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Hydrology and Earth System Sciences Discussions

Interactive comment on "Technical note on measuring run-off dynamics from pavements using a new device: the weighable tipping bucket" *by* T. Nehls et al.

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Reply to comments of referees on

Technical Note on Measuring Run-Off Dynamics from Pavements Using a New Device: the Weighable Tipping Bucket, T. Nehls, Y.-N. Rim, and G. Wessolek

We thank both referees for their review efforts and their comments on our manuscript, which helped us to improve it. In the following we answer the comments in detail (all pages and line numbers refer to the originally published discussion paper (Hydrol. Earth Syst. Sci. Discuss., 7, 9271–9292, 2010)

Referee #2, p. 9273, 1, 16: "...fore casted..." or "...forecasted..."?

Answer: forecasted

Referee #1, p. 9274, l.1, 18 ff: For the experiments weighing lysimeters have been used. During a rain event we have two processes. The first is storage of the rain on the surface of the lysimeter, i.e. on the pavement and in the seams, respectively. The second is run-off from the surface and its measurement with the weighable tipping bucket. Why is it not possible to measure the first process (storage of rain on the lysimeter surface until that time, when run-off from the paved surface into the tipping bucket begins) directly with the lysimeter, based on changes of the lysimeter mass during the rain event?

and Referee # 2, p. 9274, 1.1, 18 ff: Why is it not possible to measure the storage of rain on the lysimeter surface as the change of lysimeter mass from starting point of the rain event and the starting point of the run-off event. The reason might be the time steps of the detection of mass change of the lysimeter or the resolution of the balance used. Additional information would be helpful.

Answer: Referees are right, the resolution of the lysimeter balance is theoretically sufficient (0.1 mm/3sec) to detect the surface storage. However, we very often observed that rain events are accompanied by a wind at the beginning, which causes a drifting of the balance, before the rain reaches the lysimeter. Additionally, the initial breakaway torque of the balance, a rather old mechanical model, varies not reproducibly around a force equal to 0.5 mm rain. That means after the wind has lifted or pressed down the lysimeters, the balance is not reproducible relaxing back to the original value after the wind has stopped. That was the reason for the development of the WTB. In the manuscript, at p.9274, 23: we changed the part after "in the laboratory":

It should additionally be estimated for whole pavements, including the storage capacities of the surface relief and the seam soil material. It can be estimated from the mass increase of a paved weighable lysimeter during a rain event until run-off starts. How-

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ever, this requires a mass detection system for the lysimeter, which has a high mass and temporal resolution. Wind, which accompanies rain events frequently can disturb such measurements. Alternatively, the surface storage can be gained from run-off measurements for rain events with differing intensities and rain sums.

Referee # 1, p. 9275, l.2, 12 ff and p. 9276, l.3, 24 ff: The description of the characteristics of the TB seems to be o.k., but a discussion of alternative measuring techniques is missing (for example, flow measurement techniques used at petrol filling stations, etc.).

and Referee # 2, p. 9278, 2.2, 22 ff: Why is it necessary to use a tipping bucket coupled to a balance. Using a balance to weigh the cumulative sum of run-off from the lysimeter surface in short time intervals will precisely describe the flow dynamics and can be synchronized to constantly timed measurements of other water balance components.

Answer: We understand the intention of the referees to broaden the introduction a little and to ask explicitly for the advantages of the TB coupled to the balance before other systems. We added both aspects to the introduction. However, we think that the discussion of alternative measuring systems would disturb the argumentation on the tipping buckets in 1.2 and 1.3. Therefore, we added the discussion at p.2975, 1: after "…and volume resolution.": For the detection of small flow rates down to 0.007 mm min-1 a bucket on a balance with a high resolution would be capable. However, the logger system and the balance must have a high mass and temporal resolution and good shock absorption. The higher the resolution of a balance, the smaller is its weighing range. In our case the available balance has a range of 4000 g. An according 4 L bucket would be filled after less than one average rain event, assuming a run-off coefficient of 1 and the rain distribution from figure 1. So the use of a bucket would lead to high maintenance efforts, while a tipping bucket is self-emptying and enables a continuously, low maintenance monitoring of run-off events. Alternative flow measurement techniques such as venturi canals, rotameters or rotary piston meters work only with completely filled tubes or filled flow cross sections of gutters thus would complicate the setup.

Referee #2, p. 9276, 1.3, 14: "...of a expected..." or "...of an expected..."?

Answer: of an expected

Referee #1, p. 9279, 2.3, 12 ff: The use of the term “weight” is physically not correct – you measure a mass or a mass change with the TB. Please correct the use of the term in the whole manuscript.

and Referee #2, p. 9279, 2.3, 13: "...water weight..." or "...water mass..."?

Answer: In fact, the use of the term weight (force caused by the mass in the gravitational field) is physically correct, as the digital balance detects a force, respectively a torque when it is used as we described it. The balance detects a force (the weight) then divides the gravitation from the weight and records the mass, which was then divided by the density to calculate the volume of the rainwater in our case. However we agree that the use of the term "weight" which is widely used in the every days language might be misleading and that the use of the terms "force", "mass" and "volume" is more precise. We checked the use of the term "weight" throughout the manuscript and changed it accordingly:

p.9278, 2.2, l26: substituted "test weights" by: standard weights p.9279, 2.2, 12: substituted "the weights detected by the digital balance" by: the detected torques processed and stored as masses p.9279, 2.3, 13: According to the comment above we added: . . .were multiplied by 0.51 and divided by the water density of 1 g cm-3 to get the water volume in the tipping bucket. p.9280, 2.3, 4: "it is simply the first positive weight change of the balance" substituted by: it is the first positive mass change detected by the balance p.9281, 3.1, 17: weights has been substituted by: water volumes

Referee #2, p. 9279, 2.3, 19: "...measured by TB is..." or "measured by TB (ROTB) is..."?

Answer: measured by TB (ROTB)

Referee # 1, p. 9280, 2.3, 10: It is not clear how you have identified the criterion for the end of the real surface run-off, a more detailed description would be helpful for the reader.

Answer: We confess, that we did not explain the criterion sufficiently, because we thought, that it is of minor interest in that paper. We just wanted to draw the reader's attention to the artifact aspects of our individual measuring and experimental design. The criterion has been conceived based on our observations on our individual gutter system and is therefore only applicable for our experiments. Other criterions are possible. One could also use the duration, when 95% of run-off entered the WTB. In order to clarify this aspect, we changed the text. p.9280, 2.3, l.10: "The run-off detection is delayed due to the measurement set up. A criterion is needed to identify the end of real surface run-off. Based on our observations at our lysimeter this criterion has been chosen to be a flow rate less than 0.002 L min-1. Such draining water is still accounted to RO, but does no longer count in terms of run-off duration (Fig. 3)." with: In general, the end of the run-off from an investigated surface might be different from the time when the last drop entered the WTB. In our case, artifacts are caused by the metal gutter and the 1.5m metal pipe leading the water to the WTB in the lysimeter basement. We observed the run-off from the surface stopping after about 10 min, but the last drop entering the WTB after 30 min. This delay is due to the water which wetted the gutter is slowly running out of the pipe after surface run-off stopped, leading to a very long tailing of the run-off curve (Figure 3). To retrospectively identify the end of the surface run-off from the WTB data, we used the time, when the flow rate was less than 0.002 L min-1. This criterion is conceived based on our observations in our individual gutter system and is therefore applicable only for our experiments. Other criterions are possible, such as the time when 95% of run-off entered the WTB. However, water with a flow rate < 0.002 L min-1 is still accounted to the sum of ROWTB, but does no longer count in terms of run-off duration.

Referee #2, p. 9280, 2.3, 15-16: "...measured by WTB is..." or "measured by WTB (ROWTB) is..."?

Answer: measured by WTB (ROWTB)

Referee #1, p. 9290, Fig. 2: This sketch of the new weighable tipping bucket system does not enable a reader to construct such a system for his purposes. To do that the dimensions of the various components need to be added. In addition, a top down view, also with dimensions, is required.

and Referee #2, p. 9290, Fig. 2: can you give dimensions of the different components?

Answer: A new figure has been drawn and was inserted into the manuscript.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 9271, 2010.

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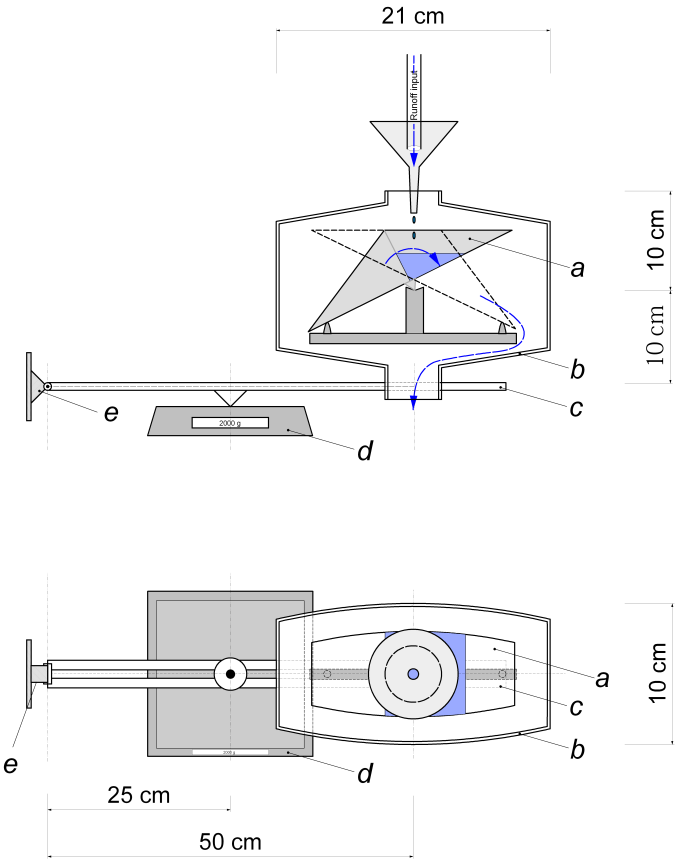

Fig. 1. revised figure 2

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