

# Climate Science using HPC

## IPCC and Climate projections

For each of the four Assessment Reports published by the IPCC (Intergovernmental Panel on Climate Change) in 1990, 1995, 2001 and 2007, extensive greenhouse gas scenario simulations have been carried out by the world's leading climate modeling groups.

The German simulations, which contributed to this effort, were performed on DKRZ's supercomputers, with models developed by the Max Planck Institute for Meteorology. In 2004, 25% of DKRZ's HPC resources (24 Node NEC SX-6 Supercomputer) were exclusively used for the IPCC AR4 simulations with the ECHAM5/MPI-OM model. The atmospheric model component ECHAM5 had a horizontal resolution of approximately 200 km with vertically 31 model levels. The ocean model MPI-OM was used with a regionally varying horizontal resolution between approximately 10 km and 150 km.



Figure 1: Model resolution used for the IPCC Assessment Reports (left: AR4, right: AR5)

The results of these simulations carried out by the MPI-M and the Model and Data Group, were stored in a relational database for further analysis. The data, amounting to 150 Tb, are made available by the World Data Center for Climate (WDCC) and can be accessed on:

<http://ipcc.wdc-climate.de>

## The next IPCC report

The simulations for the next IPCC report, IPCCAR5, are currently carried out. The model has a spatially much higher resolution (T159, horizontal resolution ~80 km) compared with the IPCCAR4 experiments (T63, ~180 km). The ocean model component uses a horizontal grid interval of 0.4 degrees (~45 km). With this increased resolution, physical processes such as strong storms or ocean eddies can be simulated more realistically. Furthermore, MPI-M's new model includes a model component for the land biosphere (JSBACH) as well as an ocean biogeochemistry model (HAMOCC) in order to interactively simulate the full carbon cycle.

The computational effort necessary to carry out the IPCC AR5 simulations with this enhanced and extended model is approximately 60 times the effort needed for the AR4 simulations.

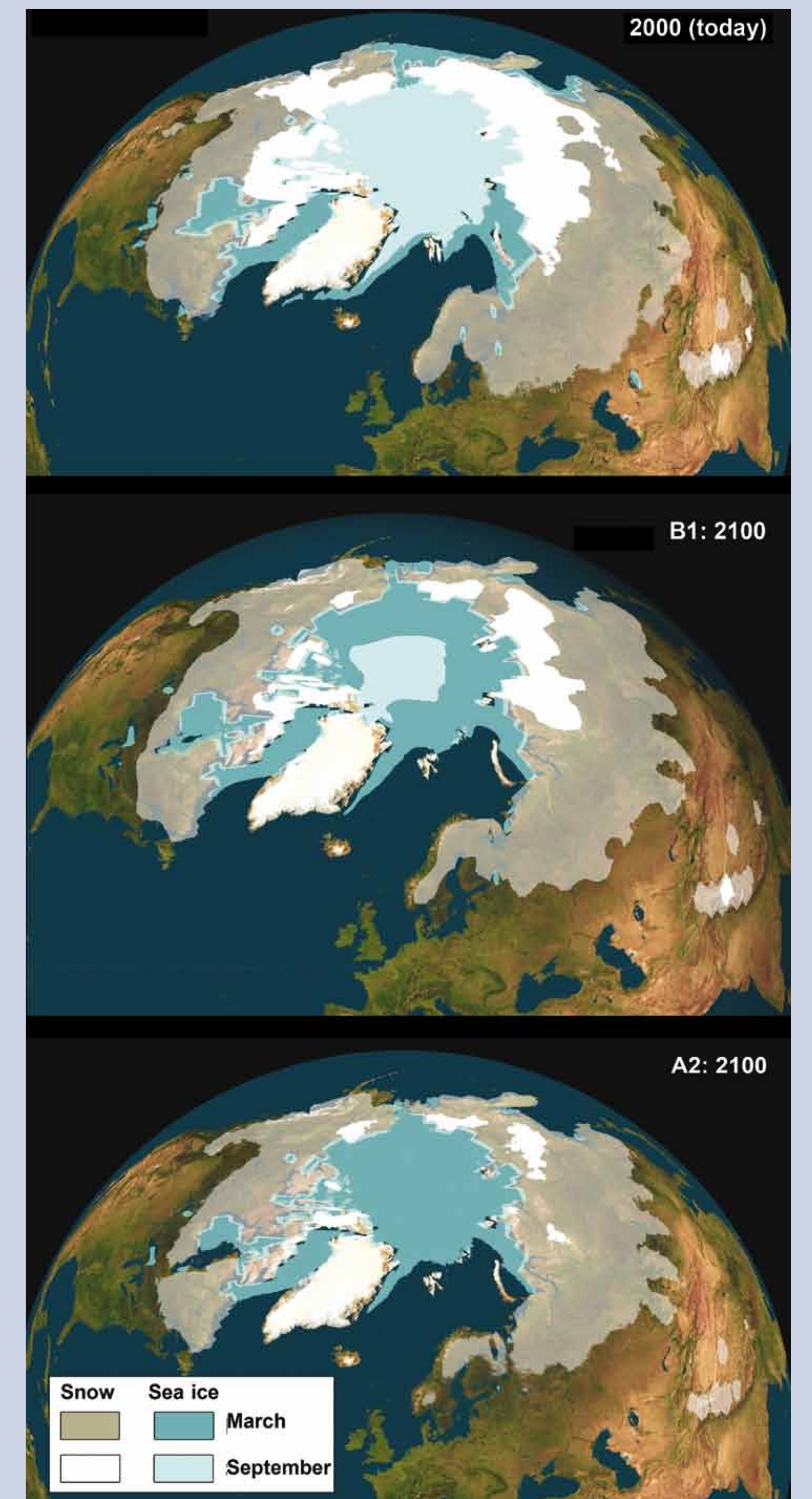


Figure 2: Simulations with ECHAM5/MPI-OM for the IPCC AR4

## The „STORM“ experiment

In the KlimaCampus project „STORM“, long-term climate changes in the ocean and the atmosphere over several centuries are simulated with a particularly high degree of horizontal and vertical resolution. Previous calculations, such as those for the most recent IPCC Report, had to be carried out with much lower resolution. Regional small-scale events such as storms, cyclones or hurricanes could not be simulated at all. In the future, it will also be possible to investigate gravity waves in the atmosphere, mesoscale eddies in the ocean and topographic particularities. For the „STORM“ model calculations, the horizontal resolution of the ocean and the atmosphere is at least 10 km. In the vertical, the atmosphere will be resolved up to 80 km in 500 m layers. This is a great advantage, since – together with global processes – the small scale phenomena determine the effects of greenhouse gases to a large degree.

Figure 3 (left): Simulated temperature and clouds

Figure 4 (right): Circumpolar current in the southern hemisphere

