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Comparing simple and complex approaches to simulate the impacts of soil water repellency on runoff and erosion in burnt Mediterranean forest slopes

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Fires impact soil hydrological properties, enhancing soil water repellency and therefore increasing the potential for surface runoff generation and soil erosion. In consequence, the successful application of hydrological models to post-fire conditions requires the appropriate simulation of the effects of soil water repellency on soil hydrology. This work compared three approaches to model soil water repellency impacts on soil hydrology in burnt eucalypt and pine forest slopes in central Portugal:
1) Daily approach, simulating repellency as a function of soil moisture, and influencing the maximum soil available water holding capacity. It is based on the Thornthwaite-Mather soil water modelling approach, and is parameterized with the soil's wilting point and field capacity, and a parameter relating soil water repellency with water holding capacity. It was tested with soil moisture data from burnt and unburnt hillslopes. This approach was able to simulate post-fire soil moisture patterns, which the model without repellency was unable to do. However, model parameters were different between the burnt and unburnt slopes, indicating that more research is needed to derive standardized parameters from commonly measured soil and vegetation properties.
2) Seasonal approach, pre-determining repellency at the seasonal scale (3 months) in four classes (from none to extreme). It is based on the Morgan-Morgan-Finney (MMF) runoff and erosion model, applied at the seasonal scale and is parameterized with a parameter relating repellency class with field capacity. It was tested with runoff and erosion data from several experimental plots, and led to important improvements on runoff prediction over an approach with constant field capacity for all seasons (calibrated for repellency effects), but only slight improvements in erosion predictions. In contrast with the daily approach, the parameters could be reproduced between different sites
3) Constant approach, specifying values for soil water repellency for the three years after the fire, and keeping them constant throughout the year. It is based on a daily Curve Number (CN) approach, and was incorporated directly in the Soil and Water Assessment Tool (SWAT) model and tested with erosion data from a burnt hillslope. This approach was able to successfully reproduce soil erosion.
The results indicate that simplified approaches can be used to adapt existing models for post-fire simulation, taking repellency into account. Taking into account the seasonality of repellency seems more important to simulate surface runoff than erosion, possibly since simulating the larger runoff rates correctly is sufficient for erosion simulation. The constant approach can be applied directly in the parameterization of existing runoff and erosion models for soil loss and sediment yield prediction, while the seasonal approach can readily be developed as a next step, with further work being needed to assess if the approach and associated parameters can be applied in multiple post-fire environments.