TRMM CRS Edition 2b Validation

CERES Science Team Meeting

GFDL, Princeton N.J., 17 Sept. 2002

Surface and Atmosphere Radiation Budget (SARB) group:

T. P. Charlock (NASA LaRC)

Fred G. Rose (AS&M)

David A. Rutan (AS&M) – validation and “CAVE” URL

Zhonghai Jin (AS&M) - coupled radiative transfer

Lisa H. Coleman (SAIC) - Data Management Team

Thomas E. Caldwell (SAIC) - Data Management Team

access to CAVE on line surface and CERES validation:

www-cave.larc.nasa.gov/cave/

CERES Surface and Atmosphere Radiation Budget (SARB)

Fred Rose will give Part II of presentation

Update of Fu-Liou code and other changes for Terra

Part III on validation of surface SGP albedo retrieval using CARE

helicopter in Co-I Reports (Rutan et al.)

Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) meets Charlottesville 9-10 Oct. (Bill Smith, Jr.)

CLAMS (CERES-MODIS-MISR-GACP) issue of JGR

Test radiometers on **balloon at 35km (!)** in Dec. 2002 (Wenying Su)

CERES Ocean Validation Experiment (COVE) OV-10 flights

and Su foam observations continue

CAVE web site (google CAVE CERES) www-cave.larc.nasa.gov/cave/

Point and click radiative transfer, on line data and plots, etc.

CRS Edition 2B TRMM Jan-Aug 1998

CRS (cloud radiation swath) is the instantaneous, footprint scale SARB product

"Edition": okay for publication

Surface and Atmospheric Radiation Budget (SARB)

SW/LW/WN (surface, 500-200-70 hPa, TOA)

Cloud forcing, aerosol forcing, PAR

Adjustments (tuning) to PW, UTH, AOT, skin T, cloud tau, cloud fraction, cloud height

Inputs include SSF, ECMWF, MATCH, SMOBA

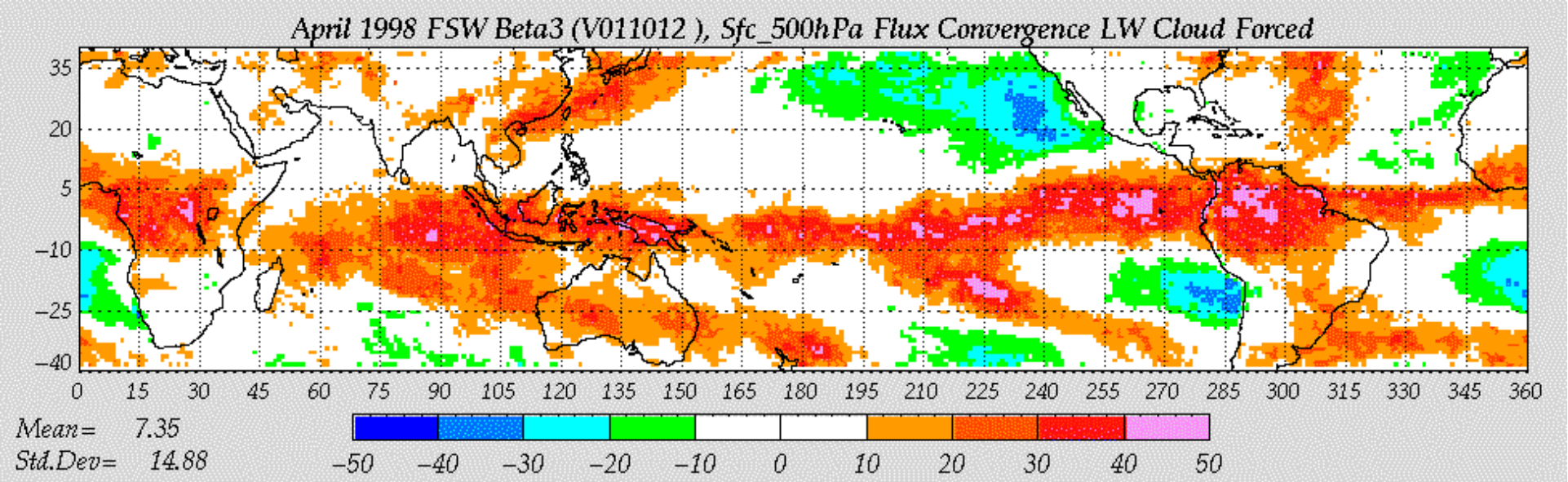
Modified Fu-Liou 2 stream SW (2/4 LW)

LUT to Jin coupled ocean-atmosphere model

Cloud forcing to LW convergence (Surface to 500hPa) April 1998

All sky LW convergence is generally negative.

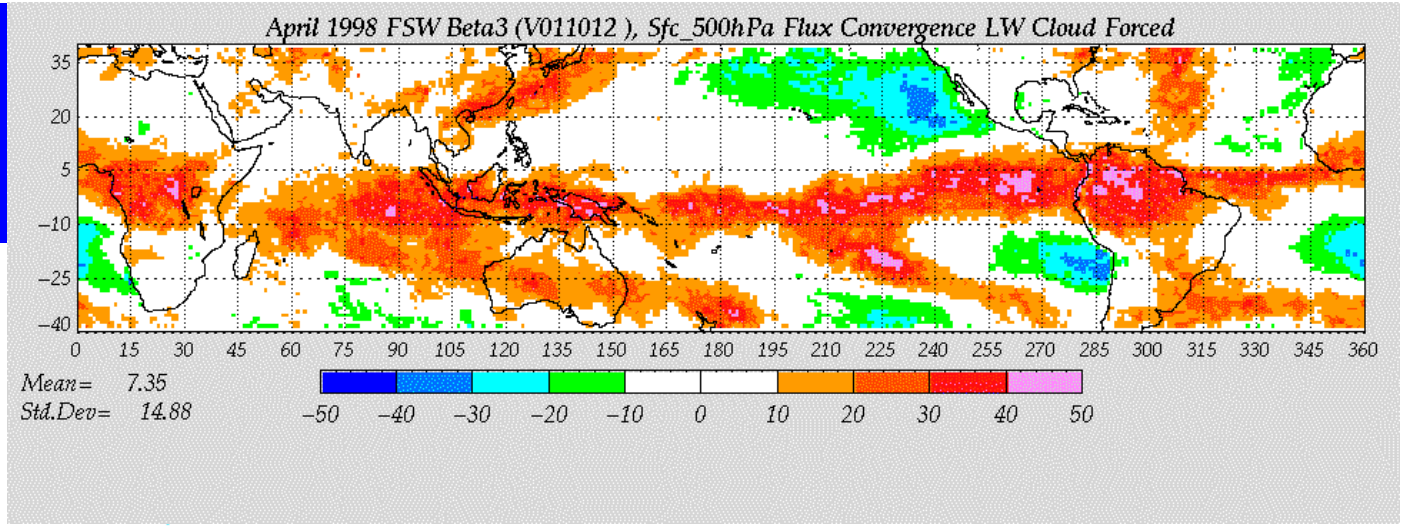
gridded “FSW Beta3”= hourly mean of ungridded “CRS Ed2B”



Cloud Forcing

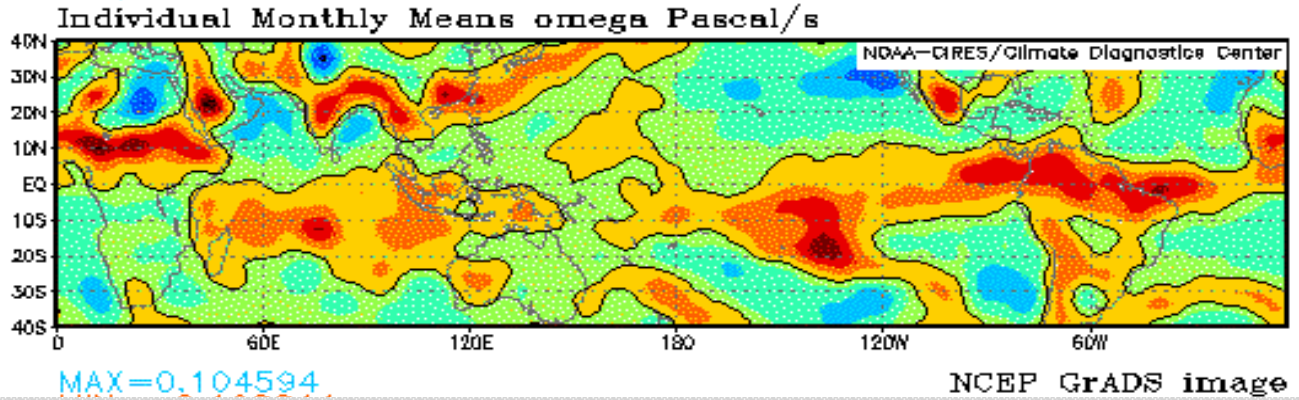
LW Conv Sfc-500hPa

range -50 to +50 Wm-2



Omega 700 hPa

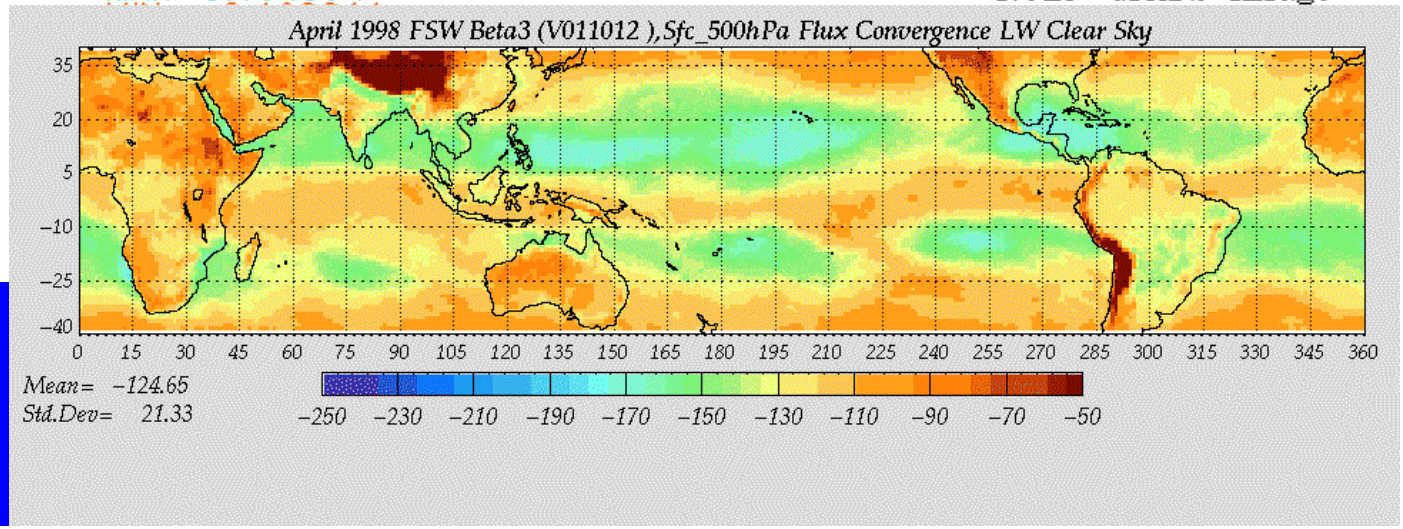
red = ascent

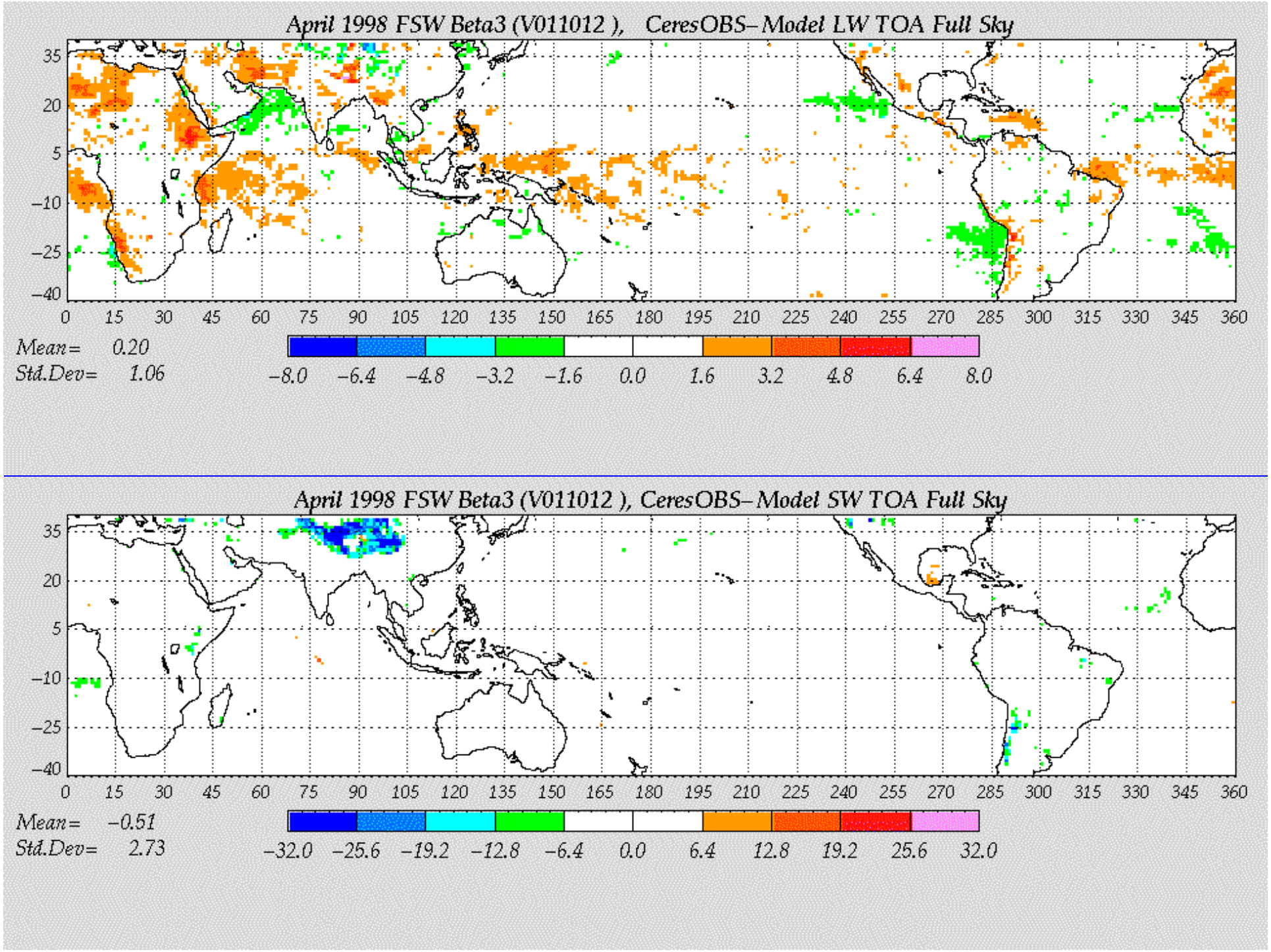


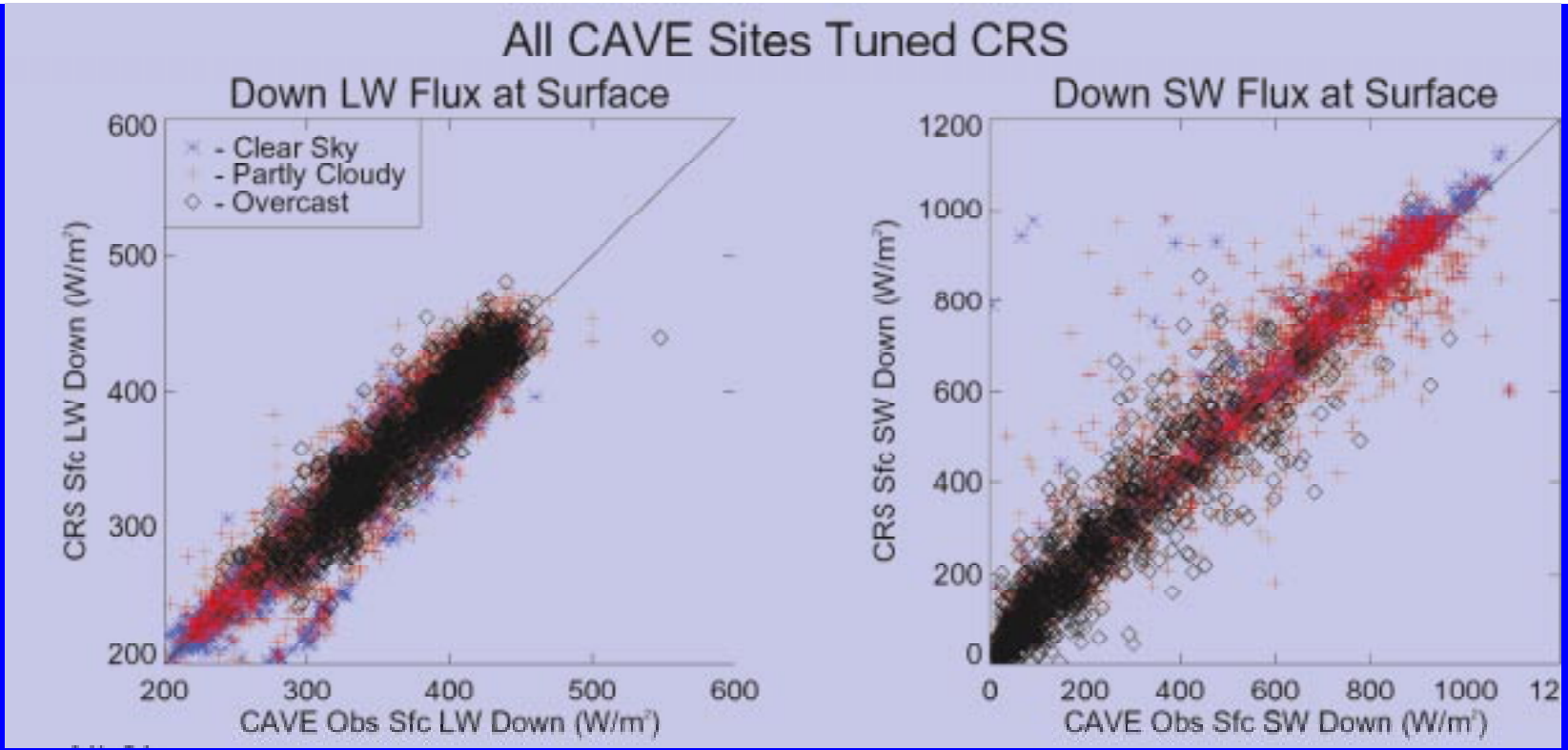
Clear Sky

LW Conv Sfc-500hPa

range -150 to -50 Wm-2




April 1998 FSW Beta3 (V011012), CeresOBS– Model LW TOA Full Sky
35
20
5
−10
−25
−40
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360
Mean= 0.20
Std.Dev= 1.06
−8.0 −6.4 −4.8 −3.2 −1.6 0.0 1.6 3.2 4.8 6.4 8.0
April 1998 FSW Beta3 (V011012), CeresOBS– Model SW TOA Full Sky
35
20
5
−10
−25
−40
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360
Mean= −0.51
Std.Dev= 2.73
−32.0 −25.6 −19.2 −12.8 −6.4 0.0 6.4 12.8 19.2 25.6 32.0



www-cave.larc.nasa.gov/cave/ select "Site Statistics"

	Obs Mean	N	Bias Obs-CRS	RMS	Cld Forc All-Clr
ALL SKY					
LW Dn Sfc	358	8601	2	19	18
LW Up Sfc	429	6780	2	20	
SW Dn Sfc	443	4990	-34	89	-142
SW Up Sfc	91	4162	12	26	
LW Up TOA	252	9282	0	4	-24
SW Up TOA	219	5158	1	17	89

ARM SGP E13 (collocated with Central Facility)

	Obs Mean	N	Bias Obs-SARB	RMS	Cloud forcing
ALL SKY					
LW Dn Sfc	349	455	-3	18	17
LW Up Sfc	416	430	-3	16	
SW Dn Sfc	428	260	-21	60	-128
SW Up Sfc	87	260	11	20	
LW Up TOA	247	457	0	4	-27
SW Up TOA	224	258	2	10	87
OVERCAST					
SW Dn Sfc	243	68	-27	87	
CLEAR VIRS					Aer Forc
SW Dn Sfc	512	94	-23	29	-16/0.6
					SW/LW
CLEAR VIRS + pyranometer					
SW Dn Sfc	324	17	-14	17	-12/0.5
SW direct			-5		
SW diffuse			-9		

How does CRS Ed2b differ from earlier CRS Beta3?

1. When cloud fraction < 0.05, cloud properties in Edition 2b are NOT tuned (but “clear” parameters like PW and surface albedo are tuned).

2. CRS Beta3 did not run in sunglint. CRS Edition 2b runs in glint.

CRS Ed2b suggests SSF TOA error due to sunglint

- Huge effect for tiny number of footprints.

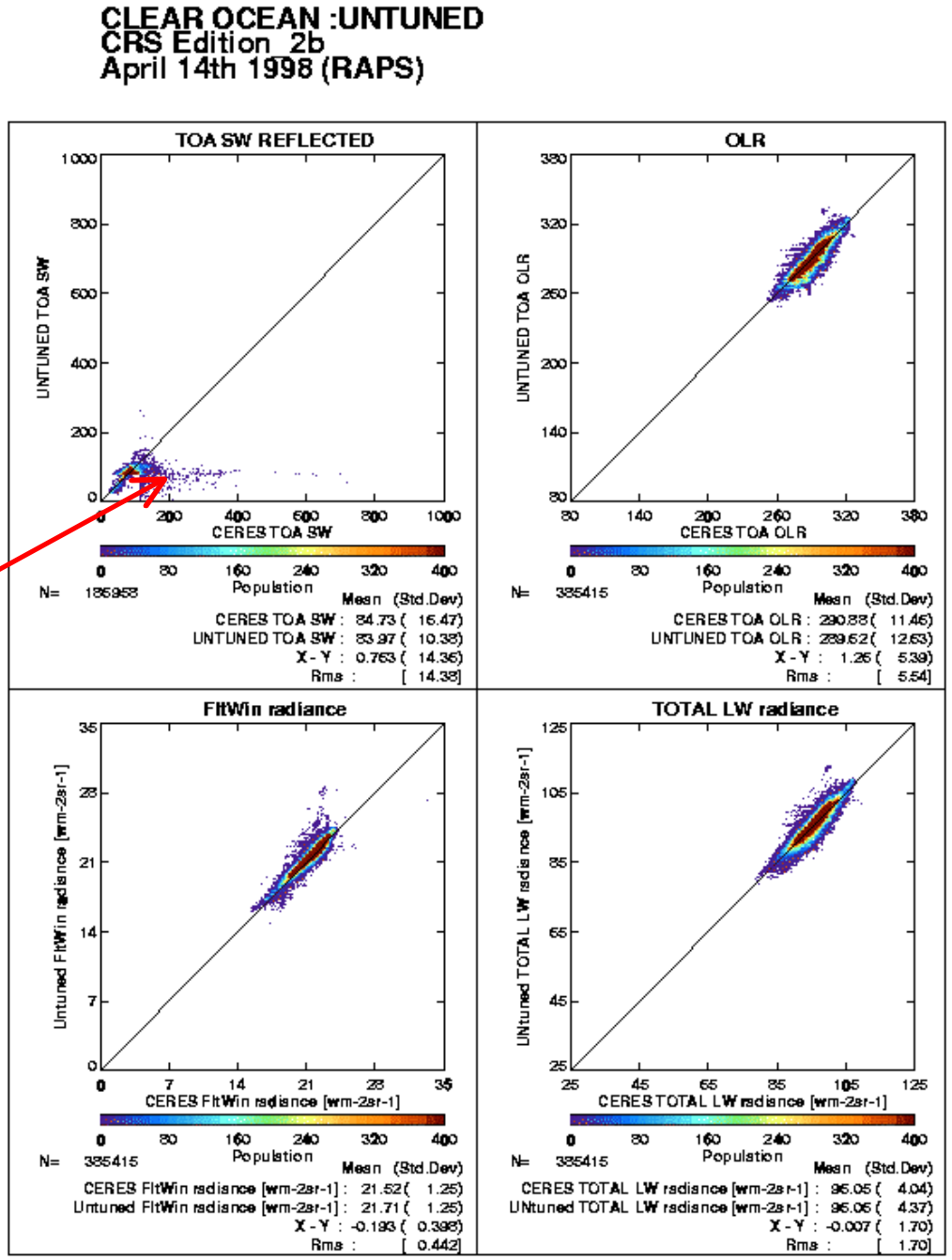
CRS Beta3 & Ed2b have large snow errors

- Footprint with snow AND cloud → error
- Not a major issue in tropics
- Corrected in Terra processing

y axes: Calculation

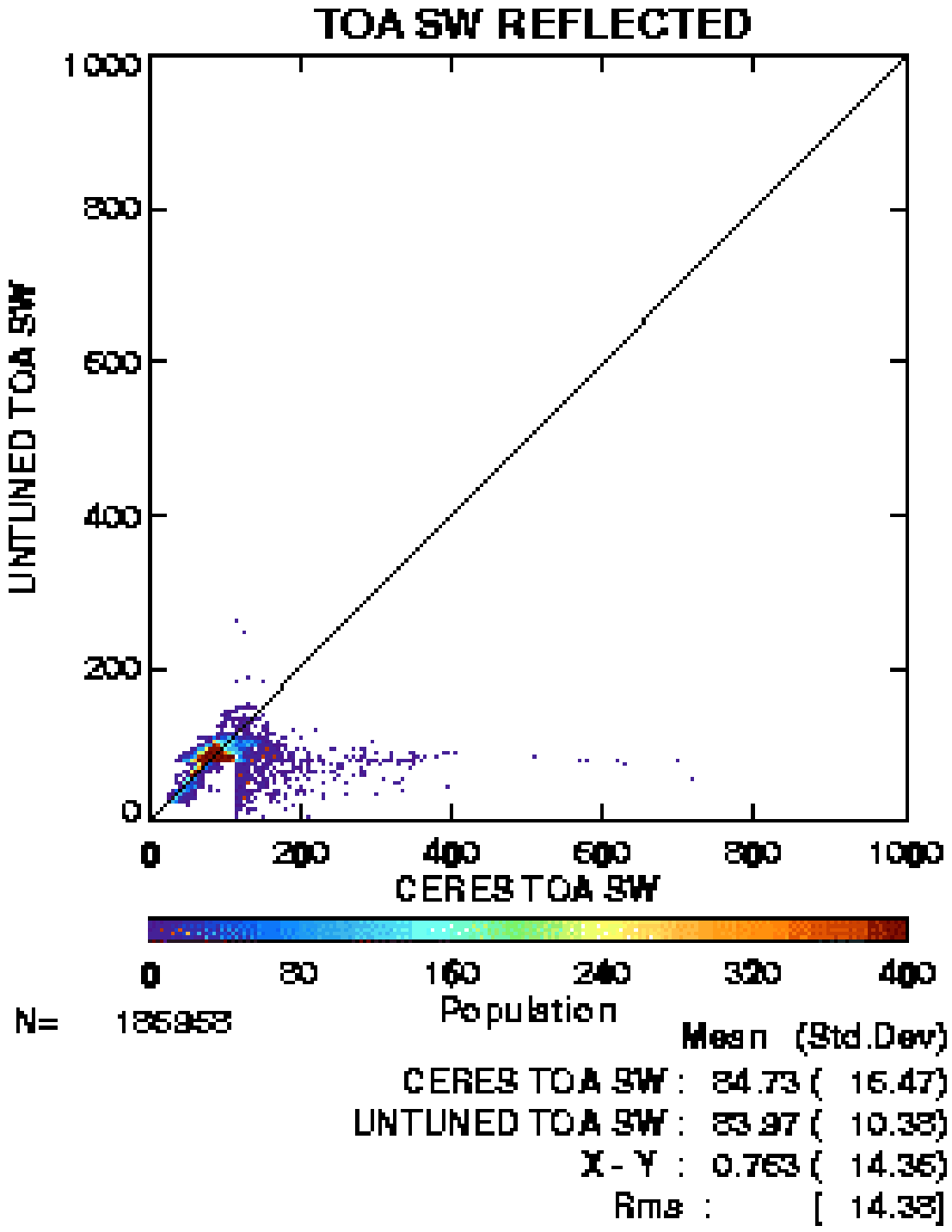
x axes: Observation

Observed >> Computed for reflected SW at TOA



April 14, 1998

Clear ocean only



Left panels:

Imager View Zenith Angle (VZA) vs. Imager Relative Azimuth Angle

Right panels:

CERES View Zenith Angle (VZA) vs. CERES Relative Azimuth Angle

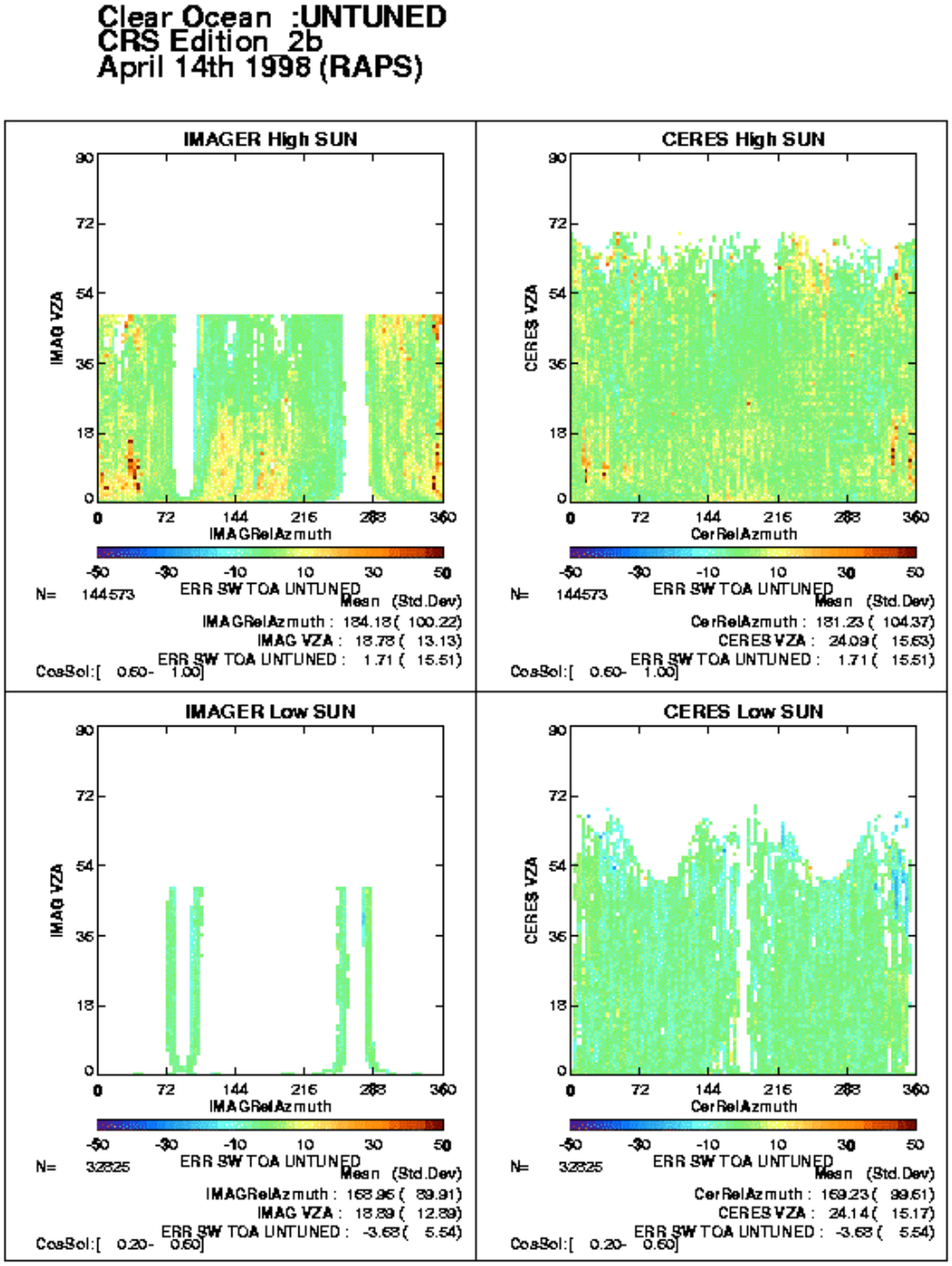
Forward scattering at relative azimuth 0 & 360 .

Error in Reflected SW at TOA =

(Observed value from SSF)

-(Untuned calculation)

RED shows untuned calculation "error" over 50 Wm-2.

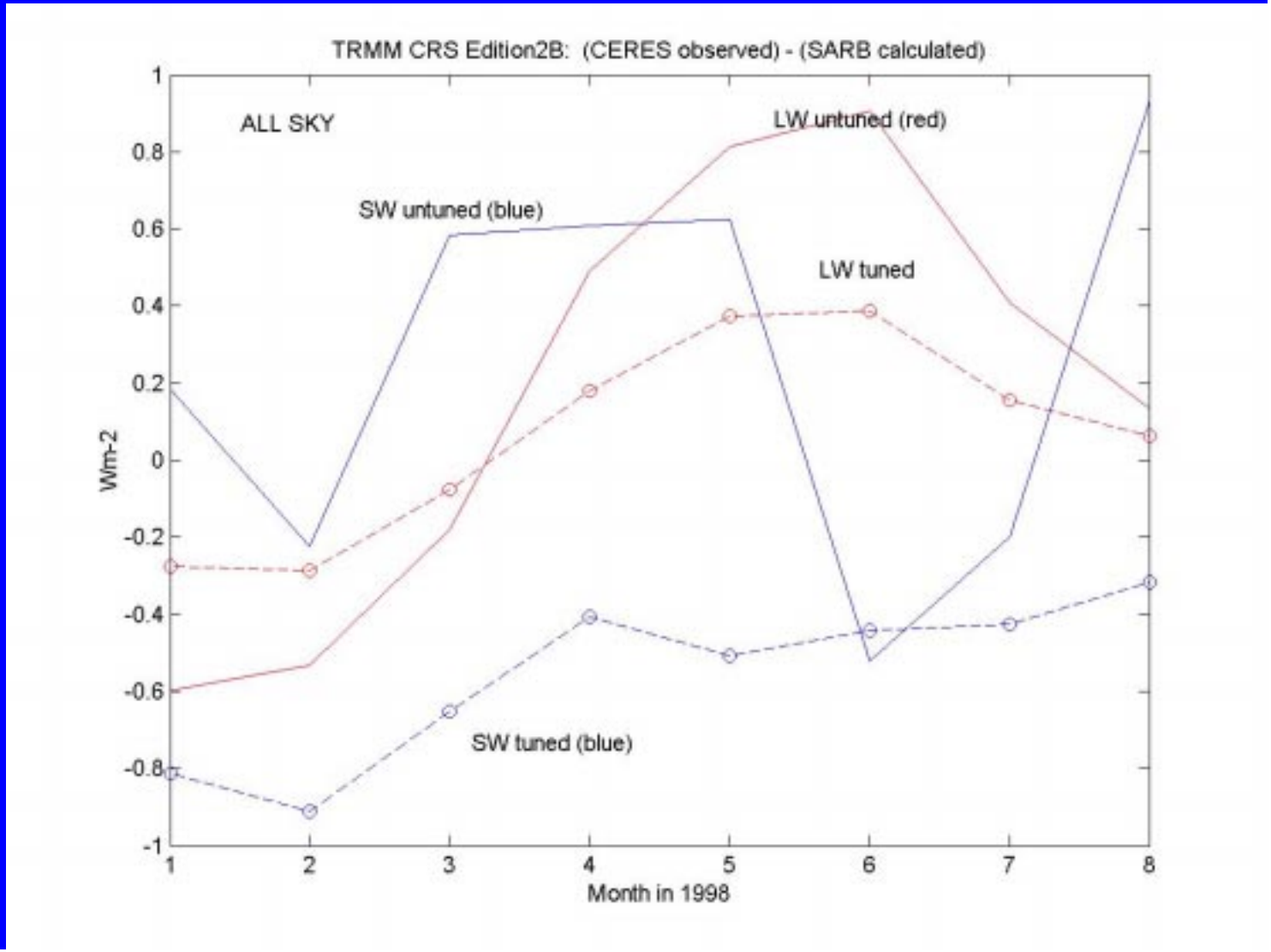


Coarse means (Jan-Aug98) CERES minus SARB Fu-Liou (Wm-2)

Untuned (dash) Tuned (solid) LW(red) SW(blue)

Tuning is not a perfect match to CERES TOA. It mimimizes adjustments to inputs, as well as differences between computed and observed fluxes.

A "drift" remains. As time passes, observations reflect relatively more SW and emit more LW than calculations.

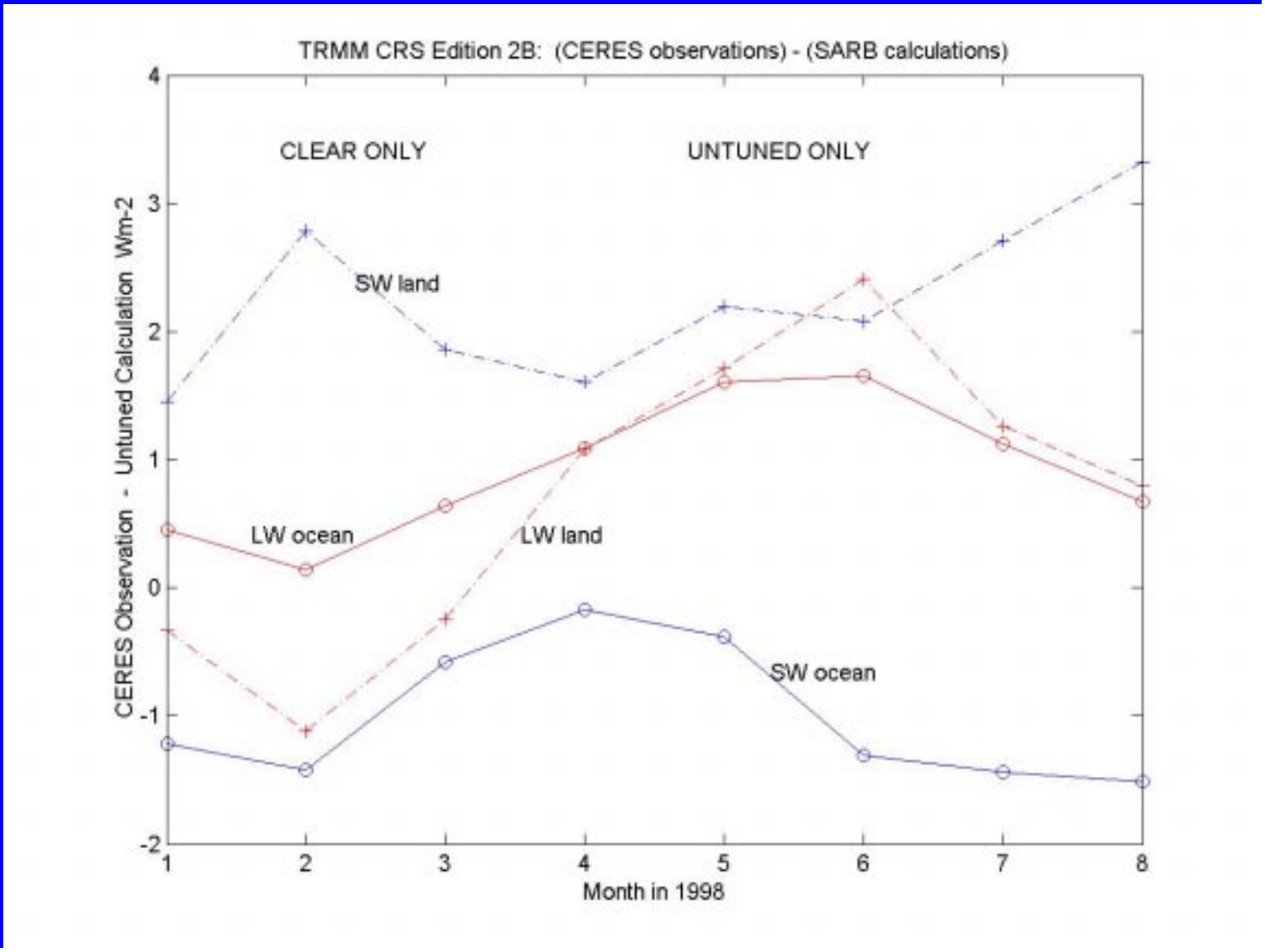


Coarse means (Jan-Aug98) CERES minus SARB Fu-Liou (Wm-2)

Untuned & Clear SW=blue LW=red Ocean=solid Land=dash

VIRS has minimal impact on clear LW over ocean, but small drift remains.

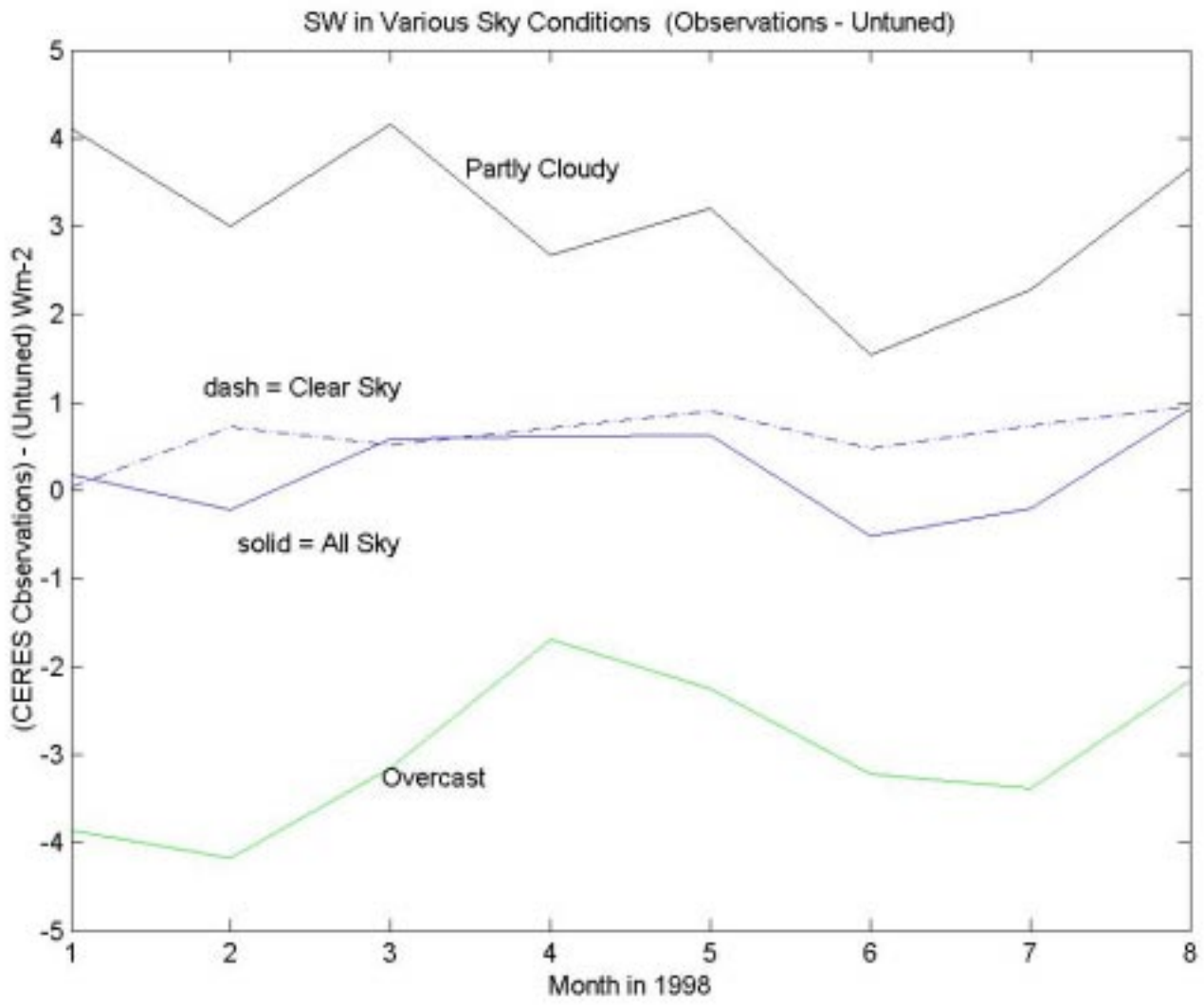
Drift in clear SW over land suggests SARB algorithm needs changes for Terra.



Coarse means (Jan-Aug98) CERES minus SARB Fu-Liou (Wm-2)

Untuned SW All=solid blue Clear=dash Ovcst=green PC=black

For SW, errors in simulating partly cloudy (PC) and overcast (OVCST) are significant but compensating.

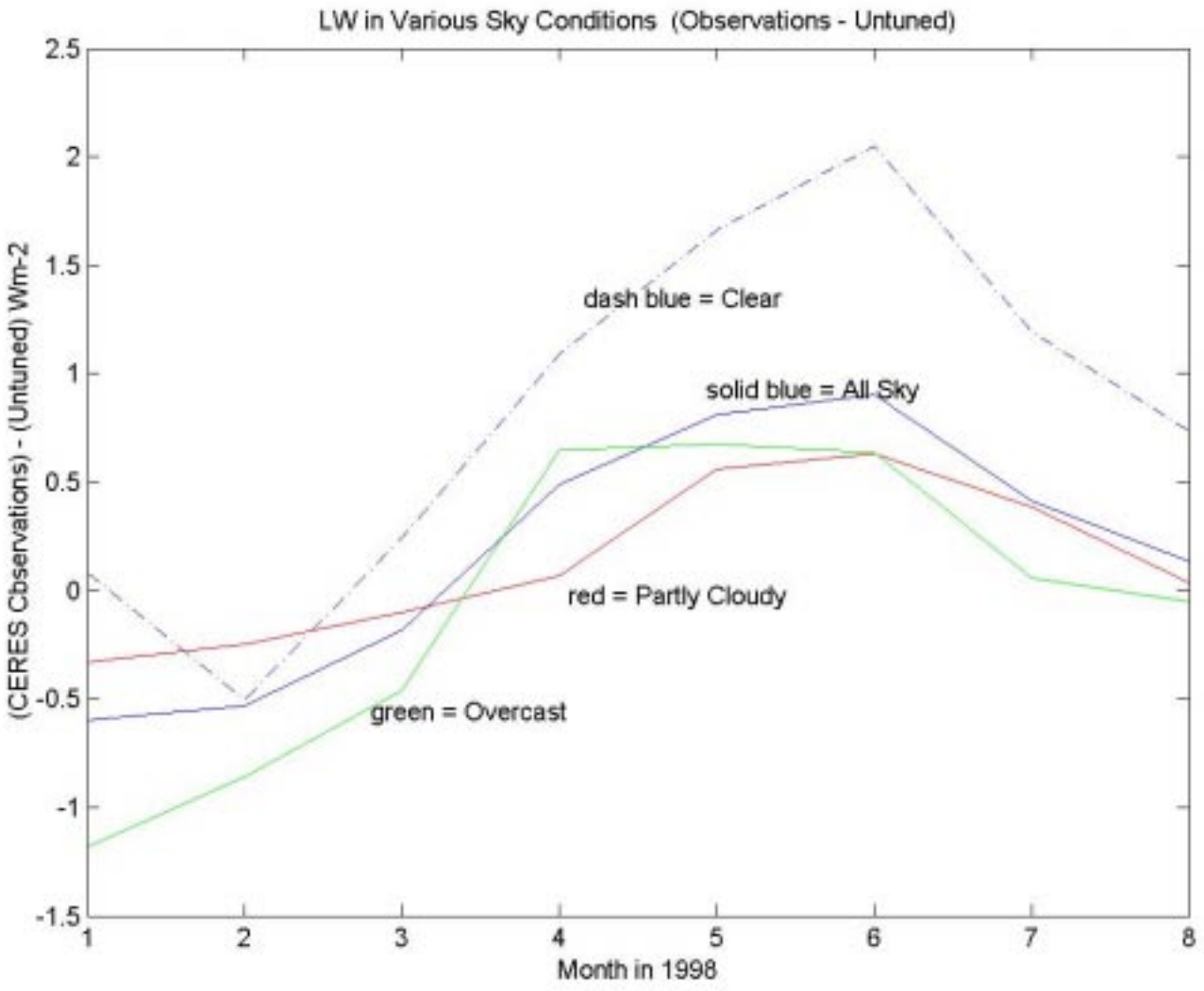


Coarse means (Jan-Aug98) CERES minus SARB Fu-Liou (Wm-2)

Untuned LW All=solid blue Clear=dash Ovcst=green PC=red

Nothing funny about Partly Cloudy and Overcast compensating errors for LW.

The drift in LW appears for all sky conditions



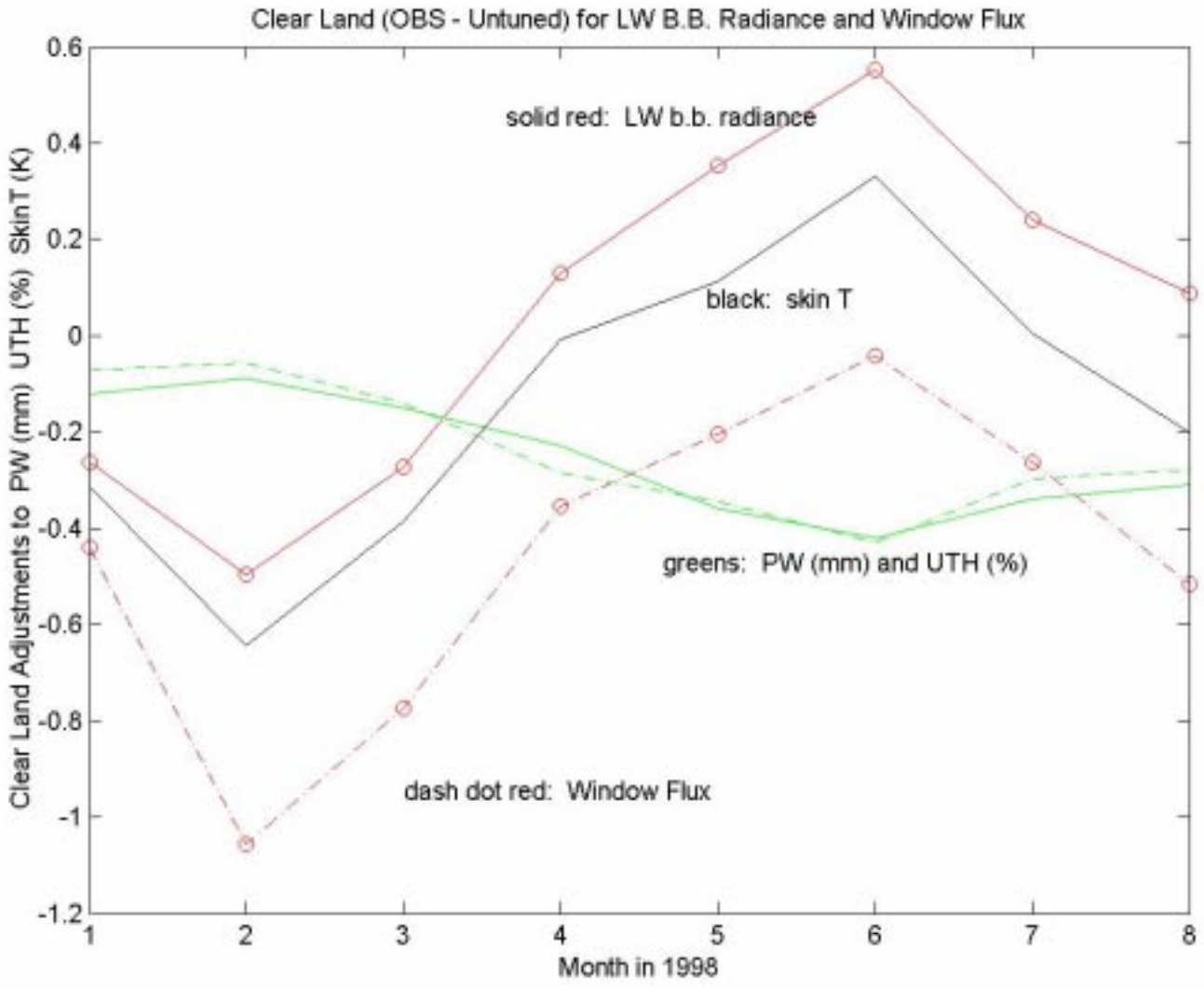
Coarse means (Jan-Aug98) CERES minus Untuned SARB

Clear-sky Land: LW B.B. radiance, Window flux, H2O, skin T

Here show LW b.b. RADIANCE for y-axis scale.

Most adjustment is to skin T (large a priori "sigma" in tuning).

LW Window and B.B. closely linked.



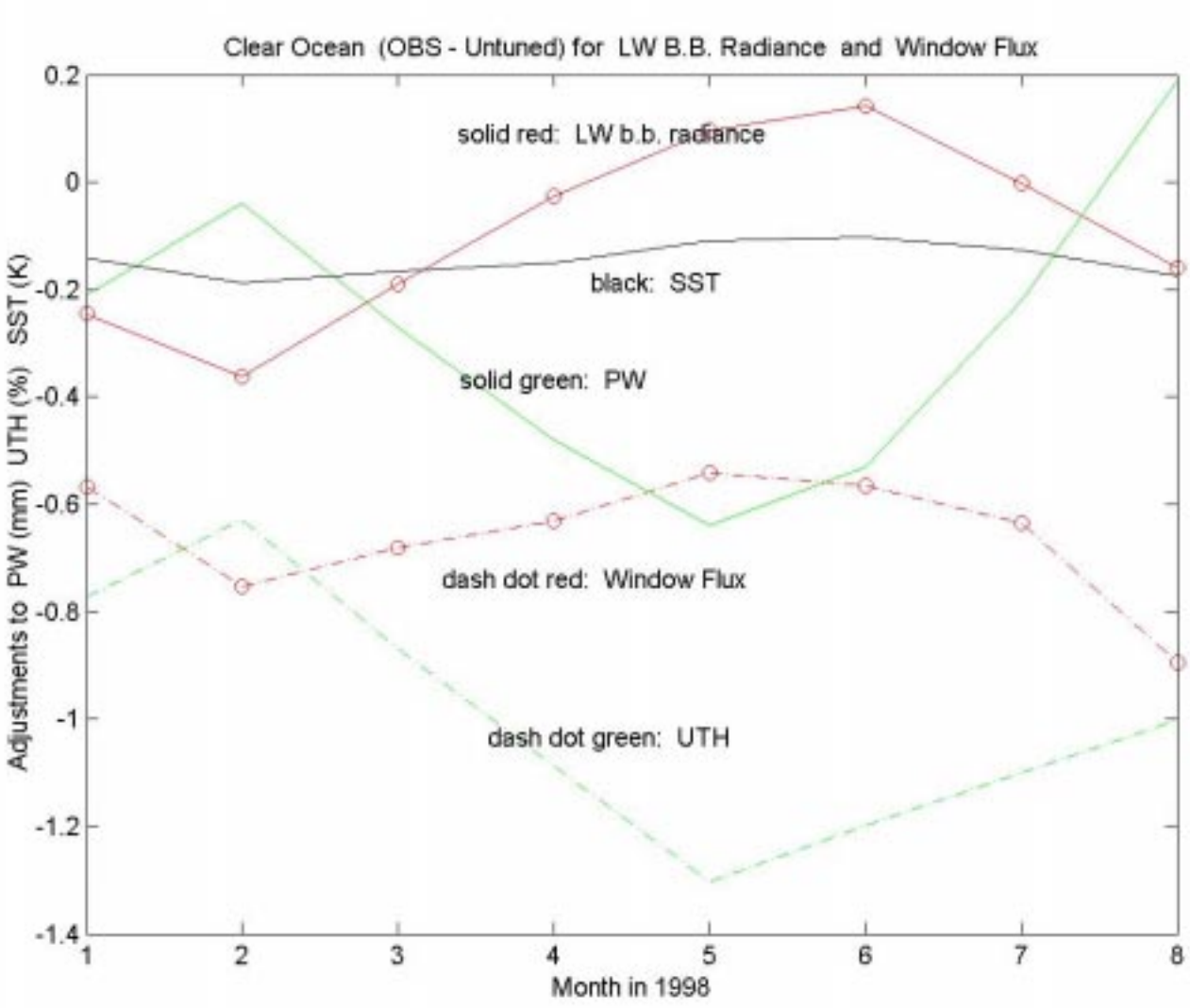
Coarse means (Jan-Aug98) CERES minus Untuned SARB

Clear-sky Ocean: LW B.B. radiance, Window flux, H2O, skin T

Here show LW b.b. RADIANCE for y-axis scale.

Small adustment to skin T as a priori "sigma" for SST is small.

Broadband drifts up. Window drifts down.



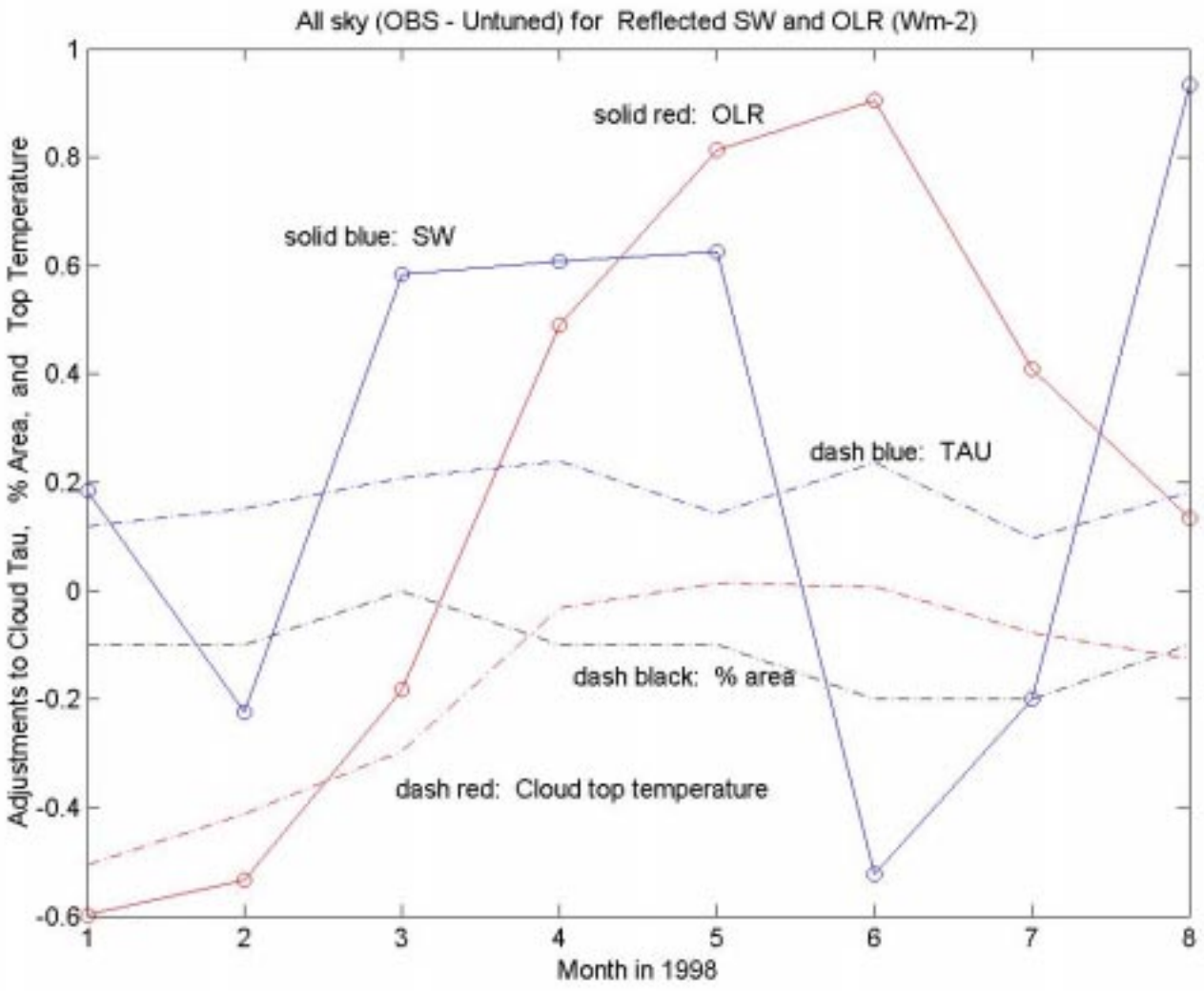
Coarse means (Jan-Aug98) CERES minus Untuned SARB

All-sky SW/LW and Cloud Tau, Height, Top Temperature

Drift in untuned SW and LW shown earlier.

Cloud optical depth is adjusted up, cloud area is adjusted down.

Cloud top temperatures reduced (heights increased) Ja n-Feb-Mar 1998 over TRMM domain.



In Wed. Working Group (WG) sessions SARB and Surface-only will meet jointly

Zhonghai Jin - Snow and ice review for CERES and remote sensing

David Kratz – quick summary of how HITRAN changes affect WGs

Discussion of monthly header "logic" card for CRS

Multiple sources for snow, ice, and aerosols

HITRAN 2000 SW Absorption Update of LARC Fu-Liou code

Fred Rose
Tom Charlock
Lisa Coleman
Seiji Kato
Dave Kratz
Tom Caldwell

LARC Fu_Liou Update History

- Fu-Liou AFTER June 2002
  - HITRAN 2000 absorption in Near IR
  - O_2 , CO_2 ,CH_4, O_3 absorption explicitly included in Near IR
  - SW Continuum absorption included
- Fu_Liou code BEFORE June 2002
  - Original line shapes from AFGL 1982.
  - No SW Continuum absorption
  - UV/Visible O_3 absorption updated as of March 2000
  - O_2 & CO_2 SW parameterized absorption correction (Chou) May 1999
  - LW window absorption update as of May 1998
  - LW continuum based on Clough et al CKD 2.4 October 2001
- Tests (Kratz) with LBL code show small <1 Wm^{-2} changes in Non-Window LW using HT2000 and earlier HT databases.

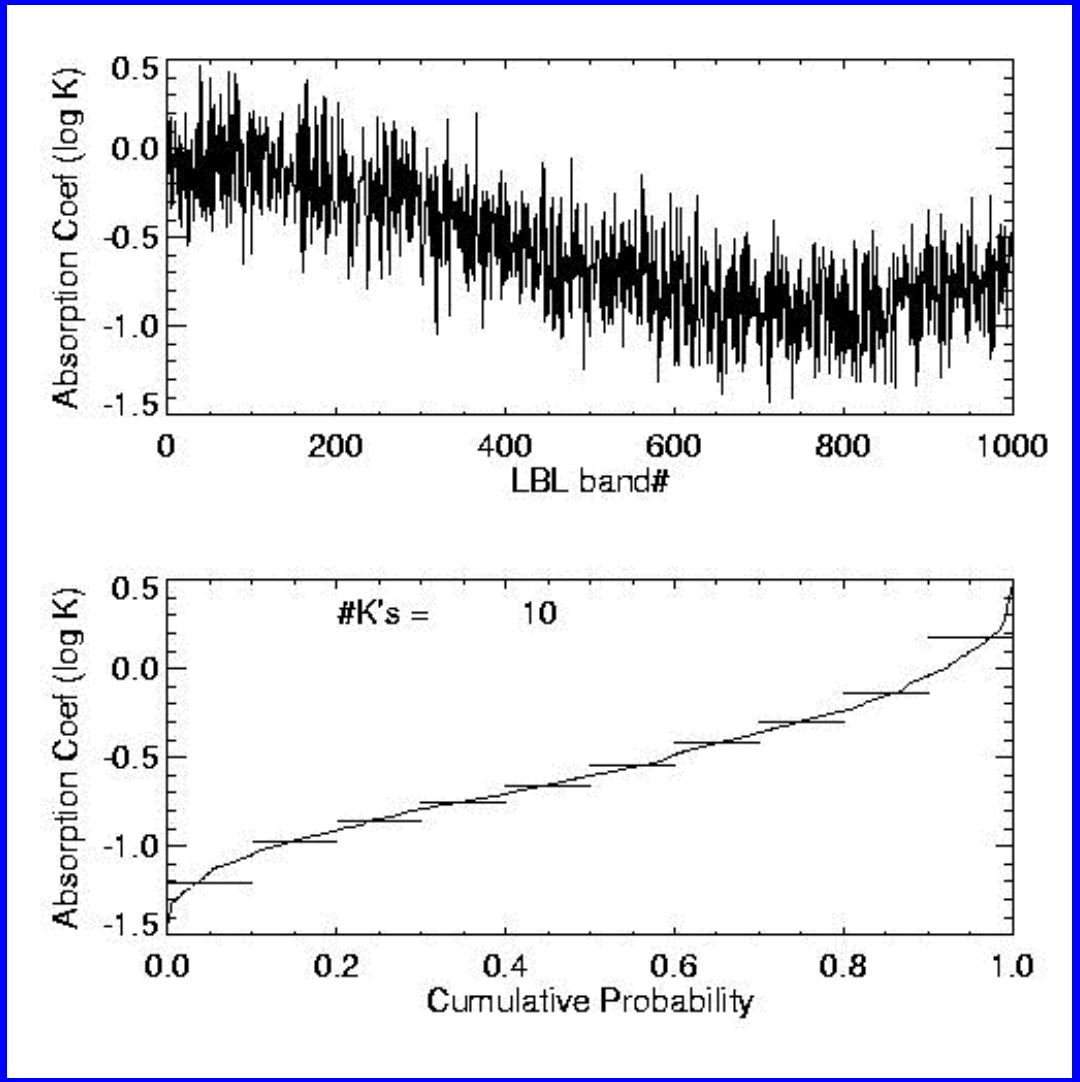
Correlated-k Computation (S.Kato)

- Line by Line radiative transfer calculations over band of interest
  - New :17 Pressures , 11 Temperatures ,13 H_20 Concentrations
  - Old : 19 Pressures, Quadratic Fit to Temperature
- Inversion of absorption vs. wavelength to cumulative probability space.
- Gaussian quadrature integration over increasing number of points till < 1% accuracy difference
- Inclusion of Correlated-k coefficients in L.U.T for access in Fu-Liou code.

LARC Fu-Liou Bands & Gases

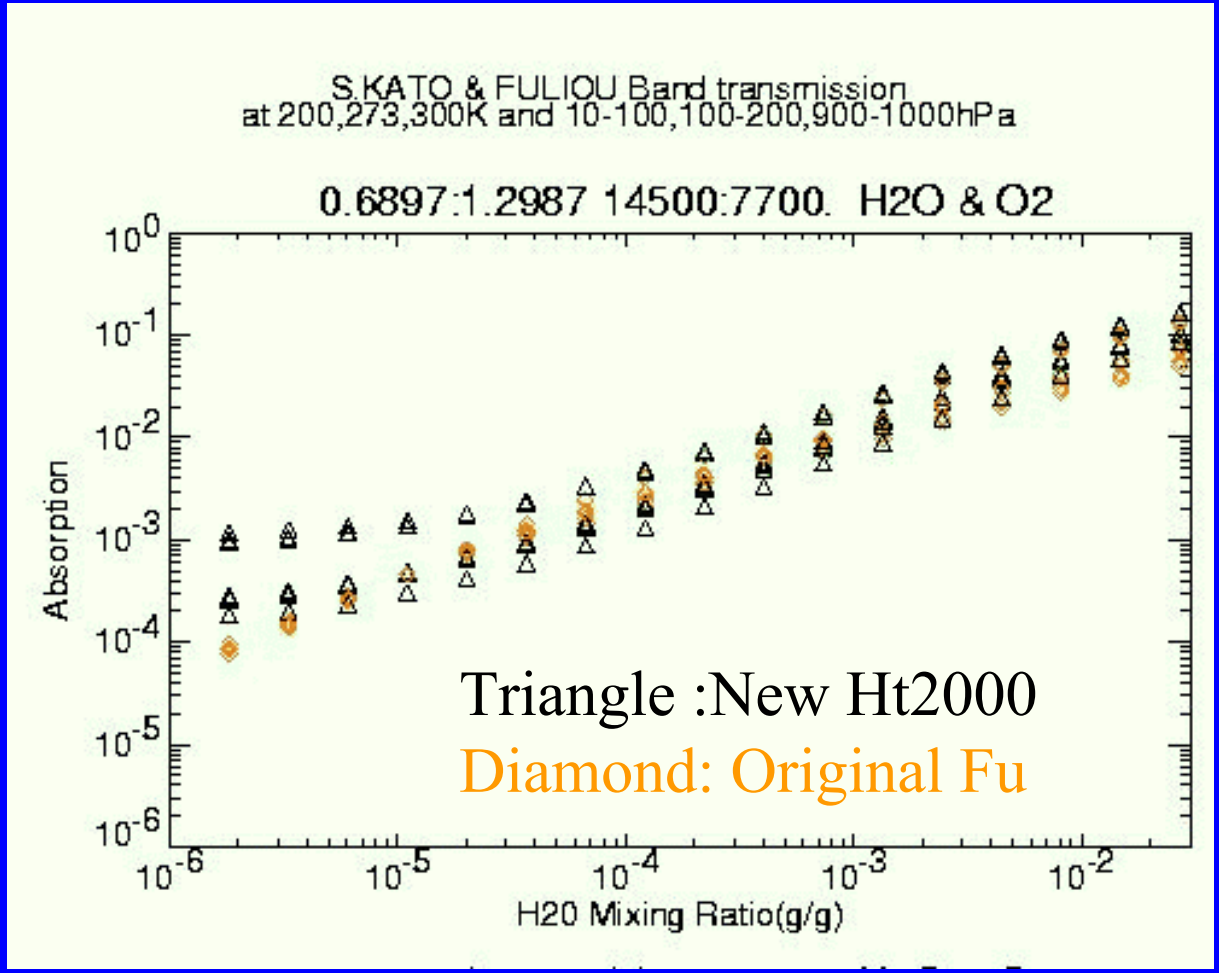
Band #	Microns Beg	End	Wave# Beg	End	#K's	HITRAN 2000	#K's	Original Fu
1	0.1754	0.2247	57000	44500	1	O3	1	O3
2	0.2247	0.2439	44500	41000	1	O3	1	O3
3	0.2439	0.2857	41000	35000	1	O3	1	O3
4	0.2857	0.2985	35000	33500	1	O3	1	O3
5	0.2985	0.3225	33500	31008	1	O3	1	O3
6	0.3225	0.3575	31008	27972	1	O3	1	O3
7	0.3575	0.4375	27972	22857	1	O3	1	O3
8	0.4375	0.4975	22857	20101	1	O3 & H2O	1	O3 & H2O
9	0.4975	0.5950	20101	16807	1	O3 & H2O	1	O3 & H2O
10	0.5950	0.6896	16807	14500	1	O3 & H2O	1	O3 & H2O
11	0.6897	1.2987	14500	7700	7	H2O & O2	8	H2O
12	1.2987	1.9048	7700	5250	8	H2O & CO2	12	H2O
13	1.9048	2.5000	5250	4000	7	H2O & CO2&CH4	7	H2O
14	2.5000	3.5088	4000	2850	8	H2O & CO2&CH4&O3	12	H2O
15	3.5088	4.0000	2850	2500	7	H2O & CO2&CH4	5	H2O

Example: Correlated-k Generation



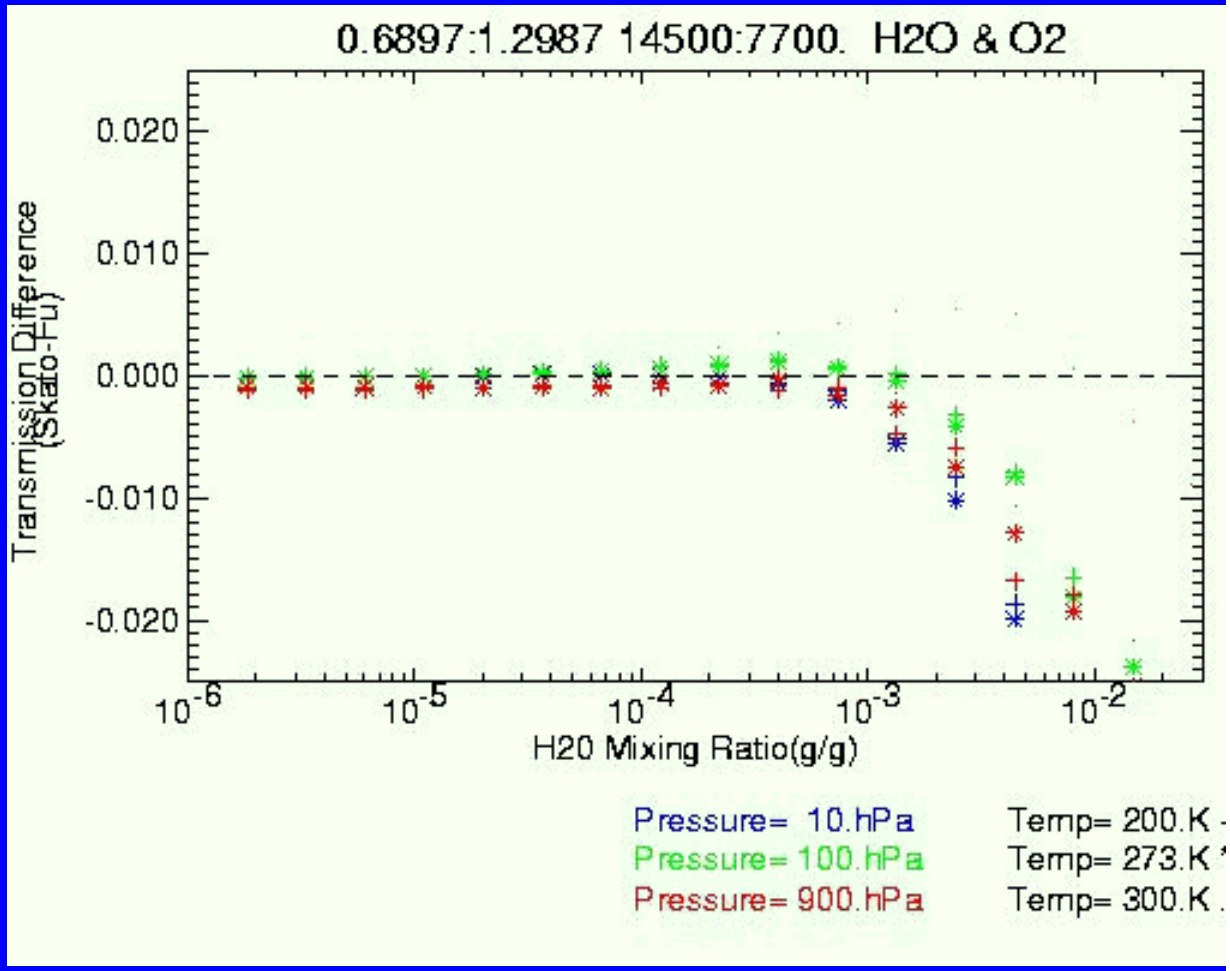
Change for a Single Near IR Band

- Absorption
- 0.7-1.3 micron Band
  Has ~35% of SW
- H20 & O2 Absorption
- Computed @
  3 Temperatures
  (200,273,300K)
  3 Pressures
  (0-100,100-200,900-1000)



Change for a Single Near IR Band

- Transmission Difference
- 0.7-1.3 micron Band
  Has ~35% of SW
- H20 & O2 Absorption
- Computed @
  3 Temperatures
  (200,273,300K)
  3 Pressures
  (0-100,100-200,900-1000)



Comparison to Modtran 4 Surface SW Direct

- Modtran 4
  - HITRAN 1996 Database
  - Curvature effects at large Solar Zenith angles (Shorter Path)
- Fu-Liou
  - HITRAN 2000 Database
- 200-4000 nm

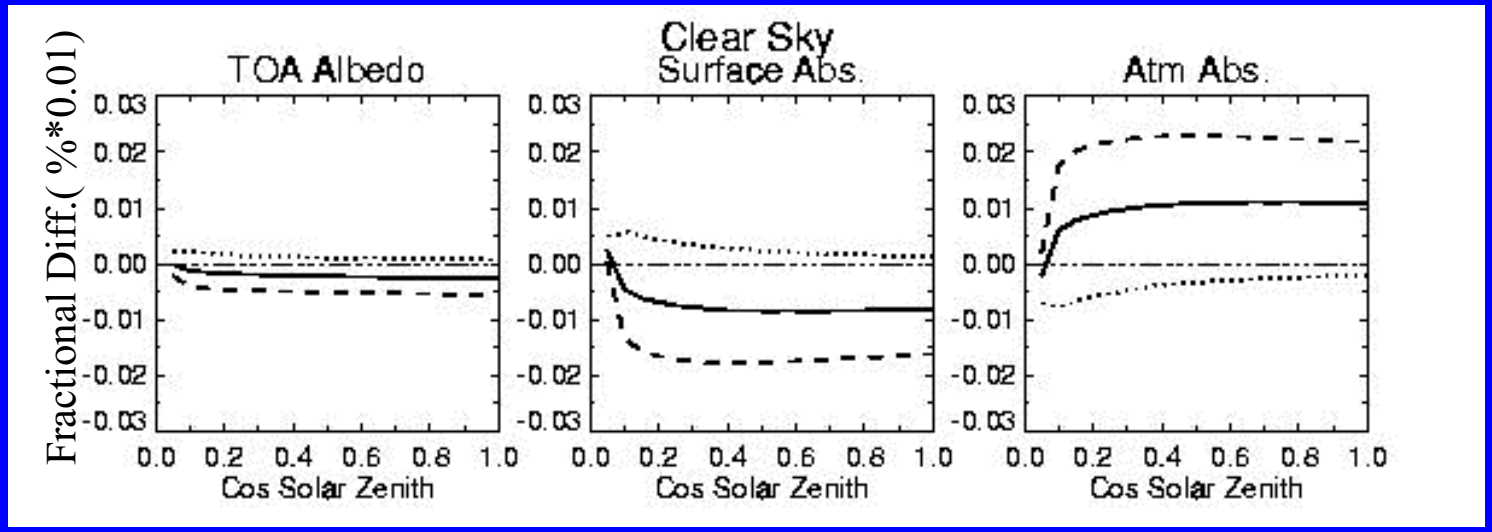
ATM	SZA	FuLiou HT2K	Modtran4 HT96	Fu-Modtran	%Difference
TRO	0	993.6	997.7	-4.1	-0.4
TRO	30	839.8	843.8	-4.0	-0.5
TRO	45	659.9	663.8	-3.9	-0.6
TRO	60	431.7	435.5	-3.7	-0.9
TRO	75	182.7	186.3	-3.5	-1.9
MLS	0	1011.8	1015.0	-3.2	-0.3
MLS	30	855.7	859.0	-3.2	-0.4
MLS	45	673.1	676.4	-3.3	-0.5
MLS	60	441.2	444.4	-3.3	-0.7
MLS	75	187.6	190.7	-3.1	-1.6
MLW	0	1068.6	1071.6	-3.0	-0.3
MLW	30	906.3	909.2	-2.9	-0.3
MLW	45	716.0	718.7	-2.7	-0.4
MLW	60	473.2	475.7	-2.5	-0.5
MLW	75	204.9	207.7	-2.7	-1.3
SAS	0	1030.7	1033.6	-2.9	-0.3
SAS	30	872.6	875.5	-2.8	-0.3
SAS	45	687.4	690.3	-2.9	-0.4
SAS	60	451.7	454.6	-2.9	-0.6
SAS	75	193.1	196.1	-3.0	-1.5
SAW	0	1094.6	1095.9	-1.2	-0.1
SAW	30	929.0	930.7	-1.7	-0.2
SAW	45	734.7	736.8	-2.1	-0.3
SAW	60	486.9	489.1	-2.2	-0.4
SAW	75	212.8	215.0	-2.1	-1.0

Clear Sky: ICRCCM Style Comparison

FU with Hitran 2000

minus

FU Pre Hitran w/Chou O_2,CO_2



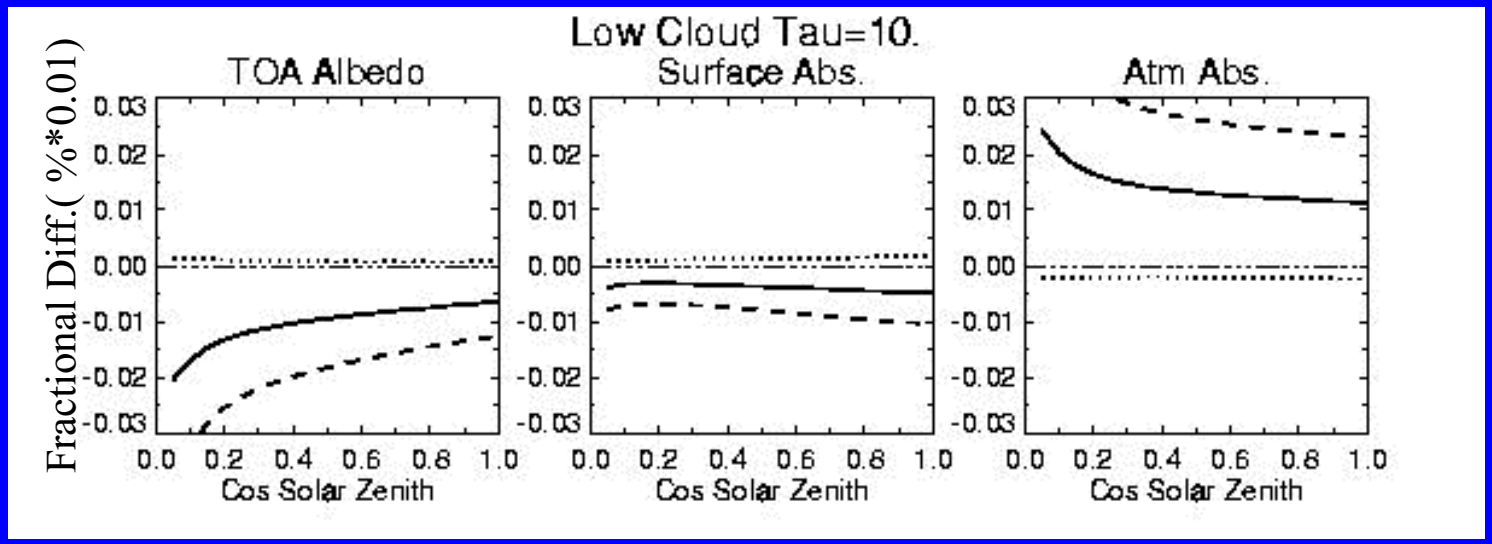
- **BB SW ___**
- **Visible . . .**
- **Near IR - - -**

Thick Low Cloud: ICRCCM Style Comparison

FU with Hitran 2000

minus

FU Pre Hitran w/Chou O_2,CO_2



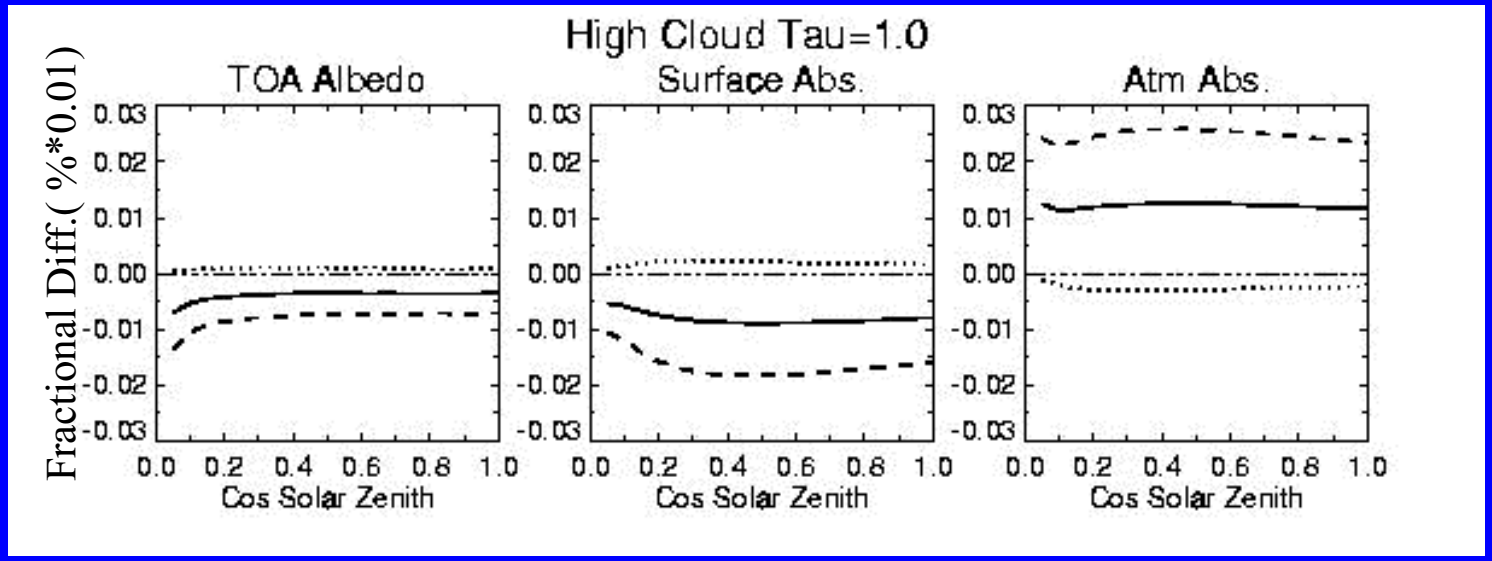
- **BB SW ___**
- **Visible . . .**
- **Near IR - - -**

Thin High Cloud: ICRCCM Style Comparison

FU with Hitran 2000

minus

FU Pre Hitran w/Chou O_2,CO_2



- **BB SW ___**
- **Visible . . .**
- **Near IR - - -**

CRS Code Revisions (9/13 delivery)

1) FULIOU upgrade to fu0602b Hitran2000 SW absorption

2) MODIS SSFA instantaneous aerosols.

3) MODIS Daily interpolated MOD08_d3 product.

4) Collins/Rasch MATCH aerosols, multi-constituent global AOT (Jan-Jun 2001)

5) Module to alter IGBP vector to be consistent with Cloud Group snow/ice fraction.

6) Include Cloudy Sky over Snow surface albedo retrieval routines.

7) Snow & Ice surface albedo spectral shape look-up table.

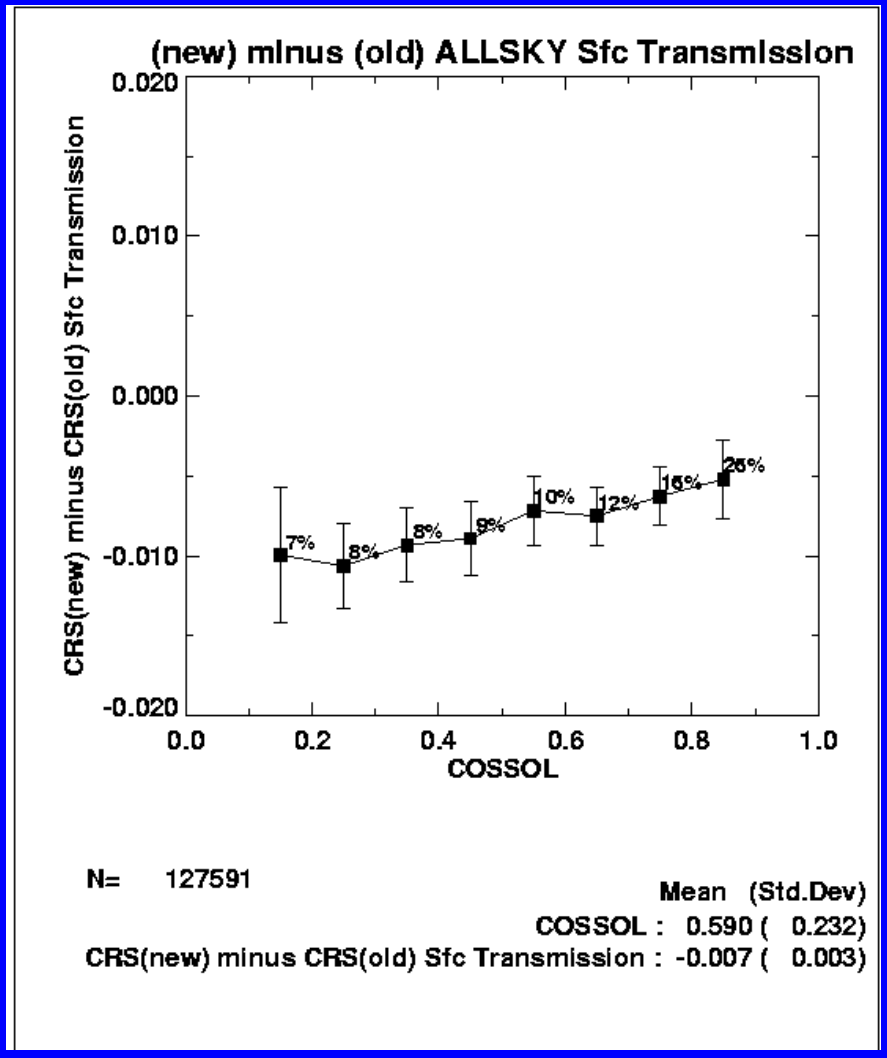
8) Clear Sky surface albedo retrieval to include treatment of absorbing aerosols

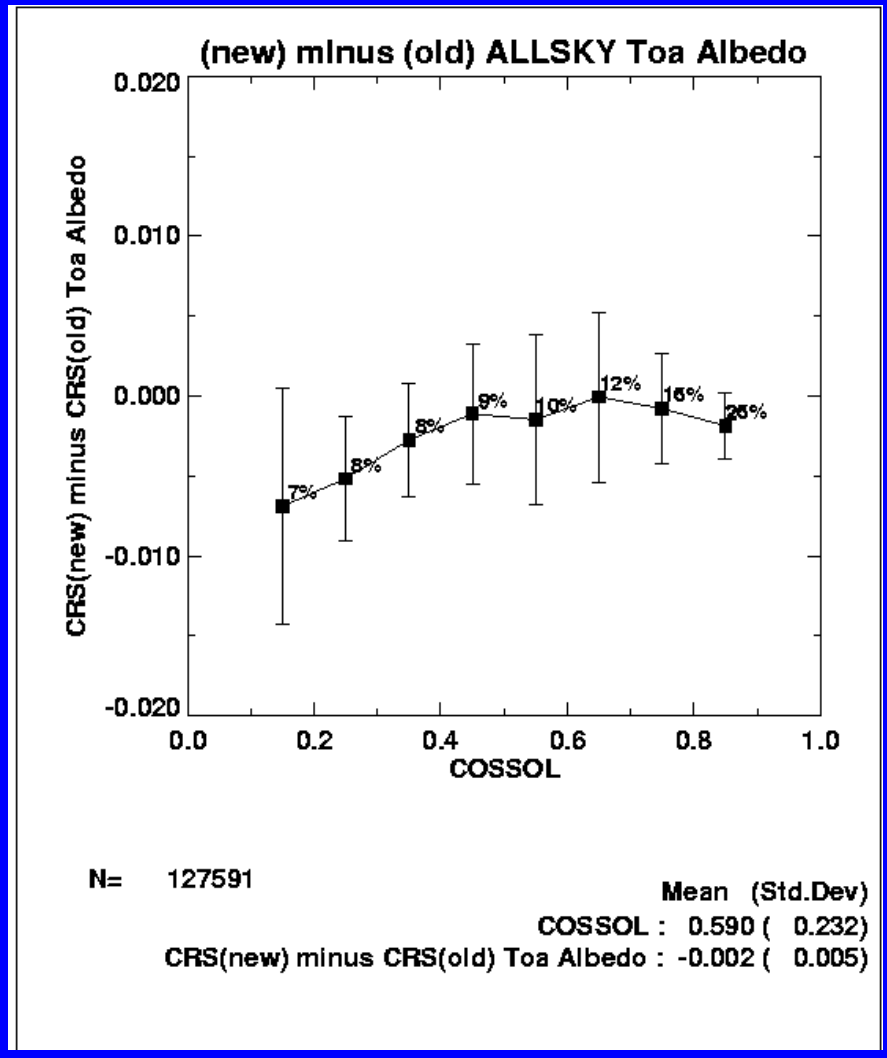
9) "Logic Key" code to assign by IGBP type, Latitude, Cloud %, CosSol ,Ice %

a) Tuning Sigma's b) Aerosol Source c) Surface Albedo Retrieval Method.

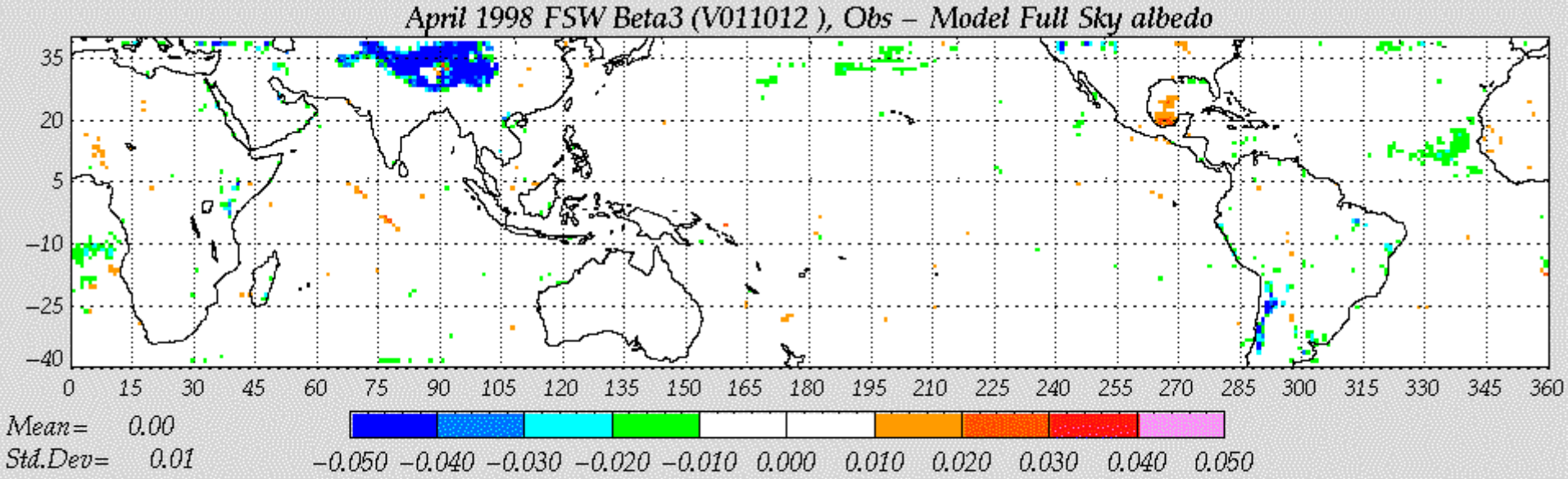
10) Use of Cloud WG window monthly emissivity maps.

Inclusion of Fu w/Hitran2000 in CRS



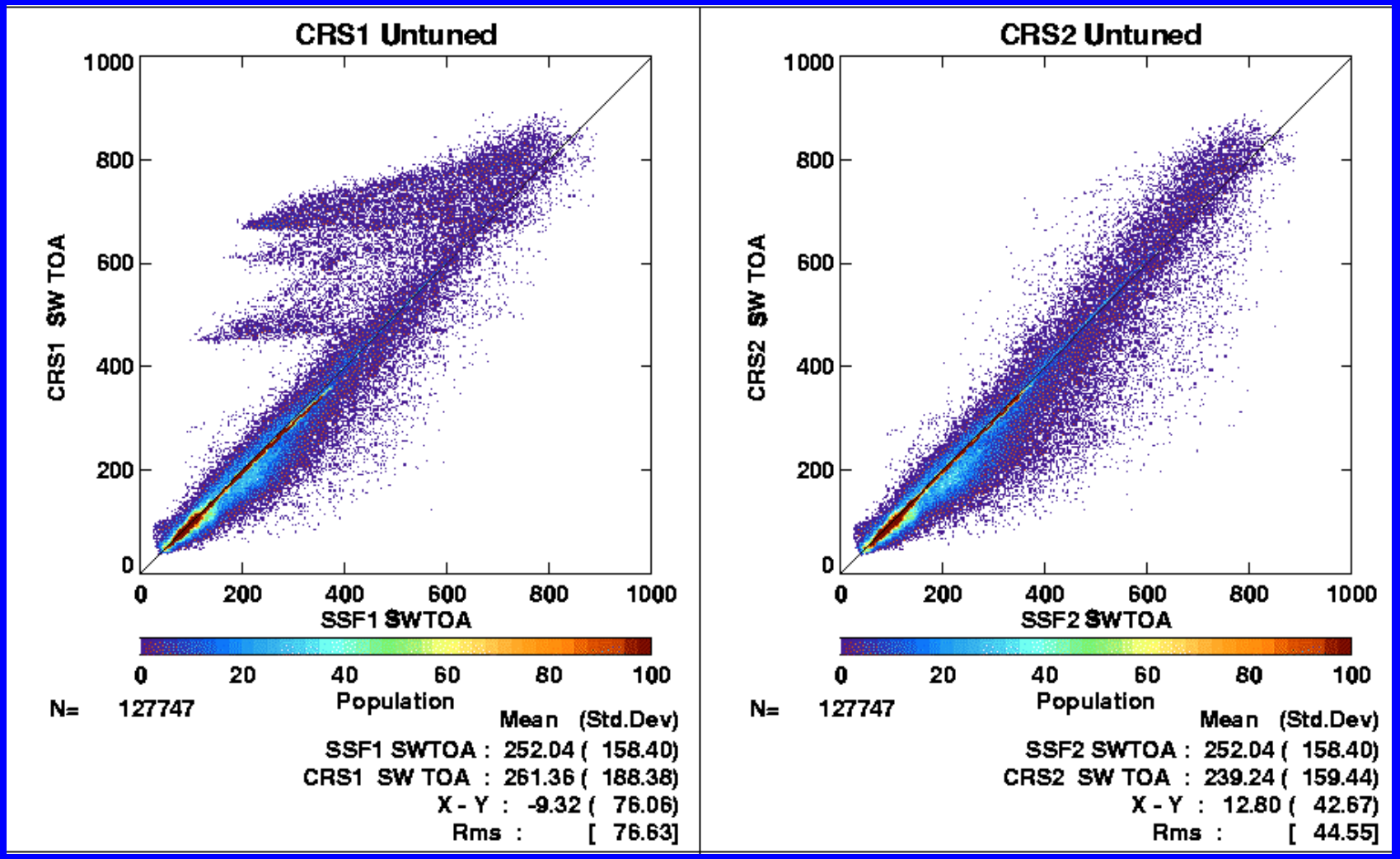


Beta3 CRS TOA ALBEDO



- Problem:
  - Snow as identified by snow ice maps not consistent with retrievals
- Actions:
  - Modified SARB CRS to use cloud WG snow % retrievals
  - SARB Retrieval of initial surface albedo for thin cloud over snow

CRS Results Un-Tuned



CRS Results Tuned