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Quantifying thresholds for post-wildfire debris flow initiation using a combination of process-based modeling and machine learning

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Debris flows are a common hazard in steep, recently burned terrain. Rainfall intensity-duration (ID) thresholds, which are often derived for a specific geographic region, are commonly used to assess the likelihood of post-fire debris flows. However, traditional methods for estimating rainfall ID thresholds require historical data that quantify the rainfall intensities that produce debris flows. Debris flows are most common in the first year after a fire and extended monitoring of post-wildfire debris flows throughout the recovery period is rare. As a result, currently employed rainfall ID thresholds are most applicable for quantifying debris flow hazards in the first year after wildfire. Furthermore, it is difficult to derive rainfall intensity-duration thresholds in areas with little historical data. In this work, a method is proposed that combines process-based numerical modeling and machine learning to derive thresholds for post-wildfire debris flow initiation based on critical values of dimensionless discharge. By using a support vector machine method, the logistic regression functions are trained using a combination of monitoring data and hydrologic modeling of debris flow events following the 2016 Fish Fire in southern California, USA. Assuming some knowledge of soil hydrologic properties, it is shown how this dimensionless discharge threshold can be used to estimate a rainfall ID threshold. The proposed method results in a dimensionless discharge threshold that is consistent with previously derived rainfall ID thresholds for southern California. The proposed approach based on a threshold dimensionless discharge can be used to estimate rainfall ID thresholds in areas with no historical data on post-fire debris flow occurrence.