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## **Dynamical and Thermodynamic Changes in the Historical Response of Atlantic Sector Rainfall to Anthropogenic Emissions in the IPSL-5A Model.**

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CMIP5 models, including IPSL-5A, developed at the Institut Pierre Simon Laplace, largely reproduce the observed post-World War II decline in Sahel precipitation. We use all- and single-forcing historical simulations performed with IPSL-5A to better understand the impact of emissions of aerosols and greenhouse gases in Sahel drought. Specifically, we analyze the moisture budget to assess the two main processes, namely stabilization and moisture supply, that are hypothesized to shape moisture convergence and precipitation in the Atlantic sector.

1) The net change has the sign of the expected thermodynamic change: an increase in precipitation in GHG-induced warming, and a decrease in aerosol-induced cooling. Thermodynamic change is opposed by dynamical change.

The rainfall change in GHG-induced warming, in the Sahel as well as across all other regions of climatological precipitation, including the Atlantic Intertropical Convergence Zone (ITCZ), is positive and largely dominated by the change in the thermodynamic term associated with convergence, meaning that the change is consistent with an increase in moisture that assumes no change in the atmospheric circulation: as the ocean warms, it supplies more moisture to the monsoon.

This wetting thermodynamic term associated with convergence is opposed by drying associated with the corresponding dynamical term, which is especially strong at the margins, and signifies a weakened mass flux, or slow-down of the overturning circulation. This negative change in mass convergence is symptomatic of stabilization in a warmer world.

The effect of sulfate aerosol-induced cooling is equal and opposite to that of GHG-induced warming.

2) The ITCZ response is complicated by the dynamical ocean feedback associated with changes in the meridional gradient in sea surface temperature. GHG-induced warming leads not only to an increase in precipitation, but also to a poleward shift of the ITCZ. This poleward shift is accompanied by (south) westerly wind anomalies, which drive an off-equatorial cooling Ekman flow equatorward of the ITCZ. These same westerly anomalies induce a weakening of equatorial upwelling, and warming of the eastern equatorial Atlantic cold tongue.

Here, too, the effect of sulfate aerosol-induced cooling is equal and opposite to that of GHG-induced warming. An equatorward shift of the ITCZ is accompanied by (north) easterly wind anomalies, which drive off-equatorial warming, and equatorial cooling.