Changes in Kinetic Energy Flux of Wind-Driven Rains (WDR) with Different Slope Gradients and Aspects

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ABSTRACT

Recent studies have shown that the vector physics of wind-driven rain (WDR) varies with the angle of rain incidence, and especially under high rain inclinations, the slope aspect makes significant differences in the vectoral partitioning of the total rain energy flux. Since such interrill erosion processes of WDR as soil detachment by raindrop impact and particle transport by raindrop-impacted thin flow transport require a component-wise evaluation of fall vectors of both rainfall intensity and raindrop impact velocity, knowing energy flux distribution over a soil surface with a given slope gradient and aspect play a key role to model the sub-processes physically. In this study, vectoral distribution of kinetic energy flux of the wind-driven rains with different slope gradients and aspects were measured using two-dimensional experimental setups at the wind and rain simulation facility of the International Center for Eremology (ICE) in Ghent University in Belgium. Varying fall incidences were obtained by the rains driven by the wind speeds of 0, 6, 10, 12 ms^{-1} over a test surface placed on windward and leeward slopes of 2, 3, 4, 5, 7, 9, 11°. In the experiments, the WDR incidence angles, calculated by integrating the degrees of rain inclination, slope gradients and aspects, ranged between 2^o and 72^o and 2^o and 85^o for windward and leeward slopes, respectively. Depending upon the wide range of the incidence angles, the partition of the total kinetic energy flux (KE_T, J m^{-2} s^{-1}) into its components also changed highly; for example, although the highest normal rain energy flux (KE_N = 0.247 J m^{-2} s^{-1}) was obtained with the wind free rains incident on windward slope of 2^o, the lowest was with the wind-driven rains driven by 12 ms^{-1} wind speed and incident on leeward slope of 11^o (KE_N = 0.025 J m^{-2} s^{-1}). On the other hand, for the same WDR incidences, the values of the along-surface rain energy flux (KE_S) were 0.0003 and 0.602 J m^{-2} s^{-1}, respectively. For these extreme conditions the changes for KE_N and KE_S were in the order of magnitudes of 10 and 10^3, respectively. Given the fact that the sub-processes of interrill erosion under WDR are closely related to the vector field to be formed at the impact-flow boundary and the differences in the distribution of KE_N and KE_S would result in diverse sediment delivery rates as the angle of WDR incidence vary.

Keywords: wind driven rain, vector physics, kinetic energy, angle of rain incidence,