Research

Contributions of the Brazil's National Institute for Space Research (INPE) to emergency response in the International Space and Major Disasters Charter

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Abstract

Brazil participates, through the National Institute for Space Research (INPE), in the International Charter Space and Major Disasters—Disasters Charter, an international cooperation effort to provide satellite images of major disasters around the world. The Disasters Charter is a joint and voluntary cooperative effort of 17 members. The characteristics of how the Charter works and the support of the satellites CBERS-4, CBERS-4A and AMAZONIA-1, including its cameras, are presented. There were 213 Charter Activations during the studied period (from mid-2018 until the end of 2022) with as many as 368 satellite images being provided (43% from the WFI camera-presented in all three satellites). Floods were the most frequent type of disaster and with the highest number of images provided. Of all the Activations during this period, INPE provided as much as 70% of all the Charter requested remote sensing data. Our internal operational scheme is revealed and the limitations of the satellite imaging are discussed to foster Brazil's capacity in satellite imaging.

Article Highlights

- Flood disasters had the highest occurrence and the highest number of images provided by INPE in the studied period.
- INPE provided images for the Charter in about half of the Activations, both pre-disaster and post-disaster images.
- For more than 4 years, INPE provided 368 images (around 250 GB of data) to the Charter, the majority from the WFI camera.

1 Introduction

The images from Earth Observation satellites allow for quick engagement of humanitarian teams to major natural or anthropogenic disasters that occur around the world. To organize the emergency response based on these images, several Space Agencies and Institutions around the world congregate themselves in an international cooperation called International Charter Space and Major Disasters (hereafter referred to as the *Charter*) [9–11].

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Discover

The Charter was formed in October 2000 by the European Space Agency (ESA), *Center National d'Etudes Spatiales* (CNES) – France, and Canadian Space Agency (CSA)—Canada, and currently brings together 17 members (Space Agencies or Institutions): *Agencia Bolivariana para Actividades Espaciales* (ABAE)—Venezuela; China National Space Administration (CNSA)—China; European Organization for the Exploitation of Meteorological Satellites (EUMETSAT); German Aerospace Center (DLR)—Germany; Indian Space Research Organization (ISRO)—India; Japan Aerospace Exploration Agency (JAXA)—Japan; Korea Aerospace Research Institute (KARI)—South Korea; National Institute for Space Research (INPE)—Brazil; National Oceanic and Atmospheric Administration (NOAA)—United States; National Commission for Space Activities (CONAE)—Argentina; The State Space Corporation (ROSCOSMOS)—Russia; UAE Space Agency (UAESA)—United Arab Emirates; UK Space Agency (UKSA)—United Kingdom and United States Geological Survey (USGS)—United States [5]

The Charter is a joint and voluntary cooperative effort of the members, working in a rotation cycle in a way where each agency remains six months in the leadership, with the functions of planning, organizing, hosting and chairing the meetings of the Charter groups: Board, Executive Secretariat and Communications [9].

Charter members provide images from their satellites regularly when requested by Authorized Users (AU). AU are institutions or services responsible for rescue and civil protection, as well as State defense and security [1, 10, 11]. The request for images is carried out when disasters occur, such as cyclones, earthquakes, wildfires, floods, snow hazards, ocean waves, oil spills, eruptions, landslides, among other types, such as technological disasters, missing ocean-going vessels or aircraft, disease and sandstorms [6].

Charter Activation requests (hereafter referred to as Calls) are registered in an operational system (COS-2—Charter Operational System, maintained by ESA), then processed and analysed by the person in charge of the Charter, called On Duty Officer (ODO). The ODO transfers the Call to the responsible Emergency on-Call Officer (ECO), who defines which satellites must be requested, with the completion of an image request form (Emergency Request Form) and sends to the Charter members. From this point on, an Executive Secretariat analyses, approves[1] the Activation and appoints a Project Manager (PM), a person responsible for organizing and managing the provision of maps from the VAPs (Value Added Product Providers) to the end user [1, 5].

Each image provided by Charter can be made available by a virtual constellation of more than 60 satellites, with optical cameras or radar. The spatial resolutions of the provided images range from very high spatial resolution, around 50 cm (examples include WorldView and Pleiades) to low spatial resolution, around 1 km (example: Meteosat).

Maps produced from Charter´s accessible satellite data (called VAP—Value Added Products) are used to guide rescue actions and evaluate consequences of disasters (see example in Fig. 1).

Brazil, through INPE—which is a research unit of the Ministry of Science, Technology and Innovation, has been participating in the Charter since November 8th, 2011, when INPE signed the entrance in Charter, during the meeting of the Committee on Earth Observation Satellites (CEOS). But even before that, in November 2008, INPE had acted by requesting Charter during flooding and landslides in Santa Catarina state, Brazil, and also in January 2011, during the raining and landslides that hit mountainous regions in Rio de Janeiro state, Brazil.

INPE´s effective participation in the Charter has taken place since August 2018, with the regular supply of satellite images, VAPs and with the administrative support in the organization of the Charter by a series of monthly meetings by members of the Board, Executive Secretariat and Communications group.

A whole new perspective based on new and freely available remote sensing data from CBERS-4, CBERS-4A and AMAZONIA-1 satellites allowed Brazil, through INPE, to effectively collaborate with the Charter, sharing satellite images and value added products in a joint international cooperation.

This article reports the operation of the Charter, characteristics of the Satellites provided by Brazil and its cameras, and the supply of satellite images from INPE in the occurrence of major disasters around the world since the effective participation of INPE in the Charter (from August 15th, 2018) until the end of 2022.

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[1] Charter Activations depends of approval because there are cases of duplication and cases that it is not concern to Charter, e.g. armed conflict. Charter promotes cooperation between space agencies and space system operators in the use of space facilities as a contribution to the management of crises arising from natural or technological disasters [7].
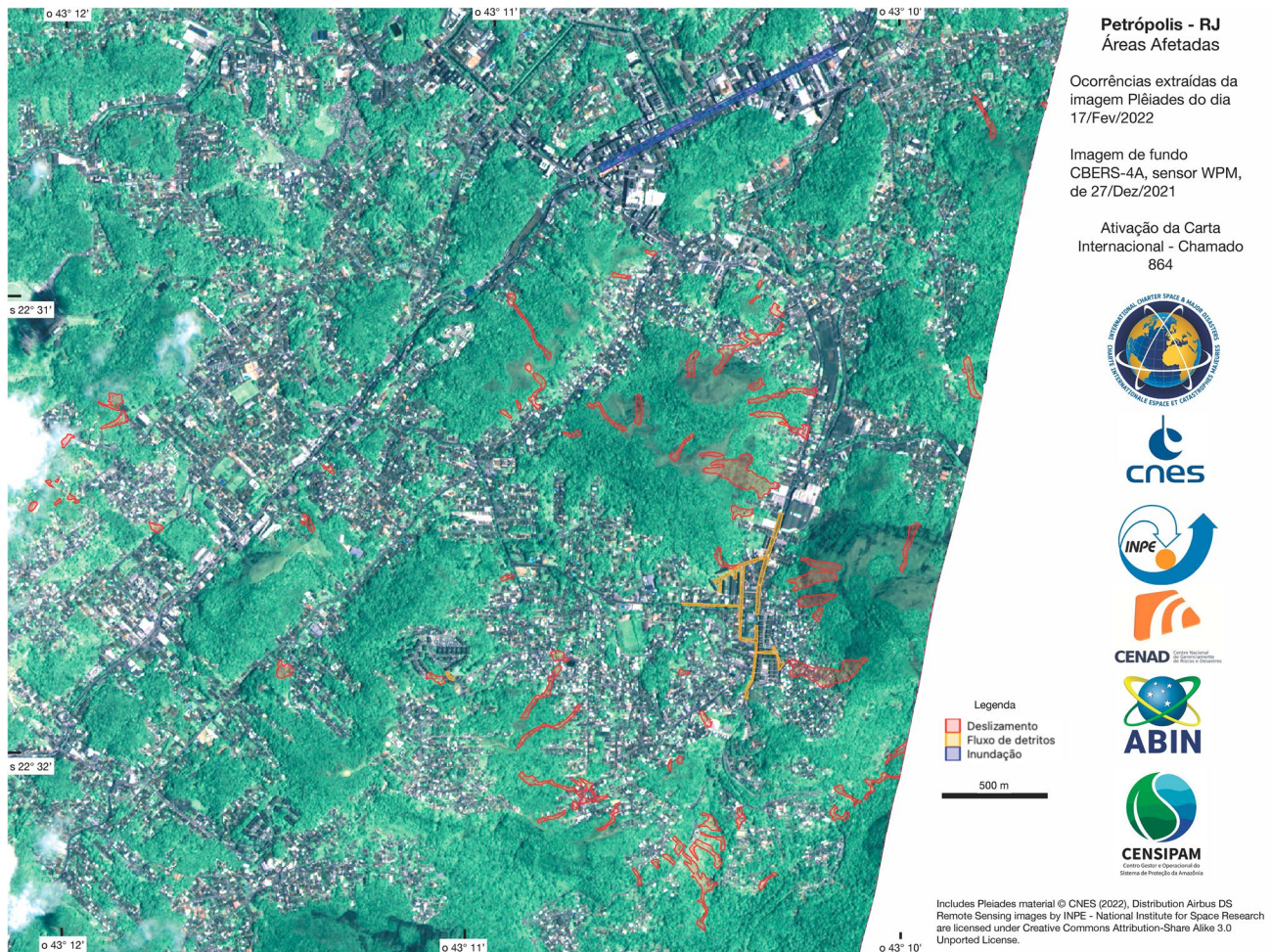
Fig. 1 VAP with a map produced for landslides in Petrópolis/Brazil (Activation 751 of the Charter) (available at https://disasterscharter.org/image/journal/article.jpg?img_id=20457038&t=1681909246413)

2 Satellites provided by Brazil and its cameras

Brazil provides two satellite Missions, CBERS and AMAZONIA. CBERS Missions are being conducted by Brazil and China while the AMAZONIA Mission by Brazil only. CBERS satellites is acronym for China Brazil Earth Resources Satellite and it is composed by both CBERS-4 and CBERS-4A Satellites.

The AMAZONIA Mission, on the other hand, is integrated by a single satellite called AMAZONIA-1, the first Earth Observation satellite completely designed, integrated, tested and operated by Brazil.
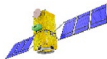
Both satellites are equipped with cameras to Earth observation for environmental monitoring and acquiring images to helping the Charter.

2.1 CBERS and AMAZONIA satellite cameras

The cameras of CBERS and AMAZONIA satellites are supplying images to the Charter. The cameras are Panchromatic and Multispectral (PAN) (CBERS-4), Wide Swath Panchromatic and Multispectral (WPM) (CBERS-4A), Multispectral (MUX) (CBERS-4 and CBERS-4A), Wide Field Imager (WFI) (CBERS-4 and CBERS-4A) and Advanced Wide-Field Imager (AMAZO-NIA-1) [3].

The MUX cameras on board CBERS-4 and 4A satellites have the same technology, as well as, AWFI/WFI cameras aboard CBERS and AMAZONIA satellites, but each one has different spatial resolution and swath width due to the different operating altitude of the satellite (Table 1).

Table 1 Aspects of the imaging cameras (spatial resolution, side looking and swath width) of the active satellites CBERS and AMAZONIA-1

Cameras	CBERS-4	CBERS-4A	AMAZONIA-1
Panchromatic and multispectral—PAN	5 m (Pan.) / 10 m (Mult.), SL:~32°, SW: 60 km	–	–
Wide Swath Panchromatic and Multispectral camera - WPM	–	2 m (Pan.) / 8 m (Mult.), without SL, SW: 92 km	–
Multispectral—MUX	20 m, SL:~4°, SW: 120 km	16,5 m, SL:~4,4°, SW: 95 km	–
Wide Field—WFI/Advanced Wide Field Imager—AWFI	64 m, without SL, SW: 866 km	55 m, without SL, SW: 684 km	~64 m, without SL, SW:~850 km

www.cbers.inpe.br and www.inpe.br/amazonia1

Mult, multispectral; Pan, panchromatic; SL, side looking; SW, swath width

3 Supplying images to the charter

Among the 213 Charter Activations that occurred in the studied period (mid-2018 to the end of 2022) there were 45.8% flood-type[2] disasters, 24.1% hurricanes / cyclones, 7.9% forest fires, 6.9% earthquakes, 4.9% volcanic eruptions, 3.9% oil spills, 3.4% landslides, 1% other type: industrial accident, 0.5% snow disaster, and the rest being, others: dam collapse; ship sinking; and, lost aircraft, each one with 0.5% (Fig. 2). They represent almost all types of disasters characterized by the Charter [4].

INPE's participation with the supply of optical remote images occurred in response to the Charter Activations, which were mostly floods, followed by hurricanes and forest fires (see the information for each Activation in Appendix 1). Floods were also the most frequent types of disasters and the highest number of images provided by INPE for this kind of disaster throughout the studied period. In the last Charter report, available in September 2022, floods were also recorded as the most frequent [4].

The CBERS-4 images have been provided since the beginning of INPE's participation, in mid-2018, while the CBERS-4A and AMAZONIA-1 images after the post-commissioning period (image correction analysis stage), in mid-April 2020 and mid-June 2021, respectively. The images provided by INPE come from archives (pre-disaster), or new image acquisitions (post-disaster), with the satellites being programmed out of routine specifically for this purpose.

The images used in Charter Activations are requested by Authorized Users, who are guided by several criteria established by the Charter, that show the best way to request Charter satellites data for the various types of disasters, considering the mapping needs of the affected areas and the characteristics of the most appropriate sensors that are needed for each disaster type. Over the period analysed, from 2018 to 2022, there has been a considerable increase in requests to INPE, probably related to the increase in Charter Activations in this period. Overall, requests to INPE occurred in more than 70% of the total Activations in the studied period (Table 2).

INPE's participation with the supply of images took place in 105 out of the 213 Charter Activations in the studied period, that is, almost half (about 49%) of the Activations. When we consider all the requests to INPE and its respective supply, there is almost 70% of attendance (Table 2).

Out of the 213 Charter Activations analysed in the studied period, 60 (around 28%) were not requested to INPE and in 54 Activations requested (around 25%) images could not be provided by INPE, e.g. not attended Activations (Table 2). The absence of requests to INPE generally occurred due to the type of disaster being not adequate to the spatial resolution of INPE sensors. Those requests not attended by INPE generally occurred due to the presence of

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[2] Methodologically, any type of disaster that mentions flooding was considered a flood, except for hurricanes (including cyclones) which were considered a specific type of disaster.

Fig. 2 Types of Disasters in Charter Activations that occurred in the period from 2018* to 2022 (in percentage**). The other unspecified representations refer to the types "Dam Collapse" (gray color); "Ship Wreck" (cyan color); and, "Snow Hazard" (white color), all with 0.5%
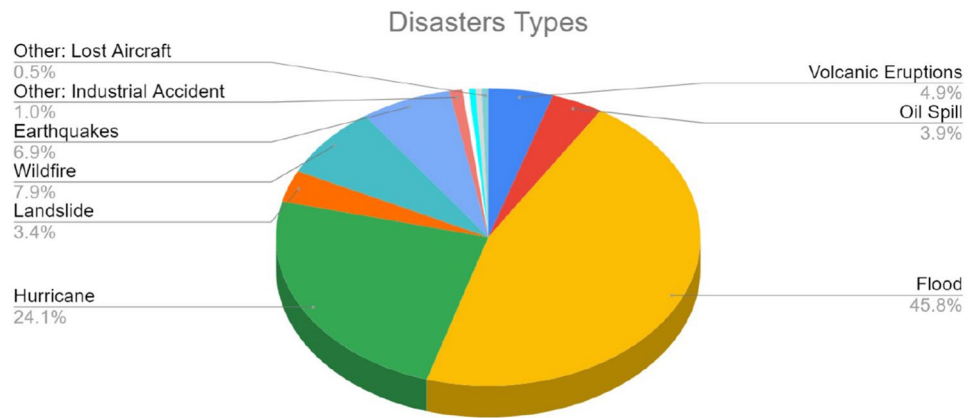
clouds, error in the image generation or operational inability. This last factor may have occurred due to the conflict in the operation of the satellites for imaging the disaster area, since Brazil shares with CRESDA (China Center for Resources Satellite Data and Applications) the operation of the CBERS-4 and CBERS-4A satellites, limiting the possible time for recording images; or also by the limitation of focused human resources, since the work policy for Charter members is always by the best effort.

It is important to point out that the process of acquiring and making available INPE satellite images involves different operational teams, such as the one that evaluate the next window of observation of the areas affected by the disasters, including the command of the reprogramming and repositioning of the satellite (Tracking and Satellite Control); the one that controls the reception and availability of images, including maintenance and positioning of the antennas (Image Generation); and, the one that makes the satellite image comprehensible to the human eye (Image Processing). Image processing involves the use of a significant number of algorithms (pre-processing—registration, clipping, atmospheric correction, etc.), as well as the final processing stage (enhancement, merging, classification, etc.).

Image acquisitions by INPE occur whenever possible, with the analysis of the estimated passage of satellites over the area affected by the disaster to verify and to maximize the viewing angle of the cameras, observing its side looking capability (Table 1). In sequence, generating and providing images, usually within 72 h after the occurrence of the disaster or when the acquisition is available.

It should also be mentioned that the hardware for data storage is a shared resource and, therefore, constant dialogue with the Chinese partner (CRESDA) is required.

Around the four year studied period, INPE has participated in 105 Charter Activations, providing a considerable number of images as specified below (See Appendix 1). All these images are also accessible to the general public through the INPE Catalog (http://www.dgi.inpe.br/catalogo), through which around 400,000 images are also provided annually.

Out of a total of 368 images (around 250 GB of data) provided, 76 (about 20%) were generated from the PAN/CBERS-4 camera, 45 (about 12%) from the WPM/CBERS-4A camera, 88 (about 24%) from the MUX/ CBERS-4 and CBERS-4A cameras and 159 (about 43%) from the WFI/CBERS-4, CBERS-4A and AMAZONIA-1 cameras (Appendix 1 and Fig. 3). The greater use of WFI images is due to the fact that this sensor has the largest swath width (swath width: 866 km in the CBERS-4 and 684 km in the CBERS-4A). Besides, WFI images are more available, as they are also less subject to processing problems due to its smaller file size.

A larger swath provides the largest imaging range, allowing it to reach a larger terrestrial area, and a better temporal revisit (higher temporal resolution) that can encompass adjacent areas from endured disasters, enabling them to be reused in other Charter Activations. All of this can be useful for immediate evaluation of the humanitarian team involved in the search, recovery or rescue of victims in other disasters, as well as for damage assessment.

Most image requested (from Emergency Request Forms) were for images from cameras with the highest spatial resolution (PAN/CBERS-4 and WPM/CBERS-4A), and most of the images provided by INPE were those with the lowest spatial resolution (WFI/CBERS-4, CBERS-4A and AMAZONIA-1) (Figs. 3 and 4). Higher spatial resolution images are the most requested in the Charter [4], such as Pleiades/CNES which are very useful in disasters in urban areas [13].

The provision of images with different spatial resolution is a common practice in Charter Activations through the efforts of different Space Agencies or Institutions in obtaining satellite images. The combination of images with different spatial resolution allows the analysis of the size of the disaster together with the analysis of the specificity of the place for the correct intervention during a possible search and recovery of victims.

Table 2 Number of charter activations and INPE contributions from 2018[a] to 2022

Reference year	2018[a]	2019	2020	2021	2022	Total[b]
Number of charter activations	14	43	55	50	51	**213**
Number of activations <u>with request</u>	09	27	38	39	40	153 (71.8%)
Number of activations <u>without request</u>	05	16	17	11	11	60 (28.2%)
Number of activations <u>with images provided</u>[1] Requested images	03	16	34	25	27	105/213 (49.3%) 105/153 (68.6%)
Number of <u>not attended activations</u> [1]	07	14	05	15	13	54 (25.3%)

[a]since August 15, 2018; [b]rounded percentage values

Fig. 3 Number of Images provided by INPE for the Charter by type of camera in the period from 2018* to 2022. *since August 15, 2018; **rounded percentage values
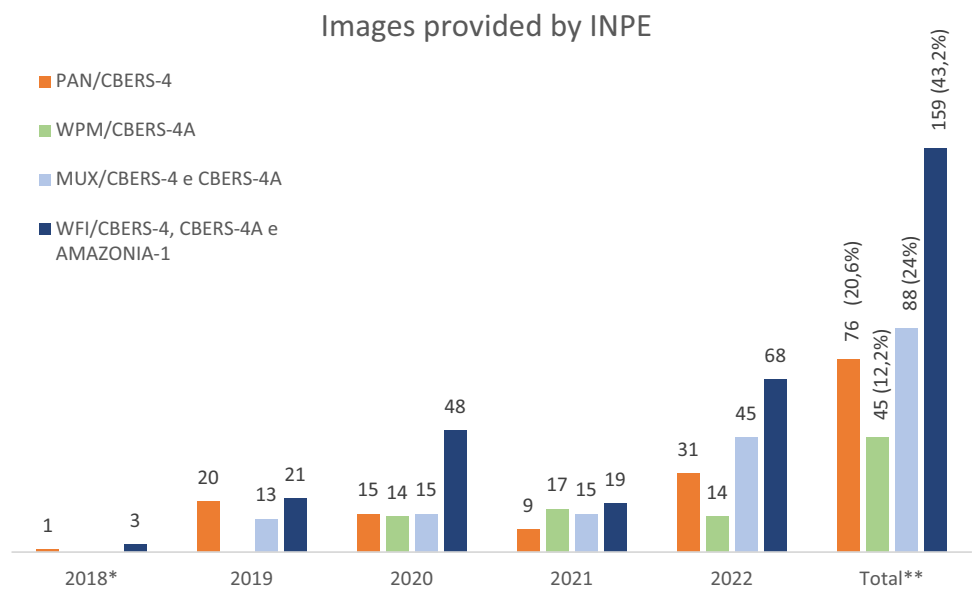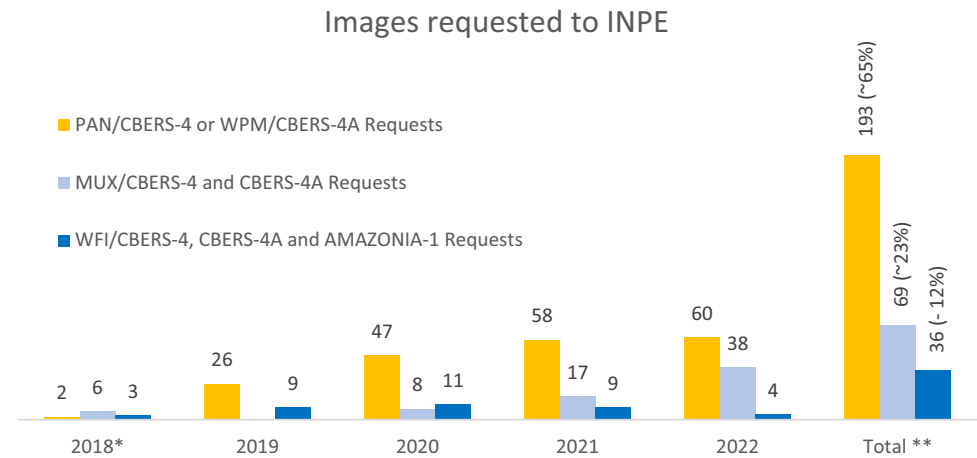

Images provided by INPE

PAN/CBERS-4
WPM/CBERS-4A
MUX/CBERS-4 e CBERS-4A
WFI/CBERS-4, CBERS-4A e AMAZONIA-1

Fig. 4 Number of images requested in Charter Activations to INPE by type of camera in the period from 2018* to 2022. *since August 15, 2018; **rounded percentage values

The imaging system carried out by the different cameras on the CBERS and AMAZONIA-1 satellites involves aspects related to spatial, spectral and temporal resolution, offering a great diversity of images. Specifically, the availability of cameras with different spatial resolutions allows for more diverse applications in a common scenario of different types of disasters, such as earthquakes, landslides, floods and forest fires. Considering that the spatial resolution should be half the width of the smallest object of interest [8], the highest spatial resolution becomes necessary in earthquakes or landslides with the need to observe the damage in built-up areas. While in the case of floods or wildfires, where it is important to analyse the extent of the affected area, the greater field of view provided by cameras with lower spatial resolution, allows for greater image coverage. Namikawa and Körting [12] recommend the use of WFI images (present on the CBERS and AMAZONIA-1 satellites) to be used in flooded areas, where temporal and spatial resolution helps in observing the extent of the disaster.

It is important to highlight that the images provided by INPE are not requested as often due to the limitations of its spectral bands as despite having a considerable spatial resolution (5 m in PAN/CBERS-4 and 2 m in WPM/CBERS-4A). The limitations of the spectral resolution come from the absence of thermal bands and the blue spectral range, not allowing more detailed images to be created for viewing. Furthermore, the satellite regular imaging routine acquisition does not occur for several of the disaster areas, which severally impacts the quantity of archive images available.

In the studied period, around 36 maps (Value Added Products) (Appendix 1) were produced with the images provided by INPE, which allowed helping the teams in the field in the search and recovery of victims of disasters, as well as for damage assessment. Maps produced for the Charter have already been effectively evaluated by other image processing techniques, demonstrating their importance in responding to emergency disasters [2].

4 Conclusions

Brazil has been fostering its role in satellite imaging with the inclusion of the AMAZONIA-1 operation in May 2021, providing a greater range of images and adding more acquisition frequency, percentage of land coverage and autonomy in the operation and satellite image recording. However, it's necessary to increase the number of human resources available at INPE involved in the process, as well as upgrading Brazils capacity in satellite imaging by including the use of more advanced remote sensing technology.

Besides the efforts in image provision, it's worth to consider improvements in the products themselves, e.g. by adding a forecasting component to highlight the susceptibility of disaster prone areas.

INPE's contributions to the Charter allows for the improvement of several issues related to data organization, joint work, prioritization of tasks, as well as issues related to the need for refinement in obtaining, processing and making available satellite images.

Charter's importance in providing images for humanitarian aid is unparalleled. The global base/nature of the International Charter and its universal access efforts are the most active available form of emergency response for obtaining satellite imagery [14].

Declarations

Appendix 1

List of images provided by INPE for the Charter in the period from 2018[1] to 2022, with the specification of the Disaster Type, Location and Activation attended, satellite(s), camera(s) and the respective number of images. NOTE: The letters in the sensor designation/number of images indicates the respective number of images for each sensor. Each of these disasters are specified on the Disasters Charter page (https://disasterscharter.org/web/guest/charter-activations).

Year	Disaster Type, Location (Activation)	Satellite(s)	Camera(s)	Number of Images
2018[1]	Flooding, Venezuela (581)	CBERS-4	WFI	02* (01**)
	Hurricane, USA (585)	CBERS-4	WFI	01
	Wildfire, USA (591)	CBERS-4	PAN	01
2019	Flooding, Brazil (595)	CBERS-4	PAN	08 (06*); (04**)
	Technological disaster, Brazil (596)	CBERS-4	PAN	04 (02*); (02**)
	Hurricane, India (608)	CBERS-4	MUX	02 (01**)
	Flooding, Paraguay (609)	CBERS-4	PAN	06 (02*); (01**)
	Flooding, Russia (611)	CBERS-4	WFI	02 (01**)
	Volcanic Eruption, Peru (613)	CBERS-4	PAN^A, WFI^B	05 [01^A (01*) + 04^B (02*)]
	Hurricane, Russia (615)	CBERS-4	WFI	01
	Flooding, Sudan (617)	CBERS-4	MUX	03*
	Wildfire, Bolivia (619)	CBERS-4	WFI	03*
	Wildfire, Paraguay (621)	CBERS-4	PAN^A, WFI^B	05 [04^B (03*) + 01^A (01**)]
	Flooding, India (623)	CBERS-4	WFI	01 (01**)
	Hurricane, Japan (625)	CBERS-4	MUX^C, WFI^B	06 [05^C (05**); 01^B]
	Wildfire, Lebanon Syrian (626)	CBERS-4	WFI	01
	Flooding, Cameroon (627)	CBERS-4	WFI	03*
	Wildfire, Australia (631)	CBERS-4	WFI^B, MUX^C	03 (01^B; 02^C)
	Hurricane, Fiji Islands (637)	CBERS-4	MUX	01
2020	Flooding, Zambia (640)	CBERS-4	MUX	01*
	Hurricane, Vanuatu (647)	CBERS-4	PAN^A, WFI^B, MUX^C	06 ($02^A + 02^B + 02^C$)
	Hurricane, Fiji Islands (648)	CBERS-4	MUX	02
	Flooding, Somalia (650)	CBERS-4	PAN	02
	Wildfire, Guatemala (651)	CBERS-4	PAN^A, WFI^B, MUX^C	04 ($01^A + 02^B + 01^C$)

Year	Disaster Type, Location (Activation)	Satellite(s)	Camera(s)	Number of Images
	Hurricane, Bangladesh (652)	CBERS-4	WFI	02
	Hurricane, India (653)	CBERS-4	WFI	02 (01**)
	Flooding, El Salvador (654)	CBERS-4	WFI	01
	Flooding, Japan (657)	CBERS-4	WFI	01
	Flooding, Colombia (659)	CBERS-4	WFI	01
	Flooding, Bangladesh (660)	CBERS-4	WFI	02
	Flooding, India (661)	CBERS-4	WFI	01
	Flooding, Indonesia (662)	CBERS-4	WFI	01
	Flooding, India (663)	CBERS-4	WFI^B; MUX^C	02 ($01^B + 01^C$)
	Technological disasters, Lebanon (664)	CBERS-4A	WPM	01
	Oil Spill, Mauricio Islands (666)	CBERS-4A	WPM	01
	Flooding, Sudan (667)	CBERS-4	WFI^B, MUX^C	04 [02^{B*} (01**); 02^C (01**)]
	Flooding, Sudan (667)	CBERS-4A	WPM^A, MUX^D	03 ($02^A + 01^D$)
	Hurricane, Korea (673)	CBERS-4	WFI	04
	Hurricane, Japan (674)	CBERS-4	WFI	03 (01**)
	Flooding, Sudan (675)	CBERS-4	WFI	01*
	Wildfire, Bolivia (676)	CBERS-4	WFI	08 (05*); (01**)
	Wildfire, Bolivia (676)	CBERS-4A	WFI	01* (01**)
	Flooding, Nigeria (677)	CBERS-4	WFI	01*
	Wildfire, Argentina (678)	CBERS-4	WFI	01 (01**)
	Wildfire, Argentina (678)	CBERS-4A	WPM^A, WFI^E	09 [$04^A + 04^{A*} + 01^E$ (02**)]
	Hurricane, Vietnan (680)	CBERS-4	WFI	01
	Hurricane, Vietnan (681)	CBERS-4	WFI	01
	Hurricane, Filipinas (682)	CBERS-4	WFI	01
	Flooding, Mexico (683)	CBERS-4	PAN^A, WFI^B	03 ($02^A + 01^B$)
	Flooding, Panama (684)	CBERS-4	PAN^A, WFI^B, MUX^C	04 ($02^A + 01^B + 01^C$)
	Flooding, Filipinas (686)	CBERS-4	WFI	01
	Hurricane, Colombia (687)	CBERS-4A	WPM	01
	Hurricane, India (688)	CBERS-4	WFI	01
	Landslide, Mexico (689)	CBERS-4	PAN^A, WFI^B	06 ($05^A + 01^B$)
	Landslide, Mexico (689)	CBERS-4A	WPM^A, WFI^E	02 ($01^A + 01^E$)
	Hurricane, Sri Lanka (690)	CBERS-4	WFI	01
	Hurricane, Fiji Islands (691)	CBERS-4	PAN^A, MUX^C	03 ($01^A + 02^{C*}$)
	Hurrinace, Fiji Islands (691)	CBERS-4A	MUX	02
2021	Flooding, Bolivia (693)	CBERS-4A	WPM	03 (02**)
	Flooding, Marrocos (694)	CBERS-4A	MUX	01
	Hurricane, Eswatini (697)	CBERS-4A	MUX	01
	Flooding, Chile (699)	CBERS-4	PAN^A, MUX^C	02 ($01^A + 01^C$)
	Hurricane, Timor Leste (701)	CBERS-4	PAN^A, WFI^B	02 ($01^A + 01^B$)
	Hurricane, Timor Leste (701)	CBERS-4A	MUX^D, WFI^E	03 ($01^D + 02^E$)
	Hurricane, Indonesia (702)	CBERS-4A	MUX^D, WFI^E	05 ($03^D + 02^E$)
	Flooding, Russia (704)	CBERS-4A	WPM	02
	Flooding, Russia (705)	CBERS-4	WFI	01*
	Flooding, Somalia (706)	CBERS-4	PAN	01*
	Flooding, Russia (707)	CBERS-4A	WPM^A, WFI^E	02 ($01^A + 01^E$)
	Flooding, Russia (708)	CBERS-4	MUX^C, WFI^B	03 ($02^C + 01^B$)
	Oil Spill, Sri Lanka (715)	CBERS-4	PAN	02 (01**)
	Flooding, Sri Lanka (716)	CBERS-4	PAN^A, WFI^B	03 ($02^A + 01^B$)
	Flooding, Guiana (717)	CBERS-4A	WPM	04*
	Flooding, Switzerland (720)	CBERS-4	WFI	02
	Flooding, Luxemburgo (721)	CBERS-4	WFI	01

Year	Disaster Type, Location (Activation)	Satellite(s)	Camera(s)	Number of Images
	Wildfire, Russia (722)	AMAZONIA-1	WFI	02 (01*)
	Flooding, Russia (726)	CBERS-4	WFI	01
	Flooding, Japan (727)	CBERS-4	MUX^C, WFI^B	03 (02^C+01^B)
	Wildfire, Russia (728)	CBERS-4	WFI	01
	Flooding, Haiti (730)	CBERS-4	PAN	01
	Flooding, Togo (731)	CBERS-4	PAN^A, WFI^B	02 (01^A*+01^B)
	Flooding, Sudan (732)	CBERS-4	MUX	02*
	Flooding, Sudan (732)	CBERS-4A	WPM^A, MUX^D	03 (01^A*+02^D)
	Flooding, Tailand (734)	CBERS-4	WFI	01
	Flooding, Brazil (742)	CBERS-4A	WPM	05**
2022	Volcanic Eruption, Tonga (744)	CBERS-4	PAN^A, MUX^C	02 (01^A+01^C)
	Volcanic Eruption, Tonga (744)	CBERS-4A	MUX	01
	Hurricane, Mozambique (748)	CBERS-4A	WPM	01**
	Flooding, Brazil (751)	CBERS-4A	WPM	01**
	Flooding, Brazil (754)	CBERS-4A	WPM^A, MUX^D	15 [03^A (04**)+12^D (01**)]
	Flooding, South Africa (755)	CBERS-4A	WPM^A, WFI^E	07 (06^A+01^E)
	Landslide, Brazil (758)	AMAZONIA-1	WFI	01*
	Landslide, Brazil (758)	CBERS-4A	WPM	01*
	Flooding, Bangladesh (762)	CBERS-4	WFI	08
	Wildfire, Tunisia (766)	CBERS-4	PAN^A, WFI^B	03 (01^A*+02^B)
	Flooding, Gambia (768)	CBERS-4	PAN	02*
	Flooding, Sudan (769)	CBERS-4	WFI	01
	Flooding, Sudan (769)	CBERS-4A	MUX^D, WFI^E	04* (02^D+02^E)
	Wildfire, Russia (770)	CBERS-4	WFI	01*
	Hurricane, Filipinas (771)	CBERS-4	MUX^C, WFI^B	08 [03^C+05^B (01*)]
	Flooding, Paquistão (772)	CBERS-4	MUX^C, WFI^B	10 (03^C+07^B)
	Hurricane, Korea (773)	CBERS-4	MUX^C, WFI^B	06 [03^C+03^B (01*)]
	Hurricane, Russia (774)	CBERS-4	WFI	01*
	Flooding, Nigeria (777)	CBERS-4	PAN^A, MUX^C, WFI^B	11 [02^A*+03^C (01*)+06^B (02*)]
	Hurricane, Ilhas Turcas e Caicos (779)	CBERS-4	WFI	03
	Hurricane, República Dominicana (780)	CBERS-4	WFI	02
	Hurricane, Canada (781)	CBERS-4	WFI	01
	Hurricane, Filipinas (782)	CBERS-4	WFI	02 (01*)
	Hurricane, Laos (783)	CBERS-4	WFI	03
	Flooding, Tailand (784)	CBERS-4	WFI	02 (01*)
	Flooding, Venezuela (785)	CBERS-4	WFI	01
	Flooding, Honduras (786)	CBERS-4	PAN^A, MUX^C, WFI^B	30 [20^A+05^C+05^B (01*)]
	Flooding, Honduras (786)	CBERS-4A	WPM^A, MUX^D, WFI^E	09 (02^A+05^D+02^E)
	Flooding, Chade (788)	CBERS-4	PAN^A, MUX^C, WFI^B	08 [02^A+04^C+02^B (01*)]
	Hurricane, Filipinas (789)	CBERS-4	WFI	04 (03*)
	Flooding, United Kingdom (790)	AMAZONIA-1	WFI	03*
	Flooding, United Kingdom (790)	CBERS-4	PAN^A, MUX^C	06 (03^A+03^C)

NOTE: [1] since August 15, 2018; *from archival imagery; **with map (Value Added Product).

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