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Biweekly Climate Variability of the Space Scaling Properties of Two Vegetation Indices in the Brazilian Amazon

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Abstract

We analyzed the biweekly climate variability of the spatial scaling properties (prefactor and scaling exponent) of the Vegetation Normalized Index (NDVI) and Enhanced Vegetation Index *(*EVI*)*, from September the 29th, 2000 to March the 22nd, 2001, on a spatial scale of 250 m in two Brazilian Amazon regions (Mato Grosso and Tocantins, Piauí, and Bahía). We estimated bi-dimensional Fourier spectrum, moment-scaling analysis and statistics moments. Results indicate that NDVI and EVI exhibit three scaling regimes associated with long-range spatial correlations characterized by $0<\beta<2$. The biweekly time series of prefactor, *c(t),* and scaling exponent, $\beta(t)$, to NDVI (EVI) showed a strong negative correlation in Mato Grosso –0.76 (–0.85) and Tocantins, Piauí, and Bahía –0.82 (–0.89), with *p-value* < 0.05. Moment-scaling analysis revealed the presence of spatial multistage variability of NDVI and EVI. In two regions, NDVI (EVI) values were in the range 0.52-0.95 (0.34-0.54) where the lowest is in Tocantins, Piauí, and Bahía (indicators of drier vegetation). The statistical moments displayed differences between regions. The biweekly climate variability of vegetation index can be used to help the knowledge of the processes that affect the dynamics of vegetation.

Keywords: Bi-dimensional Fourier spectrum, spatial scaling, space-time variability.

INTRODUCTION

The vegetation index can be used to understand the coupling and feedback of the earth-atmosphere system carried by a linked in the ecological-hydrologic dynamics (1, 2, 3). This index has a significant role to identify differences in vegetation (4). According to Anderson *et al.* (5), the Amazon basin is government to prolonged epochs of cloud cover and episodes of strong biomass burning. So, the same authors mention that droughts and precipitation are normal and recurring climatic phenomena that affect people and the landscapes they occupy at many scales (locally, regionally, and nationally) for periods of time varying from weeks to decades.

The Normalized Difference Vegetation Index (NDVI) measures the photosynthetic activity of plants in terms of the interaction of solar radiation and the presence of chlorophyll in leaves (6). The sensor products are built every 16 days, and are based on the quality of the data and the maximum value of NDVI for this period, through the Moderate–Resolution Imaging Spectroradiometer (MODIS). It is defined through the relation of the spectral response of the near infrared (ρNIR), 0.73–1.10 µm and red (ρR) bands, 0.55–0.68 µm (2, 6):

$$NDVI = \frac{\rho NIR - \rho R}{\rho NIR + \rho R}. \qquad (1)$$

The range of NDVI is between -1 to 1 (7). Values close to zero (0) indicate highly spaced vegetation, while values close to one (1) are indicators of dense vegetation (8). Equally, Huete *et al.* (7) established the Enhanced Vegetation Index (EVI) from the MODIS data to "optimize" the vegetation signal, improving sensitivity in regions with high biomass (7). The EVI values were calculated for the spectral response of the red, infrared and blue bands (ρB), 0.46–0.48 µm through satellite imagery, and this is less influence by atmospheric noise than NDVI, so, to improve this the ρB is used:

$$EVI = G\frac{\rho NIR - \rho R}{\rho NIR + C_1\rho R - C_2\rho B + L} \qquad (2)$$

where C_1 and C_2 are designed to correct the effects of the dispersion and absorption of the aerosols, respectively. The value of *C1* has been set at 6 and *C2* at 7.5. *G* represents a change factor equal to 2.5, and *L* corresponds to a setting of the antecedent signal of the canopy of plants whose value is 1 (6).

The need of use NDVI and EVI time series observations can be used to examine the dynamics of the growing season or monitor phenomena such as droughts (9). In addition, Moura *et al.* (10) mentions that the detailed knowledge of vegetation structure is required for accurate terrestrial ecosystems models, also the results can be extrapolate to measures of canopy entropy across different forest types, providing additional estimates of vegetation structure in the Amazon. Equally, the use of vegetation index information requires an accurate understanding of how human modification influences ecosystem processes and these relationships are most accurate when based on functional traits (11), and the management of the drought in this tropical forest could be improve. In this senses, Christian *et al.* (12) mentions that tropical dry deciduous forests exhibit diverse phonological behavior that has significant impact on Gross Primary Productivity (GPP).

In turn, using multistage functions can recognize the range of scales, where the dependency of the scale of the model and observed variability can be determined, and the range of scales where the two converge (13-14). The scaling theory also permit advance in the understanding and modeling of the spatio-temporal dynamics of the varied bio-geophysical practices such as: vegetation structure (10, 15-18); precipitation (19) and stream flow (20-23) and ecological processes (8, 11).

This work characterizes and quantifies the scale of the dependence of spatial variability of NDVI and EVI, on the spatial resolution of 250 m, in two Brazilian Amazon regions (Mato Grosso and Tocantins, Piauí, and Bahía).

MATERIALS AND METHODS

The NDVI data set is available on a 16 day basis for the six year period between 2001 and 2006 through the Global Land Cover Facility (GLCF) satellite of the Maryland University, (http://glcf.umd.edu/data/ndvi/) to spatial resolutions of 250 m and the information data for South America (73.32º-39.04º W and 0.00º N to 20.00º S) are only available for the period September 29th, 2000 to March the 22nd, 2001. The product is derive from bands 1 and 2 of the MODIS on board NASA's Terra satellite (9) with range 0 to 250. So, Hansen *et al.* (8) suggests scaled the specific NDVI values (*Dn*) using Equation 3, within the image for the corresponding period:

$$NDVI = \frac{Dn - 128}{100}, \qquad (3)$$

EVI data was downloaded for the same time period of NDVI of the United States Geological Survey obtaining from the MODIS/Terra Vegetation Index 16-Day L3 Global 250m sensor (https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mod13q1). The valid range for the EVI is given between -0.2 to 1, although first the metadata value (*Vm*) was scaled using the Equation 4 (7):

$$EVI = \frac{Vm}{10000}, \qquad (4)$$

In this study, we selected two sectors (Mato Grosso and Tocantins, Piauí, and Bahía) with square areas (1.05 Tm^2, side 1.02 x 10^{-6} m). Mato Grosso is located at the upper vertices 60.80º-51.04º W, and lower 62.00º-52.69º W, while Tocantins, Piauí, and Bahía are located at the upper vertices 49.61º-40.30º W, and lower 50.82º-41.41º W (Figure 1). For both sectors and for the two indices, the latitudinal location is the same (5.34º-14.65º S).

Figure 1. Map showing forecast domains and two study regions (Mato Grosso and Tocantins, Piauí, and Bahía) for NDVI and EVI fields.

Source: Adapted to google map (https://www.google.com.co/maps/@-8.3924517,-55.1086245,2081426m/data=!3m1!1e3).

The Mato Grosso sector is located in the northeast of the country, characterized by an average precipitation of 768 mm per year and an average temperature of 26.5 °C with a dry season marked for the months of August to November (5). This sector is the main national producer of cotton, and has the largest soybean area in the country corresponding to 6.4 million hectares (24). Meanwhile, Tocantins, Piauí, and Bahía, located in the Midwest region of Brazil have an average annual precipitation and temperature of 1349 mm and 27.6 °C, respectively. The tropical savanna climate (Aw) dominated in both areas, although Piauí and Bahía also present warm semi-arid climates (BSh) according to the classification of Köppen-Geiger.

We used tools to characterize and quantify the dependence of the spatial variability of NDVI and EVI field (simple and multiple scaling of random fields in the Amazon) respect to the scale, such as the bi-dimensional Fourier spectrum and the scale moments function following the works of Gupta & Waymire (13) and Gupta (14). So, the bi-dimensional Fourier spectrum is calculated using the Fast Fourier Transform (FFT) algorithm developed in 1965 by IBM researchers and implement by Hoyos (25), using the FFT function of IDL software (26):

$$E(k) \sim k^{-\beta} = ck^{-\beta} \quad (5),$$

where, c represent the prefactor, β is the scaling exponent (spectral slope), and k is the wave number (inverse of the distance). The β quantifies the roughness, so a low spectral slope value means less correlated fields, while the opposite is indicative of much roughness and more organized structures (19).

According to Harris *et al.* (19), the moment-scaling of random bimonthly fields (NDVI and EVI) can be used to show the intermittence or roughness, and evaluate the type of spatial scaling (simple or multiple). The momentum analysis of a bi-dimensional field denoted by X is calculated for a scale range r (a high value of r implies small scales) as a function of the moment of order q (Deidda *et al.*, 1999 cited in Salazar & Poveda (15)):

$$\left\langle \left| X(r)^{q} \right| \right\rangle = M_q(r) \sim \mathrm{r}^{-\sigma(q)} \quad (6)$$

where $\sigma(q)$ is a function of the scalar exponent of the moments that is valued by a Log-Log linear regression of the *qth*, and $\langle \cdot \rangle$ denotes the average over all scale pixels r in the field. The linearity of the function $Mq(r)$ *vs.* r in the Log-Log space offers a test of the hypothesis of the scaling type of the moments of order q and provides information of the field intermittence (15).

Statistical moments are used to understand the differences between the two areas. So, we calculated four statistical moments: in relation to the origin, the mean is the first moment. Now, in relation to the mean, the others moments are the standard deviation, asymmetry, and kurtosis.

The climatic variability of the biweekly temporal evolution of the prefactor, $c(t)$ and the scaling exponent $\beta(t)$, to t = 1, … , 176 corresponding to the time period in study, and it is evaluated as a function of linear dependence, $c(t) = f[\beta(t)]$.

RESULTS

Bi-dimensional Fourier spectrum

For the two sectors during the period analyzed, the bi-dimensional Fourier spectrum is similar. The biweekly NDVI fields in the two sectors (Figure 2a and 2b) for October the 15th 2000, presented three regions characterized by different scaling exponent, β, separated by wave numbers $k = 1.3\text{x}10^{-3}$ m^{-1} (769.23 m), $2\text{x}10^{-4}$ m^{-1} (5000.00 m) and $3\text{x}10^{-5}$ m^{-1} (33333.33 m).

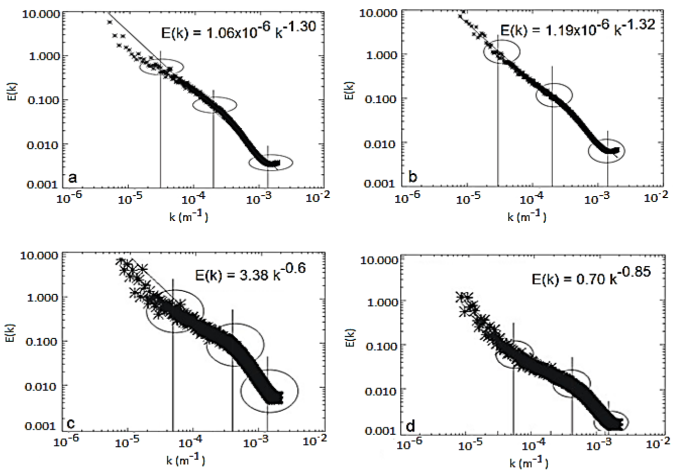

Figure 2. Bi-dimensional Fourier spectrum for the: NDVI field of October the 15th 2000 in a) Mato Grosso sector with β = 1.30 and c = $1.06\text{x}10^{-6}$, b) Tocantins, Piauí, and Bahía sector with β = 1.32 and c = $1.19\text{x}10^{-6}$; and EVI field of December the 18th 2000 in c) Mato Grosso sector with β = 0.68 and c = 3.38, d) Tocantins, Piauí, and Bahía sector with β = 0.85 and c = 0.70.

For the case of the EVI biweekly fields of the bi-dimensional Fourier spectrum for December the 18th 2000 in the two selected sectors (Figures 2c and 2d), three regions is also characterized by different scaling exponents, β, separated by wave numbers $k = 1.3\text{x}10^{-3}$ m^{-1} (769.23 m), $3\text{x}10^{-4}$ m^{-1} (2500 m) and $5\text{x}10^{-5}$ m^{-1} (20000 m). In this case, the first region is the same as for NDVI.

Moment-scaling analysis

Figure 3a show the moment-scaling results to NDVI (q = 0.50, 1.00, …, 4.00), and Figure 3b present the curve of $\tau(q)$ to March the 22nd 2001 (end of the rainy season). These results indicate that NDVI biweekly data present a multistage in the spatial variability, indicated by the nonlinear behavior of the function $\tau(q)$. In addition, the results for EVI are similar (Figure 3c and 3d); however, in this case, we use data from November the 16th 2000 (rainy season).

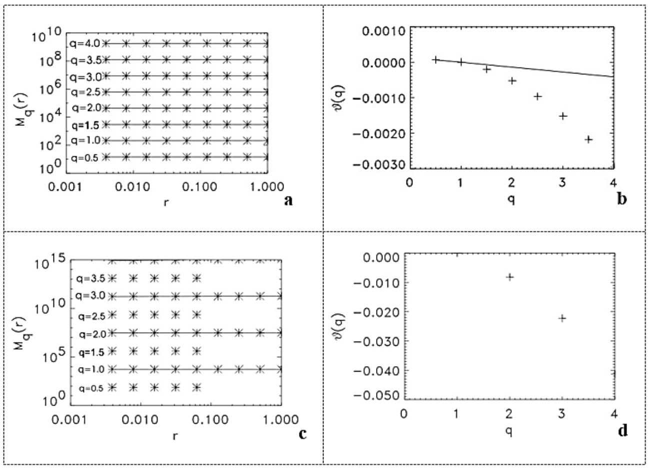

Figure 3. NDVI a) Scaling the marginal moments with q = 0.50, 1.00, …, 4.00, b) Estimated curve of $\tau(q)$ to March the 22nd 2001; EVI c) Scaling the marginal moments with q = 0.5, 1.0, …, 4.0, d) Estimated curve of $\tau(q)$ to November the 16th 2000.

Statistical moments

The results of the four statistical moments (mean, standard deviation, asymmetry coefficient, and kurtosis) for the study area are presenting in Table 1. For the whole study period, the biweekly field value of the NDVI is in the range of 0.52-0.95, so it was found that the data were not very dispersed with respect to the mean. For the two sectors, Mato Grosso and Tocantins, Piauí, and Bahía, in general, the biweekly NDVI values are based to the left (negative asymmetry values). In Mato Grosso sector kurtosis values in general are greater than 3, while in Tocantins, Piauí, and Bahía sector, kurtosis values are lower than 3.

Table 1. Results of the four statistical moments (mean, variance, the coefficient of skewness and kurtosis) for NDVI data.

Date	Mato Grosso				Tocantins, Piauí, and Bahía			
	μ	σ	γ	κ	μ	σ	γ	κ
29/09/2000	0.88	0.15	-2.31	3.53	0.52	0.17	1.27	3.76
15/10/2000	0.86	0.15	-2.31	3.36	0.52	0.17	1.22	3.62
31/10/2000	0.80	0.18	-1.82	1.36	0.58	0.23	0.24	0.10
16/11/2000	0.96	0.22	0.90	-0.63	0.84	0.17	-1.41	2.22
02/12/2000	0.65	0.24	-0.59	-0.90	0.69	0.20	-0.73	0.97
18/12/2000	0.95	0.13	-1.97	2.49	0.87	0.15	-1.46	2.65
01/01/2001	0.85	0.18	-2.39	3.61	0.84	0.15	-1.28	2.82
17/01/2001	0.86	0.17	-2.36	3.64	0.84	0.16	-1.45	2.76
02/02/2001	0.93	0.14	-2.34	4.19	0.86	0.16	-1.49	2.46
18/02/2001	0.84	0.18	-2.24	2.82	0.82	0.16	-1.29	2.55
22/03/2001	0.89	0.16	-2.43	4.02	0.86	0.16	-1.49	2.74

μ = mean, σ = standard deviation, γ = coefficient of skewness, κ = kurtosis.

For the all study period the biweekly field of EVI varied between 0.34-0.54 (Table 2), with the distribution of data very close to the mean. For Mato Grosso sector the biweekly NDVI values are skew to the right and for Tocantins, Piauí, and Bahía sector; and the bias is present to the left. The kurtosis values for the two sectors are lower than 3.

Table 2. Results of the four statistical moments (mean, variance, the coefficient of skewness and kurtosis) for EVI.

Date	Mato Grosso				Tocantins, Piauí, and Bahía			
	μ	σ	γ	κ	μ	σ	γ	κ
29/09/2000	0.53	0.13	-0.31	0.99	0.34	0.13	0.81	1.07
15/10/2000	0.54	0.13	-0.25	1.19	0.35	0.14	1.00	1.62
31/10/2000	0.54	0.15	0.01	0.35	0.41	0.15	0.40	0.42
16/11/2000	0.53	0.13	0.03	1.21	0.45	0.13	-0.29	0.65
02/12/2000	0.50	0.18	0.06	-0.34	0.44	0.16	0.14	0.40
18/12/2000	0.51	0.12	0.00	1.78	0.47	0.12	-0.43	0.45
01/01/2001	0.50	0.14	0.35	0.85	0.48	0.13	-0.28	0.42
17/01/2001	0.52	0.14	0.27	0.75	0.48	0.14	0.01	0.83
02/02/2001	0.53	0.14	0.22	0.63	0.49	0.13	-0.22	0.89
18/02/2001	0.51	0.14	0.34	0.66	0.48	0.12	-0.23	1.08
22/03/2001	0.49	0.13	0.24	1.55	0.46	0.12	-0.19	1.27

μ = mean, σ = standard deviation, γ = coefficient of skewness, κ = kurtosis.

Biweekly climate variability of prefactor, c(t), and scaling exponent, β(t)

The biweekly temporal record of prefactor, $c(t)$ and scaling exponent, $\beta(t)$ for NDVI is shown in Figure 4. A statistically significant (p-$value$ < 0.05) negative correlation coefficient is find for Mato Grosso (r = –0.85) and Tocantins, Piauí, and Bahía (r = –0.89). While for the EVI (Figure 3) the statistically significant negative correlation are maintained, but with lower values for Mato Grosso (r = –0.67) and Tocantins, Piauí, and Bahía (r = –0.82).

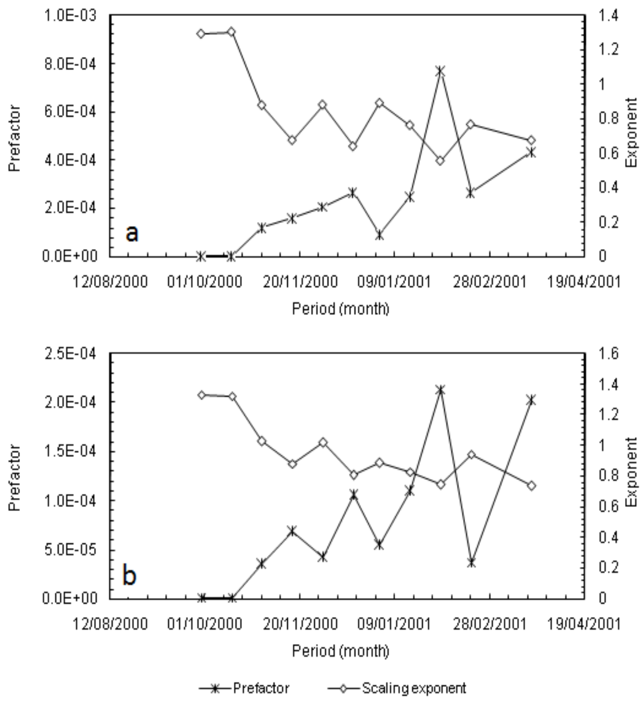

Figure 4. Biweekly temporal evolution of the prefactor, $c(t)$, and the scaling exponent, $\beta(t)$, estimated with the bi-dimensional Fourier spectrum for bimonthly NDVI fields, during the study period, a) Mato Grosso sector and b) Tocantins, Piauí, and Bahía sector.

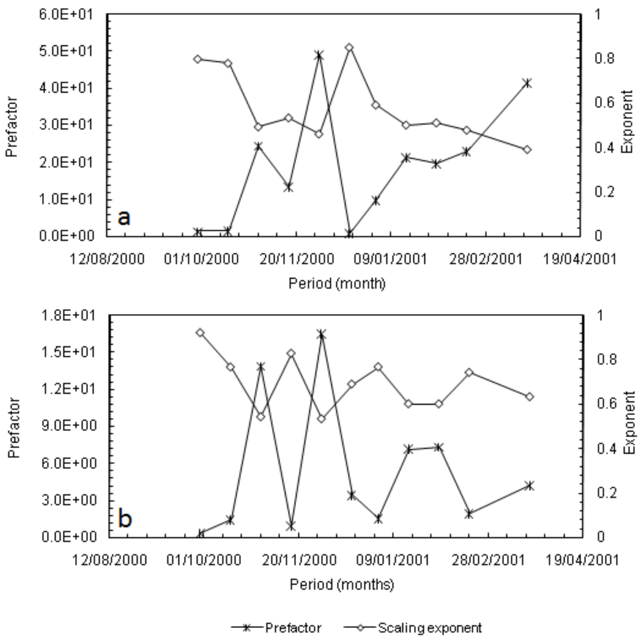

Figure 5. Biweekly temporal evolution of the prefactor, *c(t)*, and the scaling exponent, *β(t)*, estimated with the bi-dimensional Fourier spectrum for bimonthly EVI fields, during the study period, a) Mato Grosso sector and b) Tocantins, Piauí, and Bahía sector.

DISCUSSION

It is important to mention that this study had temporary limitations given by the NDVI data (six month), so the study focused on proving the existence of spatial scaling (prefactor and scaling exponent) and analyzing the biweekly climatic variability of them, in two regions of the Brazilian Amazon (Mato Grosso and Tocantins, Piauí and Bahia). So, from the bi-dimensional Fourier spectrum we found that at a larger spatial scale, the biweekly NDVI fields showed a wide range of correlation characterized by three regions, which responded to the wave number. In the moment that $\beta \approx 0$, the spectrum behaved independent of the scale, and the spatial variability of the NDVI responds irregularly as a noise in space (16). According to Anderson *et al.* (5), the estimation of natural and managed ecosystems answer to climate variability systems, in which parameters such as precipitation, temperature, and humidity play a fundamental role in the variation of climatological conditions, associated with the availability of water or water stress regimes that directly affect the behavior of vegetation. In this sense, Moura *et al.* (10) and Moura *et al.* (27) note that the evapotranspiration is controlled much more by canopy roughness, as it reduces direct radiation on the soil surface; according to type, development status and area of vegetation cover. Also, these authors mention that it will be essential for improving our understanding of climate tolerance and responses to Amazonian forests to extreme events. To Anderson *et al.* (5) it is important to the health and resilience of Brazilian forested lands, which constitute a major fraction of the Amazon rainforest.

In turn, the biweekly EVI fields in the bi-dimensional Fourier spectrum behaved similarly to those of the NDVI, defined by three regions with little variation in the separation distances of the same. These regions in magnitude are smaller than the NDVI's region, possibly because the NVDI is highly sensitive to air pollution (2). In the same senses, Matsushita *et al.* (4) mention that the coefficient of variations of NDVI and EVI are 0.05 and 0.30 respectively, indicating that the EVI is more sensitive to topographic effect than NDVI. In this way, Abelleira-Martínez *et al.* (11) mention that the statistical relationships that link local trait variation to regional environmental gradients can fail to capture these anthropogenic effects on trait variation and can be limited use in human-modified regions.

NDVI and EVI biweekly data for the two sectors (Mato Grosso and Tocantins, Piauí, and Bahía), present a multiscale behavior in space, indicated by the nonlinear behavior of the function $\tau(q)$ as reported by Poveda & Salazar (16) for the NDVI in the Amazon. This may also be associated with vegetation activity strongly coupled with climate, hydro-ecological flows and terrestrial dynamics (16). Thus, Abelleira-Martínez *et al.* (11) in their work, captured vegetation variation with multiple spatial scales. To improve their accuracy, ecosystem services assessments should take advantage of features that can be detected remotely.

Statistical analysis of data showed that the Tocantins, Piauí, and Bahía sector corresponds to a drier region. Associate with the interval value for the two indices (NDVI 0.52-0.86; EVI 0.34-0.49), corresponding to the hot semi-arid climate of some areas, represented in deciduous cover with respect to Mato Grosso with intervals (NDVI 0.65-0.95; EVI 0.49-0.54), associated with a greater coverage present in the Brazilian Cerrado. Although, the deviation of the data from the mean for the two sectors was no higher than 0.24, indicating that the distribution of the data was around the mean. Mato Grosso (Central West) and Tocantins, Piauí, and Bahía (Northeast) sectors have different and statistically significant means, possibly associate to environmental conditions of each of the sectors. According to the answer of the vegetation in relation to the foliar area of the present coverages, the Tocantins, Piauí, and Bahía sector conditions help the development of deciduous and shrub species. Whereas, in Mato Grosso has a greater diversity associated with species of arboreal and shrub habit, also there is a greater uniformity represented in the same way by the agricultural activities of the area (11).

On the other hand, these differences can indicate a degradation of the health of the vegetation in Tocantins, Piauí, and Bahía, due to the decrease in the absorption and greater reflectance of the visible energy in this area (5). For vegetation index dynamics in the Brazilian Cerrado, the second largest biome in South America, Ferreira *et al.* (28), Galvão *et al.* (29) and Grant *et al.* (30), found that the EVI showed a higher sensitivity to seasonality than the NDVI. Perhaps in relation to the uniqueness of the seasons that it presents with a rainy season marked by variability in the precipitation regime of approximately 800 mm annually. Also, Ferreira *et al.* (31) find a synergism between the NDVI and EVI and together, these two indices were capable of correctly classifying 82% of the total data set.

In Mato Grosso prevalence of the forest (principally Amazonia) located over north Brazil, while in Tocantins, Piauí, and Bahía predominant agricultural use (32), but are expanding north with new fronts of land occupation (5). According to Anderson *et al.* (5), this area show different characteristics, for example: a) It is the largest area of extractive agriculture located in the north; while the Northeast region is distinguished by a great diversity of agricultural and extractive uses; b) North enhances the evaporative flux over the Amazon River network; c) Reductions in evapotranspiration can be associated with major forest logging cuts in Tocantins, Piauí, and Bahía, since most of the crops in the area are soybeans, cotton, rice, and sugar cane; Crops of low size and low production of biomass, which represent a smaller leaf area available in photosynthetic processes; d) Negative anomalies in NDVI and EVI during the dry season drought events (2005 and 2010) possibly due to alterations in the reduction of coverage and change of land use in the study sectors, generating not only greater water stress for both prevailing and soil species, but also a modification of the evapotranspiration and photosynthesis.

Equally, the climate in Mato Grosso is characterized by rainy season (from last day of September to April) with a South-North gradient, so, the farmers usually planted soybean crops from late September to early November and harvested from January to March. The average annual precipitation ranges are from 1200 to 2000 mm. Thus, the natural vegetation reflects a high diversity of landscapes represented by three main ecoregions: The Amazonian forest, El Cerrado and El Pantanal (32).

The asymmetry coefficient values associated with the sign permit evaluate the availability of water and the density of vegetation; therefore this result confirm that Mato Grosso sector is better than Tocantins, Piauí, and Bahía sector. For the sector, all kurtosis values were less than 3, which means that the distribution of the data is flat with values dispersed around the mean, while in the Mato Grosso sector, both kurtosis values were found greater than less than 3, these show that the data are concentrated near the mean as a pointy distribution.

The temporal progress of prefactor, $c(t)$, and scaling exponent, $\beta(t)$ of NDVI coincide with those reported by Salazar & Poveda (15) and Poveda & Salazar (16), for an 11 year period *vs.* 6 months (11 values) of this study, who record the existence of a strong association through potential laws and scaling relationships. So it can be considered as a function of time through the relationship $E_t(k) = c(t)K^{-\beta\,(t)}$. Also, this is consistent with the findings of Anderson *et al.* (5) for the period 2003–2013, who argued that in the Amazon exist a co-vary in response to year-to-year variability in weather and moisture conditions.

In this way, the biweekly climate variability evolution must be understood and interpreted for making a decision in the ecosystem protection policies of the Amazon Basin. Bush (33), mentioned that in the near future, the local climate of Amazonia is likely to become warmer and drier as a result of deforestation. Since the elimination of cover affects the ecosystem dynamics from the alteration of processes like the runoff, the transpiration, the cycling and the permeability of water and nutrients, regulated by the state of the soil and the biomass. Thus, this author suggested that management plans prioritize central Amazonia as a zone of regulated land use centered on sustainable silviculture or agroforestry, or (with the reservations noted above) for use as 'Indian lands'. However, Christian *et al.* (12) found that spectral sensitivity of the vegetation is more important than spatial resolution in identifying critical changes in phenological events and vegetation indices, which are established as a strategy of evaluation of the monitoring processes and with it the climatic variability resulting from them.

Finally, within the entire time scale studied, NDVI and EVI four periods were randomly selected, in order to calculate the percentage of negative values in the study areas. This is because negative values represent sectors with bare soil and bodies of water. For this, equation (7):

$$\%\text{ of negative values} = \left(\frac{\#\,pnv}{n}\right)x100 \quad (7)$$

where *# pnv* corresponds to pixel numbers with negative values and *n* the total pixel number. When the percentage of pixels with negative values were checked, it was found that for NDVI this percentage was zero (0), whereas for EVI the percentages ranged from 0.024% to 0.093%. These results finally influenced the determination of scaling of moments in each of the times of the temporal scale of the EVI.

CONCLUSIONS

NDVI and EVI biweekly data used for the two sectors (Mato Grosso and Tocantins, Piauí, and Bahía), present a multiscale behavior in space, and indicates by the nonlinear behavior of the function $\tau(q)$. From the bi-dimensional Fourier spectrum we found that at a larger spatial scale, the biweekly NDVI fields showed a wide range of correlation characterized by three regions, which responded to the wave number. In this way, the biweekly EVI fields behave similarly to those of the NDVI, defined by three regions with little variation in the separation distances of the same. Statistical analysis of data showed that the Tocantins, Piauí, and Bahía sector corresponds to a drier region. The above indicates that the biweekly climate variability of vegetation index can be used to monitor processes that affect the dynamics of vegetation.

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