APPLYING GEOBIA METHOD TO ANALYZE CLIMATE CHANGES ASSOCIATED TO ENERGY GENERATION - ANALYSIS ABOUT OIL EXPLORATION *ONSHORE* AT POTIGUAR BASIN

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ABSTRACT:

This paper deals with the discussion of the analysis of remote sensing data on onshore oil exploration occurring in the Potiguar Basin, in the state boundaries of Rio Grande do Norte - Brazil, from the perspective of changes in albedo index, surface reflectance and surface temperature associated with to those aspects. The albedo is considered a significant variable in understanding the energy balance that makes up an important element of the analysis of global climate change. Through the use of remote sensing tools and GIS, based on surface reflectivity algorithms and surface temperature from GEObia (GEOgraphic-Object-Based Image Analysis) from the sequence - Pan-sharpened composite, Radiance with atmospheric correction, Reflectance with atmospheric correction, and Surface temperature with emissivity correction, used in scenes produced by OLI sensors (Operational Land Imager) and TIRS (Thermal Infrared Sensor) Landsat-8 satellite, it was possible to determine the variations in surface reflectance and surface temperature, and compare them to index albedo therein the oilfield based on the method 6S + Liang (2000). The research indicates, with the determination of processed values, which areas of oil exploration to the analyzed time, present significant change rates, with a tendency to increase in reflectance and temperature associated with albedo changes, as well as other areas of renewable energy exploration.

1. INTRODUCTION

The present research is based on the initial analysis of albedo as a relevant factor to energy balance, in earth surface related to 101 *onshore* production fields, that exist in the limits of Rio Grande do Norte State - Brazil.

Potiguar Basin has a total area of around 49.000 km², of which 27.000 km² are *offshore* and 22.000 *onshore*, divided between CE and RN states. Currently, this basin has been considered the biggest field of exploration in Brazil, in RN state it has an estimated area of 16.903,9 km², it represents 34,5% of the total area. (Brazil – AnP, 2014)

Based on the need of observing about the oscillation wether conditions and related systems, index albedo control is necessary because it is a very significant reflectance index of solar radiation. Index albedo focus of interpretation is done in a kind of superficial scale of atmosphere and albedo index of surface.

The Potiguar Basin is located at a semiarid climate region with a severe semiarid subclassification in the center of this climate region, except in the area between coast zone and savanna, the weather is dry and hot, with temperatures over 25ºC and rainfall annual measures lower than 600mm. The natural desertification process is present in this region and it has been changed by anthropic action (ANDRADE, 1973, p. 153).

Oil exploration in Potiguar Basin has origin in 50's, in twentieth century ant it had greatly grown, by the time new fields were discovered along the way, and new technologies in exploration were in the same sense, it turned possible oil extraction and natural gas extraction *onshore* in all 7.071 oil wells in the State (AnP, 2014).

Beside that and according to the Report of Energy Reserch Company – Brasil, EPE (2013) another forms of energy are explored in the State of RN, in a significant way, such as wood, eletric, (thermo and wind power) and biomass of sugar cane.

The albedo index is a concept that is associated to reflectance of solar radiation through the atmosphere and surface, where around 30% of radiation is reflected back to space, it is done mainly through short waves. It is considered an important sign about global climate changes.

In what is related to local and regional weather conditions, the superficial albedo index is a meaningful variable in the analysis when comparing to other ones (temperature, humidity, precipitation, evaporation / evapotranspiration). The main modulatory of atmospheric and superficial albedo is the cloud cover associated to atmospheric aerosol composition and the amount of solar rays, according to area location in analysis. (VEISSID, PEREIRA, 2000; FADIGAS, 2006; GOLDENBERG, 2007).

On the field of study's reality, the superficial albedo index changes that originated from exploration of biomasses (deforestation), desertification process, besides changes in the atmospheric composition due to the introduction of aerosols and gases from biomass burning, all of those factors are an important tool to the atmosphere energetic balance. (ECK et al., 1998; GALDINO, 2003)

Considering natural aspects related to savanna biome, that form almost total area of Potiguar Basin *onshore*, in the semiarid, albedo index represent an important variable to be observed, to evaluate a real climate evolution, taking into account natural structure and other relation in the anthrop actions, that occurs in that area.

Intending a comparative analysis, it was made an investigation based on 6S method associated with correction rates for albedo calculation defined by Liang (2000), and data superficial reflectance established by applying the method GEOBIA (GEOGRAPHIC-Object-Based Image Analysis, 2014), both by ArGis 10 software. The results point towards a wider and detailed description of surface reflectance index through GEOBIA method, considering that all spectrum bands available in Landsat 8 were used in the analysis.

2 . APPLIED METHODOLOGY

Using remote sensing techniques and SIG, the arising data that were necessary to observe superficial albedo levels at Potiguar Basin were based on images from Landsat 8 satellite that came from USGS, through OLI sensors (Operational Land Imager) sensors and TIRS (Thermal Infrared Sensor) (USGS, 2013).

Five scenes were used to cover all the area we analyzed 216/063(159), 216/064(191), 215/063 (152), 215/064(152) e 214/064(161). The dates were defined taking into account time proximity to measurement period of aphelion of July, 2013, and we chose the scenes where less cover cloud (<7%), we follow the tendency work, quoted by Roy, et. all (2014).

In the absence of 214/064 images of the scene with the cloud cover within the set margin of error, and there is no oil exploration field in this area is less than 5%, the eastern end of the study area, the data in this scenario We were not used into account in the statistical analysis.

The outdoor work we had done allowed us to identify geo-reference points to have information spatial exact points for granted, they were associated to WGS-84 projection system, and it had also granted the biggest precision of about 7,64m to images in analysis with a kind of resolution of 14,96 x 14,96m per pixel. We used data from DBOPE (Data bank of Oil Production and Exploration), (BDEP in Brazil), associated to those images.

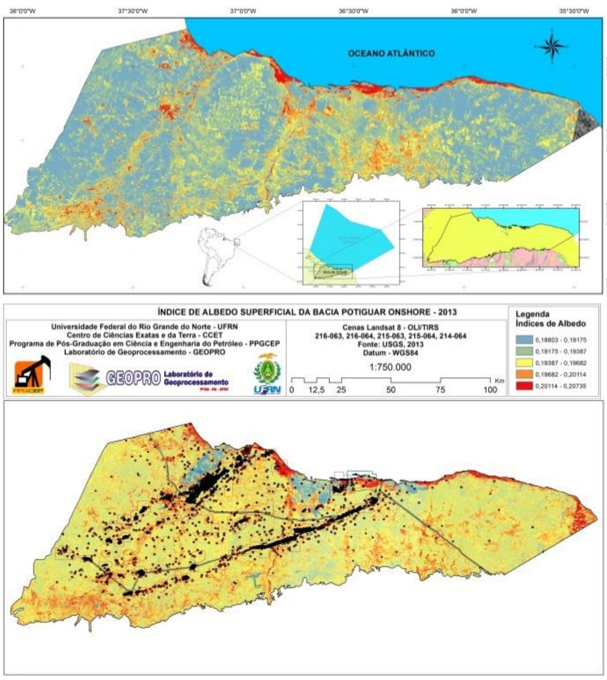


Figure 1. Image of area under analysis. Field location, wells and gas pipelines at Potiguar Basin - PB (BDEP, 2013).

Taking into account the composition of combined scenes, this is: RGB-I (R-6, G-234, B-53, I-7), it was possible to detach different structures of vegetation, explored areas, exposed soil, soil variation, hydrographic reserves and so many other forms of human occupation (Figure 2)

These information easy the reading comprehension of oil exploration area, as well as the comprehension of natural processes of high levels of reflectance.

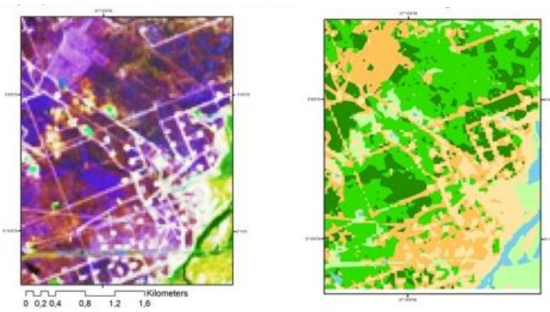


Figure 2. Composition of Images Landsat 8 (RGB-I) (left); and Classification NS from Landsat 8 Scene – 216-063(152/2013) (right).

We had still used information from high levels resolution images as complementary resources, images from satellites Rapideye e Topodata (MMA, 2014), we wanted to check how images were classified. Taking into account these basic information, we applied systems correction of atmosphere and reflectance analysis: the first one the 6S(Vermont, et all, 2006) associated to another one proposed by Liang (2000) to albedo. We also used Geobia tool (GEOgraphic-Object-Based Image Analysis, 2014) through the software ArcGis 10 to analyze the medium of surface temperature and reflectance.

Through of Geobia Method, it was possible to do a panoramic reading of all reflectance degree that comes from Potiguar Basin surface, in a regional perspective. In the analysis, the variation through comparative analyzes among preserved areas and another activities developed there.

The method is based on the calculation of reflectance with atmosphere correction:

$$R_{earth} = R_{sat} - (R_{scatter} - 0.01) \quad [1]$$

Where:
R_{earth}: Reflectance of earth`s surface
R_{sat}: Reflectance of ToA

$$R_{sat} = \frac{(DN - 0.0002) - 1}{cosSZ} \quad [2]$$

Where:
DN = Digital Number;
cos SZ = cosine of 90º – degree of solar elevation;
$R_{scatter}$: Reflectance scattered in the atmosphere

$$R_{scatter} = \frac{(DN_{min} - 0.0002) - 1}{cosSZ} \quad [3]$$

Where:
DN_{min} = minimum value of DN;
cos SZ = cosine of 90º – degree of solar elevation;

Considering the use of correction system 6S (ANTUNES et al, 2014, p. 03; VERMOTE, 2006) we applied band corrections 2, 3, 4, 5, 6 and 7, it was divided into three following levels: 2, 3, 4 (visible), 5 (infra red low), 6 e 7 (infra red medium).

It is important to point out that the observation in this method is based on the following variables: solar angle, zenithal angle, sun-earth distance, aerossol cover and atmosphere model.

The atmosphere correction was individually done, by bands, and it had as consequences a high level of interpretation though three steps: calibration and radiance, atmosphere correction (ToA), and finally surface albedo measurement through of method Liang (2000).

Calibration and radiance:

$$L_\lambda = 1 + \frac{L_{max} - L_{min}}{Q_{cal\max} - Q_{cal\min}} (Q_{cal\max} - Q_{cal\min}) + L_{min} \quad [4]$$

Where:
L_λ: Radiance Value
L_{max}: Maximun value radiance (W/Ester-radiano/m^{-2}/μm)
L_{min}: Minimun Value Radiance (W/Ester-radiano/m^{-2}/μm)
Q_{calmax}: Maximum value of grey levels used in quantifying data
Q_{calmin}: Minimum value of grey levels used in quantifying data.

Atmosphere Correction

$$\rho_{ap} = \frac{\pi \; x \; L_{\lambda \; x \; d^2}}{E_{sol \; x \; cos\theta_s}} \quad [5]$$

Where:
π : solid angles in steradian.
L_λ: Radiance Value;
d : distance sun-earth in astronomic units (AU);
E_{sol} = Solar irradiance on one of the bands in W/m^{-2}/μm;

After atmosphere correction, OLI sensor bands analyzed were underwent to the calculation of superficial albedo, it was based on method adaptation proposed by Liang (2000, p. 227) to the sensor ETM+ to OLI sensor, but it was done observing short wave adaptation and visible band.

Superficial Albedo:

$$\alpha^{OLI} = (0.356\alpha_2 + 0.317\alpha_3 + 0.130\alpha_4 + 0.373\alpha_5 + 0.085\alpha_6 + 0.072\alpha_7) - 0.0018 \quad [6]$$

Where:

α^{OLI} = Sensor Operational Land Image – Landsat 8, adapted from a relation among the bands sensor ETM+; *0,356α_2:* Specific value of band calibration.

After composition, classification and ToA albedo analysis, ToA and superficial we did a comparative analysis through the global albedo table proposed by Otterman (1977), where we verify the relationship between natural conditions that induce natural albedo in that area and changes caused by oil fields under our analysis.

Kind of surface	**Albedo**
Stable snow cover in high latitudes (> 60° of latitude)	0,80
Stable snow cover in medium latitudes	0,70
Unstable snow cover in the Autumn	0,50
Forest covered by stable snow	0,45
Forest covered by unstable snow in the Autumn	0,30
Desert	**0,28**
Forest with falling leaves during a dry period, cerrado and semi desert.	**0,24**
Forest falling leaves during a rainy period, thick and semi desert.	**0,18**
Estep or decidua forest (temperature over 10° in the Spring before snow covering).	0,18
Tundra without snow covering.	0,18
Acicular Forest (temperatures over 10°).	0,14
Steep and forest during transition period.	0,13

Tabel 1. Medium albedo values, according to Otterman, 1976.

2. RESULTS AND DISCUSSION

If we consider the first results obtained through the application of GeoBia and 6S + Liang (2000) techniques, it is possible to observe the following considerations:

The area under analysis has a level of reflectance based on superficial albedo associated to what is estimated by Otterman (1977), in the item "forest falling leaves during a dry period, thick and semi desert" with albedo estimated at 0,18.

Considering that albedo index in desert zones at (0,28), the area under analysis is in an inferior level, so if we consider data band VIS/IR-P/IR-M (0,1571) and nearer to those areas in relation to VIS/IR-P (0,2066). This fact can be associated to natural conditions level and its chemical-physical properties after the period of higher rain period in the region (jan-jun).

By the establishment of controlled points: preserved vegetation, cover clouds, shadows of clouds, saline deposit and urban areas, it was possible to analyze in a comparative way albedo index related to these areas but with different changes tendencies.

At preserved caatinga region there is a tendency of lower rates of albedo, they are shown in a variation from 0,10 to 0,15. According to Otterman (1977), the medium of albedo related to forests in semiarid tropical areas is approximately about 0,14 (Figure 4).

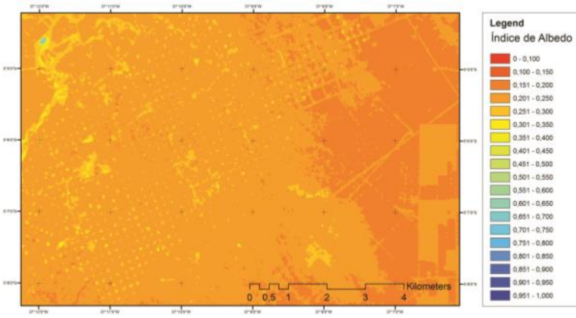


Figure 3: Superficial reflectance values, through Geobia Method from part of the CAM field.

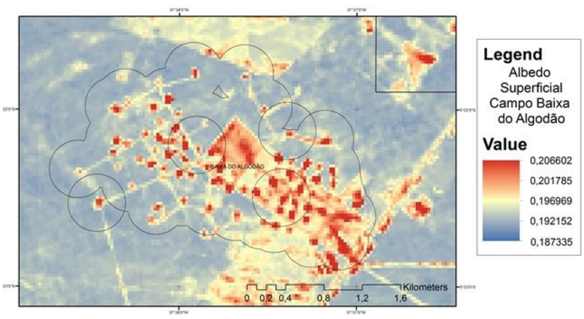


Figure 4. Estimated superficial albedo by the method 6S & Liang (2000), at BAL field.

After the selection of fields whose influence presents regional potential of climatic alteration (>3000m^2 - based in used scale 1:750.000), it was done a classification of data in relation to total area of the field and the area of direct influence of exploration (wells, gas pipelines, preprocessing and processing).

These data indicate that many fields presents altered index by presenting parallel activities in its area (agriculture, biomass exploration, urban areas and visible salt exploration in blue area of the figure 03) that alter the perspective in analysis by field, because of this was adopted the selection with 300m area just around of the activities of direct exploration of oil and natural gas.

Nº	Code	Min_EP	Max_EP	Mean_EP	St_Dev_EP
1	ARG	0,053504	0,645346	0,258199	0,069645
2	BAL	0,043490	0,385675	0,122982	0,031405
3	BEM	0,104291	0,377356	0,161016	0,049158
4	BVS	0,098585	0,356945	0,154126	0,050452
5	BR	0,070176	0,441374	0,176264	0,051777
6	CAM	0,010811	0,538074	0,162068	0,064278
7	ET	0,002076	0,580894	0,190535	0,061223
8	FMQ	0,079314	0,313120	0,112323	0,024831
9	FP	0,111341	0,672718	0,253326	0,067567
10	GMR	0,160705	0,655301	0,215433	0,044648
11	LV	0,029691	0,407038	0,143798	0,043619
12	LOR	0,061638	0,441435	0,131587	0,039384
13	MAG	0,157249	0,661390	0,224118	0,049708
14	MOR	0,104310	0,325440	0,125611	0,028852
15	PJ	0,082404	0,323103	0,119520	0,024016
16	PML	0,100714	0,609326	0,193112	0,075072
17	RE	0,106152	0,491453	0,145318	0,037128
18	REP	0,100501	0,349091	0,142265	0,042173
19	RFQ	0,043400	0,354268	0,121550	0,028443
20	SE	0,097460	0,428327	0,158731	0,044776
21	UPN	0,080534	0,366530	0,156513	0,033263
22	SCR	0,017223	0,701261	0,195982	0,105308
23	SER	0,059948	0,607719	0,368373	0,143655
24	MA	0,029696	0,640282	0,302815	0,198782
25	PITI	0,018971	0,617492	0,256322	0,110869

Table 2. Field General Reflectance Index with regional influence (>3000 m^2).

The observation of rates band by band provided the integration of bands of visible electromagnetic spectrum, near infra-red and mid infra-red, what demonstrate that bands of short frequency presents one indicative significant tendency of values of albedo in the area under analysis, providing a quantification more precise of analyzed areas.

Through the quantification with the use of statistic free software (R – The R Foudation for Statical Computing - 2015) was possible to analyze the general table of PB (Potiguar Basin), with covering of about 97% of total area, it was exempt only one part of extreme east where there is no any oil exploration and whose scenario presents clouds covering above average of other scenarios.

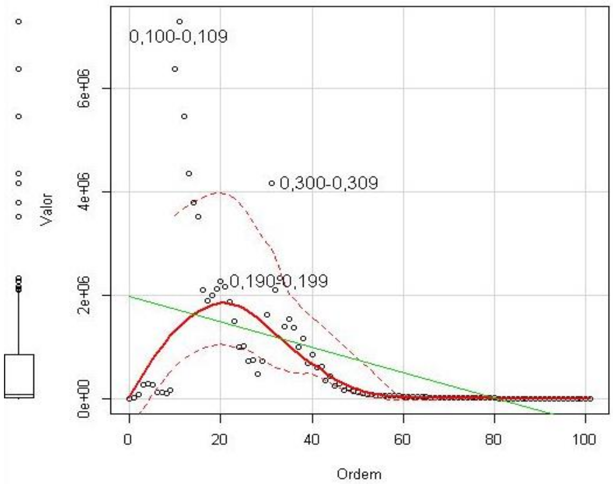


Figure 5. Scatterplot general reflectance data determination of Bacia Potiguar.

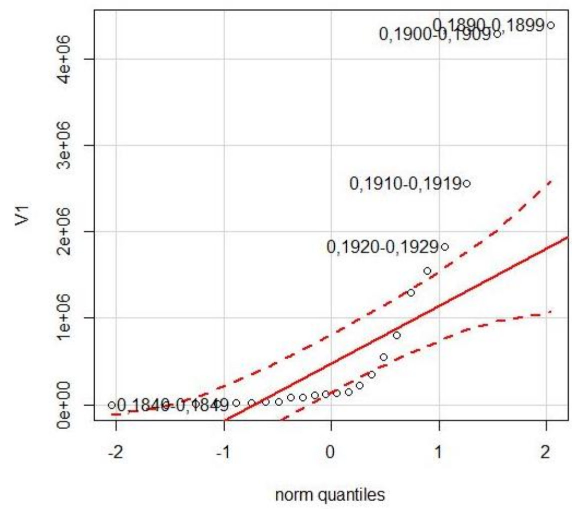
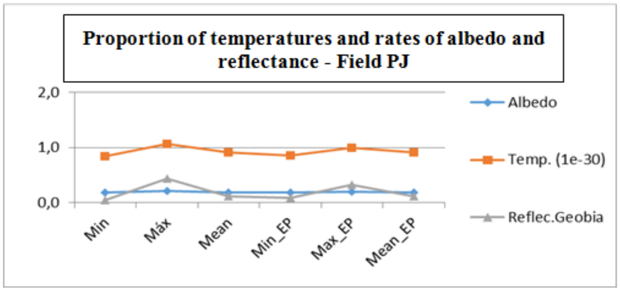


Figure 6. Norm Quantiles of superficial index albedo analysis, highligting the values 0,1900-0,1909 and 0,1890-0,1899 at Potiguar Basin.

We identify 11 oil exploration fields with index that is considered a high level, above average (>0,16), those values are above average of preserved vegetation areas and they're of lower levels in the areas of high index of albedo and natural temperatures.

Those data are not really concluded in their statistic treatment, but it searches to show a kind of general profile, and at the same time it tries to identify oil fields of higher changes influence, that are under observation. A significant order of reflectance in a band from 0,1 to 0,3 fits in data that can be found in the oil exploration area, but the areas highly depends on geosystem where they are located. So, it is necessary a selection and classification of those sub-divisions.

We also applied the analysis of superficial temperature, it is an important aspect in climate analysis, because this way it was possible to see the relationship among rates of albedo, values of superficial reflectance in a wide spectrum and the own changes of temperatures.



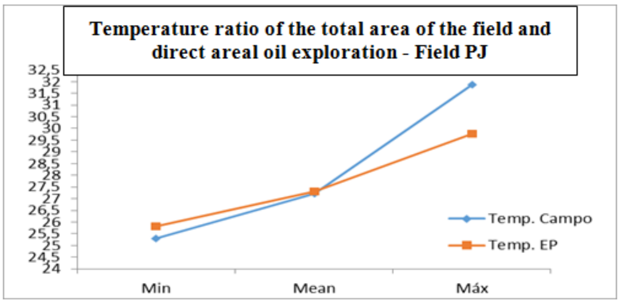


Figure 7. Graphics proportion between temperatures, albedo and relfectance – PJ Field; Relation between the total area of the field and the direct area of exploration – PJ Field.

As we can observe at the figure 7, variation of temperature are more related to variation on reflectance in general, maximum temperature variation are not direct associated to oil exploration areas, i.e. direct to areas of oil wells or gas pipeline used as reference.

CONCLUSIONS

The results show that the oil area under analysis presents variations on the superficial albedo index of low significance, with the analysis in course, related to the associated changes on the anthropic activities on the region (farming, urban areas, and the exploration of other energy resources).

On overall perspective in the use of energy exploration activities, considered renewable and non-renewable energy provided changes in the superficial aspects of albedo and superficial temperature jointly in the area under analysis in this research.

Potiguar Basin has natural areas with high levels of reflectance and albedo, located in areas of dune fields, crystalline outcrops and soils with low rate of absorption associated with dryland vegetation due to semi aridity of the region, taking into account it has low potential for solar radiation absorption. Great dune fields on the coast naturally presents high levels of albedo index and temperature without direct anthropic influence. Rocky sandstone outcrops also presents positive variations in its natural aspect.

When we analyze temperature alteration in a comparative way we can see that they are proportionally related to reflectance alterations by Geobia method than to albedo index, however, this relation happens in a more local-regional scope. Meanwhile, the albedo refers to a more regional-global scope.

Those variations are important to understand the final frame of identification in the more affected areas, and those that need a special attention in order to avoid future irreversible degradation scenes.

The relations among the geosystemic structures that compose the areas under study should be considered in order to observe the causes of the alterations on the superficial albedo indexes in exploration areas.

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