Back to the Future

Bridging paleo-climatology and seasonal climate prediction to explain European summer climate variability

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WANTED

Understanding and predicting European summer climate extremes




Over the last decades, Europe experienced a number of extreme summers, including extremely hot and dry summers as well as flash flood summers. Socio-economic and ecological impacts of such extreme events can be severe.

Understanding the precursors and climate teleconnections of extreme European summers can help society prepare for the impacts months ahead.

The scientific community identified potential avenues and precursors for seasonal prediction of summer climate anomalies in the framework of the last 40 years, but we do not know if these relationships are stable or reliable over longer time periods and going into the future.

We want to change that.

Take-home message

1. By correlating independent proxy data with new paleo-reanalyses, we could highlight the atmospheric dynamics recorded by the European oxygen isotope network from tree rings.
2. We could also identify spring SST precursors to the recorded summer conditions.
3. We could identify the same mechanism in physical seasonal prediction models by subsampling for these SST conditions in their initial conditions.
4. The newly extended time frame and causation analysis gives us more confidence in the strength and stationarity of this teleconnection and prediction chain.

Data references in this poster

Delta o18 isotope time series from tree ring network:

- Treydte et al. 2024 Recent human-induced atmospheric drying across Europe unprecedented in the last 400 years Nat. Geosci. 17 58–65

EKF400v2:

- Valler et al. 2021 An updated global atmospheric paleo-reanalysis covering the last 400 years Geosci. Data J. gdj3.121

SSTs:

- Samakinwa et al. 2021 An ensemble reconstruction of global monthly sea surface temperature and sea ice concentration 1000–1849 Sci Data 8 261

ERA20C:

- Poli et al. 2016 ERA-20C: An Atmospheric Reanalysis of the Twentieth Century Journal of Climate 29 4083–97

CERA20C:

- Laloyaux et al. 2018 CERA-20C: A Coupled Reanalysis of the Twentieth Century J. Adv. Model. Earth Syst. 10 1172–95

AFS-20C:

- Weisheimer et al. 2017 Atmospheric seasonal forecasts of the twentieth century: multi-decadal variability in predictive skill of the winter North Atlantic Oscillation (NAO) and their potential value for extreme event attribution: Atmospheric Seasonal Forecasts of the Twentieth Century Q.J.R. Meteorol. Soc. 143 917–26

Chapter 1: The Story of Correlation

(Looking into the Past)

1 Oxygen isotopes from tree-rings store information about the moisture and temperature conditions in the vicinity of the tree. A recent effort by Treydte et al. 2024 consolidated multiple such isotope time series into a network.

We further aggregate this information and extract the first prinicple component time series of this network.

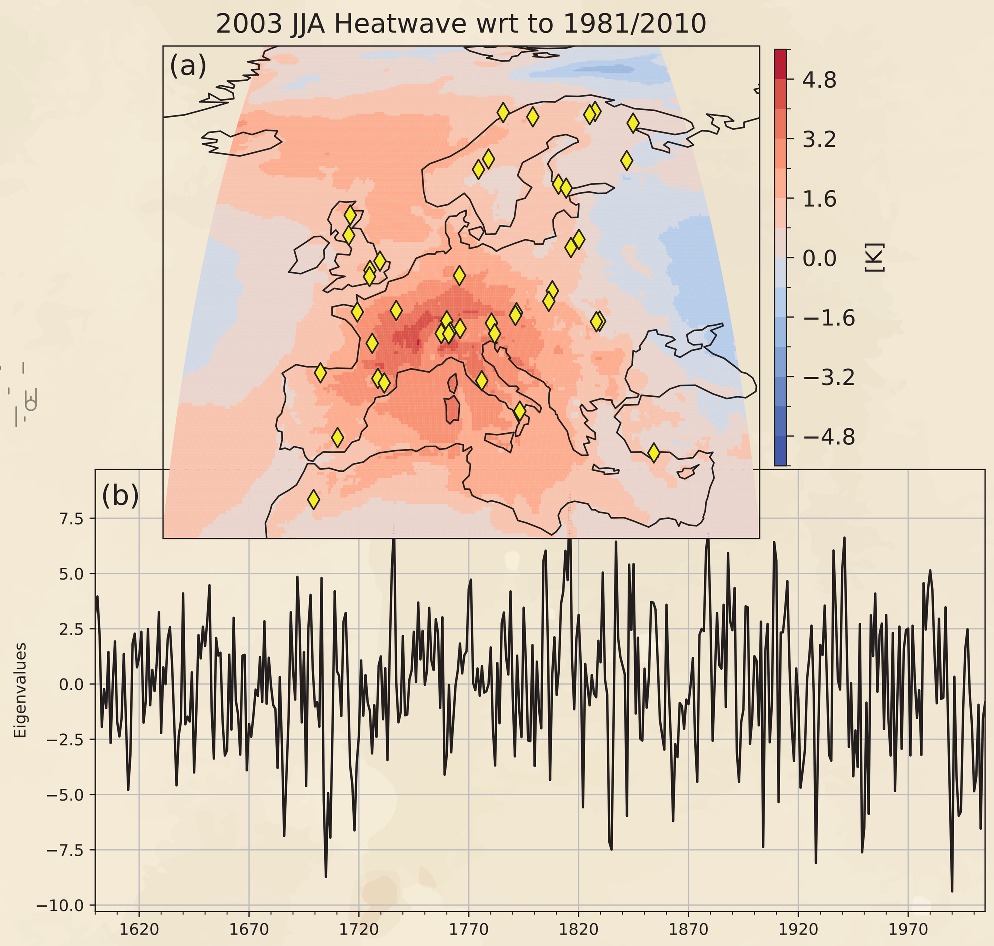

Fig. 1: a) Distribution of tree rings samples and 2003 JJA temperature anomaly. b) Detrended yearly time series of the first principcal component of the oxygen isotope network for the period 1600–2005.

2 We use completely independent paleo-reanalysis products to examine the correlation of this isotopic information with climate fields, such as temperature, precipitation and atmospheric blockings. And thanks to the multi-dimensional output of the reanalysis, we can also look at upper-air atmospheric dynamics.

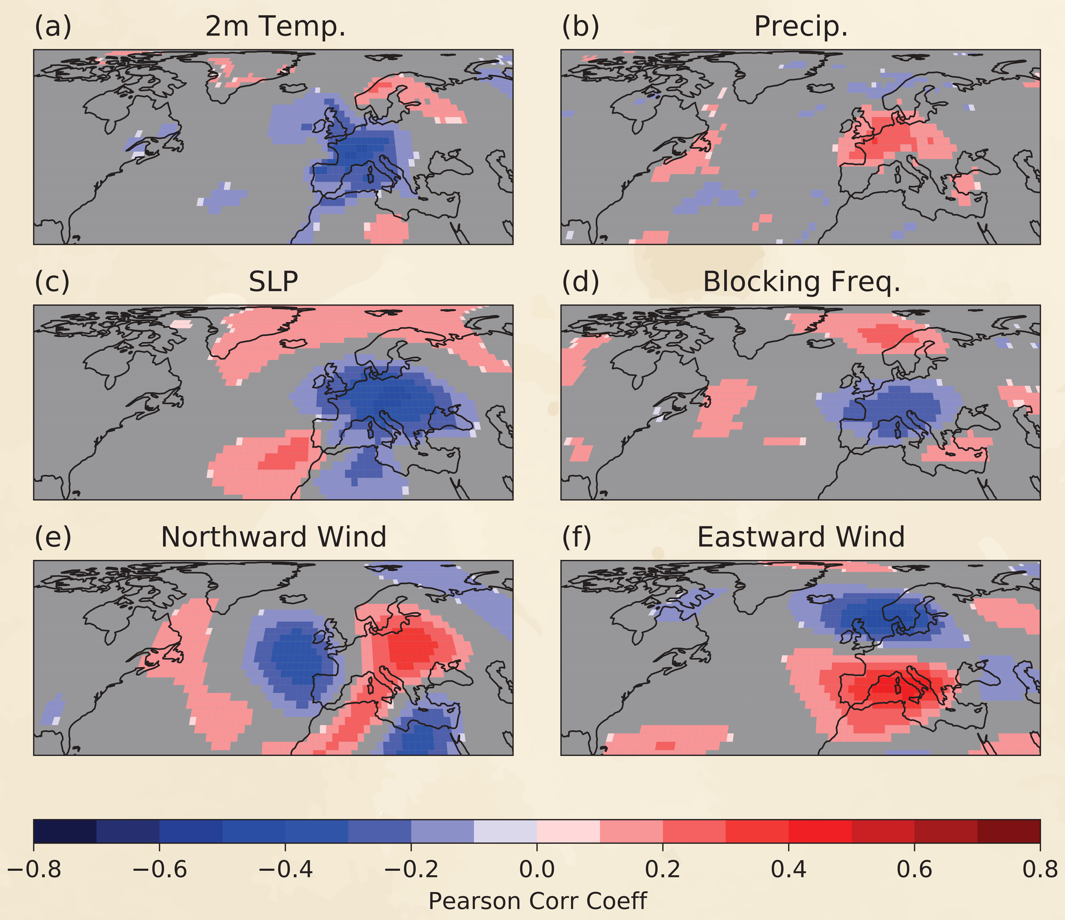

Fig. 2: Maps of significant (95%) correlation coefficients between EKF400v2 boreal summer anomalies and the first PC of deltao18 values of the tree ring network for the period 1602–2003. Depicted are correlations with a) 2m temperature, b) precipitation, c) Sea Level Pressure, d) blocking frequency, e) meridional wind at 200 hPa and f) zonal wind at 200 hPa.

3 And finally, we can investigate the correlation to precursors of this summer signal, by linking the isotopic signal to spring sea surface temperatures.

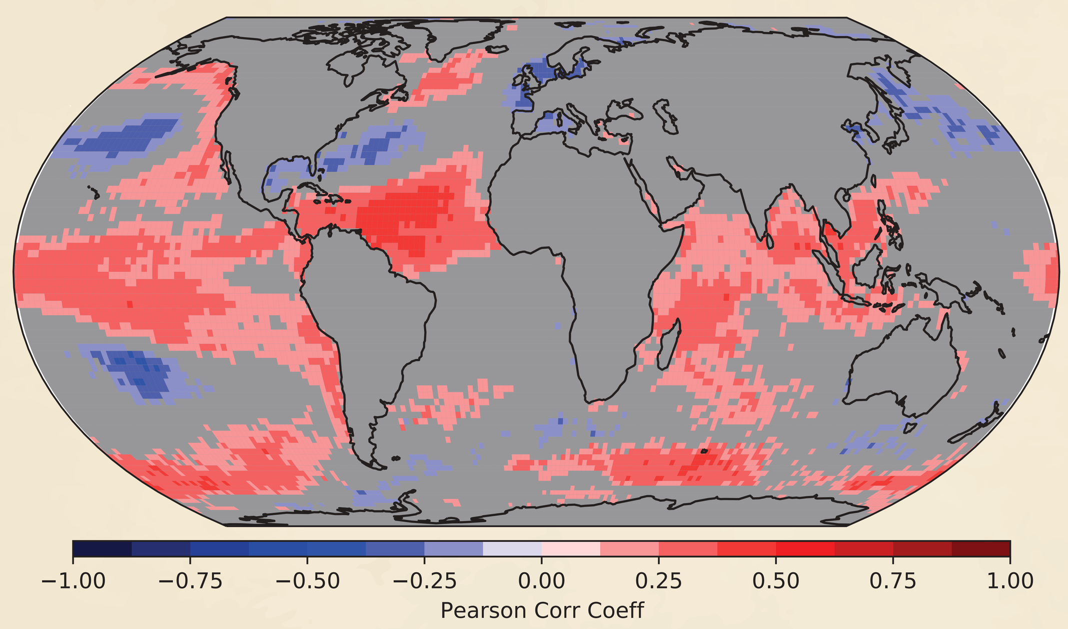

Fig. 3: Significant (95%) correlation coefficients between April-May mean sea surface temperature anomalies and the first PC of deltao18 values of the tree ring network for the period 1850–2005.

Chapter 2: The Story of Causation

(Checking for the Future)

4 In Chapter 2, we look into a huge data set of seasonal prediction runs for the 20th century (ASF-20C) & check if spring SSTs from Chapter 1 are triggering European summer extremes.

Each summer (June, July, August) in the 20th century is forecasted by initializing a weather model on May 1st, using May 1st SST conditions. This model produces 50 ensemble member for a good uncertainty estimation.

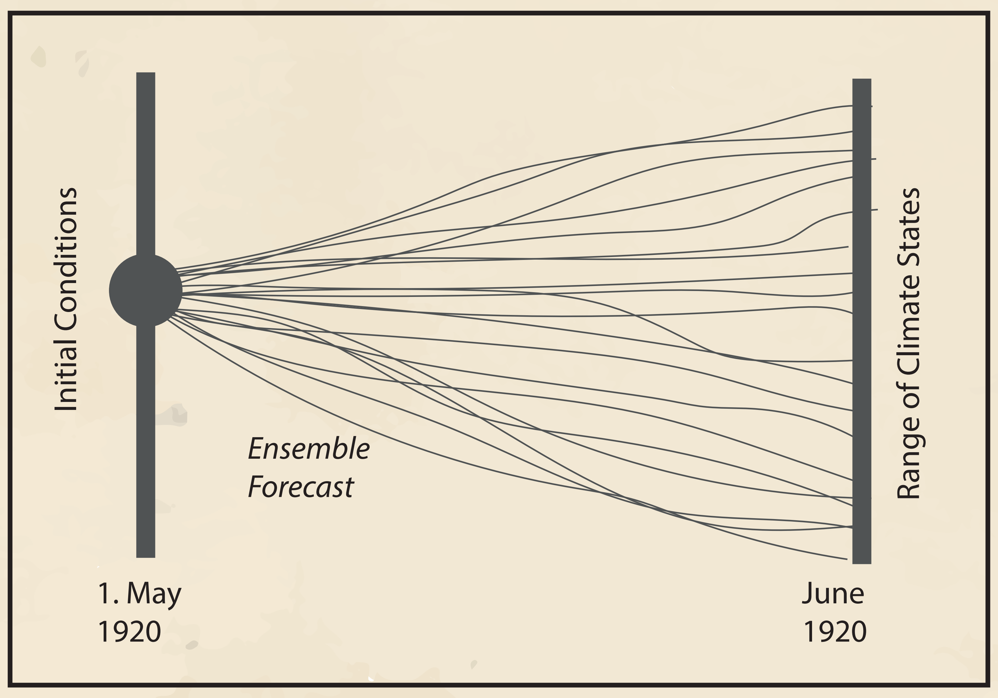

Fig. 4: Schematic depiction of a seasonal prediction model producing ensemble members

5 We subsample the 20th century predictions into two composites of initial May SST conditons, based on the SST patterns our European summer variability is linked with (Fig. 3).

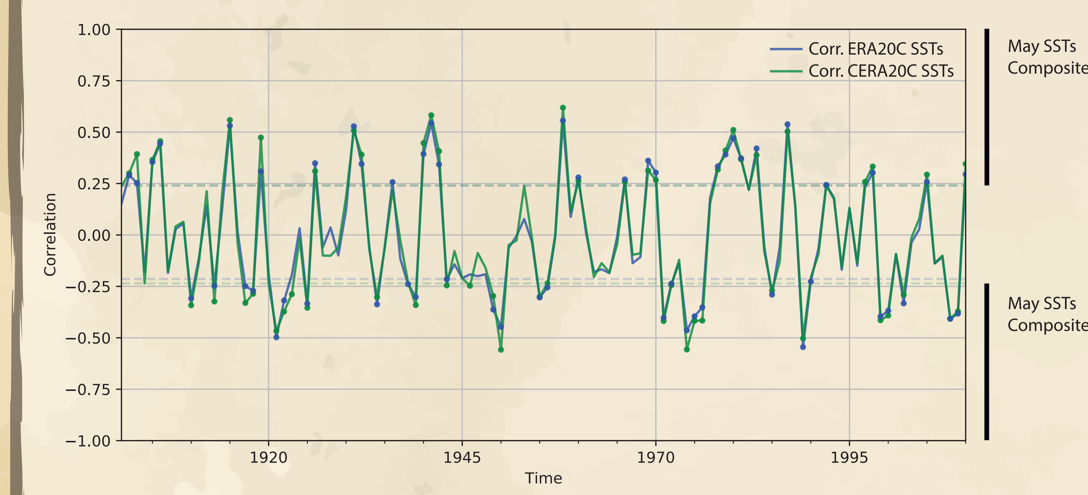

Fig. 5: Correlation coefficient between pattern in Fig.3 and May 1st SST anomalies in two SST products 1901-2010

6 We then compare the climate pattern produced in both composites. We find that the seasonal prediction weather model creates the same atmospheric dynamics and surface climate impacts that we saw in our correlation analysis.

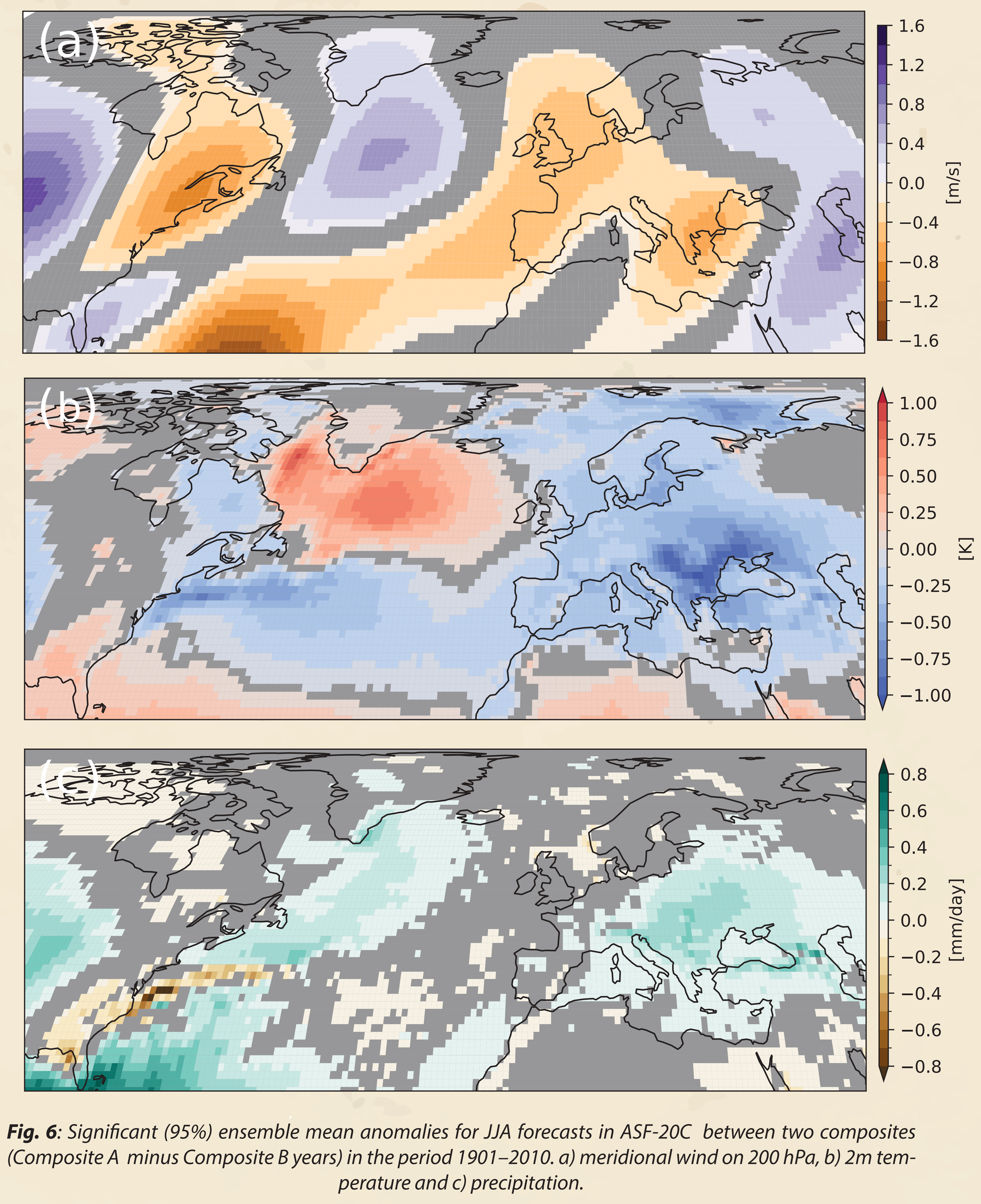

Fig. 6: Significant (95%) ensemble mean anomalies for JJA forecasts in ASF-20C between two composites (Composite A minus Composite B years) in the period 1901–2010. a) meridional wind on 200 hPa, b) 2m temperature and c) precipitation.