**Policy Brief on Climate Change and It's Impacts in Senegal**

The climate of the planet is changing, as is evident from steady increases in global temperatures and sea levels over the last 100 years. Scientists are clear that these changes are due to man-made emissions of greenhouse gases, notably carbon dioxide from fossil fuel burning. In spite of efforts by the United Nations Intergovernmental Panel on Climate Change (IPCC), emissions have continued to rise. How much the world will warm in the future is strongly related to how rapidly the global economy can decarbonise.

In this policy brief, we set out how the climate of the Sahel has changed in recent decades, what future changes are expected, and some implications of these changes for agriculture and flooding. There are many uncertainties when considering future impacts of global warming within a specific region. Here we present the range of plausible futures so that this uncertainty can be taken into account by decision-makers.

**Changes in temperature**

Overall, West Africa has warmed by about 1.1°C since 1950, a period for which we have relatively good observations. Compared to the pre-industrial climate of 1850, it is estimated that temperatures have increased by 2.1°C, with the strongest warming in the northern Sahel and Sahara. The warming in the Sahel has not occurred equally across the year. In particular the pre-monsoon months of April to June have warmed most rapidly. For example temperatures have risen by 1.4°C in April, compared to 1.1°C average over the whole year. The pre-monsoon months are the hottest time of the year, and so the warming has produced record-breaking high temperatures. Night-time temperatures especially have increased.

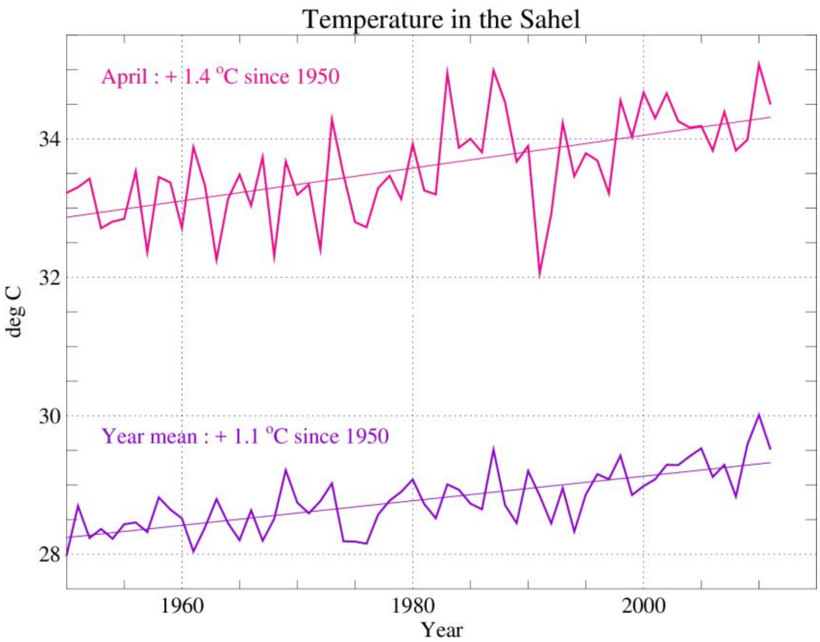



**Figure 1**. Observed increases in temperature since 1950. There are individual warm and cool years throughout this period, but the overall trend (represented by the straight lines) show a clear warming.

To make projections of the future, climate centres around the world run complex computer simulations which depict the impact that greenhouse gases have on the climate system. They run these climate models for different scenarios of future greenhouse gas emissions. In the most recent IPCC assessment, RCP8.5 is a high emission scenario, which assumes that emissions will continue to rise throughout the 21st Century. In the intermediate RCP4.5 scenario, greenhouse gas emissions peak around 2040. A low emissions scenario (RCP2.6) was also used, but this assumes that emissions peak around 2020, which is rather unlikely to occur.

For a given emissions scenario, different climate models simulate different rates of warming. The map (Figure 2) shows the average warming across the different models over the first half of the 21st Century under a high emissions scenario. The African continent warms more than the surrounding oceans, with the most rapid warming in the most arid regions. The right-hand plot shows the simulated changes in temperature (compared to the mid 20th Century) in the Sahel. Overall, the models project that the Sahelian warming that has been observed over the last 60 years will continue out to mid-century. Whilst the models agree that warming will occur, the range of warming simulated by the models (compared to pre-industrial times) is quite large (1.5 to 4°C). If emissions peak by the 2040s (intermediate scenario, RCP4.5) then temperatures will start to stabilise.

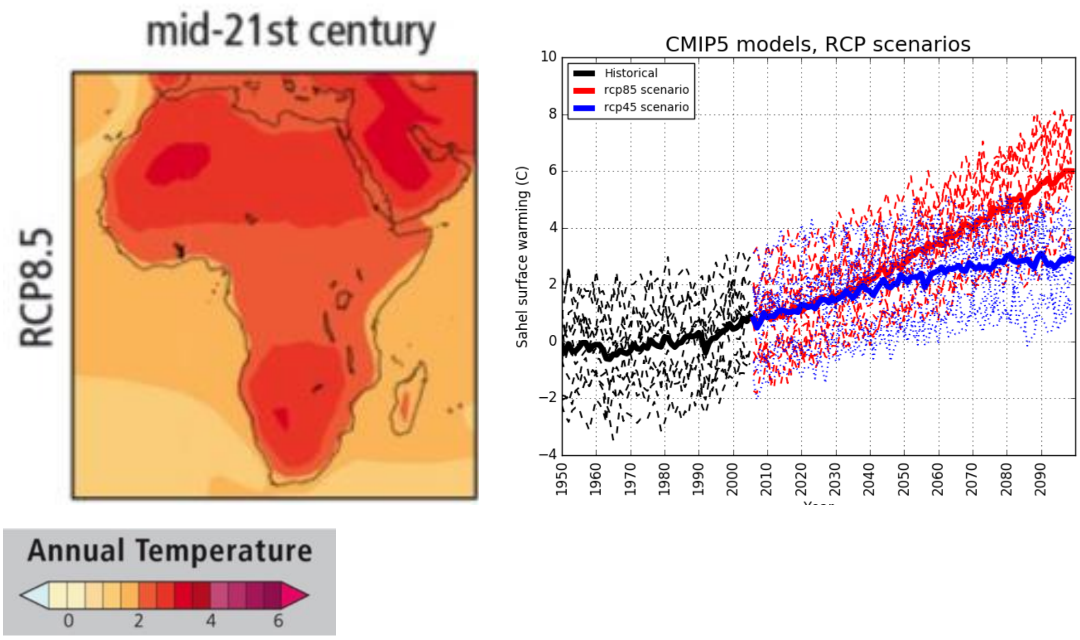



**Figure 2**. ***Left***: Change in temperature (°C) for the period 1986-2005 to 2040-2060 averaged across climate models assuming a high emissions scenario. ***Right***: changes in Sahel temperatures based on historical (black) and future emissions. The future simulations assume either a medium (blue) or high (red) emissions scenario. For the period to 2005, using historical emissions estimates (black), and using intermediate (blue) and high (red) future emissions scenarios out to the end of the 21st Century. The thick lines indicate the average warming, and the dashed lines illustrate the range of warming found in different models.

**Changes in seasonal rainfall**

West Africa has always experienced large variations in rainfall from year to year and decade to decade. During the 1950s and 60s, there was generally very strong rainfall, followed by an intense drought period during the 1970s and 80s (Figure 3). Since then annual rainfall has increased, but remains well below the levels seen during the 1950s and 60s.

The large natural rainfall fluctuations from decade to decade in the Sahel make it difficult to draw strong conclusions about whether man-made climate change has already affected rainfall. Some climate models suggest that man-made emissions of particulates and greenhouse gases influenced the drought and the subsequent recovery, but there is no consensus on the relative importance of the different effects

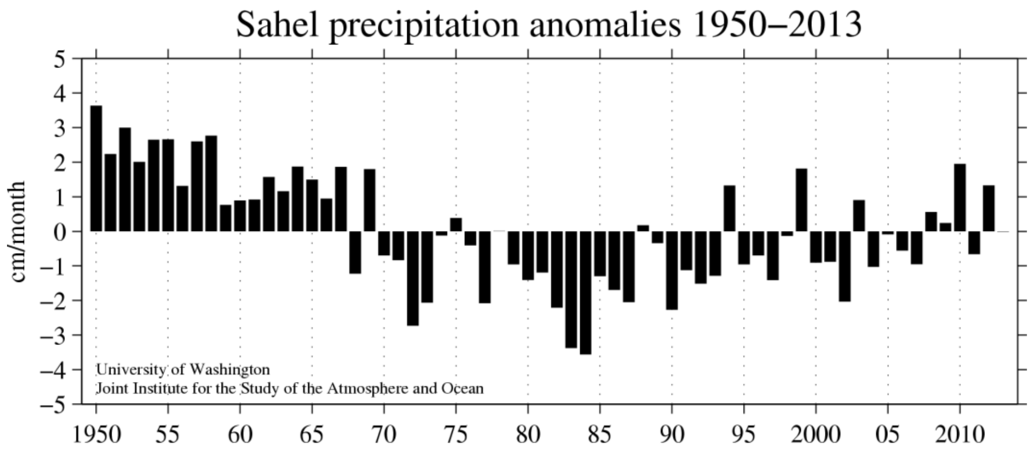



**Figure 3**. Observed fluctuations in wet season rainfall relative to the long-term average across the Sahel.

We are much less certain about how average rainfall totals will change by 2050 than we are about future temperature changes (Figure 4). For any given emissions scenario, some models depict decreased rainfall over Senegal, and others suggest increases, or little change. Having said that, considering higher emissions scenarios, a majority of models indicate rainfall reductions of between 10 and 60%. However, there remains a reasonable chance of a wetter climate by 2050 given high greenhouse gas emissions.

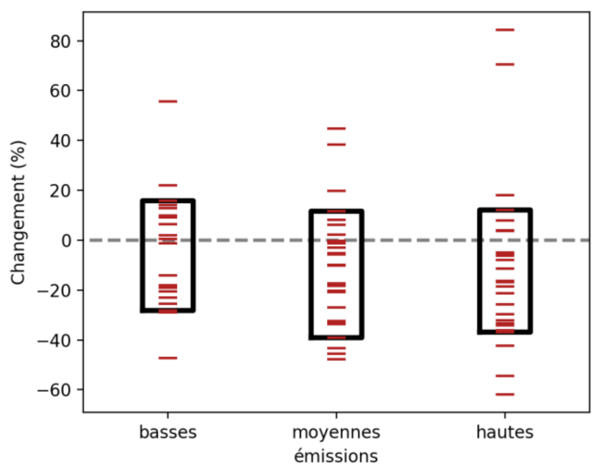


**Figure 4**. Changes in rainfall by 2050, as simulated by climate models under low, medium and high emissions scenarios. Each red line indicates the projection from one model. Rainfall reductions lie below the dashed line and increases are above.

**Wet season duration**

Alongside large changes in the amount of rainfall within a season, Senegal experiences big fluctuations in the length of the growing season from year to year (Figure 5). During the 1950s, on average the season lasted for 108 days. This fell to 88 days in the 1980s but has since increased to about 95 days. As with total rainfall, the large natural fluctuations in rainy season length from decade to decade make it difficult to draw strong conclusions about whether man-made climate change has already affected wet season length.

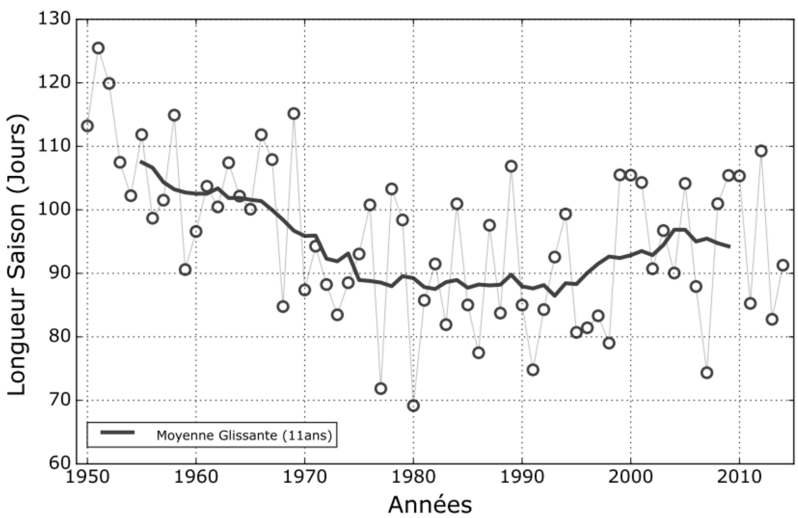



**Figure 5**. Observed growing season length (in days) in Senegal since 1950. Following the AGRHYMET definition, the season starts when there is sufficient rain in 3 consecutive 10 day periods for crops to grow. Similarly, the season ends when there are 3 consecutive 10 day periods without sufficient rain. Each circle on the graph shows an individual year, and the dashed and solid lines are averages of the data over 5 and 11 years respectively, making it easier to see longer-term trends in growing season length.

Future projections of wet season length are rather uncertain. Each red line in this graph shows the change in length for an individual climate model for a given greenhouse gas emissions scenario. There is a large range of projected changes in season length and it is therefore not possible to say with any certainty how the season length will change. The rectangles shows the central range covered by 50% of the models, and this measure indicates a 1 in 2 chance that the change in length will be between a shortening of 15 days and no change. At the same time, 10% of the models indicate decreases of more than 30 days. This scenario would exceed the drop in season length of 20 days experienced between the 1950s and 1980s.

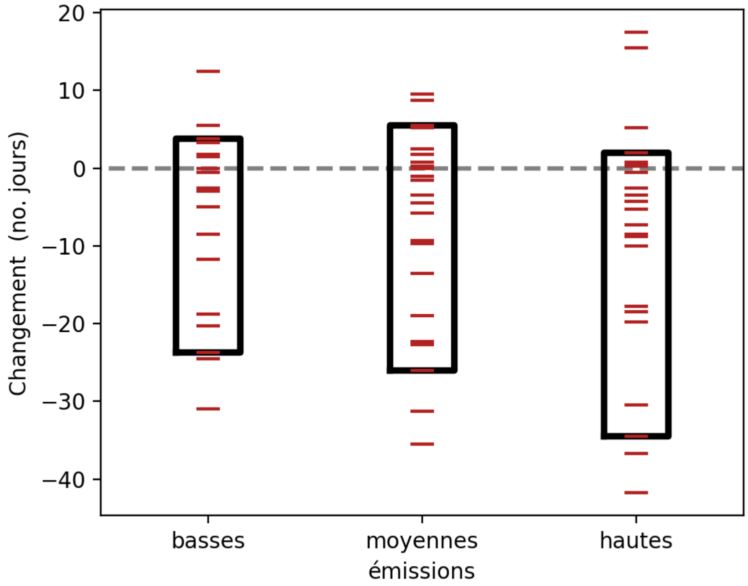



**Figure 6** . Changes in wet season length (in days) by 2050, as simulated by climate models under low, medium and high emissions scenarios. Each red line indicates the projection from one model.

**Changes in intense rainfall**

Climate change is expected to make the strongest rain storms more intense. There is now good evidence from observations that this intensification is already taking place in the Sahel. The frequency of intense storms across the region has tripled since the 1980s (Figure 7). A larger proportion of the season's rain is now arriving in heavy storms than at any time since 1950. This trend has contributed to the increase in reported flood events, particularly in rapidly expanding urban areas where drainage may not be adequate. Whether seasonal rainfall totals increase or decrease, more intense rain from individual storms can be expected in the future. This will further increase the frequency and extent of flash flooding (Figure 8). For agriculture, rainfall intensification will also increase soil erosion, and reduce the fraction of rainfall which crops can use to grow.

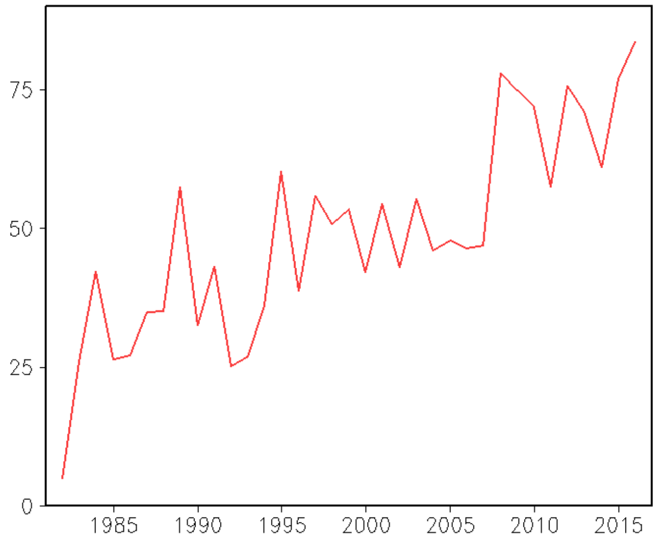
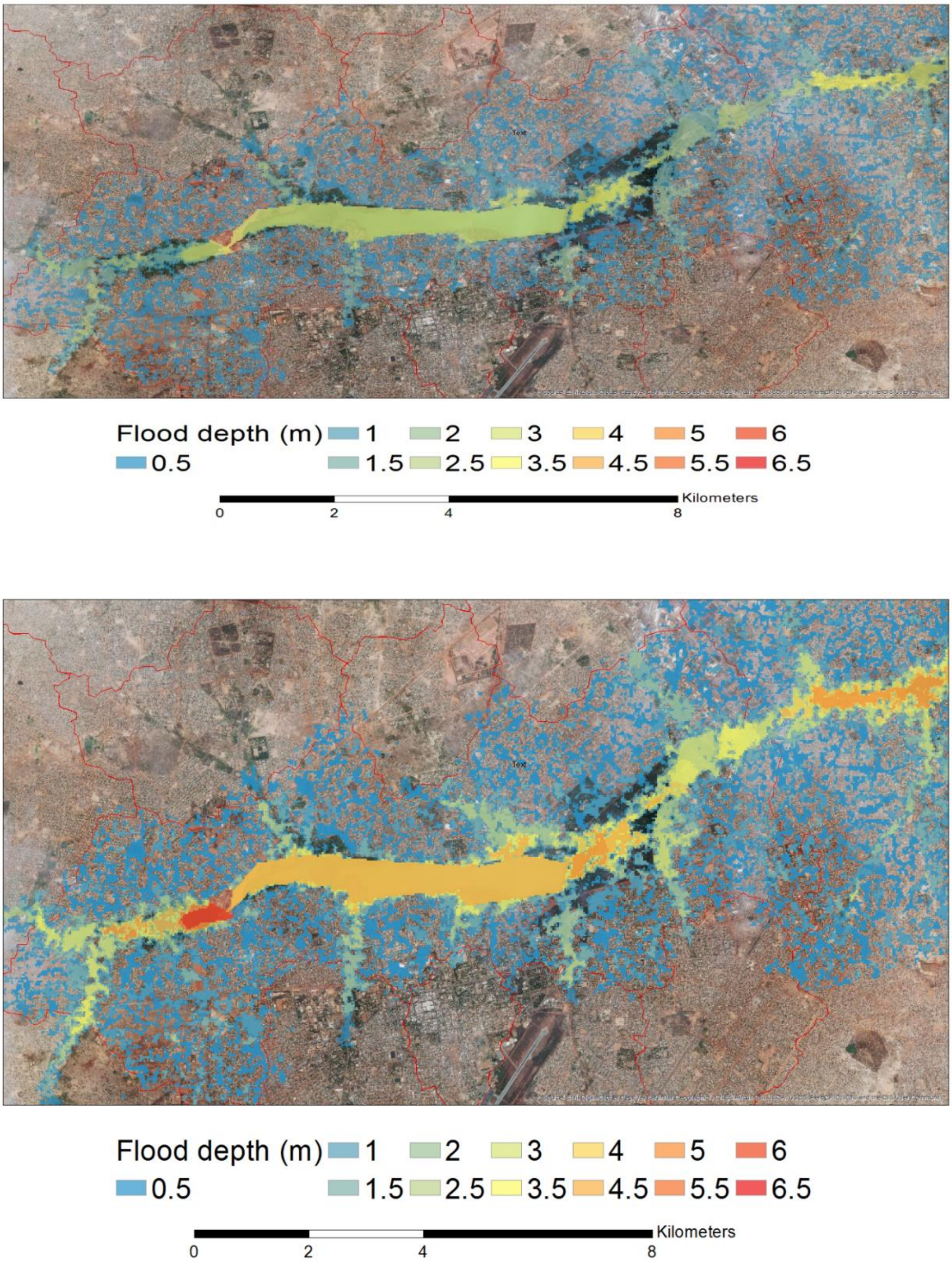



**Figure 7**. Average number of intense storms per day observed across the Sahel since 1982.

**Figure 8**. Maps illustrating how the changes in intense rains and plant cover from 2016 (above) to 2050 (below) will affect the depth of the floods in the city of Ouagadougou for a particularly extreme thunderstorm (expected only once in 100 years). More of the city will be flooded and areas already prone to flooding will experience higher levels of flooding for a longer period of time.



**Impacts on agricultural production**

Global warming has been affecting agricultural production en West Africa over the past 20 years**.** While many studies have indicated a drop in regional agricultural yields of 10 to 15% by 2050 due to the future rise in temperatures, none have considered the impact of historical warming. Figure 9 shows the effect of anthropogenic global warming on agricultural production between 2000 and 2009 based on 200 simulations of a climate model. The result is unambiguous; anthropogenic activities have caused a drop in yields of 10-20% in millet, and of 5-15% in sorghum. From an economic point of view, the losses for the countries involved range from 2 to 4 billion dollars for millet and 1 to 2 billion dollars for sorghum. These losses in yield will grow in the future if global greenhouse gas emissions are not reduced, and if adaptations to higher temperatures are not implemented.

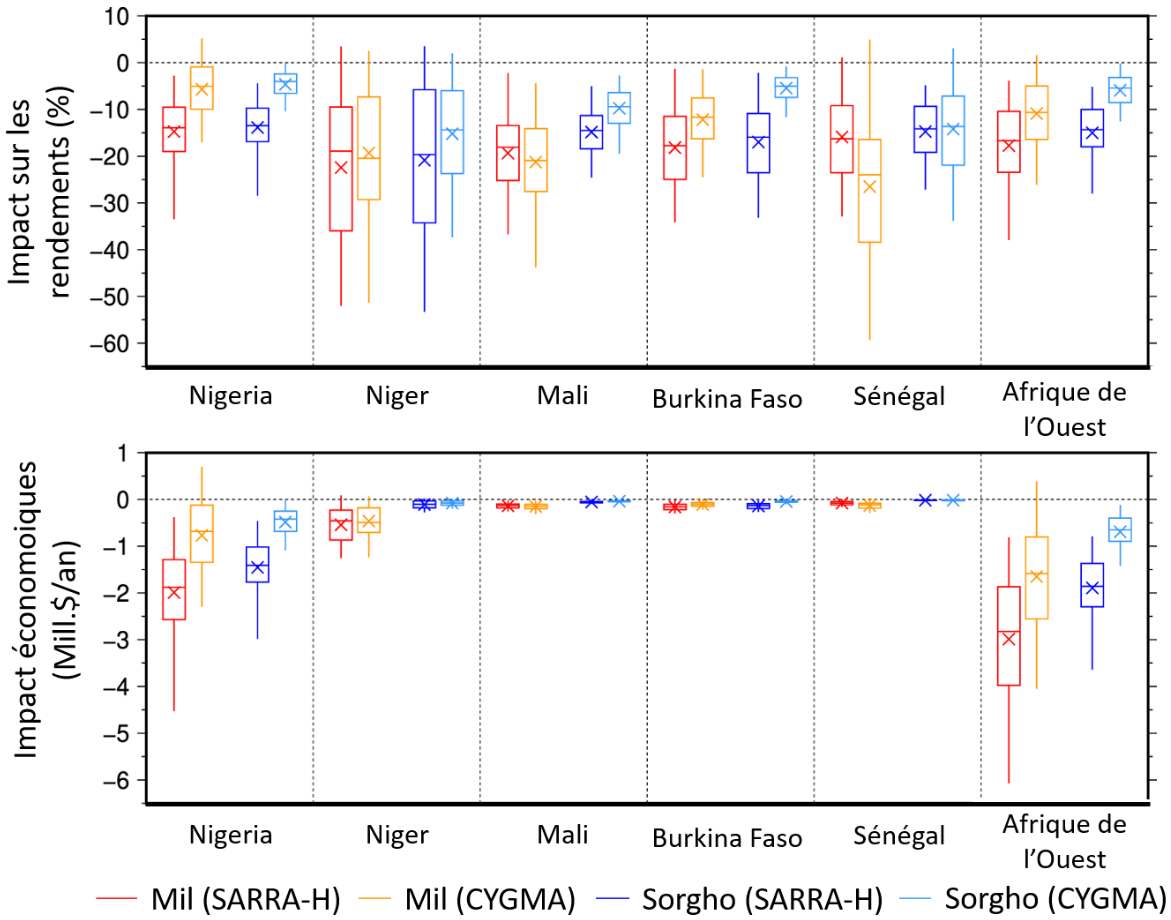



**Figure 9.** Impact on agricultural production of millet and sorghum (as a percentage) and economic losses (in billions of dollars) due to global warming during the decade 2000-2009, as simulated by two crop models SARRA-H and CYGMA. Mean values derived from the ensemble of simulations are shown by crosses, the upper and lower bounds of the rectangles mark the inter-quartile range (central 50%) of the members, and the vertical lines denote the range covered by the lower and upper extremes (each corresponding to a 1 in 20 probability). The regional average data for West Africa are based on averages over Benin, Burkina Faso, Gambia, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

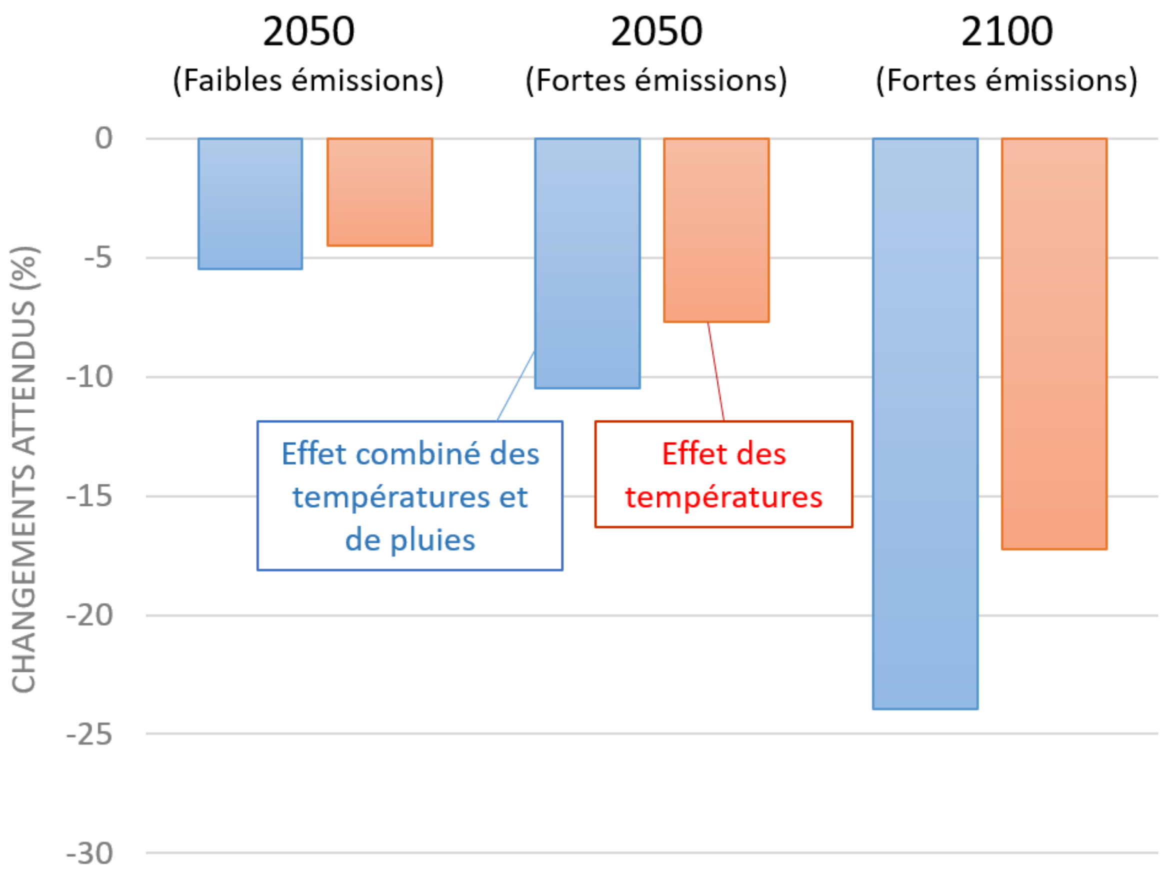



**Figure 10**. Expected changes in millet yield in the Bambey region of Senegal, as simulated with the CELCIUS agronomic model and climate projections from 30 CMIP5 models. The blue bars take into account the combined effects of changes in temperature and rainfall while the red bars consider only changes in temperature.

Global warming presents a threat to future cereal production in West Africa. Many studies, such as the one illustrated in Figure 10, have shown that increases in temperatures are detrimental for millet, sorghum and/or corn because it shortens the crop cycles and increases water loss through enhanced evaporation. Furthermore in certain parts of Africa (including Senegal), the warming may combine with a possible reduction in rainfall by 2050 or 2100, which would further worsen losses in yield. The higher the emissions, the greater the impacts on agricultural production, and this demands efforts on both mitigation and adaptation in order to reduce risks.

Future projections for Senegal can be found here:

http://retd1.teledetection.fr/climap/

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