE-WNW between 83-86°E. Here we use cardinal directions as a standard to compare stream orientation on both sides of the Saryjaz river, and we think this sufficiently clearly shows the differing trends of these two sets of rivers.

Authors also need to clarify their zone of interest. What means "South Tianshan"? Why not considering longitude >E83°?

Following previous studies (e.g., Yin et al., 1998; Jourdon et al., 2017; Morin et al., 2019; see complete reference below) and the Cenozoic topography, we added a definition of the "South Tian Shan" as ***between the Talas-Fergana fault to the west (around 75°E) and Huola Tage Mountain to the east (around 85°E), separated from the North Tian Shan by the Main Terskey fault, and from the Tarim Basin by the Maidan fault and South Tian Shan fault.***

Yin, A., Craig, P., Harrison, T. M., and Ryerson, F. J.: Late Cenozoic tectonic evolution of the southern Chinese Tian Shan, Tectonics, 17, 1–27, 1998.

Jourdon, A., Petit, C., Rolland, Y., Loury, C., Bellahsen, N., Guillot, S., Le Pourhiet, L., and Ganino, C.: New structural data on Late Paleozoic tectonics in the Kyrgyz Tien Shan (Central Asian Orogenic Belt), Gondwana Res., 46, 57–78, https://doi.org/10.1016/j.gr.2017.03.004, 2017.

Morin, J., Jolivet, M., Barrier, L., Laborde, A., Li, H., and Dauteuil, O.: Planation surfaces of the Tian Shan Range (Central Asia): Insight on several 100 million years of topographic evolution, J. Asian Earth Sci., 177, 52–65, https://doi.org/10.1016/j.jseaes.2019.03.011, 2019a.

Moreover, while in the introduction the authors describe an EW contrast of drainage pattern across the South Tianshan, most of the paper focuses only on a U-turn made by the main stem of the Saryjaz river.

Yes, the Introduction focusses on a general pattern we observe (transverse flow in the west, longitudinal in the east), whereas the paper focuses on an approach we believe will help us to identify whether a change in drainage pattern resulted from capture of a longitudinally flowing portion of the landscape by a transverse flowing portion. **The introductory sentences are meant to set up a more regional scope: why studying the evolution of the Saryjaz catchment might be significant beyond the local peculiarity it presents.** We hope that our revisions of some of the sentences in the Introduction (described below) make this sufficiently clear now.

The motivation of the paper being unclear, the goals and the reasons why authors have chosen the methods they used are also unclear.

It is said L53-54 "However, it is not clear how or if the drainage pattern responded to Cenozoic structural reactivation and the uplift of individual ranges, a major change in climate, or the impacts of locally intense glacial erosion."and L55-59: "To unravel these complexities, we investigated the transition area between the regions of longitudinal and transverse drainage: the anomalously large

Saryjaz catchment, which drains the highest part of the South Tian Shan, and includes two Neogene intermontane basins: the Ak Shyyrak and Saryjaz basins (Figs. 1, 2).

What means "unraveling these complexities"? Is the goal to explain the supposed East West difference in drainage pattern (assuming it is real)? If yes what are the hypotheses to explain this difference and how these hypotheses can be tested? For instance, what would be an impact of a Cenozoic reactivation? How would it differ from a change in climate and/or glacial erosion? Consequently, what are the methods to test these hypotheses, why, how do they help to test these hypothesis/the different scenari? Why in particular focusing on knickpoints?

We agree some of these sentences near the end of the Introduction were insufficiently clear, and caused confusion regarding the main motivations of the work. To address this, we modified the sentence L53-54 to the following:

"However, it is not clear how or if the drainage pattern responded to Cenozoic structural reactivation and the uplift of individual ranges, a major change in climate, or the impacts of locally intense glacial erosion***, any of which may have had an impact on how regional drainage patterns have evolved***."

We also modified the sentence about "unraveling these complexities"; it now states: ***The anomalously large Saryjaz catchment sits within a transition zone between the longitudinal and transverse drainages. As such, it may offer clues as to whether the drainage pattern has changed through time, and if so, what might have triggered the change (Fig. 1b)."***

We hope these two changes, although somewhat minor, better explain how our study of the Saryjaz catchments helps us address questions about whether the regional drainage pattern evolved over time, and if so, why.

Authors only said they combine series of topographic analyses and metrics without explaining in detail their goals and what each method will provide "We combine quantitative analysis of topography using fluvial metrics (i.e. slopes, channel steepness, integral proxy χ), with mapping and characterization of knickpoints throughout the catchment."

We rephrased the last paragraph of the ***Introduction***, together with the two changes outlined above, and hope that will make the goal of the topographic analyses clearer.

Here we combine quantitative analysis of topography using fluvial metrics (i.e. slopes, channel steepness, integral proxy χ), with mapping and characterization of knickpoints throughout the Saryjaz catchment and in some small neighbouring catchments. ***Based on multiple lines of evidence that point to a landscape undergoing a transient adjustment (e.g., prominent migrating knickpoints, systematic shifts in channel steepness values), we next consider whether tectonic forcing or drainage capture can explain the observations.*** We use a 1-D stream-power model to explore expected differences in these metrics for a base-level fall versus a drainage-capture scenario. ***Finally, we use recently published denudation rates inferred from ^{10}Be concentrations of river sands to calibrate an erodibility parameter and place constraints on the duration of transient knickpoint migration, to help determine the role of regional forcing conditions on the drainage evolution.*** While this type of analysis is common in tectonically active regions, only a few studies have considered how geomorphic metrics may be used to detect drainage-capture events (Yanites et al., 2013; Giachetta and Willett, 2018; Penserini et al., 2023; Rohrmann et al., 2023).

The methodological part is very technical and does not provide much more information regarding the goals and what each method will provide to address the general question and hypotheses of the study, which are, I recall, unclear.

We understand the reviewer's concerns, but a separate section on the theory behind knickpoint migration and transient landscape evolution comes between the Regional context and the Methods – which we believe addresses both concerns raised by the reviewer. If the theory were included in the Methods, the Methods section would be quite long, and would mix important background (which we want all readers to understand) with technical details (which likely only a subset of readers will care about). We understand that a separate section on theory is not a part of a "standard" manuscript structure, but we believe it is the most effective way to organize our manuscript.

We have made this separation clearer by now making this theoretical part a full section on its own: "***Background theory: Knickpoint generation and river-profile evolution***". This section now includes the general description of knickpoints and also the bedrock-river equations needed to explain the 1D river profile modelling – this new section was also suggested by the Reviewer#2, for a comparison of theoretical and empirical knickpoints patterns. This approach keeps the ***Methods*** section relatively concise, and focused on the morphometric analyses themselves.

Interpretation of the knickpoints

First, it is said L244 that knickpoint at distance <250m from a fault are identified as "tectonic knickpoints" and hence disregarded. But why 250m? please justify this value.

The value was chosen somewhat arbitrarily, based on our consideration that in such a remote area with common DEM errors due to the very high relief of the topography, the exact mapped position of faults could be inaccurate. We added the phrase ***"(chosen somewhat arbitrarily, considering that there could be some error in the fault positions in such remote regions)"***.

Moreover, could tectonic knickpoints migrate upstream and hence be at a distance >250m from the fault they originated from? For instance, in the Apenin in Italy, tectonic knickpoints are localized several kilometers upstream of the faults (see Whitaker et al., 2008). This point should be better discussed/argued.

The reviewer is correct that in the case of a recent change of activity along a fault, there could be a knickpoint that has transiently migrated upstream from the fault contact. However, these would be classified as "transient knickpoints" (see Fig. 3 in the main text). In such cases, there would still be a stationary knickpoint expected at the fault trace, which we refer to as a "structural" knickpoint, separating areas of differential rock uplift along a fault trace. To clarify this point, we have modified the text:

"We identified lithologic and structural knickpoints as those lying within 250 m horizontal distance ***(chosen somewhat arbitrarily, but considering that there could be some error in the fault positions in such remote regions)*** from the boundaries of lithologic contacts or Cenozoic faults, respectively.

We expect these knickpoints to be stationary, marking a spatial change in erodibility and/or rock-uplift rates."

These knickpoints clearly differ from transient knickpoints that have migrated upstream, either due to a change in base-level fall rate or drainage capture.

More importantly, it is said L410: "our observation are **clearly** more consistent with transient knickpoint migration triggered by drainage capture". To support this conclusion, according to authors (see Fig. 3a), the knickpoints should "clearly" have the same Incision Depth and have initiated all at the same time. First and so far, the Onset time vs. Distance from outlet is not shown anywhere. This is surprising.

I understand that the Onset time are shown in Fig. 7b, where, indeed they seems similar in all studied basins (whatever the glacial model is). But Fig. 7b is a "Caltech plot" while an indisputable demonstration would be to show the onset time as function of the Distance from outlet as suggested in Fig 3.

Figure 7d shows χ versus distance, which is nearly equivalent to "Onset time" versus distance; the two are related through the erodibility K (assumed constant). How χ versus distance for the knickpoints in different tributaries should vary between the two drivers is now shown through the new modelling results in Fig. 4. Moreover, we realized that "Onset time" is probably not the best term to use, and a better equivalent to chi would be "***Duration of knickpoint migration***". To transform $\boldsymbol{\chi}$ into actual "Duration of knickpoint migration", we need to calibrate the erodibility, which is what is illustrated in Figure 8. **We have added another sentence to the caption of Fig. 7 to explain how χ relates to "Duration of knickpoint migration" to help clarify this point.** In *Fig. 4* (i.e., previous Fig. 3) we use "*migration of knickpoint*", since χ_t *actually indicates the lateral distance of knickpoints migration*.

Yet, I wanted to plot the Onset time vs. Distance from outlet to check authors conclusions but I couldn't because the data are not provided. The onset time of knickpoint migration should be given in Table 1 and not only shown in a "Caltech" plot in Fig. 7b.

According to ***equation (8)*** in our main text, τ ('onset time' or 'duration of knickpoint migration') is linearly related to χ through the erodibility K. To help the manuscript flow better, we thought that the presentation of τ should come after the Erodibility calculations. Therefore, we added an additional Table in the supplementary information (***Table S3***) that reports τ calculated from the three scenarios used to infer denudation rates from cosmogenic-nuclide data.

Second and similarly, in Fig. 6b, giving the scattering of the data, the fact that incision depths are similar in all basins is far from being obvious and "clear" as argued by authors.

The lack of a trend is the most important result of this particular plot, given that a number of factors can contribute scatter to the actual migration rate of a knickpoint (e.g., anything that affects the erodibility of the rock between the tributary junction and the location of the knickpoint, and any change in erosion process that could affect n). **We have added linear regressions to these plots, which show a high p value (0.98), and low R-squared value (3.96e-05), demonstrating that there is no significant trend. We also now explain in the main text the importance of this lack of a statistically significant trend.**

To support their conclusion about the origin of the transient knickpoints, authors could better statistically analyze their data (Online Isoplot R, F-Test ??).

We greatly appreciate this suggestion from the reviewer; as noted above, we have added linear regressions with reported statistics that show significant trends (or lack thereof), and these additions have helped to strengthen our arguments.

Scenario to explain the supposed drainage capture

But let's assume that the drainage capture is robust and supported by a better statistical analyze of the data. The scenario that is proposed to explain this capture also questions and may request more quantitative analyzes/observations.

The mechanism that is proposed is "overtopping of the divide: during the Pliocene-Pleistocene period, the Ak Shyyrak Basin gradually filled with sediment, until river aggradation caused the west-flowing channel to eventually reach and overtop the drainage divide." To support this mechanism the authors claim that "the sedimentary remnants, inferred from satellite imagery" occur "east of and high above the Saryjaz river in the vicinity of the "U-turn" (Fig. S6). It is very challenging to see sediments on the Google Earth capture presented in Fig S6. I zoomed on google Earth on the crest where authors claim sediments remain (see Fig. C). I don't see any evidence for sediments here. The crest is darker but I think it is just a shade and a misfit between the image and the DEM. And we can see the bedrock everywhere on both flanks. To better support the presence of sediment high above the river, do authors have any other observations? Like field photo? Geological map?

The Quaternary Geological Map of the Khan Tengri Massif (ISTC project No. KR-920) actually shows deposits that are mapped as "mid-Pleistocene" on the right side of the 'U-turn', exactly where we showed them on the Google Earth image. We also include an extract of this map in the revised supplementary ***Fig. S6***.

Mikolaichuk, A.V., Charimov, T. A., Zubovich, A., Gubrenko, M., Bobrovski, A.: Quaternary Geological Map of the Khan Tengri Massif (Kyrgyzstan), ISTC Project No. KR-920, 2008.

Moreover, those supposed sediments lie at >3200m more than 950m above the modern river. What is the elevation of sediments in the Ak Shyyrak basin, is it consistent with such elevation downstream above the U-turn ? Do you have any Geological map of Ak Shyyrak basin ?

I understand it is difficult to do field work in this region but I think a better geomorphic analyze of the different valleys/basins and their sediment remains/filling is still possible using high resolution satellites images and DEM. It is important to better support the proposed scenario for instance focusing on recent alluvial deposits that could be found in the different valleys/basins. What are their elevation? Do they support sediment overfill of the basin and a major incision since 2-4Ma?

Indeed, these "middle Pleistocene" deposits were mapped at 3200 m elevation, which would be consistent with overflow of the Ak Shyyrak basin being at the origin of the capture. Please see our response to the next comment.

Also, in the proposed scenario "in Miocene time, a west-flowing river connected two intermontane basins, Saryjaz and Ak Shyyrak, and likely continued westward to join the current Naryn River." Then

“The capture event would also have reversed the Ak Shyyrak river to flow east into the Saryjaz catchment rather than west into the Naryn catchment”. **I think a more quantitative analyze of the implication of this inverse flowing is requested. The modern water divide between the river that flows West toward the Naryn basin and the Ak Shyyrak river that flows East lies around 3500m. In the proposed scenario the elevation of the divide should not have changed (assuming negligible uplift and sediment filling?). If we assume that the Miocene East flowing Ak Shyyrak river had a similar slope (<0.5-1%) than today in the Ak Shyyrak basin, then the elevation of this river at the U-turn location (90 km east from the modern divide) should be >600m above 3500m. The valley bottom being now at 2300m at the U-turn, this would require >1800m (3500+600-2300) of incision in 2-3 Ma (>0.6-0.9 mm/a), and even more upstream.** Is it realistic for the Tianshan? How does this value compare with other region where drainage basin captures have been documented? **Is it consistent with the order of magnitude of incision depth observed with the transient knickpoints?** Any observations upstream of the U-turn to support more than 1800m of incision? A figure with the paleo-profiles vs modern profiles to see the implication in terms of incision would be helpful.

This is a very helpful thought experiment from the reviewer. While we will avoid speculating on whether ca. 2 km of incision could be realistic for the Tian Shan generally, we can examine how much incision is recorded in the transient profiles in the vicinity (just downstream) of the U-turn. We see a lot of scatter (Fig. 6c), but the range is around 200 to 600 m, not 1800 m. This raises two possibilities: (1) our scenario for the paleo-drainage flowing into the upper Naryn River basin is incorrect, or (2) the upper Naryn River basin had substantial sedimentary infill since the capture time to raise its elevation. Absent any direct age constraints on the basin fill, we cannot rule out (2). But the possibility of (1) remains. A simple overtopping of a divide in the vicinity of the U-turn could similarly result in a drainage capture. That scenario would suggest that **the modern upper Saryjaz catchment could have been a closed basin, not one that flowed into the upper Narin Basin**. We have modified the **Discussion** to include these possibilities, and we modified the text to highlight the potential inconsistency between low incision depths downstream from the U-turn and the scenario of the upper Saryjaz flowing into the Naryn Basin.

More importantly, in the revised manuscript, we added a transient ***1D river profile model*** responding to (1) capture, and (2) base-level drop triggered by a change of uplift rate. We then calculated the theoretical incision for both scenarios. It is very interesting that for the capture scenario, the tributary incision increases upstream; i.e., it is higher for tributatries that are closer to the capture point. However, the tributary incision reaches a threshold of around 500 m (see updated ***Fig. 4***) around 5 Ma after the capture. We think this is because only the trunk has captured more drainage; but each tributary responds to a base-level drop as its outlet due to the trunk incision, and this response only migrates upstream relatively slowly due to the smaller catchment areas of the tributaries relative to the trunk stream.

Therefore, even if the elevation difference between the modern Naryn-Ak Shyyrak divide and the river bed at the “U-turn” would require >1800m of incision for the trunk of the Saryjaz river, it is not necessary to expect the same amount of incision in each tributary. Therefore, we think that our empirical incision depths between 200 and 800 m are reasonable.

Other comments

Part 2.3 should go in the method (3.3) and not along the Geological/climate background of the Tianshan. This would avoid several useless repetitions and would make the reading more straightforward and easier.

Please see our response to the comment above. We tried this in an early draft of the manuscript, but we found that (1) it made the methods section extremely long, and (2) it created a mix of general theory and detailed explanations/equations that was not effective. The latter in particular was problematic, as it is important that all readers understand the theory and predictions, but not that they follow the detailed explanations and equations. In re-examining the text, we do not believe that the very minor reduction in material that is repeated is worth the risk that readers skip over critical aspects of the theory and our predictions for different hypotheses.

In response to this comment and similar comments from reviewer #2, however, we added a section ***"3 Background theory: Knickpoint generation and river-profile evolution"*** to address the theories of knickpoints and stream power law which our modelling and empirical work based on.

The calibration of the erodibility coefficient is limited to 8 unpublished 10Be derived basin average denudation rates located around the Naryn basin, >200km west of the studied area. Why not using the largest 10Be dataset of Charreau et al. 2023 which includes much more larger drainage basins in the Eastern Tianshan? Lithology, climate history etc is likely similar in Eastern Tianshan.

The location of the data from *Charreau et al. (2023)* is significantly further east, between 83 and 87 °E, at a lateral distance of more than 300 km from the Saryjaz catchments. We carefully selected the 8 catchments from *Kudriavtseva et al. (2023),* which has now been published, to resemble as closely as possible the situation we would have in the Saryjaz in terms of tectonics and main lithologies. Therefore, we would rather stick to this dataset. See the answer below for the reference.

By the way, the reference of Kudriavtseva et al., even if in review, is not provided in the list of publication at the end of the paper. Instead of this unpublished paper I would rather quote the PhD thesis.

The paper is now published and added to the list of references.

Kudriavtseva, A., Codilean, A. T., Sobel, E. R., Landgraf, A., Fülöp, R. H., Dzhumabaeva, A., Abdrakhmatov, K., Wilcken, K. M., Schildgen, T., Fink, D., Fujioka, T., Gong, L., Rosenwinkel, S., Merchel, S., and Rugel, G.: Impact of Quaternary Glaciations on Denudation Rates in North Pamir—Tian Shan Inferred From Cosmogenic 10Be and Low-Temperature Thermochronology, J. Geophys. Res. Earth Surf., 128, 1–23, https://doi.org/10.1029/2023JF007193, 2023.

L112: In the Eastern part the Tianshan is bounded by the Junggar basin to the north. Not the Kazakh plateform

We rephrased to “The Tian Shan is bounded by the Tarim Basin to the south, Kazakh platform ***and Junggar block*** to the north.”

L116: what about the Kazakh plateform mentioned before?

We included Kazakh into the sentence “The ancestral Tian Shan was formed by ***several large-scale*** collisions between the Tarim***, Kazakh*** and Junggar blocks, and continental accretion during the Paleozoic.”

Besides, we clarified the extent of the South Tian Shan after the general geological evolution of the whole Tian Shan, to focus on the main research target of this work.

The South Tian Shan is the southernmost part of the Tian Shan, lying between the Talas-Fergana fault to the west (around 75°E) and Huola Tage Mountain to the east (around 85°E), separated from the North Tian Shan by the Main Terskey fault, and from the Tarim Basin by the Maidan fault and South Tian Shan fault.

L142: those rates are derived from GPS. This should be said.

We added “***GPS data indicate that the …***” in the text.

L142-145: several studies have also constrained the Quaternary deformation rates across the South Tianshan using geomorphic markers.

We agree with the reviewer, and add this sentence to the beginning of this paragraph.

L145-148: these values are for the entire Eastern Tianshan, not only for the South range.

We deleted the “South”.

L213: some explanation in sup info of how fig S1 has been made would be helpful. Not everyone is a specialist of the power law approach.

In the caption of Fig. S1, we added more explanation: ***The Bayesian Optimization algorithm attempts to minimize a scalar objective in a bounded domain. The function ‘mnoptim’ in Topotoolbox 2 uses χ analysis to linearize river long profile, and pick a random subset of channels/basins to calculate the best-fit concavity and test with other channels/basins.***

For further information, please see the function ‘mnoptim’ in Topotoolbox 2: https://github.com/wschwanghart/topotoolbox/blob/master/%40STREAMobj/mnoptim.m.

L245: again why 1000000m2 ? justify this choice

The choice was somewhat arbitrary, but it is a common choice, since it often excludes hillslope portions of the catchment. Indeed, we do not see any evidence of systematic decreases of ksn in the uppermost portions of the river network, which suggests that the cut-off we used was sufficient.

We changed the text to read “Streams used for longitudinal profile and χ analysis were extracted with a minimum drainage area of 10^6 m^2, ***which we found was sufficient to exclude portions of the basin dominated by hillslope processes***.”

L308-309: it is very hard from Fig 2b to see this gradian. May be a plot of slope vs distance along the basin and/or a zoomed map would be helpful (could be given in sup info)

In our updated supplementary information, we added an additional figure to show the slope along the stream that flows through the Ak Shyyrak basin to the outlet. Notice that the range of slope seems quite big (light blue shade), considering the noise in DEM data and swift change of direction along the profile; while the mean value (thick blue line) can be a good proxy to show the change of slope within a certain distance (in this case 5 km) to the channel.

L313-314: how can we see the change in Ksn in the Ak Shyyrak basin from fig 2b while it shows the slope?

We split Fig. 2 into two separate figures, one showing the geologic and topographic information (new ***Fig. 2***); the other one showing river steepness (k_{sn}) with distribution of knickpoints (new ***Fig. 3***).

L348-349: please provide a figure (map, plot) that shows this "slight" increase.

Please see ***Table S1*** where we included 'k_{sn} downstream' and 'k_{sn} upstream'. To better show the trend, we also added a plot in the supplementary information (***Fig. S5***).

L381-382: useless repetition. This was already said in the method part.

We deleted the sentence.

L315-316: what is the width of the swath profile? This is important since it could bias the data and derived interpretation. The distinction between the so-called low-relief vs high-relief region is arbitrary and qualitative. The change in reliefs along the main stem is in general very gradual and I don't see two zones marked by a sharp change between them. Only the region around the U-turn shows a rapid change in relief but if we overlook this area, reliefs gradually increase from 130km to 60km, then remain high from 60 to 20km and then decrease slowly up to the outlet of the basin

For instance, in Fig6a, reliefs are relatively high from 90 to 100km (>3000m) while authors call this region low-relief. Similarly, reliefs are low near the outlet (<1000m) while called high-relief.

We agree with the reviewer, that the boundary between 'high-relief' and 'low-relief' topography should be changed. Please see ***Fig. 7*** (old Fig. 6) for updates.

We chose 15 km as the width of the swath to fully cover the topography surrounding the trunk of the Saryjaz river, which we added to ***Fig. 7***, and we now show the location of the swath in the new ***Fig. 2***.

L474-476: this is wrong. 10Be derived paleo-denudation rates reconstructed in the Eatsern Tianshan increase from 9 to 4Ma and then remained steady (see fig 11 of Puchol et al., 2017). Moreover, Kudriavtseva et al. worked in western Kyrgyz Tianshan, not in the eastern region.

We appreciate this correction and changed the text to:

Erosion-rate estimates derived from in-situ ^{10}Be in dated sedimentary records from the southeast and northeast Tian Shan (Puchol et al., 2017) show an increase between ~9 and ~4 Ma.

Figures

Figre 2c: it is very hard to see the Ksn “lines” and their values

Please see ***Fig. 3*** in our updated manuscript with both knickpoints and streams coloured by k_{sn} values. Besides, ***Fig. 5*** (previous Fig. 4) also shows a zoomed view of k_{sn} values especially downstream of the ‘U-turn’.

Figure 3: the definition of the Onset time is unclear. Is it an absolute time? A duration with respect to the onset of base level drop ? or the time since knickpoint started to migrate (ie time before present)?

This is a very good point. The “onset time” here indicates the inferred time since knickpoints started to migrate. We rephrased to “***Duration of knickpoint migration***”, which is more precise.

Figure 6: as said before, what is the width of the swath profile? How were defined the low- vs high-relief zones? Reliefs >2000m can be found in the so-called low-relief zone while reliefs <500m are present in the “high-relief” zone.

Please see response to the comment above.

Figs. 6a-c: horizontal scales should be the same for all these 3 figures and the same than figure 6a. Moreover, I would put those figures below each other and aligned to figure 6a. It is unclear which type of knickpoints is shown here. I guess transient ones but please clarify this in the caption.

Distance along the river is needed to do a proper linear regression of the data points, but swath profiles necessarily show distances along the swath. We add the reference point of the U-turn to help readers align the data. Repeating the plots based on distance along the swath would take substantially more space for very little added value.

I see only 3 “upstream knickpoints” in figure 6a while 5 are shown on figs 6b and c.

We updated the figure to correct this omission. Please see the new ***Fig. 7*** (old Fig. 6) for the locations of upstream knickpoints in the swath profile, and new ***Fig. 3*** for a map view.

RC2: 'Comment on egusphere-2023-2651', Julien Babault, 21 Mar 2024

Review of manuscript by Gong, Ling Xiao et al. submitted to Earth Surface Dynamics (ESurf) and titled "Drainage rearrangement in an intra-continental mountain belt: A case study from the central South Tian Shan, Kyrgyzstan"

Authors: Lingxiao Gong, Peter van der Beek, Taylor F. Schildgen, Edward R. Sobel, Simone Racano, Apolline Mariotti

Gong et al observe transient knickpoints in tributaries downstream of a sharp 180° bend in the main stem of the Saryjaz River in the south flank of the Tian Shan mountains. The analysis of the knickpoint distribution show that their elevations decrease downstream, whereas incision depth, χ values of knickpoints (measured from the trunk river tributary junctions) and steepness index (ksn) values and ratios are constant among tributaries. They interpret ~500 m of incision as driven "top-down" by a large-magnitude river-capture event, and that late Cenozoic tectonic rock and surface uplift did not trigger the capture.

Main comment

That is a very interesting study that should help gain insight into the interactions between mountain building and the dynamics of surface processes. Disentangle the relative effect of external factor and intrinsic drainage dynamics on river profile evolution in tectonically active settings is not an easy task. However, in its current form the manuscript lacks some analysis to support the conclusions, and I recommend the authors to add analysis following my comments below, before publication. In general, the text is clear and concise, well written and the figures are of good quality. References to previous work is also good.

We thank the reviewer for his overall positive assessment and constructive comments. In the following we detail how we addressed these. We made the following modifications to the text (***bold, italic text*** is new):

The authors base their interpretation on diagnostic features for river capture extracted mainly from three papers cited in the manuscript (Giachetta and Willett, 2018; Whipple et al., 2017 and Rohrmann et al., 2023). However, my main concern is that the geomorphic evidence highlighted in their analysis of the topography do not exactly fit with such diagnostic features for river captures. The geomorphic evidence presented in the manuscript is:

1) in the tributaries of the Saryjaz River, the increase of elevation of knickpoints (interpreted as transient features) parallel the modern trunk river profile, and

2) their location at similar chi values (5.4+-30%) measured from the trunk river.

The authors analyze the amount of incision in tributaries of the downstream reach below the capture point inferred to be located at a prominent "U-turn" in map view of the Saryjaz River. The amount of tributaries incision in the downstream reach of the Saryjaz River does not increases upstream. However, I would have expected to see a graph where knickpoint elevation increases upstream, jointly with an increasing amount of incision.

The increase in incision depth with distance upstream could be subtle in a capture scenario, as it is the result of the change in the slope of the trunk stream after it has adjusted to the increased discharge. Differences in incision depths downstream of the capture point will be even less apparent if we are only looking at a limited stretch of the channel. Considering that the Saryjaz River extends several hundreds of km farther downstream from the South Tian Shan range front, the difference in predicted incision depths due to drainage capture along our study reach could be substantially reduced compared to predictions shown by, for example, Giachetta and Willett (2018).

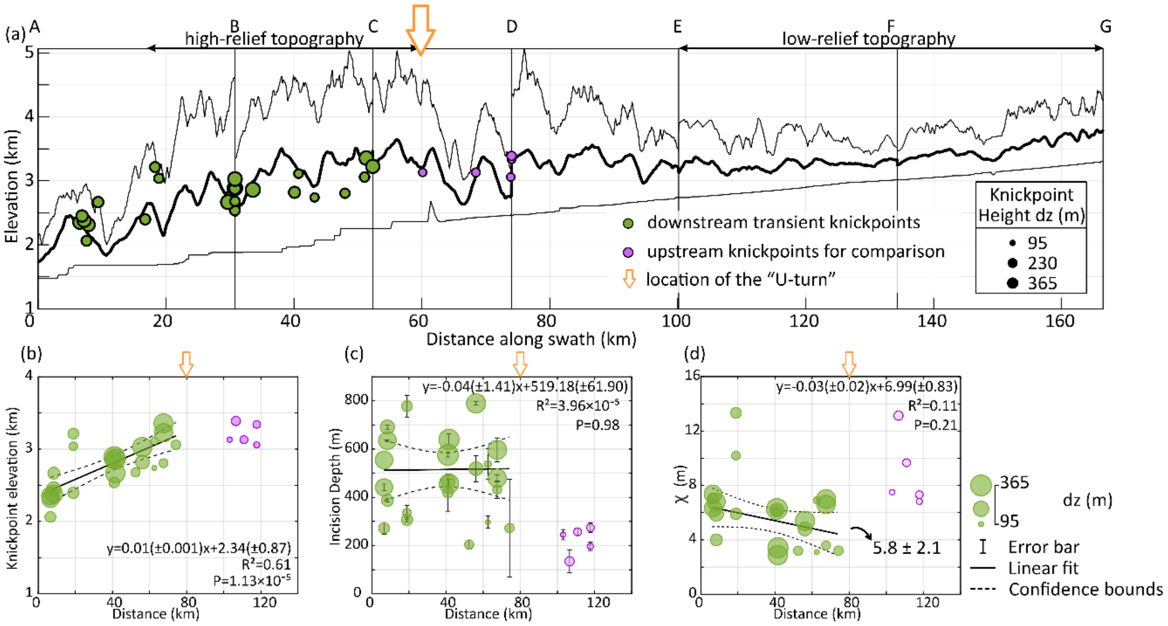
However, to better answer the reviewer's question, we have now included a numerical 1D river profile model following the methods of Rudge et al. (2015), Giachetta and Willett (2018), and included a new section ***"3 Background theory: Knickpoint generation and river-profile evolution"***. The modelling aims to present the evolution of transient river profile under two scenarios: (1) capture; and (2) relative base-level drop by a change in uplift rate. Instead of a qualitative description in our old Fig. 3, our numerical modelling (***new Fig. 4***) quantifies the spatial pattern of transient knickpoints, vertical incision, and χ_t (i.e. chi in tributaries), shortly after the events, as well as after a longer period of time. It is noteworthy that in the capture scenario, even after 5 Ma, a migration time that exceeds that estimated in our study (1.5 – 4.4 Ma), the predicted wave of incision shows a maximum of 500 m, for a catchment and increase in drainage area that was scaled to our study area (new ***Fig. 7***).

However, a positive trend of incision vs. distance; i.e., higher incision in tributaries that are closer to the capture point, is also predicted by the model. Given the scatter we see in the data (original Fig. 6c, ***new Fig. 7c***), any subtle trend is difficult to discern. We therefore focus more on the knickpoint elevations, which are predicted to differ more strongly in the two scenarios we outline in ***Fig. 4***. Indeed, knickpoint elevations vs. distance do show a significant trend, which guides our assessment of the potential mechanism of knickpoint generation. We have added regression lines and confidence intervals to the plots in ***Fig. 7*** to support a more robust interpretation of these knickpoint features. Please see the reproduction of our new ***Fig. 7*** on the next page.

Upstream of the capture point, knickpoints in tributaries of the Saryjaz trunk river would be expected to lie at the same elevation, jointly with a decreasing amount of incision headward, which is what is theoretically expected in the case of a gain in drainage area of a trunk river. Because these behaviors are not recorded in the tributaries, I conclude the authors do not show an analysis that support the transient knickpoints to result from an increase in erosion rate downstream of a capture point. Rather, the slight decrease in the amount of incision from km40 to km80 (Figure 6c) seems to disprove their interpretation.

The five knickpoints that we unambiguously identify as transient above the capture point lie at similar elevations, in contrast to those downstream of the capture point. This difference is consistent with a capture mechanism. We acknowledge that we do not see a significant decrease in incision depth upstream of the inferred capture point (km 90-120 in the original Fig. 6c), although the incision depths for these knickpoints are significantly smaller than for those downstream of the capture point. And given the scatter typically seen in such analyses, we are not entirely surprised by this lack of a clear trend. One more thing to note is that the transient knickpoints upstream of the "U-turn" do not overlap well in chi-z plots. Following the modelling result of sediment-limited stream power law by Giachetta and Willett (2018), and considering the extensive coverage Neogene intermontane basin sediments upstream, we suggest that the upstream transient knickpoints may not strictly adhere to the detachment-limited stream power law. However, a detailed discussion of this is beyond the scope of this manuscript.

After adding linear regressions to this plot, we show that there is actually no significant trend in the incision depths downstream from the knickpoint (km0 to km80 in Fig. 7c, see the figure below), which is consistent with the drainage-capture scenario if we consider that our study area is relatively far upstream from the final outlet of the river. Also, by scaling the marker size with the size of the knickpoint, we show that many of the datapoints contributing to scatter (and the apparent decrease in incision depths noted by the reviewer) are linked to relatively minor knickpoints.



However, they refer in the discussion to geological evidence that support a capture event around the "U-turn" in the Saryjaz River. The contradiction between geomorphic and geological data should be investigated. The problem may lie in the location of the capture point which may not be located at the "U-turn" in the modern river path, as proposed by the authors. I think the effect of drainage integration of the upper Saryjaz catchment on the chi-elev plot should be quantified to predict the amount of incision such a capture would produce at the capture point and downstream, like the test of capture gain effect on river profiles in Giachetta and Willett (2018).

We agree with the reviewer that the capture point may not be exactly at the "U-turn", since the trend of incision is not that clear. One possibility is that the capture occurred slightly downstream of the "U-turn"– it was actually a tributary of the upper Saryjaz that was captured, as indicated in the new ***Fig. 8***.

Reviewer 1 provided a helpful thought experiment that illustrated that our original capture scenario would predict an amount of incision near the capture point (ca. 1800 m) that far exceeds the amount we observe (ca. 300 to 600 m). For this reason, we have reconsidered the possible capture scenario, particularly raising the possibility that the upper Saryjaz river could have been a closed basin that overtopped a divide to flow into what is now the lower Saryjaz river. This refined scenario would be consistent with our observations (or more specifically, nothing is inconsistent with this scenario). Moreover, as we explain in our response to the comment above, our new river-profile modelling (see ***Fig. 4 and Section 3***) predicts a range of tributary incision between 100 and 500 m with a slightly increasing trend upstream, distinct from the clearly decreasing trend upstream that would result from a change in uplift rate (i.e., base-level drop). Combined with our empirical studies, we are confident that the transient knickpoint migration observed in Sarjyz is most likely due to capture.

Maybe a comparison of the longitudinal river profiles of the transverse rivers sourced in the South Flank of the Tian Shan and that emerge in the Tarim Basin, with the Saryjaz trunk river and its tributaries would help convince the reader that a capture event produced the main transient knickpoints. See Giachetta and Willett (JGR 2018) for the diagnostic features suggesting capture events (Scenario 2). Please consider also to add a plot of knickpoint distance from the Saryjaz outlet vs chi (calculated from the trunk river outlet) to compare with the theoretical prediction of the scenario 3 in Giachetta and Willett (JGR 2018).

We appreciate this suggestion from the reviewer. We extracted the trunk channels of 6 streams from the south flank of the South Tian Shan to the west and east of the Saryjaz, and plot them in both long profile and χ space (see figure below). Importantly, these catchments lack knickzones between 2000 and 3000 m, which would be expected if the knickpoints along the Saryjaz river were driven by faster uplift along the south flank of the South Tian Shan ***(new Fig. S8).*** These comparisons, together with knickpoint metrics from tributaries of the Saryjaz (which we assessed based on predictions in Giachetta and Willett, 2018, together with similar findings reported by Yanites et al. 2013 and Rohrmann et al., 2023), support our inference that the transient knickpoints in the Saryjaz were triggered by capture rather than by base-level drop from (a change in) Cenozoic uplift along the South Tian Shan fault (or Maidan fault). The plot noted by the reviewer (χ versus distance from the Saryjaz outlet) was included in the original Fig. 6d. We also added a χ plot of all transient knickpoints and their tributaries in ***Fig. 5*** (old Fig. 4) to show the locations of knickpoints along the river profile.

Specific comments

L171 [… the amount of incision recorded below the knickpoint will be similar for all Tributaries…], what data or model support this assertion? that's not what Giachetta and Willett, 2018 and Rohrmann et al., 2023 show in their studies. They argue for a downstream decrease in the amount of incision in the downstream portion located below a capture point, after a gain in stream power of a capturing river. Channel gradients typically tend to relax downstream of a capture due to the amplified stream power, whereas upstream of a capture, a knickzone tends to gradually form and expand.

We agree with the reviewer, that our original sketch in Fig. 3 and incision depth trend from tributaries downstream of the capture point should be slightly modified. However, we emphasize that the change in incision depth with distance in a capture scenario (upstream increase) could be far smaller than the change in incision depth predicted for a base-level fall scenario (upstream decrease). Soon after capture, only a limited amount of incision will occur, which could make the trend hard to detect. Our revised figure (*updated* ***Fig. 4***) now includes predictions from a numerical model of river profile evolution; these show a flattening of the trunk stream and a decrease in incision depth downstream from the capture point in the capture scenario, but one that may not be detectable in some natural cases.

The authors decided to show only a subset of the tributaries and the associated knickpoints they studied. I think the reader needs to see the raw data in a synthetic figure in the main text. Please add a chi-elevation plots of each tributary subcatchment with all their tributaries (not a stack of S4 subplots), together with the localization of the knickpoints used in the inversion. this would help support the interpretations. I think the 'representative' χ – z plot of transient slope-break knickpoints in figure 4b does not give enough information of the general geometry of the tributary profiles of the Saryjaz River. Also, a companion figure of fig 4a with the geological map would help to assess any possible tectonic/lithologic control on the spatial distribution of transient knickpoint.

In the new ***Fig. 5*** (previous Fig. 4), we plot all the transient knickpoints in χ space (calculated from the outlet of the Saryjaz trunk stream). For geological information, we think that the ***Fig. 2a*** contains sufficient details to give readers an impression of possible tectonic/lithologic controls. The level of detail used in our analysis is not practical to include in a figure, as this extends over several full-scale geologic maps.

We already have Fig. S4 in the supplementary information to show all tributary sub-catchments in chi plots. Moreover, we added a new Fig. 3 (from old Fig. S3) tht shows all knickpoints with their inferred origins on a topographic map with Cenozoic faults.

l411-412: "infer that the capture position is marked by the "U-turn" in the Saryjaz River" models predict deeper incision at capture point! This is not what fig6c shows.

We appreciated this very good point. We have added a linear regression to the figure that shows a high p value (0.977) and low R-square value (3.96×10^{-5}), demonstrating that there is no significant trend in the incision depths with distance below the capture point**.** Furthermore, the apparent decrease in incision depth close to the U-turn is due to very small knickpoints that may not be as reliable as the larger ones, which we now indicate with differing marker sizes. In the main text, we discussed this lack of a statistically significant trend, and acknowledged that ***We infer that the capture position may have been near the "U-turn", or slightly downstream of it (Figs. 2, 3, 7).*** We also marked both location of the "U-turn" and possible location of the capture point in drainage evolution sketch in ***Fig. 9.***

L412"Ak Shyyrak River corresponds to a paleo-downstream reach of the upper Saryjaz," in this interpretation, but the authors don't show new data (e.g. paleoflow directions) to support that. Maybe, better say "…would correspond…"

We agree with the reviewer, and changed this to "***would correspond***" to the text. However, we have reconsidered this scenario based on comments from Reviewer 1, and we no longer believe this to necessarily have been the case.

L416-418: that's not what models show… maximum amounts of incision are expected at and around a capture point.

See our comments above regarding this point.

L442-444: "The divide lies within Neogene sediments, providing a minimum elevation reached by the fill of the Ak Shyyrak basin prior to the capture and supporting a scenario in which capture was driven by overtopping of the Ak Shyyrak basin." Please add the position of the sediment remnants on the topographic profile in figure 6a. This would help visualize the degree of overfilling in the previously closed longitudinal valleys in the interior of the Tian Shan.

We agree with the reviewer, and added the “mid-Pleistocene deposits” mapped in the Quaternary Geological Map of the Khan Tengri Massif (ISTC project KR-920) in the ***supplementary Fig. S6.***

L449-452: “Our analysis of the Saryjaz catchment demonstrates that over a long period of time after the capture event, the impacts of drainage capture will migrate from the trunk to the tributaries, producing transient ksn anomalies, and eventually reshaping the whole river profile into a new equilibrium state.” If true, why do only ~200m of incision is observed around the U-turn (fig 6c)? I would expect a deeper incision after 2.8 ± 1.3 Ma (l459) of upstream propagation of the capture-induced wave of incision. Actually, models predict the maximum of capture-induced incision at the capture point which is not what is observed. Please discuss this point.

This is a very good point, and similar to a point made by Reviewer 1. Indeed, the “Incision Depth” measured downstream of the ‘U-turn’ shows a lot of scatter between 200 and 600 m. In our updated swath profile (new ***Fig. 7***), we weighted the knickpoints by knickpoint height (dz), and use linear regression to fit the trend of incision depth downstream of the ‘U-turn’. It is clear that the knickpoints closest to the U-turn, with around 200 m of incision, are more akin to vertical-step knickpoints in long profile, while the main slope-break knickpoints indicate higher incision of around 500 m. However, the issue here is that the value of incision is still much smaller than the elevation difference between the relict sediments (~3200 m) and valley bottom near the ‘U-turn’ (~2300 m). We suggest two possibilities: (1) our scenario for the paleodrainage flowing into the upper Naryn River basin could be incorrect, or (2) the upper Naryn River basin had substantial sedimentary infill since the capture time to raise its elevation. Absent any direct age constraints on the basin fill, we cannot rule out (2). But the possibility of (1) remains. A simple overtopping of a divide to the north of the U-turn could similarly result in a drainage capture. **That scenario would suggest that the modern upper Saryjaz catchment was a closed basin, not one that flowed into the upper Naryn Basin.** This scenario would explain our observations without requiring what appears to be an unrealistic amount of incision. We added this possibility into the main text, and modified the final sketch (new ***Fig. 9***) of the drainage evolution process.

More importantly, we developed a 1D river profile model (added to the revised main text in ***Section 3*** and ***Fig. 4***) predicting river-profile evolution following (1) capture, and (2) relative base-level drop by a change in uplift rate, both shortly after the event and after a longer period of time. We then calculated the theoretical incision for both scenarios. Tributary incision increases upstream; i.e., it is higher for tributaries that are closer to the capture point for the capture scenario, which agrees with the model in Giachetta and Willett (2018). However, tributary incision reaches a threshold of around 500 m after 5 Ma of the capture. Therefore, even if the elevation difference between the modern divide and current “U-turn” could require >1800 m of incision for the trunk of the Saryjaz, we do not necessarily expect the same amount of incision in each tributary, and suggest that our observed incision depth between 200 and 800 m is reasonable.

l480-482 “our study here do not see transient knickpoints associated with this reactivation from Saryjaz catchment, which might indicate that the change in uplift rates was rather low, or that it actually occurred earlier and no longer visible as a transient signal in river profiles” please explain why the knickpoints in the Saryjaz River especially the ones close to the South Tian Shan Fault may not be tectonically-induced. I guess the inversion of river profile with chi values calculated from the outlet of the Saryjaz River would give ages similar to l477-478 "[…] sharp change in provenance from a mixed Tian Shan-Pamir source to local source between 6 and 3.5 Ma (Rittner et al., 2016; Richter et al., 2022)." If true, rock uplift may explain some of the observed transient knickpoint, while others could have been driven by a river capture event. If not, this point would reinforce authors' interpretation.

The lack of knickpoints in other channels draining the southern flank of the South Tian Shan (both east and west of the Saryjaz) argues against a change in uplift rate accommodated by the South Tian Shan Fault or Maidan Fault generating knickpoints, at least up to an elevation of ca. 3000 m, which is as high as any of the knickpoints we map along the lower Saryjaz River. For this reason, together with all of the other arguments and metrics presented, we have no evidence to support a contribution from tectonics in generating the knickpoints visible along the lower Saryjaz River today. It may be necessary to reconsider what the change in provenance between 6 and 3.5 Ma really implies. Incidentally, thermochronology data presented by another group in the vicinity of the lower Saryjaz River (Lyu et al., 2024) show a decrease in exhumation rates in the last ca. 5 Ma, which further supports the conclusions we arrived at through our morphometric analyses. We added a sentence about this in our ***Discussion***, although we do not want to put too much emphasis on results that are so far only presented in an abstract.

Lyu, L., Li, T., Jia, Y., and Chen, J.: Multi-stage Cenozoic exhumation history of southern Central Tian Shan: implications for geodynamic and sedimentary evolution, EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-7773, https://doi.org/10.5194/egusphere-egu24-7773, 2024.

L486-496. In the last paragraph the authors suggest a 3 phases evolution, with 1) uplift of a new south topographic barrier, 2) the infill of closed basins in the center of the Tian Shan and 3) the opening of the closed basins by overtopping of sediments at the origin of a capture event. The bottom Paleozoic bedrock of the longitudinal valleys in the central Tian Shan, where late Cenozoic clastic sediments aggraded, is more than 1000 m above the northern margin of the Tarim Basin. If such a difference would have existed at the time of disconnection/closure of the Ak Shyyrak and Saryjasz Basins in the center of the orogen, one may have expected the erosion by the Saryjaz River to have balanced the uplift rate. The authors claim this did not append and that the Saryjaz River have been defeated by rock uplift, which in turn would imply that in Miocene times(?) the Saryjaz River did not have yet its present high potential energy toward the South. A corollary is that the center of the Tian Shan should have been surface uplifted by 1000 m with respect to the Tarim Basin before event 3. This would support the view that a delay exists between orogen building and drainage reorganization, as observed in many geological settings (e.g. Babault et al., J of Asian Earth Sci 2018, Rohrmann et al., Science Advances 2023). Maybe the authors may discuss this reasoning in their model of mountain building and drainage evolution.

This is a very good thought. We added this possible reasoning to the last paragraph of ***Section 6.3***:

In summary, we infer that both tectonic and climatic drivers may have contributed to drainage reorganization of the Saryjaz catchment, sometime between ~ 1.5 and 4.4 Ma, by influencing the filling of the intramontane Ak Shyyrak basin. ***This scenario implies that the Saryjaz river was initially defeated by rock uplift of the South Tian Shan in Miocene time, preventing it from reaching its present outlet toward the south. The river only reconnected to the Tarim Basin later, after the capture event. Thus, a delay could have existed between orogen building and drainage***

reorganization, as observed in different geological settings (e.g. Babault et al., 2018; Rohrmann et al., 2023).

Specific comments

Please add a cross-section in the geological settings of the South Tian Shan that passes close to the transverse reach of the Saryjaz River.

The pre-Cenozoic geological evolution is not a main part of this manuscript, and there are already published cross-sections extending N-S. Considering the current length and scope of this manuscript, we decided to cite the original mapping project (ISTC project KR-920), instead of just copying the cross section here.

I did not find a reference to the method that has been used to calculate the steepness index values.

This is explained in ***section 3.1.***, and ***Fig. S1*** in the supplementary information, in which we used the function 'mnoptim' within TopoToolbox 2 to calculate *best-fit m/n* = 0.4 as reference concavity. Then we calculated k_{sn} from the gradient (*G*) and drainage area (*A*) of the stream, based on detachment-limited stream power law (i.e. equation (2)). Please see the reference in the main text.

It may help the reader to see the Figure S3 in the main text, also add the location of the U-turn in that figure and highlight the location of the transient knickpoints upstream of the U-turn, I can't see them.

Following the reviewer suggestions, we moved Fig. S3 to the main text as a new ***Fig. 3***. We slightly changed colormaps of river steepness and knickpoints to highlight key information, added the location of "U-turn", and highlighted the main stem as well.

L406 "tributaries upstream of the "U-turn", especially within the intermontane basins, show lower slopes (mostly < 30°) and generally lack slope-break knickpoints." Please give a comment/explanation for this feature which seems significant to understand the drainage evolution of the Saryjaz River.

The new ***Fig. 3*** (based on old Fig. S3) shows the location and possible origins of all knickpoints in the Saryjaz catchment, the only transient knickpoints recognized upstream of the 'U-turn' mostly sit within 40 km of it, *indicating that the* ***migration of this group of knickpoints has not reached the upstream Saryjaz basin yet. In combination with the low-slope topography (Fig. 2b), low k_{sn} of stream (Fig. 3), we think that upstream part of the Saryjaz has not yet responded to the relative base-level drop induced by the capture.*** We also added this discussion to the main text.

l409-410: 'Considering theoretical predictions of the differences in patterns of knickpoint elevation and incision depth for knickpoints triggered by drainage capture versus base-level fall (Fig. 3),' there is a difference between theoretical predictions and the trends in figure 3. This should be corrected, with increasing incision upstream in the tributaries of the downstream reach of the Saryjaz River, see comments above.

We appreciate that the reviewer's thoughts and modified the text in describing differences between theoretical predictions and our data from Saryjaz. We also updated ***Fig. 3*** (now ***Fig. 4***) to better show these predictions.

L410-412: "our observations are clearly more consistent with transient knickpoint migration being triggered by drainage capture. We infer that the capture position is marked by the "U-turn" in the Saryjaz River" to help the reader, it may be worth to recall here which are the features you observed that you take as diagnostic for river capture.

Good point! We added the observed features in the main text.

Other comments

L52-53 and L83-84 "…transverse drainage in the east…" true in the south flank only! Should be explained with more details

It is true that the south flank of the South Tian Shan shows a major composition of 'transverse' drainage, while the north flank also includes some streams that flow parallel to the strike. However, a quantitative analysis shows peaks in drainage directions for "eastern" streams between [0,45] and [135, 180]; i.e. transverse. Please see the histogram plots in our new ***Fig. 1c***.

L168: "…up tributary valleys" specify downstream of the capture point

We added "***downstream of the capture point***".

L169 "…constant vertical velocity" specify, true if n=1 in the detachment-limited stream power incision model.

When uplift rate varies temporally, knickpoints are shown to travel through the basins with constant vertical velocity, independent of the value of n (although the velocity itself depends on n). See equation (12) in Niemann et al., 2001.

Niemann, J. D., Gasparini, N. M., Tucker, G. E., and Bras, R. L.: A quantitative evaluation of Playfair's law and its use in testing long-term stream erosion models, Earth Surf. Process. Landforms, 26, 1317–1332, https://doi.org/10.1002/esp.272, 2001.

L172-173: "…all tributary knickpoints will have retreated a similar distance from the tributary junctions because they were all initiated around the same time" assuming detachment-limited stream power model and n=1. I would expect this is not true if n ≠ 1. Horizontal and vertical migrations of knickpoint are function of the erosion rate of the propagating slope patch raised to the power of 1/n, and of the background uplift rate also raised to the power of 1/n (Royden and Perron 2013). If you have a look the figure 3b in Giachetta and Willett (2018), after a capture event, knickpoints in the lower tributaries have lower slopes than tributaries just below a capture point. The difference of migration rates might be small but it would be interesting to quantify it.

See the point above regarding n and vertical knickpoint velocity. The difference in vertical migration rates would be predicted to scale similarly to the difference in total incision for the different knickpoints downstream from the capture point, which we quantified through modelling (***Fig. 4***). In empirical studies in Sarayjaz, we see scatter in the relationship of incision depth vs. distance without any significant trend, so vertical migration rates would show a similar pattern

Figure 6d please reverse axis and plot distance from outlet vs chi as in Giachetta and Willett JGR 2018. Although I understand that the plots 6b and 6c show distance from outlet in the x axis. Please check you specify/add everywhere in the ms. i.e., in the text and in the figures (not only in the figure captions of the plots) if chi is measured from the trunk stream or from the outlet (of the trunk river) in the Tarim Basin. Because the studies you refer to values are plotted against both variables.

We agree with the reviewer that the definitions of χ from outlet and tributaries could be confusing to readers. Here we updated the term using subscripts, e.g. χ_o: χ measured from outlet; χ_t: χ measured from tributary junction. As for reversing the axis, since we have shown theoretical trends in ***Fig. 4*** (old Fig. 3), we think it would be easier and clearer to plot observed data following the same way. Moreover, standard convention, which is also required for linear regression analysis, is to plot the independent variable on the x-axis, which we have done in our plots.

Other edits

We rephrased one scenario of transient knickpoints migration from “base-level drop” to “a change in the rate of base-level fall”, “accelerated uplift” and “accelerated base-level fall”

Page 1, Abstract, line 23:

These results, together with a comparison of other rivers in the vicinity that show no evidence of transient knickpoints, suggest that transient incision in the Saryjaz catchment is driven “top-down” by a large-magnitude river-capture event rather than “bottom-up” by accelerated uplift/base-level fall.

Page 8, Line 186-187:

Two common drivers for transient knickpoint generation and retreat include: (1) drainage capture or diversion, and (2) an increase in rock-uplift rate (or increase in the rate of base-level fall).

Page 11, Fig. 4 caption

Sketch of two common drivers for knickpoint retreat: (a) capture and (b) accelerated uplift;

Page 25, Conclusion, Line 593:

(2) By considering the impacts of drainage capture versus tectonically driven accelerated base-level fall on river topographic metrics from a 1-D river profile modelling, we infer that the transient landscape in the Saryjaz catchment was triggered by a large-magnitude drainage-capture event, which replaced an extensive longitudinal drainage system by a transverse draining system.

We also edited the background description of detachment stream-power law:

Page 8, Line 196:

At steady state, i.e. if $dz/dt = 0$, Equation (1) can be rewritten as a power-law relation between slope (S) and drainage area (A):

$$S = k_s A^{-\theta} \quad (2)$$

Page 9, Line 215:

If χ is calculated starting at the junction of a tributary and the trunk stream, its value at a knickpoint can be interpreted as a proxy for how much time has passed since the onset of knickpoint migration up the tributary channel.

Page 9, Line 219-220:

By projecting the “relict” portion of the profile (i.e., upstream of the knickpoint) to the position of the outlet, or confluence with trunk, one can recreate the former “steady-state” profile, and provide a minimum constraint on the magnitude of relative incision and/or surface uplift between downstream and relict parts (Harkins et al., 2007; Kirby and Whipple, 2012; Smith et al., 2022; Clementucci et al., 2023.

We also updated the Acknowledgement,

Page 25, Line 609-611:

We thank Wolfgang Schwanghart, Gerold Zeilinger, and Stefanie Tofelde for their discussions and comments on an early draft, and Leo Günther for his suggestions on the river evolution script. We also extend our gratitude to one anonymous reviewer and Julien Babault for their insightful feedback, which helped to significantly improve our manuscript.

Data Availability Statement,

Page 26, Line 615-617:

A Python script for the 1-D river profile evolution model is available through the Zenodo repository: https://doi.org/10.5281/zenodo.11505509, McNab, F., & Gong, L, 2024.

And Author contributions.

Page 26, Line 621-622:

FM: software, writing: review & editing.