European temperature extremes in CMIP5: present-day biases and future uncertainties

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Introduction

Objectives

- European temperature extremes: understand model biases & uncertainties under future scenarios.
- Isolate respective roles of large-scale circulation, clouds, soil processes etc.

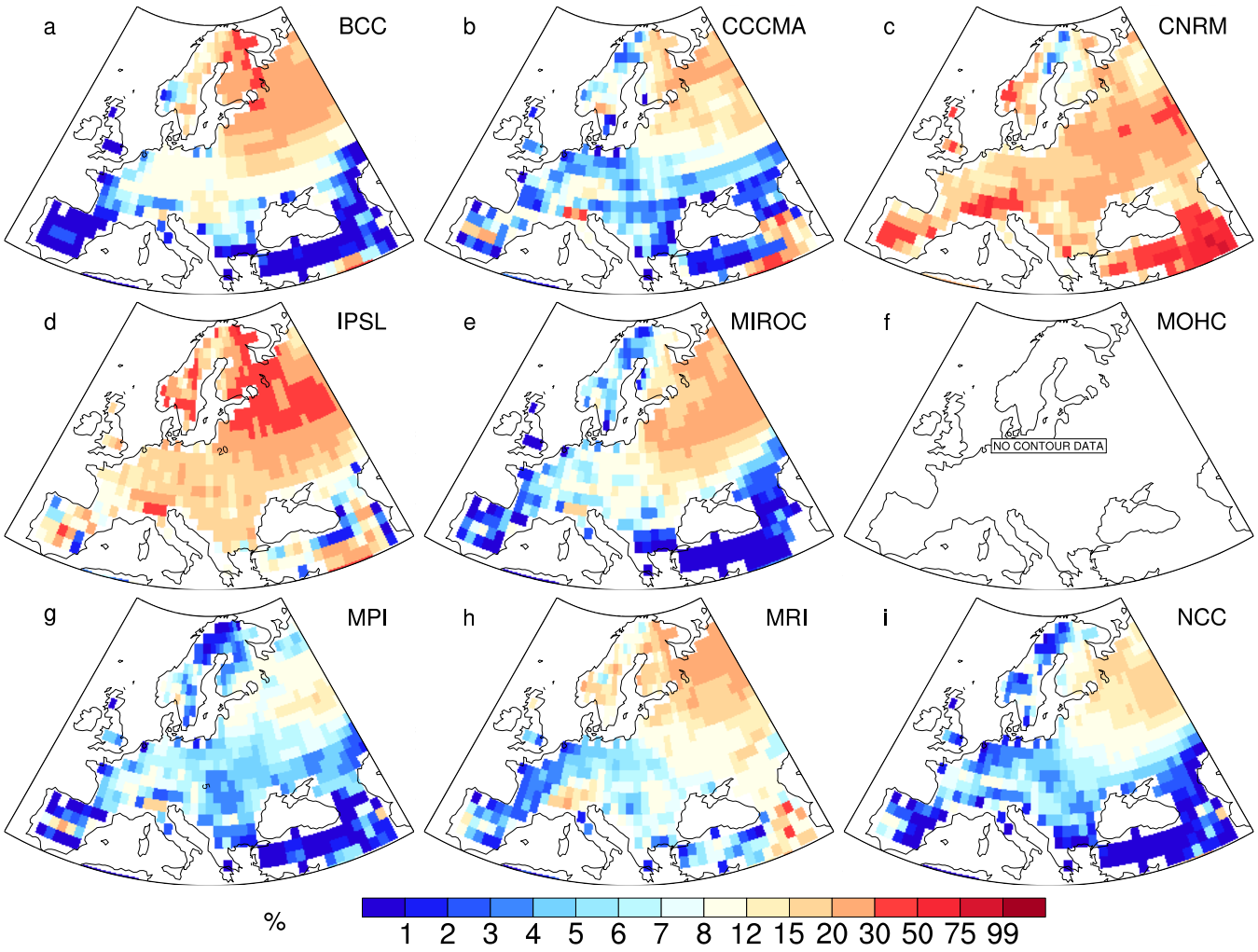
Data & Methods

- Original methodology to separate dynamical *vs.* non-dynamical contributions.
- Data: 9 GCMs of CMIP5/CFMIP2 (*amip*, *historical* and *rcp85*).

Present-day biases in temperature extremes

historical vs. E-OBS over 1979–2008

DJFM – Probability of $Tmin^{mod} \leq C10^{obs}$ (PC10)



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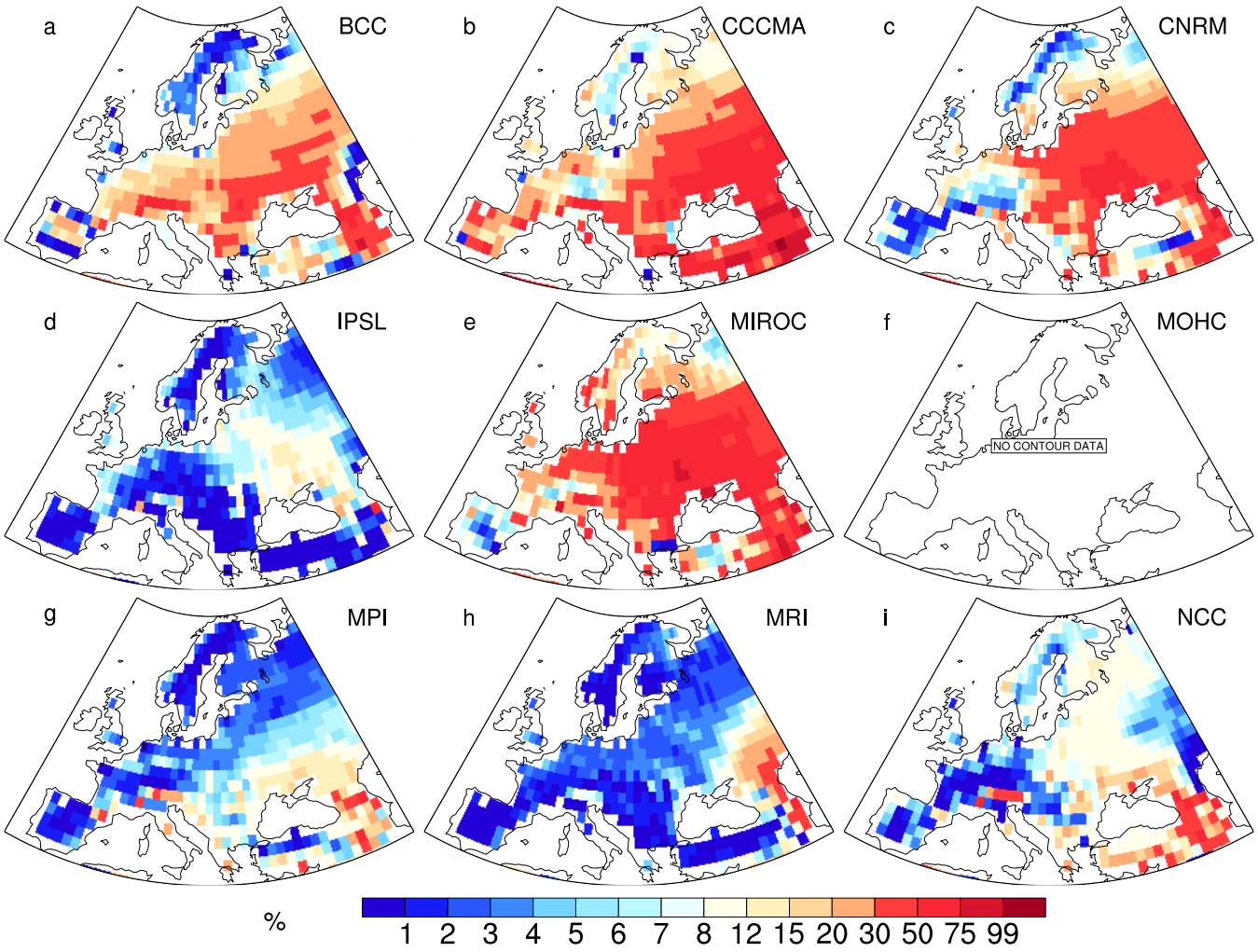
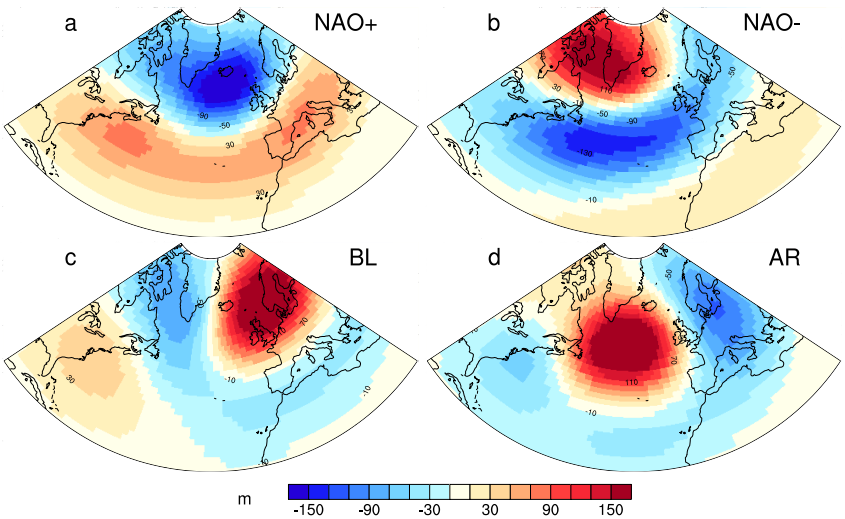


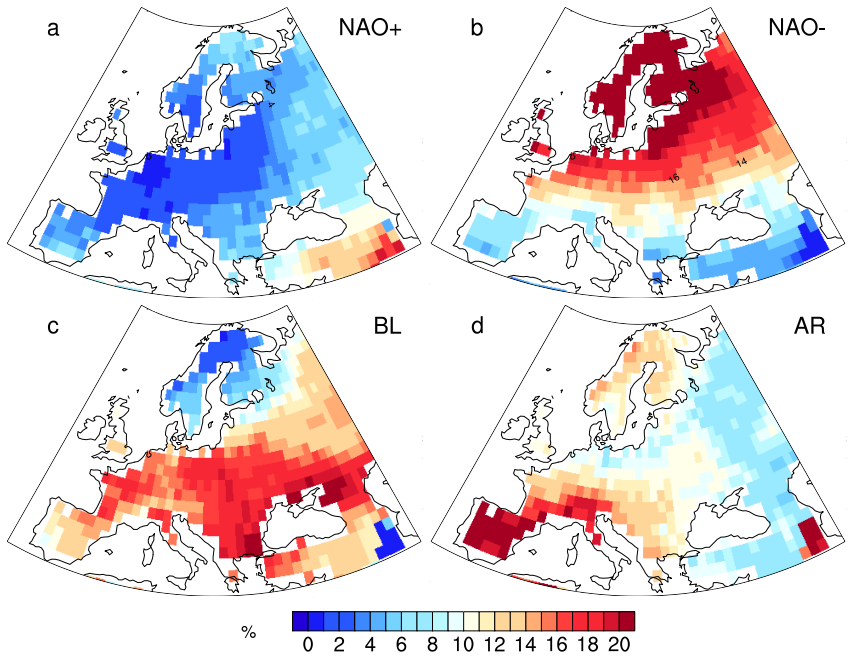
North-Atlantic weather regimes

- Clustering of daily *Z500* anomalies (*k-means*, 4 classes).
- Temperatures well discriminated among the regimes.

Z500 (NCEP2) – DJFM



PC10 (E-OBS) – DJFM



- $\forall k \quad x_k = \Phi(d_k) \implies \overline{X} = \sum_k f_k \cdot \Phi(d_k)$

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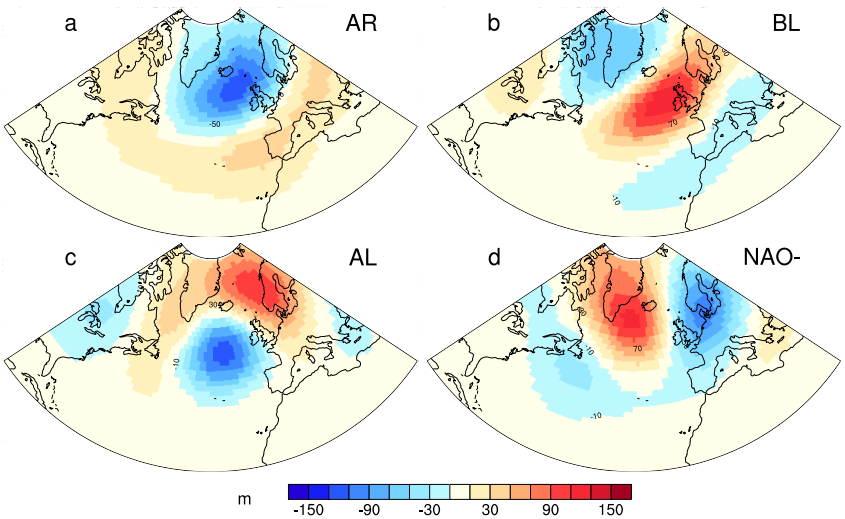
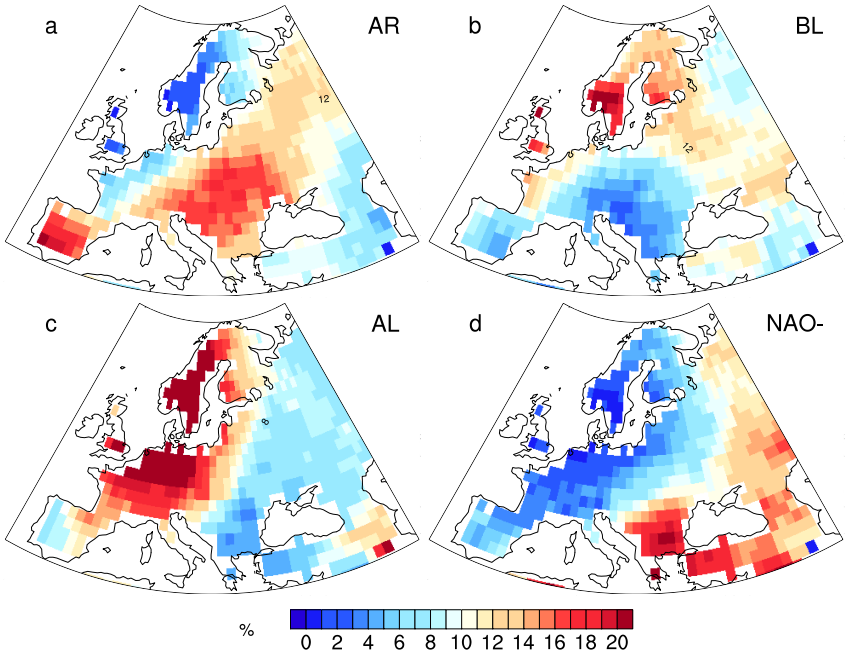


PC90 (E-OBS) – JJAS



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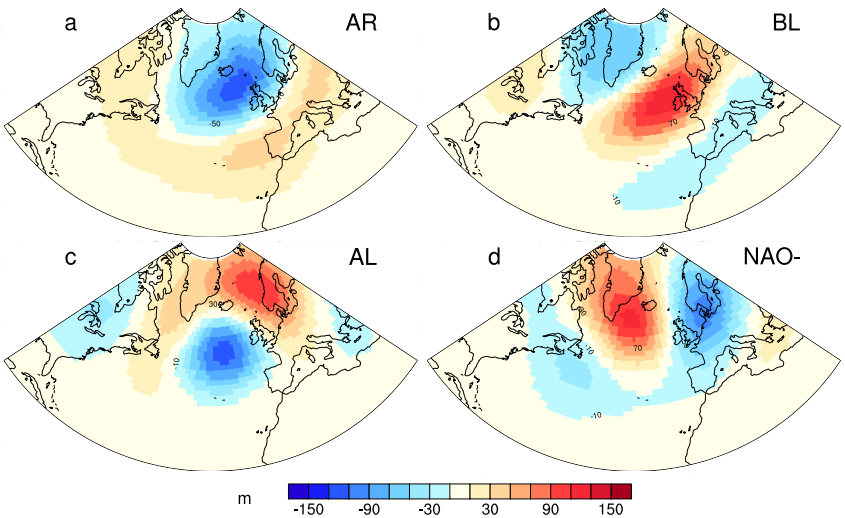
d_k $(k \in 1..4)$



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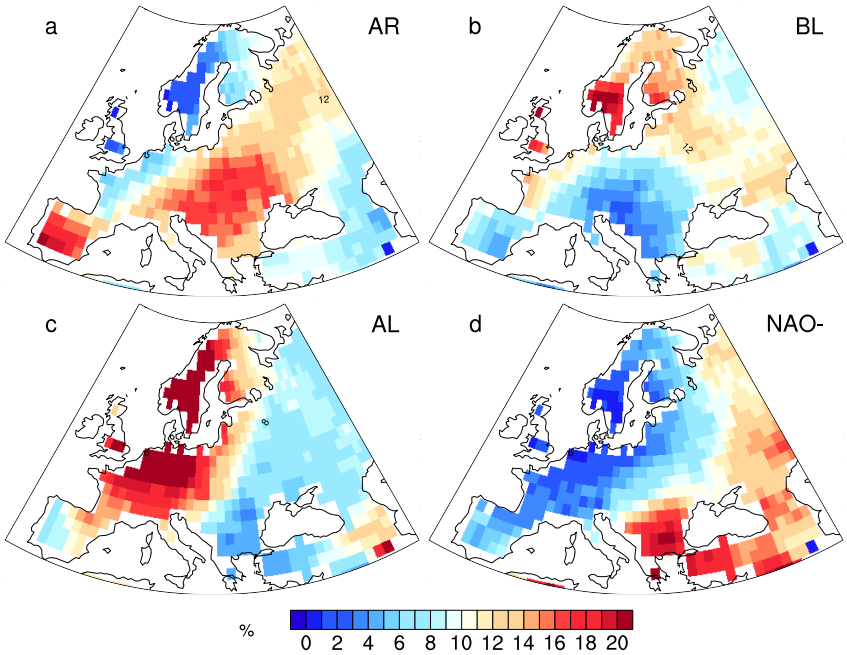

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Evaluating dynamical contributions

Recall $\overline{X} = \sum_k f_k \cdot \Phi(d_k)$,

$$\Longrightarrow \Delta^{mod-obs}\overline{X} = \sum_k \Delta f_k \cdot \Phi(d_k) + \sum_k f_k \cdot \Phi(\Delta d_k) + \sum_k f_k \cdot \Delta\Phi(d_k) + \varepsilon$$

Δf_k Contribution of biases in regimes' frequencies.

Δd_k Contribution of biases in regimes' structures.

$\Delta\Phi$ Contribution of non-dynamical processes.

DJFM JJAS

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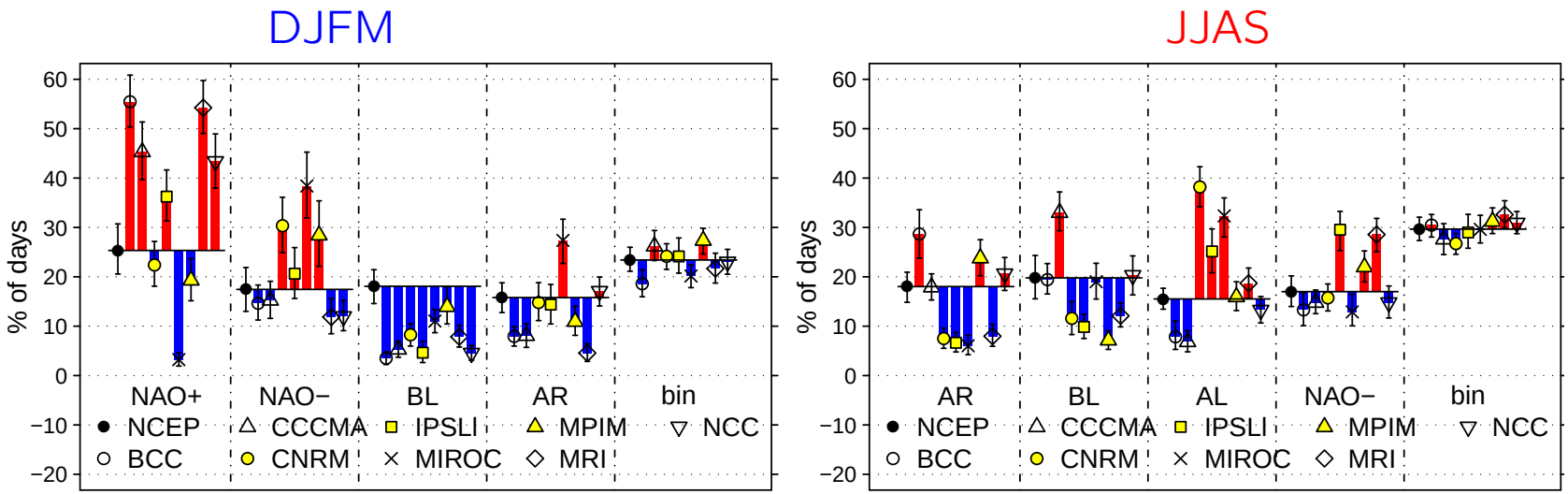

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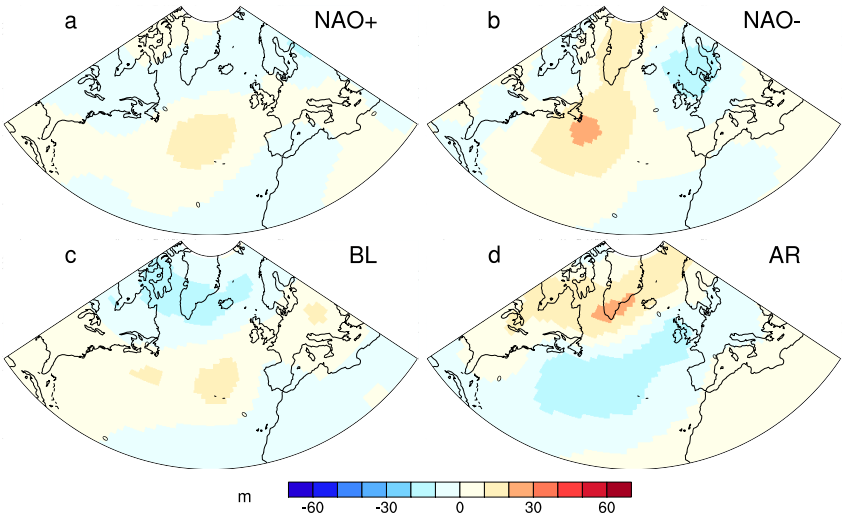

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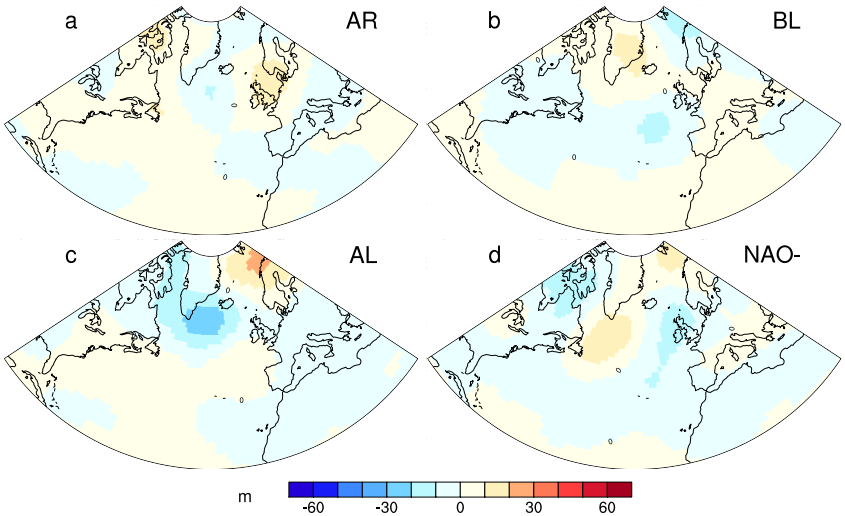

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Breakdown of biases in temps extremes

DJFM PC10 (Tmin)

Ensemble mean of each term in:

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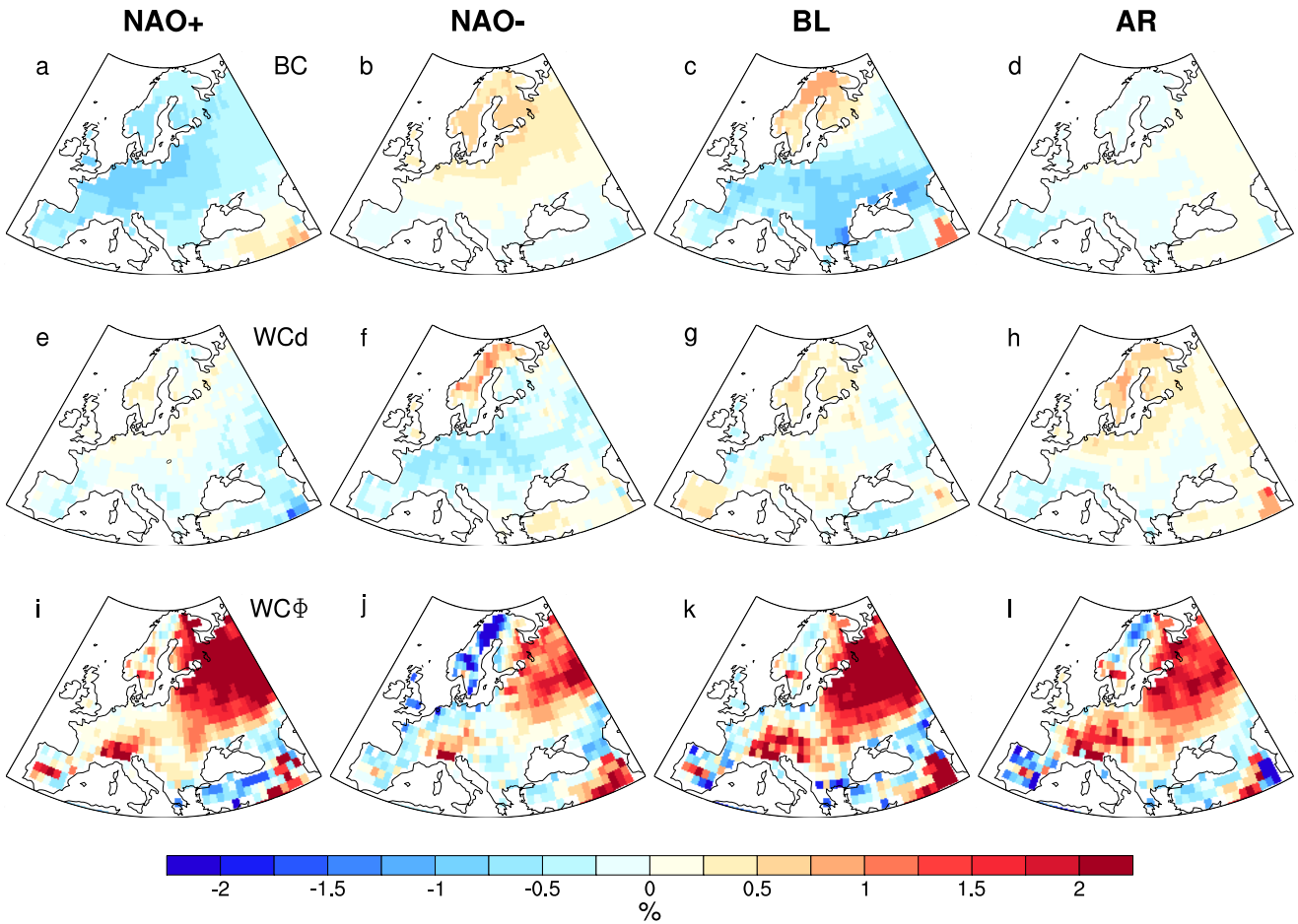
Regimes' frequencies (Δf_k)

Regimes' structures (Δd_k)

Non-dynamical processes ($\Delta\Phi$)



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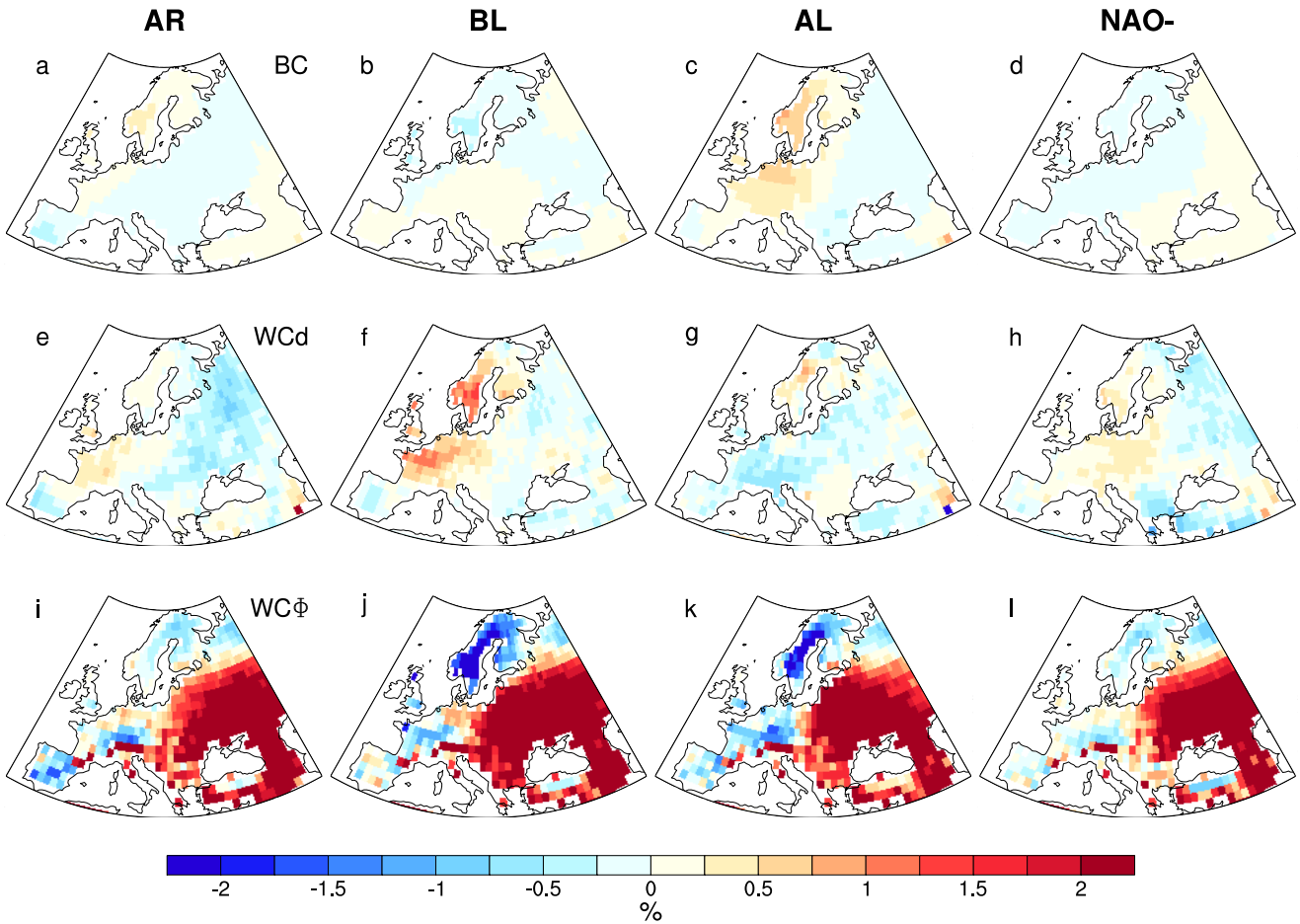


Half-time summary

What I did show

- Biases in temperature extremes dominated by biases in non-dynamical processes (especially summer).

What I did not show (today)

- Future changes in temperatures extremes (*rcp85* − *historical*) dominated by changes in non-dynamical processes.
- Biases/changes in regimes frequencies or structures can substantially contribute to the model dispersion (both present and future).

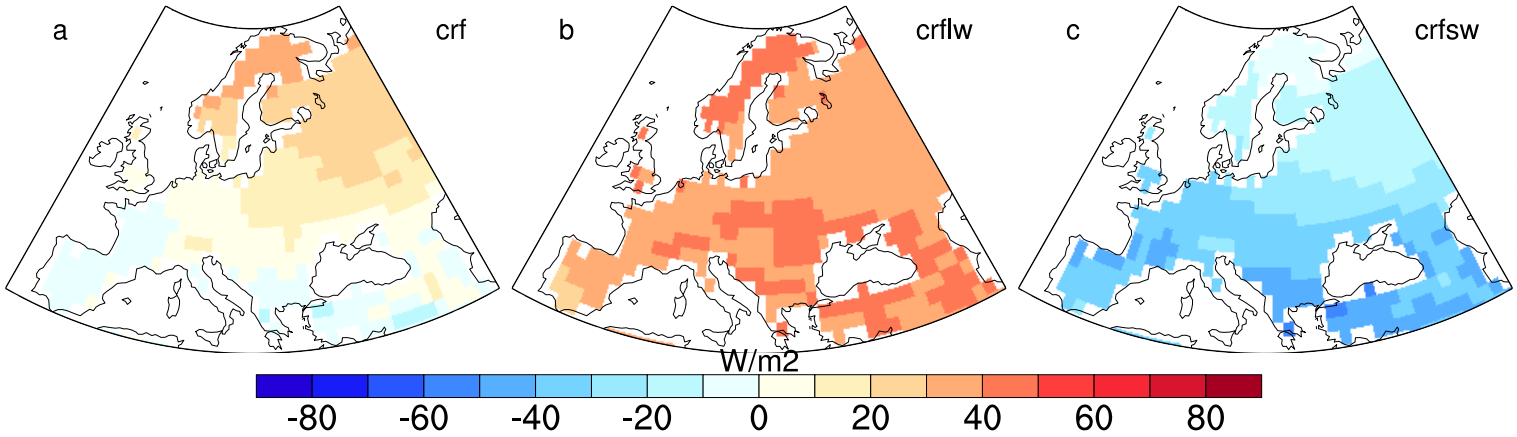
Now?

- Understanding non-dynamical processes.
- Isolating the contribution of clouds.

Cloud radiative forcing in observations

SRB data over 1984–2007

DJFM



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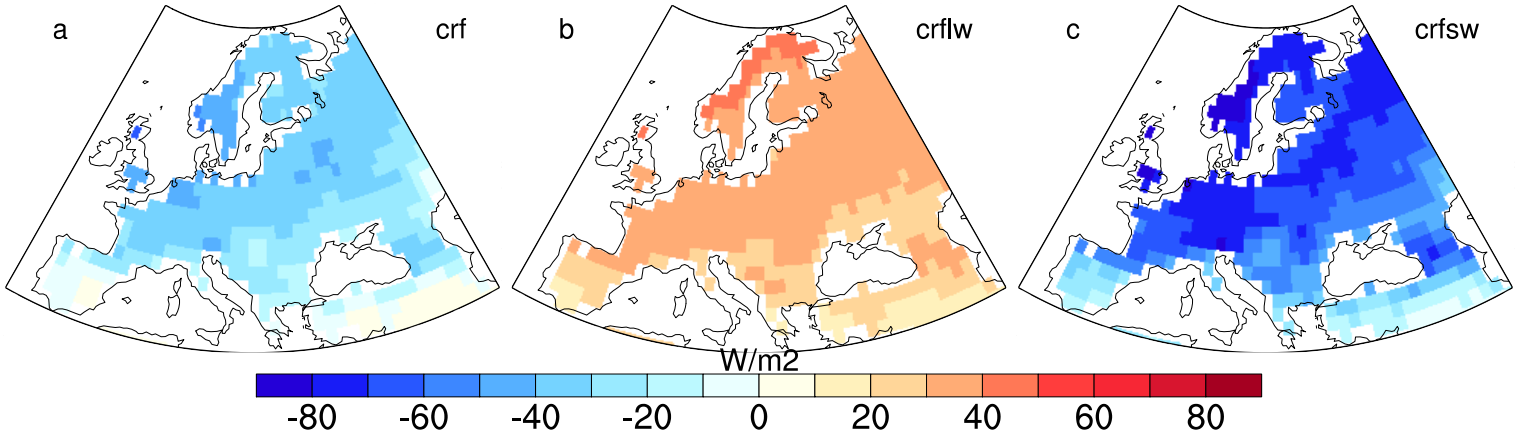


Clouds vs. temps: biases in *amip*

amip vs. SRB over 1984–2007

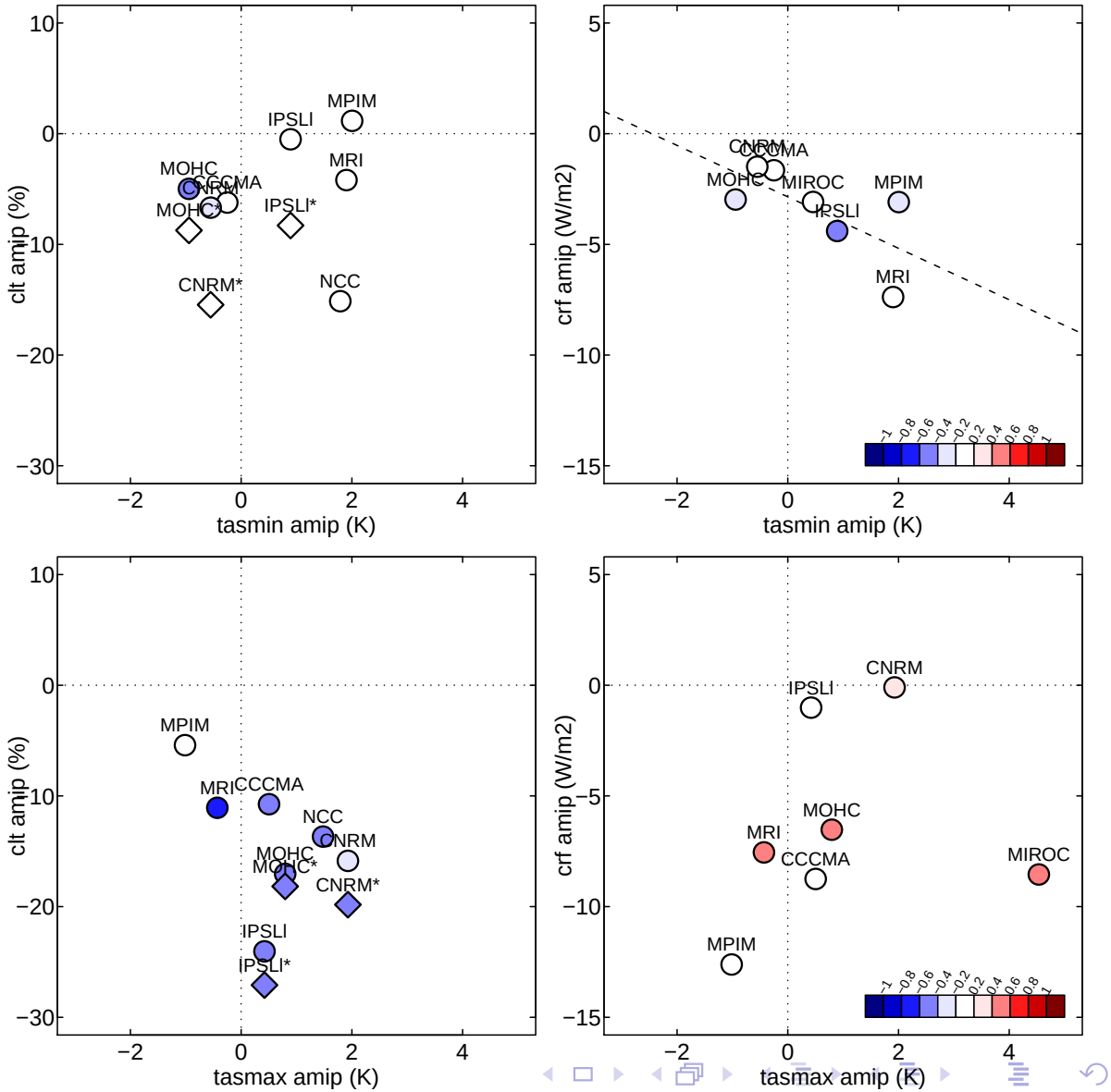
DJFM

Tmin vs. CC & CRF

- ○ *clt*
- ◇ *cltisccp*

JJAS

Tmax vs. CC & CRF



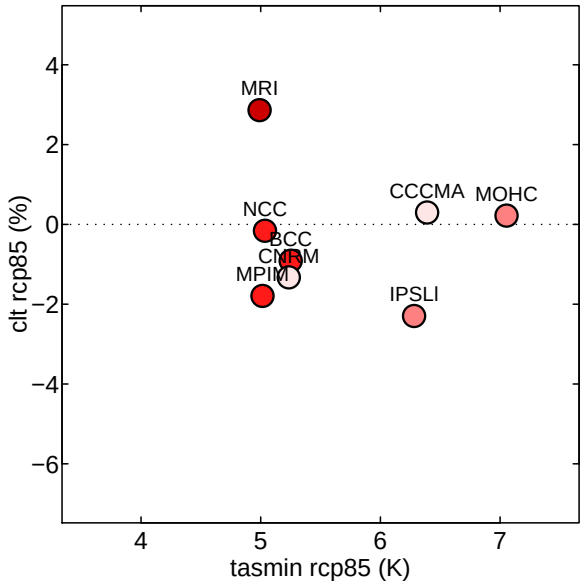
Clouds vs. temps: future changes under *rcp85*

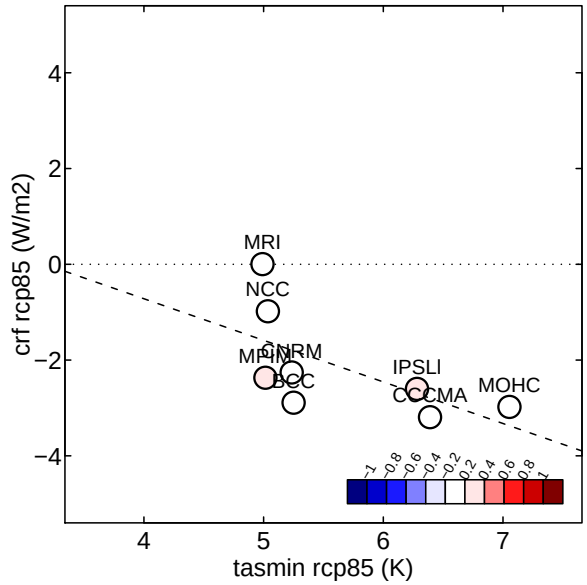
rcp85 over 2070–2099 vs. *historical* over 1979–2008

DJFM

Tmin vs. CC & CRF

- ○ *clt*
- ◇ *cltisccp*





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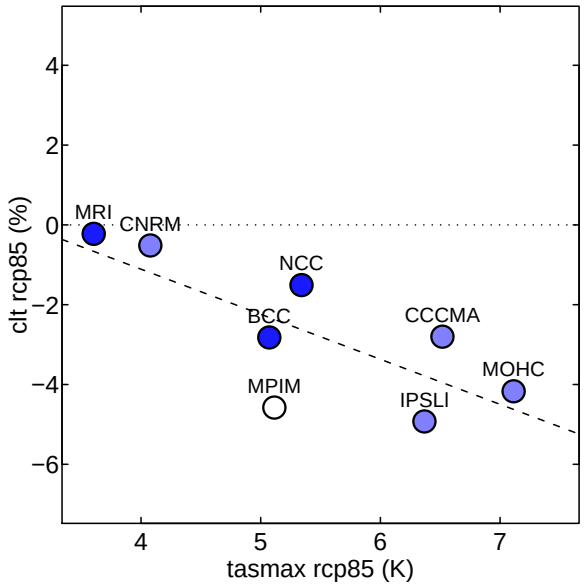

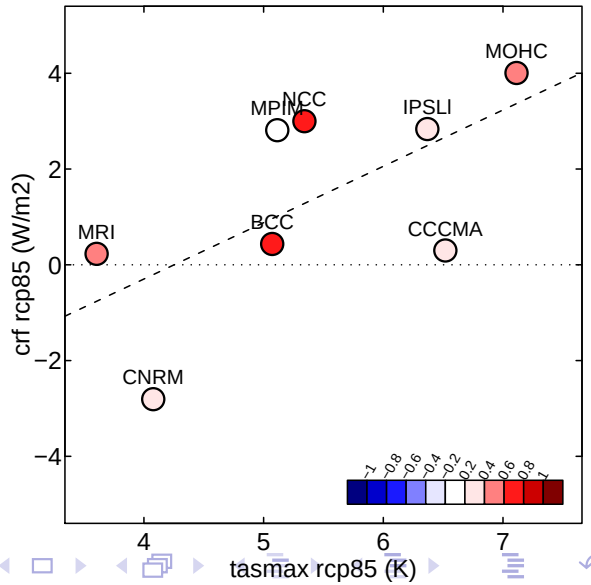

Concluding remarks

Summary

- Original methodology to separate dynamical *vs.* non-dynamical contributions to biases/changes.
- Dynamical contribution: minor on mean biases/changes, substantial on dispersion/uncertainties.
- Non-dynamical contribution: possibly linked to cloud processes in summer.

Work in progress...

- Refining the relationship between clouds and summer temperature extremes.
- Estimating contribution of soil processes (snow in winter, soil moisture in summer).
- Extend the methodology to other regions and/or variables (e.g., precipitations).

Thanks.

References

- Cattiaux, J., H. Douville, A. Ribes, F. Chauvin, and C. Plante (2012), Towards a better understanding of changes in wintertime cold extremes over Europe: A pilot study with CNRM and IPSL atmospheric models, *Climate Dynamics*, resubmitted.
- Cattiaux, J., H. Douville, Y. Peings, and A. Ribes, European temperature extremes in CMIP5: present-day biases, future uncertainties and relationship with large-scale circulation, *to be submitted to Climate Dynamics*.

Extremes vs. mean? *historical* vs. *amip*?

DJFM
PC10 & Tmin

JJAS
PC90 & Tmax