Geophysical Research Abstracts
Vol. 14, EGU2012-7712, 2012
EGU General Assembly 2012
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The Effects of Wind Driven Rain Vectors on the Stream Power of Thin Flow

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Stream power of a thin flow is generally explained as a function of runoff and slope under wind-free rainfall conditions, and the effect of vertically impinging raindrops on flow is always considered as a resistance to its downward movement. On the other hand, the raindrop and flow interactions for interrill erosion with wind-driven rain (WDR) differ at the impact-flow boundary. Since WDR fall trajectory varies with differences in horizontal wind velocity, both magnitude of raindrop normal and lateral stresses on flow change and a vector field is established, resulting in differentially directed lateral jets of raindrop splashes with respect to downward flows occur. Therefore, to account for these differences, a vector approach with the kinetic energy fluxes or the stream powers of raindrop splashes and flow is required instead of vector-free parameters of rainfall intensity and interrill runoff. WDR experiments were conducted to evaluate the changes in the resultant stream power (Ω_r, J m^{-2} s^{-1}) with the raindrop impact velocity vector with a two-dimensional experimental set-up in a wind tunnel. Synchronized wind and rain simulations - the rains were accompanied by the horizontal wind velocities of 0, 6, 10, 12 ms^{-1} - were applied to the test surfaces on windward and leeward slopes of 2, 3, 4 5, 7, 9, 11°. By this way, the diverse WDR fall trajectories with the angle of rain incidences (Φ^o) between the wind vector and the plane of the test surface were obtained by changing slope aspect from windward to leeward. The rainfall intensity was directly measured with 20 small collectors placed over a 20 x 200 cm test pan on the inclined planes before the runs and the runoff discharges were taken every 5 min interval during 60 min WDR simulations. The results showed that the normal energy flux of WDR ($\Omega(_{drop)n}$, J m^{-2} s^{-1}) was as much as 45.4 times more in the windward slope than that of the leeward although the along-surface energy flux of WDR ($\Omega_{(drop)s}$) did not change that much as $\Omega(_{drop)n}$ did with the aspect and the value was 7.7. Whereas, the considerable differences occurred in Ω_r with the slope aspect and the ratio as large as 259.4 was attained with the rains driven by the wind velocity of 12 ms^{-1} and incident on the sloping test surface of 11°. This fact indicated that the thin flow hydraulics varied significantly with the slope aspects under WDR and could bring about substantially different sediment delivery rates.

Key words: stream power, WDR vectors, thin flow, lateral jets, angle of incidence