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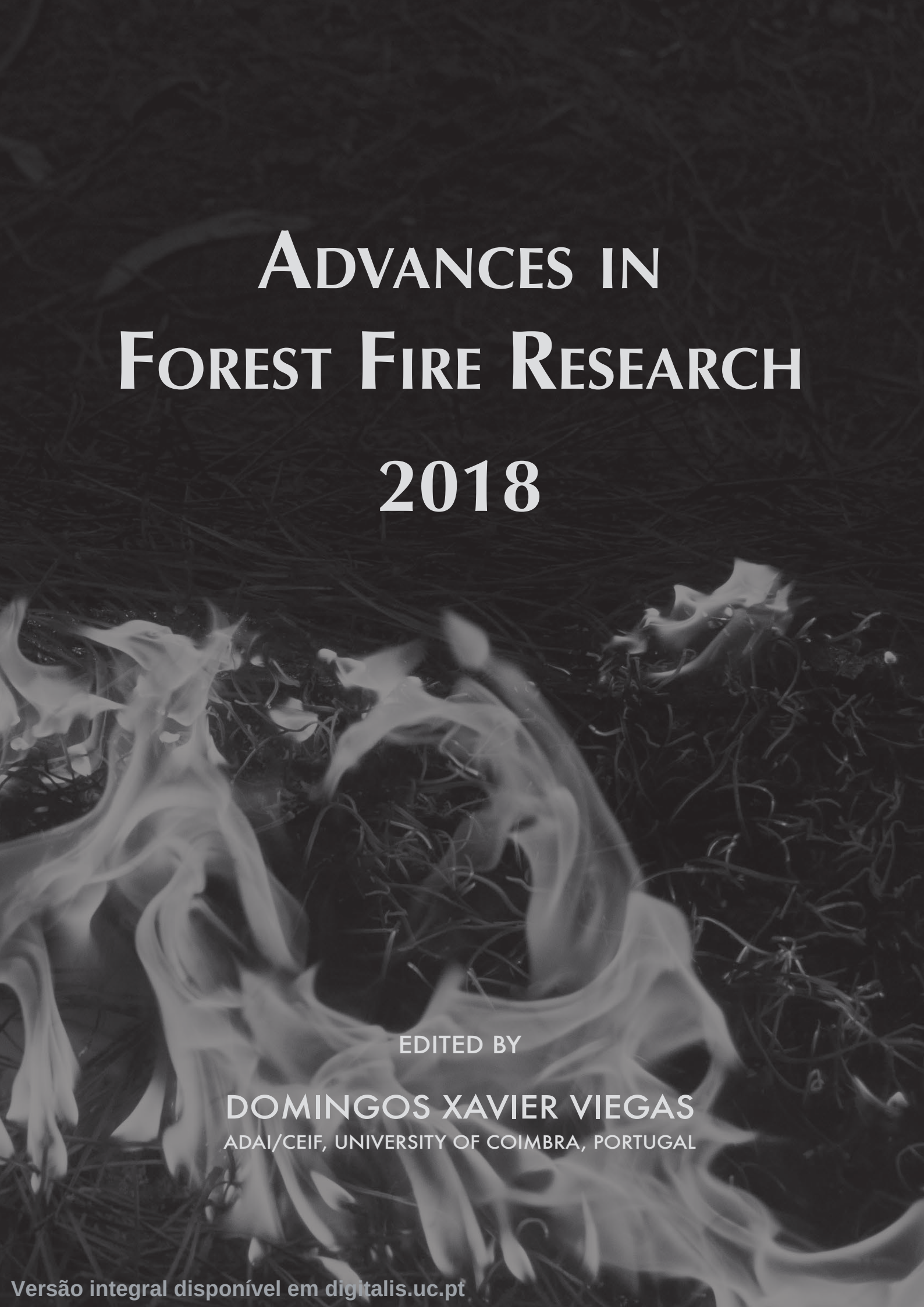

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The role of the terrain-modified wind on driving the fire behaviour over hills – an Experimental and Numerical Analysis.

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Abstract

This paper analyses the fire behaviour over two hills placed in series in the direction of the wind. Laboratory-scale experiments under various slope and wind velocity conditions with changing the distance between the hills revealed two sorts of extreme fire behaviour that might take place. One is a lateral fire spread over the lee slopes (fire channelling), and the other is an eruptive fire behaviour (blow-up) happens over the windward face of the secondly ordered hill in the direction of the wind. The changes in the blowing wind velocity and the distance between the hills were found to have a significant effect on fire behaviours, where increasing the wind speed or the distance resulted in a faster rate of spread of the fire. Also, the change of the ignition point, or spreading direction of the fire relatively to the wind direction has a significant effect on the fire channelling behaviour where it was found that the fire channelling is more extreme if the fire is spreading against the main wind direction. Numerical analysis of the adiabatic flow field showed that the change the presence of these extreme fire behaviour is related directly to the terrain-modified flow topology. The interactions between the terrain-modified wind mechanisms and the fire result in accelerated flows that drive the indicated extreme fire behaviours.

Keywords: Fire channelling, lateral fire spread, fire over slopes, fire-induced wind, eruptive fire, fire blow-up

1. Introduction

Wildfire behaviour has caught the attention of wildfire researchers during the last decade to understand how the fire is behaving under certain conditions in order to better predict the wildfire evolution. Identifying the conditions where an extreme fire behaviour (Viegas 2004) may take place is crucial for the safety of the firefighting teams and the wildland-urban-interface (WUI) communities. The wind, complex terrain and their interactions are common conditions that may lead to extreme fire behaviour. Many numerical and experimental studies were carried out to analyse the fire behaviour over the complex terrains namely on slopes and hills. However, we still lack understanding on the behaviour of fire spreading over complex terrains, namely the effect of having other topographic obstacles around the topography of interest (i.e. the topography that the fire propagates over it). In this paper, we are investigating the fire behaviour over hills ordered in series in the direction of the wind. This configuration is closer to the existence of hills in nature, where the hills are rarely found isolated as the configuration that was investigated on the previously mentioned studies.

Previous studies (McRae 2004; Sharples *et al.* 2012) showed that, for a fire spreading over the leeward face of a hill with the wind blowing perpendicularly to the hill's ridgeline, a lateral enlargement of the fire front near the ridgeline occurs. McRae (2004) first noticed this phenomenon and designated it as 'fire channelling' or 'lee-slope channelling'. Sharples *et al.* (2012) has investigated the phenomena based on real-fire observations, where analysis of several possible mechanisms revealed that hill's lee-slope eddy plays a key role in driving the fire channelling process. The process is proposed to be a result of an interaction between the fire-induced convection (pyro-convection) and the terrain-modified winds through mechanisms that still needs to be investigated. An experimental study by (Raposo *et al.* 2015) was conducted on an isolated prismatic hill with horizontal ridgeline, and it demonstrated that the fire enlarges symmetrically on the two directions near the top of the crest