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Christiansen Revisited: Rethinking Quantification of Uniformity in Rainfall Simulator Studies

Daniel Green (1) and Ian Pattison (2)

(1) Loughborough University, Department of Geography, Loughborough, United Kingdom (d.green@lboro.ac.uk), (2) Loughborough University, School of Civil and Building Engineering, Loughborough, United Kingdom

Rainfall simulators, whether based within a laboratory or field setting are used extensively within a number of fields of research, including plot-scale runoff, infiltration and erosion studies, irrigation and crop management and scaled investigations into urban flooding. Rainfall simulators offer a number of benefits, including the ability to create regulated and repeatable rainfall characteristics (e.g. intensity, duration, drop size distribution and kinetic energy) without relying on unpredictable natural precipitation regimes. Ensuring and quantifying spatially uniform simulated rainfall across the entirety of the plot area is of particular importance to researchers undertaking rainfall simulation. As a result, numerous studies have focused on the quantification and improvement of uniformity values.

Several statistical methods for the assessment of rainfall simulator uniformity have been developed. However, the Christiansen Uniformity Coefficient (CUC) suggested by Christiansen (1942) is most frequently used. Despite this, there is no set methodology and researchers can adapt or alter factors such as the quantity, as well as the spacing, distance and location of the measuring beakers used to derive CUC values. Because CUC values are highly sensitive to the resolution of the data, i.e. the number of observations taken, many densely distributed measuring containers subjected to the same experimental conditions may generate a significantly lower CUC value than fewer, more sparsely distributed measuring containers. Thus, the simulated rainfall under a higher resolution sampling method could appear less uniform than when using a coarser resolution sampling method, despite being derived from the same initial rainfall conditions. Expressing entire plot uniformity as a single, simplified percentage value disregards valuable qualitative information about plot uniformity, such as the small-scale spatial distribution of rainfall over the plot surface and whether these patterns are consistent between experimental runs. Inclusion of these factors would allow a more descriptive and detailed understanding of uniformity but they are seldom included in analyses. Therefore, researchers must challenge whether their sampling methodologies provide a realistic representation uniformity across the entire plot surface.

This paper will discuss the issues with relying on a single percentage value to represent uniformity across a surface plot underneath rainfall simulators and suggests that researchers should seek to utilise multiple methods to quantify and describe uniformity across a plot surface. These may include combining methods such as densograms and grid representations of descriptive statistics with uniformity coefficient values to create a more holistic understanding of uniformity. Additionally, this paper will present results from a series of spray nozzle rainfall simulator tests (positioned over a 9m2 plot surface) which were conducted to investigate the influence of sampling resolution on rainfall uniformity values. Alternative methods of expressing rainfall distribution will be presented, such as a grid representation of uniformity, generated by calculating the standard deviation from the mean volume of each individual measuring beaker, which is believed to provide a clear understanding of the spatial distribution of simulated precipitation and express areas which are under- and over-watered, when presented alongside other methods of uniformity quantification.