Projected increase in diurnal and inter-diurnal variations of European summer temperatures

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Previously in European summer temperature variability

- Evidences for increase at intra-seasonal and/or inter-annual time scales:
  - in recent observations – Parey et al. 2010, Schär et al. 2004, Yiou et al. 2009;
  - in regional climate projections – Fischer and Schär 2009, Kjellström et al. 2007;
  - in CMIP3 global climate projections – Cattiaux et al. 2011.
- Suggested physical mechanisms:
  - soil-atmosphere processes associated with the European summer drying;
  - changes in the atmospheric circulation;
  - ...
- Some key challenges:
  - identify all drivers and quantify their contributions;
  - understand the model discrepancies in future projections;
  - investigate observational constraints to reduce future uncertainties.

What we did

- Focus on day-to-day and within-day variations (E3P project):
  - Inter-diurnal temperature variability:

$$\mathrm{ITV} = \frac{1}{n_d - 1} \sum_{d=1}^{n_d - 1} |\mathrm{ITD}_d| = \frac{1}{n_d - 1} \sum_{d=1}^{n_d - 1} |T_{d+1} - T_d|$$

  - Diurnal temperature range:

$$\mathrm{DTR}_d = T_d^x - T_d^n.$$

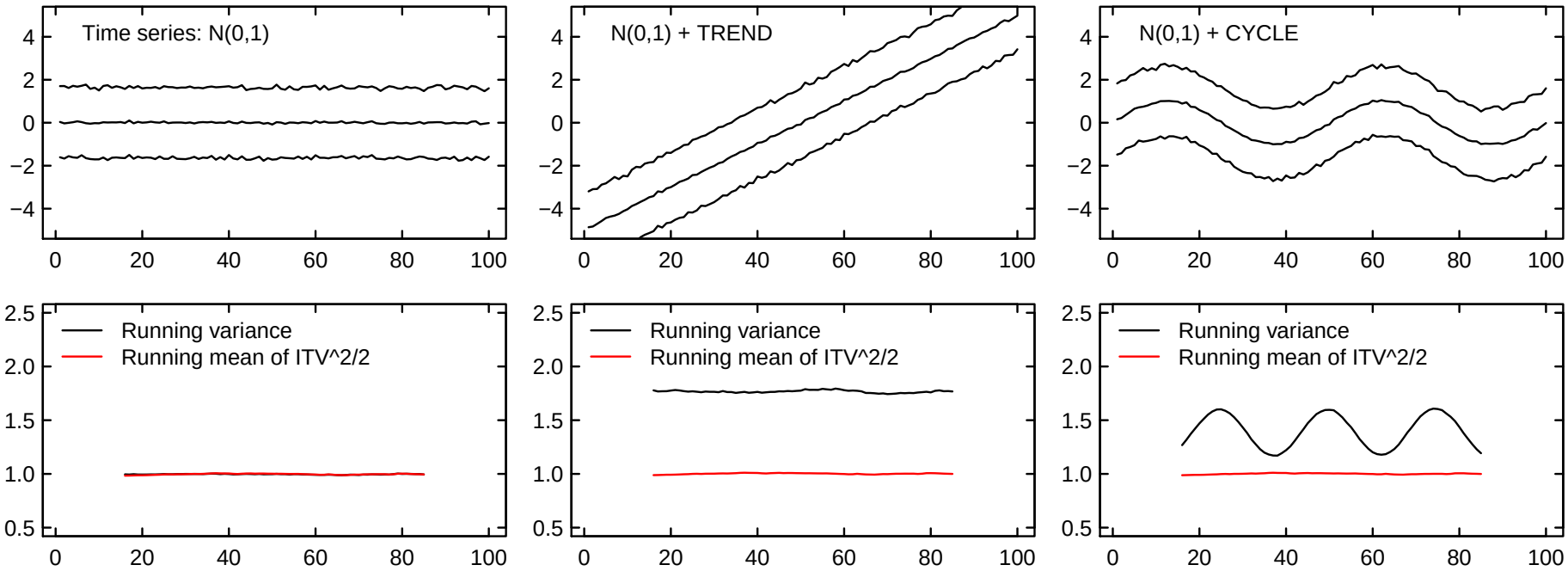
- Data:
  - 34 CMIP5 models, historical and future simulations (3 RCPs);
  - changes assessed as differences between 1979–2008 and 2070–2099;
  - EOBS temperatures for evaluation over 1979–2008;
  - 10 historical runs of CNRM-CM5 for internal variability.

Why ITV?

- Day-to-day absolute variations are linked to the daily variance:

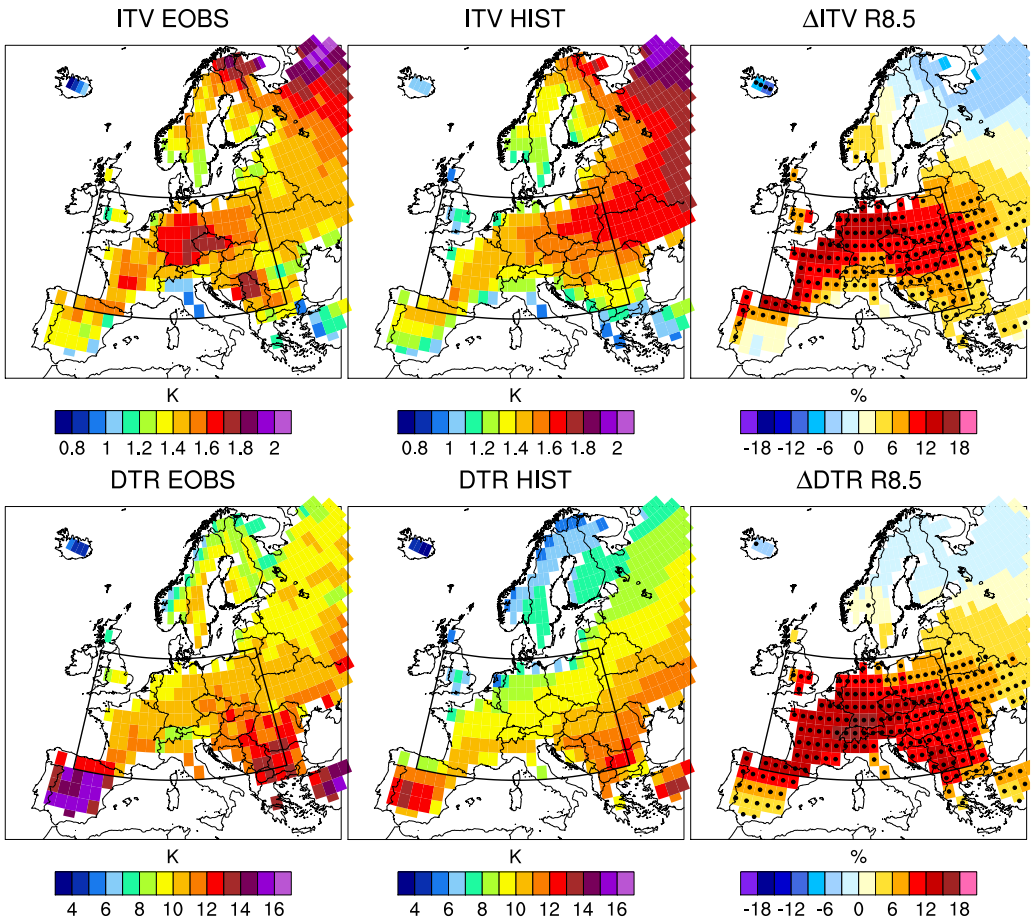
$$|\mathrm{ITD}_d| = |T_{d+1} - T_d| = \sqrt{2}\,\sigma(T_{[\![d,d+1]\!]})$$

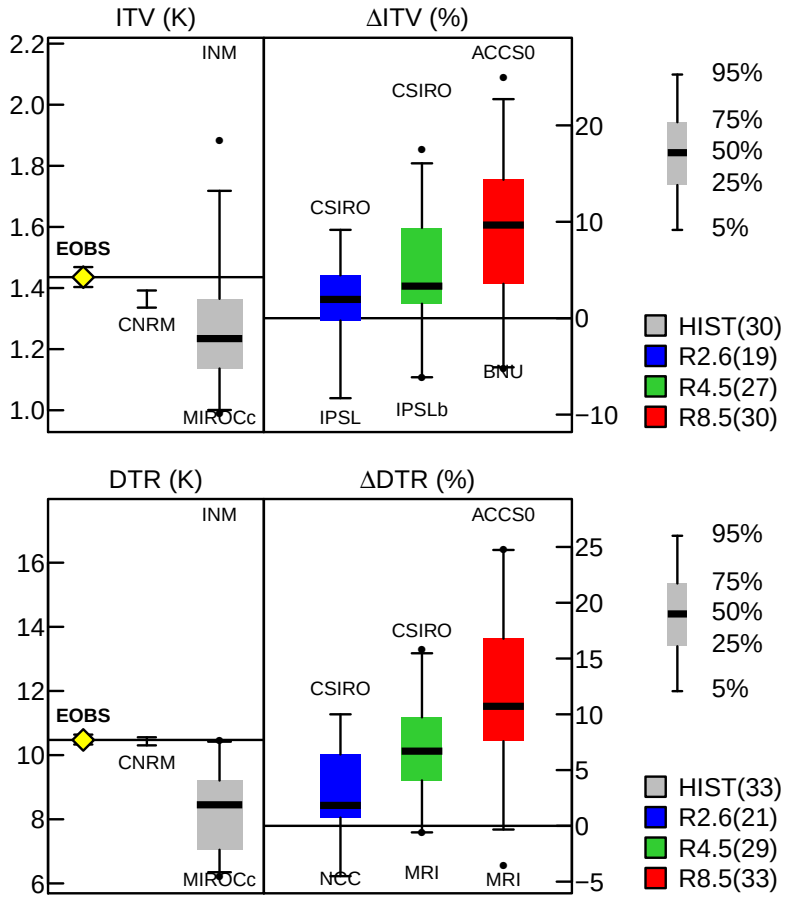
- Contrarily to the variance, the ITV is not sensitive to long-term variations:



Based on 1000 random simulations of white noises.

ITV & DTR changes The mean





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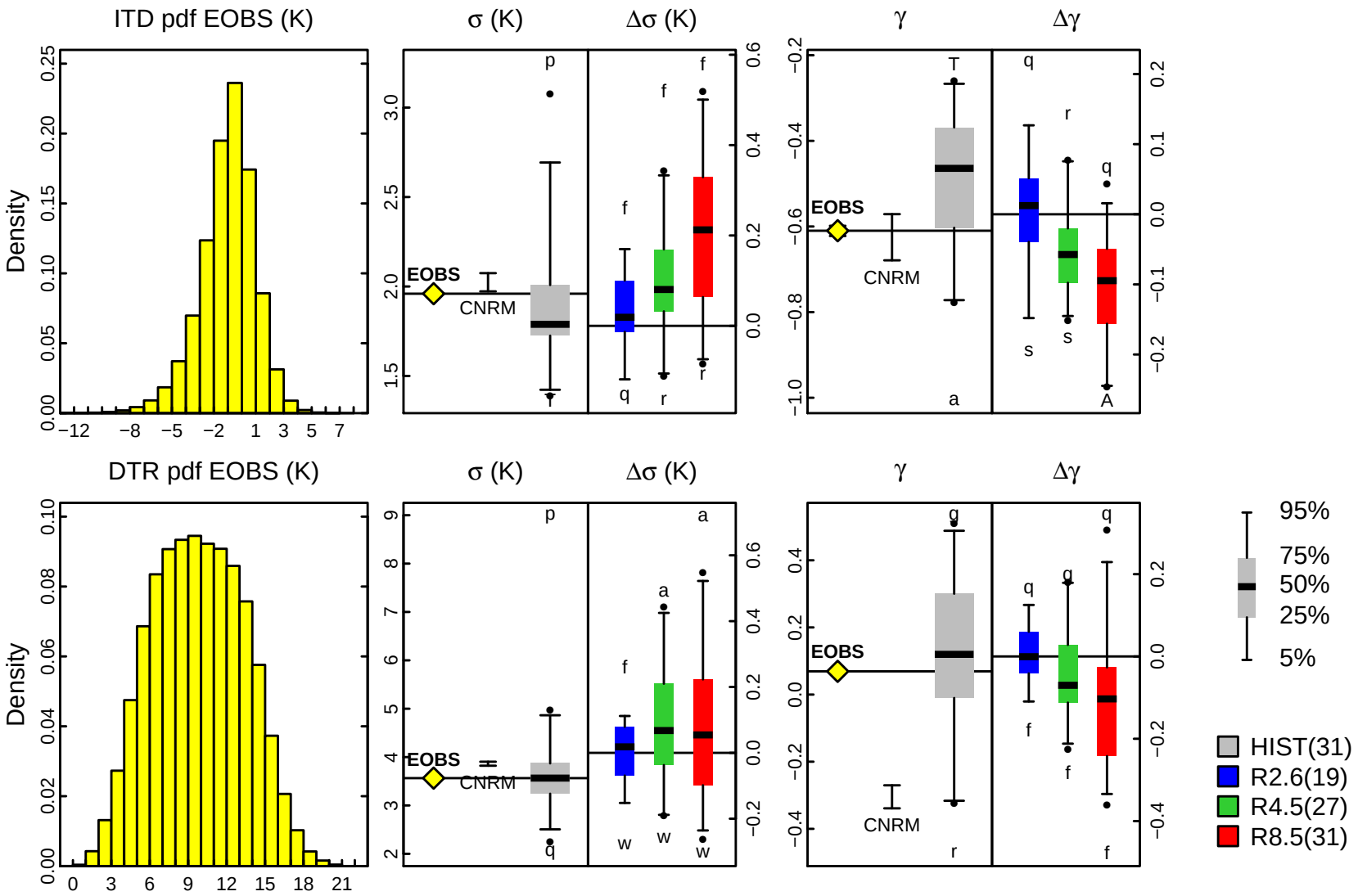
- Consistent with Kim et al. 2013 & Lindvall and Svensson 2014 (global).

ITV & DTR changes The pdf



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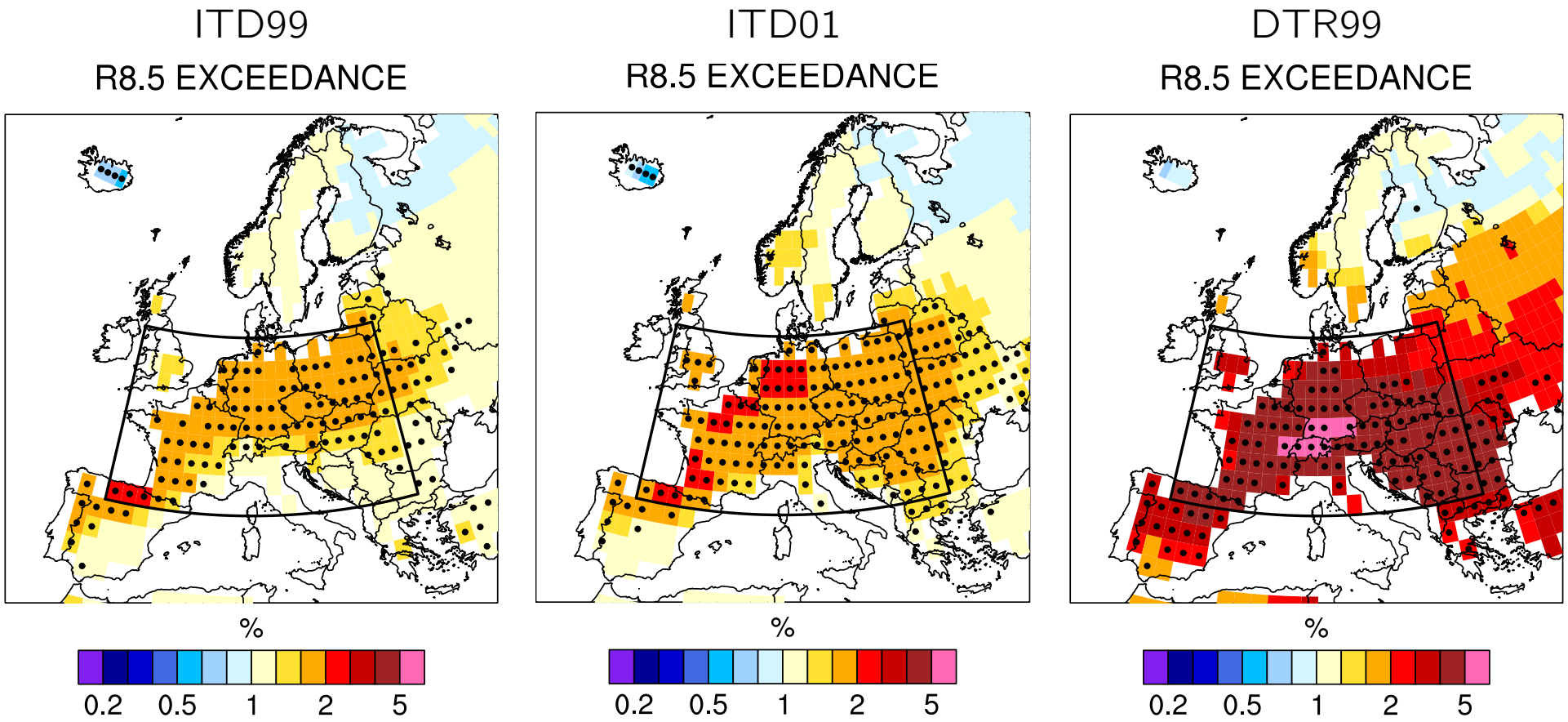
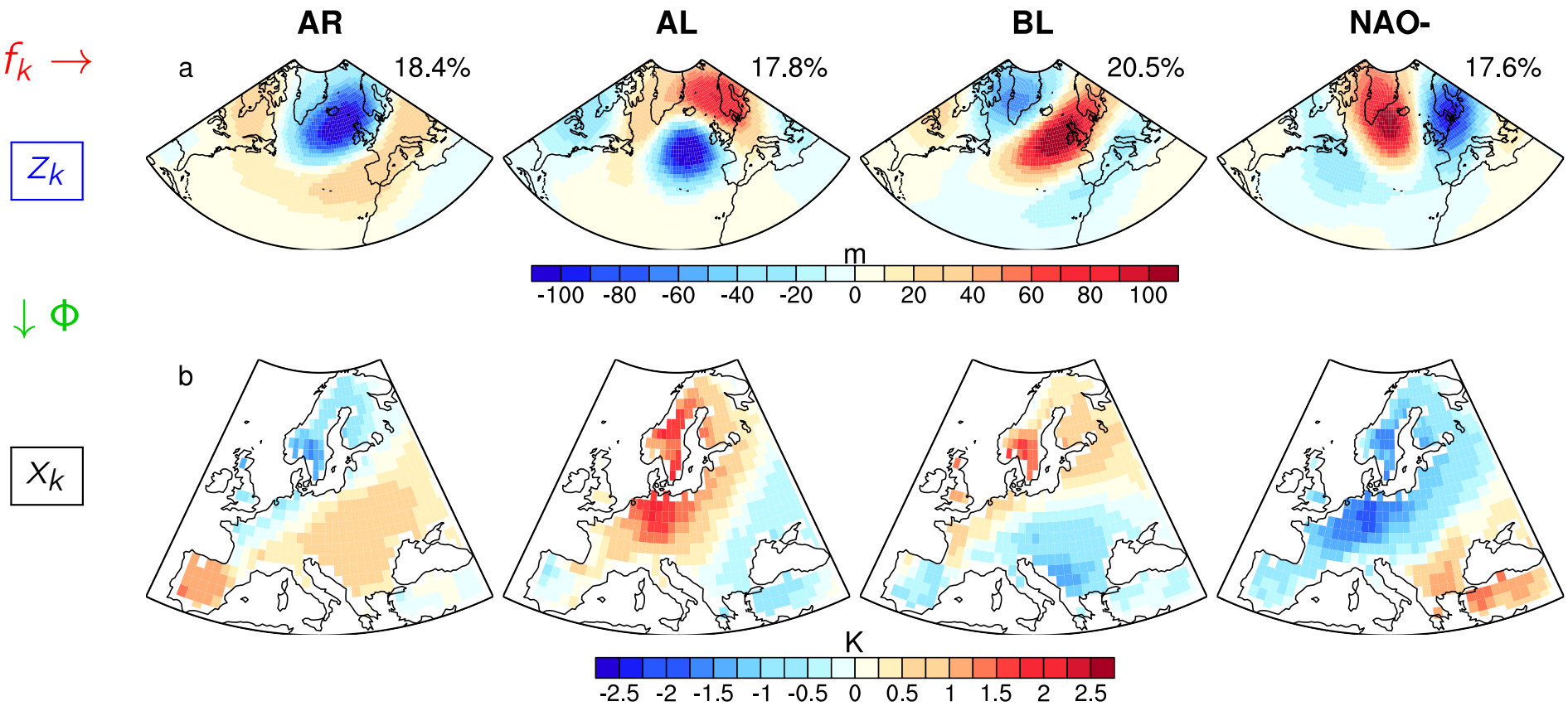
ITV & DTR changes The extremes



© CDSPY14 Fig. SM2.

Contribution of the North-Atlantic dynamics Methodology

- For X the ITV or DTR: $\overline{X} = \sum_k f_k \cdot x_k = \sum_k f_k \cdot \Phi(z_k)$.

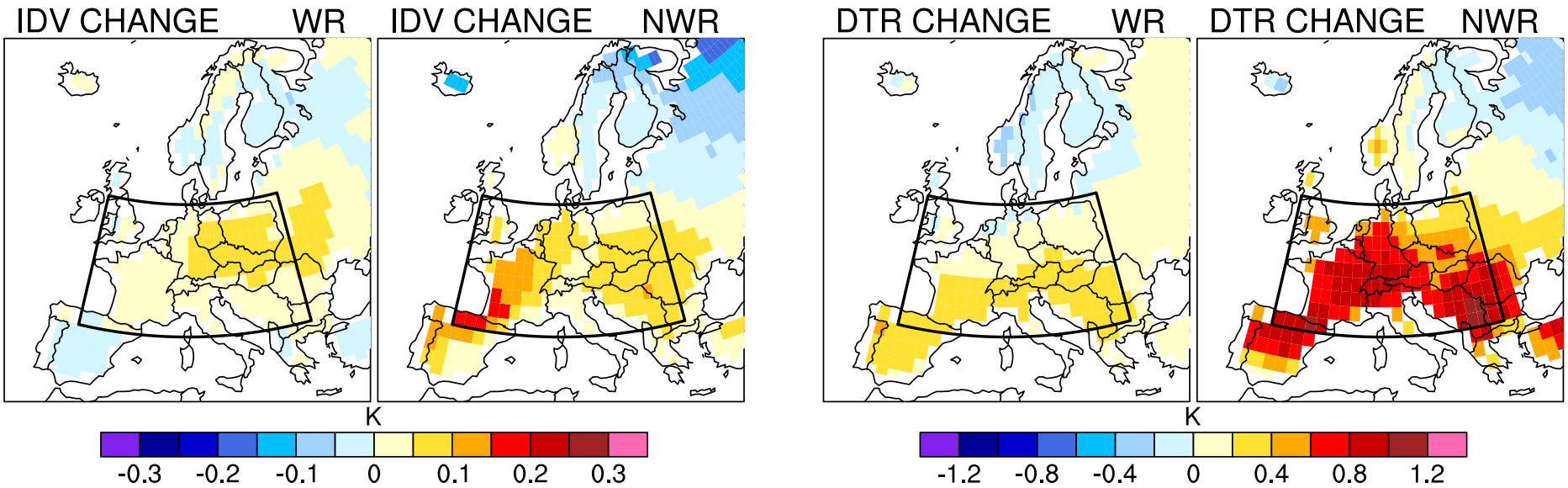


Data: Z500 NCEP2 & DTR EOBS | Methodology: Cattiaux et al., 2013, *Climate Dynamics*.

Contribution of the North-Atlantic dynamics Results

- For X the ITV or DTR: $\overline{X} = \sum_k f_k \cdot x_k = \sum_k f_k \cdot \Phi(z_k)$.

$$\Delta\overline{X} = \underbrace{\sum_k \Delta f_k \cdot \Phi(z_k) + \sum_k f_k \cdot \Phi(\Delta z_k)}_{\text{Weather Regimes (WR)}} + \underbrace{\sum_k f_k \cdot \Delta\Phi(z_k)}_{\text{Non WR}} + \varepsilon$$



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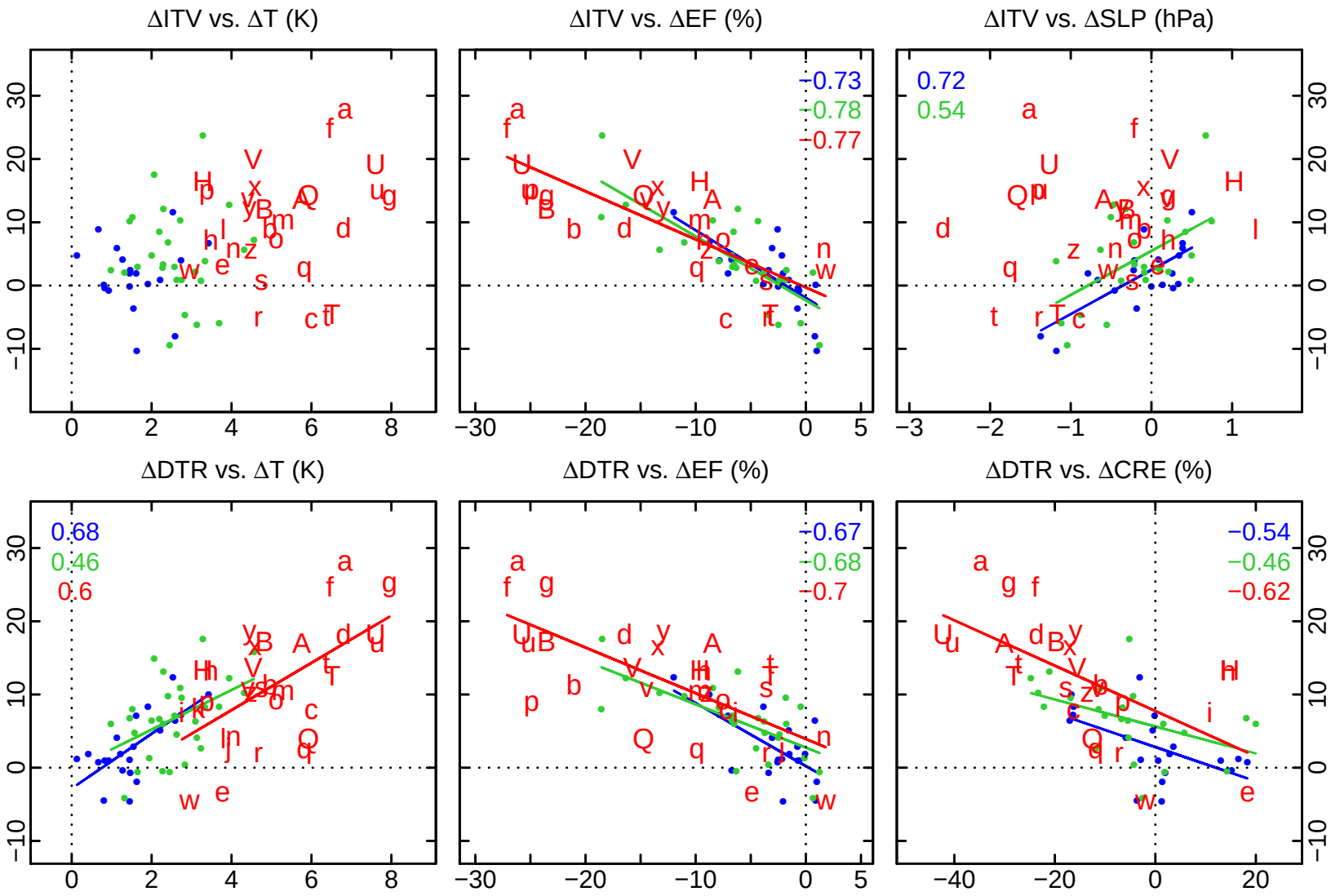
Links with other variables



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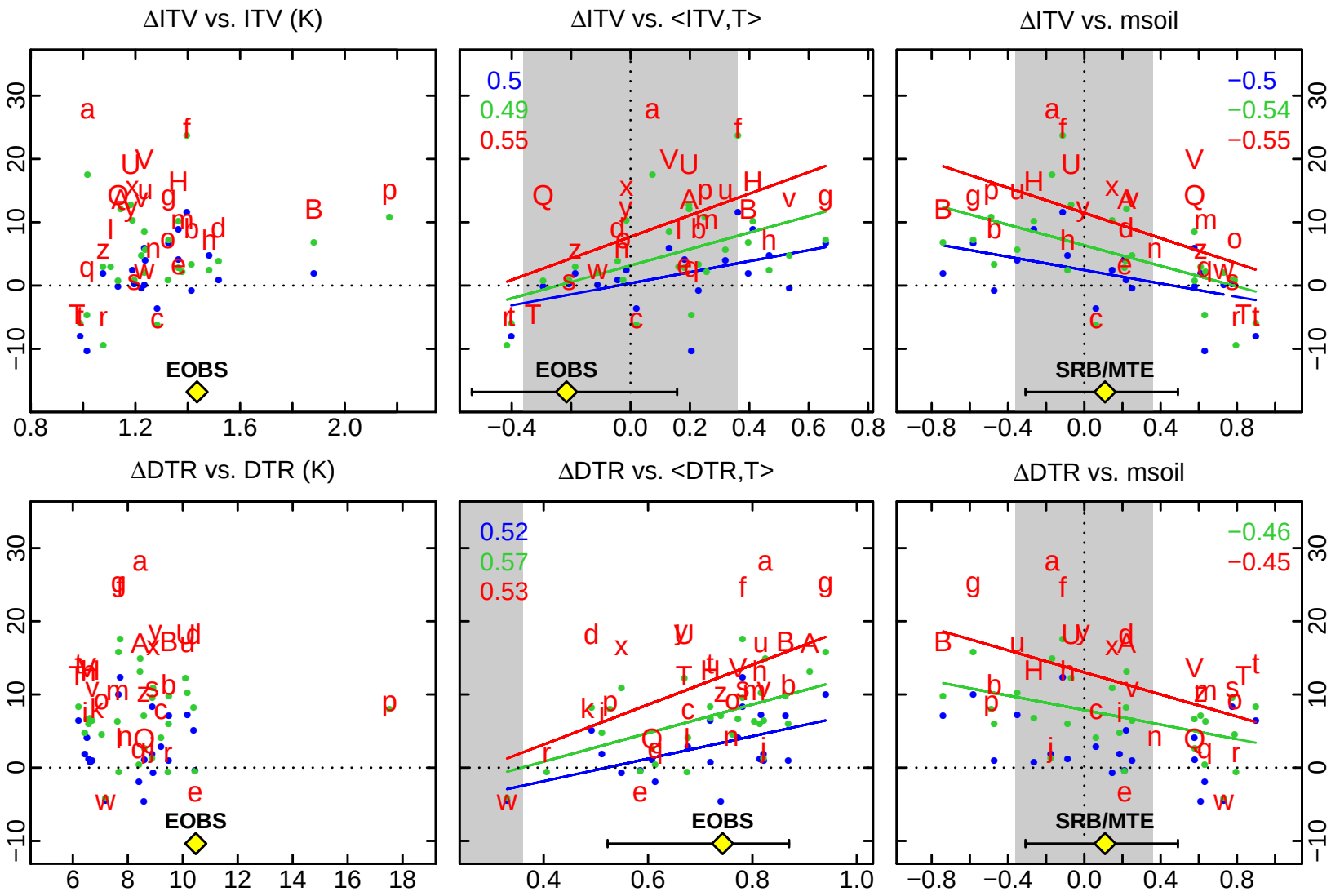
Observational constraints?



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Summary

- ✓ Increase in short-term European summer temperature variability.
- ✓ Widening of the ITV distribution vs. shift of the DTR distribution.
- ✓ Both ITV and DTR increases associated with soil drying.
- ✓ Among other processes: circulation (ITV), cloudiness reduction (DTR).
- ✓ Emerging constraints in inter-annual present-day correlations.

$\longrightarrow$ Detection and attribution of present-day trends?

$\longrightarrow$ Sensitivity experiments to confirm the drivers?

$\longrightarrow$ Role of horizontal temperature gradients (e.g. land-sea warming ratio)?

Cattiaux, J., H. Douville, R. Schoetter, S. Parey and P. Yiou (2014), Projected increase in diurnal and inter-diurnal variations of European summer temperatures, *Geophys. Res. Lett.*, accepted.