# A MULTI-SOURCE WFI DATACUBE OF CBERS-4 AND CBERS-4A IMAGES: IMPROVING VISUAL INTERPRETATION

*Jeferson Souza Arcanjo*[1], *Rennan de Freitas Bezerra Marujo*[1], *Ricardo Cartaxo Modesto de Souza*[1],*Raphael Willian Costa*[1]
*Gilberto Ribeiro de Queiroz*[1] *Karine Reis Ferreira*[1]

National Institute for Space Research (INPE), Av. dos Astronautas, 1758, São José dos Campos, 12227-010, São Paulo, Brazil
{jeferson.arcanjo, rennan.marujo, ricardo.cartaxo, raphael.costa, gilberto.queiroz, karine.ferreira}@inpe.br

***ABSTRACT***

*PRODES and DETER, Brazilian programs to monitor deforestation, rely on free optical images for visual interpretation, which can be obtained from the sensors on-board several satellites, such as Landsat-8, Landsat-9, Sentinel-2, CBERS-4, CBERS-4A and Amazonia-1. However, in optical remote sensing images, clouds and cloud shadows have a direct impact on the number of Earth's surface observations. Combining images from different sources can help to overcome this information gap. Based on that, the Brazil Data Cube started to produce an experimental product that combines CBERS-4 and CBERS-4A images from the WFI sensor on-board both satellites. The main idea of this product is to provide spatial and temporal mosaics with less clouds and cloud shadows than products containing images from a single satellite, improving visual interpretation.*

***Key words*** *– CBERS, Brazil Data Cube, Visual Interpretation, Optical Remote Sensing, Data Cube.*

## 1. INTRODUCTION

Clouds and cloud shadows have a direct impact on the number of Earth's surface observations through optical remote sensing images. Since optical remote sensing images is the main source of information for deforestation monitoring, e. g. PRODES [1] and DETER [2], these programs are dependent of these observations. Due to this reason, both mentioned programs, use data from multiple sources to overcome this information gap. Among the optical free available data PRODES and DETER use images from the satellites Landsat-8, Landsat-9, Sentinel-2, CBERS-4, CBERS-4A and Amazonia-1. The Landsat program and the Sentinel-2 constellation are very well known by the remote sensing community around the world, while CBERS-4, CBERS-4A and Amazonia-1 aren't. The three satellites carry a Wide Field Imager (WFI) camera and are part of the Brazilian Space Program, being Amazonia-1 exclusively developled and operated by Brazil.

### 1.1. CBERS Program

CBERS stands for China-Brazil Earth Resource Satellite, it's a partnership between Brazil and China in the aerospace area that has lasted more than 30 years [3].

So far, five satellites have been launched, however the last two are still in operation. CBERS-4 was launched in December 2014 and operates until today, even after reaching its useful time life while CBERS-4A was launched in December 2019.

CBERS-4 takes approximately 100 minutes to complete one orbit of the Earth also carries a WFI, MUX, PAN and IRS cameras while CBERS-4A takes approximately 97 minutes to complete one orbit of the Earth and carries a WFI, MUX and WPM instruments.

WFI and MUX are the sensors on-board both satellites. The WFI has wider swath, allowing an increased revisit rate in comparison to the MUX sensor, although this trade-off implies in MUX presenting a thinner spatial resolution in comparison to WFI (20 m for MUX against 55 m or 64 m for WFI). Considering the improved revisit rate, WFI is more suitable for obtaining images with less clouds.

### 1.2. Wide Field Imager camera

The WFI (Wide Field Imager) camera was developed on the Brazilian side of the partnership, as well as its data transmission subsystem, responsible for transmitting data from the camera while it is imaging the Earth's surface for ground stations to record the data. The camera has 10 bits quantization, a field of view of approximately +/- 28 degrees, transmits data from the satellite to the earth station at 50 Mbits/s and has four spectral bands, in this case, blue (0.45-0.52), green (0.52 -0.59), red (0.63-0.69) and NIR (0.77-0.89) channels.

The WFI camera's differential is the wide swath on the Earth's surface, therefore it reduces the revist period to 3 to 5 days. The WFI camera is the same on both satellites, there are some differences in relation to resolution and swath, due to the difference in the platforms altitude, as shown in Table 1.

| | CBERS-4 | CBERS-4A |
|---|---|---|
| Altitude | 778 km | 629 km |
| Swath | 866 km | 684 km |
| Resolution | 64 m | 55 m |
| Revisit | 5 days | 5 days |

**Table 1: CBERS 4 and 4A WFI characteristics.**

## 2. MATERIAL E METHODS

INPE distributes freely images from the CBERS satellite series in its catalog (http://www2.dgi.inpe.br/catalogo). The products are distributed as Digital Number (DN) in relation to radiometry and in levels of geometric correction such as Level 2 (L2), which are geometric corrected based on auxiliary data sent by the satellite and Level 4 (L4), which uses control points and DEM data to produce an orthorectified GeoTiff.

Additional processing is performed on DN images to obtain the surface reflectance (SR) product and also to

generate additional products, e. g., the cloud mask [4]. These additional products are cataloged and distributed as Collections by the Brazil Data Cube [5] on its portal, alongside several products of medium spatial resolution of optical images, including image collections at surface reflectance, data cubes composed of images obtained from the Landsat, Sentinel-2 and CBERS program, as well as classifications, all freely available through the project website (http://www.brazildatacube.org) [5].

A software called *Data Cube Builder* is the responsible for generating data cubes. One of the most recent product being developed is the CBERS WFI composite data cube. This product combines images obtained from the WFI sensor on-board CBERS-4 and CBERS-4A satellites, in other words, a multi-source product.

The generation of this cube follows the production line adopted by the BDC Project [5]. For this product specifically, the BDC Large Grid was used, also called BDC_LG (v2), which divides Brazil into tiles of 4224400m x 4224400m; a temporal composition of 8 days is used to select the best pixel through Least Cloud First (LCF) temporal composition function and the cube was generated ranging from January 2020 to October 2022.

Figure 1 illustrates that several CBERS-4/WFI images are affected by clouds or cloud shadows, while in several CBERS-4A/WFI the same occurs. Considering that when observing a time window, e. g. 8 days, these images can complement each other by providing information not initially available due to the presence of clouds and cloud shadow, a compositing mosaic could improve visual interpretation of these areas. Following this logic, a CBERS WFI composite data cube could provide more information of the Earth's surface than when observing it from a single satellite/sensor approach.

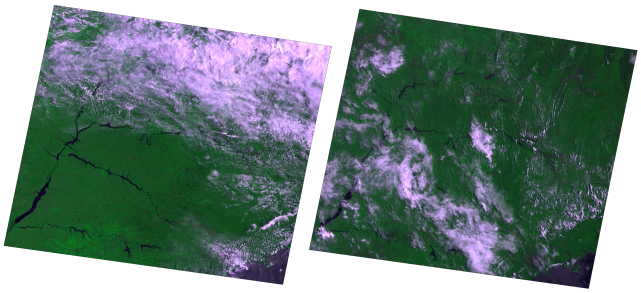


**Figure 1: Complementary CBERS images**

In order to compare the 8-day cube CBERS WFI (multi-source), an 8-day cube using only CBERS-4 WFI surface reflectance images was created. Four tiles were generated distributed throughout Brazil, covering the entire 2020 year as follows:

- 004002: Amazon region (near Manaus)
- 007004: Bahia and Tocantins region
- 007007: São Paulo and Vale do Paraiba
- 010003: Northeastern coast (Refice and João Pessoa)

## 3. RESULTS AND DISCUSSION

Once with the two cubes in hand for evaluating the four tiles generated over a year (about 45 time lines per year) in general, there was an improvement in the visual quality of the tiles composed of images from the two satellites compared to the ones generated from a single satellite.

Figure 2 shows how the composed data cube improve by reducing the quantity of clouds and cloud shadows, single source (left) against multi-source (right).

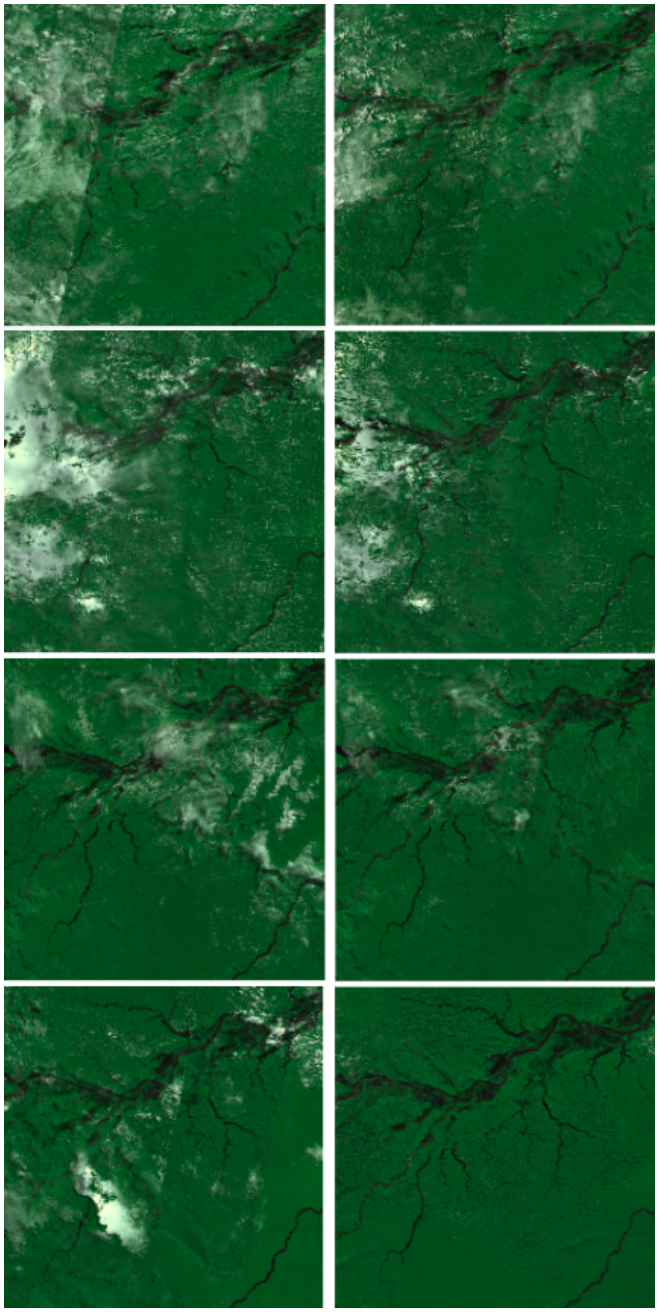


**Figure 2: CBERS-4 images (left) and composed WFI data cube (right) images from tile 004002 on the dates (up to down): 2020-04-30, 2020-06-01, 2020-06-09, 2020-06-25.**

In some observed time lines, chunks of the tile that were not populated with data from just one satellite were completed using two sources, moreover, some clouds disappeared from the bottom of the tile, as shown in Figure 3

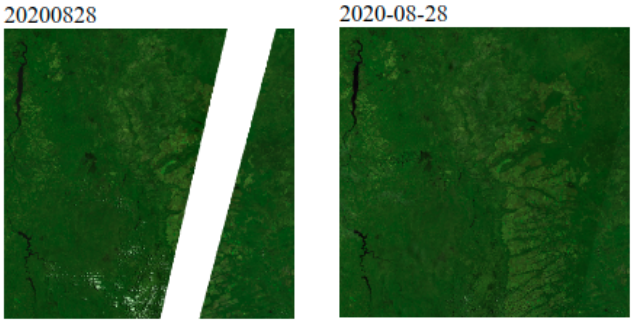



**Figure 3: Tile 007004 - 2020-08-28 single source (left), two sources (right)**

On the other hand, some images presented problems in the composition of the tiles, we believe that due to a problem with the CBERS-4A Cloud Mask, as shown in Figure 4. This kind of problem should be properly addressed in a short time.

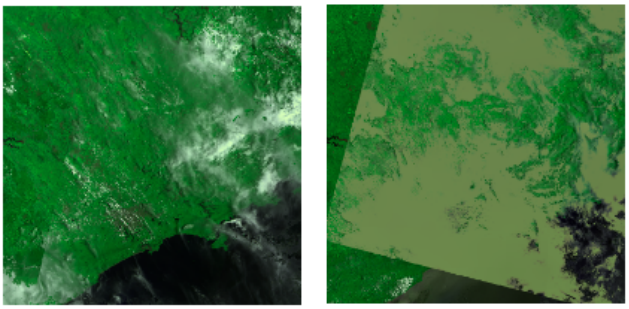


**Figure 4: Tile 007007 - 2020-01-09 single source (left), two sources (right)**

## 4. CONCLUSIONS

A product containing images from CBERS-4 and CBERS-4A is more suitable for detecting areas with less clouds than when considering a single satellite/sensor approach. Even though both of the used satellites carry the same WFI camera, for physical measurements, more studies are required to verify the differences between the two imaging systems.

In the future, we intend to incorporate images from the Amazonia-1 WFI camera, aiming to further improve the product quality or even reduce the time step, that is, the frequency that the tiles are generated. By using the three satellites, it is estimated that it is possible to obtain images of certain points in the Brazilian territory every one or two days.

Another advance that can be obtained is in relation to the creation of tools to analyze the number of clouds in the datasets, thus facilitating the evaluation.

## 5. REFERENCES

[1] INPE. Prodes project: Brazilian amazon forest monitoring by satellite. `http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes`, 2022. (03 Nov. 2022).

[2] C. G. Diniz, A. A. d. A. Souza, D. C. Santos, M. C. Dias, N. C. d. Luz, D. R. V. d. Moraes, J. S. Maia, A. R. Gomes, I. d. S. Narvaes, D. M. Valeriano, L. E. P. Maurano, and M. Adami. Deter-b: The new amazon near real-time deforestation detection system. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 8(7):3619–3628, July 2015.

[3] INPE. Cbers program: China-brazil earth resource satellite. `http://cbers.inpe.br`, 2022. (03 Nov. 2022).

[4] Marco Aurélio Oliveira da Silva and Frederico dos Santos Liporace. Detecção automática de nuvem e sombra de nuvem em imagens de sensoriamento remoto. *Boletim de Ciências Geodésicas*, 22:369–388, 2016.

[5] Karine R. Ferreira, Gilberto R. Queiroz, Lubia Vinhas, Rennan F. B. Marujo, Rolf E. O. Simoes, Michelle C. A. Picoli, Gilberto Camara, Ricardo Cartaxo, Vitor C. F. Gomes, Lorena A. Santos, Alber H. Sanchez, Jeferson S. Arcanjo, José Guilherme Fronza, Carlos Alberto Noronha, Raphael W. Costa, Matheus C. Zaglia, Fabiana Zioti, Thales S. Korting, Anderson R. Soares, Michel E. D. Chaves, and Leila M. G. Fonseca. Earth Observation Data Cubes for Brazil: Requirements, Methodology and Products. *Remote Sensing*, 12(24):4033, dec 2020.