By Air and Land: Estimating Post-Fire Debris-Flow Susceptibility Through High-Resolution Radar Reflectivity and Tipping-Bucket Gage Rainfall

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Wildfires often increase the occurrence of post-fire hazardous flash floods and debris flows from steeplands during intense rainfall. Rainfall intensity-duration thresholds have been used to forecast when this hazard increases rapidly; one threshold for Southern California is 15 mm/hr. However, such thresholds are usually developed with point measurements that only capture a small portion of the landscape. In an attempt to limit potential loss of life, the USGS is collaborating with NOAA on a demonstration early-warning system. To address the lack of spatial rainfall coverage, NOAA deployed a small mobile radar truck (SMART-R) to the Day fire in the western Transverse Range during the 2006-07 winter, and to the Canyon and Corral fires in the Santa Monica Mountains near Malibu during the 2007-08 winter. The SMART-R's C-band Doppler radar can be used to estimate rainfall rates over entire burned areas. On topography susceptible to debris flows within these 3 fires, the USGS installed a dense array of ground-based instruments, including 8 tipping-bucket rain gages in the Day fire, and 3 each in the Canyon and Corral fires. After converting hourly time-step grids of SMART-R reflectivity (150 m node spacing) into precipitation estimates, we compared the gage data to its spatially coincident SMART-R cell.\\Results from the Day fire indicate that SMART-R derived seasonal and event-based rainfall totals were typically greater than gage totals during the 2006-07 winter

of record-low rainfall. Both data sets, however, reflected similar spatial patterns of rainfall intensity. In contrast, for the Malibu fires there is no systematic agreement in spatial pattern or rainfall mismatch; the difference between the two data sets. Of the 9 storms recorded during this 2007-08 winter, SMART-R estimates of rainfall totals exceeded the gage totals for only 3, underestimating totals for the remaining 6. The mismatch magnitudes also exceed that of the previous winter recorded at the Day fire, and, for the largest storm of the season, was 129 mm less than a rain gage total.\\These discrepancies reduce the reliability of a potential SMART-R-advised warning system, assuming truth from ground-based gages. During the 2007-08 winter near Malibu the rain gages recorded that the 15 mm/hr warning threshold was exceeded during only one storm, and only at one gage in the Corral fire. This event transported large amounts of sediment that resulted in road closures, and it produced at least one “firehose” debris flow generated by runoff from steep, exposed bedrock. In contrast, SMART-R derived rainfall intensities exceeded this threshold at all gage locations for 2 of the 3 storms with overestimated rainfall intensities. It underestimated rainfall intensities for the 6 remaining storms; such underestimates could have led to potential false negatives, which are of concern for preserving human life.\\It is not yet clear which storms are amenable to the use of SMART-R technology for capturing spatial estimates of rainfall intensity, but results from the Day fire showing topographically forced rainfall patterns support validity of the system. Future work needs to address discrepancies arising from comparing spatially continuous atmospheric radar measurements with terrestrial point measurements. One effort to mitigate some interpretation complexities could include the installation of a disdrometer along with the rain gages, to measure rain drop-size distributions to calibrate in near real-time the relation between measured reflectivity and inferred rainfall.