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 truth data. Reflectance. Constituents. IOP

• Chris-Proba processing
  Destriping.
  Atmospheric correction.
  Georeferencing.

Sampling points in Aracena dam

- 4 field campaigns
- 3 Chris acquisitions
- Only 1 date with simultaneous data
- 2 July 2005
Sampling points Gergal dam

4 field campaigns
2 Chris acquisitions
Only 1 date with simultaneous data
6 June 2005
### Available data 2005-2006

<table>
<thead>
<tr>
<th>Aracena dam</th>
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<th>Chris-Proba</th>
<th>Field data</th>
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Ground Truth

Field spectroscopy measurement
Field spectrometer Ocean Optics (400-800 nm)
Above water reflectance $R(\lambda^+)$.
Spectralon (10% refl.). 45° zenith 135° azimuth
$L_{\text{down}}(\lambda), L_{\text{up}}(\lambda), L_{\text{sky}}(\lambda)$ 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

<table>
<thead>
<tr>
<th></th>
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Sampling points
Aracena dam

Field reflectance spectra
IOP variability

Total particulate absorption.

Total abs. spectra (Aracena 2-07-2005)

- Wavelength (nm)
- Total absorption (m$^{-1}$)

IOP variability

Phytoplankton specific absorption.

![Graphs showing phytoplankton specific absorption coefficients](image-url)
IOP variability

Susp. solids spec. absorption.

Normalized TSS spec.abs.spectra (Aracena 2-07-2005)

<table>
<thead>
<tr>
<th>Sample</th>
<th>S</th>
<th>$a_{ss}(440)$</th>
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<tr>
<td>AA1</td>
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<td>AA2</td>
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<td>Mean</td>
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IOP variability

CDOM absorption.

CDOM absorption spectra (Aracena 2-07-2005)

<table>
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<th>Sample</th>
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<td>AA9</td>
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<td>AA10</td>
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<tr>
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Chris-Proba processing

Destriping by MNF transformation.

Atmospheric correction of inland water

Georeferencing with enough GCP.

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

Original (Chris 0°)  After MNF(Chris 0°)

Spectral Profiles before MNF

Reflectance

Wavelength (nm)

Spectral Profiles after MNF

Reflectance

Wavelength (nm)
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
- Regression on Chris band ratio

Chl-a
Empirical models

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

\[ a_{\text{CDOM}}(440) \]
Empirical models

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

\[ \text{Chl-a} = 32.18 - 29.95 \times \frac{b4}{b8} \]

\[ R^2 = 0.935 \]
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
- Regression on Chris band ratio

\[ \text{TSS} = 27.41 - 25.09 \frac{b9}{b18} \]
\[ R^2 = 0.878 \]

\[ \text{Turbidity} = -22.18 + 20.63 \frac{b12}{b16} \]
\[ R^2 = 0.7749 \]
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
- Regression on Chris band ratio

\[
\text{DOM} = 42.33 - 28.48 \times \frac{b9}{b18} \\
R^2 = 0.819
\]

\[
a_{\text{cdom}(440)} = 1.383 - 1.171 \times \frac{b2}{b7} \\
R^2 = 0.73
\]
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)
\[ R(\lambda) = f \frac{b_b(\lambda)}{a(\lambda)} + b_b(\lambda) \]

\[ a(\lambda) = a_{ph}(\lambda) + a_d(\lambda) + a_{CDOM}(\lambda) + a_w(\lambda) \]
\[ b_b(\lambda) = b_w(\lambda) + b_{bp}(\lambda) \]

- \( a(\lambda) \): 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)
- \( b_b(\lambda) \) 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 assessed.

• Different band ratios in the green-blue spectral range are good predictors of Chl-a and $a_{\text{cdom}}(440)$ 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 acquired and validation with 2007 Chris-Proba campaigns.

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