Assessment of Climatic Impact Drivers in Ethiopia

Focus Regions: Afar; Amhara; Oromia; Southern Nations, Nationalities, and Peoples’ Region (SNNP) and Tigray

This assessment describes seven important climatic impact drivers for Ethiopia, with a special focus on the regions Afar; Amhara; Oromia; Southern Nations, Nationalities, And Peoples´ Region (SNNP) and Tigray. It shows how the climatic impact drivers are projected to change under two climate change trajectories in the future (2030, 2050 and 2080). The presented drivers are mean temperature, mean precipitation, precipitation cycle, very hot days, heavy precipitation frequency and intensity as well as extremely dry months. For further guidance and background information about the figures and analyses presented here kindly refer to the supplemental information on how to read the assessment of climatic impact drivers.

Ethiopia is a country of very heterogenous topography and consequently a very diverse climate. Therefore, also the climate risk projections show distinctive regional differences for the future climate of Ethiopia.

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Mean Temperature

The average temperature in Ethiopia varies strongly across regions (Figure 1). This is determined by the country's heterogenous topography. The highlands of Oromia and Amhara show the coldest mean temperatures, while the warmest areas are in Afar, in the Northeast of the country. The model projections show a very likely future warming in all of Ethiopia. By **2030**, the projected warming under both RCPs, 2.6 and 7.0, ranges between 0.6 and 1°C. By **2050**, the projections diverge. Under no mitigation (RCP 7.0), the daily mean temperature rises by more than 1.5°C in all observed regions of Ethiopia and under the mitigation scenario (RCP2.6), temperature rise is less than 1.5°C in all regions. By **2080**, the temperature rises less than 2°C under RCP2.6, while under the high emission scenario of RCP7.0, the temperature increases by up to 3.6°C in the west. Generally, there is a strong model agreement on warming in all regions, only the degree of warming differs across scenarios.

Figure 2 shows the projected temperature time series for individual regions for the model ensemble. The model ensemble spread varies across the different regions. For example, in the Southern Nations, Nationalities, and Peoples´ region (SNNP) the spread and therefore the uncertainty in the warming intensity is small (around 1.5°C) and comparatively large in Afar (around 3°C). The model median shows weakest warming in SNNP (~2.9°) and strongest in Amhara (~3.3°) under RCP7.0.

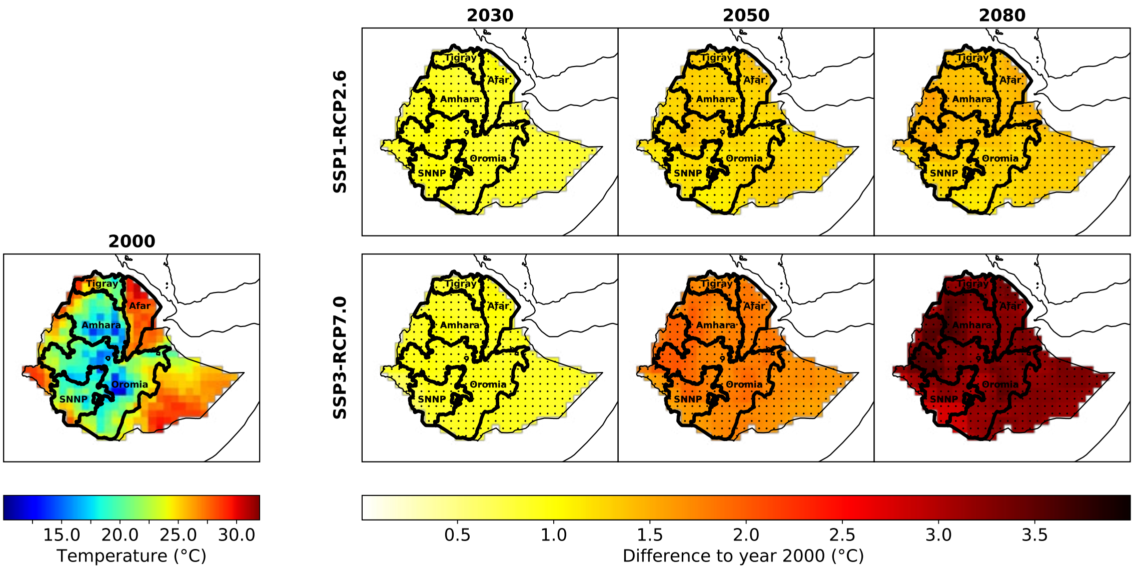

Figure 1: Projected change of mean temperature across Ethiopia in 2030, 2050 and 2050 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change in this location.

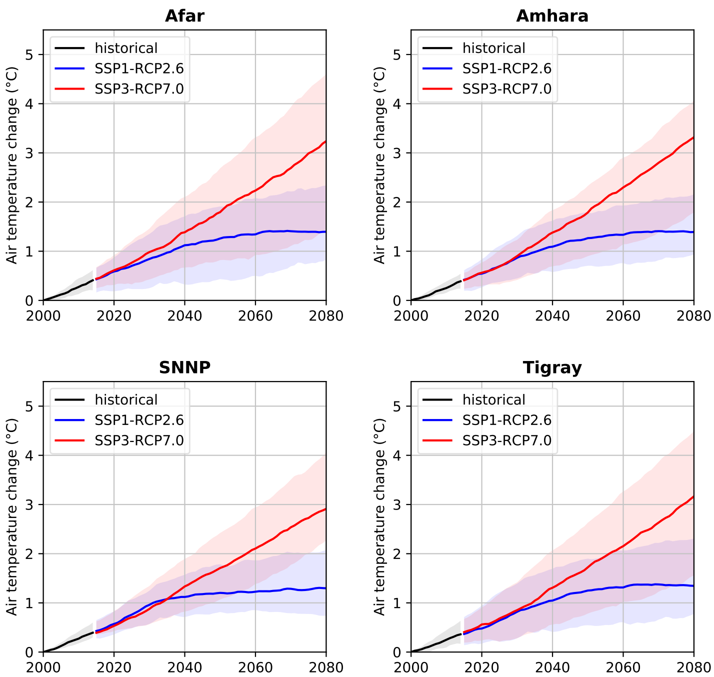

Figure 2: Projected temperature time series (difference to 2000) of the focus regions in Ethiopia for the model medians (lines) and range of the model projections (shading) under two future trajectories.

Mean Precipitation

Precipitation levels greatly vary across Ethiopia, which is mostly determined by the topography of the region (Figure 3). The highest precipitation rates (up to almost 2000 mm/year) are found on the western slopes of the highlands in Oromia, SNNP and Amhara. The driest regions are in the Eastern regions. Annual mean precipitation is projected to increase all over Ethiopia. By 2030 and 2050, there is a similar increase under both RCPs, with the strongest relative increase in the Afar region. By 2080, the no-mitigation scenario RCP7.0 shows a stronger wetting than RCP2.6. Maximum precipitation increases of up to 80% is found in the Northeast of Ethiopia (in parts of Afar). Results are robust on wetting trends in Northern Ethiopia and the Southeast, as dots mean at least 9 out of 10 models agree on the wetting trend.

Figure 4 shows the time series of projected annual precipitation. As already seen in Figure 3, all regions show a stronger wetting trend under the no-mitigation scenario RCP7.0. However, there are striking regional differences. The weakest wetting trend can be observed in Oromia and SNNP and the strongest relative wetting trend in Afar – which shows an increase by 40% in 2080. Generally, the trajectories of RCPs diverge after 2050. SNNP shows the weakest relative trend, but projections are uncertain. In comparison, Amhara, shows a clear wetting trend with the smallest model spread. None of the models show a strong decrease in precipitation within the 21st century.

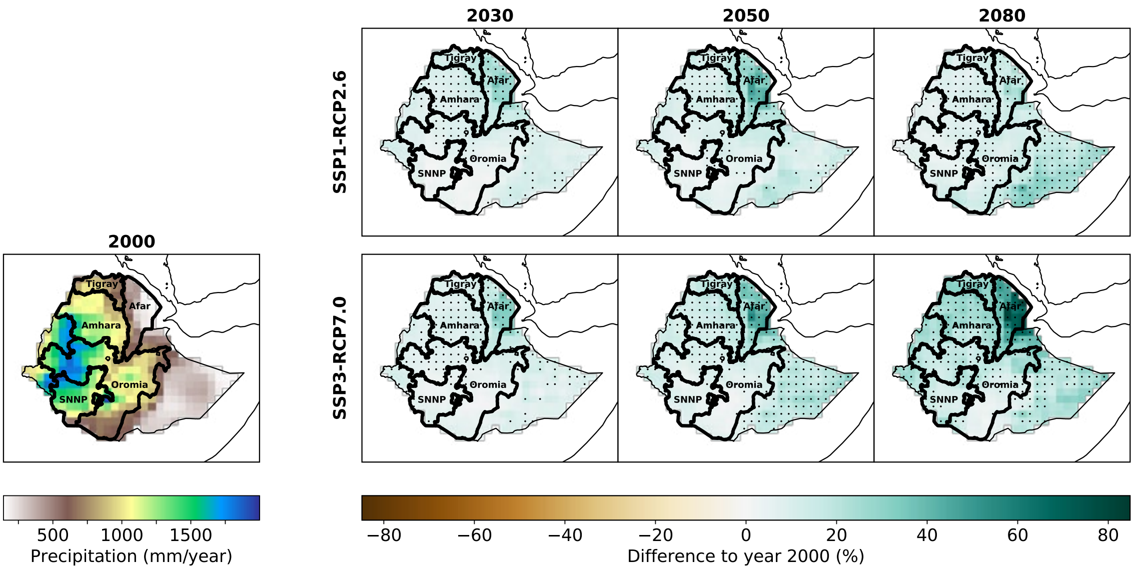

Figure 3: Projected changes of annual precipitation sums across Ethiopia in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

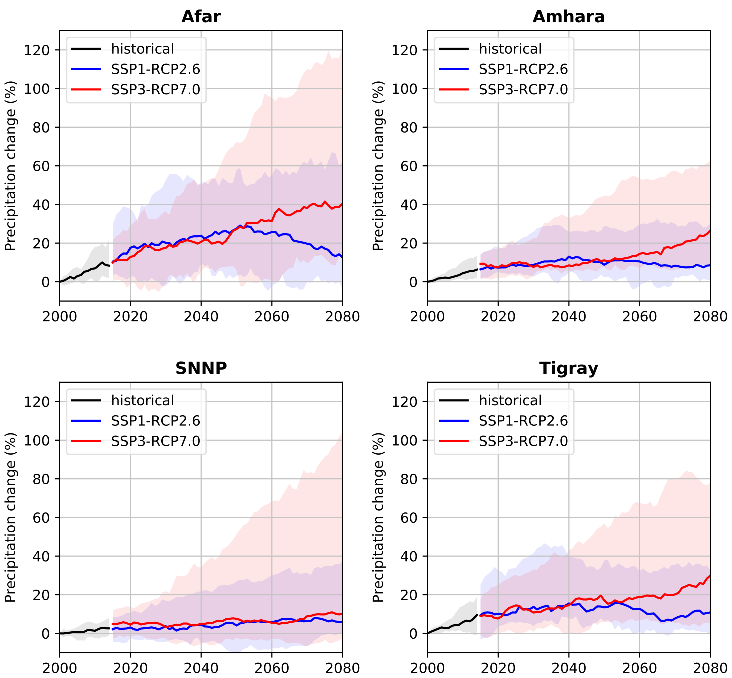

Figure 4: Projected precipitation time series of the focus regions in Ethiopia for the model medians (lines) and range of the model projections (shading) under two future trajectories.

Precipitation Cycle

Afar, Amhara and Tigray show the largest precipitation increase during rainy seasons, while Oromia and SNNP show a more even increase throughout the year. Generally, the largest model spread can be observed during rainy season (see Figure 5). Nevertheless, the projections do not indicate a shift of the rainy seasons.

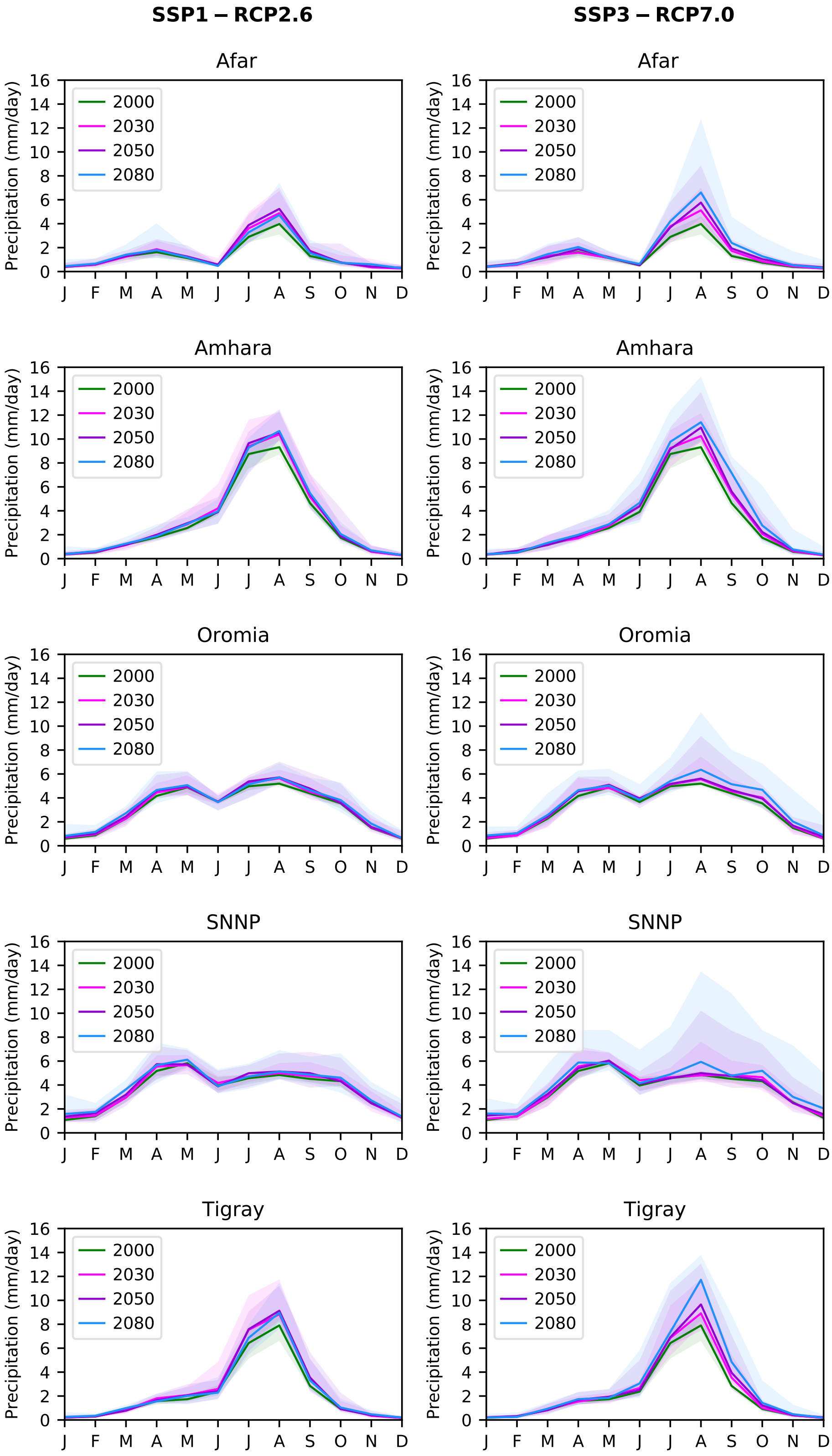

Figure 5: Projected monthly mean precipitation rates for the focus regions in Ethiopia, shown as the model medians (lines) and range of the model projections (shading) under two future trajectories.

Very hot days

In Ethiopia, very hot days are only found in low-altitude areas. In the historical period, most very hot days are found in the Western regions of Tigray and in Afar (see Figure 6). The maximum of 277 very hot days per year are in West Tigray, which means that most of the year is already considered very hot. The projections show a similar increase of very hot days for both RCPs across the country by 2030. The maximum increase of 70 days is projected to happen in the Southeast of Ethiopia. By 2050, the trajectories diverge. In 2080, a strong increase of very hot days can be observed, while under the no-mitigation scenario, the development stabilizes and almost no further increase is projected. The strongest increase of almost 200 very hot days is projected for the Southeast of Ethiopia, but also parts of Afar and the very East of Ethiopia show increases beyond 100 days per year. Generally, the climate models show a strong agreement on the increase in very hot days.

The analysis for the target regions shows even more clearly the strong average increase in Afar (~100 days by 2080) and Tigray (~60 days by 2080). The average absolute increase in hot days in Amhara, Oromia and SNNP is comparably low, as there are large areas without hot days in the present and future (see Figure 7).

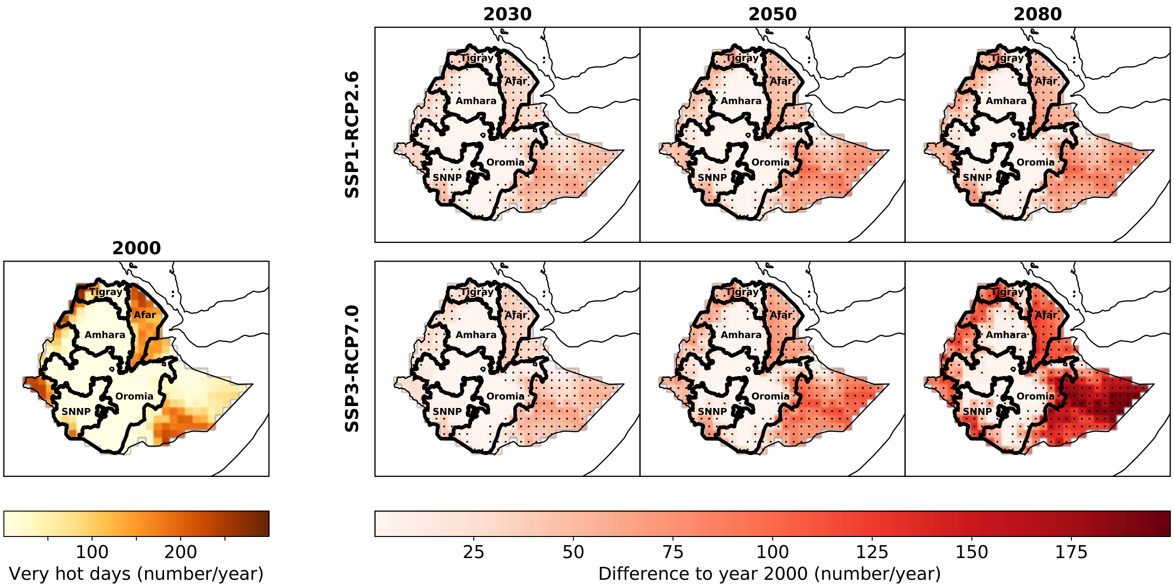

Figure 6: Projected changes in the number of very hot days across Ethiopia in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

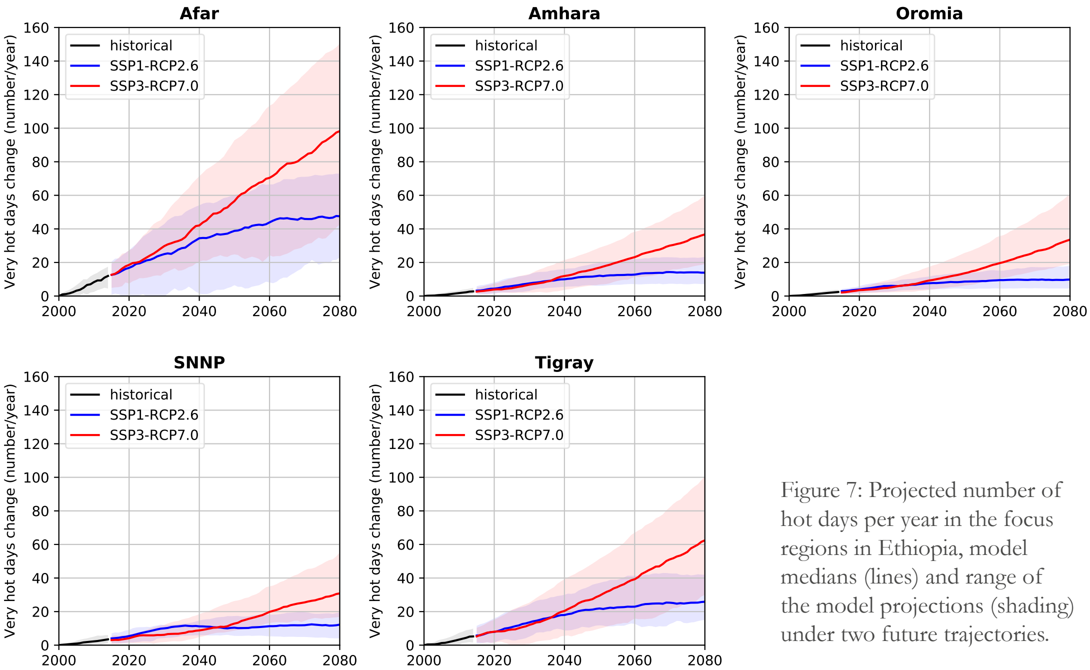

Figure 7: Projected number of hot days per year in the focus regions in Ethiopia, model medians (lines) and range of the model projections (shading) under two future trajectories.

Heavy precipitation frequency

Overall, there is an increase of heavy precipitation events projected in most of Ethiopia under both RCP scenarios (see Figure 8). By 2030, there are less than three more days per year under mitigation and no-mitigation in all of Ethiopia. By 2050, there is only a weak further increase. In 2080, the increase in heavy precipitation days stabilizes under mitigation, while there is a sharp increase under RCP7.0 of up to 8 days per year. The strongest increase is projected to happen in parts of SNNP and Oromia. The models show a strong agreement in the north-western half of the country (see Figure 8).

Regarding the regional averages in the target regions, the strongest increase is found in Amhara (almost 5 days per year by 2080 under RCP7.0). Amhara also has the smallest model spread. The strongest model spread occurs in SNNP. All models show a neutral or positive trend for all regions, enhancing the confidence in the positive trend. A clear divergence of trajectories occurs only after 2050 (see Figure 9).

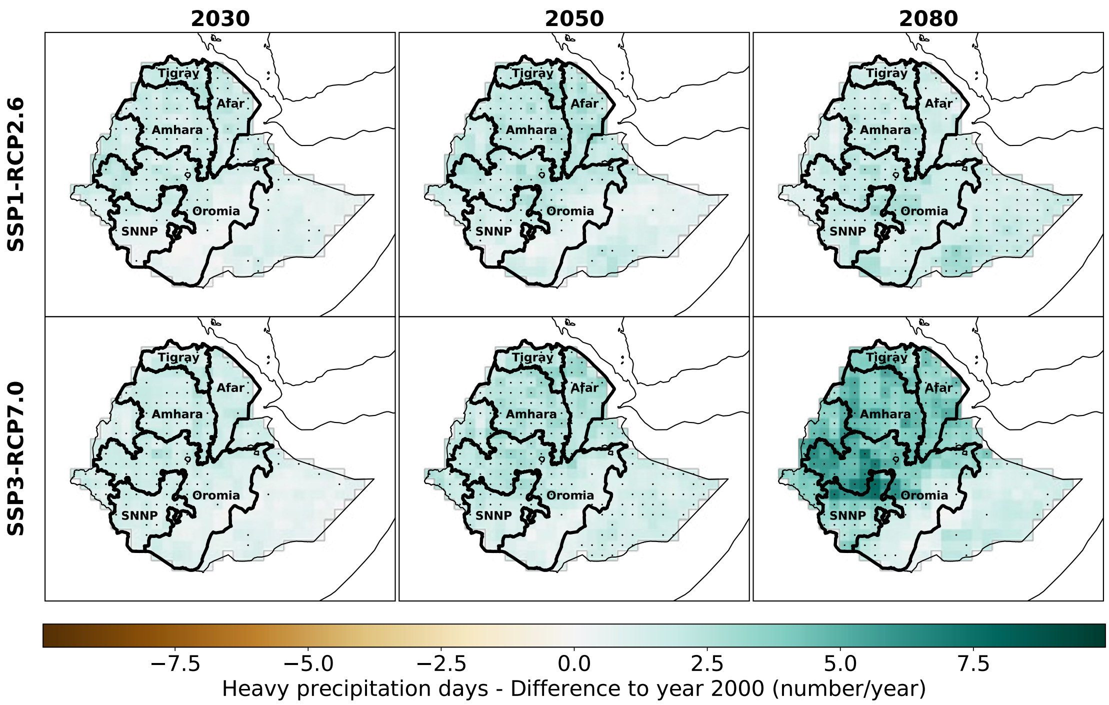

Figure 8: Projected changes in heavy precipitation events across Ethiopia in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

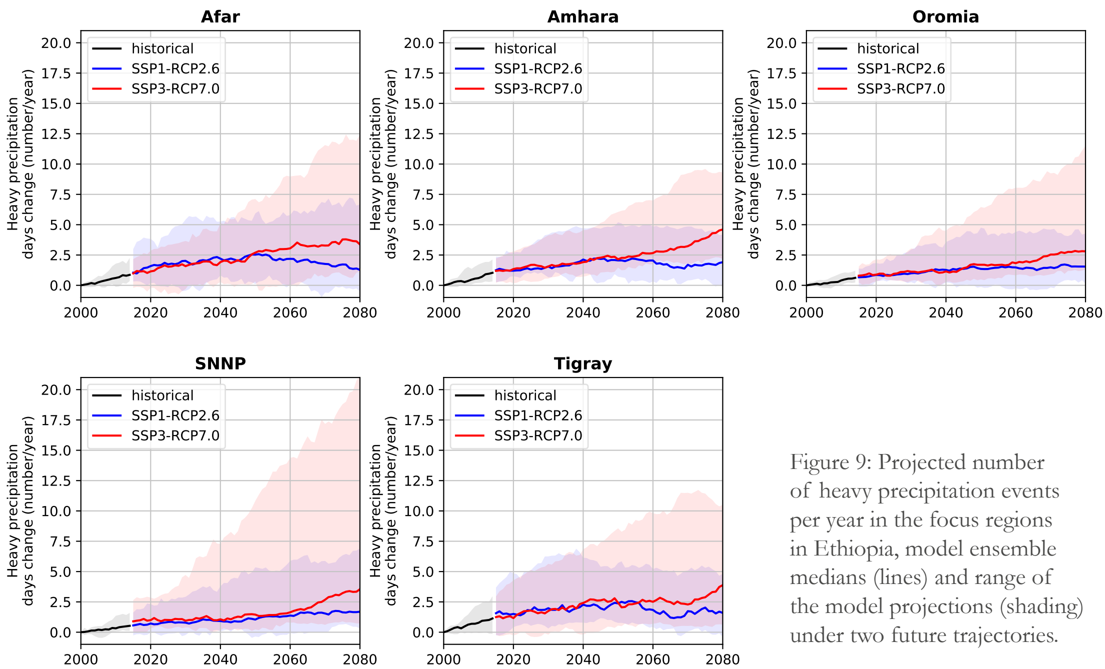

Figure 9: Projected number of heavy precipitation events per year in the focus regions in Ethiopia, model ensemble medians (lines) and range of the model projections (shading) under two future trajectories.

Heavy precipitation intensity

In the historical period (around 2000) the heavy precipitation intensity follows similar patterns as the precipitation mean indicator (see left picture in Figure 10). Therefore, the lowest intensities are found in the lowlands of Afar with values between 5 and 13 mm/day, while in the highlands of Western Amhara and North-Western Oromia the precipitation intensity is up to 35 mm/day.

The projections into the year 2030 show a precipitation intensity change between 0 and 33% throughout Ethiopia and for both RCPs. In 2030, the projections already diverge, being slightly higher for the mitigation RCP than for the no mitigation scenario. By 2050, the trajectories diverge further, showing a stronger increase for the no-mitigation scenario. Under RCP2.6 the intensity increases until around 2050, and then reduces again in the far future. Under RCP7.0, there is a continuous increase with a maximum change in the very Northeast of Ethiopia of up to 60%.

Like all precipitation indicators, there are distinct regional differences in the model range (see Figure 11). The smallest change under RCP 7.0 is projected for Oromia (12% by 2080), the strongest change is projected for Afar (30% by 2080). Also, the model spread varies regionally. There is a wide model spread in SSNP and Afar, showing the climate models agree less on the amplitude of the change in these regions. For example, one climate model shows an increase of ~10%, another model an increase of ~100% for Afar by 2080 under RCP 7.0. In contrast, there is a clear positive trend with a small model range in Amhara. Here, the weakest model projection results in 8% increase by 2080 under RCP7.0 and the strongest model projection an increase of 31%.

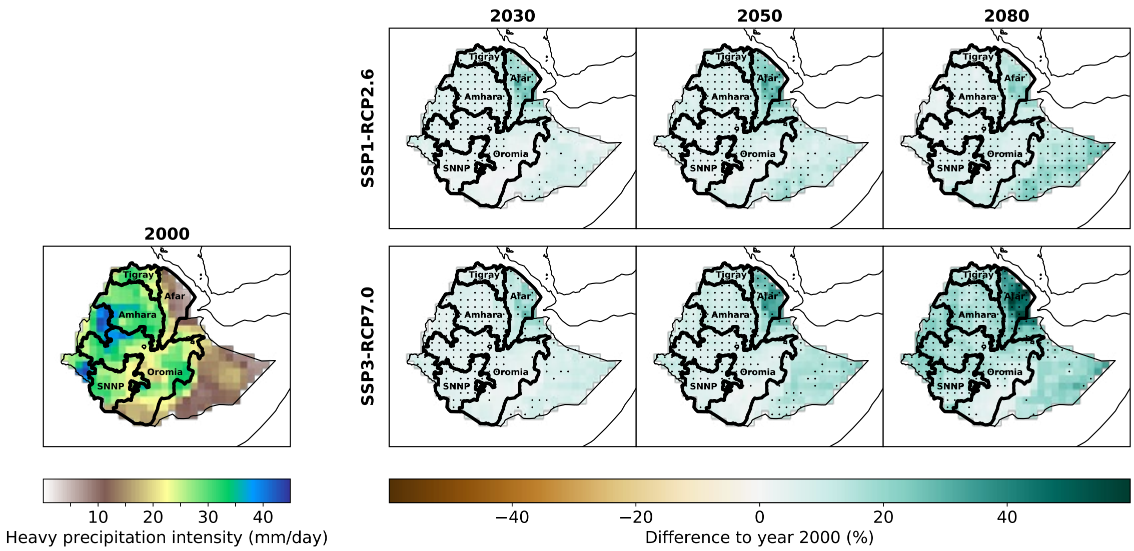

Figure 10: Projected changes in heavy precipitation intensity across Ethiopia in 2030, 2050 and 2080 compared to 2000 under two different trajectories. Dots indicate that at least 9 out of 10 models agree on the sign of change.

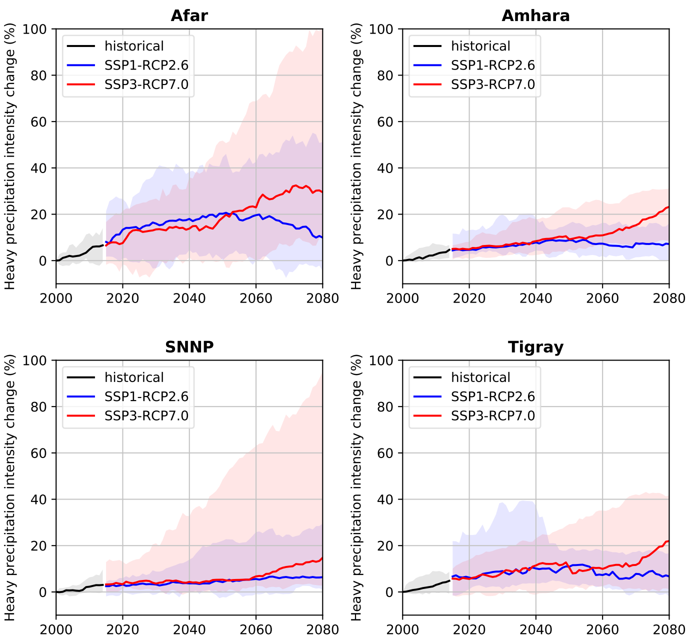

Figure 11: Projected intensity of heavy precipitation in the focus regions in Ethiopia, model ensemble medians (lines) and range of the model projections (shading) under two future trajectories.

Extremely dry months

The number of extremely dry months changes rather evenly throughout the focus regions in Ethiopia (see Figure 12). Generally, there is slight increase under both RCPs and in all regions, except from Afar, where the change is strong. There is a clear drying signal already in 2030, which heavily increases by 2050 and again by 2080 and is strongest under RCP7.0. Maximum increase by 2080 under RCP7.0 is almost 12 months, which means those regions (parts of Afar and Somalia) are in a constant drought situation.

The time series for the target regions confirms the dramatic drying in Afar, but also shows a great model range. In comparison, the weaker drying in the other regions is supported by a stronger model agreement (Figure 13).

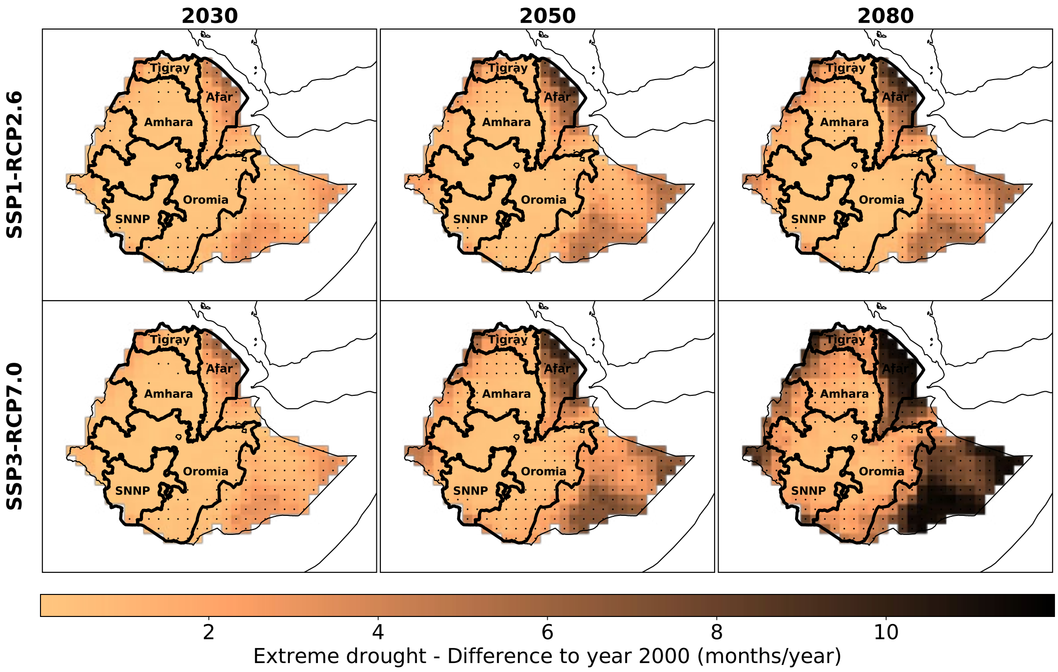

Figure 12: Projected changes in extremely dry months across Ethiopia in 2030, 2050 and 2050 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

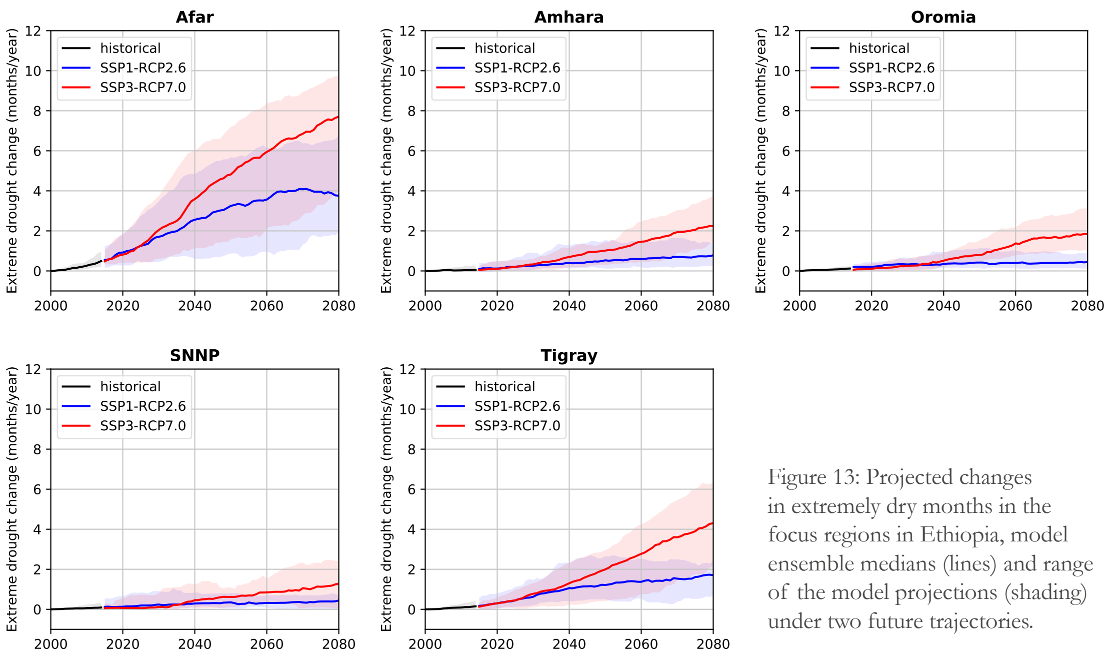

Figure 13: Projected changes in extremely dry months in the focus regions in Ethiopia, model ensemble medians (lines) and range of the model projections (shading) under two future trajectories.

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