SPECTRAL MIXTURE ANALYSIS OF AMAZON FLOODPLAIN WATER SURFACE REFLECTANCE USING HYPERION/EO-1 FOR THE COMPREHENSION OF TEMPORAL VARIABILITY OF WATER COMPOSITON

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Brazilian National Space Research Institute (INPE)

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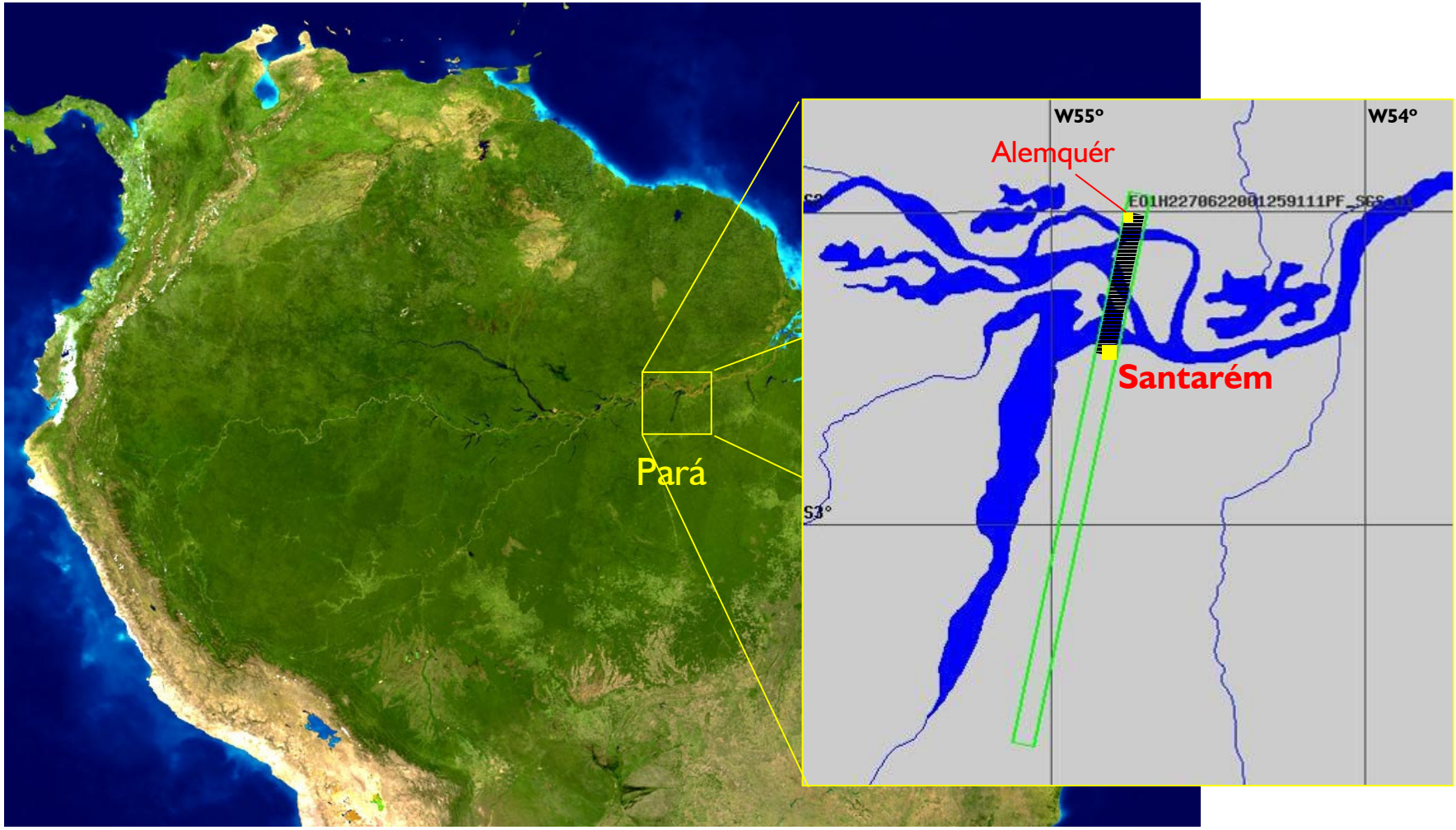
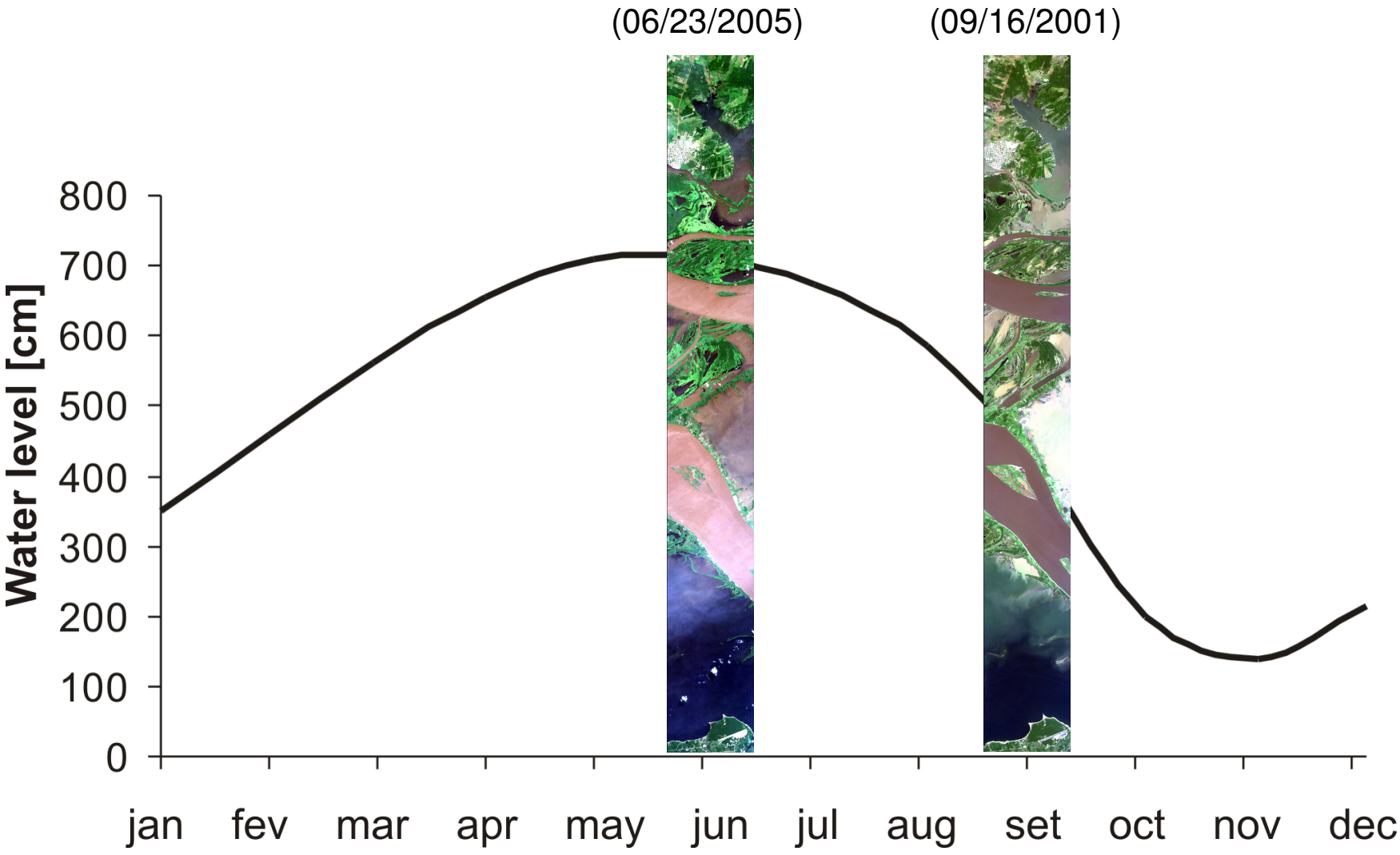
Site location and description

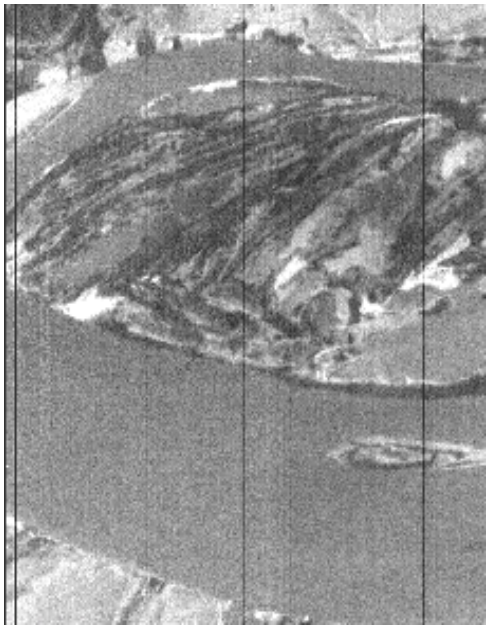


Hyperion data



Pre-processing

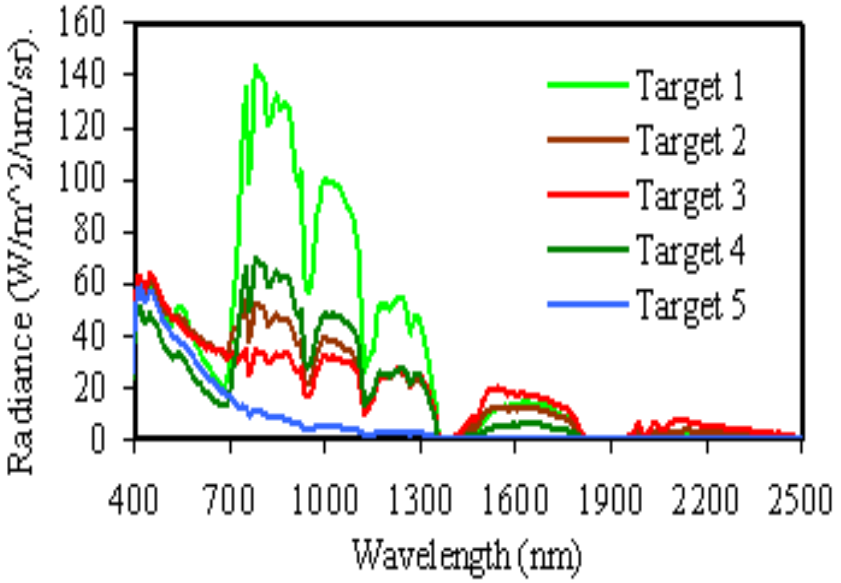
- Destriping to remove anomalous pixels

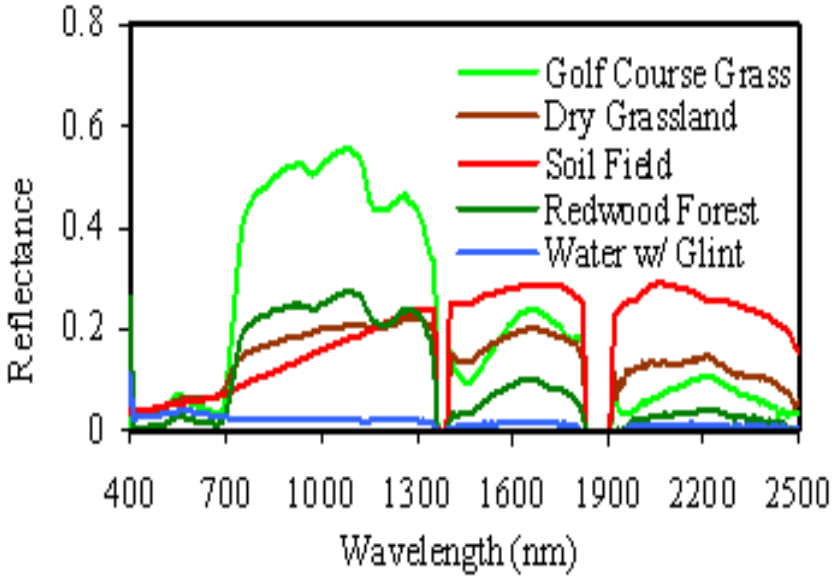


Band 10 (447 nm)

Pre-processing

Atmospheric CORrection Now (ACORN)
MODTRAN4 technology



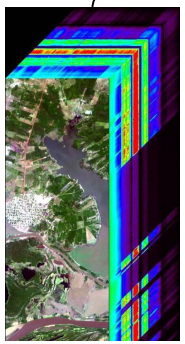


Pre-processing

- spectral subset
  - (457-885nm)
- masking to remove land targets
  - 2300 nm reflectance limiar (< 1%)

RGB
29 (640 nm)
20 (549 nm)
11 (457 nm)

HYPERSPECTRAL IMAGE ANALYSIS



Hyperespectral image (surface reflectance)

Minimal Noise Fraction (MNF)

Purity Pixel Index (PPI)

n-D Visualization

ID

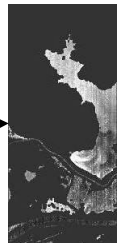
Spectral Mixture Analysis

Sub-pixel abundances

Clear-water

Dissolved organic matter

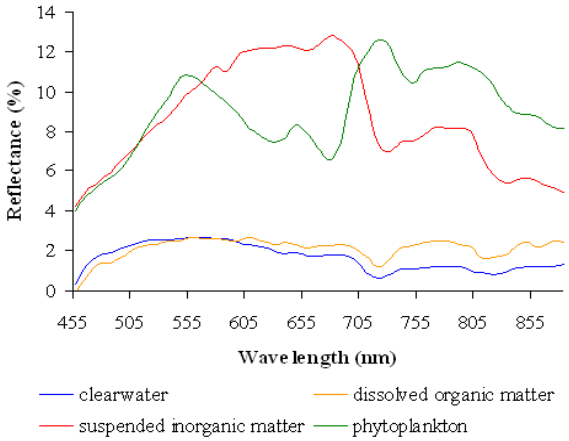
Suspended sediments



Phytoplankton

Semi-automated endmembers selection

Kruse et al. (2003)

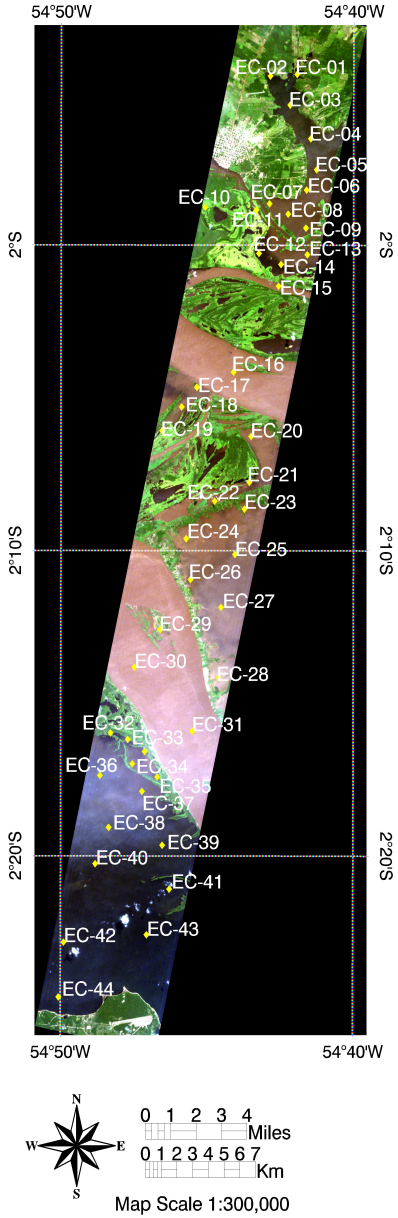


$$R_{pi} = \sum f_j r_{ij} + \varepsilon_i$$

Ground truth

Field campaing during the high water period (23-29/06/2005)

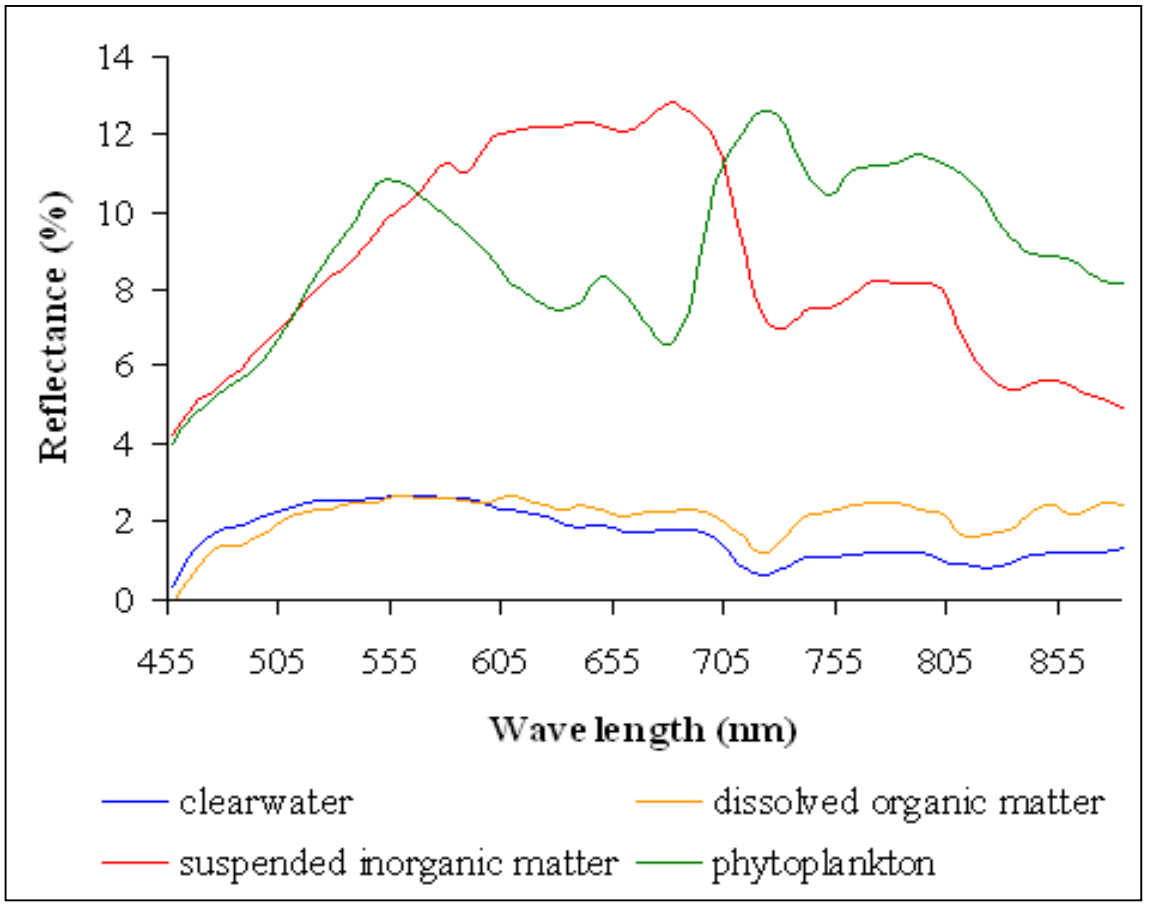
- Water samples:
  - Chlorophyll-*a* (Chl-*a*; µg/l);
  - Suspended Inorganic Matter (SIM; mg/l);
  - Dissolved Organic Carbon (DOC; ppm).



RESULTS

Selected endmembers

High Water



Decaying

Spectral mapping (High water period)

RGB
29 (640 nm)
20 (549 nm)
11 (457 nm)

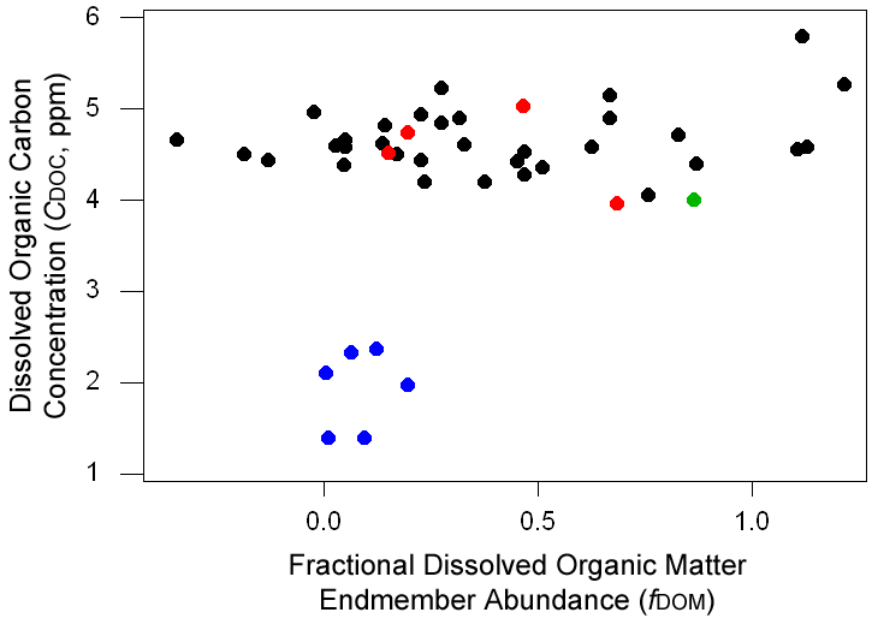
Clear-water

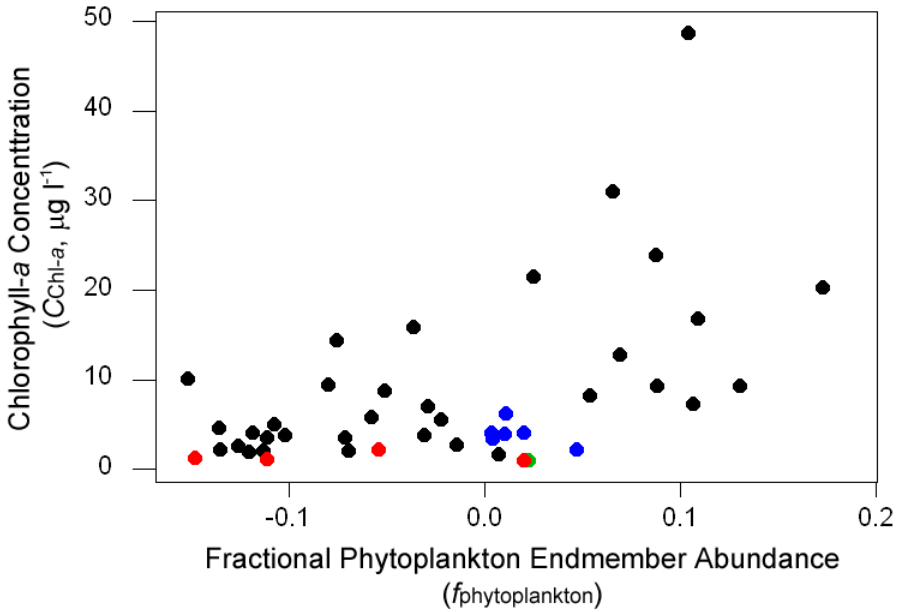
Dissolved Organic Matter

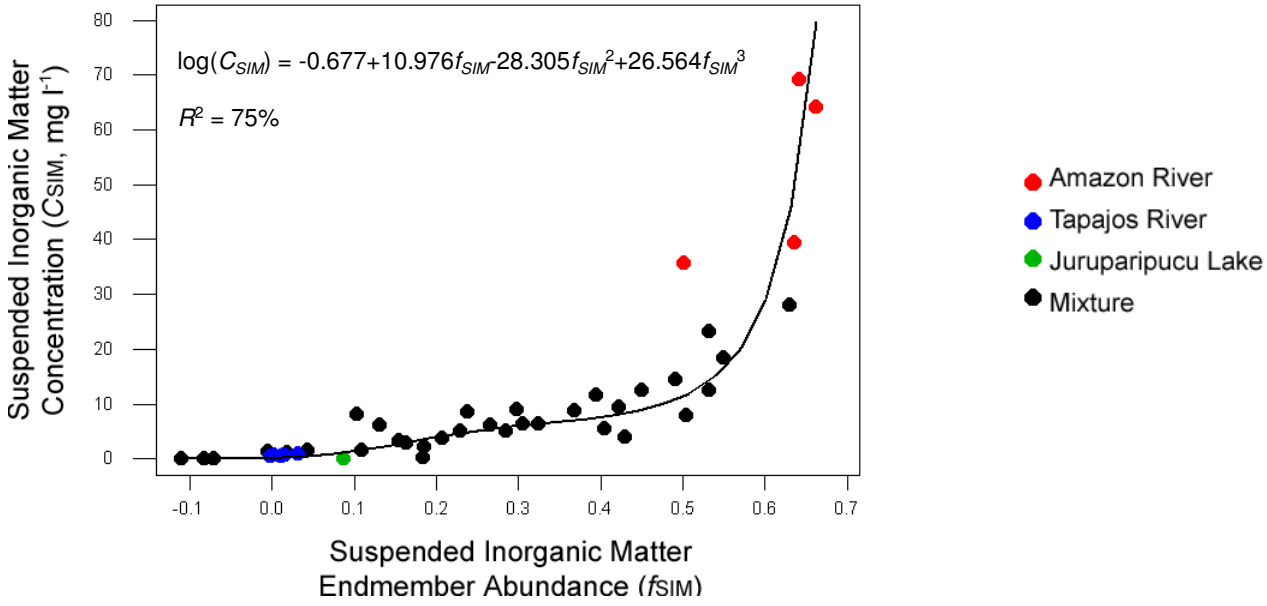
Suspended sediments

phytoplankton

RMS error


Dissolved Organic Carbon Concentration (C_{DOC}, ppm)
Fractional Dissolved Organic Matter Endmember Abundance (f_{DOM})

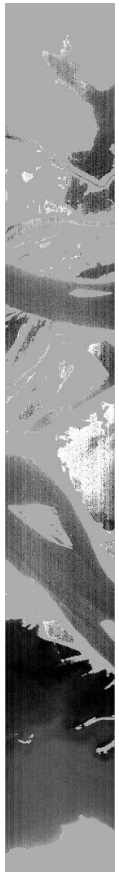

Chlorophyll-a Concenttration (C_{Chl-a}, µg l^{-1})
Fractional Phytoplankton Endmember Abundance ($f_{phytoplankton}$)


log(C_{SIM}) = -0.677+10.976f_{SIM}-28.305f_{SIM}^2+26.564f_{SIM}^3
R^2 = 75%
Suspended Inorganic Matter Concentration (C_{SIM}, mg l^{-1})
Suspended Inorganic Matter Endmember Abundance (f_{SIM})
Amazon River
Tapajos River
Juruparipucu Lake
Mixture

Spectral mapping (decaying period)

RGB
29 (640 nm)
20 (549 nm)
11 (457 nm)

Clear-water



Dissolved Organic Matter

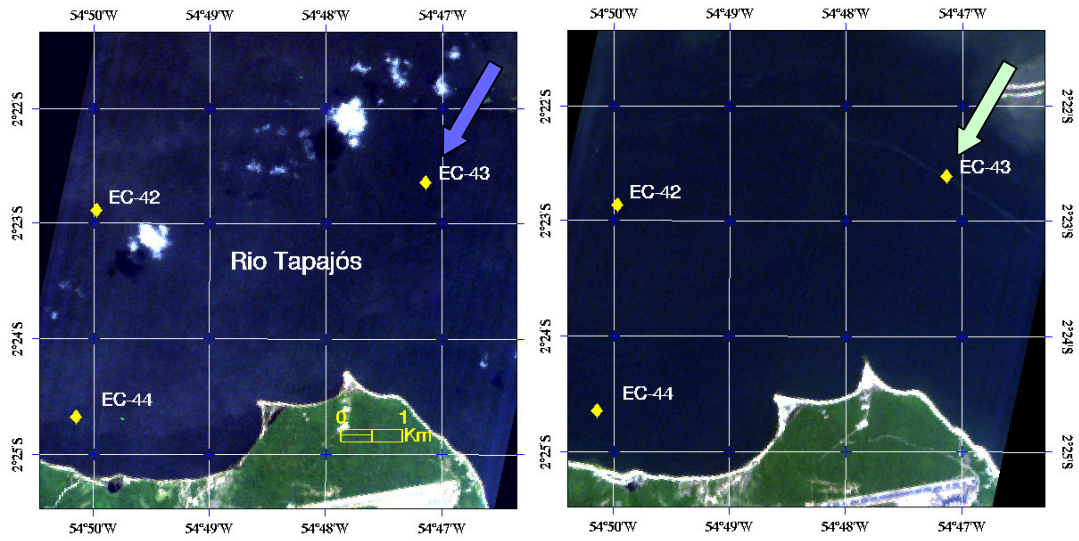
Suspended sediments

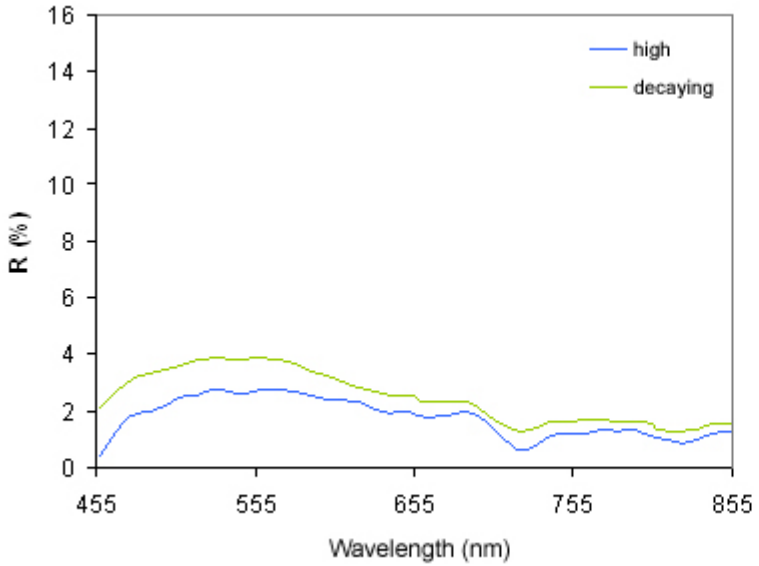
phytoplankton

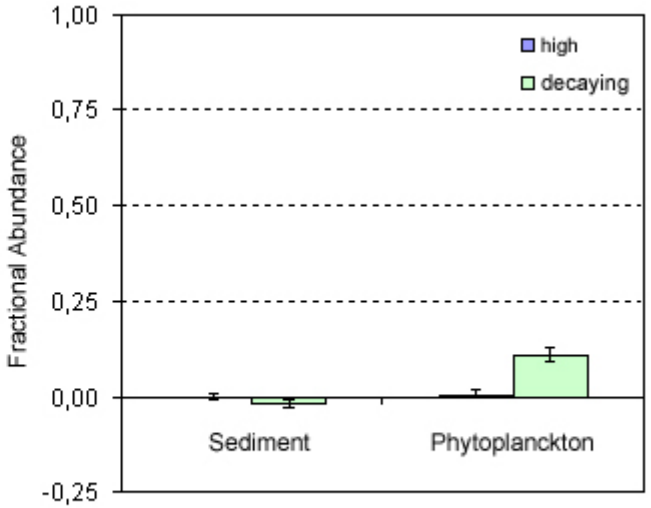
RMS error

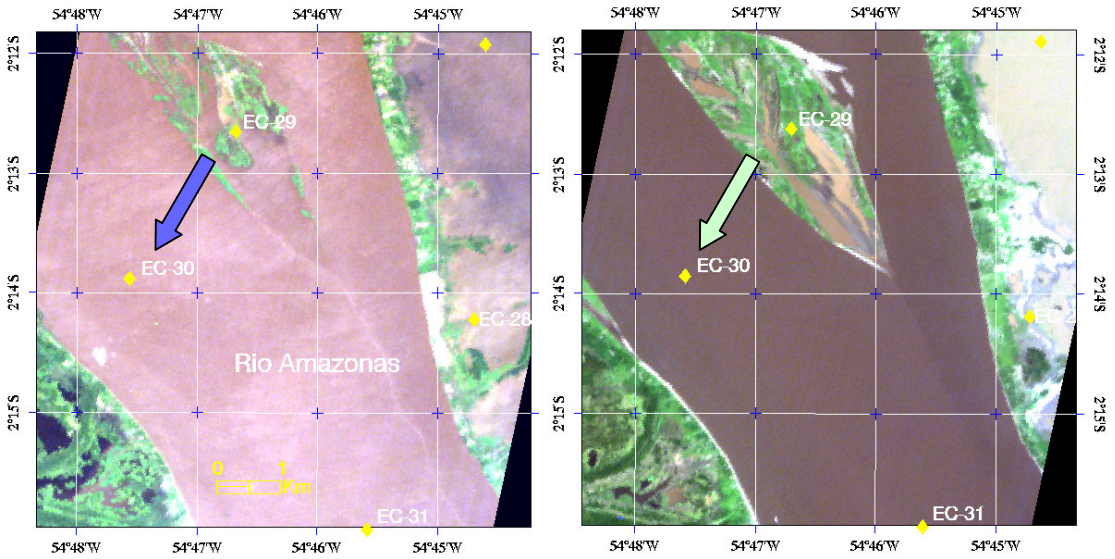
Temporal variability

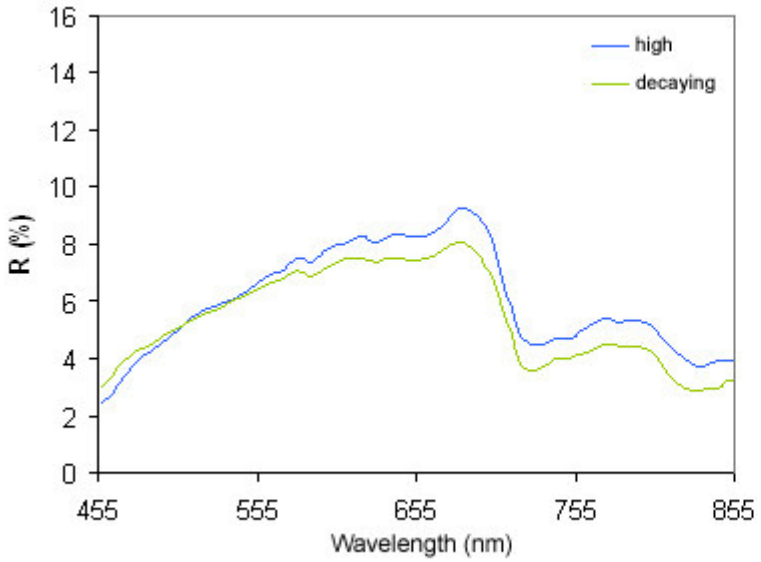
High water → decaying period

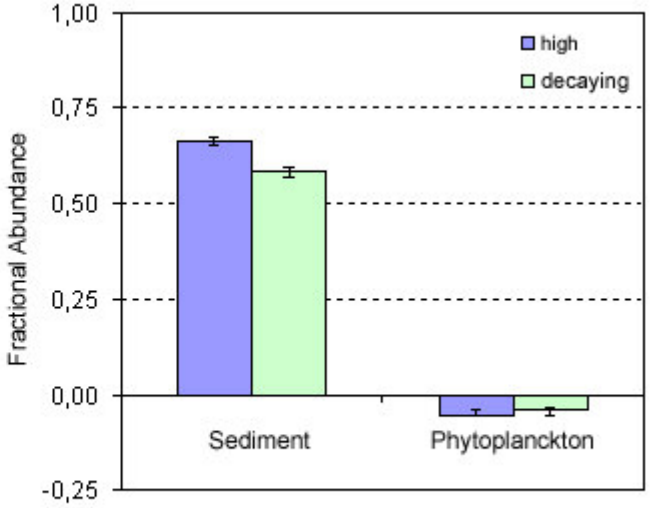

54°50'W
54°49'W
54°48'W
54°47'W
2°22'S
2°23'S
2°24'S
2°25'S
EC-42
EC-43
EC-44
Rio Tapajós
0
1
Km

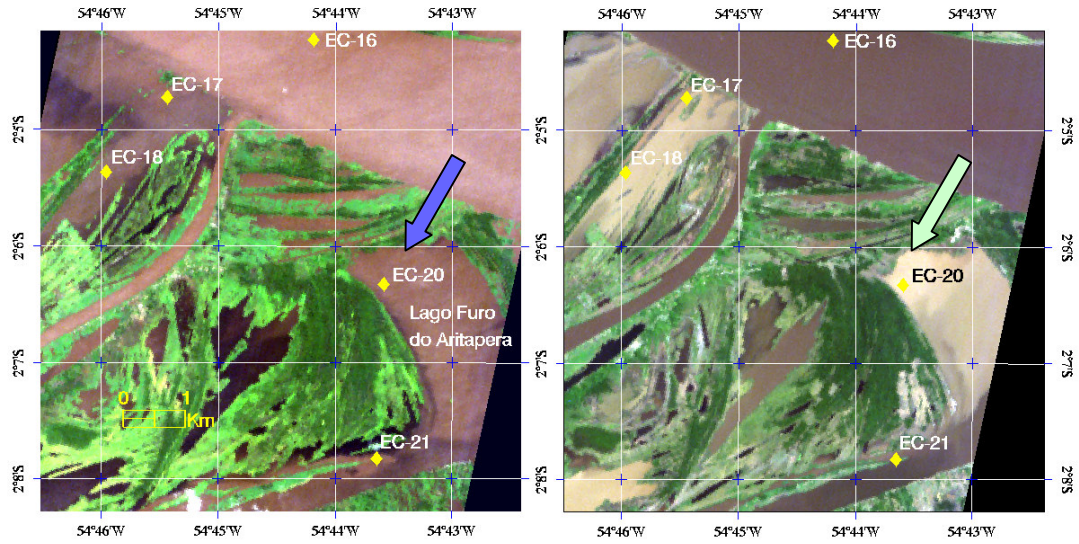

R (%)
Wavelength (nm)
high
decaying
16
14
12
10
8
6
4
2
0
455
555
655
755
855

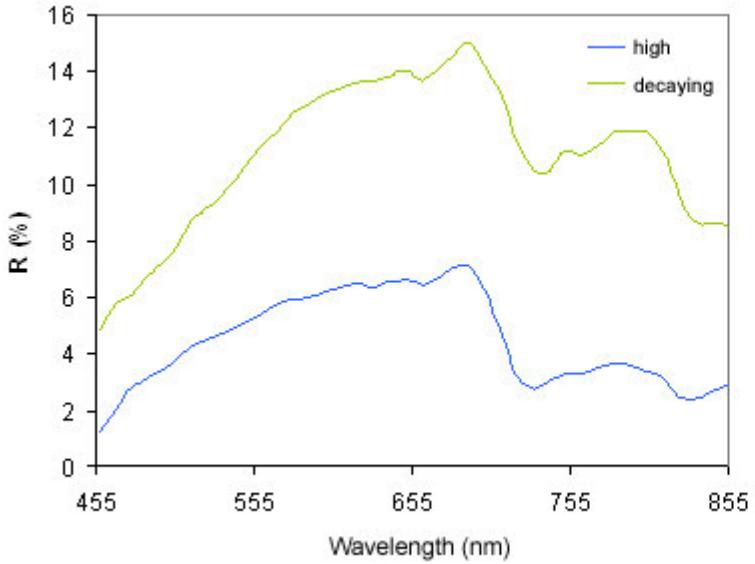

Fractional Abundance
high
decaying
1,00
0,75
0,50
0,25
0,00
-0,25
Sediment
Phytoplanckton

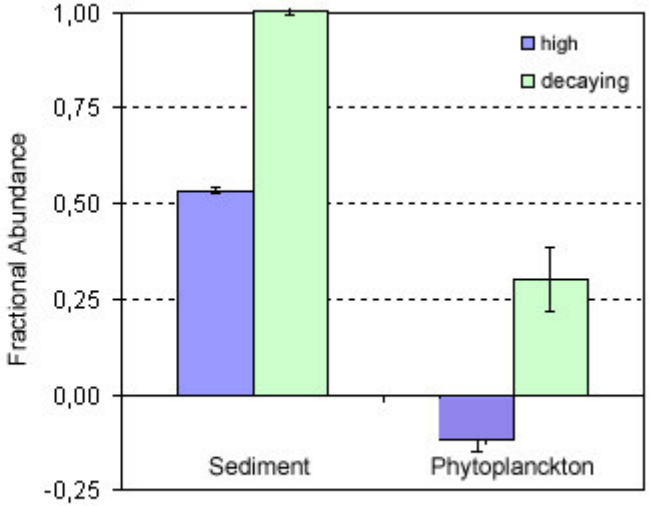

54°48'W
54°47'W
54°46'W
54°45'W
2°12'S
2°13'S
2°14'S
2°15'S
EC-29
EC-30
EC-28
EC-31
Rio Amazonas
0 1
Km

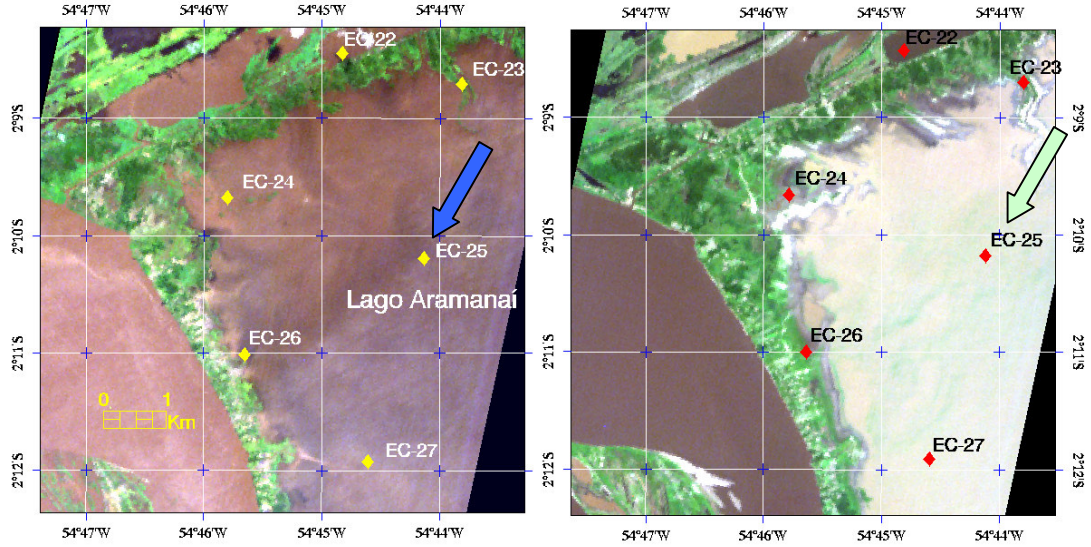

high
decaying
R (%)
16
14
12
10
8
6
4
2
0
455
555
655
755
855
Wavelength (nm)

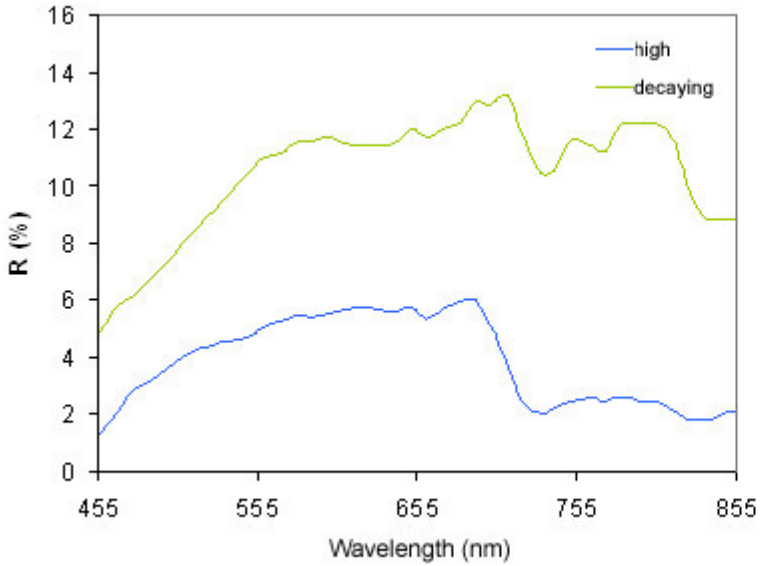

high
decaying
Fractional Abundance
1,00
0,75
0,50
0,25
0,00
-0,25
Sediment
Phytoplanckton

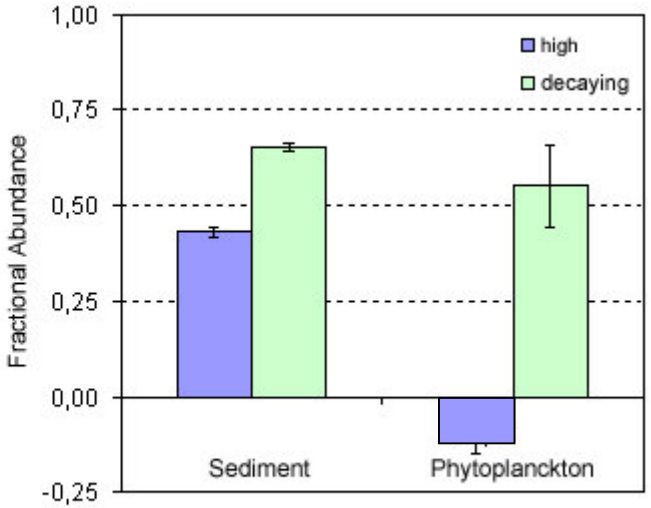

54°46'W
54°45'W
54°44'W
54°43'W
2°5'S
2°6'S
2°7'S
2°8'S
EC-16
EC-17
EC-18
EC-20
EC-21
Lago Furo
do Aritapera
0
1
Km

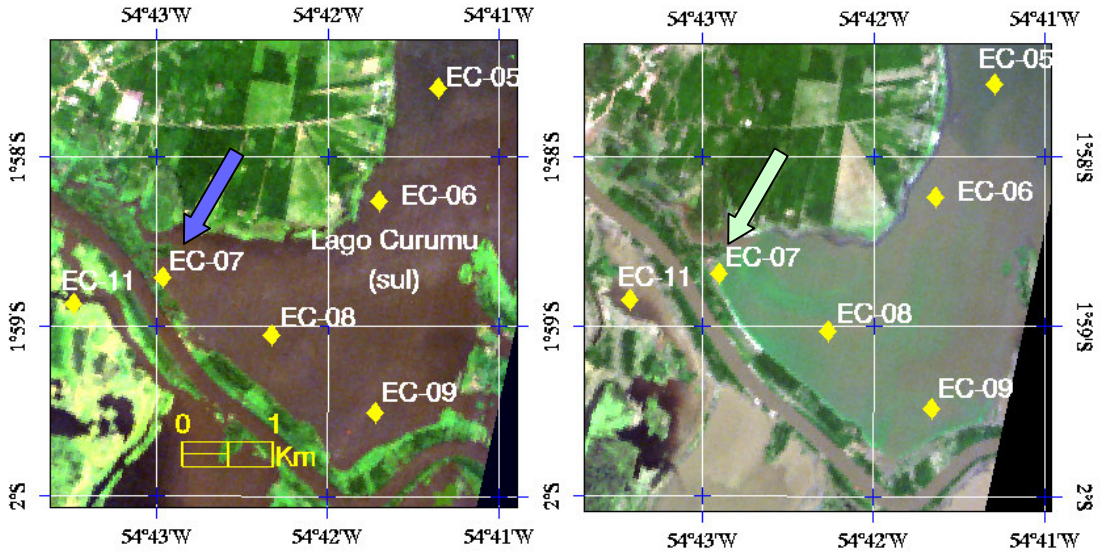

high
decaying
R (%)
Wavelength (nm)
0
2
4
6
8
10
12
14
16
455
555
655
755
855

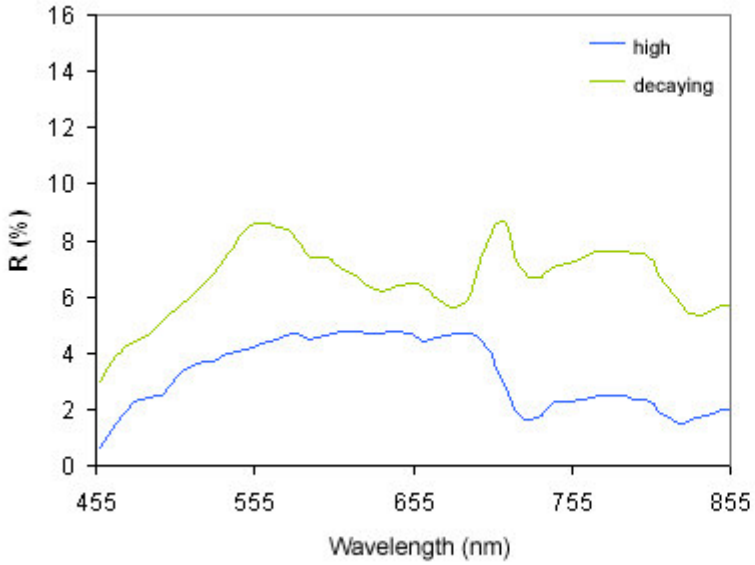

high
decaying
Fractional Abundance
1,00
0,75
0,50
0,25
0,00
-0,25
Sediment
Phytoplanckton

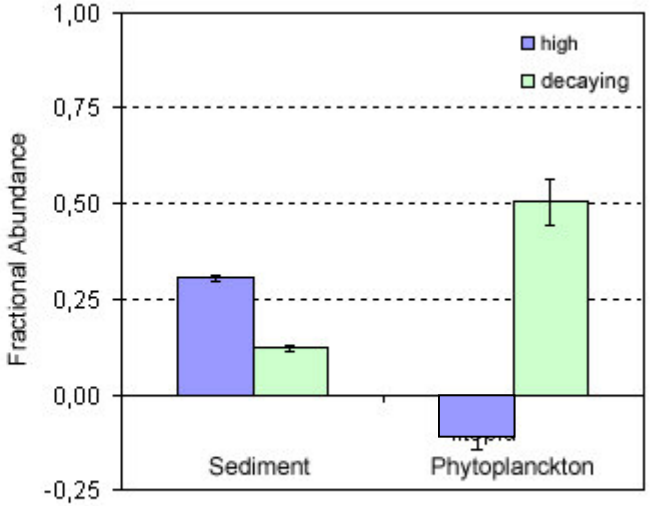

54°47'W
54°46'W
54°45'W
54°44'W
2°9'S
2°10'S
2°11'S
2°12'S
EC-22
EC-23
EC-24
EC-25
EC-26
EC-27
Lago Aramanaí
0
1
Km

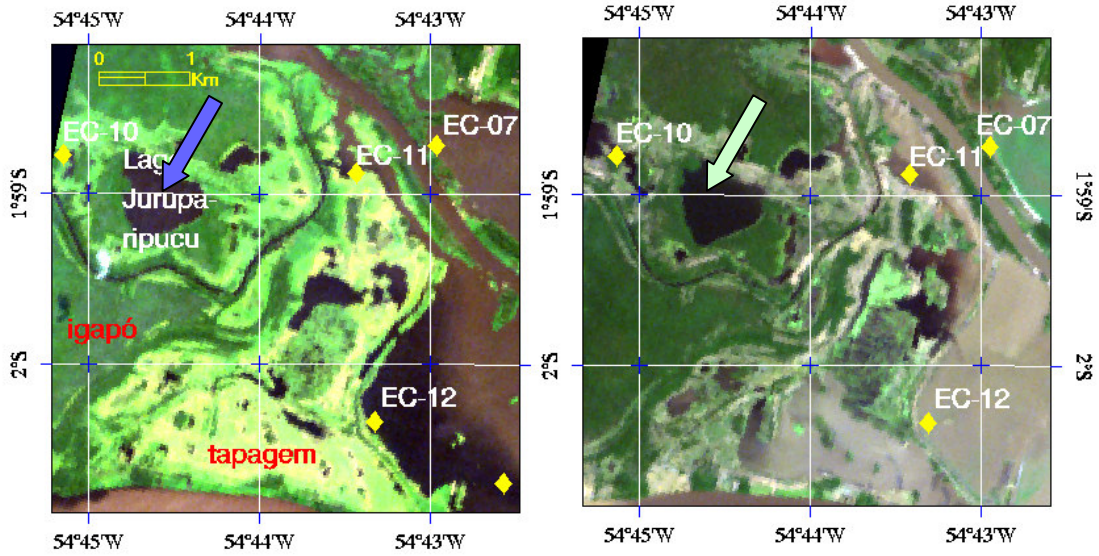

R (%)
Wavelength (nm)
high
decaying
16
14
12
10
8
6
4
2
0
455
555
655
755
855

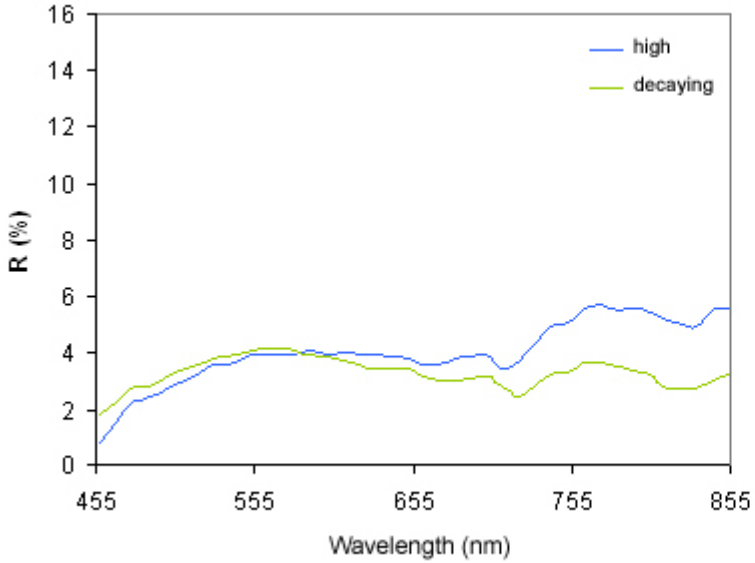

Fractional Abundance
high
decaying
1,00
0,75
0,50
0,25
0,00
-0,25
Sediment
Phytoplanckton

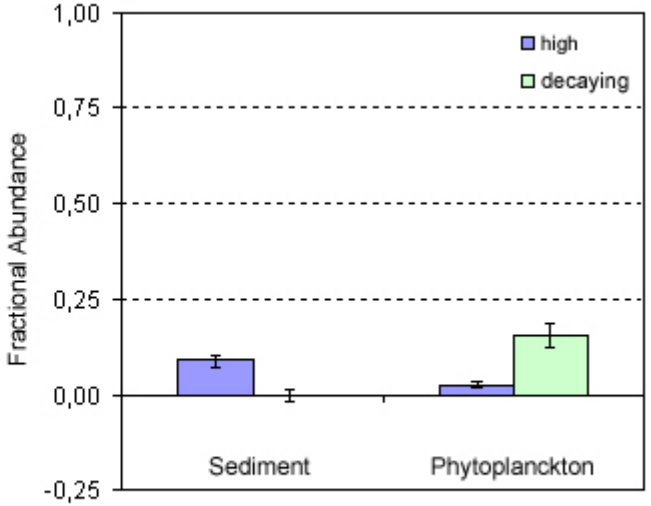

54°43'W
54°42'W
54°41'W
1°58'S
1°59'S
2°S
EC-05
EC-06
Lago Curumu
(sul)
EC-07
EC-11
EC-08
EC-09
0
1
Km


high
decaying
R (%)
Wavelength (nm)
0
2
4
6
8
10
12
14
16
455
555
655
755
855


high
decaying
Fractional Abundance
1,00
0,75
0,50
0,25
0,00
-0,25
Sediment
Phytoplanckton


54°45'W
54°44'W
54°43'W
0
1
Km
EC-10
Lag
Jurupa-
ripucu
igapó
EC-11
EC-07
EC-12
tapagem
1°59'S
2°S


16
14
12
10
8
6
4
2
0
R (%)
455
555
655
755
855
Wavelength (nm)
high
decaying


1,00
0,75
0,50
0,25
0,00
-0,25
Fractional Abundance
high
decaying
Sediment
Phytoplanckton

CONCLUSIONS

Conclusions

- The endmember selection from the Hyperion images of both flood periods that were analyzed (high water and decaying) provided better chances to find spectrally dominated (‘pure’) pixels for each optically active constituent (OAC).
- Spectral mixture analysis represents good potentials to characterize the temporal variability of the water composition in Amazonian floodplains.

Final Remarks

- Each OAC contributes nonlinearly to the light signal that returns to a remote sensing detector.
  - The sensitivity to changing concentration of each individual OAC decreases with increasing concentration.
  - In water sediment-algae mixtures, the sensitivity in the reflectance response to the addition of sediment also decreases with increasing chlorophyll concentrations.

???

Linear Spectral Unmixing Algorithm

$$R_{pi} = \sum f_j r_{ij} + \varepsilon_i$$

X

Analytical IOP Model

$$R(0-) = f \frac{b_b}{a + b_b}$$

$$f \frac{1}{1 + (\bar{\mu}_d / \bar{\mu}_u)}$$

$$a = a_0 + \sum_{j=1}^{N} a_j^* C_j$$

$$b_b = b_0 + \sum_{j=1}^{N} b_{b\,j}^* C_j$$