TerraFLOPS
Service for earth-system-research
Newsletter
Deutsches Klimarechenzentrum
Modelle & Daten

Issue Number 9 - February 2008

TerraFLOPS
Service für die Erdsystemforschung

20th Anniversary of DKRZ

On 11th November 1987 the German Climate Computing Centre (DKRZ) was founded to provide the computer power for quantitative computation of complex climate processes with sophisticated, realistic models.

Already then, twenty years ago it was recognized that our planet's capacity is limited and that nature's balance is vulnerable. The public and policymakers expected science to provide a reliable basis for climate and environmental protection policy. However, it was realized that the global environment and the climate in particular are extremely complex systems, whose internal dynamics and future evolution can only be understood with the help of extensive numerical simulations.

Today, DKRZ, who provides not only supercomputing but also data services and other associated services, has become an indispensable tool of German climate research and is one of the cornerstones of the Hamburg climate campus and the CLISAP cluster of excellence (see page 7).

"Without DKRZ's supercomputers, data archives and user support we could not accomplish the necessary simulations of the global and increasingly also of the regional climate, for example the German contributions to the IPCC reports", says Jochem Marotzke, scientific director of the computing centre and director of the Max-Planck-Institute for Meteorology.

The first supercomputer purchased by DKRZ was a CRAY 2S, at that time one of the world's most powerful systems. Since then, it has been possible to approximately double the computing power at DKRZ every 18 months and thus keep abreast of technical development (see TerraFLOPS 5).

Hightech Strategy for Climate

The outstanding research infrastructure for model-based simulations of the global climate change and its regional effects provided by DKRZ, complements the new High-Tech-Strategy for climate protection which was presented by the federal minister for education and research, Annette Schavan at the 2nd climate research summit in Berlin, October 16th, 2007.

For further information refer to:
http://www.bmbf.de/pub/hightech_strategie_fuer_klimaschutz.pdf

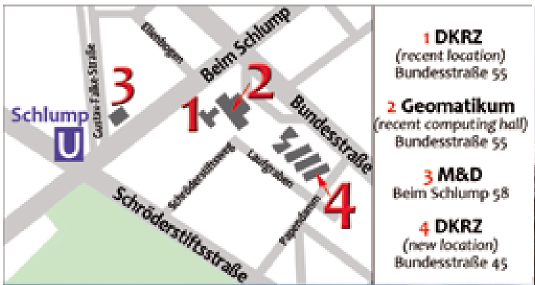

Figure 1: At the end of 2008 DKRZ will move into a new building. View from the Bundestraße to the projected DKRZ building which will not only accommodate the new supercomputer HLRE II but also the offices of DKRZ and M&D employees.
Top left: Map showing the location of the new DKRZ building. Top right: Construction site – the existing building will be fundamentally reconstructed.

In this issue

"Birthday present": Investments into new facility and computers

At the end of 2008 DKRZ will move into a new building, which is funded with 26 million euro by the City of Hamburg (Figure 1). In addition a new high performance computer and a new data archive, being funded by the BMBF with more than 33 million euro will be installed at the new facilities. The new supercomputer, an IBM Power6 system, will exceed the capacity of the existing system approximately by a factor of 60. With a peak performance of more than 140 Teraflop/s (140 trillion floating point operations per second) the computer will again be one of the world-wide largest supercomputers being used for scientific purposes.

The annual operation costs of the centre of approximately six million euro will be borne by the shareholders of DKRZ (see page 8).

[Joachim Biercamp]

HLRE II Facts

At the end of 2008 the new High Performance Computer System for Earth System Research (HLRE II) will be installed in the new building of DKRZ (Figure 1).

HLRE statistics:

- 240 IBM "Power6" Nodes
- 16 Dual core CPUs each, thus altogether 7680 Cores
- 19 GigaFlops/Core, i.e. more than 140 TeraFlops Peak performance
- 120 TeraByte Memory
- 2 PetaByte Disc (additional 3 PetaByte to be installed in 2011)

Users involvement in the HLRE II procurement

The requirements of the DKRZ user group for the new supercomputer were taken into account in the preparation of the request for tender and the selection of a benchmark suite. DKRZ jointly with representatives from IfM Geomar, MPG, University Hamburg, University Hannover, GKSS, DLR and University Cottbus, chaired by Bernadette Fritzsch, evaluated the results and decided on the priority of individual benchmarks. Thereby the present usage profile of NEC SX-6 as well as the future developments were considered. It is expected that the workload of the new computer will consist of larger (and coupled) models requiring an increasing number of processors and at the same time still many moderately parallel applications. From this estimated mix of capability and capacity computing it followed that both - the throughput rate and the single benchmark performance - had to be considered.

The selection and evaluation process for HLRE II as well as DKRZs decision for IBM were reviewed and endorsed by a committee appointed by BMBF. The members of the committee were Al Kellie (NCAR), Walter Zwieflhofer (ECMWF), Gerd Hegering (LRZ, Gauss-Centre), Rupert Klein (PIK, WLA), Detlef Stammer (University Hamburg, WLA), Bernadette Fritzsch (AWI, usergroup).

Important for the users is that not only the hardware platform itself meets the requirements but that also qualified support by the vendor, e.g. for porting of codes to the new platform will be provided. In addition a co-operation of DKRZ with NCAR, ECMWF and the Computer Center Garching, all operating computers of the same architecture is planned. The computer in Garching will already be installed April/May 2008 (i.e. some months prior to DKRZ) and DKRZ users will get access to this machine for the porting of their codes.

[B. Fritzsch, J. Biercamp]

DKRZ Visualisation Server

In 2007, DKRZ installed a new high end visualisation server system ("HP SVA") with the aim to complement the HLRE compute service and data service.

The system is primarily intended for interactive visualisation of model data, especially for challenging applications such as the 3D visualisation of 3D time dependent multivariate data. A client-server solution for remote 3D rendering enables to work interactively with the system via the internet. Also, a new domain specific visualisation software based on "Amira" substantially simplifies the 3D visualisation workflow compared with other solutions.

In January 2008, two introductory courses on the usage of the new system have already been held at DKRZ (Figure 2). Two further courses at GKSS and AWI will be given in the near future. The slides can be found at: ***http://www.dkrz.de/dkrz/workshops/Vis_Introduction_2008_slides***

How to get access to the system: Ask your project administrator to apply for access to "vision" for your account. This can be done by using the usual project administration pages.

For further information or request for additionally courses, please contact Michael Böttinger (***boettinger@dkrz.de***).

[Jana Meyer, Michael Böttinger]

Figure 2: *Introduction to the visualisation system and its usage given by Michael Böttinger.*

Regional Climate Simulations of Climate Local Model (CLM)

- A short summary of the CLM - workshop activities -

In December 2007 the Service Group Adaptation (SGA) organized the "CLM – workshop and contact forum" which was held to present the CLM regional climate simulations performed by Model & Data group. The CLM – workshop and contact forum was addressed to the project partners of the funding priority of 'klima*zwei* – Research for Climate Protection and Protection from Climate Impacts', the CLM – Community as well as other interested scientists and players in practice.

Topics presented on the workshop were the tasks of SGA, the regional model CLM and its history, its configuration and further development. A special focus was set on the quality control of the CLM data in the database and the detailed quality control at the CLM-working group of BTU Cottbus. The use of regional climate model data was explained and useful examples were shown. SGA initiated the workshop and gave advice in understanding, interpretation and use of regional climate model data for the adaptation projects of klima*zwei* and KLIMZUG (Funding priority of the German Federal Ministry of Education and Research, BMBF). Additionally SGA focused on better communication between scientists of different fields and players in practice. During the contact forum there was a lot of time for discussions and questions between approximately 100 scientists and application oriented players. Several posters were prepared by SGA and CLM – Community to present the CLM model, first results of CLM simulations and available observational data of DWD (Deutscher Wetterdienst). Different animations of the CLM – simulations have been shown to illustrate possible future climate changes of 2m-temperature and precipitation. More information about the workshop presentations, posters and animations is found on the SGA homepage:

http://sga.wdc-climate.de

The Climate Local Model calculates the West European climate of recent and future decades from 1960 to 2100 in about 20 km horizontal resolution (0.165 deg.). The CLM simulation of the recent climate and the IPCC scenarios A1B and B1 are directly driven by results from the coupled ocean atmosphere model ECHAM5/MPI-OM. The recent climate is simulated in 3 versions and the IPCC scenarios A1B and B1 are simulated in 2 versions, respectively. One example is shown in Figure 3: the climatological mean (2001-2030) of the annual sum of total precipitation for the A1B_1 scenario. More information about the CLM simulations, the experiment plan and further data products is located on the homepage of SGA (Service Group Adaptation, ***http://sga.wdc-climate.de***). Please choose the topic "CLM regional climate model community runs".

The data of the CLM simulations is provided free of charge to all interested users via the CERA data base. Please contact **sga@dkrz.de** for user access.

[Elke Keup-Thiel]

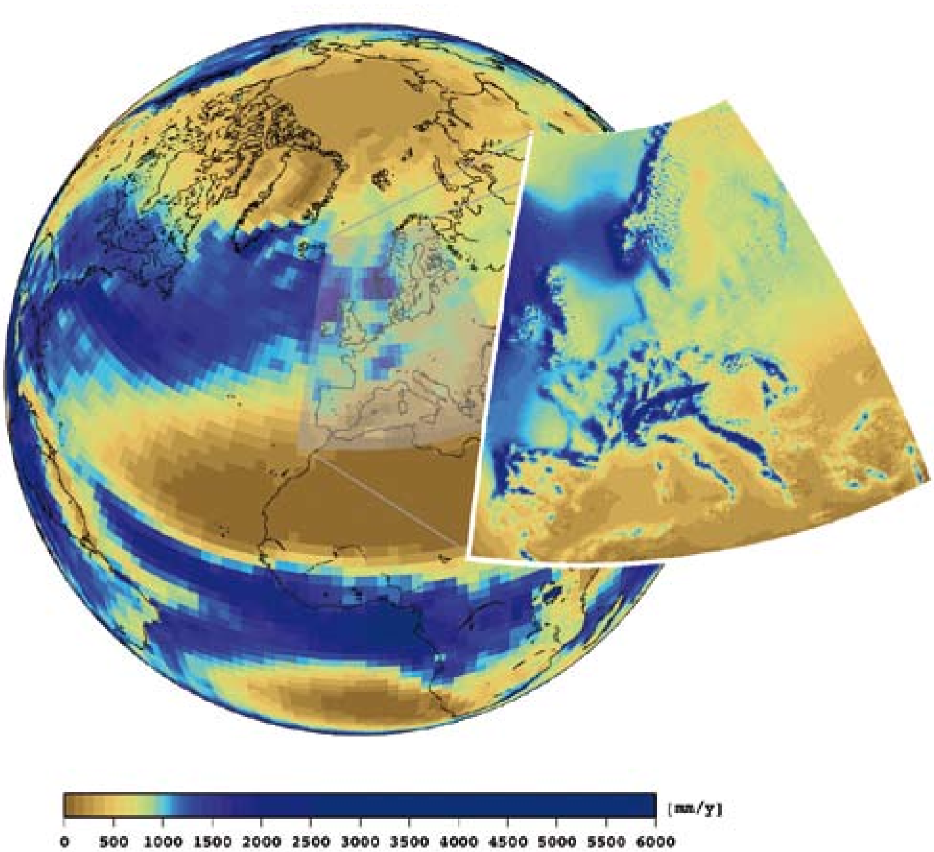

Figure 3: *Shown is the 30-year mean (2001-2030) of the annual sum of total precipitation for the A1B_1 scenario simulated by the global model ECHAM5/MPI-OM and by the regional model CLM for Europe only.*

Global and Regional Ocean Data Syntheses

[Armin Köhl, Nuno Serra, and Detlef Stammer, Institute of Oceanography at the University of Hamburg]

http://www.ifm.uni-hamburg.de

For understanding future or ongoing changes in the World Ocean, synthesis methods are necessary that combine dynamical concepts, as formulated by numerical models, with observed data. This optimal description of the changing circulation and their associated forcing fields using a data assimilation technology is also called reanalysis. Several such reanalyses are currently available but only very few exist that span a time period considerably longer than one decade, which is necessary to address climate relevant problems. Among those, only the GECCO synthesis (Köhl and Stammer, 2007), spanning the region 80°S-80°N on a 1° grid, uses a dynamical consistent assimilation method that does not introduce artificial sources and sinks of momentum, heat or freshwater. This assimilation is based on the MIT model (Adcroft et al., 2002) and uses the adjoint method to bring the trajectory of the model into consistency with all available oceanic observations over the last 50 years. To this end, the initial conditions of the model, the surface forcing fields as well as freshwater fluxes from river runoff and ice sheet melting, become adjusted in an optimal way.

The geographical pattern of surface warming from climate change scenarios reveals a clear focus of the warming at high northern latitudes (IPPC report, 2007). Likewise, largest changes in the ocean are expected to happen in the polar regions, ultimately affecting the water mass formation in the subpolar North Atlantic and thus the thermohaline circulation. These changes will crucially be determined by changes in the cryosphere. In order to properly address the dynamics of these components, the configuration of the GECCO syntheses was modified to additionally include the Arctic and a sea ice model on a slightly finer grid. To be truly global the model now uses a cube sphere topology (GECCO2 hereafter) which is shown in the top part of Figure 4a including a schematic overview of the OpenMPI communications. Since the size of each box is only 90x90 gridpoints, the vector length is too short for this configuration to run efficiently on the NEC SX-6. However, the Sun ***Tornado cluster*** is ideally suited for this configuration since it accommodates relatively small

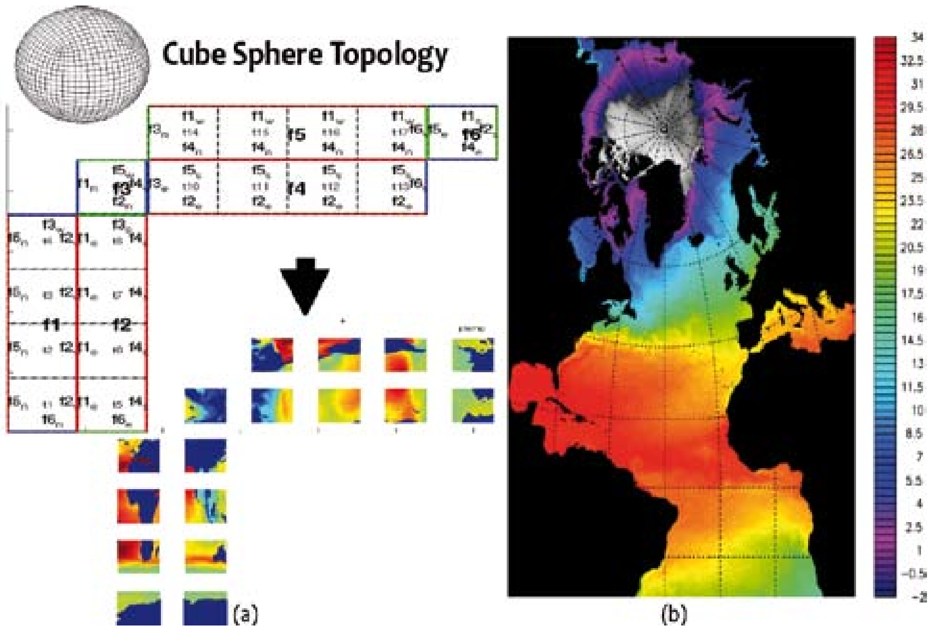

Figure 4: (a) Cube sphere topology including communication and mapping of sea surface temperature on the globe for the GECCO2 set-up. (b) Average sea surface temperature (colour scale) and sea ice concentration (greyscale – values between 0 and 100%) for September 2007 from the NORDATLANTIK 1/6th degree model.

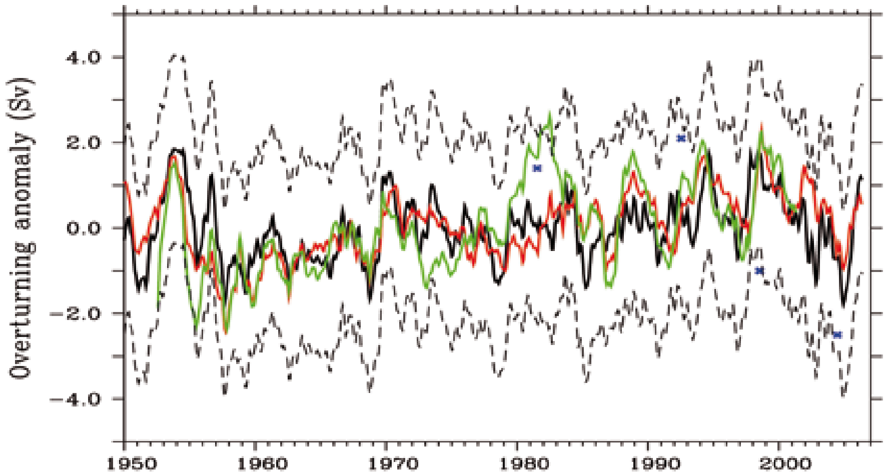

Figure 5: Anomaly of the 1000 meters overturning at 26°N from the 1/6th degree NORDATLANTIK model (black), the 1 degree GECCO2 forward model (red) and the 1 degree GECCO data assimilation (iteration 23) model (green). Dashed lines show one standard deviation of the overturning anomaly in the high resolution model. All quantities are smoothed with a 1 year running average to remove the annual cycle. Blue crosses correspond to the Bryden et al. (2005) estimates of the 1000 m overturning at 25°N.

tile-sizes. Hence, 72 cores can be used without loosing efficiency.

In a parallel higher resolution but regional effort in the framework of the BMBF/CLIVAR project NORDATLANTIK (*http://www.zmaw.de/NORDATLANTIK.105.0.html*), a sea ice-ocean circulation model was set-up with a horizontal resolution of 1/6th of a degree for the Atlantic region north of 30°S including the Nordic Seas and the Arctic Ocean (Figure 4b). Both new models are forced at the surface by fluxes of momentum, heat and freshwater computed using the 1948-2007 NCEP reanalysis atmospheric state and bulk formulae. The bulk formulae and the sea ice model require additional communication and limit, even in this large domain model (750x864x50 grid points), the number of efficiently usable nodes on the NEC SX-6 was limited to three. On the other hand, 120 cores can efficiently be used on the Sun Tornado cluster, resulting in about twice the performance than that on the SX-6.

Both model runs are now being analysed and prepared to initiate the data assimilation procedure that will lead to a synthesis of the circulation over the past 60 years at two different horizontal resolutions. We show here the variability of the 1000 m meridional overturning circulation (MOC) at 26°N over the past 60 years. Three model solutions are here presented (Figure 5): the eddy permitting "NORDATLANTIK" solution (black), the 10 data assimilation GECCO run of Köhl and Stammer (green) and the 1° GECCO2 forward run (red). For comparison, the Bryden et al. (2005), estimates of the same quantity at 25°N are superimposed (blue crosses). The estimates from in-situ data fall within one standard deviation of the NORDATLANTIK model MOC (shown by dashed lines). Computational requirements for state estimation are much larger (about a factor of 100) than for pure forward simulations. Therefore, even though simulating one year of GECCO2 takes only slightly more than 2 hours, a 60 years long estimation is just about to become feasible.

References

Adcroft A. and J.-M. Campin, P. Heimbach, C. Hill and J. Marshall 2002: Mitgcm Release 1, *http://mitgcm.org/sealion*.

Bryden H. L., H. R. Longworth, and S. A. Cunningham, 2005: Slowing of the Atlantic meridional overturning circulation at 25N, Nature, 438, 655-657.

Köhl A. and D. Stammer, 2007: Decadal Sea Level Changes in the 50-Year GECCO Ocean Synthesis, J. Climate, in press.

Linux cluster "Tornado" in action

Since April 27th last year, a Linux-based cluster named ***Tornado*** is available to DKRZ shareholders. The Tornado system comprises 256 compute nodes, each with four processor cores operating at 2.6 GHz, and 5 head nodes, each with 16 processor cores operating at 2.6 GHz. All nodes of the cluster are connected through a double-data-rate Infiniband network, and disk storage is provided by a 130 TB high-performance Lustre filesystem.

The most important climate models of the Max Planck Institute for Meteorology have been ported to the Tornado system, and relative performance estimates for these models running on Tornado compared to Hurrikan (NEC SX-6) are summarized in Table 1. However, tuning and adaptation efforts for the mentioned models are still in progress, and the given performance figures are subject to change. As can be seen from Table 1, each Tornado processor core is considerably weaker than one Hurrikan processor. On the other hand, the Tornado system exhibits better scalability, and thereby enables the number of used processors to be more easily adapted to the problem and/or other objectives.

Table 1: Relative Performance estimates for climate models running on Hurrikan and Tornado.

	Hurrikan	Tornado
ECHAM5	1.00 (8 CPUs)	1.66 (80 cores)
MPI-OM	1.00 (8 CPUs)	0.86 (96 cores)
Coupled Model	1.00 (8 CPUs)	1.38 (68 cores)

As reported on page 2 of this issue, the contract has been signed for the HLRE II system, which is to replace the current Hurrikan. Conceptually, the HLRE II will be similar to the Tornado system, i.e., using scalar processors, cache-based memory systems, and an Infiniband interconnect. Consequently, by adapting performance-sensitive software so as to run efficiently on Tornado, the resulting programs are expected to run efficiently also on the HLRE II. The availability of the Tornado system thus represents an opportunity to embark upon the adaptation and tuning of programs for the HLRE II well *in advance* of its arrival.

From a performance-programming perspective, the main difference between vector supercomputers and scalar supercomputers is that the former have flat, but heavily interleaved memory systems, whereas the latter have multi-level cache-based memory systems. For this reason, efficient use of vector supercomputers requires that the same memory bank is not accessed too frequently in each sufficiently long period of time. Efficient use of scalar supercomputers, on the other hand, requires that only a limited number of memory locations be accessed during each sufficiently long period of time. Performance-promoting programming styles therefore differ noticeably between vector and scalar supercomputers, and adapting programs to run efficiently on Tornado may therefore require more or less extensive source code changes. Further information about the Tornado system itself is available at:

https://tornado-wiki.dkrz.de/

and users who need assistance or advice in adapting their programs are encouraged to contact DKRZ user support (see page 8 for contact details).

[N. Peter Drakenberg]

The Modelling and Data Environment of M&D:

Integrating Modelling and Data Infrastructure (IMDI)

The PRISM project aimed at the establishment of a climate research network in Europe. An important step towards this goal was considered the development of a common, flexible, efficient, portable, and user friendly infrastructure software under standardised coding conventions. Since the end of PRISM, M&D continues to use, maintain, and develop the infrastructure software developed during PRISM with a focus on the integration of data aspects. The 'Integrating Modelling and Data Infrastructure' (IMDI) includes the PRISM 'Standard Compile Environment' (SCE) and the 'Standard Running Environment' (SRE) in a more comprehensive modelling environment offering also graphical experiment monitoring, meta data management, pre- and post-processing of model I/O, as well as archiving and database filling facilities (***http://mad.zmaw.de/imdi***).

A prominent example of use is the dynamical downscaling for Europe of the IPCC AR4 climate projections 20C3M, SRESA1B, and SRESB1 produced with the global climate model ECHAM5/MPI-OM and with the regional climate model CCLM (***http://mad.zmaw.de/projects-at-md/sg-adaptation***). The environment offers the flexibility to run different tasks (e.g. pre-processing of the global input data or post-processing of the CCLM output) synchronously in the same chain as the proper model integration or in separate chains. The experiments can be run in a single computing environment or in a distributed environment (e.g. Linux ia64 nodes at DKRZ and SX-6 node at the HLRS, University Stuttgart). Configuration is by keyword specification. Another example is the COSMOS Earth System model (***http://cosmos.enes.org***). IMDI provides an environment with a common look and feel for a number of different coupled combinations including standalone models.

For more information please contact: ***model@dkrz.de***.

[Stephanie Legutke]

New land use data in CERA

Humans have substantially modified the Earth's land cover, especially by transforming natural ecosystems for use in agriculture. In pre-industrial times, this expansion of managed land was probably the dominant process by which humankind altered the Earth system, but little is known about its extent, timing, and spatial pattern. A new data set developed at the Max Planck Institute for Meteorology has now made progress in this direction by reconstructing spatially explicit changes in global land use and land cover over the last millennium.

The data set is based on published land use maps for the last three centuries. For earlier times, a country-based method is developed that uses population data as a proxy for agricultural activity. With this approach, the extent of permanent cropland and pasture and the resulting changes of natural vegetation are consistently estimated since AD 800 (Figure 6). An area of about 5 million km² is found to be transformed to agriculture between AD 800 and 1700, slightly more to cropland (mainly at the expense of forested area) than to pasture (mainly at the expense of natural grasslands). Historical events such as Black Death in Europe are found to lead to considerable dynamics in land cover change, especially on regional scales.

The reconstruction can be used with global climate and ecosystem models to assess the impact of agricultural activity on the Earth system throughout the last 1200 years. An important application will be in the Community Simulations of the last Millennium (see TerraFLOPS 8). The historical land cover reconstruction is available for scientific use from the CERA database (DOI: 10.1594/WDCC/RECON_LAND_COVER_800-1992).

[Julia Pongratz]

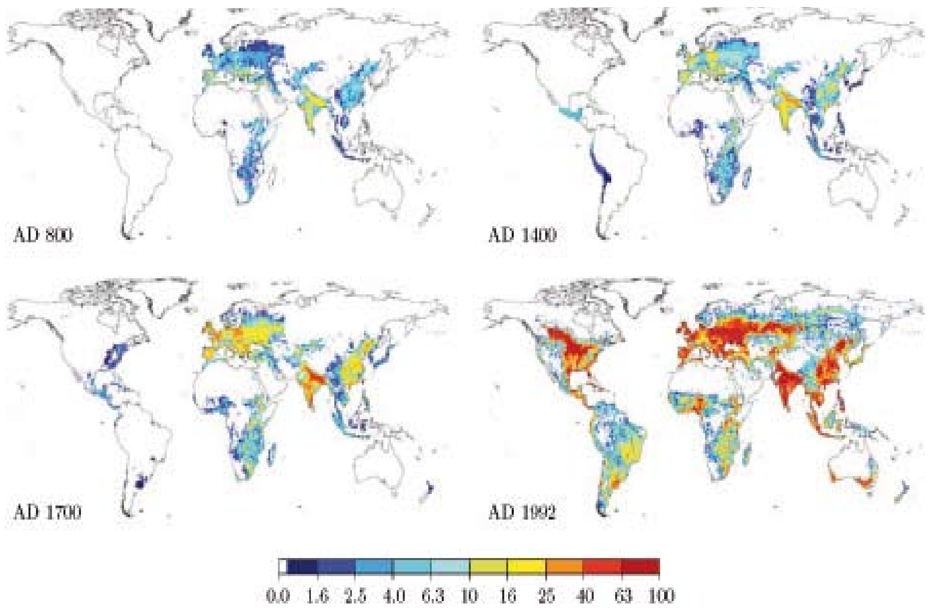

Figure 6: *Global historical cropland area in percent of grid cell.*

New dataset search functionality for the CERA Web-Interface

The CERA user interface has been enhanced with a new search functionality (Figure 7). It offers an easier way to find specific datasets within the CERA database by specifying multiple search keys. Users can now select one or more search values from given lists or even enter their own values to specify predefined parts of the (available) metadata.

List-of-values based search keys are : Topic, Projects, Keywords and Aggregation.

Each list-of-values is generated depending on previously selected keys, thereby assuring that only existing combinations of search values can be selected.

Free text search (including wild cards) is available for the following search keys:

- Contact information (e. g. person, institute)
- General dataset information (e.g. dataset name, summary, quality)
- Temporal Coverage

For best results, it is recommended to use the free text search options prior to the list-of-values based options.

The (dataset) search page is accessible from the CERA portal page at: *http://cera.wdc-climate.de/* ('CERA user interface' -> '*Find datasets*') or at *http://cera-www.dkrz.de/WDCC/ui/findDatasets*.

[Michael Kurtz]

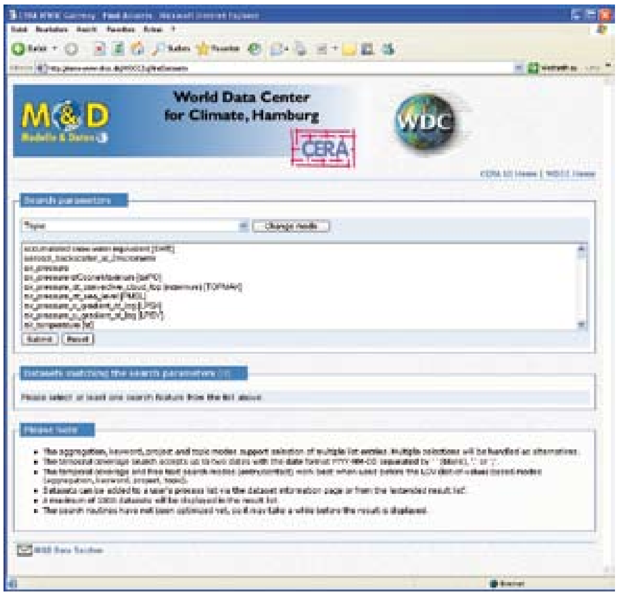

Figure 7: *Screenshot of the new dataset search functionality*

KlimaCampus Hamburg

The University of Hamburg, the Max Planck Institute for Meteorology, the GKSS Research Centre and DKRZ, jointly with the Federal Maritime and Hydrographic Agency and the German National Meteorological Service, successfully applied for an interdisciplinary excellence cluster focussing on Integrated Climate System Analysis and Prediction (CliSAP). The approval of CLiSAP is associated with a grant of 25 million euro by the Federal Government over the next 5 years and further 9 million euro by the City of Hamburg.

CLiSAP focuses on four research areas: the analysis of ongoing and past climate changes, regional consequences of climate change especially for the German coastal regions, weather and climate prognoses over a broad range of space and time scales and beyond the year 2100 and the impact of human activity on the atmosphere.

The Research Areas are supported by research platforms such as DKRZ and Central IT Services, wind tunnel and laboratory equipment, a model development platform and a climate data center.

Further information about CLiSAP is available at: *www.clisap.de* and *www.climacampus.de*

[Jana Meyer]

Call for Consortial Runs

DKRZ, M&D and the scientific steering committee (WLA) welcome new applications for consortial runs (*Konsortialrechnungen*). These are large modeling efforts which typically need up to 25% of DKRZs (considerably increasing, see page 2) computing resources for several months.

These calculations have to accomplish a number of requirements to be approved by WLA:

- The requested calculations are basis for a major research activity in Germany and must be specified in consensus with the related scientific community.
- The suggested numerical model, preferably a community model, must cover some criteria with respect to validation and documentation, the executable version must be included into the M&D model repository and an HLRE optimised code must be available.
- The resulting earth system model data are generally available in the database system of the World Data Centre for Climate (WDC-Climate) just after the calculations and the data quality assessment are completed.

After approval and assignment of HLRE resources the consortial runs will be performed by the responsible scientific institute in cooperation with M&D. Examples of such calculations are the German contribution to the last IPCC assessment report (AR4), the subsequent CLM (regional) climate scenario calculations and the ongoing Millenium-Experiment calculating the climate of the last 1000 years.

A written application should be sent to Michael Lautenschlager (*michael.lautenschlager@zmaw.de*) and Joachim Biercamp (*biercamp@dkrz.de*). The decision on the allocation of resources will be taken by WLA at its annual meeting in summer.

[M. Lautenschlager, J. Biercamp]

News from WLA

Prof. Rupert Klein retired from the WLA Committee. His follower should be appointed at the next WLA meeting. Prof. Detlef Stammer (IfM, University Hamburg) takes over his position in the Executive Board.

[Jana Meyer]

OUR SERVICES

- **HIGH PERFORMANCE IT-RSOURCES**

  Top level computing ressources, archive capacity and access to a 3D visualisation server are available to all interested research groups working on earth system modelling. DKRZs scientific steering committee (WLA) selects admissible projects.

  INFORMATION: ***http://www.dkrz.de/projects***
  EMAIL: ***projects@dkrz.de***
  CONTACT: ***Joachim Biercamp (EXT -314)***

- **SUPPORT FOR USERS:**

  Support for porting models to DKRZ computers, support for model optimisation, visualisation services and general user support to all users.

  INFORMATION: ***http://www.dkrz.de/support***
  EMAIL: ***beratung@dkrz.de***
  CONTACT: ***Help Desk (EXT -275)***

- **LATEST ONLINE INFORMATION:**

  Announcements and latest news regarding DKRZ facilities and services: **http://www.dkrz.de/news** (or **http://www.dkrz.de/news/ann** for registered users).

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Phone: +49 40 41173-334
Email: sekretariat@dkrz.de
Web: http://www.dkrz.de

- **COMMUNITY CLIMATE MODELS:**

  M&D provides numerical models and diagnostic software as well as user support for their application and carries out comprehensive climate model runs.

  INFORMATION: ***http://www.mad.zmaw.de***
  EMAIL: ***model@dkrz.de***
  CONTACT: ***Stephanie Legutke (EXT -104)***

- **DATA SUPPORT:**

  Provision, maintenance and easy access of climate research relevant data of different research groups as well as post-processing tools and the support of users of the climate data base.

  INFORMATION: ***http://www.wdc-climate.de***
  EMAIL: ***data@dkrz.de***
  CONTACT: ***Michael Lautenschlager (EXT -297)***

- **MAILINGLIST:**

  For news regarding M&D, such as announcements of workshops and conferences, new models and datasets, changes in accessing M&D etc. send "***subscribe mad_info***" to ***majordomo@dkrz.de*** .

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