



MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO  
**INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS**

# Agency Report National Institute for Space Research – INPE Brazil

Lubia Vinhas

WGISS/CEOS – 42 Meeting, September 2016, Frascati, Italy

# Fostering the concept of public-good data

## Brazil, 2004

INPE set a free data policy for CBERS in Brazil  
CBERS data available free of charges on the Web  
Impacts on EO consulting and services in Brazil  
Increasing EO data distribution for society

## South Africa, 2007

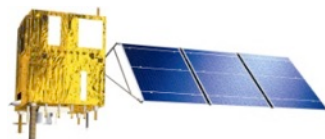
Announcement of the CBERS for Africa Initiative  
Extension of CBERS free data policy for Africa

## America, 2008

USGS adopted a free data policy for Landsat  
Landsat image data also available free of charges

## Europe, 2009

ESA announced a free data policy for Sentinels



# CBERS Program - Status

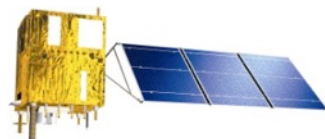
CBERS-3 was lost after a failure in the last stage of the launching rocket in 2013.

CBERS-4 was successfully launched in December 2014.

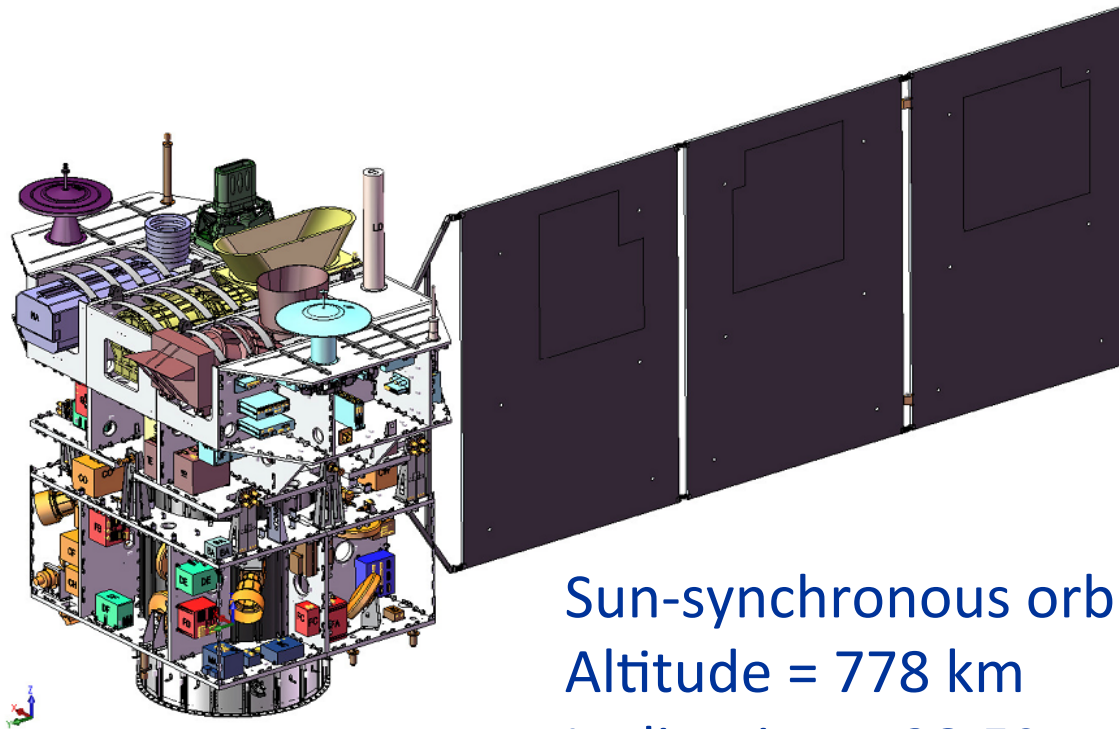
CBERS-4 images have been regularly acquired in Cuiabá.

Commissioning phase was executed from December 2015 to May 2016 to assess and validate CBERS-4 cameras.

Images are available on the web ([www2.dgi.inpe.br/CDSR](http://www2.dgi.inpe.br/CDSR)).



# CBERS 3 & 4 – 2<sup>nd</sup> generation series



Sun-synchronous orbit

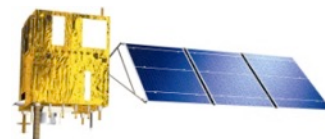
Altitude = 778 km

Inclination = 98.5°

Nodal period = 100.26 minutes

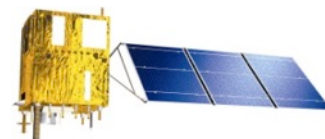
Repeat cycle = 26 days

Descending node at 10h30 local time



# CBERS 3 & 4 – 2<sup>nd</sup> generation series

| Parameter       | CBERS 1, 2, 2B | CBERS 3, 4 |
|-----------------|----------------|------------|
| Total mass      | 1,450 kg       | 2,020 kg   |
| Power           | 1,100 W        | 2,300 W    |
| Data rate       | 100 Mbit/s     | 305 Mbit/s |
| Design lifetime | 2 years        | 3 years    |



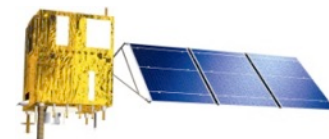
# CBERS 3 & 4 – cameras

| Payloads     | MUX        | PAN  | IRS        | WFI        |
|--------------|------------|--|------------|------------|
| Manufacturer | Brazil     | China  | China      | Brazil     |
| Type         | Pushbroom  | Pushbroom  | Scanner    | Pushbroom  |
| Revisit time | 26 days    | 52 days (nadir operation)<br>side looking (32 degrees) | 26 days    | 5 days     |
| Quantization | 8 bits     | 8 bits   | 8 bits     | 10 bits    |
| Data rate    | 68 Mbits/s | 67, 100 Mbits/s  | 17 Mbits/s | 53 Mbits/s |
| Compression  |            | 2:1 pan band   |            |            |



# CBERS 3 & 4 – cameras

| Payloads    | MUX                       | PAN                       | IRS                       | WFI                       |
|-------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Band 1      | 0.45 - 0.52 $\mu\text{m}$ | 0.51 - 0.73 $\mu\text{m}$ | 0.77 - 0.89 $\mu\text{m}$ | 0.45 - 0.52 $\mu\text{m}$ |
| Band 2      | 0.52 - 0.59 $\mu\text{m}$ | 0.52 - 0.59 $\mu\text{m}$ | 1.55 - 1.75 $\mu\text{m}$ | 0.52 - 0.59 $\mu\text{m}$ |
| Band 3      | 0.63 - 0.69 $\mu\text{m}$ | 0.63 - 0.69 $\mu\text{m}$ | 2.08 - 2.35 $\mu\text{m}$ | 0.63 - 0.69 $\mu\text{m}$ |
| Band 4      | 0.77 - 0.89 $\mu\text{m}$ | 0.77 - 0.89 $\mu\text{m}$ | 10.4 - 12.5 $\mu\text{m}$ | 0.77 - 0.89 $\mu\text{m}$ |
| Resolution  | 20 m                      | 5 m, 10 m                 | 40 m, 80 m                | 70 m                      |
| Swath width | 120 km                    | 60 km                     | 120 km                    | 866 km                    |



# Basic processing levels of CBERS-4

**L0:** raw image data.

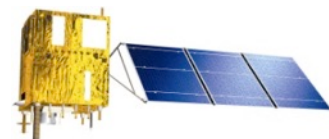
**L1:** radiometrically corrected images.

**L2:** L1 plus geometric system-correction.

**L3:** L2 plus registration through ground control points.

**L4:** L2 plus registration through ground control points and terrain correction (orthorectification).

**L3** and **L4** are processed automatically by means of image correlation techniques and geometric transformations.



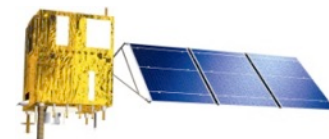


# Internal accuracy estimation for MUX

| Points | Scenes | L4 RMSE (m) | L4 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 50   | 330    | 12.112      | 2.165            | 1.0002      | 0.0011               | 1.0000      | 0.0002               |
| > 40   | 489    | 11.981      | 2.247            | 1.0002      | 0.0012               | 1.0000      | 0.0002               |
| > 30   | 686    | 12.192      | 2.676            | 1.0001      | 0.0013               | 1.0000      | 0.0002               |
| > 20   | 996    | 12.154      | 2.944            | 1.0001      | 0.0014               | 1.0000      | 0.0006               |

Ground control points extracted from terrain-corrected (orthorectified) Landsat-8 images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



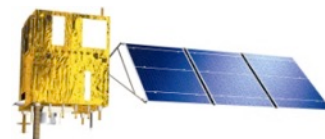
# Internal accuracy estimation for MUX

| Points | Scenes | L3 RMSE (m) | L3 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 50   | 15     | 18.277      | 3.229            | 1.0004      | 0.0005               | 0.9999      | 0.0002               |

| Points | Scenes | L2 RMSE After translation (m) | L2 RMSE After translation $\sigma$ |
|--------|--------|-------------------------------|------------------------------------|
| > 50   | 386    | 30.427                        | 28.931                             |

Ground control points extracted from terrain-corrected (orthorectified) Landsat-8 images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track

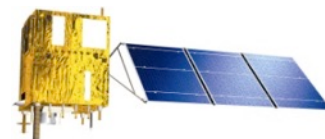


# Internal accuracy estimation for WFI

| Points | Scenes | L4 RMSE (m) | L4 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 200  | 4      | 62.014      | 3.446            | 0.9993      | 0.0005               | 1.0000      | 0.0000               |
| > 150  | 5      | 61.227      | 3.416            | 0.9994      | 0.0005               | 1.0000      | 0.0000               |
| > 100  | 8      | 62.256      | 3.198            | 0.9995      | 0.0004               | 1.0000      | 0.0000               |
| > 50   | 13     | 63.089      | 4.461            | 0.9994      | 0.0004               | 1.0000      | 0.0001               |

Ground control points extracted from subsampled terrain-corrected Landsat-8 images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



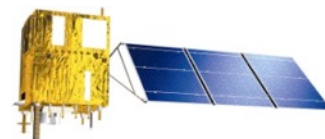
# Internal accuracy estimation for WFI

| Points | Scenes | L3 RMSE (m) | L3 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 50   | 11     | 72.116      | 27.360           | 1.0015      | 0.0034               | 1.0000      | 0.0001               |

| Points | Scenes | L2 RMSE After translation (m) | L2 RMSE After translation $\sigma$ |
|--------|--------|-------------------------------|------------------------------------|
| > 150  | 21     | 184.197                       | 103.466                            |

Ground control points extracted from subsampled terrain-corrected Landsat-8 images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



# Internal accuracy estimation for PAN5

| Points | Scenes | L4 RMSE (m) | L4 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 50   | 51     | 13.060      | 2.157            | 1.0001      | 0.0028               | 1.0000      | 0.0001               |
| > 40   | 66     | 12.997      | 2.072            | 1.0002      | 0.0028               | 1.0000      | 0.0001               |
| > 30   | 82     | 12.806      | 2.113            | 1.0004      | 0.0026               | 1.0000      | 0.0001               |
| > 20   | 105    | 12.899      | 2.223            | 1.0002      | 0.0028               | 1.0000      | 0.0001               |

Ground control points extracted from terrain-corrected (orthorectified) RapidEye images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



# Internal accuracy estimation for PAN5

| Points | Scenes | L3 RMSE (m) | L3 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 20   | 7      | 11.346      | 1.810            | 1.0023      | 0.0003               | 1.0000      | 0.0000               |

| Points | Scenes | L2 RMSE After translation (m) | L2 RMSE After translation $\sigma$ |
|--------|--------|-------------------------------|------------------------------------|
| > 50   | 52     | 46.731                        | 12.797                             |

Ground control points extracted from terrain-corrected (orthorectified) RapidEye images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track

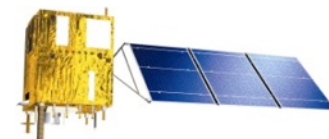


# Internal accuracy estimation for PAN10

| Points | Scenes | L4 RMSE (m) | L4 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 50   | 120    | 15.340      | 2.362            | 1.0001      | 0.0026               | 1.0000      | 0.0001               |
| > 40   | 141    | 15.194      | 2.517            | 1.0000      | 0.0026               | 1.0000      | 0.0001               |
| > 30   | 164    | 15.249      | 2.564            | 1.0000      | 0.0027               | 1.0000      | 0.0001               |
| > 20   | 194    | 15.193      | 2.701            | 1.0000      | 0.0027               | 1.0000      | 0.0001               |

Ground control points extracted from terrain-corrected (orthorectified) RapidEye images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



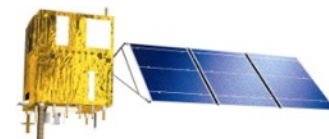
# Internal accuracy estimation for PAN10

| Points | Scenes | L3 RMSE (m) | L3 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 20   | 7      | 17.822      | 3.661            | 0.9963      | 0.0003               | 1.0002      | 0.0001               |

| Points | Scenes | L2 RMSE After translation (m) | L2 RMSE After translation $\sigma$ |
|--------|--------|-------------------------------|------------------------------------|
| > 50   | 130    | 45.037                        | 18.087                             |

Ground control points extracted from terrain-corrected (orthorectified) RapidEye images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



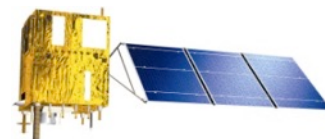


# Internal accuracy estimation for IRS

| Points | Scenes | L4 RMSE (m) | L4 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 50   | 2      | 29.787      | 1.592            | 0.9981      | 0.0009               | 0.9963      | 0.0000               |
| > 40   | 4      | 34.376      | 5.222            | 0.9994      | 0.0015               | 0.9960      | 0.0005               |
| > 30   | 6      | 34.556      | 4.272            | 1.0001      | 0.0015               | 0.9959      | 0.0004               |
| > 20   | 10     | 34.008      | 4.238            | 1.0001      | 0.0013               | 0.9960      | 0.0005               |

Ground control points extracted from terrain-corrected (orthorectified) Landsat-8 images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



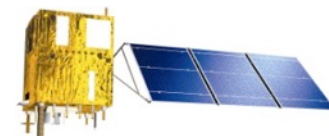
# Internal accuracy estimation for IRS

| Points | Scenes | L3 RMSE (m) | L3 RMSE $\sigma$ | L2 CT Scale | L2 CT Scale $\sigma$ | L2 AT Scale | L2 AT Scale $\sigma$ |
|--------|--------|-------------|------------------|-------------|----------------------|-------------|----------------------|
| > 5    | 11     | 43.648      | 11.795           | 0.9999      | 0.0015               | 1.0003      | 0.0030               |

| Points | Scenes | L2 RMSE After translation (m) | L2 RMSE After translation $\sigma$ |
|--------|--------|-------------------------------|------------------------------------|
| > 50   | 2      | 146.455                       | 9.155                              |

Ground control points extracted from terrain-corrected (orthorectified) Landsat-8 images

RMSE: root mean square error;  $\sigma$ : standard deviation; CT: across-track; AT: along-track



# Summarizing

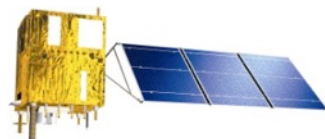
MUX L4 images are suitable for mapping at scales 1:50,000 and smaller.

WFI L4 images are suitable for mapping at scales 1:250,000 and smaller.

PAN5 and PAN10 L4 images are suitable for mapping at scales 1:50,000 and smaller.

IRS L4 images are suitable for mapping at scales 1:100,000 and smaller.

These conclusions are based on the comparison of resulting RMSEs with commonly accepted cartographic standards.



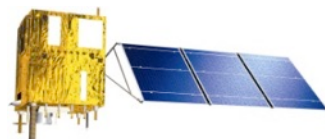
# Final remarks

MUX L4 images are extremely consistent in time in terms of their geometric internal accuracies.

Although WFI L4 images have acceptable geometric internal accuracies, a refinement in the optical distortion model of the two optical systems of the camera is still being analyzed.

PAN5 and PAN10 L4 images have acceptable geometric internal accuracies that are about to be improved by the application of optical distortion models provided recently by our Chinese partners.

IRS L4 geometric internal accuracies are not as acceptable as it should be, as a result of inaccurate modeling of its camera push broom system.



**SOME IMAGES**

Brasilia, DF, Brazil - MUX



Rio de Janeiro, RJ, Brazil - PAN -10

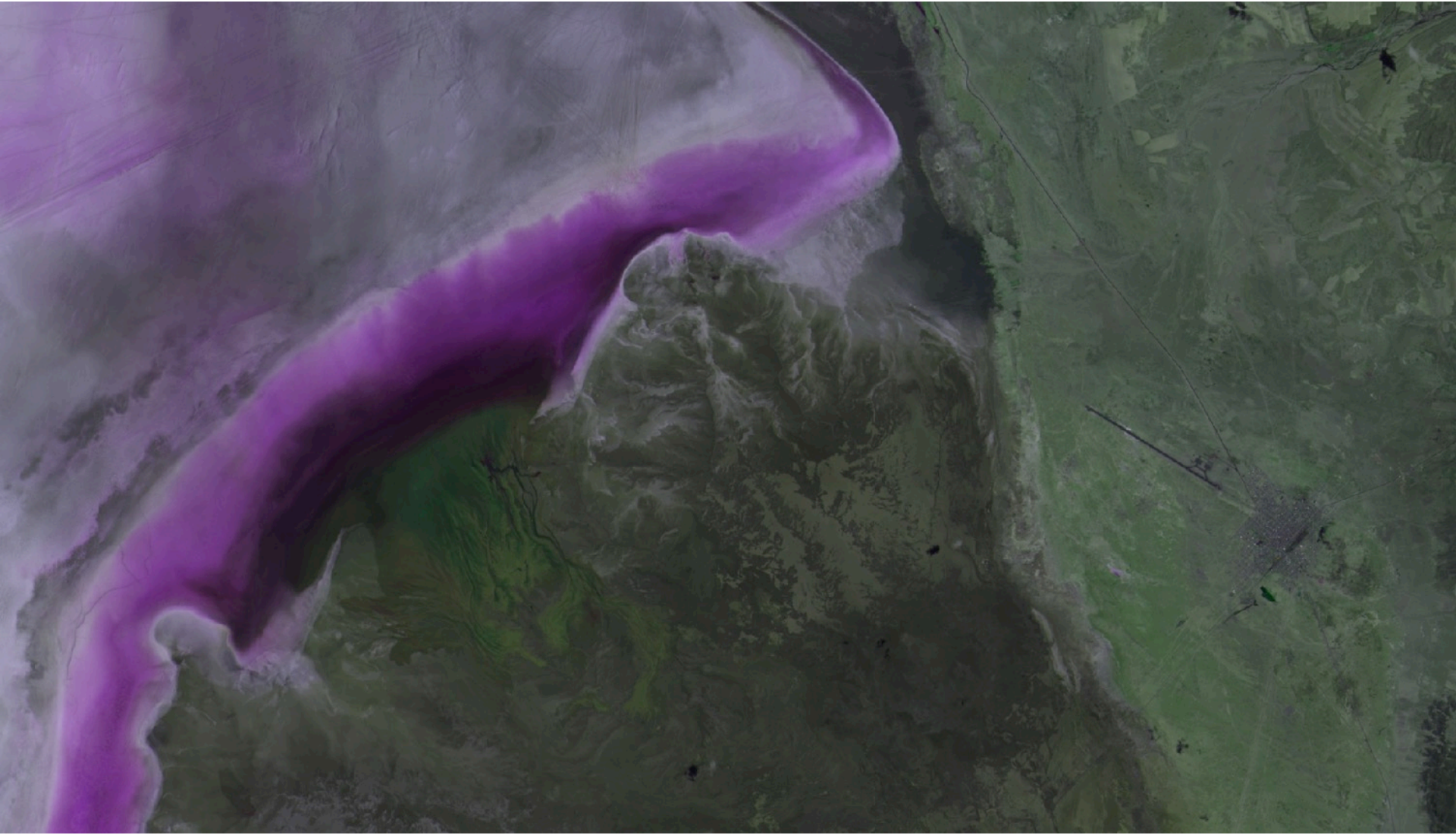


# EUA – WFI

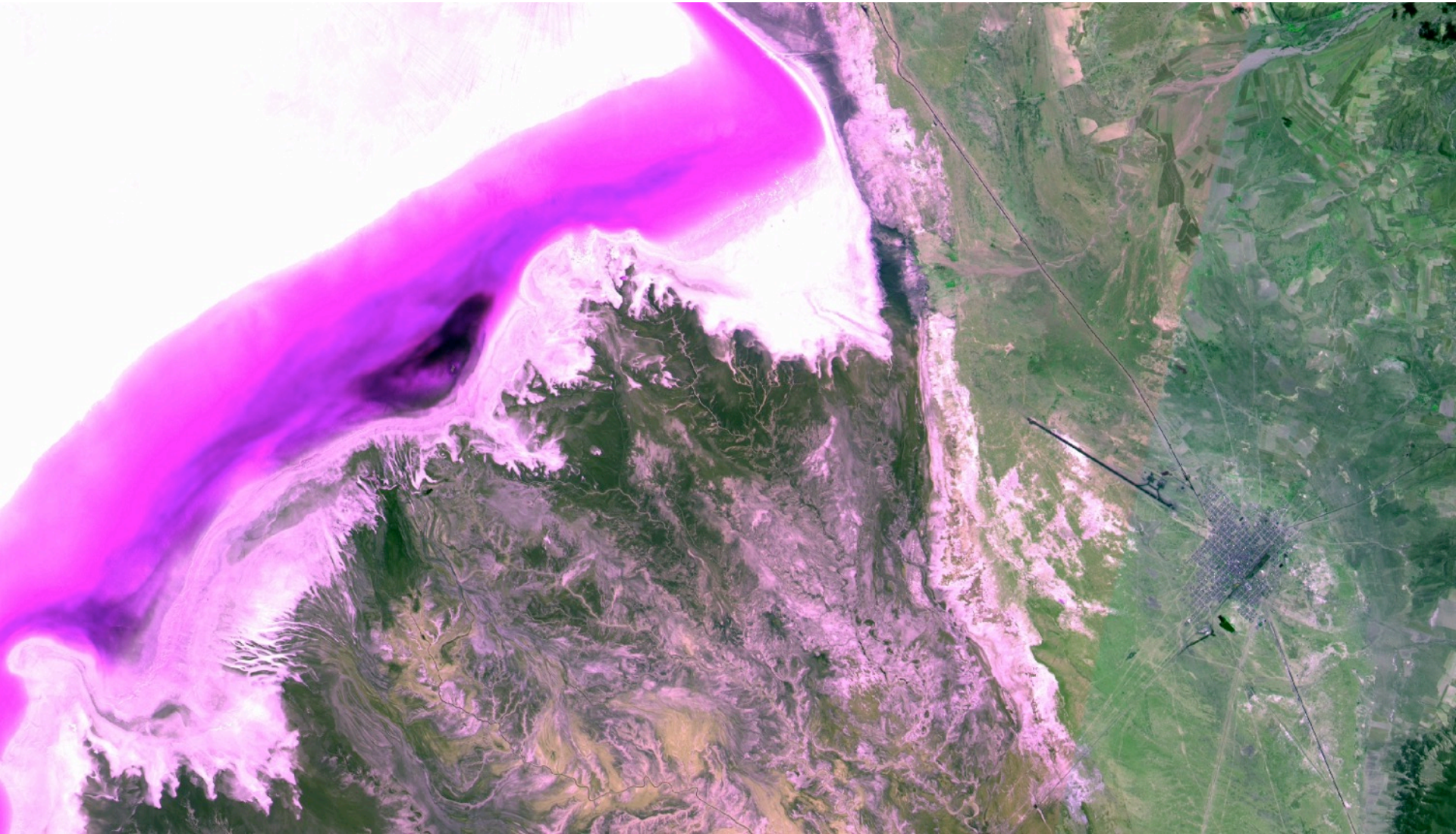




# Uyuni Salar, Chile – WFI




# Uyuni Salar, Chile – Pan 10



# Distribution

Images are available on the web ([www2.dgi.inpe.br/CDSR](http://www2.dgi.inpe.br/CDSR)).

 **MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO**  
**INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS**

Log in Cart Help

No scene found.

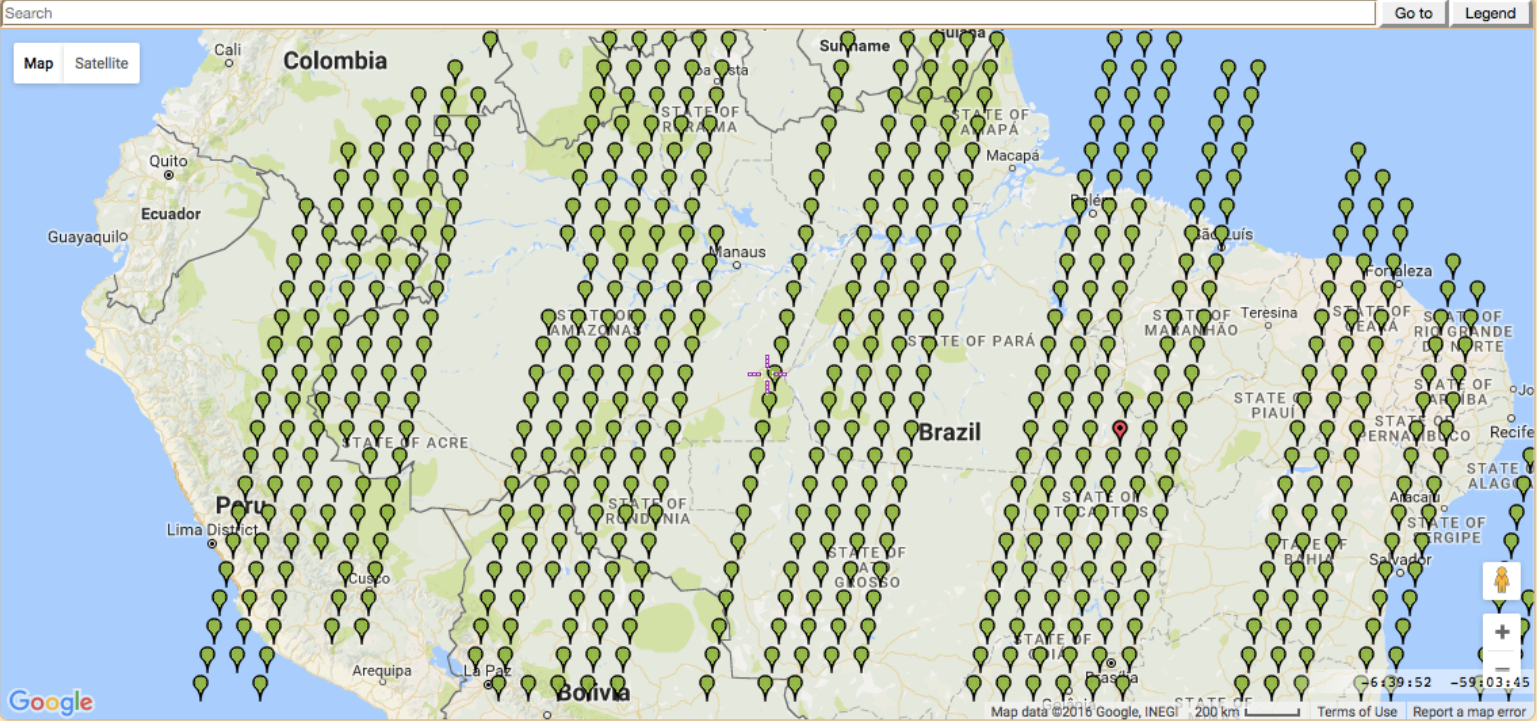
**Selection**    **Map**    **List**    **Details**

Dataset: All  
Satellite: CBERS-4  
Instrument: MUX  
Seasonal:   
Start Date: 2016-09-01  
End Date: 2016-09-19

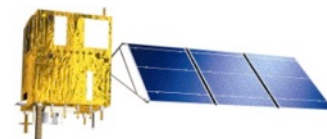
**Maximum Cloud Coverage**  
Q1:  Q2:   
Q3:  Q4:

**Path/Row Range**  
Path:  to   
Row:  to

Search:



Map data ©2016 Google, INEGI 200 km Terms of Use Report a map error

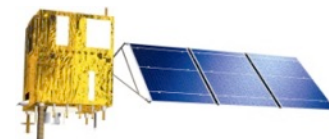


# Distribution

## PHP access API to support CWIC connector



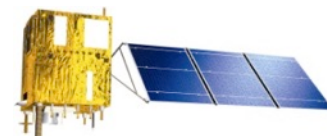
```
<searchResponse xsi:schemaLocation="http://upe.ldcm.usgs.gov/schema/metadata http://edcsns17.cr.usgs.gov/EE/metadata.xsd">
  <returnStatus value="success">Completed Successfully</returnStatus>
  <startrec>0</startrec>
  <maxrecs>1000</maxrecs>
  <totalRecords>17</totalRecords>
  <recordsRecovered>17</recordsRecovered>
  - <metaData>
    <browseAvailable>Y</browseAvailable>
    - <browseURL>
      http://www.dgi.inpe.br/cwic_cb4/display.php?TABELA=Browse&PREFIXO=Cbers&INDICE=CB4MUX15412620160831
    </browseURL>
    - <cartURL>
      http://www.dgi.inpe.br/cwic_cb4/cart-cwic.php?SCENEID=CB4MUX15412620160831
    </cartURL>
    <sceneID>CB4MUX15412620160831</sceneID>
    <sensor>CB4_MUX</sensor>
    <acquisitionDate>2016-08-31</acquisitionDate>
    <dateUpdated>2016-08-31 19:32:36</dateUpdated>
    <path>154</path>
    <row>126</row>
    <upperLeftCornerLatitude>-22.6469</upperLeftCornerLatitude>
    <upperLeftCornerLongitude>-46.5629</upperLeftCornerLongitude>
    <upperRightCornerLatitude>-22.8261</upperRightCornerLatitude>
    <upperRightCornerLongitude>-45.3924</upperRightCornerLongitude>
    <lowerLeftCornerLatitude>-23.7049</lowerLeftCornerLatitude>
```



# Discovery

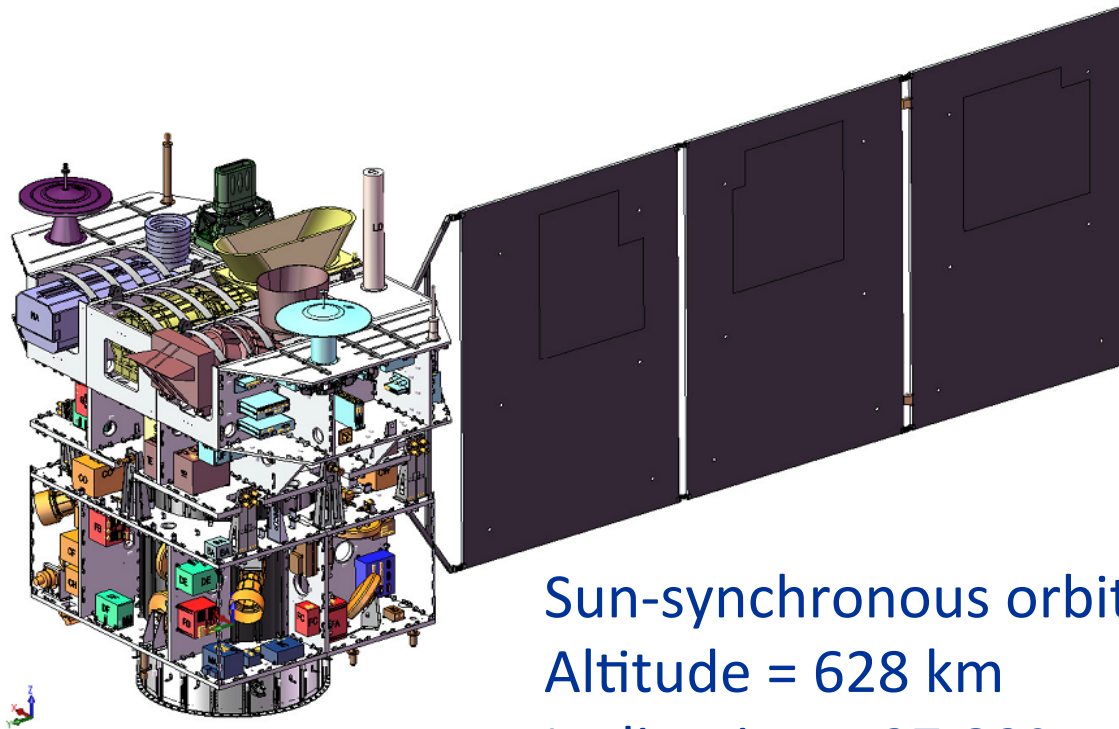
## OpenSearch prototype implementation

```
<OpenSearchDescription xml:lang="en"
xmlns="http://a9.com/-/spec/opensearch/1.1/"
xmlns:geo="http://a9.com/-/opensearch/extensions/geo/1.0/"
xmlns:time="http://a9.com/-/opensearch/extensions/time/1.0/">
  <ShortName>INPE Granule Search</ShortName>
  <Description>INPE - National Institute for Space Research granule search using
  OpenSearch Geo and Time extensions</Description>
  <Tags>INPE granule</Tags>
  <Contact>atus@dgi.inpe.br</Contact>
  <Url type="application/atom+xml" template="{url}atom/granule?bbox={geo:box?}
  &searchTerms={searchTerms}&
  count={count?}&startIndex={startIndex?}&start={time:start}&end={time:end}"/>
  <Url type="application/json" template="{url}json/granule?bbox={geo:box?}
  &searchTerms={searchTerms}&
  count={count?}&startIndex={startIndex?}&start={time:start}&end={time:end}"/>
  <Query role="example" geo:box="-70,-50,-20,0" searchTerms="LANDSAT" time:start="2014-01-01"
  time:end="2014-04-01" count="10" startIndex="1" title="INPE Granule Search"/>
</OpenSearchDescription>
```





# CBERS 4A – equipment reuse



Sun-synchronous orbit

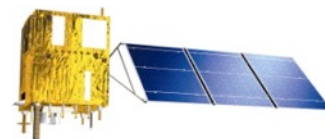
Altitude = 628 km

Inclination =  $97.89^\circ$

Repeat cycle = 31 days

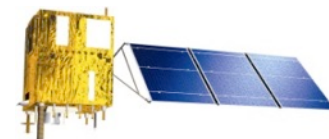
Descending node at 10h30 local time

**Launching: 2018**



# CBERS 4A – cameras

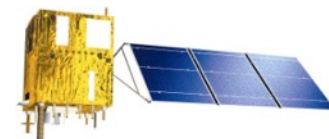
| Payloads     | MUX       | WPM           | WFI       |
|--------------|-----------|---------------|-----------|
| Manufacturer | Brazil    | China         | Brazil    |
| Type         | Pushbroom | Pushbroom TDI | Pushbroom |
| Revisit time | 31 days   | 31 days       | 5 days    |
| Quantization | 8 bits    | 10 bits       | 10 bits   |
| Swath width  | 95 km     | 92 km         | 684 km    |





# CBERS 4A – cameras

| Payloads     | MUX                       | WPM                       | WFI                       |
|--------------|---------------------------|---------------------------|---------------------------|
| Band 1       | 0.45 - 0.52 $\mu\text{m}$ | 0.45 - 0.52 $\mu\text{m}$ | 0.45 - 0.52 $\mu\text{m}$ |
| Band 2       | 0.52 - 0.59 $\mu\text{m}$ | 0.52 - 0.59 $\mu\text{m}$ | 0.52 - 0.59 $\mu\text{m}$ |
| Band 3       | 0.63 - 0.69 $\mu\text{m}$ | 0.63 - 0.69 $\mu\text{m}$ | 0.63 - 0.69 $\mu\text{m}$ |
| Band 4       | 0.77 - 0.89 $\mu\text{m}$ | 0.77 - 0.89 $\mu\text{m}$ | 0.77 - 0.89 $\mu\text{m}$ |
| Band 5 (PAN) |                           | 0.45 - 0.90 $\mu\text{m}$ |                           |
| Resolution   | 16 m                      | 2 m, 8 m                  | 55 m                      |





MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES  
**INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS**



lubia.vinhas@inpe.br

**OBRIGADO. GRAZIE.**