



## Brief Communication: Drought Likelihood for East Africa

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**Abstract.** The on-going effects of severe drought in East Africa are causing high levels of malnutrition, hunger, illness and death. Close to 16 million people across Somalia, Ethiopia and Kenya need food, water and medical assistance (DEC, 2017). Many factors influence drought stress and ability to respond. However, inevitably it is asked: are elevated atmospheric greenhouse gas (GHG) concentrations altering the likelihood of extreme rainfall deficits? We find small increases in probability of this for East African, based on merging the observation-based reanalysis dataset by the European Centre for Medium-Range Weather Forecasts (ECMWF) (Dee et al., 2011) with Global Climate Models (GCMs) in the CMIP5 database (Taylor et al., 2012).

ECMWF re-analysis data shows that August to October (ASO) of 2016, large parts of Somalia, Ethiopia and Kenya (Black rectangle, Fig. 1a) had a reduction of 30% or more in rainfall compared to a baseline period 1979-2015. For this region, the spatial average of monthly rainfall during ASO of 2016 lies at least one standard deviation below the climatological mean of the other years (Fig. 1b). During these months, other parts of Africa also experienced severe rainfall deficits. We concentrate on East Africa, as this experienced poor harvest and where famine is widely reported.

To assess any influence of increasing atmospheric GHG concentrations, we use monthly rainfall data from 37 GCMs simulations for the historical period and future “business-as-usual” RCP8.5 scenario. We multiply modelled mean ASO rainfall estimates, both past and future, with a GCM-specific value such that the climatological mean of each GCM during the period 1979-2015 equals that of the ECMWF reanalysis. This is also for the spatial average over our study region (Fig. 1a). Each GCM is considered equally plausible. Considering different 31-year periods, Probability Density Functions (PDFs) of mean ASO rainfall (e.g. 31 times 37 numbers) are constructed.

Our PDFs enable estimation of the probability, in any year, of rainfall being less than 46 mm month<sup>-1</sup> (shaded, Fig. 1c), which is the ASO mean rainfall level in 2016 (red curve within yellow highlight, Fig. 1b). We compare modelled period 1861-1891, representative of pre-industrial, with present day (period 2001-2031), and find this probability increases slightly from 5.3% to 5.6% (inset, Fig. 1c). This is caused by a stretch in the distribution tail, as overall rainfall increases. These trends continue, giving probabilities 6.3% and 7.4% for periods 2035-2065 and 2070-2100 respectively. The stretched left-tails are caused by a few models that estimate this region becomes drier, and some models exhibiting increased interannual variability.



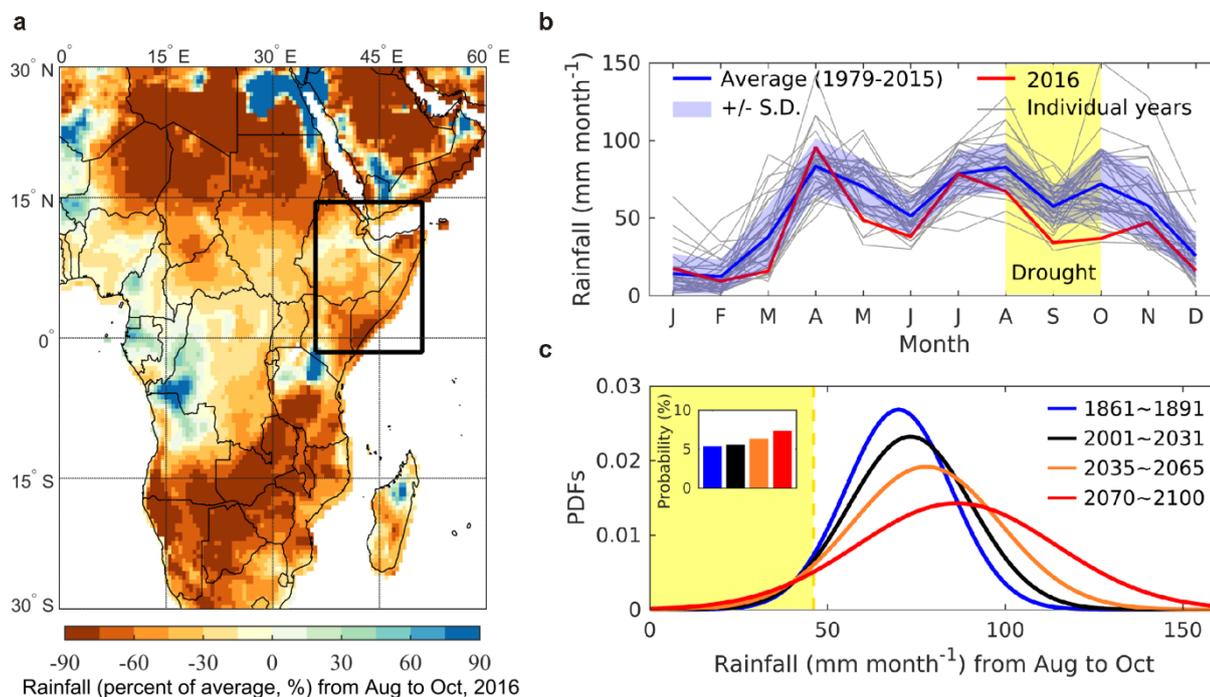
Our simple analysis that considers models equally, suggests East Africa ASO drought risk is increasing, although general rainfall levels are rising. The climate research community may need to be confident enough to rank climate models based on performance to refine future projections (Knutti et al., 2017). Which models are most accurate for East Africa? Furthermore, under global warming, raised evaporation may offset rainfall gains, affecting crop photosynthesis (Adhikari et al., 2015). Food and water availability in East Africa has multiple socio-economic drivers, alongside climatic influences (Little et al., 2001). Any holistic approach, including climate and crop impact modelling, will hopefully create better protections and disaster preparedness against future famine.

## References

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**Figure 1:** (a) Black rectangle is location of study region (14.5°N~1.5°S, 36°E~51°E). Plotted is mean rainfall from 2016 August to October inclusive (ASO), relative to long-term average ASO values (1979-2015) and based on ERA-Interim reanalysis product. (b) ERA-based monthly total rainfall ( $\text{mm month}^{-1}$ ) over study region (panel a; land within black rectangle) for years 1979 to 2016. Year 2016 is red, other years are individual grey lines, and multi-year average (not including 2016) is blue. Blue shading is  $\pm$  one standard deviation of monthly rainfall across years 1979-2015. The drought event (shaded in yellow) is defined as the three consecutive months of ASO when rainfall in year 2016 is below blue shading. (c) CMIP5-based PDFs of mean ASO rainfall for periods 1861-1891 (blue), 2001-2031 (black), 2035-2065 (orange) and 2070-2100 (red). Each curve corresponds to merged normalised outputs from 37 CMIP5 models forced by historical emissions and RCP8.5 future scenario. Yellow shading is mean ASO rainfall less than  $46 \text{ mm month}^{-1}$ , which is the 2016-based threshold (mean of ASO, red curve in panel b). Inset shows probabilities of mean rainfall of ASO falling below the threshold for the same modelled periods (colours match those of curves).