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Reading

PRIMAVERA

Impact of blocking on low wind events and its representation by high-resolution GCMs: An energy perspective

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- With **higher penetration of renewable energies** and the effort to decarbonize power production there is a strong interest in the **objective characterization of wind resource**.
- Over Europe, **wind power** accounts for around **17% of total power capacity** and almost 30% of renewable capacity, and is the overall second largest form of generation capacity after gas.
- In addition to the description of mean capacity factors, there is a **need to characterize extremes**.
- e.g.: **low wind events & persistent low wind events** → During these, the energy system needs to rely on 'backup' sources such as gas, coal and nuclear.
- Over the UK and other parts of Europe, these are often linked to the occurrence of **blocking** → **focus of this study**.
- To fully address the impact of blocking on the power system, **we now include surface temperature as a proxy for electricity demand**.

Datasets

- Daily 10m wind speeds, t2m and blocking index for :

1) REANALYSIS: ERA-Interim 1979-2011

2) PRIMAVERA MODELS: 1950-2014, highresSST-present experiment (AMIP runs)

Institution	MOHC	MPI-M	CMCC	EC-Earth	ECMWF
Model Name	HadGEM3-GC3.1	MPI-ESM-1-2	CMCC-CM2	EC-Earth3	ECMWF-IFS
Model Versions	MM, HM	HR, XR	HR4, VHR4	, HR	LR, HR
Atmos grid	N216, N512	T127, T255	1x1, 0.25x0.25	T1255, T1511	Tco199, Tco399
Atmos res @50N	60km, 25km	67km, 34km	129km, 64km	71km,36km	50km, 25km

Blocking Index

- **AGP5** index described on Schiemann et al. 2017

Events identification

- **Low wind (LW)** and **low temperature (CE)** events were identified as days below the 20th percentile, and **high temperature events (WE)** and days above the 80th percentile.
- percentile definitions were obtained for **each grid point** and **each calendar month**, to account for seasonality. Also, they were calculated for **each model independently** to account for systematic biases.
- Country-wide events were identified when **at least 50% of the grid points** qualified as an event.

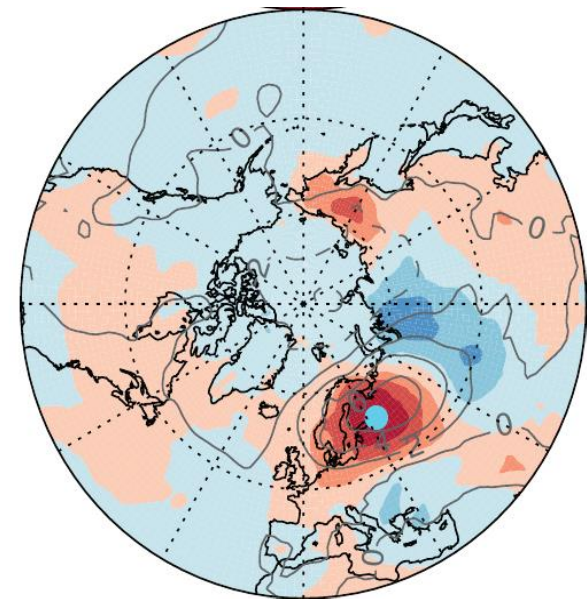
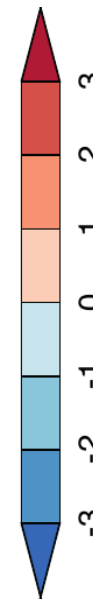
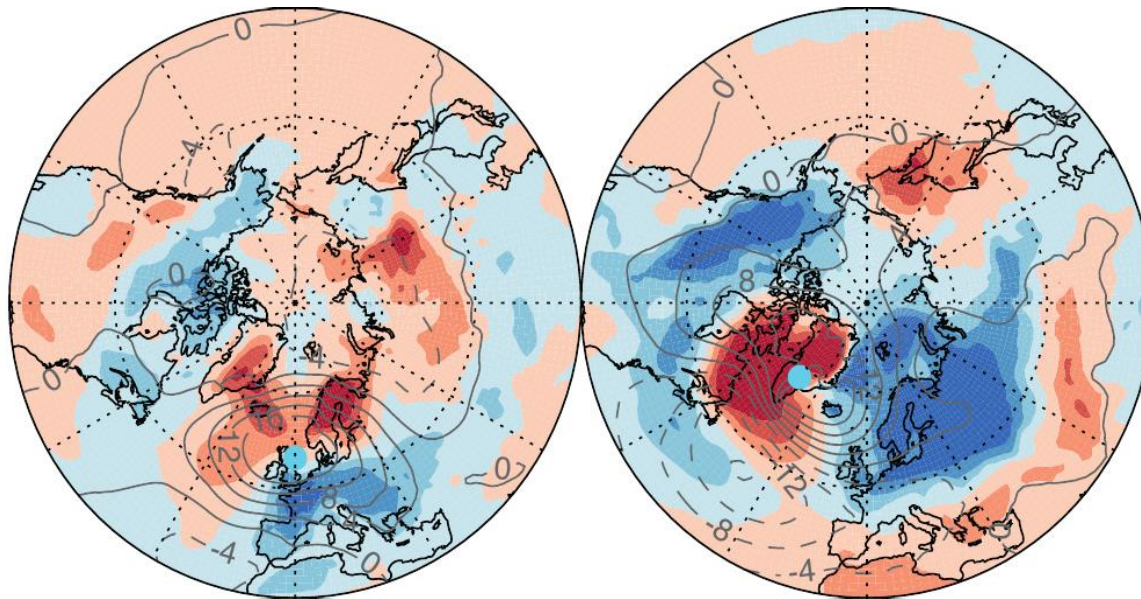
REGIONAL BLOCKING INDICES

Schiemann et al. 2017

Composites for t2m and mslp anomalies

WINTER

SUMMER



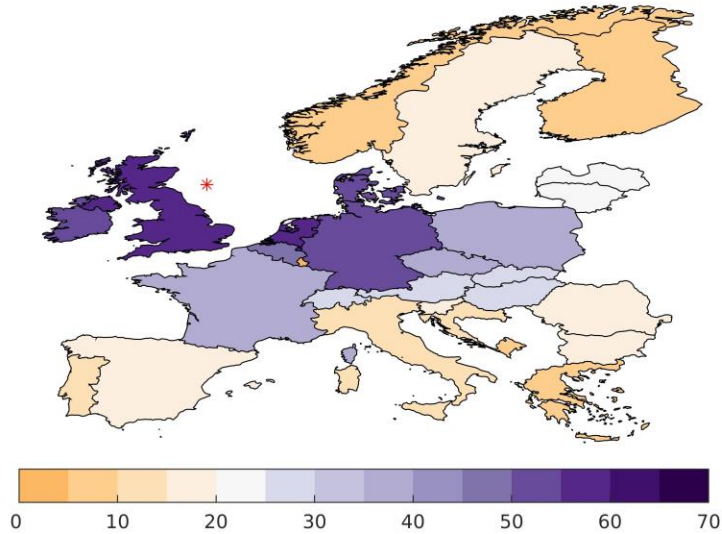
ATL (DJF)

GRL (DJF)

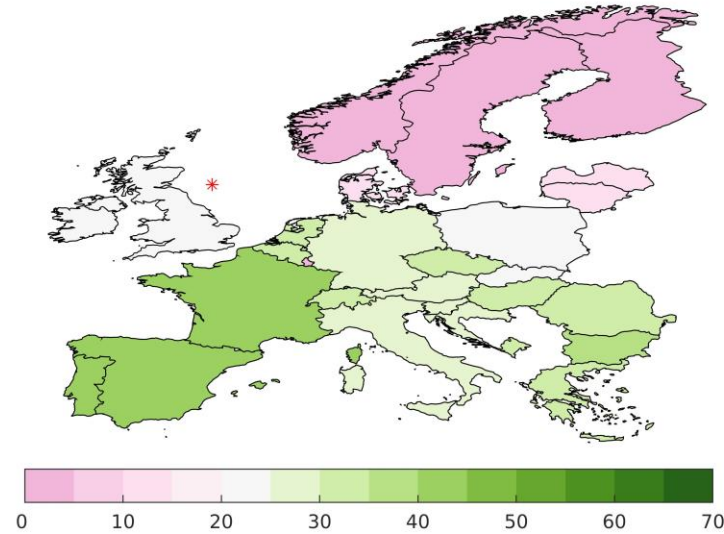
BAL (JJA)

IMPACT OF ATL BLOCKING - DJF: frequency of occurrence of events

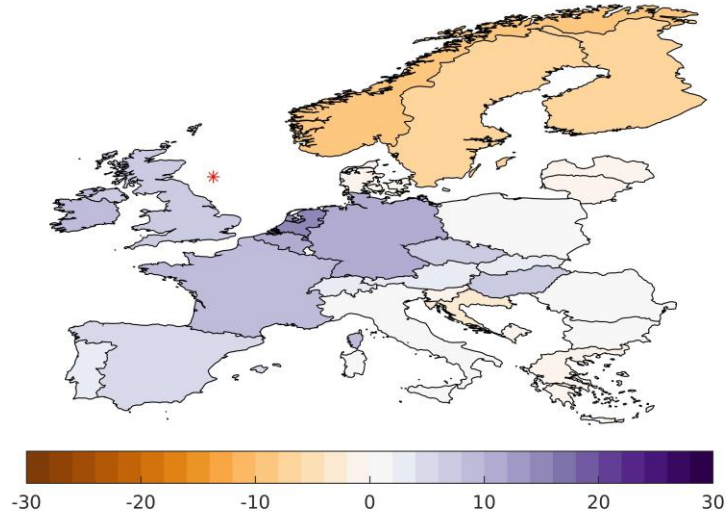
DJF: ERA fraction of low spd days given ATL blocking [%]



DJF: ERA fraction of low t2m days given ATL blocking [%]



DJF: ERA joint LW - CE given ATL block [% diff wrt clim]



A large region in central and SE Europe presents:

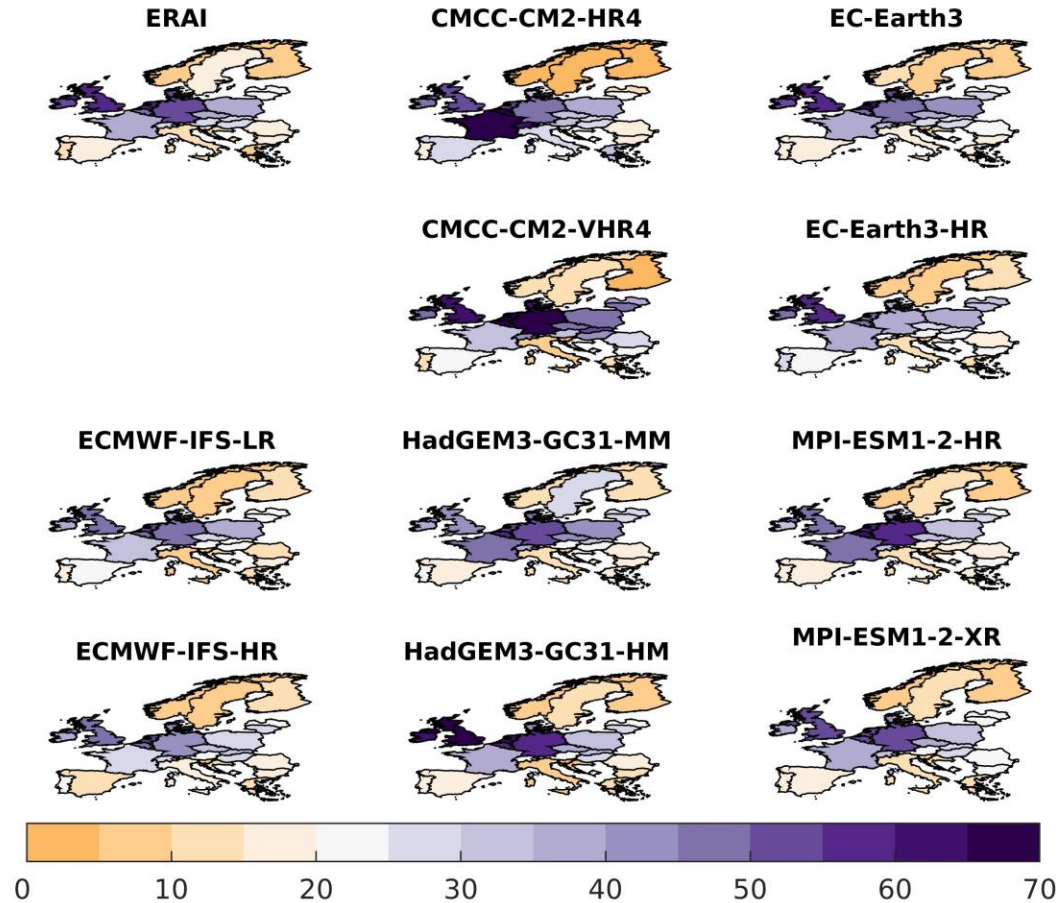
- an increased probability of observing low winds (up to 40%)
 - an increased probability of cold events (up to 30%)
 - an increased probability of joint LW-CE (~10%)
- with respect to the climatology of each event.

Joint LW-CE in winter are challenging for power system MGMT

-> High demand but decreased generation

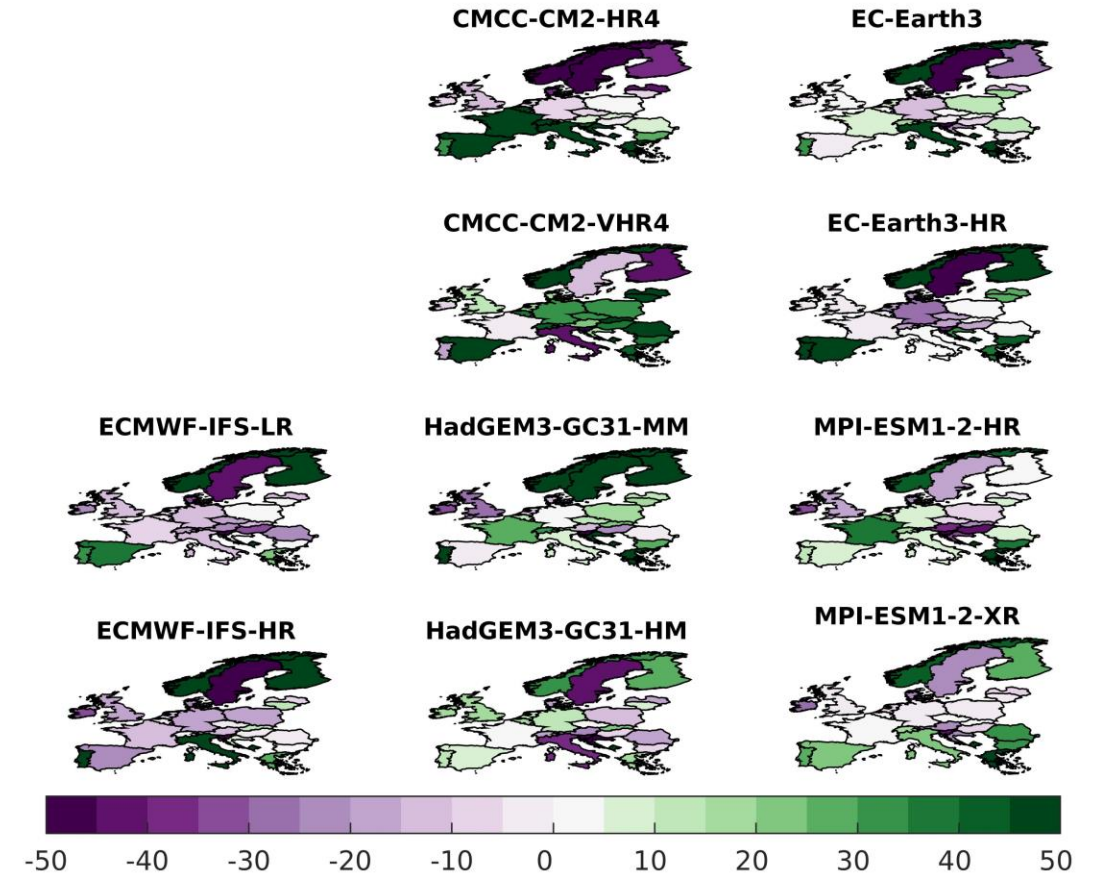
IMPACT OF ATL BLOCKING - DJF: frequency of occurrence of events

DJF: fraction of LW days given ATL blocking [%]



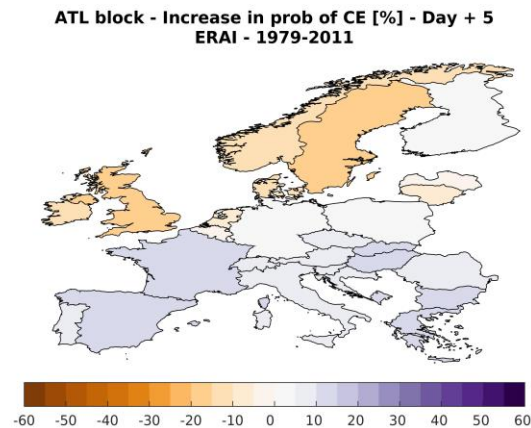
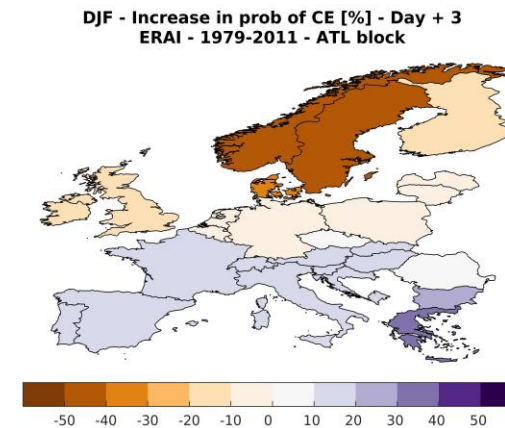
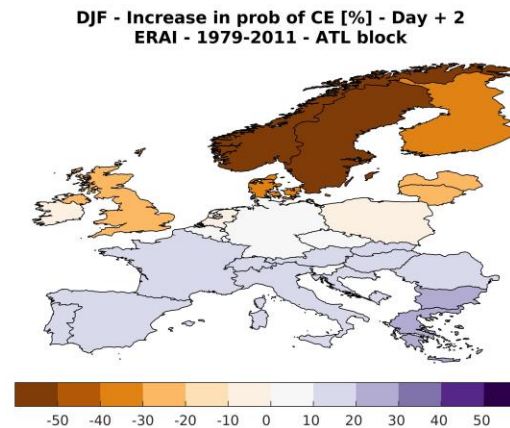
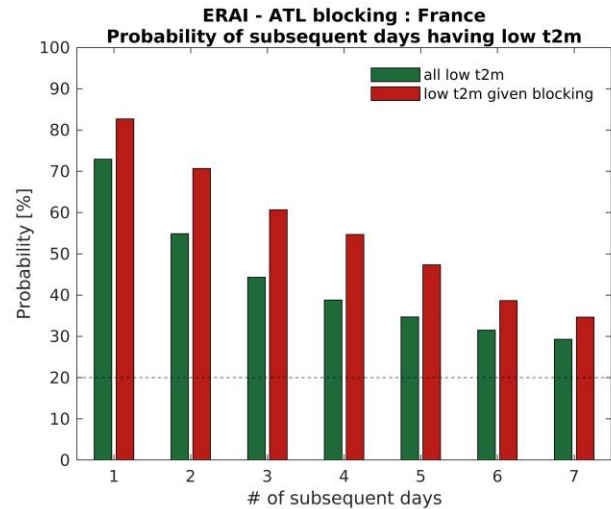
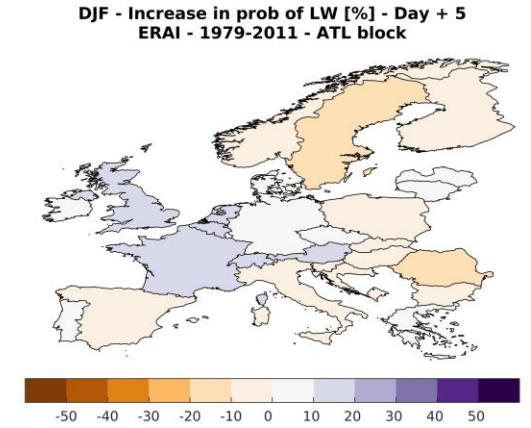
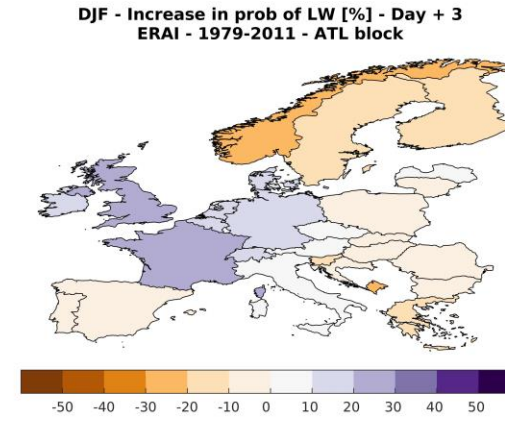
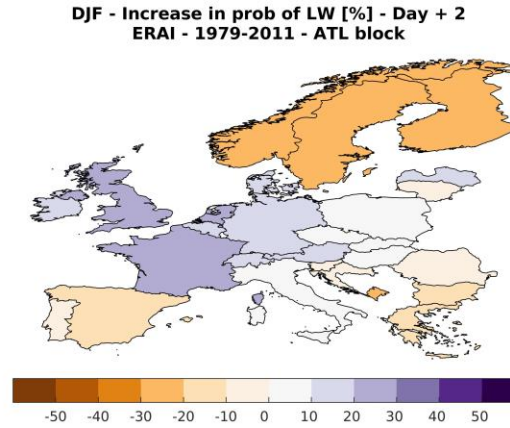
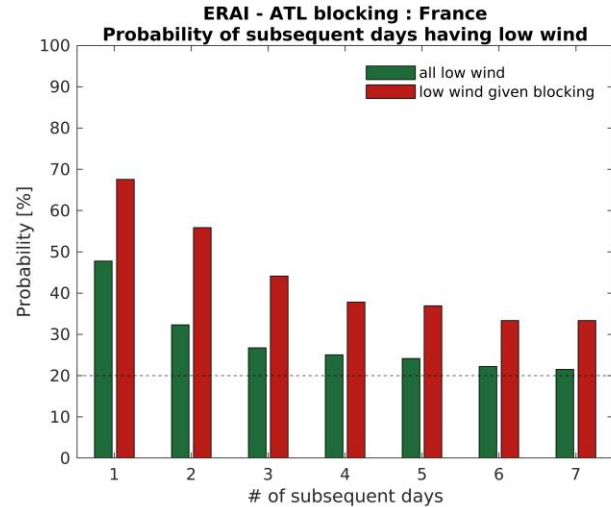
- all models capture the overall effect
- significant biases are present, in particular over Scandinavia
- no systematic improvements are seen with increased resolution

DJF: Relative error in fraction of LW days given ATL blocking [%]



IMPACT OF ATL BLOCKING - DJF: persistence of events

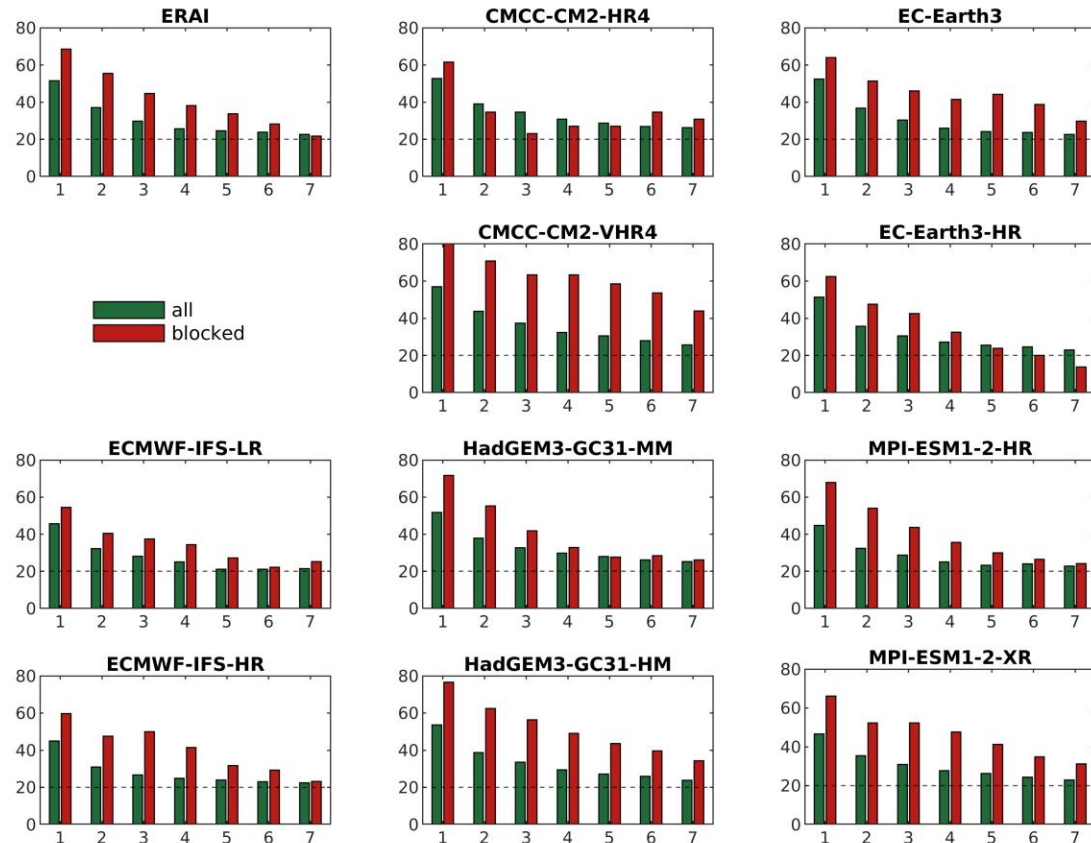
Given **ATL** blocking at **DAY 0** of an event (LW/CE), what is the **probability of observing an event n days later**



- large regions observe increased probabilities of observing an event even 5 days after the condition of ATL blocking is imposed

IMPACT OF ATL BLOCKING - DJF: persistence of events

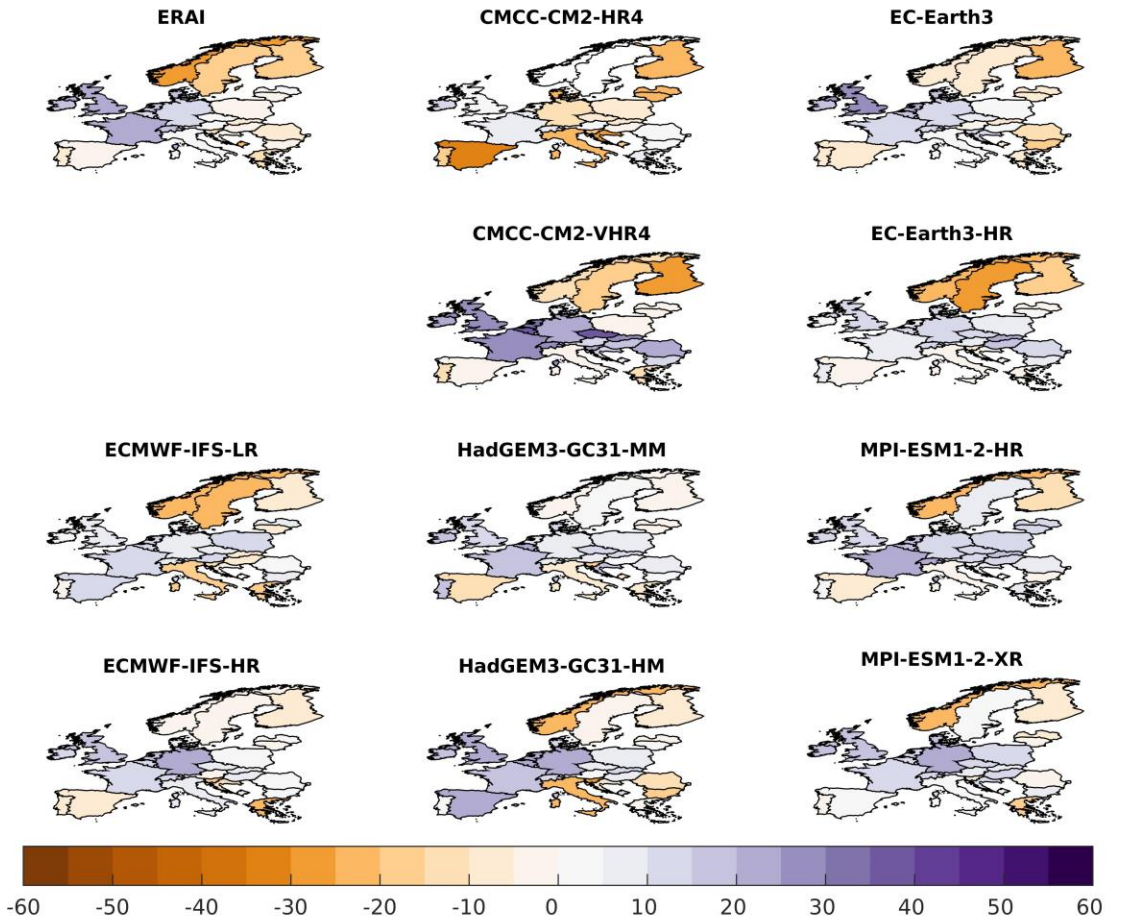
highresSST-present: DJF - Germany - ATL block - LW



EXAMPLE:

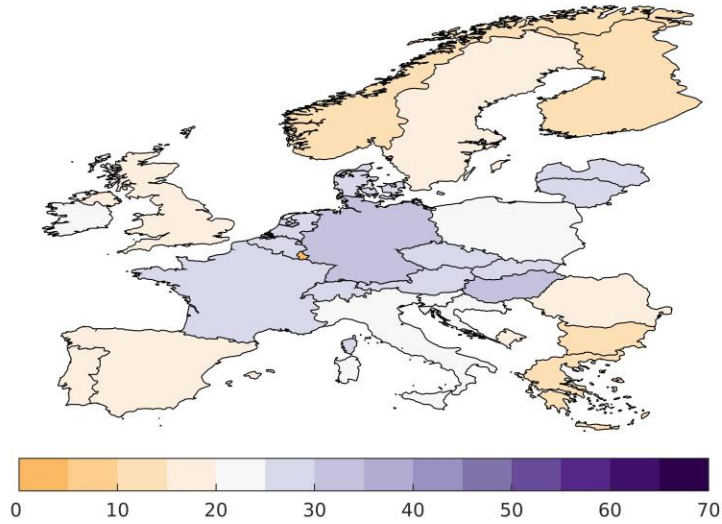
Persistence of low wind events

highresSST-present: DJF - United Kingdom - ATL block - LW - Day + 3

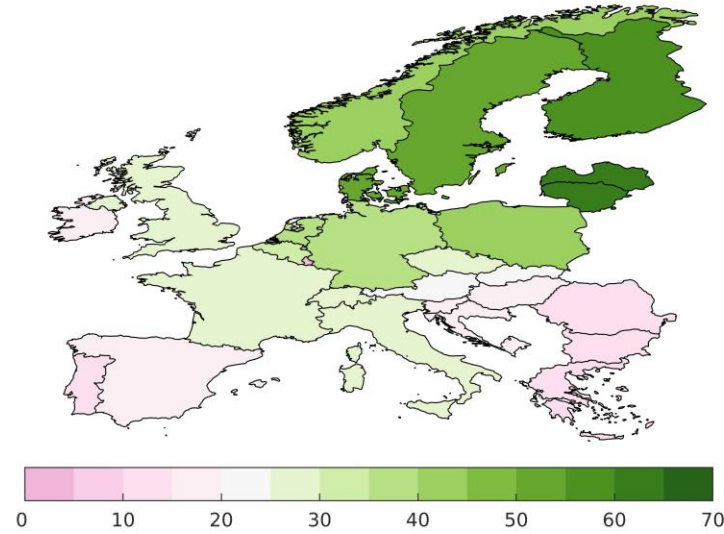


IMPACT OF BAL BLOCKING - JJA: frequency of occurrence of events

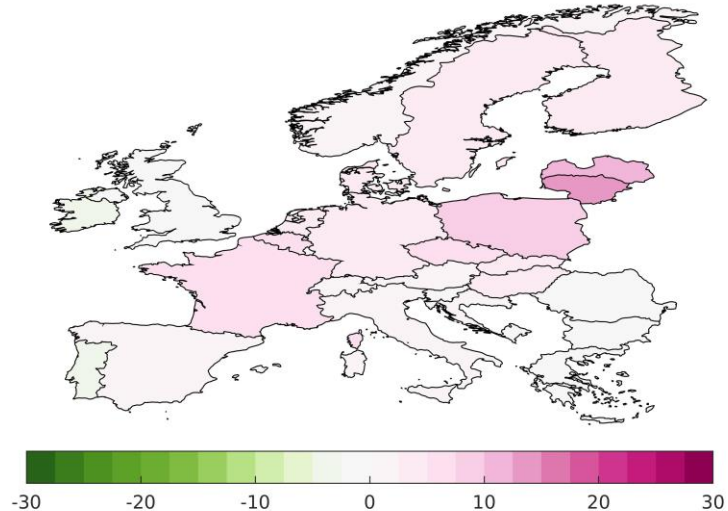
JJA: ERA fraction of low spd days given BAL blocking [%]



JJA: ERA fraction of high t2m days given BAL blocking [%]



JJA: ERA joint LW - WE given BAL block [% diff wrt clim]



A large region in central Europe presents:

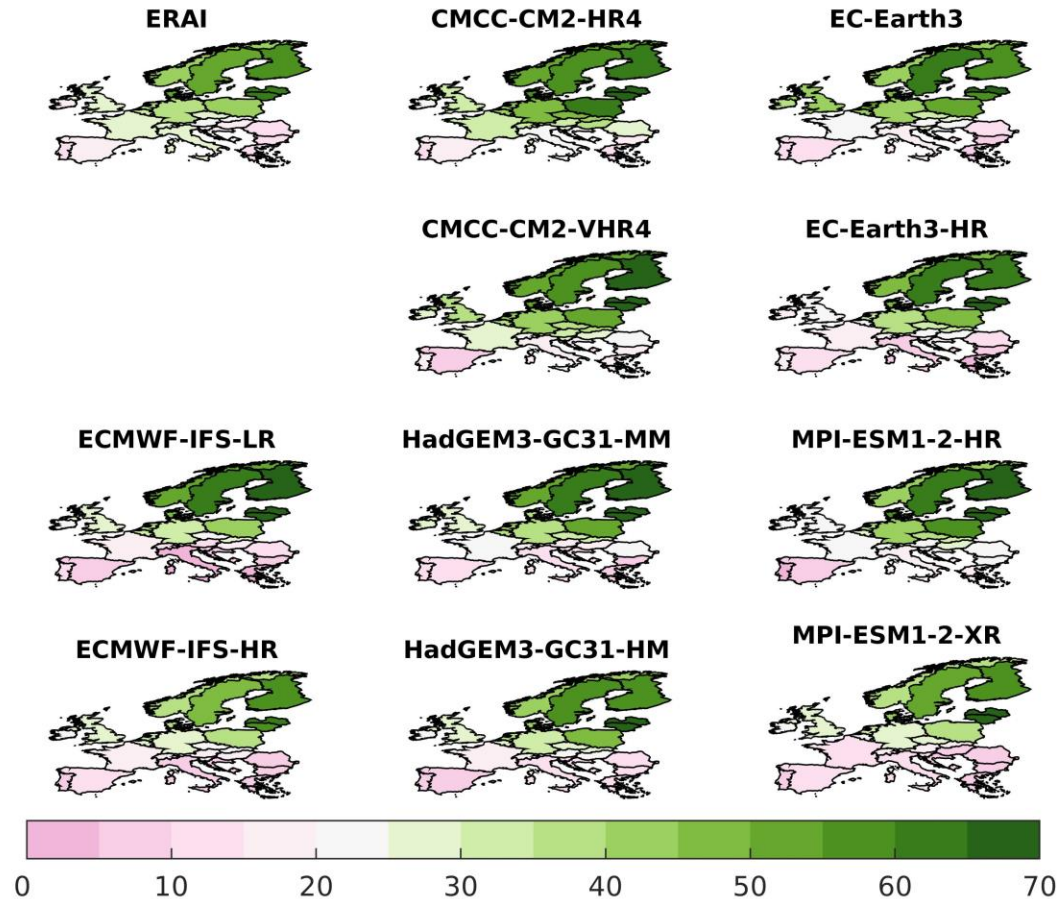
- an increased probability of observing low winds (up to 15%)
 - an increased probability of warm events (up to 30%)
 - an increased probability of joint LW-WE (~10%)
- with respect to the climatology of each event.

Joint LW-WE in summer are challenging for power system MGMT

-> High demand but decreased generation

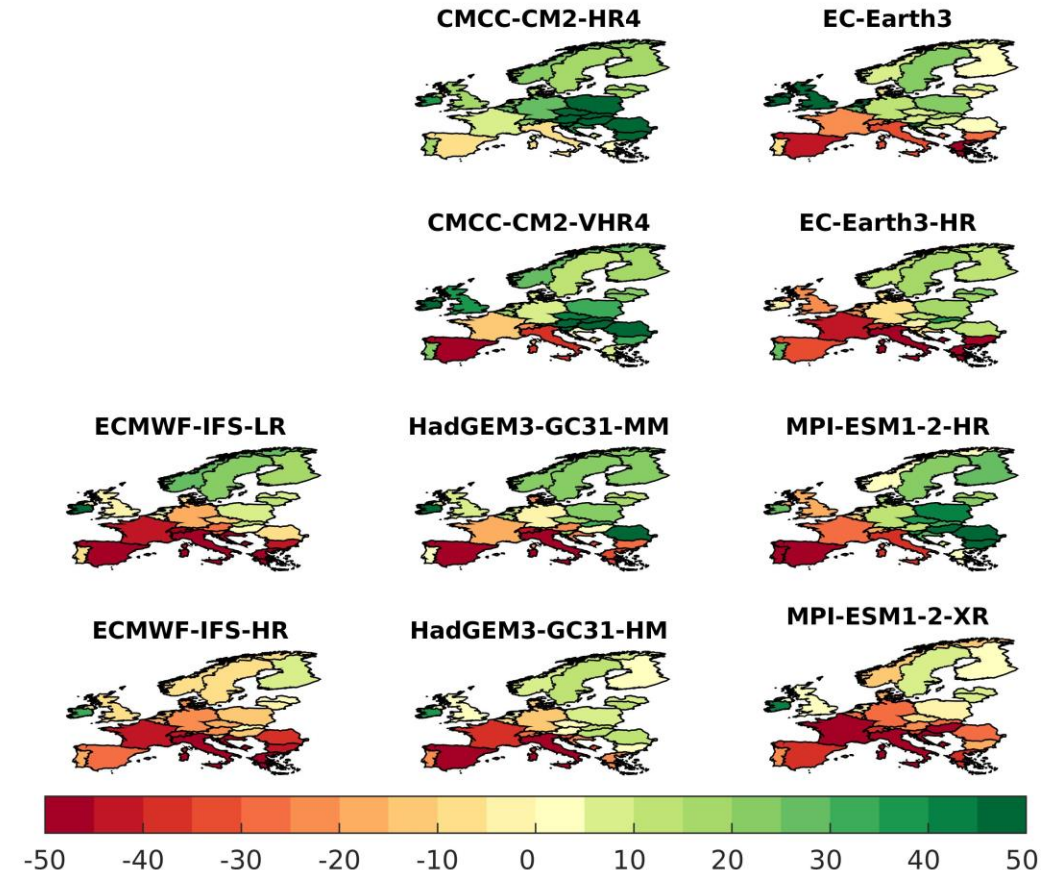
IMPACT OF BAL BLOCKING – JJA: frequency of occurrence of events

JJA: fraction of WE days given BAL blocking [%]



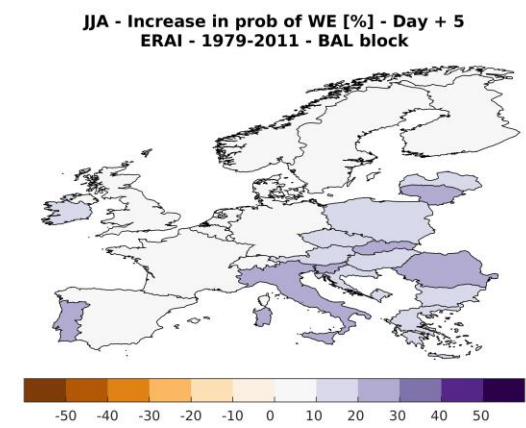
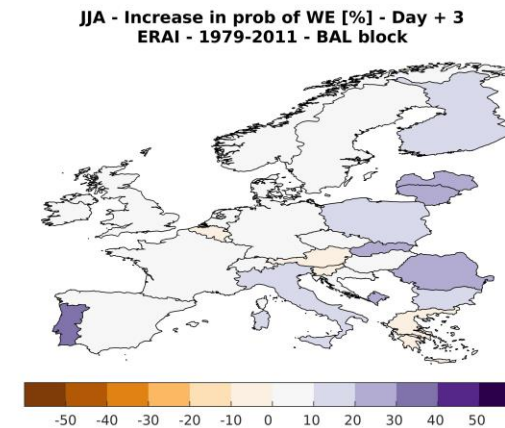
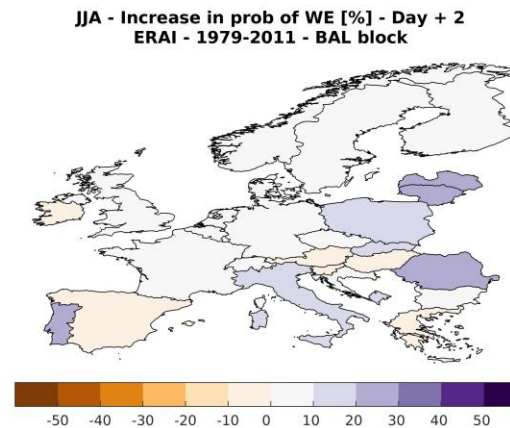
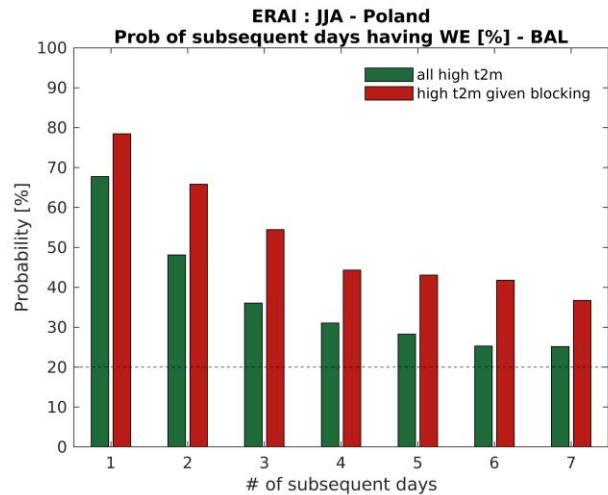
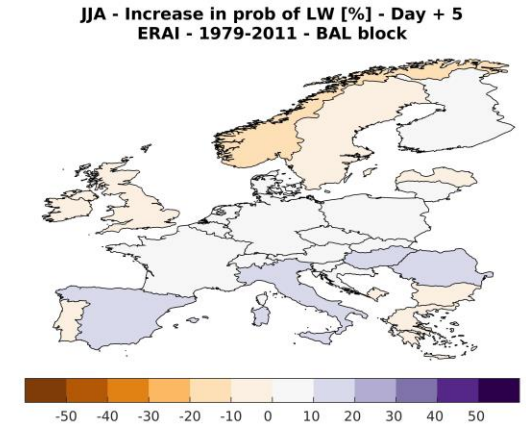
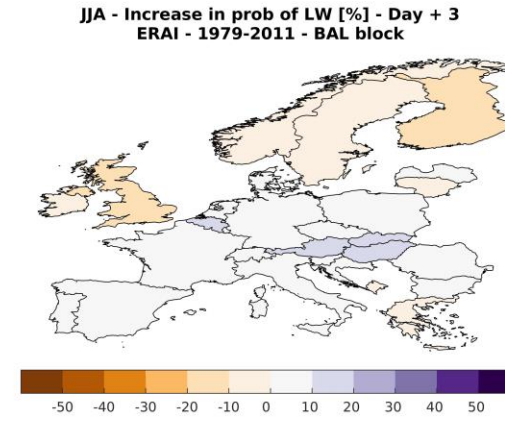
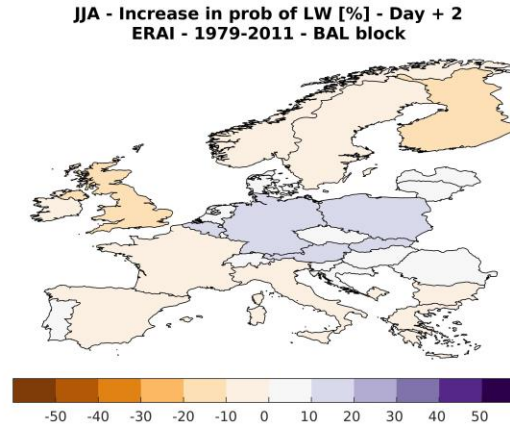
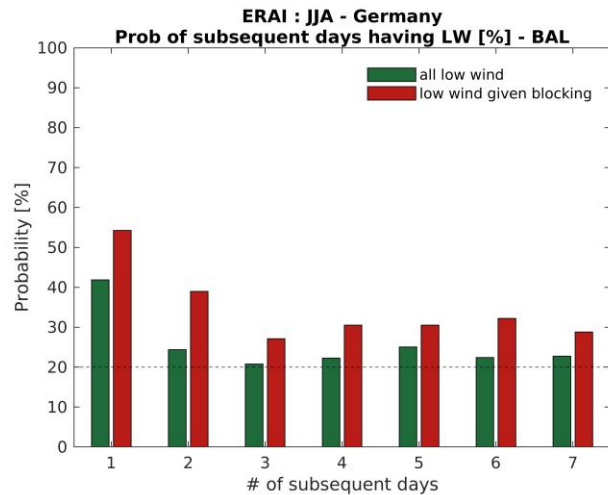
- all models capture the overall effect
- significant biases are present, in particular over SW Europe
- no systematic improvements are seen with increased resolution (maybe ECMWF?)

JJA: Relative error in fraction of WE days given BAL blocking [%]



IMPACT OF BAL BLOCKING - JJA: persistence of events

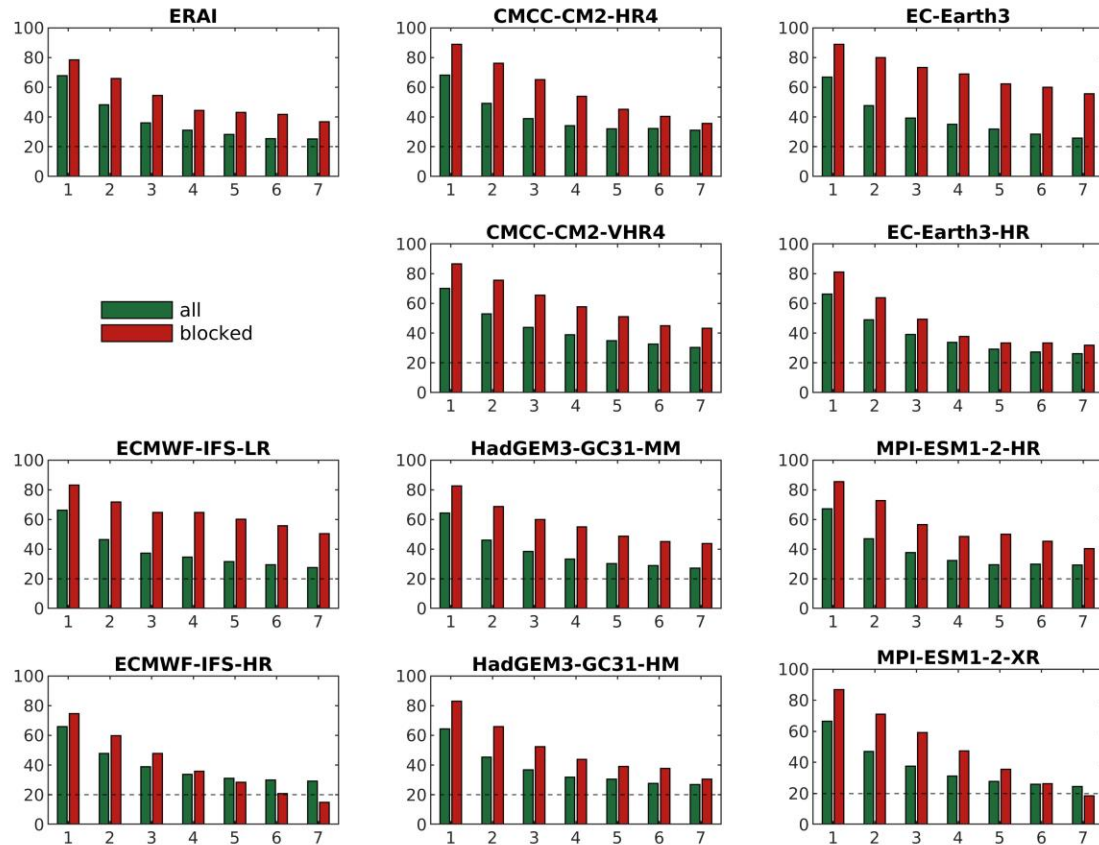
Given **BAL** blocking at **DAY 0** of an event (LW/WE), what is the **probability of observing an event n days later**



- the effect on the persistence of the events due to summer BAL blocking is weaker

IMPACT OF BAL BLOCKING - JJA: persistence of events

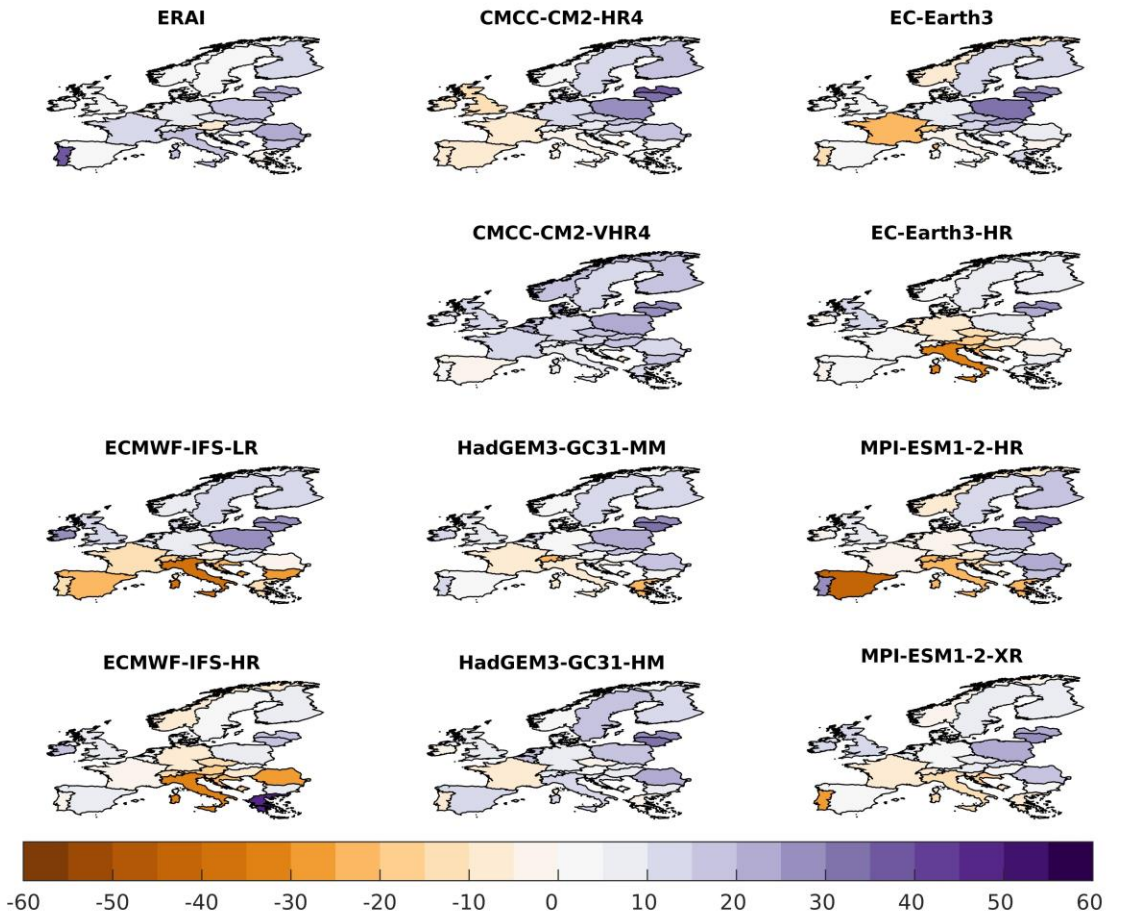
highresSST-present: JJA - Poland - BAL block - WE



EXAMPLE:

Persistence of warm events

highresSST-present: JJA - Poland - BAL block - WE - Day + 3



- Blocking conditions have a significant impact on 10m wind speeds and 2m temperature over large regions of Europe. The impact depends on the choice of index, the season and the country. Overall changes manifest as a **shift in the variable's pdf**.
- Blocking conditions affect the **frequency** of occurrence of LW, CE, WE and their joint occurrence.
- Furthermore, blocking also affects the **persistence** of those events.
- These effects are captured by most of the PRIMAVERA GCMs analyzed here, revealing that models which simulate blocking reasonably under highresSST-present forcing (AMIP runs) also **capture the basic dynamical connection with wind and temperature anomalies**.
- **Biases** in the models depend on the **statistic, country and resolution**, but some consistent bias patterns can be observed.
- **No consistent improvement** was observed with the increase in resolution. CMCC-CM2-HR4 is clearly the worse model and the one with coarser resolution.
- **Note of caution for the use of PRIMAVERA data for power system simulations:** though some wind speed / t2m mean biases could be easily corrected, **errors in the frequency or duration** of weather events are not that easily dealt with and will introduce **errors in wind power and energy demand simulations**.