The climate of the Iberian Peninsula during the last five centuries from a regional climate model perspective

J.J. Gomez-Navarro, J.P. Montavez, S. Jerez, P. Jimenez-Guerrero, J.A. Garcia-Valero, E. Zorita and J.F. Gonzalez-Rouco

Outline

I. Motivation & experiment design

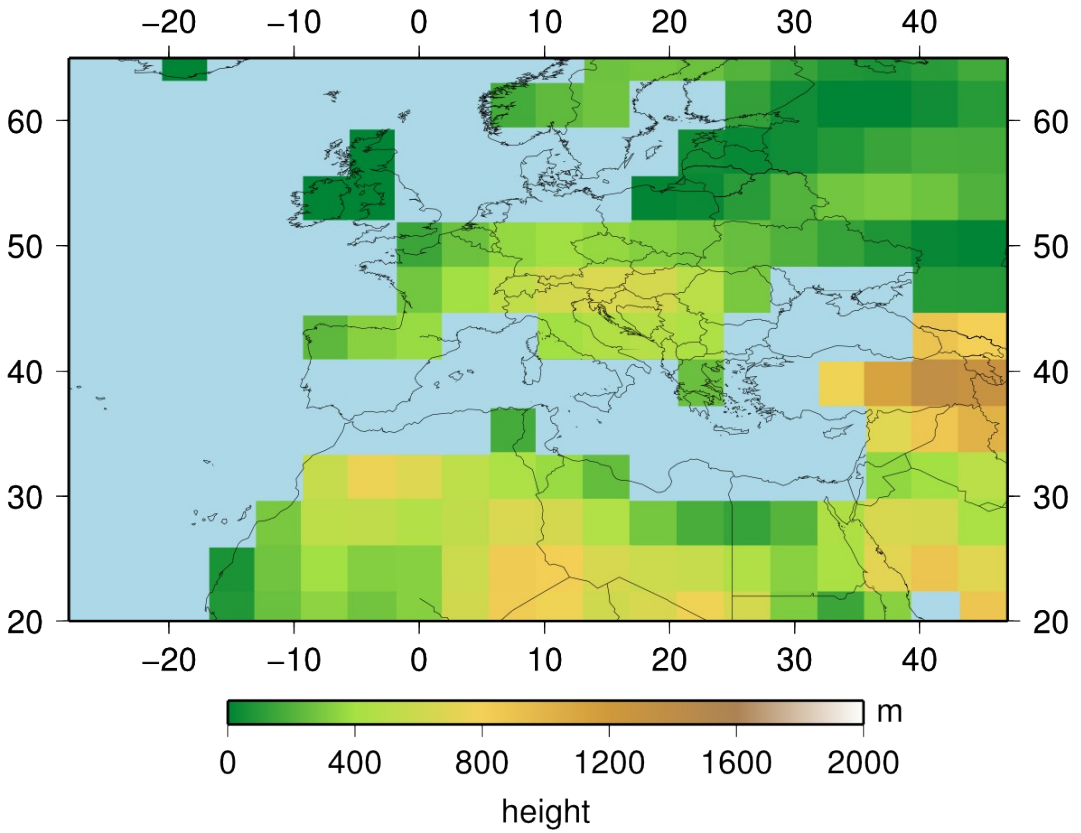
II. Added value by the RCM

III. RCM's climate in the last 500 years

IV. Model vs. Proxy data

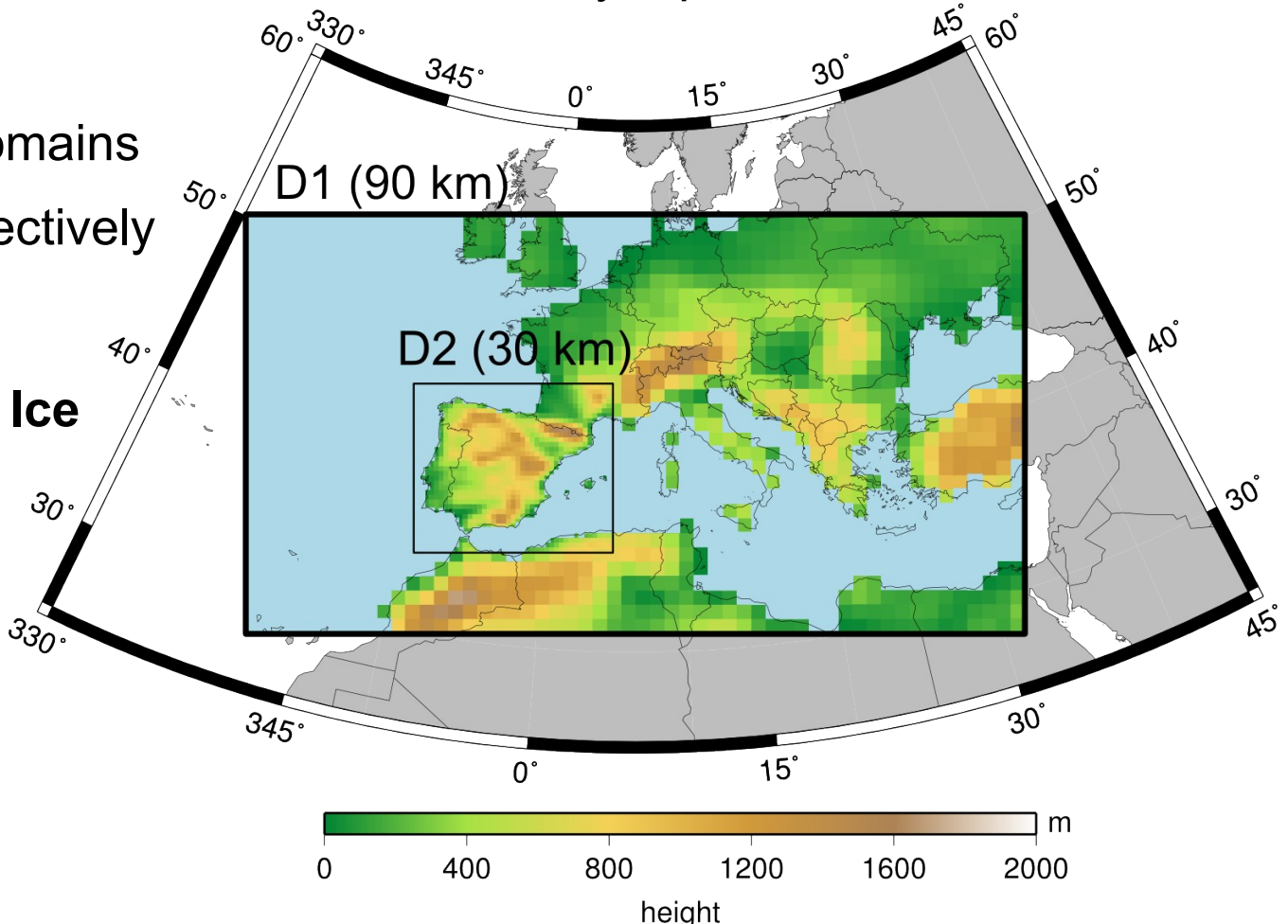
I. Motivation & experiment design: *GCM simulation*

- The regional simulation is driven by **ECHOG**, whose external forcings are GHG concentration, evolution of solar constant and the effect of big volcano events
- Due to the computation costs involved in a GCM simulation, the spatial resolution has to be coarse
- GCMs are not able to reproduce **local climates**. This may difficult the comparison between models and proxy data



I. Motivation & experiment design: *MM5 nested to ECHOG*

- To solve this problem, a dynamic downscaling process has been performed for a climate period (1501-1990) with a climate version of MM5
- The regional experiment has been forced exactly equal to the GCM simulation
- Two 2-way nested domains of 90 and 30 km respectively
- Physics options:
  - Microphysic: **Simple Ice**
  - Cumulus: **Grell**
  - PBL: **MRF**
  - Radiation: **RRTM**
  - ***Noah LSM***



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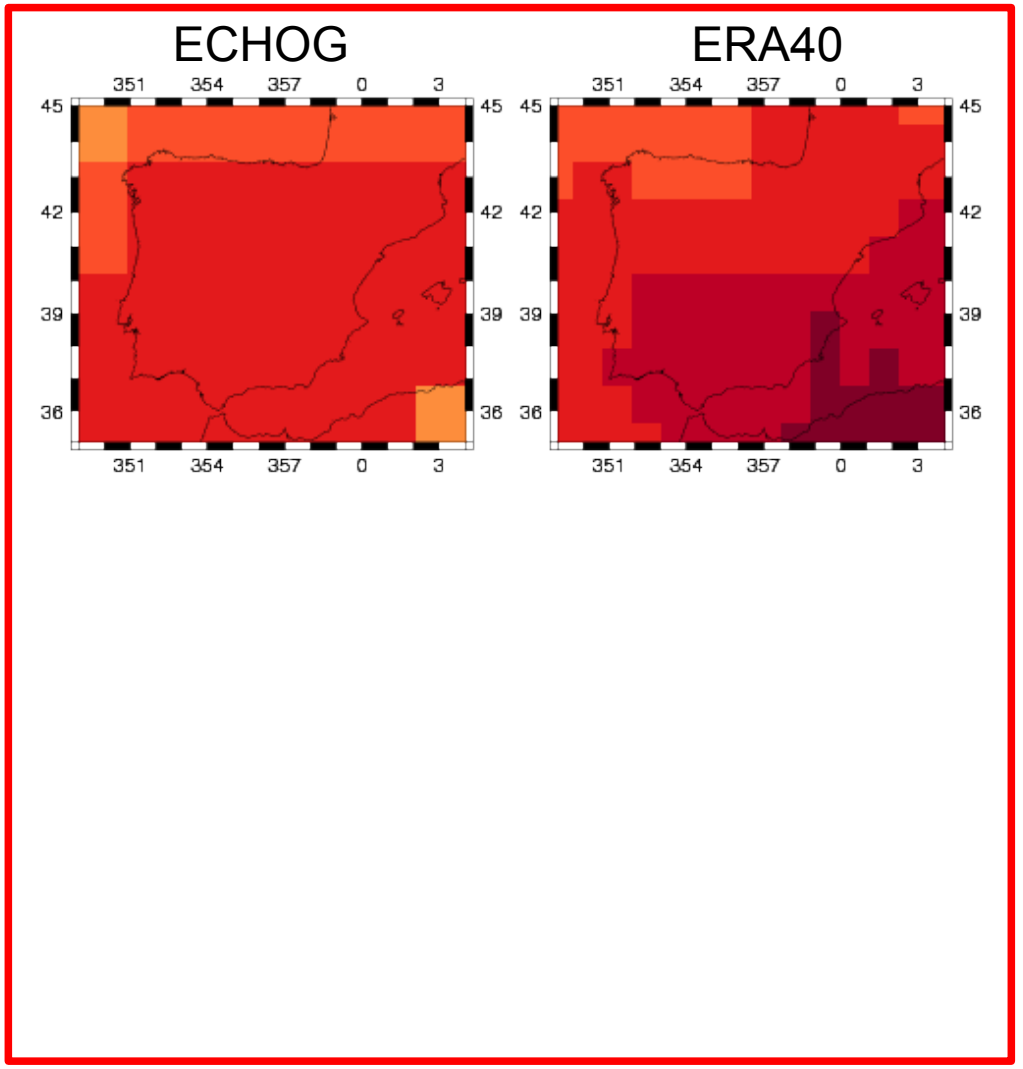
II. Added value: *ECHOG vs. ERA40 dynamic downscaling*

- In order to asses the skill of the dynamic downscaling process, an analogous downscaling using ERA40 as boundary condition has been performed for comparing purposes
- It has been shown in previous work that this reanalysis regionalization process reproduces accurately the climatology in the Iberian Peninsula (IP)
- The comparison has been carried out in the period **1961-1990**

II. Added value: *T2M seasonal climatologies (1961-1990)*

Climatologies for both GCM differ (as it could be expected)...

Summer



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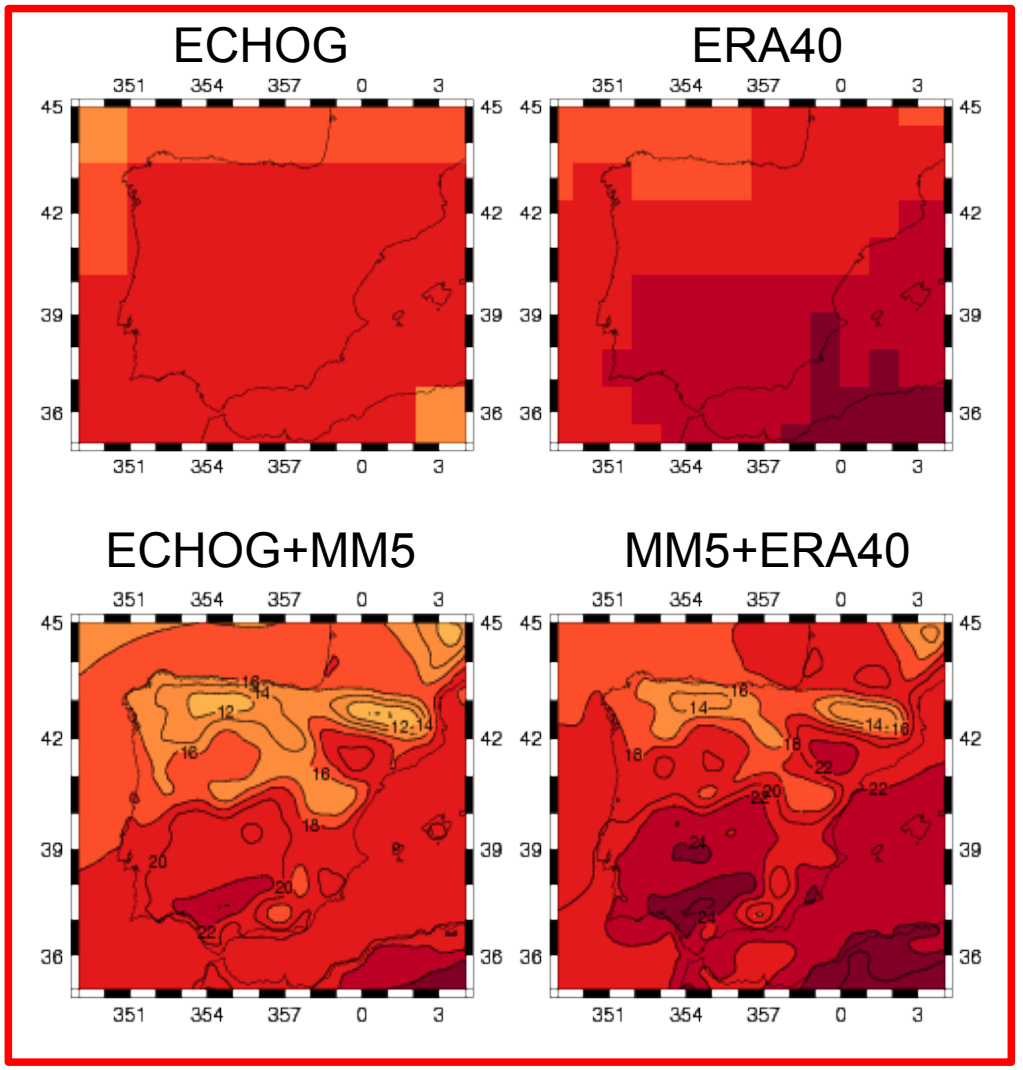
… but this is corrected in the downscaling (spatial correlation 0.95)



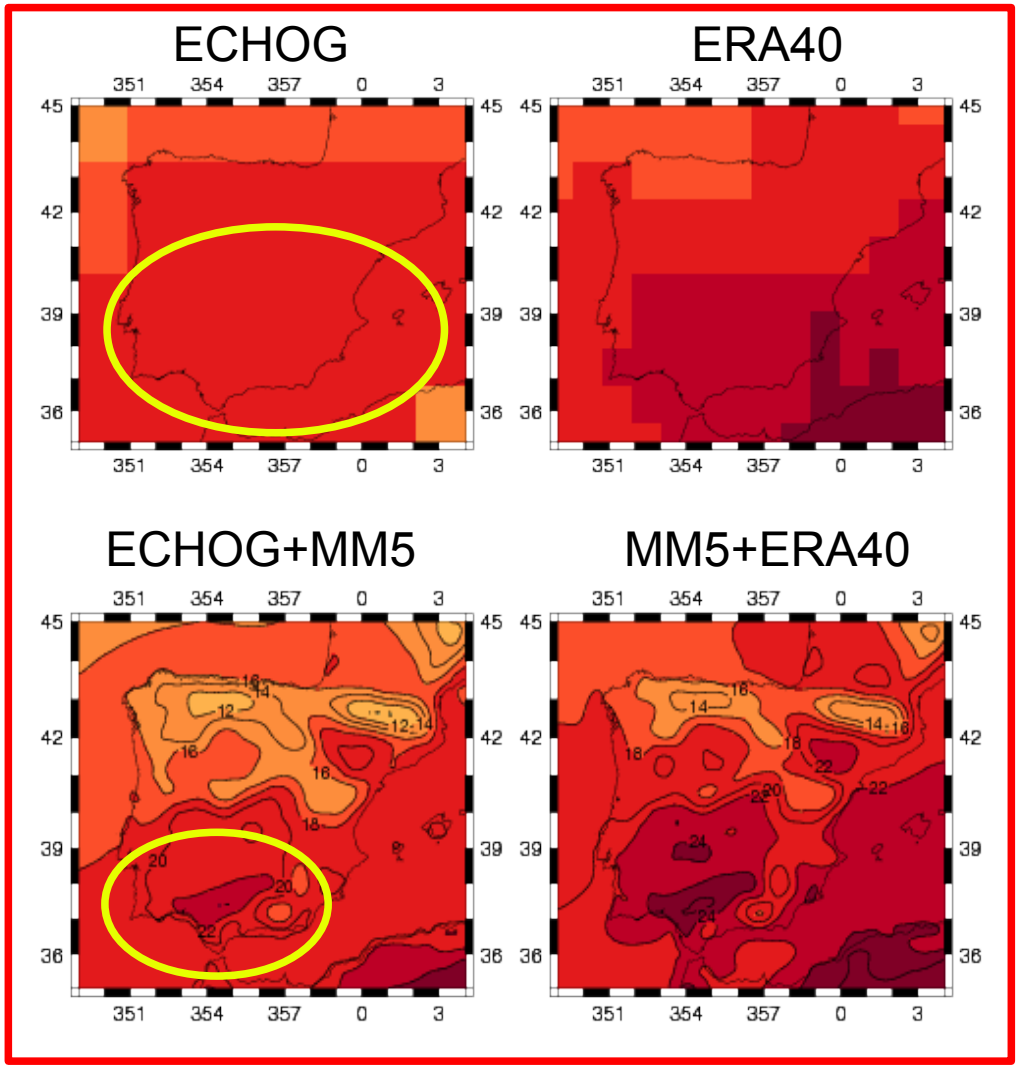
II. Added value: *T2M seasonal climatologies (1961-1990)*

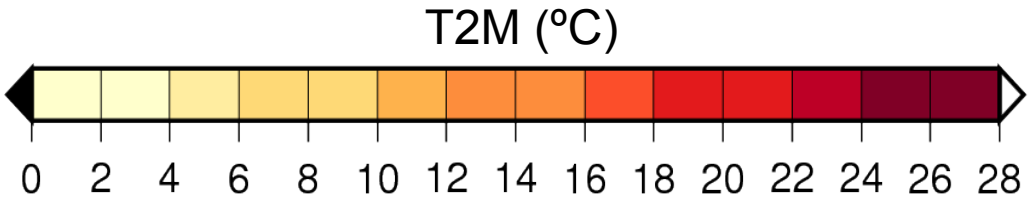
Climatologies for both GCM differ (as it could be expected)...

… but this is corrected in the downscaling (spatial correlation 0.95)

Nevertheless, ECHOG **summers are too cold**, and MM5 is not able to correct it completely

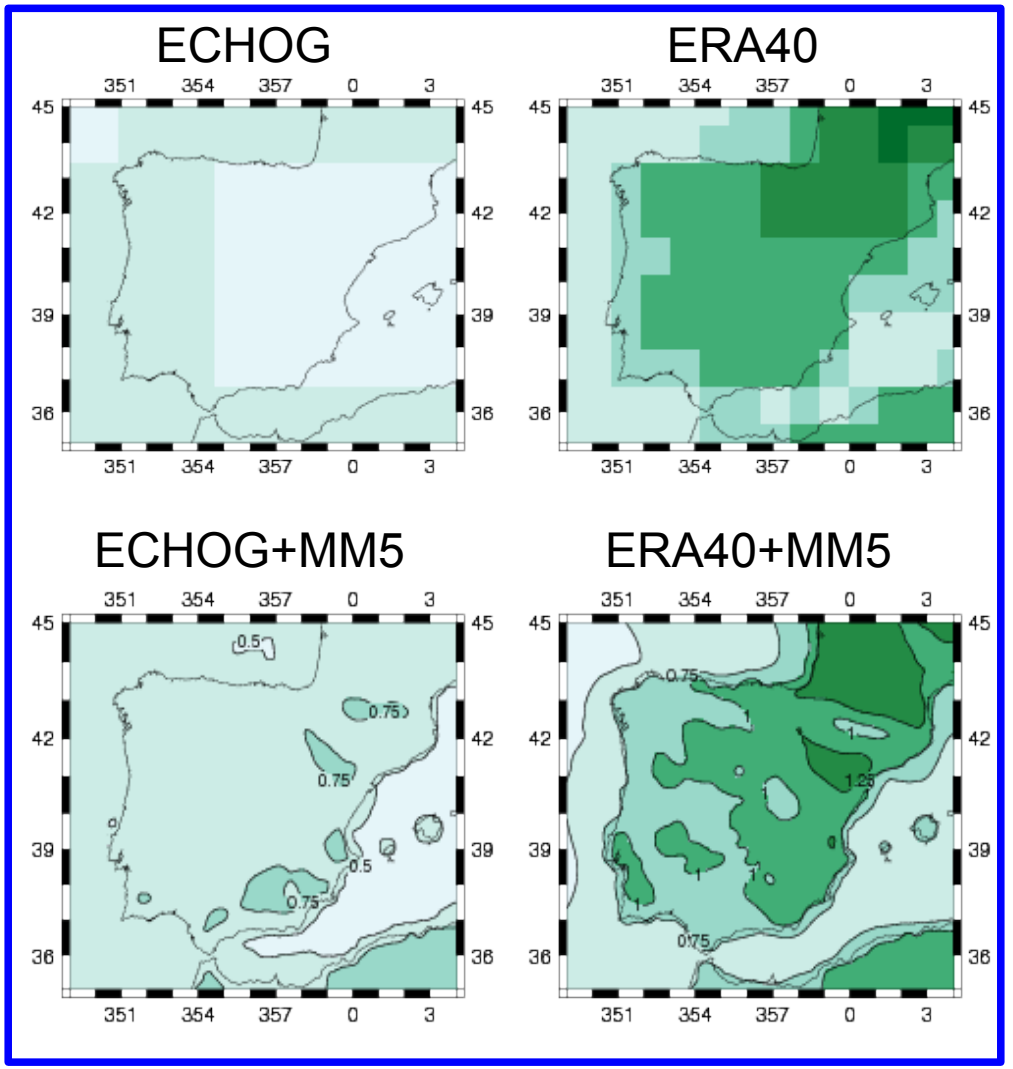
Summer





II. Added value: *T2M seasonal variability (1961-1990)*

Winter



T2M winter variability is underestimated in ECHOG for the control period.

The downscaling process increases the variability over the domain in **high areas**

T2M stand. Deviation (ºC)

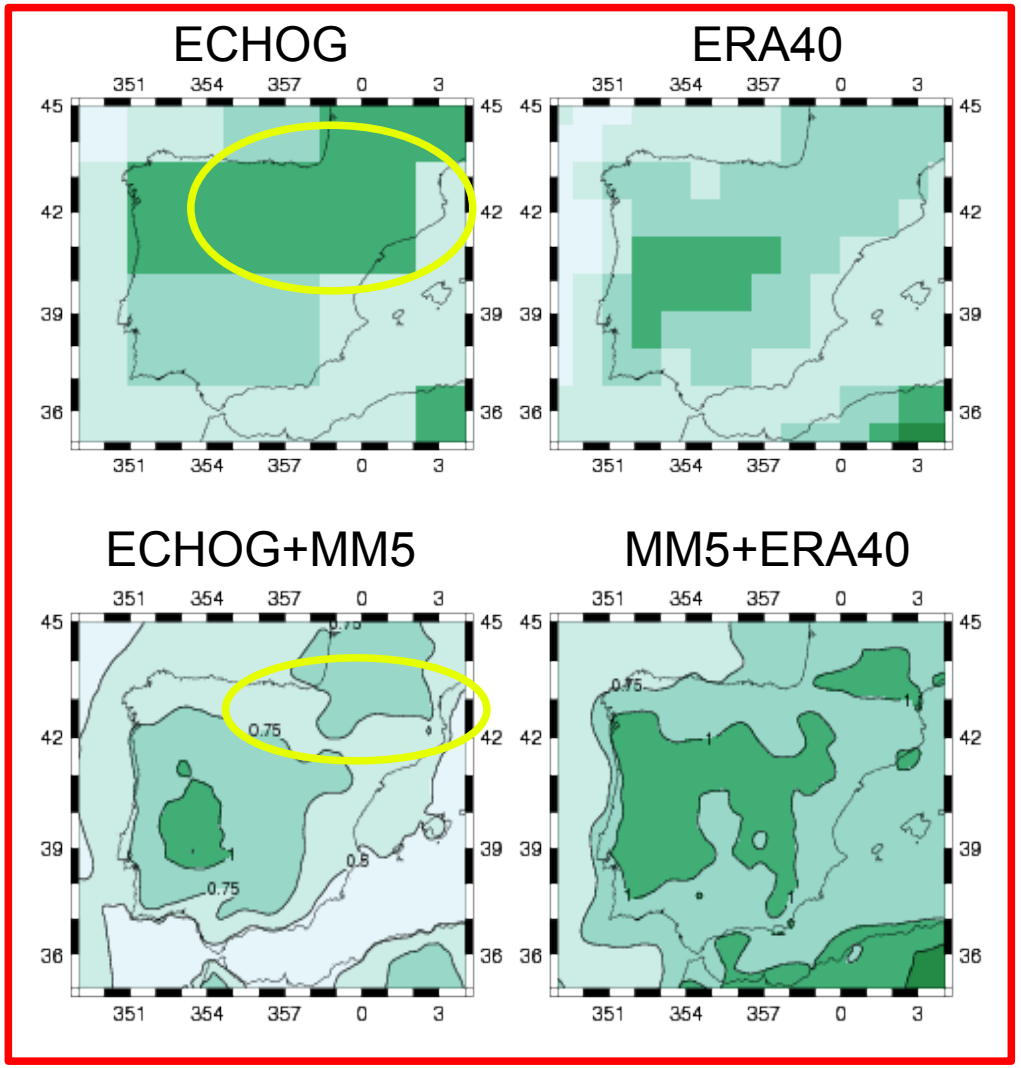
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00

II. Added value: *T2M seasonal variability (1961-1990)*

Nevertheless ECHOG overestimates the variability in the northern IP

In this case, MM5 **reduces the variability**, according to the climatology developed in the reanalysis simulation

Summer



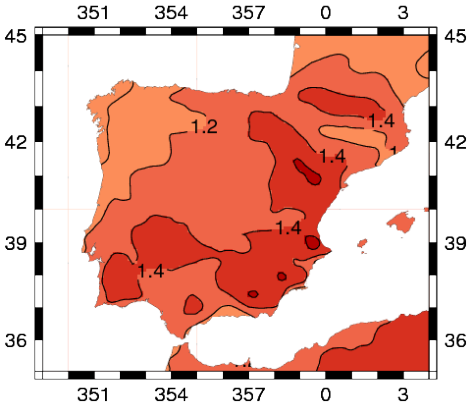
T2M stand. Deviation (ºC)

0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00

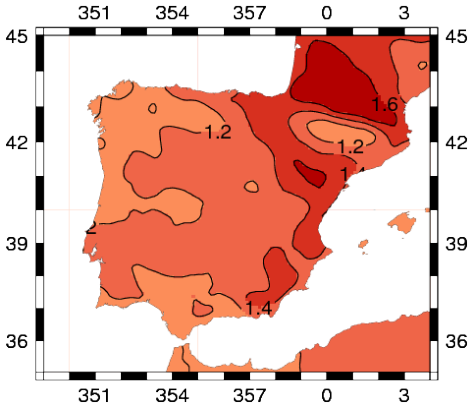
II. Added value: *T2M main variability modes (1961-1990)*

EOF1 Winter

ECHOG (78,93%)

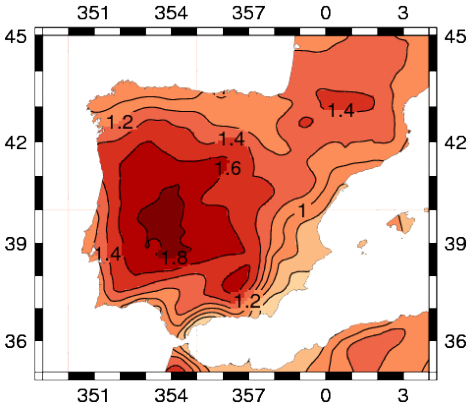


ERA40 (87,01%)

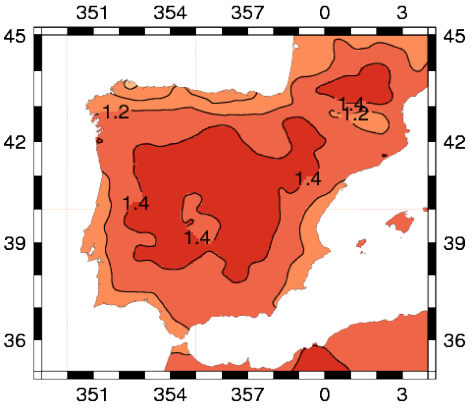


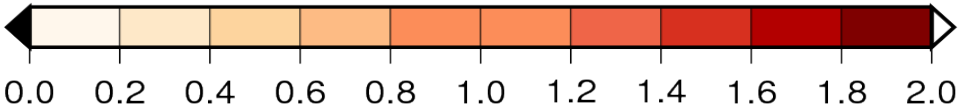
EOF1 Summer

ECHOG (79,68%)



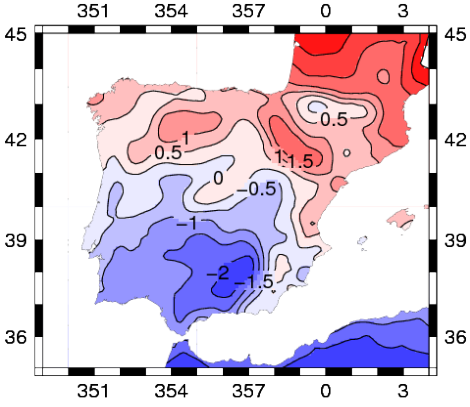
ERA40 (79,73%)



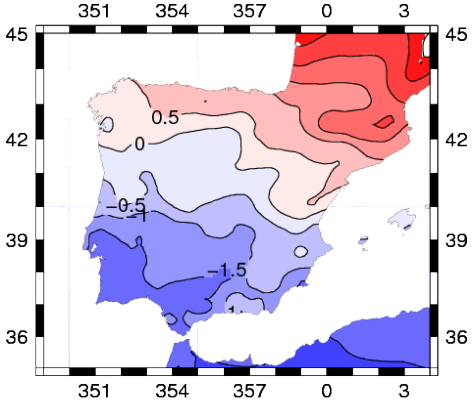


EOF2 Winter

ECHOG (7,39%)

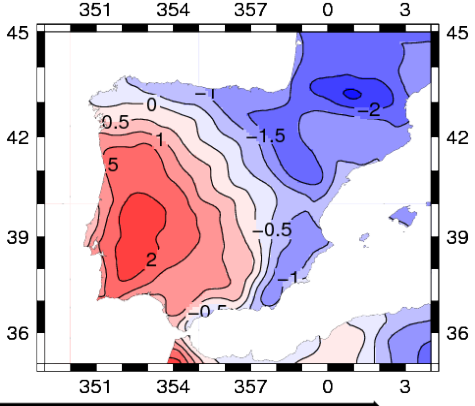


ERA40 (7,89%)

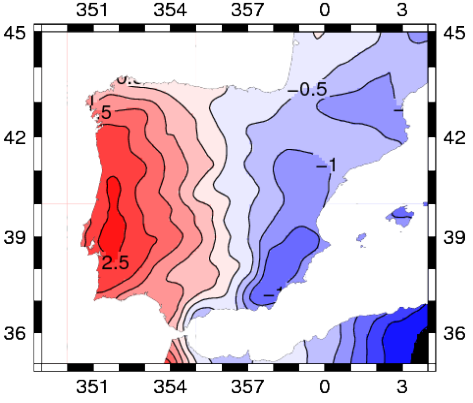


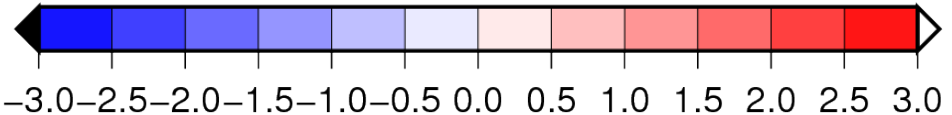
EOF2 Summer

ECHOG (10,12%)



ERA40 (9,86%)





II. Added value: *Conclusions*

- The regional downscaling process is able to **narrow the different climatologies** developed by ECHOG and ERA40 for the same period
- Not only climatologies, but also main variability modes are similar in both regionalization experiments
- This suggests an improved reconstruction of **physical processes** in the ECHOG+MM5 simulation over the IP

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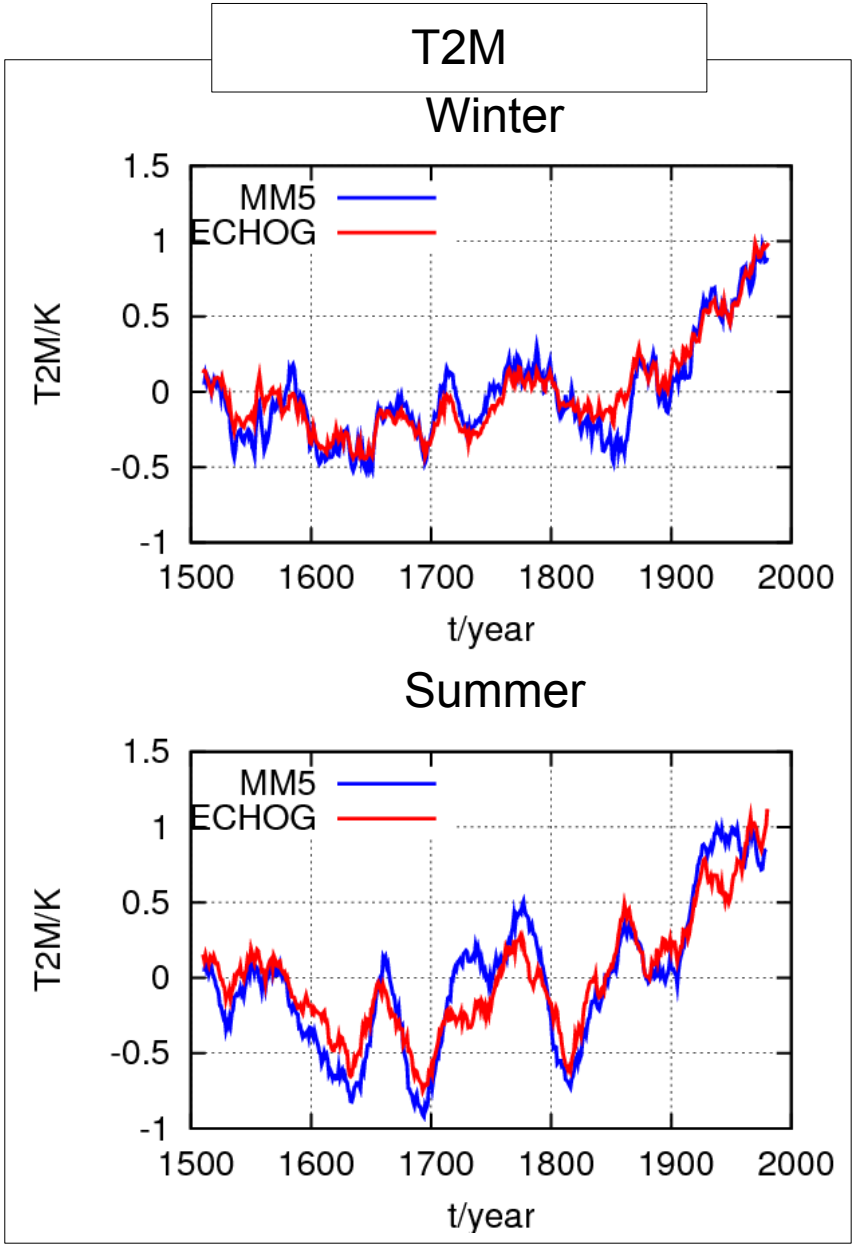
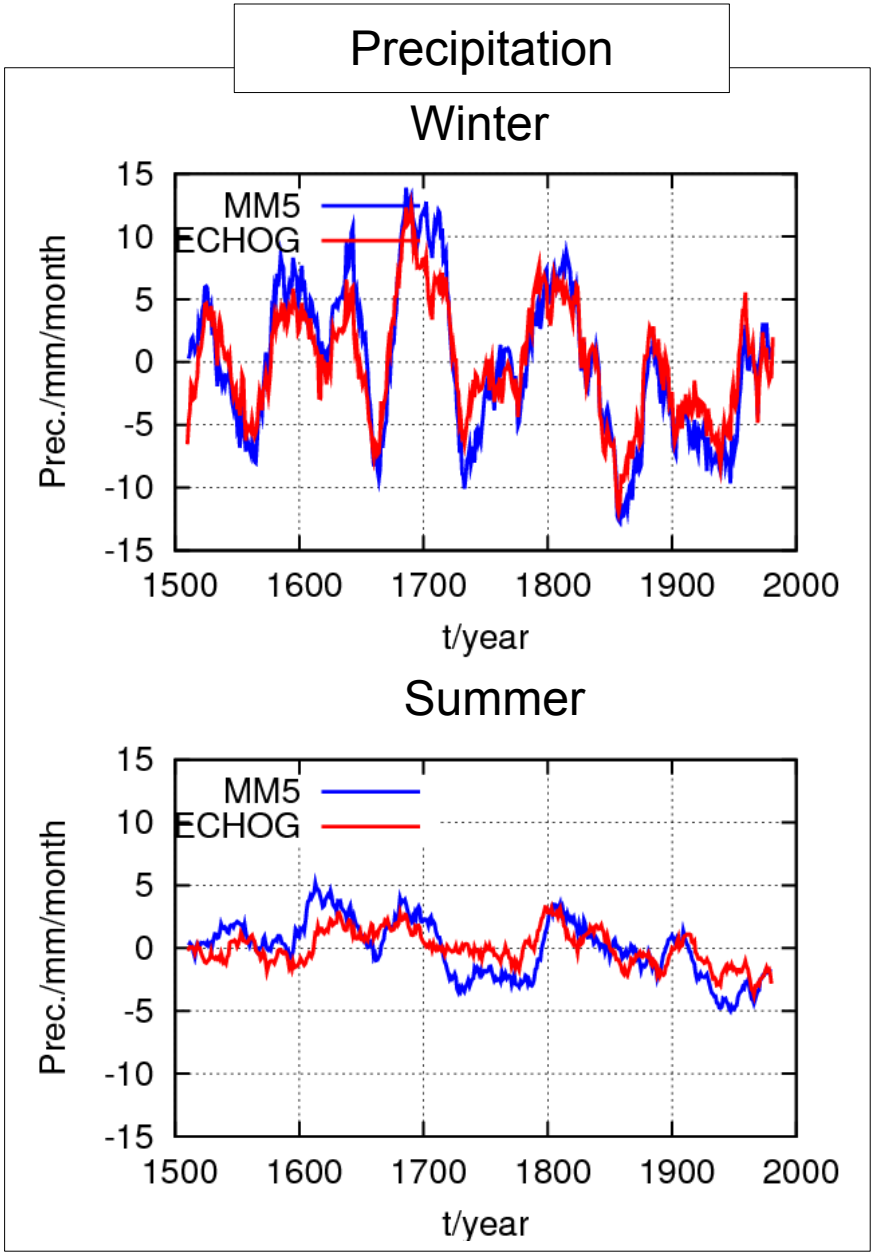
III. Last 500 years climatology: *IP anomaly series (1501-1990)*

- There exist general agreement between the RCM and GCM.





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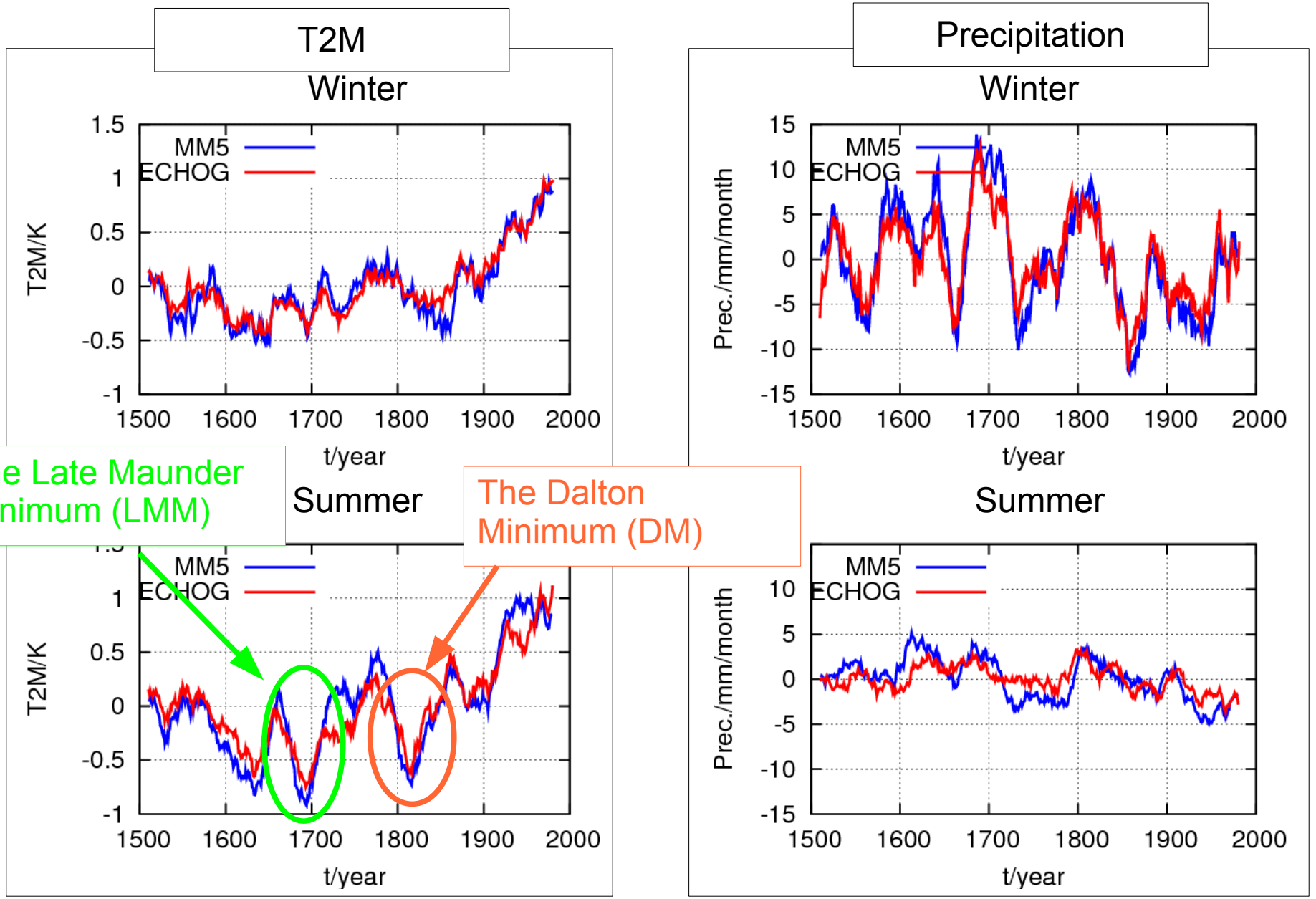
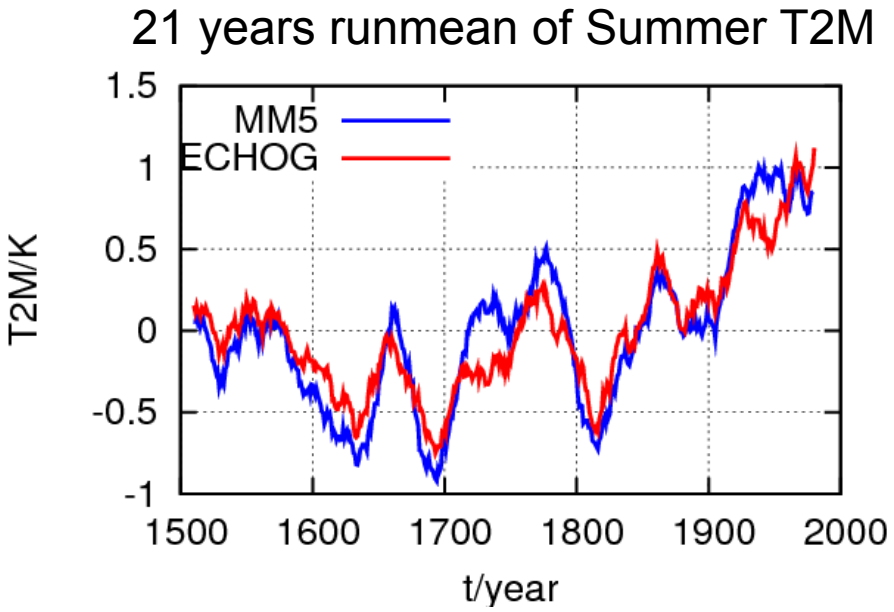


III. Last 500 years climatology: ***Cold summer periods***

- But main differences appear at regional scales
- Anomalies calculated respect **1501-1990**



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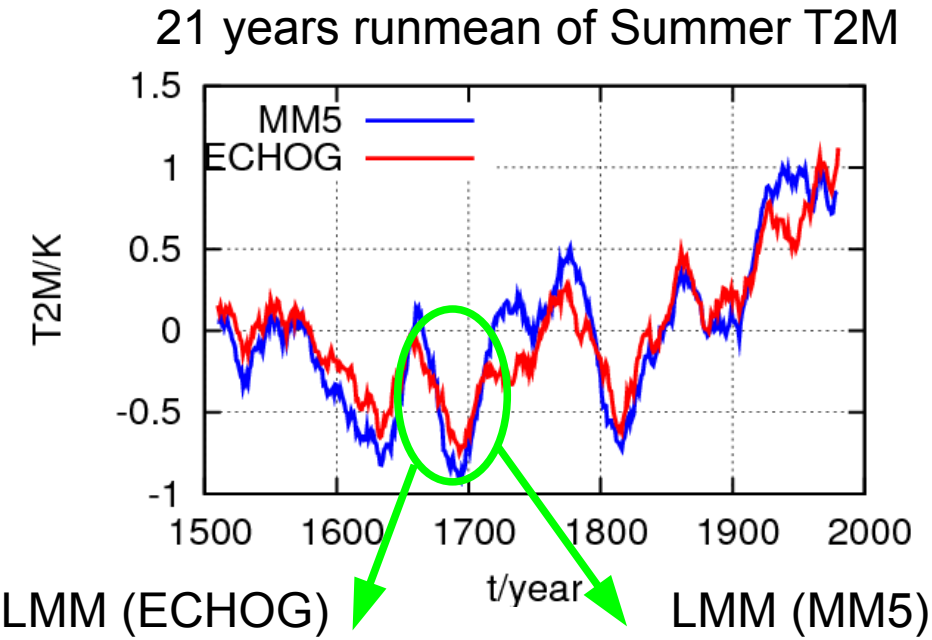

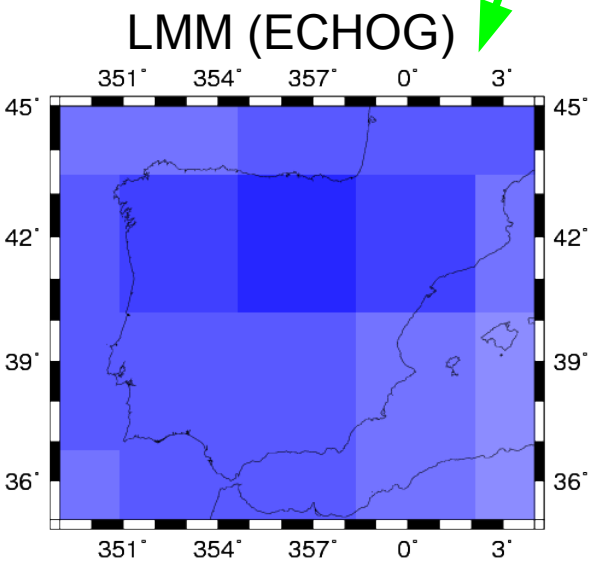

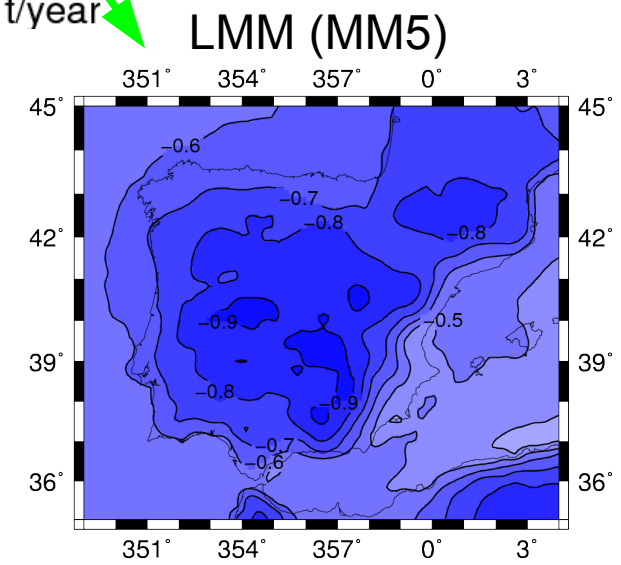

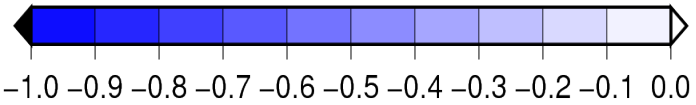

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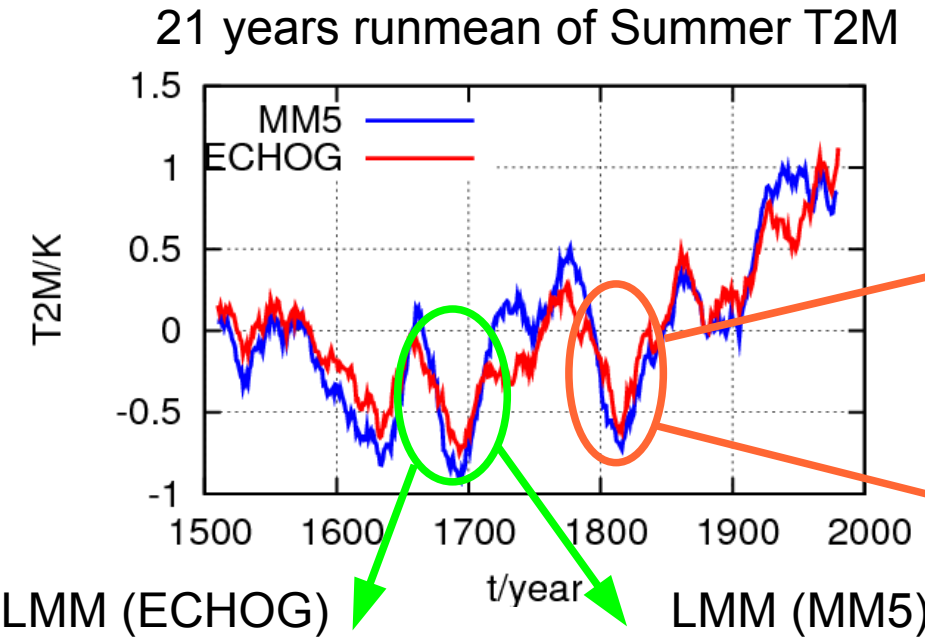
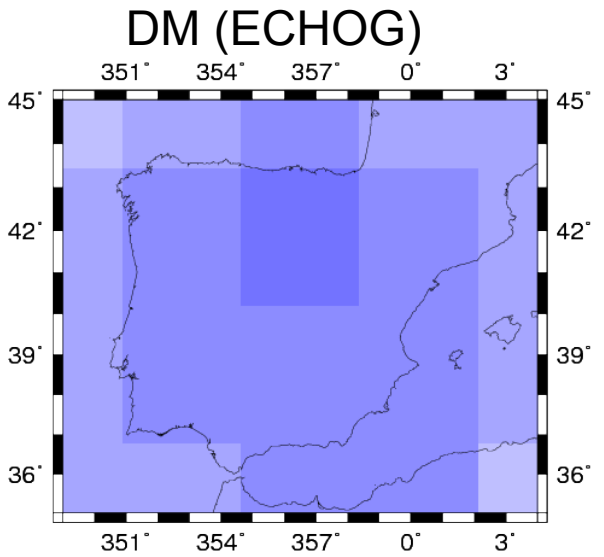
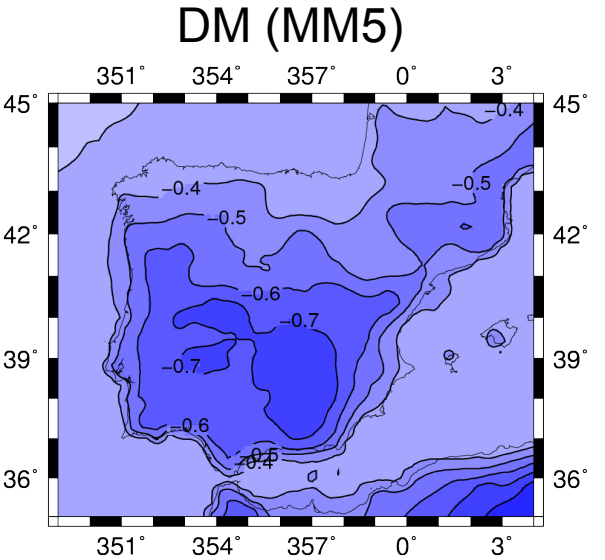
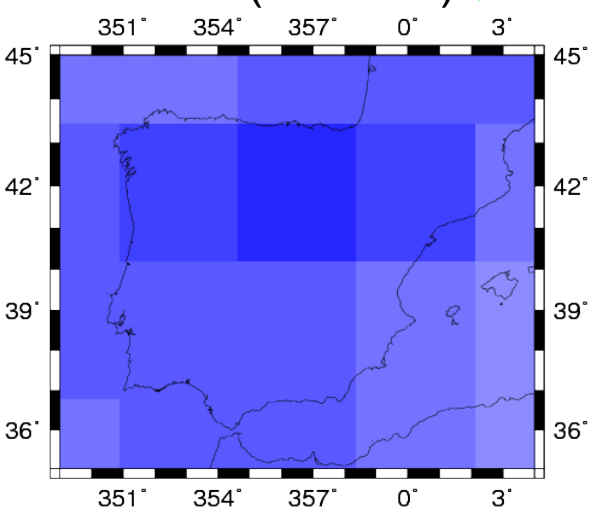
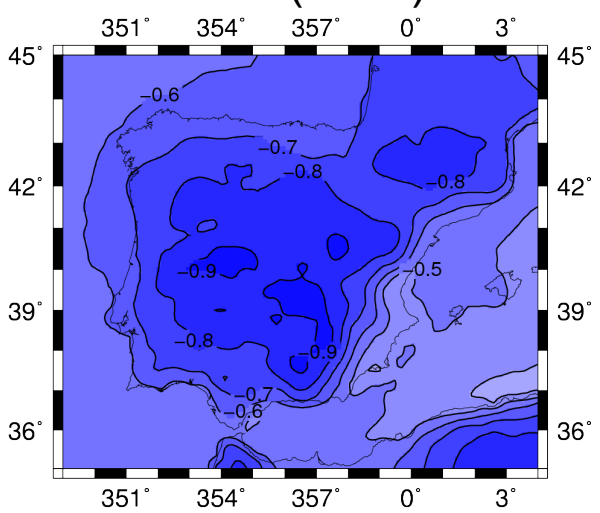
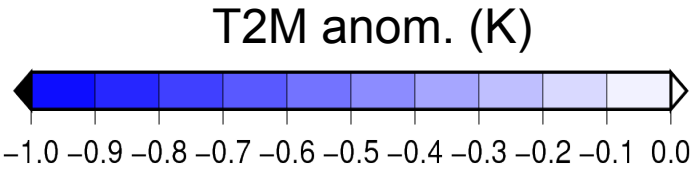






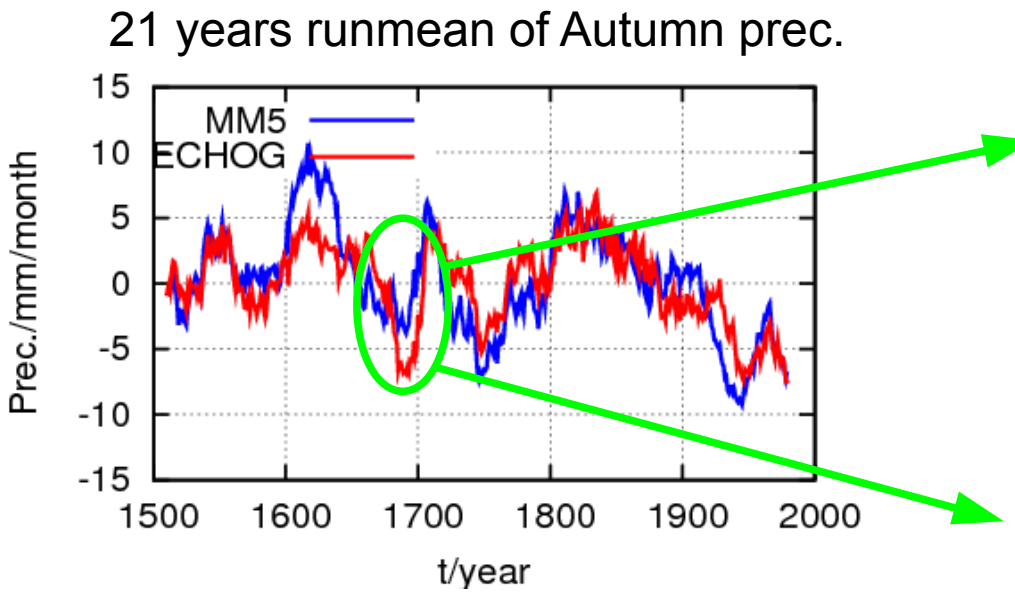


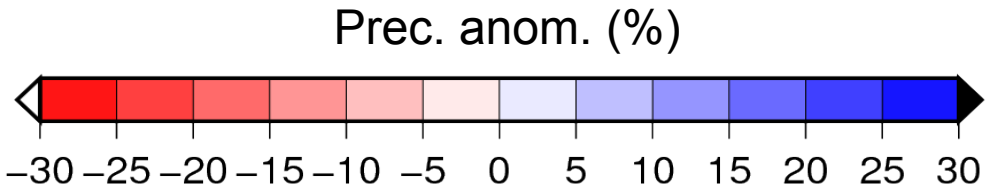


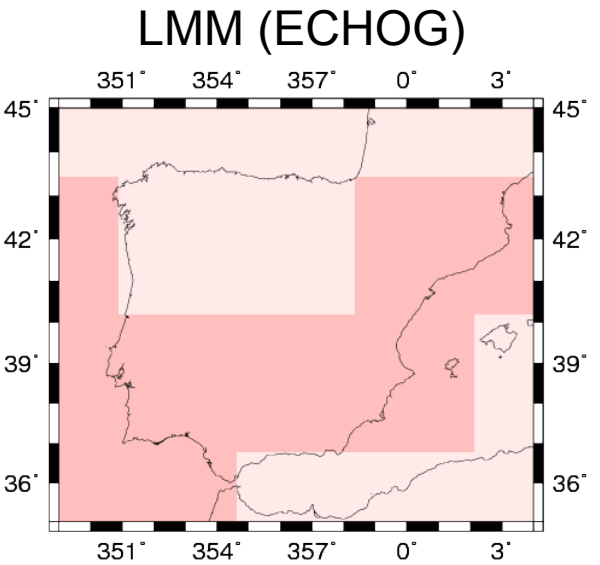


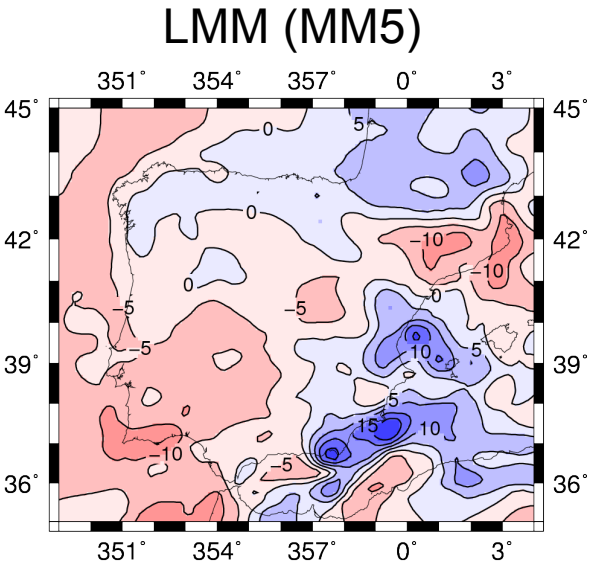
III. Last 500 years climatology: ***Precipitation discrepancy***

- Precipitation anomalies at regional scales shows different sign respect to the global model
- This may be due to the better characterization of the terrain in MM5
- Anomalies calculated respect **1501-1990**









III. Last 500 years climatology: ***Conclusions***

- Some well known historical cold periods such as the Maunder Minimum (1675-1710) are reproduced in warm seasons in both the GCM and the RCM simulation
- Although mean series for both simulations are similar, important differences appear when looking at spatial distribution
- These differences could be linked to an improved characterization of the terrain and the physical processes in the regional simulation

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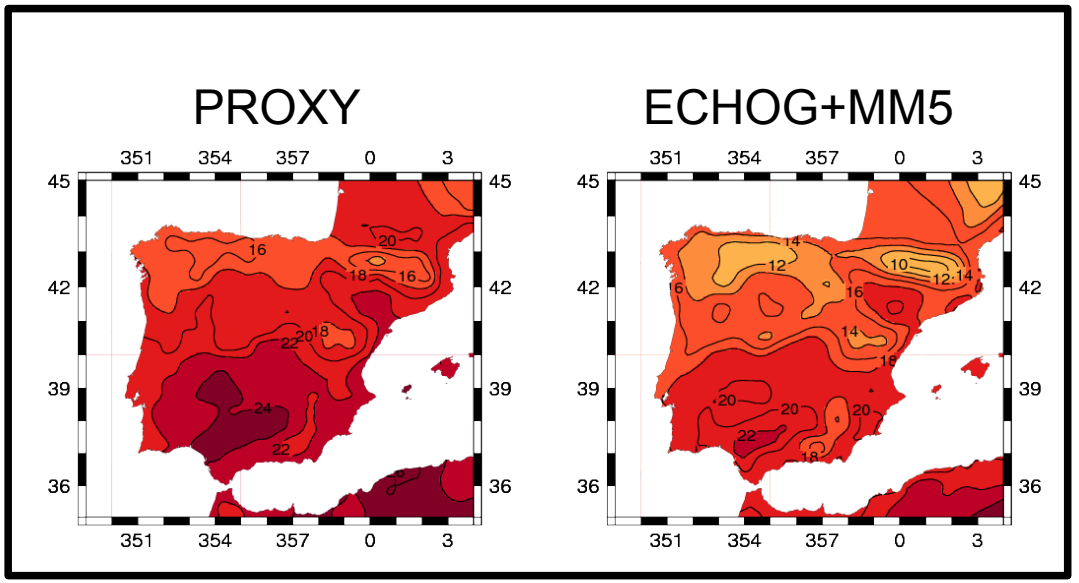
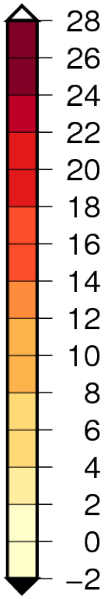
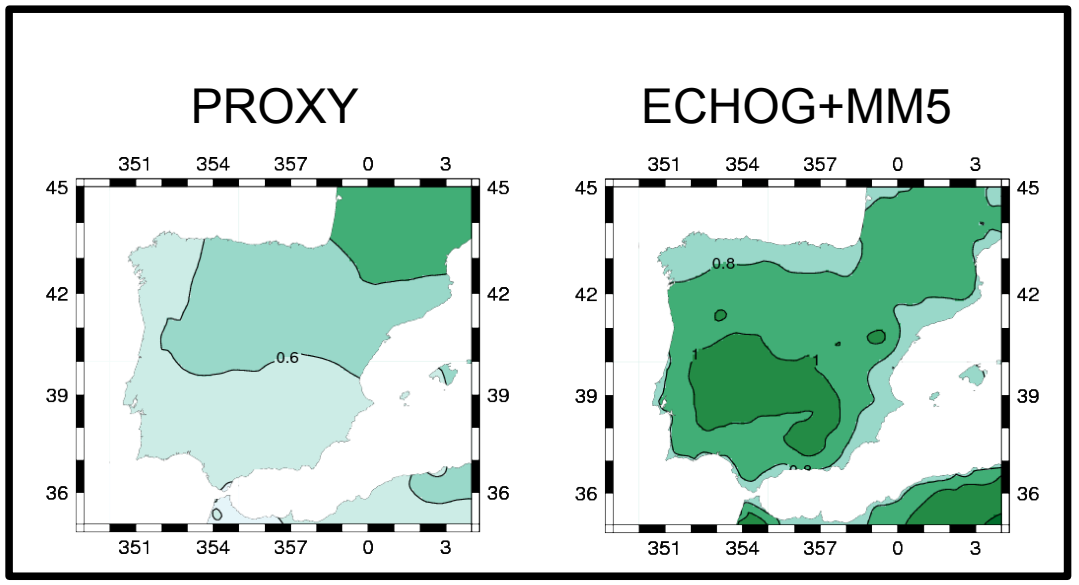
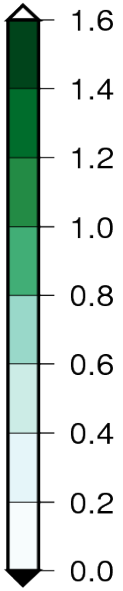
IV. Model vs. Proxy data

IV. Model vs. Proxy data: *Summer T2M climatologies (1501-1990)*







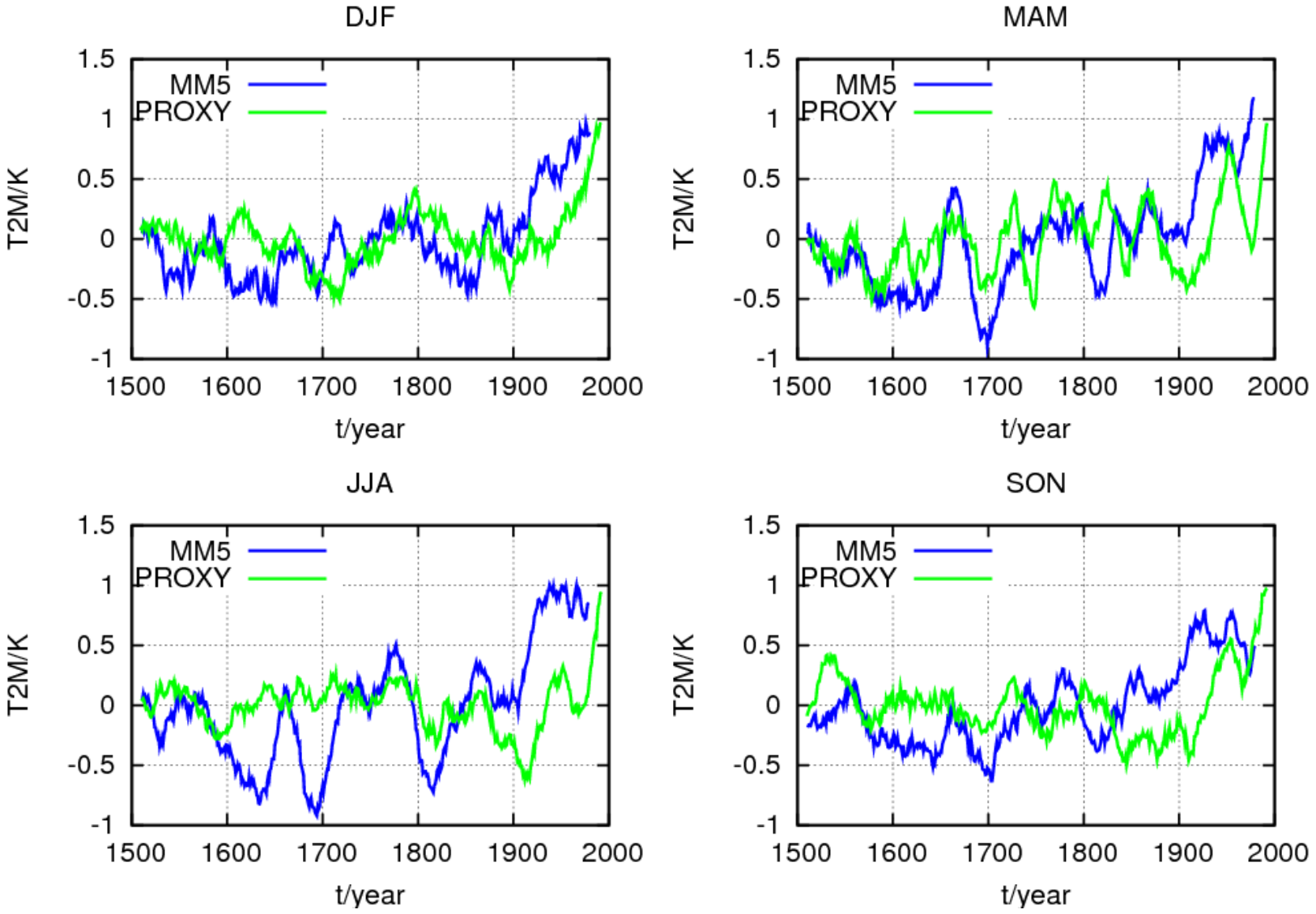


T2M dataset

- J. Luterbacher et al. 2004
- Period: 1501-1990
- Window: 25W-40E / 30N/70N
- Spatial resolution: 0.5º x 0.5º (land points)
- Temporal resolution: seasonal

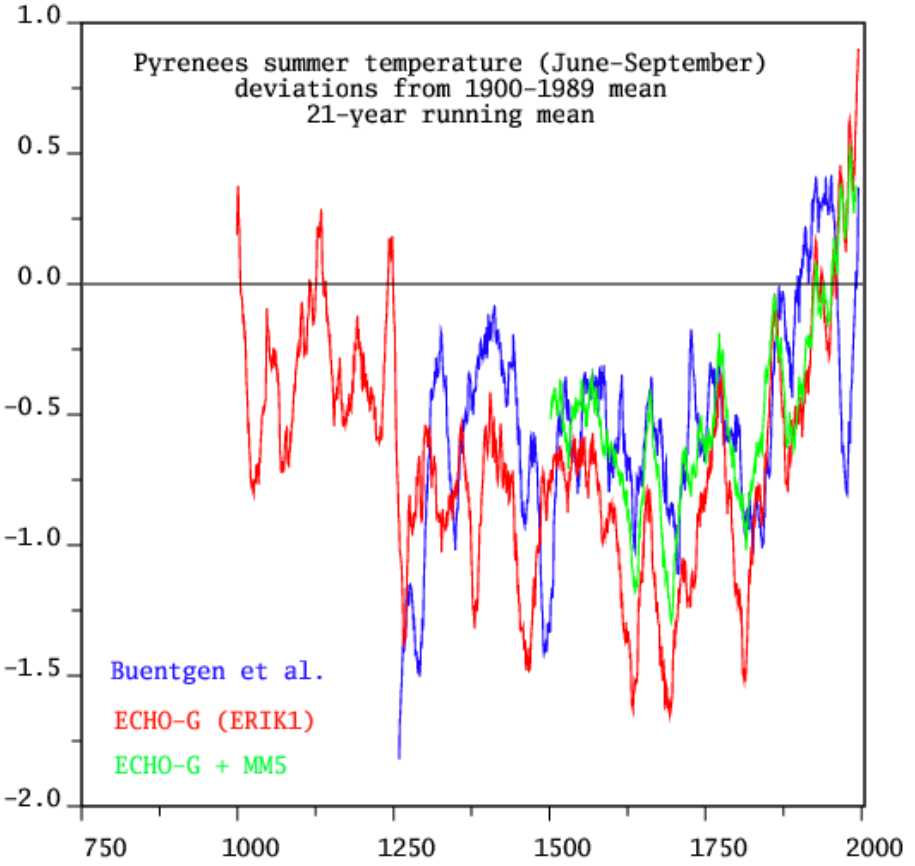
IV. Model vs. Proxy data: *Temperature series*

- Less agreement there exists in the temporal domain



IV. Model vs. Proxy data: *Temperature series in Pyrenees*

- On the other hand, another comparison between the regional simulation and proxy data from tree rings Buentgen et al. (2008) in the **Pyrenees** show good temporal agreement



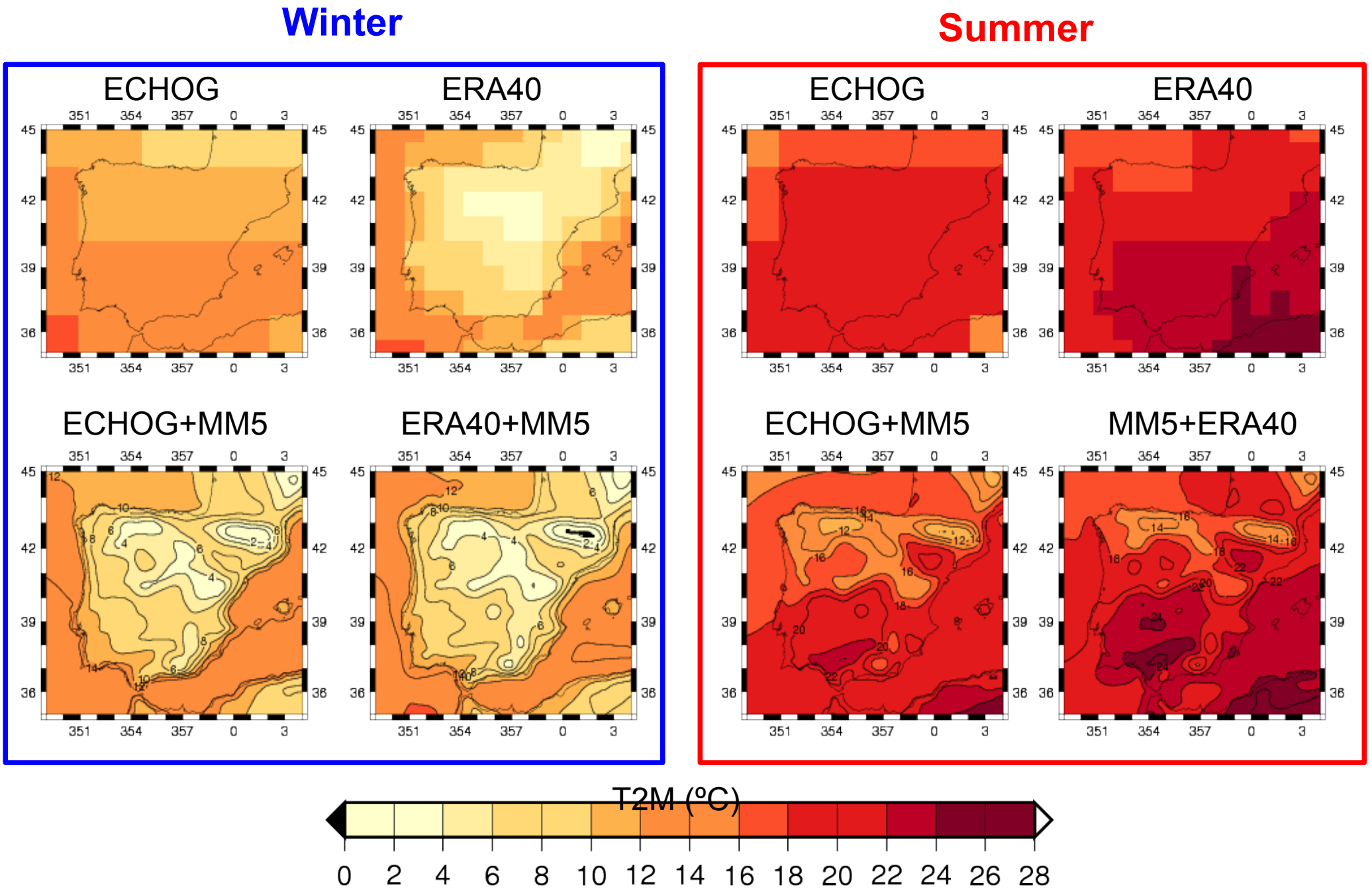
IV. Model vs. Proxy data: ***Conclusions***

- Some preliminary comparatives with proxy data shows relatively good agreement in the spatial structure and variability of T2M and precipitation.
- No so good agreement may be found when looking at the temporal series
- Great temporal agreement may be found between the regional model and some tree ring reconstructions in the Pyrenees.

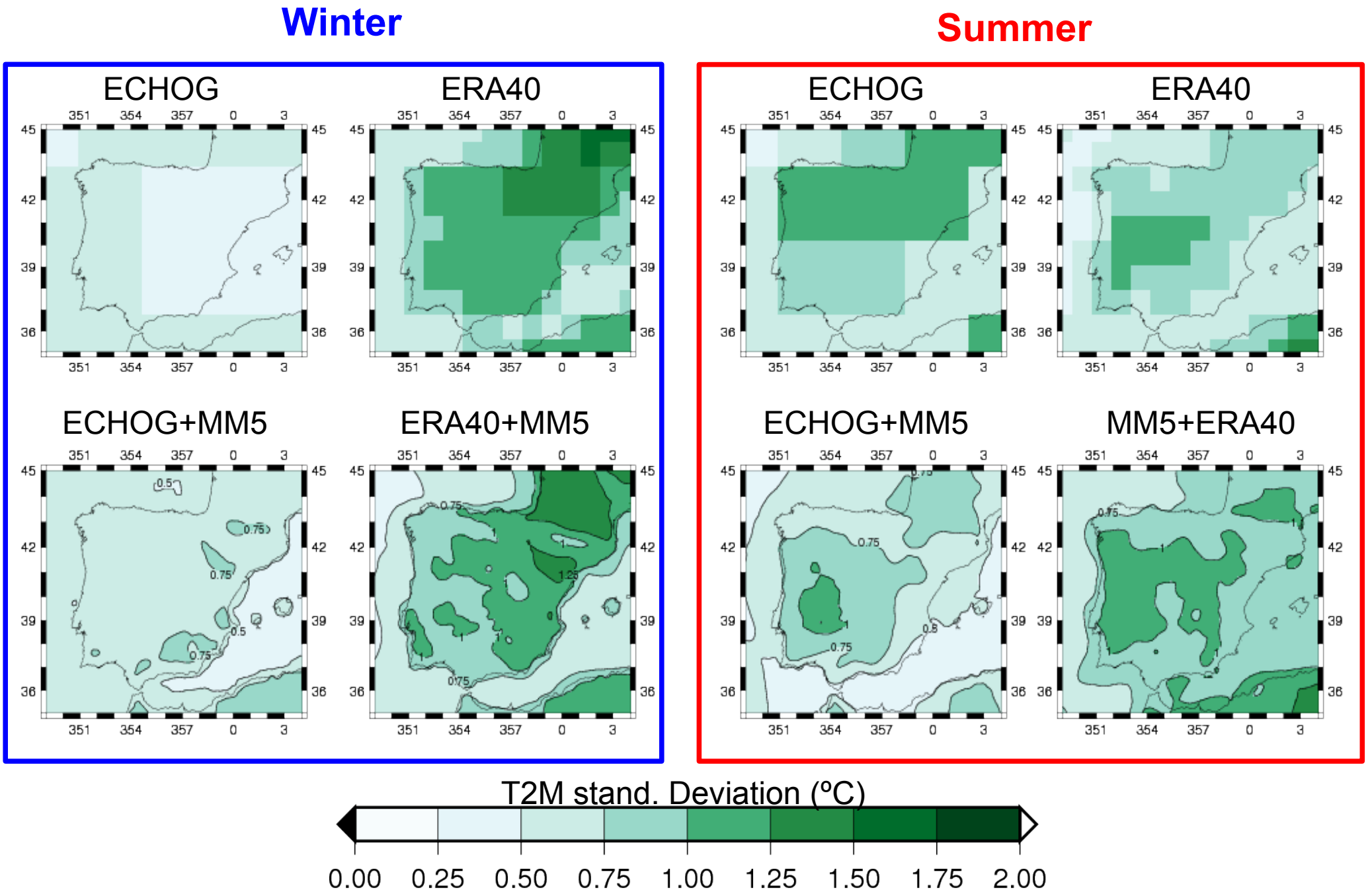
V. Conclusions: ***Thank you***

Thank you for your attention

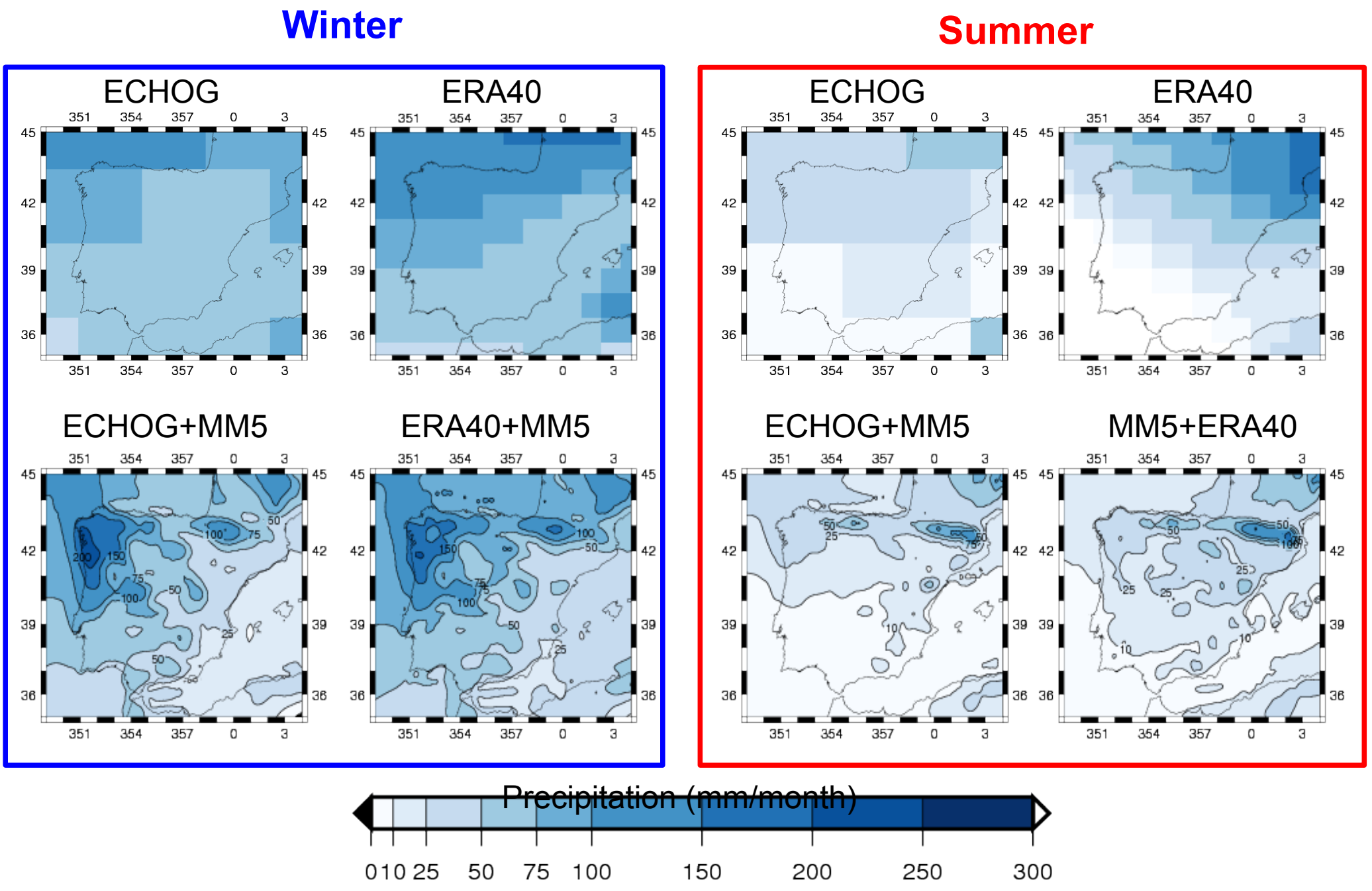
III. Added value: *T2M climatologies*



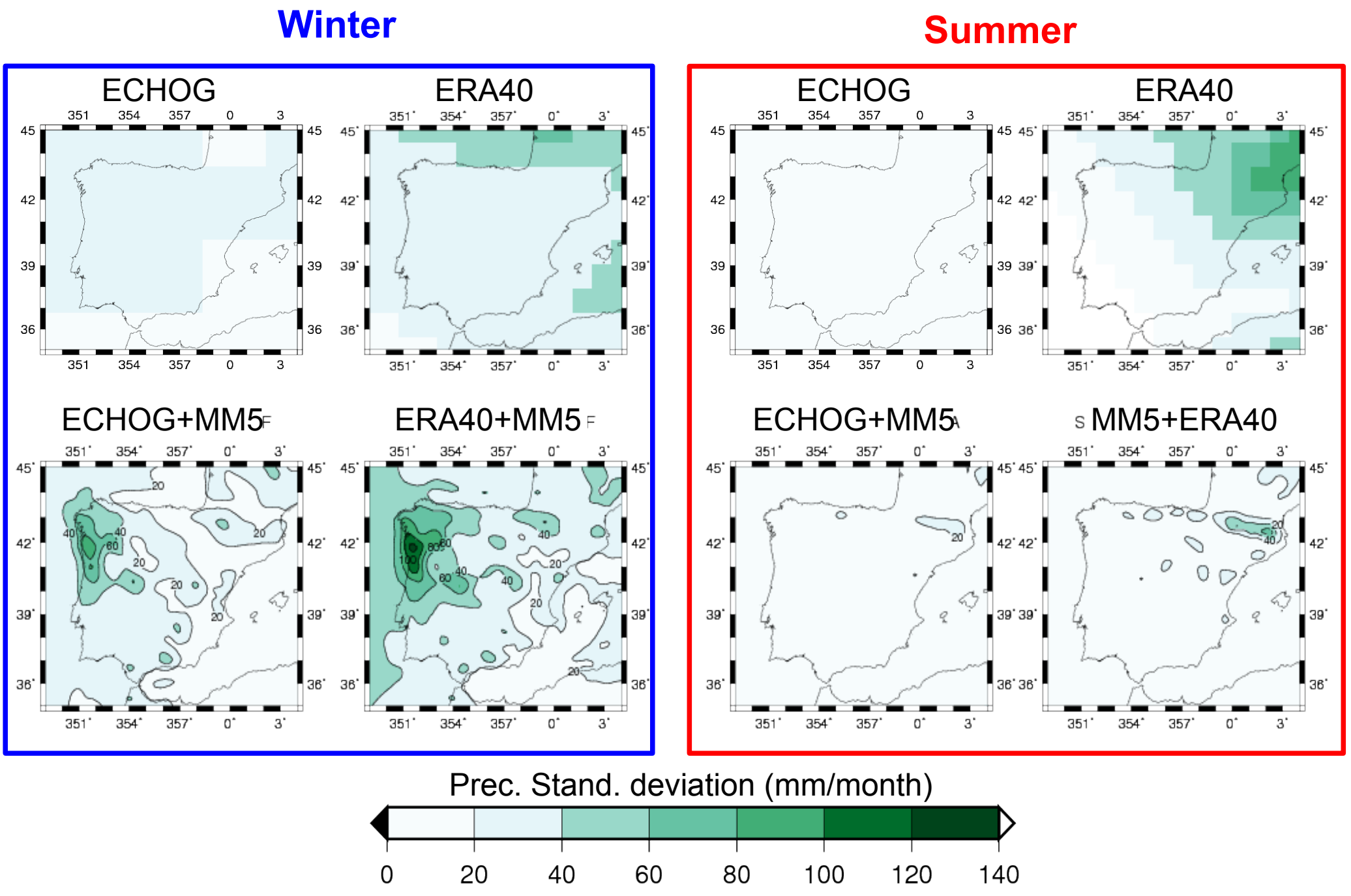
III. Model Skill: *T2M variability*



III. Added value: *Precip. seasonal climatologies (1961-1990)*



III. Model Skill: *Precipitation variability*



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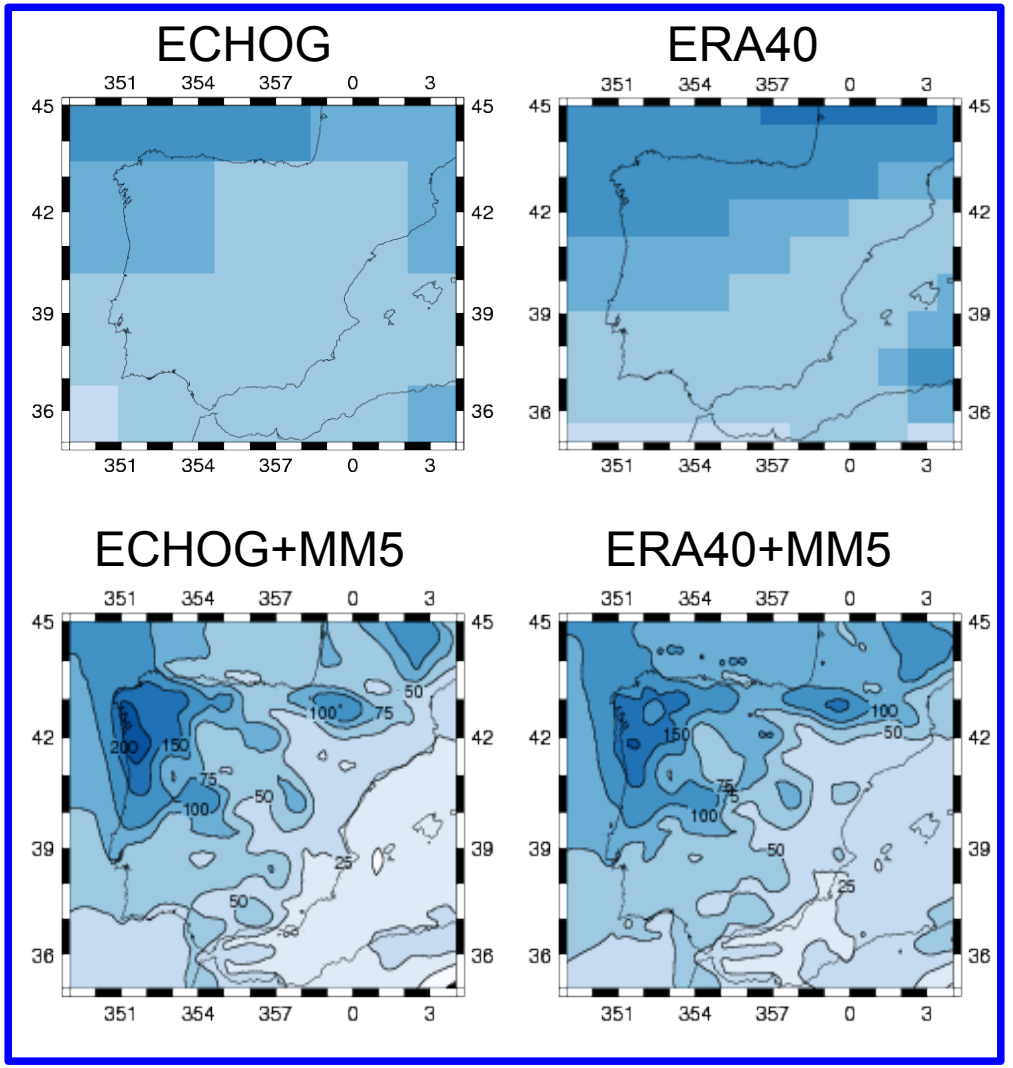
Winter



Analogously, the dynamic downscaling process is able to catch the main winter precipitation shape in the IP (correlation 0.96)

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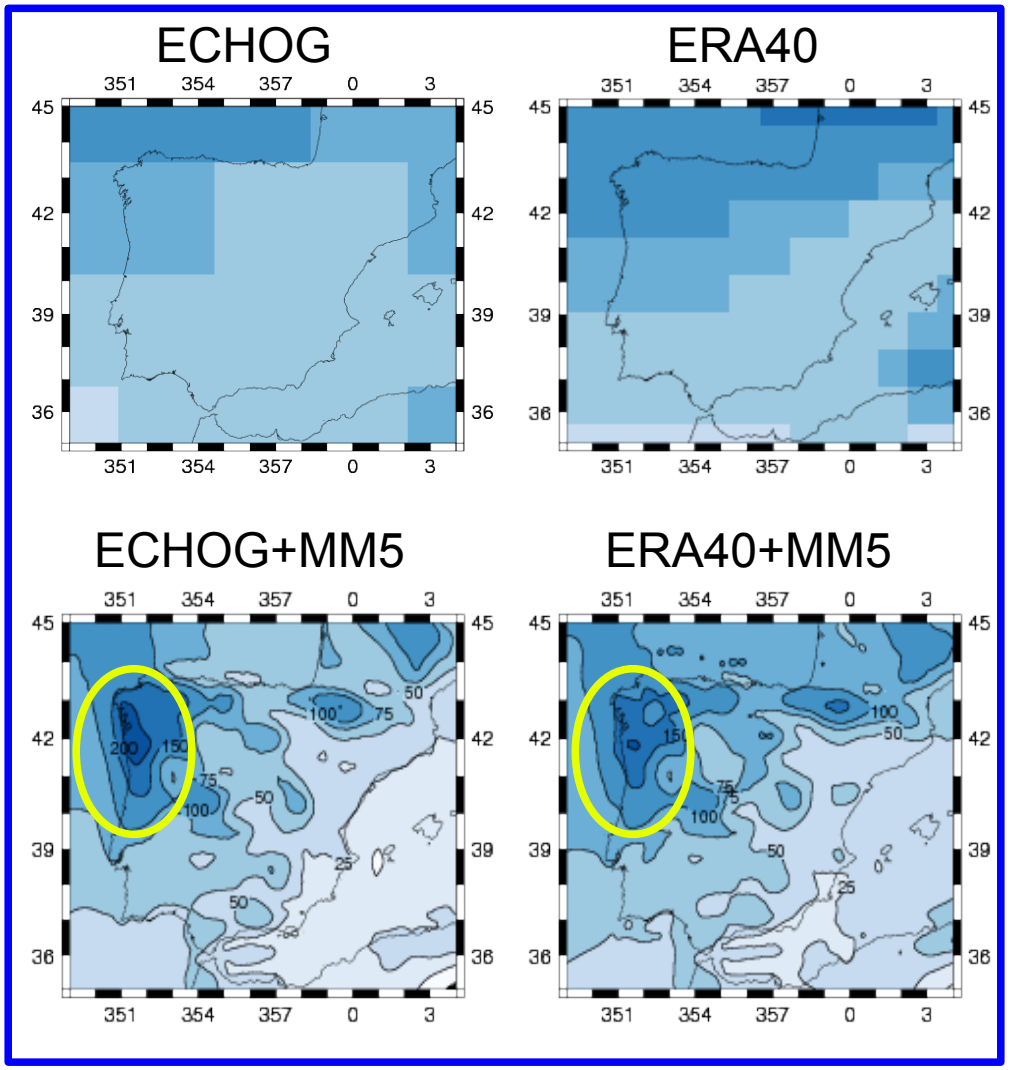
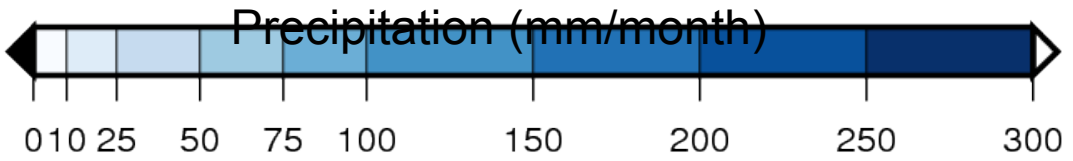


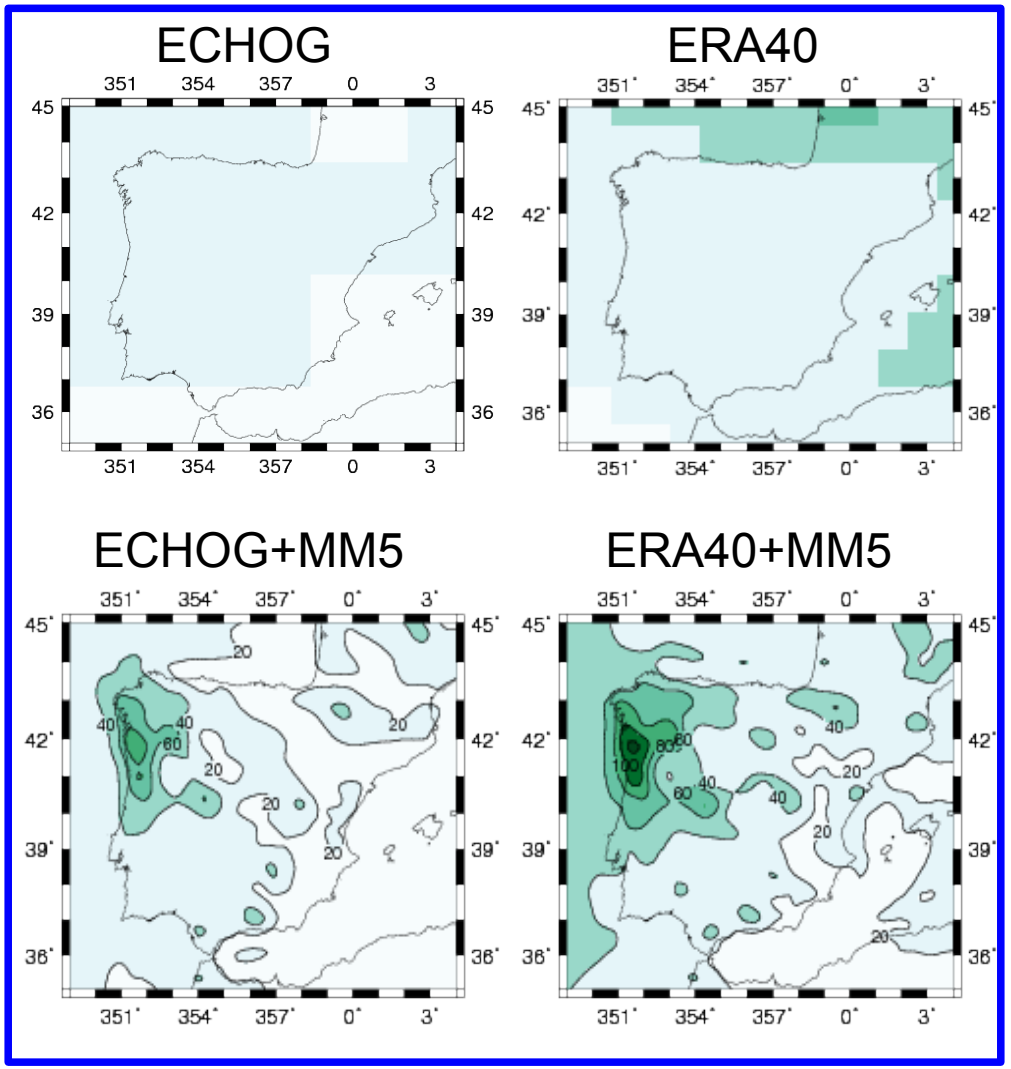
Analogously, the dynamic downscaling process is able to catch the main winter precipitation shape in the IP (correlation 0.96)

There is a bit overestimation in the northwestern parts though



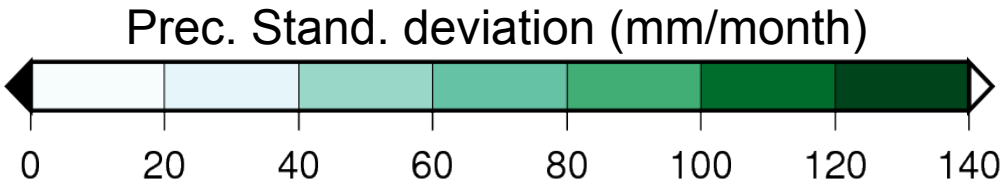
II. Added value: *Precip. seasonal variability (1961-1990)*

Winter



Regarding precipitation variability, ECHOG tends systematically to underestimate it

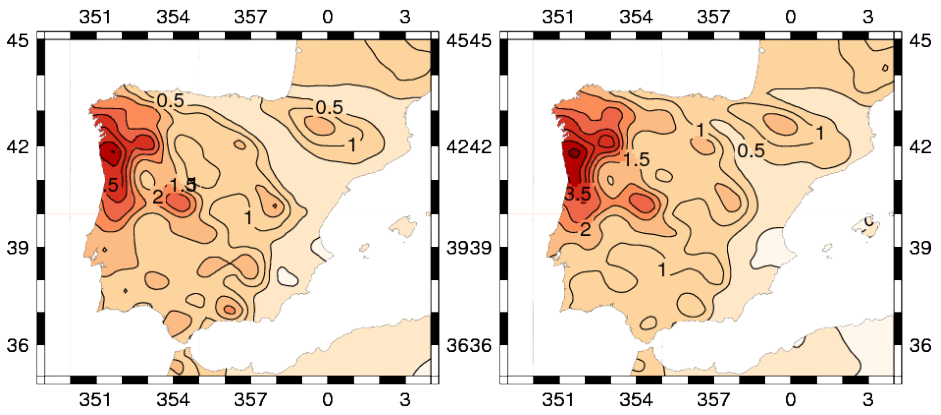
MM5 is able to correct partially this behaviour



II. Added value: *Precip. main variability modes (1961-1990)*

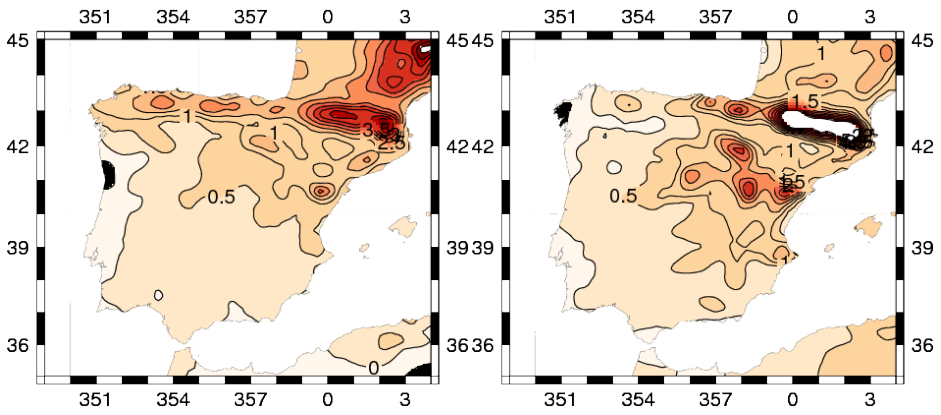
EOF1 Winter

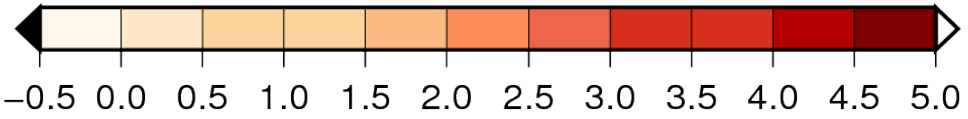
ECHOG (75,01%) ERA40 (70,2%)



EOF1 Summer

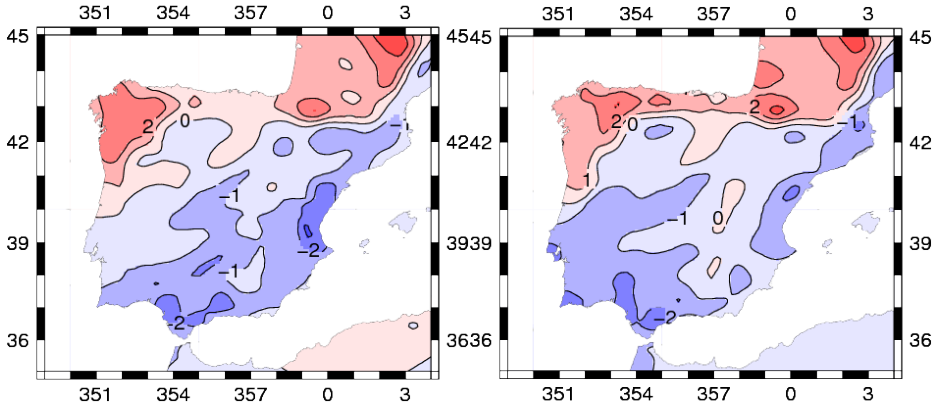
ECHOG (34,61%) ERA40 (36,87%)





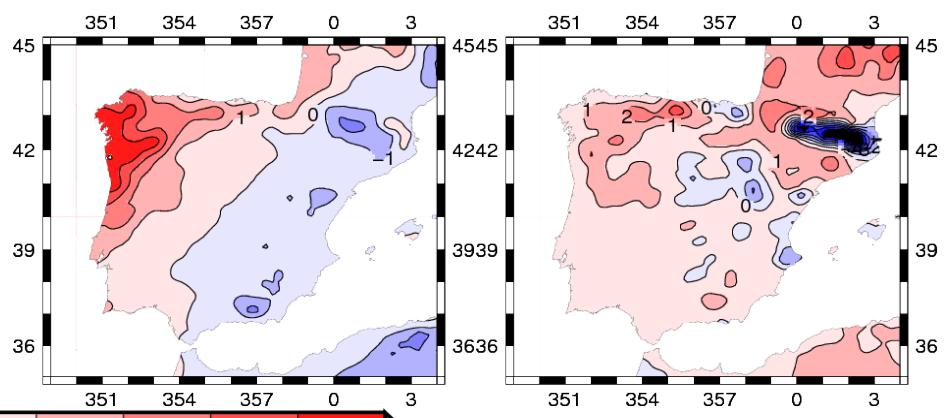
EOF2 Winter

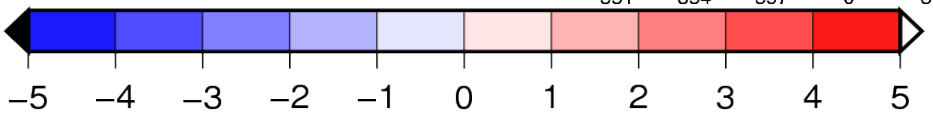
ECHOG (7,49%) ERA40 (11,15%)



EOF2 Summer

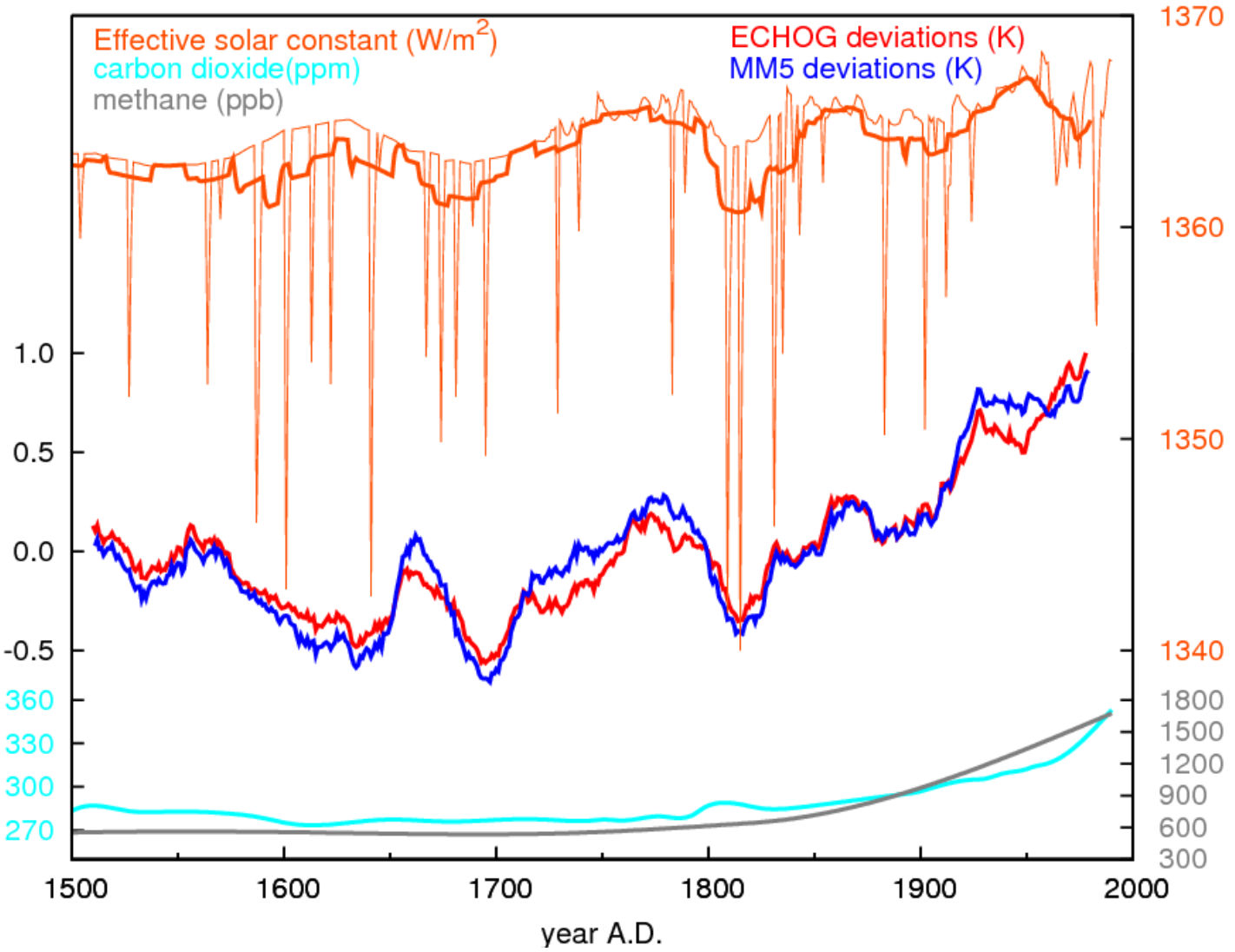
ECHOG (16,91%) ERA40 (15,92%)





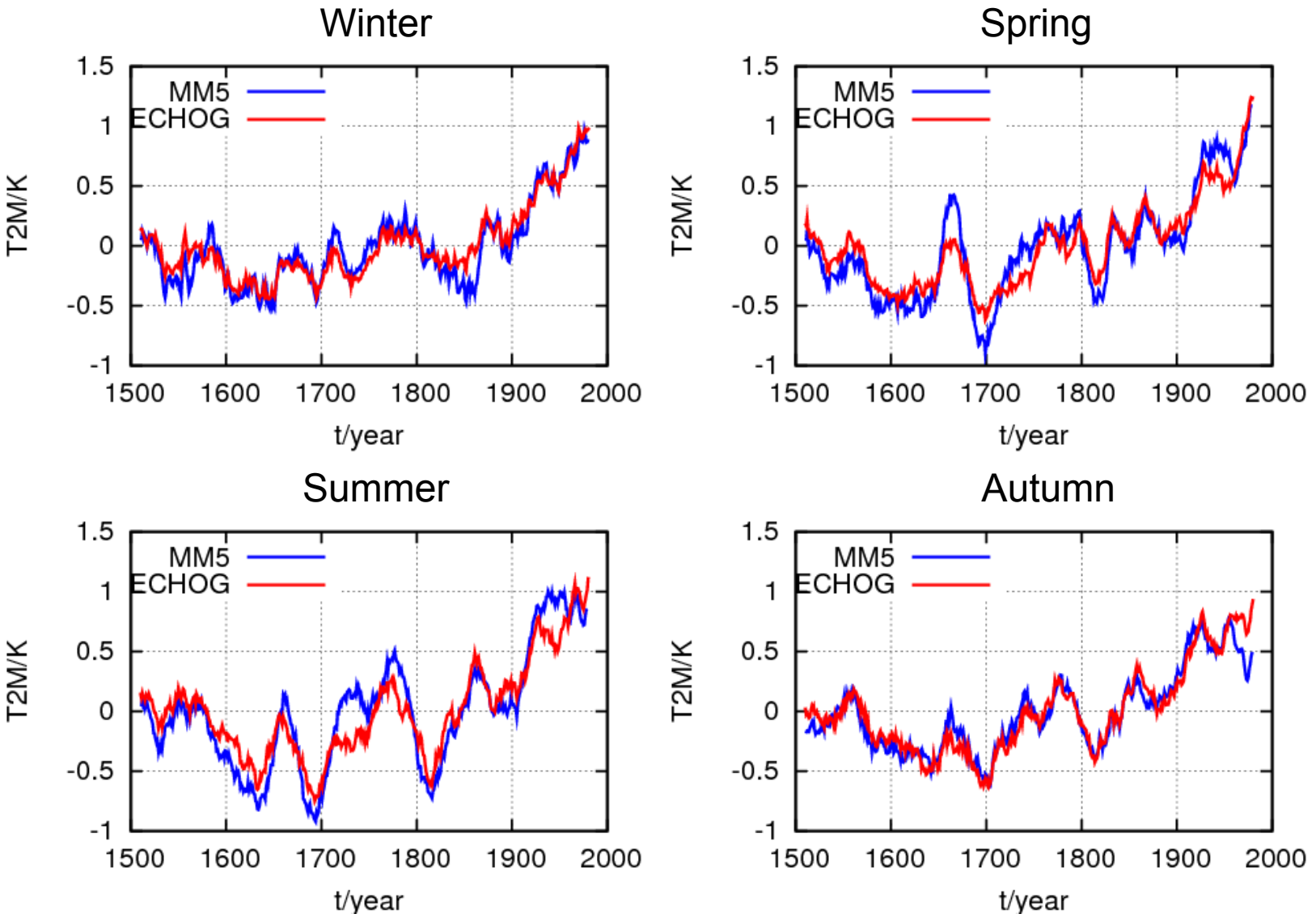
III. Last 500 years climatology: *Influence of the forcing*

- T2M anomaly series (1501-1990) for ECHOG, as well as MM5, are driven by the external forcings
- Some differences appear between both though



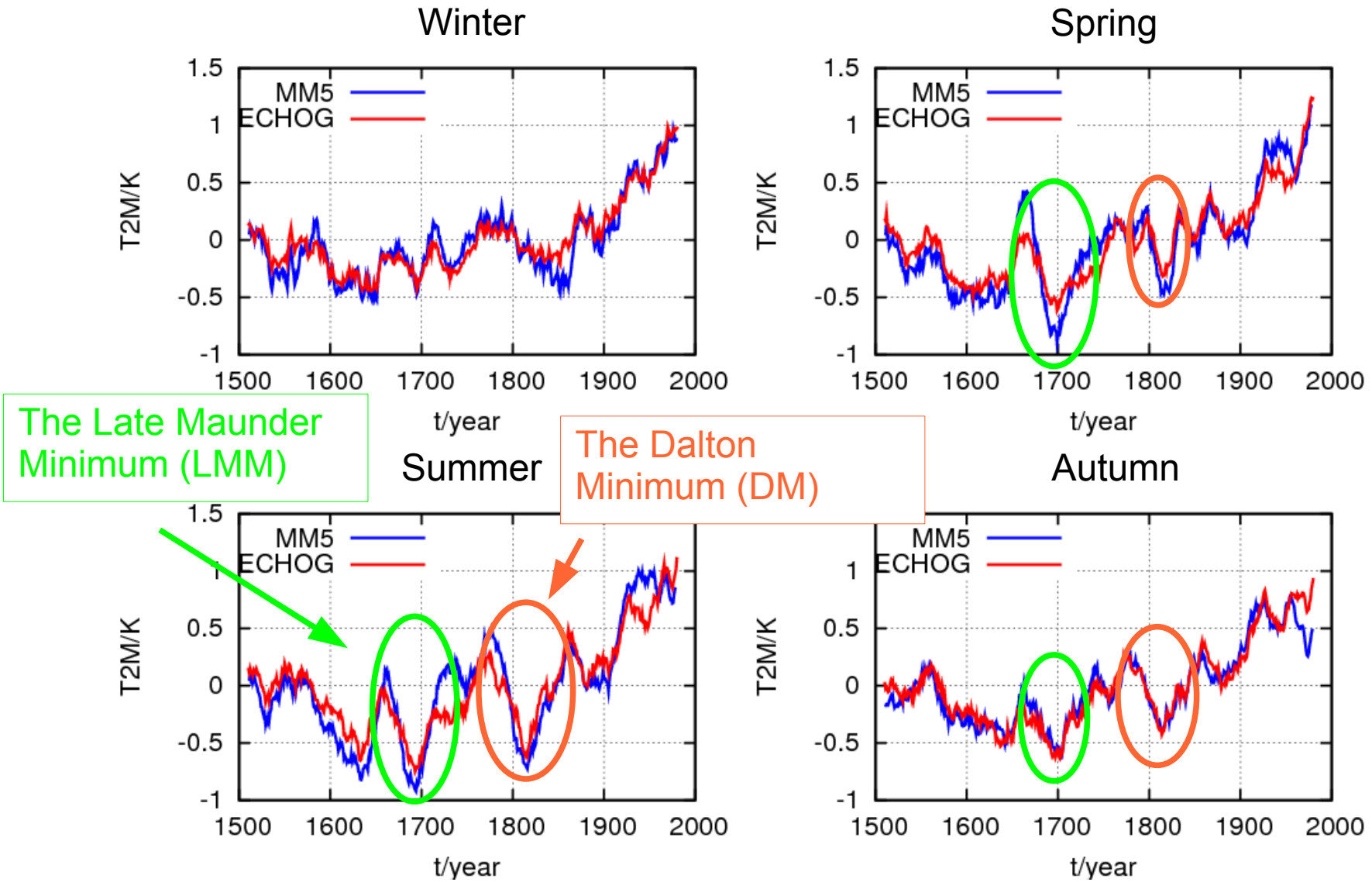
III. Last 500 years climatology: *IP T2M anomaly series (1501-1990)*

- There exist general agreement between the RCM and GCM.
- Some bigger differences are notable in warmer seasons



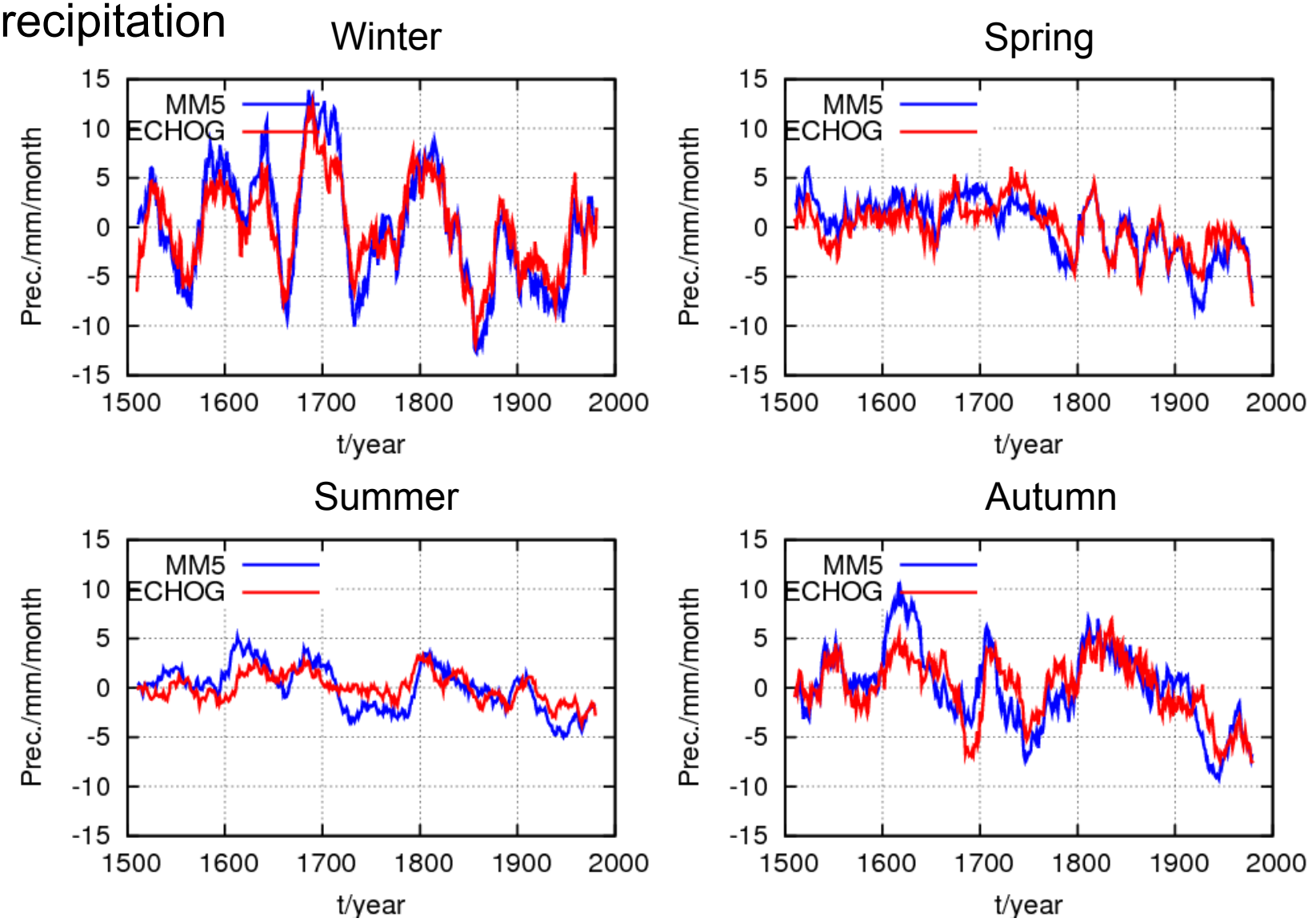
III. Last 500 years climatology: *IP T2M anomaly series (1501-1990)*

- In the warmest seasons is easy to identify some cold periods



III. Last 500 years climatology: *IP Precip. anomaly series (1501-1990)*

- Regarding precipitation, MM5 increase the global variability
- Some differences in T2M may be explained by differences in precipitation



III. Last 500 years climatology: *IP Precip. anomaly series (1501-1990)*

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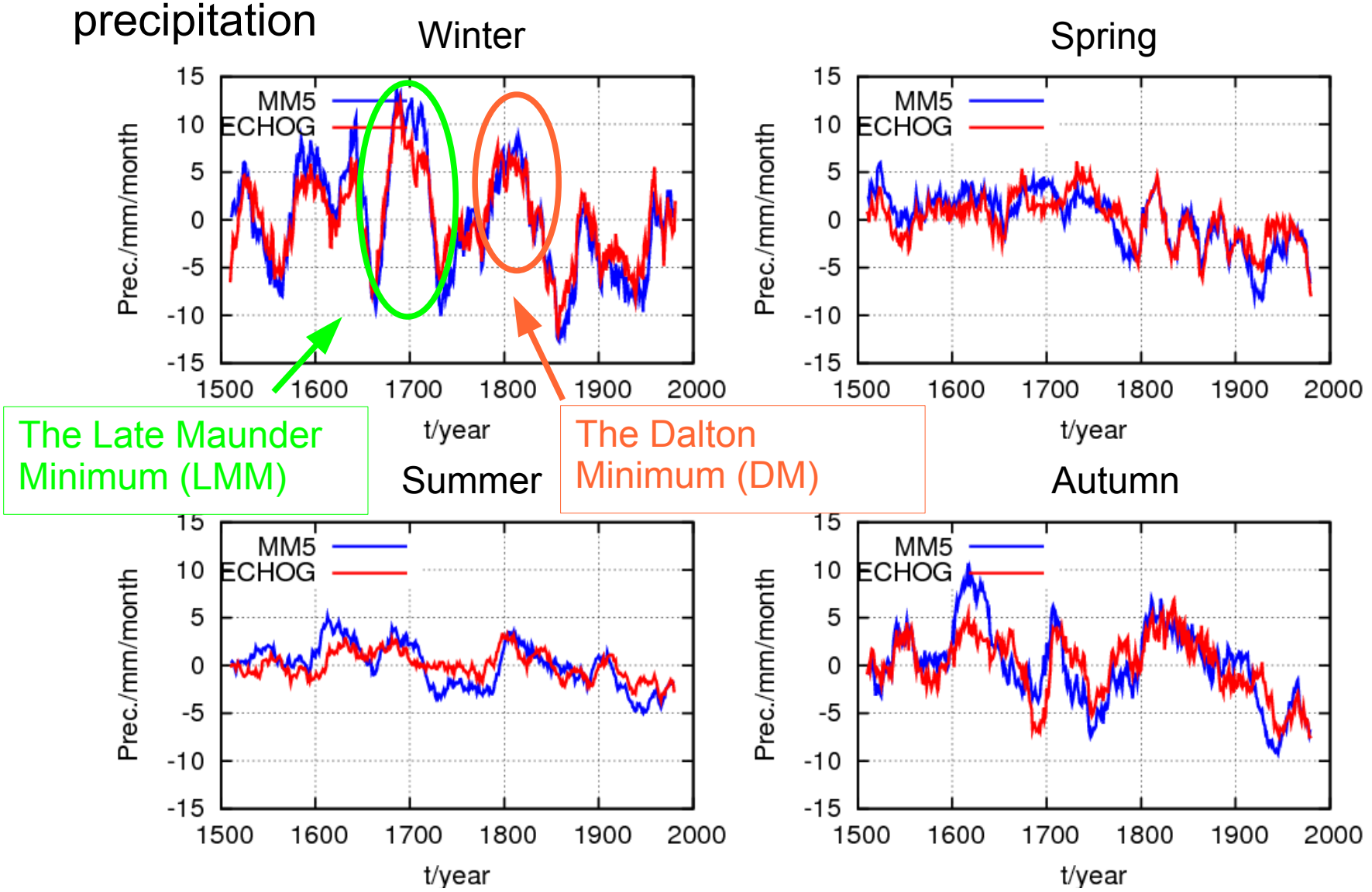
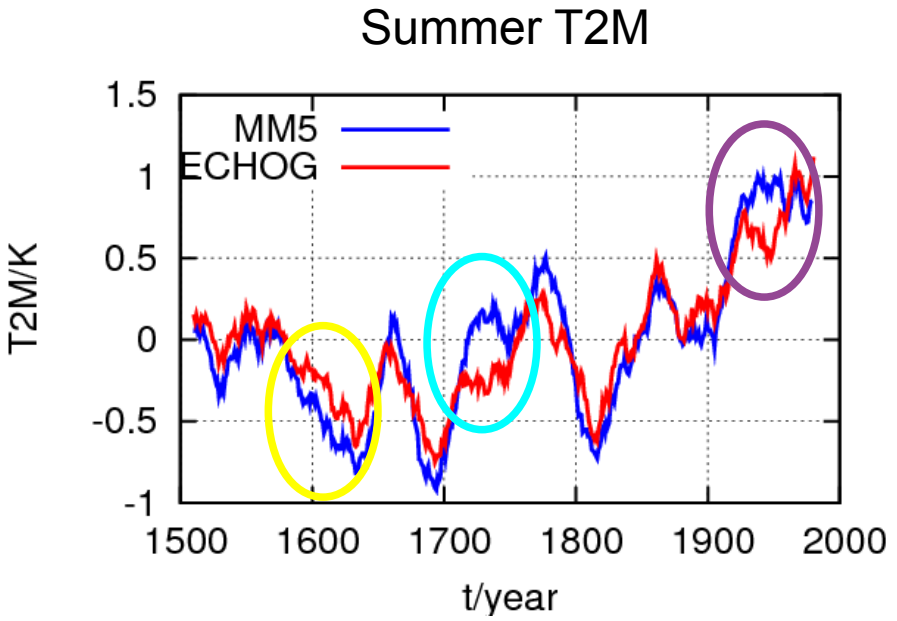
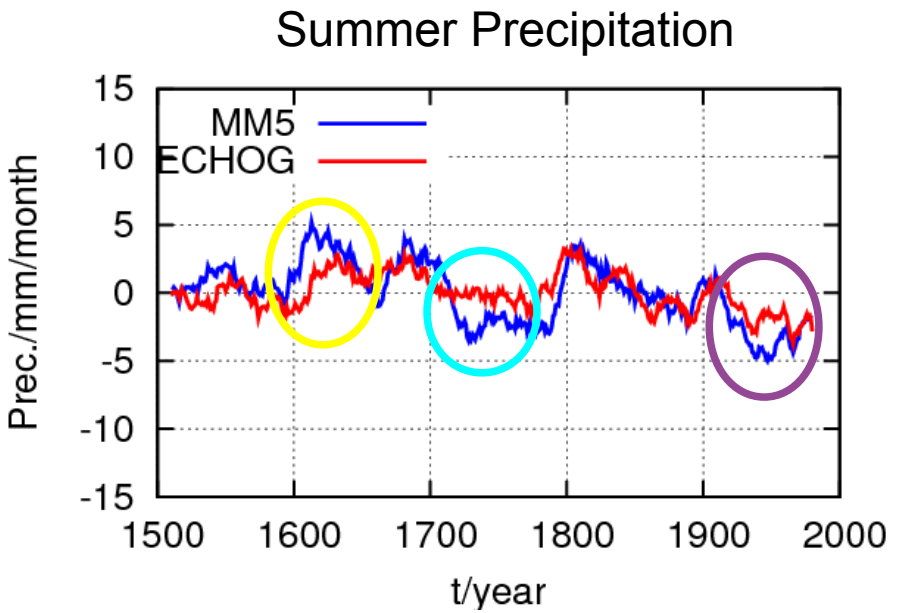


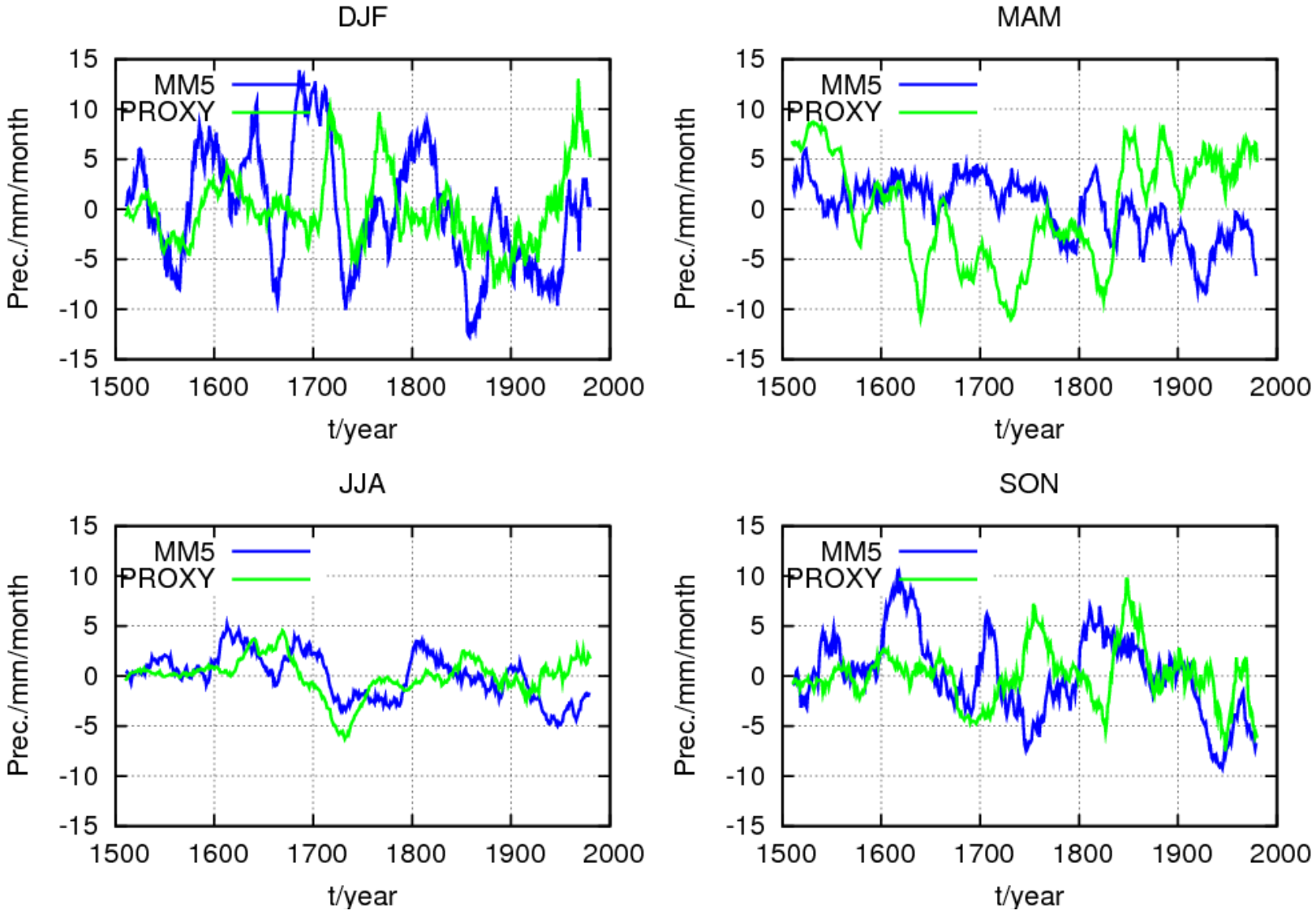
III. Last 500 years climatology: ***Summer T2M discrepancies***

Differences in summer T2M may be due to the positive feedback between the increase of soil moisture and changes in latent and sensible heat

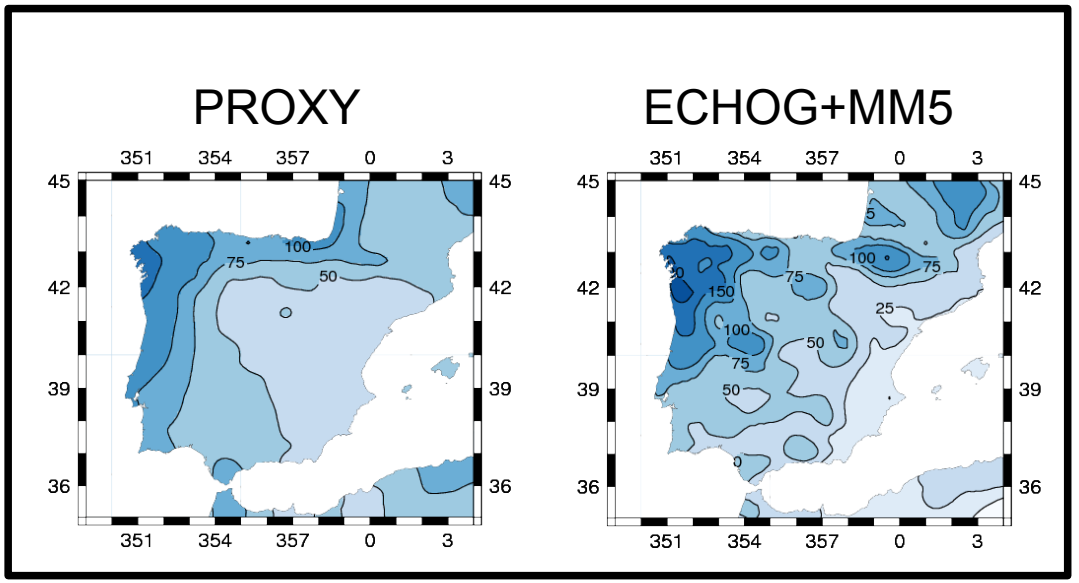


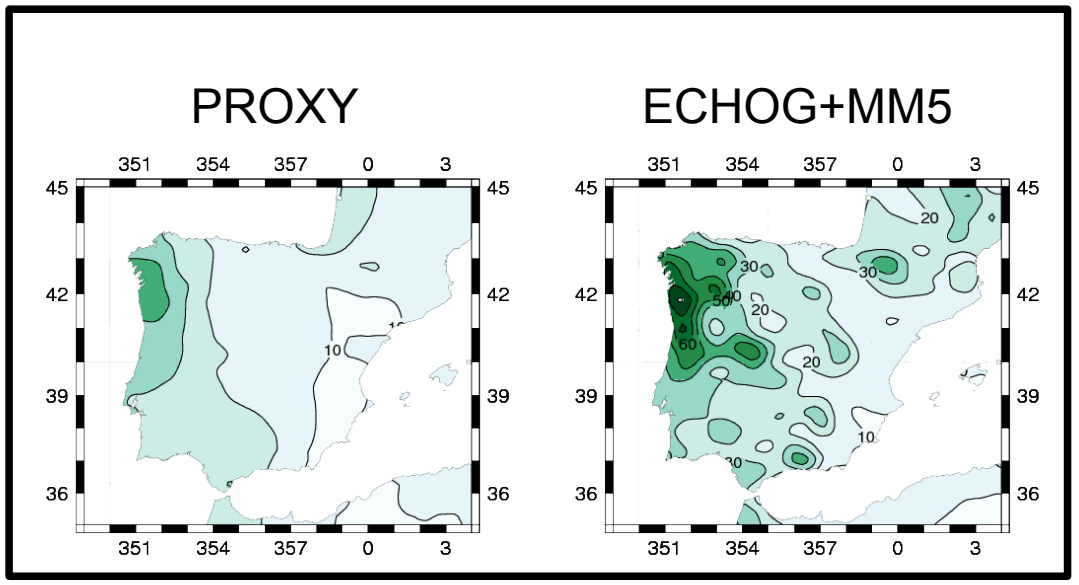


IV. Model vs. Proxy data: ***Precipitation series***



IV. Model vs. Proxy data: *Winter prec. climatologies (1501-1990)*

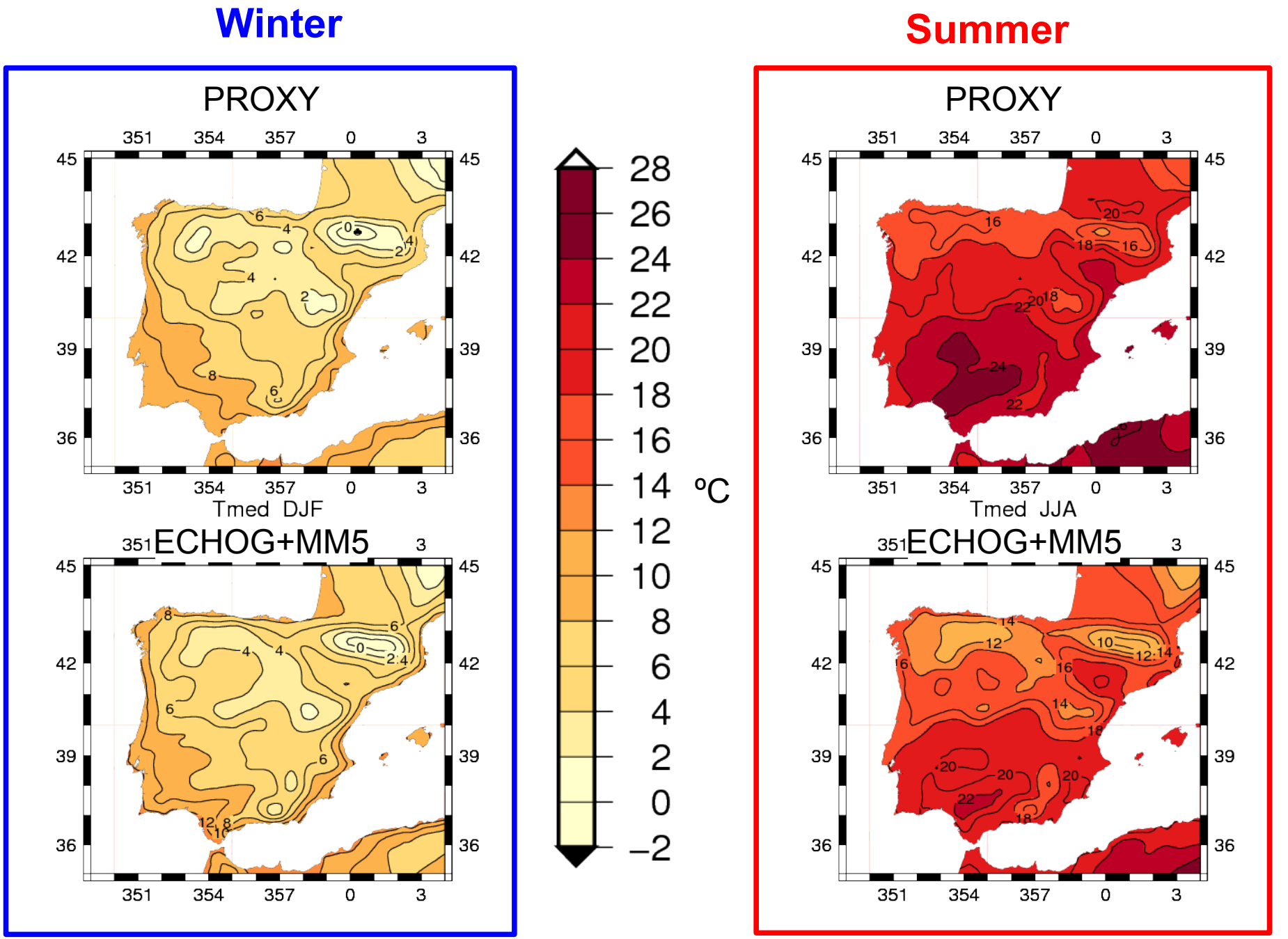




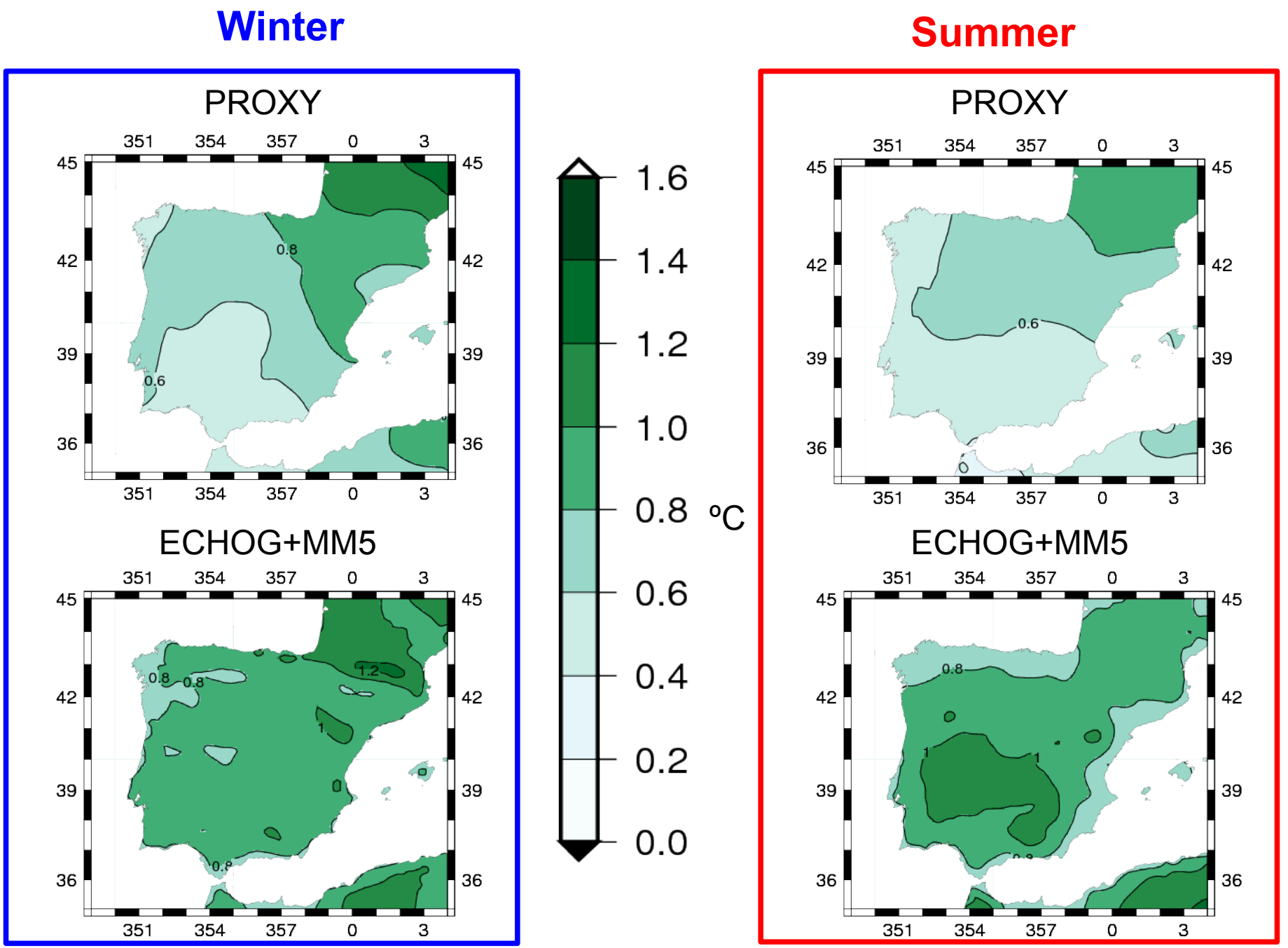
Prec. dataset

- A. Pauling et al. 2005
- Period: 1501-1990
- Window: 29.75W-39.75E / 30.25N/70.75N
- Spatial resolution: 0.5º x 0.5º (land points)
- Temporal resolution: seasonal

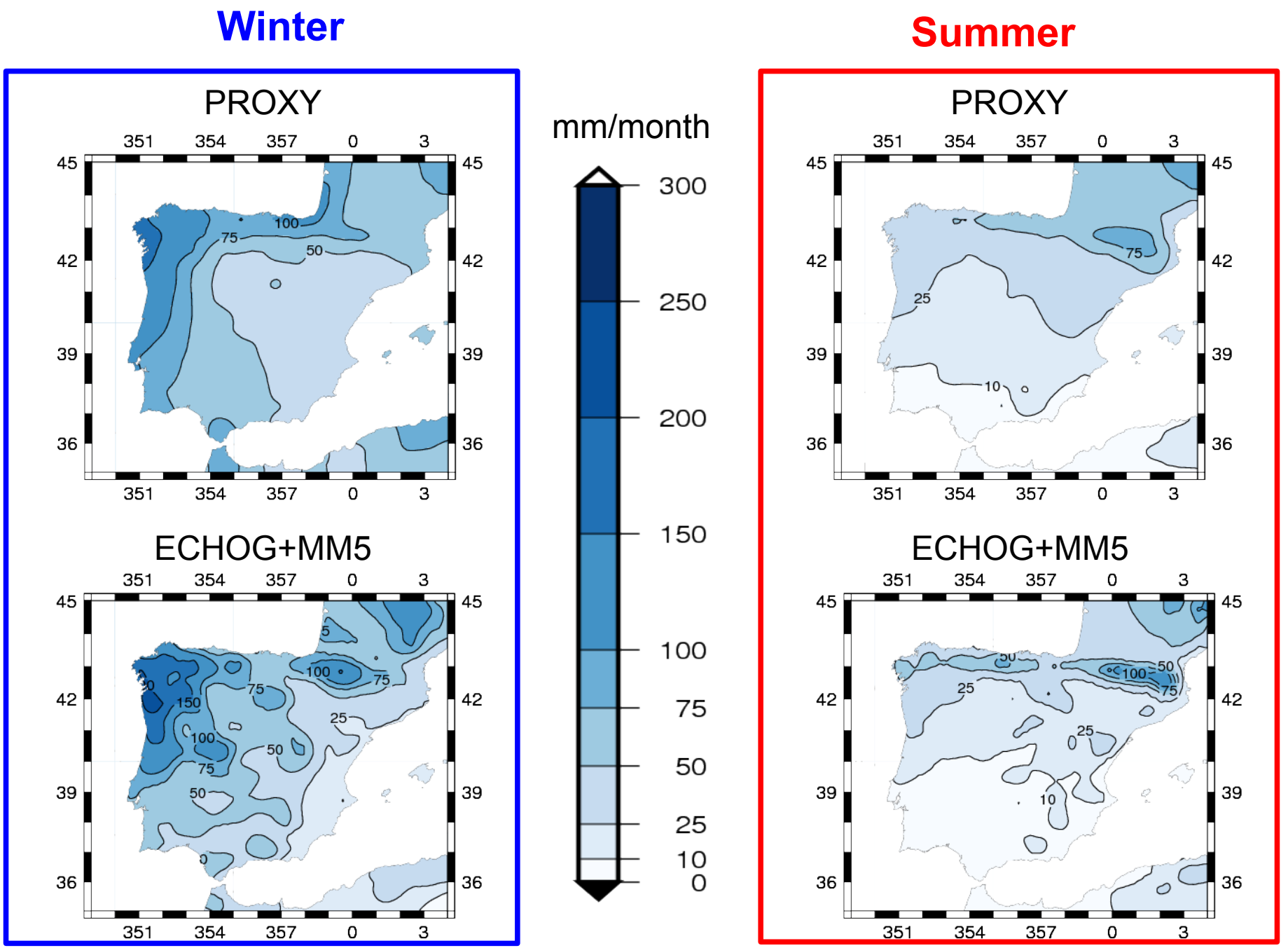
V. Model vs. Proxy data: *Temp. climatologies*



V. Model vs. Proxy data: *Temp. stand. deviations*



V. Model vs. Proxy data: *Prec. climatologies*



V. Model vs. Proxy data: *Prec. stand. deviations*