1	LAT	LON	SCA	TRAC	DATE	DAY	MONTH	TIME PER GMT4	SAT	INST	CONF	VER	BT1	BT2	XBT	FRP	FI (C2-adapte
69779	-1.02551	-60.4782	0.39	0.36	Friday, September 15, 2023	Fri	Sep	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	337.17	301.14	319.16	5.31	LOW (FR
69780	-1.02516	-60.4778	0.58	0.7	Friday, September 15, 2023	Fri	Sep	12:00 - 18:00 PM	1	VIIRS	h	2.0NRT	367	294.91	330.96	32.79	LOW (FR
69781	-1.01301	-62.112	0.54	0.51	Sunday, September 3, 2023	Sun	Sep	12:00 - 18:00 PM	1	VIIRS	n	2.0NRT	330.27	296.07	313.17	1.79	LOW (FR
69782	-1.00805	-60.3748	0.39	0.36	Sunday, October 1, 2023	Sun	Oct	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	341.4	292.83	317.12	3.87	LOW (FR
69783	-0.98538	-61.9304	0.52	0.41	Thursday, September 14, 2023	Thu	Sep	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	332.68	301.19	316.94	4.01	LOW (FR
69784	-0.97423	-60.5545	1.02	1.01	Sunday, October 29, 2023	Sun	Oct	12:00 - 18:00 PM	Aqua	MODIS	50	6.1NRT	315.1	299.47	307.29	5.92	LOW (FR
69785	-0.97292	-60.5455	1.02	1.01	Sunday, October 29, 2023	Sun	Oct	12:00 - 18:00 PM	Aqua	MODIS	84	6.1NRT	332.18	300.17	316.18	24.8	LOW (FR
69786	-0.96747	-60.2204	0.53	0.42	Tuesday, October 3, 2023	Tue	Oct	12:00 - 18:00 PM	1	VIIRS	n	2.0NRT	337.8	294.81	316.31	50.77	MOD (50-
69787	-0.96685	-60.2248	1.02	1.01	Tuesday, October 3, 2023	Tue	Oct	12:00 - 18:00 PM	Aqua	MODIS	91	6.1NRT	341.19	291.55	316.37	40.06	LOW (FR
69788	-0.96571	-60.3843	2.63	1.56	Monday, September 4, 2023	Mon	Sep	12:00 - 18:00 PM	Aqua	MODIS	59	6.1NRT	316.76	299.51	308.14	37.15	LOW (FR
69789	-0.96524	-60.5519	0.43	0.46	Wednesday, September 27, 2023	Wed	Sep	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	332.13	298.59	315.36	14.97	LOW (FR
69790	-0.96466	-60.548	0.43	0.46	Wednesday, September 27, 2023	Wed	Sep	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	340.93	299.94	320.44	14.97	LOW (FR
69791	-0.96456	-60.5624	0.45	0.63	Monday, September 4, 2023	Mon	Sep	12:00 - 18:00 PM	1	VIIRS	n	2.0NRT	334.29	297.52	315.91	5.82	LOW (FR
69792	-0.96427	-60.561	0.43	0.38	Monday, September 4, 2023	Mon	Sep	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	345.23	305.23	325.23	5.86	LOW (FR
69793	-0.96397	-60.5483	0.43	0.46	Sunday, October 29, 2023	Sun	Oct	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	335.12	294.01	314.57	17.69	LOW (FR
69794	-0.96394	-60.5468	1.02	1.01	Sunday, October 29, 2023	Sun	Oct	12:00 - 18:00 PM	Aqua	MODIS	60	6.1NRT	315.05	299.29	307.17	5.89	LOW (FR
69795	-0.96338	-60.5444	0.43	0.46	Sunday, October 29, 2023	Sun	Oct	12:00 - 18:00 PM	N	VIIRS	n	2.0NRT	342.84	294.98	318.91	17.69	LOW (FR
69796	-0.96223	-60.3848	0.44	0.62	Monday, September 4, 2023	Mon	Sep	12:00 - 18:00 PM	1	VIIRS	n	2.0NRT	349.35	299.6	324.48	49.84	LOW (FR
69797	-0.96167	-60.381	0.44	0.62	Monday, September 4, 2023	Mon	Sep	12:00 - 18:00 PM	1	VIIRS	h	2.0NRT	367	305.42	336.21	49.84	LOW (FR
69798	-0.96163	-60.5447	0.53	0.5	Sunday, October 29, 2023	Sun	Oct	12:00 - 18:00 PM	1	VIIRS	n	2.0NRT	342.4	296.74	319.57	27.29	LOW (FR
69799	-0.95974	-60.381	0.44	0.62	Monday, September 4, 2023	Mon	Sep	12:00 - 18:00 PM	1	VIIRS	h	2.0NRT	367	301.65	334.33	114.85	HIGH (100
69800	-0.95916	-60.545	0.43	0.46	Sunday, October 29, 2023	Sun	Oct		N	VIIRS	n	2.0NRT	343.89	294.16	319.03	85.9	MOD (50-
69801	-0.95885	-60.384	0.43	0.38	Monday, September 4, 2023	Mon	S			VIIRS	n	2.0NRT	343.35	309.05	326.2	19.7	LOW (FR
69802	-0.95795	-60.3785	2.63	1.56	Monday, September 4, 2023	Mon				OIS	43	6.1NRT	312.98	297.68	305.33	24.9	LOW (FR
69803	-0.94709	-60.6233	0.36	0.58	Friday, October 27, 2023	Fri					n	2.0NRT	345.65	292.15	318.9	3.5	LOW (FR
69804	2.667	-59.446	2859	3559	Thursday, September 28, 2023	Th					74	1.0NRT	348.8	290.2	319.5	262.9	HIGH (100
69805	2.901	-61.002	2872	3477	Wednesday, October 4, 2023	W					98	1.0NRT	335.9	296.1	316	139.5	HIGH (100

Article on the Brazilian Amazon Region

Seeking answers: what do almost NASA's 70,000 records reveal?

Dr. Jonas Gomes da Silva - www.jgsilva.org

Professor at the Federal University of Amazonas
Research Visitor at Sustainable Consumption Institute
Alliance Manchester Business School/The University of Manchester
Columnist at Jornal do Comércio do Amazonas

jgsilva@ufam.edu.br
jgsilva@manchester.ac.uk

Adapted from the article published in JCAM
29th November 2023 - one day before the celebration of Land´ Statute

Figure 1: Burned areas surrounding Manaus rural area on 8th October 2023

Source: NASA FIRMS, da Silva (2023) and Google Earth

On the eve of Brazilian land statute day, NASA satellite images reveal thousands of fires around Manaus (Figures 1 and 2), with certain cities standing out. By analyzing about 69,805 records of active fires or thermal anomalies, this article identifies the main municipalities that most burned green areas in Amazonas, worsening regional air pollution.

Tomorrow marks 59 years of Law 4504 <**https://tinyurl.com/y2j6t7jk>**, which generated the land statute to promote agrarian reform and agricultural policy in Brazil. The statute was approved in 1964, in a context of rural exodus, pressure from social movements in the countryside and high land concentration, a problem not solved until today: about 3% of landowners occupy 57% of the country's arable area <**https://tinyurl.com/5n74epy9>**.

Although a report <**https://tinyurl.com/4f8sk4nf>** published this year by the World Bank Group reveals that the Amazon rainforest is worth more standing (BRL 1.5 trillion/year) than exploited by traditional means (BRL 98 billion/year), there is still much to be done so that the management of our lands and forests meets part of the guidelines of this statute or the most modern best sustainable development practices, especially in relation to the rational and planned use of these resources. To exemplify the size of the challenge, from 1850 to 2021, Brazil was the fourth country on the planet that emitted the most CO2 (113 gigatons), with 97 Gt (86%) related to land use and forests <**https://bit.ly/3x8qvIP>**.

As expected, the misuse of land and forests affects the entire environment, as deforestation and fires release large amounts of polluting gases into the atmosphere, worsening air quality, as we have witnessed every year in our cities in Amazonas. Given this, in recent articles, statistics were presented involving data collected from NASA's FIRMS system, related to satellite images pointing to active fires and thermal anomalies in the region.

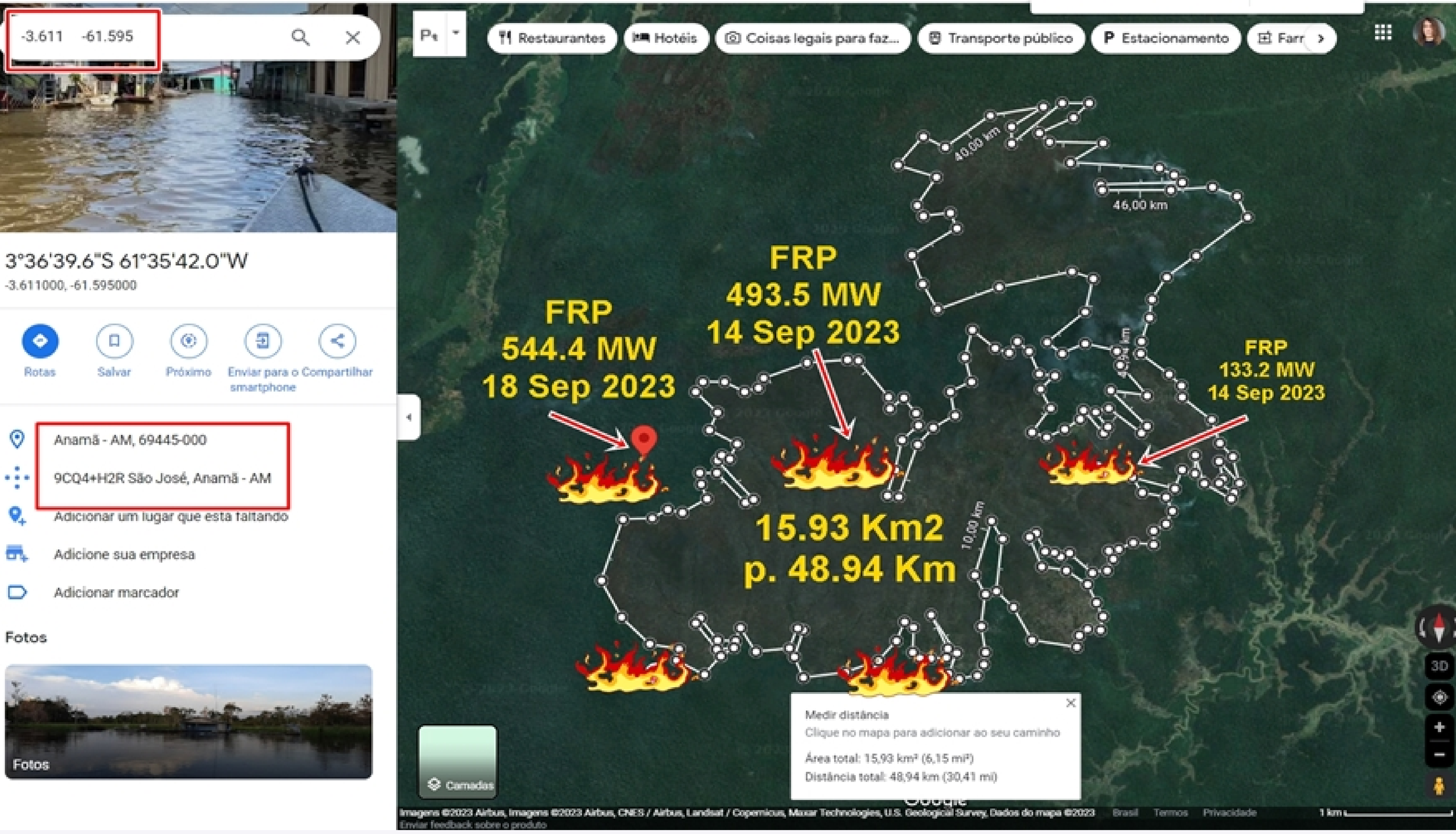

Figure 2: Active fires & destroyed areas in São José, Anamã - September 2023

Source: NASA FIRMS, da Silva (2023) and Google Maps

The collection and analysis of these records has been going on since October/23 when Manaus was completely covered in smoke. The collection focuses on outbreaks that occurred in an area that revolves around 300Km from the capital of Amazonas, between the period considered hottest, from August 1 to October 31, 2023. Each record contains the latitude, longitude, date, time, satellite, two bright temperature measurements (TB in Kelvin), confidence level, one Fire Radiative Power measurement (FRP in MW), day or night etc.

In total, about 80 thousand records were collected from the site or obtained through a request from NASA. After that, only those with confidence levels above 30%, average brightness temperature above 300K (average Earth temperature), and FRP above 1MW remained. Thus, the total number of records decreased to 69,805, of which 43,834 (62.7%) came from VIIRS orbital satellites (NOAA-20 and Suomi NPP; 375m resolution) and MODIS satellites (Water and Earth; 1Km resolution), while 25,971 came from the GOES16 geostationary satellite (KLC/IPMA), whose resolution is 2Km.

In general, each orbital satellite records two images per day, while the geostationary satellite records several images per day, as can be seen at the link <**https://firms.modaps.eosdis.nasa.gov/**>.

Next, it was searched areas with fires of high or very high intensity. The key variable is FRP, widely used in the scientific literature. Although there is no consensus on the classification of FRP as a function of fire intensity, based on the studies of Robert et al. (2005; **https://tinyurl.com/ev77vppw**), Silva-Júnior et al. (2018; **https://tinyurl.com/bdhf7xw9**) and Laurent et al. (2019; **https://tinyurl.com/mr2725t6**) the following ranges were created: low (FRP <= 50MW); moderate (50MW <FRP <= 100MW); high (100 <FRP <= 600MW); and very high (FRP> 600MW).

Applying these ranges, it was observed that the majority (56,035; 80.27%) of events are of low intensity, followed by 8,522 (12.21%) moderate outbreaks, 5,125 (7.34%) of high intensity and 123 (0.18%) of very high intensity, that is, large fires. This result suggests an interesting hypothesis: small fires, although generating less energy and smoke individually, when added together, happening in a scattered, uncontrolled way, in a period of record drought, can cause substantial damage to Amazonian air quality.

But as the focus of the research is on the highest cases, a second analysis focused on the 5,248 outbreaks considered high or very high. Here is important to note that the geostationary satellite can detect several outbreaks over the same location throughout the day, generating multiple daily records referring to the same event. In order not to overestimate the actual number of distinct events, a filter was applied, limiting to a maximum of 2 daily records per location, prioritizing those with the highest FRP value. Thus, the total studied was 2,274, of which 1,810 came from the stationary satellite and 464 from the orbital satellites.

After that, the most time consuming work came, using Google Maps tools, for each record, the geolocation of the outbreak was identified, the city, the distance (in Km) to downtown Manaus, a reference point near the location, the profile of the place where the event occurred and it was even possible to estimate the area already destroyed around the identified location.

In short, the analysis identified that:

- Monday (348 outbreaks with XFRP=241.53MW), Tuesday (404; XFRP=210.7MW), Sunday (311; XFRP=196.1MW) and Saturday (356; XFRP=196.6MW) were the most critical days in terms of average FRP value. Thus, it appears that weekends are the preferred days to promote more intense fires since there is no inspection, extending into early next week.
- The majority (2,000; 88%) of these events were recorded by satellites in the period from 12:00 to 18:00, followed (248; 11%) by the period from 06:01 to 11:59.
- The majority (966; 42.5%) of these intense outbreaks occurred in green areas near rivers, lakes or streams, followed by green areas near already destroyed areas (33.3%), totaling 76% of cases .
- When analyzing the average FRP of each of the 29 identified cities, it is observed that the most critical are: Urucará (18 outbreaks with XFRP=316.73 MW), Borba (161; XFRP=237 MW), Manaquiri (192; XFRP=225 MW), Novo Aripuanã (14; XFRP=223MW), Urucurituba (46; XFRP=221MW), Nova Olinda do Norte (209; XFRP=216 MW), Autazes (487; XFRP=214MW), São Sebastião do Uatumã (73; XFRP=213MW), Itacoatiara (338; XFRP=205MW), Manaus (43; XFRP=198MW), Anamã (61; XFRP=189MW), Careiro (222; XFRP=188MW), Novo Airão (16; XFRP=166MW), Boa Vista do Ramos (22; XFRP=164MW), Maués (49; XFRP=163MW), and Caapiranga (59 outbreaks with XFRP=160 MW).

Finally, this diagnosis provides more transparency about the situation of a problem that is becoming chronic, and can help authorities rethink their priorities and strategies. And the next articles will focus on each of these cities, with more statistics, geolocation and access to a digital bank created at the University of Harvard, containing images of the most critical locations, with estimates of areas already destroyed, stay tuned.