Comments and replies to Anonymous Referee #2

Your comments (RC2) are written in Chinese language and I guess you are the scholar from China or other Asian countries. The author members of this manuscript are all Chinese and I found the RC2 comments are same with the RC3. I have written a letter to ask the handling editor Thom Bogaard how to reply the RC2 and he told me just reply the RC3. Here, we made a point-to-point response to the RC3 and submitted to RC2.

Brief comments: This work exhibits the important of hydro-mechanical properties on the soil loss in channel bed and on steep slope in the mollisol region of Northeast China. In comparison with previous studies on gully erosion at monitoring sites, the work clearly shows the some unknow, but extreme important aspects in the gully development that previous studies haven't been addressed, including the headwater hydrology, suction stress, and their influence on the soil loss. In lots of studies on gully development, most works either solely analyze the channel head retreat rate, gully area expansion, gully area-volume, etc., or develop soil loss equation on rainfall index, they cannot combine the observed soil loss on steep sidewall, with the hydrological factors, not to mention the hydro-mechanical status in the headwaters. Therefore, I recommend the work could be accepted after some minor revisions. Following comments can be considered for the author and may be helpful for the quality improvements for the manuscript.

Replies: Thanks for your positive recognition for our study.

This work mainly contributes to know the physical process of permanent gully development in the mollisol region of Northeast China. Traditionally, the studies of permanent gully development focus on the some empirically-based finding, such as the area-volume, channel head retreat rate, and tillage measures on the soil loss. However, there were no studies about the hydrological process and the hydro-mechanical response of head cut. Therefore, this work clearly presents the knowledge gap by analyzing the hydrological and hydro-mechanical response. Besides, our finding also contributes to know about the soil loss problems, e.g., the rain depth of storm event cannot be used in predicting soil loss, as the soil moisture level has a considerable effect on the surface runoff production and the suction stress, which have a close relationship with the erosion on channel bed and the steep bank.

In the final part of Abstract, we also strength our finding using flowing contents: Therefore, it is more important to predict the soil loss in permanent gully from both soil water storage and the hydromechanical response of soil mass, other than sole rainfall amount. In other words, the required water storage capacity to produce runoff intensity and low suction stress would give more accurate results in predicting soil loss in the permanent gully head-cut.

Comment 1: The title or the abstract should highlight the important finding of this work. The methods in "3.4 Soil water storage and drainage" and the figure 11 sufficiently illustrate that the soil loss prediction cannot be from the event rainfall, but from the antecedent precipitation. It is rational and logistical to consider antecedent precipitation in predicting soil loss because the soil water status greatly influent the time, intensity of runoff and the stability of soil on the steep slope. Therefore, I suggest the authors should extend the finding in the discussion part.

Reply: Thanks for your insightful comments on the title and abstract of hess-2024-268. Meanwhile, we should strengthen our finding in the discussion part.

Anonymous Referee #1 also give us the same comments on the title and abstract of hess-2024-268. We revised the previous title "Understanding soil loss in two permanent gully head cuts in the mollisol region of Northeast China", into "Understanding soil loss in mollisol permanent gully head cuts by hydrological and hydro-mechanical response". The revised title would be better than the previous one as it highlights the ideology used in this work.

We revised the previous Abstract into "During permanent gully development, soil losses on steep slope and in channel bed are typically driven by the hydromechanical response and water storage within the soil mass, while such knowledge have been neglected in previous studies of gully erosion in the mollisol region of Northeast China. In this study, erosion intensities during the 111 d of the rainy season and 97 d of the snow melting season were analyzed with respect to soil water storage and drainage capacity, soil suction stress, supported by the monitoring results of soil moisture, temperature, and precipitation and experimental analysis of soil hydromechanical properties. Under the same confining stress, the mollisols in the interrupted head cut of Gully No. II increased more rapidly and dissipated pore water pressure more than at the uninterrupted head cut of Gully No I. The combination of the soil water characteristic curve and the hydraulic conductivity function indicates that the mollisols of Gully No. II had a lower air entry pressure and higher saturated hydraulic conductivity during the wetting and drying cycles than Gully No. I. The head cut area of Gully No. II exhibited rapid response of water infiltration and drainage, and high soil water storage capacity. The absolute suction stresses within the mollisols of Gully No. II was lower than that in Gully No. I, which could lead to high erosion per unit of steep slope area. Importantly, gravitational mass wasting on steep slopes is closely related to soil suction stress and we observed a correlation between erosion per unit gully bed area and the soil water storage. Therefore, it is more important to predict the soil loss in permanent gully from both soil water storage and the hydromechanical response of soil mass, other than sole rainfall amount. In other words, the required water storage capacity to produce runoff intensity and low suction stress would give more accurate results in predicting soil loss in the permanent gully head-cut.".

In the last two paragraphs in the Discussion part, we extended our finding, e.g., the figure 11. The last two paragraphs were revised into "Commonly, the gully bed erosion rates mainly depend on runoff intensity, and some study found that the hydraulics of runoff in the rainy season was significantly higher than the snow melting runoff. However, some studies also proved that gully head may retreat faster in the snow-melting season than in the summer (Wu et al., 2008; Hu et al., 2009). In fact, the accumulated snowfall depth during the monitoring duration in this work was high up to 49.6 mm, which was far more than the average snow depth of 30 mm. Besides, the snowfall was melted all during 3 to 10 May 2023 (Figs. 7a and 7b). Therefore, heavy snowfall during the winter 2022 and early spring 2023 and the intensive melting may result in the high soil moisture, intensive runoff causes strong bed erosion. Long-term saturation during the snowmelt season provides sufficient water infiltration and low suction stress. Therefore, the highest erosion per unit area occurred in the snowmelt season, but not in the rainy season.

Dong et al. (2011) revealed that a critical mass water content for gravitational mass wasting ranged from 31.0% to 33.8%, corresponding to a volumetric water content of 39.0% to 48.0% for the soil mass and a suction stress of 11.0 kPa. This showed that the direct-shear apparatus limited the ability to differentiate between the effective cohesion and suction stress contributions to total cohesion. As shown in Fig. 10b and supported by Xu et al. (2020), the high soil water storage during the snow melting season in Gully No. II (Fig. 9a) and long-term water infiltration can result in lower suction stress and higher erosion per unit area. This suggests a potentially reciprocal relationship between the absolute suction stress and erosion per unit area. The result in Figs. 11c and 11d is a key finding and main contribution in the study domain of gully erosion, as it clearly clarifies the role of suction stress of storied water on soil loss from slope and gully bed respectively. It also tells the truth that the soil water storage couldn't equal to the event rainfall amount, but partially from the initial soil water. In fact, figure 11 specially illustrate that antecedent soil moisture or precipitation have influence on surface runoff depth and soil loss during the permanent gully expansion in MEC, while this important aspect has been neglected. In other words, the effect of antecedent precipitation would be assessed in predicting soil loss as it closely relates to the soil water and generate indirect influence on the runoff generation and intensity (Sachs and Sarah, 2017; Wei et al., 2017; Schoener and Stone, 2019; Wang et al., 2019). Importantly, the ideology of this work adopts the theory frame that the soil loss at the steep slope occur by the mechanism of bank slope stability and the loss in the gully bed occur on condition that the balance between the shear force from runoff water to soil erodibility. Therefore, it is better way to predict the soil loss in permanent gully from both soil water storage and the hydromechanical response of soil mass, other than sole rainfall amount."

Comment 2: I have some issues on the figure 6. Why the lines of wetting and drying process for the same soil are different? Is it because of the air pressure or different tests procedures? Can you give some explanations in the text? This would be helpful for the readers?

Reply: Done.

We used the Transient Release and Imbibition Method to obtain the wetting and drying process of the soil. We added sentences in the revised manuscript to give a brief explanation "The reason why the SWCC and HCF of drying process and wetting process are different lies in that water flow from drying process relates to the applied suction level, while the water flow during the wetting process was measured at a positive pressure head (Lu and Godt, 2013)."

Comment 3: Some references about the antecedent precipitation on the runoff or soil loss can be considered in citation. In fact, most of the soil loss prediction (such as USL equation) mainly base on the rainfall and runoff factor. The effect of antecedent precipitation has a great influence on the runoff factor.

Reply: Good suggestion. You and the Anonymous Referee #1 remined us that important references should be cited in the discussion part. In particular, some references about the antecedent soil moisture could be cited in the text, which can be helpful for manuscript improvement.

We cited four references in the last paragraph in the discussion part. The added sentences are: "In fact, figure 11 specially illustrate that antecedent soil moisture or precipitation have influence on surface runoff depth and soil loss during the permanent gully expansion in MEC, while this important aspect has been neglected. In other words, the effect of antecedent precipitation would be assessed in predicting soil loss as it closely relates to the soil water and generate indirect influence on the runoff generation and intensity (Sachs and Sarah, 2017; Wei et al., 2017; Schoener and Stone, 2019; Wang et al., 2019)."

The four references are:

Wei, L., Zhang, B., and Wang, M.: Effects of antecedent soil moisture on runoff and soil erosion in alley cropping systems, Agr Water Manage., 94, 54-62, https://doi.org/10.1016/j.agwat.2007.08.007, 2007.

Schoener, G. and Stone, M. C.: Impact of antecedent soil moisture on runoff from a semiarid catchment, J Hydrol., 569, 627-636, https://doi.org/10.1016/j.jhydrol.2018.12.025, 2019.

Wang, F., Tian, P., Guo, W., Chen, L., Gong, Y., and Ping, Y.: Effects of rainfall patterns, vegetation cover types and antecedent soil moisture on run-off and soil loss of typical Luvisol in southern China, Earth Surf Process Landf., 49, 2998-3012, https://doi.org/10.1002/esp.5871, 2024.

Sachs, E. and Sarah, P.: Combined effect of rain temperature and antecedent soil moisture on runoff and erosion on Loess, Catena, 158, 213-218, https://doi.org/10.1016/j.catena.2017.07.007, 2017.