CRS, the CERES Footprint-scale Surface and Atmosphere Radiation Budget (SARB)

CERES Science Team Meeting (Paris, Sept. 13-16, 2010)

T. P. Charlock (NASA LaRC)
Fred G. Rose (SSAI) - Algorithm development
David A. Rutan (SSAI) - Surface validation with CAVE
David Fillmore (Tech X, Boulder) - MATCH aerosol assimilation
Thomas E. Caldwell (SSAI) - Data Management

Zhonghai Jin (SSAI) – consults on snow grain size retrieval
Wenying Su – developed PAR and UV retrievals
Seiji Kato – radiative tranfer, CCCM

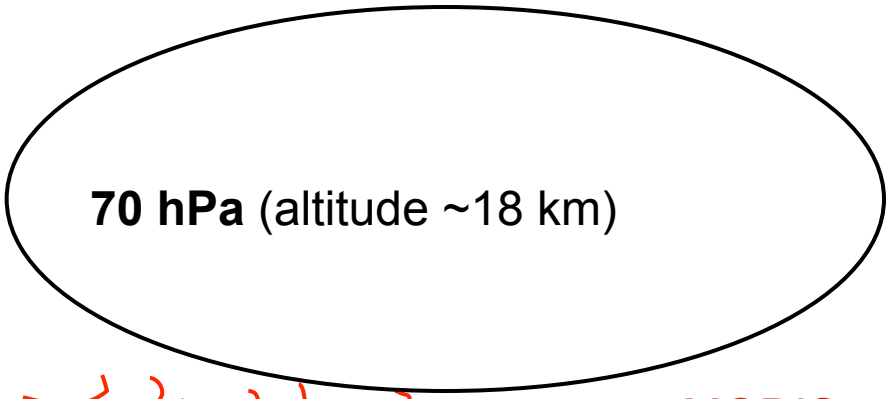
David Fillmore – Poster on stratospheric aerosols in Model for Atmospheric Transport and Chemistry (MATCH)

David Rutan – Co-I presentation on CAVE URL
Google "CERES CAVE"

Ungridded SARB vertical profile at ~2,000,000 CRS footprints/day

Langley Fu-Liou radiative transfer: Kato 2005 SW upgrade, Kratz-Rose LW window

NCEP O3(z)
Mostly from SBUV/2



MINNIS modis

GSFC NWP

GEOS4 T(z), q(z), surface wind
Jin ocean surface albedo = f(wind)

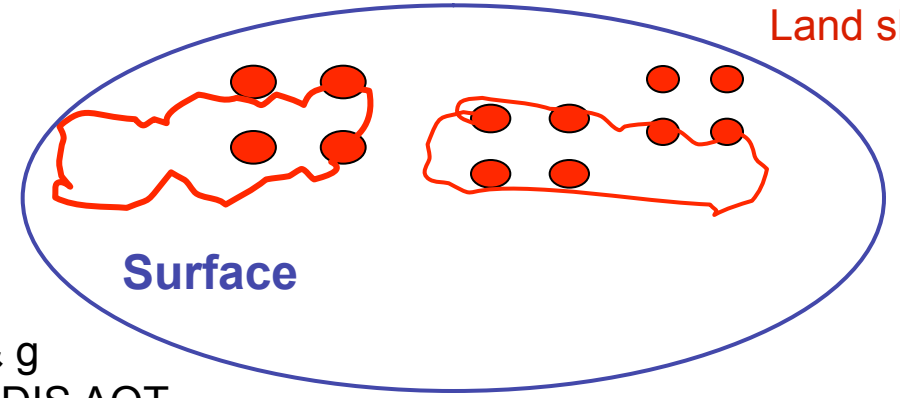
Modis Atmosphere Team

MODIS ~1km pixels provide

Cloud properties (almost always)

Aerosol AOT (sometimes)

Land skin temperature (if clear)



David Fillmore

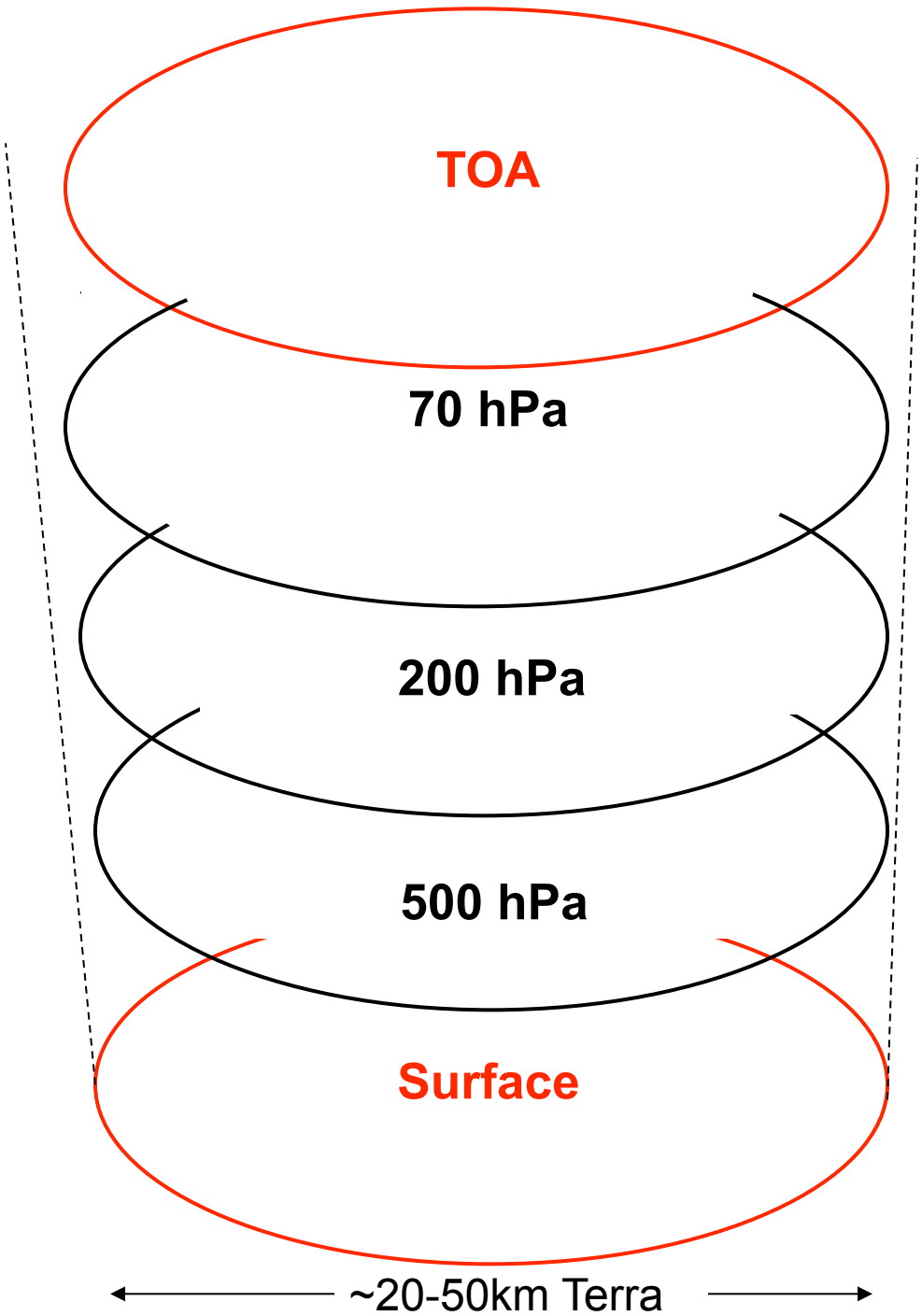
MATCH aerosols
Always used for SSA & g
Used for AOT if no MODIS AOT

Loeb

Priestley

~20-50 km

Large CERES footprint for TOA flux



CERES CRS: Surface and Atmosphere Radiation Budget (SARB) Product

Tuned fluxes at all 5 levels
All-sky & Clear-sky, Up & Down,
SW and LW

Surface & TOA also have Untuned fluxes
Fluxes with aerosols
Pristine fluxes (no aerosols)

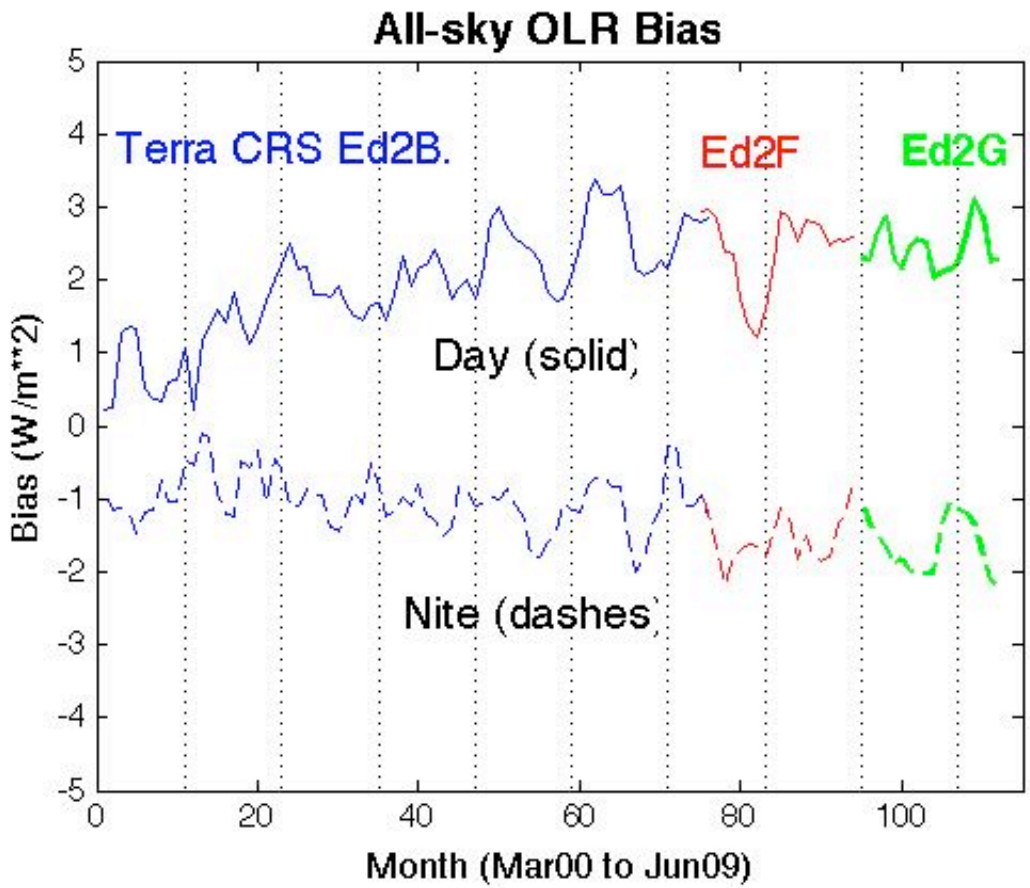
Aerosol forcing for all-sky & clear-sky

Tuning does NOT yield a perfect match to TOA observations.

Parameters adjusted when clear:
Skin temperature, aerosol AOT, precipitable water (PW)

Parameters adjusted when cloudy:
LWP/IWP, cloud top temperature, cloud fractional area within footprint

Untuned calculations vs. observations



Ed2B: MODIS Collection 4, GEOS-4

Ed2F: MODIS Collection 5, GEOS-4

Ed2G: MODIS Collection 5, GEOS-5

Terra LW Fluxes

16 global sites -- fairly consistent observations 2000-2009

~1030 LST and ~2230 LST Instantaneous footprint statistics

Observation W/m**2	Bias W/m**2	RMS W/m**2	N	ALL-SKY LW
				OLR
229	1	5	86765	Tuned CRS Ed2B/2F/2G
229	1	8	86765	Untuned CRS Ed2B/2F/2G
				Surface Down
306	-8	23	86765	Tuned CRS Ed2B/2F/2G
306	-7	22	86765	Untuned CRS Ed2B/2F/2G

Terra SW Fluxes

16 global sites -- fairly consistent observations 2000-2009

~1030 LST Instantaneous footprint statistics

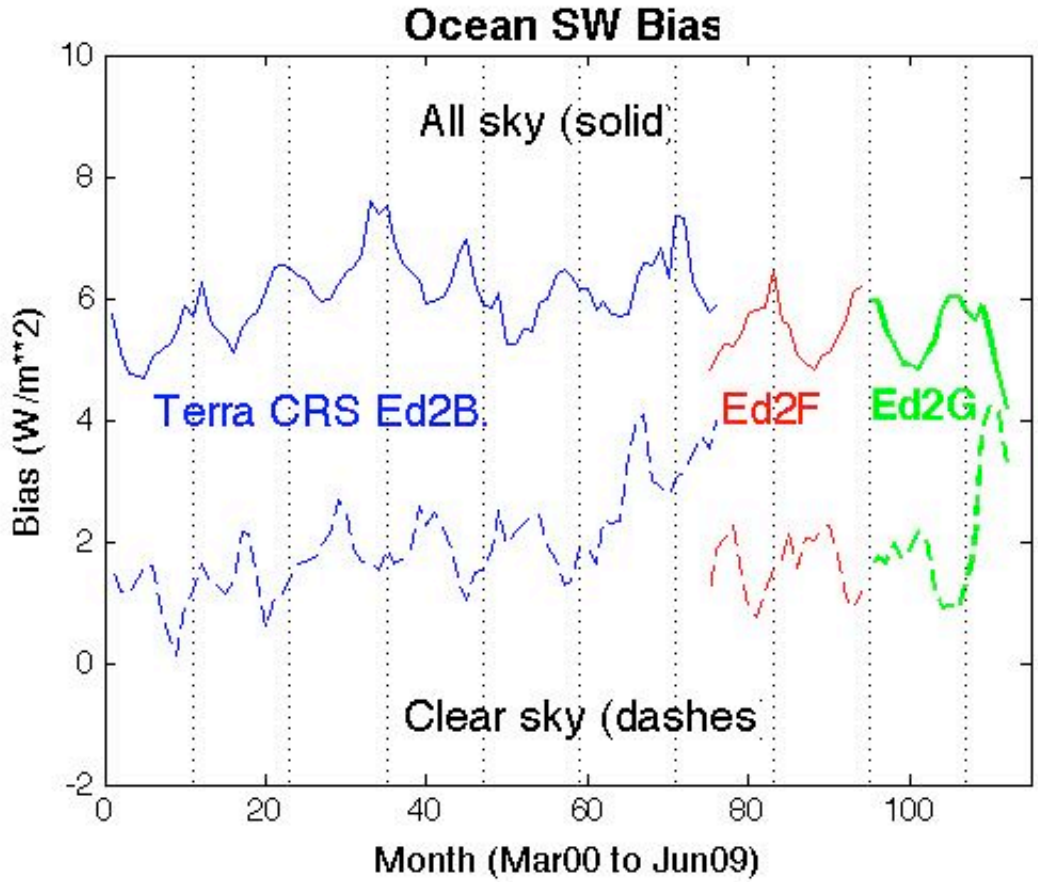
Observation W/m**2	Bias W/m**2	RMS W/m**2	N	ALL-SKY SW
				TOA Reflected
259	2	9	42789	Tuned CRS Ed2B/2F/2G
259	6	26	42789	Untuned CRS Ed2B/2F/2G
259	1	27	42789	Untuned No Aerosol
				Surface Down
541	18	108	42789	Tuned CRS Ed2B/2F/2G
541	13	105	42789	Untuned CRS Ed2B/2F/2G
541	29	108	42789	Untuned No Aerosol

Reflected fluxes to TOA are larger in calclations than observations.

Tuning adjusts inputs to bring calculated fluxes closer to CERES (i.e., tuning decreases the cloud optical depth).

This tuning INCREASES the bias for surface insolation (as if the untuned optical depth was already too low).

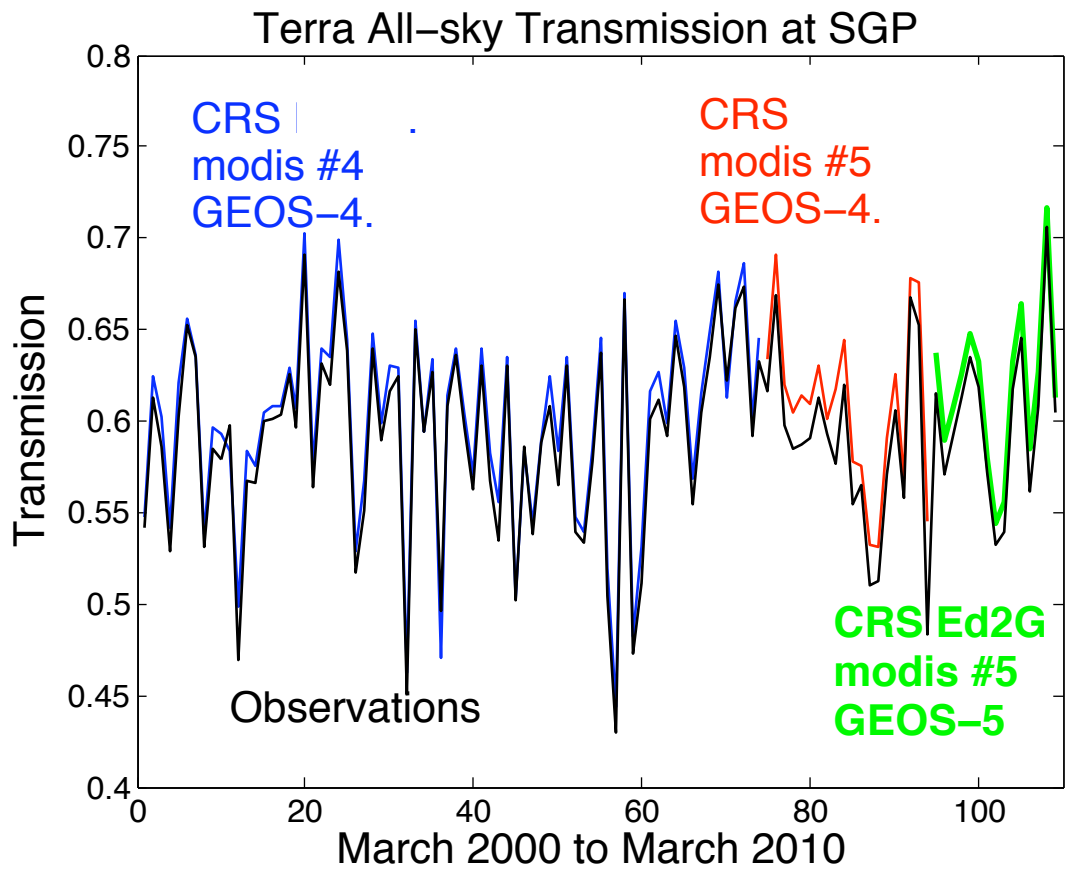
Untuned calculations vs. observations



Ed2B: MODIS Collection 4, GEOS-4

Ed2F: MODIS Collection 5, GEOS-4

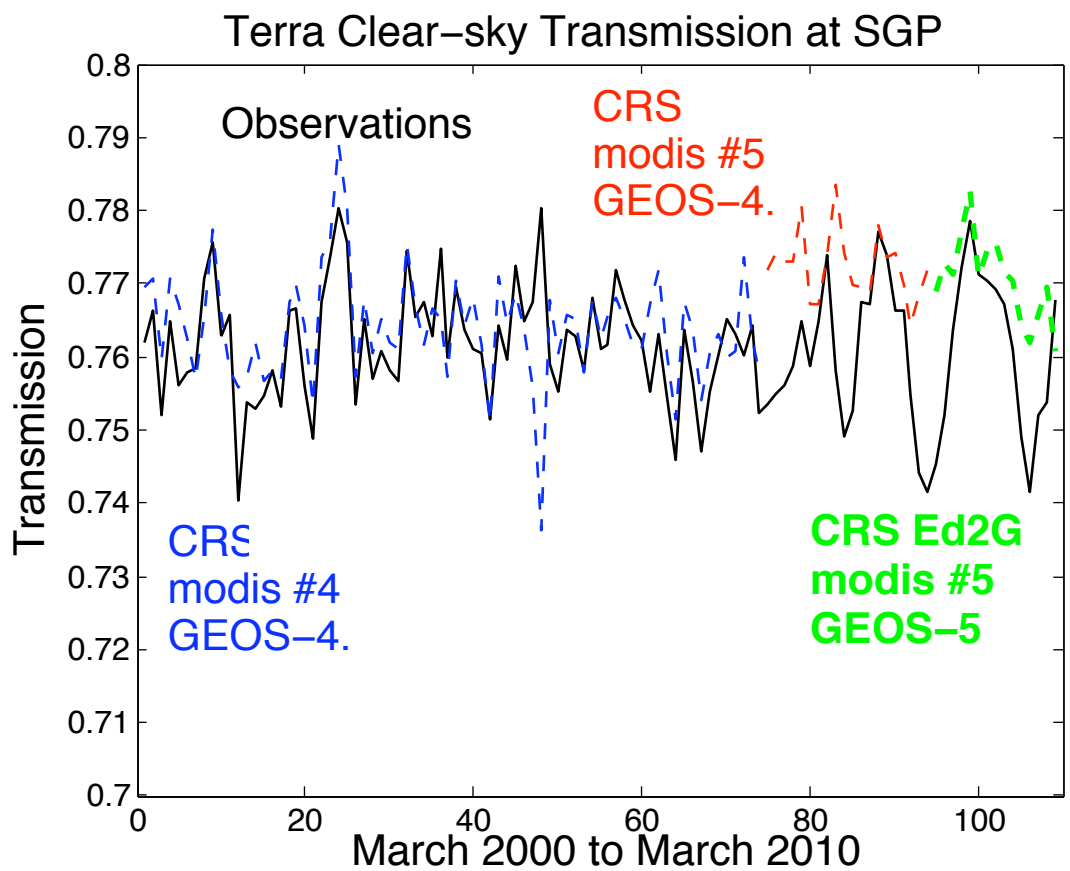
Ed2G: MODIS Collection 5, GEOS-5



Ed2B: MODIS Collection 4, GEOS-4

Ed2F: MODIS Collection 5, GEOS-4

Ed2G: MODIS Collection 5, GEOS-5



Ed2B: MODIS Collection 4, GEOS-4

Ed2F: MODIS Collection 5, GEOS-4

Ed2G: MODIS Collection 5, GEOS-5

Terra Surface Insolation (SW down) versus Ground observations
19 sites -- ARM Southern Great Plains (SGP)
~1030 LST

Observation	Bias	RMS	SW DOWN (W/m**2)	
			Edition 2B Mar00-Apr06	
593	11	94	SSF Model B	
593	10	86	CRS Untuned	
753	-26	32	SSF Model B	CLEAR SKY
753	3	20	CRS Untuned	CLEAR SKY
			Edition 2F May06-Dec07	
601	15	100	SSF Model B	
601	22	92	CRS Untuned	
727	-24	31	SSF Model B	CLEAR SKY
727	13	21	CRS Untuned	CLEAR SKY
			Edition 2G Jan08-Mar09	
581	8	88	SSF Model B	
581	13	78	CRS Untuned	
714	-25	34	SSF Model B	CLEAR SKY
714	8	21	CRS Untuned	CLEAR SKY

RMS from instantaneous statistics (not monthly averaged)

Fig. 4a LW Divergences for Theoretically Clear Daytime FOVs (15 December 2007)

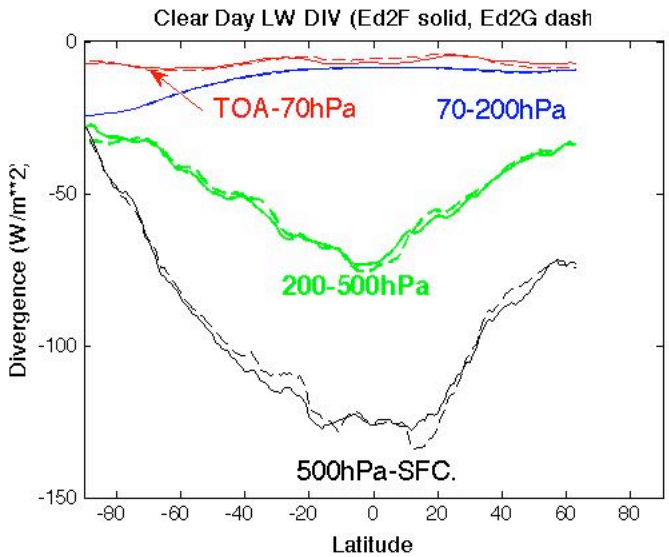
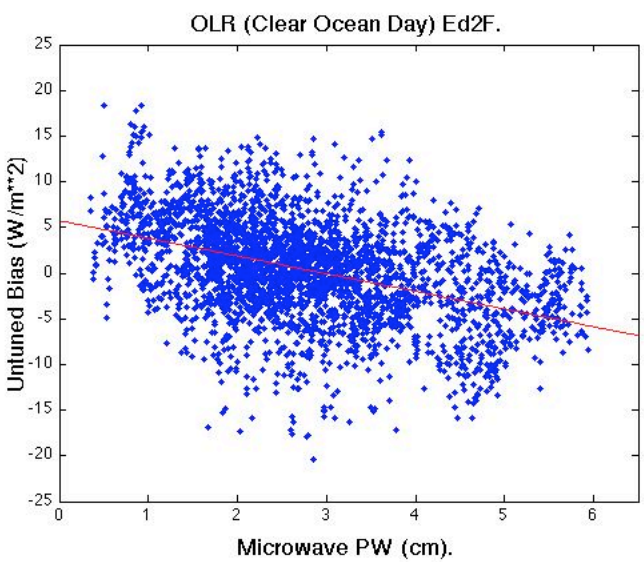
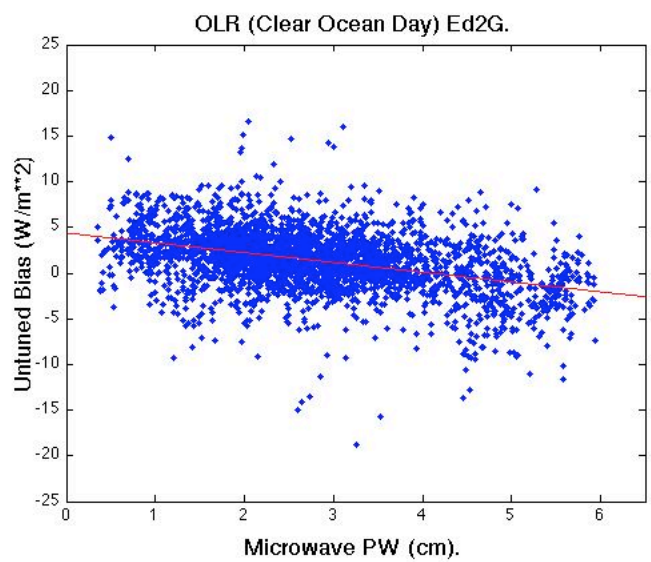
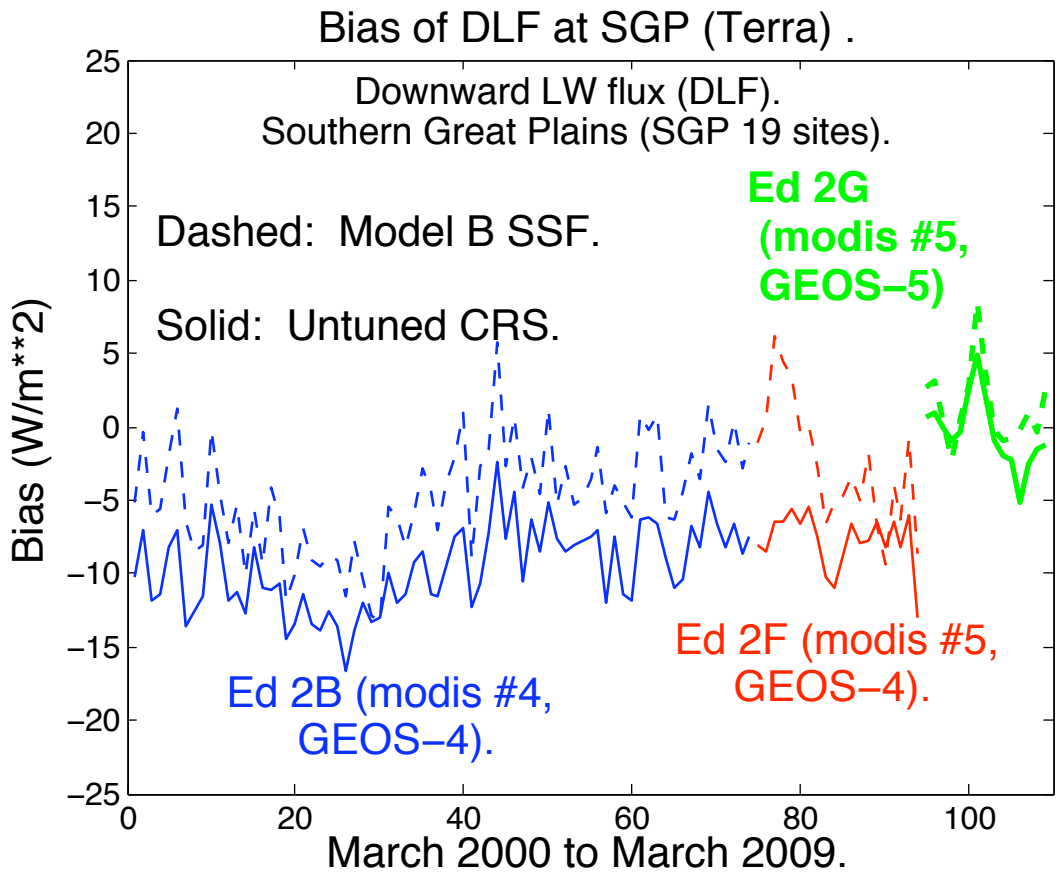


Fig. 4b Untuned OLR Biases for Clear-sky (MODIS screen), Ocean only Daytime FOVs (15 Dec 2007)



Reduced RMS on right shows that GEOS-5 (Terra CRS Ed2G) has better input.

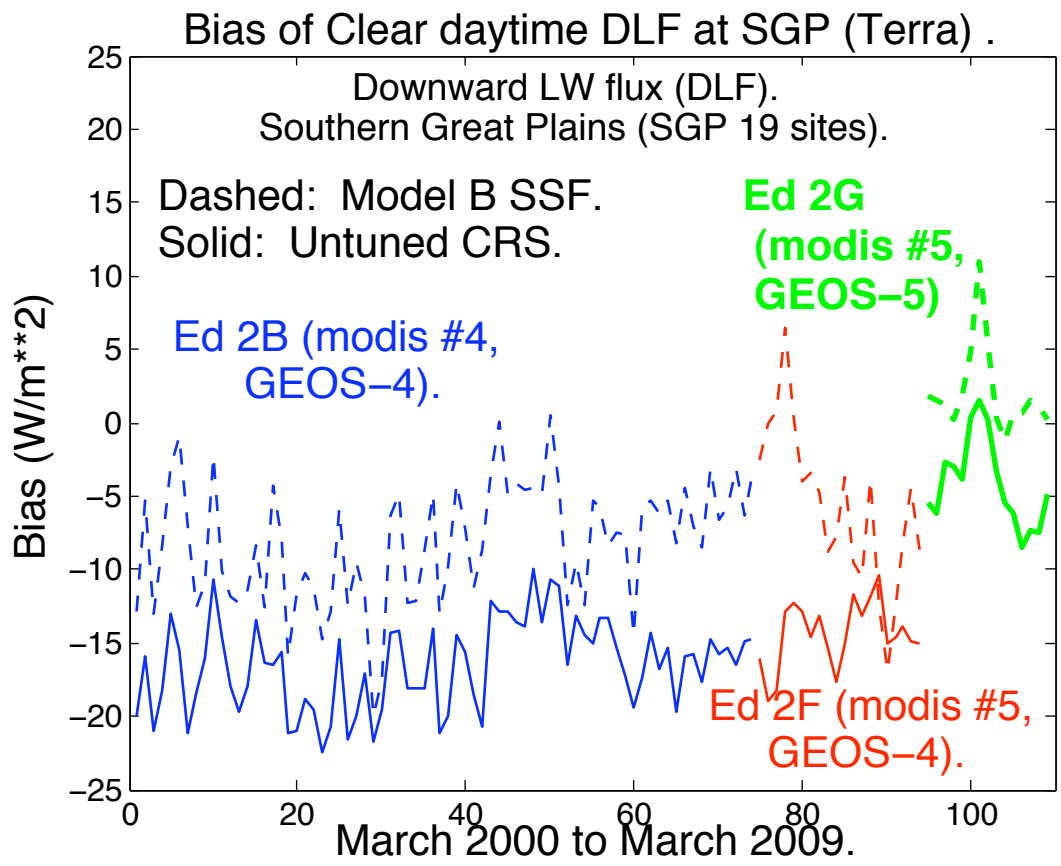


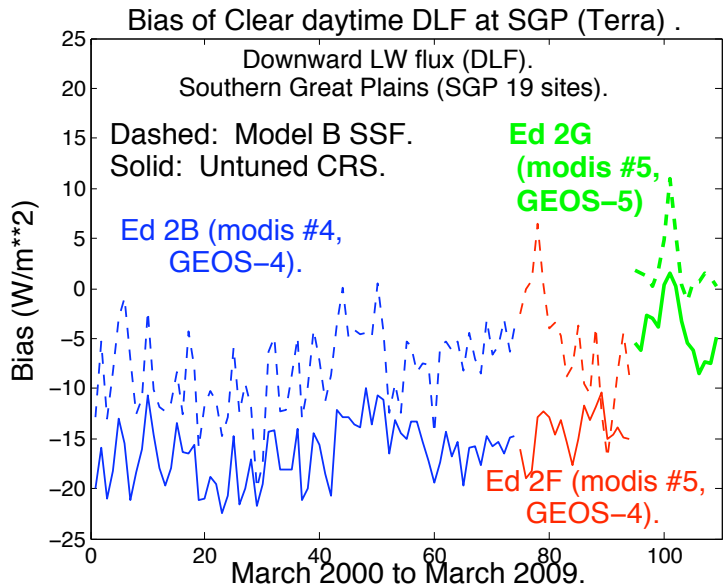

Bias of DLF at SGP (Terra) .
Downward LW flux (DLF).
Southern Great Plains (SGP 19 sites).
Dashed: Model B SSF.
Solid: Untuned CRS.
Ed 2G (modis #5, GEOS−5)
Ed 2F (modis #5, GEOS−4).
Ed 2B (modis #4, GEOS−4).
Bias (W/m**2)
25
20
15
10
5
0
−5
−10
−15
−20
−25
0
20
40
60
80
100
March 2000 to March 2009.

Terra Downward LW Flux (DLF) versus Ground observations
19 sites -- ARM Southern Great Plains (SGP)
Day and Night (~1030 LST and 2230 LST)

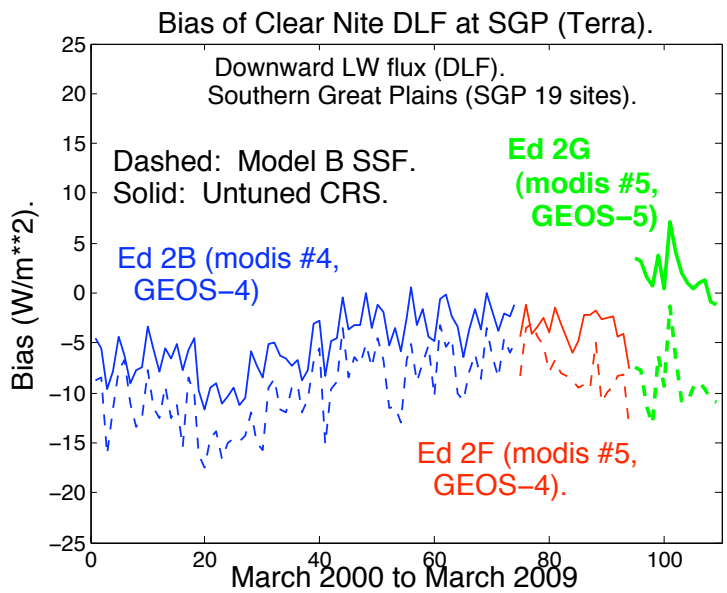
Observation	Bias	RMS	(W/m**2)	DLF
			Edition 2B	Mar00-Apr06
332	-5	20	SSF Model B	
332	-10	20	CRS Untuned	
309	-9	17	SSF Model B	CLEAR-SKY
309	-11	18	CRS Untuned	CLEAR-SKY
			Edition 2F	May06-Dec07
341	-2	18	SSF Model B	
341	-8	17	CRS Untuned	
314	-7	13	SSF Model B	CLEAR-SKY
314	-8	14	CRS Untuned	CLEAR-SKY
			Edition 2G	Jan08-Mar09
319	1	18	SSF Model B	
319	0	13	CRS Untuned	
291	-4	12	SSF Model B	CLEAR-SKY
291	-1	8	CRS Untuned	CLEAR-SKY

RMS from instantaneous statistics (not monthly averaged)


Bias of Clear daytime DLF at SGP (Terra) .
Downward LW flux (DLF).
Southern Great Plains (SGP 19 sites).
Dashed: Model B SSF.
Solid: Untuned CRS.
Ed 2G
(modis #5,
GEOS−5)
Ed 2B (modis #4,
GEOS−4).
Ed 2F (modis #5,
GEOS−4).
Bias (W/m**2)
25
20
15
10
5
0
−5
−10
−15
−20
−25
0
20
40
60
80
100
March 2000 to March 2009.



Day ~1030 LST
Clear sky



Nite ~2230 LST
Clear sky

Gridded Monthly Product SYN uses geostationary, as well as MODIS
Global validation and comparison 2000-2005

Model	SW Down		LW Down	
	BIAS	RMS	BIAS	RMS
GEWEX-SRB	-3	23	-1	11
ECMWF	-5	24	-0	14
ISCCP FD	-1	21	7	22
CERES Model B	1	24	-1	10
SYN Aqua Tuned	4	11	-6	12
SYN Terra Tuned	5	13	-5	12

Ungridded Terra CRS - Instantaneous using MODIS but DIFFERENT sites from above

Terra CRS Fluxes
16 global sites -- fairly consistent observations 2000-2009
~1030 LST and ~2230 LST

Observation W/m**2	Bias W/m**2	RMS W/m**2	N	Tuned CRS Ed2B/2F/2G
306	-8	23	86765	Downward LW Flux (DLF)
541	18	108	42789	Surface SW Down

Gridded Monthly Product SYN uses geostationary, as well as MODIS
Validation with ground data and comparison 2000-2005

Model	SW Down		LW Down	
	BIAS	RMS	BIAS	RMS
GEWEX-SRB	-3	23	-1	11
ECMWF	-5	24	-0	14
ISCCP FD	-1	21	7	22
CERES Model B	1	24	-1	10
SYN Aqua Tuned	4	11	-6	12
SYN Terra Tuned	5	13	-5	12

Previous slides showed ungridded Terra CRS at different locations, but they suggest that GEOS-5 would eliminate much of the SYN bias for LW Down (DLF).

Cloud Forcing = (All-sky flux) – (Clear-sky flux)

Due to Ramanathan (1980s)
Used to validate GCMs (Cess et al., 1990… Bony et al., 2006…)
and to assess the role of clouds in climate change.

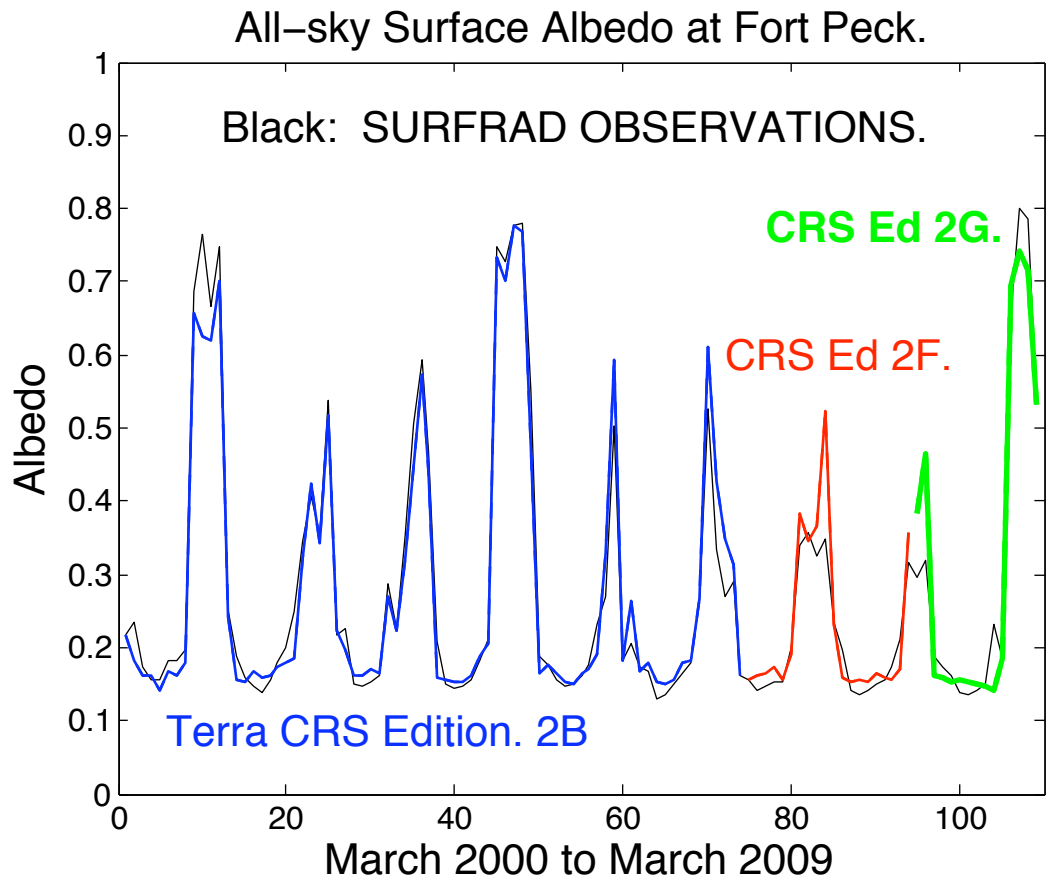
Do you prefer to say "cloud effect" or "cloud forcing"?
Generally applied to thermodynamic quantities like flux
(or albedo and transmission as dimensionless fluxes)

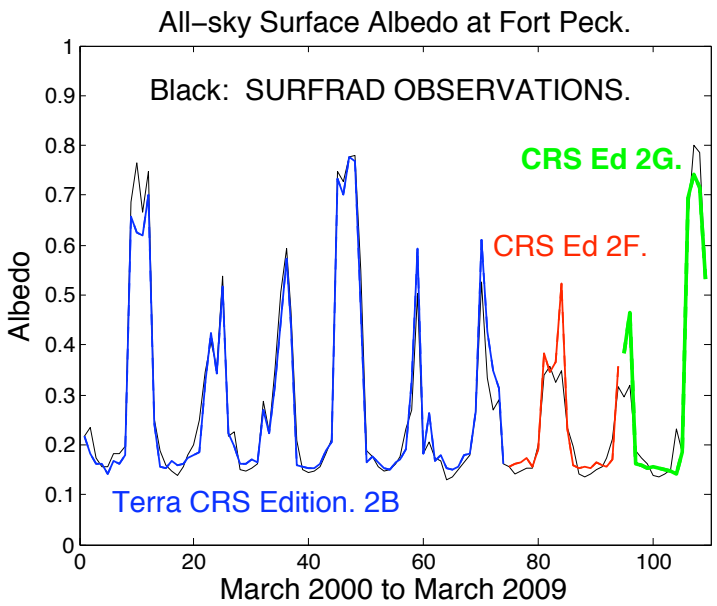
"All-sky" is nature's combination of cloudy and clear.
"Clear-sky" as observed to be cloud free, or even computed.

Surface Albedo Forcing = (All-sky flux)

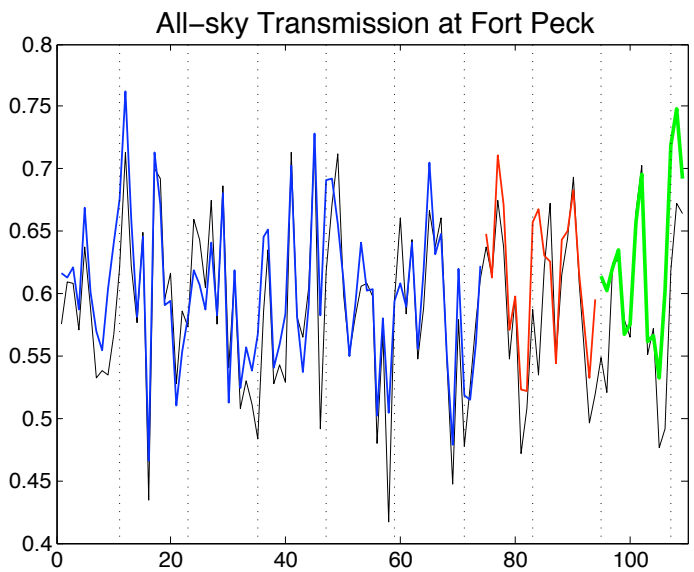
– (Flux with no reflection by surface)

Must be computed


All−sky Surface Albedo at Fort Peck.
Black: SURFRAD OBSERVATIONS.
CRS Ed 2G.
CRS Ed 2F.
Terra CRS Edition. 2B
Albedo
March 2000 to March 2009
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100



Surface Albedo



Transmission

Computed Upwelling SW (W/m**2) to TOA

Monthly mean for 200407

Hourly calculation with MODIS, geostationary and interpolated clouds; GEOS-4; MATCH aerosols

Surface Albedo Forcing

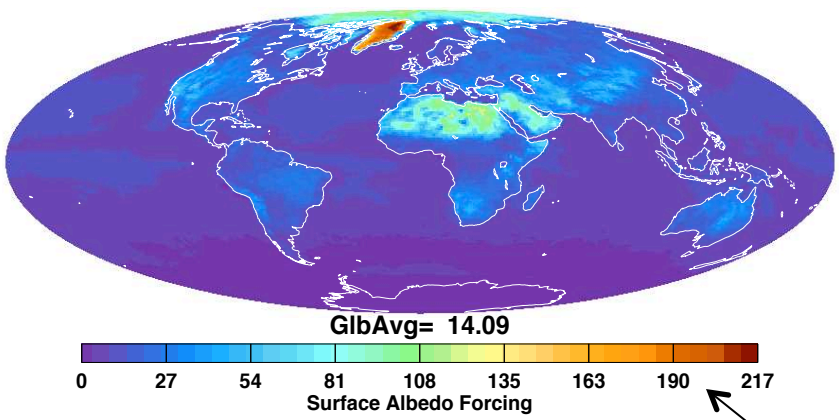
= (All-sky SW)

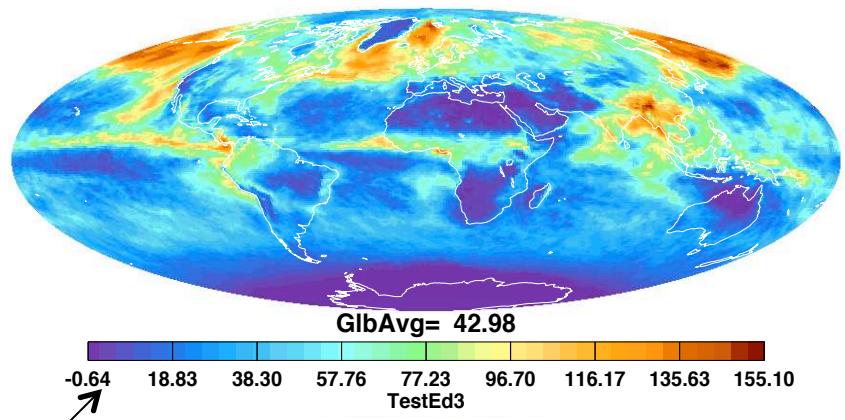
- (All-sky SW with zero surface albedo)

Cloud Forcing

= (All-sky SW)

- (Clear-sky SW)

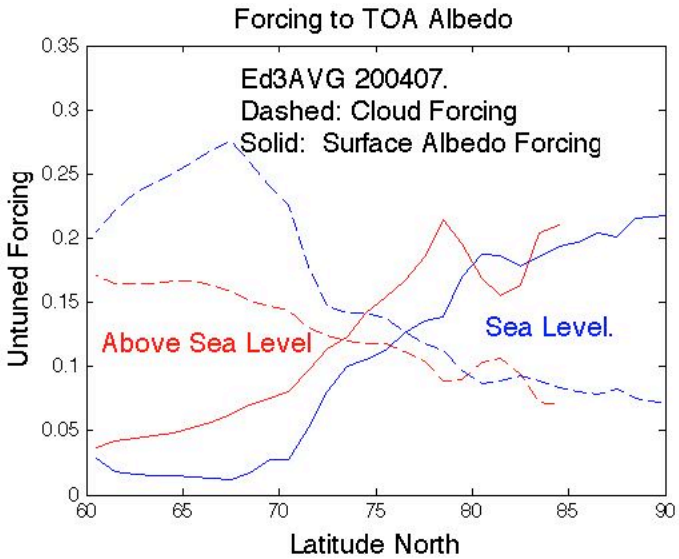


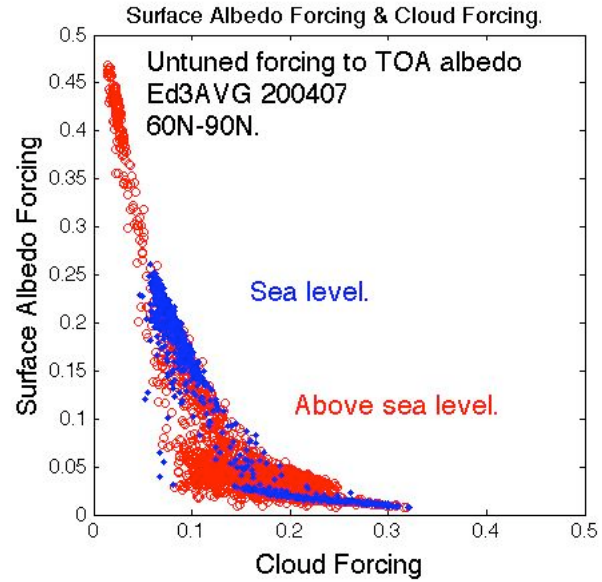


Scales differ

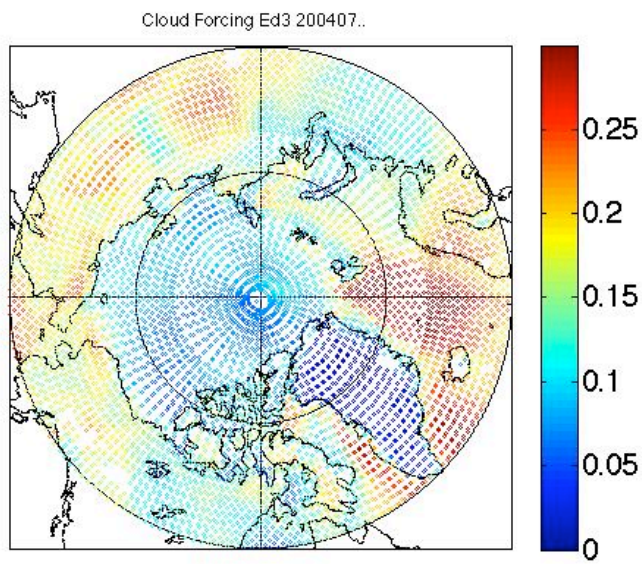
Surface Albedo Forcing product will not appear until CERES Edition 4.
It should be valuable for testing high latitude feedbacks in GCMs.

code used: CER_SYNI_Terra-Aqua-MODIS_SfcAlb0Edition3_999999.200407

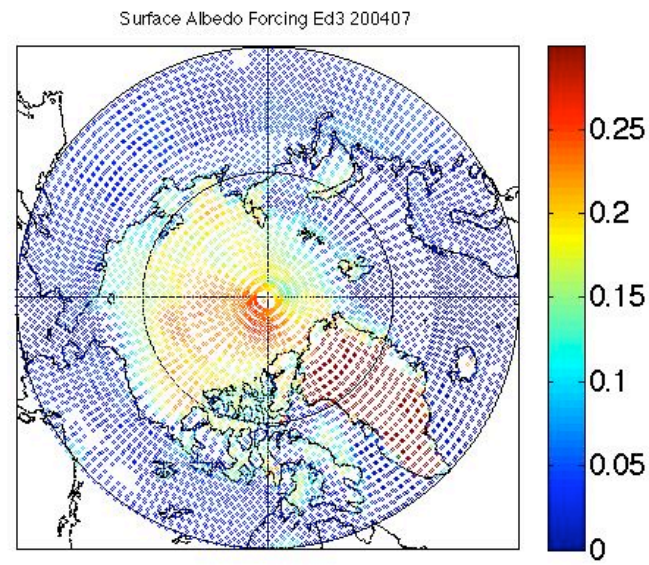




Cloud Forcing



Surface Albedo Forcing



Terra CRS Ed2B: MODIS Collection 4, GEOS-4 (Mar00-Apr06)

Ed2F: MODIS Collection 5, GEOS-4 (May06-Dec07)

Ed2G: MODIS Collection 5, GEOS-5 (Jan08…)

MODIS Collection 5 cloud inputs
- No significant marks in calculated vs. surface, TOA observations

MODIS Collection 5 aerosols increase bias of SW insolation.

GEOS-5 improves of calculated DLF and clear-sky OLR.

Surface albedo forcing in Edition 4 but not Edition 3.

Fillmore will report on change to MATCH stratospheric aerosols
- Edition 3 will use and ad hoc climatology based on SAGE 2000-2005