# Heat and carbon fluxes over a large Mediterranean reservoir

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# Summary

- Alqueva reservoir
- Heat and $CO_2$ fluxes
- Water temperature profile
- Satellite Remote sensing over Alqueva
- Final Remarks
- References

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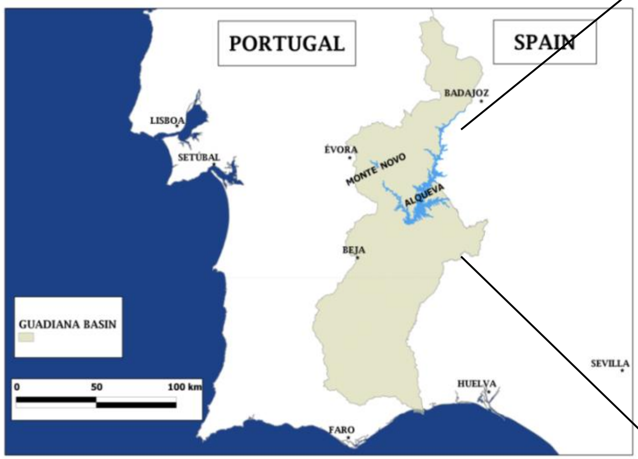
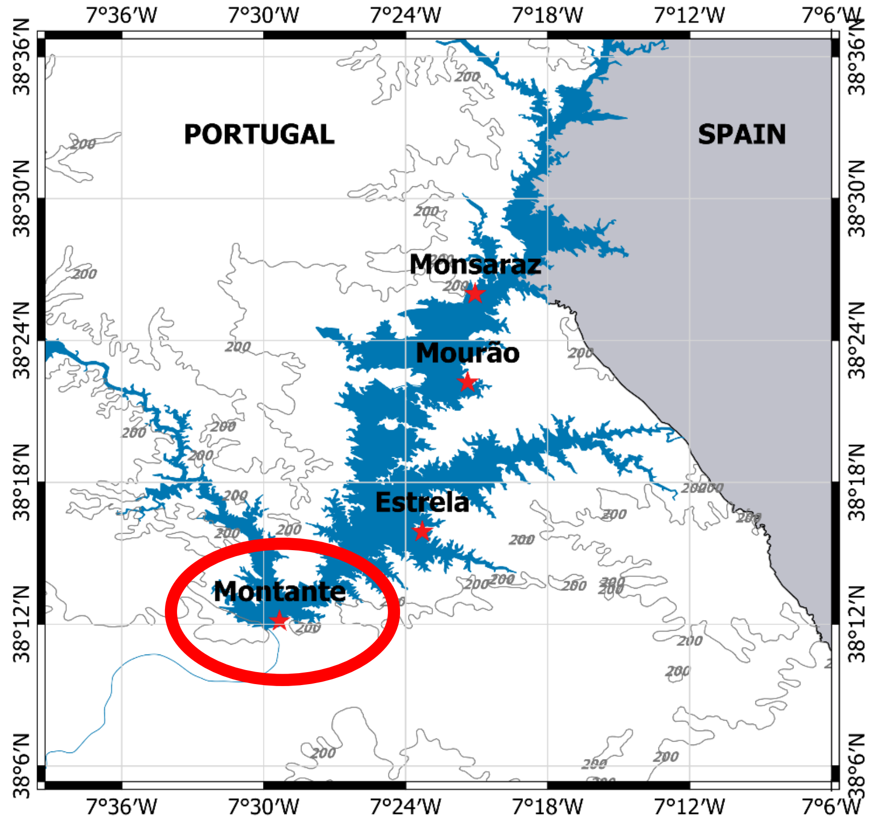
# Alqueva reservoir




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

Surface area of 250 km$^2$
Average depth of 16.6 m (92m max)
Age: since 2002
Mesotrophic
Monomictic

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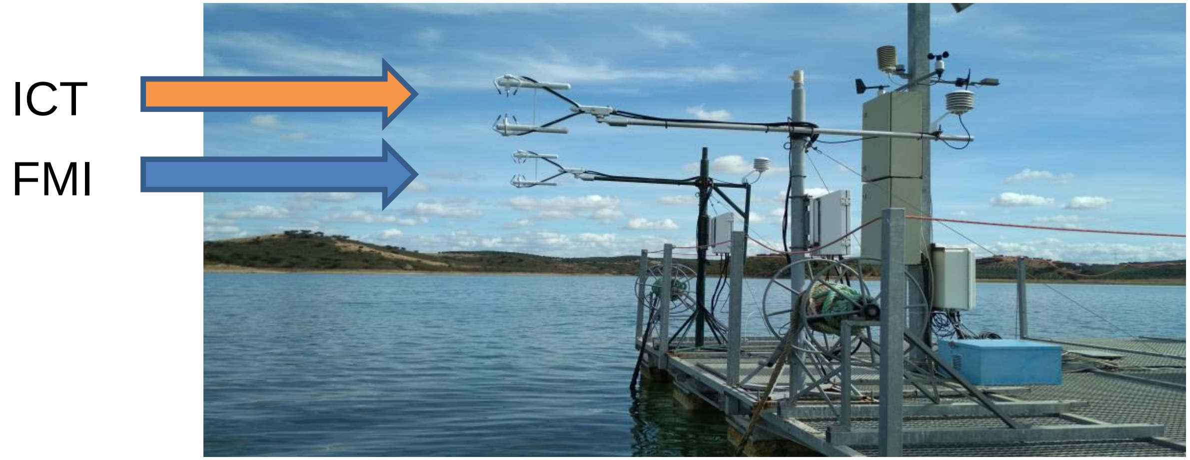
# Intercomparison campaign in Alqueva




During the period 12-10-2018 to 25-10-2018 it was possible to obtain precise estimates of random instrument uncertainty ($\varepsilon_F$), since both instruments were in the same area and footprint.

Shevnina *et al.*, 2022

# Intercomparison campaign in Alqueva

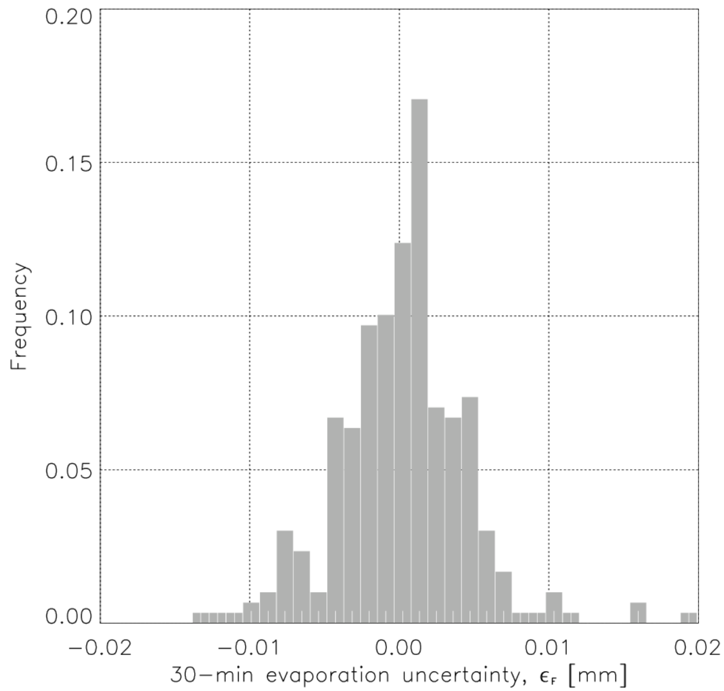



Figure – Frequency distribution of the 30-minute evaporation random instrument uncertainty ($\varepsilon_F$) during the intercomparison campaign that took place in Alqueva reservoir, southeast of Portugal.

Uncertainty: $\varepsilon_F = \frac{1}{\sqrt{2}}(E_{ICT} - E_{FMI})$

This frequency distribution presents a similar distribution shape as the study from Dragoni et al. (2007). The random instrument uncertainty in 30-minute evaporation, estimated as the standard deviation of the evaporation random instrument uncertainty ($\varepsilon_F$), is $4.324\times10^{-3}$ mm. Thus, in relative terms, the intercomparison campaign allows to obtain an estimate of the random instrument error of 7.0%.

Shevnina *et al.*, 2022

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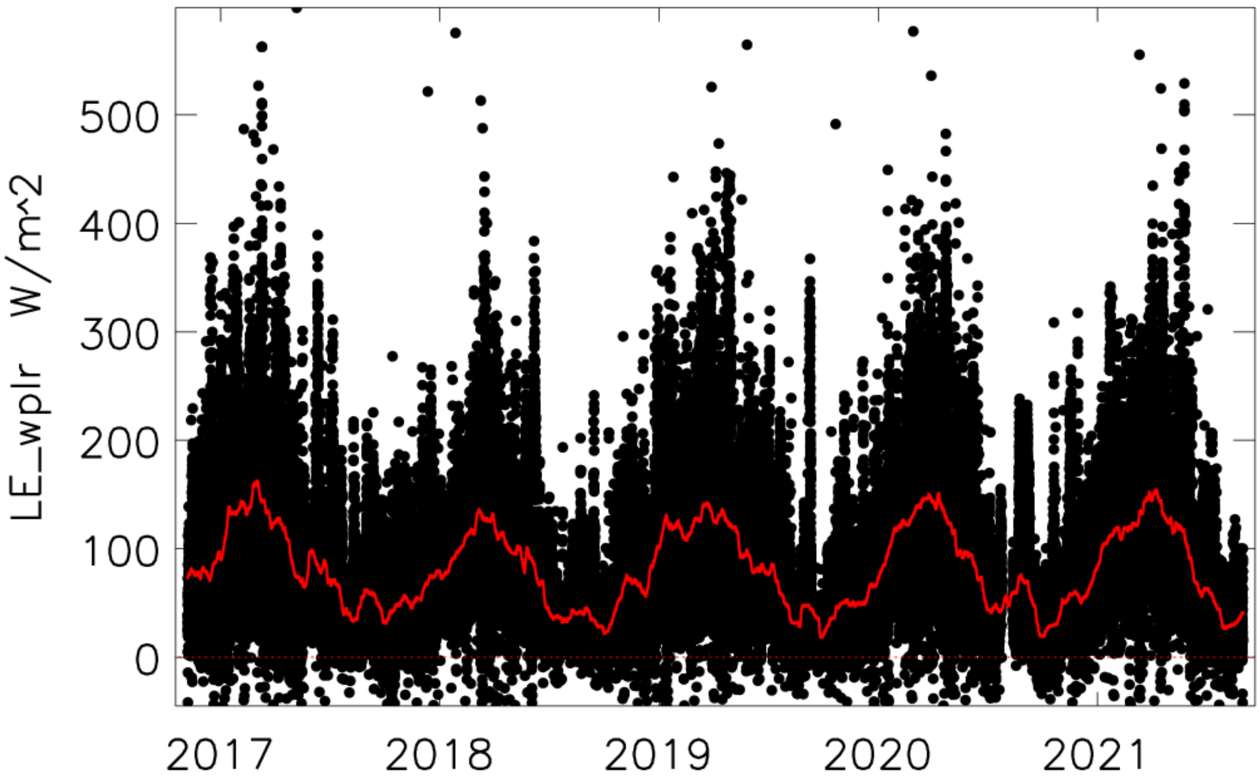
# Latent heat flux (2017-2022)




Average: 83,30 W m$^{-2}$

Moving average of the 30-minutes data

Latent Heat Flux $$F_{LE} = L_v \, w'\rho_w'$$ [W m$^{-2}$]

Potes et al., 2025, in prep

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# Daily Evaporation [mm]

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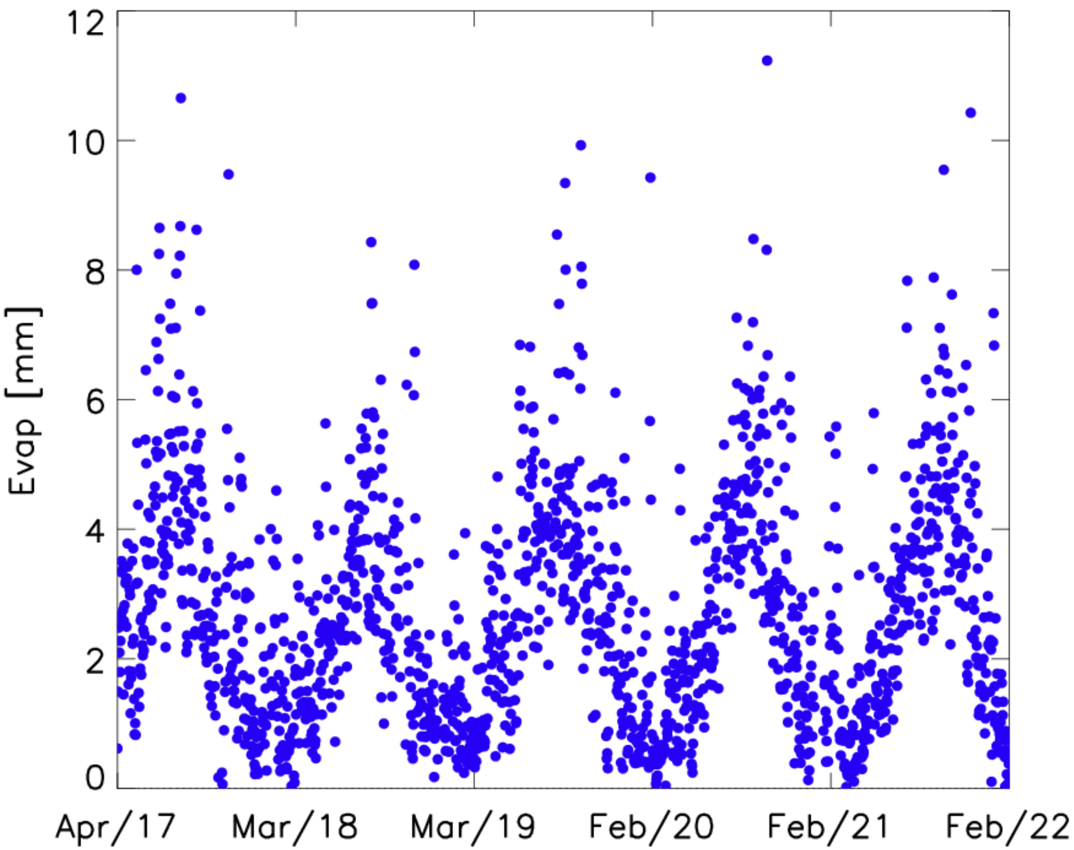


Daily values from the period 2017-2022.

Summer presents values up to 11 mm/day while winter mainly around 1 mm/day.

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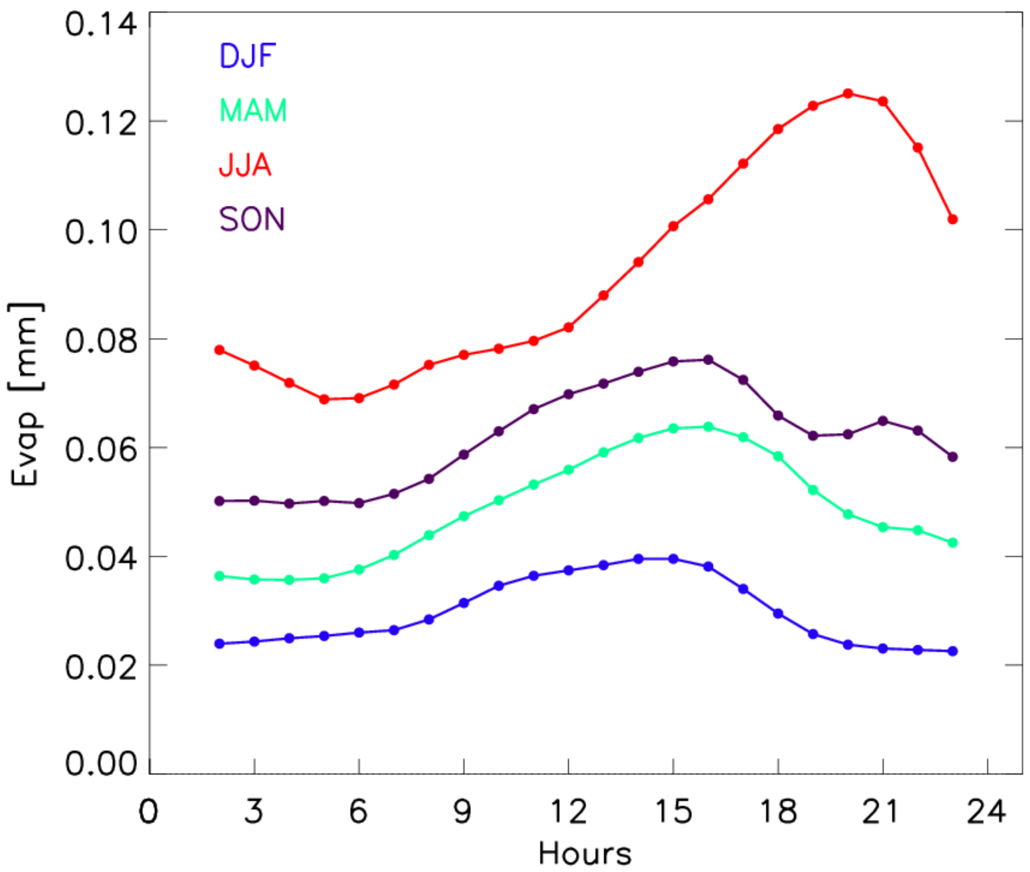
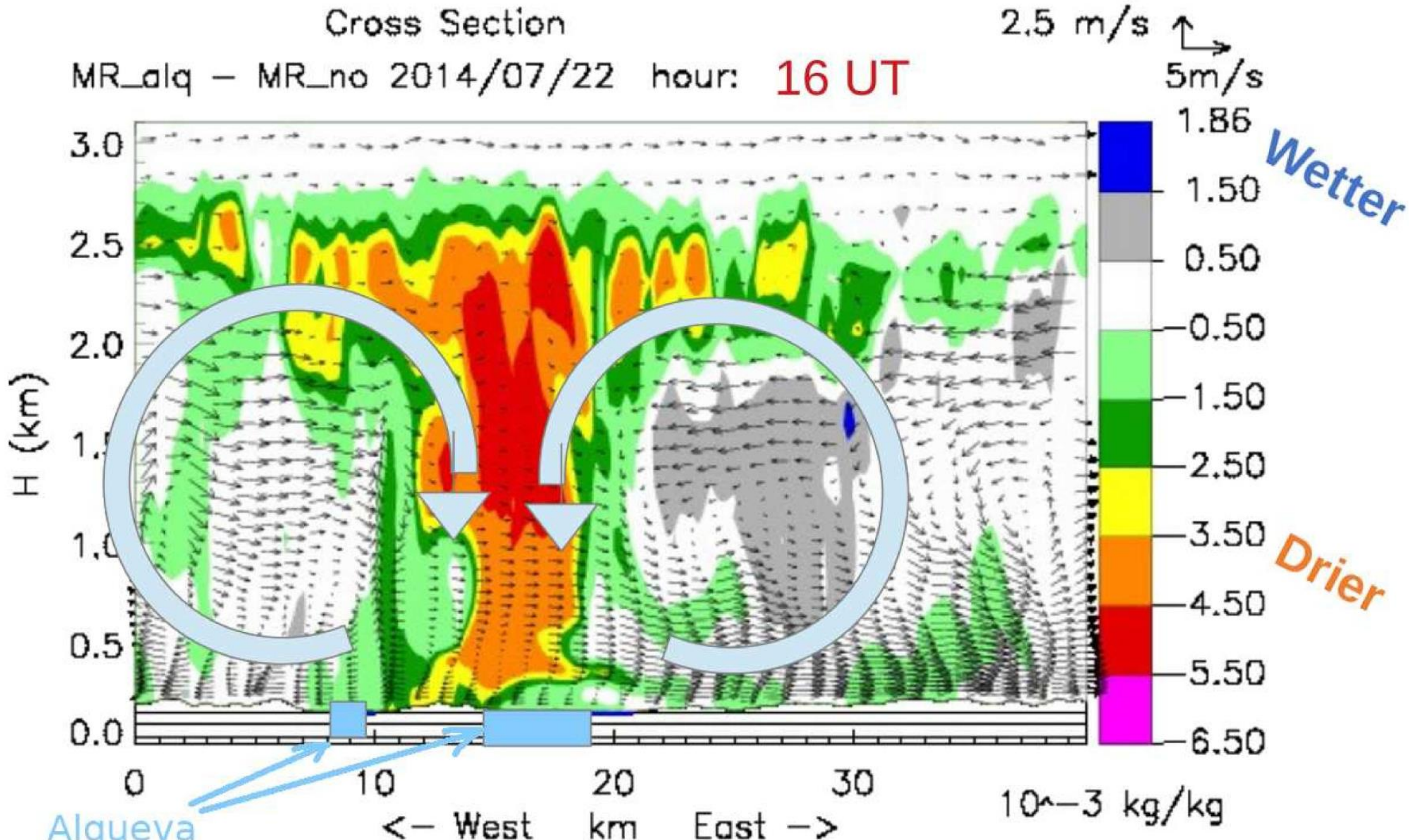
# Seasonal Hourly Evaporation [mm]




Summer values are higher in late afternoon (explained by sea and lake breeze) while winter in daytime driven by solar radiation.

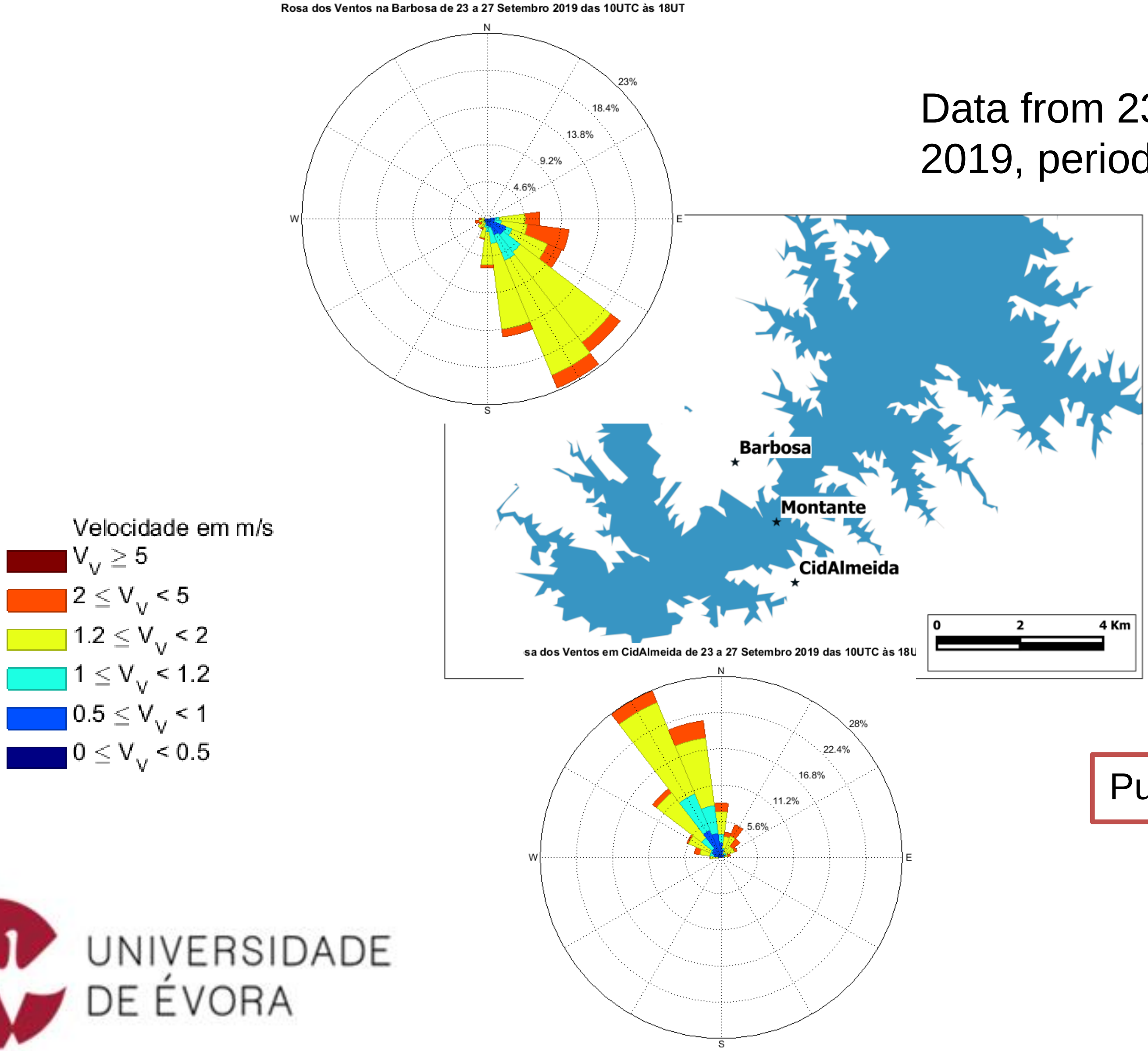
# Lake breeze (MesoNH model)




Iakunin et al., 2018

# Lake breeze (in situ observations)

Data from 23 to 27 September 2019, period of 10-18 UTC




Purificação et al., 2021

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# Hydrometeorological dataset (2018–2023)

**Table 1**
Summary of meteorological data collected at the Alqueva reservoir stations. The table presents the measured variables, units, stations where measurements are taken, data frequency, and the type of statistics applied.

| Variable name (Unit) | Applicable Stations | Data Frequency | Statistic Type |
|---|---|---|---|
| Air temperature (°C) | Both Stations | Hourly, Daily | Hourly Average, Daily Max/Min |
| Relative humidity (%) | Both Stations. Montante after December 2020 | Hourly, Daily | Hourly Average, Daily Max/Min |
| Upward/downward solar radiation ($W/m^2$) | Both Stations | Hourly | Average |
| Atmospheric Pressure (hPa) | Both Stations | Hourly | Average |
| Wind intensity (m/s) | Both Stations | Hourly | Average |
| Maximum wind gust (m/s) | Both Stations | Hourly | Maximum |
| Wind direction (degrees) | CidAlmeida | Hourly | Average |
| Precipitation (mm) | CidAlmeida | Hourly | Accumulated |
| Soil temperature (°C) | CidAlmeida | Hourly | Average |
| Surface water temperature (°C) | Montante | Hourly | Average |

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Rodrigues et al., 2024

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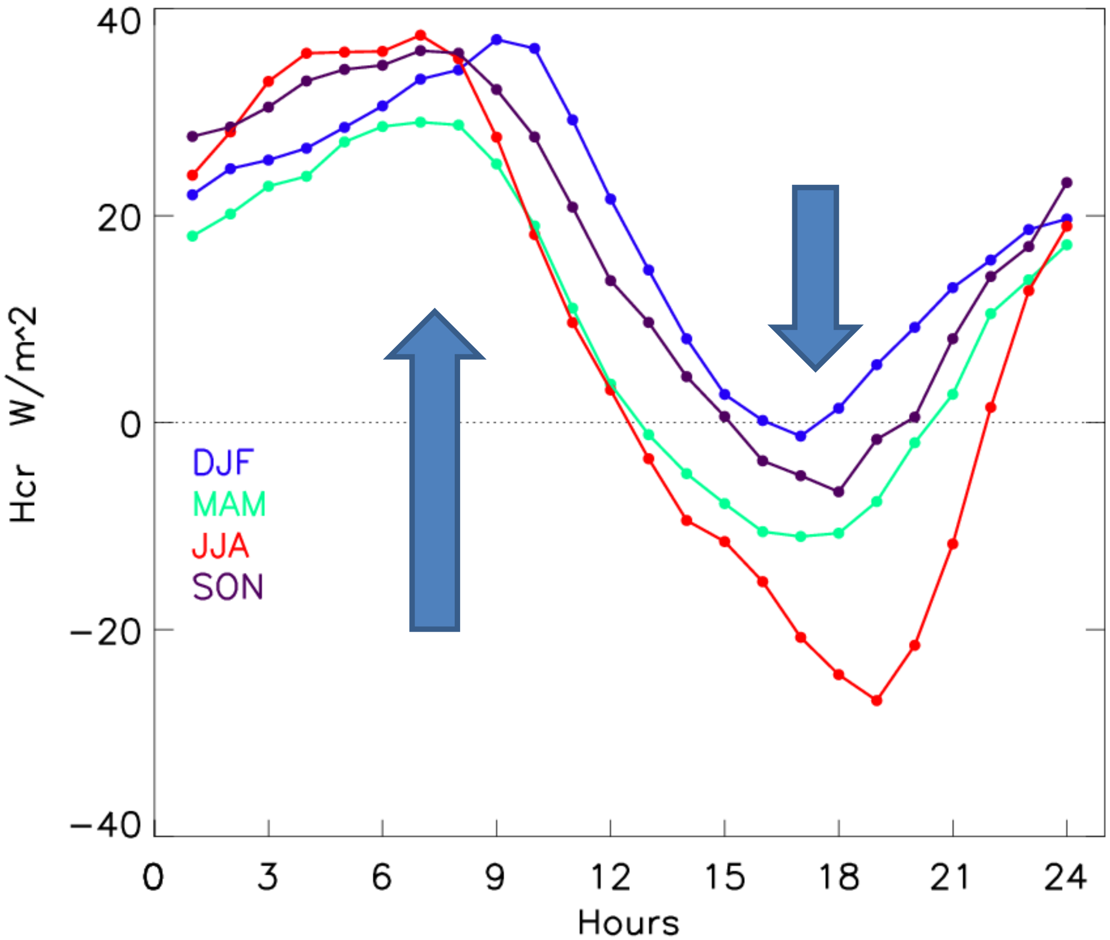
# Seasonal hourly sensible heat flux

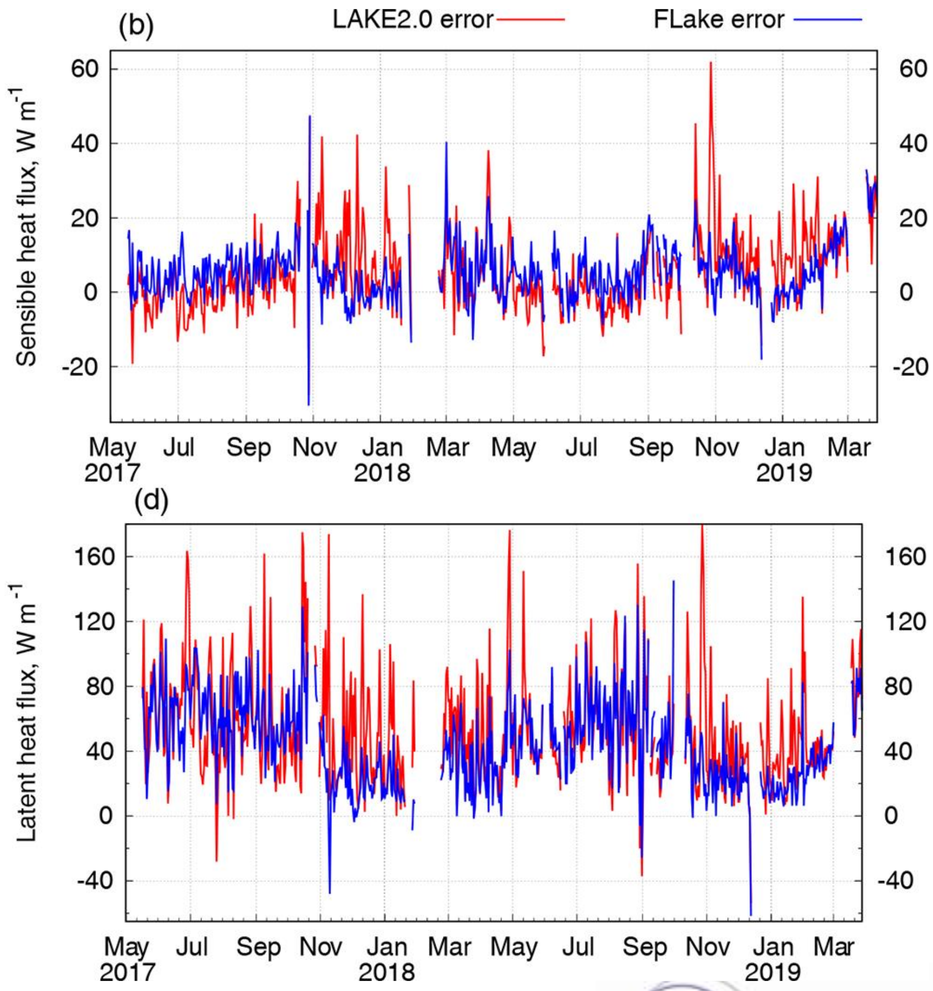



- Nighthime is always positive because lake is hotter than atmosphere.
- Summer has a higher negative values in the afternoon because of hotter atmosphere heating the water.
- Winter presents positive values except at 17 UTC when air temperature can exceed water.

# H and LE Fluxes comparison with FLake and LAKE 2.0

**Table 3.** Sensible and latent heat flux errors and correlation coefficients.

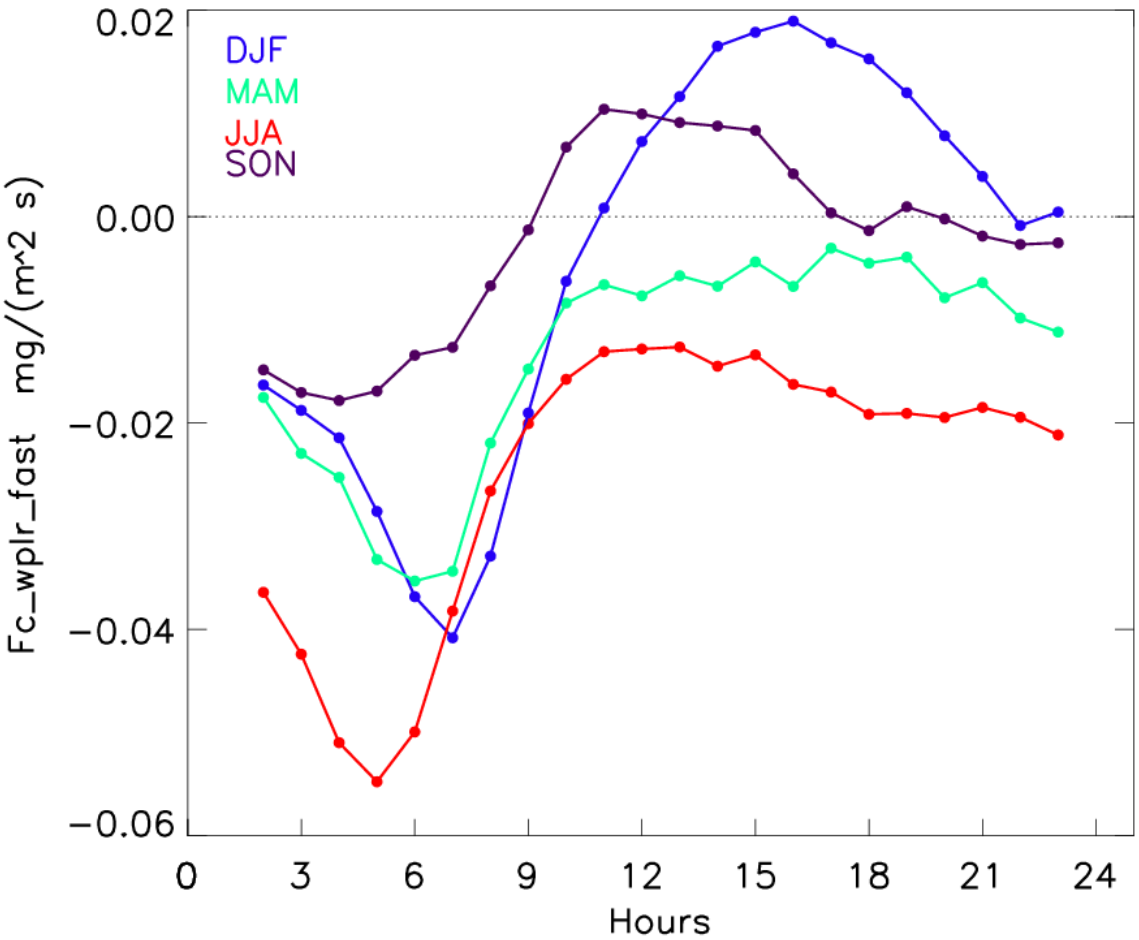
| | Sensible heat | | Latent heat | |
|---|---|---|---|---|
| | LAKE 2.0 | FLake | LAKE 2.0 | FLake |
| Mean error, $W\,m^{-2}$ | 5.51 | 5.36 | 52.93 | 43.46 |
| MAE, $W\,m^{-2}$ | 8.38 | 6.85 | 53.40 | 44.02 |
| Correlation coefficient | 0.88 | 0.87 | 0.92 | 0.92 |




Sensible heat flux is well represented by the models
Latent heat is overestimate by both models with higher error for LAKE 2.0

Iakunin et al., 2020

# Seasonal Hourly $CO_2$ Fluxes




Negative $CO_2$ flux is recorded in Summer and Spring. Oscillation between positive and negative flux is recorded in Winter and Autumn.

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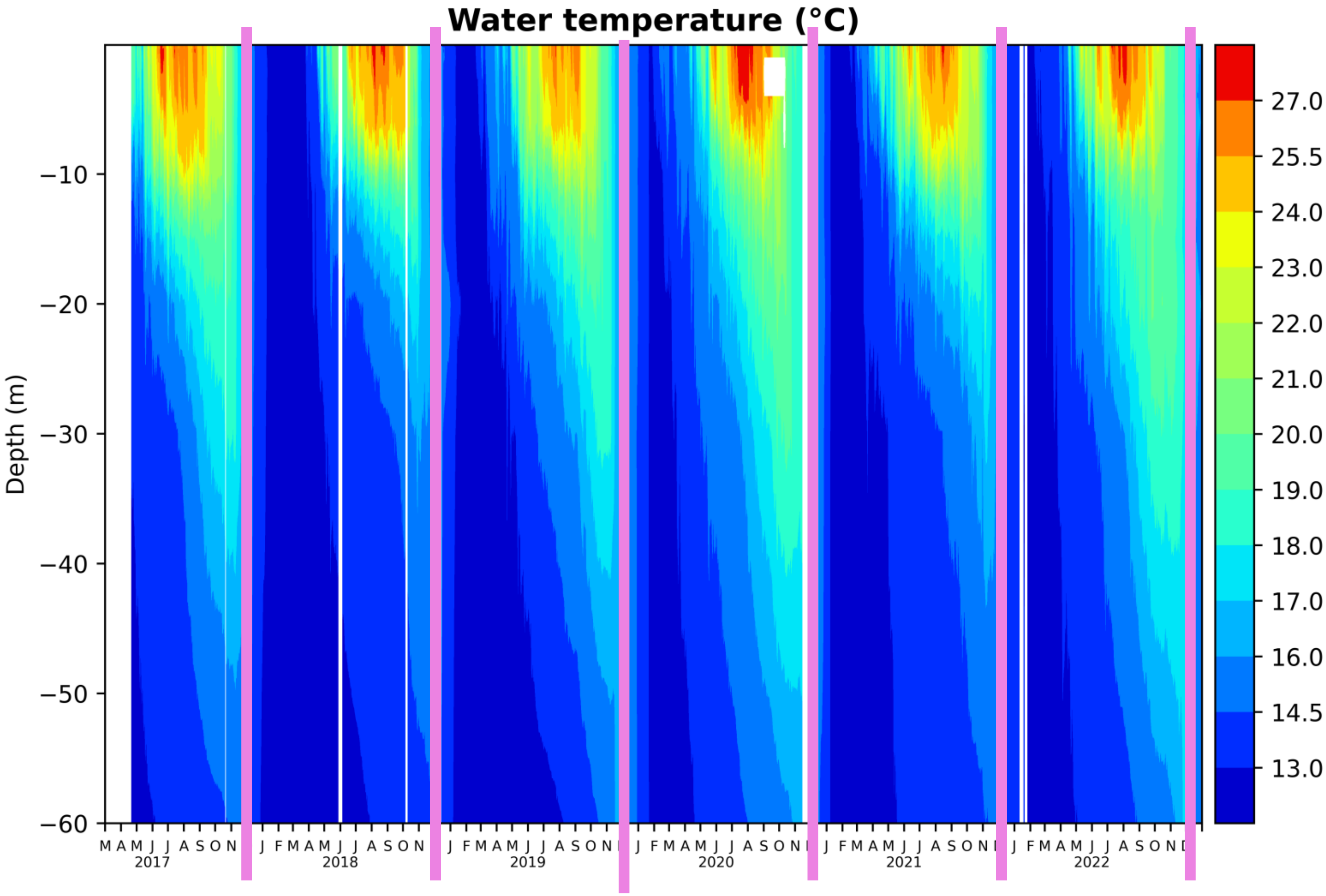
# Water temperature profile (2017-2022)




The reservoir is stratified during the Spring, Summer and beginning of Autumn. During the Autumn the overturn process starts and is concluded in December where the lake is fully mixed (pink bars). In Spring the cycle restarts.

# The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP)

ISIMIP

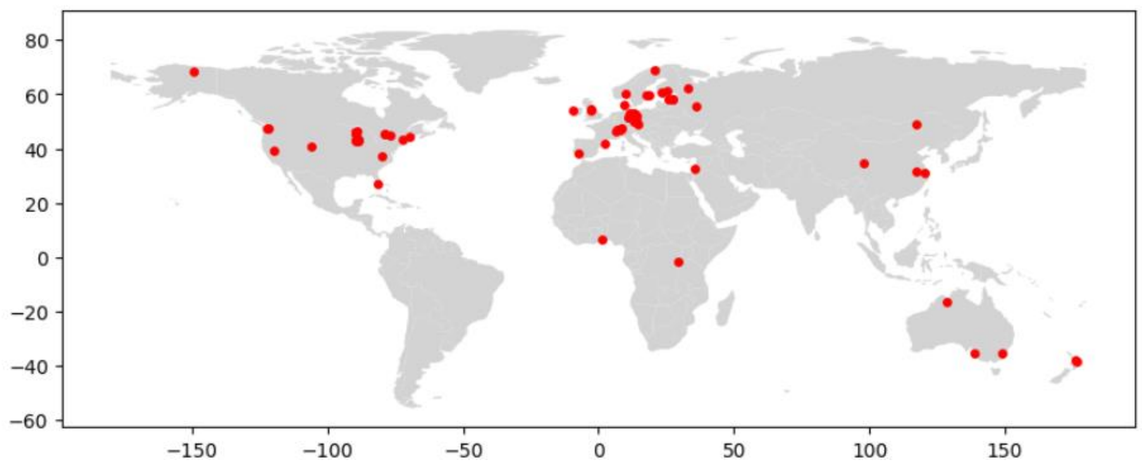
ABOUT ▾ GETTING STARTED ▾ PROTOCOL ▾ IMPACT MODELS ▾ RESOURCES ▾

Search

## ISIMIP3 local lake sites

Atmospheric variables were extracted from both the ISIMIP3a and 3b climate datasets for 72 lakes. They were identified within the Lakes sector as locations (grid cells of the ISIMIP 0.5° grid) where models can be calibrated based on observed temperature profiles and hypsometry (Golub et al., 2022). Shown below a simple map and the full list with coordinates.

ISIMIP3 local lakes sites

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# Satellite remote sensing (2017-2019)

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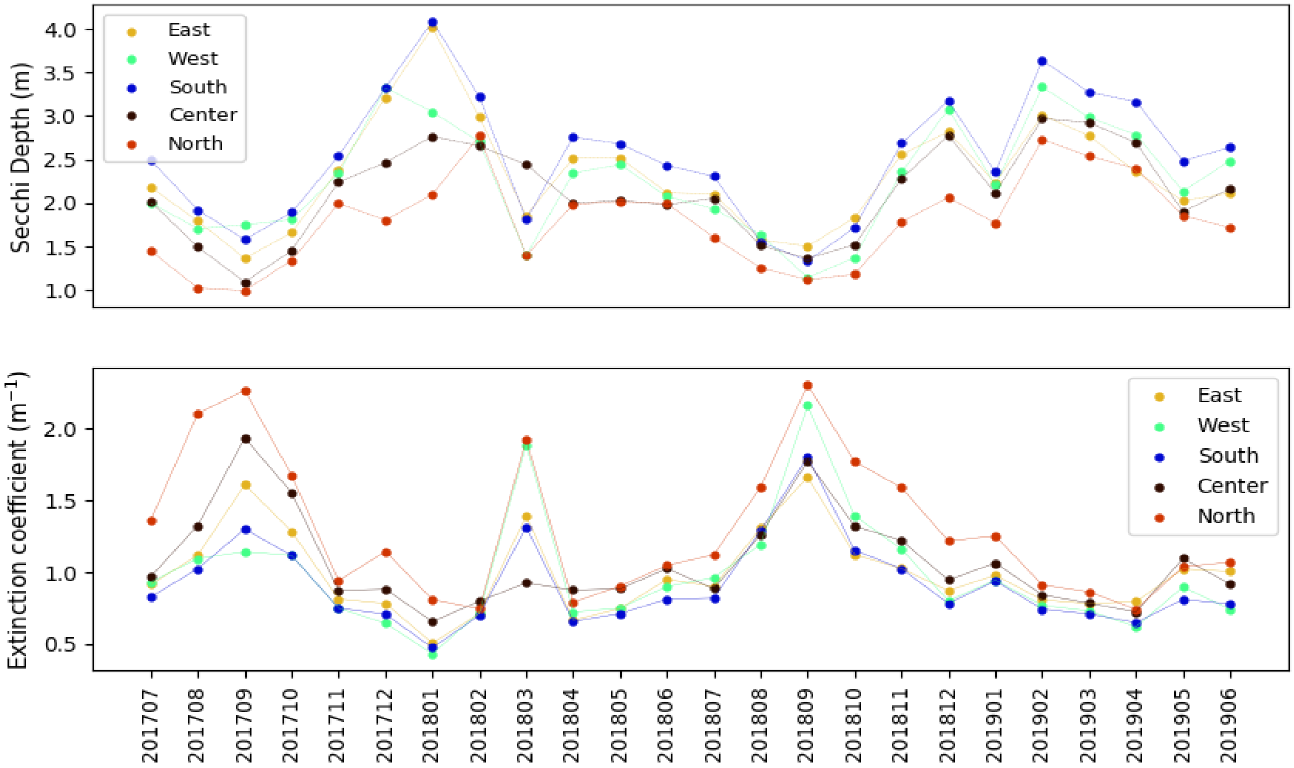


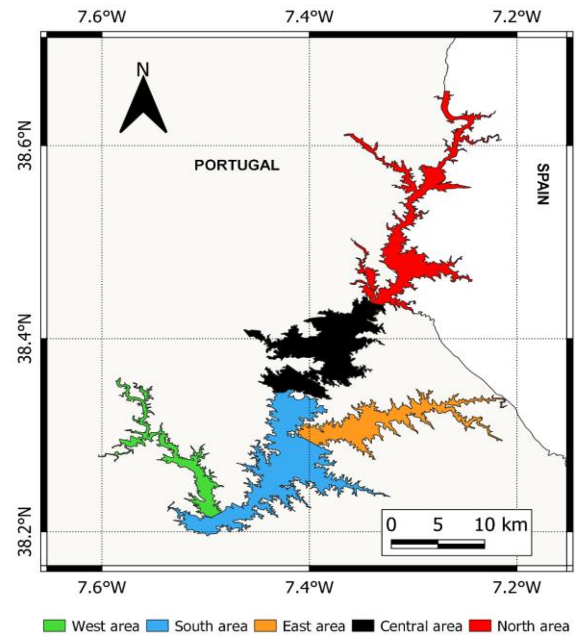


Data from MSI – Sentinel 2 from five areas of Alqueva reservoir over the period July 2017 to June 2019.

Rodrigues et al., 2020

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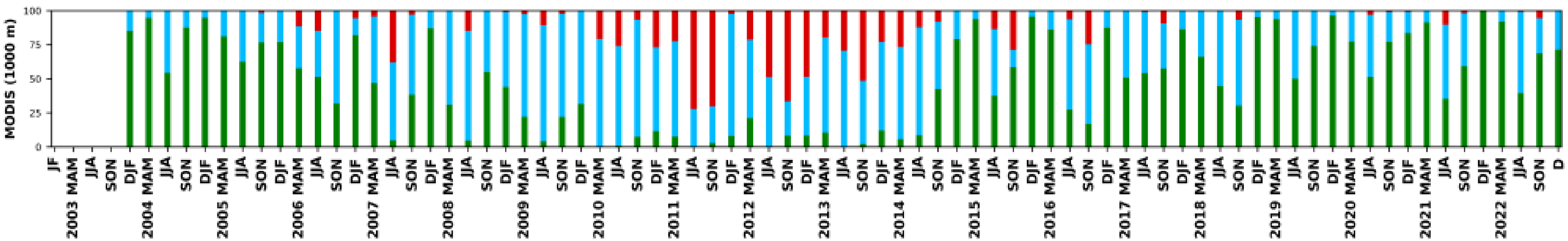
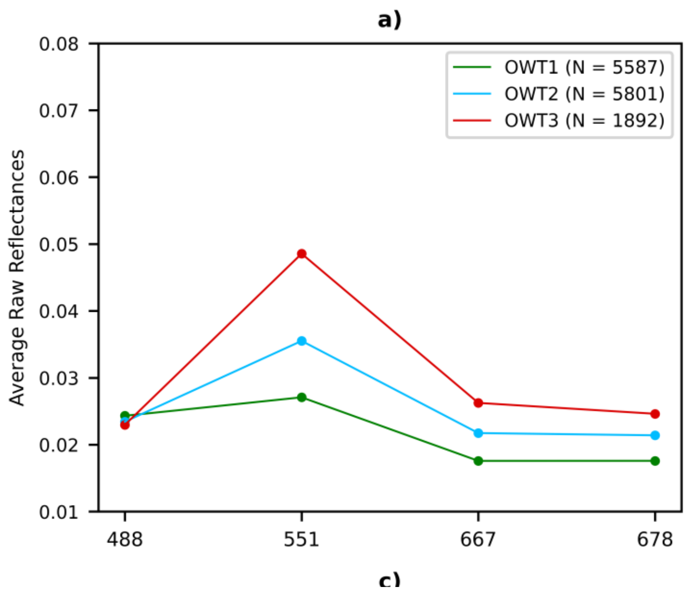
# Satellite remote sensing (2003-2022)

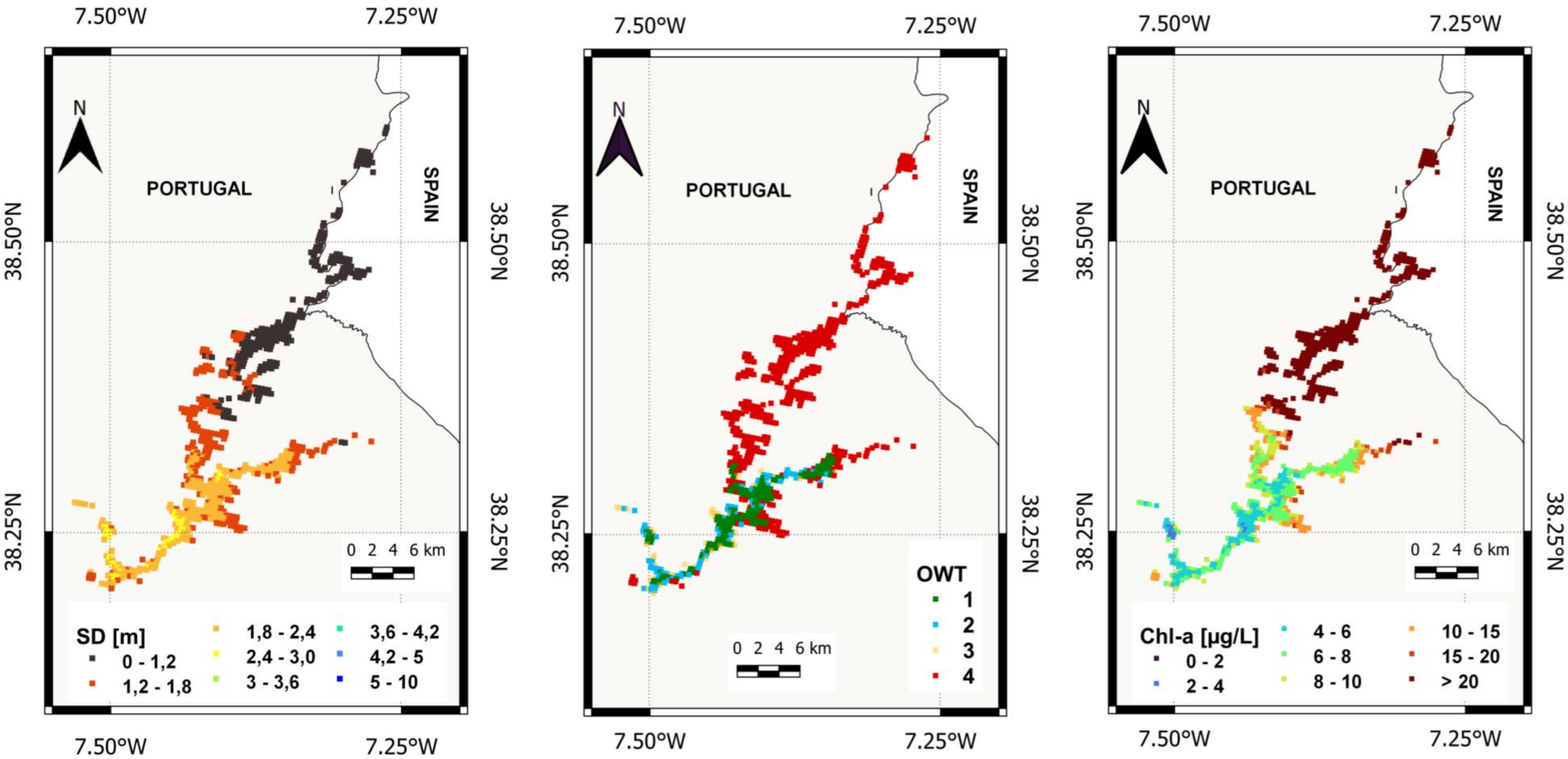



Optical Water Type (OWT) analysis using MODIS for the period 2003 to 2022.
Each OWT represents a group of similar optical characteristics and similar reflectance spectra. The K-means approach was used for clustering. The OWT's are a qualitative analysis nevertheless very useful for warning systems.

Rodrigues et al., 2024, in revision

# Satellite remote sensing
# bloom case of September 2017




Rodrigues et al., 2022

# Final Remarks

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- Eddy Covariance technique it is a valuable tool for heat and mass flux calculations however, it is very expensive.

- Alqueva reservoir has high evaporation rates. The sensible heat fluxes is positive in average. $CO_2$ fluxes are driven by the water stratification.

- Satellite remote sensing allows a fully coverage of the Alqueva reservoir for different water quality parameters, with different spatial resolution and with daily revisiting time (or quasi-daily depending on the satellite used).

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# Thank you!

# Questions/Comments?

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