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Spatio-Temporal Dynamics in Climatic Moisture Balance across Sub-Saharan Africa under the High-Emission SSP5-8.5 Scenario

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Abstract

Sub-Saharan Africa faces escalating water stress under accelerating climate change, yet spatially resolved assessments of future moisture availability remain limited. To assess how evaporative demand and precipitation changes may alter moisture regimes under high-emission climate scenarios (SSP5-8.5), this study investigates the spatiotemporal evolution of Climatic Moisture Balance (CMB) defined as the difference between precipitation and potential evapotranspiration (P − PET), across the Sub-Saharan African continent. A six-model ensemble mean, derived from CMIP6 projections at high spatial resolution was employed to quantify regional-scale moisture trajectories for Mid-Century (2036–2065) and End-Century (2071–2100) relative to the historical baseline (1980–2014). Results reveal a strong spatial heterogeneity of climatic moisture balance under SSP5-8.5, with pronounced declines concentrated in Southern and Western Africa. By end-century, Southern Africa is expected to experience the most severe regional moisture deficit, declining from −816 to −1,005 mm/yr (−189 mm/yr), while Western Africa decreases from −497 to −637 mm/yr (−141 mm/yr). Eastern Africa remains comparatively stable, with CMB improving slightly from −585 to −554 mm/yr. In contrast, Middle Africa retains a positive regional moisture balance, increasing from +37 to +73 mm/yr, despite substantial country-level variability. National-scale results identify Mauritania, Chad, Niger, Mali, and Botswana as the most severe structural moisture-deficit hotspots by end-century, whereas parts of Central and coastal West Africa retain localized moisture surpluses. While SSP5-8.5 provides upper-bound risk benchmark, evaluating intermediate emission pathways remains priority for future research. These findings provide macroscopic baselines for transboundary water governance, agricultural climate resilience, and adaptation planning across Sub-Saharan Africa.

Keywords: *climatic moisture balance; CMIP6 ensemble; SSP5-8.5; Sub-Saharan Africa*