# EVALUATING MODIS VEGETATION INDICES USING GROUND BASED MEASUREMENTS IN A MOUNTAINS SEMI-NATURAL MEADOWS OF NORTHEAST PORTUGAL

*ABSTRACT*

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## 1. INTRODUCTION

Ancestral semi-natural meadows, locally called "Lameiros", are an essential element of the mountain landscapes in Northern Portugal. These meadows are frequently located in areas of high water availability, loamy soils and over 700-800m hight. In association with these meadows can be found traditional irrigation systems, in which the water is applied all year around, to assure the crop water requirements but also to promote a thermal regulation effect [1].

Lameiros are mainly used for forage production to feed autochthonous bovine livestock, but they are also important for the water and nutrients cycle regulation, erosion control and as barrier to forest fires propagation. Although the economical, environmental, landscaping, cultural and genetic value of the semi-natural meadows is recognised, their presence in the future is at risk, mainly due to the human desertification of these mountain regions and to the announced constraints in water resources use.

To preserve these meadows landscapes, it is essential to gather as much information as possible in order to better characterize them. Field surveys of vegetation dynamics monitoring, related with phenology and management practices, although useful are difficult and time-consuming. Hence, alternative approaches, with quick and reliable performance, must be considered and tested, as the case of remote sensing monitoring.

A great variety of vegetation indices (VI), derived from remote sensing measurements, are commonly used to characterize the growth pattern of grass in different biophysic conditions [2]. For example, the

Normalized Difference Vegetation Index (NDVI) is chlorophyll sensitive and responds mostly to the visible or red band variations, the Enhanced Vegetation Index EVI is more near-infrared (NIR) sensitive and responsive to canopy structural variations, including Leaf Area Index (LAI), canopy type, and canopy architecture [2, 3, 4].

The main purpose of this work is to evaluate the most appropriate VI from MODIS (250 m resolution), to identify and assess the growth pattern of semi-natural meadows in mountainous environments. Sixteen-day image composites from MODIS-TERRA [5] were used to examine the annual temporal profile of the NDVI and EVI, and their relationship with ground based observation of vegetation growth and reflectance inferred by spectroradiometer.

## 2. METHODOLOGY

*Test sites*

This work was carried out in the semi-natural meadows of northern Portugal. The pixel size of MODIS-TERRA images, 250 $m^2$, turns important the selection of test sites including large contiguous areas with semi-natural meadows. The CORINE Land Cover maps from 2000 and information from field work were used to select suitable test sites, with at least 2x2 km mostly covered by semi-natural meadows. Two test sites were defined in Montalegre (Northwest Portugal), in two specific regions, Paredes do Rio (PRR, 28 pixels) and Salto (SLT, 6 pixels). These two test sites were established over semi-natural meadows coverage, in compact groups of contiguous satellite pixels, and both including the areas defined for the ground field measurements.

*MODIS Data*

The 16-days MODIS TERRA composites from 2001 to 2008 were used to produce temporal NDVI and EVI profiles for each test site. Since each VI is obtained by merging data from 16 consecutive days, the whole site was considered as a unit, instead of using a pixel by pixel approach. This is done to prevent misregistration and other sources of errors to contaminate the temporal profiles. The median value of all pixels in each test site is used to compute the NDVI and EVI temporal profiles.

*Ground based measurements*

Spectral measurements were performed monthly at field level using a handheld spectroradiometer, ASD FieldSpec UV/VNIR, with reflectance data captured between 325nm and 1075nm of the

electromagnetic spectrum. Field reflectance measurements were sampled in 17 points (SLT) and 15 points (PRR). Eighteen campaigns of reflectance measurements were carried out in the period between July 2007 and December 2008, sampling all phenological stages of the semi-natural meadows.

The spectroradiometer field measurements were used to compute NDVI and EVI data using the information of bandwidth from MODIS.

*Smoothed process and VI metrics*

The Savitzky-Golay filter [6] was used for smoothing and suppressing disturbances of each VI time series, as well as to extract a number of NDVI and EVI metrics by computing derivatives. Then the first ($\delta_1(t)$) and second ($\delta_2(t)$) derivatives of the smoothed VI curve are calculated, which represent the change and the rate of change in curvature of the logistic model respectively. The start of growing season or Green-Up (GU) was considered when a maximum change rate ($\delta_2$ maximum) and a positive change ($\delta_1>0$) occurs. The "full canopy" or peak (Fc) was considered when a negative change rate ($\delta_2<0$) and a turning point from a positive change to a negative [$(\delta_1(t) \times (\delta_1(t+1)]<0$ occurs. Based on these VI metrics, a number of derived NDVI and EVI metrics or periods were calculated.

## 3. PRELIMINARY RESULTS

The smoothed VI profiles have been successfully used to extract curve features and relevant NDVI and EVI metrics related with semi natural pastures. The Savitzky-Golay filter was flexible enough to apply to a complex vegetation dynamics characterized by one annual growth cycle and frequent re-growths early in autumn and winter. Moreover, the NDVI and EVI profile fit in the characteristic vegetation growth dynamics and associated management practices in the region.

Significant linear regression relationships were found between VI from MODIS and ground based measurements, mainly for EVI during the spring and summer period. The analysis of VI temporal profile from different sensors showed more sensibility of the spectroradiometer to detected small in-season variations of the growth, related with the pasture re-growth. Furthermore, the EVI from MODIS demonstrated more sensibility to detected re-growth than the NDVI.

When VI metrics from MODIS or Spectroradiometer were compared, longer periods (about 16 days) between GU and FC were found with NDVI. For both test sites, the NDVI gives earlier GU and later FC.

The relationship between vegetation height and both VI fit a non linear growth curve with similar pattern function for each sensor (MODIS and Spectoradiometer) and test site. Appropriated statistical tests show that, according to tests sites, about 75 to 85% of the in-season grass height variability could be explained by the EVI and 60 to 70% by the NDVI. While both vegetation indices were sensitive to changes in plant height at the beginning of growing season, the NDVI became insensitive to additional growth when grass reached heights of 0.4 m (30% of maximum height). The EVI performed reasonably well up to grass plant heights of 0.7 m.

Preliminary results suggest a great sensibility EVI temporal profile from MODIS to detect the main phenological events of semi-natural meadows, even in situations of high plant height. Since the biomass and LAI are parameters highly related with vegetation height, the information derived from this study might help to understand the impact of management practices on vegetation dynamics and to compare the differences of vegetation dynamics between years in response to inter-annual climatic variations.

## 4. REFERENCES


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