Point-by-point reply to the comments (revision #2)

1. Editor Decision: Reconsider after major revisions (23 Jun 2014) by Dr. Paola Passalacqua

"Based on the reviewers' comments and my own reading I find that the paper has greatly improved. One of the reviewers still raised some significant issues, particularly on the organization of results versus discussion in your manuscript, which should be accounted for. Please consider carefully both reviewers' comments as you revise your manuscript."

Reply: We thank you and the reviewers for your support. We took into account every comment and suggestion. A detailed list of changes is given below.

2. Reply to the re-review by Maximiliano Sassi

"The manuscript significantly improved. Section 3.3.1 lacks information on the sediment transport module. For example, how are deposition and erosion fluxes described ? Is there limited sediment availability in the bed ? How many sediment classes are there being used ? I suggest expanding this section, perhaps breaking it down in two parts, one dealing with hydrodynamics and the other dealing with sediment transport."

Reply: The following section was added to the paper (the new references were also added):

3.3.2 The cohesive sediment transport module

The cohesive sediment transport module of MIKE11 is based on the 1-D advection dispersion equation:

$$\frac{\partial AC}{\partial t} + \frac{\partial QC}{\partial x} - \frac{\partial}{\partial x}\left(AK_H \frac{\partial C}{\partial x} \right) = C_2 q + wS_E - wS_D \qquad (5)$$

where C is the suspended sediment concentration (kg m^{-3}), A the cross sectional area (m^2), K_H the horizontal dispersion coefficient (m^2 s^{-1}), C_2 the tributary concentration, q the tributary (lateral) inflow per unit length, S_E is the source term resulting from erosion (kg m^{-3} s^{-1}), S_D is the sink term resulting from deposition (kg m^{-3} s^{-1}) and w the river bed surface per unit length (in m^2, its value being the river width x 1). The deposition rate is given by:

$$S_D = \frac{W_s C}{h_*}\left(1 - \frac{\tau_b}{\tau_{c,d}}\right) \text{ for } \tau_b \le \tau_{c,d} \text{ and } S_D = 0 \text{ for } \tau_b \ge \tau_{c,d} \qquad (6)$$

where W_s is the settling velocity (m s^{-1}); τ_b is the bed shear stress (N m^{-2}); $\tau_{c,d}$ is the critical bed shear stress for deposition (N m^{-2}); h_* is the average depth through which the particles settle (m), calculated by the model from the water depth and the Rouse number (see DHI, 2009). The rate of erosion is given by:

$$S_E = \frac{M_*}{h}\left(\frac{\tau_b}{\tau_{c,e}} - 1\right) \text{ for } \tau_b \ge \tau_{c,e} \text{ and } S_E = 0 \text{ for } \tau_b \le \tau_{c,e} \qquad (7)$$

where M_* is the erodibility of the bed (kg m^{-2} s^{-1}); $\tau_{c,e}$ the critical shear stress for erosion (N m^{-2}), and h is the water depth. In our simulations, sediment was assumed to always be available at the bed for erosion.

The resolution of the cohesive sediment transport module requires outputs from the hydrodynamics module, namely water discharge, water level, cross-sectional area and hydraulic radius, and calibrated specific parameters (critical shear stress for erosion, critical shear stress for deposition, erodibility). This cohesive sediment transport module associated with MIKE11 has been successfully applied to sediment transport studies by, e.g., Neary et al. (2001), Etemad-Shahidi et al. (2010) and Kourgialas and Karatzas (2014).

I include below a few more minor corrections.

29-31, it is unclear what you mean by 'the coupling between …'

Reply: "the coupling between the changed water regulation (in particular enhanced flow in dry season) and tidal pumping is discussed as a possible cause of the enhanced siltation" was replaced by "the effect of tidal pumping on enhanced flow occurring in dry season and resulting from changed water regulation is discussed as a possible cause of the enhanced siltation".

78, please add comma after 'consequences'

Done

87, do you mean 'complementing' ?

Reply: Yes, sorry. The error was corrected.

92, 'no systematic record exists' ?

Done

164, 'inferred' is strange within this context, perhaps 'induced' ?

Done. Thank you for your suggestion.

168, citation is not in reference list

Reference added

169, concerning sediment division mechanisms see Sassi et al. (2013) Sediment discharge division at two tidally-influenced bifurcations, WRR

Reference added

180, 'and the tide is'

Done

222-224, the given precision is unrealistically high, consider lowering significant figures in reported values

Reply: "0.1 $m^3 s^{-1}$ and 0.1 t yr^{-1}" was changed into "1 x 10^9 m^3 yr^{-1} and 1 x 10^6 t yr^{-1}, respectively, for the Red river, and to 0.1 x 10^9 m^3 yr^{-1} and 0.1 x 10^6 t yr^{-1} for its tributaries and distributaries"

250, 'set up'

Done

265-268, information is missing concerning the sediment transport module

Reply: see our first comment and the new section 3.3.2.

270, 'set up'

Done

286, perhaps mention that in the following paragraphs you explain why you chose to fix the boundary condition during flood

Reply: We added the following sentence: "A varying C at river mouths during floods would necessitate either available continuous measurements, or a coupling to a coastal sediment transport model, out of the scope of the present study."

291, mg per liter is missing after the value 61

Done

307, which model parameters?

Reply: We added the following precision: "Optimization of the model's parameters (n distribution for hydrodynamics; critical shear stress for erosion $\tau_{c,e}$, critical shear stress for deposition $\tau_{c,d}$ and erodibility M_*)…"

326, is there only one sediment class?

Reply: Yes. The sentence was changed into: "Only one-class of particles, of 15 μm-diameter, was considered in our simulations. This value is in agreement with bed sediments size in estuaries, dominated by silts (see §2.6 and Lefebvre et al., 2012). Their corresponding settling velocity obtained from Stoke's law is 0.2 mm s^{-1}."

329, you should mention how calibration is done, I guess in the same manner as for roughness, and using eq. 5 but adapted for concentration, please mention

Reply: Right after eq. 5 and "the sum of the absolute squared differences between the predicted and observed values", we added "(Q for hydrodynamics, C for sediment transport)"

451-468, this paragraph presents no information about results and therefore should belong to the discussion section or the introduction

Reply: (see also our reply to the first comment by John Shaw, on the same topic) As also suggested by the other reviewer, old sections 4.4 and 4.5 were moved from results to the discussion.

565, the wording 'low energetic episodes' is unclear, please consider rephrasing

Reply: After "in low energetic episodes", we added "which are characteristic of slack water periods (i.e., with a Kolmogorov microscale >1,000 μm),"

583, 'may be superimposed'

Done

593-596, you can safely place this piece of text after line 302

Reply: (see also our reply to the last comment by John Shaw, on the same topic) The validity of our suspended sediment transport model strongly relies on its boundary conditions, the most critical one being the imposed and fixed value of C during flood periods at river mouths. This piece of text, suggested by the other reviewer, aims at showing how these boundary conditions could be improved in future studies. So we suggest keeping them in the discussion. This paragraph was completed by an additional sentence: "The coupling of the river basin model to a coastal hydro-sedimentary model should allow better estimating estuarine deposition rates, and estimating erosion and accretion rates along the delta as well, enabling a closer analysis in regards to the available measurements."

610, please add a comma after 'subsidence'

Done

620, these references in the conclusion section may not be necessary

Reply: The conclusion seems appropriate to enlarge applications of such work to other disciplines, and we would like to remind that sediment balance has a high impact on ecosystems health and water quality. The quoted studies were performed at the same site and are not, in our feeling, out of purpose. We would like to keep them. Thank you for your understanding.

3. Reply to the re-review by John Shaw

"Upon my second review of Vu et al. (hess-2013-555), I find the manuscript to be much improved. I find the new "Comparison with Former Studies" and "Boundary Conditions" sections to be a big help in understanding the paper. That said, I still find significant issues with some of the article's main points and structure. I will ask for major revisions of the paper due to how central my issues are, but I still think that once these issues are addressed it will be a valuable paper.

Despite improvements, I believe that Results and Discussion should be better separated. In my opinion, the results of this paper are model results only. It should be the discussion section where the model results are compared with other findings. Vu et al. did not produce any results on siltation of estuaries or erosion and accretion along the Red River Delta. I therefore believe that these sections (4.4 and 4.5) should be moved to the discussion."

Reply: (see also our reply to a comment by M. Sassi on the same topic) As also suggested by the other reviewer, old sections 4.4 and 4.5 were moved from the results to the discussion.

The authors have done a good job developing a model that suggests changes in water and sediment flux partitioning on the Red River Delta. These results by themselves warrant publication in my opinion. However, the relation between these model results and coastal erosion still need work. In Section 4.5, it is not clear what the effect of the dam has been on coastal change, although several studies are cited. Is there a way to compare the quantitative output of the MIKE11 model to changes in rates? If so, it would be extremely valuable. As the paper currently reads, the output of the model has not increased our understanding of coastal erosion beyond the previous studies.

Let me repeat that the model outputs are themselves valuable and their predictions could lead to improved tests of the dam's importance to coastal processes and morphology. It is fine to suggest qualitative relationships in the Discussion section, but the current paper does not provide new results on coastal morphology.

Reply: Outputs of the MIKE11 model stops at the river mouths and can not help by themselves to estimate erosion and/or accretion rates in coastal zones. However, a model is ready in the river basin and delta which can be coupled to a 2D or 3D coastal sediment model to answer this question (see an example of such coupling in Ouillon and Caussade, 1991, available on ResearchGate or at http://www.legos.obs-mip.fr/ouillon/publications/Ouillon_Caussade_1991.pdf). We added a sentence in the last section of the discussion: "The coupling of the river basin model to a coastal hydro-sedimentary model should allow better estimating estuarine deposition rates, and estimating erosion and accretion rates along the delta as well, enabling a closer analysis in regards to the available measurements." In conclusion, the following sentence was complemented: "Although the estimates of water and sediment discharge can be improved in the future (e.g. measuring C at the river mouths during flood periods; taking into account bedload transport; *connecting the river basin model to a 2D or 3D coastal hydro-sedimentary model*; etc)."

I have found several instances where the numbers given in the Tables do not match the numbers in the text. Examples are the numbers in line 405. These should be double and triple checked before publication.

Reply: CVs in the text and in the tables differ because they correspond to different parameters. CVs line 405 refer to inter-annual values (calculated from a series of annual sediment discharges), while those in Table 2 refer to intra-annual values (calculated from monthly values of sediment discharge). As it was not clear, the title of Table 2 "Average monthly and annual suspended sediment concentration (mg L^{-1}), and coefficient of variation of mean monthly values obtained from measurements at five gauging stations…" was changed into "Average monthly and annual suspended sediment concentration (mg L^{-1}), and intra-annual variability (coefficient of variation of mean monthly values) obtained from measurements at five gauging stations…".

On to smaller comments:

Line 66, 138, 176: I suspect that the measurements were of suspended sediment flux. It is important to state what type of sediment flux is being measured.

Reply: You're right. We added "suspended" in these three sentences.

In lines 78-86, the authors describe previous studies on changes to coastal sediment transport. This would be a good place to also mention changes in coastal erosion and sedimentation rates.

Reply: Coastal erosion and sedimentation rates were moved from the results to the discussion.

Line 159, "14 day cycle."

Done

Line 166, "since they may alter the discharge division amongst distributaries by several percent" (a suggestion)

Done. Thank you for the suggestion.

Line 296, it is difficult to compare the 1.5 m below the surface and above the bed. It would be better to reference all data to above the bed, or below the surface.

Reply: The values 1.5 m above the bed were removed.

Line 327, 0.2 mm s-1 corresponds to what grain size, has grainsize within the delta been published?

Reply: The sentence was changed into: "Only one-class of particles, of 15 μm-diameter, was considered in our simulations. This value is in agreement with bed sediments size in estuaries, dominated by silts (see §2.6 and Lefebvre et al., 2012). Their corresponding settling velocity obtained from Stoke's law is 0.2 mm s^{-1}."

Regarding grainsize, we added the following section and one reference:

2.6 Grainsize within the river basin and the delta

Values of the median diameter D_{50} of surface sediment are, on average, 0.35, 0.16 and 0.175 mm in the Da, Thao and Lo rivers, respectively (Ministry of Agriculture and Rural Development, 2009). Its value is 0.2 mm between the confluence of Da and Thao rivers and the apex and, in the upper two distributaries, 0.18 mm in the Red river and 0.22 mm in the Duong river (Ministry of Agriculture and Rural Development, 2009). Downstream, in the estuaries and coastal zones, D_{50} of the superficial sediments ranges from 5 to 195 μm (Do et al., 2007). In the lower Cam-Bach estuary, surface sediments result from a combination of fine silt and fine sand whose ratio varies greatly over a distance of 5-10 kilometers (Lefebvre et al., 2012).

Line 331, I am not fully qualified to evaluate this model, but I don't understand how a rate of erosion could be set completely independently of shear stress.

Reply: They are separate parameters but their values may depend from each other. See e.g. Winterwerp et al., 2012, A conceptual framework for shear flow–induced erosion of soft cohesive sediment beds, JGR, vol. 117, C10020, doi:10.1029/2012JC008072

Line 360, "annual" water distribution

Done

Line 376, the first two paragraphs in Section 4.2 should be combined.

Done

Line 447, We switch from cubic meters to tons between sentences. Perhaps provide both quantities (one in parenthesis) to allow better comparisons.

Done. We gave the following precision: "Nowadays, 4-5 x 10^6 t (1600 - 2000 x 10^3 m^3) of sediments are annually dredged". The calculation was based for sediments composed of 90% of rocks (2650 kg m^{-3}) and 10% of pore water.

Line 592, While I applaud the creation of the Boundary Conditions section, I think it can be significantly expanded. How would the increased boundary condition C at river mouths change model outputs?

Reply: (see also our reply to a comment by M. Sassi on the same topic) We are sorry, we can't infer how increased boundary condition C at river mouths would change model outputs. More realistic calculations would not necessitate increased values, but varying values of C during flood periods. This section was

completed by an additional sentence: “The coupling of the river basin model to a coastal hydro-sedimentary model should allow better estimating estuarine deposition rates, and estimating erosion and accretion rates along the delta as well, enabling a closer analysis in regards to the available measurements.”

4. Additional changes

- The former “SSC” (for suspended sediment concentration) was too heavy to be used in the new section describing the suspended sediment transport model. We thus decided to change “SSC” into “C” all along the paper.
- The ref DHI (2004) was changed into DHI (2009).