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The competitive impacts of global SST warming and CO2 increase on Sahelian rainfall: results from CMIP5 idealized simulations

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Background
West Africa is affected by large climate variability at different timescales, from interannual to multidecadal, with consequent strong environmental and socio-economic impacts, especially in the Sahelian countries, where the economy is mainly sustained by rainfed agriculture. The annual precipitation in the Sahel is limited to the boreal summer season, from July to September (JAS), and it is strongly linked to the West African monsoon (WAM) dynamics. After a wet period during the 70s-80s, Sahel has undergone a severe (large scale and long-lasting) drought in the 70s-80s period, and a partial recovery of precipitation is observed at the turn of the 21st century.

Objective
- To study the effects of CO2 concentration increase and global SST warming on the WAM variability in July-September (JAS);
- Focusing on the regional-versus-global aspects of the WAM dynamics and drivers.

Conclusions
Competition between the global SST warming and the CO2 increase in driving the WAM variability:

SST warming -> Dry Sahel
(reinforced evaporation in the global Tropics -> reduced MSE meridional gradient over West Africa -> inhibition of the monsoonal flow and the ITCC northward migration);

CO2 increase -> Wet Sahel
(atmospheric radiative warming -> enhanced evaporation over the Sahel and warmer Sahara -> reinforced MSE meridional gradient -> more intense monsoonal circulation and precipitation).

1) Comprehension of the mechanisms linking the WAM variability to SST and CO2 forcings;
2) Ability of the climate models in reproducing these mechanisms, for reliable simulations of the past, present and future variability.

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**Figure 1:** JAS mean of precipitation (mm/day) for the period 1979-2008: a) GPCP data, b) CTL MMM and c) difference with observations, and modifications in d) 4K and e) 4xCO2 MMM. Significant differences are shaded.

**Figure 2:** JAS MMM of precipitation (mm/day) for the period 1979-2008: a) CTL MMM, and c) difference with b) CTL. Differences with CTL (displayed in Figure 1d, e) and b) 21stcentury trend in the RCP8.5 scenario, presented as the difference between the end point of the linear trend over the period 2006-2100.

**Figure 3:** Significant relative differences between 4K (blue) and 4xCO2 (red) simulations in a) JAS climatological precipitation, in Sahel (15°-20°N, 25°W-30°E, cloudy, western part of G5, eastern Sahel and central Sahel, respectively), and in b) 4xCO2 MMM, off-4xCO2 MMM

**Figure 4:** JAS mean of the SDS-700 kPa thickness [m] for the period 1979-2008: a) CTL MMM and c) difference with b) 4K. Differences are shaded.

**Figure 5:** JAS mean of wind and moisture transport divergence at 850 hPa [kg/m²s] for the period 1979-2008: a) CTL MMM and b) difference with c) 4K and d) 4xCO2 MMM. Significant differences are displayed.

**Figure 6:** JAS mean of the zonal wind at 400 hPa [ms⁻¹] for the period 1979-2008: a) CTL MMM and modifications in b) 4K and c) 4xCO2 MMM. Significant differences are displayed.

**Figure 7:** Moist and dry static energy [Wm²] for the period 1979-2008: a) CTL MMM and b) difference with c) 4K and d) 4xCO2 MMM. Significant differences are displayed.

**Figure 8:** (Left) 4K-CTL and (right) 4xCO2-CTL differences of the meridional profiles, averaged over West Africa (10°W-10°E), of (top) HUM and (bottom) SCM, integrated in the SDS-700 kPa layer [(J/kg)*Pa]. Significant differences are displayed.