Bias correction of global daily rain gauge measurements

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Abstract. Up to the present global precipitation climatologies based on rain gauges have been corrected for systematic measurement errors using monthly correction factors only. We present results from a statistical correction model for daily measurements. It was developed in the framework of BALTEX and adapted for the Global Precipitation Climatology Centre (GPCC) to correct global daily rain gauge data routinely transmitted via GTS. We focus on regions of the GEWEX continental scale experimets BALTEX (Europe), GAME (Asia), LBA (South-America) and GCIP (North- America). The correction model was applied to 2 years of data (1996, 1997) and compared with the correction factors of the widely used precipitation climatology of Legates (1987). In the BALTEX region our averaged daily correction factor is about equal to the monthly correction given by Legates during the summer months, while Legates estimated higher corrections for snow (up to 50 %). In the regions of GAME and LBA the corrections given by Legates are also generally higher (50 - 100 %) than our corrections. This is opposite to the corrections calculated for GCIP rain gauges, which are not significantly different.

1 Introduction

Goal of this study is to develop an improved statistical method for the reduction of the systematic measurement errors of rain gauge data. The method must routinely be applicable on global scale and be fitted to available meteorological and instrumental meta data.

The correction method currently used by the GPCC is based on long-term mean monthly corrections described by Legates (1987), Legates and Willmott (1990) and Reiss et al. (1992). Since the precipitation phase (solid or liquid) is important for the error size, even a rough on-event correction using synoptic data would be an improvement of the estimation of daily and monthly precipitation totals. The global precipitation analyses of GPCC calculated from corrected rain gauge observations are the basis for the verification of precipitation forecasts from NWP model runs or for the calibration of global satellite estimates (Rudolf et al., 2000). The correction model, based on the results of the WMO Solid Precipitation Measurement Intercomparison (Goodison et al., 1998), was originally developed for BALTEX (Rubel and Hantel, 1999). The Baltic Sea Experiment (BALTEX) is one of 5 continental scale experiments of the Global Energy and Water Cycle Experiment (GEWEX) a project of the World Climate Research Programme (WCRP). Therefore discussing our global results we focus on the GEWEX regions. These comprise BALTEX, the GEWEX Continental-Scale International Project (GCIP), the GEWEX Asian Monsoon Experiment

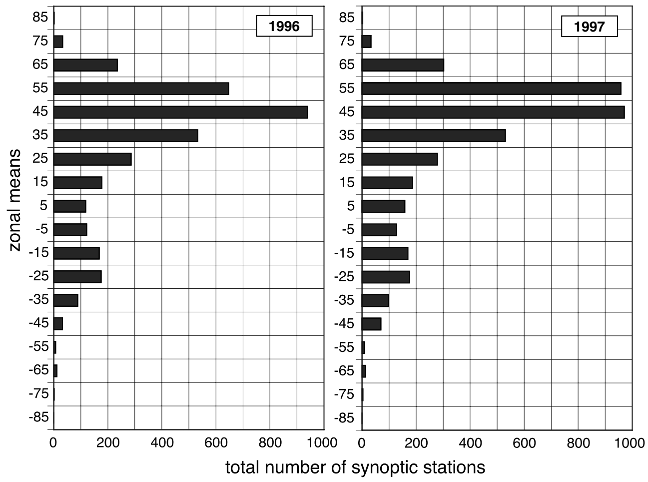

Fig. 1. Zonal distribution of the global synoptic precipitation measurements available for this study. The mean number of daily rain gauge observations increases from 3 700 (1996) to 4 100 (1997).

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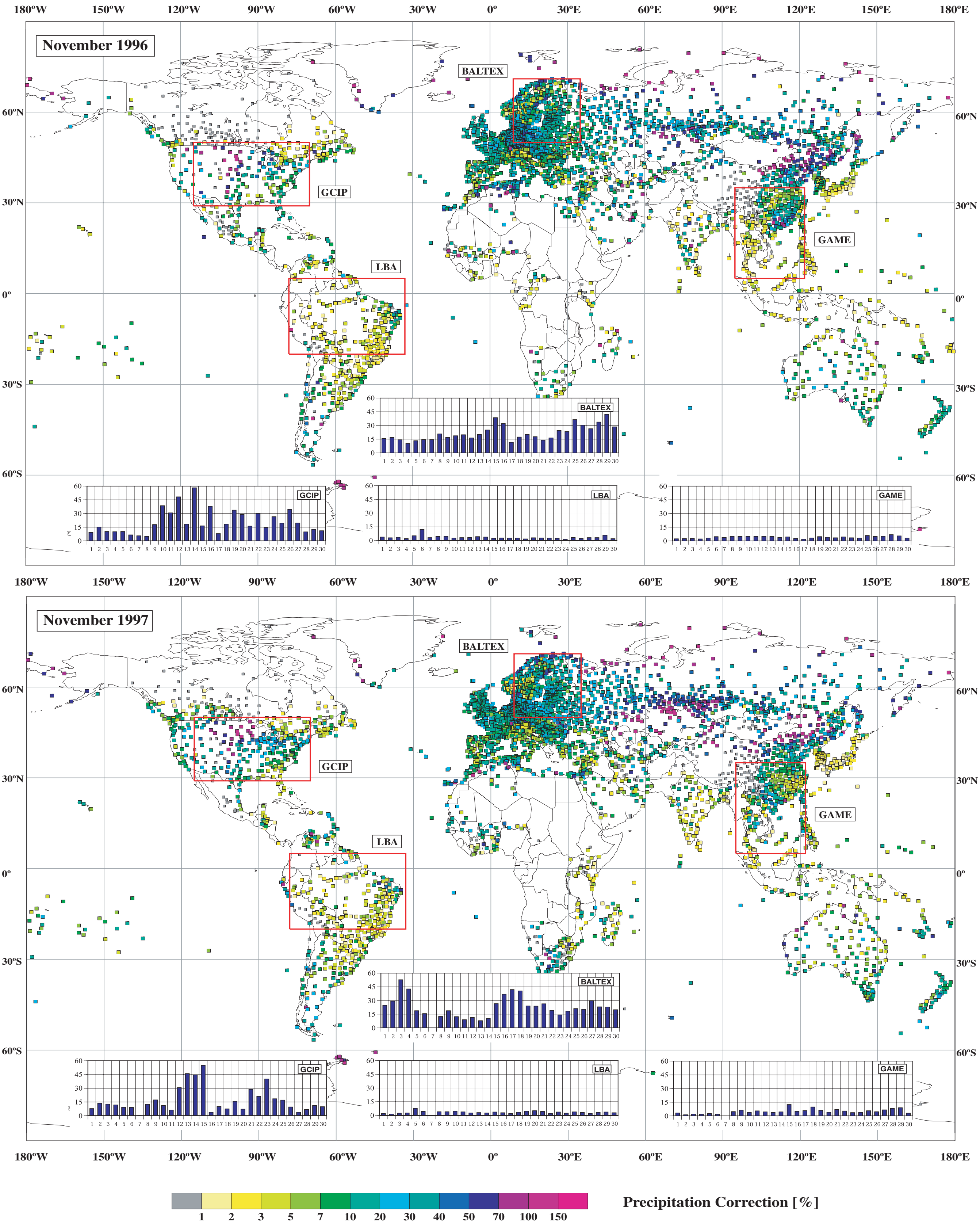

Fig. 2. Monthly mean corrections of daily rain gauge measurements for November 1996 and 1997. Time series of daily averaged corrections are given for the 4 GEWEX experimental regions BALTEX, GAME, GCIP and LBA. Following Legates (1987) the Canadian rain gauges have not been corrected for solid precipitation and therefore results from the MAGS region are not shown. Units percent.

(GAME), the Large-Scale Biosphere-Atmosphere Experiment in Amazonian (LBA) and the Mackenzie GEWEX Study (MAGS, not considered here).

2 Data and Method

The data used in this study are those of the global synoptic stations available from the GTS network. Fig. 1 shows the zonal distribution of the rain gauges with a maximum in the mid-latitudes of the Northern Hemisphere and a minimum in the polar regions of the Southern Hemisphere. The spatial distribution of the synoptic stations (Fig. 2) shows that the density is highest in Europe and South-Eastern Asia, while for large areas of Africa no observations are available.

Observations were corrected for systematic measurement errors with a statistical correction model (Rubel and Hantel, 1999; Rubel et al., 2000). Its main purpose is to correct for the wind-induced losses, which is the largest error. The correction formulae use observed wind speed and temperature as well as estimated rain intensity. For evaporation and wetting losses, which represent the second largest error of the precipitation measurements, climatological corrections are applied. Further the correction take instrument-specific properties into account; these comprise differentiation between unshielded (e.g. HELLMANN) and shielded (e.g. TRETJAKOV) gauges.

3 Results

Two years (1996, 1997) of about 4 000 daily rain gauge observations have been corrected for systematic measurement errors (Ungersböck, 2000) and are used for case studies over Europe (Fuchs et al., 2000). Fig. 2 shows the monthly averaged daily corrections for November 1996 and 1997. The corrections (corrected minus observed precipitation) are given in percent of the observed values. Comparing the time series of the daily corrections, which are given for the different climatic regions of GEWEX (Fig. 2), the dominance of solid over the liquid precipitation phase on the amount of the corrections becomes visible. The high variability of the daily averaged corrections indicate the importance of the on-event correction. Compared to monthly mean corrections the application of a correction model for daily measurements results in a more realistic bias reduction.

The corrections for BALTEX and GCIP rain gauges during the winter months are about 20 - 60 %, while liquid precipitation measurements have been corrected by less than 10 % (Fig. 3). In the tropical regions of GAME (5 - 10 %) and LBA (3 - 5 %) the corrections are significantly lower. It was generally noticed that the climatological corrections given by Legates are significantly higher in the tropics. Note further that single

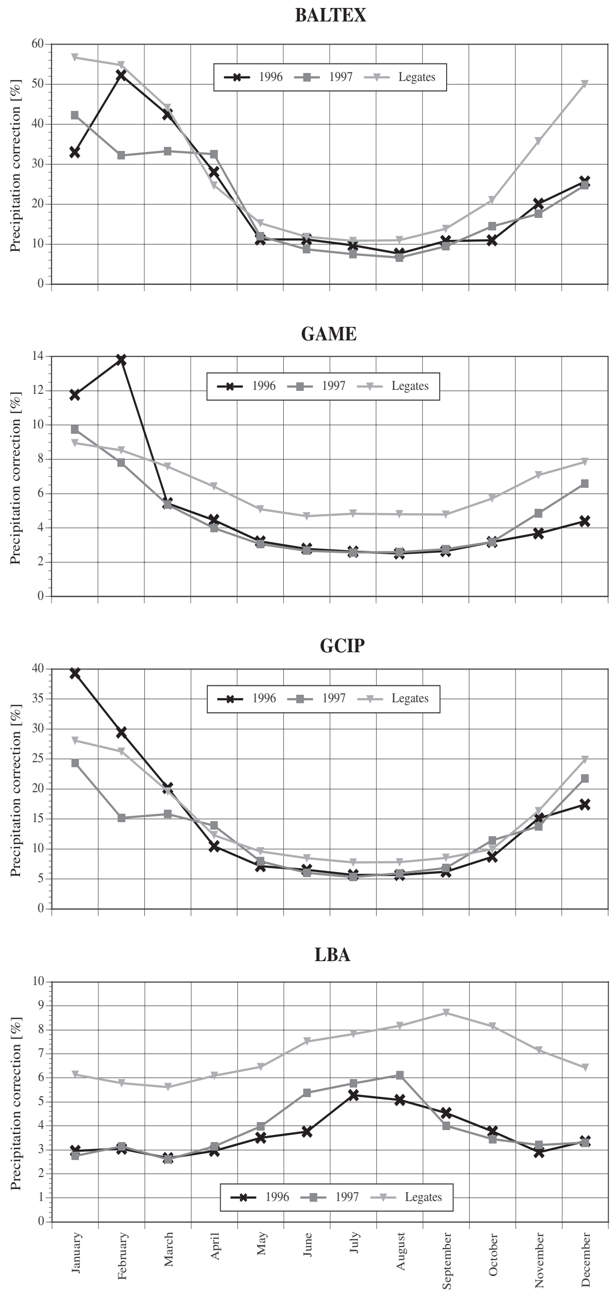

Fig. 3. Annual cycle of the corrections calculated for 1996 and 1997, compared with the corresponding climatological corrections from Legates (1987). The corrections are averaged over the GEWEX regions BALTEX, GAME, GCIP and LBA (Fig. 2). Note that scaling is different for individual plots.

high corrections (Fig. 2) are generally due to low precipitation amounts. In these cases wetting and evaporation losses are of same order as measured values resulting in a high percentage of the corrections.

4 Conclusions

Selected results from a correction model, designed to reduce the measurement bias of daily rain gauges in real time, have been presented. The correction model concentrates on the main effect that causes the undercatch of gauges, specifically the wind-induced error. Actual wind speed, temperature, rain intensity (estimated from 6- and 12-hourly observations) and information on the gauge (type, shielded or unshielded, height of the orifice) are regularly implemented into the correction procedure. Further, the currently used data base on the national rain gauges (Sevruk and Klemm, 1989), will be updated using the forthcoming initiative of the WMO on compiling a new catalogue of national standard rain gauges. Site specific parameters (Sevruk and Zahlavova, 1994) cannot be included since they are generally unknown.

Currently no corrections have been done for trace and blowing snow, which has been shown to be important in the wind-loss adjustment in polar regions (Yang et al., 1998). For simplifications we use a threshold of wind speed to avoid the influence of blowing snow. Despite these simplifications, necessary to apply the correction model to global data sets, the results have been shown to be similar to those given by other authors (Legates and Willmott, 1990).

Daily corrected precipitation estimates will be used by the Global Precipitation Climatology Centre (Fuchs et al., 2000) for evaluation of the monthly precipitation estimates corrected after Reiss et al. (1992). The purpose of these data is the verification of climate model results and the calibration of global satellite precipitation estimates (Rudolf et al., 2000). Finally, the correction model was applied to the very dense non-synoptic rain gauge networks of BALTEX. By this application 3 years of daily corrected meso-scale precipitation fields over the Baltic Sea drainage basin (Rubel and Hantel, 2000) are now available.

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