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West African Monsoon dynamics in idealized simulations: the competitive roles of SST warming and CO_2

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The West African Monsoon (WAM) is affected by large climate variability at different timescales, from interannual to multidecadal, with strong environmental and socio-economic impacts associated to climate-related rainfall variability, especially in the Sahelian belt. State-of-the-art coupled climate models still show poor ability in correctly simulating the WAM past variability and also a large spread is observed in future climate projections.

In this work, the July-to-September (JAS) WAM variability in the period 1979-2008 is studied in AMIP-like simulations (SST-forced) from CMIP5. The individual roles of global SST warming and CO_2 concentration increasing are investigated through idealized experiments simulating a 4K warmer SST and a 4x CO_2 concentration, respectively. Results show a dry response in Sahel to SST warming, with dryer conditions over western Sahel. On the contrary, wet conditions are observed when CO_2 is increased, with the strongest response over central-eastern Sahel. The precipitation changes are associated to modifications in the regional atmospheric circulation: dry (wet) conditions are associated with reduced (increased) convergence in the lower troposphere, a southward (northward) shift of the African Easterly Jet, and a weaker (stronger) Tropical Easterly Jet. The co-variability between global SST and WAM precipitation is also investigated, highlighting a reorganization of the main co-variability modes. Namely, in the 4xCO_2 simulation the influence of Tropical Pacific is dominant, while it is reduced in the 4K simulation, which also shows an increased coupling with the eastern Pacific and the Indian Ocean.

The above results suggest a competitive action of SST warming and CO_2 increasing on the WAM climate variability, with opposite effects on precipitation. The combination of the observed positive and negative response in precipitation, with wet conditions in central-eastern Sahel and dry conditions in western Sahel, is consistent with the future precipitation trends over West Africa resulting from CMIP5 coupled simulations. It is argued that the large spread in CMIP5 future projections may be related to the weight given to SST warming and direct CO_2 effect by individual models. The capability of climate models in reproducing the SST-precipitation relationship appears to be crucial in this respect.