Assessing the Physical Consistence of Several Gridded Reconstructions Over Europe Through a High-Resolution Climate Paleosimulation

J.J. Gómez-Navarro, J.P. Montávez, P. Jiménez-Guerrero, J.F. González-Rouco, E. García-Bustamante, J. Luterbacher and E. Zorita

University of Murcia, Murcia, Spain (*jjgomeznavarro@um.es*) Unversity Complutense of Madrid, Madrid, Spain
Justus Liebig University, Giessen, Germany Helmholtz-Zentrum Geesthacht, Geesthacht, Germany

Climate reconstructions are fundamental to put the current warming in a longer temporal context. They are based on natural and anthropogenic indicators that contain information at local scale. These sources can be put together using statistical techniques to create gridded reconstructions, although their physical consistence and coherence with other variables is not ensured. The use of climate simulations is a valuable tool to check this consistence, given that it is ensured by the construction of the models.

In this study we use a high-resolution climate simulation to analyze the consistence of SAT, PRE and SLP reconstructions over Europe. We identify some important agreements, as well as some inconsistence which deserve some deeper analysis.

Data

Simulation of the past

The simulation spans the period 1501-1990 with a spatial resolution of 45 km over most parts of Europe. It has been performed with the regional model MM5 driven by the global model ECHO-G. Both simulations share the same three sources of external forcings variability: Total Solar Irradiance, greenhouse gases concentration and the net effect in radiative balance of big volcanic events. All these sources were extracted from the Crowley (2000) reconstruction.

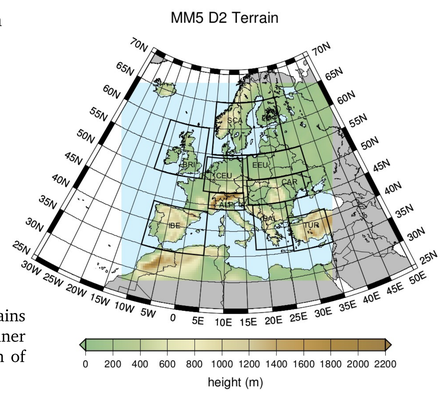


Fig.1: Two two-way area-limited domains were implemented in MM5. Only the inner one, smaller and with a spatial resolution of 45 km, is shown. ►

Observational data base

The third version of the CRU database has been employed for validation purposes. The seasonal series of temperature and precipitation fields during the 20th century were spatially interpolated to the model grid before further calculations were carried out. The SLP field has been extracted from of NCEP reanalysis.

Climate reconstructions

Three reconstructions were employed in the analysis:

- Gridded Surface Air Temperature (SAT) reconstruction in the period 1500-1990 by Luterbacher et al. (2004)
- Gridded Precipitation (PRE) reconstruction in the period 1500-1990 by Pauling et al. (2006)
- Gridded Sea Level Pressure (SLP) reconstruction in the period 1750-2000 by Küttel et al. (2010)

Conclusions

- The methodology employed to generate the gridded reconstructions analyzed in this study ensures that main variability patterns are, to a great extent, coherent with observations and model simulations.
- The model overestimates the percentage of variability explained by first mode compared with the observations.
- Reconstructions further overestimate this variance, which suggests that they oversimplify the variability of the actual climate system.
- Some CCA pairs change their structure in the observed and reconstructed period, which hardly happen in the simulation.
- Some inconsistencies between SLP and SAT and PRE reconstructions are identified.

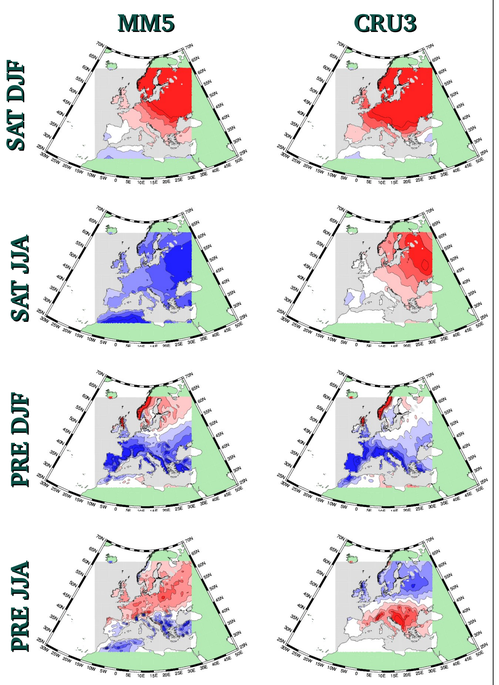
Empirical Orthogonal Function analysis

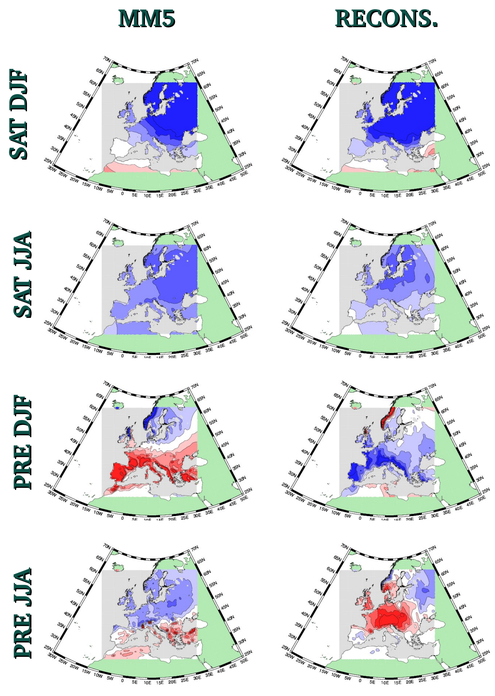
EOFs during the 20th century

First EOF during the 20th century present a very similar pattern in the simulation and the observations (note that the change of sign is meaningless). Similar behaviour can be found in second and third EOFs (not shown). The percentage of variance explained by each EOF is presented in the table below. The model tends to overestimate variability in the first mode, which indicates that the model tends to oversimplify main variability modes, as could be expected due to the spatial resolution employed.

	SAT		PRE	
	DJF	JJA	DJF	JJA
EOF1	72/61	60/32	38/30	14/15
EOF2	11/16	12/19	13/15	9/14
EOF3	6/8	7/12	10/8	6/8

Tab. 1: Percentage of variance explained by first three EOFs in the simulation and the observations, respectively.





EOFs during 1500-1990

During the whole simulated period, the first EOFs also show a remarkable similarity with the results obtained in the reconstruction. Although in general terms, summer reconstructions present larger differences with the model. A major difference with the 20th century results, is that in this case the percentage of variance is larger in the reconstructions.

	SAT		PRE	
	DJF	JJA	DJF	JJA
EOF1	71/72	57/48	34/44	12/19
EOF2	13/17	12/25	15/22	8/18
EOF3	6/5	11/13	11/8	6/9

Tab. 2: Percentage of variance explained by first three EOFs in the simulation and the reconstructions, respectively.
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Canonical Correlation Analysis

CCA for winter series of SLP and PRE

Canonical Correlation Analysis allows us to identify joint variability modes between independent variables, and allows to establish physical coherence between independent reconstructions.

Below, we show a canonical pair for PRE and SLP in winter. The first pattern resembles the characteristic North/South pattern of the first EOF for precipitation. Both, model and observations reproduce the same pattern en support the same physical mechanism. However, reconstructions reproduces a pattern with some differences over the IP compared with observations. Given that the model produces no such change in different periods, the consistence of SLP and PRE reconstructions can not be warranted.