Use of OASIS at MPI-M

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Outline

OASIS3

OASIS3 from our perspective

- Pros:
  - large user community
  - quasi standard
  - open source
  - continued support
  - model independent development
- Cons:
  - a lot of legacy heritage
  - site centric, non-standard build system
  - steep initial learning curve
  - cannot be build as an independent library and binary (could be done easily)

Application environment

Our production systems

- NEC SX-6 @ DKRZ, switch off at 28 May
- Sun Linux Cluster - Opteron Shanghai/IB @ DKRZ, MPIM
- IBM AIX Cluster - Power6/IB @ DKRZ (RZG and ECMWF)

Application environment

Our production systems

- NEC SX-6 @ DKRZ, switch off at 28 May
- 192 tasks
- Sun Linux Cluster - Opteron Shanghai/IB @ DKRZ, MPIM
- 2048 tasks
- IBM AIX Cluster - Power6/IB @ DKRZ (RZG and ECMWF)
- 15360 tasks

Application environment

Partner production systems

- SGI Altix - Itanium @ LRZ
- SGI Altix - Xeon @ HLRN
- Cray XT3 @ CSCS
- Cray XT4 @ CSC, CSCS, DMI
- SX-8/9(ES) @ ES, DWD, HLRS, University Kiel
- ...

Planned changes

Replace current setup by OASIS4

- reduce serial part in simulations
- use improved more user-friendly interface
- improves debugging due to cleanly implemented new code base
- no legacy inheritance!

Planned changes

Replace current setup by OASIS4

- reduce serial part in simulations
- use improved more user-friendly interface
- improves debugging due to cleanly implemented new code base
- no legacy inheritance!
- rewrite of our model interfaces in a clean way

Currently used model configurations

ECHAM5/MPI-OM (COSMOS)

- ECHAM5/MPI-OM
- ECHAM5/MPI-OM/HAMOCC
- ECHAM5/JSBACH/MPI-OM/HAMOCC

Note:

We decided to couple only the atmosphere-ocean interface, because otherwise memory requirements are exploding and communications cost is dramatically increasing. This is not caused by OASIS capabilities but hardware restrictions.

The Millennium experiment

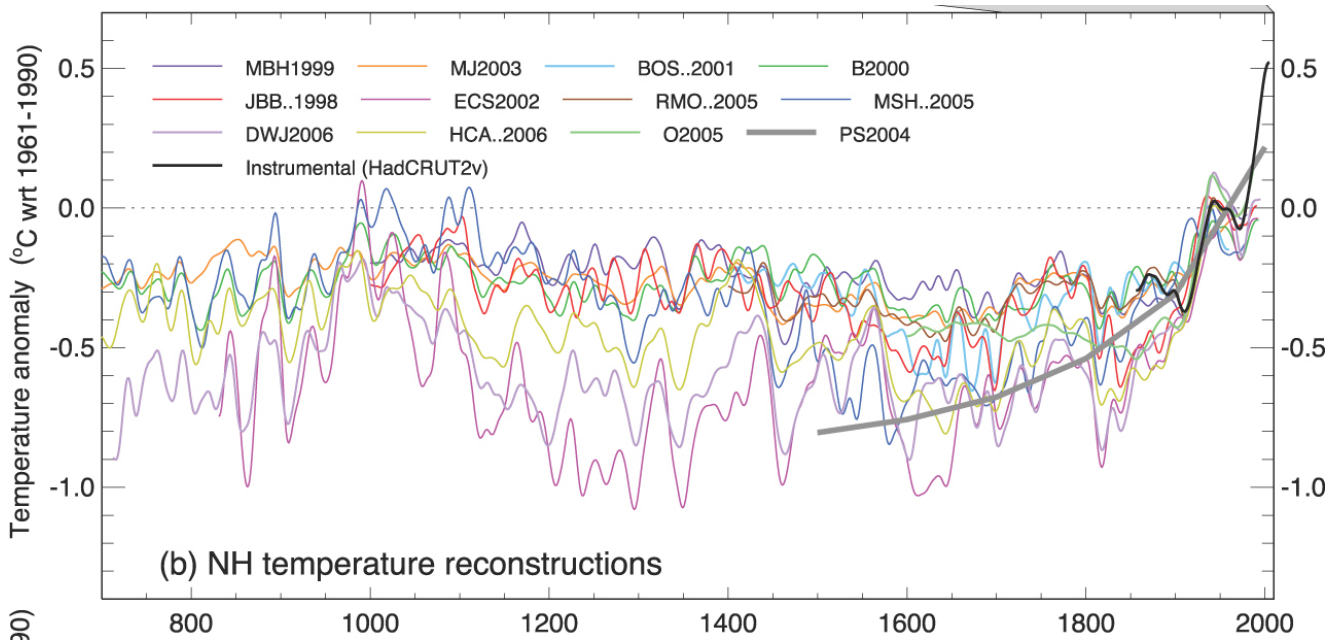
Simulating the last 1000 years

- using latest solar forcing
- using latest available volcanic forcing
- model contains interactive carbon-cycle
- ECHAM5/JSBACH/MPI-OM/HAMOCC

Note:

JSBACH is hosted by ECHAM5 and HAMOCC hosted by MPI-OM

Why do we care on the climate of the last 100 years?



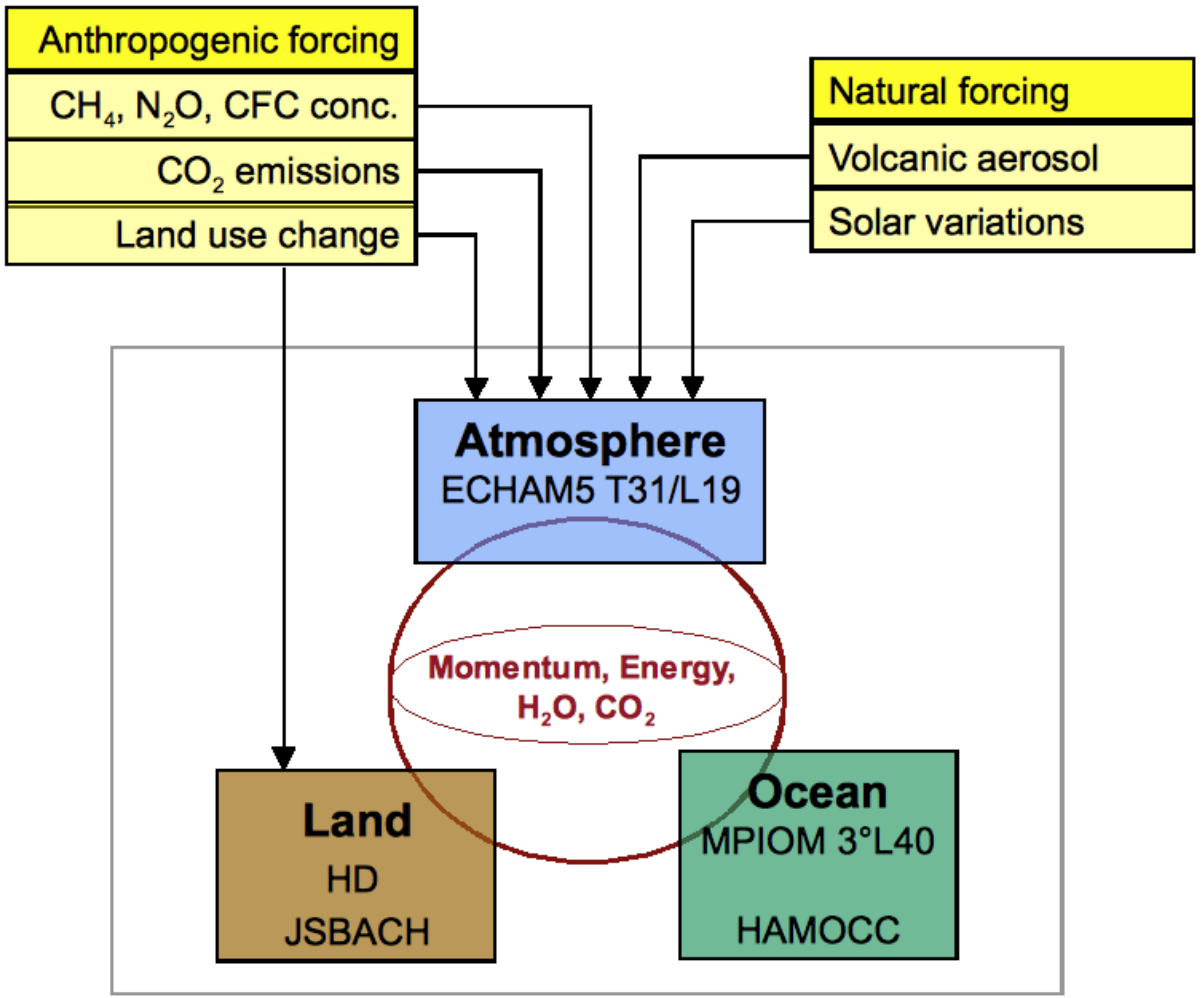
Medieval warm period

Little ice age

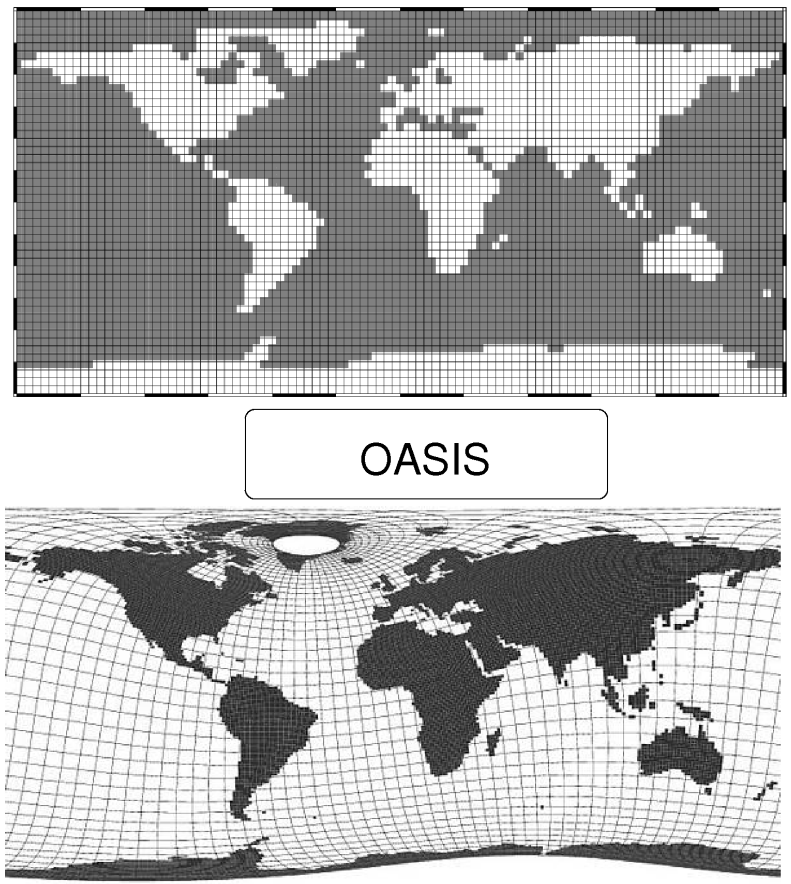
Research questions:

- To what extent are the observed pre-industrial climate variations driven by natural forcings (orbital, solar, volcanic)?
- How did the climate system respond to human activities (land use changes, industrialization)?
- How did the carbon cycle respond to natural and anthropogenic disturbances and how important are carbon-climate feedbacks?
- What are the relations between forcing, climatic states, and variability patterns?
- Can ensemble simulations support the interpretation of proxy-based reconstructions?

The Earth System Model conceptual

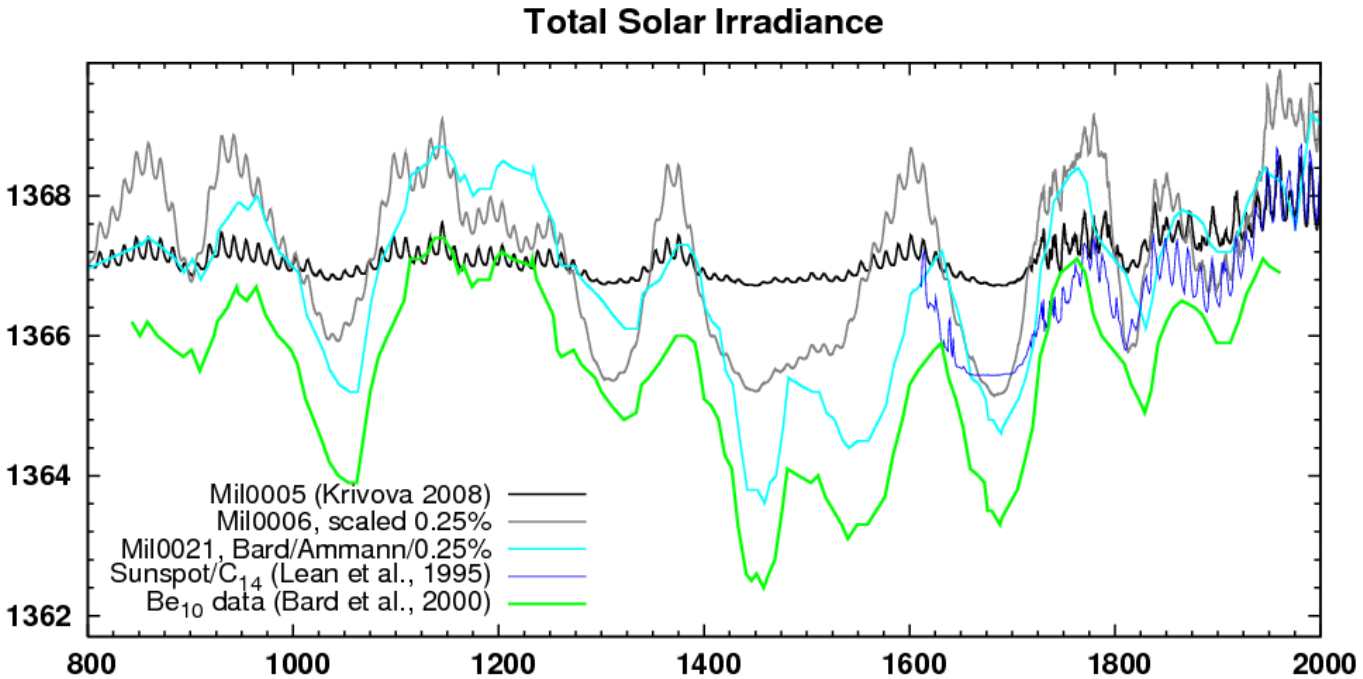


The Earth System Model components



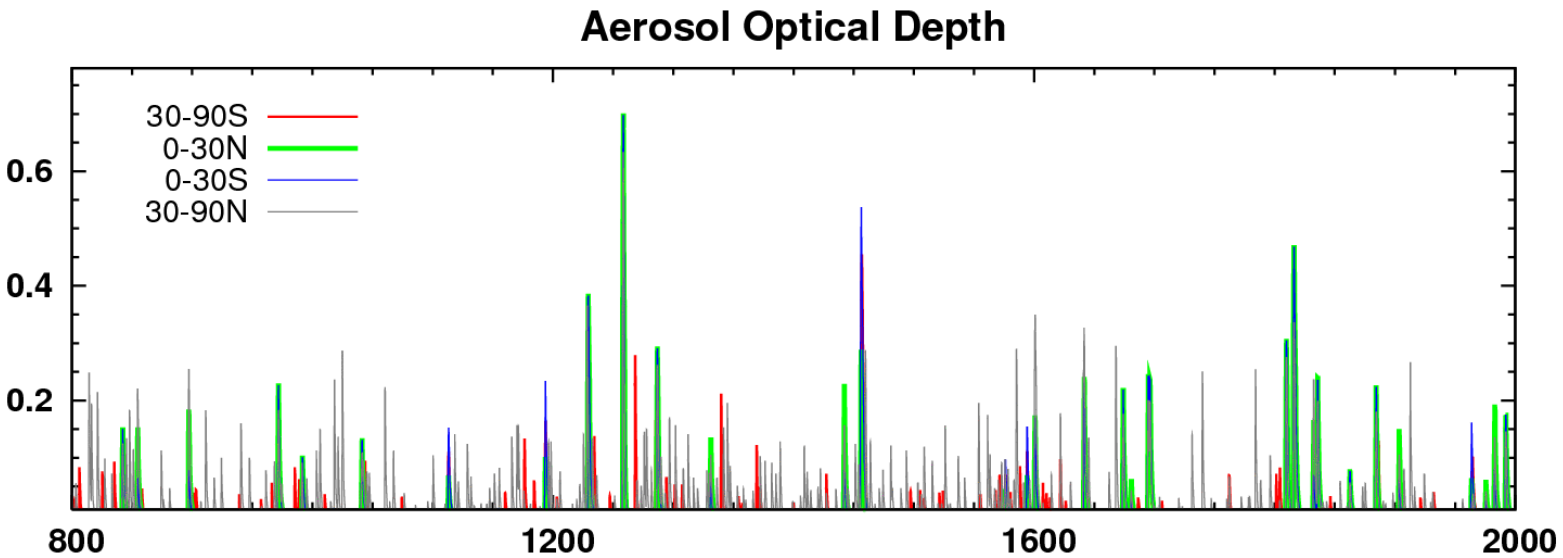
- Atmosphere: ECHAM5, Roeckner et al. 2003, interactive runoff and glacier calving
- Land surface: JSBACH, Raddatz et al. 2007
- OASIS3
- Ocean: MPI-OM, Marsland 2003, C-grid, z-level, partial cells, bi-polar conformal mapping
- Biogeochemistry: HAMOCC, Wetzel 2007

The Earth System Model solar Forcings



- Recent reconsiderations have drastically reduced the range of solar variations from the Maunder Minimum to present to 0.1% of TSI
- "The larger amplitude secular irradiance changes of the initial reconstruction are likely upper limits of long-term solar irradiation variability" (Lean, PAGES Newsletter, 2005)

The Earth System Model volcanic forcings

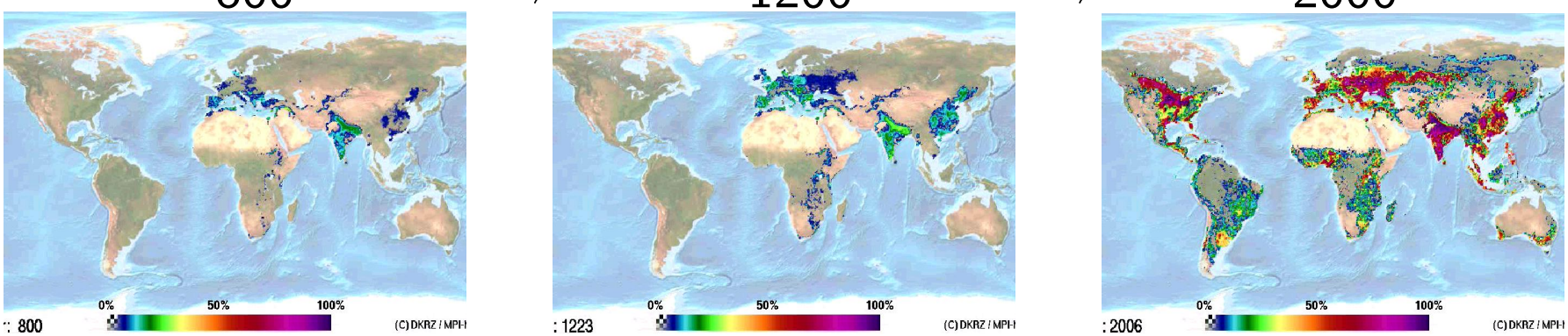


Time dependent information - aerosol optical depth (shown) and effective radius, all data given in latitude bands (Crowley, University of Edinburgh)

The Earth System Model land use change

- Reconstruction of anthropogenic land cover changes for the last millennium (Pongratz, 2009)
- Fractional maps for land use types: crop and pasture combined with potential vegetation map
- Based on existing data (1700-1992) and extended based on population density in earlier times

800 → 1200 → 2000



The Millenium experiment realisations

Exp. ID	Description	Length
mil0001	control run	800-2800
mil0002	land-use-change only (best guess)	800-2100
mil0003	land-use-change only (max. est.)	800-2100
mil0005	solar only	800-2005
mil0006	solar only (scaled to 0.25% amp.)	800-2005
mil0007	as mil002, only biogeochemical influence of land cover changes	800-2100
mil0008	as mil002, plus fossil fuel emmissions	1860-2100
mil0009	volcanoes only	800-2005
mil0010	all forcings exp. 1	800-2005
mil0012	all forcings exp. 2	800-2005
mil0013	all forcings exp. 3	800-2005
mil0014	all forcings exp. 4	800-2005
mil0015	all forcings exp. 5	800-2005

The Millenium experiment realisations

Exp. ID	Description	Length
mil0016	scenario ext. mil0010	2005-2200
mil0017	scenario ext. mil0012	2005-2200
mil0018	scenario ext. mil0013	2005-2200
mil0019	scenario ext. mil0014	2005-2200
mil0020	scenario ext. mil0015	2005-2200
mil0021	0.25% solar forcing	800-2005
mil0023	control run, increased atmospheric vertical resolution	1400-1900
mil0024	effect of stratosphere, UV effect on ozone chemistry	1400-1900
mil0026	0.25% solar forcing	800-2005
mil0027	0.25% solar forcing	800-2005

Millennium Data

- Millennium simulations have been carried out by a consortium formed by the partners of the Community Earth System Modelling Initiative (COSMOS: http://cosmos.enes.org)
- Consortium simulations carried out on the DKRZ HLRE computer are presently being processed and will be made available to the general community later in 2009
- Data distribution is through the CERA database of the Model and Data group (http://www.dkrz.de)
- The Millennium group will ask users to submit proposals for diagnosis sub-projects following the example of PCMDI IPCC AR4 data management

Millennium experiments Results

Results are published soon in articles and presented on conferences.

OASIS3 lessons learned

OASIS3, based on more than 10 years of usage

- used for IPCC simulations and Millennium (tenth of thousands of simulated years)
- stable MPI based software needs to be checked on all available MPI software stacks, because standards are sometimes not sufficiently understood
- clean code allowing for memory checking and debugging is important to speed up developments. As models are hardly following this requirements - it helps, if all libraries do.
- a good development team helps in getting your model running
- developing generic code at the beginning prevents from rewriting later
- check your own interfaces carefully

OASIS4:

OASIS4 in our perspective:

- Pros:
  - large potential user community
  - hopefully standard soon
  - open source
  - continued support
  - model independent development
  - parallel
  - no inherited legacy source
  - clean code for memory checking and debugging
- Cons:
  - is it thread-safe? can it be used in hybrid mode?
  - site centric, non-standard build system
  - steep initial learning curve
  - adaptation to new hardware/software models (accelerators, multicore)

SCRIP:

SCRIP and grids

- properly working for small rectangular grids
- problems with grids at the poles in certain circumstances - algorithmic problem
- hard to analyse and fix
- hardly usable for large grids (eg. remapping of 2" resolution to 6" resolution of arbitraty grids) due to excessive runtime for generating the SCRIP matrices

Future configurations 1

All supported OASIS3 configurations

- ECHAM6/MPIOM
- ECHAM6(Aerosols,Chemistry,Upper atmosphere)/MPIOM

Note:

ECHAM6 contains JSBACH and MPIOM HAMOCC as internal components and will not be denoted extra anymore in the future. This model version is going to be released for IPCC AR5.

Future configurations 2

ICON configurations

- fully unstructured atmosphere and ocean
- arbitrary triangular or hexagonal/pentagonal grids
- currently being extended for any type of orthogonal grid as well supporting eg. the cubed sphere.
- conformal remapped grids
- two way nesting
- direct refined areas

OASIS4 wishlist

What needs to be done?

- active development for finishing the parallelization of the conservative remapping
- more users on using it for debugging purposes
- proactive development for the next two generations of HPC computers instead of post computer deployment adaptation
  - multicore - OpenMP
  - GPUs, Cell, FPGAs - explicit threading, OpenCL offloading
- SCRIP review on mathematical and algorithmic level

Questions ?