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Geoscientific Model Development Discussions

Interactive comment on "Simulation of Extreme Heatwaves with Empirical Importance Sampling" *by* Pascal Yiou and Aglaé Jézéquel

Anonymous Referee #1

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A) GENERAL COMMENTS

The manuscript represents a weather-generator-type algorithm for simulating extreme events like heatwaves. Using so-called empirical importance sampling in generating the daily sequences of weather, the algorithm can be tailored to produce extremely warm summers much (presumably, several orders of magnitude) more commonly than they would occur in the real world or without the importance sampling. The algorithm is generic and should therefore also be applicable to other types of "long" extreme events such as extended periods of heavy precipitation.

Importance sampling has previously been applied to simulations by dynamical atmospheric models (e.g., Ragone et al. (2017) cited in the manuscript). Compared with this, the use of a stochastic weather generator requires much less computing time, and

therefore potentially allows a much larger number of simulations.

However, I have a major scientific concern about the fidelity of the method. If the motivation is anything else than to find the extremes of the summer (June-July-August) mean temperature and the associated summer mean atmospheric circulation, the realism of the daily time series also matters. However, as shown by Fig. 5, the warmest simulated summers have no seasonality at all, with equally high temperatures occurring from the beginning of June to the end of August. This appears quite unrealistic, since very high temperatures are much less probable (if possible at all) in the beginning and the end of the summer than in July or early August.

The problem likely results from the fact that the method has no strict constraint on the time of year of the circulation analogies, and the warmest trajectories therefore sample days from the height of the summer even in the beginning and the end of the summer. This could be mitigated, though at the cost of reduced sampling space, by only accepting analogue days from a moving window of (e.g.) +/- 15 calendar days around the target day. Alternatively, it might be possible to work with anomalies (removing the mean seasonal cycle before applying the algorithm) or with normalized anomalies of Z500 and T (removing the mean seasonal cycle and dividing by standard deviation), although this is uncharted terrain that might create its own problems.

B) SPECIFIC COMMENTS

1. P5L1. Does this mean the best 20 analogues regardless of the time of the year (cf. general comments)?

2. P5L18-19 and 26-27. I suppose the weight is directly, not inversely proportional to the correlation, i.e., days with higher correlation are more likely chosen as analogues.

3. P5L28-30. Does this procedure lead to a realistic autocorrelation of the daily mean temperatures?

4. P7L10. I assume that this is an addition to the factors 1-2 on P5L24-27, not a

replacement.

5. P7L16-18. Is physical relevance really ensured? See the general comment about the lack of seasonality.

6. P9L26-27. The only way in which this paper currently answers this question ("how likely is the occurrence of an event") is by fitting a normal distribution to the observed JJA mean temperatures (right scale in Figure 4). Would it be possible to refine these estimates based on the SWG approach (cf. Figure 4 in Ragone et al. (2017), cited in the manuscript)?

7. P12L22-24. This interpretation "small perturbations of the atmospheric Z500 structures can add $\approx$ 4K . . ." is dubious, because there is no one-to-one physical relationship between Z500 and surface temperature. Much more likely, the 4 K addition in temperature comes from the tendency of the algorithm to select the warmest days among days with similar Z500 fields. The slight changes in the Z500 anomalies are a side effect of this, but they are not large enough to "cause" the change in surface temperature. Note that, for the whole atmospheric column to be 4 K warmer, the layer between 500 and 1000 hPa should become 80 meters thicker.

8. P12L27-29. How long does the simulation remember its initial conditions? Would there still be a difference in the Z500 fields if they were only averaged over July-August?

C) TECHNICAL COMMENTS AND CORRECTIONS

1. P1L19: ensembles in plural

2. P2L26: linked to

3. P3L1: recalls

4. Figure 3 could be improved by including the values of the alfa parameter in the figure panels. In addition, it would be useful to describe the interpretation of the box plots in the caption (there are several versions around, although some are more common than

others).

5. Figures 6, 7, A2, A4 and A6. These maps could be improved by using different colors for positive and negative anomalies. It would also be better to use the same contour interval in all panels of each figure.

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