New IPCC Assessment Report: Improved models, more accurate statements

How has climate changed up until the present? How will it change in the future? Questions like these are answered in the recently published first part of IPCC´s Fifth Assessment Report, which summarizes the scientific facts about climate change. This first part will be supplemented with two more parts in the coming spring, addressing adaptation to potential impacts of climate change and its potential mitigation. A synthesis report of the three parts will be published in autumn 2014.

The Max Planck Institute for Meteorology (MPI-M) contributed to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) with its extensive model calculations and contributions from numerous scientists. MPI-M Director Prof. Jochem Marotzke, for example, is coordinating lead author of the chapter on the evaluation of models. In addition, he worked on the summary for policy makers. MPI-M Director Prof. Bjorn Stevens is one of the lead authors of the chapter on clouds and aerosols, while MPI-M scientist Dr. Victor Brovkin is lead author of the chapter on carbon and other biogeochemical cycles.

Observations

Climate change

With its analysis of the current climate status and the observed changes, the new report corroborates and specifies the findings of the previous report from 2007. The mean temperature of the atmosphere and the ocean has increased further, the melting of glaciers and the thawing of permafrost soils continues, as does the mass loss from the large ice sheets in Greenland and Antarctica. In contrast to the previous report, the analysis now takes dynamic changes of the ice sheets into account. The report also finds that the concentration of atmospheric greenhouse gases has increased further in recent years.

Temperature increase

An analysis of observational data in the new IPCC report estimates the global mean warming from 1901 to 2012 to be about 0.9 °C. The last three decades have each been warmer than any previous decade since 1850, the 10-year period starting in 2001 was the warmest. In the Northern Hemisphere the most recent 30 years have probably been the warmest in the last 1400 years.. Over the past 15 years, the rate of temperature increase has decreased. This does not mean that climate change has slowed down, because internal fluctuations of the climate system can dominate any long-term climate signal on time scales of 10-15 years. Moreover, the warming of the atmosphere may have decelerated owing to an increased ocean heat uptake, the minimum in the 11-year solar cycle or the cooling effect of aerosols originating from several small volcanic eruptions. Furthermore, observations show that extreme temperature conditions have changed: fewer cold days and nights and more warm days and nights occur, and heat waves have increased regionally.

Major influence of greenhouse gases on climate change
The scientists involved in the IPCC process agree that human activities are "extremely likely" to be responsible for more than half of the observed global warming in recent decades. The term "extremely likely" corresponds to a likelihood of over 95%. Compared to the previous report of 2007, scientists are more certain that humans have caused most of the observed climate change during the last decades, mainly due to the emission of greenhouse gases.

For the first time, an upper limit for CO_2 emissions into the atmosphere is set in the present report beyond which the two-degree target of warming above pre-industrial levels would be difficult to meet. This upper limit is about 1,000 gigatons of carbon. In the period 1750-2011, 545 gigatons of carbon were released by human activities, of which more than half was released in the last three decades. Around 44% of the emitted carbon remained in the atmosphere, the rest was absorbed by land surface (plants and soil) and the ocean. The carbon uptake by the ocean leads to an increasing ocean acidification.

Climate sensitivity, describing the change in global temperature for a doubling of CO_2 concentration in the atmosphere, is given as 1.5-4.5 °C in the new report. Thus, the range is a bit wider than in the last report that estimated a range of 2-4.5 °C.

Improved models

Carbon cycle
The new report is based on significantly improved climate models. For instance, in contrast to the previous report, now the entire carbon cycle has been included into Earth system models. MPI-M scientist Dr. Victor Brovkin, lead author of the corresponding chapter, comes to the conclusion that by considering the carbon cycle, model calculations and their results allow more specific statements since more elementary processes are taken into account. For example, forests located in the tropics remove CO_2 from the atmosphere at increased temperatures while at high latitudes forests emit CO_2 at increased temperatures.

Clouds
A number of processes are represented more realistically in the models that were used for the new IPCC report. This includes the simulation of clouds and aerosols which play a particularly important role in global climate, but that are still subject to considerable uncertainties. To take this important role into account, an extensive chapter on clouds and aerosols has been added to the current climate assessment report, which was co-written by MPI-M Director and lead author Prof. Bjorn Stevens. The analysis of present scientific studies showed that changes in cloud cover "likely" enhance global warming. The term “likely” corresponds to a likelihood of over 66%.

The future

Future scenarios
In order to perform simulations of the possible future evolution of the Earth?s climate, many assumptions including the future greenhouse gas emissions must be made. Therefore, four scenarios have been developed for the new report, which include not only different levels of economic development, but also a number of policy decisions including, for example, measures to reduce greenhouse gas emissions or the adaptation to global warming. These new scenarios, referred to as "representative concentration pathways", were used as boundary conditions for all models used in this report in order to make their results comparable. One of these scenarios is used to investigate the possibility of meeting the politically ambitious two-degree target. According to the MPI-M model runs in this scenario, this target can be met if the anthropogenic CO_2 emissions are reduced so drastically from 2020 onwards that global emissions are halved by 2050 and then abate to zero within a few decades.

Climate projections
In the chapter on climate projections, scientists assess that additional warming will take place in all components of the Earth system owing to increasing greenhouse gas emissions. The global average surface air temperature will increase by +0.3-4.8 °C by 2100, depending on the underlying scenario. The warming will, however, strongly vary regionally and will, in particular, be significantly higher in the Arctic. The temperature will rise significantly more over land than over the ocean. The global water cycle will respond accordingly and humid areas will become moister and dry regions will become drier. The estimated 26-81 cm rise in sea level by the end of this century is a somewhat higher estimate of sea-level rise compared to that given in the last report.

Background information

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About the chapters of AR5, WGI, Physical Basis

2,3,4 – Observations: Atmosphere, Ocean, Cryosphere:
Stephan Bakan, Dirk Notz

5, 6 – Paleoclimate and Carbon Cycle:
Victor Brovkin

7 - Clouds:
Thorsten Mauritsen, Bjorn Stevens

8 – Radiative Forcing:
Marco Giorgetta

9 –Evaluation of Climate Models:
Jochem Marotzke, Johann Jungclaus, Florian Rauser

10 – Detection and Attribution of Climate Change:
Johann Jungclaus

11 – Near-term Climate (Projections and Predictability)
Johann Jungclaus

12 – Long-term Climate Change:
Marco Giorgetta

13 – Sea Level Change:
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