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New insights into the mechanisms of splash erosion using high speed, three dimensional, particle tracking velocimetry

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The detachment of soil by raindrop impact is an important transport mechanism within the process of soil erosion. Not only is the energy available for raindrop detachment several orders of magnitude greater than that available for interrill and rill erosion, but also much of the sediment transported through runoff processes is initially detached by raindrop impact. Consequently, further understanding of the raindrop-detachment process is fundamental to the development of soil-erosion models and their predictive capabilities. Part of this understanding requires measurement of how energy is transferred from the impacting raindrop to the soil particles, quantifying their displacement. Recent studies have contributed important information regarding splash travel distances from dry surfaces and have provided insight into the mechanism of grain movement. However, these studies have been two-dimensional in nature, with results limited in the range of conditions examined. Also, no information has been provided on the specific particle trajectories, which is needed to provide a mechanistic understanding of the role of this process in soil erosion.

In the present study, the detachment of sand particles by raindrop impact is investigated using high-speed particle tracking velocimetry. This experimental arrangement and subsequent analysis provides data on particle trajectory and velocity, in all three dimensions of space, during the impact, detachment, transport and deposition processes. Through these measurements, both particle-travel distance and the total amount of detachment are investigated, providing valuable insight into raindrop-erosion processes. Additionally, this detailed information on particle motion can be used to examine momentum transfer from the raindrop to the sand particles during the impact and detachment process. In this presentation the influence of different sand grain size is investigated, demonstrating its influence on the detachment process and the resultant redistribution of the sand bed.

The results from this work (1) provide an evaluation of the link between rates of splash and raindrop detachment, thereby overcoming a major limitation in existing understanding of the dynamics of erosion processes; (2) enable the complex mechanics of splash to be investigated providing quantitative information on energy and momentum transfer; and (3) establish a process by which the dynamics of raindrop detachment can be investigated over a broad range of conditions. These methodological advances underpin the development of more realistic characterisations of the dynamics of raindrop, flow and erosion processes; advances which are vital for the continued development of increasingly accurate soil erosion models.