Design of the 30-year NCEP CFSRR

T382L64 Global Reanalysis
and
T126L64 Seasonal Reforecast Project
(1979-2009)

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With Input from

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For a new Climate Forecast System (CFS) implementation

Two essential components:

A new Reanalysis of the atmosphere, ocean, seaice and land over the 31-year period (1979-2009) is required to provide consistent initial conditions for:

A complete Reforecast of the new CFS over the 28-year period (1982-2009), in order to provide stable calibration and skill estimates of the new system, for operational seasonal prediction at NCEP

For a new CFS implementation (contd)

1. Analysis Systems :	Operational GDAS: Atmospheric (GADAS)-GSI Ocean-ice (GODAS) and Land (GLDAS)
2. Atmospheric Model :	Operational GFS
3. Ocean Model :	New MOM4 Ocean
4. Land Model :	Operational Noah Land Model
5. Sea Ice Model:	New Sea Ice Model

An upgrade to the coupled atmosphere-ocean-seaice-land NCEP Climate Forecast System (CFS) is being planned for Jan 2010.

This upgrade involves changes to all components of the CFS, namely:

- **improvements to the data assimilation of the atmosphere with the new NCEP Gridded Statistical Interpolation Scheme (GSI) and major improvements to the physics and dynamics of operational NCEP Global Forecast System (GFS)**
- **improvements to the data assimilation of the ocean and ice with the NCEP Global Ocean Data Assimilation System, (GODAS) and a new GFDL MOM4 Ocean Model**
- **improvements to the data assimilation of the land with the NCEP Global Land Data Assimilation System, (GLDAS) and a new NCEP Noah Land model**

For a new CFS implementation (contd)

1. **An atmosphere at high horizontal resolution (spectral T382, ~38 km) and high vertical resolution (64 sigma-pressure hybrid levels)**
2. **An interactive ocean with 40 levels in the vertical, to a depth of 4737 m, and high horizontal resolution of 0.25 degree at the tropics, tapering to a global resolution of 0.5 degree northwards and southwards of 10N and 10S respectively**
3. **An interactive sea-ice model**
4. **An interactive land model with 4 soil levels**

There are three main differences with the earlier two NCEP Global Reanalysis efforts:

- **Much higher horizontal and vertical resolution (T382L64) of the atmosphere (earlier efforts were made with T62L28 resolution)**
- **The guess forecast will be generated from a coupled atmosphere – ocean – seaice - land system**
- **Radiance measurements from the historical satellites will be assimilated in this Reanalysis**

To conduct a Reanalysis with the atmosphere, ocean, seaice and land coupled to each other will be a novelty, and will hopefully address important issues, such as the correlations between sea surface temperatures and precipitation in the global tropics, etc.

UPGRADES TO THE ATMOSHERIC MODEL

- **Hybrid vertical coordinate (sigma-pressure)**
- **Noah Land Model : 4 soil levels. Improved treatment of snow and frozen soil**
- **Sea Ice Model : Fractional ice cover and depth allowed**
- **Sub grid scale mountain blocking**
- **Reduced vertical diffusion**
- **RRTM long wave radiation**
- **ESMF (3.0)**

SOME TEST UPGRADES TO THE ATMOSHERIC MODEL

- Enthalpy
- MODIS Albedo
- AER RRTM Shortwave Radiation
- Ferrier-Moorthi Microphysics
- New Boundary Layer Parameterization
- New Shallow Convection
- New Aerosol Treatment
- New Convection Scheme (RAS)
- New convective gravity wave drag formulation
- Inclusion of historical CO2, solar cycle and volcanic aerosols

4 Simultaneous Streams

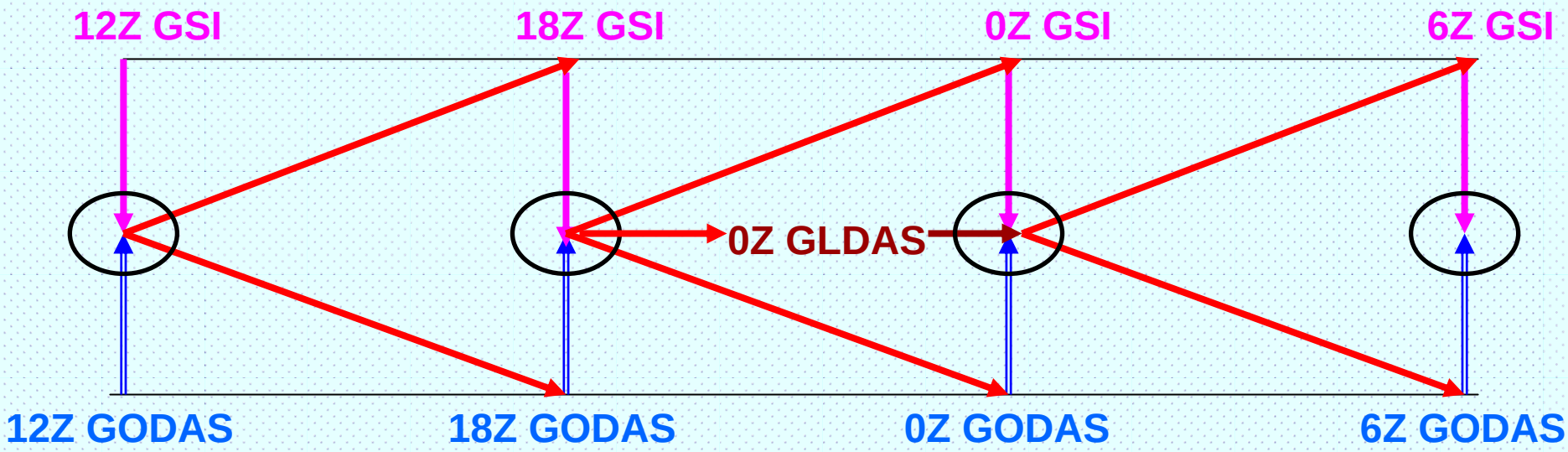
- Jan 1979 – Oct 1989 — 11 years
- Apr 1989 – Oct 1998 — 10 years
- Apr 1998 – Oct 2004 — 7 years
- Apr 2004 – Dec 2009 — 6 years

6 month overlap for ocean and land spin ups

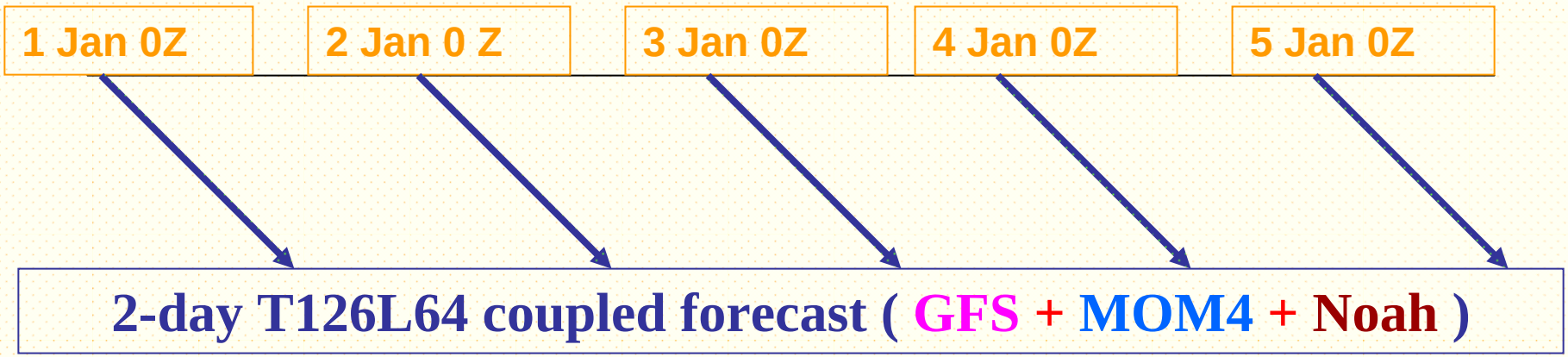
Reanalysis to cover 31 years (1979-2009) + 21 overlap months

Reforecasts to cover 28 years (Jan 1982 – Dec 2009)

ONE DAY OF REANALYSIS



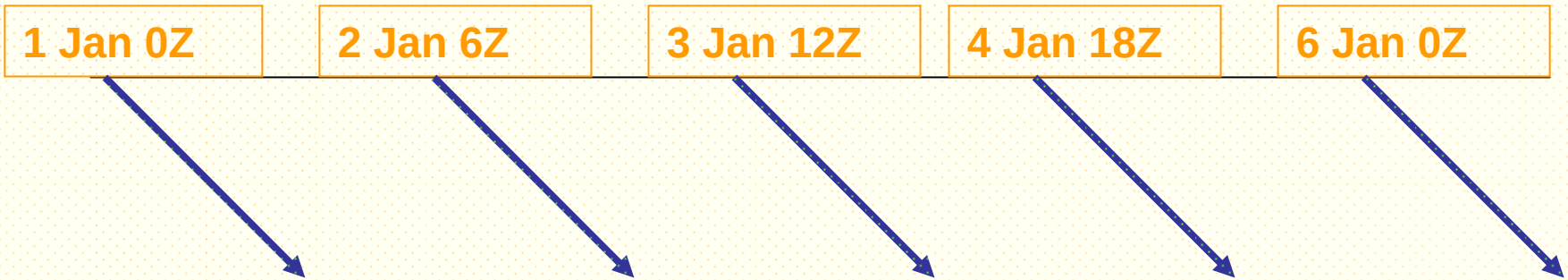
9-hr coupled T382L64 forecast guess (GFS + MOM4 + Noah)



ONE DAY OF REANALYSIS

- **Atmospheric T382L64 (GSI) Analysis at 0,6,12 and 18Z, using radiance data from satellites, as well as all conventional data**
- **Ocean and Sea Ice Analysis (GODAS) at 0,6,12 and 18Z**
- **From each of the 4 cycles, a 9-hour coupled guess forecast (GFS at T382L64) is made with hourly coupling to the ocean (MOM4 at 1/4^{o} equatorial, 1/2^{o} global)**
- **Land (GLDAS) Analysis using observed precipitation with Noah Land Model at 0Z**
- **Coupled 2-day forecast from initial conditions from every 0Z cycle, will be made with the T126L64 GFS with hourly coupling to the ocean (MOM4 at 1/3^{o} equatorial, 1^{o} global) for sanity check.**

CFS REFORECASTS (292/year for a total of 8176)



1 year T126L64 coupled forecast (GFS + MOM4 + Noah)

Coupled one-year forecast from initial conditions 30 hours apart will be made for 2 initial months (April and October) with the T126L64 GFS with hourly coupling to the ocean (MOM4 at 1/3º equatorial, 1º global). Total number of forecasts = 28 x 2 x 30 = 1680

For each cycle, there will be approximately 7 members per month, with a total of 210 members over a 30-year period. This ensures stable calibration for forecasts originating from each cycle, for a given initial month

SOME NOTES

PROPOSED TIME LINE FOR COMPLETION OF CFSRR

- **January to December 2008**: Begin Production and Evaluation of the CFS Reanalysis for the full period from 1979 to 2008 (30 years)
- **January to December 2008**: Begin running CFS Retrospective Forecasts for 2 initial months: October and April, and evaluate the monthly forecasts as well as the seasonal winter (Lead-1 DJF) and summer (Lead-1 JJA) forecasts.
- **January to October 2009**: Continue running the CFS Reforecasts (for the rest of the 10 calendar months)
- **November 2009**: Begin computing calibration statistics for CFS daily, monthly and seasonal forecasts.

January 2010: Operational implementation of the next CFS monthly and seasonal forecast suite.

HUMAN REQUIREMENTS

Project Managers

Suru Saha and Hua-Lu Pan

REANALYSIS

6 people (TBD) managing 4 streams and rotating through

REFORECASTS

3 people (TBD) managing 4 streams and rotating through

Science Advisory Panel

Jeff Anderson, Saki Uppala, Jim Carton, Rick Rosen, Lars Peter Riishojgaard, Eric Wood, Mark Serreze, Gabriel Lau, Gil Compo, and Huug van den Dool

CFSRR TEAM

Shrinivas Moorthi, Xingren Wu, Jiande Wang, Dave Behringer, Catherine Thiaw, Sudhir Nadiga, Robert Kistler, Jack Woollen, Haixia Liu

T382L64 CFS REANALYSIS AND T126L64 REFORECASTS

	IBM Power 5	
Specs for 4 days of T382L64 Reanalysis, including a 2-day T382L64 forecast every cycle (4 simultaneous streams)	88 nodes, 160 minutes Will take 1 calendar year (on HAZE upgrade)	
Specs for 8 one-year coupled reforecasts (T126L64) (2 per stream)	16 nodes, 24 hours Will take 8 calendar months to complete 2 initial months (on ZEPHYR)	
Total Disk Space	100 TB	
Total Mass Store (HPSS) Space	3 PB	

Computer resources for CFSRR

- **Needs 88 nodes to run four streams of the Reanalysis (starting production runs in January 2008) + 16 nodes for making reforecasts from 2 initial months (all 28 years)**
- **On Haze, we have 44 dedicated nodes**
- **On Zephyr, we have 16 dedicated nodes**
- **Will make do until the Haze upgrade**

Resource issue

- **We were anticipating the arrival of the upgrade to Haze to add the 44 nodes needed.**
- **Haze upgrade is delayed until June or July 2008.**
- **The Reanalysis completion date may slip a few months due to this delay.**
- **We will try to use the nodes we have until the upgrade**

Reforecast

- **The CFS Reforecast is scheduled to start in Jan 2009, pending the upgrade of the development machine (Dew) and production machine (Mist).**

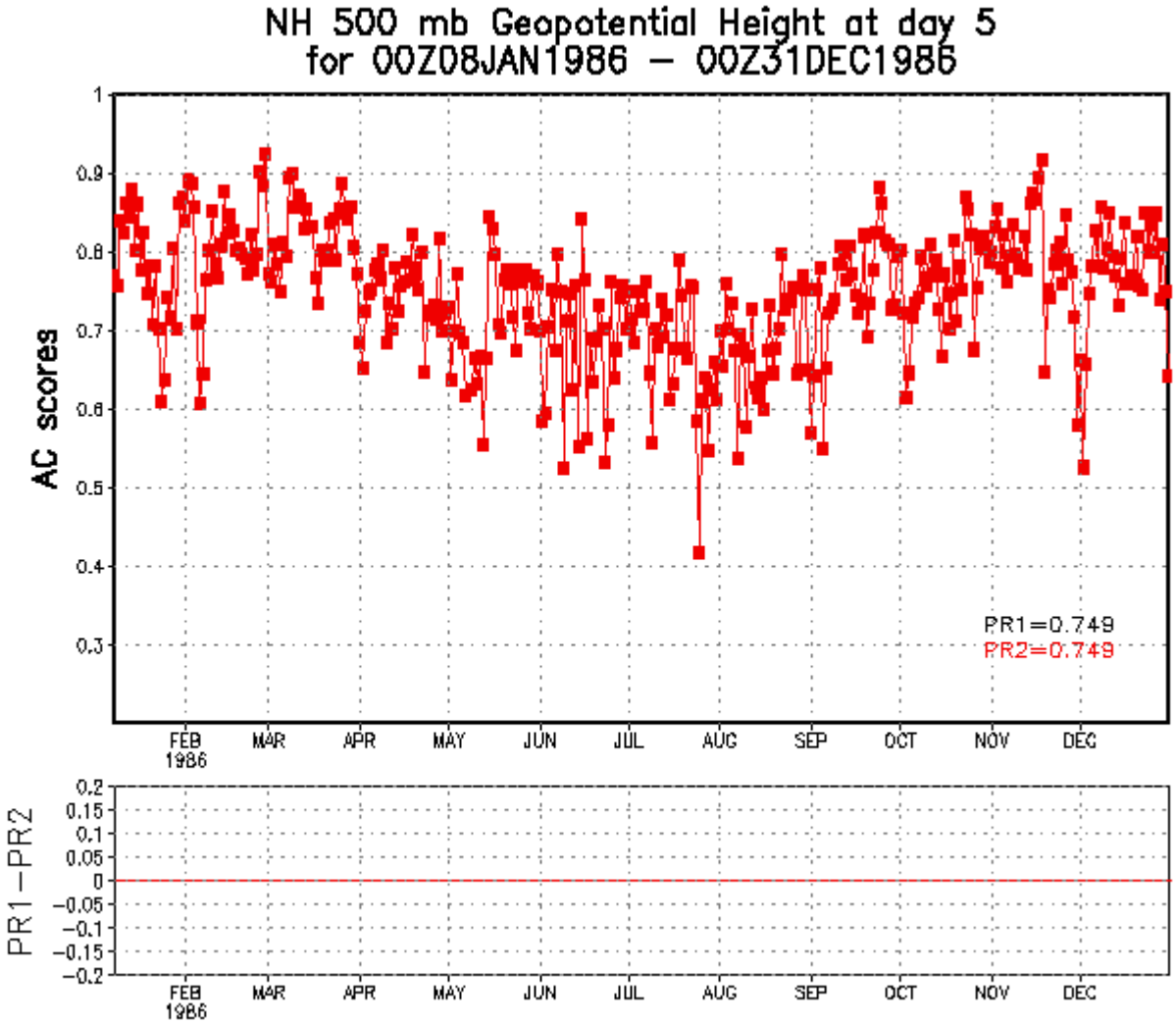
Status

- **New format and improved SBUV ozone data**
- **Calibrated SSU radiance data (corrected for cell pressure leaks) is being tested for impact**
- **High resolution SST analysis is being tested for impact**
- **Satellite radiance bias correction estimates for each new satellite needs a 3-month run of the full coupled GDAS at T382L64. There are 10-15 satellites to cover.**

6 of these runs are now underway

Status (contd)

- **A mini T62L64 atmospheric-only Reanalysis is completed to pass through all atmospheric data from 1979 – 2007**
- **We had to adjust the streams as the later year data amount is much larger than earlier ones**
- **Results of 5-day forecasts made from every 0Z cycle are encouraging.**


NH 500 mb Geopotential Height at day 5
for 00Z08JAN1986 – 00Z31DEC1986
AC scores
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
PR1=0.749
PR2=0.749
FEB
1986
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
PR1–PR2
0.2
0.15
0.1
0.05
0
–0.05
–0.1
–0.15
–0.2
FEB
1986
MAR
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AUG
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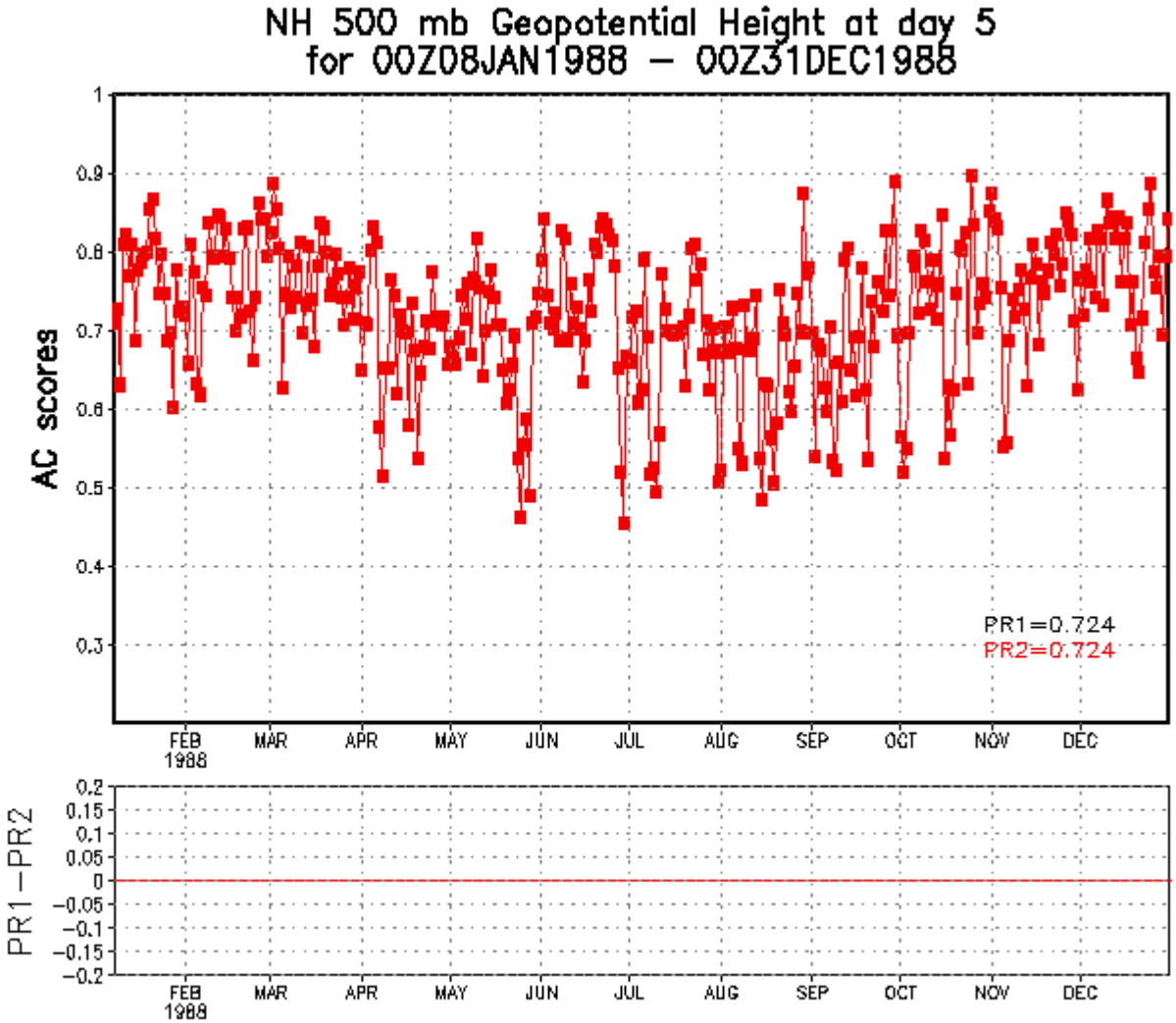
DEC


NH 500 mb Geopotential Height at day 5
for 00Z08JAN1988 – 00Z31DEC1988
AC scores
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
PR1=0.724
PR2=0.724
FEB
1988
MAR
APR
MAY
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JUL
AUG
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OCT
NOV
DEC
PR1–PR2
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FEB
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Collaborators

- **NOAA/CPC is actively involved in the monitoring of the Reanalysis**
- **NOAA/NCDC is actively involved in the archival of the Reanalysis**
- **NCAR has shown interest in providing additional data for university researchers**

SOME NOTES - 1

DATA ARCHIVAL

Using 0.75 TB tapes, it would require more than 3000 tapes to archive almost everything.

EMC does not have the resources to do any data distribution. However, they will provide CPC with whatever data they need for their operational CFS predictions.

NCDC/NOAA will be responsible for the archival and distribution of both the CFS Reanalysis and Reforecasts, through their NOMADS system. They will work with EMC to make the CFS Reanalysis data available to the community in mid 2009, and the Reforecast data available in mid 2010.

SOME NOTES - 2

REANALYSIS WITH CONVENTIONAL DATA

CPC may be interested in using the same CFS Reanalysis system, but with conventional data only (no satellite data) to go back to 1948, and continue into the future with the same system.

This Reanalysis may be more homogeneous over a longer period (60+ years) and be more suitable for CPC's monitoring of the atmosphere, land and ocean.

EMC will help in this endeavor.

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