Annual and Interannual Variability of Forest Fires in Tropical South America and their association with the Normalized Difference Vegetation Index (NDVI) during 2000-2010

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Abstract: Climate and vegetation are closely related, the rainforest are responsible for the cushion and regulate climatic variables such as temperature and relative humidity through the process of evapotranspiration. This study case presents a spatiotemporal variability of the activity of vegetation by Normalized Difference Vegetation Index (NDVI), in Tropical South America, during the period from 2000 and 2010. For the analysis, NDVI maps were built using the product of the MOD13A2 MODIS sensor (Moderate Resolution Imaging Spectroradiometer) with a spatial resolution of 1 km and a temporal resolution of 16 days, using the reference GRS80 ellipsoid and sinusoidal map projection, during the mentioned period. Thermal anomalies were identified from Landsat TM image processing obtained from MOD14A2 MODIS sensor with a spatial resolution of 1 km and a temporal resolution of 8 days during the same period. Information is then synthesized into maps that integrate monthly NDVI values with the location of thermal anomalies, allowing forest fires to relate with the type of vegetation. Additionally, the monthly NDVI maps associated with forest fires were related with the records of El Niño/Oscilación del Sur (ENSO) provided by the National Oceanic and Atmospheric Administration (NOAA) for the decade. We analyzed the average annual cycle, limiting five study regions: western Amazonia, central Amazonia, Amazon South, East and Amazon Colombo-Venezuelan flat plains (Llanos). Fires in tropical South America exhibit a marked annual cycle (unimodal) associated with the NDVI defined as the ratio between the terms (NIR-Red) and (NIR + Red), where NIR is the spectral response in the band of the near infra -red (0.73-1.1 μm)) and Red is the spectral response in the red band (0.55 to 0.68 μm)).

Key Words: NDVI, Thermal Anomalies, Forest Fires, MODIS, Remote Sensing.

DATA AND METHODOLOGIES

Sources and selection of the analyzed information

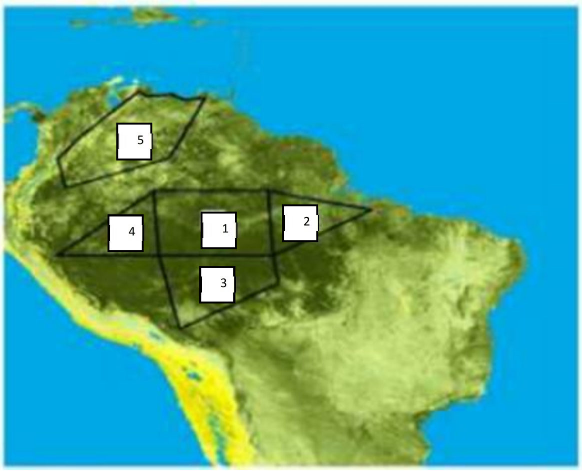
The data for the analysis of Normalized Difference Vegetation Index (NDVI), were taken from satellite images of NASA Laads WEB, which was loaded onto the ENVI software. The software automatically loads stored in NDVI bands images, then by the sum of the reported files for the region and period corresponding monthly georeferenced mosaics were created throughout South Tropical America, these were stored in "tiff" format, in order to perform the subsequent supervised classification of digital levels in the Arc Gis software.

NDVI maps were constructed using the MOD13A2 product sensor MODIS (Moderate Resolution Imaging Spectroradiometer) with a spatial resolution of 1 km, and a temporal resolution of 16 days, GRS 80 reference ellipsoid and projection Mapping sinusoidal during the period 2000 -2010. Identified anomalies from thermal processing of Landsat TM images obtained from MOD14A2 MODIS sensor with a spatial resolution of 1 km and a temporal resolution of 8 days, during the same period. The information is then synthesized in monthly maps integrated NDVI values with the location of thermal anomalies, allowing forest fires relate to the type of vegetation cove.

For analysis of the variability of fires in areas of study, five defined geographic regions as shown in Table 1 and Figure 1.

TABLE 1. Names, areas and location of the quadrants of the study areas.

Zone	Area (km^2)	Lower left corner		Top right corner	
		Latitude	Length	Latitude	Length
Central Amazonia (CA)	862283	-67	-7	-57	0
Eastern Amazonia (EA)	385491	-57	-10	-48	2
Southern Amazonia (SA)	663703	-67	-15	-57	-7
Western Amazonia (WA)	386574	-76	-7	-67	0
Llanos Colombo - Venezolanos	875609	0	74	9	63



Zone	Nº
Central Amazonia (CA)	1
Eastern Amazonia (EA)	2
Southern Amazonia (SA)	3
Western Amazonia (WA)	4
Llanos Colombo -Venezolanos	5

FIGURE 1. Map of the quadrants in study area.

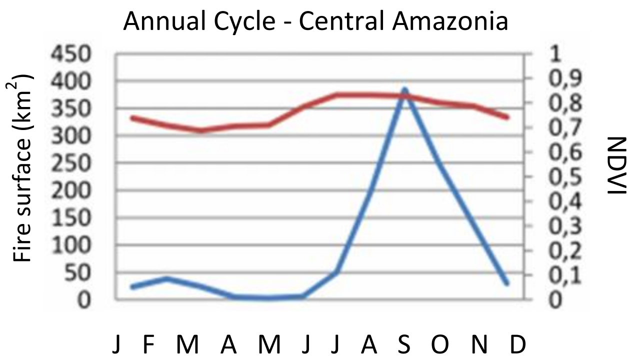
Methods

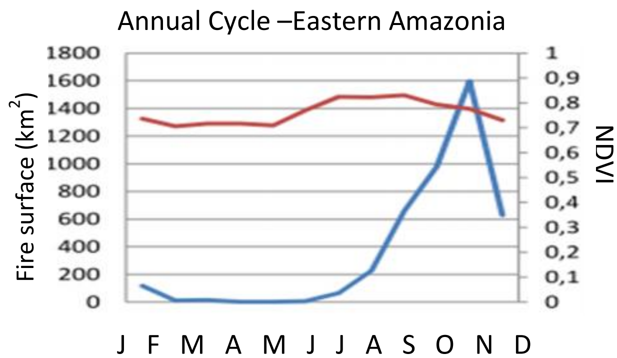
For the analysis of information of each of the areas, the average was obtained NDVI and surface fires (km^2) for each of the areas specified in the Table 1. Monthly averages of data obtained images were performed satellite and then average the annual cycle. Then both correlated variables using a scatter plot and trend line stroke with the respective equation and R^2 value.

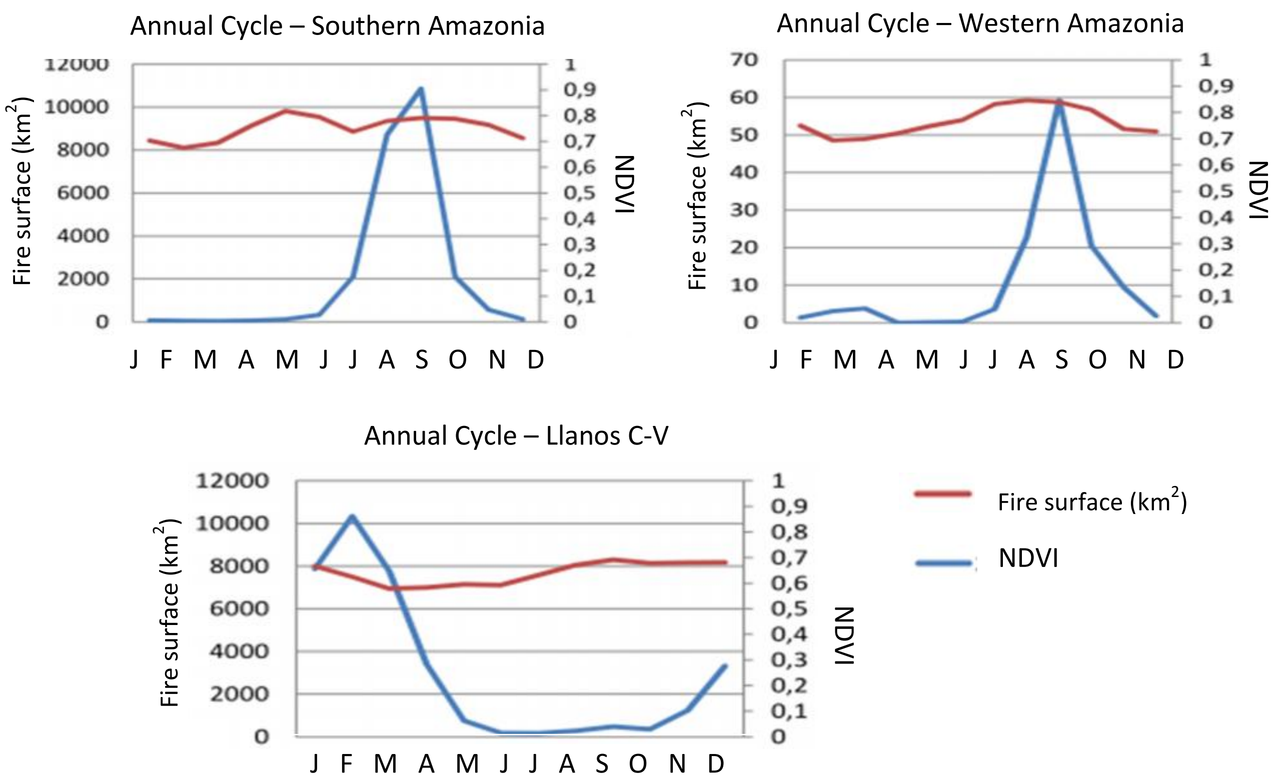
Results

In Figure 2, the average annual cycle of NDVI and burnt areas associated with each of the areas described in Table 1. is presented.

FIGURE 2. Average fire NDVI annual cycle and correlation between them, for Tropical South America during the period 2000-2010.







Conclusions

In the central Amazon, burned areas averages vary between $4km^2$ and $384km^2$ presenting relative maxima in the quarter from August to October, and an absolute maximum at September; the relative minima occur in the quarter from April to June, with an absolute minimum in the month of May. For this area, the average NDVI varies between 0.68 and 0.83, corresponding to coverages developed as forest very humid tropical forests or climax state, the maximum range was obtained between July and August.

In eastern Amazonia, the averages of the burned areas vary between 1.5km2 and $1597km^2$ with maximal relative in the September quarter - November, and absolute maximum in the month of November; the relative minima occur in the quarter from April to June, with an absolute minimum in the month of May. For the same area, the average NDVI varies between 0.7 and 0.83, corresponding to coverages developed as a very wet tropical forest, the maximum range was obtained between the months of August and September. Of the four studied regions of the Amazon was most affected by thermal anomalies and forest fires, which spread quickly through the area. During November 2002, an area was reported burned 2255 km^2.

In the southern Amazon, the averages of the burned areas vary between $42km^2$ and 10855 km^2 showing relative maxima in the quarter from August to October, and a maximum all in the month of September; the relative minima occur in the quarter February to April, with an absolute minimum in March. For this area, the Average NDVI varies between 0.67 and 0.81, corresponding to coverages developed as the tropical rain forest, the maximum range was obtained between the months of May and June. In aerial photographs observe a strong impact in this area, by opening agricultural boundaries and wildlife harvesting.

In western Amazonia, the averages of the burned areas vary between $0{,}11km^2$ and $59km^2$ showing relative maxima in the quarter from August to October, and a maximum all in the month of September; the relative minima occur in the quarter February to April, with an absolute minimum in March. For this area, the average NDVI varies between 0.69 and 0.84, corresponding to coverages developed as the very wet tropical forest or forest climax state, the maximum range is obtained between the months of August and September. Of the four regions of the Amazon was less impacted by the fires and more stable vegetation cover.

Finally, in the Llanos Colombo - Venezuelan averages burned areas vary between $10331km^2$ and $161km^2$ with maximal relative in the January - March, and an absolute maximum in the month of February; the relative minima occur in June-August quarter, with an absolute minimum in July. For this area, the Average NDVI varies between 0.59 and 0.68, corresponding to coverages as stubble low, pastures and secondary forests intervened, the maximum range was obtained between September and November.

In the Amazon regions studied, forest fires occur with more frequently in the second half of the year with a defined unimodal annual cycle, largely extending from the east toward the center, reaching its maximum in the months, September and November.

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