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Influence of atmospheric blocking on heatwaves in large model ensembles*

*Schaller, N. et al. (2018). Environmental Research Letters, 13(5)

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GEWEX, Canmore, 07.05.18

Motivation

Using atmospheric blocking as covariate improves fit of extreme minimum temperature for winter in Europe (*Sillmann et al., 2011*)

- ➡ Quantifying conditional return periods
- ➡ Disentangling dynamics and thermodynamics

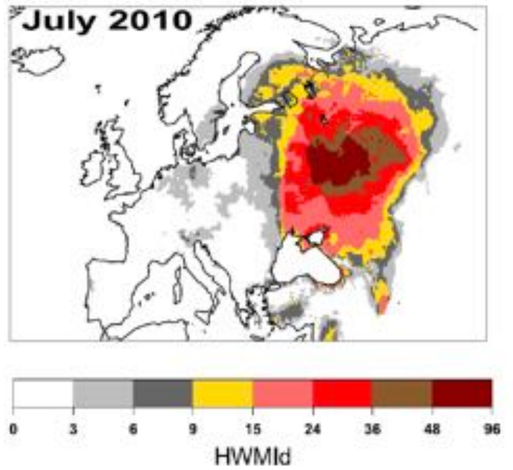
Research questions

To what extent are summer heatwaves associated with atmospheric blocking?

Are GCMs able to capture this relationship?

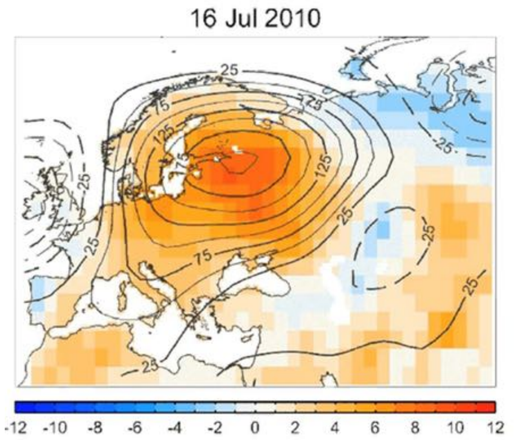
Can blocking be used as covariate to improve the quantification of heatwave return periods?

Heatwave magnitude



Russo et al. (2015)

Geopotential height anomaly (500hPa)



Barriopedro et al. (2011)

Three large initial condition ensembles

* ERA-Interim, 0.75° x 0.75°
(Dee et al., 2011)

ERAI

50-member ensemble of CanESM2
(CanSISE project)
Resolution: 2.5° x 2.5°

CanESM2

21-member ensemble from NCAR-DOE CESM (CAM4)
(Fischer and Knutti, 2013)
Resolution: 1.9° x 2.5°

CESM-CAM4

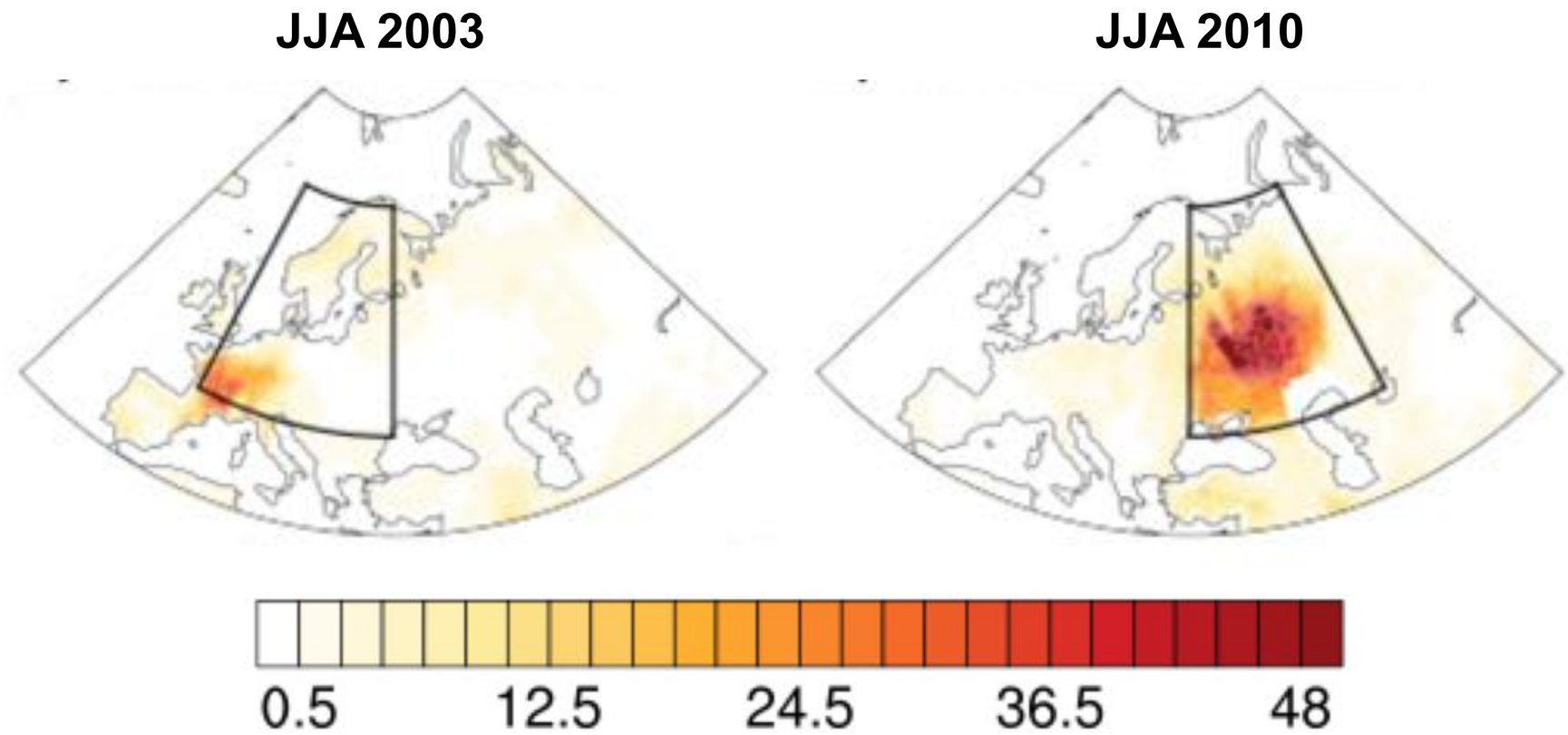
40-member ensemble from NCAR CESM1 (CAM5)
(Clara Deser and Jennifer Kay, Kay et al., 2015)
Resolution: 1° x 1°

CESM-CAM5

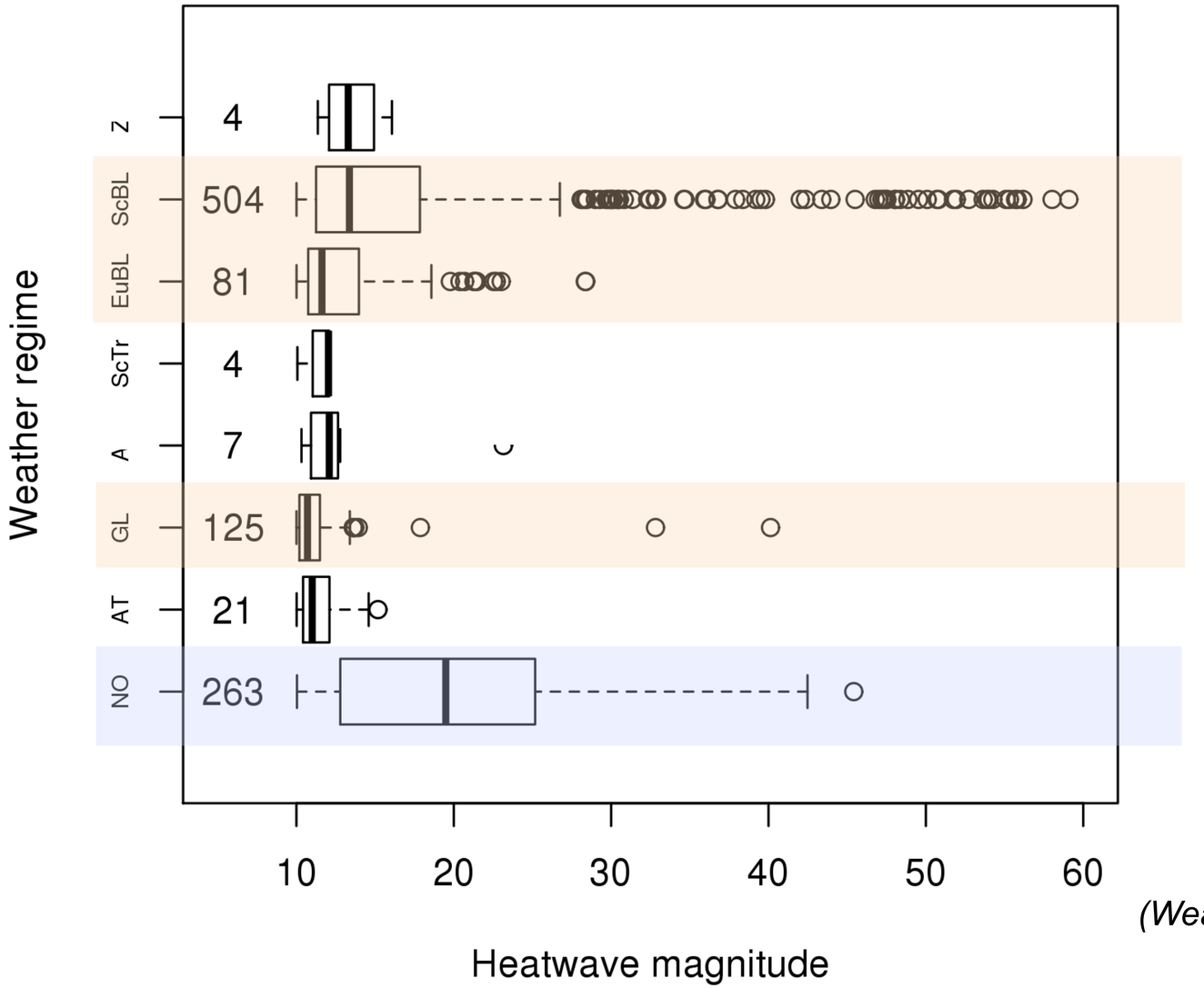
Heatwave index

Heat Wave Magnitude Index daily

Combined measure of intensity and duration of a heatwave (*Russo et al., 2015*)



Most heatwaves associated with blocking

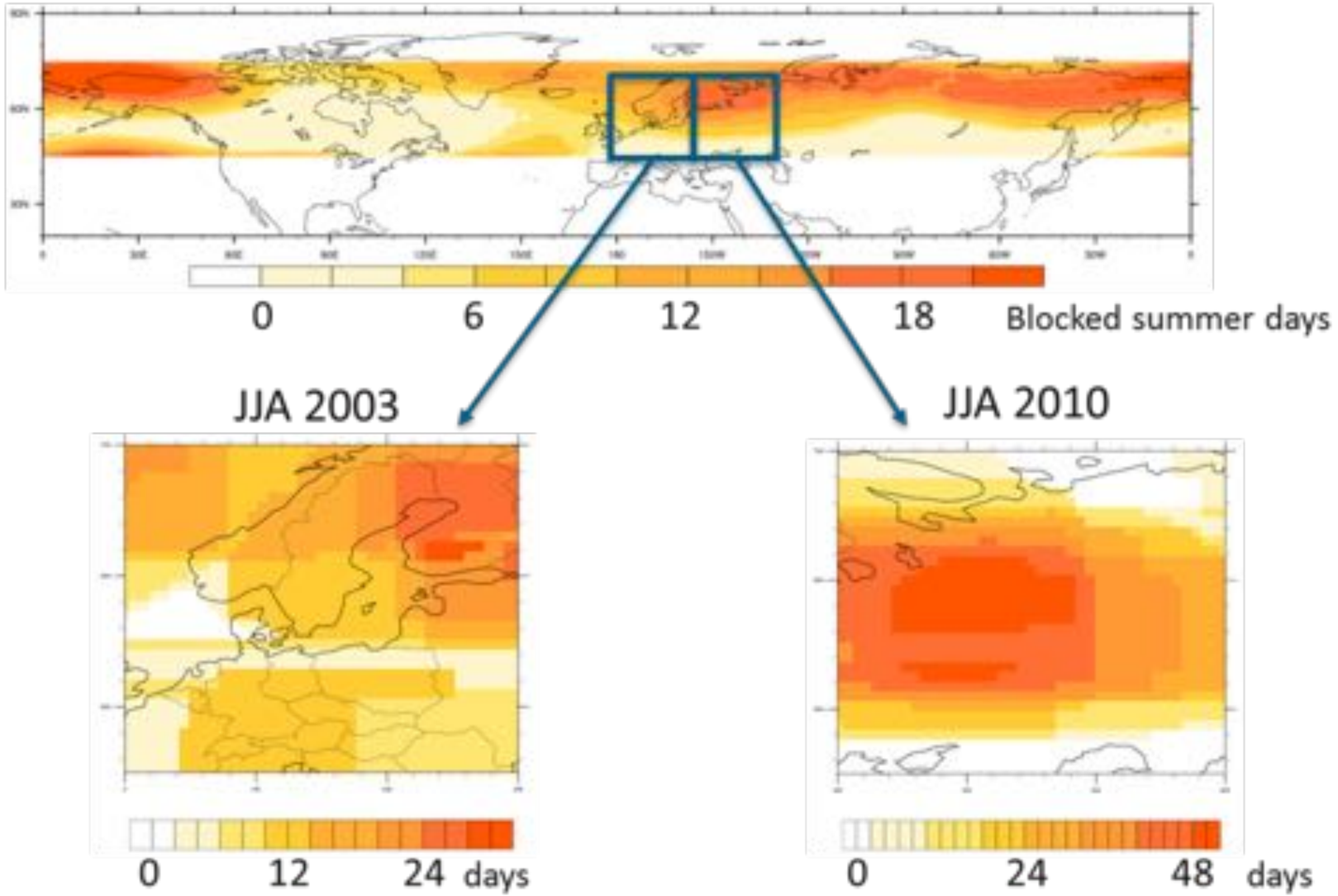


70% of strong heatwaves (HWMId≥10) associated with Scandinavian, European or Greenland blocking

26% of strong heatwaves (HWMId≥10) associated with no particular weather regime

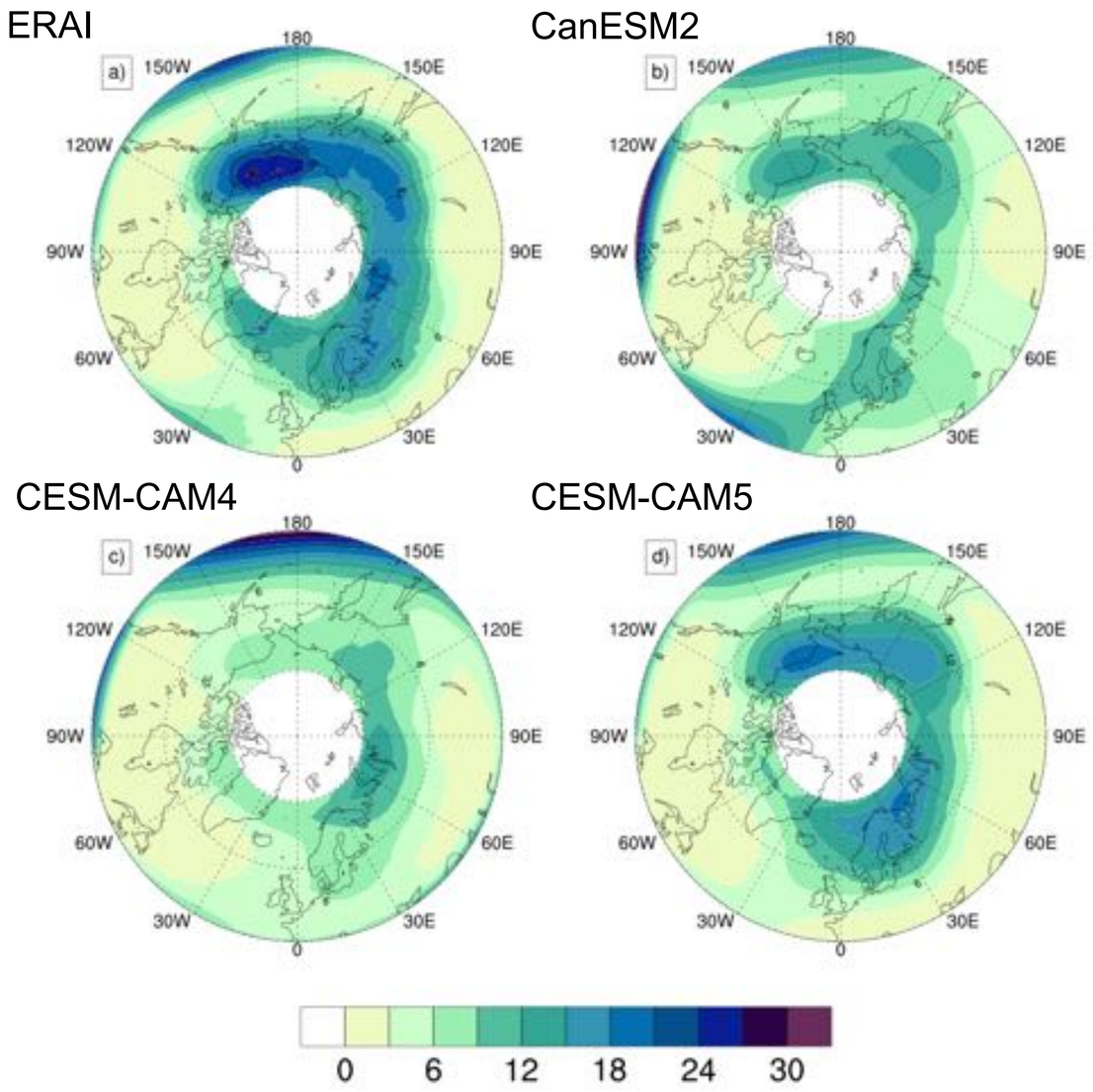
(Weather regimes calculated following Grams et al., 2017)

Blocking index



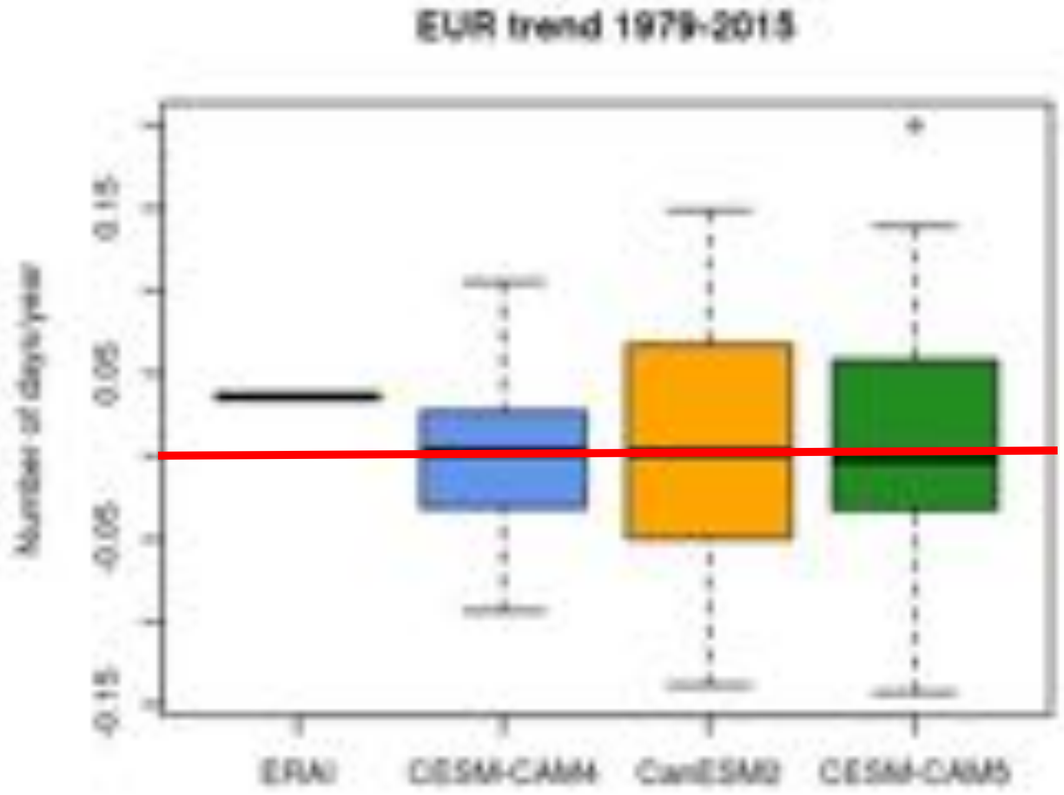
Based on geopotential height at 500 hPa (*Anstey et al., 2013*)

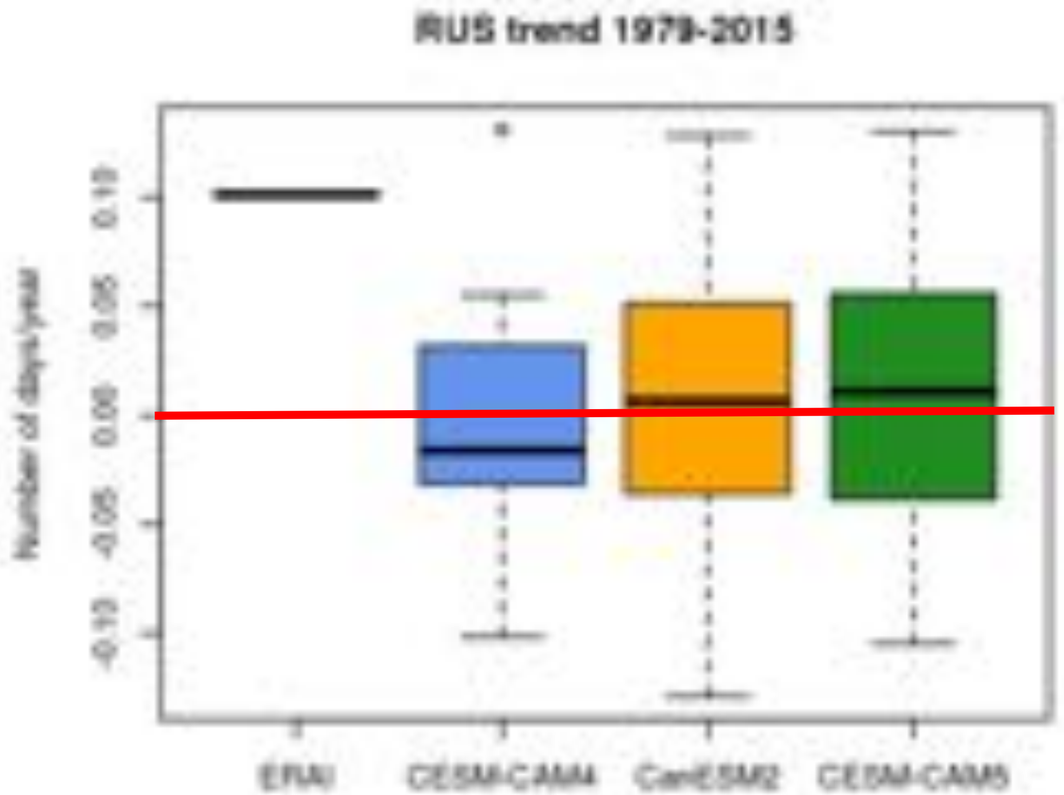
Not all models capture blocking frequency well



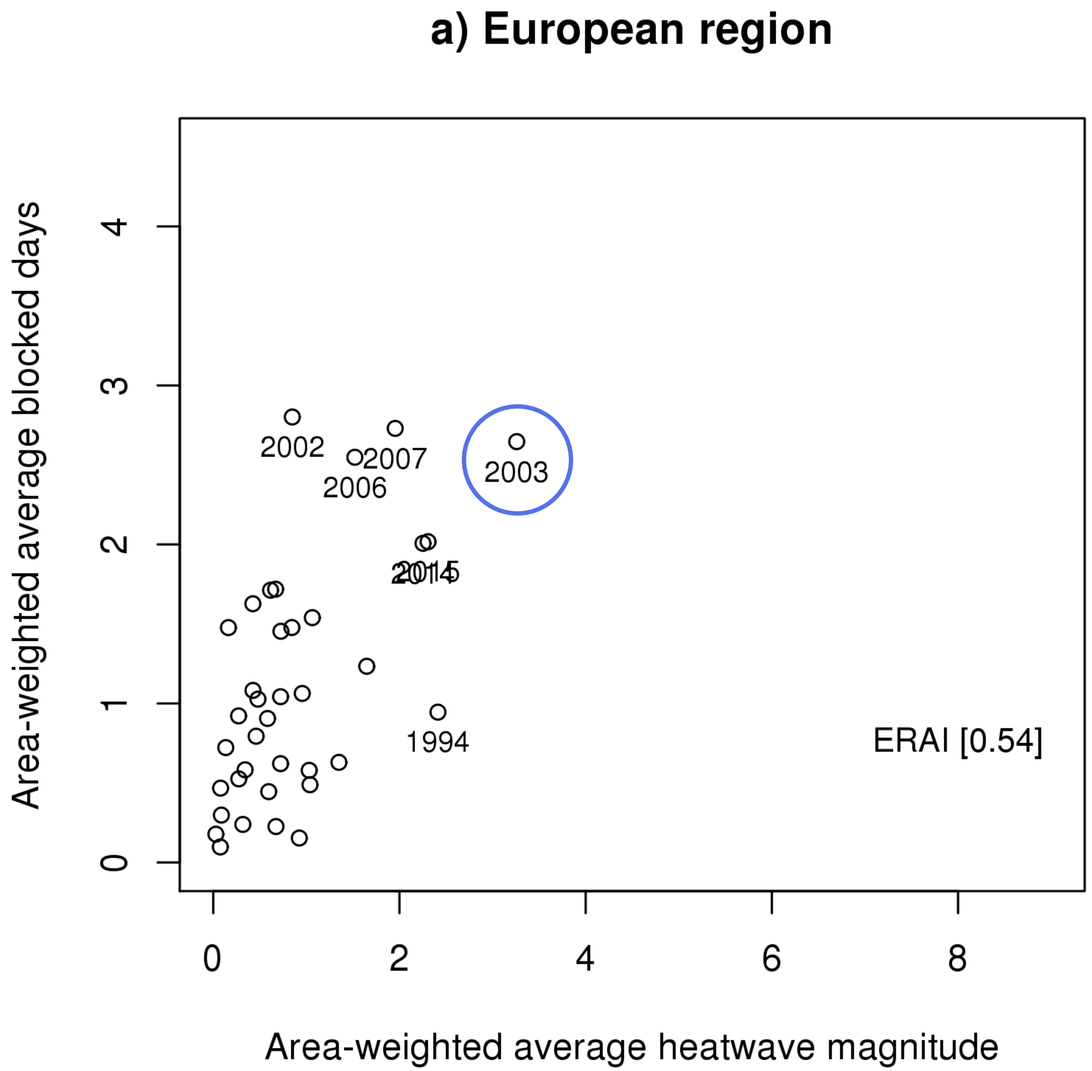
Number of blocked summer days *captured* by CESM-CAM5, but *underestimated* by CESM-CAM4 and CanESM2

No robust trend in blocking





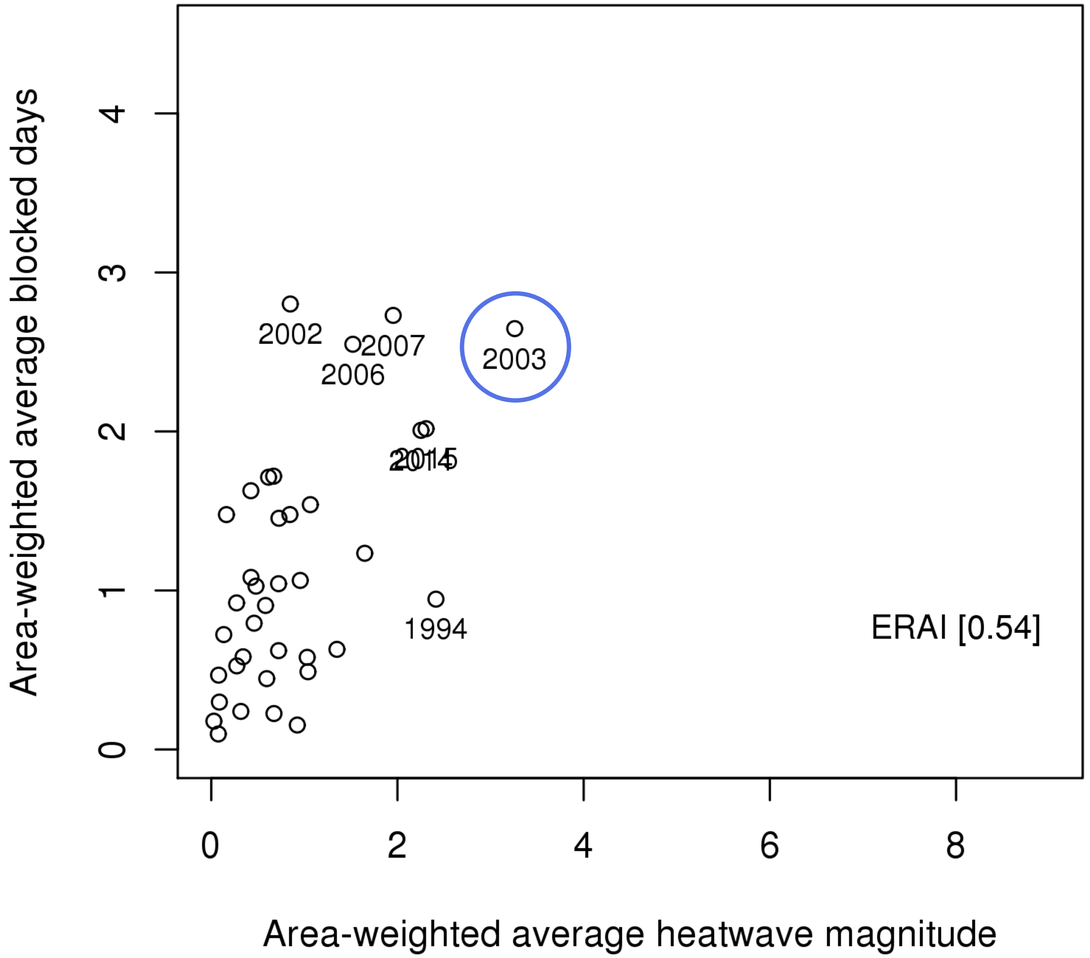
Relationship between blocking and heatwaves



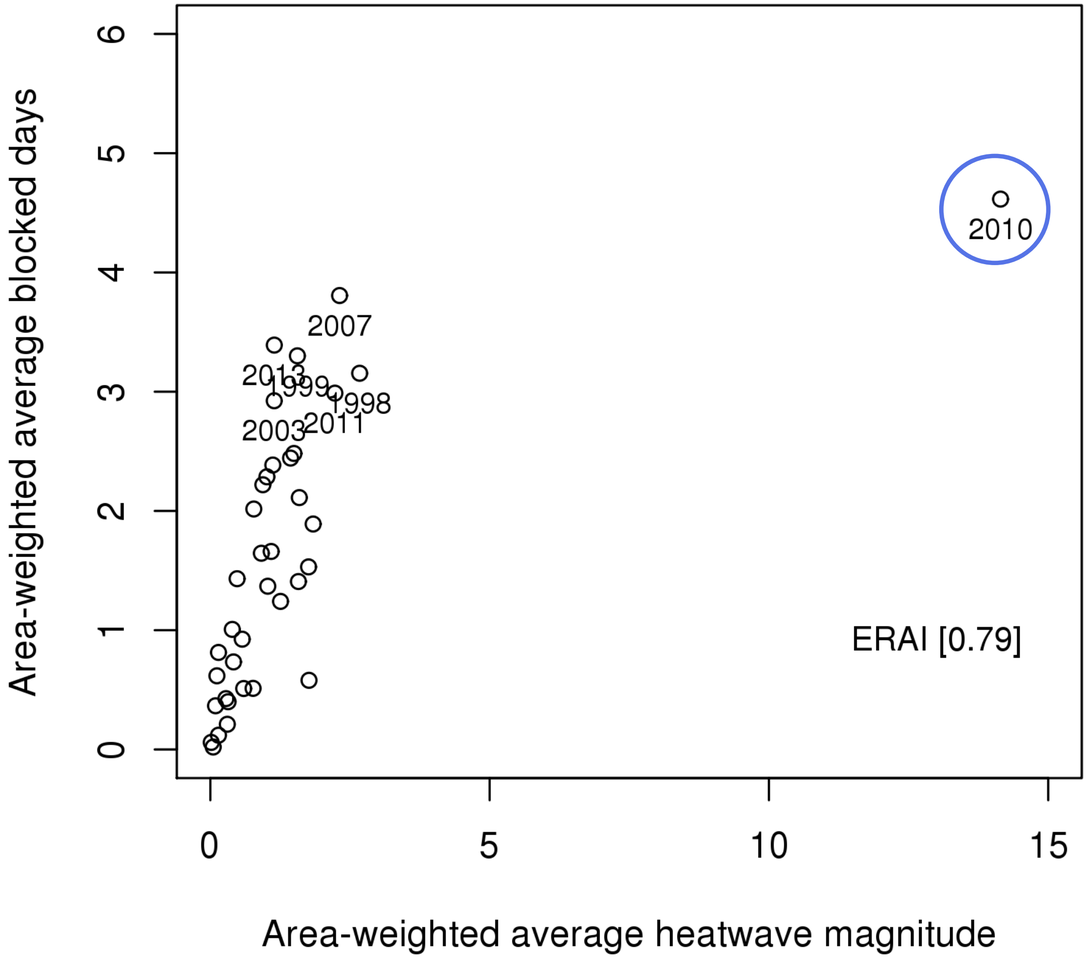
Higher blocking frequency in 9 days after onset -> higher HW magnitude

Relationship between blocking and heatwaves

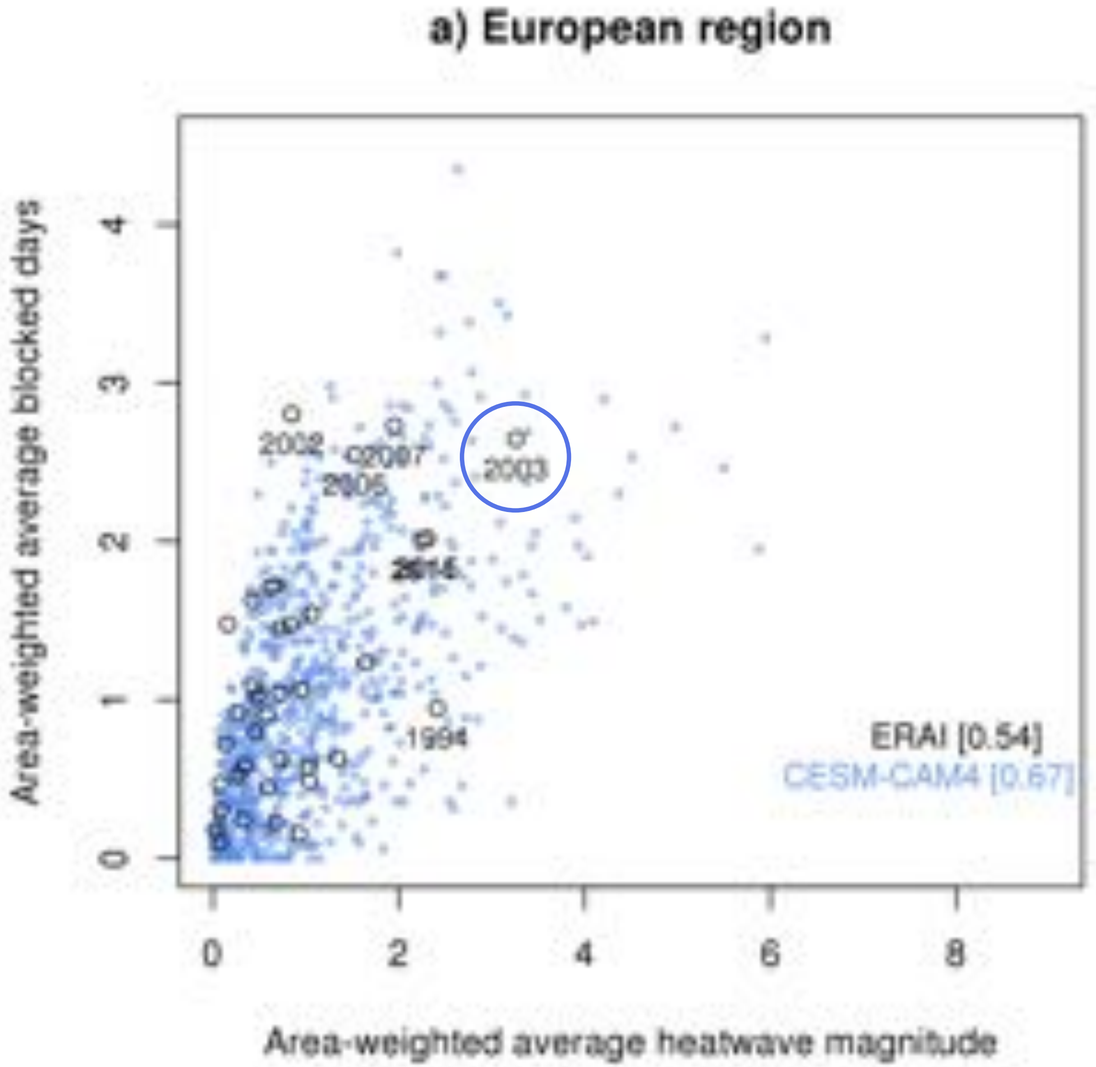
a) European region

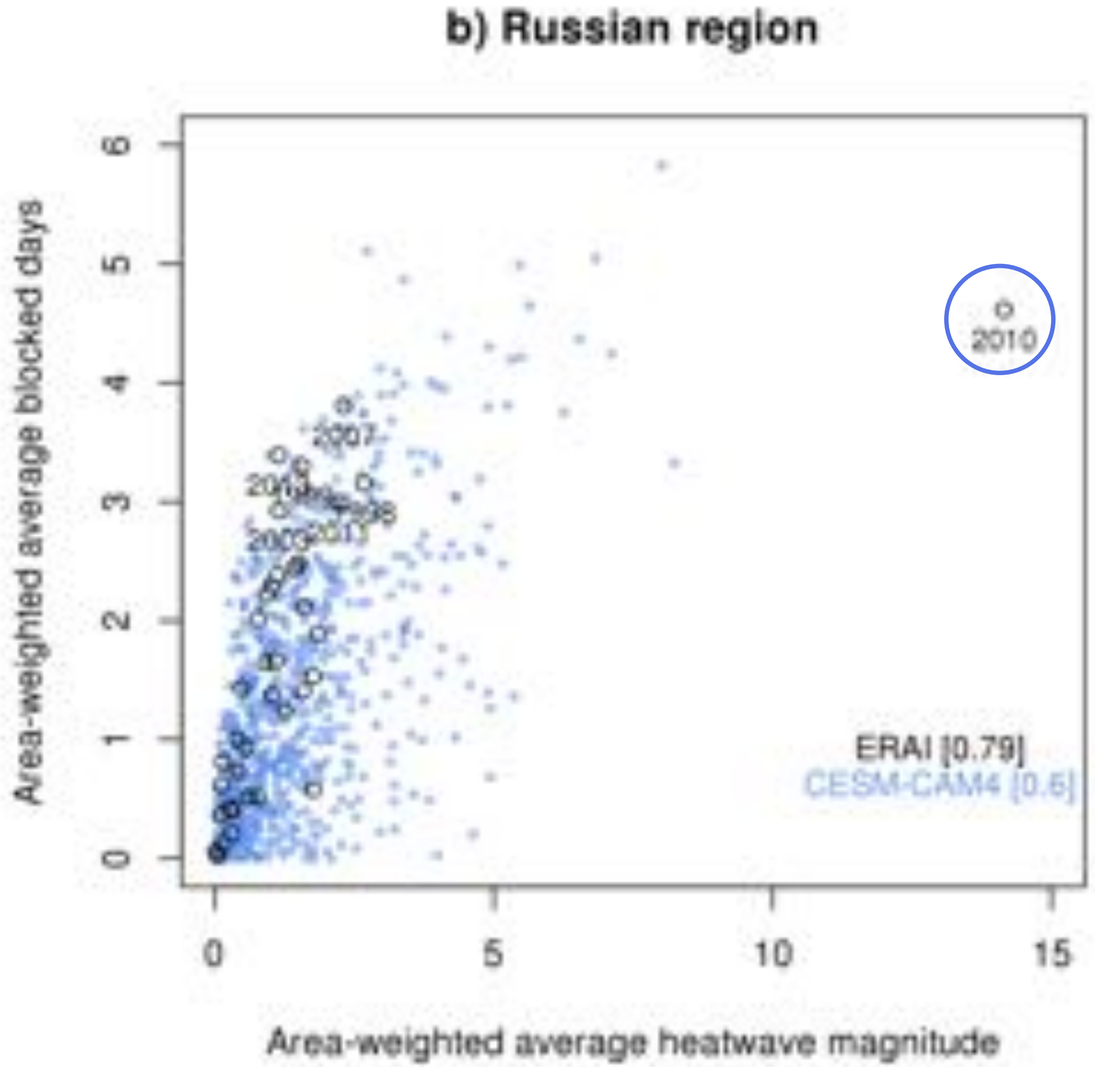


b) Russian region

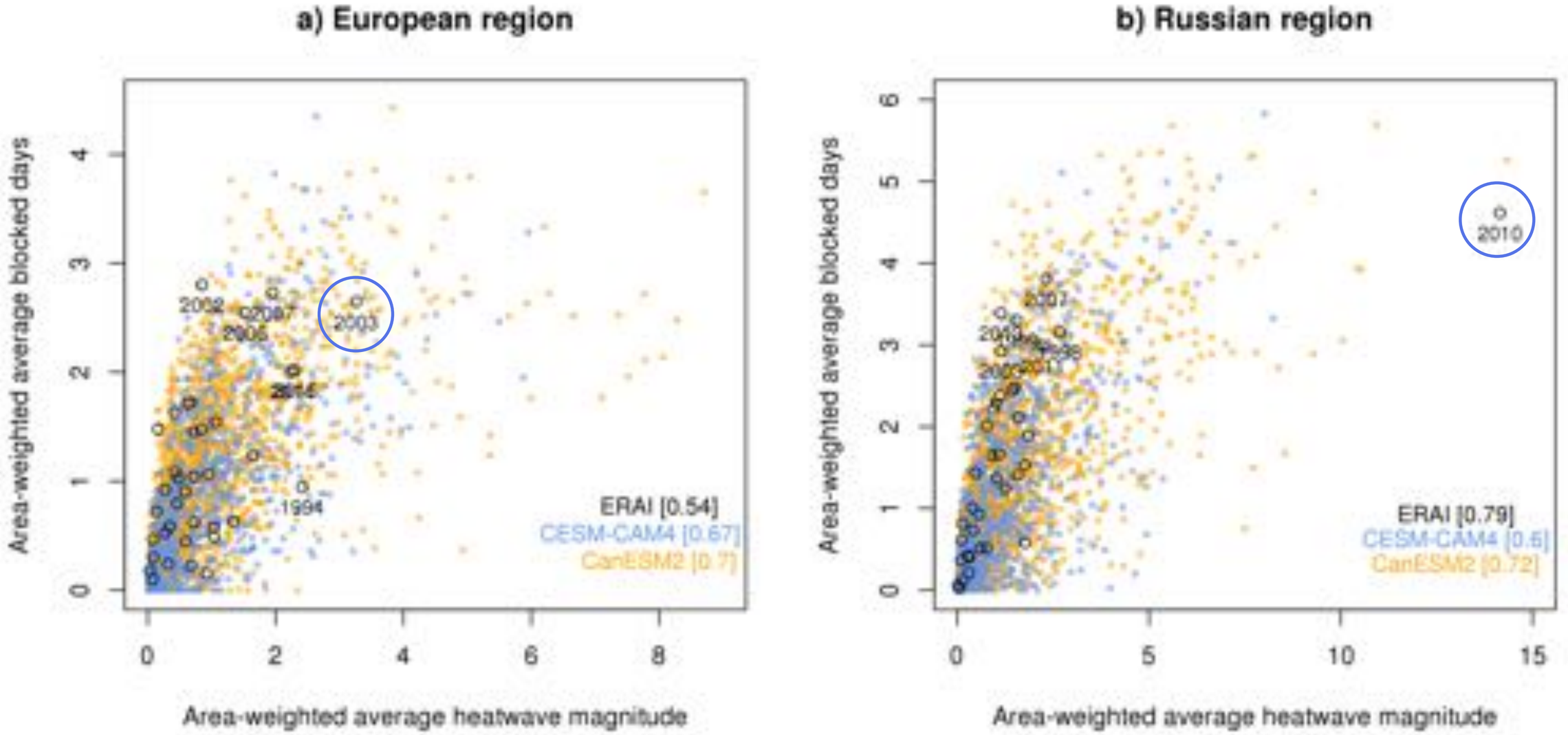


Models capture observed relationship

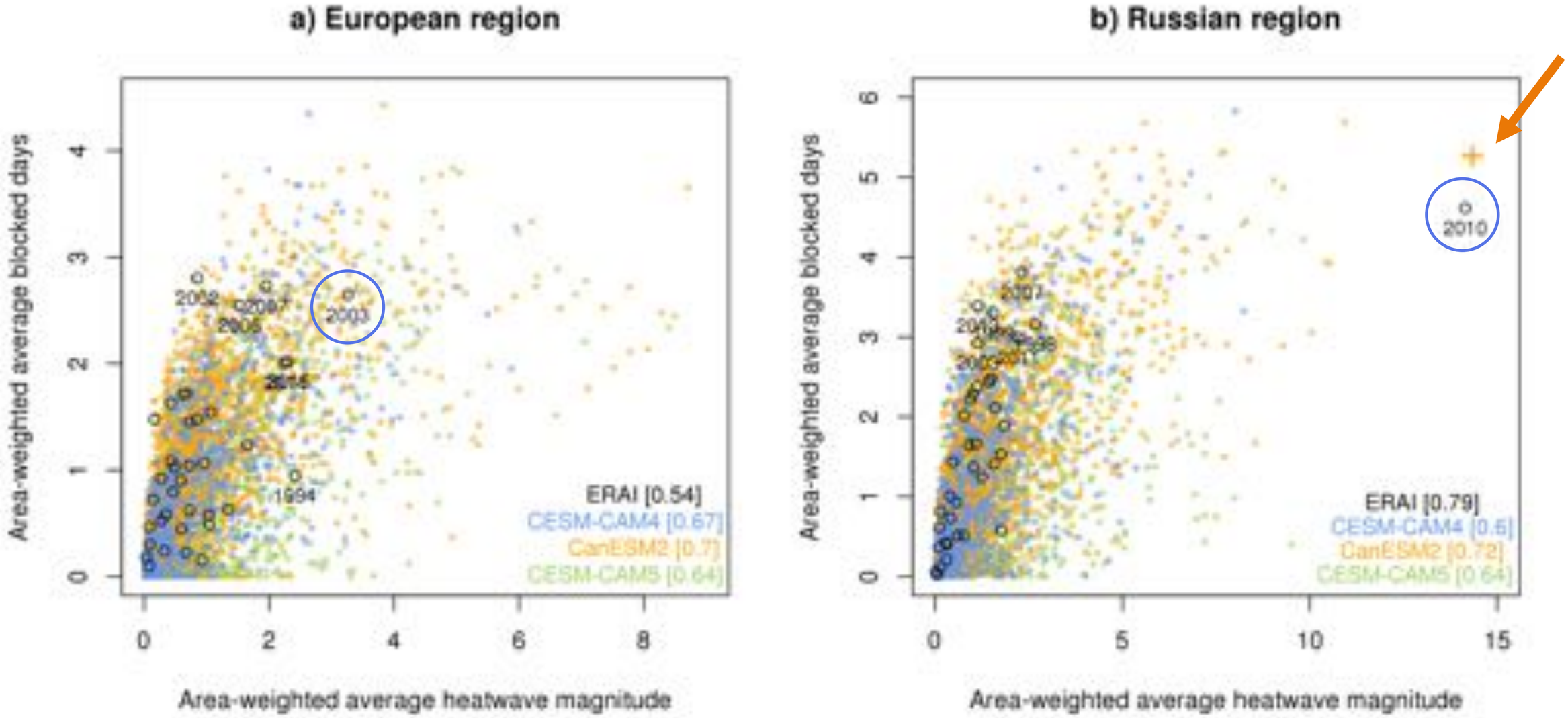




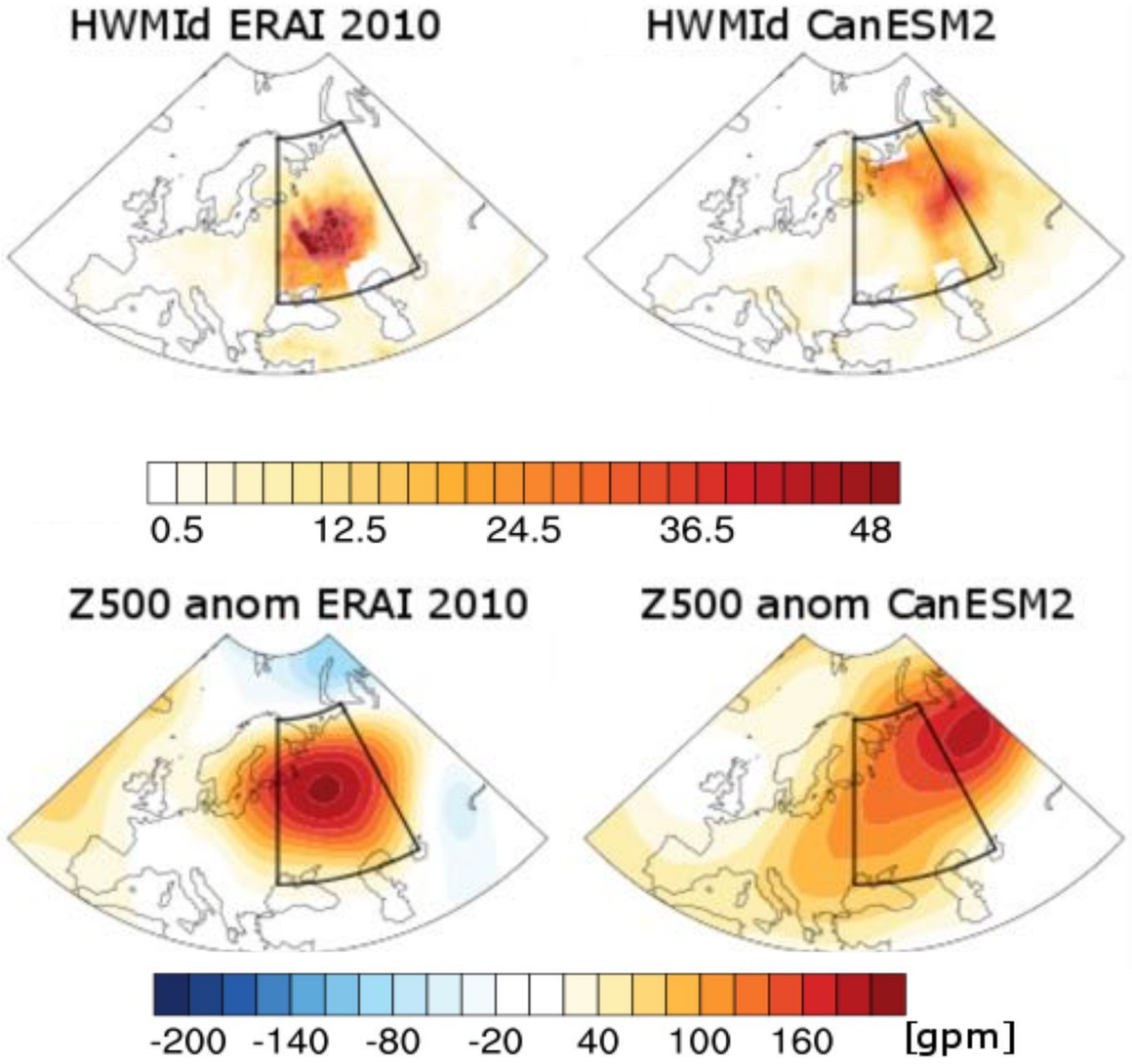
Models capture observed relationship



Models can produce 2010-type heatwaves

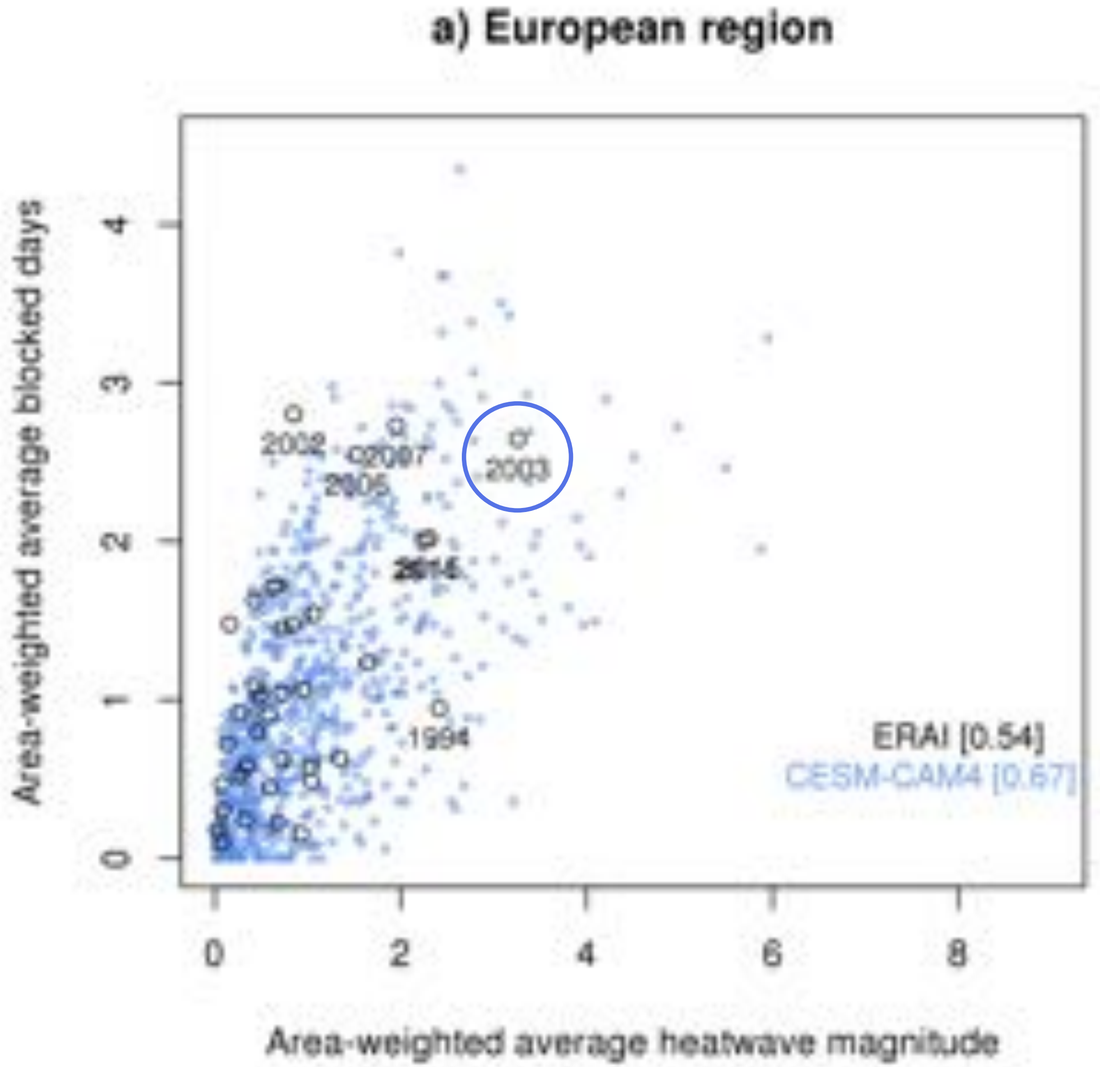


2010-type heatwave in climate model

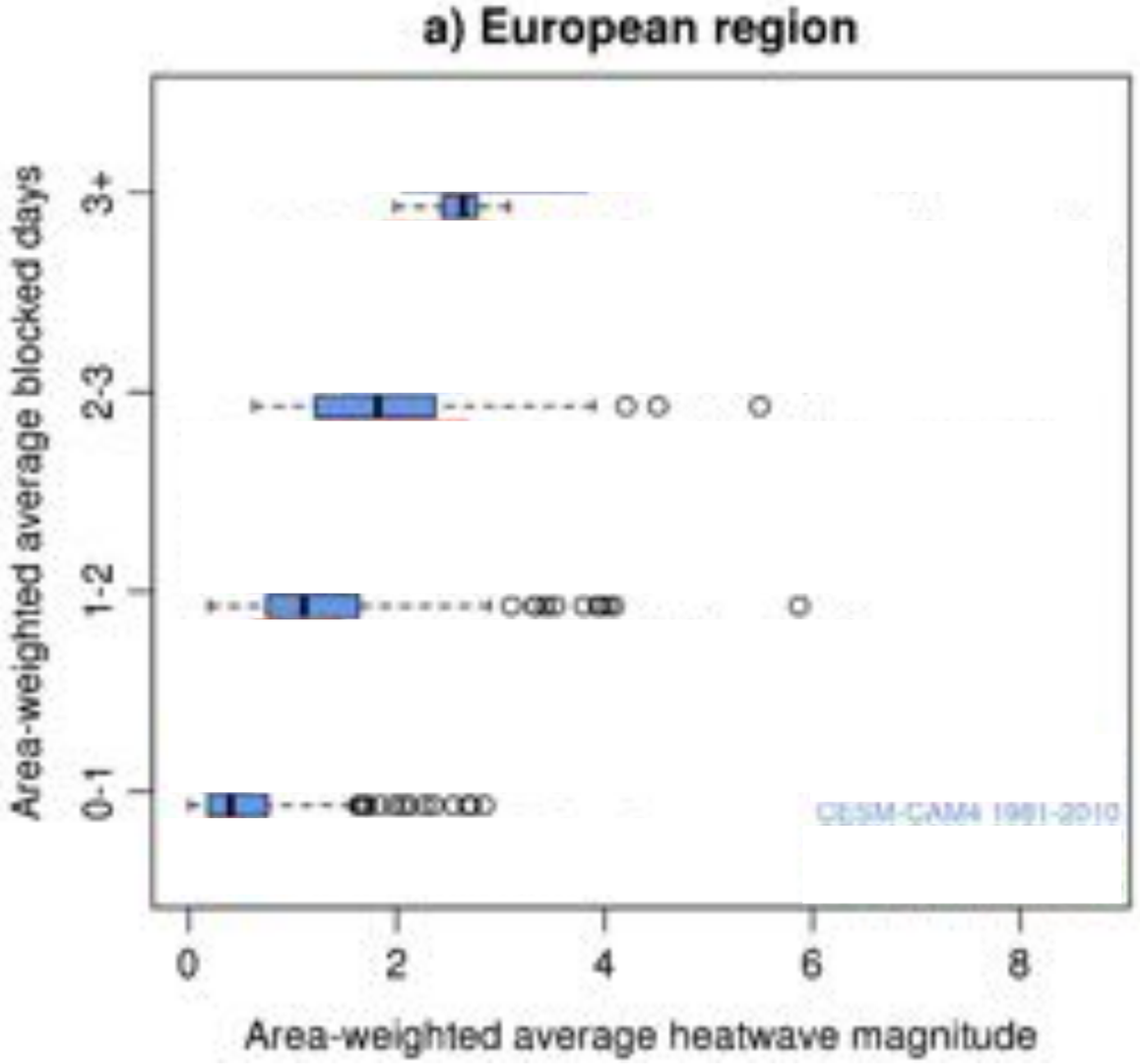


CanESM2, with the lowest resolution, is able to simulate an event similar to the 2010 Russian heatwave

Blocking is a suitable covariate for HW



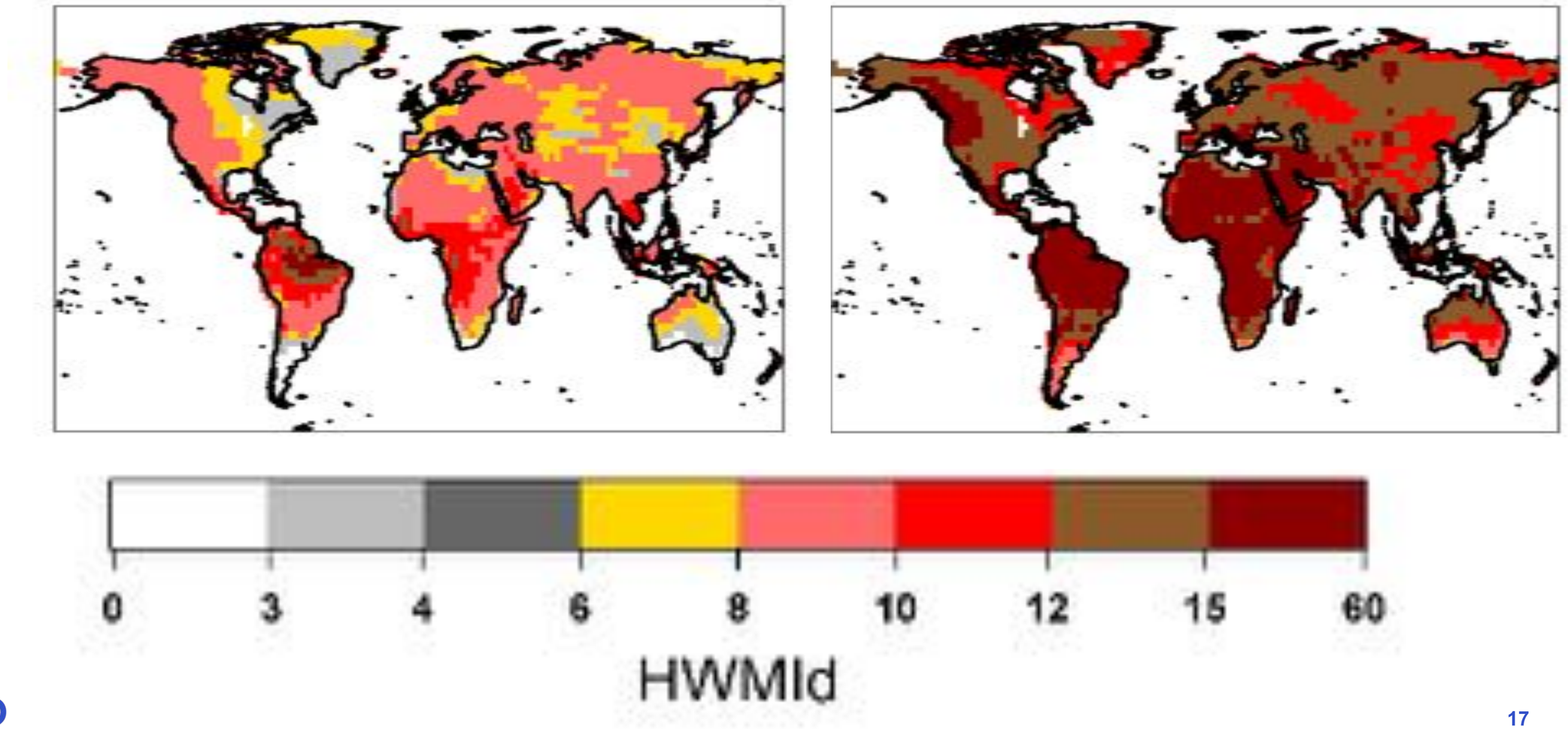
Blocking is a suitable covariate for HW



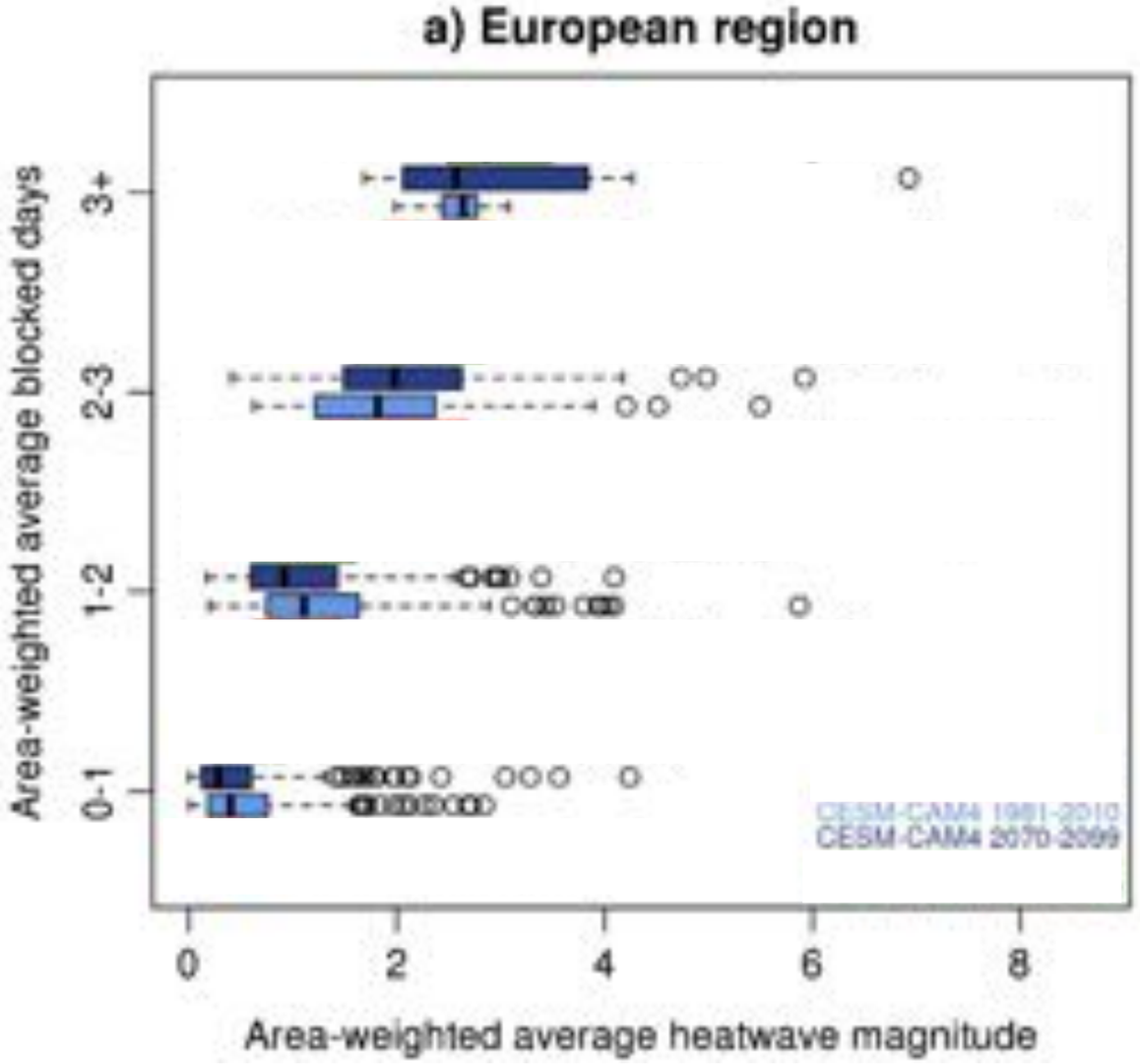
Heatwaves are becoming much more intense

2031-2040 (RCP8.5)

2091-2100 (RCP8.5)



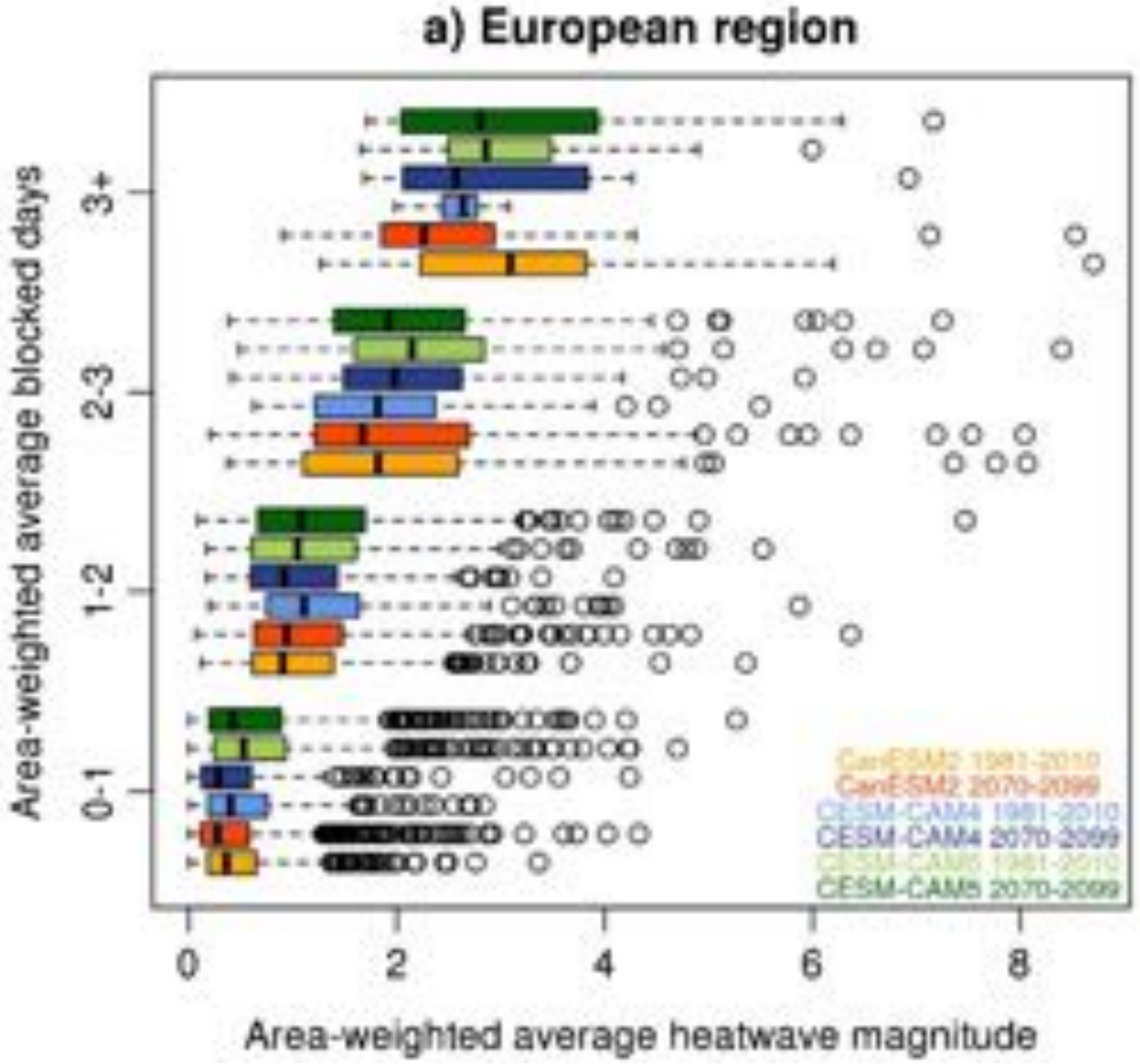
Future: Same blocking, same relative HW



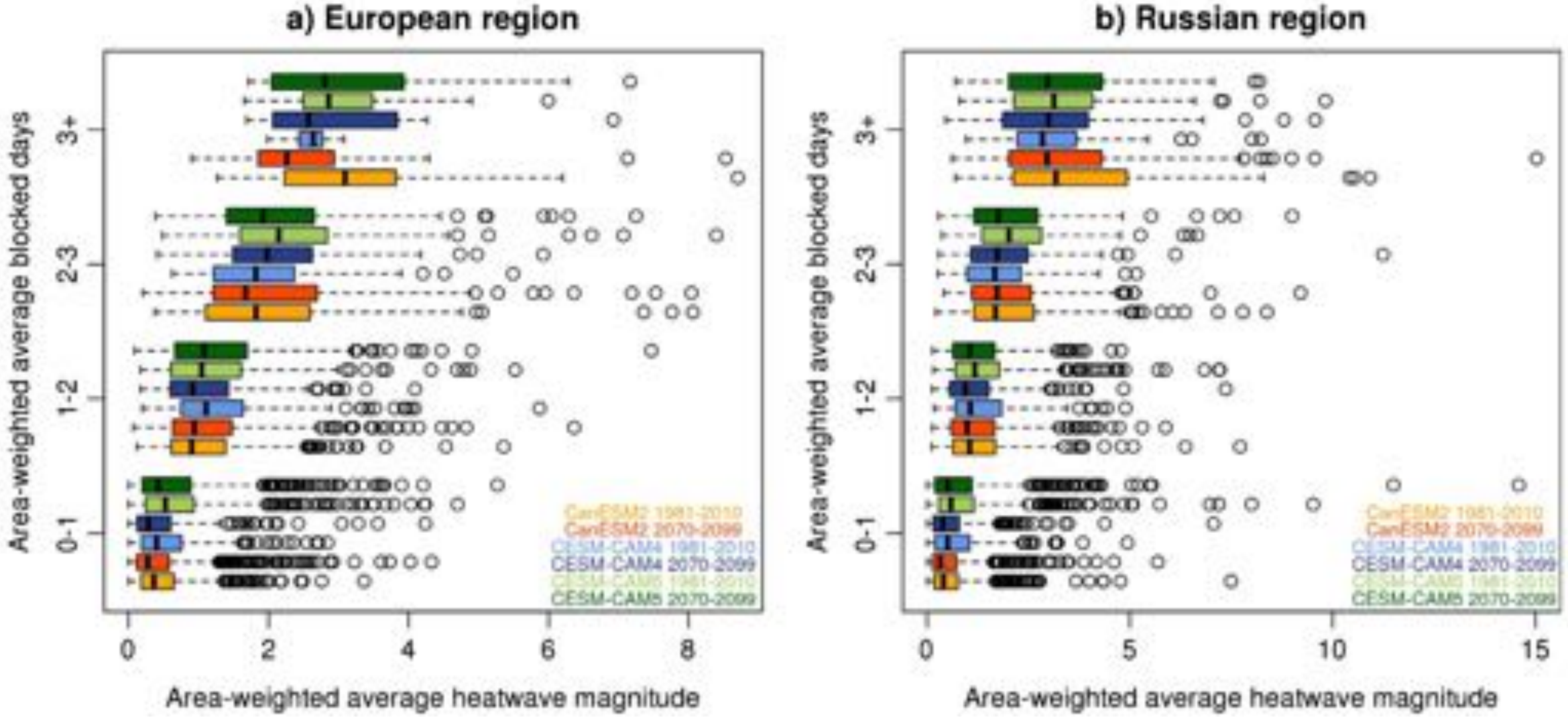
Future HWs are defined wrt future climatology.

Absolute HW magnitude increases strongly

No robust dynamic contribution to HW change



Thermodynamics can explain HW change

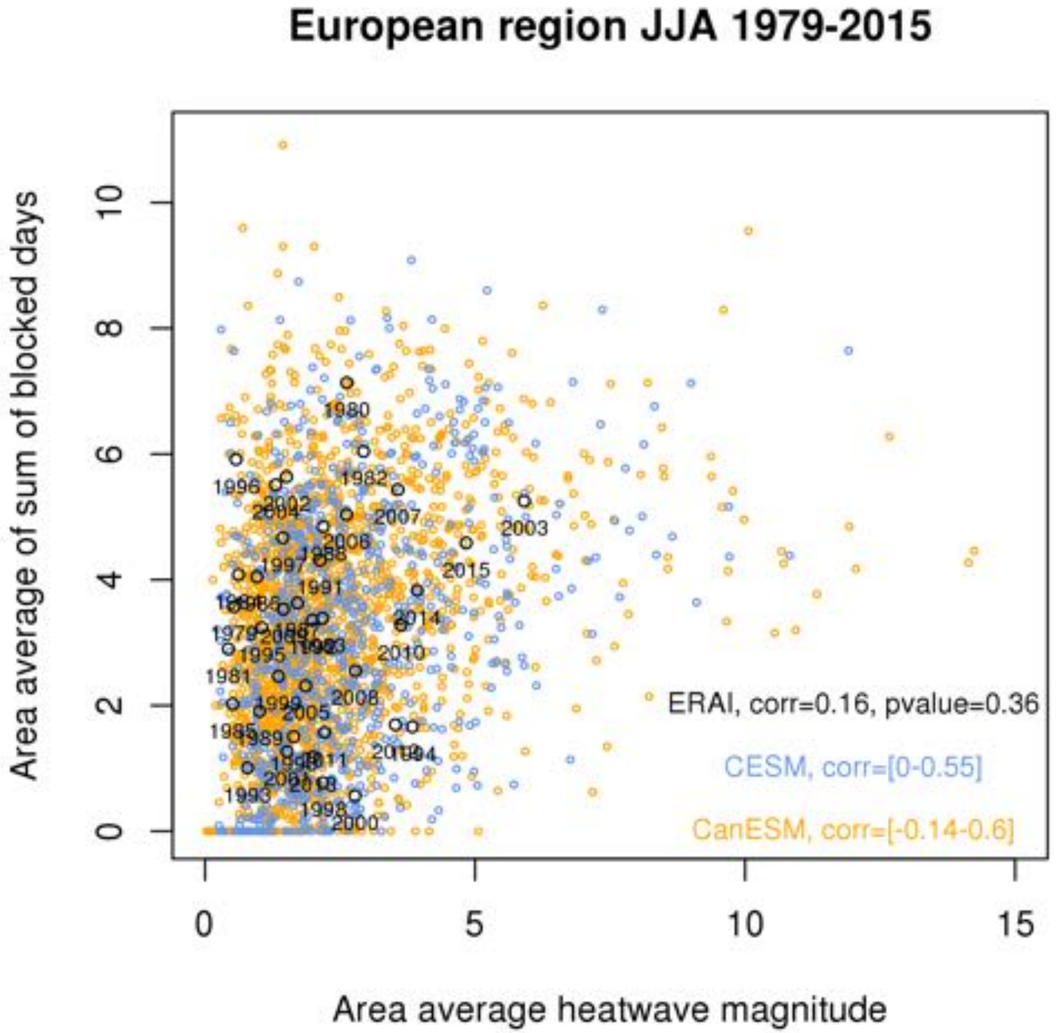


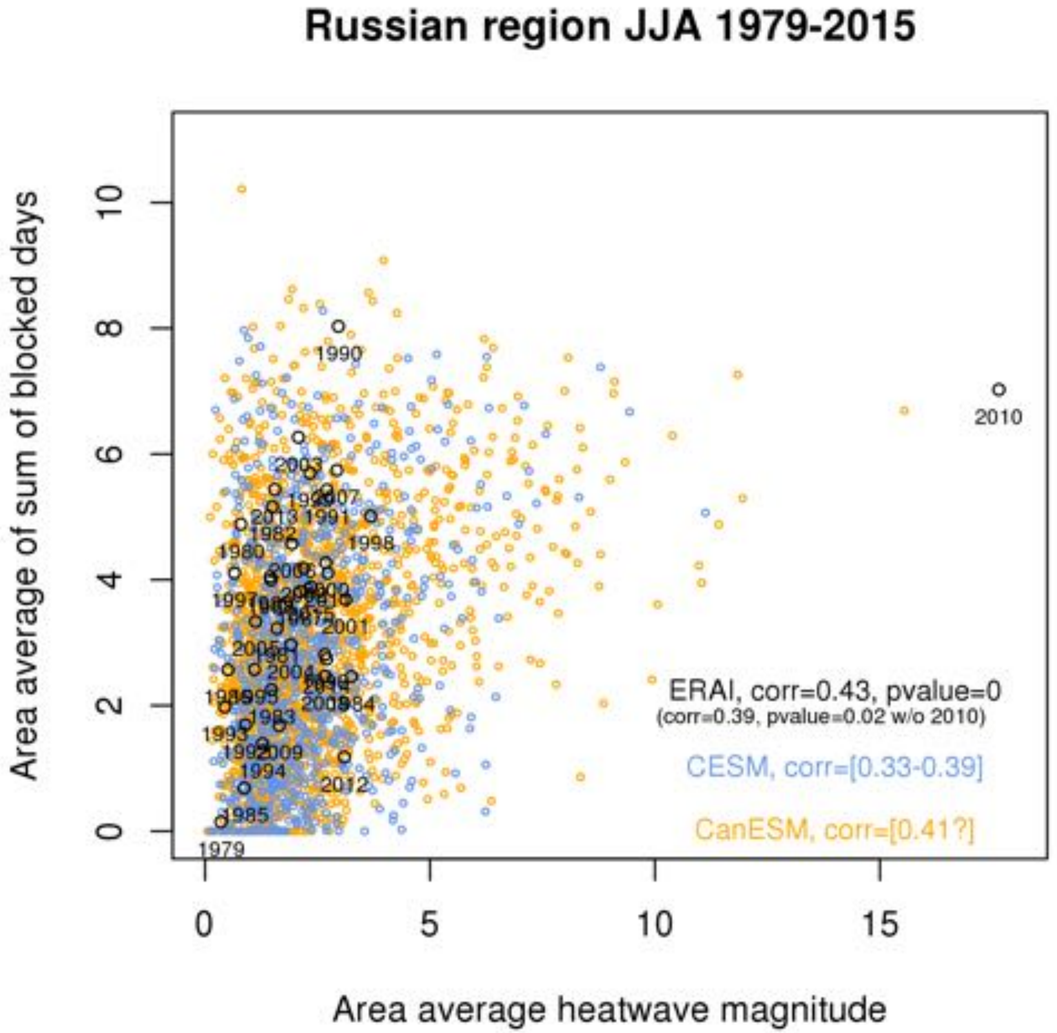
Conclusions

- 70% of strong heatwaves are associated with blocking
- Even if GCMs underestimate blocking frequency, they capture the relationship between blocking and heatwaves
- Relationship does not change in future hence blocking is a meaningful covariate in estimating the GEV parameters of summer heatwaves in Europe/Russia
- No indication dynamic contribtuion to future heatwave changes but for individual events, actual circulation pattern is a key player

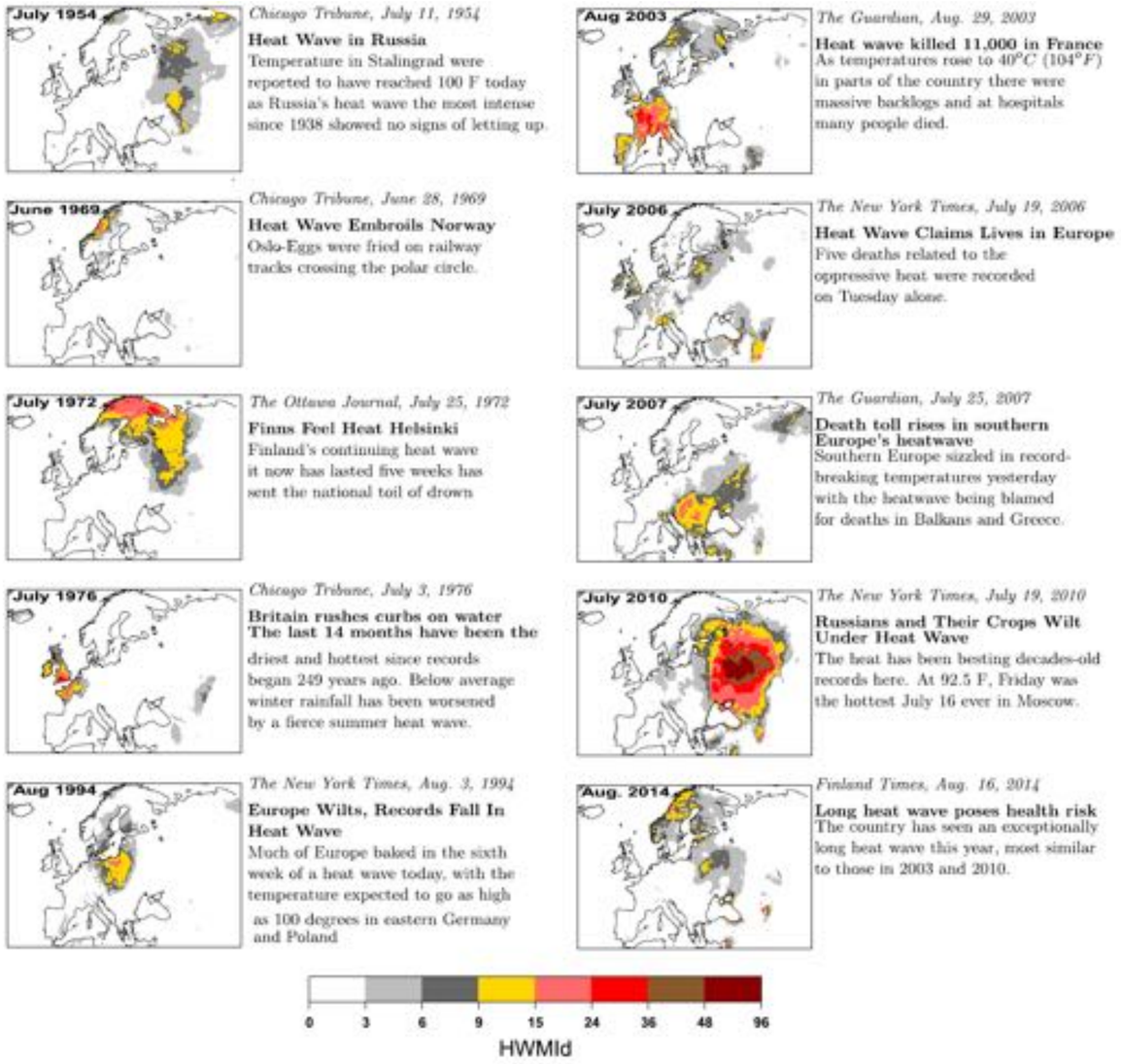
Reference: Schaller, N., Sillmann, J., Anstey, J., Fischer, E.M., Grams, C.M. and Russo, S (2018). *Environ. Res. Lett.*, 13(5)

Backup


European region JJA 1979-2015
Area average of sum of blocked days
Area average heatwave magnitude
ERAI, corr=0.16, pvalue=0.36
CESM, corr=[0-0.55]
CanESM, corr=[-0.14-0.6]


Russian region JJA 1979-2015
Area average of sum of blocked days
Area average heatwave magnitude
ERAI, corr=0.43, pvalue=0
(corr=0.39, pvalue=0.02 w/o 2010)
CESM, corr=[0.33-0.39]
CanESM, corr=[0.41?]

HWMId validation



Russo et al. (2015)