INTERACTIONS LAKE-ATMOSPHERE UNDER MEDITERRANEAN CONDITIONS: ALEX 2014 OBSERVATIONS AND SIMULATIONS

R. Salgado, M. Potes, C. Policarpo, P. Le Moigne and ALEX 2014 Scientific team

Institute of Earth Sciences (ICT) Évora, University of Évora, Portugal
CNRM-GAME, METEO FRANCE, France

ALEX2014
ALqueva hydro-meteorological EXperiment

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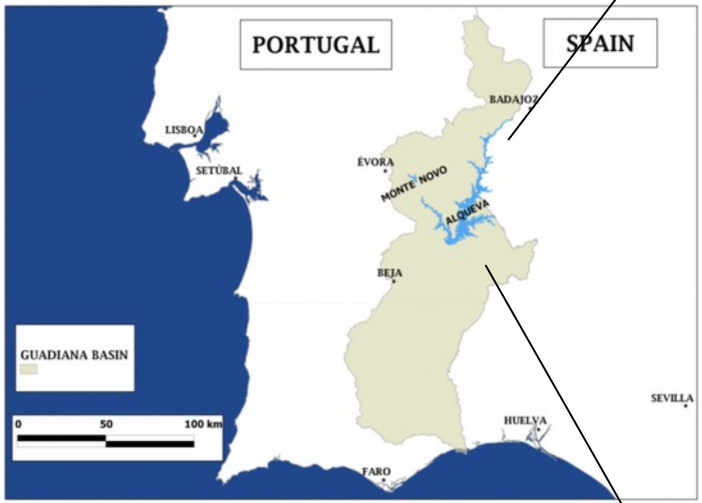
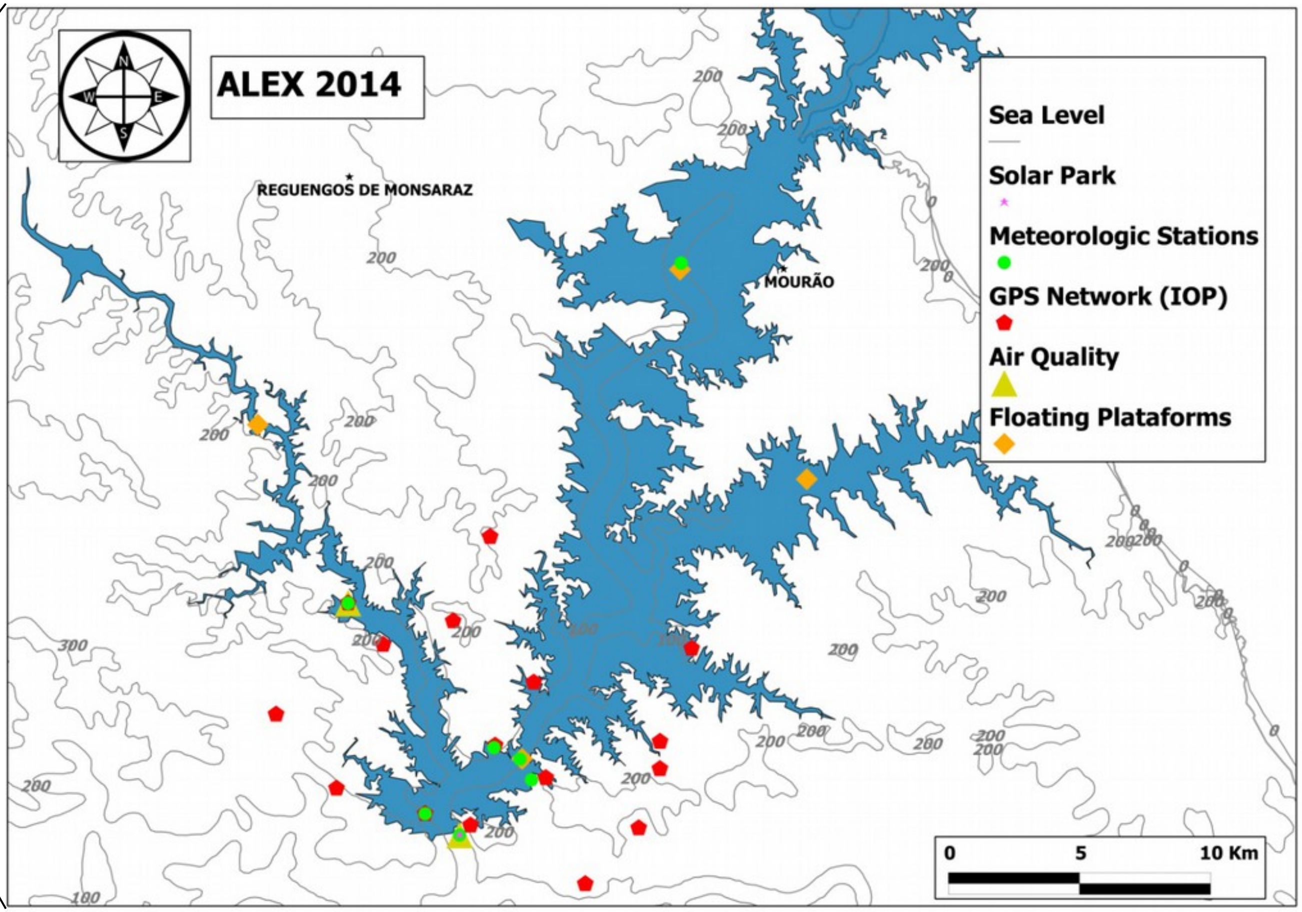
The Alqueva and the region





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

ALEX2014 field campaign

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Understanding and predicting the complex interactions between climate, hydrology, ecosystem processes, water quality and biodiversity form the basis for a future sustainable management of Mediterranean systems and are important to:

- Improve the representations of lakes in NWP models (improve weather forecast and access climate impacts of man made lakes)
- Fulfil the requirements of the Water Framework Directive
- Improve the environmental management of the reservoir.

ALEX2014 field campaign

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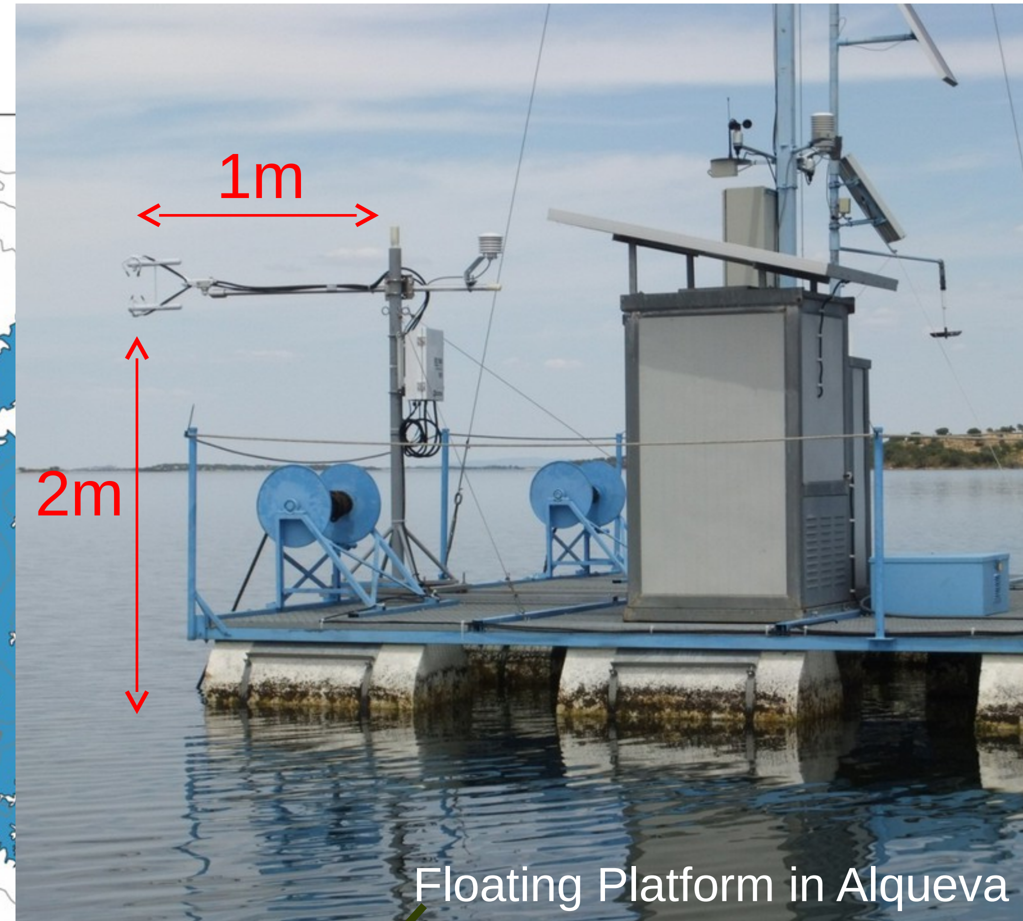
The ALqueva hydro-meteorological EXperiment, ALEX 2014

- An integrated field campaign with measurements of chemical, physical and biological parameters at different experimental sites in the Alqueva reservoir and in its surrounding region.
- With the purpose of studding the lake-atmosphere interactions
- From June to September and comprised a three days Intensive Observation Period (IOP) from 22 to 24 July.
  - Meteorological and flux measurements
  - Solar resource
  - Water quality – Chemical and phytoplankton composition
  - Inwater solar attenuation
  - Air quality - Atmospheric, aerosols and gases measurements
  - Water vapour mapping through GPS network (IOP)
  - Radiossondes with Meteorology and Atmospheric Electricity components (IOP)

Eddy covariance measurements

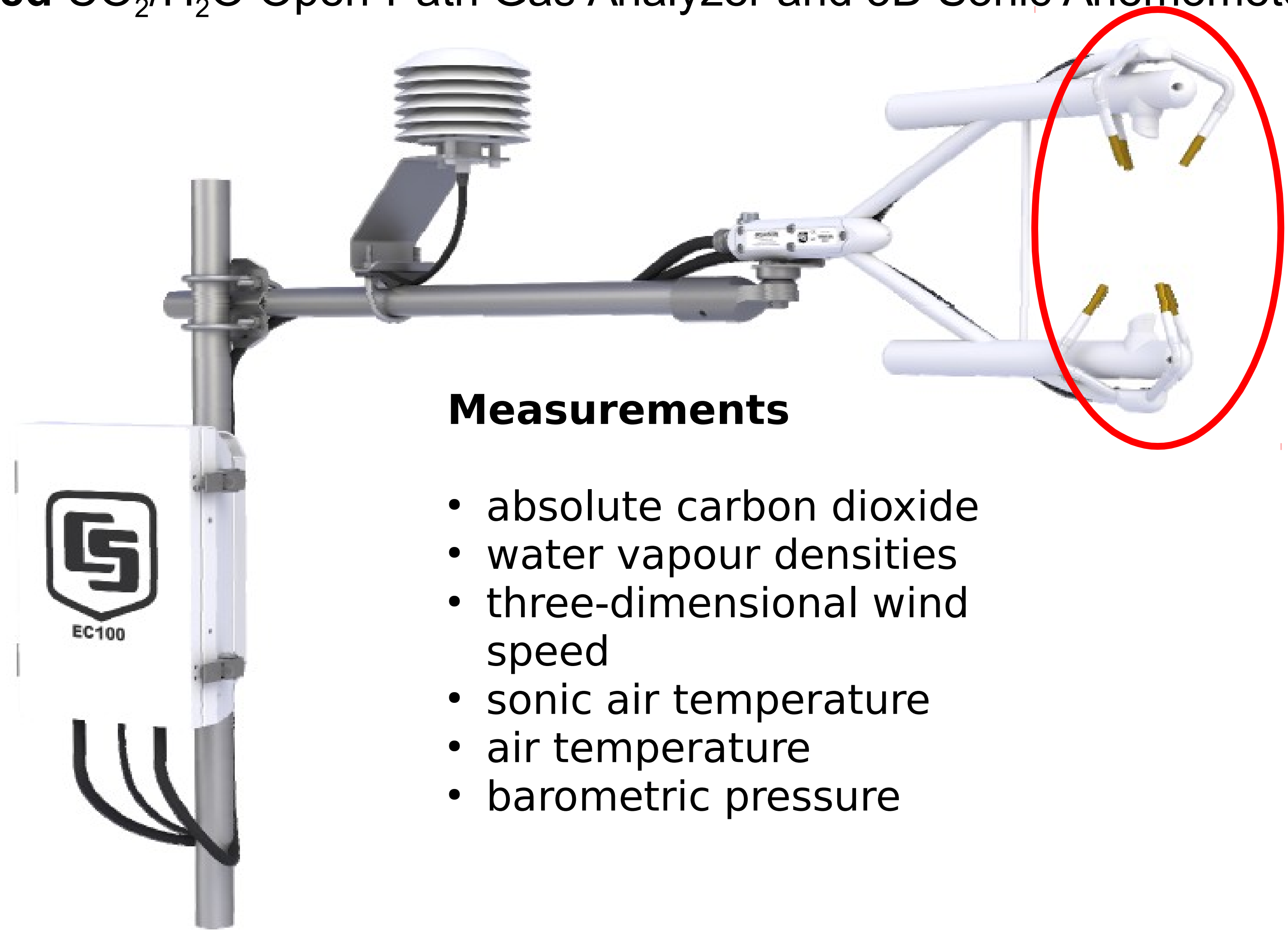
- Energy fluxes (radiative and sensible and latent heat), CO_2 and H_2O over the reservoir

Built-in accelerometer in Waspmote board – Libelium to compute the vertical velocity of the arm



Eddy covariance system - IRGASON

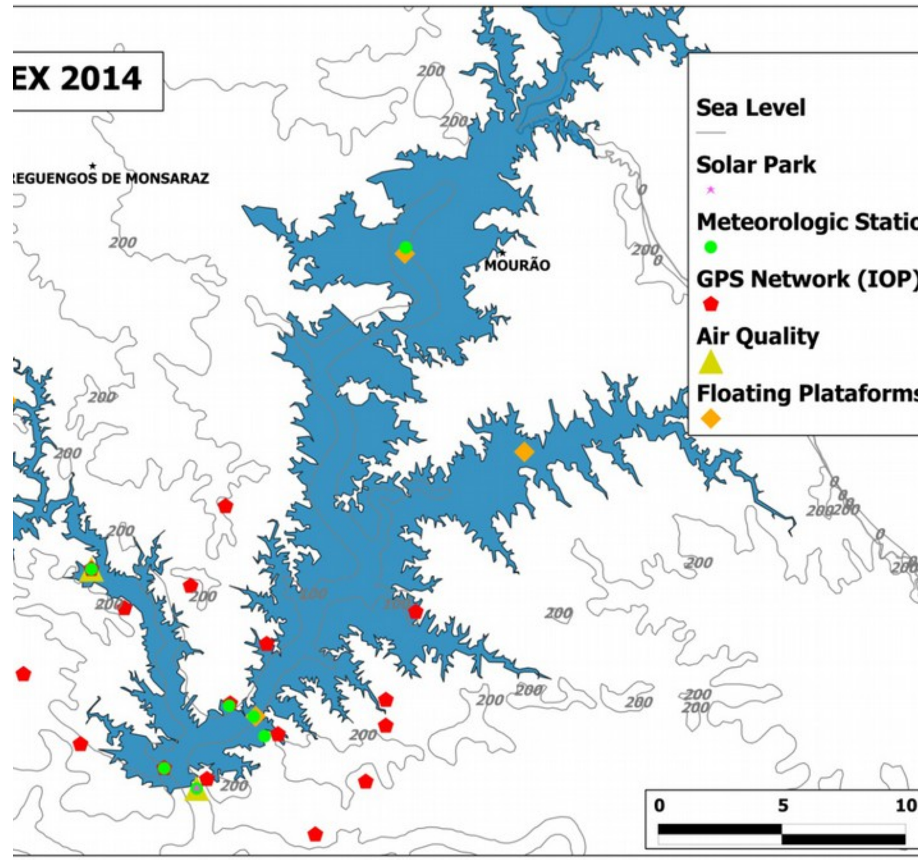
Integrated CO_2/H_2O Open-Path Gas Analyzer and 3D Sonic Anemometer



Measurements

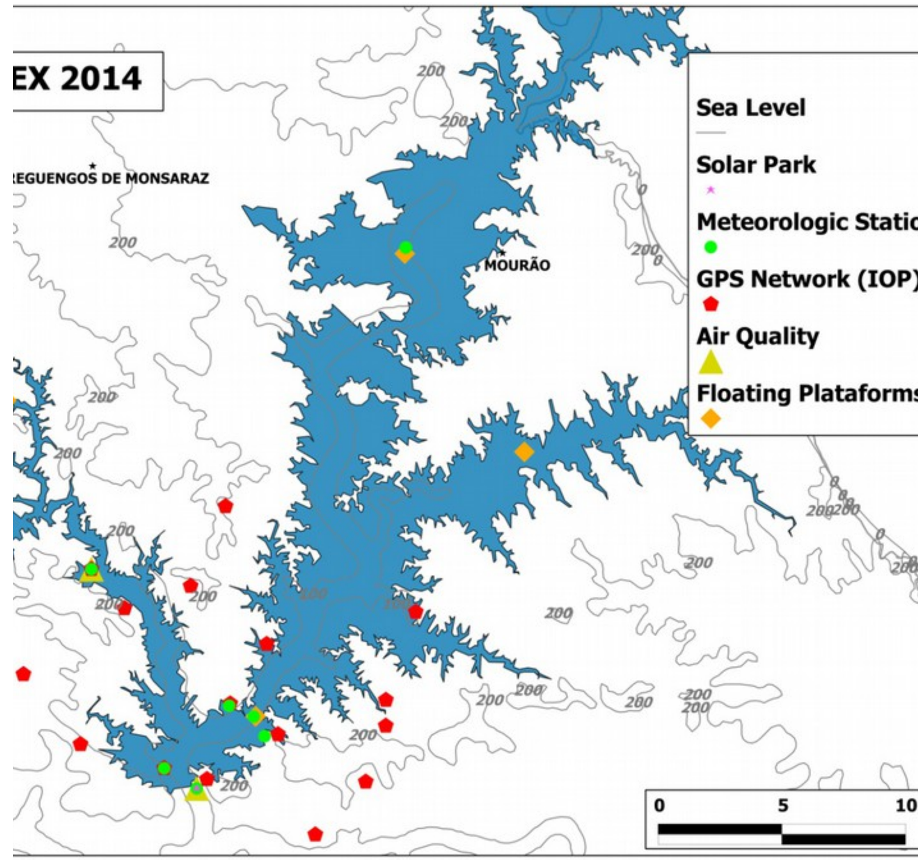
- absolute carbon dioxide
- water vapour densities
- three-dimensional wind speed
- sonic air temperature
- air temperature
- barometric pressure

Weather stations



- near surface meteorological stations: temperature, humidity, wind, precipitation and pressure.
- 7 automatic weather stations were in place
  - upwind and downwind

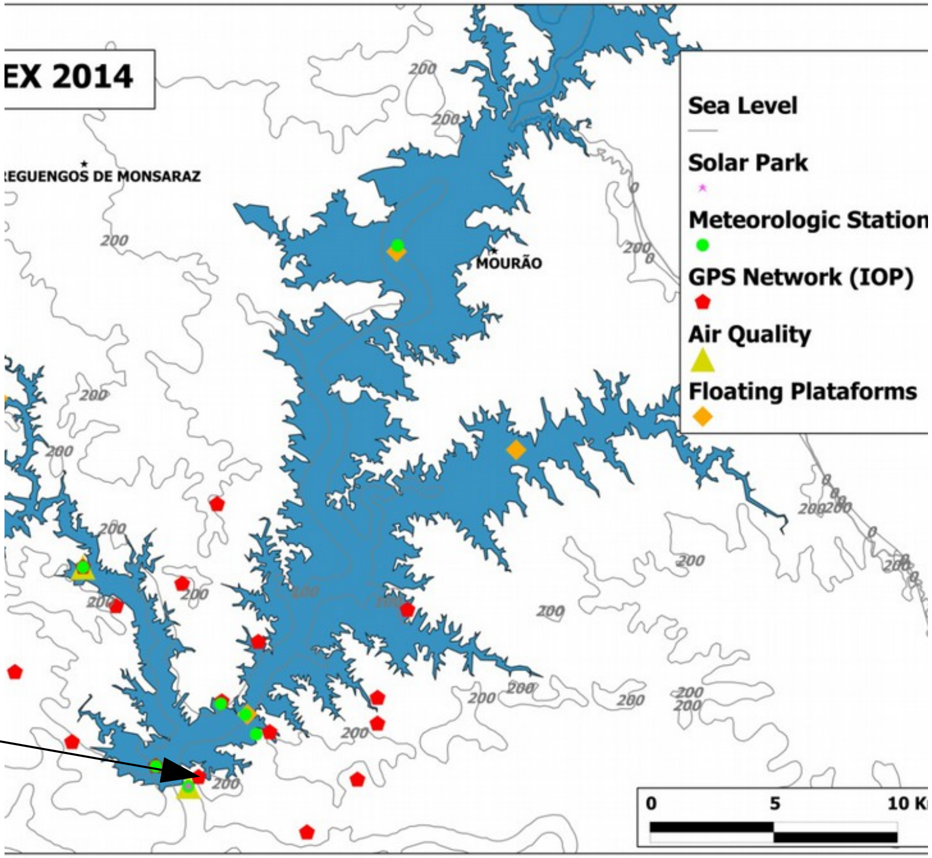
Air quality



To study the relationship between the air quality, meteorology and the electric field of the atmosphere, the Commission for Coordination and Regional Development of Alentejo (CCDR-A) provided a mobile unit with analysers of a set of gases.

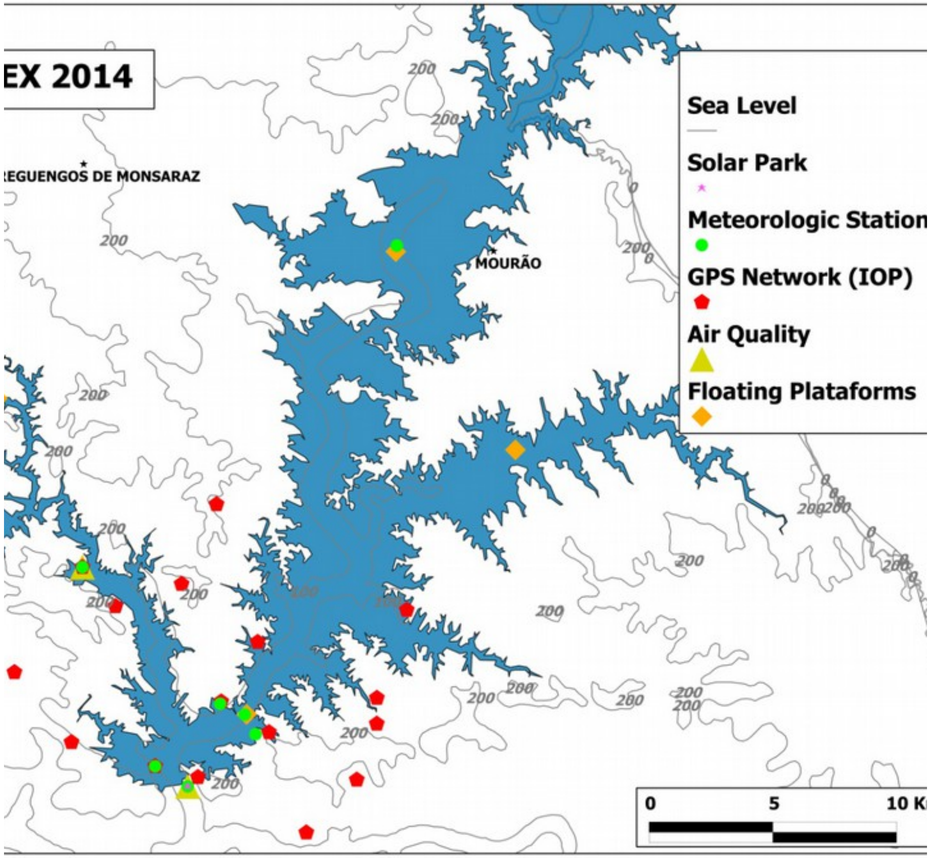
SO_2; NO; NO_2; NO_x; CO; O_3; BTEX

Solar resource: Global and Direct



Sun tracker with pyranometers:
Global, diffuse and direct solar radiation
→ Characterize the solar resource, in particular the DNI

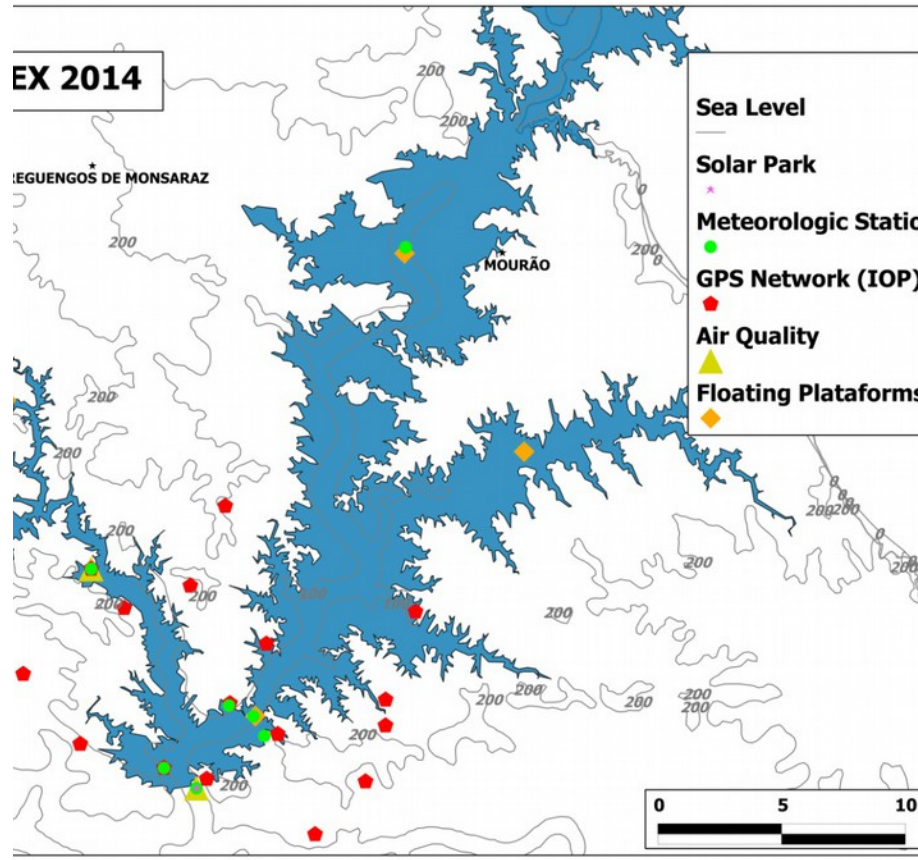
Atmospheric electric field



The ALEX2014 includes the study the Potential Gradient (PG) against the two principal ingredients influencing it at a local scale:

- ^{222}Rn: main Atmospheric-ions source
- aerosols and water droplet: main AI sink.

GPS network



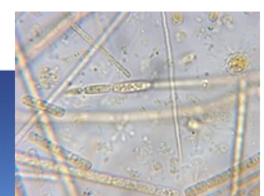
A GNSS network of 15 stations was installed, during 2 weeks campaign, in order to determine the water vapor distribution from GPS tomography

Biological Characterization

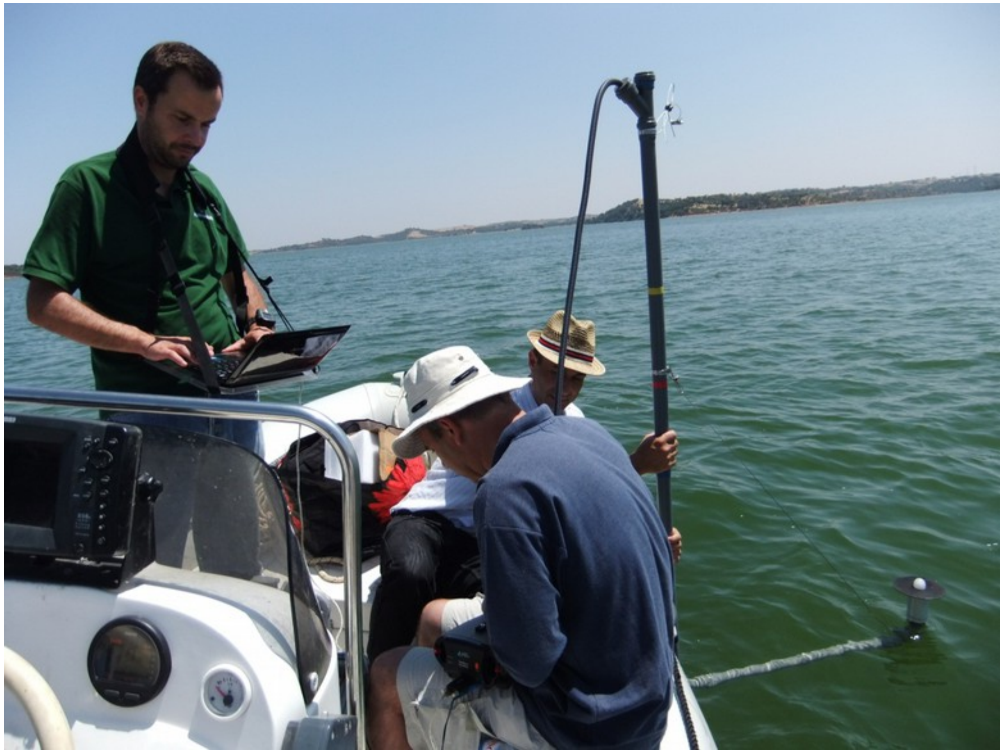
Sampling

Several observations were made on a monthly basis:

- water column profiles of dissolved oxygen (mg DO L-1 and %), pH, oxidation-reduction potential
- Biological Characterization close to lake margins: pupal exuviae collection of Diptera
- Diatoms on artificial substrates in depth + planktonic diatoms in the water column
- Microscopic and molecular characterization of cyanobacteria



Underwater irradiance system



FieldSpec UV/VNIR da ASD coupled to an optical cable and a cosine receptor

- Wavelengths between 325 – 1075 nm
- Spectral resolution of 3 nm
- 180º of FOV
- Maximum depth of 3 m

Turbidity measurements

Intensive Observation Period

IOP: 22, 23 and 24 of July 2014, during which:

- 18 meteorological balloons with meteorological radiosondes were launched.
- every 3 hours

atmospheric ionization profile

- Geigersondes (Harrison et al., 2012, Reading University) were coupled to the meteorological radiosondes in order to obtain the atmospheric ionization profile
  - based on two miniature Geiger tubes
  - using a digital interface system, the radiosonde's meteorological data are also be retained.

Atmospheric characterization

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- the Boundary layer were characterized with a Ceilometer

- The Vertical distribution of O3 and NO2 were obtained by the Spectrometer for Atmospheric Tracers Measurements

Sky Brightness

Alqueva is the first site in the world to receive the "Starlight Tourism Destination" certification, supported by UNESCO, UNWTO and IAC.

SQM-L model

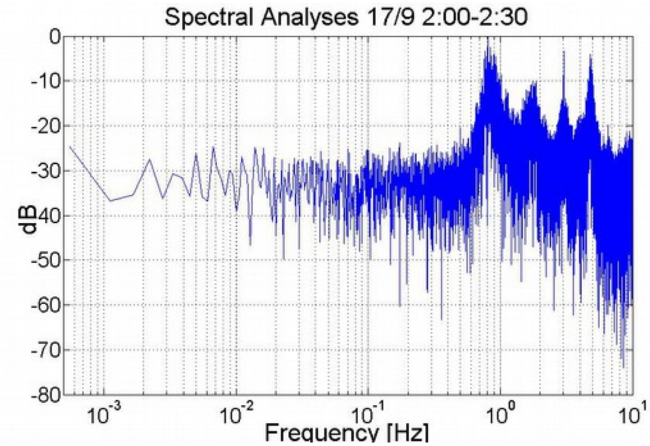
measurements of the sky brightness with an Unihedron Sky Quality Meter

Foto: A Península Ibérica à noite, 26 de julho de 2014 ©NASA

Preliminary Results

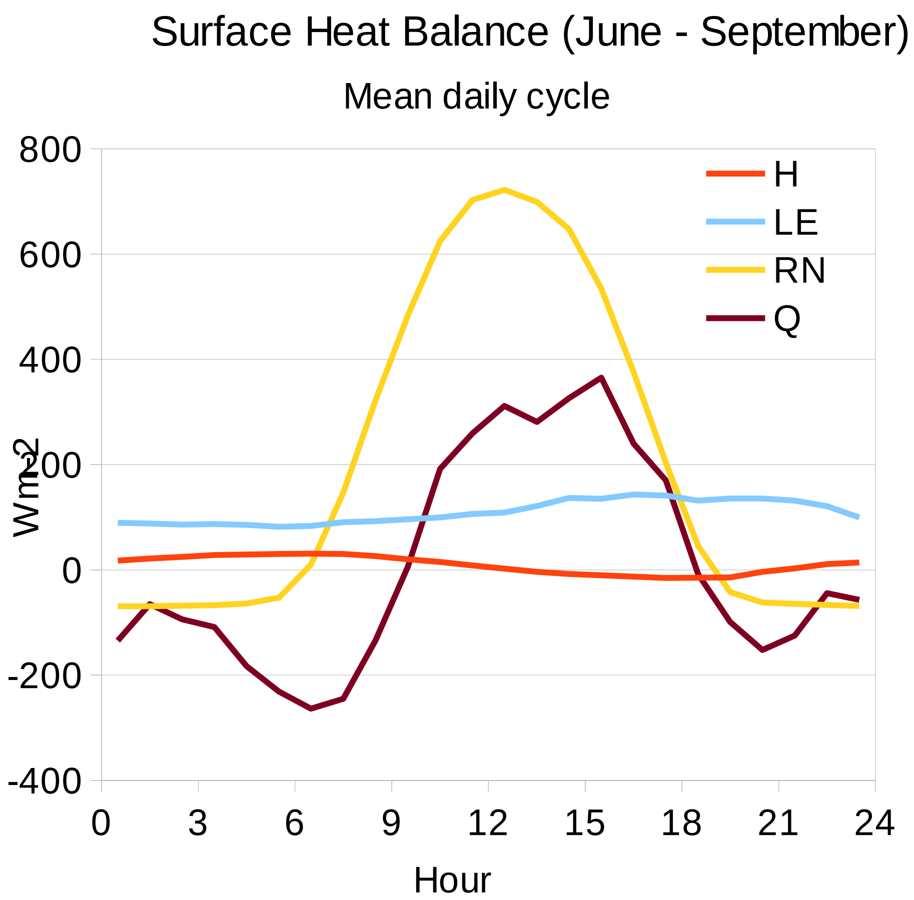
Flux computation Platform Oscillation

- The vertical velocity of the arm was of the order of 10^{-3} or 10^{-2} ms^{-1} (one order less than the vertical wind).
- A spectral analysis showed that the dominant frequencies of the platform are normally around 1, 3 and 5 Hz
- A comparison between the fluxes with and without the correction for the platform motion is shown in the table
- Differences are negligible. **it is not necessary to take in account the raft motion and that float oscillation does not contaminate the flux calculations**



	tau	H	LE	CO_2
nbias	3.32 x10^{-3}	2.63 x10^{-3}	-2.54 x10^{-3}	2.01 x10^{-3}
nmae	1.19 x10^{-2}	9.45 x10^{-3}	7.52 x10^{-3}	4.17 x10^{-3}
nrmse	2.38 x10^{-2}	1.82 x10^{-2}	1.87 x10^{-2}	1.09 x10^{-2}

Surface energy Balance



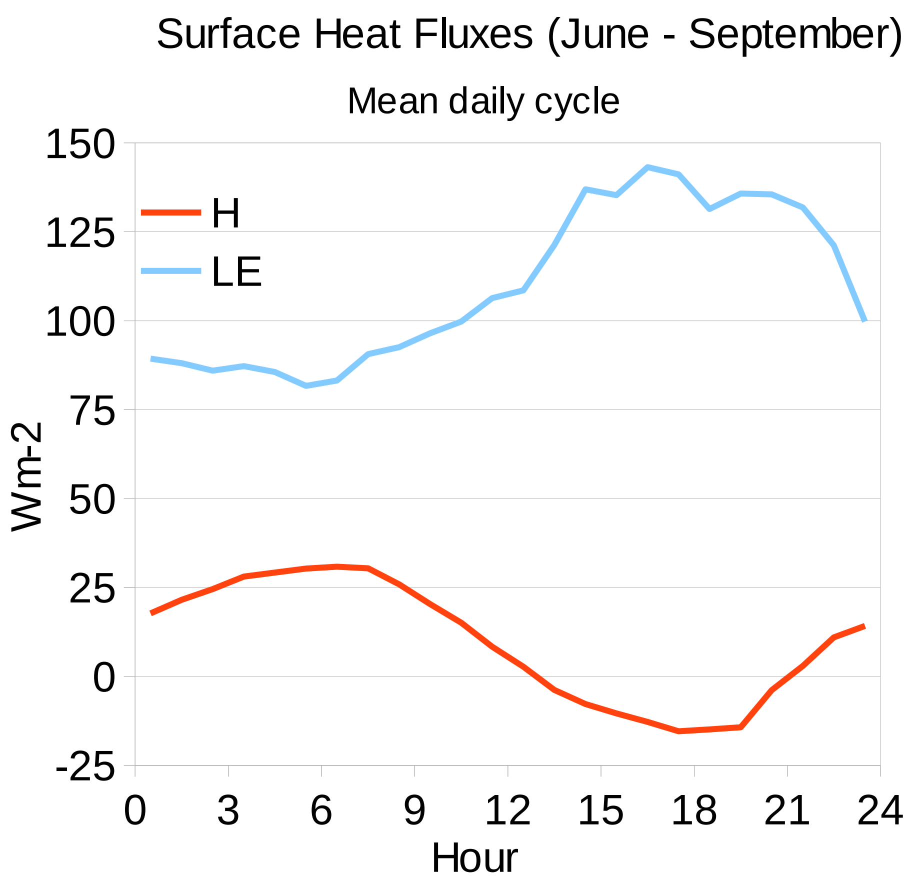
At a hourly basis, it is better to take in account only the first 4 meters to compute.

- the water column heat storage change (per time unit) may be computed as:

$$\Delta Q = \rho_w C_{pw} \sum_{i=1}^{n} \frac{\Delta T_{wi}}{\Delta t} \Delta z_i$$

- As expected, the most important term is the heat storage, which is positive during the day. and negative during the night and early morning.

Surface energy Balance



- The H is generally small (usually less than 30 Wm-2), with a maximum at sunrise. In the afternoon it is normally slightly negative.
- In average, the latent heat flux is always positive, reaching the highest values in the afternoon, when the wind speed is higher. In the evening, the values are, on average, about 150 Wm-2,

CO2 over reservoir (June to September)

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At night – CO_2 plants respiration

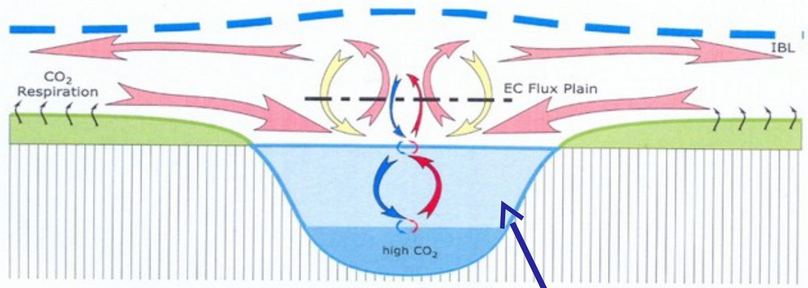
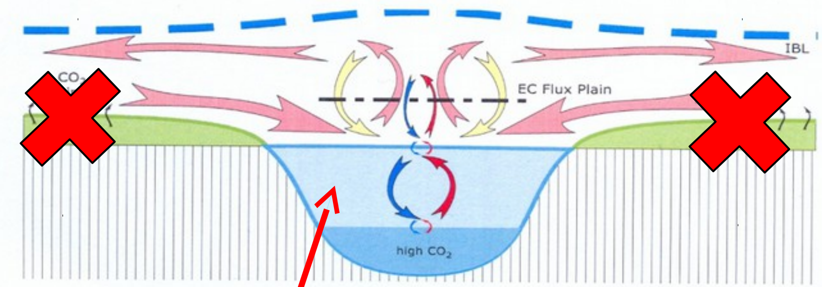


Figure 14. Processes influencing the eddy covariance (EC) flux measurements above a lake surface at night. Because EC measurements cannot be performed directly at the air-water interface, the CO_2 exchange with the lake (blue and red arrows) at EC reference height (black dash-dotted line) is measured together with the exchange flux of CO_2-rich air from the land surrounding the lake (pink and yellow arrows) where CO_2 originates from respiration of soils and vegetation (black arrows). This local lake-breeze type circulation is expected to be restricted in its vertical extent by an internal boundary layer (IBL).

Reprinted from Eugster et al. (2003)

During day – CO_2 plants photosynthesis



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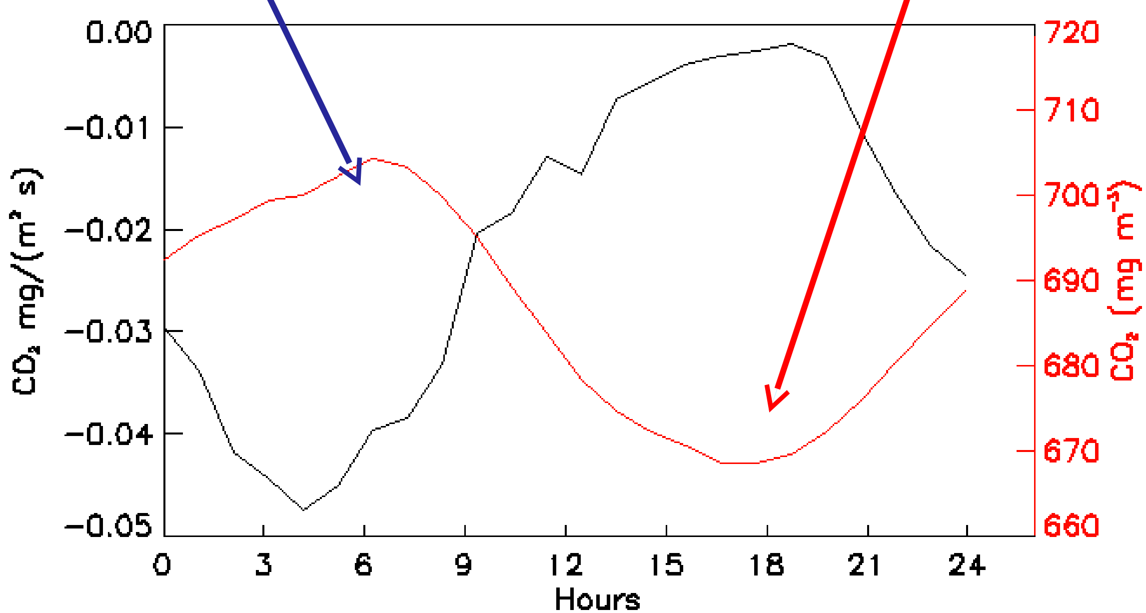
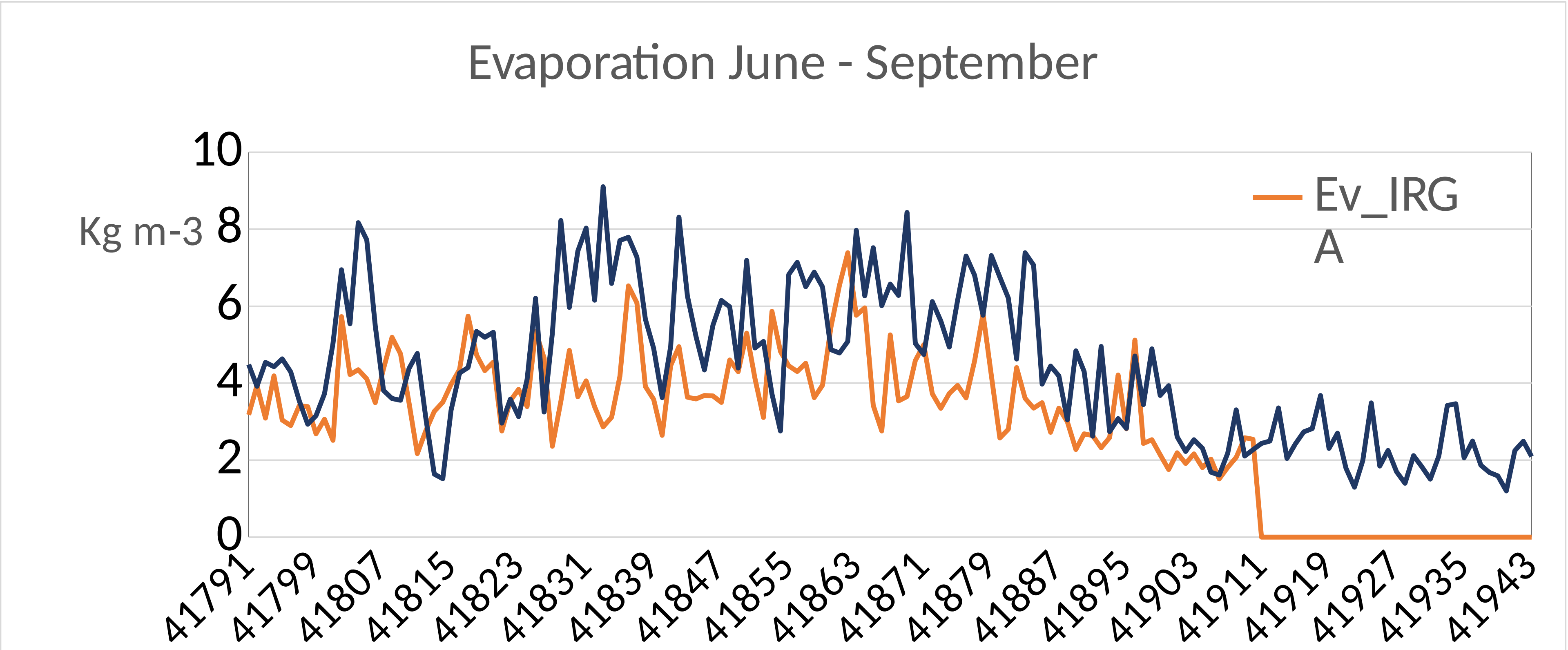
Greater uptake by the reservoir during night – High negative flux (into water)



Lower uptake by the reservoir during day – Weaker flux, still negative

Evaporation calculation



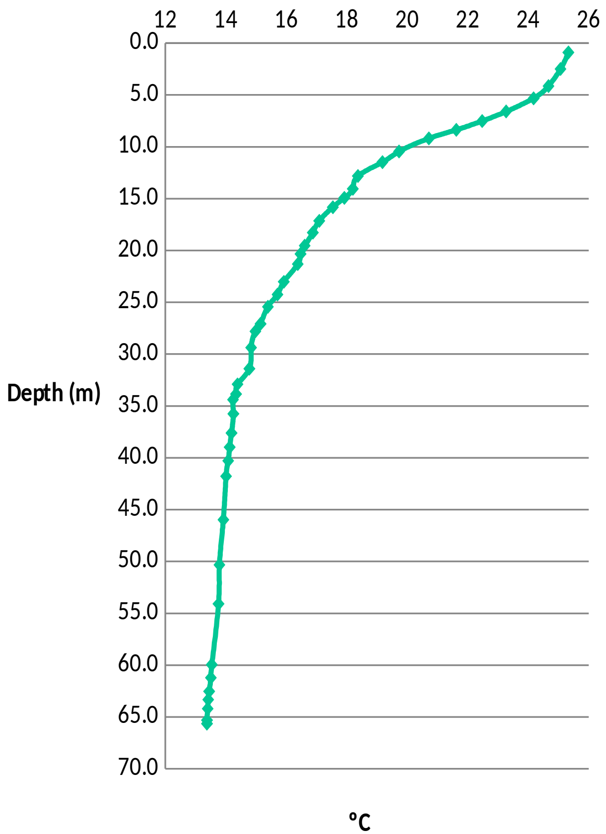
The lake evaporation (Ev_lake) was calculated by multiplying the value measured on a class A pan installed on a station located in a small island in Alqueva.

The results were compared against the EC Irgason system (Ev_IRGA) .

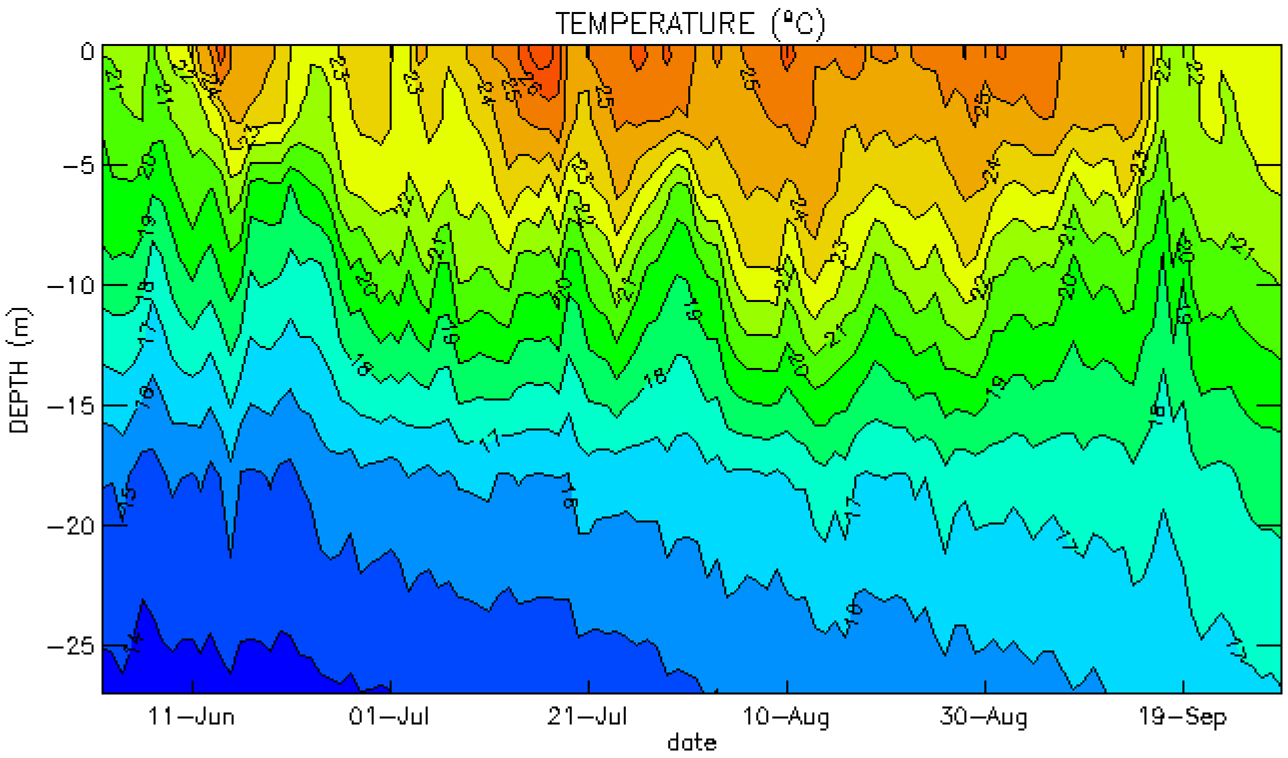
The comparison shows that the pan method tends to overestimate the evaporation when compared to the EC measurements.

Inwater temperature

Ponctual temperature profiles up to bottom



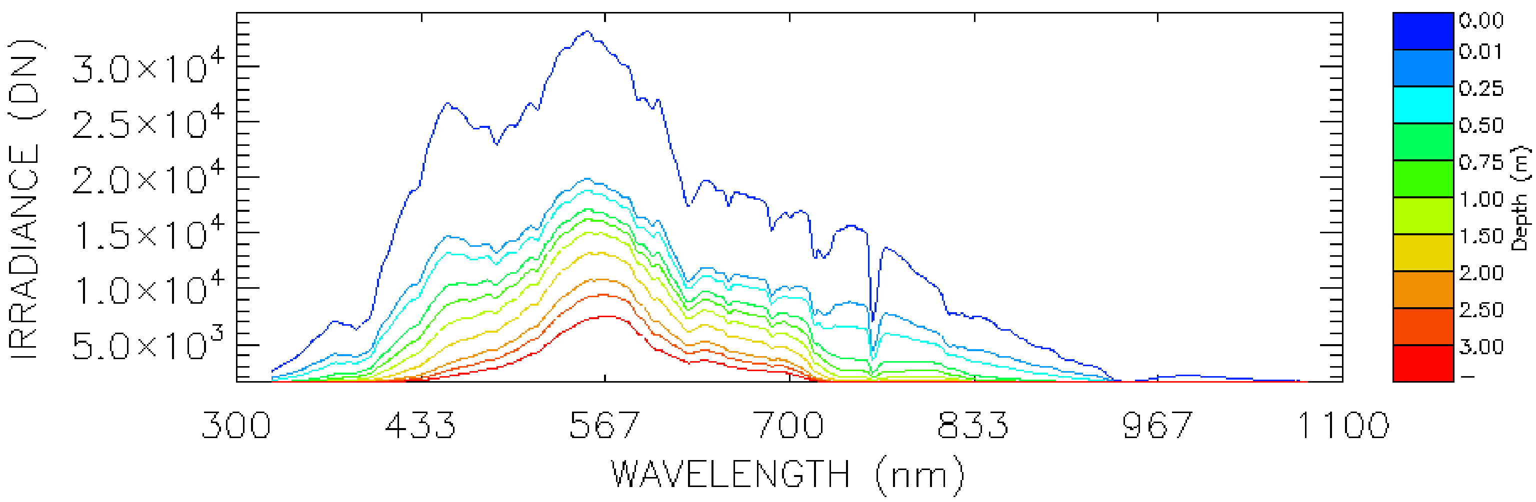
Continuous measurements up to 27 meters depth during the 4 months

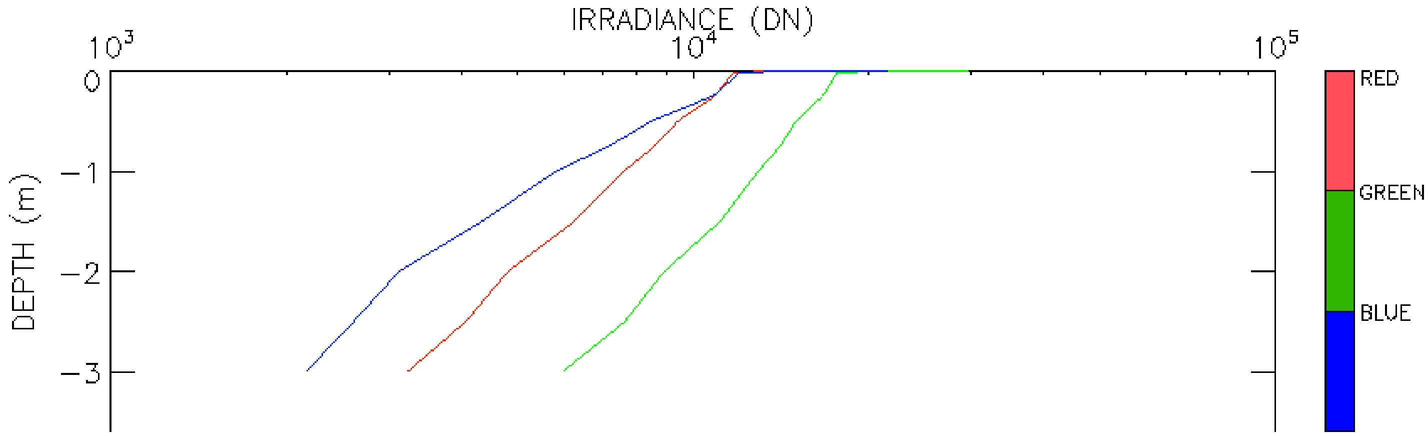


Thermocline between 5 and 15 meters. Also visible in the right graph.

It shows the diurnal warming in the first meters and progressive increase of temperature in deeper layers (below 10 meters)

Underwater irradiance profiles

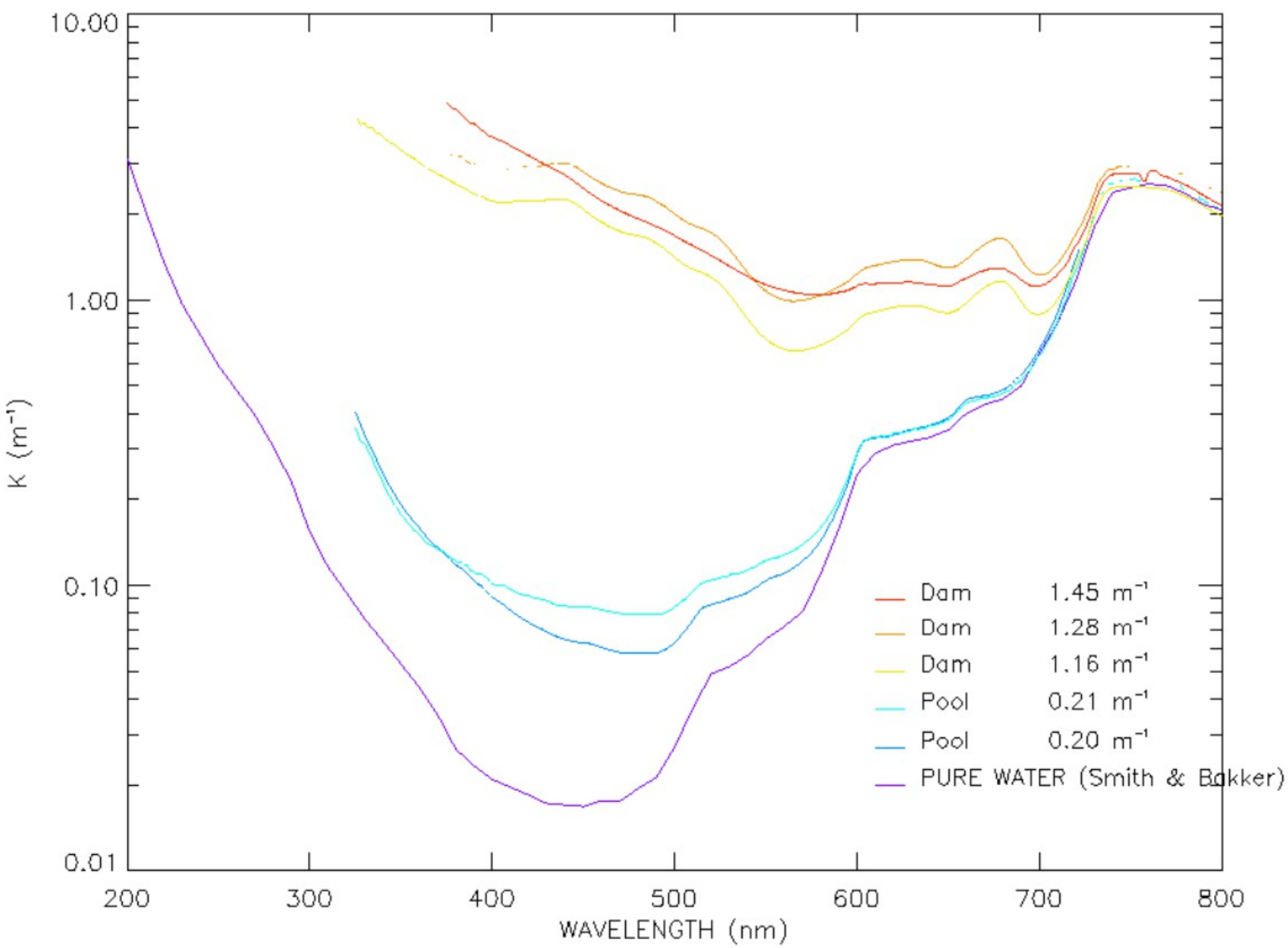




IOP 23 July
Clear Sky
Low wind

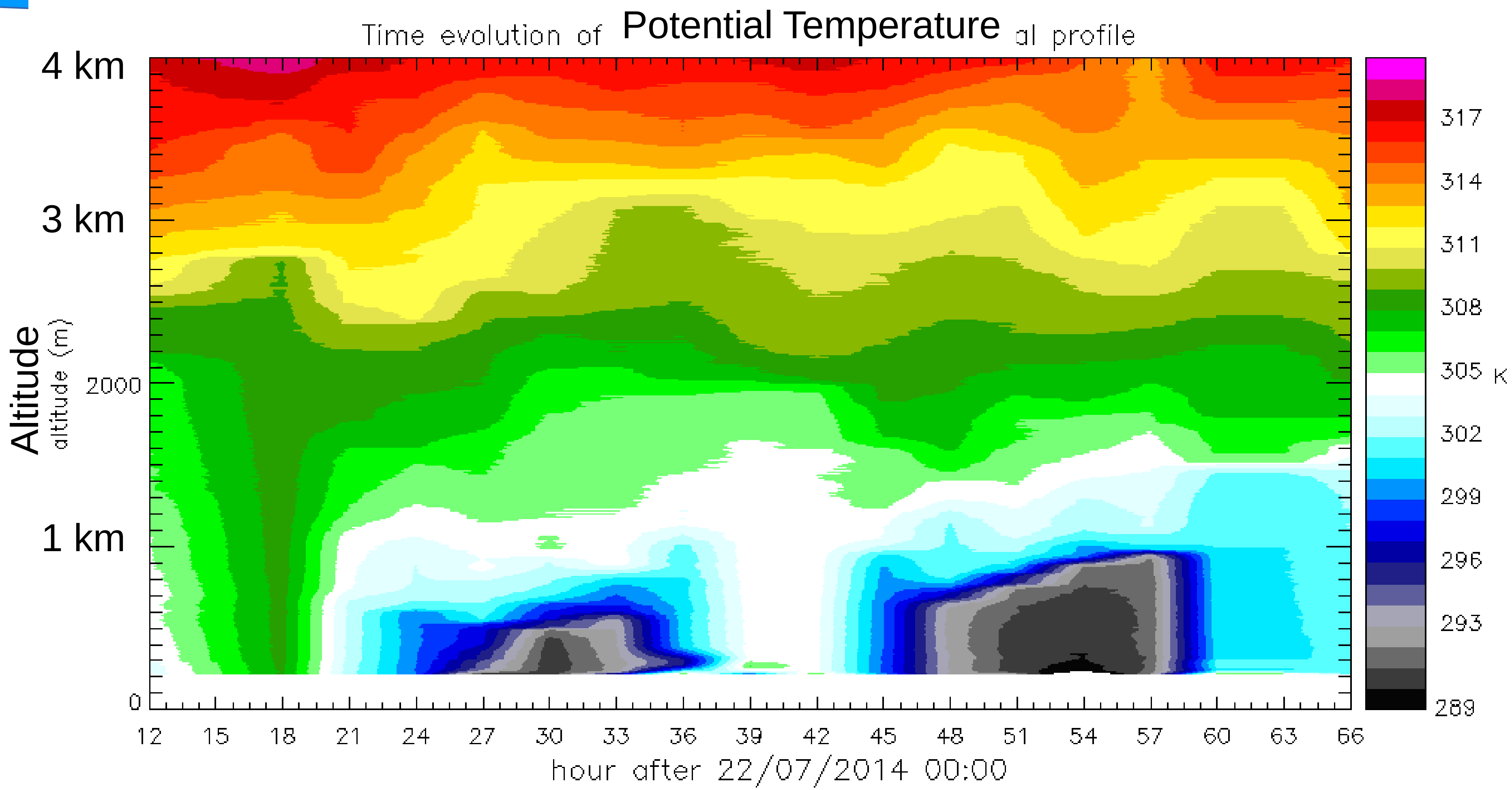
Profiles of the sum of irradiance between 400-500, 500-600 and 600-700 nm.

Attenuation Coefficient and PAR values



For pure and pool water the minimum of attenuation is between 400-500 nm and with increasing turbidity (in dams) this minimum shifts to 500 to 600 nm. PAR values (400-700 nm) increase with turbidity (not shown here).

IOP Atmospheric Radiossondes



Characterization of the vertical structure and synoptic conditions

- Anticyclonic conditions
- Boundary layer well developed (more than 2500m deep in 1st day)
- Instable surface layer in the region (over land) with high values of sensible heat flux
- Near surface temperatures greater than 35ºC (1st day)

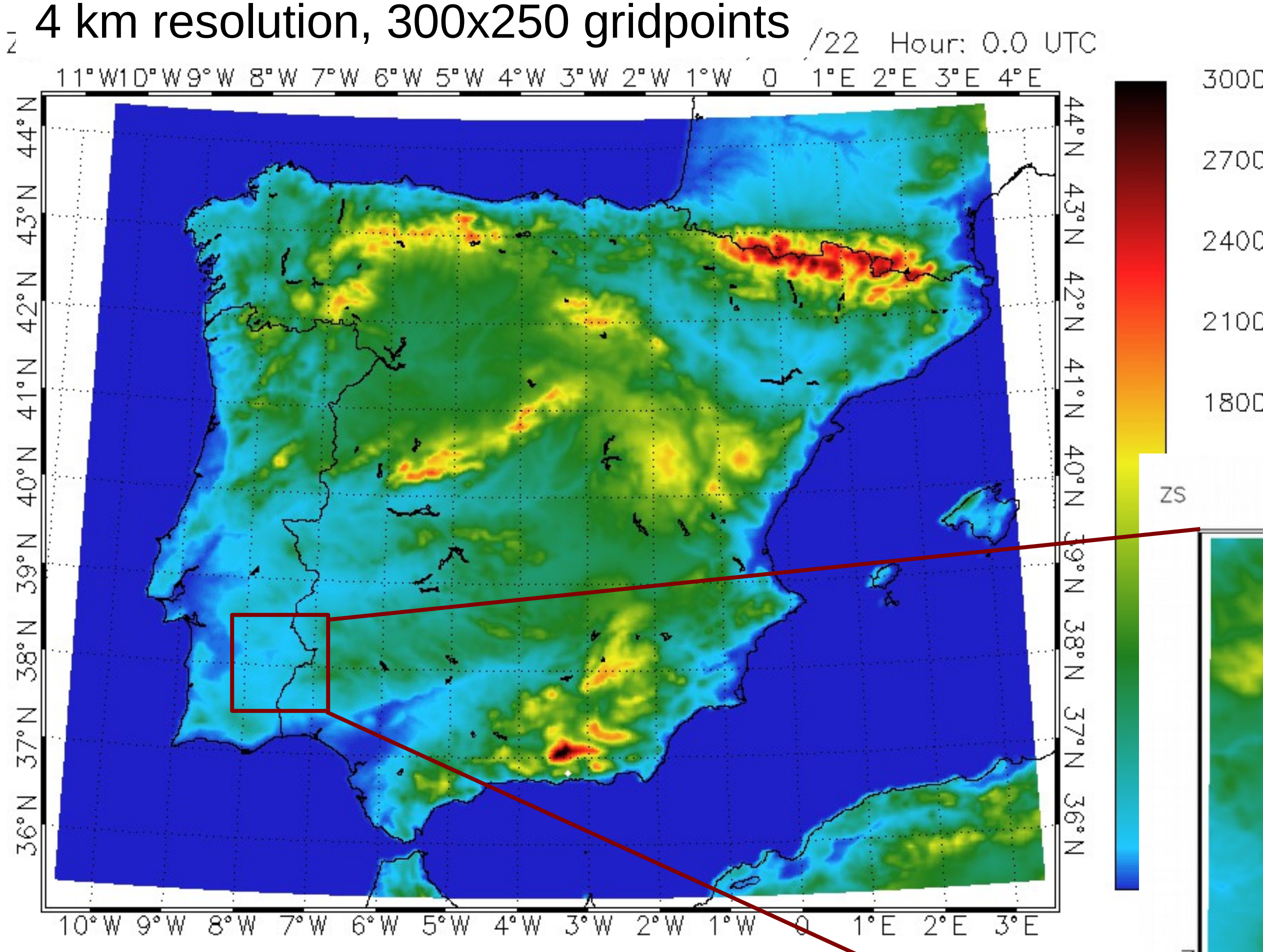
Summary

- We presented the ALEX2014 field campaign
- More information and **Data** are available from: http://www.alex2014.cge.uevora.pt/

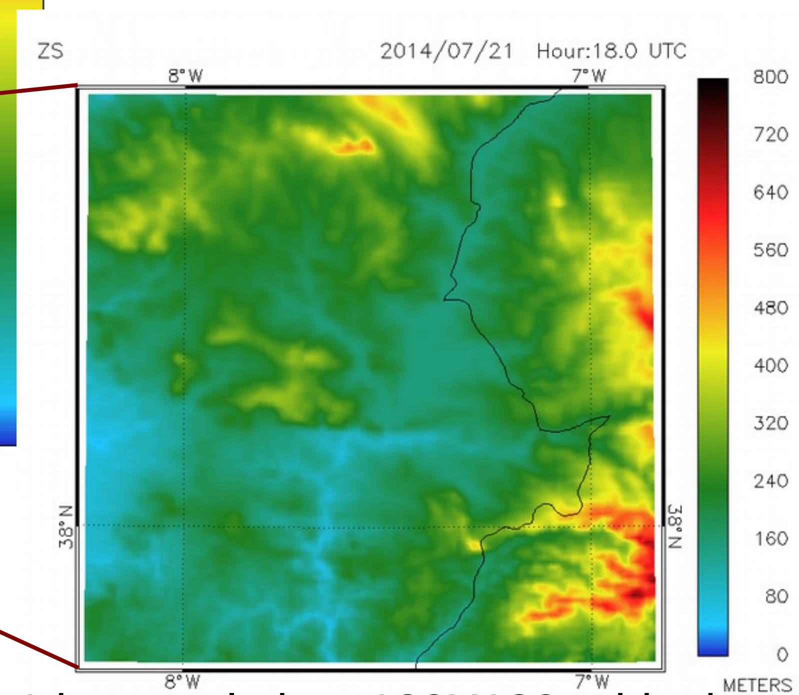
  preliminary results:
- The newest underwater irradiance allows the calculation of solar attenuation of the water column and thus euphotic depth determination.
- The results from the built-in accelerometer installed in the platform show no need to correct the fluxes measurements for the raft oscillations.
- Results from carbon dioxide flux show the reservoir as a sink of carbon especially during night and morning, when the concentration is higher above reservoir.
- The energy balance was estimated for the surface of the reservoir.
- The lake evaporation calculated through a class A Pan tends to overestimate the evaporation compared to EC method.

High resolution Meso-NH Simulations

4 km resolution, 300x250 gridpoints



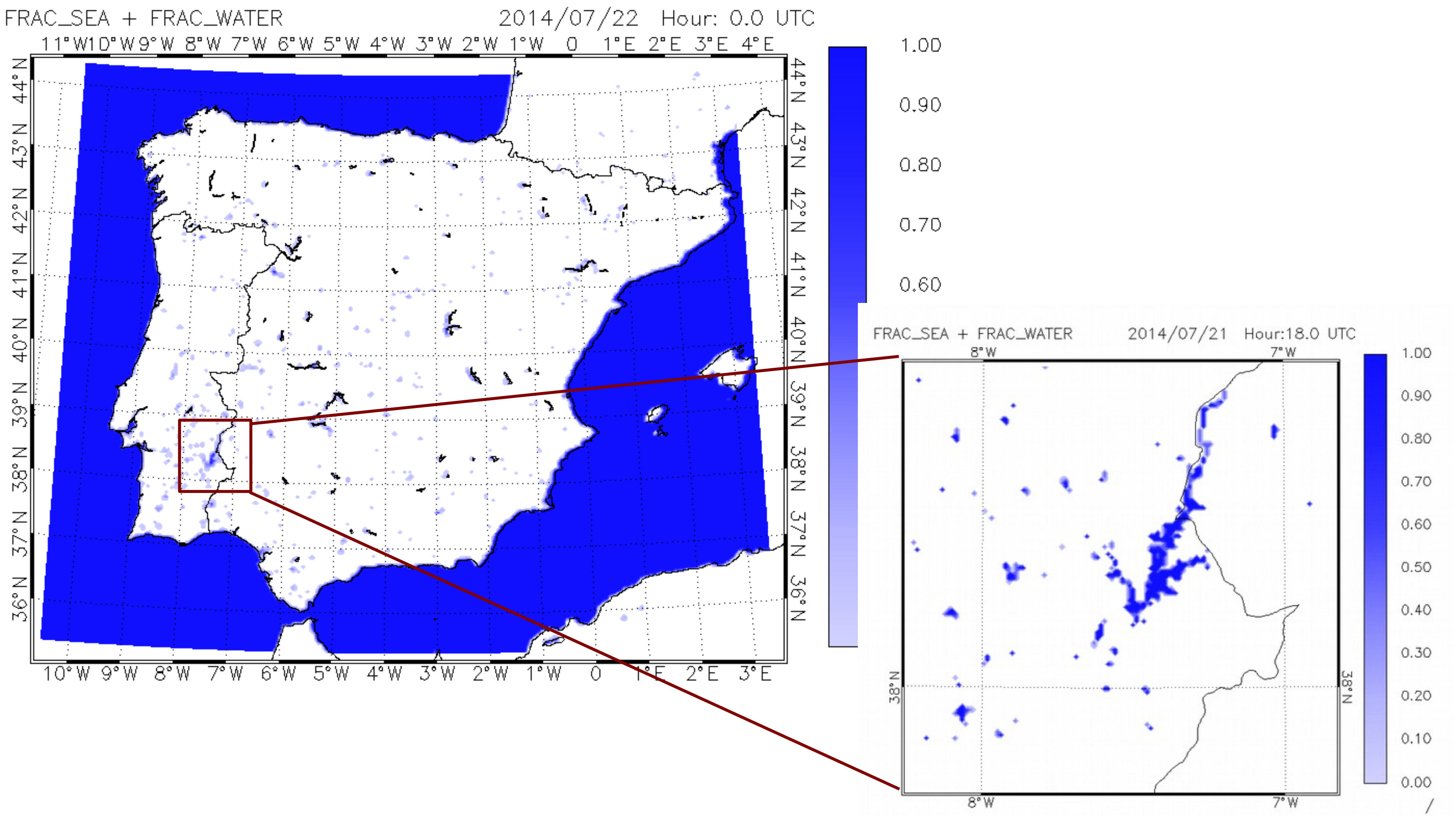
- ALEX IOP case: 22-24 July 2014
- Initialization and forcing: ECMWF
- 94 hours of simulation
- 54 vertical levels, concentrated in the BL



2 Nested Domains & Orography

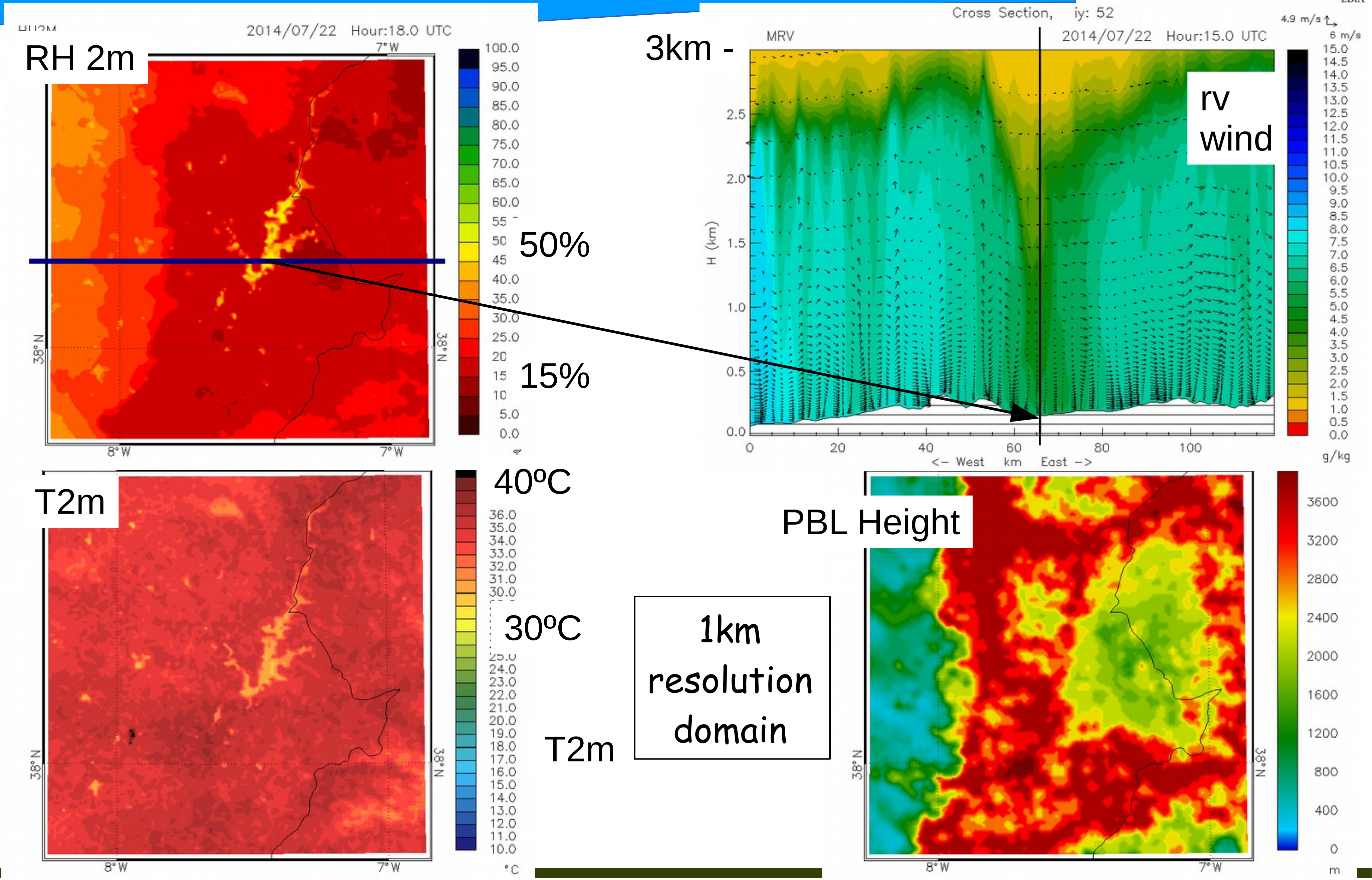
1 km resolution, 120X120 gridpoints

Numerical surface water fraction

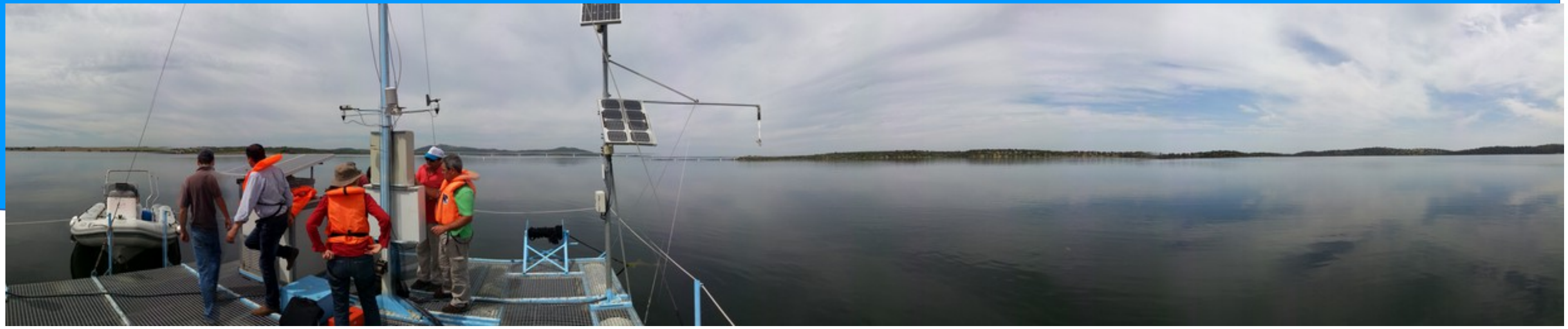


Simulation results: Examples

22/07/2014
18 TU



1km resolution domain



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4th Workshop on
"Parametrization of Lakes in Numerical Weather Prediction and Climate Modelling"

07-09 May 2015, University of Évora, Évora, Portugal

http://www.lake15.cge.uevora.pt

Themes:

- Lake-atmosphere interactions and coupling.
- Snow and ice on lakes, reservoirs and other water bodies
- External parameters
- Assimilation of observational data on lake surface state
- Model validation and intercomparison
- Processes in fresh-water bodies

Participation and deadlines

To take part in the Workshop, please fill the registration form through the workshop web page by March 31, 2015.
more informations: rsal@uevora.pt.

Organizing Committee

Rui Salgado, Miguel Potes and Maria João Costa, University of Évora;
Maria José Monteiro and Pedro Viterbo, Portuguese Inst. for the Ocean and Atmosphere
Ekaterina Kourzeneva and Laura Rontu, Finnish Meteorological Institute
Dmitrii Mironov, German Weather Service

Thank you

Apoios

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