The German contribution to the CMIP5 (IPCC/AR5)

K. Glushak[1], S. Legutke[1], H.-D. Hollweg[1], J. Wegner[1], H. Widmann[1], K. Fieg[1],
M. Lautenschlager[1], M. Giorgetta[2], J. Jungclaus [2], C. Reick [2]

(1) The German Climate Computing Center (DKRZ), Hamburg, Germany
(2) Max Planck Institute for Meteorology, Hamburg, Germany

CMIP5 overview

The **C**oupled **M**odel **I**ntercomparison **P**roject Phase 5 (CMIP5) is enabling a comprehensive and systematic evaluation and intercomparison of **E**arth **S**ystem **M**odels (ESM), run in a standardised configuration and responding to standardised forcing. The CMIP5 experiments based on the ESM developed at the Max Planck Institute for Meteorology (MPI-ESM) are performed at the DKRZ using the modeling environment IMDI. IMDI was developed at DKRZ and is adapted to the specific needs of MPI-ESM and the requirements given by the CMIP5 protocol. IMDI offers many benefits, such as flexibility in model and experiment configuration. The global climate-change experiments (see scheme on the right) were divided into five groups presented in Fig I-V.

The IMDI model environment

The **IMDI** (**I**ntegrating **M**odel and **D**ata **I**nfrastructure) software provides support for the full suite of workflow steps involved in the performance of experiments with earth system models. The suite starts with the source code retrieval and ends with the visualization of model diagnostic output.

The infrastructure is extendable in order to accommodate new projects, models and platforms, and facilitates the replacement of components in coupled models, while still being low in maintenance. It is highly modularized and thereby gives the user a common 'look & feel' for all activities in the workflow independent of the models or platforms.

All aspects of an experiment configuration are laid down in setup files. Scripts to perform the different experiment tasks (compilation, pre-processing, simulation, monitoring, post-processing, and archiving) are assembled according to the setup files with the help of meta-scripts from fragments of script code (k-shell, python, m4, g-make). The fragments are grouped into sub-directories according to whether they dependent on the project, on the components or models, on the platforms, or on both or none of them.

The particular activities reported here CMIP5 are run on the HPC platforms at the **DKRZ (IBM Power6)**. The models are run on up to 16 nodes (potential parallelism up to 1024 cores). This means that the model simulations start to have a smaller WCT (WallClockTime) than the data post-processing unless the post-processing itself can be done with a certain degree of parallelism. The use of 16 CPUs for the data processing turned out to be sufficient in the CMIP5 experiments with MPI-ESM (condition: WCT of simulation >> WCT of postprocessing.)

The IMDI workflow

The **IMDI** workflow includes model compilation, monitoring, post-processing, as well as archiving of the model raw output data. The monitoring can be done for all workflow steps, graphical monitoring is possible of the model results (see Fig 6.).

	Stand-alone exp.	Fully coupled exp.	Total number of model years	Total amount of raw data
MPI-ESM-LR	7	252	7751	293TB
MPI-ESM-MR	5	67	2803	233TB
MPI-ESM-P		10	3028	114TB
Total	12	329	13582	640TB

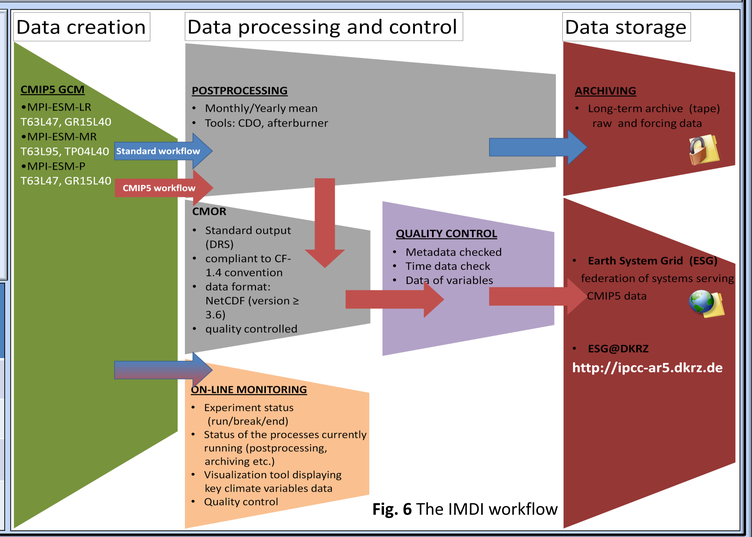
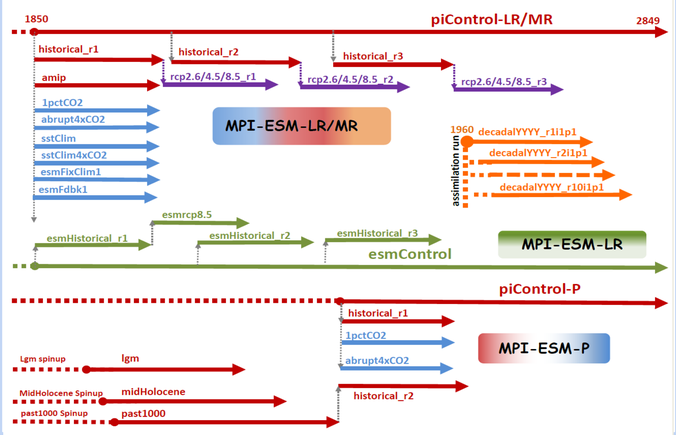


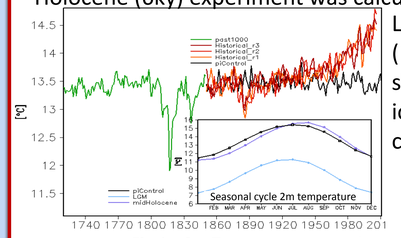
Fig. 6 The IMDI workflow

Schematic overview of CMIP5 experiments



I Baseline simulations for model evaluation and for understanding historical and paleoclimates

To evaluate MPI-ESM against present climate and observed climate changes, control and historical experiments were calculated. To study response to known orbital forcing changes and changes in greenhouse gas concentrations mid-Holocene (6ky) experiment was calculated.



Last-glacial maximum (18kyr) experiment shows the response to ice-age boundary conditions.

Fig.1 2m Temperature annual mean

II Diagnostic experiments for understanding the long-term simulations

The diagnostic experiments estimate both the forcing and some of the important feedbacks in MPI-ESM. There are fixed SST experiments to refine the estimates of forcing and help interpret differences in model response. 1pctCO2 and abrupt4xCO2 experiments studied types of climate changes that occur at the time of doubling or quadrupling of atmospheric CO2 and the range of, and difference in, model responses.

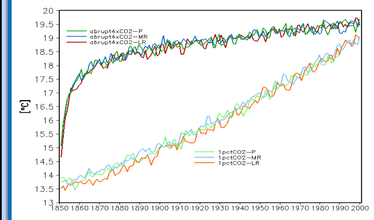


Fig.2 Globally averaged Sea Surface Temperature (SST)

III Decadal prediction (hindcasts and projections)

To explore the degree to which future climate states depend on the initial climate state, focusing in particular on whether we can more accurately predict the actual trajectory of future climate if we initialize the models with at least the observed ocean state.

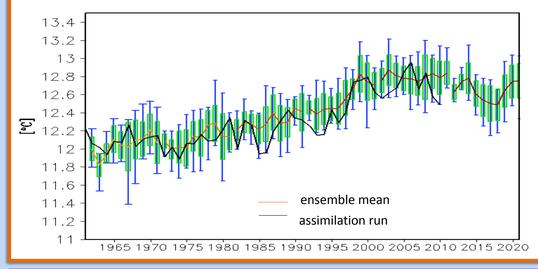


Fig.3 SST in North Atlantic

IV Additional coupled carbon/climate model simulations of the past and future

The carbon cycle diagnostic experiments provide a way of diagnosing the components of the total carbon cycle responses and the roles they play in carbon cycle feedback. Fully coupled carbon/climate model experiments with prescribed anthropogenic CO2 emissions are of considerable interest.

The esmHistorical and esmrcp8.5 main difference to historical experiment are prescribed anthropogenic CO2 emissions, rather than concentrations.

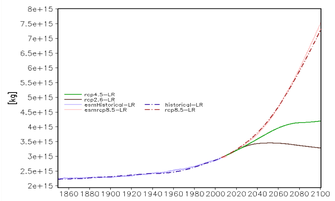


Fig.4 Total atmospheric mass of CO2 (kg)

V Future climate projections

Three prescribed concentration scenarios were calculated. The difference is taking into account various levels of mitigation. "Representative concentration pathways "(RCPs) has begun in year 2006 and continue through the end of year 2100 for two ensemble members (2300 for one ensemble member). Fig. 5 shows September sea-ice distribution in central Arctic at the beginning of simulation and at the end.

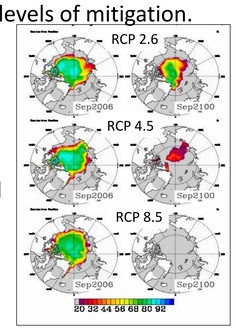


Fig.5 Sea ice concentration (%).

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