WRF bias and sensitivity to PBL scheme over an annual cycle during the year 2001.

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No time to show everything! Those interested please check the paper:

García-Díez M, Fernández J, Fita L, and Yagüe C. 2012. Seasonal dependence of WRF model biases and sensitivity to PBL schemes over Europe. *Quarterly Journal of the Royal Meteorological Society* Accepted

Available in our web http://www.meteo.unican.es/

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5. Discussion and conclusions

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1. **Introduction**

2. Objectives

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INTRODUCTION

The Weather Research & Forecasting model (WRF) is being extensively used, among others, for local weather forecasting, air quality studies and as a Regional Climate Model (RCM).

Large number of configurations available: There is no consensus about which configuration is the best for each particular case, and specifically the set of physical parametrizations.

Scheme validation and sensitivity studies usually lack generality (*Stensrud 2007*).

PROBLEM

Case studies:

- Small homogeneous regions, short periods.

- Large number and density of obs.

- Detailed validation possible.

?

"Long term" studies:

- Scarce obs.

- Large non-homogeneous regions & long periods

- Generic statistics, no detailed validation is possible.

Validation of the different PBL schemes is often carried out using case studies.

Models do not resolve turbulence.

- **Parametrization:** $$\overline{u'_i u'_j} = f(\overline{u_i}, \overline{p}, \overline{T}, \overline{q}, \ldots)$$

$\overline{u'_i u'_j}$ Covariances or kinematic fluxes.

$\overline{u_i}, \overline{p}, \overline{T} \ldots$ Temporal averages.

- **Local closure schemes:** Use local parameters, which are defined on each level or it's neighbours.

- **Non-local closure schemes:** Use parameters that depend on the whole vertical profile.

• **Local closure schemes produce shallower and moister PBLs** than non-local ones, as a consequence of less turbulent mixing. (Alapaty et al., 1997; Hong & Pan,1996; Stensrud & Weiss, 2002) and other.

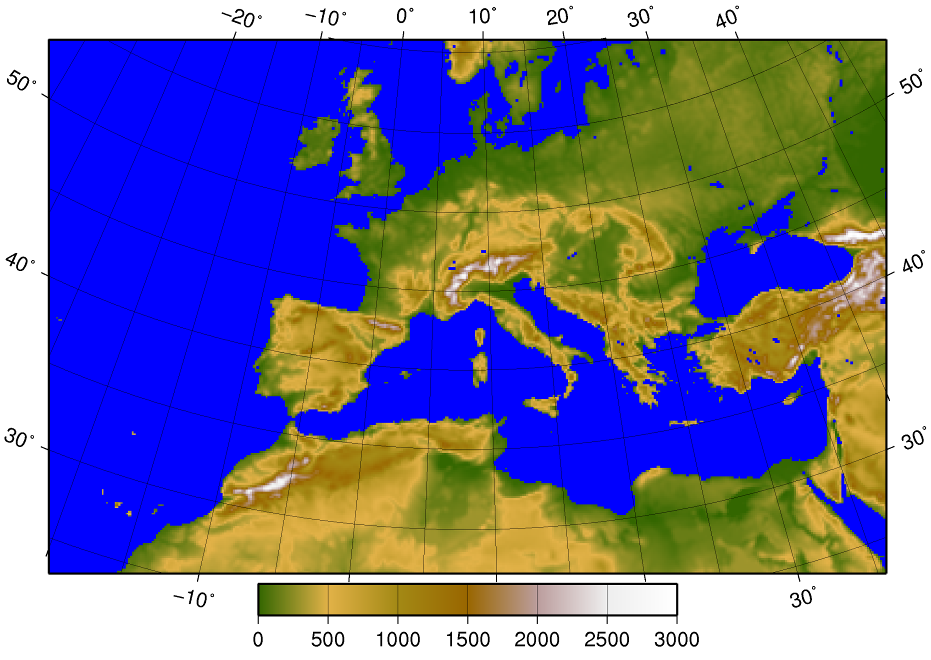
• To fix this issue local schemes have been improved to produce **more mixing** (Zhang & Zheng, 2004), adding higher order terms to the equations. These can represent indirectly the entrainment.

• The most popular local closure schemes are the ones using a TKE diagnostic equation (Mellor-Yamada jerarchy, UW, etc.)

OBJECTIVES

- Explore spatial and temporal structures of both temperature bias and sensitivity to the PBL scheme over Europe.

- The main goal is to provide a link between short term case studies, based on field campaigns, and long term statistics.



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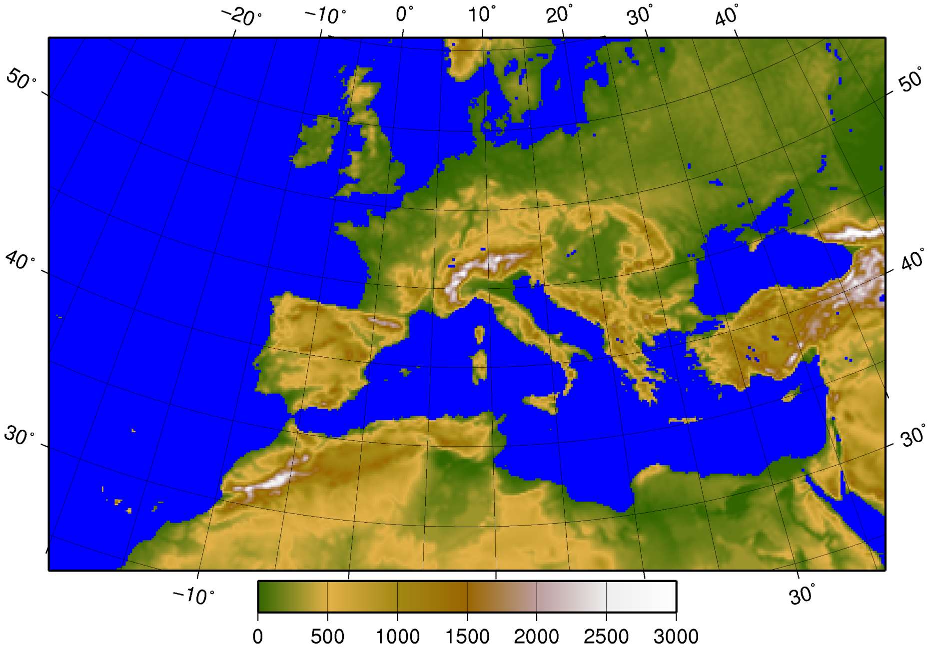
• Model: WRF 3.1.1 (Skamarock et al., 2008). Non-hydrostatic primitive equation limited area model.

YSU	**Non-local** difussion (Hong et al., 2006).
MYJ	**Local TKE closure** (Janjić,1990; Janjić ,1994; Janjić, 2002).
ACM2	**Local closure in stable enviroments and combined local and non-local in unstable enviroments.** (Pleim, 2007).

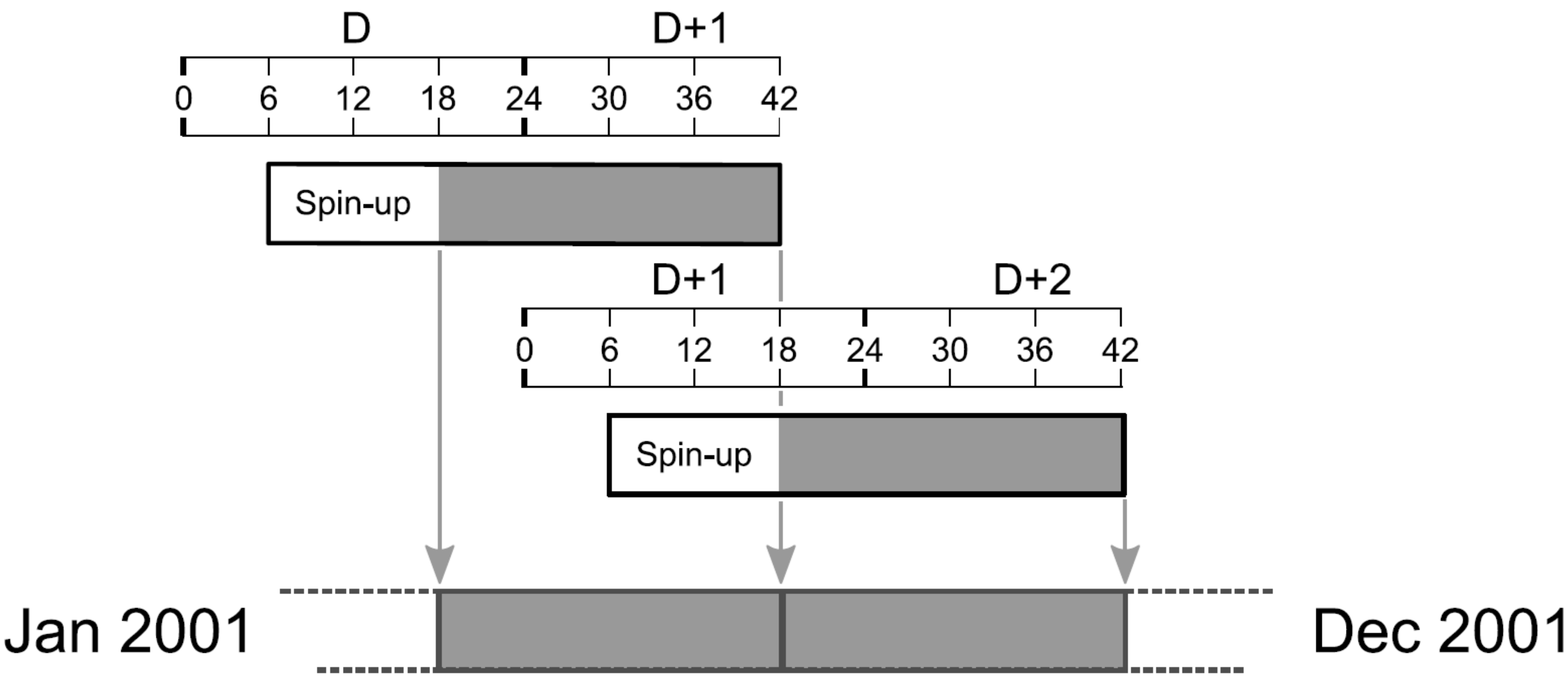
- The simulations cover the **year 2001**.



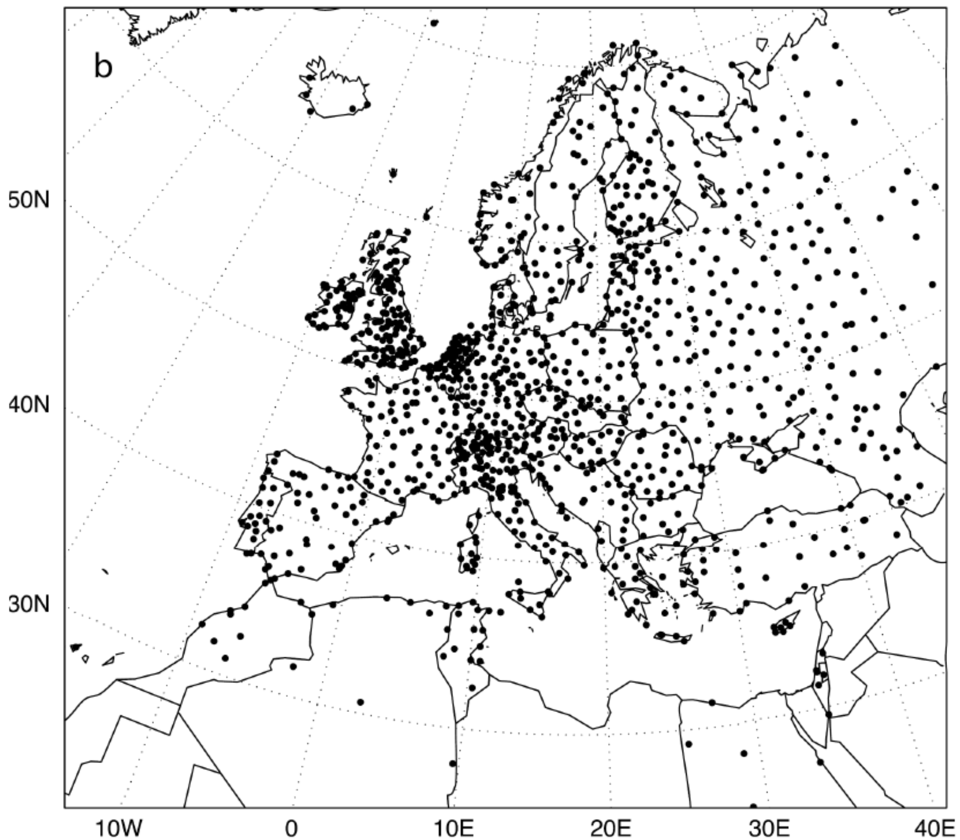
WRF configuration	
Domain	390x250 points
Time step	90 s
Horizontal resolution	15 km
Vertical levels	39
Initial and boundary data.	**ERA-INTERIM**

- **365x3 daily simulations** starting at **6 UTC** and running for 42h.

- The daily simulations are concatenated to create a pseudo-continous series leaving 12 hours as spin-up.

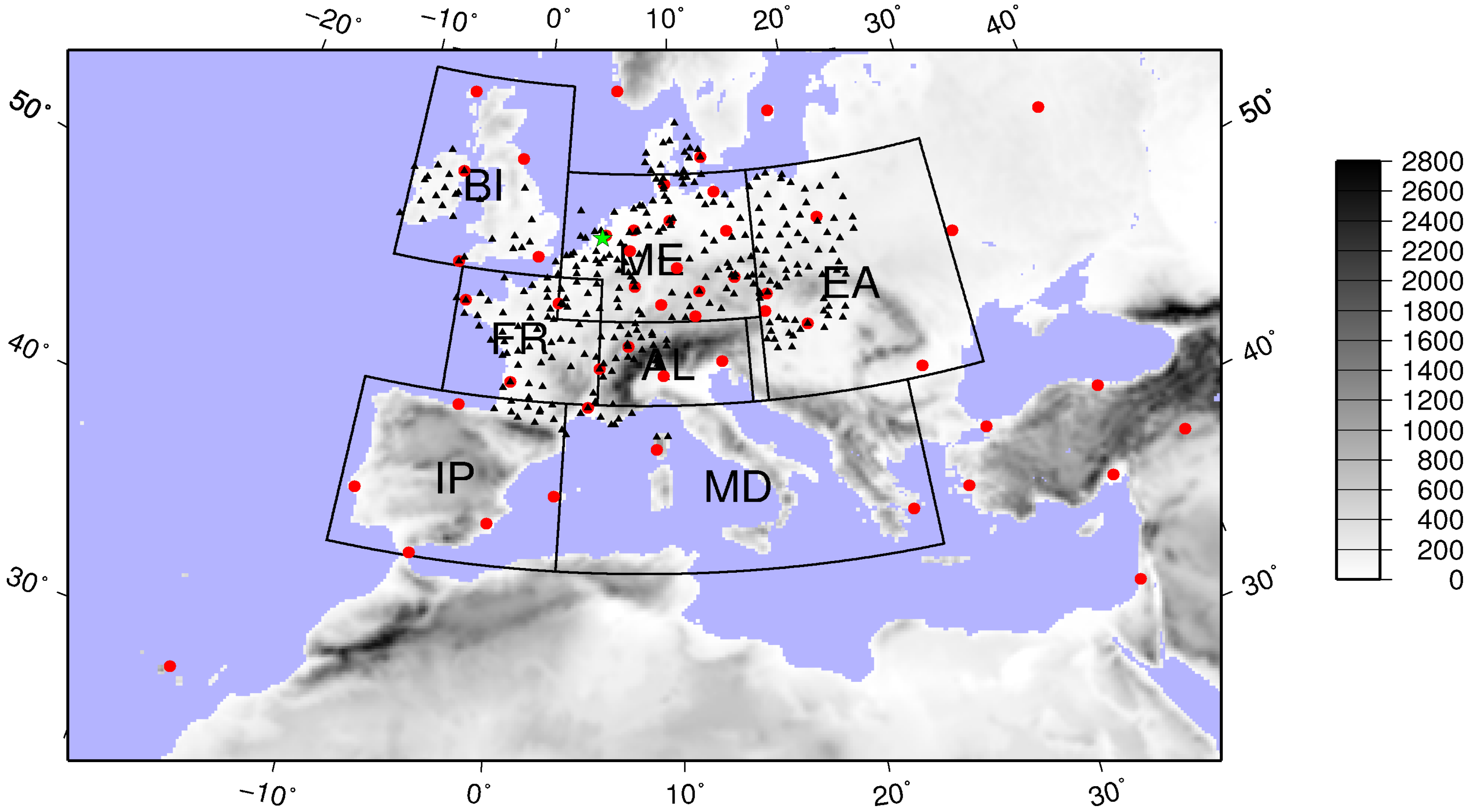


- E-OBS gridded dataset (Haylock et al. 2008).

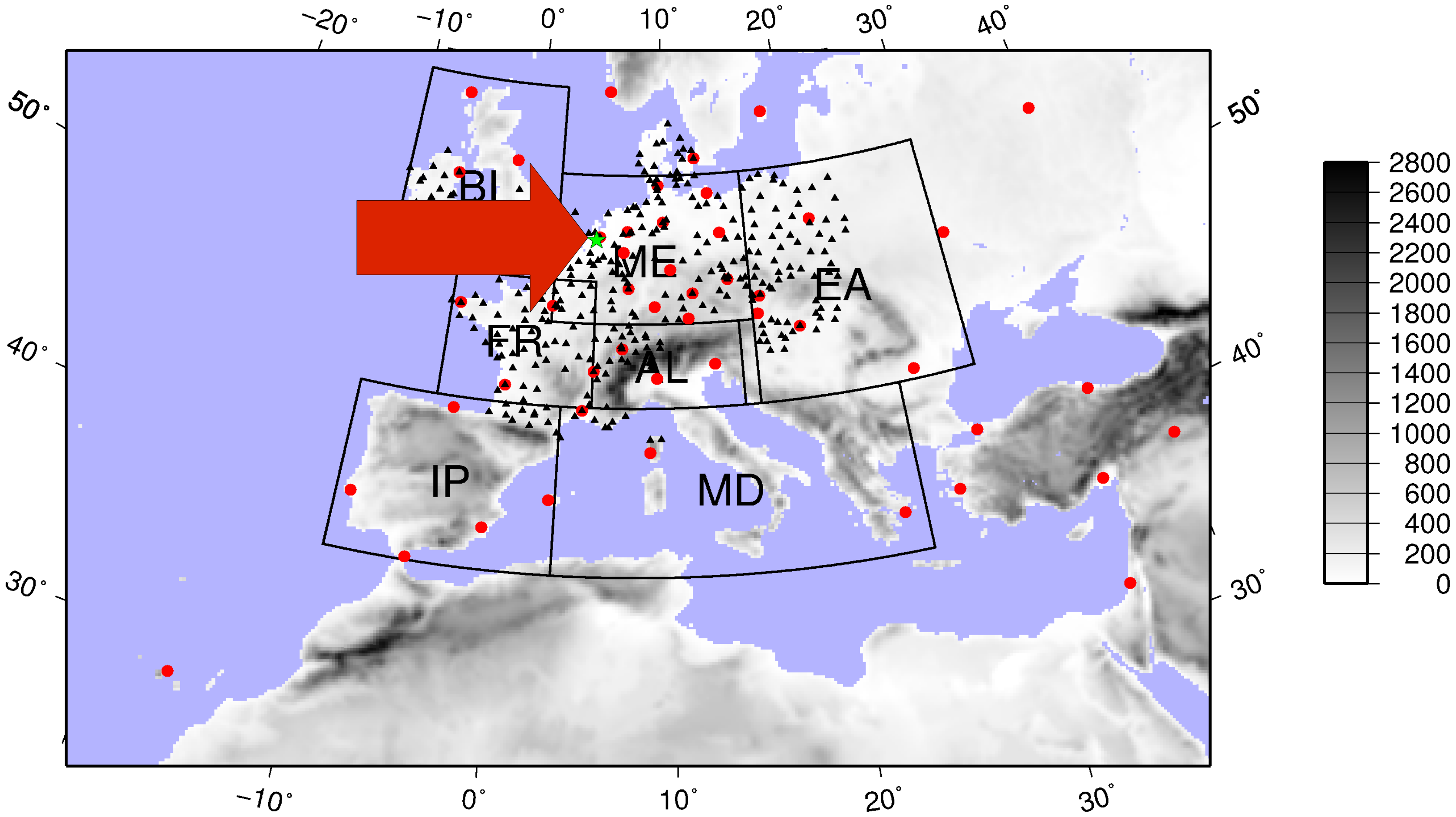


From Haylock et al. 2008

Hourly SYNOP reports have been processed and cleaned from outliers, to check daily cycles.



Cabauw Experimental Site for Atmospheric Research (CESAR) tower: Non-standard variables as latent and sensible heat fluxes.



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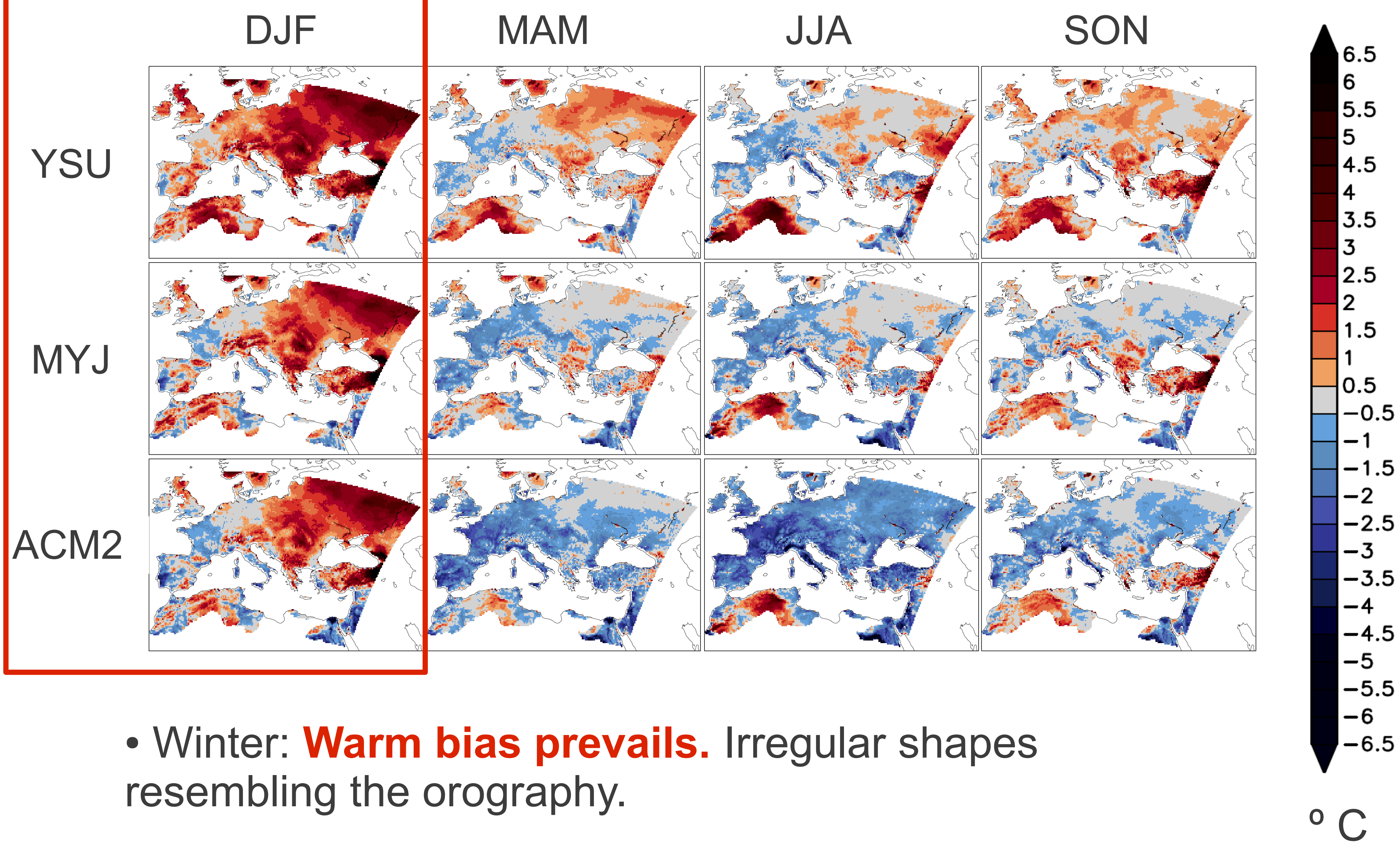
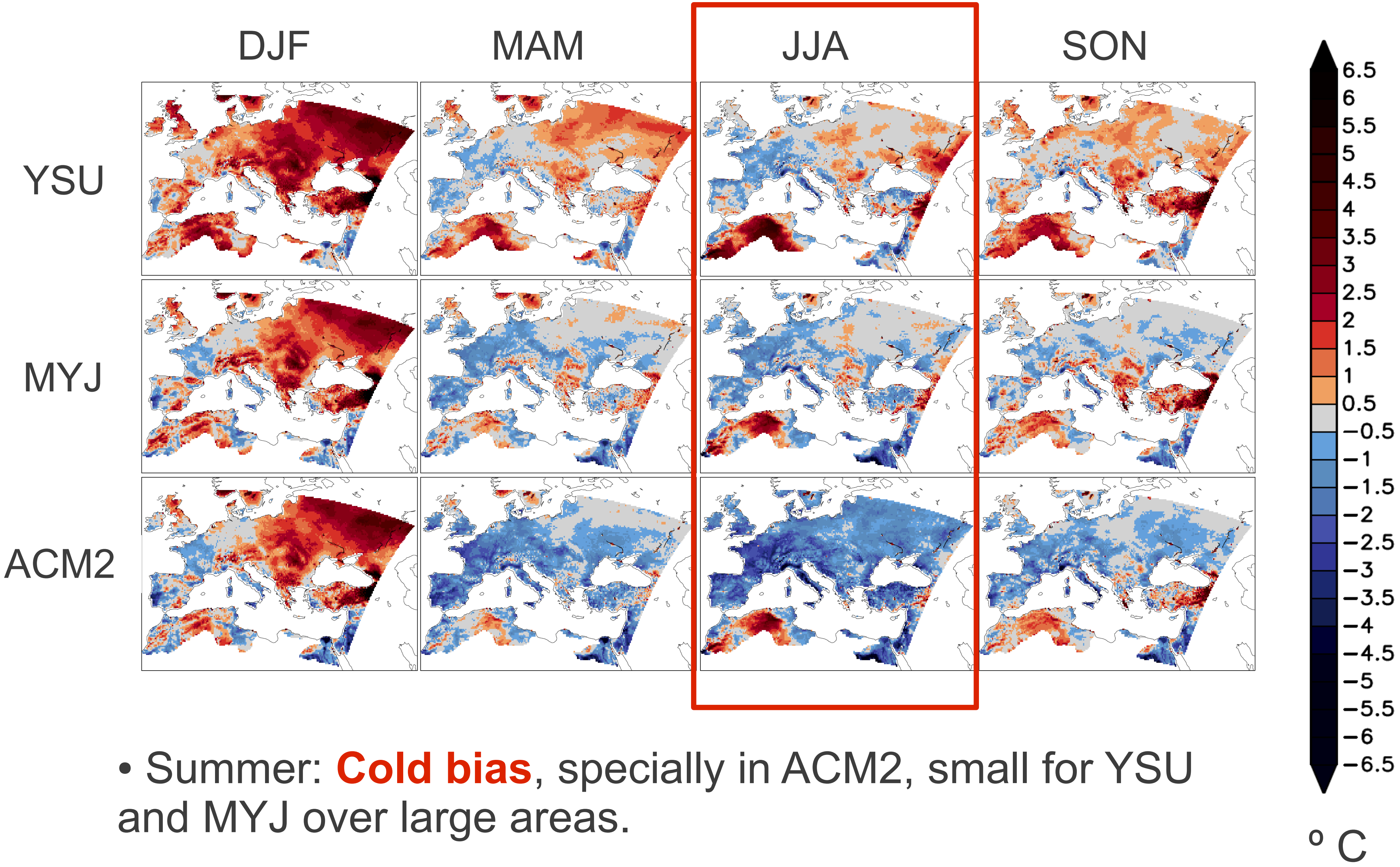
Minimum temperatures WRF - E-OBS.



• Winter: **Warm bias prevails.** Irregular shapes resembling the orography.

RESULTS

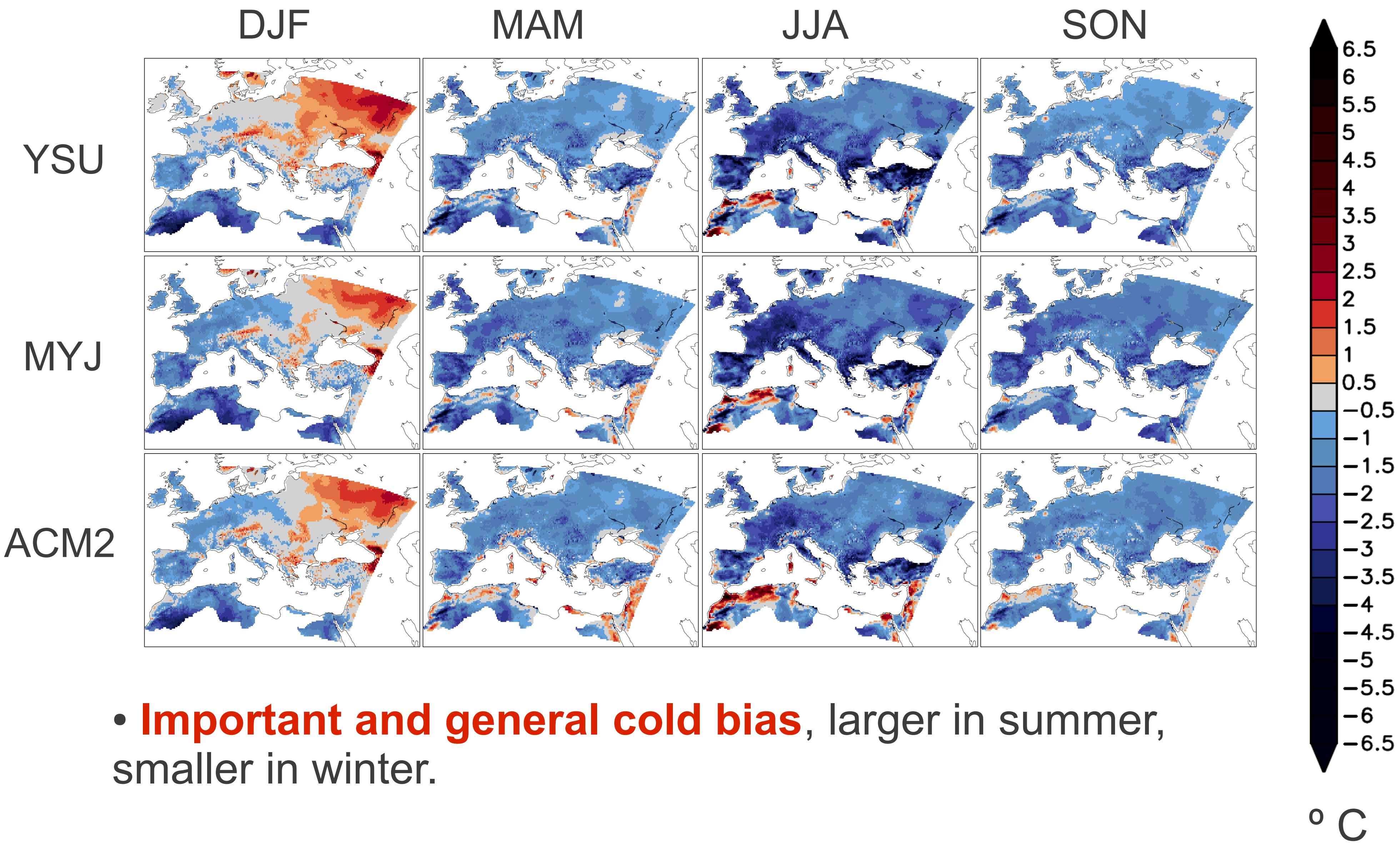
Minimum temperatures WRF - E-OBS.



• Summer: **Cold bias**, specially in ACM2, small for YSU and MYJ over large areas.

RESULTS

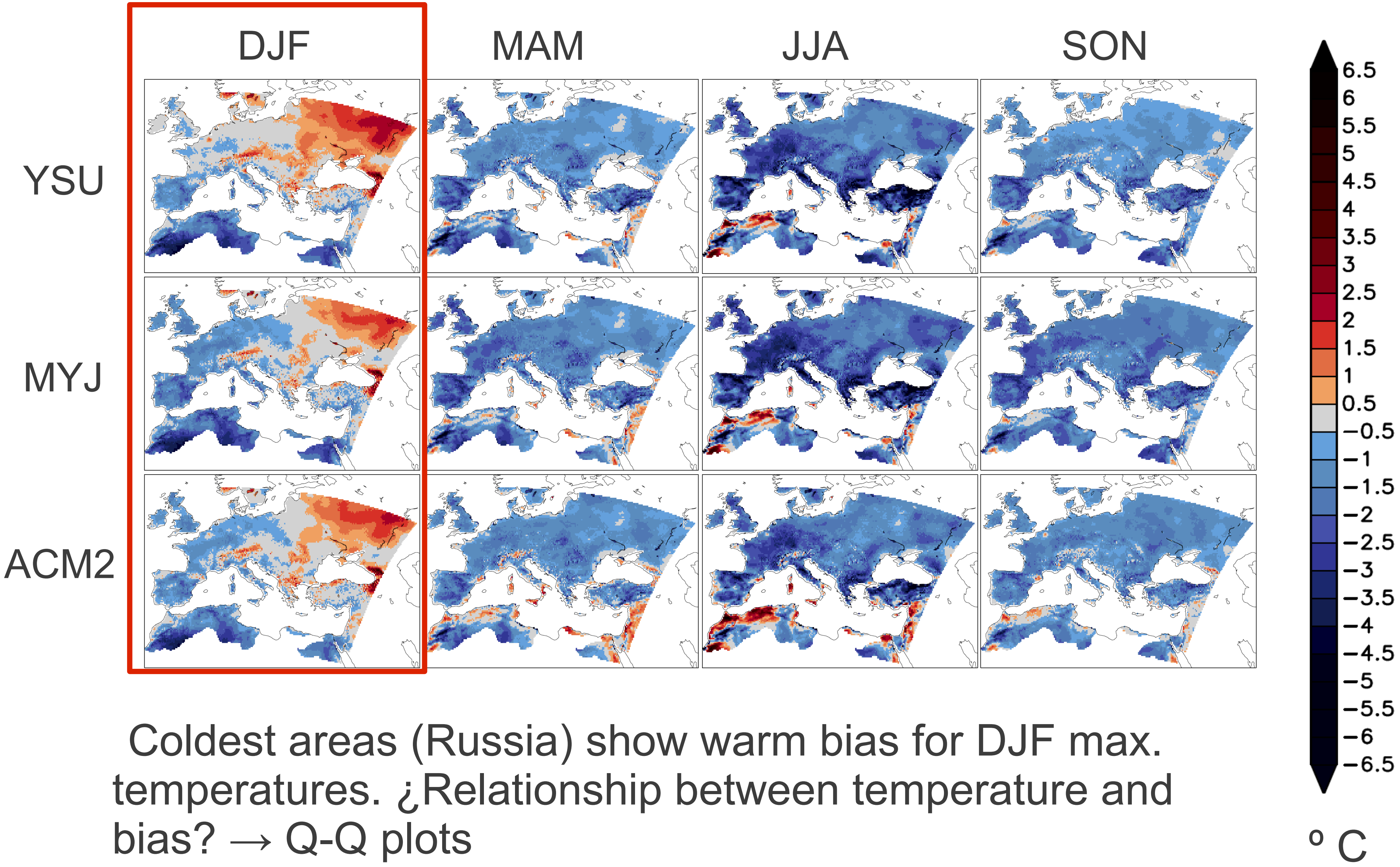
Maximum temperatures WRF - E-OBS



- **Important and general cold bias**, larger in summer, smaller in winter.

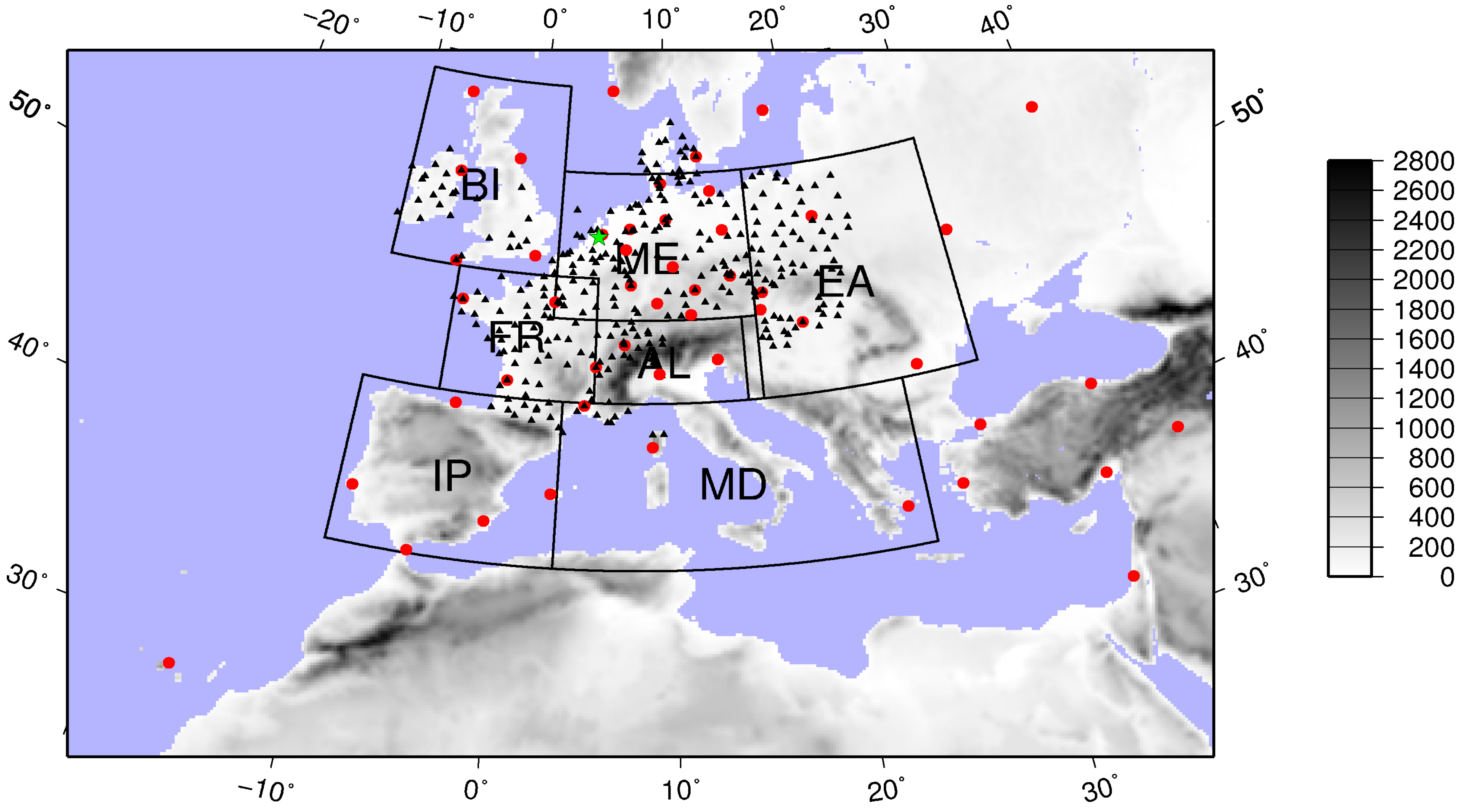
RESULTS

Maximum temperatures WRF - E-OBS



Coldest areas (Russia) show warm bias for DJF max. temperatures. ¿Relationship between temperature and bias? → Q-Q plots

Q-Q plots have been made for each PRUDENCE region.

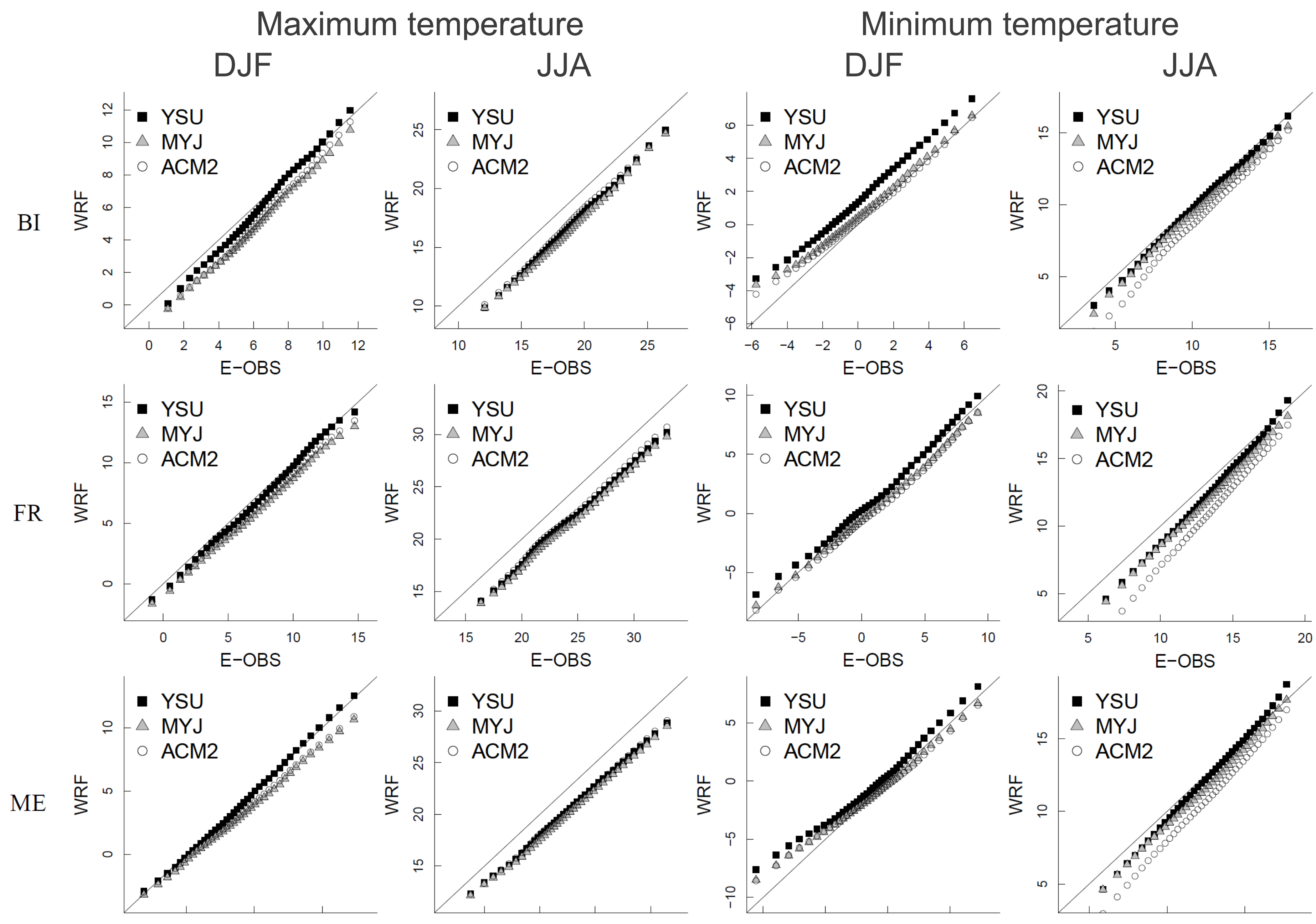


Quantile-quantile plots:

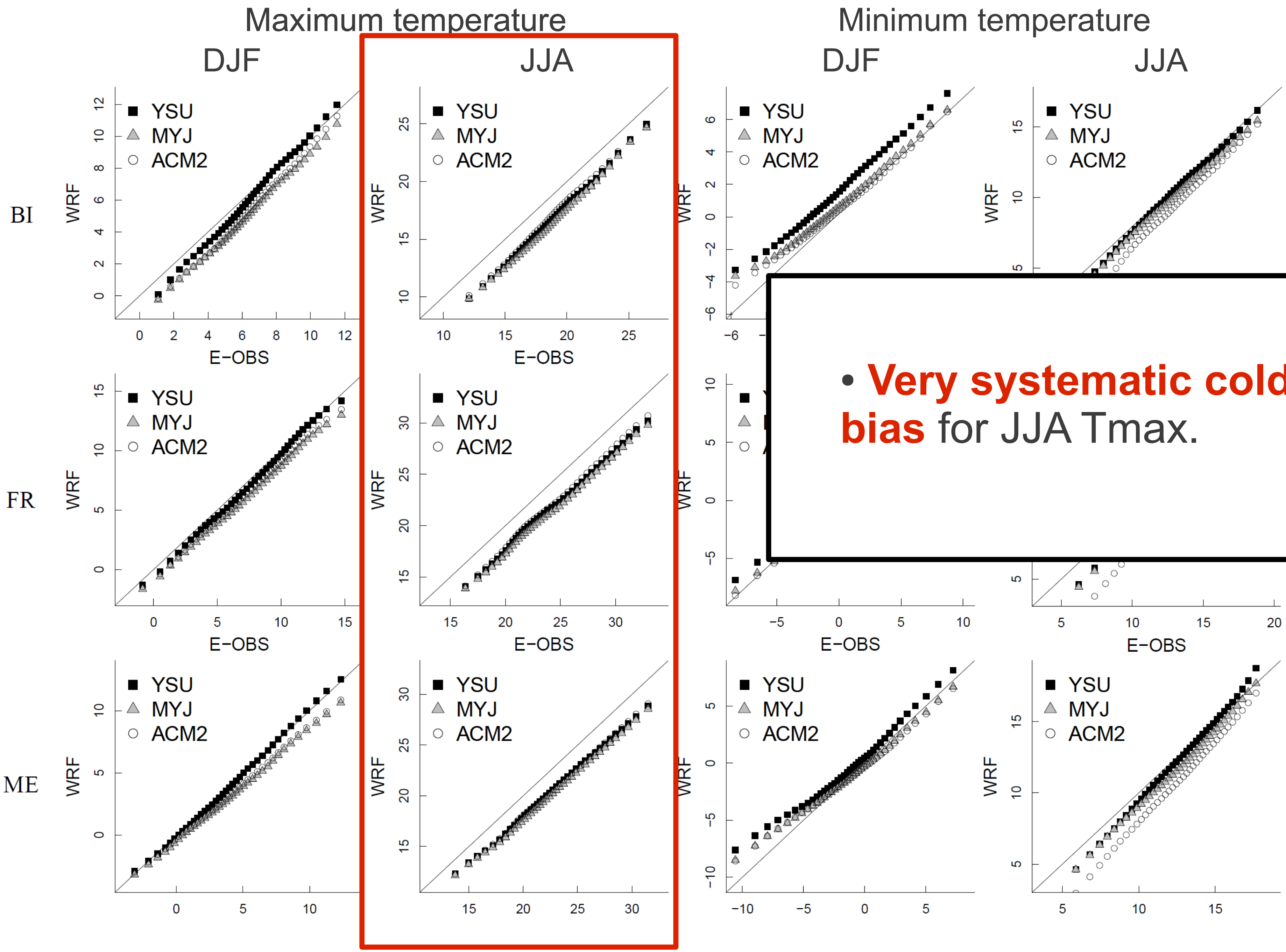
- They show quantiles of two distributions against each other in a 2-D plot.

- Straight diagonal q-q plot → Identical distributions, different mean.

- Curved in an extreme → The distributions differ in that tail.

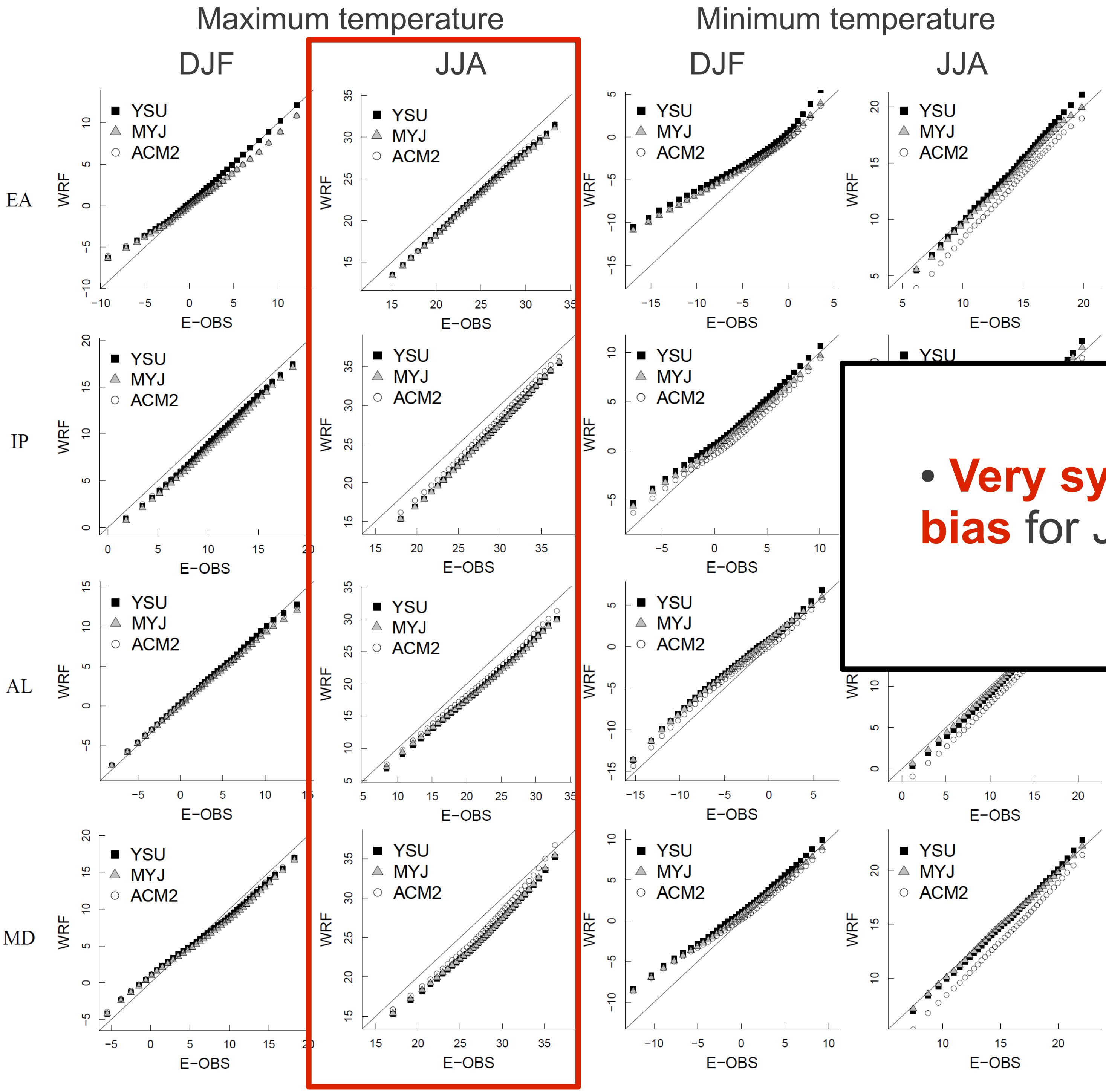

Maximum temperature
Minimum temperature
DJF
JJA
DJF
JJA
BI
FR
ME
WRF
E−OBS
YSU
MYJ
ACM2

RESULTS

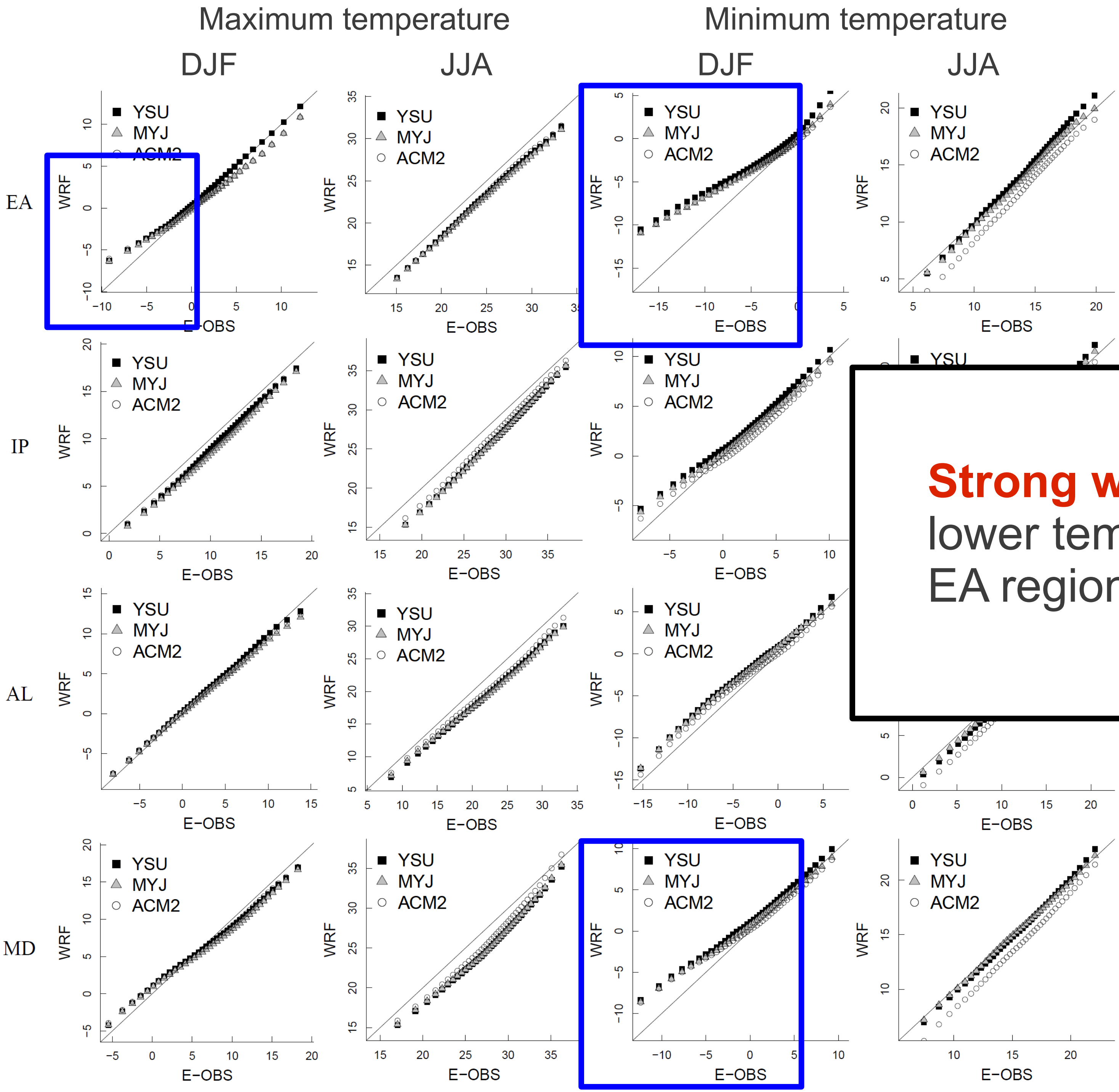


- **Very systematic cold bias** for JJA Tmax.

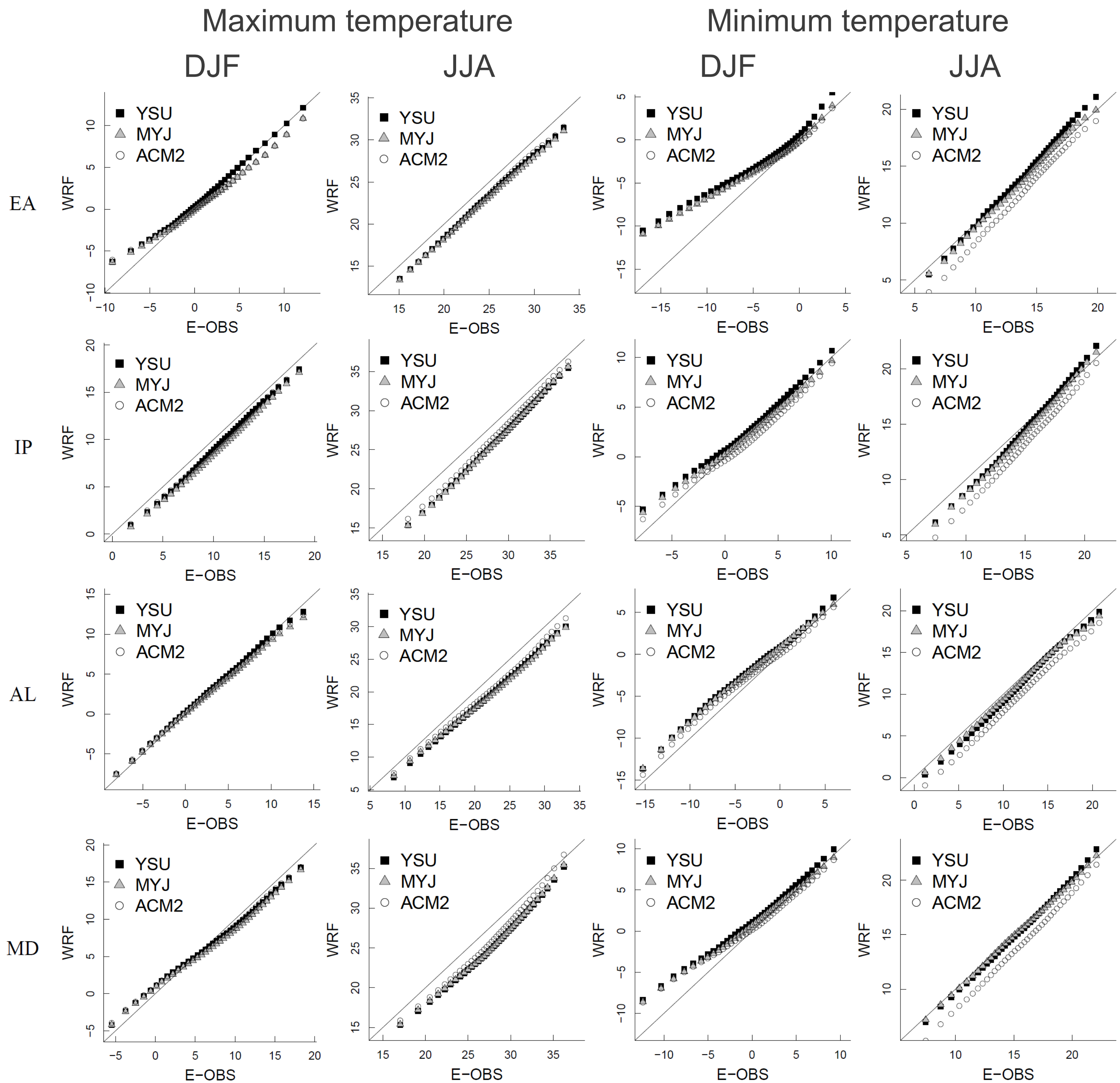
RESULTS



- **Very systematic cold bias** for JJA Tmax.



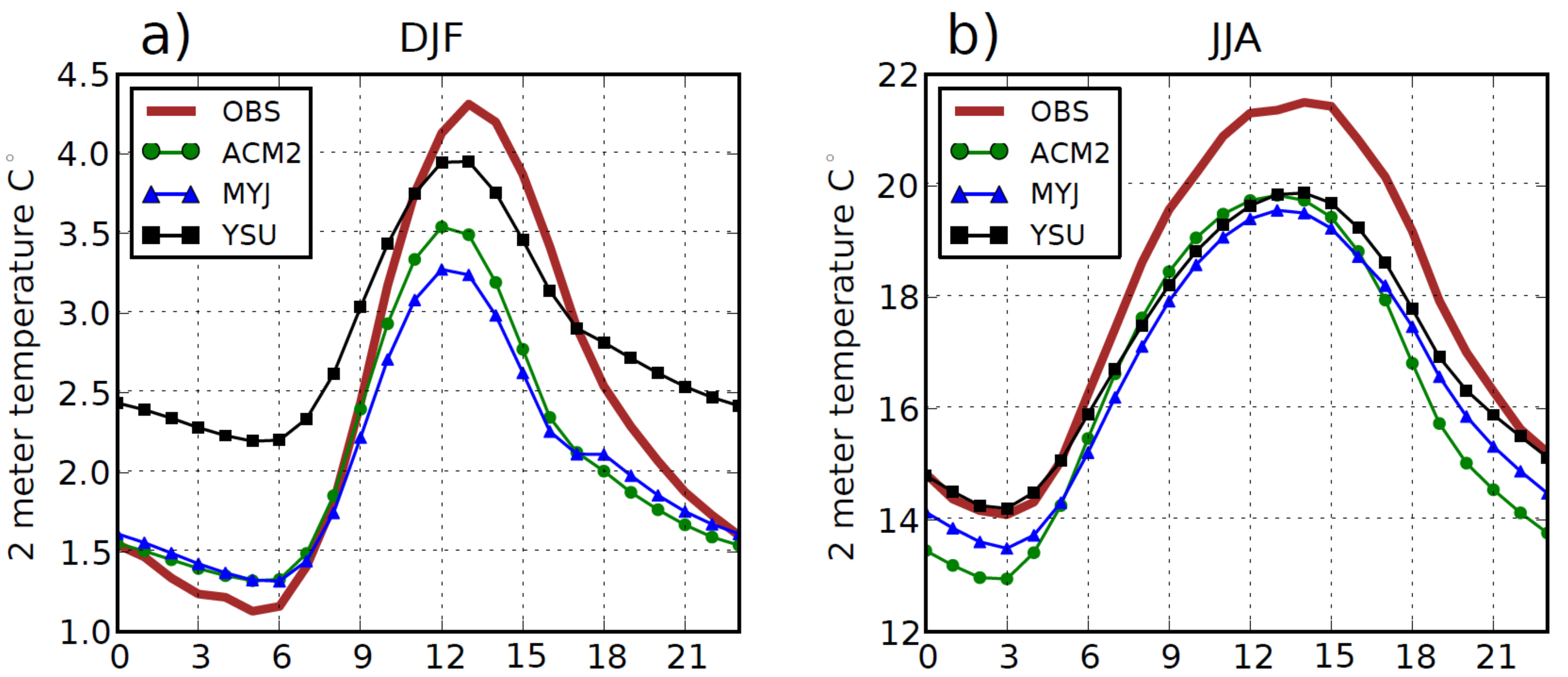
Strong warm bias for lower temperatures (see EA region).



Bias generally larger than sensitivity to PBL scheme.

Temperature daily cycle compared with SYNOPS:

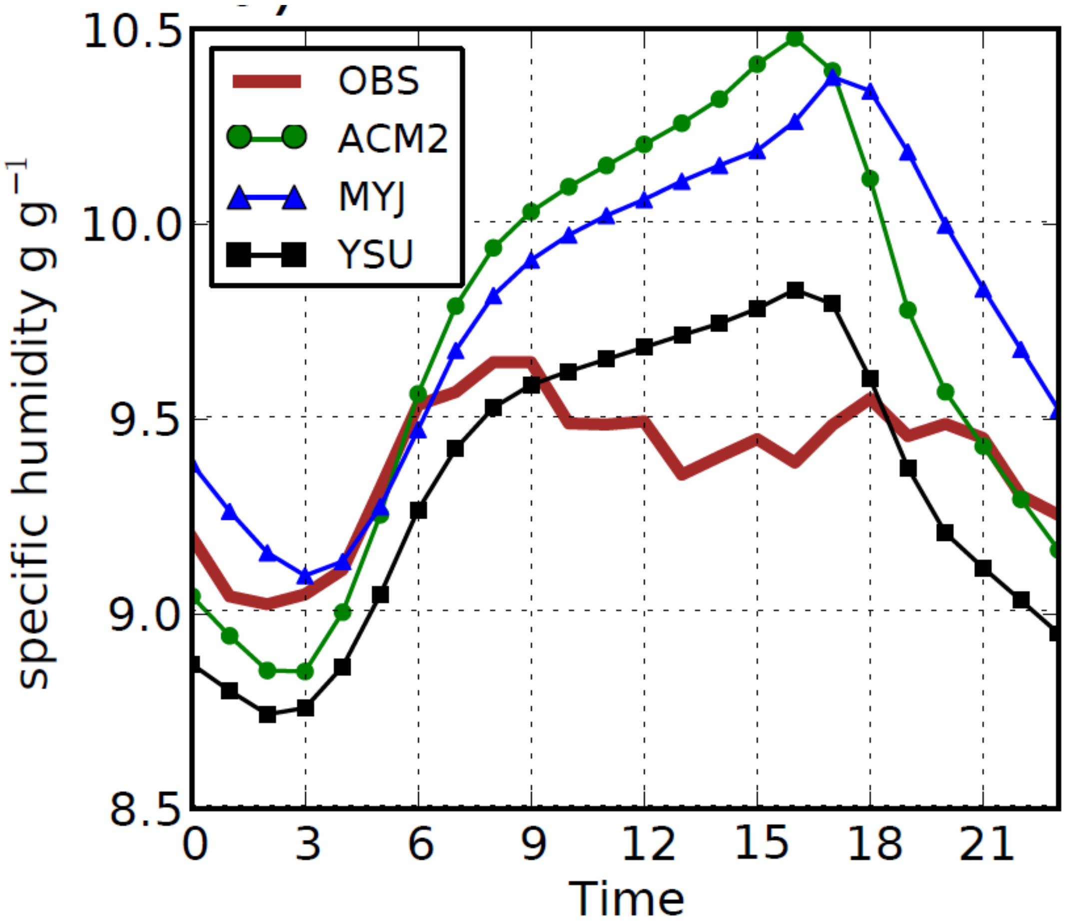
- YSU's warmer nights are the best in summer and the worse in winter. Shapes are consistent with the ones seen in E-OBS.



Specific humidity daily cycle is overestimated by the three schemes in summer.

This is indicative of not enough entrainment (entrainment is not balancing evaporation). YSU generates more entrainment than ACM2 and MYJ.

JJA

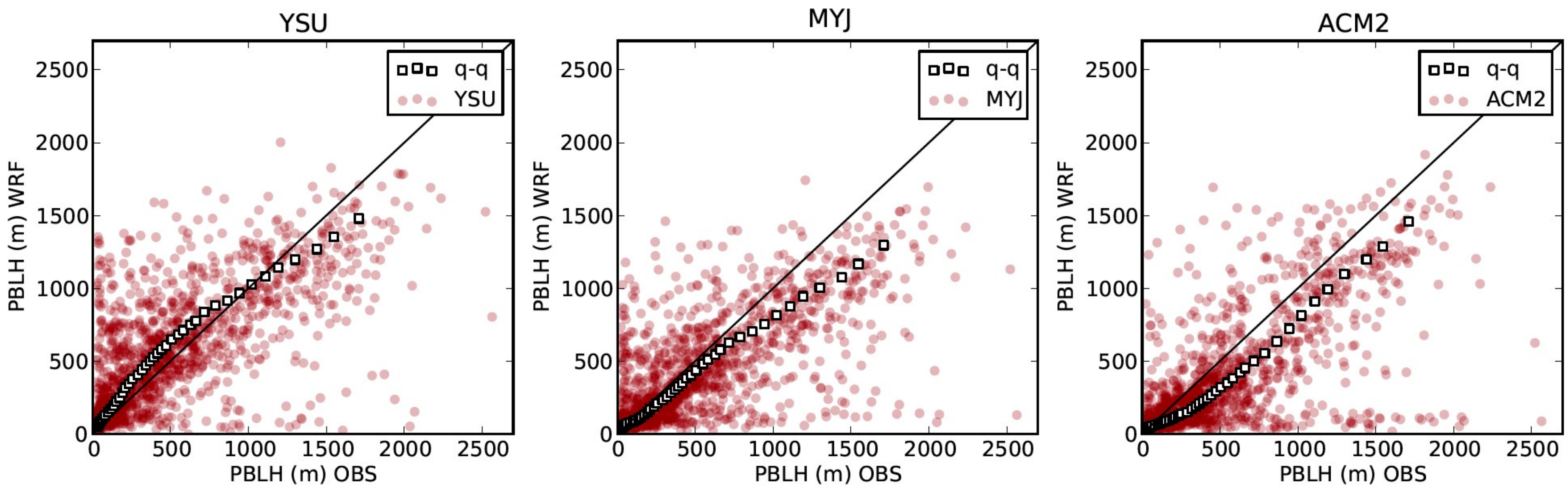


RESULTS

- Cold bias could be related to underestimation of entrainment.

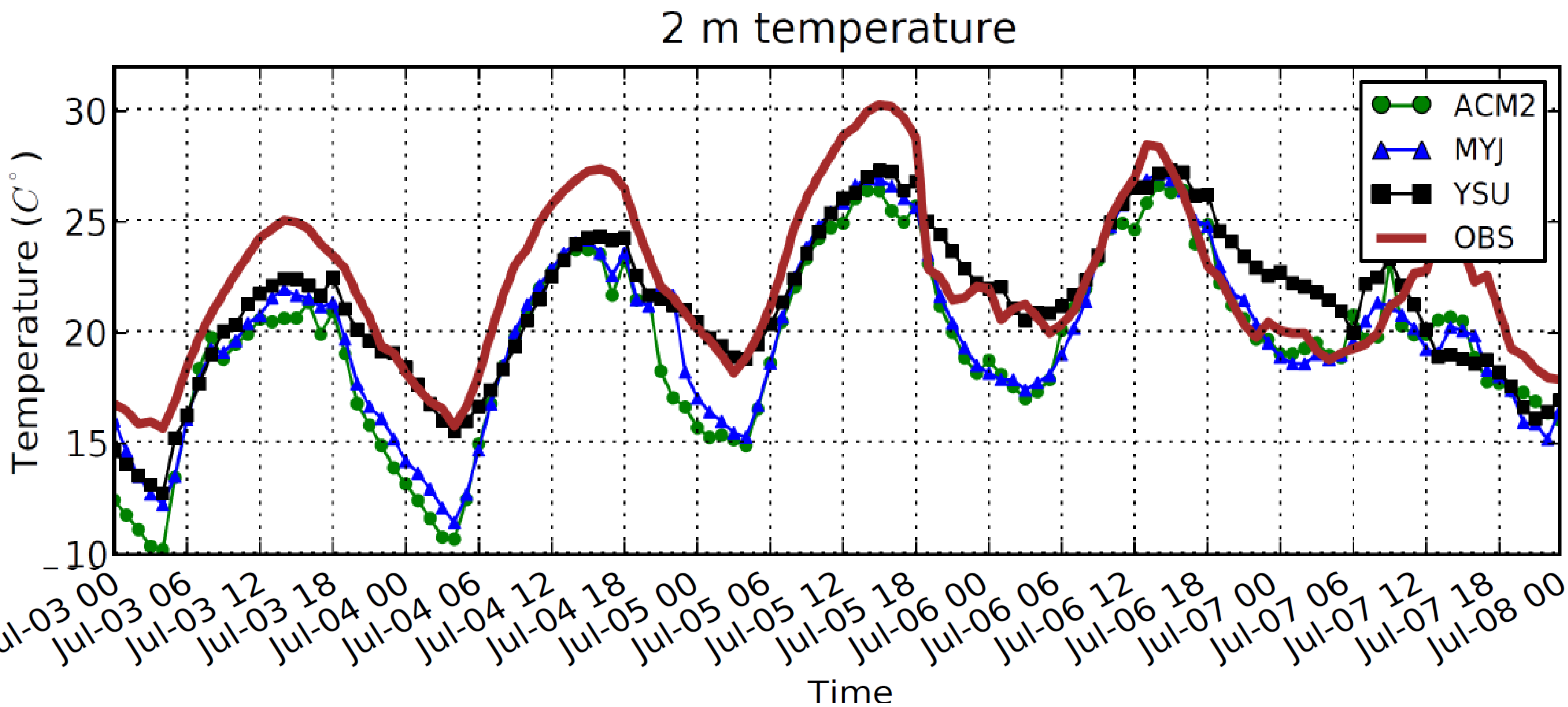
- Entrainment can also be diagnosed looking to the PBL thickness.

- PBL top height and daily cycles show that YSU produces more entrainment, and very similar JJA max. temperatures.



Cabaw data in 4 warm clear-sky days.

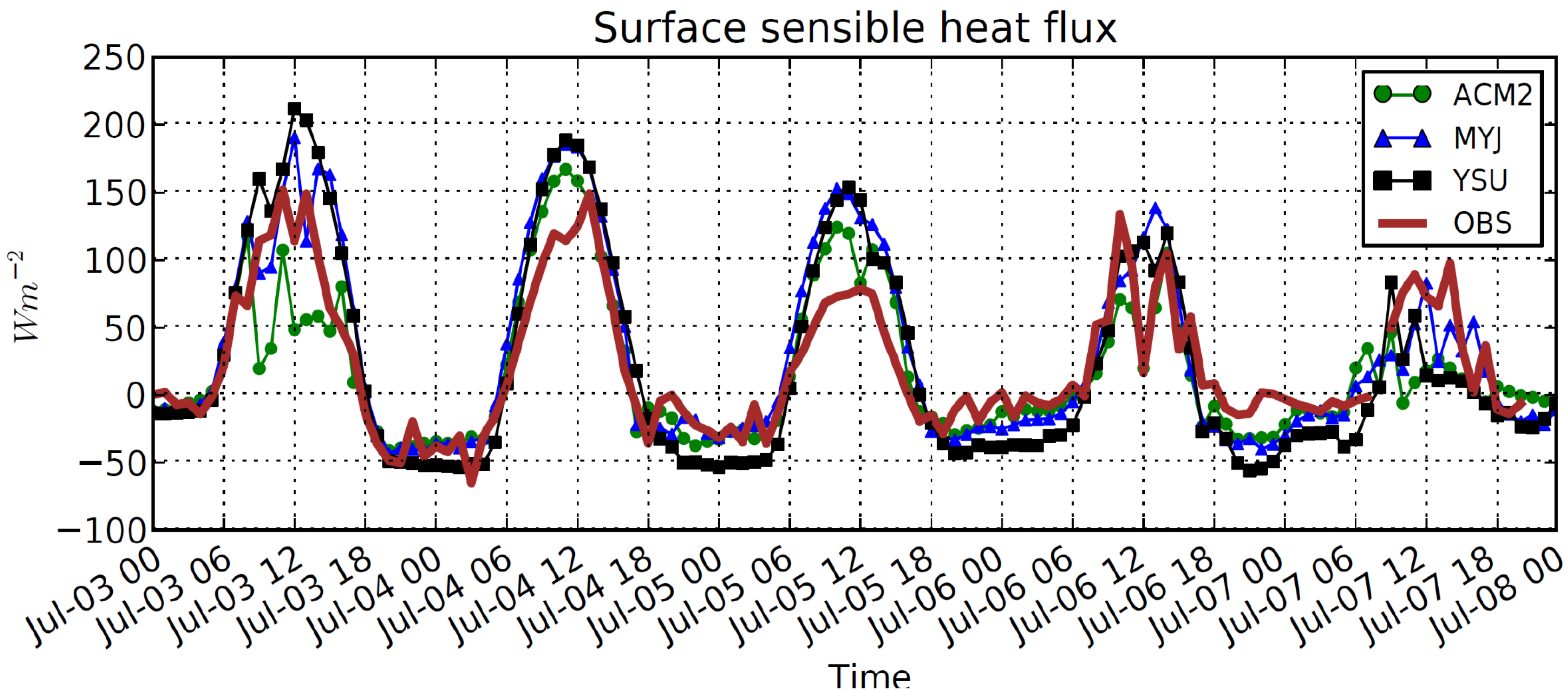
Temperature: The same behaviour already observed when comparing with SYNOPS is shown.



RESULTS

Cabaw data in 4 warm clear-sky days.

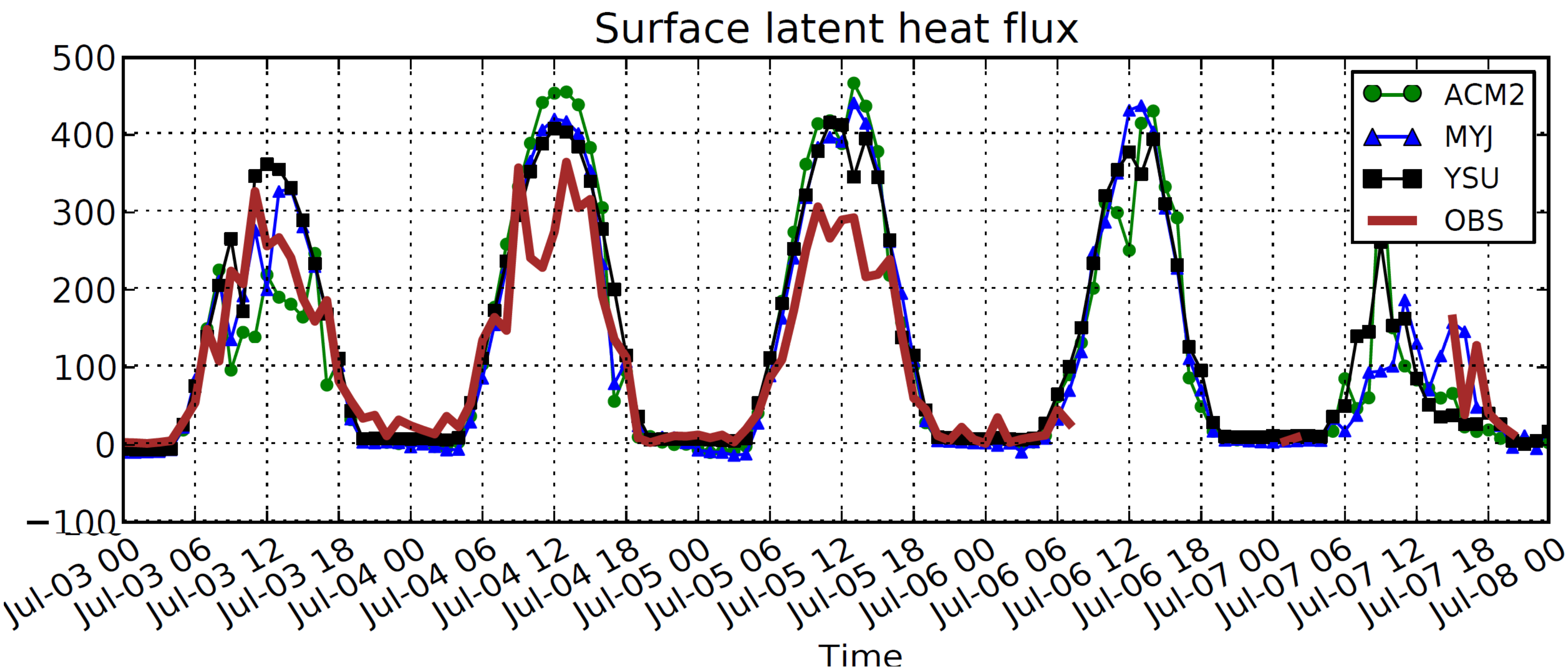
Sensible heat flux is overestimated during daytime.



RESULTS

Cabaw data in 4 warm clear-sky days.

Latent heat flux is also overestimated during daytime.



This errors do not explain the bias → Must be radiative fluxes

CONCLUSIONS

• Summer → Systematic cold bias. Winter → Warm bias appearing in the cold <u>absolute</u> extremes.

• A long term average bias can be masking different biases with different structures and origins. Users must be aware of this when tuning the model.

• Cold bias is not caused by a underestimation of the turbulent mixing/entrainment.

• Bias does not seem to be caused by errors in the surface heat fluxes → Radiation/albedo are suspicious to be causing it.

AKNOWLEDGEMENTS

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Thank you

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Paper to appear in QJRMS,
find it at:

http://www.meteo.unican.es