GRID Perspectives in Earth System Modelling

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GRID Perspectives in Earth System Modelling

Introduction
- Earth System Sciences
- Earth System Modelling
  - GRID related issues

Status
Projects
- Europe:
  - Unicore application by DWD
  - Climateprediction.*
- US: Earth System GRID

European Initiatives
- GMES: GRID type solutions needed
- C³ Grid

Future Perspectives
Earth System Sciences
Earth System Sciences

Problem:

- Time scales range from a few seconds (chemical compounds) to multi century (ocean interior)
- Space scales from local (0 km’s; where you live) to global (0 1000’s km’s, where we live)
- State of the complete system is never known
Earth System Sciences

- Observation
- Theory
- Experiment

courtesy N. Noreiks, L. Bengtsson, MPI

AV/Global0101
Earth System Sciences

Long glacial periods; short interglacials

Periodicity at ca. 100 000 years

Atmos composition and climate are closely coupled

Set points at ca. 200 & 290 ppm

Observational Data Base

Number of Sensors
- Space-born: Increasing
- Earth-born, Ocean: Rather decreasing

Data volume per Sensor
- Dramatically increasing

Demand to link Sensors
- Dramatically increasing

Reanalysis data sets
- Very high volume data sets (10s of TB)
Towards an Earth System Model

Physical Climate System

Atmospheric Physics/Dynamics

Climate Change

Sun

Volcanoes

External Forcing

Stratospheric Chemistry/Dynamics

Ocean Dynamics

Terrestrial Energy/Moisture

Global Moisture

Soil

Terrestrial Ecosystems

Marine Biogeochemistry

Tropospheric Chemistry

Biogeochemical Systems

Pollutants/Greenhouse Gases

Water

Greenhouse Gases

Land Use

Human Activities

Earth System Sciences
Earth System Sciences

- High degree of complexity in all processes
- High number of processes
- High number of interfaces
Earth System Sciences
Earth System Modelling

=> Numerical Weather Prediction
Earth System Modelling

courtesy N. Noreiks, L. Bengtsson, MPI
Earth System Modelling

Model subsystems

Atmosphere

Ocean

Sea Ice

Biogeochemistry

Ocean

Land Surfaces

Regional Climate

Atmospheric Chemistry
Earth System Modelling

Atmosphere

Atmospheric Chemistry

Ocean

Sea Ice

Coupler

Land Surface

Regional Climate

Ocean Biogeochemistry
Earth System Modelling

First “Complete” ESMs are now configured
- General Circulation Models as test cases
- Models of reduced complexity state of the art

Reduce uncertainty: Use
- Ensembles,
- Multi Model –,
- Multi Site – Configurations
Data Storage @ DKRZ
Earth System Modelling

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Reduce uncertainty: Use
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Data volumes increase above all measures: many Petabyte archives by mid decade
Earth System Sciences

GRID related issues:

Observations and there derivatives, i.e. data processing:
-> Go GRID <-

Theory/Modelling:
- Coupled models are -> not apt for GRID <-
  - Very high demand on low latencies, bandwidth
  - Difficult to realize even within a single machine
  - Very communication intense

Complete experiments and there evaluation:
-> GRID based solution environments seem to be promising
GRID Perspectives in ESM: Projects

- Meteo-Grid
- ClimatePrediction.*
- Earth System Grid
- GMES
- C³Grid
Meteo-GRID

Idea: Your individual weather forecast using the HPC-NWP model LM of DWD

- Manchester CSAR SGI
- Lugano CSCS NEC
- Offenbach DWD IBM and Cray
- Paris IDRIS IBM

Unicore based

Fig. 3.3.3 Schematic illustration of the information and data flow within Meteo-GRID (3).
Meteo-GRID

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Unicore based

Problems:
- Who pays?
- How?
1.) ClimatePrediction.net
2.) ClimatePrediction.eu

1.) Running, 2.) Planned

1.) A low resolution atmosphere model + slab ocean on ten thousands of PCs
2.) 4 AOGCMS in different resolutions on ten thousands of PCs, + Cluster computing

Both:
- Comparable to seti@home
- Vary parameters to decrease uncertainty
- GRID approaches to distribution, data analysis and visualisation
Earth System Grid

The Earth System Grid (ESG) integrates supercomputers with large-scale data and analysis servers located at numerous national labs and research centers to create a powerful environment for next generation climate research.

ESG Collaborators

Argonne National Laboratory
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
National Center for Atmospheric Research
Oak Ridge National Laboratory
University of Southern California/Information Sciences Institute

Funded by the U.S. Department of Energy (DOE)
Earth System Grid
EU-Project GMES

Global Monitoring for Environment and Security
Partners: EC, EEA, ESA, Eumetsat and others
Integration of
- Environmental Data
- Earth System Models, incl. human dimension
- Assimilation
... to provide relevant information to policy makers and the public

Problems:
- Distribution of information and data
- Integration of data into even higher-volume data sets
- Short resources in emergency cases, fast resource sharing
- Short term establishment of virtual organizations
C³ Grid

- Collaborative Climate Community Data and Processing Grid
- Access to distributed data archives
- Efficient distributed data processing
- Inter-institutional data exchange
  - Metadirectories
  - Effective access
  - Integrated analysis tools
  - Replicates
  - Scheduling
  - Resource Brokers
C³ Grid

Bestehende Ressourcen der Institute

Lokale Ressourcen-Schnittstellen bei den Instituten

Verteilte Grid-Infrastruktur

Nutzer-Schnittstelle

Archiv-Daten

Metadaten

Archiv-Anbindung

Pre-Processing

Nutzer-Module

Informations-Dienst

Daten-Transfer Dienst

Daten-Management-Dienst

Job-Management-Dienst

API

GUI

Verteilte Processing Ressourcen

Daten

Job

Nutzer
C³ Grid

Collaborative Climate Community Data and Processing Grid

Access to distributed data archives

Efficient distributed data processing

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Teil der deutschen D-Grid-Initiative
Future Perspectives

Variations of the Earth’s surface temperature: year 1000 to year 2100

Departures in temperature in °C (from the 1990 value)

Observations, Northern Hemisphere proxy data

Global instrumental observations

Projections

Several models at SRES envelope

Bars show the range of year 2100 produced by several models

Scenarios

A1B
A1F
A1T
A2T
A2
B1
B2
1890a

SYR - FIGURE 9-1b

IPCC
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
Future Perspectives

For ESM:

Issues:
- Data
- QoS on the network
- “Sociology”

Non-Issues:
- “Meta-computing”

Ensemble runs (trivially parallel) might become an issue

Education is key
Future Perspectives

Germany is lagging behind
See US and UK initiatives resulting in a considerable competency gap for Germany
D-GRID initiative deserves full support, especially by the industry
Standardization and “Sociology” are key
!!! Danke !!!

??? Fragen ???

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