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Evaluating MODIS vegetation and water indices for detecting canopy stress during the 2005 drought in Amazonia

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Abstract. This communication reports a first attempt to assess the capability of MODIS NDVI, Enhanced Vegetation Index (EVI) and Normalized Difference Water Index (NDWI) from 2002 to 2005 time-series to detect the effects of the 2005 drought on dense tropical forest canopies in Amazonia. The preliminary results reported in this communication suggest that the NDVI and NDWI have not responded to the rainfall anomaly in 2005 directly in a month basis. Positive anomalous values founded in the dry period suggest a lag in the vegetation response to the high rainfall in the previous period. On the other hand, the EVI seemed to have a more directly response to the rainfall changes. A study looking to others vegetation covers and including the 2000, 2001 and 2006 data is being carried out to better understand how different ecosystems in the Amazonia respond to a drought event.

Palavras-chave: remote sensing, tropical forest, Amazon, drought, sensoriamento remoto, floresta tropical, Amazônia, seca.

1. Introduction

In the last decades, the detection of drought onsets, ends and assessing its severity using satellite data are becoming popular in disaster, desertification, crop production, phenology, land cover changes and climate change studies. The definitions of drought are varied, but in natural and cultivated vegetation studies it usually involves an abnormal dry weather which affects plant growth, development and physiology.

To detect the drought effects on different vegetation types, many methodologies have been developed, mostly relying on the use of vegetation indices. Normalized Differencing Vegetation Index (NDVI) has been largely used not only for the detection of drought in natural land cover formation (Peters et al., 2002), but also for crop productions (Chen et al., 2005). The two channels used in NDVI sense through different depths of vegetation canopies. The near-IR channel can see roughly eight leaf layers, while the red channel sees only one leaf layer or less (Lillesaeter, 1982). However, the NDVI is also known by its saturation in dense canopies. Though, many other indices have been tested, as normalized difference water index (NDWI) (Gao, 1996), using near-infrared and short wave infrared spectral bands in different combinations with the red channel (Liu & Kogan, 1996, Bayarjargal et al., 2006).

In this communication, we reported a preliminary attempt to assess the capability of MODIS NDVI, Enhanced Vegetation Index (EVI) and NDWI time-series to detect the effects of the 2005 drought on dense tropical forest canopies in Amazonia.

2. Material and Methods

The study area was selected based on the spatial distribution of the most affected region during the 2005 drought event; the south-western Amazonia (Aragão et al., in preparation). Their precipitation anomaly data were used to support the interpretation of the spectral indices response. The 16-day MODIS MOD13 1km product was acquired for the period from January 2002 to December 2005 and monthly composite data were generated based on the maximum value of the NDVI. The NDWI was calculated according to Gao (1996).

Based on the land cover map for the South America (Eva et al., 2004), 3 samples of 100 km^2 each were acquired over dense tropical forest, in homogeneous regions, coincident with the areas with higher precipitation anomaly in 2005.

The effect of the 2005 drought on the canopy reflectance was evaluated in terms of monthly anomalies for each spectral index. Firstly, we calculated the mean value for the three samples for each month. Then, the monthly means from 2002 to 2005 were generated. Finally, monthly anomalies were calculated as the departure from the mean values from 2002 to 2005 normalized by the standard deviation. Anomalies were defined as values higher than 1 standard deviation (σ).

3. Results

In general, NDVI and NDWI anomalies present the same seasonal pattern (**Figure 1a** and **1c**). NDVI results for 2005 shows a positive anomaly for the March-July period, followed by a negative value for August. September and November also presents positive values. This same pattern is observed on the NDWI 2005 data. The precipitation anomaly data for 2005 shows a wetter period for February to May and a very dry period from June to October (Aragão et al, in prep.). It suggests that the vegetation response in the March-July period is related to the very wet period from February to May, while the negative value of August, October and December (for NDVI) and low values in these months for NDWI seems to be related with the beginning of the anomalous dry period, in June.

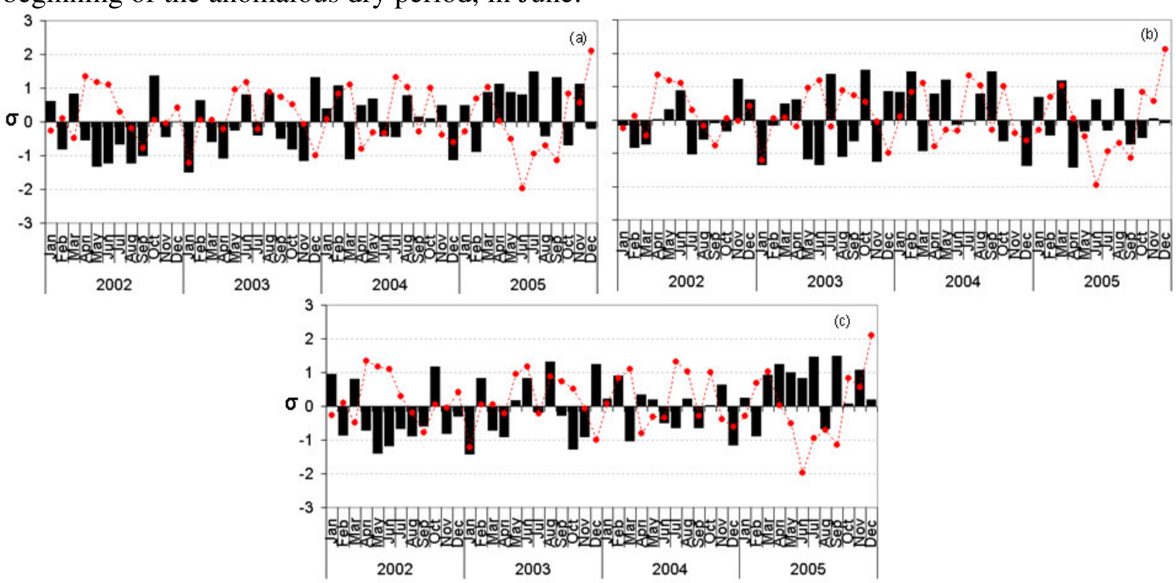

Figure 1. Spectral indices anomalies: (a) NDVI, (b) EVI, (c) NDWI. Black bars correspond to the anomaly for the spectral indices and red line corresponds to rainfall anomaly. Positive anomalies indicate that the value is higher than the mean, and negative values point out the opposite.

The EVI anomaly presents a different pattern comparing to NDVI and NDWI. The EVI seems to be more related to structural changes in the canopy (Huete et al., 2006), while the other two indices are related to water content and leaf physiological stress. In 2005, EVI presented negative anomalies in February, April, May, July, September and October, coincidently to the anomalous dry period. It is speculated that the spectral indices should present high negative anomalies due to the drought; however it is possible to discuss two factors that were detected in this study. Firstly is the possibility of a lag in the reaction of the stressed canopy. Phillips and Jimenez (personal communication) related the increase of dead trees (without fall) after the 2005 drought, and the change in the structure should be more visible in the following years. Secondly, is the possibility of the increase in the photosynthesis rate due to the decrease of cloud cover, showing up as the positive anomalies, which would confirm Huete et al., 2006 findings.

4. Conclusions

The preliminary results reported in this communication suggest that the NDVI and NDWI have not responded to the rainfall anomaly in 2005 directly in a month basis. Positive anomalous values founded in the dry period suggest a lag in the vegetation response to the high rainfall in the previous period. On the other hand, the EVI seems to have a more directly response to the rainfall changes.

A study looking to others vegetation covers and including the 2000, 2001 and 2006 time series is been carried out to better understand how different ecosystems in the Amazonia respond to a drought event.

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