ERB in NCEP CFSRR
Planning Radiation/Cloud outputs of Climate Forecast System Reanalysis and Reforecast

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w/ slides from Suru Saha and Hua-Lu Pan
CERES Science Team Meeting
Victoria, Canada 11/14-16/07
Outlines

• CFSRR Project

• CFSRR Radiation/Cloud Outputs
Current Operational NCEP GFS and CFS

• **Global Forecast System, GFS,**
  an atmospheric assimilation and forecast system:
  T382L64 (~35km horizontal resolution) for 0-180hr
  T190L64 for 180-384hr
  Radiation: Chou-SW, RRTM-LW

• **Climate Forecast System, CFS**
  an ocean-atmosphere coupled assimilation & forecast sys:
  T62L64 (~200km horizontal res) twice/day --> 9m fcst
  Radiation: Chou-SW, GFDL-Fels LW
Toward new CFS implementation 2010

• Two main components:
• CFS Reanalysis (1979-2007)
• CFS Retrospective Forecasts (1981-2007)

CFSRR Objective:

to provide database for forecast calibration in the future.

Saha and Pan, 2006
Future CFS model and assimilation system

1. Analysis Systems: GSI, GODAS, GLDAS

2. Atmospheric Model: GFS

3. Ocean Model: MOM4

- RRTM long wave and short wave radiation
- Clouds maximum random overlap, -> decrease Ac
- ESMF Version (Earth System Modeling Framework)
- NRL Based Ozone Climatology for Production and destruction
- Unification of GFS-CFS physics

Saha and Pan, 2006
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 half-hourly coupling to the ocean (MOM4 at 1/4° equatorial, 1/2° global)

Land (GLDAS) Analysis using observed precipitation with Noah Land Model at 0Z

Coupled 2-day forecast from initial conditions from every cycle, or coupled 5-day forecast from every 0Z cycle (starting every year from 1 Jan 00Z) will be made with the T382L64 GFS with half-hourly coupling to the ocean (MOM4 at 1/4° equatorial, 1/2° global) for sanity check.
ONE DAY OF REANALYSIS

12Z GSI  18Z GSI  0Z GSI  6Z GSI

12Z GODAS  18Z GODAS  0Z GODAS  6Z GODAS

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

1 Jan 0Z  1 Jan 6Z  1 Jan 12Z  1 Jan 18Z  2 Jan 0Z

2-day T382L64 coupled forecast (GFS + MOM4 + Noah)
ONE DAY OF REANALYSIS

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

5-day T382L64 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 half-hourly coupling to the ocean (MOM4 at 1/4° equatorial, 1/2° 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.
4 Simultaneous Streams

- Jan 1978 – Sep 1987  9 years
- Oct 1985 – Sep 1994  9 years
- Oct 1992 – Sep 2001  9 years
- Oct 1999 – Sep 2008  9 years

2-year overlap for ocean and land spin ups

Total of 36 years of Reanalysis
Computer Time Requirements

Each Stream of Reanalysis

9 years * 366 days = 3294 days

Each Day of Reanalysis takes 120 minutes of CPU time on 7 nodes

Each 48-hour coupled forecast takes 72 minutes of CPU time on 5 nodes, and may be extended to 5 days at lower resolution

Each 1 year coupled reforecast takes 24 hours of CPU time on 2 nodes, 2 jobs to run simultaneously.

Total for each stream is 9.15 months in real time on 16 nodes
Total for all Streams:

4 Reanalysis Streams (4 x 7 nodes = 28)
4 Reanalysis Forecast Streams (4 x 5 nodes = 20)
4 CFS Reforecast Streams (4 x 4 nodes = 16)

28 + 20 + 16 = 64 nodes

For four streams, we will need 64 dedicated nodes for 1 year at a minimum.
CFSRR Radiation/Cloud Outputs

• Spring 2007: Compiled a Wish list with inputs from the community, mainly K-M Xu, T. Charlock and T. Wong of LaRC.

• Summer 2007: A survey to the community for possible usage

• Results submitted to CFSRR management
Wish List, Part 1, hourly 3-D Fields

3-D (1409 records)

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Profile Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cld Fraction</td>
<td>Profile Sfc to 100hpa</td>
</tr>
<tr>
<td>2</td>
<td>Cld Freq Dist</td>
<td>Profile Sfc to 100hpa</td>
</tr>
<tr>
<td>3</td>
<td>Cld Condensate</td>
<td>Profile Sfc to 100hpa</td>
</tr>
<tr>
<td>4</td>
<td>Cld Condensate Freq Dist</td>
<td>Profile Sfc to 100hpa</td>
</tr>
<tr>
<td></td>
<td>Net LW flux</td>
<td>Profile Sfc to TOA</td>
</tr>
<tr>
<td>5</td>
<td>Up LW flux</td>
<td>Profile Sfc to TOA</td>
</tr>
<tr>
<td>6</td>
<td>Dn LW flux</td>
<td>Profile Sfc to TOA</td>
</tr>
<tr>
<td>7</td>
<td>Up SW flux</td>
<td>Profile Sfc to TOA</td>
</tr>
<tr>
<td>8</td>
<td>Dn SW flux</td>
<td>Profile Sfc to 100hpa</td>
</tr>
<tr>
<td>9</td>
<td>Aerosol</td>
<td>Profile Sfc to 100hpa</td>
</tr>
</tbody>
</table>
Wish List, Part 2, Hourly 2-D fields

- **TOA**: ULWRF, USWRF, DSWRF, CS-ULWR, CS-USWR
- **70hPa**: ULWRF, DLWRF, USWRF, DSWRF
- **200hPa**: ULWRF, DLWRF, USWRF, DSWRF
- **500hPa**: ULWRF, DLWRF, USWRF, DSWRF
- **Sfc**: ULWRF, DLWRF, USWRF, DSWRF
- **Sfc**: CS-\{ULWRF, DLWRF, USWRF, DSWRF\}
- **Atm**: Total-Cld, Hi-[Cld, Tc], Mid- [Cld, Tc], Low- [Cld, Tc]
Guess T382L64 Hourly Output

<table>
<thead>
<tr>
<th>Hourly</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard pressure GRIB (0.5x0.5)</td>
<td>155 MB</td>
</tr>
<tr>
<td>Standard flux GRIB (Gaussian 1152x576)</td>
<td>70 MB</td>
</tr>
<tr>
<td>Radiation flux GRIB (Gaussian 1152x576)</td>
<td>60 MB</td>
</tr>
<tr>
<td>Per hour</td>
<td>285 MB</td>
</tr>
</tbody>
</table>

**Total for 1 day**  
185 x 24 = 6.84 GB
## Analysis T382L64 Atmospheric Output

### 6-hourly

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepbufr Analysis</td>
<td>28 MB</td>
</tr>
<tr>
<td>Sigma hybrid analysis</td>
<td>228 MB</td>
</tr>
<tr>
<td>Surface analysis</td>
<td>117 MB</td>
</tr>
<tr>
<td>3-D diagnostic model level GRIB</td>
<td>976 MB</td>
</tr>
<tr>
<td>3-D diagnostic pressure level GRIB</td>
<td>454 MB</td>
</tr>
<tr>
<td>Isentropic diagnostic GRIB</td>
<td>100 MB</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2 GB</strong></td>
</tr>
</tbody>
</table>

**Total for 1 day**  2 x 4 = 8 GB
<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Total for 1 day of CFS Reanalysis</td>
<td>30 GB</td>
</tr>
<tr>
<td><strong>DISK SPACE</strong></td>
<td></td>
</tr>
<tr>
<td>Each Stream for CFS Reanalysis and Reforecasts</td>
<td>10 TB</td>
</tr>
<tr>
<td><strong>HPSS SPACE (TAPE)</strong></td>
<td></td>
</tr>
<tr>
<td>Total for CFS Reanalysis</td>
<td>400 TB</td>
</tr>
<tr>
<td>Total for 12 months CFS Reforecasts</td>
<td>730 TB</td>
</tr>
</tbody>
</table>
New GFS output to be incorporated to CFSRR: Clear Sky Radiation Fluxes

• 2-D clear-sky fluxes are valuable in diagnosing moisture, and heating distributions.
• The addition enables a complete estimate of climate forcing at the top of atmosphere (TOA) and surface (SFC)
• The additional fields are:
  – Three clear-sky radiation fluxes at TOA: downward SW, upward SW, and upward LW
  – Four clear-sky radiation fluxes at SFC: upward SW, downward SW, upward LW, and downward LW
Where We Stand?

- R-1 type 6 hr-ly outputs, including clear-sky, secured
- Monthly-hourly will be generated.
- Hourly wish-list data could be incorporated into H3D hourly restart file-> NCDC archive, or Radiation GRIB file -> NCDC; still require post-process.
- Require post-reprocessing for statistics.
- Can offer re-run for specific period.
No data distribution from NCEP. NCDC/NOAA has shown an interest in the archival and distribution of both the CFS Reanalysis and Reforecasts, through their NOMADS system. If they decide to participate, they will poll the community for data requests. They will work with EMC to siphon all data, while it is being generated in real time.
CPC is 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. Wayne Higgins to lead.

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.
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.
Current and Future SMOBA Ozone Analysis
## Comparison of current and future ozone analysis products

<table>
<thead>
<tr>
<th></th>
<th>SMOBA</th>
<th>MERRA</th>
<th>CFSRR</th>
<th>SMOBA II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>type</strong></td>
<td>Obs analysis</td>
<td>assimilation</td>
<td>assimilation</td>
<td>Assimilation+analysis</td>
</tr>
<tr>
<td><strong>Scheme</strong></td>
<td>Successive correction method</td>
<td>AGCM</td>
<td>Coupled GCM</td>
<td>Assimilation post processing</td>
</tr>
<tr>
<td><strong>Input data</strong></td>
<td>SBUV/2+TOVS</td>
<td>SBUV(/2) v8</td>
<td>SBUV(/2) v8</td>
<td>CFSRR O₃+TOVS</td>
</tr>
<tr>
<td><strong>No. of output data layer</strong></td>
<td>24</td>
<td>72</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td><strong>Domain</strong></td>
<td>1000~0.2 hPa</td>
<td>Sfc~0.01 hPa</td>
<td>Sfc~0.3 hPa</td>
<td>Sfc~0.3 hPa</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>2.5° x 2.5°</td>
<td>0.5° x 0.67° lat/lon</td>
<td>0.5° x 0.5°</td>
<td>0.5° x 0.5°</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>1/day</td>
<td>4/day</td>
<td>4/day</td>
<td>1/day</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>Now</td>
<td>soon</td>
<td>Mid 2008</td>
<td>Mid 2008</td>
</tr>
<tr>
<td><strong>Pro</strong></td>
<td>IR for polar night, has been used for years</td>
<td>High resolution</td>
<td>High resolution</td>
<td>Resolved polar night, and high resolution</td>
</tr>
<tr>
<td><strong>Con</strong></td>
<td>Low resolution</td>
<td>No obs in polar night</td>
<td>No obs in polar night</td>
<td>Still tuning process after CFSRR</td>
</tr>
</tbody>
</table>
• Combined SBUV/2 and TOVS ozone objective analysis
• Version 6 SBUV/2
• In Polar night TOVS data are filled in and adjusted to SBUV/2
• Frozen system
• Smooth feature due to low resolution
Total ozone monitoring maps (Oct. 14, 2007)

Aura OMI

KNMI assimilation

SMOBA

Source: http://es-ee.tor.ec.gc.ca/cgi-bin/dailyMaps
Ozone mixing ratio

SMOBA ozone mixing ratio (ppm)
Jan. 15, 2006

Polar night

Total ozone (DU)

O3 mixing ratio (60N–90N)

SMOBA
MLS

Polar night (20060115)
CFSRR
(Climate Forecast System Reanalysis and Reforecast)

- T382L64 coupled GCM
- The AGCM part is the same as operational GFS
- GSI assimilation
- Ozone is a prognostic variable
- Improved NRL ozone chemistry parameterization
- Beginning in Jan. 2008

\[
\frac{df}{dt} = (P - L)^0 + \frac{\partial(P - L)}{\partial f} \left( f - f^0 \right) + \frac{\partial(P - L)}{\partial T} \left( T - T^0 \right) + \frac{\partial(P - L)}{\partial O_3} \left( c - c^0 \right)
\]

NRL ozone chemistry (courtesy: John McCormack)
GFS total ozone
(CFSRR ozone will be similar)

SMOBA total ozone
SMOBA II

- Combined CFSRR and TOVS in polar night
- Version 8 SBUV(/2)
- Higher horizontal and vertical resolution than SMOBA
- Have ozone mixing ratio in troposphere
  (tropospheric ozone column is determined by SBUV/2, profile is determined by model).
GFS experiments (20070921--- 20070930)

SBUV/2 v6 has bias with more ozone in SH polar region in this time of year. SBUV/2 v8 reduced such bias. CFSRR and SMOBA II will use SBUV/2 v8.

SBUV/2 v6 has bias with more ozone in SH polar region in this time of year. SBUV/2 v8 reduced such bias. CFSRR and SMOBA II will use SBUV/2 v8.