

# The Earth System Grid (ESG)

PI's: Ian Foster (ANL), Dean Williams (PCMDI), &  
Don Middleton (presenting), NCAR/SCD

**On Behalf of the ESG Team**

DOE SciDAC PI Meeting

Napa, Ca.

March 10-11, 2003



# The Earth System Grid

<http://www.earthsystemgrid.org>

- U.S. DOE SciDAC funded R&D effort
- Build an “Earth System Grid” that enables management, discovery, distributed access, processing, & analysis of distributed terascale climate research data
- A “Collaboratory Pilot Project”
- Build upon ESG-I, Globus Toolkit™, DataGrid technologies, and *deploy*
- Potential broad application to other areas



The Earth System Grid



# ESG Team

- ANL
  - Ian Foster (PI)
  - Veronika Nefedova
  - (John Bresenhan)
  - (Bill Allcock)
- LBNL
  - Arie Shoshani
  - Alex Sim
- ORNL
  - David Bernholdt
  - Kasidit Chanchio
  - Line Pouchard
- LLNL/PCMDI
  - Bob Drach
  - Dean Williams (PI)
- USC/ISI
  - Anne Chervenak
  - Carl Kesselman
  - (Laura Perlman)
- NCAR
  - David Brown
  - Luca Cinquini
  - Peter Fox
  - Jose Garcia
  - Don Middleton (PI)
  - Gary Strand



NCAR





## Primary ESG Servers

Mass storage,  
disk cache,  
and computation



Web and applications-  
based access to  
management, discovery,  
analysis, and  
visualization

**NCAR:** Climate  
change  
prediction and  
data archive

**LBNL/NERSC:**  
Climate  
data archive

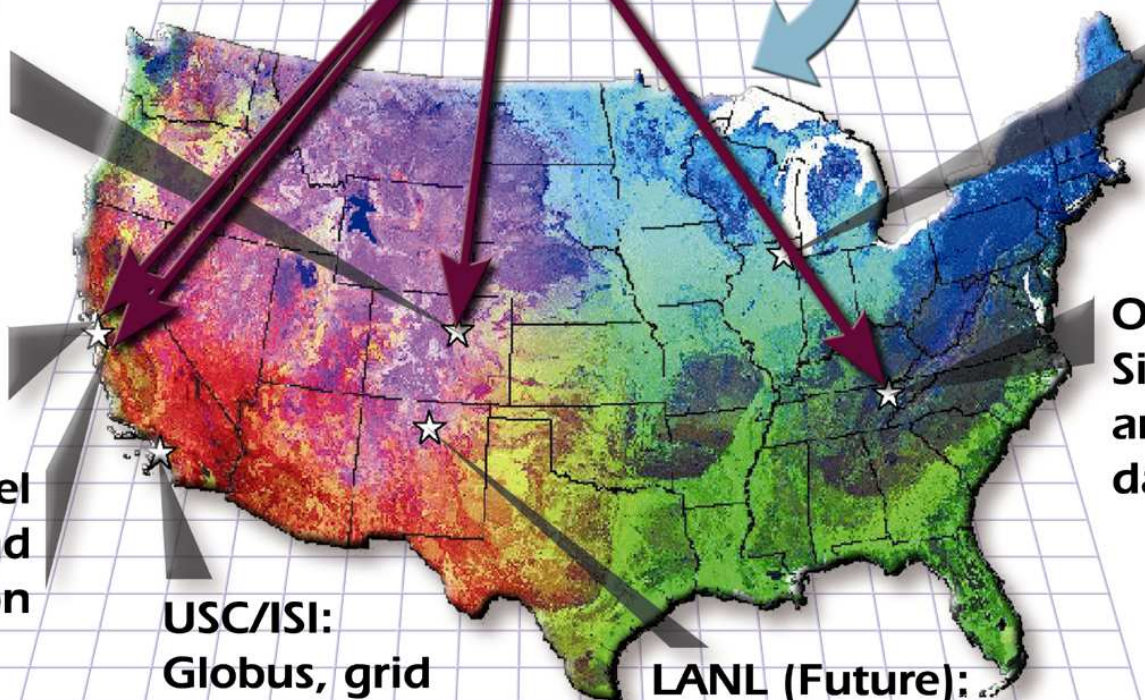
**LLNL:** Model  
diagnostics and  
inter-comparison

**USC/ISI:**  
Globus, grid  
applications, and  
metadatabases

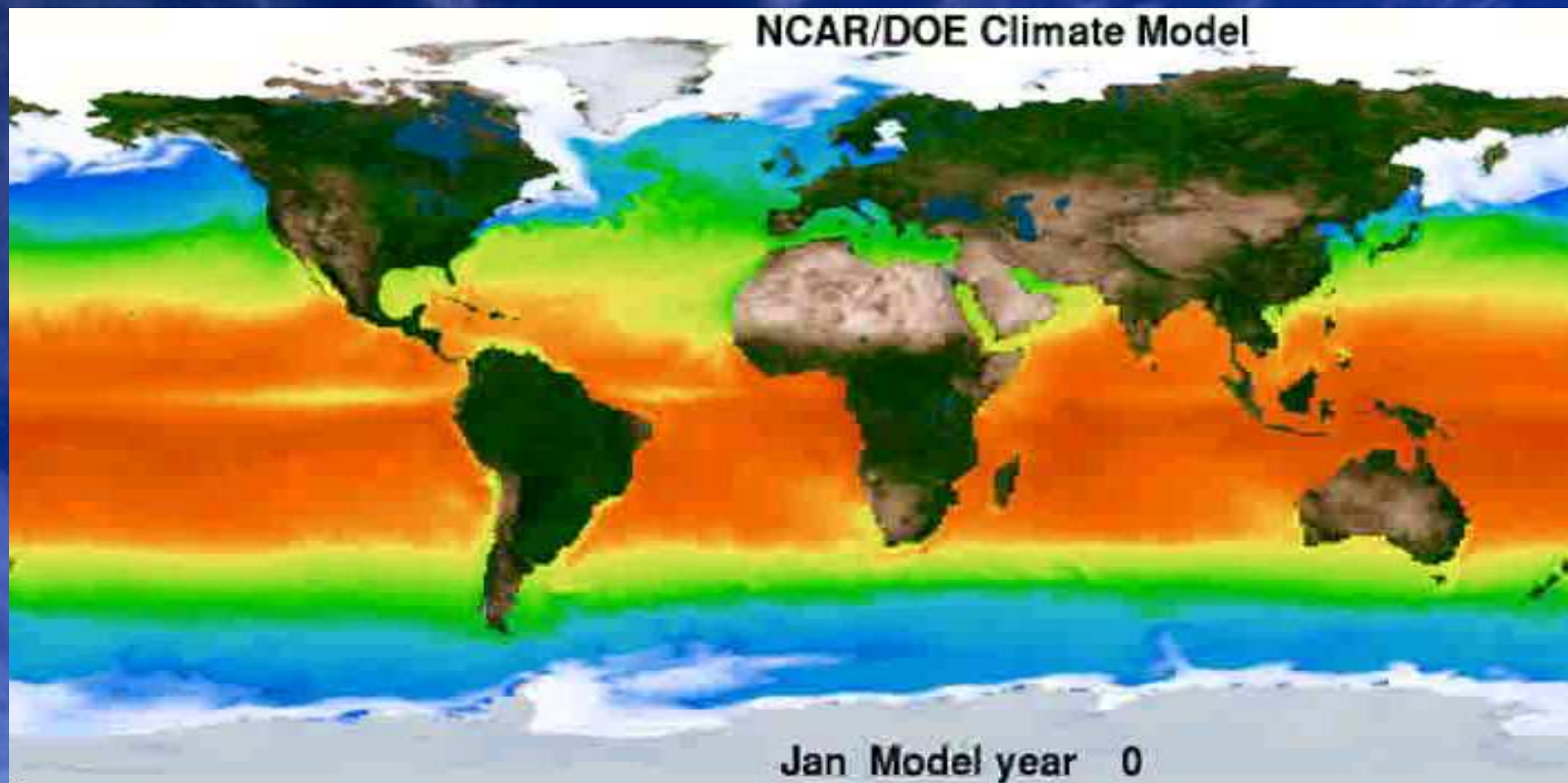
**LANL (Future):**  
Climate and ocean  
data archive

**ANL:**  
Globus  
and grid  
applications

**ORNL:**  
Simulation  
and climate  
data archive



# A Global Coupled Climate Model



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Scientific Discovery  
through Advanced  
Computing



# Baseline Numbers

- T42 CCSM (current, 280km)
  - 7.5GB/yr, 100 years -> .75TB
- T85 CCSM (140km)
  - 29GB/yr, 100 years -> 2.9TB
- T170 CCSM (70km)
  - 110GB/yr, 100 years -> 11TB



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# Capacity-related Improvements

Increased turnaround, model development, ensemble of runs

***Increase by a factor of 10, linear data***

- Current T42 CCSM

- 7.5GB/yr, 100 years  $\rightarrow .75\text{TB} * 10 = 7.5\text{TB}$

The ESG logo features a stylized globe with a grid pattern, set against a dark background. The letters "ESG" are prominently displayed in a white, serif font to the right of the globe.

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The logo for "Scientific Discovery through Advanced Computing" features a circular, multi-colored pattern resembling a stylized flower or a complex network, with the text "Scientific Discovery through Advanced Computing" written in a white, sans-serif font to its right.

Scientific Discovery  
through Advanced  
Computing

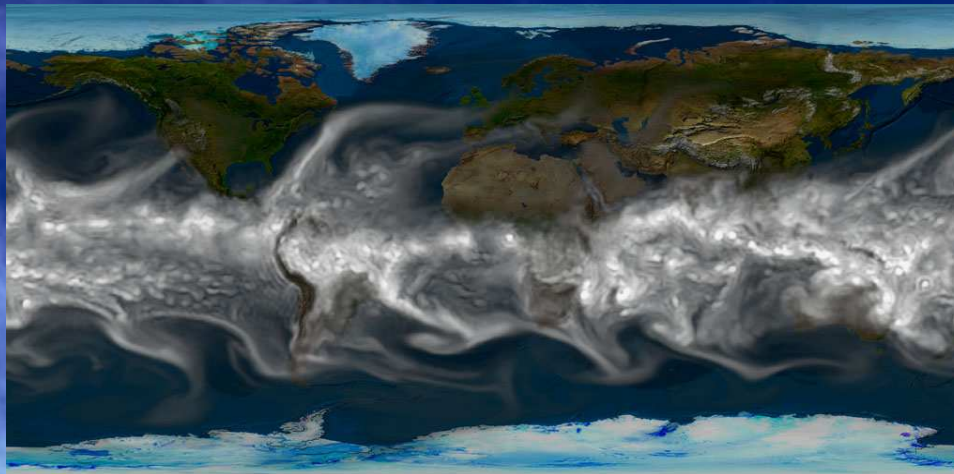
# Capability-related Improvements

Spatial Resolution: T42 -> T85 -> T170

***Increase by factor of ~ 10-20, linear data***

Temporal Resolution: Study diurnal cycle, 3 hour data

***Increase by factor of ~ 4, linear data***



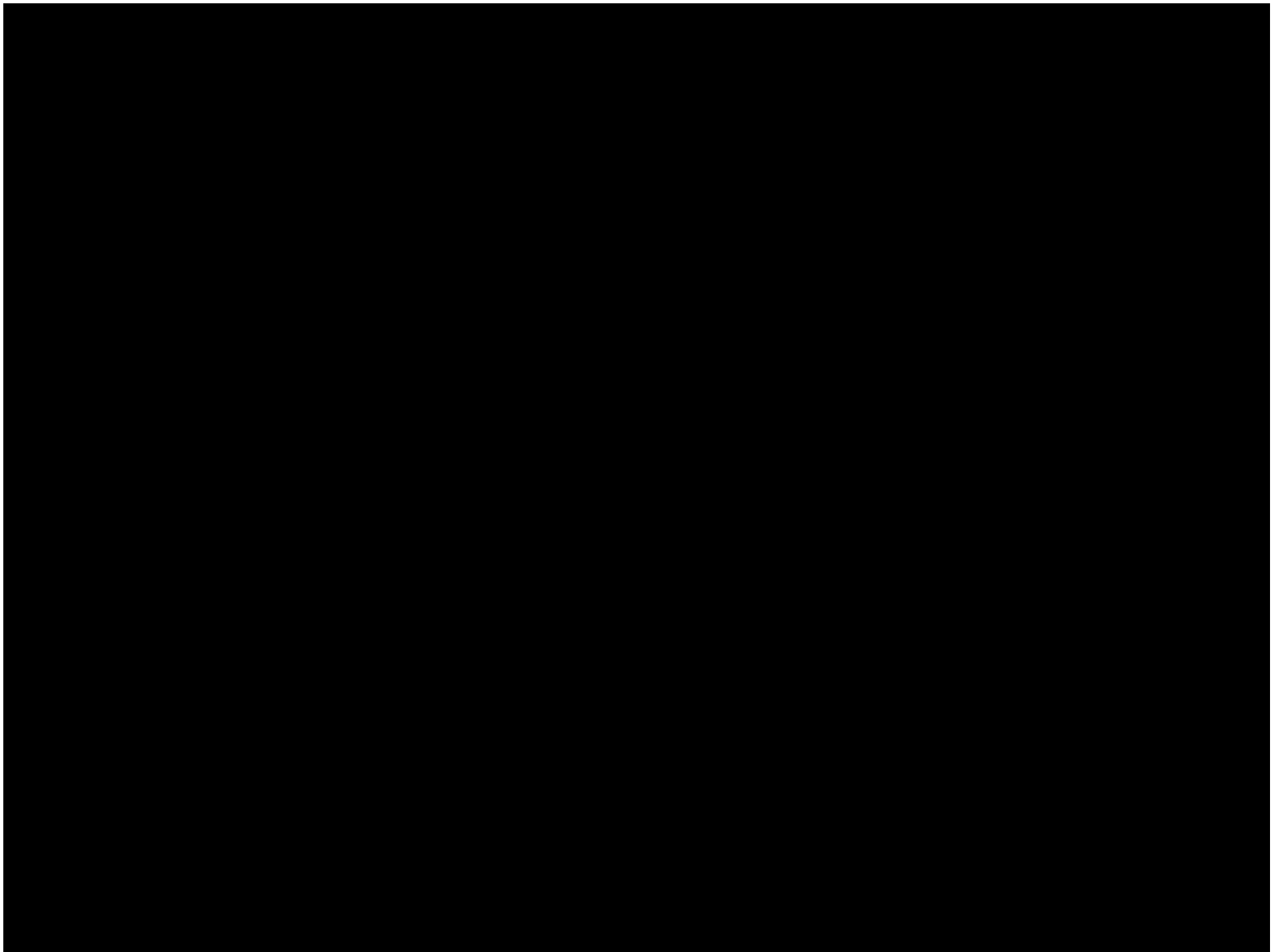
CCM3 at T170 (70km)

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# Capability-related Improvements

Quality: Improved boundary layer, clouds, convection, ocean physics, land model, river runoff, sea ice

***Increase by another factor of 2-3, data flat***

Scope: Atmospheric chemistry (sulfates, ozone...), biogeochemistry (carbon cycle, ecosystem dynamics), middle Atmosphere Model...

***Increase by another factor of 10+, linear data***



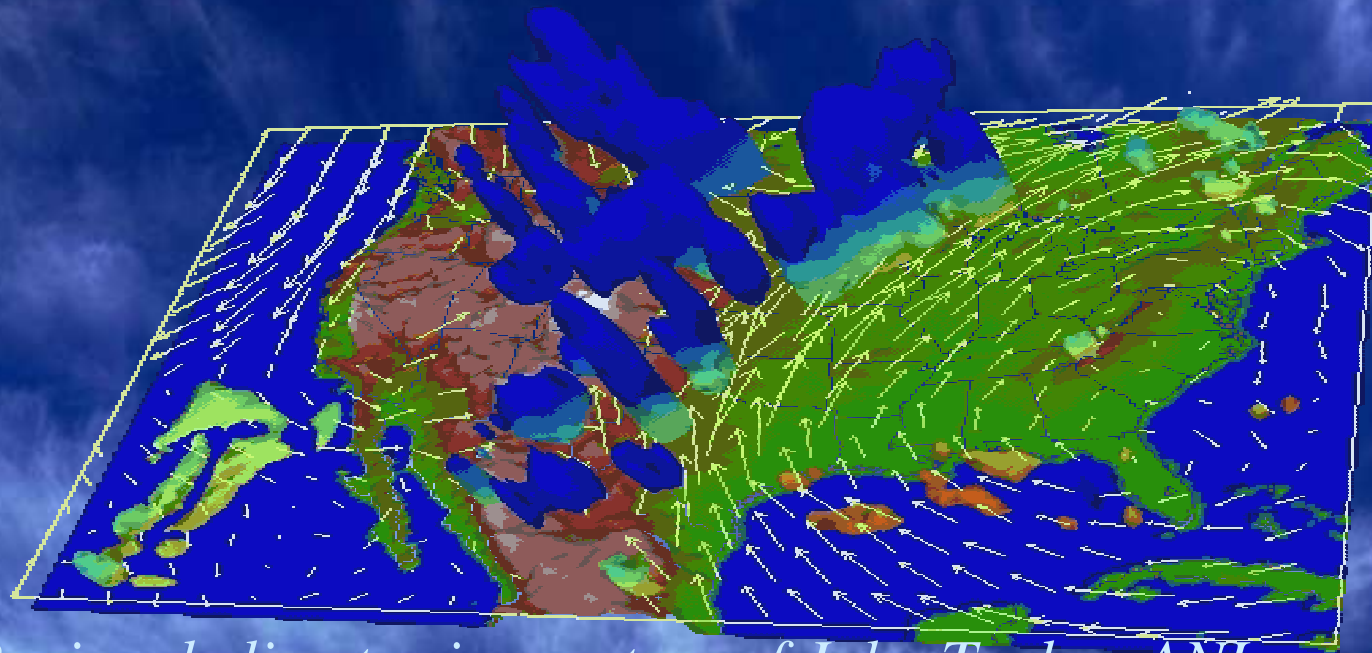
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# Approaching Mesoscale (i.e. “weather”) Resolution

05:00:00  
06 Jul 93  
5 of 24  
Tuesday



*Regional climate vis courtesy of John Taylor, ANL*

Vis5D

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# Model Improvements cont.

Grand Total:

*Increase compute by a Factor  $O(1000-10000)$*



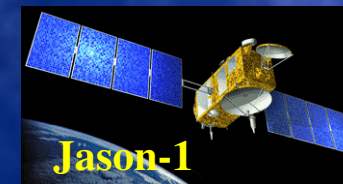
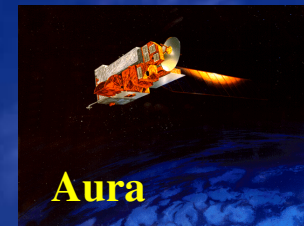
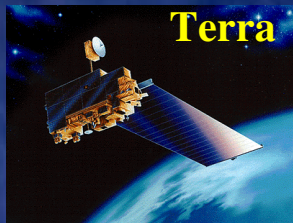
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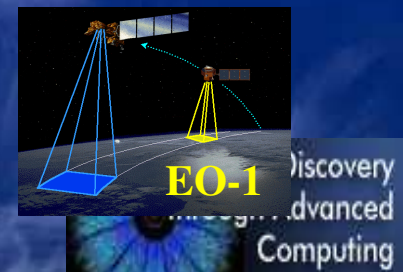
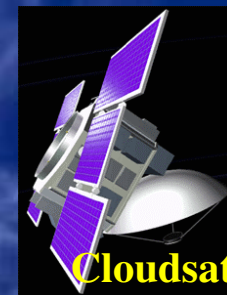
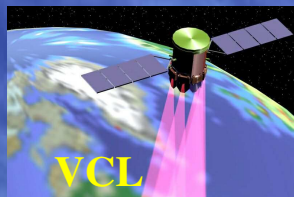


# We Will Examine Practically Every Aspect of the Earth System from Space in This Decade

## Longer-term Missions - Observation of Key Earth System Interactions



## Exploratory - Explore Specific Earth System Processes and Parameters and Demonstrate Technologies



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# ESG: Challenges

- Enabling the simulation and data management team
- Enabling the core research community in analyzing and visualizing results
- Enabling broad multidisciplinary communities to access simulation results

*We need integrated scientific work environments that enable smooth WORKFLOW for knowledge development: computation, collaboration & collaboratories, data management, access, distribution, analysis, and visualization.*



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# ESG: Strategies

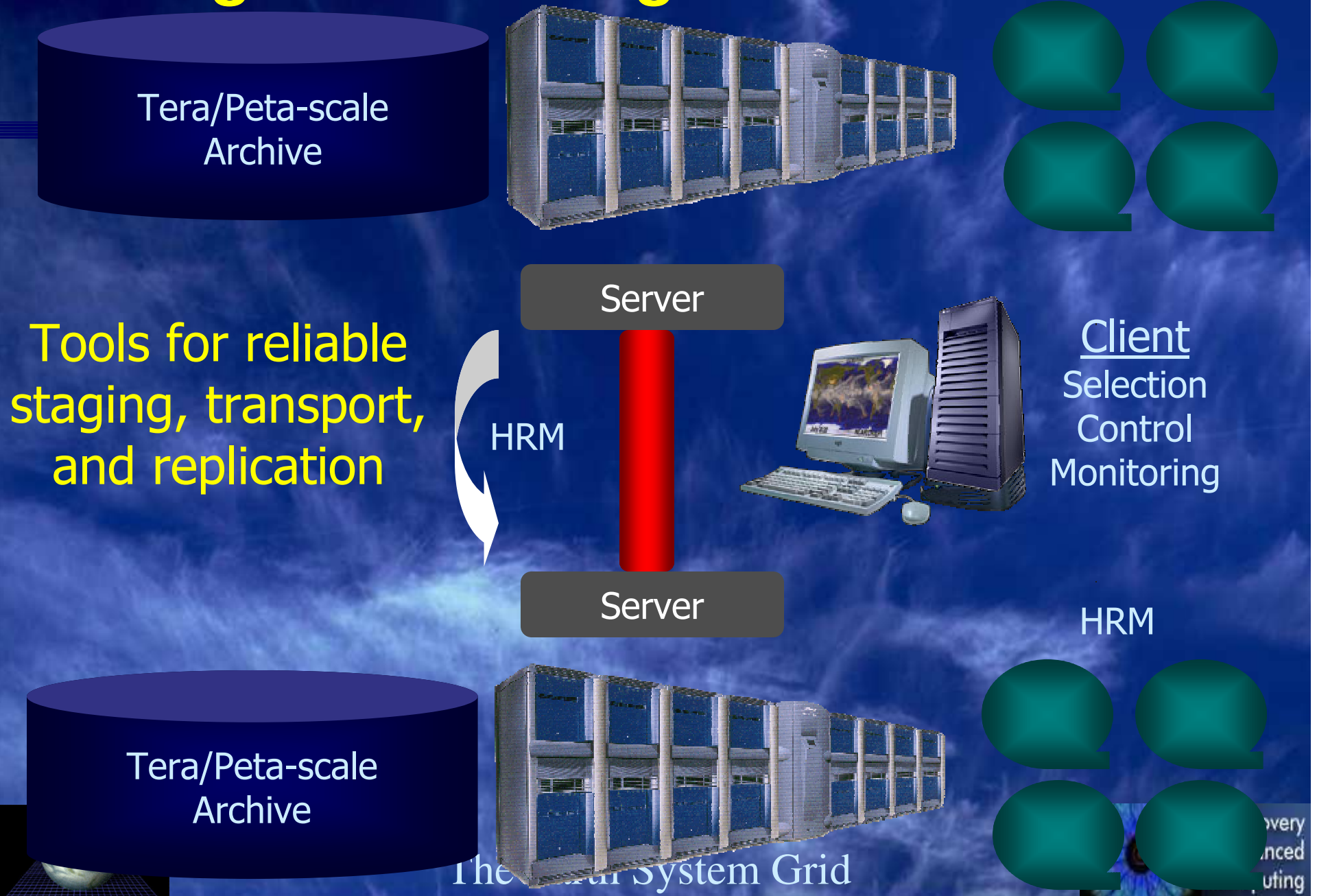
- Move data a minimal amount, keep it close to computational point of origin when possible
  - *Data access protocols, distributed analysis*
- When we must move data, do it fast and with a minimum amount of human intervention
  - *Storage Resource Management, fast networks*
- Keep track of what we have, particularly what's on deep storage
  - *Metadata and Replica Catalogs*
- Harness a federation of sites, web portals
  - *Globus Toolkit -> The Earth System Grid -> The UltraDataGrid*



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# Storage/Data Management





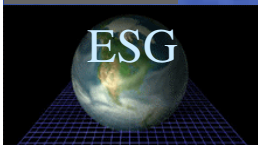
# HRM aka “DataMover”

- Running well across DOE/HPSS systems
- New component built that abstracts NCAR Mass Storage System
- Defining next generation of requirements with climate production group
- First “real” usage

*“The bottom line is that it now works fines and is over 100 times faster than what I was doing before. As important as two orders of magnitude increase in throughput is, more importantly I can see a path that will essentially reduce my own time spent on file transfers to zero in the development of the climate model database” – Mike Wehner, LBNL*

# OPeNDAP

An Open Source Project for a  
Network Data Access Protocol  
(originally DODS, the Distributed  
Oceanographic Data System)

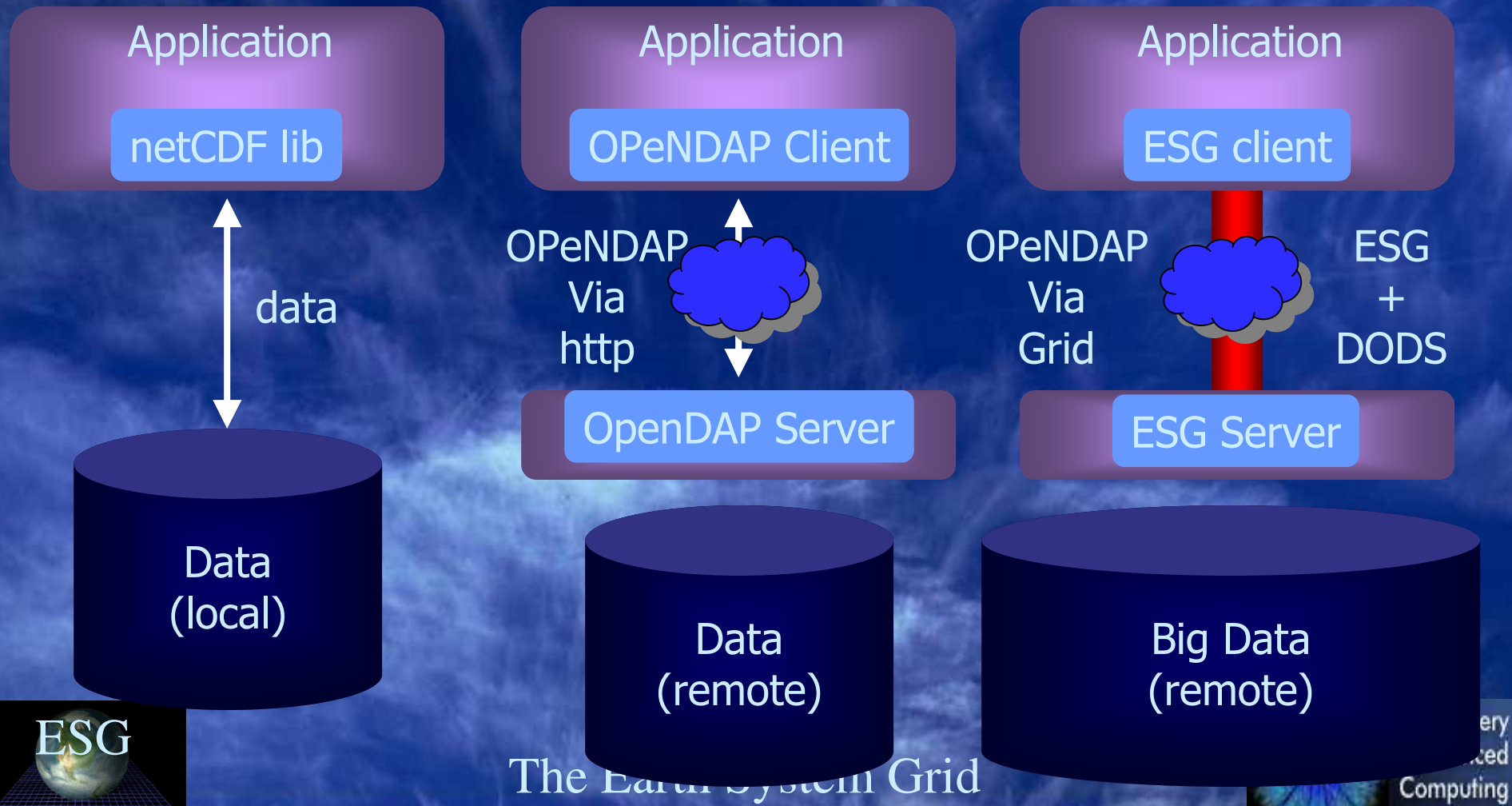


# Distributed Data Access Protocols

Typical Application

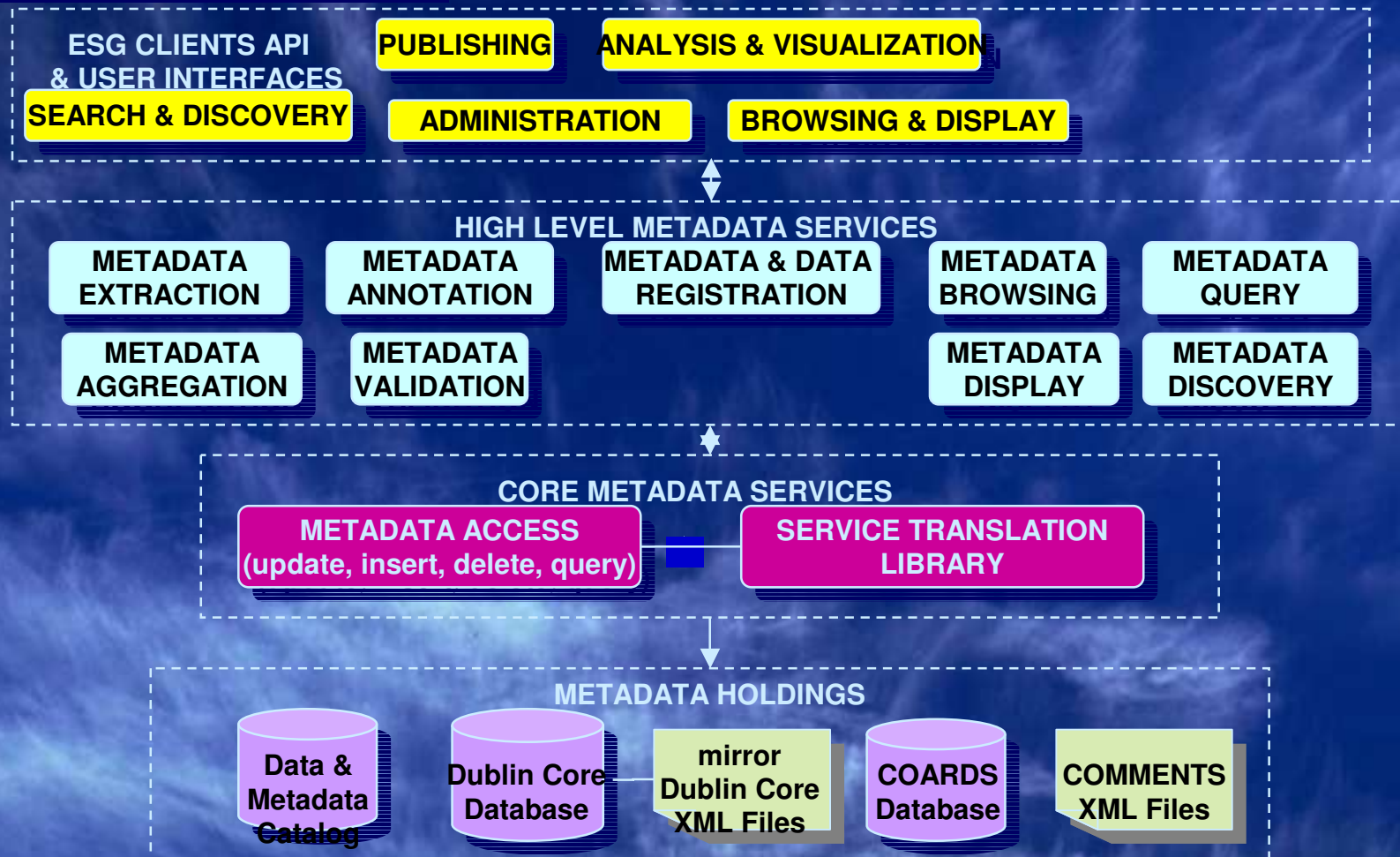
Distributed Application

OPeNDAP-g  
-Transparency  
-Performance  
-Security  
-Authorization  
-(Processing)





# ESG: Metadata Services



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# Metadata Status

- Co-developed NcML with Unidata
  - CF conventions in progress, almost done
- Developed & evaluated a prototype metadata system
- Finalizing a specific schema for PCM/CCSM
- Addressing interoperability with federal standards and NASA/GCMD via the generation of DIF/FGDC/ISO
- Addressing interoperability with digital libraries via the creation of Dublin Core
- Working with U.K. e-Science on schema sharing
- Experimenting with relational and native XML databases
- Exploratory work for first-generation ontology
- Catalog population begins this month

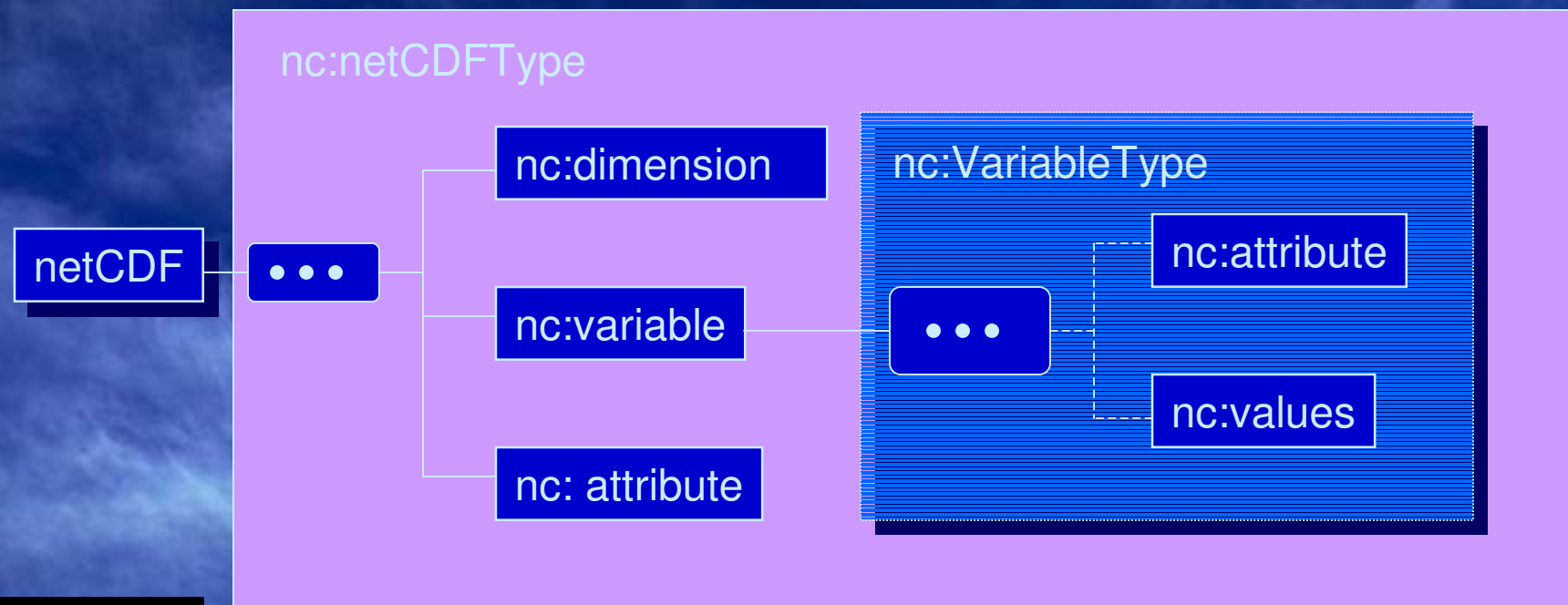
ESC

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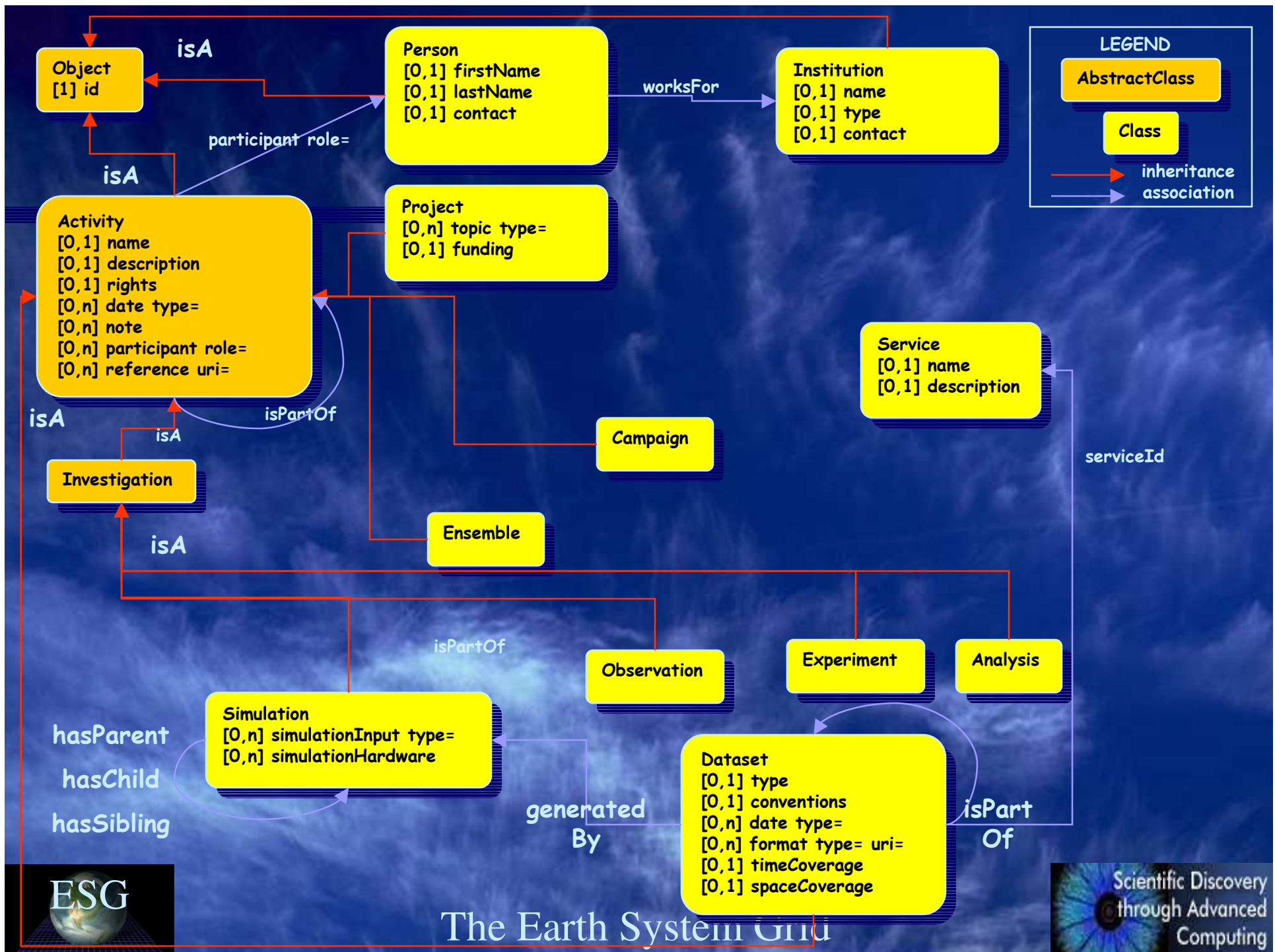


# ESG: NcML Core Schema

- For XML encoding of metadata (and data) of any generic netCDF file
- Objects: netCDF, dimension, variable, attribute
- Beta version reference implementation as Java Library  
([http://www.scd.ucar.edu/vets/luca/netcdf/extract\\_metadata.htm](http://www.scd.ucar.edu/vets/luca/netcdf/extract_metadata.htm))

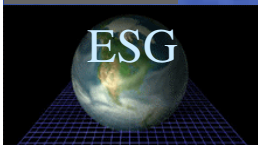




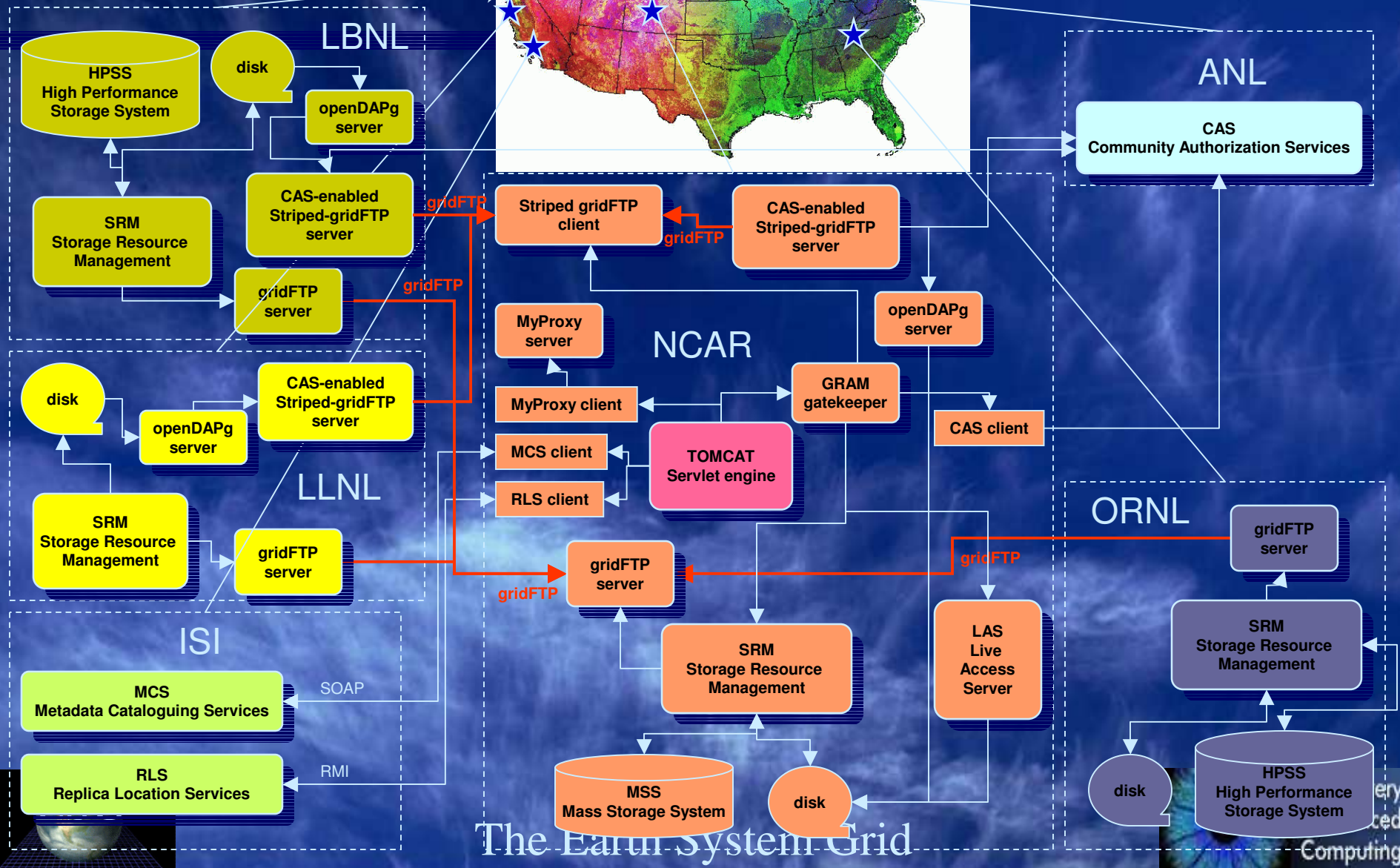
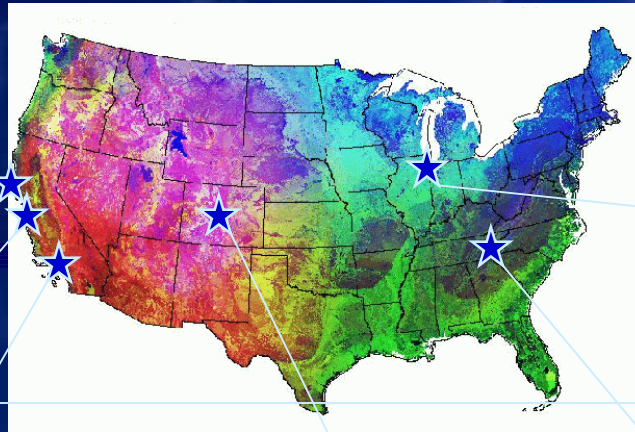


# ESG Web Portal

SC2002 Prototype *Technology*  
Demonstration



# SC2002 Demonstration





# Collaborations & Relationships

- CCSM Data Management Group
- The Globus Project
- Other SciDAC Projects: Climate, Security & Policy for Group Collaboration, Scientific Data Management ISIC, & High-performance DataGrid Toolkit
- OPeNDAP/DODS (multi-agency)
- NSF National Science Digital Libraries Program (UCAR & Unidata THREDDS Project)
- U.K. e-Science and British Atmospheric Data Center
- NOAA NOMADS and CEOS-grid
- Earth Science Portal group (multi-agency, intl.)

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# Immediate Directions

- Broaden usage of DataMover and refine
- Build data catalogs with rich metadata
- Release “real” ESG portal
  - Search, browse, access
- Alpha version of OPeNDAPg
  - Test and evaluate with three client applications (ncview, CDAT, & NCL)
- Move software and web portals into the hands of serious users, and get feedback!
- Later: OGSA, server-side analysis



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# Closing Thoughts

- Building an environment for the long-term
  - Difficult, expensive, and time-consuming
  - But a worthwhile investment
- Team-building is a critical process
  - Collaboration technologies really help
- Managing all the collaborations is a challenge
  - But extremely valuable
- Good progress, first real usage



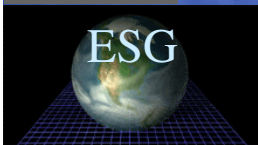
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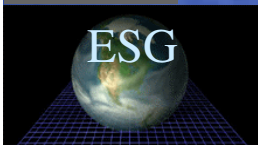


*<http://www.earthsystemgrid.org>*

Questions?



# END







- About ESG
- (public access)
- [Home](#)
- [Overview](#)
- [People](#)
- [Calendar](#)
- [Public Documents](#)
- [Contact Us](#)

- ESG at Work
- (registration required)  
under construction
- [New User Registration](#)
- [Login](#)
- [Data Discovery](#)
- [Extract Metadata](#)
- [Browse Data Catalog](#)
- [Metadata Query](#)

## The Earth System Grid II:

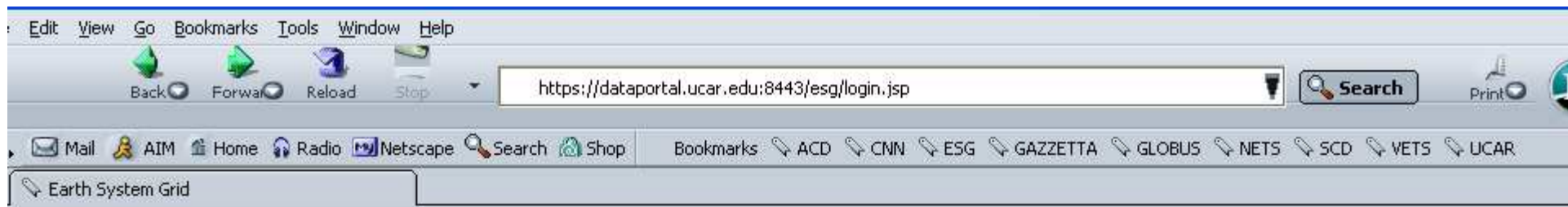
### Turning Climate Model Datasets Into Community Resources

The Earth System Grid II (ESG) is a new research project sponsored by the U.S. DOE Office of Science under the auspices of the Scientific Discovery through Advanced Computing program (SciDAC). The primary goal of ESG is to address the formidable challenges associated with enabling analysis of and knowledge development from global Earth System models. Through a combination of Grid technologies and emerging community technology, distributed federations of supercomputers and large-scale data & analysis servers will provide a seamless and powerful environment that enables the next generation of climate research.

#### *Project Abstract*

High-resolution, long-duration simulations performed with advanced DOE SciDAC/NCAR climate models will produce tens of petabytes of output. To be useful, this output must be made available to global change impacts researchers nationwide, both at national laboratories and at universities, other research laboratories, and other institutions. To this end, we propose to create a new Earth System Grid, ESG-II - a virtual collaborative environment that links distributed centers, users, models, and data. ESG-II will provide scientists with virtual proximity to the distributed data and resources that they require to perform their research. The creation of this environment will significantly increase the scientific productivity of U.S. climate researchers by turning climate datasets into community resources. In creating ESG-II, we will integrate and extend a range of Grid and collaborative technologies, including the DODS remote access protocols for environmental data, Globus Toolkit technologies for authentication, resource discovery, and resource access, and Data Grid technologies developed in other projects. We will develop new technologies for





## ESG LOGIN

**INSTRUCTIONS:** please log into the ESG system through one of the authentication methods below.

**ANONYMOUS MYPROXY LOGIN** Creates anonymous proxy on dataportal.ucar.edu with two hours lifetime

**ANONYMOUS USERNAME:**

**ANONYMOUS PASSWORD:**



**AUTHENTICATED MYPROXY LOGIN** Retrieves delegated credentials from specified MyProxy server

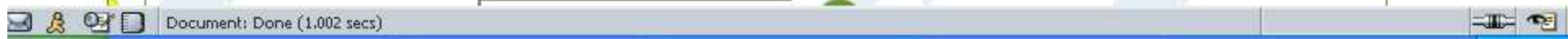
**MYPROXY USERNAME:**

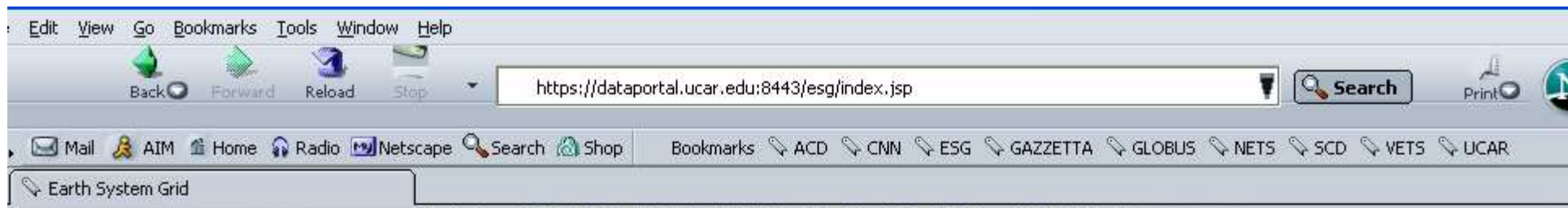
**MYPROXY PASSWORD:**

**HOST:**



**AUTHENTICATED GLOBUS PROXY LOGIN** Loads previously created Globus proxy from dataportal.ucar.edu





## ESG @ WORK APPLICATIONS INDEX

### Data Search and Discovery

#### ▶ **ESG Data Discovery**

*This integrated application allows identification of data (logical files and replica locations) based on a query to the ESG Metadata Catalog and Replica Catalog, display of logical files and logical collections metadata, and transfer of files.*

#### ▶ **Browse ESG Data Catalogs**

*Hierarchical browsing of ESG Data Catalogs in THREDDS format, and display of associated metadata.*

#### ▶ **Query ESG Metadata Catalog**

*Query of static and user defined attributes associated with logical collections or logical files in the ESG Metadata Catalog.*

### Data Management

#### ▶ **Data Transfer**

*Web interface to HRM (Hierarchical Resource Manager). HRM allows high speed, reliable, parallel streams, multiple files transfer between permanent storage systems and ESG nodes.*

#### ▶ **Metadata Extraction**

*Web Service for the automatic extraction of metadata in NcML format from any network retrievable netcdf file.*

### Data Analysis and Visualization

#### ▶ **DODS**

*Access to the ESG DODS servers.*

#### ▶ **LAS**

*Access to the ESG LAS servers.*

#### ▶ **CDAT**

*Access to the ESG CDAT servers.*

### ESG System

#### ▶ **Monitor Status**

*Monitor the status and availability of the resources comprising the ESG system.*

#### ▶ **Query Logs**

*Interactive query of log files recording ESG access and usage.*

**KNOWLEDGMENTS:** ESG applications are based on a variety of computing and information technologies. In particular, we wish to acknowledge the use of Globus technology and related COG (Commodity Grid Kit) toolkits.



Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop

https://dataportal.ucar.edu:8443/esg/dataDiscovery.jsp?collectionName=PCM/B06.20/atm Search Print

Mail AIM Home Radio Netscape Search Shop Bookmarks ACD CNN ESG GAZZETTA GLOBUS NETS SCD VETS UCAR

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ESG Home ESG Login CAS proxy ESG Logout ESG @ Work:

## ESG DATA DISCOVERY

**INSTRUCTIONS:** This interface allows search and discovery of data through associated metadata. Using the user filled parameters, a query is first performed to the **MCS (Metadata Cataloguing Services)** to retrieve all matching logical files. Then a second query is performed to the RLS (Replica Location Services) to find all registered replica locations, sizes, and access services for each logical file. The user may select replicas on disk or remote storage (**HPSS, MSS**) and transfer them with the **SRM (Storage Resource Manager)**; or the user may select and access replicas served by distributed **striped gridFTP openDAP** servers. Optionally, the user may also view the metadata (stored in the MCS) associated with a logical collection or logical file. Please note that currently the query supports only a limited number of parameters.

**QUERY FORM**

**LOGICAL COLLECTION NAME**  (required) **DISPLAY COLLECTION LEVEL METADATA**

**VARIABLE NAME**  (optional)

**START YEAR**  (required)

**STOP YEAR**  (required)

 **SUBMIT QUERY**

**SESSION ID:** 00AFCA2870A97FD8E572993D94F168BBB **PROXY TIME LEFT:** 7107 secs

**DN:** CN=proxy,CN=proxy,CN=proxy,CN=Globus User,OU=Network Engineering and Technology Section,OU=Scientific Computing Division,O=National Center for Atmospheric Research,O=Globus,C=us



## QUERY RESULTS

NUMBER OF RESULTS FOUND: 5

**LOGICAL FILE** /PCM/B06.20/atm/B06.20.atm.1980.nc

**SIZE** 268722384

- REPLICAS**
- /raid/f1/ESG\_SC2002/PCM/B06.20/atm/B06.20.atm.1980.nc [ [DISK@NCAR](#) [DODS@NCAR](#) ]
  - /dataportal.ucar.edu/PCM1/pcm/B06.20/atm/B06.20.atm.1980.nc [ [MSS@NCAR](#) ]
  - /hpss.ccs.ornl.gov/home/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1980.nc [ [HPSS@ORNL](#) ]
  - /archive.nersc.gov/nersc/gc5/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1980.nc [ [HPSS@LBL](#) ]
  - /data/esg/sc2002/PCM/B06.20/atm/B06.20.atm.1980.nc [ [DISK@LBL](#) [DODS@LBL](#) ]

▶ [DISPLAY METADATA](#)

**LOGICAL FILE** /PCM/B06.20/atm/B06.20.atm.1981.nc

**SIZE** 322461980

- REPLICAS**
- /raid/f1/ESG\_SC2002/PCM/B06.20/atm/B06.20.atm.1981.nc [ [DISK@NCAR](#) [DODS@NCAR](#) ]
  - /dataportal.ucar.edu/PCM1/pcm/B06.20/atm/B06.20.atm.1981.nc [ [MSS@NCAR](#) ]
  - /hpss.ccs.ornl.gov/home/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1981.nc [ [HPSS@ORNL](#) ]
  - /archive.nersc.gov/nersc/gc5/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1981.nc [ [HPSS@LBL](#) ]
  - /data/esg/sc2002/PCM/B06.20/atm/B06.20.atm.1981.nc [ [DISK@LBL](#) [DODS@LBL](#) ]

▶ [DISPLAY METADATA](#)

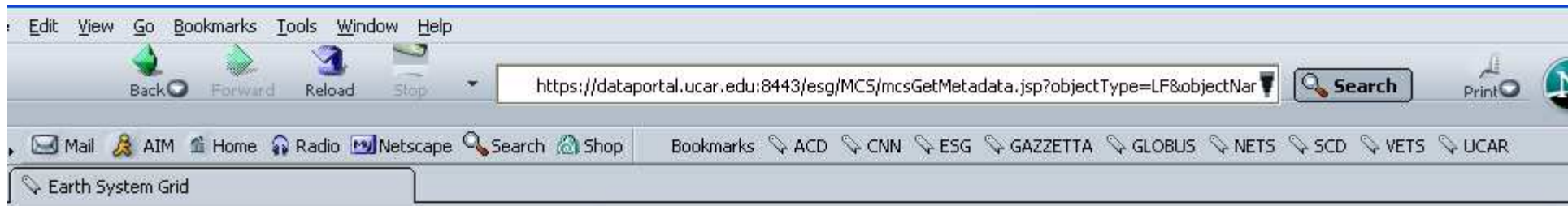
**LOGICAL FILE** /PCM/B06.20/atm/B06.20.atm.1982.nc

**SIZE** 322461980

- REPLICAS**
- /raid/f1/ESG\_SC2002/PCM/B06.20/atm/B06.20.atm.1982.nc [ [DISK@NCAR](#) [DODS@NCAR](#) ]
  - /dataportal.ucar.edu/PCM1/pcm/B06.20/atm/B06.20.atm.1982.nc [ [MSS@NCAR](#) ]
  - /hpss.ccs.ornl.gov/home/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1982.nc [ [HPSS@ORNL](#) ]
  - /archive.nersc.gov/nersc/gc5/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1982.nc [ [HPSS@LBL](#) ]
  - /data/esg/sc2002/PCM/B06.20/atm/B06.20.atm.1982.nc [ [DISK@LBL](#) [DODS@LBL](#) ]

▶ [DISPLAY METADATA](#)

**LOGICAL FILE** /PCM/B06.20/atm/B06.20.atm.1983.nc



## ESG METADATA CATALOG QUERY


**INSTRUCTIONS:** This page allows to retrieve all types of metadata associated with a given **logical collection** or **logical file** in the ESG Metadata Catalog. Metadata in the MCS can be stored in the form of **static attributes**, **user-defined attributes**, or **XML**.

**QUERY FORM**

**OBJECT TYPE** Logical File

**OBJECT NAME** /PCM/B06.20/atm/B06.20.atm.1984.nc

**METADATA TYPE** XML

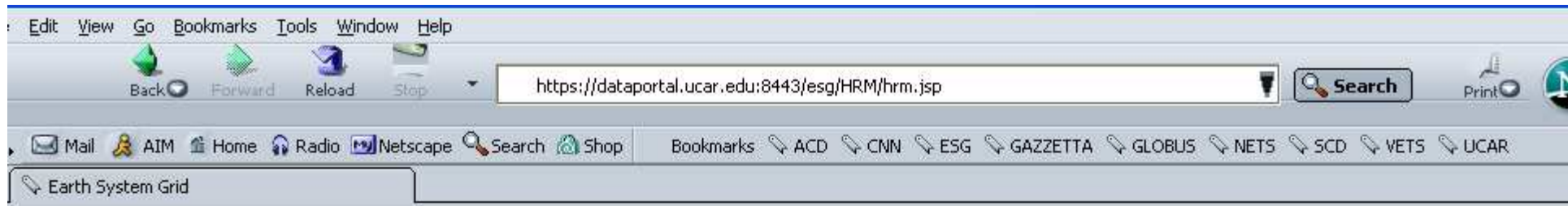
 **GET METADATA**

## QUERY RESULTS

### XML

```
?xml version="1.0" encoding="UTF-8"?>
<nc:netcdf xmlns:nc="http://www.ucar.edu/schemas/netcdf" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.ucar.edu/schemas/netcdf
  http://www.ucar.edu/schemas/netcdf.xsd">
  <nc:dimension length="128" name="lon" />
  <nc:dimension length="18" name="lev" />
  <nc:dimension length="19" name="ilev" />
  <nc:dimension length="64" name="lat" />
  <nc:dimension length="81" name="nchar" />
  <nc:dimension isUnlimited="true" length="12" name="time" />
  <nc:variable name="ntrk" type="int">
    <nc:attribute name="long_name" type="string" value="spectral truncation parameter K" />
  </nc:variable>
  <nc:variable name="PRECSC" shape="time lat lon" type="float">
    <nc:attribute name="long_name" type="string" value="Convective snow rate (water equivalent)" />
  </nc:variable>
</nc:netcdf>
```





## HRM WEB INTERFACE

**INSTRUCTIONS:** Please check all physical files that you wish to transfer. The HRM (Hierarchical Resource Manager) is a product of the Scientific Data Management Research Group at the Lawrence Berkely National Laboratory. HRM allows fast, reliable, tunable transfer of files to/from disk and note storage (HPSS, MSS) through the gridFTP protocol and implementation. This prototype web interface is being developed by the Earth System Grid collaboration.

### DATA TRANSFER FORM

#### INPUT FILES:

	PHYSICAL FILE	SIZE	SERVICE
<input checked="" type="checkbox"/>	/raid/f1/ESG_SC2002/PCM/B06.20/atm/B06.20.atm.1980.nc	268722384	DISK@NCAR
<input checked="" type="checkbox"/>	/dataportal.ucar.edu/PCM1/pcm/B06.20/atm/B06.20.atm.1981.nc	322461980	MSS@NCAR
<input checked="" type="checkbox"/>	/hpss.ccs.ornl.gov/home/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1982.nc	322461980	HPSS@ORNL
<input checked="" type="checkbox"/>	/archive.nersc.gov/nersc/gc5/asim/esg/sc2002/pcm/b06.20/atm/B06.20.atm.1983.nc	322461980	HPSS@LBNL
<input checked="" type="checkbox"/>	/data/esg/sc2002/PCM/B06.20/atm/B06.20.atm.1984.nc	322461980	DISK@LBNL

OUTPUT DIRECTORY: /scratch/sc2002/tmp/

USER ID: esguser (user@host)

#### gridFTP PARAMETERS:

Block size:	<input type="text" value="1000000"/>
TCP buffer size:	<input type="text" value="1000000"/>
Number of streams:	<input type="text" value="4"/>



[SUBMIT REQUEST](#)



[RESET FORM](#)



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Earth System Grid - Netscape

CURRENT GRAM JOB

(this screen will refresh automatically every 5 seconds until the job is complete)

ID : https://dataportal.ucar.edu:45714/2235/1047335915/

STATUS : ACTIVE

ERROR : 0

STDOUT :

```
Client Callback CONFIGURATION
base: esguser
source[0] = gsiftp://dataportal.ucar.edu/raid/f1/ESG_SC2002/PCM/B06.20/atm/B06.20.atm.1980.nc
target[0] = file:/scratch/sc2002/tmp//B06.20.atm.1980.nc
size[0] = 268722384
source[1] = hrm://dataportal.ucar.edu:6191/HRMServerNCAR/dataportal.ucar.edu/PCM1/pcm/B06.20.atm.1981.nc
target[1] = file:/scratch/sc2002/tmp//B06.20.atm.1981.nc
size[1] = 322461980
source[2] = hrm://sleepy.ccs.ornl.gov:6191/HRMServerORNL/hpss.ccs.ornl.gov/home/asim/esg/sc2002/PCM/B06.20.atm.1982.nc
target[2] = file:/scratch/sc2002/tmp//B06.20.atm.1982.nc
size[2] = 322461980
source[3] = hrm://datagrid.lbl.gov:6191/HRMServerLBNL/archive.nersc.gov/nersc/gc5/asim/esg/sc2002/PCM/B06.20.atm.1983.nc
target[3] = file:/scratch/sc2002/tmp//B06.20.atm.1983.nc
size[3] = 322461980
source[4] = gsiftp://datagrid.lbl.gov/data/esg/sc2002/PCM/B06.20/atm/B06.20.atm.1984.nc
target[4] = file:/scratch/sc2002/tmp//B06.20.atm.1984.nc
```

OUTPUT DIRECTORY: /scratch/sc2002/tmp/

USER ID: esguser (user@host)

gridFTP PARAMETERS:

Block size:	1000000
TCP buffer size:	1000000
Number of streams:	4

→ SUBMIT REQUEST

→ RESET FORM

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Earth

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SKatNCAR

SatNCAR

SSatORNL

SSatLBNL

SKatLBNL

Transferring data from dataportal.ucar.edu...



## ESG LAS CONFIGURATION INTERFACE

**INSTRUCTIONS:** Submitting this form will regenerate the configuration file of the local LAS server. This process may take a little time. Please select all files that you will want to be accessible by LAS.

### LAS DATA FILES

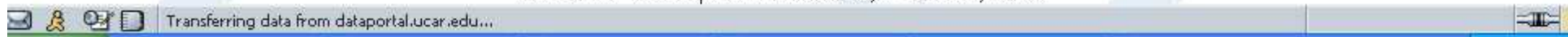
- ☒ /scratch/sc2002/tmp/B06.20.atm.1980.nc
- ☒ /scratch/sc2002/tmp/B06.20.atm.1981.nc
- ☒ /scratch/sc2002/tmp/B06.20.atm.1982.nc
- ☒ /scratch/sc2002/tmp/B06.20.atm.1983.nc
- ☒ /scratch/sc2002/tmp/B06.20.atm.1984.nc



**SUBMIT** (configuration may take a little time...)

**SESSION ID:** 00AFCA2870A97FD8E572993D94F16BBB **PROXY TIME LEFT:** 6581 secs

**N:** CN=proxy,CN=proxy,CN=proxy,CN=Globus User,OU=Network Engineering and Technology Section,OU=Scientific Computing Division,O=National Center for Atmospheric Research,O=Globus,C=us





Edit View Go Bookmarks Tools Window Help

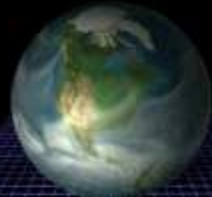
Back Forward Reload Stop

http://dataportal.ucar.edu/esg-las/main.pl? Search Print

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Live Access to Climate Data

Home Help Options



# THE EARTH SYSTEM GRID

# ESG

Scientific Discovery through Advanced Computing

**data Sets**

- B06.20.atm.1980.nc
  - Average of Cloud when omega is < 0 (up)
  - Average of Omega when omega is < 0 (up)
  - BEVAP
  - BTRAN
  - CH4VMR
  - Clearsky net longwave flux at surface
  - Clearsky net longwave flux at top
  - Clearsky net solar flux at surface
  - Clearsky net solar flux at top
  - Cloud fraction
  - CO2VMR
  - convective adjustment tendency of water vapor
  - Convective precipitation rate
  - Convective snow rate (water equivalent)
  - Counter-gradient coefficient on surface kinematic fluxes
  - DMI
  - East-west gravity wave drag surface stress
  - Effective cloud fraction
  - F11VMR
  - F12VMR

B06.20.atm.1980.nc

## Average of Cloud when omega is < 0 (up)

Select view xy (lat/lon) slice

Select ☒ single variable ☐ comparison

Go Full Region

Get Data

87.8638000

180.0 W 180.0 E

87.8638000

Zoom In Zoom Out

Select depth 4.8092999458313 4.8092999458

Select time 05-Mar-1980 05-Mar-1980

Select product Shaded plot (GIF) in 800x600 window

Document: Done (0.13 secs)



