Remotely Sensed Cloud Properties & TOA Radiation Validation

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ARESE II Science Team Meeting

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Satellite Data Sets

- **GOES-8**

  0.5 hour TOA SW albedo and LW OLR, cloud properties

  0.5° box centered on ARM SGP Central Facility **(sent to archive)**

  0.5° gridded domain 32°N - 42°N; 90°W - 104°W **(on line at larc)**

- **Visible-Infrared Scanner (VIRS) for radiances & cloud properties**

  - TRMM Orbital Characteristics
    - 35° Inclined Orbit, Precesses Through 24 Hours in 46 Days
  - VIRS: 0.65, 1.6, 3.75, 10.8, 11.9 µm, 2 km nadir resolution

- **CERES Broadband SW & LW Scanners (available at LaRC DAAC)**

  - TRMM, morning & late afternoon overpasses
  - Terra (FM1, FM2), 1030AM overpasses
  - 1° TOA albedo & OLR; SGP site & domain

Approach for Validation

- **Compare CERES instruments to establish baseline expectations**

  - **CERES albedos over clear land average 6.5% less than those from ERBE**
  - **GOES-8 albedos 0.011 - 0.028 higher than CERES using ERBE NB-BB formula & AVHRR calibration**
  - **TRMM albedos 0.017 > Terra albedos**
  - **Conclusion GOES-8 albedos too high**

- **Evaluate GOES-8 VIS channel calibration based on AVHRR**

  - **Last meeting AVHHR cal looked odd, VIRS-GOES less**

    VIRS stable, cloud properties consistent w/ sfc obs
  - **Extend VIRS-GOES trend back to 1995, compare to ATSR-2**

- **Derive and apply GOES-8/CERES NB-BB conversion function**

- **Compare cloud retrievals with surface data (Dong)**

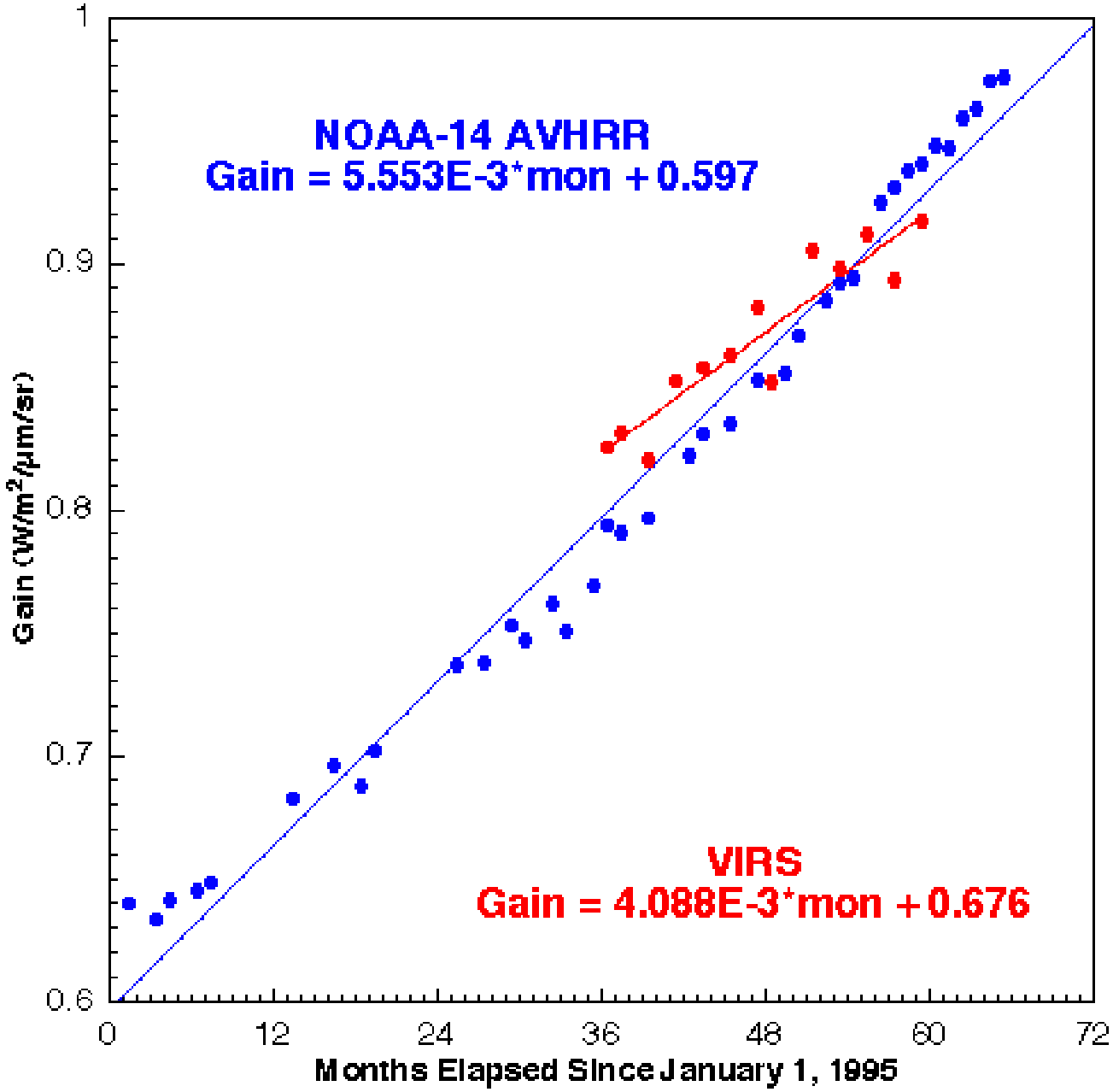
SUMMARY OF CERES VS NB-BB ALBEDOS

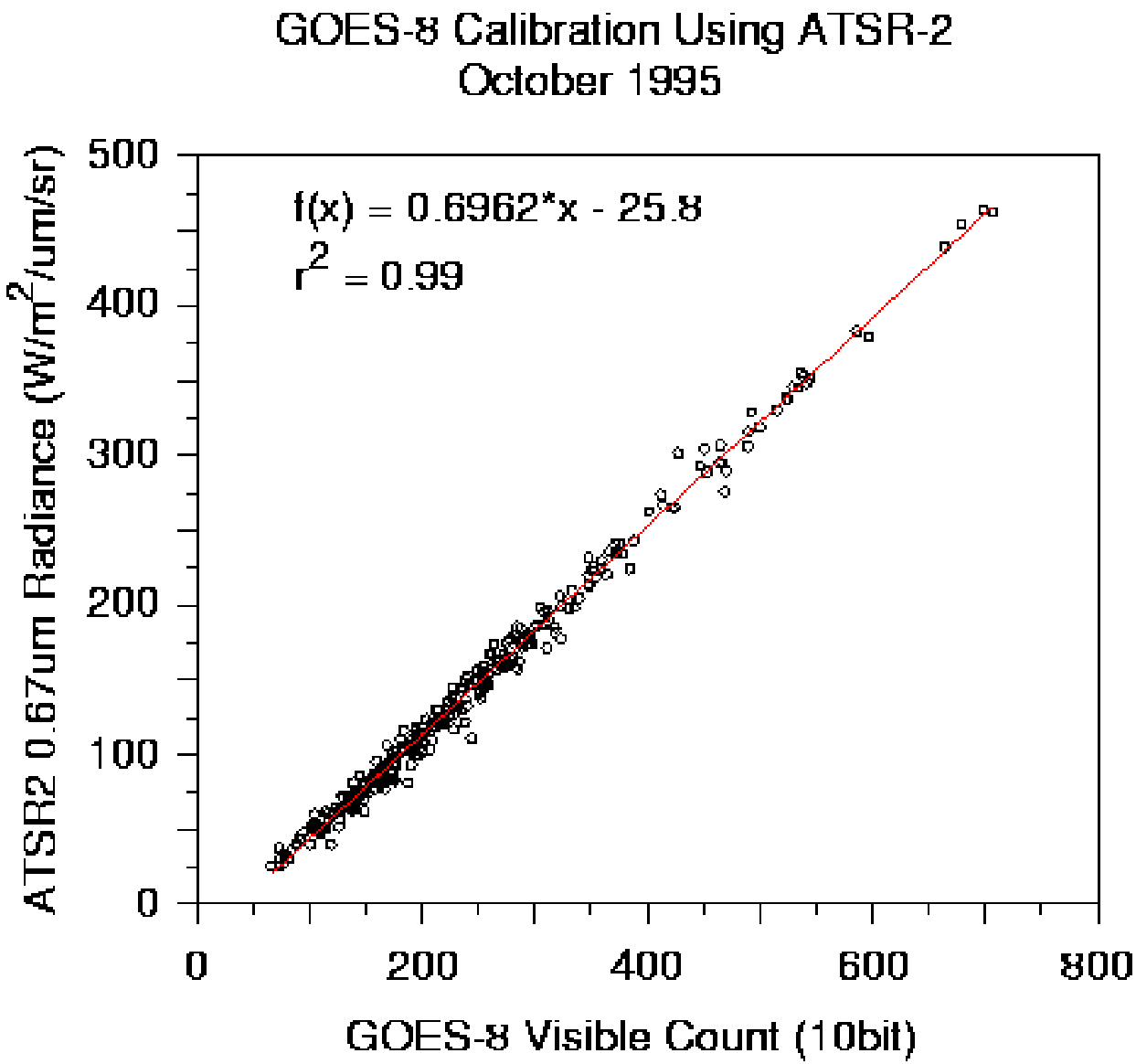
Instruments	bias	rms (%)
Terra FM2-FM1	0.0015	2.6
TRMM - Terra	0.0174	15.6
G8 - TRMM	0.0284	13.5
G8 - Terra	0.0113	10.5
G8 - TRMM (3 sat case)	0.0120	9.1
G8 - Terra (3 sat case)	0.0198	11.4
TRMM - Terra (3 sat case)	0.0079	9.3
VIRS - TRMM	0.0180	8.0

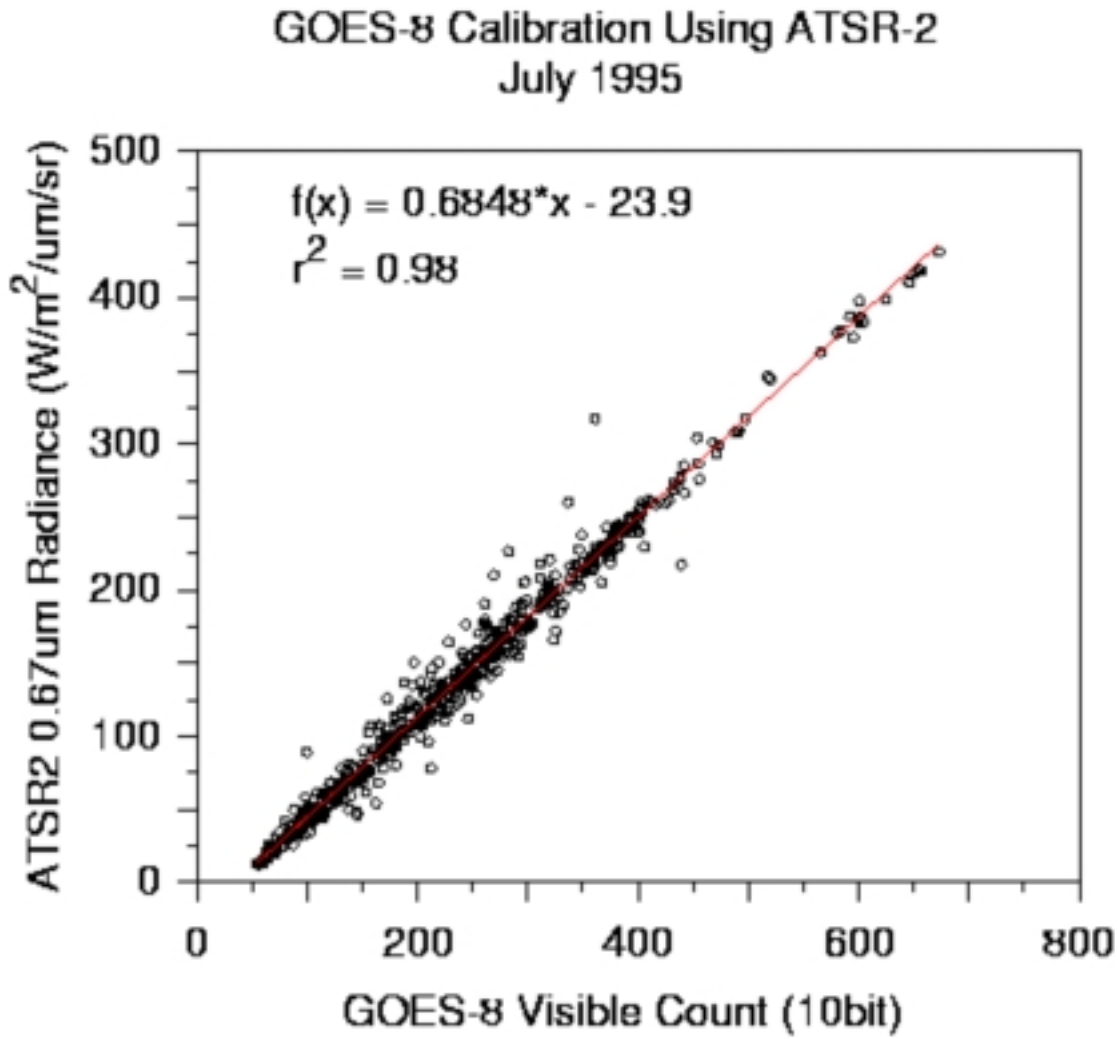
HISTORICAL BB COMPARISONS WITH GOES BB SW

G7-SCARAB 1994	-0.005
G7-ERBE/WFOV 1994	0.000
G8-ERBE/WFOV 95-96	-0.002
G8-TSBR (ER2) 95	0.012
G8-CERES Terra 00	0.0113
G8-CERES TRMM 00	0.0284

Comparison of GOES-8 Visible Gain Trend

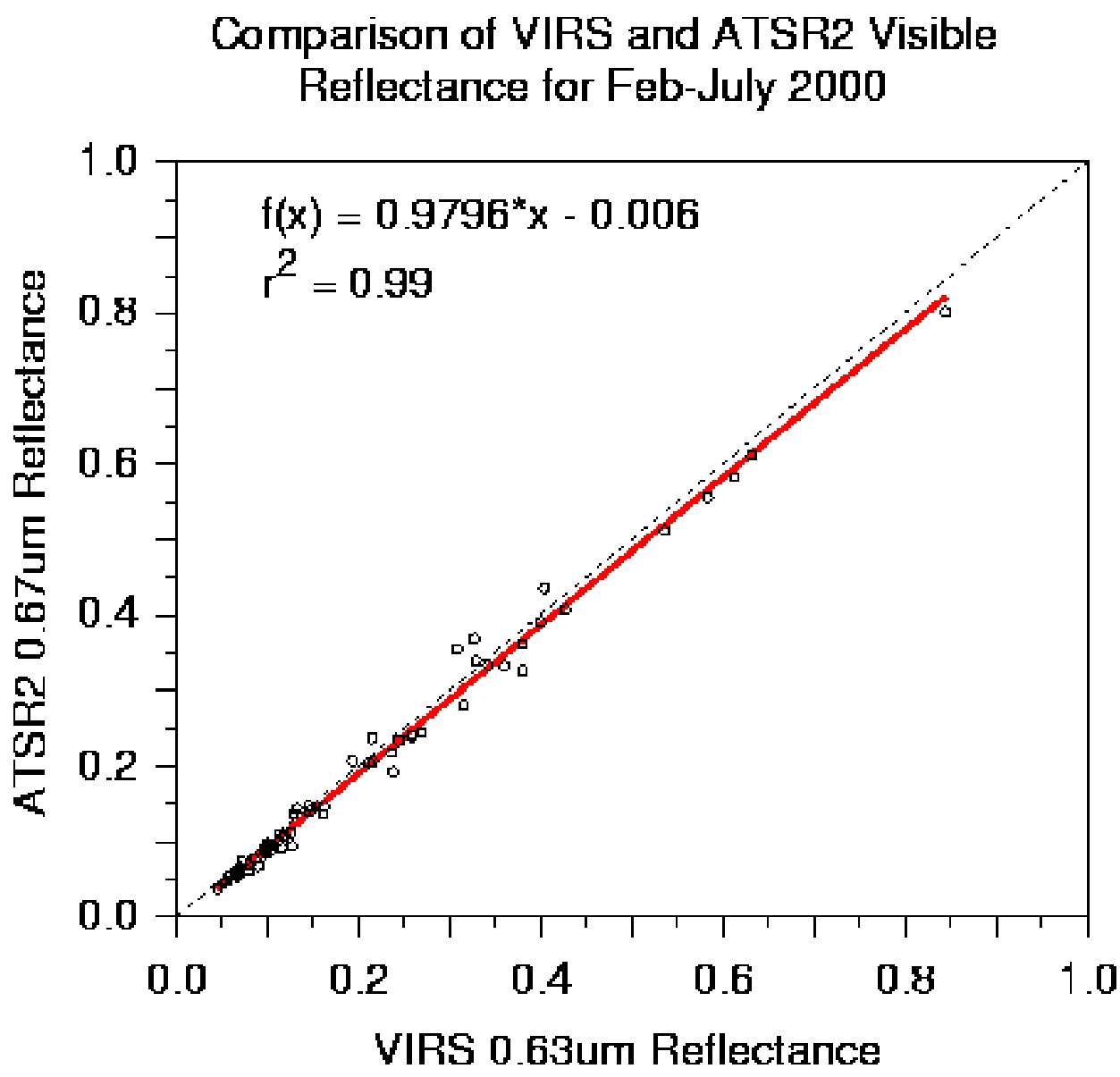


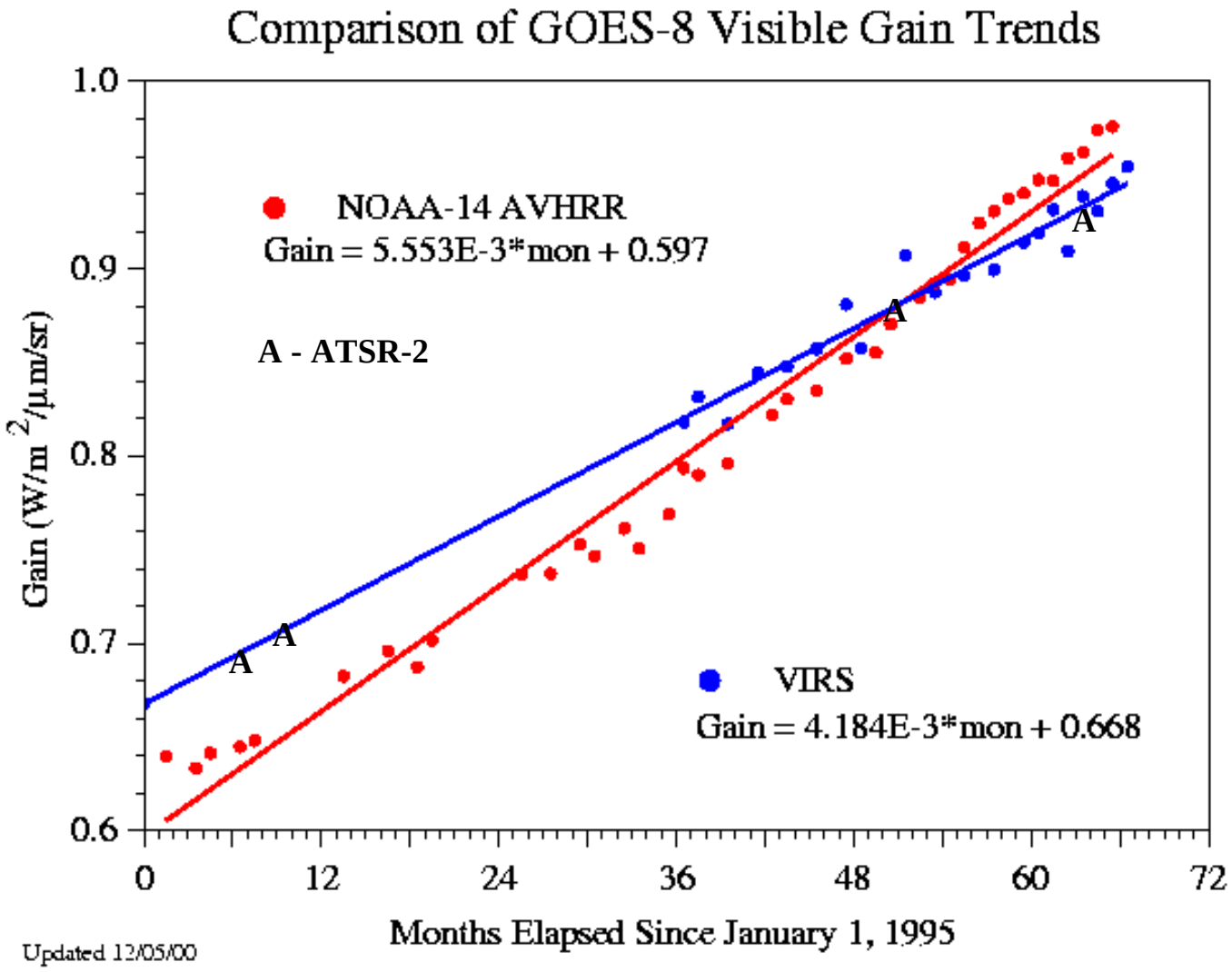

GOES-8 Calibration Using ATSR-2
October 1995
f(x) = 0.6962*x - 25.8
r2 = 0.99
ATSR2 0.67um Radiance (W/m2/um/sr)
GOES-8 Visible Count (10bit)
0
100
200
300
400
500
0
200
400
600
800



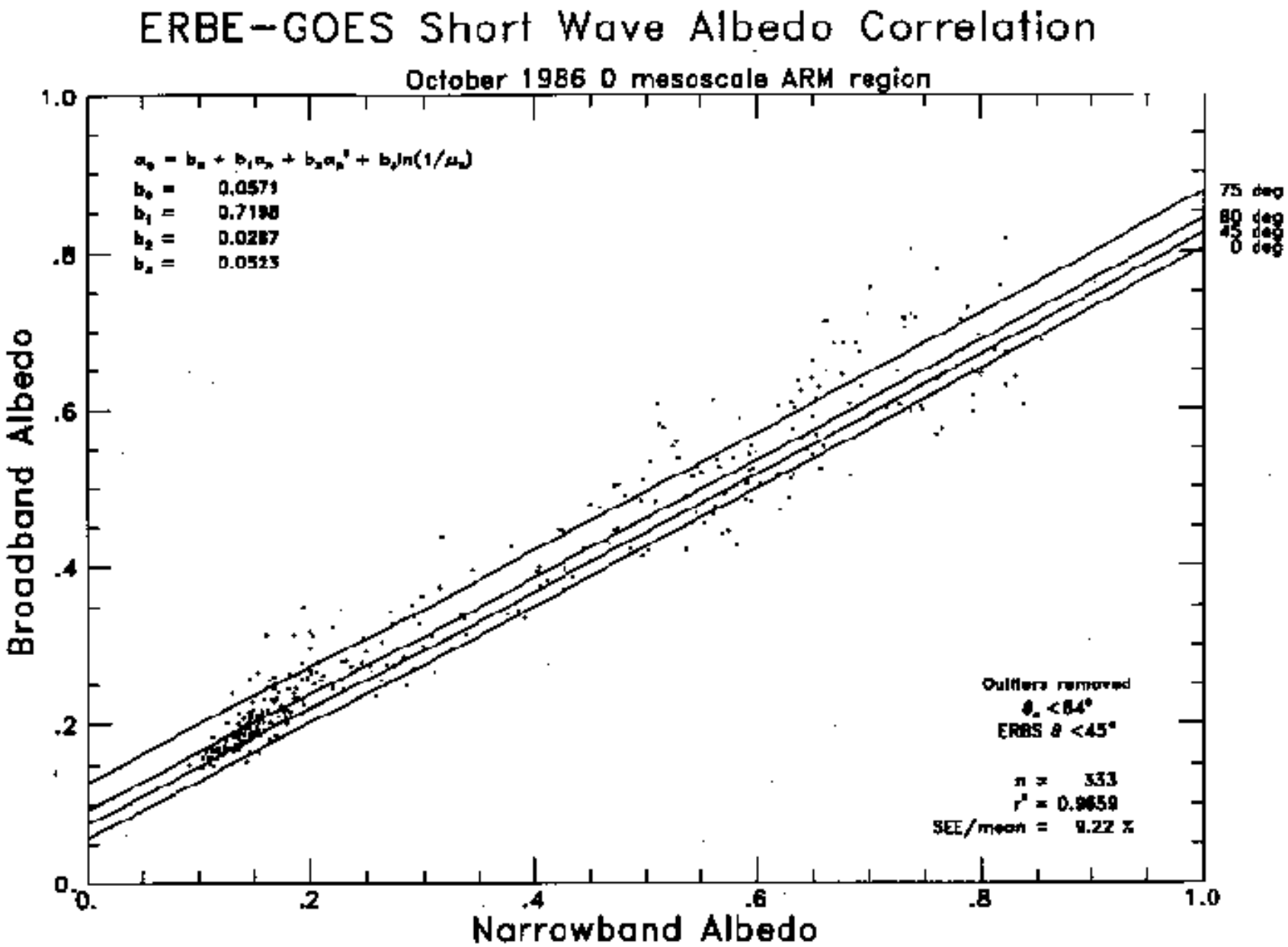
LN 02/06/2001

Solar Constant normailized to 526.9

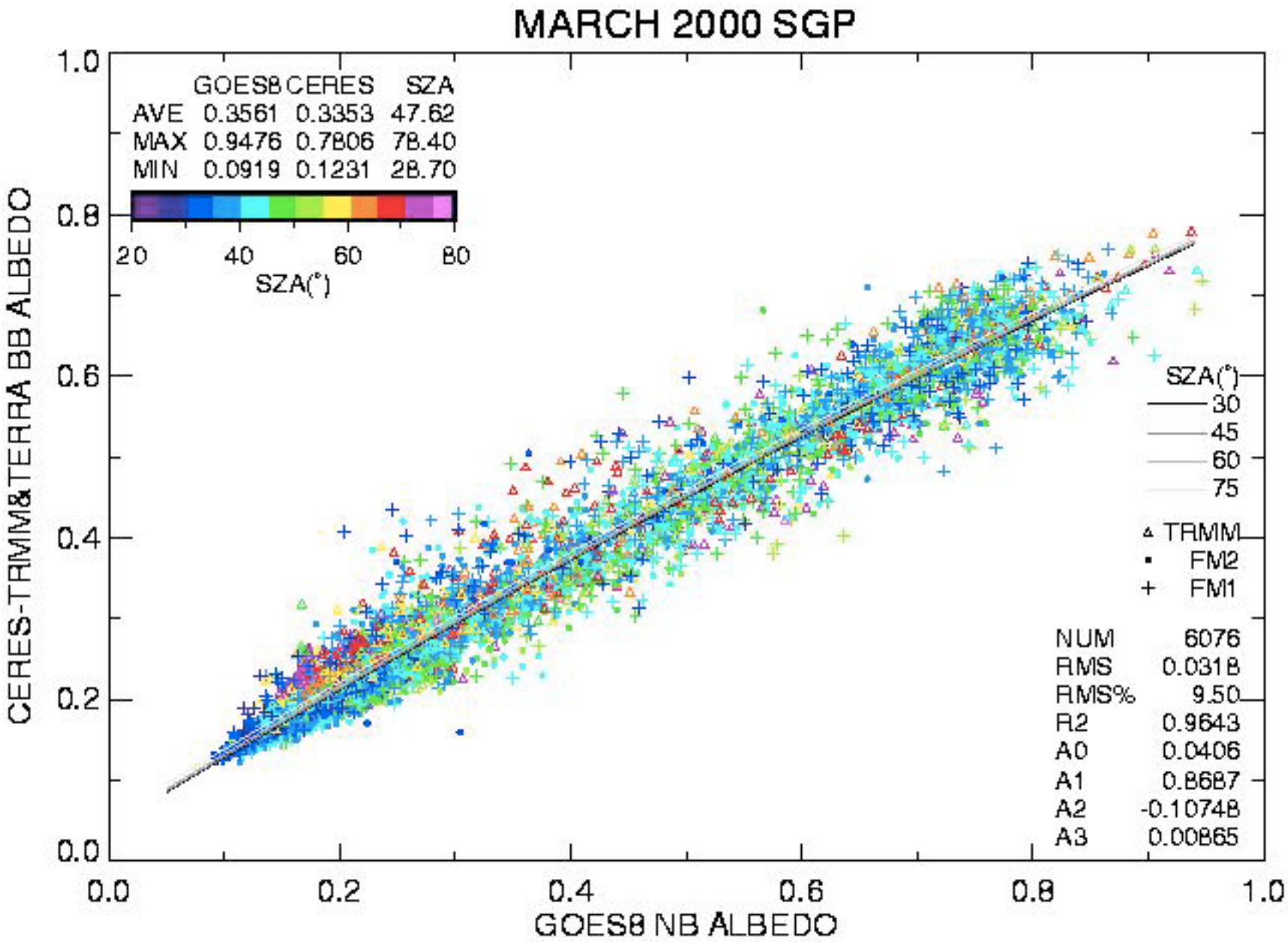

Comparison of VIRS and ATSR2 Visible Reflectance for Feb-July 2000
f(x) = 0.9796*x - 0.006
r2 = 0.99
ATSR2 0.67um Reflectance
VIRS 0.63um Reflectance
0.0
0.2
0.4
0.6
0.8
1.0


Comparison of GOES-8 Visible Gain Trends
NOAA-14 AVHRR
Gain = 5.553E-3*mon + 0.597
A - ATSR-2
VIRS
Gain = 4.184E-3*mon + 0.668
Gain (W/m 2/µm/sr)
Months Elapsed Since January 1, 1995
1.0
0.9
0.8
0.7
0.6
0
12
24
36
48
60
72
A
Updated 12/05/00

ERBE-GOES NB-to-BB Conversion Function Used for ARM GOES

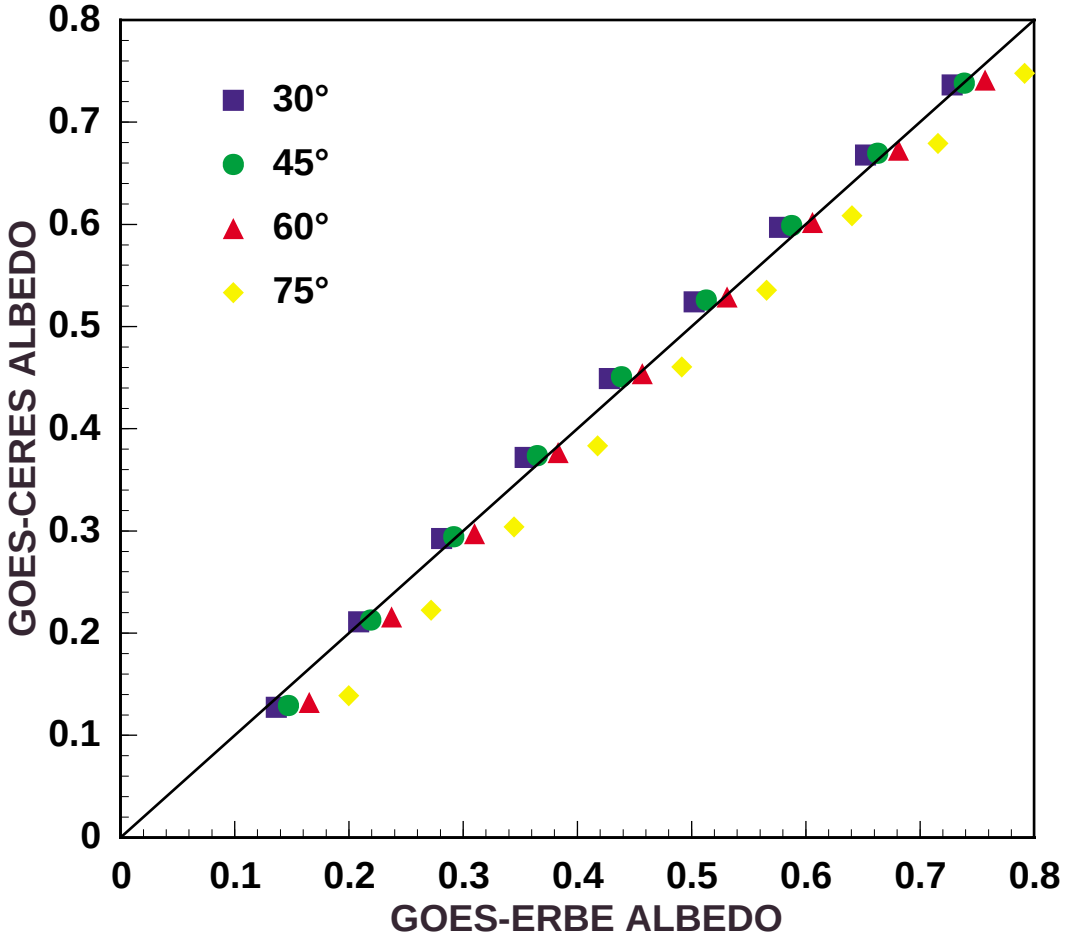


CERES-GOES NB-to-BB Conversion Function Using March 2000 VIRS NB Calibration for GOES-8 & All Terra and TRMM CERES Data

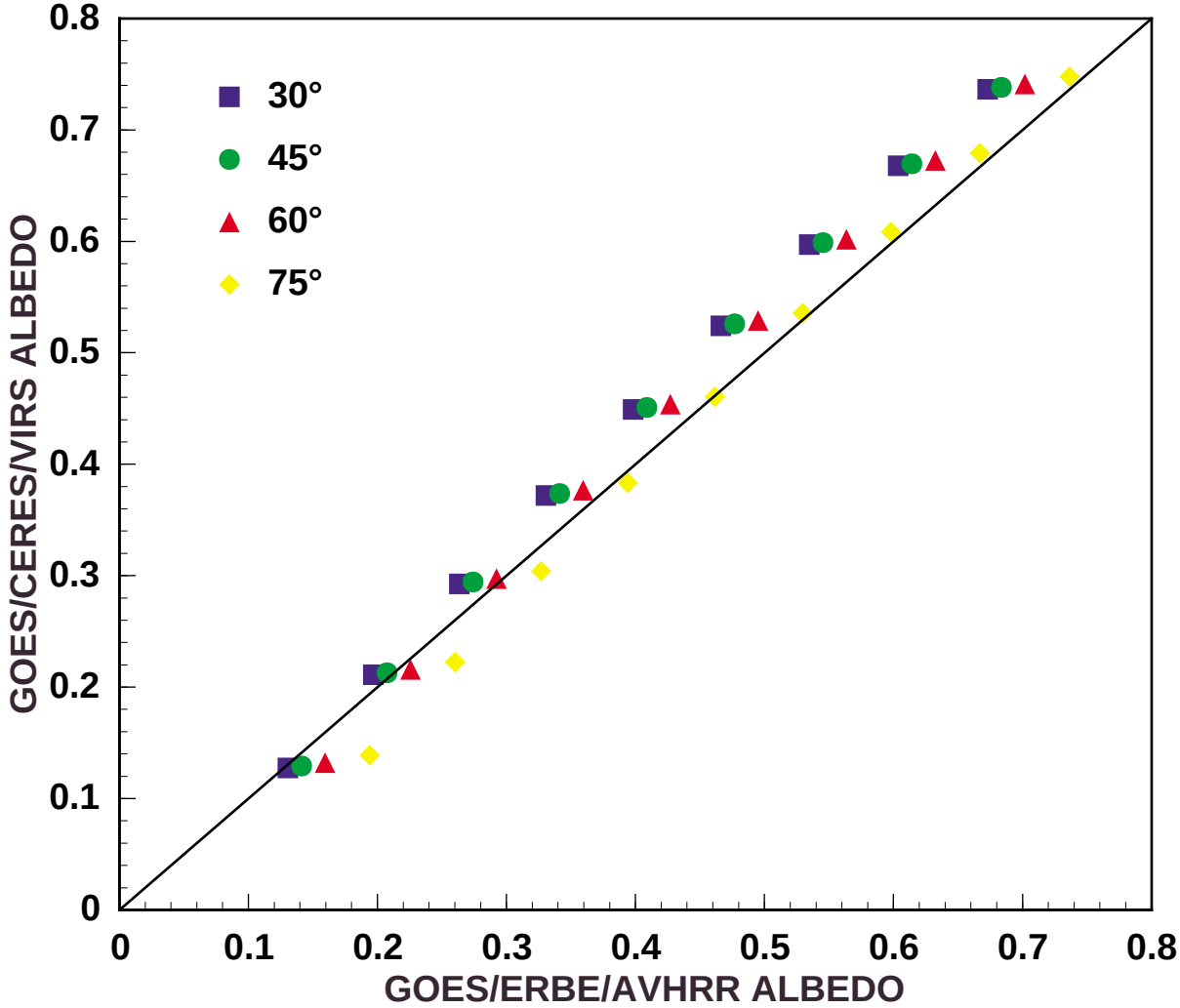


COMPARISON OF GOES-8 ALBEDOS USING 1986 ERBE/GOES-6 & 2000 CERES/GOES-8

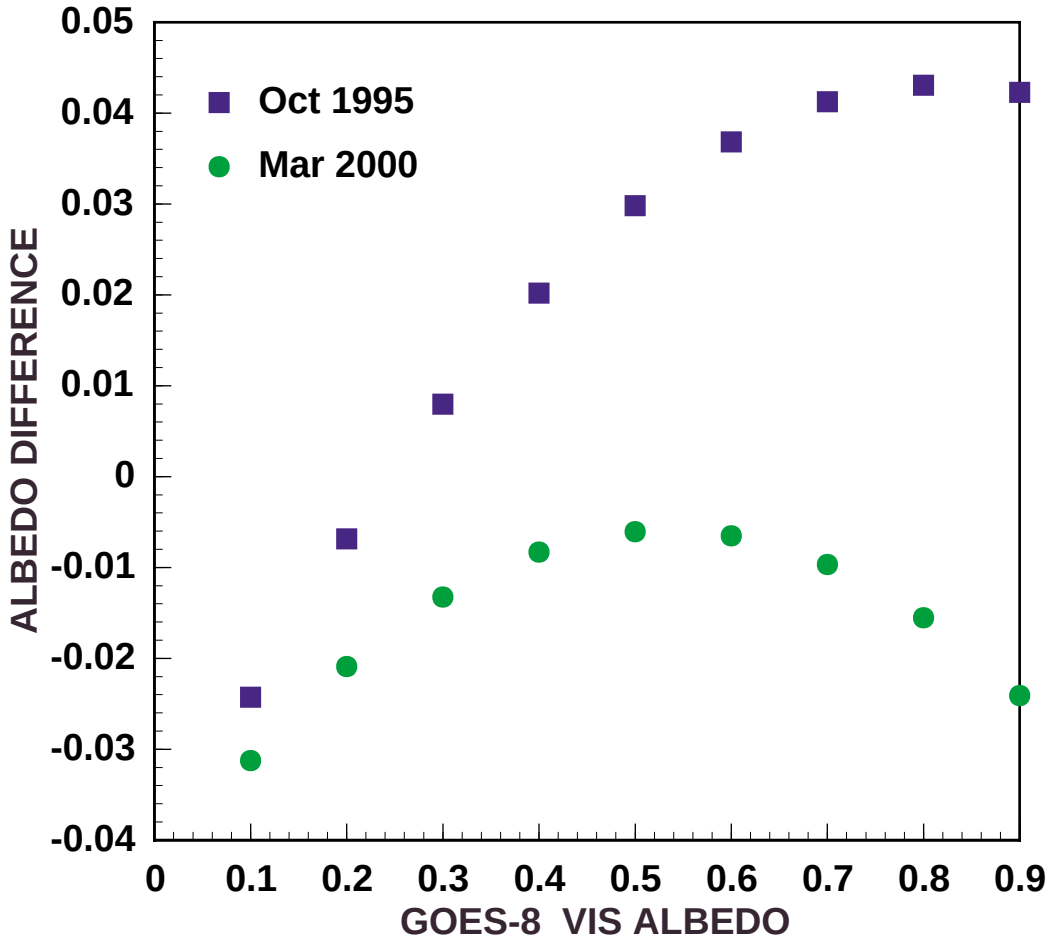
VIRS-BASED VISIBLE CALIBRATION



COMPARISON OF OCT 1995 GOES-8 ALBEDOS USING 1986 ERBE/GOES-6 & AVHRR CALIBRATION
2000 CERES/GOES-8 & VIRS CALIBRATION



GOES-8 ALBEDO DIFFERENCES BETWEEN
2000 CERES/GOES-8 & VIRS CALIBRATION
1986 ERBE/GOES-6 & AVHRR CALIBRATION



CONCLUDING REMARKS

- **GOES-8 ALBEDOS ~7% > CERES**

  - Clear-sky expected to be different by 6%, but closer to 10%

- **GOES-8 a valuable resource for BB albedo estimates**

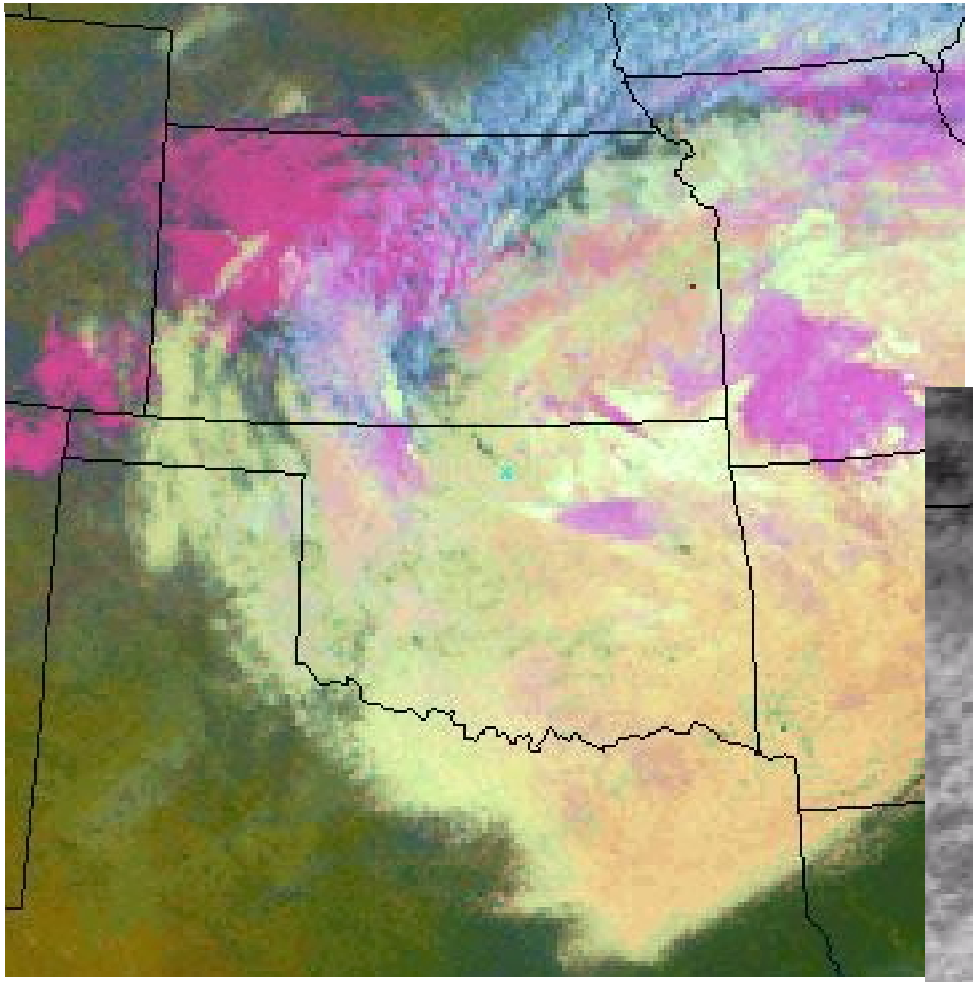
  VIRS is now the NB reference

  CERES and ERBE NB-BB formulae differ in SZA dependence

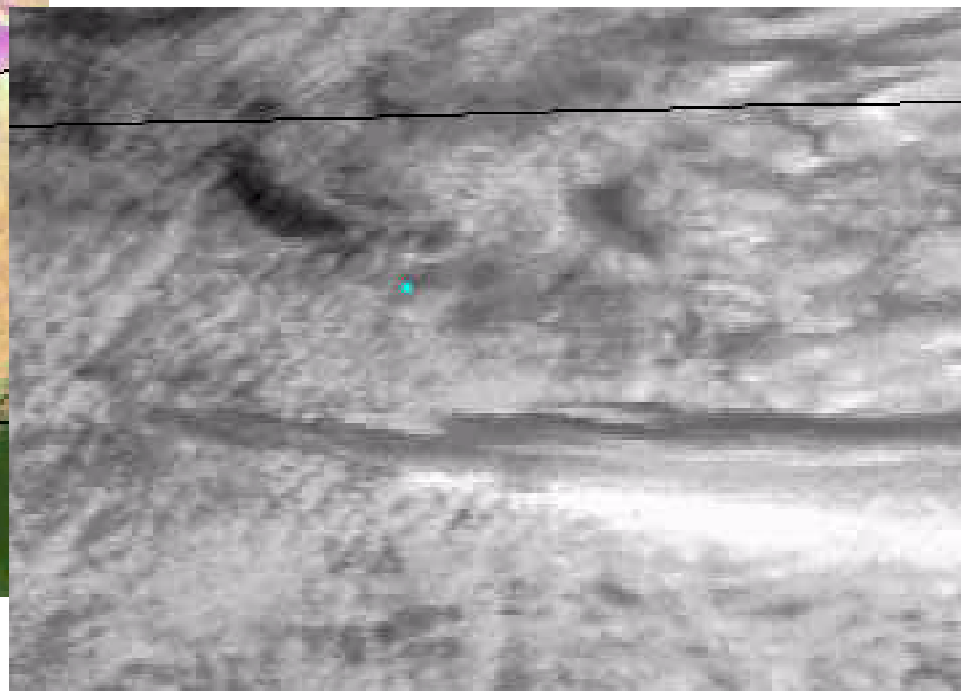
Cloud Property Validation

- **Comparisons by X. Dong (U. Utah)**
  - 30 min sfc avgs compared to 0.5° region avgs
  - effective radius & OD from radar and µwave & SW radiometers
  - LWP from µwave radiometer
  - TOA albedo from sfc albedo & cloud parameters in 2-stream

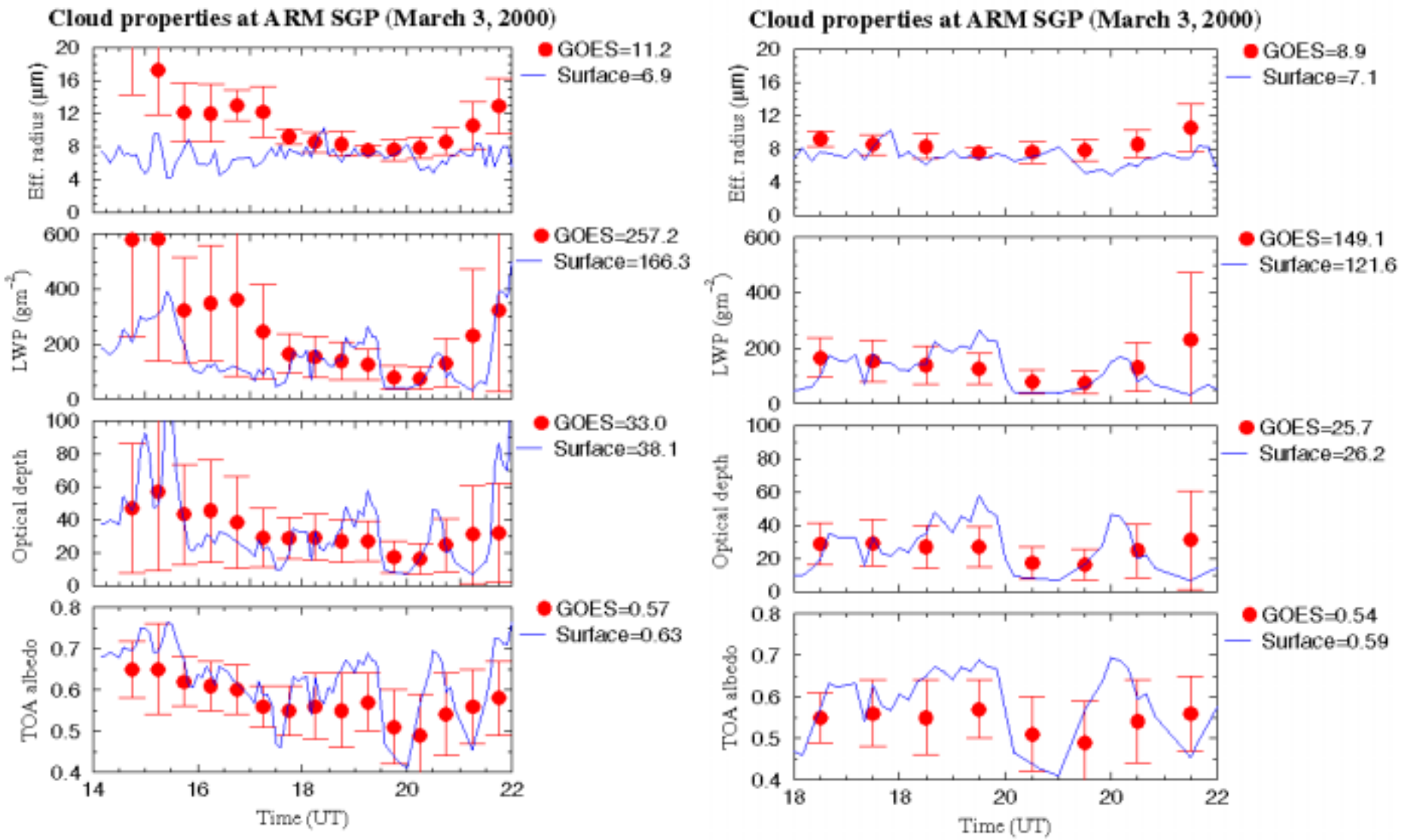
March 3, Various cirrus contaminations, supercooled clouds

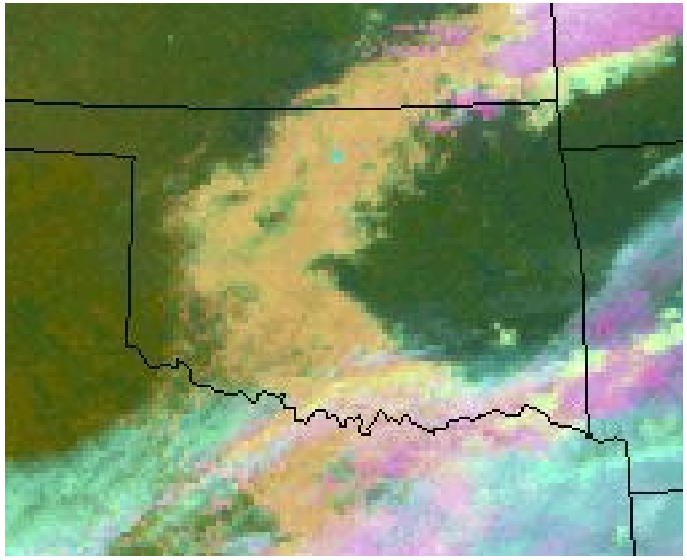


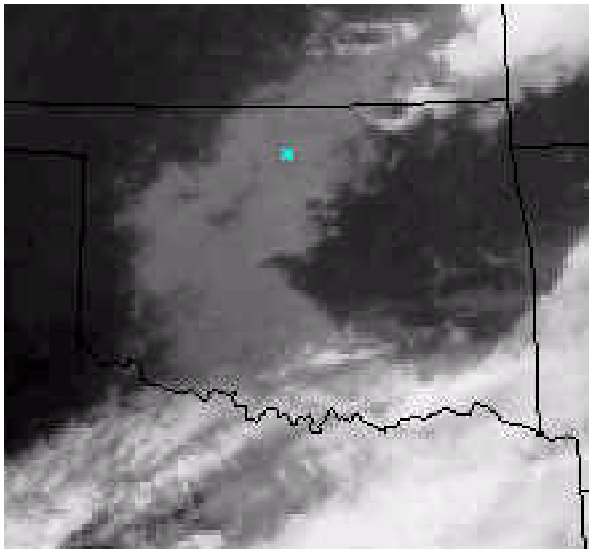
VIS 1-km 1815z

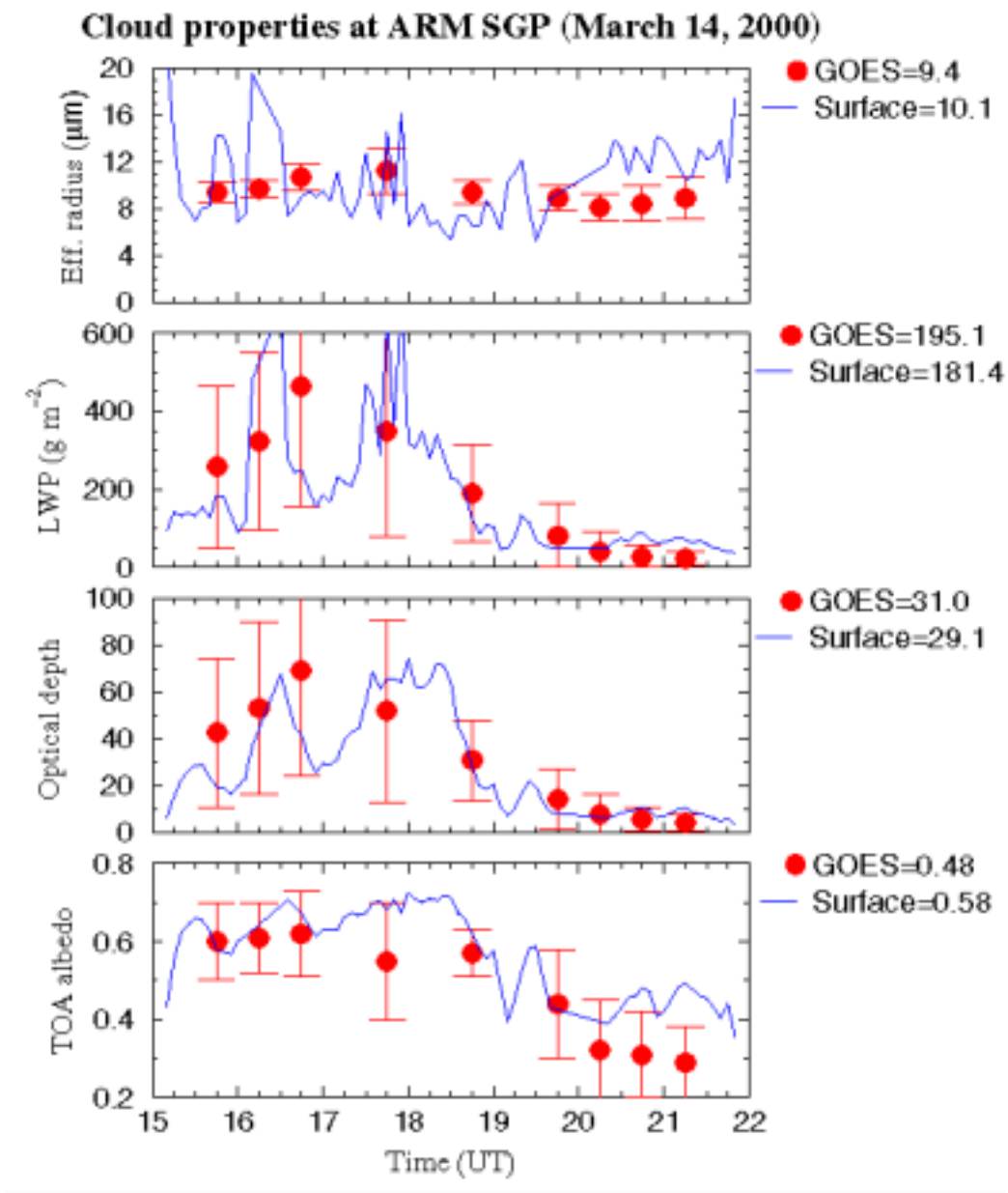


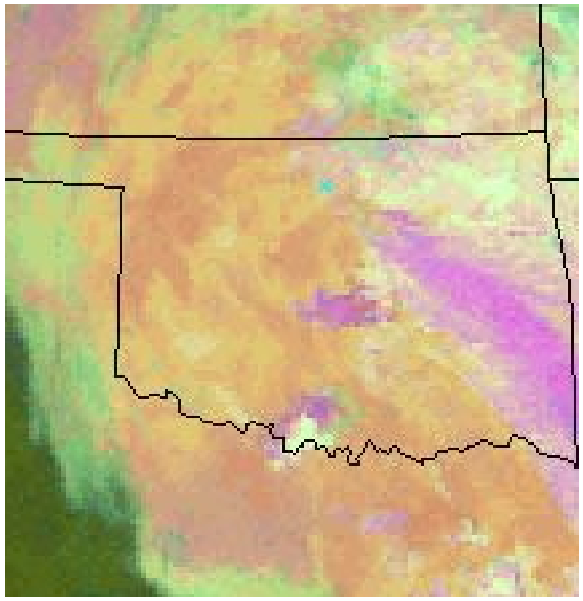
March 3, Various cirrus contaminations, supercooled clouds

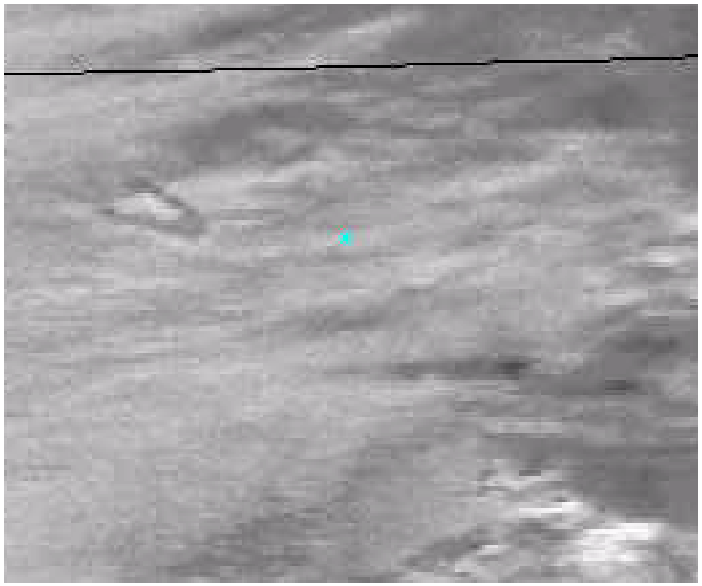


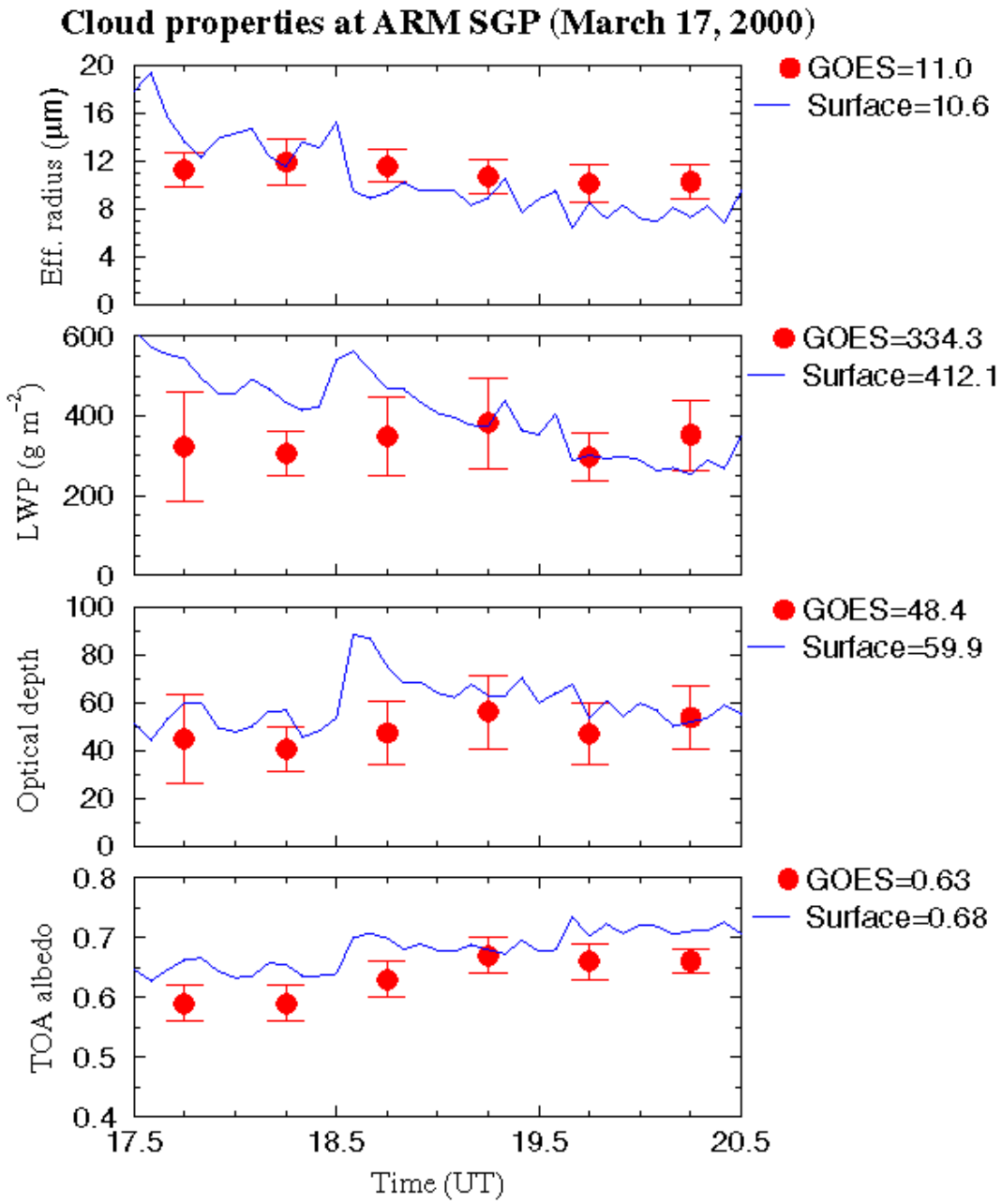





Cloud properties at ARM SGP (March 14, 2000)
Eff. radius (μm)
GOES=9.4
Surface=10.1
LWP (g m^{-2})
GOES=195.1
Surface=181.4
Optical depth
GOES=31.0
Surface=29.1
TOA albedo
GOES=0.48
Surface=0.58
Time (UT)



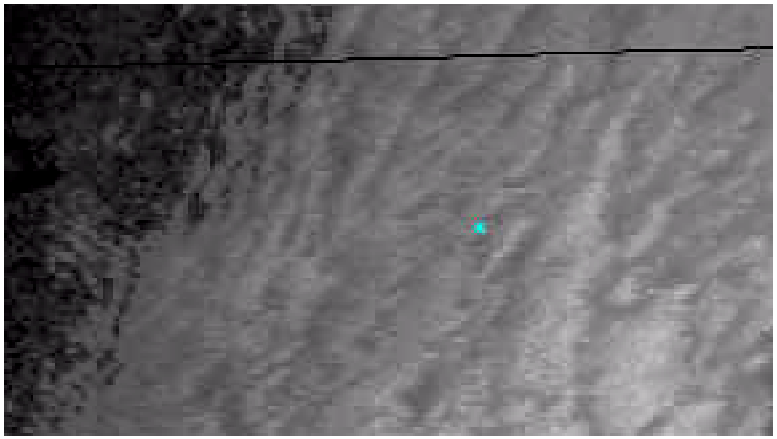


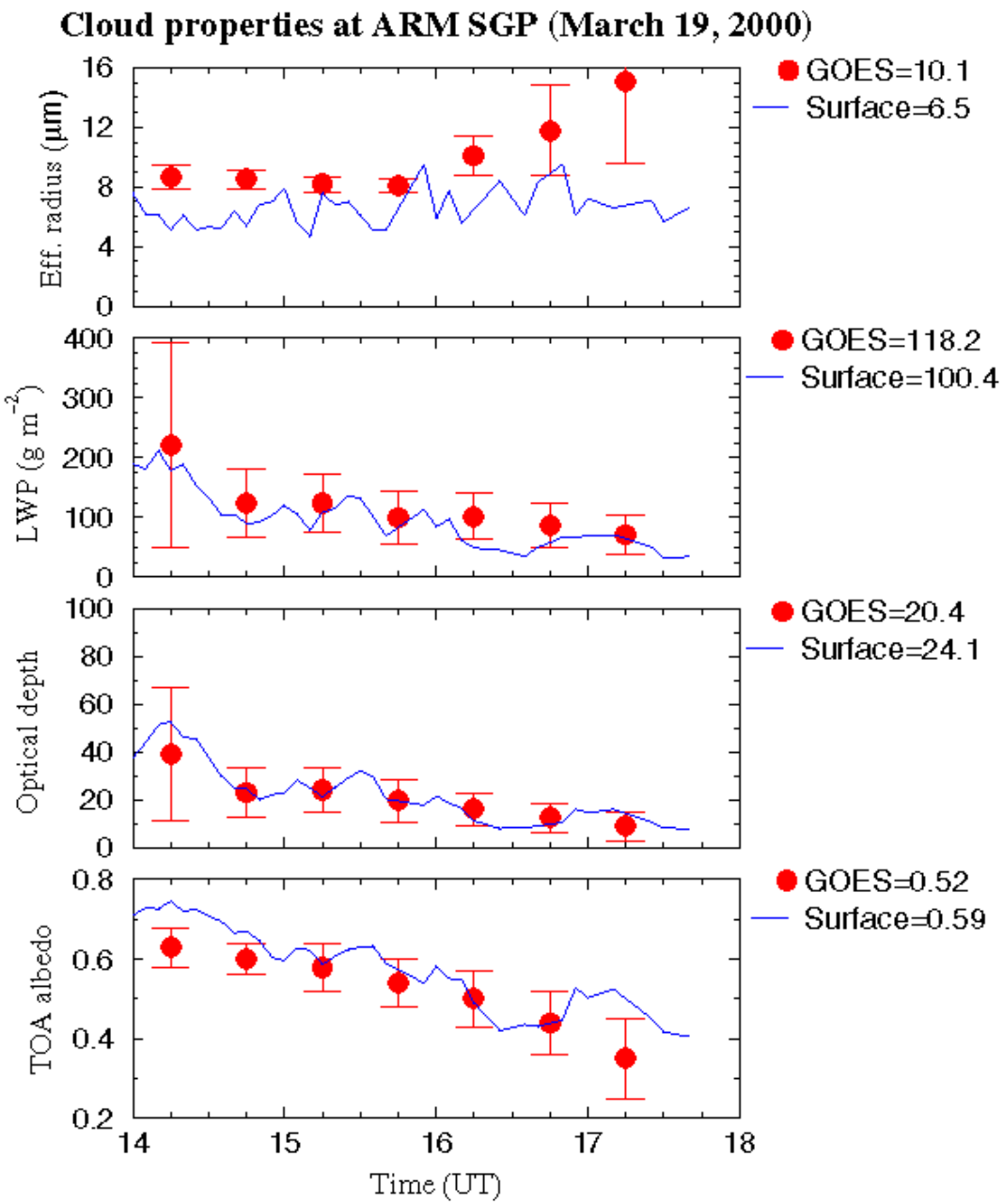

Cloud properties at ARM SGP (March 17, 2000)
Eff. radius (μm)
GOES=11.0
Surface=10.6
LWP (g m^{-2})
GOES=334.3
Surface=412.1
Optical depth
GOES=48.4
Surface=59.9
TOA albedo
GOES=0.63
Surface=0.68
Time (UT)
17.5
18.5
19.5
20.5

March 19

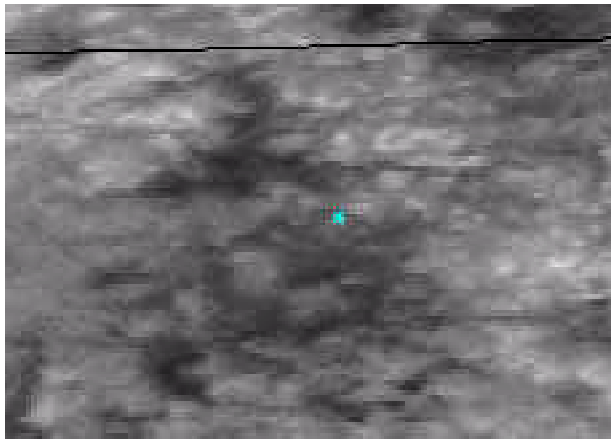
Clouds breaking up

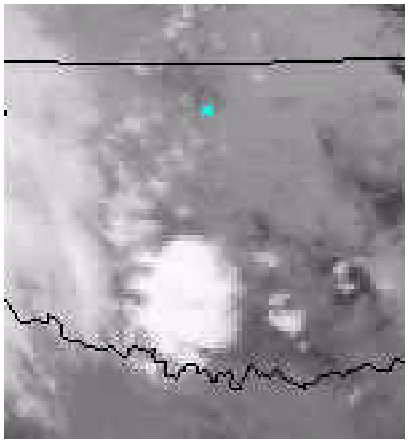
VIS 1-km 1545z

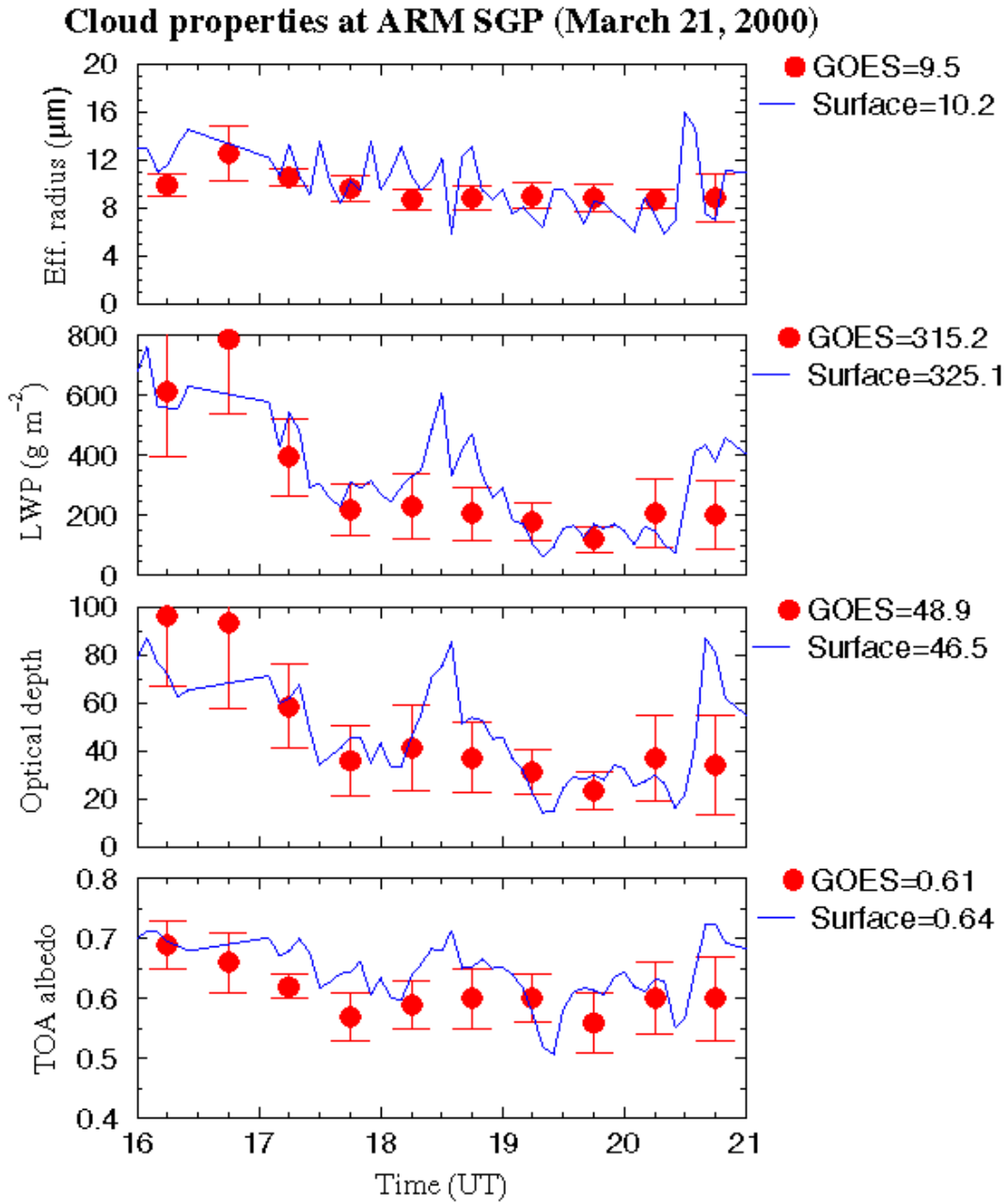




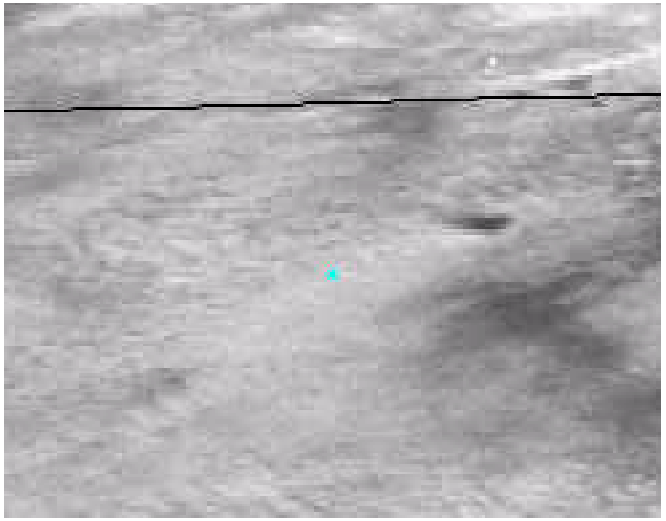
VIS 1-km 1715z

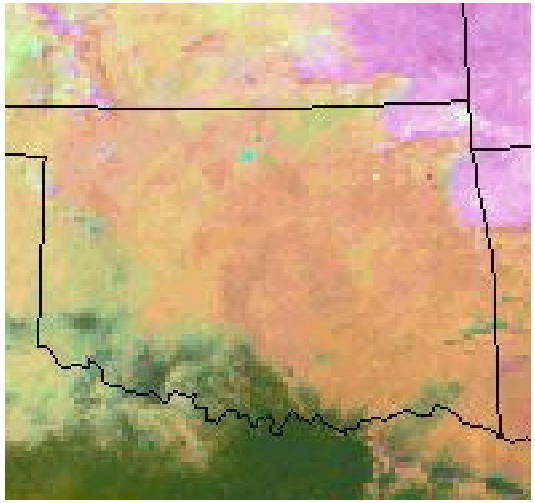


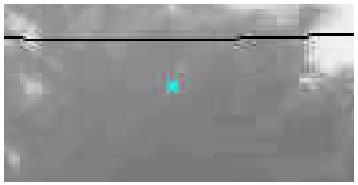


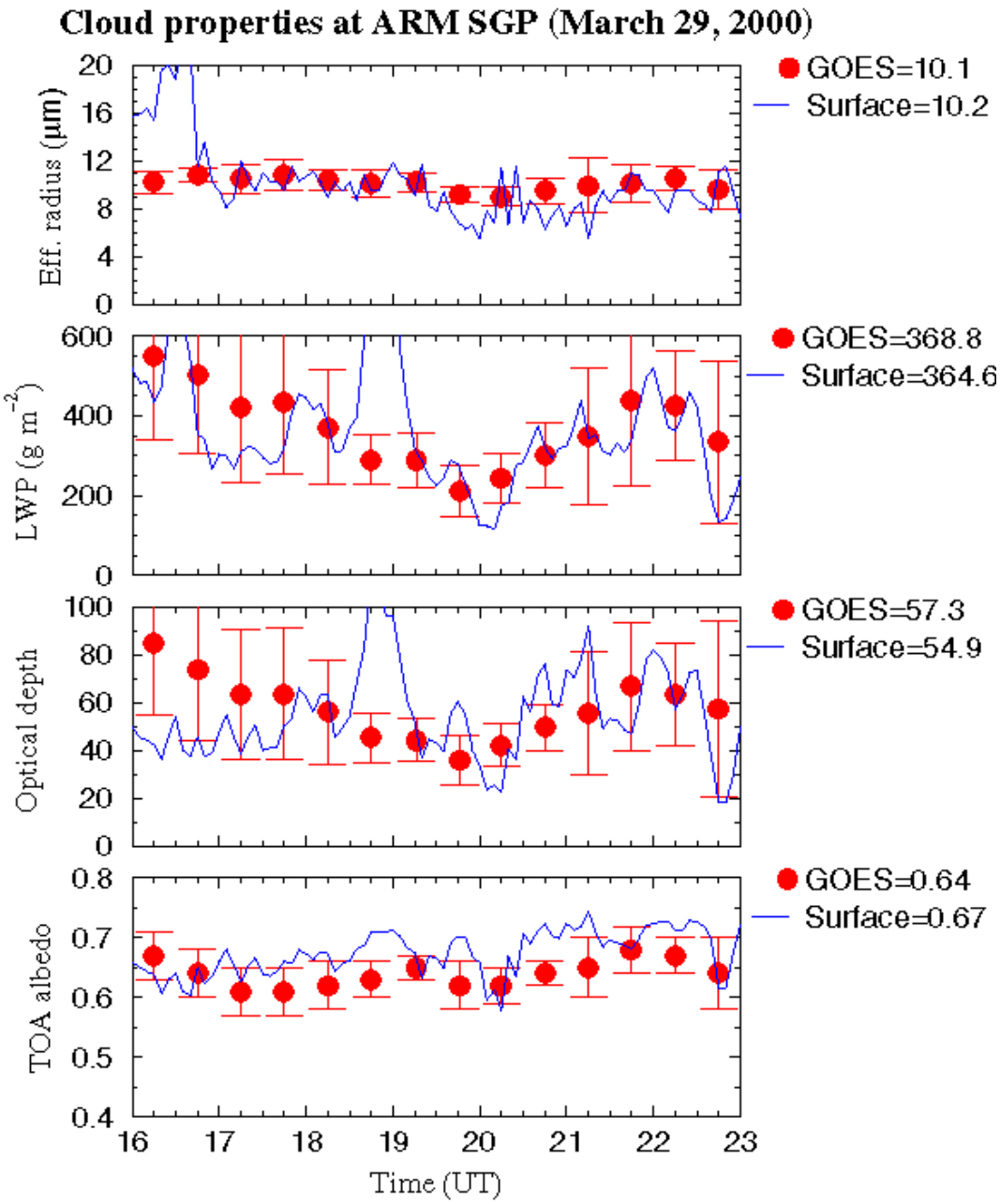


March 29 No cirrus
VIS 1-km 1845z

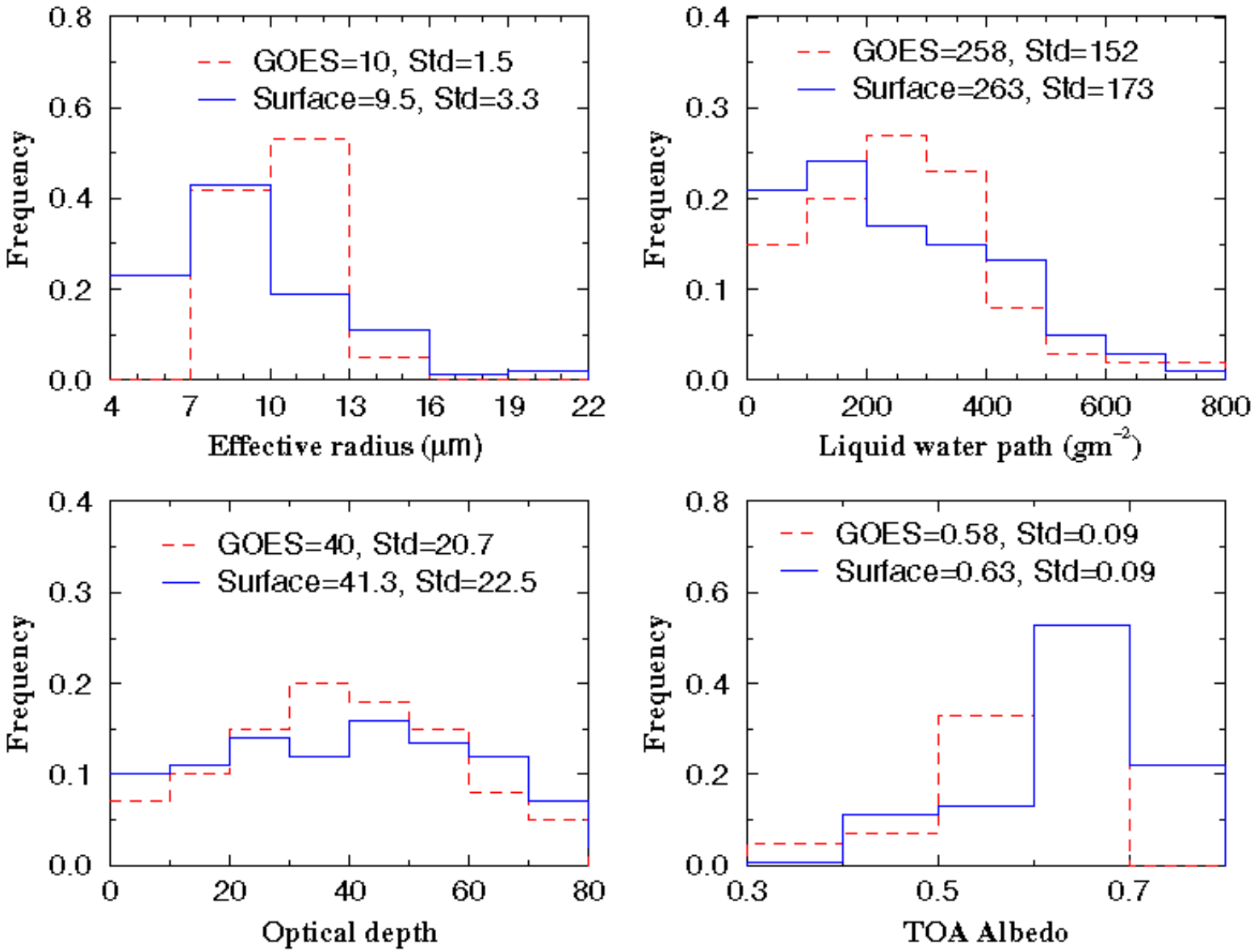








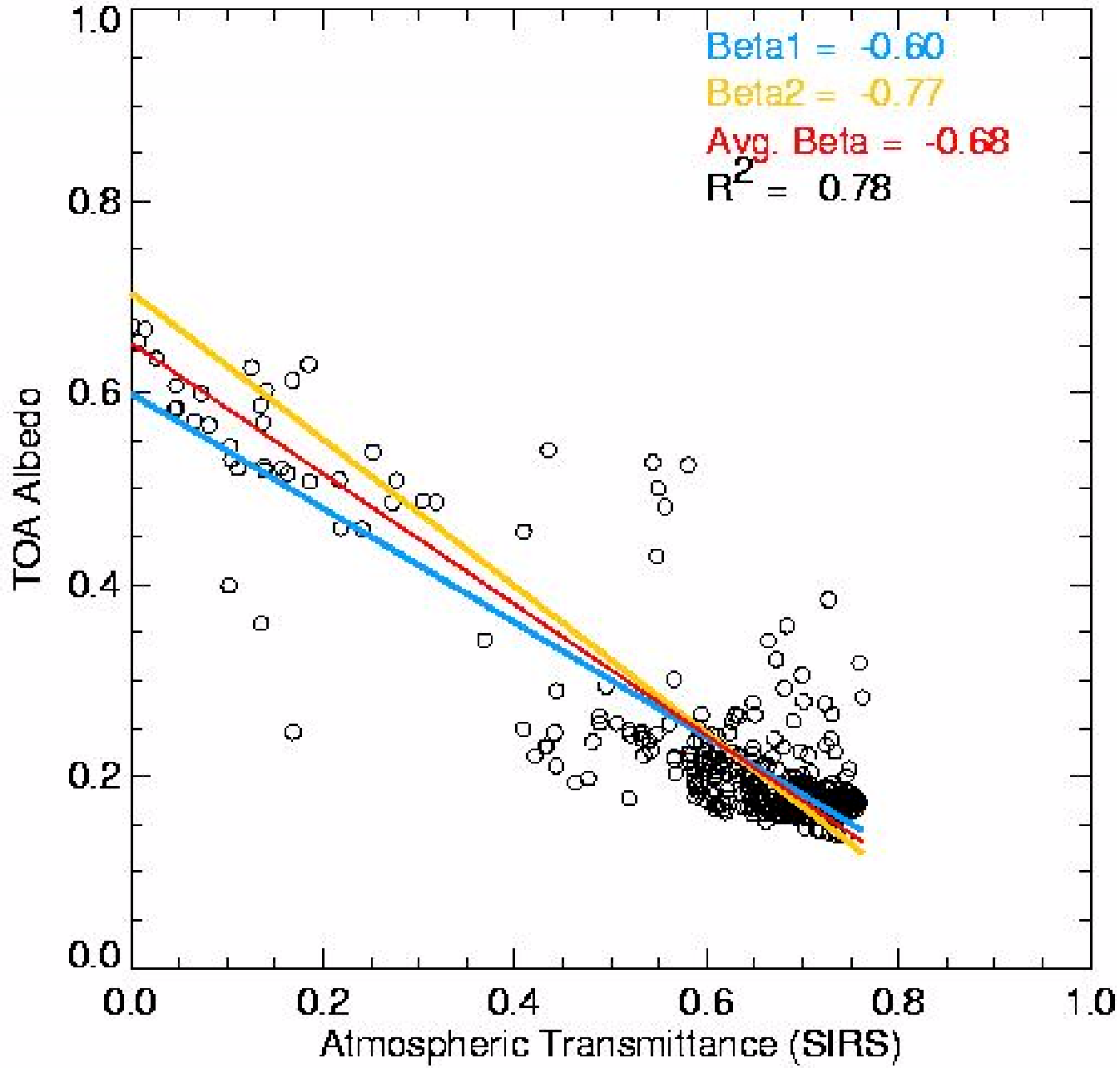
Frequency Distributions of GOES and Surface Retrievals



SIRS vs GOES-8

VIRS/ERBE

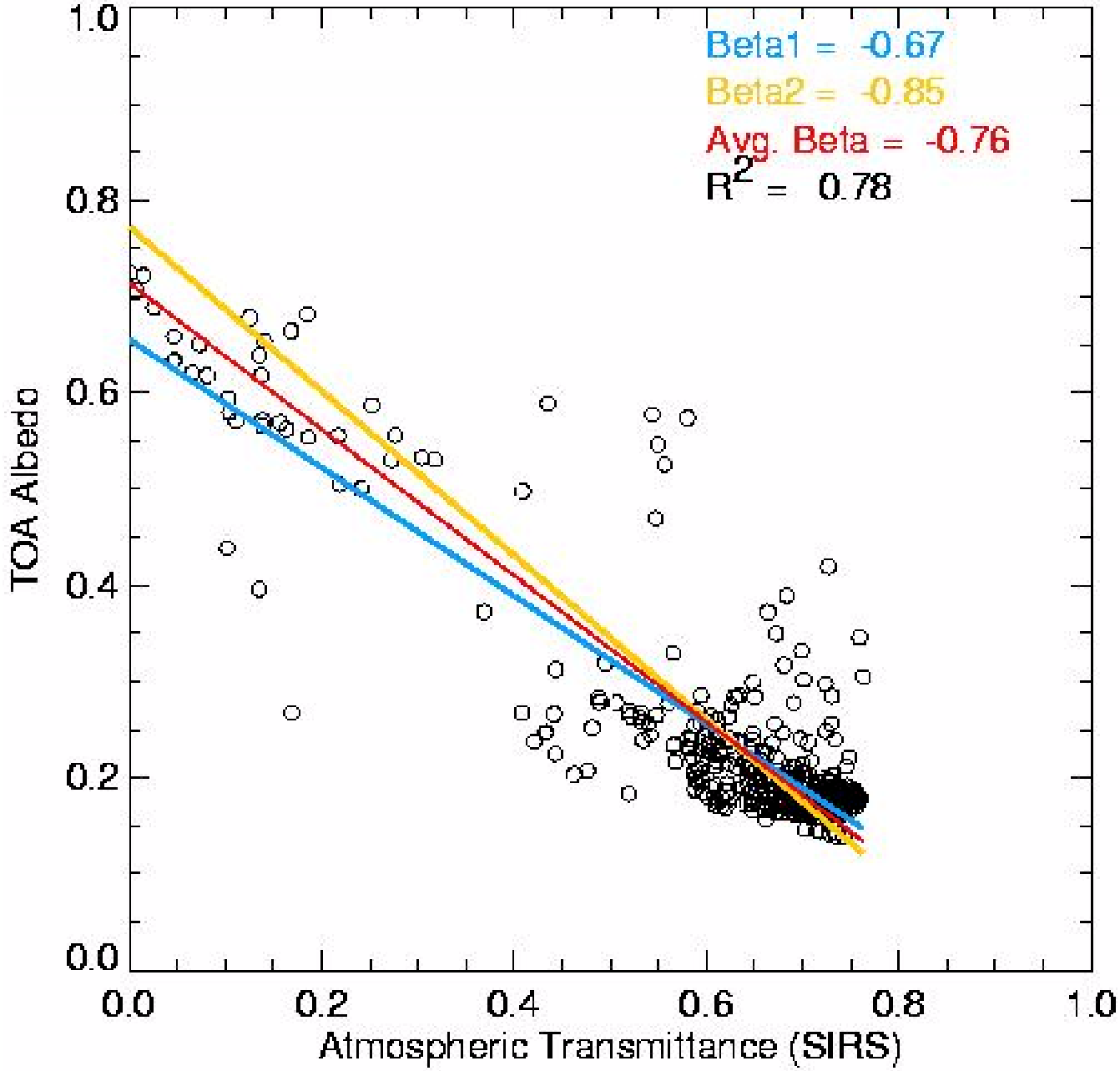
Oct 1995



SIRS vs GOES-8

VIRS/CERES

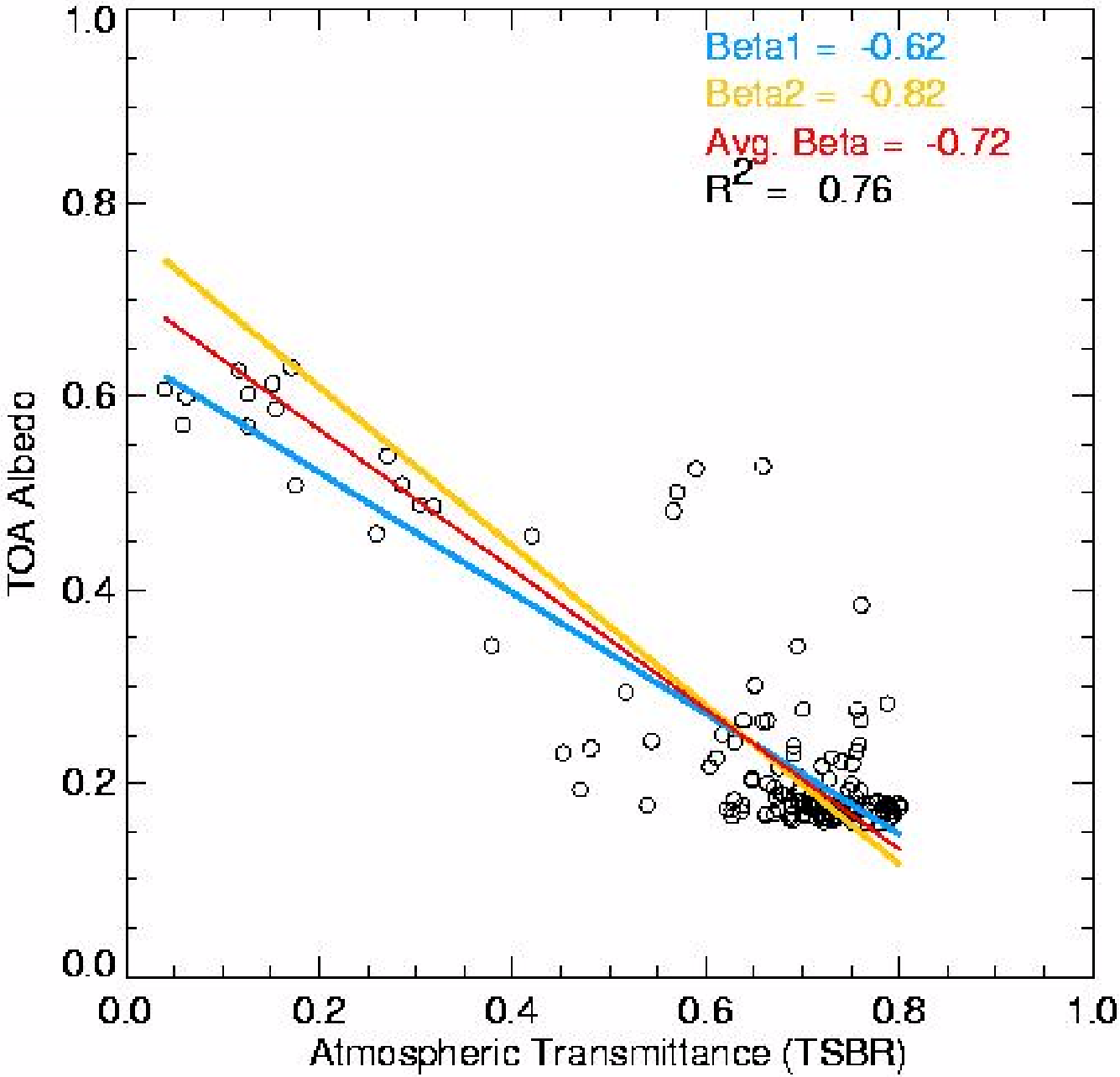
Oct 1995



TSBR vs GOES-8

VIRS/ERBE

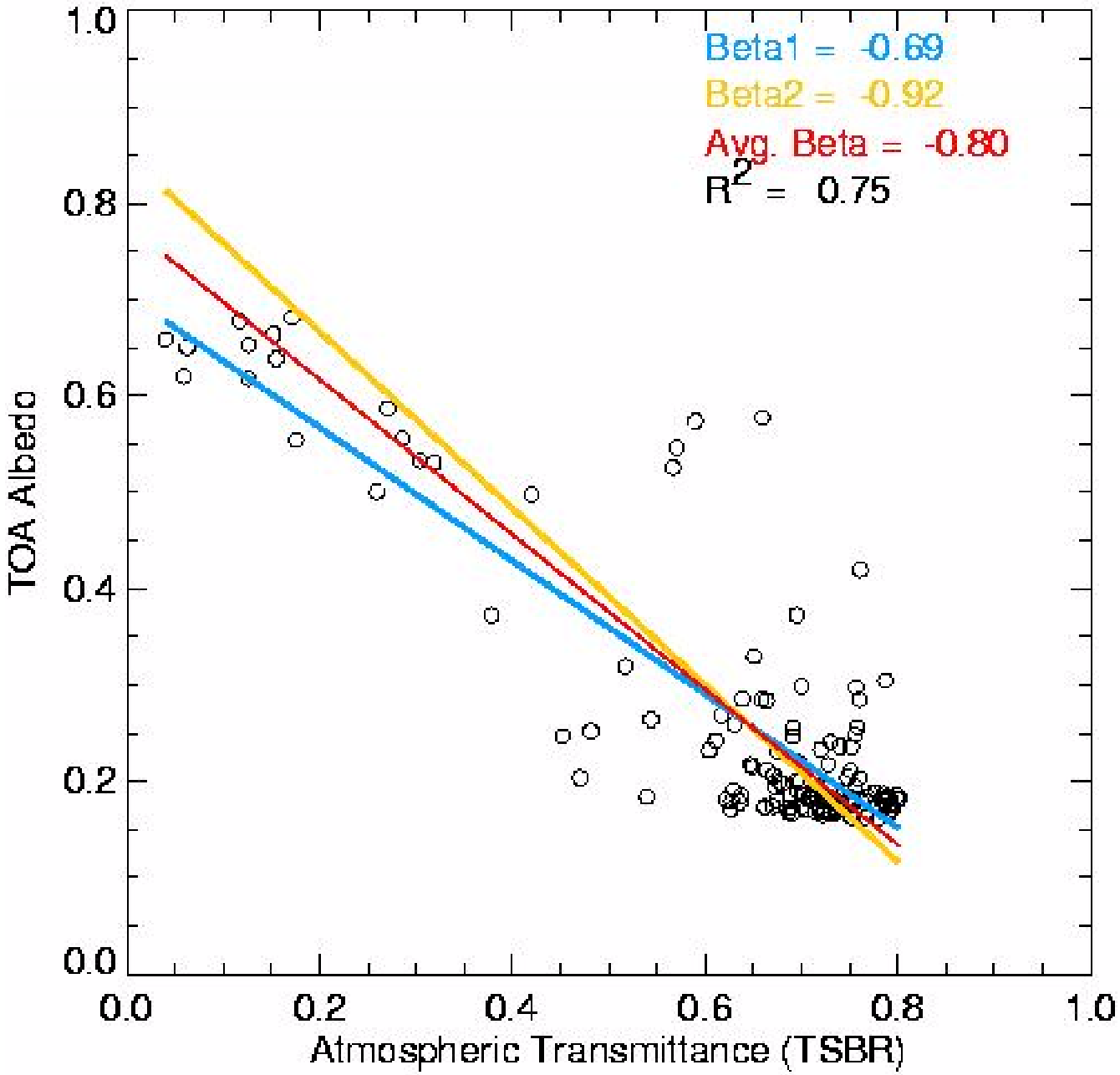
Oct 1995



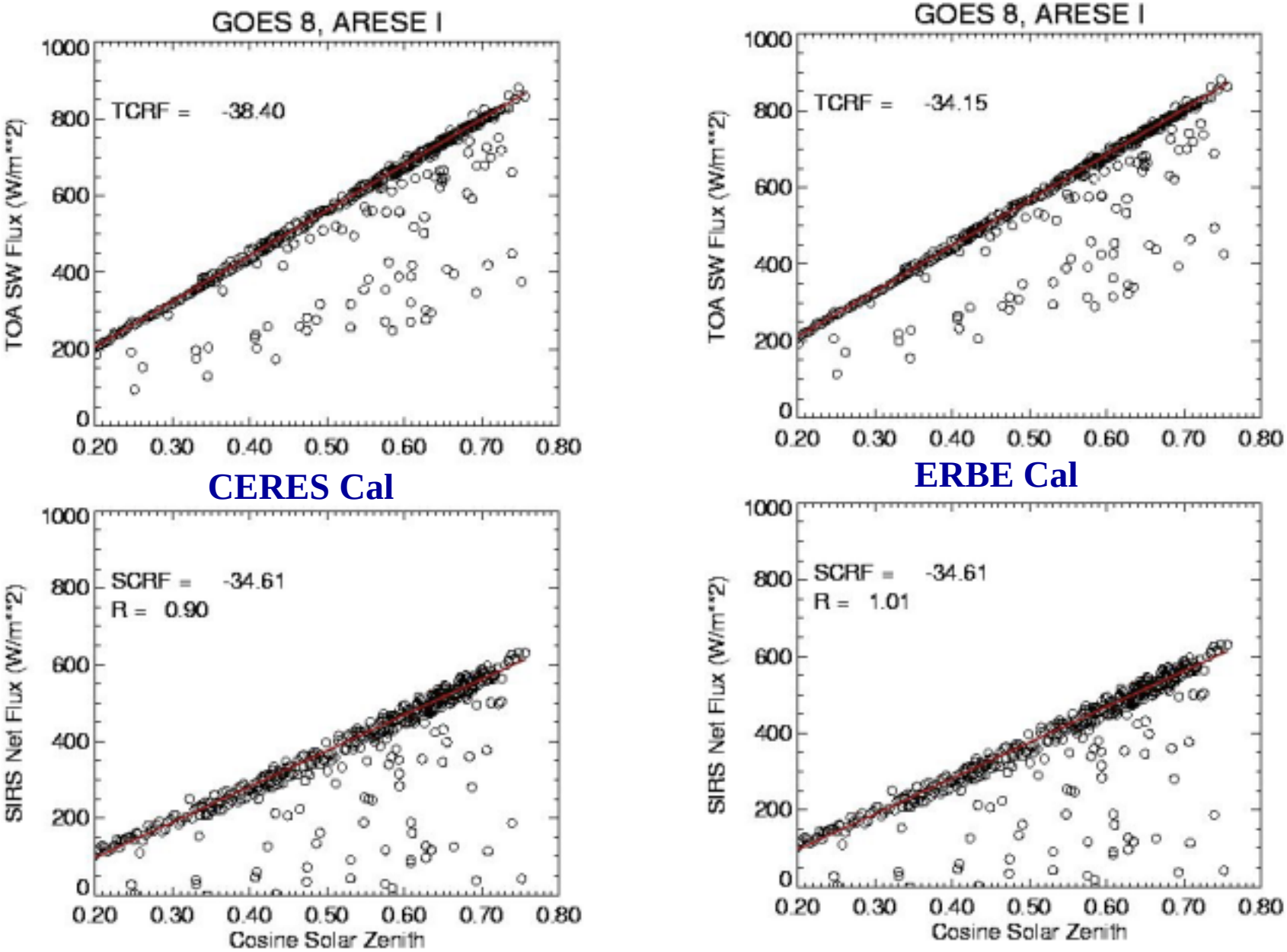
TSBR vs GOES-8

VIRS/CERES

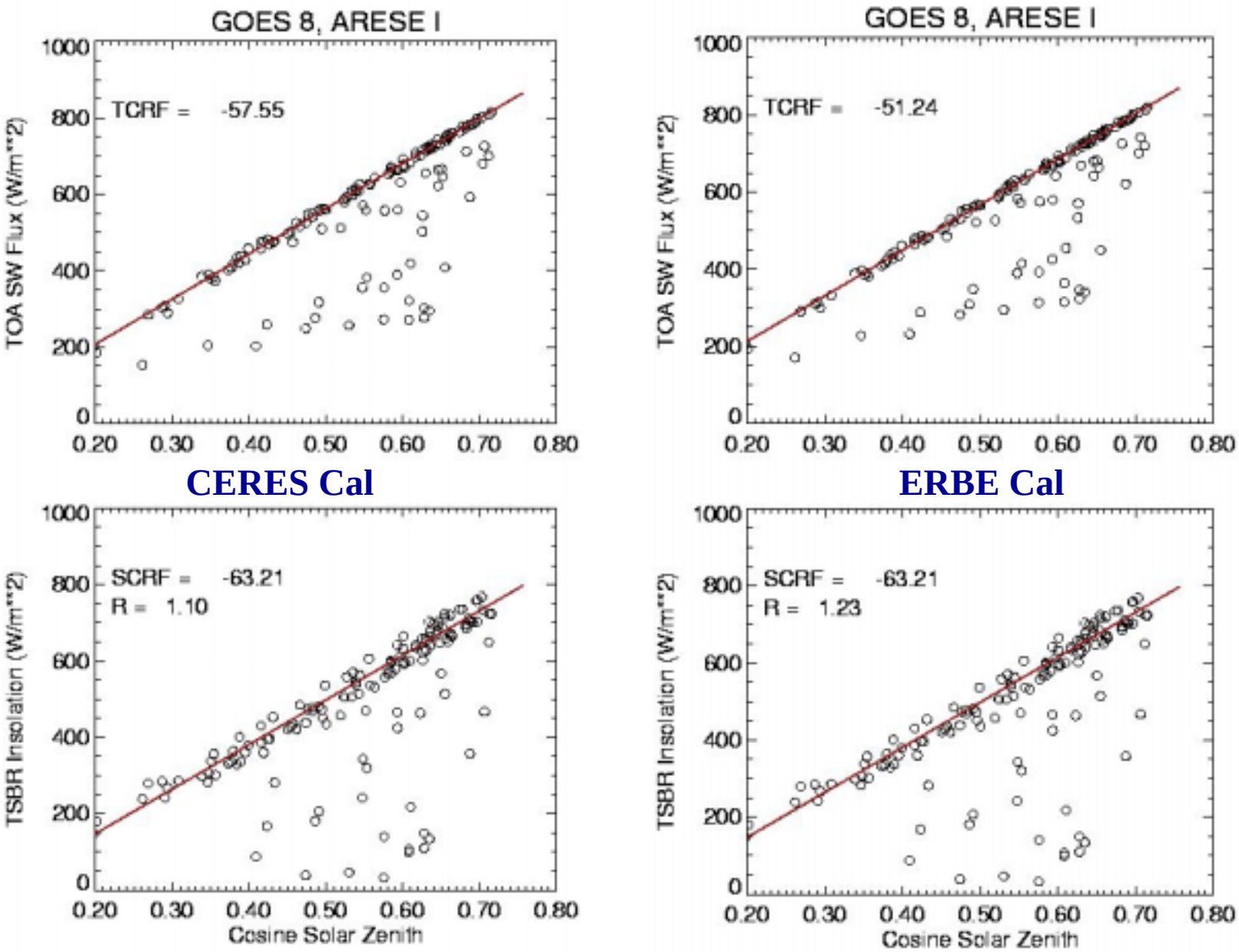
Oct 1995



SIRS vs GOES-8 Net Fluxes Oct 1995



TSBR vs GOES-8 Flux Ratios Oct 1995



CONCLUDING REMARKS

- **New VIRS calibration for ARESE I yields no enhanced absorption**
  - **ERBE/AVHRR** **max albedo ~ 0.68**
  - **CERES/VIRS** **max albedo ~ 0.74**

- **Slope method shows no anomalous absorption if mean slope used**
  - **ERBE/AVHRR** $\beta \sim -0.70$
  - **CERES/VIRS** $\beta \sim -0.78$

- **Cloud properties during ARESE-II in good agreement w/sfc**
  - **VIRS calibration excellent**

- **CERES/VIRS data in the archive**

ARESE-II Results

OBJECTIVES

- **Measure clear and cloudy sky shortwave absorption**
  - Calculate estimates of cloud radiative forcing (CRF) at the surface and top-of-atmosphere
- **Compare measured results to model predictions**

SATELLITE DATA

- GOES 8
  - GOES 8 broadband fluxes calculated from GOES vs. CERES narrowband to broadband conversion
  - 0.3° boxes centered on the SGP Central Facility
  - Measured half hourly

- CERES
  - 1° boxes centered on the SGP Central Facility
  - Measured 1-3 times/day

DATA

Surface

- **BSRN,CM21,HAEFFELIN PSP, SIRS, TSBR**
  - 1/2 hour average fluxes centered on the GOES time

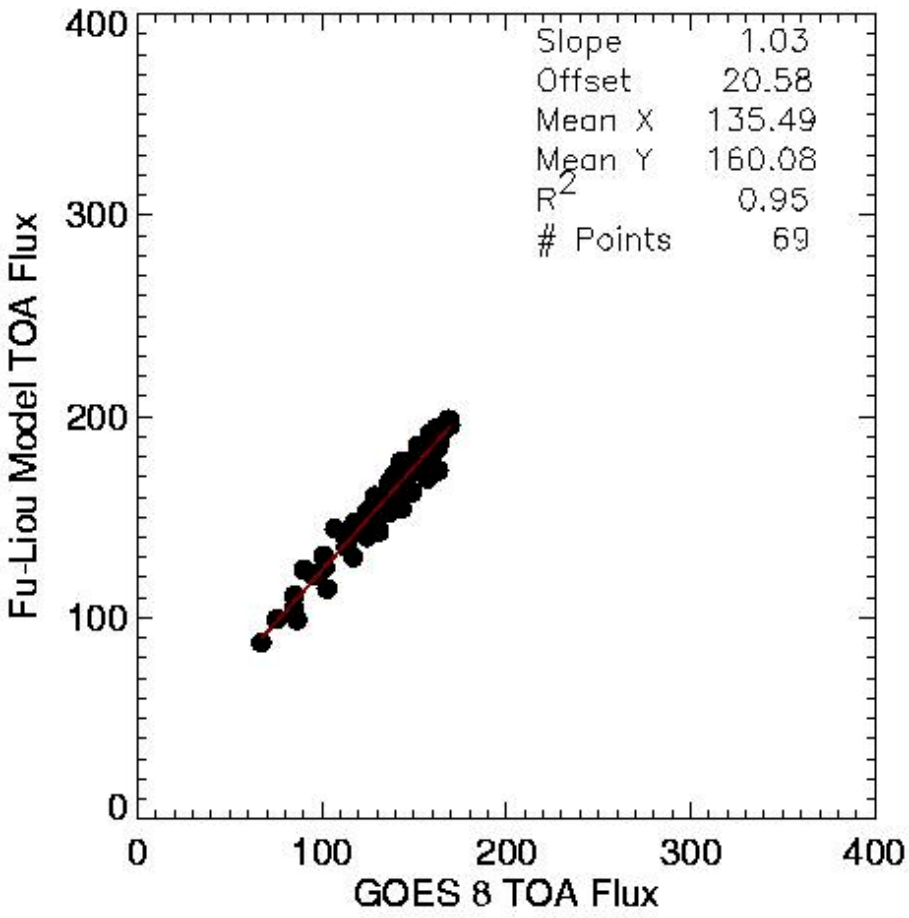
Fu-Liou Model

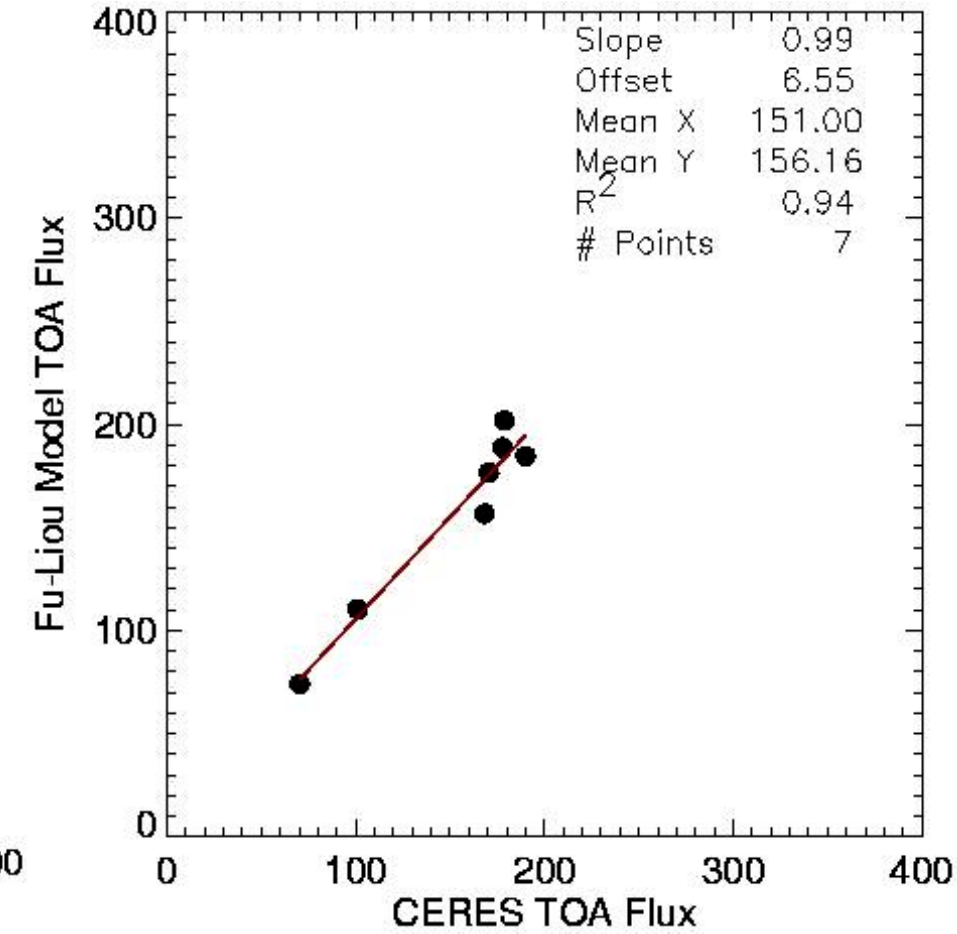
- **Identified and ran clear sky cases using the following inputs:**
  - Nearest sounding from CART site (clear days only)
  - MFRSR Aerosol Optical Depths
  - SIRS Surface Albedo

Fu-Liou Model (continued)

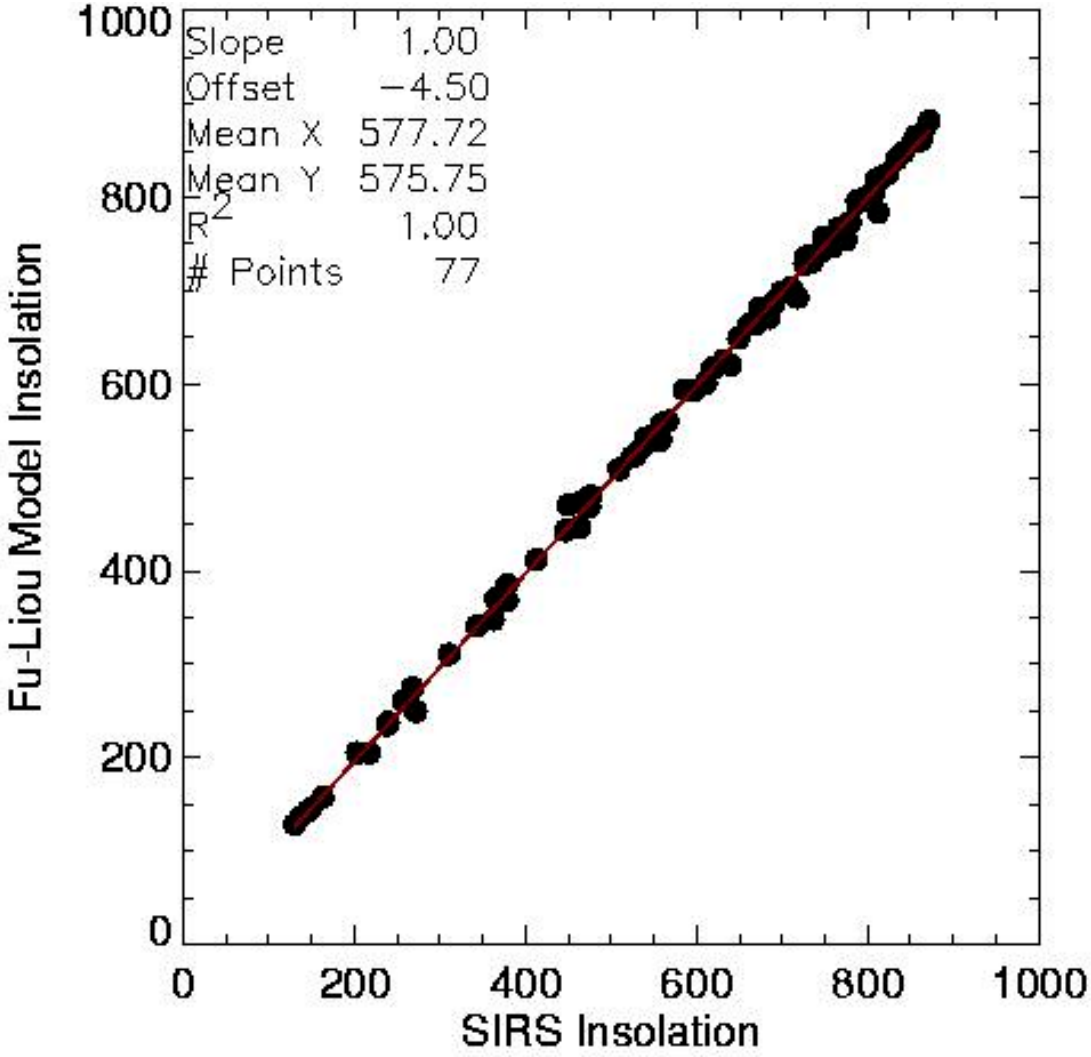
- **Calculated fluxes for 5 cloudy scenarios**
  - 3 stratus cases
    - Tau = 5,20,60
  - 1 cirrus case
    - Tau = 2
  - 1 broken cloud case
    - Used 50% stratus (tau=20) and 50% clear

TOA Flux Comparison Clear Days





Surface Insolation Comparison, Clear Days



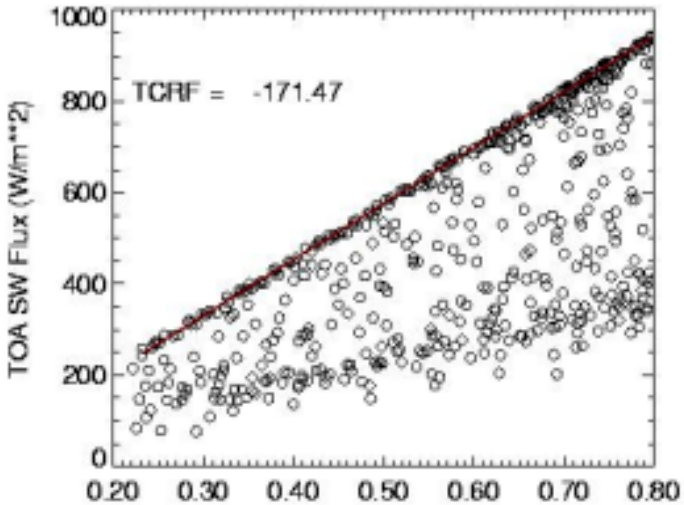
METHODOLOGY

- **Followed methods of Cess et. al (1995)**
  - Determined clear sky insolation and TOA flux using linear regression
  - Calculated SCRF and TCRF where:
    - SCRF = M_{clr} - M_{cld}
    - TCRF = E_0 $(\delta)\mu_0(\alpha cld-\alpha clr)$

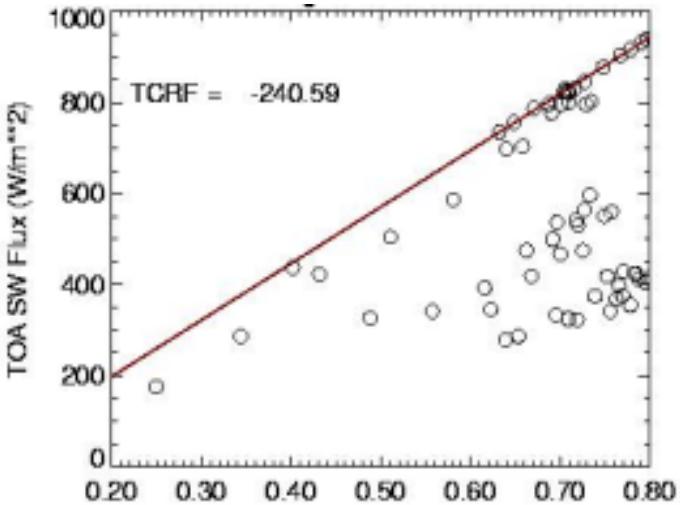
- **Calculated R = SCRF/ TCRF (insolation & net)**
  - Used 4 subsets of data
    - GOES 8 and surface instrument coincident points
    - GOES 8 and surface instrument coincident points during flight times
    - GOES 8 and surface instrument coincident points also coincident with CERES measurements
    - CERES and surface instrument coincident points

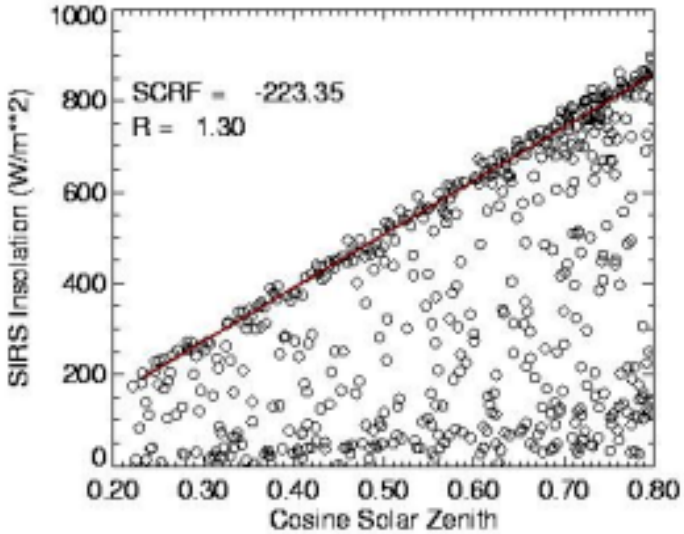
Rinsol, SIRS & TSBR vs GOES

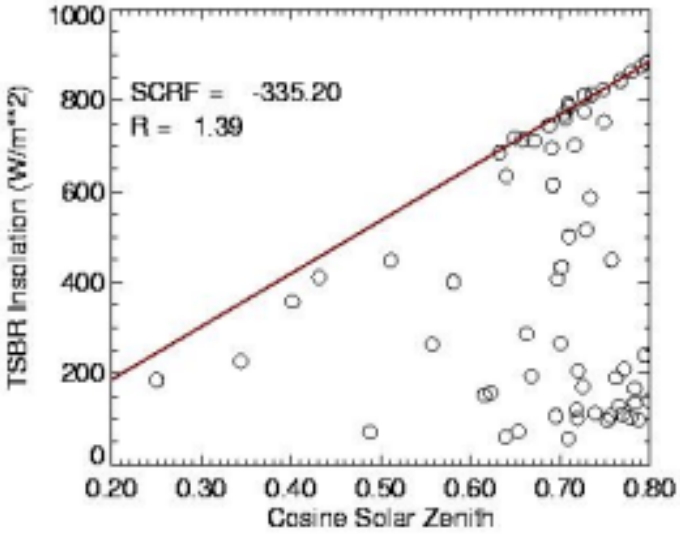
All Points



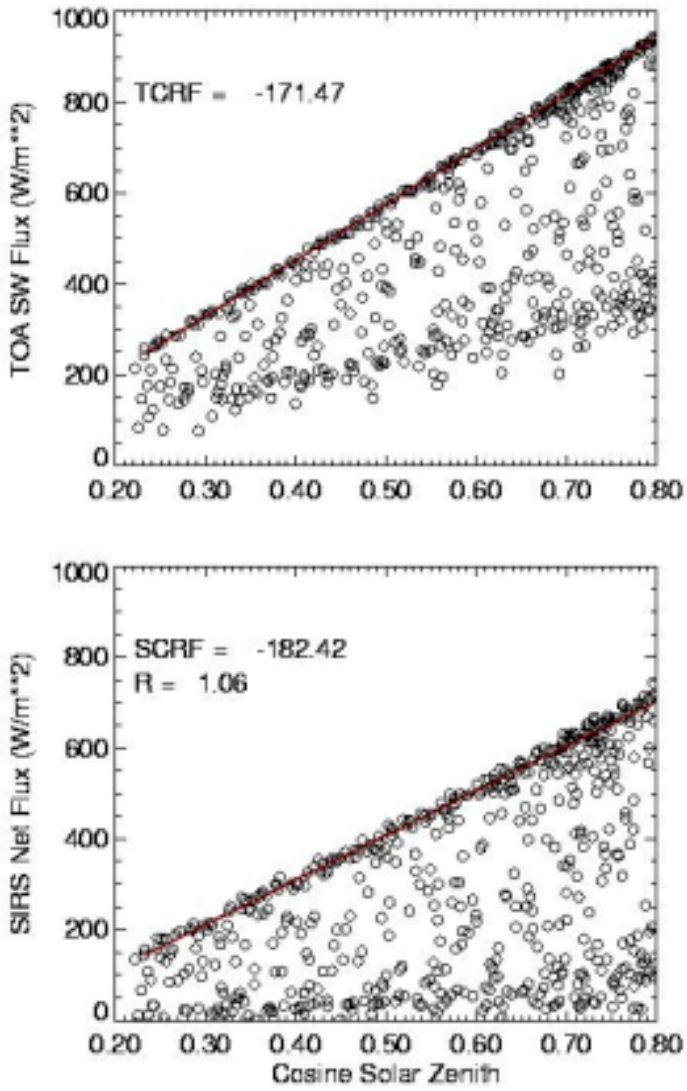
Flight Times







All Points, Rnet SIRS vs GOES



METHODOLOGY (continued)

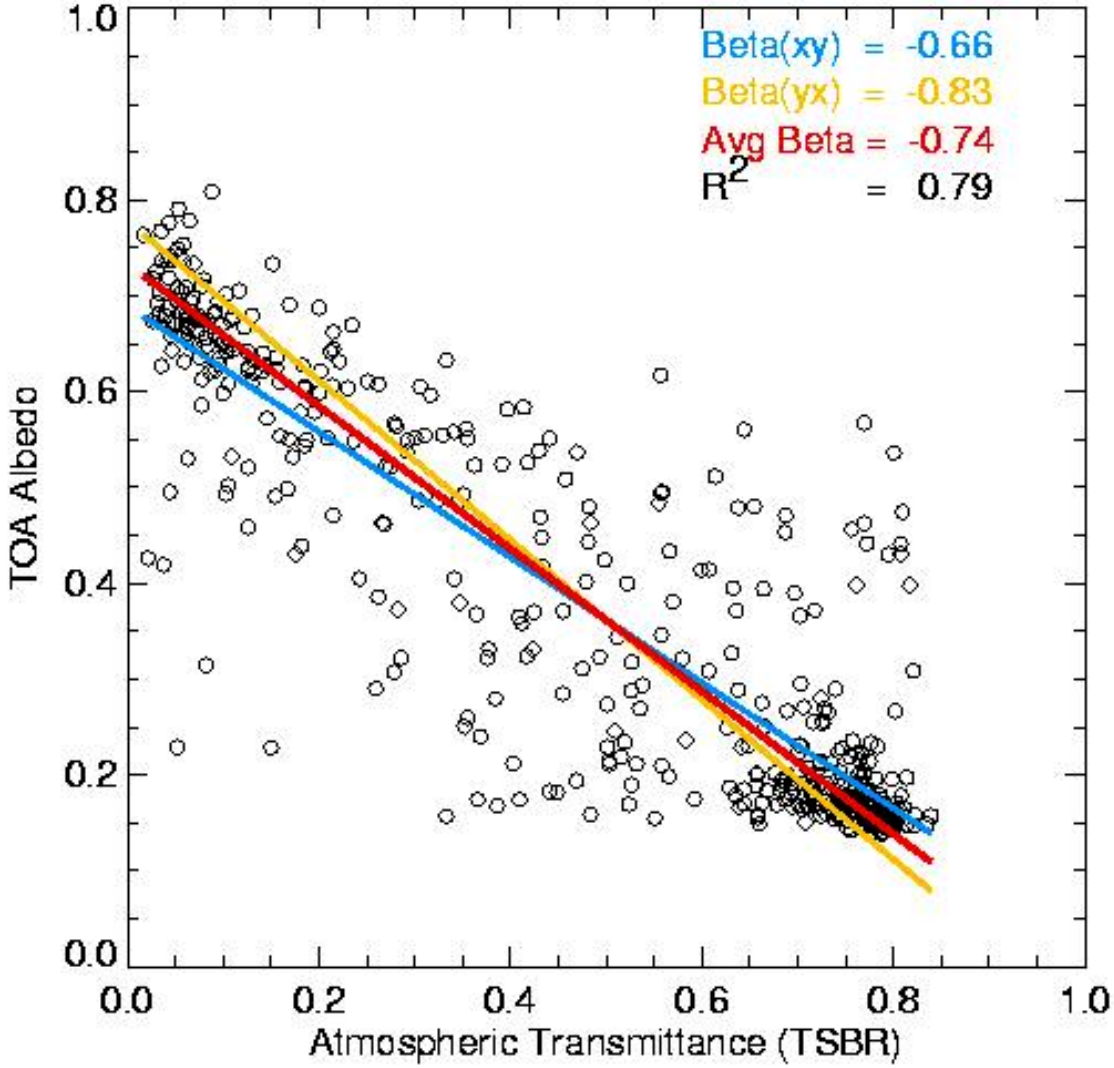
- **Calculated Albedo/Transmission Slope (Beta)**

$$\beta = -(1 - \alpha_{SFC})\ CRF_{SFC} / CRF_{TOA}$$

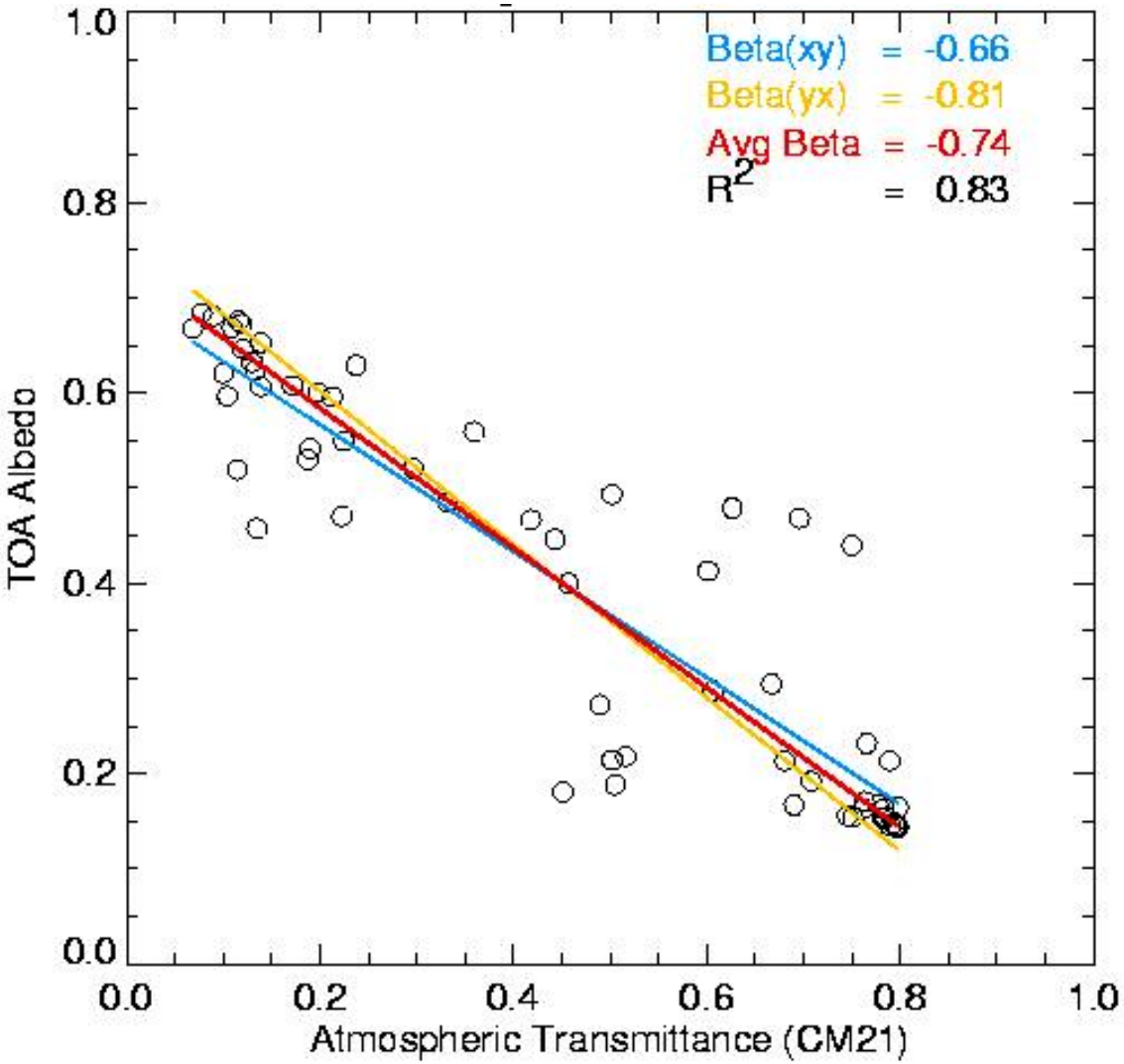
  - Used same subsets as R
  - Calculated slope using an average fit method due to the two-way error associated with mismatched fields of view of GOES 8 and the surface instruments,
    - ***line actually intersects main data clusters***
    - ____ ***actually*** $= -(1 - \alpha_{SFC}) / \beta$ _____

- **Calculated R and Beta using Fu-Liou Model**

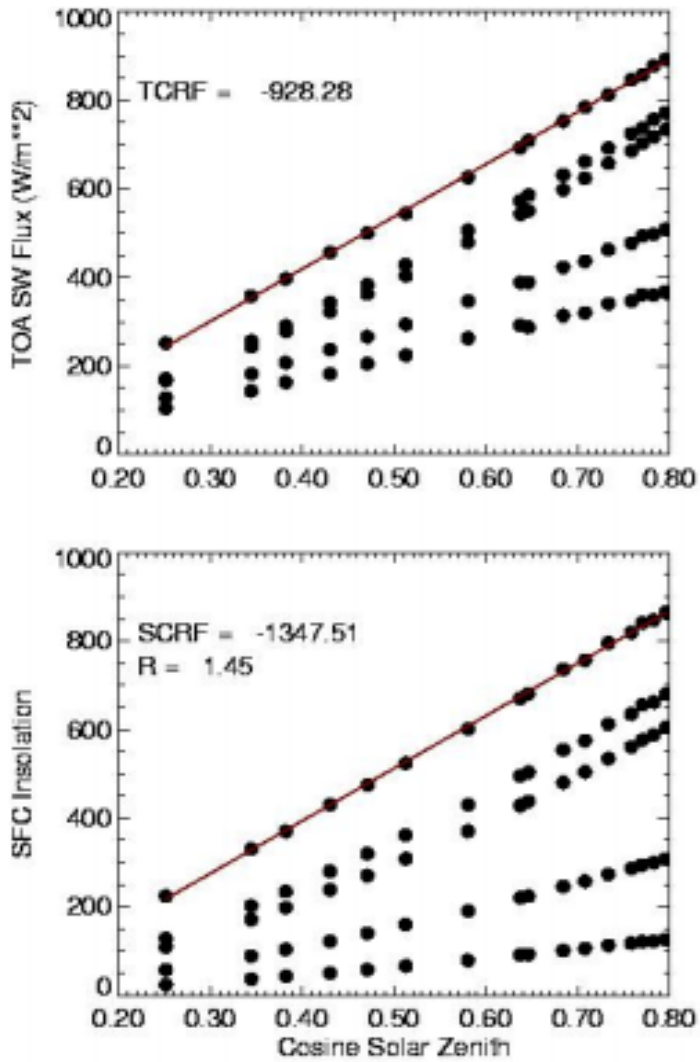
All GOES Points vs TSBR

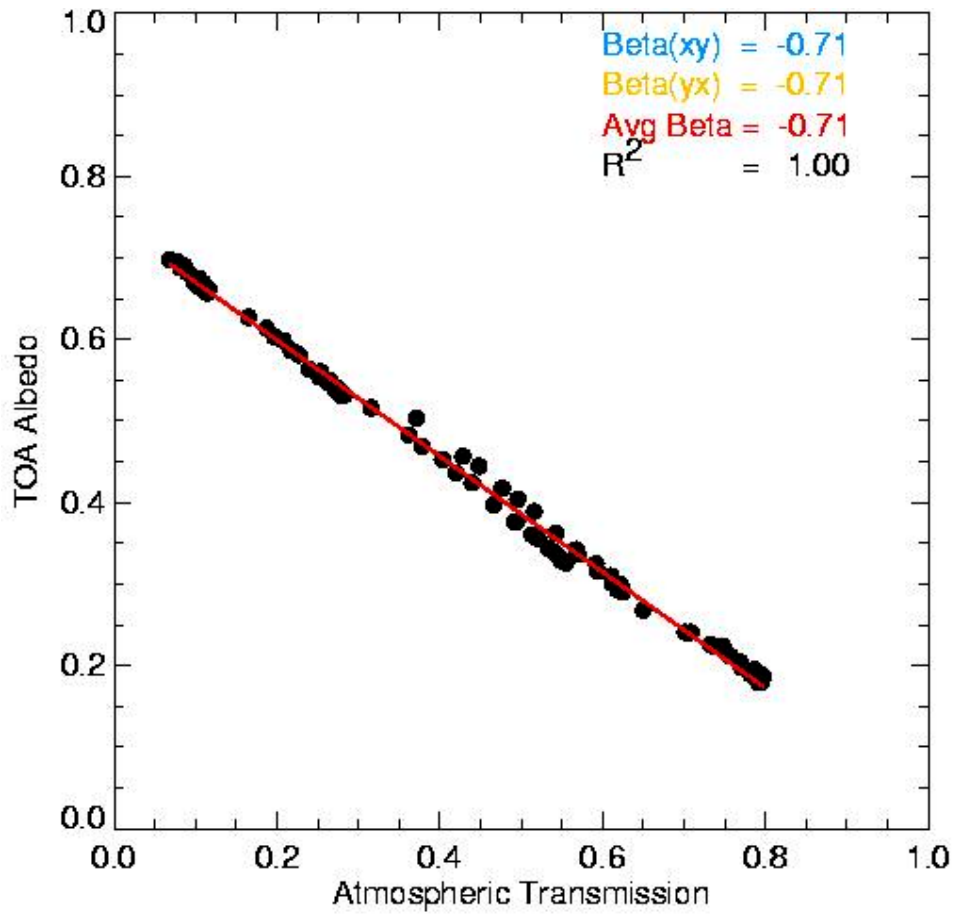


Flight Times, GOES vs CM21



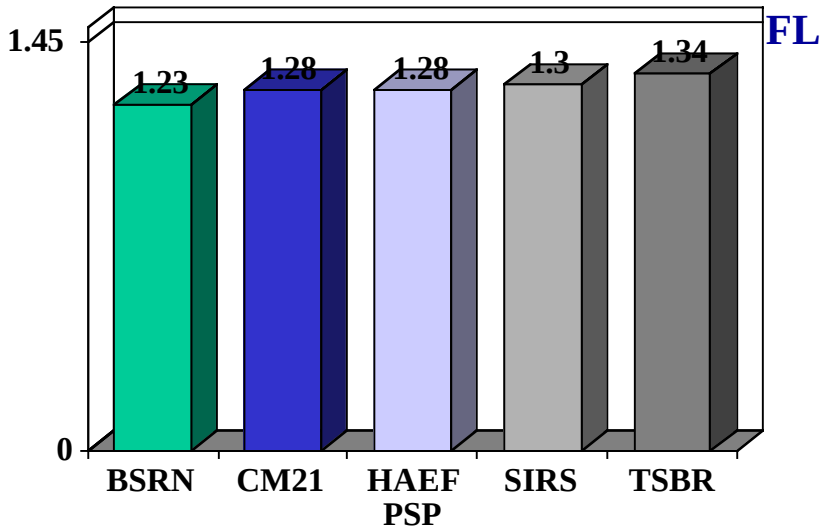
Fu-Liou Model



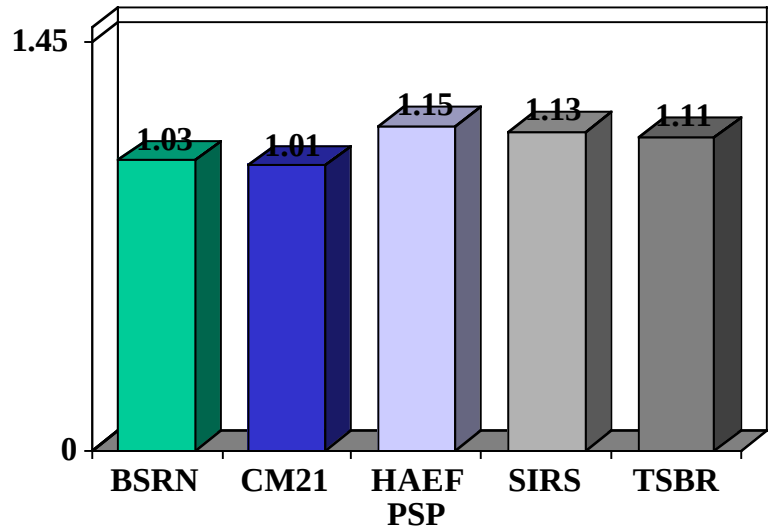


Summary, Rinsol

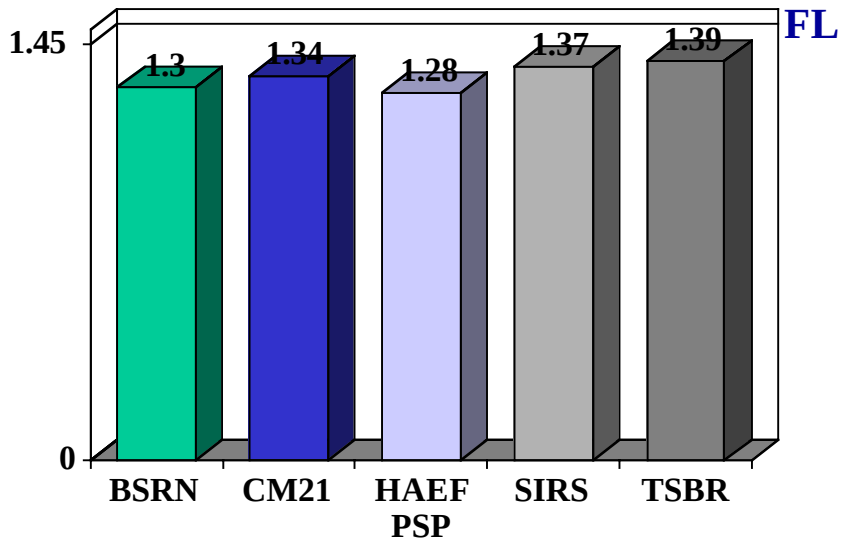
R_{insol} for All GOES Points



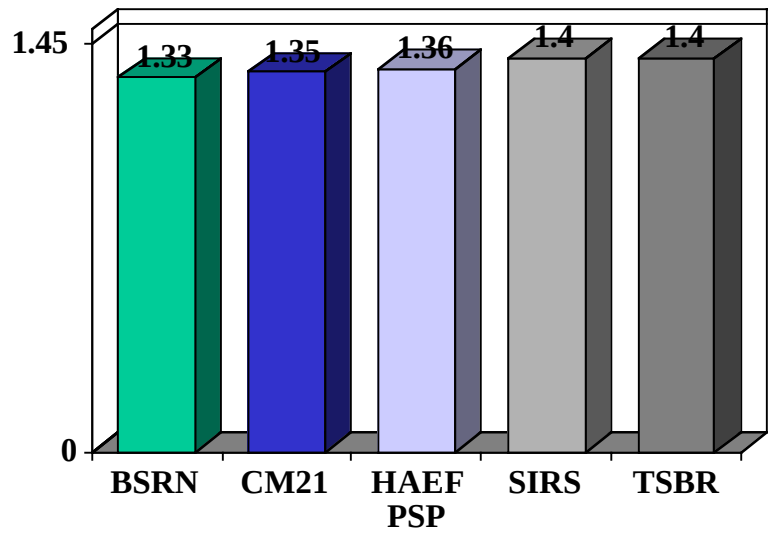
R_{insol} for Points Coincident with CERES



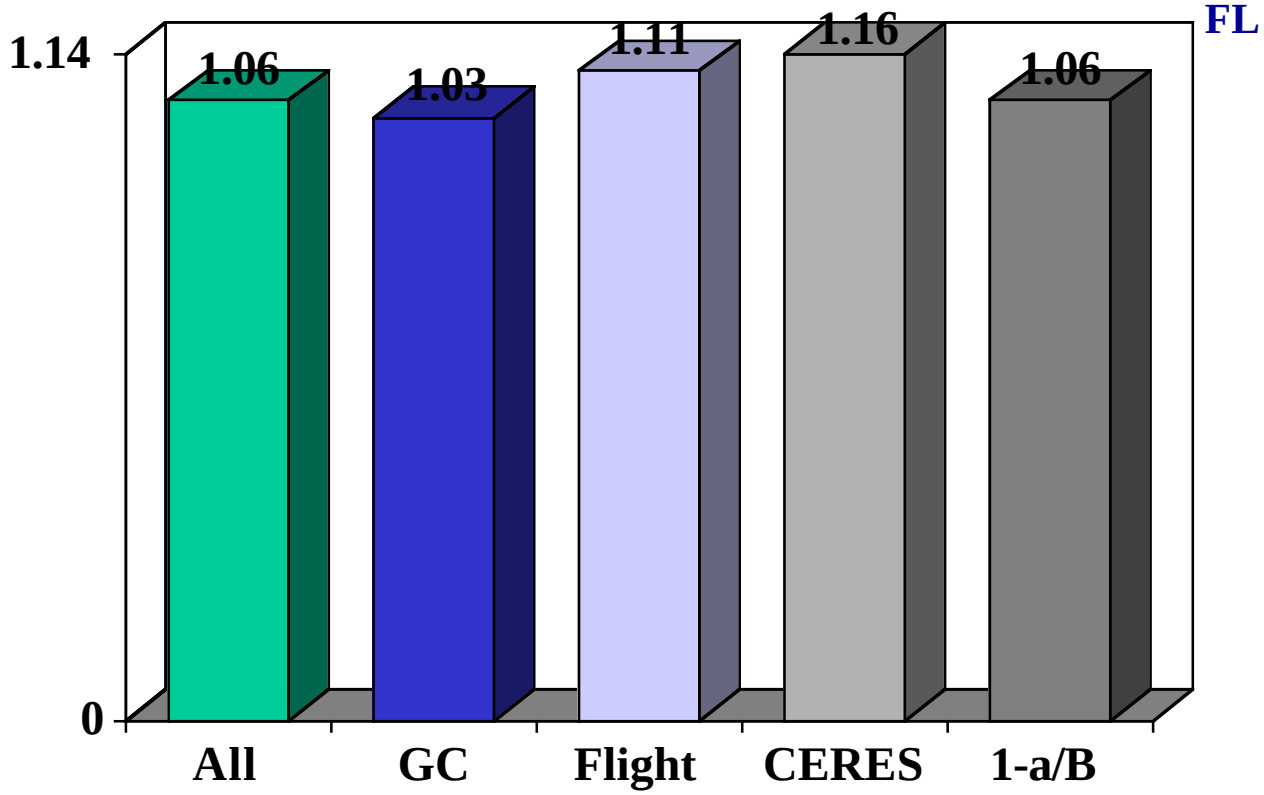
R_{insol} for Points During Flight Times



R_{insol} for CERES Points

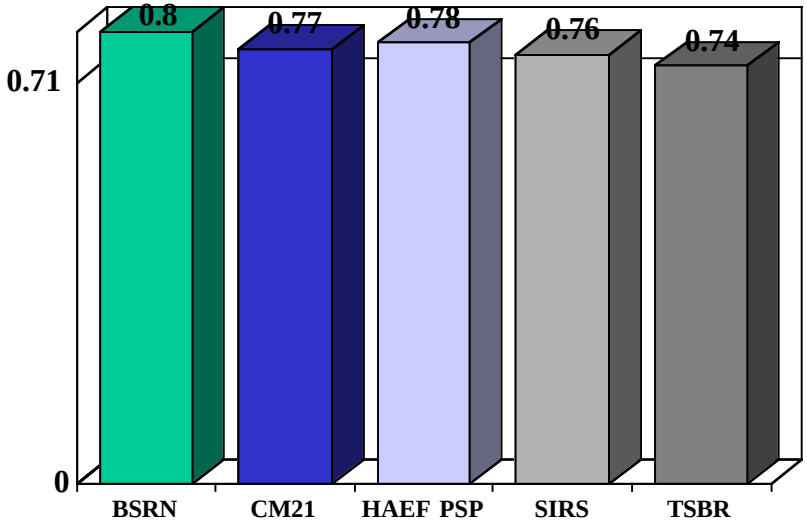


Rnet Summary

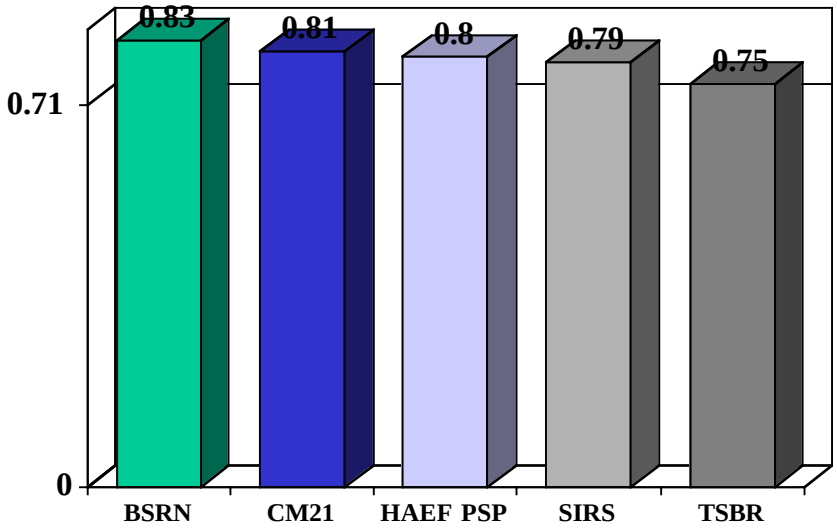


Beta Summary

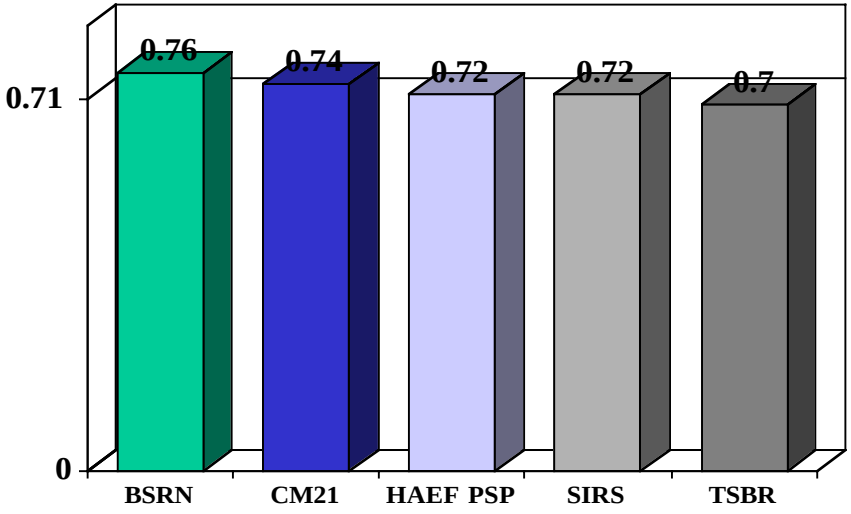
All GOES



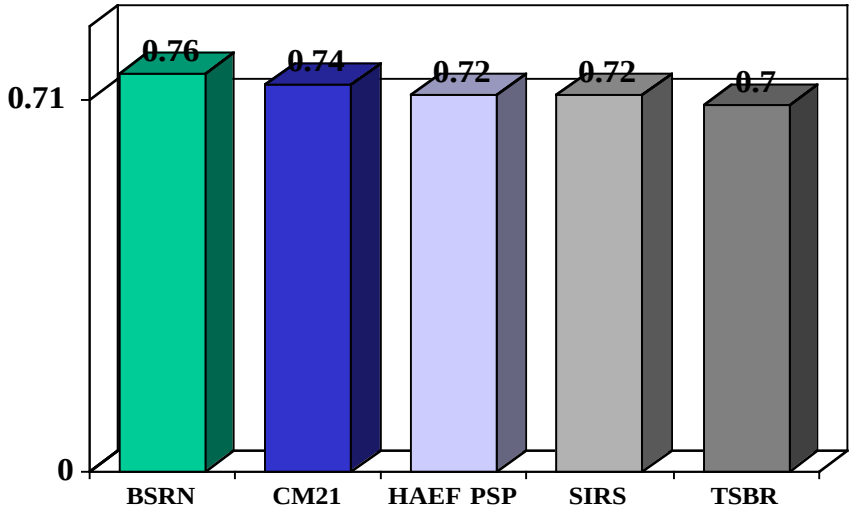
GOES/ CERES



Flight Times



CERES Points



SURFACE ALBEDOS COMPUTED FROM BETA

	βxy	βavg
All	**0.28**	**0.19**
Flight	**0.29**	**0.20**
GOES-CERES	**0.26**	**0.19**
All CERES	**0.21**	**0.18**
SIRS	**0.19**	

SUMMARY

• **Mean Absorption Parameters for ARESE-II**

	R_{insol}	R_{net}	$-\beta$
All	**1.29**	**1.06**	**0.77**
Flight	**1.32**	**1.11**	**0.73**
GOES-CERES	**1.09**	**1.03**	**0.80**
All CERES	**1.37**	**1.16**	**0.72**
Fu-Liou	**1.45**	**1.14**	**0.71**

• **Excellent agreement between model and CERES/sfc data**

• **Still issues on GOES vs CERES conversion**