Dung Duc Tran et al. Assessing impacts of dike construction on the flood dynamics in the Mekong Delta

Responses to Reviewer#1 comments

By Dung Duc Tran

dung.ductran@wur.nl or dungtranducvn@yahoo.com

General comment: The authors used a hydrology model to evaluate the relationship between dike construction and the hydrography during the flood season in the Vietnamese Mekong Delta. In general, this study is interesting and important, considering the frequency of flood events and high-density dike constructions. However, the impact of artificial construction on flood dynamic obviously has been extensively studied in many previous literature, so I would not say this is a novel study although the numerical modeling method is rarely seen. There are several issues that needed to be addressed before the paper can be accepted in HESS. I recommend a major revision with further review by the editors and referees.

Response: We highly appreciate Reviewer#1 for the dedicated reviews and valuable comments on the manuscript. Please find below our details responses and corresponding revisions.

1. Comment P1, Ln19: I expect the authors to explain and define some technical terms/words at the first time in the paper, such as the high-dike and semi-dike. In addition, please use the consistent word throughout the paper, for example, correct the August-dike to semi-dike.

Response: We agree with Rewiewer#1 to define some key terms (i.e. high-dike, semi-dike) at the beginning of the paper. The high-dikes we considered in the study are the closed polders/compartments used mainly for protecting triple-rice production. We added short text to describe dike types in the Abstract and further elaborated on these terms in the main text.

Added text to the Abstract: "*Accelerated high dike building on the floodplains of the upper delta to allow triple cropping of rice*"

Regarding the semi-dike, we defined it in the Introduction section of the manuscript only because this dike was not considered as a factor causing flood risk downstream. However, we have replaced the "semi-dike" term with "low-dike" term. This term helps readers understand the meaning easily in reference to our use of "high-dike". In addition, the "low-dike" term is used throughout the manuscript to ensure the consistency.

2. Comment P1, Ln22-23: This sentence needs to be rephrased:...is assessed through the flood hydrographs modeling under different dike density scenarios in 2011 and 2013.

Response: We rephrased the sentence as Reviewer#1's comment in the revised manuscript.

Rephrased text: "*This paper assesses the hydraulic impacts of upstream dike construction on the flood hazard downstream in the Vietnamese Mekong Delta. We combined the existing one-dimensional (1D) Mekong Delta hydrodynamic model with a quasi-two dimensional (2D) approach. First we calibrated and validated the model using flood data from 2011 and 2013. We then applied the model to explore the downstream water dynamics under various scenarios of high dike construction in An Giang Province and the Long Xuyen Quadrangle*".

3. Comment P2 Ln2: What is a Quadrangle? I don't think it is a right word for hydrology study. Try to use the watershed name.

Response: We agree with the reviewer that using a watershed name is better in a hydrology study. But in our case, "Long Xuyen Quadrangle" term is widely used in literature (Hung et al., 2012, 2014a, 2014b, Manh et al., 2014, 2015; Mekong Delta Plan, 2013), referring to one of the two geographical floodplains in the Vietnamese Mekong Delta (the other floodplain is Plain of Reeds). In addition, Figure 1 shows the geographical extent of the Long Xuyen Quadrangle in the manuscript which helps readers know the location of this floodplain. We also described the Long Xuyen Quadrangle in the Introduction section.

4. Comment P2, Ln18-20: I don't suggest to write the future work in the abstract, since it is not part of the authors' work reported in this paper. Also, the authors mentioned that the historical monitoring data are absent, so it is actually difficult or even impossible to do the future assessments.

Response: We fully agree with Reviewer#1. These sentences are removed from the Abstract.

5. Comment P3, Ln2-8: The information of economic and food production is too detailed within this paper. Try to shorten this part.

Response: We agree to shorten this part in the revised manuscript. In particular we have merged two paragraphs about flood benefits and damages into one and remove some unnecessary details.

6. Comment P3, Ln9-17: The economic cost and loss are not related to the scientific question in this paper.

Response: We agree with the reviewer to remove the content in the revised manuscript.

7. Comment P5, Ln1-3: The authors used one point observation to demonstrate a clear correlation between the dike construction and water level. There is no clear evidence showing the cause and effect between the dike construction and water level. In addition, I don't suggest to write one data point in the introduction part.

Response: We agree with Reviewer#1 that one point observation could not be used to demonstrate a clear correlation between the dike construction and the increase in water levels. We used this example to highlight a public concern about the flood risk downstream caused by upstream dike construction. It was confused for readers when we used the "suggest there is a clear correlation" phrase in the manuscript. We rephrase this sentence as one of the evidence/example indicating flood risks downstream which would be potentially exacerbated by the large-scale high-dike constructions. This evidence is also presented in a recent study by Triet et al. (2017).

Text are changed as follows: *"At the upstream station of Tan Chau, for example, water levels in 2011 were 0.63 m lower than in 2000 (4.27 m versus 4.90 m). Yet, water levels at the downstream Can Tho station were 0.36 m higher in 2011 than in 2000 (2.15 m versus 1.79 m). This suggests a correlation between the proliferation of dike construction on the floodplains, particularly high dikes, and higher water levels and flood risk downstream".*

8. Comment P5, Ln9-24: I recommend the authors to cite the reference right after each reason of flood risk (Ln10-11), instead of explaining each reference separately in detailed. The other reasons associated with the flood risks are not strongly related to the scientific questions discussed in this paper. And, are these studies focus on the same study site (Vietnamese Mekong Delta) as well?

Response: We thank Reviewer#1 for this useful suggestion. We rewrote this paragraph to better connect references to different reasons of flood risks. We also revised the text to link the information with the objective of the paper. We also added text to inform the study site (VMD) of the referenced papers.

Revised text: *"Several studies have concluded that the flood risk in the VMD delta has increased over time. Numerous reasons have been proposed, such as climate change, sea level rise, hydropower projects, land subsidence and local rainfall. Wassmann et al. (2004) concluded based on a hydraulic model that the higher water levels in the delta were caused by sea level rise in association with climate change. Fujihara et al. (2015) investigated the impacts of upstream runoff, sea level rise and land subsidence on flood levels. They found that flood depths would be significantly increased in 19 tide-dominated areas, and that land subsidence and sea level rise would worsen inundation. Lauri et al. (2012) and Hoang et al. (2016) explored potential impacts of climate change and reservoir management scenarios on the future hydrology of the Mekong River. Numerous authors have considered the effects of climate change and sea level rise on flood propagation, inundated area and sediment transport (Apel et al., 2012; Hung, 2012b; Quang et al., 2012; Manh et al., 2014)."*

9. Comment P6 Ln22-23: I suggest the authors highlight the gap of modelling approach within this manuscript. The previous studies of modelling approaches and applications should be addressed in the introduction as well.

Response: We highlighted the important gaps of the modelling approach, namely the lack of mechanistic understanding about impacts of upstream high-dike development on downstream flood hazards, and the missing quantifications of the water balance. We added text to emphasize these two gaps in the revised manuscript.

Added text to the revised manuscript: *"Despite the rapid expansion of high dike systems for triple rice cultivation in the upper Mekong Delta, few modelling studies have as yet assessed the implications of such dikes for floodwater regimes. Additionally, most previous studies have focused on changes in peak water levels, based on monitoring data or model results. No study has as yet analyzed the distribution of floodwaters and changes therein. However, water distribution analyses are essential for understanding how floodwaters may spread under different dike construction scenarios."*

10. Comment P8 Ln4: What is a.m.s.l?

Response: We clarified the term of "a.m.s.l" as "*above mean sea level*".

11. Comment P9 Ln3-5: Again, move these explanations forward to help readers understand their meanings.

Response: We agree with Reviewer#1 to move these explanations forward to help readers understand the characteristics of low dikes and high dikes. In the revised manuscript, these explanations are moved forward in the third paragraph of Section 2 (**Study area**).

12. Comment P8 Methodology section: I think a more detailed introduction of the hydrologic model and software are necessary, including the governing equations and physics used in the model, their applications, pros and cons, etc. The authors can't just cite the references.

Response: We added a brief introduction of the hydrologic model and software. In the revised manuscript, we also present detailed introduction in the Appendix.

Added text to the revised manuscript: "*We developed a one-dimensional (1D) hydrodynamic model using the Mike 11 software developed by the Danish Hydraulic Institute (DHI). This is an implicit finite difference model for 1D unsteady flow computation. In addition, it can be applied to a quasi-two dimensional (quasi2D) flow simulation appropriate for detailed modelling of rivers, including special treatment of floodplains, road overtopping, culverts, gate openings and weirs (Doulgeris et al., 2012). The modelling procedure allows use of kinematic, diffusive or fully dynamic, vertically integrated equations for conservation of continuity and momentum (the Saint Venant equations) to solve complex flow and mass transport problems (Patro et al., 2009; Dung et al., 2011; Manh et al., 2014).*

We developed our model to represent the river network and floodplains of the Mekong Delta. Appendix 1 (A1) presents the equations and computational components."

Text added in the Appendix:

The Saint-Venant equations were formulated as follows (DHI, 2011)*:*

Continuity equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial A}{\partial t} = q$$

Momentum equation:

$$\frac{\partial Q}{\partial t} + \frac{\partial \left(\frac{\propto Q^2}{A} \right)}{\partial x} + gA\frac{\partial h}{\partial x} + \frac{gQ|Q|}{C^2 AR} = 0$$

Where

Q-discharge [m^3/s]

A-flow area [m^2]

q-the lateral inflow [m^2/s]

h-stage above datum [m]

C-Chezy resistance coefficient [m$^{1/2}$/s]

R-hydraulic or resistance radius [m]

$\propto$*-momentum distribution coefficient*

13. Comment P11 Ln5-7: How did you select these Manning coefficients? Any references? And, try to use a clearer word rather than "global" to avoid misunderstanding.

Response: We agree to explain our selection of the Manning Coefficients in the revised manuscript and will add references. Beside, "global" term is replaced with "generic" and the sentence will be clarified to explain our input for a coefficient for the whole rivers in the network.

Explained how to select the Manning Coefficients and references: "*River roughness was represented in the model as Manning coefficients, which we initially estimated based on published values corresponding to particular types of rivers and canals (Chow, 1959; Fabio et al., 2010; Dung et al., 2011)*".

The text will be rewritten as follows: "*First, referring to Chow (1959), we set the Manning coefficients as 0.020 (irrigation channel, straight, on hard-packed smooth sand), 0.025 (earth channel excavated in alluvial silt soil, with deposits of sand on the bottom and grass growth) and 0.033 (natural channel, somewhat irregular side slopes, very little variation in cross section)*"

14. Comment P14 Ln19: I'm confused about the Q-Q plots in figure 3. What does each point represent? Are they daily simulated and observed streamflow? If yes, the authors should consider the time-series plot for the streamflow results.

Response: Each point in the Q-Q plot in Figure 3 represents the correlation between daily simulated and observed streamflow, based on Correlation Coefficient (R^2) and Nash-Sutcliffe Efficiency (NSE).We agree with Reviever#1 to present some time-series plots in the manuscript instead of the Q-Q plots. Another reason is that Table 1 already shows the NSE and R^2. All the Q-Q plots are presented only in the Appendix. We also add all time-series plots to the Appendix. Figure 3 is captioned as "Time-series from simulation and actual flows observed in 2011 at representative stations".

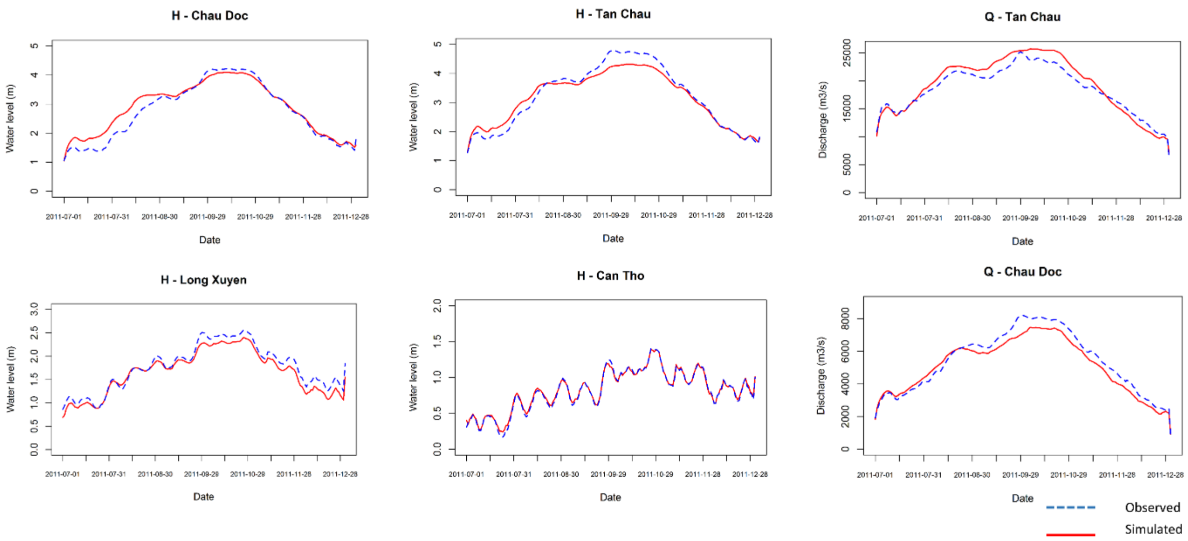

Figure 3: Time-series from simulation and actual flows observed in 2011 at representative stations

In Appendix:

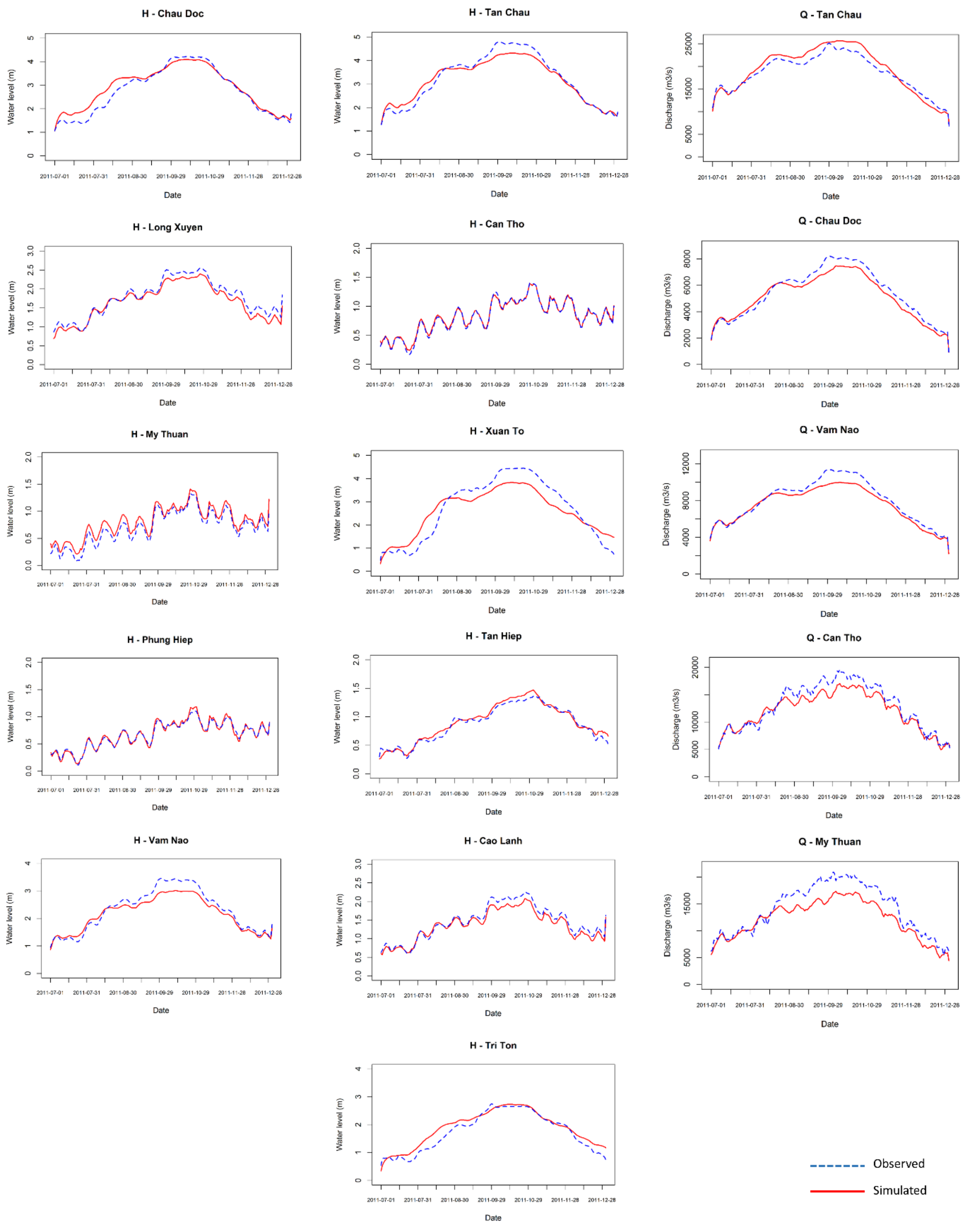

Figure A4: Time-series of daily simulated and observed flows in 2011 at all stations used for model calibration

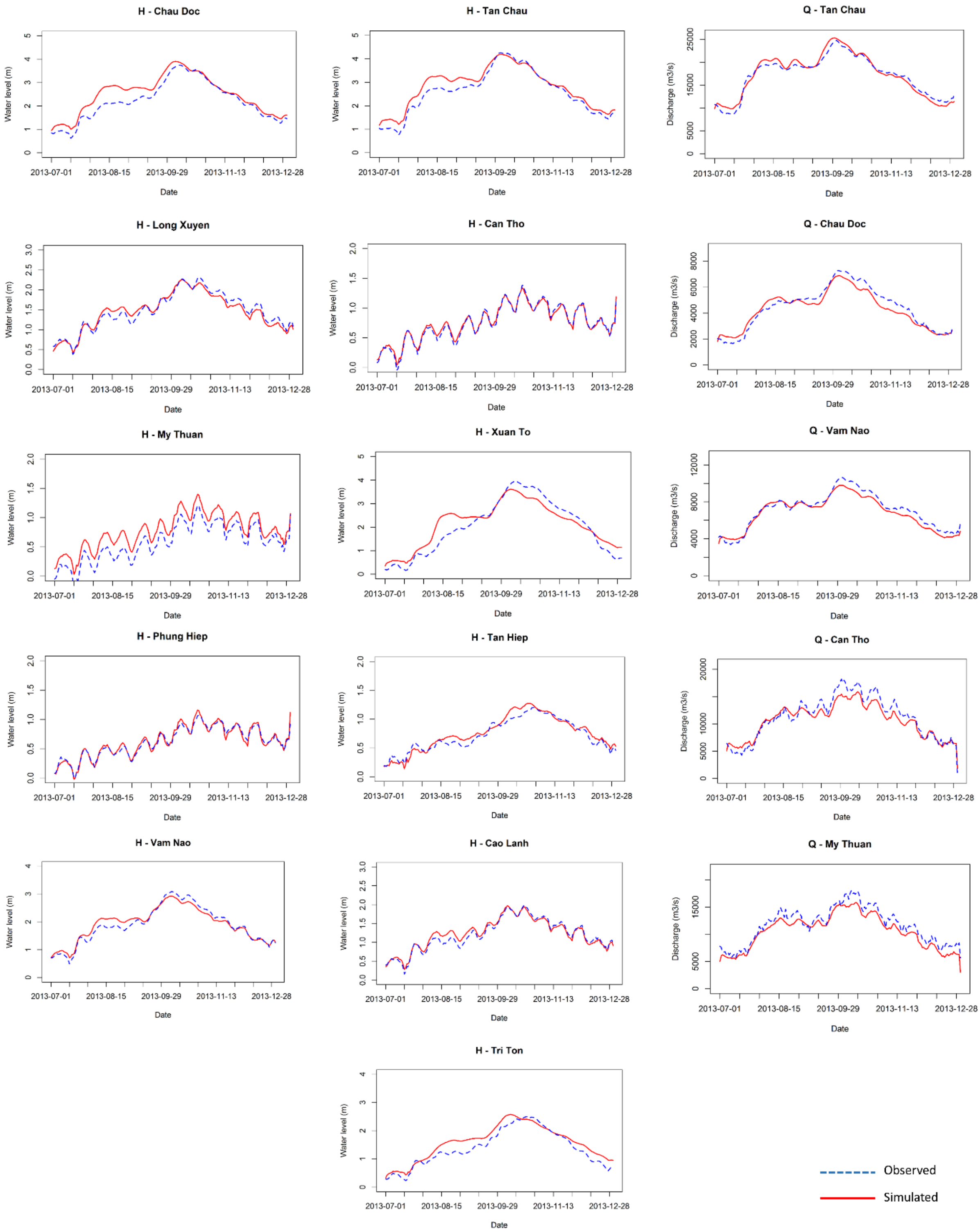

Figure A5: Time-series of daily simulated and observed flows in 2013 at all stations used for model calibration

15. Comment P15 Ln12-13: The x-axis of figure 4 should be the distance instead of the sites. I expect the explanation of underestimated simulated streamflow to be right after the figures.

Response: In the submitted manuscript, we used the 4 sites instead the distance shown in the axis because these are important points measured along the Hau River. For example, Chau Doc and Can Tho are two points we exlore the difference in measured water levels between the floods of 2000 and 2011. In addition, the x-axis of Figure 4 also shows the distance of 4 sites. We added an explanation of underestimated simulated streamflow from Figure 4 (below) in the revised manuscript.

We added an explanation to Figure 4:

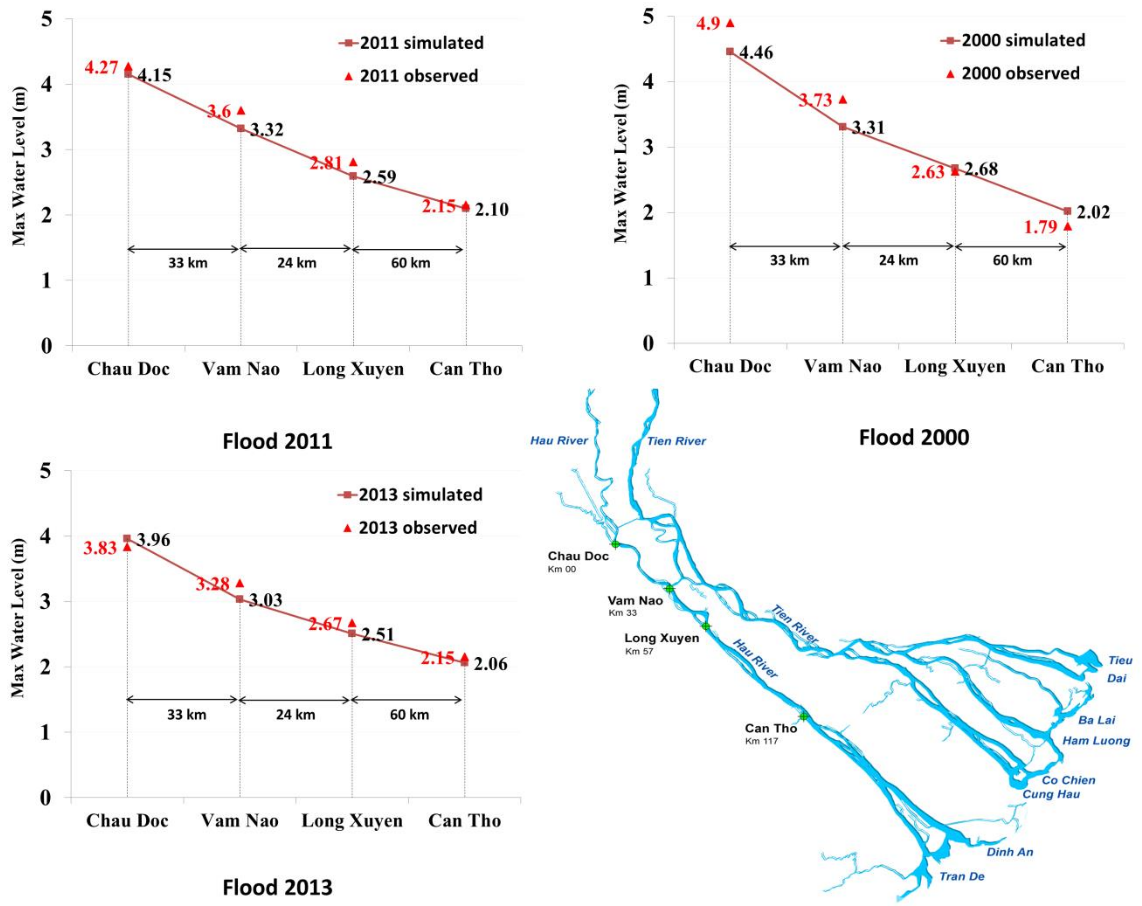

Figure 4: Simulated and observed maximum water levels for the 2000, 2011 and 2013 flood years at 4 different stations along the Hau River.

Added text right after the figure: *"Figure 4 shows a good fit between the simulated and observed peak water levels for the floods in 2011 (calibration) and 2013 (validation). In the flood 2000, the fitness is low due to the significant changes in physical topography such as river network and branches and river cross-sections between the model setup of 2011 and the measured data in 2000."*

16. Comment P15 Ln20: Should be 2011?

Response: We corrected the number to "2011".

17. Comment P17 Ln5-6, Ln 15: A general comment: The authors should use more quantitative criteria to demonstrate either the difference or similarity between different scenarios. Statistical measures are highly desired.

Response: We thank for the comment of Reviewer#1. We added some statistical calculations to the Appendix to present the difference and similarity between water levels in different dike scenarios. In addition, we explained whether there are significant differences in the water levels or not in the text of the revised manuscript.

In Appendix:

Table A1: Paired sample test for water level time series along the Hau River in 2011

Scenario and Difference	N	Mean	Peak	Peak Time	Std. Deviation	95% Confidence interval of the difference		t-value	df	p-value
						Lower	Upper			
Paired Sample Test for water level (m) time series at Chau Doc										
S1	4393	2.567	3.486	12/10/2011	0.669					
S2	4393	2.908	4.152	12/10/2011	0.882					
S3	4393	2.912	4.166	12/10/2011	0.885					
S4	4393	2.920	4.179	12/10/2011	0.890					
Pair S1-S2						-0.374	-0.308	-20.415	8188	0.000
Pair S1-S3						-0.377	-0.311	-20.569	8175	0.000
Pair S1-S4						-0.385	-0.319	-20.968	8153	0.000
Paired Sample Test for water level (m) time series at Vam Nao										
S1	4393	1.937	2.664	13/10/2011	0.521					
S2	4393	2.030	2.943	26/10/2011	0.583					
S3	4393	2.035	2.963	26/10/2011	0.588					
S4	4393	2.040	2.975	26/10/2011	0.593					
Pair S1-S2						-0.116	-0.070	-7.914	8674	0.000
Pair S1-S3						-0.122	-0.075	-8.304	8656	0.000
Pair S1-S4						-0.127	-0.081	-8.726	8640	0.000
Paired Sample Test for water level (m) time series at Long Xuyen										
S1	4393	1.654	2.431	27/10/2011	0.499					
S2	4393	1.653	2.593	27/10/2011	0.509					
S3	4393	1.658	2.614	26/10/2011	0.514					
S4	4393	1.664	2.625	26/10/2011	0.519					
Pair S1-S2						-0.020	0.022	0.083	8780	0.934
Pair S1-S3						-0.025	0.017	-0.370	8776	0.711
Pair S1-S4						-0.031	0.012	-0.862	8771	0.389
Paired Sample Test for water level (m) time series at Can Tho										
S1	4393	0.843	2.054	27/10/2011	0.480					
S2	4393	0.829	2.098	27/10/2011	0.499					
S3	4393	0.830	2.102	27/10/2011	0.499					
S4	4393	0.832	2.106	27/10/2011	0.500					
Pair S1-S2						-0.006	0.035	1.368	8771	0.172
Pair S1-S3						-0.008	0.033	1.197	8770	0.231
Pair S1-S4						-0.010	0.031	1.008	8770	0.314

18. Comment P17 Ln 20-23: The authors should provide a more detailed explanation of the “hinge response”. A modified hydrograph as forcing should be presented in the paper as well to help readers understand the “hinge response”.

Response: Based on the responses of both reviewers we have come to the conclusion that the use of the term "hinge response" is confusing. Therefore in the revised version of the paper, we do not use the term "hinge response" anymore. We also rename this section in chapter 4.

19. Comment P21 Discussion section: In general, I think the discussion section is too long and verbose. The discussion must be shortened with clearer statements for each analysis. The authors can also try to reconstruct the discussions with results section to help the readers better understand the highlighted study results.

Response: We shortened and reconstructed the Discussion section to help readers have better understanding about the significance of the study results.

20. Comment P26: Again, a reconstruction of discussion and conclusion sections is needed for this paper. I strongly recommend the authors to use bullets to clearly state the major findings of this study in the conclusion part. Tables and figures should be listed separately. Why did you list the peak water levels in Table 4 instead of plotting in the figures? Probably try to plot the peak water levels under different dike construction as well unless any other reasons.

Response: We substantially revised and tightened the structure of the discussion section and create better links to the main results. We also rewrote the Conclusion section by using bullets to state the major findings. Regarding Table 4, we would like to keep it in the revised manuscript because we want to show the detailed differences between peak floodwater levels in different points on canals of the floodplain.

References

DHI, 2011. A Modelling System for Rivers and Channels. DHI Software Licence Agreement, Danish Hydraulic Institute.

Doulgeris, C., Georgiou, P., Papadimos, D., Papamichail, D., 2012. Ecosystem approach to water resources management using the MIKE 11 modeling system in the Strymonas River and Lake Kerkini. Journal of Environmental Management 94, 132–143. doi:10.1016/j.jenvman.2011.06.023

Dung, N.V., Merz, B., BĂ¡rdossy, A., Thang, T.D., Apel, H., 2011. Multi-objective automatic calibration of hydrodynamic models utilizing inundation maps and gauge data. Hydrology and Earth System Sciences 15, 1339â€“1354. doi:10.5194/hess-15-1339-2011

Duong, V.H.T., Trinh Cong, V., Franz, N., Peter, O., Nguyen Trung, N., 2014. Land use based flood hazards analysis for the mekong delta, in: Proceedings of the 19 Th IAHR - APD Congress 2014, Hanoi , Vietnam. Presented at the IAHR, Ha Noi, Vietnam. doi:10.13140/2.1.5153.9842

Fujihara, Y., Hoshikawa, K., Fujii, H., Kotera, A., Nagano, T., Yokoyama, S., 2015. Analysis and attribution of trends in water levels in the Vietnamese Mekong Delta. Hydrological Processes n/a-n/a. doi:10.1002/hyp.10642

Hoang, L.P., Lauri, H., Kummu, M., Koponen, J., van Vliet, M.T.H., Supit, I., Leemans, R., Kabat, P., Ludwig, F., 2016. Mekong River flow and hydrological extremes under climate change. Hydrology and Earth System Sciences 20, 3027–3041. doi:10.5194/hess-20-3027-2016

Hung, N.N., Delgado, J.M., Güntner, A., Merz, B., Bárdossy, A., Apel, H., 2014a. Sedimentation in the floodplains of the Mekong Delta, Vietnam Part II: deposition and erosion. Hydrological Processes 28, 3145–3160. doi:10.1002/hyp.9855

Hung, N.N., Delgado, J.M., Güntner, A., Merz, B., Bárdossy, A., Apel, H., 2014b. Sedimentation in the floodplains of the Mekong Delta, Vietnam. Part I: suspended sediment dynamics. Hydrological Processes 28, 3132–3144. doi:10.1002/hyp.9856

Hung, N.N., Delgado, J.M., Tri, V.K., Hung, L.M., Merz, B., Bárdossy, A., Apel, H., 2012. Floodplain hydrology of the Mekong Delta, Vietnam. Hydrological Processes 26, 674–686. doi:10.1002/hyp.8183

Lauri, H., de Moel, H., Ward, P.J., Räsänen, T.A., Keskinen, M., Kummu, M., 2012. Future changes in Mekong River hydrology: impact of climate change and reservoir operation on discharge. Hydrology and Earth System Sciences 16, 4603–4619. doi:10.5194/hess-16-4603-2012

Manh, N.V., Dung, N.V., Hung, N.N., Kummu, M., Merz, B., Apel, H., 2015. Future sediment dynamics in the Mekong Delta floodplains: Impacts of hydropower development, climate change and sea level rise. Global and Planetary Change 127, 22–33. doi:10.1016/j.gloplacha.2015.01.001

Manh, N.V., Dung, N.V., Hung, N.N., Merz, B., Apel, H., 2014. Large-scale suspended sediment transport and sediment deposition in the Mekong Delta. Hydrology and Earth System Sciences 18, 3033–3053. doi:10.5194/hess-18-3033-2014

Marchand, M., Pham Quang, D., Le, T., 2014. Mekong Delta: Living with water, but for how long? Built Environment 40(2), 230–243.

Mekong Delta Plan, 2013. Kingdom of the Netherlands & The Socialist Republic of Vietnam. Report.

Patro, S., Chatterjee, C., Mohanty, S., Singh, R., Raghuwanshi, N.S., 2009. Flood inundation modeling using MIKE FLOOD and remote sensing data. J Indian Soc Remote Sens 37, 107–118. doi:10.1007/s12524-009-0002-1

Tri, V. P. D., Trung, N.H., Tuu, N.T., 2012. Flow dynamics in the Long Xuyen Quadrangle under the impacts of full-dyke systems and sea level rise. VNU Journal of Science Earth Science 28.

Tri, Van Pham Dang, Trung, N.H., Tuu, N.T., 2012. Flow dynamics in the Long Xuyen Quadrangle under the impacts of full-dyke systems and sea level rise. VNU Journal of Science Earth Science 28.

Triet, N.V.K., Dung, N.V., Fujii, H., Kummu, M., Merz, B., Apel, H., 2017. Has dyke development in the Vietnamese Mekong Delta shifted flood hazard downstream? Hydrology and Earth System Sciences 21, 3991–4010. doi:10.5194/hess-21-3991-2017

Wassmann, R., Hien, N., Hoanh, C., Tuong, T.P., 2004. Sea Level Rise Affecting the Vietnamese Mekong Delta: Water Elevation in the Flood Season and Implications for Rice Production. Climatic Change 66, 89–107. doi:10.1023/B:CLIM.0000043144.69736.b7

Dung Duc Tran et al. Assessing impacts of dike construction on the flood dynamics in the Mekong Delta

Responses to Reviewer#2 comments

By Dung Duc Tran

dung.ductran@wur.nl or dungtranducvn@yahoo.com

General comment: This paper is about assessing the impacts of dike construction on the flood dynamics in the Mekong Delta. This is an interesting topic, because the number of floods in this region is increasing. However, several aspects in this paper have to be thoroughly revised because it can be published. This is explained below. Therefore, I recommend a major revision before this paper can be published.

Response: We highly appreciate Reviewer#2 for the dedicated reviews and valuable comments on the manuscript. We addressed all your comments and substantially revised the manuscript accordingly. Our revisions are described in detail below.

1. Comment Readability: The paper is not to-the-point. This paper is about a 1D-hydrodynamic model that has been calibrated and validated for floods in 2011 and 2013. However, the introduction in Chapter 1 is very long and contains many aspects that are not relevant for this study. The same holds for Chapter 2. Also the discussion in Chapter 5 is much too long and should be made to the-point. Please rewrite Chapters 1 to 6 in a to-the-point way, so that the number of pages will reduce significantly.

Response: The manuscript was sent to a professional English editing service to revise all the text. We have shortened and rewrote all the Chapters in to-the-point way in the revised manuscript as suggested by the reviewer.

2. Comment Description of model set-up: A crucial aspect is the flooding in cross-sectional direction in this 1D model. A quasi-2D approach is applied for the flood plains. This is explained very briefly and should be explained in detail, because it has a large impact on the model results.

Response: We agree with Reviewer#2 to describe more about the methodology of quasi-2D approach in the revised manuscript. We added and revised text to explain more about the methodology and model technicalities. In addition, a figure (Figure A2) is added to the Appendix to illustrate the quasi-2D modelling method.

Added text: "*To simulate the hydraulic dynamics of the floodplains, the quasi2D approach was combined with 1D modelling. In the quasi2D model, the floodplains were described as a network of fictitious river branches and spillovers with the main rivers. This approach had several advantages: (i) transferring some of the benefits of 2D flow calculations and flow directions to the 1D hydrological model; (ii) saving computation time because less input data was needed; and (iii) reliable model representation of physical processes (Karl-Erich et al., 2008; Soumendra et al., 2010)".*

Revised text:

"We used different approaches to model the floodplains in Cambodia and in Vietnam. The Cambodian floodplains without channels and dikes were simulated by wide cross sections using the 1D method. For the LXQ, we applied the quasi2D approach to formulate the hydrodynamic interactions between the floodplains and rivers under various dike construction scenarios. Although the Plain of Reeds itself was not a focus of this research, we included it in the model with the dikes as constructed in 2011, to better understand the hydraulic interactions between the Tien and Hau rivers via the Vam Nao River and tributaries. The LXQ floodplains are characterized by a dense network of dikes and channels, producing multitudes of compartmentalized fields for agriculture. Each compartment was considered a flood cell and modelled as a fictitious river branch with a low and wide cross section, as extracted from a digital elevation model (DEM, 90 m x 90 m resolution). The control structures linked these fictitious river branches to real channels. Weirs represented dikes and overflows. Dike height was adjusted by changing the sill level of the control structures. This approach, from Dung et al. (2011), is illustrated in Figure A2 in the Appendix."

Figure A2 in the Appendix:

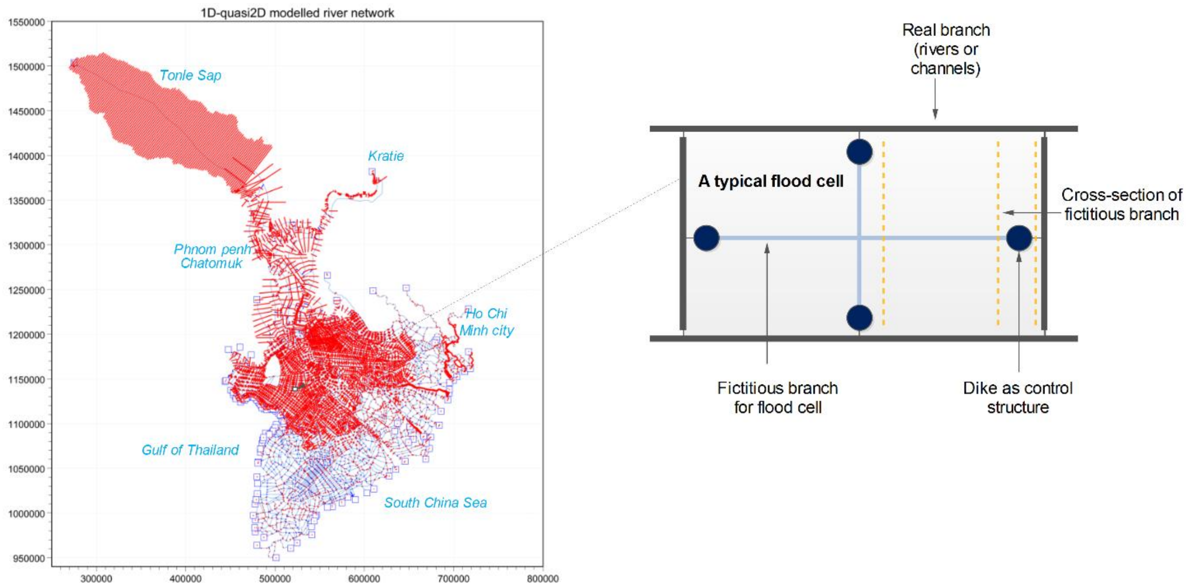

Figure A2: The left figure describes the 1D-quasi2D modelled river network of the VMD and the right figure show a representative typical floodplain compartment. The approach is from Dung et al. (2011).

3. Comment Lack of validation data: In the abstract and in the conclusions is stated that there is a lack of validation data. However, in Section 3.2 is stated that hourly discharge and water levels are available at 15 locations, of which four locations are even in floodplains. This is a nice validation set. So, there seems to be no lack of validation data.

Response: We agree with Reviewer#2 about this point. We did not mean there is a lack of data for simulation and calibration for different locations on the main rivers, but we expected having more data in the floodplain of Cambodia and the downstream part of VMD floodplain. This would have helped us to validate the model performance in these areas as well as to improve accuracy in water balance calculations.

4. Comment Presentation of model results: One expects figures with time series of water levels and discharges that contain both numerical results and measurements. However, such plots are missing. Therefore, a reader does not have any insight whether the time behavior of the floods is simulated accurately. Instead, correlation numbers and maximum high water are presented in the figures. However, this is of secondary importance. The authors are strongly advised to add several time history figures with computed and measured results.

Response: We added time-series of computed and measured water and discharges for several representative stations (Figure 3) in the revised manuscript. Besides, the Q-Q plots and time-series plots of all stations are presented in the Appendix.

Added Figure:

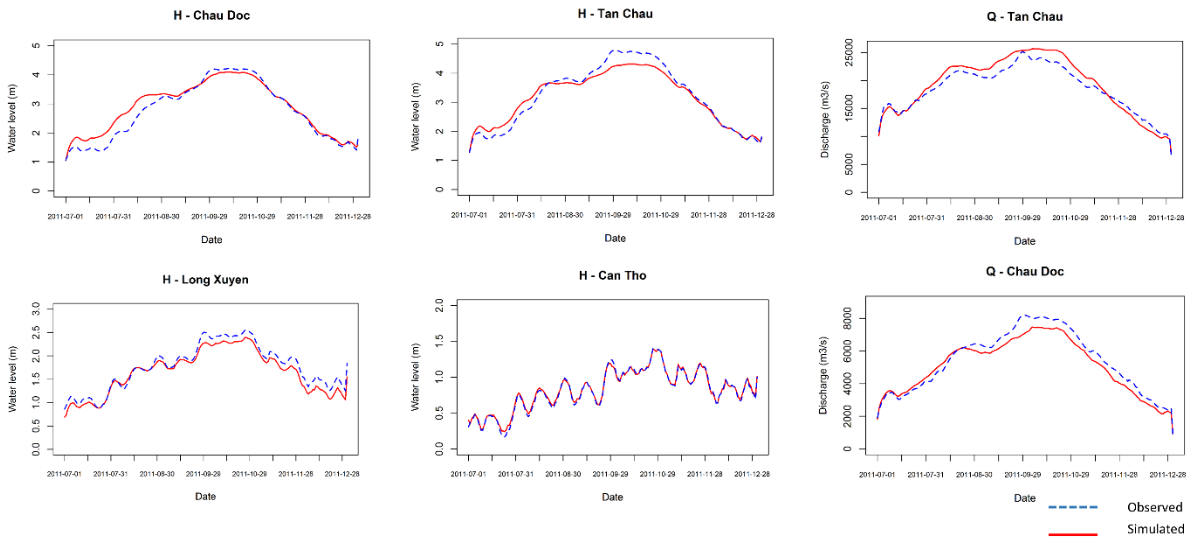

Figure 3: Time series from simulation and actual flows observed in 2011 at representative stations.

In Appendix:

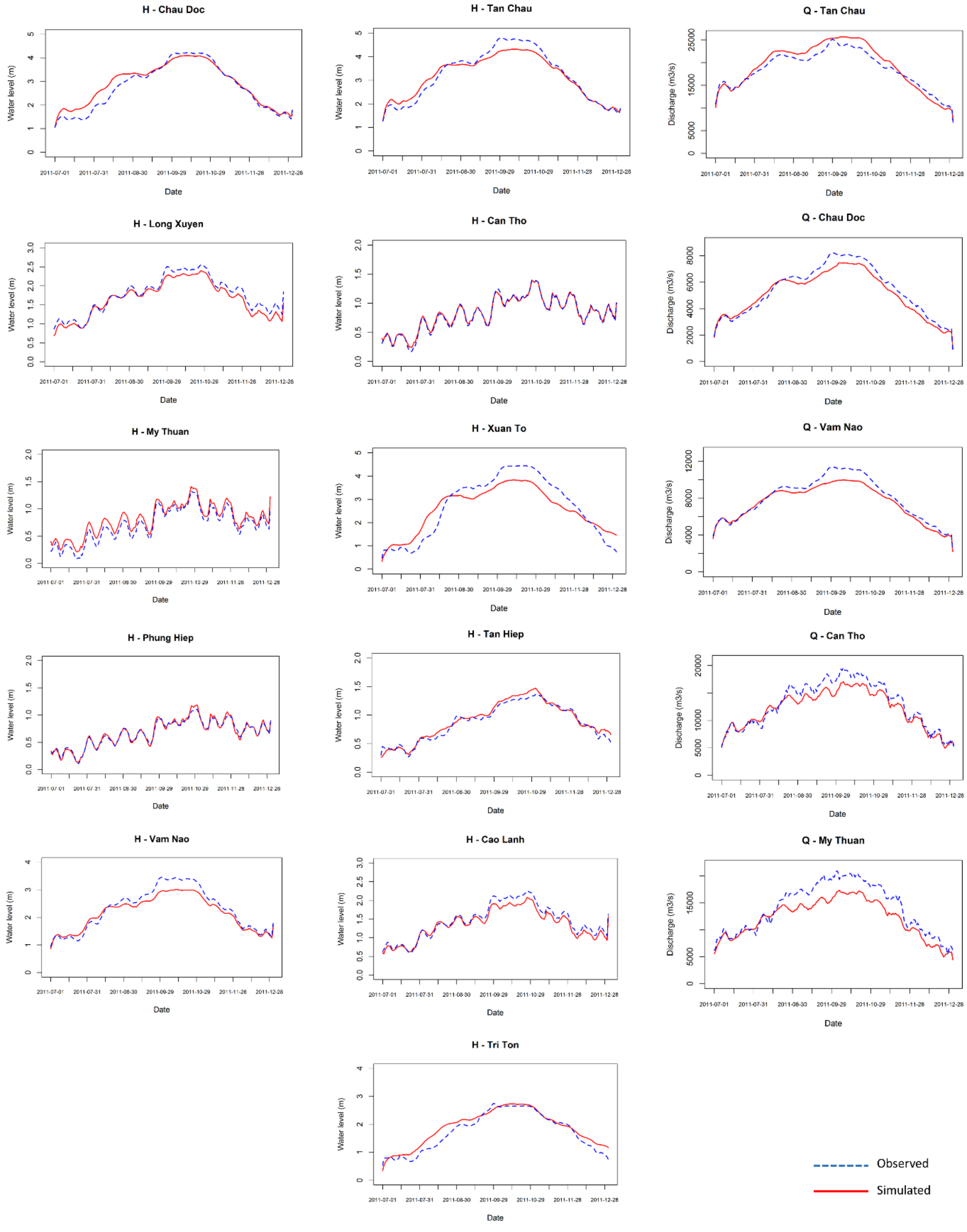

Figure A4: Time-series of daily simulated and observed flows in 2011 at all stations used for model calibration

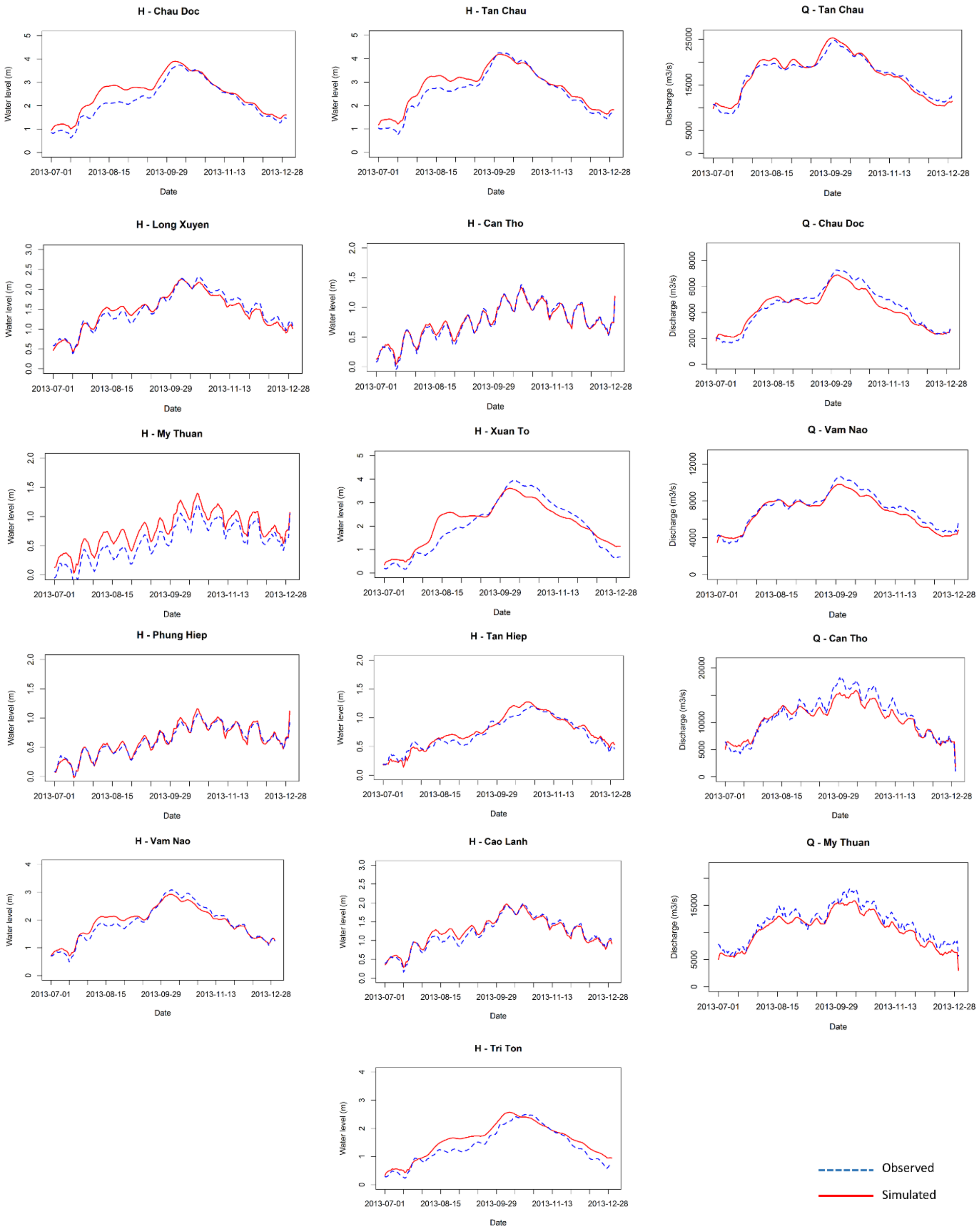

Figure A5: Time-series of daily simulated and observed flows in 2013 at all stations used for model calibration

5. Comment Description of dykes: Please clarify the differences between the dyke types (semi-dyke, August dike, high dyke) that are mentioned in this paper.

Response: In the revised version of the manuscript, we clarified differences between the semi-dike and high-dike in the Section 2 (last paragraph). The differences between these two dike types were also described in the original manuscript, however in the revision we move the explanation forward (third paragraph in the Section 2) in the revised version to help readers understand these types of dike. In addition, we change “semi-dike” into “low-dike” to help reader understand the term. We also use the term throughout the manuscript, instead of using “August dike” at some points in the text.

6. Comment Hinge response: What is a hinge response? Please clarify.

Response: With the Hinge response we want to explain the differences of model results in water level variability between upstream and downstream locations. Water level fluctuations are much higher upstream compared to downstream locations. However, we realize based on the reviews that the use of the term “hinge response” is confusing; therefore, in the revised version of the paper we do not use the term “hinge response” anymore. We also renamed this term in Section 4.

7. Comment What is new in this paper? In the discussion (P. 21) is stated that the results are consistent with earlier studies with 1D hydrodynamic models. What is new in this paper? Please add the references of the other studies.

Response:

We thank reviewer#2 for his/her suggestions on strengthening the paper’s innovation and contribution to current knowledge body. Our study’s main innovation and contributions are in assessing changes in floodwater regimes and flow volumes under multiple dike construction scenarios and in adding the water balance component to our modelling analyses. While many previous studies focused on assessing impacts of historic dike developments (Duong et al., 2014; Hoa et al., 2007; Tri et al., 2012), we present one of the first study assessing possible impacts of future dike developments in the Mekong Delta. In addition, our water balance analyses help to better understand the mechanisms of changing flood dynamics due to dike construction. To the best of our knowledge, there are no previous studies reporting results on water balance analyses. Although we agree that our main results are consistent with previous studies, we think that our findings for future dikes development impacts and water balance calculation represent important new contributions. We have rewritten and reconstructed the result and discussion sections to better highlight these aspects in the revised manuscript.

8. Comment Validation for 2000 flood. Suddenly in the paper the authors start with a validation of the 2000 flood. The results are not very accurate because the geometry of the Mekong Delta was somewhat different in 2000. What is the purpose of this validation? Should this be left out?

Response: We agree with Reviewer#2 on differences between the Mekong Delta geometry in different time periods, however we would like to clarify that we do not intend to use the 2000 flood for model validation. We calibrated the model with the 2011 flood and the 2013 flood was used for model validation. We used the flood of 2000 to understand how the model behaves using the historical extreme flood hydrograph in this year. This was done for two main reasons. First, the 2000 flood is one of the major floods happened in the year when very few high-dikes for triple rice production existed in the floodplains. We therefore assumed S1 (the baseline scenario without any high-dike compartment), as similar to as the physical conditions in 2000, to compare the dike impacts with other large-scale dike construction scenarios (S2, S3, and S4). Second, we aim to explore how the model handles the correlation between upstream and downstream water levels (Tan Chau and Can Tho) in the 2000 and 2011 when the boundary conditions of the 2000 flood were put into the model with existing conditions in 2011. Due to abovementioned reasons, we would like to include the 2000 flood for the comparisons in the manuscript.

9. Comment Accuracy of model results. In the discussion (P. 25) is stated that the model results are in line with other studies with 1D model, but that that 2D (and possible) 3D modeling is required for an in-depth understanding of the flood behavior in the Mekong Delta. In other words, do the authors conclude that 1D modeling with a quasi-2D approach for flooding is not suitable for this?

Response: It is clear that our model with 1D-quasi2D approach could simulate peak water levels in the dike scenarios of the floodplains, based on good model fitness of calibration and validation results. However, the quasi-2D was just applied to simulate the floodwater interactions mainly for the floodplains of Plain of Reeds and Long Xuyen Quadrangle instead of the context of whole Mekong Delta. We think that the model results could become more accurate if 2D or 3D models will be used for solving complex interactions in the floodplains with the whole river system. Although we acknowledge the potential added values of such 2D and 3D approach, at the moment it is very difficult to pursue such modelling exercise for the whole Mekong Delta due to limited data availability and high computational demands.

Reference

Dung, N.V., Merz, B., BĂ¡rdossy, A., Thang, T.D., Apel, H., 2011. Multi-objective automatic calibration of hydrodynamic models utilizing inundation maps and gauge data. Hydrology and Earth System Sciences 15, 1339â€“1354. doi:10.5194/hess-15-1339-2011

Duong, V.H.T., Trinh Cong, V., Franz, N., Peter, O., Nguyen Trung, N., 2014. Land use based flood hazards analysis for the mekong delta, in: Proceedings of the 19 Th IAHR - APD Congress 2014, Hanoi , Vietnam. Presented at the IAHR, Ha Noi, Vietnam. doi:10.13140/2.1.5153.9842

Hoa, L.T.V., Nguyen, H.N., Wolanski, E., Tran, T.C., Haruyama, S., 2007. The combined impact on the flooding in Vietnam's Mekong River delta of local man-made structures, sea level rise, and dams upstream in the river catchment. Estuarine, Coastal and Shelf Science 71, 110–116. doi:10.1016/j.ecss.2006.08.021

Karl-Erich, L., Huang, S., Baborowski, M., 2008. A quasi-2D flood modeling approach to simulate substance transport in polder systems for environment flood risk assessment. Science of The Total Environment 397, 86–102. doi:http://dx.doi.org/10.1016/j.scitotenv.2008.02.045

Soumendra, N.K., Dhrubajyoti, S., Paul, D.B., 2010. Coupled 1D-Quasi-2D Flood Inundation Model with Unstructured Grids. Journal of Hydraulic Engineering 136, 493–506. doi:10.1061/(ASCE)HY.1943-7900.0000211

Tri, V.P.D., Trung, N.H., Tuu, N.T., 2012. Flow dynamics in the Long Xuyen Quadrangle under the impacts of full-dyke systems and sea level rise. VNU Journal of Science Earth Science 28.