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Exploring the Potential of Sentinels-1 & 2 of the Copernicus Mission in Support of Rapid and Cost-effective Wildfire Assessment

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ABSTRACT

The present study explores the use of the recently launched Sentinel-1 and -2 data of the Copernicus mission in wildfire mapping with a particular focus on retrieving information on burnt area, burn severity as well as in quantifying soil erosion changes. As study area, the Sierra del Gata wildfire occurred in Spain during the summer of 2015 was selected. First, diverse image processing algorithms for burnt area extraction from Sentinel-2 data were evaluated. In the next step, burn severity maps were derived from Sentinel-2 data alone, and the synergy between Sentinel-2 & Sentinel-1 for this purpose was evaluated. Finally, the impact of the wildfire to soil erodibility estimates derived from the Revised Universal Soil Loss Equation (RUSLE) model implemented to the acquired Sentinel images was explored. In overall, the Support Vector Machines (SVMs) classifier obtained the most accurate burned area mapping, with a derived accuracy of 99.38%. An object-based SVMs classification using as input both optical and radar data was the most effective approach of delineating burn severity, achieving an overall accuracy of 92.97%. Soil erosion mapping predictions allowed quantifying the impact of wildfire to soil erosion at the studied site, suggesting the method could be potentially of a wider use. Our results contribute to the understanding of wildland fire dynamics in the context of the Mediterranean ecosystem, demonstrating the usefulness of Sentinels and of their derived products in wildfire mapping and assessment.

1. Introduction

At a global scale, about 350 million hectares of land are annually affected by fire events (van der Werf et al., 2006). Wildland fires play an important role in the evolution, organization and distribution of ecosystems (Knorr et al., 2011; Koutsias et al., 2012; Ireland and Petropoulos, 2015). They also have negative effects, such as being a threat to the natural environment, wildlife, the economy and putting human life at risk (Tanase et al., 2015; Vhengani et al., 2015). In the Mediterranean region, wildfires are regarded as one of the most threatening natural disasters to effect property and infrastructure, with wildfires having a long and important presence in the region, intertwined with the area's history. On a regional scale, nearly 90% of all wildland forest fires within the boundaries of the European Union take place in Mediterranean countries (Petropoulos et al., 2011). This translates to approximately 65,000 fires every year, which in turn burn, on average, half a million hectares of forested areas (European Commission, 2010). The damages caused by wildfire events and the potential for more frequent events have led to policy changes to reflect changing attitudes globally. Policies towards wildfires in the European region in particular are driven by the European Union (EU), specifically the establishment of the European Forest Fire Information System (EFFIS, http://effis.jrc.ec.europa.eu/). This collaboration has allowed EU member states to have uniform information on forest fires in the Pan-European region (European Commission, 2015). Exchanges of information on fire prevention and restoration practices, amongst other activities are enabled by this collaboration.

One of the issues with an increase interest in fires occurrence globally and regionally is that there is an accompanying rise in costs to monitor and suppress these events. Therefore, there is a need to understand patterns of fires and develop or further improve cost-efficient techniques of mapping burned areas (Kalivas et al., 2013; Lentile et al., 2006; Said et al., 2015). A number of approaches are available to evaluate the extent and damage of wildfires. Due to the rise in

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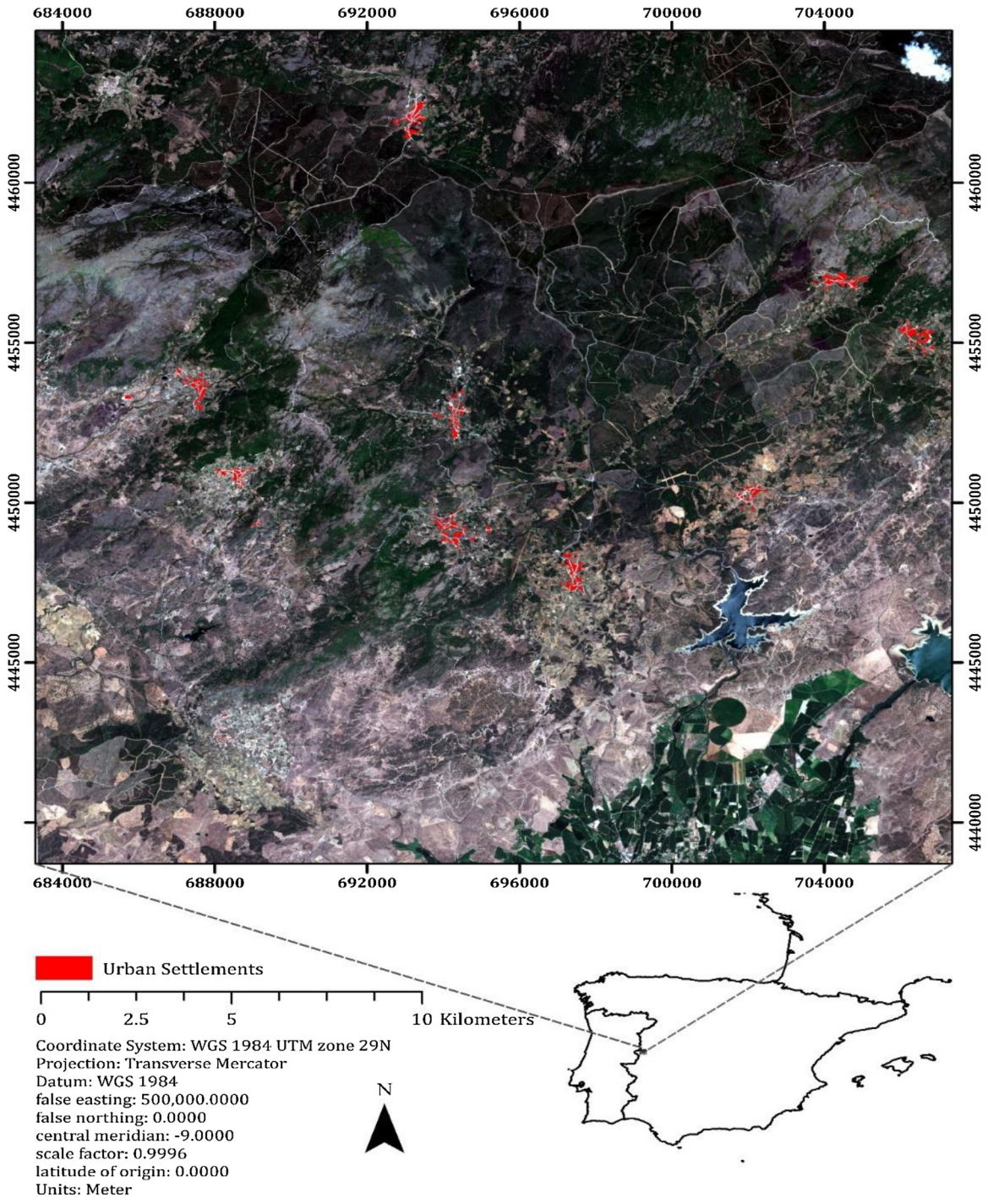

Fig. 1. Location of study site, Sierra de Gata, within Caceres, Spain. Image acquired from Sentinel -2 on August 4, 2015.

accessible Earth Observation (EO) products, wildfire risk and areas affected can be mapped with relatively low labor-intensive costs over large areas (Vhengani et al., 2015). The use of EO datasets for this purpose has been advocated by many, as when gathering ground fire severity estimates there is considerable effort and labor involved. EO has been recognized as being essential for landscape level assessments of wildland fires (Tanase et al., 2015). Some of the main advantages of using EO data when exploring wildland fires is that large areas can be assessed with relative ease and cost (Cohen and Goward, 2004; Petropoulos et al., 2014), as well as assessing regions that are inaccessible at regular time intervals (Tanase et al., 2015).

The Copernicus is the umbrella name for a number of satellite missions including optical instruments, altimetry systems, radiometers and spectrometers (Borgeaud et al., 2015). Two of the most recent missions within Copernicus are the Sentinel missions. Each Sentinel is based on a constellation of 2 satellites in the same orbiting pattern, with Sentinel-1 a C-band SAR system (Torres et al., 2012) and Sentinel-2 a multispectral high-resolution optical satellite system (Drusch et al., 2012; Fletcher, 2012; Fernández-Manso et al., 2016; Chatziantoniou et al., 2017). Sentinel-1 A was launched on 03 April 2014 and -1B on 25 April 2016, with Sentinel-2 A launched on 23 June 2015 and 2B planned for launch in 2017 (Fernández-Manso et al., 2016; European Space Agency, 2016). Sentinel-2 in particular, has been used in a wide range of applications, including land-use and land-cover mapping

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