Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-242-AC2, 2017

Hydrology and Earth System Sciences Discussions

Open Access

EGU

HESSD

Interactive comment

Interactive comment on "Comparison of the impacts of urban development and climate change in exposing European cities to pluvial flooding" *by* Per Skougaard Kaspersen et al.

Per Skougaard Kaspersen et al.

pskk@dtu.dk

Received and published: 10 July 2017

The authors thank the reviewer for the positive and constructive comments, which will assist us to further improve the paper. Find the author responses to the specific review comments in the following.

1. The authors present a novel approach to compare the impacts on urbanization and climate change on pluvial flooding in four European cities. The paper is well written and easily read and understood. Results are interesting in that sense that the impact of urbanization and climate change on flooding is in the same order of magnitude. There are some assumptions, which in my opinion need to be clarified in order to justify the

simplifications of models and inputs. However since focusing on relative comparisons between the four cities and different climate scenarios, the effect of these assumptions on the final results and conclusions might be small - however still relevant to discuss from a scientific point of view.

Author response: The authors agrees with the reviewer that some of the assumptions made in this paper would have been too simplistic for other applications, including for detailed planning of drainage system updates or for recommendations for location-specific adaptation measures. However, as the reviewer also notices, since the focus of the paper is on the relative comparison of the impacts of urban development and climate change on flood exposure between four European cities, the effect of these assumptions are not considered to affect the results, nor the conclusions, considerably. The authors agree with the reviewer that the importance and influence of some of the assumptions are highly relevant to discuss in a broader scientific context. In the following we will initiate this discussion, and, where appropriate, amend the manuscript accordingly. However, in order to preserve the focus on the paper we will focus on highlighting what assumptions are reasonable in the context of the study and avoid making (too many) diversions on other possible framings.

2. In the abstract and the introduction the presence and impacts of an urban drainage system in terms of pluvial flooding is not mentioned. The first pages would benefit from a clarification on this.

Author response: The authors agree with the reviewer that the paper will improve by including this information in the initial sections of the paper. A clarification on the presence and impacts of an urban drainage system in terms of pluvial flooding will be included in both the abstract and the introduction. See the following suggestions for insertions:

The following text will be added to a revised version of the manuscript:

Abstract page 1 line 24: In addition, two different assumptions are examined with regards to the development of the capacity of the urban drainage system in response to urban development and climate change. In the “stationary” approach, the capacity resemble present-day design, while it is updated in the “evolutionary” approach to correspond to changes in imperviousness and precipitation intensities due to urban development and climate change respectively.

Abstract page 2 line 4: Developing the capacity of the urban drainage system in relation to urban development is found to be an effective adaptation measure as it fully compensates for the increase in run-off caused by additional sealed surfaces. On the other hand, updating the drainage system according to changes in precipitations intensities caused by climate change only marginally reduce flooding for the most extreme events.

Introduction page 3 line 33: We investigate the effectiveness of updating the urban drainage system in response to urban development and climate change simulating two scenarios; (1) the capacity of the drainage system is updated to correspond to changes in impervious surfaces and precipitation intensities and (2) no modifications in the capacity of the drainage systems are assumed.

3. In section 2.1 on the framework, it would be worth noting which type of precipitation input is used in the modelling concept.

Author response: This information will be included in section 2.1. The following text will be added to a revised version of the manuscript: Page 4, Line 29: High-intensity precipitation events with intensities corresponding to RPs of 10, 20, 50 and 100 years are included in the analysis.

4. Line 1, page 6: Why the near-linear relationship. In eq.1 the relationship is linear.

Author response: This is an error. The text will be changed from “near-linear” to “linear”.

5. I think the assumption on assuming fully saturated soils at all times, thus simplifying Horton, might need some more clarification. If you have a dry soil the initial infiltration

capacity might easily be a decade larger than the end infiltration. In that case you risk overestimating the surface runoff. For some of the sandy soils, e.g. the example for Odense, has a saturated infiltration capacity of âĹij30 mm/h. If the initial capacity is ten times larges, it is doubtful that the soil will ever get saturated, since you would need rainfall intensities larger than 300 mm/h (for a longer period). But as you write in the discussion the problem decrease for larger return periods, thus larger rainfall intensities.

Author response: The authors agrees that this assumption may lead to overestimations of surface run-off and consequently exaggerated flood extents. Indeed, based on the work we present here we have made an analysis of typical soil and precipitation characteristics for Denmark and have found that in general the initial conditions will lead to changes in the runoff of approximately 1-6 mm depending on soil type and independent of return period (results are not published yet). However, since the assumption is consistent across all sites, soil types, and return periods, and because we are primarily interested in comparing the influence of urban development and climate change on changes in flooding between the different urban areas, this assumption is not expected to influence the results. Instead, if the purpose of our analyses were to accurately estimate the precise area experiencing flooding during specific precipitation, a more detailed representation of infiltration processing, e.g. including initial losses should be applied. In addition, it should be noted that because infiltration varies considerably across small distances, infiltration data is associated with large uncertainties, and accurate location-specific infiltration data is thus not readily available for many locations. In our analyses, we attempt to address this uncertainly by simulating the precipitation events using low, average and high estimates of infiltration. We discuss this on page 8, lines 7-18. Given that we have not made the analysis of the importance of this assumption the word ‘slightly’ will be added to line 14 in a revised version of the manuscript.

6. In the “method section”, page 8, the assumption of subtracting the rainfall intensities

with a 5 yr return period needs more clarification. It is discussed later on, but it could be relevant to discuss here also. I think neglecting the drainage system, by subtracting the rainfall from a 5 yr return period might be too simple an approach. Partly due to the fact that not all parts of the drainage systems might be designed for a 5 yr return period, and partly due to the fact that even designed for a 5 yr return period, there might be lots of local capacity left in the drainage system, depending on the rainfall dynamics. Furthermore, what about capacity of bassins, channels, recieving waters, etc.?

Author response:We agree that a more complex model would yield more precise results if we collected the data needed to build and calibrate a full 1D2D model of both subsurface infrastructure, topography, and natural waterways. As mentioned in the beginning of this rebuttal, that might have been a reasonable approach if the objective of the study was to make detailed designs of adaptation measures. However, for the purpose of the study the methodology is perfectly valid and has been used before, e.g. (Arnbjerg-Nielsen & Fleischer, 2009) and is recommended as one of several simulation methods for both planning and real-time applications by (Henonin, Russo, Mark, & Gourbesville, 2013). The last, but also important, reason is that we do not have access to the data needed in order to make a 1D2D simulation more accurate than the method we have employed.

7. Page 12, top. The construction of precipitation events needs to be detailed. Are you using design storms e.g. the Chicago design storm constructed from the IDF-curves? These types of storms require a very linear rainfall- flood response in order to be valid. Has this been investigated?

Author response: We do employ CDS-storms and have clarified this in the revised manuscript. We need this assumption first of all because we only have IDF-curves available at some of the sites we study. Our results are not a linear function of neither return period nor rainfall volume so we do not understand this part of the reviewers comment. The key assumption for CDS-storms is that a well-defined time of concentration exists, which we need to assume and think that this is reasonable in the current situation. Testing of this particular hypothesis was the focus of a presentation at the International Conference on Flood Resilience in Exeter (Newton et al, 2013). Because the proceedings only contain extended abstracts we have been in contact with the authors regarding more detailed reporting of the results. Unfortunately, they have not published these results. The following text will be added to page 12, line 16 in a revised version of the manuscript: "... Chicago design storm...".

8. Also, why limit the duration to 4 hours – you might underestimate the role of storage bassins, and natural waterways, only looking at the very short durations, thus high intensity, rainfall.

Author response: See also response to point no 6. We have highlighted that we only focus on pluvial flooding, i.e. assumed that the response is so short that flooding from larger waterways can be neglected.

9. Page 12. You state that you include the total rainfall amounts in the supplementary material, but I think it would be relevant to present here along with the max. intensities over different durations. In that case it would be possible to compare the infiltration rates to rainfall intensities.

Author response: We agree with the point of not only presenting the infiltration rates and climate factors but also the actual rainfall intensities. In a revised version of the manuscript we will therefore add the maximum 1 hour intensity as well as total volume of the CDS storms for all return periods and all sites.

10. Section 3.4. I guess that you assume all surfaces to be impervious during the flood, meaning that you only account for the infiltrating water to the soil in the rainfall input to the model. In reality you might have a flood where water flows from impervious surface to pervious surfaces and infiltrated, but a I guess this is not accounted for. Please comment on this.

Author response: Infiltration continues during the flood, meaning that water flowing from fully saturated surfaces to areas with excess capacity will infiltrate accordingly. To accommodate this, a net infiltration rate is defined in MIKE 21 (infiltration is accounted for as a separate input to the model, i.e. as an evaporation type2 file in MIKE 21 and not as part of the rainfall input) allowing for both precipitation and runoff to infiltrate at any stage during the events. We will clarify this in a revised version of the paper. We will clarify this on page 9, lines 7-8 in a revised version of the manuscript by adding the following text: The runoff from each grid cell is allowed to infiltrate later during the events, i.e. runoff flowing from fully saturated surfaces to areas with excess capacity during the events will infiltrate accordingly. To accommodate this, a net infiltration rate is defined in MIKE 21 allowing for both precipitation and runoff to infiltrate at any time during the events.

11. Line 12, page 15: I think the limit of 10 cm water levels considered flooding needs some clarification. If you have grid cells of 25 x 25 m2 and with a min water level of 10 cm you discard 62.5 m3 of water. This is a significant amount! Please comment.

Author response: We have studied several thresholds ranging from 1-50cm (not included in the paper) and found that our results are consistent independent of the selected threshold. Again, see response to point 6: our main focus is not on detailed calculation of the spatial distribution of the floods, but a comparative analysis of the drivers causing changes in flood hazards at city level.

12. In fig. 6 you use km2 and in fig. 7 you use ha. Please apply same units.

Author response: Using the same units leads to very large or very small numbers in one of the graphs. In a revised version of the manuscript we will therefore add the following text to the fig.7 legend: Please note the differences in unit on the y-axis compared to Figure X to each of the figures.

Litterature refered to used in the author responses:

Arnbjerg-Nielsen, K., & Fleischer, H. (2009). Feasible adaptation strategies for in-

Printer-friendly version

Discussion paper

creased risk of flooding in cities due to climate change. Water Science and Technology, 60(2), 273–281. https://doi.org/10.2166/wst.2009.298.

Henonin, J., Russo, B., Mark, O., & Gourbesville, P. (2013). Real-time urban flood forecasting and modelling – a state of the art. Journal of Hydroinformatics, 15(3), 717–736. https://doi.org/10.2166/hydro.2013.132.

Newton, C., Jarman, D., Memon, F.A., Andoh, R., Butler, D. (2013): Implementation and assessment of critical input hyetograph generation methodology for use in a decision support tool for the design of flood attenuation systems. Proceedings from the International Conference on Flood Resilience, Exeter, 5-7 September 2013, pp 229-230.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2017-242, 2017.