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Political activity in social media induces forest fires in the Brazilian Amazon

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ABSTRACT

Authors have presented several discussions and they suggest that Google Trends data did not only reflect the current state of events, but may have also been able to anticipate certain future trends. A major peak of devastation and fire occurred on August-2019 in Brazilian Amazon forest and messages were spread out in social media and on the Internet announcing protests over “the day of fire”. Investigations of journalists indicate that a group formed by producers, land grabbers and prospectors set fire to roads in the Brazilian Amazon. Social media is part of the routine of statements by presidents and political representatives with a high impact on actions that directly affect the population. Our goal is to use Google Trends as an indicator or predictor of actions as that were part of the fires in the Amazon in 2019. In this article we investigate what is a possible influence of President of Brazil Jair Bolsonaro in the increase of fire outbreaks due their speeches, using cross-correlations between the President’s speech with keywords in Google Trends and current data of fires alerted by INPE– Instituto Nacional de Pesquisas Espaciais (National Space Research Institute). We found a cross-correlation of 55.73% that support this fact after looking up keywords related in Goggle Trends. The cross-correlation indicates that the maximum value is seven days from the peak of the search for the keyword, on the same date of “day of fire”. When data are observed hour by hour, the cross-correlation between keywords and the beginning of “day of fire” is 53.96%, with a lag between 10 h and 32 h until the increase of fires in Legal Amazon. The cross-correlation for Google Trends between the keyword “Germany” and the keyword “Altamira+Fires+BR-163” was of 72.87%, showing high relationship in the attacks to Mrs. Angela Merkel (Germany) and Altamira (region of Amazon) with highest fires outbreaks appearing along the BR-163 highway.

1. Introduction

In the literature many authors have presented several discussions and they suggest that Google Trends data did not only reflect the current state of events, but may have also been able to anticipate certain future trends. [Preis et al. \(2013\)](#) found consistent results that notable drops in the financial market are preceded by investors searching for information before making a decision whether to buy or sell between 2004 and 2011 using Google Trends. The authors detected increases in Google search volumes for keywords related to the financial market before stock market falls.

[Carrière-Swallow and Labbé \(2011\)](#) constructed a Google Trends Automotive Index using queries for Chile showing that the model outperforms competing benchmark specifications by up to 14%. In the macroeconomic model, [D’Amuri and Marucci \(2017\)](#) conclude that the predictions constructed by using Google-based data provides forecasts that are more accurate than models based on labor force flows. They

used the keyword “jobs” for Google Index on a monthly average basis in Google trends.

In terms of renewable energy, [Park and Kim \(2018\)](#) compare the relationship between electricity consumption and the “renewable” Google Trends keyword. The authors said that household electricity consumption decreases for every one unit increase in the search for the keyword “renewable”.

Therefore, the large volume of studies using analyses with Google Trends is concentrated on the health area. For instance, [Ginsberg \(Ginsberg et al., 2009\)](#) constructed a method processing hundreds of billions of individual searches for 5 years of Google web-search logs and system-generated comprehensive models to be used in influenza surveillance. The authors relate that they obtained a correlation of 0.9 in the percentage of influenza provided by the state of Utah (USA). [Jun et al. \(2021\)](#) used the social big data provided by Google RSV to investigate how the WHO’s pandemic declaration for Covid-19 affected public awareness and behavior. They confirmed that the pandemic

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declaration increased public awareness and had the effect of increasing searches for information on COVID-19 by more than 20%.

The use of Google Trends as a way to anticipate events is justified because of the current globalization. With greater displacement of people and the advent of the internet, events can no longer be associated with a single country. Searching for keywords globally can anticipate catastrophic events from one country to another. With regards to the flu, for instance, [Zhang et al. \(2019\)](#) have recently investigated whether seasonal influenza epidemics in Australia, China, US and UK found correlation coefficients above 0.95 with p -level < 0.01 to all cases related to influenza strain A(H3N2).

Due to globalization, it is necessary to predict waves of people using the health system, anticipate campaigns and treatment to avoid epidemics. [Bragazzi et al. \(2017\)](#) used Google Trends to monitor the interest in preventable infections and related vaccines. With the increase of Tuberculosis, an early detection of a possible epidemic is the first defense line. [Zhou et al. \(2011\)](#) constructed a real time system to detect new cases of tuberculosis using Google Trends and a dynamic model.

[Tkachenko et al. \(2017\)](#) related that the results demonstrate that Google Trends can detect early signs of diabetes by monitoring combinations of keywords, associated with searches for hypertension treatment and poor living conditions. [Morsy et al. \(2018\)](#) showed a good autocorrelation between Google Trends and confirmed cases of the Zika virus in Brazil and Colombia.

Public health policy can be applied with better precision using Google Trends to prevent suicide cases in cities. For instance, [Parker et al. \(2016\)](#) tested Google Trends data on 27 terms on alcohol-induced death, drug-induced death and suicide cases. The authors showed that the model fitted to the pre-2015 data was much better than the classical model used to forecast death rates.

[Dos Santos \(2018\)](#) used Google Trends data with multivariate analysis and econometric models to nowcast and forecast insights about the role to new trends in aquaponics in Europe. In terms of Economy Google trends have helped several studies to forecast trends of unemployment ([Simionescu, 2020](#); [Naccarato et al., 2018](#)). [Jun et al. \(2018\)](#) analysed 657 Google Trends related documents using descriptive statistical analysis, and utilize network analysis for the analysis of specific research directions. The authors found three areas in which the distinction in the direction of research using Google Trends: Information system or computer science, Medicine & bio science and Economy & Business.

The most iconic study using google trends is to predict voting intentions and the Referendum outcome. Could Google Trends be a credible enough tool to predict Referendum results? With this question, [Mavagrani and Tsagarakis \(2016\)](#) answer is yes. They used statistics test to analyze pre-Referendum intension in Greece to leave European Union, tracking with google trends data, day after day, the intention to vote for YES or NO.

The increase of fire spots in Brazilian Amazon forest in 2019 alarmed the entire international scientific and political community. After assuming the presidency of Brazil, Mr. Jair Bolsonaro has made use of social media directly and he has denied important facts, figures and data, thus starting several crises with leaders from other countries via the Internet.

In this article we investigate what is a possible influence of President Jair Bolsonaro in the increase of fire outbreaks due their speeches using cross-correlations between the President's speech with keywords in Google Trends and current data of fires in Brazilian Amazon.

With this work we demonstrate that is possible extract and investigate qualitative information from social networking predicting possible drastic events and consequences from influencers ideas. For cross information with quantitative data, we used moving median for Box-Plot and techniques of time serial, such as cross-correlations.

Quantitative data were grouped every four years because of Brazil's term of office (elections every four years). For each additional year the oldest data was discarded and a Box-Plot was applied to a new year. The idea is to use the moving median to build a Box-Plot by using

observation from previous years to decrease the big oscillations for fire outbreak and average monthly rainfall. Then to compare data for different years and different months is used ANOVA (Analysis of Variance and Hypothesis test).

2. Material and methods

To investigate what is a possible influence of President Bolsonaro and minister of Environment in the increase of fire outbreaks due their speeches we used cross-correlations between the President's speech with keywords in Google Trends and current data of fires alerted by INPE (National Space Research Institute). We analyzed and processed for this work 3,036,666 pieces of data from official websites of public domain of Brazilian government in historical data for fires, rainfall index, budget government and keywords of Google Trends.

We have researched data monthly from INPE since 1998 and have adopted the statistical technique of Box-Plot to observe distribution of fires in the Amazon region. To correlate fires and President Bolsonaro's speech, we used data from Google Trends collected exactly in the same period when fires suddenly broke out in the Amazon. Finally, we download data from IBAMA- (the Brazilian Institute of Environmental Protection and Renewable Natural Resources) to analyze reported infractions of fire outbreaks in the last years and its consequences.

The major region in the Amazon rain forest is known as the Legal Brazilian Amazon (BA), which corresponds to a total area of 5,217,423 km². This region is formed by nine states: Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Mato Grosso, Tocantins and Maranhão. Originally 4×10^6 km² of BA was covered by the rain forest, but activities, such as cattle ranching, have depleted it ([Tyukavina et al., 2017](#)).

The graph in [Fig. 1](#) shows the total of fire outbreaks since 1998 until August of 2019, where it is possible to see a strong reduction of fires from 2004 until 2013 in the Legal Amazon. After 2013, it is possible to observe, once more, an increase of fire outbreaks in the Legal Amazon. But to observe only the total numbers during year is not, enough, or correct, due to seasonal variations in Brazil.

In [Fig. 2](#), we separated only the total of fire outbreaks for the months of August in the Legal Amazon since 1998. The dotted line shows that in August/2019 the total of fires was the highest since 2010.

But the volatility of fire outbreaks causes many discussions in statistical comparisons due the season of rain, years with extreme drought, due to El Nino, or low investment to combat fires in past governments. Therefore, we adopt here an observation by using moving Box-Plot, ANOVA (Analysis of Variance and Hypothesis test) and cross-correlation to compare data for different years and different months. With the advent of Google Trends, we make correlations among speech, interviews, and keywords that most appeared in internet and it correspondence with the increase of the fires.

For these, data observations the years were grouped every four years because of Brazil's term of office (elections every four years). For each additional year the oldest data was discarded and a Box-Plot was applied to a new year. The idea is to use the moving median to build a Box-Plot by using observation from previous years.

With this concept, it is possible to eliminate and screen outliers, as well as large oscillations, and we can statistically compare if there were significant differences in the fire outbreaks. This methodology was adopted for all months in the Legal Amazon and the State of Amazon (AM).

3. Results and discussion

The escalation of news about fires in the Amazon as well as its association with deforestation has grown since the early months of 2019. On July 19th, President Bolsonaro said that data from INPE – Instituto Nacional de Pesquisas Espaciais (National Space Research Institute) were not real in report of newspaper Folha de S.Paulo ([2019](#)): "With all the devastation that you accuse us of doing and having done in the past,

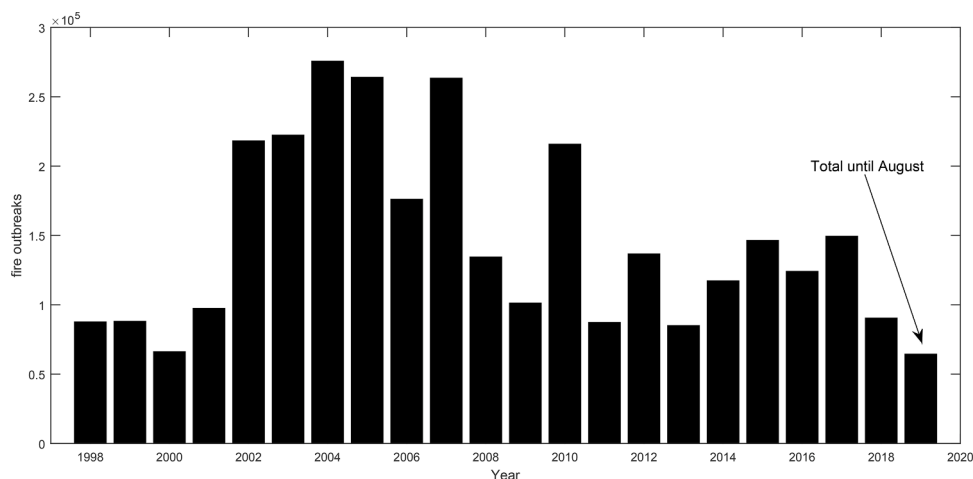


Fig. 1. Total of fire outbreaks/year since 1998 in Legal Amazon.

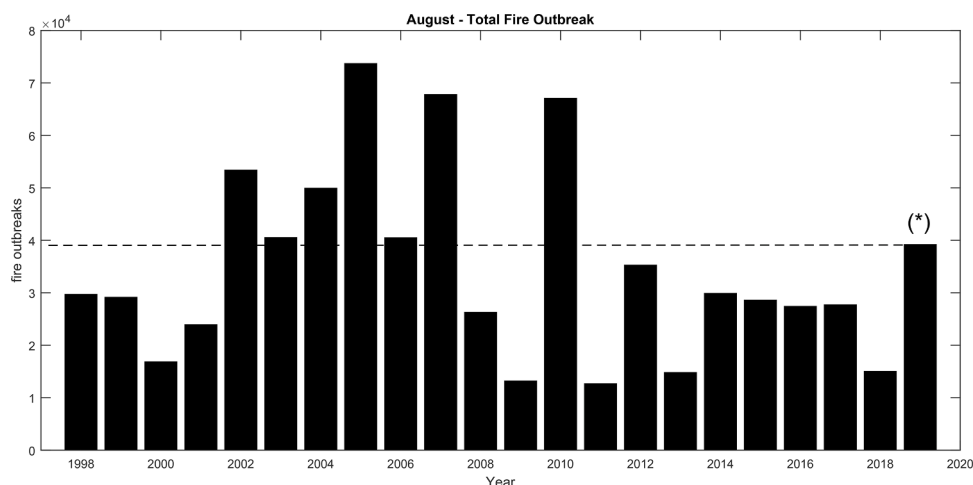


Fig. 2. Total of fire outbreaks in Legal Amazon (August).

the Amazon would already be gone”, he said. “Of course I will talk to the president of Inpe. [They are] Repeated stories that only help make the name of Brazil misleading abroad”. The president stated that Inpe’s data were not true and suggested that Galvão could be “at the service of some NGO (non-governmental organizations)”.

Because of this accusation Dr. Ricardo Magnus Osório Galvão, director of INPE, answered in an interview to newspaper (Folha de S. Paulo, 2019): Galvão said that “he [Bolsonaro] behaves as if he is in a tavern. That is, he has made undue accusations to people of the highest level of the Brazilian scientific community, I am not saying just myself, but many other people”. “This is a joke of a 14-year-old boy who is not up to a President of the Republic to make”, said the director of INPE.

After that Dr. Galvão was fired, President Bolsonaro begins a series of declarations about international and national financial resources for the preservation of the Amazon, such as to Brazilian website (UOL, 2019): “Brazil does not need money from Germany to protect the Amazon, says Bolsonaro”. The newspaper O Globo published declarations of President Bolsonaro (O Globo, 2019): “Bolsonaro says Brazil does not need money from Germany to preserve the Amazon”.

Then, Minister of Environment, Mr. Ricardo Salles, accused former director of INPE of being left wing and a producer of “false” notification of data. Dr. Galvão said in interview for Brazilian website (UOL, 2019b): Galvão said that “any leader of a country has to understand that when it comes to scientific issues, there is no authority above the sovereignty of science. Neither military nor political nor religious”.

The answer of the Minister of Environment for the same website was (UOL, 2019): Minister Salles responded by saying that “the problem is when ideology is disguised within science. What we have seen for a long time is science taking over the right to say this or that”.

Two days later, President Bolsonaro answered again to Germany again with regards to the Amazon Fund reported by website UOL (UOL, 2019): “I even wanted to send a message to dear Angela Merkel, who suspended \$ 80 million for the Amazon. Take this money and reforest Germany, okay? You will make more use of it there”.

According to a report from the Amazon Fund, the amount of 1.9 billion reais (Brazilian currency) worth of projects has been disbursed since 2008 (Fundo Amazônia, 2018). The portfolio has 120 projects and helped with a 75% drop in deforestation. By observing the federal budget (Portal Transparência, 2019), it is possible to notice that the financial resources from the government is smaller than the total resources of the Amazon Fund. In 2019 the budget for IBAMA (The Brazilian Institute of Environmental protection and Renewable Natural Resources) was of 106,717,990.00 reais (Brazilian currency). This institute is responsible for combating deforestation and fires across the country. This value is only 5,6% of the total invested in the Amazon Fund. The Amazon fund is very important to protect the Amazon forest and the work is carried out by non-governmental organizations (NGO) that help poor and indigenous communities (Fundo Amazônia, 2018). The governors of the States in the Legal Amazon responded by saying that international resources should not be refused. At the same time, the

fire outbreaks intensified with each new statement by the President and Ricardo Salles (Minister of Environment) according to reports on BBC News (Aug/27/2019) and Folha de S.Paulo (Aug/14/2019).

3.1. Statistical analysis for distribution of fire outbreaks and precipitation

Data for fire outbreaks from INPE are available with cumulative totals by month on http://queimadas.dgi.inpe.br/queimadas/portal-sta-tic/estatisticas_estados/. In order to compare the volatility of fire outbreaks, we chose the region of the Legal Amazon and in particular case, the State of Amazon (AM) because its area is 30% of the Legal Amazon.

It is possible to notice in Fig. 3 the median oscillation since 1998 considering moving Box-Plot and its whiskers in the Legal Amazon. By observing the median, it is possible to notice that the fire outbreaks increased until 2007, regardless of the month assessed for each Box-Plot in the figure. It is also possible to observe that after the fires steadily decreased by 2015, a sudden increase appears again in the data collected and smoothed by the median.

Between 2015 and 2016, a political turmoil occurred in Brazil culminating in the final impeachment of President Dilma Rouseff. In the figure, we note the period of the process and completion of the impeachment, where, according to IBAMA, the numbers of infractions reported rapidly decreased (IBAMA, 2019).

Fig. 4 shows a region of the highlighted chart for the years 2015 to 2019 (only August), including 2019. In details, it is possible to verify that 2018 and 2019 were the worst years between 2015 and 2019 for the fire outbreaks in the Legal Amazon. The statistics for these Box-Plot are presented in Table 1, where it is possible to calculate the volatility (strong oscillations around median) for each four years of the fire outbreaks. In 2015 50% of fire outbreaks were below the median of 14,780 fires, whereas in 2019 50% of the fires were above the median of 27,712 fires.

When the comparison is in terms of quantile, while in 2015 25% of the data were above 25,021 fires, in 2019 25% of fires were above 28,150 fires.

President Bolsonaro said that the average of fires in the Amazon forest is smaller than previous years (Exame, 2019). The data shows that the median of fires in 2016–2019 is better than 2015–2018, but the worst when compared with 2012–2015, the beginning of the second term of President Dilma Rouseff (beginning in 2015). The median of fires including August in 2016–2019 is 87% higher than 2012–2015. Many reasons are given for this worst-case scenario in this period, including drastically cutting funding to combat deforestation (IBAMA, 2019). Minister Ricardo Salles, for instance, declares in an interview on the Brazilian TV channel Cultura that 2019 is the worst in terms of

rainfall in the region of Legal Amazon (Piauí, 2019 and EBC, 2019).

We downloaded data of rain accumulated by month and grouped samples for Altamira, Belem, Obidos, Manaus, Labrea and Rio Branco (Fig. 5). These cities were chosen because the official data files are most complete and these cities are in different regions of the Legal Amazon. Another reason is that few cities keep historical routinely acquired data.

By using Pivot Table, a new table was generated with the average monthly rainfall in the city since 2015 to 2019 to confront with data of fires and decrease in the number of infraction notices in the period of political turmoil in Brazil. The results converge to the same conclusion of technical report from IPAM- Instituto de Pesquisa Ambiental da Amazônia (Silvério et al., 2019). Fig. 5 shows data of rainfall index for a sample of the cities in the Legal Amazon. We can observe that, data of the rainfall index (cumulated mm/month by city) downloaded from INMET (National Institute of Meteorology) of public domain (INMET, 2019) showing no statistical differences between 2017, 2018 and 2019 for July and August in Fig. 6.

The Box-Plot in Fig. 6 was built by following the same methodology adopted for the fire outbreaks, using a moving median for each of the four years. We grouped several cities in the northern region of Brazil because INMET data does not separated rainfall index for the Legal Amazon, only for some cities. For July we have run the ANOVA (Analysis of Variance) for 2015–2018 in comparison with 2016–2019. Considering level of 0.05, we found *p-level* < 0.5255, and in this case, we cannot reject the hypothesis of equality between these two periods. For August, ANOVA showed the result considering the level of 0.05, a *p-level* < 0.2899 in the same period. In this case, also, there is no statistical evidence to reject the hypothesis of equality between period 2015–2018 and 2016–2019 in the months July and August. Considering this analysis we cannot claim that the increase in fire outbreaks was due to the lack of rainfall in the Legal Amazon region.

The main state where there is a large concentration of rainforest in Brazil is State of Amazon according to an official technical report from IBGE (2014), with an annual average higher than 3000 mm. The area in km² of the State of Amazon is 30% of the Legal Amazon, so in order to evaluate the evolution of the fire outbreaks in this state, Fig. 7 shows a comparison between the months July and August.

It is possible to observe that Box-Plot is much more expressive in terms of difference of fires. Comparing the fire outbreaks with window of four past year between 2012–2015 and 2016–2019, in August of 2015 the median was 1,981 fires while in 2019 the number was 4,235. An increase of 113% in four years.

The discussion in Brazil and around the world is about the comparison of fire outbreaks between 2018 when the president was Michel Temer, and 2019, considering the political situation with regards to the

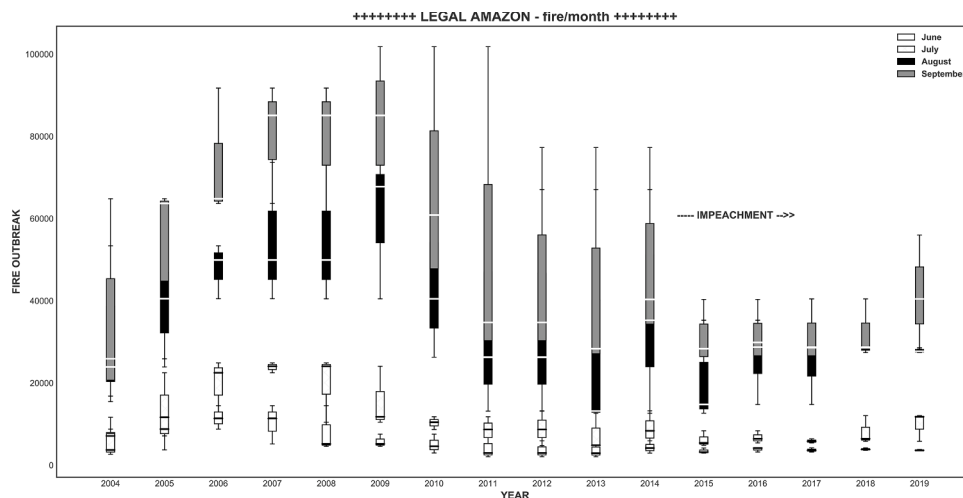


Fig. 3. Fire outbreaks in Legal Amazon by month grouped for each four years.

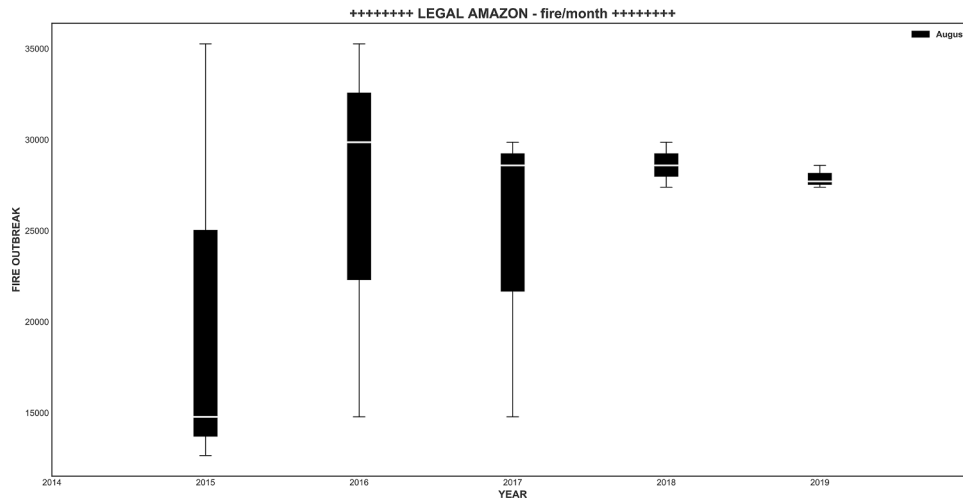


Fig. 4. Comparison of fire outbreaks in Legal Amazon between 2015 and 2019 in August.

Table 1
Statistics for the Legal Amazon for fire outbreaks every four years in August.

	Median	Quantile-1(25%)	Quantile-3(75%)
2012–2015	14,780	13,716	25,021
2013–2016	29,861	28,320	32,562
2014–2017	28,589	21,684	29,225
2015–2018	28,589	27,990	29,225
2016–2019	27,712	27,551	28,150

environment during the Bolsonaro administration. The Minister of Environment- Ricardo Salles and Minister of International Relation- Ernesto Araujo said that the fires are normal and the same as previous years. For the State of Amazon we have the statistical analysis in Table 2.

It is possible to observe in Fig. 7 that in August (2015–2018), 50% of the fires were below 3,652 outbreaks while in August (2016–2019), 50% of the fires were above 4,235. In 2015-2018 25% of the fires were above 3,943 outbreaks when in comparison, in 2016-2019, 25% of the fires were above 4,514. The increase of fires is almost 15% in Bolsonaro administration in terms of Quantile-3. Minister Ricardo Salles and Minister Ernesto Araujo were not correct in their arguments.

Then regarding the State of Amazon we statistically observed an increase in the median of fires between 2015–2018 and 2016–2019. When a comparison between August of 2012–2015 to August of

2016–2019 is made, we can observe a larger difference in 50% of the fire outbreaks in 2019 above 4,235 while 50% in 2015 were below 1,981. It is possible to notice that August 2019, by using a window for the four past years, had many more fire outbreaks than August 2015.

3.2. Google Trends and actual fire outbreaks

After firing INPE's director, President Jair Bolsonaro said in several talks with the press that Brazil did not need money from Germany or Norway (Folha de S.Paulo, UOL and Globo, Aug/11/2019). On August 14th news from the press announced that farmers set fire to the Amazon rainforest along the highway BR-163 in the State of Para. The news reported by Brazilian newspaper that farmers said: "Farmers say the idea of the fires is to show work to President Jair Bolsonaro" (Folha de S. Paulo, 2019).

At the same time INPE reported an increase in fire outbreaks by 743% with 194 events in the city of Altamira-PA. On the following day, the fires continued with 237 fire outbreaks. This period was known as "the day of fire". Then President Jair Bolsonaro began to speak about the non-governmental organizations (NGO). He said that there was evidence that NGOs had been setting fires to the Amazon rainforest to attack his government (UOL, 2019), but investigations not proved this fact.

We decided search for keywords in a google tool known as "Google Trends", in the same period, to check if is possible to see any correlation

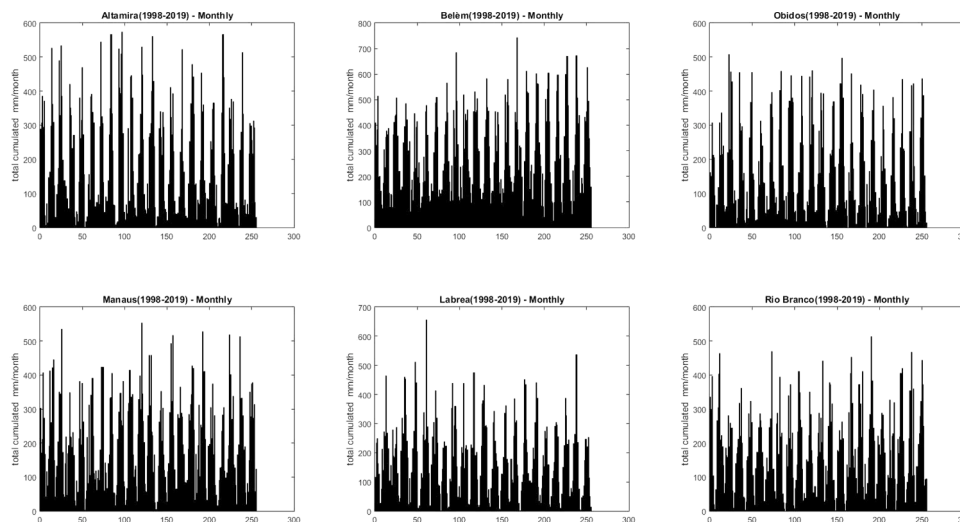


Fig. 5. Rainfall index for the samples of cities.

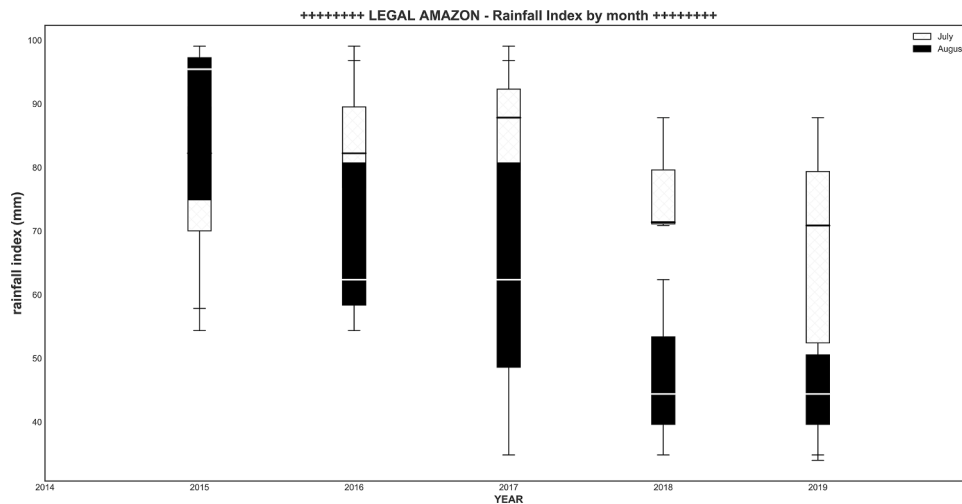


Fig. 6. Rainfall index in Legal Amazon since 2015 to 2019 for July and August with window of four past years.

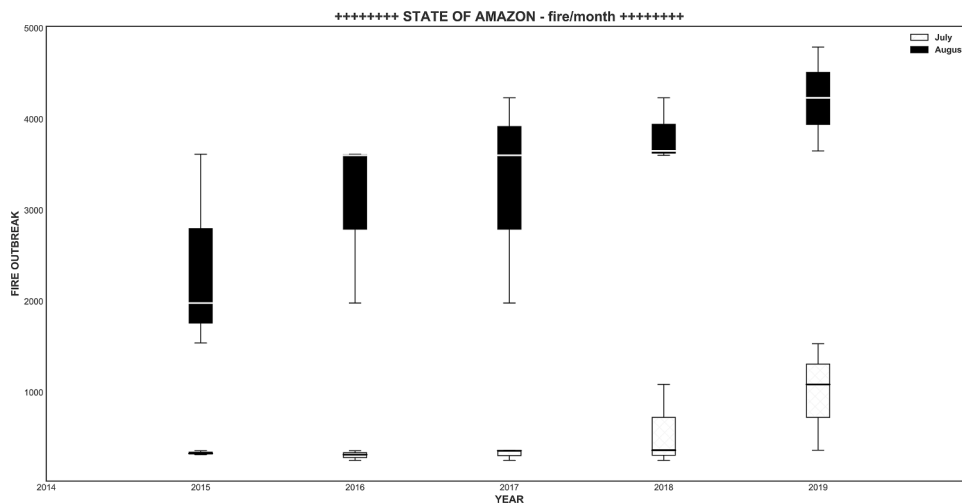


Fig. 7. Comparison of fire outbreaks in State of Amazon between 2015 and 2019 in July and August with window of four past years.

Table 2
Statistics for State of Amazon for fire outbreaks between August of 2018–2019.

	Median	Quantile-1 (25%)	Quantile-3 (75%)
2012–2015	1,981	1,762	2,798
2015–2018	3,652	3,628	3,943
2016–2019	4,235	3,943	4,514

between a speech by President Jair Bolsonaro and the increase in fire outbreaks. This type of relationship is not direct and the possible correlations between events and search of keywords on the Internet is a subject for several articles in literature previously mentioned. This approach for cross-correlations was used in several works to help in the forecasting and observations of trends (Strauss et al., 2020; Lee, 2020; Höpken et al., 2019)

In order to analyze what induced the “day of fire”, we carried out a search in Google Trends for the period between speech of President Bolsonaro against Germany and Norway and the actual fire outbreaks in the Amazon region. We developed a script in Python language to search for the occurrences of three keywords in Portuguese: “Alemanha” (Germany), “Noruega” (Norway) and “Fogo Amazônia” (Fire Amazon). The results for August/2019 can be observed in Fig. 8.

The data were normalized by maximum values for each category. For

instance, we take the maximum value of the fire outbreaks and divide all numbers by it. The same concept was used for keyword data from Google Trends. Thus, all data will have minimum of zero and maximum of one.

In this figure the bold line is the actual fire outbreaks collected by INPE using satellite images to alert places where fires occurred. The square markers are data from the keyword “Germany”. Google Trends presented a sharp increase in the keyword “Germany” on August 3rd, after the President began a discussion about data of fires produced by INPE, and Norway canceled financial support for the Amazon Fund. It is possible to notice that the fire outbreaks increased from August 9th to August 11th, growing from 0.3 to 1.0. In terms of non-normalized values, the increase was 784 to 2,548 fires, or, 225% in 10 days.

Brazilians just started searching for the keyword “Fire Amazon” when the news in a television reported, with images and videos, fires and smoke in several cities of the Amazon region. It is possible to observe, in Fig. 8, a sharp increase in this search after August 19th, one week after “a day of fire”. Then by focusing only on the keyword “Germany” the strongest fire outbreak appears exactly one week after the search for that word increased in Google Trends.

From August 2nd to August 9th, president Jair Bolsonaro spoke several times to the press about Germany, Norway, the Amazon Fund, non-governmental organizations, Indian reservations and sovereignty of the Amazon. In addition to the increased search for this subject on the

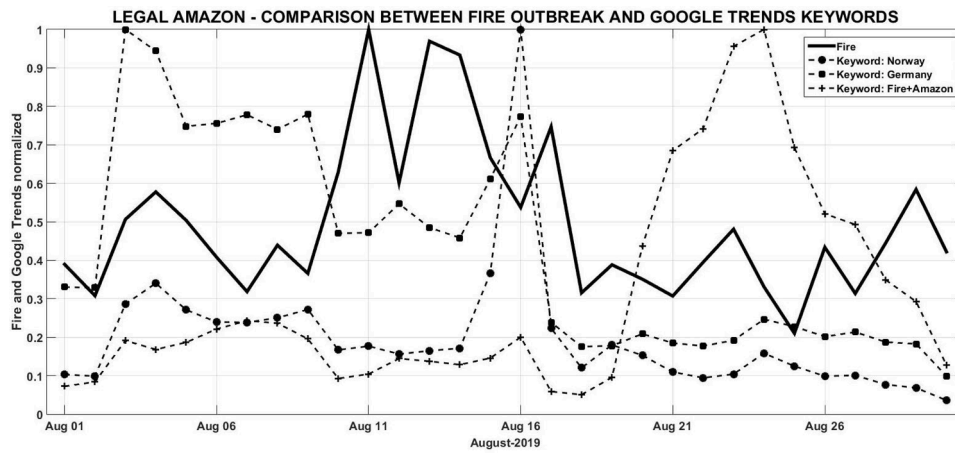


Fig. 8. Relation between fire outbreak and keywords in Google Trends for Legal Amazon.

internet, what is the president’s power of influence to allow the “day of fire” to happen?

In order to observe this behavior, or, how this search for the keyword “Germany” could be an influence in the increase of fires, we calculated the cross-correlation between the keyword Germany and actual fire outbreaks. The results are shown in Fig. 9 where is possible to observe that the maximum lag (days) found by cross-correlation was exactly 7 days (second graphic). The value of cross-correlation was 0.5573 or 55.73% between the keyword “Germany” and the actual fire outbreaks.

This result shows that the influence in the increase of fire outbreaks have correlation in data series of about 55.73% for the 7 days after the strong search on the Internet for the keyword “Germany”. Social media messaging corroborates this correlation, as its users said they wanted to “show work to President Bolsonaro.”

Although Jair Bolsonaro cannot be accused directly to have encouraged the fires, he have influenced them with his speech the intense search for issues related to Mrs. Angela Merkel and Germany, correlating with a probability of 55.73% the actual fire outbreaks. On August 4th (2019) the Legal Amazon presented 1,472 fires outbreaks. After these declarations and arguments with Mrs. Merkel (Germany) the Legal Amazon presented 2,548 fire outbreaks on August 11th. Seven days after those arguments, the day known as “the day of fire” through social media, the increase of fire outbreaks in the Legal Amazon was that of 73%. In a single day the number of fire outbreaks was 7% of the historical average in August in 22 years.

The result of the election for President Jair Bolsonaro in the Legal Amazon was immensely favorable, where, for instance, he obtained in the State of Acre 62.2%, in the State of Amazon 43.4%, in the State of Rondônia 62.24%, in the State of Roraima 62.97% and in the State of Mato Grosso 60.04%, regions where increased the fire outbreaks. His-voters are known for calling President Bolsonaro a “myth” on social media, following and backing his ideas. Bolsonaro’s words about Germany and Angela Merkel may have support from their social media followers, at least it is noticeable by the interest in Google Trends.

The power words have in the influence of other people on social media has been the subject of intense debate for a long time. Vitak et al. (2011) conducted an experiment with Facebook volunteers. The authors showed that 70% of users observe the behavior of friends that reply status updates that mention politics. Another 49.3% observe photos that have something to do with politics.

In the last years search engines have worried the academic community with regards to its power to influence elections. Margetts (2017) discussed a case that investigates on the effect of people seeing that their friends had clicked an “I voted today” icon on the day of the 2010 congressional elections in UK. The author comments that people were more likely to both click the icon and vote themselves if they had been shown images of their friends who claimed to have voted.

In the specific case of WhatsApp, Arun (2019) discusses the spread of rumors and lynching in India. Spread of fake news using social media is a worldwide phenomenon and a huge problem for democracies. In

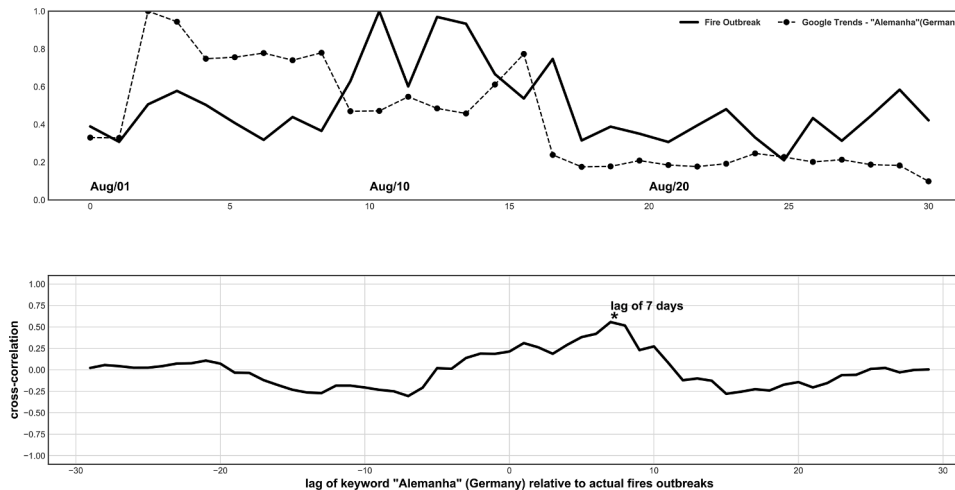


Fig. 9. (Above): Fire outbreak normalized and keyword “Alemanha” (Germany) in Google Trends normalized for Amazon Legal. (Below): Cross-correlation between data of Fire outbreaks and keyword “Alemanha” (Germany).

addition to slogans, or worship of political leaders on social media more important are the signs sent by a government. In the specific case of fires in the Amazon, there is still the fact of the dismantling of the inspection system in Brazil since 2015 (IBAMA, 2019).

Today social media messages quickly spread real news, fake news and calls for protests. Data from Google Trends were acquired hour by hour in the early days before “the day of fire”. Data are presented in Fig. 10 and it is possible to notice the correlation between two different keywords. Altamira was the city where the fires outbreaks increased in the Legal Amazon on August 11th on the “the day of fire”. The press reported that fire outbreaks were appearing along the BR-163 highway in the Amazon region (BBC, 2019).

The keywords composed “Altamira+Fogo+BR-163” in Portuguese were chosen (“Altamira+Fire+BR-163” in English) and compared with the keyword “Alemanha” (Germany). Both data were compared with actual data for fires outbreaks in the Legal Amazon, hour by hour. As data of actual fires are only available on a daily basis, in Fig. 10, it appears as a constant dashed line. The cross-correlation between the keyword “Germany” and the keyword “Altamira+Fires+BR-163” was of 72.87%.

When the keyword “Alemanha” is compared (Germany) with current data of fire outbreaks the cross-correlation was 53.96% with a lag (hour) of 10 h. When the keyword “Altamira+Fogo+BR-163” is compared with actual fires outbreaks the cross-correlation was of 50.85% with lag of 32 h. These results show that the peaks observed in Fig. 10 after August 7th have high correlation with the beginning of fires in the Legal Amazon, more specifically in Altamira, in the “day of fire” related by social media.

The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) is the official government agency to monitor and punish environmental crimes. Official data were obtained from IBAMA are presented in Fig. 11 for reported infractions in Legal Amazon. As in previous analyses, the same methodology was applied to data referring to reported infractions, taking moving Box-Plot for each of the four years studied.

Fig. 11 shows moving Box-Plot for each of the four years analyzed and the results were compared with fire outbreaks in the same region also for each of the four years studied. The white Box-Plot are the total of fire outbreaks by year and the black Box-Plot are reported infractions by year, from 2004 to 2019 (August).

It is possible to observe that since 2015 the fires outbreaks have been increasing (white Box-Plot) while reported infractions are decreasing (Black Box-Plot). This is an important factor to observe why in the last years the fire outbreaks have increased and social media words reinforce

the sense of impunity that intensified this year, especially in August (2019).

The results presented in Table 3 prove a decrease in official reported infractions. Between 2010 and 2013, 50% of infractions were above 80 reported while in the last four years the infractions reported were below 13. In 2019, until August, the median for the last four years is only 4 reported infractions. For the downloaded data, the field research was carried out by IBAMA as “VAL_AUTO_INFRACAO” on Excel spreadsheet for the whole period.

A major peak of devastation and fire occurred on August 11th and messages were spread out in social media and on the Internet announcing protests over “the day of fire” on highway BR-163 (BBC News, 2019). Investigations of journalists indicate that a group formed by producers, land grabbers and prospectors set fire to roads in the Amazon (BBC News, Aug/27/2019 and Folha de S.Paulo, Aug/14/2019).

Official alert from INPE showed that fire outbreaks increased by record levels (INPE, 2019) with 2,254 km² of alerts, or a 278% increase in comparison to 2018 in the same period (July). Then minister Ricardo Salles said on the Ministry of the Environment official twitter account (Salles, 2019) that data from INPE were correct, but that the fires were a consequence of weather conditions, due to a seasonal drought. His-remark was echoed by several media companies, such as O Globo (2019) and UOL (2019).

3.3. Discussion

We analyzed the growth of fire outbreaks in the Brazilian Amazon forest after intense declarations of President Jair Bolsonaro for the international community, especially against Germany and Norway in August (2019). Bolsonaro’s speech and his refusal to accept financial support to for the Amazon fund caused worries and the arguments raised the hypothesis of their influence on what became known as “a day of fire”.

Another statement about the fires was the government’s claim that the outbreaks were the same average as that of previous years. Finally, there was the claim that in 2019 winter season was worse than previous years.

By using official data from INPE (National Space Research Institute), INMET (National Institute of Meteorology) and IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) we did not find any evidence that the winter season in 2019 was worse than previous years.

In order to consider the volatility effects and avoid distortions, we

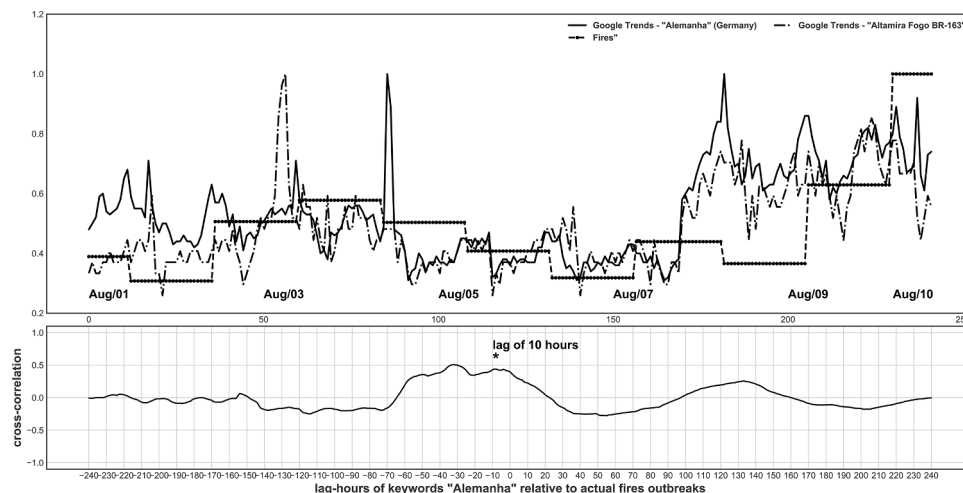


Fig. 10. (Above): Fire outbreak normalized and keyword “Alemanha” (Germany), “Altamira+Fogo+BR-163” (Altamira+fire+BR-163 in English) in Google Trends normalized for Amazon Legal and “Altamira Fogo BR-163. (Below): Cross-correlation between Fire outbreaks and keyword “Alemanha” (Germany) with lag in hours.

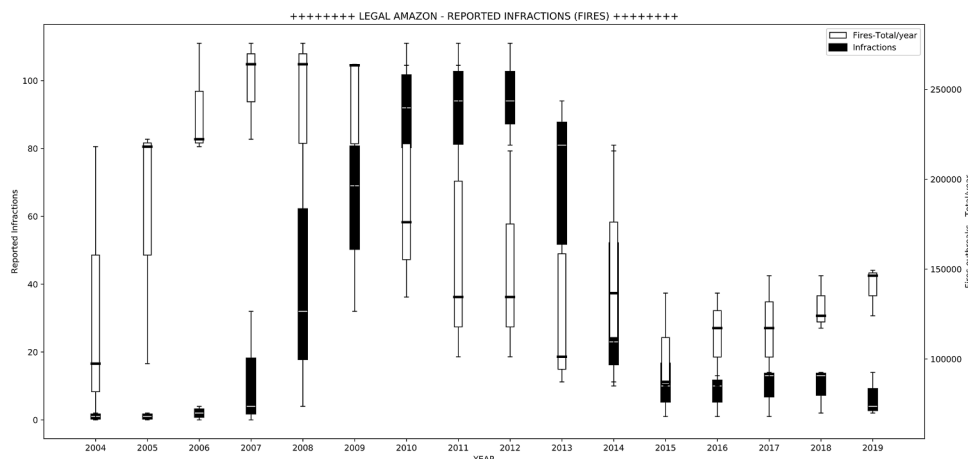


Fig. 11. Reported infractions (fires) for Legal Amazon.

Table 3

Statistics for median of infractions reported in Legal Amazon since 2010.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019 (August)
Infraction (median)	92	94	94	81	23	10	10	13	13	4

Font: IBAMA(2019).

consider in this study the moving Box-Plot with a period of four years, once, in Brazil, the term of office is four years.

The comparison between July (2015–2018) against July (2016–2019) found $p\text{-level} < 0.5255$ by running an Analysis of Variance test (ANOVA). In August (2015–2018) against August (2016–2019) the result was $p\text{-level} < 0.2899$, both statistical tests considering level of 0.05. We cannot reject the hypothesis of equality between events.

August was chosen because it was the worst month with regards to forest fires in Brazil, when fire outbreaks increase due to the winter season. About the consideration that fire outbreaks are on the same level as that of previous years, the results show that Aug/2019 followed the same trend as that of four years before, not showing stationary in the process of fire outbreaks in the amazon as the president said. We found that since 2015 the fire outbreaks have been increasing.

When data are compared between period 2012–2015 (median 1,981 fires) and 2016–2019 (median 4,235 fires) in August, the median of fire outbreaks increased 113%. While August of 2015–2018 had 25% above of 3,943 spots, in August 2016–2019 the 25% worst were above 4,514 spots. We observed that in all statistical measures (median, quantile-1, quantile-3) the fires for August-2019 were the worst ones.

We also analyzed the consequences of President Jair Bolsonaro’s speech and the possible correlation with the day known as the “the day of fire”, the worst week in the Legal Amazon where the fires increased abruptly. Using cross-correlation statistical technique and information from Google Trends, we found a correspondence between the keyword “Alemanha” (Germany) and fire outbreaks of 55.73% and a maximum lag of 7 days. This fact shows that one week after the keyword “Germany” had a sharp increase in Google Trends, the fire outbreaks followed the trend in the Legal Amazon with Altamira as the most affected city.

When data are observed hour by hour in Google Trends by adding the keywords “Altamira+Fogo+BR-116” (“Altamira+Fire+BR-116” in English) and “Alemanha” (Germany) we found the cross-correlation with current fire outbreaks of 53.96% and 50.85%. The lags between the keywords on the Internet and the beginning of fires on August 11th was between 10 h and 32 h.

When comparison is made between keywords “Altamira+Fogo+BR-

116” with keyword “Alemanha” (Germany), the relationship between search in Google by highway in the Amazon where occurred “day of fire” and Germany had cross-correlation of 72.87%.

Besides the words of President Bolsonaro downplaying the infractions report, it is possible to notice that the reported infractions decreased abruptly until Aug/2019. While in 2010–2013 the 50% of reported infractions were above 80 infractions, in 2019, until August, only 4 infractions were reported. Unfortunately, this shows the degree of impunity for deforestation and fires, which when coupled with the president’s speeches, sends a strong message of tolerance towards environmental crimes.

We understand that this analysis and official data need to be disseminated and recognized by the entire scientific world community, so that discussions can grow in order to develop effective and strong policies against deforestation in the Amazon region.

Author statement

Caetano, M. A. L. was responsible for Conceptualization, Methodology, Code in Python, Code in Matlab, Data extraction from spreadsheet and websites, Writing- Original draft preparation and Investigation, Reviewing and Editing.

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