EGU2012-6448: Evaluation of Regional Climate Models: Extremes important for Hydrology

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1. Objective

The impact of climate change on extreme hydrologic characteristics has important socio-economic implications. Regional Climate Models (RCMs) downscale atmospheric information from Global Climate Models to smaller spatial scale, which is then widely used as drivers for hydrological models. Extreme hydrologic phenomena like floods or droughts are often directly linked to extremes in these downscaled meteorological forcing. Consequently, it is important to investigate how reliable RCMs can reproduce extreme statistics of precipitation that have large implications for hydrology.

2. Data Set and Study Area

The RCM data employed in this study was provided by the ENSEMBLES project [3]. The RCMs used for the domain of Germany are shown in Table 1.

Symbol	Name	Symbol	Name
A	C4IRCA3	G	KNMI-RACMO2
B	CHMIALADIN	H	METNOHIRHAM
C	CNRM-RM4.5	I	METO-HC HadRM3Q0
D	DMI-HIRHAM5	J	MPI-M-REMO
E	ETHZ_CLM	K	RPN-GEMLAM
		L	SMHI

Table 1: Names of RCMs and abbreviation

The RCM runs were conditioned by the ERA40 data set. As reference, the REGNIE product of the German Weather Service (DWD) was aggregated to the spatial resolution of 25 km of the RCMs.

3. Methodology

Principal Component Analysis (PCA) on the correlation matrix of the daily rainfall fields as well as the relative bias for various statistics presented in Table 2 were used to assess the overall performance of all RCMs during the period from 1961 to 2000.

ID	Name	Definition	Unit
Total	Annual Totals	Annual Total precipitation	mm
Rx5	Max 5-day precipitation amount	The maximum of the 5-day precipitation amount	mm
R10	Number of very heavy precipitation days	number of days with more than 10 mm precipitation	days
CDD	Consecutive dry days	The largest number of consecutive days with no more than 1mm rainfall	days
R95p	Very wet days	The amount of precipitation higher than the 95 percentile of precipitation	mm

Table 2: Precipitation indices (following [1])

The Wilcoxon test was used to test the null hypothesis, that the average value of the RCMs (μ_{RCM}) and the observations (μ_{Obs}) for these statistics (Table 2) are equal.

$$H_0 = \{\mu_{RCM} = \mu_{Obs}\}$$

4. Results for the PCA [2]

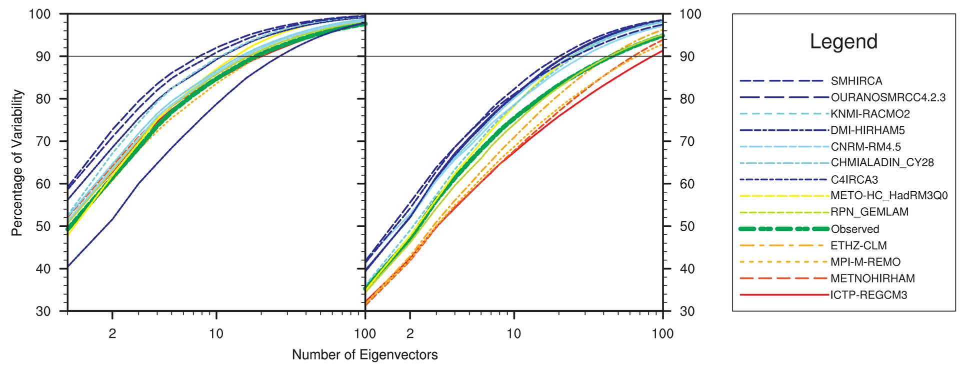

Fig. 1: Cumulative distribution of variance among principal components

The percentage of variance explained by a certain number of principal components (pc) is shown in Fig. 1. In summer, approximately 40 principal components are required to explain the 90% of the total observed variance, whereas only 20 are required in winter. The spread of the cumulative variance explained by the k largest eigenvalues is larger in summer than that obtained in winter. Fig. 2 shows

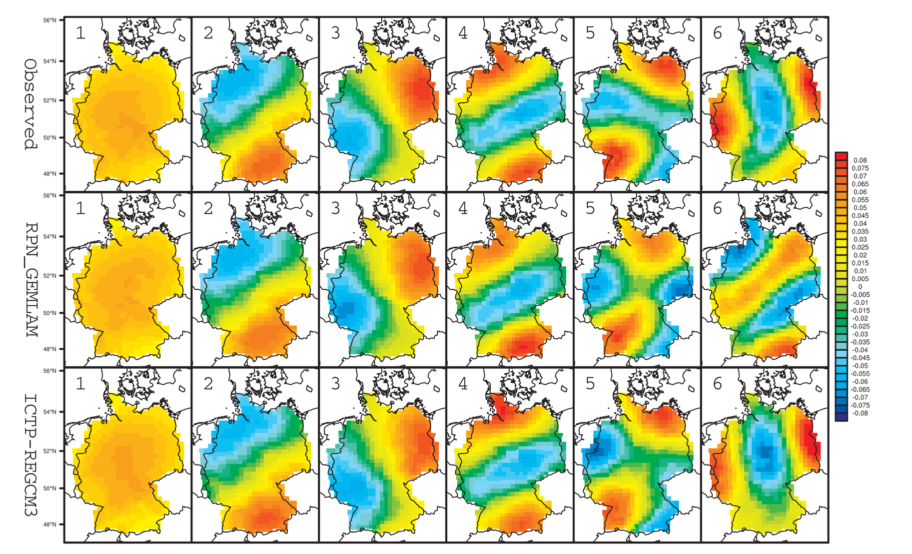

Fig. 2: Spatial distribution of eigenvectors

the spatial distribution of the first six pcs during summer for the observations, RPN_GEMLAM, and ICTP-REGCM3. The pattern of the sixth pc is better represented by ICTP-REGCM3, although its contribution with respect to the total variance is too small.

5. Evaluation of Extreme Indices [2]

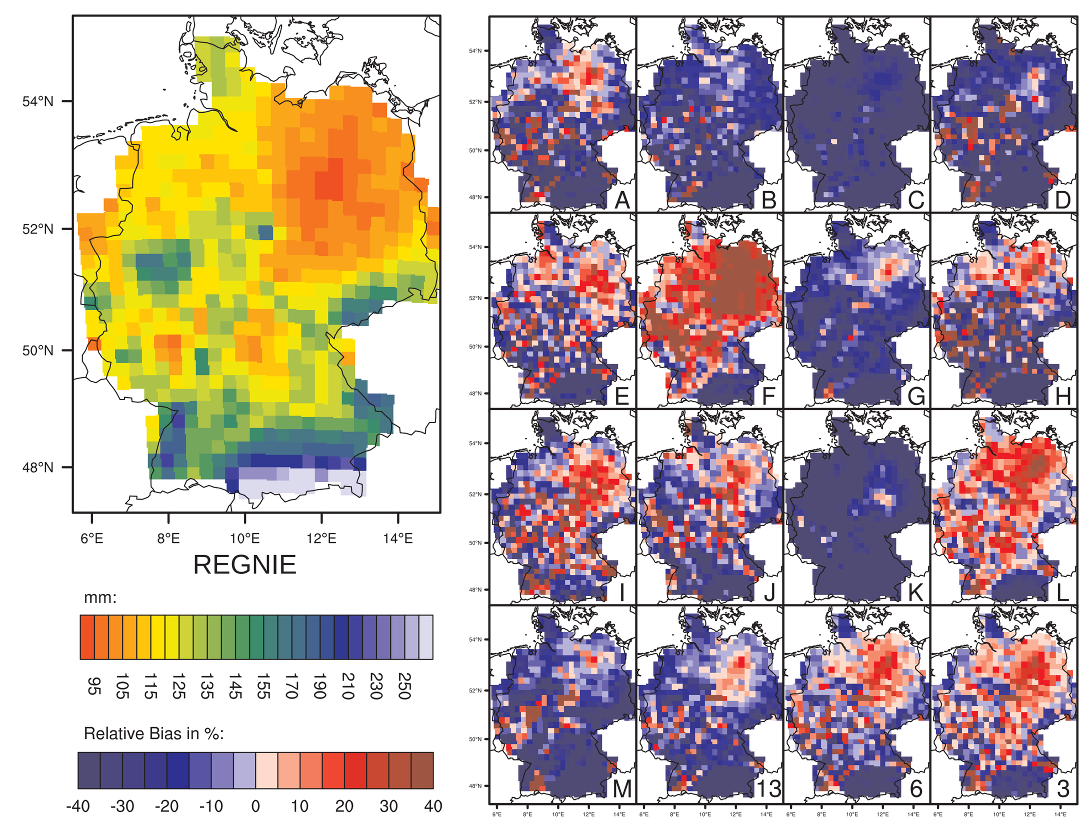

Fig. 3: R95p during summer - R95psum

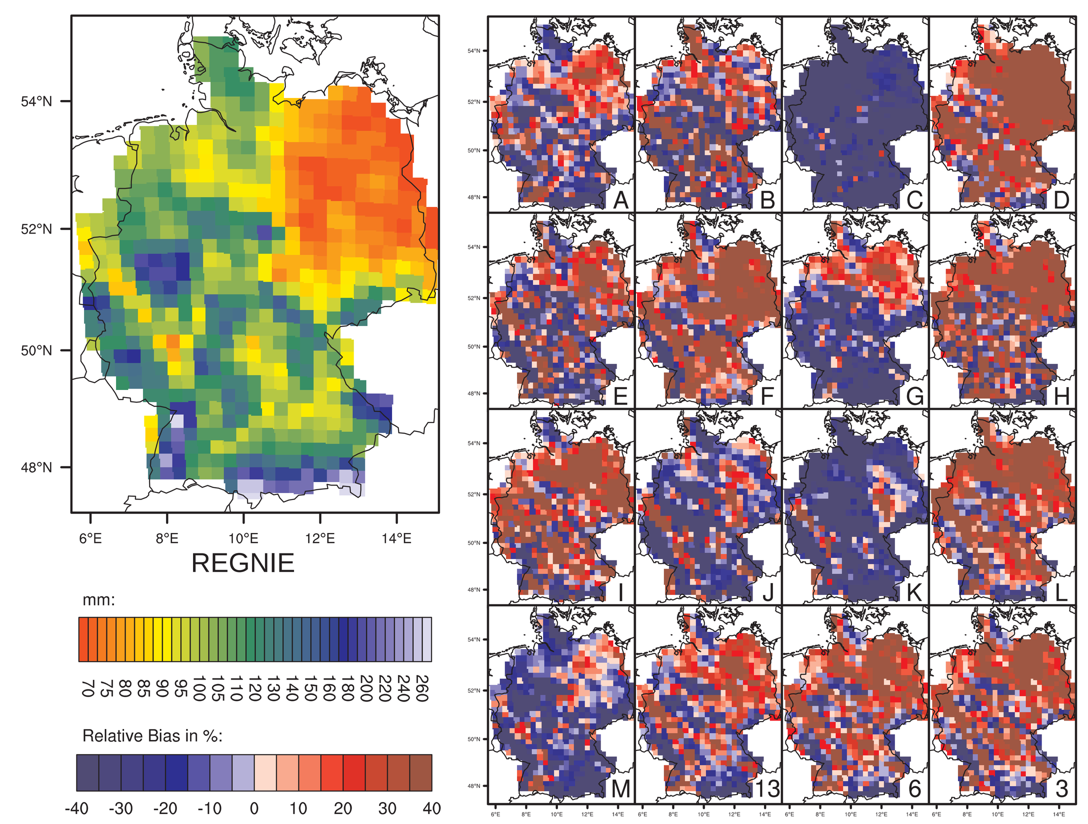

Fig. 4: R95p during winter - R95pwin

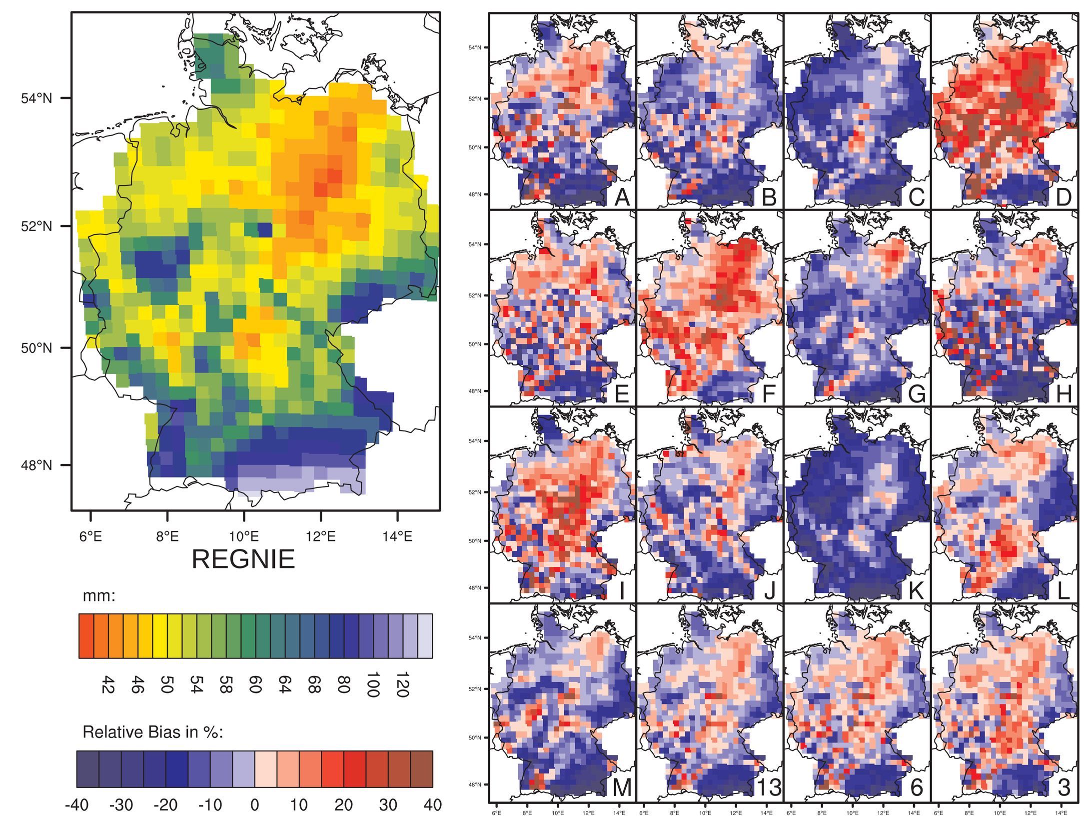

Fig. 5: Rx5 during summer - Rx5sum

The index R95p obtained with summer observations is depicted on the left panel of Fig. 3. The relative bias of each RCM and of the 3-best, 6-best and 13 ensemble members with respect to the latter are shown on the right panel of Fig. 3. Figs. 4 and 5 correspond to the indices R95p in winter and Rx5 in summer, respectively. All models are underestimating R95p and Rx5 during summer in the Alps, but overestimate these indices in the northeast part of Germany with the exception of models C and K. This indicates that the spatial variability is underestimated by most RCMs, since the gradient of both indices is in the northeast - southwest direction.

6. Summary [2]

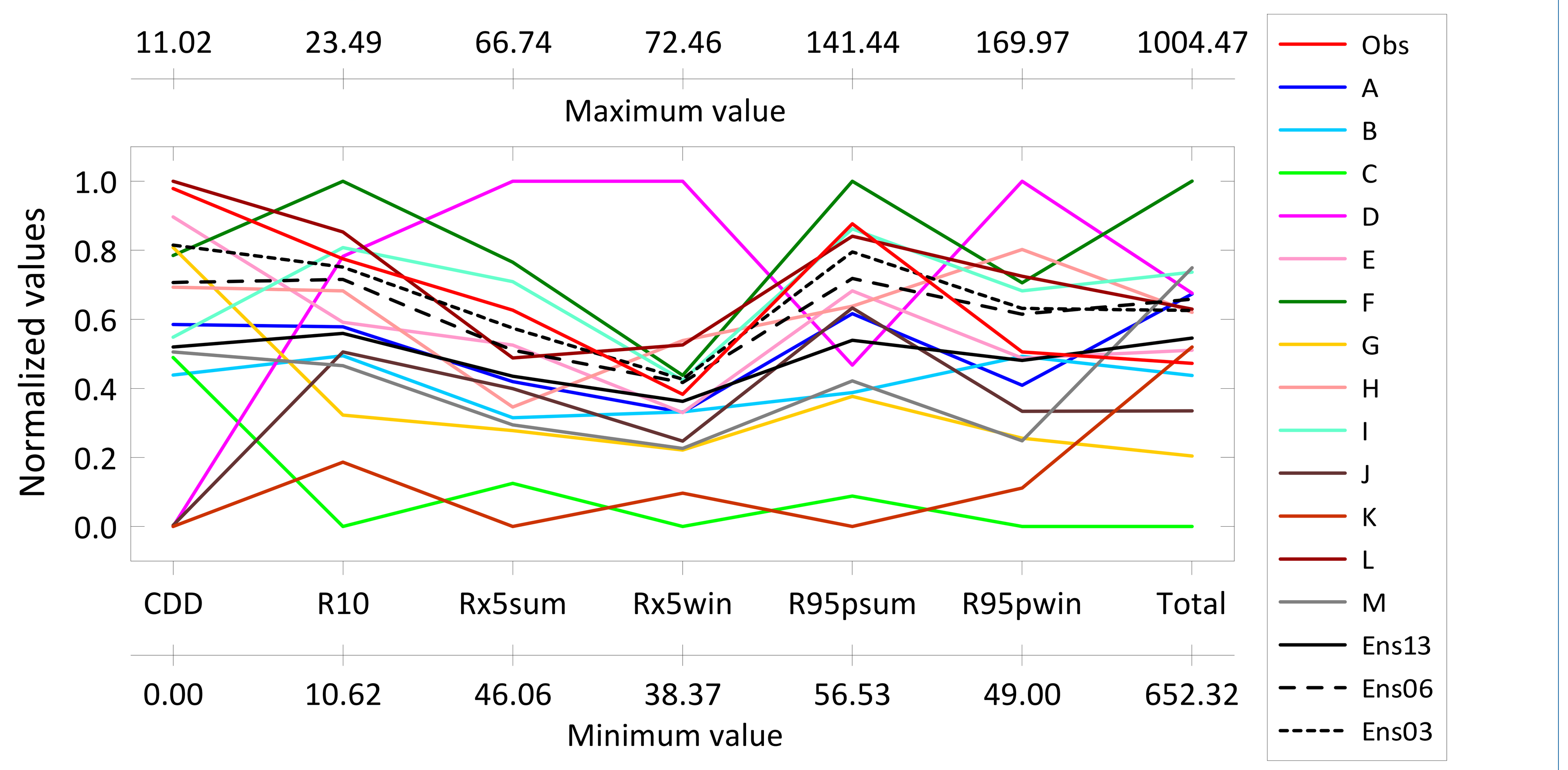

Fig. 6: Summary of the performance of all RCMs and three ensembles

Most RCMs are either under- or overestimating the statistics obtained with the observations. For this reason any 3- and 6- member ensemble performs better than most of the RCMs.

7. Results for the Wilcoxon test [2]

The level of rejection of the null hypothesis as well as its spatial distribution is depicted with blue and red colors in Fig. 7, which indicate under- and overestimation, respectively. The number of cells, for which rejection at the 10% significance level was detected, does not decrease for the ensemble statistics and is remarkably high for the annual total precipitation, which is not even an extreme statistic.

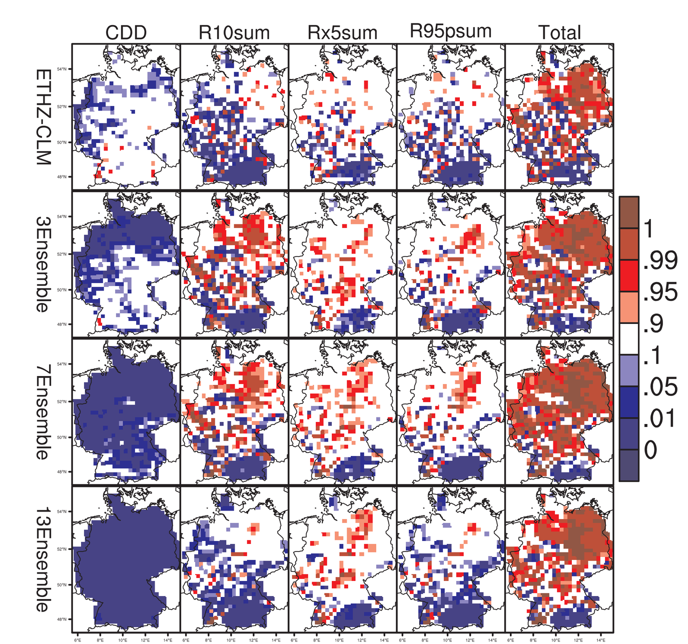

Fig. 7: Spatial distribution of P-values for Wilcoxon test

8. Conclusions

The PCA indicates that most RCMs are able to preserve the spatial variability of precipitation. Nevertheless, the performance of the RCMs with respect to the selected indices (Table 2) is marked by large biases, which are mostly identified as significant. In general, ensemble with 3, 6 and 13 members outperform all individual models with the exception of ETHZ-CLM.

Consequently, it is not advisable to use coarse RCM data directly for impact assessment studies, because of the highly significant biases detected in all selected extreme indices.

References

[1] J. Sillmann and E. Roeckner, "Indices for extreme events in projections of anthropogenic climate change," *Climatic Change*, vol. 86, no. 1-2, pp. 83–104, Aug. 2007. [Online]. Available: http://www.springerlink.com/index/10.1007/s10584-007-9308-6

[2] S. Thober, L. Samaniego, and R. Kumar, "Evaluation of RCMs: Extreme Precipitation and Temperature Indices important for Hydrology," *in prep.*

[3] van der Linden P. and J.F.B.Mitchell, "ENSEMBLES: Climate Change and its Impacts: Summary of research and results from the ENSEMBLES project." p. 160pp., met Office Hadley Centre, FitzRoy Road, Exeter EX1 3PB, UK.

Acknowledgments: This work was supported by a grant from the Ministry of Science, Research and Arts of Baden-Wrttemberg (AZ Zu 33-721.3-2) and the Helmholtz Center for Environmental Research, Leipzig (UFZ).

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