

**NOAA National  
Climate Model  
Portal**

NCMP

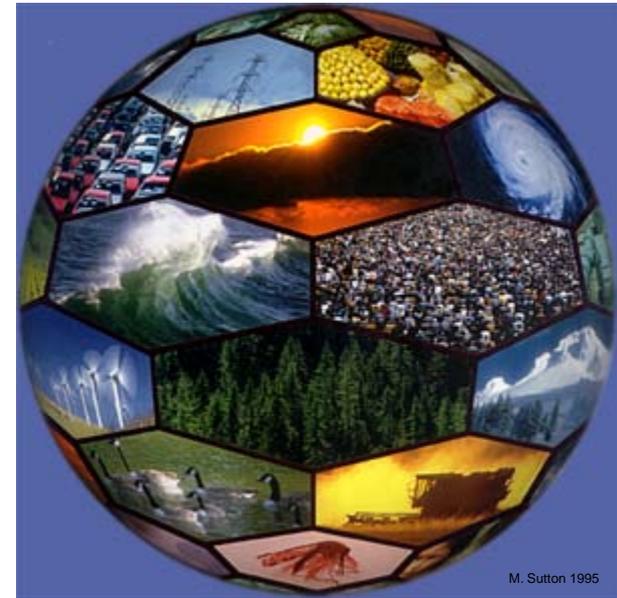
# NOMADS and NCMP Science and Data Management Services

Jay Hnilo

NOMADS/NCMP Senior Scientist

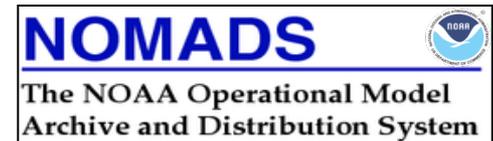
NOAA's Cooperative Institute for Climate and  
Satellites (CICS-NC)

NOAA's National Climatic Data Center  
Asheville, NC 28801



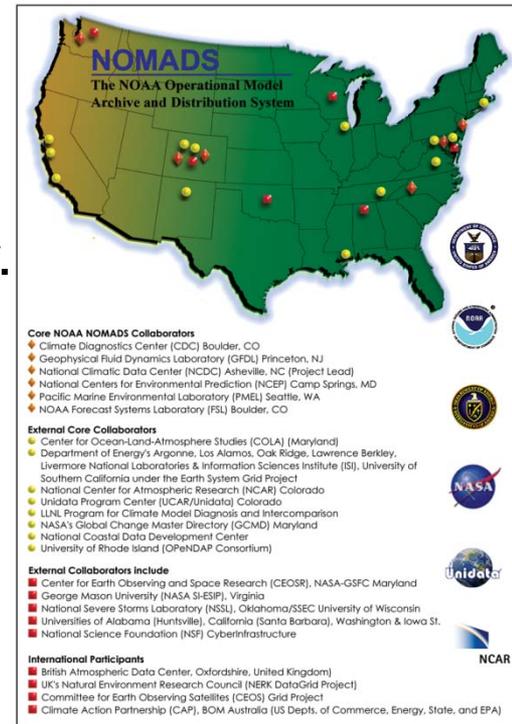
M. Sutton 1995

# NCMP

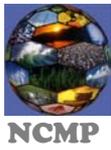


# NCMP Background: NOMADS

- 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.
- NOAA's NCDC initiated NOMADS with NCEP, GFDL, PCMDI, NCAR.PMEL and others. The collaboration quickly grew under a distributed data access philosophy.
- Founding member of GO-ESSP. Focus on NWP. NCMP will address climate models, diagnostics, and model-to-obs intercomparisons.



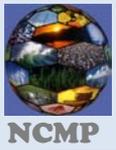
FY10  
**Distinct hosts served: 83,370**  
**Successful requests: ~125 million**  
**1 day record: 4.9TB**



# NCMP Benefits

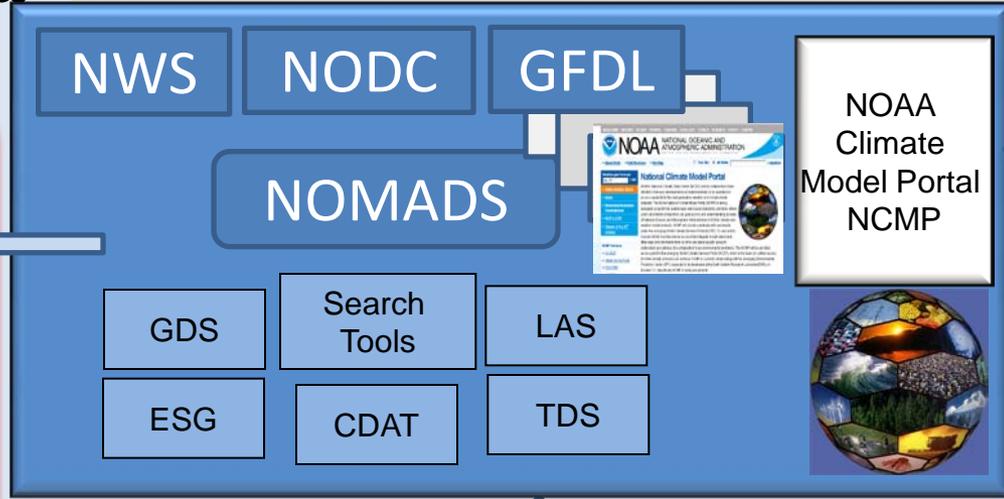
- ▶ In 2009 NWS systems engineers studied the bandwidth “cost savings” obtained via the NOMADS vs. traditional “gateway” servers.
- ▶ In a nutshell, they found an overall savings of 80% of the volume by using NOMADS for the same services.
- ▶ “GO-ESSP” services (OPeNDAP, GDS, LAS, TDS, [ftp4u](#), ...).





# NOAA National Climate Model Portal

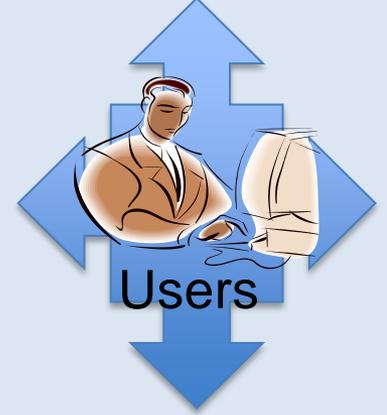
# NOMADS Access Infrastructure



**Reanalysis.**  
**Org**  
**Climate Clearing-house**  
 Community vetted observational database

- Global Interoperability Program  
 - National Climate Predictions and Projections Center

**NOAA Cooperative Institute Climate and Satellites CICS-NC Asheville**



**NOAA Climate Assessment Services**

Private or Unpublished results

**Collaborations**

**Earth System Grid Framework**

**NCDC**

**Distributed Archive Services**





# NOMADS Data Availability

## NWP Model and Climate Reanalysis

- ▶ Global Forecast System (GFS), 1 and 1/2 degree
- ▶ NCEP Climate Forecast System Reanalysis (CFSRR) Global 32km
- ▶ NCEP Climate Forecast System Reforecast (CFSRR) Global 32km
- ▶ NCEP North American Regional Reanalysis (NARR) 30 years 32km
- ▶ NCEP/NCAR/DOE R1 & R2 Global Reanalysis
- ▶ NCEP Global Ensembles (GENS) / TIGGE (w/ NCAR)
- ▶ ESRL Twentieth Century Reanalysis Project (20CR) (2011)
- ▶ NCEP Spectral Statistical Interpolation (SSI) Global Data Assimilation System (GDAS) w/ model restart
- ▶ North American Mesoscale (NAM, formally Eta) 12km
- ▶ Rapid Update Cycle (RUC) 20km and 13km

- ▶ March 2004 – Present, October 2006 - Present
- ▶ January 1979-Present
- ▶ January 1979 – Present
- ▶ January 1979 - Present
- ▶ Jan 1948 – Present, Jan 1979 - Present
- ▶ December 2007 - Present
- ▶ January 1850-Present
- ▶ January 2001 - Present
- ▶ February 2002-Present
- ▶ February 2005 - Present
- ▶ January 2006 – Present, March 2007 - Present

## Climate Data / Coupled AOGCM

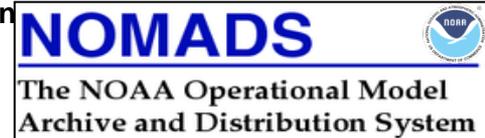
- ▶ Limited GFDL CM2.0 and CM2.1 Climate Experiments
- ▶ Paleoclimate Model Intercomparison Project (PMIP)
- ▶ CMIP3/5 multi-model suite via ESGF (2011)
- ▶ Downscaled CMIP3/5 (2011)

- ▶ Limited AR4/5
- ▶ POR
- ▶ AR4/5
- ▶ AR4/5

## Observational 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 1/4 SST's Service Records Retention System (SRRS)

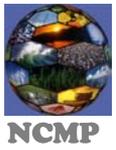
- ▶ Jan 1880 – Present, Jan 1900 - Present
- ▶ Varies by station
- ▶ Jan 1854 – Present, Jan 1985 – Present
- ▶ April 2001 - Present





# Existing NOMADS-NCMP Servers

- **Archive** services supported by NCDC is available at <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>)
  - 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/>. 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://nomad3.ncep.noaa.gov/ncep\\_data/index.html](http://nomad3.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)
- **Ocean**-NOMADS at [http://edac-dap2.northerngulfinstitute.org/ocean\\_nomads/](http://edac-dap2.northerngulfinstitute.org/ocean_nomads/). This server provides most NCEP and some Navy Ocean Models.



# NCMP Recommendation

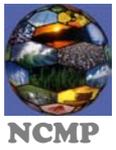
- **National Academies of Sciences, National Research Council, Board of Atmospheric Sciences and Climate:**

“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”<sup>1</sup>*

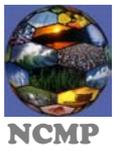
NCMP will be built on top of NOMADS as a suite of Services and Tools. It is an extension and an expansion of NOMADS





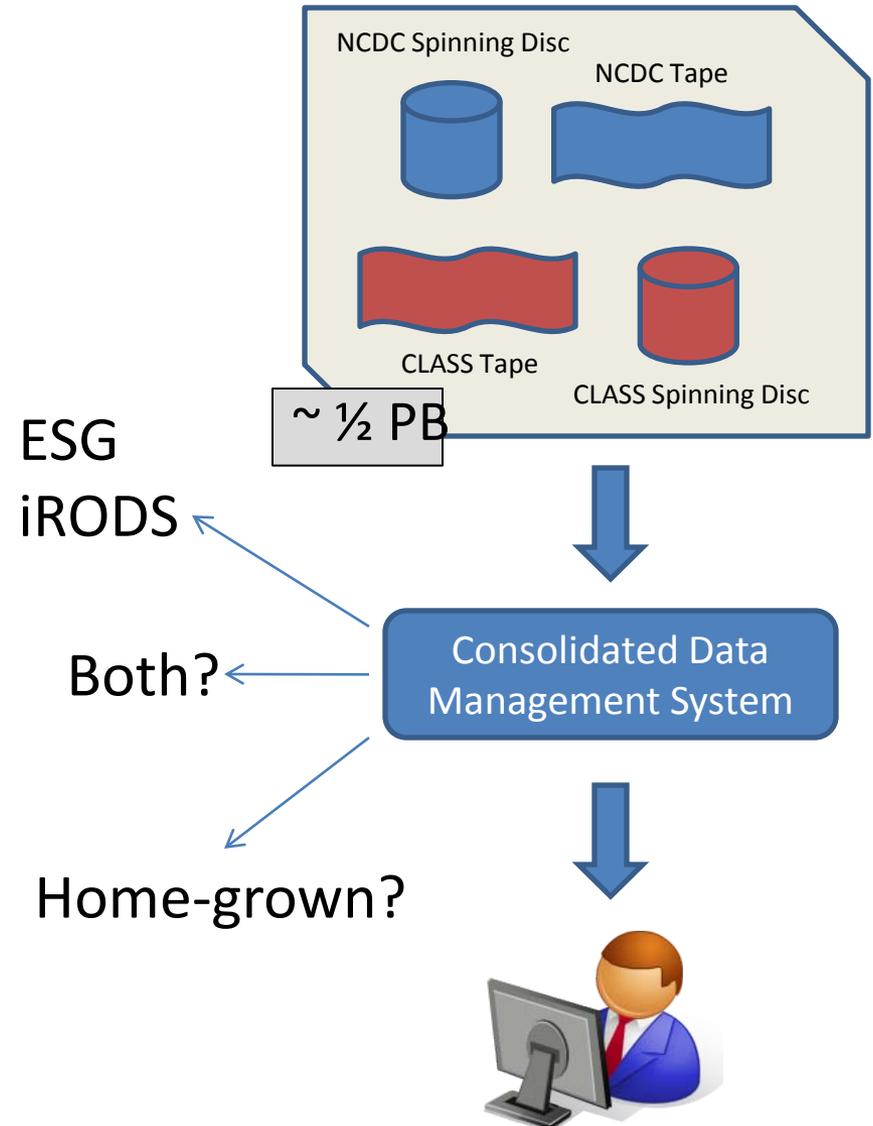
# Architectural Design Functional Areas

- Project Management
- Planning & Engineering
- Climate Science Applications
- Application Development
- Sector Engagement
- Systems Technology
- Dataset Management
- Model Data Dissemination Support



# Improved Data Management

- NOMADS' holdings continue to grow, especially with additions of new data as part of NCMP
- Holdings now spread across 4 different NOAA/NCDC media
- NCMP will leverage/create and/or select a data management system to abstract the handling of these media
- NOMADS/NCMP users will gain a more consistent user experience across all datasets



# NOMADS as data store → NCMP as data discovery



NCDC's Geodata Portal

HOME SEARCH

Search

Reanalysis

Search In: This Site  
Additional Options  
Clear

WHERE

Anywhere  Intersecting  Fully within



Search results:

-  NCEP Reanalysis version 2
-  CDC Derived NCEP Reanalysis Products Tropopause Level
-  Climate Forecast System Reanalysis (CFSR)  
The NCEP Climate Forecast System Reanalysis (CFSR) was completed for the 31-year period from 1979 to 2009, in January 2010. The CFSR was designed and executed as a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system to provide th...  
[Web Services](#) [Preview](#) [Data Access](#) [Details](#) [Metadata](#) [Zoom To](#)
-  NCEP Reanalysis Tropopause Level
-  NCEP/DOE AMIP-II Reanalysis (Reanalysis-2) Monthly Values
-  CPC Merged Analysis of Precipitation Standard
-  Climate Prediction Center Global Monsoons

See results through REST API: [GEORSS](#) [ATOM](#) [HTML](#) [FRAGMENT](#) [KML](#) [JSON](#)

This Geoportal was built using the ArcGIS Server Geoportal Extension 9.3.1. Please read the [Disclaimer](#) and [Privacy](#) or [Contact Us](#).

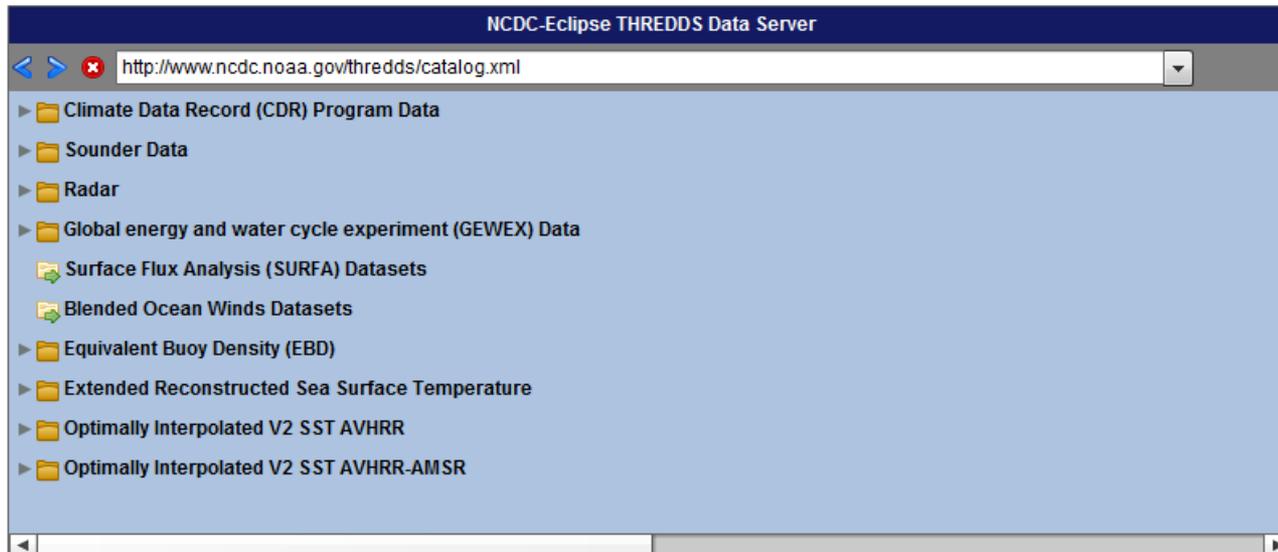
- Metadata-based search and discovery
- Extending distributed access mechanisms
- Technology & tools such as
  - ncISO
  - ESGF
  - ERDDAP / GI-cat / GI-go
  - UAF
  - esri GeoPortal

# NCMP / NOMADS

## Technology Enhancements

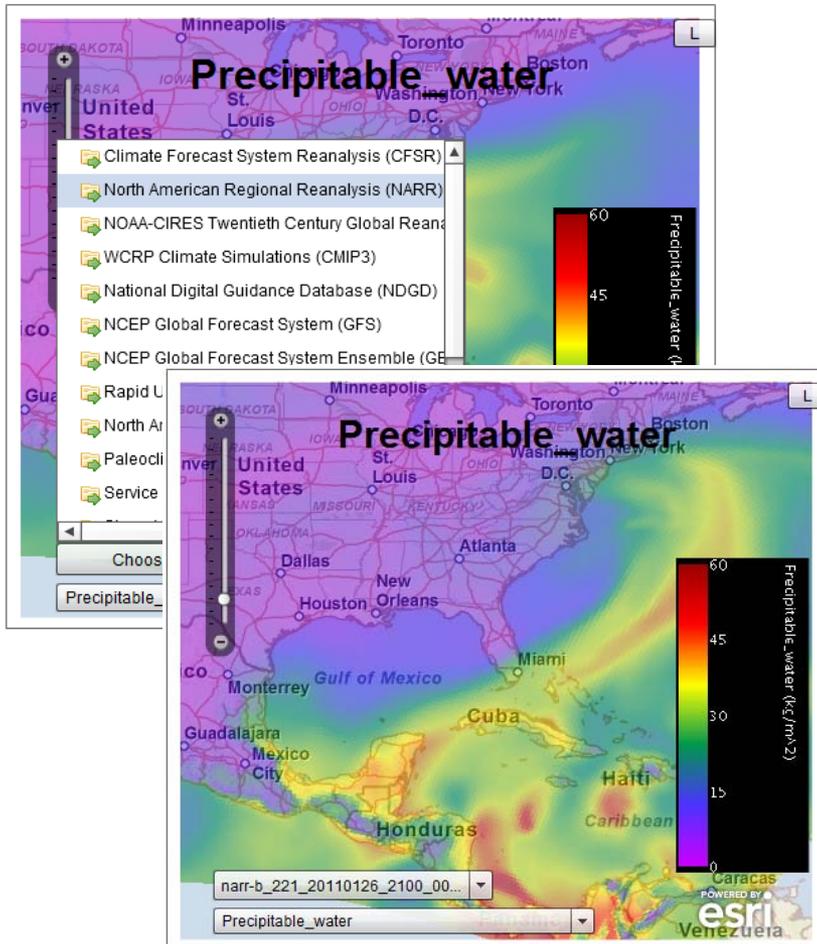
- Extending NOMADS into interactive and sector-utilized formats and technologies

Example: THREDDS Catalog Navigation in Adobe® Flash®



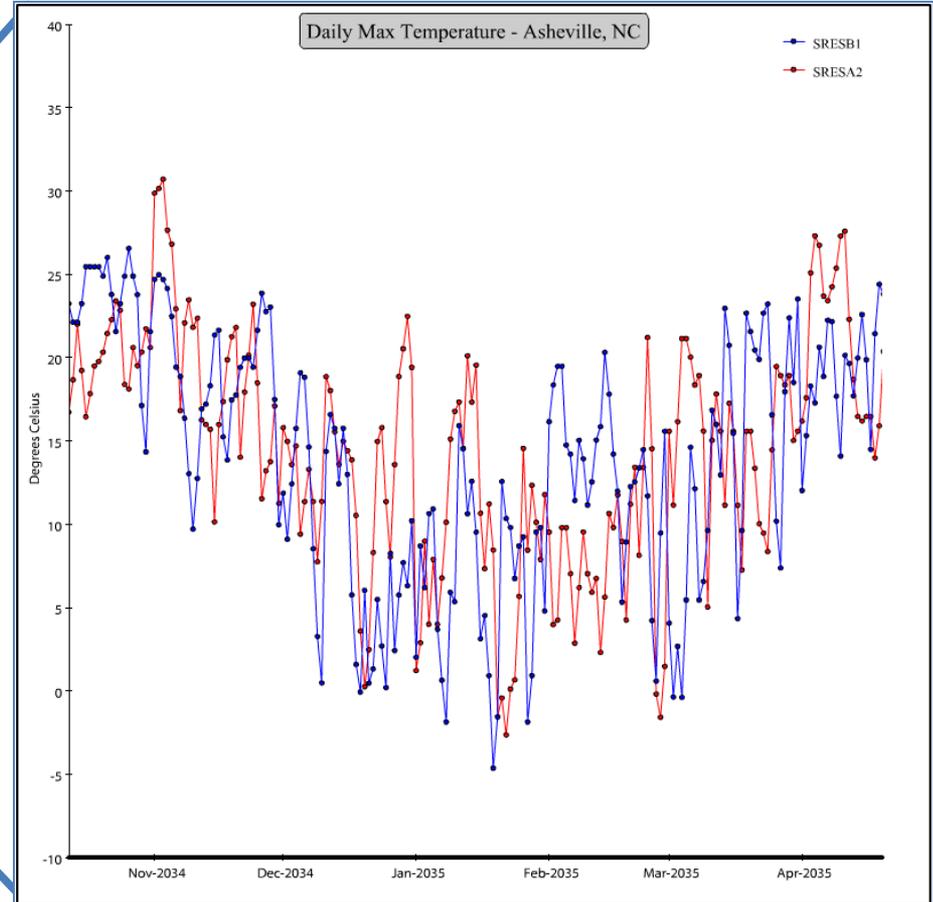
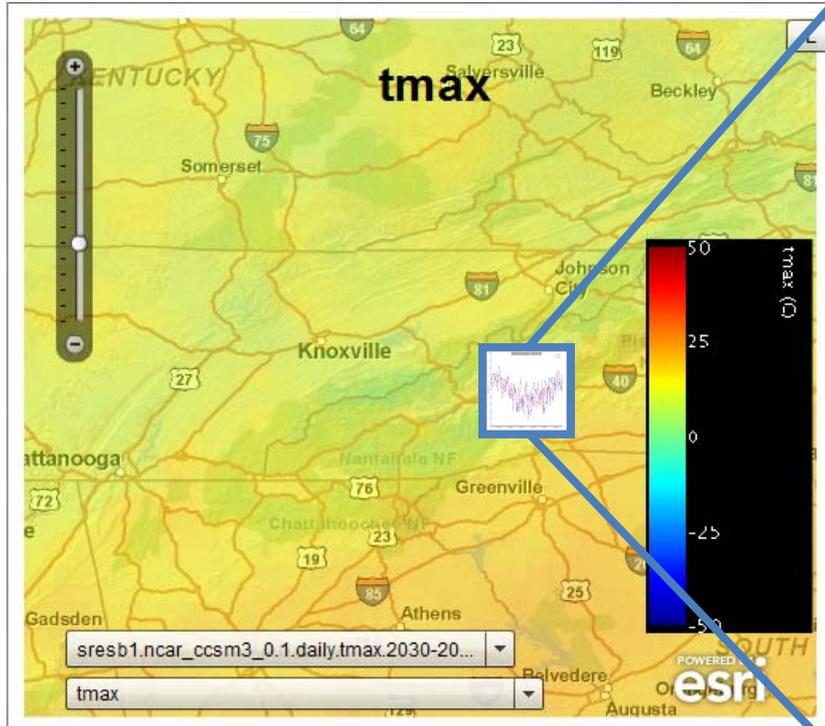
# NCMP / NOMADS

## Technology Enhancements (cont.)

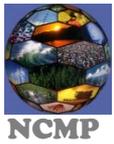


- Incorporating THREDDS-based data into interactive mapping applications
- Utilizing OGC components from THREDDS (WMS, WCS, etc.)

## Technology Enhancements (cont.)



Interactive experiences: CMIP3 data in a web-based mapping application with multi-scenario timeseries comparisons via Multigraph



# NCMP Science Tools for Users

## PROFESSIONAL USERS- Diagnostics & Model-to-Obs Inter-comparisons

- On-line access to Climate Model Analytical Engines
  - Climate model Data Analysis Tool (CDAT) for advanced model diagnostics and model-to-obs intercomparisons.
  - other tools such as NCDC's SPEC (Ansari et al) will be leveraged to help develop thumbnail plots generated from CDAT python code as to be extensible with CDAT to accurately geo-locate non-discrete points to grids.
- Variability (identification of regions of climate sensitivity)
  - Tools will be developed to find a simple ratio of variances for (projected model results) / (observations)
  - e.g., Twentieth Century Reanalysis Project, or Climate of the 20<sup>th</sup> Century run or, 2x or 4xCO<sub>2</sub> GFDL IPCC CM.x runs
- Decadal Temperature Trends and Average Annual Cycles  
Anomalies can be pre-staged. Average annual cycle differences between a control run and a doubled CO<sub>2</sub> would infer that presently precip maximums are in June – but in a 2xCO<sub>2</sub> run precip maximizes in January. These are important direct measures appropriate for an advanced audience.

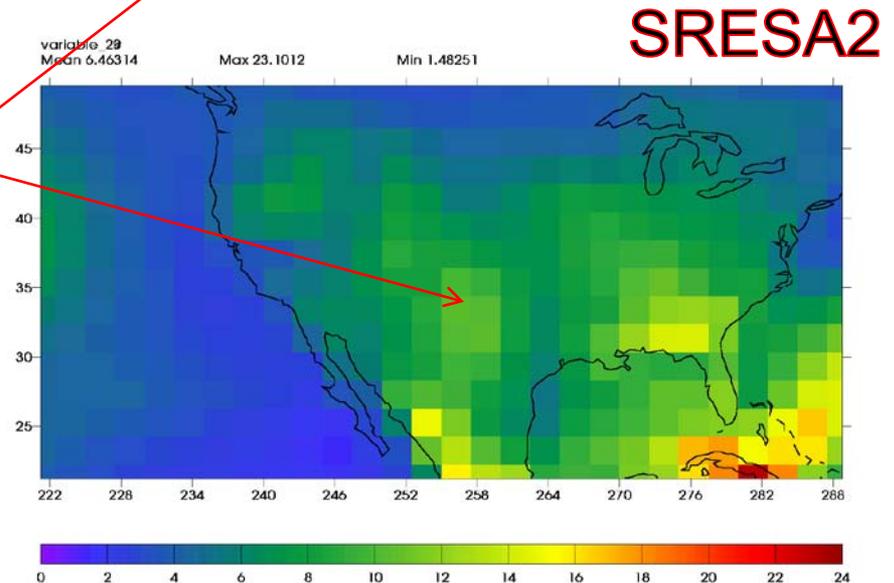
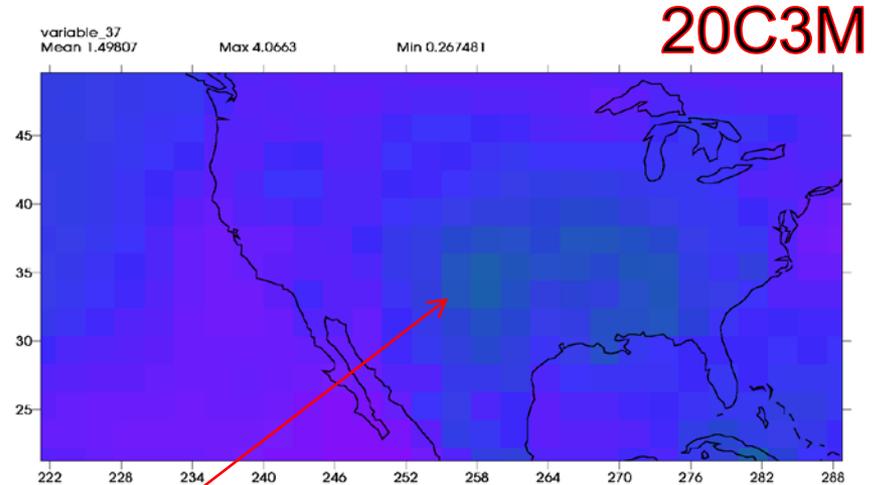
# NCMP Science Tools for Users

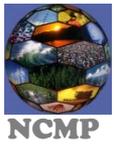
Climate of the 20<sup>th</sup> century runs (Annual averages):  
Global variance of surface temperature (C).

NCEP/NCAR R2 reanalysis (1948-2000) = 0.064  
GFDL 2.1 (1948-2000) = 0.071

GFDL 2.1 (2000-2099) A2 = 0.841  
GFDL 2.1 (2000-2099) A1B = 0.553  
GFDL 2.1 (2000-2099) B1 = 0.193

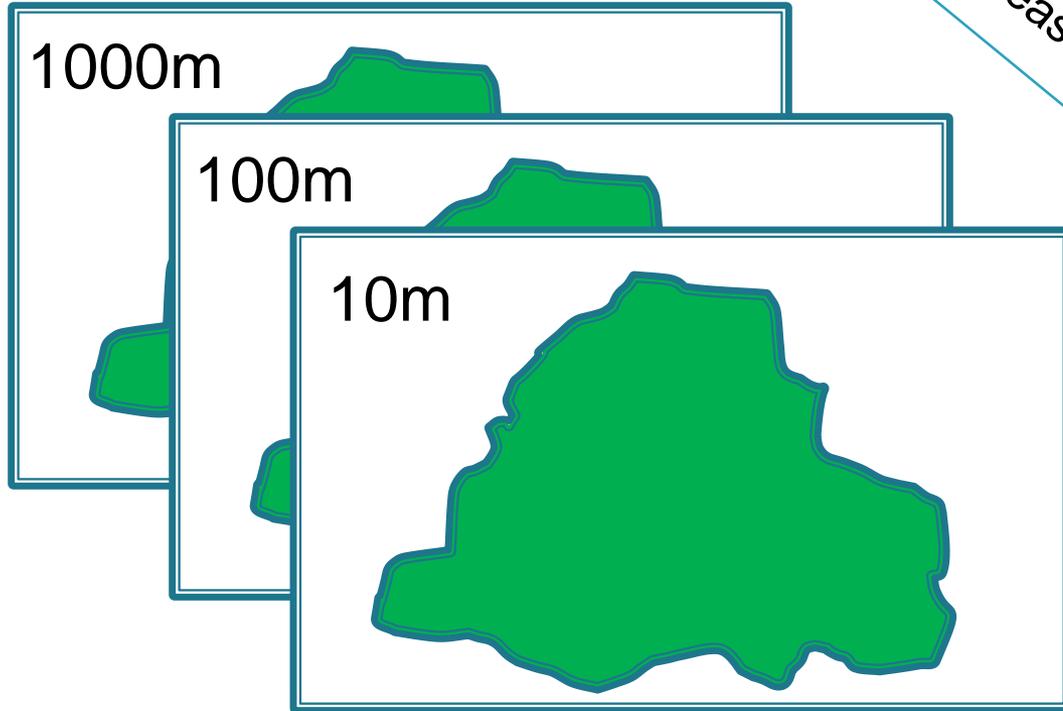
**A ratio of variance of annually  
averaged surface temperature  
(same scale)**





# Advanced Tasks: GIS to NetCDF

Tiles, GIS format

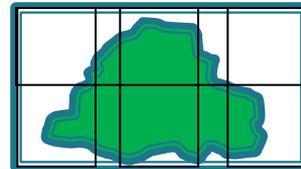


Increasing Depth  
Increasing Elevation

Gridding high/deep topography to netCDF



+



=

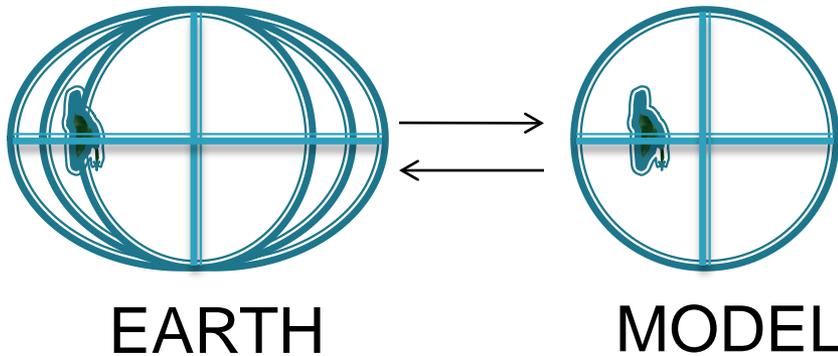


GIS geometries

Tiles at different scales

# NCMP Support for GIS Users

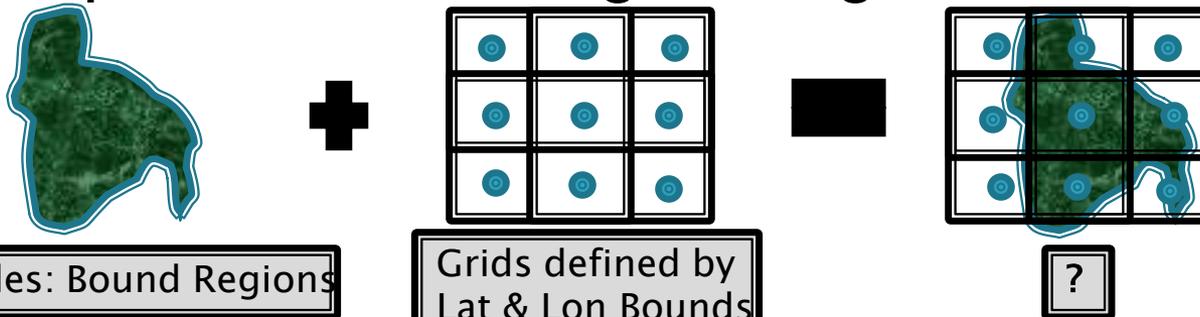
Oblate spheroid (aka, Earth) to sphere



At present there are no commonly used transformations when going from one to the other

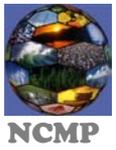
No Datums included in datasets

Shapefile defined region to gridded data



Shapefiles: Bound Regions

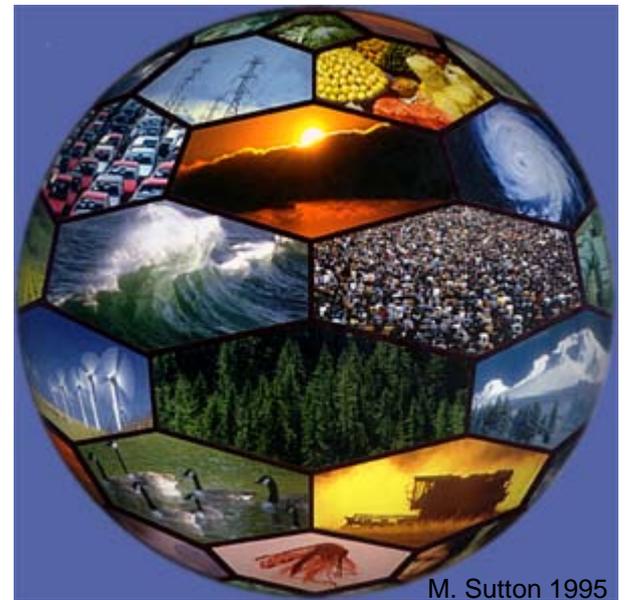
Grids defined by  
Lat & Lon Bounds



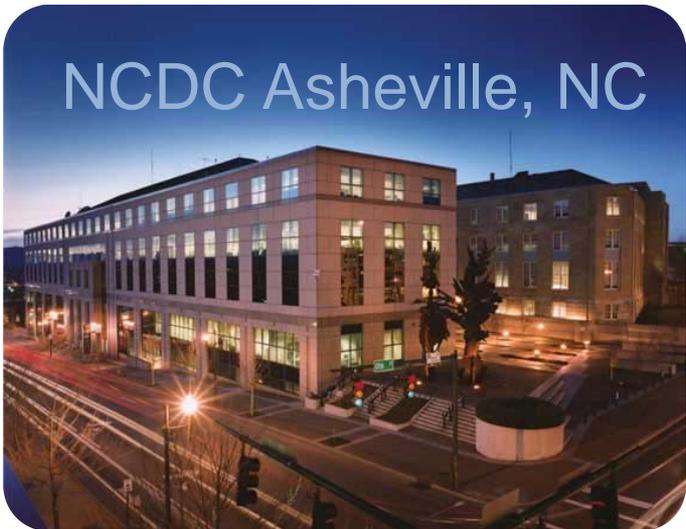
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[Glenn.Rutledge@noaa.gov](mailto:Glenn.Rutledge@noaa.gov)

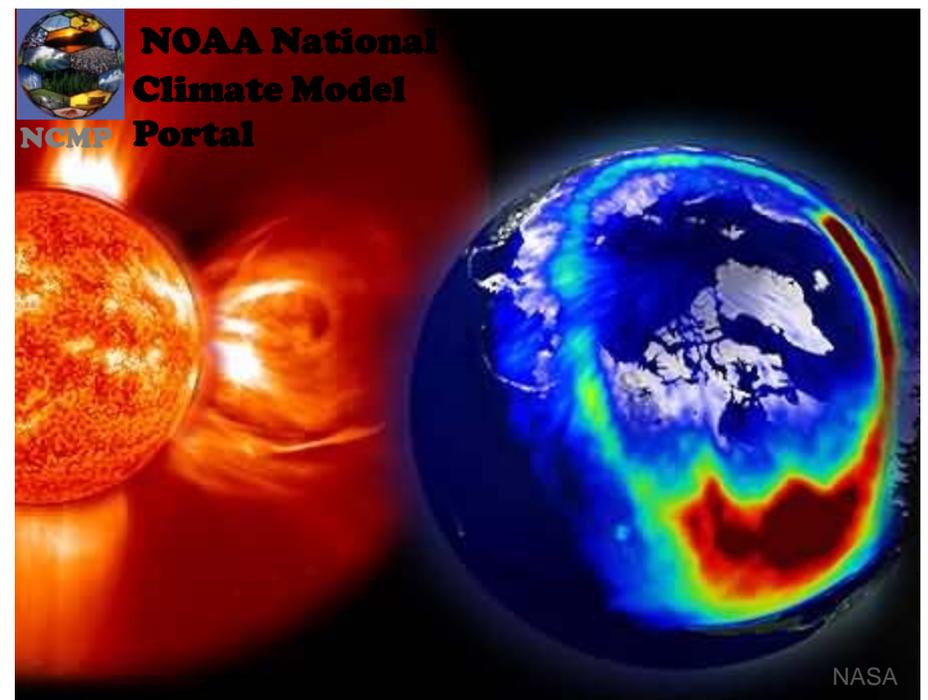


M. Sutton 1995



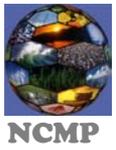
<http://nomads.ncdc.noaa.gov>

Questions?



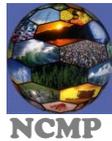
NASA





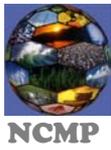
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# BACKUP



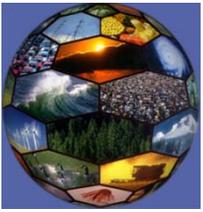
**NOAA National  
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NCMP





# Select Bibliography

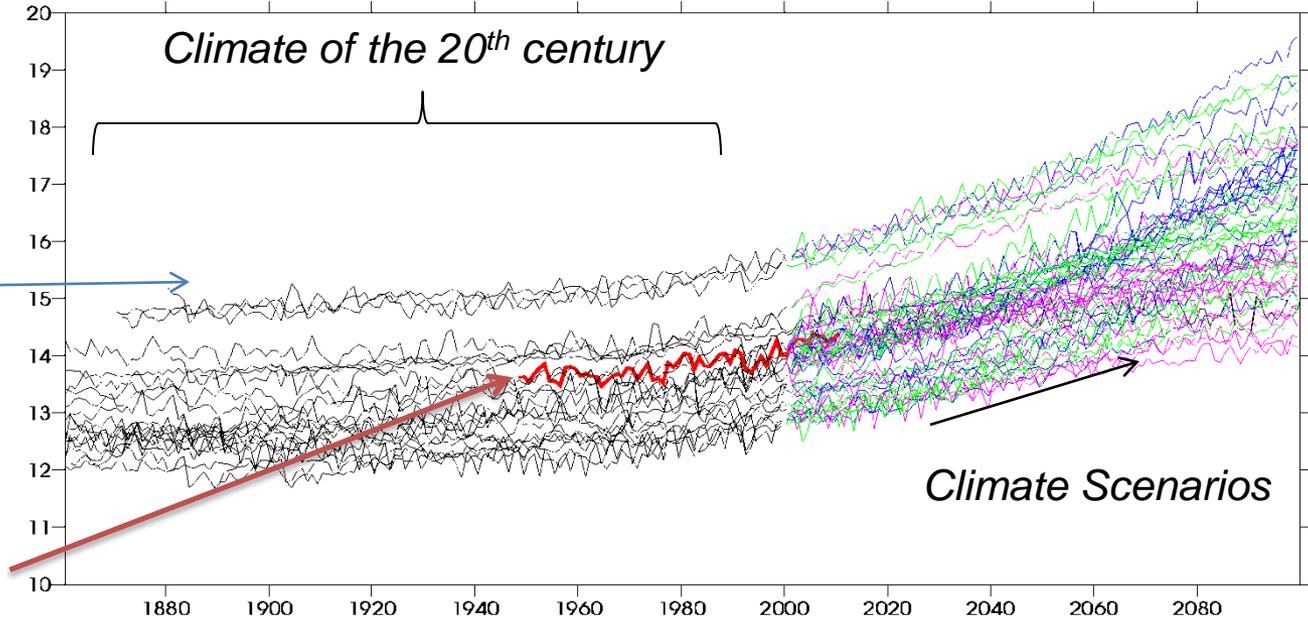
- ▶ Rutledge, G.K., J. Alpert, and W. Ebisuzaki, 2006: NOMADS, a climate and weather model archive at the National Oceanic and Atmospheric Administration. *Bulletin of the American Meteorological Society*, 87 (3), 327-341.
- ▶ Saha, Suranjana, and Coauthors, 2010: The NCEP Climate Forecast System Reanalysis. *Bull. Amer. Meteor. Soc.*, **91**, 1015–1057.
- ▶ Compo GP, et al., 2011. The Twentieth Century Reanalysis Project. *Q. J. R. Meteorol. Soc.* **137**.
- ▶ 2010 BAMS Global State of the Climate Report, 2011: (in press)



# NOAA National Climate Model Portal

## Intercomparison Projects

Global Surface Temperature °C



R2 reanalysis

This plot is dynamically generated from CMIP3 and requested by NCSP

A2 Scenario:: Average of 19 different models and average of last ten annual values = 17.00 °C

A1B Scenario:: Average of 24 different models and average of last ten annual values = 16.45 °C

B1 Scenario:: Average of 20 different models and average of last ten annual values = 15.51 °C

# NOMADS Ensemble Probability Tool

PDF's on the fly

NOMADS **Ensemble**  
**Probabilities** on the fly:

20 model runs

30 fcst projections

10 days of forecast

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    
 Lat  (-90 to 90) Lon  (-180 to 180)

**When**

Latest model run (2009 Oct. 23 06z)  
 Year  Month  Date  Model Run

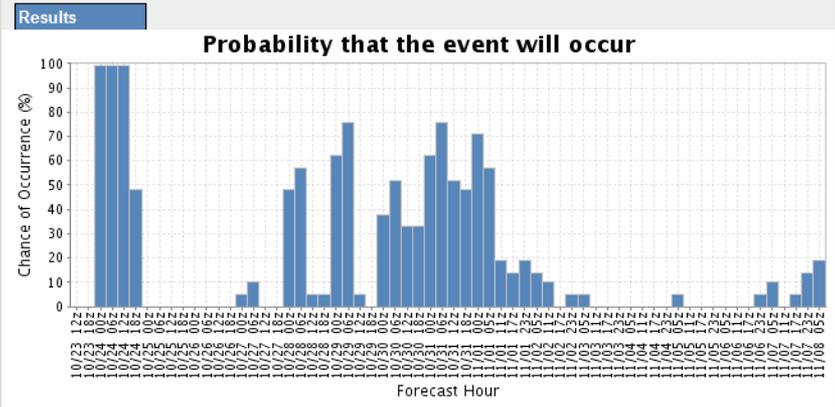
**What**

Air Temperature at 2 meter height  
 6 hour Highest temperature      
 6 hour Lowest temperature      
 Precipitation  
 Wind at 10 meter height  
 Cloud Cover  
 Air Temperature at 850 millibar pressure level  
 Convective Available Potential Energy (CAPE)

**Request**

**Location:**  
Asheville, Asheville Regional Airport, NC, United States (35-25-55N, 082-32-15W)  
**Time:**  
Oct 23, 2009 06z  
**Event:**  
where the highest temperature is greater than 65 degrees F.

**Progress**



NOMADS Ensemble Probability Tool

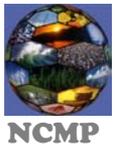
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Probability that the following event will occur:  
where the highest temperature is greater than 65 degrees F.

At the location:  
Asheville, Asheville Regional Airport, NC, United States (35-25-55N, 082-32-15W)

For the GENS model run at the given time:  
Oct 23, 2009 06z





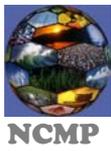
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# National Climate Model Portal Architecture

# National Climate Model Portal

## Services

- Data Access Services
  - THREDDS Data Server
    - OPeNDAP access form
    - NetCDF Subset service
    - GIS/WCS and WMS capabilities
    - Raw data file server
    - Limited aggregation capabilities
  - Grads Data Server
    - OPeNDAP access for GrADS compatible data
    - Full aggregations to ease access
  - Web applications
    - Ensemble probability tool: Easy interpretation of GFS ensembles
    - SRRS archive / NCEP charts access application
- Raw/Scriptable data access
  - Partial-HTTP subsetting
  - Anonymous FTP for select datasets
  - Bulk access through wget scripts
- Archive Access
  - N-HAS offline data request system within NOMADS web interface
  - Bulk FTP access through N-HAS
  - OPeNDAP enabled offline cache.
  - CLASS bulk and OPeNDAP access proxy
- Requirements and Outreach
  - User requirements
  - “Sectoral” engagement (energy, water, transportation, Ag, etc.)
  - NCMP Program Plan



# Model Archive Growth Exebyte (EB)

- Since 1966, model output volume closely mirrors “Moore’s Law”:
  - a doubling of volume (CPU processing speed) approximately every two years\*.
- Derived estimates below show existing archive storage requirements without data reduction practices. Volumes approach 1 Exabyte (1 Billion Gigabytes).
- Simple data reduction policies to remove forecast products, and outdated reanalysis reforecasts, and Atmospheric-Ocean General Circulation Models (AOGCM’s) at the Archive level greatly reduces archive and stewardship requirements.

