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Activation of Sahelian monsoon under future warming

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Rainfall variability in the Sahel has been affecting the lives of millions through devastating droughts, such as in the 1970s and 80s, but also destructive rain and flood events. Future climate change is likely to alter rainfall patterns, but model projections for the central Sahel diverge significantly, with climate models simulating anything between a slight drying and a substantial wetting trend. Here we analyze 30 coupled global climate model simulations from the CMIP5 archive. We identify seven models where central Sahel rainfall increases by 40% to 300% over the 21st century, under the RCP8.5 concentration pathway. The same models also outperform the rest of the ensemble in reproducing the magnitude of the 1970s/80s drought. The magnitude and seasonality of the projected future rainfall change, together with a concurrent increase in near-surface wind speed, indicate a northward expansion of the West African monsoon domain. We further find that Sahel rainfall does not increase linearly with rising global temperatures; it is insensitive to moderate warming but then abruptly intensifies beyond a certain temperature. This non-linearity is even more pronounced when instead of global warming, sea surface temperature change in the tropical Atlantic moisture source region is considered. We propose an explanation for this behavior based on a self-amplifying dynamic-thermodynamical feedback, and suggest that the gradual increase in oceanic moisture availability under climate change can trigger the sudden activation of a continental monsoon in the Sahel region, which reaches further inland than the present-day, predominantly coastal West African monsoon. Such an abrupt regime change in response to gradual forcing would be consistent with paleoclimatic records from the Sahel region. More detailed comparison between the model simulations that exhibit this sudden rainfall increase under future warming and those that do not may help to verify this hypothesis.