Tropical Forcing of the Summer East Atlantic (SEA) Pattern

C. Ole Wulff[1], Richard J. Greatbatch [2,3], Daniela I. V. Domeisen[1], Gereon Gollan[2], Felicitas Hansen[2]

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

1. The SEA pattern is part of a circumglobal Rossby wave train (Fig. 2a) forced by tropical diabatic heating
2. The PCD, a tropical precipitation dipole, can serve as a predictor for the wave train and thus the SEA
3. The PCD is related to the developing ENSO phases which provides potential for seasonal SEA prediction

Motivation

Large parts of the mid-latitude near surface seasonal variability are related to large scale atmospheric **circulation regimes**.

These can arise as parts of quasi-stationary atmospheric **teleconnection patterns** which can be driven by diabatic heating anomalies related to tropical convection[1].

During **summer** over the **North Atlantic-European (NAE)** region the SNAO is the dominant pattern of variability[2] but shows little **seasonal predictability**.

➢ Is there another mode of variability that might be more predictable?

Summer East Atlantic pattern

We define the SEA as **EOF2** of seasonal (JJA) z_{500} anomalies (1979-2016) in the **NAE** sector (white box in Fig. 1a).

It is related to distinct circulation, surface temperature and precipitation anomalies (Figs. 1a-d) in the NAE region and beyond.

Under positive SEA conditions, the likelihood of **occurrence of extreme temperatures** is likely enhanced[3].

Seasonal hindcasts

ECMWF IFS, initialized beginning of May, 9 ensemble members, two set-ups[4]:

OBS: observed SST/SI (HadISST)

CLIM: daily climatologies of SST/SI

A Tropical Forcing?

Regressing JJA z_{500} from reanalysis onto the SEA index results in a **wave train pattern** (Fig. 1a-b).

Precipitation and SST in the tropical Pacific and Caribbean co-vary with the SEA (Fig. 1c-d).

➢ Does the tropical diabatic heating act as a Rossby wave source?

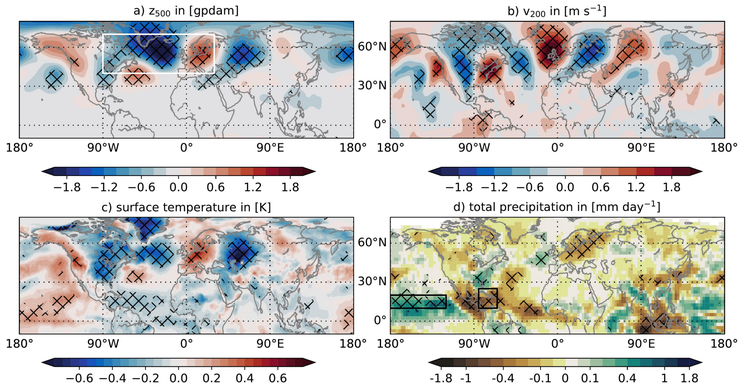

Figure 1: *Regression of JJA anomalies (detrended) of the fields indicated in the title of each panel (from ERA-Interim for a-c and CMAP for d). Hatching indicates regression coefficients significant at the 95% level (t-test).*

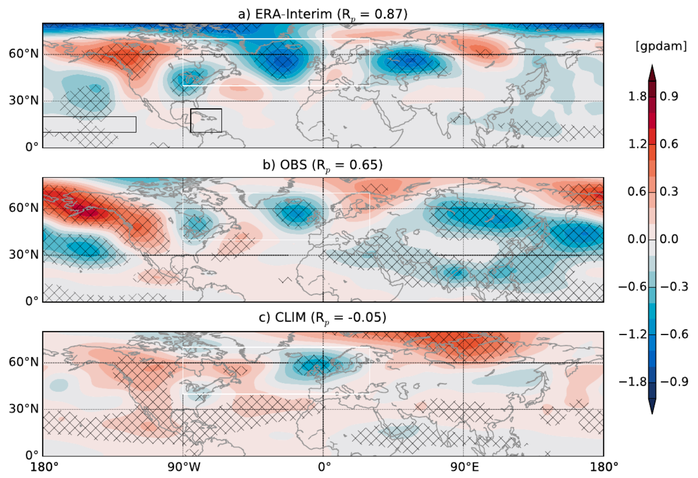

Figure 2: *Regression of JJA z_{500} anomalies (a: ERA-Interim, b-c: seasonal hindcasts) onto the PCD index (a: CMAP, b-c: hindcasts). Hatching for significance at the 95%-level (t-test). Values left of color bar refer to a, on the right to b-c. R_p is the pattern correlation between regression pattern and SEA pattern inside the white box.*

Pacific Caribbean dipole (PCD)

We define a Pacific Caribbean dipole (**PCD**) as the difference between area averaged JJA **precipitation** in the **Pacific minus** the **Caribbean** (see black boxes in Fig. 1d)

The wave train structure including the **SEA** pattern can be **reproduced** by regressing z_{500} onto the PCD (Fig. 2a).

This is confirmed by **seasonal hindcast** experiments with **realistic SST** (OBS, Fig. 2b) while climatological SSTs do not provide the necessary forcing (CLIM, Fig. 2c).

ENSO relationship

PCD precipitation anomalies in the Pacific and Caribbean are characteristic of the **developing ENSO** phases (Fig. 3).

Developing El Niño	Developing La Niña
PCD +	PCD −
SEA +	SEA −

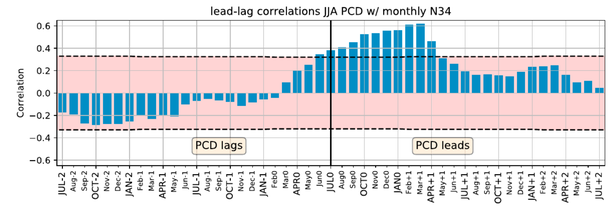

Figure 3: *Lead-lag correlations between the JJA PCD and the monthly Niño3.4 index. Correlations falling outside the red envelope are significant at the 95% level (t-test).*

Conclusions

The SEA arises as part of a circumglobal tropical-extratropical teleconnection pattern forced by tropical diabatic heating anomalies summarized in the PCD.

Relation of the SEA with tropical precipitation and developing ENSO phases provides potential for seasonal prediction.

Seasonal hindcasts point to an influence of SST. Atlantic SSTs could play a role in phase-locking the PCD-related wave train.

Our paper

Wulff et al. (2017). Tropical forcing of the Summer East Atlantic pattern. *Geophys. Res. Lett. 44: 11,166-11,173*

Find it here:

References

[1] Sardeshmukh & Hoskins (1988). The generation of global rotational flow by steady idealized tropical divergence. *J. Atmos. Sci. 45(7):* 1228-1251

[2] Folland et al. (2009). The summer North Atlantic Oscillation: Past, present, and future. *J. Clim.*, 22(5): 1082-1103

[3] Cassou et al. (2005). Tropical Influence on European heat waves. *J. Clim., 18:* 2805-2811

[4] Hansen et al. (2017). Remote control of North Atlantic Oscillation predictability via the stratosphere. *Quart. J. Roy. Meteor. Soc., 143(703):* 706-719

Contact

Ole Wulff

ole.wulff@env.ethz.ch

Affiliations: [1]**Institute for Atmospheric and Climate Science, ETH Zurich;** [2]GEOMAR Helmholtz Centre for Ocean Research Kiel; [3]Faculty of Mathematics and Natural Sciences, Kiel University