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Data Article

Hydrometeorological dataset (2018–2023) from the largest Portuguese reservoir: 2 weather stations located at the shore and centre of the reservoir

Gonçalo Rodrigues*, Carolina Purificação, Miguel Potes, Maria João Costa, Rui Salgado

Institute of Earth Sciences—ICT (Polo de Évora), Earth Remote Sensing Laboratory (EaRSLab), Instituto de Investigação e Formação Avançada (IIFA) and Escola de Ciências e Tecnologia (ECT), Universidade de Évora, 7004-516 Évora, Portugal

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ABSTRACT

The databases provided for two meteorological stations installed in the Alqueva reservoir (the largest artificial lake in Europe), one located on a floating platform and the other on the shore (approximately 1 km away in a straight line), cover a period of 6 years, from 2018 to 2023. The data available are, the hourly accumulated precipitation as well as the hourly averages of surface water temperature (0.25 m of depth), soil temperature, and meteorological parameters (wind intensity and direction, relative humidity, upward/downward solar radiation, air temperature, and relative humidity). Additionally, daily maximum and minimum values of the air temperature and relative humidity are provided, together with the time at which they were recorded. These data can potentially be used for various purposes, including hydrometeorological analysis, monitoring and assessing local environmental conditions, analysing local meteorological patterns, integrating or validating results from high-resolution numerical model simulations, or gaining a better understanding of changes in water quality or microalgae blooms in large reservoirs. The

* Corresponding author.
E-mail addresses: grodrigues@uevora.pt (G. Rodrigues), ana.purificacao@uevora.pt (C. Purificação), mpotes@uevora.pt (M. Potes), mjcosta@uevora.pt (M. João Costa), rsal@uevora.pt (R. Salgado).
Social media: @Carol_Puri_25 (C. Purificação), @The_mjcosta (M. João Costa)

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percentage of failures/gaps per parameter for each hour and day is provided to give users the flexibility to choose their own requirements regarding the maximum acceptable limit.

Specifications Table

Subject	Earth and Planetary Sciences: Atmospheric Science
Specific subject area	*Meteorological data including water and soil surface temperature*
Type of data	*Text files (.csv) – Temperatures (Air, Soil and Water in°C), Relative Humidity (%), Wind (intensity in m/s and direction in degrees), Solar Radiation (W/m^2), Atmospheric Pressure (hPa) and Precipitation datasets (mm);*
Data collection	*The data were collected using dataloggers from Campbell Scientific (CR1000X and CR3000 - codes available in the ZENODO repository). According to the World Meteorological Organization (WMO), the data were scanned every second. Statistics were computed every minute, and hourly averages were defined during post-processing. The meteorological instruments installed at the station comply with WMO standards and represent companies such as Campbell Scientific, Philipp Schenk, Vaisala, Rotronic, and Gill Instruments.* *Data were not subjected to rejection criteria based on the percentage of errors; instead, a column with this percentage is provided, allowing potential data users to choose their own rejection criteria. All gaps and outliers were filled with NaN. Outliers were defined based on the monthly climatological normals (1970–2000) of the station from the Portuguese Institute for Sea and Atmosphere (IPMA), Évora station (Code-558).*
Data source location	*Alqueva reservoir, Alentejo, Portugal* *Lat = 38.2235 N Lon = -7.4595 W*
Data accessibility	Dataset from two meteorological stations with water and soil temperature measurements in the Alqueva reservoir (Portugal) Data identification number: https://doi.org/10.5281/zenodo.11182305 Instructions for accessing these data: The datasets are freely available for scientific and public purposes through Zenodo.
Related research article	Purificação C, Potes M, Rodrigues G, Salgado R, Costa MJ. Lake and Land Breezes at a Mediterranean Artificial Lake: Observations in Alqueva Reservoir, Portugal. Atmosphere. 2021; 12(5):535. https://doi.org/10.3390/atmos12050535

1. Value of the Data

- Meteorological data, along with water temperature, can serve as tools to support a comprehensive understanding of reservoir impacts, providing valuable insights for environmental management and mitigation of risks associated with climate change in a region characterized by severe irregularities in precipitation and very high temperatures in summer (typically reaching maximum temperatures between 28 and 46 degrees Celsius).
- Researchers can utilize these data for hydrometeorological analysis, enabling the identification of relationships and interactions between meteorological patterns and the hydrology of the reservoir. Furthermore, it supports understanding how these weather conditions influence water availability in the Alentejo region (Southern Portugal).
- The hourly data provided facilitates monitoring and assessing local environmental conditions, including the response of aquatic ecosystems in the Alqueva reservoir to changes in water temperature and meteorological variables such as solar radiation, precipitation, wind, and air temperature. By considering various scenarios regarding human influence on climate, ranging from mild to severe, researchers can study and make predictions for the next decades concerning water resources and local ecosystems.

- The data provided by two meteorological stations, one situated on a floating platform and the other on the shore, present researchers in the field of meteorology an opportunity to analyse local meteorological patterns, including potential microclimate interactions with synoptic patterns on a larger scale. The data provided also enables researchers to identify how the presence of the reservoir influences the gradients of temperature, relative humidity, wind, and other meteorological variables from the centre towards the shores. Additionally, these data can be utilized to validate numerical models of weather forecasting.
- This data can be used to force water quality models to predict water quality parameters, such as water turbidity, chlorophyll-a concentrations, dissolved carbon dioxide, dissolved oxygen levels, among others. This integration can also enhance the analysis of thermal stratification phenomena and to monitor events associated with water quality deterioration, such as algae blooms.

2. Background

The multidisciplinary project ALOP (ALT20-03-0145-FEDER-000004), ALentejo Observation and Prediction systems, aimed to strengthen research and innovation in the Alentejo region (Southern Portugal) by integrating observation and forecasting in the fields of meteorology, water quality [1-8] and understanding/modelling fluxes of water, energy, and carbon dioxide (CO2) at the water-atmosphere interface [9,10]. As part of this initiative, one of the key objectives was to investigate and model the meteorological conditions in Alqueva reservoir, namely their spatial variations within a few hundred meters, due to the presence of breezes [11,12], and also to conduct numerical modelling in the region using high-resolution models [13,14]. This initiative aims to understand the atmospheric state and reservoirs in the region, with special emphasis on the study in Alqueva (the strategic water reservoir in Alentejo), from which three meteorological stations were installed in early 2017—two on the shores and one in the centre of the reservoir. One of them was deactivated in early 2020 with regular monthly maintenance performed on the other two up to the present day, the meteorological data collected from these stations are now being shared.

3. Data Description

The construction of the Alqueva reservoir was completed in 2002, making it the largest artificial lake in Europe since then. Situated along the Guadiana River, this reservoir serving as a crucial source of drinking water, irrigation, power and tourism for the Alentejo region in southern Portugal. The Alentejo region is historically prone to long periods of drought, particularly between May and September, when average precipitation is scarce being this area characterized as Csa according to the Köppen climate classification (Mediterranean climate with dry and hot summers). Given the significance of the reservoir in this area, monitoring meteorological conditions and water quality is essential. To this end, two operational meteorological stations are located south of the reservoir, collecting and transmitting real-time data to the University of Évora. These stations measure various parameters, most of which are available in the repository, namely wind intensity and direction, atmospheric pressure, air temperature, soil/water temperatures, relative humidity, solar radiation, and precipitation.

Fig. 1 shows the map of the two meteorological stations located at the Alqueva reservoir. The Montante station is positioned on a floating platform, roughly equidistant from both shores, with a water depth of approximately 70 meters (38.2235 N, -7.4595 W), and it is situated to the Northwest of the second station, known as CidAlmeida (38.21539 N, -7.45454 W). Located on the shore, the CidAlmeida station is approximately 1 km away from the Montante station in a straight line. While the CidAlmeida station is situated on land, it is very close to the water, being only a few meters away from the shore, particularly when the reservoir is near its maximum capacity.

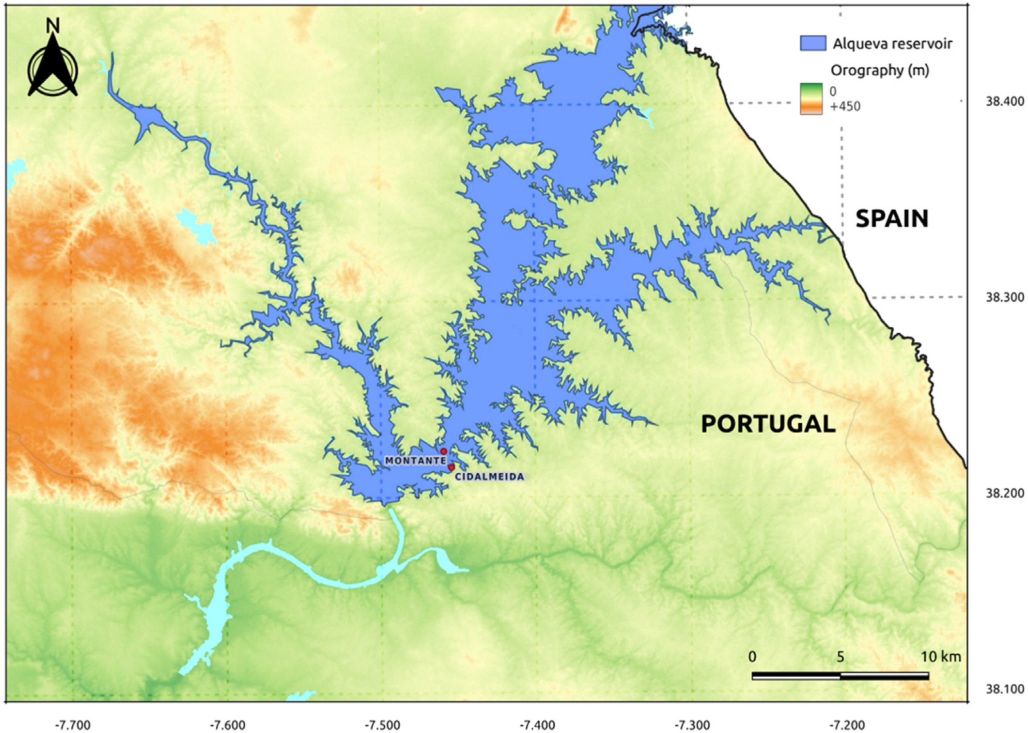

Fig 1. Map showing the location of the two meteorological stations installed in the south of the Alqueva dam.

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

Most of the parameters provided are measured at both stations, including parameters with spatial variations that may be relevant within a few hundred meters from the center of the reservoir towards the inland. These parameters include:

(a) Hourly averages of air temperature, wind intensity, relative humidity, upward solar radiation, downward solar radiation and atmospheric pressure.
(b) Maximum gust in a 1-hour period.

In addition to these parameters, the hourly average water temperature at a depth of 0.25 m is also provided for the station located in the middle of the reservoir (Montante). From the station located on the shore (CidAlmeida), in addition to the common parameters, the hourly accumulated precipitation, the hourly average soil temperature and wind direction are also provided. Table 1 provides a summary of all the measured variables and the main characteristics of the provided data. As an example of the data presented in this database, the water, air and soil temperatures in May 2020 are shown in Fig 2. These datasets are freely available from the Zenodo platform [15]. Each parameter is represented by a separate column, with the column headers specifying the parameter names in the files available in the Zenodo repository, while the units for each measurement are provided in Table 1. Each dataset provides hourly measurements covering the time period from 2018 to 2023 using Coordinated Universal Time (UTC) and is presented in two CSV files.

The content of the two .csv files is organized such that the first column represents the year and month (yyyymm), the second column represents the day (dd), the third column represents the hour (hh), and the subsequent columns represent hourly averages for all parameters with exception for the precipitation (hourly accumulation) and the maximum gust (hourly maximum). In addition to these two files, daily measurements are provided in the Zenodo repository including maximum temperature, minimum temperature, maximum relative humidity, and minimum relative humidity. These daily extremes are calculated based on minute-by-minute data collected throughout the entire day.

The code written in Visual Basic that enables data transmission and real-time statistical processing and the percentage of hourly and daily failures for each meteorological parameter is also included in the repository. The following section presents the quality details.

4. Experimental Design, Materials and Methods

The data repository for the two weather stations (Montante and CidAlmeida) involves several sequential steps: acquisition, installation of weather stations, and data transmission to the University of Évora, where data reception and verification are performed **(a)**; creation of two

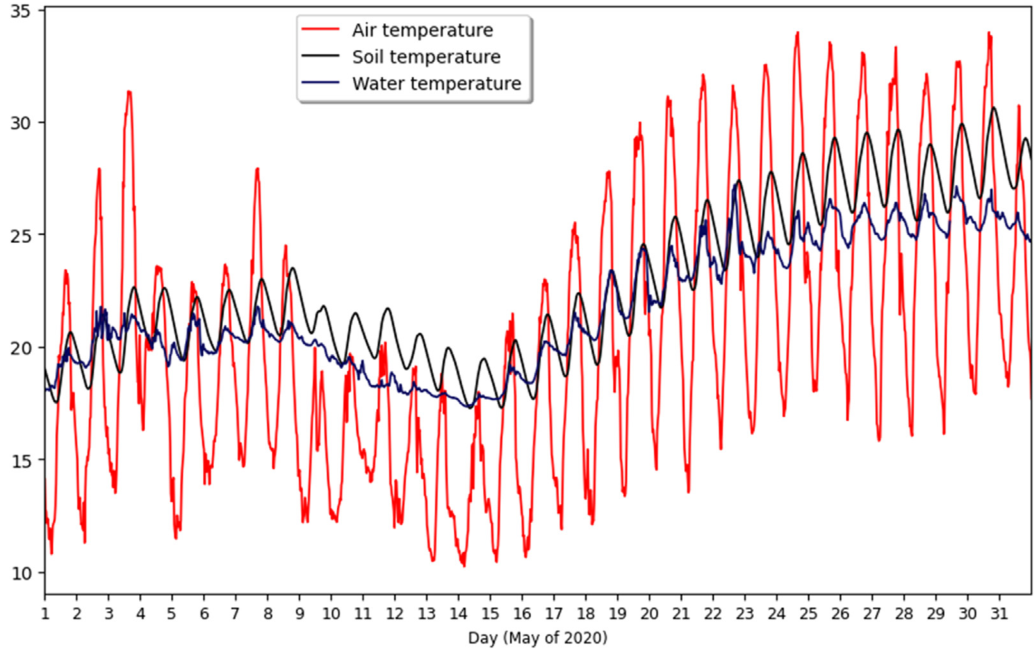

Fig 2. Air temperature (2 m) and soil temperature (0.15 m) for CidAlmeida station in May 2020. Water temperature measured at the Montante platform (at a depth of 0.25 m) in the same month.

Table 2
Instruments used and their main characteristics.

Station	Instrument	Parameter	Manufacturer	Model	Accuracy
Montante	Barometer	Atmospheric Pressure	Vaisala	PTB110 1B0CB	±0.3 hPa @ 20°C
	Temperature sensor	Water temperature	Campbell Scientific	107	±0.4°C
	Albedometer	Solar Radiation	Philipp Schenk	8104	Linearity < 0.5% over 0.5 – 1330 W/m^2
	Thermo-Hygrometer	Temperature/Relative humidity	Rotronic	HydroClip2 – HC2A – S3	±0.1K @ 23°C / 0.8% @ 23°C
CidAlmeida	WindSonic	Wind (Intensity, Direction)	Gill Instruments	1 – 1405-PK-021	±2% @ 12 m/s
	Temp/Humidity	Temperature/Relative humidity	Campbell Scientific	CS 215	±0.3°C @ 25°C / ±2% over 10 - 90%
	Temperature Sensor	Soil temperature	Campbell Scientific	107	± 0.4°C
	Udometer	Precipitation	Campbell Scientific	ARG 100	4% @ 25 mm/hr
	Albedometer	Solar Radiation	Philipp Schenk	8104	Linearity < 0.5% over 0.5 – 1330 W/m^2
	Barometer	Atmospheric Pressure	Vaisala	PTB1101B0CB	±0.3 hPa @ 20°C

databases for the organization of meteorological data and soil/water temperatures (**b**); and finally, data quality control (**c**).

(a) Table 2 presents the manufacturer, model, and parameters measured by each of the instruments used for measurements. Meteorological data was collected and transferred in real-time using dataloggers from the manufacturer Campbell Scientific (CR1000X and CR3000). A scan was performed every second according to WMO recommendations, and using VirtualBasic language, data processing and writing occurred every minute in table format. Real-time data transfer between the two weather stations and the local server was carried out using the well-established file transfer protocol (FTP). Both weather stations undergo maintenance approximately every 25 days to ensure measurement quality.

(b) Two databases and Python code were developed to automatically add daily records measured at the two weather stations. These databases were designed to be more efficient and optimized for accessing weather information and for quickly updating information using MySQL instructions, either to correct outliers and data transmission failures, or to fill gaps. Finally, a website (http://www.alop.ict.uevora.pt/obs/) was developed to visually identify the evolution of meteorological parameters, with these graphs being updated daily and automatically.

(c) In post-processing, the possible existence of anomalies in the measured values was checked for the entire period. Once these anomalies were identified, they were replaced with the NaN error code. These failures were identified very punctually, particularly on days with several lines without records (when e.g., uploads were made in the program and sent to the datalogger). The major outliers were filtered out however, the user should note that in hours/days with a high percentage of data failures: 1) decide whether to use the available data on these days and 2) if used, a robust quality analysis of the data should be performed for these days.

Considering that significant spatial variations may occur at the lake-land interface due to temperature gradients over a few hundred meters, no gap filling by interpolated values or other methods was performed. Three quality control filters were applied to the raw data from the two meteorological stations (steps of one minute):

i. Identification of hourly periods with less than 60 records, and filling in missing data with NaN values for each minute without records in the database.
ii. Elimination of duplicate lines, keeping the first line if the values of the meteorological parameters are repeated, or replacing these with NaN if the values are different for each line for the same minute and meteorological parameter.

iii. Filter for unexpected and unrealistic outliers, filled in with NULL values. These unrealistic outliers occurred very sporadically, mostly when maintenance was performed on the meteorological stations or when the associated programs from the datalogger were restarted.

Hourly averages were calculated for all analyzed parameters (Table 1), except for precipitation, which was summed and for maximum wind gusts, where the hourly maximums were calculated. Hourly values are provided for all meteorological parameters, even for hours with a high percentage of failures (but not 100% - in this case, NaN is assigned). This is because different applications may have different requirements regarding the accepted percentage of minutes to be considered in the hourly average. The hourly error percentage for each meteorological parameter is provided in the Zenodo repository, allowing the user to select the appropriate filter for each study.

Daily extremes (daily maximums and minimums for air temperature, relative humidity) are only provided for days where the percentage of errors within the day does not exceed 25% of the 1440 min of each day. However, it is advisable for the user to check the importance of using that daily extreme when error percentages are between 10% and 25%. For example, the daily maximum/minimum may be slightly different from the real value, even for reduced error percentages between 10% and 25%, if such a failure period covers the hottest/coldest period of the day. The daily error percentage for each of the measured parameters at the two stations for the period 2018-2023 is available in the Zenodo repository.

Limitations

In hours or days with a significant percentage of errors (NULL assigned) for a certain meteorological parameter, the records should be used with much greater care, as there may be errors in data transmission from the datalogger. Anomalies were found in these days, especially when NULL values are interspersed with measurements. While more extreme values were filtered out, not all of these days were individually analyzed. Therefore, it is essential to conduct a detailed analysis of these specific days with a high percentage of errors.

Ethics Statement

The work did not involve the use of human subjects, animal experiments and data collected from social media platforms. No ethical issues are identified.

CRediT Author Statement

Gonçalo Rodrigues: Conceptualization, Software, Data Curation, Database creation, Visualization, Writing - Original Draft, Writing - Review & Editing; **Carolina Purificação:** Visualization, Writing - Review & Editing; **Miguel Potes:** Conceptualization, Software, Methodology, Visualization, Supervision, Writing - Review & Editing; **Maria João Costa:** Conceptualization, Methodology, Supervision, Writing - Review & Editing; **Rui Salgado:** Conceptualization, Methodology, Writing - Review & Editing, Project administration, Funding acquisition.

Data Availability

Dataset from two meteorological stations with water and soil temperature measurements in the Alqueva reservoir (Portugal) (Original data) (Zenodo).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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