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Interactive comment on "Using the Storm Water Management Model to predict urban headwater stream hydrological response to climate and land cover change" *by* J. Y. Wu et al.

J. Y. Wu et al.

jrrt@iastate.edu

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jrrt@iastate.edu

General Comments

1. Better understanding the combined impacts on hydrologic response of land use

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changes and climate change is important. A National Research Council 2012 report, Challenges and Opportunities in the Hydrologic Sciences, argues that, “hydrologic science is now challenged to understand, quantify, and delineate the contribution of human land use change to flooding in comparison to those changes driven solely by anthropogenic changes in greenhouse gases." I believe this research could contribute to our understanding of the impact of land use changes versus climate change on hydrologic response, but these contributions are not clearly articulated. In the introduction, (p. 7095 lines 26-29), the authors write “To date, however, relatively few studies have been conducted in Midwest USA to quantify responses of multiple urban streams to potential changes in both climate and land cover using a hydrological model specifically designed for use in urban environments (e.g. SWMM) and to examine a suite of variables to describe stream responses.” But how will examining the combined impacts of land use and climate changes in the Midwest further our understanding of these impacts on hydrologic response? Why might hydrologic response be different in these watersheds than in the studies that are cited? A better review of the literature examining combined impacts of land use and climate changes on hydrologic response is warranted. What are the outstanding questions this study will address?

We thank Anonymous Referee #2 for these comment and suggestions. New text (as indicated in Wu et al., 2013 Interactive comment) with further review of the literature (p. 7095, beginning at l. 12) will be added in the paragraph preceding the passage cited above. In addition, we will replace text currently on p. 7095, l. 26-29 with the following: “Thus, there is considerable variation in predicted outcomes for climate change, land cover change, and their potential impacts on streams (Praskievicz and Chang, 2009). Previous research in the Midwest, however, consistently indicates a strong likelihood of increased storm intensity and total precipitation delivery in this region (Jha et al., 2004; Takle et al., 2010). Further, it has been suggested that small basins may experience greater impacts than larger ones (Praskevicz and Chang, 2009). The potential impacts of these changes on small streams in urban areas require additional investigation in order to better elucidate their separate and combined effects and to identify appropriate mitigation strategies. In the research described in this paper,. . ..”

2. The conclusions of the study are drawn on the results of modeling analyses alone. But if the goal of the study is to examine the impacts on hydrologic response of increasing imperviousness and increasing precipitation, why not also examine field observations of rainfall and runoff? The authors state that they’ve collected 16 months of data that could provide a catalog of real storms to examine. For these storms, what is the relationship between the runoff ratio, peak discharge, and RB-Index and watershed imperviousness? For a single watershed, how do these indices vary with increasing storm size? Perhaps through analysis of field data, hypotheses could be developed that could then be tested using the SWMM model.

Of the storm events that occurred during the period of study, we selected those with relatively simple hydrographs and comparable delivery periods to develop the models, and used them for calibration and validation. Other events we measured differed, for example, because they were of either shorter or longer duration, or had multiple hydrograph peaks related to variation (within a storm) in precipitation rates. Variation in field event characteristics made comparison of the hydrologic indices less reliable. In response to this comment we did generate values for our hydrologic indices for the validation model we developed for WS1 and WS4 (an event with an increase in storm size relative to others presented), to examine relationships with event size. Our original analysis of responses to imperviousness among the watersheds along the gradient our sites represent describes the relationship to IS (e.g. p. 7106, l. 4-8, and current condition information in the first three rows of Table 4). We will add text to the results and discussion sections to describe the additional analyses for storm event size as per the following:

Results (text to be added on p. 7103, l.23): A separate analysis (data not shown) of responses for the three indices in WS1 and WS 4 to the storm event in the validation model (21.3 – 23.1 mm precipitation) indicated consistent trajectories of change for all three indices at both levels of initial IS beyond that tested in the climate change scenario (e.g. the precipitation gradient from 16.8 mm [current condition] to 19.8 mm [climate change scenario] to 23.1 mm for the validation scenario).

Discussion (text to be added at p. 7107, l. 11): “We should note, though, that our ability to test responses by the three indices to a greater number of field observations of storm events was limited by the relatively brief (two-year) duration of our study, as well as variability in the characteristics of the events that occurred in that time frame (e.g. differences in duration of storm events, or multiple hydrograph peaks related to variation in precipitation rates within storm events). A longer period of study with more observations of a greater number of storm events would add to our understanding of how response variables are related to precipitation and impervious surface amounts. Notwithstanding these limitations, for already developed watersheds. . ..”

3. The relationships between imperviousness and runoff volumes and imperviousness and peak discharge are (theoretically) linear. As are the relationships between rainfall depth and runoff volume and rainfall depth and peak discharge. So we would expect that as imperviousness increases, so do runoff volumes and peaks and that as rainfall depths increase, so do runoff volumes and peaks. Thus the modeling results are not providing any new information about the impacts of increasing rainfall and increasing imperviousness. However, in reality, urbanization is much more complex and response is not necessarily linearly dependent on rainfall. Elements of the urban landscape such as stormwater pipes, stormwater management structures, as well as impervious surfaces combine with rainfall to produce hydrologic response that can be unexpected. A model like SWMM can be used to examine some of these complexities of the urban landscape to help us better understand and provide new information about hydrologic response in urban watersheds.

We will add text to address this in the discussion section. First, to address the relationship of these indices to % IS (p. 7106, l. 8): “..However, although runoff ratio responds fairly linearly to increases in impervious surface, R-B index and unit-area peak discharge do not, with disproportionately large responses between 5% and 10%

IS, and again between 28% and 37% IS"; and to address the relationship to precipitation amount (p. 7107, l. 11): "However, examination of response indices for WS1 and WS4 for an extended precipitation gradient (to 23.1 mm) indicates that unit-area peak discharge may not respond linearly to increasing precipitation, possibly owing to differences in storm sewer density and structure. In any case, for already developed. . ."

Specific Comments: 1. p. 7092 lines 25-28. This sentence is misleading. It makes it seem like the increases in all 3 indices for the combined scenario were significantly larger than the increases in indices for the land use scenario. But the increases in the R-B Index and runoff ratio are not significantly different between these two scenarios.

We will re-write this sentence to read: "The combined climate and land cover change scenario resulted in slight increases on average for R-B index (43.7%) and runoff ratio (74.5%) compared to the land cover change scenario, and a substantial increase, on average, in unit area peak discharge (80.1%)."

2. p. 7099 lines 23-24 Why was this event chosen for climate change modeling scenarios. Is it a typical event? Was this also the event chosen for the land use scenario? I assume so but this is not explicitly stated in Section 2.5.

We provided additional information and new text about selection of this event in response to Anonymous Referee #1 (Wu et al., 2013, Interactive comment). We will further clarify (p. 7100, l. 10) that this applied to the land use scenario as well, by adding this text at the end of the first sentence of section 2.5: ". . .land cover condition, again using the 10 June 2011 rainfall event."

3. Fig. 4 and Table 4 There appears to be a significant difference in the total runoff produced in each modeling scenario. Even though the runoff ratio does not significantly increase with the increases in precipitation, the runoff volume clearly does. It could be useful to also include percent changes to runoff volume.

We used runoff ratio as a response metric because it is closely related to the underlying characteristics of each watershed, independent of precipitation amount. For a single precipitation-runoff cycle, changes in runoff volume are proportional to changes in runoff ratio and the amount of precipitation input to the watershed. Further, unit area peak discharge indicates how runoff volume is changed due to the combined effects of climate and land use. As illustrated in Figure 4, the shape of the hydrograph was very consistent between the scenarios and only the magnitude was affected. We will add the following text to the discussion (p. 7108, l. 13): "Further, hydrographs for WS 4 (Figure 4) indicate that runoff volume increases for each predictive scenario, most significantly for to the combined effects of climate and land cover change."

4. Fig. 1 This figure is very difficult to interpret. The cross-hatching fill used for the watersheds makes it so one cannot see the distribution of impervious surfaces within the watershed. At the scale and coloring used, it is also difficult to distinguish an impervious surface from a stream channel.

We revised this figure as per comments from Anonymous Reviewer #1, it is attached in supplemental material for the manuscript as per Wu et al., 2013, Interactive comment.

5. Fig. 5 and Table 5 and Conclusion 3. To me, it doesn't appear that the location of the impervious surfaces within the watershed makes much of a difference. For the % differences in Table 5, it would be more useful to show the % difference compared to the uniform scenario.

The uniform scenario assumes an 18% increase in IS across the entire watershed, the locational distribution scenario actually adds less total IS because it is 18% added to only one third of the watershed and the other two thirds of the watershed were not changed. We have added clarifying statements about this in section 4.6 and the conclusions as per Wu et al., Interactive comment.

References

Jha, M., Pan, Z., Takle, E., and Gu, R.: Impacts of climate change on streamflow in

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the Upper Mississippi River Basin: a regional climate model perspective, J. Geophys. Res.-Atmos., 109, 2004.

Praskievicz, S, and Chang, H.: A review of hydrologic modeling of basin-scale climate change and urban development impacts, Prog. in Phys. Geogr. 33, 650-671, 2009.

Takle, E. S., Jha, M., Lu, E., Arritt, R.W., Gutowski,W. J., and the NARCCAP Team: Streamflow in the upper Mississippi river basin as simulated by SWAT driven by 20th-century contemporary results of global climate models and NARCCAP regional climate models, Meteorol. Z., 19, 341–346, 2010.

Wu, J., et al.: Interactive comment on “Using the Storm Water Management Model to predict urban headwater stream hydrological response to climate and land cover change, Hydrol. Earth Syst. Sci. Discuss. 10, C3587-3598, 2013.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 7091, 2013.