Seasonal predictability of European summer climate re-assessed

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1. Introduction & Model

Current state-of-the-art prediction systems show seasonal predictability in various areas, including large parts of the North Atlantic, but the prediction skill for European climate is still very limited, particularly during the summer season (Fig. 1). Here, we propose to improve the seasonal predictability by including a mechanism into the prediction analysis, that connects areas of high prediction skill with the summer climate over Europe.

For this we investigate:

- A potential driving mechanism in the ERA-Interim Reanalysis from 1982 - 2016 (Dee et al., 2011).
- Prediction skill in a hindcast ensemble with an initialized version of MPI-ESM-MR including 30 ensemble members initialized every May in the time period 1982-2016 (as in Dobrynin et al., 2018). Currently this seasonal prediction system shows no hindcast skill over Europe (Fig. 1).

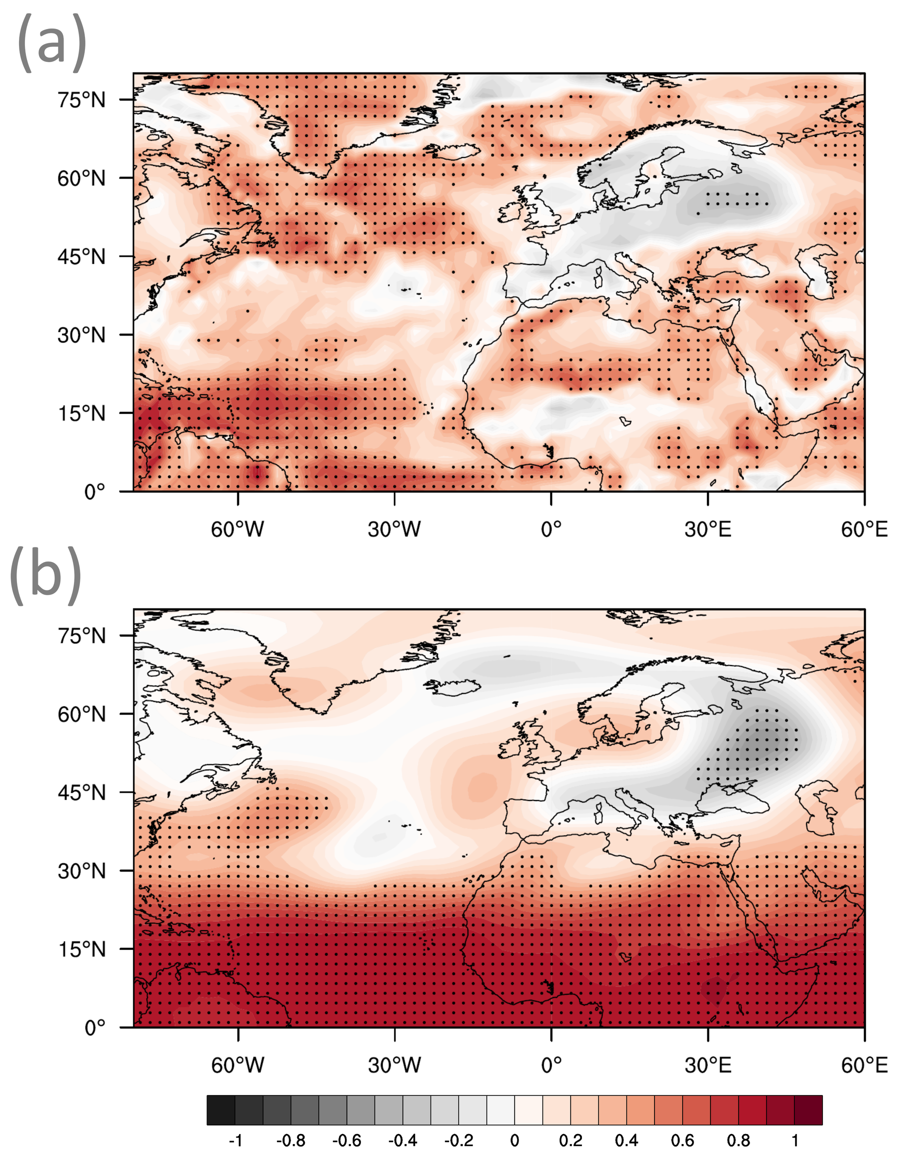

Figure 1: Anomaly correlation in July-August comparing the full hindcast ensemble mean to ERA-Interim for (a) surface temperature and (b) 500hPa geopotential height. Dots represent significance at the 95% confidence level.

2. A potential driving mechanism of European summer climate

A mechanism, that connects areas of high predictability with European summer climate on seasonal time scales, has its origin in the tropical North Atlantic in spring (e.g., Saeed et al., 2014; Wulff et al, 2017):

(1) Warm sea surface temperatures (SSTs) are the source of strong convection in the tropical region, which act as a Rossby wave source (Gastineau and Frankignoul, 2015; Fig. 2a).

(2) This Rossby wave is known as the circumglobal teleconnection pattern (CGT, Ding&Wang, 2005) and here defined as the first EOF of 200hPa meridional wind in July-August (JA; Fig. 2b).

(3) The CGT generates an east-west pressure gradient (Fig. 2c) that is opposed to the summer North Atlantic Oscillation, which has a rather north-south pressure gradient.

(4) The zonal pressure gradient in turn is related to the surface temperatures over central Europe (Fig. 2d).

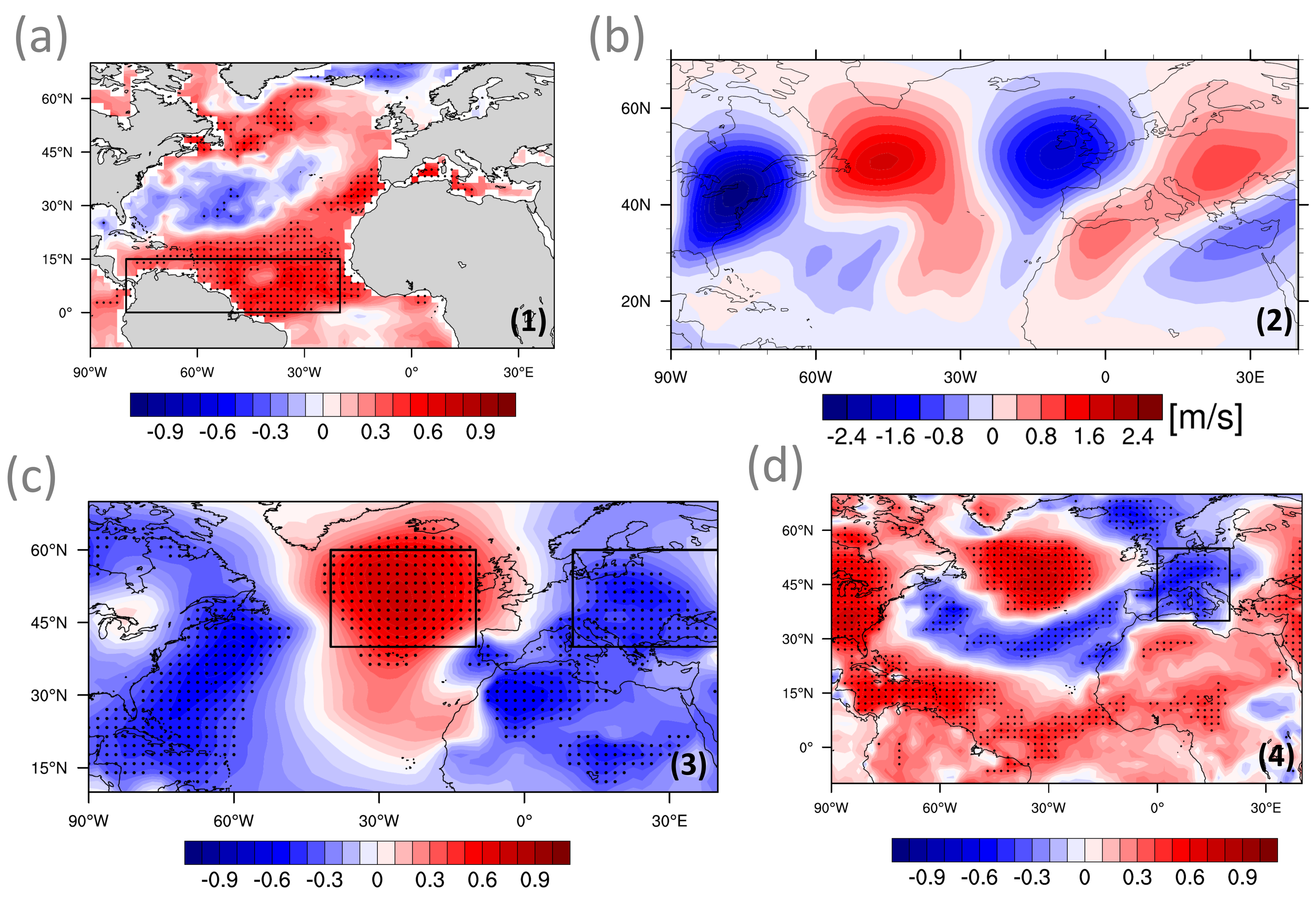

Figure 2: ERA.-Interim: (a) Pointwise correlation of the sea surface temperatures in April with the principal component associated with (b) the spatial pattern of the first EOF of 200hPa meridional wind in July-August (JA), explaining about 22.4% of the total variance. (c),(d) Same as in (a), but for (c) the sea level pressure in JA and (d) the temperatures in JA. Dots represent significance at the 95% confidence level.

3. Model analysis & hindcast skill

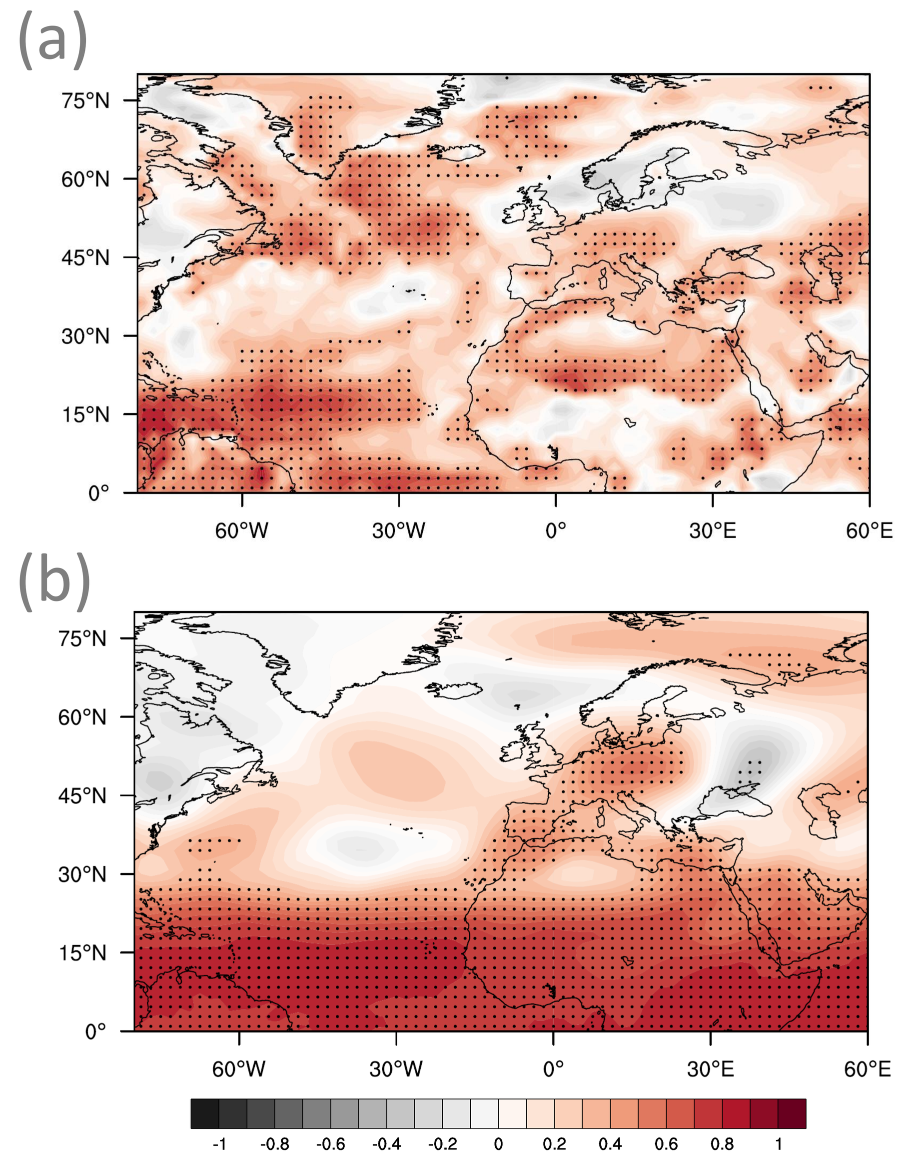

Figure 3: Anomaly correlation in July-August comparing the selected hindcast ensemble mean to ERA-Interim for (a) surface temperature and (b) 500hPa geopotential height. Dots represent significance at the 95% confidence level.

We conduct a hindcast analysis with an ensemble mean taken over only those ensemble members that represent the mechanism described above.

We test every individual ensemble member for the connection between the wave-train **(2)**, the zonal pressure gradient **(3)** and their impact on European summer temperatures **(4)**. To determine whether the mechanism in the considered year is in its positive or negative state, we use the observed condition of the spring SST anomalies **(1)** as a predictor.

The selected ensemble mean shows significantly improved seasonal summer hindcast skill over Europe (compare Figs. 3 and 1).

If reliability diagrams of the full ensemble are compared to the selected ensemble averaged in a region over central Europe (Fig. 4), improvements are achieved through the ensemble selection by getting closer to the line of perfect reliability, thus resulting in more reliable hindcasts. Furthermore, the data of the selected ensemble mean are more uniformly distributed which results in smaller uncertainties, especially for extreme values.

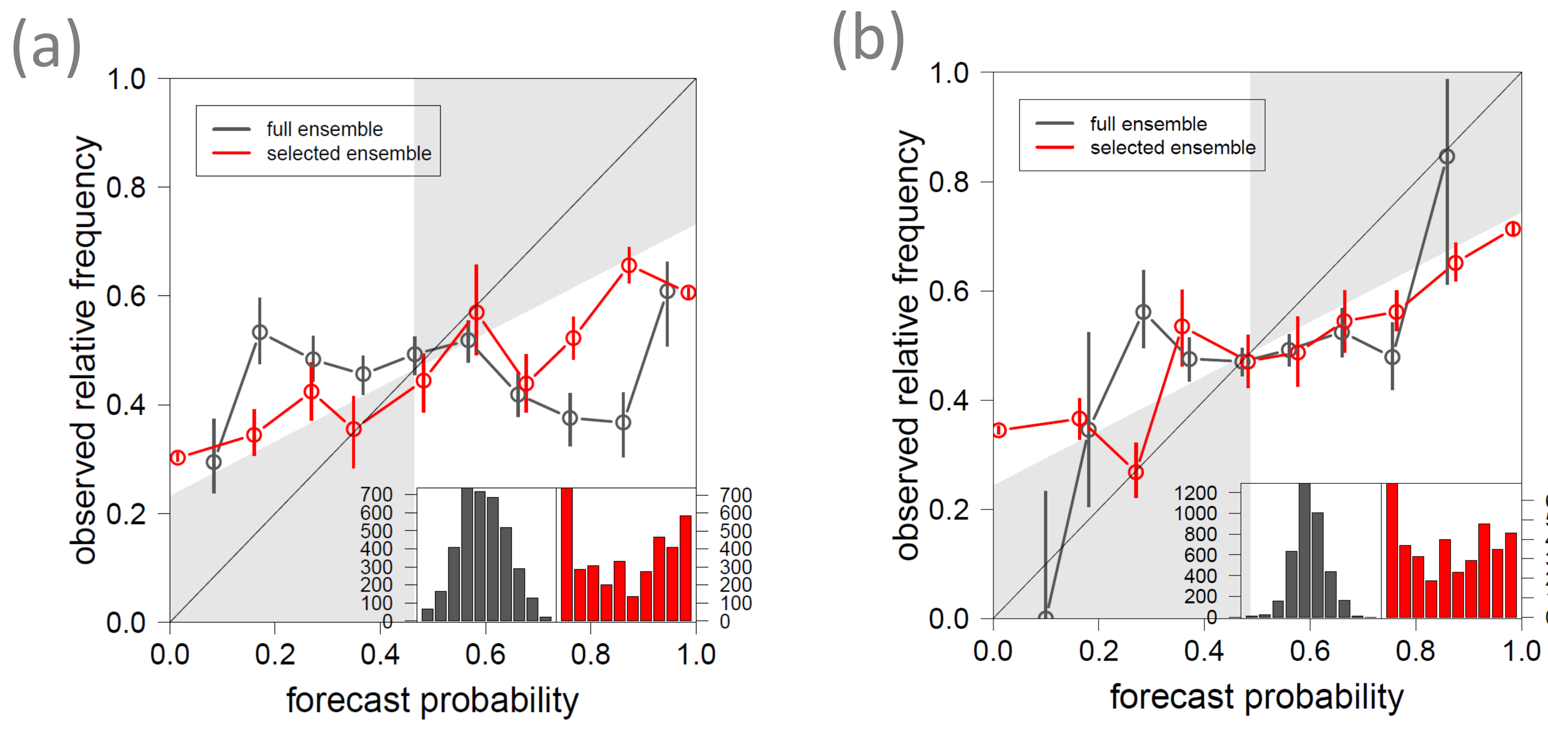

Figure 4: Reliability diagrams comparing the mean over the full (grey) an the selected (red) ensemble to ERA-Interim for (a) surface temperature and (b) 500hPa geopotential height averaged over central Europe [35°-55°N,0°-20°W]. Points that lie inside the grey box contribute positively to the forecast skill, based on the climatological reference. Vertical lines show the uncertainties bootstrapped at the 95% confidence level. The histograms depict the distribution of the data.

4. Summary & Conclusions

We assess the seasonal hindcast skill of 30 ensemble members of the MPI-ESM-MR prediction system in summer over the North-Atlantic-European sector with regard to a mechanism that connects areas of high predictability with the summer climate over Europe and that is influencing this region on seasonal time scales (Fig. 2). By selecting only those ensemble members in which the proposed mechanism is present and by using spring SSTs as a predictor, we find that:

Seasonal hindcast skill in summer significantly improves when a mechanism that is influencing the North-Atlantic-European climate on seasonal time scales is taken into a account in the analysis of hindcast skill (compare Figs. 1 and 3).

Literature

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