Adjusting spatial dependence of climate model outputs with Cycle-Consistent Adversarial Networks

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Résumé

Climate model outputs often present statistical biases and are commonly corrected using univariate bias correction methods. Most of the time, those 1d-corrections do not modify the ranks of the time series to be corrected. This implies that biases in the spatial or inter-variable dependences of the simulated variables are not adjusted. Hence, over the last few years, some multivariate bias correction (MBC) methods have been developed to account for inter-variable structures, inter-site ones, or both. As proof-of-concept, we propose to adapt a computer vision technique used for Image-to-Image translation tasks (CycleGAN) for the adjustment of spatial dependence structures of climate model projections. The proposed algorithm, named MBC-CycleGAN, aims to transfer simulated maps (seen as images) with inappropriate spatial dependence structure from climate simulations outputs to more realistic images with spatial properties similar to the observed ones. For evaluation purposes, the method is applied to adjust maps of temperature and precipitation from climate simulations through two cross-validation approaches. The first one is designed to assess two different post-processing schemes (Perfect Prognosis and Model Output Statistics). The second one assesses the influence of non-stationary properties of climate simulations on the performance of the MBC-CycleGAN algorithm to adjust spatial dependences. Results are compared against a popular univariate bias correction method, a "quantile-mapping" method, which ignores inter-site dependencies in the correction procedure, and two state-of-the-art multivariate bias correction algorithms aiming to adjust spatial correlation structure. In comparison with these alternatives, the MBC-CycleGAN algorithm reasonably corrects spatial correlations of climate simulations for both temperature and precipitation, encouraging further research on the improvement of this approach for multivariate bias correction of climate model projections.

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