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Comparison of two fAPAR remote sensing methods for estimating Gross Primary Production

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INTRODUCTION

Holm oak savannah (*dehesas*) cover 3x10^6 ha in the Iberian Peninsula and the management of these multifunctional ecosystems have a strong impact in rural economy. Thus, decision-makers need the support of quality and accurate information at large scale of dehesa productivity and its externalities. However, measuring Gross Primary Production (GPP) and carbon exchange is time consuming, the measurements are sparse in space, and still prone to uncertainty. In addition, upscaling in situ GPP is challenging for regional and global studies when significant spatial variability of plant functional types or vegetation stress is present. Remote sensing techniques on the other hand have potential to provide cost-effective spatially distributed fields of GPP.

In this study we evaluated the estimation of GPP through Monteith's model based on the relation between plant growth and absorbed solar radiation. The fraction of Absorbed Photosynthetically Active Radiation (fAPAR) was estimated using two remote sensing methods.

METHODOLOGY

Three hyperspectral airborne acquisitions were used: 29th of April (maximum of vegetation vigor), 20th of May (annual vegetation is decreasing vigor) and 27th of August (only perennial vegetation).

Gross primary production was obtained using an adaptation of Monteith model (1977)*:

$$GPP = \int fAPAR * PAR * \varepsilon * dt$$

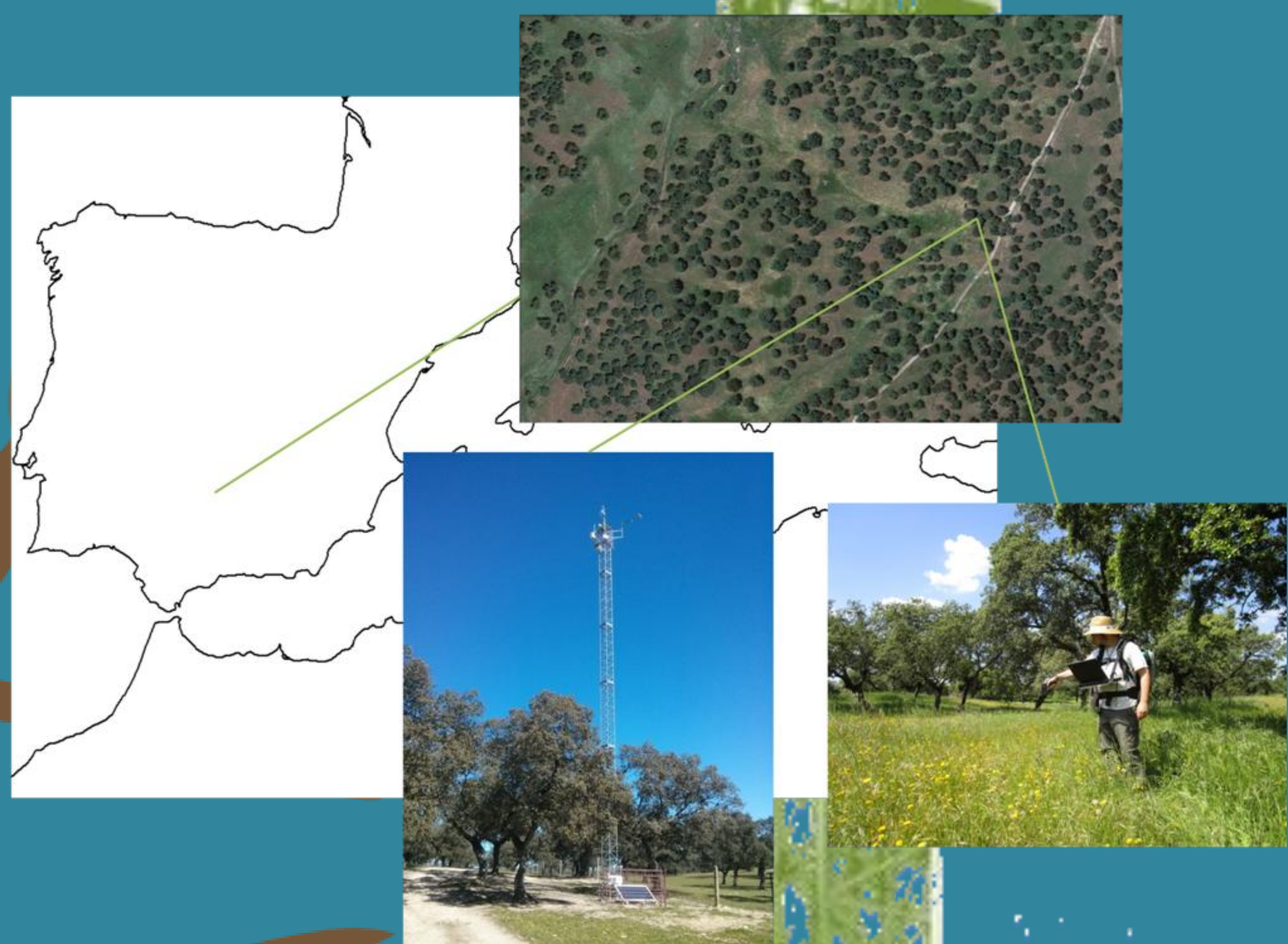
it is modified according to daily minimum temperature and vapor pressure deficit.

fAPAR (dimensionless): is estimated from two different ways:

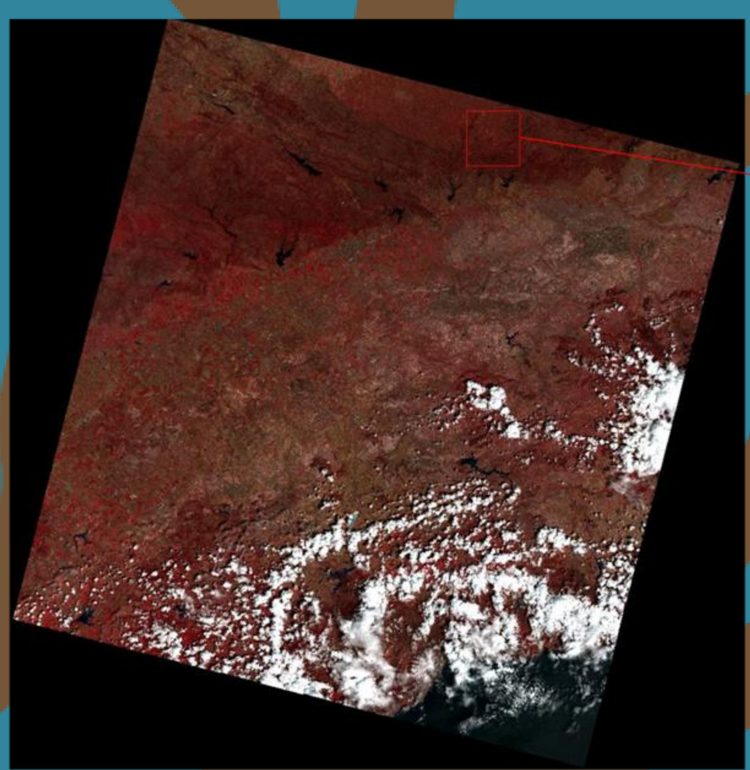
1) fAPAR relating NDVI and *in situ* data. fAPAR for oak was estimated as an average of 15 trees of the area with LP-80 ceptometer. For pasture fAPAR, an empirical linear equation NDVI-fAPAR using LP-80 ceptometer and ASD-FieldSpec FR radiometer was applied. fAPAR at Landsat scale was estimated based on the fraction of tree cover within the pixel.

2) fAPAR using hyperspectral data by inverting Prospect4SAIL using an Artificial Neural Network. : 100 000 forward simulations were run and split into a training dataset (70000 cases) and a testing dataset (30000 cases) for an ANN with 1 hidden layer with 50 nodes and linear activation functions.

GPP estimates using both approaches were compared with in situ daily GPP measured with an Eddy Covariance system applying an estimate of the daily EC footprint.

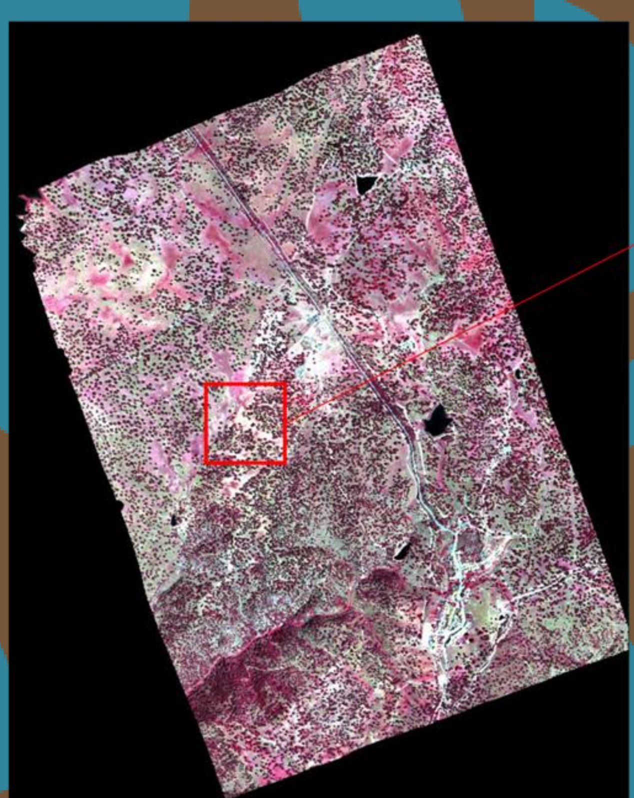


RESULTS

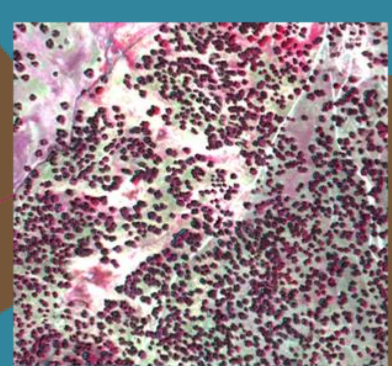


Infrared composition of LANDSAT 8 for 20 of May (Bands 5,4,3)

fAPAR estimated relating NDVI and in situ data

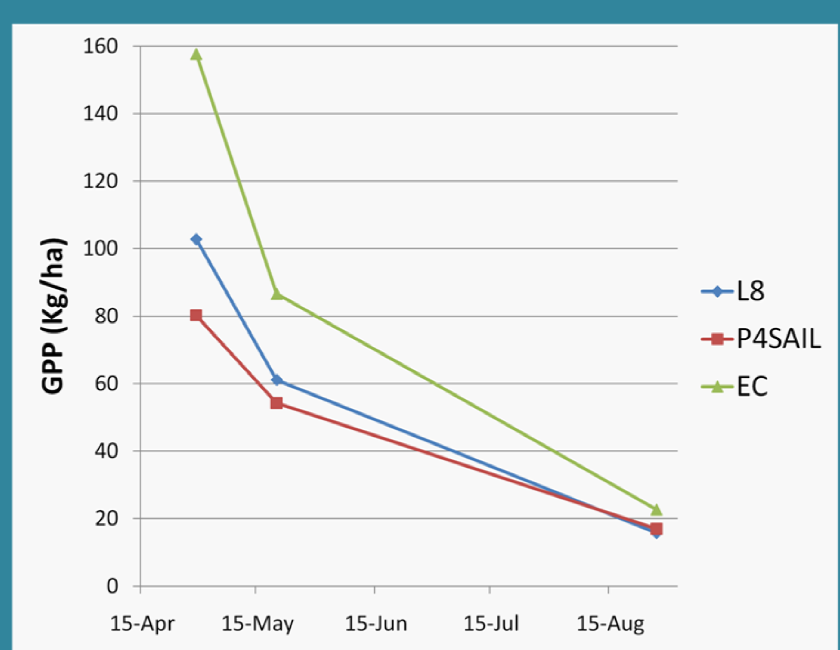


Infrared composition of hyperspectral image from airborne adquisition for 20 of May



fAPAR estimated inverting Prospect4SAIL

Date	GPP L8 (Kg/ha)	GPP RTM (Kg/ha)	GPP EC (Kg/ha)	Error L8 Abs (Kg/ha)/rel	Error RTM Abs (Kg/ha)/rel
29 April	102.8	80.2	157.7	54.8 / 35%	77.5 / 49%
20 May	61.1	54.3	86.6	25.4 / 30%	32.3 / 37%
27 August	15.7	16.9	22.7	6.9 / 30%	5.7 / 25%



CONCLUSIONS

→Monteith model underestimated the GPP in both cases.

→Underestimation decreasing as annual vegetation is dried.

→The model gives better results at seasonal scale where the extreme days are smoothed.

→GPP estimated using LANDSAT provided better results when vegetation vigor is the maximum.

→GPP estimated using hyperspectral data is slightly (5%) better in dry season.

→ In this case it can be concluded that the use of hyperspectral reflectance imagery acquired with airborne platforms is not necessary and multispectral satellite imagery might be enough.

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*Monteith, J. (1977). "Climate and efficiency of crop production in Britain." Philosophical Transactions of the Royal Society of London, Ser. B: 277-294.