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Geoscientific Model Development Discussions
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Interactive comment on "A globally calibrated scheme for generating daily meteorology from monthly statistics: Global-WGEN (GWGEN) v1.0" *by* Philipp S. Sommer and Jed O. Kaplan

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We thank the anonymous reviewer for his helpful comments to our manuscript. The manuscript for GWGEN, a weather generator for precipitation, temperature, cloud fraction and wind speed using a hybrid Gamma-GP distribution, a hybrid-order Markov Chain and a cross correlation approach) has been revised and improved.

In summary, a bug has been fixed that now makes the quantile-based bias correction for the minimum temperature redundant and instead another quantile-based bias correction for the wind speeds intercept has been implemented to further improve the results. Furthermore we made several attempts to improve the reading. This includes

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a schematic representation of the workflow, changes in the structure of the paper, more explanations to the figures and a fix of the notation in the equations.

Detailed responses to the comments of the reviewer can be found below.

Responses

Reviewer Section 2.2.1 : Why are you not interested in p011 and p111?

Respones We use the hybrid-order Markov Chain as recommended by Wilks (1999) as a tradeoff between accuracy and simplicity. This model retains first-order Markov dependence for wet spells but allows second-order dependence for dry sequences. It therefore only requires the three parameters p_{11}, p_{001} and p_{101}, i.e. the probabilities up to the last wet day. We specified it explicitly now.

Reviewer Figure 2 : There is no histogram.

Respones It is a 2D histogram, i.e. the value for each grid cell represents the sum of observations that fall into this cell. To clarify this point, we replaced the word histogram with *density plot*.

Reviewer Table 1 and Figure 11 : you should mention the fact that R2 are artificially high for models without constant because the R2 formulae is modified for such models.

Response We now acknowledge this fact in the paper.

Reviewer In equation (5), can ξ be equal to 0?

Response Yes, in this case, $g(x) = \frac{1}{\sigma} e^{-\frac{x-\mu}{\sigma}}$. We added it to the equation.

Reviewer Line 19 : you should explain how you estimate the parameters.

Response The parameters of the Gamma distribution are estimated using likelihood. We included it in the text.

Reviewer Lines 20 to 25 : it is not clear, you should explain quickly what is done in Geng et al. (1986)

Response We clarified in the text that the expected value of the Gamma distribution is the product of the shape and scale parameter, i.e. $E(\Gamma) = \alpha\theta$. This justifies equation (7) and (8).

Reviewer Equation (10) : x_{wet} and x_{dry} have to be replaced by $\bar{x}_{wet}$ and $\bar{x}_{dry}$? Same remark for equation (11).

Response They have been replaced.

Reviewer Figure 5 and 7 : As you write, the adjustement is very bad. I think you should propose another way of fixing the standard deviations. You write "we believe that the error introduced by the poor linear fit is negligible", but this is not convincing.

Response We agree with this comment and in our revised version of the model have completely re-thought the way we estimate the SD of temperature. These changes are described in the revised manuscript. In summary, instead of a linear fit, we now use a combination out two polynomials combined with a linear extrapolation at the cold and warm extremes. For minimum temperature that means, that values below $-40°C$ and above $25°C$ are linearly extrapolated, whereas $\sigma_{T_{\text{min,dry/wet}}}$ between $-40°C < \bar{T}_{\text{min,dry/wet}} \leq 0°C$ and $0°C < \bar{T}_{\text{min,dry/wet}} \leq 25°C$ is modeled by two different polynomials of order 5. We use the same methodology for maximum temperature with $-30°C$ instead of $-40°C$, and $35°C$ instead of $25°C$ (see attached figures below).

Although this procedure is more complicated, results in a significant improvement in the simulation of extreme temperatures, and an overall improvement in the simulation of daily temperature.

Reviewer Equation (12) : please explain how this formulae has been chosen.

Response We wrote in the original manuscript that we chose the shapes of the curves to reflect the phenomenon that wet days should be cloudier on average than dry days. We clarify our selection of these equations based on the constraints presented by the variable, e.g., that cloud fraction on wet days must be 0 when total mean cloud fraction is 0 and 1 when the total mean cloud fraction is 1. We used a qualitative graphical analysis to develop "best guess" equations that had the desired shape.

Reviewer Page 13 line 5 : $c_{sd,dry}$ has to be replaced by $\sigma_{c,dry}$, same for "wet".

Response They have been replaced

Reviewer Equation (12) : c has to be replaced by c_{wet} or c_{dry}. Moreover, bars have to be added, since you describe mean cloud cover.

Response Bars have been added but c (or rather $\bar{c}$) should not be replaced by $\bar{c}_{wet}$ or $\bar{c}_{dry}$ since in this case we use the monthly mean cloud fraction $\bar{c}$ to calculate the mean of the wet ($\bar{c}_{wet}$) or dry ($\bar{c}_{dry}$) days in the month

Reviewer Equation (13) : same remark, bars have to be added.

Response They have been added

Reviewer Section 2.2.6 : Please describe how you add the residual noise in practice. It is described at the end of Algorithm 1 but it is not clear : residuals for one day are really computed from the residuals of the previous day as written line 18? If so, you should explain why.

Response Yes, they are computed from the previous day. We extended the explanation in the corresponding section. The procedure is based upon Matalas (1967) and preserves the serial and the cross correlation between the simulated variables. Otherwise longer periods of, e.g. warm temperatures, could not be simulated.

Reviewer Section 2.5 : Can you present/discuss some references about the estimation problem of GP parameters?

Response We acknowledge that choosing globally fixed parameters for the location parameter μ and the threshold ξ is a simplified aspect of our model (we also state that in the revised manuscript) and is generally not easy (e.g. Davison and Smith, 1990; Neykov et al., 2014; Rootzén and Tajvidi, 1997). Frigessi et al. (2002) suggest to use a dynamical mixture model instead of a fixed threshold. Rust et al. (2009) vary the parameters with seasonality.

However, to our knowledge, no global application of these methods has been published and for now, therefore we stick to the simplest methodology with fixed parameters that are based on a sensitivity analysis (described in detail in section 3.5 of the revised manuscript). We also performed extensive data analysis in an attempt to correlate the GP parameters with other input variables for our weather generator, but could not find any relationship that would allow us to perform a dynamic calculation. As we say in the discussion section, this is subject to further improvement, but, nevertheless, despite the simplicity of our parameterization of the hybrid Gamma-GP distribution, the results are excellent.

Reviewer Section 3 : I think such a global presentation of the model should be given at the beginning of the paper in order to help the reader following al steps. Maybe with a schematic description?

Response It has been moved and a schematic of the workflow has been added

Reviewer I think Sections 4 et 5 could be merged.

Response They have been merged.

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Reviewer Section 5 : I am not convinced that the introduction of a spatial autocorrelation field on the sequence of random numbers would solve the problem so easily. The spatial correlation will not be the same for the whole globe and for all variables, and may be hard to fix.

Response We agree, but also continue to believe that implementation of spatial autocorrelation is beyond the scope of the current manuscript, and does not affect the utility of the weather generator for a wide range of applications. We clarify the challenge of implementing autocorrelation in the manuscript, and remove our specific recommendation, tending to agree with the reviewer that, although possible, the solution would not be **that** simple.

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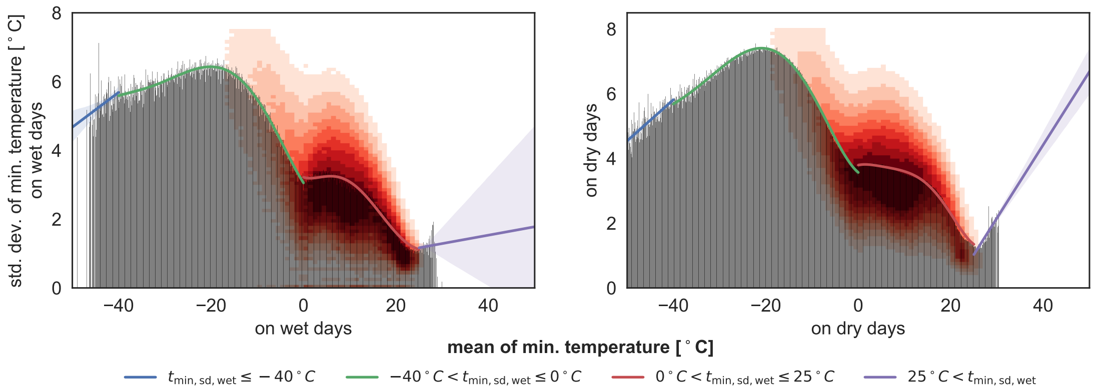

Fig. 1. Correlation of standard deviation of min. temperature to the monthly mean

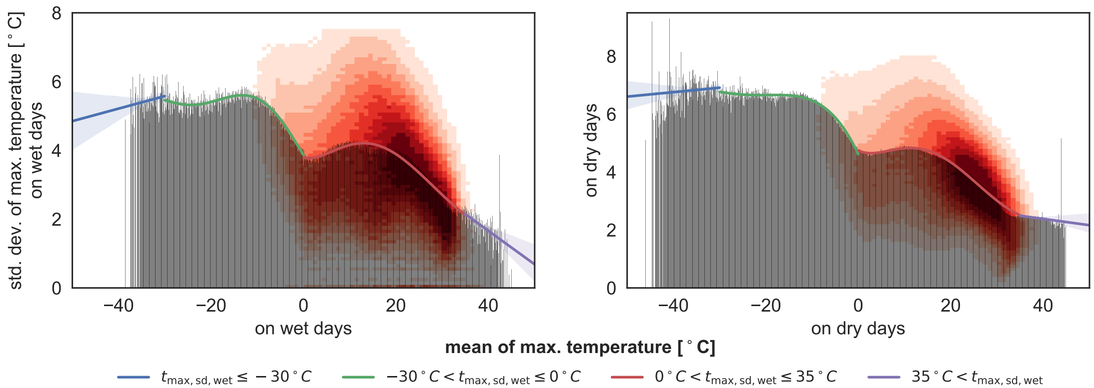

Fig. 2. Correlation of standard deviation of max. temperature to the monthly mean

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