Dear Editor and Referees,

Thank you for your comments regarding the manuscript. These were valuable suggestions for revising and improving the quality of the revised manuscript. After your considerations, we performed several changes and new analysis, and clarified the novelty of the manuscript, as will be empathized below. The Cerrado is a biome distributed over an area of more than 2 million km^2 and the relationship between fires and environmental drivers varies within the biome, highlighting the importance of characterizing the spatial patterns of fire occurrence and their correlation with climatic variables and vegetation condition. Within this context, we consider that, in addition to use a longer time series, we advanced by analysing the correlation between hotspots and burned area with precipitation and VCI spatially (pixel-based), which is not present in Moreira de Araújo et al. (2012) or the other references cited, showing the areas within the Cerrado where the variables are more correlated.

New analysis performed on the revised manuscript are listed below:

- Boxplot and trend analysis of the 2002-2015 time series of monthly total hotspots, monthly total burned area, monthly average precipitation and monthly average VCI (Fig. 4 of the new manuscript);
- Spatial analysis of the mean Fire Radiative Power (FRP) estimated by the MODIS active fire products in the Cerrado between 2002 and 2015 (Fig. 5(b) of the new manuscript);
- Spatial analysis of the month with highest incidence of hotspots and burned area, minimum amount of precipitation and minimum VCI in the Cerrado (Fig. 6 of the new manuscript), as well as the lag in months between the minimum of precipitation and maximum of hotspots, minimum of precipitation and maximum of burned area, minimum of VCI and maximum of hotspots and minimum of VCI and maximum of burned area (Fig. 7 of the new manuscript).
- Spatial correlation of the monthly total hotspots and burned area with monthly average precipitation from one, two, three and four months before.

Moreover, we have substantially rewritten the manuscript considering the comments on the review reports. Main changes performed are described below:

- More than twenty new references were cited in the updated version of the manuscript;
- A new title was proposed for the new version of the manuscript: Satellite observations for describing fire patterns and climate-related fire drivers in the Brazilian savannas;
- Abstract section was entirely rewritten;
- Introduction section was improved, clarifying the research question. Eleven new references were cited in the revised Introduction section;
- Conclusion section was substantially improved, considering both review reports and the new analysis performed.

Regarding the specific comments of the Referees, they are properly replied below:

Abstract. From my point of view it fails to state why the subject is important and what is the problem and how it has exactly or partially address. Fires occur and in the lines 10-12 natural and anthropic causes are mentioned, yet the abstract is not clear about these two and mentions the use of data. Results do not mention LULC and no conclusion is presented.

The abstract was rewritten in the revised paper considering the suggestions of the Referee. Mostly, we focused on clarifying the research question, removed the statements regarding the data used, mentioned the results regarding LULC, results found from the new analysis performed and presented some of the conclusions obtained from the study.

Introduction. In general terms the introduction can be improved. In the same way that the abstract is written, the introduction clearly lacks a presentation of the nature of the problem and both the scope and the state of art regarding seasonality, climatic changes, land use, ignition sources, etc… In this sense paragraph 1 of the introduction needs to develop what is known of both the relationship between natural causes and fires and also human activities. When and where are one more important than others?. What is know about these in particular in Brazil.? As an example also, page 2 L7 the phrase that starts with Moreover…, instead of only mention role of climatic variables…, the authors should develop what is known, what kind of climatic relationships have been found, regarding total rainfall, seasonality, drought period rainfall, etc? What about interannual and intraannual variability, much is already known about it. It is important to establish what is known to have a better clarity of why this work is important and adds to the current knowledge. Further, not much is included on the relationship between the vegetation conditions previously or during burning season, needs to be developed. In a similar way, page 2 L13-23 lists studies that have used orbital sensors, but why is it important? What those studies have shown? What are the limitations ? in a way that it could eventually lead to state clearly why there is a need for more consistent information (P2L25) which is not clear. Too much of the methods at the end of the introduction, there is no need to state the data used here, leave this for the methods section. No clear objectives or research questions are presented. Finally, so far is difficult to get the value added of this work to others that have already published dynamics of fire occurrence in the region, like some of the cited references for example (Moreira et al 2012, 2015) and others like see (Pivello, 2011) (Chen et al., 2013).

The Introduction section was entirely rewritten, considering the very helpful comments of the Referee. In the section of the revised manuscript, eleven new references were cited. For example, papers were cited regarding the frequency of fire weather seasons (Jolly et al., 2015), the bimodal pattern of fire occurrence (Benali et al., 2017), the role of climate and vegetation condition in the occurrence of fires (Archibald et al., 2010; Chéret and Denux, 2011; Leblon et al., 2012; Chen et al., 2013; Bajocco et al., 2015), the role of fire in the LULCC process of the Cerrado (Pivello, 2011), and other works that analysed the temporal and spatial distribution of fires in the Cerrado (Libonati et al., 2015a; Libonati et al., 2015b; Libonati et al., 2016).

The citation of the studies on P2 L13-23 intended to show that the use of orbital sensors is a widespread approach to understand the role of fire in ecosystems and climate, especially in the savannas around the globe, also showing that MODIS was previously used in regional and global studies of the savannas. In fact, results found were compared with some of the studies presented on P2 L13-23 of the Discussion paper, such as those that are specific for the Cerrado (Nascimento et al., 2010; Moreira de Araújo et al., 2012; Moreira de Araújo and Ferreira, 2015). Nevertheless, we reduced the number of citations in this statement of the new Introduction section. Moreover, we removed the statement regarding the method and reduced the information regarding the data used.

Finally, we considered that the changes applied to the Introduction section were able to better clarify the research question, especially the paragraph starting at P2-L32, as well as the objective, which is present in the last paragraph of the section.

Methods. Not needed so much information on Modis sensors, can be reduced P3L19 onwards P4 L5 is repeated information. In general terms dataset used have different spatial resolution, how the authors have used them? Please clarify in the text. I have a strong concern about the methods used to analyze the relationships and I am afraid at this stage Pearson correlation might not be enough and a time series analysis is needed to capture the complex climate-vegetation conditions-fire occurrence relationships. I would suggest the authors to review some literature in relation to this see for instance (Armenteras-Pascual et al., 2011)(Aragão et al., 2008) etc I found the format changes of the Modis products not necessary and basic information that is totally unneeded as it stands (P5 L29-), same with other sections (P6 L15 tiles) etc. P6 L 5-7 The use of a 4 km grid is not justified. P6 L 12 What is most confident? I found extremely confusing the paragraph P7 L3-9, this is the most important part of the methods, to clarify the type of analysis for each research question.

We reduced the information related to the MODIS sensors in the section. Regarding the spatial resolution of the datasets, time series of monthly and annual averages presented in Figs. 3, 4 and 7 of the Discussion paper considered the entire area of the Cerrado, therefore, values corresponded to the sum of the hotspots and burned area and to the average of precipitation and VCI for the whole biome. Regarding the concern of the Referee, we have applied the Breaks For Additive Seasonal and Trend (BFAST), an additive method that decomposes a time series into seasonal, trend and noise components (Verbesselt et al., 2010), in the Cerrado 2002-2015 time series of monthly total hotspots, monthly total burned area, monthly average precipitation and monthly average VCI in order to find trends in the four time series (Fig. 4 of the revised manuscript).

Regarding the spatial results, all maps of the revised paper considered the same grid size (0.25º x 0.25º, spatial resolution of TRMM data), enabling that all results are comparable, therefore, Figs. 8, 10 and 11 of the Discussion paper were replaced by Figs. 5(a), 8 and 9 of the revised manuscript, respectively. All new figures were generated using the values of hotspots, burned area, precipitation and VCI corresponding, respectively, to the sum of monthly total hotspots, sum of monthly total burned area, the original TRMM monthly precipitation values and the monthly average VCI for each grid cell of the 0.25º x 0.25º grid over the Cerrado. This was clarified in the Data Processing section of the revised paper. Still, most confident in P6 L12 are highly reliable observations, and, therefore, the most probable pixels of being burned area.

Results and Discussion Since there is no clear research questions, the results are hard to follow but basically the Moreira de Araujo et al 2015 paper shows the same pattern and is heavily used in the discussion, so again the question is what is the value added of this work? I found the fire density reported really high (can be interpreted as every year all km are burnt), and is confusing if it is over the 2002-2015, I think a yearly density should be calculated or a map of fire frequency for the period. The LULC and fire relationship is weakly treated. P7 L 30 first time dry season is mentioned, needs to be explained before in the intro or study area description P8 Lines3-8, consider abbreviating years, summarizing in a table, using ranges when applicable. P8 L 14-15 any other possible explanation? Human ignition? Management practices? P8 L15- 17. Is difficult to get where this point

originates or relates to the current study. P8L27 consider introducing these general annual trends before monthly patterns P10L2 land use is well settled, not clear the meaning P11L16-21 what about in tropical? And if soil moisture is so important, was not mentioned in the introduction.

Considering the new analysis proposed and the comments of the Referee, we think that the value added of the work is clearer in the revised paper. Fire density reported considered the entire 2002-2015 period, and, in the revised paper, yearly density were calculated. Additionally, the relationship between LULC and fire was better explored and discussed, especially citing the work of Pivello (2011). Dry and rainy season explanation were moved to the Study Area section. Results beginning in P8 L3-8 of the Discussion paper were summarized in Table 2 of the revised paper.

In P8 L14-15 of the Discussion paper, precipitation and vegetation conditions due to the accumulated months of drought are the better explanation, however, management practices may also influence and were cited as a possible explanation in the revised paper. As a result of the new analysis, we can see that spatially there is a variation in the maximum values of hotspots and burned area and minimum precipitation and VCI and in the lag between the variables, which helps to understand why there are still high averages in October. Additionally, P8 L15-17 was rewritten. In the revised manuscript, annual trends are introduced before monthly patterns (P9 L6).

In P10 L2, land-use well settled means that land-use change is not usual in recent days, once human occupation in these areas is older and there are few natural remnants of the Cerrado, which was clarified in the revised paper. The citations in P11 L16-21 of the Discussion paper intended to present other climate controllers that have influence over fires in other vegetated areas of the globe and may also influence the occurrence of fires in the Cerrado, but were not analysed yet. Considering the comment of the Referee and once these variables were not tested for the Cerrado we removed the P11 L16-21 sentence of the Discussion paper from the revised paper.

Conclusions. This section needs to be heavily rewritten, first two paragraphs are not conclusions but mostly repetition of results. P12 L 12 How have you established the conclusion of the Cerrado as adapted and dependent of fires? This conclusion is not clear, neither in L19-21

The Conclusions section was entirely rewritten considering the comments of both Referees and the new results found, especially the first two paragraphs. The new Conclusions section included the following topics regarding the new analysis proposed:

- Analysing only average values may not the best approach to characterize the occurrence of fires in the Cerrado;
- Spatial analysis and its relationship with the variation of hotspots, burned area, precipitation and VCI in the Cerrado;
- Usually, there is a lag of 2 or 3 months between the minimum values of precipitation and hotspots/burned area in the Cerrado and no lag between VCI and hotspots/burned area in the biome;
- A statement regarding VCI as a good instantaneous indicator of the occurrence of fires in the Cerrado;
- More intense fires are not necessarily located in the areas where hotspots are more concentrated in the Cerrado.

Figures. Too many, select the most relevant ones, eg. I would remove Fig

The number of figures was reduced in the revised version of the manuscript. For example, Figs. 2, 5 and 6 of the Discussion paper were removed. Even considering the four new figures resulting from the new analysis performed, the number of figures was reduced to ten.

The authors must be careful when talking about the lack of such specific studies. In fact, there are some studies that show the spatial and temporal patterns of fire and relation between fires and climatic variables in Cerrado. The authors should see the authors they mention (Moreira et al 2012, 2015; Pivello, 2011,) and also papers listed below: The work of Libonati et al., 2015a shows that the intra-annual variability of burnt area over the Brazilian woody savannah mostly relates to the seasonal regime of precipitation. These authors also show that there is a marked dry season from May to September, characterized by very low precipitation amounts and that, during the dry period, there is a steady displacement towards higher values of the median, lower and upper quartiles and extremes of the distributions of monthly values of burnt area. The work of Libonati et al., 2015b analyzed the results of three currently burned area products derived from MODIS data, namely AQM (INPE), MCD45A1 (NASA) and MCD64A1 (NASA). The procedure is applied to quantify the overall temporal and spatial distribution patterns of burned areas in Brazil for the period 2005 – 2010 and obtained patterns are compared for each Brazilian biome and related to the respective patterns of fire pixels derived from remote sensing. The Cerrado biome was found the one with the largest BA, followed by Caatinga and Amazônia. Estimates of BA over Brazil from AQM, MCD45 and MCD64 products for the period present a similar inter-annual variability. In addition, the work of Libonati et al., 2016 allows analyzing the overall temporal and spatial distribution patterns of BA for the last decade. The highest monthly mean amount is observed in September, followed by October, and March presents the lowest amount. The most severe year is 2007, followed by 2005 and 2010; 2006 and 2009 are the years with less area burned, followed by 2008. The spatial pattern of BA shows that the north region of Cerrado presents the highest frequency of occurrence. The spatial pattern of BA shows that the north region of Cerrado presents the highest frequency of occurrence. The intra and inter-annual variability of BA over Cerrado are closely related to the variability of precipitation but it is worth emphasizing that, despite the major role played by climate conditions, the human factor has also a prominent role on fire dynamics in this region and cannot be disregarded.

This paper is not focused on Burned Area (BA) or how to estimate it. We used this variable as an additional dataset to spatially analyse fire patterns and their correlation with precipitation and vegetation condition over the Cerrado. Most of the articles cited by the Referee used averaged/summed values for the entire Cerrado and are focused only in BA and fire count. In the present study, we analysed, besides averaged/summed time series, datasets at pixel-based statistics, such as spatial correlation or lags. We included the references of Libonatti et al. in the Introduction section of the revised paper and when discussing results found for BA. Regarding the lack of studies, this sentence was corrected in the revised paper. The lack of studies is regarded analysing the correlation between hotspots/BA and climate-related drivers spatially, such as the results presented in Fig. 8 of the revised paper and in the new analysis performed. Pivello (2011), Moreira de Araújo et al. (2012), Moreira de Araújo and Ferreira (2015), and Libonati et al. (2015a, 2015b, and 2016) did not provide this information. In fact, all the works cited above, except to Pivello (2011), who presented an overview of the fire history in the Amazon and in the

Cerrado and described how fire regime changed in the biomes, are focused on BA, which was only one of the variables analysed and discussed in the paper. Two of the references are focused on describing an algorithm for BA detection and validating the MCD45A1 BA product (Libonati et al. (2015a) and Moreira de Araújo and Ferreira (2015), respectively). Moreira de Araújo et al. (2012) and Libonatti et al. (2015a) analysed the correlation between BA and precipitation in the Cerrado, however, not spatially, therefore, they did not show in which areas of the biome these two variables are more correlated.

Libonatti et al (2015b), which was published in the proceedings of the Brazilian Symposium on Remote Sensing, compared 3 different BA datasets (AQM, MCD45A1, and MCD64A1) and also analysed the spatial and temporal variability of BA in the Brazilian territory for the 2005-2010 period. Their work did not analyse the spatial and temporal variability in the area corresponding to the delimitation of the Cerrado, only nationally. We analysed the temporal distribution of hotspots and BA in the Cerrado considering a longer time series (2002-2015), as well as the spatial distribution of hotspots, not BA, in the Cerrado (Fig. 5(a) of the revised manuscript). Regarding Libonati et al. (2016), we found only a one-page abstract of the reference published in the proceedings of the EGU General Assembly. The results cited by the Referee were obtained from AQM product, are described in one paragraph and do not show the annual or monthly values of BA or the map showing that the highest concentration of BA is in the North of the Cerrado. Moreover, we have substantially discussed the role of human activities in the occurrence of fires in the savannas (from P11 L23 to the end of the Results and Discussion section of the Discussion paper), as well as in the citation of Pivello (2011) present in the Results and Discussion section of the revised paper (P11 L20-28).

It is worth mentioning that the manuscript uses the same precipitation data from Libonati et al., 2015a.

TRMM is the most used dataset in studies of precipitation conducted using remote sensing, once it provides excellent estimation of spatial and temporal patterns of precipitation considering a period of more than 15 years and is widely validated. The efficiency of TRMM data in the Brazilian territory is shown in works such as Pereira et al. (2013), cited in the Discussion paper, which justifies the choice of the dataset. In fact, Libonati et al. (2015a) was not the first paper that used TRMM dataset for analysing precipitation in the Cerrado. We can find several references that use the same product, for example, this reference from 2011 related to the environmental analysis in South America using TRMM and fire datasets (http://www.mdpi.com/2072-4292/3/10/2110), which is prior to the mentioned study. Furthermore, Moreira de Araújo et al. (2012) also used TRMM data when analysed the distribution patterns of burned area in the Brazilian biomes.

Moreover, Moreira de Araújo et al. (2012) and Libonati et al. (2015a) used an average value for the entire Cerrado and did not considered the spatial variability of precipitation, which includes distinct mechanisms. In the Cerrado, we have a substantial variation of the dry season peak, for example, the North region of the biome is mainly controlled by the Intertropical Convergence Zone and Upper Level Cyclonic Vortex disturbances, while the South region of the biome is mainly controlled by anticyclones and cold fronts. Thus, using only average values for the entire biome may not be the best approach. Therefore, we performed spatial approach with statistical analysis pixel-by-pixel, as presented in Figs. 6, 7, 8, 9 and 10 of the revised manuscript.

Accordingly, all the results shown in the manuscript were previously reported by the above studies.

VCI analysis was not present in any of the studies cited by the Referee, as well as the spatial correlations presented in the Discussion paper. Nevertheless, the trend analysis, spatial analysis of the month with highest incidence of hotspots and burned area, minimum amount of precipitation and minimum VCI in the Cerrado, and the lag in months between the minimum of precipitation and maximum of hotspots, minimum of precipitation and maximum of burned area, minimum of VCI and maximum of hotspots and minimum of VCI and maximum of burned area performed and presented in the revised paper are also not provided in the works cited by the Referee, highlighting the novelty of the new version of the manuscript.

For instance, the work of Veraverbeke et al. (2014) is no about social and economic costs of fires, but on remote sensing techniques aiming fire severity assessment. In addition, the authors argue the efficiency of MCD45A1 product for mapping and understanding fire behavior and its impacts in the Cerrado. These results are not in agreement with previous works such as Roy et al (2008) and Libonati et al. (2015a), who have pointed out an under-detection of BA by the MCD45 product in savannas regions of Brazil.

The citation of the social and economic costs of fires was corrected in the revised paper; works of Brunson and Tanaka (2011) and Stephenson et al (2013) were cited. Regarding the efficiency of the MCD45A1 product for mapping and understanding fire behavior and its impacts in the Cerrado, this sentence was rewritten, and the works of Roy et al. (2008) and Libonati et al. (2015a) were cited in the revised paper (P8 L18-24). Moreira de Araújo and Ferreira (2015) analysed the performance assessment of the BA product MCD45A1 in the Cerrado by comparing the product with BA maps derived from Landsat images and found good results, however, they analysed only BA detected during September, which is the month with highest concentration of BA in the Cerrado.

5) Some conclusions are not based on the results: 1) 'Nevertheless, the annual variability of hotspots and precipitation and between burned area and precipitation during the 2002-2015 period is evidenced.' 2) Besides the seasonal modulation by precipitation, fire occurrence seems to respond to its interannual variability. Drier (wetter) years are associated with more (less) fires in the studied area. There is no clear evidence in the manuscript, despite visual comparison, about the statistical significance of this relation. The authors say in the conclusions that 'The methods applied are easily implemented and can be used for analyzing the occurrence and dynamics fires in different areas of the globe'. I don't think this work shows a 'method'. Instead, it is mainly devoted to a spatial and seasonal description of available variables.

The Conclusions section was entirely rewritten considering the comments of both Referees and the new results found, especially the first two paragraphs, also improving the relationship of the variables, not only described them. The word 'method' was replaced by 'approach'. The new Conclusions section included the following topics regarding the new analysis proposed:

- Analysing only average values are not the best approach to characterize the occurrence of fires in the Cerrado;

- Spatial analysis and its relationship with the variation of hotspots, burned area, precipitation and VCI in the Cerrado;
- Usually, there is a lag of 2 or 3 months between the minimum values of precipitation and hotspots/burned area in the Cerrado and no lag between VCI and hotspots/burned area in the biome;
- A statement regarding VCI as a good indicator of the occurrence of fires in the Cerrado;
- More intense fires are not necessarily located in the areas where hotspots are more concentrated in the Cerrado.