MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Enhancement of HRC and CCD images of the CBERS-2B Satellite

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Outline

- CBERS-2B Radiometric problems: residual stripes and blurring effect
- Radiometric correction and enhancement techniques to improve CBERS-2B image quality
- Case study for evaluating hybrid CBERS-2B images: mapping remaining forest

CBERS-2B

CCD (Multispectral)

B1: 0.45 – 0.52 μm; B2: 0.52 – 0.59 μm; B3: 0.63 – 0.69 μm
B4: 0.77 – 0.89 μm; B5: 0.51 – 0.73 μm
Swath: 117Km; Resolution: 20m

HRC (Panchromatic)

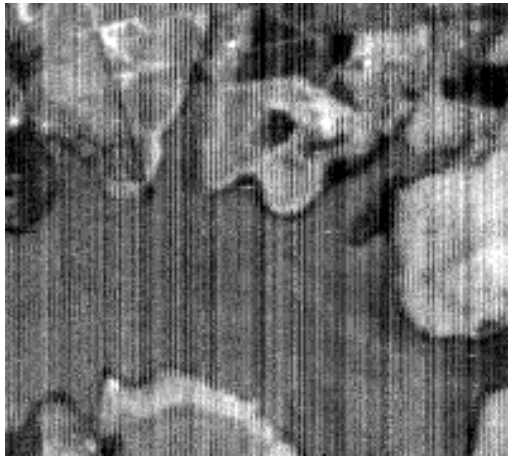
B6: 0.45 – 0.85 μm
Swath: 27Km; Resolution: 2.7 m

WFI

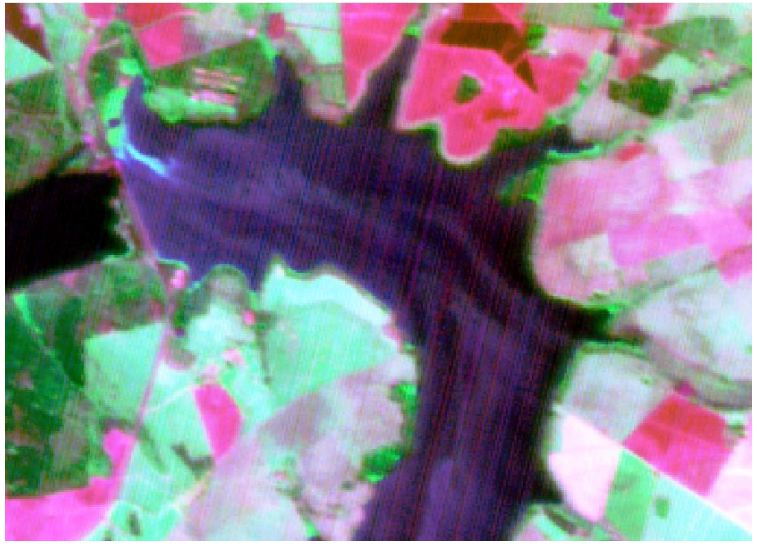
B7: 0.63 – 0.69 μm; B8: 0.77 – 0.89 μm
Swath: 890Km; Resolution: 260m

CBERS-2B CCD

- Relative calibration: residual stripes in the CCD images
  - instability of the CCD camera
- Blurring effect: CCD (band 4)
  - Defocus of the CCD camera



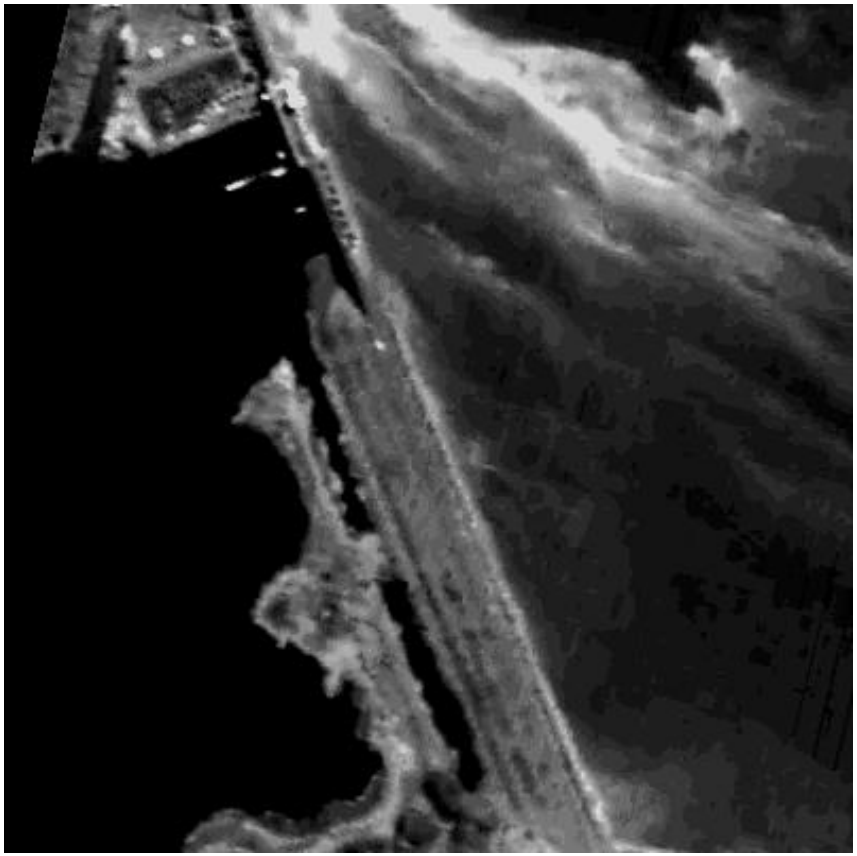
Band 1 (blue)



CBERS 2B CCD 3R4G2B (Level 2)

CBERS-2B HRC: blurring effect

lossy compression (1:8) and camera defocus



PRISM – ALOS (2.5 m)
08/22/2008

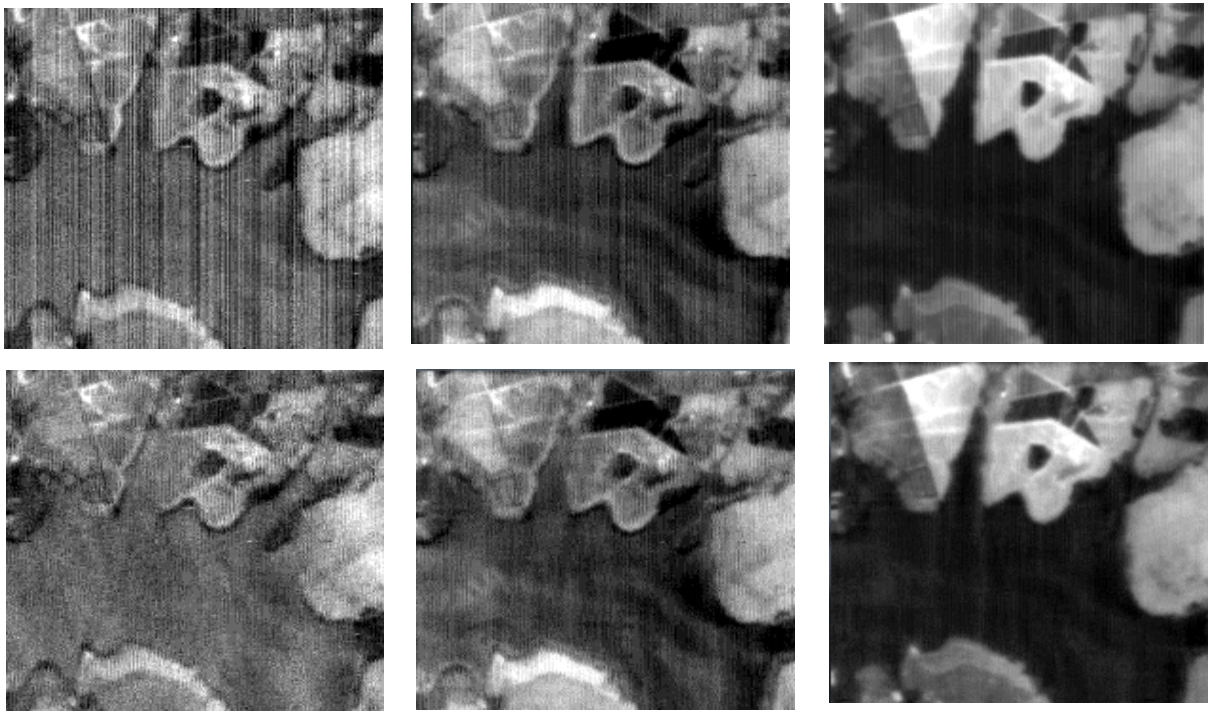
CBERS 2B – HRC (2.7 m)
04/11/2008

CCD: Striping correction

Median Filter

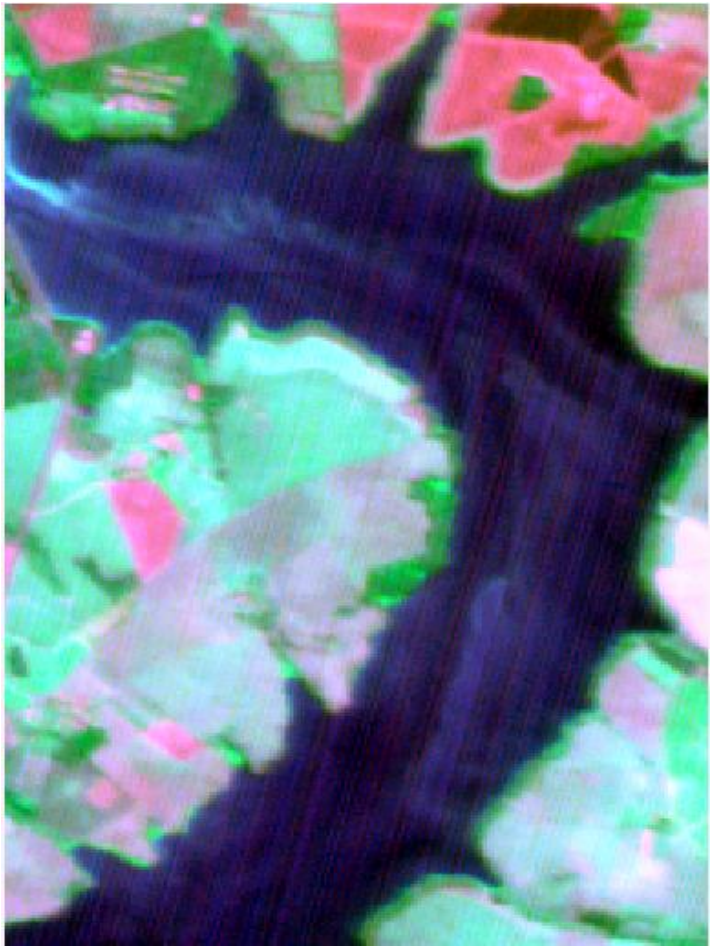
Moment Matching filter: Adjust Mean and Standard Deviation

Fourier filter: filter noise frequencies

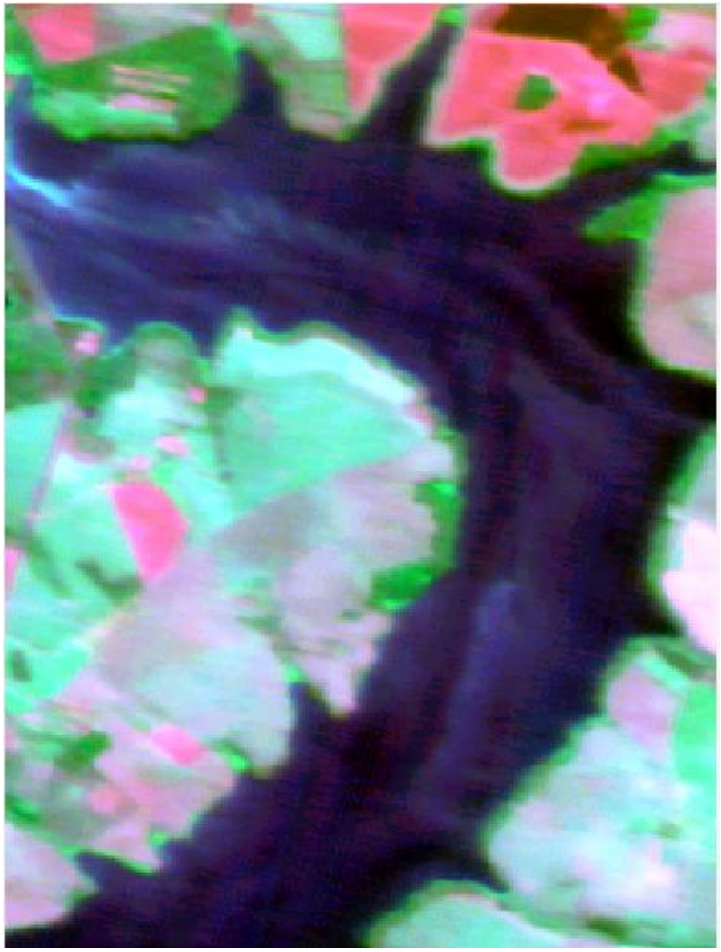


B1 B2 B3

Corrected CBERS-2B CCD



Original CCD (3R4G2B)



Corrected CCD (3R4G2B)

Restoration Methods

Richardson- Lucy Filter

$$f'_{i+1}(x,y) = f'_i(x,y)\left[h(x,y)^T * \frac{g(x,y)}{h(x,y) * f'_i(x,y)}\right]$$

Modified Inverse Filter

$$MIF(u) = \begin{cases} \frac{D(u)}{H(u)} & |u| \le u_c \\ 0 & Otherwise \end{cases} \qquad D(u) = \begin{cases} 0 & 0 \le u \le u_w \\ 0.5*(1+\cos\left[\frac{\pi(u-u_w)}{(u_c-u_w)}\right] & u_w \le u \le u_c \end{cases}$$

Bilateral Filter

$$BLF(g)_p = \frac{1}{k_p}\sum_q G_{\sigma_s}(\|p-q\|)G_{\sigma_r}(\|g_p - g_q\|)g_q \qquad (1)$$

$$k_p = \sum_q G_{\sigma_s}(\|p-q\|)G_{\sigma_r}(\|g_p - g_q\|) \qquad (2)$$

g image; p and q indicate spatial locations of pixel; Gσs and Gσr are gaussian functions, σs determines the spatial support and σr controls the sensitivity to edges.

References:

TOMASI, C., AND MANDUCHI, R. 1998. Bilateral filtering for gray and color images. In Proc. ICCV '98, IEEE Computer Society, 839–846.

L.M.G. Fonseca, G.S.S.D. Prasad, N.D.A. Mascarenhas, "Combined Interpolation-Restoration of Landsat Images Through a FIR Filter Design Technique", International Journal of Remote Sensing, vol. 14, no.13, pp. 2547-2561. 1993

W. H Richardson, Bayesian-based iterative method of image restoration. Journal of the Optical Society of America, v. 62, no. 1, p. 55–59, 1972.

HRC: Restoration

HRC

Restored HRC

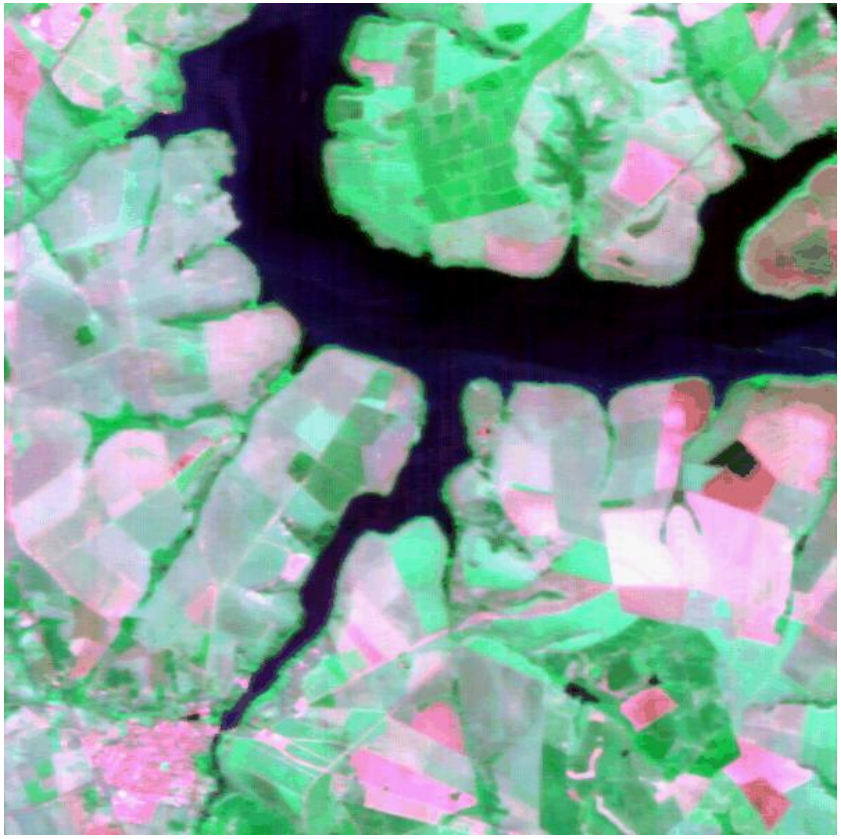
HRC: Restoration

HRC

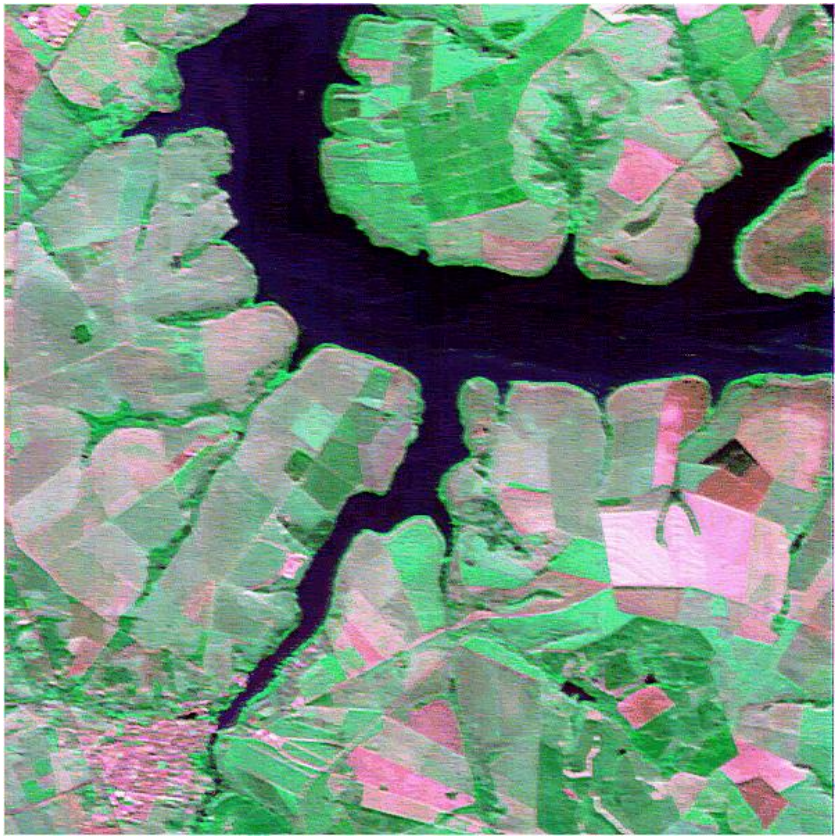
Restored HRC

Enhancement: Bilateral Filter

A parameter controls the level of enhancement



Original CCD (3R4G2B)



Filtered CCD (3R4G2B)

Case study: Monitoring of remaining forest in the Ibitinga reservoir, located at São Paulo-state- Brazil

Restored HRC

Restored CCD 3R4G2B

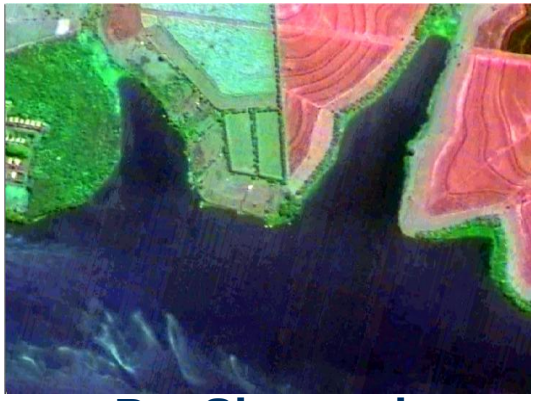
CBERS-2B Image Fusion

Restored CCD

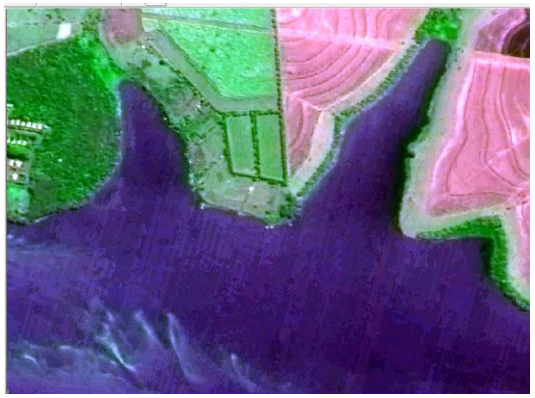
PanSharpening

PCA

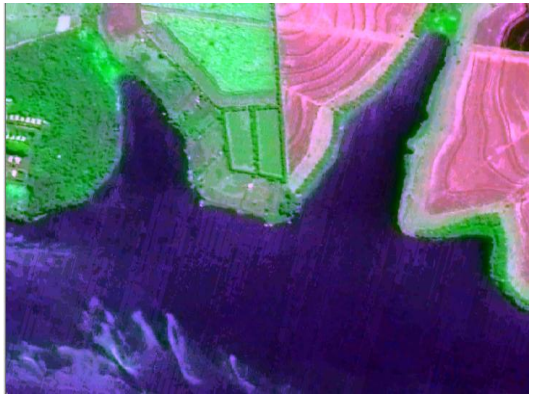
IHS



PanSharpening

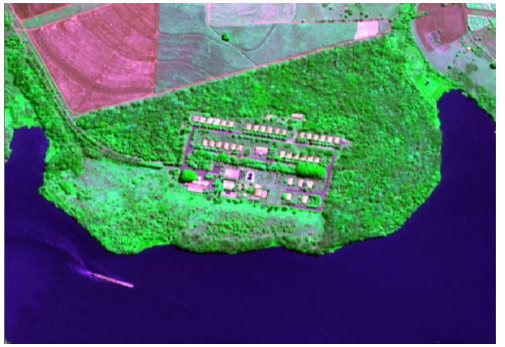


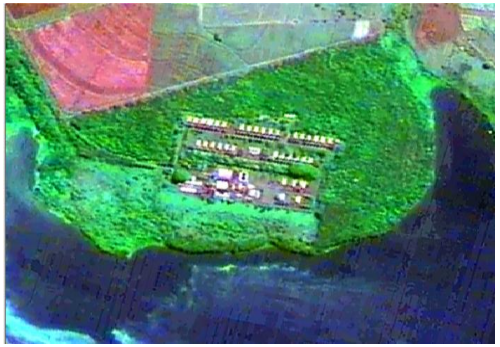
PCA



IHS

QuickBird x Hybrid CBERS-2B

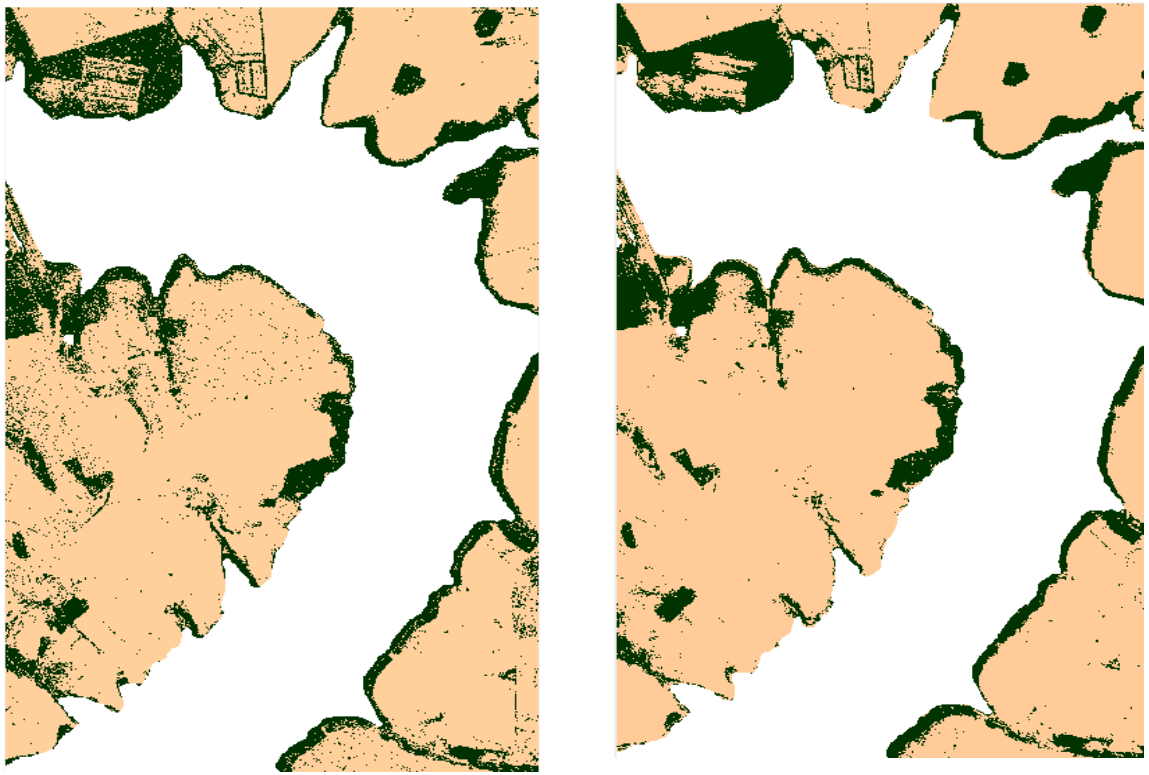




QuickBird (3G4B2): 08/22/2008
2.4 m

Fused CBERS 2B (R3G4B2): 09/01/2008
2.5 m

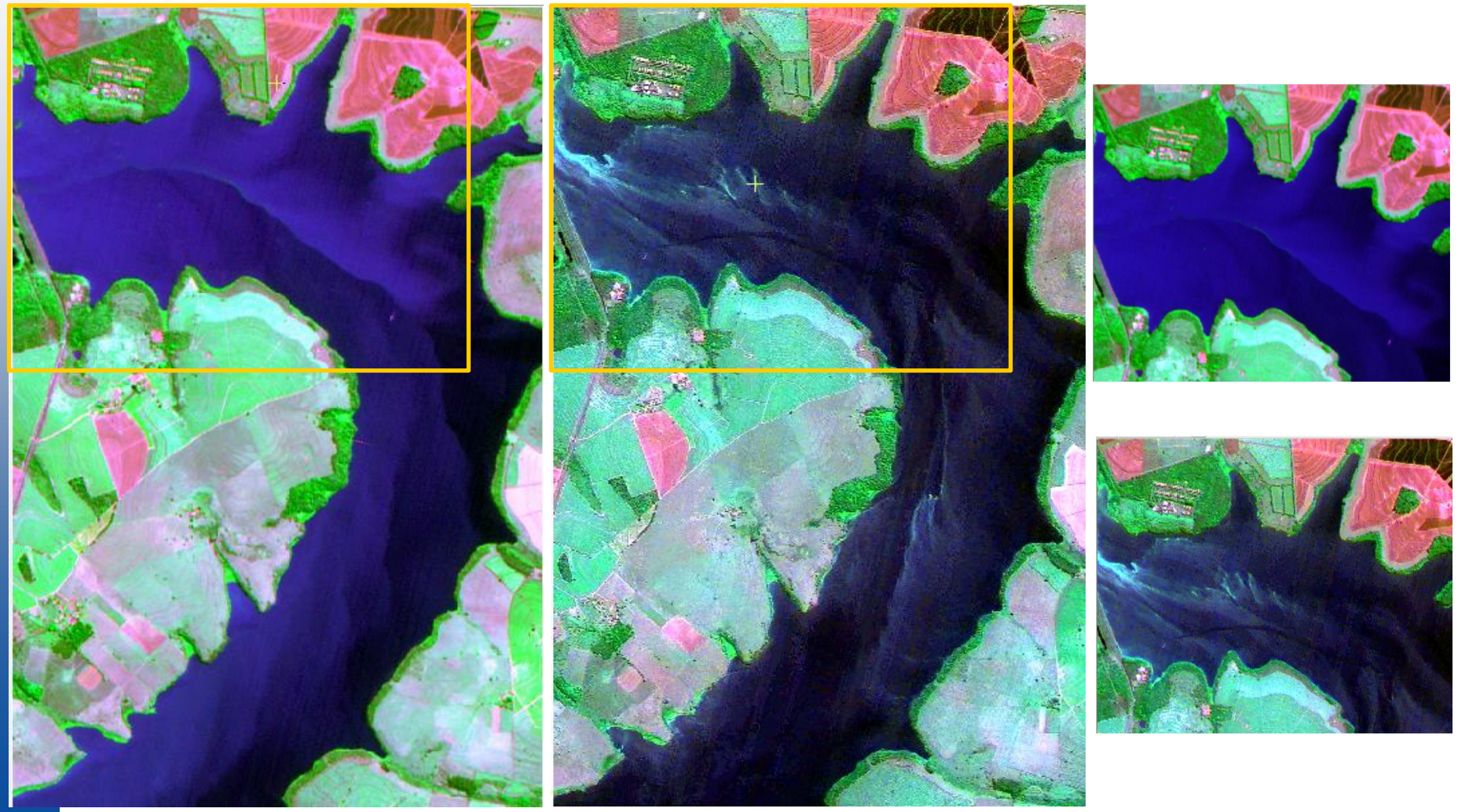
Thematic Maps: QB and hybrid CBERS-2B



Thematic Maps: a) image QB and (b) hybrid CBERS-2B image. Forest and non-forest are represented by green and beige colors, respectively.

Thematic map	Overall accuracy	Kappa
Hybrid CBERS-2B	0.93	0.83
QB	0.93	0.84

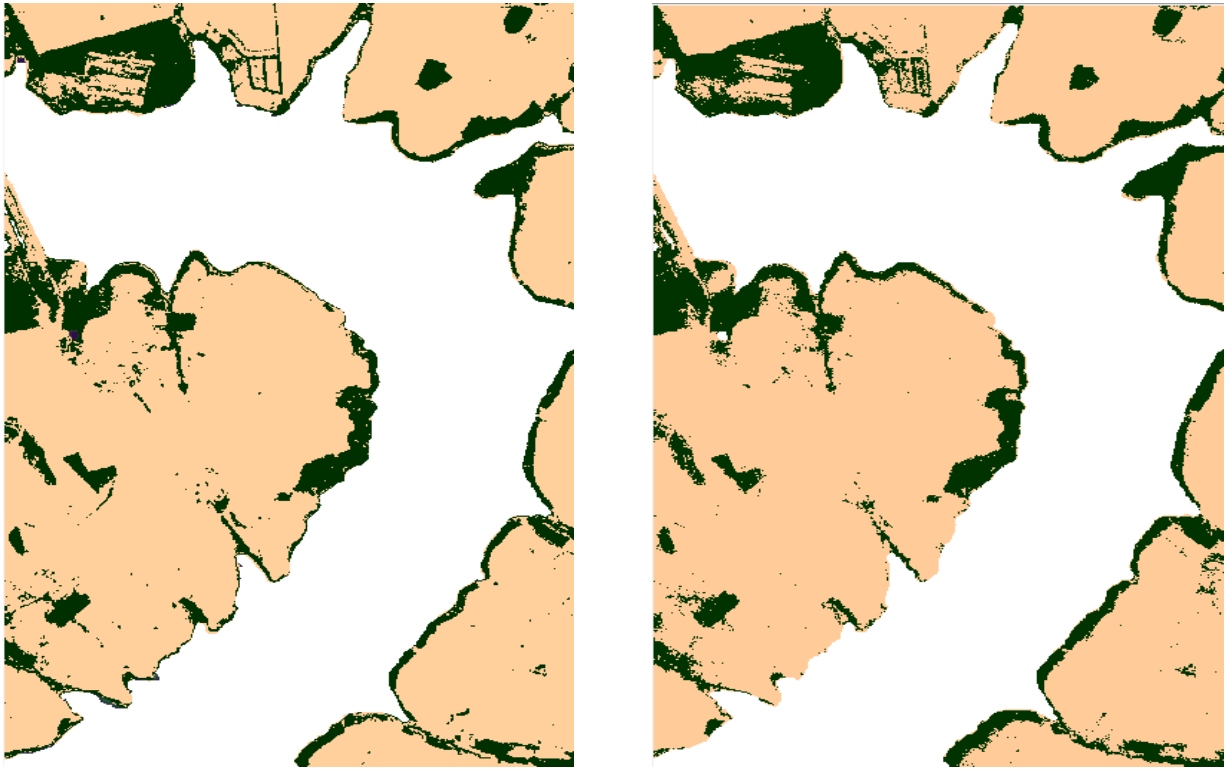
ALOS – AVNIR x Fused CBERS-2B



ALOS AVNIR 2 (R3G4B2)
10 m

Fused CBERS 2B (R3G4B2)
10 m

Thematic Maps: AVNIR-2 and hybrid CBERS-2B



Thematic Maps: a) image AVNIR-2 10 m and (b) hybrid image CBERS-2B, 10 m . Forest and non-forest are represented by green and beige colors, respectively.

Thematic map	Overall accuracy	Kappa
Hybrid CBERS-2B	0.91	0.79
AVNIR 2	0.92	0.81

Summary

- Pos processing striping characterization and correction is required for CBERS-2B
- After radiometric correction and fusion process, hybrid CBERS-2B images showed similar results compared to QB (2.5 m) and AVNIR-2 (10 m) for mapping remaining forest
- It is expected that radiometric problems present in CBERS-2B be solved in the satellite CBERS-3
- Automatic registration of HRC and CCD images is necessary to operationally produce fused products in the CBERS Image Processing station

Enhancement of HRC and CCD images of the CBERS-2B Satellite

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Thanks!

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