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Hydrology and Earth System Sciences
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Interactive comment on "A 2-D process-based model for suspended sediment dynamics: a first step towards ecological modeling" *by* F. M. Achete et al.

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Thank you very much for the detailed review and comments to improve this work. We will update the manuscript with the following responses. The responses to questions 1a,c will be added in the model description chapter, section 2.1 as additional paragraphs.

1. Does the work apply novel numerical/conceptual techniques?

(a) New numerical techniques (e.g. polyhedral mesh) and their advantage

The advantages of the numerical method are addressed by Kernkamp (Kernkamp et

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al., 2010). In this paper, for the first time a real-world case is run with the new model. With a personal computer it is possible to address challenging morphologies combining rectangular and triangular mesh. The advantage of this approach is the reduced number of cell since it is not compulsory for the entire mesh to be triangular, hence less cells and lower computational time.

Another advantage is the possibility of directly converting Delft3D grids and settings to DFlow-FM. Delft3D is commonly used models for coastal engineering applications, and DFlow-FM will allow coupling existing Delft3D models with inland models and complex geometry estuaries (van der Wegen and Roelvink, 2012; Guo et al., 2015; Dastgheib et al., 2012; Roelvink, 2006; Lesser et al., 2004).

(b) novel algorithms for fast or parallel processing (please note that a computational focused paper would be more suited for a journal like Computers Geoscience rather than HESS)

The algorithm is developed by a partner group, and the publication of computational developments and new schemes is more suitable to them than us. The publication about the grid and solvers is published by Kernkamp (Kernkamp et al., 2010).

(c) novel transport equations and couplings.

The transport equations are the same one used in many other models, the advective-diffusion equation, and for the cohesive sediment Krone-Parteniades.

The novelty here is that the flexible mesh model is directly coupled with water quality, sediment transport and habitat model. In this sense the exchange of model input/output between the hydrodynamics, sediment and ecology model is facilitated. For habitat model having SSC as input improves results of light attenuation therefore better primary production and habitat definition.

—– The responses to question 2 will be added in the end of the introduction on page 4. We agree that the choice of the specific site was not discussed enough.

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2. What insight can be obtained from choosing this specific field site?

(a) Is the field site characteristic end member case of transport?

The Sacramento San-Joaquin Delta is a typical case of a highly impacted estuary. Being able to numerically simulate and determine sediment transport, budget and turbidity levels in this type of environment open possibilities to better informed political, ecological and management decisions including how to respond to climate change and sea level rise. This type of model is an important management tool that is applicable to other impacted estuaries such as Guanabara Bay (Rio de Janeiro, Brazil) and the Hudson estuary (New York, USA).

(b) Is the field site very well suited for calibration/model output comparison due to high quality available flow/topographic data?

As you already posed, the field site is very well suited for calibration. The Delta and Bay has a big survey network. There is a big data base of freely available data on river stage, discharge and suspended sediment concentration among other parameters, maintained by USGS. The continuous sediment in suspension measurement stations are periodically calibrated by water collection in situ, filtered and weighted in the laboratory.

The Bay-Delta system has high resolution bathymetry (10m) for all the channels and bays.

(c) Is the field site of specific importance, especially with respect to the ecological focus of the paper's title.

The focus of the paper is to improve the connection between physical and ecological numerical models. In this sense the ecological importance of the Delta is discussed below. Starting from the bottom of the food web, the Delta is the most important area for primary production in the San Francisco Estuary. The Delta is one order of magnitude more productive than the rest of the estuary (Jassby et al., 2002;Kimmerer, 2004).

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The Delta is an area for spawning, breeding and feeding for many endemic species of fishes and invertebrates, including some endangered species like delta smelt (Brown et al., 2013), Chinook salmon, spring run salmon and steelhead. Several projects for marshes restoration in the Delta are planned and the success of these projects depends on sediment availability (Brown, 2003).

3. What general conclusions can be drawn from the analysis besides comparing (calibrated) simulation with field observations?

Here we present the first real case application of the flexible mesh model DFlow-FM. The good agreement with data and reproducibility of the main events gives us confidence in the model. The mesh flexibility makes a perfect model for estuaries and complex geometry areas. DFlow-FM was developed with the possibility of a direct coupling with ecological and water quality models speeding the knowledge interchange between the two areas (physical and biological).

Sediment is a key-factor to estuaries water quality and ecology. The already calibrated model generates high quality input for the ecological models and is ready for forecast scenarios.

Brown, L., Bennett, W., Wagner, R. W., Morgan-King, T., Knowles, N., Feyrer, F., Schoellhamer, D., Stacey, M., and Dettinger, M.: Implications for Future Survival of Delta Smelt from Four Climate Change Scenarios for the Sacramento–San Joaquin Delta, California, Estuaries and Coasts, 36, 754-774, 10.1007/s12237-013-9585-4, 2013. Brown, L. R.: A Summary of the San Francisco Tidal Wetlands Restoration Series, San Francisco Estuary and Watershed Science, 1, 2003. Guo, L., van der Wegen, M., Roelvink, D., and He, Q.: Exploration of the impact of seasonal river discharge variations on long-term estuarine morphodynamic behavior, Coastal Engineering, 95, 105-116, http://dx.doi.org/10.1016/j.coastaleng.2014.10.006, 2015. Jassby, A. D., Cloern, J. E., and Cole, B. E.: Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem, Limnology and Oceanography,

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47, 698-712, 10.4319/lo.2002.47.3.0698, 2002. Kernkamp, H. W. J., Van Dam, A., Stelling, G. S., and De Goede, E. D.: Efficient scheme for the shallow water equations on unstructured grids with application to the Continental Shelf, Ocean Dynamics, 2010, 29, Kimmerer, W.: Open Water Processes of the San Francisco Estuary: From Physical Forcing to Biological Responses, San Francisco Estuary and Watershed Science, 2, 2004. Lesser, G. R., Roelvink, J. A., van Kester, J. A. T. M., and Stelling, G. S.: Development and validation of a three-dimensional morphological model, Coastal Engineering, 51, 883-915, 10.1016/j.coastaleng.2004.07.014, 2004. Roelvink, J. A.: Coastal morphodynamic evolution techniques, Coastal Engineering, 53, 277-287, 10.1016/j.coastaleng.2005.10.015, 2006. van der Wegen, M., and Roelvink, J. A.: Reproduction of estuarine bathymetry by means of a process-based model: Western Scheldt case study, the Netherlands, Geomorphology, 179, 152-167, 10.1016/j.geomorph.2012.08.007, 2012. Wright, S. A., and Schoellhamer, D. H.: Estimating sediment budgets at the interface between rivers and estuaries with application to the Sacramento-San Joaquin River Delta, Water Resources Research, 41, W09428, 10.1029/2004wr003753, 2005.

Answering the more specific comments:

P2, Line 24- P3, Line 16 What do the anthropogenic impacts mentioned here have to do with the presented results? Please clarify how this paragraph contributes to the understanding of context of the presented analysis.

The idea behind these 2 paragraphs is to put the work in a broader context, in terms of world sediment budget (P2 line 24) and the importance of numerical models to forecast scenarios because the conditions and forcing are constantly changing.

P2, Line 6: "A robust sediment model ..." Do the authors mean sediment transport? Please clarify. Also 'chain of models' as the authors describe several.

Corrected to: "A robust sediment transport model is the first step towards a chain of models...". Regarding the explanation about the chain of models, we will modify P2

Line6-7 to: "The chain of model means that each model provides input to the next model. For example the sediment transport model output is the input to contaminants, phytoplankton and habitat numerical models."

P2, Line 20: "...are subject..." should be "are subjected"

The sentence was corrected in the manuscript.

P4, Line 3-7: Please explain shortly what the "2DH process based model" physically is? I suppose it integrates height averaged Saint-Vernant type equations, together with some transport equations for sediment as mentioned three pages later. However a (short) physical explanation should be given when the modeling framework is introduced in the text. For example adding a phrase like "...solves the 2d height integrated shallow water equations coupled with advective diffusive transport ..." would help a lot to understand the physics behind the 2DH process based model.

We will include the sentence in P4, Line 3-7. "The 2DH model solves the 2D vertical integrated shallow water equations coupled with advective-diffusive transport."

P4 Line 6 "sediment budgets [..] in time (days)" seems to contradict line 8 "... yearly sediment budget ...". Please clarify.

In P4 Line 6 we were aiming to explain the several time scales, as we present in the results the yearly budget and seasonal analysis the sentence will be rephrased as: " This process-based model will be able to quantify high resolution sediment budgets and SSC, both in time ($\sim$ monthly/yearly) and space ($\sim$10s-100s of m)."

P6 Line 8: Pumping keeps salinity constant. How does this justify the height integrated modeling approach? The (possible) justification for this, (limited saltwater-freshwater interaction in the Delta) is given only 2 pages later. The authors should justify their statements at the point where these are made rather than assuming that the reader has already advanced several paragraphs in the text.

In this case we assumed that it is clearer to remove the sentence "allowing the 2-

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DH modeling approach." from P6 line 8. And modify P7 line 10 as: " We assume that the main flow dynamics in the Delta are 2D with no vertical stratification. This assumption is supported by the lack of salt-fresh water interactions in the Delta due to the pumping operations. We also assume that temperature differences do not govern flow characteristics."

P10 Line 10-15: Please explain abbreviations at first usage.

All the abbreviations in these lines are the stations names. They will be written as: " The river water flow hourly input data are from the following stations, at Sacramento River at Freeport (FPT), San Joaquin River near Vernalis (VNS) and Yolo Bypass (YOLO) were obtained from California Data Exchange Center website (cdec.water.ca.gov/) (Figure 2). The sediment input data, for both input stations FPT and VNS, and calibration stations S Mokelumne R(SMR), N Mokelumne R (NMR), Rio Vista (RVB), Mokelumne (MOK), Little Potato Slough (LPS), Middle River (MDM), Stockton (STK), Mallard Island (MAL) (Figure 2), was obtained by personal communication from USGS Sacramento; this data is part of a monitoring program (http://sfbay.wr.usgs.gov). Since 1998, USGS has continuous measuring stations for sediment concentration which is derived from optical backscatter sensors (OBS) measurements every 15 minutes, and nearly monthly calibrated with bottle samples (Wright and Schoellhamer, 2005)."

Equation 3 and 4 are confusing. The index over which the sum runs is "i" and the summation is from "i-1" to "N". I suppose it should be "i=1" under the sum.

You are right, there was a typo error. I was already corrected.

Fig. 2 The labels and the location points of the calibration stations are too small. Please increase the font size.

Figure updated.

Fig. 3: It is hardly visible that the blue line is dashed. The authors may increase the dash spacing or simply plot a blue line.

Figure updated.

Fig.4: Same problem with red dashed line as in Fig. 3. Increasing the dash spacing and plotting the dashed line on top of the solid line may also improve the visibility where both lines overlap considerably.

Figure updated.

Fig.8: The 3D flow effects mentioned in the caption are not discussed in the main text. Please update the manuscript accordingly.

I will add a line in the manuscript as follow: "Seawards from MAL, figure 8 shows preliminary sediment flux for the bay in dashed line, because we don‘t have confidence on them. The model here presented is 2DH, seawards from MAL stratification takes place in the water column due to salinity intrusion, meaning that 3D effects become important and they are not capture by a 2DH model. "

Figure A1: The figure is too small Figure updated. The manuscript will be updated accordingly. We hope to have properly addressed your comments.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 1507, 2015.