Analysis of dense optical time series for the spectral and temporal characterization of bark beetle attacks

Recent years have seen an increase in the frequency and severity of disturbances[1], with 17% (39 million ha) of Europe's forested areas affected between 1986 and 2016[2]. Accordingly, it is important to better understand disturbance dynamics to 1) define forest management practices to improve resilience; 2) improve reaction and mitigation strategies; and 3) develop better detection algorithms based on remote sensing data. Disturbance monitoring with remote sensing has been widely addressed, even though most of the focus has been devoted to stand replacing disturbances. Existing works focused on non-stand replacing disturbances (NSRD), often considered only yearly composites [3,4]. With Sentinel-2 and other constellations in orbit for several years, time series with unprecedented combined spatial and temporal resolutions spanning several years have become widely accessible. Consequently, it is now possible to characterize NSRD at a monthly or higher temporal resolution on a large scale.

The aim of this work is to explore the temporal and spectral patterns of bark beetle attacks by analyzing Sentinel-2 time series. To this end, 500 30x30m areas attacked by bark beetles were sampled in the Trentino province, northern Italy, from existing disturbance maps[5]. For each attacked area, 25 points were randomly sampled in healthy forest at 20 m from the border of the attack, for a total of roughly 12000 samples. This was to provide reference spectral values for comparison and to standardize the spectral trajectories of the affected areas relative to their environmental context. For each area, we computed the spectral trajectory of 3 spectral indexes: Normalized Burned Ratio (NBR), Normalized Difference Moisture Index (NDMI) and Normalized Difference Vegetation Index (NDMI). Then, we estimated the start and end dates and magnitude of attack using the 3 indexes. Start and end dates were estimated as the first dates when the spectral index surpassed a threshold (two separate thresholds for start and end of attack) for all the remaining of the series. Results showed that the NDVI allows for the detection of the start of the attack slightly earlier with respect to the NBR and NDMI. In contrast, the end of the attack is detected in average 10 days earlier with NBR and NDMI compared to the NDVI. Regarding attack magnitude, NBR and NDMI showed the highest average values (0.49 and 0.48) compared to NDVI (0.38).

Accordingly, in the second part of the analysis, only the NBR was considered. For each point, we considered the elevation, and we estimated the daily minimum, maximum and mean temperature by kriging spatial interpolation of field meteorological stations data. Preliminary results showed that elevation is weakly correlated to attack duration and magnitude. In contrast, temperature showed a correlation with both attack duration and magnitude. As the average temperature during the attack increases, the attack duration decreases while the magnitude increases. Moreover, we also analyzed the thermal sum in the period prior to the attack. Results showed that as elevation increases, the thermal sum required for the start of the attack decreases.

References

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