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Evaluation of the OpenLisem and MohidLand models to simulate post-fire hydrological events

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The hydrological impacts of wildfires on downstream waterbodies are well documented and pose risks to both aquatic ecosystems and flood zones. Consumption of vegetation and heating-induced changes in topsoil properties by fire can substantially increase peaks in runoff and sediment yield during rainfall events, making the prediction of the hydrological response of recently burned catchment of extreme importance for assessing downstream flooding and water contamination risks. Despite recent advances, calibration of hydrological models to simulate post-fire events is still a major challenge. This is mainly due to the rapid changes in post-fire conditions between successive events (e.g. vegetation recovery, soil water repellency) and the high sensitivity of models when applied to event-based simulations.

This work aims to advance in the application of existing hydrological models to post-fire rainfall-runoff events. To this end, a calibration methodology was developed using explanatory variables measured in the field as proxies for model inputs and, as such, has the potential to be reproduced in burned catchments in different environmental settings.

Among the existing hydrological models, OpenLisem and MohidLand were selected both for their established use in Portuguese territory and for their ability to predict the hydrological response at high temporal resolutions. OpenLisem is an event-based model that simulates quickflow at a fixed time step (dependent on grid size) while MohidLand is a continuous model that simulates not just quickflow but all components of the water cycle at a variable timestep.

As a case study, a small (<1 km^2) headwater catchment in north-central Portugal was selected. The catchment was burned by a wildfire during summer 2016 at mostly moderate fire severity. A total of 12 rainfall events were selected during the first post-fire year, of which seven were used for model calibration and five for validation.

After calibrating and validating quickflow, peak flow, and time of the peaks with OpenLisem, the input field data and the calibrated parameters were used to run MohidLand at event scale. The increasing complexity from OpenLISEM to MohidLand allowed us to study the reliability of applying such methodology, and to obtain additional components of the hydrologic cycle, which are unavailable when applying OpenLISEM alone.

Saturated hydraulic conductivity and Manning's n are among the most sensitive parameters when simulating quickflow in recently burned areas and have been used as calibration parameters for the simulations. The spatio-temporal variability of both parameters at catchment level was derived from a combination of fire severity, post-fire vegetation cover, and initial soil moisture content.

Our preliminary results show that the calibration methodology provided satisfactory model performance for both OpenLisem and MohidLand. Unexpectedly, MohidLand was efficiently able to simulate quickflow at this temporal scale despite not having been, contrary to OpenLisem, developed to be applied at this temporal scale.