Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2017-90-AC1, 2017

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Analysis of fire dynamics in the Brazilian savannas" *by* Guilherme Augusto Verola Mataveli et al.

Guilherme Augusto Verola Mataveli et al.

mataveli@usp.br

Received and published: 14 June 2017

Dear Referee 1,

Thank you for your suggestions. These were very helpful and will significantly improve the quality of the revised manuscript. Once there is no option of sending the updated version of the manuscript during this stage of the reviewing process, we will answer each topic indicating the modifications that we made and the new results found.

1) Title. Analysis of fire dynamics in the Brazilian Savannas This paper analyses the dynamics of fire occurrence in the Brazilian savannas with the aim to understand the occurrence and the dynamics of fires in the Cerrado using precipitation and vegetation condition as explanatory variables. The Cerrado is a key biome for the country and has

been heavily transformed over the years, however in the current state, is hard to extract the added value of this paper to for instance Moreira de Araujo et al paper heavily used in the manuscript.

After your considerations, we performed several new analyses, which will be included in the revised paper. The novelty of the manuscript will be empathized below. Most of Moreira de Araújo et al. (2012) is focused on the entire Cerrado, not pixel-based analysis. The Cerrado is a biome distributed over an area of more than 2 million km2 and the relationship between fires and environmental characteristics varies according to several factors. In this work, we used spatial statistical tools to indicate the most vulnerable areas to the occurrence of fires, showing its variation in the biome. 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 in the Cerrado where the variables are more correlated. Moreover, considering the comments of the Referees, we will add new analysis in the revised paper, described below:

In the updated version of the manuscript we will present a spatial analysis of the month with highest incidence of hotspots and burned area, minimum amount of precipitation and minimum VCI in the Cerrado (Figure 1 in this response letter), 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 (Figure 2 in this response letter). Maximum of hotspots and burned area usually occur two or three months after the minimum of precipitation in the Cerrado, while the maximum of hotspots and burned area are concentrated in the same month when VCI is minimum for most of the Cerrado.

In the updated version of the manuscript we will present the seasonality and trend of hotspots, burned area, precipitation and VCI in the Cerrado for the 2002-2015 time series using 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) (Figure 3 in this response letter). A small decrease in the trend of hotspots was found in 2011 and in 2007 for precipitation, while burned area trend was regular during the period and VCI presented a tendency break between 2007 and 2010, showing that VCI is a good indicator of the occurrence of fires in the Cerrado, once 2007 and 2010 were the two years with highest detection of hotspots and burned area in the biome.

In the updated version of the manuscript we will present the mean Fire Radiative Power (FRP) estimated by the MODIS active fire products in the Cerrado between 2002 and 2015 (Figure 4 (b) in this response letter), which showed that more intense fires are not necessarily located where hotspots are more concentrated.

Specific comments:

2) 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 will be rewritten in the revised paper considering the suggestions of the Referee. Mostly, we will emphasize the importance of fires in the Cerrado, clarify that considering the heterogeneity of the biome a pixel based approach is necessary to understand the complex climate-vegetation conditions-fire occurrence relationships, as well as mention the results regarding LULC, the new results found from the analysis described above and the conclusions obtained in the study.

3) 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 introduc-

tion 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 will be revised, improved and new references will be cited according to the comments of the Referee, such as Benali et al. (2017), who analysed the extent of the fire regime globally and identified a bimodal seasonality pattern which indicates an anthropogenic fingerprint; Jolly et al. (2015), who studied climate-induced variations in global wildfire danger and found an increasing frequency of longer fire weather seasons in recent years; Leblon et al. (2012), who studied the use of remote sensing in wildfire management and presented an overview of the role of vegetation and weather conditions over the ignition and spread of wildfires; Chéret and Denux (2013), who used NDVI derived from MODIS to estimate the susceptibility of Mediter-

ranean forest to fires; Chen et al. (2011), who studied long-term trends and the inter-annual variability of fires in South America and found large year-to-year changes associated with extreme climate conditions; 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; and Rissi et al. (2017), who compared fire behavior in early, mid and late dry season of the Cerrado and found that fire intensity is mainly influenced by the combination of dead fuel percentage and fuel load. 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, 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). Moreover, we will remove the statement regarding the data used in the introduction of the revised version of the paper, and clarify the research question and the value added of the paper to others considering the results found and the new analysis proposed in the revised paper.

4) 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 will reduce the information related to MODIS sensors in the section. Regarding the spatial resolution of the datasets, time series of monthly and annual averages presented in Figures 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 spatial results, all maps of the revised paper will consider the same grid size (0.25° x 0.25°, spatial resolution of TRMM data), enabling that all results are comparable, therefore, Figures 8, 10 and 11 of the Discussion paper will replaced by Figures 4(a), 5 and 6 of this response letter, 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 0.25° x 0.25° grid over the Cerrado. This will be clarified in the revised paper. Furthermore, considering the comments of the Referee and in order to better understand the complex climate-vegetation conditions-fire occurrence relationships, we will add the new analysis proposed above, which are represented in Figures 1, 2 and 3 of this response letter. All the information considered unnecessary by the Referee will be removed or rewritten in the revised paper. In P6 L12, most confident are pixels flagged as 1 in the MCD45A1 product, which are highly reliable observations, that is, they are the most probable pixels of being burned area. The paragraph P7 L3-9 will be rewritten and the method for estimate the spatial correlations will be clarified, mostly considering the information of the second paragraph of this response letter regarding the Methods section.

5) 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 will be clearer in the revised paper. Fire density reported considered the entire 2002-2015 period, and, in the revised paper, yearly density will be calculated. Additionally, the relationship between LULC and fire will be better explored and discussed, and the dry and rainy season explanation will be moved to the Study Area section. Results beginning in P8 L3-8 will be summarized in a table in the revised paper. In P8 L14-15, precipitation and vegetation conditions due to the accumulated months of drought are the better explanation, however, management practices may also influence and will be cited as a possible explanation in the revised paper. As a result of the new analysis (Figures 1 and 2 of this response letter), 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. These results will be better explored in the revised version of the paper. Additionally, P8 L15-17 will be rewritten. The suggestion regarding P8 L27 will be considered in the revised paper. 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. The citations in P11 L16-21 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 will remove the P11 L16-21 from the revised paper.

6) 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 will be entirely rewritten considering the comments of the Referee and the new results found, especially the first two paragraphs. The new Conclusions section will include 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 located in the areas where hotspots are more concentrated in the Cerrado.

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

After several changes and new analysis, the number of figures will be reduced, such as Figure 5 of the Discussion paper.

New references:

Benali, A., Mota, B., Carvalhais, N., Oom, D., Miller, L. M., Campagnolo, M. L.,

Pereira, J. M. C.: Bimodal fire regimes unveil a global-scale anthropogenic fingerprint, Glob. Ecol. Biogeo., doi: 10.1111/geb.12586, 2017. Chen, Y., Morton, D. C., Jin, Y., Collatz, G. J., Kasibhatla, P. S., van der Werf, G. R., DeFries, R. S., and 5 Randerson, J. T.: Long-term trends and interannual variability of forest, savanna and agricultural fires in South America, Carbon Manag., 4, 6, doi: 10.4155/cmt.13.61, 2014. Chéret, V., Denux, J. P.: Analysis of MODIS NDVI Time Series to Calculate Indicators of Mediterranean Forest Fire Susceptibility, GISci. Rem, Sens., 48, 2, doi: 10.2747/1548-1603.48.2.171, 2013. Joly, W. M., Cochrane, M. A., Freeborn, P. H., Holden, Z. A., Brown, T. J., Williamson, G. J., Bowman, D. M. J. S.: Climate-induced variations in global wildfire danger from 1979 to 2013, Nature Comms, 6, doi: 10.1038/ncomms8537, 2015. Leblon, B., Bourgeau-Chavez, L., San-Miguel-Ayanz, J.: Use of Remote Sensing in Wildfire Management, in Sustainable Development - Authoritative and Leading Edge Content for Environmental Management, 1 st edition, InTech, Press, Rijeka, Croatia, 55-82, 2012. Pivello, V. R.: The use of fire in the Cerrado and Amazonian rainforests of Brazil: past and present, Fire Ecol., 7, 1, doi: 10.4996/fireecology.0701024, 2011. Rissi, M. N., Baeza, M. J., Gorfone-Barbosa, E., Zupo, T., Fidelis, A.: Does season affect fire behaviour in the Cerrado?, Int. J. Wildland Fire, 26, 5, doi: 10.1071/WF14210, 2017. Verbesselt, J., Hyndman, R., Newnham, G., Culvenor, D.: Detecting trend and seasonal changes in satellite image time series, Rem. Sens. Env., 114, 1, doi: j.rse.2009.08.014, 2010.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2017-90, 2017.

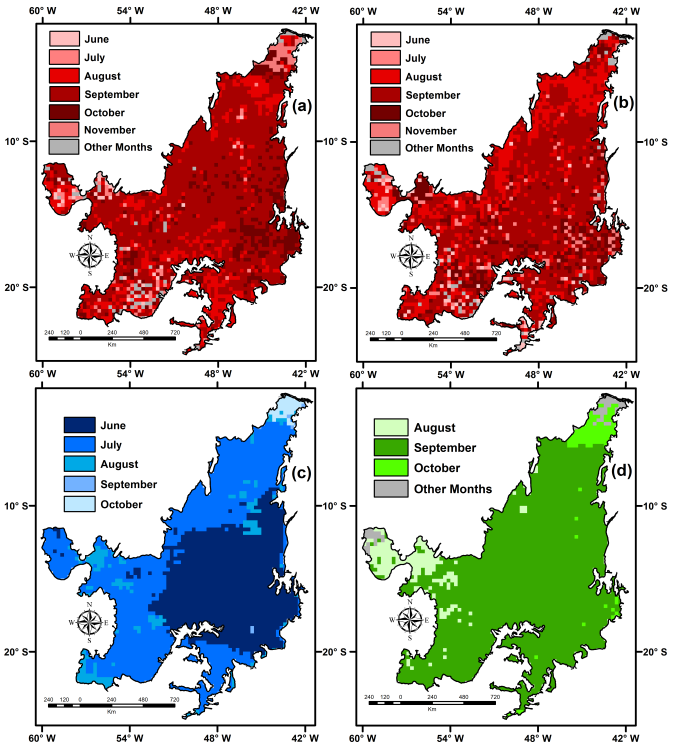

Fig. 1. Estimate of the month when (a) maximum of hotspots (b) maximum of burned area, (c) minimum of precipitation and (d) minimum of VCI was found in the Cerrado for the 2002-2015 time series.

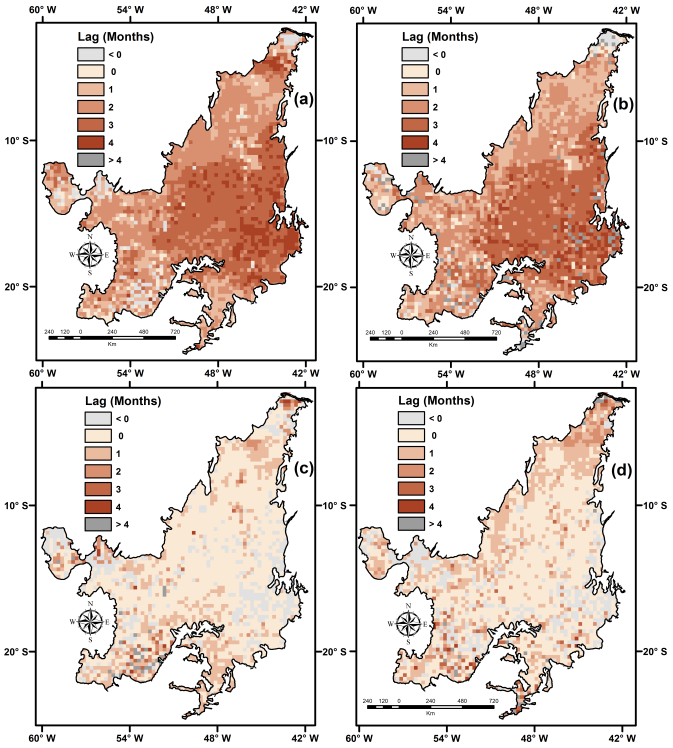

Fig. 2. Lag in months between minimum and maximum values of (a) precipitation and hotspots, (b) precipitation and burned area, (c) VCI and hotspots and (d) VCI and burned area in the Cerrado.

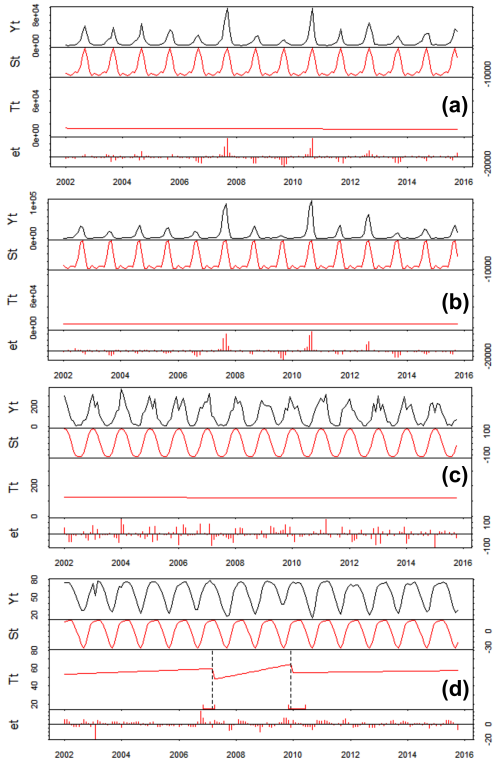

Fig. 3. Decomposition of the (a) hotspots, (b) burned area, (c) precipitation and (d) VCI time series in the Cerrado (Yt) into seasonality (St), Trend (Tt) and Remainder (et) components.

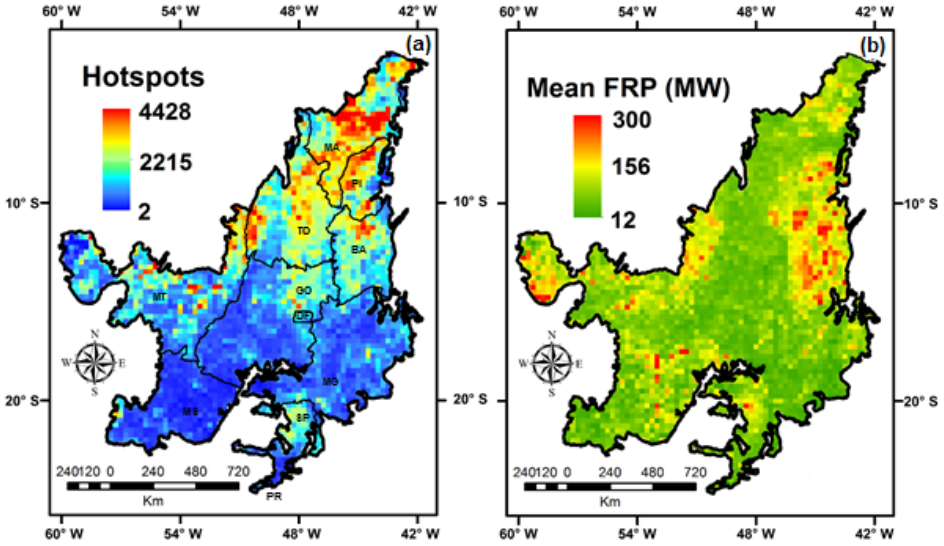

Fig. 4. (a) Total of hotspots and (b) Mean FRP detected by the MODIS active fire products in the Cerrado biome between 2002 and 2015.

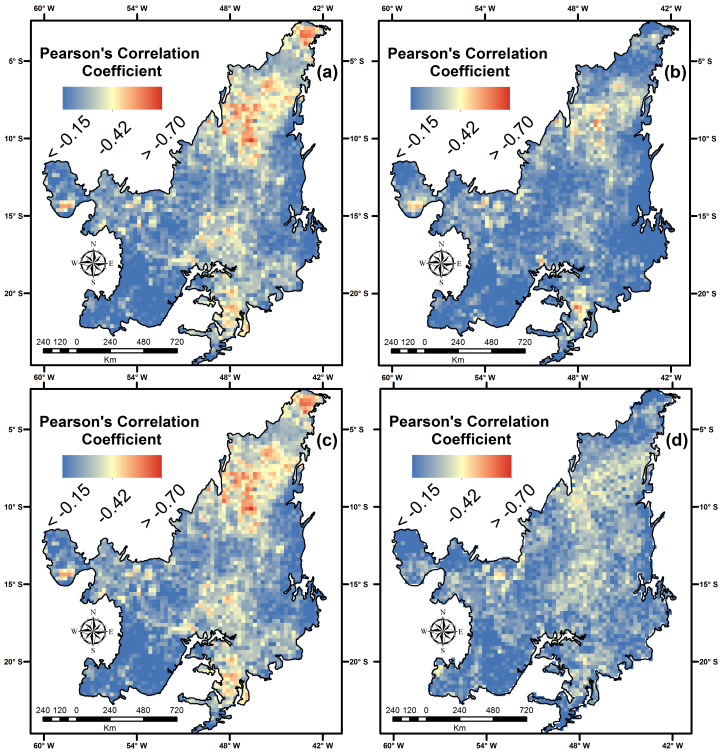

Fig. 5. Spatial correlation between (a) hotspots and precipitation, (b) burned area and precipitation, (c) hotspots and VCI and (d) burned area VCI in the Cerrado biome.

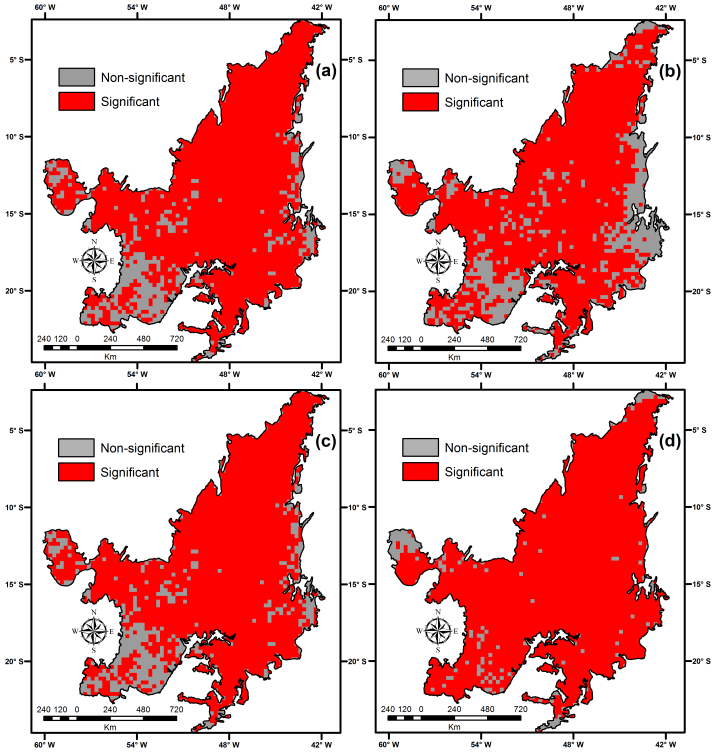

Fig. 6. Spatial t-Student test for the spatial correlation between (a) hotspots and precipitation, (b) burned area and precipitation, (c) hotspots and VCI and (d) burned area VCI in the Cerrado biome.