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## Reply on RC2

Shengping Wang et al.

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Author comment on "Agricultural intensification vs. climate change: what drives long-term changes in sediment load?" by Shengping Wang et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-567-AC2>, 2022

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### Authors response

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*The following documents the authors' response to reviewer' comments. Whilst the reviewers' comments are displayed in blue, the authors' comments/responses are displayed in black.*

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Reviewer#2:

General comment

R2\_1: Language not well written for the most part but with well written sections. Lots of od sentences. Lots of missing "the"'s (I am not a native English speaker).

RESPONSE: We will edit our manuscript, by revising the language.

R2\_2:The structure of the paper is good. But with some short comings. The introduction needs to be more informative and more relevant to the rest of the paper. The is some information lacking about the sediment and water flow data.

RESPONSE: We will revise the introduction to account for this comment (R2\_2). We may note that R1 seemed to be happy with the introduction. For details please see comment R2\_37.

R2\_3: The paper spans 72 years of data but only actually utilizes 25 of these, which is a pity. I think the paper would be stronger with for example 6, 12 year periods instead of 9 year in the beginning and 16 in the end.

RESPONSE: The reason of this choice was that the data set of discharge and sediment concentration for Period I was only available for the time between 1945-1954. After that, measurements were stopped and only started again in 1990. We used the wording of "72 years" to emphasize the relevance for climatic change analysis. However, although only a limited amount of data is available for period I, we think that their information content is

extremely valuable because to our best knowledge, for this period of time (1945-1954), almost no sediment concentration data are available.

#### Detailed comments

R2\_4: Line 27-28, it is a 36% increase, i would say that, that is a significant increase.

RESPONSE: Thank you for pointing this out. We have checked the statistics and agree. We will rephrase the text to "given that the mean daily streamflow significantly decreased from  $5.0 \pm 14.5 \text{ l/s}^{-1}$  for Period I to  $3.8 \pm 6.6 \text{ l/s}^{-1}$  for Period II."

R2\_5: Line 30-31, have these been shifted? Wont this give the highest yields in period 1? Number of decimals is probably too high.

RESPONSE: Thank you for pointing this out. We have updated the slope values and reduced the number of decimal places.

R2\_6: Line 36, medium?. <Q20% is low not medium. (or state that Q20% is the highest 20%?)

RESPONSE: We consider "Q20%" as the highest 20%. This means, for Q less than Q20% approximately, both median and low flows are included. To make this sentence clearer we will change it to: "At low and median streamflow conditions, land consolidation in Period II (i.e. the parcel effect) had no apparent influence on sediment production".

R2\_7: Line 39, increasingly important?

RESPONSE: We have rephrased this part to "parcel structure became more important in controlling sediment yield".

R2\_8: Line 36-41, consider rephrasing

RESPONSE: We have rephrased this part to "With increasing stream flow, parcel structure became more important in controlling sediment yield, as a result of an enhanced sediment connectivity in the landscape, leading to a dominant role at extremely high flow conditions."

R2\_9: Line 40-41, is 7day/year = extremely high, I think it is just high.

RESPONSE: We agree. Terminologies such as "extremely", or "significant" should have a conceptual basis when used. We therefore have deleted "extremely" and rephrased this sentence to read "With increasing stream flow, parcel structure became more important in controlling sediment yield, as a result of an enhanced sediment connectivity in the landscape, leading to a dominant role at high flow conditions."

R2\_10: Line 41, in period 2 or between period 1 and 2?

RESPONSE: We have revised this sentence to "between Periods I and II".

R2\_11: Line 41-43, rephrase, consider deleting the last part. Unfavorable? = increased erosion => increased suspended sediment transport?

RESPONSE: Yes, "Unfavorable effect" herein means an increased sediment regime. To make this clearer, we revised this sentence to "The increase in cropland between Periods I and II at the expense of grassland led to an increase in sediment flux, although its relevance was surpassed by the effect of parcel changes at high flow conditions".

R2\_12: Line 44, explain "land consolidation" and "parcel structure"

RESPONSE: We use the terms "land consolidation" and "parcel structure change" almost interchangeably. The term "land consolidation" is intended to mean parcel structure change due to land use policy adjustment which aims at enhancing agricultural intensification by combining scattered land parcels into bigger ones. This is a land policy terminology. We suggest keeping this terminology because it is of common use and directs the reader towards the bigger picture of policy driven land structure changes related to agricultural industrialization.

R2\_13: Line 54, soil erosion is a process or a phenomenon not a risk.

RESPONSE: We agree and replaced the term with "a phenomenon".

R2\_14: Line 61-63, do you mean the effect of LULC change on soil erosion?

RESPONSE: Yes, it means the effect of LUCC on soil erosion. We added the abbreviation LUCC to the text to be used later on.

R2\_15: Line 63-65, what did they find?

RESPONSE: Our research purpose was to understand the respective effects of climate change, LUCC, and landscape structure change. A lot of studies have been previously carried out on individual effects. For those studies paying only attention to revealing the impact of LUCC, we do not want to use more space to introduce their findings. We therefore simply mentioned that this kind of analysis has been conducted previously.

R2\_16: Line 66, consider using LULC

RESPONSE: As a consequence of introducing LUCC in line 61-63, we can use the abbreviation now - thanks for the suggestion.

R2\_17: Line 68, References needed

RESPONSE: Thank you for pointing this out, we have added additional references.

R2\_18: Line 71, Wet or moist? A climatic period is usually considered to be 30 years, I guess that this refers to a shorter period, consider using "weather" instead.

RESPONSE: In the revision of the introduction (as requested in comment R2\_2) we will delete this part.

R2\_19: Line 71-73, rephrase. Does this mean that increased sediment loads were only found as a result of prolonged/more severe drought periods? Is this in contrast to earlier periods? And please explain why.

RESPONSE: In the revision of the introduction (as requested in comment R2\_2) we will delete this part.

R2\_20: Line 73-77 In what direction was the contributions? Consider rephrasing

RESPONSE: We will rephrase the latter part of the sentence to "with the contributions being +29%, +40%, and +31%".

R2\_21: Line 75, sediment reduction? Do you mean reduction in sediment load?

RESPONSE: Yes, it means reduction in sediment load. We will rephrase this to "reduction in sediment load".

R2\_22: Line 78 , and engineering measures

RESPONSE: Thank you for pointing this out. We will rephrase this.

R2\_23: Line 78-79, during "the period" instead of over?

RESPONSE: We prefer "over" to "during" here, because we would like to emphasize the trend of the reduction.

R2\_24: Line 84-86, In what way? Make relevant.

RESPONSE: We will rephrase the sentence to "The previous findings provide valuable information on understanding how land use and/or climate change affect soil erosion and/or sediment load".

R2\_25: Line 86-87, please explain "land consolidation", "landscape structure" and what it has to do with land use policies.

RESPONSE: The term "land consolidation" in our study means combining small land parcels into bigger ones. This usually causes landscape structure to change because field edge structures such as hedges disappear. In our analysis both terms refer to the same human activity, and sometimes we use them interchangeably. The term "land consolidation" has also been widely used, as a plan or policy in many countries, such as Austria (since 1955), the Czech Republic or China. There exist even national agencies to carry out land consolidation plans. The main reasons behind the policy of land consolidation are to enhance agricultural intensification, to be conducive to using advanced machine technology, and thus to be helpful for easier land management.

R2\_26: Line 84-91, consider splitting sentence

RESPONSE: Thank you for the suggestion, we will split this sentence into more.

R2\_27: Line 93, land uses and land units? What does this mean? Is it that field edges/margins usually has permanent vegetation and therefore some trapping capacity, and therefore smaller fields will have smaller soil losses than larger fields because they have more field edges?

RESPONSE: To our understanding, boundary effects do not necessarily related to permanent vegetation on edges/margins, although this is often the case. Boundary effects may also result from different field properties (such as field infiltration, water/sediment trapping capacity, and so on) between two adjacent land parcels. This may for instance be the case when two fields are managed in a different way, say one is without cover, another one has some soil cover developed. For a given crop, a small field will exhibit smaller infield (onsite) soil losses compared to a larger field, but this is due to the effect of the field properties which is different from processes that occur at the edges of fields.

R2\_28: Line 100, studies not authors (they are "et al.")

RESPONSE: We will revise this line accordingly.

R2\_29: Line 92-101, what did they find beside that parcel structure matters. Are small better than large, long better than round...? You should enlighten the reader.

RESPONSE: The key findings of both studies are to underline that inner organization of field blocks have a strong effect on the risk of soil erosion, and both studies are dedicated to revealing the relevance of boundary effects on soil erosion controls from the perspective of hydrological/sediment connectivity. Both studies did not explicitly conclude that "small blocks are better than large" or "long better than round". To our understanding, hydrological/sediment connectivity is essentially resulting from landscape heterogeneity, instead of a simple size effect or shape effect. Thus, after consideration we suggest to show only the actual findings of both studies and keep the text as is.

R2\_30: Line 101-105, what did they find? Anything the reader should know about, otherwise consider deleting

RESPONSE: This part is intended as a short summary for all of the previously mentioned studies. Since most of their findings have been illustrated in the previous paragraphs, we did not want to expand this section to report their results/conclusions more than necessary. However, as a summary we still think that these lines are helpful and thus suggest keeping them unchanged.

R2\_31: Line 108, <suggestion> showing that the same land structural changes have different impact in different landscape and agricultural settings?

RESPONSE: Yes. According to studies such as David et al. (2014) and Cantreul et al. (2020), the impact of land structure change on soil erosion would be different in different environmental settings, in which underlying soil and/or vegetation are different.

R2\_32: Line 114, what practical perspective?

RESPONSE: During the revision process of the introduction, this sentence will be deleted.

R2\_33: Line 115 is this the first time land use and land cover change is mentioned

Response: We will define the term "LUCC" at the place where it was mentioned first (line 63 in the original manuscript).

R2\_34: Line 121, parcel structure change? Is the change made with the intention of reducing erosion?

RESPONSE: The change has been made without any consideration of the soil erosion problem. It is a consequence of agricultural industrialization that has taken place since the 1940's. Like with many changes during this period of agricultural industrialization it now turns out that very negative side effects exist (in our case erosion). To better specify this, we will revise the sentence to "has experienced a significant change in land use and land cover as well as parcel structure due to an altered land management policy during the past decades".

R2\_35: Line 122, sediment concentration? And yield/load calculated from these? Is it suspended sediment or total load, including bed load?

RESPONSE: We will revise this to "suspended sediment concentration". Sediment yield/load is calculated from these observations. There is no bedload existing in the HOAL stream, because it is located in an area which consists of fine tertiary sediments and the soils do not have any stone content.

R2\_36: Line 126, I see that the two ends of the period are interesting to compare, but the inter long period in between is also of interest and could/should act as kind of validation period. What if you find differences between the end periods, and draw conclusions on these but these conclusions might not explain what happened between 1954 and 2002. Why 9 years between 1946 and 1954 and 16 years between 2002 and 2017. I guess 9 years is a relatively short period could be influenced by "extreme years".

RESPONSE: We completely agree that a long-term observation records is valuable and important for understanding the trend of the change in sediment load/yield. However, the datasets of sediment concentrations and flow rates between 1954 until the 1990's are not available, due to a lack of measurements. Therefore, we are compelled to restrict our investigations to the described time periods. What we do have, is a record of climatic observations over 1946 to 2017. On the one hand, according to the long-term observations of precipitation, we found that there are no significant trends ( $p > 0.05$ , Mann-Kendall test) with respect to climatic parameters over the past decades (see the following Figures). This reinforces our confidence in comparing the two (relatively) short-time periods. Additionally, the focus of our study is to compare the SHIFT and/or change of sediment regime between the two periods, rather than a TREND of sediment regime over 1945 to 2017.

Figure1 Time series of climatic parameters for the HOAL Petzenkirchen; left upper: average annual precipitation, right upper: number of erosive events, left lower: average rainfall erosivity as defined in the RUSLE soil erosion model; right lower: average erosion density (this was used in this study as a climatic indicator for the change in erosive potential rainfall) The red line represents the 15 years moving averages.

R2\_37: Line 55-114 The introduction mentions many relevant subjects and lots of references but does not really make them relevant for the study. The reader does not get much better prepared for reading the paper, by reading the paper. Consider focusing on fewer and the most relevant subjects and let the reader know what all/some of the studies referred to found and why this is relevant to the present study/paper.

RESPONSE: We will reorganize the introduction to account for this comment. Specifically, we will confine relevant studies to a few of attribution analysis. We then point out that most of the previous analyses considered LUCC and landscape structure change as a whole to understand it's role in affecting sediment load. Next, we will emphasize that the relevance of landscape structure changes has so far received less attention, even though land-use policies, such as land consolidation, have been changing agricultural practices. We now also elaborate on the relevant studies about the impacts of landscape structure change subsequently, which is then followed by our research purposes. R#1 emphasized the quality of the introduction, and we therefore kept the changes to a moderate level.

R2\_38: Line 133 is there a map somewhere?

RESPONSE: Yes, there is Figure 1. R2\_44 also addresses this point.

R2\_39: Line 146 suspended sediment (or suspended matter, thus including the organic part). Please be more precise here.

RESPONSE: Thank you for pointing this out. We will revise this to "suspended sediment concentration".

R2\_40, Line 150 "at" not "by"? and using some water level/stage measuring devise and calculating flow using a stage-flow relationship (Q/h)?

RESPONSE: We prefer "by" over "at" here, because we want to emphasize the observational approach, i.e. "a Thompson weir and a paper chart recorder". Streamflow was calculated by water level and a flow rating curve (i.e. a stage-flow relationship).

R2\_41: Line 152 measured "manually" meaning that samples were collect manually? Through bottle dipping?, surface/depth integrated?

RESPONSE: Yes, this was done by bottle dipping directly into the mixing zone of the weir. The brook is very small (baseflow of about 2 l/s), so mixing is reached quickly. There is therefore no need of depth integration unlike in larger rivers.

R2\_42: Line 153 automatic method, meaning? ISCO samplers/turbiditymeter? What is the additional manual sampling used for and how often is it collected, and what is the time resolution of the unspecified automatic method?

RESPONSE: In the second period we used 2 ISCO samplers (48 bottles). The start of the sampling was triggered by increased flow rates to obtain samples for the rising and the falling limb of the hydrograph. The sampling interval for the first sampler was set to 15 min, the second sampler was set to 1 h. In addition, manual sampling took place once a week in Period II.

R2\_43: Line 156 what is "the vegetation period"?

RESPONSE: We will revise the text to "growing season".

R2\_44: Fig 1 a) Ok to zoom in a bit. b & c) the gauge looks like it is in the same place

in both maps. I guess it should be moved down stream for 1946? In the text "paved" or "roads and settlements (line 159)" is used rather than "sealed", please choose one and correct throughout. What are the lines within the catchment, roads? I don't think they are part of the "symbol key" or "legend"

RESPONSE: The gauges in Fig b) and c) are located at different places. This makes a small, negligible difference in catchment size (about 200 m<sup>2</sup>). We will indicate this difference in the legend for this Figure. As for the "roads and settlements" (in line 159), we rephrased this to "roads and settlements (i.e. paved area)", and "paved area" was used throughout the following text. The lines within the catchment refer to the stream or to contours. This is indicated in the legend for this Figure. Please see also #R1\_10.

R2\_45: Line 175        This is the kinetic (potential erosive power) of rain events. You cannot say what the effect of rainfall is quantified by this measure as it also depends on the erodibility.

RESPONSE: We agree that soil erosion is dependent on many factors such as rainfall erosivity, soil erodibility, and some others (such as crop management, conservation practices, and topography). However, in this paper the focus is on how climate change\weather change affect soil erosion. The parameter EI30 is a combination of kinetic energy and maximum intensity of rain. It is a commonly accepted parameter to describe the erosive power of rain. Our intention in using this parameter is to have an indicator for the power of rainfall to cause erosion, because one of our assumptions at the beginning of our study was that the erosive power of rainfall has increased due to climate change. We could show that this was not the case for the studied periods. Soil erodibility (however is defined and measured) is a measure of the susceptibility of the soil against erosion and does not affect EI30. We agree that a change in soil erodibility may have influenced the erosion susceptibility of the catchment between the two periods. The main driving force of soil erodibility is soil texture which has not changed during the periods. Furthermore, organic carbon of a soil is usually a parameter that may modify soil erodibility, but to a much lesser extent compared to soil texture. Only few results on soil organic carbon are available from Period I, but they suggest no substantial shift in organic carbon contents between the two periods. Therefore, we are confident that a change in soil erodibility is not a major reason for the differences in sediment loads.

R2\_46: Line 184        event precipitation?

RESPONSE: Yes, we calculated rainfall erosivity for each precipitation event according to 5-min rainfall intensity data records, and then estimated the statistic of rainfall erosivity by month and by year, respectively.

R2\_47: Line 184-186        please explain why

RESPONSE: We will add an explanation to the revised manuscript such as "We assumed erosivity density ED (i.e. EI30 divided by event precipitation) to be a particularly relevant climatic indicator of the soil erosion process and catchment sediment yield because it is calculated as a combination of rainfall kinetic energy and maximum rainfall intensity of rain events. These are commonly considered as the relevant parameters of rain to trigger the soil erosion process." R (or EI30) is commonly a measure of the erosion force of specific rainfall, determined by the amount of rainfall and rainfall peak intensity. ED is calculated as EI30 divided by event precipitation, so ED actually addresses the impact of the difference in the amount of precipitation. Thus, ED is an indicator of erosional forces of rainfall irrespective of different amounts of precipitation.



R2\_48: Line 189 but wouldn't you expect that this is the period where it is most relevant? As there are no/less crops/vegetation in the fields.

RESPONSE: Less vegetation is of course present during the dormant season. However, the main driving force of erosion remains erosive rainfall. Erosive rain may very well be characterized by EI30. Erosive rainfall does not take place during winter in Austria, therefore the risk of soil loss during the dormant season is very low compared to the vegetation period. We may refer to Figure 3a which demonstrates the monthly distribution of erosive rainfall at the site (very similar to the rest of Austria and Central Europe by the way) to show, that the risk of soil loss during the winter months is very low compared to the soil loss risk during the vegetation period. This is also the reason why we separated our analysis into dormant and vegetation period.

R2\_49: Line 198-192 how good/bad is this relationship ( $R^2=0.xx$ )? Is it validated against other periods?

RESPONSE: This relationship was established by using the dataset of 2006 to 2017, and it performed well with  $R^2=0.82$  ( $n= 12$ ) (Please see the following figure). Also, it performed well for the validation period of 2000 to 2005, with  $R^2$  over 0.8.