Supplementary material for

Contrasting dynamics of hydrological processes in the Volta River basin under global warming

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1 Content

This supplementary material file contains additional figures and tables to support the analysis of the results presented in the main manuscript. The methodology used to obtain these results is explained in the main manuscript.

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2 Seasonal cycle of hydroclimatic variables

2.1 Rainfall

Figure S1. Annual cycles of rainfall ($P$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.2 Average temperature

Figure S2. Annual cycles of average air temperature ($T_{avg}$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.3 Maximum temperature

Figure S3. Annual cycles of maximum air temperature ($T_{\text{max}}$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.4 Minimum temperature

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2.5 Potential evaporation

Figure S5. Annual cycles of potential evaporation ($E_p$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.6 Actual evaporation

Figure S6. Annual cycles of actual evaporation ($E_a$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.7 Surface runoff

Figure S7. Annual cycles of surface runoff (Q_{run}) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
Figure S8. Annual cycles of groundwater recharge ($R_r$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.9 Soil moisture

Figure S9. Annual cycles of root-zone soil moisture (\(S_u\)) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
2.10 Terrestrial water storage

Figure S10. Annual cycles of terrestrial water storage ($S_t$) over the historical and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
3 Changes in the seasonal cycle of hydroclimatic variables

3.1 Rainfall

Figure S11. Changes in annual cycles of rainfall ($\Delta P$) over the future periods in comparison to the historical period (1991-2020). Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).

Figure S11. Changes in annual cycles of rainfall ($\Delta P$) over the future periods in comparison to the historical period (1991-2020). Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
Figure S12. Percentage changes in annual cycles of rainfall ($\Delta P$) over the future periods in comparison to the historical period (1991-2020). Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
3.2 Average temperature

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3.3 Maximum temperature

Figure S15. Changes in annual cycles of maximum air temperature ($\Delta T_{\text{max}}$) over the future periods in comparison to the historical period (1991-2020). Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
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3.4 Minimum temperature

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3.5 Potential evaporation

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3.6 Actual evaporation

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3.7 Surface runoff

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3.8 Groundwater recharge

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5 Annual trends of hydroclimatic variables

Figure S32. Annual trends in hydroclimatic variables over the historical (1991-2020) and future periods. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).
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8 High and low flows

Figure S55. High flows (Q₁₀) and low flows (Q₉₀) trends over the historical (1991-2020) and future periods at selected streamflow gauges. Each boxplot represents the spread among the RCM-GCMs combinations under RCP2.6 (9 models), RCP4.5 (16 models) and RCP8.5 (18 models).

Table S1. Percentage of model agreement on the direction of change between the RCM-GCM combinations for high flows (Q₁₀) in three sub-basins (Black Volta, White Volta and Oti).

| Q₁₀  | Bui Amont (Black Volta) | Daboya (White Volta) | Saboba (Oti) |
|------|-------------------------|----------------------|--------------|
| Period | RCP2.6 | RCP4.5 | RCP8.5 | RCP2.6 | RCP4.5 | RCP8.5 | RCP2.6 | RCP4.5 | RCP8.5 |
| 2021-2050 | 55.6 | 56.3 | 72.2 | 55.6 | 56.3 | 66.7 | 55.6 | 56.3 | 66.7 |
| 2051-2080 | 55.6 | 62.5 | 66.7 | 66.7 | 56.3 | 55.6 | 55.6 | 75.0 | 55.6 |
| 2071-2100 | 66.7 | 62.5 | 55.6 | 66.7 | 75.0 | 66.7 | 66.7 | 75.0 | 55.6 |

Table S2. Percentage of model agreement on the direction of change between the RCM-GCM combinations for low flows (Q₉₀) in three sub-basins (Black Volta, White Volta and Oti).

| Q₉₀  | Bui Amont (Black Volta) | Daboya (White Volta) | Saboba (Oti) |
|------|-------------------------|----------------------|--------------|
| Period | RCP2.6 | RCP4.5 | RCP8.5 | RCP2.6 | RCP4.5 | RCP8.5 | RCP2.6 | RCP4.5 | RCP8.5 |
| 2021-2050 | 55.6 | 66.8 | 77.8 | 55.6 | 50.0 | 72.2 | 55.6 | 50.0 | 61.1 |
| 2051-2080 | 55.6 | 50.0 | 66.7 | 55.6 | 50.0 | 55.6 | 55.6 | 50.0 | 55.6 |
| 2071-2100 | 66.7 | 66.8 | 61.1 | 55.6 | 50.0 | 61.1 | 55.6 | 50.0 | 55.6 |
9 Climate sensitivity of hydroclimatic variables

Baseline (1991-2020)  

Future changes (2021-2100)

Figure S56. Climate sensitivity of hydrological processes in the VRB over the historical period (left column) with associated future changes (right column). The coloured dots represent RCM-GCM combinations per RCP and the colour dashed lines represent the fitted linear regression.

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