Assessment of Climatic Impact Drivers: Supplemental Information

The assessments of climatic impact drivers were compiled by HFFA Research and the Potsdam Institute for Climate Impact Research (PIK) in close cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ). The assessments present a condensed overview of climatic impact drivers to identify future climate risks in the intervention zones of the Global Programme Soil Protection and Rehabilitation for Food Security (ProSoil). This document will help readers to better understand the assessments by providing more detailed information on the data base (section 1), climatic impact drivers (section 2), scenarios and pathways (section 3) as well as guidance on how to interpret the figures (section 4).

Section 1: Data base

The assessments were calculated with a model ensemble which consists of biased-adjusted data from the Coupled Model Intercomparison Project Phase 6 (CMIP6) models from the Inter-Sectoral Impact Model Intercomparison Project 3 (ISIMIP3) generation. Hence, the number of models on which the here presented projections are based exceeds the number used in other analyses such as "Climate risk analyses for adaptation planning in sub-Saharan Africa" (AGRICA) for Ethiopia, Kenya, and Burkina Faso. Using this larger model ensemble, we can gain more information on the robustness of the climate change signals. The ten models are GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1-2-HR, MRI-ESM2-0, UKESM1-0-LL, CNRM-CM6-1, CNRM-ESM2-1, CanESM5, EC-Earth3 and MIROC6. Climate projections used in this analysis are shown at the 0.5° grid-cell level, which corresponds to an area of approximately 50 × 50km near the equator.

Section 2: Climatic Impact Drivers

Mean temperature refers to annual mean near-surface (2m) air temperature in degree Celsius. We show the projected absolute changes mean temperature in degree Celsius.

Mean precipitation refers to annual precipitation sums in mm. As regional comparisons of precipitation changes are more meaningful in comparison to the average conditions of a larger area, we show relative precipitation changes in %. For example, when considering absolute changes, a precipitation change of 100 mm in the desert is a major change in comparison to a 100 mm change in the rainforest, where the general precipitation level is much higher.

Precipitation cycle projections show average daily precipitation rate for each month in mm/day for the different time periods.

Very hot days are defined as days with a maximum near-surface air temperature above 35°C. We show the change in the number of such days.

Heavy precipitation frequency refers to the number of heavy precipitation events. A heavy precipitation event is defined as a day on which the precipitation sum exceeds the 98th percentile of the daily precipitation sums of all wet days from 1861 to 1983, where a wet day is a day with a precipitation sum of at least 0.1 mm. So, the thresholds are defined based on a historical period and local conditions. The nature of the driver's definition with percentiles leads to a similar amount of heavy precipitation events in all grid cells in the historical period (generally about 6–9 days). Therefore, the historical figures are not meaningful and consequently not shown.

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Heavy precipitation intensity is defined as the value of the 98th percentile of the daily precipitation sums in mm within the 29-year period. The change, however, is indicated in percentage change, because total values are often not very meaningful in showing changes in precipitation and comparing different areas.

Extremely dry months are defined as months with a Standardized precipitation-evapotranspiration index (SPEI) of less than −2. The SPEI describes the deviation of the precipitation-evapotranspiration difference from the long-term conditions (1986 to 2014). The calculation of the SPEI is based on monthly precipitation anomalies and evapotranspiration, which are accumulated over 6 months. Evapotranspiration is approximated by the Thornthwaite method from monthly temperature data. SPEI values below −2 can be interpreted as below 2 standard deviations. This means that, similar to heavy precipitation events, these events are considered extreme due to their low frequency. As such the frequency in the historical period is not meaningful, as all grid cells show similar values between 0 and 0.3 months per year. Therefore, we do not show the historical figures. The maps show the projected changes in the annual number of extremely dry months.

Section 3: Scenarios and Pathways

We present the modelled climatic impact drivers in figures that show the differences of future projections to historic conditions represented by the year 2000. Projected changes are shown for 2030, 2050 and 2080. Generally, the drivers are shown as long-term (29-year) averages. Hence, the maps show the 29-year averages around the center years 2000 (historic conditions), 2030, 2050 and 2080. This means that the average around the center year 2000, shows the climate signal from 1986 to 2014, 2030 for 2016 to 2044 and so on.

We show the model median of an ensemble of ten climate models, as well as the range of the full ensemble, where applicable. Further, the projections follow two trajectories which show possible outcomes considering the current scientific knowledge on climate change. These are defined by two pathway categories. The first category is called Shared Socioeconomic Pathway (SSP). The scenarios of this category have distinct assumptions on the future economic and social development of all countries. The second category is Representative Concentration Pathway (RCP). Different RCP scenarios have distinct assumptions on the future concentration of greenhouse gas emissions, which influence the climate. These two categories are closely linked. For example, strong mitigation policies and actions can reduce the greenhouse gas emissions. To portray a broad spectrum, we show two trajectories. The first one is a combination of RCP 2.6 under SSP1, and the second portrays RCP7.0 under SSP3. The specific scenarios are defined as follows:

SSP1 is also called the sustainability pathway as it envisions relatively optimistic trends for human development, with substantial investments in education and health, rapid economic growth, and well-functioning institutions.

SSP3 is more pessimistic in its future economic and social development, with little investment in education or health in poorer countries coupled with a fast-growing population and increasing inequalities.

RCP2.6 is a stringent scenario which adheres to the targets of the Paris agreement. Global warming of more than 2°C in 2100 is not exceeded. This is achieved by drastically reducing emissions. This scenario is called *mitigation scenario* in the text.

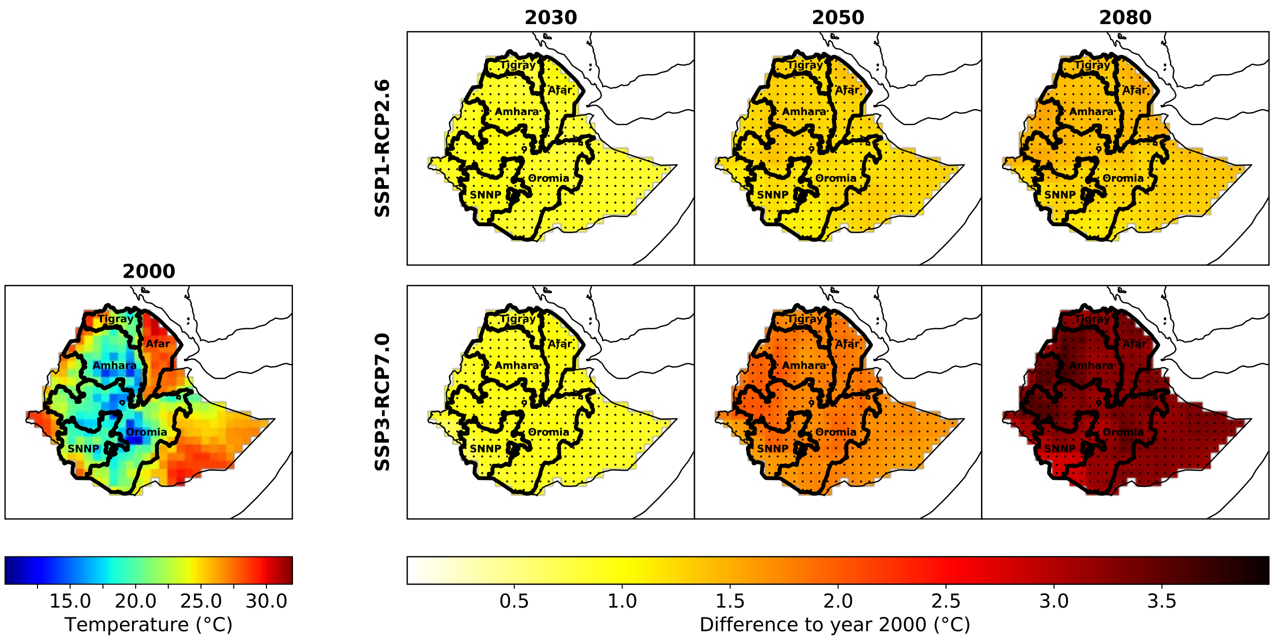
RCP7.0 is a no-policy baseline emission scenario, where no mitigation is employed. Hence, the status quo regarding emissions is projected in the future. This scenario is called *no-mitigation scenario* in the text.

Section 4: Guidance on How to Interpret the Figures

Maps

The maps show the spatial distribution of the climatic impact drivers. Future changes in these are shown in comparison to the historic conditions around the central year 2000. Due to different shapes of the ProSoil country packages and to provide a better overview, the maps are arranged differently for each country package, but the content is the same.

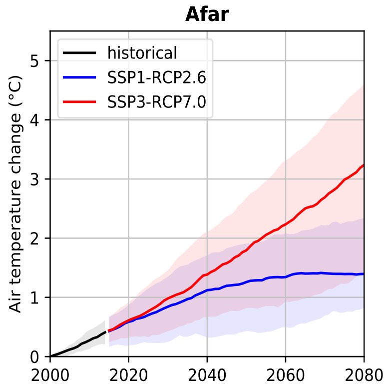
Here we will explain how to read the example map below. Here, the baseline conditions around the year 2000 are shown on the left-hand map. All maps to the right show projections under the two trajectories or pathways. In the example map the top row maps show median values under SSP1 and RCP2.6, and the bottom row maps SSP3 RCP7.0. The mean is calculated from all ten models in the model ensemble. The projection years are shown subsequently from left to right: 2030, 2050 and 2080. The colors show the differences to the baseline period 2000. Depending on the climatic impact driver, the projections show the absolute (climatic impact driver unit) or relative (%) differences of a climatic impact driver to the baseline. The example figure below shows absolute differences. Therefore, we can answer the following question: By how many degrees Celsius will the mean temperature likely change in 2030, 2050 or 2080 compared to 2000? To show the agreement between the ten climate models on the projected changes, dots indicate grid cells where at least 9 out of 10 models agree on the sign, i.e., increase or decrease in temperature. As dots are present in each grid cell (50 × 50km) of the below shown example map, there it is very likely that temperatures will increase in the whole region.



Example map - Projected change of mean temperature across Ethiopia

Line plots

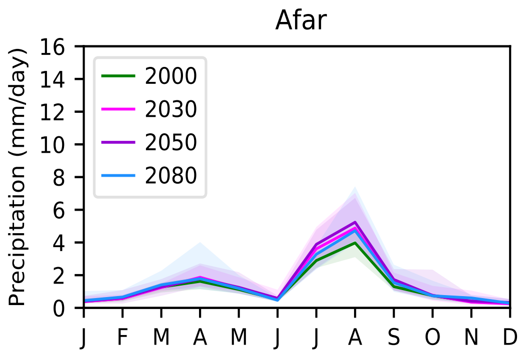
Line plots show the timeline of a climatic impact driver. To capture climatic changes and not interannual variability, we also show 29-year averages for each year (this means a 29-year running average time series). In the example plot it is the air temperature change from 2000 to 2080. For each region where ProSoil is working, the projected change is given in an individual plot. Again, the projections show two possible trajectories: SSP1-RCP2.6 and SSP3-RCP7.0. For each trajectory, the best estimate is displayed as a blue or red line. Mathematically, the best estimate corresponds to the median of all ten models in the model ensemble. The shaded areas around the line show the so-called model spread. This means that the shaded area shows the likely range of projections as they spread from the highest and lowest values of the ten models with which the projections are calculated. Such a spread can be for example well observed in the plot for Afar, where for RCP 7.0 in 2050 the model that projects the smallest change shows a temperature increase of 0.8°C, and the model that projects the strongest change shows an increase of 2.7 C. All other models show value within the shading.



Example line plot – Projected temperature time series on individual regions for the model medians (lines) and range of the model projections, which show the highest and lowest values (shading).

Precipitation cycle chart

The precipitation cycle charts show changes in the precipitation rates (mm per day) for each month. Hence, they show the distribution throughout the year. These figures are also shown for all the ProSoil regions individually. As for the line plots, the figure shows the median value of all ten models as a line. Different colors indicate different years (see legend in the top left corner of the figure). The shading around these lines indicates the full range of projections, i.e., possible outcomes, for each projection year in the same way in the line plots.



Example precipitation cycle chart showing the monthly precipitation for the model medians (lines) and range of the model projections, which show the range of projections (shading). Different colors indicate the year.

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