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

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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 assimilatn & fcst 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

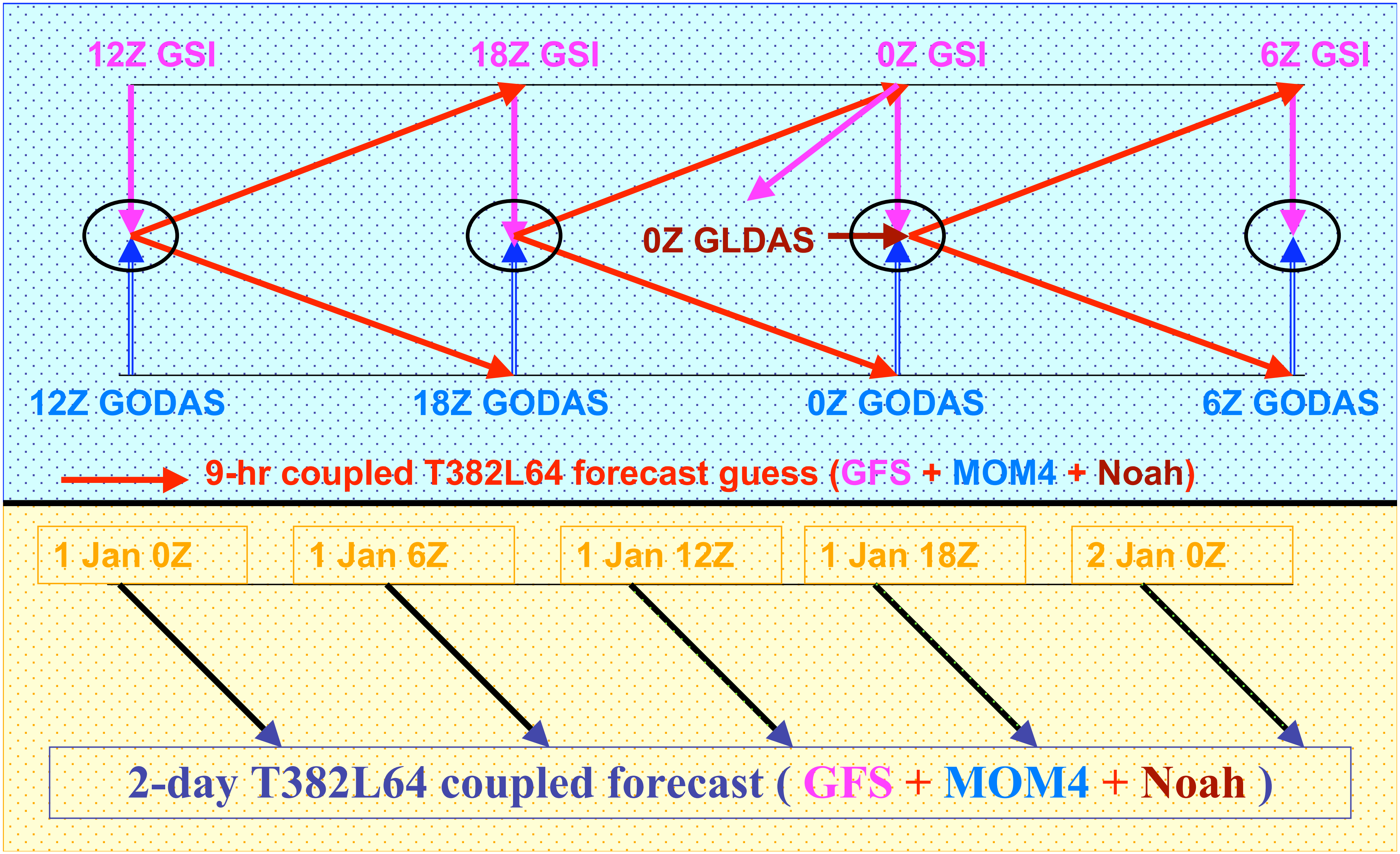
- RRTM long wave and short wave radiation
- Clouds maximum random overlap, -> decrease Ac
- ESMF Version (Earth System Modeling Framework)
- NRL Based Ozone Climatology for Production and destruction
- Unification of GFS-CFS physics

Saha and Pan, 2006

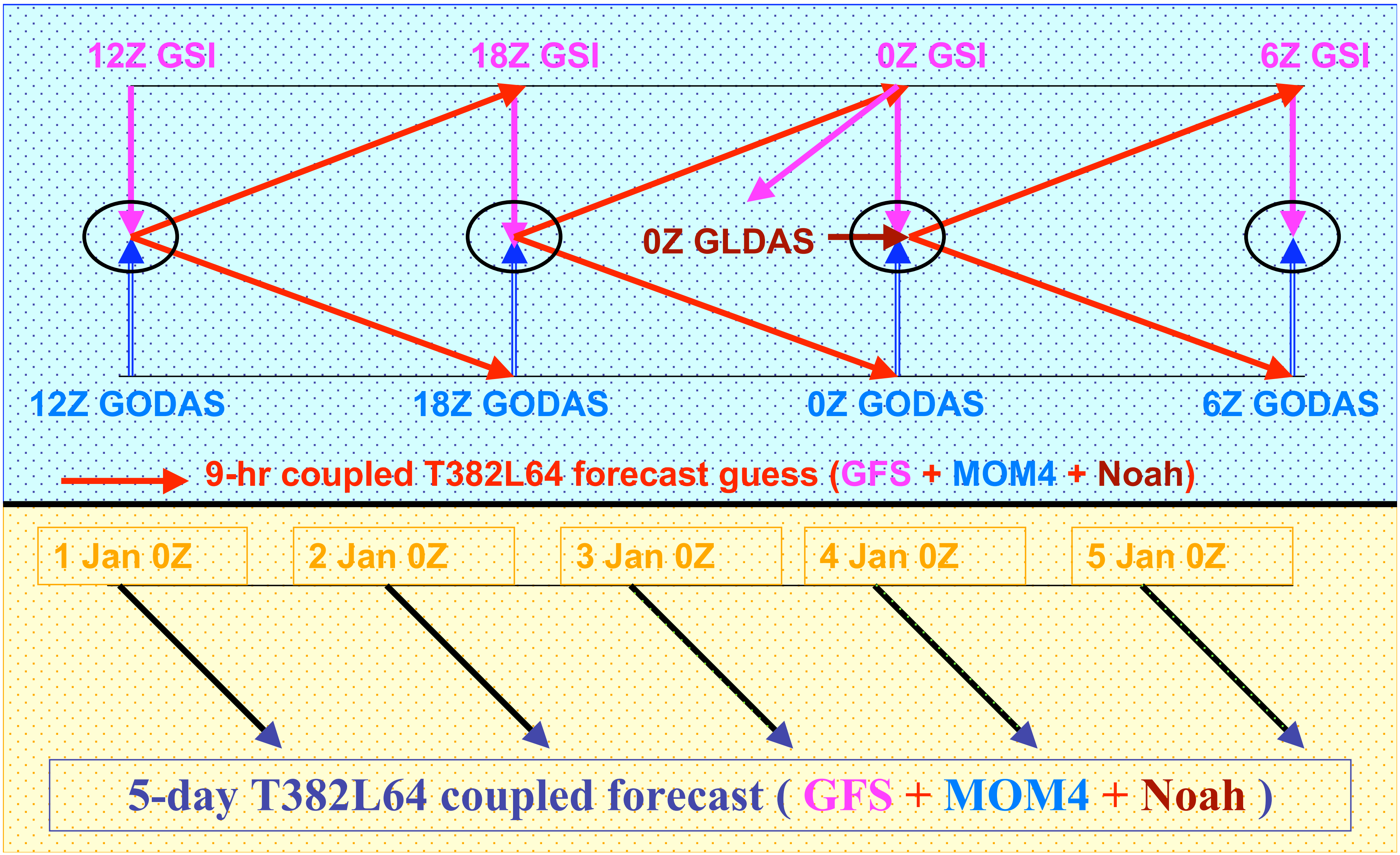
ONE DAY OF REANALYSIS

- 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 half-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 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 $1/4^{o}$ equatorial, $1/2^{o}$ global) for sanity check.

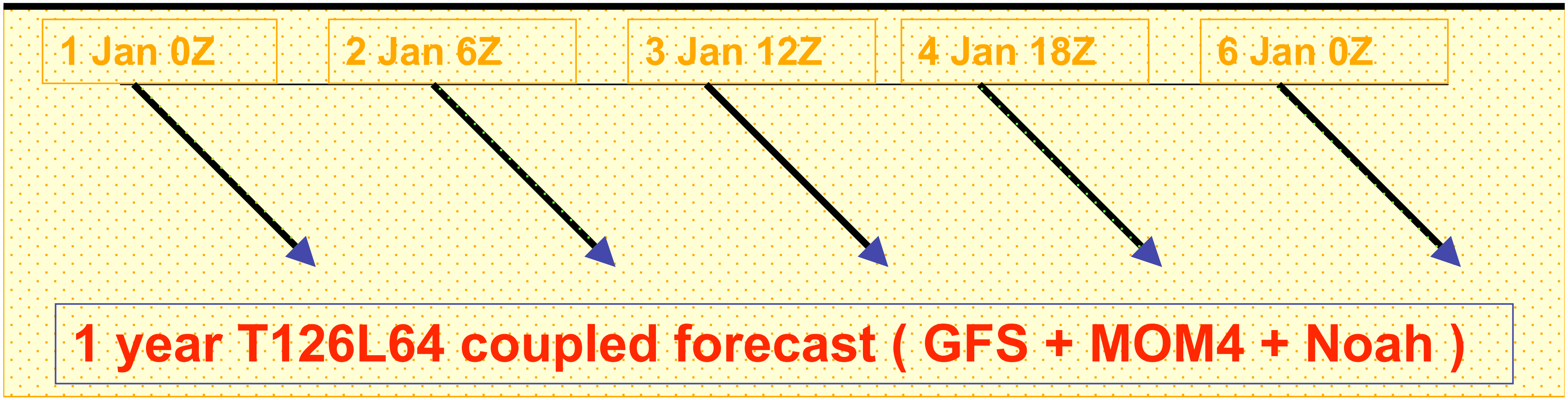
ONE DAY OF REANALYSIS



ONE DAY OF REANALYSIS



CFS REFORECASTS



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 $1/4^{\circ}$ equatorial, $1/2^{\circ}$ 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

Computer Time Requirements

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)	
1	Cld Fraction	Profile Sfc to 100hpa
2	Cld Freq Dist	Profile Sfc to 100hpa
3	Cld Condensate	Profile Sfc to 100hpa
4	Cld Cndnsate Freq Dist	Profile Sfc to 100hpa
	Net LW flux	Profile Sfc to TOA
	Net SW flux	Profile Sfc to TOA
5	Up LW flux	
6	Dn LW flux	
7	Up SW flux	
8	Dn SW flux	
9	Aerosol	Profile Sfc to 100hpa

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

Hourly

Standard pressure GRIB (0.5x0.5)	155 MB
Standard flux GRIB (Gaussian 1152x576)	70 MB
Radiation flux GRIB (Gaussian 1152x576)	60 MB
Per hour	285 MB

Total for 1 day **185 x 24 = 6.84 GB**

Analysis T382L64 Atmospheric Output

6-hourly

Prepbufr Analysis	28 MB
Sigma hybrid analysis	228 MB
Surface analysis	117 MB
3-D diagnostic model level GRIB	976 MB
3-D diagnostic pressure level GRIB	454 MB
Isentropic diagnostic GRIB	100 MB
Total	2 GB

Total for 1 day **2 x 4 = 8 GB**

SPACE REQUIREMENTS

Grand Total for 1 day of CFS Reanalysis	30 GB
DISK SPACE	
Each Stream for CFS Reanalysis and Reforecasts	10 TB
HPSS SPACE (TAPE)	
Total for CFS Reanalysis 13176 * 30 =	400 TB
Total for 12 months CFS Reforecasts 8500 x 86 =	730 TB

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.

SOME NOTES - 1

DATA ARCHIVAL

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.

SOME NOTES - 2

REANALYSIS WITH CONVENTIONAL DATA

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.

SOME NOTES - 3

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

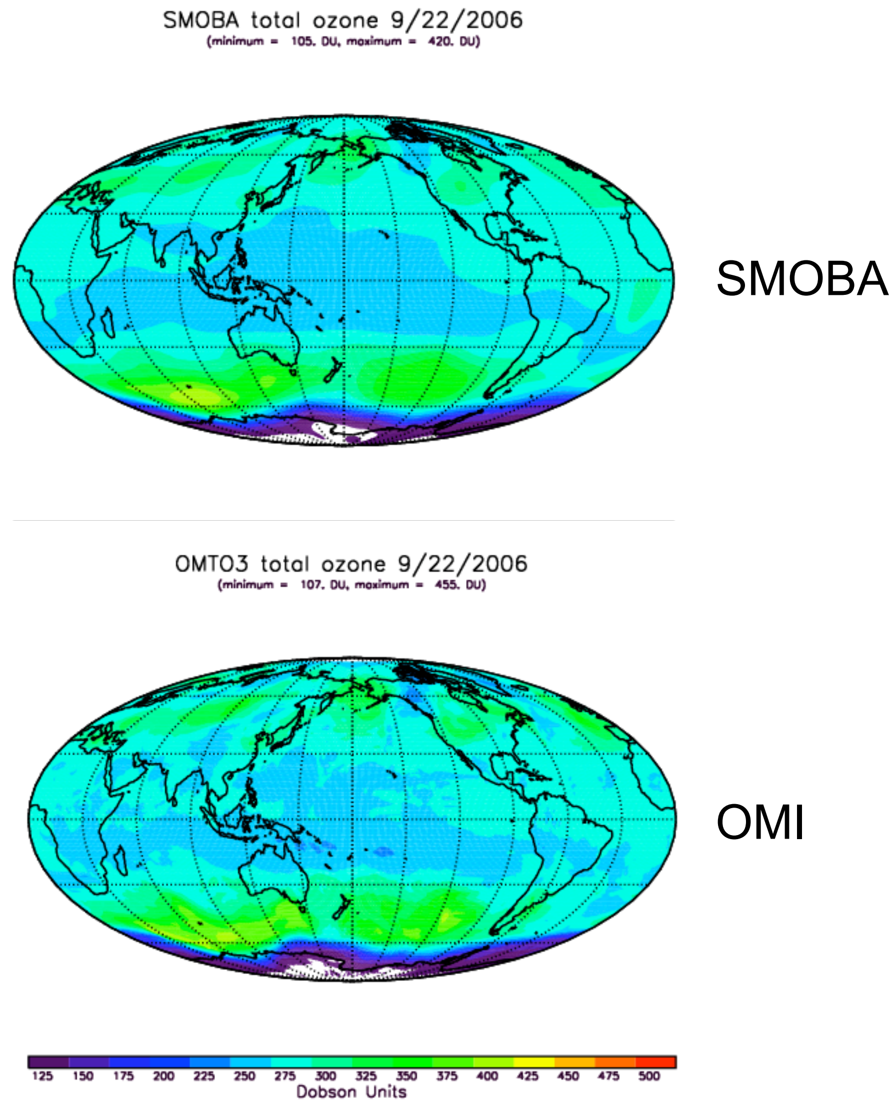
Comparison of current and future ozone analysis products

	SMOBA	MERRA	CFSRR	SMOBA II
type	Obs analyisis	assimilation	assimilation	Assimilation+analysis
Scheme	Successive correction method	AGCM	Coupled GCM	Assimilation post processing
Input data	SBUV/2+TOVS	SBUV(/2) v8	SBUV(/2) v8	CFSRR O_3+TOVS
No. of output data layer	24	72	64	64
Domain	1000~0.2 hPa	Sfc~0.01 hPa	Sfc~0.3 hPa	Sfc~0.3 hPa
Resolution	2.5^o x 2.5^o	0.5^o x 0.67^o lat/lon	0.5^o x 0.5^o	0.5^o x 0.5^o
Frequency	1/day	4/day	4/day	1/day
Availability	Now	soon	Mid 2008	Mid 2008
Pro	IR for polar night, has been used for years	High resolution	High resolution	Resolved polar night, and high resolution
Con	Low resolution	No obs in polar night	No obs in polar night	Still tuning process after CFSRR

SMOBA

(Stratospheric Monitoring Ozone Blended Analysis)

- 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

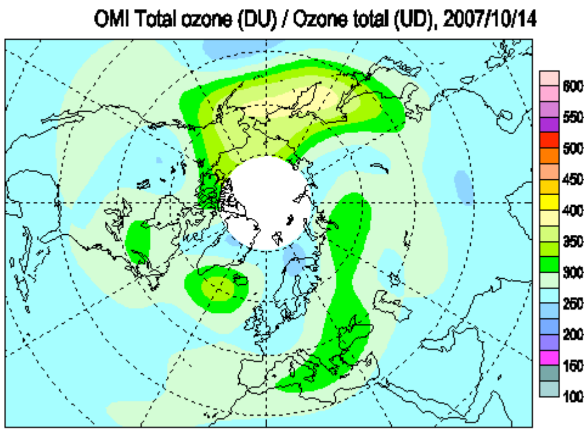


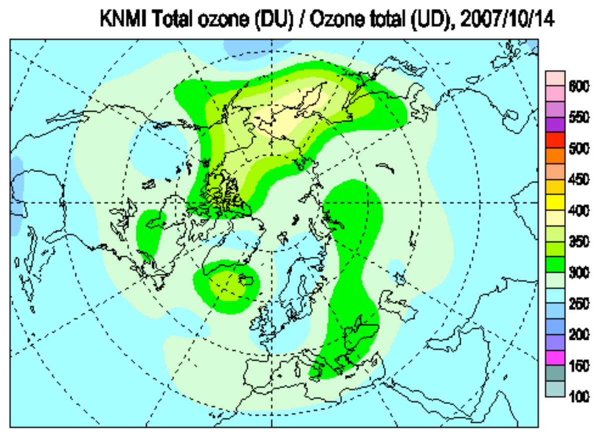
Total ozone monitoring maps (Oct. 14, 2007)

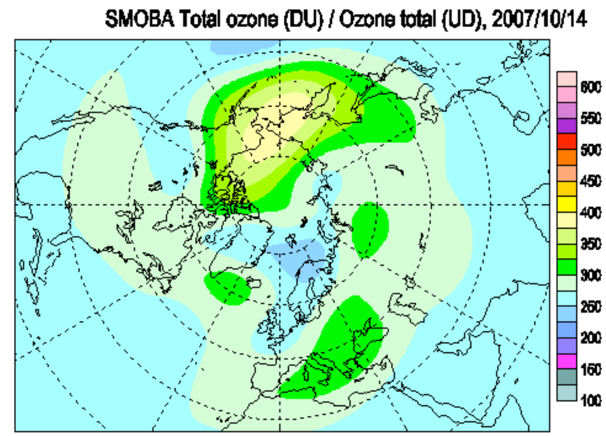
Aura OMI

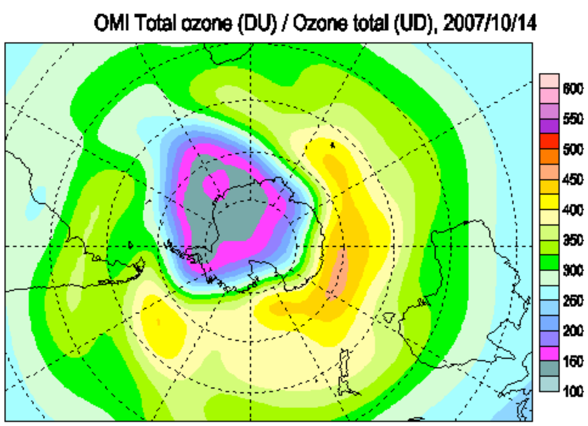
KNMI assimilation

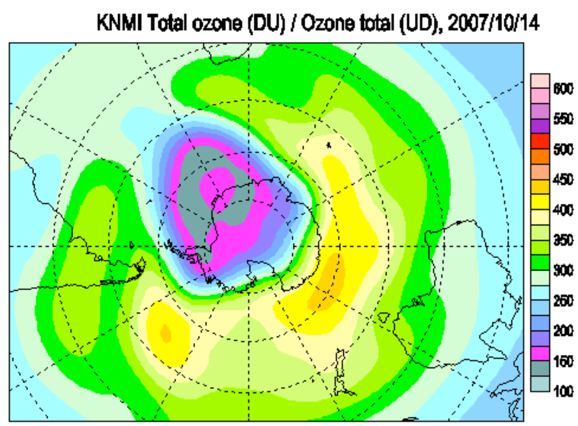
SMOBA

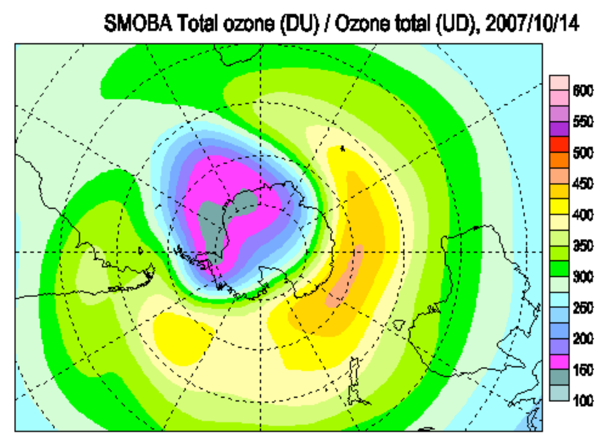






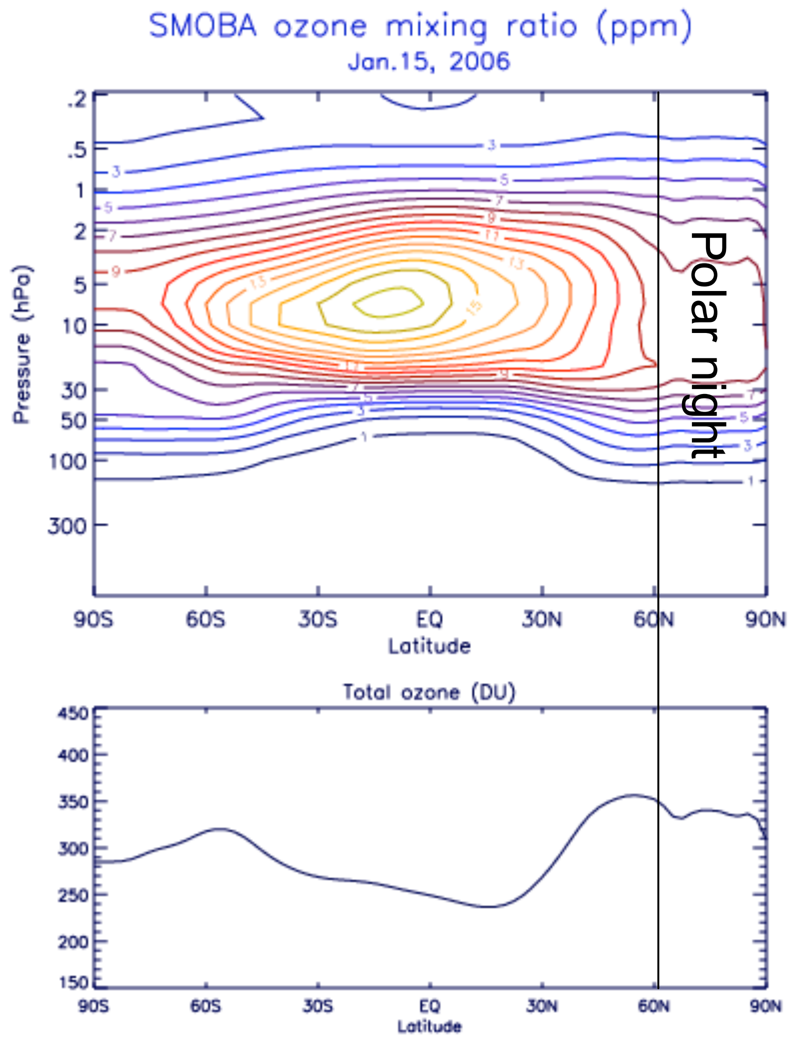


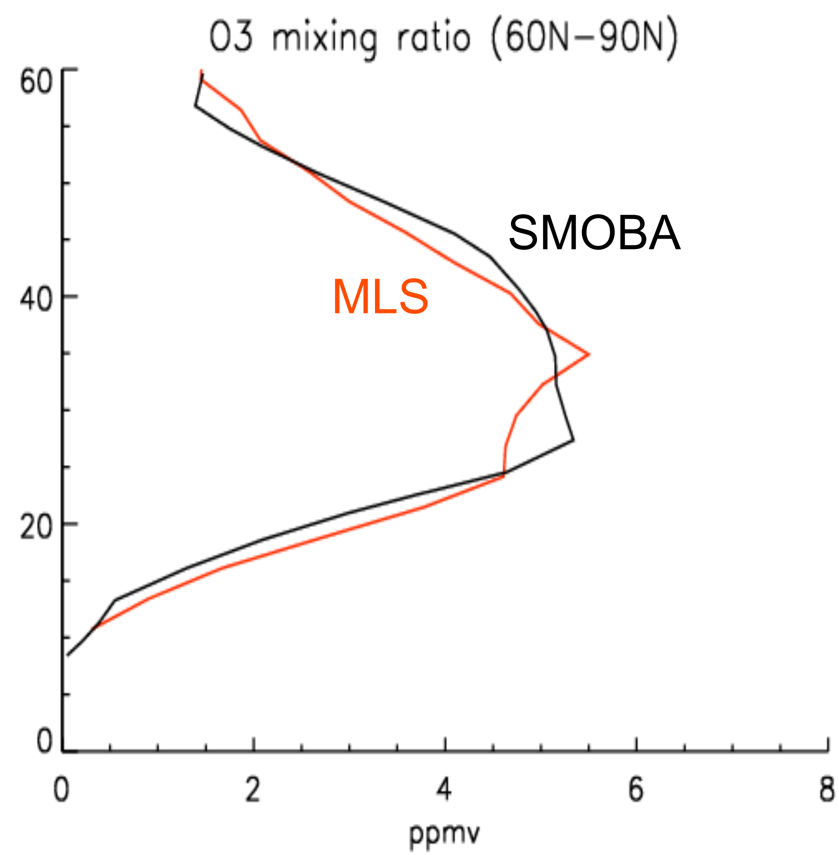




Source: http://es-ee.tor.ec.gc.ca/cgi-bin/dailyMaps

Ozone mixing ratio

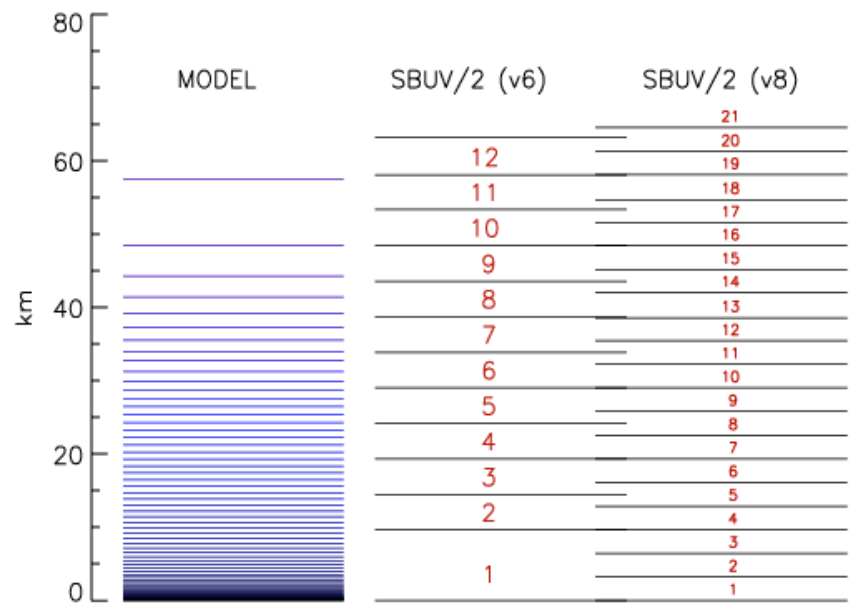




CFSRR

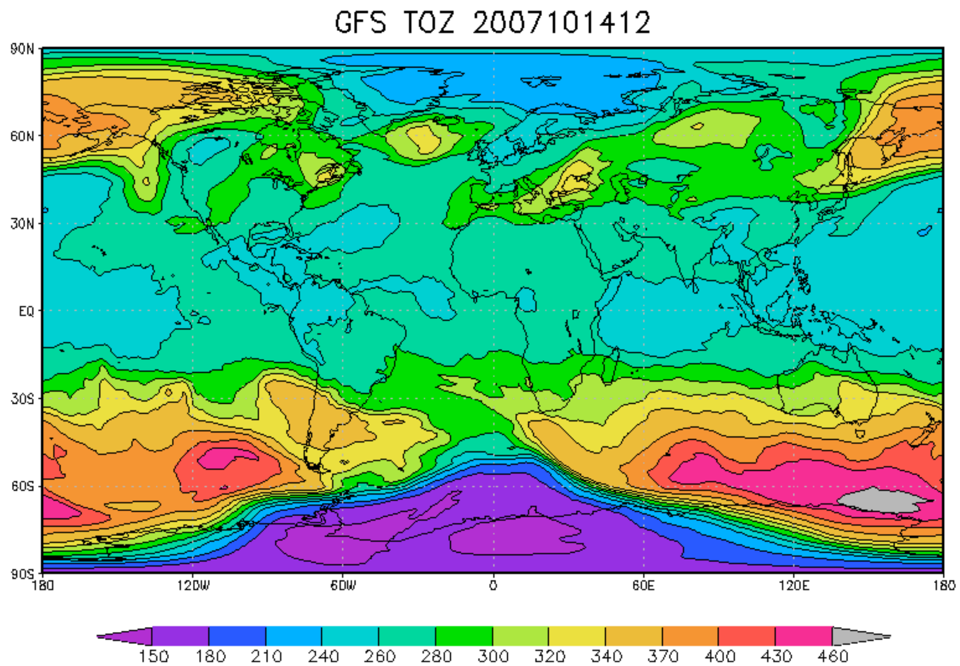
(Climate Forecast System Reanalysis and Reforecast)

- 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

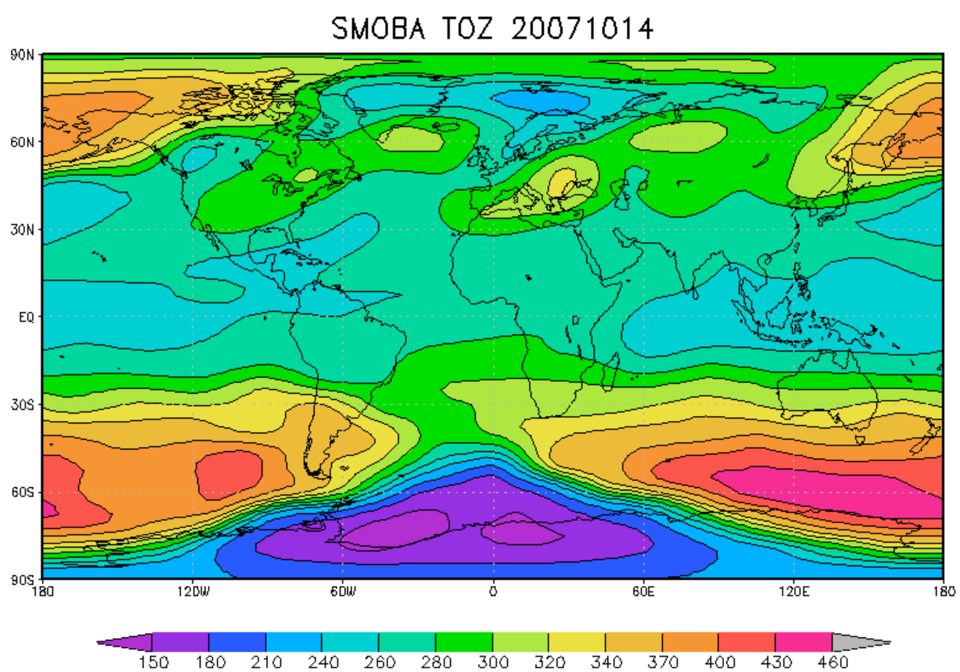


NRL ozone chemistry (*courtesy: John McCormack*)

$$\frac{df}{dt} = (P-L)^{o} + \left.\frac{\partial(P-L)}{\partial f}\right|_{o}(f-f^{o}) + \left.\frac{\partial(P-L)}{\partial T}\right|_{o}(T-T^{o}) + \left.\frac{\partial(P-L)}{\partial c_{O_3}}\right|_{o}(c-c^{o}_{O_3})$$



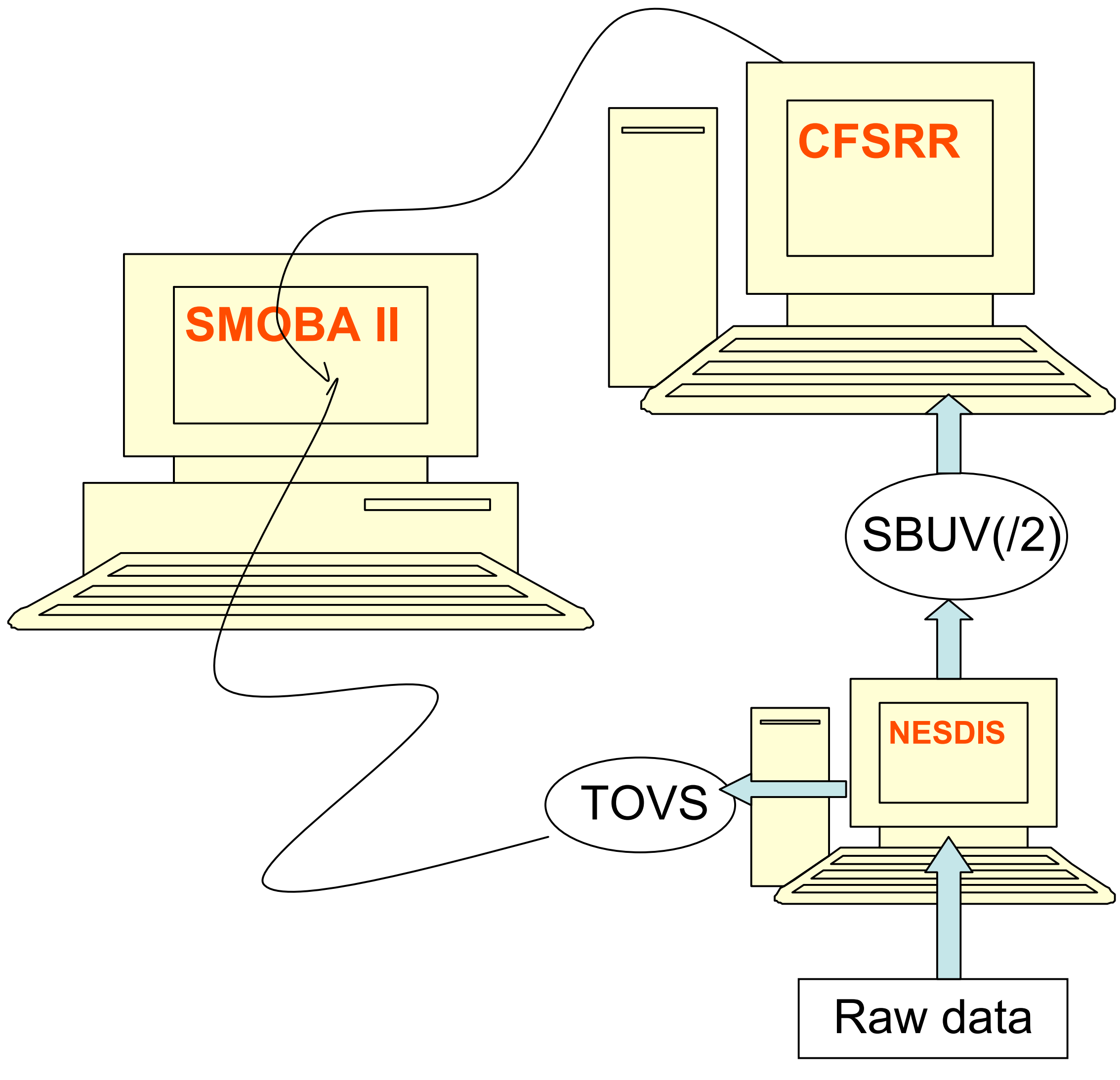
GFS total ozone (CFSRR ozone will be similar)

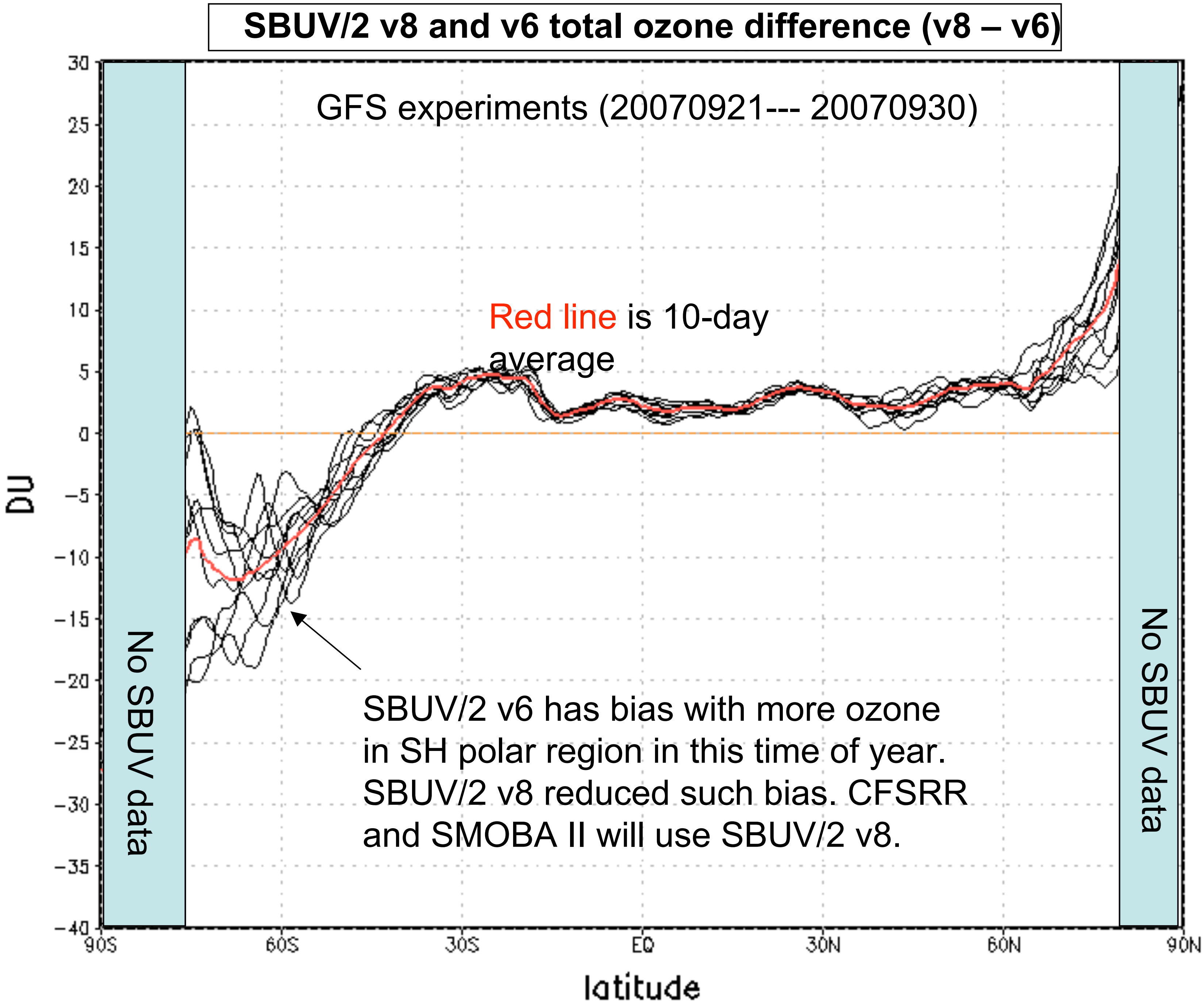


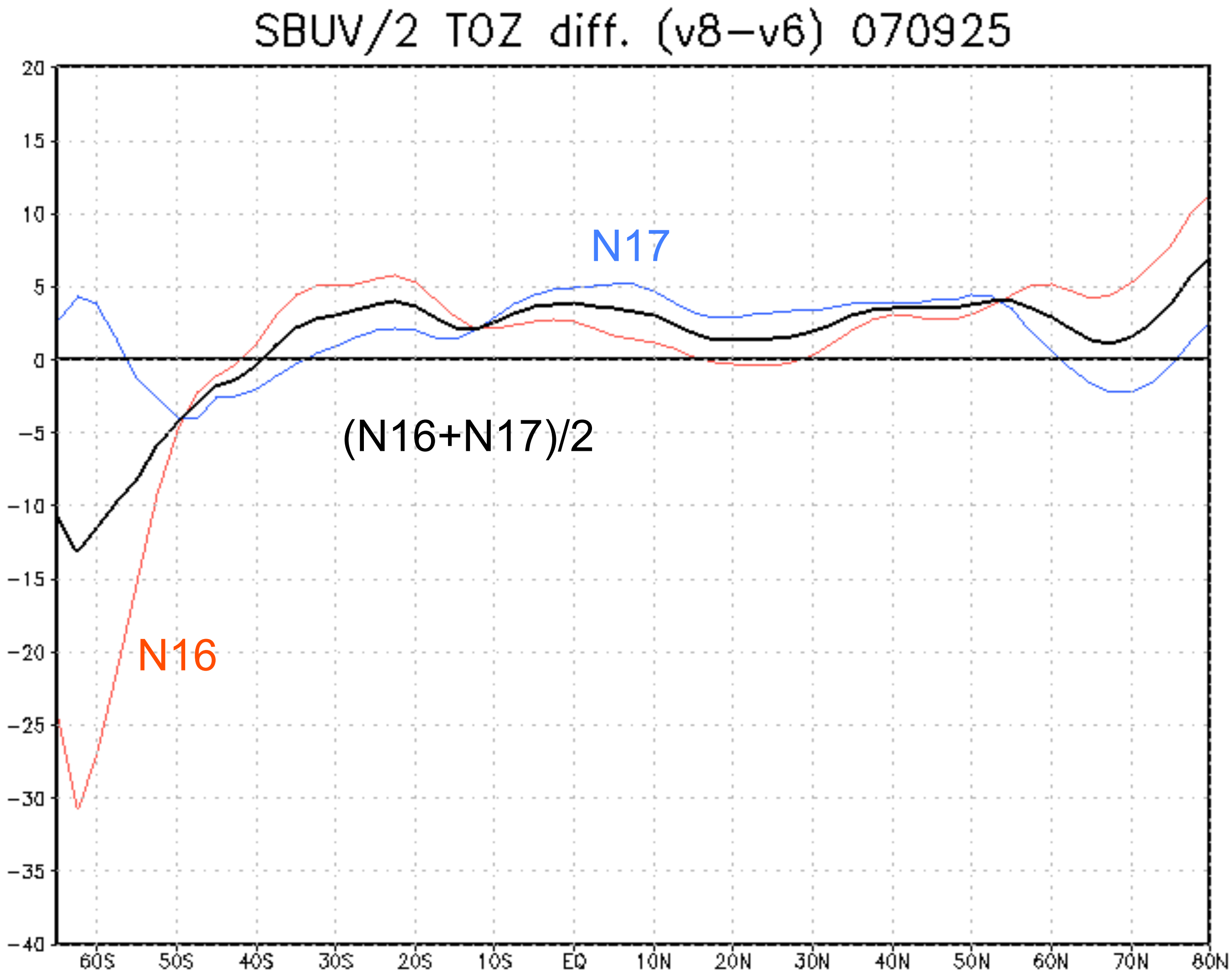
SMOBA total ozone

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).




SBUV/2 v8 and v6 total ozone difference (v8 – v6)
GFS experiments (20070921--- 20070930)
Red line is 10-day average
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.
No SBUV data
No SBUV data
DU
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
−35
−40
90S
60S
30S
EQ
30N
60N
90N
latitude



SBUV/2 TOZ diff. (v8−v6) 070925
20
15
10
5
0
−5
−10
−15
−20
−25
−30
−35
−40
60S
50S
40S
30S
20S
10S
EQ
10N
20N
30N
40N
50N
60N
70N
80N
N17
(N16+N17)/2
N16