

## ***Interactive comment on “Development and testing of a large, transportable rainfall simulator for plot-scale runoff and parameter estimation” by T. G. Wilson et al.***

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Received and published: 18 August 2014

C3183

### **Response to comments from Anonymous Referee #2**

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18 August 2014

Thank you very much for your comments. Here are our responses to your individual concerns.

“The paper needs to discuss in more detail the specifics of the rainfall simulator design and costs in section 2.1.”

We recognize that some readers may desire additional information on the components of the rainfall simulator. We will incorporate the overall cost of the rainfall simulator into the paper and elaborate on the system components. However, many aspects of the simulator such as the nozzle line supports, structural frame, collection system, and runoff flow meter, do not need to be of a particular design or manufacturer. Furthermore, there is just as much emphasis on the parameter estimation method in the paper as there is on the rainfall simulator itself; including far more details on the customizable aspects of the rainfall simulator itself appear to the authors to be too much for one paper and unnecessary. We will instead explicitly state in the paper which components of the rainfall simulator are open to design changes. The overall cost of the rainfall simulator is less than 1,000 USD.

C3184

The following will replace the current section 2.1, which addresses several of your comments:

The rainfall simulator consists of several parts: nozzle lines, nozzle supports, structural frame, and water delivery system. The four independently-operated nozzle lines have either 11 or 12 nozzle assemblies (46 total) connected with 1.5 cm inner diameter PVC pipe and compression fittings. Each nozzle assembly, as shown in Fig. 1a, consists of a 0.5 mm opening pressure washing nozzle, threaded hex connector, and threaded hose barb. The barbed ends of the hose barbs were wrapped in teflon tape and gently hammered into a short length of PVC pipe, which was then attached to the compression tees on the main line as shown in Fig. 1b. The centers of the nozzles are 33.3 cm apart; the lengths of pipe between the nozzles were cut to attain this length and will vary based on the pipe fittings used in other applications. Each line is a total of 4.2 m long with a plugged length of pipe at one end and a 0 - 600 mbar pressure gage and elbow at the other end that connects to the water delivery system. The nozzle lines are configured as shown in Fig. 5 [figure location will be moved], with two sets of nozzles that face each other at a distance of 2.3 m apart.

The nozzle assemblies are supported by L-shaped pieces of metal mounted to stiff metal rods as shown in Fig. 1b. The nozzles point upwards at alternating angles of 48 and 54 degrees from horizontal; the drops then fall from a height of approximately 3 m. Shorter lengths of the stiff rod support 15 cm bolts that are used to set and maintain the angle. Plastic zip ties hold the nozzles in place on top of the bolts during the experiments. Other than the spacing and angles of the nozzles, other aspects of the support system may be adapted to suit the needs and available materials of other researchers.

The structural frame, shown in schematic in Fig. 2, consists of six 2 m ver-

C3185

tical beams, three 4 m horizontal beams to which the nozzles are mounted, and two 4 m horizontal beams to complete the frame. The present frame uses 6 cm metal tubing and clamp connectors since it was readily available, but other materials may be used; Schedule 40 PVC is a good inexpensive alternative. Additionally, a plastic mesh attached to these final two beams helped randomize the spray pattern (Foster et al., 2000). The mesh was a heavy gauge 4 mm grid mesh that was doubled along the edges to prevent ripping and attached to the frame using plastic mesh clips and zip ties to prevent sagging.

The water delivery system conveys water from the 2 m<sup>3</sup> tank to the nozzle lines. A submersible pump with a filter, powered by a gasoline generator, pumps water out of the tank via flexible hose. Three tees are used to split the single line into four, and each of these four lines contains a butterfly valve near the pressure gages so the pressure can be adjusted if necessary.

The overall cost of the rainfall simulator in 2010 was less than 1,000 USD. This cost includes the simulator components above and the instrumentation discussed below. The dimensions and operating parameters should be matched to what is discussed here, but other components may be changed to suit the needs of other researchers.

“Why was 2 m selected for the height of the simulator?”

The nozzle height is 2 m to make the parts of the simulator easier to see and access. However, as noted in Section 2.1, the nozzle are pointed upwards, so the actual fall height of the drops is slightly higher. A full drop size and velocity analysis was conducted and is documented in Corona (2013), which is referenced in the original manuscript.

C3186

“Number of hours required to build the simulator”

This particular simulator was constructed over the course of several months through an extensive trial and error process. It is therefore very difficult to estimate an overall construction time.

"Number of hours required to construct onsite and number of hours and staff required to disassemble and move to next plot"

To address this and other concerns regarding the operation of the rainfall simulator, a new section 2.3 will be added as follows:

### **2.3 Simulator logistics**

The components of the rainfall simulator can fit on a small truck with a flat bed approximately 3 to 4 meters long. Once on site, it takes four people approximately 90 minutes to set up the rainfall simulator. Ideally, the water tank will be located close to the plot to reduce the pressure required of the submersible pump, so the tank should be able to be filled on site. If the simulator is to be moved to a nearby plot, it can be picked up by four people and walked to the new location instead of disassembled and reassembled, leaving only the soil moisture sensors, plot border, and collection system to be re-installed.

Operation of the rainfall simulator can be accomplished with a staff of three to four people. Once the simulator and other components are installed, the generator is started and the pump is turned on. The simulator is run for a short time to prime the system, adjust the butterfly valves so each pressure gage reads 100 mbar ( $8 \times 10^3$  Pa), and verify that the data logger is working.

C3187

Then, the starting value of the in-line flow meter and start time are recorded as the system pump is turned back on. During operation, it is useful to have one person monitoring the pressure in the nozzle lines, another monitoring the tipping bucket, and a third person observing the plot to record when and where ponding occurs and to make sure water is draining properly. To turn off the system after the desired experiment time, the pump is turned off and the butterfly valves are closed. The data logger is allowed to continue recording until runoff stops.

“Why is the rainfall simulator set inside the plot walls?”

The rainfall simulator is set inside the plot walls in order to be able to balance the measured water delivered to the plot and the calculated water delivered.

“Why the development of a large scale tipping bucket device to measure runoff?”

The tipping bucket device was developed as a way to measure the runoff using the materials that were already on hand in the lab. This caveat will be added to the manuscript. The details are included in the paper for completeness, but in reality any other researchers may use whatever device they choose to measure the runoff. Concerning the chatter in the record, since experiments are not performed unattended and are not very long, it is easy to manually check the runoff record for any extra tips that may be present. Furthermore, the parameter estimation method uses the cumulative runoff and continuous soil moisture to optimize the values of the saturated hydraulic conductivity, so high temporal accuracy in the runoff record are not critical to the analysis.

C3188

“Did the authors consider installing an in-line water filtration system to prevent clogging of the nozzles during rainfall simulation? If not why not?”

The submersible pump had a filter that prevented clogging. This detail has been added to the Section 2.1 rewrite as shown above.

Requests for pictures

Details describing the water supply and screen have been added to Section 2.1 as shown above. The authors feel that photos of these items are not necessary, as other investigators may do whatever works best for their application as long as the stated operational criteria are met.

Again, thank you very much for your comments, particularly in regards to Section 2. We hope you find that the responses are adequate and improve the manuscript.