A Climate-Informed Regional Weather Generator for Exploring Hydrological Extremes in a Changing Climate

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Abstract

Assessing hydrological extremes under climate change requires long, realistic, and spatially consistent weather series that can capture non-stationary dynamics. We present recent developments of our non-stationary regional weather generator (nsRWG). The nsRWG simulates multi-site meteorological fields such as daily precipitation and temperature, conditioned on large-scale weather circulation patterns (CPs) and regional mean temperature, allowing marginal distributions to evolve dynamically with large-scale climate drivers.

We apply the nsRWG over central Europe, calibrated with the E-OBS gridded observation dataset and ERA5 reanalysis data, and driven by climate simulations from the CMIP6 ensemble, including historical (with counterfactual) and future SSP-based experiments. The generator reproduces key statistical properties of the meteorological fields across both moderate and extreme conditions.

We demonstrate its use in several applications: black-swan event exploration, extreme event attribution, and flood risk and drought assessment under future climate. Our results demonstrate the nsRWG's potential as a powerful tool for exploring climate-driven extremes and supporting risk assessment and adaptation planning in a changing climate.

Keywords: Climate informed weather generator, hydrological extremes, climate change impacts, extreme event attribution, flood and drought risk

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