

Response n2 to Vivek Arora, editor for the manuscript

Extending MESMER-X: A spatially resolved Earth system model emulator for fire weather and soil moisture

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Dear Vivek Arora,

Thank you for your positive review of this manuscript and your attentive reading. We have integrated your comments in this new version.

I am grateful to you, such a valuable editing process represents an important experience to any researcher, and even more to early career scientists.

Line 19: Please reword. Calculating how much do quantiles deviate doesn't result in good performance but rather allows to evaluate performance.

Thanks for pointing out to this shortcut. We have rephrased this sentence as follows:

“For each of the four variables considered, we evaluate the performances of the emulations by calculating how much do their quantiles deviate from those of the ESMs.”

Line 45: IAMs don't mitigate climate change, they simulate mitigate climate change using bio-energies.

This is indeed another shortcut, that we have corrected as follows:

“For instance, IAMs simulate the mitigation of climate change by using bio-energies with carbon capture and storage (BECCS) and afforestation.”

Line 48: simulated by

This is indeed an useful precision.

“Thus, accurately replicating regional changes in climate extremes and water conditions simulated by Earth System Models (ESMs) at a lower computational cost would help in exploring mitigation potentials and new emissions scenarios.”

Line 100: with

Line 104: represent; for; and AT annual time steps

All of these suggestions were implemented.

Line 123-124: Please consider rewording, perhaps - the representation of primary interactions within the Earth system.

This sentence was rephrased more adequately:

“Using variables such as global mean surface temperature, radiative forcing or ocean heat content facilitates the representation of the most relevant processes within the Earth system.”

Line 136: This is the first time you have used the term "spatially correlated innovations". Can you please define it here?

We have rewritten several sentences in this paragraph, for a better explanation of what this statistical process entails:

“To integrate these effects, we follow the approach of (Beusch et al., 2020), that parametrizes internal climate variability using the spatially autoregressive (SAR) noise model described in (Cressie and Wikle, 2011; Humphrey and Gudmundsson, 2019). The SAR model reproduces the temporal and spatial autocorrelation structure of the training data, using two components. Temporal correlations are represented by an auto-regressive process (equation 3). Spatial correlations are reproduced with spatially correlated innovations, randomly generated from a multivariate Gaussian with zero mean and covariance matrix derived from the training sample (equations 4 to 6).”

Line 147: Please consider rewording. Perhaps something like ... equation (2) works equally well if D is a discrete distribution

We have followed your suggestion.

Line 148-149: Did you mean "spatially correlated innovations"?

Thanks for noting this issue, we have corrected.

Line 151: It seems r has not been defined yet. It's defined later on next page in equation (6). We acknowledge that r was defined later. We delayed this definition to privilege the continuity of the introduced elements, yet it was unclear with r . We follow your suggestion and add this sentence:

“Here, r designs the ratio of geographical distance between points and a localization radius, and the next paragraphs explaining how $\Sigma_v(r)$ is obtained from the empirical covariance matrix.”

Line 236: Shouldn't this be FWIsa?

Thank you very much for pointing out this typo! We have corrected that.

Line 244: I think, these haven't been introduced before. Although obvious you do not to tell these are mean and std dev.

These parameters were indeed not explicitly introduced before, only implicitly in this sentence. We have rephrased this sentence for an explicit definition, and added the link to the definition of the first equation related to the conditional distributions.

“For a normal distribution, the parameters α introduced in equation (1) are the location and scale, written respectively μ and σ in Figure 1, corresponding to the mean and standard deviation of the distribution. For a GEV distribution, the parameters α are the location, scale and shape, written respectively μ , σ and ξ in Figure 1.”

Line 326-327: Doesn't Poisson distribution has only one parameter - lambda, and it's mean is in fact lambda?

The basic Poisson distribution has only this lambda as a parameter. However, having this sole parameter constrains too much the distribution. This is why the additional parameter mu allows for more freedom, through a shift of the distribution. We have edited this sentence to reflect this aspect.

“Here, the parameters α introduced in equation (1) are the rate λ and a shift μ . The training of the distribution gains in freedom using this shift of the distribution by μ , with its mean becoming $\mu + \lambda$, while the variance remains λ .”

Another important modification of the manuscript was the modification of the Competing Interests:

“Yann Quilcaille, Lukas Gudmundsson and Sonia I. Seneviratne declare that they do not have any competing interests. Though, for the sake of transparency, we notify that Sonia I. Seneviratne is a member of the editorial board of Earth System Dynamics. However, we point out that it had no impact on the reviewing and editing processes of this manuscript, for which the handling editor is Vivek Arora.”

Beusch, L., Gudmundsson, L., and Seneviratne, S. I.: Emulating Earth system model temperatures with MESMER: from global mean temperature trajectories to grid-point-level realizations on land, *Earth Syst. Dynam.*, 11, 139-159, 10.5194/esd-11-139-2020, 2020.

Cressie, N. and Wikle, C. K.: *Statistics for spatio-temporal data*, John Wiley & Sons, Hoboken, New Jersey, USA, 624 pp.2011.

Humphrey, V. and Gudmundsson, L.: GRACE-REC: a reconstruction of climate-driven water storage changes over the last century, *Earth Syst. Sci. Data*, 11, 1153-1170, 10.5194/essd-11-1153-2019, 2019.