European temperatures in CMIP5: origins of present-day biases and future uncertainties

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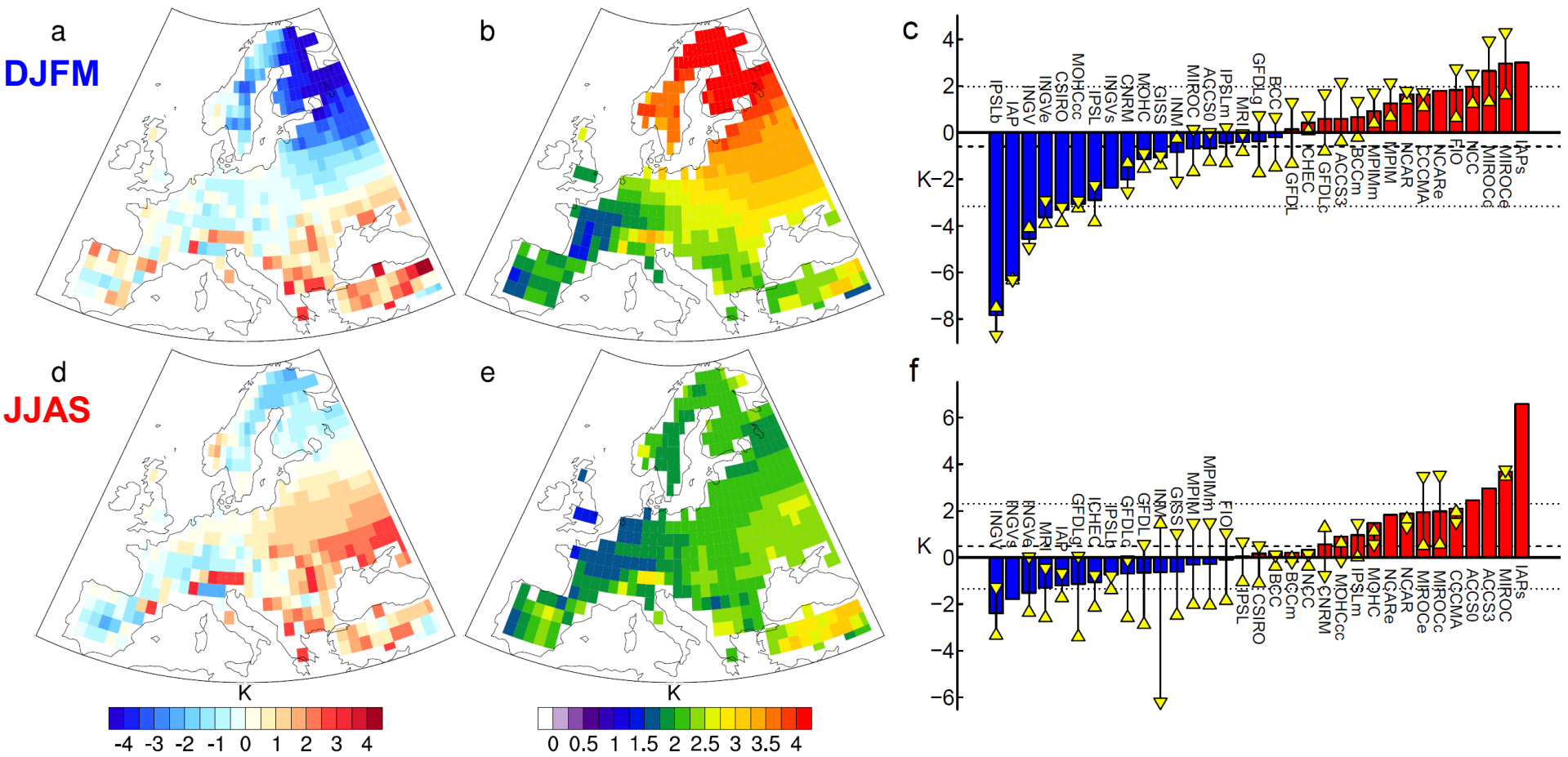
12th IMSC — June 24, 2013

Motivations

- ◇ Skill of CMIP5 GCMs at simulating European temperatures?
- ◇ Future changes under RCP 8.5? Uncertainties?
- ◇ Links between biases and sensitivity? Regional and global?
- ◇ Contribution of large-scale atmospheric dynamics?
- ◇ Other contributions (non-dynamical)?

⟶ 33 CMIP5 GCMs, *tas* (+ other variables);
⟶ Biases: HIST vs. E-OBS (1979–2008);
⟶ Changes: R85 (2070–2099) vs. HIST (1979–2008);
⟶ Seasonal approach: DJFM & JJAS.

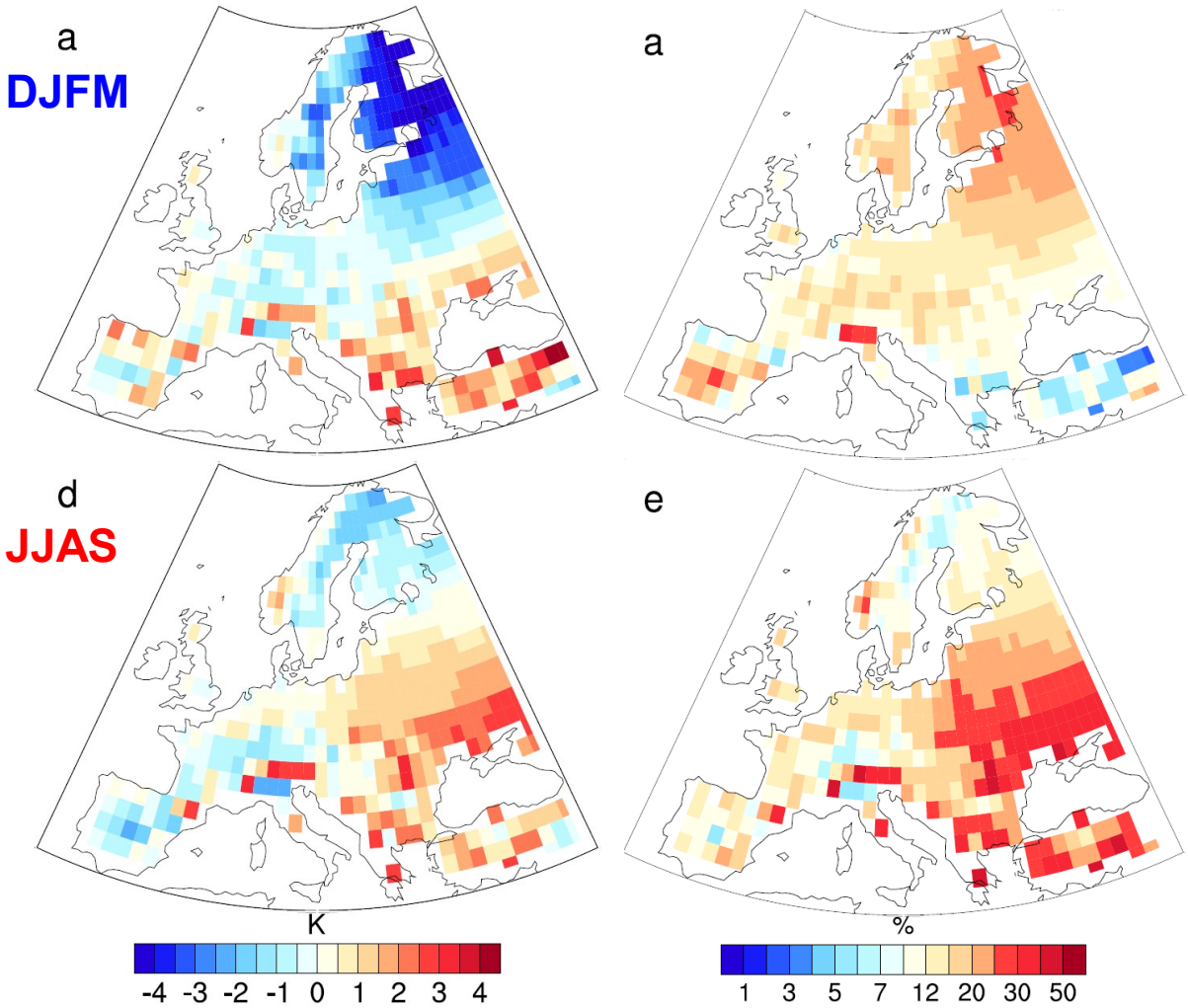
Ensemble mean and spread



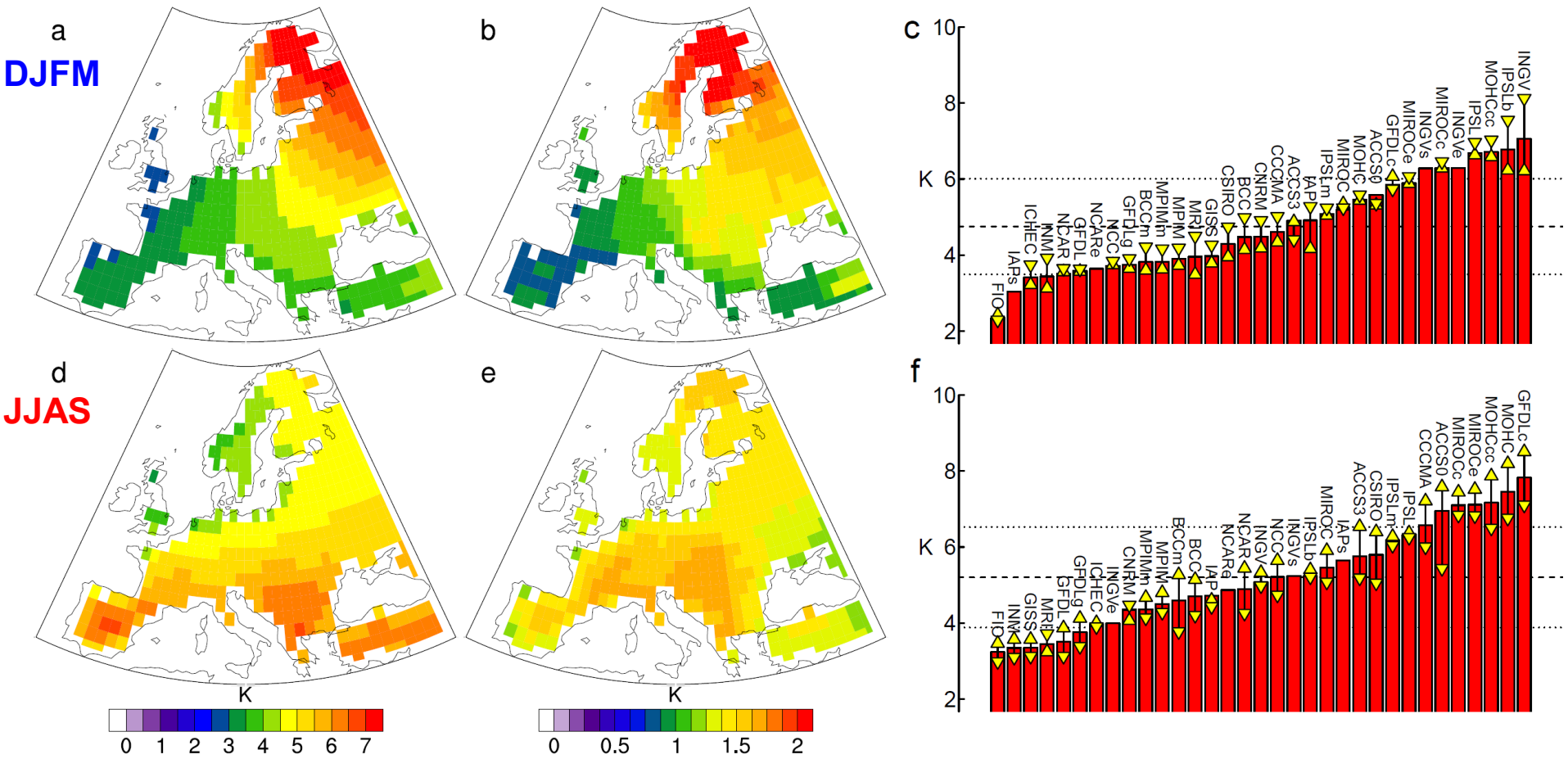
HIST vs. E-OBS (1979–2008).

Extremes vs. mean

- Percentage of cold/hot days wrt. 10^{th}/90^{th} EOBS percentiles.
- Extremes scale on mean biases at the first order.



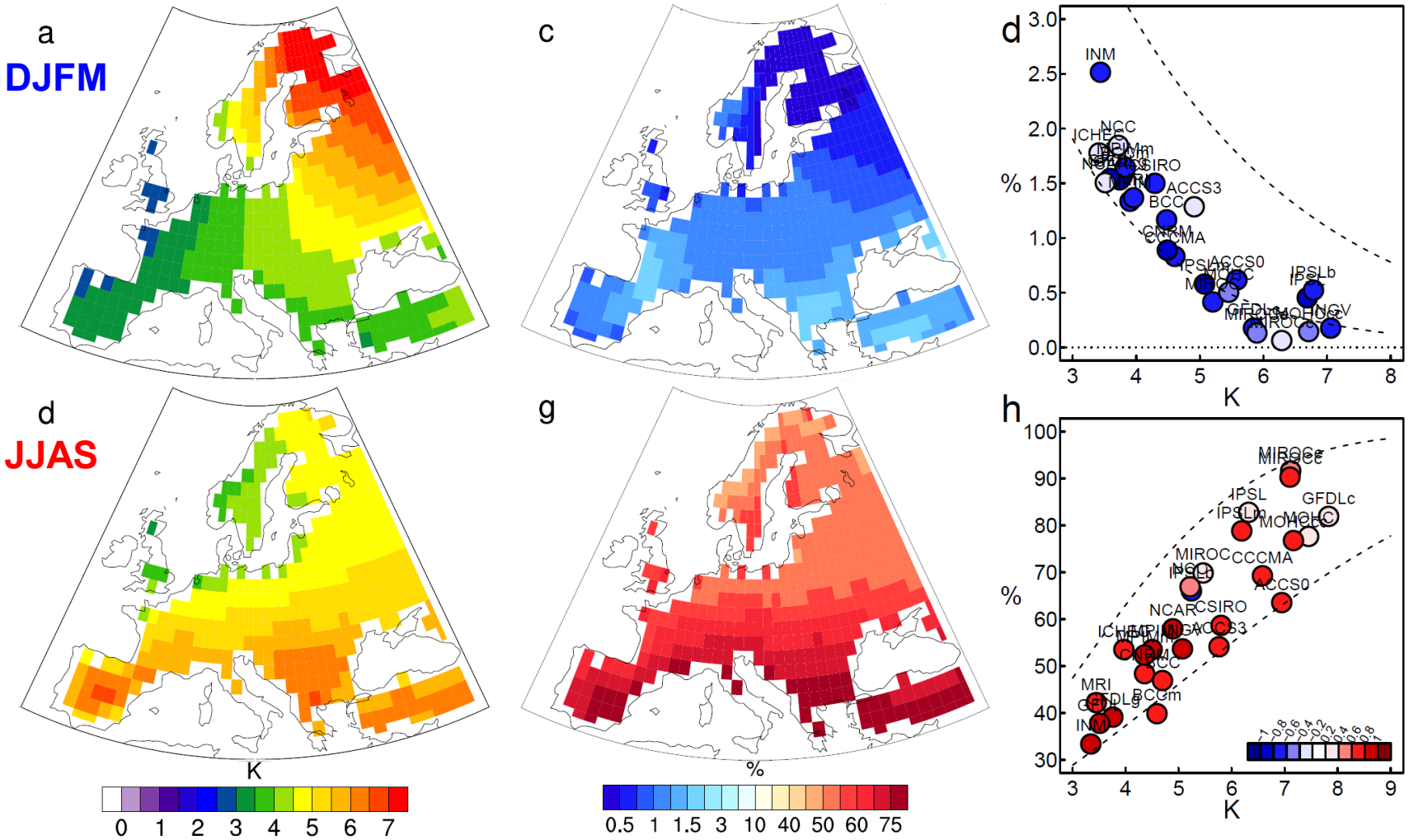
Ensemble mean and spread



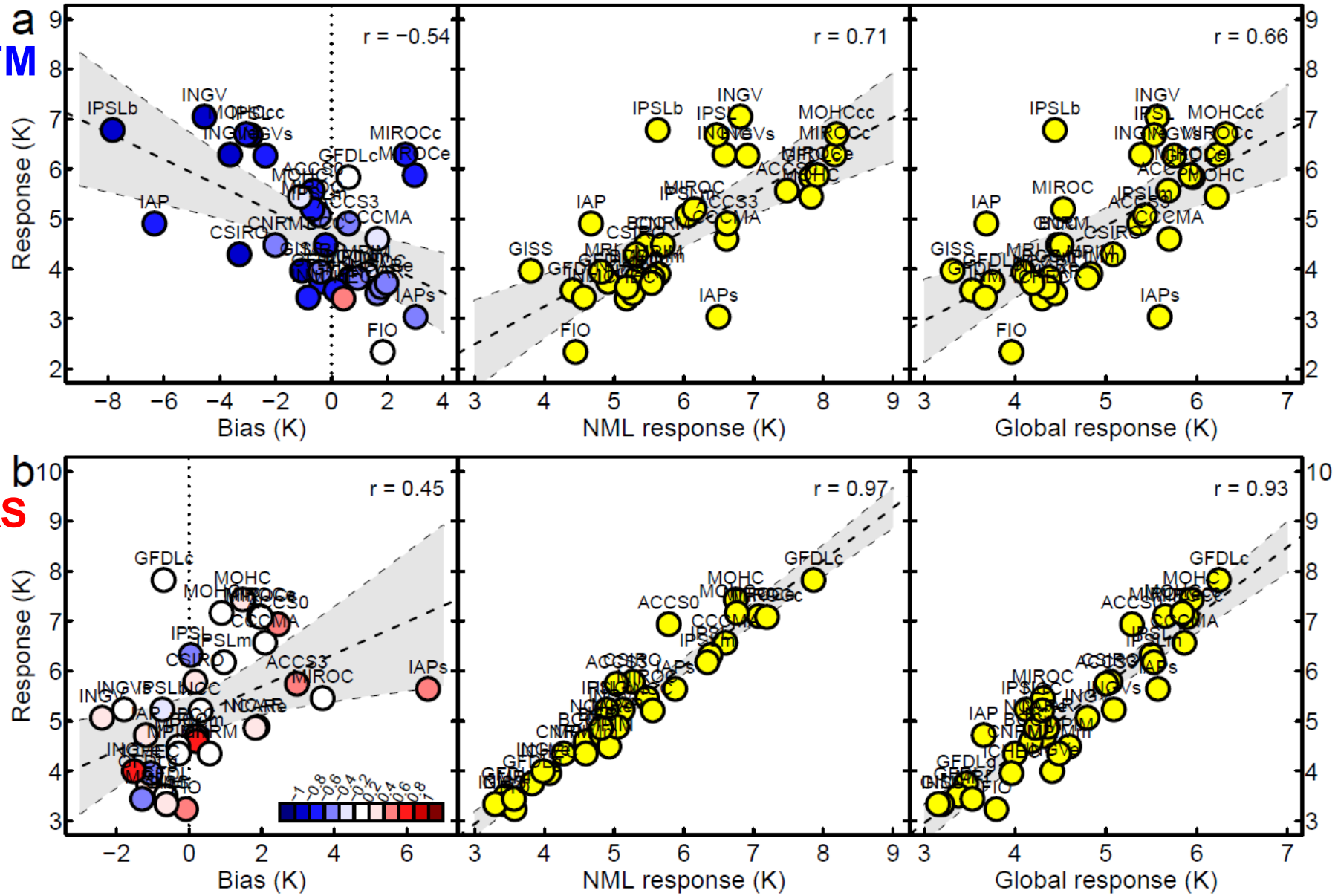
R85 (2070–2099) vs. HIST (1979–2008).

Extremes vs. mean

- Percentage of cold/hot days wrt. 10^{th}/90^{th} HIST percentiles.
- Decrease (increase) of intra-seasonal variability in winter (summer).

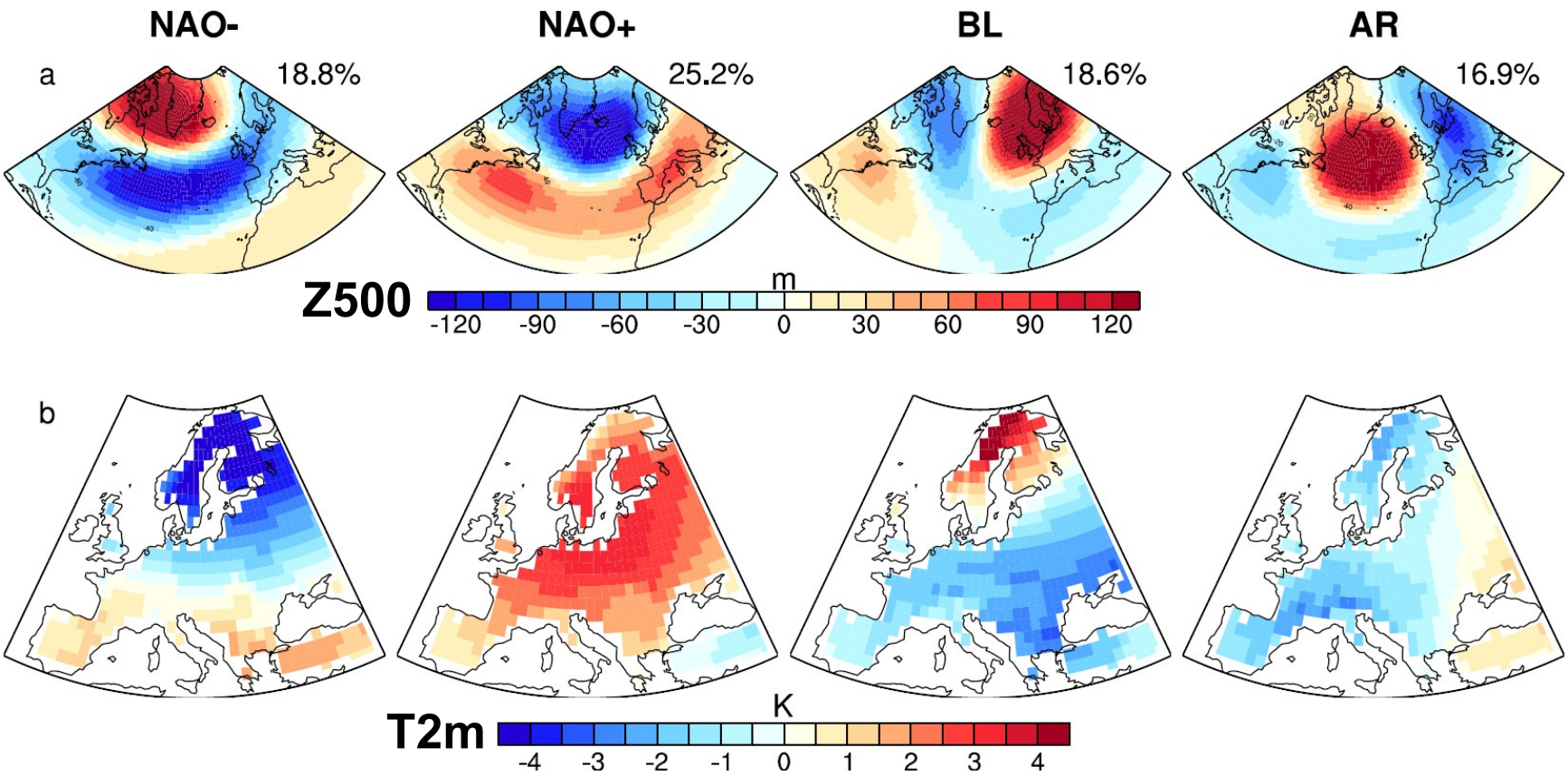


Biases vs. sensitivity? Regional vs. global?



Weather regimes

- Quasi-stationnary patterns, clustering of daily Z500 anomalies (*k-means*).
- Temperatures well discriminated, especially in winter (>50% of explained variance).
- $\overline{T} = \sum_k f_k \cdot t_k = \sum f_k \cdot \Phi(z_k)$.



Breakdown methodology

Recall $\overline{T} = \sum_k f_k \cdot \Phi(z_k)$,

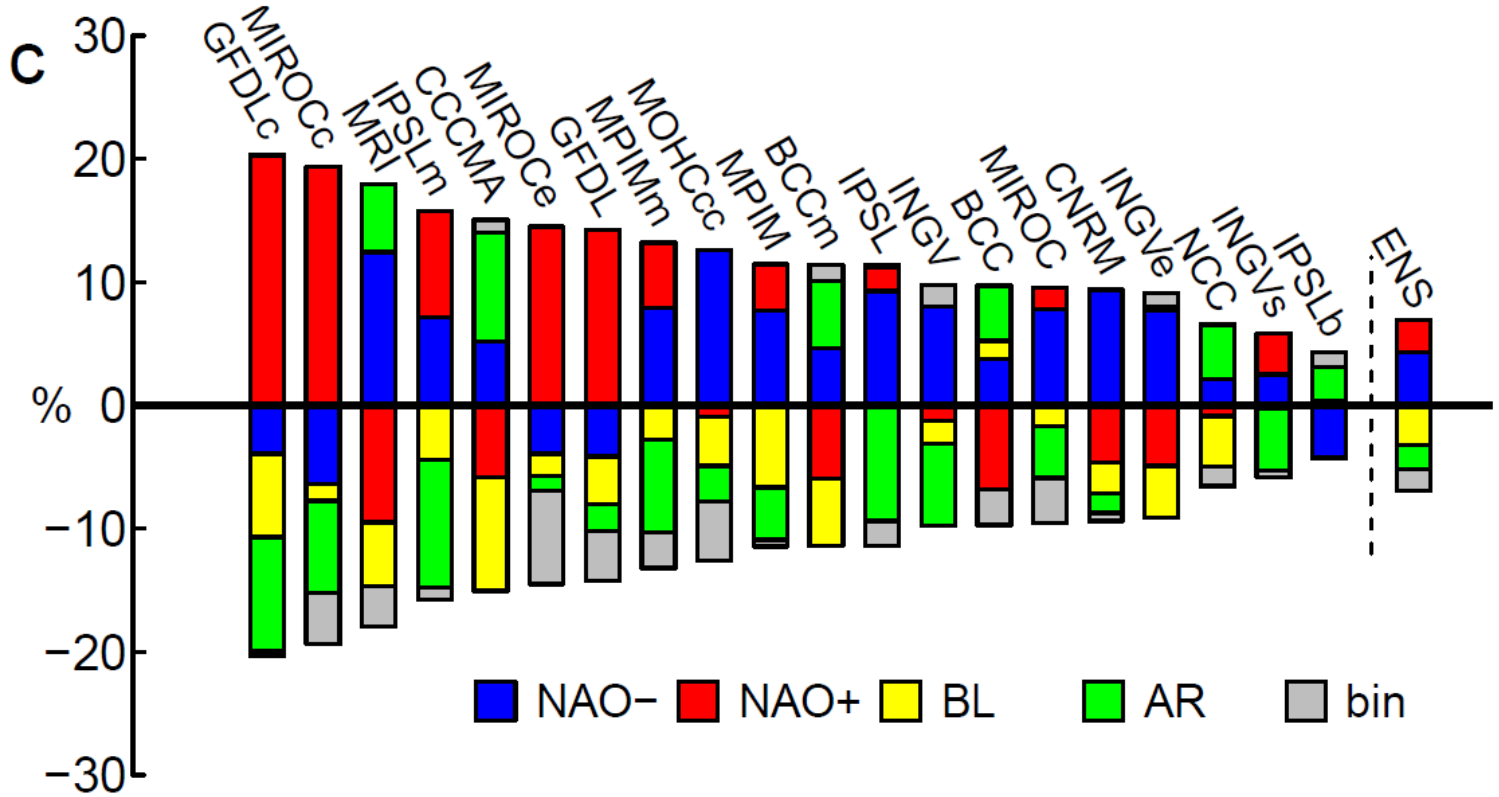
$$\Rightarrow \Delta^{R85-HIST}\ \overline{T} = \sum_k \Delta f_k \cdot \Phi(z_k) + \sum_k f_k \cdot \Phi(\Delta z_k) + \sum_k f_k \cdot \Delta\Phi(z_k) + \varepsilon$$

- Δf_k Contribution of changes in regimes' frequencies (BC).
- Δz_k Contribution of changes in regimes' structures (WCd).
- $\Delta\Phi$ Contribution of non-dynamical processes (WCΦ).
- ε Residual (second-order terms).

Cattiaux et al. (2013), Clim Dyn, Special Issue on CNRM & IPSL models.

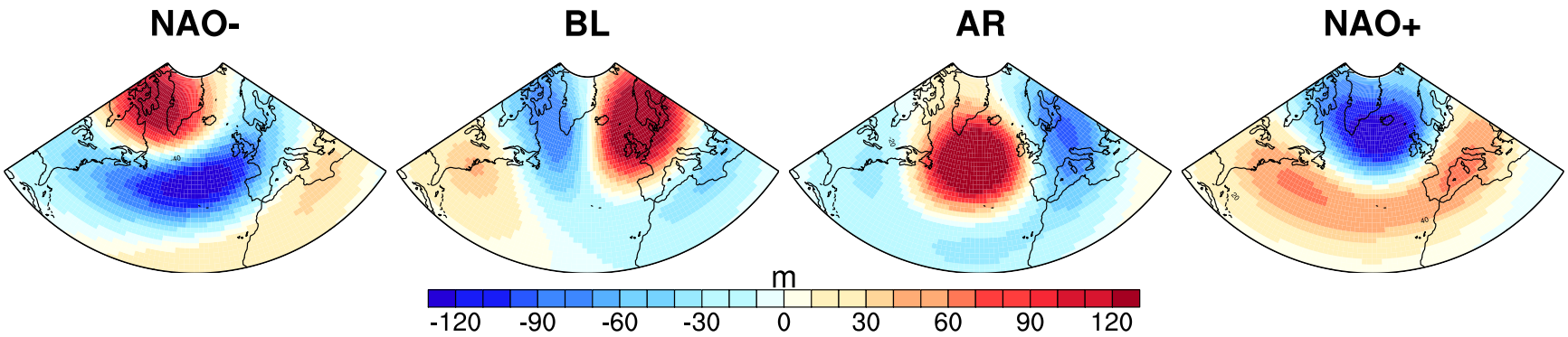
Changes in frequencies (f_k)

- General increase in NAO− frequency (see previous talk).
- General decrease in other regimes, except NAO+ in GFDL and MIROC models.

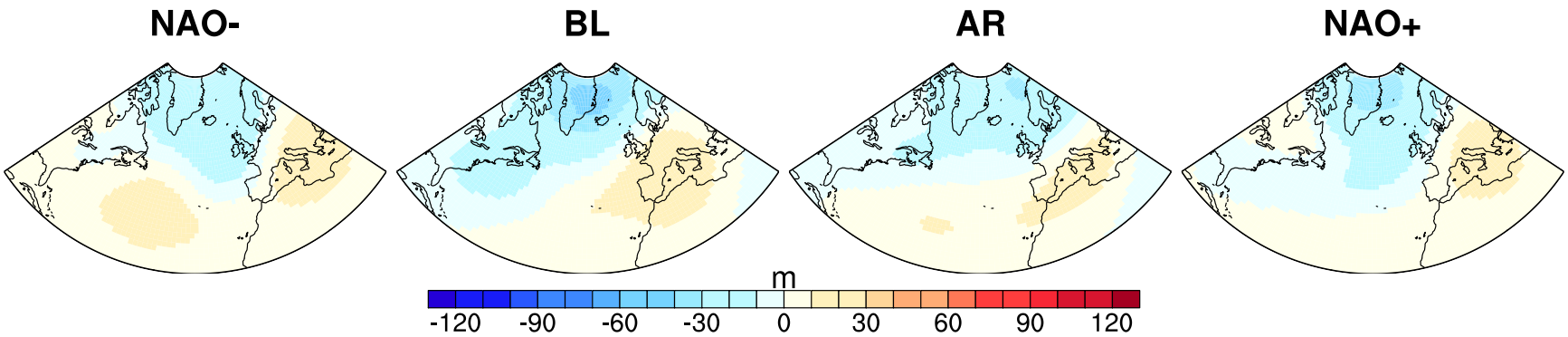


Changes in structures (z_k)

Ensemble-mean HIST

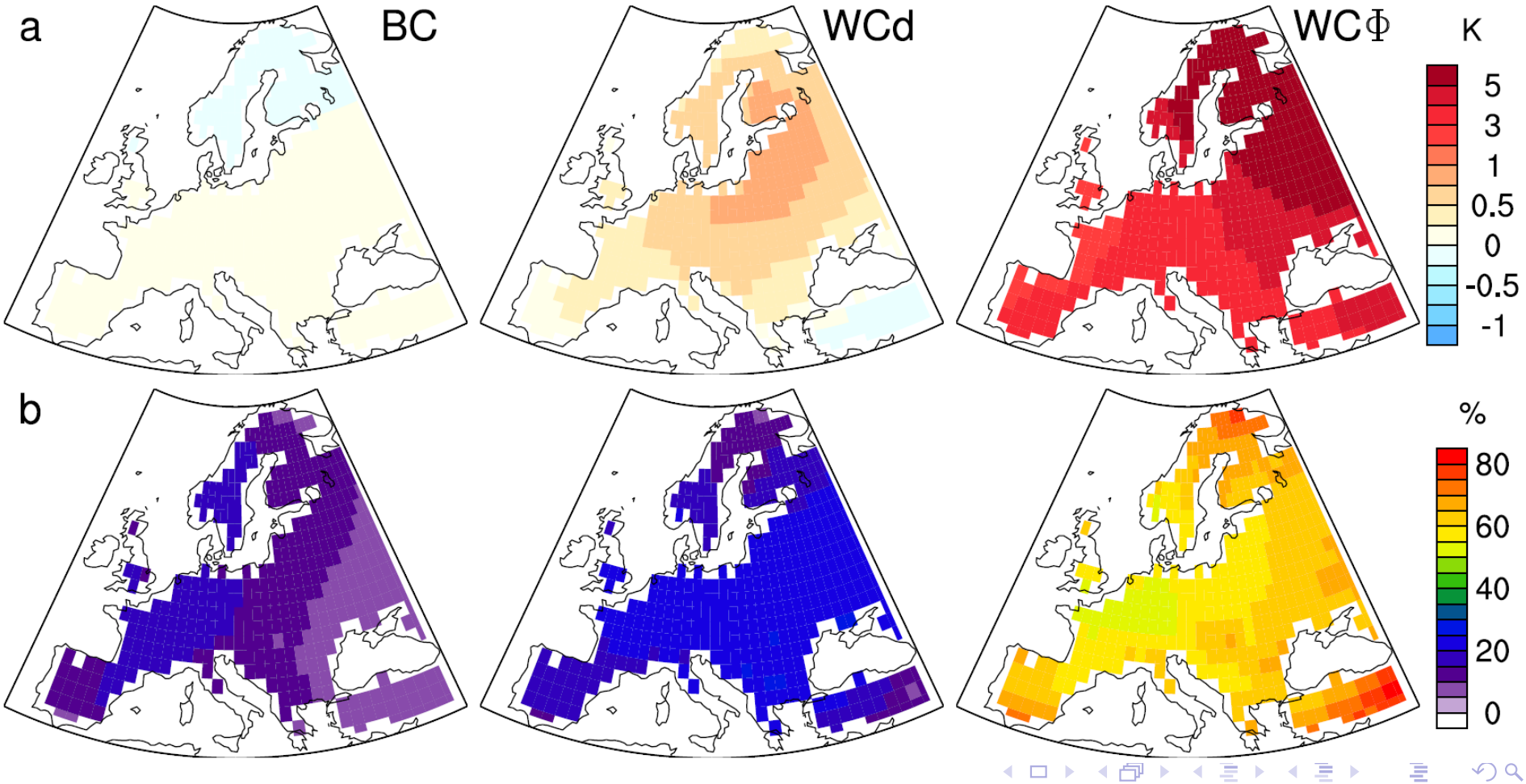


Ensemble-mean R85−HIST difference

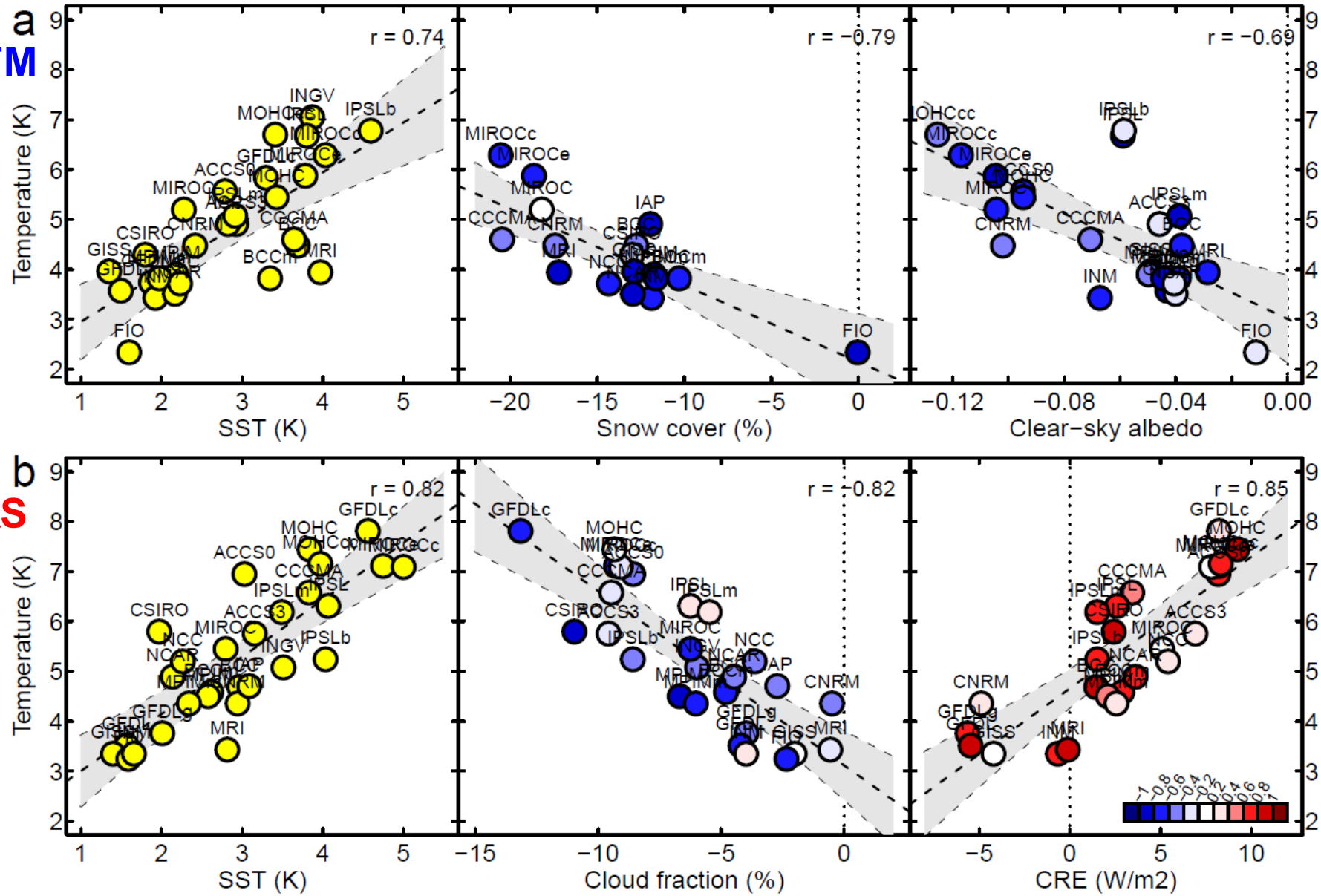


Breakdown of mean and spread

- Projected warming dominated by non-dynamical processes.
- Dynamics contribute up to 50% to the warming spread.



Non-dynamical contributors



Conclusions

- ✓ No major change since CMIP3 in simulating European temperatures;
- ✓ Extremes mostly scale on mean, but decrease (increase) in winter (summer) variability;
- ✓ Link between biases and sensitivities in winter (snow cover?);
- ✓ Future warming dominated by non-dynamical processes (also in summer);
- ✓ Dynamics contribute up to 50% to the warming spread (40% in summer);
- ✓ Other contributors include Atlantic SST, snow cover (winter) and clouds (summer).

$\longrightarrow$ Further analysis of non-dynamical contributors?
$\longrightarrow$ Application to other variables (eg. precipitation)?

Cattiaux, J., H. Douville and Y. Peings (2013), European temperatures in CMIP5: origins of present-day biases and future uncertainties, *Clim. Dyn.*, in press. doi:10.1007/s00382-013-1731-y.