TIME SERIES OF MICROWAVE DERIVED PRODUCTS: LOOKING FOR DISTURBANCES IN ARGENTINE CHACO FOREST REGION

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1. INTRODUCTION

Monitoring forest disturbances is critical for addressing its impact on carbon storage and fluxes, biodiversity, and other socioecological processes. Satellite remote sensing enables cost-effective and accurate monitoring at frequent time steps over large areas. In order to extract meaningful information about vegetation land surface variations, a useful framework is to analyze the seasonal patterns of vegetation, known as land surface phenology (LSP), using time series data obtained by remote sensing systems. In this way, we can relate the ecosystem dynamics with land surface phenology variations [1]. Nowadays there is interest in studying the LSP using microwave an optical indexes [2], since both are able to generate complementary information about vegetation condition. There is a critical need for methods that enable analysis of satellite image time series to detect forest disturbances in near-real time, especially in developing countries (e.g. Argentina).

The region addressed in this paper is the Argentine part of the Chaco Region (Fig. 1), that covers 675.000 km^2 (approximately 24% of the country). This large, not homogeneous region, in addition to having one of the largest native forests areas, presents temperature and humidity gradients with an increasing arid gradient from east to west which defines five distinct regions: Humid Chaco, Transition Chaco, Semiarid Chaco, Arid Chaco and Hilly Chaco (see Figure 1). There are several native forest species, but the dominating ones are "Quebracho colorado santiagueño" *(Schinopsis quebracho colorado*) and "Quebracho Blanco" *(Aspidosperma quebracho blanco*). Although there are areas of continuous forest, extensive measurements indicate moderate values of biomass typically in the range 70–110 t/ha (7–11 kg/m). Nowadays one of the most important threat to this forest is the fast expansion of agriculture (mainly soybean). Moreover, the expansion of livestock has also been documented as a major driver of deforestation in recent years, especially in north-west Argentina around the Chaco area, due the international demand of those products.

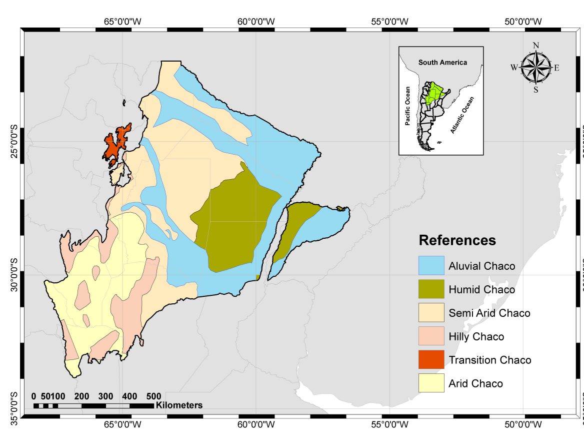

Fig. 1. Main ecological units of the Chaco region

Updated land cover and deforestation maps of the area [3] [4] show land conversion (from forest to agriculture), and land-cover modifications due to disturbances such as floods, droughts, fires, selective logging, others. The changes within land cover classes cannot be identified through classification procedures based on land-cover changes. One possible approach is to analyze time series of biophysical attributes that characterize the land cover.
Previous works in the area [5] [6] have shown the ability of optical data and microwave data to monitor flood events and land cover changes. A recent paper [7] shows a comparison between SMOS Vegetation Optical Depth (VOD) product and forest height estimated by GLAS LIDAR, showing a significantly increasing trend of VOD with respect to forest height.

In this context, the objectives of this work are: (1) to determine the variations in timing and duration of key vegetation phenological phases along Chaco area using microwave derived vegetation optical depth (VOD) products and optical indices; (2) to evaluate the potential of these vegetation phenological phases to identify disturbed patterns within different regions of the Chaco region, 3) to evaluate the possible contribution of spatiotemporal patterns defined by soil moisture (SM) and VOD products to forest disturbance and degradation. In particular, we address the following questions: What are the seasonal patterns of passive microwave products and optical indices in the study area? Do passive microwave products provide additional information to the traditional optical remote sensing analysis? And finally, could passive microwave products be good proxies to evaluate forest degradation at regional scale?.
It is important to mention that this work has several motivations: on one hand the promising capabilities of microwave derived products to detect disturbances within forests environments, second the new L band satellites missions such as NASA SMAP (L band radar/radiometer) and Argentine L band SAOCOM SAR, third an Argentine national project addressing forest disturbances and degradation.

2. DATA AND METHODS

We processed microwave derived SM and VOD data from the AMSR-E LPRM product, and optical data by the MODIS land surface reflectance product (MYD09A1) from 2002 to 2010. We also used SM and VOD SMOS products from 2010 up to now. Using MODIS data we calculated the vegetation optical index EVI. The 8-days 500 m MODIS data set was aggregated to 25 km spatial resolution. In the aggregation process, the EVI value of the 25 km pixel is calculated as the mean over 25 km VIs values of high quality only. Furthermore, we calculated 8-day composition period of microwave products based on MODIS time series composition criteria.

We studied the following phenological metric as is described by [8] (Fig. 2) for the optical and microwave indices: (1) Start of Growing Season (SGS), The beginning date of the growing season associated with one or more the vegetation strata; (2) Peak of Growing Season (PGS): the date of maximum vegetation productivity; (3) End of Growing Season (EGS): the end date of the growing season associated with one or more of the vegetation strata; (4) Length of Growing Season (LGS): the duration of the growing season, defined as the difference between the end and start of growing period.

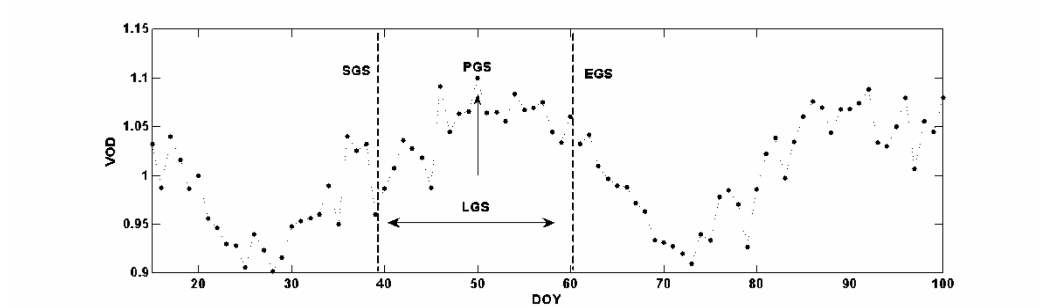

Fig. 2. The example presented here corresponds to Semi Arid Chaco forest. SGS (Start of Growing Season) is the beginning date of the season, EGN (End of Growing Season) is the end date of season and LGS (Length of Growing Season) is the duration of the season, and PGS (Peak of Growing Season) is the maximum value during the growing season.

3. PRELYMINAR RESULTS AND FURTHER WORK

The 8-day time series of each mean dataset (VOD and EVI) are plotted in Fig. 3. These time series were evaluated by correlation analysis and evaluation of phenological metrics of both time series. The selected areas were characterized for natural vegetation sites; one located over the semi arid Chaco forest (24.87° S, 62.12° E) and the other one over the humid Chaco (24.87° S, 58.65° E).

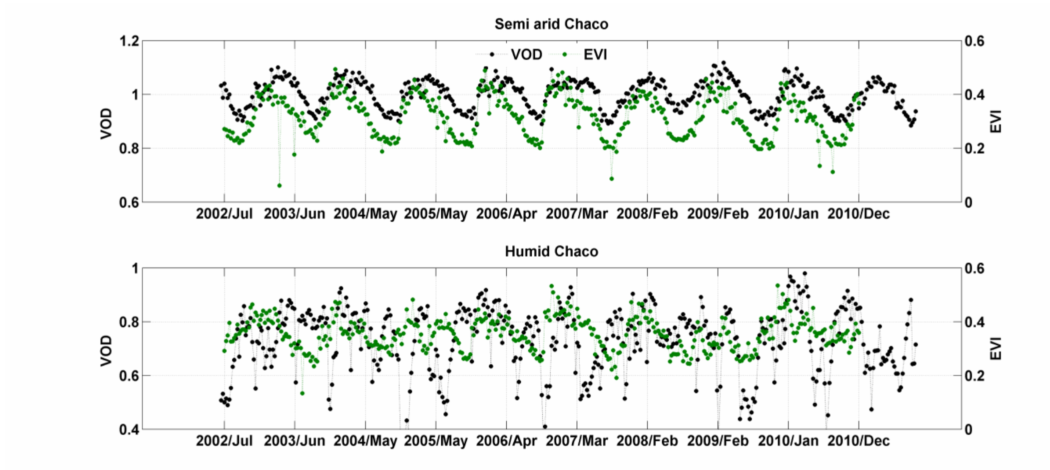

Fig. 3. Eight-day VOD and EVI time series data for 2002–2010. The selected sites correspond to semi arid Chaco forest (top) and humid Chaco (bottom).

We observed different seasonal behaviors of the VOD and EVI in the analyzed study areas. At the semi arid Chaco the VOD time series were positively significant related to MODIS EVI ($r= 0.74$, $p<0.001$). Both indices show a strong seasonal component, with higher values during summer and lower during winter. A lag between the peak of the growing season between EVI and VOD is observed. This was in agreement with [9], who hypothesize that these offsets are related to seasonal differences in photosynthetic and non-photosynthetic biomass, and associated to low temperature and water supply constraints to plant physiology and growth. By contrast, the temporal trend of VOD and EVI for humid Chaco is more complex. There is not a clear annual seasonal behavior for the VOD and EVI time series. This could be related to the heterogeneity of the area. Furthermore, the time series of both indices are not significantly correlated ($r=0.05$, $p>0.01$). Several key phenological metrics, previously described, are under analysis (SGS, PGS, EGS and LGS) for both optical and passive microwave time series. Also the analysis of trend slopes and breakpoints are in progress.

As an example of the behavior of SM and VOD patterns at regional scale, Fig. 4 shows monthly spatial patterns of both products over the whole Chaco region for April and June, 2012. Distinct patterns can be observed in both variables distribution. The soil moisture patterns reflect the gradient from humid to arid and show differences over time related to the annual precipitation cycle and its effects in the river floodplain SM pattern. VOD patterns are more stable in time but still show distinct changes, especially in the southern part of the region, affected by a strong agricultural expansion.

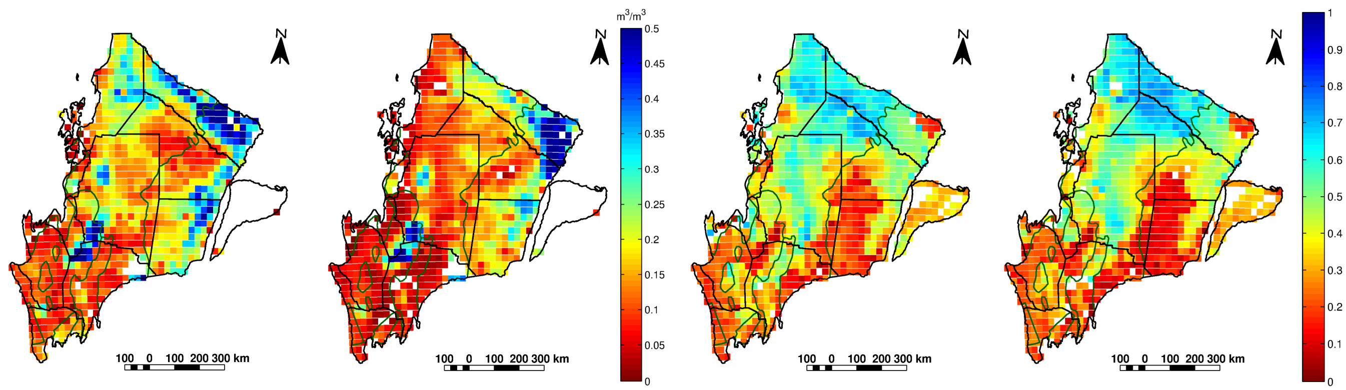

Fig. 4. From left to right: SM April 2012, SM June 2012, VOD April 2012, VOD June 2012 for the Argentine part of Chaco Region

4. REFERENCES

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