The drought in Ethiopia, 2015

Science summary

Key messages

- North and central Ethiopia suffered their worst drought in decades in 2015, a year marked by a strong El Niño.
- The drought affected nearly 10 million Ethiopians.
- Scientists with World Weather Attribution used multiple methods of attribution science to look at the possible roles that climate change and El Niño played in the drought.
- They found that El Niño made this rare drought even drier in the *kiremt* season.
- No influence of climate change could be found, with the spread of possible trends ranging from drought being 40% less to four times more probable.

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Event

The worst drought in decades gripped north and central Ethiopia in 2015, affecting nearly 10 million people. The dry conditions left hundreds of thousands of farmers with failed crops and weakened or dead livestock. The resulting food scarcity meant more than eight million people in the parched country needed emergency food aid, according to the United Nations (UN).[1] The

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magnitude of the devastation to Ethiopia led the UN's Allahoury Diallo to declare that the "drought is not just a food crisis – it is, above all, a livelihood crisis."[2]

Signs of trouble began to surface early in the year. Farmers waited for the *belg* rains that generally occur between February and May in the central and eastern parts of the country (Figures 1, 2 and 3). About 10% of the Ethiopian population is completely dependent on this season to provide rainfall for crops and pastures.[3] But in 2015, after a false start, the *belg* rains came a month late in northern and central Ethiopia.

What also arrived was a particularly strong El Niño, associated with the warming of equatorial waters in the Pacific Ocean. The effects of El Niño play out in different ways across the planet. In Ethiopia, El Niño can lead to drier conditions, mainly in the north-western part of the country, affecting the rainy season known as *kiremt* that occurs in June–September. In a normal year, the *kiremt* rains account for 50–80% of annual rainfall.[4] But in 2015, the *kiremt* season was delayed and the rains were erratic and below average. From February to August 2015, the northern-central and some eastern parts of the country received only 500 mm of rainfall, a deficit of 167 mm from the long-term average (Climate Hazards Group Infrared Precipitation with Stations, CHIRPS). Only half to three quarters of the rainfall expected was received from February to September.[5]

In a world warmed by human-induced climate change, droughts are expected to become more common and more severe in some parts of the world. Is this region one of these?

Analysis

Given the extreme nature of the 2015 drought in Ethiopia, scientists with Climate Central, the Royal Netherlands Meteorological Institute (KNMI), the University of Oxford and the University of Melbourne – as part of the World Weather Attribution (WWA) partnership, which also includes the Red Cross/Red Crescent Climate Centre – conducted an analysis to determine whether climate change played a role in this drought. The influence of El Niño was also analysed.

Researchers looked at the dry central to northern region of the country (Figure 1), basing the boundaries on the homogeneity of rainfall and topography. They studied the more reliable data from 1960 to 2015 (data from before 1960 are considered less reliable), focusing on February–September during which almost all rain falls.

To assess the extent to which the Ethiopian drought of 2015 was linked to human-induced climate conditions, the WWA team conducted independent assessments with three peer-reviewed approaches that use: (1) statistical analyses of historical observational datasets, (2) data from global climate models, and (3) a large ensemble of simulations of possible weather scenarios with a global climate model. Analysing the event using numerous methods provides a means to assess confidence in the results.

The set of global climate models used in this analysis were EC-Earth, weather@home and Climate Model Intercomparison Project Phase 5 (CMIP5). The coupled general circulation model EC-Earth's analysis[6] was applied to 16 ensembles based on CMIP5 (1861-2005) and RCP85 (2006-2100) scenarios protocol. Weather@home, an atmosphere-only general circulation model, provided weather simulations under observed climate conditions (sea-surface temperatures and sea-ice conditions), as well as simulations without human-induced climate change. CMIP5 is the multi-model ensemble prepared for the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report*.

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Figure 1. Map showing area of analysis, north-eastern Ethiopia, 8°–13°N, 38°–43°E. Anomaly in precipitation (CHIRPS, over 1981-2010 climatology) averaged over February–September 2015.[7]

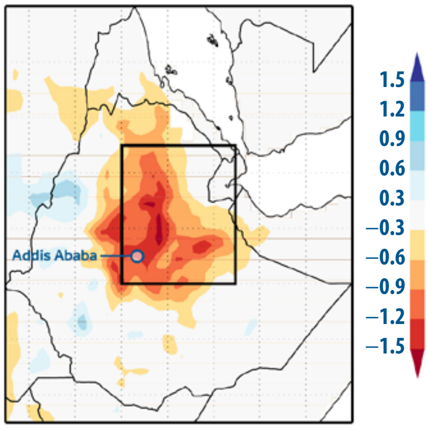


Figure 2. Map showing the areas that receive rain during the *belg* season (A) and the *kiremt* season (B).[8]

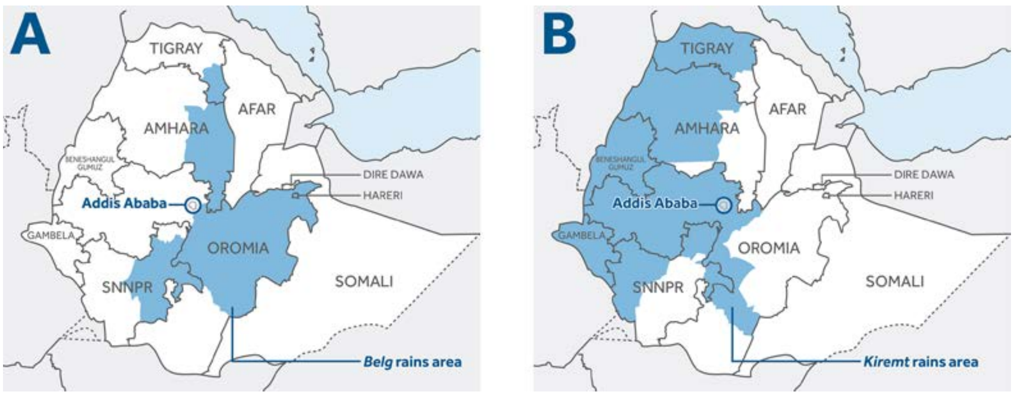
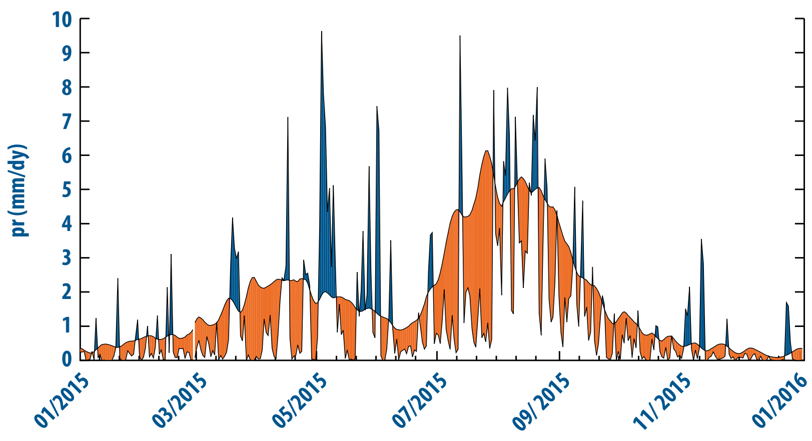


Figure 3. Time series of daily rainfall for 2015 in northern and central Ethiopia, 8°–13°N, 38°–43°E. Anomaly in precipitation (CHIRPS), compared to the 1981-2010 climatology (red: drier, blue: wetter).[9]



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Two key outputs from these analyses were determining the return period of the February–September precipitation amount, and examining how the likelihood of the event has changed due to global warming. For the observational data and EC-Earth model, this was explored by fitting the precipitation data to a Gaussian distribution. For the weather@home and CMIP5 models, the return times are directly estimated in the current climate and in a counterfactual climate without human influence. The ratio of the resulting frequency of occurrence of such a drought event today compared with the past (before there was a strong human influence on the climate system) measures the extent to which climate change has affected the likelihood of the event.

Results

The observed 2015 drought was an extremely rare event that is expected to happen in the central to north-eastern parts of Ethiopia only about once every few hundred years (best estimate 260 years, lowest estimate 60 years, according to the 95% confidence interval [CI], based on the gridded CenTrends dataset extended with CHIRPS, mainly satellite data in 2015) in the current climate. The longest return periods are in the south-western region of the study area. The return period at the station in Addis Ababa, however, was found to be only three years (95% CI: two to five years). This disparity with the gridded CenTrends dataset may result from one or more of a few possible reasons, including scarcity of station data, different characteristics of point data and area-averaged data, and small-scale variability within the study area. Using the regression between El Niño (NINO3.4 index) and the precipitation series to subtract the influence of El Niño from the observational data suggested that the 2015 drought was exceptional and enhanced by El Niño. Without El Niño, the event would likely have been wetter, with results indicating a return period of 80 years (lowest estimate 20 years, 95% CI) instead of the actual 260 years (lowest estimate 60 years, 95% CI).

The story is more complex when it comes to the role of human-induced climate change in the 2015 extreme drought. Overall, the climate models used indicated a wide spread of results regarding the possible influence of climate change. The EC-Earth model analysis indicated a non-significant drying trend, with a risk ratio between now and 1960 of 1.4 (95% CI: 0.9–1.9). The weather@home simulations painted different pictures for the *belg* and *kiremt* rainy seasons. The *belg* season showed no significant change in likelihood of such drought events due to human-induced climate change or sea surface temperatures. During the *kiremt* season, and concomitantly also for the joint season *belg–kiremt*, simulations indicated that human-induced climate change did increase the frequency of such an event. For example, a once in 100 years joint-season event in the world today was simulated as a once in over 230 years event in a world without human-induced climate change. Analysis of the CMIP5 ensemble indicated a return period of the drought of about 30 years, with no difference in frequency from pre-industrial times. Overall, the trends in droughts in the models between the current and pre-industrial climate ranged from a factor of 1.7 **less** likely to 4 times **more** likely. While these model results are statistically compatible with gridded observations (due to the large spread of possible trends from gridded observations ranging from a factor five decrease to a factor 10 increase in likelihood), they are not compatible with each other, which implies that the differences are not only due to natural variability, but also due to model spread, which has been taken into account in the final uncertainty range. As this range encompasses no change, the drought cannot be attributed to climate change.

Exposure and vulnerability

In December 2016, the Government of Ethiopia and the UN jointly released a *Humanitarian requirements document* (HRD)[10] calling for emergency assistance for 10.2 million people, in addition to the 7.9 million people under routine support from the national social safety net programme, Productive Safety Net Programme (PSNP).[11] Beyond total precipitation deficits, both the timing and the spatial distribution of rainfall impacted livelihood activities, such as agriculture and pastoralism.[12] In 2016, many parts of central and northern Ethiopia were reported to be in Integrated Phase Classification Phase 3 of food insecurity – the 'acute crisis' phase.[13] In the most affected areas, over 75% of crop production was reported lost, one million livestock were reported to have died, 1.7 million people are estimated to experience moderate to acute malnutrition (MAM) and 435,000 people are estimated to experience severe acute malnutrition (SAM).[14] The Government of Ethiopia and the international humanitarian community mobilised to meet emergency needs, including provision of water, sanitation and hygiene, food and nutrition.

Ethiopia is one of the fastest-growing economies in Africa, with an average economic growth rate of 10.8% per annum between 2003 and 2015.[15] In parallel, over a similar period, the number of Ethiopians living in extreme poverty dropped by 22 percentage points, reducing from 55.3% in 2000 to 33.5% in 2011. The Government of Ethiopia is currently implementing the second phase of its Growth and Transformation Plan in an effort to further advance these strong trends.[16] In addition, in collaboration with longstanding development partners, the Government of Ethiopia has implemented the PSNP since 2005. The PSNP uses food and cash transfers to help households overcome food deficits to improve overall food security. As of 2017, the programme has entered its fourth phase and serves 7.997 million food-insecure people each year.[17] During the 2015-2016 drought, the PSNP continued to provide cash transfers to clients and extended cash transfers into the Somali region. While food transfers were delayed, cash transfers were increased to fill the gap. In addition, the PSNP suspended infrastructure requirements in some areas because of the drought conditions.

Despite its impacts, with the current drought estimated to be most likely a one in several hundred years event (a rarity that would place significant strains on most public services), the lower impact of this drought compared to those in 1984 and 1973 is a testament to the advances being made in improving the resilience of Ethiopians to climate shock and stresses.

The University of Melbourne · University of Oxford · Royal Netherlands Meteorological Institute, Ministry of Infrastructure and the Environment · Climate Central · Red Cross Red Crescent Climate Centre · Climate & Development Knowledge Network

Funded by Ministry of Foreign Affairs of the Netherlands · UKaid from the British people · Eric and Wendy Schmidt

Summary of key scientific parameters

Variable	Precipitation
Event definition	Feb–Sept 2015, which combines the *belg* (Feb–May) and *kiremt* (June–Sept) rainy seasons
Domain	Central to north-eastern Ethiopia, 8°–13°N, 38°–43°E
Observational data	Two gridded precipitation datasets: CenTrends, 1960-2014 CHIRPS, 2015 Station data (Addis Ababa, Alem Ketema, Combolcha)
Models used	EC-Earth 2.3 model, at T159, about 125-km resolution weather@home (50-km resolution) CMIP5 multi-model ensemble HadGEM3A (considered but not used)
Results	El Niño enhanced the drought, making a rare event (1 in 80 years) even more rare (1 in several hundred years), according to correlations in the observations. The models and observations do not show conclusive results on the influence of climate change.

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Notes

1 UN (2015) 'Ethiopia: UN warns of deepening food insecurity, allocates emergency funds to tackle severe drought'. United Nations News Centre (www.un.org/apps/news/story.asp?NewsID=52569#.WQr5X4nyui5).
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13 FEWS NET (2016) *Ethiopia food security outlook October 2016 to May 2017*. Famine Early Warning Systems Network (www.fews.net/east-africa/ethiopia/food-security-outlook/october-2016).
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15 World Bank (2016) 'World Bank Country Overview: Ethiopia'. October 2016. (www.worldbank.org/en/country/ethiopia/overview).
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This publication is an output from the Raising Risk Awareness project. The project is funded by the UK Department for International Development (DFID) through the Climate and Development Knowledge Network (CDKN), and by Eric and Wendy Schmidt through Climate Central, Inc. CDKN is a programme funded by DFID and the Netherlands Directorate-General for International Cooperation (DGIS) for the benefit of developing countries.

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