UNDERSTANDING REFERENCE EVAPOTRANSPIRATION DISTRIBUTION AND EVOLUTION IN THE NORTHWESTERN MEDITERRANEAN BASIN

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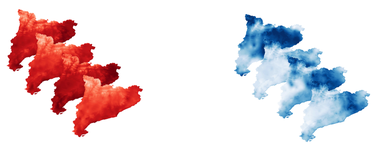
This study aims to analyze the relative impact of different meteorological variables on evapotranspiration to better understand the factors affecting this relevant phenomenon for drought management in Catalonia. Such insights will provide valuable information for adapting to future drought episodes. The study proposes an in-depth analysis of evapotranspiration in Catalonia, using data collected from the Automatic Weather Station (AWS) network (XEMA) of the Meteorological Service of Catalonia (SMC) and reanalysis data from ERA5-Land. This network extensively covers the region, providing data for calculating evapotranspiration on monthly, daily, and even hourly time scales. Taking advantage of this dataset, the Penman-Monteith formulation is employed to compute reference crop evapotranspiration (ET0). The evolution of this variable in the territory, its spatial distribution, and case studies such as the recent 2020-2024 episode are studied.

DATA & METHODS

Region of study: Catalonia (NW Mediterranean)
Time resolution: hourly
Spatial resolution: 1 km
Period: 2000-2023
Observation data: AWS network (XEMA) of the Meteorological Service of Catalonia (SMC)
Reanalysis data: ERA5-Land hourly data (1)
ET0 methodology: Penman-Monteith (2)

OBSERVATIONS (XEMA - SMC)

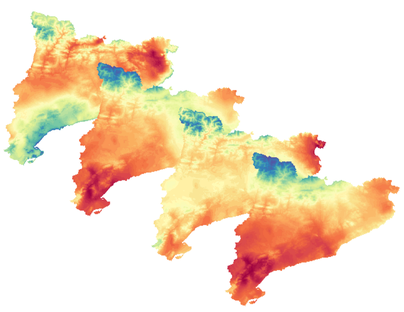
Temperature | Relative humidity



ERA5-LAND

Wind speed | Solar radiation

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{37}{T_{hr}+273}U_2(e^0(T_{hr}) - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$



$$ET_{0Ra} = \frac{0.408\Delta(R_n - G)}{\Delta + \gamma(1 + 0.34U_2)}$$ **Radiative component**

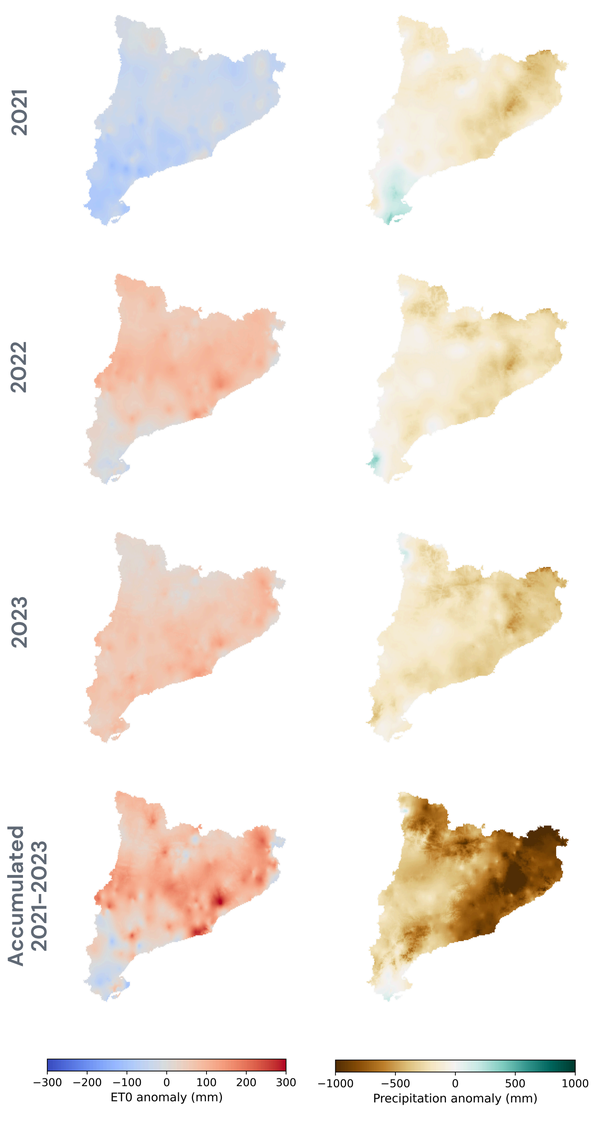
$$ET_{0Ae} = \frac{\gamma\frac{37}{T_{hr}+273}U_2\left(e^0(T_{hr}) - e_a\right)}{\Delta + \gamma(1 + 0.34U_2)}$$ **Aerodynamic component**

ETO *reference evapotranspiration [mm hour-1]*
Rn *net radiation at the grass surface [MJ m-2 hour-1]*
G *soil heat flux density [MJ m-2 hour-1]*
Thr *mean hourly air temperature [°C]*
Delta *saturation slope vapour pressure curve at Thr [kPa °C-1]*
Gamma *psychrometric constant [kPa °C-1]*
e°(Thr) *saturation vapour pressure at air temperature Thr [kPa]*
ea *average hourly actual vapour pressure [kPa]*
u2 *average hourly wind speed [m s-1]*

The **reference crop evapotranspiration (ETO)** is a climatic variable that represents the evaporative demand of the atmosphere independently of crop type, crop development and management practices.

The Food and Agriculture Organization of the United Nations (FAO) recommends the use of the Penman–Monteith equation, which is a physically-based method that accounts for both radiative and aerodynamic variables components of ET0.

DROUGHT EPISODE 2021-2023



Positive anomalies in evapotranspiration (except in 2021)

Negative anomalies in precipitation

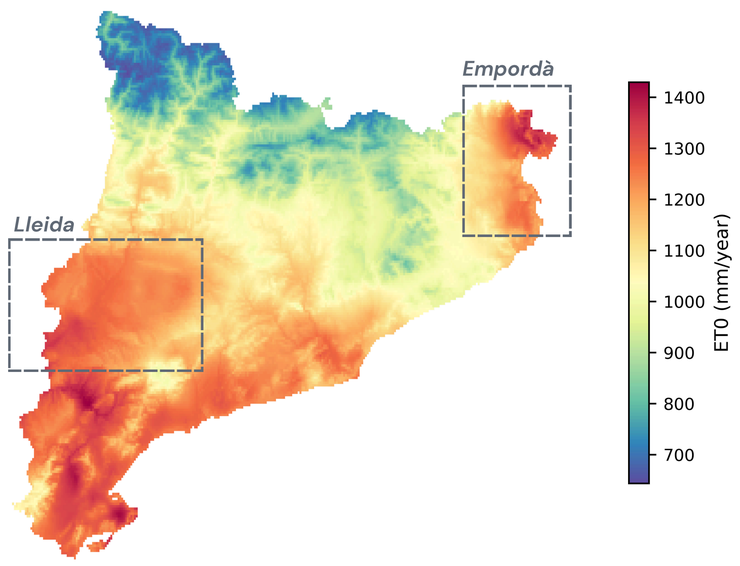
300 mm accumulated evapotranspiration anomaly for the period 2021-2023

-1000 mm accumulated precipitation anomaly for the period 2021-2023

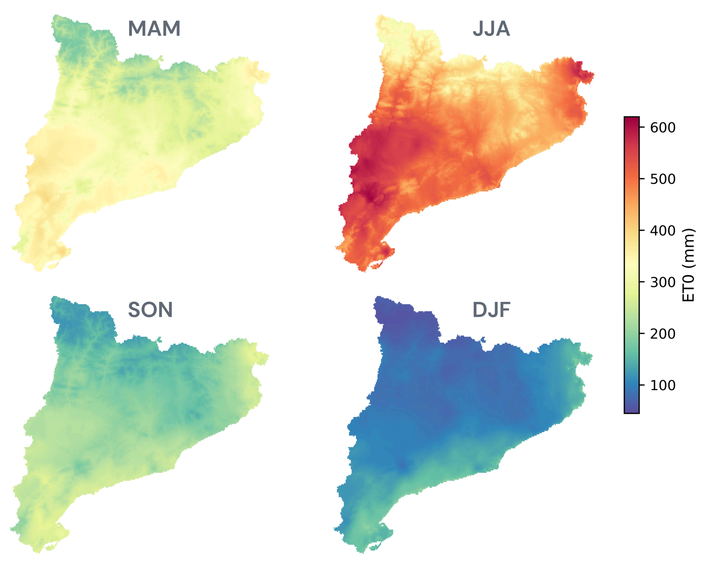
The largest negative precipitation anomalies broadly coincide with the largest positive evapotranspiration anomalies.

CLIMATOLOGY (2000-2023)

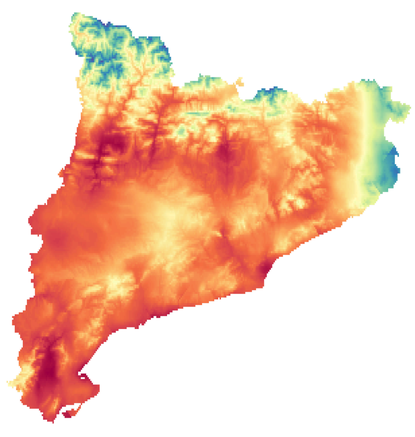
Mean annual values of ET0



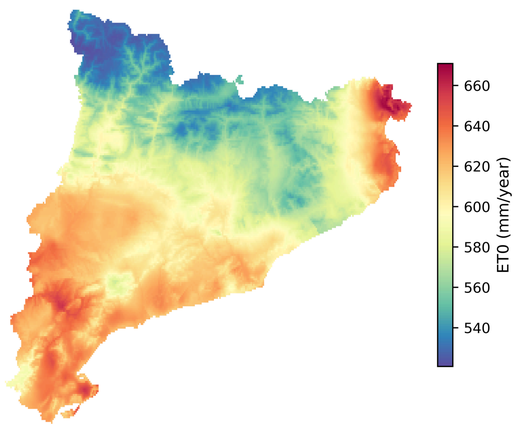
Mean seasonal values of ET0



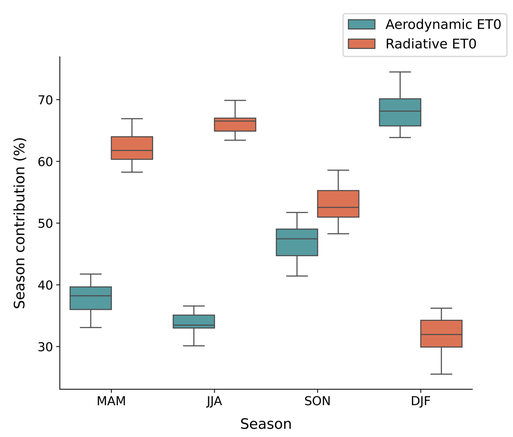
Radiative component of ET0



Aerodynamic component of ET0

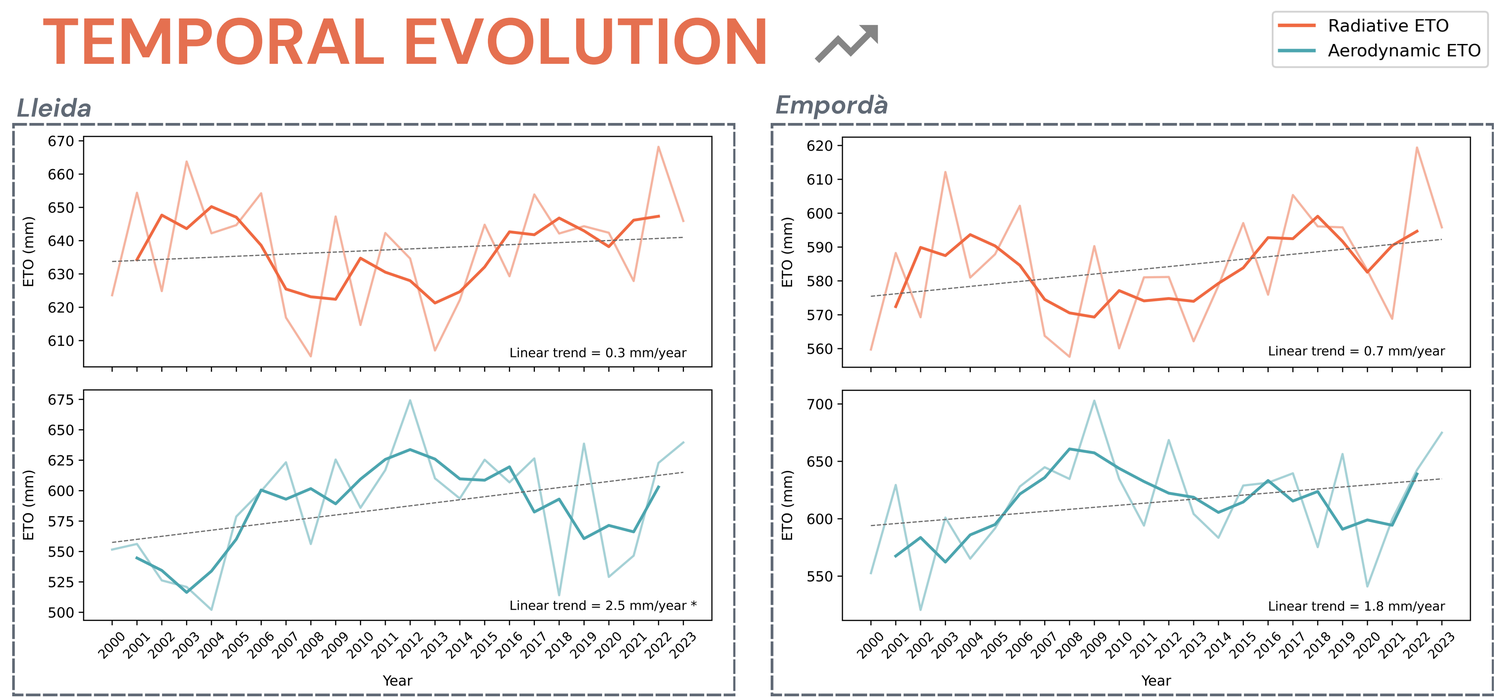


Contribution of ETO components



Catalonia exhibits average annual ETO values ranging from **650 to 1450 mm/year**, with the lowest values found in mountainous areas (N-NW) and the highest values in the southwestern region. The radiative component has the greatest influence on the annual ETO values (with the exception of the NE); however, during the winter months (DJF), the aerodynamic component contributes the most.

TEMPORAL EVOLUTION



From 2000 to 2023, the radiative and aerodynamic components of ETO in the Lleida and Empordà regions show an **upward trend**, with the aerodynamic ET0 increasing more significantly in both areas. Pale colors represent the annual raw data, while intense colors indicate the 3-year moving average. The asterisk represents a significant trend (Mann-Kendall).

CONCLUSIONS

- The highest values of evapotranspiration are in the southwest and northeast of the region, with the summer months (JJA) contributing the most. The contribution of the radiative component of ETO is generally higher across the entire region and throughout the seasons, except in the northeast of the region and during the winter months (DJF).
- Some inconsistencies have been identified in the temporal and spatial analysis when using high-resolution grids.
- Future work will involve refining wind speed and solar radiation variables using observational data to enhance evapotranspiration calculations.

REFERENCES

(1) Muñoz Sabater, J. (2019): ERA5-Land hourly data from 1950 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.e2161bac
(2) Allen, R. G., Pereira, L. S., Raes, D., and Smith, M. (1998). FAO Irrigation and Drainage Paper Crop by. Irrigation and Drainage, 300(56):300.

ACKNOWLEDGEMENTS

Teammates of the Meteorological Service of Catalonia.
Muñoz Sabater, J. (2019) was downloaded from the Copernicus Climate Change Service (2022). The results contain modified Copernicus Climate Change Service information 2020. Neither the European Commission nor ECMWF is responsible for any use that may be made of the Copernicus information or data it contains.

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