CERES TSI/SYNI/AVG STATUS

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10th CERES-II Science Team Meeting

October 27-29 2008

Goddard Institute Space Science

New York, NY

Outline

- Product Introduction
- Model vs. Observed (Agreement?)
- TSI <31 day per month bug (Fixed !)
- Global Mean TOA Flux (Net Balance ?)
- Validation Spatial Subset
  - Hourly, Daily, Monthly & Station Averages
  - UVB and PAR
- Beta4_AVG “content survey”
- PAR compared with SeaWiFS product
- Atmosphere radiation budget
  - AVG Product and NCAR/NCAR Reanalysis

SYNI Product *What is it?*

Global Hourly

- 1 x 1deg Equal Area Grid N=44012

Fu-Liou Radiative Transfer

- Broadband SW,LW
- TOA, surface and atmosphere

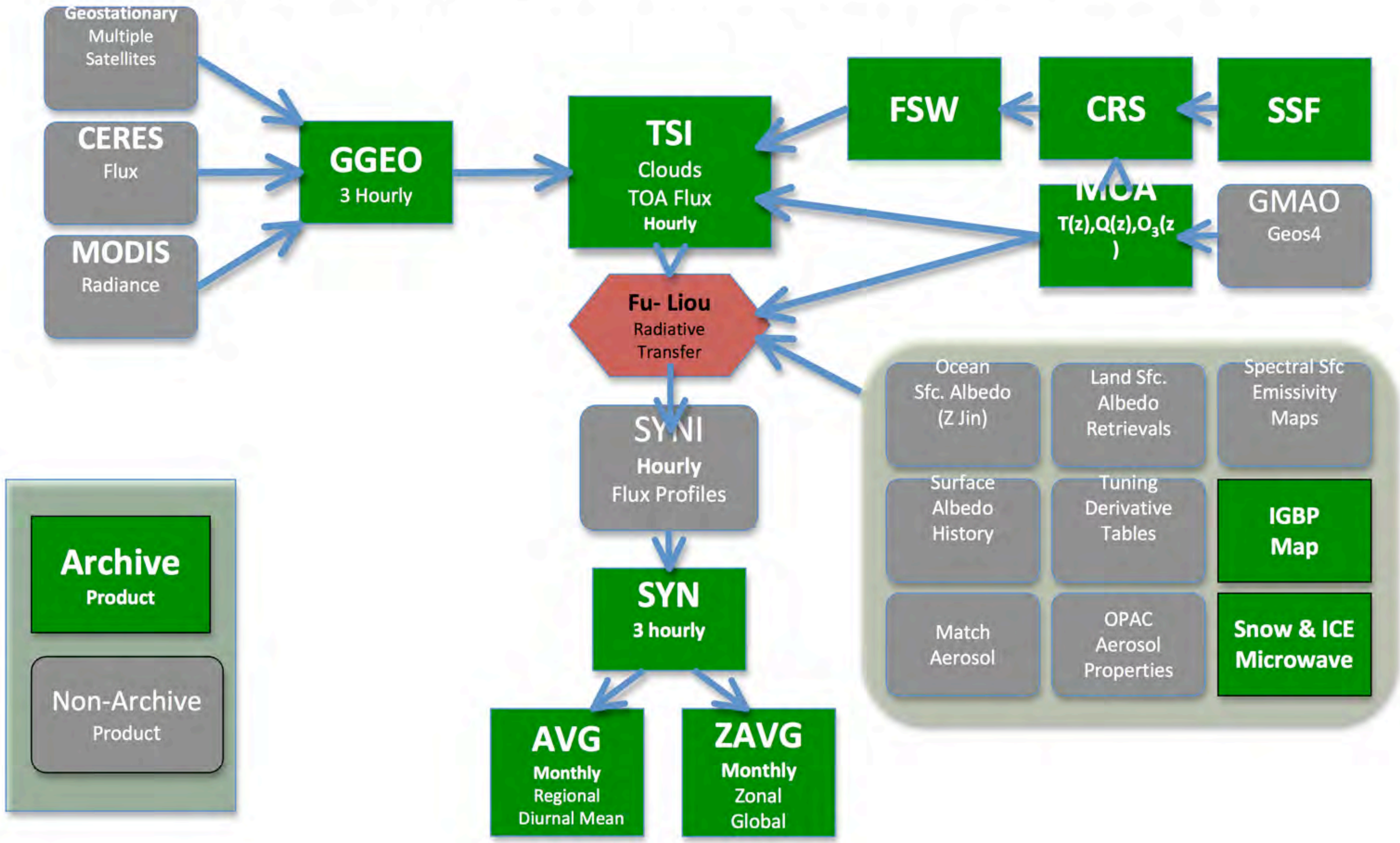
TSI Input product for SYNI

- CERES (~12 hourly)
- MODIS (~12 hourly)
- Geostationary (3 hourly)
  - Normalized to CERES for TOA Fluxes
  - Geostationary radiances calibrated to MODIS
  - Cloud Properties
    - Fraction, height, *optical depth, phase, particle size*

Other major input products for SYNI

- GEOS4 Temperature & Humidity
- SMOBA Ozone
- MODIS and MATCH AOTs , MATCH constituents / OPAC properties
- Daily Microwave Snow & Ice

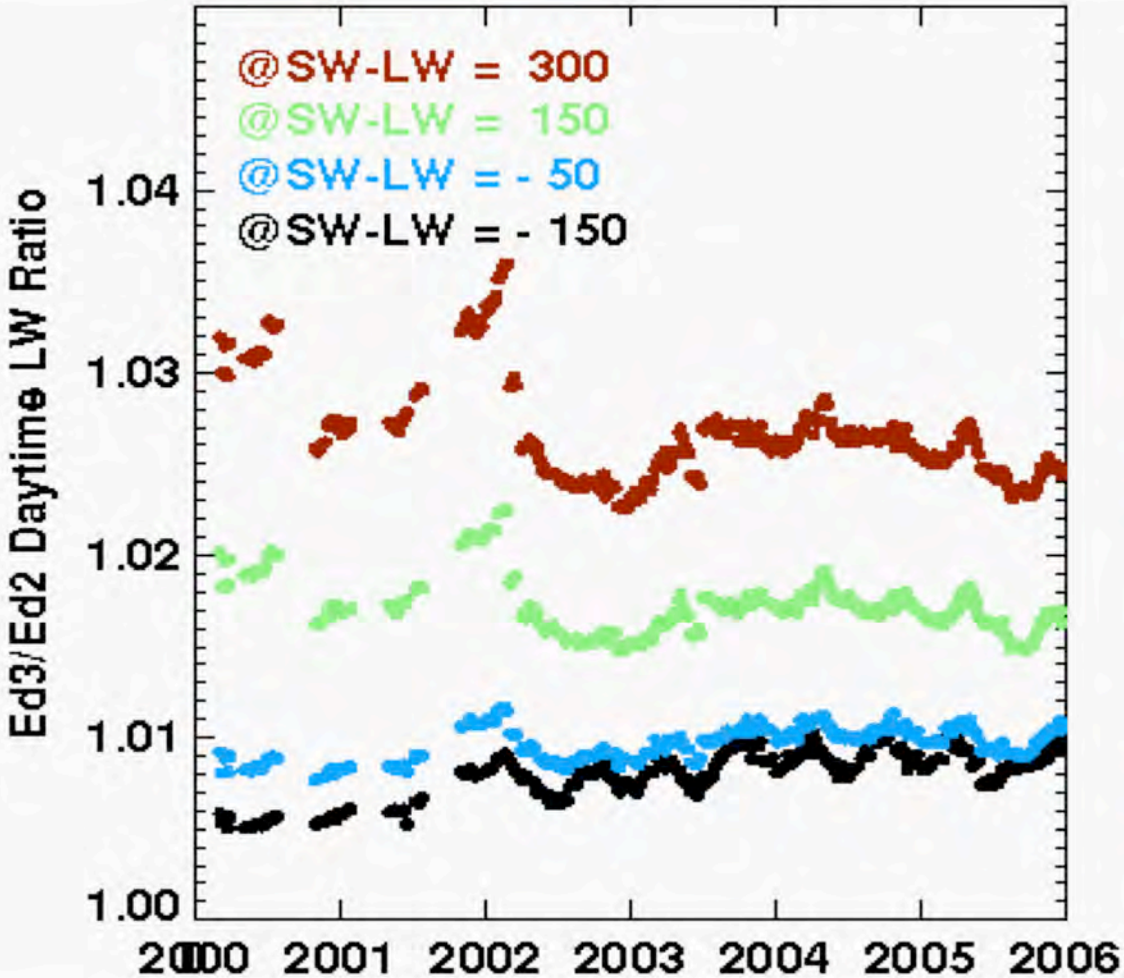
TSI/SYNI/AVG PRODUCT FLOW



Fu-Liou Code for SYNI

- 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 : 29 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 [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 ,Dge)
  - 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

Daytime Longwave Correction
FM1 Trends as function of SW *minus* LW value



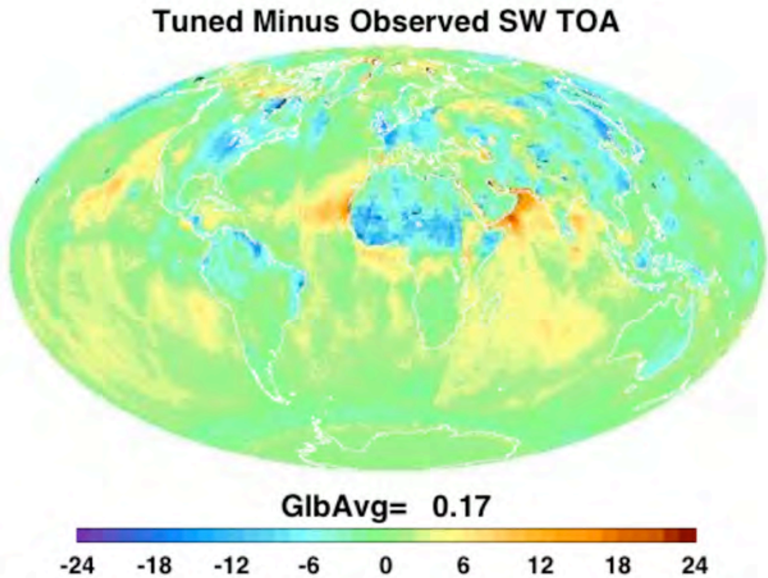
TIME (Year)

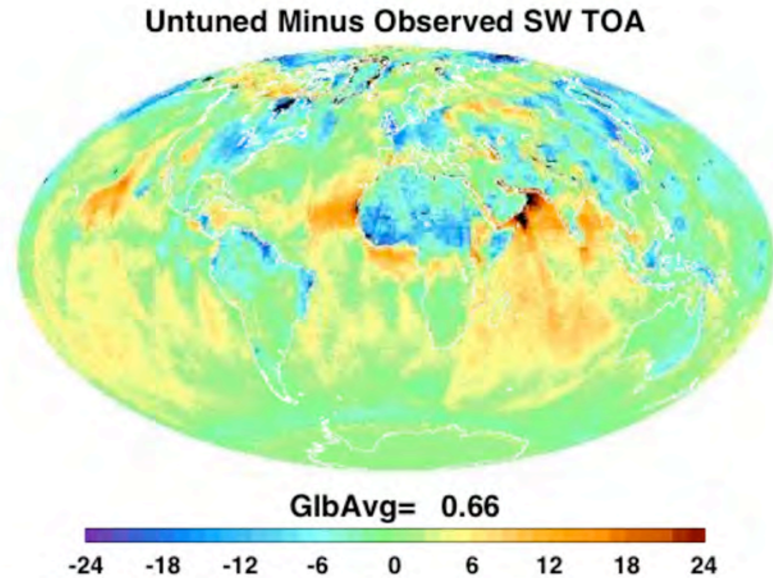
Correction Ratio always positive: *Increasing mean OLR by about 1%*

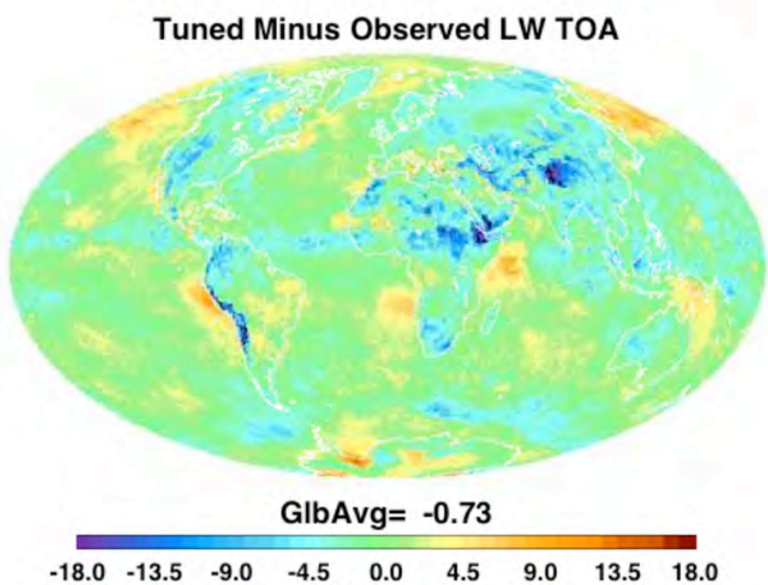
Bright/Cold scenes correction <u>decreases</u> <u>with time</u>

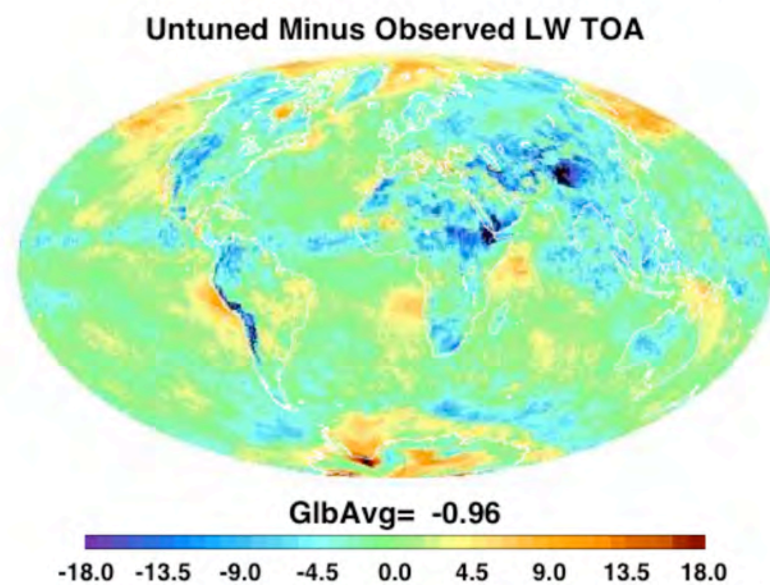
Dark/Warm scenes correction <u>increases</u> <u>with time</u>

Beta4 “AVG” July 2004
TOA Model – Observed [Wm^{-2}]

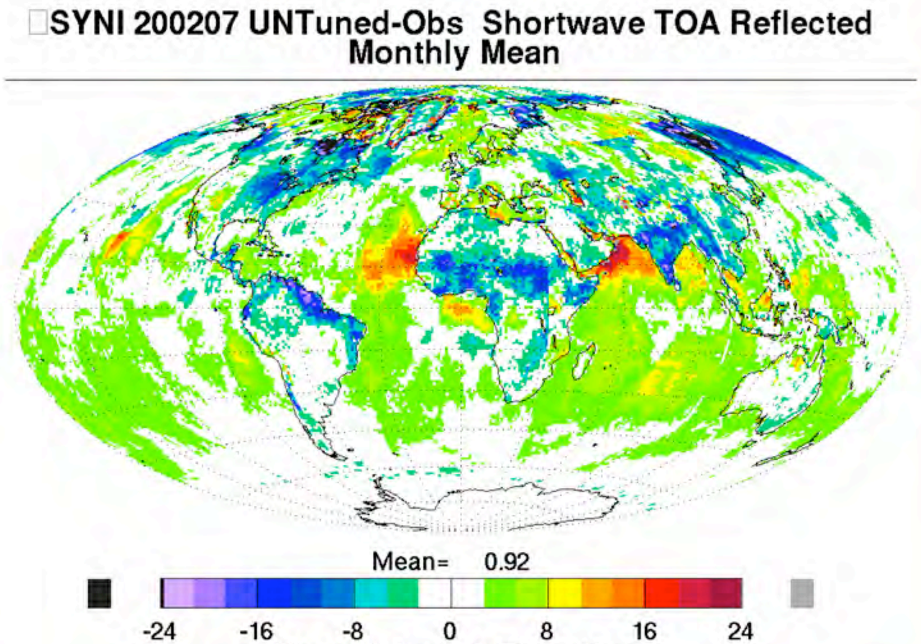






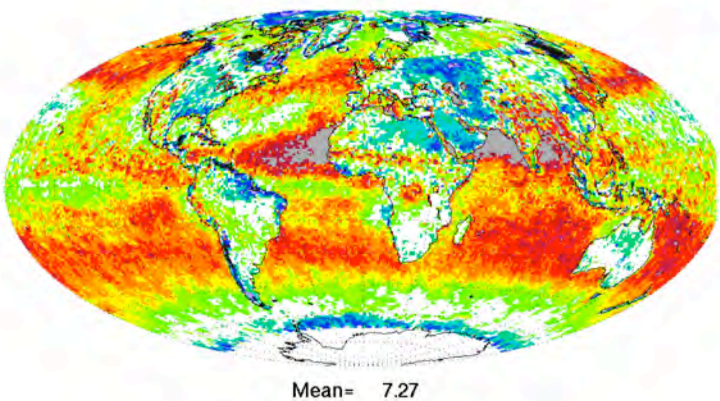


UNtuned-Observed SW TOA [Wm^{-2}] July 02

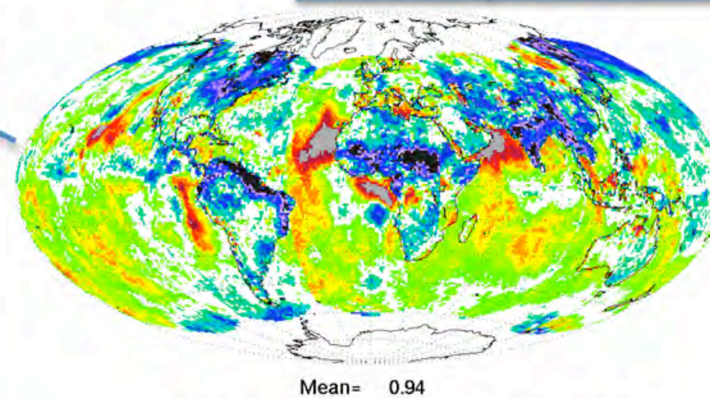


Combined Daytime
~12 hr/day

Global Mean Shortwave TOA Untuned -Obs	
All	**0.92** wm-2 **.001** albedo
CERES	7.27 (.007)
GEO	0.94 (.002)
Interp	0.65 (.0009)

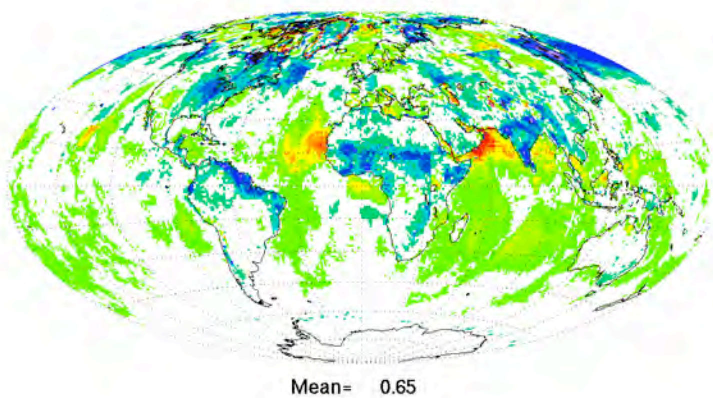


CERES Flux
~1 hr/day
MODIS Multispectral
Clouds

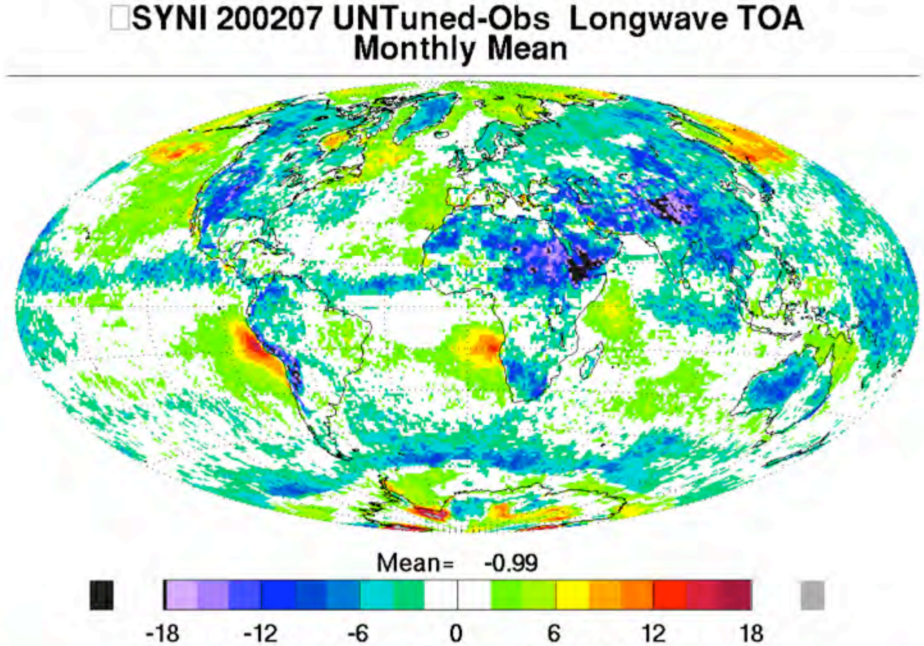


Geostationary NB/BB
Flux
~3 hr/day
Vis/Ir Clouds

Interpolated
~7 hr/day

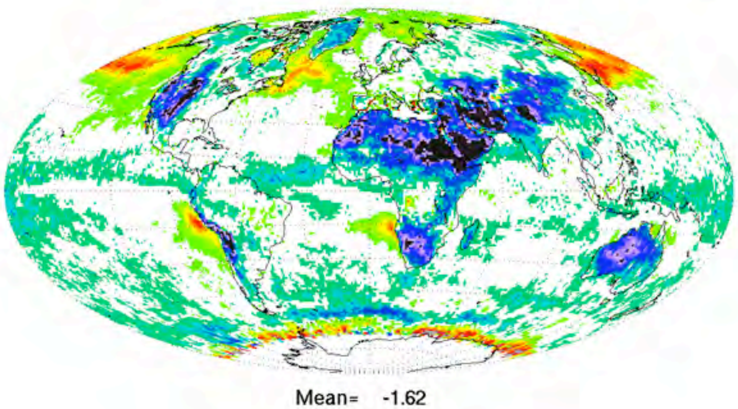


UNtuned - Observed LW TOA [Wm^{-2}] July 02



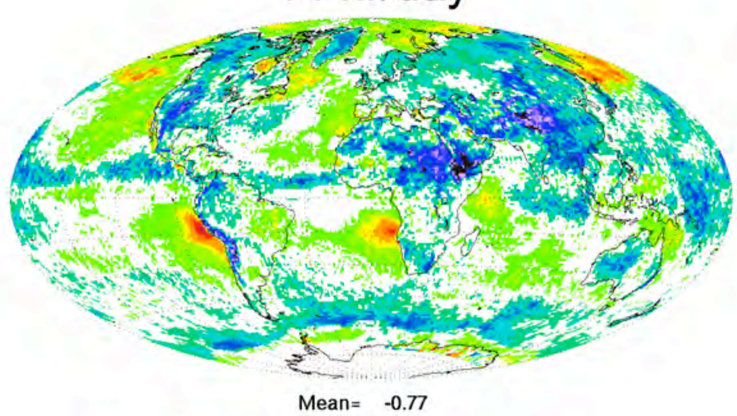
Global Mean Longwave TOA Untuned -Obs	
All	**-0.99**
CERES	-1.62
GEO	-3.14
Interp	-0.77

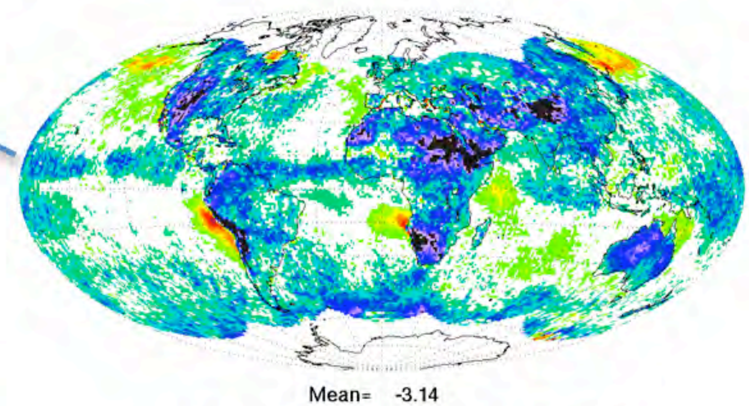
Combined LW
24 hr/day



CERES Flux
~2 hr/day
MODIS Multispectral
Clouds

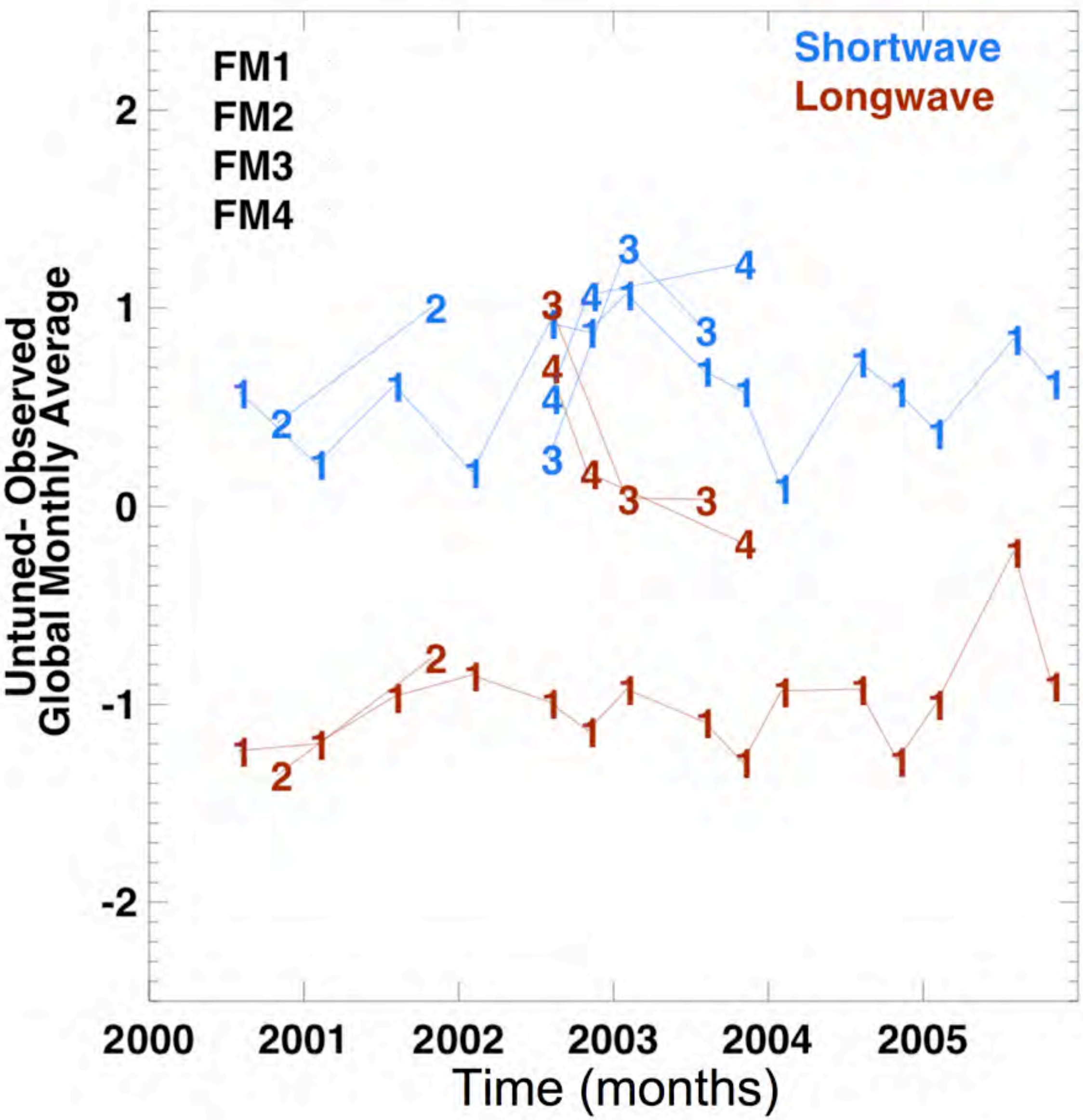
Interpolated
~14 hr/day





Geostationary NB/BB
Flux
~8 hr/day
IR only Clouds

Beta4 SYNI
UNtuned *minus* "Observed" TOA



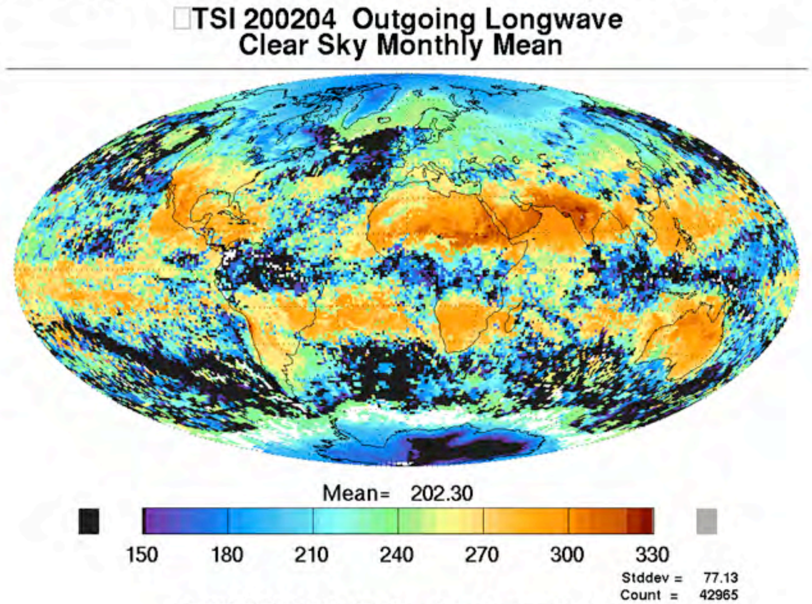
- Longwave Correction applied to observed CERES/GEO TOA
- Rev1 Shortwave Correction

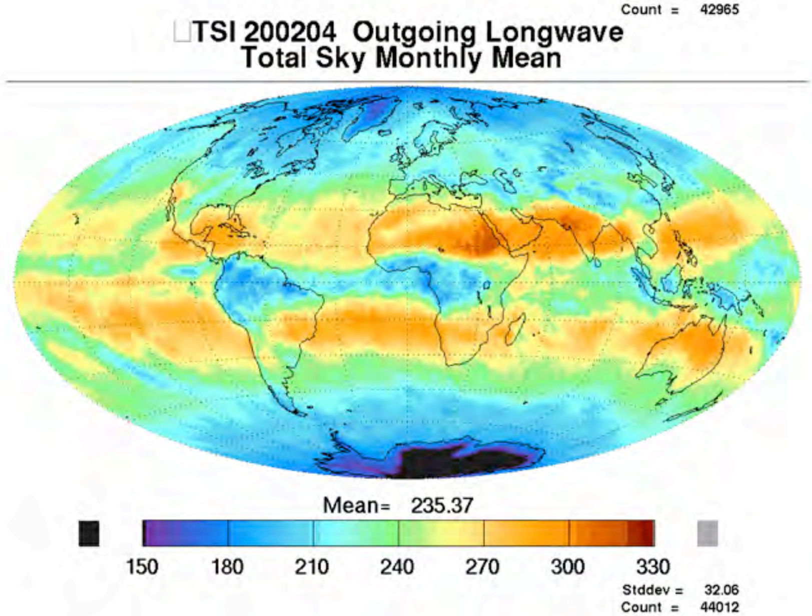
	Untuned – Observed Global Mean TOA Flux Mean & (Regional Stddev)			
Instrument	FM1 15mth	FM2 2mth	FM3 3mth	FM4 3mth
Longwave	-1.0 (11.6)	-1.1 (11.6)	0.4 (11.4)	0.2 (11.3)
Shortwave	0.6 (16.5)	0.7 (16.6)	0.8 (17.7)	1.0 (17.4)
Window	0.2 (5.4)	0.1 (5.32)	0.7 (5.4)	0.3 (5.3)

Note: April (30 day) months omitted due to Beta4 TSI Observed ClrSky OLR bug

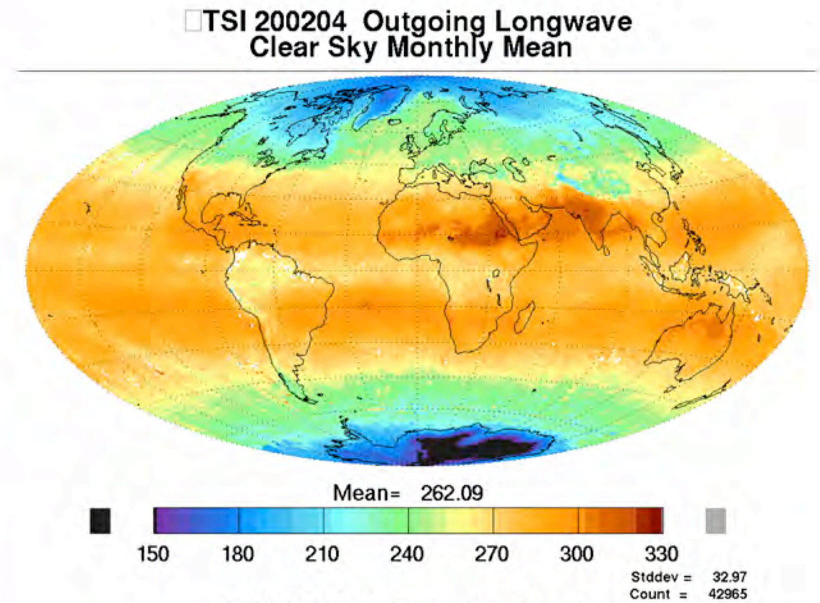
TSI Beta4 *Bug*

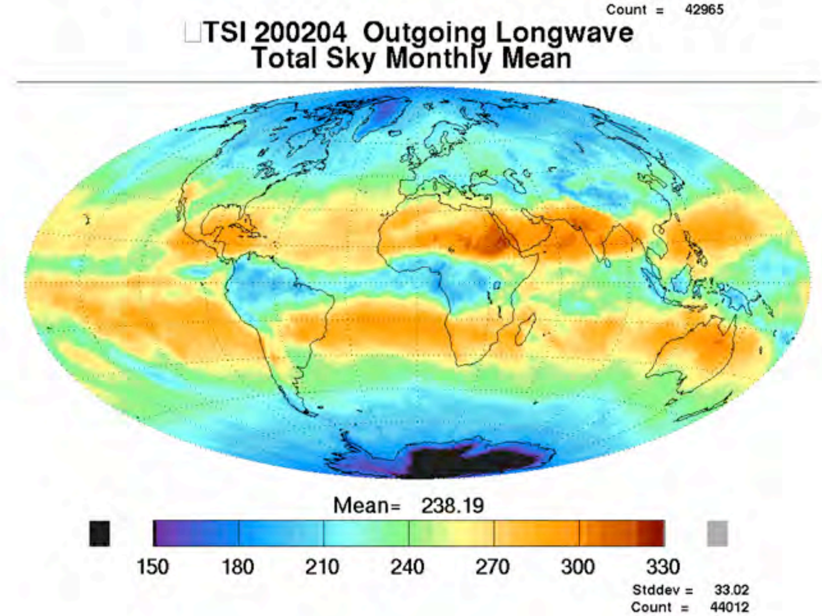
<30 Day/Month Clear Sky OLR Bug





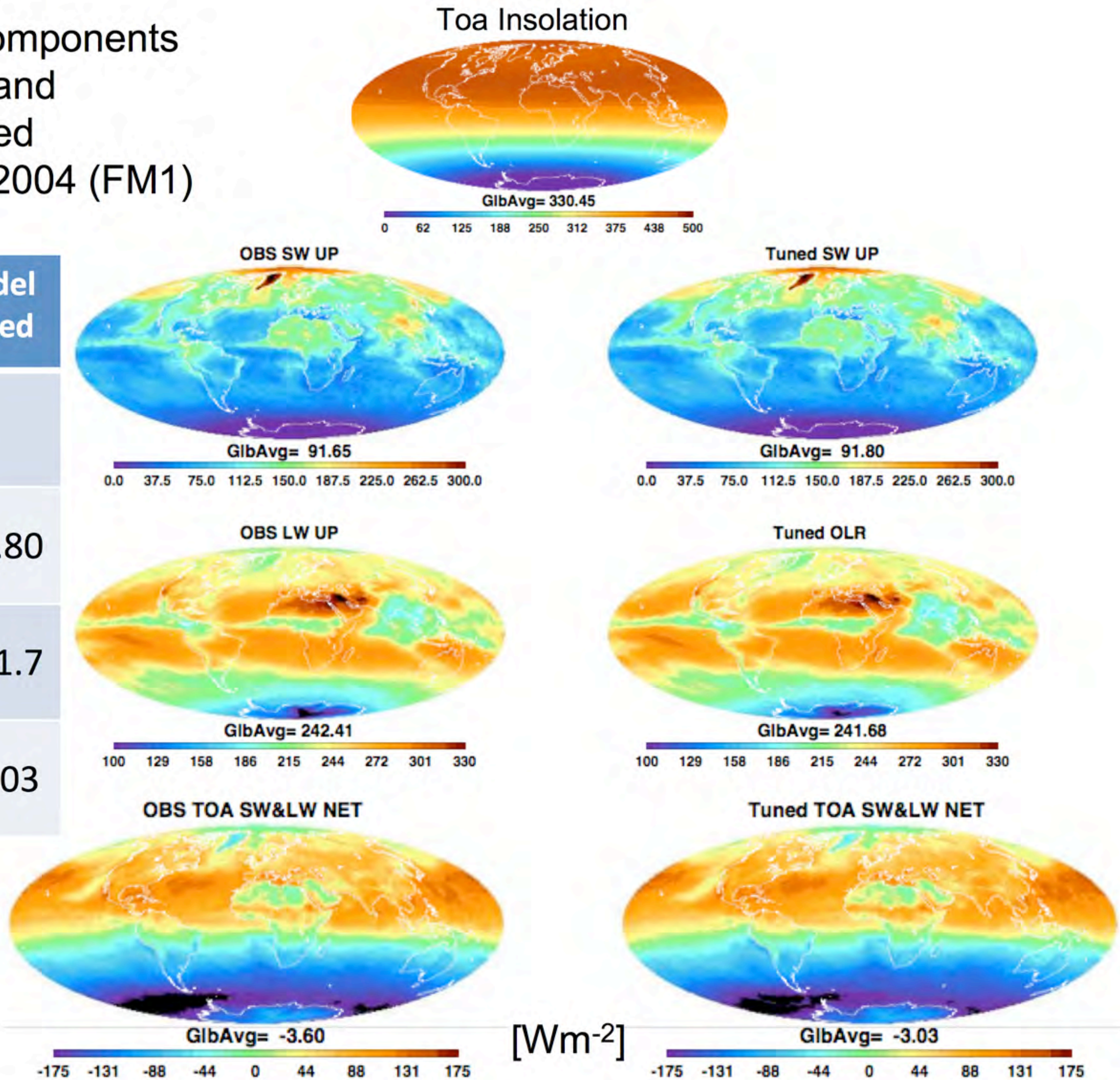
Corrected Re-Run





Net TOA Balance Components OBSERVED and MODEL Tuned Single Month of July 2004 (FM1)

July 2004 FM1 [Wm-2]	Obs	Model Tuned
TOA Insolation	330.45	
TOA SW Up	91.65	91.80
OLR	242.41	241.7
TOA SW&LW Net	-3.60	-3.03

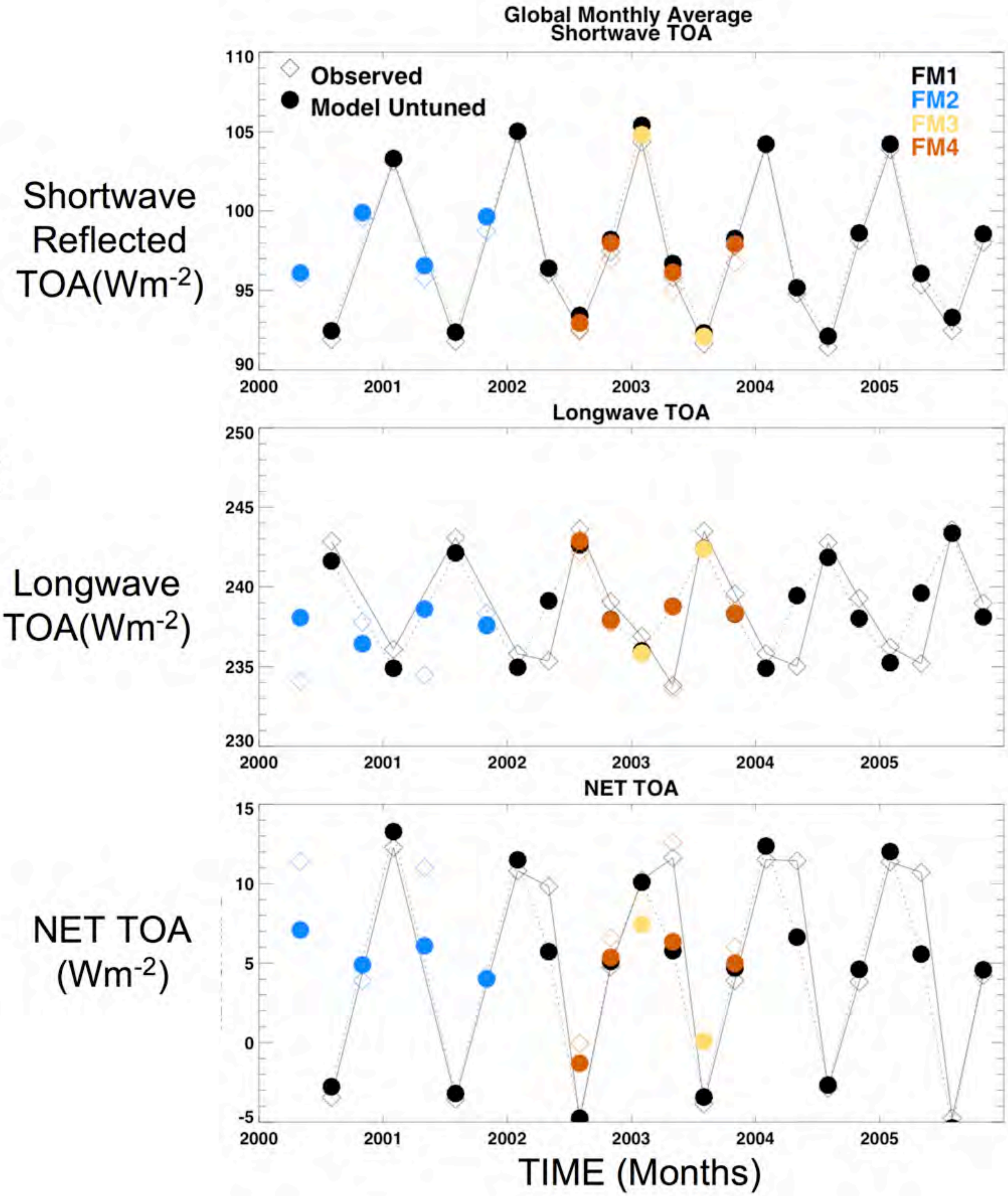


Beta4 SYNI

Global Monthly Mean TOA 2000-2005

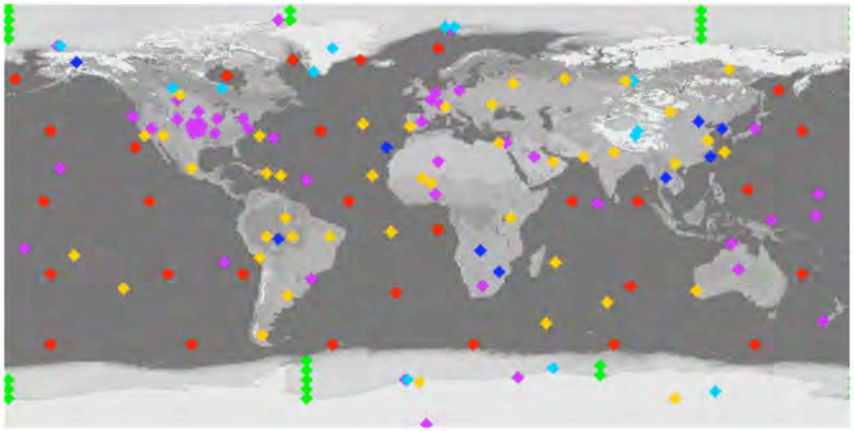
Jan, *Apr*, Jul, Oct

April has TSI CSOLR bug



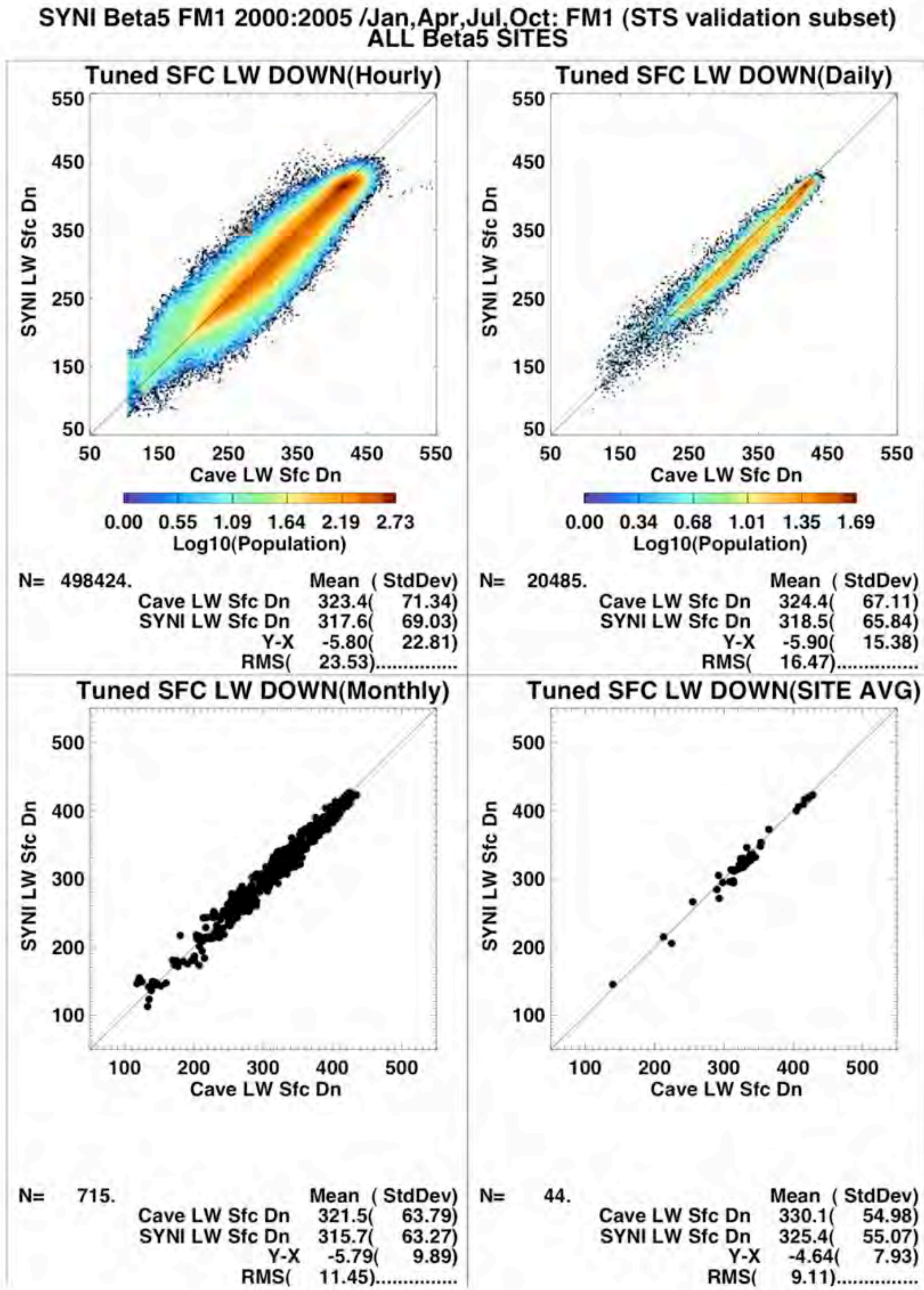
Spatial Subset Validation

- 170 grid boxes out of 44012
  - Planned as part of CAVE website (Edition release)
- Selected according to…….
  - Surface validation sites
    - CAVE
      - ARM, SURFRAD, BSRN CMDL
      - BB SW&LW
    - Aeronet sites
  - Variety of IGBP types
    - Crude global representation

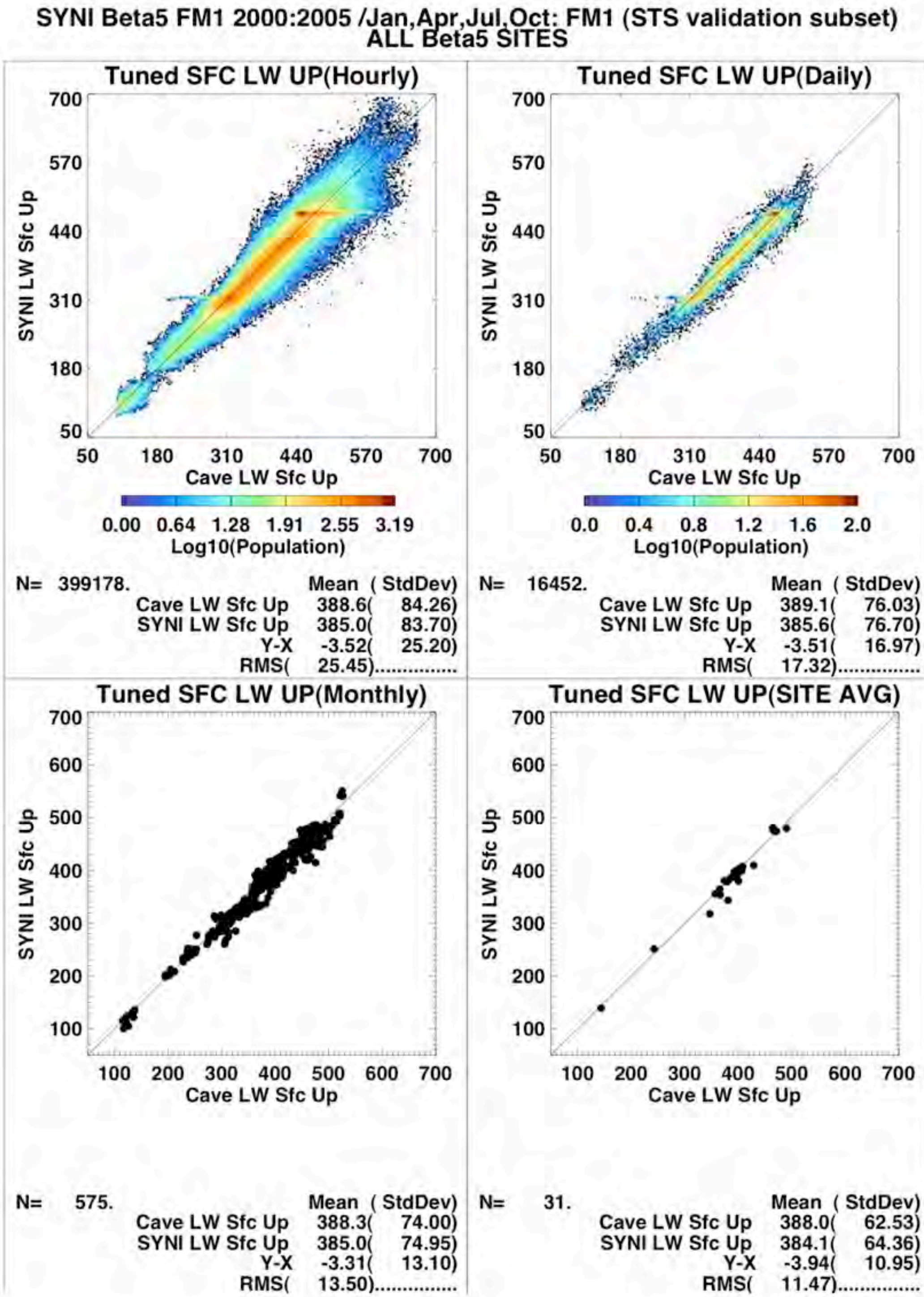


Surface
Downward
Longwave
Comparison to
Surface
Validation sites

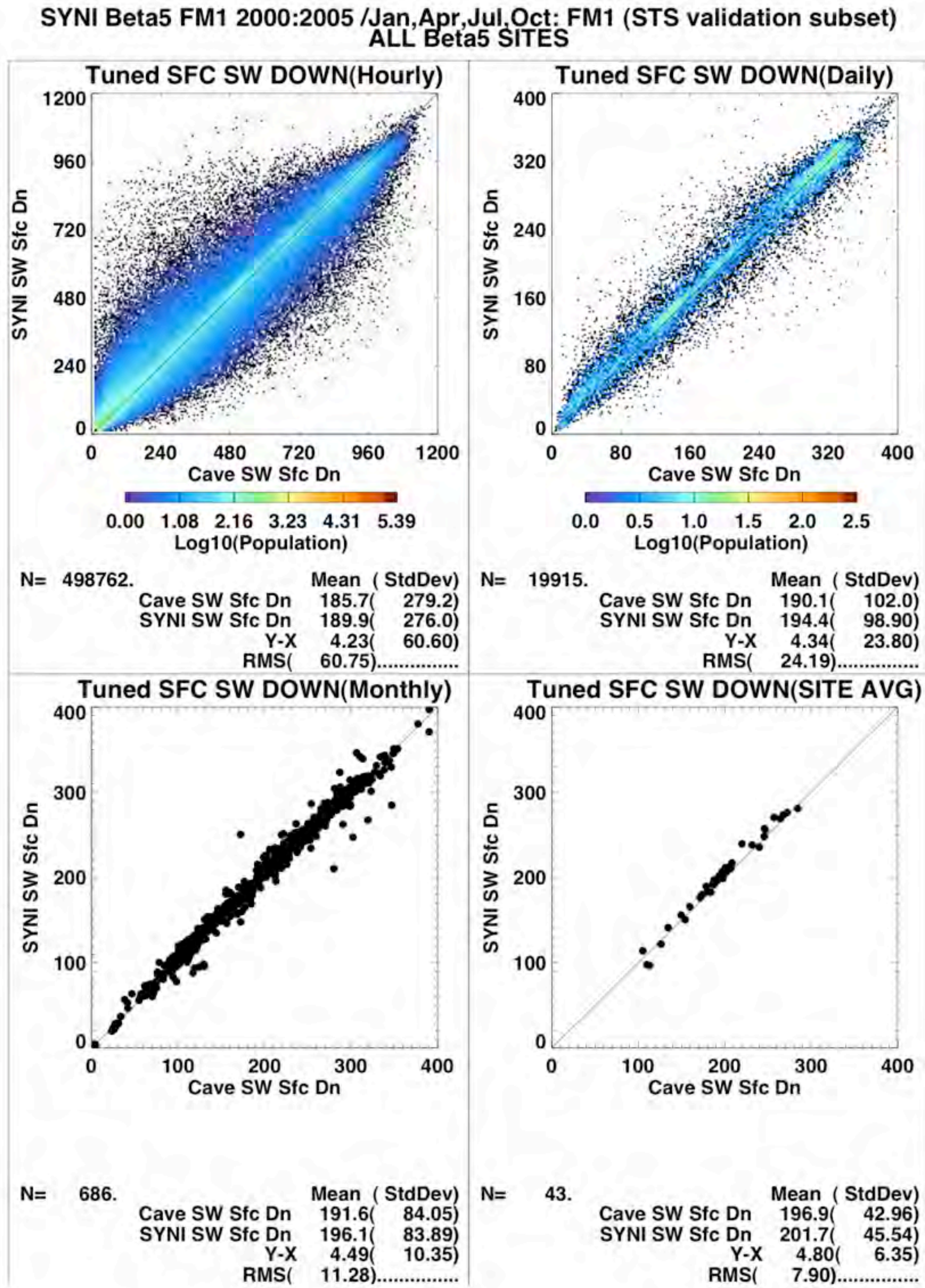
Remember these are point to grid-box comparisons



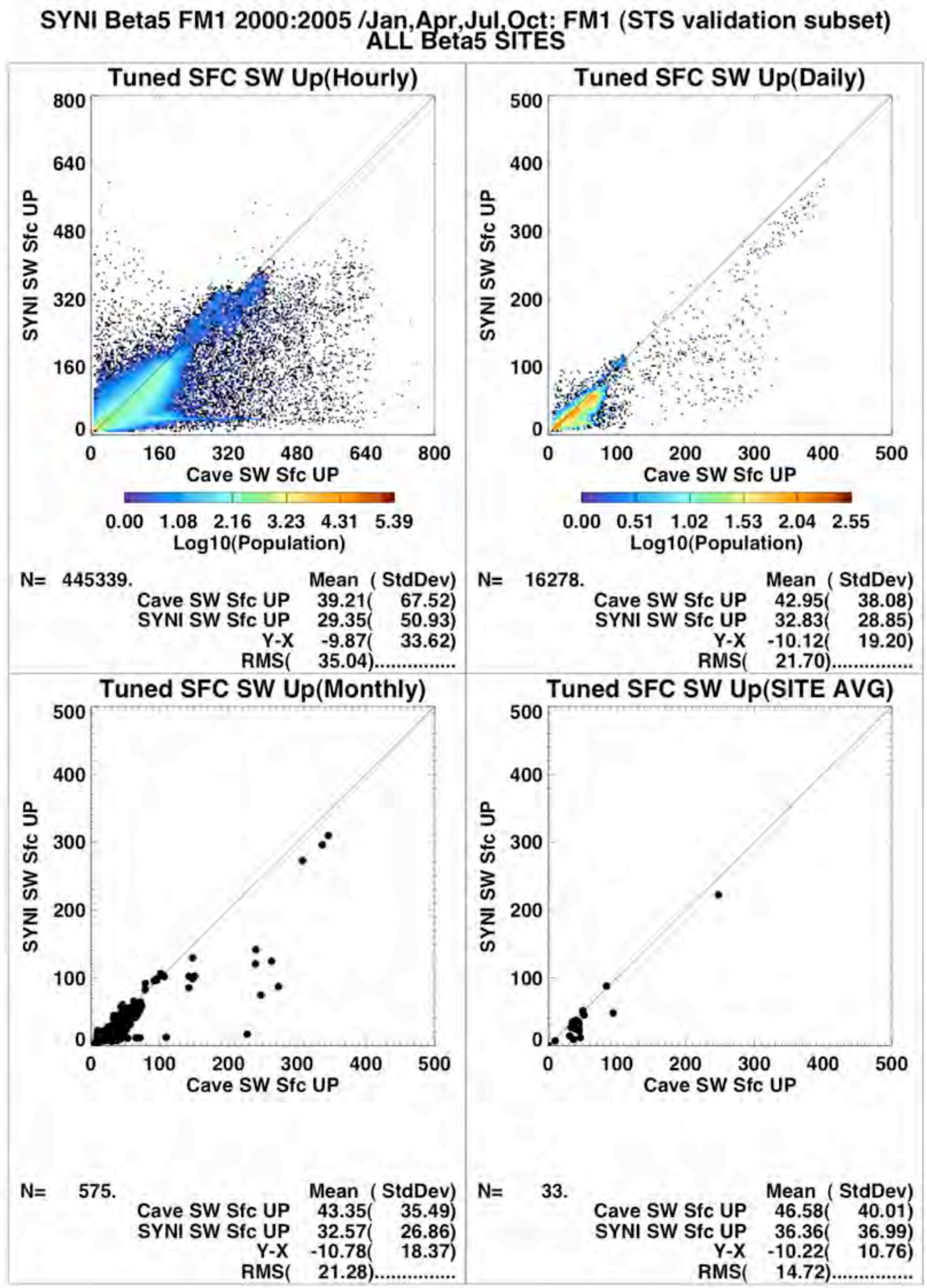
Surface **Upward Longwave** Comparison to Surface Validation sites



Surface **Downward Shortwave** Comparison to Surface Validation sites



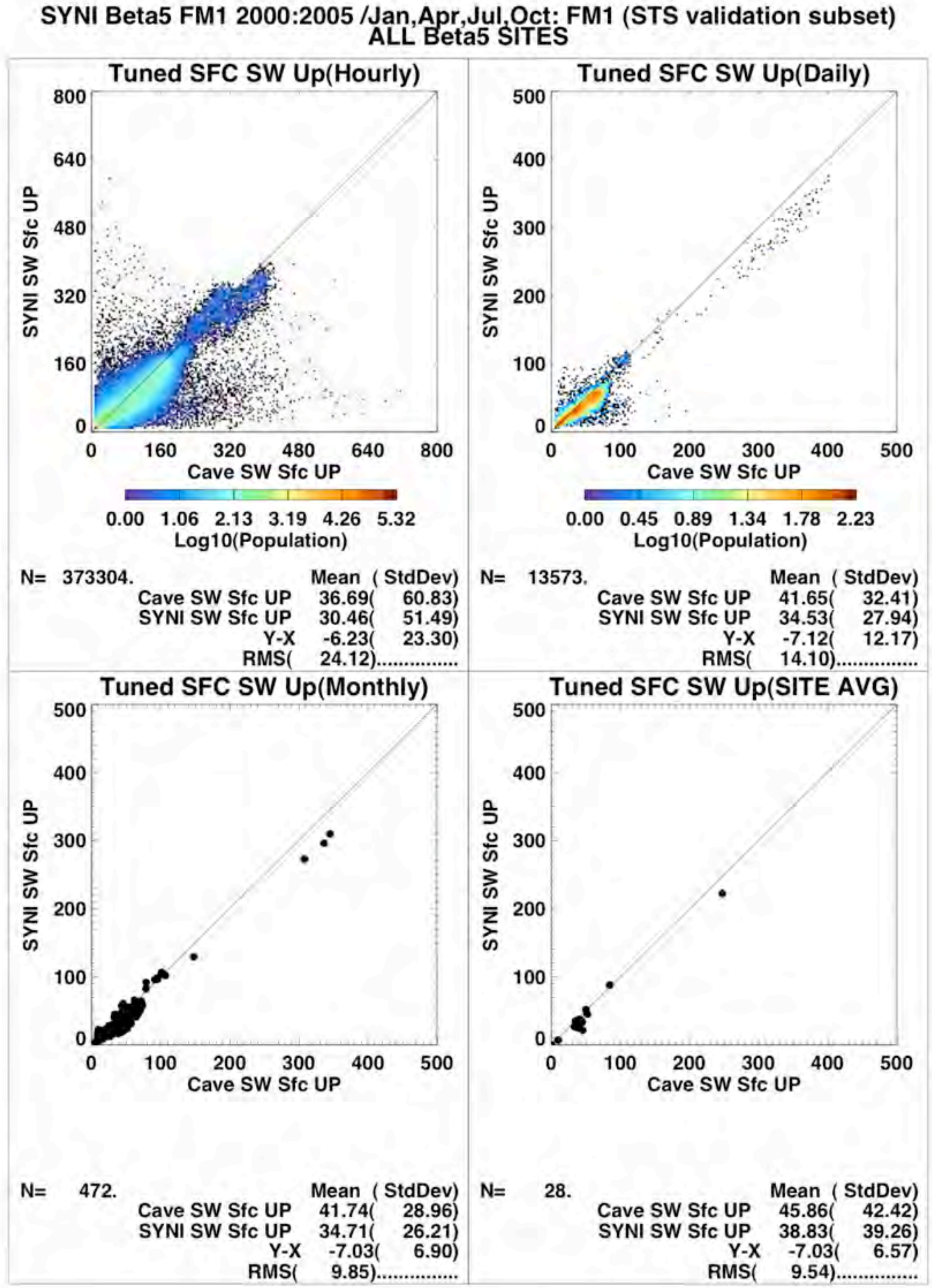
Surface
Upward
Shortwave
Comparison to
Surface
Validation sites



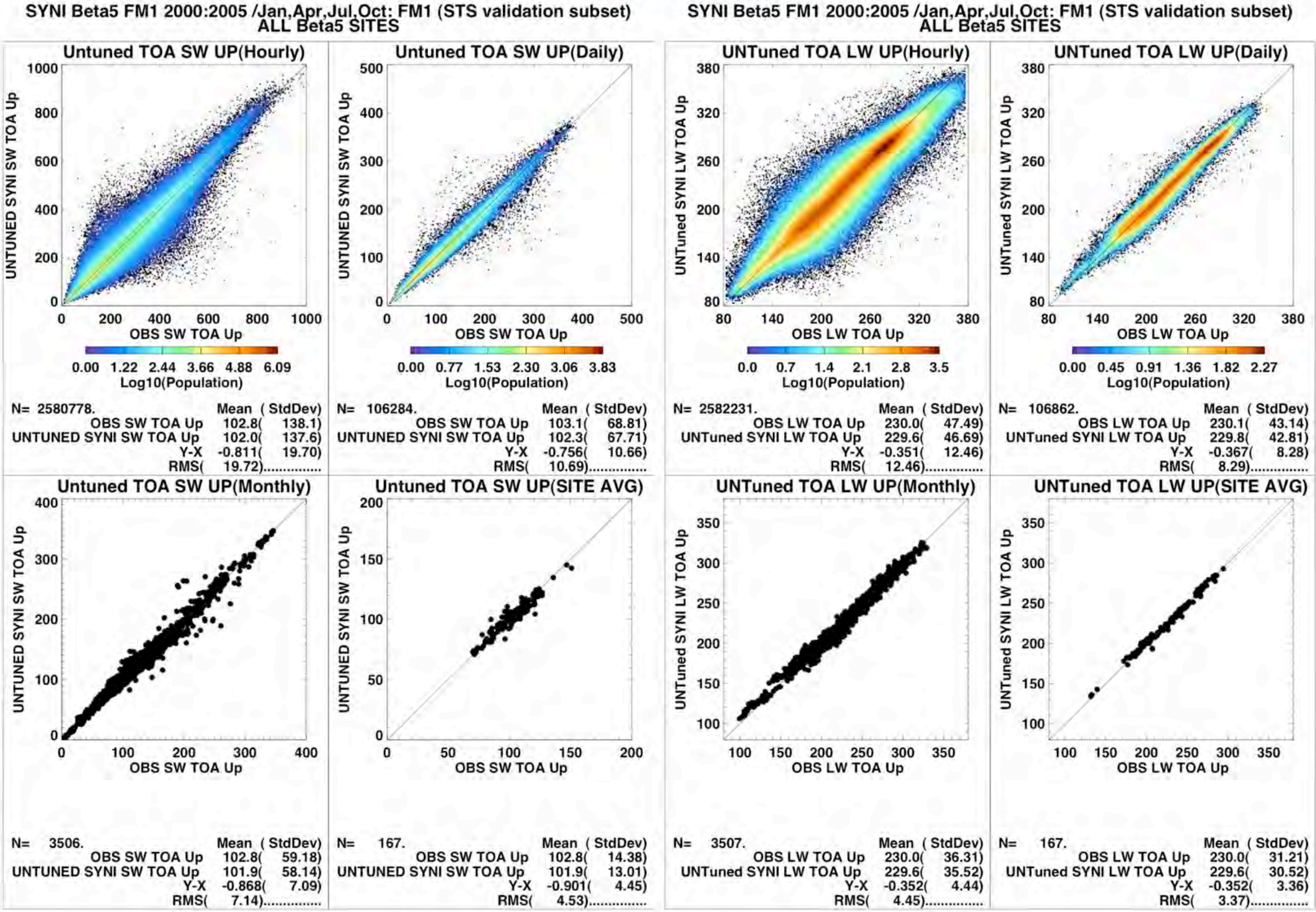
Surface
Upward
Shortwave
Comparison to
Surface
Validation sites

Edited to removing mainly **coastal** sites

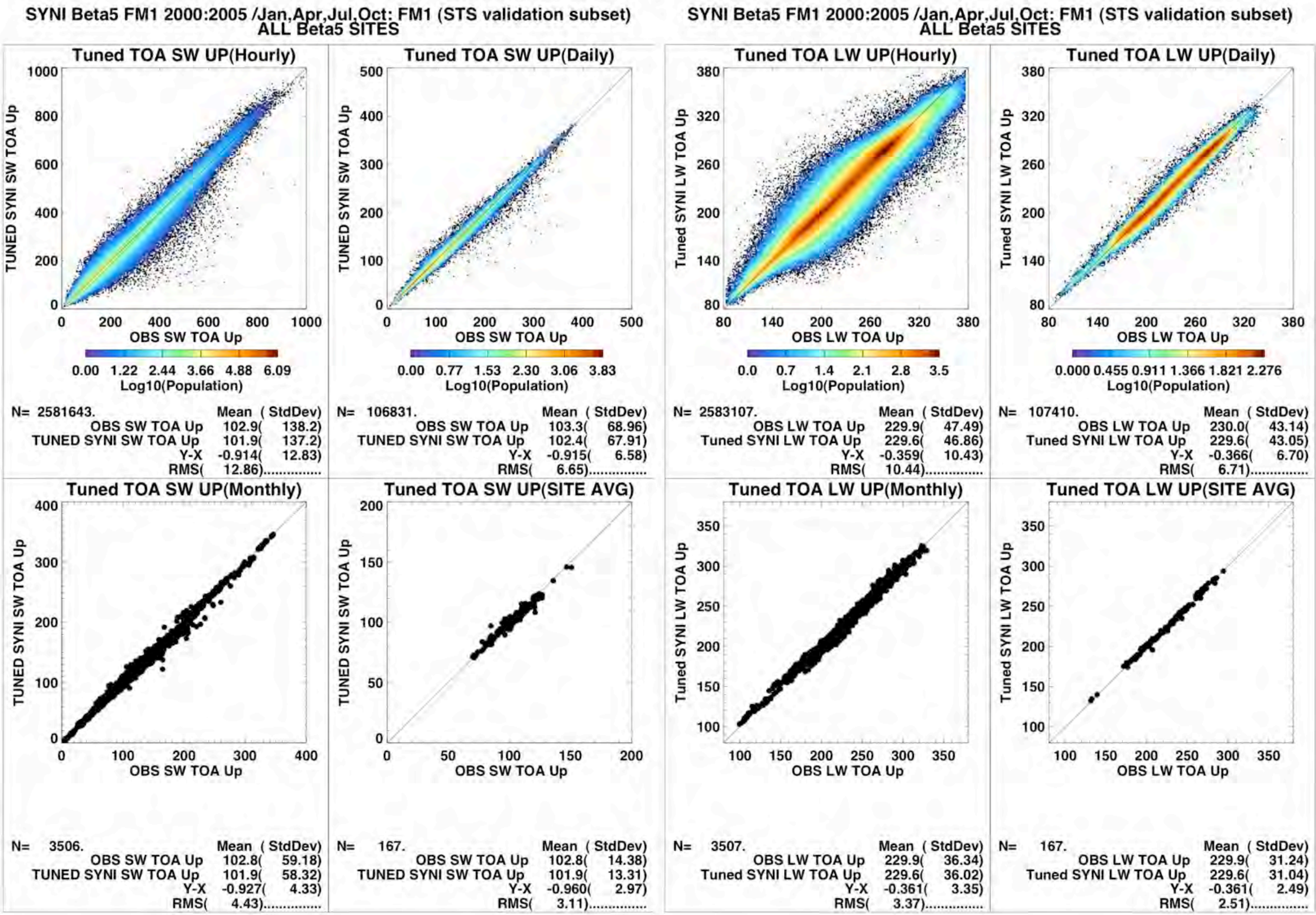
1.Georg von Neumayer
2.Manus
3.Nauru
4.Tateno
5.E12 sgp (some suspect data)



UNtuned TOA


SYNI Beta5 FM1 2000:2005 /Jan,Apr,Jul,Oct: FM1 (STS validation subset)
ALL Beta5 SITES
SYNI Beta5 FM1 2000:2005 /Jan,Apr,Jul,Oct: FM1 (STS validation subset)
ALL Beta5 SITES
Untuned TOA SW UP(Hourly)
UNTUNED SYNI SW TOA Up
OBS SW TOA Up
0.00 1.22 2.44 3.66 4.88 6.09
Log10(Population)
N= 2580778.
Mean (StdDev)
OBS SW TOA Up 102.8(138.1)
UNTUNED SYNI SW TOA Up 102.0(137.6)
Y-X -0.811(19.70)
RMS(19.72)...............
Untuned TOA SW UP(Daily)
UNTUNED SYNI SW TOA Up
OBS SW TOA Up
0.00 0.77 1.53 2.30 3.06 3.83
Log10(Population)
N= 106284.
Mean (StdDev)
OBS SW TOA Up 103.1(68.81)
UNTUNED SYNI SW TOA Up 102.3(67.71)
Y-X -0.756(10.66)
RMS(10.69)...............
UNTuned TOA LW UP(Hourly)
UNTuned SYNI LW TOA Up
OBS LW TOA Up
0.0 0.7 1.4 2.1 2.8 3.5
Log10(Population)
N= 2582231.
Mean (StdDev)
OBS LW TOA Up 230.0(47.49)
UNTuned SYNI LW TOA Up 229.6(46.69)
Y-X -0.351(12.46)
RMS(12.46)...............
UNTuned TOA LW UP(Daily)
UNTuned SYNI LW TOA Up
OBS LW TOA Up
0.00 0.45 0.91 1.36 1.82 2.27
Log10(Population)
N= 106862.
Mean (StdDev)
OBS LW TOA Up 230.1(43.14)
UNTuned SYNI LW TOA Up 229.8(42.81)
Y-X -0.367(8.28)
RMS(8.29)...............
Untuned TOA SW UP(Monthly)
UNTUNED SYNI SW TOA Up
OBS SW TOA Up
N= 3506.
Mean (StdDev)
OBS SW TOA Up 102.8(59.18)
UNTUNED SYNI SW TOA Up 101.9(58.14)
Y-X -0.868(7.09)
RMS(7.14)...............
Untuned TOA SW UP(SITE AVG)
UNTUNED SYNI SW TOA Up
OBS SW TOA Up
N= 167.
Mean (StdDev)
OBS SW TOA Up 102.8(14.38)
UNTUNED SYNI SW TOA Up 101.9(13.01)
Y-X -0.901(4.45)
RMS(4.53)...............
UNTuned TOA LW UP(Monthly)
UNTuned SYNI LW TOA Up
OBS LW TOA Up
N= 3507.
Mean (StdDev)
OBS LW TOA Up 230.0(36.31)
UNTuned SYNI LW TOA Up 229.6(35.52)
Y-X -0.352(4.44)
RMS(4.45)...............
UNTuned TOA LW UP(SITE AVG)
UNTuned SYNI LW TOA Up
OBS LW TOA Up
N= 167.
Mean (StdDev)
OBS LW TOA Up 230.0(31.21)
UNTuned SYNI LW TOA Up 229.6(30.52)
Y-X -0.352(3.36)
RMS(3.37)...............

TUNED TOA



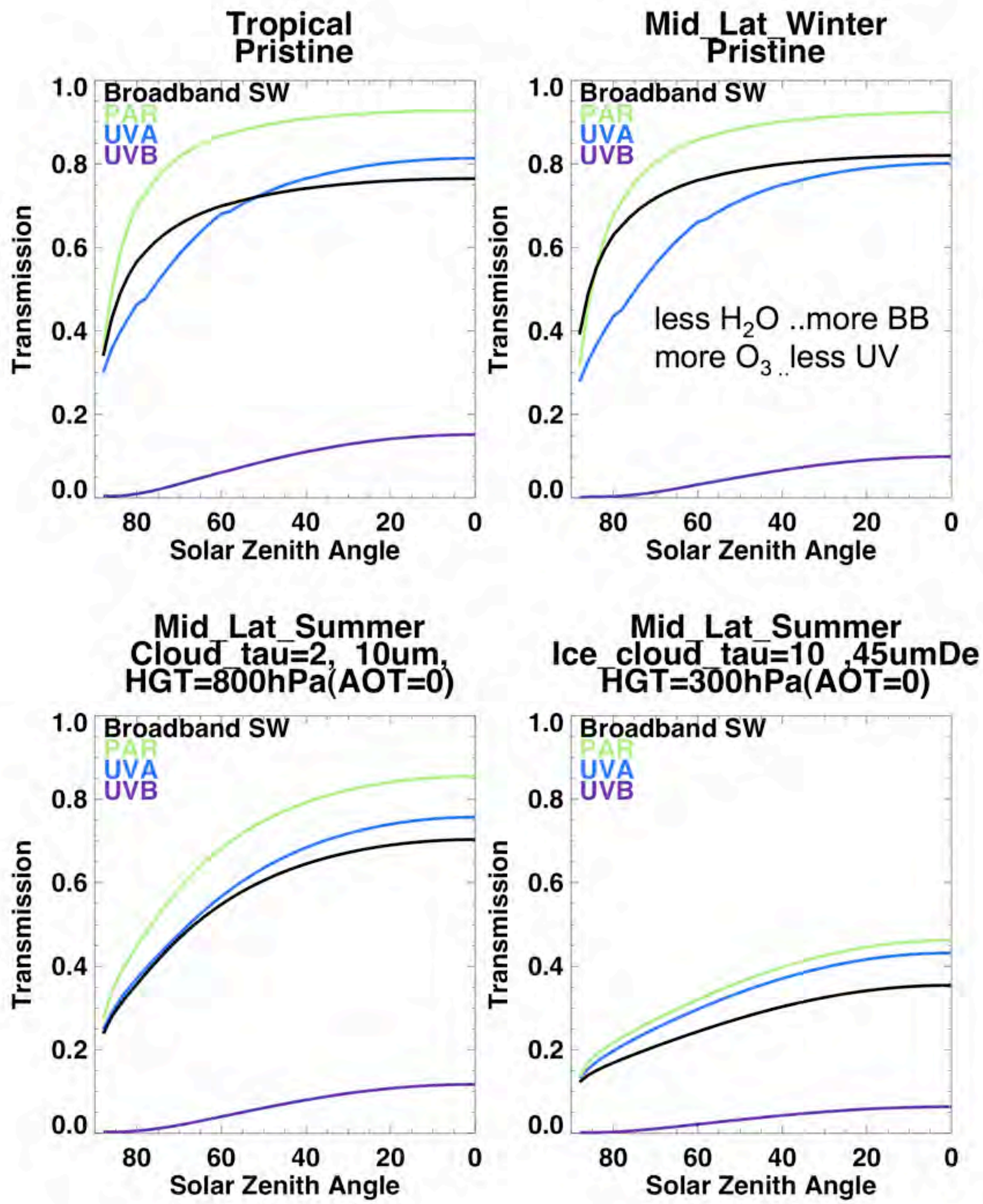
SYNI Beta5 FM1 2000:2005 /Jan,Apr,Jul,Oct: FM1 (STS validation subset)
ALL Beta5 SITES
Tuned TOA SW UP(Hourly)
TUNED SYNI SW TOA Up
OBS SW TOA Up
0.00 1.22 2.44 3.66 4.88 6.09
Log10(Population)
N= 2581643. Mean (StdDev)
OBS SW TOA Up 102.9(138.2)
TUNED SYNI SW TOA Up 101.9(137.2)
Y-X -0.914(12.83)
RMS(12.86)...............
Tuned TOA SW UP(Daily)
TUNED SYNI SW TOA Up
OBS SW TOA Up
0.00 0.77 1.53 2.30 3.06 3.83
Log10(Population)
N= 106831. Mean (StdDev)
OBS SW TOA Up 103.3(68.96)
TUNED SYNI SW TOA Up 102.4(67.91)
Y-X -0.915(6.58)
RMS(6.65)...............
Tuned TOA SW UP(Monthly)
TUNED SYNI SW TOA Up
OBS SW TOA Up
N= 3506. Mean (StdDev)
OBS SW TOA Up 102.8(59.18)
TUNED SYNI SW TOA Up 101.9(58.32)
Y-X -0.927(4.33)
RMS(4.43)...............
Tuned TOA SW UP(SITE AVG)
TUNED SYNI SW TOA Up
OBS SW TOA Up
N= 167. Mean (StdDev)
OBS SW TOA Up 102.8(14.38)
TUNED SYNI SW TOA Up 101.9(13.31)
Y-X -0.960(2.97)
RMS(3.11)...............
SYNI Beta5 FM1 2000:2005 /Jan,Apr,Jul,Oct: FM1 (STS validation subset)
ALL Beta5 SITES
Tuned TOA LW UP(Hourly)
Tuned SYNI LW TOA Up
OBS LW TOA Up
0.0 0.7 1.4 2.1 2.8 3.5
Log10(Population)
N= 2583107. Mean (StdDev)
OBS LW TOA Up 229.9(47.49)
Tuned SYNI LW TOA Up 229.6(46.86)
Y-X -0.359(10.43)
RMS(10.44)...............
Tuned TOA LW UP(Daily)
Tuned SYNI LW TOA Up
OBS LW TOA Up
0.000 0.455 0.911 1.366 1.821 2.276
Log10(Population)
N= 107410. Mean (StdDev)
OBS LW TOA Up 230.0(43.14)
Tuned SYNI LW TOA Up 229.6(43.05)
Y-X -0.366(6.70)
RMS(6.71)...............
Tuned TOA LW UP(Monthly)
Tuned SYNI LW TOA Up
OBS LW TOA Up
N= 3507. Mean (StdDev)
OBS LW TOA Up 229.9(36.34)
Tuned SYNI LW TOA Up 229.6(36.02)
Y-X -0.361(3.35)
RMS(3.37)...............
Tuned TOA LW UP(SITE AVG)
Tuned SYNI LW TOA Up
OBS LW TOA Up
N= 167. Mean (StdDev)
OBS LW TOA Up 229.9(31.24)
Tuned SYNI LW TOA Up 229.6(31.04)
Y-X -0.361(2.49)
RMS(2.51)...............

Beta5 SYNI FM1&FM2 (STS Subset)
2000:2005/Jan,Apr,Jul,Oct
TOA and Surface Flux Comparison [Wm^{-2}]

TOA Model-Obs Bias (RMS)	*UN-tuned Longwave*	Tuned Longwave	*UN-tuned Shortwave*	Tuned Shortwave
Hourly	***-0.4*** *(12.5)*	**-0.4** (10.4)	***-0.8*** *(19.7)*	**-0.9** (12.9)
Daily	*(8.3)*	(6.7)	*(10.7)*	(6.7)
Monthly	*(4.5)*	(3.4)	*(7.1)*	(4.3)
Site Avg	*(3.4)*	(2.5)	*(4.5)*	(3.1)
# Sites	167	167	167	167

Tuned – Obs Bias (RMS)	Downward Longwave Surface	Upward Longwave Surface	Downward Shortwave Surface	Upward Shortwave Surface	Upward Shortwave Surface *edit*
Hourly	-5.8 (23.5)	-3.5 (25.5)	4.2 (60.8)	-9.9 (35.0)	-6.23(24.1)
Daily	-5.9 (16.5)	-3.5 (17.3)	4.3 (24.2)	-10.1 (21.7)	-7.12 (14.1)
Monthly	-5.8 (11.5)	-3.3 (13.5)	4.5 (10.4)	-10.8 (18.4)	-7.03 (9.9)
Site Avg	-4.6 (9.1)	-3.9 (11.5)	4.8 (7.9)	-10.2 (14.7)	-7.03 (9.5)
# Sites	44	31	43	33	27 (no coast)

Spectral Diurnal Transmission Examples



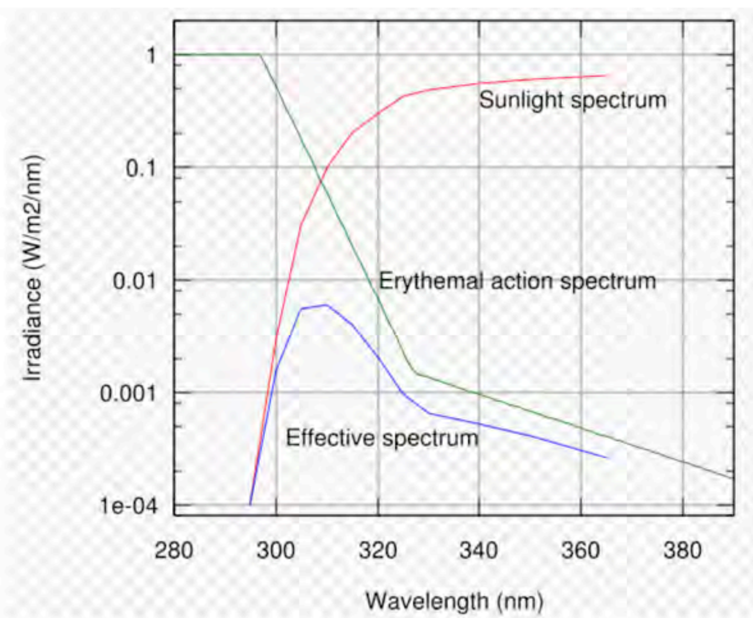
Uses LaRC Fu-Liou code for UVA, UVB , PAR see JGR 2007 W.Su

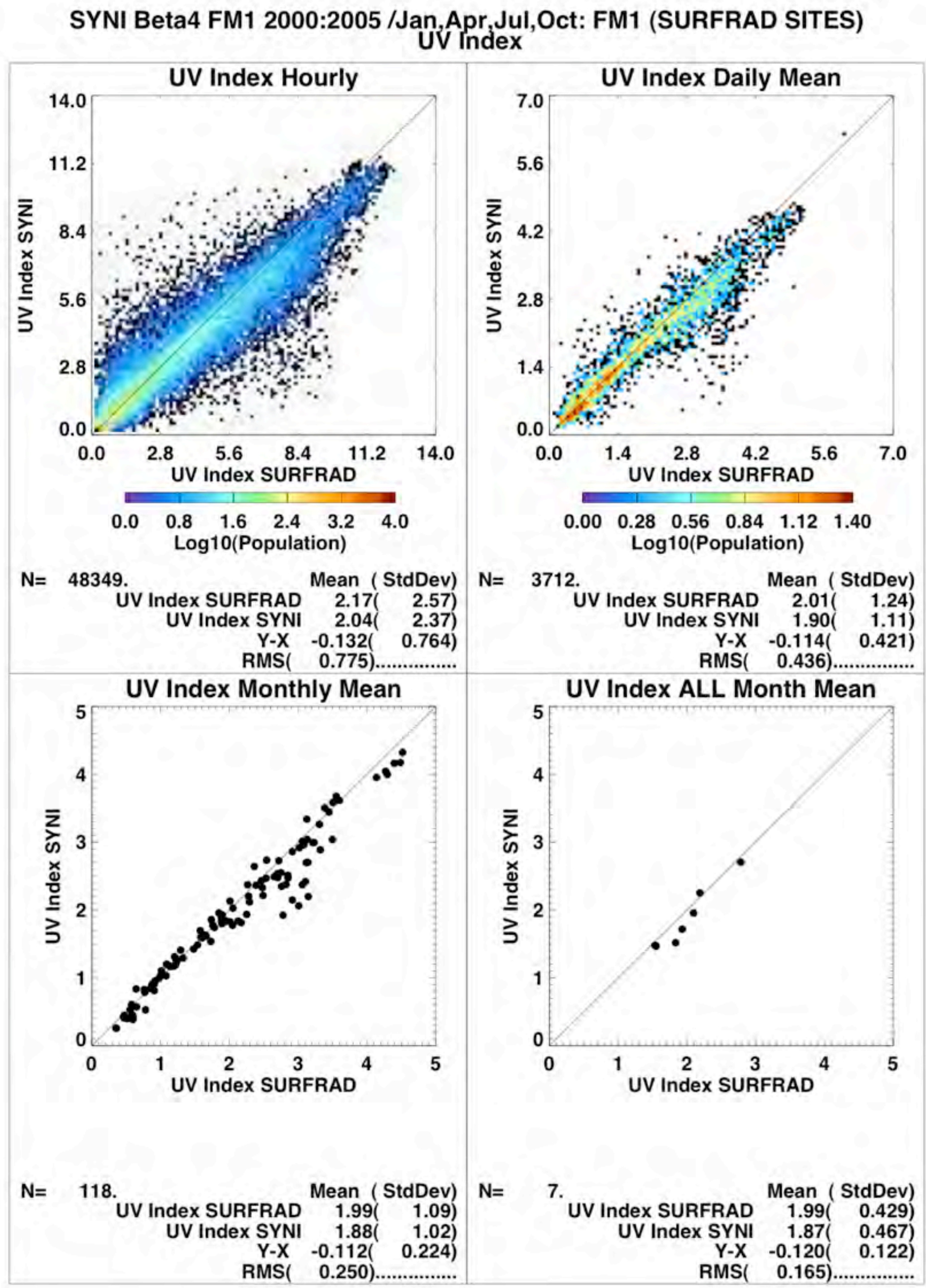
Surface

UV INDEX

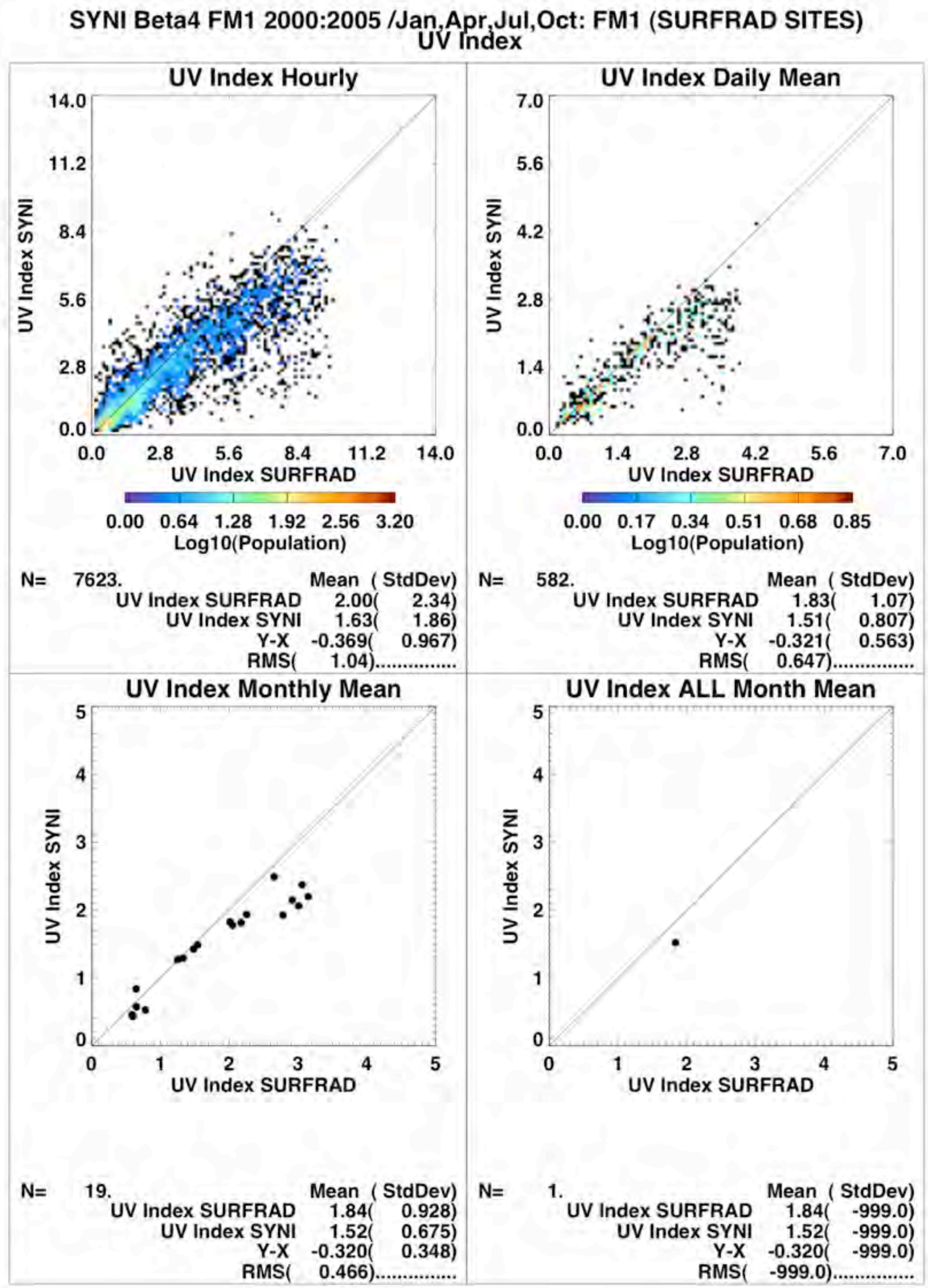
Comparison to seven SURFRAD Validation sites

UV INDEX equals erythemal action spectra over 215:380nm in Wm^{-2} times 40

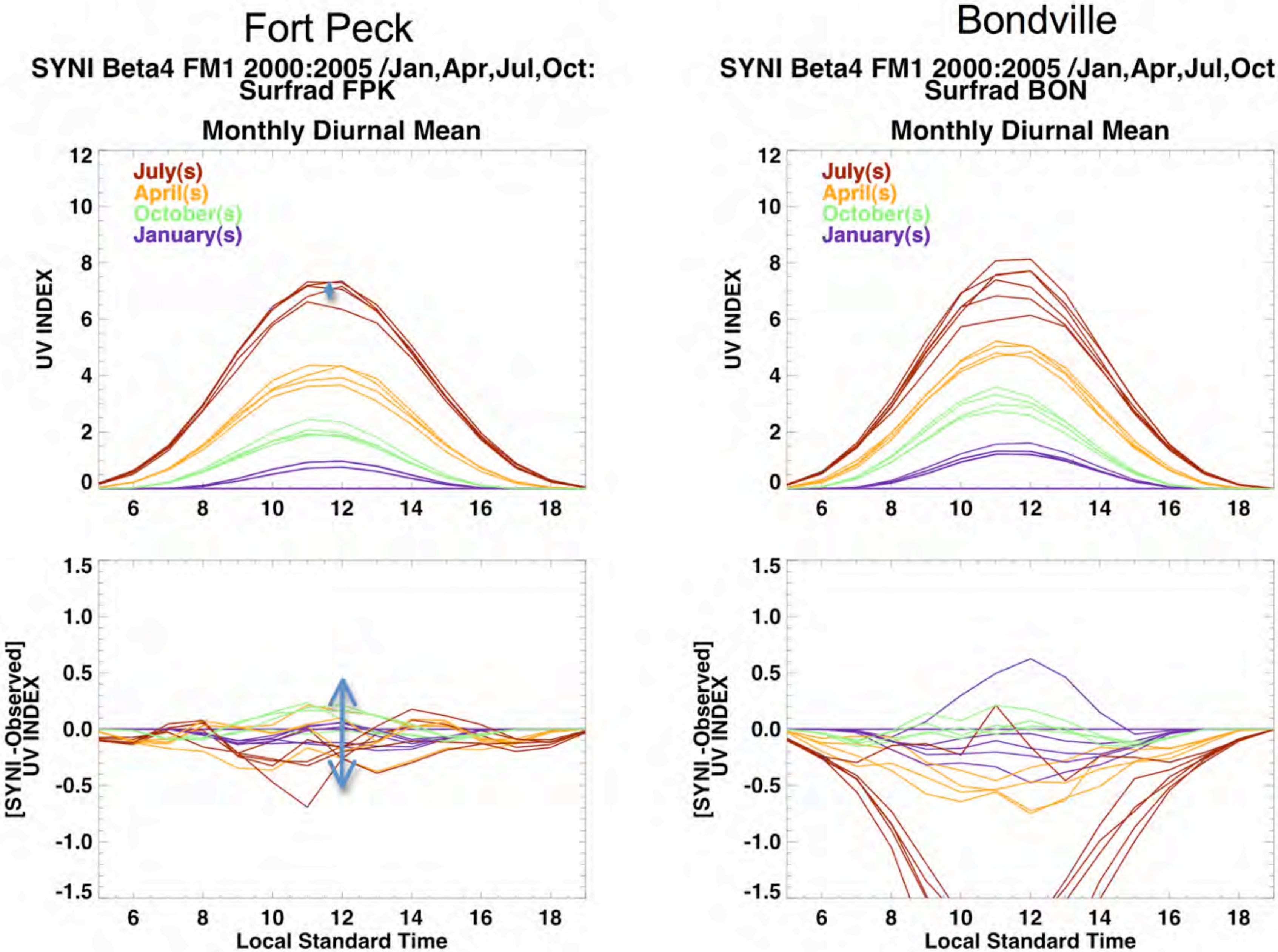




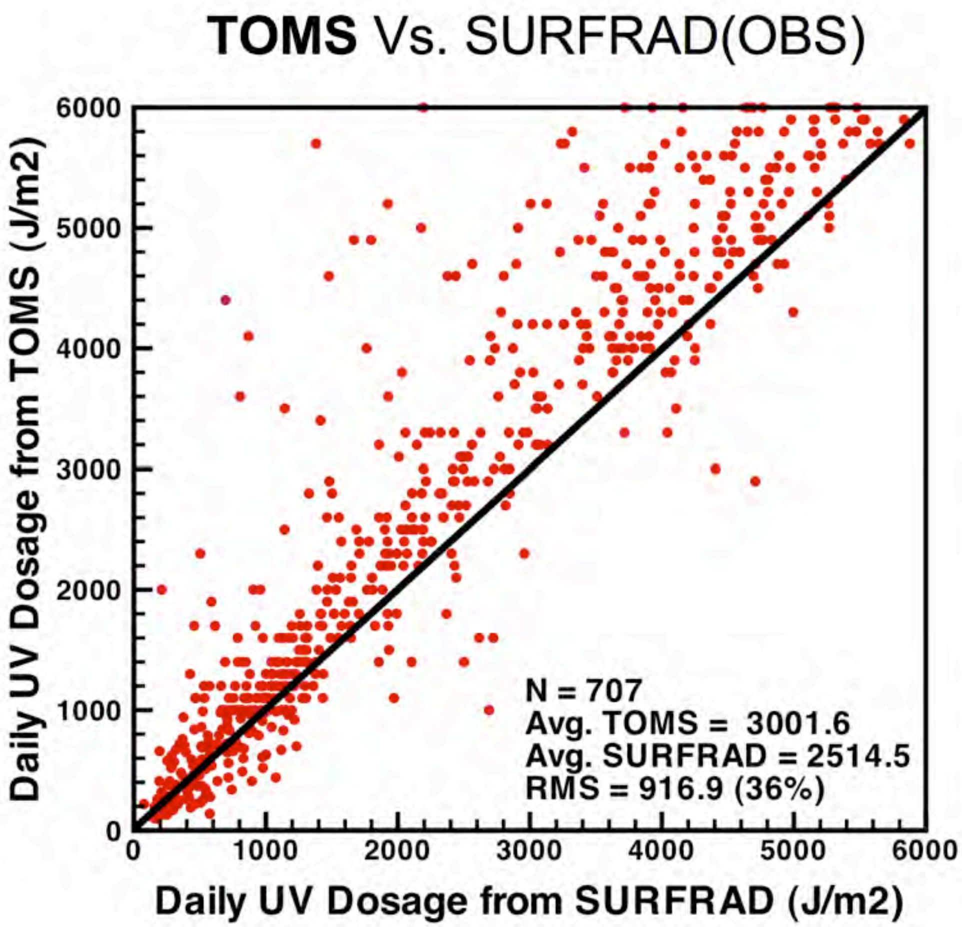
Bondville:
Some surface UVB measurements are suspect?

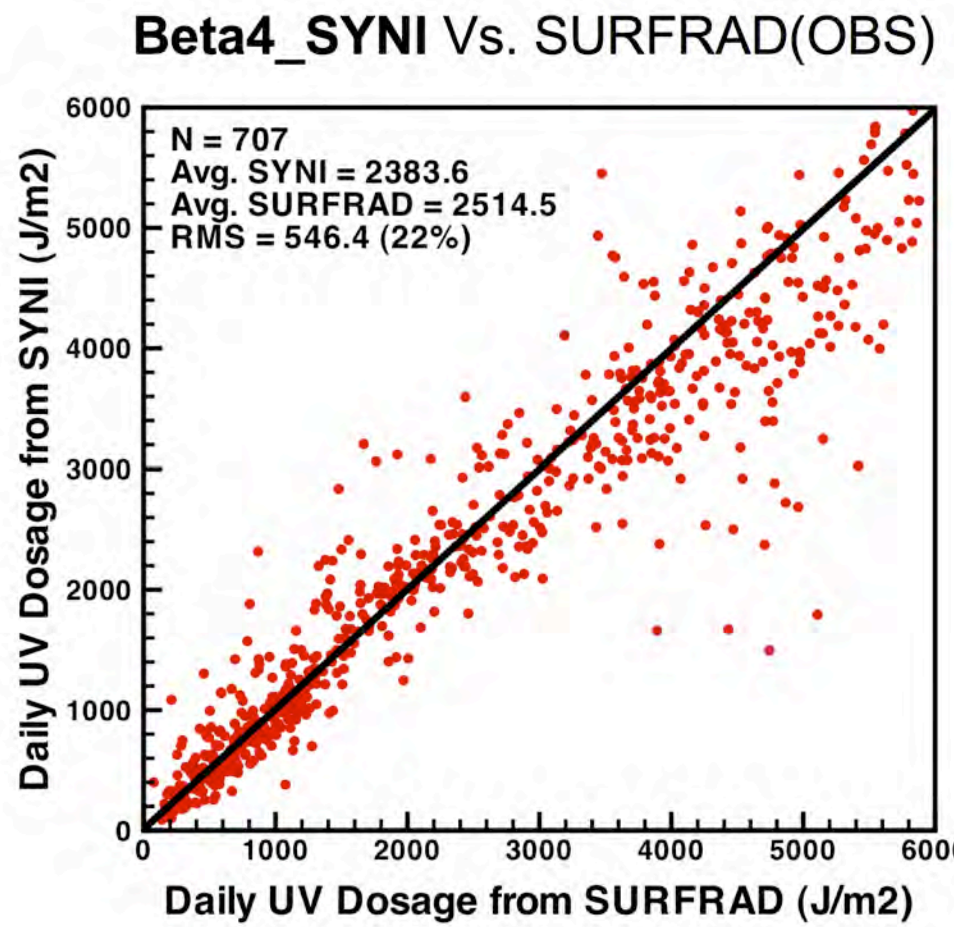


IAV of Monthly Mean UV Index



Daily Integrated UV Dosage (J m^{-2})





Analysis courtesy : Wenying Su(NASA LaRC)

Surface

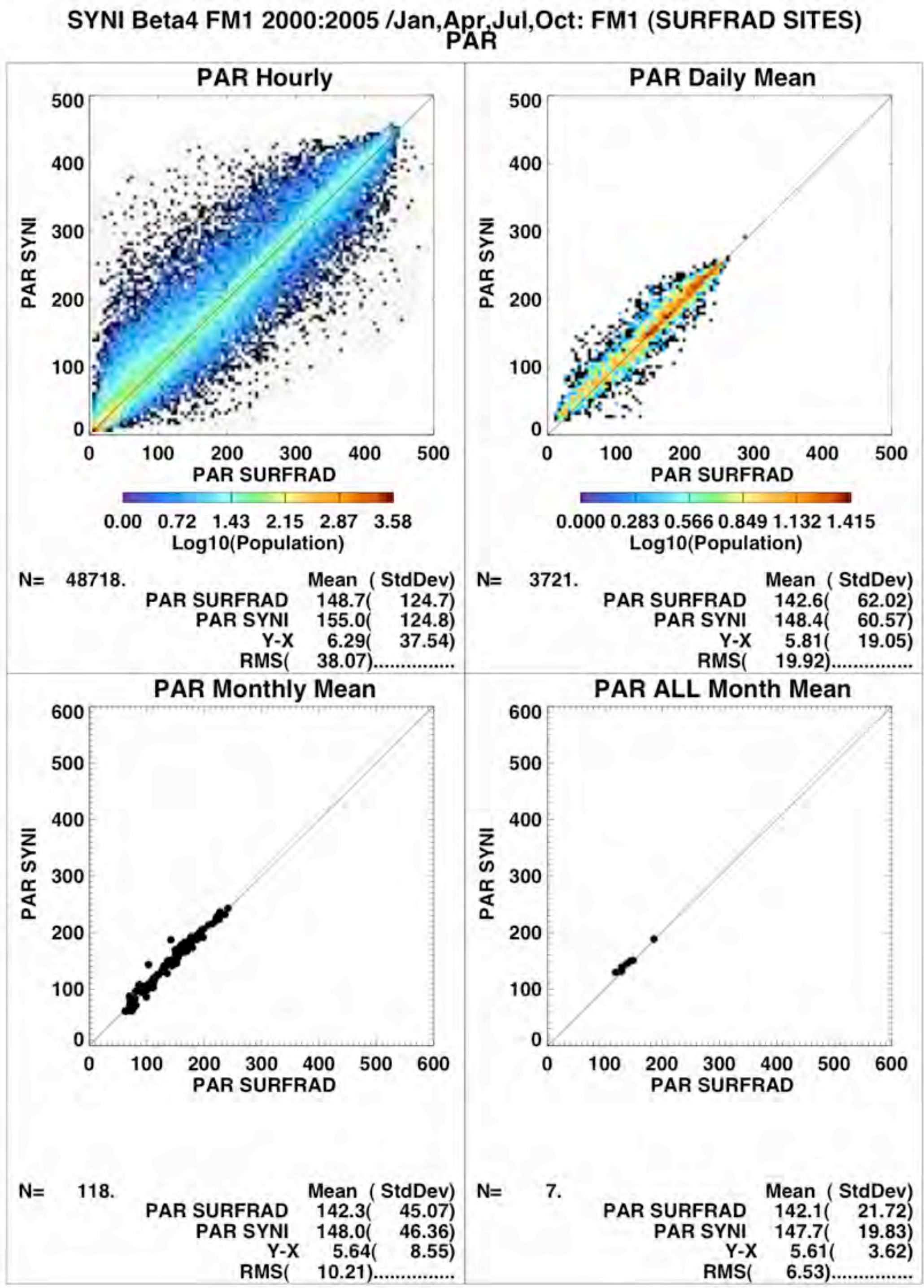
PAR

Comparison to

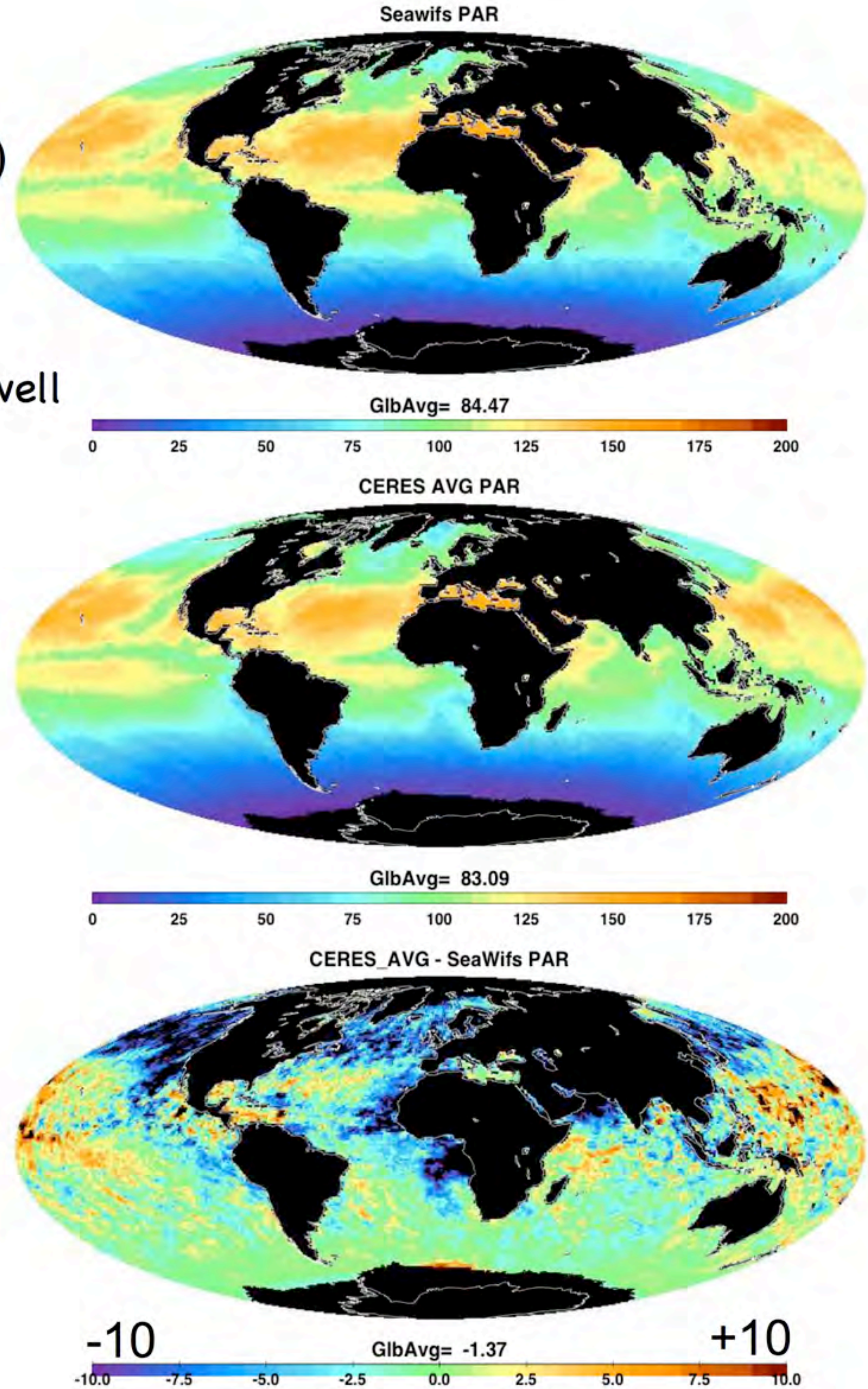
Sfc. SURFRAD

Validation sites

PAR =400:700nm Wm^{-2}



CERES "AVG" PAR
(Photosynthetic Active Radiation)
Compared to SeaWiFs
July 2004.
OCEAN ONLY!
But remember CERES does land as well



CERES "AVG" PAR
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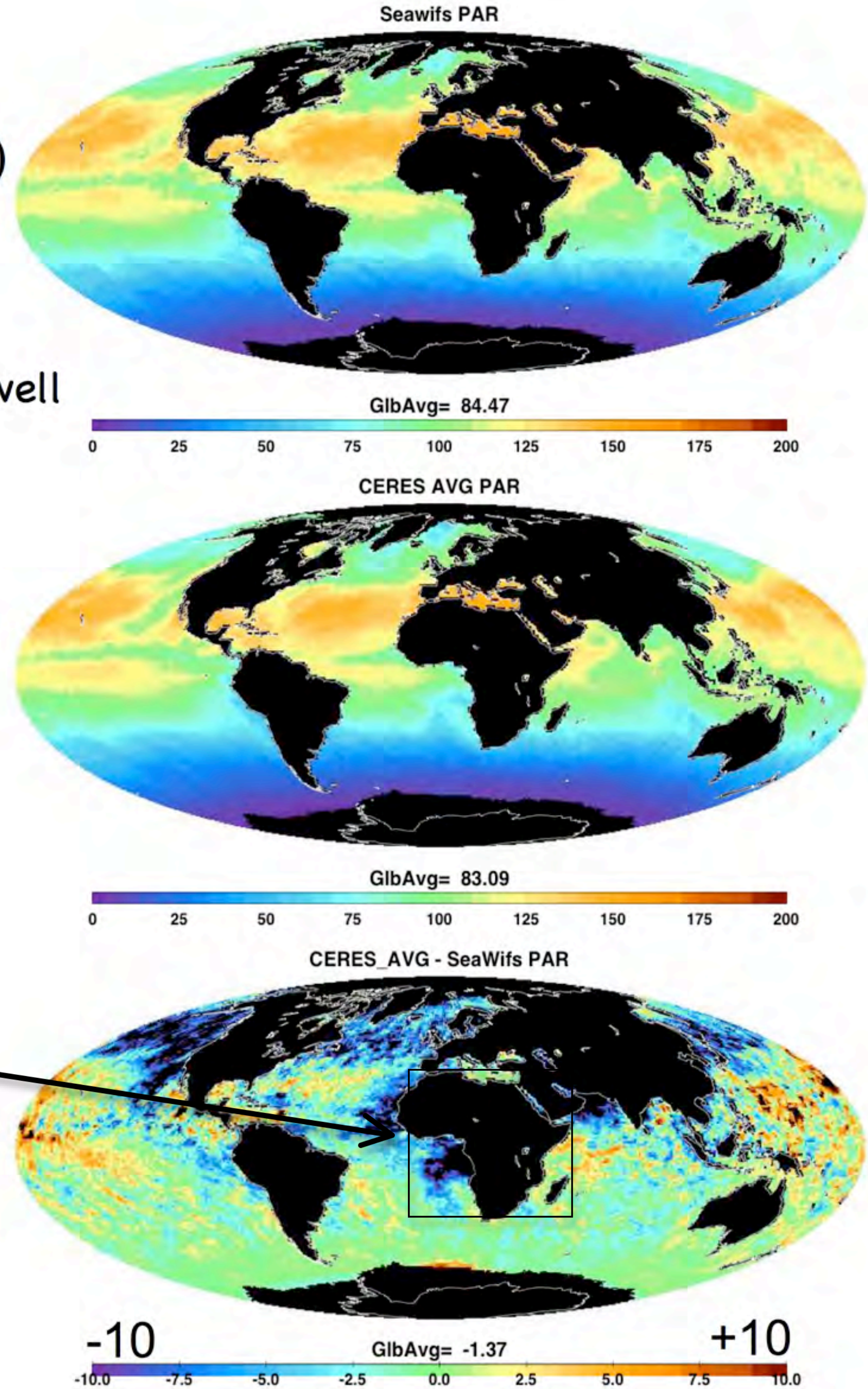
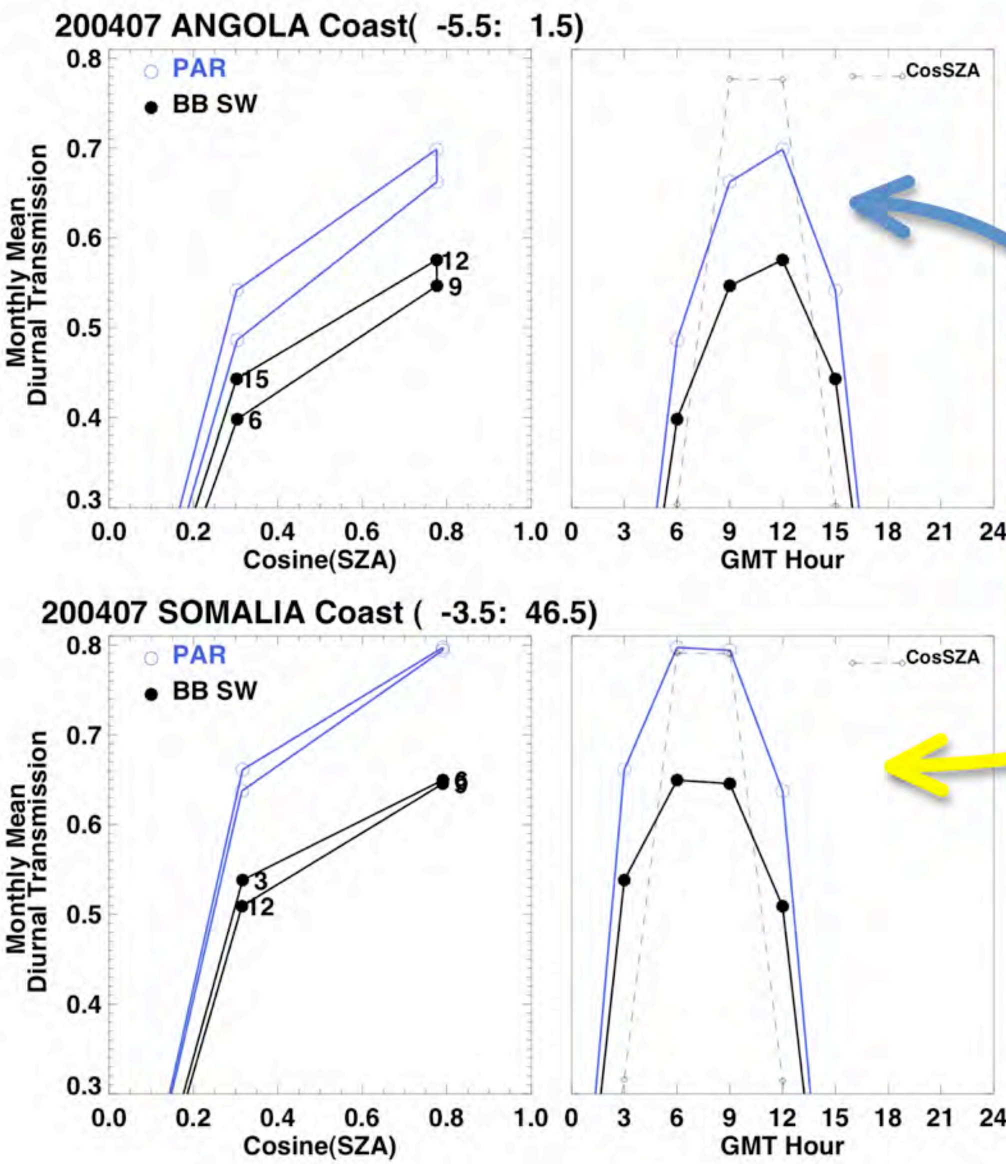
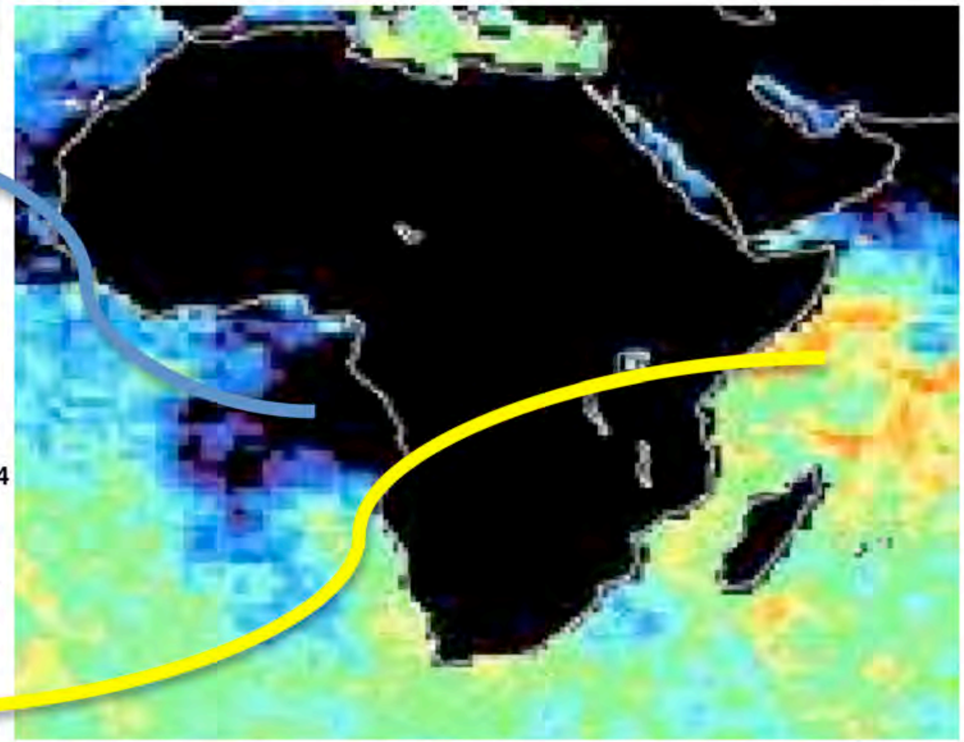


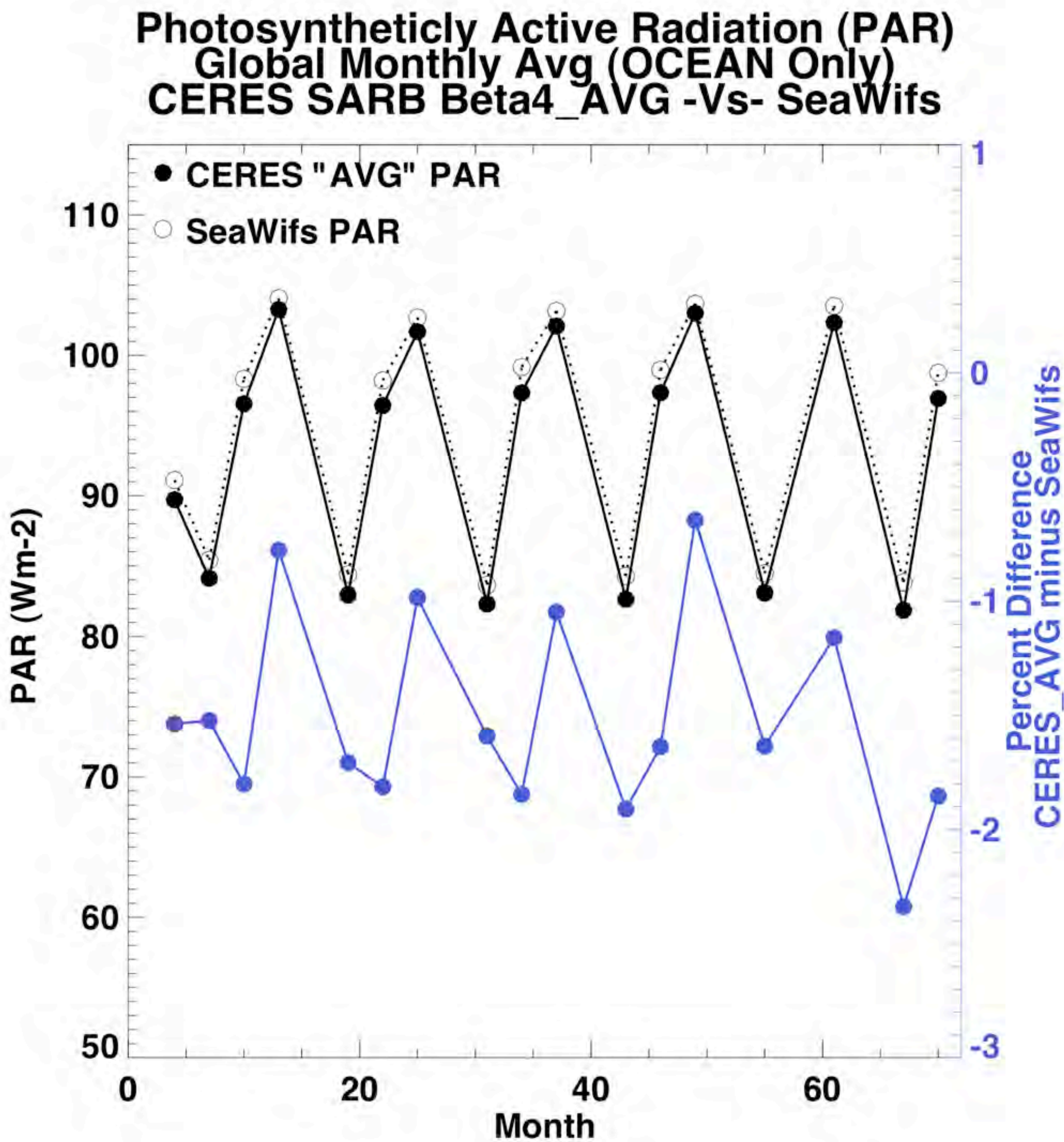
Lets look at a region with two locations one with a positive and another with a negative bias

Monthly Diurnal Mean Sfc. Transmission Broadband SW & PAR





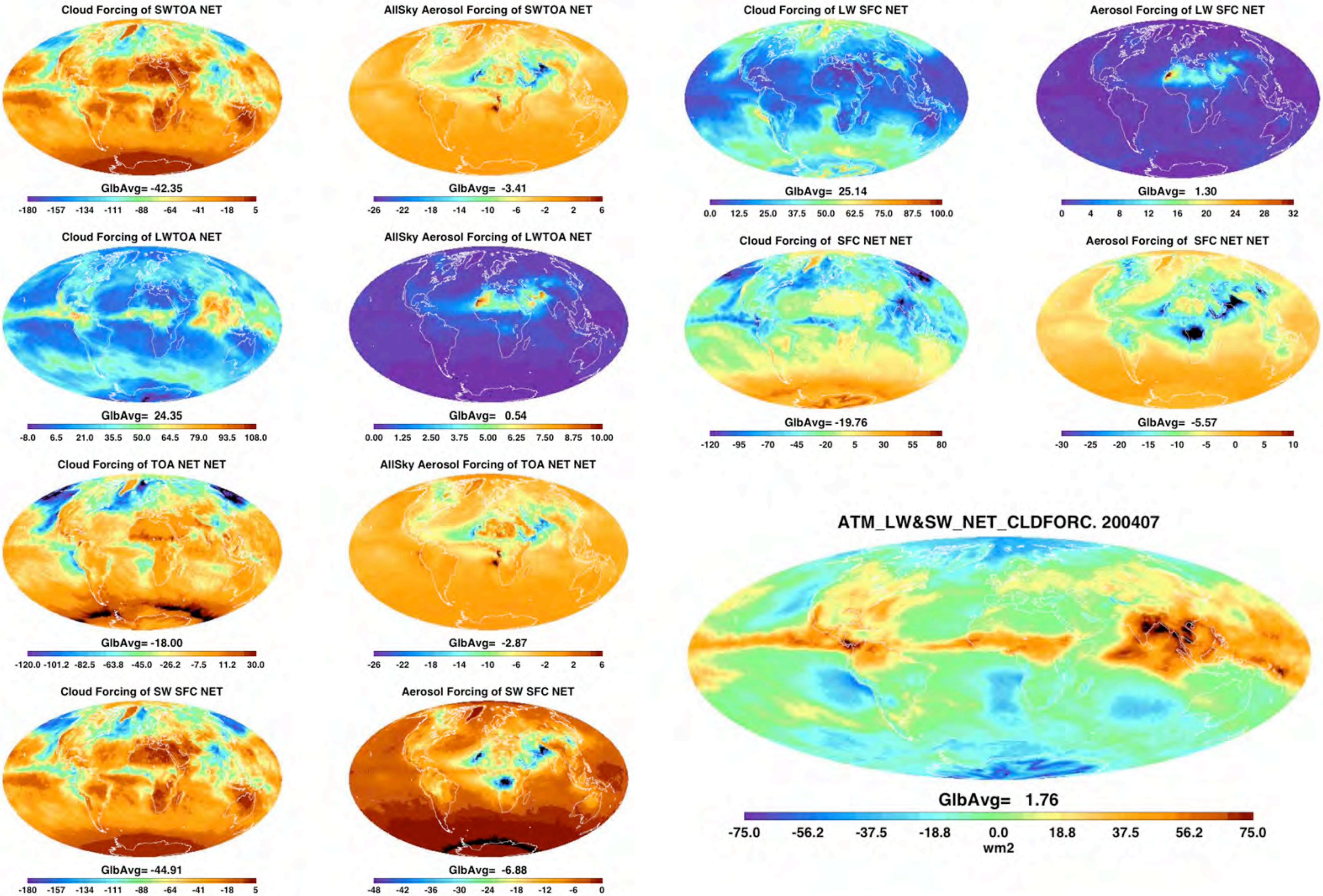
We had seen monthly mean PAR bias compared to NOON overpass SeaWifs.
Could diurnal cloud differences be the cause?
(Yes) CERES TSI/SYNI/AVG gives better diurnal sampling.

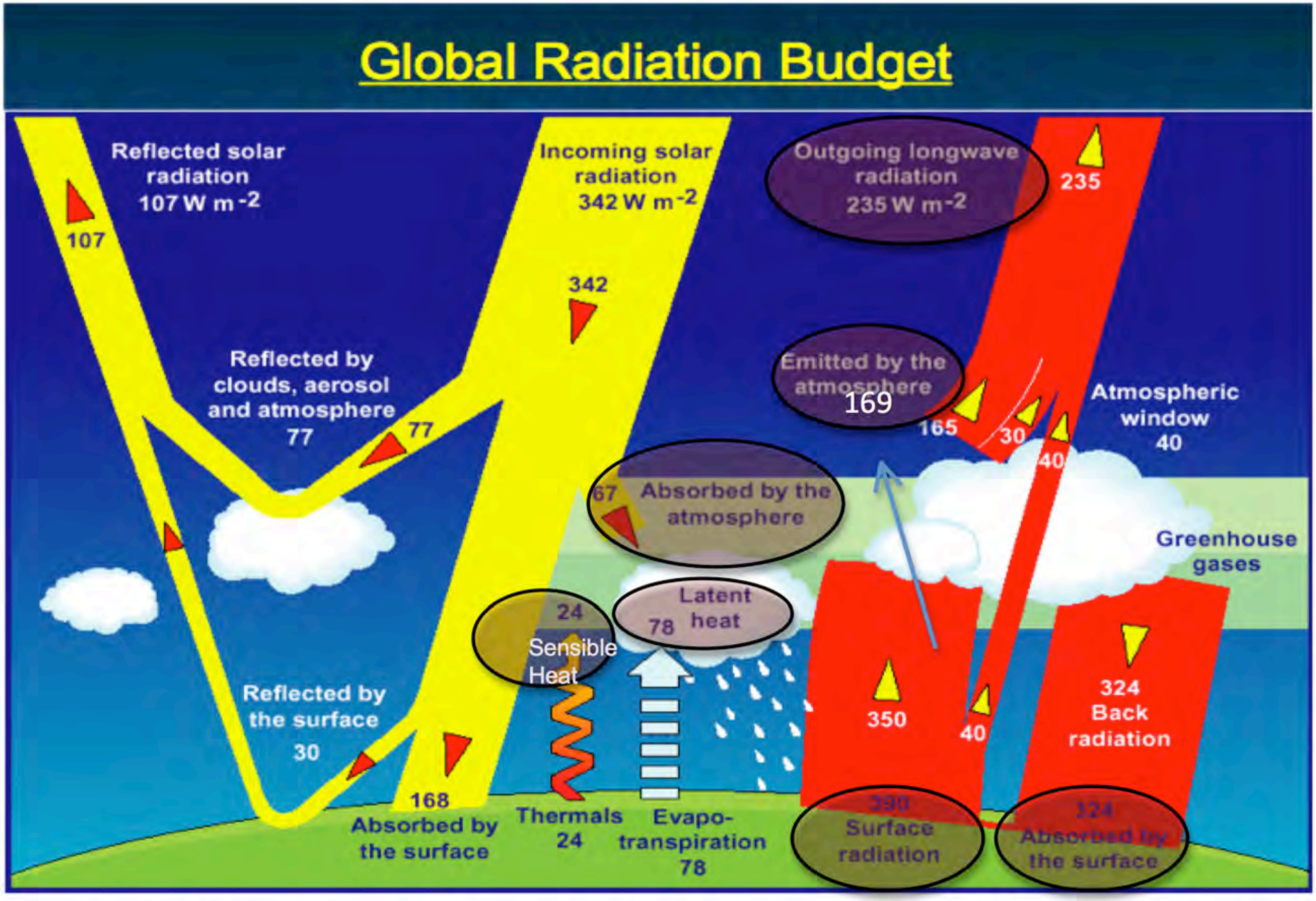

Photosyntheticly Active Radiation (PAR)
Global Monthly Avg (OCEAN Only)
CERES SARB Beta4_AVG -Vs- SeaWifs
CERES "AVG" PAR
SeaWifs PAR
PAR (Wm-2)
Percent Difference
CERES_AVG minus SeaWifs
Month
110
100
90
80
70
60
50
0
20
40
60
1
0
-1
-2
-3

Beta4 “AVG”

- Survey of Cloud and Aerosol forcing variables
- Atmospheric Radiation Budget
  – Diabatic (SH +LE = ATM NET RAD)
  – Compare Subsidence and Radiative Cooling

Survey of Beta4 “AVG” Forcing Quantities (July 2004) [Wm^{-2}]





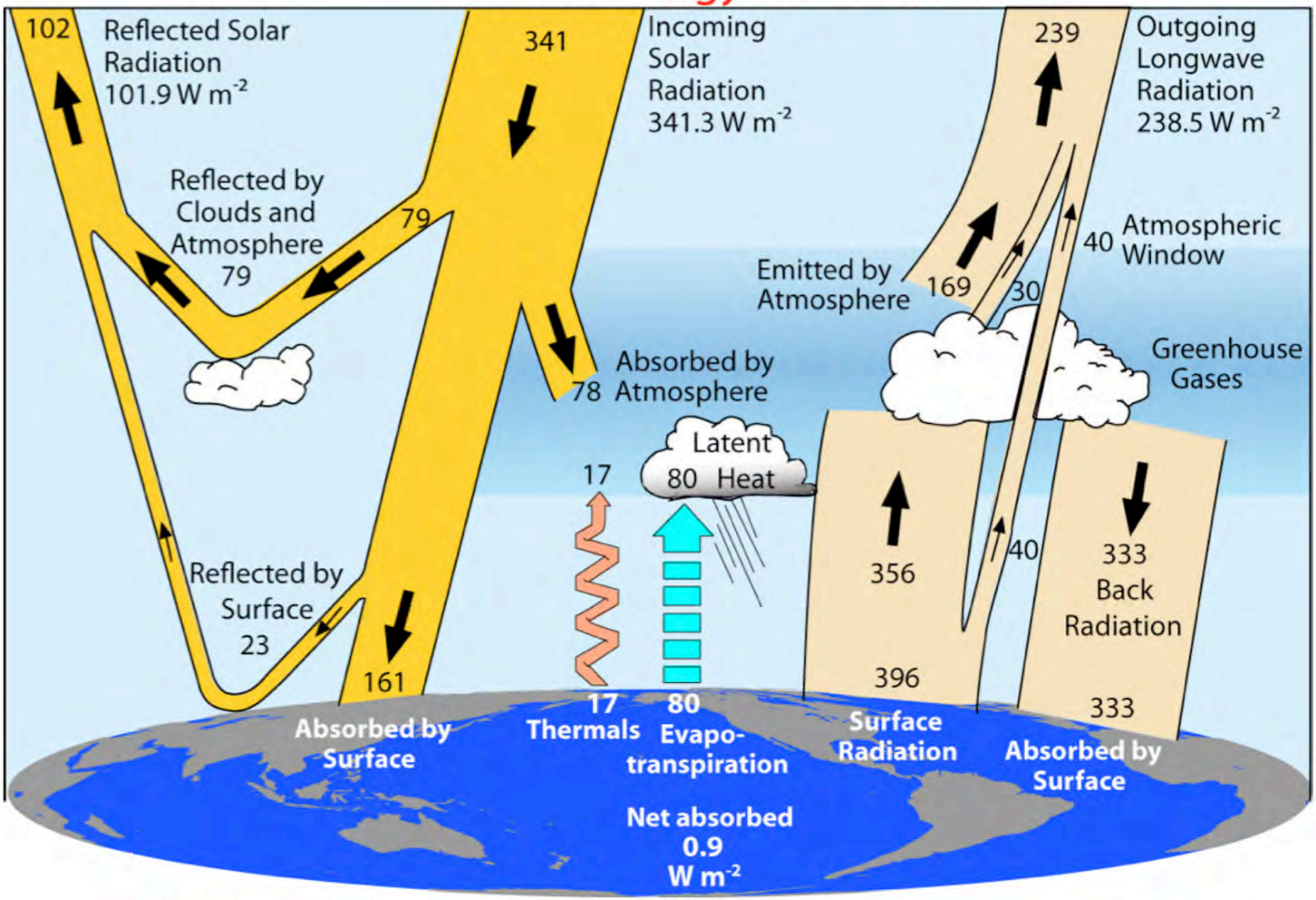
Sensible(24) + Latent(78) + SW_ATM_Absorbed(67) = LW_ATM_Emitted(-169)

-OR-

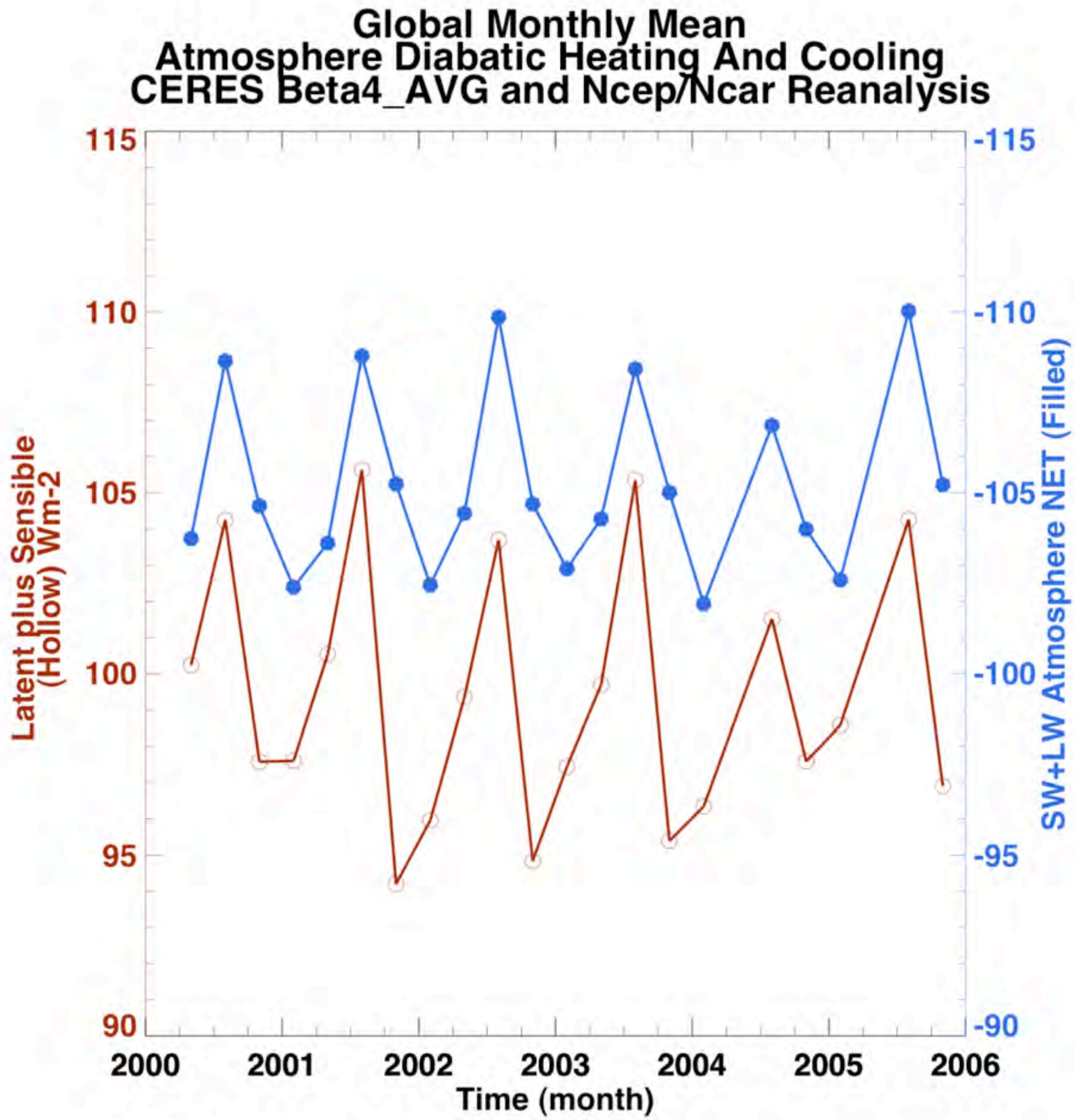
Sensible&Latent(102) = Atm_Net_SW&LW(-102)

{Kiehl and Trenberth 1997}

Global Energy Flows W m^{-2}



Sensible&Latent(97) = Atm_Net_SW&LW(-98) +Ocean(0.9)::
{Trenberth, Fasullo, Keihl :2008}



Beta4_Avg SW&LW Atmosphere NET *minus* NCAR/NCEP Latent & Sensible

-5.0

Tuned - Observed	Downward Longwave Surface(site)	Upward Longwave Surface(site)	Downward Shortwave Surface(site)	Upward Shortwave Surface (site edited)	TOA SHORTWAVE (global)	TOA LONGWAVE (global)	NET ATMOSPHERE SW+LW
Bias	-4.6	-3.9	4.8	-7.0	+0.6	-1.0	-10.7

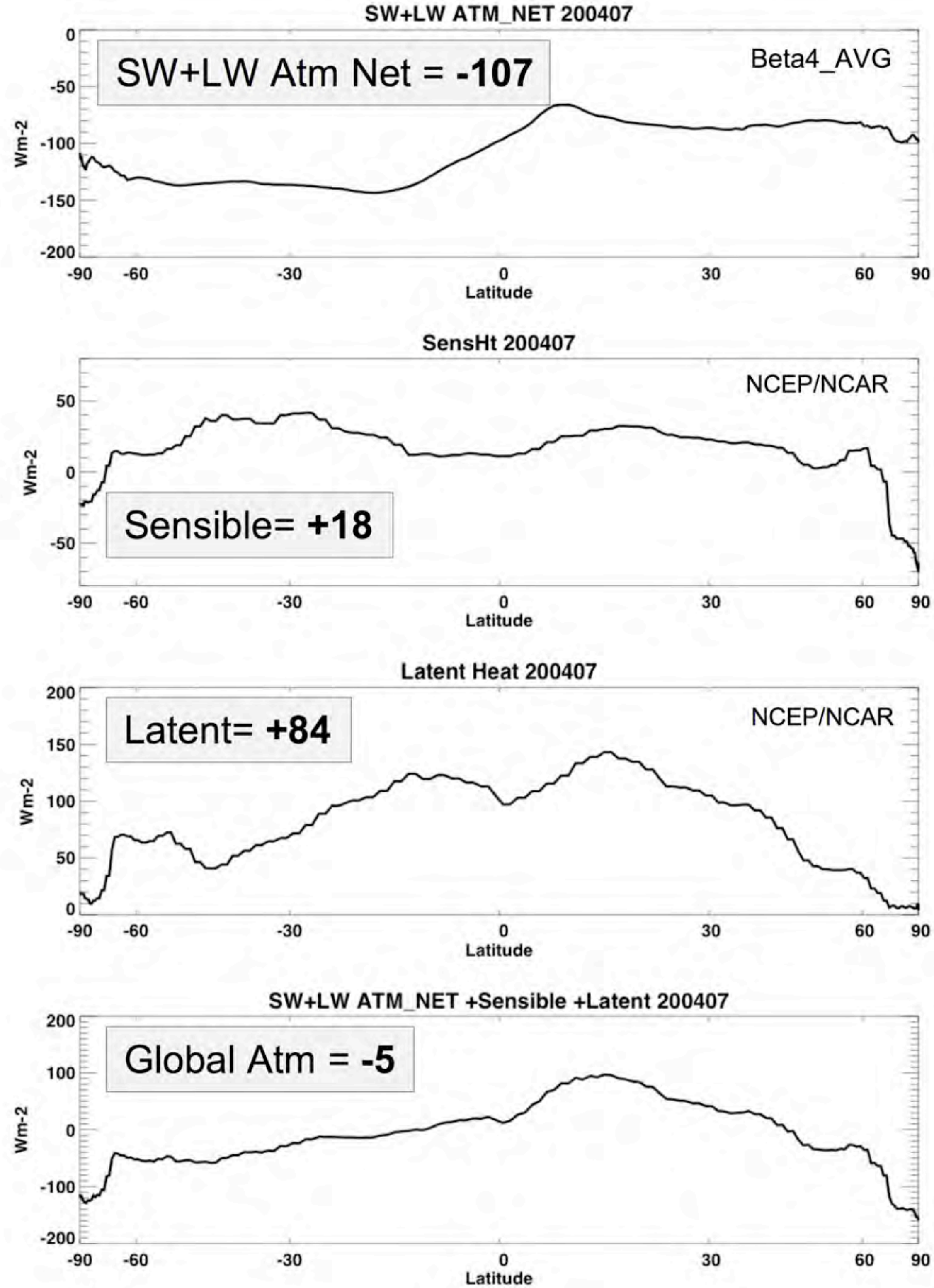
Atmosphere Diabatic Radiation Budget

Atmosphere gains ..
Latent and Sensible Heat
Shortwave absorption

Atmosphere loses …
Longwave cooling

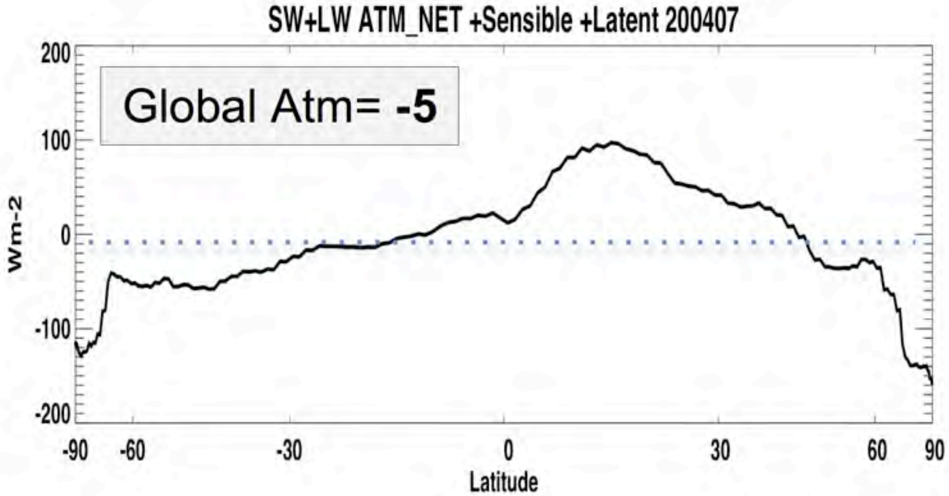
On monthly global scale the processes are *nearly* in equilibrium.

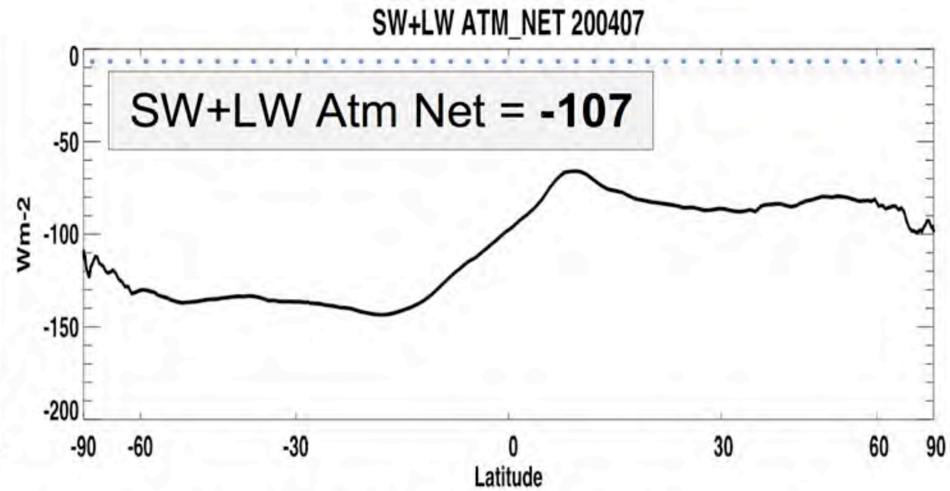
Zonal gradient drives global atmosphere circulation
Hadley cell
poleward heat transport



Kalnay et al.,The NCEP/NCAR 40-year reanalysis project,
Bull. Amer. Meteor. Soc., 77, 437-470, 1996.
Source NOAA/OAR/ESRL PSD,Boulder, Colorado, USA

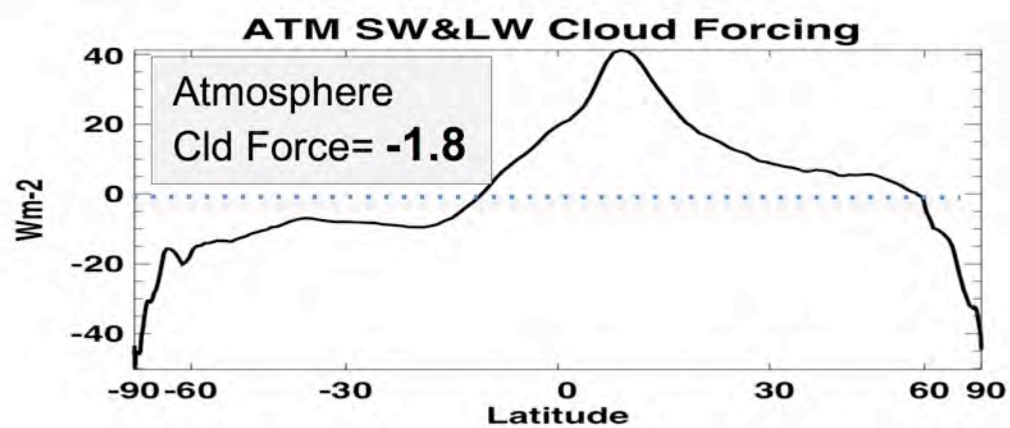
Comparison of CLOUD FORCED Atmosphere Net Radiative Process to TOTAL Diabatic Processes 200407





- Clouds increase atmosphere radiative cooling in polar regions and reduce cooling in tropics

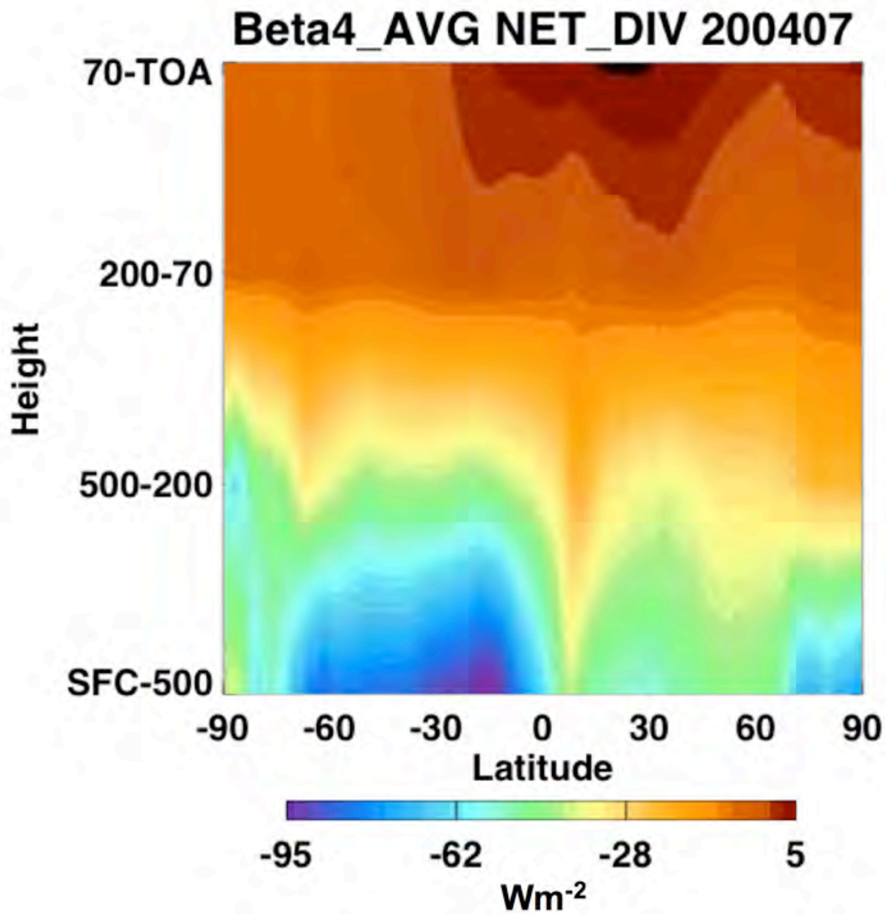
- Increasing atmosphere zonal heat transport

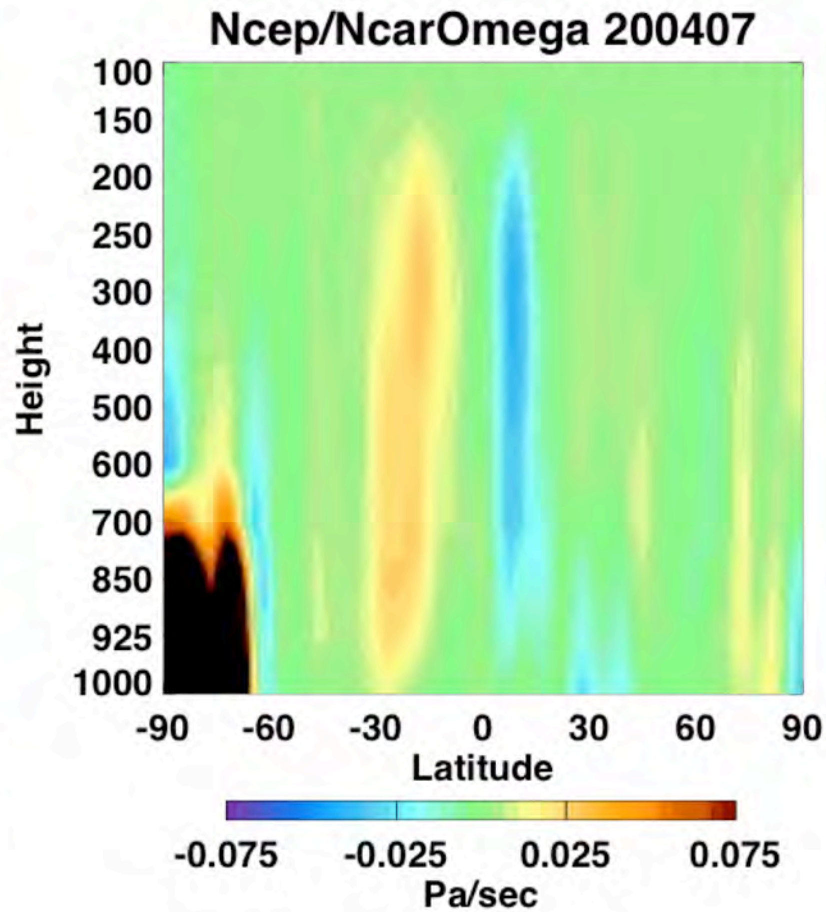


Zhang, Y.-C., and W. B. Rossow, 1997:
Estimating meridional energy transport by the atmospheric and oceanic general circulations using boundary fluxes, *J. Climate*, 10, 2358-2373.

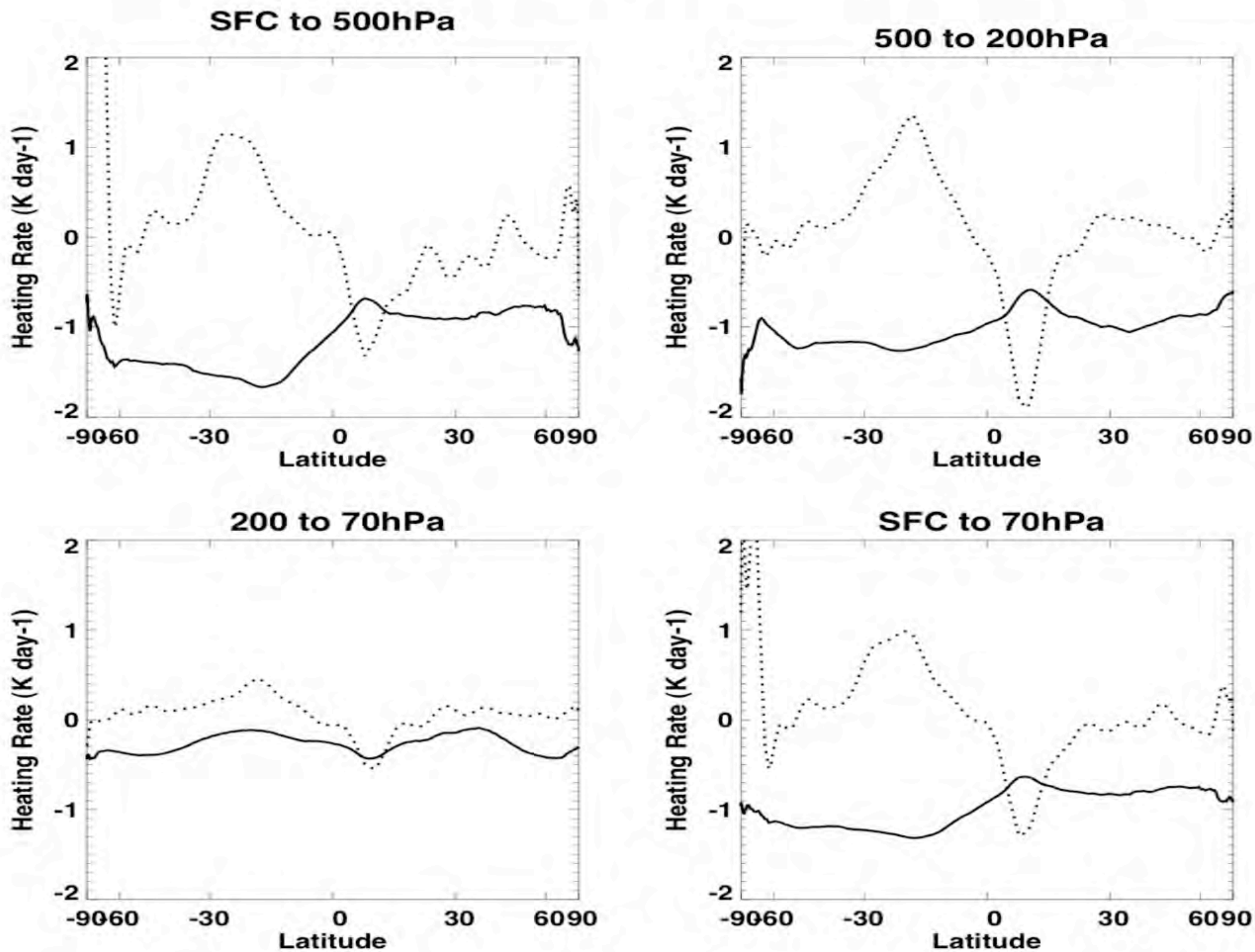
Kato S., Rose F., Rutan D., Charlock T.,
Cloud Effects on Meridional Atmospheric Energy Budget Estimated from Clouds and the Earth's Radiant Energy System (CERES) Data. *J. Climate* ,**Sept 2008**

Zonal Height profile of OMEGA/Vertical Motion (Adiabatic) Radiational Cooling (Diabatic)





Zonal Temperature Tendencies for July 2004
Beta4_AVG Net Atmosphere SW&LW(Radiative/Diabatic) SOLID
NCEP OMEGA based (Vertical Motion/Adiabatic) DASHED



Summary

- Point to grid-box surface validation of Beta4_**SYNI** and Beta4_**AVG** are encouraging.
- Diurnal effects of GEO clouds and fluxes are consistent and add value.
- Atmosphere Net budget closes to within 5% of Ncar/Ncep Reanalysis.
- A Full 12 month year will be processed and analyzed before an Edition decision is made.