Prototype of CRS Edition 4: the CERES Footprint-scale Surface and Atmosphere Radiation Budget (SARB)

CERES Science Team Meeting (Newport News, 26-28 April 2011)

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

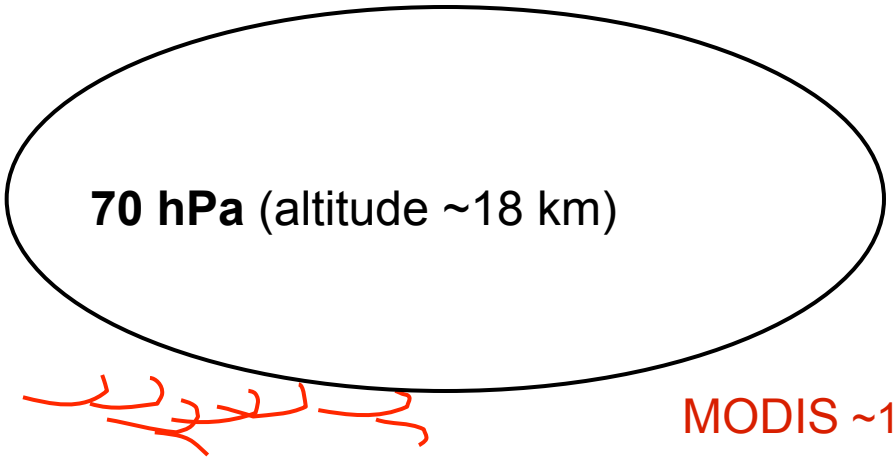
Thanks to: Victor Sothcott, Sunny Sun-Mack, Seiji Kato,
Joe Corbett, Pat Minnis, Fu-Lung Chang, Wenying Su, and Walt Miller

For CAVE website with on-line radiative transfer, data, plots:
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



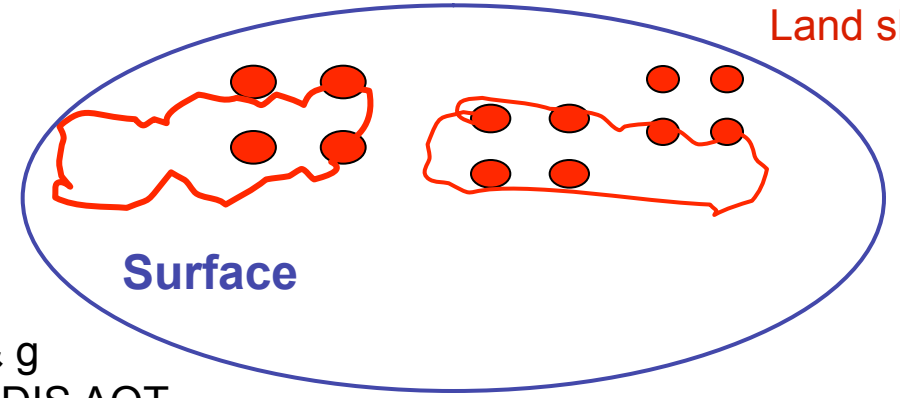
MODIS ~1km pixels provide

Cloud properties (almost always)

Aerosol AOT (sometimes)

Land skin temperature (if clear)

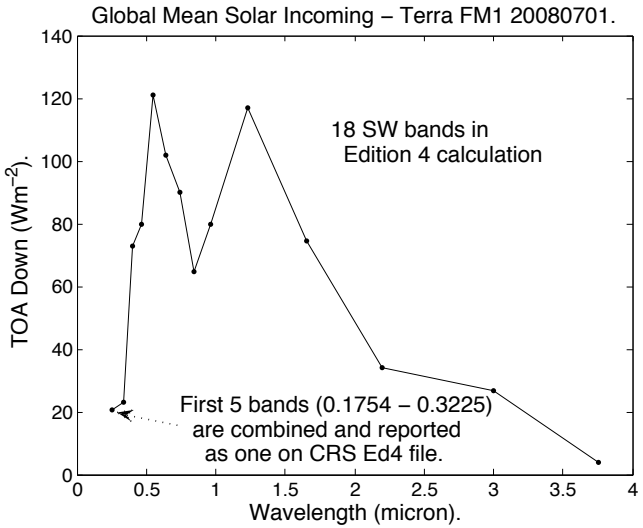
GEOS5 T(z), q(z), surface wind
Jin ocean surface albedo = f(wind)

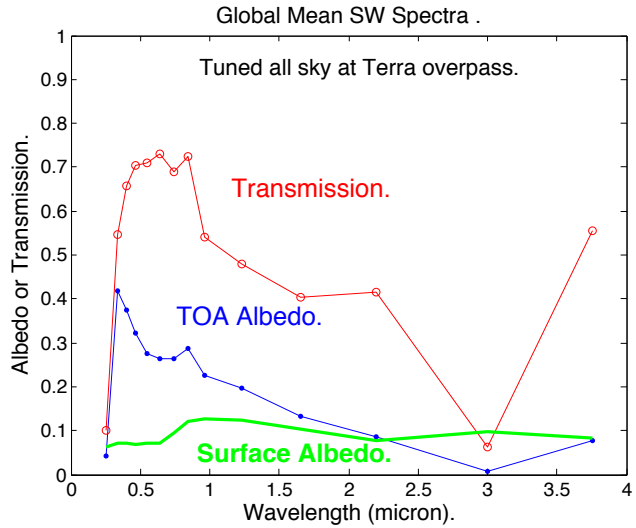


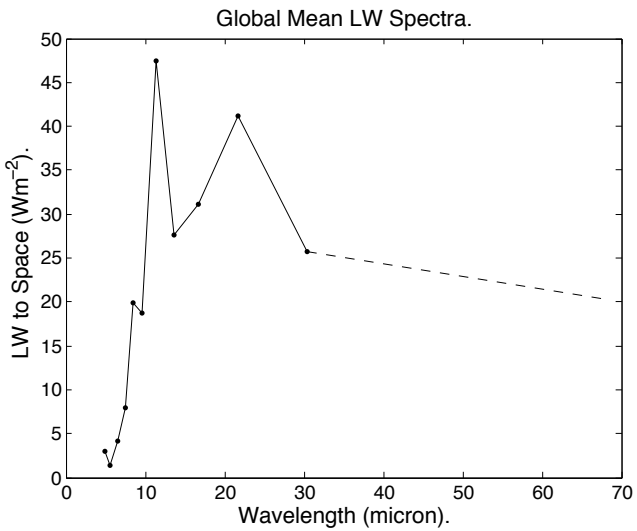
MATCH aerosols
Always used for SSA & g
Used for AOT if no MODIS AOT

~20-50 km

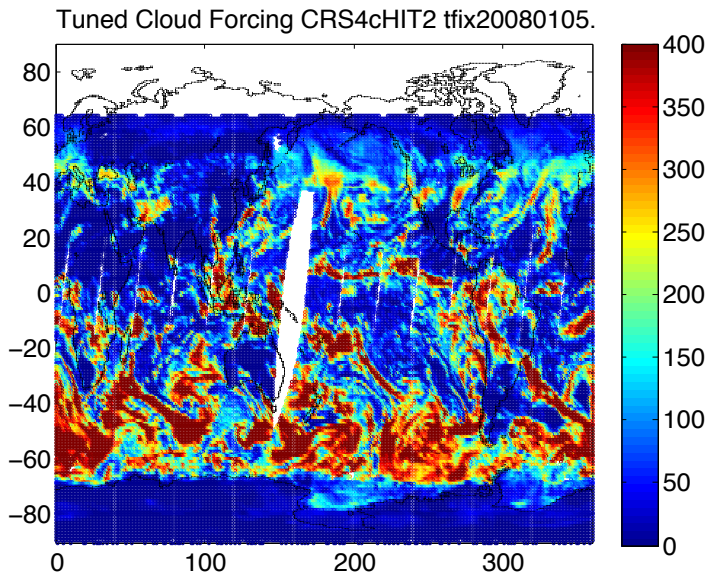
Large CERES footprint for TOA flux

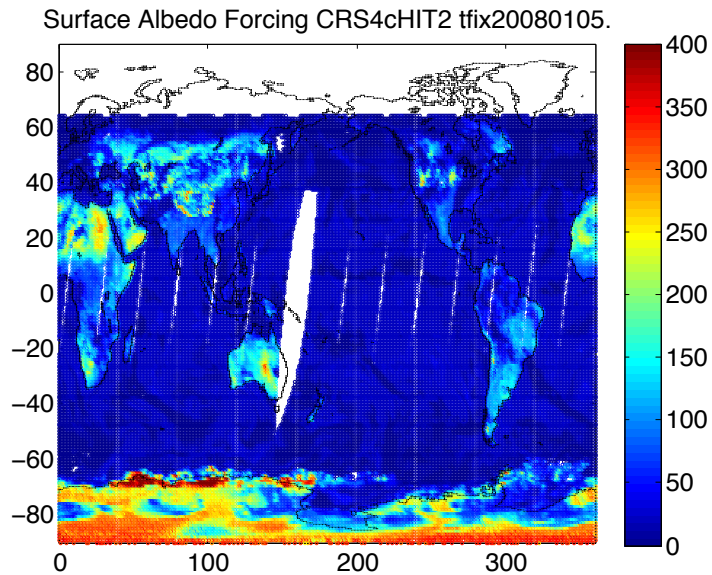


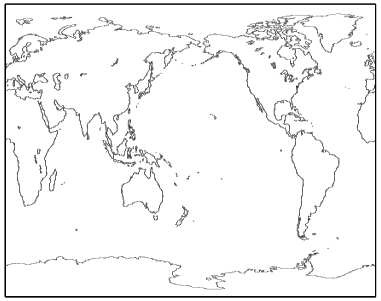




CER_CRS4_Terra-FM1-MODIS_scheme4cHIT2_tfix.20080701





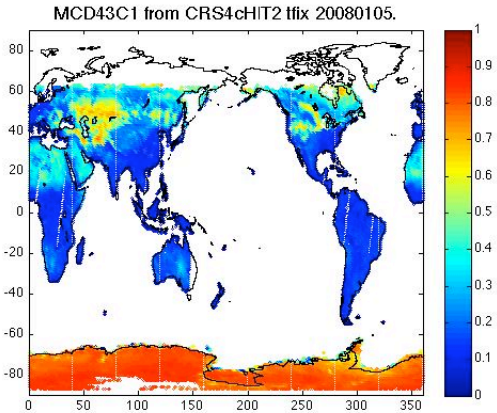


Surface Albedo Forcing =
(All-sky flux) – (Flux with no surface reflection)

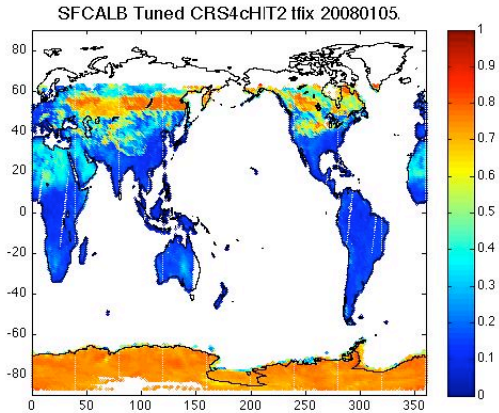
Satellite Cloud Forcing is used diagnose cloud feedbacks in models and in the climate record. Edition 4 Surface Albedo Forcing is intended to serve in such a role for ice albedo and vegetation feedbacks . Quality sources of both cloud forcing and surface albedo forcing are needed to parse signals of clouds versus sea ice in the high latitudes.

CRS Edition 4 continues with calculations of aerosol forcing to SW/LW/clear/cloudy/surface/TOA

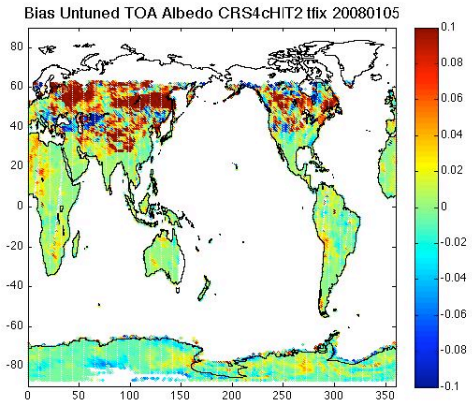
Surface Albedo from MODIS Land Team



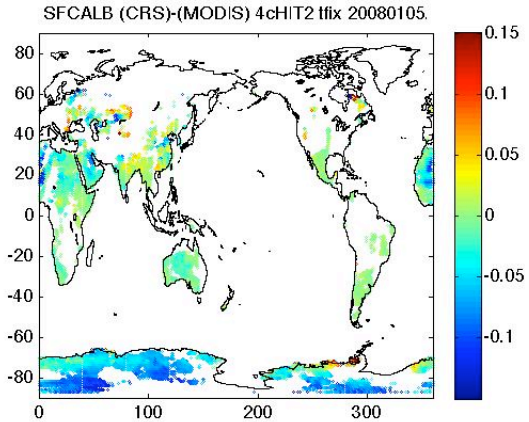
Input from CRS Surface Albedo History (SAH)



Bias of Untuned TOA Albedo (CRS Ed4)



Surface Albedo: (CRS Ed4) – (MODIS Land Team) over clear FOVs



Daytime Globe FM1 20080701 All except sample N as W/m**2

SW TOA SSFed4Test

as Truth	Bias	RMS	N	
230	7	31	1005704	CRS Ed4c Untuned
230	5	28	1005704	CRS Ed2G Untuned

OLR SSFed4Test

as Truth	Bias	RMS	N	
246	-2	7	1005704	CRS Ed4c Untuned
246	-1	8	1005704	CRS Ed2G Untuned

CRS Ed4 Insolation

as "Truth"	Bias	RMS	N	
479	8	46	1005704	CRS Ed2G Untuned
479	19	50	1005704	SSFed4Test Model B

CRS Ed4 DLF

as "Truth"	Bias	RMS	N	
351	-7	13	1005704	CRS Ed2G Untuned
351	-2	11	1005704	SSFed4Test Model B

Only FOVs with Multilayer Clouds (Daytime Ocean) FM1 20080701

All except sample size N in W/m**2

SW TOA SSFed4Test

as Truth	Bias	RMS	N	
324	3	28	115996	CRS Ed4 Untuned
324	4	16	115996	CRS Ed4 Tuned
324	14	28	115996	CRS Ed2G Untuned

Screaming hint of Kato, Rose, Sun-Mack et al. (2011) describes effects of muli-layering on SW radiative transfer.

OLR SSFed4Test

as Truth	Bias	RMS	N	
207	-5	11	115996	CRS Ed4 Untuned
207	-5	12	115996	CRS Ed4 Tuned
207	2	8	115996	CRS Ed2G Untuned

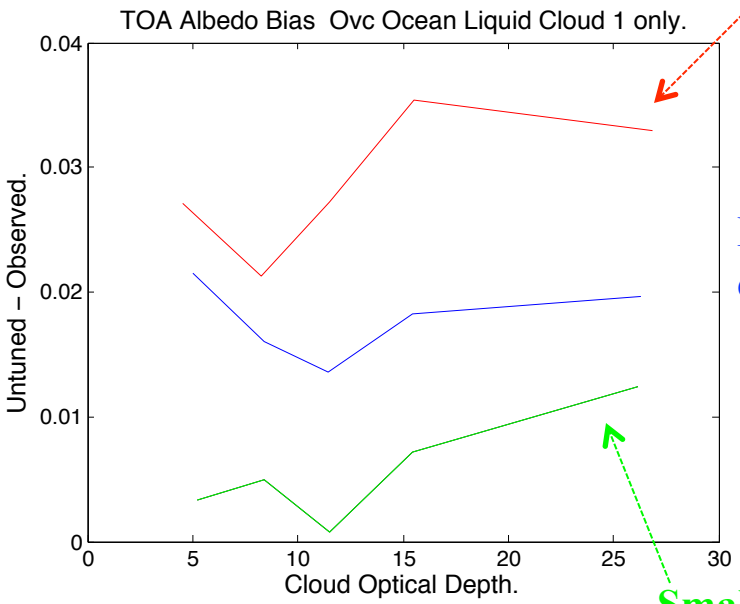
"Single" Layer Liquid Water Overcast Ocean:

Bias of computed TOA albedo increases with dispersion of MODIS radiance at 14.24 um. Not much effect on OLR bias.

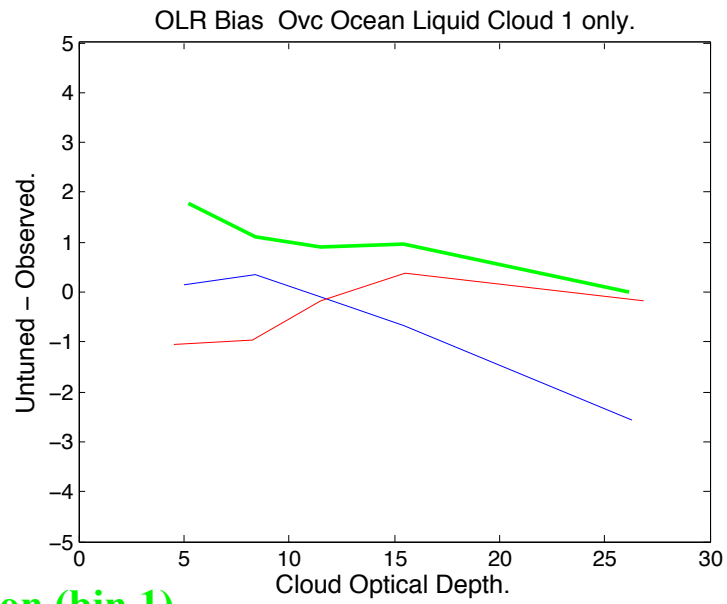
55970 FOVs with 2D sorting
5 Tau bins
29 Dispersion bins

Dispersion of 14.24 um =
(Std radiance)/(Mean radiance)

Largest 14um dispersion (bin 29)

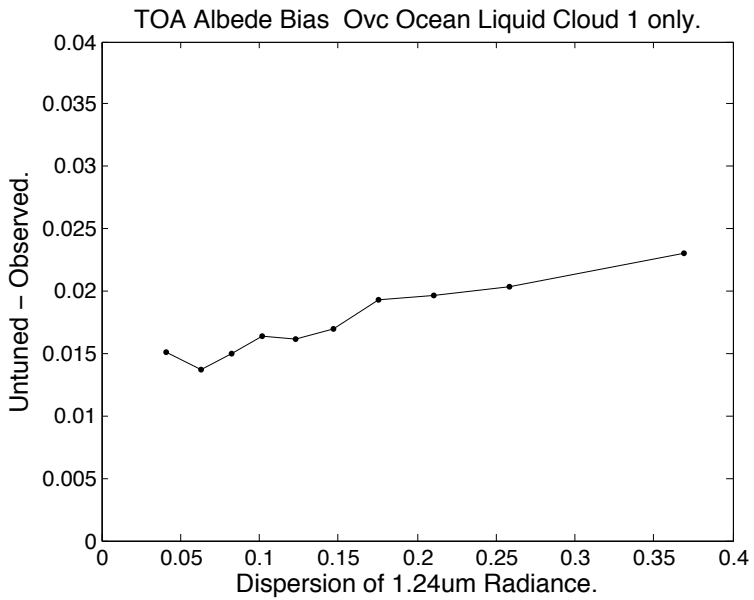


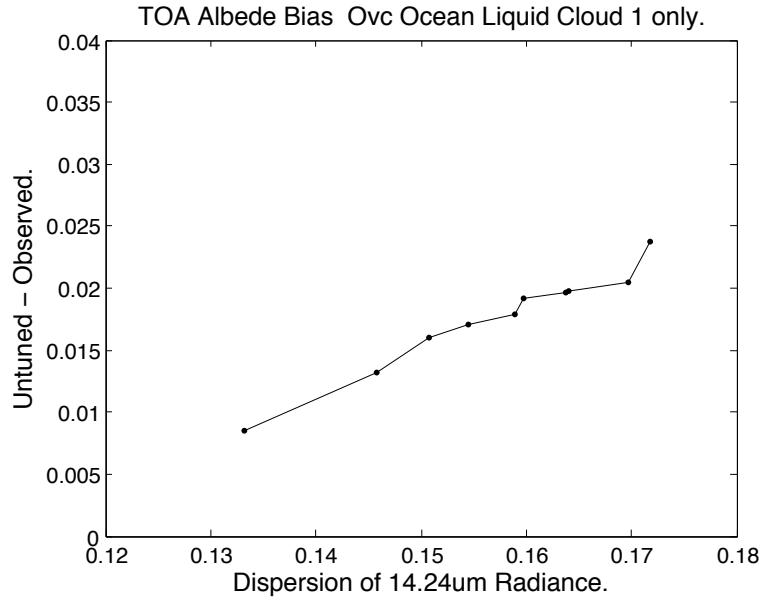
Moderate 14um dispersion (bin 15)



Smallest 14um dispersion (bin 1)

CER_CRS4_Terra-FM1-MODIS_scheme4cHIT2.20080701
CER_SSF_Terra-FM1-MODIS_Ed4Test_000000.20080701


TOA Albede Bias Ovc Ocean Liquid Cloud 1 only.
Untuned – Observed.
Dispersion of 1.24um Radiance.
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4


TOA Albede Bias Ovc Ocean Liquid Cloud 1 only.
Untuned – Observed.
Dispersion of 14.24um Radiance.
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0.12
0.13
0.14
0.15
0.16
0.17
0.18

Correlation of Bias in Untuned TOA Albedo with Dispersion of MODIS Radiance

Albedo bias and dispersion calculated for each of 55970 FOVs
Data sorted into 10 bins; then correlations computed.
Overcast ocean, Cloud 1, liquid water

Wavelength	Correlation
0.47	0.61
0.56	0.70
0.64	0.77
0.86	0.91
1.24	0.93
1.64	0.58
3.79	-0.29
6.72	-0.60
8.55	0.29
11.03	0.22
12.02	0.12
14.24	0.86

Correlations with SW channels are expected.

But why the correlation to 14 um channel?

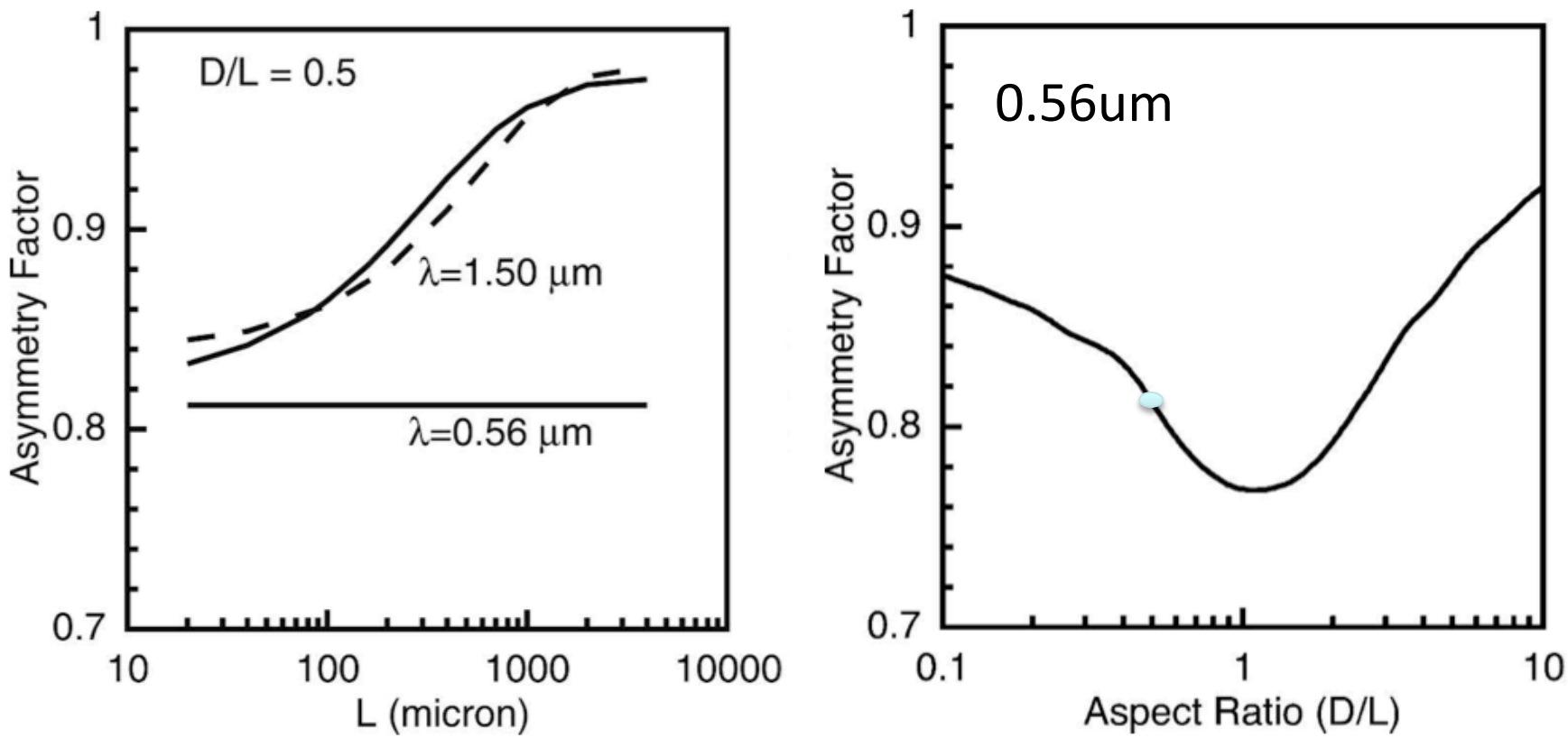
Obtaining Cloud Optical Property Consistency for Roughened Ice Crystals Models between Cloud WG Retrievals (P.Yang) & SARB Forward model (Fu2007)

F. Rose, R. Arduini, S. Mack,
T. Charlock, S. Kato

Ed4 CRS Ice Cloud Optical Properties

- Cloud Working Group (retrievals)
  - Ping Yang (2010) personal communication Minnis
  - Ed4 to use “roughened crystal” model
  - 11 Effective Diameter (De) cases
- SARB Working Group (forward model)
  - Fu Q. A new parameterization of an asymmetry factor of cirrus clouds for climate models. J Atmos Sci 2007;64:4144–54.
  - Function of D_{ge} and Aspect ratio
  - Rough model : No forward delta correction
  - Ed2CRS used Fu1996

Asymmetry Factor :
Visible depends on Aspect Ratio
Near IR dependent on Particle Size

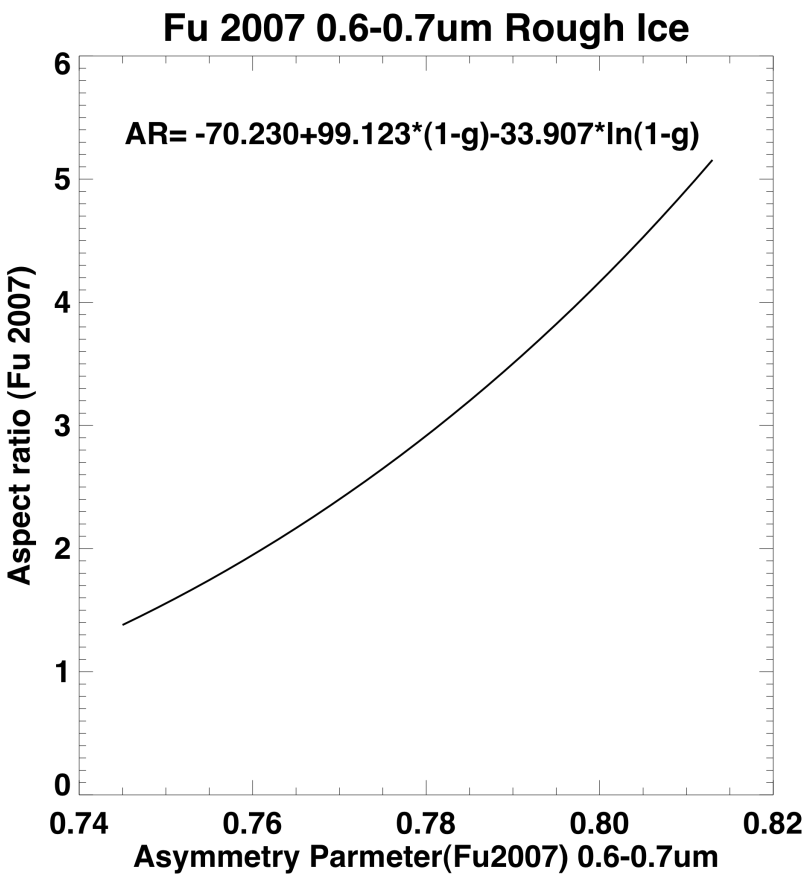


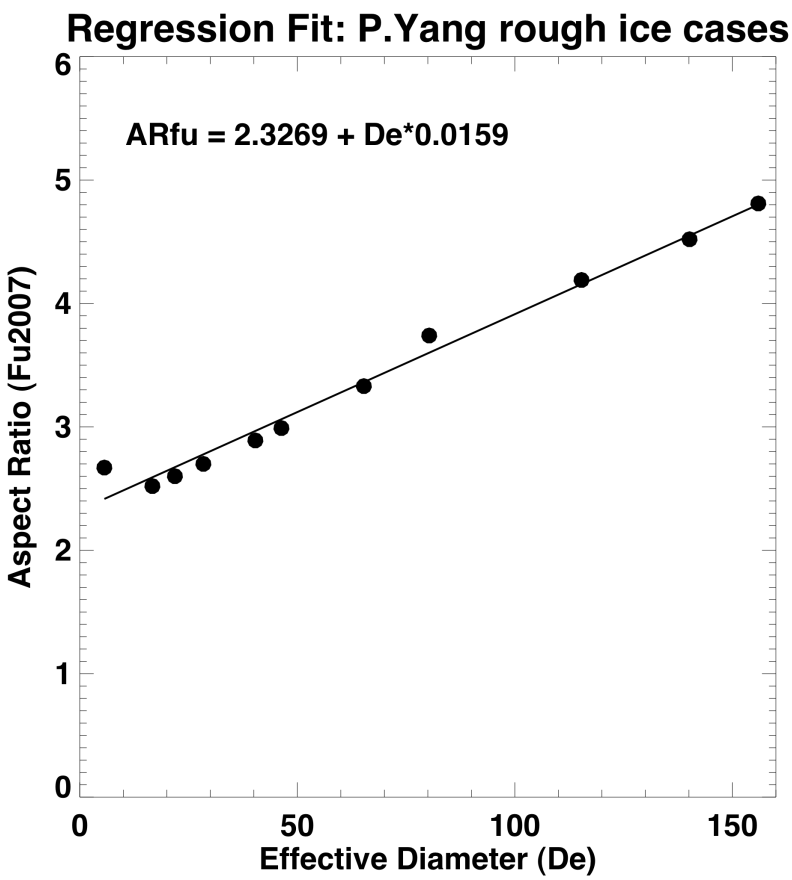
Citation: A New Parameterization of an Asymmetry Factor of Cirrus Clouds for Climate Models, Qiang Fu, Vol 64 p4140-4150 .2007 *Journal Atmospheric Science*

Process

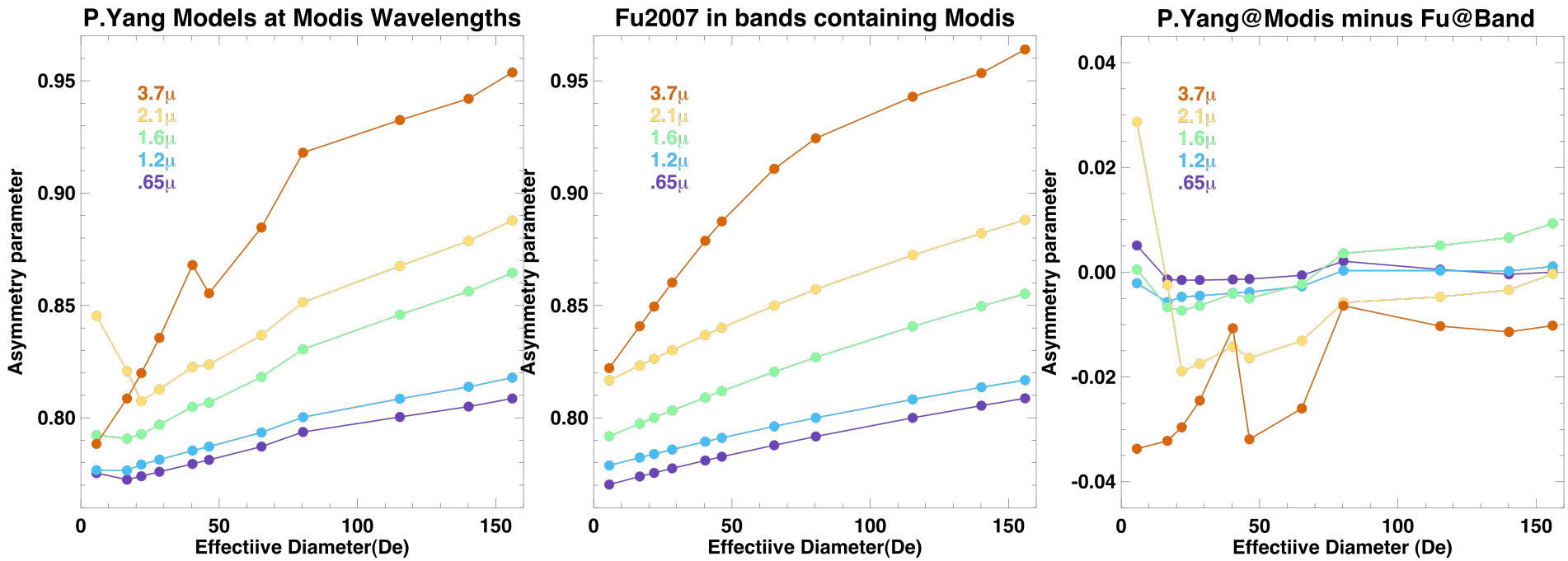
- Force consistency of asymmetry factor “g” for visible channels.
- Assume domain of eleven P. Yang rough ice models “De” and “g”
- Since Aspect ratio is not retrieved
  - use Fu2007 g = f(AR) & P.Yang g = f(De)
  - to find AR = f(De) for 0.65 wavelength

$Ar = f(g_{.65})$ where $g_{.65}=f(De)$





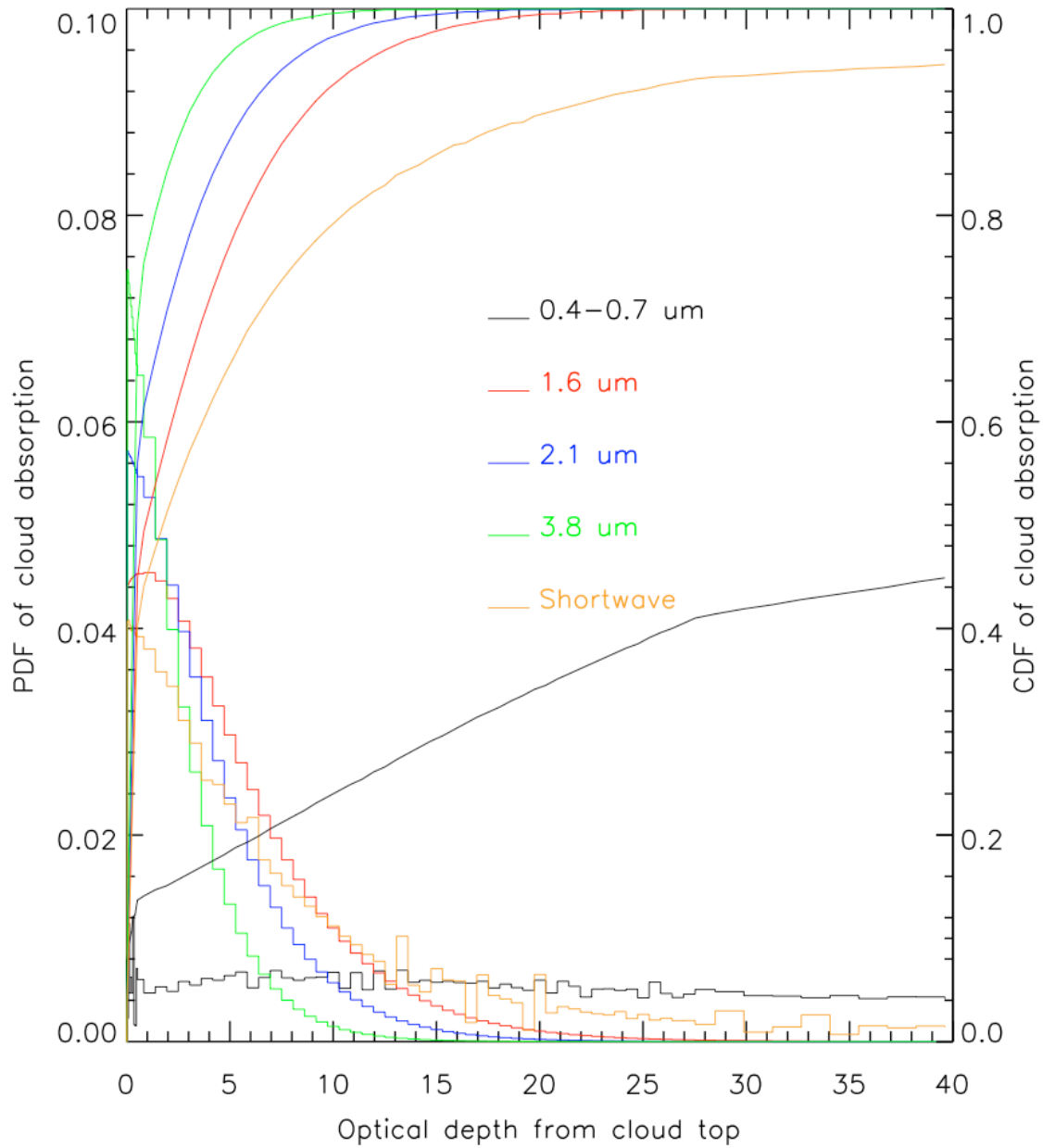
Asymmetry Factor Consistency



Prototype-Ed4 CRS Tests

- Uses one day of ED4 SSF :20080701
- Tests of asymmetry factor consistency scheme
- Tests use Ice particle size from alternate MODIS channels (3.7 , 2.1, 1.2)micron
  - Shorter wavelengths see deeper into cloud and typically sense larger particles.
  - Broadband scattered energy represented better by shorter wavelength particle size retrievals.

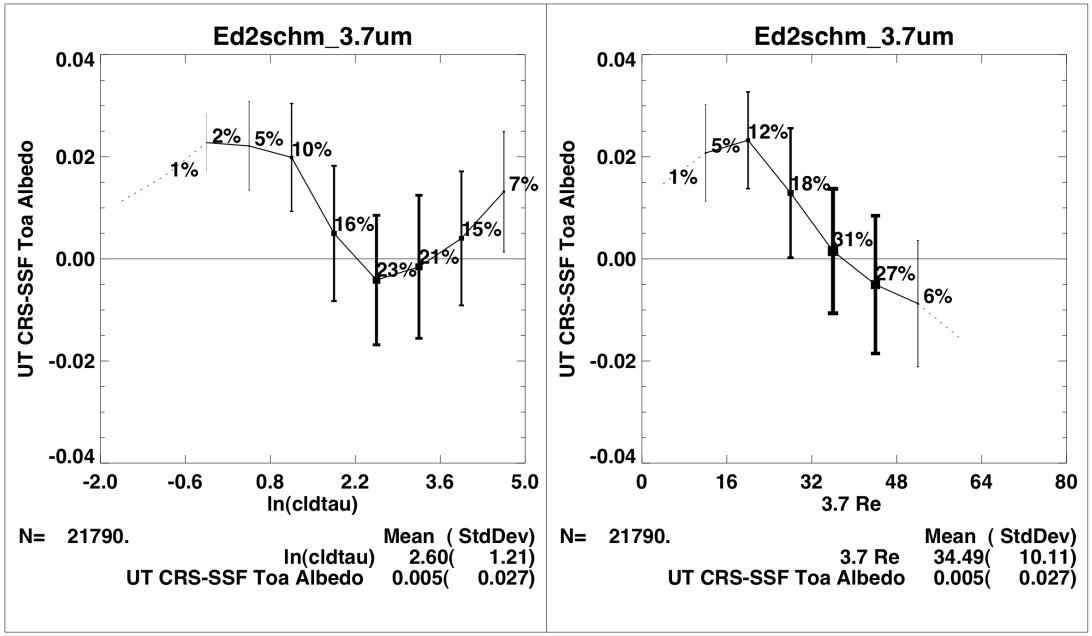
Wavelength Dependent Cloud Absorption .vs. Optical Depth from Cloud Top



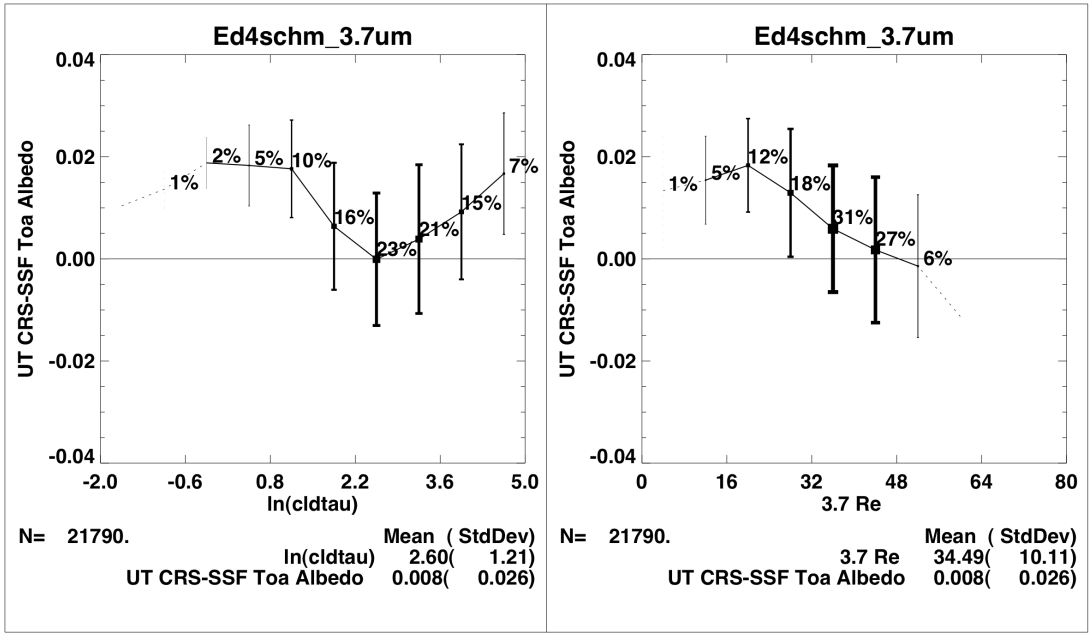
Citation: Dong, X., B. A. Wielicki, B. Xi, Y. Hu, G. G. Mace, S. Benson, F. Rose, S. Kato, T. Charlock, and P. Minnis (2008), Using observations of deep convective systems to constrain atmospheric column absorption of solar radiation in the optically thick limit, J. Geophys. Res., 113, D10206, doi:10.1029/2007JD009769.

Prototype Ed4 CRS tests Using Ed2 & Ed4 Ice cloud property scheme

Uses **3.7** Modis channel with Ed2 Fu1996 Ice Cloud Properties

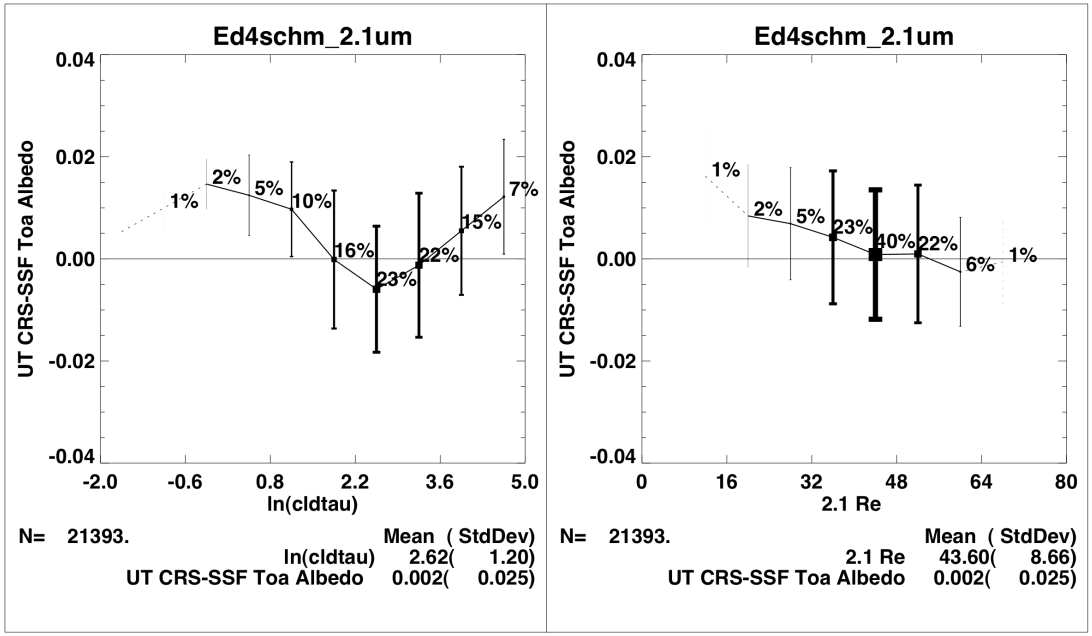


Uses **3.7** Modis channel with Fu2007 Ice Cloud Properties tied to P.Yang



Prototype Ed4 CRS tests Using Alternate MODIS channels for Ice Particle Size

Uses **2.1** Modis channel with Fu2007 Ice Cloud Properties tied to P.Yang



Uses **1.2** Modis channel with Fu2007 Ice Cloud Properties tied to P.Yang