

## ***Interactive comment on “Erosion-induced massive organic carbon burial and carbon emission in the Yellow River basin, China” by L. Ran et al.***

**T. Hoffmann (Referee)**

thomas.hoffmann@uni-bonn.de

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The manuscript presents a detailed sediment and sediment-burden carbon budget of the Yellow River for the time from 1950-2010 AD. The authors try to fill the notable research gap of large scale sediment and carbon budgets; which is a very significant contribution not only to the biogeochemical and geomorphological community. Thus the manuscript is of high scientific significance and I highly recommended a publication in Biogeosciences. However, the manuscript needs minor revisions to improve the scientific and presentation quality. I have not doubt that the manuscript will increase from very good to excellent, if the given issues are addressed

General comments:

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The script is very long and difficult to read due to the large number of estimated budget components and the wealth of the presented data. To simplify the structure of the script I suggest to present the conceptual sediment and c-budget framework at the beginning of chapter 3 and describe data sources and methods for each budget component afterwards. Therefore, I suggest deleting chapter 3.1 and moving text within 3.1 to the associated budget components.

Concerning the budget framework, I wonder if the differentiation between soil erosion and slope soil control is correct. I assume that the term “soil erosion” accounts for the eroded soils. If slope control measures are installed soil erosion should decline. Therefore total amount of eroded soils (given with 134 Gt) is the net/effective soil erosion, e.g. the amount of soils that is eroded despite the installation of erosion measures. If I understand Table 1 correctly, the referenced works include human-induced reductions (e.g. Chen 1983, Wang et al 2003, Fu 2011 → measuring soil erosion in 2000 AD after soil protection). If this is correct you reduce the human impact twice. Please comment on this.

Chapter 4.3 and subsection in the discussion are partially redundant. Thus, I suggest to start the Discussion with a summary of the sediment budget and a plausibility test (assessments of uncertainties)

The English needs to be improved. I made several suggestions.

Abstract:

The abstract is well structured and informative. I suggest to add a final statement regarding the implications of the presented study with respect to the source-sink discussion of soil erosion.

Introduction:

The introduction starts with a short description of the importance of soils in the global C cycle and subsequent statements on soil erosion. Then there is a break at transition

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from second to third paragraph, which deals with the Yellow River. I suggest to present the state of art on C transport in rivers in general: give references on the transport and processes of C in rivers, e.g:

Cole, J. J., et al. (2007), Plumbing the global carbon cycle: Integrating inland waters into the terrestrial carbon budget, *Ecosystems*, 10(1), 171-184.

Battin, T. J., L. A. Kaplan, S. Findlay, C. S. Hopkins, E. Marti, A. I. Packman, J. D. Newbold, and F. Sabater (2008), Biophysical controls on organic carbon fluxes in fluvial networks, *Nature Geoscience*, 1, 95-100.

Battin, T. J., S. Luysaert, L. A. Kaplan, A. K. Aufdenkampe, A. Richter, and L. J. Tranvik (2009), The boundless carbon cycle, *Nature Geoscience*, 2(9), 598-600.

Aufdenkampe, A. K., E. Mayorga, P. A. Raymond, J. M. Melack, S. C. Doney, S. R. Alin, R. E. Aalto, and K. Yoo (2011), Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere, *Frontiers in Ecology and the Environment*, 9(1), 53-60.

I suggest to discuss your results in comparison to following reference: Hoffmann, T., Schlummer, M., Verstraeten, G., and Notebaert, B.: Significance of sediment and carbon storage on hillslopes and floodplains, *Global Biogeochemical Cycles*, 27, doi:10.1002/gbc.20071, 22013, 2013.

I suggest to more clearly define the aims of the studies. What are the detailed aims, e.g. which components of the C-cycle do you want to study? Currently the given aim is very general. The link between the aims and the used methods should be very clear. Define your time scale here; and repeat it in the methods and results section. Why do you focus on the 1950-2010 time-scale?

#### Data and Methods

Due to the wealth of data and studies I suggest to restructure the methods and results chapter: first present the concept and afterwards the data and the results (e.g. delete chapter 3.1).

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Eq.1:

1. Does soil erosion  $E_s$  represent the "potential for soil erosion" without soil conservation? (see comment above) 2. If I correctly understood your approach  $R_s$  is the residual to balance the sediment budget Eq. 1! If correct, please clearly highlight that fact. I have the feeling that hillslope deposition is strongly underestimated. A hillslope SDR of  $>0.9$  is very unlikely; discuss these limitations (e.g. compare with Hoffmann et al., 2013, GBC).

#### Results

Sediment deposition within dams and channels does only consider sedimentation in reaches along depositional basins and excludes deposition on floodplains. The given values are, for sure, minimum values since the full depositional length of the Yellow river and its tributaries and the floodplains are not considered. Recent results from Hoffmann (2009 and 2013) indicate that a large fraction of C has been deposited on the floodplains.

To simplify the presentation of your results I suggest to summarize all results in one table: this table should include total sediment storage (or mean sedimentation from 1950-2010, including the relevant reference), mean SOC content, and OC-deposition for each considered budget-component. If budgets components are resulting from a sum of different sub-components, this should be represented in the table as well (e.g. soil control measures is the sum of revegetation and terrace formation).

#### Discussion

Large-scale sediment and C-budgets are inevitably link with large uncertainties. Thus, this study provides a valuable distribution despite these uncertainties. However, the uncertainty assessment requires a more robust statistical sensitivity analysis. Please indicate in a summarizing table (as suggested above), which components are of high confidence and which have very low confidence. Indicate which values are taken from

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literature, and which are calculated by yourself. Further I suggest to propagate the uncertainties to the estimation of the residuals of Eq. 1 and 2.

Statements in Chapter 5.3 are very general and should be supported by your data.

Figures:

Figure 1: Increase font size; currently is rather small

Figure 2: I suggest adding terms from budget eq. 1 and 2 in that sketch. Increase the font size.

Figure 5: Add the desert to the legend and give references to the map in the figure caption.

Figure 6: 1. I suggest to plot two budget figures (e.g. 6a and 6b): one for sediments and one for carbon. 2. If plotting two figures, I suggest to give absolute numbers (preferred in Gt / yr) and relative numbers (based on soil erosion = 100%) 3. Indicate then which numbers are associated with human impact (as you do in the paper) and which budget components are estimated by balancing the budget

Figure 7: This Figure does not add any new information. Can be deleted.

Tables:

I suggest to add a table with the total sediment storage, applied mean OC concentrations and total OC storage, including the used references for each number and for each budget component in Eq. 1 and 2.

Specific comments:

P218: natural processes and human activity are interacting rather than integrated

P2110: change slope lands to 'hillslopes' throughout the text

P2110: delete "Among the produced sediment"

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P315: cycle → cycles

P316: difficulty → difficulties

P3125: change to "...concerning the OC-cycling in the..."

P3126: change to "...is transported as particulate OC, while..."

P3127: the total → the total C-flux

P416: What do you mean with "conventional methods"?

P417: fates → fate

P4110: change to "The Yellow River flows from its origin in the Qinghai-Tibet Plateau at an altitude of 5000-6000 m along a 5464 km course towards eastern China, ..."

P4113: change to "..., ranging from humid climates in the SE section to subarid climates ... to arid climates..."

P4121: change to "Mean annual water discharge from 1950 to 2010 at Lijin..."

P5101: add the following reference: Hassan, M. A., M. Church, J. Xu, and Y. Yan (2008), Spatial and temporal variation of sediment yield in the landscape: Example of Huanghe (Yellow River), Geophysical Research Letters, 35, L06401, doi:06410.01029/02008GL033428, 032008.

P5105: sediment flux → sediment yield

P5112: How much does this represent of the total discharge?

P5116: change to "...Quaternary loess is usually 130-180m thick, up to ..."

P5127: use terminology of FAO-classification

P6109: "...national soil survey conducted sine 1979 by thee Institute..."

P6108: "The Yellow River basin is covered..."

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P6I14: "a soil profile" → "one soil profile"

P6I16: remove "...in soil horizon. . ."

P6I17: change "... because it is the topsoil horizon that closely correlates with soil erosion processes." → "...because soil erosion is limited to the topsoil horizon." P7I04: change to: "Soil erosion by water at the basin scale is usually composed of three phases, including detachment, transport, and deposition of soil particles. The detachment occurs at uplands where soil is vulnerable to erosion. The eroded soil..."

P7I08: remove the sentence: "Understanding erosional effect...all three phases."

P7I09: "...all the three phases..." → "...all three phases..."

P7I15: Eq.1 is not a transport model rather a budget equation

P7I15: I suggest to visualise each term in Figure 2

P7I17: remove "The subscript S represents bulk sediment".

P7I22: budgetary → budget

P8I08: change to "Equivalent to Eq. 1, a similar budget equation can be obtained for OC:"

P8I12: remove "The subscript C represents OC."

P8I22-23: give references

P9I2-4: give units for terms in Eq.4

P10I09: "for the studied 61 years": so far the study period (1950-2010) is only mentioned in the abstract. I suggest to repeat it several times in the text (for example in the methods chapter; please indicate why 61 years?).

P10I11: remove the first sentence of the paragraph

P10I14: remove "...in the basin. . ."

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P10I15: "Temporally, the sediment transport. . ." → which 4 stages do you mean? I suggest to remove this sentence.

P10I23: approx.. 2.83 km<sup>3</sup> or 22.4% of its initial storage capacity has been lost due to sedimentation (Ministry. . .)"

P10I26: change to "...Ran et al (2013c) estimated reservoir sedimentation within the Yellow River basin."

P11I13: Change 17.8 Gt to mean sedimentation given in Gt/yr

P12I07: Is the value (1.3 Gt) included in the 3 Gt given in line 274?

P13I14: what is the mean sediment yield in the period from 1950-1968? Give numbers!

P14I03: plummeted → declined

P14I05: How did the SDR changed through time? Do you have any numbers?

P15I05: Is the higher SOC in the headwaters a result of higher input of OC or lower decomposition?

P18I24: This paragraph could introduce chapter 5.3.

P19I01: "...increasingly more on human. . ." → "...increasingly on human. . ."

P19I02: change to "...have dominated soil erosion, transport and storage."

P20I22: what do you mean with "reconstructed soil erosion rate"? Why reconstructed?

P20I16: Change to 'The soil erosion rate of the Yellow River basin during the last 61 years ranges between 1.7-2.5 gt a<sup>-1</sup> with a mean of 2.2 gt a<sup>-1</sup>.

P20I18: remove 'indeed'

P20I21-23: unclear

P20I26: It is unquestionable that sand mining is not important at that scale. I suggest

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deleting that sentence.

P2111-10: Currently the deposition on floodplains is not considered. Could you comment on the importance of floodplain deposition after the construction of flood protection measures? The embanked part of the floodplain might be characterized by very high sedimentation rates, which are not effected by the sediment regulation. As shown by Hoffmann et al (2007, The Holocene and 2009, Geomorphology), the large number of small tributary floodplains may significantly contribute to the storage of sediment and OC. Please refer to these papers.

P21118: Please specify that you are talking about the hillslope SDR

P21127: Can you give a range of possible SDR values?

P23104: change unpractical → unlikely

P25111: change 'three phases of soil erosion' to 'erosion, transport and deposition'

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