Comparison of monthly mean precipitation rates from GPCP observations and ECHAM5 simulations

Rebekka Posselt*, **Fredy Heinzmann, and Ulrike Lohmann**
Institute for Atmospheric and Climate Science, ETH Zurich,
8092 Zurich, Switzerland

1. Introduction

Clouds and precipitation play an important role in the hydrological cycle of the earth. Changing precipitation patterns due to climate change will result in shifted vegetation zones, will have an influence on water quality, soil structure/erosion and runoff into the rivers and oceans (Hatfield and Prueger 2004). Through feedback processes, this changed precipitation rates have an impact on cloud formation and microphysical processes which, on their part, influence the precipitation rates. The prediction of precipitation is, therefore, an important issue for the climate modeling community. In order to obtain reliable results and to evaluate the model behavior it is essential to compare precipitation rates from model simulations with observation. This study uses observational data from the Global Precipitation Climatology Project (GPCP) to evaluate model simulations conducted with the ECHAM5 GCM.

2. Data description

2a. *The general circulation model ECHAM5*

The general circulation model (GCM) ECHAM5 is based on the ECMWF model and is now further developed at the Max-Planck-Institute for Meteorology in Hamburg. Within ECHAM5 the prognostic equations for temperature, surface pressure, divergence, vorticity are solved on a spectral grid with a triangular truncation (Roeckner et al. 2003). Prognostic equations for cloud water and cloud drop number concentration, for cloud ice and the ice crystal number concentration as well as detailed cloud microphysics was introduced by Lohmann and Roeckner (1996), Lohmann et al. (1999), and Lohmann (2002). In this study the autoconversion parameterization of Khairoutdinov and Kogan (2000) is used to form precipitation. The precipitation (i.e., rain and snow) is treated diagnostically such that within on model time step rain and snow which do not evaporate or sublimate below cloud base are completely removed from the model.

2b. *The Global Precipitation Climatology Project GPCP*

The GPCP combines satellite data with surface rain gauge measurements to retrieve precipitation datasets from 1979 up to now. The satellite measurements include microwave (SSM/I) and infrared precipitation estimates as well as low earth orbit estimates from TOVS (TIROS Operational Vertical Sounder) and OPI (Outgoing Longwave Radiation (OLR) Precipitation Index). (from: http://precip.gsfc.nasa.gov/gpcp_v2_comb.html)

3. Results

The precipitation rates of a 3-year ECHAM5 simulation in T42 resolution ($2.8125° \times 2.8125°$) were compared to a dataset of 26 years (1979-2004) from GPCP. For the statistical analysis monthly mean values of the precipitation rates were used.

The resulting frequency distributions (figs. 1,2,

*rebekka.posselt@env.ethz.ch

and 3) are grouped according to the seasons and are, further on, separated into global, land, and ocean precipitation.

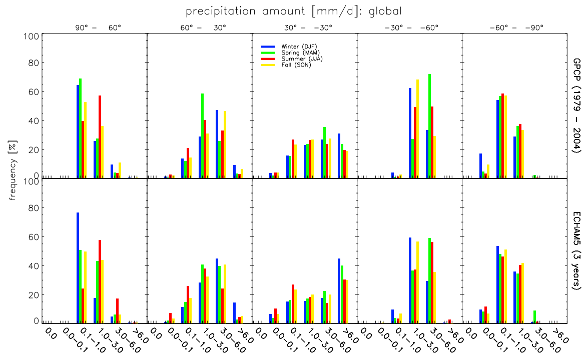

Fig. 1: Frequency distributions of global precipitation

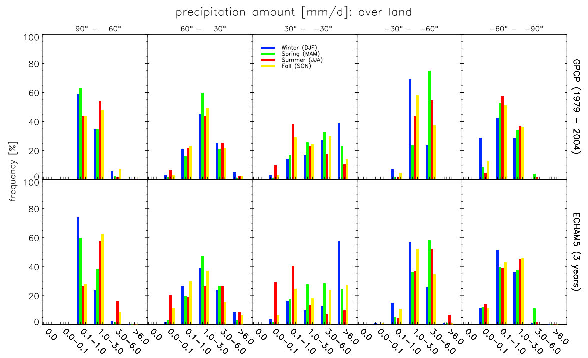

Fig. 2: Frequency distributions of precipitation over land

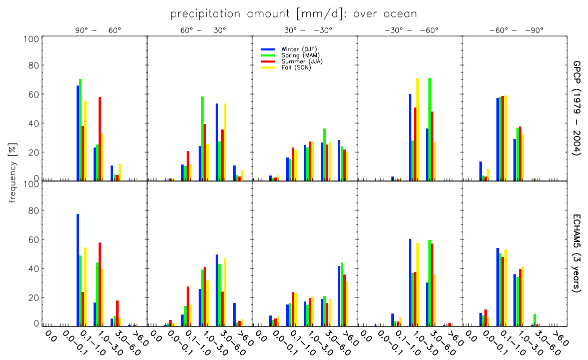

Fig. 3: Frequency distributions of precipitation over the oceans

In general the distributions of the GPCP observations and the ECHAM5 simulations show a very similar form. Differences are mainly observable within the representation of the seasonal precipitation especially in the midlatitudes. Within the tropics the model produces a higher percentage of strong precipitation events than the measurements. The differences between precipitation over land and ocean are mainly located in the midlatitudes of the northern hemisphere. The maximum of the distribution changes from class $1-3\,\mathrm{mm/d}$ over land to class $3-6\,\mathrm{mm/d}$ over ocean for both observations and model. This is mainly observable during winter and spring. But from an overall view, the model is able to represent the zonal precipitation patterns rather good.

Fig. 4 shows the global distribution of the precipitation rate for the GPCP and ECHAM5. It can be seen that the ECHAM5 represent the distribution of the precipitation rather well. However, the dry regions are even dryer in the model than in the observations and the wet regions get even more precipitation. This feature occurs mainly in the tropics where precipitation due to convection is dominating. In a zonal mean this features might cancel out.

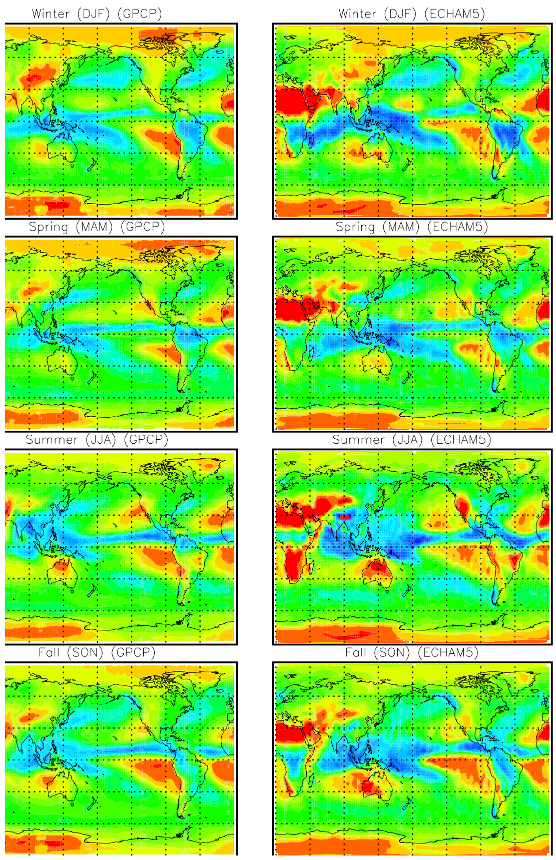

Fig. 4: global precipitation rate $[\mathrm{mm/d}]$

4. Conclusions and Outlook

According to the findings in this study the model seems to treat the precipitation formation rather well. In the midlatitudes differences are mainly present in the seasonal distribution, whereas, in the tropics the strong precipitation events are overestimated. This is also reflected in the global precipitation distribution.

Finally, it has to be admitted that a three year model simulation might be not enough to derive trustable statistics. Thus, it is planned to redo this study with a longer model simulation. Further, it is intended to investigate the influence of different autoconversion schemes on the precipitation formation.

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