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Timescale Decomposition of Climate and Correction of Variability Using Synthetic Samples of Stable Distributions

Martin Gomez-Garcia (1), Akiko Matsumura (1), Daikichi Ogawada (1), and Kiyoshi Takahashi (2)

(1) Nippon Koei R&D Center,Advanced Technology Department 1,Tsukuba,Japan (gomez-mr@n-koei.jp), (2) National Institute for Environmental Studies,Tsukuba,Japan

One of the principal inputs of climate change impact evaluations is the quantitative information on future climate generated by the atmosphere-ocean General Circulation Models (GCMs). Some form of bias-correction, however, is routinely applied before the simulated climate can be employed in the impact models. The objective of the bias-correction is to adjust the probability distribution of the GCM-simulated climate towards the real (observed) one without altering the temporal evolution and spatial structure. Although the different variations of the widely-used quantile-mapping method broadly fulfill this objective, other requirements that might be relevant to end-users are not entirely addressed. These requirements include (i) preserving the climate trends, (ii) avoiding the transfer of the sampling error of the calibration period, (iii) being able to reproduce the observed indicators of extreme weather, and (iv) including the long-term effect of climate change in the observed distributional properties. To address these four mathematical challenges, in this study, we propose a bias-correction method in which we firstly decompose daily timeseries of atmospheric variables into three temporal elements that represent the climate mean state, interannual variability and daily variability. While we trivially correct the climate mean state assuming the stationarity of the associated bias, the novelty of the proposed method is the adjustment of the distributions of interannual and daily variability by replacing the simulated data with synthetic samples of Stable Distributions (SDs). On the one hand, the timescale-separated correction of biases allows to preserve the simulated climate trends (i). On the other hand, without altering the temporal evolution of the atmospheric variables, the replacement of simulated variability with synthetic samples that follow the distribution of the observed data prevents the transfer of the sampling error of the calibration period (ii) and makes the observed and adjusted-simulated distributional properties practically equal (iii). The choice of fitting SDs to climate variability was motivated by their versatility since the location, scale, symmetry and heaviness of the tails of the probability density function are parameterized. In this way, not only SDs can be well-fitted to simulated and observed climate variability, but the distributional changes in scale, symmetry and frequency of extremes caused by the effects of GCM-simulated climate change can be measured and applied to the distribution of observed variability (iv). To illustrate the performance of the proposed method, we correct the biases in GCM-simulated daily mean and maximum temperature and precipitation over northern South America. We use the available initial condition members (runs) of the same GCM to assess how the proposed method deals with sampling error and how well observed extremes can be reproduced. Finally, we discuss how the temporal evolution of the measured distributional properties of climate variability can be eventually used to evaluate the ability of GCMs to simulate climate change.