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Triggering rainfall conditions of post-fire debris flows in Campania, Southern Italy

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The Campania region, in Southern Italy, is affected by hundreds of wildfires every year, mainly during the summer season. Starting from the month of September, mountain watersheds including those hit by wildfires are impacted by even more frequent intense rainstorms. In such conditions, the high sediment availability, lack of recovered vegetation and a likely stronger soil water repellency increase the likelihood of surface runoff and soil erosion, leading to potential post-fire debris flows downstream.

This work provides information on more than 100 post-fire debris flows (PFDFs) that occurred in Campania between 2001 and 2021, with a particular focus on the triggering rainfall conditions. Rainfall measurements at a high temporal resolution (10 min) were gathered from a dense rain gauge network, with an average distance between sensors and PFDFs initiation areas of 2.6 km. Information on the occurrence of PFDFs was obtained from web news, social networks, and reports produced by the Fire Brigades. The collection of accurate information related to the debris flow timing and location allowed retrieving and analyzing properties of the triggering rainfall inputs, by identifying the minimum triggering conditions with rainfall thresholds. Moreover, to evaluate the temporal structure and type of the storms associated with the PFDFs (e.g., convective or frontal systems), the standardized rainfall profiles of the triggering events were defined. The return times of the peak cumulative rainfall of the bursts in 10, 20, and 30 minutes were also calculated.

Results show that the triggering rainfall events are very short (37 minutes on average), with high average intensity (73.2 mm/h and 49 mm/h in 10 and 30 minutes, respectively), and mostly associated with severe convective systems (i.e., thunderstorms). The estimated return times are quite low, with 75° percentiles of the related distribution ranging from 2.7 to 3.2 years, indicating that these rainfall events are neither rare nor extreme, as also observed by other authors worldwide. Differences are observed in return times and the spatial distribution of the events that occurred in July-September (higher rainfall magnitudes and longer return times) rather than in October-December. The time window in which PFDFs are more likely to occur in the study area has an extension of four months, from September to December. According to the defined triggering rainfall threshold, a rainfall of 11.4 mm in 30 minutes (corresponding to an average intensity of

22.8 mm/h) is likely sufficient to trigger a PFDF in the study area.

These research outcomes provide reliable and effective support to inform decision-makers engaged in hazard assessment and risk management, in order to implement suitable countermeasures in terms of monitoring and early warning systems. It is worth noting that PFDFs often occur in small-scale watersheds characterized by very short concentration times, in response to intense bursts of less than 60 minutes. This means insufficient lead time to fully develop an effective emergency response. This and other criticalities represent serious challenges requiring additional work.