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Sahel rainfall in the past and future—disentangling the forced response from internal variability using a large ensemble

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The presence of large internal variability makes detecting a forced response of rainfall to global warming difficult—in particular for regional studies. Therefore, we use a large ensemble of a comprehensive climate model to disentangle the forced response from internal variability in Sahel rainfall. We use both historical simulations to understand the observed record and different future scenarios to investigate the response of Sahel rainfall to future warming in the Max Planck Institute Grand Ensemble (MPI-GE).

Observed Sahel rainfall has been decreasing from the 1960s to the 1980s and recovering in the decades thereafter. Moreover, some studies have suggested that the interannual variability in Sahel rainfall has increased in the recent decades. Using the large ensemble, we are able to disentangle internal variability and the forced response and find an externally forced increase in mean Sahel rainfall in the end of the 20th century. In addition we find evidence for a forced increase in interannual rainfall variability. However, the presence of large internal variability makes it impossible to robustly detect and attribute these forced changes in a single realisation. If the simulated magnitude of change is realistic, this implies that even if we can identify these changes in the observed record, they cannot be clearly attributed to a change in the forcing. Only a large ensemble allows a clean separation of forced changes and internal variability.

In a strong forcing scenario, we find a forced increase in Sahel rainfall and rainfall variability in the 21st century. For weaker forcing scenarios, we find no change or even a projected decrease in Sahel rainfall with no forced change in the variability. For future scenarios, a large ensemble not only enables us to identify forced changes, but also to estimate how likely it is that we will be able to detect these changes in the single realisation of the real world.