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Analysis of the PDFs of temperature from a multi-physics ensemble of climate change projections over the Iberian Peninsula

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Regional climate change projections are affected by several sources of uncertainty. Some of them come from Global Circulation Models and scenarios.; others come from the downscaling process. In the case of dynamical downscaling, mainly using Regional Climate Models (RCM), the sources of uncertainty may involve nesting strategies, related to the domain position and resolution, soil characterization, internal variability, methods of solving the equations, and the configuration of model physics. Therefore, a probabilistic approach seems to be recommendable when projecting regional climate change. This problem is usually faced by performing an ensemble of simulations.

The aim of this study is to evaluate the range of uncertainty in regional climate projections associated to changing the physical configuration in a RCM (MM5) as well as the capability when reproducing the observed climate. This study is performed over the Iberian Peninsula and focuses on the reproduction of the Probability Density Functions (PDFs) of daily mean temperature. The experiments consist on a multi-physics ensemble of high resolution climate simulations (30 km over the target region) for the periods 1970-1999 (present) and 2070-2099 (future). Two sets of simulations for the present have been performed using ERA40 (MM5-ERA40) and ECHAM5-3CM run1 (MM5-E5-PR) as boundary conditions. The future the experiments are driven by ECHAM5-A2-run1 (MM5-E5-A2). The ensemble has a total of eight members, as the result of combining the schemes for PBL (MRF and ETA), cumulus (GRELL and Kain-Fritch) and microphysics (Simple-Ice and Mixed phase).

In a previous work this multi-physics ensemble has been analyzed focusing on the seasonal mean values of both temperature and precipitation. The main results indicate that those physics configurations that better reproduce the observed climate project the most dramatic changes for the future (i.e, the largest temperature increase and precipitation decrease). Among the three parameterized processes that are at stake, the most influential is the PBL scheme. Regarding the uncertainties in such projections, ensemble spreads of about 50% for temperature changes and over 100% for precipitation changes were found.

This contribution pays attention to the simulated variability, particularly in the extreme events, through the evaluation of the PDFs of daily temperature. For all the members, the PDFs from MM5-ERA40 simulations present characteristics that are in between of MM5-E5-PR and MM5-E5-A2 . Furthermore, they show a bimodal shape that is weaker than in the projected PDFs, not appearing in MM5-E5-PR. The bimodal behavior is related to the amplitude of the annual cycle, which is underestimated in MM5-E5-PR. This is mainly due to the colder summer temperature simulated as a consequence of an excessive steady precipitation simulation in detriment of the convective precipitation, leading to significant changes in the surface radiative balance. The most influential factor on the bimodal shape of the PDFs in present simulations is the change of the PBL scheme while the use of different cumulus schemes is the more perturbing factor in MM5-E5-A2 simulations.

The analysis of the PDFs by seasons and the analysis of the PDFs of temperature anomalies (in which the influence of mean values disappear) shows a better agreement between MM5-E5-PR and MM5-ERA40. Comparison with PDFs of A2 scenario indicates that the future higher mean values are accompanied by a larger probability

of the unusual warm events. These findings are common for all the experiments. Differences among them appear specially for summer seasons, but are not as important as the spreads obtained for mean values. As in the study for mean values, there is some dependence of the simulated PDFs tails with the election of the physics configuration. Such dependence is opposite for winter and summer. In summer, the warmest configurations provides the largest variability and projects the largest increase, while in winter it provides the lowest values of both variability and variability increase.