SURFACE REFLECTANCE AND UNDERWATER DOWNWELLING IRRADIANCE IN ALQUEVA RESERVOIR, SOUTHEAST PORTUGAL

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PROAMBIENTE

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Outline

- Introduction
- Data
- Validation of satellite data
- Water surface reflectance
- Underwater downwelling irradiance
- Summary
- Next step
- Acknowledgments

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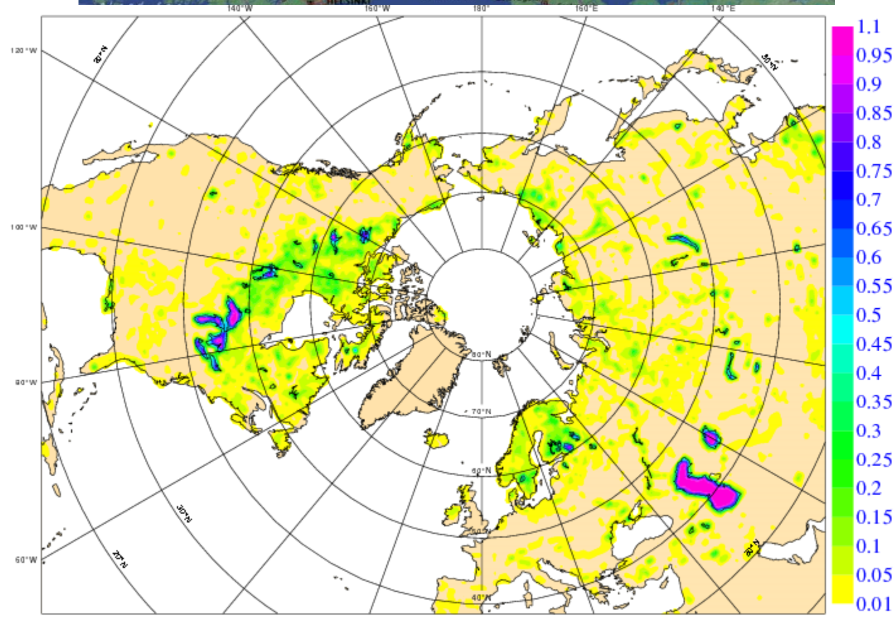
Why Lakes/Reservoirs ?

Lakes are an important component of the land surface, influencing the weather at different scales. Some regions can be highly influenced by the presence of lakes:

- The boreal zone (10% of the area of Finland)
- Eastern Africa and American Great Lakes
- **In many regions (example of the Mediterranean basin) dams and reservoirs have been constructed**

Lakes in Finland and Karelia region



Lake Cover fraction in ECMWF

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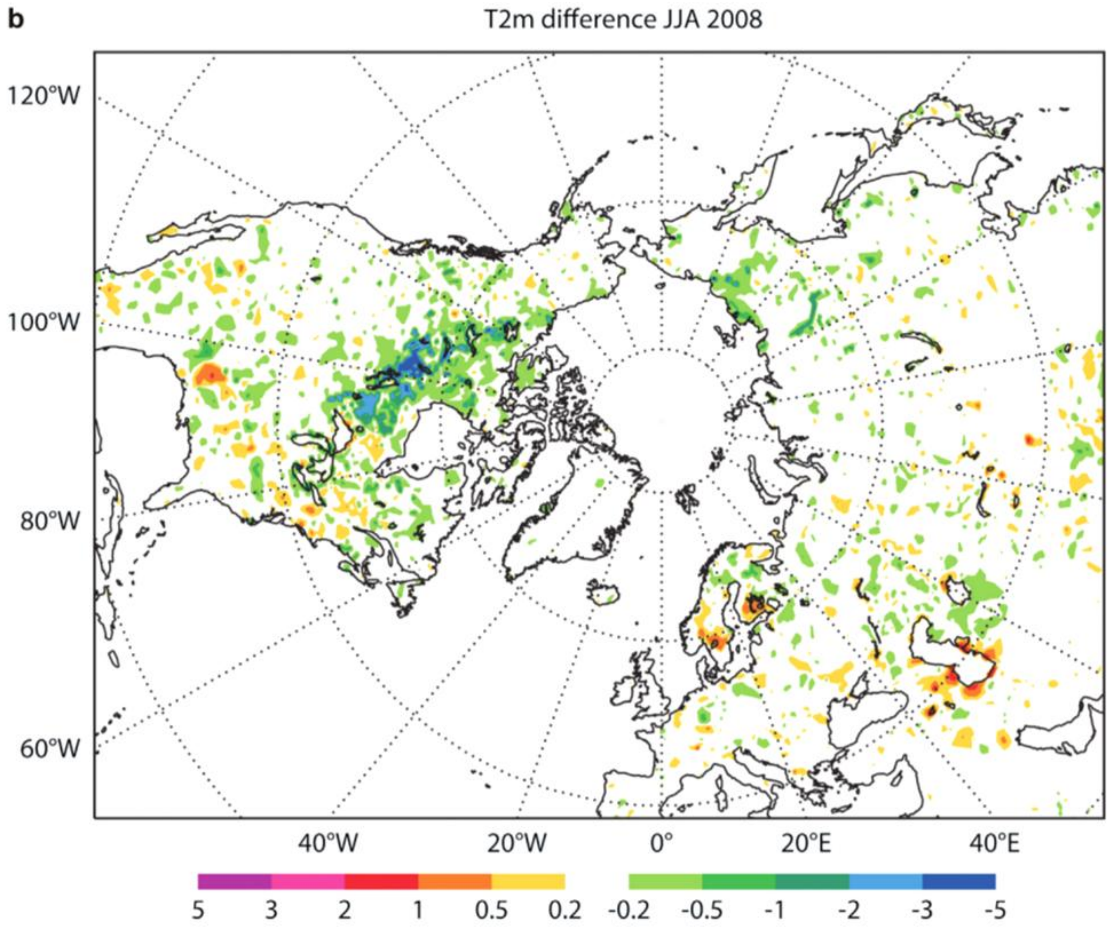
Importance of Lakes/Reservoirs (Example)



- ECMWF IFS with FLAKE Sensitivity of 48-hour T2m forecasts (valid at 00 UTC) for **LAKE** compared with **NOLAKE** for summer.

- In summer the cooling effect is pronounced, due to incoming radiation that is stored in the lakes.

- Lakes can release more latent heat than dry land

(Balsamo *et al.*, 2012)

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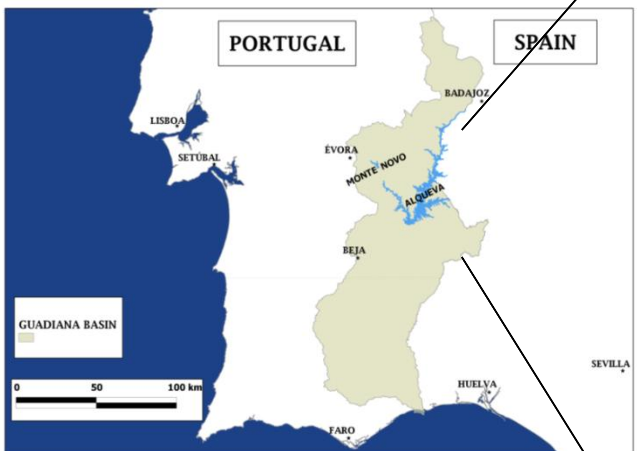
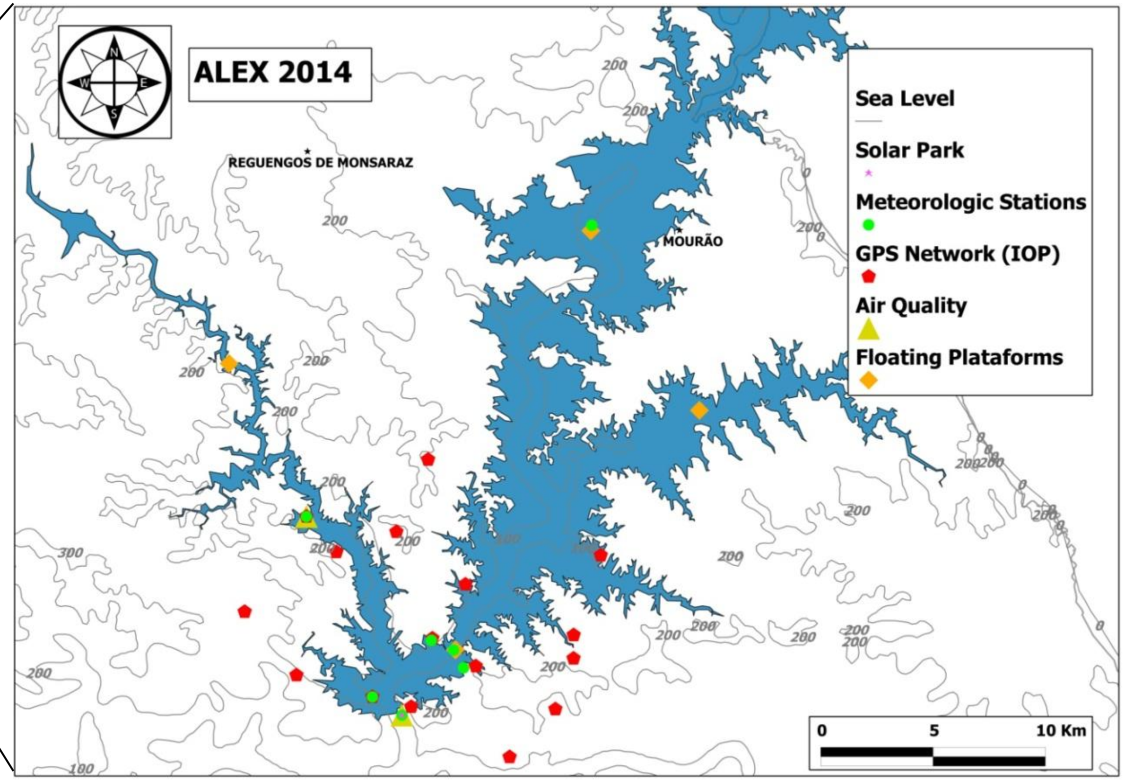
Alqueva reservoir





Alentejo Region:
Köppen classification: Csa
Annual precipitation: 571,8 mm
Number of days above 30ºC: 77.1

Surface area of 250 km^2
Gates were closed in 2002

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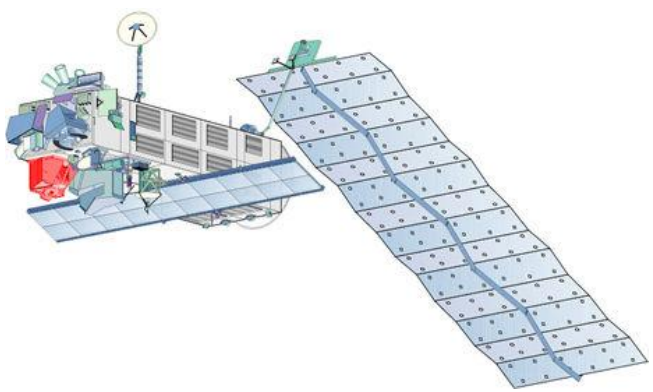
Data

SATELLITE



ATMOSPHERIC

FIELD

LABORATORY

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FieldSpec UV/VNIR

A Portable spectroradiometer from ASD - FieldSpec UV/VNIR was acquire in 2008 by Evora Geophysic Centre from University of Évora (http://www.cge.uevora.pt/en).

- 325 – 1075 nm range
- Absolute or relative measurements of light energy
- 3 nm spectral resolution at around 700 nm
- 1, 10, 25 and 180 degrees of view angle
- 17 ms to several minutes of integration time

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FieldSpec UV/VNIR measurements

- **Spectral water surface reflectance** over Alqueva reservoir
  - Validation of atmospheric correction of satellite remote sensing reflectance
  - Review of spectral absorption bands of biologic quantities

- **Underwater spectral downwelling zenith (ir)radiance** at Evora Municipal Swimming complex and Alqueva reservoir
  - Attainment of underwater ir(radiance) profiles until 3 m depth
  - Estimation of spectral attenuation coefficient of the water column

GOAL

- Implementation of remote sensing algorithms to daily monitor (or close) all surface area of Alqueva reservoir in terms of physical and biological quantities.

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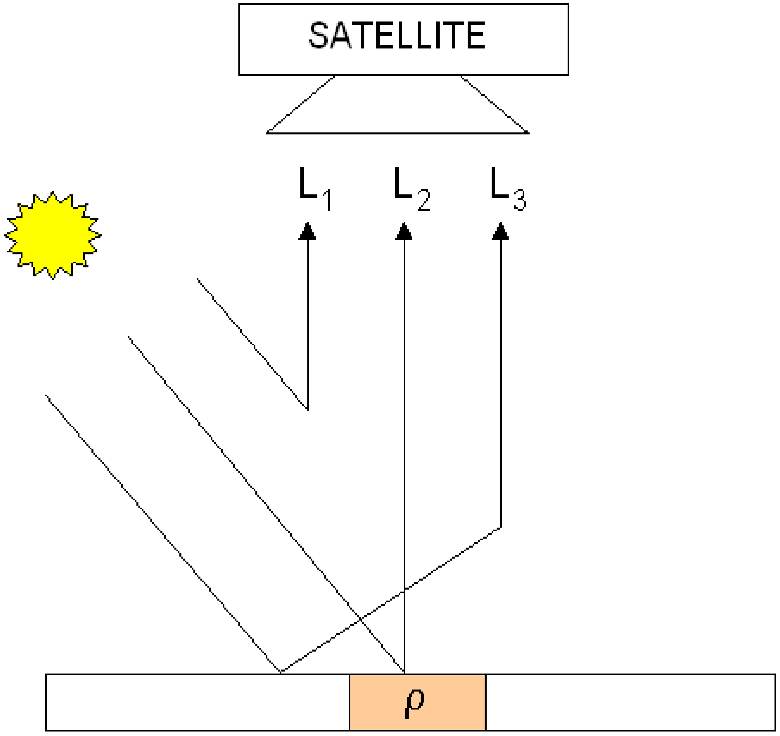
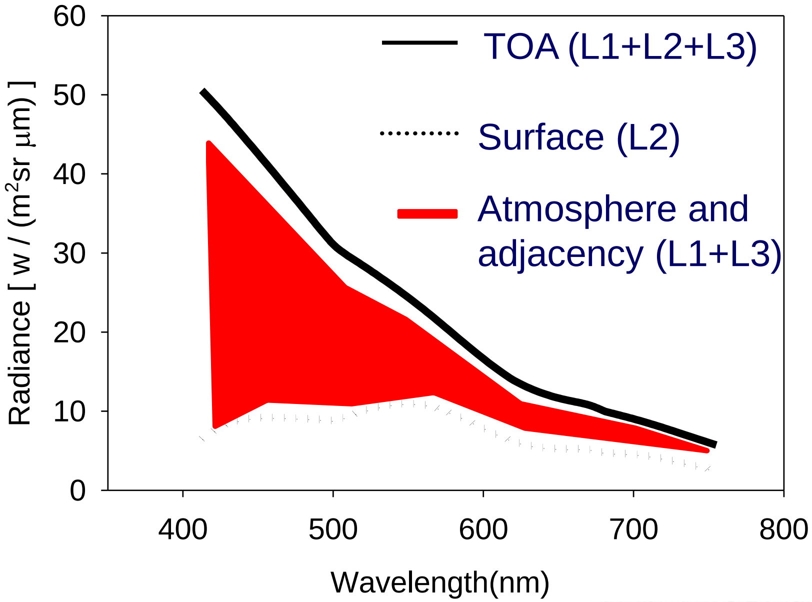
Atmospheric correction of satellite data



L1 : Radiation scattered by the atmosphere

L2 : Reflected radiation from the viewed pixel

L3 : Radiation reflected by the neighborhood and scattered into the view direction (adjacency effect)



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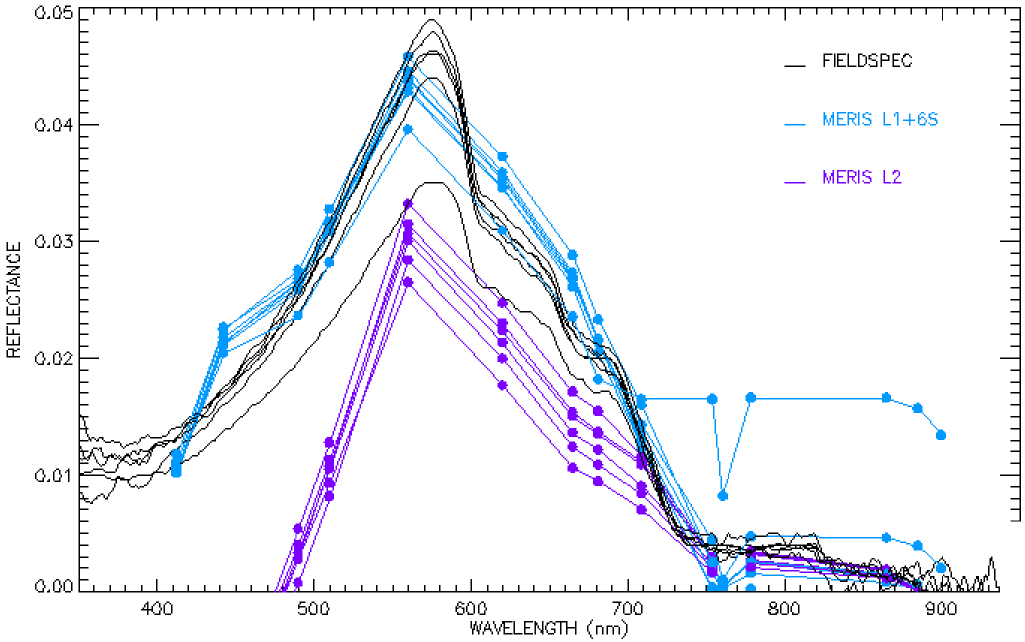
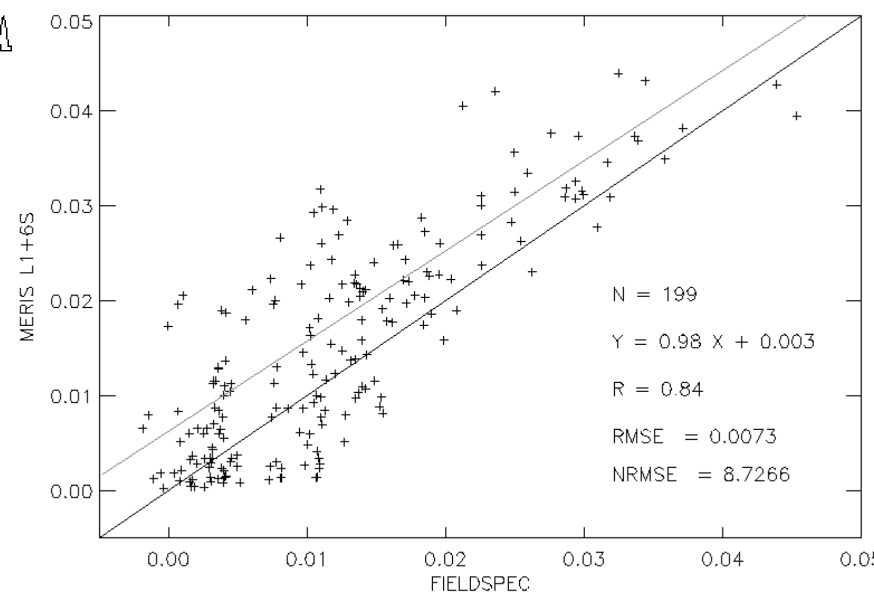
Satellite and in situ water reflectance



- FieldSpec
- MERIS L1 + 6S (atmospheric correction)
- MERIS L2

R = 0.84
RMSE = 0.0073



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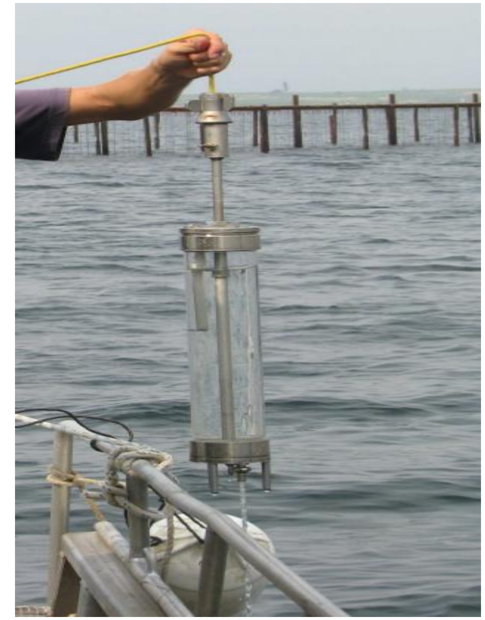
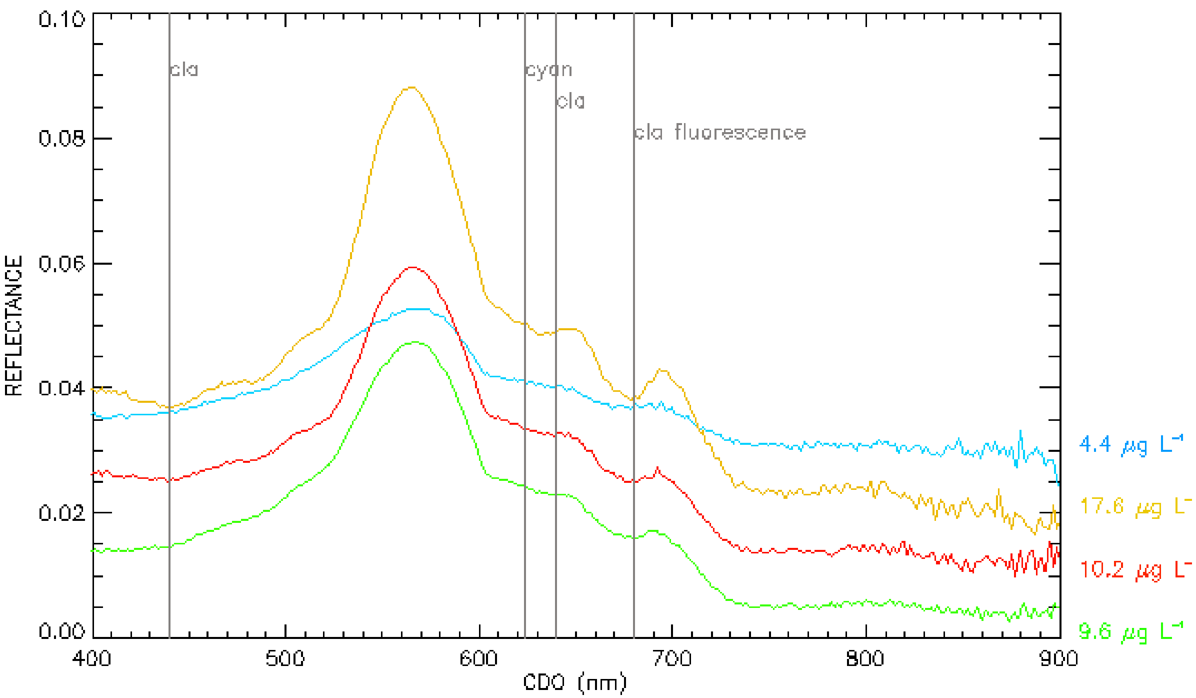
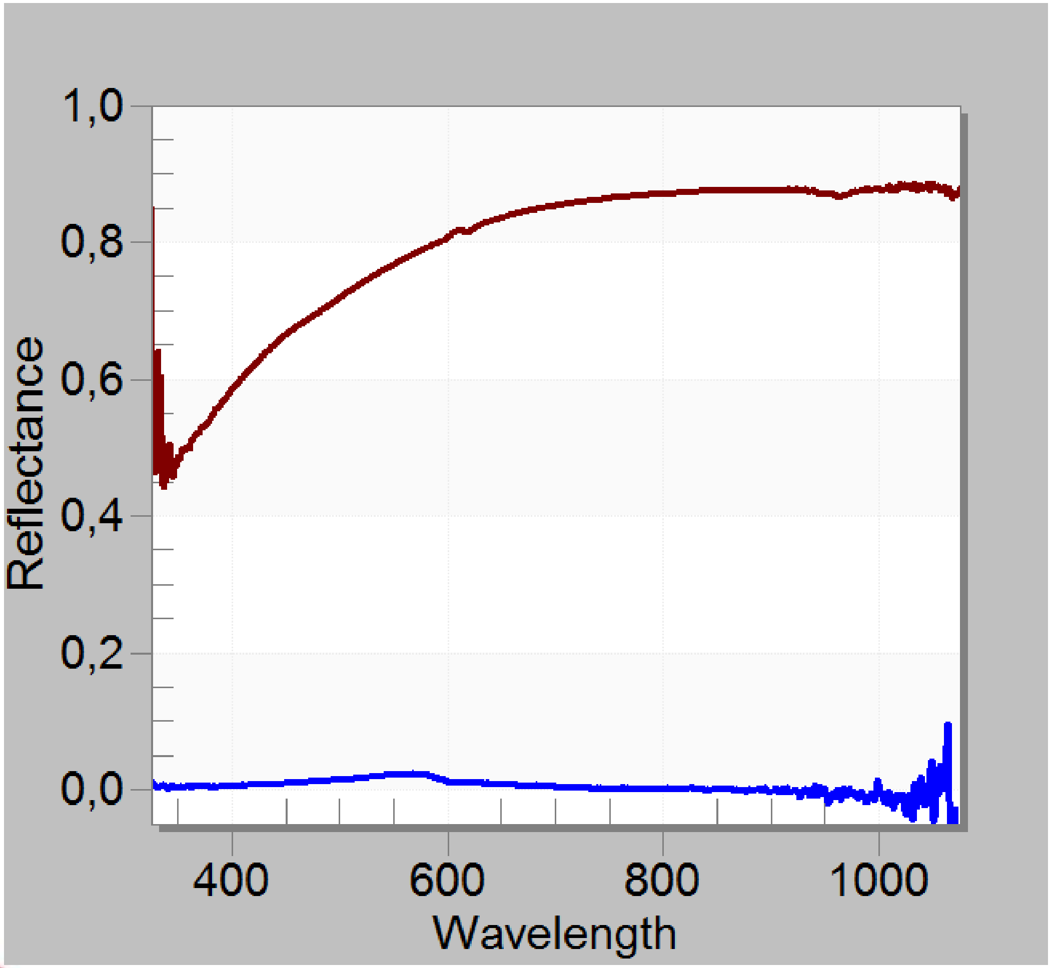
Water reflectance and Chlorophyll a





Chlorophyll a has special absorption bands that change the spectrum through its concentration allowing spectral remote sensing detection

Water vs Petalite reflectance



It's a mineral composed by silica

The target here isn´t the boat!
It is the dark green colored water!

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Biological algorithms

Remote sensing of water quality parameters in Portugal 3385

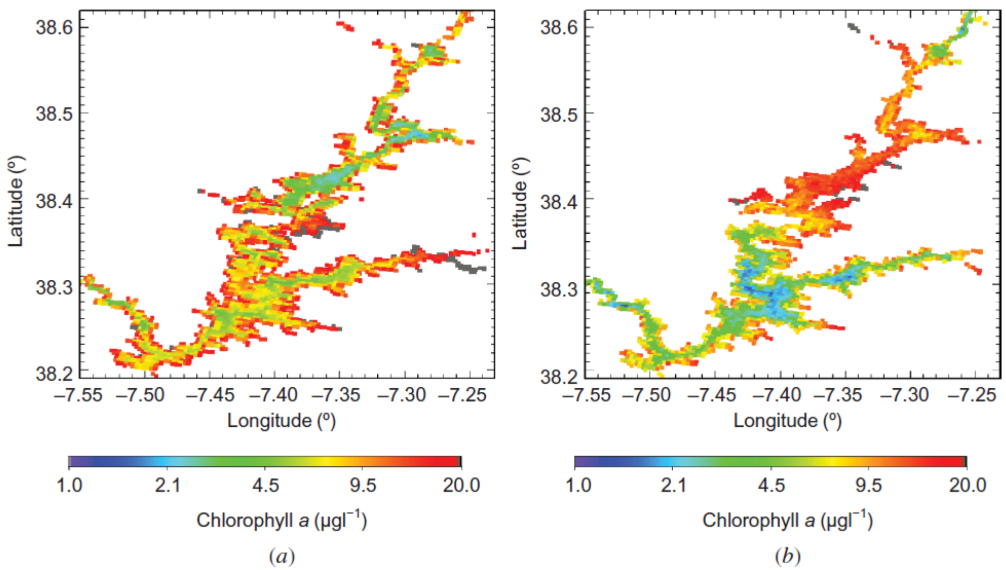

Figure 7. Chlorophyll *a* concentration maps over the whole Alqueva Reservoir surface for the year 2007: (*a*) 5 June; (*b*) 14 November.

The results of this work indicate that the methodology proposed allows the regular and inexpensive water quality monitoring, in terms of chlorophyll and cyanobacteria concentration.

Potes et al., 2011

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Underwater Equipment

A portable FieldSpec UV/VNIR (ASD, Inc) is used to measure spectral irradiance coupled to a protector and directional frame by an optical cable which guide the light from a the tip to the fieldspec. A hemispherical tip (180º FOV) was built to have measurements independent of solar zenith angle.

FieldSpec UV/VNIR

Optical cable

180º FOV

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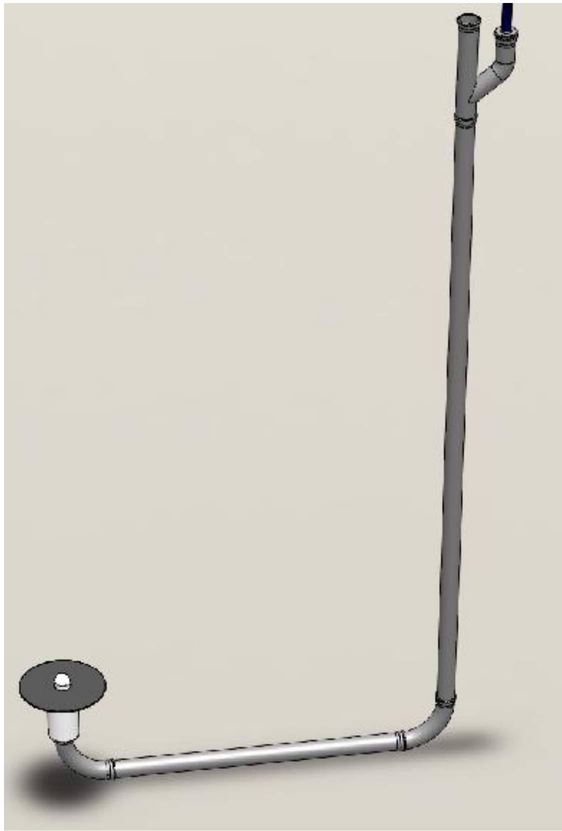
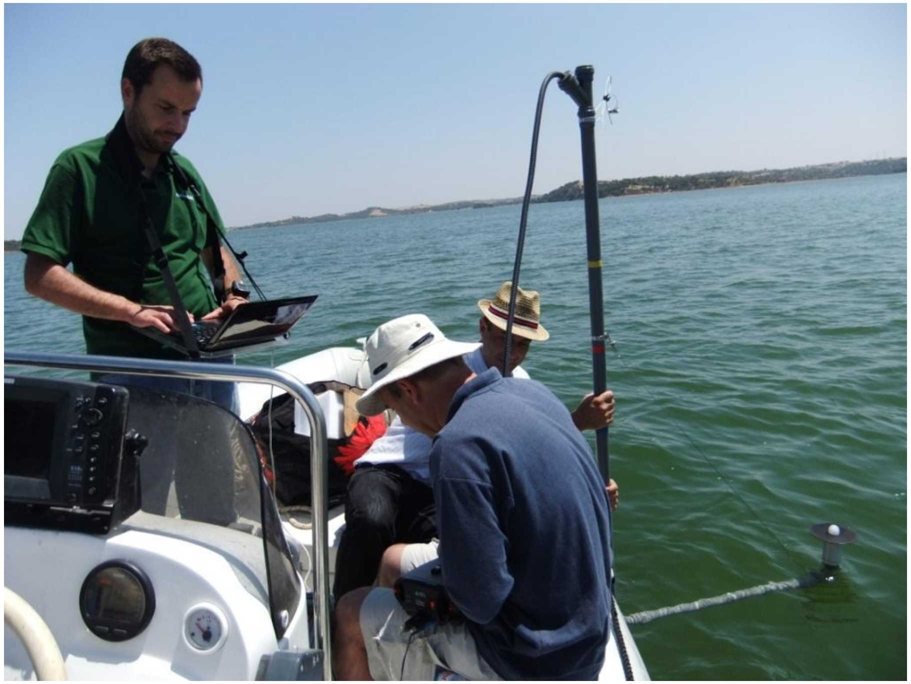
Underwater apparatus developed by the team





- Portability
- Limited to **clear sky days**. A profile (3 m depth) takes in average 4 minutes and during this period the atmospheric condition should be the same.

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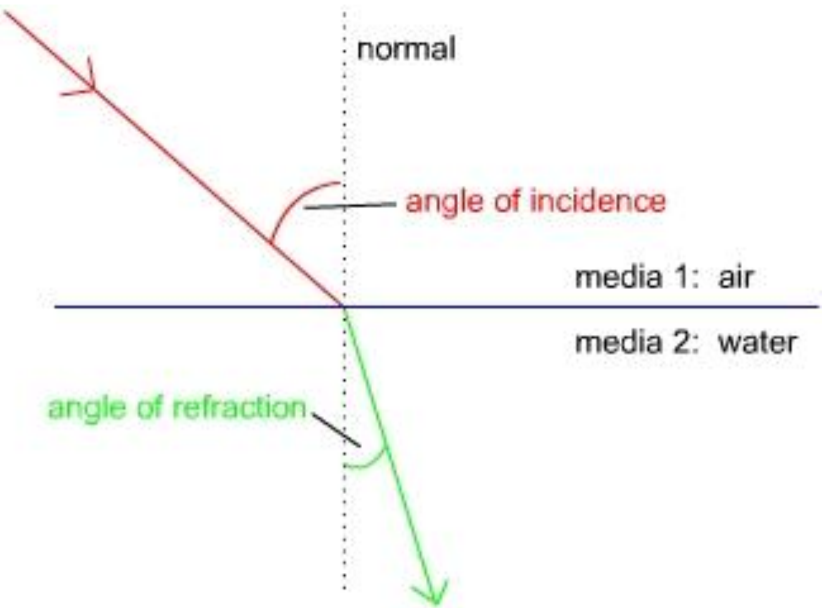
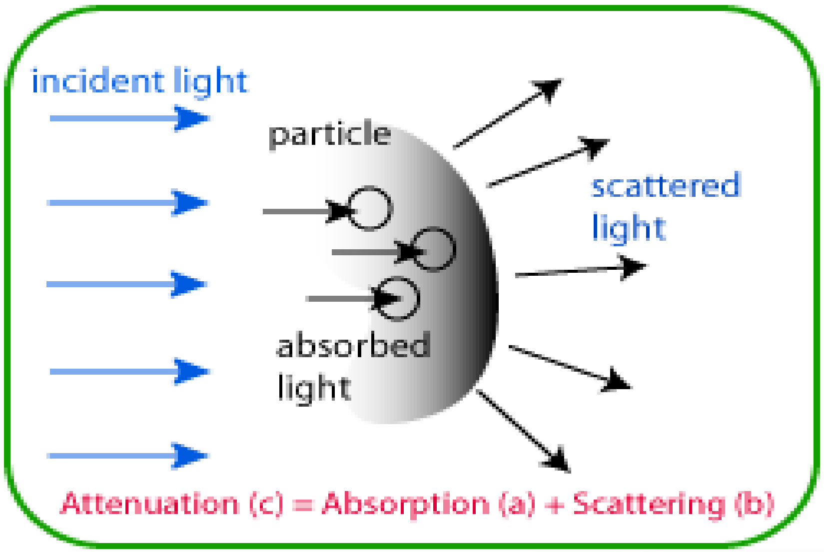
Downwelling irradiance profile -> Attenuation coefficient

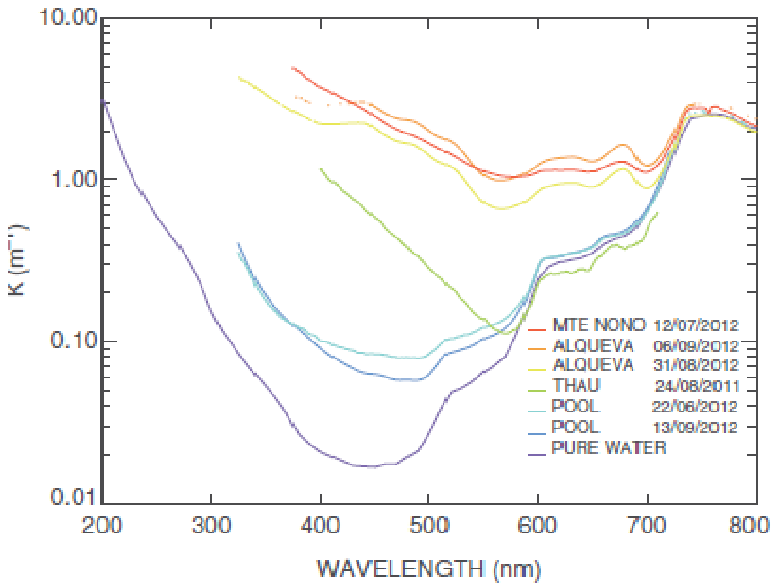
$$\frac{-1}{E(z,\theta,\phi,\lambda)}\frac{dE(z,\theta,\phi,\lambda)}{dz} = K(z,\theta,\phi,\lambda)$$

Preisendorfer, 1958





Attenuation coefficient outcome



ig. 8. Spectral attenuation coefficient for pure water obtained om Smith and Baker (1981) and for five cases of the campaigns uring the summers of 2011 and 2012, derived from eq. (5).

This is spectral attenuation coefficient measured in different water types, in several field campaigns, with a portable fieldspec coupled to an optical fiber and a radiance/irradiance underwater receptor.

Potes et al., TellusA, 2013

K = 1.0 m^{-1}

K = 6.1 m^{-1}

1630 M. Potes et al.: Satellite remote sensing of water turbidity in Alqueva reservoir

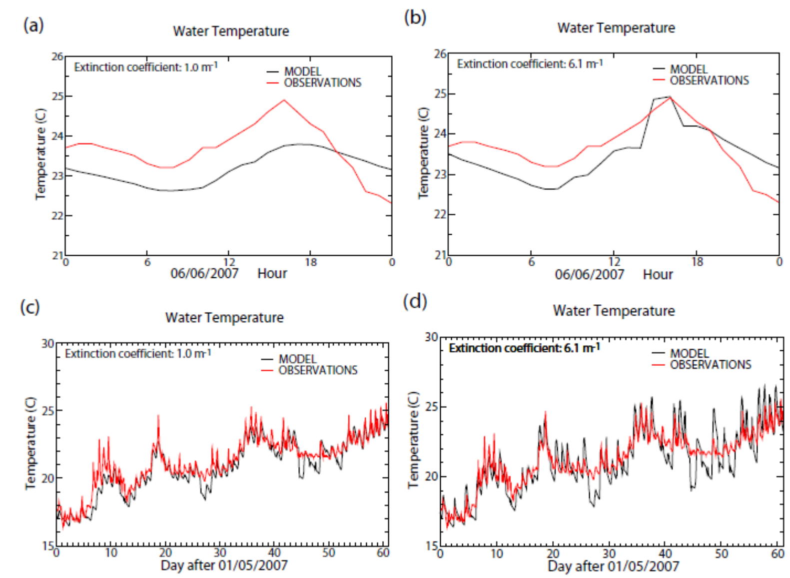


Fig. 6. Comparison between the lake water surface temperature observed and modeled with FLake for: **(a)** 6 June 2007 with an extinction coefficient of 1.0 m^{-1} (simulation Mo10); **(b)** 6 June 2007 with an extinction coefficient of 6.1 m^{-1} (simulation Mo61); **(c)** May and June 2007 with an extinction coefficient of 1.0 m^{-1} (simulation Mo10); **(d)** May and June 2007 with an extinction coefficient of 6.1 m^{-1} (simulation Mo61).

FLake model (Mironov et al., 2010) represents better the daily cycle of water temperature with attenuation coefficient of 6.1 m^{-1}.

Potes et al., HESS, 2012

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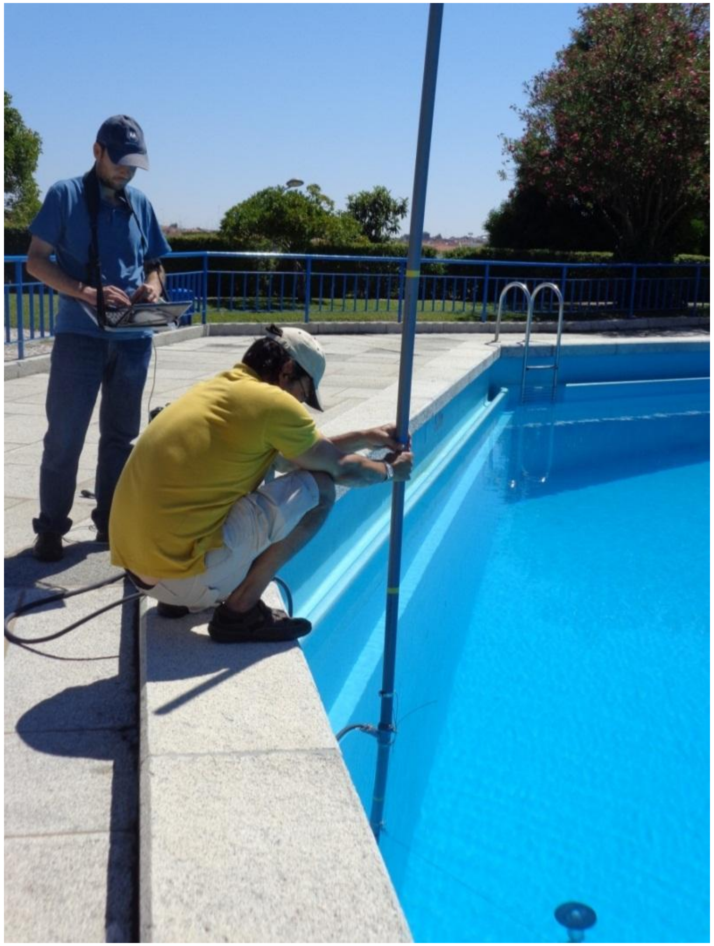
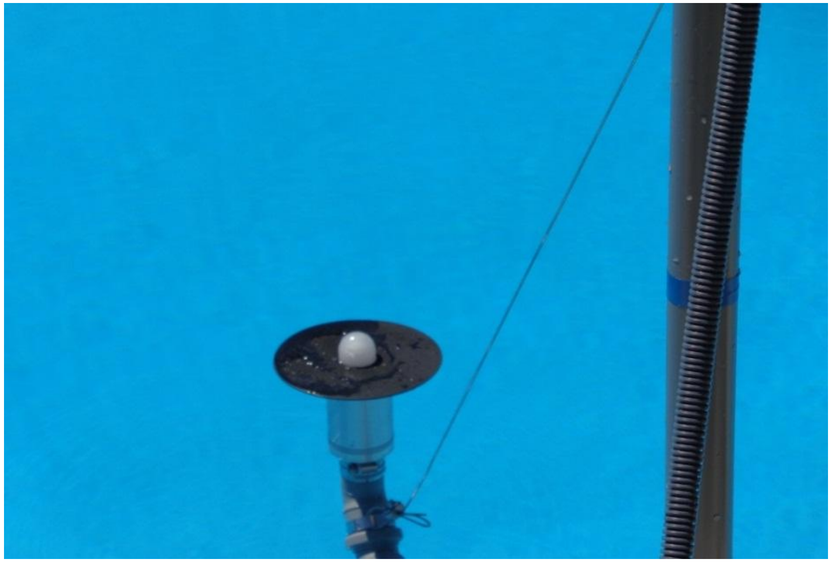
Tests in Evora Swimming Complex





This is the reservoir !

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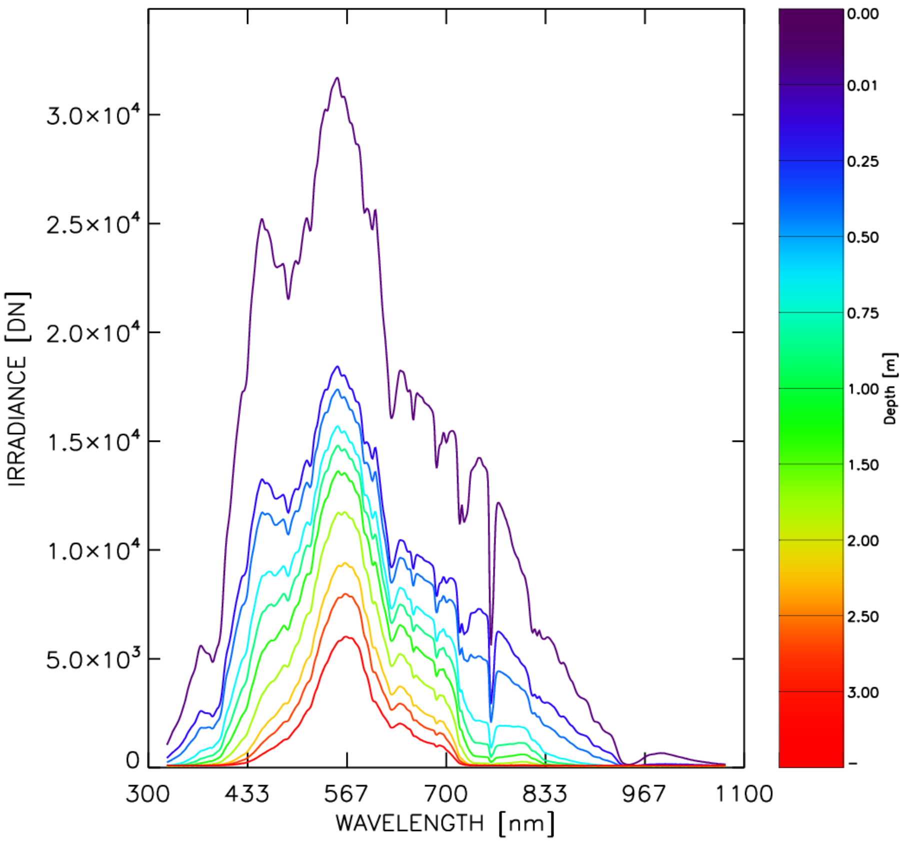
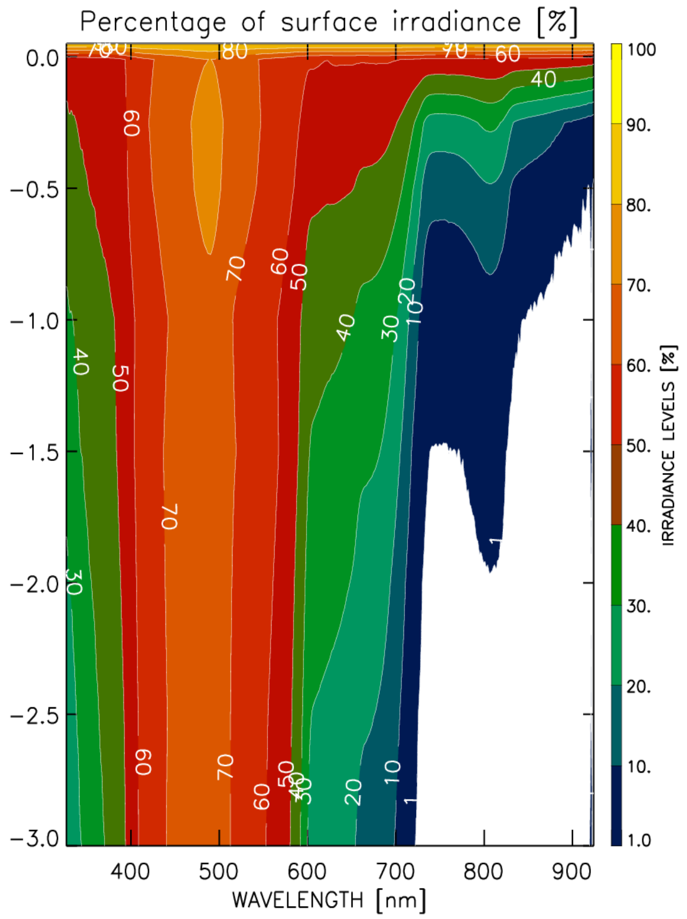
Tests in Evora Swimming Complex

Solar zenith angle = 18,24º
All spectrum decreasing irradiance with depth.





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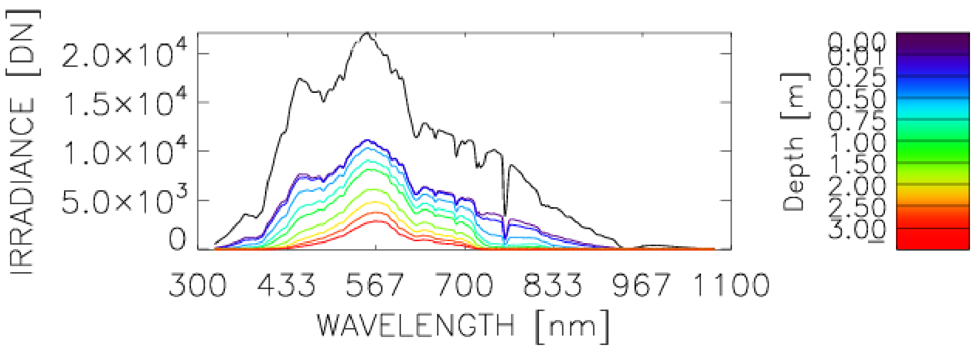
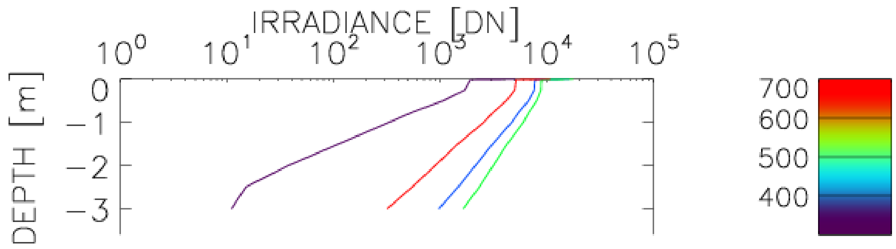
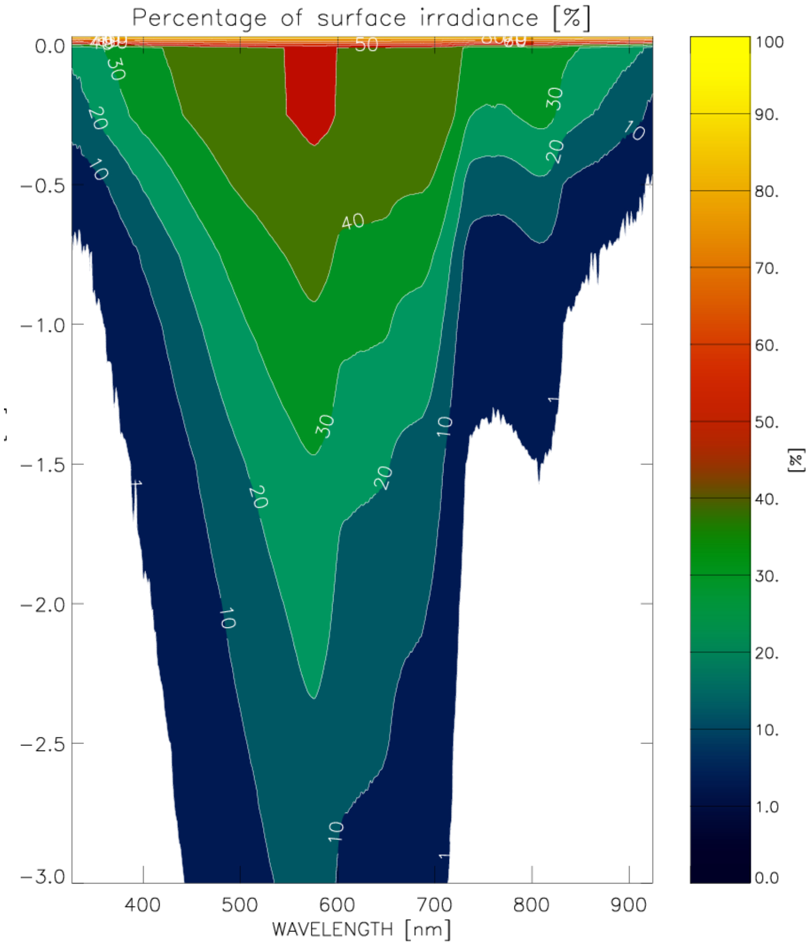
Measurements in Alqueva Reservoir







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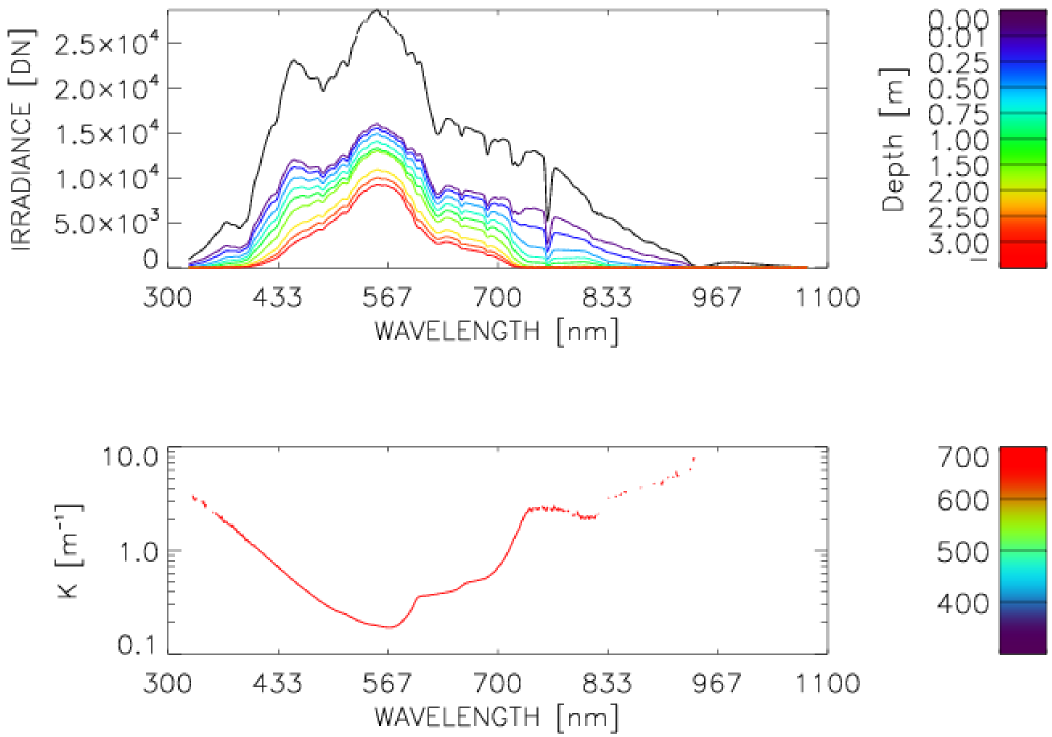
Irradiance and Attenuation Coefficient

$$\frac{-1}{E(z,\theta,\phi,\lambda)}\frac{dE(z,\theta,\phi,\lambda)}{dz} = K(z,\theta,\phi,\lambda)$$

Preisendorfer, 1958



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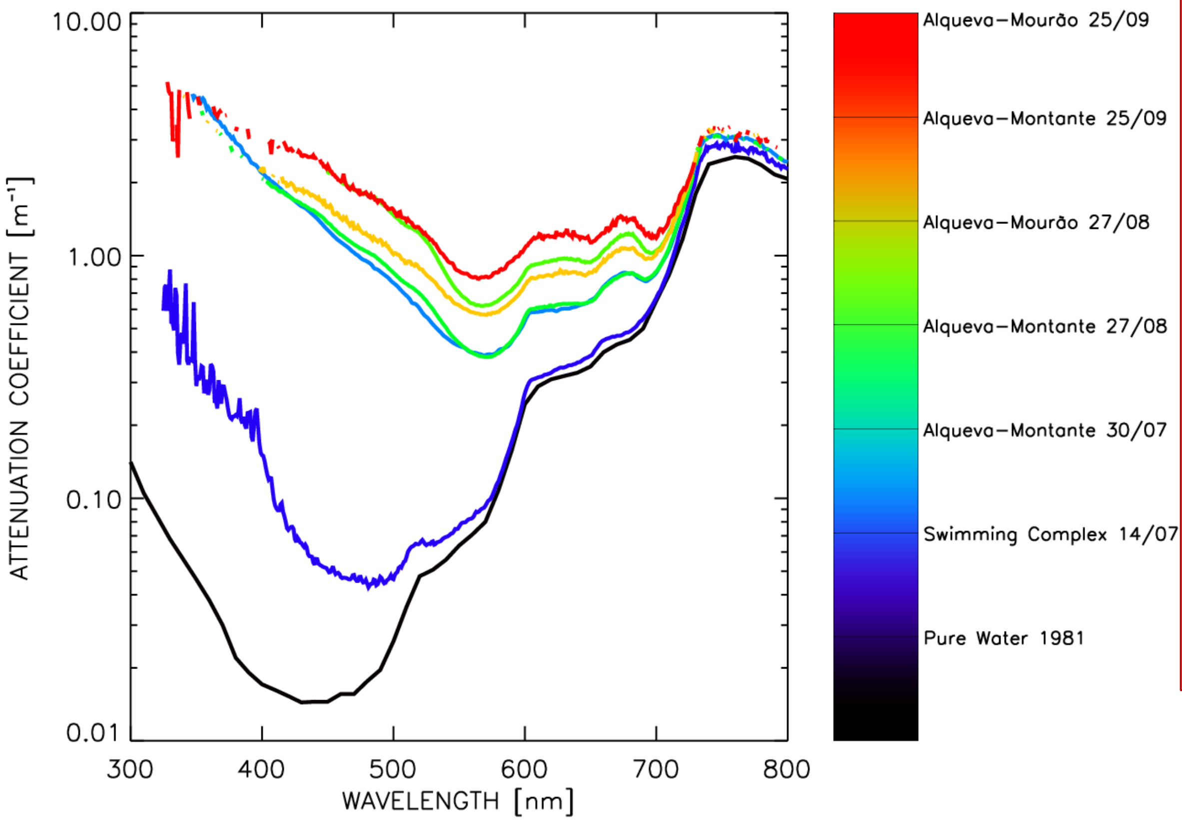
Attenuation coefficient and water type



Alqueva Reservoir K PAR (400-700 nm) between 0.85 and 1.46 m^{-1}

Pool K PAR = 0.2 m^{-1}

Pure water K PAR ≈ 0.05 m^{-1}

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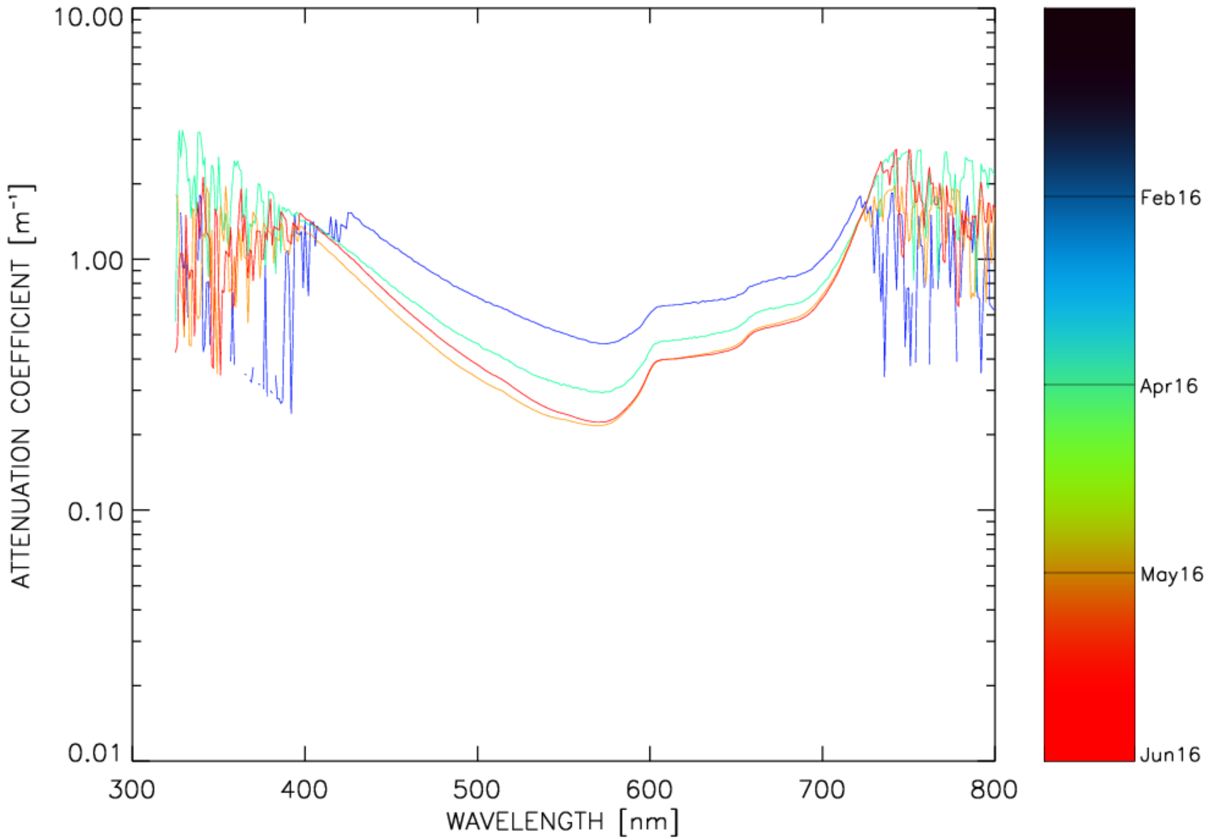
Attenuation coefficient and turbidity



K PAR (m^{-1})	Turbidity (FNU)
0.79	10.56
0.58	8.89
0.48	8.42
0.51	8.41

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Next Step

- Use the attenuation coefficients obtained in Alqueva reservoir together with satellite data and develop an algorithm capable to estimate this coefficient.
- Test the algorithm in other lakes and reservoir for global estimation of this coefficient with a possible database in mind.

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OBRIGADO!

GRACIAS !

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