Geophysical Research Abstracts
Vol. 18, EGU2016-936, 2016
EGU General Assembly 2016

Rainfall simulators – innovations seeking rainfall uniformity and automatic flow rate measurements

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Field rainfall simulators are used worldwide for many experimental purposes, such as runoff generation and soil erosion research. At CTU in Prague a laboratory simulator with swinging nozzles VeeJet has been operated since 2001. Since 2012 an additional terrain simulator is being used with 4 fixed FullJet 40WSQ nozzles with 2,4 m spacing and operating over two simultaneously sprinkled experimental plots sizing 8x2 and 1x1 m. In parallel to other research projects a specific problem was solved: improving rainfall spatial uniformity and overall intensity and surface runoff measurements. These fundamental variables significantly affect investigated processes as well as resulting water balance of the plot, therefore they need to be determined as accurately as possible. Although the original nozzles setting produced (commonly used) Christiansen uniformity index CU over 80 %, detailed measurements proved this index insufficient and showed many unrequired rainfall extremes within the plot. Moreover the number of rainfall intensity scenarios was limited and some of them required problematic multi-pressure operation of the water distribution system. Therefore the simulator was subjected to many substantial changes in 2015. Innovations ranged from pump intensification to control unit upgrade. As essential change was considered increase in number of nozzles to 9 in total and reducing their spacing to 1,2 m. However new uniformity measurements did not bring any significant improvement. Tested scenarios showed equal standard deviations of interpolated intensity rasters and equal or slightly lower CU index. Imperfections of sprinkling nozzles were found to be the limiting factor. Still many other benefits were brought with the new setup. Whole experimental plot 10x2 m is better covered with the rainfall while the water consumption is retained. Nozzles are triggered in triplets, which enables more rainfall intensity scenarios. Water distribution system is more stable due to single pressure operating mode, which is ensured by the pressure probe controlled electromagnetic valve. Previous experiments implied the need of automatic continuous measurements of selected variables. To this end the control unit was equipped with a datalogger. In a several seconds time step it collects the values of water pressure, nozzle-valves operation, control point rainfall intensity from a tipping bucket rain gauge, topsoil moisture from several Theta ML2x probes and most recently the plot outlet runoff rate. For a continuous runoff rate measurement a 0,4-foot HS-flume was constructed and equipped with S18U ultrasonic sensor. Assemble setting was optimised both in flow rate laboratory flume and in laboratory rainfall simulator. Namely the rating curves for particular flume bottom slopes were derived. Employment of the flume in the terrain is scheduled for the experimental season 2016, but laboratory results already show sufficient measurement accuracy and are promising in terms of experimental campaigns simplification.
The abovementioned activities have been supported by the research grants SGS14/180/OHK1/3T/11, QJ1530181, QJ1520265 and QJ1330118.