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EXAMPLES OF RECONSTRUCTIONS OF POLISH CLIMATE BY GCMS AND PROJECTIONS FOR FUTURE

Abstract: In recent years great efforts have been made to develop climate modelling. The most sophisticated tools to simulate the behaviour of the ocean and atmosphere over time are general circulation models. The new centre IPCC DDC has been recently established to co-ordinate the distribution of data resulting from many climate simulation experiments provided by the world climate centres. Several countries carry out analyses of data available from the DDC for their regions. The present work is a part of such an analysis for Poland.

Key words: climate simulations, general circulation models.

The best approach to the problem of reconstructing climate is physical modelling of all interacting components of the climate system: atmosphere, hydrosphere, cryosphere, surface biosphere. Trying to understand the laws governing the climate system we simulate the behaviour of the atmosphere and analyse obtained patterns. We construct the whole hierarchy of inter-related models describing the climate system in various spatial scales. It is only in the last decades of this millennium that a great development in climate modelling has been made, mainly due to new computers' abilities. A great number of simulations for different forcings has been recently performed using most powerful computers. The analysis of results of experiments shows big differences especially when looking at regional scales. The paper presents some examples of temperature and precipitation patterns for Poland derived from simulations by general circulation models.

Three dimensional general circulation models (GCMS) are the most comprehensive description of climate system's dynamics and physics. These are formulated as sets of momentum equations, continuity equation for dry air, the equation of state, and a continuity equation for moist air. Divers numerical techniques to integrate the equations have been developed aiming at the most possible accuracy of solutions and fastness of computations. GCMS explicitly simulate the evolution over

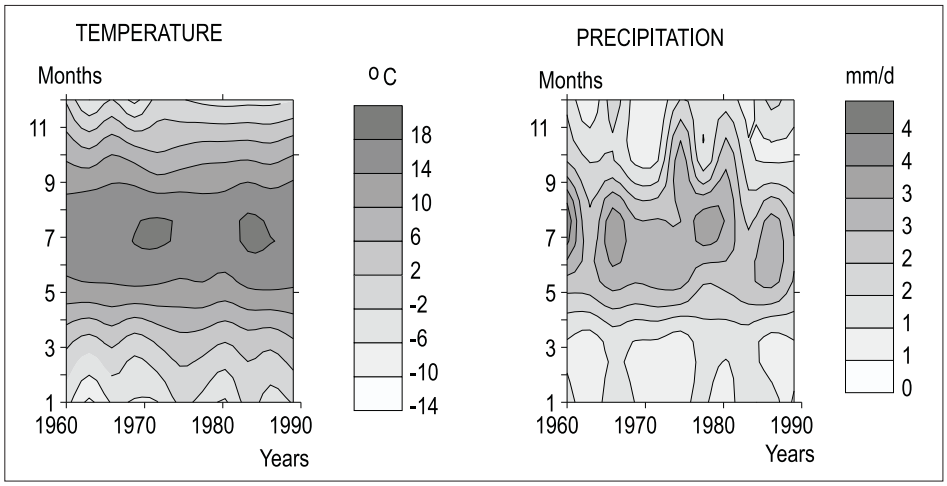

Fig. 1. Reanalysed temperature and precipitation in Poland for the reference period 1960-1989.

time of large scale atmospheric systems accounted as principal climate factors. The predominant physical processes of smaller scales such as radiation, cumulus convection or surface processes are parameterized.

The intention for this paper was the analysis of output from selected most up-to-date GCMS in grid points covering Poland. The following models have been chosen: the CCCM model of the Canadian Center for Climate Modelling and Analysis, the HadCM3 model of the Hadley Centre for Climate Prediction and Research and the ECHAM4/OPYC3 model of the Max-Planck Institute in Hamburg. Two variables, temperature and precipitation from two experiments, GG - „Greenhouse Gas" and GS - „Greenhouse Gas plus Sulphate", for the period 1950-2099 have been analysed. Only in the case of the ECHAM4/OPYC3 model and the scenario GS the integration period was shorter, up to 2049. The data have been received from the IPCC DDC (Intergovernmental Panel on Climate Change - Data Distribution Centre).

The paper presents some examples of climate reconstructions for Poland, monthly means of temperature (Fig. 2 and 3) and precipitation (Fig. 4 and 5) for the analysed time period. The Figure 1 shows the observed distributions for the reference period 1960-1989, based on the NCEP reanalyses (Kalnay et al. 1996) for temperature and the reanalyses by Doherty et al. (1999) for precipitation.

Generally speaking, in the case of temperature, the simulation GS gives milder results than the simulation GG, the differences are much stronger at the end of the experiments. In both integrations there can be observed well marked warming, during summer, the summer season is extended, especially for the scenario GG. The climate of the CCCM model in both scenarios is warmer than the observed Polish climate,

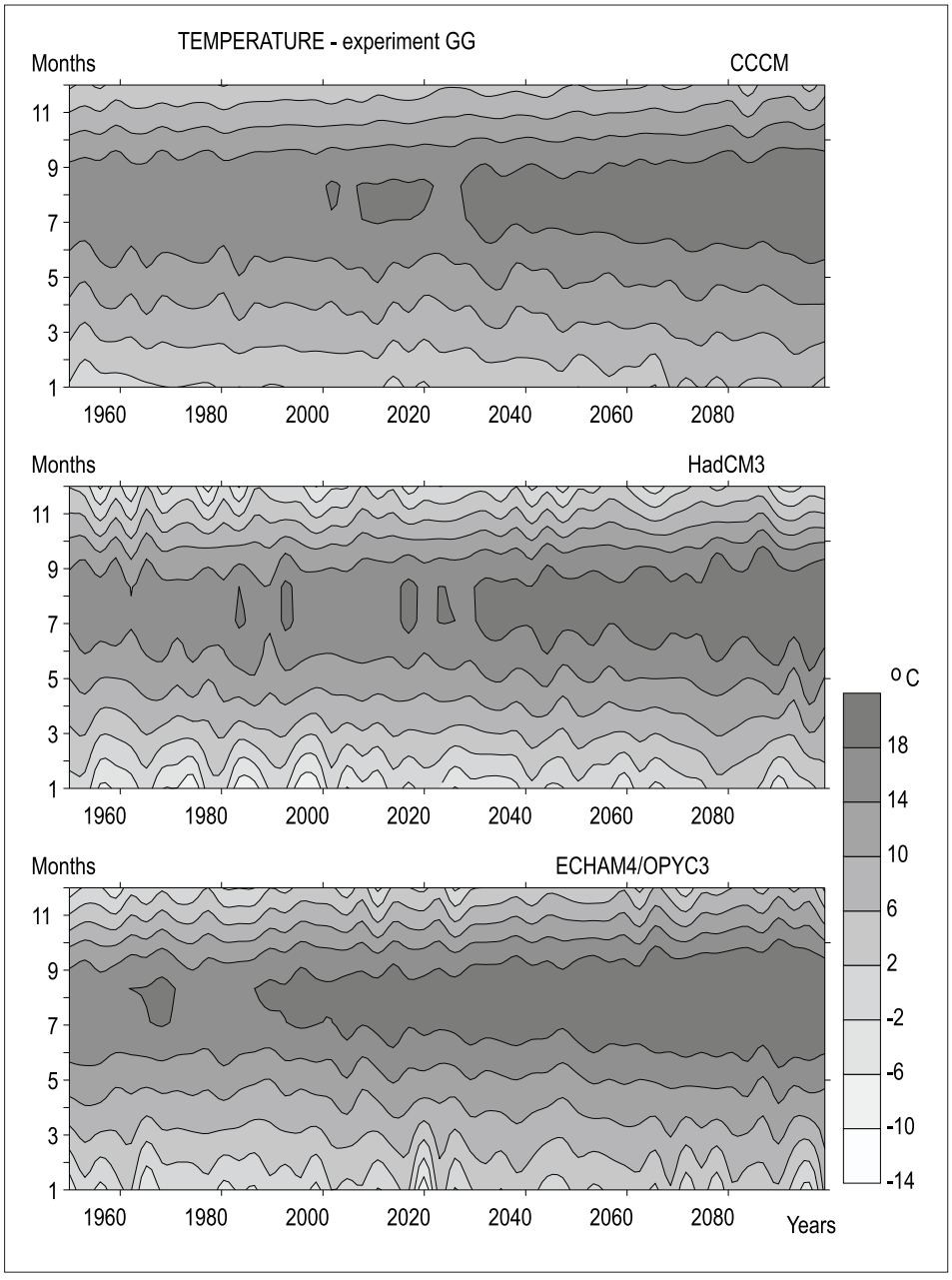

Fig. 2. Simulated temperature in Poland - scenario GG.

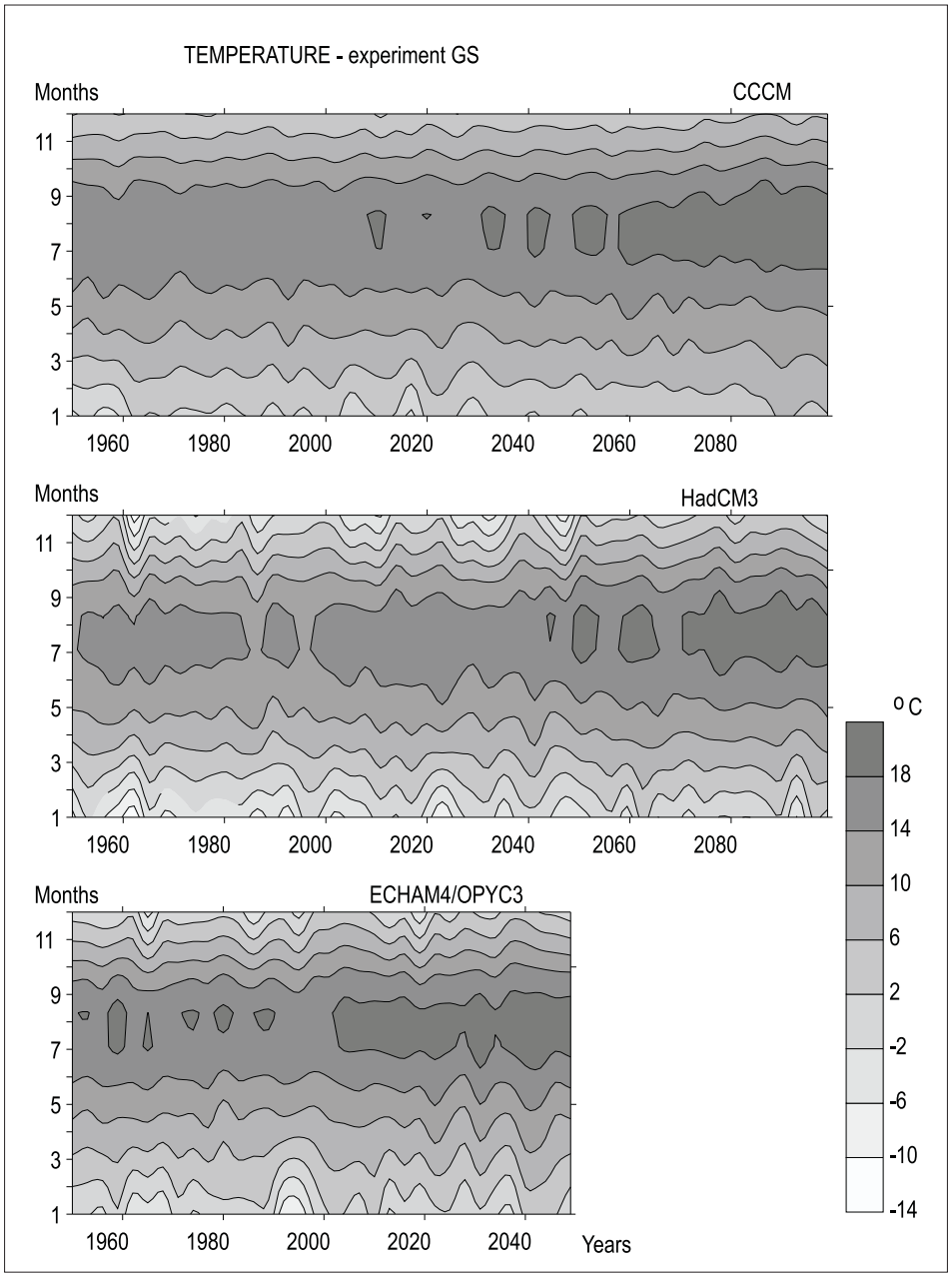

Fig. 3. Simulated temperature in Poland - scenario GS.

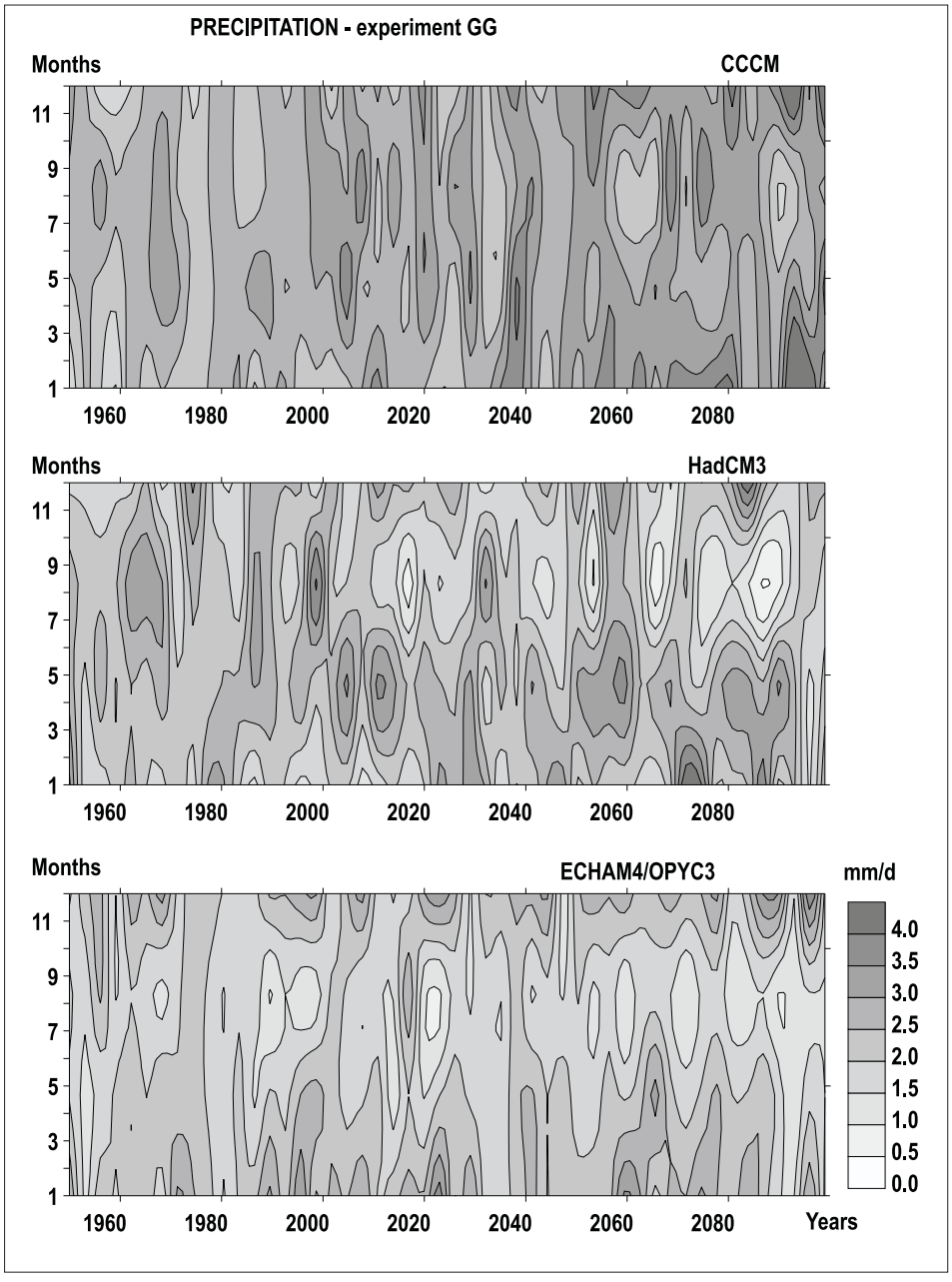

Fig. 4. Simulated precipitation in Poland - scenario GG.

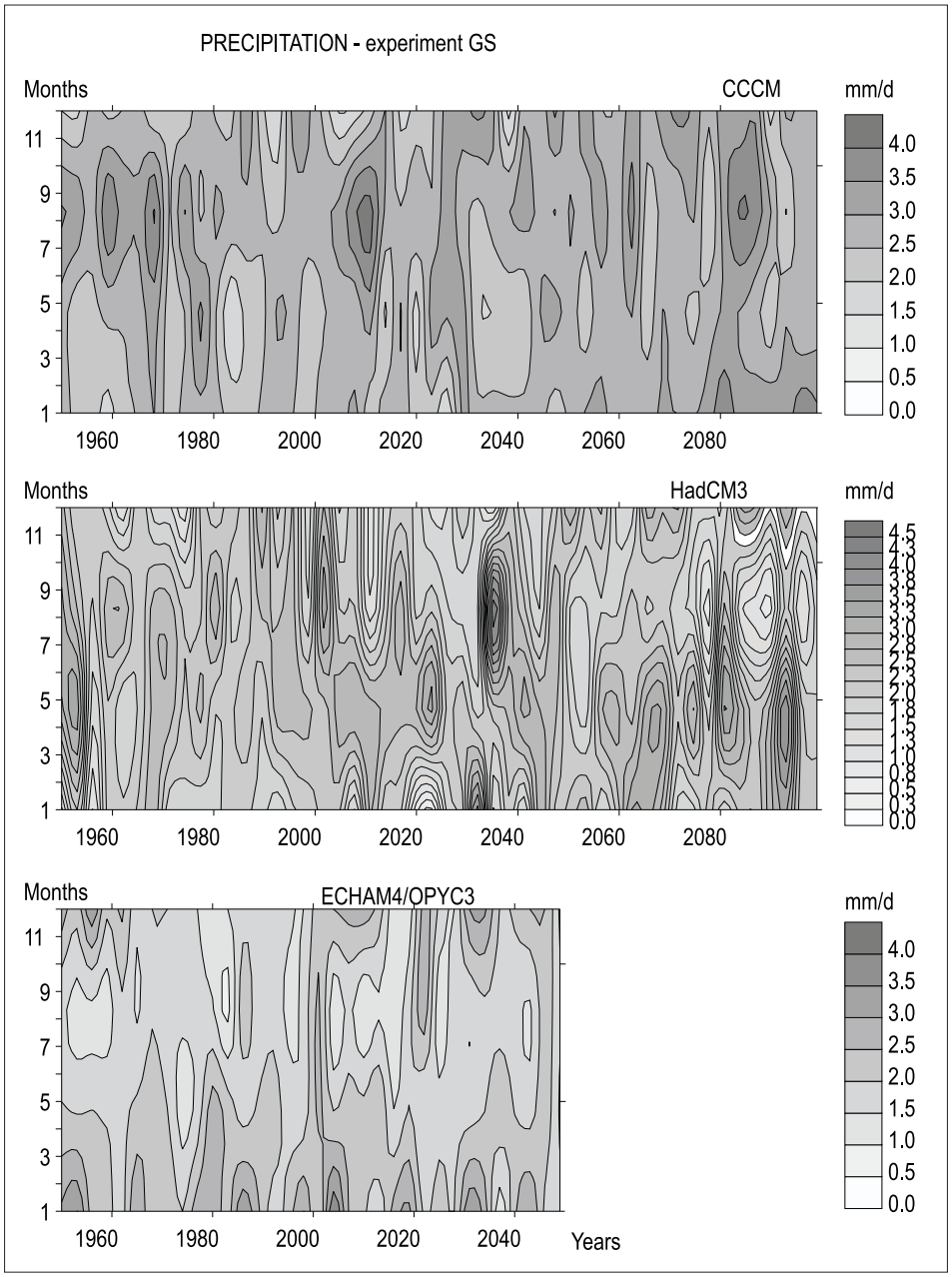

Fig. 5. Simulated precipitation in Poland - scenario GS.

particularly during the winter season; monthly temperatures are above 0°C for almost whole year, there is only in the experiment GS a small region of lower temperatures in January - February in 1950-1960 and before 2020. The HadCM3 model seems to represent the temperature distribution in Poland closer to reality: there are winters with temperatures below 0°C, but on the other hand the simulated summer is colder than observed, particularly in the scenario GG. Another feature which can be noticed is that the ECHAM4/OPYC3 model as well as the CCCM model extend the summer season towards September. The greatest warming, beginning from thirties of the next century, is projected in the experiment GG by the ECHAM4/OPYC3 model.

None of the models reconstructs the yearly distribution of precipitation in Poland in the reference period 1960-1989 correctly. Polish precipitation is characterised by maximum values in summer and minimum values in winter (Fig. 1), and this cannot be found in the analysed experiments. In general, the GG projections are wetter than the GS projections, the CCCM model simulates more rainfall than other models. The HadCM3 model gives a very strange pattern showing a strong variability of precipitation for the scenario GS. The image of changes in simulated rainfall is not clear.

Conclusions

The paper presents only some examples of results of analysis of three selected most current models. For more conclusions concerning the DDC data set and the Central European area and Poland see Liszewska, Osuch (1999), Osuch (2000). The problem of reconstructing climate is a big challenge for climatologists and at the same time it is an extremely difficult, if only feasible, task. The most expensive tools to simulate the climate system behaviour over time give very different results. It is also a characteristic feature that some variables are modelled with better accuracy while other are more difficult to be reconstructed. Precipitation is this meteorological parameter which is of great interest to climate impact researchers and is insufficiently simulated. The temperature distributions presented in the paper show a certain consistency between them though they differ in details. The extending summer warming is present in all experiments. At the same time in the case of precipitation no explicit trends can be seen.

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