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Interactive comment on "Morphodynamic model of Lower Yellow River: flux or entrainment form for sediment mass conservation?" *by* Chenge An et al.

Anonymous Referee #1

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Review of "Morphodynamic model of Lower Yellow River: flux or entrainment form for sediment mass conservation?" by Chenge An et al.

The authors asses the differences between modelling sediment conservation using a flux-based formulation and an entrainment-deposition type formulation. They apply the two types of models to the Lower Yellow River and study the differences between them. The writing is clear and the manuscript is well structured, although the authors could use less words for what they want to say. The analysis is definitely of interest to the ESurf reader, but I think the manuscript message could be stronger. I have two main problems with the manuscript. The first is the fact that it seems that the main ques-

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Discussion paper

tion the authors are answering ("what are the differences between an entrainment form conservation equation and when to use a flux-based formulation") rather is "When does a modeller need to properly account for the lag of suspended load tranpsport?". The second problem is the fact that the authors treat the flux form of the mass conservation equation as a synonym to a capacity-based or equilibrium approach, and the entrainment form of the mass conservation equation is considered a noncapacity-based or non-equilibrium based formulation. I think the two types of models (flux form and entrainment form) are not synonyms for capacity-based and noncapacity-based. The terms are not equivalent, which has some impact on the message of the manuscript. Also, I would suggest the authors to develop generic guidelines for when to use an entrainment form conservation equation and when to use a flux-based formulation, and only after this move toward the case of the Lower Yellow River.

Main comments: 1. It seems that the main question the authors are answering ("what are the differences between an entrainment form conservation equation and when to use a flux-based formulation") rather is "When does a modeller need to properly account for suspended load mechanisms?"

2. The authors treat the flux form of the mass conservation equation as a synonym to a capacity-based or equilibrium approach, and the entrainment form of the mass conservation equation is considered noncapacity-based or non-equilibrium. I think the two types of models (flux form and entrainment form) are not synonyms for capacity-based and noncapacity-based. These terms are not equivalent. Revising this may impact several parts of the text.

3. Associated with the previous comment: Could Bell and Sutherland (1983) and Armanini and Di Silvio (1988) be examples of the flux-form combined with a non-capacity approach?

4. Associated with the same comment: And may Blom and Parker (2004), Blom et al. (2006, 2008) be an example of the entrainment form combined with a capacity-based

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approach?

5. Isn't the Exner equation of conservation of sediment mass a flux-based approach? Shouldn't the authors consider another (other than "Exner") name for the entrainment form of conservation of sediment mass?

6. Ln 26 "study this problem by comparing the results of flux-based and entrainment-based morphodynamics". Please explain in what way you are comparing the two types of conservation models. This also holds for ln 105-106. One of the ways seems to be by mimicking "the reduction of the sediment load in the LYR in recent years" (Ln 279). I think this information needs to be moved to the Introduction section. Figs 6 and 7. Shouldn't the equilibrium channel slope and bed surface texture be equal for the flux form and the entrainment form? It would be nice if the authors would confirm this.

7. Ln 26 "study this problem by comparing the results of flux-based and entrainment-based morphodynamics under conditions typical of the Lower Yellow River". I would suggest to develop generic guidelines for when to use an entrainment form conservation equation and when to use a flux-based formulation, and only after this move toward the case of the Lower Yellow River.

8. Ln 45-47. I'd rephrase this as application of the entrainment form of the conservation equation is not necessarily limited to suspended sediment.

9. Ln 57-71. These lag issues are not only covered by the entrainment form, but may also be covered by the flux form... Also see comment 2.

10. Ln 78. "More recently, however, since the operation of Xiaolangdi Dam in 1999 the LYR has seen a substantial reduction in its sediment load (Fig. 1(b))". - The authors do not address the distinct temporal decrease of the annual sediment load between 1950-2000. - Why is the year 2000 indicated in Figure 1b and not 1999? Please indicate in the figure whether 2000 is supposed to indicate the year of the Xiaolangdi Dam construction.

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11. Figure 1 shows a number of very interesting features that are currently not addressed by the authors: - the distinct temporal decrease of the annual sediment load between 1950-2000. What is the cause of this decrease? - The three lines for the three cities are highly correlated. Please indicate and explain. - The suspended load is significantly finer than the bed material (i.e., grain size selective transport) - Does the “bed material” consider the bed surface or substrate? Please specify. - The bed material nicely shows downstream fining. Please explain. Is this due to preferential deposition of coarse sediment or particle abrasion? Or a combination?

12. I’d change the order of the research questions in Ln 94-96 “Is the entrainment formulation really necessary when modeling the LYR? Or more specifically, under what circumstances should a numerical modeler be impelled to implement the entrainment formulation instead of the flux formulation for river morphodynamic modeling?” to 1. “Under what conditions should one apply an entrainment form or flux form description of conservation of sediment mass?” 2. “Which form of the sediment conservation equation is most suitable for LYR?”

13. Ln 118. No bedrock. Please explain to the reader how valid this assumption is.

14. Ln 119. I think here you say that you impose a constant flow rate and sediment supply rate at the upstream end. What impact does this assumption have on the model results and conclusions? Please address this in the discussion section. Also holds for ln 133-137.

15. Ln 164 or Eq.7. It is about the interface elevation and not the bed surface elevation. The parameter La is missing. Right-hand terms should read d(zb-La)/dt<0 and d(zb-La)/dt>0.

16. Ln 226-230. The friction term in the original E&H formulation includes form drag. If there is barely any form drag such as in the LYR, then it makes sense that the original E&H does not do well and needs to be adjusted.

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17. Ln 232-247. It may be interesting to mention that a fractional version of E&H was first proposed by Van der Scheer et al. (2002) and was later used by Blom et al. (2016, 2017a, 2017b).

18. Ln 310. Please be specific. “Slower degradation” refers to a slower downstream propagation of the degradational wave? Differences between Figs 3a and 4a are difficult to see anyway..

19. Ln 310. “more diffusive sediment load reduction”. Or a faster downstream propagation of the disturbance?

20. Ln 342. 0.05. Why so extreme? Ln 483. 20. Why so extreme?

21. Ln 363-364. “The sediment supply rate of each grain size range is 364 set at 10% of its equilibrium sediment transport rate. This results in .... and a grain size distribution of the sediment supply ... that is identical to the grain size distribution of the equilibrium sediment load.” Here it is essential for the reader to understand that the GSD of the sediment supply does not change: only the total sediment supply is reduced by 90%. This means that also the equilibrium GSD of the suspended load must be the same as the one of the sediment supply and so does not change with time. The equilibrium bed surface texture gets coarser with a reduction of the total sediment supply (Blom et al. 2016, 2017a). This is because with a reduced total sediment supply the equilibrium flow velocity decreases and the mobility difference between the grain size fractions increases. This implies that with a decrease of the total sediment supply the bed surface needs to coarsen to allow for the supplied sediment to be transported downstream. These things need to be explained to the reader.

22. Ln 372. “with at least two kinematic waves”. Each grain size fraction induces the migration of a perturbation (Stecca et al., 2014, 2016). It would be nice to illustrate this.

23. Ln 376. See previous two comments. I think it would be illustrative and helpful if the authors would validate whether, if they continue their runs for a very long time, the

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GSD of the suspended load becomes equal to the GSD of the sediment supply.

24. Ln 438. The authors neglect the temporal derivative. Can the authors quantify or justify this assumption?

25. Figs 6 and 7. Shouldn't the equilibrium channel slope and bed surface texture (Blom et al, 2017a) be equal for the flux form and the entrainment form? It would be nice if the authors would confirm this.

26. Section 3.2. Has the value of the active layer thickness been provided, and the total number of grain size fractions n? What is the height of the grid cells used to register the surface and substrate GSD? The flow is solved using a Godunov type scheme. What about the conservation equations for sediment mass? How are they solved?

27. The authors mention that they fix the downstream bed elevation by assuming normal flow at the downstream end. Yet, later the authors seem to mention that actually they put the downstream boundary condition sufficiently far to avoid backwater effects. Isn't this a contradiction?

28. In the simulation results one observes that changes in grain size arrive at the downstream end although bed elevation is constant with time. I do not understand this.

29. Has the CFL criterion for modelling bed elevation and the flow been considered?

30. Section 3.2. Have the authors experienced any unreasonable instabilities in their numerical runs (Chavarrias et al, 2018)?

31. Figure 9. The adaptation length is represented by 3-4 cells. Could the conclusion that the adaptation is irrelevant be due to not well solving it?

32. Section 4.2. I think the authors may like to consider these results in the context of the results of Stecca et al (2014, 2016).

33. Equation (37). The authors treat only one fraction and consider the equation to be an advection equation. In reality they have a system of advection equations in which

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the source terms links them. This may yield different behavior.

34. Equation (38). The authors are not the first ones. I think the authors should compare these results to the ones of Stecca (2014, 2016).

35. Lines 494-498: I'd propose to rephrase.

36. Line 557-558. The authors say the entrainment form is needed when studying sorting processes. I do not think this conclusion can be drawn.

37. The conclusion section reads as a summary. I'd recommend revision and limiting the section to conclusions.

38. Ln 643-646. Is the entrainment form recommended provided that all 3 requirements are fulfilled or if only 1 of the 3 is fulfilled?

39. Ln 643-646. Please provide some more information here. When more information is added this finding should be one of the main results, I think. Also see suggestion on research questions.

40. Line 681. Please explain why the time derivatives may be omitted.

Minor comments:

41. Ln 17 and 45. alternate → alternative?

42. Ln 35. Reference to Parker 2004 can be omitted.

43. Ln 85. bed material → surface or substrate?

44. Ln 90. "and thus more likely to be" → "as it is"

45. Ln 141. I think the 0.4 value should be listed at a later point in the manuscript.

46. Ln 154. "La is often related to the height of dunes so that" → "La is often related to the height of dunes (Blom, 2008) so that"

47. Ln 161 and 162. You'll need to apply Eq (6) to n-1 sediment fractions.

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48. Ln 248-249. I'd rephrase 'hiding effects between coarse and fine sediment'.

49. Ln 267. Blom et al 2003 → Blom 2008

50. Ln 277 and 621. I'd avoid using "=" like this in a sentence.

51. Ln 283 and 284. I'd change the unit years to something much smaller.

52. Ln 285-287. I'd rephrase the following sentence: "But it should be noted that the aim of this paper is not to reproduce specific aspects of the morphodynamic processes of LYR, but to compare the flux form and entrainment form of Exner equation in the context of conditions typical of LYR."

53. Fig 2. Caption and legend. "Initial bed" refers to surface or substrate? "Washload sizes" refers to which sizes?

54. Ln 436-437. Why repeat an equation?

55. Ln 621. I'd avoid starting a sentence with "But".

56. Ln 617 Sentence starting with "Moreover, . . . unchanged". I'd omit this.

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