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Hydrology and Earth System Sciences Discussions

Interactive comment on "Trends of streamflow, sediment load and their dynamic relations for the catchments in the middle reaches of the Yellow River in the past five decades" *by* Z. L. Gao et al.

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Thanks for the constructive comments of 14 May 2012 regarding the above manuscript. I have answered the comments one by one and therefore revised the manuscript accordantly. Also a detailed information of relevant changes made in the manuscript was presented in the file.

As attached file, the complete manuscript was also uploaded to show how and where the words or sentences were revised and the paragraphs were adjusted. In which the parts marked yellow color are those revised in the manuscript and blue words are

revised following the reviewer's comments and red words are revised through proof-reading by English native speaker.

I hope you will agree with that.

For the comments of anonymous Referee 1 in May 14,2012:

1.P5489 ln6. Replace" adopted" with "implemented"

Answer: Thanks for the kindly reminding. We have replaced the "adopted" with "implemented" in Ln6, P5489. The words in Ln5-7 P5489 read now:

"To control the severe soil erosion, a number of soil conservation measures have been implemented on the Loess Plateau since the 1950s."

2.P5489 ln 7, Delete "consequent"

Answer: Thanks for the kindly reminding. We have deleted "consequent" in Ln7, P5489, and also "land use and land cover change" was abbreviated to "LUCC". The words in Ln7-9 P5489 read now:

"The measures resulted in great land use and land cover changes (LUCC) and dramatically altered hydrological regimes and significantly reduced sediment load in the Yellow River."

3.P5489 ln11, Replace "their dynamic relations" with "the relationships between streamflow and sediment load"

Answer: Thanks for the kindly reminding. We have replaced "their dynamic relations" with "the relationship between streamflow and sediment load" in Ln11, P5489. And the words in Ln10-11 P5489 read now:

"But, it is not very clear how the soil conservation measures affect the relationships between streamflow and sediment load in a catchment." The words were organized and moved to 3rd paragraph as 2nd sentence in "Introduction" of the paper.

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4.P5490 ln 1-3, Please reword “the relation between streamflow and sediment load did not change essentially in the research of Pan et al. (1999) at a regional scale and even Zheng and Cai (2007) in the small paired catchments.”

Answer: Thanks for the reminding. We organized the words in this section and words in Ln1-5 P5490 read now:

“Rustomji et al. (2008) showed that mean annual sediment concentration in 7 of 11 catchments exhibited a statistically significant decreasing trend over time. A few researches focused on the relationship between streamflow and sediment load. However, the results were complex and inconsistent. Zheng and Cai (2007) concluded that increasing vegetation coverage didn’t change the relationship between streamflow and sediment load in the paired catchments. But a different conclusion was drawn from Liu et al. (2010), who showed that the relationship between streamflow and sediment load changed obviously with land sue change in another paired catchments under heavy rainfall and high rainfall intensity. Rustomji et al. (2008) showed that although the results from the sediment rating curves based on the daily data support the conclusion of the variations of annual suspended sediment concentration, the soil conservation measures seemly did not significantly change the sediment rating curves in two years with the similar precipitation in two catchments on the Loess Plateau. Pan et al. (1999) indicated that the relationship between streamflow and sediment load in flood season did not change essentially in a regional with area of 11 ïĆť 104 km2 on the Loess Plateau.”

5.P5492 ln 3. What do you mean by “two elements”?

Answer: “two elements” here means “streamflow and sediment load”. To make it clear, the words in ln2-5 P5492 read now:

“To reduce the effects of precipitation and drainage area on the analysis of streamflow and sediment load for the catchments of different size, the volumes of annual/ monthly streamflow and sediment load are standardized by the controlling area and the precip-

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itation in corresponding time."

6.P5492 ln 6, I am not sure about the unit for streamflow and it is essentially dimensionless.

Answer: Agree with the reviewer. After the standardization of total streamflow volume with the precipitation over a certain area and time, the unit for streamflow is dimensionless and actually the "runoff coefficient". The words in L5-8 P5492 read now:

"So a unit for streamflow is "m3.km-2.mm-1", which is dimensionless and means the runoff coefficient in a catchment, and for sediment load, "t.km-2.mm-1", actually signifies sediment availability per unit area per unit precipitation in each catchment."

7.P5495 ln 4, what is the significance level?

Answer: Table 3 showed that except the two loess hilly-gully catchments, the standardized annual streamflow in the five catchments presented negative trends at a statistically significance level by Mann-Kendall test, in which four catchments had the level with $p < 0.001$, and one is with $p < 0.05$. The words in L3-5 P5495 read now:

"Annual streamflow in the five catchments except the two loess hilly-gully catchments presented negative trends by Mann-Kendall test with statistically significance level, in which four catchments were detected at $p < 0.001$ and one at $p< 0.05$ (Table 3)."

8.P5495 ln 5, Can you express the rate of streamflow change as mm/year/year?

Answer: The rate of streamflow change was represented as "m3.km-2.mm-1.a-1" in the text. The unit came from the standardization of annual streamflow volume with the precipitation over a certain area and in one year. So the rate of streamflow change actually represented the change rate of "runoff coefficient" in a catchment.

To keep the consistency in the conception of runoff coefficient, we used the value of runoff coefficient instead of "m3.km-2.mm-1.a-1" in the text. So the words in Ln5-8, P5495 read now:

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"Average change rate of annual streamflow, i.e. runoff coefficient, was -3.39 per year in the three transition zone catchments, but only -0.67 per year in the two rocky mountain catchments."

9.P5495 ln 15, Delete "Cleary, years for the former were all earlier than those for the latter"

Answer: Thanks for the reminding. Now the sentence in Ln15-16, P5495 were deleted in the place.

10.P5495 ln 18. Can you provide any references to support your argument?

Answer: A few references gave the examples of the effects of cumulative area and the allocation of the main types of soil conservation measures on the runoff trend and sediment reduction in catchments on the Loess Plateau.

Ran et al (2000) took a great effort to investigate the historic development of soil and water conservation measures in the catchments of Loess Plateau and achieved their sediment reduction benefits. The results showed that there were big differences between catchments.

Xu and Sun (2006) took Wudinghe River on the Loess Plateau as example, and showed that the soil –water conservation beneficial could be divided three stages with the area of soil and water conservation increasing, "the increasing slowly", "increasing rapidly" and "remaining unchanged or even decreasing". The relationships between sediment reduction beneficial and the areas of soil-water conservation measures showed a non-linear variations and a threshold existed.

Yao et al (2004) took Huangfuchuan River on the Loess Plateau as example. The result showed that if the controlling area of dam-reservoir was less than 10

From above references we could get some important information about the cumulative area of soil and water conservation and their allocation in a catchment which affected the hydrologic cycle and sediment reduction.

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The words in L16-20 P5495 now read:

“Results from Ran et al. (2000), Yao et al. (2004) and Xu and Sun (2006) implied that such a percentage of the area for soil conservation measures can significantly affect hydrological recycling and sediment retention or transportation in a catchment”.

So two references were added in the reference list of the paper as following:

Xu, J.X and Sun, J.: Threshold phenomenon of sediment reduction beneficial from soil-water conservation measures in the Wudinghe river, Advances in Water Science, 17(5): 610-615, 2006 (in Chinese).

Yao, W.Y., Ru, Y.y., Kang, L.L.: Effect of flood retention and sediment reduction with different allocation system of water and soil conservation measures. J. Soil Water Conserv.. 18(2): 28-31, 2004 (in Chinese).

12.P5495 ln22, Delete “sequential”

Answer: Thanks for the reminding. We deleted “sequential” in the sentence. And the words in L21-28 P5495 read now:

”According to the change points for the five catchments and in consideration of the implementation of “Grain for Green” project after 1999, the whole time period for streamflow data is divided into three periods: period 1 (pre-change point year period, abbreviated to P1), period 2 (post-change period from pre-change point year to 1999, P2), and period 3 (“Grain for Green” period from 2000 to 2005, P3). Monthly flow duration curves were derived and relative changes of streamflow at high(5

13.P5496 ln 2-4, Reword.

Answer: Thanks for the reminding. The words in ln1-4 P5496 read now:

“From Table 4, relative changes of streamflow were negative except for the two loess hilly-gully catchments, i.e. Qinjian and Yanhe catchments. Change degrees, whenever in P2 or P3, were higher in the three transition zone catchments than those in the two

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rocky mountain catchments."

14.P5496 ln 5, what do you mean by "change extent"? 15.P5496 ln 9, should be high, median, and low percentile flows.

Answer: We mean the change degree here. We replaced "change extents" in Ln5 P5496 with "change degrees" in the sentence. The words in Ln5-14 P5496 read now:

"Change degrees of streamflow in the transition zone catchments were not only greater in P3 than those in P2, but also much greater than those in the rocky mountain catchments in P3. Average relative changes for the three transition zone catchments in P3 reached 72.5

Ln15-17 P5496 is rewritten as following:

"Change degrees were much weaker for the two loess hilly-gully catchments, i.e. Qinjian and Yanhe catchments. The result is consistent with the trend detection for the five catchments."

16.P5497 ln 3-5, Reword

Answer: Thanks for the reminding. The words in Ln3-5 P5497 read now: "To investigate relative changes in annual sediment load in all the seven catchments, the three periods are identified for the sediment load data using the same period division criteria as those for annual streamflow (Table 6)."

17.P5497 ln 25, How did you use the change points to analyse the dynamic relationships? Answer: Thanks for the reminding. When we analyzed and compared the relationship trend of streamflow and sediment load, the periods were defined referring to the change point of sediment load detected with Pettitt test in each catchment. The words in Ln25-28 P5497 read now:

"Change points of annual sediment load in the seven catchments (Table 5) are referred to identify the periods and analyze the dynamic relations of streamflow to sedi-

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ment load. Fig.2 shows a set of scatter diagrams illustrating the relationship between monthly sediment load and monthly streamflow in the three periods in the seven catchments, with simple linear regression equations presented simultaneously."

18.P5498 ln1, Why did not you include the rest of month? No data?

Answer: We used the data in the flood season from May to October to analyze the relationships of streamflow and sediment load here exactly because of the data limitation of the other months.

The words in Ln 1-2 P5498 read now:

"Because no data were recorded in some months in some of the catchments, the monthly data of sediment load and streamflow in the flood seasons from May to October were used in the study, so as to make the results comparable."

19.P5498 ln3-6, Poor correlations between streamflow and sediment load would suggest variable sediment concentrations? The authors should elaborate on this and explain how poor correlations were result from human activities. Also any physical basis for the form of relationships shown in Figure 2?

Answer: Agree with the reviewer's comments. Figure 2 is plotted to express the relationships between monthly streamflow and monthly sediment load in the flood season. Poor correlations suggest variable sediment concentration and that the phenomena of high streamflow- low sediment load and low streamflow- high sediment load exist in the catchments at the monthly scale. It closely relates to the characteristics of human activities on the Loess Plateau. We give more explanation of how poor correlations result from the human activities. The words in L3-6 P5498 read as following and were moved to the end of this section as paragraphs7 and 8.

"Compared to P1, the relationship between streamflow and sediment load generally became poor in the correlative coefficients from P2 to P3, especially in the transition zone catchments as well as Shiwang catchment, one of the rocky mountain catchments

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(Fig. 2b,c and g). On the Loess Plateau, human activities are recognized as the primary factor leading to the negative trends of streamflow and sediment load (Ran et al., 2000; Fu et al., 2004; Rustomji et al., 2008; Yao et al., 2010). But human activities are wide ranging and some of them can potentially increase soil loss in the catchments (Ran et al., 2000; Wang and Fan,2002).

The implementation of soil and water conservation was expected to control soil erosion and reduce sediment delivery to the Yellow River (Morgan 1986; Chen et al., 1988). The "Grain for Green" project implemented since 1999 resulted in a considerable improvement of vegetation coverage on the Loess Plateau. However the sediment trapping dams built up in the 1970s and 1980s were easily damaged by heavy rainstorm (Zhang, 1995). The ratio of silted storage to the total storage of reservoir was up to 40

For above description, the following references are added in the reference list :

Fu G.B., Chen S.L., Liu C.M., Shepard D.: Hydro-climate trends of the Yellow River Basin for the last 50 years. Climatic Change, 65:149-178,2004.

Xiong G.S and Ding L.Y.: The survey report of sediment deposition in the reservoirs of Yellow River Basin, Yellow River Conservation Commission, Zhengzhou, Rep., 2004 (in Chinese).

Zhang S.L.: Investigation of the influence of the flood occurred in August 1994 on flow and sediment yield in Wuding River Basin, Yellow River, 5: 24-27,1995 (in Chinese).

Liu C.X. and Han L.B.: Review of researches in vegetation restoration of freeway slopes. Acta Ecol. Sin., 27(5):2090-2908,2007 (in Chinese).

Yao W.Y., Xu J.H. and Ran D.C.(Eds): Analysis and evaluation of the water sand changing regime in catchments of Yellow River Basin. Yellow River Water Conservancy Press, Zhengzhou, 2010 (in Chinese).

The scattered distribution of streamflow and sediment load was based on the monthly scale. Although the monthly data couldn't reveal the important event based detail, the

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form of relationships in figure 2 is still related to the characteristics in fluid mechanics of hyperconcentrated flow frequently occurred on the Loess Plateau.

20.P5498, ln7-10, Replace “domain” with “range”.

Answer: Thanks for the kindly reminding. The words in Ln7-10 rewritten to

“The range of the scattered distributions of monthly sediment load against monthly streamflow in the three transition zone catchments is up to 1400,1000, whereas in the two rocky mountain catchments, only 600,100. Apparently, the former is much wider than the latter. The range of the scattered distribution in the two loess hilly-gully catchments lies in the middle.”

21.P5498, ln24-27, Do you mean the soil conservation measures implemented in the 1970s to 1980s reduced the sediment generation capacity in most of the catchments?

Answer: The trend analysis showed that in the most catchments the decreasing trends of sediment load are much greater than that of streamflow. Compared to the period 1, the linear regression coefficients in the period 2 for all the catchments showed a decreasing trend ranging from -40.9

Precipitation was sources of water in catchment, so any change of precipitation would affect the streamflow and sediment yield and transportation. However, the data of streamflow and sediment load recorded were standardized by the precipitation and the controlling area in the catchment, so the effect of precipitation and the physical feature of catchment were expected to be eliminated to some extent.

The analysis showed that most of the change points examined with the Pettitt test for the catchments are in the latter of 1970s and the beginning years of 1980s (Table 3, 5). The land use /cover change in the 1970s to 1980s was characterized with consecutive implementation of soil conservation measures. The effect of soil conservation practices on hydrological cycle aggravated and then discernable reduction in streamflow and sediment load occurred.

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To make it more clearly, we re-wrote the sentence in Ln24-27 P5498 as following:

"In consideration of standardization of streamflow and sediment load data with precipitation and controlling area, human activities such as soil conservation measures from the 1970s to 1980s and the "Grain for Green" project after 1999 were expected to make the sediment generation capacity in the catchments to be increasingly negative trends period by period, except the two loess hilly-gully catchments (Table 7)."

22.P5499, ln 4-5, It is not clear to me what this means.

Answer: In this study, the regression coefficient was regarded as "sediment generation capacity" in a catchment. Apart from the regression coefficient, the absolute value of a constant in the linear regression could also indicate the amount of sediment yield in a catchment in a given streamflow volume and signify the "sediment generation capacity". The Loess Plateau is most severely eroded area in China. Especially the water-wind erosion crisscross region on the Loess Plateau, i.e. the place where the three transition zone catchments located, is characterized with highest soil erosion and sediment delivery modulus due to both the water and wind erosion processes.

In general, soil is eroded by rainfall or wind from hill slopes and bank of gully, and stored in channel. In the flood season, the existing in-channel sediment was transported by the runoff in a rainstorm.

From the erosion processes and the transport mechanics in a catchment, the regression coefficient and the absolute value of constant in the linear regression were closely related each other and both of them could demonstrate the "sediment generation capacity" on the Loess Plaetau.

To make it more clear, the words in Ln4-5 P5499 were rewritten as following:

"In this study, the absolute value of a constant in the linear regression equation for each of the catchments implies the existing in-channel sediment storage in a given period to some extent, which can demonstrate the "sediment generation capacity" in another

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way."

23.P5499, ln 4-20. The authors interpreted the constants in the regression equations as sediment storage. Is there any physical basis for the argument? What happens if they fit different functional relationships to the data?

Answer: From the equation, the absolute value of constant was the sediment volume when the streamflow was zero. As the statement in the above question and answer, soil was eroded in the processes such as rainfall splash, sheet erosion, rill erosion from the hill slope and gravitational erosion, land slide, avalanche and debris slide in the gully, and stored in the channels. During the rainstorm, the existing in-channel sediment was transported from channel to river bed. The amount of sediment was observed in a gauge station of catchment after the processes of sediment "preparation-transportation" in a hydrographic year or longer time.

The sediment "preparation- transportation" processes were affected greatly by rainfall type, LUCC and other human activities. The implementation of soil and water conservation and vegetation restoration would dramatically influence the streamflow regime and sediment "preparation- transportation" processes leading to the change of regression of streamflow and sediment load in a catchment.

Based on the physical principle of soil erosion and sediment transportation, the paper gave the linear regression on the monthly scale and investigated the trend of parameters to check the effects of soil and water conservation and vegetation restoration on the relationships between streamflow and sediment load in the catchments of the Loess Plateau.

The form of power function was used commonly to illustrate the relationship between streamflow and sediment load in the world. The form of power function was used to fit the data, and found the coefficient of determination was poorer than that of linear regression probably due to the monthly scale. The monthly data didn't show the detailed information occurred in the event. In fact the relationship between streamflow and sed-

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iment load expressed even by daily data couldn't be fitted well using the form of power function because of the hydraulic mechanics of hyperconcentrated flow occurred on the Loess Plateau.

24.P5500, ln13. What do you mean by standard streamflow?

Answer: Thanks for reminding. We replaced the words of "standard streamflow" with "standardized streamflow". Also the "standard sediment load" and "their dynamic relation" was replaced "standardized sediment load" and "their dynamic relationship". The sentence in Ln12-15 P5500 reads now:

"The impacts of soil conservation measures and the subsequent "Grain for Green" project on streamflow, sediment load, and their dynamic relations were examined for the seven catchments in the middle reaches of the Yellow River, China."

P5501, ln 2, what do you mean by elements? Are you referring to streamflow and sediment load?

Answer: Yes, we refer "elements" in ln 2, P5501 to the streamflow, sediment load, and their relationships.

To make it more clearly, we have replaced the "elements" here with "streamflow, sediment load and their relationships". The sentence in Ln1-4 P5501 reads now:

"The effects of the LUCC on the streamflow, sediment load and their relationships were much weaker in the two loess hilly-gully catchments, probably due to the other intensive human activities."

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/9/C2232/2012/hessd-9-C2232-2012-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 5487, 2012.