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EVALUATION OF LIGHTNING DETECTION EFFICIENCY OF BRASILDAT DATASET

O. Pinto Jr. and I. R. C. A. Pinto

Atmospheric Electricity Group (ELAT), Division of Meteorological Satellites and Sensors – DISSM, Earth Science Coordination – CGCT
National Institute for Space Research – INPE, Brazil

Abstract - Lightning detection efficiency is a key parameter for evaluating the performance of a lightning detection system, having direct impact on the interpretation of its real time and historical data. However, its determination in the space and time domains is a complex task since it depends on many aspects that can be grouped in sensors characteristics (electromagnetic field component(s) detected, frequency response, gain, noise threshold, site features, uptime, among others), network characteristics (number of sensors, mean distance among sensors, location of sensors with respect to specific ground features like mountains and water bodies, configuration changes with time, among others) and lightning characteristics (type of flash, waveform, peak current, among others). In consequence, its evaluation should be done in different locations and different times, always considering a reasonable number of events. Evaluate the detection efficiency of a lightning location system taken into account all aspects is in general not possible. While observations by triggering lightning facilities and high speed cameras are very limited in space, observations of lightning effects such as transmission line faults, lightning damages and lightning fatalities are dependent on specific characteristics of the target, besides to include space and/or time uncertainty. Also, lightning detection efficiency models can be developed, but in general they provide only relative values. In this report we evaluate the lightning detection efficiency of BrasilDAT Dataset, which combines VLF-LF ground network data and optical GOES-16 satellite data, using for the first time accurate information of lightning related damages and fatalities reported in the period from April, 2020 to March, 2021 for all regions of Brazil. The results indicates that BrasilDAT Dataset have very high flash and stroke detection efficiencies, with values unprecedented in the country.

1 - INTRODUCTION

Lightning is a quite common phenomenon on Earth, happening tens of times per second on planet [1]. In Brazil it is estimated that around 70 million clod-to-ground flashes occur every year and are responsible for more than 100 fatalities and loss of the order of one billion dollars [1]. For such reasons, real time monitoring and historical mapping of its occurrence is very important in order to minimize these effects. Such achievements can be made by using lightning location systems (LLS). These systems have largely been used for the last three decades to real time monitoring and historical mapping of lightning activity [2]. The information is used for many applications including aviation, power operation, safety, etc. The benefits of their use are dependent on the LLS performance, which can be determined by evaluating their lightning detection efficiency (DE). The LLS DE has a direct impact on the interpretation of real time and historical lightning data.

However, the DE determination in the space and time domains is a complex task since it depends on many aspects that can be grouped in sensors characteristics (electromagnetic field component(s) detected, frequency response, gain, noise threshold, site features, uptime, among others), network characteristics (number of sensors, mean distance among sensors, location of sensors with respect to specific ground features like mountains and water bodies, configuration changes with time, among others) and lightning characteristics (type of flash, waveform, peak current, among others). In consequence, its evaluation should be done in different locations and different times, always considering a reasonable number of events. Evaluate LLS DE taken into account all aspects is in general not possible. While observations by triggering lightning facilities and high speed cameras are very limited in space, observations of lightning effects such as transmission line faults, lightning damages and lightning fatalities are dependent on specific characteristics of the target, besides to include space and/or time uncertainty. In turn, the use of lightning detection efficiency models to evaluate LLS DE in general provides only relative values, which needs to be complemented by observations.

The aim of this study is to evaluate for the first time the absolute flash and stroke detection efficiency of BrasilDAT Dataset. This dataset combines different sources of lightning data for all regions of Brazil. The study uses observations of lightning damages and fatalities reported in the period from April, 2020 to March, 2021 in all regions of the country.

2 - DATA

Basically, there are two different LLS DEs: flash DE and stroke DE. This is due to the fact that it is known that most lightning flashes contain multiple strokes, usually referred as first and subsequent strokes [3] and it is necessary to detect only one stroke of a flash to detect the flash. In consequence, stroke DE is always less than

flash DE. Typical values of flash DE and stroke DE are very sensitive to the LLS characteristics, varying in the literature for individual LLS from 20% to 90% for flashes and from 10% to 70% for strokes.

In this report we use information of lightning damages and fatalities reported in all regions of Brazil in the period from April, 2020 to March, 2021 for evaluating the flash DE and stroke DE of BrasilDAT Dataset. The information was checked to confirm the lightning occurrence by eye witness or clear lightning-related evidences and selected in such way to consider only events were the location accuracy is better than 500 m and time uncertainty is less than a two hours. Table 1 shows 42 events of lightning damages and fatalities reported in Brazil in the period from April, 2020 to March, 2021 that were used in the study.

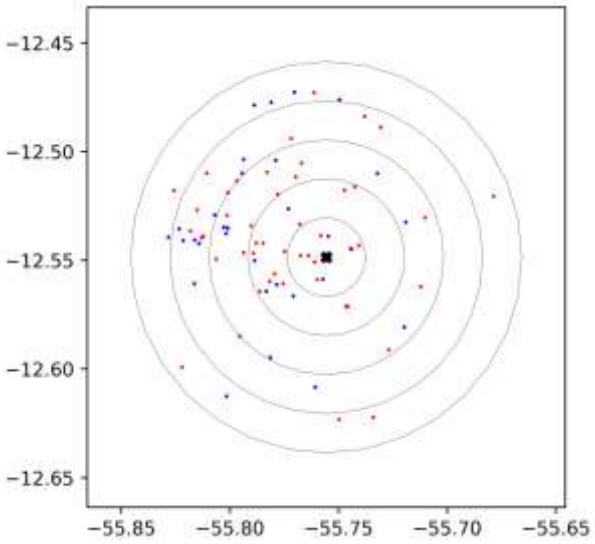
Table 1 - List of 42 events of lightning damages and fatalities reported in Brazil in the period from April, 2020 to March, 2021.

YEAR	MONTH	DAY	MUNICIPALITY	STATE
2020	10	28	Rio das Ostras	RJ
2020	12	28	Campinas	SP
2020	10	2	Itapema	SC
2020	8	18	Manaus	AM
2021	2	4	Santos	SP
2021	3	8	Guarulhos	SP
2021	2	26	Guaratuba	PR
2020	11	10	Nova Ubiratã	MT
2020	11	9	Sorriso	MT
2020	11	1	Sorriso	MT
2021	2	24	Francisco Ayres	PI
2021	1	6	Belo Horizonte	MG
2020	10	7	Campo Grande	MS
2020	10	18	Porto Velho	RO
2021	2	20	Brasília	DF
2021	3	30	Ubatuba	SP
2020	12	27	Muriaé	MG
2020	10	13	Angélica	MS
2020	12	18	Resende	RJ
2021	3	30	Iguaba Grande	RJ
2020	12	16	Cornélio Procópio	PR
2020	12	16	Londrina	PR
2020	10	25	Carmo do Rio Claro	MG
2021	1	15	Belo Horizonte	MG
2020	10	29	Cordeiro	RJ
2021	1	11	Guratinguetá	SP
2020	10	25	Resende	RJ
2020	4	22	Cascavel	CE
2021	3	26	Araucária	PR
2021	1	31	Peixoto de Azevedo	MT
2020	5	21	Formigueiro	RS
2021	2	26	João Pessoa	PB
2021	3	30	Atílio Vivácqua	ES
2020	12	21	Limeira	SP
2021	2	16	Casa Nova	BA
2021	3	18	Bauru	SP
2020	4	23	Fortaleza	CE
2020	5	15	Araguaína	TO
2020	5	23	Franca	SP
2020	10	28	Varzea Grande	MT
2020	12	15	São José dos Campos	SP
2020	11	3	Macapa	AP

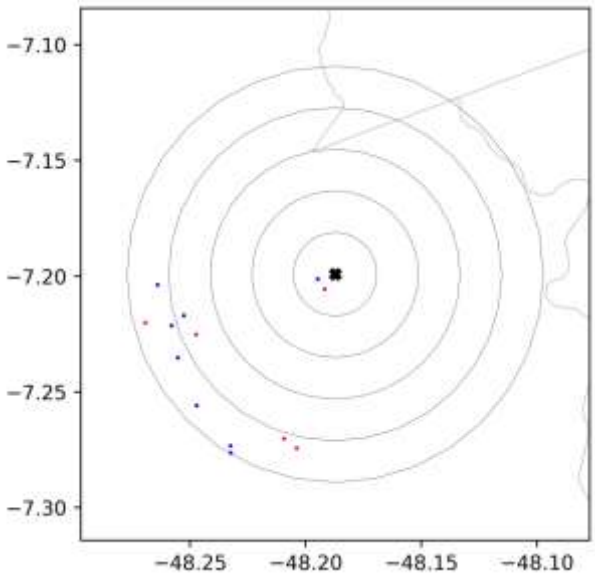
The information of the lightning events is, then, compared with the lightning data of the BrasilDAT Dataset [4], which combines different sources of lightning data using proprietary algorithms. The analysis considers lightning data in the region of 10 km around the location of one event. If there is at least one stroke at distances less than to 2 km of the location of the event, it is considered it as the cause of the event. Otherwise, if there are no strokes at distances less than 2 km, but there is at least one stroke at distances lees than 10 km, it means that the cause of the event was a stroke not detected of a flash. Finally, if there are no strokes at distances less than 10 km the cause of the event was not detected. The 10 km distance was assumed as representative of the maximum distance between the first stroke in the flash and subsequent ground strike points [5]. Typically, median values of the separation distance are found to vary between 1.3 and 2.75 km [5].

3 – RESULTS

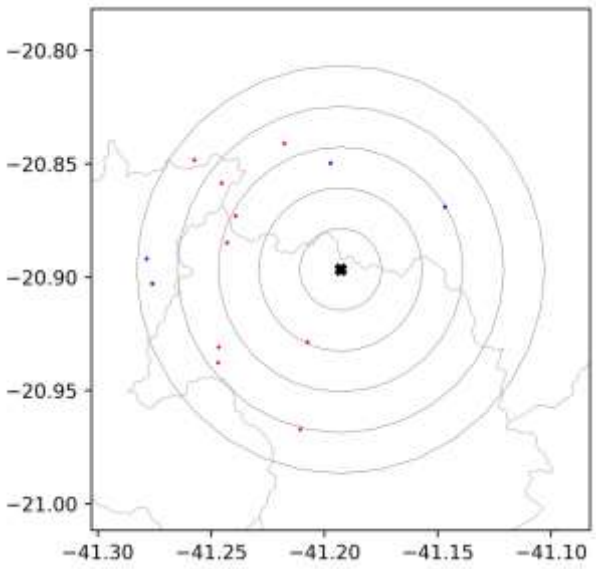
Figure 1 shows the BrasilDAT Dataset lightning data for some of the events listed in Table 1. The plots in the figure show cloud-to-ground and intracloud data for circular regions of 2, 4, 6, 8 and 10 km radius around the event locations.



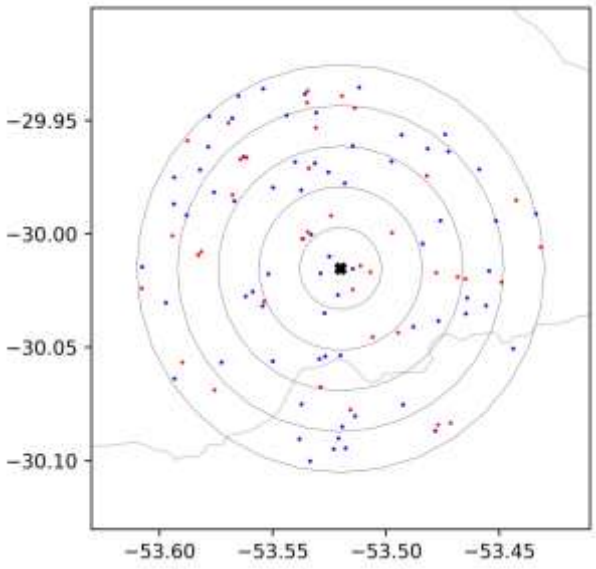
(a)



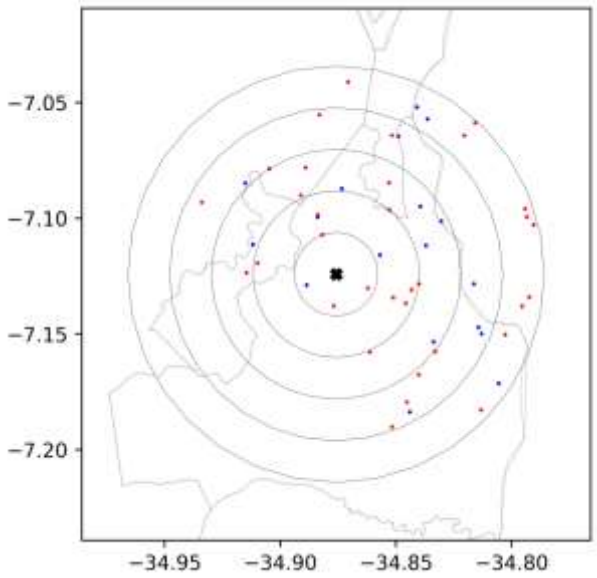
(b)



(c)



(d)



(e)

Figure 1 - BrasilDAT Dataset lightning data for some of the events listed in Table 1: (a) 11/01/2020, Sorriso, MT; (b) 05/15/2020, Araguaína, TO; (c) 03/30/2021, Atílio Vivácqua, ES; (d) 05/21/2020, Formigueiro, RS; and (e) 02/26/2021, João Pessoa, PB. The plots in the figure show cloud-to-ground (red dots) and intracloud (blue dots) data for circular regions of 2, 4, 6, 8 and 10 km radius around the event location.

The analysis indicates that BrasilDAT Dataset has a stroke DE of 85.7% and a flash DE of 97.6%. These values can be considered very high, much higher than any other dataset in Brazil at any time.

Only one event had no strokes in the region of 10 km around its location. This case may be due to a low peak current subsequent stroke distant more than 10 km from the first and other subsequent strokes of the flash.

4 - CONCLUSIONS

The study presented here evaluate for the first time the absolute flash and stroke detection efficiency of BrasilDAT Dataset in Brazil using accurate information of lightning related damages and fatalities. The results indicates that BrasilDAT Dataset have very high flash (97.6%) and stroke (85.7%) detection efficiencies, with values unprecedented in the country. These values can be considered very high, much higher than any other dataset in Brazil at any time.

5 - REFERENCES

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Main author

Name: Osmar Pinto Junior

Address: National Institute for Space Research (INPE)

Phone: 12-39234254

E-mail: osmar.pinto@inpe.br