

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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For the comments of anonymous Referee #3:

My overall comment is that this paper needs a substantial re-write to clarify the methods, the units of measure, and the interpretation of coefficients and changes in coefficients. Figure 2, which is critical to the analysis is virtually unreadable. The scales have no labels, the data are terribly crowded into a small part of each graph. Making them log-log plots and scaling them appropriately would go a long way towards making the paper more understandable. Also, the idea that these relationships (shown in figure

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2) are actually changing, is the heart of the paper's hypothesis, and yet no statistical test was done to demonstrate that there really are differences among the three periods (analysis of covariance would provide such a test).

Answer: Thanks very much for the constructive comments. Based on the comments of referee 1, 2 and 3, we have improved the manuscript including method description, the units of streamflow and sediment load and give more explanation of coefficients and changes in coefficients.

Figure 2 (Figure 3 after revision) was reworked using log-log plots to make the data more scattered following the suggestion.

Instead of “covariance” which is not very strong, “Chow test”, a kind of F test, was used in the manuscript to demonstrate there really exists differences among the three periods within catchment. “Chow test” was invented by economist Gregory C. Chow (1960) and commonly used to test for the presence of a structural break in a time series analysis.

Page 5495, line 5-6, the units don't make sense. They have dimensions of $L^3 \cdot L^{-2} \cdot L^{-1} \cdot T^{-1}$. The net result of this is dimensions of T^{-1} . I think the mm^{-1} is extraneous.

Answer: To make the change of streamflow and sediment load comparable, the volume of streamflow (m^3) and the amount of sediment load (t) were standardized with controlling area (km^2) and precipitation (mm). So the units of standardized streamflow and sediment load were “ $m^3 \cdot km^{-2} \cdot mm^{-1}$ ”, “ $t \cdot km^{-2} \cdot mm^{-1}$ ”, respectively. For streamflow, in fact it is dimensionless and signifies the runoff availability (m^3) per km^2 area and per mm precipitation.

The words in Ln5-8, P5492 read now: “So a unit for streamflow is “ $m^3 \cdot km^{-2} \cdot mm^{-1}$ ”, which is dimensionless, the value is 1000 times the runoff coefficient and means the runoff availability (m^3) per km^2 area per mm precipitation in a catchment in a given period. And a unit for sediment load, “ $t \cdot km^{-2} \cdot mm^{-1}$ ”, actually signifies sediment avail-

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ability (t) per km² area per mm precipitation in each catchment in a given period.”

Due to the standardization of data, the words in Ln5-6 P5495 read now: “Average change rate of annual streamflow was -3.39 per year in the three transition zone catchments, but only -0.67 per year in the two rocky mountain catchments.”

Page 5495 and Table 3. The streamflow records are evaluated for monotonic trends (Mann-Kendall) and change point (Pettitt), but the authors don't seem to suggest which one of these is a better characterization of the changes. Presentation of time series graphs for these data sets would be very helpful and the authors need to suggest their preferred interpretation. The methods section explains the Mann-Kendall test but not the Pettitt test and yet both are used in table 3. The authors need to explain their methods.

Answer: In this study, nonparametric Mann-Kendall method was used to test trends in streamflow and sediment load in catchments. If a significant trend was tested, non-parametric Pettitt method was applied to test if change point existed in the data series. At the same time, sequential Mann-Kendall method was also used to validate these change points.

A new figure (Figure 2) was presented to illustrate the data series of standardized streamflow in seven catchments and the change point years detected using Pettitt test in five catchments and given in another two catchments.

Thanks very much for your reminding. The missing words in the method section were appended in P5493 to describe the method of Pettitt test.

Page 5514. Figure 2. These plots are very hard to read. They would be much improved streamflow and load were both plotted on a log scale. Even better than that, if the y-axis would show flow-weighted mean concentration (that is, monthly load/monthly flow). Most of the variation in load is due to flow itself, so the plots make it very difficult to discern the differences between the three periods. It is not clear why the x-axis

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always ends at 1400. In several of the graphs the data are all bunched up at the left edge of the graph, making it very difficult to see the spread. As they are, the plots really do not convey the information that the authors want to convey. Conversion to a log-log scale is crucial to making them useful.

Answer: Following the suggestion, Figure 2 (after revision, it is Figure 3) was reworked using log scale both in X and Y axis. It is better to see the spread of the data now. The variation in load resulting from the flow was discussed in P5499 of the revised manuscript, the relationship between streamflow and sediment load was weakened from the analysis and also discussed from the nature of human activities on the Loess Plateau in section 4.3. There were no specific reason for x-axis ending at 1400. The purpose was to compare the differences in behavior of streamflow and sediment load in catchments under one same scale. After log-log transition in X and Y axis, the scope was found to be in (2000,1000).

The units on the x and y axes of these graphs needs to be shown either on the graphs or in the caption. The equations shown on the figures are all linear, and yet the graphs show curves. I suspect that this is because the equations were fit on logarithms (but I'm not sure).

Answer: Units of streamflow and sediment load were shown both in each graph and caption. From the graphs, some catchments has high correlation coefficients in linear regression, that means the relationship between streamflow and sediment load can be represented well using linear equation for monthly data in the study. Other functional relationships were fitted to the data, for example power and logarithms, results were not satisfied at all.

Where are x and y defined? The authors seem to want to show that these relationships are different for different periods. The standard way of doing that is to use analysis of covariance. I see no indication that there was any effort to demonstrate in a statistical sense that the periods are different.

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Answer: For now, x and y in Figure 2 (after revision, it is Figure 3), are defined in Ln1-2 P5498 as following: "Streamflow and sediment load were showed as X and Y axis variables, respectively."

The relationships between streamflow and sediment load among three periods in catchments were tested using "Chow test", which is commonly used to test if there was a structural break in a time series analysis. The words talking about the test as following in 2nd paragraph of P5498: "Before analysis of the trend and change of the coefficient of equation, the structure of linear regression between streamflow and sediment load was tested using Chow test to see if there was statistical difference in relationships among three periods in each catchment. Chow (1960) constructed F test to detect the presence of a structural break and commonly used in time series analysis. The results showed that there was statistically significant difference with $p < 0.05$ in relationship comparison between streamflow and sediment load in six catchments except for Yunyan, one of two rocky mountain catchments. The result was basically consistent with the annual trend test in Table 3 and 5, but the disagreement between annual trend and monthly relationship in Qingjian, Yanhe and Yunyan catchments was probably due to the hydrological regime in monthly scale greatly affecting the relationship. "

Following reference are added in the list of references of the manuscript. Gregory C. Chow (1960). "Tests of Equality Between Sets of Coefficients in Two Linear Regressions". *Econometrica* 28 (3): 591–605. DOI:10.2307/1910133.

Page 5497, lines 21-22. The statement about the changes being larger for sediment load as compared to flow need to be put in context. Because load is generally a nonlinear function of flow we would expect that load trends would be larger than flow trends (expressed in percentage terms). The key question is, are the load trends simply a reflection of the flow trends or is the relationship between flow and load changing?

Answer: Agree with the reviewer. It is key question in this study even in the research field. From the whole study, five of seven catchments have significant negative trend

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in both of annual streamflow and sediment load. At the meantime, the relationship between monthly streamflow and sediment load also changed with significant level in six of seven catchments. In general, the conclusion could be drawn that the change of sediment load was the result from both of the change of discharge and their relationship. This conclusion was strengthened in abstract, summary and section 4.3, respectively.

Page 5498, line 3, use the words "correlation" not "correlative".

Answer: Thanks for reminding. The word has been changed in the revised manuscript.

Page 5498, lines 4 and 5. The logic is not explained. Why does poor correlation between load and flow indicate that the "periods were largely influenced by human activities." This seems to be a very important conclusion, but no logic is presented to justify it.

Answer: Thanks for reminding. The relevant words were added to discuss the point of view as following in P5499: "Compared to P1, the relationship between streamflow and sediment load generally became poor in the correlation coefficients from P2 to P3, especially in the transition zone catchments as well as Shiwang catchment, one of the rocky mountain catchments (Fig. 2a,b,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, 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% in the seven catchments (Xiong and Ding, 1994). The variability of sediment concentration in the catchments in P2

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was closely related to the ruined sediment trapping dams and the release regime of reservoirs (Zhang, 1995; Ran et al., 2000). Moreover, rapid urbanization and extensive infrastructure construction were simultaneously proceeding in the region (Liu and Han, 2007), which usually produced a huge amount of sediment deposition and dreg on the river bed and probably led to a high concentration flow, even in a medium rain event (Xu, 2002).”

Page 5498, lines 7-11, I really don't understand this paragraph at all. What are the numbers (1400, 1000) intended to represent? What units do they have? Is this difference just a reflection of basin size or climate? What is the importance of this observation?

Answer: For both X and Y axis were represented as log scale, the data distribution from the scope of 1400 in x-axis and 1000 in y-axis was changed to the scope of 2000 in x-axis and 1000 in y-axis. Their units were similar with the standardized streamflow and sediment load, respectively. The differences between catchments is a reflection of other factors such as hydrology geology, soil and climate as well as. To describe their distributing scope is to illustrate the difference from different aspects. The words Ln7-11 P5498 read now: “The range of the scattered distributions of monthly sediment load against monthly streamflow in the three transition zone catchments is up to {2000,1000}, whereas in the two rocky mountain catchments, only {500,100}. 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. The other factors, such as frequency of rainstorm, vegetation coverage, soil and hydrological geology were supposed to determine the distribution scope of streamflow and sediment load in catchments (Ran et al., 2000).”

Page 5498, lines 12-23, there is a set of interpretations made here about the regression coefficients. What are the units of these coefficients? What do they represent (stated in words)? Without this background it is impossible for the reader to understand the interpretation made.

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Answer: The linear relationship was obtained from two variables of streamflow and sediment load. So the unit of regression coefficients here is $t \cdot m^{-3}$, which means sediment availability (t) per unit streamflow (m^3) in a mean annual status in a given period in a catchment. In general the regression coefficient represents the sediment generation capability in a given period in a catchment. The unit was given in the corresponding context.

Page 5499, lines 4-14, What is the basis for the interpretation of the meaning of the intercept? What are the units?

Answer: To some extent the constant in the linear regression implies the existing in-channel sediment storage in a given period when the streamflow equal zero. The positive value means the silted status in river bed and negative value means the scoured status in river bed. The unit of a constant is $t \cdot km^{-2} \cdot mm^{-1}$. The unit was given in the corresponding context.

The revised words were marked as yellow color in the attached manuscript.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/9/C2739/2012/hessd-9-C2739-2012-supplement.pdf>

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

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