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Towards general models of the three-dimensional occurrence of soil water-repellency, its hydrological significance, temporal dynamics and response to climatic change

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Although it is well-established that soil water-repellency exists – at least transiently - in some vegetation/land-use types within a wide range of climatic zones, it varies greatly both in its four-dimensional character and the nature and significance of its hydrological effects. Thus within landscapes, soil water-repellency varies not only in severity, but also in percentage cover, spatial pattern and connectivity; in vertical position and vertical extent; in its temporal regime; and in the presence/absence and frequency of bypass routes through any hydrophobic layer. The nature and degree of significance of any hydrological impacts of hydrophobicity are very dependent on these variations. Assessments of the likely impacts of current and future climatic change on hydrophobic (or potentially hydrophobic) environments need to take these variations in the four-dimensional nature of hydrophobicity and their controlling factors and mechanisms into account.

This poster paper presents and discusses a series of conceptual models that together attempt to understand the factors and mechanisms controlling soil water-repellency and its hydrological consequences. The paper draws on a combination of: (1) results of field measurements and experiments in burned and unburned scrub, pine and eucalyptus terrain in central Portugal; (2) laboratory experiments of the influence of the presence/absence of basal impedance and cracks, root-holes and stones on the temporal dynamics of three-dimensional patterns of repellency in wetting and drying cycles; and (3) findings from a wider range of environments and locations from the published literature.

Three conceptual models are considered. The first addresses the environmental factors that control and influence the occurrence and three-dimensional structure of soil water-repellency within landscapes. Within this model, the emphasis is placed on vegetation, land-use and land management (including their influence – together with climate - on fire frequency, nature and impact) as the fundamental factors driving spatial and vertical patterns of soil water-repellency via their influence on spatiotemporal regimes of supply, depletion and replenishment of hydrophobic substances. Geological, topographic and geomorphological and land-use history factors, via their influence on key soil variables, are also identified as being of basic importance. The second model considers the factors and mechanisms influencing the three-dimensional temporal dynamics of soil water-repellency (including the speed and patterns of disappearance and re-establishment in wet weather and following fire episodes). The third model focuses on the factors and mechanisms influencing the nature and significance of hydrological consequences of soil water-repellency within landscapes. Of key importance here are not only factors influencing the presence, temporal regime and degree of severity of hydrophobicity, but also those controlling its spatial contiguity and vertical extent and the frequency of preferential flow routeways. Possible implications of future climatic change on hydrophobicity and its hydrological significance are explored with reference to the three models presented.