Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2019-34-RC2, 2019

Earth System Dynamics
Discussions

Interactive comment on "Emulating Earth System Model temperatures: from global mean temperature trajectories to grid-point level realizations on land" *by* Lea Beusch et al.

Anonymous Referee #2

Received and published: 20 August 2019

General comments

This study developed a modular framework for statistically emulating the CMIP5 ESM global spatially and temporally correlated yearly land temperature field time series. It is shown that this emulator framework can reasonably well emulate the median of the single-ESM initial-condition ensembles of yearly temperature at a negligible computational cost, and with separate emulators calibrated for 40 individual ESMs of the CMIP5, can generate a large ensemble that closely resemble a multi-ESM initial-condition ensemble.

However the visual and quantitative verification of the emulations from this modular

framework have demonstrated that further improvement in the emulators' design is needed before it can be used for the main focus of this study, of using the emulated large ensemble for initializing the climate impact and integrated assessment models used for quantifying the uncertainties in the possible climate system's responses to specific GHG emission pathways. In particular the main concerns are related to the non-dependency of the emulated future projections on the historic ESM performance, the need for more detailed evaluation of the emulation performance, and that the local grid-point scaling reduces the inter-model spread or suppresses the internal variability compared to the ESMs of CMIP5.

Specific comments

1. The computationally cheap statistical emulator developed in this study aims to produce realizations which closely resemble initial-condition ensemble members of the considered ESMs. It will be useful to make a statement on whether it is expected that the future warming projected by each emulation member will be affected by the known differences between observed and simulated historical climate in the ESM considered for calibrating each modular emulator framework. An earlier study cited by the authors (Goodwin, 2016), using large ensemble from an efficient ESM, had suggested that part of the upper range of twenty-first century CMIP5 warming projections may reflect historical simulation–observation inconsistencies.

2. The ability of the ensemble of emulations to capture the distribution of ESM runs is evaluated in this study. It would have been useful to additionally evaluate the performance of these emulations in comparison with the pattern scaling approach used to relate the grid-scale local temperature linearly with the global mean temperature. An earlier study cited by the authors (Castruccio et al., 2014), demonstrated using a lack-of-fit statistic that the emulated local annual temperatures outperformed pattern scaling at grid point scales, and captures the nonlinear evolution of spatial patterns of climate anomalies inherent in transient climates. A similar evaluation could have been used in the present study to compare the measured emulation performance with a simple

global pattern scaling.

3. The quantitative verification in section 6.2 brought out that although the CMIP5 ESM median is emulated well, the emulations are underdispersive compared to the training run, particularly at regional scales. This issue is identified to be related to the emulators' design. Although the authors conclude that this underestimation is the result of a trade-off between parameter estimation robustness and ensemble reliability, it will be challenging to expect that the climate impact and integrated assessment models initialised with these emulations will be able to infer properties of the existing CMIP5 multi-ESM initial-condition ensemble runs which have not been generated yet.

Technical comments

1. Section 2 introducing the proposed modular emulation framework in the context of previous studies may be merged into Section 4 describing this additive framework with three sub-modules so that the extent to which the previously developed methods were utilised in the implementation of this modular framework can be brought out clearly.

2. Line 353, please correct "underdispersion".

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