STATISTICAL DOWNSCALING OF CLM PRECIPITATION USING ADJUSTED RADAR DATA AND OBJECTIVE WEATHER TYPES

by

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ABSTRACT

A statistical downscaling method has been developed to produce highly resolved precipitation data from regional climate model (RCM) output, using the model CLM (2 runs, scenario A1B). The procedure is based on the analogue method with the predictors precipitation (daily sums on CLM grid points) and objective weather types (DWD). Analogue days of the time period 2001-2009 are searched using corrected and adjusted data of radar Essen and DWD measurements of objective weather types. The radar data is used to produce high-resolution precipitation data sets (1km², 5min) with realistic spatial and temporal correlations for three catchments in North Rhine-Westphalia. Results in the reference period (1961-1990) are examined using extreme value statistics and compared to corrected station data. Data sets of the near and the far future (2021-2050, 2071-2100) are analysed with respect to future trends, and uncertainties of the downscaling procedure are discussed.

Keywords: statistical downscaling, extreme precipitation, radar

1 INTRODUCTION

To use results from global and regional climate models for hydrological modelling, spatial and temporal scale differences have to be overcome. Dynamical and statistical downscaling procedures are used to close this gap. Statistical procedures can produce high resolution data using statistical relationships between the different scales which are derived from observations.

Small-scale hydrological models and dynamical sewer models require precipitation input with a high spatial and temporal resolution. This is due to the small scale and the short response time of the hydrological processes. For these models, radar-based precipitation measurements (1km², 5min) provide adequate input (Einfalt et. al., 2004). Within the scope of the BMBF funded project *dynaklim* (www.dynaklim.de) a statistical downscaling procedure has been developed using adjusted radar data as a predictand. The focus was on the applicability of the results for small-scale hydrological models with a special regard to extreme events.

2 DOWNSCALING PROCEDURE

The basis for the downscaling procedure were corrected and adjusted data from radar Essen (DWD, 1km x 1°, 5 min, DX-product) from Nov 2001 - Nov 2009 (Frerk et al., 2012). In addition, daily classifications into objective weather types for the measurement period of the DWD were used (Bissolli and Dittmann, 2001). Data from the regional climate model CLM, based on the global circulation model ECHAM5, were provided by the Climate Service Center (Lautenschlager et al., 2009): run 1 and run 2 for 1961-2000 („C20“) and 2001-2100 (scenario A1B). Objective weather types for the ECHAM-CLM data (Krahé et al., 2011) were also employed.

The area used for the downscaling was chosen due to similar orographic conditions and precipitation characteristics and comprises 10 CLM grid points in the Emscher-Lippe Region. For three catchments near Dortmund, Duisburg and Bönen (area size of each catchment: 70-76 km²) high resolution data sets should be produced for the reference period (1961-1990), near and far future (2021-2050, 2071-2100). Trend analysis of CLM precipitation in the region has been done by Freistühler et al. (2012). They found positive future trends for daily and sub daily heavy precipitation.

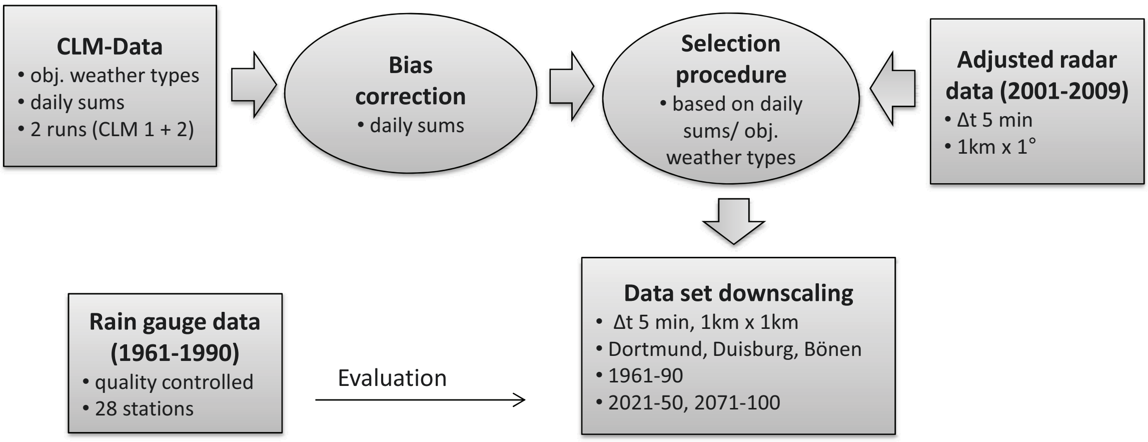

Figure 1– Overview of the downscaling procedure

The presented statistical downscaling procedure combines the analogue method (Zorita and Storch, 1999) with a weather type approach. A schematic overview of the procedure is given in Figure 1. Daily sums from the CLM model were bias corrected with a quantile mapping method (Piani et al., 2010). To account for the characteristics of the model precipitation as area means, the bias correction was done using radar based areal precipitation for the CLM grid points. In this way, the bias correction differs from the correction based on rain gauge data described by Quirmbach et al. (2012). As RCM values of single grid points do not necessarily reflect the regional mean, probability density functions (PDFs) of 10 neighbouring CLM grid points were determined, and the time series of the grid points covering the selected catchments were modified to match the mean PDF.

The modification of the daily sums was followed by the selection of historical analogues from the period 1 Nov 2001 – 1 Nov 2009. "Similar" days to a model day were selected, defined through the same objective weather type and a similar 24h precipitation sum from the radar data. From the number of historical events satisfying these criteria, one was randomly selected. If no suitable event was found, neighbouring objective weather types were included, and the permitted precipitation difference was increased (to a maximum of 4mm). In order to enlarge the database, a displacement of the radar data within the 10 CLM grid points of the research area was performed.

The selection process was done for each 30 year period. Using the full resolution of the radar data of the selected events, time series for the catchments were generated, constructing data sets with spatial resolution 1kmx1km and time step 5min.

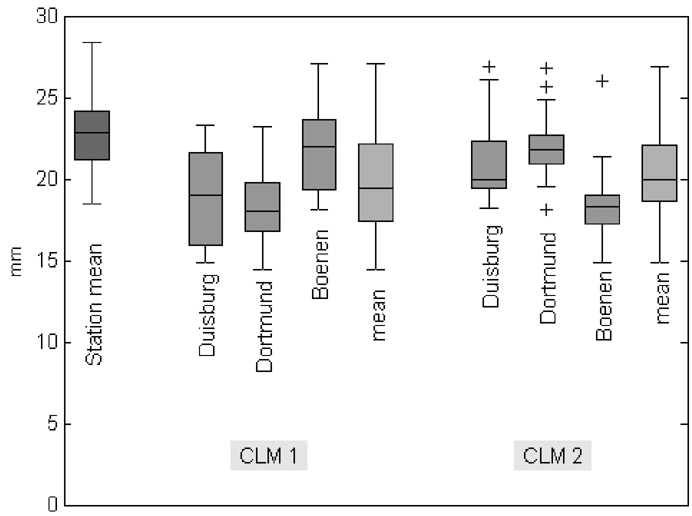

Figure 2 – Extreme precipitation (duration 1h, return period 5a) in the reference period from 28 stations and from the downscaling results within the catchments; catchment size is 70-76 km².

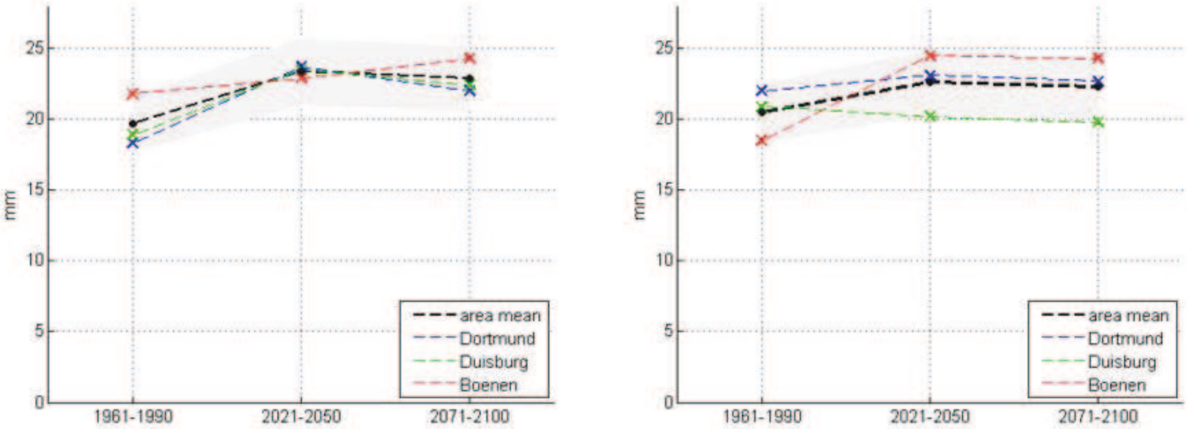

Figure 3 – Extreme precipitation (duration 1h, return period 5a) for reference period, near future and far future as result from the downscaling for CLM 1 (left) and CLM 2 (right). Catchment means of Dortmund, Duisburg and Bönen are displayed in colour. The black dots represent the mean of the three catchments and the shaded uncertainty area is ±10% according to KOSTRA (DWD, 2005).

3 RESULTS

Extreme precipitation of the high resolution data sets was analysed. Figure 2 shows results of the extreme precipitation in the reference period (duration 1h, return period 5a) in comparison to observations of 28 quality controlled rain gauge stations in the research area. The downscaling results show a notable variability between the radar pixels within the catchments with a mean standard deviation of ±2.4mm. The absolute mean from the stations (22.7mm) is higher than the mean values of the downscaling results: 19.7mm/ 20.5mm (CLM 1/ CLM 2). This discrepancy can be explained by different characteristics of the radar data (1km² area means), employed for the downscaling, compared to rain gauge measurements (point values). Scheibel et al. (2012) found a similar difference between radar and rain gauge extreme values when analysing data from 2001-2010 for the Wupper area.

Future extreme precipitation trends are displayed in Figure 3. Trends are mostly positive and range from -5% to +32% compared to the reference period. Mean trends are +18.8%/ +16.4% (CLM 1/ CLM 2) for the near future and +16.4%/ +8.8% for the far future.

The applicability of the high resolution data as input for hydrological models was tested with a model of the Rossbach catchment (Dortmund). Results for the reference period were found to be satisfying in comparison to a model run driven by observations.

4 CONCLUSION

With the described downscaling chain, starting from RCM output, high resolution data can be produced. The resulting data is suitable as input for small-scale hydrological models. A prerequisite is the availability of adjusted radar data in high quality. The uncertainties of the regional climate model are conserved during the downscaling process. When passing to smaller scales additional uncertainty appears, as various realisations can be in consistency with a single RCM run. The uncertainties are notably high for the extremes which react sensitively on the random occurrence of single events. In the downscaling process this uncertainty is found in the bias correction above the 99% quantile, where the correction function depends considerably on the exact choice of the time period of model and observation data. This affects both absolute values and trends. The uncertainty is also found in the random component of the described selection process, particularly in case of the highest rain events: parameters as the spatial and temporal distribution of the precipitation field influence the result, and a convective realisation has a different effect than a stratiform one. Starting from the CLM runs, the three independent downscaling realisations for the three catchments give an impression of the uncertainty range and the range of possible trends within the region.

5 ACKNOWLEDGEMENTS

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