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Future changes and signal analyses in the Mediterranean Area deduced from a CMIP3 multi-model ensemble

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Considering its social, economic and natural conditions the Mediterranean Area is a highly vulnerable region by designated affections of climate change. Furthermore, its climatic characteristics are subordinated to high natural variability and are steered by various elements, leading to strong seasonal alterations. Additionally, General Circulation Models (GCMs) project compelling trends in specific climate variables within this region. These circumstances recommend this region for the scientific analyses conducted within this study, which has been conducted in the German KLIWEX-MED project (Klimawandel und Extremereignisse im Mediterranen Großraum) in collaboration of the University of Wuerzburg and the University of Augsburg.

Based on the data of the GCMs in the CMIP3 database, the fundamental aim of this study is a detailed investigation of the total variability and the accompanied uncertainty, which superpose these trends, in the projections of temperature, precipitation and sea-level pressure by GCMs and their specific realizations. Special focus in the whole study is dedicated to the German model ECHAM5/MPI-OM. Following this ambition detailed trends and mean values are calculated and displayed for meaningful time periods and compared to reanalysis data of ERA40 and NCEP. To provide quantitative comparison the mentioned data are interpolated to a common 3x3° grid.

The total amount of variability of these simulations is separated in its contributors by the application of an Analysis of Variance (ANOVA). For individual GCMs and their ensemble-members this is done with the application of a 1-way ANOVA, separating a treatment common to all ensemble-members and variability perturbating the signal given by different initial conditions. With the 2-way ANOVA the projections of numerous models and their realizations are analysed and the total amount of variability is separated into a common treatment effect, a linear bias between the models, an interaction coefficient and the residuals.

By doing this, the study is fulfilled in a very detailed approach, by considering yearly and seasonal variations in various reasonable time periods of 1961-2000 to match up with the reanalysis data, from 1961-2050 to provide a transient time period, 2001-2098 with exclusive regard on future simulations and 1901-2098 to comprise a time period of maximum length. The statistical analyses are conducted for regional-averages on the one hand and with respect to individual grid-cells on the other hand. For each of these applications the SRES scenarios of A1B, A2 and B1 are utilized. Furthermore, the spatial approach of the ANOVA is substituted by a temporal approach detecting the temporal development of individual effects. Additionally, an attempt is made to enlarge the signal by applying selected statistical methods (e. g. bootstrapping).

In the detailed investigation it becomes evident, that the different parameters (i.e. length of temporal period, geographic location, climate variable, season, scenarios, models, etc...) have compelling impact on the results, either in enforcing or weakening them by different combinations. This holds on the one hand for the means and trends but also on the other hand for the contributions of the variabilities affecting the uncertainty and the signal. While temperature is a climate variable showing strong signals across these parameters, for precipitation mainly the noise comes to the fore, while for sea-level pressure a more differentiated result manifests. In turn, this recommends the distinguished consideration of the individual parameters in climate impact studies and processes in model generation, as the affecting parameters also provide information about the linkage within the system.