Project: **888**

Project title: **Assimilation of paleoclimate proxy data into MPI-ESM using ensemble member selection**

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Data assimilation (DA) is an emerging research area and can be considered as one of the key challenges in palaeoclimatology. Different ensemble-based DA approaches for palaeoclimate reconstructions have been recently undertaken, but no systematic comparison among them has been attempted and large understanding gaps of the ideal characteristics and input data that would give the best state estimates remain. In this project, we are among the first to perform DA using a GCM, specifically the MPI Earth System Model (MPI-ESM), based on ensemble member selection for specific periods of the last millennium. ECHAM6 was run at T31 horizontal resolution with 31 vertical levels, and MPIOM at a GR30 horizontal resolution and 40 vertical levels. The land surface model was JSBACH and no ocean biogeochemistry model was employed. The model is a low-resolution version of the model used for the Coupled Model Intercomparison Project (CMIP) Phase 5 simulations.
After we have studied the respective values of on-line and off-line data assimilation (Matsikaris et al., 2015a) and the role of continental-scale data assimilation for more regional changes (Matsikaris et al., 2016a) we have, in 2016, focused on the influence of proxy data uncertainty (Matsikaris et al., 2016b).

We have analysed simulations performed using the on-line DA scheme for the period 1850-1949 AD. Two sets of DA simulations are conducted, one selecting the best among 20 ensemble members based upon comparison with the PAGES 2K proxy-based reconstructions, and the second by selecting ensemble members after comparison with the HadCRUT3v instrumental record. The simulations for the instrumental period allow validating the assimilation method against instrumental records, which would be a substantial contribution to the research area of palaeoclimatic modelling and thus an essential part of the study. Both DA schemes follow the large-scale target and observed climate variations well, but the assimilation of instrumental data improves the performance. This improvement cannot be seen for Asia, where the limited instrumental coverage leads to errors in the target data and low skill for the DA-I scheme. No skill on small spatial scales is found for either of the two DA schemes, demonstrating that errors in the assimilated data are not the main reason for the unrealistic representation of the regional temperature variability in Europe and the NH. It can thus be concluded that assimilating continental mean temperatures is not ideal for providing skill on small spatial scales.

We have examined the spatial maps for each decade for the DA analyses and the observations, for Europe and the NH in winters and summers. The DA patterns for the NH in most decades show no agreement with the observed patterns in either of the two schemes (not shown). The patterns in the European sector, where the instrumental data set is almost complete, are also inconsistent. As an example, Fig. 1 shows the European decadal surface air temperature maps for the two DA analyses and the HadCRUT3v gridded observations for the summers of 1850–1859 AD and 1940–1949 AD. The spatial correlations of the DA analyses, regridded onto the coarser resolution observational grid, with the HadCRUT3v data are not significant. The fact that the assimilation of observational data does not provide any added value on regional scales shows that the errors in the proxy-based reconstructions are not the main source of this lack of skill. The use of the continental-scale target temperatures in the cost function is thus the dominant source of error for the unrealistic representation of the small-scale temperature variability.

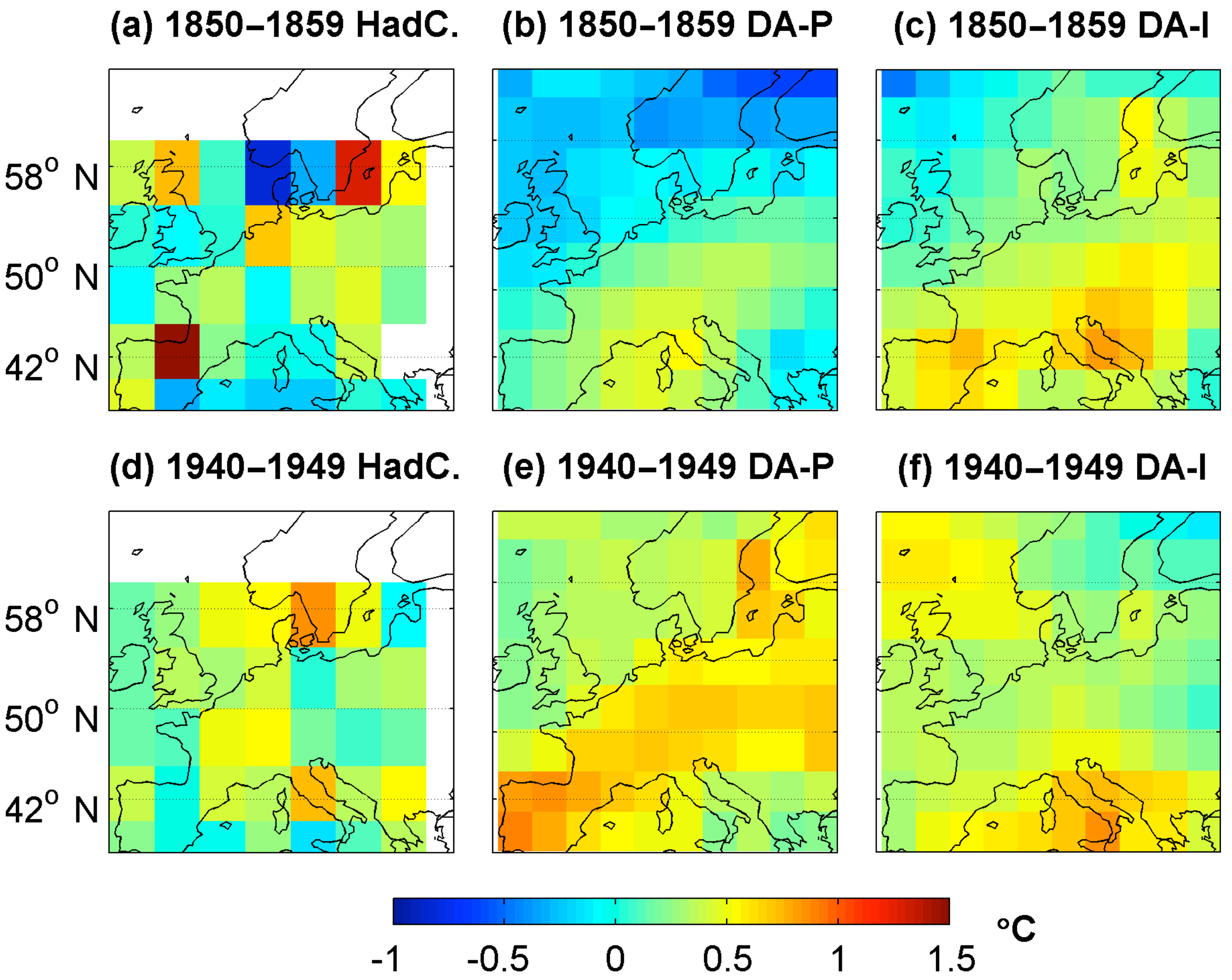

Figure 1: European decadal surface air temperatures (anomalies with respect to the 1850–1949 AD mean) for the DA-P analysis, the DA-I analysis and the HadCRUT3v reconstructions, for the summers of 1850–1859 AD and 1940–1949 AD (from Matsikaris et al., 2016b).

References

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