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Drinking Water Engineering and Science Discussions

Interactive comment on "The large-scale impact of climate change to Mississippi flood hazard in New Orleans" *by* T. L. A. Driessen and M. van Ledden

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- No relation to drinking water engineering ***Authors: The authors have been asked to publish in special issue of DWES regarding the Young Scientist Workshop which was an integrated part of International Water Week 2011.

- The authors suggest a strong link between the existing flood risk in New Orleans and the Mississipi River (MssR). Such a link exists of course (and is underestimated by the New Orleans public) but flood risk coming from Lake Pontchartrain is considerably higher; hurricanes have limited effects on the MssR discharges. Damage sensitivity of the urban and industrial areas of New Orleans is very high - self-evident - and Katrina unfortunately proved that. ***Authors: The Authors acknowledge the high flood risk of the area originating from storm surges. The Lower Mississippi Delta is an area where

several hydraulic aspects come together (high sea level rise, high discharge regimes and storm surges). Since Katrina the focus has largely been on storm surges, while the authors believe that the flood hazard of a combination of high discharges and a high relative sea level rise rate becomes more significant in the future.

- Land subsidence in New Orleans is particularly concentrated in the Northern part of the town and has limited influence on flood damage sensitivity (vulnerability) functions in case of fluvial flooding. The article gives the impression that relative sea level rise (SLR) has a strong impact on the damage sensitivity of the town. ***Authors: Land subsidence varies throughout the area, but is relatively strong in the entire delta region. The river may 'follow' the subsidence of the ground level by erosion of the river bed and is therefore not the main driver for the flood hazard. However, subsidence means a higher relative sea level which is additional to the regional sea level. The relative (subsidence) and absolute (regional/global rise) rise in sea level means increased water levels, while ground levels decrease. Hence, increase in relative SLR increases the flood hazard.

- Although mentioned at the very end, sediment transport regime will be influenced by changes in the MssR flow regime and SLR. River morphological changes are neglected in the scenarios. ***Authors: This is correct. This is one of the assumptions in this study.

- P 334 Abstract L 12: Improved model: what is improved? What is the old one? ***Authors: This refers to the HEC-RAS schematisation which is described in the main text. Since the use of the word "improved" may be confusing it will be deleted in the abstract.

- L 13: Remove "Subsequently" ***Authors: The authors take the comment into account and will revise the text accordingly

- L 15: remover "very"; replace "necessity" with "influence" ***Authors: The authors take the comment into account and will revise the text accordingly

- L 19: "of these scenarios" on what? ***Authors: The authors propose to change the text as follows:"The impact of these scenarios on the water levels near New Orleans is analysed..."

- L 20: high flows will not be affected: But how about the frequency of extremes? ***Authors: The increased frequency of extremes will increase. No text adjustments are proposed, since the increased frequency is also shown in the part on L23-24 "Climate change impacts necessitate a more frequent use of the spillways..."

- L 21: "presence of the spillways ensures a constant discharge"(1) Is there any risk that these spillways won't function? (2) is the MssR discharge really constant under these conditions? No information is provided on the operating regime and functioning of these spillways. Pls add more info. ***Authors: (1) There is always a risk that the spillways malfunction. However, the Bonnet Carre Spillway consists of 350 bays that includes wooden beams. Malfunction of a bay would not signficantly endanger the entire functioning of the inlet structure. (2) The Mississippi River discharge at New Orleans is regulated to be maximum 1,25 million cfs. This is done by changing the number of open bays in the inlet structure of the spillway according to the surplus of discharge. In Figure 4 of the paper the near constant water level at Carrolton supports this strategy The authors propose to include the following text in the main text (not in the abstract) at L20 (page 336): "The Bonnet Carre Spillway is closest to New Orleans and consists of 350 bays that includes wooden beams. Its inlet structure is opened when the upstream discharge at Tarbet Landing exceeds 35,396 m3/s. The spillway is capable of discharging almost 7,080 m3/s. The Morganza Spillway is opened when the upstream discharge at Red River landing exceeds 42,475 m3/s and consists of 125 gates which are able to divert a maximum flow of almost 17.000 m3/s. The Morganza Spillway diverts water to..."

- L 24: "more frequent use of the spillways". (1) This is not evidenced in the article. (2) Does failure risk increase due to more frequent use and (3) how about the damage due to opening the spillways; isn't this damage relevant for the opening strategy? ***Au-

thors: (1) L14-15 on P341 states show the result that upstream discharge changes would affect the frequency and duration for 15 opening of the spillways. This is a direct result. (2) the failure risk of the inlet structure of the spillway is considered out of the scope of this study and is rather a question of structural engineering (3) The ecological damage (Bonnet Carre Spillway) and societal impact (Morganza Spillway) is considerable and is watched after, but in the end play no rule in the opening strategy. The opening criteria are legal values and operational prescribed.

- L 24: opening strategies based on stages: Isn't that the case now? ***Authors: No, the official opening criterium is based on Red River Landing discharge which becomes inefficient when sea level rise occurs.

- P 335 L 1-13 can be shortened. ***Authors: The comment will be considered during revision

- L 2: remove "in all its greatness";41 % including Alaska and Hawai? ***Authors: The authors take the comment into account and will revise the text accordingly

- L 9-13: Not related to MssR flood hazard. See general remarks ***Authors: The authors take the comment into account and will revise the text accordingly

- L 21-25: See general remarks; rather mention river bed level changes due to morphological changes here. ***Authors: The authors take the comment into account and will include this aspect into the text

- P 336 L1-4: Role of the spillways in the sediment management of the MssR and Mss delta? And role of the spillways in the salinization of the coastal wetlands? ***Authors: The impact of spillways on sediment transport and salinity of the coastal wetlands is not part of the scope of this study.

- L 5-7: Sediment starvation due to the levees are indeed a reason for coastal mashland deterioration and erosion. But what is the role of the spillways in sediment starvation? ***Authors: The spillways likely play a rol in sediment starvation since they act as a bar-

rier to transport sediments into the marshes. The sediment concentrations are highest near the river bed whereas the spillways extract the water near the water surface..

- L 10: Process enhanced by strong subsidence. How? I can see no relation. ***Authors: Strong subsidence means more intrusion of salty sea water which deteriorates the fresh and brackish marsh lands

- L 22-23: This question seems to be the key question of the article. Pls highlight this. ***Authors: The authors take the comment into account and will highlight the point made.

- L 25: climate change and SLR. ***Authors: The authors take the comment into account and will revise the text accordingly

- L 28: Some Potential solutions for Gr NO are indeed mentioned at the end of this paper, but without any logic or evidence. Pls. focus the paper on the impact assessment and skip that brief list of first thoughts. ***Authors: The authors take the comment into account and will reduce the section where possible solutions are proposed.

- P 337 L 14: replace "will hardly receive" with "receives" ***Authors: The authors take the comment into account and will revise the text accordingly

- L 14-15: how about losses or inflow via groundwater? These could be substantial and a reason for the problems with modeling the time shift of the peak discharge. ***Authors: With a peak discharge of more than 45,000 m3/s the lateral outflow to the groundwater is assumed to be not significant. The time shift of the peak discharge can largely be explained by incorrectly simulated flow velocities and morphological processes.

- L 17 and P 340 L 11-12: How about the impact of climate change on the upstream boundary condition. The way it is dealt with in the scenarios looks like we don't know what to expect. I would assume that studies of the impact of climate change on the MssR flow regime will be available somewhere. ***Authors: There is very limited info

available how the effect of climate change affects the Lower Mississippi area (influenced by the entire catchment). Only general effects are described in USGCRP (2000). The authors propose the following text at P340 L10:"A study from USGCRP (2000) describes the general effects of climate change to the American catchments. These effects are used to simulate potential changes in river discharges. Hence, four projections..."

- L 24: How about the influence of storm surges? As negligible as tidal influences? ***Authors: No, because surges can be much higher. The authors propose to include the following text:"Storm surges on the other hand can have a considerable effect. However, the study focuses on peak flows of the Mississippi River, which occur mostly during the first six months of the year. Storm surges are related to hurricanes that mostly occur from June to November. Hence, the effect of storm surges is not within the scope of this study.".

- P 338 L 1-3: remove first sentence ***Authors: The authors take the comment into account and will revise the text accordingly

- L 7-9: grammar of this sentence? Remover "earlier mentioned". ***Authors: The authors take the comment into account and will revise the text accordingly

- L7-9: How are the spillways calibrated? Is their stage discharge relation very well known? Isn't there any backwater effect from the floodplain behind the spillway of the discharge curve? ***Authors: The spillways are not calibrated and explicitly schematised, but a lateral outflow is introduced when the local discharge exceeds the spillway criterion. Following text is proposed at L9: "The discharge into the spillway is schematised as a lateral outflow that is the surplus of discharge relative to the discharge criterion of the spillway."

- L 3-20: What is the data set used for calibration? ***Authors: discharge and water level time series from the flood season in 1997 as mentioned in L7 to L9

- L 18: Is six segments out of 164 sufficient for calibrating the whole stretch? ***Authors: Yes, because the water level varies gradually over the stretch.

- P339 L 15: Use of the spillways goes not without substantial damage. Is it acceptable to use them more frequently? ***Authors: There will always be damage due to the spillways. The displacement of 25,000 people in 2011 was deemd necessary in order to protect over 400,000 people living in New Orleans. This paper focuses on the hydraulic consequences and does not elaborate on the ethical aspects of the pros and cons of these flood control measures.

- L 21-22: Velocities are underestimated: friction coefficient too high or overcompensation for losses to groundwater? ***Authors: Velocities are underestimated, since locally the cross-sectional area is smaller than schematised

- P340 L 9: How realistic is it to assume SLR of 0.7 or 1.0 m without substantial morphological changes in the MssR mouth and delta? ***Authors: These numbers are derived from an official USACE directive as mentioned in the text. Morphological changes of the river bed are not considered in this directive.

- L 6-19: Need to stress that this is all under the assumption of an unchanged river bed. ***Authors: The authors take the comment into account and will revise the text accordingly

- P431 L 4: why "minimum"? ***Authors: P340 L25 and P341 L1-2 indicate that during high flow conditions the minimum stage differences are occurring, since then the water levels are dominated by the discharge instead of the downstream boundary (SLR). In terms of flood hazard the increase during high flow conditions are of interest.

- L 6-8 delete sentence, as we should focus on high flow conditions ***Authors: The objective of this study is to address the future changes in the Mississippi stages in the context of climate change and their impact on flood hazard in New Orleans. The impact of SLR during low flow conditions do not contribute to the flood hazard aspect,

but certainly to the expected future changes of the adaptation length of the Mississippi River water levels.

- L 9: "stages along the entire modelled reach are affected by SLR" would mean that the upper boundary condition of the model is influences too. Is that true? ***Authors: Yes, this is mainly the case during low stages when the SLR protrudes further upstream (see Figure 5). However, for high stages this is hardly the case. It shows that the adaptation length in the Mississippi River is very large. This is due to the very mild slope and the large depth of the river.

- L22-23: "due to the confined levees" this refers to the stretch downstream of Baton Rouge only? ***Authors: Yes. the text will be changed to "..due to the confined levees downstream of Baton Rouge"

- L 23 P 342 L 6: Pls remove these open-ended suggestions for solutions or, even better, elaborate and underpin the solution mentioned in line 24-25 ("a number of spillways or small-scale river diversions") with model calculations. ***Authors: The authors take the comment into account and will revise the text accordingly

- P 432 L 8-21 Pls quantify your conclusions ***Authors: The authors take the comment into account and will revise the text accordingly

- L 22-end: Pls remove these open-ended, unfounded suggestions; no conclusions from your study. ***Authors: The authors take the comment into account and will revise the text accordingly

- P 345 Fig 1 Pls show the alternative flowpath of the water downstream of the two spillways. Could be in an indicative way. ***Authors: The authors consider the comment during revision

- P 349 Fig 5: Colors in legend do not match the colors in the graph. ***Authors: The authors take the comment into account and will update the figure accordingly