Geometric Quality Assessment of CBERS-1 Images

Julio d'Alge Ricardo Cartaxo Guaraci Erthal

XI SBSR

Summary

- CBERS-1 WRS
  - Satellite orbit control
- System corrected images
  - What to expect of such images?
  - Internal error ... attitude data
  - Positioning error ... ephemerides
- Geometric quality of CBERS-1 images

CBERS-1 WRS

- Geographic position of scene center
  - WRS 158/124 ... real - nominal
    - 04/15/00: 14km (N), 8km (W)
    - 08/22/01: 11km (N), 16km (W)
    - 09/17/01: 14km (N), 26km (W)
    - 11/07/02: 14km (N), 10km (W)
    - 12/29/02: 13km (N), 18km (W)
  - Variation along east-west direction
  - Possible problems with orbit control

System corrected images

- Ephemerides
  - Satellite position and velocity on time t
- Attitude data and instrument
  - Viewing direction on time t
- Intersection with earth ellipsoid
  - Geographic coordinates of pixel acquired on time t
- Use of a cartographic projection

System corrected images

- Internal accuracy
  - Relative position of pixels with respect to a cartographic projection
  - Mean error of 1.5 pixel (TM-LANDSAT)
  - Adequate use of attitude data
- A good internal accuracy allows users to easily integrate images and maps

System corrected images

- Positioning accuracy
  - Global displacement of the image
  - Mean error of 1,500m (Landsat-5)
  - Mean error < 100m (Landsat-7)
  - Adequate use of ephemerides
- The positioning accuracy defines how far an image is from its true position

Assessment procedure

- CBERS-1 CCD, IRMSS, and WFI system corrected images were imported to a SPRING database
  - CCD, 158/124, GeoTiff, UTM/WGS84
    - 5 scenes
  - IRMSS, 158/124, GeoTiff, UTM/WGS84
    - 4 scenes
  - WFI, 158/124, GeoTiff, Lambert/WGS84
    - 2 scenes

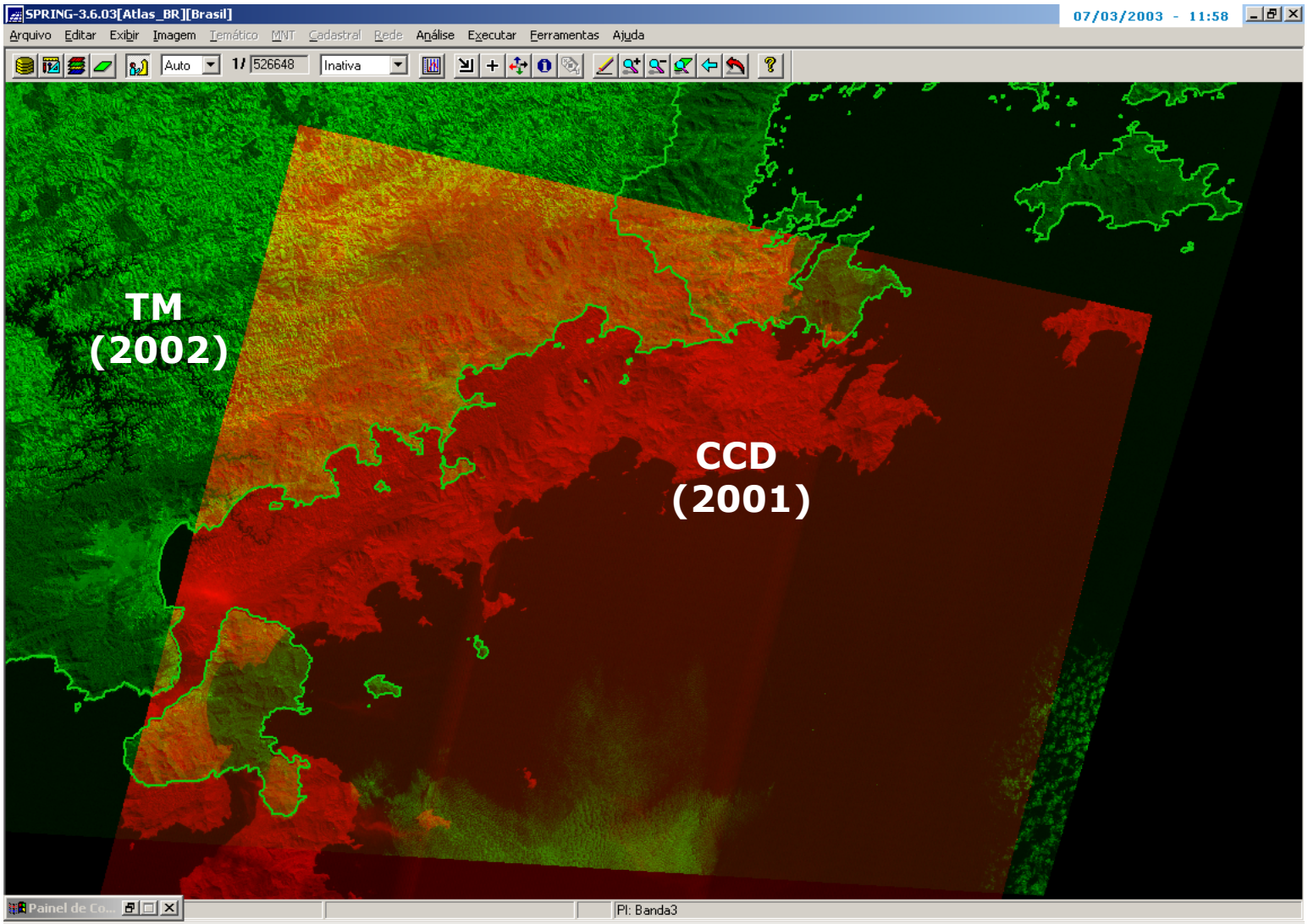
Assessment procedure

- NASA (ESAD) ETM LANDSAT-7 orthorectified images were imported to the same SPRING database
  - GeoTiff converted from MrSID
  - UTM, WGS84
- CBERS-1 and LANDSAT images were remapped to a common reference system
  - Lambert Conformal Conic, WGS84

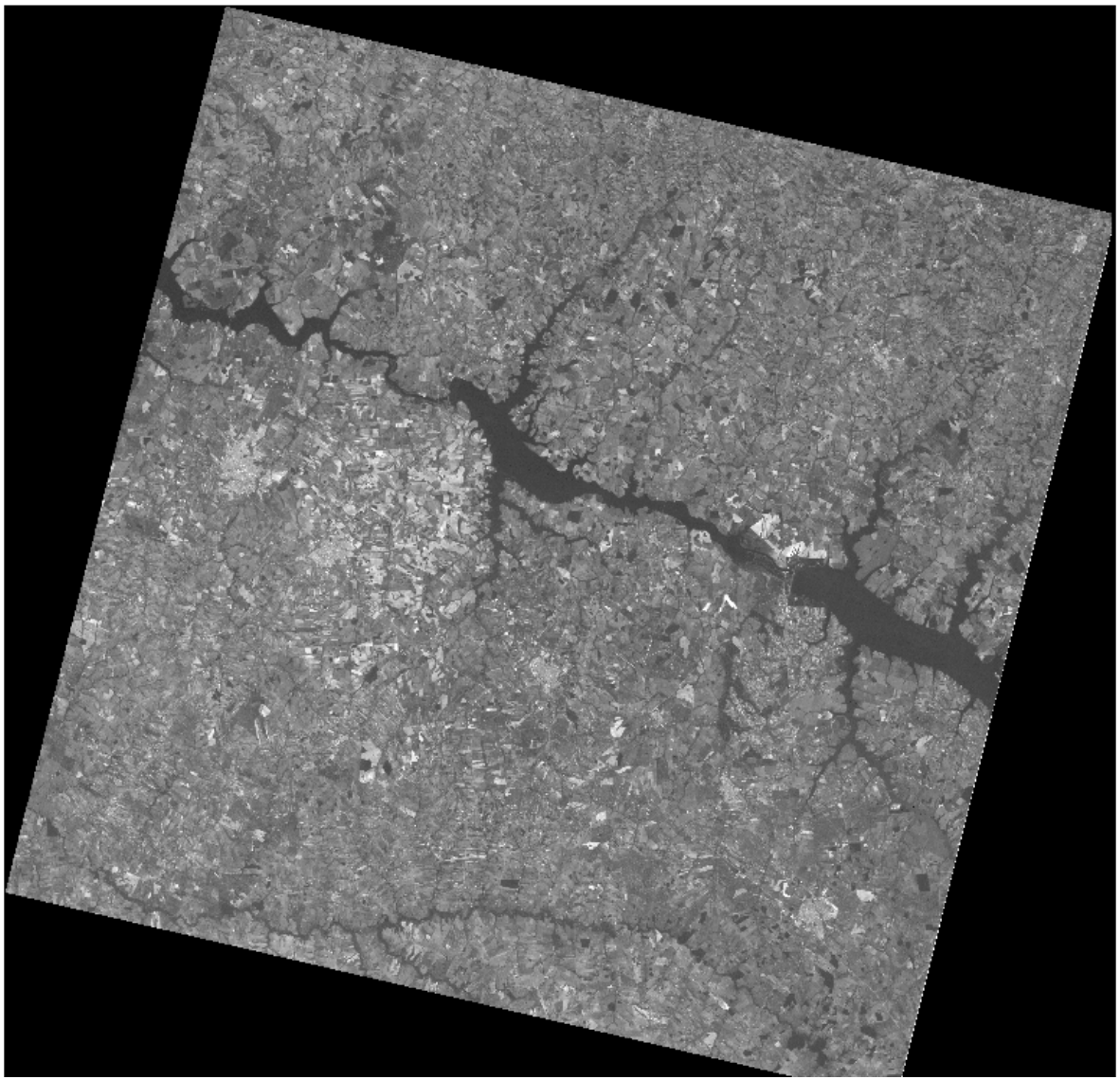
Assessment procedure

- Measurement of control points
  - Projection coordinates on both CBERS-1 and LANDSAT images
  - 16 control points for CCD, 6 for IRMSS, and 10 for WFI
- Geometric transformations
  - Similarity and orthogonal-affine were used for the assessment
  - Affine was used for image registration

CBERS-1 CCD


SPRING-3.6.03[Atlas_BR][Brasil]
07/03/2003 - 11:58
Arquivo Editar Exibir Imagem Temático MNT Cadastral Rede Análise Executar Ferramentas Ajuda
Auto
526648
Inativa
TM
(2002)
CCD
(2001)
Painel de Co...
PI: Banda3

CBERS-1 CCD



CBERS-1 CCD

Similarity Transformation

```
S    = 0.999432
Teta = 0.357003 graus dec. (0.006231 rad.)
X0   = 13294.288204
Y0   = -7089.307451

x2 = 9.994e-01 * x1 + 6.227e-03 * y1 + 1.329e+04
y2 = -6.227e-03 * x1 + 9.994e-01 * y1 + -7.089e+03

*** RMSE    = 505.395511
*** RMSE[x] = 361.706484
*** RMSE[y] = 352.977395
*** RMSE(sel) = 505.395511
```

CBERS-1 CCD

Orthogonal-affine transformation

```
Sx   = 0.995199
Sy   = 1.004094
Teta = 0.359178 gr. (0.006269 rd.)
X0   = 15151.611907
Y0   = 3939.009167

x2 = 9.952e-01 * x1 + 6.294e-03 * y1 + 1.515e+04
y2 = -6.239e-03 * x1 + 1.004e+00 * y1 + 3.939e+03


*** RMSE(sel) = 462.600777
```

CBERS-1 CCD

Affine transformation

```
a1 = 0.995305
a2 = -0.004199
a3 = -9713.061037
b1 = -0.015853
b2 = 1.004328
b3 = 8395.939926

x2 = 9.953e-01 * x1 + -4.199e-03 * y1 + -9.713e+03
y2 = -1.585e-02 * x1 + 1.004e+00 * y1 + 8.396e+03

*** RMSE    = 48.367885
*** RMSE[x] = 44.637183
*** RMSE[y] = 18.627244
*** RMSE(sel) = 48.367885
```

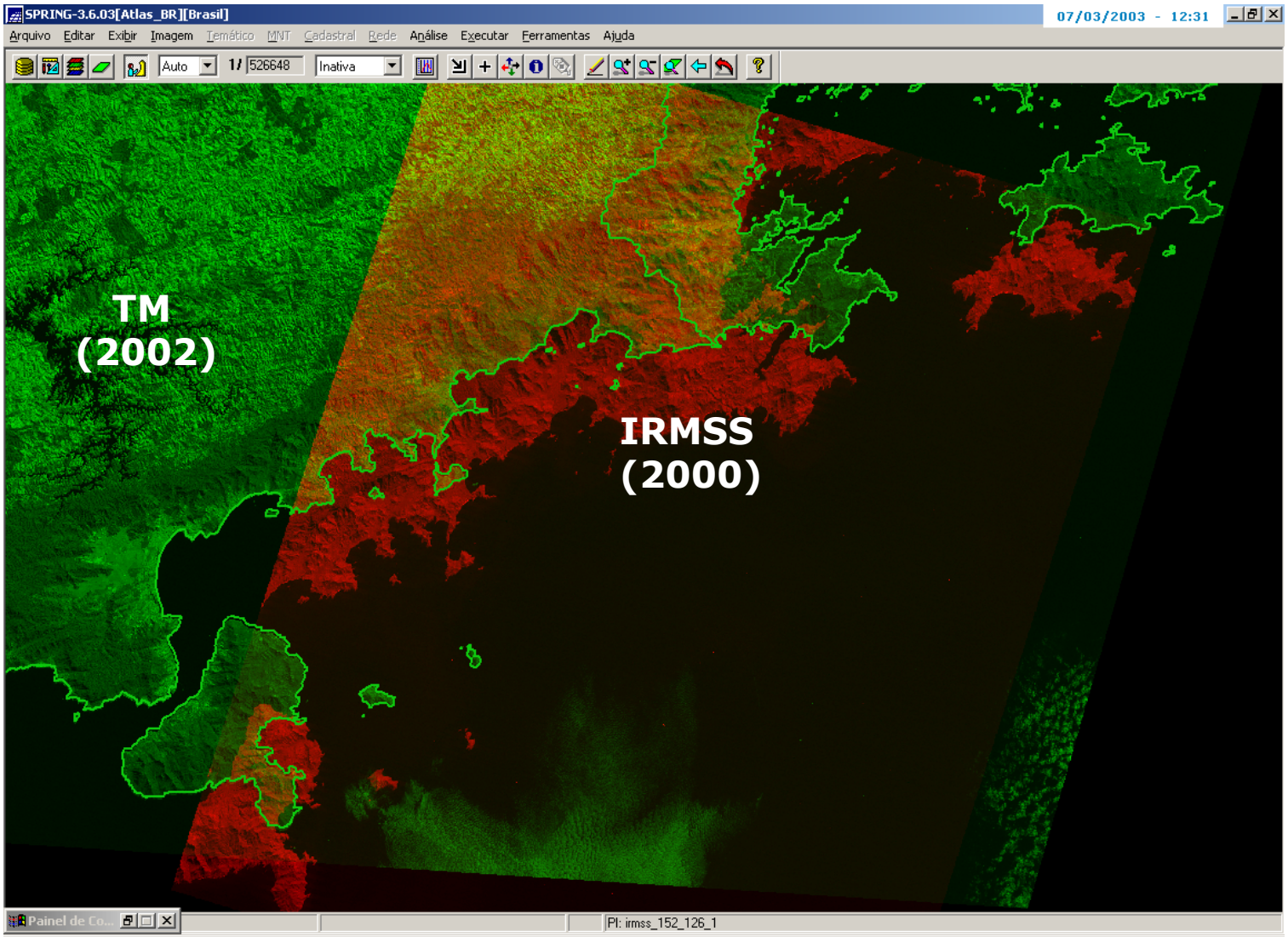
CBERS-1 CCD

- Positioning accuracy
  - North-south direction: 13km
  - East-west direction: 7km
- Internal accuracy
  - Use of a similarity transformation
    - Mean error of 505m, scale around 1
  - After using the affine transformation
    - Mean error of 48m
    - Shearing of 0.59^{o} detected

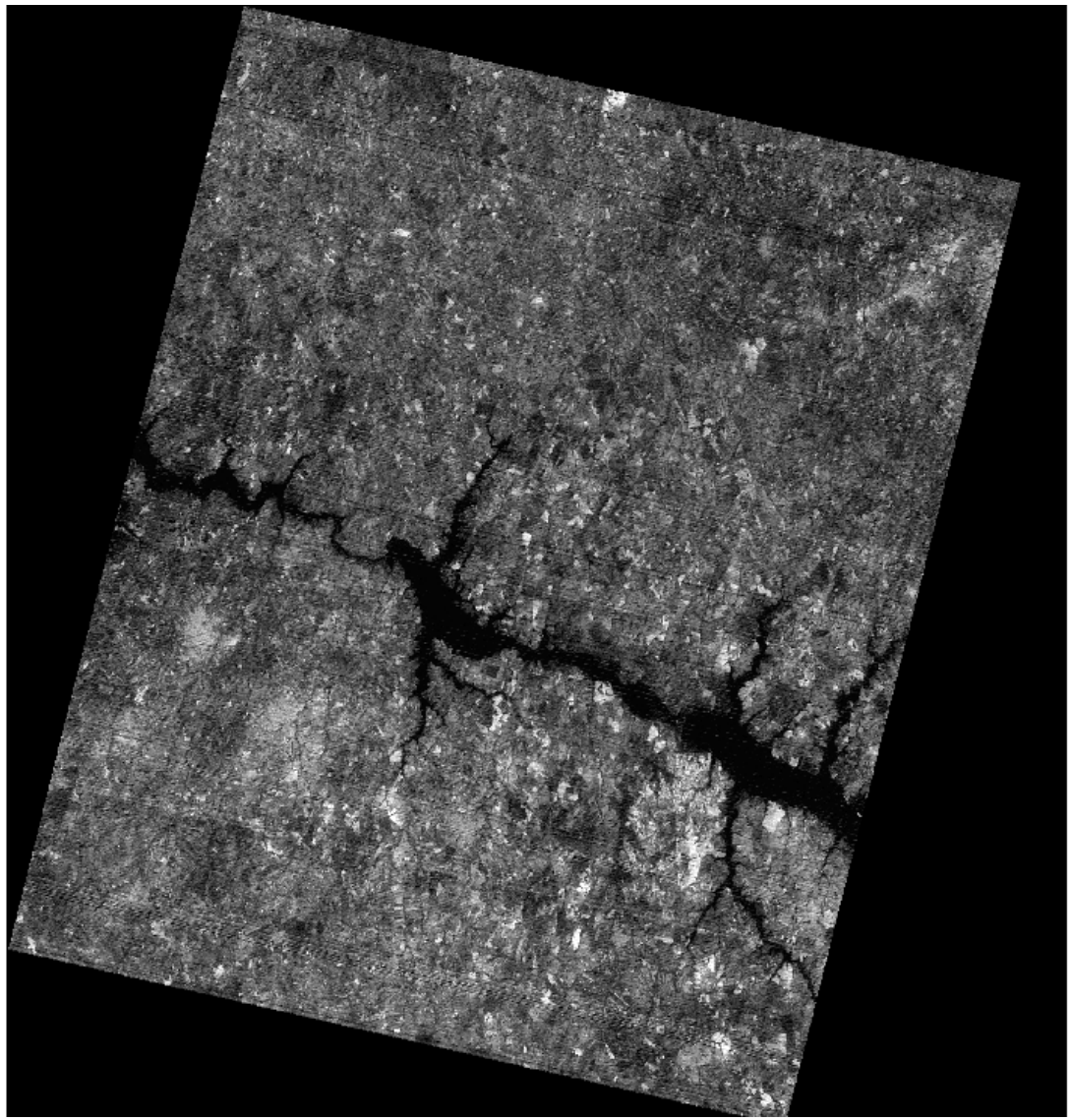
CBERS-1 CCD

- Conclusion
  - Poor internal accuracy, as the error is larger than 20 pixels
  - Shearing should have been modeled in the system correction procedure
    - Attitude data (yaw)?
    - Instrument mounting (boresight)?
  - Image registration is feasible, as indicated by the mean error of 48m after applying the affine transformation

CBERS-1 IRMSS



CBERS-1 IRMSS



CBERS-1 IRMSS

Similarity transformation

```
S    = 0.910867
Teta = 1.843105 graus dec. (0.032168 rad.)
X0   = 8764.043775
Y0   = -19624.340578

x2 = 9.104e-01 * x1 + 2.930e-02 * y1 + 8.764e+03
y2 = -2.930e-02 * x1 + 9.104e-01 * y1 + -1.962e+04

*** RMSE     = 2618.713604
*** RMSE[x] = 1507.074026
*** RMSE[y] = 2141.585586
*** RMSE(sel) = 2618.713604
```

CBERS-1 IRMSS

Orthogonal-affine transformation

```
Sx   = 0.852189
Sy   = 0.983378
Teta = 0.047503 gr. (0.000829 rd.)
X0   = 4490.172462
Y0   = -36721.327883

x2 = 8.522e-01 * x1 + 8.153e-04 * y1 + 4.490e+03
y2 = -7.065e-04 * x1 + 9.834e-01 * y1 + -3.672e+04


*** RMSE(sel) = 845.593702
```

CBERS-1 IRMSS

Affine transformation

```
a1 = 0.861028
a2 = 0.022486
a3 = 9212.415386
b1 = 0.019237
b2 = 0.993540
b3 = -21127.882038

x2 = 8.610e-01 * x1 + 2.249e-02 * y1 + 9.212e+03
y2 = 1.924e-02 * x1 + 9.935e-01 * y1 + -2.113e+04

*** RMSE     = 325.840052
*** RMSE[x] = 286.819432
*** RMSE[y] = 154.616794
*** RMSE(sel) = 325.840052
```

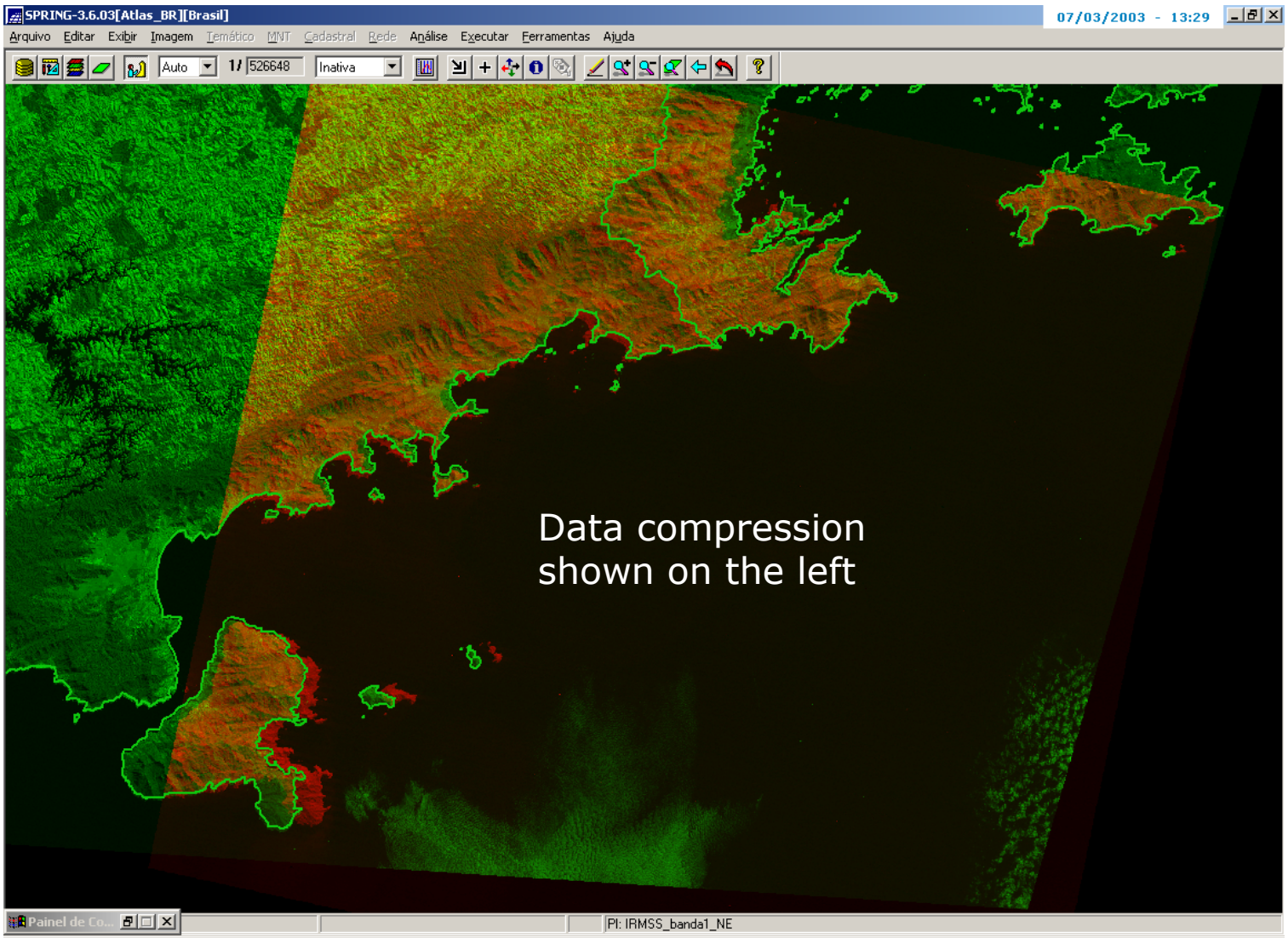
CBERS-1 IRMSS

- Positioning accuracy
  - North-south direction: 9km
  - East-west direction: 19km
- Internal accuracy
  - Use of a similarity transformation
    - Mean error of 2,600m
    - S_X of 0.85 (east-west compression)
  - After using the affine transformation
    - Mean error of 325m

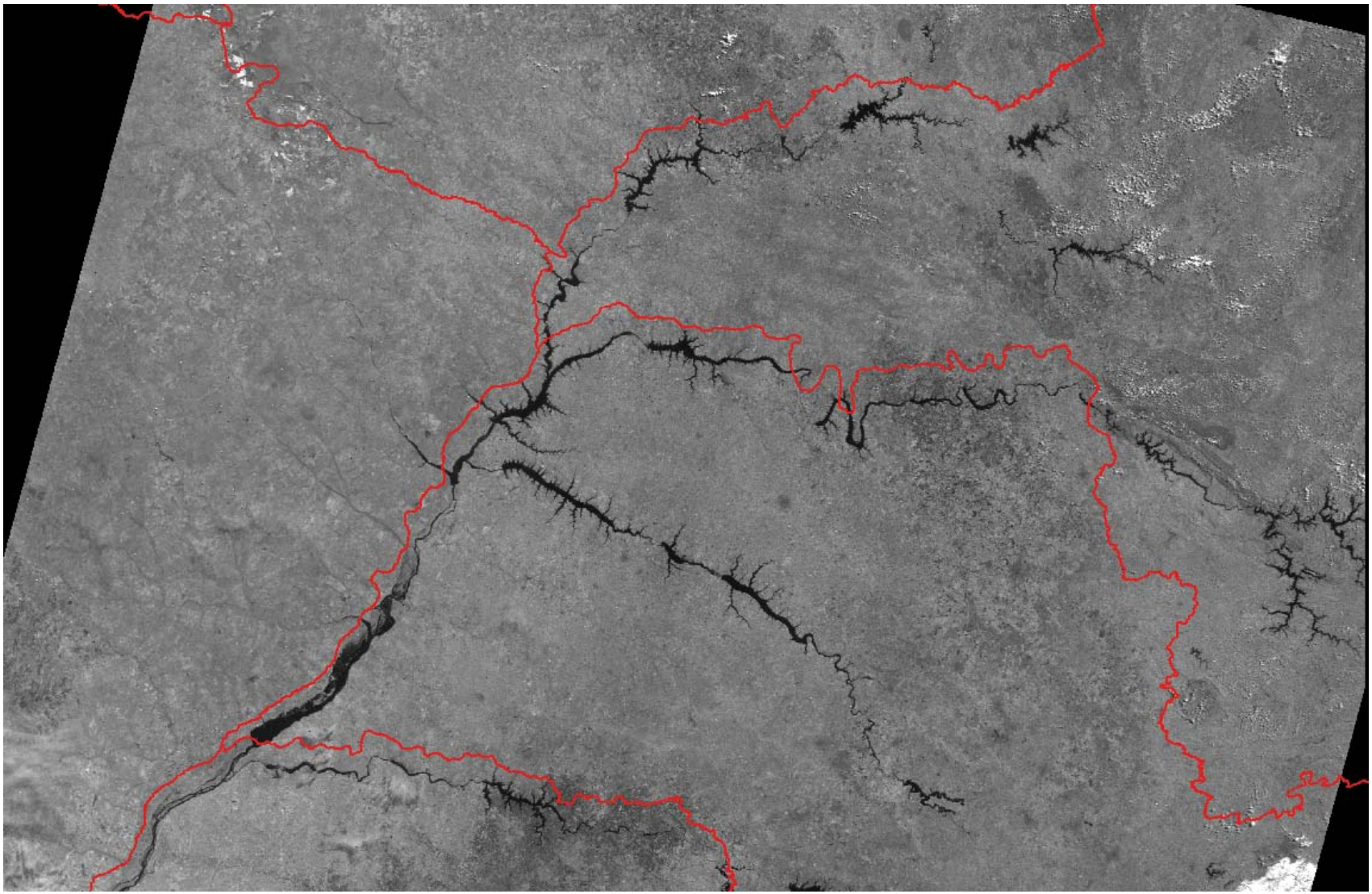
CBERS-1 IRMSS

- Conclusion
  - Poor internal accuracy, as the error is larger than 30 pixels
  - East-west compression should have been modeled in the system correction procedure
    - Incorrect modeling of mirror profile?
  - Image registration is not acceptable, as indicated by the mean error of 325m after applying the affine transformation

CBERS-1 IRMSS



CBERS-1 WFI



CBERS-1 WFI

Similarity transformation

```
S    = 0.995211
Teta = 0.886556 graus dec. (0.015473 rad.)
X0   = 4339.516875
Y0   = -25786.490685

x2 = 9.951e-01 * x1 + 1.540e-02 * y1 + 4.340e+03
y2 = -1.540e-02 * x1 + 9.951e-01 * y1 + -2.579e+04

*** RMSE    = 1139.969421
*** RMSE[x] = 926.823561
*** RMSE[y] = 663.723112
*** RMSE(sel) = 1139.969421
```

CBERS-1 WFI

Orthogonal-affine transformation

```
Sx   = 0.994046
Sy   = 0.998238
Teta = 0.913146 gr. (0.015937 rd.)
X0   = 4503.586407
Y0   = -18365.520637

x2 = 9.939e-01 * x1 + 1.591e-02 * y1 + 4.504e+03
y2 = -1.584e-02 * x1 + 9.981e-01 * y1 + -
1.837e+04


*** RMSE(sel) = 1078.535163
```

CBERS-1 WFI

Affine transformation

```
a1 = 0.994858
a2 = 0.009614
a3 = 29565.363304
b1 = -0.018294
b2 = 0.999193
b3 = -14896.382947

x2 = 9.949e-01 * x1 + 9.614e-03 * y1 + 2.957e+04
y2 = -1.829e-02 * x1 + 9.992e-01 * y1 + -1.490e+04

*** RMSE     = 755.516458
*** RMSE[x] = 680.065884
*** RMSE[y] = 329.113221
*** RMSE(sel) = 755.516458
```

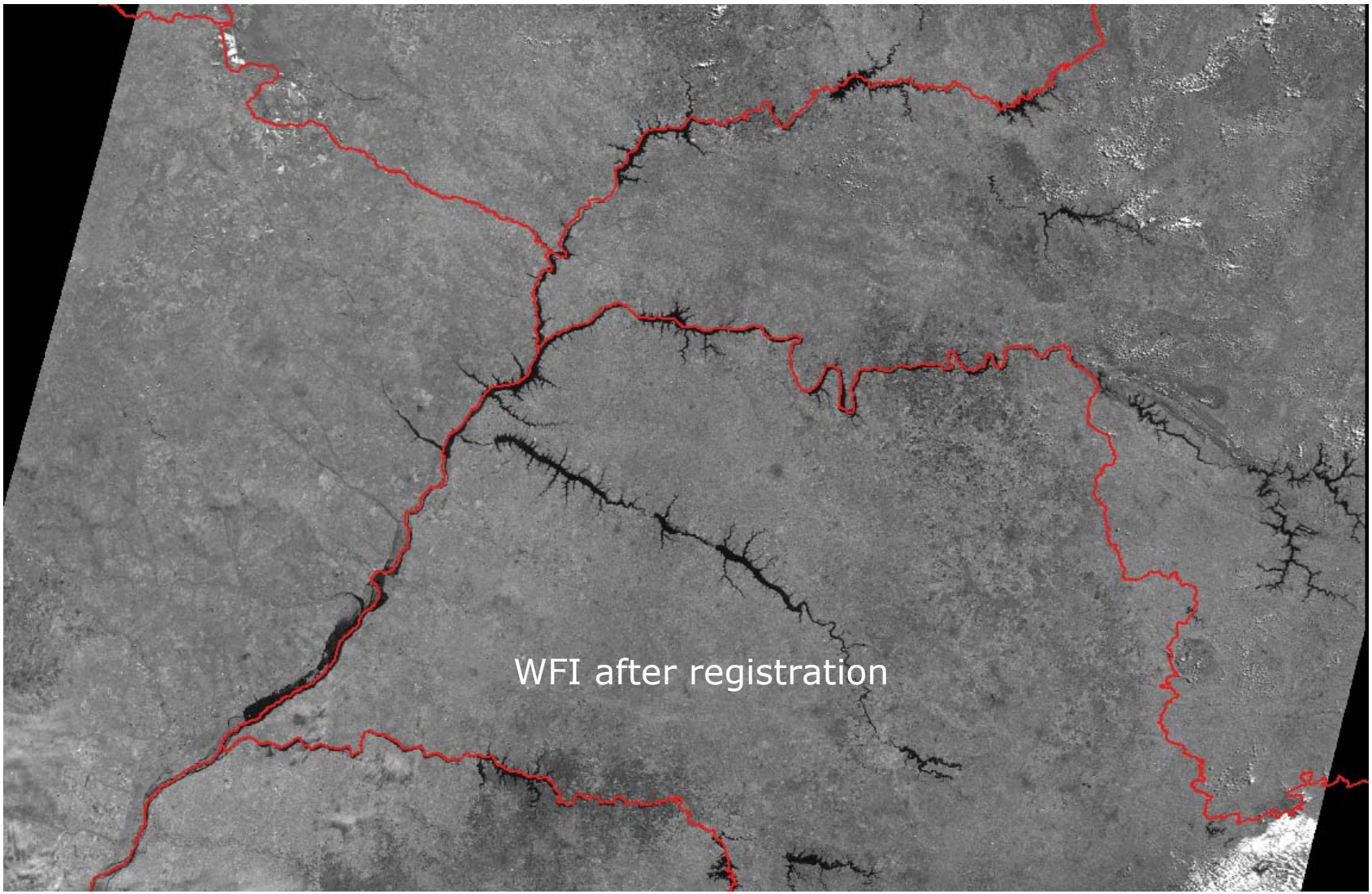
CBERS-1 WFI

- Positioning accuracy
  - North-south direction: 4km
  - East-west direction:26km
- Internal accuracy
  - Use of a similarity transformation
    - Mean error of 1,140m, scale around 1
    - Is the two-mirror instrument being correctly modeled?
  - After using an affine transformation
    - Mean error of 755m

CBERS-1 WFI

- Conclusion
  - Internal accuracy is not bad, as the error is less than 5 pixels
  - Geometric correction software should be carefully revised to account for a proper operation of the WFI two-mirror optical instrument
  - Image registration is feasible, as indicated by the mean error of 755m after applying the affine transformation

CBERS-1 WFI



Perspectives

- Develop local capabilities for remote sensing satellite ground stations
- Redesign software for the CBERS station ... GISPLAN project
- Establish a systematic evaluation methodology for use in the CBERS station