Surface and Atmosphere Fluxes

Surface and Atmospheric Radiation Budget (SARB)
“CRS” bubble in CERES processing

T. P. Charlock, Fred. G. Rose, David A. Rutan, Lisa H. Coleman, T. E. Caldwell

CERES Science Team Meeting, Newport News (1-3 May 2001)

Comparing Computed TOA to NEW “VIRS200+” ADMs

TRMM-wide run 1 May 98 using Loeb’s ADM module

Exercises to Tighten Tuning

Single orbits for 1 May 98 using old “VIRS12” ADMs

Subset Run Compared with Surface Data [David A. Rutan presents]

Subset to validation regions

Full months of May, July, August 98 with old “VIRS12” ADMs

“CAVE” ground data at www-cave.larc.nasa.gov/cave/

Input

T(z), H2O(z)	ECMWF
O3(z)	SBUV-HIRS (SMOBA – Yang and Miller)
Clouds	VIRS (Minnis Cloud WG) Area, height, optical depth Particle size and phase Estimate of geometrical thickness
Aerosol optical thickness (AOT)	VIRS (Stowe) for some clear ocean 6-hourly Collins-Rasch assimilation (AVHRR+NCEP+model) OPAC-GADS optical properties guided by assimilation Fixed estimates of scale heights

Input: details on aerosols

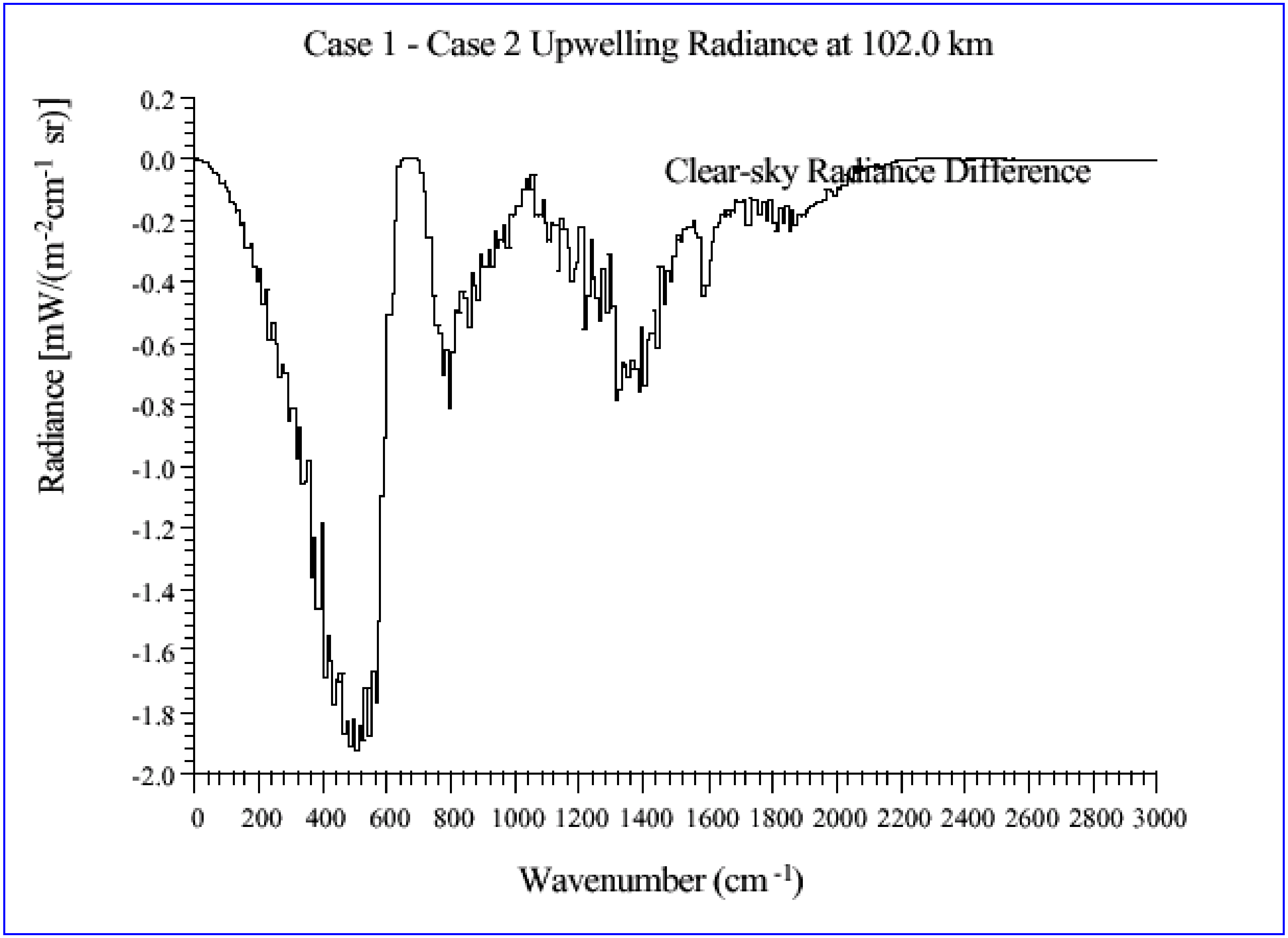
Collins-Rasch assimilation	CERES aerosol type	scale height
dust (0.01-1.0 um)	dust (0.5 um) Tegen-Lacis	2 km
dust (1-10 um)	dust (2.0 um) Tegen-Lacis	1 km
dust (10-20 um)	dust (2.0 um) Tegen-Lacis	1 km
dust (20-50 um)	dust (2.0 um) Tegen-Lacis	1 km
hydrophilic black carbon	soot (OPAC)	5 km *
hydrophobic black carbon	soot (OPAC)	5 km *
hydrophilic organic carbon	soluble organic (OPAC)	5 km *
hydrophobic organic carbon	insoluble organic (OPAC)	5 km *
sulfate	sulfate (OPAC)	5 km *
sea salt	sea salt (OPAC)	0.5 km

* sorry,
we goofed

VIRS aerosol optical depth is apportioned with assimilation
(fractionate to dust, sulfate, etc., as per Collins-Rasch)

Radiative Transfer Computation

Basic code	Fu-Liou (1993)
	LW scattering included
	CO_2, H_2O, CH_4, N_2O, O_3
	Hexagonal ice crystals
	2-stream SW
	2/4 stream LW (Fu et al., 1998)
	---- LW cut off at 2200 cm-1
LW changes	Radiance output for LW broadband and window
	8-12 um window (Kratz and Rose)
	CKD 2.1 (Clough) LW continuum
	---- Dated, but is CKD 2.4 better?
	CFCs
SW changes	Overlap of Rayleigh, O_3 for 0.2-0.7 um
	Absorption by CO_2, O_2, visible H_2O
	Estimate effect of SW > 4 um
	Gamma distribution water clouds (Hu-Stamnes)
Ocean optics	Hu-Cox-Munk (wind, SZA, foam)
	---- Soon Z. Jin with SeaWiFS chlorophyll.
Aerosol optics	d'Almeida et al
	Tegen and Lacis mineral dust
	OPAC-GADS (Hess, Koepke)



Case 1 = TRP Case 2 = TRP –20% H2O above 600 hPa

Constrainment – tuning to approach CERES observations

A priori uncertainty ("sigma") for each adjustable parameter

CERES TOA all footprints	Sigma	Minimum	Adjustable parameter
	5.0 %	2.0 Wm-2	reflected SW flux
	2.0 %	2.0 Wm-2	broadband LW flux
	1.0 %	1.0 Wm-2	window WN flux
	1.0 %	0.3 Wm-2 sr-1	broadband LW radiance
	1.0 %	0.3 Wm-2 sr-1	filtered window radiance

Cloudy footprints	Sigma	Adjustable parameter
	0.15	ln(tau) tau=optical depth
	2.0	cloud top temperature
	0.05	total cloud fraction in footprint
	0.025	fraction swap of 2 types in footprint (i.e., increase Cu and decrease Ci)

Clear footprints	Ocean	Land	Adjustable parameter
	1.0 K	4.0 K	surface skin temperature
	0.15	0.10	ln(PW) PW: surface to 500 hPa
	0.15	0.10	ln(UTH) upper tropos. humidity
	0.002	0.015	surface albedo
	0.50	0.10	ln(tau) aerosol optical depth

Output (SARB)

All footprints	Constrained fluxes for SW, LW, WN @ surface, 500- 200-70 hPa, TOA Untuned clear SW, LW, WN fluxes @ surface, TOA Untuned pristeen SW, LW, WN fluxes @ surface, TOA
Cloudy	Adjusted cloud area, height, and IWP/LWP
Clear	Adjusted surface albedo, aerosol AOT, skin temperature, PW, and UTH

Comparing Untuned Computed TOA to NEW “VIRS200+” ADMs

Reflected SW (Wm-2)

TRMM-wide run 1 May 98 using Loeb’s ADM module

Fu-Liou code is not constrained

Old ADM

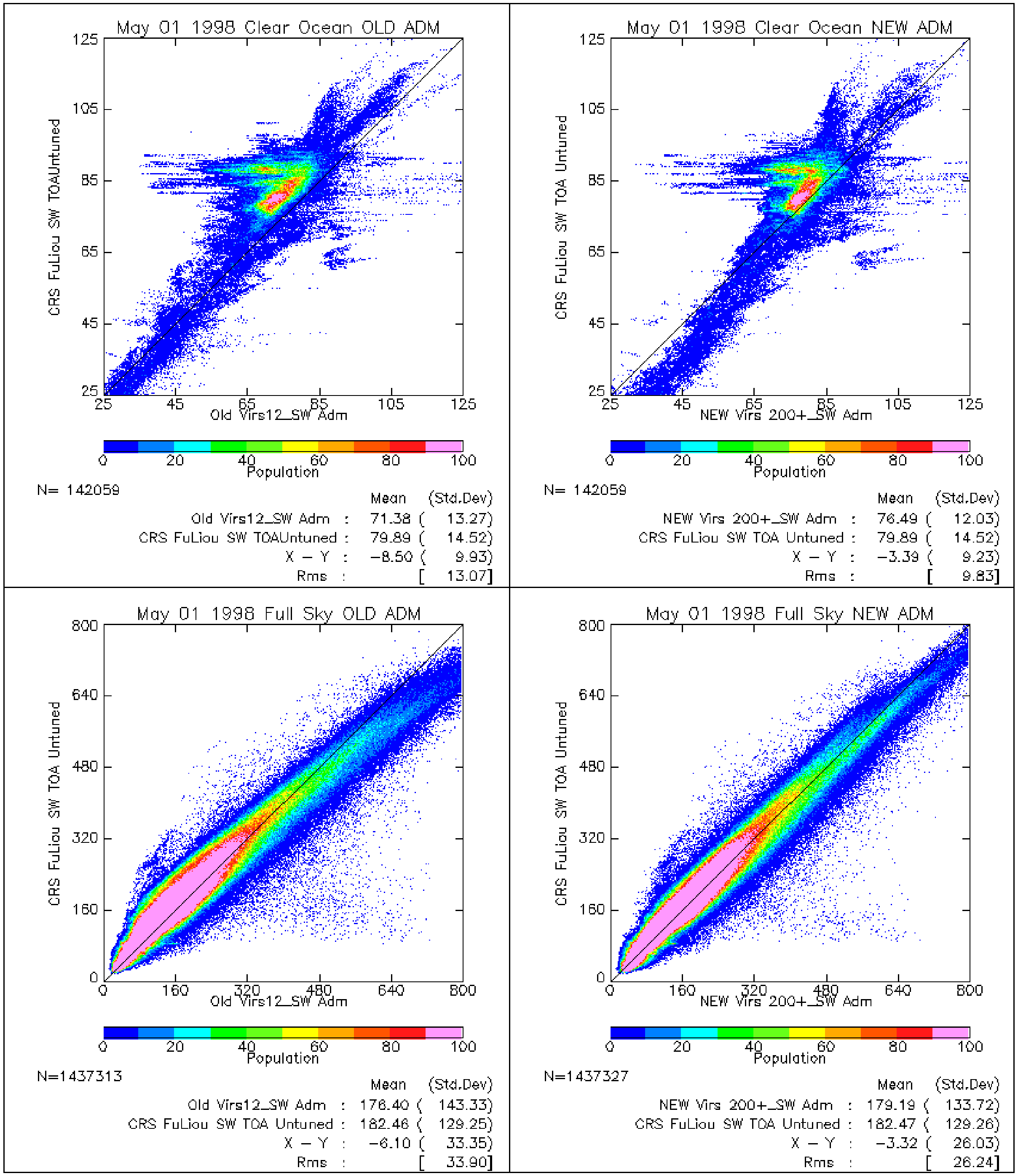
New ADM

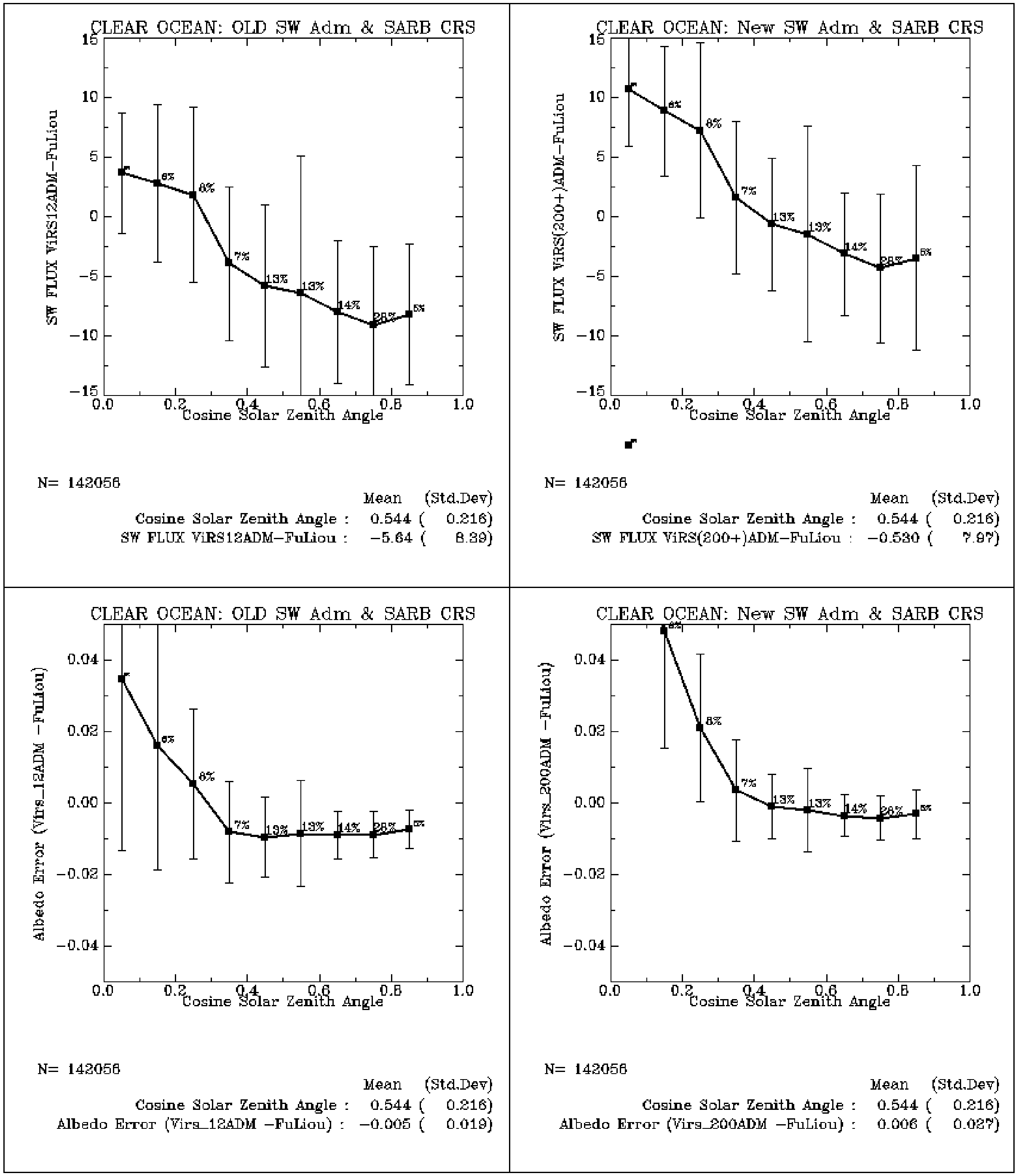
Clear ocean SW (old) N=142059	mean	std dev
Old ADM	71.4	13.3
Fu-Liou	79.9	14.5
x-y	-8.5	9.9
rms		13.1

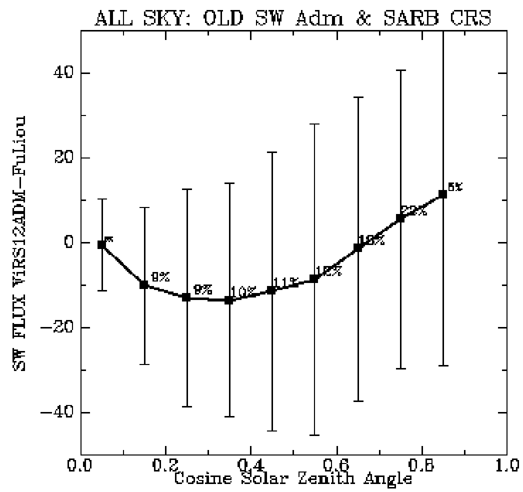
Clear ocean SW (new) N=142059	mean	std dev
New ADM	76.5	12.0
Fu-Liou	79.9	14.5
x-y	-3.4	9.2
rms		9.8

All sky SW (old) N=1437313	mean	std dev
Old ADM	176.4	143.3
Fu-Liou	182.5	129.2
x-y	-6.1	33.4
rms		33.9

All sky SW (new) N=1437327	mean	std dev
New ADM	179.2	133.7
Fu-Liou	182.5	129.3
x-y	-3.3	26.0
rms		26.2

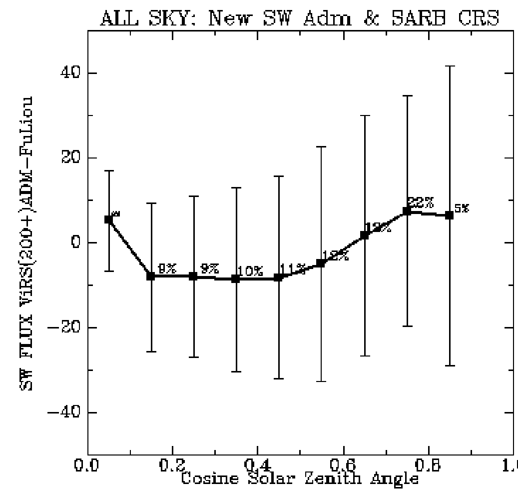

May 01 1998 Clear Ocean OLD ADM
CRS FuLiou SW TOAUntuned
Old Virs12_SW Adm
Population
N= 142059
Mean (Std.Dev)
Old Virs12_SW Adm : 71.38 (13.27)
CRS FuLiou SW TOAUntuned : 79.89 (14.52)
X − Y : −8.50 (9.93)
Rms : [13.07]
May 01 1998 Clear Ocean NEW ADM
CRS FuLiou SW TOA Untuned
NEW Virs 200+_SW Adm
Population
N= 142059
Mean (Std.Dev)
NEW Virs 200+_SW Adm : 76.49 (12.03)
CRS FuLiou SW TOA Untuned : 79.89 (14.52)
X − Y : −3.39 (9.23)
Rms : [9.83]
May 01 1998 Full Sky OLD ADM
CRS FuLiou SW TOA Untuned
Old Virs12_SW Adm
Population
N=1437313
Mean (Std.Dev)
Old Virs12_SW Adm : 176.40 (143.33)
CRS FuLiou SW TOA Untuned : 182.46 (129.25)
X − Y : −6.10 (33.35)
Rms : [33.90]
May 01 1998 Full Sky NEW ADM
CRS FuLiou SW TOA Untuned
NEW Virs 200+_SW Adm
Population
N=1437327
Mean (Std.Dev)
NEW Virs 200+_SW Adm : 179.19 (133.72)
CRS FuLiou SW TOA Untuned : 182.47 (129.26)
X − Y : −3.32 (26.03)
Rms : [26.24]


CLEAR OCEAN: OLD SW Adm & SARB CRS
SW FLUX ViRS12ADM−FuLiou
Cosine Solar Zenith Angle
N= 142056
Mean (Std.Dev)
Cosine Solar Zenith Angle : 0.544 (0.216)
SW FLUX ViRS12ADM−FuLiou : −5.64 (8.39)
CLEAR OCEAN: New SW Adm & SARB CRS
SW FLUX ViRS(200+)ADM−FuLiou
Cosine Solar Zenith Angle
N= 142056
Mean (Std.Dev)
Cosine Solar Zenith Angle : 0.544 (0.216)
SW FLUX ViRS(200+)ADM−FuLiou : −0.530 (7.97)
CLEAR OCEAN: OLD SW Adm & SARB CRS
Albedo Error (Virs_12ADM −FuLiou)
Cosine Solar Zenith Angle
N= 142056
Mean (Std.Dev)
Cosine Solar Zenith Angle : 0.544 (0.216)
Albedo Error (Virs_12ADM −FuLiou) : −0.005 (0.019)
CLEAR OCEAN: New SW Adm & SARB CRS
Albedo Error (Virs_200ADM −FuLiou)
Cosine Solar Zenith Angle
N= 142056
Mean (Std.Dev)
Cosine Solar Zenith Angle : 0.544 (0.216)
Albedo Error (Virs_200ADM −FuLiou) : 0.006 (0.027)



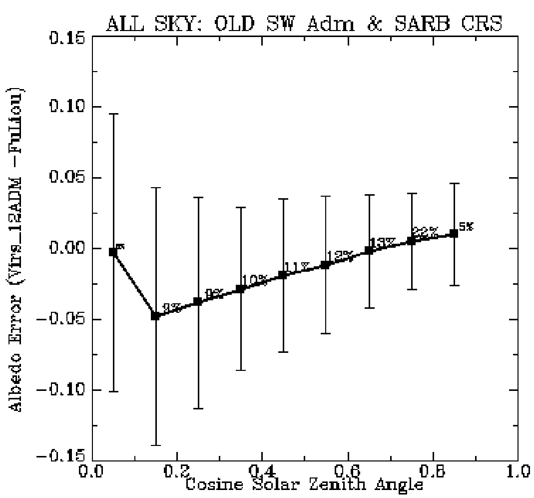
N=1437504

	Mean	(Std.Dev)
Cosine Solar Zenith Angle :	0.510 (	0.226)
SW FLUX ViRS12ADM−FuLiou :	−4.40 (	33.05)



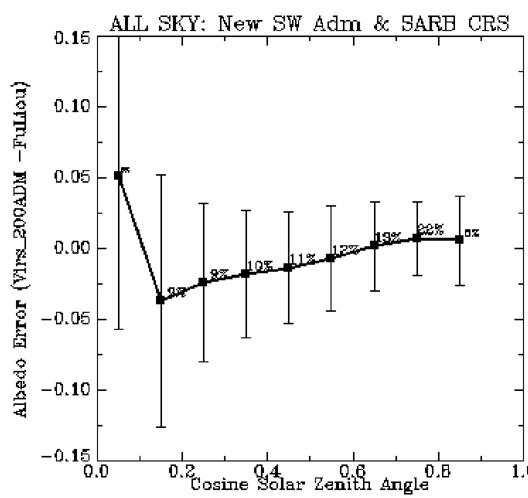
N=1437504

	Mean	(Std.Dev)
Cosine Solar Zenith Angle :	0.510 (	0.226)
SW FLUX ViRS(200+)ADM−FuLiou :	−1.62 (	26.05)



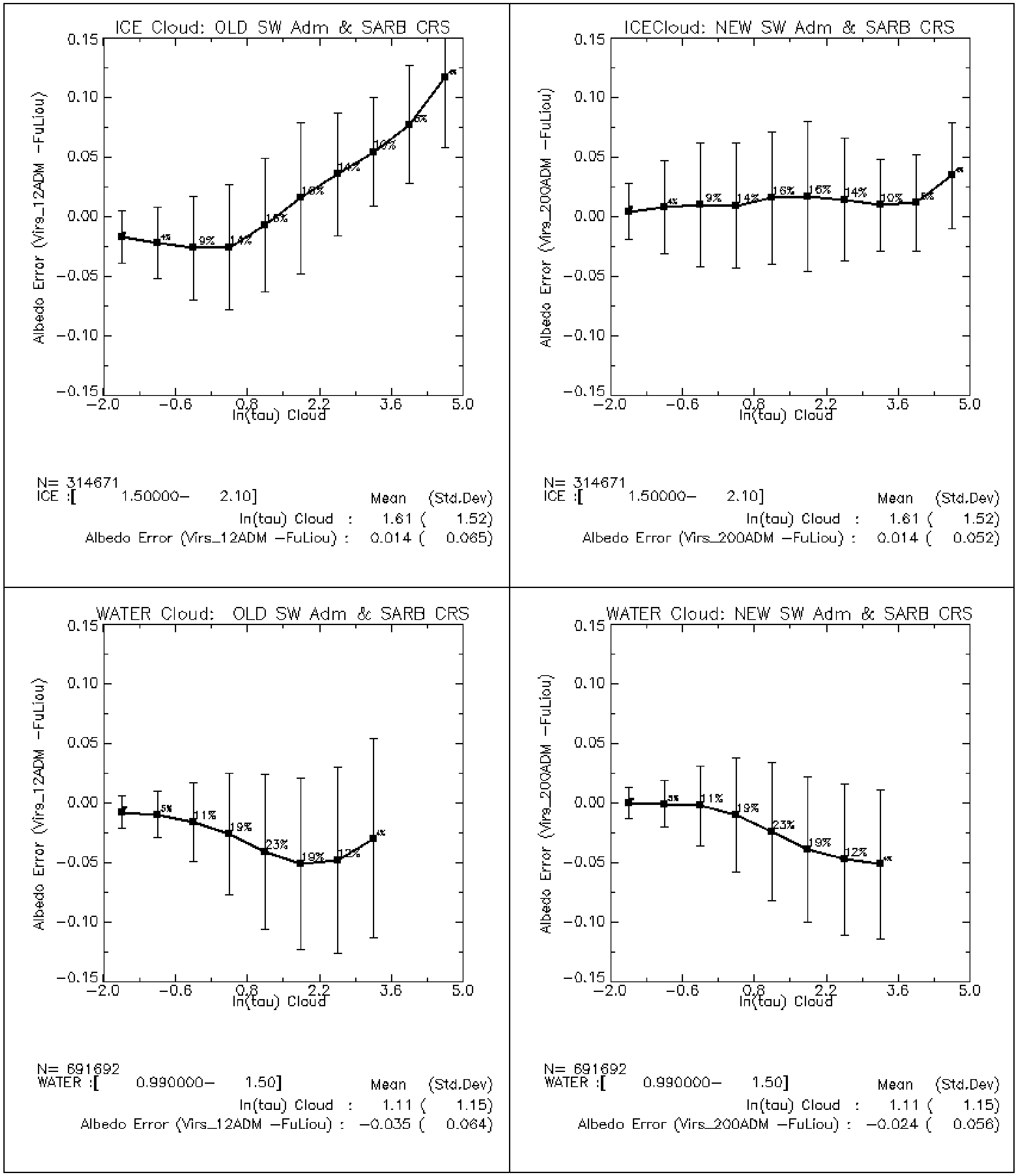
N=1437504

	Mean	(Std.Dev)
Cosine Solar Zenith Angle :	0.510 (	0.226)
Albedo Error (Virs_12ADM −FuLiou) :	−0.013 (	0.060)



N=1437504

	Mean	(Std.Dev)
Cosine Solar Zenith Angle :	0.510 (	0.226)
Albedo Error (Virs_200ADM −FuLiou) :	−0.006 (	0.052)


ICE Cloud: OLD SW Adm & SARB CRS
Albedo Error (Virs_12ADM -FuLiou)
ln(tau) Cloud
N= 314671
ICE :[1.50000- 2.10]
Mean (Std.Dev)
ln(tau) Cloud : 1.61 (1.52)
Albedo Error (Virs_12ADM -FuLiou) : 0.014 (0.065)
ICECloud: NEW SW Adm & SARB CRS
Albedo Error (Virs_200ADM -FuLiou)
ln(tau) Cloud
N= 314671
ICE :[1.50000- 2.10]
Mean (Std.Dev)
ln(tau) Cloud : 1.61 (1.52)
Albedo Error (Virs_200ADM -FuLiou) : 0.014 (0.052)
WATER Cloud: OLD SW Adm & SARB CRS
Albedo Error (Virs_12ADM -FuLiou)
ln(tau) Cloud
N= 691692
WATER :[0.990000- 1.50]
Mean (Std.Dev)
ln(tau) Cloud : 1.11 (1.15)
Albedo Error (Virs_12ADM -FuLiou) : -0.035 (0.064)
WATER Cloud: NEW SW Adm & SARB CRS
Albedo Error (Virs_200ADM -FuLiou)
ln(tau) Cloud
N= 691692
WATER :[0.990000- 1.50]
Mean (Std.Dev)
ln(tau) Cloud : 1.11 (1.15)
Albedo Error (Virs_200ADM -FuLiou) : -0.024 (0.056)

Exercises to Tighten Tuning

Single orbits for 1 May 98 using old “VIRS12” ADMs

Earlier tuning stressed radiance for LW, WN and flux for SW

Energy balance emphasizes broadband SW and LW flux

Play with sigmas (uncertainties) of CERES TOA parameters

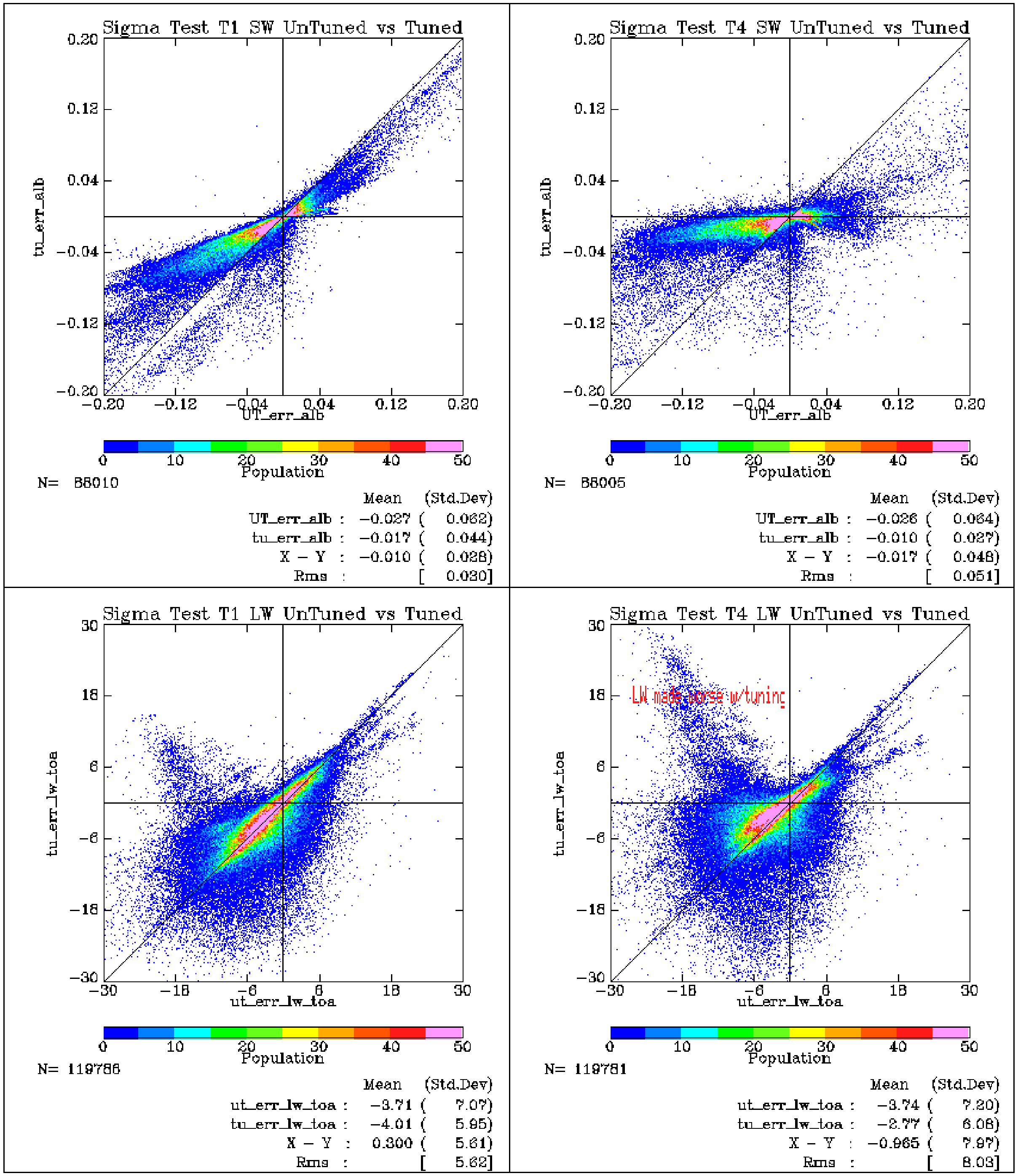
FUDGE Cases 1-2-3 below using OLR’ = OLR + exp[(x-175)*0.007]
to account for LW emission > 2200 cm-1
and to estimate Kratz’s CKD 2.4

Present test junks WN flux and LW radiance but retains tuning of window filtered radiance to uncork humidity impacts of lower (PW) and upper (UTH) troposphere.

Sophisticated tests (i.e., variable sigmas for clouds) later…

Sigmas below shown only in %

	SW flux	LW flux	WN flux	LW rad.	Flt. WN rad.
Control	5.0	2.0	1.0	1.0	1.0
Case 1	5.0	2.0	100.	100.	1.0
Case 2	3.5	1.5	100.	100.	1.0
Case 3	2.0	1.0	100.	100.	1.0


Sigma Test T1 SW UnTuned vs Tuned
tu_err_alb
UT_err_alb
Population
N= 86010
Mean (Std.Dev)
UT_err_alb : −0.027 (0.062)
tu_err_alb : −0.017 (0.044)
X − Y : −0.010 (0.028)
Rms : [0.030]
Sigma Test T4 SW UnTuned vs Tuned
tu_err_alb
UT_err_alb
Population
N= 86005
Mean (Std.Dev)
UT_err_alb : −0.026 (0.064)
tu_err_alb : −0.010 (0.027)
X − Y : −0.017 (0.048)
Rms : [0.051]
Sigma Test T1 LW UnTuned vs Tuned
tu_err_lw_toa
ut_err_lw_toa
Population
N= 119786
Mean (Std.Dev)
ut_err_lw_toa : −3.71 (7.07)
tu_err_lw_toa : −4.01 (5.95)
X − Y : 0.300 (5.61)
Rms : [5.62]
Sigma Test T4 LW UnTuned vs Tuned
LW made worse w/tuning
tu_err_lw_toa
ut_err_lw_toa
Population
N= 119781
Mean (Std.Dev)
ut_err_lw_toa : −3.74 (7.20)
tu_err_lw_toa : −2.77 (6.08)
X − Y : −0.965 (7.97)
Rms : [8.03]

What happens when we tighten tuning?

SigTab-T1 SW sigma 5% (~5wm2) LW sigma 2% (~5wm2) FltWn 1% (~0.2wm-2sr)

id#		DESCRIPTION		AVG	STDDEV	Good#	Case 1
4	ALL	UT OBS-FL ALB TOA		-0.027	0.062	87984	
5	ALL	TU OBS-FL ALB TOA		-0.017	0.044	87984	
9	ALL	UT OBS-FL SW TOA		-8.971	25.136	123995	
10	ALL	TU OBS-FL SW TOA	< -- >	-5.582	16.167	123995	
14	ALL	UT OBS-FL LW TOA		-4.046	7.686	123995	
15	ALL	TU OBS-FL LW TOA	< -- >	-4.379	8.502	123995	
19	ALL	UT OBS-FL WN TOA		-1.406	3.182	123993	
20	ALL	TU OBS-FL WN TOA		-1.587	2.414	123993	
24	ALL	UT OBS-FL LW RAD		-0.199	2.415	123992	
25	ALL	TU OBS-FL LW RAD		-0.272	2.272	123992	
29	ALL	UT OBS-FL WNfltRAD		-0.136	0.808	123993	
30	ALL	TU OBS-FL WNfltRAD		-0.181	0.726	123993	

SigTab-T3 SW sigma 2% (~2wm2) LW sigma 1% (~2.5wm2) FltWn 1% (~0.2wm-2sr)

id#		DESCRIPTION		AVG	STDDEV	Good#	Case 3
4	ALL	UT OBS-FL ALB TOA		-0.027	0.062	87896	
5	ALL	TU OBS-FL ALB TOA		-0.012	0.034	87896	
9	ALL	UT OBS-FL SW TOA		-8.980	25.173	123892	
10	ALL	TU OBS-FL SW TOA	< -- >	-4.017	10.572	123892	
14	ALL	UT OBS-FL LW TOA		-4.021	7.588	123892	
15	ALL	TU OBS-FL LW TOA	< -- >	-3.563	7.375	123892	
19	ALL	UT OBS-FL WN TOA		-1.396	3.156	123891	
20	ALL	TU OBS-FL WN TOA		-1.255	2.531	123891	
24	ALL	UT OBS-FL LW RAD		-0.189	2.384	123889	
25	ALL	TU OBS-FL LW RAD		-0.034	2.301	123889	
29	ALL	UT OBS-FL WNfltRAD		-0.134	0.803	123891	
30	ALL	TU OBS-FL WNfltRAD		-0.116	0.792	123891	

How different were the cloud adjustments?

Overcast Cloud Parameter Adjustments

SigTab-T1 Case 1

id#		DESCRIPTION		AVG	STDDEV	Good#
325	OVC	ORIG	CLDTAU	7.860	7.657	51215
326	OVC	ADJUST	CLDTAU	-0.897	1.966	51215
327	OVC	ORIG	CLDTMP	264.055	20.162	51215
328	OVC	ADJUST	CLDTMP	-1.879	3.172	51215
329	OVC	ORIG	CLDFRAC	99.691	0.907	51215
330	OVC	ADJUST	CLDFRAC	-0.008	0.015	51215

SigTab-T3 Case 3

id#		DESCRIPTION		AVG	STDDEV	Good#
325	OVC	ORIG	CLDTAU	7.848	7.659	51113
326	OVC	ADJUST	CLDTAU	-1.158	4.644	51113
327	OVC	ORIG	CLDTMP	264.094	20.158	51113
328	OVC	ADJUST	CLDTMP	-3.427	4.349	51113
329	OVC	ORIG	CLDFRAC	99.690	0.907	51113
330	OVC	ADJUST	CLDFRAC	-0.012	0.020	51113