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Increasing manmade air pollution reduces rainfall in southern West Africa

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Southern West Africa has one of the fastest growing populations worldwide. A decrease in precipitation in this region could severely affect water supply, and food and energy production for more than a hundred million people. Interannual to decadal variability in rainfall has been shown to be controlled by changes in sea-surface temperatures in the tropical Atlantic and Pacific Oceans. Precipitation also shows a strong seasonality associated with the West African monsoon. The occurrence and amount of rainfall events depend on surface solar heating and the organization of thunderstorms to large complexes.

Urbanisation and strong population growth in southern West Africa during the past decades have caused a marked increase in anthropogenic emissions and air pollution. It is unclear whether a reduction in incoming sunlight due to the strongly increased manmade air pollution has affected recent changes in precipitation.

Here we show for the first time that a rainfall suppressing impact of the increased concentration of aerosol particles can be separated from other climatic factors both for the little dry season (July–mid-September) and the following second rainy season (until end of October). Past research on this question has been hampered by the absence of long-term aerosol records of sufficient quality. Here we use the indirect evidence from observations of precipitation (Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) and station data), visibility (station data), radiation and clouds (Satellite Application Facility on Climate Monitoring (CM SAF) satellite and station data), together with their spatio-temporal variations, to detect the pollution impact.

Removing trends related to large-scale climatic changes (visible in climate indices such as ATL3 and NINO3.4) from observed rainfall time series (1983–present) allows us to quantify the residuum, i.e. the aerosol effect, on rainfall trends. In both seasons the aerosol increase causes rainfall reductions of about 0.6% per year. We corroborate this trend to be aerosol related by comparing observed radiation, cloud and horizontal visibility data sets. The observed reduction in incoming solar radiation over the past 35 years can only partly be explained with increased cloud cover. Consequently, also aerosol concentrations have increased, as visible in Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth data. Beside local emissions, increased aerosol from biomass burning in central Africa, transported to southern West Africa, potentially contributes to the aerosol increase there. More clouds and aerosol are associated with less surface solar heating and therefore a more stable boundary layer, finally causing the observed rainfall reduction.

Policymakers in Africa are advised to prevent a further increase in air pollution, because this may exacerbate rainfall suppression as it has been shown in a previous study for regions in southern Africa as well.