Geophysical Research Abstracts
Vol. 20, EGU2018-14568, 2018
EGU General Assembly 2018

Spatial-temporal modeling of forest fire behavior: modeling fire ignition and propagation from MCD64A1

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Due to the improvements in data collection systems and the availability and accessibility of these, new opportunities for the analysis of the impact of fire arouse. In recent decades, the implementation of new sensors on board of satellite platforms has allowed the development of new products and the creation, among others, of new algorithms for detecting burned areas. These algorithms allow the incorporation of dates and locations of ignition at a global scale as well as capturing spatial patterns in the behavior of fire, not feasible using other sources such as fire spread. In summary, they open new research lines to overcome some of the limitations of traditional fire databases such as the lack of data in depopulated regions, or inconsistencies when combining different data sources.

In this work, we present two algorithms, based on the MCD64A1 product, which allow (i) to identify fires, determine the point and date of ignition, and (ii) simulate the general flow of fire propagation. The process of individualization is partially based on the model proposed by Archibald and Roy (2009), developed specifically for the product MCD45A1. Their methodology has been adapted to the new product MCD64A1, also incorporating some improvements such as the detection of clusters of fire pixels from temporal moving windows, which substantially improve the individualization of fire perimeters. On the other hand, the simulation of the propagation flow is partialy based on the method proposed by Frantz et al. (2016). The method proposed in this work is based on the identification of temporal patches of affected pixels (opposed to pixel-based approaches) and then modeling the direction of the propagation, prioritizing the temporal distance over the spatial separation. By doing so we overcome some limitations of previous methods like the lack of continuity in the detection of affected pixels on the same date, which led to unrealistic patterns of spread.

The method for fire individualization has been applied successfully in four MODIS scenes (h17-18; v4-5) in the period 2008-2011. The detected ignition point cloud was later compared with existing databases in the study area. About 53% of the verified ignition points were estimated within a threshold of less than 2 days and a spatial distance of less than 2500 meters from actual ignition points reported in the EGIF database. On the other hand, the propagation simulation has been applied to two large fires that occurred during 2011 in Spain in the municipalities of Benicolet (Valencia) and Sant Joan de Labritja (Ibiza), affecting 1,480 ha and 1,443 ha, respectively. The Benicolet fire was an arson fire with several simultaneous ignition points, while fire in San Joan de Labritja was caused by negligence. In both cases, the main propagation flow has been simulated satisfactorily, although the algorithm is still in development. It needs further calibration and application to other fires, as well as more efficiently incorporating information about the uncertainty on the reported date of ignition.