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Stochastic gradient boosting classification trees for forest fuel types mapping through airborne laser scanning and IRS LISS-III imagery

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ABSTRACT

This paper presents an application of Airborne Laser Scanning (ALS) data in conjunction with an IRS LISS-III image for mapping forest fuel types. For two study areas of 165 km² and 487 km² in Sicily (Italy), 16,761 plots of size 30-m × 30-m were distributed using a tessellation-based stratified sampling scheme. ALS metrics and spectral signatures from IRS extracted for each plot were used as predictors to classify forest fuel types observed and identified by photointerpretation and fieldwork. Following use of traditional parametric methods that produced unsatisfactory results, three non-parametric classification approaches were tested: (i) classification and regression tree (CART), (ii) the CART bagging method called Random Forests, and (iii) the CART bagging/boosting stochastic gradient boosting (SGB) approach. This contribution summarizes previous experiences using ALS data for estimating forest variables useful for fire management in general and for fuel type mapping, in particular. It summarizes characteristics of classification and regression trees, presents the pre-processing operation, the classification algorithms, and the achieved results. The results demonstrated superiority of the SGB method with overall accuracy of 84%. The most relevant ALS metric was canopy cover, defined as the percent of non-ground returns. Other relevant metrics included the spectral information from IRS and several other ALS metrics such as percentiles of the height distribution, the mean height of all returns, and the number of returns.

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1. Introduction

1.1. Forest fuel type mapping

Fire is one of the most important factors affecting the dynamics of Mediterranean forests, and its intensity and recurrence may substantially affect successional pathways, even preventing post-fire auto-successional trends (Moreira et al., 2011; Brivio et al., 2009). In the period 2006–2009, fires affected approximately 1,366,000 ha of European forests (Forest Europe, 2011). The European Forest Fire Information System of the European Commission (EC, 2011) indicates that the most affected areas, excluding the Russian Federation, are the five southern member states: Portugal, Spain, France, Italy and Greece. In these five countries, fires burnt a total area of

14,620,968 ha during the period 1980–2010. Annual totals varied from 158,621 ha in 2008 to almost one million ha in 1985.

Fires reduce flows of forest ecosystem services (Mavris et al., 2012) such as wood and non-wood products, game for hunting, soil protection, recreational and social value, carbon sequestration, biodiversity protection.

The amount of fuel loading, as well as forest composition and forest structure, affect the characteristics and frequency of forest fires (Schmidt et al., 2002). Thus, an accurate description of the forest in terms of fuel conditions is essential to support fire management and to predict fire risk (Chuvieco et al., 2004).

Describing fuel conditions is an extremely complex task because multiple variables must be considered. The total amount of biomass in different forest components (herbs, shrubs, trees), as well as fuel structural characteristics (surface-area-to volume ratio, fuel density, fuel loading, height and stratification of fuel strata), fuel chemical composition and moisture content all affect fire behavior. To simplify the description of a forest area in terms of these characteristics, vegetation types with similar fuel conditions are grouped

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