The Radiation Fluxes of NCEP/Climate Forecast System Reanalysis Validated with CERES-ERBE

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Acknowledgement: W. Ebisuzaky, H-T Lee, and CFSR production team

CERES STM,

Newport News, VA, Apr 27-29, 2010

Why this Reanalysis:

For generating re-forecasts, for the calibration of the NCEP operational Climate Forecast System, CFS

Outline :

- **CFSR Intro –**

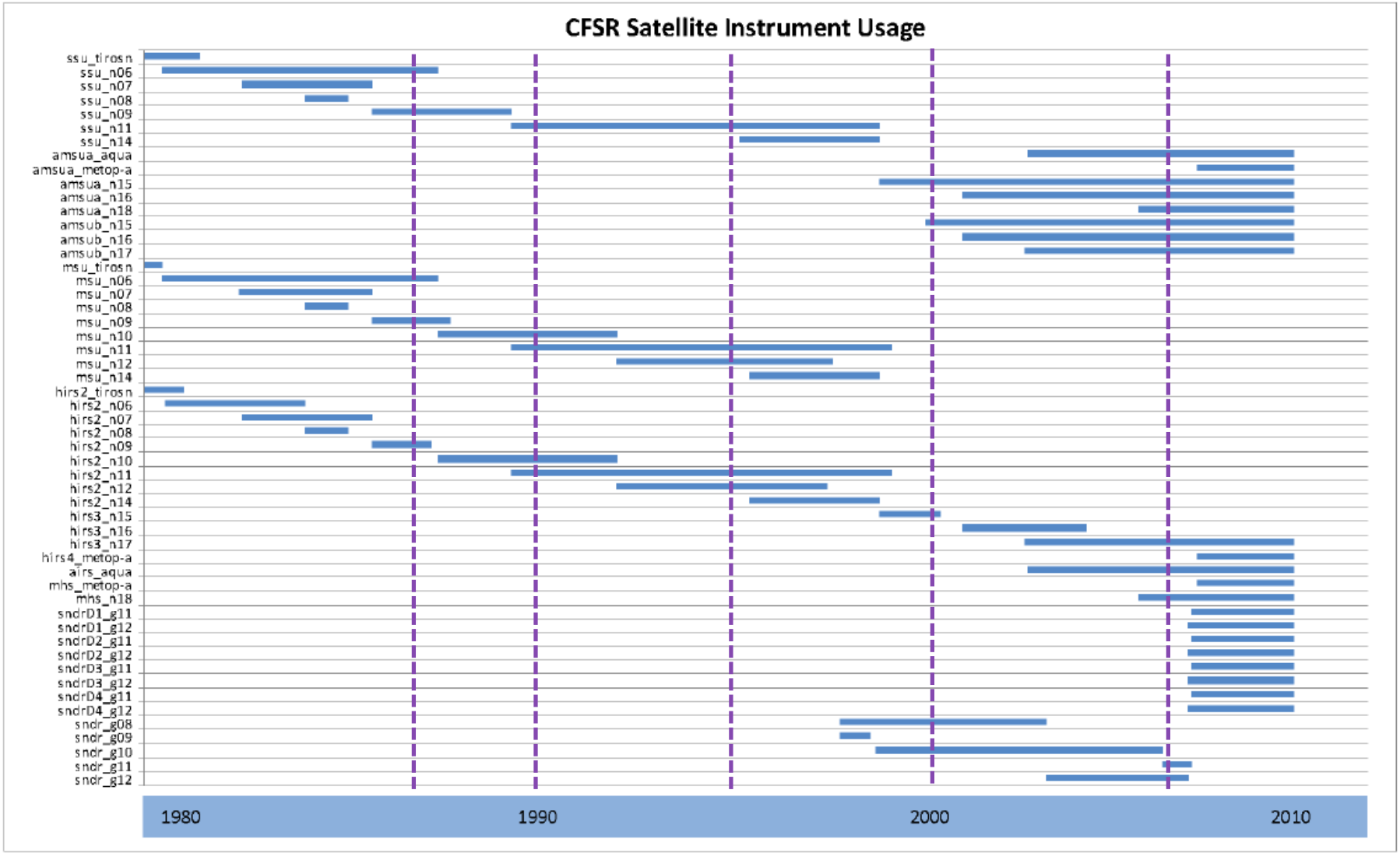
  CFSR(R), Model- streams –Ob data

  radiation modules

  Data source
- **Flux Comparison with CERES-EBAF data**
- **Tropical 20NS Time Series - ERBE**
- **Remarks**

Analysis & Model Attributes

- Couple Atmos-ocean-land models (NCEP+MOM4+NOAH)
- Coupled Analysis System (GSI + GODAS + GLDAS)
- Assimilate Satellite Radiance
- Atm model resolution T382, ~38km, Atm Layer: T64, top at 0.26hPa.
- Ocean: 0.25^0 at Equ, ext to 0.5^0 beyond trop. 40 layer, to 4737m
- Land: 4 soil level
- Sea Ice: 3 level
- Convection: S. Arakawa-Schubert (Pan and Moorthi)
- Radiation RRTM, SW/LW, computation freq. – hourly
- Variational CO_2, Strato Aerosol (SAMII, Sato '93)


CFSR Satellite Instrument Usage
ssu_tirosn
ssu_n06
ssu_n07
ssu_n08
ssu_n09
ssu_n11
ssu_n14
amsua_aqua
amsua_metop-a
amsua_n15
amsua_n16
amsua_n18
amsub_n15
amsub_n16
amsub_n17
msu_tirosn
msu_n06
msu_n07
msu_n08
msu_n09
msu_n10
msu_n11
msu_n12
msu_n14
hirs2_tirosn
hirs2_n06
hirs2_n07
hirs2_n08
hirs2_n09
hirs2_n10
hirs2_n11
hirs2_n12
hirs2_n14
hirs3_n15
hirs3_n16
hirs3_n17
hirs4_metop-a
airs_aqua
mhs_metop-a
mhs_n18
sndrD1_g11
sndrD1_g12
sndrD2_g11
sndrD2_g12
sndrD3_g11
sndrD3_g12
sndrD4_g11
sndrD4_g12
sndr_g08
sndr_g09
sndr_g10
sndr_g11
sndr_g12
1980
1990
2000
2010

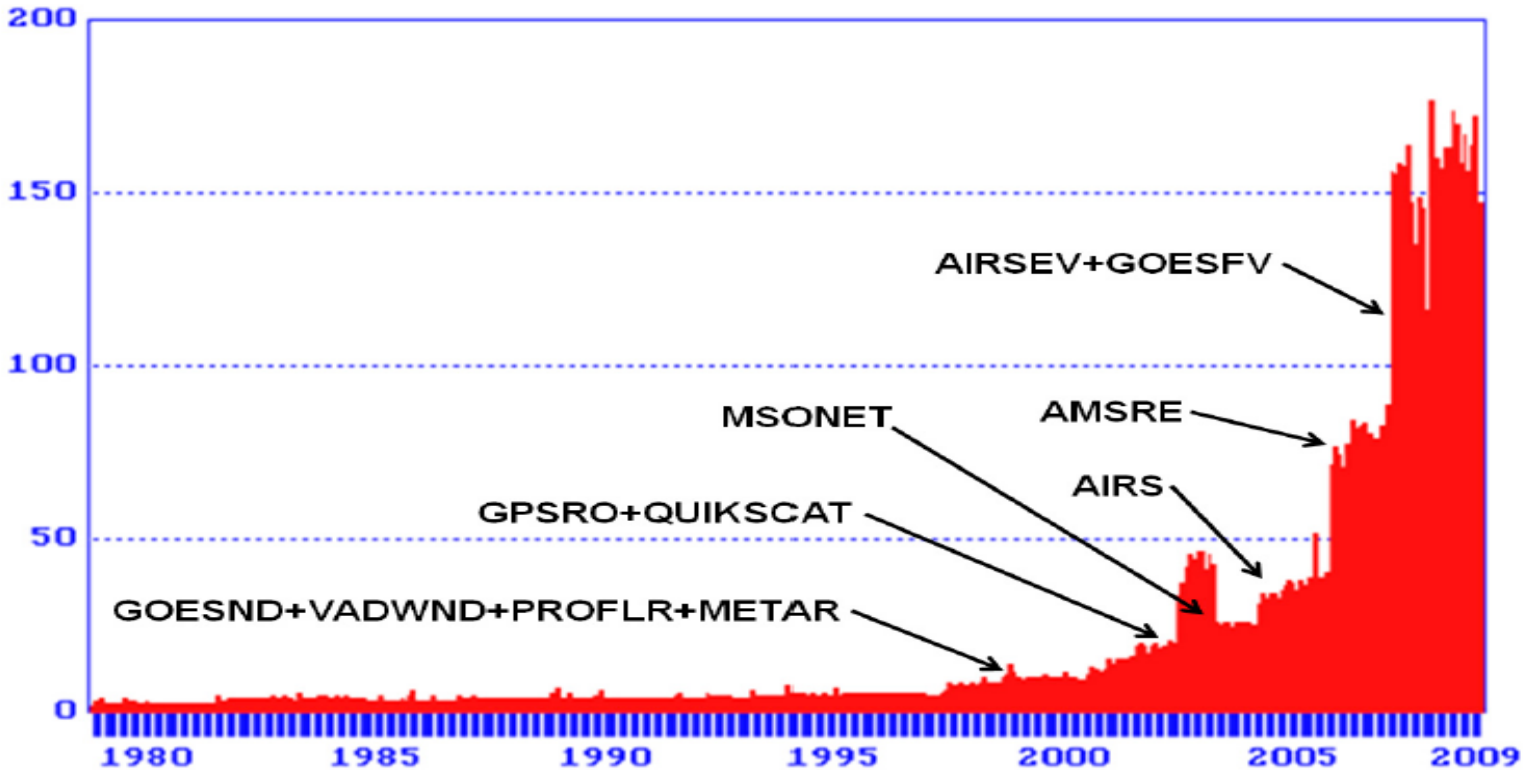
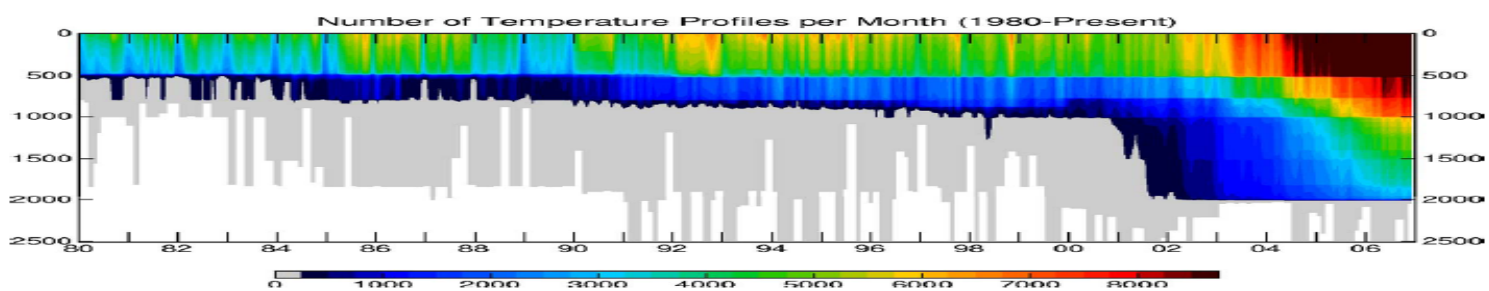


Diagram illustrating CFSR data dump volumes, 1978-2009, in GB/month.



NCEP Operational SW Radiation vs. CFSRR RRTM SW Radiation

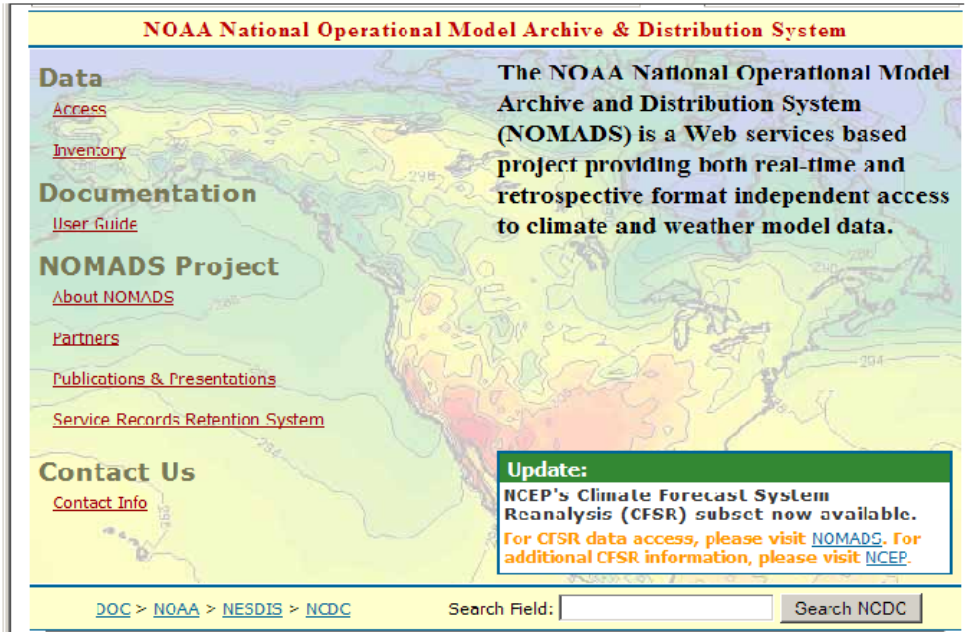
	NCEP(GFS-Chou)	RRTM (CFSRR-Iacono, 2000)
Description:	- 8 uv+vis, 1-nir; - 38 k-dis terms; - O_3,H_2O,CO_2,O_2;	5 uv+vis, 9-nir bnds 112 cor-k terms O_3,H_2O,CO_2,O_2,CH_4
Advantages:	- Comp. Efficient;	Accu. (use ARM's data) clr-sky - 10-30 w/m^2 reduction all-sky - adv. scheme
Disadvantages:	- large errors; clr-sky - und est; cld-sky - ovr est;	Comp. slow, 4 times slower than oprtnl sw

Operational CFS GFDL-LW Radiation vs. CFSRR RRTM-LW Radiation

	GFDL (Fels-Schwrtz.)	RRTM (Mlawer et al. '97)
Description:	- 15 bands;	16 bands
	- trans tbl look-up;	140 cor-k terms
	- O_3,H_2O,CO_2;	O_3,H_2O,CO_2,O_2,CH_4 CO, 4 CFCs
Advantages/ Disadvantages:	- comp efficient;	better comp efficient
	- no aerosols;	aerosol effect capable
	- fixed CO_2 onle;	varying CO_2 capable
	- fixed sfc emis;	varying emis capable
	- random cld ovlp;	max-random overlap
	- larger errors; esp at upper strat,	improved accuracy at upper stratosphere
	- simple cld opt prop;	advanced cld opt prop

CFSR Data and Documentation

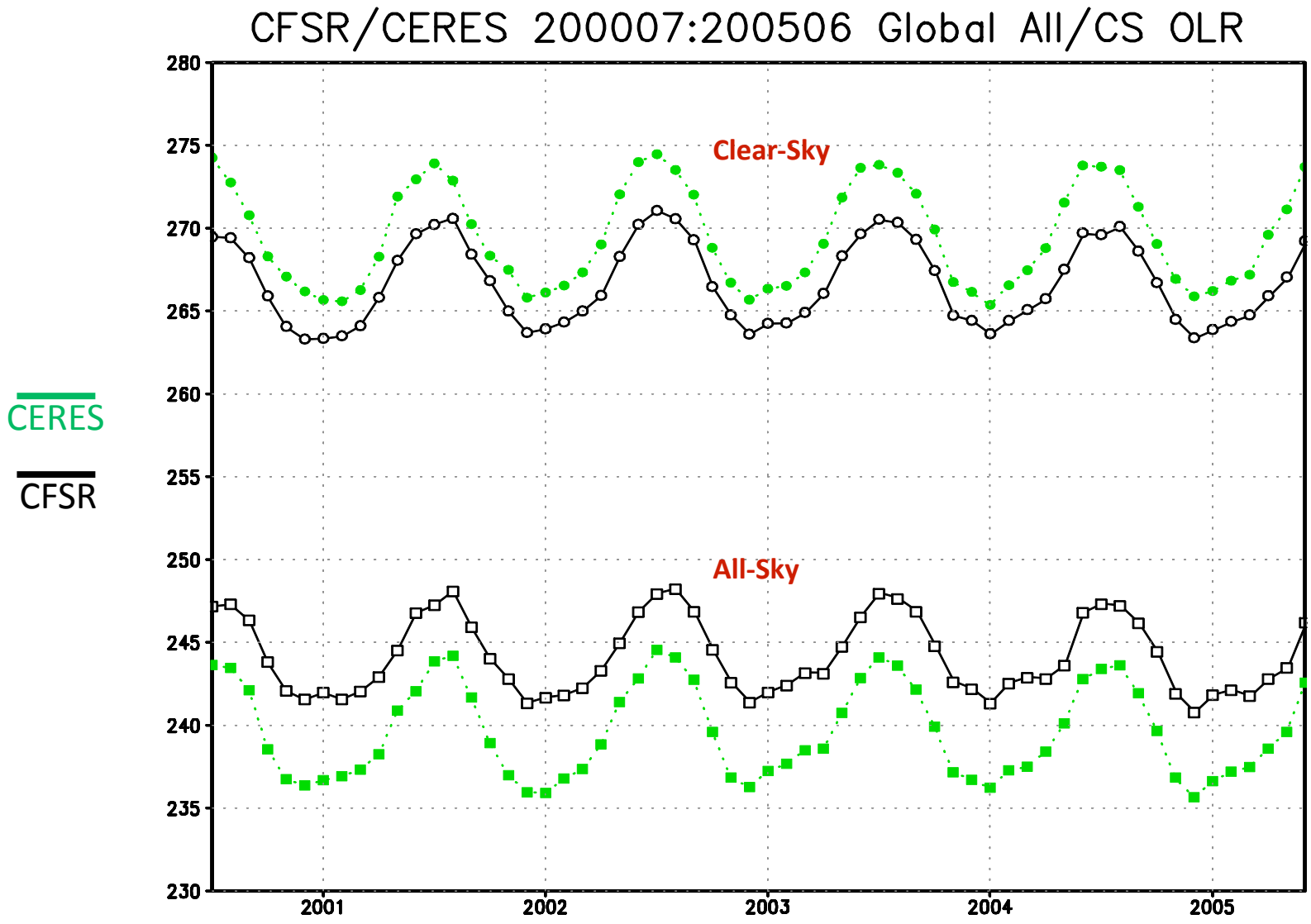
- **CFSR Site: *http://cfs.ncep.noaa.gov/cfsr***
- **NOAA Operational Model Archive Distribution System (Nomad5) *http://nomad5.ncdc.noaa.gov***
- ***33* Radiation-Cloud variables *(107 total, Monthly PGB06)***
- ***Saha et al. 2010->BAMS***

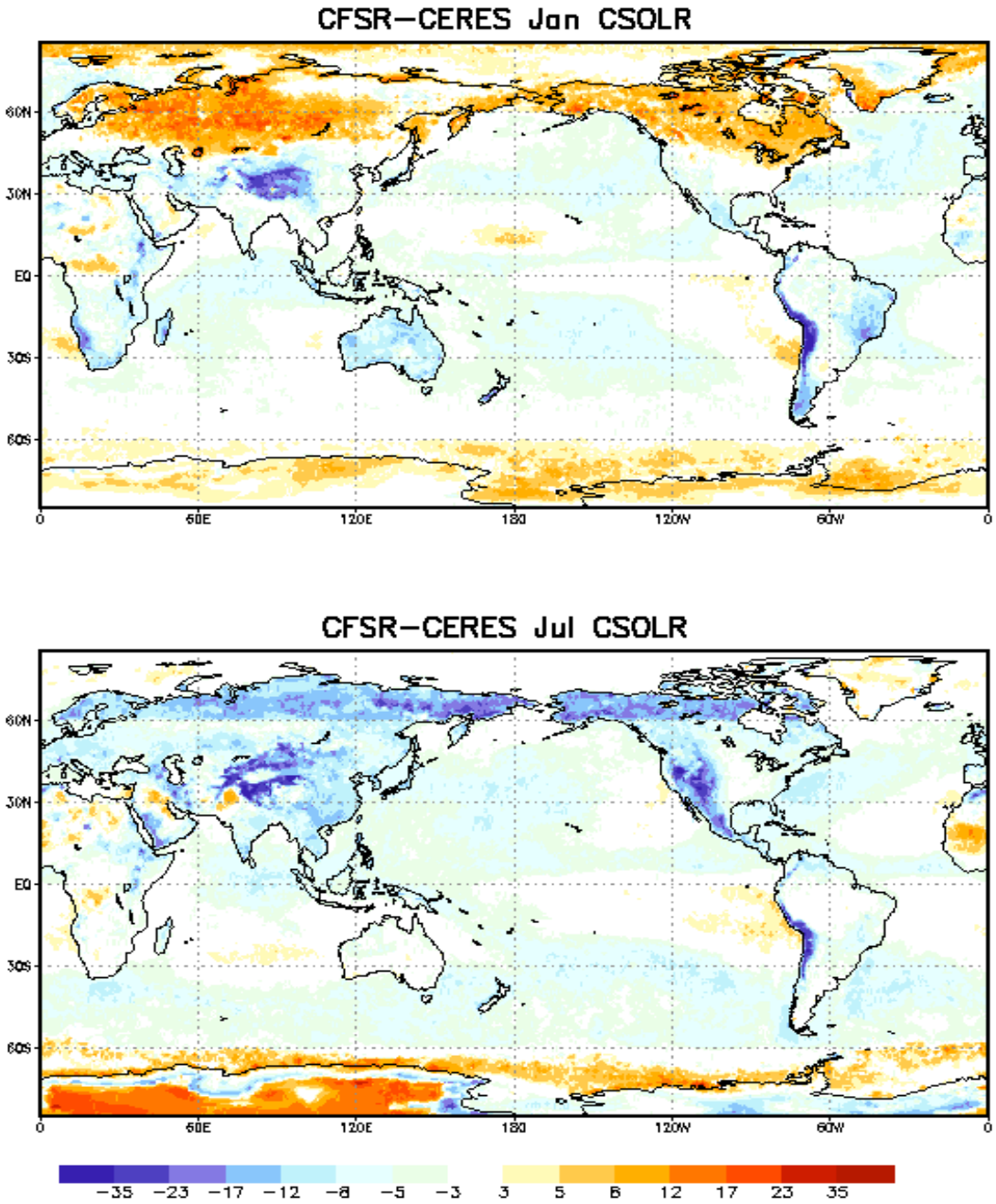


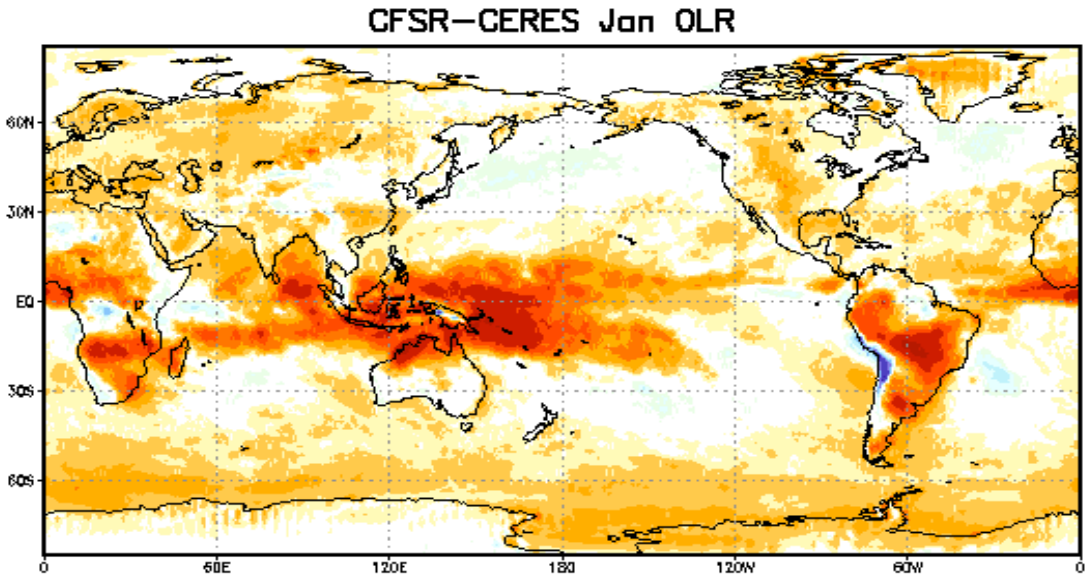
Comparison with CERES-ERBE

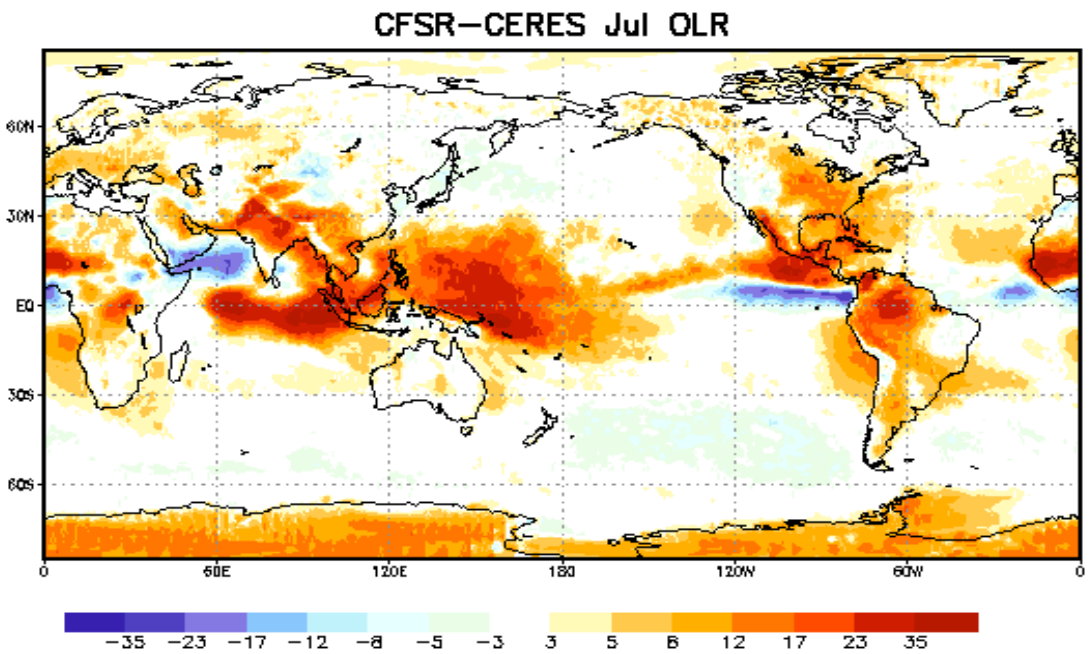
- **CERES**:
  - **TOA: EBAF, 1x1, Jul 2000 - Jun 2005**
  - **SFC: SARB, same period as TOA, from Dave R.**
- **CFSR**: 0.5x0.5, Monthly, Re-grid to 360x180 from 720x361
- **ERBE**: Tropics 20NS TOA OLR/RSW, by Tak W.

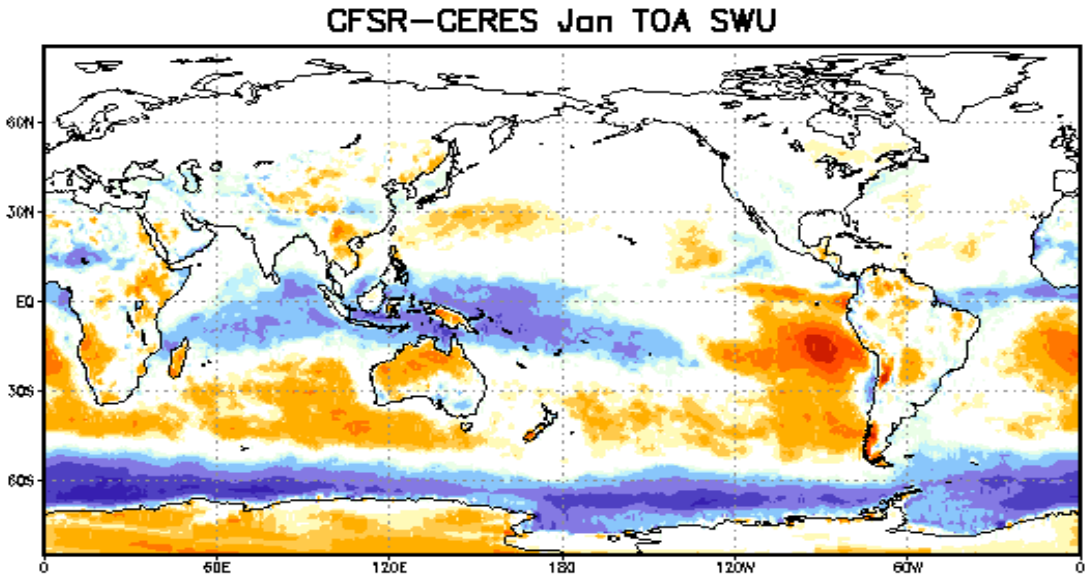
Global TOA OLR

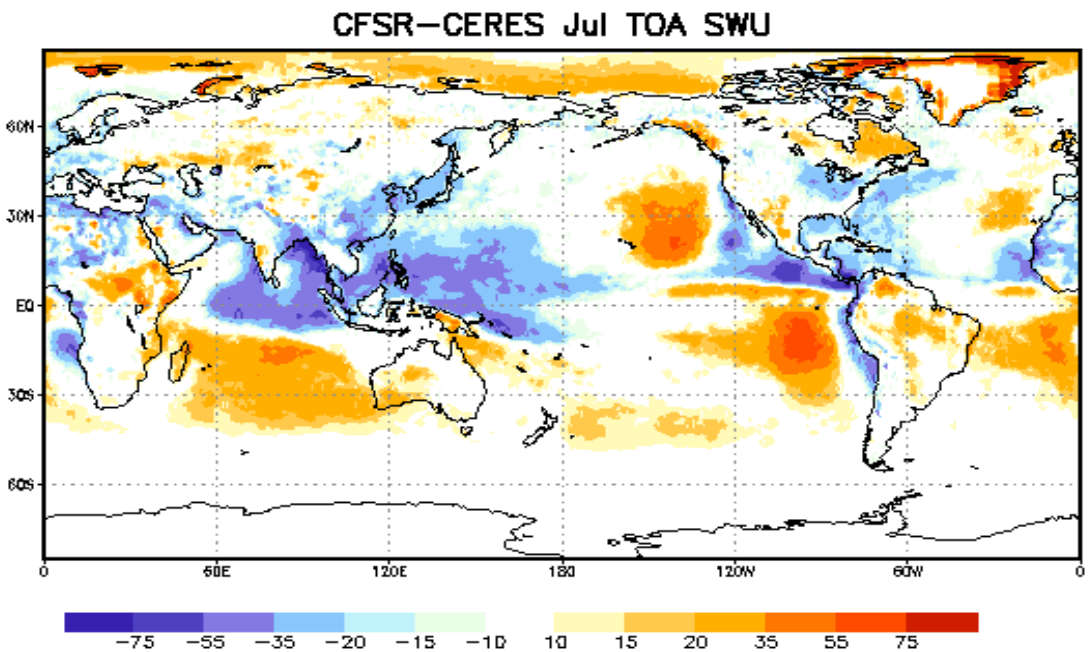


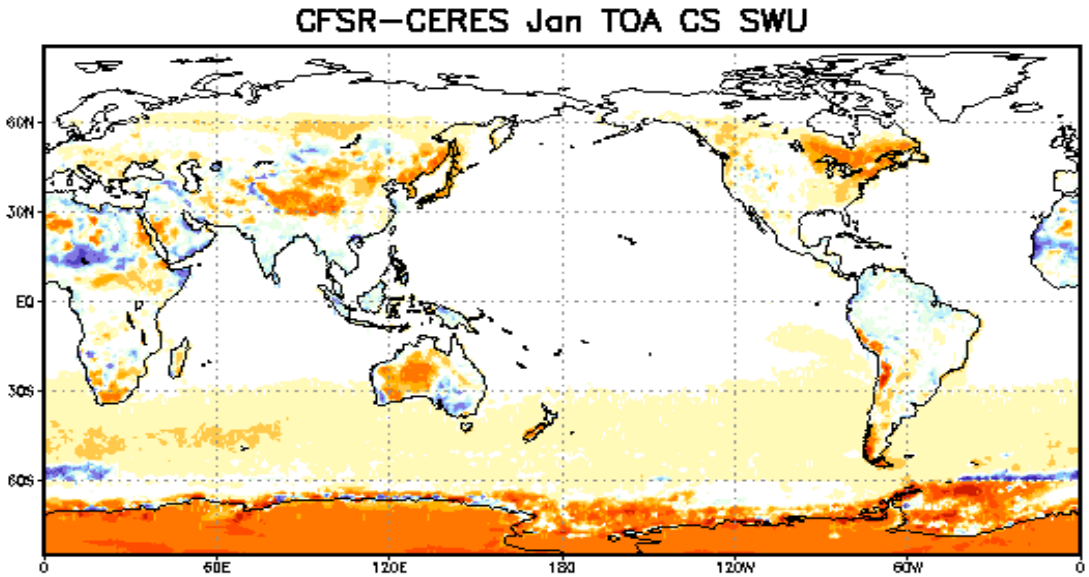

CFSR−CERES Jan CSOLR
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
CFSR−CERES Jul CSOLR
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−35 −23 −17 −12 −8 −5 −3 3 5 8 12 17 23 35

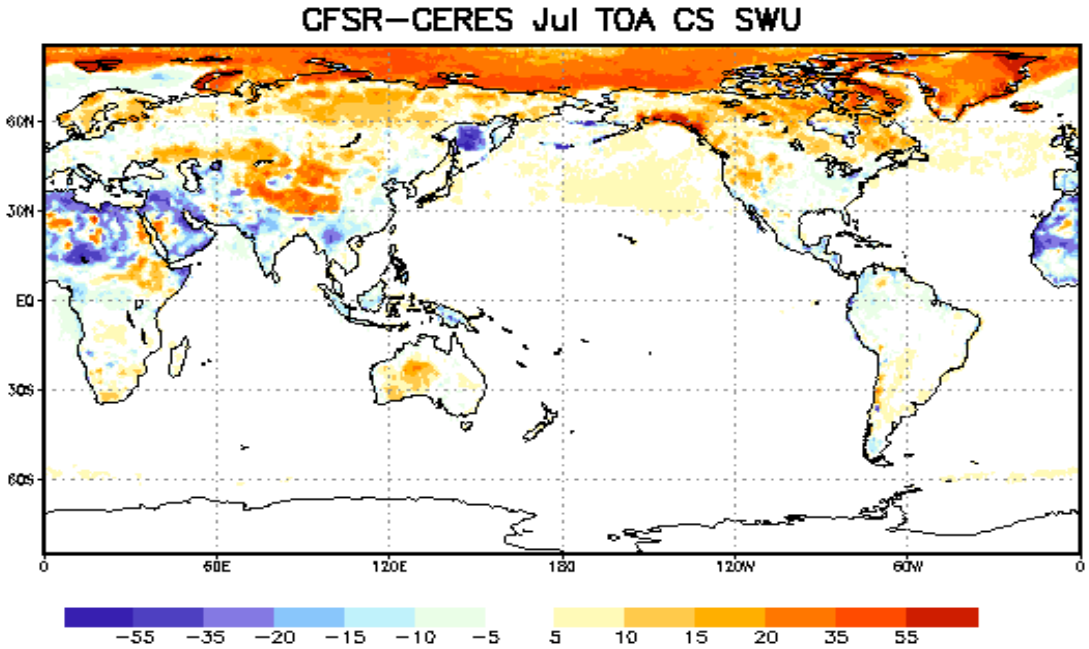

CFSR−CERES Jan OLR
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0


CFSR−CERES Jul OLR
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−35 −23 −17 −12 −8 −5 −3 3 5 8 12 17 23 35

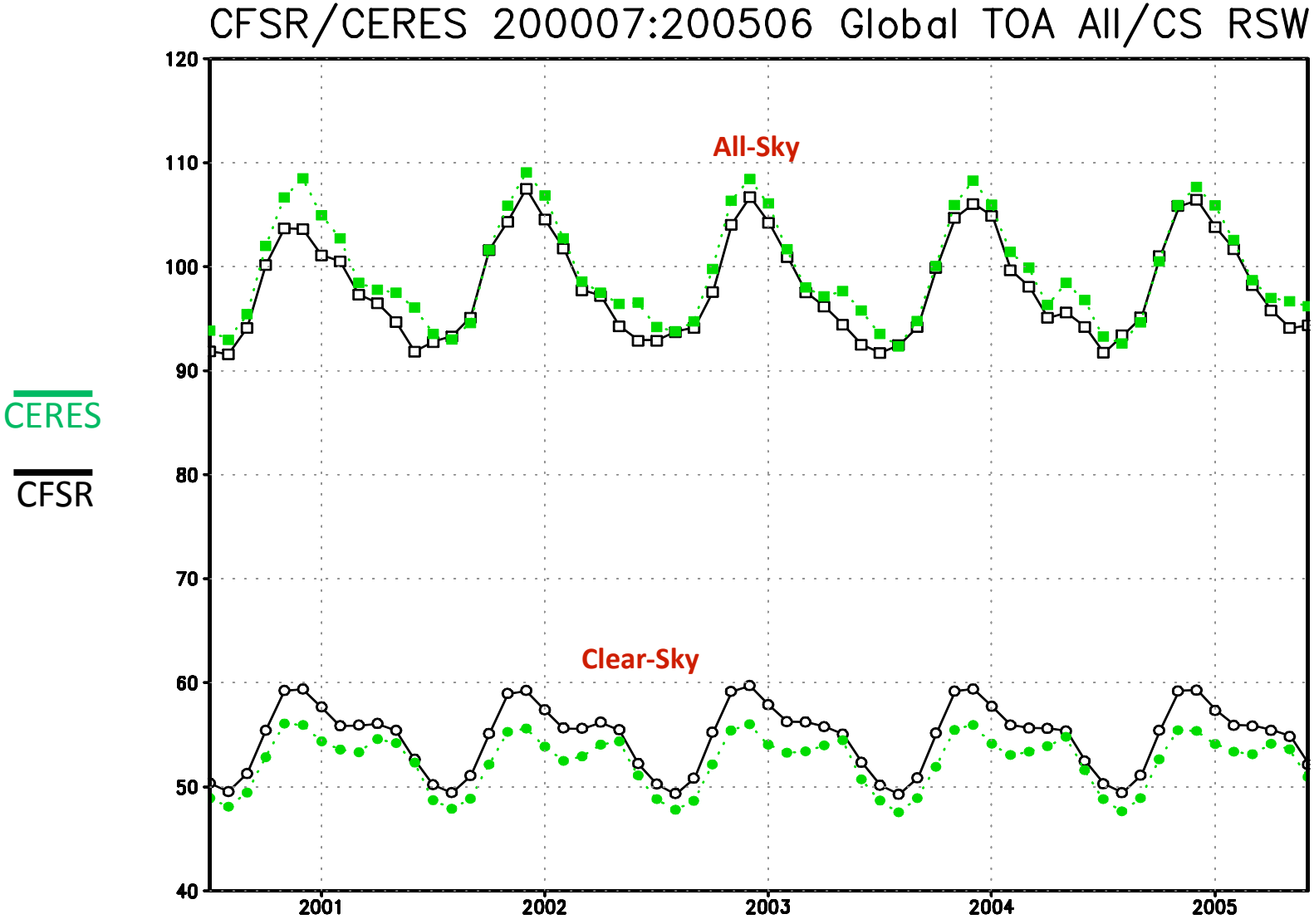

CFSR−CERES Jan TOA SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0


CFSR−CERES Jul TOA SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−75
−55
−35
−20
−15
−10
10
15
20
35
55
75


CFSR−CERES Jan TOA CS SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0

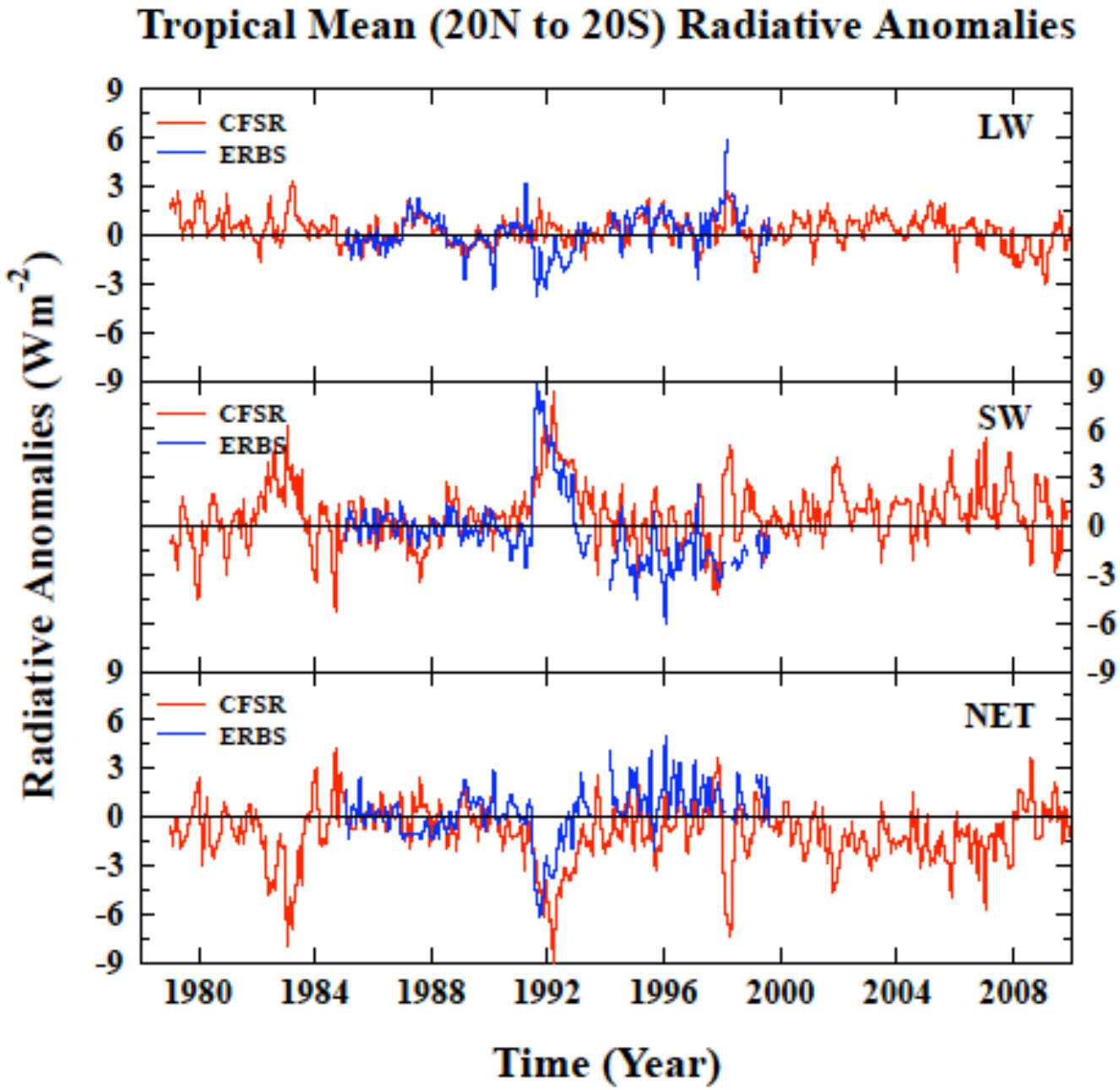

CFSR−CERES Jul TOA CS SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−55
−35
−20
−15
−10
−5
5
10
15
20
35
55

Global TOA RSW

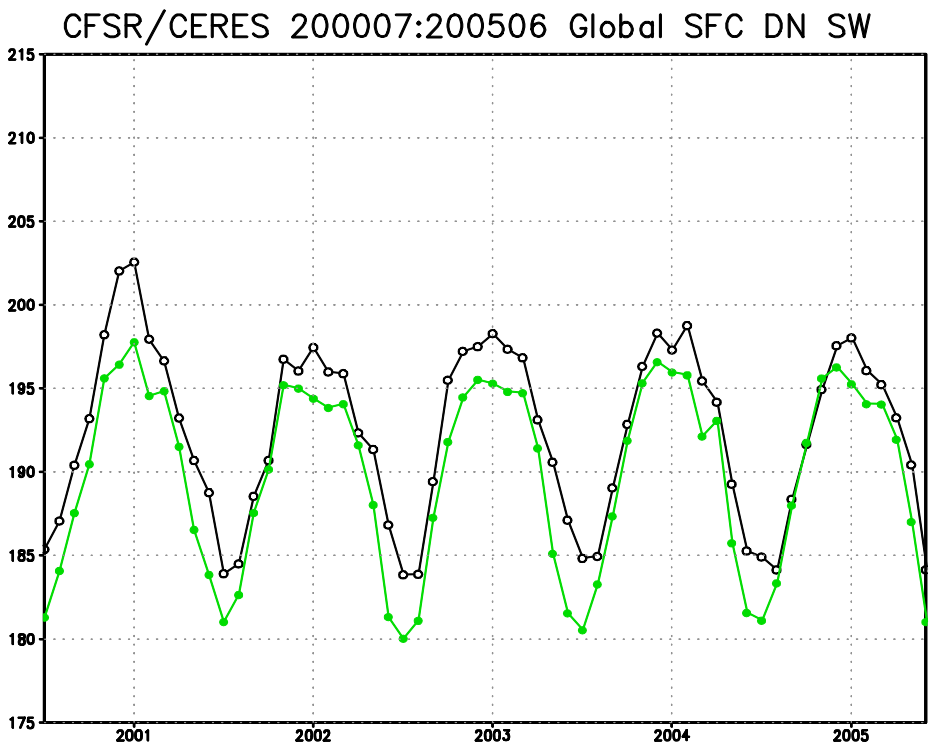


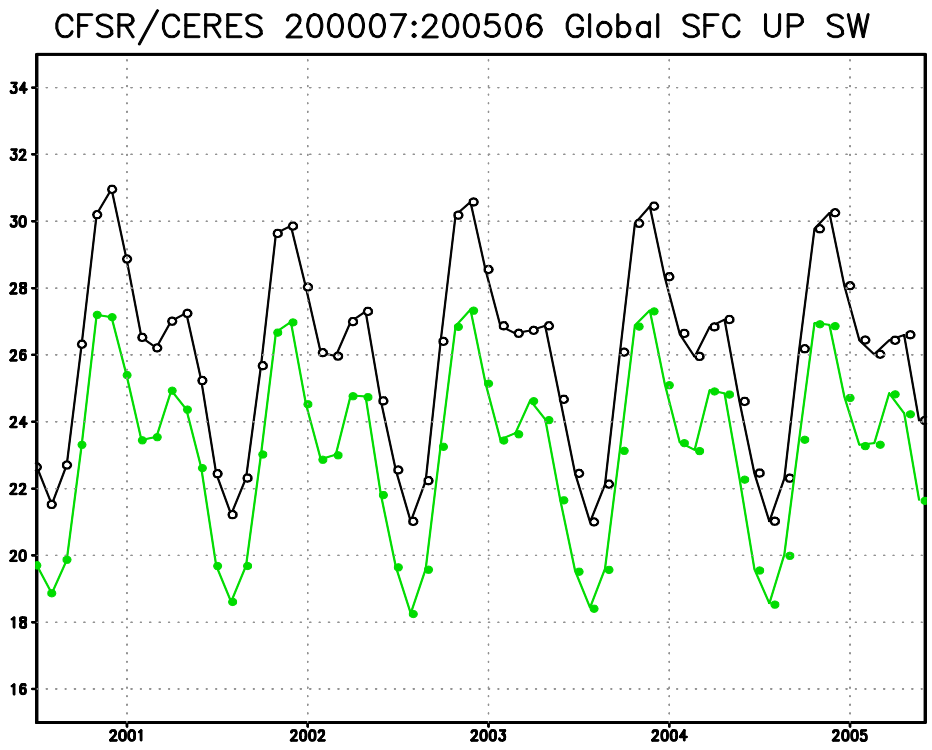
Global Annual Means*

		TOA OLR	TOA CS OLR	TOA RSW	TOA CSRSW		SFC SW DN	SFC SW UP	SFC LW DN	SFC LW UP
Jul00-Jun05	CFSR	228.1	248.2	101.8	65.2		167.6	36.9	304.2	356.4
	CERES (EBAF/SARB)	224.1	249.7	102.7	61.7		165.7	32.9	304.7	354.7
	Diff (RMSD)	4.1(6.74)	-1.5(6.12)	-0.9(16.30)	3.5(10.54)		1.9(18.02)	4.0(9.05)	-0.5(10.3)	1.6(10.14)
	Spatial Correlatn	0.9	0.87	0.72	0.88		0.76	0.91	0.92	0.92
Jan85-Dec86	R1	237.1	267.8	115.3	54.9		207.5		333	
	ERBE	234	266.7	102.7	53.1		184		349.5	
	Dif	3.1	1.7	12.6	1.8		23.5		-16.5	


Tropical Mean (20N to 20S) Radiative Anomalies
CFSR
ERBS
LW
SW
NET
Radiative Anomalies (Wm-2)
9
6
3
0
-3
-6
-9
1980
1984
1988
1992
1996
2000
2004
2008
Time (Year)

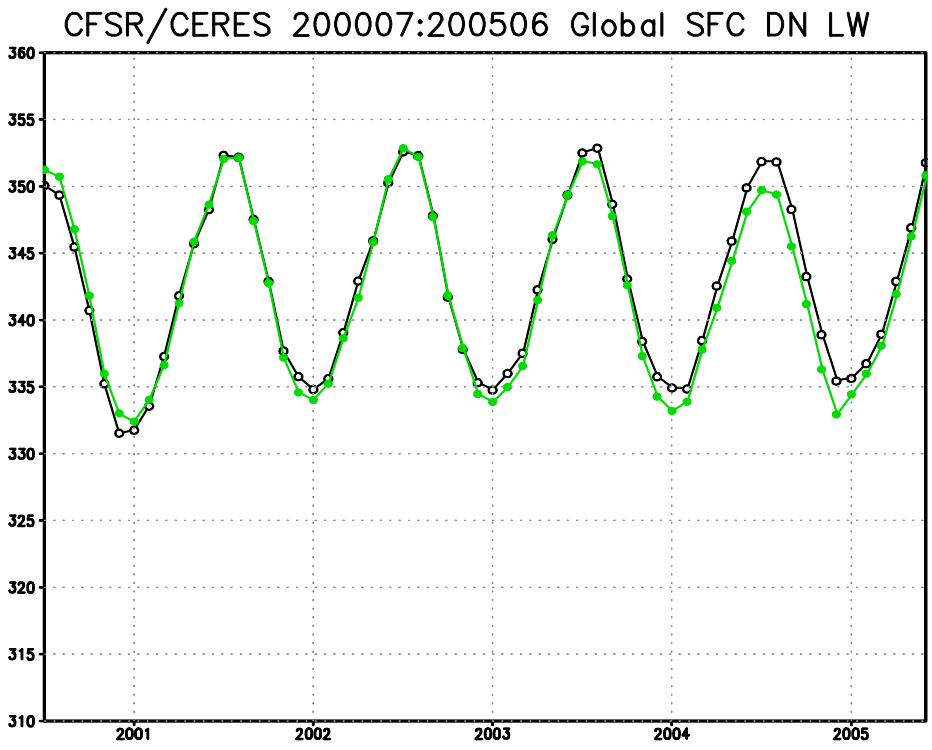
Surface Downward & Upward Shortwave

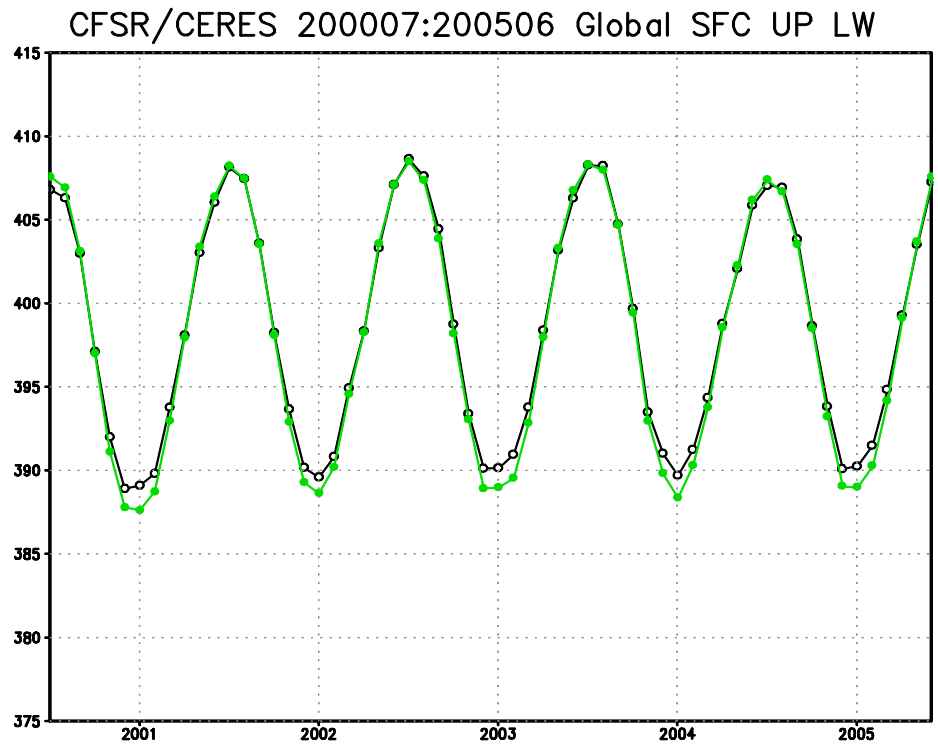




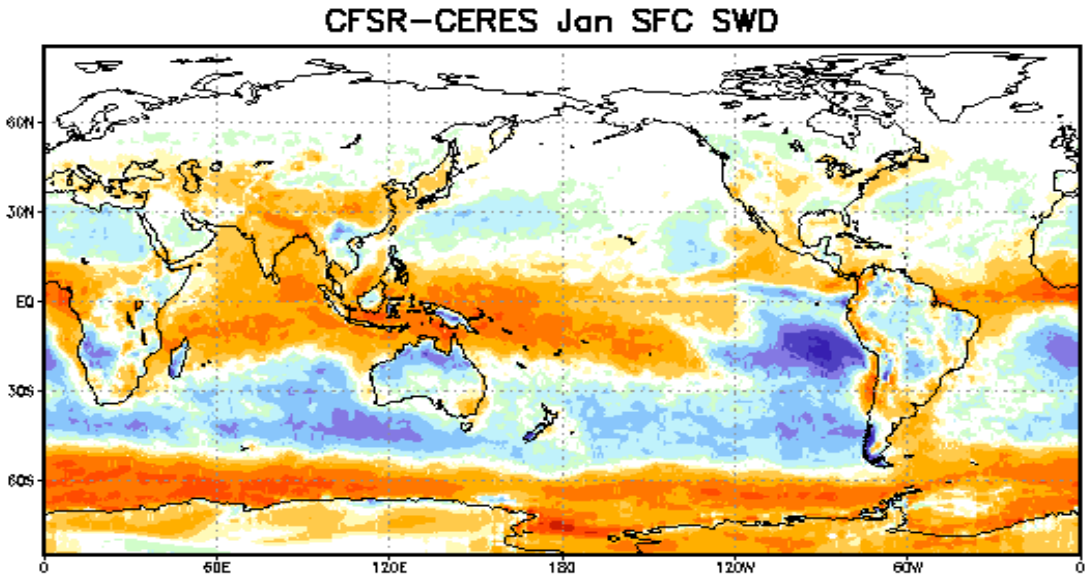
CERES CFSR

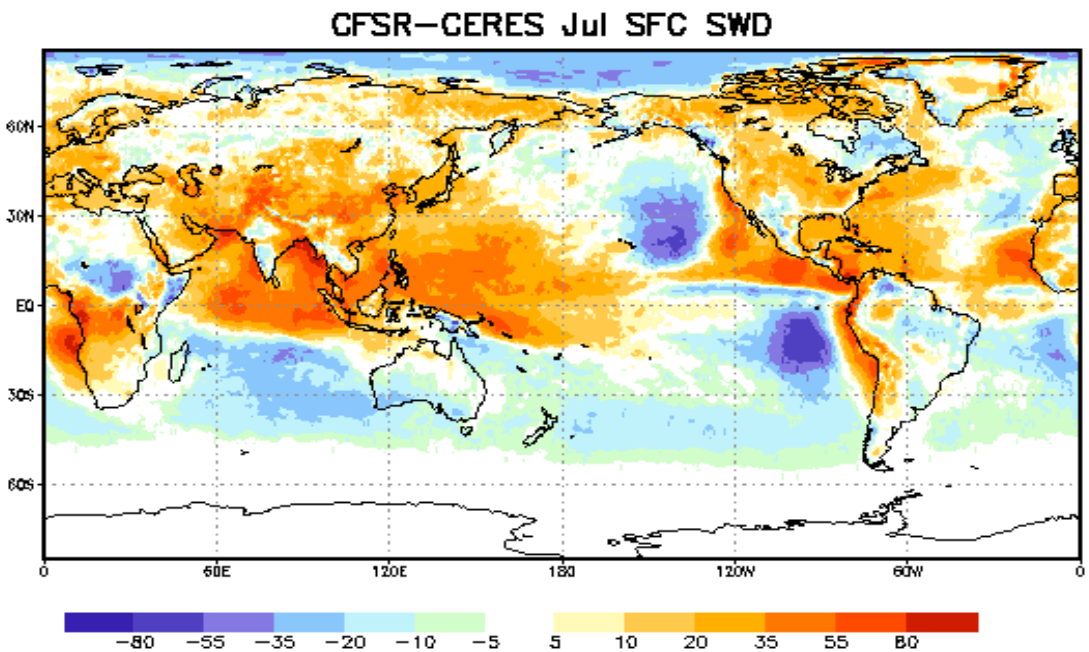
Surface Downward & Upward Longwave

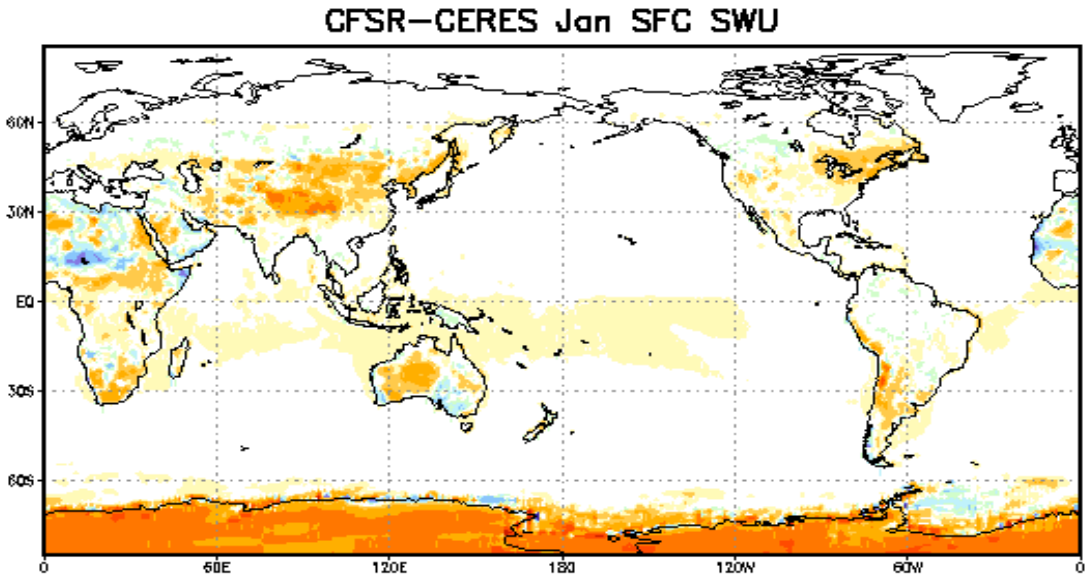


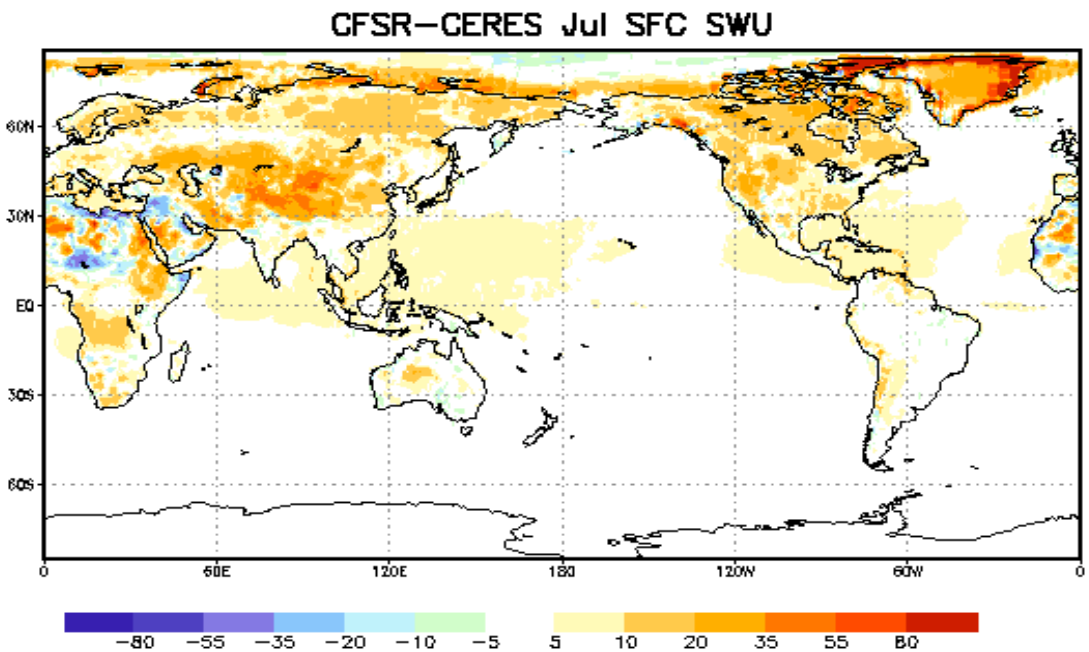


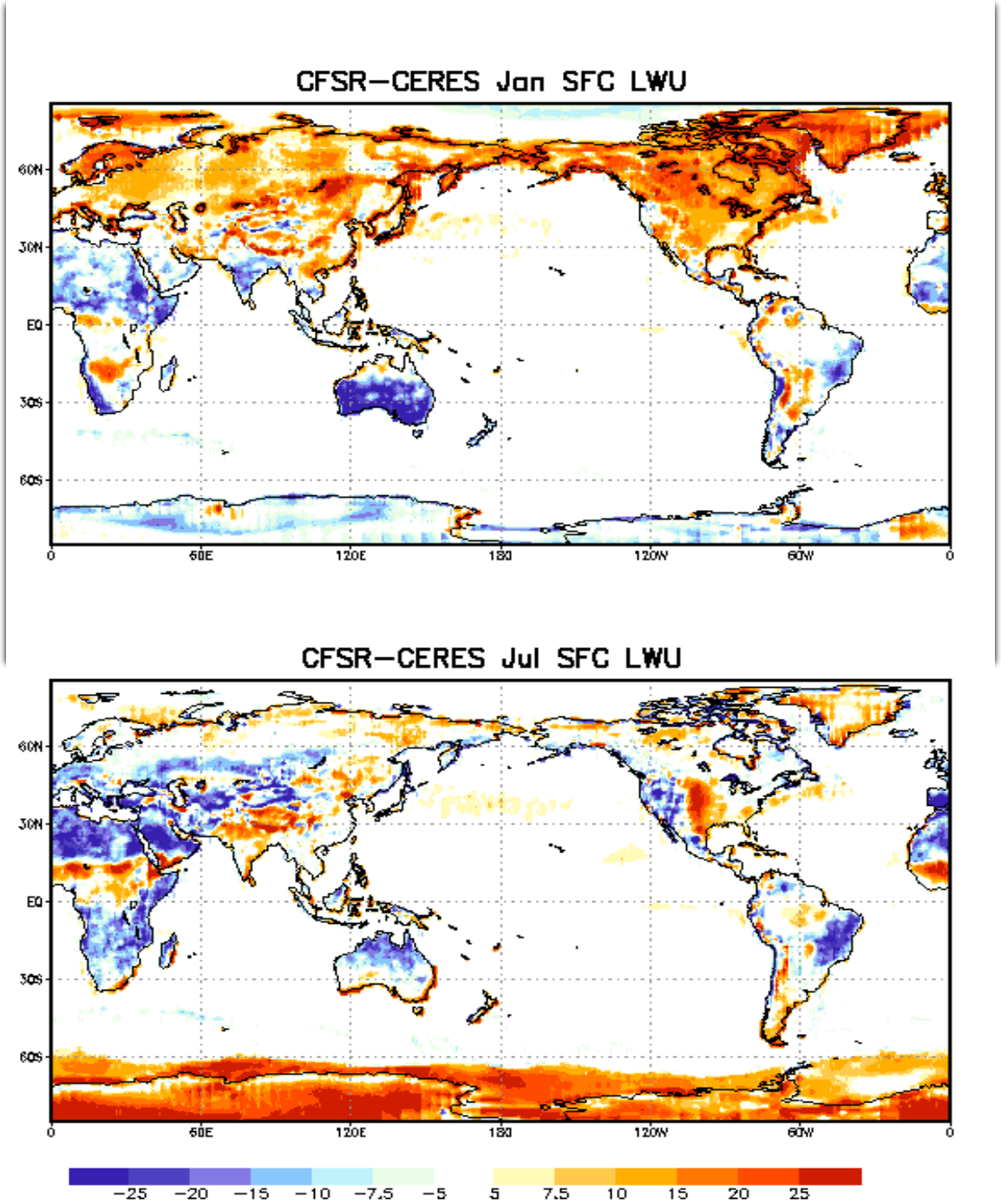
CERES CFSR


CFSR−CERES Jan SFC SWD
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0


CFSR−CERES Jul SFC SWD
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−80
−55
−35
−20
−10
−5
5
10
20
35
55
80


CFSR−CERES Jan SFC SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0

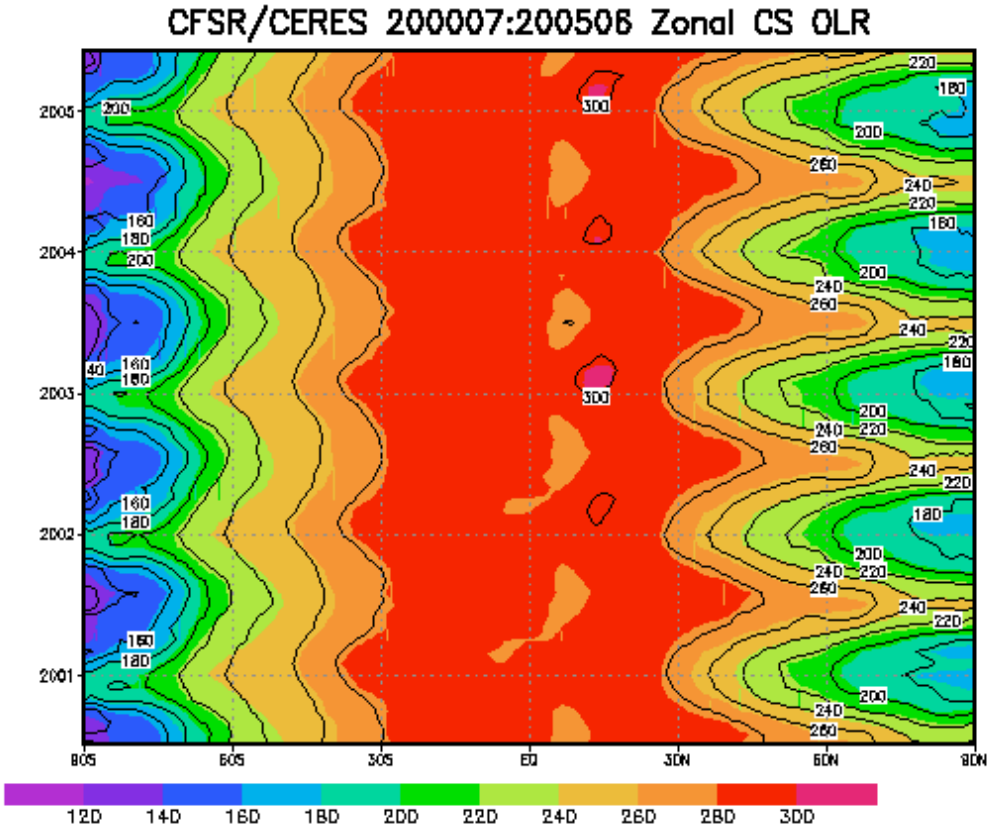

CFSR−CERES Jul SFC SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−80
−55
−35
−20
−10
−5
5
10
20
35
55
80

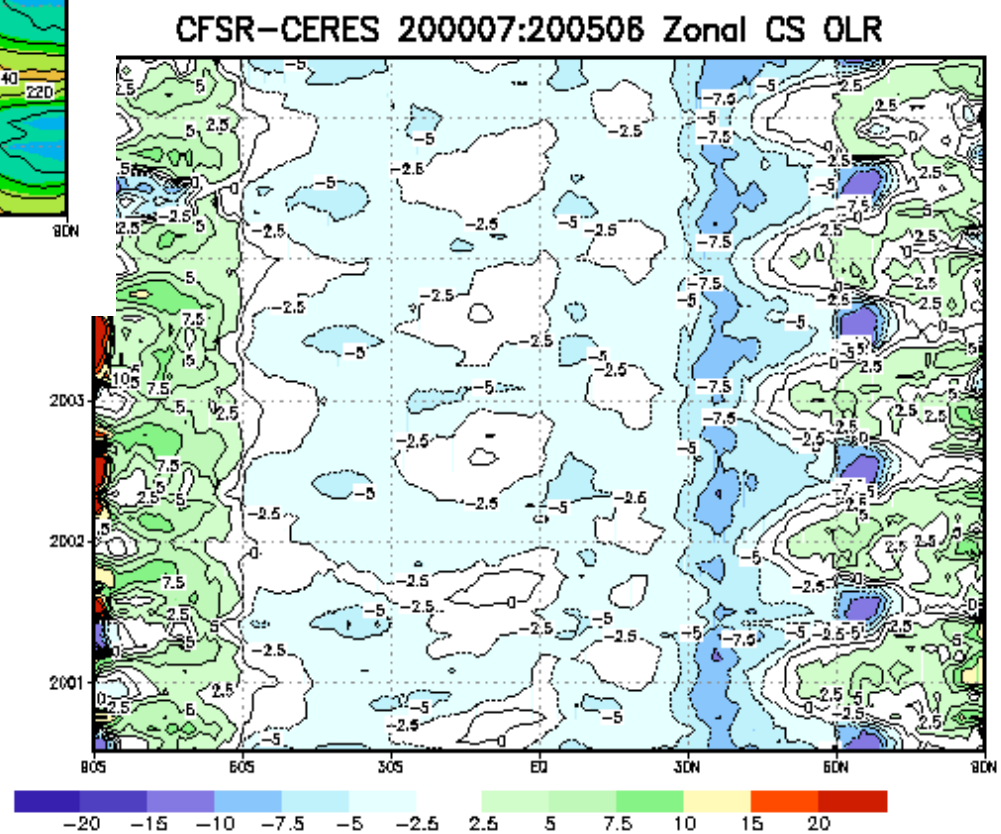

CFSR−CERES Jan SFC LWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
CFSR−CERES Jul SFC LWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−25
−20
−15
−10
−7.5
−5
5
7.5
10
15
20
25

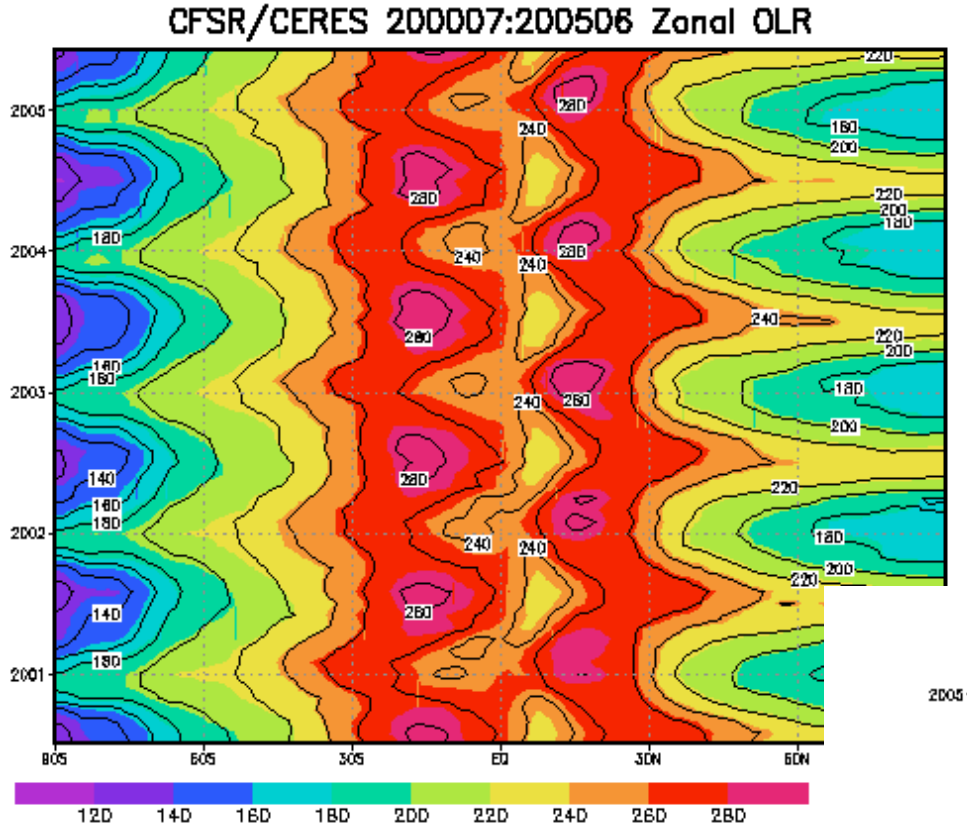
Remarks

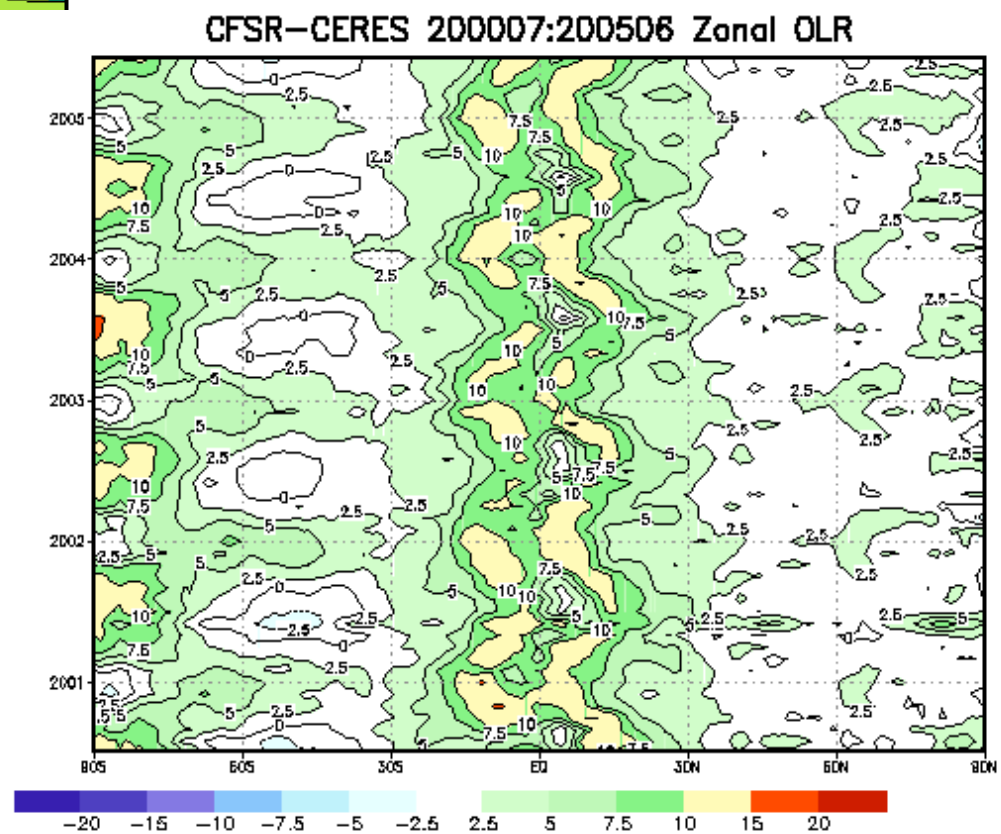
- CFSR 1979~2009 Data Available.
- Very good SW improvements from R-1/R-2, both TOA and SFC, in larger scales
- LW slight less accurate than R-1. Fewer Clouds in general for stronger CS OLR. difference in W. Tropical Pacific; Over Stratus off W. Coasts. Very good in anomalies
- Stratospheric Aerosol input file mis-match for Mt. Pinatubo Stratospheric ERB computation.
- Surface LW/, 60 deg ice-snow model affect ERB, Brighter SFC Albedo

Back Up Slides

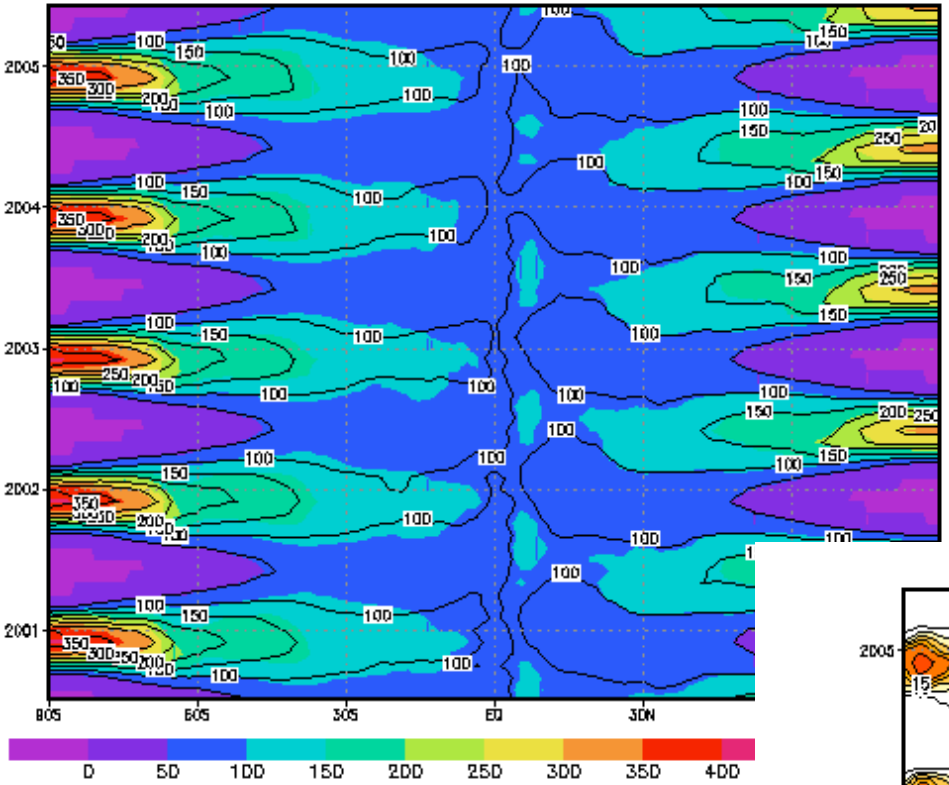

CFSR/CERES 200007:200506 Zonal CS OLR
2005
2004
2003
2002
2001
90S
60S
30S
EQ
30N
60N
90N
120
140
160
180
200
220
240
260
280
300


CFSR−CERES 200007:200506 Zonal CS OLR
2003
2002
2001
90S
60S
30S
EQ
30N
60N
90N
−20
−15
−10
−7.5
−5
−2.5
2.5
5
7.5
10
15
20

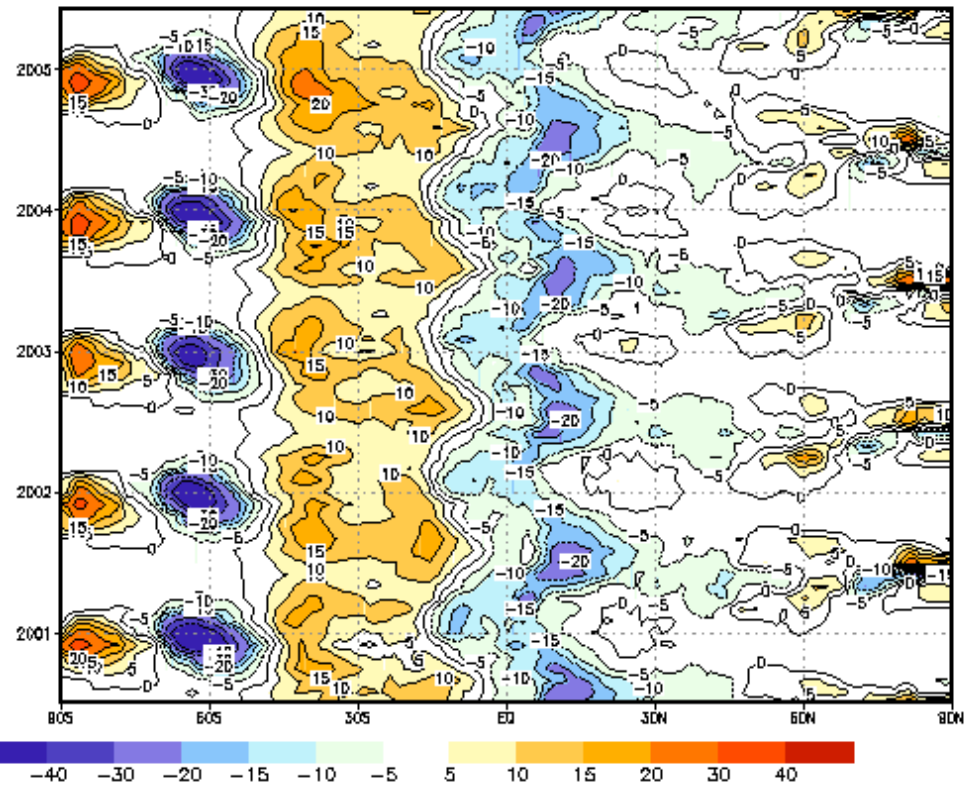

CFSR/CERES 200007:200506 Zonal OLR
2005
2004
2003
2002
2001
80S
60S
30S
EQ
30N
60N
120
140
160
180
200
220
240
260
280


CFSR−CERES 200007:200506 Zonal OLR
2005
2004
2003
2002
2001
80S
60S
30S
EQ
30N
60N
90N
−20
−15
−10
−7.5
−5
−2.5
2.5
5
7.5
10
15
20

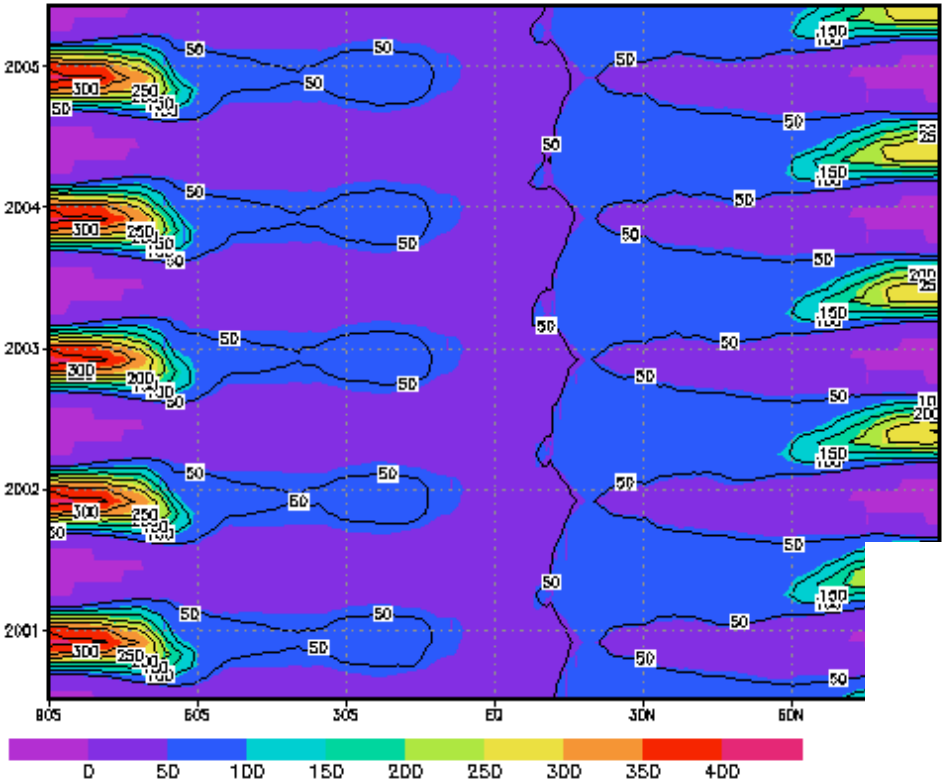
CFSR/CERES 200007:200506 Zonal TOA SWU



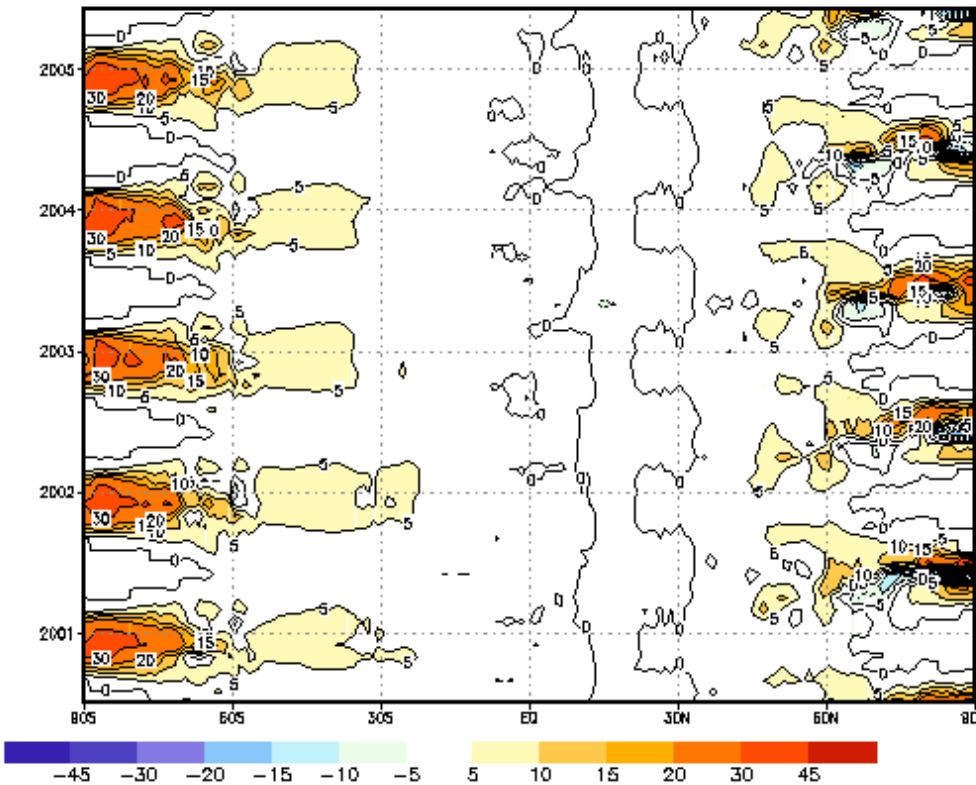
CFSR−CERES 200007:200506 Zonal TOA SWU

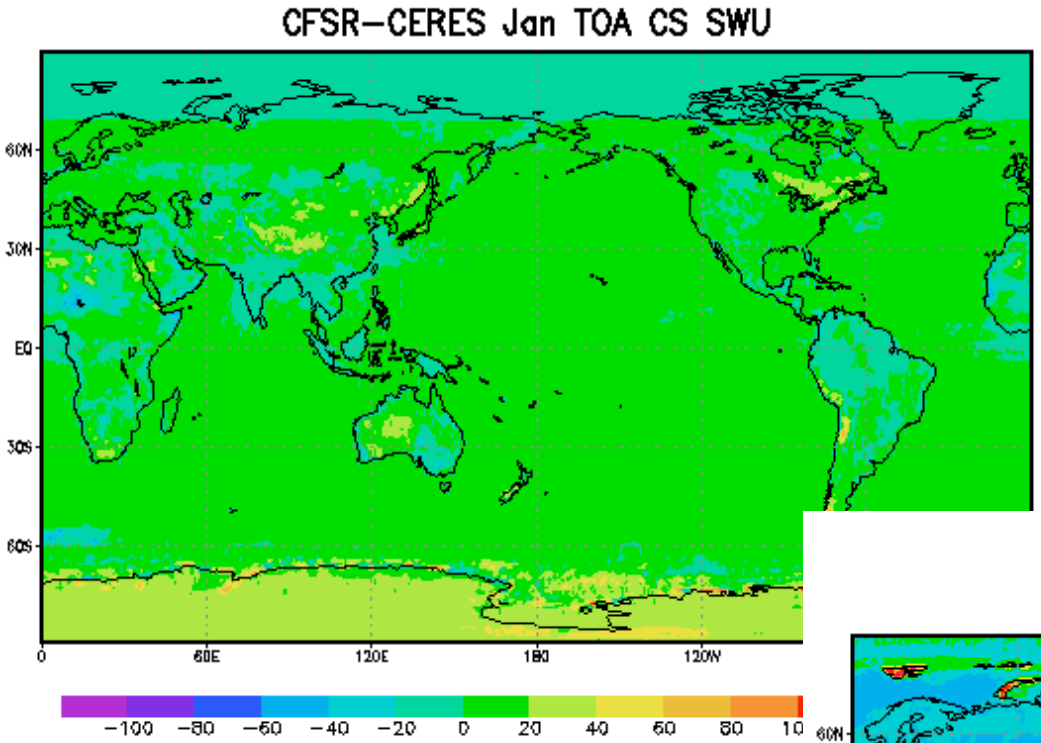


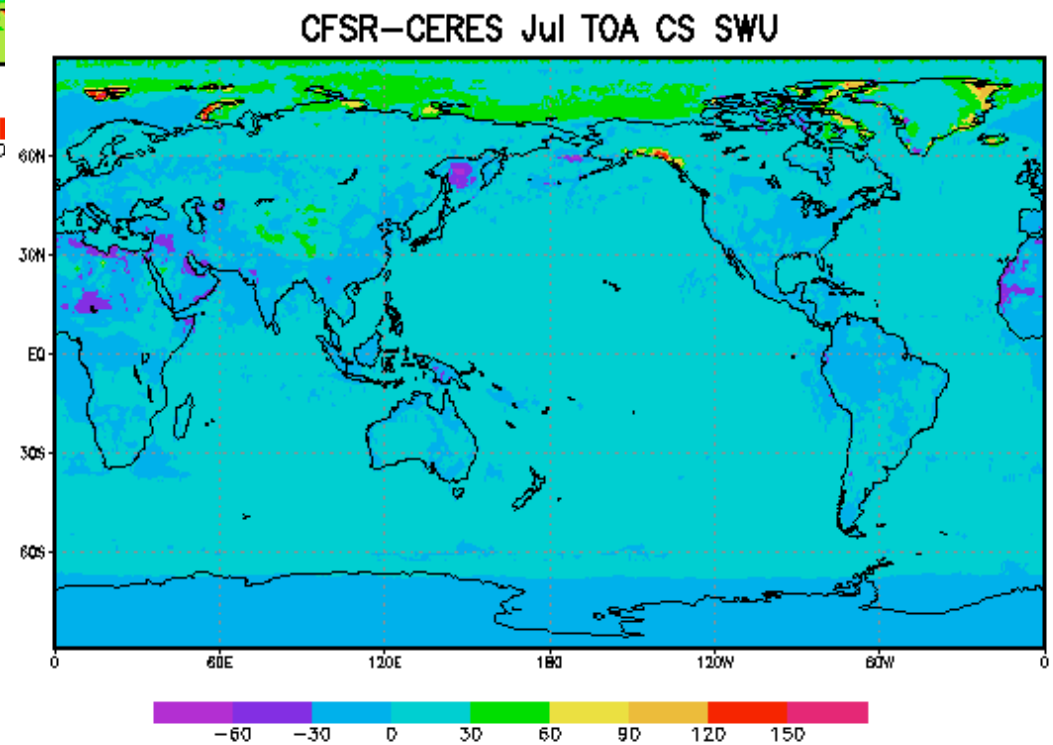
CFSR/CERES 200007:200506 Zonal TOA CS SWU

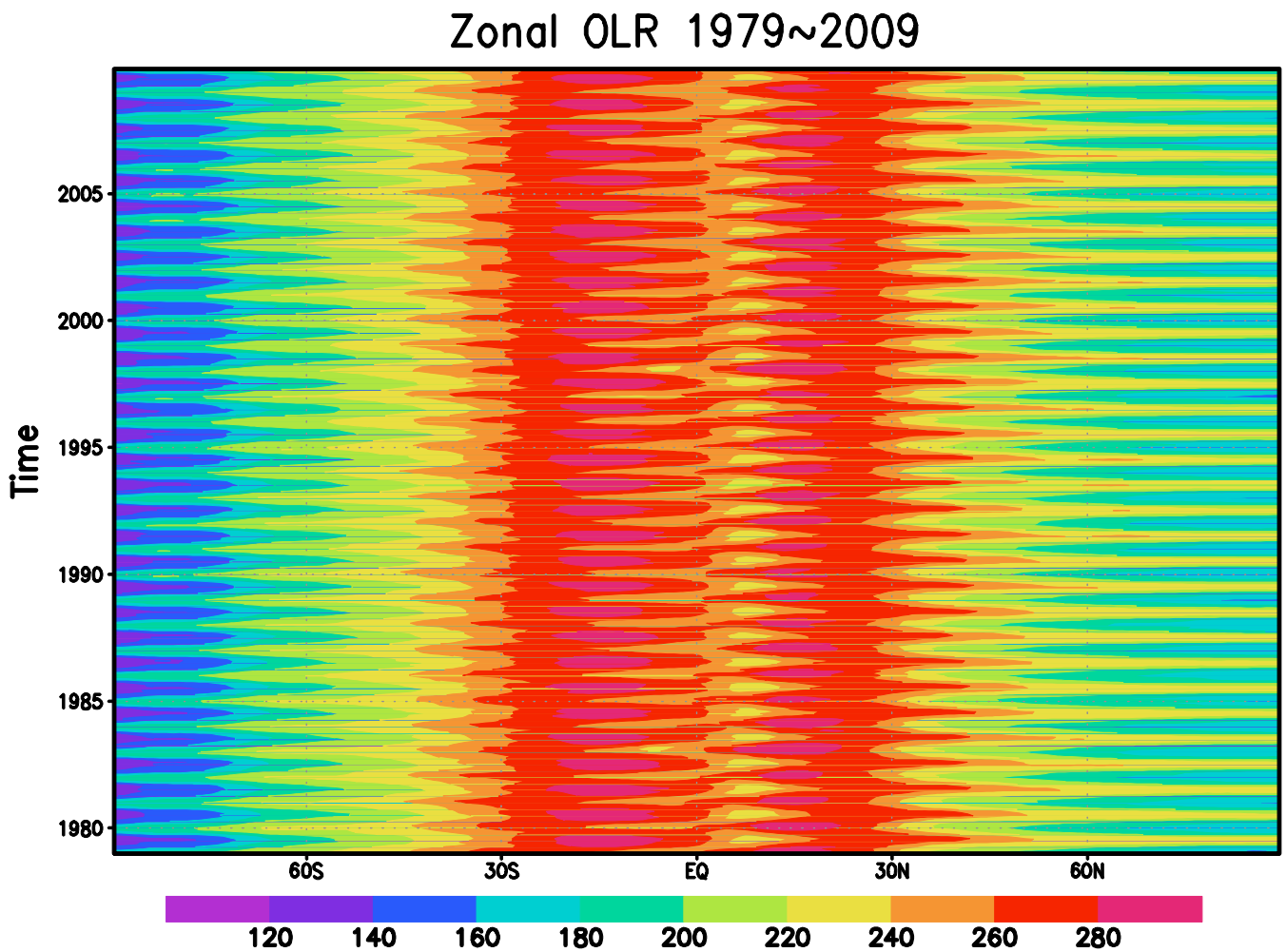


CFSR−CERES 200007:200506 Zonal TOA CS SWU




CFSR-CERES Jan TOA CS SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
-100
-80
-60
-40
-20
0
20
40
60
80
10

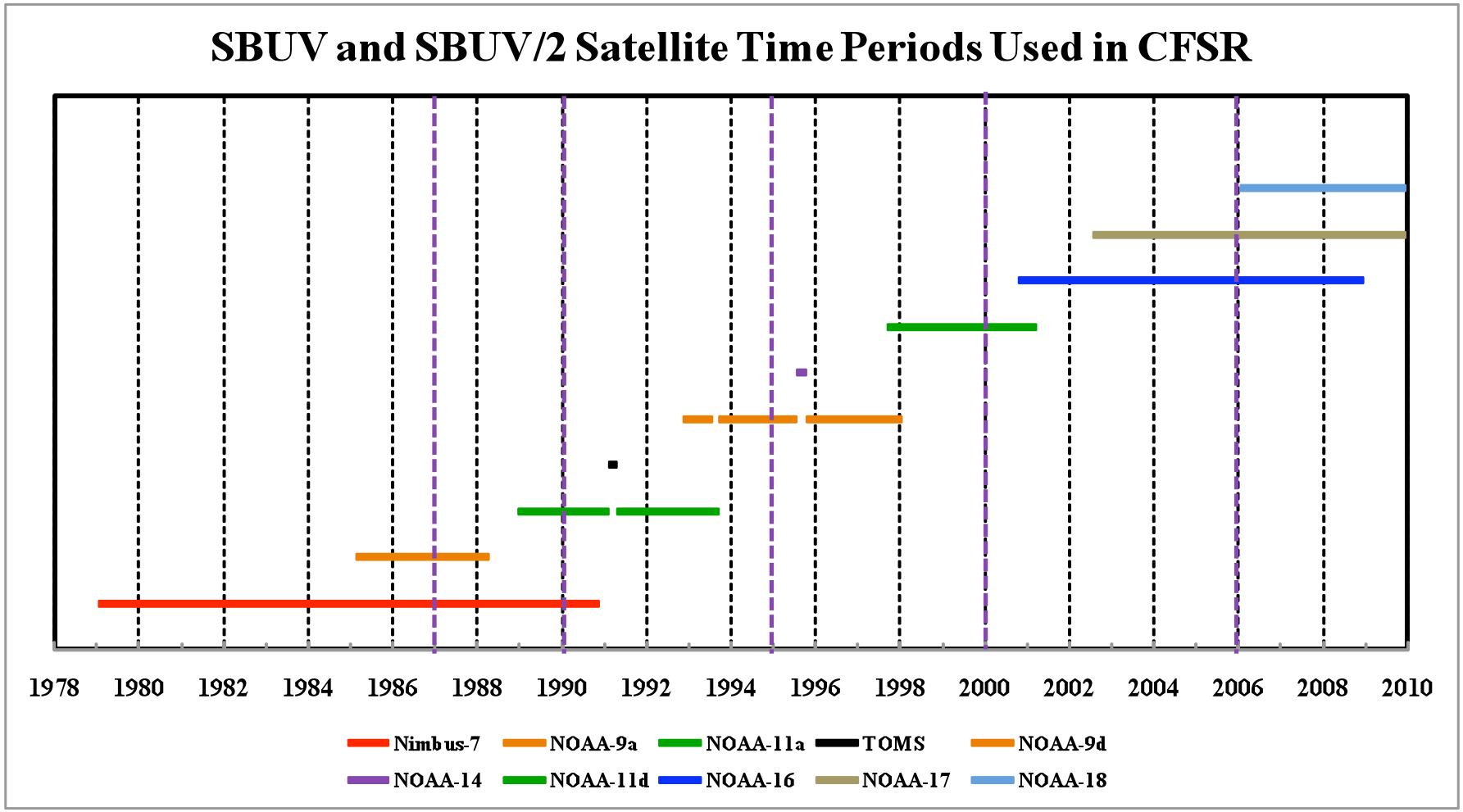

CFSR-CERES Jul TOA CS SWU
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
-60
-30
0
30
60
90
120
150

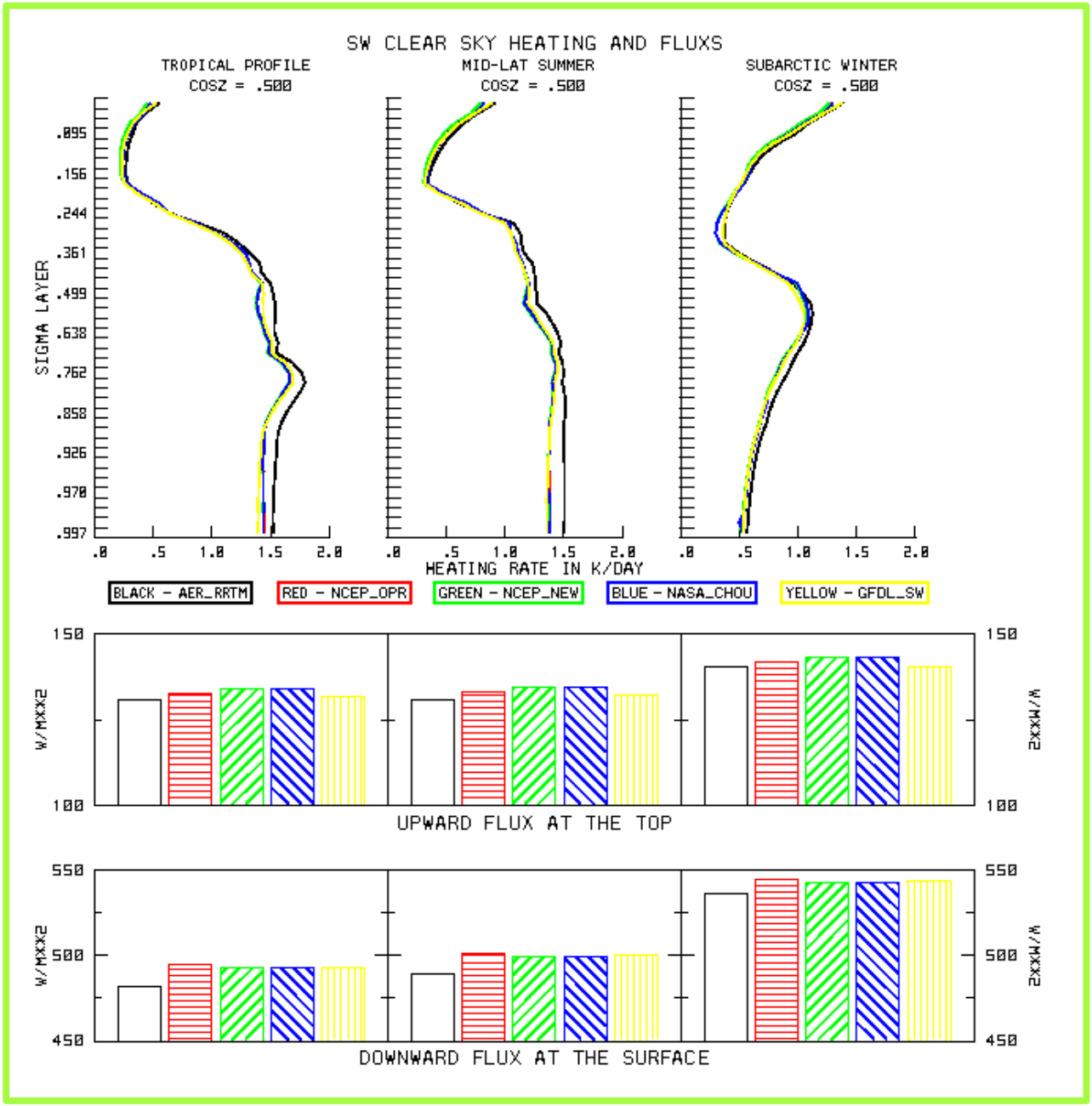


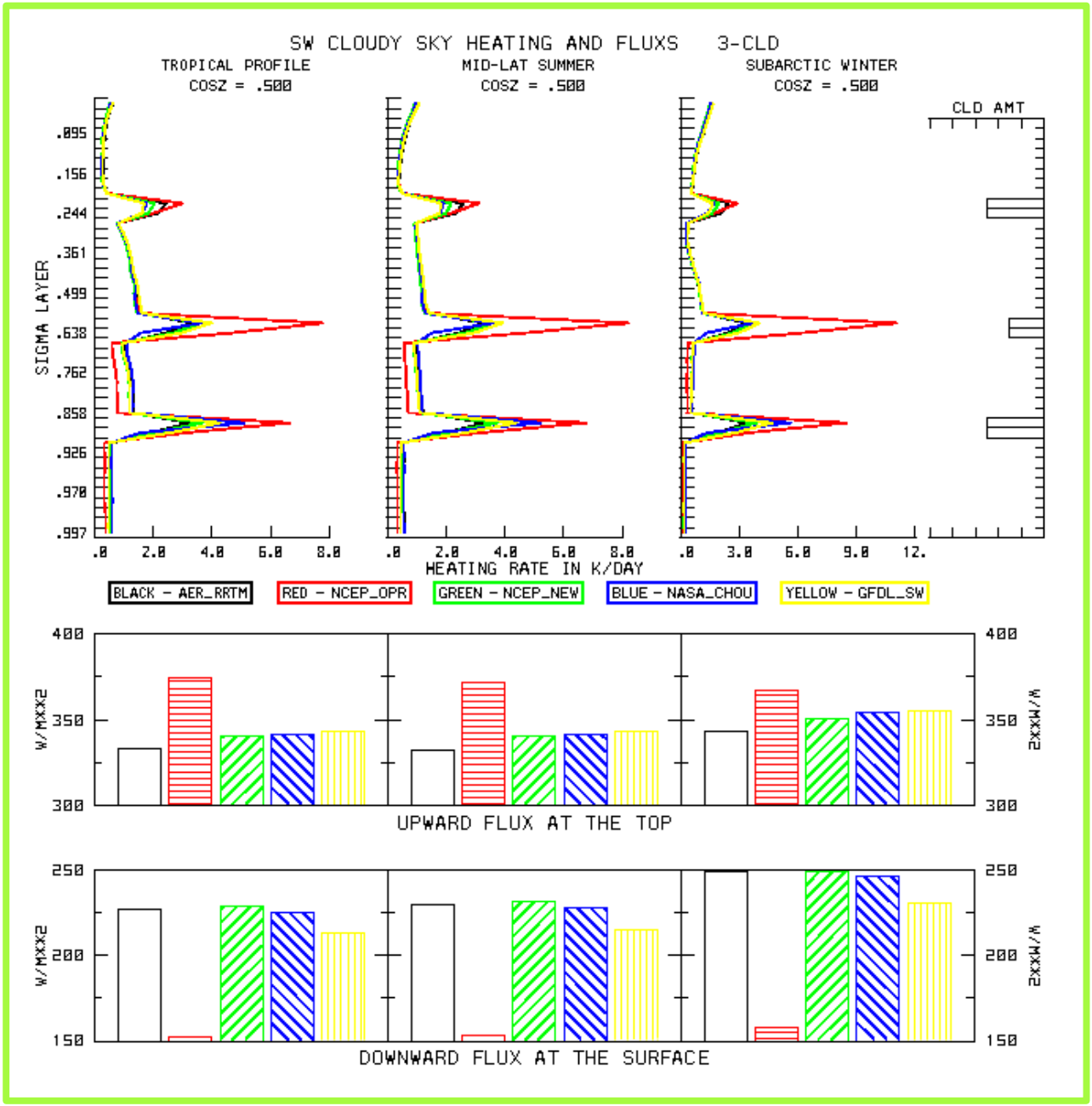
This time series of the outgoing longwave radiation from the NCEP/Climate Forecast System Reanalysis project manifests the complexity of the earth system. The regular seasonality is overlaps the ENSO and subtle inter-decadal variations with occasional large inter-seasonal variations.

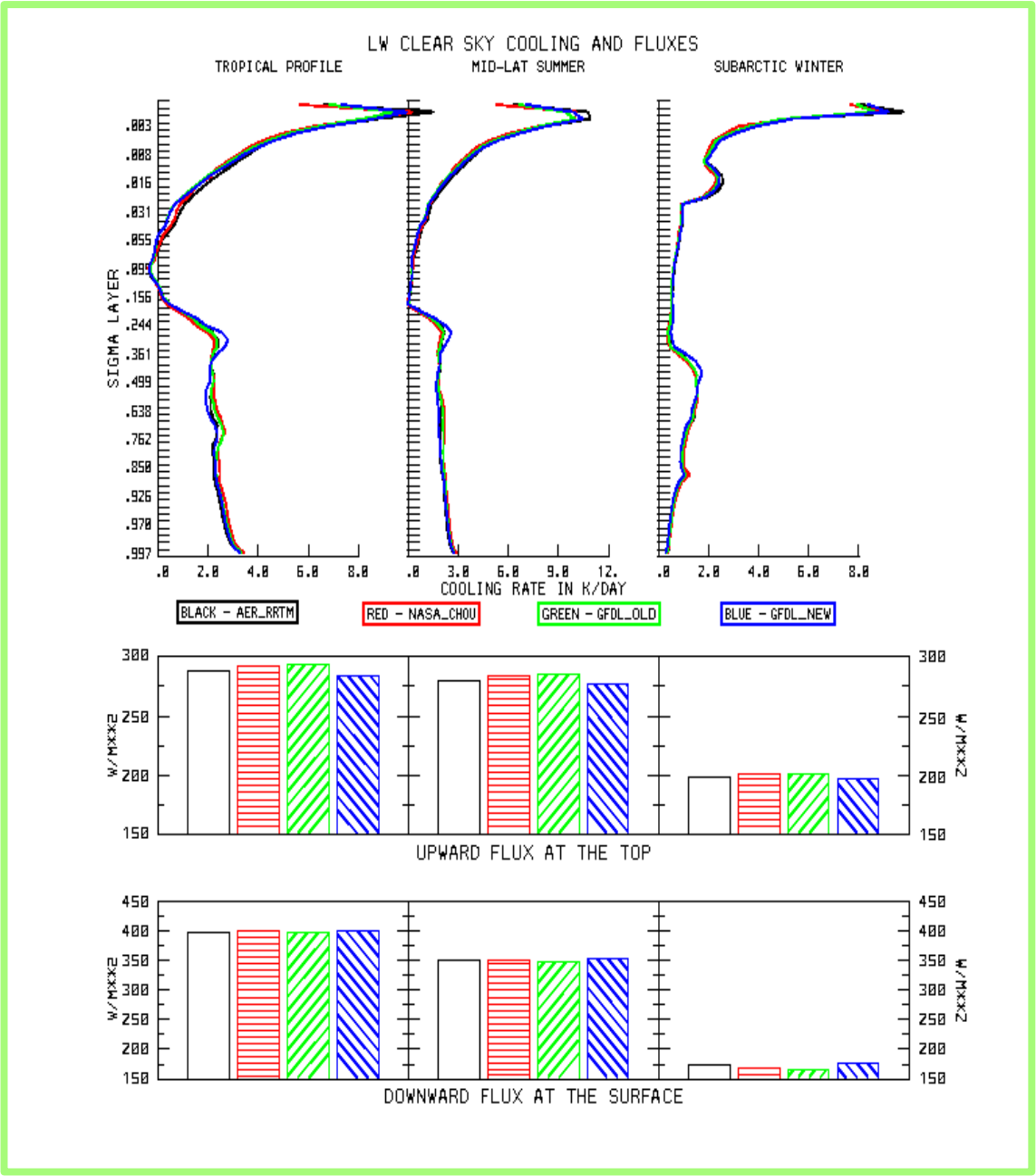
This product also reflects the cross-cutting collaborations among the experts of surface observations, satellite, modeling, assimilation , and climate analysts from STAR. CPC. EMC and JCSDA.

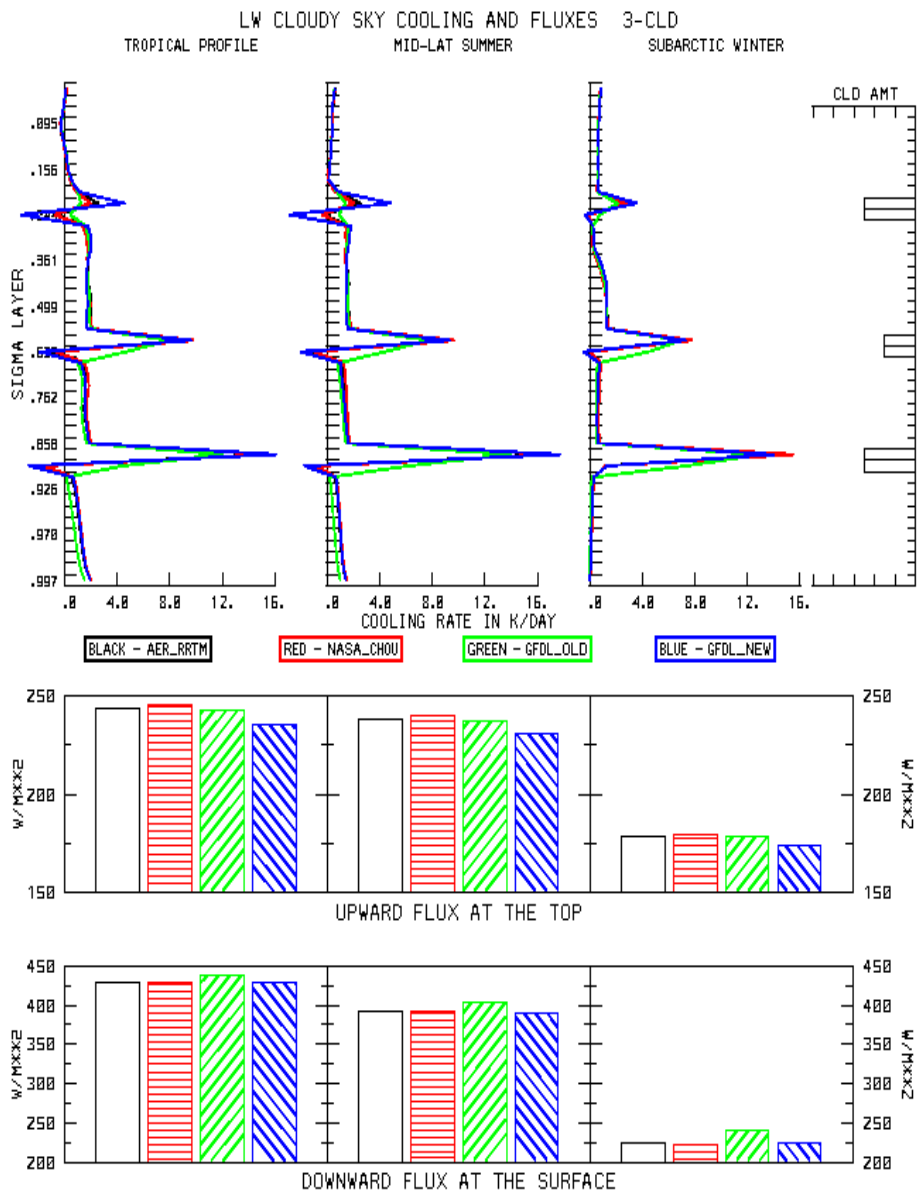
The product is highly valuable for assessing tropical hazard, intra –seasonal variability, El Nino evolutions, as well as model and retrieval system biases that are essential for NOAA Missions.

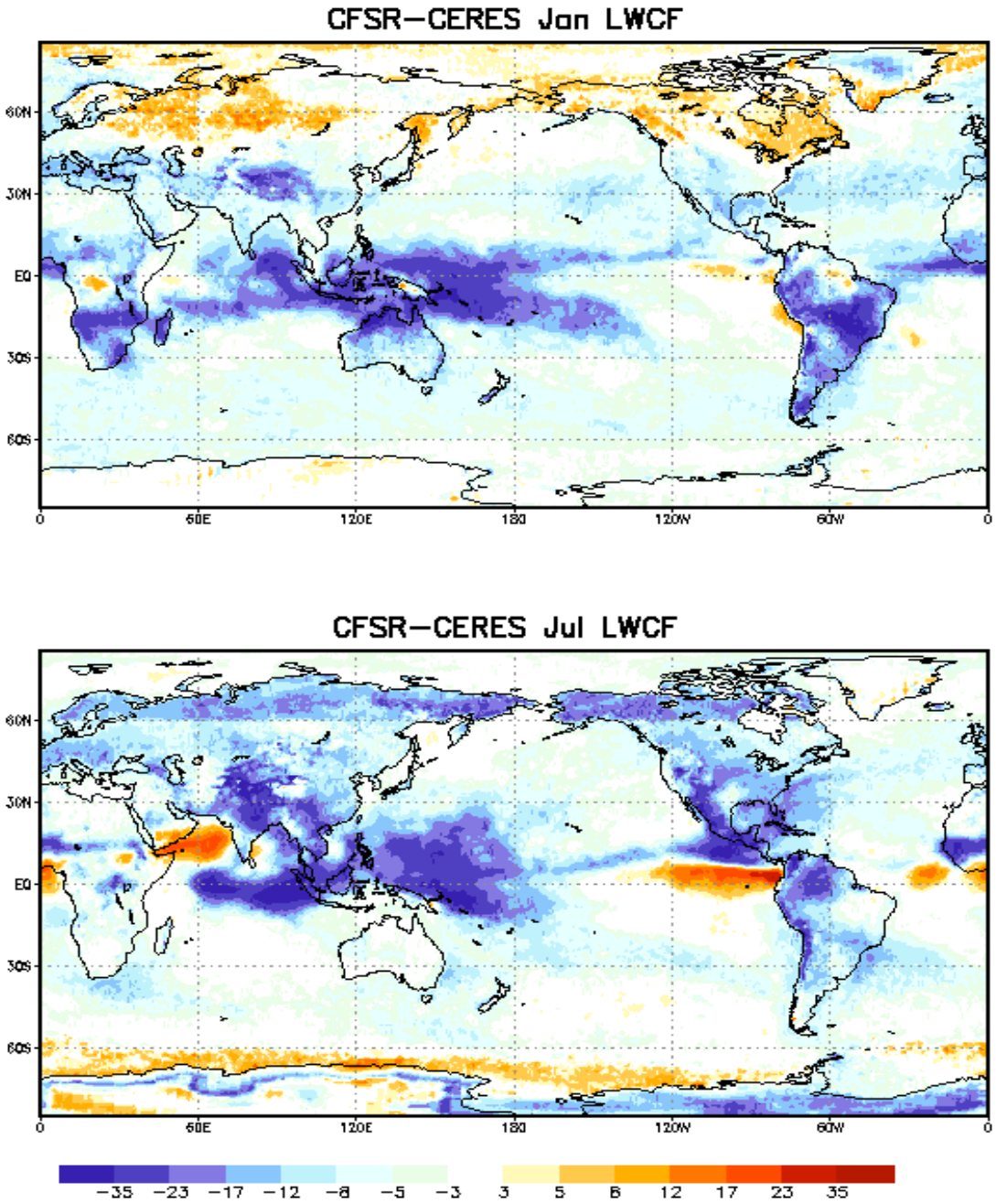

SBUV and SBUV/2 Satellite Time Periods Used in CFSR
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Nimbus-7
NOAA-9a
NOAA-11a
TOMS
NOAA-9d
NOAA-14
NOAA-11d
NOAA-16
NOAA-17
NOAA-18

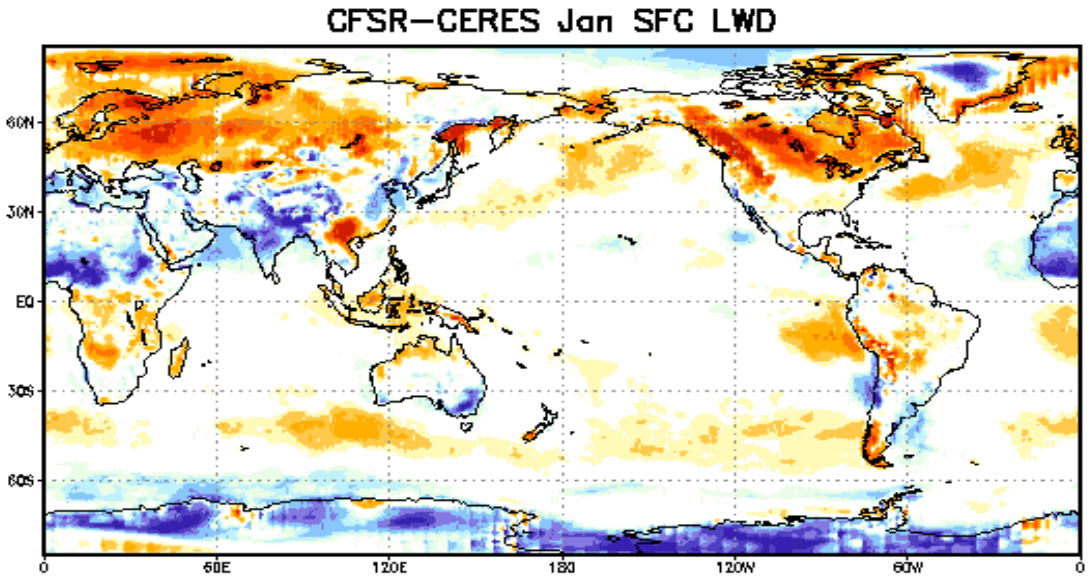

SW CLEAR SKY HEATING AND FLUXS
TROPICAL PROFILE
COSZ = .500
MID-LAT SUMMER
COSZ = .500
SUBARCTIC WINTER
COSZ = .500
SIGMA LAYER
.095
.156
.244
.361
.499
.638
.762
.858
.926
.970
.997
.0
.5
1.0
1.5
2.0
HEATING RATE IN K/DAY
BLACK - AER_RRTM
RED - NCEP_OPR
GREEN - NCEP_NEW
BLUE - NASA_CHOU
YELLOW - GFDL_SW
150
100
W/MXX2
UPWARD FLUX AT THE TOP
550
500
450
DOWNWARD FLUX AT THE SURFACE

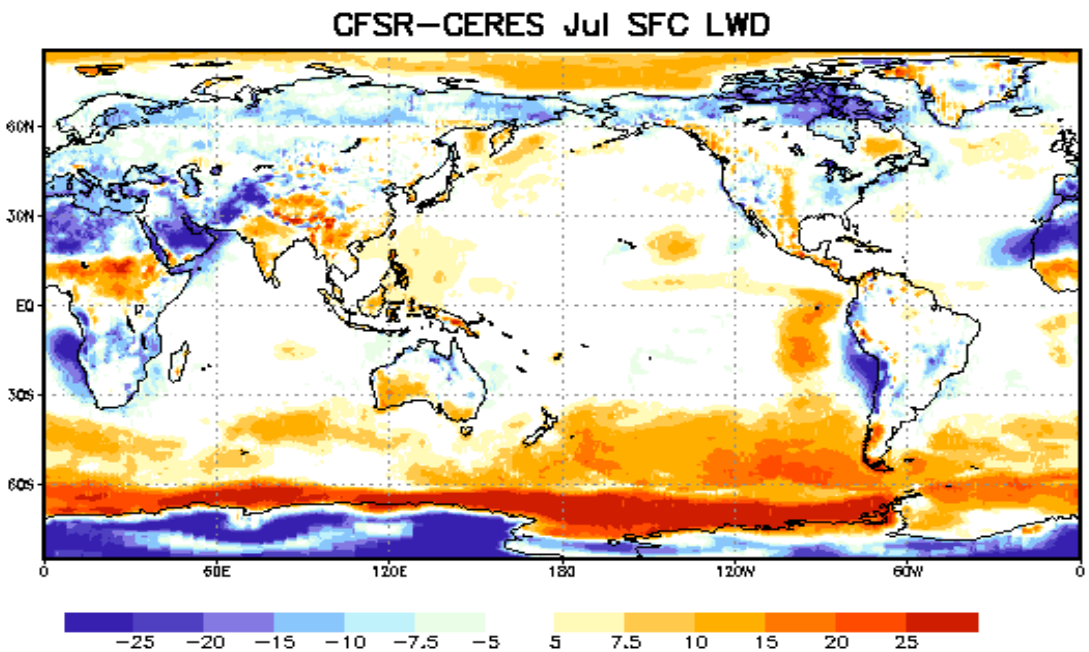

SW CLOUDY SKY HEATING AND FLUXS 3-CLD
TROPICAL PROFILE
COSZ = .500
MID-LAT SUMMER
COSZ = .500
SUBARCTIC WINTER
COSZ = .500
CLD AMT
SIGMA LAYER
.095
.156
.244
.361
.499
.638
.762
.858
.926
.970
.997
.0
2.0
4.0
6.0
8.0
3.0
9.0
12.
HEATING RATE IN K/DAY
BLACK - AER_RRTM
RED - NCEP_OPR
GREEN - NCEP_NEW
BLUE - NASA_CHOU
YELLOW - GFDL_SW
W/MXX2
400
350
300
UPWARD FLUX AT THE TOP
250
200
150
DOWNWARD FLUX AT THE SURFACE


LW CLEAR SKY COOLING AND FLUXES
TROPICAL PROFILE
MID-LAT SUMMER
SUBARCTIC WINTER
SIGMA LAYER
.003
.008
.016
.031
.055
.099
.156
.244
.361
.499
.638
.762
.850
.926
.970
.997
.0
2.0
4.0
6.0
8.0
3.0
9.0
12.
COOLING RATE IN K/DAY
BLACK - AER_RRTM
RED - NASA_CHOU
GREEN - GFDL_OLD
BLUE - GFDL_NEW
W/MXX2
300
250
200
150
UPWARD FLUX AT THE TOP
450
400
350
DOWNWARD FLUX AT THE SURFACE


LW CLOUDY SKY COOLING AND FLUXES 3-CLD
TROPICAL PROFILE
MID-LAT SUMMER
SUBARCTIC WINTER
CLD AMT
SIGMA LAYER
.895
.156
.361
.499
.762
.858
.926
.970
.997
.0
4.0
8.0
12.
16.
COOLING RATE IN K/DAY
BLACK - AER_RRTM
RED - NASA_CHOU
GREEN - GFDL_OLD
BLUE - GFDL_NEW
250
200
150
W/MXX2
UPWARD FLUX AT THE TOP
450
400
350
300
250
200
DOWNWARD FLUX AT THE SURFACE


CFSR−CERES Jan LWCF
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
CFSR−CERES Jul LWCF
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−35 −23 −17 −12 −8 −5 −3 3 5 8 12 17 23 35


CFSR−CERES Jan SFC LWD
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0


CFSR−CERES Jul SFC LWD
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−25
−20
−15
−10
−7.5
−5
5
7.5
10
15
20
25

- **Sato et al. 1993**
- Sato, Mki., J.E. Hansen, M.P. McCormick, and J.B. Pollack, 1993: Stratospheric aerosol optical depths, 1850-1990. *J. Geophys. Res.*, **98**, 22987-22994, doi:10.1029/93JD02553.
- A global stratospheric aerosol database employed for climate simulations is described. For the period 1883-1990, aerosol optical depths are estimated from optical extinction data, whose quality increases with time over that period. For the period 1850-1882, aerosol optical depths are more crudely estimated from volcanological evidence for the volume of ejecta from major known volcanoes. The data set is available over Internet.