

# The NOAA Operational Model Archive and Distribution System (NOMADS)



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Principle Investigator

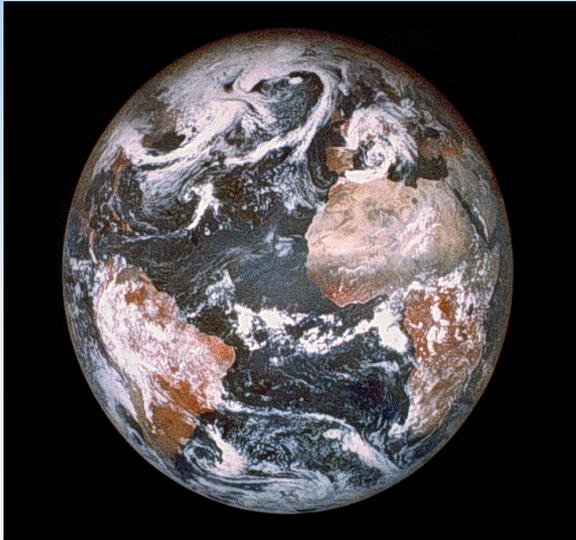
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National Climatic Data Center

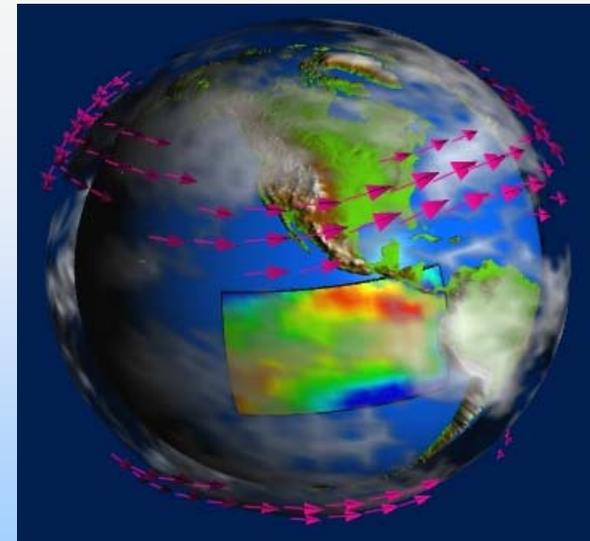


# Overview



- In the US today, there exists no long-term archive for Climate and Weather models.
- University and Institutional research goes largely untapped by NOAA scientists. Effort is wasted on data receipt and format issues with no infrastructure to collaborate.

➤ Retrospective analysis and model inter-comparison are necessary to verify and improve short term NWP models, seasonal forecasts, climate simulations, and climate change and detection efforts.



To overcome this deficiency, some of the Nations top scientists are actively engaged in a grass-roots framework to share data and research findings over the Internet...

The NOAA Operational Model Archive and Distribution System (NOMADS) is a distributed data services pilot for format independent access to climate and weather models over the Internet and the "Grid".

**Core NOAA NOMADS Collaborators**

- Climate Diagnostics Center (CDC) Boulder, CO
- Geophysical Fluid Dynamics Laboratory (GFDL) Princeton, NJ
- National Climatic Data Center (NCDC) Asheville, NC (Project Lead)
- National Centers for Environmental Prediction (NCEP) Camp Springs, MD
- Pacific Marine Environmental Laboratory (PMEL) Seattle, WA
- NOAA Forecast Systems Laboratory (FSL) Boulder, CO

**External Core Collaborators**

- Center for Ocean-Land-Atmosphere Studies (COLA) (Maryland)
- Department of Energy's Argonne, Los Alamos, Oak Ridge, Lawrence Berkley, Livermore National Laboratories & Information Sciences Institute (ISI), University of Southern California under the Earth System Grid Project
- National Center for Atmospheric Research (NCAR) Colorado
- Unidata Program Center (UCAR/Unidata) Colorado
- LLNL Program for Climate Model Diagnosis and Intercomparison
- NASA's Global Change Master Directory (GCMD) Maryland
- National Coastal Data Development Center
- University of Rhode Island (OPeNDAP Consortium)

**External Collaborators include**

- Center for Earth Observing and Space Research (CEOSR), NASA-GSFC Maryland
- George Mason University (NASA SI-ESIP), Virginia
- National Severe Storms Laboratory (NSSL), Oklahoma/SSEC University of Wisconsin
- Universities of Alabama (Huntsville), California (Santa Barbara), Washington & Iowa St.
- National Science Foundation (NSF) Cyberinfrastructure

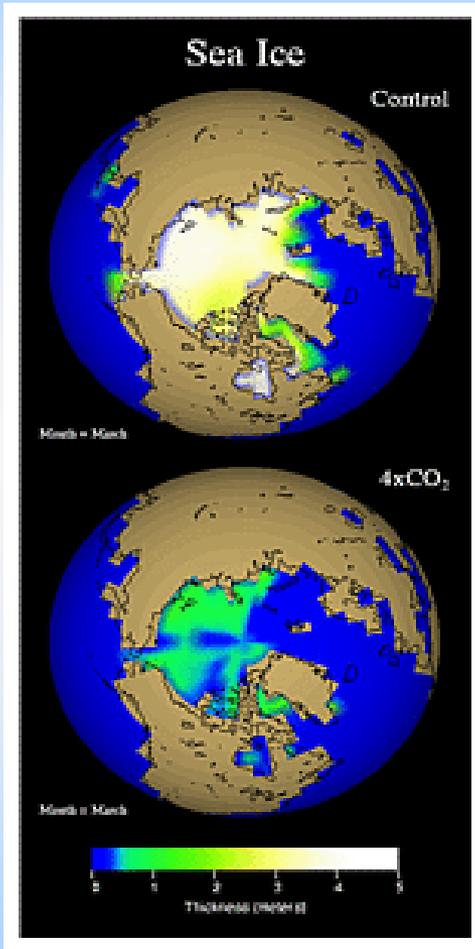
**International Participants**

- British Atmospheric Data Center, Oxfordshire, United Kingdom
- UK's Natural Environment Research Council (NERC DataGrid Project)
- Committee for Earth Observing Satellites (CEOS) Grid Project
- Climate Action Partnership (CAP), BOM Australia (US Depts. of Commerce, Energy, State, and EPA)



- Lack of access and systematic approaches for model evaluation initiated the grass roots NOMADS project. NOMADS is “user-driven” promoting standards across institutions.
- Climate model output and quality observations are vital to providing timely assessments of climate change and impacts.
- Access to retrospective NWP and GCM needed to enable a feedback mechanism to tie researchers back to quality control and diagnostics at operational institutions.
- With NOMADS interfaces users focus on science, not issues with data receipt, format, and data set manipulation.

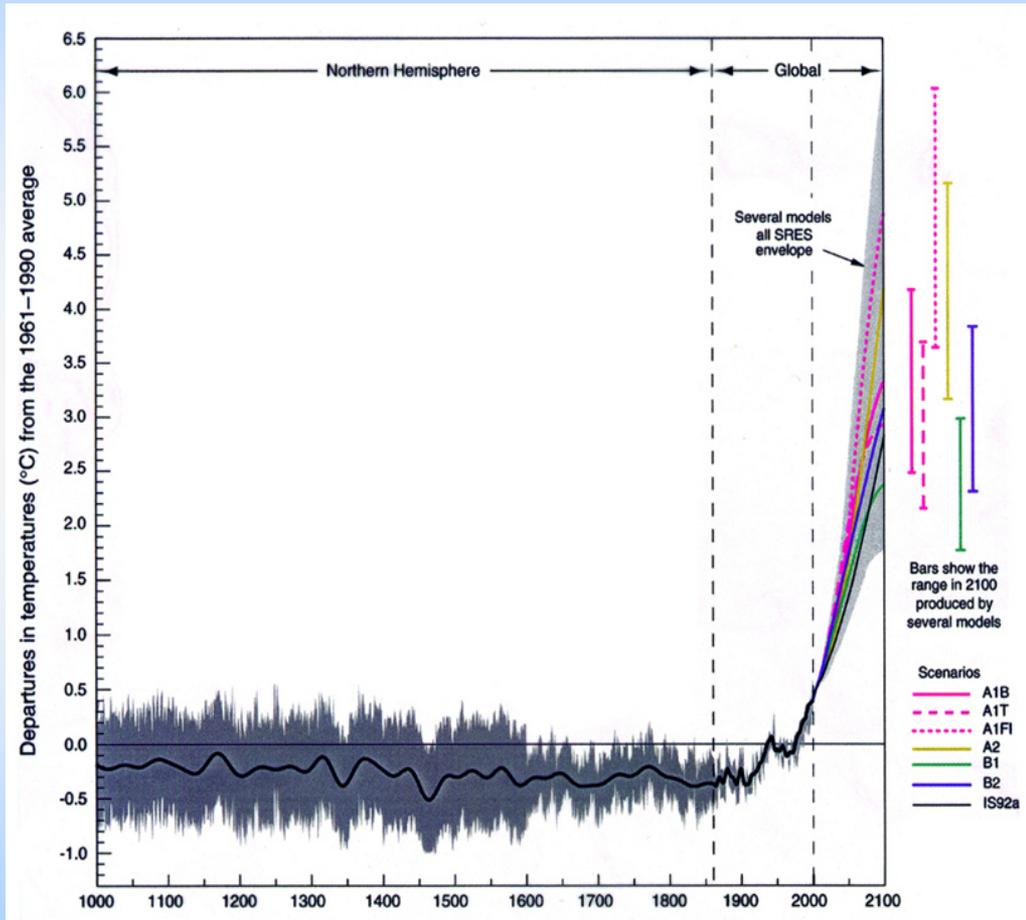




- The goals of NOMADS are to:
  - provide access to models,
  - promote product development,
  - foster research within the geo-science communities (ocean, weather, and climate) to study multiple earth systems using collections of distributed data,
  - expand institutional participation via distributed technologies.



# User Need: Reducing Uncertainties



## Changes fueled by:

Increasing recognition of importance of climate and the environment.

Ever-increasing volume of data and information (metadata).

Web access to data has increased user expectations.

Broad range in climate model projections require increased collaboration and a systematic approach to climate model evaluation.



- **British Atmospheric Data Center & NERC DataGrid**
- A “**Climate Action Partnership**” (CAP) under Dept’s of Commerce, Energy, State, and EPA with Australia.
- The **GCOS** and **GODAE** Projects
- European PProgram for Integrated Earth System Modeling (**PRISM**) Project

# *NOMADS Core Software: Leveraging Partnerships*

## ➤ **PMEL:**

NOAA's Pacific Marine Environmental Laboratory-  
Live Access Server (LAS) and Ferret.

## ➤ **COLA:**

The Center for Ocean-Land-Atmospheric Studies-  
GrADS-DODS Server (GDS) and GrADS.

## ➤ **Unidata and URI:**

Thematic Real-time Environmental Distributed Data Services  
URI/DODS-

Open Source Network for Distributed Access Protocol - DODS



# *NOMADS Core Software: Leveraging Partnerships (cont.)*

## ➤ **NCAR and DOE/LLNL:**

- Partnering with NCAR's Community Data Portal (CDP) project
- DOE's Earth System GRID-II
- Core LLNL software: CDAT / LAS Integration & QC tools

## ➤ **NASA Global Change Master Directory:**

Through the GCMD, NASA is a partner in the distributed data sharing framework in NOMADS (developed model access portal) and is assisting in developing a NOMADS based XML database search engine under the Earth Sciences Portal (ESP)

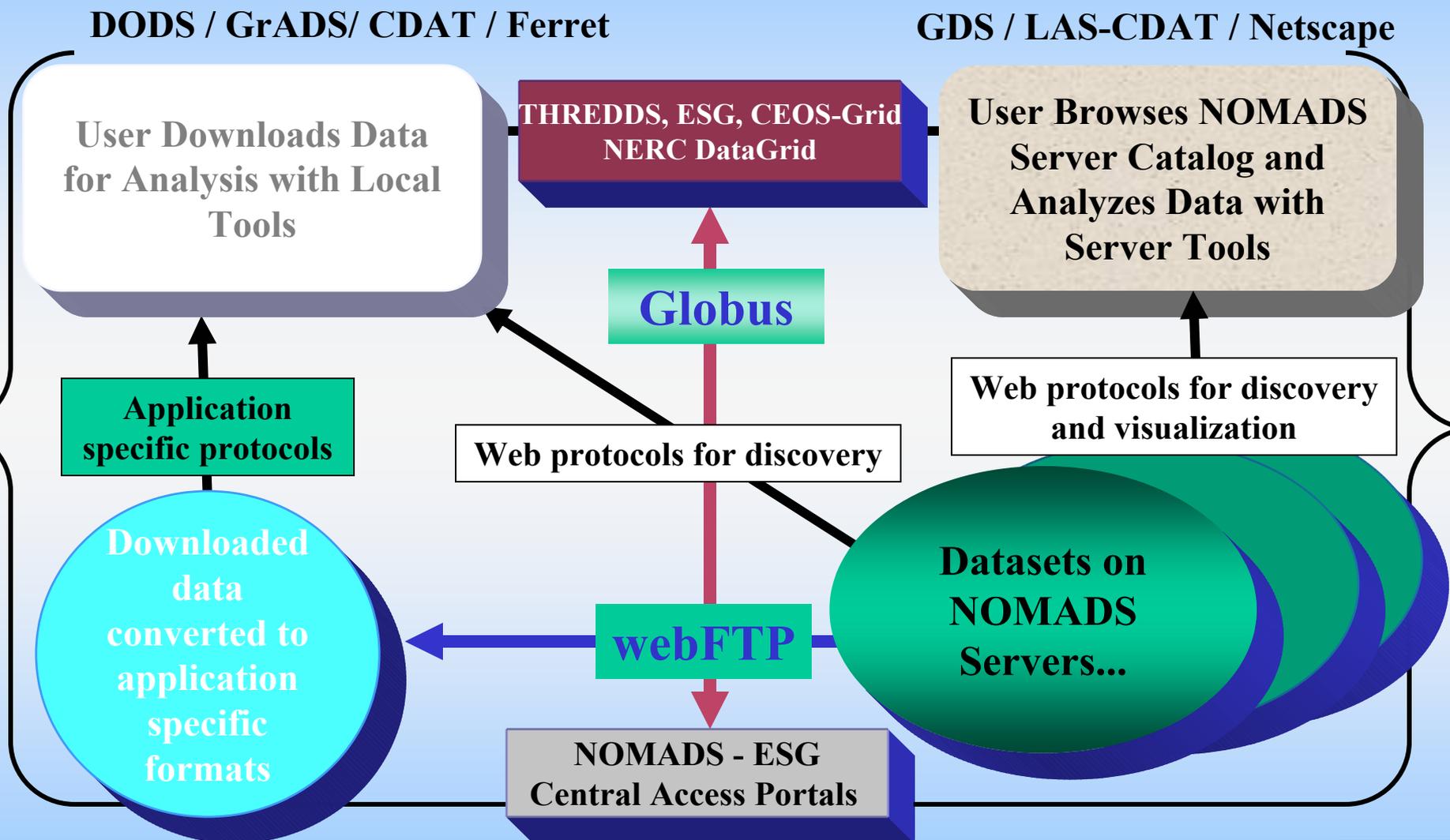


# *NOMADS Core Software: Leveraging Partnerships (cont.)*

- **The Earth Science Portal- (ESP):**
  - Common Web Portal and metadata effort across NOAA, NASA, DOE, & Europe's e-science initiative.
  - Developing a roadmap for setting and achieving metadata goals
  - Overcome common issues facing the storage and access of both observed and simulated earth-centric data sets.
  - Federate archives for search interoperability between groups.



# Network Topology



Source: NCDC/PCMDI/Unidata

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Embedded within GDS is DODS. It is a software framework that simplifies scientific data networking, allowing simple access to remote data:

➤ **Data access (client)**

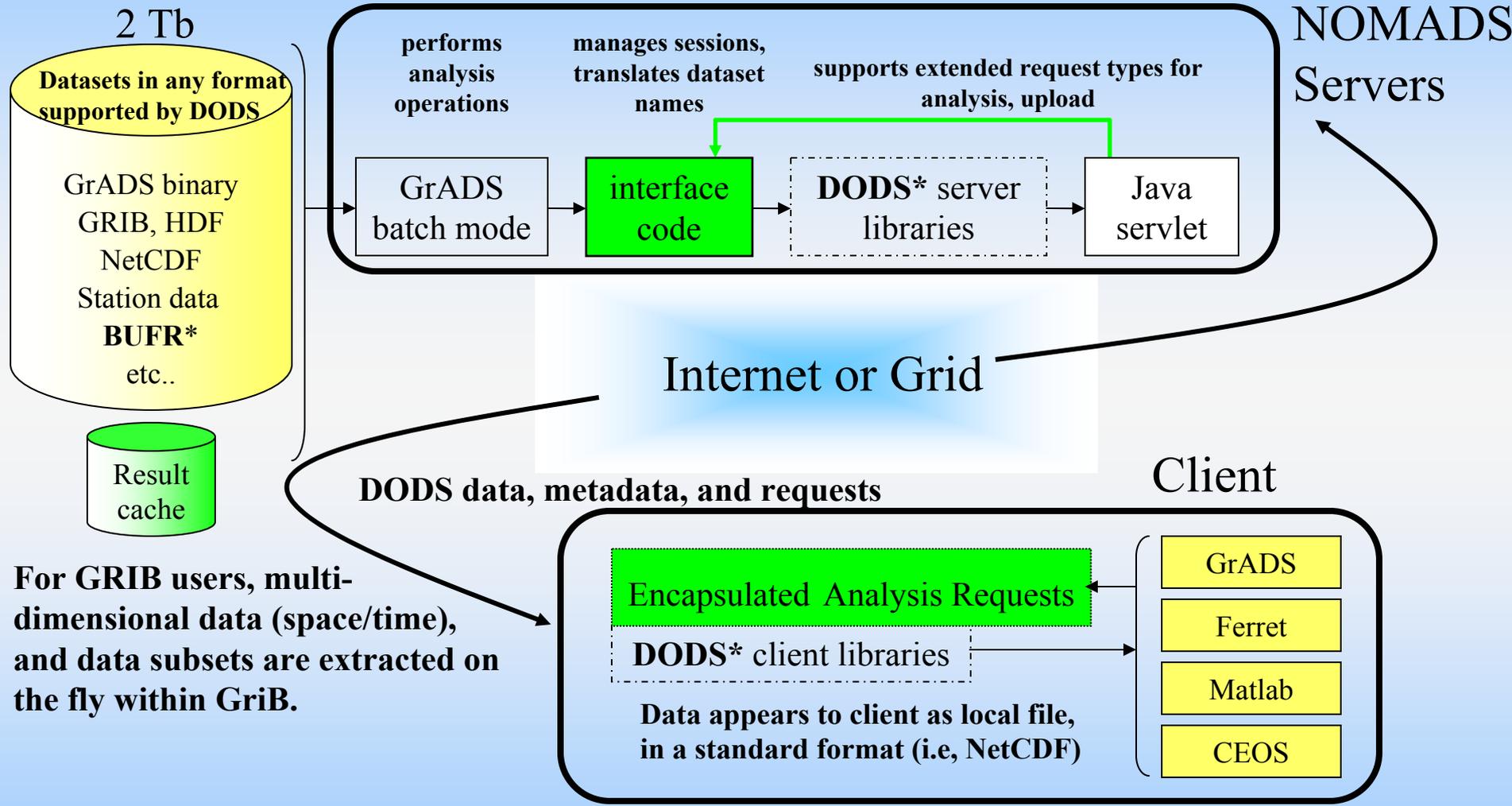
- Access to remote data in the users normal application
  - IDL
  - Matlab
  - Ferret
  - GrADS (GRIB thru GDS)
  - CDAT
  - Any netCDF application
  - Netscape / Excel / etc.
  - Don't need to know the data format in which the data is stored.

➤ **Data publishing (server)**

- Can serve data in various formats
  - netCDF
  - HDF
  - SQL
  - FreeForm
  - JGOFS
  - DSP
  - ascii
- Data subsetting



# GrADS-Data Server (GDS)



For GRIB users, multi-dimensional data (space/time), and data subsets are extracted on the fly within GriB.



Source: COLA

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# NOMADS Live Access Server (LAS)

- Manipulate distributed data sources across the Internet
- Various analysis/views, time series, profiles, and output formats
- Ferret

The screenshot displays the NOMADS Live Access web interface within a Netscape browser window. The browser's address bar shows the URL `http://ferret.wrc.noaa.gov/nomads/main.pl?`. The page title is "NOMADS Live Access".

On the left side, there is a list of data sources, with the following items circled in red:

- COADS 1-degree Equatorial Standard
- COADS 1-degree Standard
- COADS 2-degree Enhanced
- COADS 2-degree Standard
- GFDL GPS 03 model run
- GFDL GPS 03 model run (ann avg)
- NCEP MRF full res (demo)
- UEA Temperature Data absolute temp climatology
- CRUTEM1 temp anomalies
- CRUTEM1v temp anomalies
- HadCRUT temp anomalies
- HadCRUIv temp anomalies
- HadSST1 temp anomalies

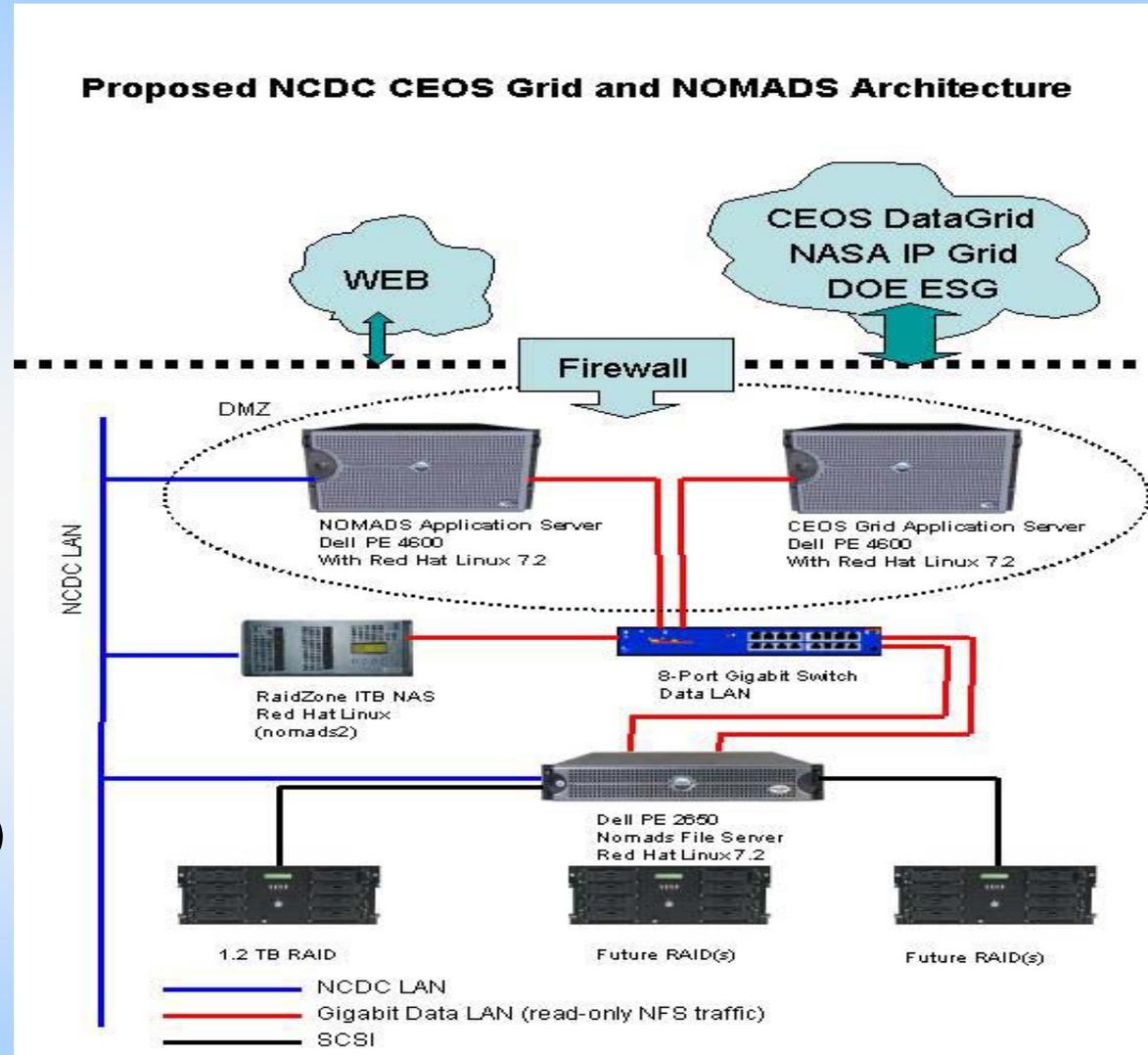
The main content area features a world map titled "UEA Temperature Data covered by Pacific Marine Environmental Lab absolute temp climatology". Below the map, there are controls for selecting a view (set to "xy (lat/lon) slice"), selecting a variable (set to "single variable"), and a "Get Data" button. The "Go" button is set to "Full Region".

Below the main interface, a detailed map titled "NOAA/PMEL TMAP FERRET Ver 6.88" is shown. The map displays "TIME : 15-JAN 00" and "DATA SET: absolute.no". The map shows a color-coded temperature climatology with a scale from -50 to 50 degrees Celsius. The axes are labeled "LATITUDE" (from 80°N to 80°S) and "LONGITUDE" (from 180°W to 140°E). The map title is "CSI\_Global\_1981-1995\_Mean\_Monthly\_Surface\_Temperature\_Climatology (celsius)".



PMEL

- Allows for both Web and Grid requests for NOMADS data
- Easy expansion of low cost RAID
- Secure transactions and independent development of other Grid Services (ESG IPG, CEOS or NREN)
- **Required: NCDC Mass Store Access**



- NOMADS is XML based and includes Federal Geographic Data Committee (FGDC); and Cooperative Ocean/Atmosphere Research Data Service (COARDS), a NOAA/university cooperative for the sharing and distribution of global atmospheric and oceanographic research data sets. Non-COARDS allowed.
- NOMADS allows for expansion of other data forms (OpenGIS SOAP, ISO, NSDL) and Digital Library for Earth Science Education (DLESE) under the National Science Foundation.
- NOMADS is following (and hopefully supporting) emerging templates as developed by various communities such as DODS (OPeNDAP), NVOODS, DLESE, and others for compatibility across organizations, datasets, and disciplines.
- **Long-term archive documentation stewardship essential !!**



## ➤ **Climate**

GFDL: Coupled Models, Control and Perturbation Integrations

NCAR: Community Climate System Model / Land Surface and CO2 predictive models (VEMAP), Reanalysis / Eta

NCDC: Select observational datasets; LTA for NCEP & GFDL

LLNL: AMIP / Probabilistic information

## ➤ **Weather**

NCDC: Retrospective NOAAPort AWIPS Grids NCEP models / Reanalysis 2 / NCEP global model data assimilation and restart files / sfc and U/A obs.  
Reference Data sets: Climate Reference Network / Regional Reanalysis

NCEP: Real-time NOMADS server

CDC: Atmospheric/Ocean/Regional Reanalysis



- NOMADS will save the minimum data necessary to regenerate model output products as close as possible to NCEP operations.
- Available will be obs, fixed fields, initial conditions, and restart files.
- The analysis files will be in the models own coordinate system (without further interpolation or adjustment). This is the models "ground truth" for verification given the optimal interpolation used.
- Files are constructed with computer and computational efficiency in mind, and not in standard coordinate systems. Programs to convert these files to standards will be made available: (e.g., spectral to gaussian, gaussian to lat/lon, sigma to pressure).

The minimum set for Global Spectral Forecast Model and the Spectral Statistical Interpolation Cycling Analysis System contains ~0.5Gb /run:

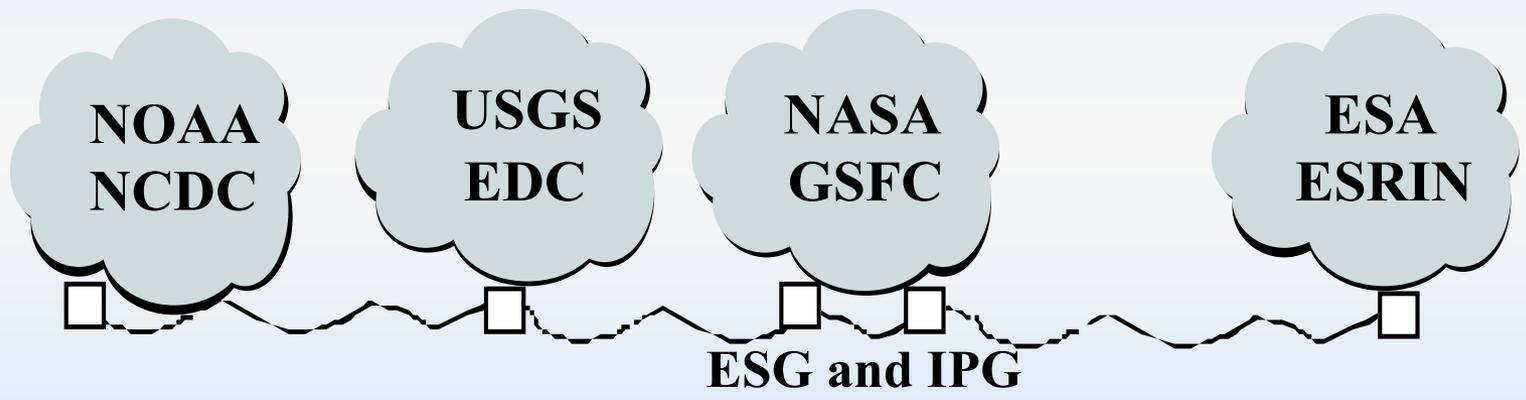
- NOAA-15/16 AMSU-A/B TOVS 1B Radiances (IEEE)
- Analysis Bias Corrected Information / Obs Toss List
- SFC U/A, ACRS, Aircft (BUFR)
- 6HR fcst guess from previous run (BUFR)
- ERSCAT Sat obs / HIRS 14/15, MSU TOVS (IEEE)
- Guess prep and and fcst guess output (BUFR)
- Analysis ready QC'ed Obs. (prepBUFR)
- Profiler, TOVS, Wind Obs. (BUFR)
- SFC Analysis Restart Files
- SST's (GRIB), Radar VAD Winds (BUFR)



- NOMADS team proposes extension of data access to satellite data for climate and NWP model analysis and verification:
- Options include:
  - Blending data streams- satellite/in situ temperature products (SSM/I sfc temp w/ station data: operational monitoring;
  - Satellite data verification of observational data (sfc and U/A);
  - Radar, model (NWP), and satellite (MODIS, GOES, etc.) for estimates for QC of in-situ precip data (rain/no rain);
  - Creation of physical processes, (e.g., convection) could be developed.



➤ NOMADS has been selected as an application for the emerging CEOS DataGrid to establish a Grid capability. GFDL, NCAR and NCEP are under the NCDC-NOMADS. Phase-one FY02 install ANL developed “GLOBUS” Toolkit. See <http://www.globus.org>



➤ Under CEOS DataGrid and NOMADS:  
DOE’s Earth System Grid (ESG): [www.earthsystemgrid.org](http://www.earthsystemgrid.org)  
NASA’s Information Power Grid (IPG): [www.ipg.nasa.gov](http://www.ipg.nasa.gov)



Source: CEOS Grid Team

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- The **NOMADS Steering Group** will:
  - Provide vision and goals for the program and direct the course of work
  - Develop the NOMADS Program and outreach Plans
  - Develop data availability recommendations
  - Oversee the development of both a science plan and a technical plans
  - Generate support for OPeNDAP (DODS), and secure long-term resources
- **Current Steering Group** members:

<u>Name</u>	<u>Organization</u>	<u>Role</u>
Glenn Rutledge	NOAA NESDIS NCDC	PI
Ronald Stouffer	NOAA OAR GFDL	co-PI
Jordan Alpert	NOAA NWS NCEP	co-PI
Stephen Hankin	NOAA OAR PMEL	co-PI
Dean Williams	DOE LLNL PCMDI	co-PI
Lawrence Buja	NSF UCAR NCAR	co-PI



## Advisory Team

The members of the Advisory Team are:

<u>Name</u>	<u>Organization</u>	<u>Role</u>
Don Middleton	NCAR	ESGrid & Earth Science Portal
Brian Doty	COLA	co-PI/NWP/Climate
Jeff Whitaker	CDC	Advisor/Climate
Jim Steenburgh	Unidata	University Representative
Michael Fiorino	LLNL	Advisor/Evaluation/NWP
Joan Brundage	FSL	Advisor/Core NOAA Partner
Chris Hill	MIT	ESMF
Bryan Lawrence	BADC	UK/NERC DataGrid/ESP
Kerstin Kleese	e-science	Advisor NERC DataGrid
Neville Smith	Australia BOM	Advisor/Ocean
Linda Mearns	NCAR	Advisor/Impacts



CDC: <http://www.cdc.noaa.gov:80/dods/Datasets/> (GDS)

<http://www.cdc.noaa.gov/cgi-bin/nph-nc/Datasets/> (DODS)

COLA: <http://cola8.iges.org:9090/dods>

GFDL: <http://nomads.gfdl.noaa.gov>

NASA: <http://gcmd.nasa.gov/Data/portals/models/>

NCAR: <http://dataportal.ucar.edu:8080/dodsC>

<http://dataportal.ucar.edu/las5/>

<http://dataportal.ucar.edu:9090>

NCDC: <http://nomads.ncdc.noaa.gov:9090/index.html>

NCEP: <http://nomad1.ncep.noaa.gov>

PCMDI: <http://www-pcmdi.llnl.gov/amip/>

**Unidata:** <http://www.unidata.ucar.edu/packages/dods/>

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## Questions?

NOMADS Principle Investigator-

Glenn.Rutledge@noaa.gov or

Jordan.Alpert@noaa.gov

The NOMADS Informational Web Page at

**[www.ncdc.noaa.gov/oa/climate/nomads](http://www.ncdc.noaa.gov/oa/climate/nomads)**

(March '03)

