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Anthropogenic aerosols modulated twentieth-century Sahel rainfall variability via impacts on North Atlantic sea surface temperature

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Sahel rainfall experienced significant multidecadal variability over the twentieth century. Previous work have proposed several drivers to explain the severe drought and the subsequent recovery of Sahel rainfall in the past century, including anthropogenic aerosols, GHGs, and internal variabilities. However, the attribution remained ambiguous. Sahel summertime monsoon has close teleconnections with North Atlantic sea surface temperature (NASST) variability, which has been proven to be affected by aerosols. Therefore, changes in regional aerosols emission can potentially drive multidecadal Sahel rainfall variability.

Here we use ensembles of state-of-the-art global climate models (the CESM-large ensemble and CMIP6 models) and observational datasets to demonstrate that anthropogenic aerosols have significant impacts on twentieth-century Sahel rainfall multidecadal variability through modifying NASST. Aerosol-induced multidecadal variations of downward solar fluxes over the North Atlantic Ocean cause NASST variability during the 20th century, altering the strength of the Hadley cell and the ITCZ position, therefore, dynamically linking aerosol effects to Sahel rainfall variability. While the observed linear trend of NASST might still be affected by a mix of various external and internal drivers, our results suggest that NASST variability is most likely caused by aerosol-induced changes in radiative fluxes rather than changes in ocean circulations, and that anthropogenic aerosols can explain most of the detrended Sahel rainfall variability. CMIP6 models further suggest that aerosol-cloud interactions contributed more to the variability than aerosol-radiation interactions. These findings highlight the importance of accurate representation of regional aerosol radiative effects for the simulation of Sahel rainfall variability.