Ref No. 13235
PIN: 4620

Assessing the Influence of Multiple Rainfall Pulses on Soil Moisture Dynamics During Long Duration Frontal Storms

Dennis M. Staley, Kevin M. Schmidt, Maiana N. Hanshaw, Jason W. Kean, and Jonathan D. Stock

Wildfire-related changes to soil properties and the consumption of vegetative canopy and root structure modify the hydrology of recently burned watersheds and may contribute to the initiation of flash floods and debris flows. To help protect communities and infrastructure from these post-wildfire hazards, the U.S. Geological Survey (USGS) and National Weather Service (NWS) have instituted a demonstration flash flood and debris flow early warning system for recently burned areas in Southern California. The criteria for issuance of a warning is based upon empirical relationships between rainfall intensities and durations, and the occurrence of past debris flow and flash flooding events from recently burned areas. While high-intensity, single-pulse rainstorms characterize spring and summer months, many flash floods and debris flows are produced in response to long-duration, frontal storm systems that occur during winter and spring months. These frontal storms commonly consist of multiple rainfall pulses. The influence of multiple pulses of rainfall on the intensity and duration of precipitation necessary to trigger flash flooding and debris flows is currently poorly understood. In order to better estimate the occurrence of flash floods and debris flows from rainfall intensity–duration thresholds during these frontal storm systems, it is necessary to determine the time period over which each rainfall pulse has an effect on watershed hydrology. The dynamics of

soil moisture during and immediately following precipitation provide a possible means of understanding the temporal effects of precipitation on the generation of saturation overland flow, one possible triggering mechanism for flash flooding and debris flows. We analyzed the temporal patterns of soil moisture decreases following precipitation events throughout the winter and spring of 2007-2008 in two recently burned watersheds in Malibu, California. Data from six soil moisture probes (4-9 cm depth) and two tipping bucket rain gages are analyzed for six long-duration frontal storms. Empirical relationships defining decreases in soil moisture were calculated for each storm were calculated for the six probes. The effects of storm duration, total accumulation and average intensity on the empirical relationship were also analyzed. Results indicate that decreasing soil moisture is best characterized by a third order polynomial. Increases in total storm accumulation, storm duration, and average storm intensity increase the amount of time necessary for soil moisture recovery. This information, when combined with overland flow and channel discharge measurements, can be used to enhance the predictive capability of the system for debris flows and flash floods generated by saturation overland flow processes produced by multiple-pulse precipitation events. The outlined methodology may also be applied to determine the temporal influence of precipitation in other regions, provided that soil moisture, rainfall accumulation and particle size distribution data are available.