From the Past into the Future: New Climate Simulations for Science and Society

"Two-degree target could still be achieved"

Scientists from the Max Planck Institute for Meteorology (MPI-M) and the German Climate Computing Centre (DKRZ) have carried out new climate simulations using MPI-M's new climate model. The results indicate that the two-degree target could still be achieved if carbon dioxide emissions would be reduced significantly. Within an international model intercomparison project researchers were able to simulate the complex carbon cycle as well as vegetation dynamics in climate projections for the 21st century. In case of an increase in CO2 emissions the simulations suggest not only an increase in temperature but also a rapid progression of ocean acidification. Oceanic calcifying organisms will be particularly affected. In addition to long-term projections, more detailed climate predictions spanning the next ten years were performed for the first time. The new climate simulations were carried out on DKRZ's supercomputer and occupied one quarter of total computing capacity over a period of two years.

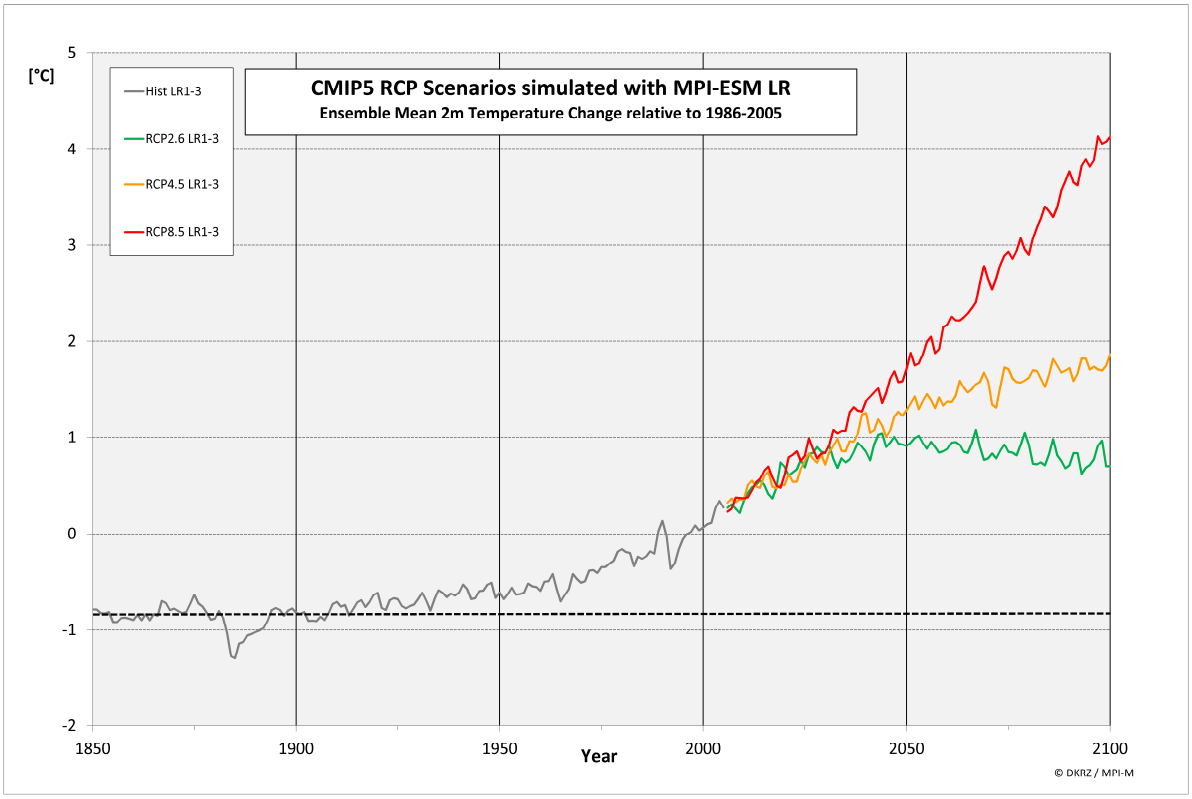

Figure: Global warming at the end of the century (relative to the pre-industrial value in 1850) will reach about 1.5°C and 4.8°C – depending on the amount of greenhouse gases emitted into the atmosphere

The model: The simulations were performed by MPI-M's Earth system model "MPI-ESM", consisting of the global circulation model "ECHAM6" for the atmosphere and "JSBACH" as land vegetation model, and by its global ocean circulation model "MPIOM" together with "HAMOCC" for the biogeochemical part. Both global models were coupled with the OASIS3 coupler. For the first time MPI-ESM now also comprises the carbon cycle besides the hydrological cycle.

The model is available to all climate researchers for their own research questions:
http://www.mpimet.mpg.de/en/science/models.html

Through dissemination of the current data sets the scientists have fired the starting shot for the interpretation of results by the climate research community. Furthermore, the findings represent the basis for socio-political discussions about possible impacts of climate change and the call for action resulting of it. The new model calculations are part of the "Coupled Model Intercomparison Project Phase 5" (CMIP5) within the World Climate Research Programme (WCRP). Within the framework of this programme the coordinated calculations of the global coupled climate models are compared with each other. The project is funded with more than 3 Mio Euros by the German Federal Ministry of Education and Research (BMBF).

The simulations performed by MPI-M's newly developed Earth system model can be characterized as follows:

1. Reconstruction of „undisturbed" pre-industrial climate
2. Climate development since the mid-19th century under given observed atmospheric trace substance concentrations (anthropogenic greenhouse gases and aerosols, and external forcings (sun, volcanoes))
3. Climate change scenario experiments based on different atmospheric trace substance concentrations estimated in the future (new scenario generation of RCP - Representative Concentration Pathways)
4. Sensitivity experiments with an assumed yearly CO2 concentration growth rate of 1 % and a sudden quadrupling in CO2 concentration
5. Experiments with an "interactive" carbon cycle
6. Projection experiments spanning decades (10 years; "hindcasts" and forecasts)
7. Climate experiments for past climates (so-called palaeo experiments, up to 1000 years in the past "Millennium")

Download from MPI's webpage:
Talk by Marco Giorgetta, group leader "Climate Modelling", 23 February 2012

First findings: In the event of continuously increasing emissions of carbon dioxide, as assumed in the least favorable scenario, scientists expect a rise in the global mean temperature by up to 4°C by 2100 (Figure). The impacts of global warming are manifold and have different implications in different regions. “We would have more frequent and intense heat waves on a global scale”, says Prof. Dr. Jochem Marotzke, Director at the Max Planck Institute for Meteorology and vice-chair of the World Climate Research Programme. “Our results demonstrate the possibility to limit global warming to below two degrees Celsius throughout this century. But it requires a drastic reduction of carbon dioxide emissions.”

According to recent calculations Arctic summer sea ice melts faster than predicted. With a smaller sea ice cover, more sunlight is absorbed by the dark open water of the polar ocean. This water therefore warms efficiently during summer (albedo effect). The melting rate of sea ice is directly connected with global warming. “Our current calculations show a higher correlation with observations of Arctic sea ice over the past decades than ever before”, explains Dr. Johann Jungclaus, ocean expert at the Max Planck Institute for Meteorology.

Climate scientists from the MPI-M have shown for the first time that the strength of the Atlantic Meridional Overturning Circulation can be predicted. By using current observational data it has been achieved to define and integrate a consistent starting point into an ocean model. It is now possible to predict climatic anomalies for the next five to ten years.

“Recent data indicate that, due to carbon dioxide pollution, ocean acidification has increased by 30 percent compared to pre-industrial times. Scientists doubt that many organisms will be able to cope with environmental change. Oceanic calcifying organisms like shells and corals are particularly affected”, says Jungclaus.

As a result of the so-called Millennium simulations (calculating past 800-1000 years) researchers were able to show that human impact on the atmospheric CO2 concentration started much earlier than with the industrial revolution. Anthropogenic land cover change such as conversion of forests to croplands and pastures has significantly influenced the carbon cycle since 1750.

The computing system: All model runs were performed by the high performance computing system of the German Climate Computing Centre. Roughly a quarter of the system’s total capacity was needed over the past two years to complete the simulations. „With a peak performance of 158 trillion TFlops/s (floating point operations per second), our scientists simulated 13.000 years of climate history in more than 350 experiments“, says Prof. Dr. Thomas Ludwig, Director at the German Climate Computing Centre. „This computing performance corresponds to 30 million processing hours of conventional computers”.

The model results were stored in a relational database and are now made available to German researchers for further analysis by the World Data Center for Climate (WDCC).

Hamburg´s climate scientists were pioneers in developing one of the first three-dimensional coupled atmosphere-ocean models. The Max Planck Institute for Meteorology is among the world's leading institutes for climate research and has made many major contributions since its foundation in 1975.

Founding Director Prof. Dr. Klaus Hasselmann and his team proved in 1996 that global warming is attributed to human activities with a probability of more than 95 %.

The World Climate Research Programme (WCRP) was established in 1980, under the joint sponsorship of the International Council for Science, the Intergovernmental Oceanic Commission and the World Meteorological Organization (WMO). The main objectives of the WCRP are to determine the predictability of climate and to define the effect of human activities on climate. Climate modelling and climate predictions are major components of the World Climate Research Programme.

The recent results of Hamburg´s climate model calculations will be integrated into the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC).

More information on the simulations can be found here: http://www.aldebaran.org/mpi/

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