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Discussions

Interactive comment on "Variations in the characteristics of Changjiang sediment discharging into the sea due to human activities" *by* J. H. Gao et al.

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Dear referee who gave the comments, My co-authors and I wish to thank the reviewers and editor for the comments and suggestions which we found very useful and relevant for improving the manuscript. In addition, the revised manuscript is also uploaded as a supplementary.

Paper summary: In this paper, the authors present a study on the change in sediment load and sediment grain size over time in the Changjiang river basin. The study uses long-term datasets (1956-2010) of annual sediment load and grain size to determine

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when and where there were changes in sediment load at each sampling station along the tributary rivers and main stem. Changing sediment supply to coastal ecosystems is an important topic in an area where there are many anthropogenic pressures (i.e. dams) on watersheds. These impacts are felt throughout the watershed and near-shore environment, but timing of these changes can be different depending on the watershed and type of disturbance. Therefore, this paper addresses an important subject in global change.

General comments: Overall, this paper is hard to understand and confusing. The introduction seems to introduce a paper that is different than what is presented in the methods and results, creating a narrative that does not fit their data. The introduction mentions a variety of sediment characteristics, but as far as I can tell the paper only includes information about load and grain size. The introduction also does not state any hypotheses or predicted trends, which makes it hard to understand the methods and their rationale. 1. The major issue with the methods is that they do not address much of the analysis that they report in the results and the discussion. For example, how was cumulative reservoir storage capacity determined? (see Specific Comments below for other examples).

Response: Revised. In fact, the cumulative reservoir storage capacity can also be named as the total reservoir storage capacity. The reservoir storage capacity index (RSCI) is defined as the ratio of the reservoir storage capacity to the annual average water discharge of the contributed catchment; thus, the total RSCI of a catchment is the ratio of total capacity of reservoir to the annual average water discharge.

2. Perhaps most importantly, it is not at all clear how the authors attributed changes in sediment flux to the various tributaries. Was this based on mass flux data? How were the sediment grain sizes used to do this (as I assume that they were)?

Response: We re-organize and re-wrote the section of result and discussion. Firstly, the changes of the total RSCI and sediment load of tributaries and the whole

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Changjiang catchment indicate that the stepwise decrease of sediment load is highly related to the significant increase of the total RSCI. In addition, over the last few decades, the cumulative water and sediment discharge relation of each tributary continuously changed, with the slop of curve decreasing, and every turning point of the curve was closely related to dam construction. The above two relationships reflected the impact dams have on sediment load. Secondly, the beginning time of sediment load decreasing of some tributaries is consistent with that of the main river, for example, the sediment load reduction entering the sea during 1970-1985 was mainly caused by Han River; upstream tributaries (mainly Jialing and Wu River), together the sub-catchment of mid-lower reach (mainly Poyang Lake) were responsible for the sediment load into the sea decreasing during 1970-1985; and the sediment load discharging into the sea lessening during 2003-2010 were mainly resulted from the emplacement of the Three Gorges Dam. In addition, in the revised manuscripts, the method based on sediment budget, concerning with calculating the sediment (sediment fraction) contribution proportion of different tributaries to the sediment load entering the sea of the Changjiang is also introduced (in the section of Discussions).

3. The methods fail to explain how they came to the numbers used in the analyses and tracing of sources of sediment in the river basin presented in the results and discussion (see Specific Comments below for examples).

Response: Revised. See the response 2 and 4.

4. Finally, the results and discussion bring up topics not discussed or detailed earlier in the paper, making the narrative confusing. There needs to be a complete reworking of the narrative (in both the introduction and discussion) and the methods section of this paper in order to fully capitalize on the potential of the long term datasets used in this manuscript.

Response: Revised. The section of introduction, method, result and discussion was re-written (see the revised manuscript in the supplementary). The topic of the re-

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vised manuscript is concentrated on variations in quantity, composition and grain size of Changjiang sediment discharging into the sea in response to human activities. In addition, source and reliability of the data are also explained: The long-term discharge and sediment monitoring program over the entire catchment has been conducted since the 1950s, by the Changjiang Water Resource Commission (CWRC) under the supervision of Ministry of Water Resources, China (MWRC). These monitoring data include field survey and measurement of discharge, suspended sediment concentration, suspended sediment load, and suspended sediment grain size, in accordance with Chinese national data standards (Ministry of Water Conservancy and Electric Power, 1962, 1975): 10-30 vertical profiles within the water column were selected for the measurements of each river cross-section, the number of profiles varying with the width of the river; For each profile, the water flow velocity (using a direct reading current meter) were measured at different depths (normally at surface, 0.2H, 0.6H, 0.8H and the bottom, where H is the height of the water column); Meanwhile, the water mass of the same depth were also sampled for measuring the suspended sediment concentration and grain size; the sediment grain size is measured using the settling of suspensions method. The homogeneity and reliability of the hydrological data, with an estimated daily error of 16% (Wang et al., 2007), has been checked and firmly controlled by CWRC before its release. The data during the period of 1956-2001 was either published in the Yangtze River Hydrological Annals or provided directly by CWRC. After 2002, these hydrological data were posted in the Bulletin of China River Sediment published by the Ministry of Water Resources, China (BCRS, 2002-2010; available at: http://www.mwr.gov.cn/zwzc/hygb/zghlnsgb/).

Specific Comments: Title – does not adequately portray what the paper is about. The authors are not really looking at the characteristics of the sediment, but the load and the grain size.

Response: Revised as “Variations in quantity, composition and grain size of Changjiang sediment discharging into the sea in response to human activities”

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Page - 9115 Line 8: What are products of the coastal catchment system?

Response: The products mainly refer to terrestrial sediment. So, in this paper, we mainly study the sediment load, sediment composition and grain size changes induced by human activities.

Line 14: How do alterations affect grain size and the proportion of sediment from different estuaries?

Response: Estuary-coastal-continental shelf areas are the final destination of catchment sediments, and the catchment sediment supplied by different sub-catchments. Due to dams of tributaries intercept a lot of sediment, especially fine-grained sediment, so the sediment load and grain size of tributaries decreased. However, the intensity and occurrence time of human activities of these tributaries is also varied, which directly lead to different time node of variations in sediment load and grain size of the sediment of every tributary. Therefore, the catchment sediment composition and grain size entering the sea during different periods are also varied.

Line 21: "The importance of these two features lies in that they reflect the sediment contribution of different sub-catchments to the marine deposits and determine the mineralogy and geochemistry characteristics." The authors do not address the mineralogy or geochemistry characteristics of the sediment contributions in the methods or results.

Response: In the revised manuscript, these two features are the grain size and composition of sediment.

Line 24: "Sediment provenance tracing is a major method used to study the spatial-temporal 25 distribution patterns of terrestrial sediments in continental margins; thus, constructing valid and accurate end-member components on the basis of the mineralogical and geochemical characteristics of catchment sediment is a prerequisite for such an analysis (Morton and Hallsworth, 1994; Svendsen and Hartley, 2002; Yang et al., 2009; He et al)." - This sentence is misleading because the authors do not create

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end-members based on mineralogical and geochemical characteristics.

Response: Deleted in the revised manuscript.

Page 9116 Line 1 – "However, variations in the composition of sediments supplied by a catchment modify the "end-member" characteristics. Therefore, knowledge about the variations in the catchment sediment composition during different periods is critical to the analysis of the change in the mineralogy and geochemical features and the selection of five terrestrial sediment end members." – Again, the authors did not include this analysis in the methods or results. The introduction sets up the reader for a different paper than what the results actually report. I think that the analysis of grain size change and sediment supply is interesting on its own without this set up. The authors need to rewrite the narrative – there is a mismatch between the rationale and the analysis.

Response: According to reviewer's suggestion, the topic of the revised manuscript is mainly concentrated on the variation in sediment load and grain size resulted by human activities, other irrelevant content was deleted.

Line 9 - Authors should support "one of the largest rivers in the world" with discharge info and the size of the delta

Response: Supplemented.

Line 16 - Gao et al 2014 – is unpublished results. Authors report 90.10% reduction in sediment because of dam interception. They should considering putting in supplemental material to support this claim.

Response: Revised.

Line 17-23 – What are the variations in sediment between the three reaches? How can the authors identify what sediment comes from each particular reach?

Response: The upper reach is from the river source to Yichang station. The middle reach extend from Yichang station to Hukou station, and down-river from Hukou station

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to Datong station is defined as the lower reach of the river. No larger tributaries join the lower reaches, and downstream of Datong station is tidally influenced. Therefore, the sediment load of Yichang station is regarded as the quantity of sediment coming from upstream; and the Datong station is the last gauging station of the Changjiang basin, and its water and sediment discharge records are generally used to represent the terrestrial flux from the Changjiang to the East China Sea.

Line 23 – Again, the authors should identify how they expect the grain size and composition to change with decreases in sediment load. What are their hypotheses?

Response: Revised. The Changjiang catchment consists of numerous branches, and these tributaries are characterized by different rock properties and climate types. On the other hand, the intensity and occurrence time of human activities of these tributaries is also varied, which directly lead to different spatial-temporal patterns of the sediment yield from these tributaries (Lu et al., 2003). Thus, the sediment contribution of each tributary to the main river of the Changjiang also changed during different periods. In addition, dam construction and land cover variation also exert an important impact on changes of sediment grain size of tributaries and main river of Changjiang (Zhang and Wen, 2004). Therefore, the sediment contribution of different tributaries to the sediment load entering the sea, the grain size and composition of the sediment might vary with decreases in the sediment load of the Changjiang River.

Section 2 – Regional Setting: This could be a good section to explain the differences in sediment in each region. I also think that this detailed description of the geography could be cut down with a better map in Figure 1.

Response: Revised.

Page 9118 Lines 1-16: Again, I am not sure why the authors describe the rock types and mineralogy when this is not the data that they analyzed. I do not understand how they trace the origins of the sediment with just grain size based on their description of methods.

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Response: Deleted.

Line 23: How often were they sampled? Whole paragraph – It is hard to understand where the hydrological stations are and their names. The names should be intuitive to the reader – maybe based on the location?

Response: Supplemented. Each hydrological station is named according its location by Chinese authorities, in addition, every hydrological station is shown in the revised Fi.1a. See the response 4.

Section 3.2: I could not tell how the authors analyzed grain size data. This is essential information and should be included here.

Response: Supplemented. See the response 4.

Page 9120 Line 19 – Authors did not detail how they calculated cumulative storage capacity. The description should be in the methods.

Response: Revised. In fact, the cumulative reservoir storage capacity can also be named as the total reservoir storage capacity. The reservoir storage capacity index (RSCI) is defined as the ratio of the reservoir storage capacity to the annual average water discharge of the contributed catchment; thus, the total RSCI of a catchment is the ratio of total capacity of reservoir to the annual average water discharge.

Page 9122 Line 14- 19 - This text should be in the discussion. Overall, the results section really needs some cleaning up. It lacks narrative and much of the results described in text could be concisely presented in a graph or table.

Response: Revised. The section of result and discussions was thoroughly re-organized and re-written, according to reviewer's suggestion. The following revision has been made in section of results of the revised manuscript: firstly, we compare the changes of the total RSCI with that of the sediment load of tributaries and the whole Changjiang catchment, the results indicate that the stepwise decrease of sediment load is highly related to the significant increase of the total RSCI, reflecting the impact

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dams have on sediment load; secondly, derived on the basis of the M-K method, of sediment load of the seven tributaries, the spatial-temporal sediment load variations within the catchment are acquired; thirdly, based on the M-K trends of sediment load variation at Datong station, four stepwise reduction stage periods of the sediment load discharging into the sea of the Changjiang were divided, and the factors leading to the sediment load into the sea between adjacent time periods gradually decreased were also analyzed; lastly, the variations in the grain size of the sediment entering the sea during different periods were explored.

Page 9123 Line 6 – This is the first time the authors have talked about the analysis of grain size. The methods need to go in the methods section for this analysis. Methods also need to detail how many and which stations have grain size data.

Response: Supplemented. See the response 4.

Page 9124 Lines 5- 8: "No clear variations" – This is a very broad statement and needs more clear cut support from data. Page 9125 Line1: Methods for determining channel erosion should go in the methods section.

Response: Revised.

Line 17: How did the authors determine the percentage of contribution of those rivers? How did they trace these numbers? It was not clear to me whether or how the authors account for erosion and deposition along the main stem before it goes out to sea. This was not detailed in the methods.

Response: Revised and supplemented. According to the concept of Sediment Budget (Houben, 2012), the flowing equation is used to calculating the sediment discharge balance of Changjiang main river: $\sum S\_input$ =ΔS+S_output=S_Jinsha+S_Min+S_Jialing+S_Wu+S_Han+S_Poyang (1)

where $\sum S\_input$

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is the sediment contribution of tributaries to the sediment load of the Changjiang main stream, S_output is the sediment load entering the sea of the Changjiang (Datong station), ΔS is the quantity of deposited (+) / erosive (-) sediment of the Changjiang main stream and Dongting Lake. Therefore, the sediment contribution proportion of different tributaries to the sediment load entering the sea of the Changjiang can be expressed as: S_Jinsha/S_output +S_Min/S_output +S_Jialing/S_output +S_Wu/S_output +S_Han/S_output +S_Poyang/S_output -ΔS/S_output =1 ïijĹ2ïijĽ

Line 4 – 11: I do not understand how they traced sediment back to particular rivers. First, what methods were used for assessing sediment composition? Second, they have not traced the sediment composition back to particular rivers (because they are only using two stations for grain size analysis), so how did they come to the conclusion that certain rivers were driving the change in sediment composition. Methods should reflect results reported and discussion.

Response: Revised. With regard to the amount of sediment originating from the Poyang Lake and Han River to the Changjiang main river, we still use the sediment budget concept, calculate different sediment fraction balance of Changjiang main river between Yichang-Datong reach: S_Yichang+S_Han+S_Poyang=ΔS+S_datong

Line 13: Citations - Thiry 2000 – Shows that it is difficult to trace origin and climate based on clay materials; Garzanti and Ando 2007 – use heavy mineral concentration index to determine source environment. Neither of these studies use similar methods to those used, or at least described, in this manuscript.

Response: Deleted.

Line 16: The authors should consider taking source samples from each of the rivers to analyze grain size and sediment composition. This could lead to better tracing results. Actually, all the data we used, concerning with the grain size and sediment composition, is acquired in situ sampling. In the revised manuscript, the source of these data is introduced. See response 4.

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Page 9127 Line 7: The manuscript states here that all of the sediment is derived from a homologous source. How do the authors trace it then? And what are “mineralogy characteristics”? These assertions seem inconsistent. Again, the methods should reflect all of the results reported in in the subsequent sections.

Response: Revised. The method calculating the sediment contribution proportion of different tributaries to the sediment load entering the sea of the Changjiang, is supplemented in the revised manuscript (see response Page 9125 Line 17). In addition, according to the reviewer’s suggestion, the content of mineralogy characteristics was deleted in the revised manuscript.

Line 14: In is unclear how the composition of the sediment at Dongting Lake was determined. This information should be in the methods section

Response: Supplemented in the section of regional setting. Dongting Lake is the second largest freshwater lake in China, and joins the main Changjiang River from the south. Part of the main river flow enters Dongting Lake via five different routes. Four tributaries enter Lake Dongting from the south and southwest, and water from Dongting Lake flows into the Changjiang main river channel at Chenglingji station. Therefore, before 2003, Dongting Lake does not directly supply sediment to the Changjiang main river, and huge quantity of sediment originating from upstream Changjiang deposited in the Dongting Lake. After 2003, however, the Dongting Lake suffered from weak erosion, which is beneficial to slowing down the atrophy of Dongting Lake area , and this part of eroded sediment is included in the ΔS (the quantity of deposited (+) / erosive (-) sediment of the Changjiang main stream and Dongting Lake) (see the equation of response Page 9125 Line 17). The sediment balance of Dongting Lake is as followed: Sinput of Changjiang=Sflowing from Dongting Lake $+\Delta S$

Page 9128 Line 3: “Briefly” does not make sense at the beginning of this sentence.

Response: Deleted.

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Line 10: How did the authors come to this conclusion: “As far as sediment provenance tracing is concerned, due to the variations in end-member components induced by changes of the sediment composition in the Changjiang catchment, the end-member components of one phase cannot be used to trace the sediment origin of another phase?” - The end-members or phases were not discussed in the methods of the paper. The methods and results do not support this conclusion.

Response: According to reviewer’s suggestion, the topic of the revised manuscript is mainly concentrated on the variation in sediment load and grain size resulted by human activities, other irrelevant content was deleted.

Line 14: There should be more detail about how change in grain size will affect these areas.

Response: Revised. The section of Discussion was re-written.

Line 23: I would change to “and deserve further study”

Response: Revised.

Conclusions: I think that the conclusions are a good outline for what this paper needs to look like. They concisely sum up your results and discussion and highlight the main points. I did not come to the same conclusions when I read the paper myself and was generally confused about the analysis. Bullet 4 in conclusions: Where in the paper did they look at the depositional area or estuarine-coastal deposits? This bullet does not reflect the text of the paper.

Response: Revised.

Tables and Figures: Table 1 – The information presented here is if it will be used to test for changes in the sediment, but the paper did not address this.

Response: Deleted.

Table 2 – This following need to be addressed in the methods: how the quantities were

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measured and analyzed for each station, how frequently samples were taken, and how were annual numbers determined.

Response: Supplemented in the method (see response 4)

Figure 1 – The map is hard to read with the font and the flowlines. This is a crucial part of the paper because they reference the different names of the reaches throughout the paper. The map needs to be clearly labelled so the reader can understand what areas are discussed.

Response: Revised. See the Figure 1 of the revised manuscript of the supplementary.

Figure 2 – This figure is a really good illustration of what I think the main story should be - Understanding the sediment load changes through time. The reservoir storage capacity index calculations need to be addressed in the methods.

Response: Revised.

Figure 5: How did they choose the time periods for breaking up the data? Was it random or based on some sort of analysis? These details need to go in methods.

Response: Supplemented. The M-K trends of sediment load variation at Datong station show that, 1969 and 1985 are two important time nodes, reflecting the beginning time of sediment load decreasing. Due to the M-K trends of the sediment load passing the 95% confidence test occurred at 1989, another important time nodes (2003) is not reflected in the M-K trends of sediment load of Datong station. Taking into account the great impact of the Three Gorges Dam on the sediment load decreasing of the Changjiang main stream (Hu et al., 2011), the variations of the sediment load entering the sea of the Changjiang could be divided into four stepwise reduction stages, namely, 1956-1969, 1970-1985, 1986-2002, and 2003-2010.

Figure 6: What data did they use for this distribution? How often was it taken? Make y-axis the labels and scale the same across all of the graphs.

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Response: The data source is introduced in the section of method. Some revision has been made in this figure.

Figure 7: This figure is a bit confusing. Do the different colors signify the different tributaries? What is the label for the x-axis of the graphs (what do the numbers stand for)? What is y-axis label on the graphs (what do they mean by sediment load variations)?

Response: This figure was replaced by Tab.2.(see the supplementary)

Figure 8: Hard to determine if there really is a relationship from four points. Is there yearly data for this graph (instead of the time periods used)? How did they come up with these time periods? Are the randomly selected? How did they calculate the data from the pie charts? Again, the methods do not reflect the results: I am confused about how they came up with the percentages from each river.

Response: Deleted.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C4062/2014/hessd-11-C4062-2014-supplement.zip

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 9113, 2014.