iFEED: Climate Extremes Calibrated Statements

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Overview

These calibrated statements describe national-scale climate extremes across Malawi, South Africa, Tanzania, and Zambia for the present-day and for future mid-century (2040-2060).

For the present-day extremes, the following climate variables are assessed for Malawi, South Africa, Tanzania and Zambia:

1) Likelihood of unprecedented high seasonal average temperatures
2) Likelihood of unprecedented high seasonal total rainfall
3) Likelihood of unprecedented low seasonal total rainfall

Extreme temperature and rainfall events are rare, and we have relatively few observations of them. In addition, the climate has changed, meaning that older weather observations may no longer be relevant. Because of this, it is difficult to accurately estimate how frequently weather extremes occur. We have used state-of-the-art climate models to simulate many possible versions of the weather that could occur under the current climate conditions. Using this approach, we can understand more about possible weather extremes conditions and assess the risk of record-breaking events in the real world.

The present-day extremes assessment combines observations and climate model simulations for the recent historical period of 1979-2016 for temperature and 1979-2018 for rainfall. The observed seasonal temperature and rainfall records are estimated from WATCH Forcing Data methodology applied to ERA-5 reanalysis (WFDE5) data (Cucchi et al., 2020). The Met Office Decadal Prediction System (DePreSys; Dunstone et al 2016) provides the climate model outputs which have been re-calibrated to represent the climate conditions in 2016. This allows us to give the likelihood of unprecedented/record-breaking temperature and rainfall in terms which are representative of the current climate.

The climate change analysis compares climate model projections of temperature and rainfall extremes in the mid-century 2040-2060 period with a recent historical period of 1990-2010. The climate projections are given for a high climate risk scenario Representative Concentration Pathway (RCP) 8.5, and a low climate risk scenario RCP2.6, defined below:

- **RCP8.5** is a high greenhouse gas concentration scenario, sometimes known as “Business-As-Usual”, with emissions continuing to increase throughout the century.
- **RCP2.6**: Low greenhouse gas concentration scenario. This scenario results in a reduction in CO_2 concentrations and therefore involves aggressive mitigation with immediate and sustained reductions in greenhouse gas emissions.

For each scenario, the number (e.g. “8.5”) represents the increase in radiative forcing in W/m^2 at the end of the 21st century, compared to pre-industrial levels. Higher levels of radiative forcing lead to increased warming. Warming is therefore greatest for RCP8.5, and least for RCP2.6.

The climate variables assessed are:

4) Average temperature each month
5) Average rainfall each month
6) Extreme temperatures – number of days each month with average temperature above 35°C
7) Extreme rainfall – total rainfall each month on the wettest 5% of days, as defined by the 1961-1990 climate
8) Extreme wet spells – average maximum number of consecutive wet days in month (daily rainfall greater than 1 mm) during each 20-year period
9) Extreme dry spells – average maximum number of consecutive dry days in each month (daily rainfall less than 1 mm) during each 20-year period

The observational dataset used as a reference in the climate change extremes analysis is the WATCH Forcing Data methodology applied to ERA-Interim reanalysis (WFDEI) data (Weedon et al., 2014). The model ensemble used in the climate change extremes analysis is the CMIP5-AMMA[1] dataset bias-corrected to the EWEMBI[2] reference dataset (Famien et al., 2018). The climate change analysis compares the mid-century 20-year period (2040-2060) with a recent historical period of 1990-2010. Projected changes are presented for the both high climate risk scenario RCP8.5 and the low climate risk scenario RCP2.6.

[1] CMIP-5-AMMA data is the bias-corrected Climate Model Intercomparison Project version 5 model output from the African Monsoon Multidisciplinary Analysis project (https://www.amma2050.org/).
[2] EWEMBI is the EartH2Observe, WFDEI and ERA-Interim data Merged and Bias-corrected for ISIMIP dataset (https://dataservices.gfz-potsdam.de/pik/showshort.php?id=escidoc:1809891).

Malawi

Present day (representative of the year 2016)

Probability of unprecedented high temperatures

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal temperature record of 24.9°C is 2.9% per year. This is equivalent to an unprecedented high temperature event occurring once in every 34 years (high robustness).

Robustness Assessment:

- High robustness as the climate models have undergone strict statistical testing, and because the uncertainty range of the probability estimate at the 95% confidence interval (1.2%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented high rainfall

- During the peak months of the growing season (January-March), the annual chance of exceeding the maximum seasonal rainfall record of 888 mm is 0.9%. This is equivalent to an unprecedented high rainfall event occurring once in every 111 years (high robustness).

Robustness Assessment:

- High robustness as the climate models have undergone strict statistical testing, and because the uncertainty range of the probability estimate at the 95% confidence interval (0.6%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented low rainfall

- During the peak months of the growing season (January-March), the annual chance of subceeding[3] the minimum seasonal rainfall record of 400 mm is 1.3%. This is equivalent to an unprecedented low rainfall event occurring once in every 77 years (high robustness).

Robustness Assessment:

- High robustness as the climate models have undergone strict statistical testing, and because the uncertainty range of the probability estimate at the 95% confidence interval (0.8%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

High climate risk - RCP8.5

Summary statement

By mid-century, climate models show average temperatures warming by roughly 2-4°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including the number of days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a tendency toward higher rainfall totals during the wettest months (December-February) accompanied by more rainfall on very wet days, increased rainfall intensity and slight reduction in the number of wet days. There are also slight trends towards longer extreme dry spells and shorter extreme wet spells during October and November. This is consistent with a general shortening of the rainy season across Malawi. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures by 2-4°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:

[3] Subceedance means to be less than, i.e. the opposite of exceedance

- Medium robustness for the projected change as the spread in the model projections [1-3°C] is similar to the amount of change projected (2-4°C). Furthermore, the model baseline is in strong agreement with the observations.

Agreement Assessment:

- Projected temperature increase in Central Malawi for 2040–2069 as compared to 1971-2000 is 2.5°C (Warnatzsch and Reay, 2020). (High agreement)
- Projected temperature increase in Malawi in the warmest month of the year for 2046–2050 as compared to is 0.75-3.5°C (Arndt et al., 2014). (Medium agreement)
- Projected annual temperature increase in Malawi 2-3°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in Malawi 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- High confidence (high robustness and medium/high agreement)

Average Rainfall

- Climate projections for the mid-century show slight increases in the average rainfall amounts during the wettest months of December-February, and also in April, by ~10-20 mm, as compared to the 1990 – 2010 period (low robustness). A slight decrease in average rainfall is projected for November and March of 5-20 mm (low robustness). Rainfall changes during the dry season months of May-October are negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected changes in the wet season months as the spread in the model projections [50-100 mm] is much greater than the amount of change projected (5-20 mm).
- Medium robustness for the projected change during the May-October dry season due to limited evidence for any significant changes in rainfall amounts. The model baseline is in reasonable agreement with the observations during the dry season.

Agreement Assessment:

- Projected annual precipitation change in Malawi -56% to +24% for 2040–2069 as compared to 1971-2000 (Warnatzsch and Reay, 2020). (Medium agreement)
- Projected annual precipitation changes in Malawi for 2046–2050 is -25% to +33% (Arndt et al., 2014). (Medium agreement)
- Projected annual precipitation decrease in Malawi 0-10% for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- September-November projected precipitation change in Malawi -19 to -11 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Low agreement)

- March-May projected precipitation change in Malawi +2 to +17 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Medium agreement)
- December-February projected precipitation change in Malawi +1 to +10 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Medium agreement)
- June-August projected precipitation change in Malawi -37 to -5 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Low agreement)
- December-February projected precipitation change in Malawi 0 to 10% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- June-August projected precipitation change in Malawi 0 to -20% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- November-February <0.1mm/day projected precipitation increase in Malawi for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November total wet-day precipitation change in Malawi of -5 to -15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- December to February total wet-day precipitation change in Malawi of -5 to +5% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- March to May total wet-day precipitation change in Malawi of -15 to +5% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- June to August total wet-day precipitation change in Malawi of -5 to -15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)

Confidence Assessment:

- Low confidence for wet season (low robustness and medium agreement)
- Medium confidence for dry season (medium robustness and medium/low agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (December - April), climate projections for the mid-century show rainfall amounts on very wet days increasing by an average of up to ~17 mm within each month, as compared to the 1990 – 2010 period (low robustness). This corresponds to increases of up to ~45% more rainfall on very wet days. However, the spread across the climate models is large, and some models show decreases in rainfall totals on very wet days. The change in rainfall amounts on very wet days during the May – November dry season is much smaller than during the wet season, and generally less than 1 mm on average (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the December to April rainy season as the spread in the model projections of rainfall on very wet days [~30 - 70 mm] is greater than the median projected change [up to ~17 mm]. This results in a disagreement in the direction of the change for some models. Furthermore, the model baseline is not in strong agreement with the observations during the wet season.
- Medium robustness for the projected change during the May-November dry season due to limited evidence for any significant changes in rainfall amounts. The model baseline is in reasonable agreement with the observations during the dry season.

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in Malawi (defined differently to our study) is < 0.5 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Low agreement)
- November-February projected change in the average intensity on rainy days in Malawi is -1 to +1 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Low-medium agreement)
- November-February projected change in the 99th percentile of daily rainfall amounts in Malawi is +10 to 20 mm for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November change in the contribution of very wet days to the total wet-day precipitation in Malawi of -5 to +15% for 2036-2065, as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- December to February change in the contribution of very wet days to the total wet-day precipitation in Malawi of -5 to +15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- March to May change in the contribution of very wet days to the total wet-day precipitation in Malawi of -5 to +15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- June to August change in the contribution of very wet days to the total wet-day precipitation in Malawi of -15 to +5% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)

Confidence Assessment:

- Low confidence for December to April (low robustness and low agreement)
- Low confidence for May-November (medium robustness and low agreement)

Extreme temperature - number of days with mean temperature greater than 35 °C

- During the hottest months of the year (September-January), climate projection for the mid-century show the number of extremely hot days increasing by an average of 4-7 days within each month, compared to the present-day (1990-2010) (high robustness). This corresponds to at least twice as many extremely hot days per month as the present-day. November is expected to experience both the highest number of extremely hot days in the mid-century (~11) and the largest average increase compared to the present-day (~7).

- The number of extremely hot days in February-August is also expected to increase, leading to 0-1 more extremely hot days per month on average (low robustness).

Robustness Assessment:
- High robustness for the September-January period as all models agree on roughly doubling the number of extremely hot days compared to the present-day.
- Low robustness for February-August because some of the models overlap with the present-day.

Agreement Assessment:
- Projected change in combined heatwaves and droughts in Malawi (defined differently to our study) is 8-10 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:
- High confidence for wet season (high robustness and medium agreement)
- Low confidence for dry season (low robustness and medium agreement)

Extreme wet spells – Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- By mid-century, climate models show changes in the average maximum number of consecutive wet days that are largest at the start of the rainy season, i.e. October-November. In these months, the average maximum number of consecutive wet days has decreased by an average of 1 day each month, as compared to the 1990 – 2010 period (low robustness), i.e. extreme wet spells are projected to be slightly shorter on average in these months. During the other months, the change in the maximum number of consecutive dry days is negligible (medium robustness).

Robustness Assessment:
- Low robustness for the projected change during October-November as the spread in the model projections of the maximum number of consecutive wet days [~2 - 10 days] is greater than the median projected change [~1 day]. This results in a disagreement on an increase or a decrease in the maximum number of consecutive wet days for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the remaining months due to limited evidence for any significant changes.

Agreement Assessment:
- Projected change in combined heatwaves and extreme rainfall in Malawi (defined differently to our study) is < 0.5 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in Malawi is -7 to -10 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)

Confidence Assessment:

- Low confidence for October-November (low robustness and medium agreement)
- Medium confidence for December-September (medium robustness and medium agreement)

Extreme dry spells – Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By mid-century, climate models show changes in the maximum number of consecutive dry days that are largest at the start of the rainy season, i.e. October-November. In these months, the average maximum duration of dry spells has increased by an average of 2-3 days each month, as compared to the 1990 – 2010 period (low robustness), i.e. extreme dry spells are projected to be slightly longer on average in these months. During the main part of the rainy season (December-April) and the May – September dry season, the change in the maximum duration of dry spells is negligible (high robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November as the range in the model projections of the maximum duration of dry spells [~6 – 14 days] is greater than the median projected change [~2 – 3 days]. This results in a disagreement on an increase or a decrease in the maximum number of consecutive dry days for some models between the future scenario projections and the present day.
- High robustness for the projected change during December-April, and May-September due to the similarity between future and present-day model spread.

Agreement Assessment:

- Projected change in combined heatwaves and droughts in Malawi (defined differently to our study) is 8-10 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in Malawi is -7 to -10 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November consecutive dry day change in Malawi of +5 to +10 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (High agreement)
- December to February consecutive dry day change in Malawi of -1 to +1 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (High agreement)
- March to May consecutive dry day change in Malawi of +1 to +5 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- June to August consecutive dry day change in Malawi of +1 to +5 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)

Confidence Assessment:

- High confidence for wet season (high robustness and medium/high agreement)
- Low confidence for dry season (low robustness and medium agreement)

Low climate risk - RCP2.6

Summary statement

By mid-century, climate models show average temperatures warming by roughly 1°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a tendency toward higher rainfall totals during the wettest months (December-February) accompanied by more rainfall on very wet days. There are also slight trends towards longer extreme dry spells and shorter extreme wet spells during October and November. This is consistent with a general shortening of the rainy season across Malawi. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures of ~1°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:

- Medium robustness for the projected change as the spread in the model projections [1-2°C] is greater than the amount of change projected (~1°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:

- Projected annual temperature increase in Malawi 1°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in Malawi 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence (medium robustness and medium agreement)

Average Rainfall

- Climate projections for the mid-century show small increases in the average rainfall amount during the wet months of December-March, of ~10 mm, as compared to the 1990 – 2010 period (low robustness). A slight decrease in average rainfall is projected for October, November, and April of 5-10 mm (low

robustness). Rainfall changes during the dry season months of May-October are negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected changes in the wet season months as the spread in the model projections [50-150mm] is much greater than the amount of change projected (5-10mm).
- Medium robustness for the projected change during the May-October dry season due to limited evidence for any significant changes in rainfall amounts. The model baseline is in reasonable agreement with the observations during the dry season.

Agreement Assessment:

- Little or no projected annual precipitation change in Malawi for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Little or no December-February projected precipitation change in Malawi for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- June-August projected precipitation change in Malawi 0 to -20% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence for wet season (low robustness and medium agreement)
- Medium confidence for dry season (medium robustness and medium agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (December - April), climate projections for the mid-century show rainfall amounts on very wet days have increased by an average of up to ~12 mm in these months, as compared to the 1990 – 2010 period (low robustness). This corresponds to increases of up to 30% more rainfall on very wet days compared to the present-day. However, the spread across the climate models is large, and some models show decreases in rainfall totals on very wet days. The change in rainfall on very wet days during the May – November dry season is much smaller than during the wet season, and generally less than 1 mm on average (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the December to April rainy season as the spread in the model projections of rainfall on very wet days [~30 - 70 mm] is greater than the median projected change [up to ~12 mm]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day. Furthermore, the model baseline is not in strong agreement with the observations during the wet season.
- Medium robustness for the projected change during the May-November dry season due to limited evidence for any significant changes in rainfall amounts.

The model baseline is in reasonable agreement with the observations during the dry season.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in Malawi (defined differently to our study) is < 0.1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence for December to April (low robustness and low/medium agreement)
- Medium confidence for May-November (medium robustness and low/medium agreement)

Extreme temperature – Number of days with mean temperature greater than 35 °C

- During the hottest months of the year (September-January), climate projections for the mid-century show the number of extremely hot days increasing by an average in an average of 0.5-3 days per month, as compared to the present-day (1990-2010) (high robustness). This corresponds to 50-75% more extremely hot days per month than the present-day. November is expected to experience both the highest number of extremely hot days in the mid-century (~7) and the largest average increase compared to the present-day (~3).
- The number of extremely hot days in February-August is also expected to increase, leading to 0-2 more extremely hot days per month on average (low robustness).

Robustness Assessment:

- High robustness for the September-January period as almost all models agree on increases.
- Low robustness for February-August because some of the models overlap with the present-day.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in Malawi (defined differently to our study) is 1-2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- High confidence for wet season (high robustness and low/medium agreement)
- Low confidence for dry season (low robustness and low/medium agreement)

Extreme wet spells – Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- By mid-century, climate models show changes in the average maximum duration of wet spells that are largest at the start of the rainy season, i.e. October-November. In these months, the average maximum duration of wet spells has decreased by roughly 1 day each month, as compared to the 1990 – 2010 period (low robustness), i.e. extreme wet spells are projected to be slightly shorter on average in these months. During the other months, the change in the maximum number of consecutive dry days is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November as the spread in the model projections of the maximum number of consecutive wet days [~2 - 3 days] is greater than the median projected change [~1 day]. This results in a disagreement in an increase or decrease in the maximum number of consecutive wet days for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the remaining months due to limited evidence for any significant changes.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in Malawi (defined differently to our study) is < 0.1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence for October-November (low robustness and low/medium agreement)
- Medium confidence for December-September (medium robustness and low/medium agreement)

Extreme dry spells - Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By mid-century, climate models show changes in the average maximum duration of dry spells that are largest at the start of the rainy season, i.e. October-November. In these months, the average maximum duration of dry spells has increased by 1-2 days each month, as compared to the 1990 – 2010 period (low robustness), i.e. extreme dry spells are projected to be slightly longer on average in these months. During the main part of the rainy season (December-April) and the May – September dry season, the change in the maximum number of consecutive dry days is negligible (high robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November as the spread in the model projections of the maximum number of consecutive dry days [~6 – 11 days] is greater than the median projected change [~1 – 2 days]. This results in a disagreement in an increase or decrease in the maximum

number of consecutive dry days for some models between the future scenario projections and the present day.
- High robustness for the projected change during December-April, and May-September due to the similarity between future and present-day model spread.

Agreement Assessment:
- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in Malawi (defined differently to our study) is 1-2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:
- Low confidence for October-November (low robustness and low/medium agreement)
- Medium confidence for December-April, and May-September (high robustness and low/medium agreement)

South Africa

Present day (representative of the year 2016; maize-growing region of the country only)

Probability of unprecedented high temperatures

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal temperature record of 24.0°C is 4.1%. This is equivalent to an unprecedented high temperature event occurring once in every 24 years (medium robustness).

Robustness Assessment:
- High robustness for the Northeast (NE) maize-growing region as the climate model ensemble used has undergone strict statistical testing and because the uncertainty range of the probability estimate at the 95% confidence interval (1.4%) is less than the estimated probability. Medium robustness for the country as a whole because the model results quoted for the NE maize-growing region will differ to those for the whole country, but the country as a whole failed the statistical tests for the January-March season and so cannot be assessed.

Agreement Assessment:
- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:
- Medium confidence (high robustness and low agreement)

Probability of unprecedented high rainfall

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal rainfall record of 427mm is 1.2%. This is equivalent to an unprecedented high rainfall event occurring once in every 83 years (high robustness).

Robustness Assessment:

- High robustness for the Northeast (NE) maize-growing region as the climate model ensemble used has undergone strict statistical testing and because the uncertainty range of the probability estimate at the 95% confidence interval (0.7%) is less than the estimated probability. Medium robustness for the country as a whole because the model results quoted for the NE maize-growing region will differ to those for the whole country, but the country as a whole failed the statistical tests for the January-March season and so cannot be assessed.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented low rainfall

- During the peak months of the growing season (January-March), the annual probability of subceeding the minimum seasonal rainfall record of 115mm is 1.0%, equivalent to an unprecedented low rainfall event occurring once in every 100 years (high robustness).

Robustness Assessment:

- High robustness for the Northeast (NE) maize-growing region as the climate model ensemble used has undergone strict statistical testing and because the uncertainty range of the probability estimate at the 95% confidence interval (0.7%) is less than the estimated probability. Medium robustness for the country as a whole because the model results quoted for the NE maize-growing region will differ to those for the whole country, but the country as a whole failed the statistical tests for the January-March season and so cannot be assessed.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

High climate risk - RCP8.5 (whole of South Africa)

Summary statement

By mid-century, climate models show average temperatures warming by roughly 2.5°C throughout the year compared to 1990-2010, with a corresponding increase in

the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including the number of days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a tendency toward lower rainfall totals during the wettest months (October-April) accompanied by more rainfall on very wet days, increased rainfall intensity and slight reduction in the number of wet days. There are also slight trends towards longer extreme dry spells and shorter extreme wet spells during the October-April period. This is consistent with a general shortening of the rainy season across South Africa. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- By mid-century, climate models show an increase in average temperatures of ~2.5°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:

- Medium robustness for the projected change as the spread in the model projections [~2°C] is similar to the amount of change projected (~2.5°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:

- Projected annual temperature increase in South Africa 1-3°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in South Africa 1-3°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence (medium robustness and medium/high agreement)

Average Rainfall

- Climate projections for the mid-century show slight decreases in the average rainfall amount during the wet months of October-April, of ~2-10mm, as compared to the 1990 – 2010 period (low robustness). Rainfall changes during the dry season months of May-October are smaller, up to ~5mm (low robustness).

Robustness Assessment:

- Low robustness for the projected changes in all months as the spread in the model projections [5-25mm] is greater than the amount of change projected (2-10mm).

Agreement Assessment:

- Projected annual precipitation decrease in South Africa 0-20% for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- September-November projected precipitation change in South Africa -36 to -3 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Medium agreement)
- March-May projected precipitation change in South Africa -27 to +2 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Medium agreement)
- December-February projected precipitation change in South Africa -14 to +7 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Medium agreement)
- June-August projected precipitation change in South Africa -56 to -7 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Low agreement)
- December-February projected precipitation change in western South Africa 0 to -20% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020).
- December-February projected precipitation change in eastern South Africa 0 to 10% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020).
- June-August projected precipitation change in South Africa 0 to -30% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Low agreement)
- November-February projected precipitation change in South Africa -0.5 to +0.5 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November total wet-day precipitation change in South Africa of -25% to +15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- December to February total wet-day precipitation change in South Africa of -15 to +5% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- March to May total wet-day precipitation change in South Africa of -5 to -25% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- June to August total wet-day precipitation change in South Africa of -5 to -25% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)

Confidence Assessment:

- Low confidence (low robustness and medium agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (October - March), climate projections for the mid-century show rainfall amounts on very wet days that have increased by an average of 0-3 mm each month, as compared to the 1990 – 2010 period (low robustness). This corresponds to an increase of up to ~15% more rain on very wet days. However, the climate models disagree on whether rainfall amounts increase or a decrease, and by how much. The change in average rainfall amounts on very wet days each month during the April – September

season is 0-1 mm on average, and smaller than during the wet part of the year (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the October to March period as the spread in the model projections of rainfall on very wet days [~10 - 20 mm] is greater than the projected change in the median [0 - 3 mm]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the April-September period due to limited evidence for any significant changes in rainfall amounts in April and June-September. However, model projections show that rainfall amounts on very wet days during May are likely to be higher with mid-century climate change (2040-2060) than in the present-day (1990-2010).

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in South Africa (defined differently to our study) is 0-2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the average intensity on rainy days in South Africa is 0 to +2 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (medium agreement)
- November-February projected change in the 99th percentile of daily rainfall amounts in South Africa is -5 to +20 mm for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November change in the contribution of very wet days to the total wet-day precipitation in South Africa of -15 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- December to February change in the contribution of very wet days to the total wet-day precipitation in South Africa of -15 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- March to May change in the contribution of very wet days to the total wet-day precipitation in South Africa of -15 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- June to August change in the contribution of very wet days to the total wet-day precipitation in South Africa of -45 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)

Confidence Assessment:

- Low confidence for October to March (low robustness and low/medium agreement)
- Medium confidence for April-September (medium robustness and low/medium agreement)

Extreme temperature - Number of days with temperature greater than 35 °C

- During the hottest months of the year (October-March), climate projections for the mid-century show the number of extremely hot days increasing by an average of 4-6 days each month, as compared to the present-day (1990-2010)

(high robustness). This corresponds to 100-200% more extremely hot days per month than the present-day. January is expected to experience both the highest number of extremely hot days in the mid-century (~12) and the largest average increase compared to the present-day (~6).

- The number of extremely hot days in April-September is also expected to increase, leading to 0-1 more extremely hot days per month on average (low robustness).

Robustness Assessment:

- High robustness for the October-March period as all models agree on the direction of the increase.
- Medium robustness for April-September because some of the models overlap with the present-day.

Agreement Assessment:

- Projected change in combined heatwaves and droughts in South Africa (defined differently to our study) is 1-14 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- High confidence for wet season (high robustness and medium agreement)
- Medium confidence for dry season (medium robustness and medium agreement)

Extreme wet spells - Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- By mid-century, climate models show changes in the average maximum duration of wet spells that are largest during the wettest part of the year, i.e. October-March. In these months, the average maximum duration of wet spells has decreased by up to ~0.5 days each month, as compared to the 1990 – 2010 period (low robustness), i.e. extreme wet spells are projected to be slightly shorter on average in these months. During the other months, the change in the maximum number of consecutive dry days is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-March as the spread in the model projections of the maximum number of consecutive wet days [~1 - 3 days] is greater than the median projected change [~0.5 day]. This results in a disagreement in an increase or decrease in the maximum number of consecutive wet days for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the remaining months due to limited evidence for any significant changes.

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in South Africa (defined differently to our study) is 0-2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in South Africa is -3 to +3 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)

Confidence Assessment:
- Low confidence for October to March (low robustness and medium agreement)
- Medium confidence for April-September (medium robustness and medium agreement)

Extreme dry spells - Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By mid-century, climate models show increases in the average maximum duration of dry spells by an average of 0.5-2 days each month throughout the year, as compared to the 1990 – 2010 period (low robustness). This means that extreme dry spells are projected to be slightly longer on average throughout the year. The increase is generally largest in August-October (1-2 days each month); however, the climate models disagree on an increase or decrease in the average maximum number of consecutive dry days and by how much.

Robustness Assessment:
- Low robustness for the projected change as the climate models results for the present-day do not show good agreement with historical observations. In addition, the spread in the model projections of the maximum number of consecutive dry days [~2 - 5 days] is greater than the median projected change [~0.5 - 2 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.

Agreement Assessment:
- Projected change in combined heatwaves and droughts in South Africa (defined differently to our study) is 1-14 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in South Africa is -3 to +3 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November consecutive dry day change in South Africa of +5 to +10 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (High agreement)
- December to February consecutive dry day change in South Africa of -1 to +1 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (High agreement)
- March to May consecutive dry day change in South Africa of +1 to +5 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)

- June to August consecutive dry day change in South Africa of +1 to +10 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)

Confidence Assessment:
Medium confidence (low robustness and medium/high agreement)

Low climate risk - RCP2.6 (Whole of South Africa)

Summary statement

By mid-century, climate models show average temperatures warming by roughly 1°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a tendency toward lower rainfall totals during the wettest months (October-April) accompanied by more rainfall on very wet days. There are also slight trends towards longer extreme dry spells and shorter extreme wet spells during the October-April period. This is consistent with a general shortening of the rainy season across South Africa. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures of ~1°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:
- Medium robustness for the projected change as the spread in the model projections [~1-2°C] is similar to the amount of change projected (~1°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:
- Projected annual temperature increase in South Africa 1°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in South Africa 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:
- Medium confidence (medium robustness and medium agreement)

Average Rainfall

- Climate projections for the mid-century show a slight decrease in the average rainfall amount during the wet months of October-February and April, of up to ~5mm, as compared to the 1990 – 2010 period (low robustness). Rainfall changes during the dry season months of May-October are smaller, up to ~2mm (low robustness).

Robustness Assessment:

- Low robustness for the projected changes in all months as the spread in the model projections [10-30mm] is much greater than the amount of change projected (2-5mm).

Agreement Assessment:

- Little or no projected annual precipitation change in South Africa for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- December-February projected precipitation change in eastern South Africa 0 to 10% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020).
- December-February projected precipitation change in western South Africa 0 to -20% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- June-August projected precipitation change in South Africa 0 to -20% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence (low robustness and medium agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (October - March), climate projections for the mid-century show rainfall amounts on very wet days increasing by an average of 0-2 mm within each month, as compared to the 1990 – 2010 period (low robustness). This corresponds to an increase of up to ~10% more rain on very wet days. However, the spread across the climate models is large, and some models show decreases in rainfall totals on very wet days. The change in rainfall amounts on very wet days each month during the April – September season is 0-1 mm on average, and smaller than during the wet part of the year (medium robustness).

Robustness Assessment

- Low robustness for the projected change during the October to March period as the spread in the model projections of rainfall on very wet days [~5 - 15 mm] is greater than the projected change in the median [0 - 2 mm]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the April-September period due to limited evidence for any significant changes in rainfall amounts in April and June-September. However, model projections show that rainfall amounts on very wet days during May are likely to be higher with mid-century climate change (2040-2060) than in the present-day (1990-2010).

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in South Africa (defined differently to our study) is <0.2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence for October to March (low robustness and low/medium agreement)
- Medium confidence for April-September (medium robustness and low/medium agreement)

Extreme temperature - Number of days with mean temperature greater than 35 °C

- During the hottest months of the year (October-March), climate projections for the mid-century show the number of extremely hot days have increased by an average of 1-3 days per month. This corresponds to 30-50% more extremely hot days per month than the present-day (1990-2010) (high robustness). January is expected to experience both the highest number of extremely hot days in the mid-century (~9) and the largest average increase compared to the present-day (~3).
- The number of extremely hot days in April-September is also expected to increase, leading to 0-1 more extremely hot days per month on average (low robustness).

Robustness Assessment:

- High robustness for the October-March period as all models agree on the direction of the increase.
- Medium robustness for April-September because some of the models overlap with the present-day.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in South Africa (defined differently to our study) is 0-4 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence for wet season (high robustness and low/medium agreement)
- Medium confidence for dry season (medium robustness and low/medium agreement)

Extreme wet spells - Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- Mid-century changes in the maximum duration of wet spells are largest during the wettest part of the year, i.e. October-March. In these months, the average maximum duration of wet spells decreases by up to ~0.5 days each month, as compared to the 1990 – 2010 period (low robustness), i.e. extreme wet spells are projected to be slightly shorter on average in these months. During the other months, the change in the maximum number of consecutive dry days is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-March as the spread in the model projections of the maximum number of consecutive wet days [~1 - 2 days] is greater than the median projected change [~0.5 day]. This results in a disagreement in an increase or decrease in the maximum number of consecutive wet days for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the remaining months due to limited evidence for any significant changes.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in South Africa (defined differently to our study) is <0.2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence for October to March (low robustness and low/medium agreement)
- Medium confidence for April-September (medium robustness and low/medium agreement)

Extreme dry spells - Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By mid-century, climate models show an increase in the average maximum duration of dry spells by an average of 0-1 days each month throughout the year, as compared to the 1990 – 2010 period (low robustness), i.e. extreme dry spells are projected to be slightly longer on average in these months. The increase is generally largest in August and April (roughly 1 day each month); however, the climate models disagree on both an increase or decrease in the maximum number of dry days and by how much.

Robustness Assessment:

- Low robustness for the projected change as the climate models results for the present-day do not show good agreement with historical observations. In addition, the spread in the model projections of the maximum number of consecutive dry days [~2 - 3 days] is greater than the median projected change [~0 - 1 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in South Africa (defined differently to our study) is 0-4 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

Low confidence (low robustness and low/medium agreement)

Zambia

Present day (representative of the year 2016)

Probability of unprecedented high temperatures

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal temperature record of 24.7°C is 2.7%. This is equivalent to an unprecedented high temperature event occurring once in every 37 years (high robustness).

Robustness Assessment:

- High robustness as the model ensemble used has undergone strict statistical fidelity testing and because the uncertainty range of the probability estimate at the 95% confidence interval (1.1%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented high rainfall

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal rainfall record of 710mm is 8.5%. This is equivalent to an unprecedented high rainfall event occurring once in every 12 years (high robustness).

Robustness Assessment:

- High robustness as the model ensemble used has undergone strict statistical fidelity testing and because the uncertainty range of the probability estimate at the 95% confidence interval (2.0%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented low rainfall

- During the peak months of the growing season (January-March), the annual probability of subceeding the minimum seasonal rainfall record of 408mm is 3.0%. This is equivalent to an unprecedented low rainfall event occurring once in every 33 years (high robustness).

Robustness Assessment:
- High robustness as the model ensemble used has undergone strict statistical fidelity testing and because the uncertainty range of the probability estimate at the 95% confidence interval (1.3%) is less than the estimated probability.

Agreement Assessment:
- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:
- Medium confidence (high robustness and low agreement)

High climate risk - RCP8.5

Summary statement

By mid-century, climate models show average temperatures warming by roughly 2°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a weak tendency toward lower rainfall totals during the wettest months (December-April) accompanied by more rainfall on very wet days and increased rainfall intensity. There are also slight trends towards longer extreme dry spells around the start and end of the rainy season (October and April) and shorter extreme wet spells during the October-April period. This is consistent with a general shortening of the rainy season across Zambia. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures of ~2°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:

- Medium robustness for the projected change as the spread in the model projections [~2-3°C] is similar to the amount of change projected (~2°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:
- Projected annual temperature increase in Zambia 2-3°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in Zambia 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:
- High confidence (high robustness and medium agreement)

Average Rainfall

- Climate projections for the mid-century show slight increases in the average rainfall amount during the wet months of December-April, of up to ~10mm, as compared to the 1990 – 2010 period (low robustness). Slight decreases in the average rainfall amount of ~10-20mm are projected for October and November. Rainfall changes during the dry season months of May-September are negligible (medium robustness).

Robustness Assessment:
- Low robustness for the projected changes in wet season months as the spread in the model projections [40-70mm] is much greater than the amount of change projected (-20-10mm).
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in rainfall amounts.

Agreement Assessment:
- Projected annual precipitation decrease in Zambia 0-10% for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- September-November projected precipitation change in Zambia -42 to -11 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Medium agreement)
- March-May projected precipitation change in Zambia -27 to +17 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Low agreement)
- December-February projected precipitation change in Zambia -14 to +10 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Low agreement)
- June-August projected precipitation change in Zambia -56 to -5 mm/day for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2009). (Low agreement)
- December-February projected precipitation change in Zambia 0 to 10% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (High agreement)

- June-August projected precipitation change in Zambia 0 to -30% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Low agreement)
- November-February projected precipitation change in Zambia -0.5 to +0.5 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November total wet-day precipitation change in Zambia of -5 to -15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- December to February total wet-day precipitation change in Malawi of +5 to +15% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- March to May total wet-day precipitation change in Malawi of -15 to +5% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- June to August total wet-day precipitation change in Malawi of -35 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)

Confidence Assessment:
- Low confidence for wet season (low robustness and medium agreement)
- Medium confidence for dry season (medium robustness and low agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (October - April), climate projections for the mid-century show an increase in rainfall amounts on very wet days of 0-8 mm per month on average, as compared to the 1990 – 2010 period (low robustness). This corresponds to an increase of up to ~25% more rain on very wet days. However, the spread across the climate models is large, and some models show decreases in rainfall totals on very wet days. an increase or decrease in rainfall and by how much. The change in rainfall on very wet days during the May – September dry season is much smaller than during the wet season, and generally less than 1 mm on average (medium robustness).

Robustness Assessment:
- Low robustness for the projected change during the October to April rainy season as the spread in the model projections of rainfall on very wet days [~40 - 50 mm] is greater than the median projected change [~0 - 8 mm]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in rainfall amounts.

Agreement Assessment:
- Projected change in combined heatwaves and extreme rainfall in Zambia (defined differently to our study) is <0.2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

- November-February projected change in the average intensity on rainy days in Zambia is 0 to -1 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Low-medium agreement)
- November-February projected change in the 99th percentile of daily rainfall amounts in Zambia is +5 to 20 mm for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November change in the contribution of very wet days to the total wet-day precipitation in Zambia of -15 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- December to February change in the contribution of very wet days to the total wet-day precipitation in Zambia of +5 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- March to May change in the contribution of very wet days to the total wet-day precipitation in Zambia of -15 to +35% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)
- June to August change in the contribution of very wet days to the total wet-day precipitation in Zambia of -55 to +55% for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Low agreement)

Confidence Assessment:

- Low confidence for October to April (low robustness and low/medium agreement)
- Medium confidence for May-September (medium robustness and low/medium agreement)

Extreme temperature - Number of days with temperature greater than 35 °C

- During the hottest months of the year (September-April), climate projections for the mid-century show ~2-10 more extremely hot days each month, i.e. roughly twice as many as the present-day (1990-2010) (medium robustness). October is expected to experience both the highest number of extremely hot days in the mid-century (~18) and the largest average increase compared to the present-day (~8).
- The number of extremely hot days in May-August is also expected to increase, leading to 1-3 more extremely hot days per month on average (low robustness).

Robustness Assessment:

- Medium robustness for the September-April period because in all but one month, all models agree on the direction of the change, but disagree on the size of the change.
- Medium robustness for May-August because in all but one month, all models agree on the direction of the change, but disagree on the size of the change.

Agreement Assessment:

- Projected change in combined heatwaves and droughts in Zambia (defined differently to our study) is 4-8 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence for wet season (medium robustness and medium agreement)
- Medium confidence for dry season (medium robustness and medium agreement)

Extreme wet spells - Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- During the wettest part of the year (October - April), climate projections for the mid-century show the average maximum duration of wet spells reducing by ~1-2 days on average each month, as compared to the 1990 – 2010 period (low robustness). This means that extreme wet spells are projected to be slightly shorter on average in these months. However, climate models disagree on an increase or decrease in the maximum number of consecutive wet days and by how much. During the May – September dry season, the mid-century change in the maximum duration of wet spells is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the October to April rainy season as the spread in the model projections for maximum duration of wet spells [~4-6 days] is greater than the projected change in the median [~1-2 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in maximum wet spell duration.

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in Zambia (defined differently to our study) is <0.2 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in Zambia is -1 to -8 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)

Confidence Assessment:

- Low confidence for October to April (low robustness and medium agreement)
- Medium confidence for May-September (medium robustness and medium agreement)

Extreme dry spells - Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By the mid-century, climate models show changes in the maximum duration of dry spells that are largest at the start and end of the rainy season, i.e. October-November and April. In these months, climate change results in the maximum duration of dry spells increasing by an average of 1-2 days each month, as compared to the 1990 – 2010 period (low robustness). This means that extreme

dry spells are projected to be slightly longer on average in these months. During the peak of the rainy season (December-March) and the May – September dry season, the change in the maximum duration of dry spells is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November and April as the spread in the model projections for the maximum duration of dry spells [~4 - 10 days] is greater than the median projected change [~1 - 2 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during December-March, and May-September due to limited evidence for any significant changes.

Agreement Assessment:

- Projected change in combined heatwaves and droughts in Zambia (defined differently to our study) is 4-8 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in Zambia is -1 to -8 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- September to November consecutive dry day change in Zambia of +5 to +10 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (High agreement)
- December to February consecutive dry day change in Zambia of -1 to +1 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (High agreement)
- March to May consecutive dry day change in Zambia of +1 to +5 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)
- June to August consecutive dry day change in Zambia of +1 to +5 days for 2036-2065 as compared to 1976-2005 (de Sousa Pinto, 2015). (Medium agreement)

Confidence Assessment:

- Low confidence for October-November and April (low robustness and medium agreement)
- Medium confidence for December-March, and May-September (medium robustness and medium/high agreement)

Low climate risk - RCP2.6

Summary statement

By mid-century, climate models show average temperatures warming by roughly 1-2°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased

occurrence and frequency of temperature extremes, including days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a weak tendency toward lower rainfall totals during the wettest months (December-April) accompanied by more rainfall on very wet days. There are also slight trends towards longer extreme dry spells around the start and end of the rainy season (October and April) and shorter extreme wet spells during the October-April period. This is consistent with a general shortening of the rainy season across Zambia. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures of ~1-2°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:

- Medium robustness for the projected change as the spread in the model projections [~1.5-2°C] is similar to the amount of change projected (1-2°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:

- Projected annual temperature increase in Malawi 1°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in Zambia 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence (medium robustness and medium agreement)

Average Rainfall

- Climate projections for the mid-century show slight increases in the average rainfall amount during the wet months of December-April, of up to ~10mm, as compared to the 1990 – 2010 period (low robustness). Slight decreases in the average rainfall amount of ~10-20mm are projected for October and November. Rainfall changes during the dry season months of May-September are negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected changes in wet season months as the spread in the model projections [30-60mm] is much greater than the amount of change projected (-20-10mm).
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in rainfall amounts.

Agreement Assessment:

- Little or no projected annual precipitation change in Zambia for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- December-February projected precipitation change in Zambia -10 to 10% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- June-August projected precipitation change in Zambia 0 to -30% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Low agreement)

Confidence Assessment:

- Low confidence for wet season (low robustness and medium agreement)
- Medium confidence for dry season (medium robustness and medium agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (October - April), climate projections for the mid-century show an increase in rainfall amounts on very wet days of 0-5 mm each month, as compared to the 1990 – 2010 period (low robustness). This corresponds to an increase of up to ~20% more rain on very wet days. However, the spread across the climate models is large, and some models show decreases in rainfall totals on very wet days. The change in rainfall on very wet days during the May – September dry season is much smaller than during the wet season, and generally less than 1 mm on average (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the October to April rainy season as the spread in the model projections of rainfall on very wet days [~5 - 30 mm] is greater than the median projected change [~0-5 mm]. This results in a disagreement in the sign of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in rainfall amounts.

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in Zambia (defined differently to our study) is <0.1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Low agreement)

Confidence Assessment:

- Low confidence for October to April (low robustness and low agreement)
- Medium confidence for May-September (medium robustness and low agreement)

Extreme temperature - Number of days with temperature greater than 35 °C

- During the hottest months of the year (September-April), climate projections for the mid-century show the number of extremely hot days increasing by an average of 1-5 days per month. This corresponds to 50-100% more extremely hot days per month than in the present-day (1990-2010) (high robustness). October is expected to experience both the highest number of extremely hot days in the mid-century (~13) and the largest average increase compared to the present-day (~5).
- The number of extremely hot days in May-August is also expected to increase, leading to 0-1 more extremely hot days per month on average (low robustness).

Robustness Assessment

- Medium robustness for the September-April period because in all but one month, all models agree on the direction of the change, but disagree on the size of the change.
- Medium robustness for May-August because in all but one month, all models agree on the direction of the change, but disagree on the size of the change.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in Zambia (defined differently to our study) is 0-4 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence for wet season (medium robustness and low/medium agreement)
- Medium confidence for dry season (medium robustness and low/medium agreement)

Extreme wet spells - Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- During the wettest part of the year (October - April), climate projections for the mid-century show the maximum duration of wet spells reducing by ~0-1 days on average each month, as compared to the 1990 – 2010 period (low robustness). This means that extreme wet spells are projected to be slightly shorter on average in these months. However, climate models disagree on an increase or decrease in the maximum number of consecutive wet days and by how much. During the May – September dry season, the mid-century change in the maximum duration of wet spells is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the October to April rainy season as the spread in the model projections for maximum duration of wet spells [~2-5 days] is greater than the projected change in the median [~0-1 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.

- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in maximum wet spell duration.

Agreement Assessment:
- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in Zambia (defined differently to our study) is <0.1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Low agreement)

Confidence Assessment:
- Low confidence for October to April (low robustness and low agreement)
- Medium confidence for May-September (medium robustness and low agreement)

Extreme dry spells - Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By mid-century, climate projections show changes in the maximum duration of dry spells that are largest at the start and end of the rainy season, i.e. October-November and April. In these months, climate change results in the maximum duration of dry spells increasing by an average of 1-2 days each month, as compared to the 1990 – 2010 period (low robustness). This means that extreme dry spells are projected to be slightly longer on average in these months. During the peak of the rainy season (December-March) and the May – September dry season, the change in the maximum duration of dry spells is negligible (medium robustness).

Robustness Assessment:
- Low robustness for the projected change during October-November and April as the spread in the model projections for the maximum duration of dry spells [~3 - 6 days] is greater than the median projected change [~1 - 2 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during December-March, and May-September due to limited evidence for any significant changes.

Agreement Assessment:
- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in Zambia (defined differently to our study) is 0-4 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:
- Low confidence for October-November and April (low robustness and low/medium agreement)
- Medium confidence for December-March (medium robustness and low/medium agreement)

Tanzania

Present day (representative of the year 2016)

Probability of unprecedented high temperatures

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal temperature record of 24.6°C is 3.6%, equivalent to an unprecedented high temperature event occurring once in every 28 years (high robustness).

Robustness Assessment:

- High robustness as the model ensemble used has undergone strict statistical fidelity testing and because the uncertainty range of the probability estimate at the 95% confidence interval (1.3%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented high rainfall

- During the peak months of the growing season (January-March), the annual probability of exceeding the maximum seasonal rainfall record of 604mm is 1.2%, equivalent to an unprecedented high rainfall event occurring once in every 83 years (high robustness).

Robustness Assessment:

- High robustness as the model ensemble used has undergone strict statistical fidelity testing and because the uncertainty range of the probability estimate at the 95% confidence interval (0.8%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

Probability of unprecedented low rainfall

- During the peak months of the growing season (January-March), the annual probability of subceeding the minimum seasonal rainfall record of 342mm is 5.3%, equivalent to an unprecedented low rainfall event occurring once in every 19 years (high robustness).

Robustness Assessment:

- High robustness as the model ensemble used has undergone strict statistical fidelity testing and because the uncertainty range of the probability estimate at the 95% confidence interval (1.6%) is less than the estimated probability.

Agreement Assessment:

- There are no equivalent studies to compare to. (Low agreement)

Confidence Assessment:

- Medium confidence (high robustness and low agreement)

High climate risk - RCP8.5

By mid-century, climate models show average temperatures warming by roughly 2°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including the number of days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a tendency toward higher rainfall totals during the wet months of December-April, accompanied by more rainfall on very wet days, increased rainfall intensity and a reduction in the number of rainy days. There are also slight trends towards longer extreme dry spells and shorter extreme wet spells around the start and end of the wet season (i.e. October and April). This is consistent with a shortening of the wet season across much of the country. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures of ~2°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:

- Medium robustness for the projected change as the spread in the model projections [~1-1.5°C] is similar to the amount of change projected (2°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:

- Projected annual temperature increase in Tanzania 2.5°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual, December-February and June-August temperature increase in Tanzania 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence (medium robustness and medium agreement)

Average Rainfall

- Climate projections for the mid-century show slight increases in the average rainfall amount during the wet months of December-April, of up to ~10mm, as compared to the 1990 – 2010 period (low robustness). Slight decreases in the average rainfall amount of ~10mm are projected for October, November and May. Rainfall changes during the dry season months of June-September are negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected changes in wet season months as the spread in the model projections [30-70mm] is much greater than the amount of change projected (10mm).
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in rainfall amounts.

Agreement Assessment:

- Projected annual precipitation increase in Tanzania 0-10% for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- November-April projected precipitation change in Tanzania +3 to +14 % for 2051–2200 as compared to 1901–2000 (Shongwe et al., 2011). (High agreement)
- December-February projected precipitation change in Tanzania 0 to 30% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- June-August projected precipitation change in Tanzania -10 to 20% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- November-February projected precipitation increase in Tanzania 0.5-2 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)

Confidence Assessment:

- Low confidence for wet season (low robustness and medium agreement)
- Medium confidence for dry season (medium robustness and medium agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (November - May), climate projections for the mid-century show an increase in average rainfall amounts on very wet days of 0-15 mm on average, as compared to the 1990 – 2010 period (low robustness). The projected increase in rainfall on very wet days is greatest during December – April; however, climate models disagree on an increase or decrease in rainfall and by how much. The change in rainfall on very wet days during the June – October dry season is much smaller than during the wet season, and generally less than 1 mm (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the November to May rainy season as the spread in the model projections of rainfall on very wet days [~30 - 80 mm] is greater than the projected change in average rainfall amounts on very wet days [~0-15mm]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the June – October dry season due to limited evidence for any significant changes in rainfall amounts

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in Tanzania (defined differently to our study) is 0-1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Low agreement)
- November-February projected change in the average intensity on rainy days in Tanzania is 0 to +1 mm/day for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)
- November-February projected change in the 99th percentile of daily rainfall amounts in Tanzania is +5 to 15 mm for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Medium agreement)

Confidence Assessment:

- Low confidence for November to May (low robustness and low agreement)
- Medium confidence for June to October (medium robustness and low agreement)

Extreme temperature - Number of days with temperatures greater than 35 °C

- During the hottest months of the year (October-March), climate projections for the mid-century show an average of 2-5 more extremely hot days each month, as compared to the present-day (1990-2010) (high robustness), i.e. roughly twice as many extremely hot days. The number of extremely hot days in April-September is also to expected increase, leading to 0-1 more extremely hot days per month (low robustness).

Robustness Assessment:

- High robustness for the October-March period as all models agree on increases of at least a doubling, and there is no overlap between future and present-day spread in the models.
- Low robustness for April-September because some of the models for the future overlap with the present-day.

Agreement Assessment:

- Projected change in combined heatwaves and droughts in Tanzania (defined differently to our study) is 4-16 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- High confidence for wet season (high robustness and medium agreement)
- Low confidence for dry season (low robustness and medium agreement)

Extreme wet spells - Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- By mid-century, climate projections show changes in the duration of the longest wet spells that are largest at the start and end of the rainy season, i.e. October-November, and April-May. In these months, the longest wet spells are projected to shorten by an average of 0-1 days each month, as compared to the 1990 – 2010 period (low robustness). During the main part of the rainy season (December-March) and the May – September dry season, any changes are negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November and April-May as the spread in the model projections for the duration of the longest wet spells [~5 - 8 days] is greater than the median projected change [~0 - 1 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during December-March, and May-September due to limited evidence for any significant changes.

Agreement Assessment:

- Projected change in combined heatwaves and extreme rainfall in Tanzania (defined differently to our study) is 0-1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in Tanzania is -10 to +10 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Low-medium agreement)

Confidence Assessment:

- Low confidence for October-November and April-May (low robustness and medium agreement)
- Medium confidence for December-March, and May-September (medium robustness and medium agreement)

Extreme dry spells - Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- By mid-century, climate projections show changes in the maximum duration of dry spells that are greatest at the start of the rainy season, i.e. October-November. In these months, the maximum duration of dry spells is projected to lengthen by an average of 0-1 days each month, as compared to the 1990 – 2010 period (low robustness). During the main part of the rainy season (December-April) and the May – September dry season, the change in the duration of the longest dry spells is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November as the spread in the model projections for the duration of the longest dry spells [~2 - 4

days] is greater than the median projected change [~0 - 1 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during December-March, and May-September due to limited evidence for any significant changes.

Agreement Assessment:
- Projected change in combined heatwaves and droughts in Tanzania (defined differently to our study) is 4-16 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)
- November-February projected change in the number of rainy days in Tanzania is -10 to +10 days for 2040–2069 as compared to 1970–1999 (Pohl et al., 2017). (Low-medium agreement)

Confidence Assessment:
- Low confidence for October-November (low robustness and medium agreement)
- Medium confidence for December-March, and May-September (medium robustness and medium agreement)

Low climate risk - RCP2.6

By mid-century, climate models show average temperatures warming by roughly 1°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including the number of days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a tendency toward higher rainfall totals during the wet months of December-April, accompanied by more rainfall on very wet days, increased rainfall intensity and a reduction in the number of rainy days. There are also slight trends towards longer extreme dry spells and shorter extreme wet spells around the start and end of the wet season (i.e. October and April). This is consistent with a shortening of the wet season across much of the country. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Average Temperature

- Climate projections for the mid-century show an increase in average temperatures of ~1°C in every month, as compared to the 1990 – 2010 period (medium robustness).

Robustness Assessment:
- Medium robustness for the projected change as the spread in the model projections [~1-2°C] is similar to the amount of change projected (1°C). The model baseline is in strong agreement with the observations.

Agreement Assessment:

- Projected annual temperature increase in Tanzania 1°C for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- Projected annual and December-February temperature increase in Tanzania 0.5-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)
- Projected June-August temperature increase in Tanzania 1-2°C for 2030–2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:
- Medium confidence (medium robustness and medium agreement)

Average Rainfall

- Climate projections for the mid-century show slight increases in the average rainfall amount during the wet months of December-May, of up to ~10mm, as compared to the 1990 – 2010 period (low robustness). Slight decreases in the average rainfall amount of ~10mm are projected for October and November. Rainfall changes during the dry season months of June-September are negligible (medium robustness).

Robustness Assessment:
- Low robustness for the projected changes in wet season months as the spread in the model projections [30-80mm] is much greater than the amount of change projected (10mm).
- Medium robustness for the projected change during the May-September dry season due to limited evidence for any significant changes in rainfall amounts.

Agreement Assessment:
- Little or no projected annual precipitation change in Tanzania for 2040–2069 as compared to 1986-2005 (Niang et al., 2014). (Medium agreement)
- December-February projected precipitation change in Tanzania for 0 to 10% 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (High agreement)
- June-August projected precipitation change in Tanzania -10 to 10% for 2030-2059 as compared to 1981-2010 (Almazroui et al., 2020). (Medium agreement)

Confidence Assessment:
- Low confidence for wet season (low robustness and high agreement)
- Medium confidence for dry season (medium robustness and medium agreement)

Extreme rainfall - Total rainfall on the wettest 5% of days

- During the wettest part of the year (November - May), climate projections for the mid-century show rainfall amounts on very wet days increasing by an average of 0-5 mm, as compared to the 1990 – 2010 period (low robustness). This corresponds to an increase of up to ~25% more rain on very wet days.

However, the spread across the climate models is large, and some models show decreases in rainfall totals on very wet days. The change in rainfall on very wet days during the June – October dry season is much smaller than during the wet season, and generally less than 1 mm on average (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during the November to May rainy season as the spread in the model projections of rainfall amounts on very wet days [~10-70 mm] is greater than the median projected change [~0-5 mm]. This results in a disagreement in the sign of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during the June to October dry season due to limited evidence for any significant changes in rainfall amounts

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in Tanzania (defined differently to our study) is <0.1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Low agreement)

Confidence Assessment:

- Low confidence for November to May (low robustness and low agreement)
- Low confidence for June to October (medium robustness and low agreement)

Extreme temperature – Number of days with temperature greater than 35 °C

- During the hottest months of the year (October-March), climate projections for the mid-century show the number of extremely hot days increasing by an average of 1-2 days per month, as compared to the present-day (1990-2010) (high robustness). This corresponds to roughly twice as many extremely hot days per month. November is expected to experience both the highest number of extremely hot days in the mid-century (~4) and the largest average increase compared to the present-day (~2).
- The number of extremely hot days in May-August is also expected to increase, leading to 0-1 more extremely hot days per month on average (low robustness).

Robustness Assessment:

- Medium robustness for the October-March period as most models agree on the direction of the change but disagree on how large the changes are.
- Low robustness for April-September because most of the climate models overlap with the present-day range.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in Tanzania (defined differently to our study) is 0-6 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Medium confidence for wet season (medium robustness and low/medium agreement)
- Low confidence for dry season (low robustness and low/medium agreement)

Extreme wet spells – Average maximum number of consecutive wet days (daily rainfall > 1 mm)

- Climate projections for the mid-century show changes in the duration of the longest wet spells that are largest at the start and end of the rainy season, i.e. October-November, and April-May. In these months, the longest wet spells are projected to shorten by an average of 0-0.5 days each month, as compared to the 1990 – 2010 period (low robustness). During the main part of the rainy season (December-March) and the May – September dry season, any changes are negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November and April-May as the spread in the model projections for the duration of the longest wet spells [~1 - 5 days] is greater than the median projected change [~0 – 0.5 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during December-March, and May-September due to limited evidence for any significant changes.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and extreme rainfall in Tanzania (defined differently to our study) is <0.1 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Low agreement)

Confidence Assessment:

- Low confidence for November to May (low robustness and low agreement)
- Low confidence for June to October (medium robustness and low agreement)

Extreme dry spells – Average maximum number of consecutive dry days (daily rainfall < 1 mm)

- Climate projections for the mid-century show changes in the maximum duration of dry spells that are greatest at the start of the rainy season, i.e. October-November. In these months, the maximum duration of dry spells is projected to lengthen by an average of 0-1 days each month, as compared to the 1990 – 2010 period (low robustness). During the main part of the rainy season (December-April) and the May – September dry season, the change in the duration of the longest dry spells is negligible (medium robustness).

Robustness Assessment:

- Low robustness for the projected change during October-November as the spread in the model projections for the duration of the longest dry spells [~2 - 4 days] is greater than the median projected change [~0 - 1 days]. This results in a disagreement in the direction of the change for some models between the future scenario projections and the present day.
- Medium robustness for the projected change during December-March, and May-September due to limited evidence for any significant changes.

Agreement Assessment:

- No suitable studies available for direct comparison (Low agreement)
- Projected change in combined heatwaves and droughts in Tanzania (defined differently to our study) is 0-6 days per year for 2070–2099 as compared to 1981-2010 (Weber et al., 2020). (Medium agreement)

Confidence Assessment:

- Low confidence for October-November (low robustness and low/medium agreement)
- Low confidence for December-March, and May-September (medium robustness and low/medium agreement)

Appendix 1

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