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Testing the impacts of wildfire on hydrological and sediment response using the OpenLISEM model

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Wildfires have become a major concern to society in recent decades because increases in the number and severity of wildfires have negative effects on soil and water resources, especially in headwater areas. Models are typically applied to estimate the potential adverse effects of fire. However, few modeling studies have been conducted for meso-scale catchments, and only a fraction of these studies include transport and deposition of eroded material within the catchment or represent spatial erosion patterns. In this study, we firstly designed the procedure of event-based automatic calibration using PEST, parameters ensemble, and jack-knife cross-validation that is suitable for event-based OpenLISEM calibration and validation, especially in data-scarce burned areas. The calibrated and validated OpenLISEM proved capable of providing reasonable accurate predictions of hydrological responses and sediment yields in this burned catchment. Then the model was applied with design storms of six different return periods (0.2, 0.5, 1, 2, 5, and 10 years) to simulate and evaluate pre- and post-wildfire hydrological and erosion responses at the catchment scale. Our results show rainfall amount and intensity play a more important role than fire occurrence in the catchment water discharge and sediment yields, while fire occurrence is regarded as an important factor for peak water discharge, indicating that high post-fire hydro-sedimentary responses are frequently related to extreme rainfall events. The results also suggest a partial shift from flow to splash erosion after fire, especially for higher return periods, explained by a combination of higher splash erosion in burnt upstream areas with a limited sediment transport capacity of surface runoff, preventing flow erosion in downstream areas. In consequence, the pre-fire erosion risk in the croplands of this catchment is partly shifted to a post-fire erosion risk in upper slope forest and natural areas, especially for storms with lower return periods, although erosion risks in croplands are important both before and after fires. This is relevant, as a shift of sediment sources to burnt areas might lead to downstream contamination even if sediment yields remain small. These findings have significant implications to identify areas for post-wildfire stabilization and rehabilitation, which is particularly important given the predicted increase in the occurrence of fires and extreme rainfall events with climate change.