REMOTE SENSING MODELLING AND MONITORING OF WATER QUALITY IN ARACENA AND GERGAL DAMS (SEVILLE ,SPAIN) .

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Overview

Objectives.

Test sites, field work and Chris images.

Empirical and semi-analytical models.

Conclusions

Objectives

❑Seasonal and spatial distribution of water quality parameters with Chris-Proba.

❑Model development for quantification of:

- Chlorophyll-a
- Coloured dissolved organic matter (CDOM)
- Total suspended solids (TSS)
- Secchi disk depth
- Turbidity

Test sites, field work and Chris-Proba images.

•Aracena and Gergal dams.

•Ground thruth data. Reflectance. Constituents. IOP

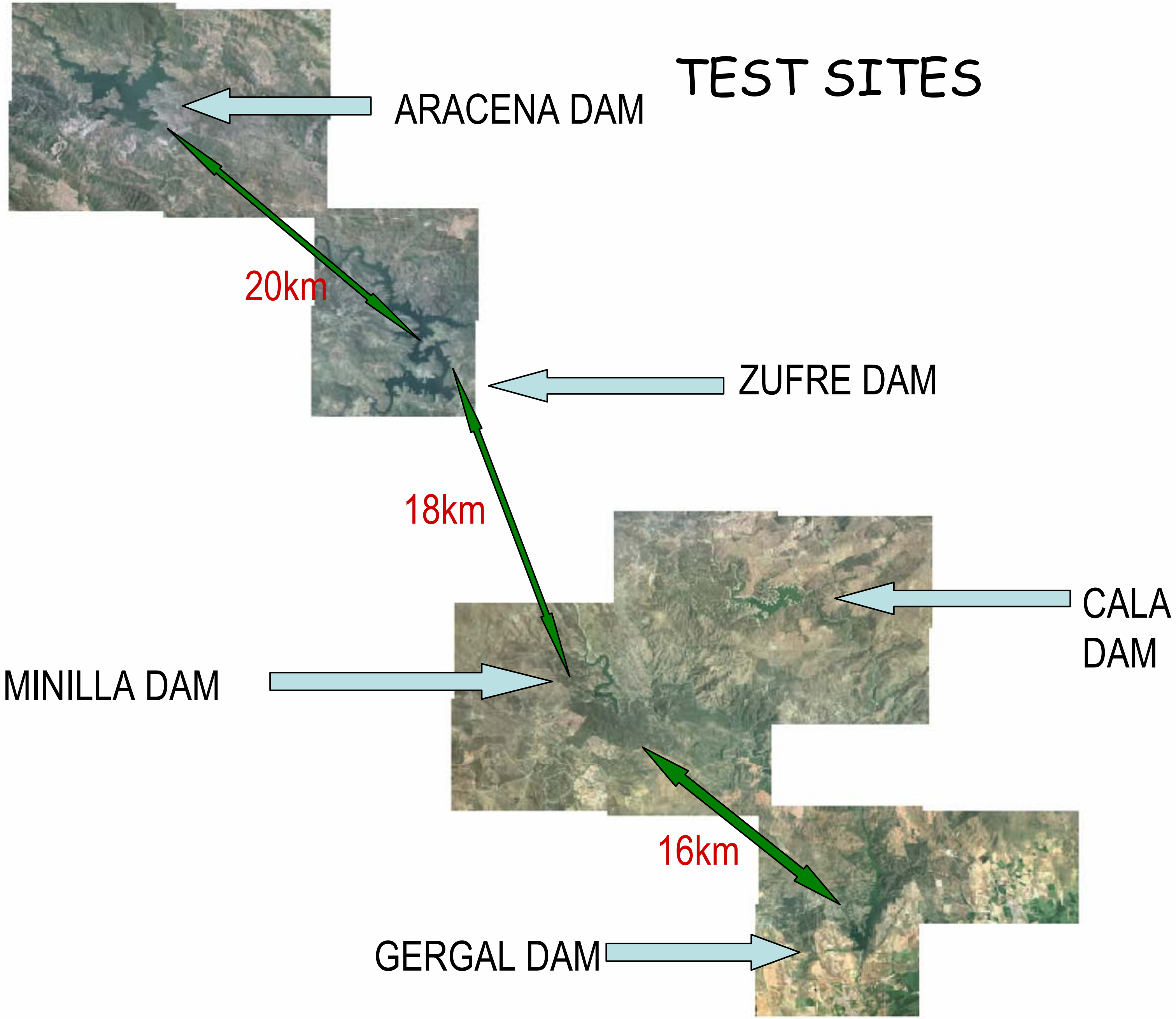
•Chris-Proba processing

Destriping.

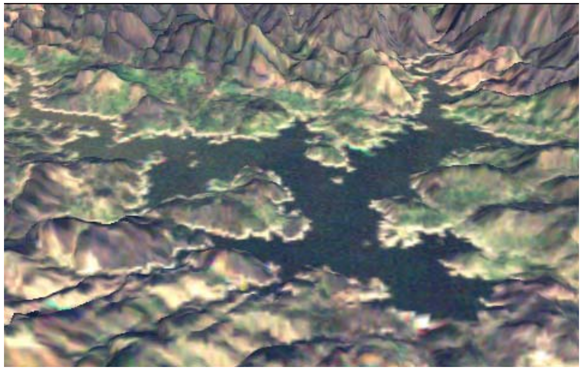
Atmospheric correction.

Georeferencing.

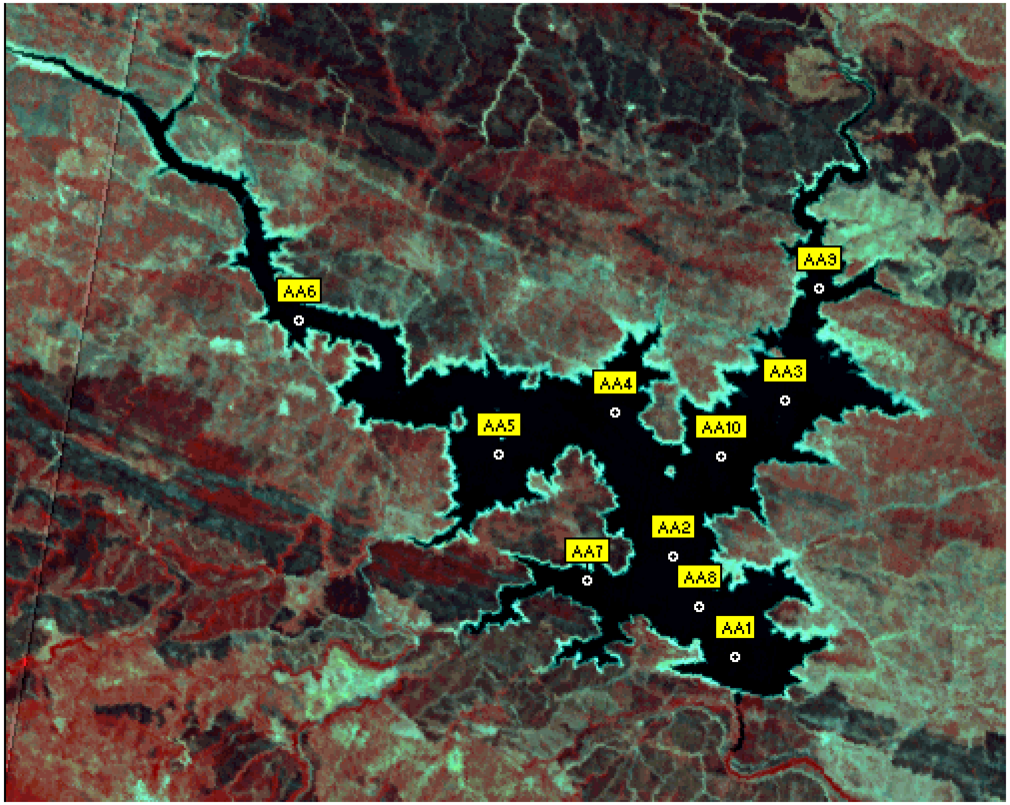
TEST SITES



ARACENA DAM
20km
ZUFRE DAM
18km
CALA DAM
MINILLA DAM
16km
GERGAL DAM

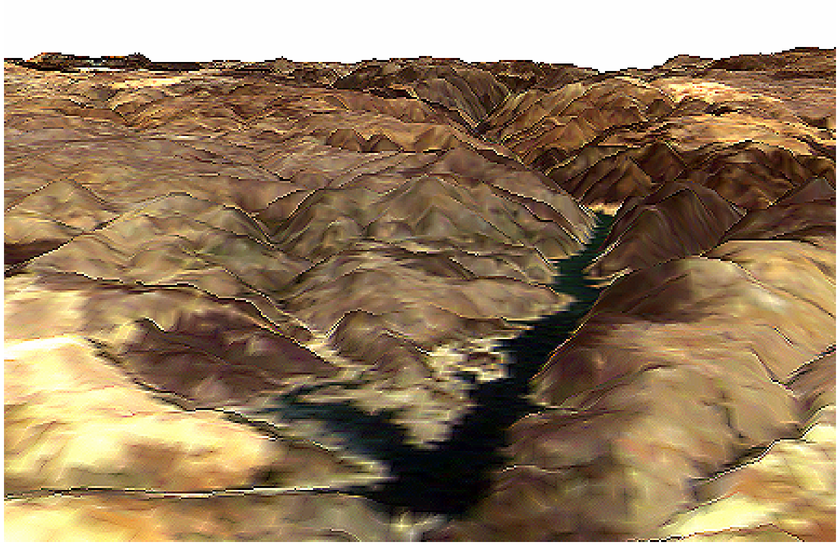


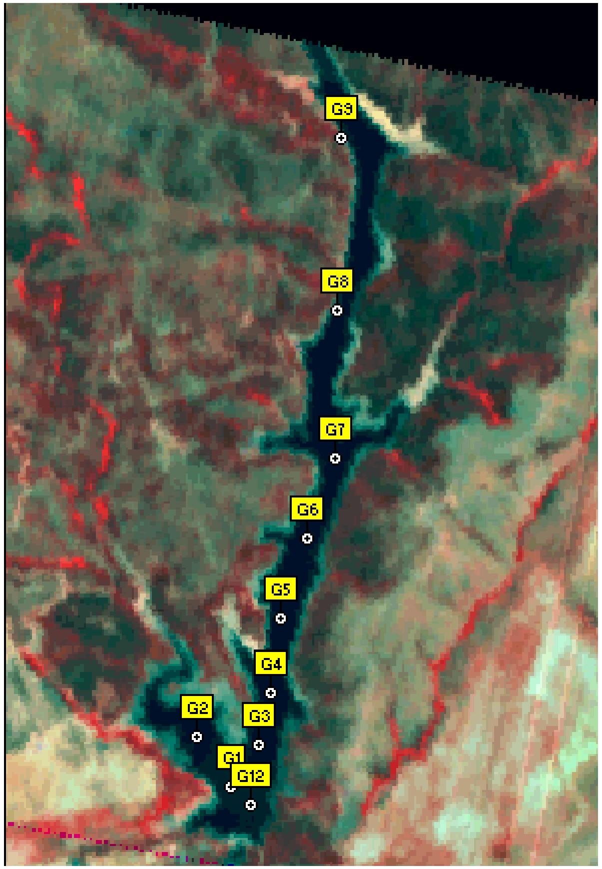
Sampling points inAracena dam



4 field campaigns
3 Chris acqusitions
Only 1 date with simultaneous data
2 July 2005

Sampling points Gergal dam





4 field campaigns
2 Chris acqusitions
Only 1 date with simultaneous data
6 June 2005

Available data 2005-2006		
Aracena dam		
Date	Chris-Proba	Field data
15 May 2005	N	Y
15 June 2005	Y	N
2 July 2005	Y	Y
18 Feb. 2006	Y/clouds	N
7 March 2006	N	Y
15 May 2006	N	Y
Gergal dam		
8 March 2005	N	Y
6 June 2005	Y	Y
6 Nov. 2005	Y	N (susp.)
19 Apr. 2006	N	Y
5 May 2006	N	Y

Ground Truth

Field spectroscopy measurement

Field spectrometer Ocean Optics (400- 800 nm)

Above water reflectance R(λ+).

Spectralon (10% refl.). 45° zenith 135° azimuth

$L_{down}(\lambda)$, $L_{up}(\lambda)$, $L_{sky}(\lambda)$ 4 scans

In-situ water data

Secchi disk depth

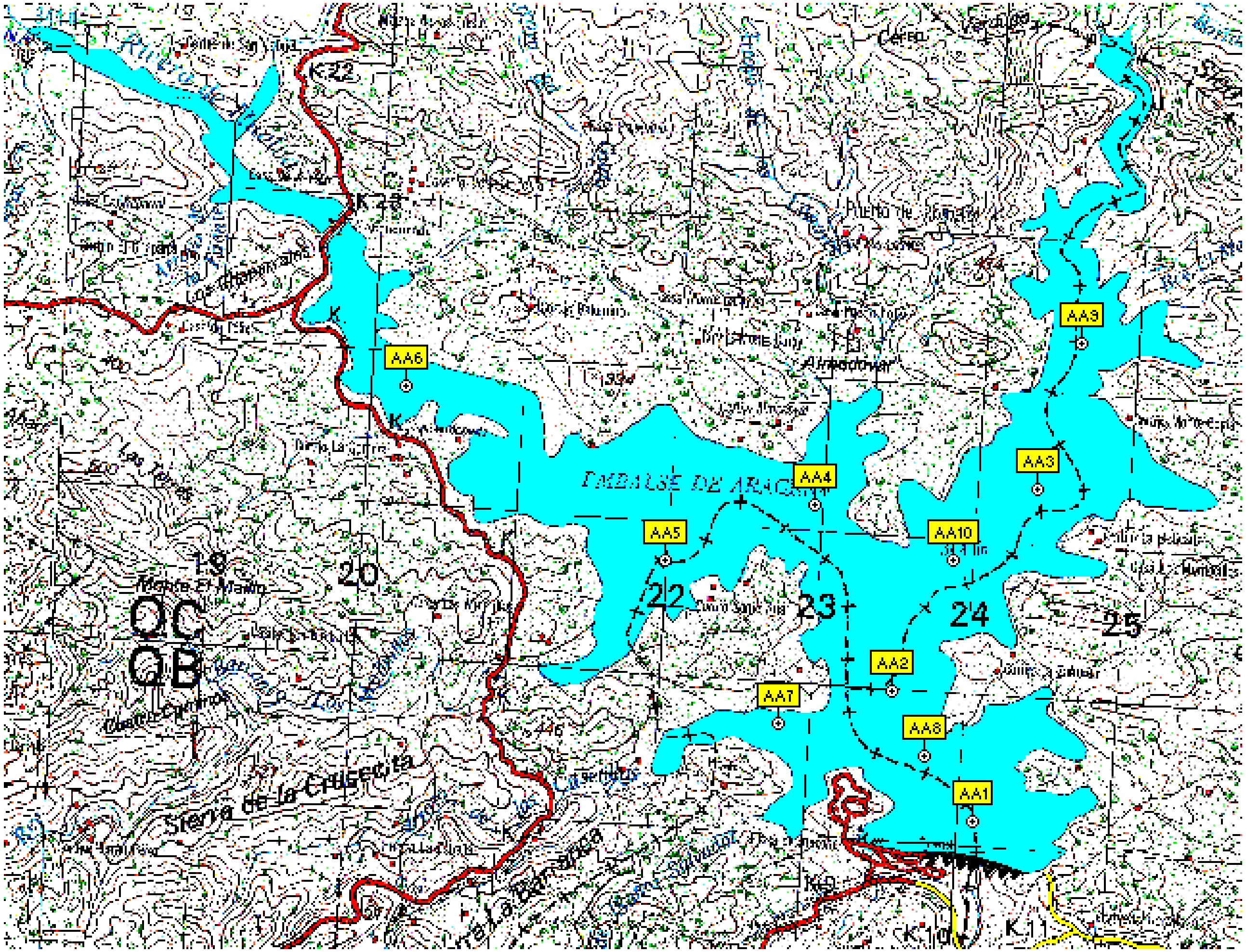
CTD data: Chlorophyll, Phycocianin, Turbidity, DOM

Laboratory data

Chlorophyll-a, Turbidity (NTU), Total suspended solids (TSS).

Total absorption spectra of particules, pigments, detritus (unpigmented particules) and coloured water dissolved substances (CDOM).

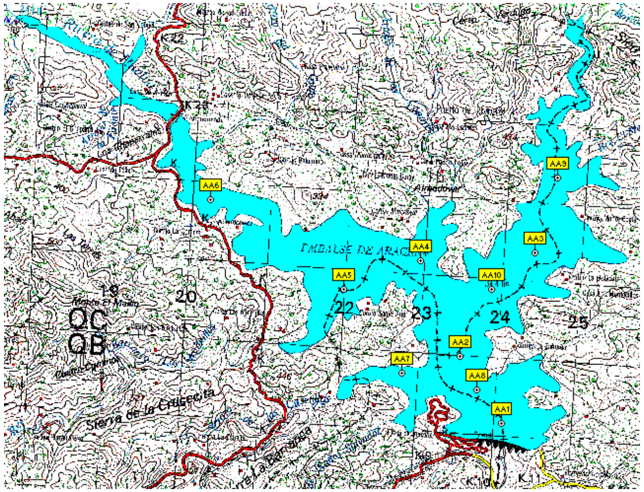
Aracena dam 2-07-2005



Statistics in Aracena dam 2-07-2005

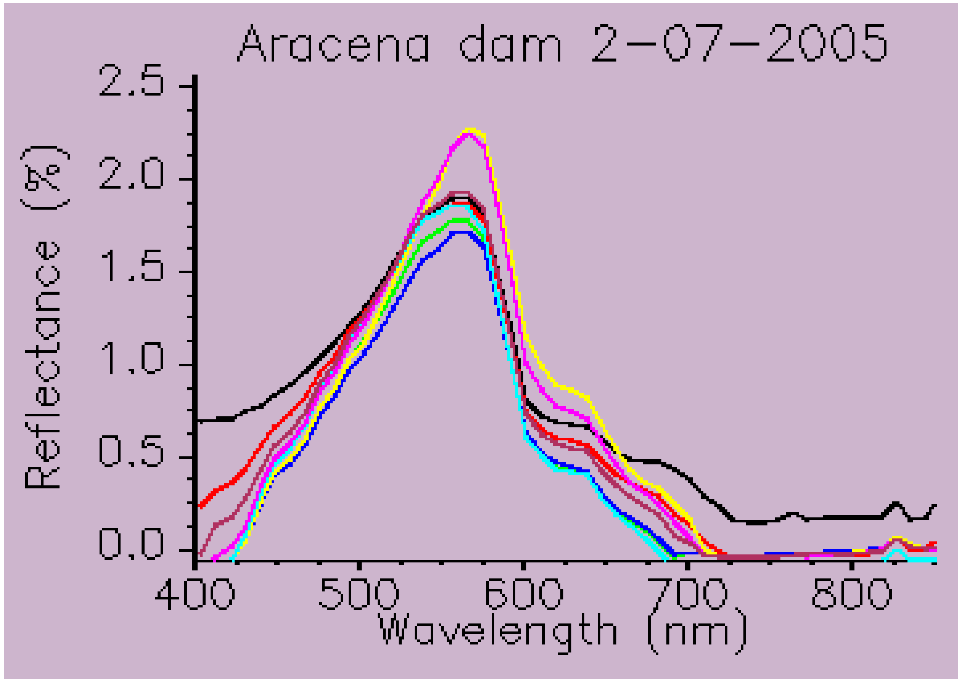
	Valid N	Mean	Minimum	Maximum	Std.Dev.
Deep (m)	10	20.8	8.0	35.	11.1
Secchi disk (m)	10	2.9	1.9	3.6	0.6
Chl-a (mg/m^3)	10	4.0	1.85	10.75	2.8
TSS (mg/l)	10	2.8	1.87	6.13	1.4
Chl-a* (mg/m^3)	10	3.4	2.44	7.18	1.7
Turidity (FTU)	10	2.5	1.2	5.4	1.2
DOM (mg/m^3)	10	14.4	13.0	17.9	1.6

	Secchi	**Chl-a**	**TSS**	**Chl-a***	**Turbidity**	**DOM**
Secchi disk (m)	1.00	-0.68	-0.03	-0.68	-0.82	-0.25
Chl-a (mg/m^3)		1.00	0.29	0.98	0.82	0.44
TSS (mg/l)			1.00	0.30	-0.04	0.94
Chl-a* (mg/m^3)				1.00	0.87	0.48
Turidity (FTU)					1.00	0.24
DOM (mg/m^3)						1.00



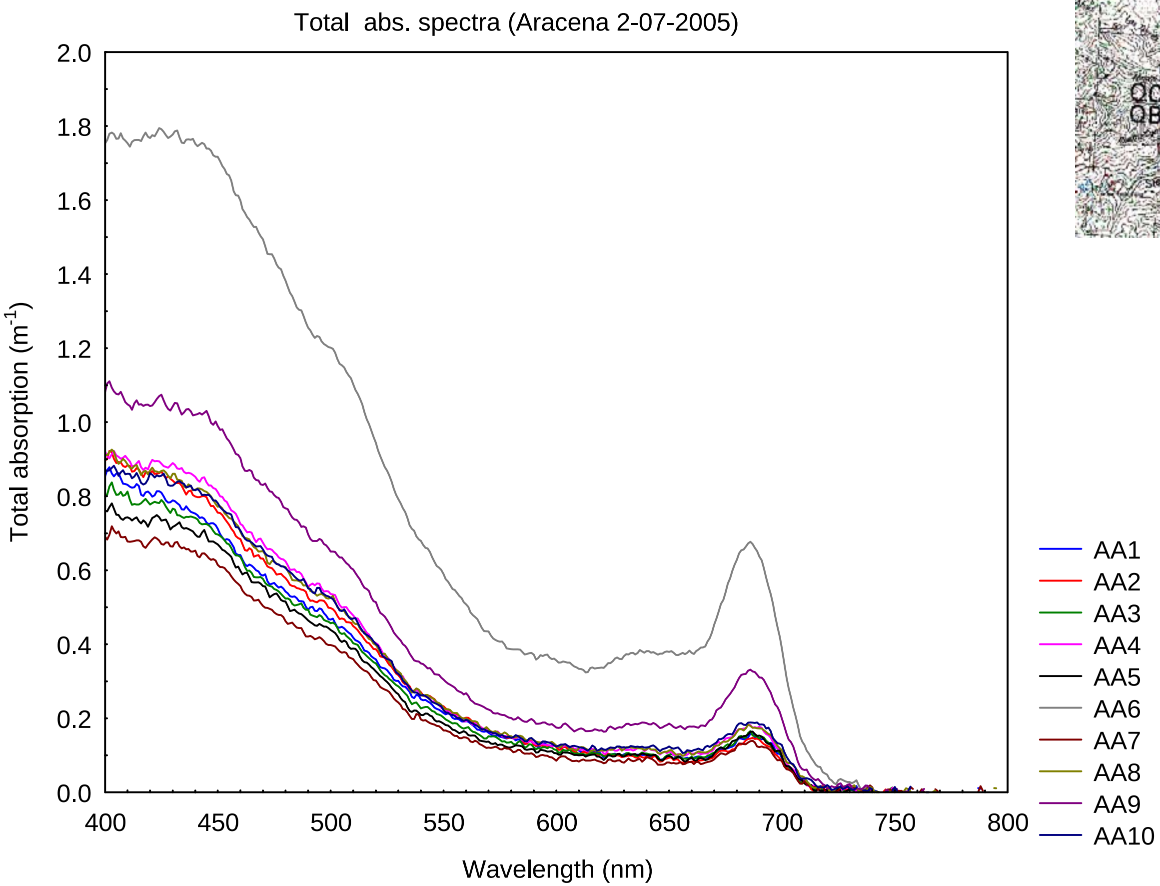
Sampling points
Aracena dam

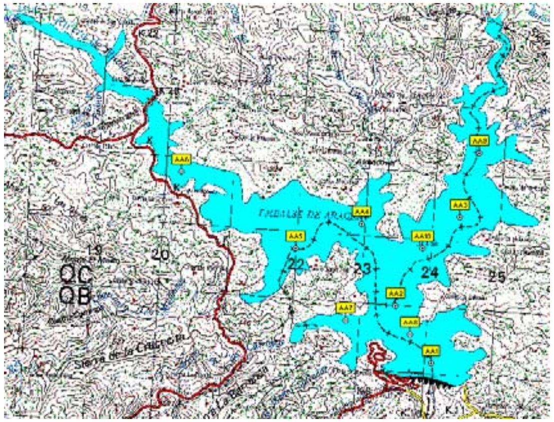
Field reflectance spectra



IOP variability

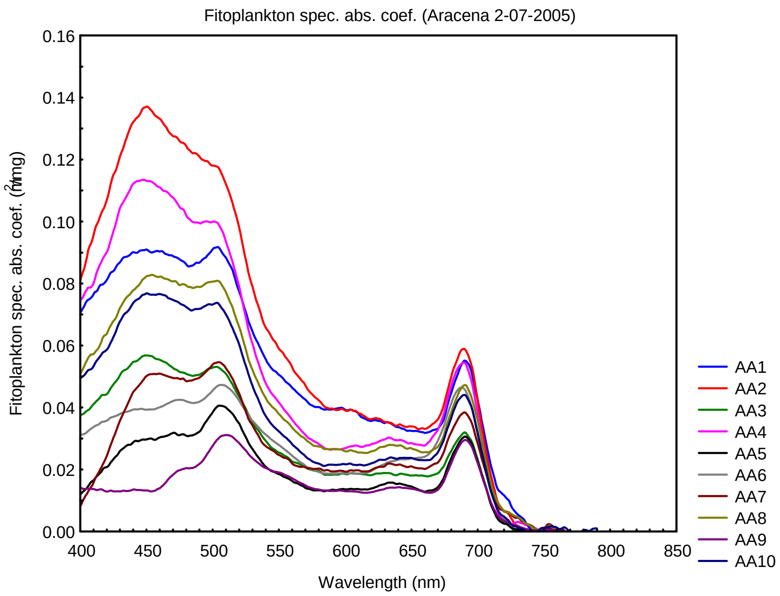
Total particulate absorption.

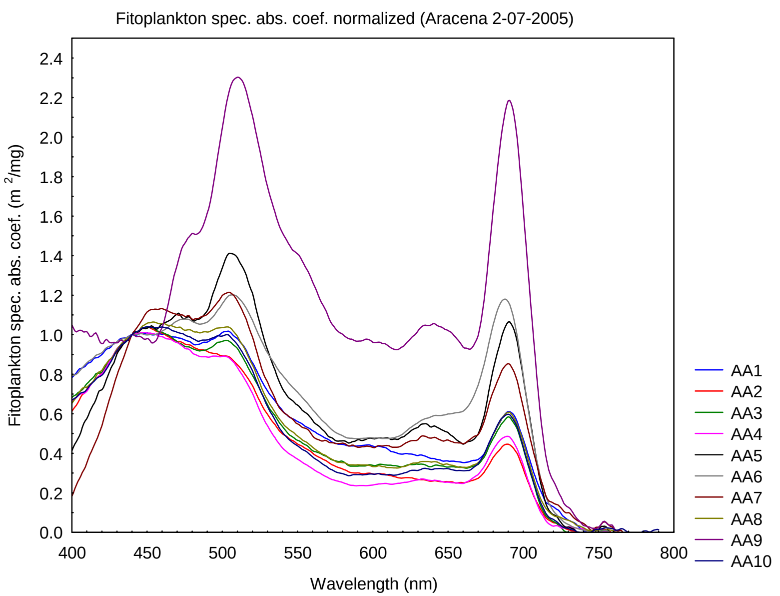




IOP variability

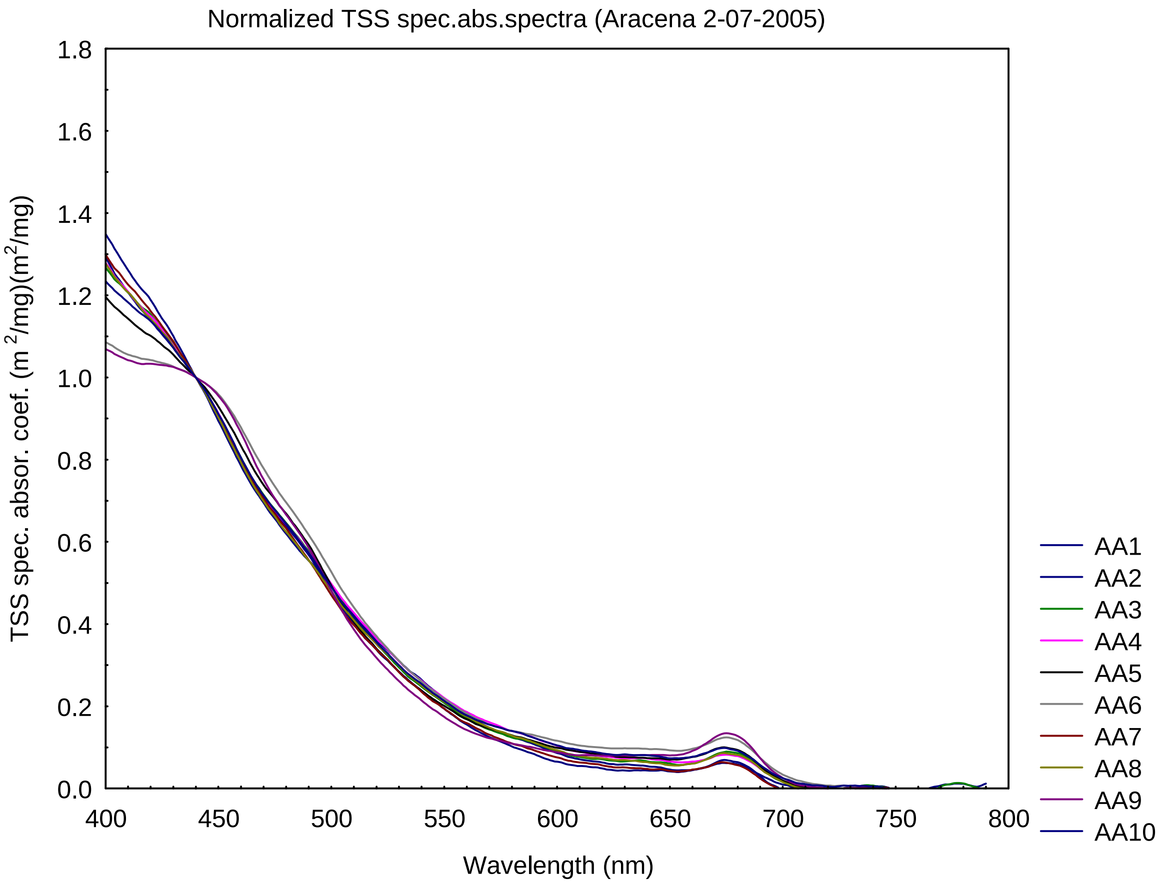
Phytoplankton specific absorption.





IOP variability

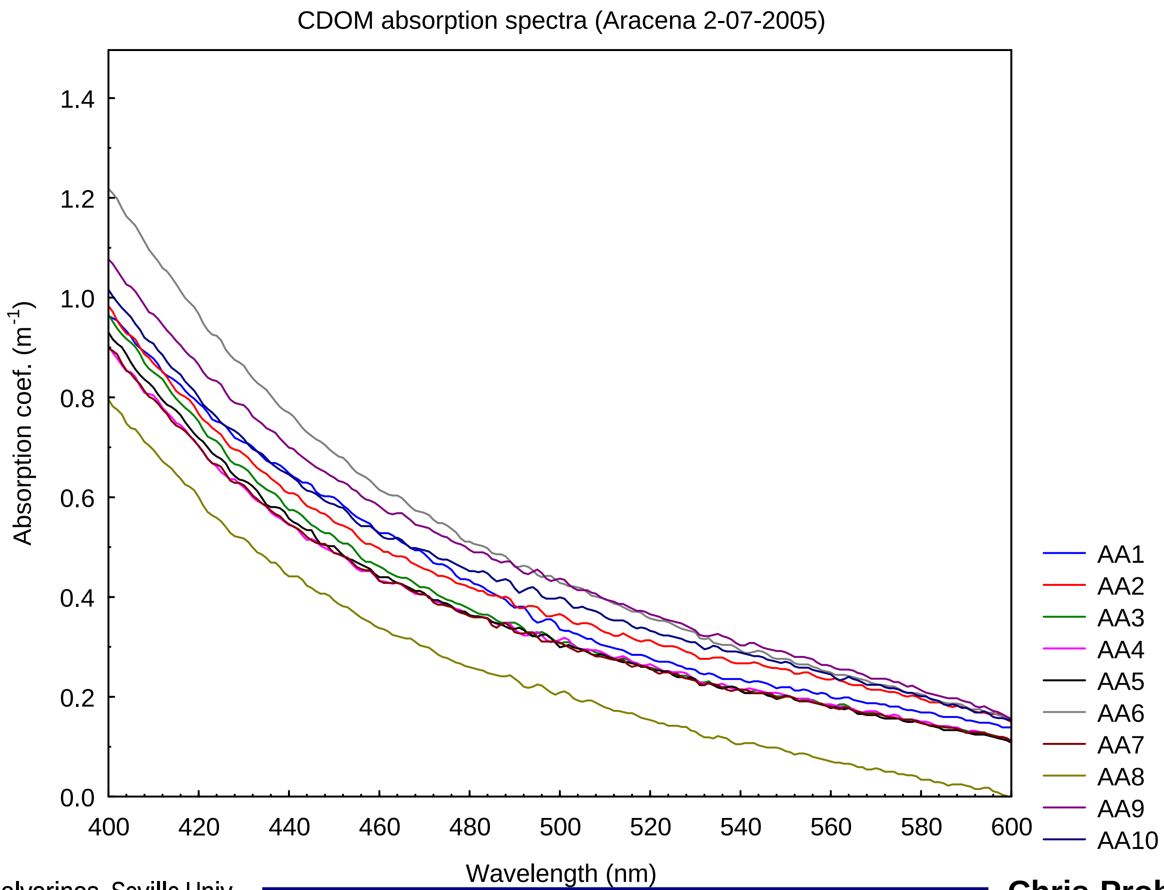
Susp. solids spec. absorption.



Sample	S	$a_{ss}(440)$
AA1	0.011	0.0835
AA2	0.011	0.2328
AA3	0.010	0.2222
AA4	0.010	0.2715
AA5	0.010	0.1961
AA6	0.009	0.2651
AA7	0.011	0.2605
AA8	0.011	0.2794
AA9	0.009	0.2905
AA10	0.010	0.2883
Mean	0.010	0.2390

IOP variability

CDOM absorption.



Sample	S	$a_{CDOM}(440)$
AA1	0.0104	0.648
AA2	0.0094	0.609
AA3	0.0109	0.577
AA4	0.0103	0.545
AA5	0.0107	0.559
AA6	0.0102	0.768
AA7	0.0104	0.546
AA8	0.0139	0.443
AA9	0.009	0.7
AA10	0.0091	0.644
Mean	0.0104	0.603

Chris-Proba processing

Destriping by MNF transformation.

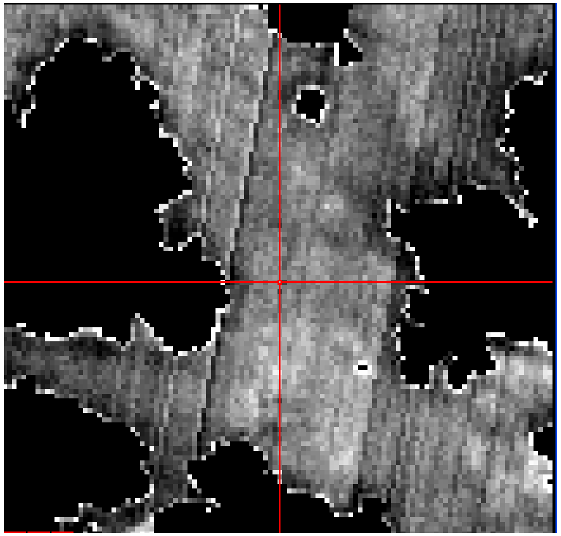
Atmospheric correction of inland water
Guanter L. et. alli (2004) method.

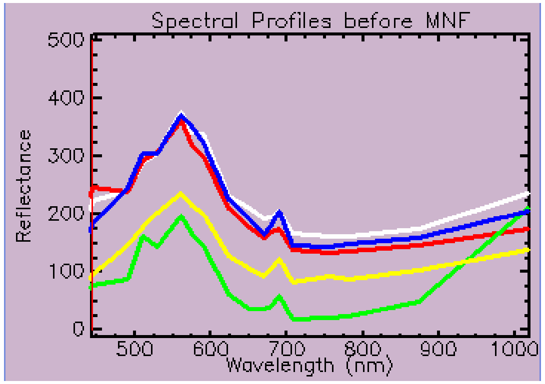
Georeferencing with enough GCP.

Spectra extraction.

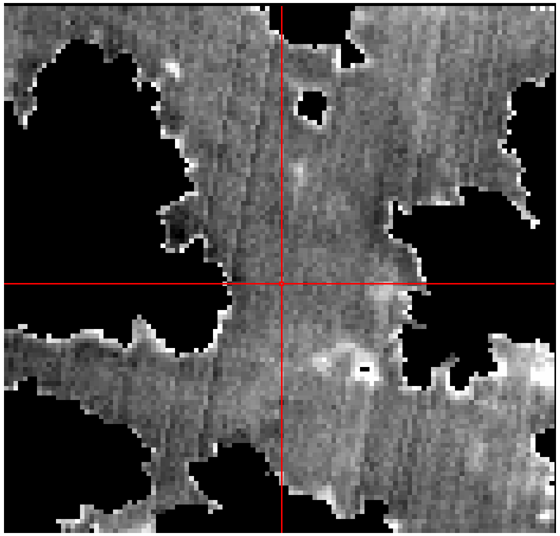
Destriping: Minimum noise fraction (MNF) on water pixels.

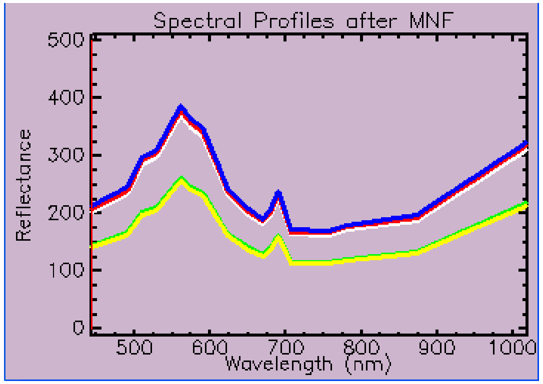
Original (Chris 0°)





After MNF(Chris 0°)

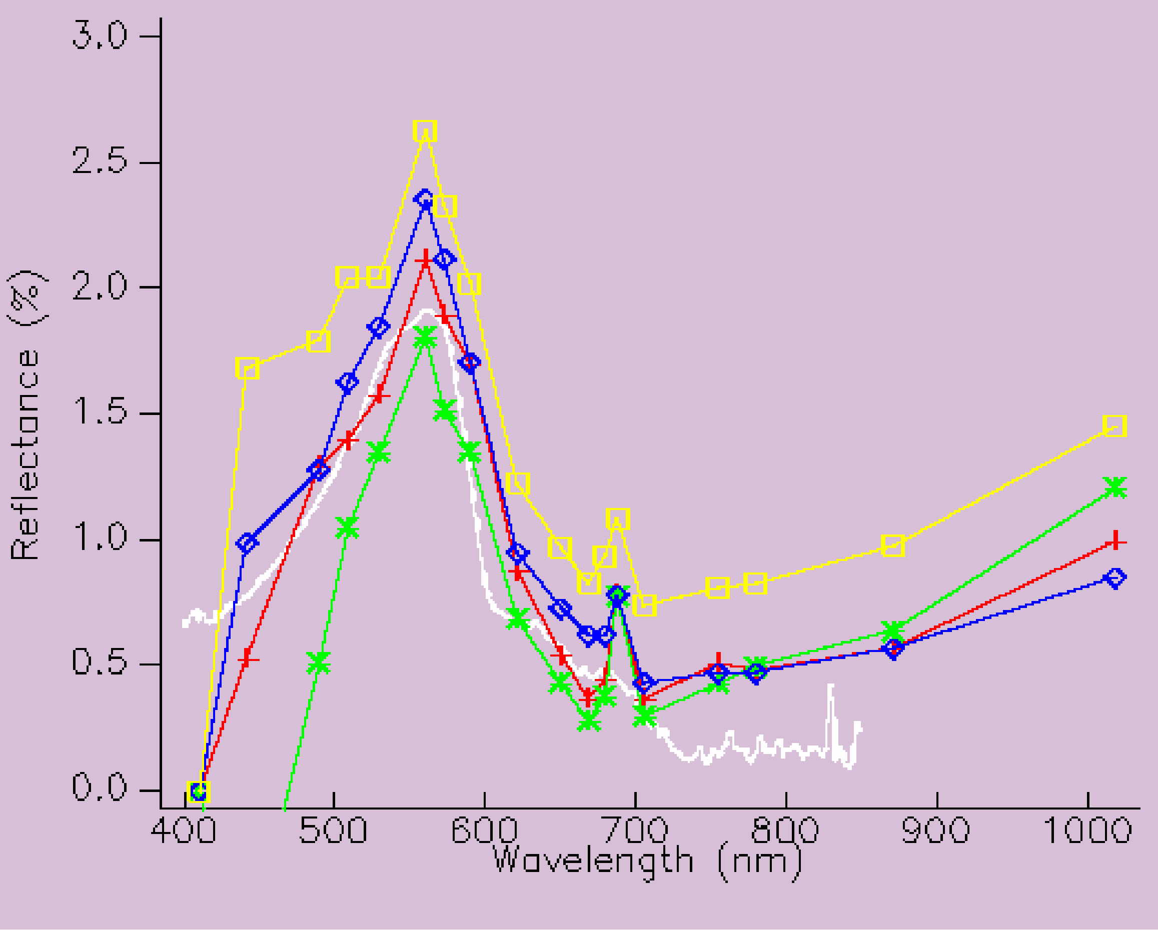




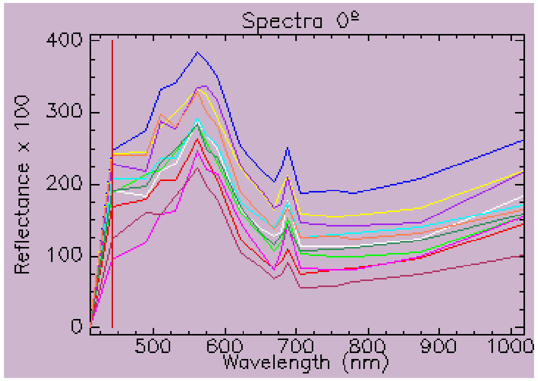
MNF transform :

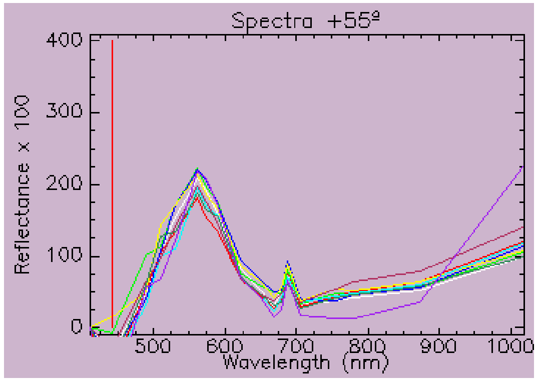
- Image dependance correction.
- Noise reduction but still residual noise
- Wavelength dependent reflectance modifications
- Atmospheric correction dependent on radiometric results.

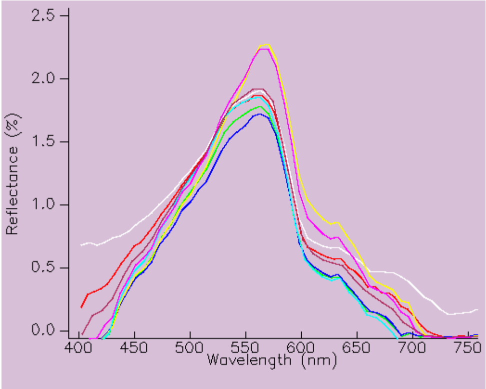
Multiangular response variability and field spectra.

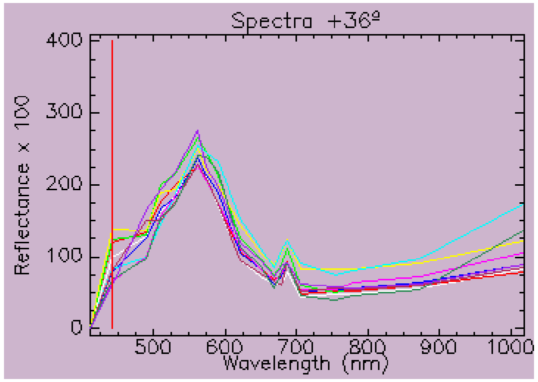


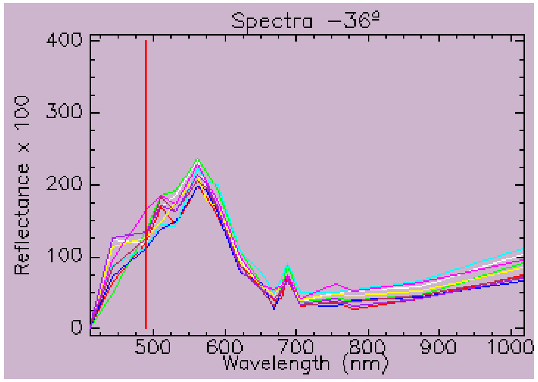
Chris and ground truth reflectances (10 points).







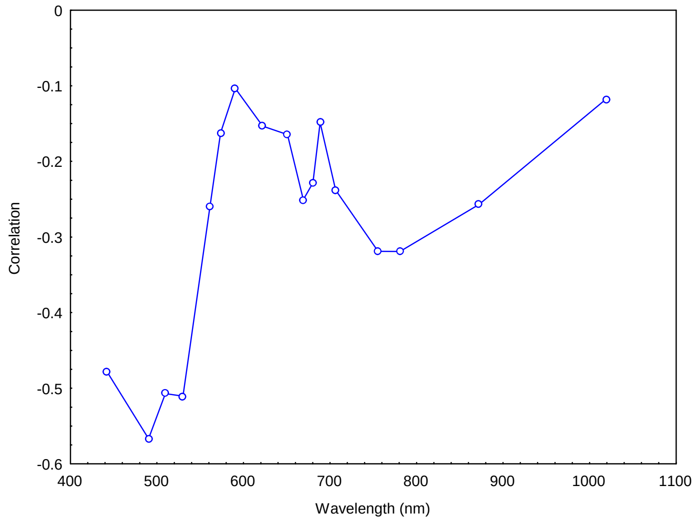




Empirical models

- Chris spectral data at sampling stations
- Spectral correlation
- Regresion on Chris band ratio

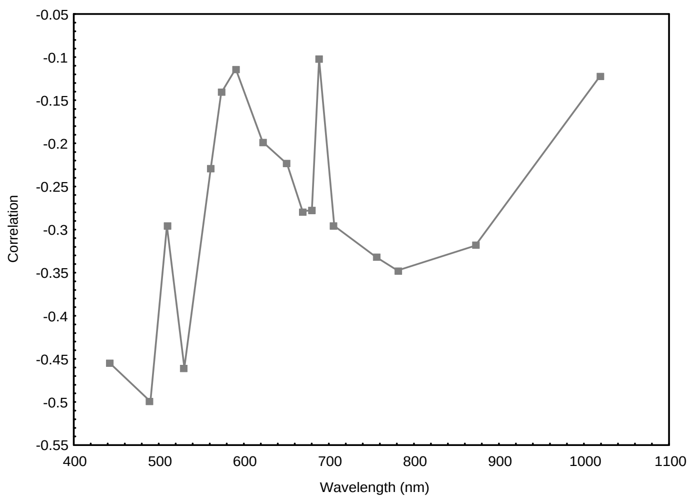
Chl-a



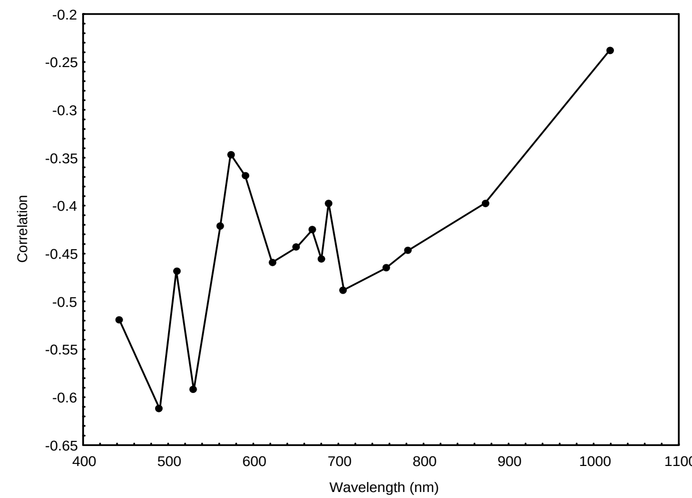
Empirical models

- Chris spectral data at sampling stations
- Spectral correlation
- Regresion on Chris band ratio

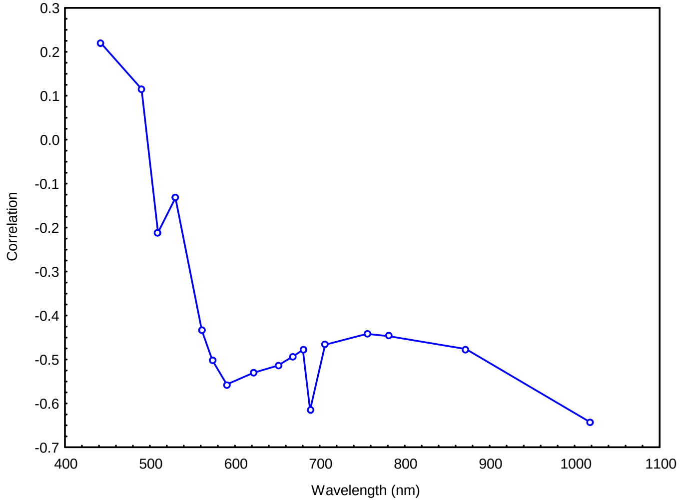
$a_{CDOM}(440)$



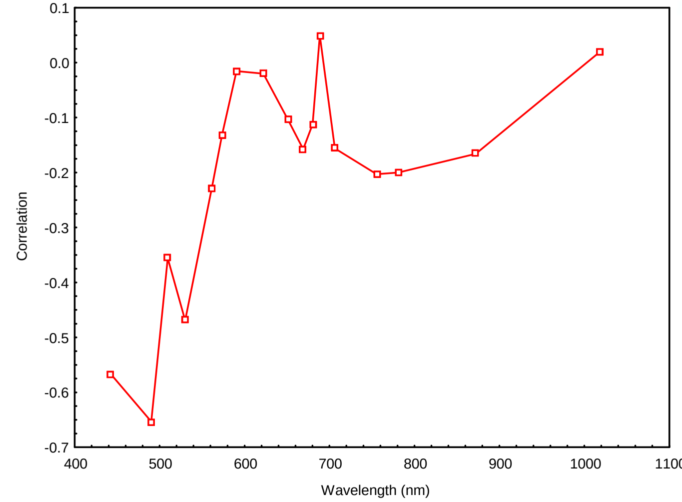
DOM



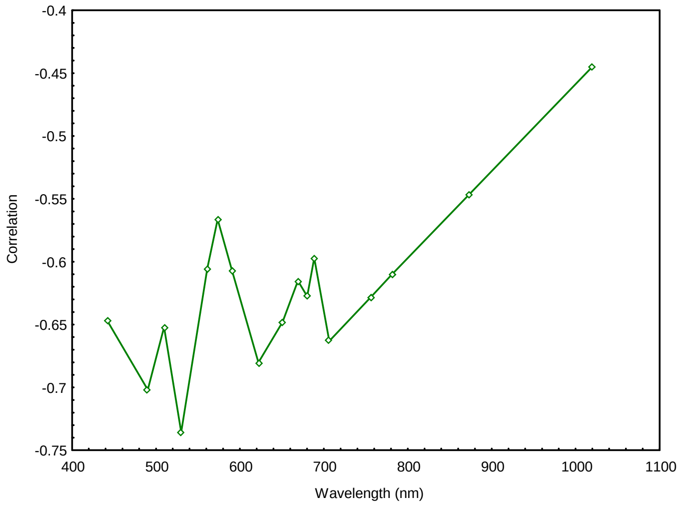
Secchi



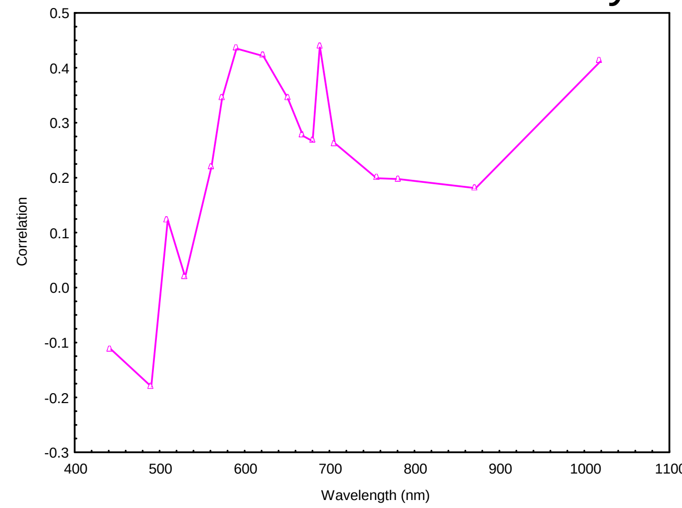
Chl-a



TSS

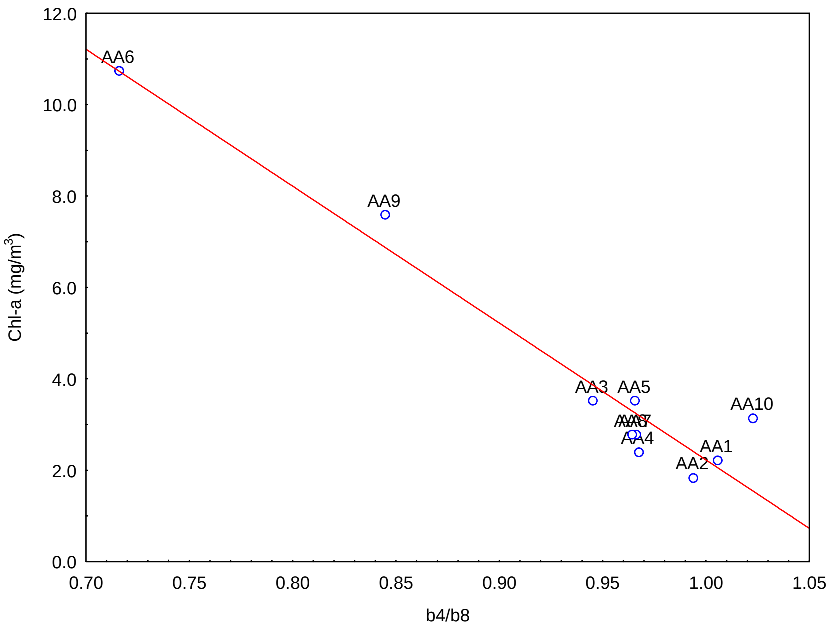


Turbidity



Empirical models

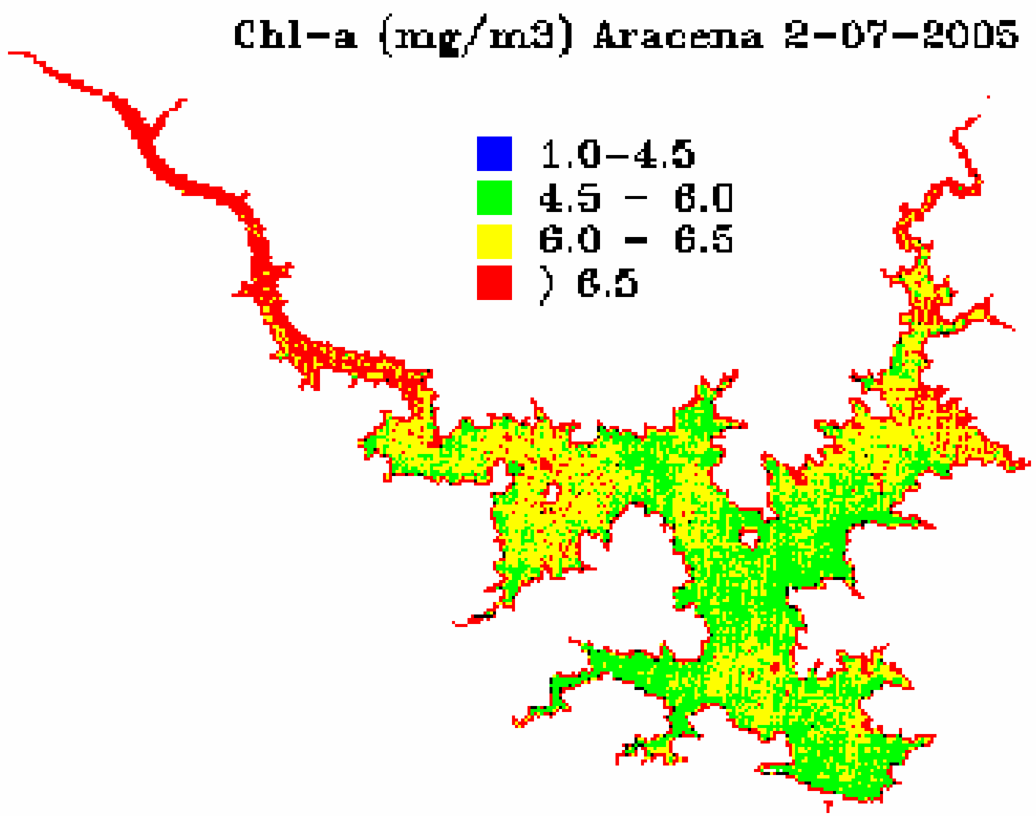
- Chris spectral data at sampling stations
- Spectral correlation
- Regresion on Chris band ratio



Chl-a = 32.18- 29.95*b4/b8

R2= 0.935

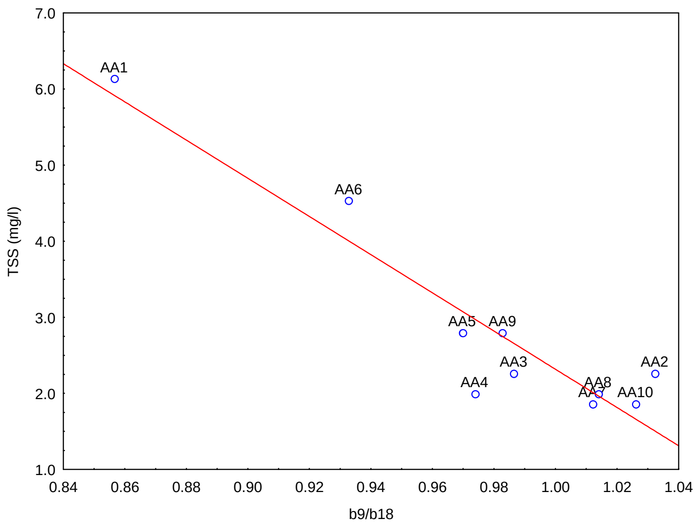
Estimated concentration of chlorophyll-a in Aracena dam on the 2th of July 2005: zero viewing angle.



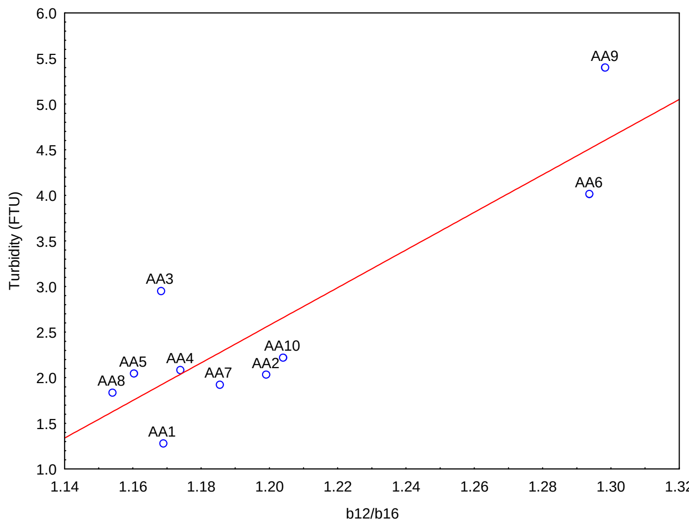
Empirical models

- Chris spectral data at sampling stations
- Spectral correlation
- Regresion on Chris band ratio

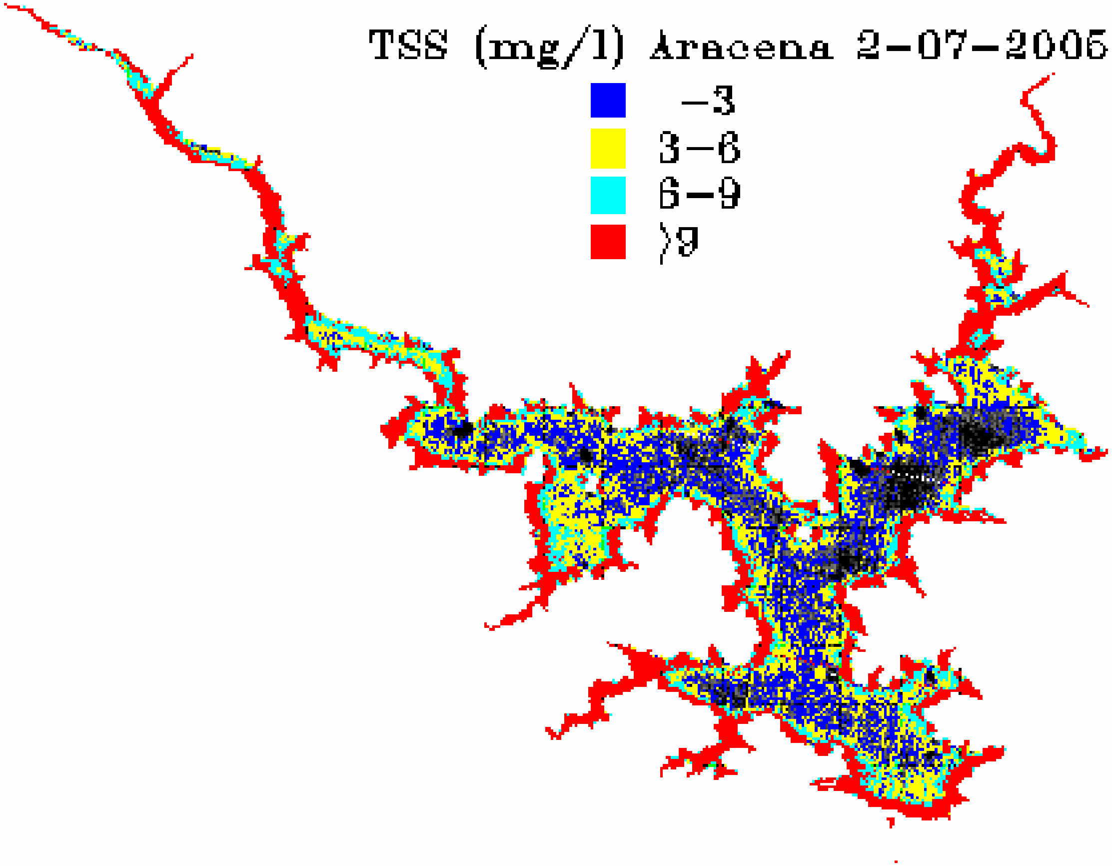
TSS = 27.41 - 25.09*b9/b18
R^2 = 0.878



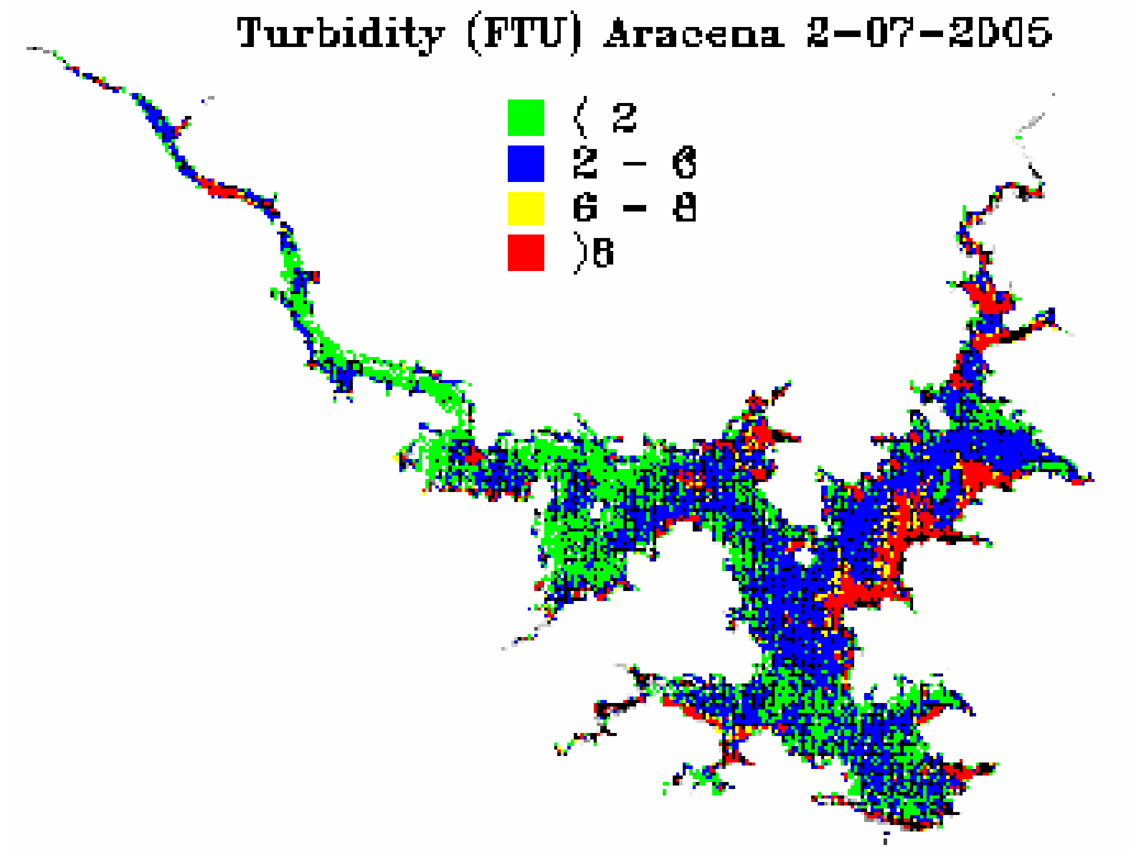
Turbidity = -22.18 + 20.63* b12/b16
R^2 = 0.7749



Estimated concentration of TSS in Aracena dam on the 2th of July 2005: zero viewing angle.



Estimated concentration of turbidity in Aracena dam on the 2th of July 2005: zero viewing angle.

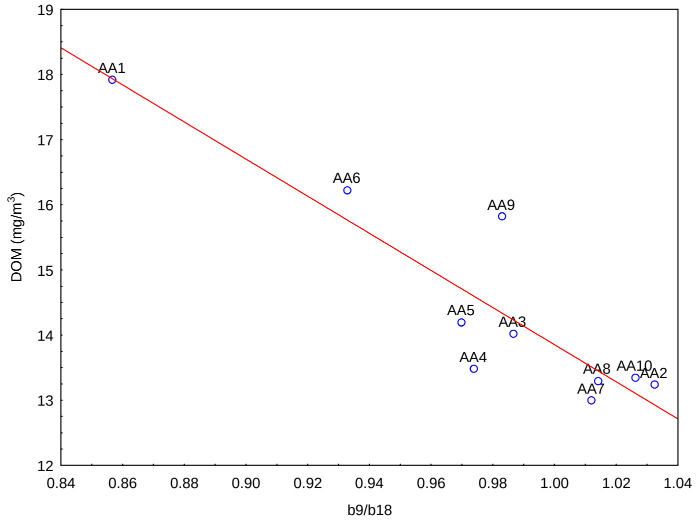


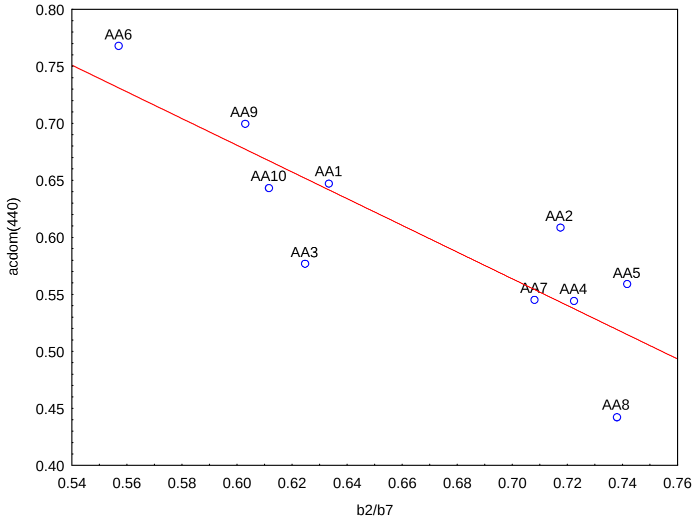
Empirical models

- Chris spectral data at sampling stations
- Spectral correlation
- Regresion on Chris band ratio

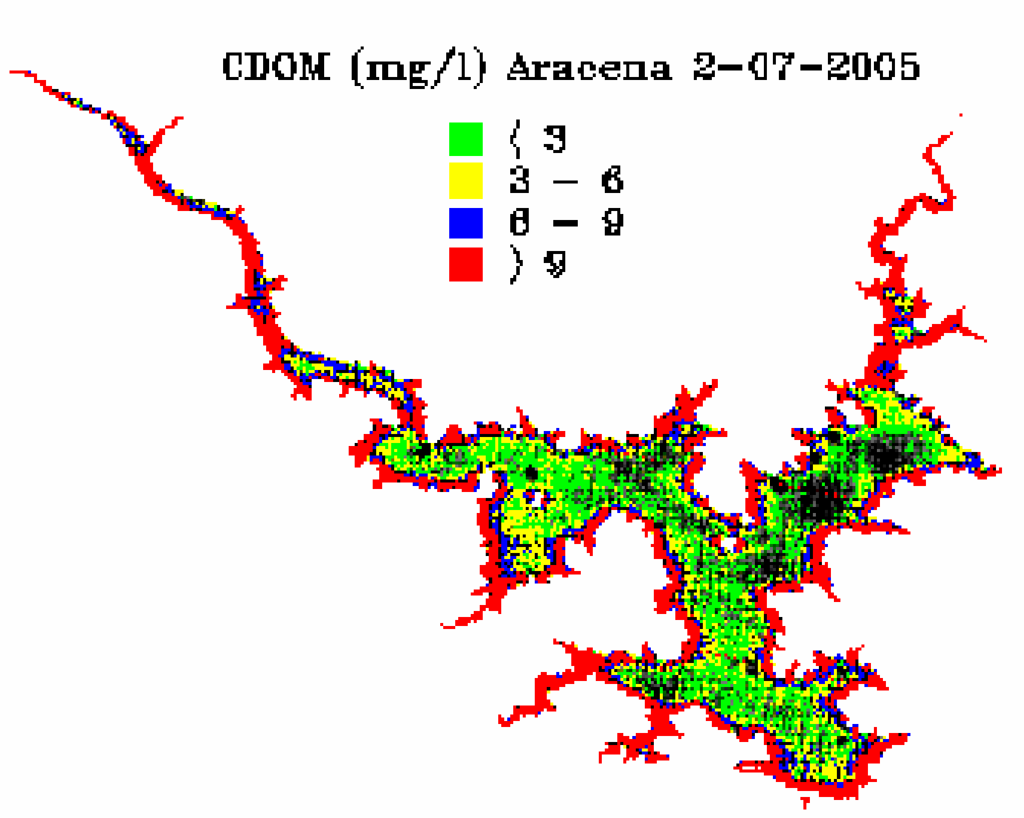
DOM = 42.33- 28.48*b9/b18
R^2 = 0.819

a_{cdom}(440) = 1.383 - 1.171*xb2/b7
R^2 = 0.73

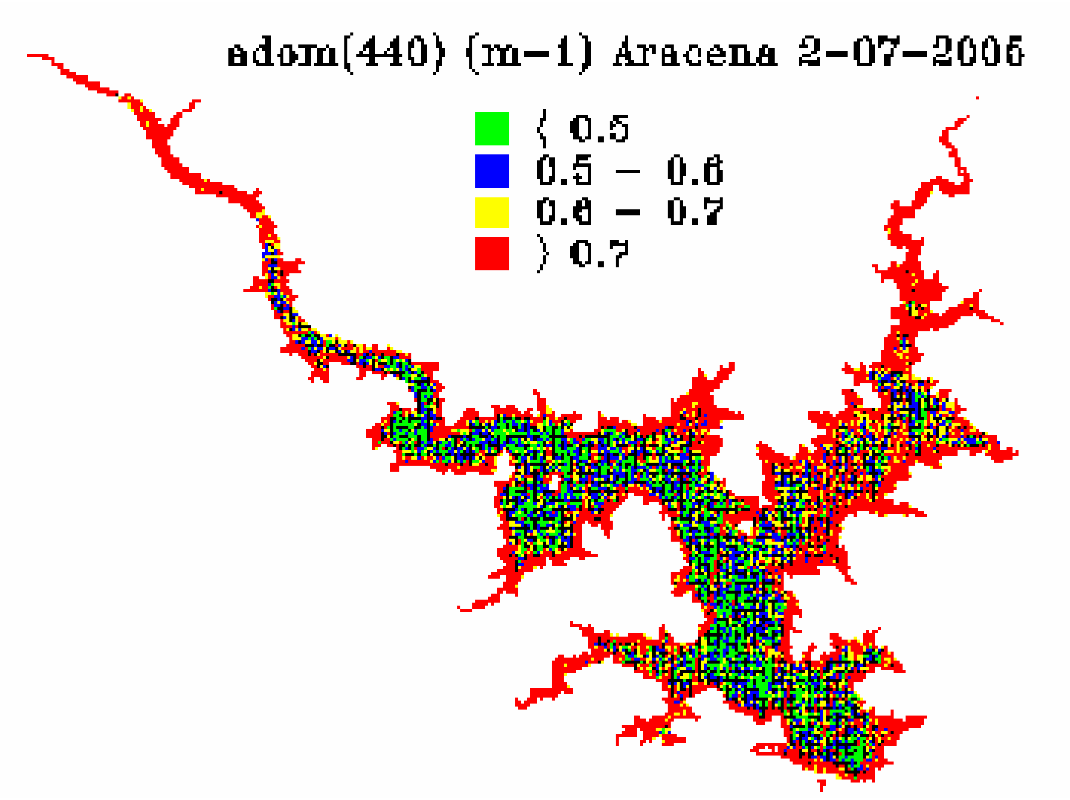




Estimated concentration of CDOM in Aracena dam on the 2th of July 2005: zero viewing angle.



Estimated concentration of $a_{CDOM}(440)$ in Aracena dam on the 2th of July 2005: zero viewing angle.



Semi-analytical model

Irradiance reflectance model by Gordon et al. (1975)

$$R(\lambda)= f\ b_b(\lambda)/a(\lambda)+b_b(\lambda)$$

$$a(\lambda) = a_{ph}(\lambda) + a_d(\lambda) + a_{CDOM}(\lambda) + a_w(\lambda)$$

$$b_b(\lambda)= b_w(\lambda)+b_{bp}(\lambda)$$

$a(\lambda)$: total absorption

$a_{ph}(\lambda)$: phytoplankton absorption

$a_d(\lambda)$: detritus or non-algal particulate matter absorption

$a_{CDOM}(\lambda)$: absorption by chromophoric dissolved organic matter

$a_w(\lambda)$: absorption of the water

$$b_b(\lambda) = b_w(\lambda) + b_{bp}(\lambda)$$

$b_b(\lambda)$: total backscattering
$b_w(\lambda)$: backscattering of pure water
$b_{bp}(\lambda)$: total particulate backscattering

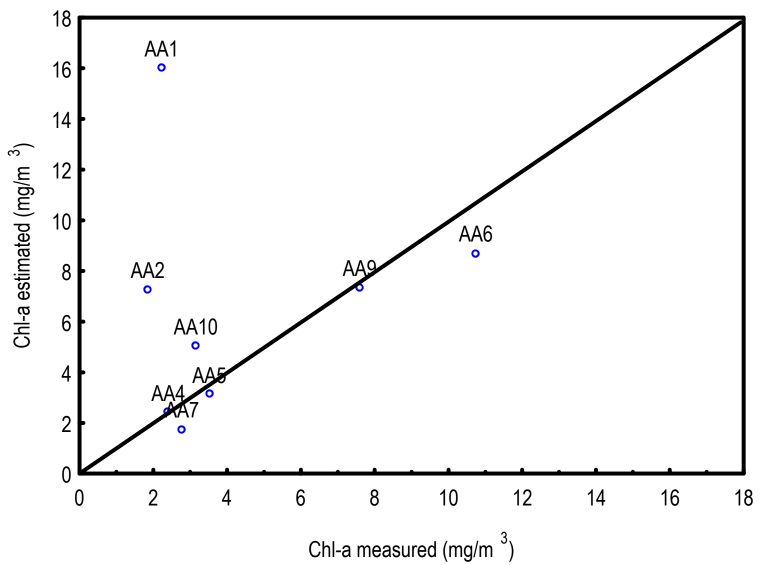
Simplifications:

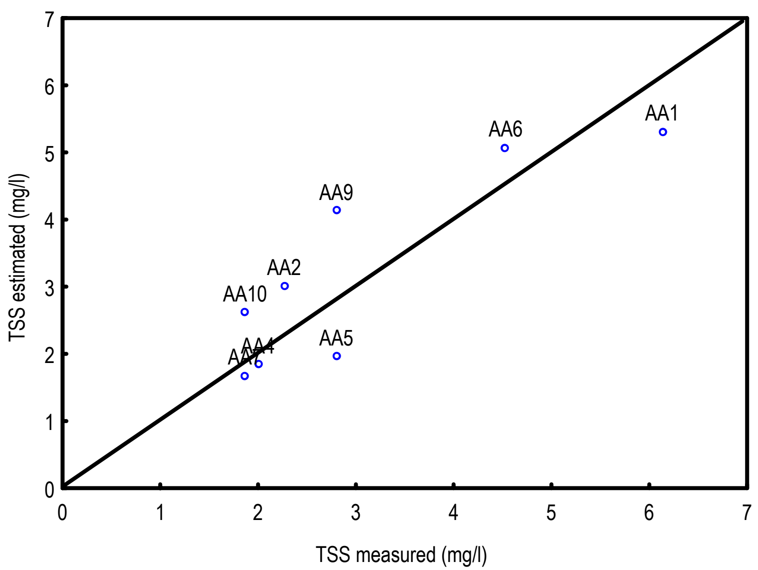
- Air-water correction of remote sensing reflectance above water to subsurface irradiance reflectance
- f and Q (fixed)
- bb(λ) inverted from spectral data
- mean SIOP models of absorption

Method:

Non linear inversion of constituents.

Inversion of constituents with in situ reflectance data





Fit and test of the model:
Q and f estimation
Measurement of $b_b(\lambda)$

Summary and conclusions:

- Striping of low radiance signal of in-land waters can be removed using MNF transformation. Spectral changes must be assesed.
- Different band ratios in the gree-blue spectral range are good predictors of Chl-a and $a_{cdom}(440)$ and in the NIR-Red band ratios for TSS, Turbidity and DOM.
- Estimations of WQ parameters are within the expected range. The main inflow streams and other spatial patterns can be identified in the WQ images estimated with Chris-Proba data.
- SIOP measured can be applied to physically based models.
- CHRIS-PROBA data have high potential for monitoring in land water quality.

Further works

•Seasonal WQ empirical algorithms with field data adquired and validation with 2007 Chris-Proba campaigns.

•Complement SIOP models with bacskcattering measurements, refinement of the semi-analitical model and recovery of water constituents with Chris data.