Response to Review #1

The authors try to use tectonic geomorphological techniques (e.g., hypsometric integral (HI), channel steepness (ksn), and local relief) to identify the impact of structural inheritance on the formation of the Shanxi Rift. The manuscript obtains new geomorphological parameters covering a large portion of the Shanxi Rift System, which is useful for understanding the tectonic characteristics of the rift. The manuscript also contains new ideas and interesting analyses regarding the tectonic evolution of the rift. Moreover, the manuscript is well prepared. Its structure is clear, and its language is easy to understand. Although I find one major issue and many minor ones (see below), I think this manuscript would be a good contribution to understanding the evolution of the Shanxi Rift System after revision.

> *We thank the reviewer. We have addressed the comments and have modified the manuscript accordingly. Below are the more detailed responses to the individual comments with references of the changed part (lines of the revised manuscript in brackets):*

Major Issue:

The manuscript tries to use tectonic geomorphological techniques (e.g., HI, ksn, and local relief) to study the impact of structural inheritance on the formation of the Shanxi Rift, but the manuscript does not show the relationship between observed geomorphological parameters and preexisting structures. There is even no discussion about the relationship between observed geomorphological parameters and the preexisting structures. The role of structural inheritance is mainly based on analyzing the relationship between the current rift structures and published geologic maps. Such discussion is somewhat similar to published works in recent years, but the authors do not mention them. Collectively, I feel there is a disconnection between the main research technique and the research target.

> *We agree that our phrasing here lacked clarity and was also noted by the other two reviewers. We agree there is no direct link between the geomorphological analysis we present and the inferred structural inheritance based on previous studies, instead our geomorphological analysis is used to evaluate fault activity and has identified areas of increased tectonic deformation. Alongside this we present our investigation of the possible impact of inherited structures on these zones of more active deformation. Geomorphology can give us a better understanding of the evolution of the Shanxi Rift which can then be related to inherited structures to study their impact. The abstract text has been modified to clear this up. (Lines 17-22)*

Specific comments:

Line 81: I don't think you need to mention seismic data. There are many seismic reflection profiles in the Shanxi Rift. Previous isopach maps (e.g., Xu and Ma, 1992; Xu et al, 1992) already take full advantage of the seismic data.

> *While we appreciate the work in Shanxi that has been conducted using seismic reflection data, we think it is still appropriate to refer to a general lack of seismic reflection data coverage especially when compared to offshore areas like the North Sea, active rifts like East Africa or even adjacent onshore basins like the Bohai basin. These are covered by a*

greater range of 2D and 3D seismic which makes detailed studies of the rift evolution using seismic data possible. Shanxi, as a subaerially exposed rift, does not have this advantage but can instead be studied with geomorphological and remote sensing approaches which we wanted to highlight with this sentence.

Lines 135-135: This is not correct. More and more studies found that the Eocene extension also occurred in western NCC, e.g., Wang et al (2013), Fan et al (2019), and Su et al (2021).

We have changed the text to indicate that the Western NCC has experienced limited extension in the Eocene. (145-146)

Line 149-151: I think the authors want to describe the thickness of the syn-rift sediments since the late Miocene rather than the sedimentary rocks. The mentioned thickness values are not correct. Please refer to Xu et al (1992) for the syn-rift sediment thickness. For the Linfen Basin, you can refer to Su et al (2023) for the syn-rift sediment thickness.

We have changed the thickness values according to the referenced papers to 3800m of synrift fill in the Taiyuan basin and 2200m for the Linfen basin: Synrift thickness across the Shanxi Rift varies; While the Taiyuan basins has the thickest synrift sediment thickness of up to 3800m (Xu et al. 1992), the Xinding only contains up to a 1800m (Xu et al. 1992) and the Linfen basin contains up to 2200m of synrift fill (Su et al., 2023). (160-162)

Lines 345-346: I think the precise description regarding the precipitation would be "...roughly little variation in precipitation...".

We have changed the text to "broadly little variation in precipitation". (376)

Lines 405-406: As the authors discussed regarding the limitations of HI in Lines 296-305, HI values may related to loess landscapes. The Lingshi RIZ is covered by widely distributed loess, which I think should also be considered when analyzing the observed high and varied HI values in the Lingshi RIZ.

We included in this section now that the presence of Loess in the Lingshi RIZ may have an impact on the high HI responses within the Lingshi RIZ. (456-459)

However, when taking the per fault averaged HI values, as we have done for the violin plots (Fig. 7c) the basins analysed are solely basins in the footwall of the Huoshan fault. The Huoshan fault footwall mostly consists of Palaeoproterozoic basement therefore high responses here are not due to the presence of Loess. Therefore, our argument still stands that the Huoshan fault and therefore the Lingshi RIZ have seen increased activity, but we acknowledge that the high HI value basins in the hanging wall of the Huoshan fault may be due to the presence of Loess.

Lines 397-98, 435: Please indicate the widths of the two swath profiles.

Both Swath profiles are 5km width, this has now been added to the figure caption.

Lines 419-422: I am not sure how you found this area experienced a "recent uplift". Also, can you specify the timescale of the "recent" you mean? For example, … experienced uplift in ~10, 100 ka, 1, or 10 Ma.

> *We infer this region to have experienced recent uplift based on the abundance of high HI value basins, steep slopes and the presence of entrenched meanders show that this region must have been tectonically active recently and the footwall of the Shilingguan fault must have been uplifted recently which outpaced erosion creating the steep flanks of the river. The footwall geology here is low grade metasediments therefore the extreme geomorphic response can not be down to a lithology effect which makes the interpretation of intense tectonic activity even more likely. Based on the data of this study it is not possible to assign exact timings of this uplift, but it is most likely Quaternary. Further studies which quantify the river capture, or the fault slip data would be needed to make more absolute assessment of the uplift age.*

Lines 452-453: This sentence needs a reference to support this idea.

> This idea is a new proposal from the results of our work, however we added a reference to Middleton et al. (2017) which propose a stable extension field for the Shanxi Rift based on geodesy and seismicity. (518-519)

Lines 576-579 (Figure 11): The timing of the three evolution stages need references.

> *The time steps were mostly speculative based on previous studies (Shi et al. 2015), based on our study we cannot assess the absolute ages of when this reorganisation occurred, therefore we removed the mention of specific time steps. The relative sequence of rifting and reorganisation is the most important part of this figure.*

Lines 589-591: The last sentence of this paragraph should be removed. Do not conduct a discussion in the Conclusion section. Also, the analysis regarding future major earthquakes is wrong. Any active faults including these basin border faults may host large earthquakes in the future.

> *We don't think this is new discussion in the Conclusions as it is covered extensively in section 5.2 where we discuss the seismic hazard implications of the study, and this sentence serves as a summary of this section. We agree that any fault hosts the potential for major earthquakes, and this is consistent with our model of a stable extension direction in which all of the faults are potentially active, however it is our suggestion here that activity may be concentrated in the RIZs. This is due to the increased tectonic activity due to strain localisation in these regions. This is also well documented by clusters of earthquakes in these regions (see Fig.2 of the revised manuscript with added ISC earthquakes).*
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> *However, we have reworded the sentence slightly:*
>
> *"This has major implications for seismic hazard assessments as it hints towards zones which show more complex and more active patterns of faulting due to the strain concentration in the RIZs, these may experience increased seismicity." (674-676)*