Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-417-AC1, 2019

Hydrology and Earth System Sciences
Discussions

Interactive comment on "The importance of city trees for reducing net rainfall: comparing measurements and simulations" *by* Vincent Smets et al.

Vincent Smets et al.

vincent.smets@kuleuven.be

Received and published: 23 January 2019

Authors: Thank you for reviewing our paper. We believe that your comments have significantly strengthened the manuscript.

Reviewer main comment 1: The manuscript is, in my opinion, too long and contains details which are not very useful and which don't help the reading. I would recommend a shorter manuscript, written in a more synthetic and efficient way and focusing on the key points of the contribution, and may more rigorous (notation and denomination of variables, model presentation).

Authors response: We agree and shortened the paper from 10340 words to 8006 words (abstract + main text + conclusions). The whole manuscript went from 33 to 24 pages, including references and appendices. Many sections such as the materials and methods, and results section were shortened. The scenario analysis and regression were removed to focus on the key points of the manuscript.

Change in manuscript: See manuscript

Reviewer main comment 2: The manuscript organization could be simplified. Each section is divided into many paragraphs (up to 9 or 10) which don't help the understanding. - The field experiment concerns individual trees. What about the tested models? Do they apply to individual trees or tree covers? Consequences concerning the model evaluation ?

Authors response: We simplified the manuscript, eliminated an merged several paragraphs, removed unnecessary figures, etc. We clarified which models are used for forest cover interception and which models are used for individual trees (Table 4). We discussed the differences between these models more in detail. More elaborated answers are written in response to the line comments.

Change in manuscript: See manuscript and line comments.

Line comments

Reviewer comment: p 1 – line 33-36: if the problem of heavy events should not be forgotten, the growing interest for vegetation in urban areas seems more related to the promotion of sustainable urban development, and more recently to urban climatology.

Authors response: We agree that there are probably other drivers promoting the incorporation of vegetation in urban areas such as for example heat reduction and personal wellbeing.

In case of hydrological ecosystem services, vegetation only functions as a part of the solution and is most functional in the case of less intense and more spread out rainfall

events. These events are the most common in our study (average intensity 1.3 mm/h for the Norway maple site and 0.9 mm/h for the small leaved lime site in comparison with an average > 2mm/h in Mediterranean climates (Pereira et al., 2009)). In the case of heavy rainfall events the storage capacity of trees and smaller vegetation will most likely be exceeded, limiting the influence of the vegetation. However, even in the case of heavy rainfall events, peak runoff will be delayed and spread out, resulting in less intense pressure on the drainage system (Szota et al., 2019).

Change in manuscript: We decided to not change the text. On p 2 – line 3 we start with 'part of the solution', emphasizing that incorporating urban green is not enough and complementary measures are also necessary. Furthermore, on p 1 – line 37-38, we say that an important challenge is an efficient water regulation policy, which includes more than just runoff reduction. We think urban green has an important part in such a policy.

Reviewer comment: p 2 – paragraph 1: I have some agreement to that. The authors may indicate that the role of vegetation in urban areas remains a very open question, largely unstudied so far.

Authors response: We don't think it is largely unstudied. Actually the influence of vegetation on the urban hydrological cycle has been a booming topic in recent years. For example when looking at google scholar: Inserting the keywords 'urban' 'vegetation' and 'hydrology' results in 17400 results since 2015. We do think however that there are still some knowledge gaps to address. For example, the most commonly used models that estimate interception storage are stand-alone interception models (Gash, Rutter) that are not incorporated in a complete water balance model. That's why we compare these specialized models with the interception storage estimates of WetSpa, a model capable of modelling the whole water balance. Another knowledge gap is that most interception studies are done in Mediterranean climates, with different rainfall distribution patterns and vegetation. We want to know if the interception potential of trees in temperate climates is different than in Mediterranean climates.

Change in manuscript: We rewrote the last paragraph of section 1.2 to better emphasize the knowledge gaps we want to address and rewrote the research questions in section 1.6.

Reviewer comment: p 3 – paragraph 1.3: in urban areas, many trees are tree lines, along streets. In that case, the soil around these trees is sealed (impervious). Is the situation studied by the authors really representative of urban trees?

Authors response: in the case of the interception process, our experimental setup is representative, as it is a solitary tree and the ground surface does not influence the interception process. Off course due to the heterogeneous nature of urban environments, trees are found in widely varying settings and cannot all be reproduced in an experimental setup (proximity to buildings and other trees, varying wind directions, sun exposure, etc). We believe it is important to simulate interception storage for such a variety of urban trees and thus propose to use a LAI-based approach to calculate interception storage with a water balance model. The LAI based interception calculation accounts for the tree development/health in the urban environment and the distributed water balance model accounts for further urban constraints in the infiltration, evaporation and runoff calculation (imperviousness, connectivity of water flow, etc.). By placing our experimental setup on a site that is free from obstructions such as buildings and other trees, we believe we represent an ideal case for urban trees that is adaptable to more specific conditions, providing that some assumptions are made.

Change in manuscript: added the text: 'These two trees represent an urban solitary tree. As the urban environment is very heterogeneous, trees are found in widely varying settings such as in parcs, private gardens and on streets. Due to the limitations of an experimental setup (safety, space and logistics) we decide to choose urban solitary trees free from obstructions and with full sun- and wind exposure. The results of our experiment can thus not simply be translated to other solitary urban trees but must undergo some assumptions of the environmental conditions.' ' to section 2.2.

Reviewer comment: p 5-11: The experiment device is interesting and original. Nevertheless, it raises issues. How representative is this experimental setting of urban trees that are subject to very different contexts ?. I would suggest that the authors write in a more synthetic way.

Authors response: See answer above. Our experimental setup represents the 'ideal' case of an unobstructed solitary urban tree. This will result in a maximum water storage. A possibility to determine the influence of urban trees in more specific conditions (eg. A tall building 3 m on the south side of a tree in a wide east-west street lane) can be estimated through simulations using our findings as a maximum value. Moreover, because WetSpa takes LAI into account, a much broader variety of urban trees can be modeled. For example, a street tree will probably have a different LAI than a park tree.

Change in manuscript: See previous comment.

Reviewer comment: p 10 – paragraph 2.6: what difference between data processing and modelling (next section ?) It is not clear to me.

Authors response: We merged both sections, eliminated some explanations that are already known for a long time and wrote in a more synthetic way.

Change in manuscript: see manuscript section 2.6 'The Data Processing And Model Comparison'

Reviewer comment: p 12 – paragraph 2: If modelling and model comparison is a central part of the manuscript, I would suggest to present the models as part of the manuscript and not in Appendix.

Authors response: We decided to keep the equations in the appendix for multiple reasons: (1) the models are not new but have been developed a long time ago, (2) we don't change the functionality (equations) of the models , and (3) the readability of the manuscript. We add the equations to the appendix for the reproducibility of our results but believe that the equations have no other added value to the manuscript as the

differences between the models is discussed in the method section (paragraph 2.6).

Change in manuscript: No changes made.

Reviewer comment: p 12 – paragraph 2.8: Do these models apply to individual trees, as the field experiment, or a tree plant cover? I suppose that there is a very important difference between the two. It is a significant point concerning the model relevance.

Authors response: Gash and Rutter developed their models on forest stands whereas WetSpa is not specialized but was built to work at a regional basin scale (therefore the simplifications). However, we adapt the interception module in WetSpa to include LAI and set-up a model representing the V-catchment experimental set-up. We agree that it is important to note that Gash and Rutter were developed on a forest stand and also discuss the possible effects on the outcome in the discussion section.

Change in manuscript: p 12- paragraph 2.6: we added the text 'The Gash and Rutter model have been developed for a forest stand whereas the WetSpa model is adapted for a solitary tree' to clarify the differences which are also summarized in table 4.

Reviewer comment: p 13: the scenario analysis appears as important as the modelling and model comparison. Is it really the case, or is it just an illustration example, in which case, I would suggest to reduce its length.

Authors response: The scenario analysis indeed is used as an illustration example to emphasize the potential of urban trees in reducing runoff. To reduce the length of the manuscript we decided to remove the scenario analysis from the paper and instead discuss the potential impact of urban trees in the hydrological cycle in the discussion section (section 4.3 'The Potential Benefit Of Trees In An Urban Context').

Change in manuscript: see section 4.3

Reviewer comment: p 15 – lines 5 to 14: I would suggest to move this lines to Section 2.

Authors response: We agree and moved section 3.1 to Material and Methods (section 2.2).

Change in manuscript: See section 2.2.

Reviewer comment : p 17 – figure 8: I am not convinced that this figure is very useful here, it could eventually be moved in Appendix.

Authors response: We agree that this figure takes up to much space. We removed the figure (it is available upon request) and we now describe the rain event characteristics in section 2.4.

Change in manuscript: See section 2.4.

Reviewer comment: p 19 – paragraph 3.3: is a full page needed to see the weak sensitivity? A few lines would be enough.

Authors response: We agree, we removed the figures and shortened this section substantially. This part is now incorporated in section 2.5.

Change in manuscript: See section 2.5.

Reviewer comment: p 20: line 1-4: small events of 1 mm are not very important from a hydrological point of view.

Authors response: We agree, this fact together with the high uncertainty associated with events < 1 mm led us to the decision to remove them from further analyses.

Change in manuscript: See section 2.4.

Reviewer comment: p 20: figure 10: the presence of the inflexion point on the regression lines is not obvious. Is it justified by physical reasons?

Authors response: A disadvantage of the Leyton method is that the inflection point is determined subjectively. We looked at the residual values of the Pg vs Tf plot to determine this point (not shown in manuscript), a sudden change in residual values

indicated the inflection point. We decided however to remove the Leyton analysis for interception storage capacity determination from the manuscript for several reasons: 1) The above described inherent subjectivity of the method. 2) The Letyon method cannot take into account seasonal changes of leaf cover. As our measurements periods encompass transition periods from leaf off to leaf on , this confuses the Leyton analysis. 3) A few large events can significantly alter the analysis. For these reasons we decided to abandon the Leyton method as a means of comparison with our chosen method to determine interception storage capacity (Equation 5, Gomez et al., 2001). The Leyton method is still used for the free throughfall coefficient calculation, as shown in appendix A.

Change in manuscript: See manuscript section 2.2.

Reviewer comment: p 22: Equation 6. The authors introduce I as interception (in mm). The legend of Table 5 mentions the Interception storage capacity (S in mm), as Equation 5 (p 11) and in Appendix A (Eq. 1) I is the interception storage, and S the crown surface storage capacity, and IS appears in following equations. In equation 6, D is duration and in A-1, it is drip-off ..... A very careful checking of notations is required. What is the difference between interception, interception storage and storage capacity.

Authors response: We carefully checked our notations in the manuscript and made some changes. The definitions of interception, interception storage and interception storage capacity are explained in section 1.3. In short: interception is a process, interception storage (I) is the total volume of water a tree can hold during an event that does not reach the ground surface and the interception storage capacity (S) is the maximum volume of water a tree can hold for a given time. The interception storage can be greater than the interception storage capacity when there are dry periods during a rainfall event and water can drip off or evaporate.

Change in manuscript: Definitions in section 1.3

Reviewer comment: p 22: Equation 6 – I am sceptical concerning the regression model

(eq. 6) which provides better results, but which introduces 9 numbers, that is 9 parameters, which means that this model is strictly limited to the analysed data set, without any generalization. Such a model is of a very limited interest.

Authors response: We decided to remove the regression analysis from the manuscript. One reason for this is the comment mentioned by the reviewer. The other reason is that it allows us to focus more on the comparison between the standard forest canopy interception models (Gash- and Rutter) and the WetSpa, solitary tree model. We think this makes our manuscript more clear.

Change in manuscript: See manuscript

Reviewer comment: p 23: Figure 12 – Interception storage – A new denomination?

Authors response: This is the interception storage as defined in section 1.3, the total volume of water intercepted by the tree for an entire rainfall event.

Change in manuscript: See section 1.3

Reviewer comment: p 25: I would suggest that Figure 13 and Table 6 to be the central points of the model comparison.

Authors response: We agree and structured the text more around this table and figure. These are now Table 7 and Figure 6.

Change in manuscript: See manuscript

Reviewer comment: p 26-27 paragraph 3.7: I wonder about the usefulness of this paragraph “land cover change scenario” in this manuscript. In the light of previous results, it is not surprising that an increase of sealed surfaces generates a runoff increase, and that tree planting generates an increase of water storage.

Authors response: To make the focus of our manuscript clearer and to limit its length, we decided to remove the scenario analyses. We did add a section discussing the relevance of our findings to the urban context (section 4.3).

Change in manuscript: See section 4.3

Reviewer comment: p 27: It seems to me that interesting discussion subject could have been the following: i) validity of this model assessment given the possible differences between individual trees and tree plant cover; ii) application of the models to a more usual urban context: available data, types of trees, ...

Authors response: We restructured the discussion in a way that it better reflects and emphasizes our research questions. It is now structured as follows: 1) Comparison of our gathered dataset with datasets from other studies. 2) Comparison of model performance between the standard forest interception models and the individual tree WetSpa model. 3) Relevance of our experimental setup and model results to an heterogeneous urban environment.

Change in manuscript: See discussion section

Reviewer comment: p 32: Table to remove, it is unreadable (the data set can be provided on request).

Authors response: We removed the table for the manuscript.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-417, 2018.