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Constrained Generative Adversarial Networks for Improving Earth System Model Precipitation

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The simulation of precipitation in numerical Earth system models (ESMs) involves various processes on a wide range of scales, requiring high temporal and spatial resolution for realistic simulations. This can lead to biases in computationally efficient ESMs that have a coarse resolution and limited model complexity. Traditionally, these biases are corrected by relating the distributions of historical simulations with observations [1]. While these methods successfully improve the modelled statistics, unrealistic spatial features that require a larger spatial context are not addressed.

Here we apply generative adversarial networks (GANs) [2] to transform precipitation of the CM2Mc-LPJmL ESM [3] into a bias-corrected and more realistic output. Feature attribution shows that the GAN has correctly learned to identify spatial regions with the largest bias during training. Our method presents a general bias correction framework that can be extended to a wider range of ESM variables to create highly realistic but computationally inexpensive simulations of future climates. We also discuss the generalizability of our approach to projections from CMIP6, given that the GAN is only trained on historical data.

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