Geophysical Research Abstracts
Vol. 18, EGU2016-1642, 2016
EGU General Assembly 2016

An important erosion process on steep burnt hillslopes

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Steep forested hillslopes often display a high degree of armouring where diffusive erosion processes preferentially remove the fine fraction of the surface soil. High infiltration capacities, hydraulic resistance to overland flow and physical anchoring by cover plants and litter mean that even the most extreme rainfall events usually do not erode the armouring substantially. We argue that fire (wild or planned) is essential to the mobilization and transport of the armouring by increasing the rates of overland flow and decreasing trapping opportunities.
We present evidence of the types of erosion that lead to the stripping of the surface armouring using post-event surveys and high-rate overland flow experiments. The type of erosion depends on the relative abundance of non-cohesive surface material to overland flow, but we found that a particular type of transport dominates that has no representation in current erosion models: On steep slopes overland flow can lead to incipient motion of individual stones that transfer their momentum to other stones leading to a rapid mobilization of the whole non-cohesive, armoured surface layer. Once in motion, the layer quickly separates out into a granular flow front and liquefied body, akin to debris flows in channels. Depending on the size of the event, these hillslope debris flows (HDF) either get trapped or enter into the channel, stripping the hillslope of most armouring on their way. They provide channels with the material and shear stress needed to erode into the channel bed, increasing the risk of channel debris flows. We present a simple physical model of HDF initiation, movement, and possible re-mobilization on hillslopes that was derived from debris flow theory.
Understanding this process, its frequency, and magnitude are important for assessing the role of fire in landscape evolution and risk to humans through debris flow impacts.