The NOAA National Operational Model Archive and Distribution System - NOMADS - and - Plans for a NOAA Climate Model Portal (NCMP)

NCDC Asheville, NC

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NOAA Global Interoperability Program Kickoff
NOAA Geophysical Fluid Dynamics Laboratory
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Outline

- NOMADS
  - Status Report
  - ECIP Reanalysis outputs
- Why NCMP?
- Plans for NCMP
  - a community approach
  - an architectural philosophy
NOMADS: 10 years old?

- NOMADS is a distributed data access project for access to real-time and retrospective high volume numerical weather prediction and climate models. Conceived in 1999 operational in 2002 without directed funding. (the power of collaborations!)

- NOAA’s NCDC initiated NOMADS with NCEP and GFDL. The collaboration quickly grew. Founding member of GO-ESSP. Focus has been on weather and reanalysis. Plans to support climate models and associated observational data.

- Users can have access to data as input to their decision making processes this information is useful on time scales from days (weather) to months (El Nino) to decades (global warming).
NOMADS Goals

- Establish a unified climate and weather model archive providing format independent access to retrospective models
- Promote model evaluation and community feedback
- Foster research within the geo-science communities (ocean, weather, and climate) to study multiple earth systems using collections of distributed data
- Develop institutional partnerships and access via distributed open standard technologies
NOMADS Benefits

- NWS systems engineers informally studied the bandwidth “cost savings” obtained via the NOMADS vs. traditional “gateway” servers.

- In a nutshell, they found an overall savings of 80% of the volume by using NOMADS for the same services.

- “NOMADS” services (OPeNDAP, GDS, LAS, TDS, ftp4u) being considered for “NOAA NexGen”.
Priorities for Development at NCDC

- Prepare for servicing NOAA’s next suite of Reanalysis projects (1.5 Petabytes).
- Climate and Weather Observing System Simulation Experiment Capability (OSSE’s)
- New Data and Models:
  - Development of a Reanalysis Clearinghouse capability for an “on-going analysis of the climate system”
  - AR5 subsets, Regional Climate Models, TIGGE, YOTC
- Develop requirements for the NOAA Climate Model Portal (NCMP).
NOMADS now Operational in NWS. New “Ocean-NOMADS”

- Archive and limited real-time services:
  - National Climatic Data Center (NCDC) Asheville, NC
  - National Ocean Data Center (NODC) Charleston, SC

- Operational National Weather Service (NWS) real-time (R/T NOMADS) services:
  - Fort Worth, TX
  - Boulder, CO
  - Silver Spring, MD
NOAA NOMADS Services

- Near-real-time services supported by NCDC is available at [http://nomads.ncdc.noaa.gov/](http://nomads.ncdc.noaa.gov/). This server provides:
  - access to most of NCEP's operational data sets
  - a long-term archive for all data sets
  - many other data sets (see [http://nomads.ncdc.noaa.gov/data.php?name=inventory](http://nomads.ncdc.noaa.gov/data.php?name=inventory))
  - A non-operational research and development server (and developing ESG node) managed by NCDC is available at [http://nomads6.ncdc.noaa.gov/ncep_data/index.html](http://nomads6.ncdc.noaa.gov/ncep_data/index.html)

- A real-time server supported 24x7 by NCEP is available at [http://nomads.ncep.noaa.gov/](http://nomads.ncep.noaa.gov/). This server provides:
  - access to NCEP's operational data sets as they are being generated
  - a short-term archive of up to a month for most data sets
  - 24x7 operational monitoring by NCEP staff
  - a geographically-diverse backup server to insure operational availability

- Four non-operational research and development servers used for customer testing of new products and services prior to operational implementation
  - These servers are not guaranteed to have current data and their content are supported only during business hours and on the basis of staff availability. Three non-operational research and development servers managed by NCEP are available at:
    - [http://nomad1.ncep.noaa.gov/ncep_data/index.html](http://nomad1.ncep.noaa.gov/ncep_data/index.html)
    - [http://nomad5.ncep.noaa.gov/ncep_data/index.html](http://nomad5.ncep.noaa.gov/ncep_data/index.html)

NOMADS Data at NCDC

NWP Model

- Global Forecast System (GFS), 1 and ½ degree
- NCEP Spectral Statistical Interpolation (SSI) Global Data Assimilation System (GDAS) w/ restart files
- North American Mesoscale (NAM, formally Eta) 12km
- Rapid Update Cycle (RUC) 20km and 13km
- NCEP North American Regional Reanalysis (NARR) 30 years 32km
- NCEP/NCAR/DOE R1 & R2 Global Reanalysis
- NCEP Global Ensembles
- NCEP Climate Forecast System Reanalysis & Reforecast (CFSRR)
- NCEP/CPC Climate Prediction Center Reanalysis (CPCR)
- NCEP 20th Century Reanalysis

In situ

- NCDC Global Historical Climate Network (GHCN) Temp/Precip
- NCDC Integrated Global Radiosonde Archive (IGRA) upper air
- NCDC Smith-Reynolds Extended Reconstructed and OI ¼ SST's
- Service Records Retention System (SRRS)

Climate Data / Coupled AOGCM

- Limited GFDL CM2.0 and CM2.1 Climate Experiments
- Paleoclimate Model Intercomparison Project (PMIP)
NCDC

NOMADS Model Data Requests (millions)

Millions

- Nomads6 (ftp)
- Nomads6 (web)
- Nomads (ftp)
- Nomads (web)
NCDC

NOMADS Model Data Downloads (TB)

[Bar chart showing the data downloads from NOMADS model with different months and years, differentiated by FTP and web access.]
The NOMADS Ensemble Probability Tool is a tool that is designed to allow users to interrogate the NCEP Global Ensemble model. The tool allows the user to describe a set of conditions and determine the probability that that set of conditions will occur at a given location.

The NOMADS Ensemble Probability Tool queries the 21 member GFS ensemble dataset located on the NCEP NOMADS High Availability server. The data is passed via OpenDAP back to the application, where it is read using the Java NetCDF library, and then the probabilities are calculated.

For more information, please see our help page.

### Where
- Station ID: Asheville, Asheville Regional Airport, NC, United States
- Lat: (-80 to 90) Lon: (-180 to 180)

### When
- Latest model run: (2009 Oct. 23 06z)
- Year: [ ] Month: [ ] Date: [ ] Model Run: [06z] [ ]

### What
- Air Temperature at 2 meter height
  - 6 hour Highest temperature: [ ] 65 [ ] °F
  - 6 hour Lowest temperature: [ ] 65 [ ] °F
- Precipitation
- Wind at 10 meter height
- Cloud Cover
- Air Temperature at 850 millibar pressure level
- Convective Available Potential Energy (CAPE)

![Probability Graph](image)

**Probability that the event will occur**

**Results**

**Event:** where the highest temperature is greater than 65 degrees F.

**Location:** Asheville, Asheville Regional Airport, NC, United States (35-25-55N, 082-32-15W)

**Time:** Oct 23, 2009 06z

**At the location:**

**Asheville, Asheville Regional Airport, NC, United States (35-25-55N, 082-32**

**For the GEMS model run at the given time:** Oct 23, 2009 06z
NOMADS Output Samples

Server side graphics
New NOAA Reanalysis Projects

1) Historical SFC Reanalysis (Compo et al.,)
   ◦ 1850 to present. ~60TB
2) Post WW-II Reanalysis (NCEP/CPC)
   ◦ 1944 to present. ~235TB
3) Climate Forecast System Reanalysis and Reforecast (CFSRR) Project (Saha et al.)
   ◦ 1978-2009 modern era Reanalysis and Seasonal Reforecast ~250TB

New: working for distributed access at NCAR!

http://nomads.ncdc.noaa.gov/NOAAReanalysis/
A standard offline data request enables more capabilities, but takes longer to process and time series are limited.

Selecting 'Bulk Request' removes most of the selection options, but delivers unaltered .tar files from the archive to a FTP server via HDSS.
NCDC NOMADS : PERL Module
- Allows both front-end CGI and back-end data management systems integrated access to dataset configuration and metadata, module and API functions, with minimal third party dependencies.
- Contains over 85 independent and reusable functions
- Easier to install and update
- Integrates a system-wide XML dataset configuration file which can be utilized by any front or back-end application using the module.
- Deprecates the previous NOMADS back-end which consisted of numerous script tool packages, which were often incompatible with each other and were generally not reusable code.

NOMADS – Hierarchal Access System (N-HAS) for HDSS Deep Archive
- PERL module in development: built on top of NCDC NOMADS
- Covers the existing primary N-HAS processes: gather/submit/process/deliver, with disk checks and throttles to prevent overloading.
  - [gather] Collects data requests from any machine capable of taking them.
  - [submit] Builds then sends a HAS request using the NCDC NOMADS dataset config file.
  - [process] Breaks apart and processes archive files and places the results onto the stage disk
  - [deliver] Completes data requests to their machine of origin.
- Will support differentiation between offline and bulk data requests
NCMP Introduction
Objectives

The FY10-FY14 National Climate Model Portal (NCMP) will:

- Ensure readiness of access to NOAA’s next generation Climate and Weather reanalysis
  - Increase capacity to handle large data volumes and high user demand
  - Develop enhanced access trees for public and NOAA Operational and Research Centers.
- Provide long term stewardship of NOAA’s models
- Develop and staff a model “HelpDesk” capability to ensure model data output is used appropriately to reduce errors and public expectation of model results.
- Leverage existing efforts under GEO-IDE and community efforts such as GIP and GO-ESSP.

The investment will be distributed between technical portal architecture development, archive access and stewardship capabilities and a customer service “HelpDesk”.
Initially this program will provide NOAA’s sole portal into the following climate model reanalysis products with a volume of approximately 1.5 petabytes:

- Coupled Climate Forecast System Reanalysis and Reforecast (CFSRR) dataset, a “modern era reanalysis”. It is the first coupled 30 year global reanalysis of the atmosphere, ocean, land, and cryosphere (sea ice) ever developed by NOAA;
- Climate Prediction Center Reanalysis (CPCR), a historical upper-air (RAOB) reanalysis that is a long time series (1908-1958);
- The 20th Century Reanalysis Project Surface Pressure Reanalysis (1850 to present) by the Earth System Research Laboratory (ESRL).

The development of a coordinated NOAA Climate Model capability including GIP and others including existing external partners at NASA, NSF, Unidata, LLNL (PCMDI), and International.
Community building and collaborations are required in the era of 150PB model output data streams - digital libraries, distributed data access and processing.

Adaptation of modeling capabilities to CLASS (backend data storage) infrastructure a priority not currently being addressed.

To advance collaborations. To include:
- GIP
- NESII
- Earth Systems Modeling Framework (ESMF);
- Earth Systems Grid (ESG);
- iRODS and other community based distributed access technologies;

Historical access a key in improving models

Users at all levels of expertise expect easy access.

Not only retrieve data, but request NOAA provide answers to questions for various Stakeholders: Energy Sector; Agriculture; Transportation; Civil Engineering
National Academies of Sciences, National Research Council, Board of Atmospheric Sciences and Climate:

“Completing the Forecast: Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts”

The NOAA National Operational Model Archive and Distribution System (NOMADS) should be maintained and extended to include (a) long-term archives of global and regional ensemble forecasting systems and their native resolution, and (b) re-forecast datasets to facilitate post-processing”

NCMP will be an extension and an expansion of NOMADS:
There are three levels of services:

1) Provide simple, predefined weather information (reports, charts, visuals, etc.) for general public consumption. Provide little or no options while requesting the data. Simple Access for Teachers, Students, the General Public: "What impact will Global Warming have on me in 25 years?"

2) Provide targeted, predefined weather information (reports, charts, visuals, etc.) for specific educational and industry requirements such as agriculture and insurance. Provide access to only a few sub-setting options.

3) Provide expert access to the full range of NOMADS capabilities for scientists and meteorologists. Allow sub-setting along 5 dimensions: longitude, latitude, level, time (2), and variable.

Targeted Presentation Mode (1.2)

User Engagement Sectors

- Agriculture {1.2.1}
- Litigation {1.2.2}
- Travel {1.2.3}
- Energy {1.2.4}
- Transportation {1.2.5}
- Water Resources {1.2.6}
- Civil Infrastructure {1.2.7}
- Coastal Hazards {1.2.8}
- Health {1.2.9}
- Insurance {1.3.0}
- Commerce {1.3.1}
- Modelers {1.3.2}
- Climate Impacts (1.4.0)

3) Expert Modeler Access {1.3.1}

Ensemble Diagnostics {1.3.2}

Observation System Simulation Experiment (OSSE) capability (1.3.3)

Sub-setting data, & datasets for targeted orders {1.3.4}
model diagnostics, uncertainty PDF’s generation, downscaling, Regional Climate users; impacts, initialization access, etc.
NCMP Conceptual Design

NCMP addressing a gap for model services in NOAA: GEO-IDE *
Green boxes indicate collaborative scope of NCMP

* from NOAA DMIT and GEO-IDE CONOPS 2007
The initial NCMP architecture is based on NOMADS and on the DOE ESG: a (advanced) Portal, the ESG/TDS Catalog Node, and the (local) Data Repository.

1) **The Portal** is the user’s real-time interface to the system, manage requests, download data, receive user input and catalog browsing.

2) **The Catalog Node** advance and leverage ESG/TDS. Heart of collaboration and concentrates on connecting partners, metadata, search and discovery and secure peer-to-peer connectivity.

3) **the Data Repository** will be based on advanced real-time access components, advancements to CLASS, and will also use the Data Center IT infrastructure for long term storage and access

- Collaborators may include EPA, DOI, NASA & other US-GEO participants
Leveraging NOAA’s Resources and Managing Community Activities?

A Value Chain for Data Management *

Infrastructure
Metadata/Vocabulary/Ontology
Technology Development
Community Building
Knowledge Management

Collect/Receive Data | Store/Manage Data | Discover/Browse Data | Transport Data | Analyze/Model Data | Archive Data

Functions
Functions add value to the raw material (in this case, data) to produce a product for Policy and Management Decisions.
It is an iterative spiral approach.


* Value Chain Construct (M. Porter, 1998 Competetive Advantage)
NCMP Architecture and Data Management Philosphy

- Different combinations of community assets will solve different problems
- Can be tailored to current near-term solutions
- Effective use of existing portals for data access and distribution, and for existing transport technologies will increase chances of success.
- NCMP will participate in a broader NOAA-wide framework for a comprehensive suite of modeling services.
Next Steps for NCMP

- Establish a NOAA Climate Model Portal Governance Team
  - How best to collaborate; define requirements & coordinate?
- Develop “sector-based” front end
- Support CF via grants / NOAA Climate Institute
- Develop Charter, Project Plan; Establish Collaborators
  - Advance NOAA collaborations and coordinate w/ NESII
  - Participate in GIP and GEO-IDE.
  - Workshops proposed: GO-ESSP; Model-to-Obs wkshp for CMIP
- Establish a joint CLASS and Data Center user requirements team to develop Level-1 (A-SPEC) access requirements for model data.
In Summary

- NOMADS “bulk-order” ftp capability providing basic user access for high volume NOAA ECIP reanalysis output completed.

- NOMADS to evolve to NCMP and partner across NOAA’s modeling efforts, leveraging resources and assets.

- NCMP to develop and support a model “HelpDesk” at NCDC in collaboration with NOAA partners.
In development:
NCDC Spring 2010 model - to-
Obs Inter-comparison
Workshop to support CMIP

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Coupled Climate Forecast System (CFS) Reanalysis and Reforecast (CFSRR) (Atm - Ocn - Land – Sealce) in two projects:

- **Reanalysis**: 31-year (1979-2009) T384L64 (~32 km and 64 hybrid layers for the atmosphere, 0.5° and 40 levels for the ocean, 4 soil levels)
  
  To be released in Jan 2010 via NOMADS / NCDC and NCAR (tbd)

- **Reforecast**: 28-year (1982-2009) T126L64 (~32 km and 64 hybrid layers for the atmosphere, 0.5° and 40 levels for the ocean, 4 soil levels) 6 hourly Reforecast for 1 year

- Approximately ~500 Terabytes in GRIB2.

- NCDC and NCEP seeking community input for access priorities to this massive dataset. For the NOMADS Survey site see:
  
  http://nomads.ncdc.noaa.gov/NOAAReanalysis/
CFS Reanalysis Monthly Mean Files (22 file types):

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<tr>
<th>FILE NAME FIELD</th>
<th>FILE NAME FIELD</th>
<th>DEFINITION</th>
<th>GRID RESOLUTION</th>
<th>VERTICAL LEVELS</th>
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### CFS Reanalysis Timeseries Files (77 file types):

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<tr>
<td>runoff</td>
<td>Ground Runoff</td>
<td>T382 Gaussian</td>
</tr>
<tr>
<td>sshf</td>
<td>Sensible Heat Flux</td>
<td>T382 Gaussian</td>
</tr>
</tbody>
</table>

### CFS Reanalysis Hi- Priority Time Series

- **snohf**: Snow Phase-Change Heat Flux | T382 Gaussian
- **soilm1**: Soil Moisture Level 1 on T382 Gaussian Grid | T382 Gaussian
- **soilm1x0.5**: Soil Moisture Level 1 on 0.5 x 0.5 Deg Lat/Lon Grid | 0.5 x 0.5 Deg Lat/Lon
- **soilm2**: Soil Moisture Level 2 on T382 Gaussian Grid | T382 Gaussian
- **soilm2x0.5**: Soil Moisture Level 2 on 0.5 x 0.5 Deg Lat/Lon Grid | 0.5 x 0.5 Deg Lat/Lon
- **soilm3**: Soil Moisture Level 3 on T382 Gaussian Grid | T382 Gaussian
- **soilm3x0.5**: Soil Moisture Level 3 on 0.5 x 0.5 Deg Lat/Lon Grid | 0.5 x 0.5 Deg Lat/Lon
- **soilm4**: Soil Moisture Level 4 on T382 Gaussian Grid | T382 Gaussian
- **soilm4x0.5**: Soil Moisture Level 4 on 0.5 x 0.5 Deg Lat/Lon Grid | 0.5 x 0.5 Deg Lat/Lon
- **soilt1**: Soil Temperature Level 1 | T382 Gaussian
- **swe**: Snow Water Equivalent | T382 Gaussian
- **swe0.5**: Snow Water Equivalent x 0.5 | 0.5 x 0.5 Deg Lat/Lon
- **t1000**: Temperature at 1000 hPa | 0.5 x 0.5 Deg Lat/Lon
- **t2**: Temperature at 2 hPa | 0.5 x 0.5 Deg Lat/Lon
- **t200**: Temperature at 200 hPa | 0.5 x 0.5 Deg Lat/Lon
- **t50**: Temperature at 50 hPa | 0.5 x 0.5 Deg Lat/Lon
- **t850**: Temperature at 850 hPa | 0.5 x 0.5 Deg Lat/Lon
- **tmax**: Maximum 2m Air Temperature | T382 Gaussian
- **tmin**: Minimum 2m Air Temperature | T382 Gaussian
- **tmp2m**: 2m Air Temperature | T382 Gaussian
- **tmp10l**: Temperature at Hybrid Level 1 | T382 Gaussian
- **tmpsfc**: Surface Temperature | T382 Gaussian
- **ulwfc**: Upward Long Wave Radiation at the Surface | T382 Gaussian
- **ulwtoa**: Upward LW at the Top of Atmosphere | T382 Gaussian
- **uswfc**: Upward SW at the Surface | T382 Gaussian
- **uswtoa**: Upward SW at the Top of Atmosphere | T382 Gaussian
- **uve500**: Vertical Velocity at 500 hPa | 0.5 x 0.5 Deg Lat/Lon
- **umd1000**: Zonal (u) and Meridional (v) Wind at 1000 hPa | 0.5 x 0.5 Deg Lat/Lon
- **umd10m**: Zonal (u) and Meridional (v) Wind at 10m | T382 Gaussian
- **umd200**: Zonal (u) and Meridional (v) Wind at 200 hPa | 0.5 x 0.5 Deg Lat/Lon
- **umd500**: Zonal (u) and Meridional (v) Wind at 500 hPa | 0.5 x 0.5 Deg Lat/Lon
- **umd700**: Zonal (u) and Meridional (v) Wind at 700 hPa | 0.5 x 0.5 Deg Lat/Lon
- **umd850**: Zonal (u) and Meridional (v) Wind at 850 hPa | 0.5 x 0.5 Deg Lat/Lon
- **umdxtr**: Zonal (u) and Meridional (v) Wind Stress at the Surface | T382 Gaussian
- **z1000**: Geopotential at 1000 hPa | 0.5 x 0.5 Deg Lat/Lon
- **z200**: Geopotential at 200 hPa | 0.5 x 0.5 Deg Lat/Lon
- **z500**: Geopotential at 500 hPa | 0.5 x 0.5 Deg Lat/Lon
- **z700**: Geopotential at 700 hPa | 0.5 x 0.5 Deg Lat/Lon
- **z850**: Geopotential at 850 hPa | 0.5 x 0.5 Deg Lat/Lon