Assessing the performance of statistical downscaling setups in Cameroon

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The purpose of this study is to estimate the response of local precipitation in Cameroon to external climate forcing as simulated by general circulation models (GCMs). This will be done by using linear and non linear statistical methods. The achieved results can also serve as a lower bound for the performace that should be obtained by regional climate models (RGMs). Cameroons climate runs from humid-equatorial close to the Atlantic ocean to arid-tropical in the vicinity of the lake Tchad, which belongs to the Sahelian zone. Hence precipitation varies intensively in space as well as in time. Thus Cameroon can be indicative of different African climates. This signifies also a strong challenge for the used methods. For brevity after a superficially description of the local climate and data only some preliminary results concerning canonical correlation analysis (CCA) are presented. One goal of further invetsigations will be will be to study the impacts of the IS92 and SRES scenarios, calculated by the ECHAM4/OPYC3 climate model.

Comments on the Climate

Cameroon is situated at the Gulf of Guinea, close to the Equator, in Central Africa and its climatic situation is complex due to several reasons: • It lies inside the Inter-Tropical-Convergence-Zone (ITCZ). Thus rainfall is dominated by two air flows, Harmattan and Monsoon, which hail from the Azores and Sainte-Hélène anticyclones respectively. Harmattan and Monsoon meet along the Inter-Tropical-Front line (ITF), whose latitude varies within the year. • Due to its proximity to the Atlantic local rainfall is strongly affected by the ocean. Even Sahelian rainfall is influenced by sea surface temperature (Wassila et al. 1999). • The mountain chain of West-Cameroon divides the country in two parts and thereby influences the rain patterns.

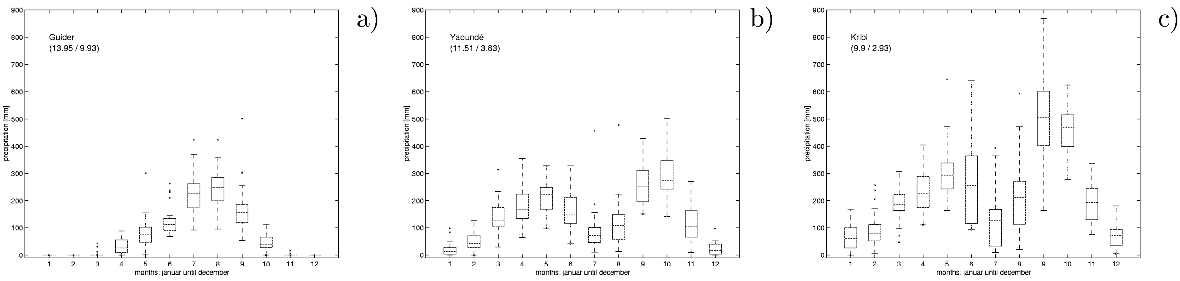

Figure 1. The panels show boxplots of representative stations.

Hence Cameroons climate is equatorial-tropical in coastal regions, semiarid in the Adamaoua plateau and arid next to lake Tchad. Three climatological rainfall regimes can be clearly identified (Kamga 2001): (i) the Sahelian climate with less than 400mm annual rain, (ii) the tropical climate with yearly totals between 400 and 1500mm and (iii) the sub-tropical climate with annual rainfall between 1500 and 4000mm (see Figure 1. a, b and c respectively).
Therefore Cameroon is a good candidate for studying different African climates and to examine the capability of the statistical models under variable conditions.

Data

1. For fitting and validating the different statisical models we consider the period from 1951 to 1990. As predictors we use monthly mean SLP, SST and surface-wind taken from the National Center for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) reanalysis (Kalnay et al. 1996). Spatial resolution is about 250 km. We choose the sector from 10°W to 20°E and 20°S to20°N.
2. On the regional scale 33 monthly mean precip. records are used (Figure 2.). Figure 1. shows the precip. statistics of stations characteristically for the different climatic regions in Cameroon (Guider, Yaounde and Kribi).
3. Predictors for the small-scale precip scenarios and the first half of the 21 century are extracted from the ECHAM4/OPYC3 IPCC scenario-realizations (Roeckner et al. 1996).

Results and Outlook

Different statistical methods will be applied - canonical correlation analysis (CCA), singular value decomposition (SVD) and multiple linear regression (MLR). These techniques are wellknown and mathematical background can be found in i.e. von Storch and Zwiers (1999). Presented results refer only to CCA, as the calculation using other methods has not been done yet. The results refer to greater rainy season August, September, October (ASO) with SST as large scale predictor.

We apply CCA after a transformation in empirical orthogonal function (EOF) coordinates. The first step is to analyse the observed data by means of EOF analysis and seperate the signal from the noise. On the basis of scree-plots we decided to retain four EOFs (94%) on the large- and seven (70%) on the small-scale. The leading local EOF (almost 20% of explained varinace) appears to divide Cameroon into three regions (Figure 2.a). One with latitudes more than 7^oN, one south of the Adamaoua plateau and the coastal region. This is in agreement with local topography. In the latter two regions the variance explained by the associated principal component reaches a flat maximum.

The first large scale EOF (not shown) explains 63% of the variance. CCA produces pairs of patterns that maximize the correlation of the canonical series. Figure 2. b), c) show the first pair of patterns.

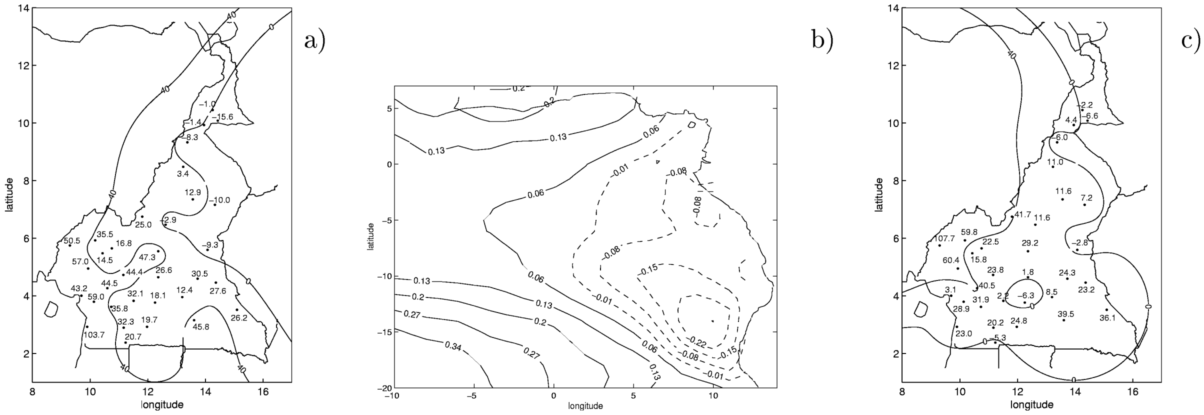

Figure 2. a): the first local EOF; b) and c): the first pair of canonical correlation patterns of observed SLP and simultaneous Cameroon precipitation anomalies. The correlation between the corresponding timeseries is 0.7. The SST [^{o}C] (rainfall [mm/month]) pattern explaines 13% (21%) of the variance. Circles indicate the stations.

To assess the performance of the method the datasets are used in the following way: period - 1951/80 for model fitting and the total for validation. CCA is applied to August, September, October seperately and the whole season (ASO). The results are displayed in Figure 3. Boxplots show the behaviour of the significant correlation coefficients (more than 95%) between estimation and observation at all stations.Figure 3 g) shows the highest correlation reached (a star indicates August, + September, . October and o the seasonal mean ASO). This might give an impression of the complexity of Cameroon rainfall. The achieved correlations demand further work. Apart from the distinction of local regions the influence of different large scale sectors is to be examined. Thus, beside the application of other methods and predictors we will also consider different regions and more sectors.

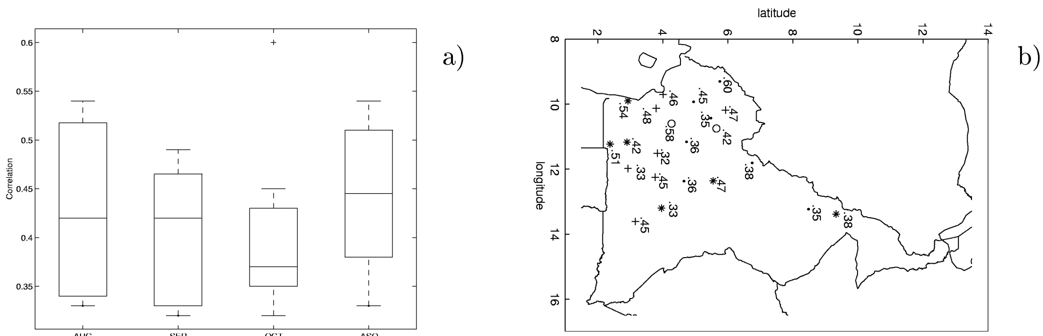

Figure 3. a) model performance for August, September, October and the seasonal mean (ASO) (no distinguishing between local regions); b) the highest performance at individual stations that can be attained with the used setup (August:*,September:+,October:.,saisonal mean:o)

Kalnay, E., M. Kanamitsu, R. Kistler, W. Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woollen, Y. Zhu, M. Chelliah, W. Ebisuzaki, W. Higgins, J. Janowiak, K.C. Mo, C. Ropelewski, J. Wang, A. Leetmaa, R. Reynolds, R. Jenne, and D. Joseph, 1996: The NCEP/NCAR reanalysis project.. *Bull.Amer.Meteor.Soc*, **77**, 437–471.

Kamga, F.M., 2001: Impact of greenhouse gas induced climate change on the runoff of the Upper Benue River (Cameroon). *Journal of Hydrology*, **252**, 145–156.

Roeckner, E., J. Oberhuber, A. Bacher, M. Christoph, and I. Kirchner, 1996: Enso varability and atmospheric response in a global coupled atmosphere-ocean gcm. , **12**, 737–745.

von Storch, H., and F. Zwiers, 1999: *Statistical Analysis in Climate Research.* Cambridge University Press, 484 pp.

Wassila, M., G.A. Barnston, and K. Vadlamani, 1999: Prediction of African rainfall on the seasonal timescale. , **104**, 31589–31597.