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Reconciling Past and Future Rainfall Trends over East Africa

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It is well known that rainfall during the East African Long Rains season has declined over recent decades, whereas the majority of climate models predict an increase due to anthropogenic carbon emissions. This raises questions about either the reliability of the model projections, or when we might expect this drought to turn to more abundant rainfall and perhaps more frequent flooding.

We first list all hypotheses that may conceivably explain this paradox, our aim being to include all possibilities regardless of preconceptions as to their likelihood:
• A: The recent observed trend is due to poor quality data.
• B: The projected trend arises from poor modelling of key processes.
• C: Trends are due to natural variability.
• D: The balance between competing forcings is changing, with the past trend driven by aerosol emissions and the future trend driven by carbon emissions.
• E: The past trend has been driven by land-use changes.
• F: The mechanistic response to CO_2 emissions is non-linear.
• Some combination of the above.

Regarding A, there is good observational evidence for a recent downward trend in rainfall. Regarding B, careful and substantial further research is essential to confidently refute or accept this idea.

The possibility that the observed trend is due to natural variability (C) is assessed using two approaches. Both suggest that the recent Long Rains droughts are either due to a very unusual natural event of the climate system, or (more likely) are at least partly due to anthropogenic forcing. Hypothesis D, that the recent observed rainfall trend may be due to anthropogenic aerosol emissions, eg. from Asia, is investigated using CMIP5 sensitivity experiments. These reveal a sometimes significant, but highly model-dependent, impact on SST trends over the Indian and Pacific Oceans, which are thought to have caused the recent Long Rains droughts. Other CMIP5 experiments suggest that land-use changes are unlikely to have caused the recent droughts, and that the response to CO_2 forcing over East Africa is not substantially non-linear (Hypotheses E and F).

Further work should therefore focus on improving the modelling of aerosol impacts on regional rainfall changes, on providing a well-considered ‘expert judgement’ of the reliability of the model’s projections for the coming century, and better understanding the relevant natural variability.