SYNI & AVG Product

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Marriott Hotel in City Center at Oyster Point
Newport News VA
April 24rd – 26th 2007

SYNI / SYN / AVG
What Are They?

*SYN***I** *:* 1 Hourly 1x1deg radiative transfer (INTERNAL)

SYN *:* 3 Hourly Averaged from SYNI global product.

AVG *:* Monthly Averaged from SYN global product.

SYNI

- SYNI Radiative transfer (Fu-Liou Code)
  - Hourly UTC (00Z day1 thru 23z day 31)
  - CERES Equal Area grid (~1deg) n=44012
- TSI Cloud Inputs: MODIS(12hr),+GEO(3hr) + Interpolated
  - (P_{top} , P_{base} , $\tau_{log\ avg}$, $\tau_{linear\ avg}$, Phase , R_e or D_e)
- Tuned to "Observed" Shortwave & Longwave TOA Fluxes
  - CERES & GEO(CERES normalized)
  - Observed Clear–sky SW used for land&snow surface albedo retrieval
- MOA GEOS_4.0.3 Atmosphere / SMOBA Ozone
- Modis & Match Aerosols
- Grid Average Surface properties

Fu-Liou Code

- Gamma weighted 2-Stream (SW) , 2/4 Stream (LW) pristine multi-stream correction to COART
  - Treats sub-computational scale Inhomogeneous clouds (S.Kato)
- Correlated k : 32 Bands : 15 SW , 14 LW , 3 of 14 LW in WN
  - Enhanced output of PAR and UVA,UVB (W.Su)
- Shortwave: (0.17 - 4.0 or *inf*)μ [0 or 2500-57000 cm-1]
  - HITRAN 2000 (H_20) w/(O_2,CO_2,CH_4)@Fixed concentration
  - JPL(1994) O_3 uv , WMO(1985) O_3 vis
- Longwave (0-2850cm-1) (3.5μ – Infinity)
  - H_20 ,CO_2 ,O_3 ,N_20 ,CH_4 ,CFCs, H20 continuum)
- Optical Properties: spectral (β, ω , g)
  - Water Cloud (Y.Hu)
  - Ice Cloud (Q.Fu 1996 , D_{ge})
  - Aerosol Optical Properties
    - OPAC, Tegin&Lacis, d'Almedia
- Major Revisions
  - 10 visible SW bands reworked for O_3 and rayleigh in 1995
  - Near-Ir 0.7-1.3μ subdivided into 4 bands in 2005
- Online Version http://www-cave.larc.nasa.gov/cave

SYNI Surface Optics

- **Scene Id**:
  - IGBP
  - Daily Snow Ice maps (NSIDC microwave)
  - Threshold of Cloud WG Daily 0.63μ & 1.6μ overhead sun albedo
- **Broadband Surface Albedo:**
  - COART ocean *apriori* surface albedo via look up table
    - (τ , solar zenith angle, wind speed, chlorophyll)
  - Clear (land+snow scenes)
    - *'CERES'* SW TOA with LaRC Fu-Liou atmosphere correction LUT
      - Clear sky CERES monthly mean diurnally modeled input (NOT Geo)
  - Cloudy land+snow(thickcld): monthly minimum clear sky albedo retrieval
    - Diurnal model to diffuse angle
- **Spectral Albedo Shape**
  - COART (Ocean,Snow,Sea Ice)
  - CARE Experiment (grassland), Bowker (all other IGBP types)
- **Emissivity**
  - Cloud WG 12 month seasonal maps (3 window bands)
  - SOFA (IGBP based for other LW bands)

Planed Changes For BETA4

- TSI Future changes..
  - Don't attempt interpolation of MODIS Aerosol during cloudy non-retrieval periods. (so SYNI can revert to MATCH)
  - Always supply clear sky TOA albedo even when overcast.
  - Produce grid-hour integrated sun angle.

- SYNI Changes
  - Use Daily MATCH aerosol assimilation when no MODIS
    - Cloudy sky aerosol retrieval contamination issue
  - Revise Monthly Surface Albedo History maps to include Ocean Sea Ice domain and monthly average snow &/or sea ice fraction field.
    - Don't attempt retrieval of surface albedo for overcast sky grid boxes containing Snow or SeaIce.
    - Instead use Surface Albedo History maps AND **daily** Snow/Ice fraction to modify monthly average surface albedo as perturbation of surface albedo correlated to sea ice fraction.
  - Separate Vis and NIR scene dependent diurnal surface albedo models
  - Fix known bugs ::
    - Insure pristine sky toa correction is output on product
    - Cloudy Sky albedo not at diffuse angle for partly cloudy grid boxes

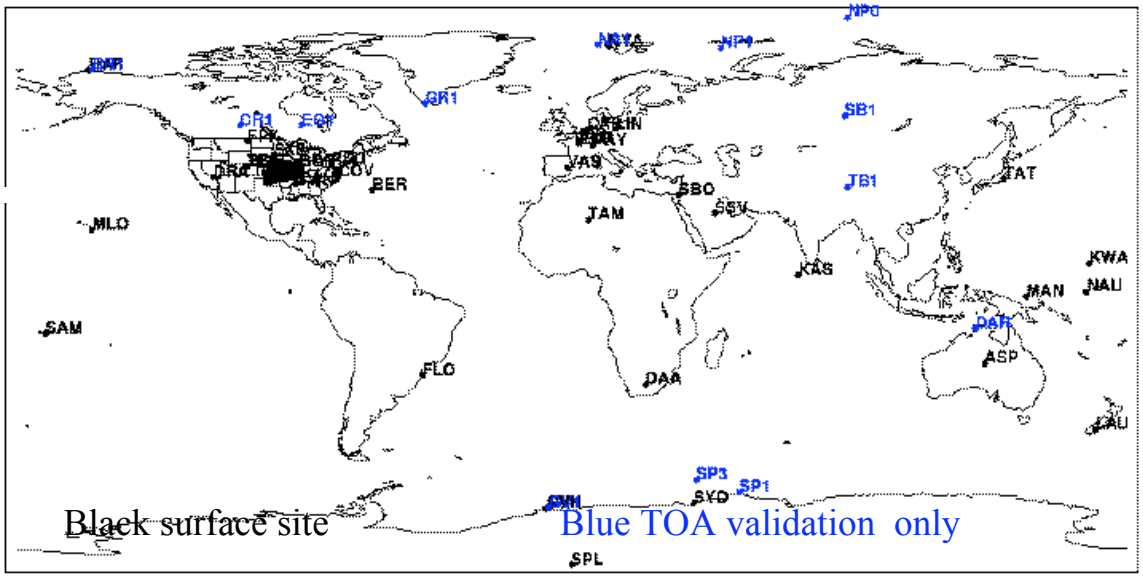
Synoptic Time Series (STS)
90 Site Validation Subset Location Map

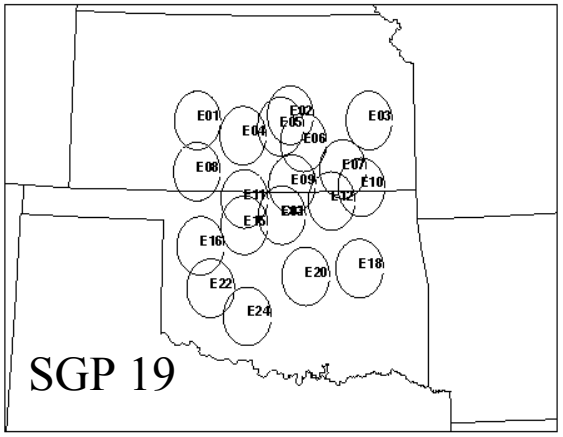
SYNI Beta3 for Year 2002

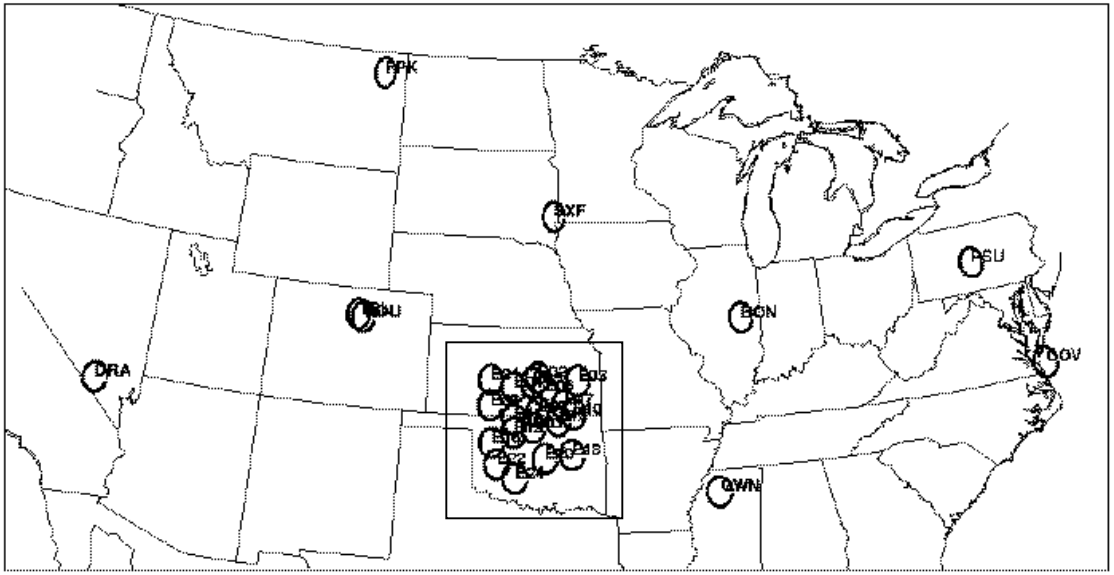
- 90 grid box subset

CERES/CAVE Hourly Avg

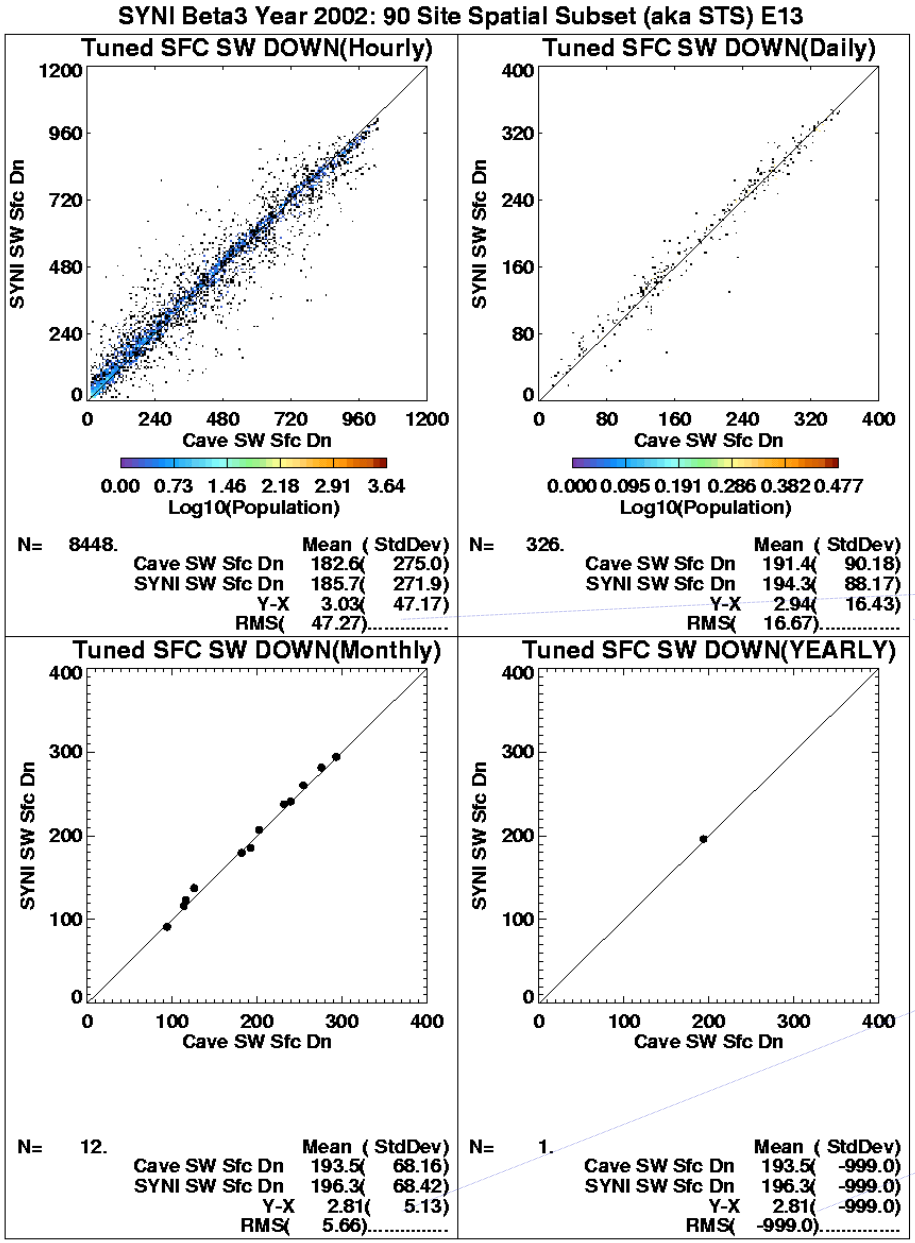
- 44 SW Sfc Down
- 44 LW Sfc Down
- 30 SW Sfc Up
- 32 LW Sfc Up
- 27 All (SW/LW)(Up/Dn)



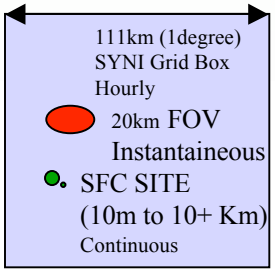


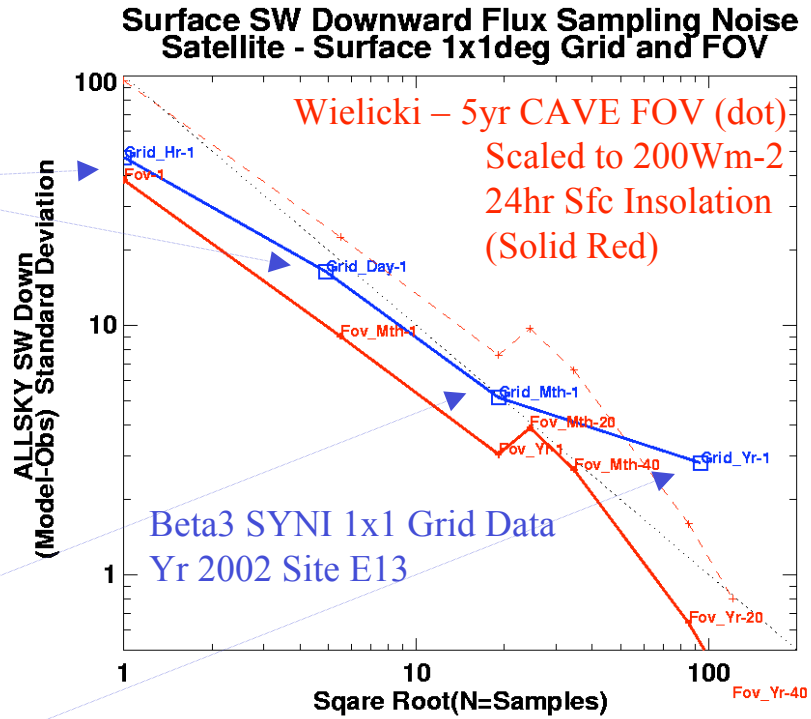


E13 SWDN (Hourly, Daily, Monthly, Yearly)

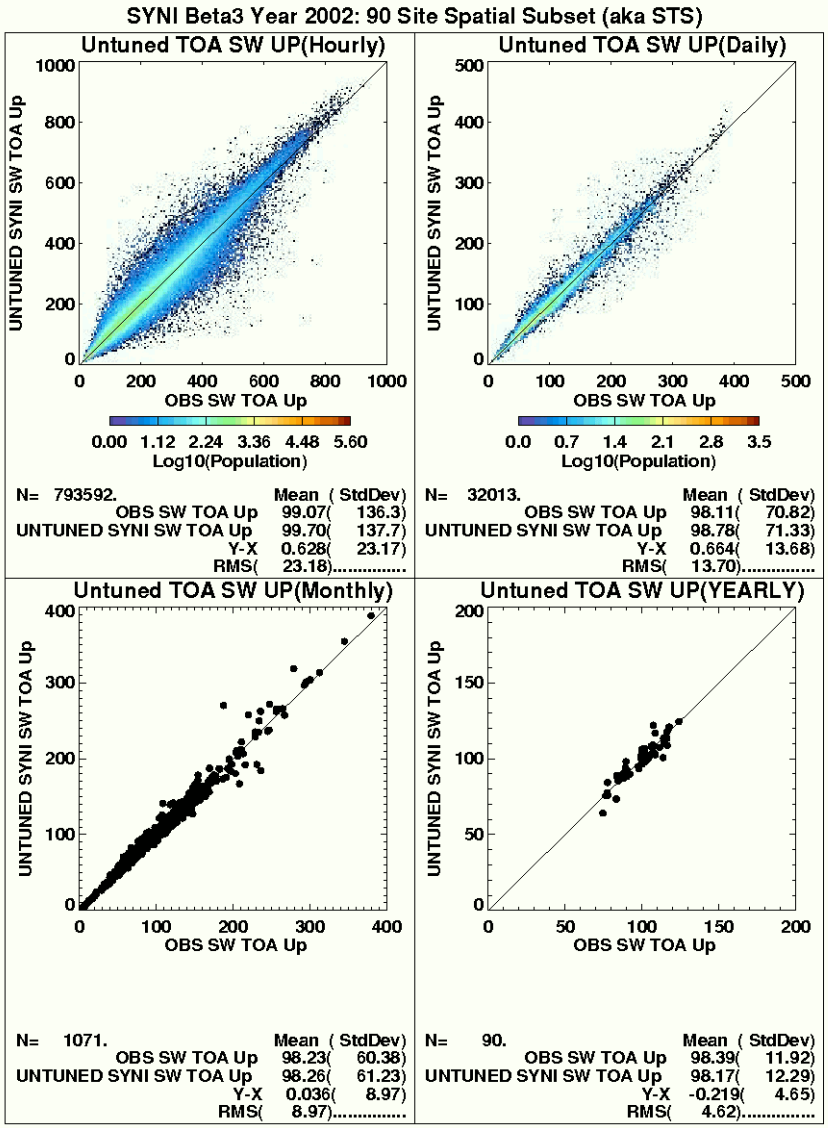


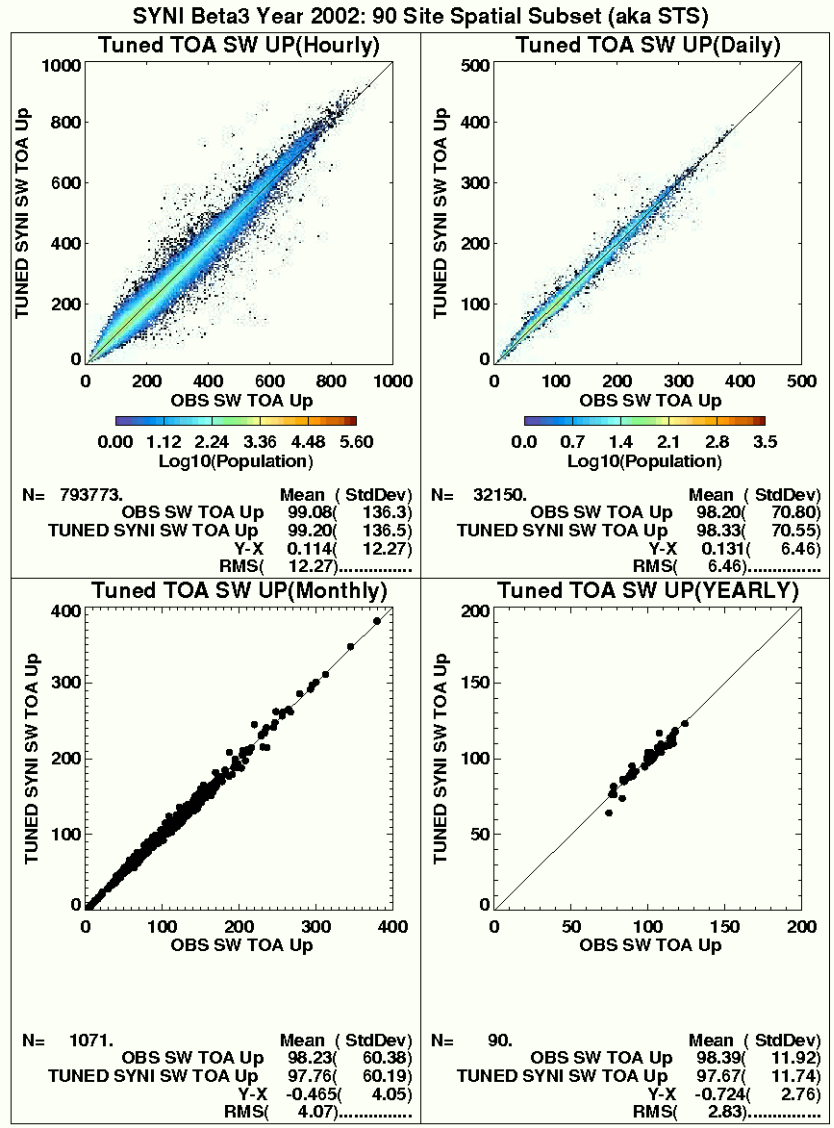
Grid Vs
Fov Vs
Site Scales



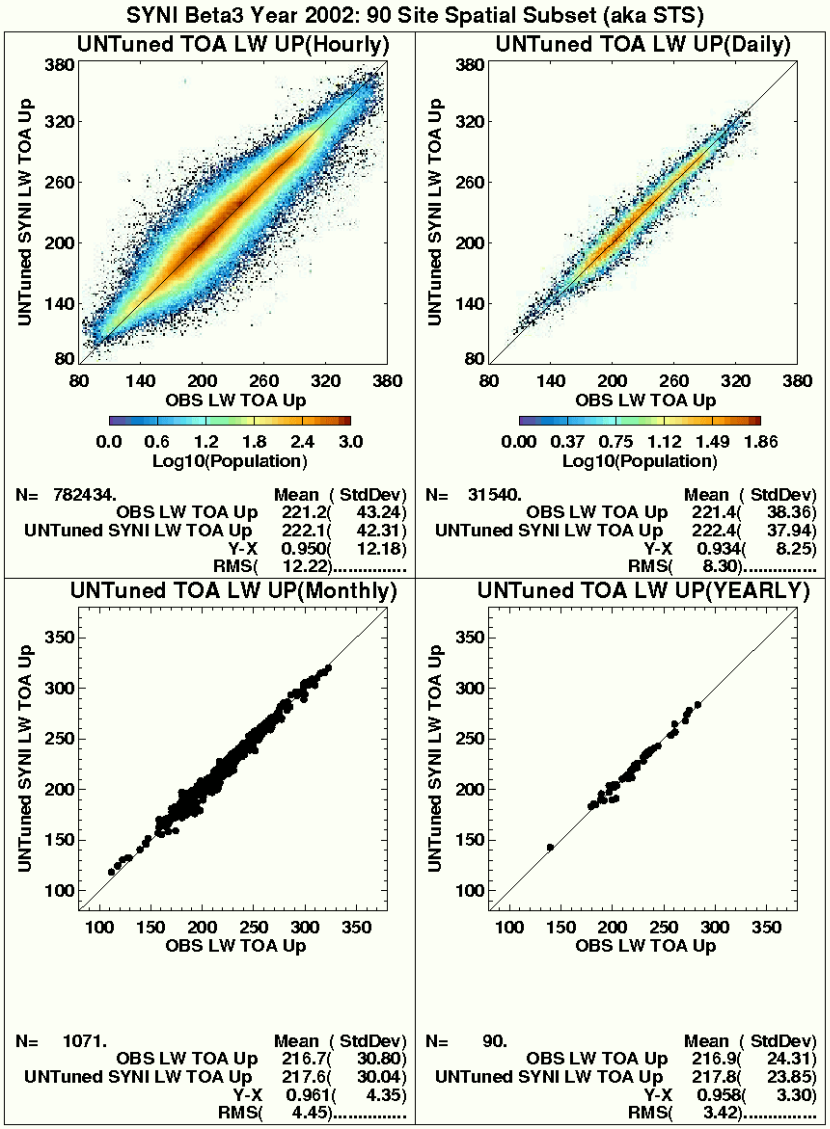


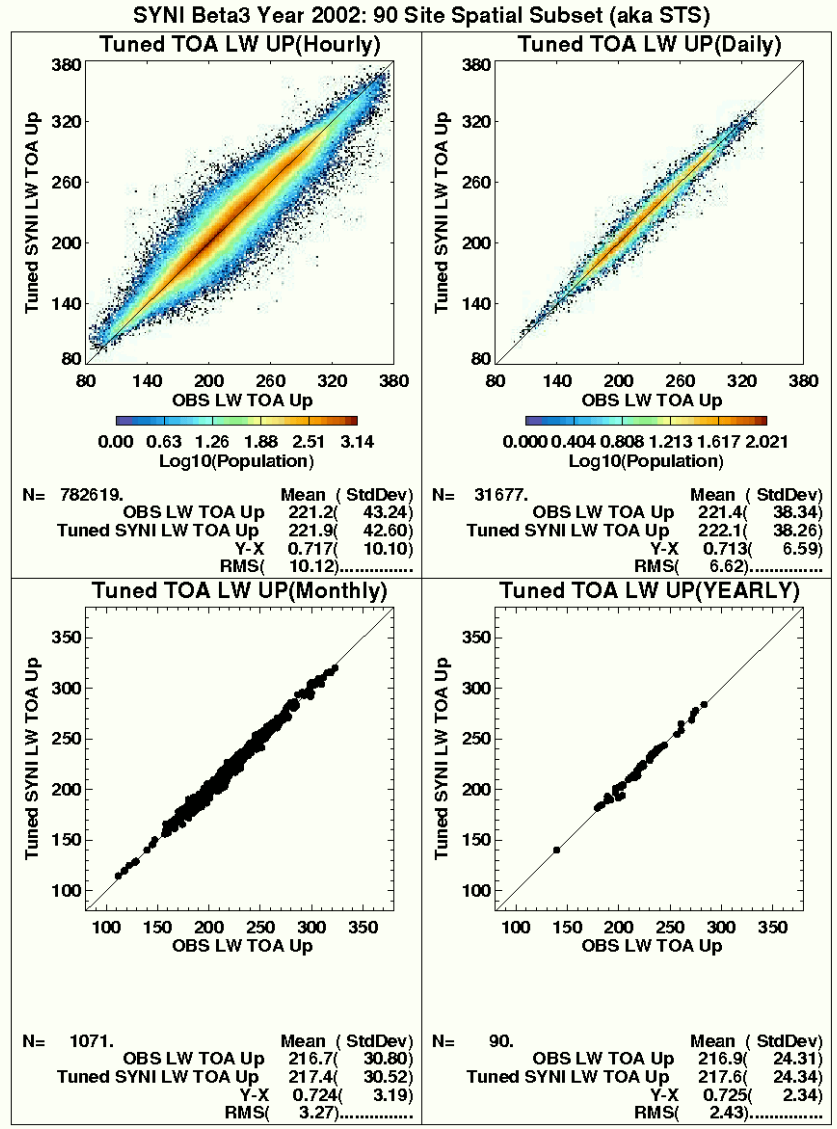
TOA SW Up(Untuned & Tuned)



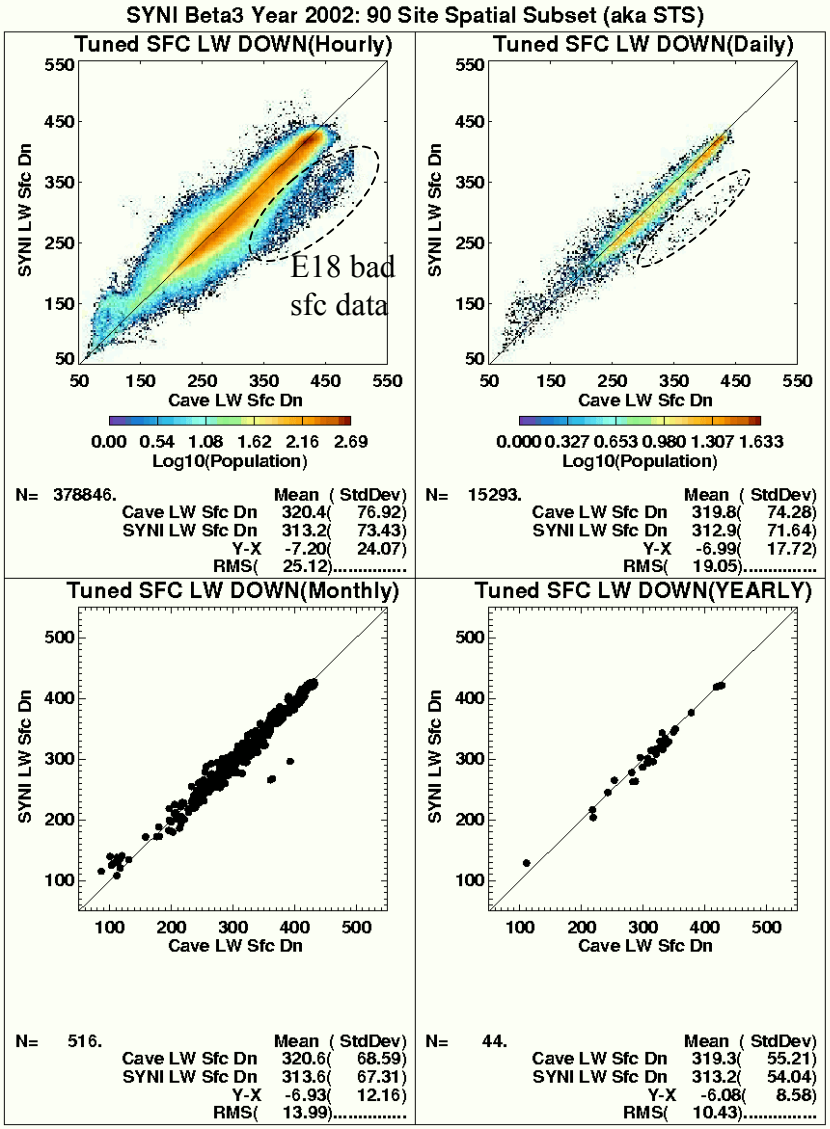


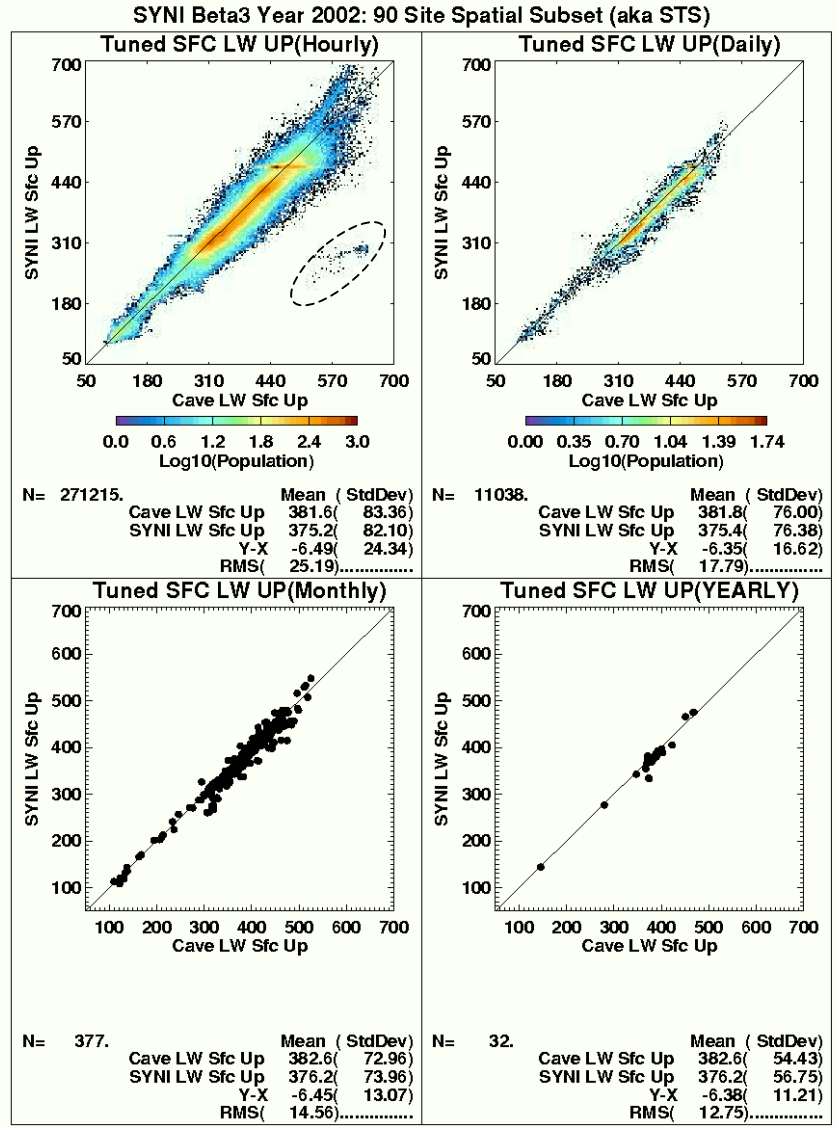
OLR(Untuned & Tuned)



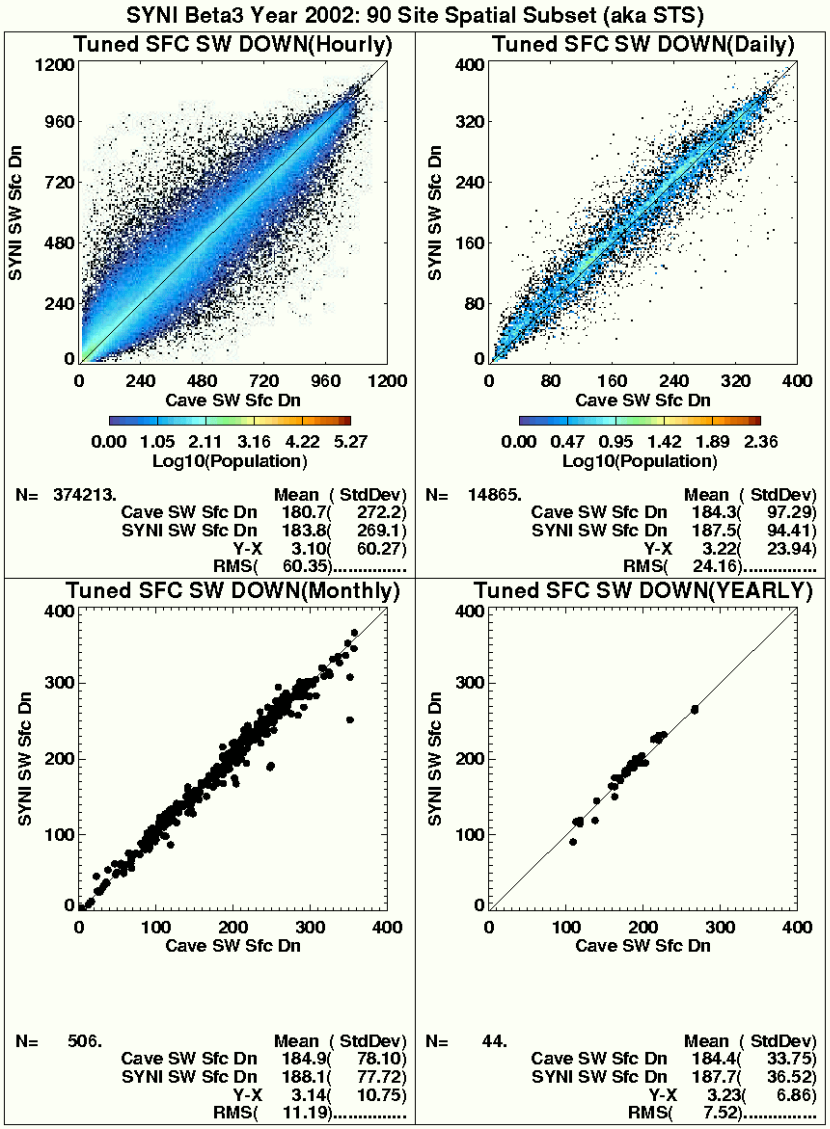


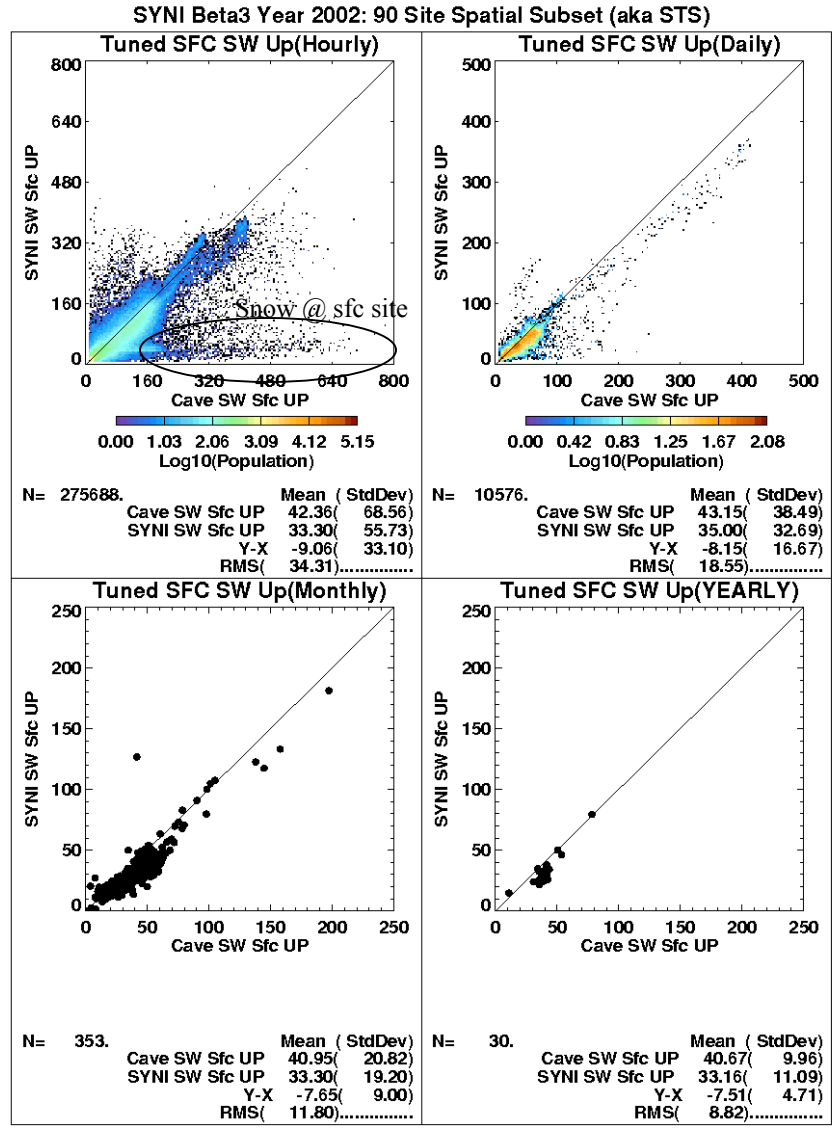
Surface Longwave (Down &Up)





Surface SW (Down & Up)

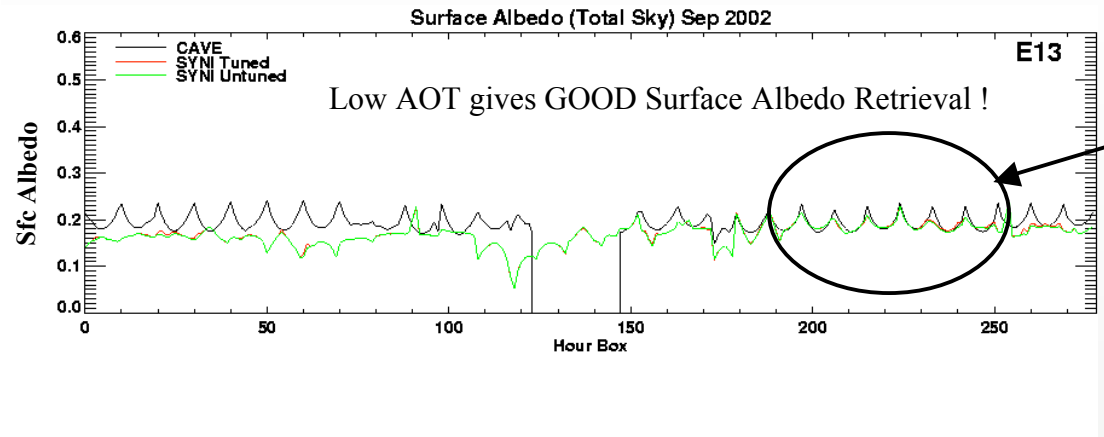


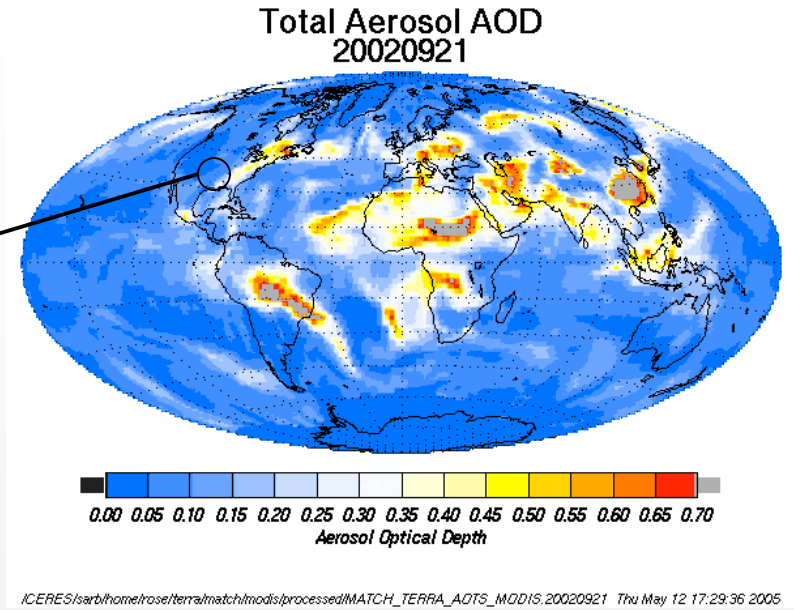


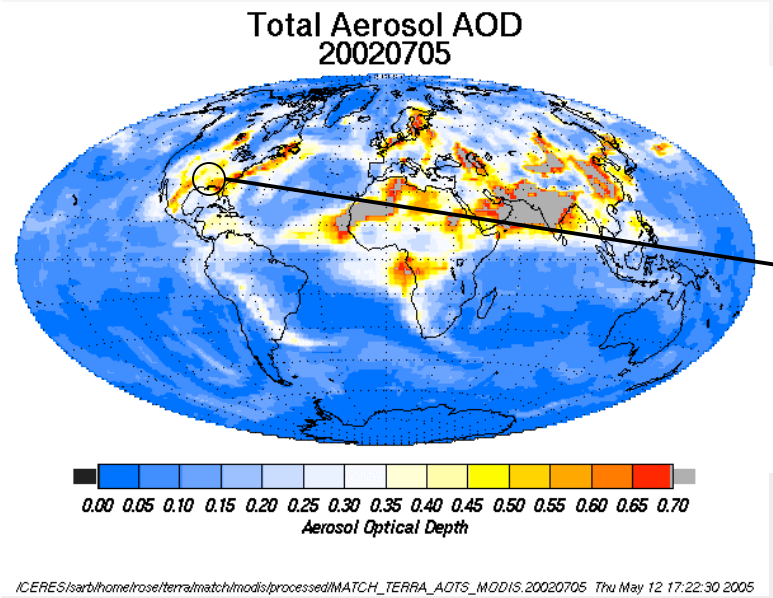
SYN Subset TOA/SurfaceValidation Beta3 Year 2002

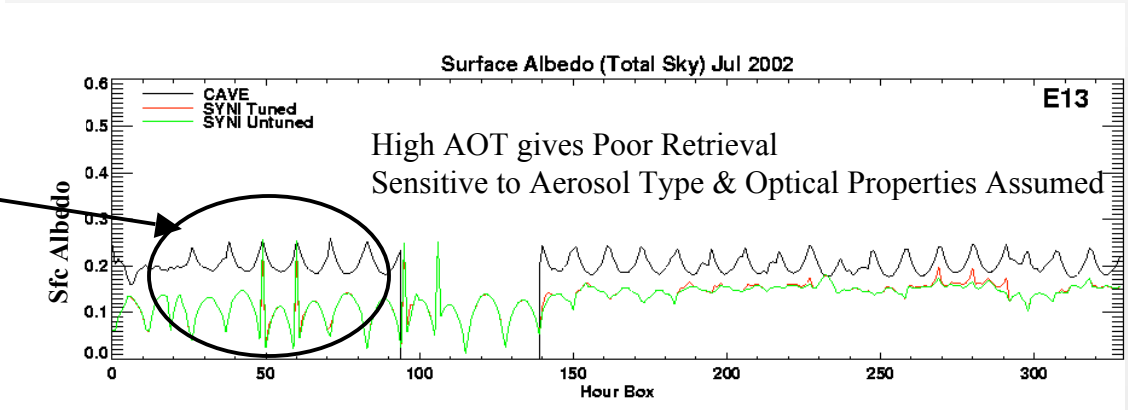
Quantity	Obs	Model	Model-Obs	Hourly Std Dev	Daily Std Dev	Monthly Std Dev	Yearly Std Dev	N Sites
SW TOA UP Untuned	98.4	98.2	-0.2/ ***-0.2%***	23.	14	9.0	4.7	90
SW TOA UP Tuned		97.7	-0.7/ ***-0.7%***	12.	6.5	4.1	2.8	90
LW TOA UP Untuned	216.9	217.8	0.9/ ***0.4%***	12.	8.3	4.4	3.3	90
LW TOA UP Tuned		217.6	0.7/ ***0.3%***	10.	6.6	3.2	2.3	90
LW SFC DN	319.3	313.2	-6.1/ ***-1.9%***	24.	18.	12.	8.6	44
LW SFC UP	382.6	376.2	-6.4/ ***-1.7%***	24.	17.	13.	11.	32
SW SFC DN	184.4	187.7	3.2/ ***1.7%***	60.	24.	10.	6.9	44
SW SFC UP	40.7	33.2	-7.5/ ***18.%***	33.	17.	9.0	4.7	30

Aerosol Loading Limits Surface Albedo Retrieval Accuracy





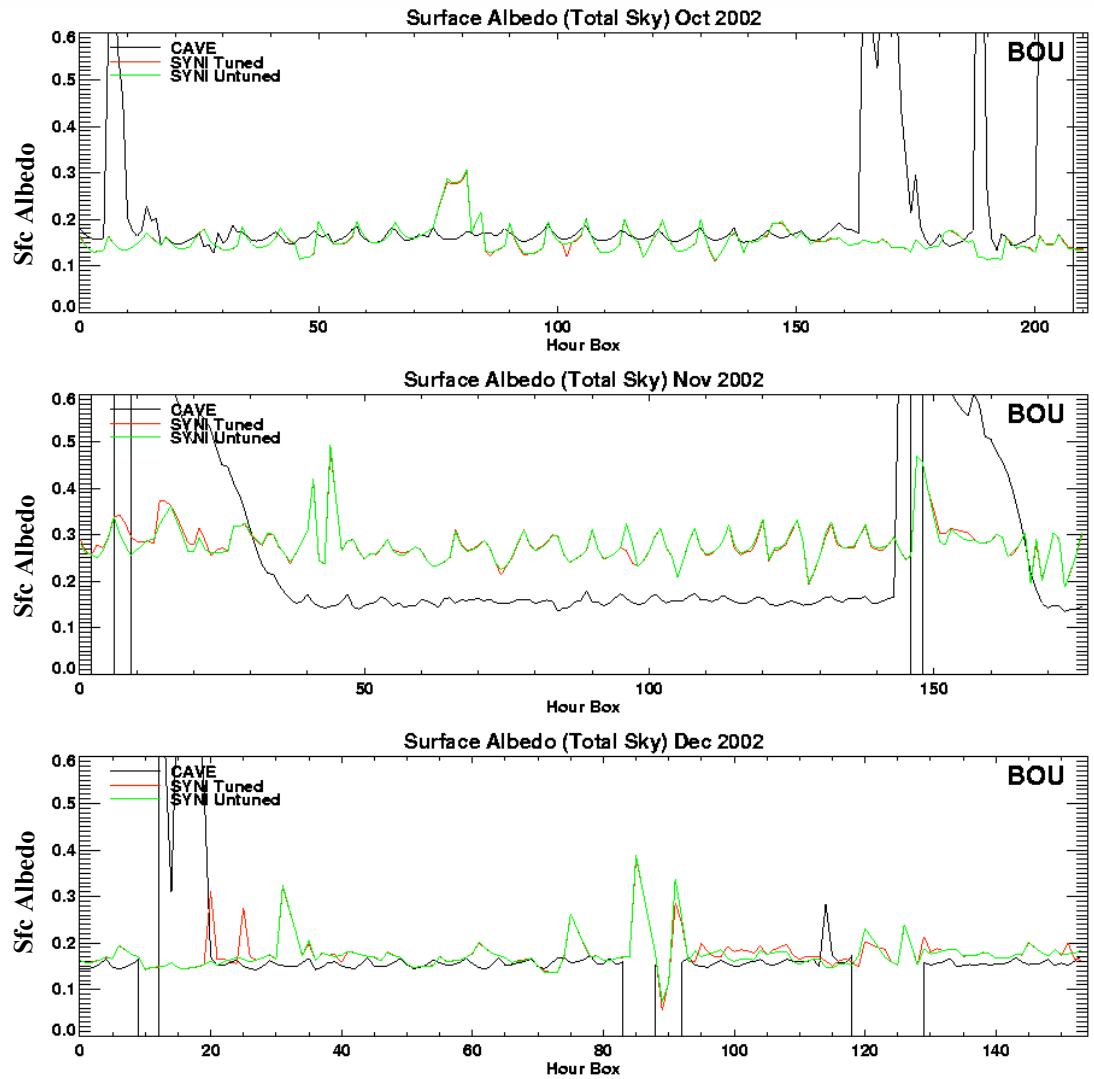




Surface Albedo & Snow Events

•Occurrences of Snow are typically not handled well!

• Currently a monthly mean diurnally modeled CERES clear sky TOA albedo is used in surface albedo retrieval when cloudy.

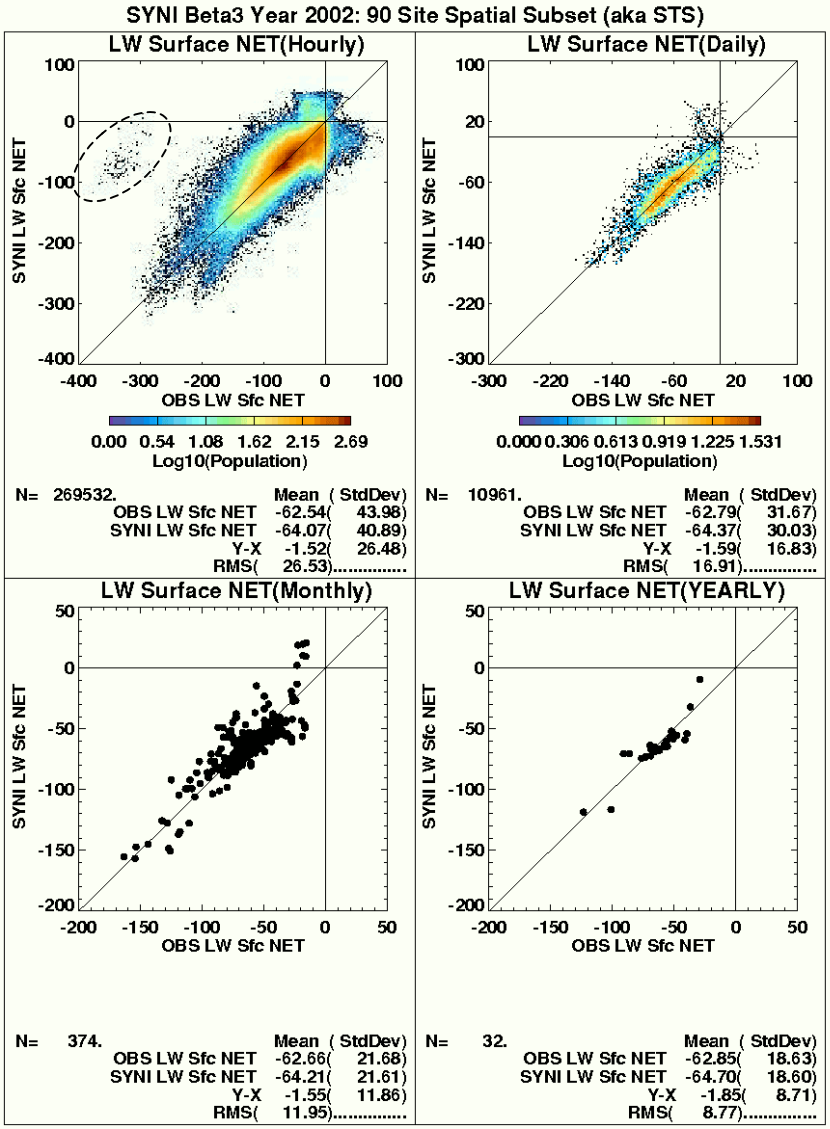


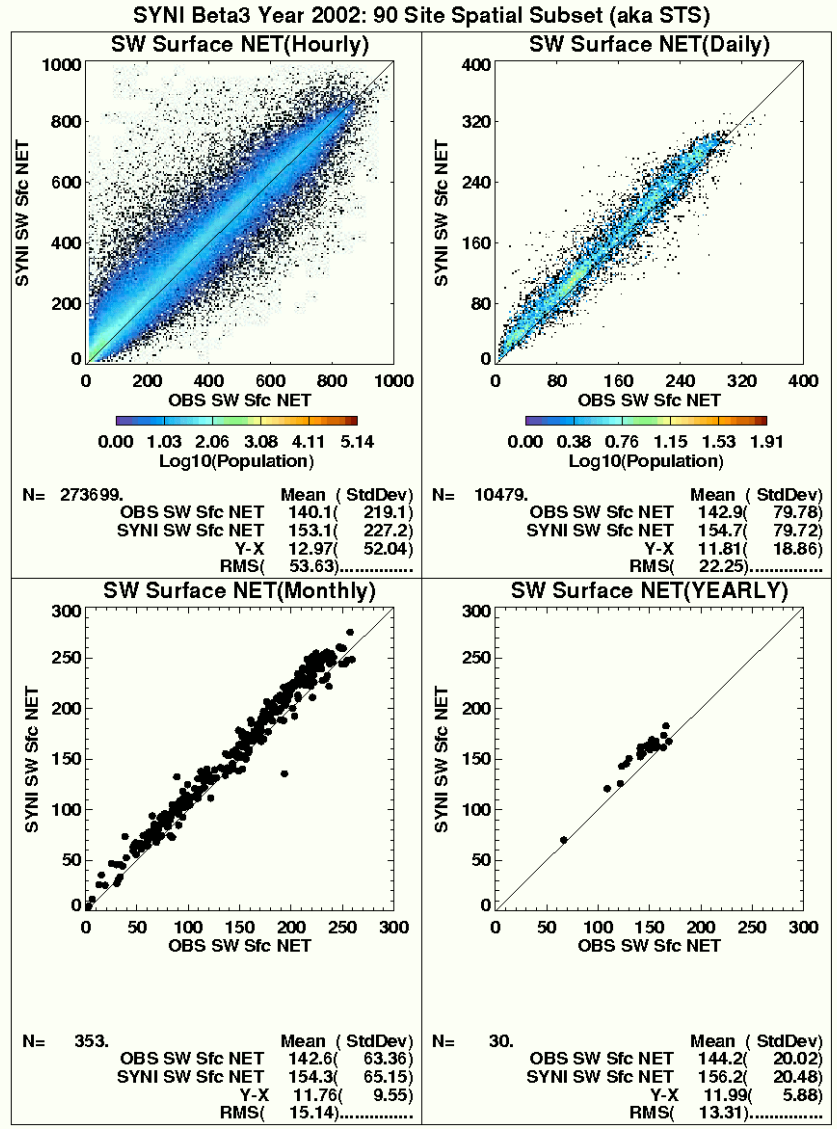
In Atmosphere Net Flux Validation

- ATMOSPHERE NET = TOA NET – SFC NET

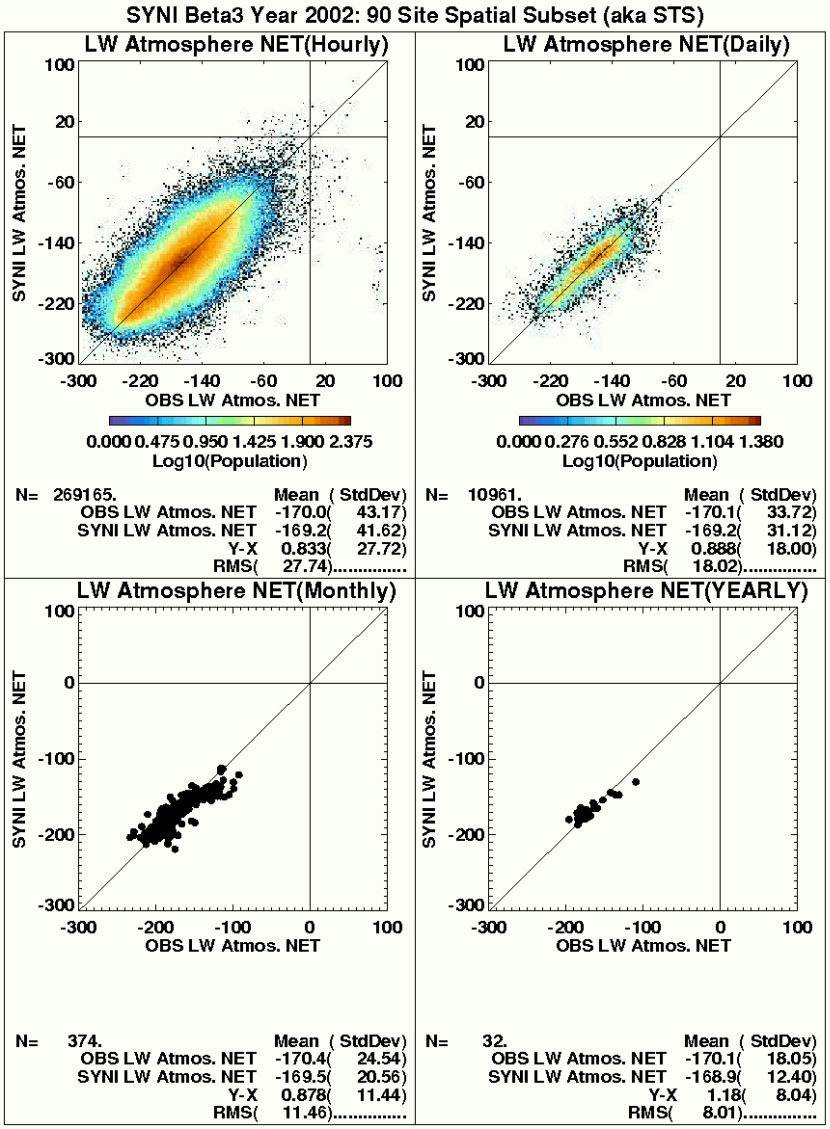
- TOA Observed from CERES & GEO normalized to CERES
- SFC Observed from CAVE(ARM,SURFRAD,BSRN)

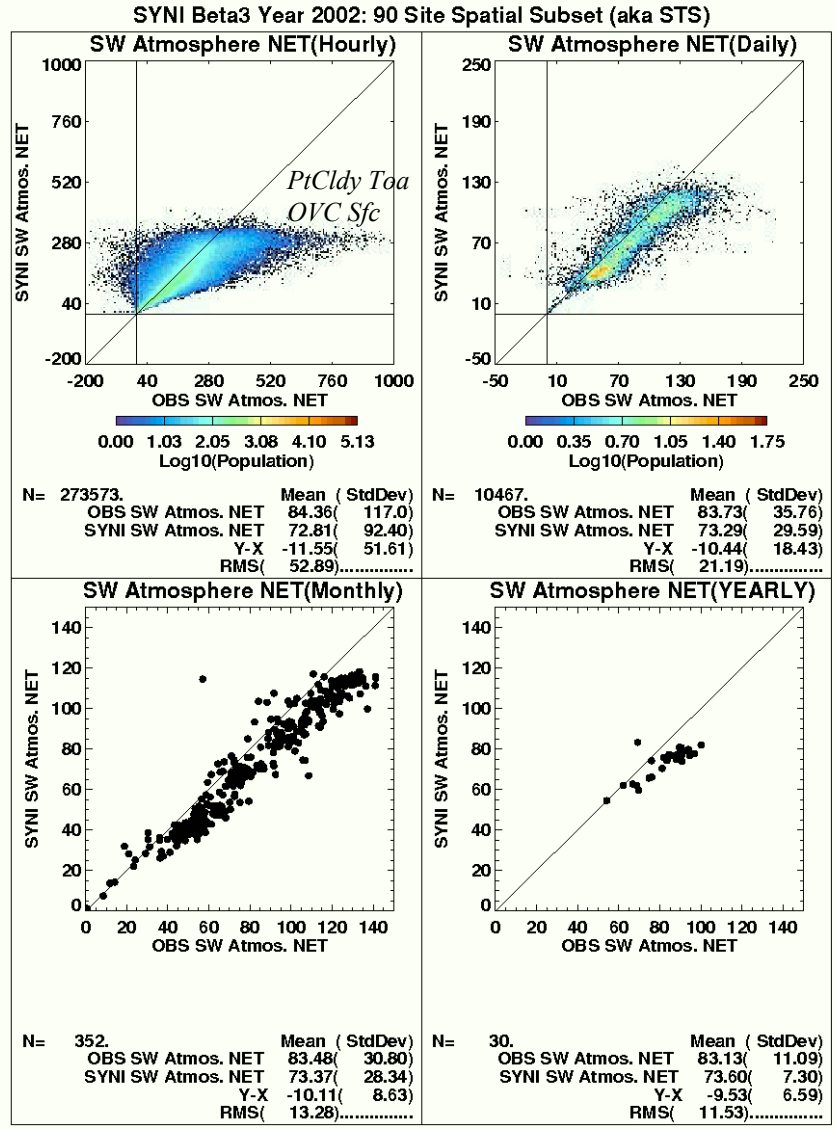
Surface Net (LW & SW)





Atmosphere Net (LW & SW)



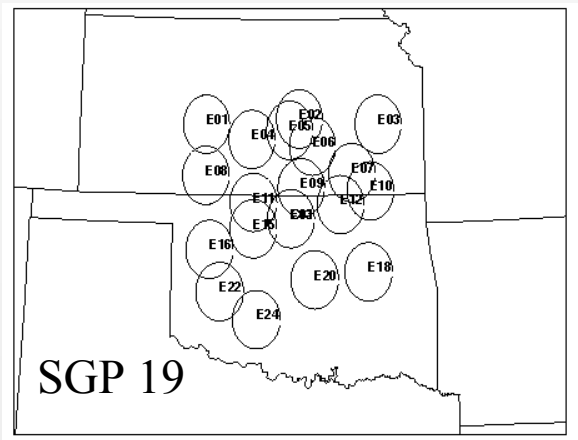


SYN Subset Atmosphere Net Validation Beta3 Year 2002

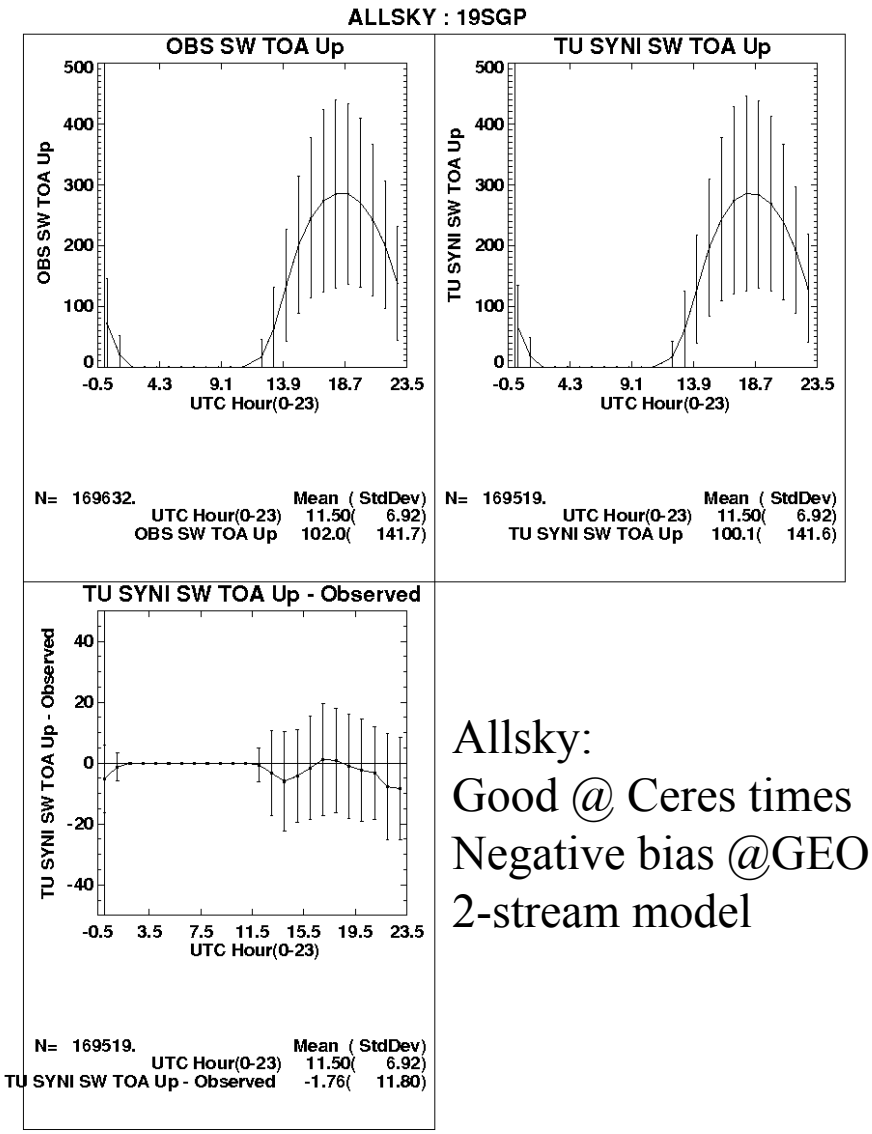
Quantity	Observed	Model	Bias Model-Obs.	Hourly Std Dev	Daily Std Dev	Monthly Std Dev	Yearly Std Dev	N Site
LW TOA NET	-216.9	-217.6	-0.7 /***-0.3%***	10.	7.	3.2	2.3	90
SW TOA NET	182.6	182.5	-0.1 /***-0.1%***	12.	7.	3.8	2.4	90
LW SFC NET	-62.8	-64.7	-1.9 /***2.9%***	26.	17.	12	8.7	32
SW SFC NET	144.2	156.2	12. /***8.3%***	52.	19.	9.6	5.9	30
ATM LW NET	-170.1	-168.9	1.2 ***/-0.7%***	28.	18.	11.	8.0	32
ATM SW NET	83.1	73.6	-9.5 /***11.4%***	52.	18.	8.6	6.6	30
ATM LW&SW NET	-82.7	-95.7	13. /***15.6%***	59.	22.	13.0	8.1	27

Diurnal Validation at SGP

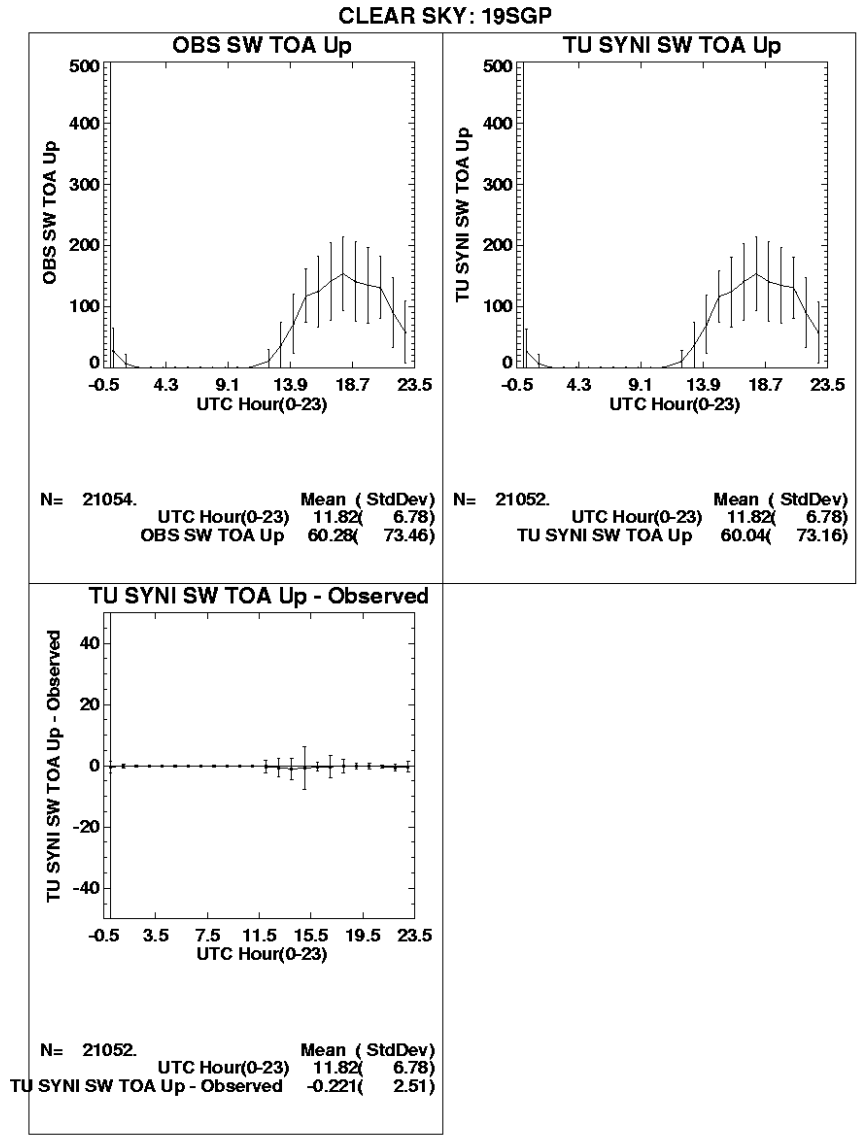
- 19 Sites grouped ~3x3 degree region
  - Complete year 2002
  - Mean differences



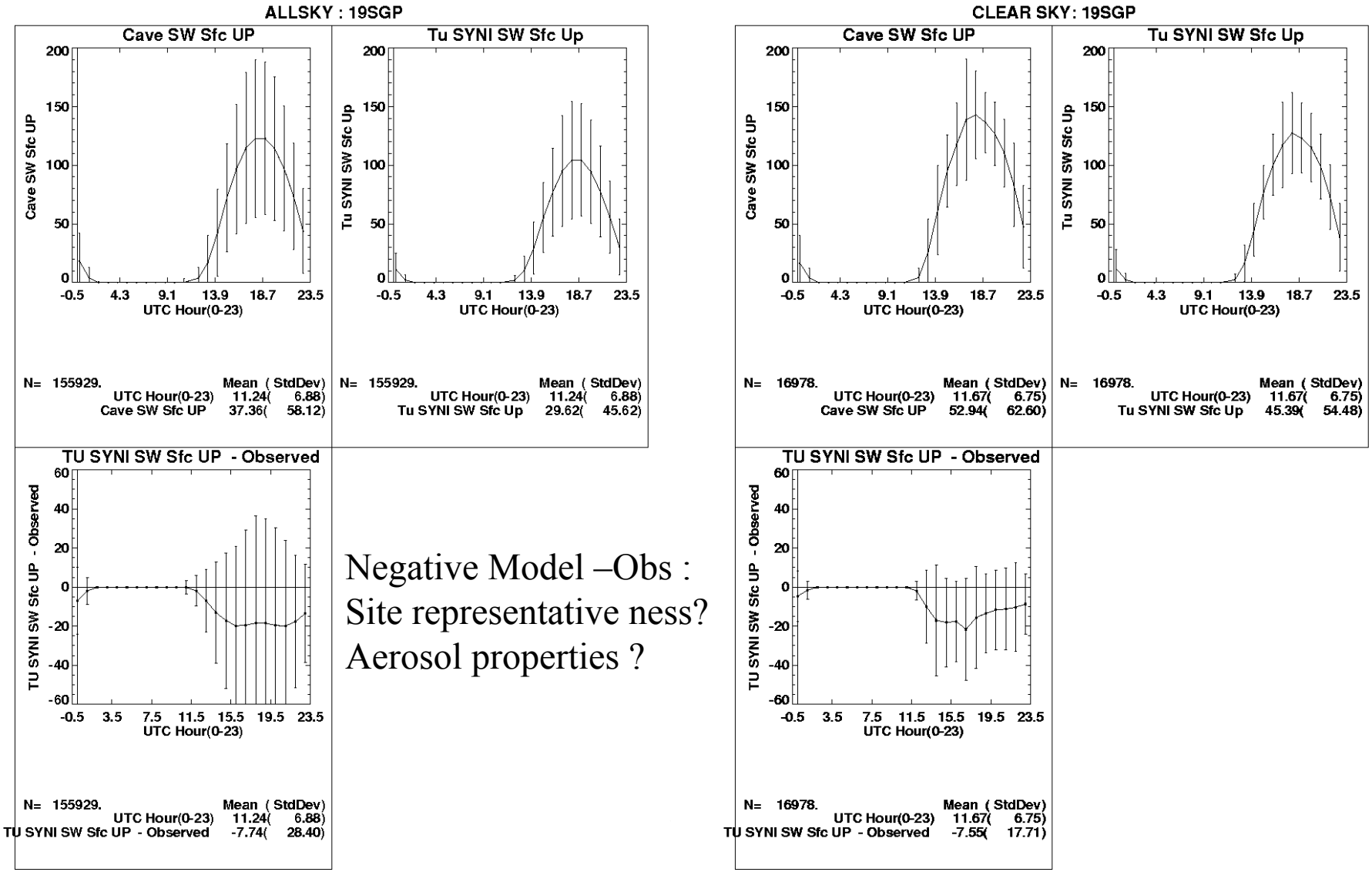
TOA Shortwave



Allsky:
Good @ Ceres times
Negative bias @GEO
2-stream model

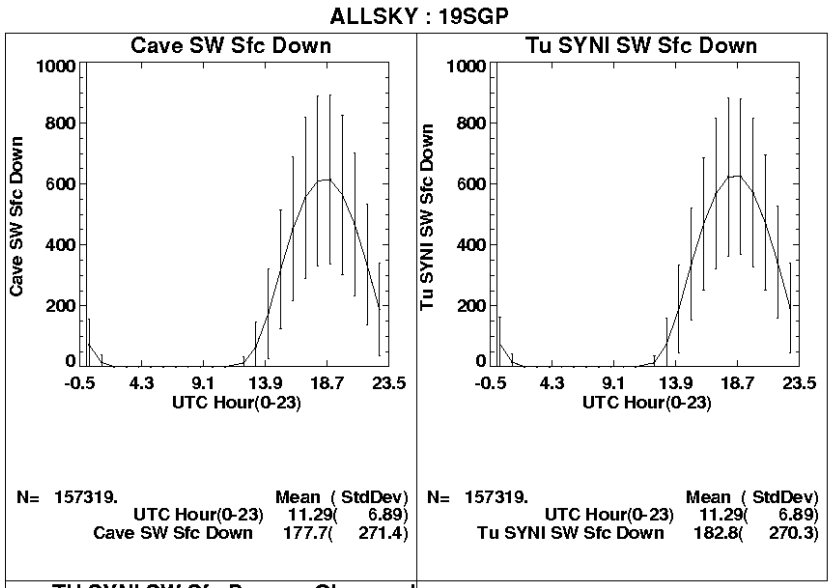


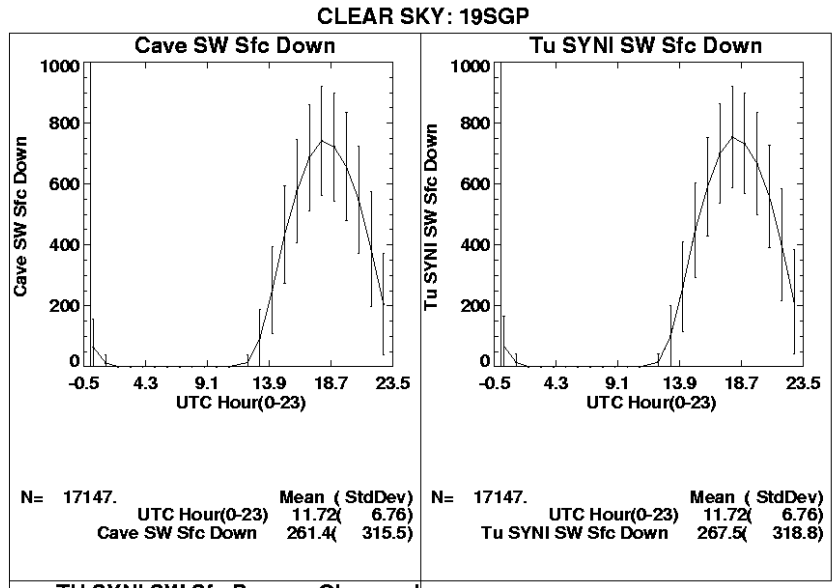
Surface Shortwave Up

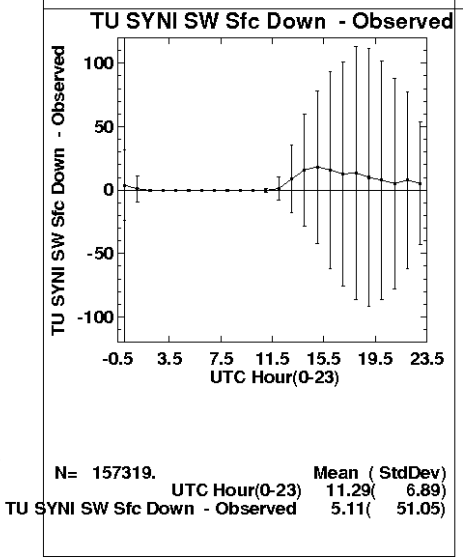


Negative Model –Obs :
Site representative ness?
Aerosol properties ?

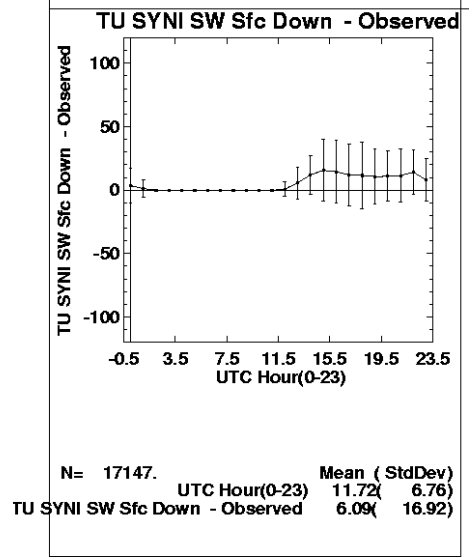
Surface Shortwave Down



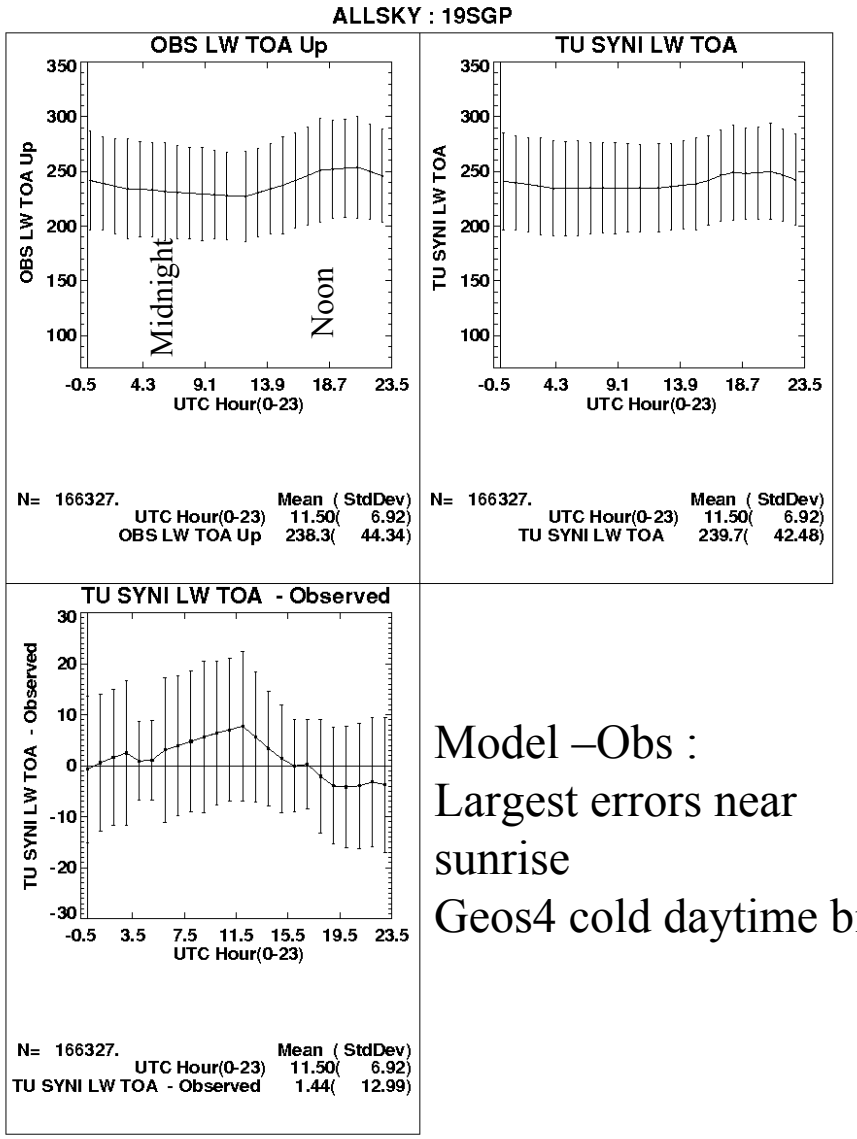




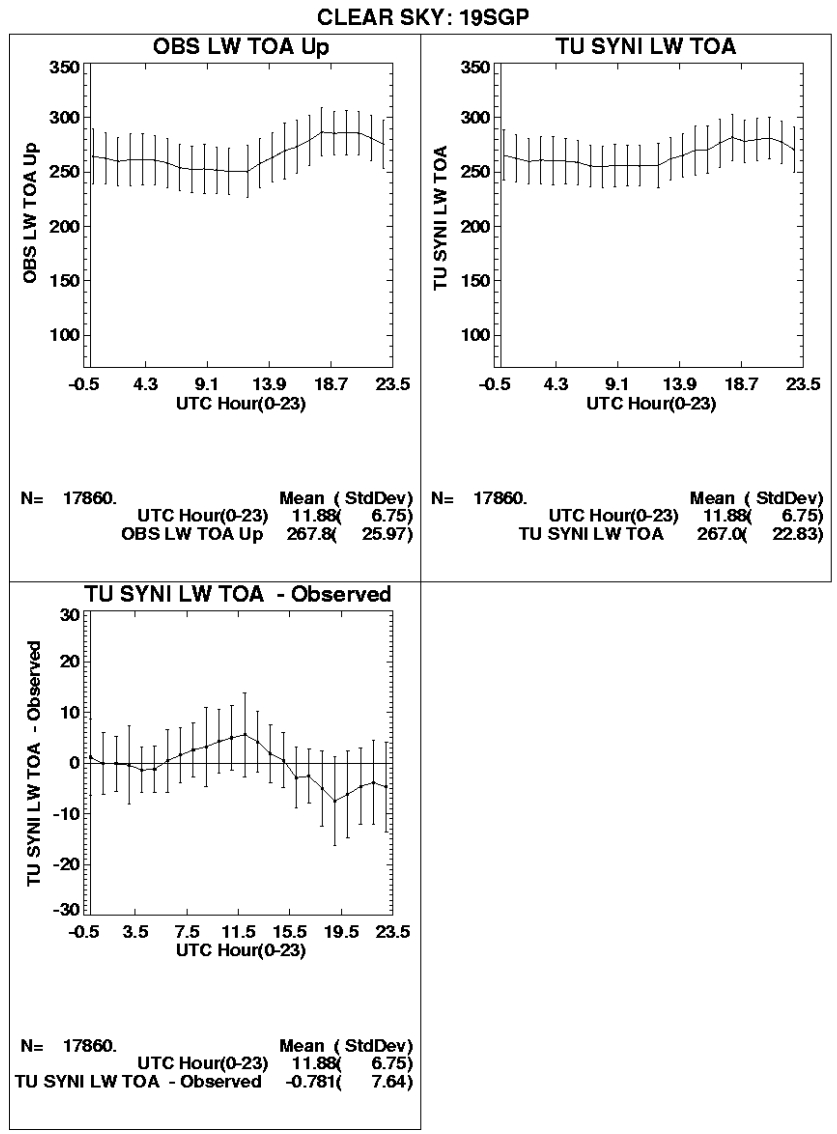
Positive Model –Obs : Larger relative bias at low sun



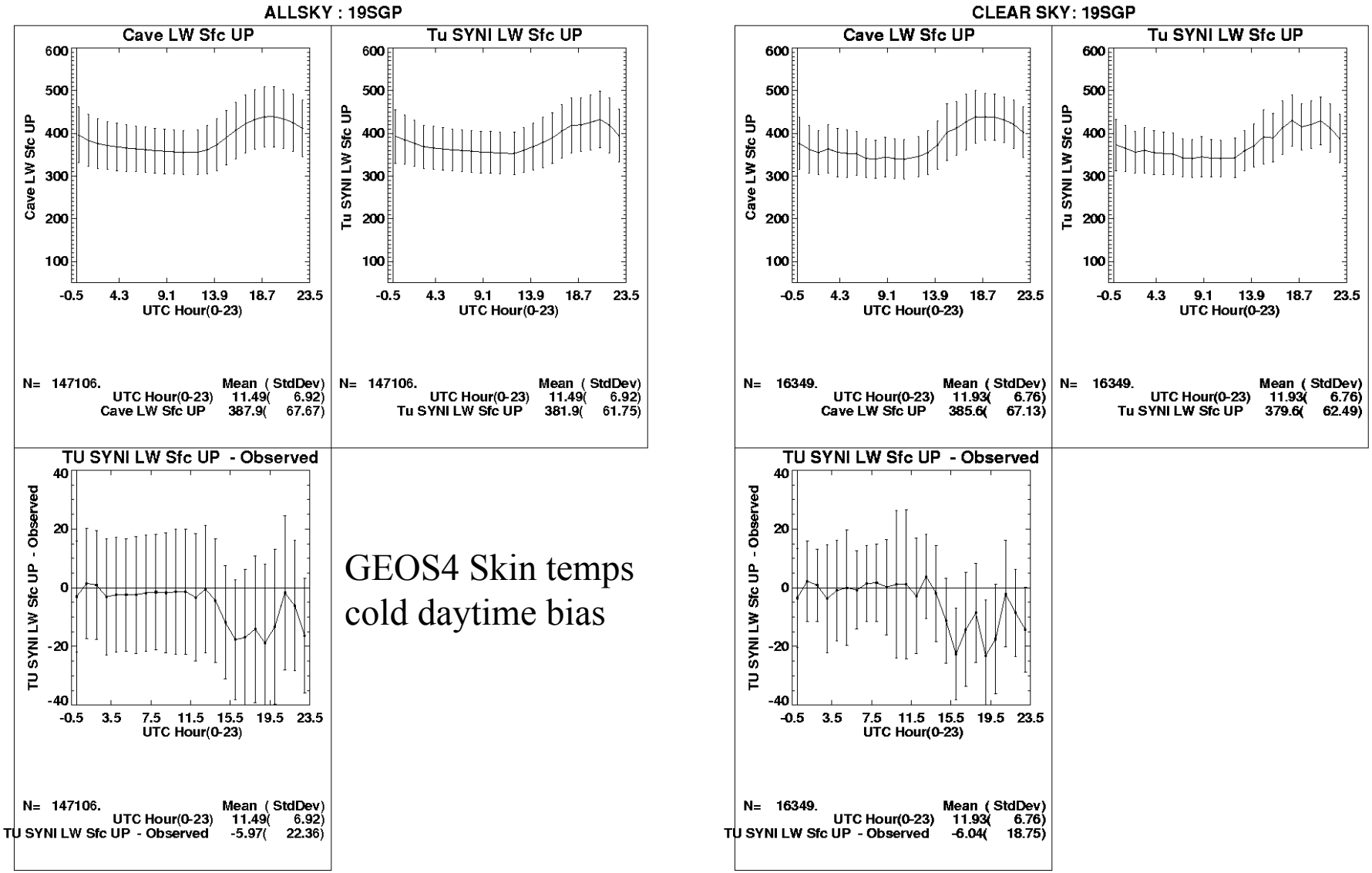
TOA Longwave



Model –Obs :
Largest errors near sunrise
Geos4 cold daytime bias

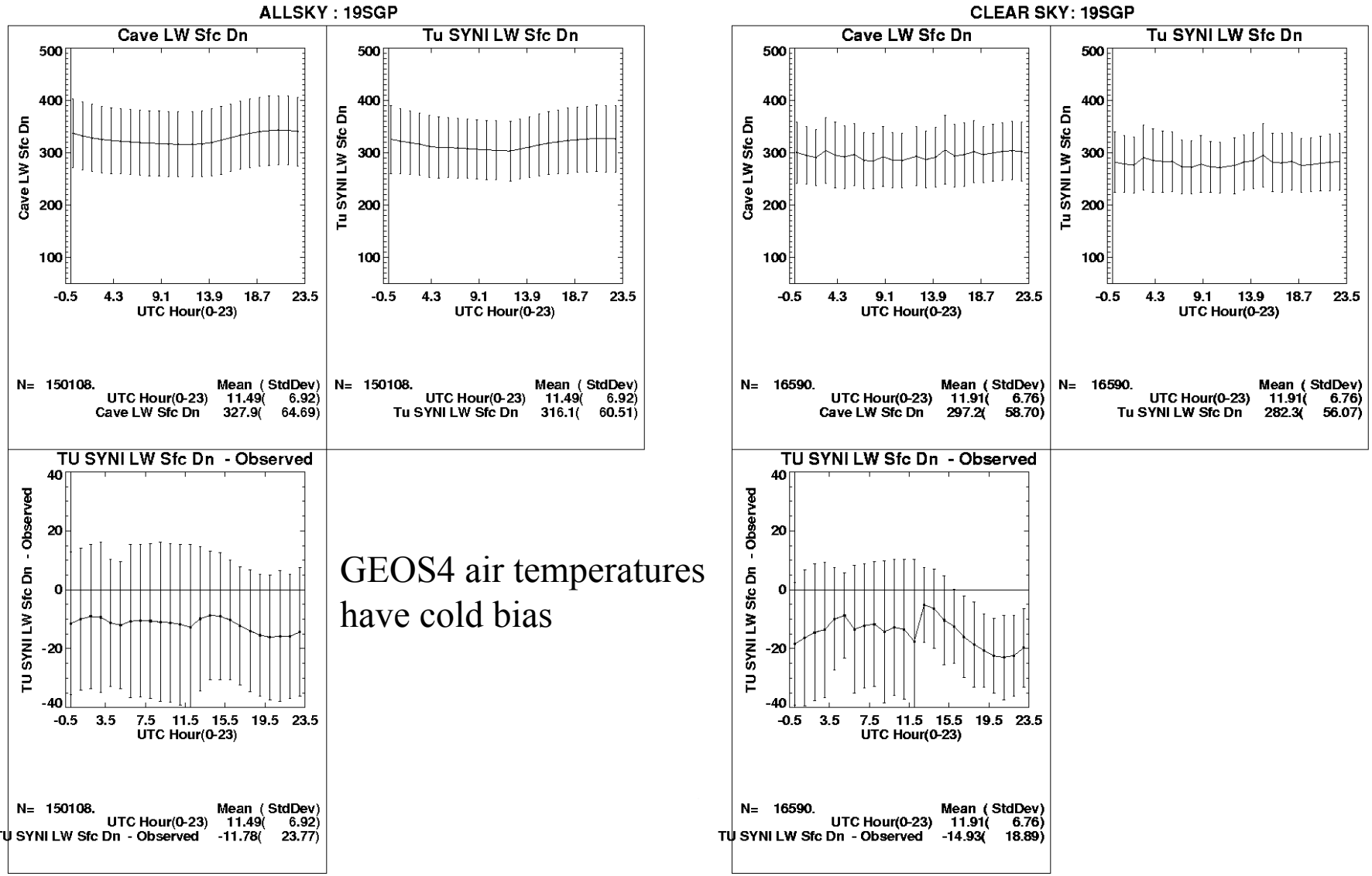


Surface Longwave Up



GEOS4 Skin temps
cold daytime bias

Surface Longwave Down



GEOS4 air temperatures have cold bias

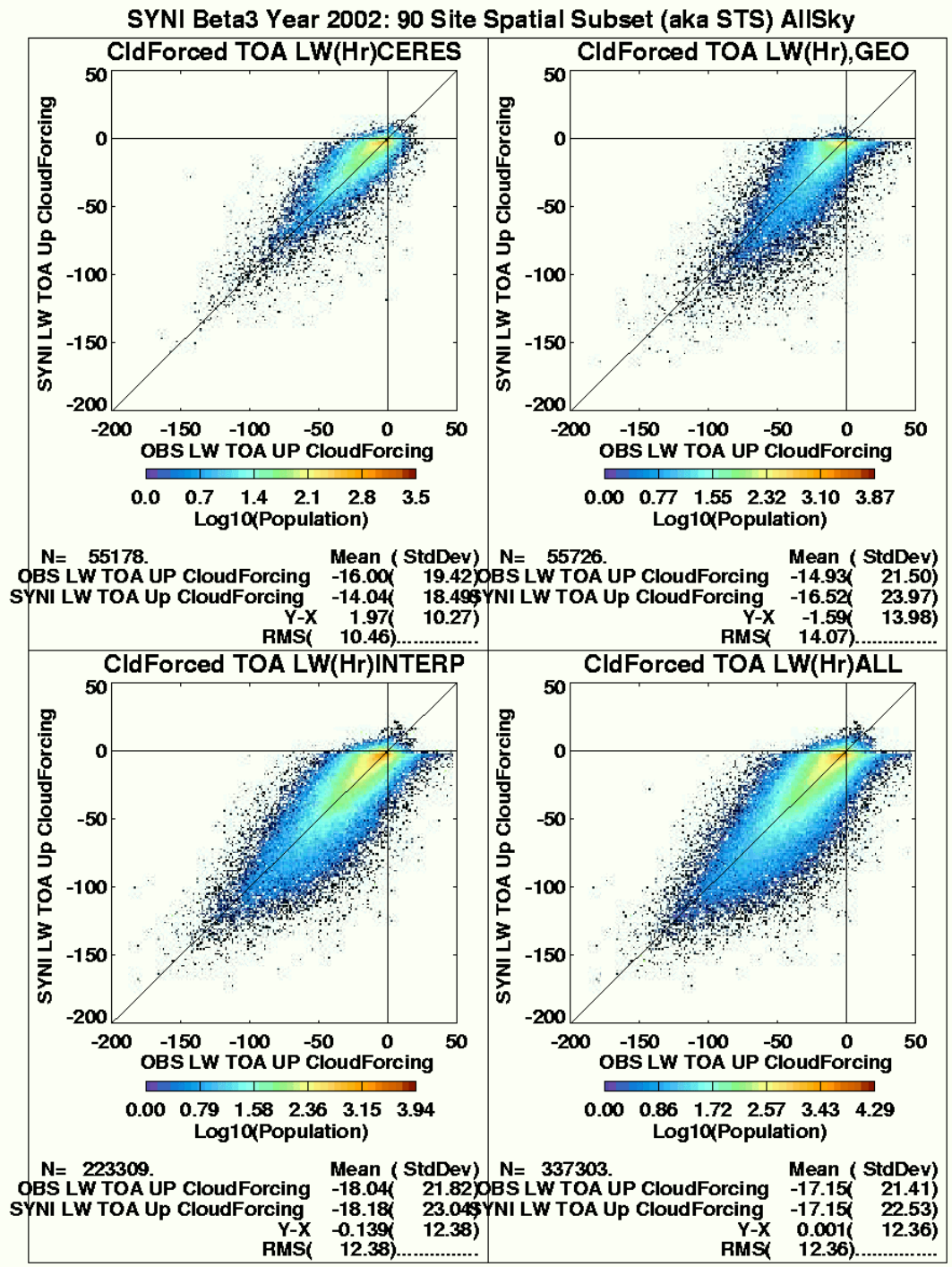
SYNI Calculations at CERES,GEO,Interpolated Times

- For 90 site validation subset for 2002
  - Cloud forced TOA LW Flux
  - Cloud forced TOA Albedo

Ceres & Geo Cloud Forced OLR @ 90 sites

- Longwave CERES/MODIS and GEO have small and compensating biases.
- GEO and has larger RMS error
- CERES only in polar regions
- MODIS particle size retrieved
  GEO fixed particle size(De=60 Re=10)
  GEO single IR & single VIS Channel.

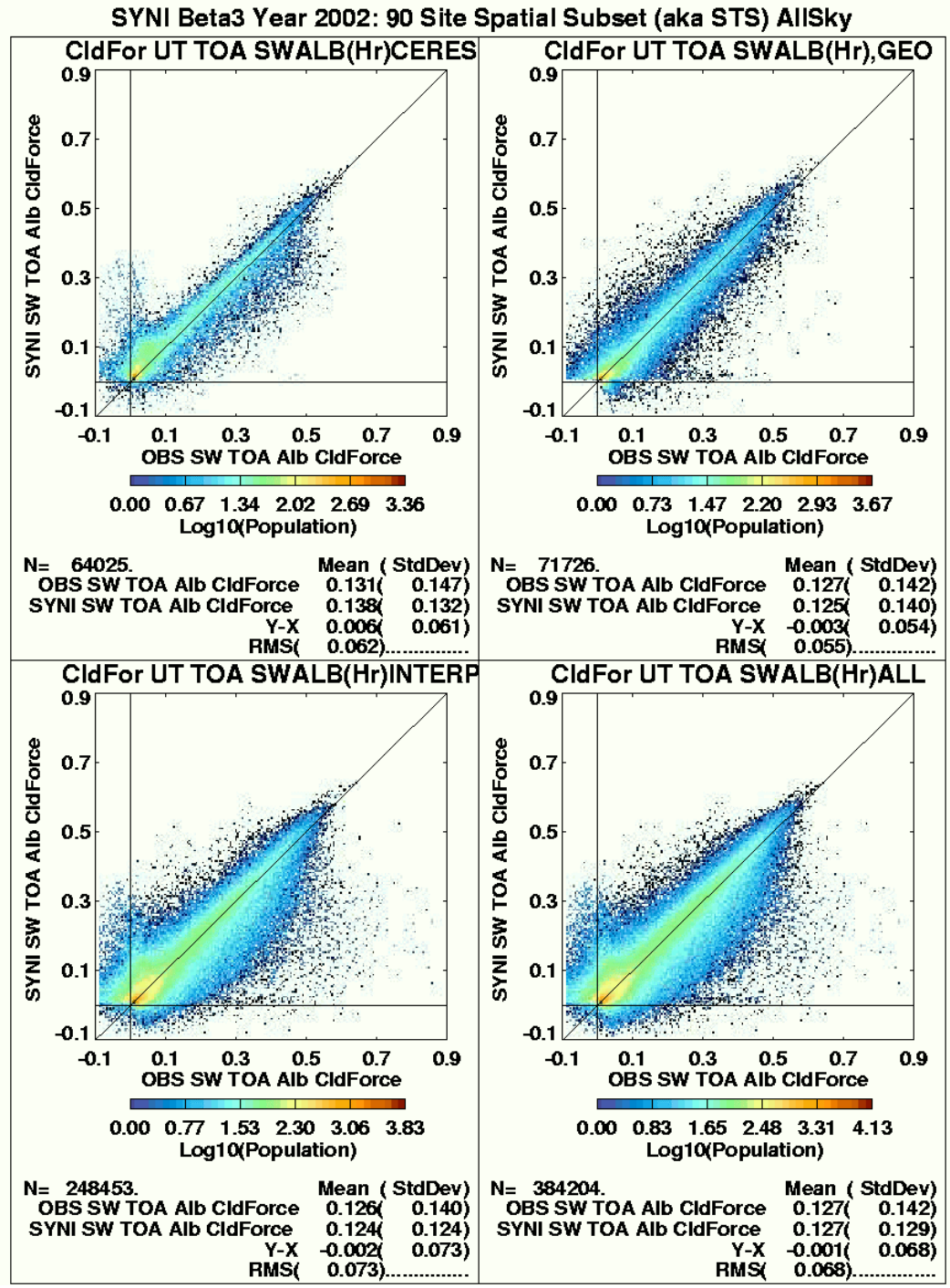
Model – Obs.	Bias	RMS
CERES	1.97	10.5
GEO	-1.59	14.1
Intrp	-0.14	12.4
All	0.00	12.4



Ceres & Geo Cloud Forced TOA Albedo @ 90 sites

- CERES/MODIS clouds more reflective than GEO and have larger RMS error!
- GEO simpler cloud retrievals fixed particle size(De=60 Re=10)
- CERES positive bias consistent with CRS footprint results

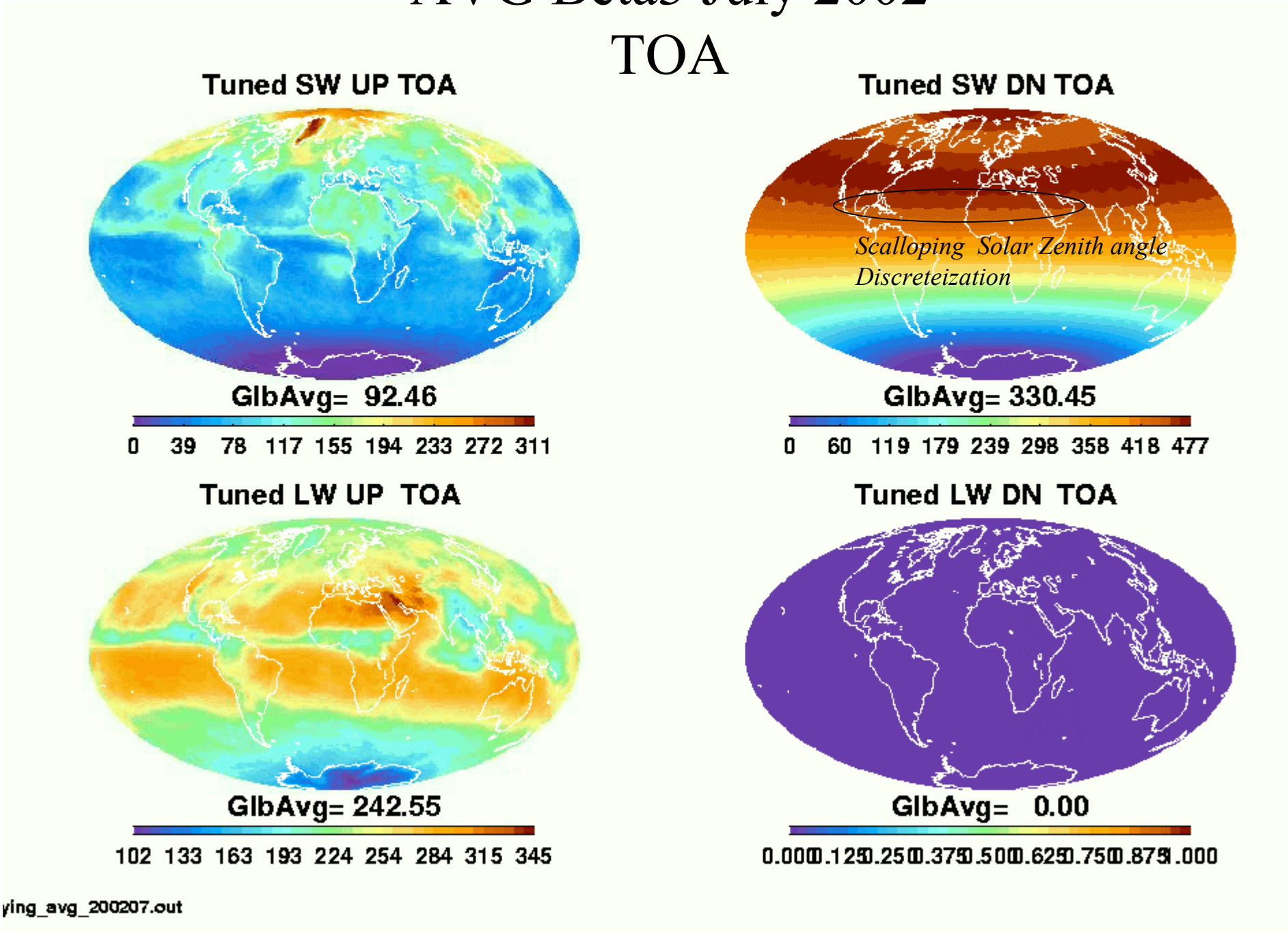
Model – Obs.	Alb Bias	Alb RMS	Flux Bias	Flux RMS
CERES	0.006	0.062	4.3	26.4
GEO	-0.003	0.055	-2.8	25.7
Intrp	-0.002	0.073	-0.9	26.2
All	-0.001	0.068	-0.8	26.1



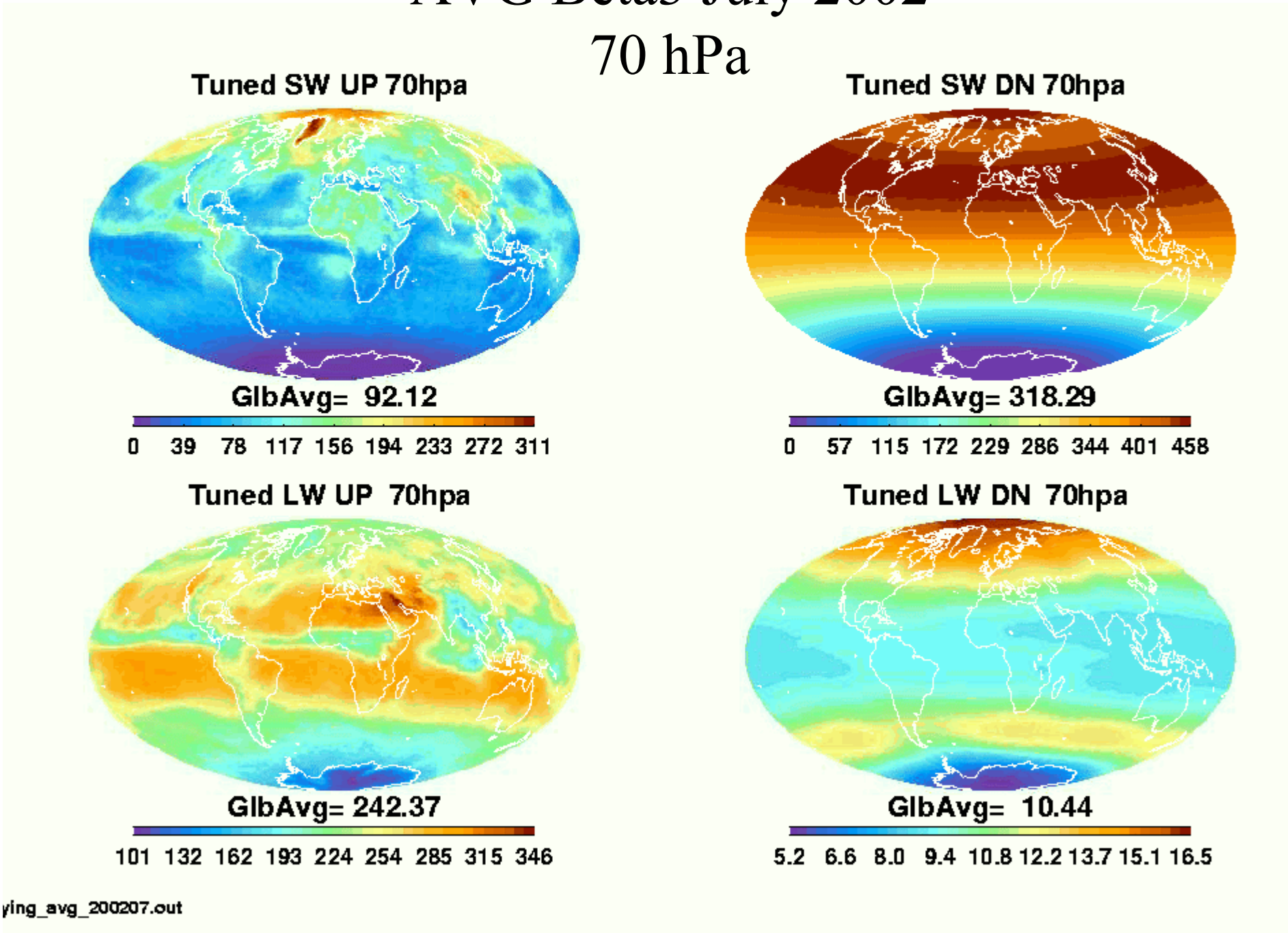
“AVG” Beta3

- Primary SARB Product for July 2002
  - Shortwave & Longwave
  - Upwelling & Downward
  - 5 vertical levels TOA, 70 , 200 ,500 ,Sfc
- 4 seasonal months
  - April 2002 , July 2002, October 2002, January 2003
    - TOA regional biases & Std Deviations
    - NET Flux

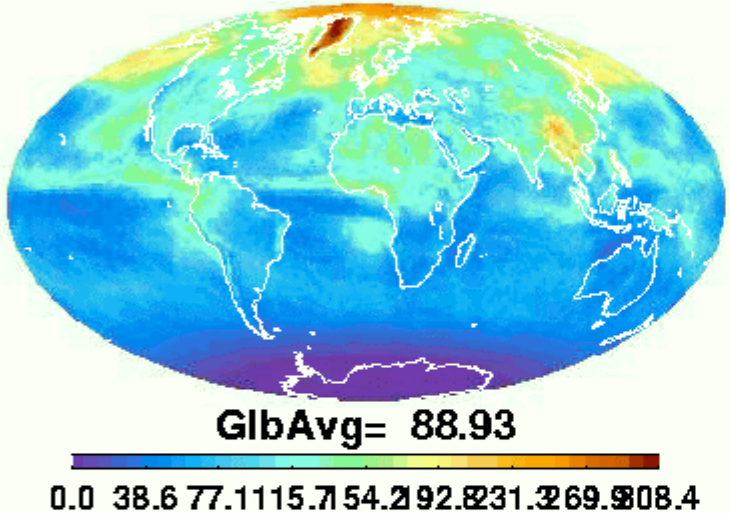
AVG Beta3 July 2002
TOA

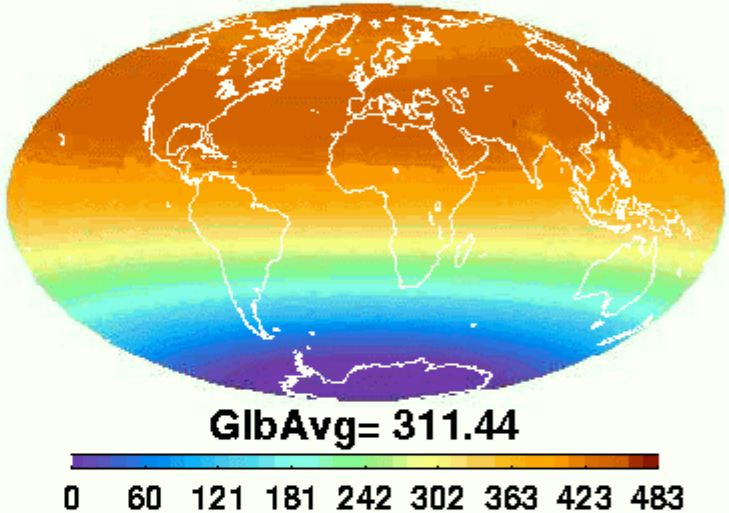


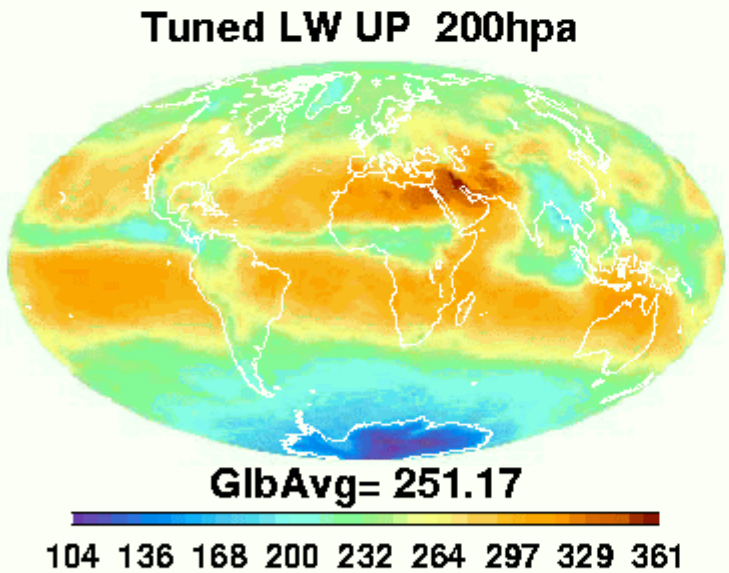
AVG Beta3 July 2002
70 hPa

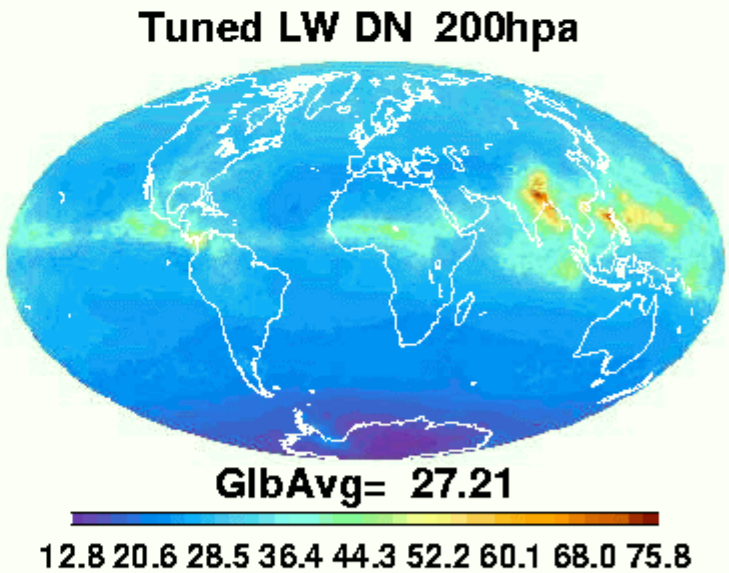


AVG Beta3 July 2002
200 hPa



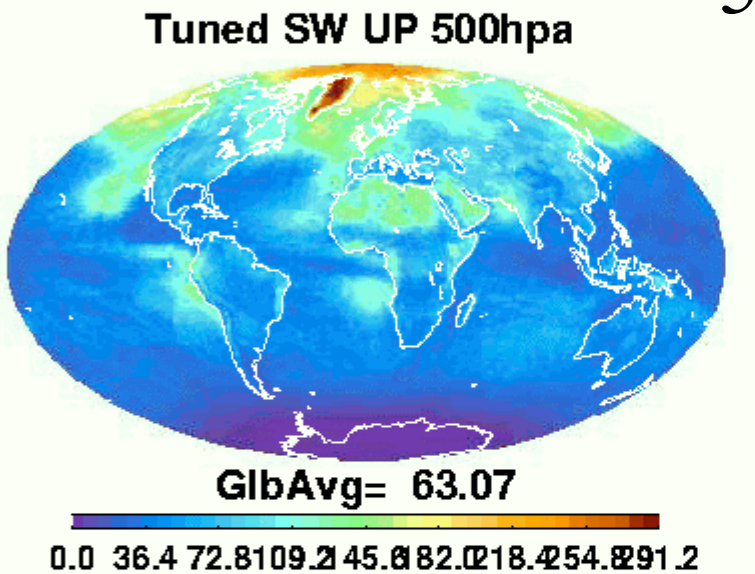


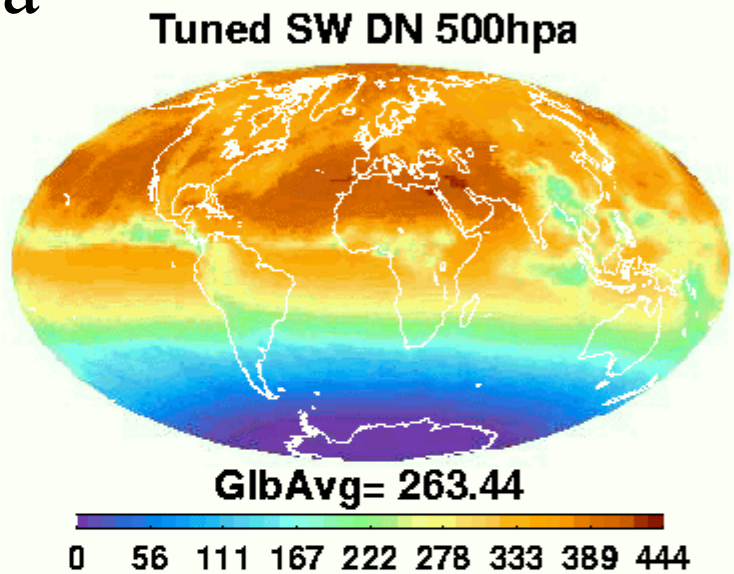


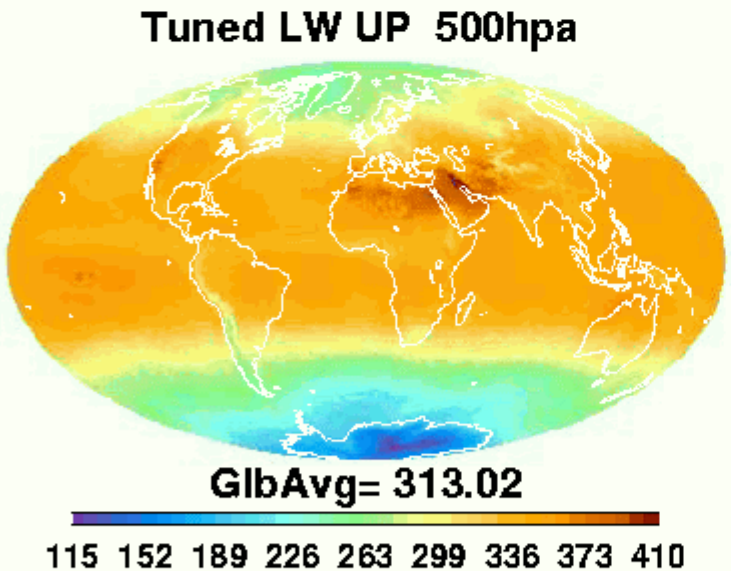


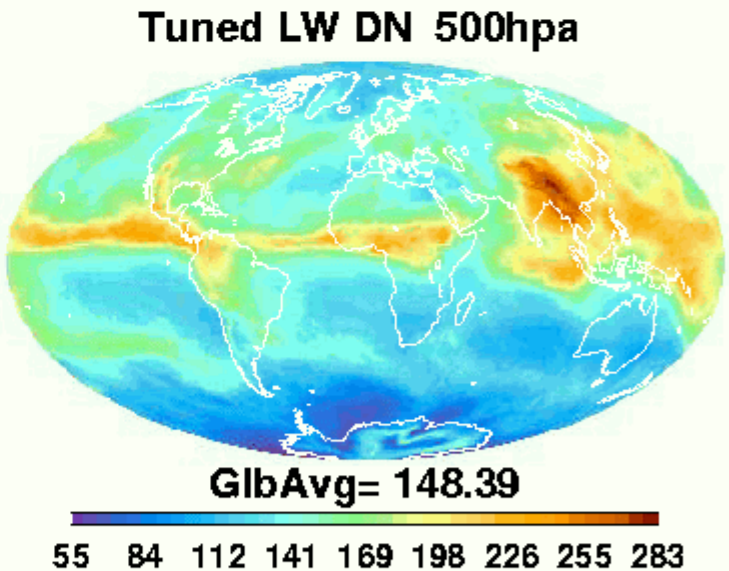
ying_avg_200207.out

AVG Beta3 July 2002
500 hPa



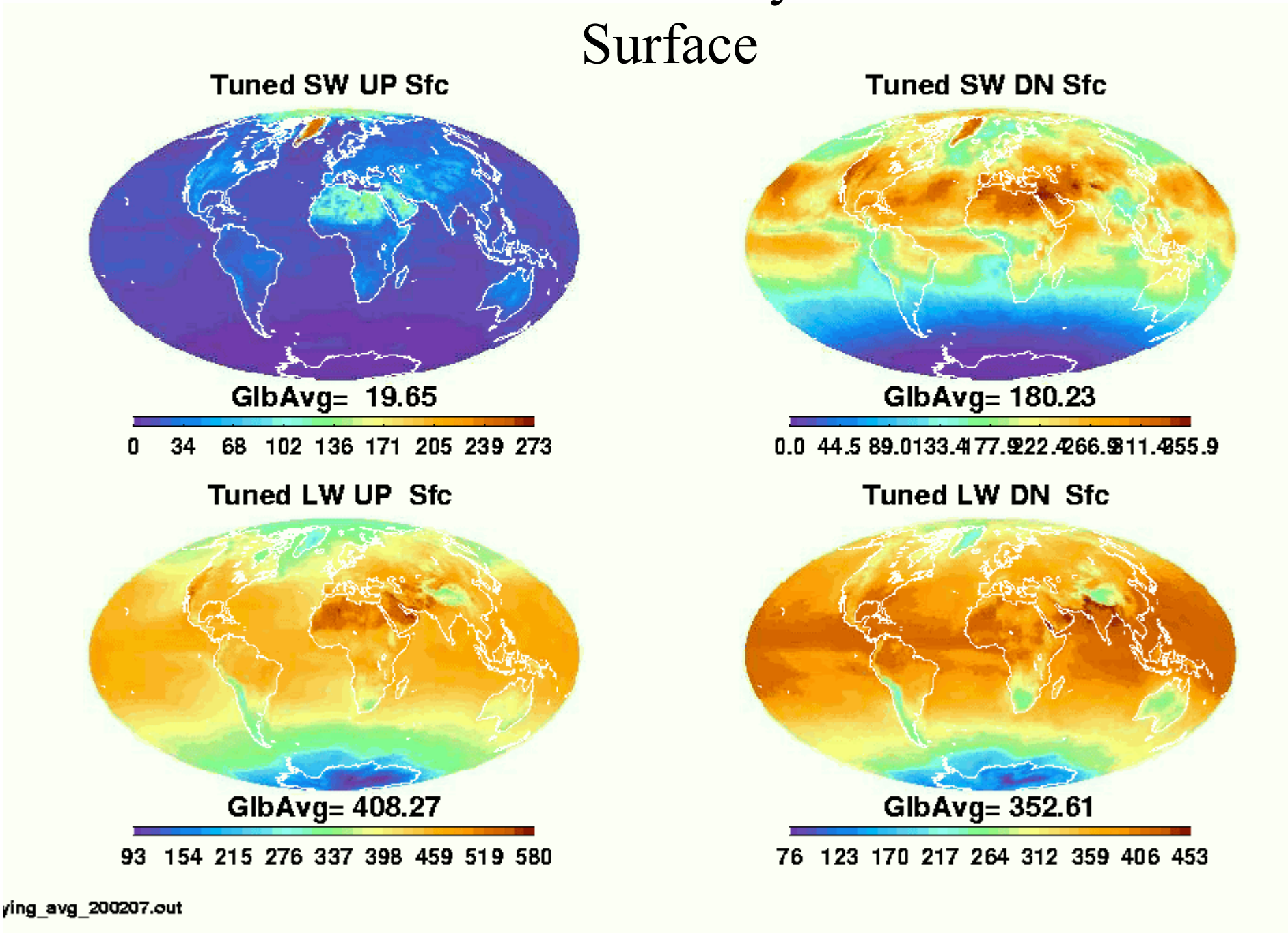




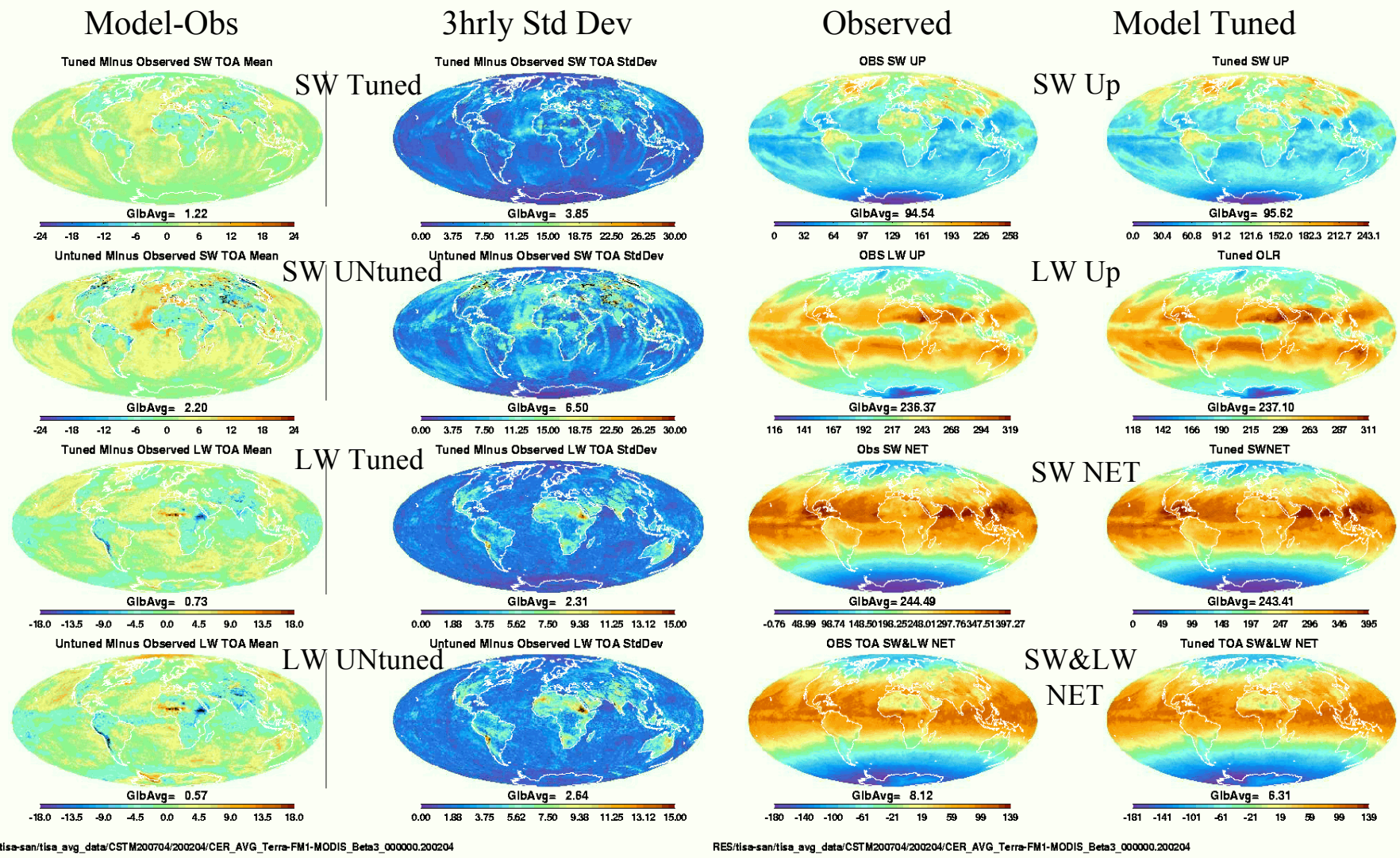


ying_avg_200207.out

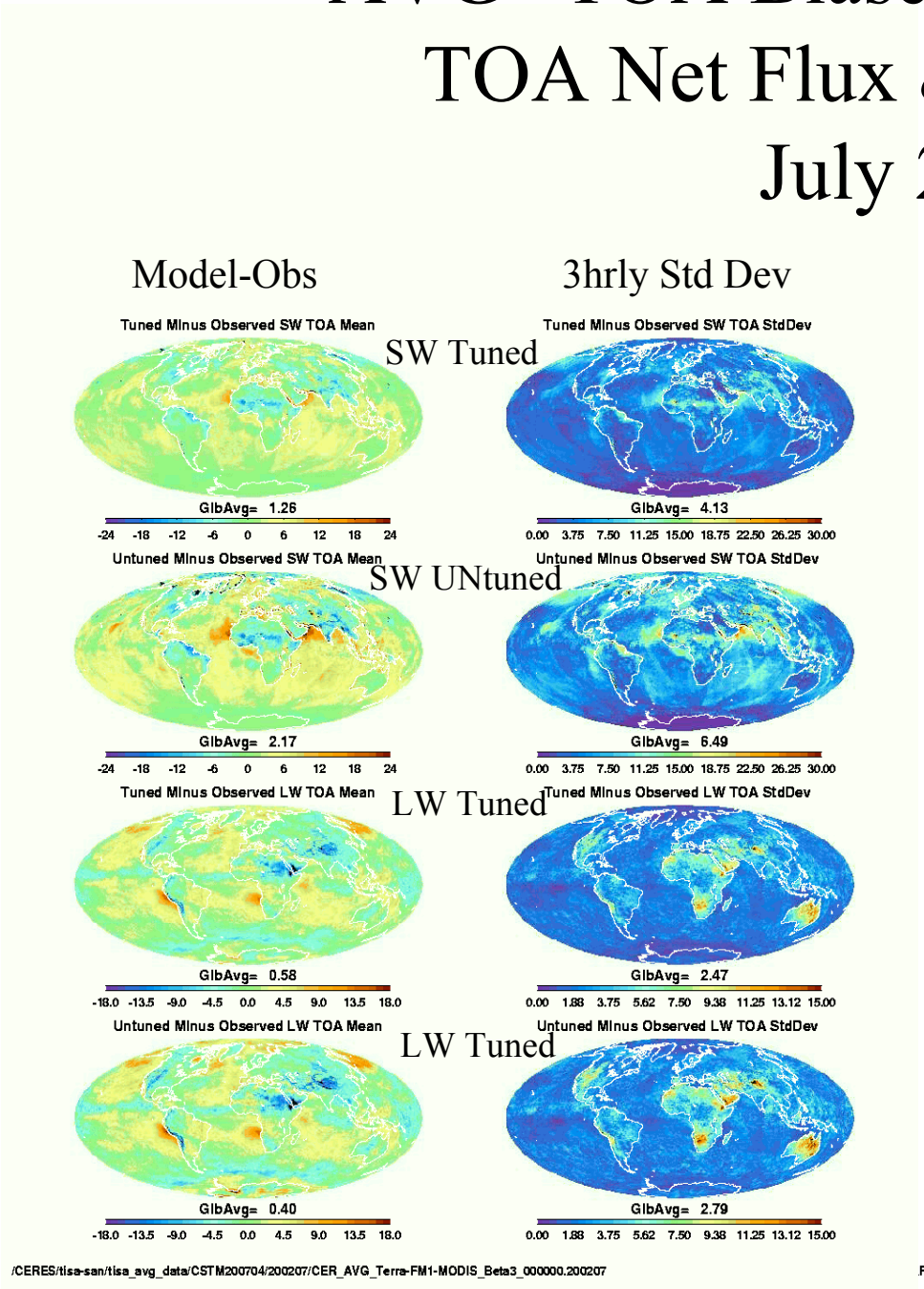
AVG Beta3 July 2002
Surface

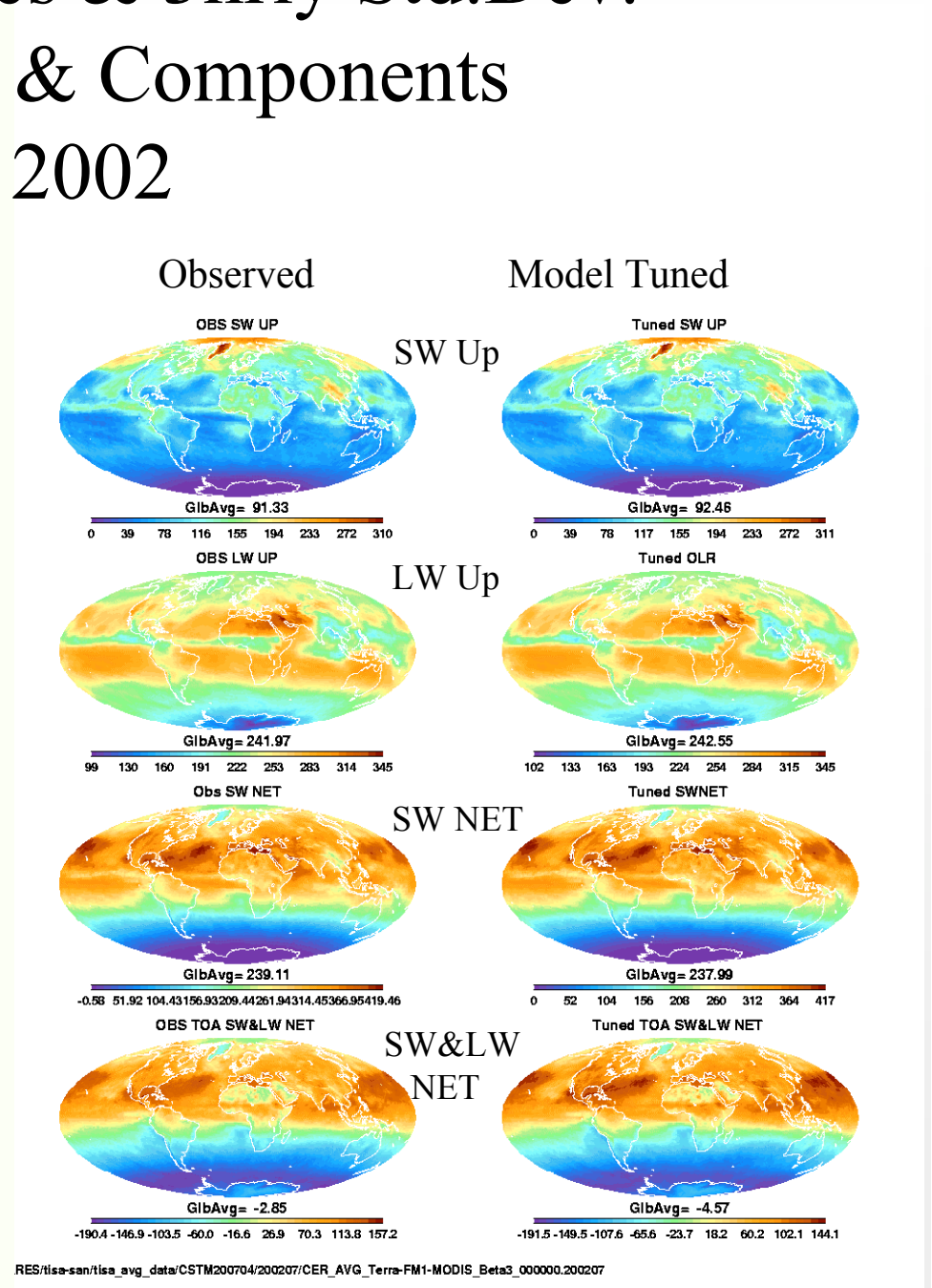


“AVG” TOA Biases & 3hrly Std.Dev.
TOA Net Flux & Components
April 2002

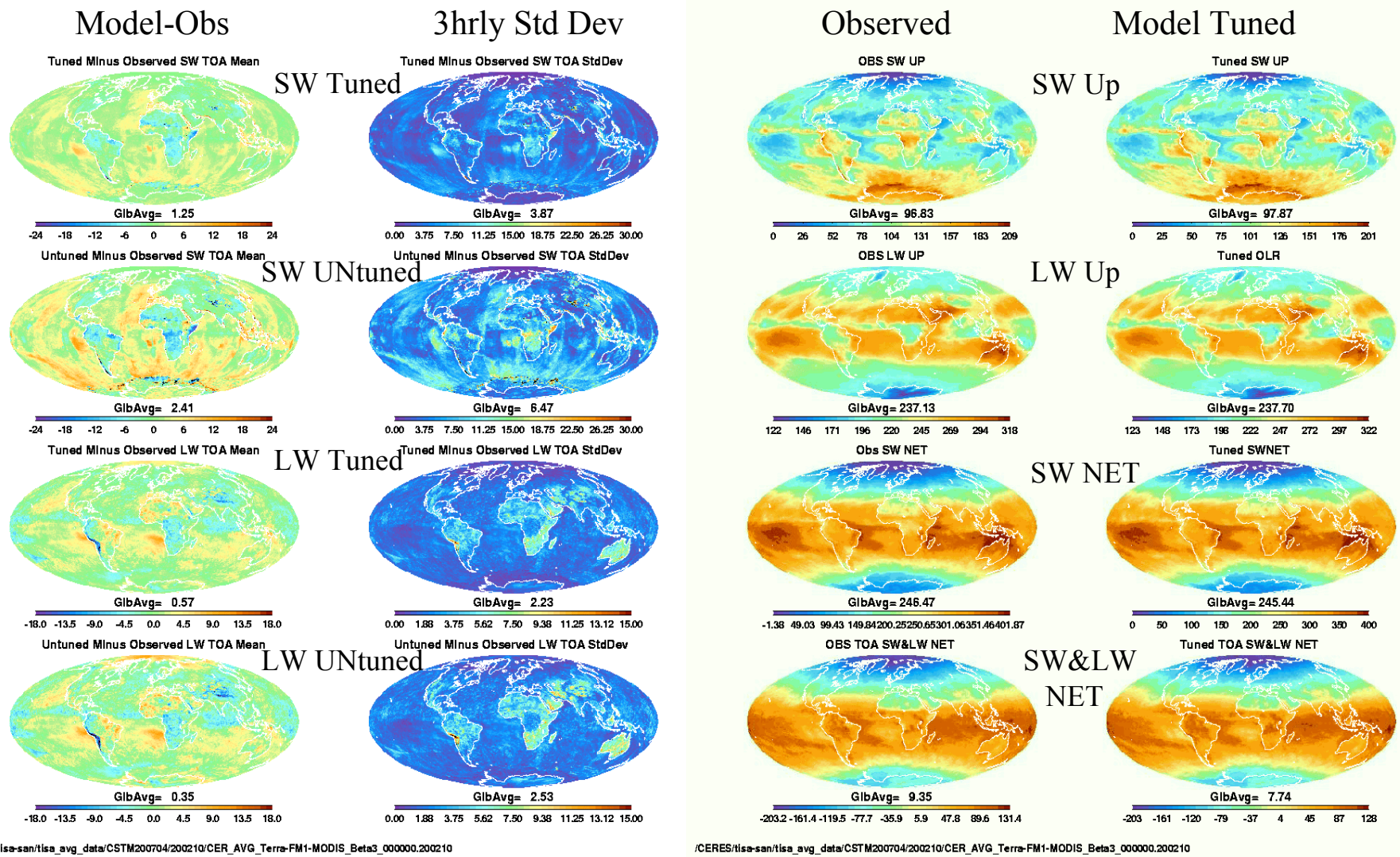


“AVG” TOA Biases & 3hrly Std.Dev.
TOA Net Flux & Components
July 2002

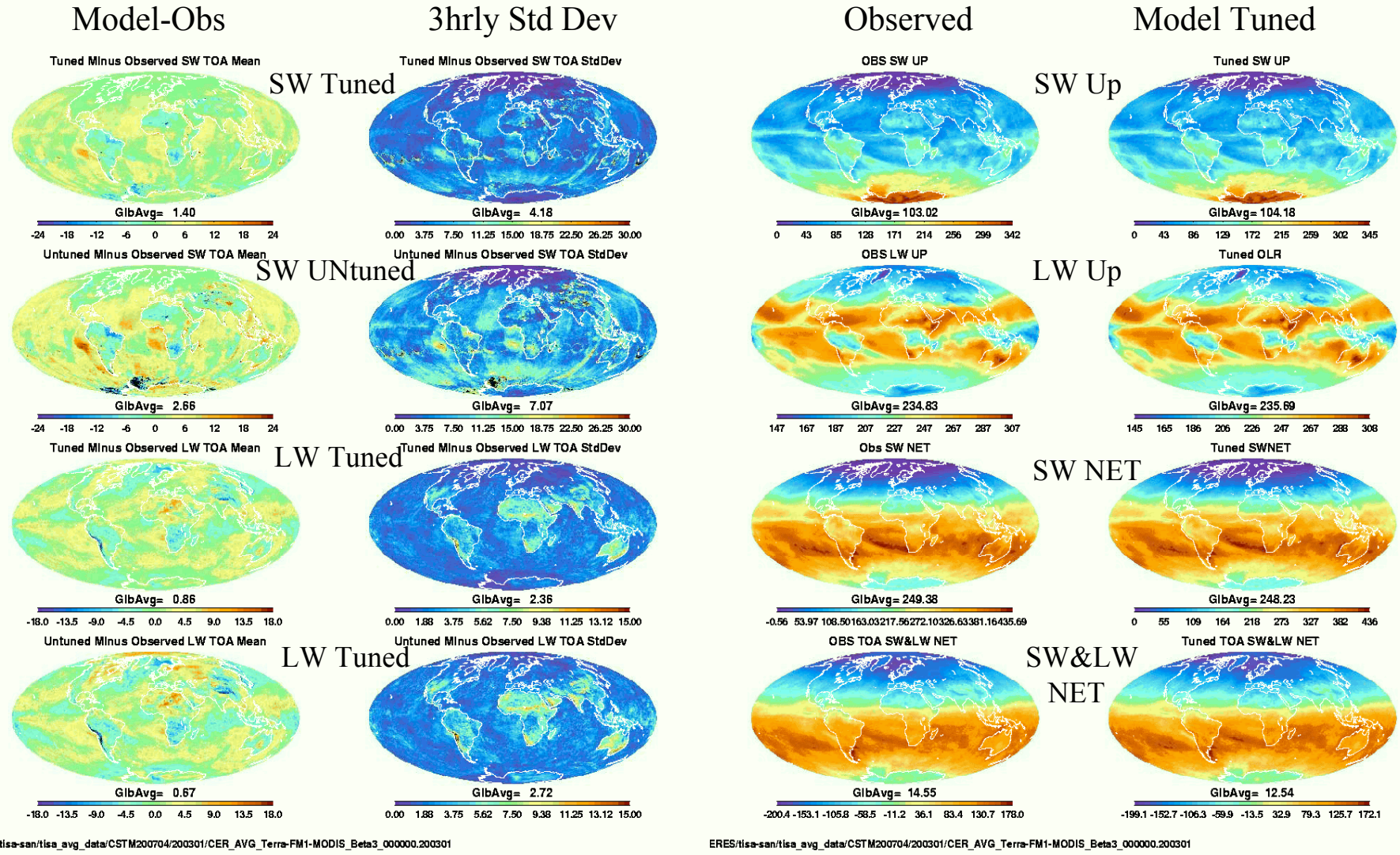




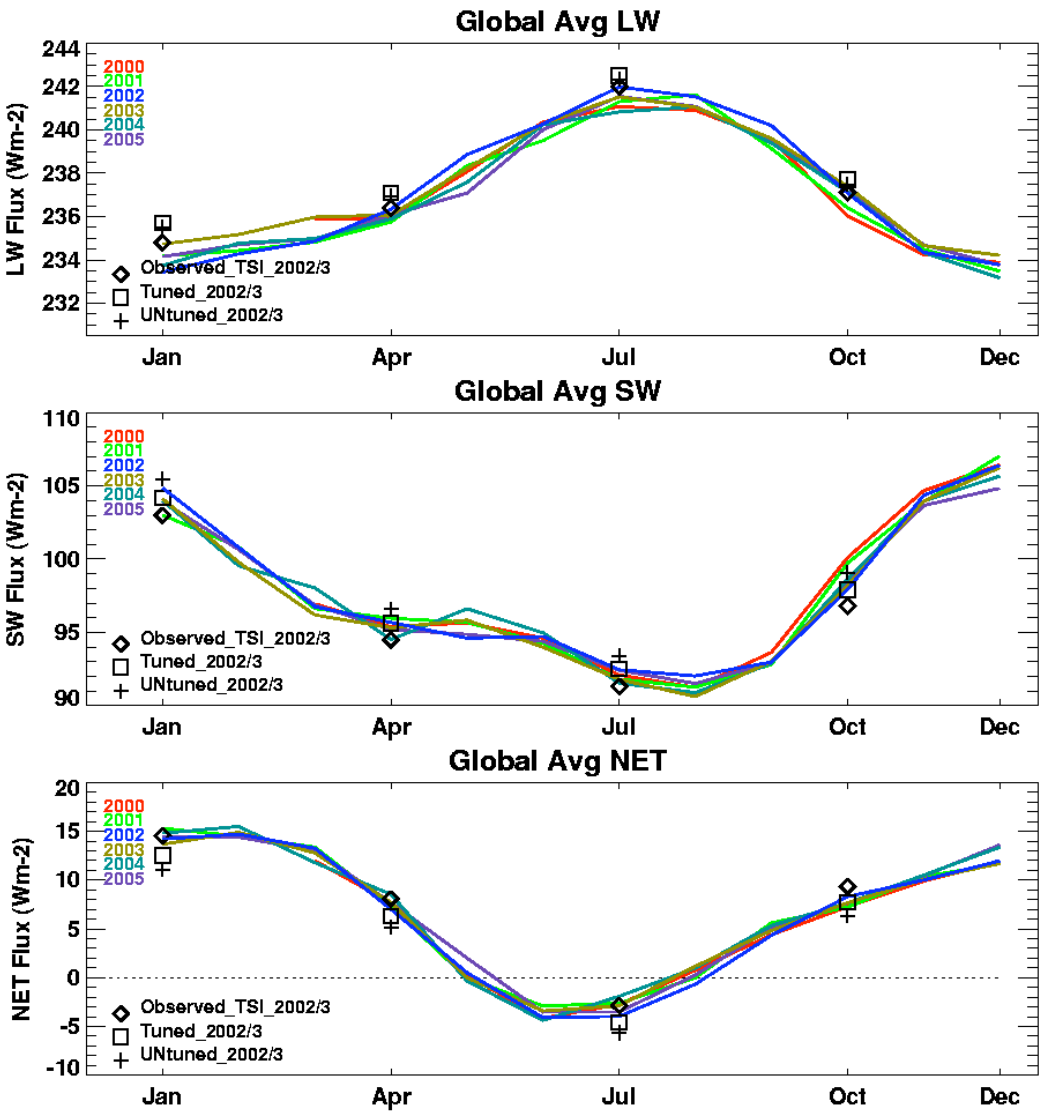
“AVG” TOA Biases & 3hrly Std.Dev.
TOA Net Flux & Components
October 2002



“AVG” TOA Biases & 3hrly Std.Dev.
TOA Net Flux & Components
January 2003



4 Seasonal Months of "AVG" Global: LW,SW,NET Compared to 70 Months of SRBAVG



Longwave	TSI Obs	Tuned	UNtuned
April 2002	236.4	237.1	236.9
July 2002	242.0	242.5	242.3
Oct 2002	237.1	237.7	237.5
Jan 2003	234.8	235.7	235.5

Shortwave	TSI Obs	Tuned	UNtuned
April 2002	94.5	95.6	96.6
July 2002	91.3	92.5	93.4
Oct 2002	96.8	97.9	99.1
Jan 2003	103.0	104.2	105.5

NET	TSI Obs	Tuned	UNtuned
April 2002	8.1	6.3	5.2
July 2002	-2.9	-4.6	-5.7
Oct 2002	9.4	7.7	6.4
Jan 2003	14.6	12.5	11.1
4mthavg	*7.3*	*5.5*	*4.3*

SYN/AVG Flux Profile Tuned Model Outputs

Four Computation Modes

- Pristine toa&sfc only
- All Sky_(CNA) toa&sfc only
- Clear (w/Aerosols)
- All Sky

Deriveable Forcings

- Clear Sky Aerosol Forcing (Pris - Clr)
- All Sky Aerosol Forcing (All - CNA)
- Cloud Forcing (w/Aerosol) (All - Clr)
- Cloud Forcing (w/o) Aerosol (All - Pris)

Upward & Downward Fluxes @ Five Levels for Clear & All Sky

1st <u>Difference</u> *Net* 2nd (*Con+)/(Div-)ergence* 3rd (De-)*Stabilization*

- **TOA**
- 70hpa
- 200hPa
- 500hPa
- **Surface**

4 Layers

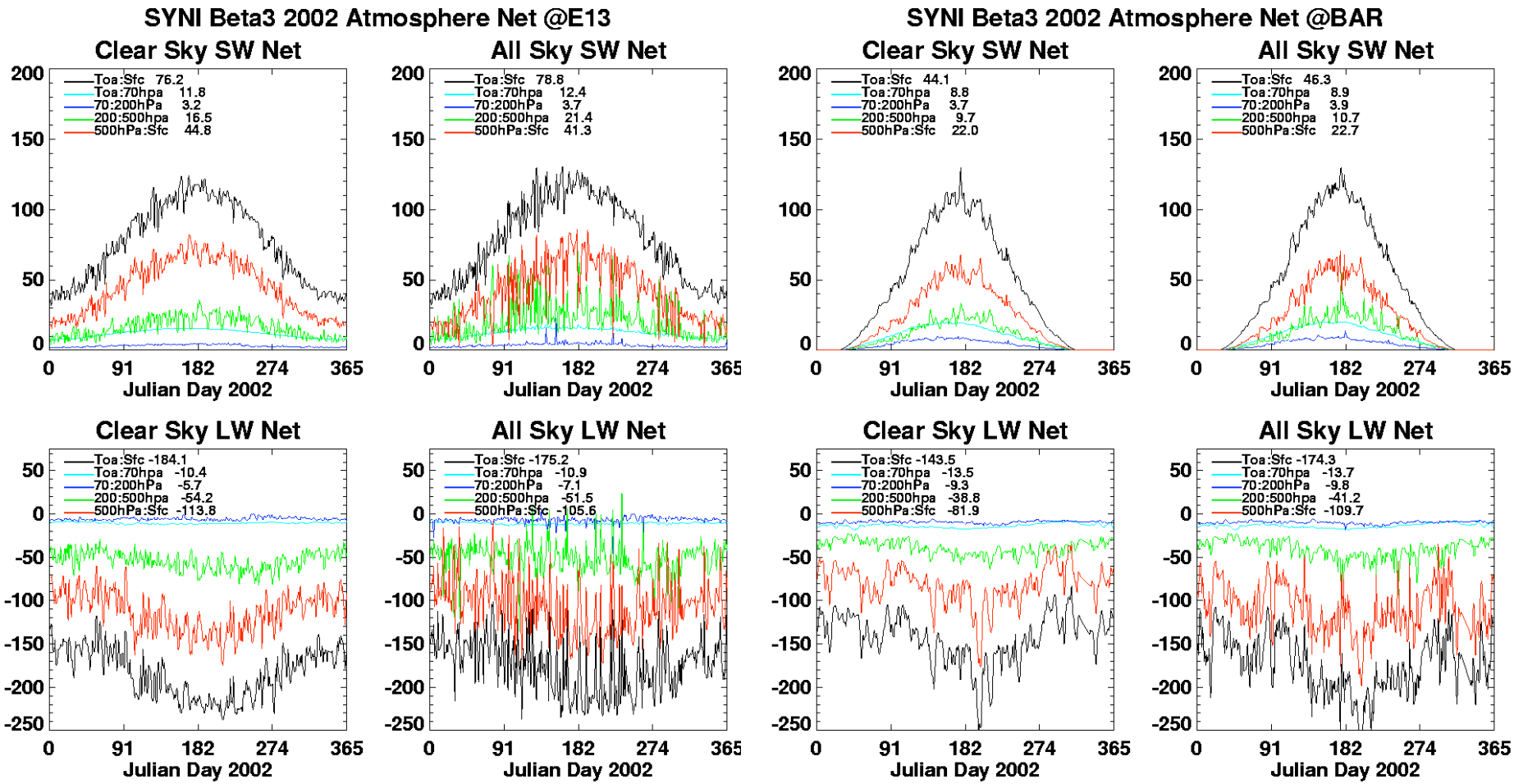
- TOA-70hPa
- 70-200
- 200-500
- 500-SFC

- Upper Troposphere
- Lower Troposphere

Daily Mean Flux Convergence (Layer Net) Yr 2002

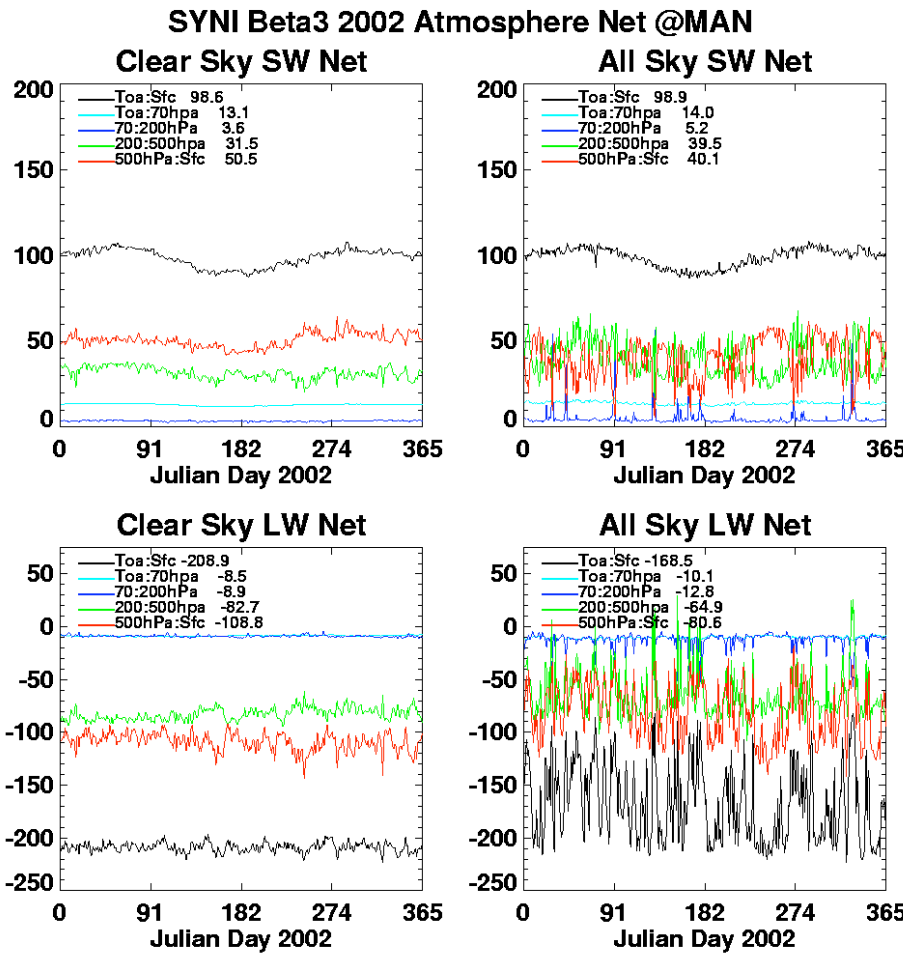
SGP Central Facility

Barrow, Alaska

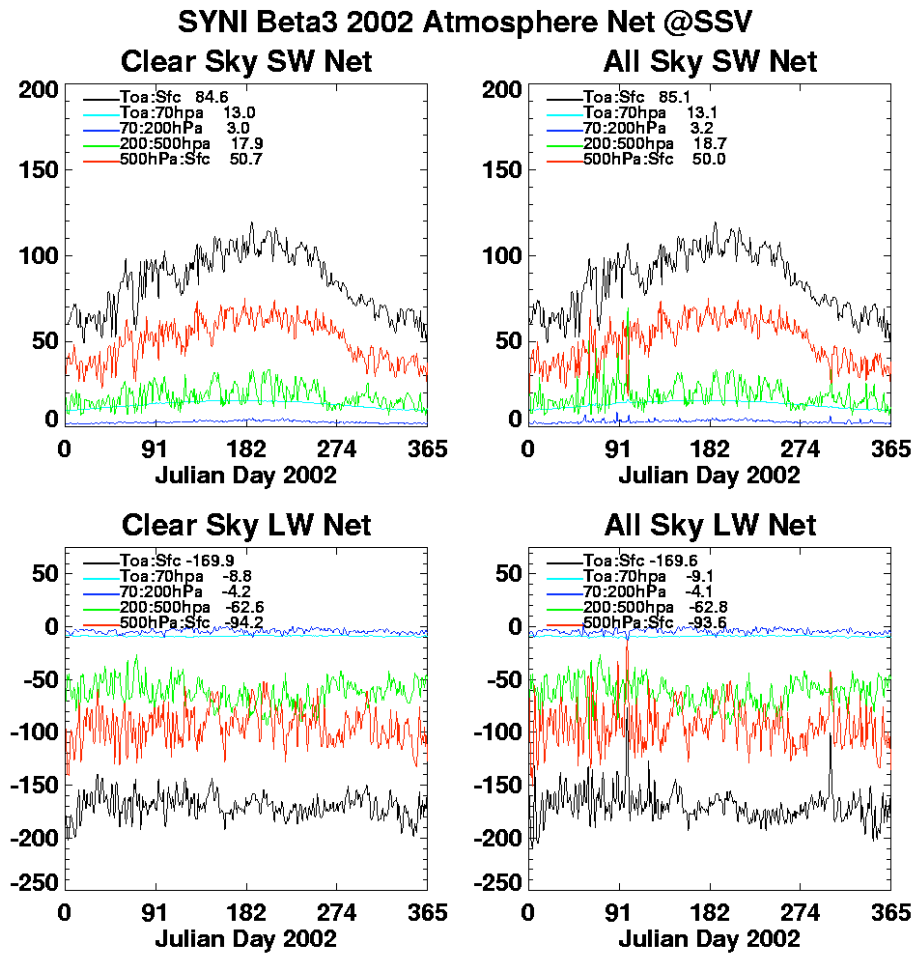


Daily Mean Flux Convergence (Layer Net) Yr 2002

Manus :Warm Pool

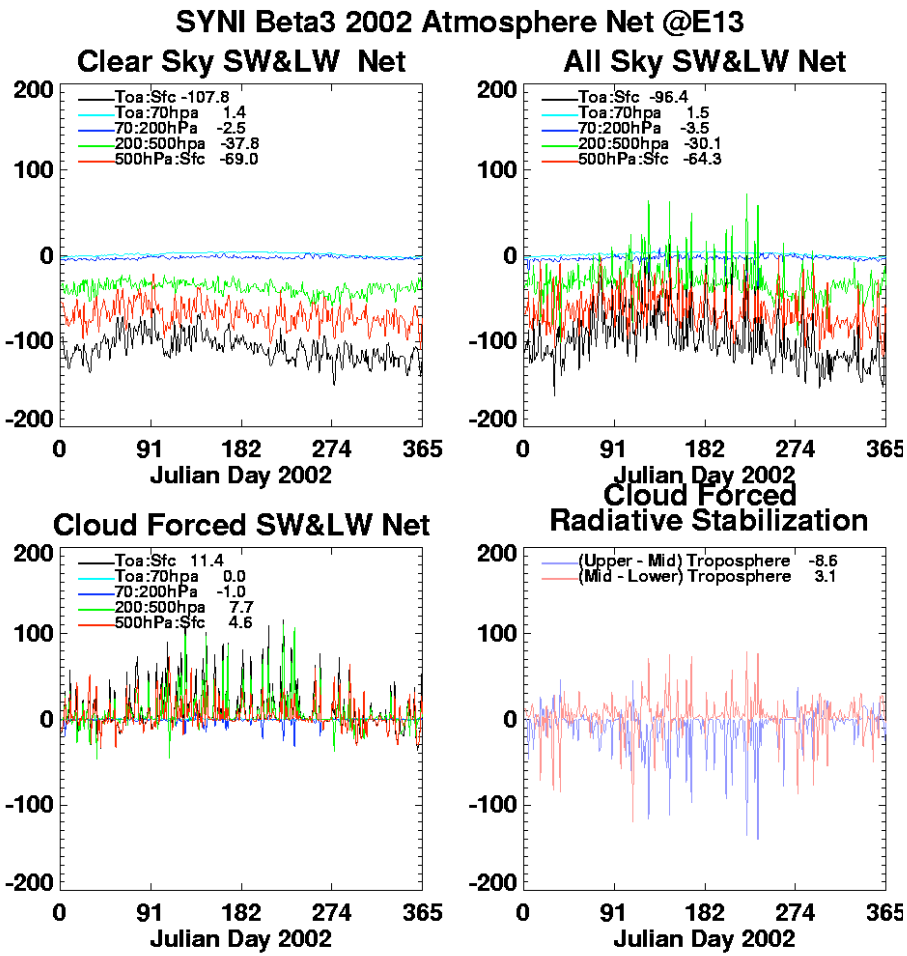


Saudi Solar Village : Desert

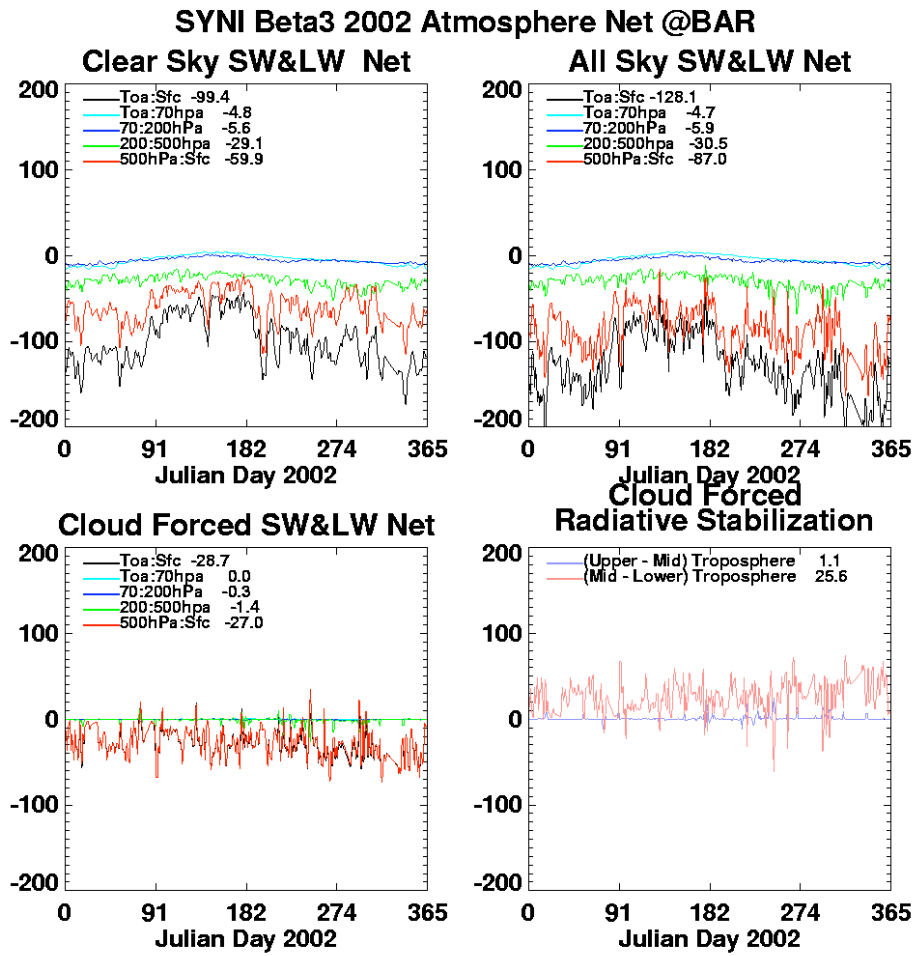


SW&LW Net & Cloud Forced

SGP Central Facility

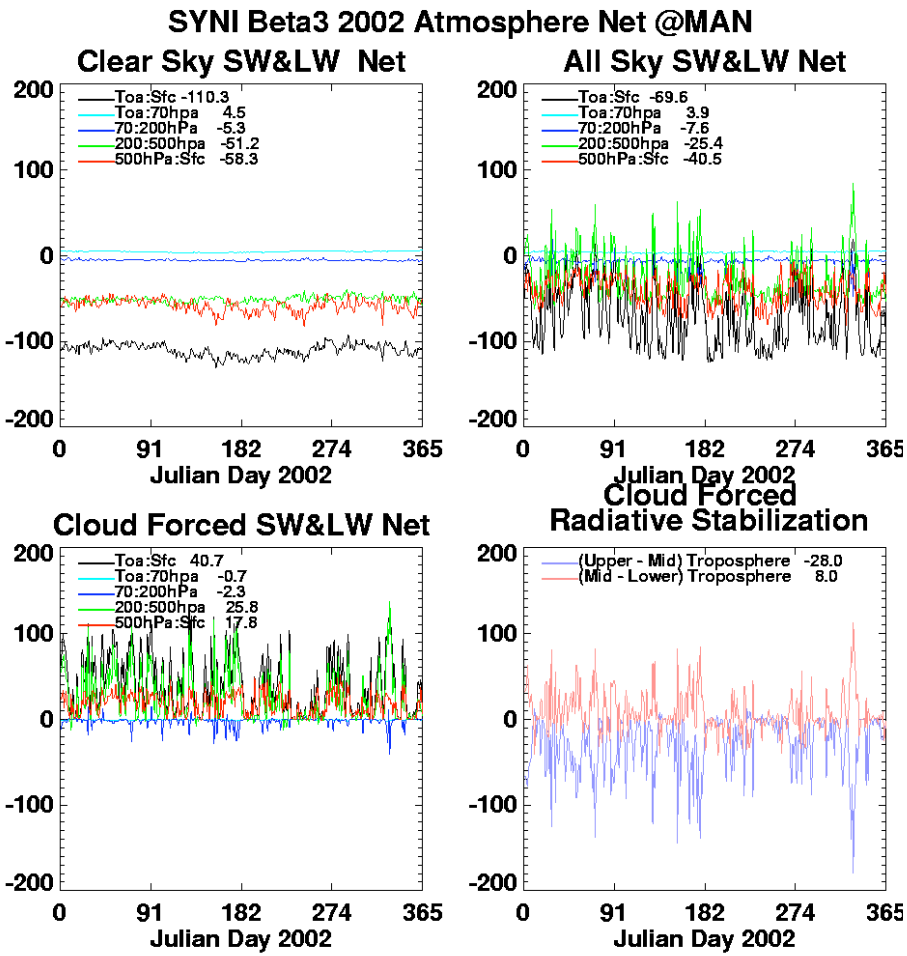


Barrow, Alaska

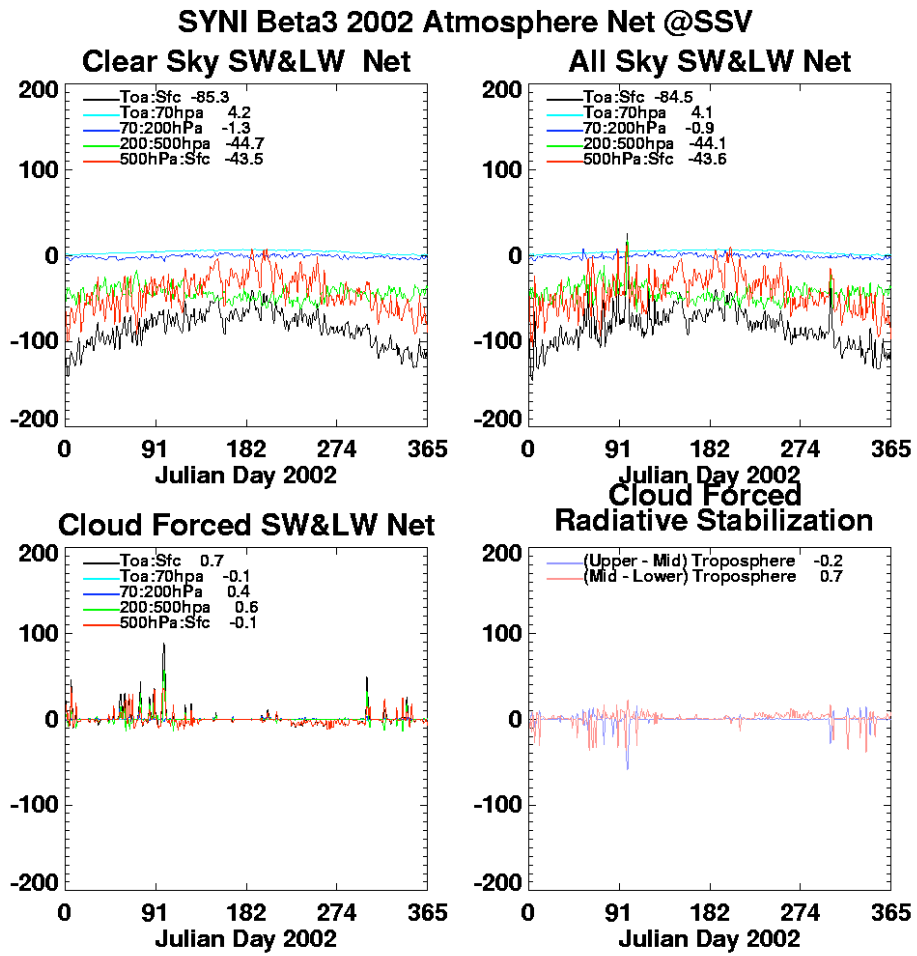


SW&LW Net &Cloud Forced

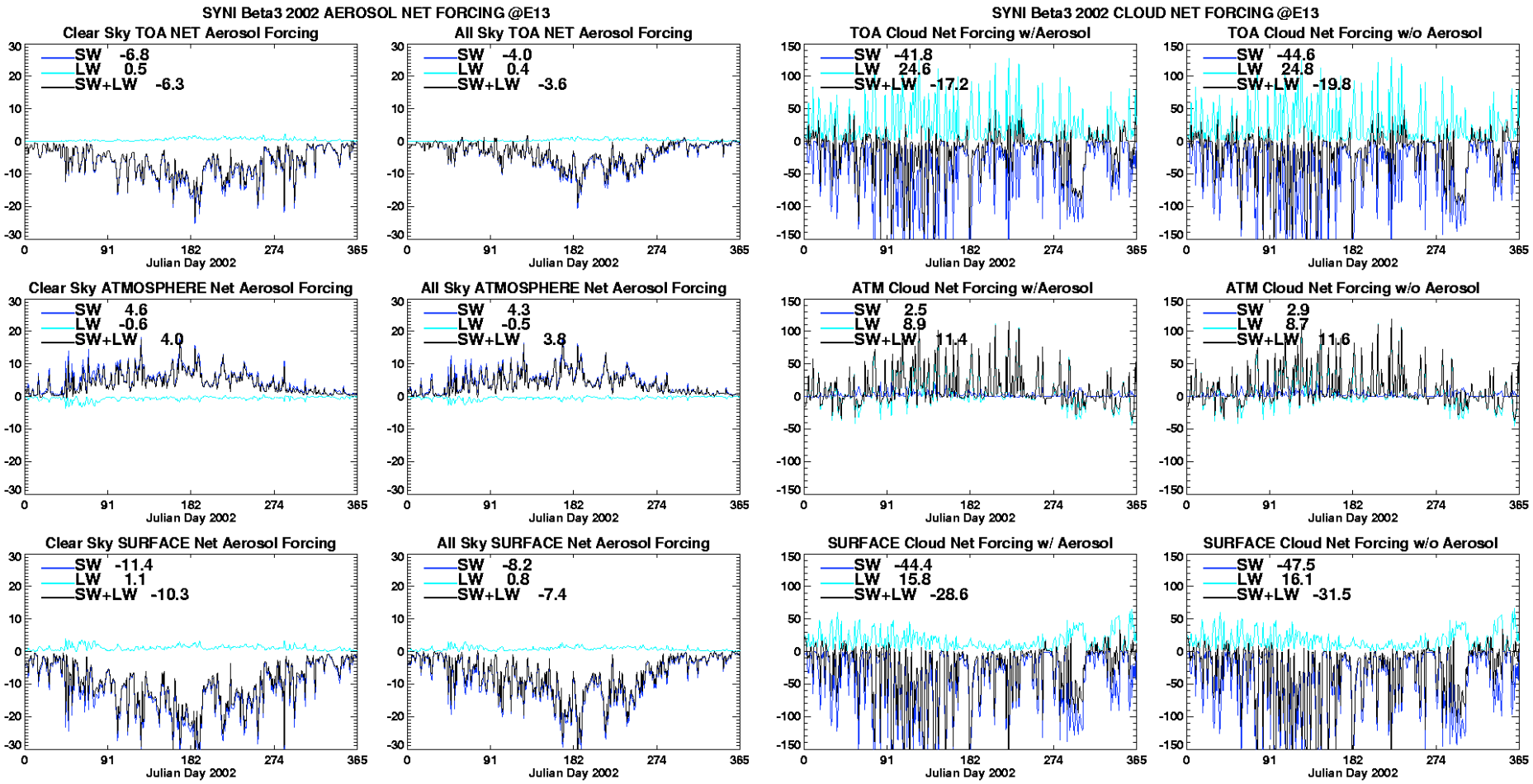
Manus :Warm Pool



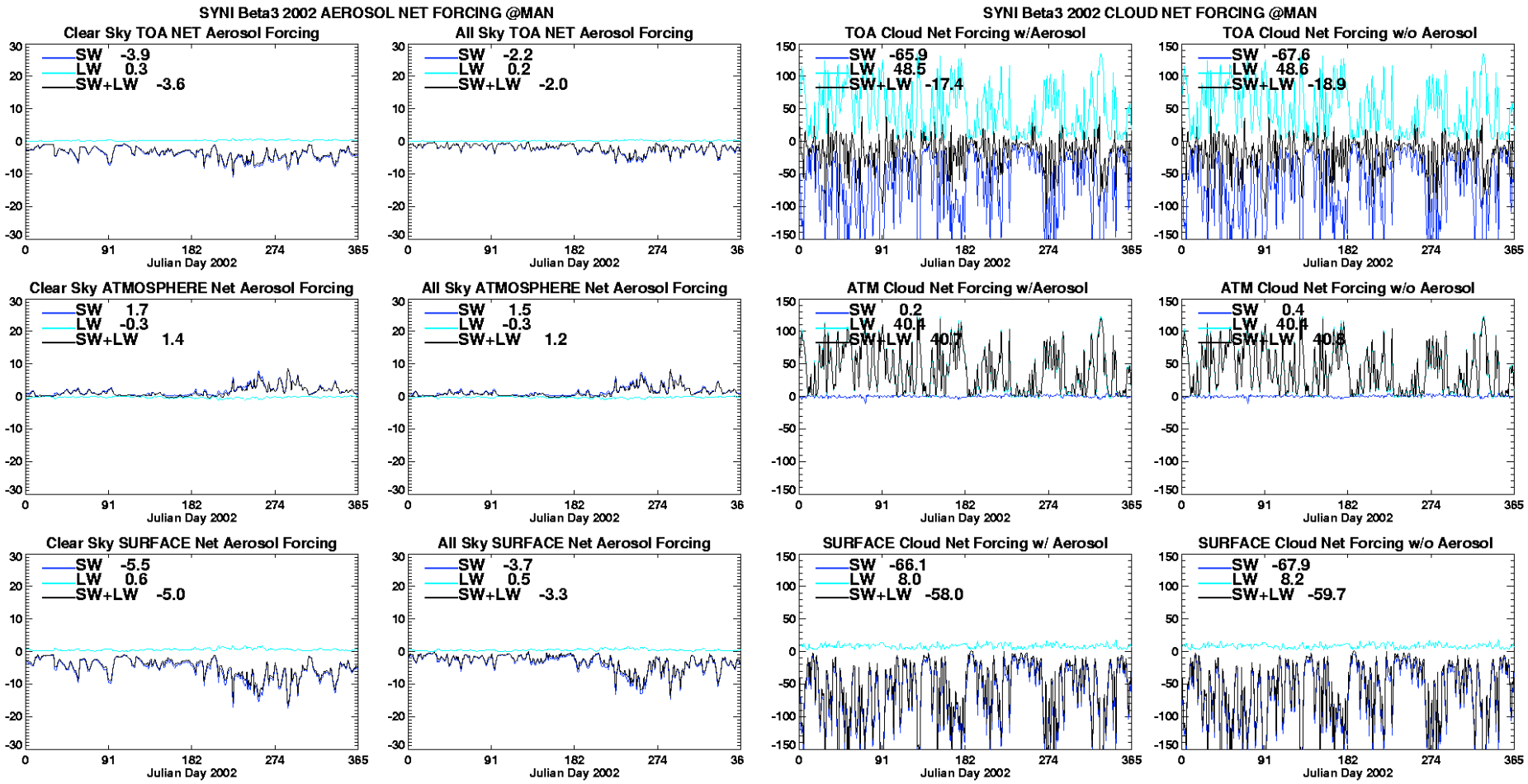
Saudi Solar Village : Desert



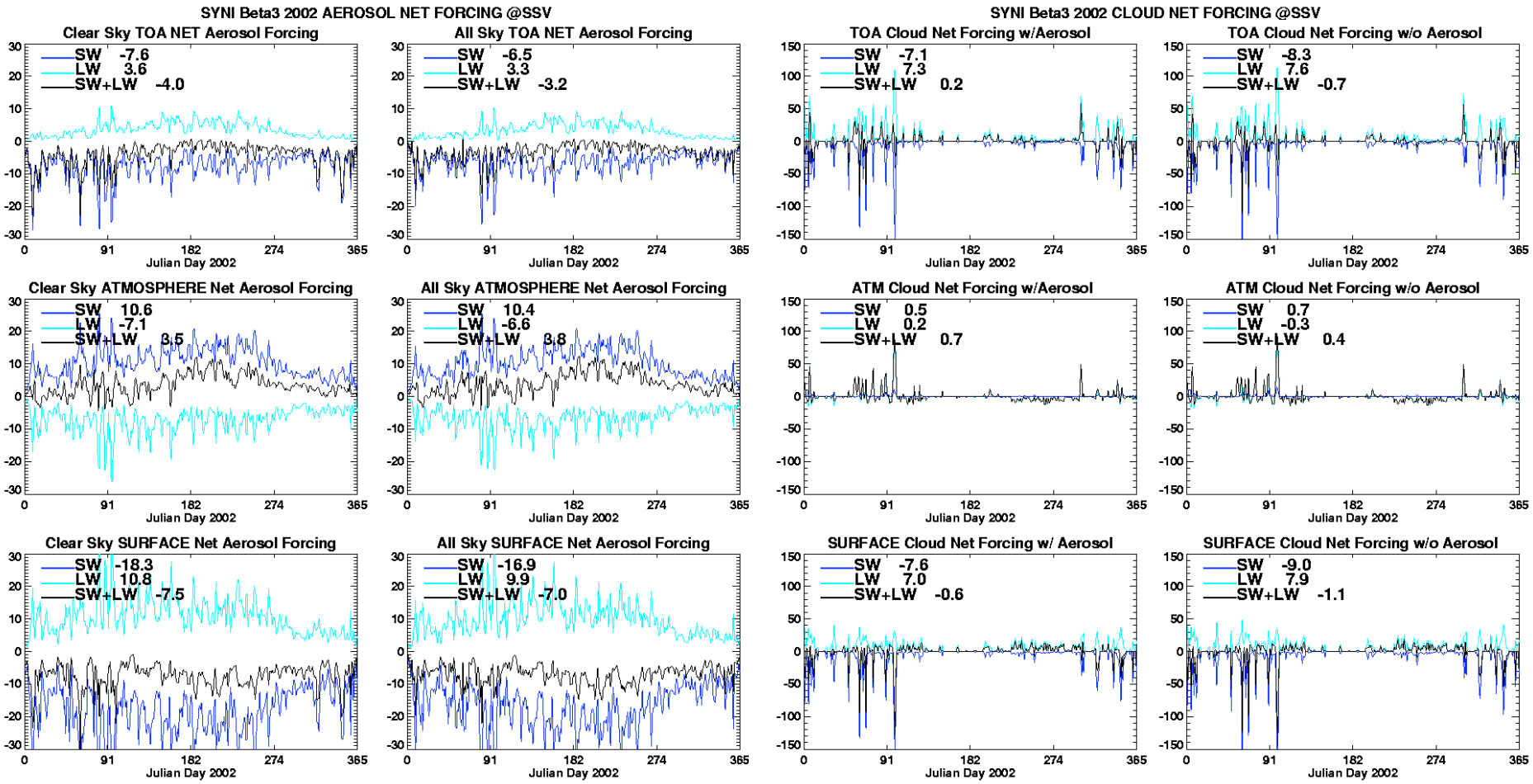
Aerosol Forcing (Clear & All Sky)
Cloud Forcing(Pristine & w/Aerosols)
TOA ,ATM ,SFC
SGP E13



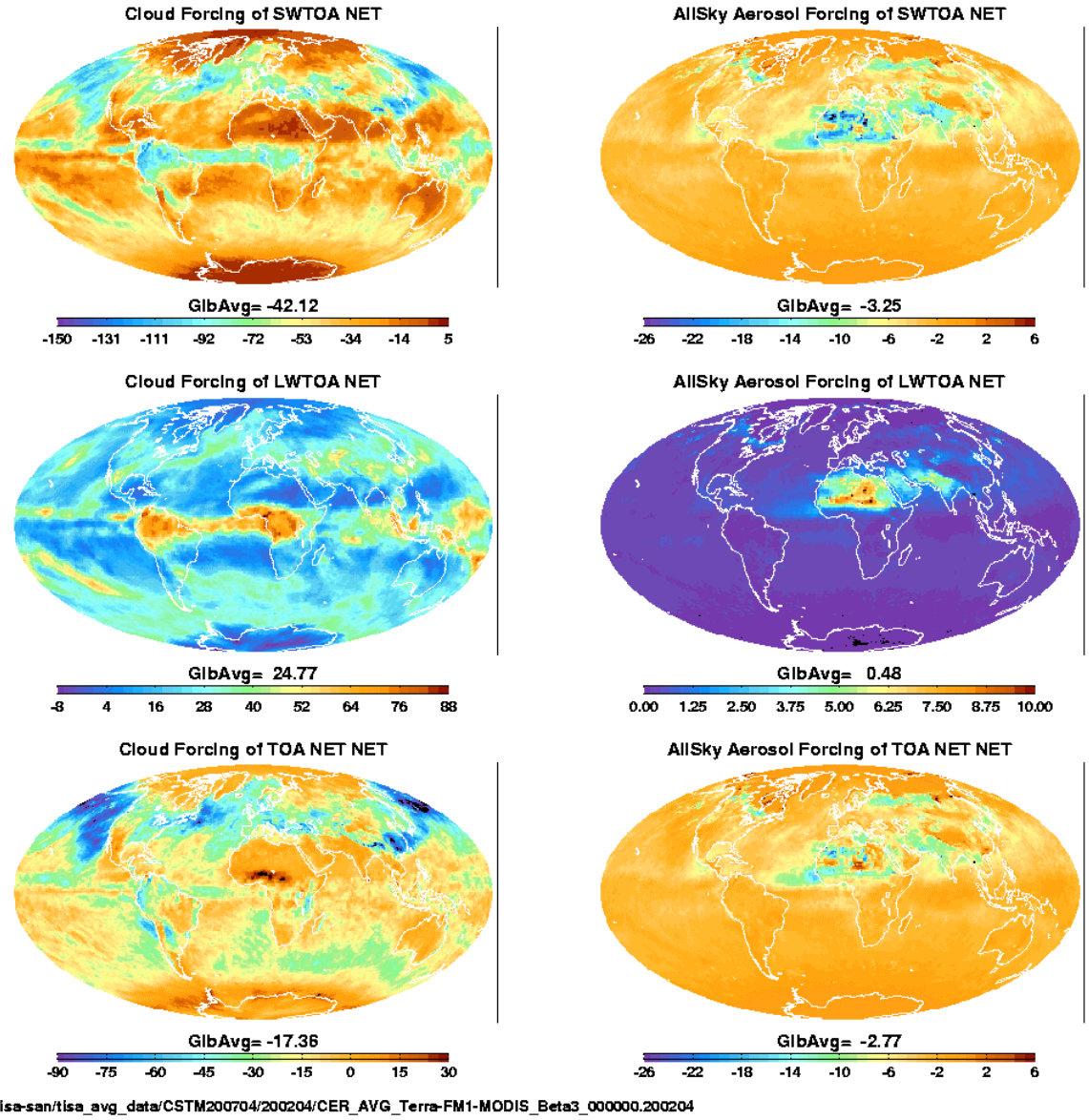
Aerosol Forcing (Clear & All Sky)
Cloud Forcing(Pristine & w/Aerosols)
TOA ,ATM ,SFC
MANUS



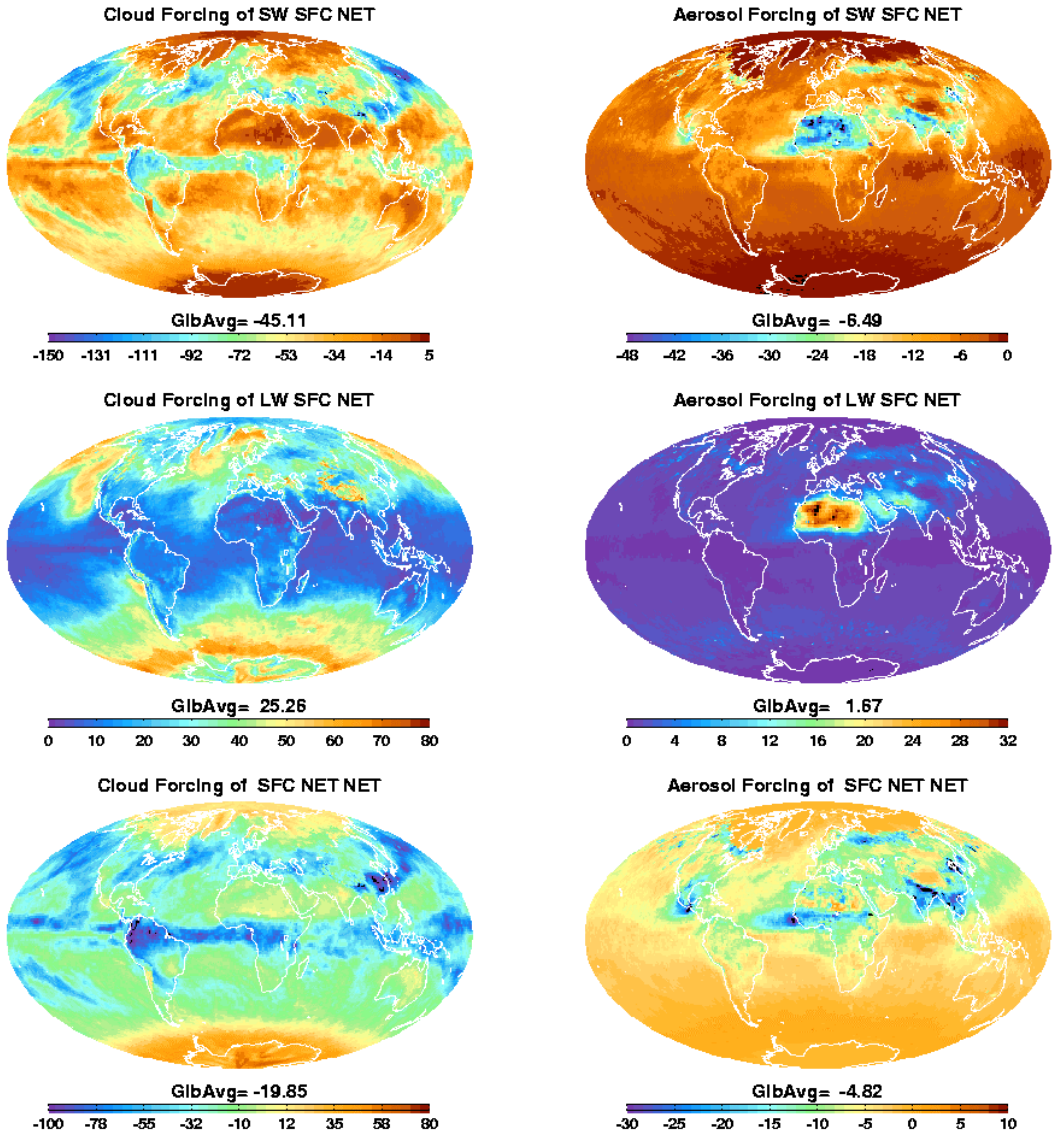
Aerosol Forcing (Clear & All Sky)
Cloud Forcing(Pristine & w/Aerosols)
TOA ,ATM ,SFC
Saudi Solar Village



TOA Cloud & Aerosol Net Forcing Beta3 “AVG” April 2002



Surface Cloud & Aerosol Net Forcing Beta3 “AVG” April 2002



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Beta3 "AVG" Global Mean TOA & Surface Cloud & Aerosol Forcing

TOA Forcing	Cloud SW Net	Cloud LW Net	Cloud SWLW Net	Aerosol SW Net	Aerosol LW Net	Aerosol SwLwNet
Apr 2002	-42.2	24.8	-17.4	-3.3	0.5	-2.8
Jul 2002	-44.1	24.3	-19.8	-3.3	0.6	-2.8
Oct 2002	-45.7	24.5	-21.2	-3.0	0.5	-2.5
Jan 2002	-50.6	24.3	-26.3	-2.6	0.2	-2.4

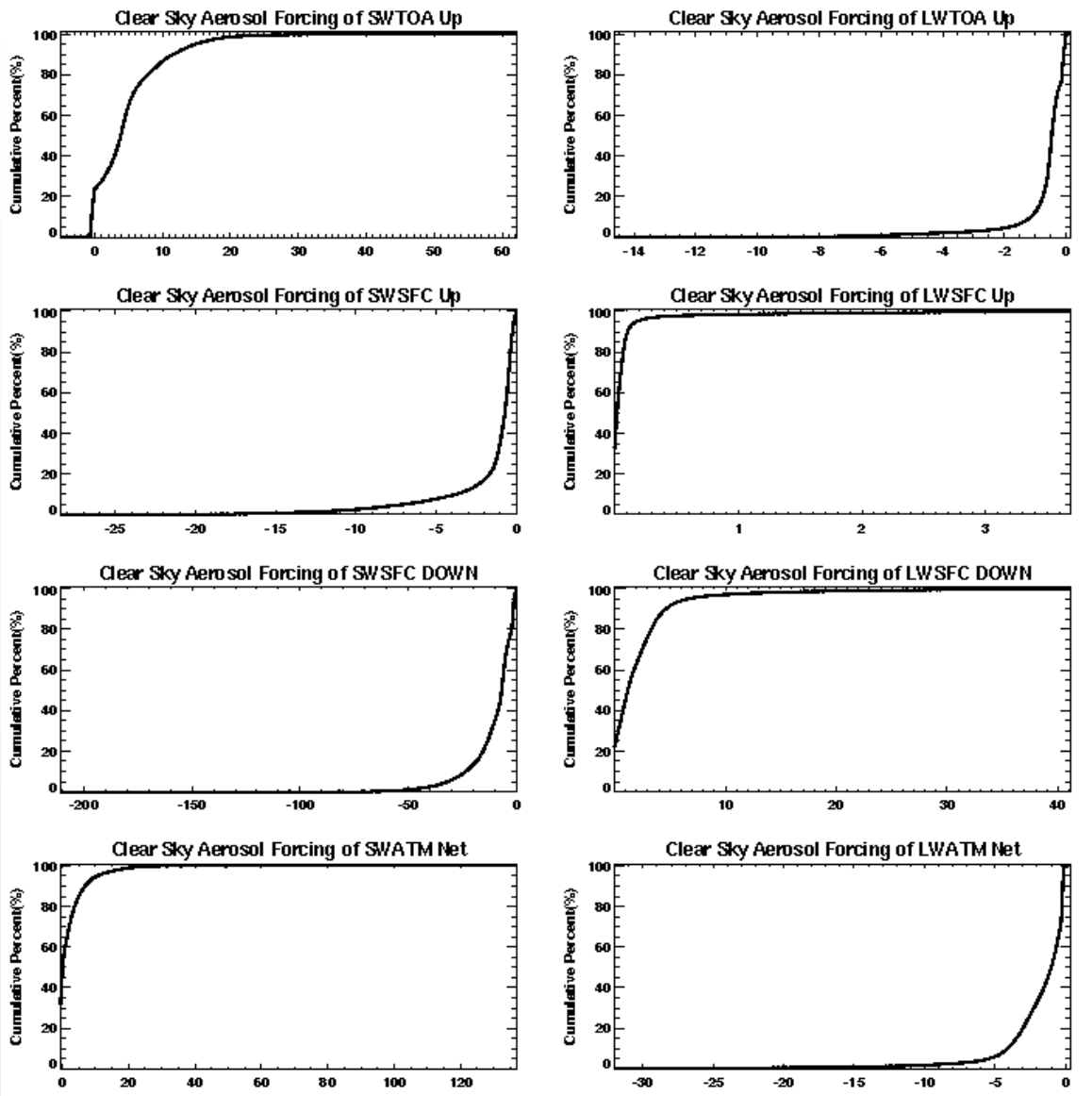
Surface Forcing	Cloud SW Net	Cloud LW Net	Cloud SwLw Net	Aerosol SW Net	Aerosol LW Net	Aerosol SwLwNet
Apr 2002	-45.1	25.3	-19.9	-6.5	1.7	4.8
Jul 2002	-46.9	25.5	-21.4	-7.0	1.4	-5.6
Oct 2002	-49.3	26.9	-22.3	-6.2	1.2	-5.1
Jan 2002	-54.4	26.2	-28.2	-4.9	1.1	-3.8

Summary

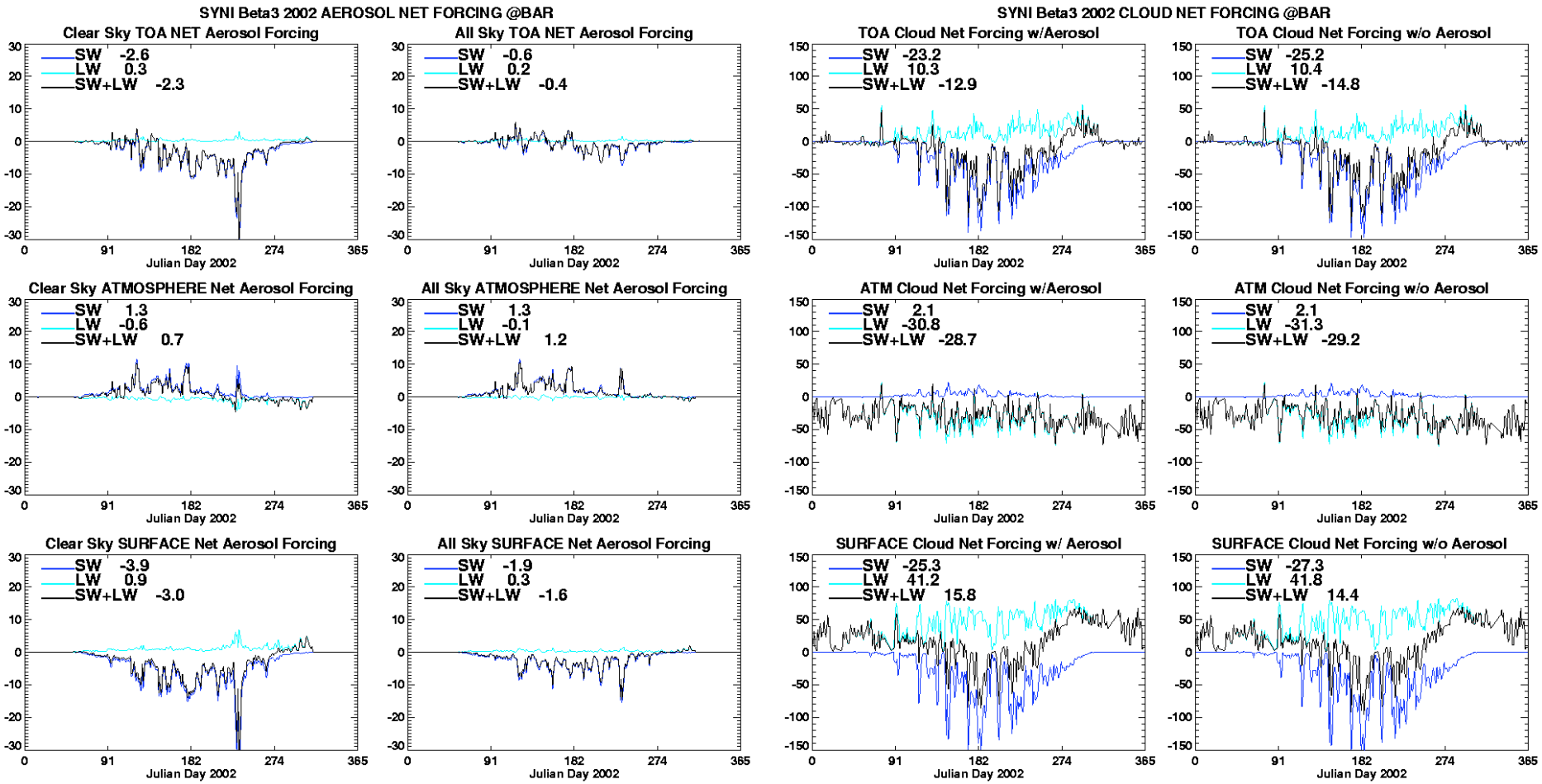
- CERES Beta3 SYNI/SYN/AVG products, *the final branch of the CERES processing scheme,* are validated against surface observations. Good agreement is noted except for surface upwelling flux.
- TOA Net fluxes are similar to SRBAVG for 4 seasonal months .
- Improvements for Beta4 will concentrate on surface albedo and best use of input aerosol products

Extra Slides

Aerosol Forcing Histograms

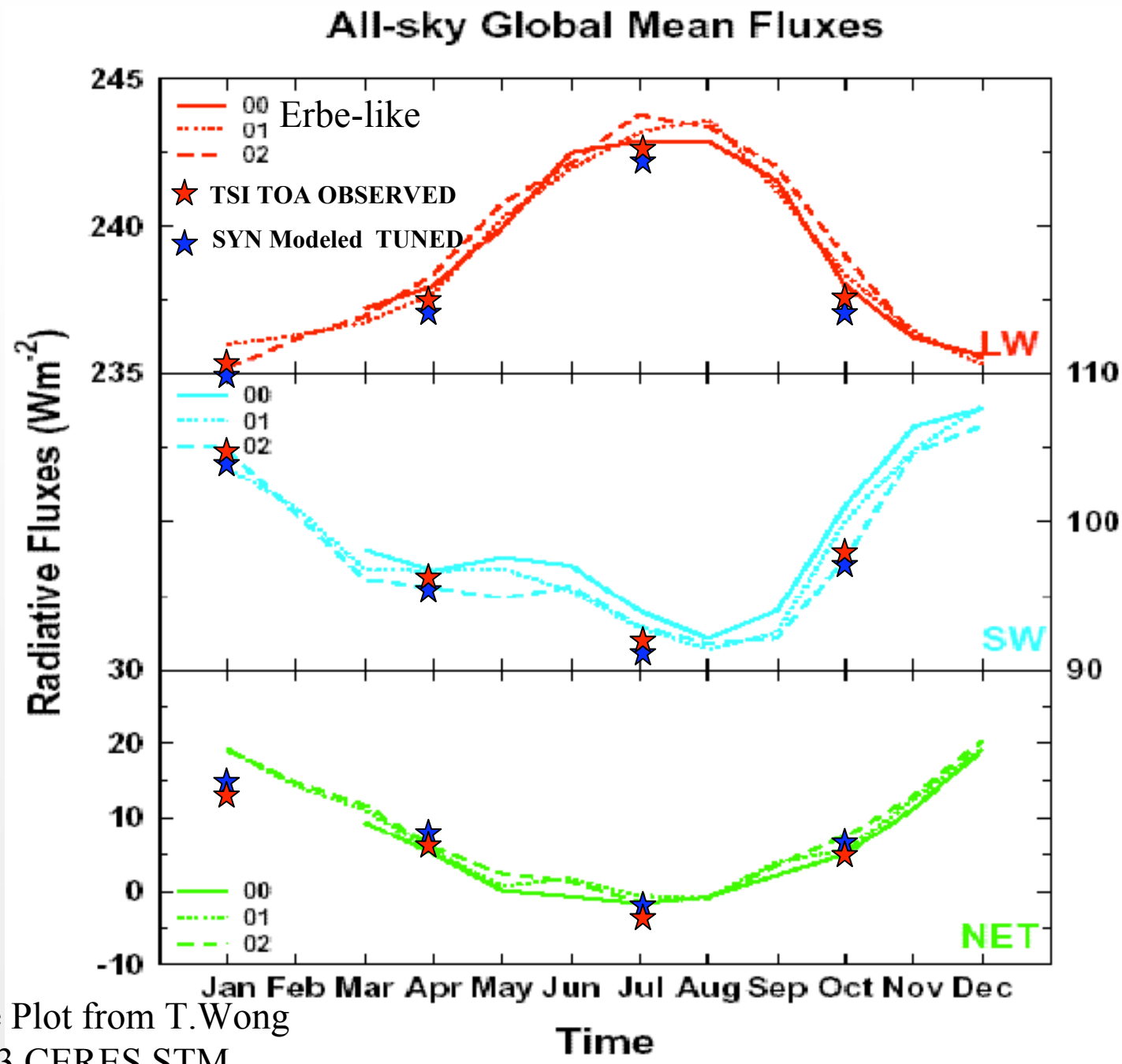


Aerosol Forcing (Clear & All Sky)
Cloud Forcing(Pristine & w/Aerosols)
TOA ,ATM ,SFC
Barrow Alaska



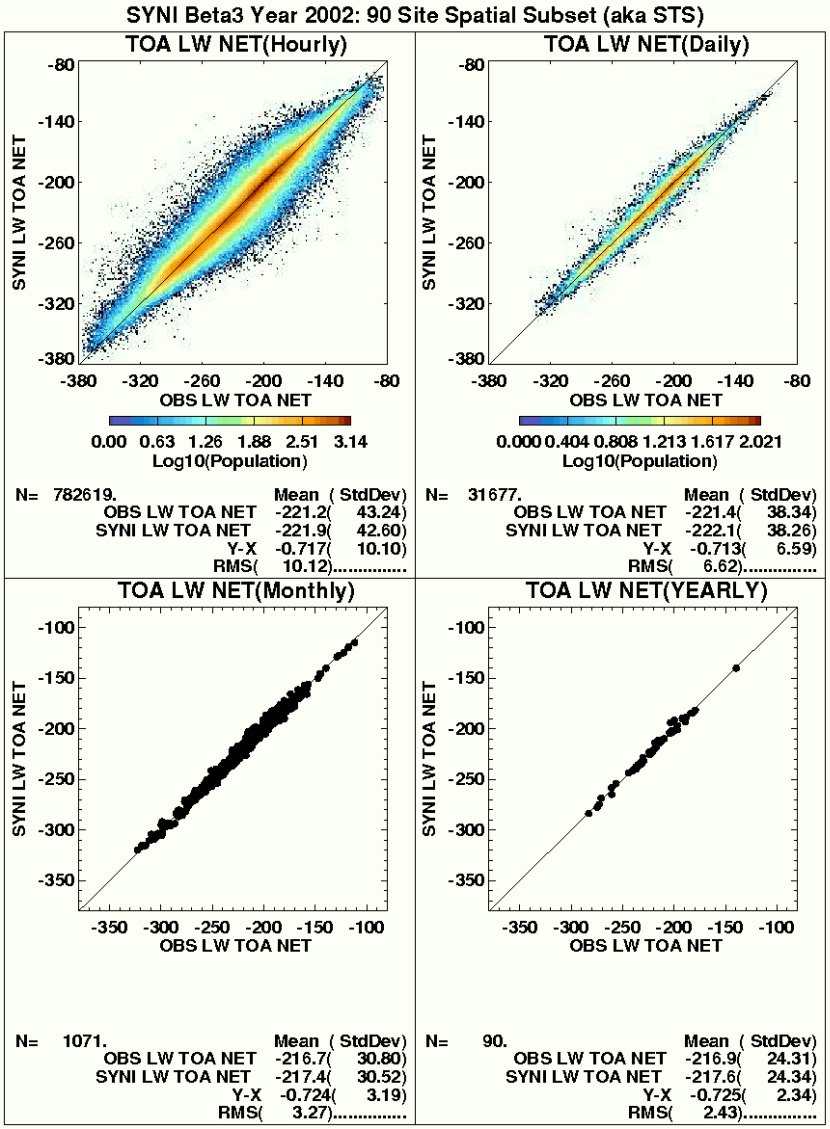
Cloud Forcing Jan03

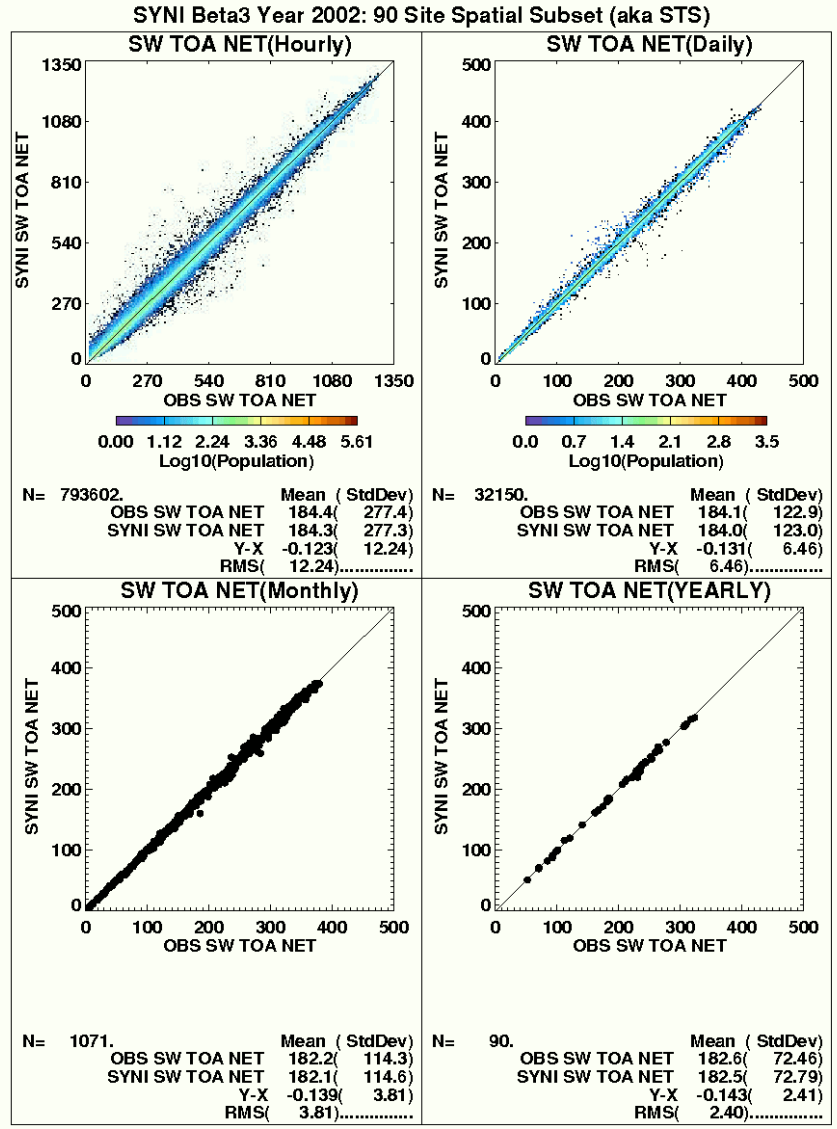
Aerosol Forcing Jan03



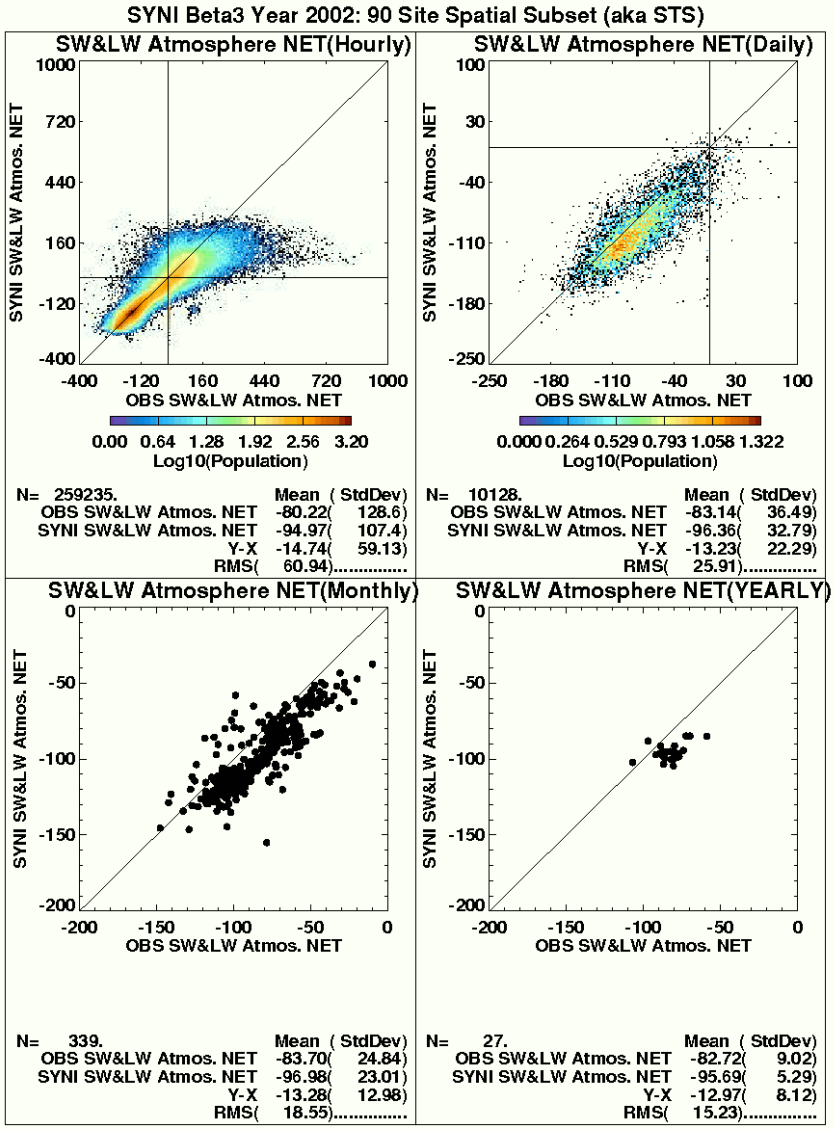
Erbe-like Plot from T.Wong
May 2003 CERES STM

TOA NET (LW & SW)


SYNI Beta3 Year 2002: 90 Site Spatial Subset (aka STS)
TOA LW NET(Hourly)
SYNI LW TOA NET
OBS LW TOA NET
0.00 0.63 1.26 1.88 2.51 3.14
Log10(Population)
N= 782619. Mean (StdDev)
OBS LW TOA NET -221.2(43.24)
SYNI LW TOA NET -221.9(42.60)
Y-X -0.717(10.10)
RMS(10.12).....
TOA LW NET(Daily)
0.000 0.404 0.808 1.213 1.617 2.021
N= 31677. Mean (StdDev)
OBS LW TOA NET -221.4(38.34)
SYNI LW TOA NET -222.1(38.26)
Y-X -0.713(6.59)
RMS(6.62).....
TOA LW NET(Monthly)
N= 1071. Mean (StdDev)
OBS LW TOA NET -216.7(30.80)
SYNI LW TOA NET -217.4(30.52)
Y-X -0.724(3.19)
RMS(3.27).....
TOA LW NET(YEARLY)
N= 90. Mean (StdDev)
OBS LW TOA NET -216.9(24.31)
SYNI LW TOA NET -217.6(24.34)
Y-X -0.725(2.34)
RMS(2.43).....

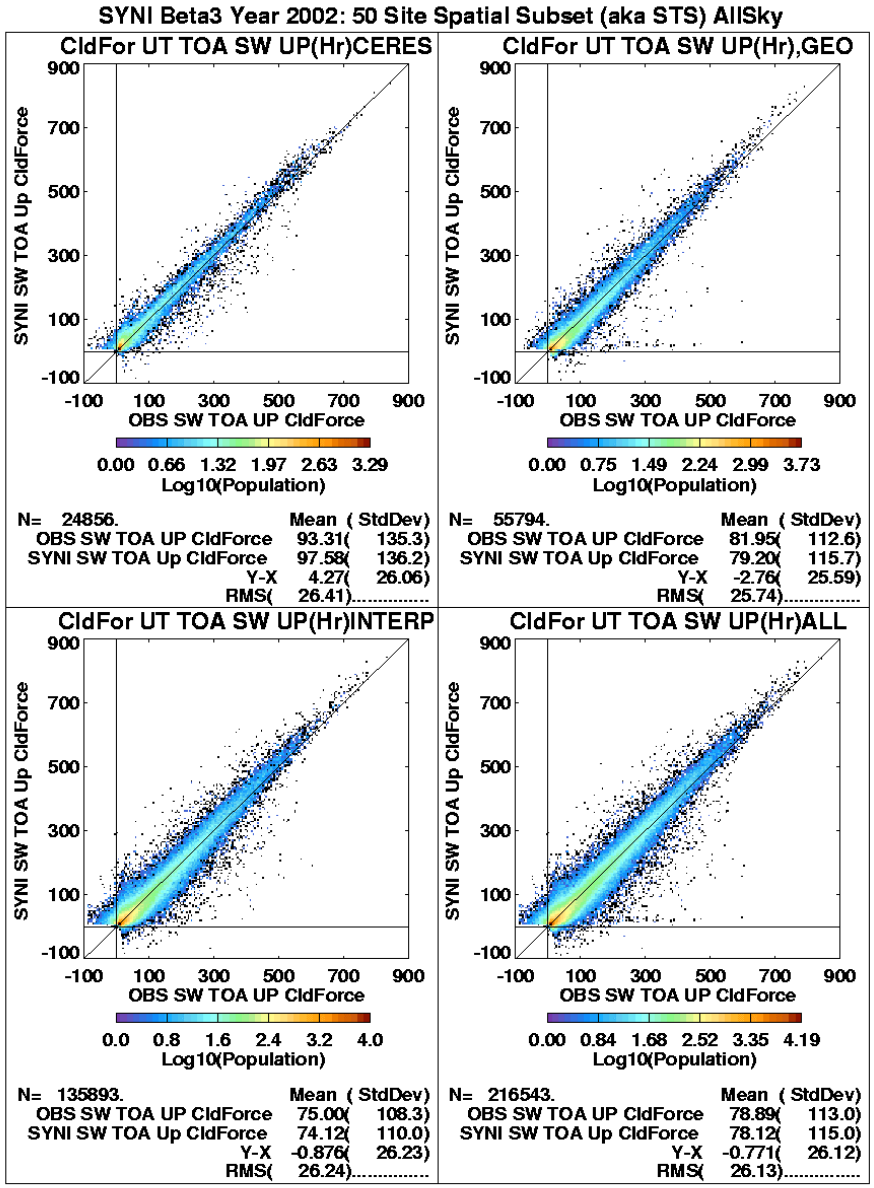

SYNI Beta3 Year 2002: 90 Site Spatial Subset (aka STS)
SW TOA NET(Hourly)
SYNI SW TOA NET
OBS SW TOA NET
0.00 1.12 2.24 3.36 4.48 5.61
Log10(Population)
N= 793602. Mean (StdDev)
OBS SW TOA NET 184.4(277.4)
SYNI SW TOA NET 184.3(277.3)
Y-X -0.123(12.24)
RMS(12.24).....
SW TOA NET(Daily)
0.0 0.7 1.4 2.1 2.8 3.5
N= 32150. Mean (StdDev)
OBS SW TOA NET 184.1(122.9)
SYNI SW TOA NET 184.0(123.0)
Y-X -0.131(6.46)
RMS(6.46).....
SW TOA NET(Monthly)
N= 1071. Mean (StdDev)
OBS SW TOA NET 182.2(114.3)
SYNI SW TOA NET 182.1(114.6)
Y-X -0.139(3.81)
RMS(3.81).....
SW TOA NET(YEARLY)
N= 90. Mean (StdDev)
OBS SW TOA NET 182.6(72.46)
SYNI SW TOA NET 182.5(72.79)
Y-X -0.143(2.41)
RMS(2.40).....

All Wave Atmosphere Net



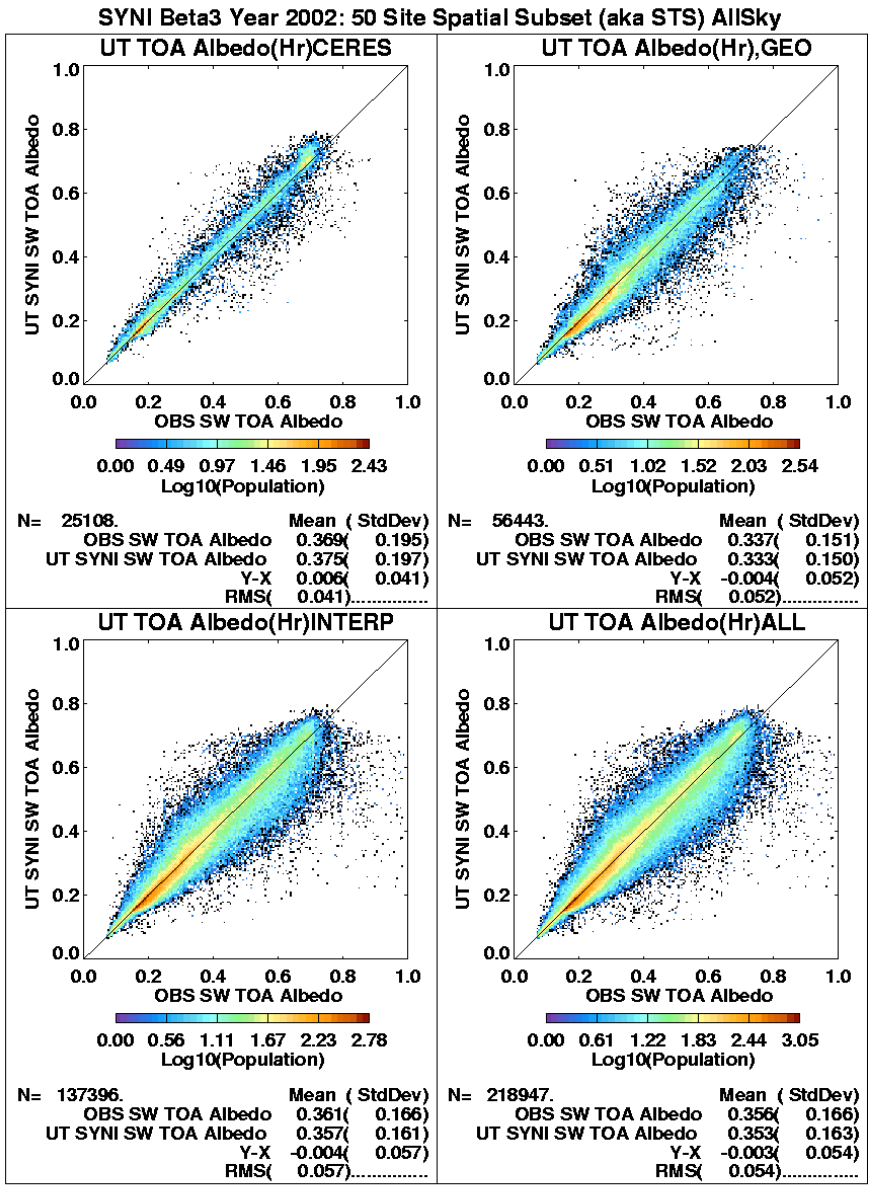
Cld Forced SW Flux

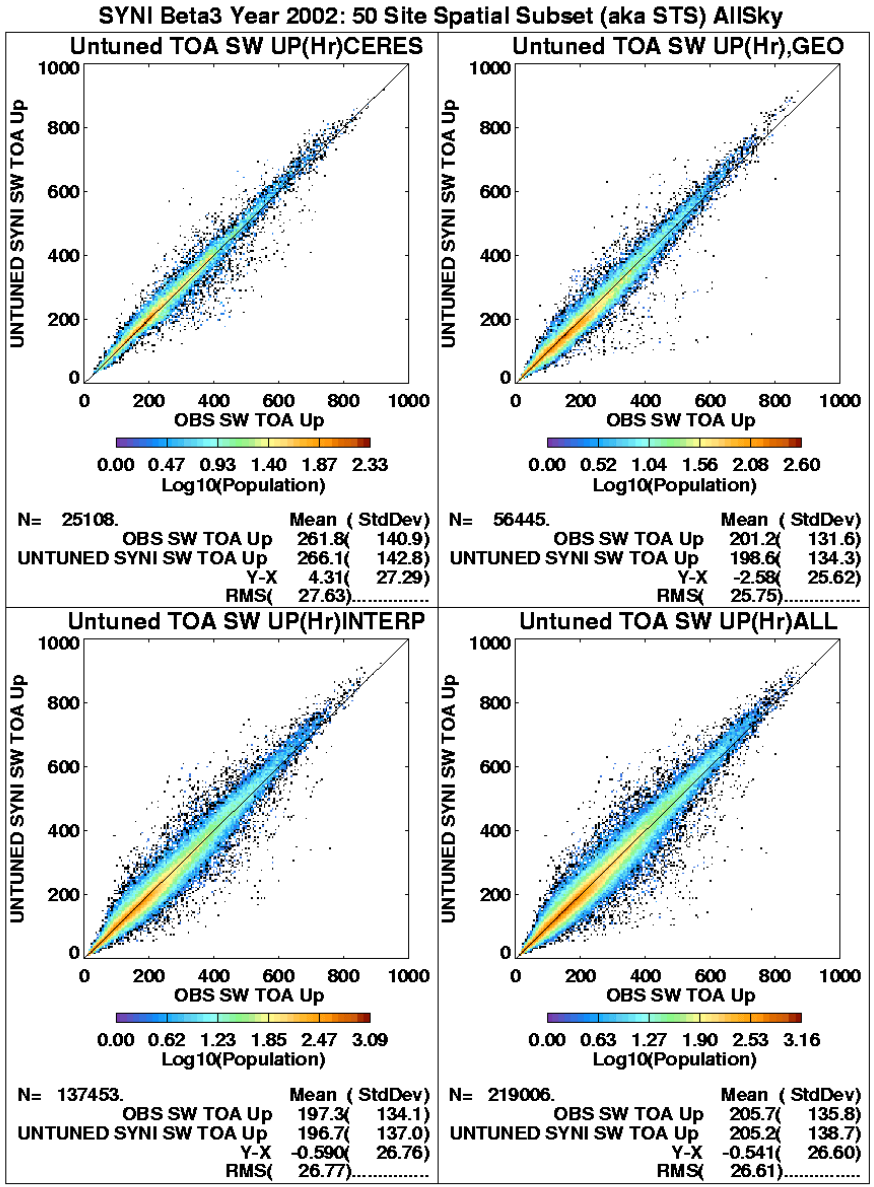
Cloud Forced SW Flux	Model - Obs	RMS
CERES	4.3	26.4
GEO	-2.8	25.7
Intrp	-0.9	26.2
All	-0.8	26.1



Albedo

Untuned Albedo	Model - Obs	RMS
CERES	.006	.041
GEO	-.004	.052
Intrp	-.004	.057
All	-.003	.054



SW Flux

Untuned SW Flux	Model - Obs	RMS
CERES	4.3	27.6
GEO	-2.6	25.7
Intrp	-0.6	26.7
All	-0.5	26.5