INFLUENCE OF THE UPPER-LEVEL MEDITERRANEAN OSCILLATION ON THE TEMPERATURE VARIABILITY IN THE MEDITERRANEAN BASIN

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ABSTRACT

- **Motivation**:
  - •Improvement of seasonal and multiannual temperature projections for Mediterranean Basin.
  - •Increase the resilience to extreme weather and climatic events.
- **Objective**:
  To design a new index to explain the climate variability of seasonal and annual temperature anomalies along Mediterranean.
- **Materials**:
  - 42 meteorological observatories.
  - A 500 hPa geopotential global reanalysis by NCEP/NCAR.
  - •Another 11 teleconnection indexes were considered to compare to the new index.
- **Methods**:
  - •**Design of index**: it was used seven windows instead of isolated points.
  - •**Analysis of interdependence and climatic variability**: FFT, ANOVA, Backward elimination stepwise, Pearson Correlation (R and its p-value), SSE, SAE, and prevailing patterns.
- **Results**:
  - **For the studied period 1950-2015**: Relationship between ULMOi and observatories was positive over the western side and negative for the eastern Mediterranean Basin.
  - •All simulations show **errors lower than** reference prediction based on the climatic average.

MATERIALS AND STUDY AREA

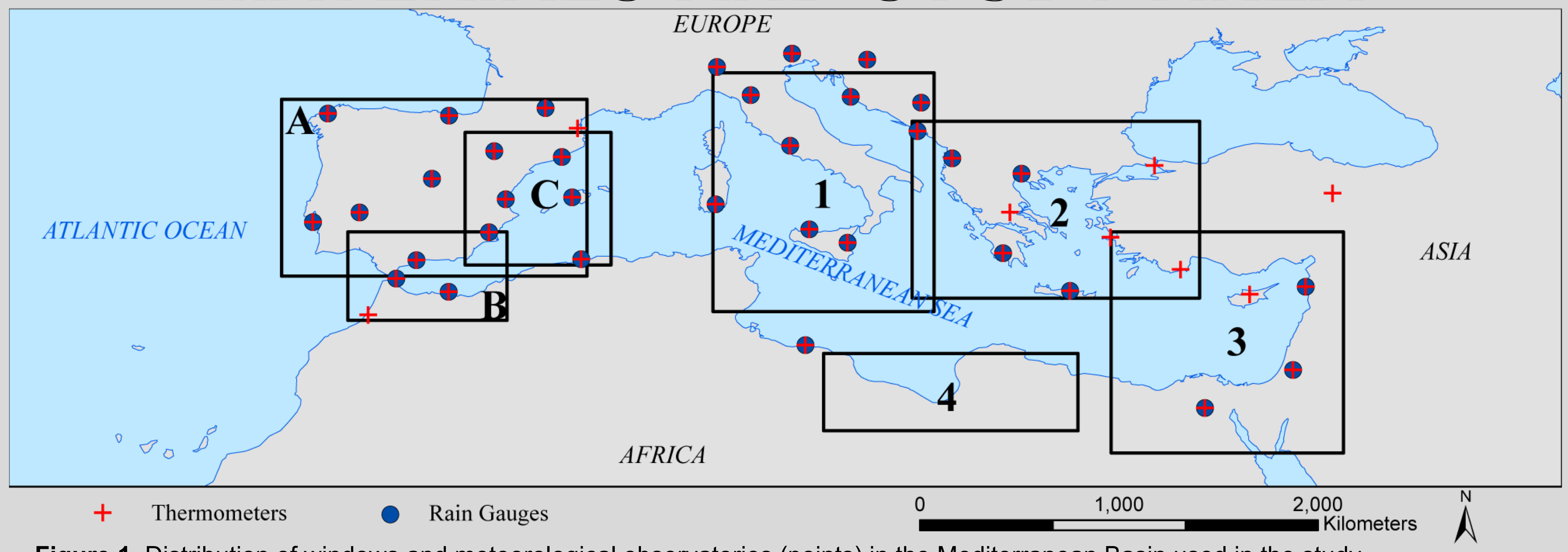

Figure 1. Distribution of windows and meteorological observatories (points) in the Mediterranean Basin used in the study.

- **42 meteorological stations** (Fig 1).
  - **European Climate Assessment and Dataset (ECA)**
  - 34 monthly thermopluviometric time-series.
  - 8 monthly temperature time-series.

Data from the NCEP/NCAR reanalysis:
- 6 hour temporal frequency.
- 500hPa Geopotential height .
- Spatial resolution of 2.5º × 2,5º

Additional indexes: AOi, NAOi, MOi, WeMOi, ENSOi, PDOi, AMOi, SAHEL-Pi, GSNWi, GJSL and AJSL.

METHODS

ULMOi was defined as **the difference between the anomaly in the western area** (windows A, B and C) **and the anomaly in the eastern area of the Mediterranean** (windows 1 to 4), **West-East: 3 x 4 versions.**

$$ULMOi_{ab} = \frac{D500_{ab} - \overline{(D500_{ab})}}{\sqrt{\frac{\sum_{i=1}^{N}\left(D500_{ab} - \overline{(D500_{ab})}\right)^2}{N-1}}}$$

Simulations of temperature were performed using the ULMOi as predictor.

The best ULMOi version was selected according to different statistical measures **such as standardized absolute error** (SAE) and **standardized mean squared error** (SSE), among others.

$$SAE = \frac{\sum_{i=1}^{N}|s_i - o_i|}{\sum_{i=1}^{N}|\bar{o}_i - o_i|}$$

$$SSE = \sqrt{\frac{\sum_{i=1}^{N}(s_i - o_i)^2}{\sum_{i=1}^{N}(\bar{o}_i - o_i)^2}}$$

where s_i is the simulation, o_i is the observation, and $\bar{o}_i$ is the mean of the observations.

In order to rank the 3 x 4 versions of ULMOi according to ability, **a Fractional Order (*FO*)** was assigned**.**

$$FO_{ij} = 1 + 11\frac{E_{ij} - \min_{1\le i\le 12}(E_{ij})}{\max_{1\le i\le 12}(E_{ij}) - \min_{1\le i\le 12}(E_{ij})}$$

Fractional order FOi of the i-version ULMOi, considering *n* statistical measures E_{ij} is**:**

$$FO_i = \frac{1}{n}\sum_{j=1}^{n} FO_{ij}$$

RESULTS AND DISCUSSION

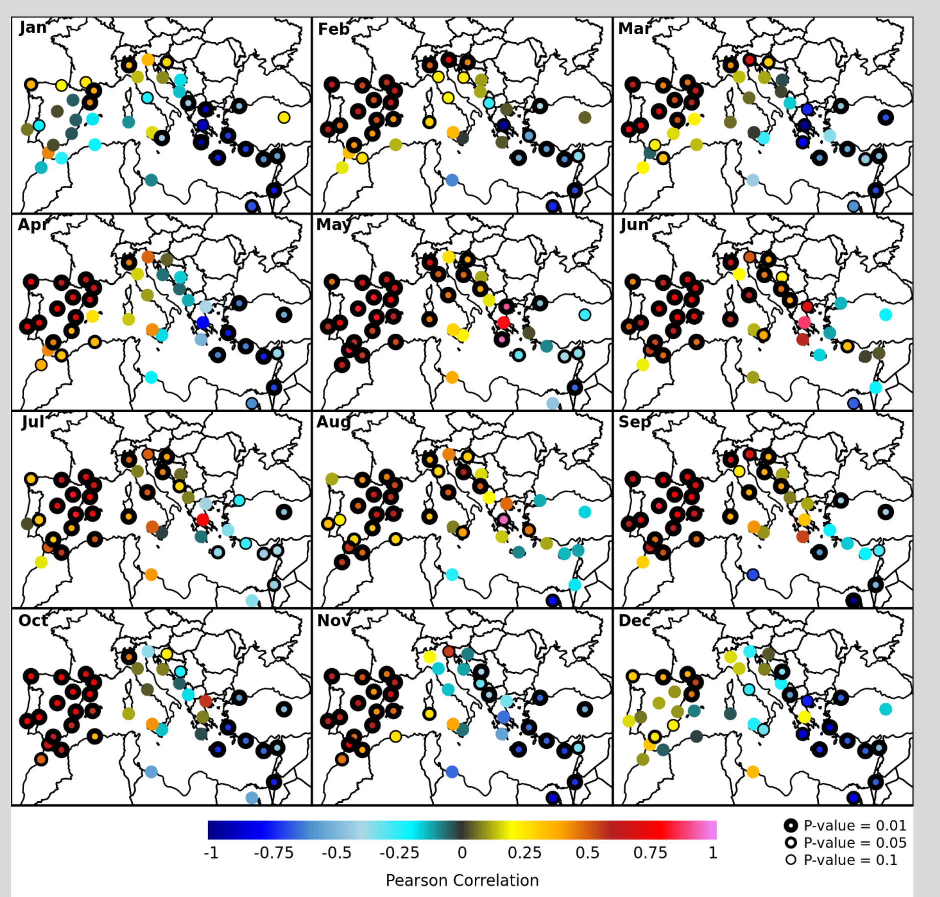

Figure 2. *R* and its *p*-value obtained comparing simulated and observed temperature for each month of the year.

The best windows are **C4** and **C3**, corresponding to Balearic Sea and North Libya and North Egypt, respectively.

We found positive and statistically significant correlations between ULMOi (C4 and C3) and temperature series in the west and center of the basin (except for January), and negative values in the south and east .

The observed spatial distribution of correlation coefficients (Fig. 2) is caused by the **atmospheric blocking** (which generates high pressure over the Iberian Peninsula) over the Mediterranean Basin in the positive phase of the ULMOi, producing subsidence that heat the air mass and, therefore, a positive temperature anomaly.

The weather stations with the lowest *p*-value for annual temperature according to the ULMOi are Madrid, Lisbon, Heraklion, Barcelona, Badajoz and Perpignan. For autumn, the temperature variability explained by all versions of ULMOi is better than in any other season in all observatories (Fig. 3).

Overall, statistics show that **ULMOi explains most of temperature variance over the Mediterranean basin** in comparison to other indices (see Figs 4 and 7).

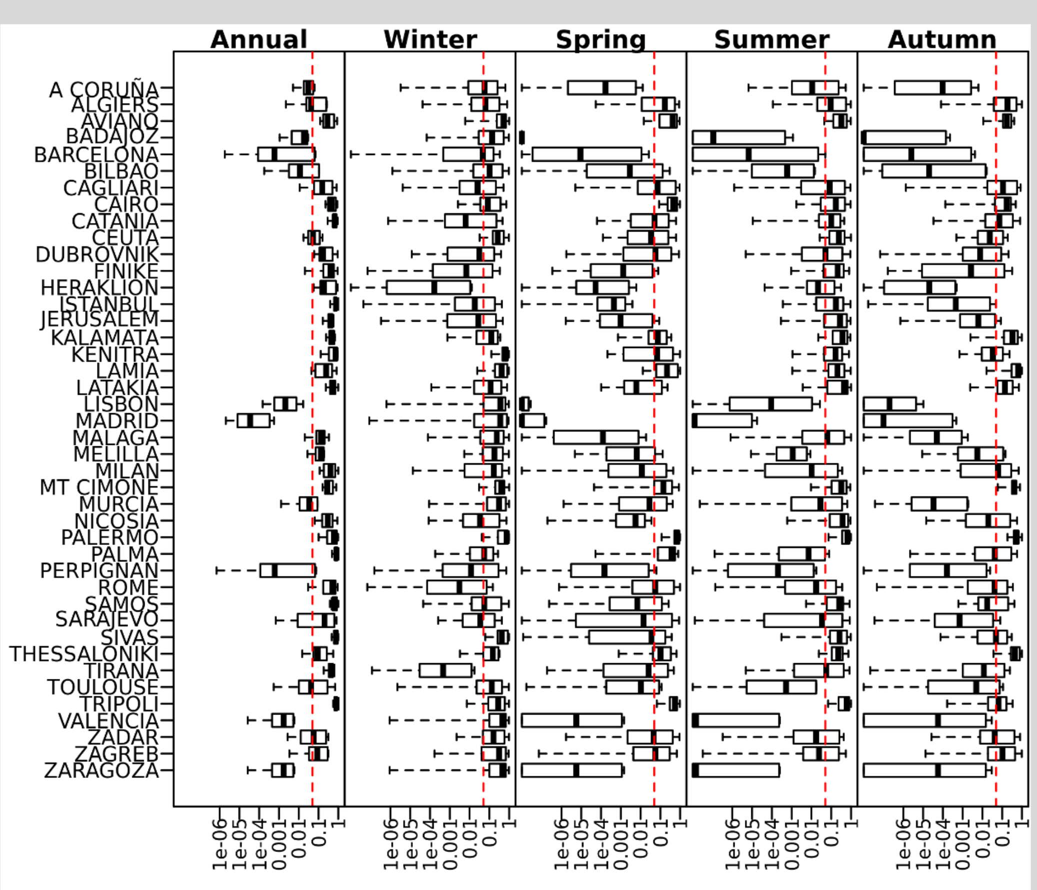

Figure 3. Pearson correlation *p*-value obtained between the seasonal ULMOi C4 simulation and the observed temperature anomaly in all stations.

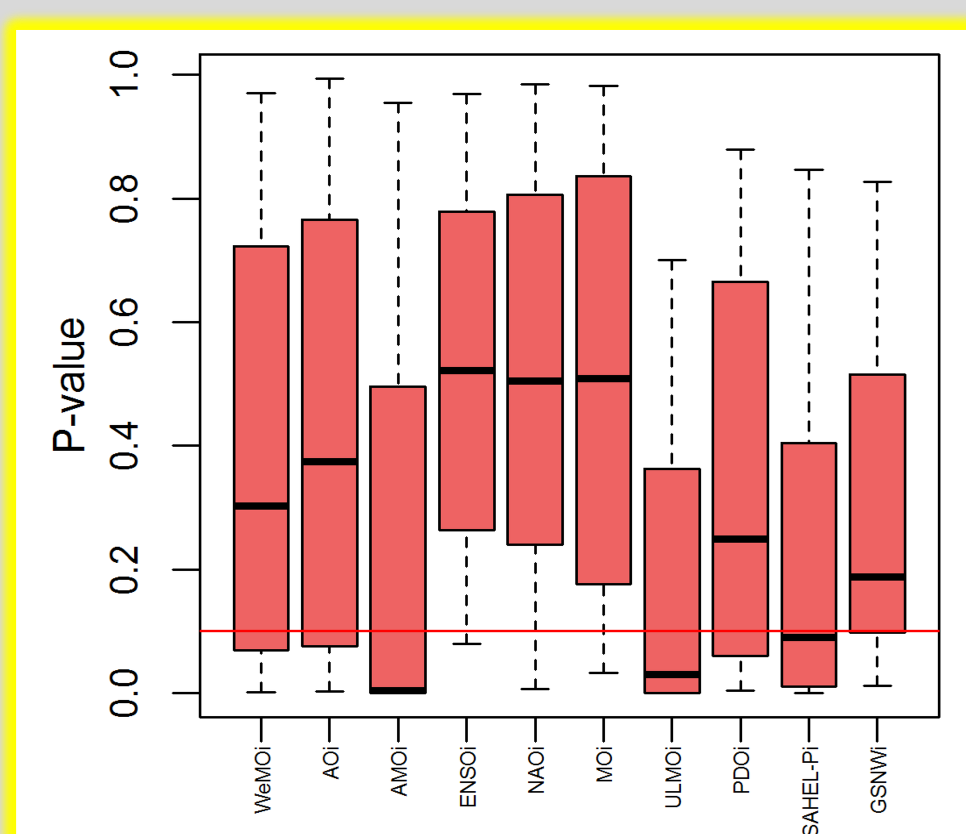

Figure 4. Pearson Correlation *P*-value obtained comparing seasonal simulation from studied indexes and the observed anomaly in temperature.

The representatives of each of the phases of C4 version are (figure 5):

1. **Neutral phase**: It is characterized by zonality of geopotential. The figure shows all 500 hPa mean height for Northern Hemisphere.
2. **Positive phase**: It is characterized by the incursion of a ridge over the Iberian Peninsula, which causes high geopotential values and low values of geopotential in the central sector. It leads to episodes of stability and warm weather in the western and cold weather in the east (c & d).
3. **Negative phase**: The lowest values of geopotential are found over Iberian Peninsula due to the position of a through over it; thus, it favors unstable and cold weather (e & f).

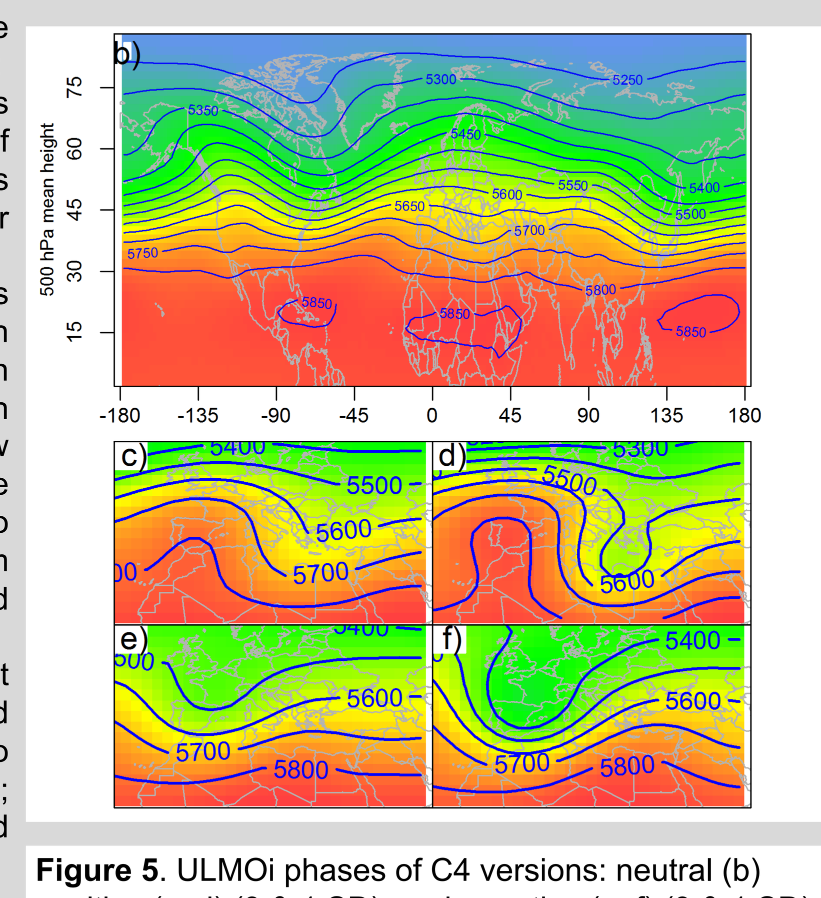

Figure 5. ULMOi phases of C4 versions: neutral (b) positive (c, d) (3 & 1 SD), and negative (e, f) (3 & 1 SD).

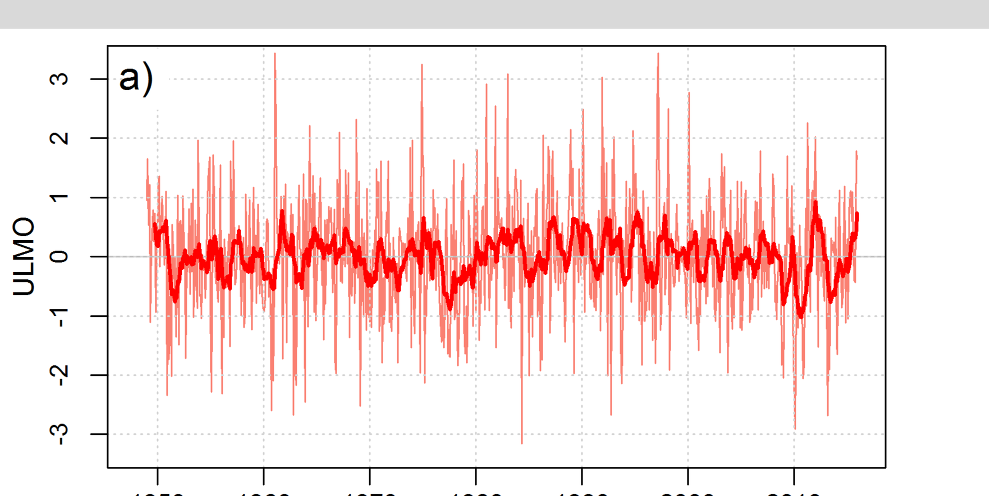

Figure 6. Temporal evolution of monthly ULMOi C4 (light red) and 10 months moving average (dark red).

Three multiyear cycles were detected according to the FFT analysis for the time-series of ULMOi (Fig. 6): **2.5 ± 0.5, 7 ± 1, and 25 ±9 years**.

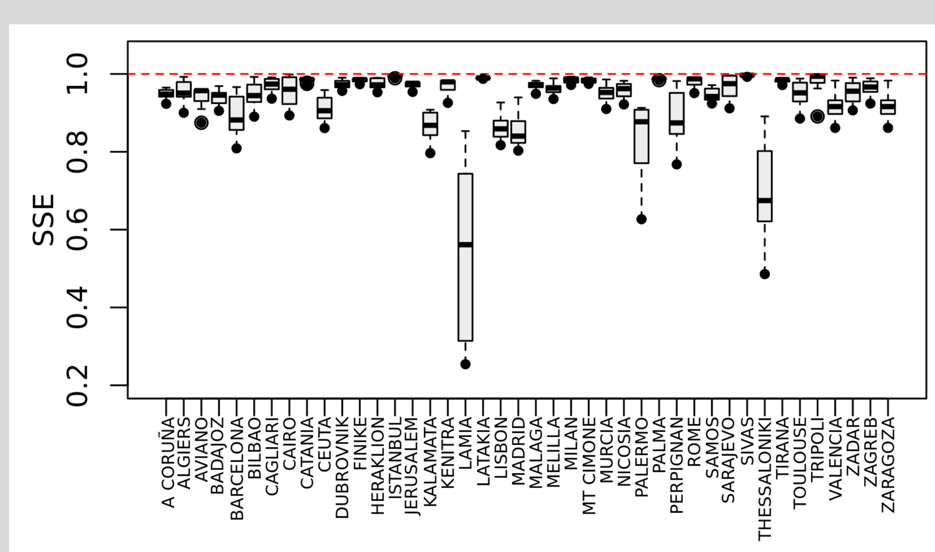

Figure 7. Standardized mean squared error (SSE) of the temperature simulation using the ULMOi C4 calculated for each month of the year and for each observatory.

CONCLUSIONS

1. This work explores the extension of MOi by using upper levels represented by areas instead of observatories or specific points: ULMOi. The new index has reported lower errors than the MOi. The physical link between ULMOi and surface temperature anomaly is positive for the western Mediterranean Basin. That is, positive ULMOi implies a higher 500hPa/1000hPa thickness over the western side with higher temperature; otherwise, it is negative for the eastern Mediterranean Basin.
2. **ULMOi** and **AMOi** show the greatest ability to explain the variance of annual temperature over the Mediterranean basin, adequately simulating it for more than half of the observatories.

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