Comment on essd-2020-370

Anonymous Referee #1

Referee comment on "Rainfall erosivity mapping over mainland China based on high density hourly rainfall records" by Tianyu Yue et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2020-370-RC1, 2021

Dear Editor

The editorial support team

Copernicus Publications

Hello

I am thankful to you for allowing me to review ESSD manuscript. The present MS targeted the calculation of R factor for China using high resolution data. The work was a good and tedious one and I liked it. However, I am against its acceptance for publication thanks to many deficits and ambiguities found in the context and made it unclear in many aspects.

The big issue refers to the rationale of the work.

The formulation of the research setup needs more strong rationale particularly in the viewpoint of agreement with real conditions.

No proper reviewing of literatures with further focuses on the main goals of the study and recent none-Chinese ones has been made.

It has no detailed and documented information on methodology.

It has no comprehensive and integrated discussion.

According to the comments mentioned above and some comments, revisions or suggestions appended in the context, I therefore suggest resubmitting a new and substantially improved MS. My all comments and suggestions have been annotated in the reviewed file as an attachment.

Responses to reviewer #1

Dear Editors and Reviewer

Thank you for your letter and the reviewer's comments concerning our manuscript "Rainfall erosivity mapping over mainland China based on high density hourly rainfall records" (ESSD-2020-370). The comments are valuable and helpful for revising and improving our paper. We have considered and addressed all the comments carefully. We have responded to each of the reviewers' comments in blue:

1.1 Line 12: "1-in-10-year". Use common unit?? For instance 10 % probability or 10 years return period!!

Response: "1-in-10-year" is a common term to describe extreme event with an annual exceedance probability of 10%. In fact, in the RUSLE Guideline (Renard et al., 1997), an expression of 10-yr EI was used (p. 31).

1.2 Line 15: "1-in-10-year". Why this one??

Response: As mentioned in Line 42, the 1-in-10-year EI_{30} is a required parameter when the support practice factor (P factor) for the contour farming is estimated in the USLE-type model. (Renard et al., 1997)

1.3 Line 16: "the R factor". Is it a "mean value"? Fix it!!

Response: Yes, the rainfall erosivity factor (R factor) in the USLE is the average annual total EI_{30} of all erosive events, which was defined in Line 35-36.

1.4 Line 17: "New maps indicated current maps existed an underestimation for most of the southeastern areas and an overestimation for most of the middle and western areas." How did you assess??

Response: As described in section 2.4, the R factor and the 1-in-10-year EI_{30} maps from Yin et al. (2019) were taken as the reference value for current maps and Section 3.1 assessed the accuracy of new maps developed in this study and those in Yin et al. (2019) by comparing the R factor and 1-in-10-year EI_{30} values with those calculated from 1-min observed rainfall data.

1.5 Line 19: "accuracy from 19.4% to 15.9% in the". It worth of you properly address the former comment!!

Response: Rainfall erovisity values in the current maps from Yin et al. (2019) were overestimated for some regions, while underestimated for others by comparison with the true values from 1-min rainfall data. This sentence focuses on the degree of improvement by comparing the new maps with the old ones from Yin et al. (2019).

1.6 Line 21: "the increase of data resolution from daily data to hourly data". How valuable this approach is for practical purposes and in reality??

Response: There are generally two ways to improve the accuracy of the rainfall erosivity maps: one is to increase the temporal resolution of the data (from daily to hourly); the other is to increase the station density (add more stations, especially in sparse density area). There are usually not many stations with long-term hourly observations (say > 30 years). However, with the installation of automatic weather stations, hourly data are becoming more widely available, and this may be supplemented with satellite-based precipitation data at hourly and sub-hourly intervals. This study presents and shares datasets on the rainfall erosivity based on more than 2000 stations of hourly rainfall observations.

1.7 Line 22: "increase of the number of stations from 744 to 2381". How necessary it is?? Reword it.

Response: As it was pointed out in Section 3.3.2, the improvement from increasing the number of stations from 744 to 2381 occurred mainly in western regions with a station density of 27.3~71.9 stations per million km^2. The station density in the eastern China (90.5~152.5 stations per million km^2) has been adequate to describe the spatial variation of the R factor and the 1-in-10-year EI_{30}, which resulted in a small improvement from tripling and quadrupling station density (Table 4 in the revision). We have revised the sentence into "The improvement of the new R-factor map can be mainly contributed to the increase of data resolution from daily data to hourly data, whereas that of new 1-in-10-year EI_{30} map to the increase of the number of stations, especially in western regions (from 87 to 150)" to make it clearer.

1.8 Line 24: "10·103 km2 1 station". Why you try to use strange presentation and writing??

Response: We have revised this into "1 station every 10,000 km^2".

1.9 Line 26: "Soil erosion has been the major threat to soil health, soil and river ecosystem services in many regions of the world." Document it!!

Response: Reference has been added (FAO, 2019b).

1.10 Line 28: "The reduction of crop production due to erosion has been estimated to be 0.4% per year on a global scale (FAO, 2019b)" Since the erosion rates are not influenced by R factor only, it is not therefore necessary to focus on soil erosion issues and related problems!! So, please remove or shorten it!!

Response: We have removed this sentence in the revised version.

1.11 Line 40: "To acquire soil erodibility factor (K factor) and cover-management factor (C factor), the seasonal distribution of EI (monthly, Wischmeier and Smith, 1965; or half-month percentage of EI, Renard, 1997, Wischmeier and Smith, 1978) were needed." Remove unnecessary materials. The ones who work in this field they know what for R factor is being utilized!!

Response: We generate the R-factor value, its seasonal distribution at half-monthly resolution, and extreme 1-in-10-year storm erosivity so that RUSLE can be applied in a manner that is consistent to RUSLE Guideline (Renard et al., 1997).

1.12 Line 41: "The other is the 1-in-10-year storm". It is not globally accepted!! It is better to provide general results and outputs. However, necessary conversions will be done by end users!!

Response: The 1-in-10-year EI_{30} is an extreme value of event EI_{30}, which is different from the average value of rainfall erosivity (the R factor). Also, it is a requirement in the USLE-type models, therefore, we generate not only R factor but also 1-in-10-year EI_{30} maps. What climate-related factors to be used for erosion prediction is subject to debate. This paper on a data product is all about enabling the application of the RUSLE in a consistent manner.

1.13 Line 46-50: The latest literatures would be given!! Even Panagos et al. (2017) would have been cited!!

Response: Panagos et al. (2017) is cited in Line 67 and Table 1.

1.14 Line 55: Here, again you have gone back to soil erosion and indispensability of erosivity factor!!

Response: This sentence had been removed in the revision.

1.15 Line 65: "which were recorded by simple rain gauges and readily available." Add "data" at the end.

Response: The sentence had been revised into "Current R-factor maps for mainland China typically used readily-available daily rainfall data from about 500-800 stations (e.g., Zhang et al, 2003; Liu et al., 2013; Qin et al., 2016; Yin et al., 2019; Liu et al., 2020), which were recorded by simple rain gauges" to make it clearer.

1.16 Line 67: "Breakpoint data and 1-min data are the best". Who said so??

Response: The true value of KE should be calculated by the distributions of raindrop sizes measured

by distrometers, which are not easy to obtain for long periods. Fortunately, there is a good relationship between kinetic energy KE and the instant intensity I, so KE was estimated based on KE-I relationship using breakpoint data in USLE and RUSLE. One-minute interval data are the finest resolution data measured by automatic tipping bucket rain gauges we can obtain up to now. Therefore, breakpoint data and 1-min data are the best datasets for deriving precipitation intensity and estimating rainfall erosivity given the absence of raindrop sizes observations. We have revised here into "One-minute data are the finest resolution data measured by automatic tipping bucket rain gauges we can obtain up to now, therefore they are one of the best datasets for deriving precipitation intensity and estimating rainfall erosivity.".

1.17 Line 72: "The study of (Yin et al., 2019) was chosen". Should be "The study of Yin et al. (2019) was chosen".

Response: We have revised the manuscript accordingly.

1.18 Line 73: "New R factor and 1-in-10-year EI30 maps were produced in this study may improve the estimation of the soil loss in mainland China." You have worked on R factor and therefore not allowed concluding soil loss or soil erosion rates!!

Response: Quality estimates of the R-factor would allow improved erosion prediction using the RUSLE technology.

1.19 Table 1: How these interpolation techniques have been matched??

Response: We agree that these interpolation techniques were not matched. After further confirmation, we modified the "Contour mapping" into" unknown", the "Kriging" method by Zhang et al. (2003) and Liu et al. (2013) into "Ordinary Kriging".

1.20 Line 89: "Observation was suspended in the snowy season". How did you do it??

Response: As mentioned in Line 111-113, if the observations were suspended in cold season, precipitation occurred during this period of time were not included in this study for the following two reasons: (1) Stations with missing observations in cold season were mostly distributed in the northern part of China, where the climate is usually dry in winter due to the monsoon system; (2) Usually the precipitation in cold season was in the form of snow other than rain.

1.21 Figure 1: How this gap region was managed??

Response: This region was interpolated with Universal Kriging. We agree that a lack of stations in this region would bring about large uncertainty in the estimation of rainfall erosivity in this region. We have added some discussions on this limitation: "(d) Station distribution and density. In western China, the stations were sparse and unevenly distributed, which affect the interpolation accuracy".

1.22 Figure 2: Same issue!! Lack of station!!

Response: It is true that station densities in Tibetan Plateau and southern Xinjiang are limited, especially for 1-min resolution data. There are large areas without any observation due to its high elevation in Tibetan Plateau and great desert in southern Xinjiang. The evaluation based on 1-min data does not cover these areas without observations in this study. As mentioned above, we have added some discussions on this limitation: "(d) Station distribution and density. In western China,

the stations were sparse and unevenly distributed, which affect the interpolation accuracy".

1.23 Line 119: "period of >= 6 hours of non-precipitation was regarded as the separation of two rainfall storms". This criterion has to be adjusted for the study region!!

Response: Minimum inter-event time (MIT) is an index used to delineate independent storms from sub-daily rainfall records. An individual storm is defined as a period of rainfall with preceding and succeeding dry periods less than MIT. To be comparable with Wischmeier and Smith (1978), and (Renard et al., 1997), 6 hrs was adopted as the MIT in this study, since this paper on a data product is all about enabling the application of the RUSLE in a consistent manner.

1.24 Line 120: "amount of >= 12 mm". Do not think it would be too much??

Response: We do not want to be too creative here, just to use ULSE/RUSLE guideline to be consistent. Some storms with total precipitation amount less than 12 mm but with high intensity and short duration may result in soil loss, whereas some storms with total precipitation amount more than 12 mm but with low intensity may not result in soil loss. As Xie et al. (2002) pointed out, in practice, it is impossible to separate erosive and non–erosive rainfalls completely based on only one or two threshold values because of the complexity of rainfall characteristics and temporal variations in the system response in terms of runoff and soil loss. Xie et al. (2002) identified the erosive rainfall threshold that storms actually caused erosion were omitted from the calculations, while certain storms that do not cause erosion were included in the calculations in order to balance those omitted. In the study, rainfall and runoff data measured for three plots and a small watershed from 1961 to 1969 at the Zizhou experimental station of the Yellow River Basin in China were used. The erosive rainfall amount threshold proposed by Xie et al. (2002) was 12 mm, which was very close to the threshold suggested in the USLE (12.7 mm).

1.25 Line 123: "intensity I30 (mm h-1)". How sure you are that it is the best index??

Response: Wischmeier and Smith (1958) analyzed precipitation and soil loss data from fallow plots at three observation stations in Missouri, Iowa, and Wisconsin and identified that the event EI_{30}, the product value of total storm kinetic energy (E) and its maximum 30-min intensity (I_{30}), estimated the single storm soil erosion best. Wischmeier (1959) analyzed approximately 8000 plot-years of basic runoff, soil loss, and associated precipitation and related data in 21 states in the eastern part of the United States gathered by the National Runoff and Soil Loss Data Center from the erosion stations that were operating at that time. They confirmed the R factor's suitability at these locations, not only for fallow plots but also for continuous row crop plots, and not only for storm-to-storm variation but also for seasonal and yearly variations.

1.26 Line 123: "1-hour intensity H60 (mm h-1)". It is strange!! What for it was??

Response: For hourly data, it cannot calculate I_{30} directly. When there is only hourly precipitation data available, product of the kinetic energy, E, and the maximum 1-hour intensity, H_{60}, in the storm was used to calculate the storm rainfall erosivity, which was then adjusted by multiplying a conversion factor proposed in Yue et al. (2020) to be comparable with EI_{30} based on breakpoint data or 1-min interval data.

1.27 Line 132 (equation 5): Still I am not convinced!!

Response: Yue et al. (2020) showed that the R factor calculated by 1-hour rainfall data had a good linear relationship with that estimated by 1-min data based on observation rainfall data at 1-min intervals from 62 stations over China. The determination coefficient R^2 was 0.994. The slope of the regression model (1.871) can be regarded as a conversion factor to obtain the R factor using hourly data.

1.28 Line 150: "The effective years of hourly data were no less than those of daily data (37% of the stations)". On which basis??

Response: We have revised here as "The calculation of the R-factor considered the following two cases: (1) The effective years of hourly data were no less than those of daily data (871 out of 2,381 stations); (2) The effective years of hourly data were less than those of daily data (1,510 out of 2,381 stations).".

1.29 Line 153: "then adjusted by the mean annual rainfall calculated by daily data". How this equation has been attested??

Response: The exponent value of 1.481 was estimated using the relationship between the mean annual precipitation and the R-factor. The latter was computed using 1-min and daily rainfall data for 35 stations in China with a common period of record of > 10 years (Fig. 2) as follows:

$$R_{min} = 0.156 \cdot P_m^{1.481}, \qquad \text{(Eq. 9 in the revision)}$$

where R_{min} was the R-factor (MJ mm ha^{-1} h^{-1} a^{-1}), and P_m was the mean annual precipitation (mm) using 1-min data. The coefficient of determination (R^2) was 0.776 for Eq. 9.

To adjust the R-factor from hourly data of shorter record length to those from daily data of longer record length with Eq. 8 in the revised manuscript, daily data from 1,510 stations were used.

$$R_{\text{hadj}} = R_{hour} \left(\frac{P_d}{P_h}\right)^{1.481} \qquad \text{(Eq. 8 in the revision)}$$

where P_d and P_h are the mean annual precipitation estimated using daily data and hourly data, respectively. The adjustment proceeded as follows:

(1) Calculate the mean annual precipitation and the R-factor (denoted as R) from the daily data of 1,510 stations;

(2) Let M be the sample size of daily data, and N that of hourly data, and M > N. Randomly select N years of daily data and calculate the mean annual precipitation (P_{sample}) and the R-factor of the sample data, and call this R_{sample};

(3) Adjust the R-factor using the mean annual precipitation for the selected N years:

$$R_{\text{adj}} = R_{sample} \left(\frac{P}{P_{sample}}\right)^{1.481}$$

where R_{adj} is the adjusted R-factor, P is the mean annual precipitation using all the available daily data;

(4) Calculate the absolute relative error of the R_{adj} and the R_{sample} using the following equation:

$$ARE_{adj} = \left|\frac{R_{adj} - R}{R}\right| \times 100\%$$

$$ARE_{sample} = \left|\frac{R_{sample} - R}{R}\right| \times 100\%$$

(5) Repeat the step (2) to (4) 50 times and calculate the 5th-, 25th-, 50th-, 75th- and 95th

percentile of ARE_{adj} and ARE_{sample};

(6) Compare the difference between the percentile values of the absolute relative error before (ARE_{sample}) and after adjusting (ARE_{adj}).

The following figure shows that for most stations, the absolute relative error of the R-factor decreased after the adjustment. The decreasing mainly ranged 0~20%, indicating a corresponding improvement in the R-factor by 0~20%.
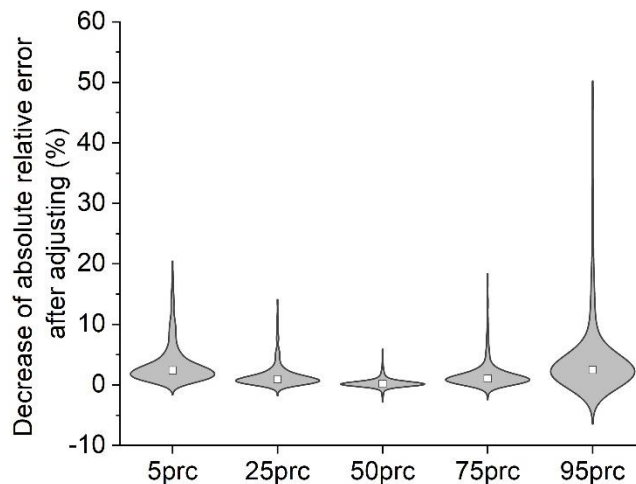

Figure 1 Decrease in the absolute relative error after following the adjustment

1.30 Line 162 (equation 9): The entire investigation hinges on a set of recessive equations and models developed by formers which certainly leads to an cumulative errors or uncertainties for which no justification has been provided!!!

Response: About the validation of Eq. 9, please refer the previous comment and response. In addition, some discussions on the uncertainty were added in the revision: "…… (c) The adjustment of the R-factor from the stations with less effective years (Eq. (8)). This is based on a power function (Eq. (9)) of the mean annual precipitation and rainfall erosivity using 1-min and daily rainfall data of 35 stations" in the discussion part.

1.31 Line 226: "3.1 Accuracy evaluation on erosivity maps" It seems to be precision rather accuracy!!

Response: Accuracy is how close a measurement/estimation is to the correct value for that measurement. The precision of a measurement system refers to how close the agreement is between repeated measurements (which are repeated under the same conditions). We think it is accuracy here in this study.

1.32 Line 230: "particularly noticeable for western China". Where limited stations are available!!

Response: We agree that limited stations were used in western China to estimate and evaluate the rainfall erosivity. More stations have been used for western China in this study compared with previous studies, which improved the accuracy of rainfall erosivity estimation for this region.

1.33 Figure 3: It seems to me senseless!!

Response: The scatterplot shows R factor values estimated in this study and those from the previous

study (Yin et al., 2019) with those calculated based on 1-min interval data, which was assumed to be the true values of rainfall erosivity. The figure (Fig. 4 in the revision) and Table 2 in the manuscript showed for the R factor, the values in the map of Yin et al. (2019) were underestimated where the R factor was relatively high, and overestimated where the R factor was relatively low. R factor values estimated in this study had smaller error comparing with those in Yin et al. (2019).

1.34 Figure 4(c): What do you imply from??
Response: Figure 4(c) (Figure 5(c) in the revision) shows the distribution of the relative errors of the 1-in-10-year EI_{30} for this study and Yin et al. (2019) by comparing them with true values based on 1-min precipitation data. It indicated that the relative errors in this study concentrated in the range of -10%~10%, whereas those in Yin et al. (2019) concentrated in the range of -25% ~ -15% and +15% ~ +25%, which were larger than those in this study. We have added these explanations in the revision to make the implication of the figure clearer.

1.35 Figure 5: Any map has to contain important places and localities!!
Response: We have added them in the revised version.

1.36 Figure 6: How reliable these differences are??
Response: Figure 6 (Fig. 9 in the revision) shows the differences between R factor and the 1-in-10-year EI_{30} in this study comparing with the previous study (Yin et al., 2019). An independent dataset (62 stations with 1-minute data) was used to evaluate the accuracy of two groups of maps. Figure 3, 4 (Fig. 4, 5 and 6 in the revision) and Table 2 demonstrated the results of comparison. It is true that most of 62 stations distributed in the eastern part of China, where most water erosion occurs. The uncertainty in western areas with limited observations is large and we have discussed it in the revision as "(d) Station distribution and density. In western China, the stations were sparse and unevenly distributed, which affect the interpolation accuracy.".

1.37 Figure 7: Firstly, the former comments and inquires have to be addressed!!
Response: We have addressed them in the revision.

1.38 Line 303: "3.3.3 Contribution of the interpolation method" Is it really contribution?? Title it properly!!
Response: We revised it into "Effect of the interpolation method".

1.39 Figure 9: To me they are not comparable, since each has been developed for a particular purpose and with a specific resolution!!
Response: The erosivity map proposed by Panagos et al. (2017) is for a global scale and it has provided a good basis for the comparison of rainfall erosivity among different regions in the world. Mainly due to the number of observation stations obtained, two studies showed some differences. It is suggested to use the R factor map in this study for China since independent 1-min precipitation dataset has been used to show that maps in this study outperform those from Panagos et al. (2017). We have added these explanations in the revision to make it clearer.

1.40 Conclusions: Avoid repetition of results and abstract!!

Response: We have revised the abstract to avoid repetition and make expressions more clear.

1.41 References: Cite new literatures and particularly from 2021!!

Response: We submitted this manuscript in 2020 and have added new works of literature in the revision (Line 67).

References

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Yin, S., Xue, X., Yue, T., Xie, Y. and Gao, G.: Spatiotemporal distribution and return period of rainfall erosivity in China(in Chinese), Trans. Chinese Soc. Agric. Eng., 35(9), 105–113, doi:10.11975/j.issn.1002-6819.2019.09.013, 2019.

Yue, T., Xie, Y., Yin, S., Yu, B., Miao, C. and Wang, W.: Effect of time resolution of rainfall measurements on the erosivity factor in the USLE in China, Int. soil water Conserv. Res., doi:https://doi.org/10.1016/j.iswcr.2020.06.001, 2020.

Comment on essd-2020-370
Anonymous Referee #2
Referee comment on "Rainfall erosivity mapping over mainland China based on high density hourly rainfall records" by Tianyu Yue et al., Earth Syst. Sci. Data Discuss.,
https://doi.org/10.5194/essd-2020-370-RC2, 2021
Dear editor,
Thanks for the review invitation. The USLE model is used in many regions over the world.
It is a general method by several indicators. The R factor, i.e., rainfall erosivity, has significant effects on the modeling results. This study maps the rainfall erosivity over mainland China by using high density hourly rainfall records. The data sources are presented well and the results would be useful for related soil-erosion research. The manuscript should be improved in several aspects before

it is considered for the publication.

Responses to reviewer #2

Dear Editors and Reviewer

Thank you for your letter and the reviewer's comments concerning our manuscript "Rainfall erosivity mapping over mainland China based on high density hourly rainfall records" (ESSD-2020-370). The comments are valuable and helpful for revising and improving our paper. We have considered and addressed all the comments carefully. We have responded to each of the reviewer's comments in blue:

2.1 The new development of USLE, especially the rainfall erosivity, should be presented and discussed in the introduction section. The meaning and rational of the study is not exhibited well.

Response: In the original version of the USLE, 181 stations with breakpoint data plus 1700 stations with annul averaged precipitation, 2-yr, 1-h amount and 2-yr, 24-h amount for eastern part of the U.S. were used to generate the erosivity maps (Wischmeier and Smith, 1965). In the successor of the USLE (Wischmeier and Smith, 1978), erosivity maps for the western part of the US were added based on 2-yr, 6-h rainfall amount data (P) using the equation of $R=27.38P^{2.17}$. In Revised USLE (RUSLE), Renard et al. (1997) released erosivity maps using same data as Wischmeier and Smith (1965) for eastern part, and 60-min rainfall data at 790 stations for the western part in the U.S.. In RUSLE2, monthly erosivity maps based on 15-min data from 3700 stations were generated (USDA–ARS, 2013). We have added these in the revision (Line 58-65). Rainfall erosivity maps can be meaningful in various fields such as soil erosion, sediment yield, environment and ecology. Current R-factor and extreme event erosivity maps over China were usually based on daily rainfall data, which demonstrated limited accuracy. Yin et al. (2015) reported the accuracy of rainfall erosivity estimation increased with the temporal resolution of rainfall data and the use of hourly precipitation data can improve the estimation of rainfall erosivities, especially those for the extreme events. Hourly precipitation data from 2381 stations were obtained to improve the current rainfall erosivity maps. In addition, the uncertainty in the generation of rainfall erosivity maps mainly comes from (1) the temporal resolution of precipitation data, (2) the distribution and density of stations and (3) interpolation methods. Therefore, objectives of this study are: (1) to develop high-precision maps of the R factor and 1-in-10-year EI_{30} over the mainland China; (b) to quantify the improvement of the new erosivity maps in higher temporal resolution and station density and better interpolation method compared to current maps. The meaning and rationale of the study is to: (1) present and share high-precision maps of the R factor and 1-in-10-year EI_{30} over the mainland China with related earth system science communities, which leads us submitting the manuscript to ESSD; (2) provide some insights in the improvement of rainfall erosivity maps for other regions over the world. We have added these in the revised version (Line 87-89).

2.2 How can the re-calculation of R factor help to reveal the mechanism of rainfall erosivity? I suggest the authors to add a flowchart for the study.

Response: Strictly speaking, this is beyond the scope of the paper. This paper is about a data product for the application of USLE/RUSLE in China. The flowchart of the data and the methods is as follows (Figure 2), and we have added it in the revised version (Fig.3 in the revision).

We may understand the connection of the re-calculation of R factor in this study and the mechanism of rainfall erosivity as follows:

Rainfall erosivity is an index describing the combined effects of raindrop splashing and runoff scouring on soil, which are quantified by the product of kinetic energy (E) and maximum 30-min intensity (I_{30}), EI_{30} in USLE models. Kinetic energy generated by raindrops can be calculated based on raindrop disdrometer data and estimated based on breakpoint or hyetograph data via KE-I equations, while I_{30} is expected to be prepared using breakpoint or hyetograph data with an observed interval ≤ 30 min. However, these data were usually in shortage not only in the length but also in the spatial coverage, which challenge the generation of rainfall erosivity maps. Statistical models have been developed to use more commonly available data, such as daily data to estimate R factor. The aggregation of temporal resolution of precipitation data results in large information loss due to the high temporal variation of precipitation, especially for extreme events. Hourly data was believed to reflect the variation of precipitation intensity better than daily data, which can be used to improve the estimation of at-site rainfall erosvity with precipitation observations. In addition, the increase of station density for the interpolation can better describe the spatial variation of rainfall erosivity and improve the estimation of rainfall erosivity for areas without observations together with the improvement of interpolation models and procedures.

We have added above information in the revision (Line 43-47 and Line 78-81).

R & 1-in-10-yr EI_{30} values at 2381 stations based on hourly data and adjusted by daily data

Spatial interpolation

R & 1-in-10-yr EI_{30} maps over mainland China

Cross validation for 62 stations for the R-factor, and 18 stations for the 1-in-10-year EI_{30}
Statistics for 6 erosion and 9 hydrological zones

Evaluation of the improvement in erosivity maps in comparison with a previous study
(Yin et al., 2019)

Effect of data temporal resolution: daily vs. hourly

Effect of the number of stations: 774 vs. 2381

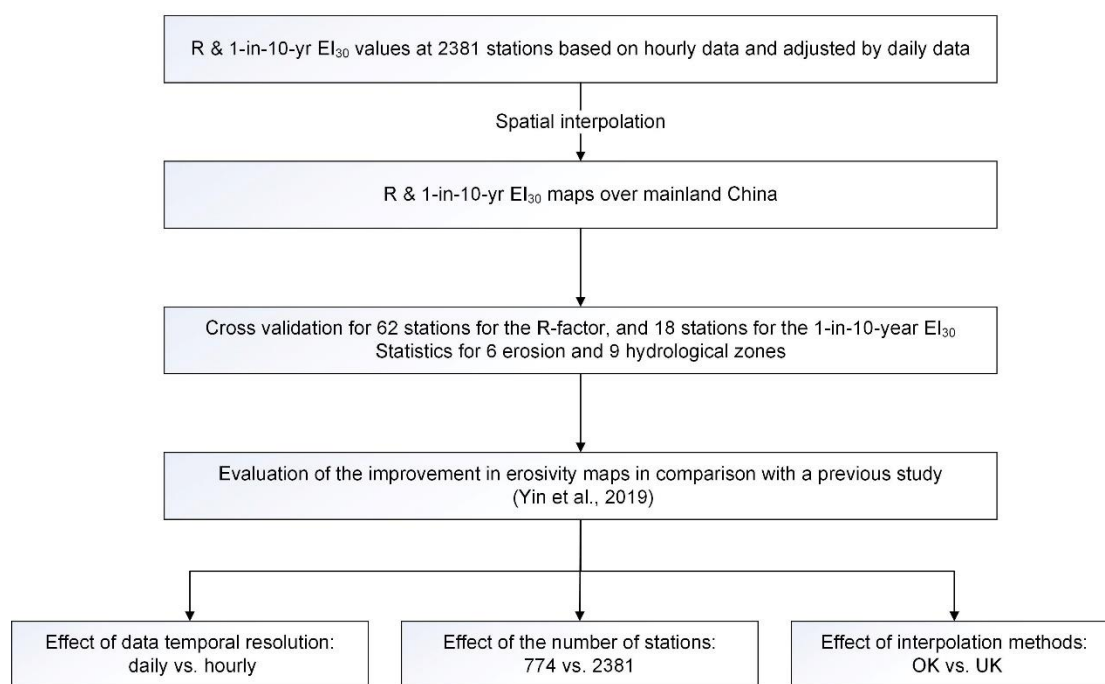Effect of interpolation methods: OK vs. UK

Figure 2 Framework of this study

2.3 The validation of the results is conducted mainly by comparing with Yin's results. If the authors provide more findings from field observation, the validation would be more meaningful.

Response: The validation of the results was conducted based on true rainfall erosivity values calculated by 1-min rainfall data from 62 stations (Fig.2) using equation (10-11). Yin's results were only used for the comparison to evaluate the improvement from present studies.

2.4 The uncertainty of the results and methods should be added by more details in the discussion.

Response: Thanks for your constructive suggestion. We have added the analysis of the uncertainty of the results and methods into the discussion (Line 355-365): The uncertainty of the results from this study mainly comes from the following aspects: (a) KE-I model for estimating Kinetic Energy (KE) from the instant precipitation Intensity (I). KE-I model used in this study is from RUSLE2 (USDA-ARS, 2013) and raindrop disdrometer observation data need to be collected to calibrate the KE-I model. (b) The estimation of the erosivity factors from hourly data (equation 5). The conversion factors were developed based on 1-min rainfall data from 62 stations (Fig. 2). Hourly data brings information loss in the estimation of instant precipitation intensity comparing with breakpoint data. (c) The adjustment of the R factor from the stations with less effective years (equation 8). This is based on a power function (equation 9) of the mean annual precipitation and rainfall erosivity using 1-min and daily rainfall data of 35 stations; The degree of uncertainty mainly depends on the annual variation of rainfall erosivity. (d) Station distribution and density. In western China, the stations were sparse and unevenly distributed, which affect the interpolation accuracy. (e) Spatial interpolation model (Universal Kriging in this study) and the interpolation procedures (the division of regions before the interpolation and the mergence of regions after the interpolation).

Reference

USDA-ARS: Science documentation: Revised Universal Soil Loss Equation Version 2 (RUSLE2), USDA-Agricultural Research Service, Washington, D.C., 2013

Yin, S., Xie, Y., Liu, B. and Nearing, M. A.: Rainfall erosivity estimation based on rainfall data collected over a range of temporal resolutions, Hydrol. Earth Syst. Sci. Discuss., 19(10), 4113–4126, doi:10.5194/hess-19-4113-2015, 2015.

Comment on essd-2020-370

Anonymous Referee #3

Referee comment on "Rainfall erosivity mapping over mainland China based on high density hourly rainfall records" by Tianyu Yue et al., Earth Syst. Sci. Data Discuss.,

https://doi.org/10.5194/essd-2020-370-RC3, 2021

Overview and general recommendation:

The authors developed a new R-factor for Mainland China that requires a huge dataset and work. This study is really beneficial to future studies that requires a representative map of the R-factor for their purposes of application related to sediment transportation. However, there are some places that should be made up before published.

Many studies have developed a better R-factor map for now. So far just developing a R factor map was meaningful as there was a few maps people can employ, but now it is different. The R-factor map at a large scale should be developed based on understanding of application domains (e.g. climate zones, hydrological regimes, and the other characteristics that can affect estimating the R-factor). In this point of view, I think authors can improve the current manuscript more.

Responses to reviewer #3

Dear Editors and Reviewer

Thank you for your letter and the reviewer's comments concerning our manuscript "Rainfall erosivity mapping over mainland China based on high density hourly rainfall records" (ESSD-2020-370). The comments are valuable and helpful for revising and improving our paper. We have

considered and addressed all the comments carefully. We have responded to each of the reviewer's comments in blue:

General comments

3.1 Mainland China has a large area consisting of a variety of climate zones and hydrological units (e.g. basins, hydrological regimes, and so on). Providing a map of rainfall erosivity is good motivation to readers and users in the future, but if authors provide the data with meaningful analysis and findings it would be great. You could consider the previous study here (Kim et al., 2020).

Response: We have added an analysis of the spatial interpolation of erosivity maps in the revised version (Line 283-290). Considering the application of the erosivity factors, we adopted the soil erosion zoning (Figure 3a; MWR, 2007) and hydrological zoning (Figure 3b). Some statistical characteristics of the erosivity factors are shown in Table 1.
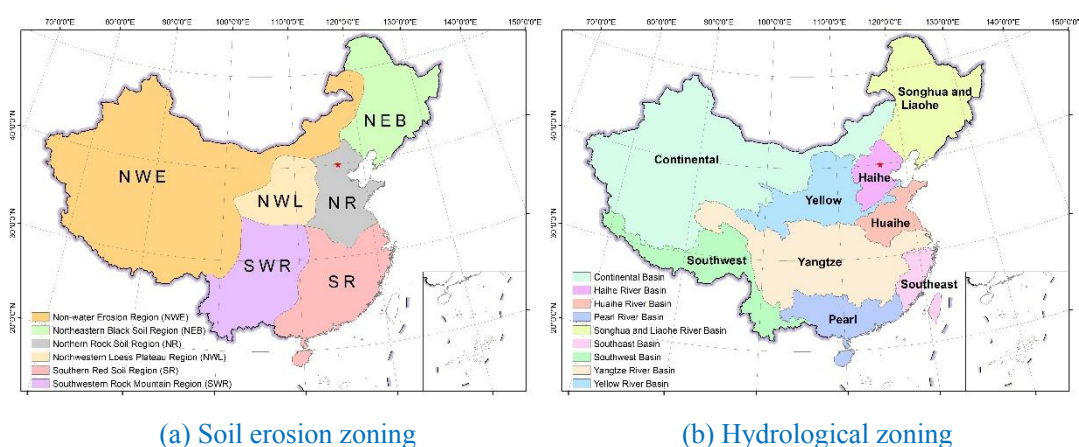

(a) Soil erosion zoning　　　　　(b) Hydrological zoning

Figure 3 Zoning schemes

Table 1 Statistical characteristics of R-factor and 1-in-10-year EI_{30} in soil erosion and hydrological zonings

Factors	Zones	Mean	Std.	5th-percentile	25th-percentile	50th-percentile	75th-percentile	95th-percentile
R-factor (MJ mm ha^{-1} h^{-1} a^{-1})	Mainland China	2200	3147	47	147	645	3503	8208
	NWE	208	192	30	70	144	276	614
	NWL	896	431	263	549	875	1239	1562
	NR	3637	1443	935	2780	3747	4577	5946
	NEB	1483	766	671	1041	1311	1611	3284
	SWR	4226	2079	841	2610	4324	5503	8060
	SR	8294	3370	4918	6140	7311	9141	16544
	Continental	138	130	25	62	92	174	424
	Haihe	2437	1169	719	1218	2717	3489	4042
	Huaihe	4744	948	3197	4062	4653	5466	6310
	SongLiao	1405	765	623	952	1235	1553	3220
	Yellow	920	754	214	402	749	1205	2199
	Yangtze	3933	2535	215	1355	4508	6052	7666
	Southwest	1318	2043	132	265	316	940	5998
	Southeast	7069	1292	4964	6014	7192	7916	9110

	Pearl	10280	3967	4450	7697	9354	12731	17591
1-in-10-year	Mainland China	1040	1259	99	166	435	1766	3206
EI_{30}	NWE	189	101	84	125	165	220	415
(MJ mm ha^{-1} h^{-1})	NWL	635	254	226	438	635	825	1031
	NR	2199	770	556	1860	2422	2717	3123
	NEB	948	449	444	669	867	1044	2055
	SWR	1706	766	439	1098	1689	2308	2952
	SR	3273	1418	1953	2375	2846	3512	6814
	Continental	164	84	80	114	140	193	363
	Haihe	1595	794	459	718	1773	2350	2626
	Huaihe	2706	394	1999	2465	2723	2957	3337
	SongLiao	902	453	422	604	823	1026	1974
	Yellow	627	472	182	293	525	813	1430
	Yangtze	1706	1039	167	711	1959	2551	3194
	Southwest	496	533	184	212	232	389	1701
	Southeast	2814	881	1781	2160	2550	3262	4570
	Pearl	3846	1822	1564	2604	3320	4698	7512

3.2 Again, as the domain is considerable, there is a question mark to using one energy equation for entire Mainland China. Also, please describe more about using the conversion factor, 1.871, as a representative value for entire domain.

Response: Calculation of the kinetic energy requires raindrop disdrometer observation data which are very limited at a national scale. Empirical formulations have been developed for KE-I relationships (Eq. 1-3; Wischmeier and Smith, 1978; Renard et al., 1997; USDA–ARS, 2013). Yin et al. (2017) compared the R-factor calculated by different energy equations (Eq. 1-3) using rainfall data at 1-min interval from 18 stations across the central and eastern regions of China. The results showed that the behavior of the Eq. (3) (RUSLE2; USDA–ARS, 2013) which was used in this study was very similar to that of the Eq. (1) (USLE; Wischmeier and Smith, 1978). While the results from Eq. (2) (RUSLE; Renard et al., 1997) was underestimated by about 9.3%. Therefore, Eq. (3) was used for entire Mainland China, although there must be the uncertainty of the energy equation, which had been discussed in the revised version (Line 355-358).

$$e_r = 0.119 + 0.0873 \log(i_r), \ i \leq 76 \ mm \ h^{-1} \tag{1a}$$

$$e_r = 0.283, \ i_r > 76 \ mm \ h^{-1} \tag{1b}$$

$$e_r = 0.29[1 - 0.72\exp(-0.05i_r)] \tag{2}$$

$$e_r = 0.29[1 - 0.72\exp(-0.082i_r)] \tag{3}$$

where e_r is the unit rainfall kinetic energy (energy per mm of rainfall, MJ ha^{-1} mm^{-1}), i_r is the intensity (mm h^{-1}).

We agree that applying the same conversion factor for the entire mainland China may result in some uncertainty. The conversion factor, 1.871, for the R-factor was developed using 1-min observation rainfall data from 62 stations over mainland China by Yue et al. (2020). It was reported in Yue et al. (2020) independent dataset for the validation showed that the symmetric mean absolute percentage error (sMAPE) was about 6.7% (ranging from 0.2% to 37.0%) after applying the conversion factor of 1.871. We have described more about the conversion factor, 1.871 in the revision.

3.3 Using a conversion factor to correct the hourly data is good for estimating the 1-in10-year EI30 but it is concerned that whether the factor, 1.489, could be employed uniformly for entire mainland China. I suggest authors provide some more details that can describe the uncertainty and its variability so readers can pre-understand its reliability before employing the newly developed map to their own applications.

Response: We are grateful for your constructive suggestions. As explained in the response above, the conversion factor 1.489 for 1-in-10-year EI_{30} was developed based on 1-min rainfall data from 54 stations over Mainland China by Yue et al. (2020). Independent dataset for the validation showed the symmetric mean absolute percentage error (sMAPE) was about 15.5% (ranging from 0.4% to 48.4%) after applying the conversion factor of 1.489. It is hoped that more data at high temporal resolution (e.g. 1-min, breakpoint) could be available in future studies to develop conversion factors for different regions. We have described more about the conversion factor, 1.489 in the revision. In addition, we have added more details about the uncertainty of this study in the discussion as follows (Line 355-365):

"The uncertainty of the results from this study mainly comes from the following aspects: (a) KE-I model for estimating Kinetic Energy (KE) from the instant precipitation Intensity (I). KE-I model used in this study is from RUSLE2 (USDA-ARS, 2013) and raindrop disdrometer observation data need to be collected to calibrate the KE-I model. (b) The estimation of the erosivity factors from hourly data (equation 5 in the manuscript). The conversion factors were developed based on 1-min rainfall data from 62 stations (Fig. 2 in the manuscript). Hourly data brings information loss in the estimation of instant precipitation intensity comparing with breakpoint data. (c) The adjustment of the R factor from the stations with less effective years (equation 8 in the manuscript). This is based on a power function (equation 9 in the manuscript) of the mean annual precipitation and rainfall erosivity using 1-min and daily rainfall data of 35 stations (Fig. 2 in the manuscript); The degree of uncertainty mainly depends on the annual variation of rainfall erosivity. (d) Station distribution and density. In western China, the stations were sparse and unevenly distributed, which affect the interpolation accuracy. (e) Spatial interpolation model (Universal Kriging in this study) and the interpolation procedures (the division of regions before the interpolation and the mergence of regions after the interpolation)."

3.4 In the verification part, suggest authors show the error on the map. This is to present the spatial distributed error and accuracy of the developed map. Also, it would be nice if authors describe errors varying in different density of gauge network.

Response: The distribution of relative error was shown on the following figure, which was evaluated using 1-min rainfall data from 62 stations (for R-factor) and 18 stations (for 1-in-10-year EI_{30}). These have been added in the revision (Fig.6 in the revision). And the variation of the errors in different density of gauge network was shown in Fig. 8 (Fig.11 in the revision) and Table 3 (Table 4 in the revision).

<div align="center">
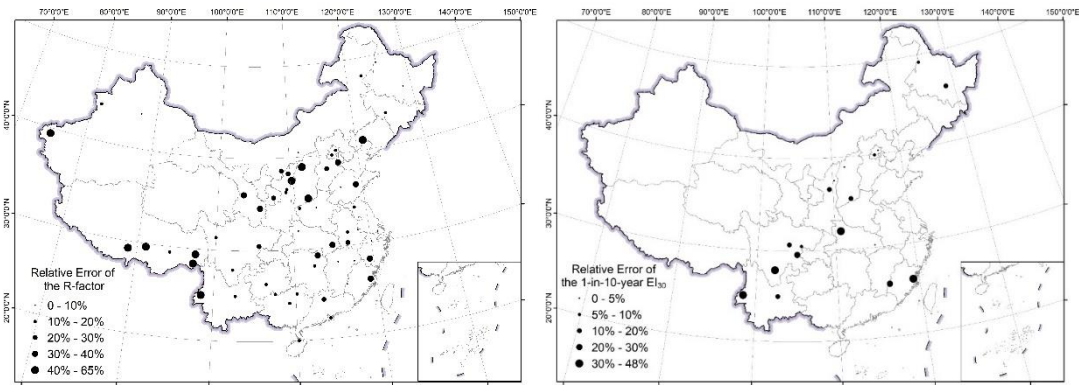
(a) R-factor (b) 1-in-10-year EI_{30}

Figure 4 Spatial distribution of the absolute relative errors in the map of R-factor for 62 stations
(a) and in the map of 1-in-10-year EI_{30} for 18 stations (b) with 1-min observation data.

</div>

Reference

Kim et al., 2020. Use of a high-resolution-satellite-based precipitation product in mapping continental-scale rainfall erosivity: A case study of the United States, Catena.

Specific comments

3.5 [Page 1 line 10] are indispensable for soil erosion assessment -> are necessary for sediment transportation estimation based on the ~

Response: We rewrote the sentence as: 'Maps of rainfall erosivity are necessary for soil erosion assessment and sediment transportation estimation based on the Universal Soil Loss Equation (USLE) and its successors.'.

3.6 Recommend using a consistent word, for example, erosivity, rainfall erosivity, rainfall erosivity factor, erosivity factor, or R factor and erosivity map or R factor map. In addition, most studies use the 'R-factor' instead of 'R factor'.

Response: We have replaced the 'R factor' with the 'R-factor' in the revised version.

3.7 [Page 1 line 12-13] not a good place to provide data-source where the data is available. Please put the information somewhere in the introduction or data section.

Response: Thank you for your suggestion. The data source is required to be added in the abstract part.

3.8 Please mark the thousand commas into all of the values that over a thousand.

Response: Thank you for the suggestion. And we have revised it.

3.9 [Table 1] Please re-write the title.

Response: We rewrote it as 'Studies on the mapping of R factor for or involving China'.

3.10 [Introduction] please re-write the first paragraph and it is too long as one paragraph.

Response: We have divided the paragraph into 4 paragraphs as Line 26-42 in the revision.

3.11 [Figure 6] Instead of saying 'changes', please find other words to express that. The developed map can be compared with the previous work, but the previous work having lower accuracy cannot be employed to analyze the changes.

Response: We used 'differences' instead of 'changes' in the revision.

References

Ministry of Water Resources of the People's Republic of China. 2007. *Standards for classification and gradation of soil erosion*. Beijing: China Water and Power Press, 3-7.