Assessing the role of Mediterranean evergreen oaks canopy cover in land surface albedo and temperature using a remote sensing-based approach

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1. Introduction
In arid and semi-arid areas such as the Mediterranean region, tree canopy cover plays a fundamental role in several ecosystem processes (e.g., water recycling, surface cooling). In this study, a savannah-type evergreen oak woodland known as montado (in Portugal) or dehesa (in Spain), was used as a case study because it represents one of the most characteristic and important ecosystems existing in the Mediterranean basin.

2. Objectives
The main goal of this study was to develop an effective remote sensing-based methodological approach to demonstrate the direct role of montado canopy cover in regulating local Land Surface Albedo (LSA) and Land Surface Temperature (LST).

3. Data and Methods

Montado tree canopy cover information:
- 849 Landsat-5 TM pixels distributed over the study area were used to calculate the percentage of montado canopy cover using high-resolution (< 1 m) aerial photographs. For each pixel, the entire montado canopy intercepted by the 30x30m polygon was screen-digitised and then the percentage of pixel area covered by montado canopy was calculated (Figure 3).
- by using the percentage of montado canopy cover as a dependent variable, and Landsat-TM multispectral bands acquired during the summer of 2011 and six derived vegetation indices as the explanatory variables, several predictive models were tested using the Stochastic Gradient Boosting algorithm.
- The estimated montado canopy cover (%) at Landsat pixel level was aggregated at MODIS 1km pixel level;

LSA and LST information:
- The MODIS data used (h17v05 tile) comprises the shortwave white sky albedo (WSA) product (Collection 5 MCD43B3, 1-km spatial resolution, 16-day composites) and the daytime land surface temperature product (Collection 5 MYD11A2, 1-km spatial resolution, 8-day composites) obtained for the period between January and December 2011.
- The 468-day observations in 2011 of MODIS products (LSA and LST) were averaged to smooth seasonal variability and to obtain the mean annual LSA and LST values.

4. Effects of montado canopy cover on LSA and LST
4.1. Land Surface Albedo
A strong statistical relationship (R² = 0.866, p<0.001) between montado canopy cover percentage and mean annual surface albedo is clearly demonstrated in Figure 5. It was found that higher canopy cover percentages correspond to lower average surface albedo.

The comparisons between contrasting montado canopy cover percentages showed marked differences in surface albedo (Figure 6a). The Kruskal–Wallis test revealed that mean annual LSA values were significantly different between the four classes of canopy cover percentages (χ² = 192.17, df = 3, p<0.001).

It was found that albedos of MT_4 and MT_1 classes, which represent, respectively, the highest (>70%) and the lowest (10-30%) level of montado canopy cover percentage, differed by 0.015 in mean annual LSA values, therefore corresponding to a relative difference of 11.2%.

4.2. Land Surface Temperature
The comparisons of respective mean annual LST between these four classes reveal statistically significant differences between them (χ² = 318.18, df = 3, p<0.001). In terms of mean annual LST, MT_1 appeared to be the warmest canopy cover class (27.22°C, SE ±0.05), followed by MT_2 (26.28°C, SE ±0.05), MT_3 (25.14°C, SE ±0.08), and MT_4 (23.80°C, SE ±0.09) (Figure 6a).

Differences in mean annual LST can be around 0.94 – 3.42 °C depending on the pairs of montado canopy cover classes (Figure 6b). The surfaces in the lowest level of montado canopy cover percentage (MT_1) were, in average, 3.42 °C warmer than dense montado areas (MT_4), being this difference even more evident during the summer season (6.57 °C, data not shown).

5. Conclusions
- The responses of both LSA and LST to different ranges of montado canopy cover percentages showed a strong negative relationship.
- treeless montado areas (MT_1) showed an increase of 11.2% and 14.4% in LSA and LST values, respectively, when compared with dense montado areas (MT_4).
- Results clearly demonstrate that a potential tree canopy cover regression in a Mediterranean semi-arid ecosystem such as the montado/dehesa may produce significant changes in two of the most important biogeophysical parameters (LSA and LST), which from a long-term perspective may potentially alter the micrometeorological conditions.