We would like to thank the anonymous reviewer #2 for his/her constructive suggestions to improve the quality of our manuscript. We have addressed all comments and give a point-by-point response to the comments below:

Gerneral Comments

The authors have submitted a paper in which precipitation fields are rescaled based on copulas. While the idea is interesting (something similar was already published in HESS by van den Berg et al., 2011), it does not really make use of the advantages of copulas. Basically, van den Berg et al. perform a rescaling where the intra-pixel variability in a coarse scale observation is estimated based on copulas (leading to the pdf of the expected rainfall within one coarse scale pixel). In this paper, more or less the same is done, except that the mean or median of the pdf is used as estimation of precipitation value. So, the total information of the pdf is lost, and actually, one obtains a relation between the expected mean (or median) and an observation (the copula in- deed corrects for bias). Actually, what is thus obtained is a kind of non-linear regression between REGNIE and (bias-corrected) WRF. My question then is: why should one go through copulas and shouldnt any kind of non-linear regression be done immediately? Why do the authors throw away all information within the conditional CDF obtained from the copula? Why did the authors rescale the REGNIE to 7 km and didnt they keep the 1 km scale (and then follow van den Berg et al.), as it is perfectly possible to compare different scales using the proposed framework.

Comment 1

Why should one go through copulas and shouldnt any kind of non-linear regression be done immediately?

Answer

The Copula-based method is a stochastic bias correction method. It provides a full PDF for the corrected value. For practical reasons and the typical needs of subsequent modellers, e.g. in hydrology, we propose in this article to reduce the final information to the mean of the PDF only. The representation of the mean is comparable to the mean regression curve.
Different to the non-linear regression, this mean regression curve, however, is derived based on the dependence between RCM and observations. In addition to the Copula-based mean regression curve, the method also provides the dependence information between them. There are two further advantages compared to the non-linear regression: 1) The Copula-based regression has a great flexibility as it can be used with different combination of marginals and Copulas; 2) Unlike the bijection non-linear regression, Copula-based regressions predicts the full ensemble of the possible outcomes which potentially allow for the estimation of an additional quality criterion of the bias correction (please also refer to answer to Comment 1 of reviewer #1).

Comment 2

Why do the authors throw away all information within the conditional CDF obtained from the copula?

Answer

Our approach calculates and stores the full conditional CDFs and PDFs. Thus, we do not throw away the information about the distributions. As introduced above, for addressing the needs of

subsequent modellers, e.g. in hydrology, and for illustration purposes, especially for the spatial plots, we are focussing on the mean value in this study. This is due to the following reasons:

1. The mean seems to perform better than other analyzed statistical moments such as the median or the mode (please see also answer to Comment 1 of reviewer #1 for this purpose).

2. Due to graphical restrictions to provide the spatial information about the full density functions in a concise manner. There is no single value to adequately describe all relevant characteristics of a distribution (mean, shape, spread, etc.), thus a lot of additional figures would be necessary to provide a detailed picture. For single grid cells, however, we give a more detailed picture about the distributions using box-whiskers plots (please see Figure 7 of the manuscript).

3. In addition to that, we think that due to limitations in computing time and other practical reasons subsequent modellers, e.g. in hydrology, using these kind of data are mostly interested in the mean instead of passing a complete probability distribution into their models. However, subsequent modellers are potentially enabled to make use of the full PDF especially if they are interested in other statistical moments, extreme values, or to estimate uncertainties coming from this approach, which actually provides a capital advantage compared to other bias correction methods.

Comment 3

Why did the authors rescale the REGNIE to 7 km and didnt they keep the 1 km scale (and then follow van den Berg et al.), as it is perfectly possible to compare different scales using the proposed framework.

Answer

We agree that it is possible to compare different scales using the proposed framework in van den Berg et al. (2010). However, the aim of our study is the bias correction of WRF precipitation fields. Therefore, the REGNIE data has been upscaled from 1 km to 7 km to achieve the same "common" resolution.

Specific Comments

Comment 1

page 7195, line 15: why only consider parametric functions?

Answer

In addition to the bias correction, we are also interested in showing the fundamental differences between the RCM and the observations. By taking the parametric distributions, one can see the basic discrepancies between them from the fitted marginal family maps. Please see also our response to Comment #6a of reviewer #1.

Comment 2

Figure 2 shows the density, while the paper is referring to cumulative probabilities (so c versus C)

Answer

The purpose of Figure 2 in the manuscript is to demonstrate the Copula model. We used the probability density function of the Copula since this density function is actually more illustrative than the cumulative density function. From the density function one can see the changed densities (probabilities) in different parts of the joint distributions. It is however hard to get an impression of the complex dependence structure by looking at the CDF. If the reviewer advises on the CDF (C) instead of the PDF (c), we will show it, otherwise we would like to keep the figure as it is. For the modified figure with C instead of c please see Figure 1.

Comment 3

page 7198, lines 24-25: it is not clear to me why step 6 is needed as in the end only the mean (or median) is used: this could be determined right away instead of first a random set from which the mean (or median) is calculated.

Answer

The purpose of the recipe of the algorithm is to interpret Copula-based prediction conditioned on the RCM output. Repeating the step 6 and step 7 can be regarded as the Monte Carlo simulation to obtain the realisations. We take the mean of the realisation as the estimation of the corrected value. But indeed, it is right that the mean (or median) can be directly derived from the analytical function. We will state this more clearly in the manuscript.

Comment 4

page 7199, last paragraph: operationally, you should also apply it to the (0,1) case, as you have no idea whether the REGNIE-data is 0 or 1.

Answer

Please see the response to Comment #3 of reviewer #1.

Comment 5

page 7199: what are the proportions of (0,0), (1,1), (0,1) and (1,0) within the data used?, Is it also possible to show a scatterplot of observations versus RCM?

Answer

We now calculated the proportions of (0,0), (0,1), (1,0) and (1,1) cases within the datasets. The results are shown in Figure 2. From the Figure 2 one can see high proportion of (1,1) and (0,0) cases, while the proportion of other two cases ((0,1) and (1,0) cases) are relatively low especially for the (1,0) case.
Scatter plots (please see Figure 3) of the (1,1) case are shown for four selected grid cells exemplarily (using the same four grid cells as selected in the manuscript (Page 7217 in the manuscript)). If desired these plots may be included into the manuscript and discussed.

Comment 6

page 7202", line 7: the Frank copula also allows to model negative dependence.

Answer

Yes, the Frank Copula can also model a negative dependence. We emphasis the formula here, because for the Clayton Copula, the formulas of negative and positive dependence are different. The description in the paper might have been not clear enough, we will try to better describe that in the manuscript.

Comment 7

page 7203 line 10: here you actually could do the same with a non-linear regression

Answer

Please see the the response to General Comment #1 of reviewer #2.

Comment 8

page 7203, line 18: does this hold if you look at the blue line?

Answer

Yes, for most of the time steps the blue line (corrected WRF precipitation) is closer to REGNIE precipitation compared to the raw WRF precipitation. We also calculated the overall proportion of successful corrections for the whole study area (please see Figure 1 in the response to Referee #1). It can be seen that the percentage of successfully corrections is higher than 50% for almost the whole domain.

References

van den Berg M.J., Vandenberghe S., De Baets B., Verhoest N.E.C., Copula-based downscaling of spatial rainfall: a proof of concept, Hydrology and Earth System Sciences, 15(5), 1445-1457, doi:10.5194/hess-15-1445-2011, 2011.

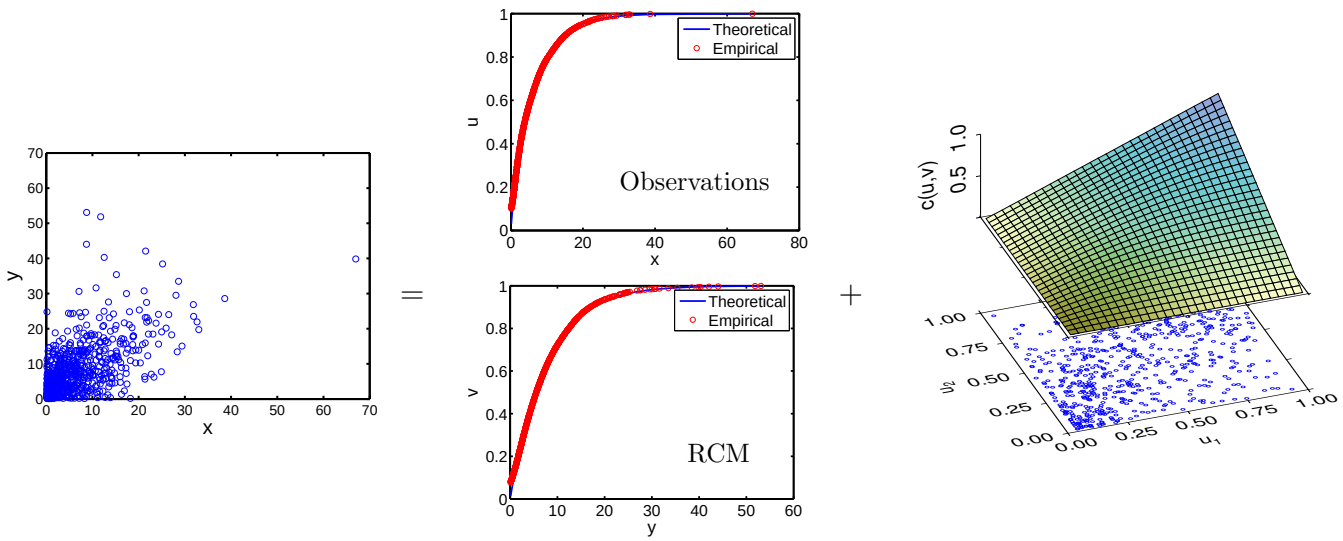

Figure 1: Visualisation of a bivariate Copula model consisting of two marginal distributions and a theoretical Copula function that describes the pure dependence.

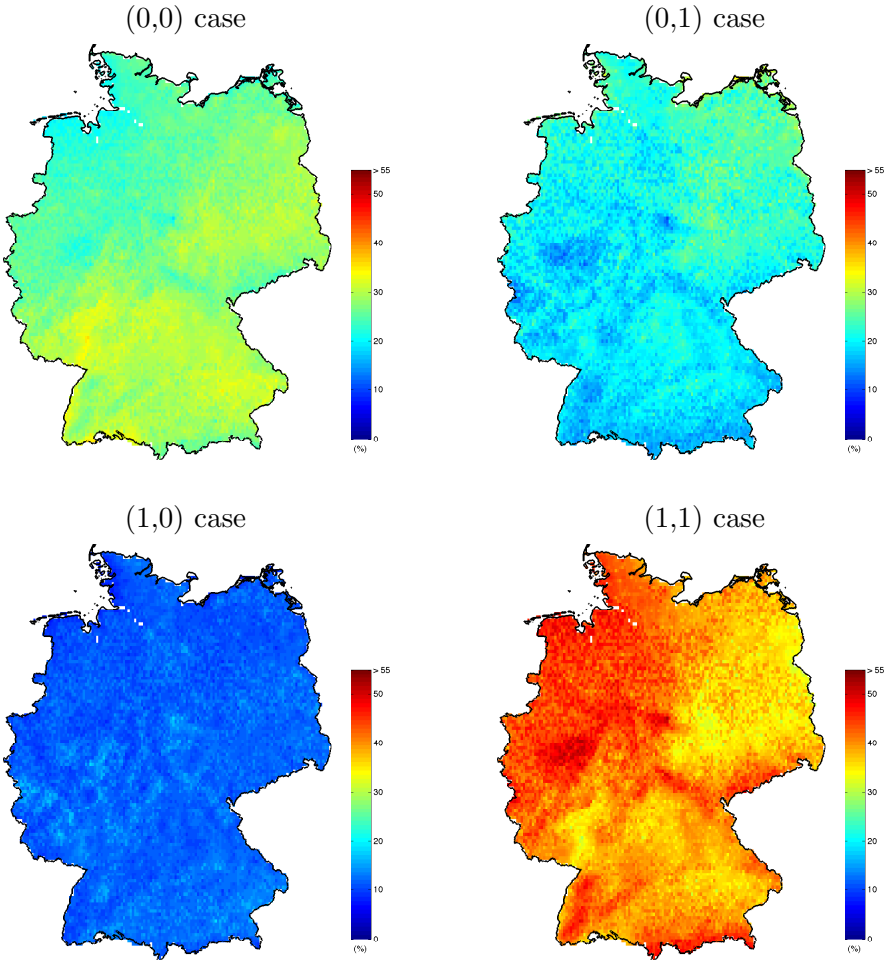

Figure 2: The proportion of four cases over the study area.

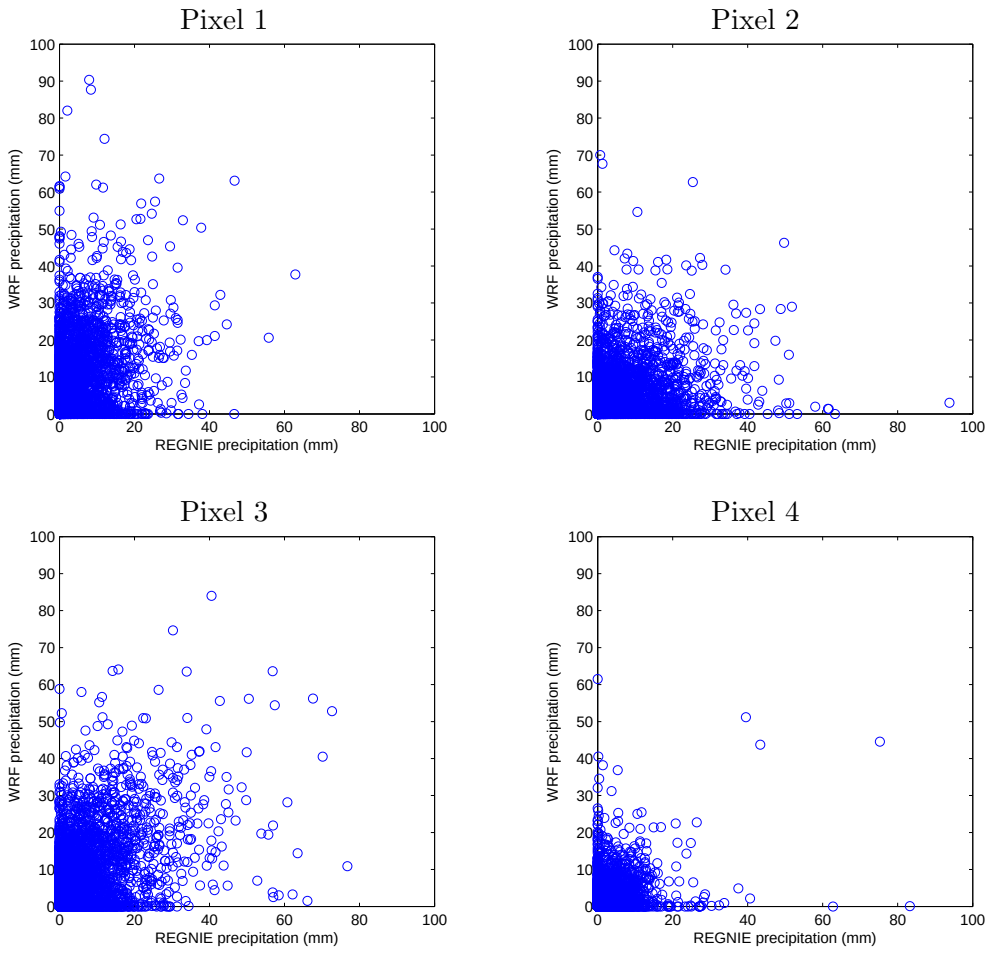

Figure 3: Scatterplot of selected pixels. The localtion of the pixels are shown in Figure 1 in the manuscript (Page 7217).