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ORIGINAL PAPER

Spatially modeling wildland fire severity in pine forests of Galicia, Spain

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Abstract Fire is a major disturbance in forests and one of the most important carbon emissions sources, which contributes to climate change. Carbon emissions are directly correlated with the degree of organic matter consumption or fire severity. Gaining knowledge about the relative strength of the various explanatory variables is essential to mitigate its environmental impact. We tested an approach that combines wind modeling, light detection and ranging (LiDAR), remotely sensed vegetation indices and topography data for assessing the occurrence of high-severity fire using the random forests ensemble learning method. Data from four wildfires that occurred in Galicia (northwestern Spain) were used to exemplify the application of this approach. The models predicted high-severity occurrence with a classification accuracy ranging from 77 to 94%. High-severity fire occurred more frequently in areas of high simulated wind speed, and more pronouncedly, for cases reported as wind-driven fires. High severity also occurred more frequently in areas of high terrain roughness, on sunny slopes and in low canopy base height stands. This approach allowed predicting spatially explicit fire severity at a mean scale level (resolution of 25 m) with accuracy rates from 80 to 95%. This approach may be helpful for fire managers when delimiting and planning fuel treatments for severity mitigation or during fire suppression, and for post hoc case studies.

Keywords High-severity fire · Fire weather · Canopy fuels · Topography · Landscape scale · Random forests model · Conifer stands

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Introduction

Wildfires are an important source of greenhouse gases emissions to the atmosphere, substantially contributing to climate change (Kasischke et al. 2005; van der Werf et al. 2006; Bowman et al. 2009; Kaiser et al. 2012). Those emissions may also have a feedback effect on wildfires. Climate change may create warmer and drier conditions (Brown et al. 2004) and affect wildfire regimes (Westerling et al. 2006; Flannigan et al. 2013), increasing area burned, fire season duration and the number of high-risk fire events (Stocks et al. 1998; Gillett et al. 2004; Turetsky et al. 2011). In the Mediterranean region, projections of climate change suggest an increase in wildland fire intensity and severity (Moriondo et al. 2006; Bedia et al. 2013, 2014). Despite the complexity in estimating the relationship between forest fires occurrence and the carbon cycle (Prentice et al. 2011), it is accepted that burned area and fire severity are positively correlated with the volume of gas emission (Balshi et al. 2009; Turetsky et al. 2011).

Although there is no single definition of the term "fire severity," it is generally used to reflect the magnitude of the effect of fire on soil and vegetation (Ryan and Noste 1985; Keeley 2009). Crown fire is often considered characteristic of extreme fire behavior during a wildfire (Alexander and Cruz in Werth et al. 2011) and is generally ranked as one of the highest degrees of fire severity