Past and present regional climate simulations for the Iberian Peninsula

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Abstract

We have performed a small ensemble of regional simulations over the Iberian Peninsula covering different periods of time between 1501 and 2100. For this purpose we have used a modified version of the MM5 model adapted for climatological simulations, coupled with the outputs of the global models ECHOG and ECHAM5 as boundary conditions. In order to be coherent, we use the same physical and domain configuration in every experiment. The study is focused in the monthly mean series of the two meter temperature, its variability in the last 400 years, as well as its future projections under several SRES scenarios.

We have used an Empirical Orthogonal Functions approach to get the most important spatial pattern of variability. This tool allow us to explain up to 90% of variance by just the first EOF in most cases. We have found that these patterns are very similar in every case, independently of the period and the boundary conditions. These patterns seem to be related with several physical parameters such as continentality, latitude or altitude over the sea. We have estimated this relation calculating the correlations, which allow us to find some interesting differences between simulations.

1. Introduction

In this work we present the main patterns of monthly mean two meter temperature variability over the Iberian Peninsula (IP), as simulated by a small ensemble of experiments performed by a Regional Climate Model (MM5). For this purpose, we have used a modified version of this model, which includes the modification of the dates routines and the added feature of changing the GHG concentrations.

. We want to check whether the variability for past climates is related in some way with the variability due to climate change in future scenarios.

2. Simulations carried out

We have performed a small ensemble of simulations covering periods between 1501 and 2100. As boundary condition for the Regional Model, we have used outputs from ECHOG and ECHAM5. In addition, we have used several future emissions scenarios: A2, B2 and A1B from SRES.

In total, we will analyse 5 experiments:

Using outputs from ECHO-G for the periods:
- 1501-1990, denoted as **ECHOG-PAST**
- 1990-2100 under A2 scenario, denoted as **ECHOG-A2**
- 1990-2100 under B2 scenario, denoted as **ECHOG-B2**

Using outputs from ECHAM5 for the periods:
- 2001-2099 under A2 scenario, denoted as **ECHAM5-A2**
- 2001-2099 under B2 scenario, denoted as **ECHAM5-A1B**

All the simulations have been performed using the same domain configuration: two way nested domains with a spatial resolution of 90km and 30km, respectively, as shown in Figure 1. In vertical direction 23 sigma levels have been considered, with the top in 100 mb.

The physical configuration for the model has been also the same in every experiment. We have used *Implicit Simple Ice* scheme for micro physics processes, *Grell* parametrization for cumulus formation, *MRF* non-local model for the planetary boundary layer description and *RRTM* as radiative model. Finally, we have used the *Noah land-surface model* to simulate accurately land-atmosphere interactions.

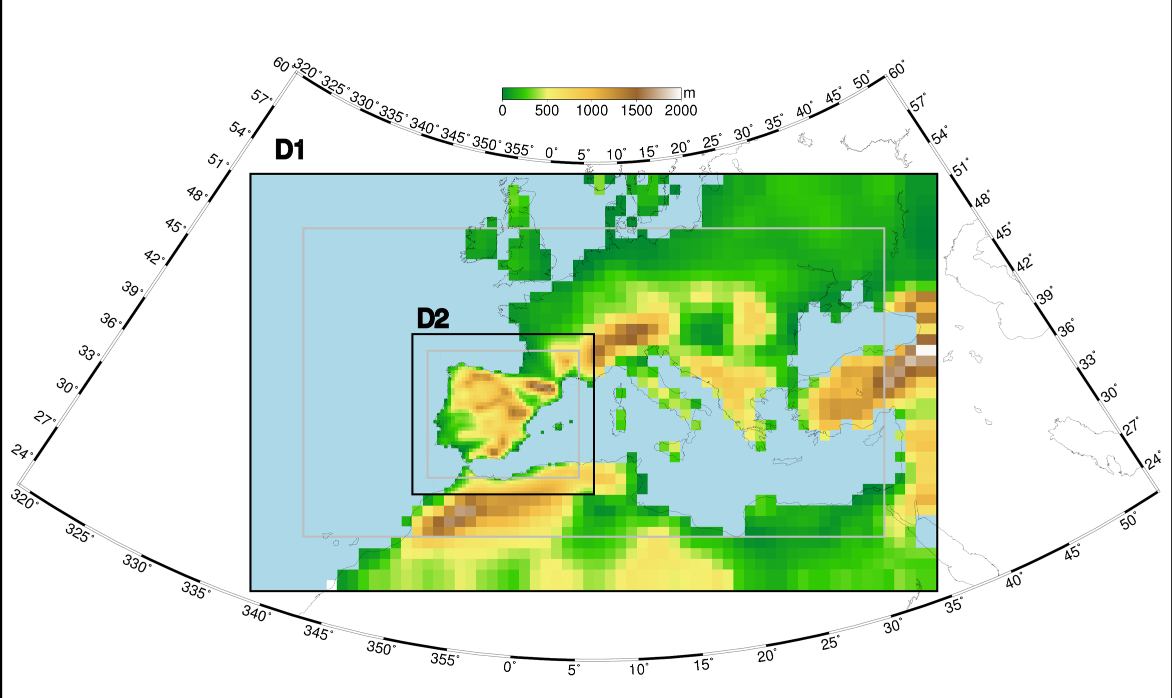

Fig 1. Domain configuration.

3. Methodology: EOF analysis

We have investigated the temperature variability for past and future scenarios using monthly mean two meter temperature. In order to find out its main features, variability and trend, we have performed an Empirical Orthogonal Function (EOF) analysis. This tool allows us to treat separately the spatial structure of the temperature variability and its temporal behaviour.

In each experiment, the first EOF is able to explain between 65% and 90% of the variability of the temperature series. As an example of this, in Figure 2 it is showed the first EOF found for the ECHOG-A2 experiment, where is also indicated the percetage of variance explained by the pattern. It can be apreciated the diferent patterns found along the year, indicating a clear annual cycle.

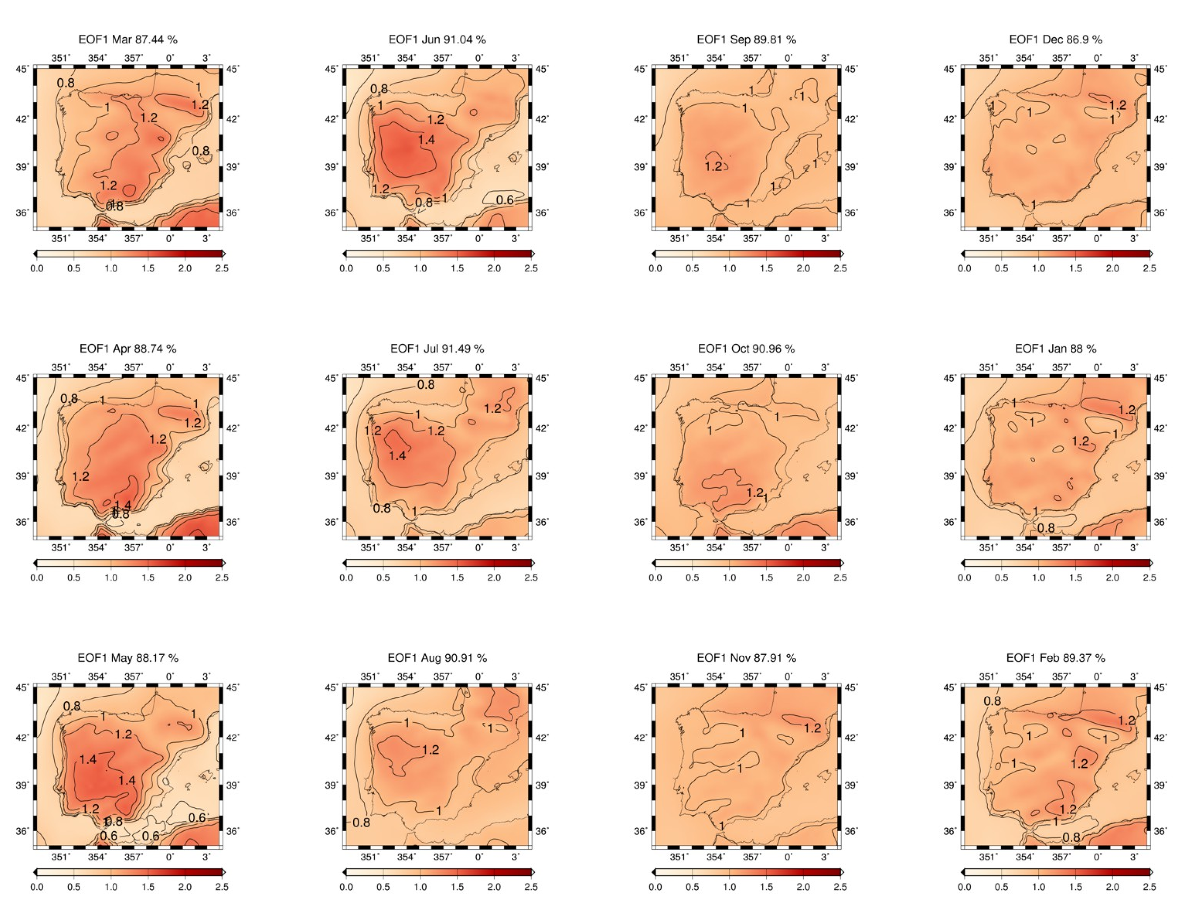

Fig 2. First EOF for every month for the ECHOG-A2 experiment.

If we remove the signal associated to the first EOF, the remaing field is detrended and with much less variability, as can be seen in the ECHOG-A2 example in Fig. 3, where it is depicted the averaged temperature, the first principal component and the difference of both. To ensure that the series is homogeneously detrended, and not only the spatial mean, the trend of differences in every point should be checked out. This has been done, but not shown in the poster, and the remaining trends are one magnitude order less than the temperature trends.

As the information is mainly sumarized in the EOFs, in what follows we will refer only to the spatial structure of these fields.

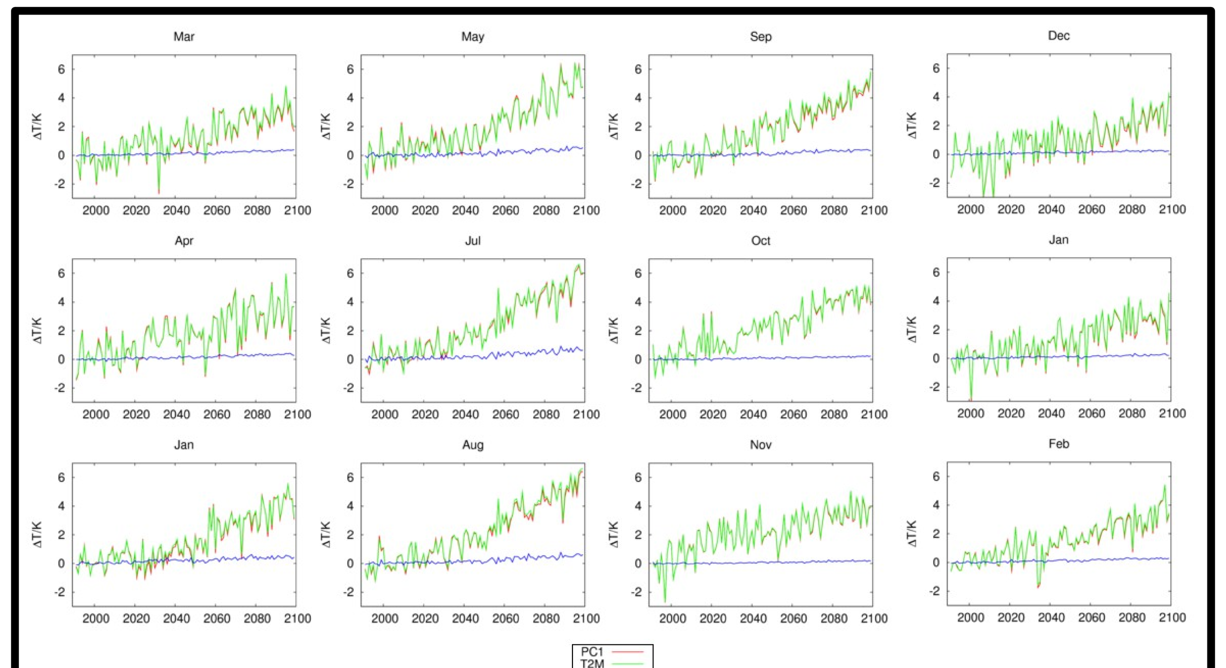

Fig 3. Anomalies of mean temperature versus first PC and difference.

4. Results

We have compared the EOFs associated to each experiment. Furthermore, the a01 experiment have been splited in two periods, roughly pre and post-industrial (1501-1800 and 1801-1990, respectively), denoted as **ECHOG-PASt-pre** and **ECHOG-PAST-post**.

The resulting patterns are very similar for each month. In fact, we have calculated the spatial correlation of the EOFs between several of these experiment (as we have 6 experiments, we have 15 different combinations), and the results is depicted in Figure 4. From this figure, we can highlight some important points:
- In general, there is very high correlations in every experiment, which shows that spatial patterns for future scenario are very close, independently of scenario and period
- The spatial pattern responsible for most of the variability for the past climate is very similar to the pattern associated to the future projections. This could be due to not important changes in the general circulation in the future scenarios
- The main difference between scenarios is the amount of warming (not shown in this poster), not its spatial structure
- There is more correlation between patterns involved to the same general model than to the same scenario. In other words, the temperature variability is more related to the global model which is used as boundary conditions than to the GHG concentrations, i.e. SRES scenarios
- There is a also big correlation between the EOFs associated to the pre and post-industrial periods. This is coherent with the fact that EOFs for the same model, but for different GHG concentrations, are very close

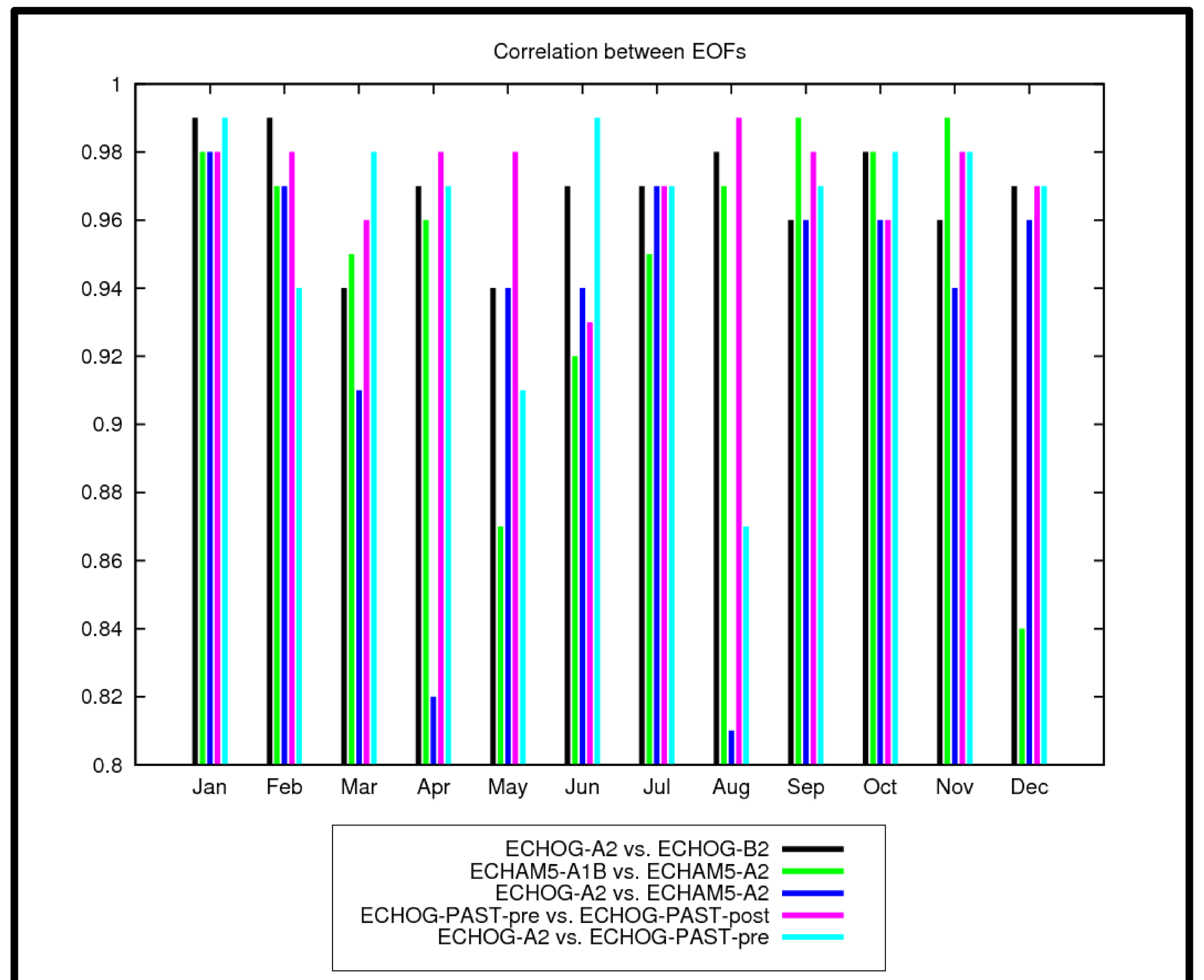

Fig 4. Correlation between monthly EOF associated to several experiments.

As can be seen in Figure 4, the spatial correlation for every month have some characteristic features, which can be related to some physical parameters. In order to quantify this, we have calculated the correlation of the EOF patterns with contiensality (defined as the minimum distance, in degrees, to the sea), latitude and altitude above the sea (for this, we have used only points with heigh over 300 m). In this calculation, we have used only land points.

In Fig. 5a) we can see a clear annual cycle in the patterns related to the continentality. This means that in the interior of the IP the variability is higher, and mostly in summer time.

Figures 5b) and 5c) show a not so clear cycle. They seem to have a biannual cycle, but there is not as much coherency between experiments as in Fig. 5a).

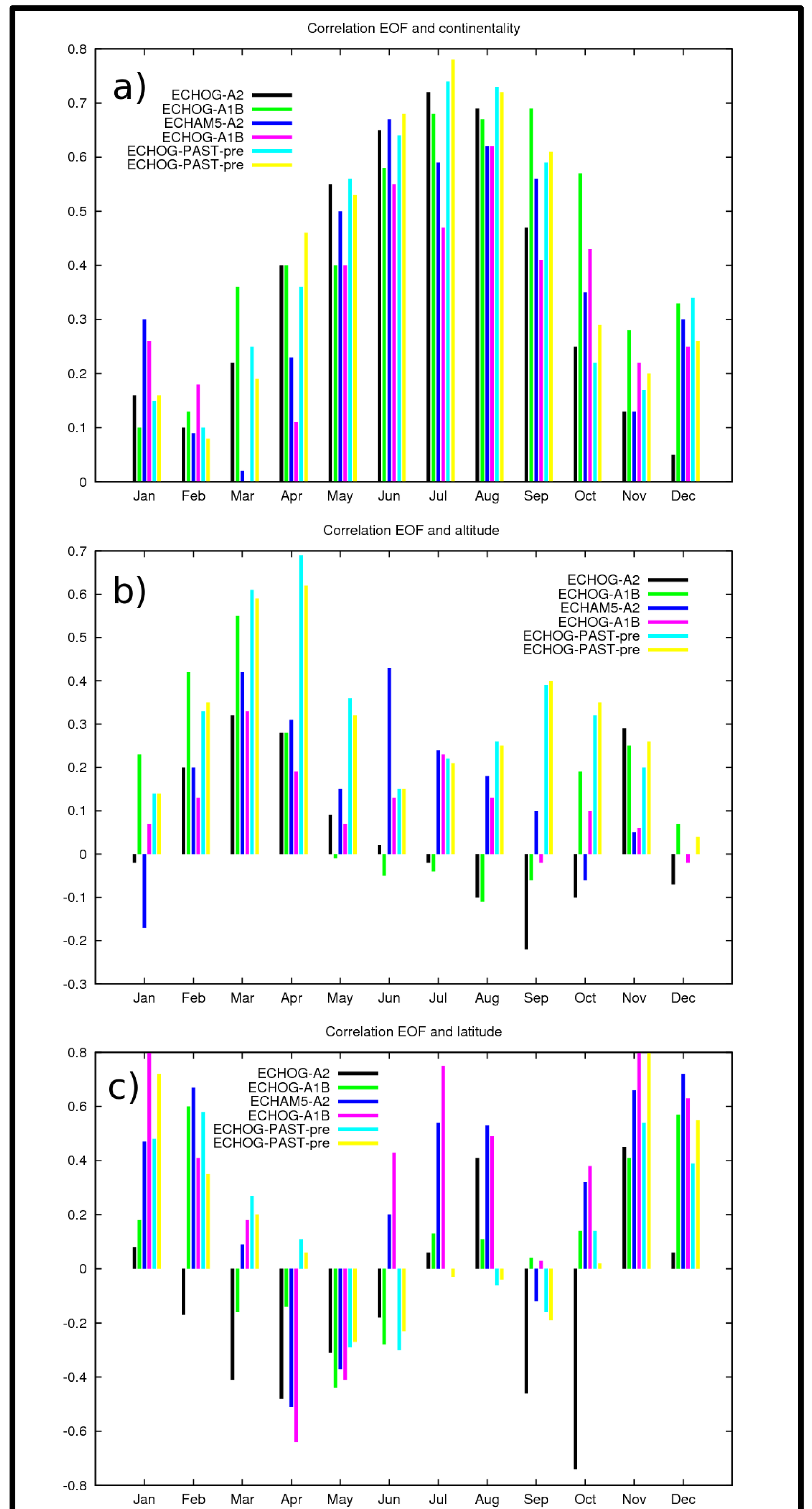

Fig 5. Correlation between first EOF and several physical parameters for each experiment.

4. Conclusions

We have performed a small ensemble of regional experiments over the Iberian Peninsula. Most of the variability of the two meter temperature is captured by the first EOF, so we use this pattern to study the spatial structure of variability.

The spatial structure of variability is mostly the same for each month, as can be seen by the correlation between experiments (Fig. 4). In particular, the variability structure for the past climate is the same that for future scenarios.

There is some features of the patterns which may be related to physical parameters as continentality, heigh over the sea or latitude. Also, we can see some differences between models looking at these figures.