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 in Europe.

For this we investigate:

- A potential driving mechanism in the ERA-Interim Reanalysis between 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 in Europe (Fig. 1).

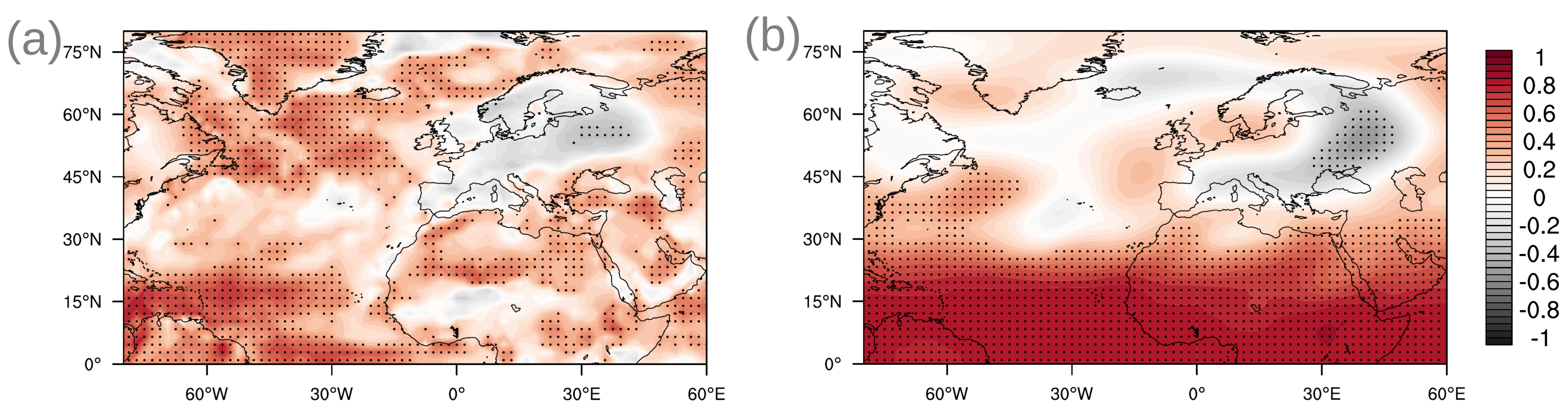

Figure 1: Anomaly correlation in July-August comparing the hindcast ensemble mean to ERA-Interim for (a) surface temperature and (b) 500hPa geopotential height. Dots represent significance at the 95% confidence level.

2. A potential driving mechanism for 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. 2b).

(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. 2a).

(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).

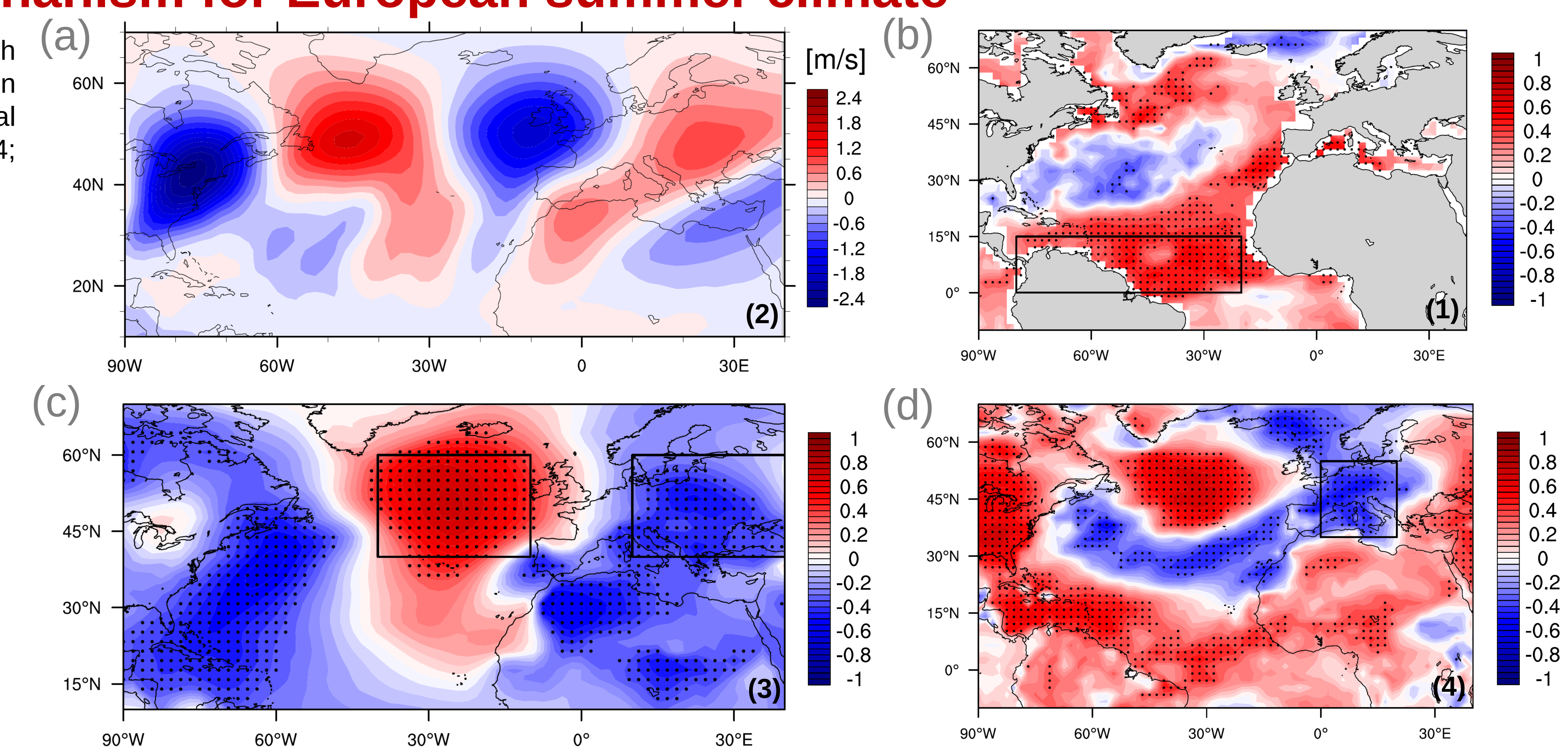

Figure 2: ERA.-Interim: (a) Spatial pattern of the first EOF of 200hPa meridional wind in July-August (JA), explaining about 22.4% of the total variance. The associated principle component is then pointwise correlated with (b) the SSTs in April, (c) the SLP in JA and (d) the temperatures in JA. Dots represent significance at the 95% confidence level.

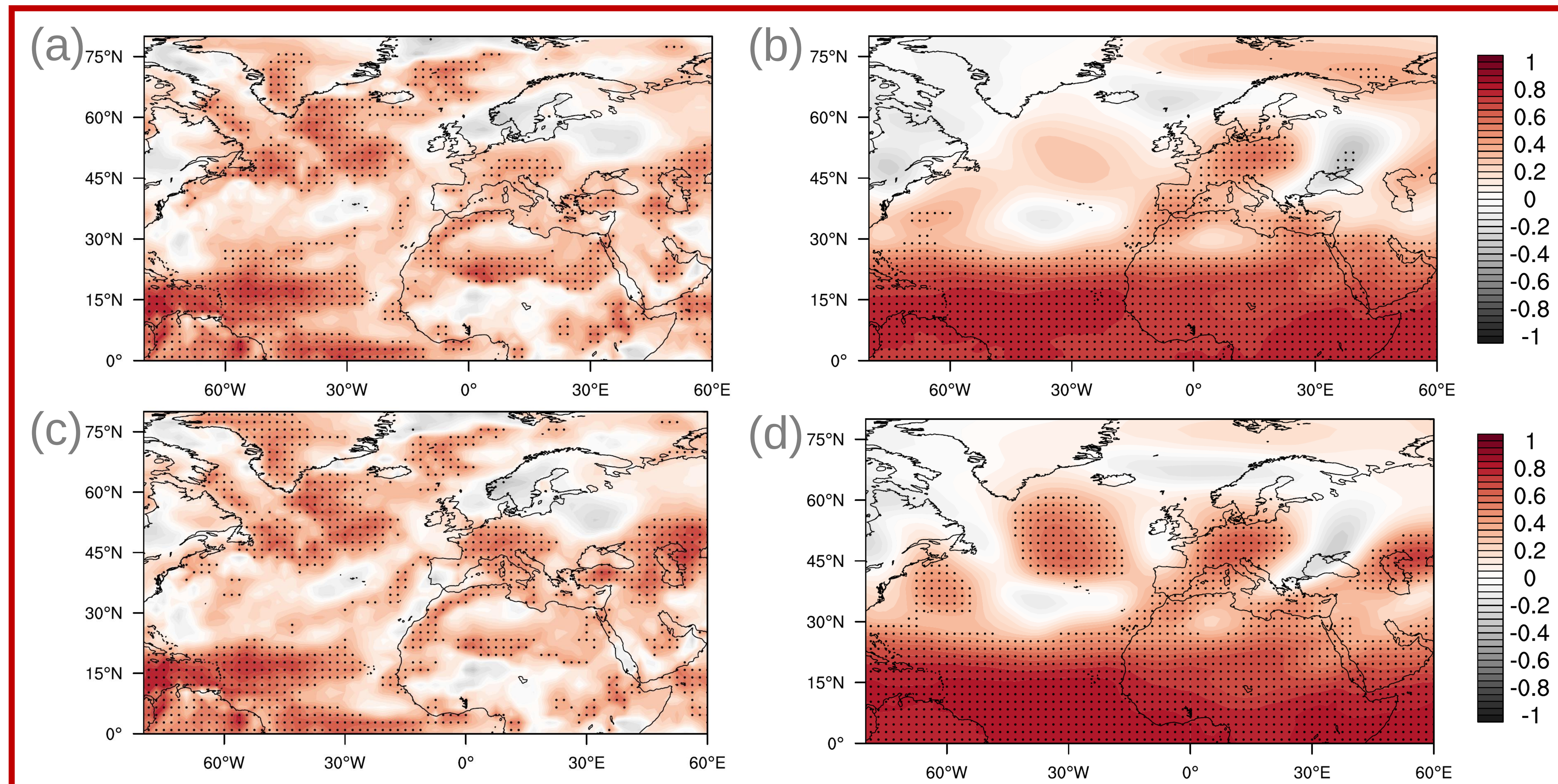

Figure 3: Anomaly correlation in July-August comparing the (a),(b) selected and (c),(d) "perfect" hindcast ensemble mean to ERA-Interim for (left) surface temperature and (right) 500hPa geopotential height. Dots represent significance at the 95% confidence level.

3. Model analysis & hindcast skill

We conduct a hindcast analysis with a reduced ensemble mean that is taken over 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 reduced ensemble mean shows significantly improved seasonal summer hindcast skill over Europe (compare Figs. 3 a,b and 1 a,b).

For comparison, we conduct the same analysis with the known state of the mechanism, which provides the hindcast skill that can be expected if the mechanism is perfectly predicted by the model.

This "perfect" analysis shows significantly improved hindcast skill in the areas where the mechanism is expected to show a prominent signal (compare Figs. 3 c,d and Fig. 2 c,d).

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 in 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 the prominent one and by using spring SSTs as a predictor, we find that:

> Seasonal hindcast skill in summer significantly improves over areas where 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

Dee et al. (2011), *Quarterly Journal of the royal meteorological society*, 137.656: 553-597
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