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Hydrology and Earth System Sciences Discussions

Interactive comment on "Building hazard maps of extreme daily rainy events from PDF ensemble, via REA method, on Senegal River Basin" *by* J. D. Giraldo and S. G. García Galiano

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Thank for your suggestions, that help us to improve the quality of the paper. The paper was re-organized, updated and extended, according to the reviewer's suggestions.

1) Which scenario was considered?

The scenario considered corresponds to the selected by ENSEMBLE Project for the RCMs worked with. In this case, A1B scenario. The corresponding sentence was modified (page 3822, lines 5-6): "Six RCMs were selected, driven by different GCMs (Global Climate Models) for scenario A1B:"

2) Pg. 3823, lines 19-20: the sentence "The first of them consists in a model performance criterion (RB), considering the present-day climate" seems incomplete.

The "reliability ensemble averaging" (REA) method, proposed by Giorgi and Mearns (2002), for calculating average, uncertainty range, and a measure of reliability of simulated climate changes from ensembles of different RCMs, is applied in the present paper. According to Giorgi and Mearns (2002), the method takes into account two "reliability criteria": the performance of the model in reproducing present-day climate ("model performance" criterion) and the convergence of the simulated changes across models ("model convergence" criterion). In our case, "present-day time" refers to period 1970-1990. Therefore, for clarification, lines 19-20 of page 3823 were modified: "The first of them, model performance criterion (RB), considers the performance of the model in reproducing present-day climate."

3) Pg. 3823, lines 20-21: the "convergence" to what?

Convergence of the simulated changes, across models, to a given forcing scenario for the future climate projections. Considering the methodology outlined by Giorgi and Mearns (2002), RD,i accounts for the convergence of each RCM to the REA average (ensemble) in the future climate projections (in the paper, 2021-2050 period). The lines 20-21 page 3823, were extended for clarification: "The second one, model convergence criterion (RD), evaluates the convergence to the "best estimated response" or REA average in the future climate projections."

4) Pg. 3823, equation 1: why were m and n set equal to 1? How sensitive are the results to different values of m and n?

The parameters m and n can be used to weigh each reliability criterion - RB and RD – (Giorgi and Mearns, 2002). In the paper, the parameters m and n were set up to 1, giving equal weight to both criteria. We consider that constitutes a natural choice in order to assess the RCM performance taking into account both the present day climate and the plausible future projections. But, this decision could be revised if there are reasons to believe that one of the two criteria should have a greater weight. A sensitivity analysis to the weighting parameters m and n, just was performed by Giorgi and Mearns (2002). They considered temperature and rainfall variables, and several cases m=n=1 (original case); m=2 and n=1, m=1 and n=2. The number of regions in which the uncertainty range showed sensitivity greater than 10% compared to the original case was lower in the case of rainfall than for temperature. For more details, please you can refer to the work of Giorgi and Mearns (2002).

5) Pg. 3827, last paragraph: why are the results in Garcia and Giraldo (2011) "numerically quite different"? Please explain.

We have included the reply to this question here, because it is related with the previous question. In the work of García and Giraldo (2011), the skill score for each RCM does not present spatial variability, and these were defined according to bias analysis (considering the observed data). This case really corresponds to m=1 and n=0, or RBˆm variable for each model and RDˆn=1, and accordingly R=RB. Therefore, the "numerically quite different" results (lines 26-29, page 3827), are justified in the different ensembles of RCMs. However, the spatial distributions of the changes and the location of significative zones, are similar (as it is presented by García and Giraldo, 2011). As additional material, the spatial distribution of mean and standard deviation of both approaches are presented (attached file of Additional Material).

6) Section 3.2: the authors use non-stationary statistical model to describe AMDR time series. However, have they first checked that there is statistical evidence against the use of a stationary model?

The GAMLSS verify the stationarity of the parameters of the distribution. First, the GAMLSS procedure tries to fit linear models, that is, the smoothing functions have zero degrees of freedom (using distributions with two parameters, the linear models will have four degrees of freedom -two degrees of freedom for each parameter-). However, sometimes the smoothing functions may have degrees of freedom different from zero,

so the fitted model would have more than four degrees of freedom. In another cases the fitted model is linear and not stationary, and the GAMLSS fit gives the p-values in order to compute the statistical significance of these trends. As example, an extended response to this question is presented as Additional Material (attached file), with an example to improve the comprehension.

7) Is it really meaningful to model a 20-year record of annual maxima with a non stationary model which uses a large number of degrees of freedom for the fit? I personally think that 20 years are not enough.

We are agreed with you, that it should be encouraged work with long series of daily observed data (more than 30 years). We consider the whole period (1970-2050) for the non-stationary modeling of AMDR from the RCMs (as it can be seen for example from Fig. 3 in the paper). We only used the dataset of observed daily rainfall, for evaluating the two criteria of REA method for building the ensemble. Unfortunately, for the study area the available observed daily dataset for this work, corresponds to 20 years of daily rainfall. Respecting to the number of degrees of freedom, some explanations could be considered for clarification. The number of freedom degrees, was restricted. We selected statistical distribution of two parameters to ensure the parsimony of fitted models. GAMLSS tools consider in the adjustment of each parameter, at least two degrees of freedom (one for the constant and one for the lineal term), plus the degrees of freedom for the smoothing. If there are not degrees of freedom for the smoothing, the adjustment of parameters obeys to lineal functions.

8) A much more extensive discussion of the statistical modeling should be provided. After reading the manuscript, I still have several questions: 1) how did the authors select their final distribution? 2) What distribution was generally chosen? 3) Can this be generalized?

8.1) how did the authors select their final distribution?

GAMLSS tools present a great variety of PDFs and functions for adjustments, but in this work four pdfs of wide application in Hydrology, were selected (Lognormal -LN-, Weibull -WEI-, Gamma -GA- and Gumbel -GU-), and the cubic spline was considered as smoothing function. For the selection of the best model (PDF), and trying to promote the selection of models with few degrees of freedom used in the smoothing, Schwarz Bayesian criterion (SBC), with penalty 3.5, was considered. In this form, the stability of the algorithm is guaranteed in the processing of selection of statistical model. The SBC is a special case of GAIC (Generalized Akaike Information Criterion), which penalizes overfitting of GAMLSS models with smoothing (Rigby and Stasinopoulos, 2005). A very extended response to this question, is presented as Additional Material (attached file), with an explanation of the code used to fit the GAMLSS models.

8.2) What distribution was generally chosen?

In general, the most of times the selected distribution was LN, following by GA and, only in some cases the WEI distribution, according with the following Table. The distribution GU has not presented the better fit anywhere. For clarification, as Additional Material (attached file), maps for the region are presented showing the sites in colour according with the "best fit" of a particular distribution on each one, and a Table presenting the number of sites where each distribution was adjusted. The maps of “best fit” exhibit a trend of colours to be clustered, specially for KNMI/RACMO and SMHI/RCA.

8.3) Can this be generalized?

If your question refers to generalization of a particular distribution, although the LN distribution could be generalized for METO-HC/HAD and INM-RCA, the maps in Fig. 1 (in the paper) demonstrate that is not recommended in all cases. If your question is about the generalization of the methodology in order to study another hydrologic variable, the answer is yes, of course, with caution of choosing the suitable probability distributions, according with the quality and length of time series.

9) Figure 3: based on this figure, I find it a bit hard to believe that the statistical models are really able to describe the data. I would be interested in seeing the corresponding

residual plots used to assess the goodness of fit. I am not sure that the statement on pg. 3828, line 6 (“the good fit of the GAMLSS statistical model to simulated AMDR time”) is really supported by the results presented.

In order to show the goodness of fit test on site 16, we are attaching (as additional material) the worm plot, qq-plot, and the computed mean, standard deviation, skewness and kurtosis of residuals for GAMLSS fit on each RCM. In general, there is a good fit of the GAMLSS statistical models to simulated AMDR time series in the Senegal River Basin. However in the region located in the north of the domain (outside of the study basin), where there are time series of AMDR with values close to zero, or with leptokurtic distributions, GAMLSS fit is no too good and the convergence was difficult. For example, the sites 1 to 12 located in the north of the region.

10) Figure 3: please add the corresponding time series from the data. It would be interesting to see whether the models can actually reproduce the patterns in the data.

According your request, the RCM time series are presented together with the IRD data in the Additional Material (attached file). As previously was stated, the observed data from IRD were used in the bias analysis to compute RB (Fig. 2 in the paper). This criterion represents the spatial patterns of the performance of the model in reproducing present-day climate (reply number 3). The GAMLSS analysis was not performed on these time series.

11) Pg. 3825, lines 20-24: the authors mention how they checked the goodness of the fit but don’t state whether the residuals supported their choice of models.

The worm-plot, qq-plot, and a summary of quantile residuals, are presented for site 16, as Additional Material (attached file). The corresponding paragraph in the paper, was extended according the suggestion of the reviewer: “The goodness of fit to the statistical model was assessed, considering the independence and normality of the residuals (hypothesis test with Filliben correlation coefficient, mean, variance, skewness, kurtosis, and plots of quantile residual versus fitted values, and quantile residual versus time), and visual inspections of the qq-plots (not shown) and the worm plot (not shown) that corresponds to de-trended representation of qq-plots. The shape of the worm indicated how the data differ from the assumed underlying distribution, and a flat worm indicates that the data follow the assumed distribution, according to the methodology presented by van Buuren and Fredriks (2001)."

12) Figure 5 and others: the authors should mention more clearly in the text that the results in the south-west part of the domain are based only on interpolation, since no data are available.

Lines 1-12 of page 3825, explained the source of Pm data. Therefore, all sites of Figure 5 present PDF ensembles because these were built using the Pm maps. The Pm maps where built using the map algebra between the interpolated maps of R. In Pg. 3825, lines 14-15, the paragraph was modified: "Maps algebra was used to build the Pm raster, from the interpolated maps of R. The Pm maps (Fig. 2) allowed for building the PDF ensembles in all sites (still where the IRD data were not available, e. g. the south part of the domain)."

- The alphabetical order in the References, was corrected.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/8/C2403/2011/hessd-8-C2403-2011-supplement.pdf

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