Chapter 6

Projections: scenarios and uncertainties

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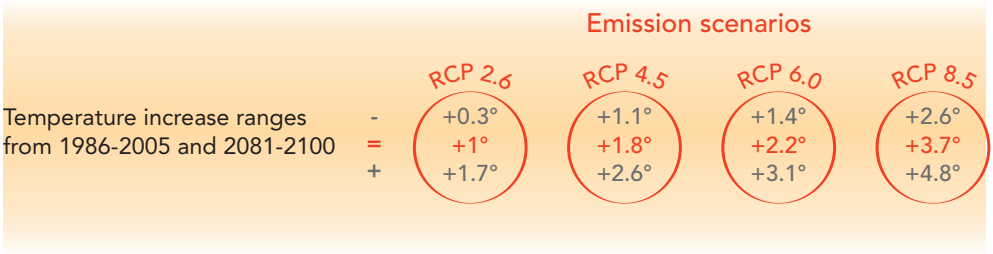
Rain arriving over the Barotse floodplain in Zambia.

Entrusted with the task of formulating scientific opinions for international negotiations concerning the climate, the IPCC assesses possible climate development with the constraint of the future pattern of greenhouse gas emissions. For this work, the climate modelling community develops climate simulations following joint protocols in order to compare the results of all the climate models used. For the IPCC, assessments of emissions were defined according to four socio-economic scenarios (also called Representative Concentration Pathways, RCP). Each scenario corresponds to an atmospheric greenhouse gas concentration in 2100. The impact of the greenhouse effect on the climate is calculated using **radiative forcing** from the most favourable (2.6 W per square metre) to the most unfavourable (8.5 W per square metre) with two intermediate values (4.5 and 6.0 W per square metre). The scenarios are named as follows according to the different forcings: RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5.

Climate projection

It is important to note that these experiments do not result in a **forecast** but in a '**projection**' of the climate that makes it possible to understand how the climate can change under these new greenhouse gas emission constraints. The projections do

Figure 15.
Climate temperature forecasts for 1986-2005 and 2081-2100 according to the 4 IPCC emission scenarios.
Source: IPCC, 2013.



not take into account either the real initial conditions of the climate at the start of the simulations (for example a positive phase of the Atlantic Multidecennal Oscillation) or future changes in natural forcings (solar activity, volcanic eruptions) that cannot be forecast. However, they are generally performed for each climate model with a set of simulations so as to allow for internal climate variability.

The projections provide a statistical envelope of possible climate pathways for each of the four emission scenarios and for each climate model. Then, considering the global coverage of the climate models used, it is assumed that for a given socio-economic scenario the real climate pathway will be within the overall envelope of these sets of simulations, but without it being possible to predict the precise pathway.

Climate forecasting

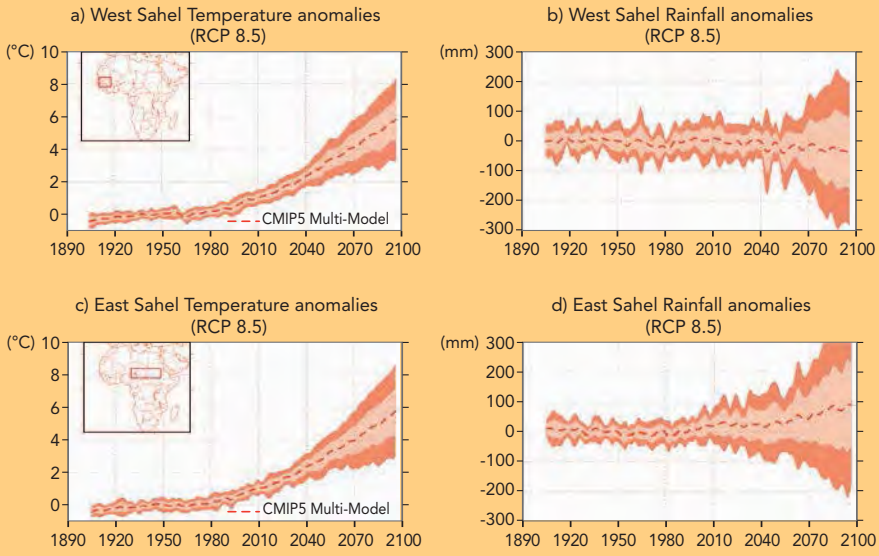
At the request of governments, a climate forecast operation has nonetheless been initiated in the Fifth Assessment Report of the IPCC. Forecasts for 2016-2035 have thus been added to projections for 2100. However, the present results of this exploratory work must be treated with extreme caution, in particular as regards their possible implications in terms of impacts on resources and the decisions to be taken by economic and political stakeholders. The aim is to gain better understanding of the climate modulations for periods of a few years and for some 30 years in order to test the degree to which they can be forecast. These modulations incorporate the internal variability of the climate system, natural forcings and anthropic forcings. In this framework it is essential to take the initial climate conditions into account to make a forecast of this type. The operation is aimed at more precise assessment of climate trends in the coming years and also includes assessments of 'retrospective' forecasts for previous periods (initialisation in 1960, 1965, 1970, etc.)—for which observations are available—in order to assess their performances and biases.

Box 12

Uncertainties are too great for the forecasting of Sahel rainfall

The climate in the Sahel has changed over the last 30 years. Temperatures have risen and there is a contrast in rainfall between east and west. Researchers have addressed the impact of the increase in greenhouse gases on the trend and on the climate projections for the region. They used the IPCC emission scenarios for this. Temperature projections confirmed the observations and indicated continued increase until 2100, with dispersion centred on the comparatively restrained mean change (envelope of uncertainties). This makes it possible, with good probability, to consider the recent warming observed as the imprint of climate change and to suppose that warming will continue.

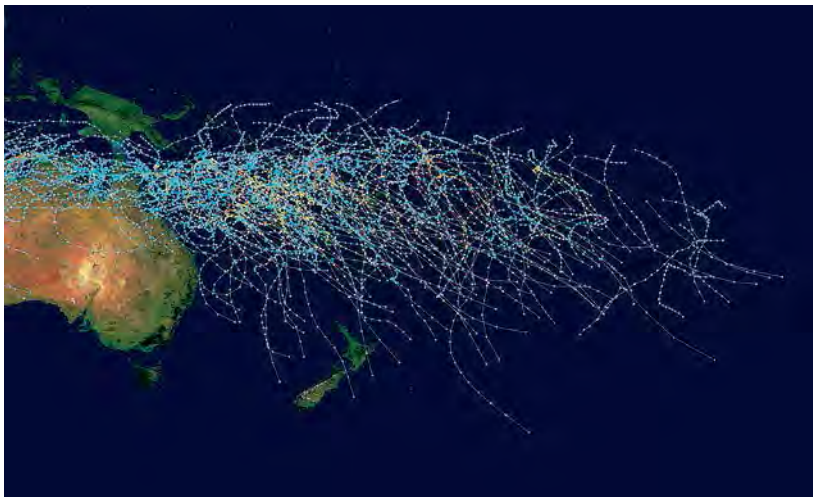
In terms of precipitation, although there is effectively a decrease in the western part of the Sahel (mainly in June and July) and an increase in the eastern part (mainly in September and October), the uncertainties with regard to these trends are much too great for it to be possible on the one hand to affirm that present changes are the imprint of climate change and on the other to indicate a clearly determined direction of change for the future.



Dashed lines show the movement of the multi-model average; orange areas cover the trajectories of all the models. Anomalies are calculated in relation to the period 1960-1990.

Figure 16. Climate forecast for temperature and precipitations for the western and eastern Sahel in the scenario RCP 8.5. The temperature movement forecast is clearly positive for all the models whereas precipitation forecasts are very uncertain.

Source: DEME *et al.*, 2015.



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Map of the paths of cyclones in 1980-2005 in the West Pacific. Careful study of extreme climate events is important to gain better understanding of their links with global warming.

More frequent extreme events

Certain El Niño events, such as those of 1982-1983 and 1997-1998, were particularly intense. They featured a shift of warm water and rainy regions from the West Pacific towards the East Pacific. The modifications markedly changed the position of the South Pacific Convergence Zone (SPCZ), the rainiest part of the southern hemisphere, with dramatic effects on ecosystems, agriculture, the frequency of forest fires and cyclone activity in the south-west Pacific. The response of this phenomenon to climate warming has been a major challenge for the scientific community for the past 15 years.

Recent studies on the latest climate simulations have shed new light on the links between El Niño and the changes in the Pacific. Although analysis has not led to a consensus with regard to the future amplitude of El Niño events, most of the models indicate that the intensification of the warming of the equatorial Pacific in the 21st century should cause a substantial increase in the frequency of rain events in the eastern Pacific and shifts of the convergence zone towards the equator. The two phenomena characterise extreme El Niño events. The frequency of extreme La Niña events should also increase in response to the rapid warming of water in the region of Indonesia. In spite of the agreement between the different climate models concerning the increase of these extreme climatic events in the tropics, confidence in these climatic projections is still limited because of imperfections in the modelling of the tropical climate.

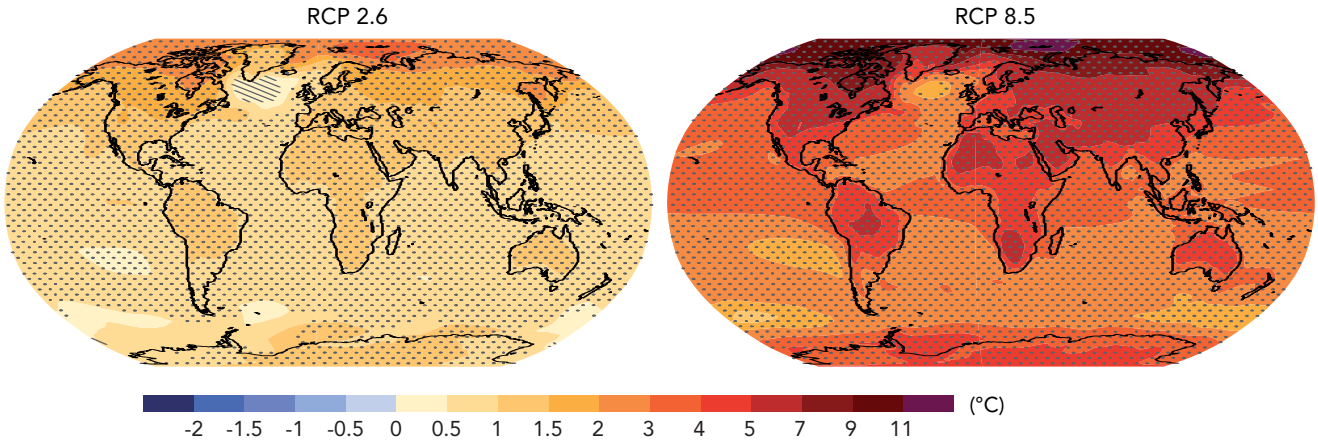

Figure 17.
Movement of average surface temperature from 1986-2005 and 2081-2100.
Source: IPCC, 2013.

The 2°C threshold

Although the climatic impacts of global warming caused by anthropic emissions are not always easy to identify, the IPCC climate projections for 2050 and 2100 show that the greatest changes are still to come: according to the most pessimistic forecasts of greenhouse gas emissions—but that are possible as they would be the continuation of present emissions—warming could be nearly 4°C in one century.

For several years, the international community has shared the aim of stabilising warming at less than 2°C at the end of the 21st century. This is the threshold at which scientists do not exclude irreversible impacts on the climate and even a spiralling effect. The IPCC report must therefore enable decision makers to identify the socio-economic scenarios that will make it possible to reduce emissions in order to keep the rise in temperature below this threshold.

Lengaigne Matthieu, Deme A., Mignot Juliette. (2015).

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