Fire in the Earth System Abstracts
Vol. 2 FES-223
Granada, Spain, 4-8 July, 2023

Capabilities of unmanned aerial vehicles for the classification of forest fuels in Mediterranean environments using machine learning techniques

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Abstract

Forest fires are one of the main disturbances in Mediterranean ecosystems. In order to understand fire behaviour in a forest stand it is necessary to know the forest fuels, as they provide valuable information on fire spread and intensity. In this study we evaluated the ability of unmanned aerial vehicles (UAVs) to classify Prometheus fuel types in several forest environments in Aragon (NE Spain) using machine learning classification models. We used two UAV units: i) a SenseFly "eBee Classic" with RGB (Sony-WX) and multispectral (Parrot Sequoia 4 spectral bands) cameras, which allowed us to obtain vegetation indices and photogrammetric point clouds; and ii) a "DJI Matrice 300 RTK" with a LiDAR sensor (DJI Zenmuse L1) to obtain three-dimensional point clouds of the entire vegetation structure, thanks to its ability to penetrate the canopy down to the ground. Both point cloud dataset allowed the generation of variables related to vegetation structure (i.e. height and density) and textural features using the grey-level co-occurrence matrix (GLCM) approach. The ground truth was formed by the fuel types estimated in the field. The Dunn's test of multiple comparisons determined the most relevant structural and textural variables and vegetation indices to be included in the predictive models generated using Support Vector Machine with radial (SVM-R) and linear (SVM-L) kernels and Random Forest (RF). The results show that UAVs can successfully classify fuel types, with higher overall accuracies when classifying with RF and when using the LiDAR UAV (accuracy=75%) instead of the optical UAV (accuracy=71%). The main confusions between types were found in types 3 and 6, many of which were classified as type 2 and 7, respectively. However, the confusions found in type 3 were minor when classifying with the LiDAR UAV. The SVM-R and SVM-L models achieved lower overall accuracies and higher confusions in all fuel types. These results show the capacity of UAVs for forest fuel classification using machine learning techniques and their potential for Mediterranean forests management.

Keywords: Fuel models, UAVs, Random Forest, Support Vector Machine, Mediterranean forests

Acknowledgments: This work was supported by the Spanish Ministry of Science, Innovation, and Universities through an FPU predoctoral contract granted to R.H. (FPU18/05027), and by the Government of Aragon (Geoforest S51_20R co-financed with FEDER “Construyendo Europa desde Aragón”).