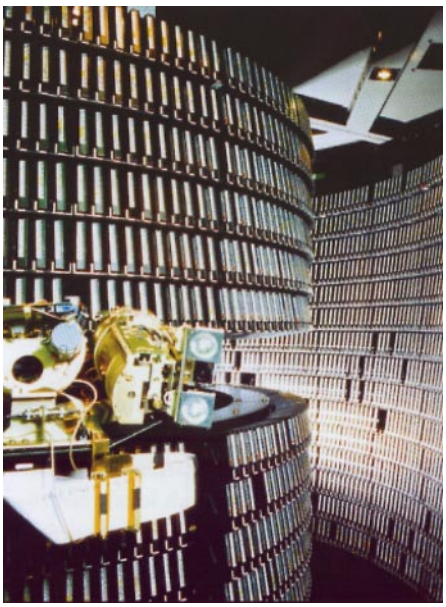
TerraFLOPS
Service for earth-system-research
Newsletter
Deutsches Klimarechenzentrum
Modelle & Daten

Issue Number 1 - January 2002

TerraFLOPS
Service für die Erdsystemforschung

Editorial

You are reading the first edition of **Terra**FLOPS, a newsletter produced for the climate research community. It is released jointly by two institutions, M&D and DKRZ, both located in Hamburg, Germany, working closely together to provide resources and support for earth-system-research. M&D, the „Model and Data Group" is hosted by the Max-Planck-Institut für Meteorologie and is supported by the Federal Ministry for Education and Research (BMBF). It is a service to the scientists running model simulations as well as managing relevant data sets. DKRZ, the „Deutsches Klimarechenzentrum GmbH" provides the necessary high-performant technical resources which are mandatory for state-of-the-art earth-system simulations.



A view into one of DKRZ`s data silos. On page 6 we give an introduction on the CERA Database System developed by M&D which can be used to retrieve data from these archives.

This newsletter will keep the community and interested groups informed about the services offered by these institutions and about their current activities. Most of this information will also become available in the internet in order to provide a detailed and up-to-date information. **Terra**FLOPS will try to draw your attention to special services and to new and important developments. It will also present outstanding examples of scientific results obtained by using the facilities at M&D and DKRZ.

Terra - the first part of the name chosen for our newsletter - refers to the field of research of our customers and reflects the fact that people are increasingly referring to „earth-system-research" rather than climate research. However, as we cannot do experiments with „terra" itself, earth-system research is an extensive computational exercise. Our community needs therefore the highest number of Flops (floating point operations per second) available for civilian use. Thus, by giving the name of **Terra**FLOPS to the successor of the former DKRZ-newsletter GigaFlops we express the hope and expectations that we will also jump from GIGA to TERA in available computing power. We expect to have TeraFlops of sustained performance available in the near future.

In this first edition of **Terra**FLOPS we provide an overview of tasks and services of the newly formed Model and Data Group and we describe the plans of DKRZ to upgrade its compute power and data storage capacity by nearly two orders of magnitude within the next 18 months. We will also introduce the scientific steering committee, called WLA, which will survey the activities of both groups and will guide them in delivering the best possible services to the scientists in Germany and elsewhere.

In the scientific part of the present issue we briefly describe the efforts currently under way to set up a comprehensive system of community models for the earth system to be supported by M&D and DKRZ.

TerraFLOPS will appear four times a year and we intend to make it an interesting and useful source of information for all of you. So please let us know your opinion, criticism, proposals and questions.

[Joachim Biercamp]
[Hans Luthardt]

Content

Introduction

The „Modellbetreuungsgruppe“ was supporting the German climate research community as part of the Deutsches Klimarechenzentrum (DKRZ) for more than 6 years. At one stage the German Ministry for Education and Research (BMBF) considered this funding structure as inappropriate. Now the group is financed in form of an ordinary BMBF project (project leader: Prof. G. Brasseur). The group is attached administratively to the Max-Planck-Institut für Meteorologie (MPIfM). The increased responsibilities of the group are reflected in its new name „Modelle & Daten“.

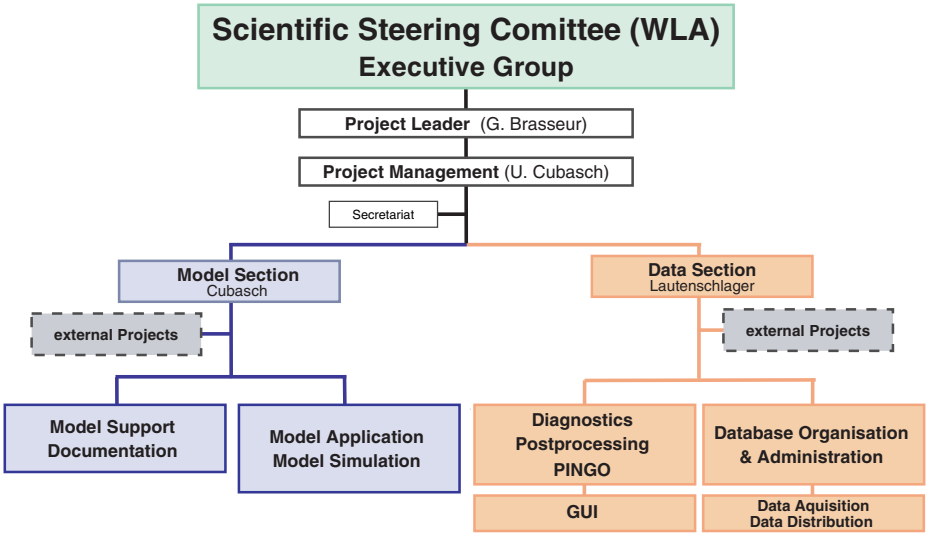
At the same time the German climate research community was given a larger possibility to influence the work of the group: Strategic decisions are taken by a scientific steering committee (wissenschaftlicher Lenkungsausschuss, WLA), whose eight members are recruited from leading climate research institutions and university institutes (see also page 5: „Introducing WLA“).

Objective

The overall objective of the Model and Data group is to develop and maintain an infrastructure which allows to carry out modelling for climate research efficiently.

This overall objective can be split into a number of individual tasks which are dealt with by the M&D-group:

- The provision of numerical models and diagnostic software as well as the support of users in the application of these models and the software.
- The adaptation of these models for new applications (different model regions and resolutions, installation of new model physics/ parameterisation, optimization).
- The development and maintenance of software for the provision of boundary and initial conditions as well as forcing data.
- The maintenance of the models and adaptation of the models to different computing architecture in collaboration with the specific computing centres.
- The preparation of documentation of the models in the form of technical reports, inside the source code and on the WWW.
- The development and maintenance of programs for data processing, diagnostics and visualisation.
- The coupling of models of the different climate subsystems
- The running of large simulations for the climate and climate impact community (consortia simulations)
- The quality control of the simulations during a consortia experiment.
- The presentation of the models and the experiments in workshops and meetings.
- The advice of users in the interpretation of model generated data sets.
- The provision, maintenance and easy access of climate research relevant data of different research groups as well as the support of users of the climate data bank.
- The organisation of workshops, provision of information and educational material about the climate problem, support of the German climate community in international projects and committees in the framework of IPCC, IGBP and WCRP.



The structure of the M&D Group at the MPIfM

Future developments:

The group Modelle & Daten (M&D) will in future support a growing number of scientists in an increasing number of projects and on an increasing number of sites. It will also be engaged in a more European framework. Therefore, mechanisms have to be established which allow to balance the increasing demands and enables a long term planning. The general idea is to create within the context of the EU-project PRISM a standardised modelling system, which is user friendly and allows the scientists to perform their work in an automated way which minimizes the manual intervention by the M&D group.

[Ulrich Cubasch]

The HLRE-System

In August 2001 DKRZ and NEC Corporation signed a contract worth 67 Million DM for delivery, installation and support of a super computer system which is referred to as HLRE (Höchstleistungsrechner für die Erdsystemforschung). The heart of HLRE is the most powerful super computer ever installed by NEC outside of Japan. It will be based on the new SX-6 architecture announced in October 2001. This system is organized into clusters or nodes, each containing 8 vector processors and 64 GByte of shared memory. The nodes are connected via inter node crossbar switches which enable each node to communicate with each other node with the same latency. The system combines the potential for vectorisation, shared memory parallelisation and message passing parallelisation and thus provides great flexibility with regard to performance enhancement of user codes. For more information on SX-6 hardware see

http://www.ess.nec.de/newsroom.

In a first phase starting in February 2002 eight nodes will be installed at DKRZ. The system will be upgraded to 16 nodes in August 2002 and finally to 24 nodes (i.e. 192 processors) in April 2003. The HLRE then will provide about half a TFlop of sustained compute-power with respect to today's typical applications in earth system research.

Since earth system simulations are not only very demanding with respect to compute-power but also very data-intensive the data storage and management concept is an essential integral part of HLRE. From autumn 2002 on the SX-6 super computer and the data-server - consisting of dedicated high performant computers and a farm of robot-served tape-silos - will be coupled via a shared file system allowing for fast and transparent user access to the data archives. In the near future these archives will contain PetaBytes of data. For an efficient usage of these huge archives we need methods for content based retrieval of relevant data as opposed to conventional file name based data access. These methods for „semantic data-management" will be developed in a joint project with M&D.

Extensive rebuilding and renovation of computer rooms and infrastructure are necessary to host the new system in the 15th floor of the Geomatikum in Hamburg. During this transition phase DKRZ provides access to two NEC SX-4 computers which are well suited for migration of codes and data from the old DKRZ servers to the new SX-6 system.

More informations on the HLRE system and the usage of the interim systems can be found at

http://www.dkrz.de/HLRE

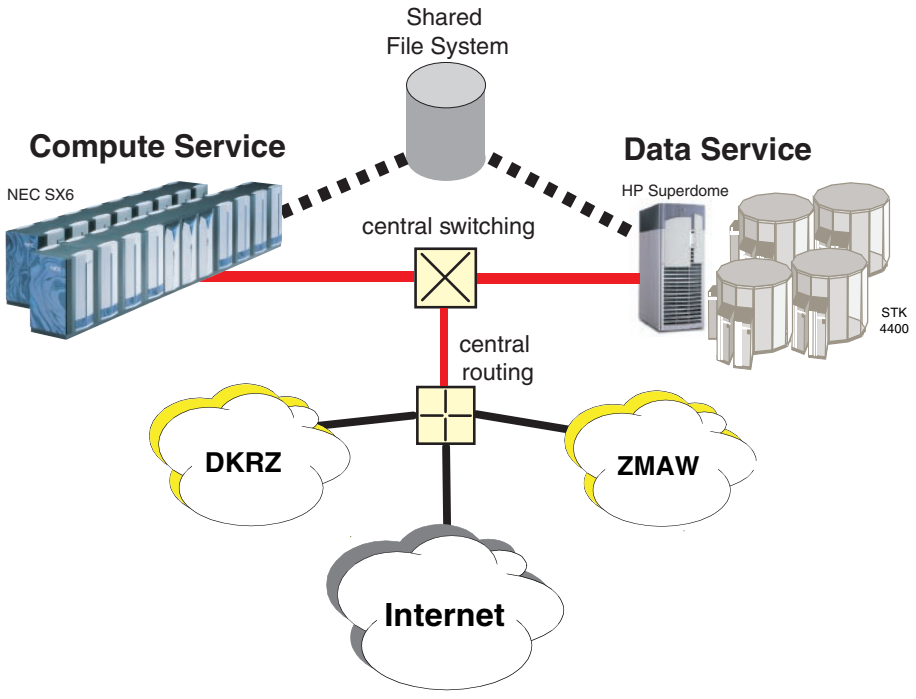
DKRZ

Getting HLRE Resources

50% of the resources of the HLRE will be at the exclusive disposal of DKRZ's shareholders (currently MPG, Uni-HH, GKSS and AWI). The other half of the resources will be made available to the community of earth-system researchers. Scientists working for german institutions and leading projects related to earth system research - having been positively reviewed by an external body or not - may apply directly for resources at DKRZ. The proposals will be reviewed by the scientific steering committee of DKRZ (WLA, see also page 5). For detailed information as well as the appropriate forms see

http://www.dkrz.de/HLRE/Antrag

[Joachim Biercamp]



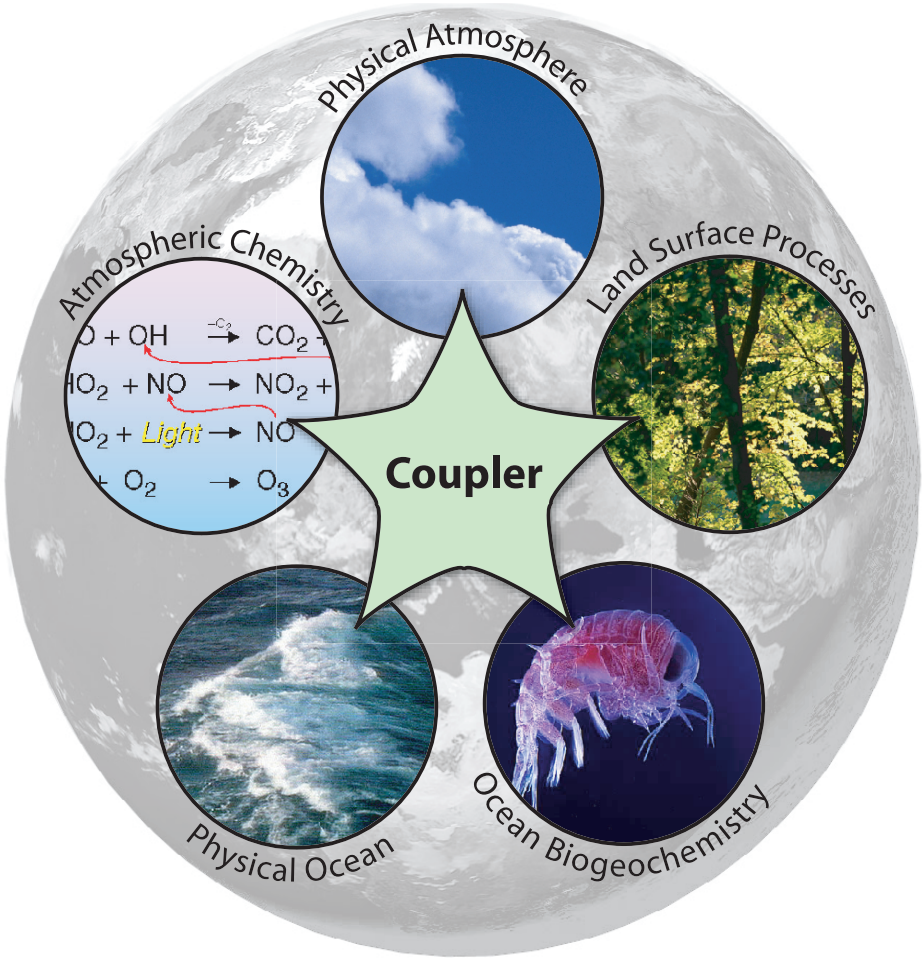
Basic Configuration of HLRE. The shared file system will be introduced in autumn 2002

Towards Community Models

Developing state-of-the-art climate or Earth system models requires dedicated efforts, efforts that cannot be provided any more by individual scientists nor even by single institutions. The development and evaluation of such models depend on the joint expertise of meteorologists, oceanographers, physicists, chemists, biologists, mathematicians, computer engineers, etc. Code architecture has evolved so much in the last years that software specialists need to be deeply involved in the development of such models.

The development of a hierarchy of model components, and the coupling of these components into an integrated model of the Earth system requires that the community in Germany, and more broadly in Europe, works together towards well defined and challenging goals. This has been emphasized by the Wissenschaftlicher Lenkungsausschuss (WLA, see page 5) and it was a central theme of the community-wide meeting held in Bremerhaven in early 2001. The European Network for Earth System Modelling (ENES), and its Programme for Integrated Earth System Modelling (PRISM) are trying to develop facilities towards a better integration of efforts conducted in different countries.

The 140 scientists who met in Bremerhaven reviewed existing models and defined long-term directions regarding the development of global as well as regional climate models. Important outcome of the meeting are the following:



For modelling tasks the earth system is viewed as a variety of subsystems which interact on a broad range of temporal and spatial scales. Efforts are under way to build up a unified framework allowing scientists to easily assemble a number of community models together with their own modules into customized applications.

1. Global Atmosphere Model:

ECHAM-5 developed at the Max-Planck-Institute for Meteorology will soon become the new community model for the global atmosphere, and will be supported by the Model & Data group in Hamburg. In the next 5 years, efforts will be made to implement a new dynamical core in the model, using the grid-point approach of GM, developed at the German Weather Service (DWD).

2. Global Ocean Models:

Both the HOPE-C model, which has been coupled to ECHAM-5, and the MOM model (developed by the Geophysical Fluid Dynamics Laboratory in the US) will be supported by the Model & Data Group.

3. Land-surface model:

The community model for land surface processes will be the LPJ (Lund-Postdam-Jena) model, currently in its completion/ evaluation phase at the Max-Planck-Institute for Biogeochemistry in Jena.

4. Global Atmospheric Chemistry:

The existing chemical-transport models, MOZART and CHEM, currently evaluated at the Max-Planck-Institutes for Meteorology in Hamburg and for Chemistry in Mainz, will be supported by the Model & Data Group.

5. Ocean Biogeochemistry:

Several models with documentation will be made available to the community: ERSM, ERGOM, ECOHAM, and HAMOCC. ➔

The last of these models will be included in HOPE-C, and will be the basis for the coupled atmosphere-ocean model.

6. Regional Atmosphere:

The current community model is REMO. Efforts, however, will be made to adapt the LM approach (developed at DWD) and use it as the dynamical core of the future regional climate model.

7. Regional Ocean:

Currently, several models are available.

8. Model Coupling:

The coupling between the global atmosphere and ocean will be completed through the French OASIS coupler, with the extensions under development within the European PRISM Project.

In addition to these community models, individual models used to address well-defined purposes, and supported by specific institutions will –and should- continue to exist. The rationale for developing general-purpose community models is to provide high quality modelling tools, while avoiding duplication of efforts. Support to the development, evaluation and computer integration of these models will be provided by M&D as well as by DKRZ.

It is important that the community continues to assess how to best reach its scientific objectives such as those stated in national programmes (e.g., AFO-2000 and DEKLIM) and in European initiatives.

[Guy Brasseur]

PRISM:
Programme for ***I***ntegrated Earth ***S***ystem ***M***odelling

Project Coordinators

Guy Brasseur (MPI für Meteorologie, M&D, DKRZ, Hamburg)

Gebrand Komen (Koninklijk Nederlands Meteorologisch Instituut, De Bilt)

Project Director

Reinhard Budich (MPI für Meteorologie, Hamburg)

http://www.mpimet.mpg.de/~budich.reinhard/PRISM

ENES
European ***N***etwork for ***E***arth ***S***ystem Modelling

Project Coordinator
Guy Brasseur

Contact: *budich@dkrz.de*

Introducing WLA

Introducing WLA

In January 2000 a Scientific Steering Committee (Wissenschaftlicher Lenkungsausschuss - WLA) for both, M&D Group and DKRZ has been established. This committee consists of eight members representing the German climate research community.

Two members are chosen by DFG (Deutsche Forschungsgemeinschaft), two are nominated by BMBF (Federal Ministry for Education and Research) and four members are delegated by the shareholders of DKRZ. The present chairman of WLA is Prof. U. Schumann from DLR (Deutsches Zentrum für Luft- und Raumfahrt).

Tasks of the WLA are to define the working packages for M&D with respect to the needs of the German Climate- and Earth System Research groups, to give recommendations for the operation of DKRZ and to allocate 50% of the DKRZ-resources to external projects (see also page 3).

WLA is also involved in the definition of community models for Climate Research to be supported by M&D.

In the first year, the WLA concentrated on the definition and selection of community models, contributed to the selection of the new computer and the selection of user projects. The WLA supports the general strategy of DKRZ and M&D to support top science, to open the computing facilities for demanding projects from the whole Earth Science community, and to increase transparency.

Members of WLA (December 2001)

Executive Committee

Prof. Dr. U. Schumann (DLR, Oberpfaffenhofen)

Prof. Dr. H. v. Storch (GKSS Forschungsz. Geesthacht)

Prof. Dr. J. Sündermann (Universität Hamburg)

Other Members

Prof. Dr. H. Graßl (MPI für Meteorologie, Hamburg)

Prof. Dr. T. Hauf (Universität Hannover)

Prof. Dr. R. Klein (PIK, Postsdam)

Prof. Dr. J. Olbers (AWI, Bremerhaven)

NN (until 2001 Prof. Dr. P. Lemke; Universität Kiel)

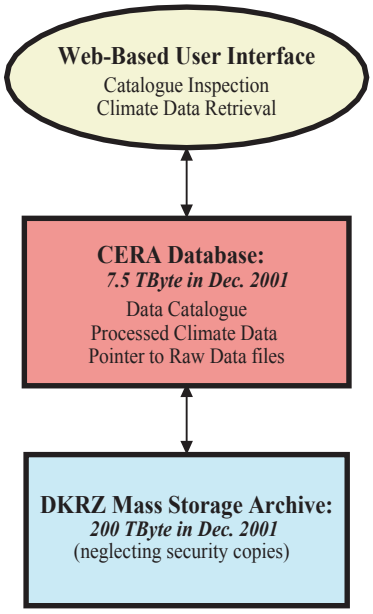
Further informations especially minutes of past meetings can be found at *http://www.mpimet.mpg.de/Depts/MaD/WLA*.

The CERA concept

Huge data archives in Earth system science are produced by climate models and by satellites. Satellite data archives normally supersede the climate model data archive sizes by one order of magnitude. Data handling problems are caused by large amounts of data and by interdisciplinary data usage. Data storage which is not application adapted forces a lot of overhead in data extraction and without additional information it is practically impossible to locate data of interest in the archives. Therefore the organisation of data in files on the operating system level seems not to be sufficient to fit the requirements of access performance and easy to use data extraction.

Archive development in the field of climate modelling is determined by the expected increase in compute power and the related data production rates. The bar chart below presents the expected archive increase at DKRZ for the next five years. Two scenarios for data growth are given related to different data production rates, namely a moderate path (with $f^{3/4}$) and an intense increase (with f^{1}). It is planned that 1/3 of the annual data production is stored directly inside the database system as table entries (CERA files in the bar chart). The total archive is the sum of Unix-files and the CERA files. Security copies are neglected in the given archive estimate.

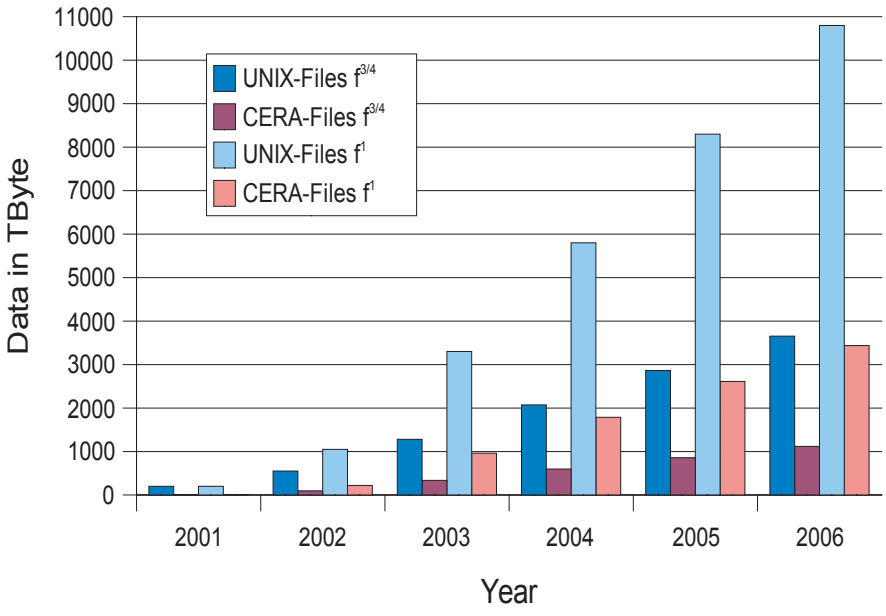
Climate model output is calculated and written in a raw data format. The model raw data time series contains the overall amount of model variables at each time interval. The raw data storage is not application adapted, because climate data are normally requested as time series of separate model variables in order to identify climate variability in terms of temperature, precipitation or wind.



Structure of the CERA database system

Access of surface climatology variables is given as an example to illustrate the daily problems in DKRZ's Unix file archive. Extraction of individual time series from 100 year model raw data infer the de-migration of 1200 files from the mass storage archive. The total number of files increases if the data storage is less than one month per file or the time series of interest increases. From each raw data file the small requested data fraction (less than 1% in the example) has to be extracted. This procedure is as time consuming as the model calculation itself. Extracting 1% of data from 1200 raw data files bears 3000 hours processing time and 400 hours access time. In practice 25% has to be added to the process time according to availability problems with the network and the mass storage system. The overall time to finish the exercise accumulates to half a year.

Both problems in raw data file archives, the missing catalogue information and the missing application adapted data structure, are addressed in the CERA (***C***limate and ***E***nvironmental data ***R***etrieval and ***A***rchiving) database system. The concept of the semantic oriented data handling has been developed as solution of the problems. Data access and storage are formulated within the semantics of the implemented data model. Details of physical data storage are transparent to the user. Data storage within CERA is application adapted. ➔



Expected increase of the DKRZ Data archive ($f^{3/4}$: moderate data increase; f^{1}: linear data increase)

Each data set is completely described in the catalogue and the related time series are stored as table entries inside the database system. Therefore data of interest can be identified, specified and extracted within the CERA data model. No additional data processing is required for extracting 2D - global data records.

The example of access of surface climatology time series is substantially improved by the semantic oriented data access. The four time series of temperature, precipitation and the two wind components are retrieved by one tape mount. The same interface allows for catalogue queries and for data extraction. Selection of parts of the time series is supported, no data processing and no raw data movement is performed. The data access is improved by three orders of magnitude compared to the raw data access. The data movement is reduced by two orders of magnitude because only the requested 1% data are transferred.

The CERA data system can be accessed by a web-based user interface using standard Internet browsers. The URL

http://mad.dkrz.de/java/CeraStart.html

contains (beside the interface itself) additional information about installation, database account and additional help

[Michael Lautenschlager].

News

New Web-Interface for the database CERA.

A new, Java based WWW-interface to the CERA database has been developed at M&D and is ready to use now. This graphical user interface permits direct access to the database, browsing the meta data description of the data included there and a direct download of selected data sets. The current version permits a search for data sets which are associated with given keywords or given projects. Furthermore access is possible to most of the meta data information which are stored in the CERA database.

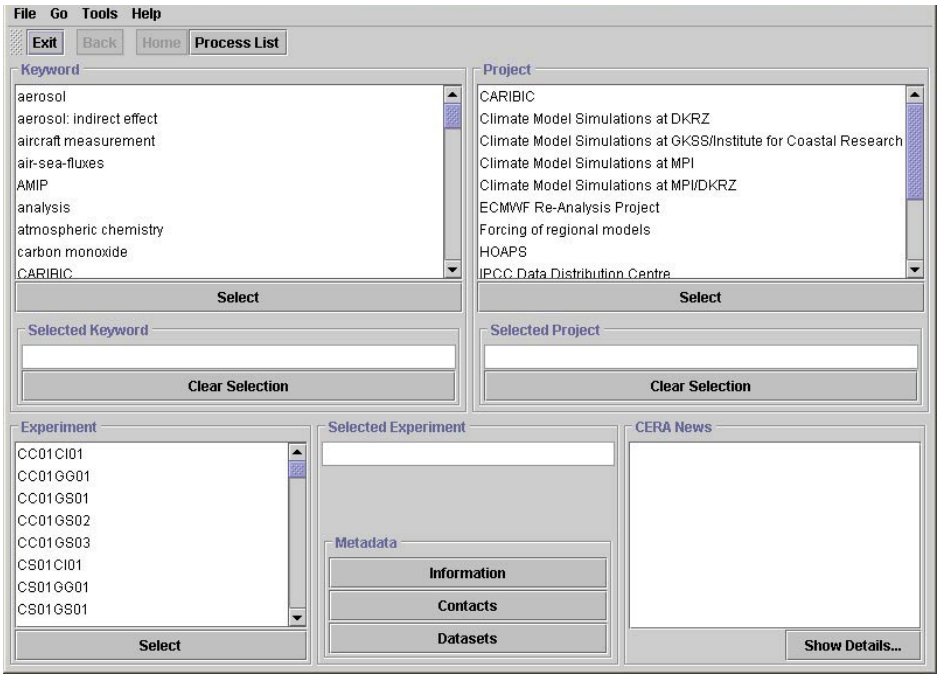
Using this interface requires some preconditions:

- a WWW-Browser with Java-Plugin (Java Version greater than 1.3.0_01) has to be set up.
- the user has to apply an user/password login into the database. The login account is available free of charge after a simple registration procedure.

For more details you may have a look on the appropriate WWW-pages:

http://mad.dkrz.de/java/install.html.

[Hans Luthardtl]



Browse window of the Java based CERA interface

Puplic Version of STOMPP

The STOMPP (Standard Ocean Model PostProcessor) is a post-processor for LSG, E-grid-HOPE and OPYC ocean model data. It was first released in 1995 by Arno Hellbach (DKRZ). Now, we finally have a first public version of the STOMPP that can be downloaded from our Web site:

http://www.mpimet.mpg.de/Depts/MaD/Tools

The program reads, unpacks and selects model data in GRIB format and calculates some derived variables, e.g. vertical velocity, density or meridional circulation. The selected variables are visualised with GrADS.

[Veronika Gayler]

Workshop

On March, 26/27 a national planning workshop on storage and processing of data in the climate data archive of Modelle & Daten and DKRZ will be held in Hamburg.

For more information please refer to

http://www.mpimet.mpg.de/Depts/MaD

=> Aktuelles

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The new DKRZ computer room in the 15th floor of the Geomatikum building in Hamburg, where the SX-6 nodes will be installed in February. A whole series of photos showing the progress of the restructuring work done at our site can be found at http://www.dkrz.de/HLRE/gallery