Identifying pyroregions by means of Self Organizing Maps and hierarchical clustering algorithms in mainland Spain

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Abstract

Defining pyro-regions, i.e., of homogenous zones of fire activity, is an on-going task in Spain with few case studies in the literature. Their characterisation and understanding is a crucial step towards improving forest fire management and prevention. It is widely agreed that fire activity is non-stationary. Several works already report temporal dynamics in fire frequency and burned area. In this work we propose a spatial-temporal approach to define pyro-regions considering both structural and temporal fire behaviour using historical fire records from the EGIF database. A combination of Self Organizing Maps (SOM) and hierarchical clustering is applied to time series (1974-2015) of fire regime features: number/burned area of summer fires, number/burned area of large fires (>500 ha), number/burned area of natural fires, number/burned area of winter fires and number of small fires (<1 ha). The structural component of fire activity is computed as the average value whereas the temporal evolution is addressed by means of Sen’s slope.

Prior to cluster analysis, fire features were submitted to Principal Component Analysis with Varimax rotation. Eigenvalues were then pre-classified using SOM. Subsequently, hierarchical clustering was applied to SOM outputs. We obtained a set of 4 structural clusters relating to increased number of fires; low fire incidence, slightly linked to winter season; large and natural fires; and moderate impact of human-related large fires mainly. The process was repeated using Sen’s slope to build the dynamic component, ultimately characterised by: highly dynamic winter with increased in summer frequency; increased summer burned area and natural fires; and small fires; and no trend.

Keywords: forest fires, pyro-regions, Sen’s Slope, SOM, hierarchical clustering, Spain

1. Introduction

Forest fires are a highly complex phenomenon affecting most ecosystems worldwide. Fire is known as a natural process responsible for the evolution of wild communities, but nowadays it has been altered, with potential undesired effects on vegetation structure, composition and ecosystemic functions. Fire activity is controlled by multiple factors such as climate, fuel, physiography and human activity. Humans influence fire incidence acting as both initiators and suppressors, increasing the complexity of the phenomena. Thus, understanding fire regime’s components and behaviour (both temporal and spatial) may improve our current knowledge. Mapping fire regimes may contribute enhancing fire planning or risk assessment; as well as diminishing undesired ecological impacts (Morgan et al. 2001). In this sense, one of the most promising lines of study lies in the definition and characterization fire regime itself. Fire regime is usually described using several quantifiable parameters such as affected area, fire frequency, cause, seasonality, fire size, etc. (Boulanger et al. 2014). Currently, there still is an open debate on the definition of the concept itself, with slight variations depending on the scale of analysis, the length of the study period or the available information.