Linking european droughts to large-scale atmospheric circulation

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CONTEXT

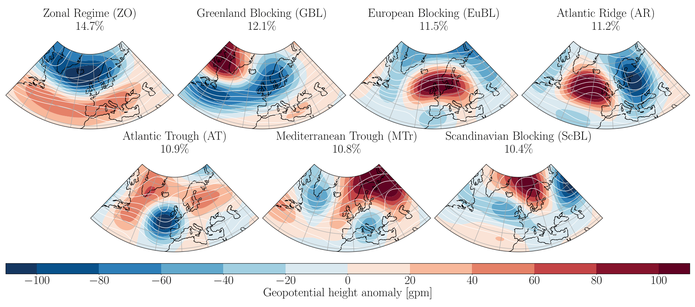
Droughts in Europe are extreme climate events, prone to be influenced by climate change

Europe is highly influenced by large-scale atmospheric circulation

Droughts can occur at any time of the year

What is the contribution of large-scale atmospheric circulation to drought development in Europe?

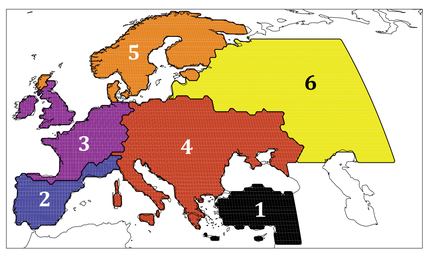
Can the frequency analysis of year-round weather regimes help answer this question ?



Seven WR and climatological frequency, expressed in term of 500hPa - geopotential

METHODOLOGY

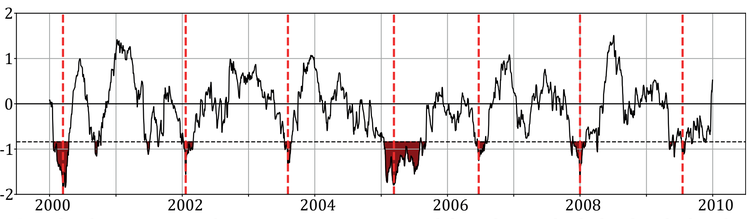
1. Data



ERA5 reanalysis (1960 - 2023) :
- Daily precipitation
- Daily zg500

Clustering of Europe in 6 subregions (UPGMA algorithm) with similar drought-behaviors

2. What is a drought ?

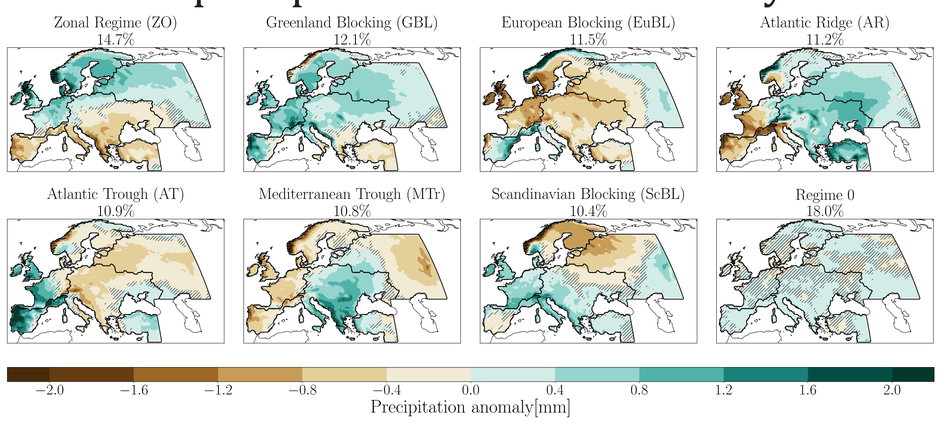


Use of the drought index Standardized Precipitation Index 3 (SPI3), averaged on each region

Drought if : SPI3 <-0.84 for more than 10 days

SPI3 for the Western Mediterranean region. Detected droughts are higlighted in dark red. Reference date for each drought is marked with a vertical red line.

3. What are the precipitation associated with year-round WRs ?



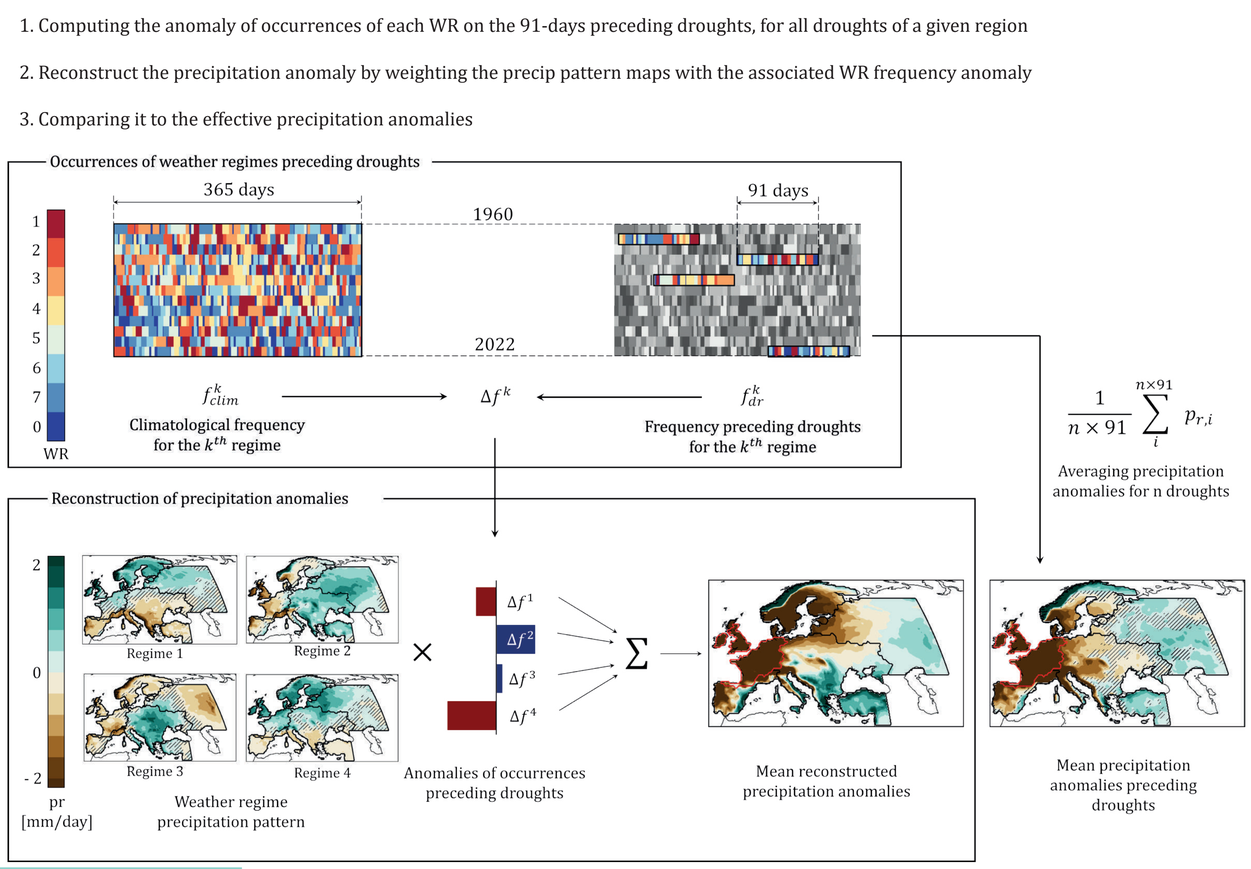
Associated precipitation anomalies for each WR, in mm/day

4. How can we link droughts and large-scale atmospheric circulation ?

1. Computing the anomaly of occurrences of each WR on the 91-days preceding droughts, for all droughts of a given region

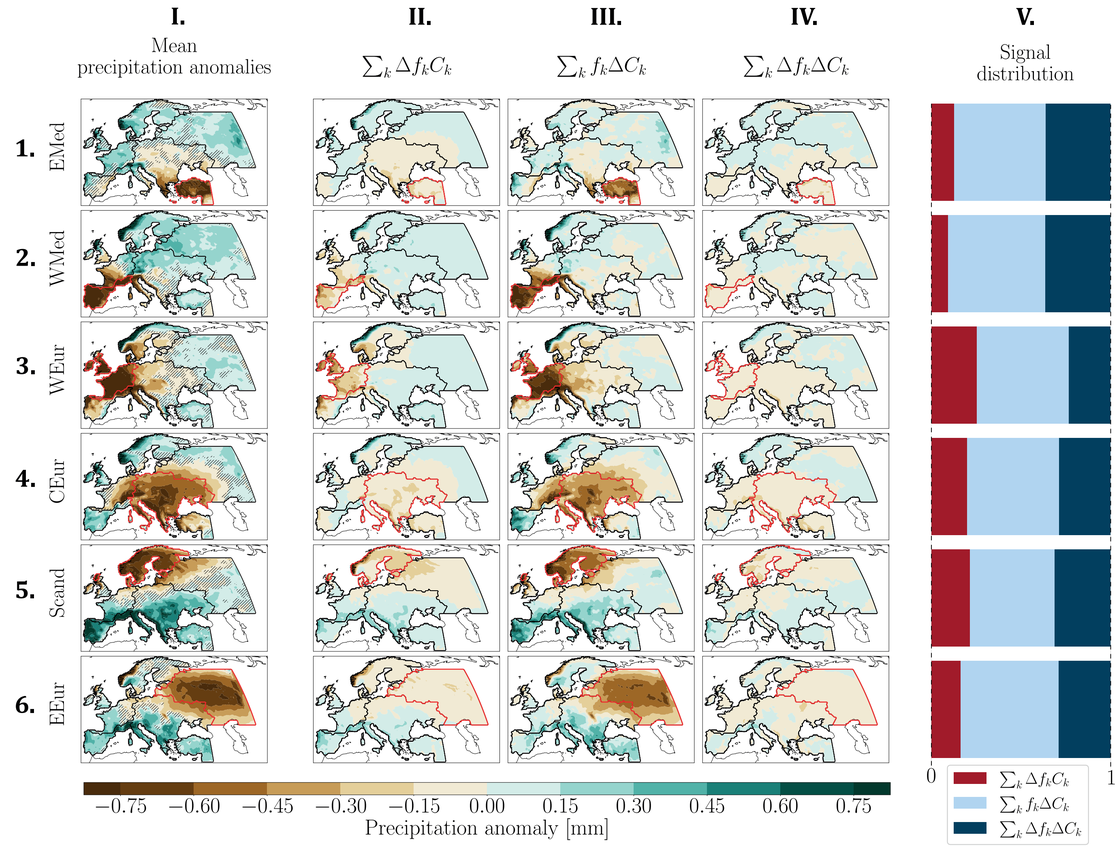
2. Reconstruct the precipitation anomaly by weighting the precip pattern maps with the associated WR frequency anomaly

3. Comparing it to the effective precipitation anomalies



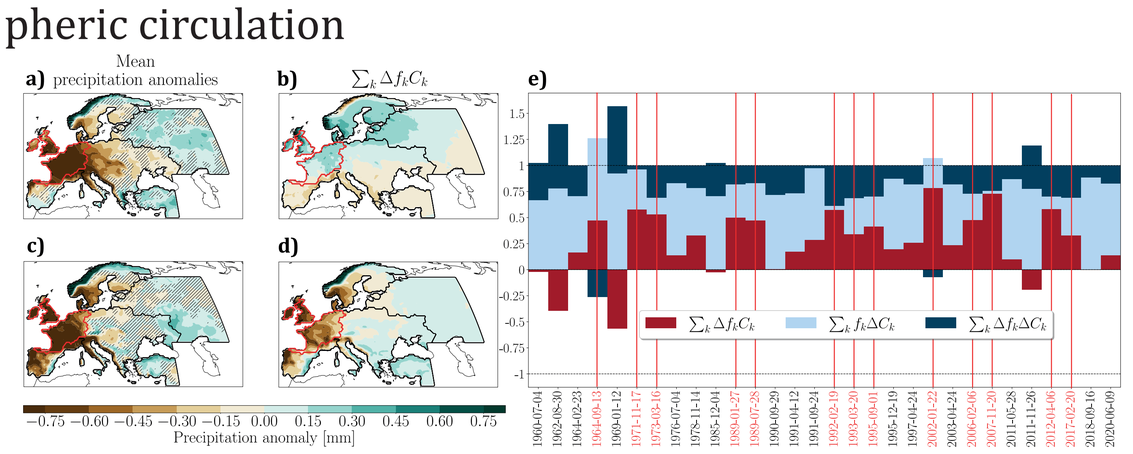
RESULTS

1. On average, WRs 's signal is relatively weak



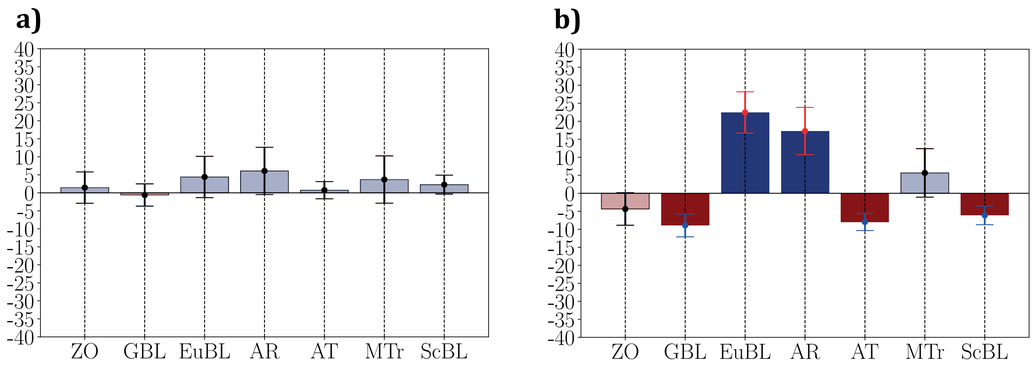
Average precipitation over the 3 months preceding the droughts (left) for each region. Non-significant results (p-value > 0.05) are hatched. Precipitation reconstructed by computing each of the term of Eq. 1 (center). Relative signal contained in each terms (right).

2. But half of drought events can be explained by LS atmospheric circulation



(a) Precipitation anomalies averaged over the 91 days preceding droughts, for all cases where droughts cannot be explained with year-round weather-regimes. (b) Mean reconstruction's first term. (c) and (d) Same for all cases where droughts can be explained with year-round weather-regimes. (e) Precipitation anomalie signal distribution for each droughts of the region WEur, red vertical lines highlighting well reconstructed droughts

3. These events are characterized by by significant anomalies of WR frequency



(a) Frequency anomalies of each of the regimes, averaged over the WEur NOT well-reconstructed droughts. (b) Frequency anomalies of each of the regimes, averaged over the WEur well-reconstructed droughts.

CONCLUSION

Regionalization of Europe using local simultaneity of droughts

For each region, droughts are characterized by a strong frequency anomaly signal in average

In around half of cases, droughts can be attributed to large-scale atmospheric circulation;

In these cases, droughts are linked to a characteristic overexcitation of weather patterns;

In the remaining cases, canonical patterns no longer adequately describe precipitation anomalies, suggesting either the limitation of WRs to characterize the atmospheric circulation, or the involvement of other processes.