2000 - 2002 Terra CRS/SSF Consistency of SARB CRS Calculations and Observations at TOA.

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2nd CERES-II Science Team Meeting
Hospitality House, Williamsburg, VA
Nov 2-4, 2004

CRS Sarb Product Combines

- MOA
  - Geos4 :Temperature(z), Humidity(z)
  - Smoba o3(z)
- SSF
  - Cloud Properties
    - Fraction , Optical depth, phase, particle size, height
  - TOA Fluxes
    - (SW,LW,Window) , Radiances (LW,Window)
  - Clear Sky Aerosols (Modis)
- Match Assimilation
  - Aerosol constituents
  - Cloudy Sky Aerosols
- FuLiou Radiative Transfer
  - (Clear, Cloudy , Pristine Clear, Pristine Cloudy)

FuLiou Radiative Transfer Model

- Gamma weighted 2-Stream (SW) , 2/4 Stream (LW)
  - Inhomogeneous clouds
- 29 Bands : 15 SW, 14 LW , 3 of 14 LW in WN
- Shortwave: (0.17 - 4.0)um (2500-57000cm-1)
  - Hitran 2000 (H20) (O_2,CO_2,CH_4) Fixed : H_20 continuum
  - JPL(1994) O_3 uv ,WMO(1985) O_3 vis
- LW (0-2850cm-1) (3.5um – Infinity)
  - H_20 ,CO_2 ,O_3 ,N_20 ,CH_4 ,CFCs, H20 continuum)
- Water Cloud Optical Properties (Y.Hu)
- Ice Cloud Optical properties (Q.Fu 1993 ,Dge)
- Aerosol Optical Properties
  - OPAC, Tegin&Lacis,D'Almedia
- 10 visible SW bands reworked for O_3 and rayleigh in mid 90's

CRS – SSF

Untuned FuLiou Model

minus

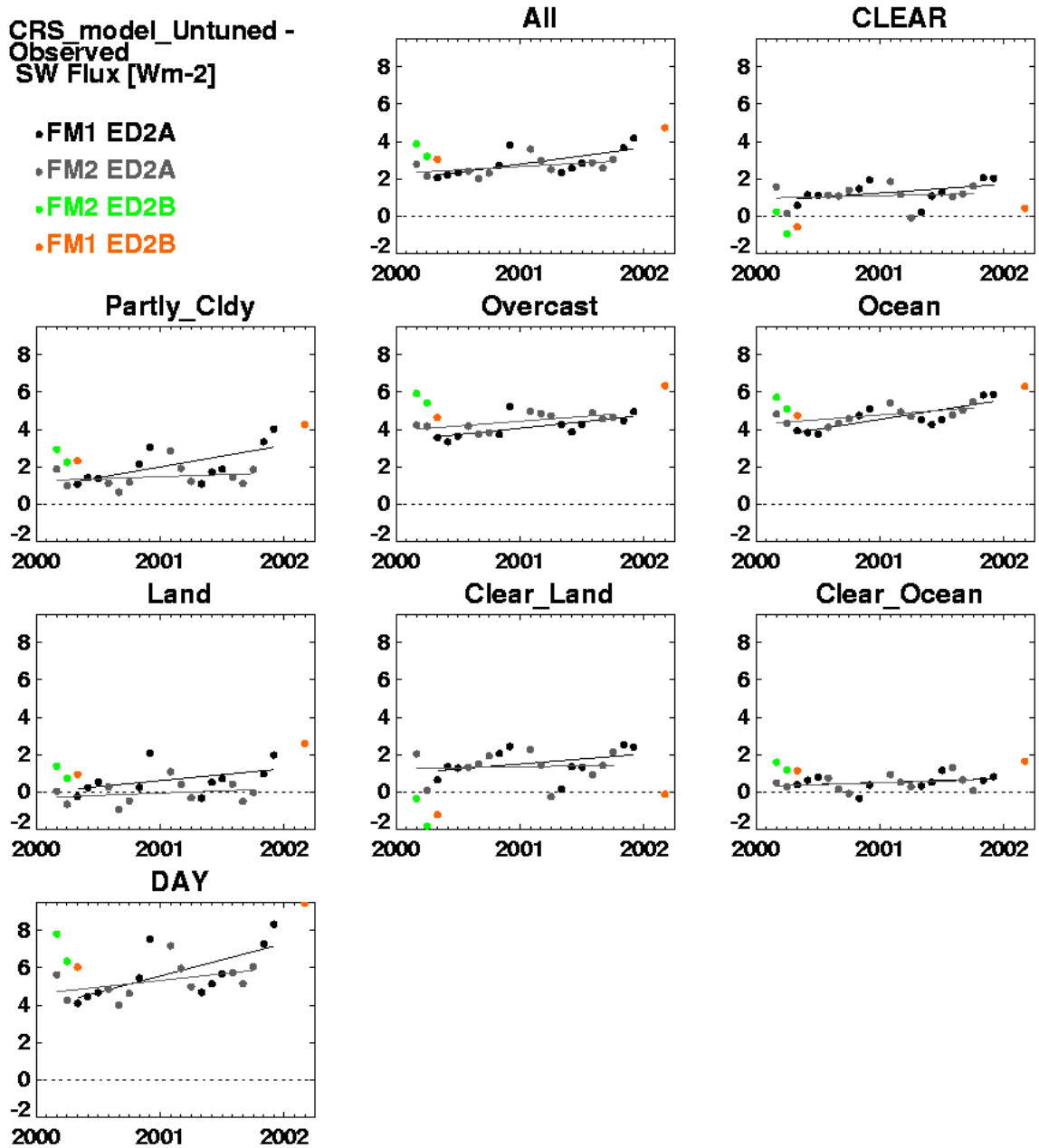
CERES Observed

Toa Flux Bias Drift

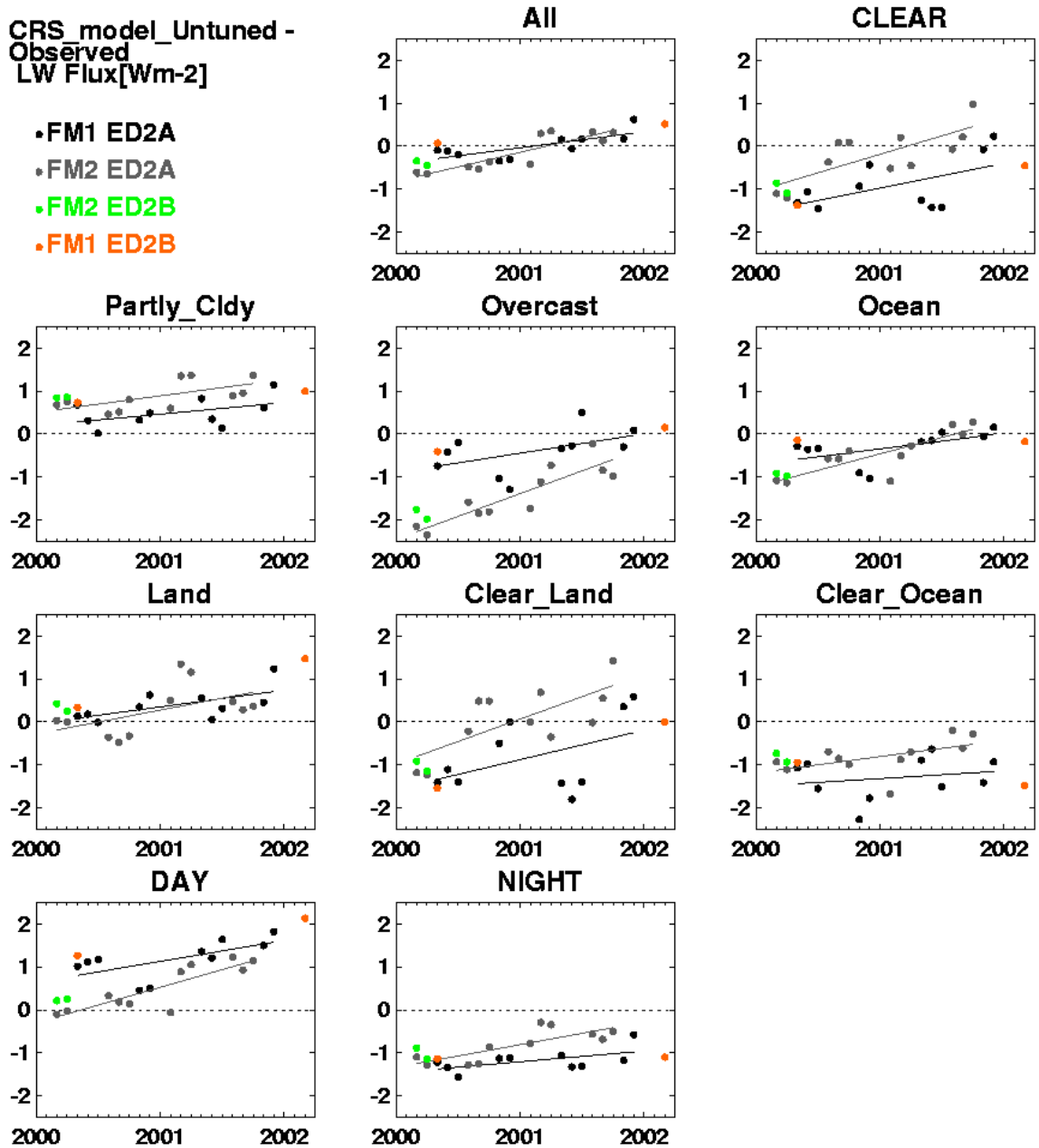
CRS Based FOV Monthly Mean QC Report Statistics

- Simple FOV weighted mean ,24hr avg most cases
- NOT representative of Equal Area Global domain!
- CRS (FuLiou Untuned) minus CERES Observations
- Subsets containing land & snow use CERES observations indirectly for Untuned model input of surface albedo retrieval
- Oceans independent of CERES observations

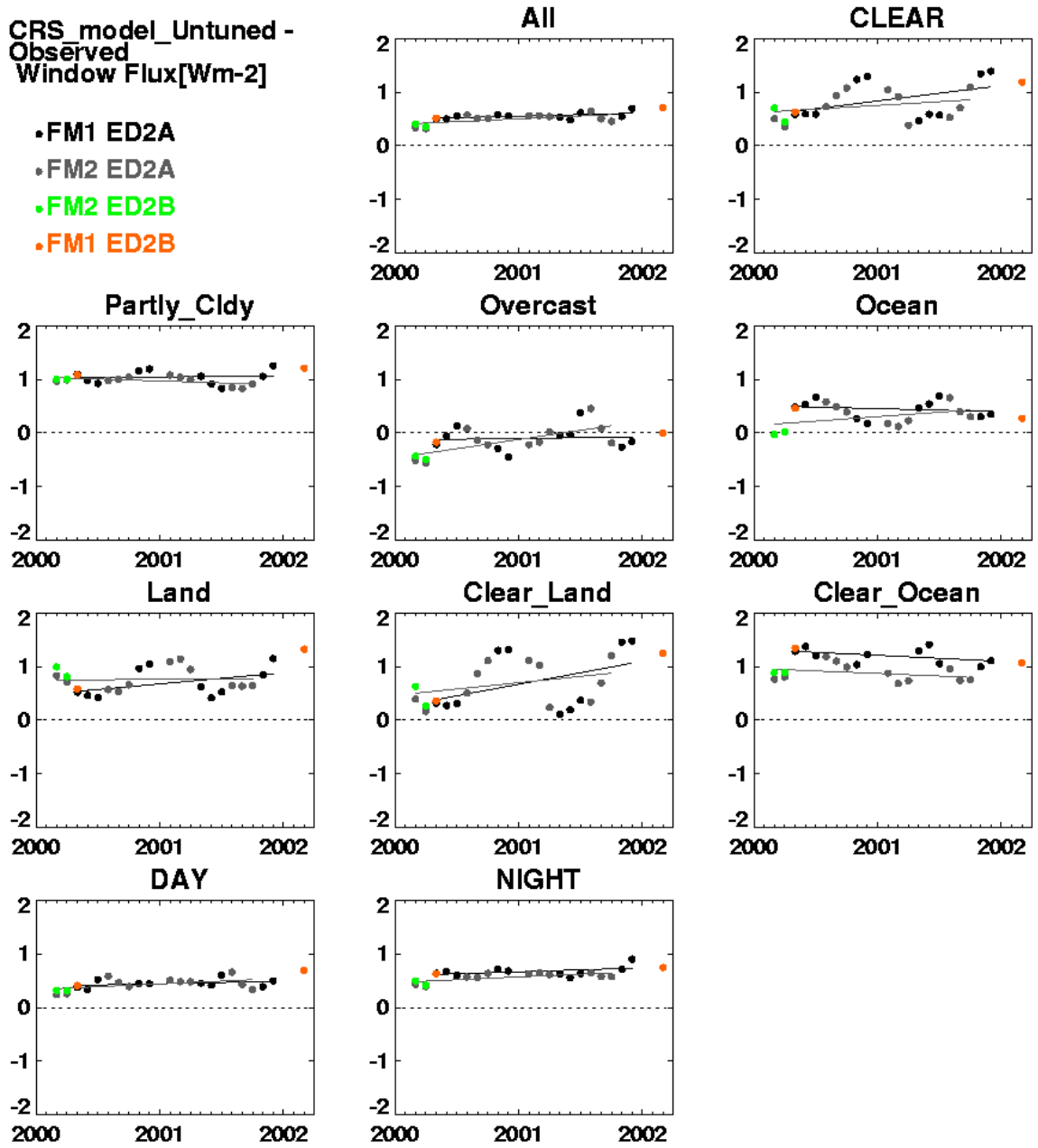
Shortwave TOA Flux



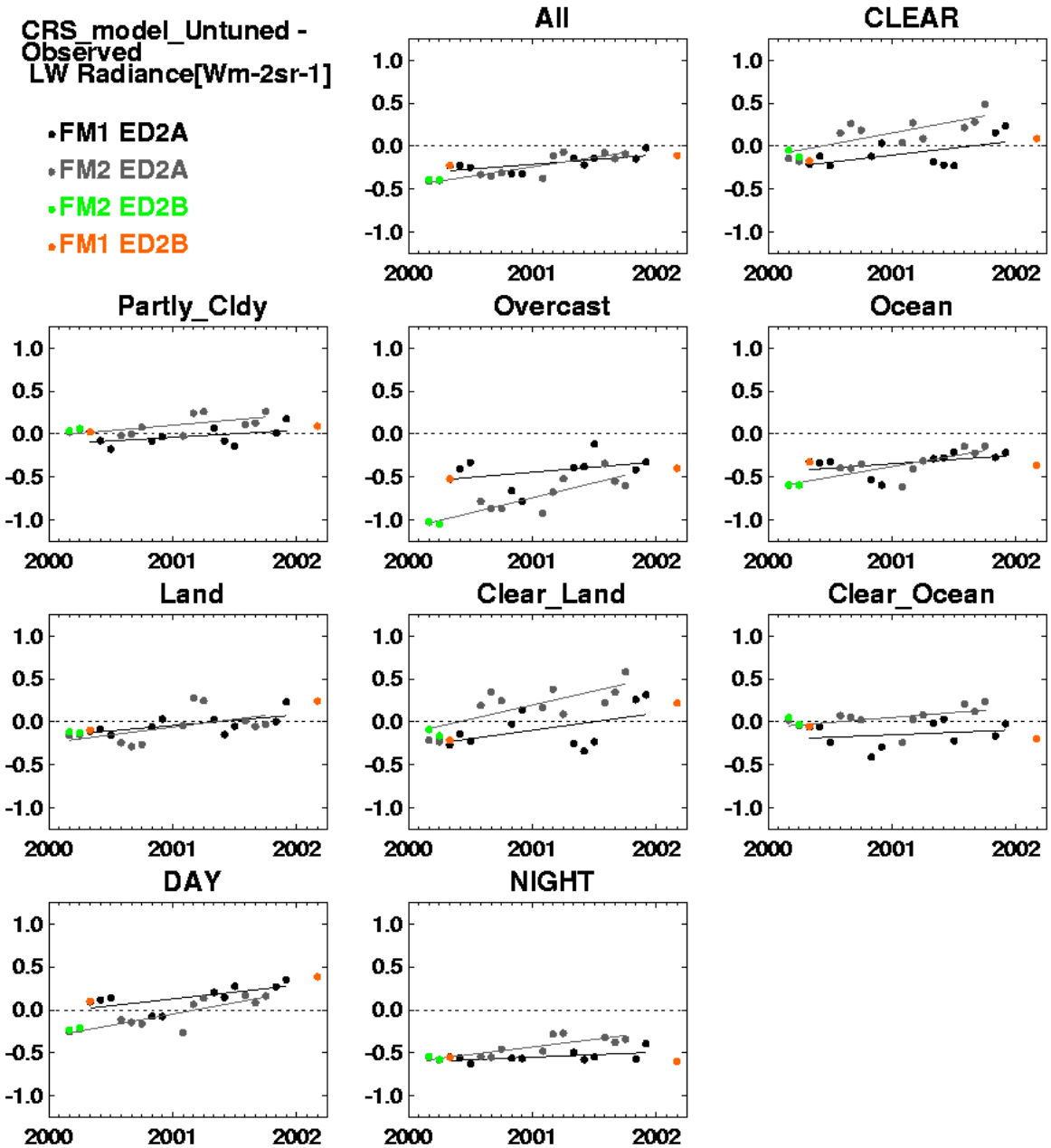
Longwave TOA Flux



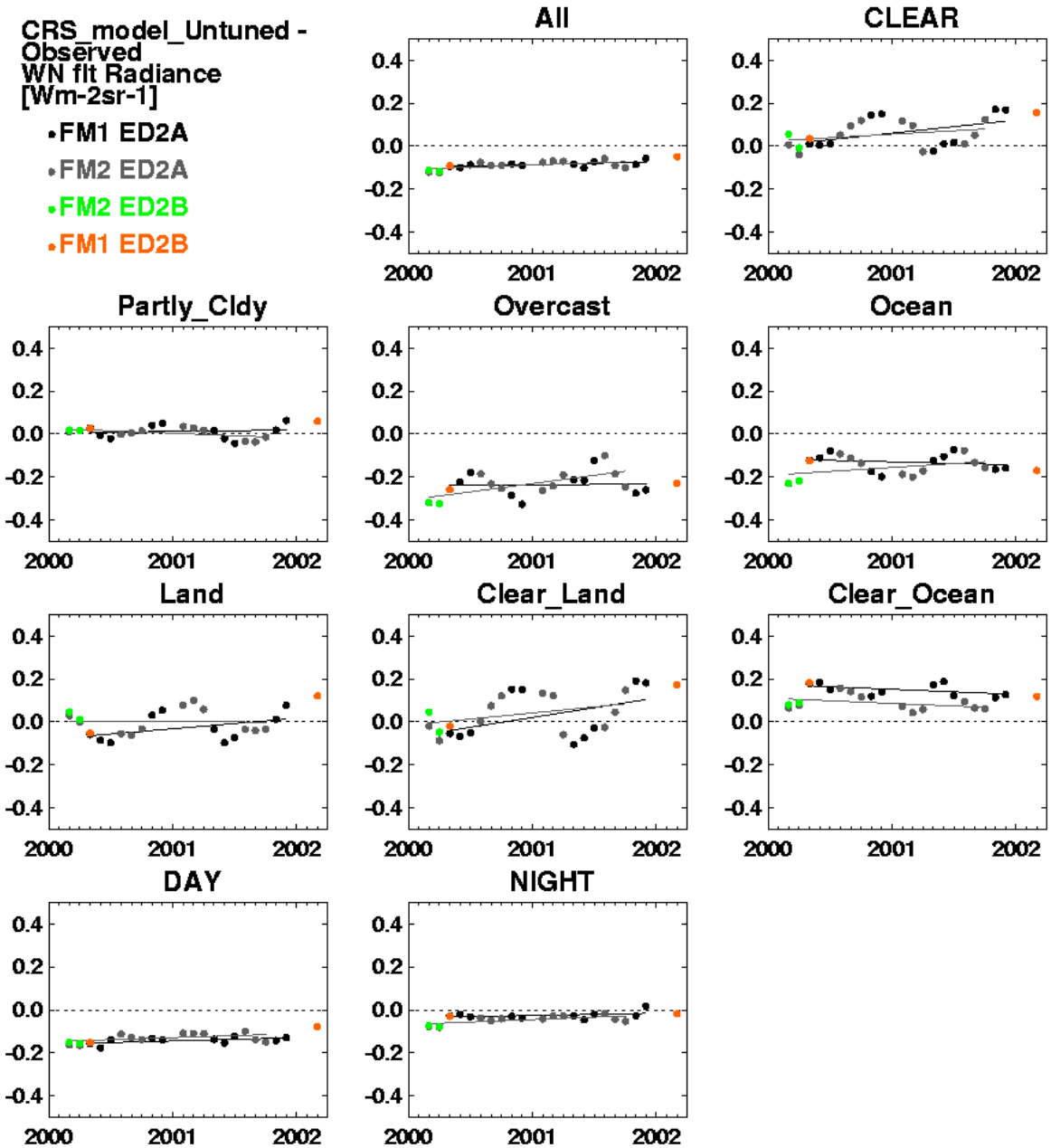
Window TOA Flux



Longwave Radiance [Wm-2sr-1]



Filtered Window Radiance [Wm-2sr-1]

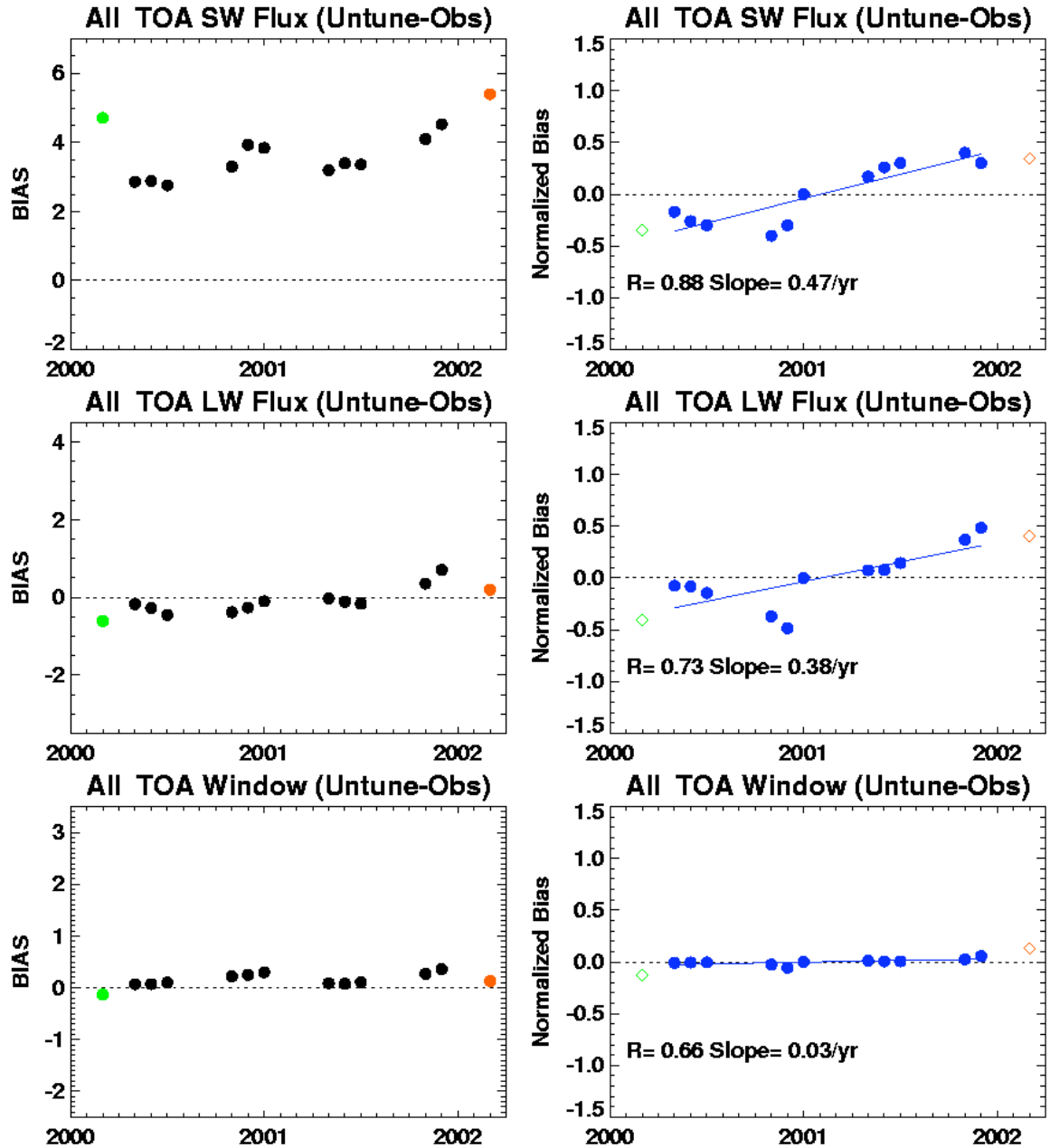


FSW Equal Area Results

- Ceres Equal Area Grid
  - -Instantaneous Fovs gridded to ~1deg
- Monthly Averaged
  - -No diurnal modeling
- Mostly Edition 2A Fm1, 2 partial months of ED2B
- Normalization by multi-year monthly means to Emphasize inter-annual variability

All Sky

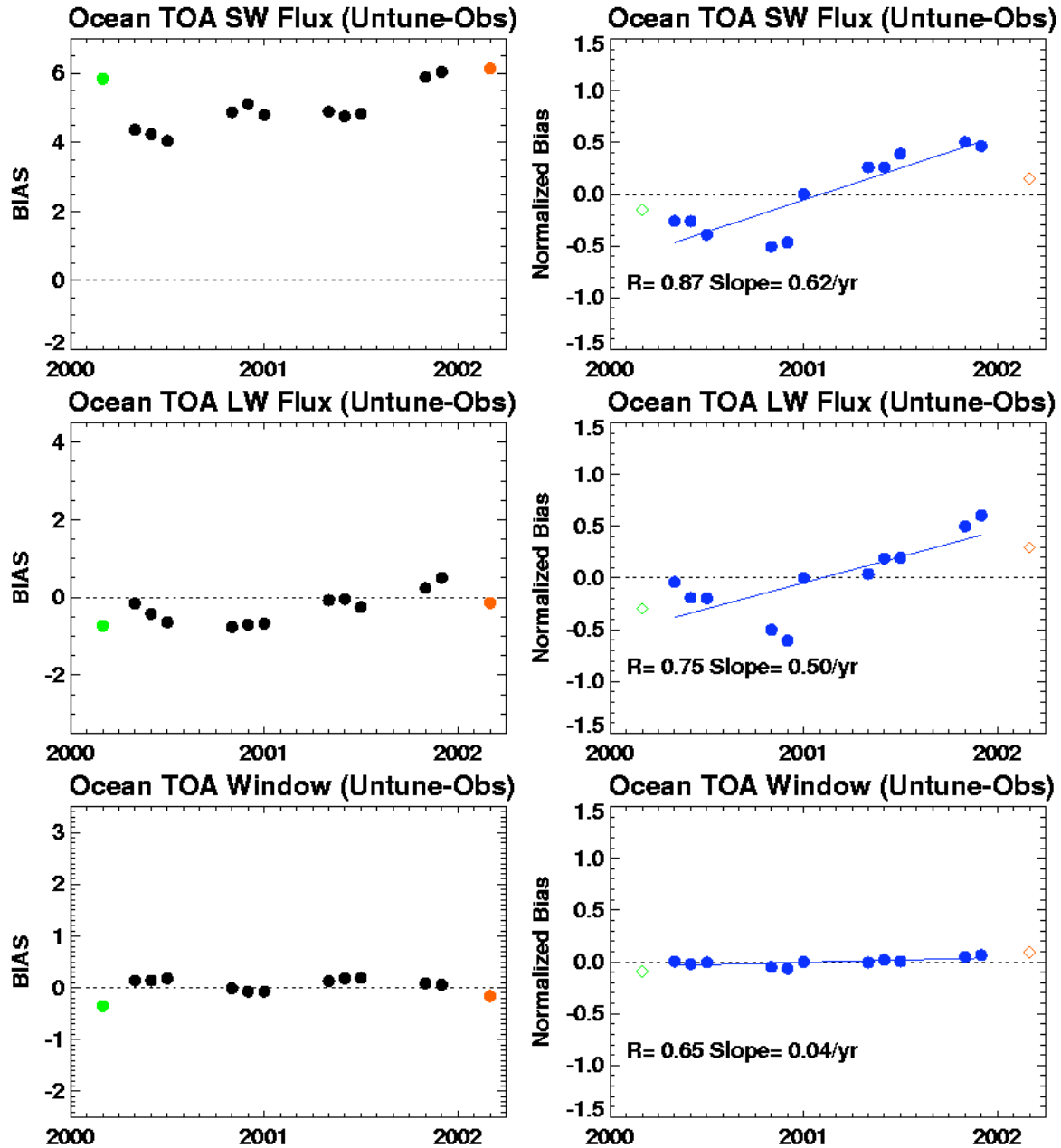
- FM1 ED2A
- FM2 ED2A
- FM2 ED2B
- FM1 ED2B



Normalized by multi-year monthly means

Ocean

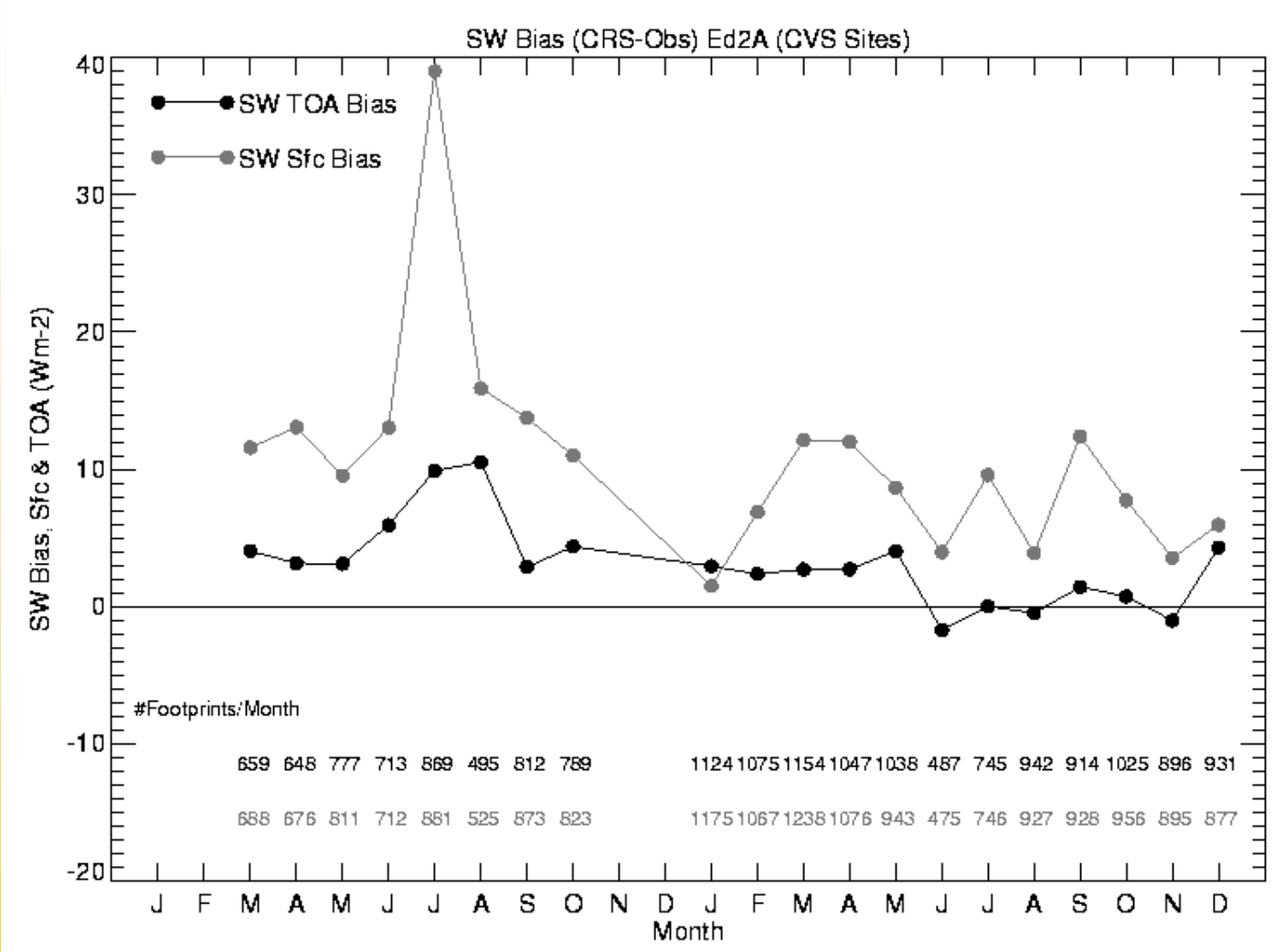
- FM1 ED2A
- FM2 ED2A
- FM2 ED2B
- FM1 ED2B



Normalized by multi-year monthly means

Ceres Surface Validation Sites

- Untuned SW Bias
  - TOA
  - Surface
- Edition 2A CRS
- Small Sample Size



Untuned CRS – CERES Observed SW Toa Flux Bias Causes?

Typical TOA Albedo Bias Occurrence

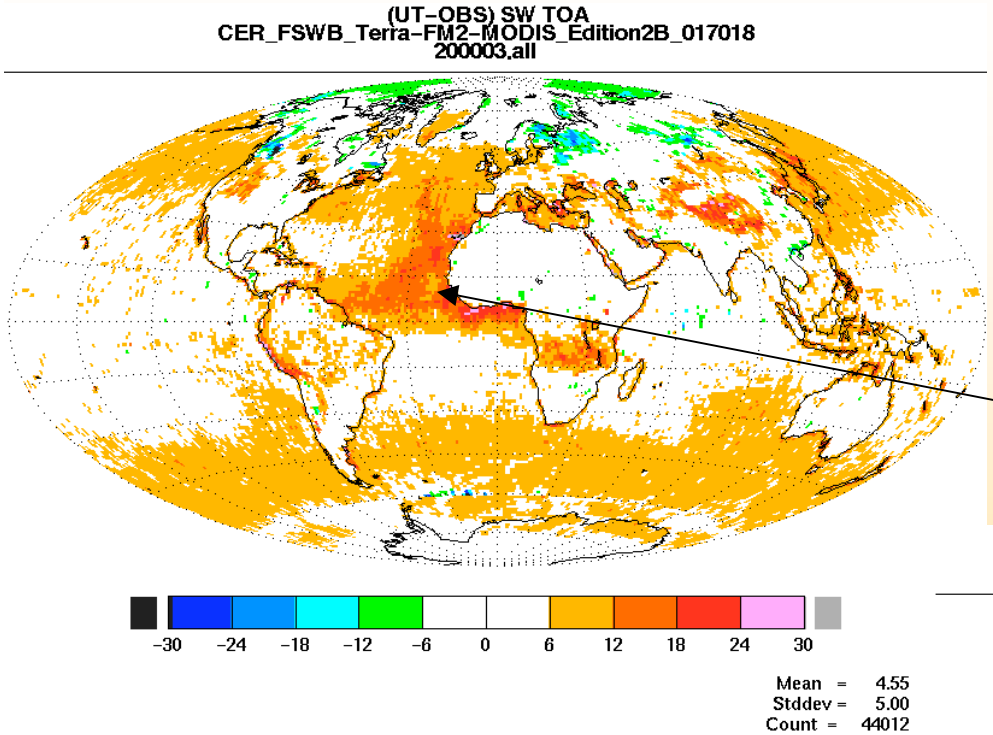
But not exclusively

- [Untuned – Observed] Positive, Model too reflective
- Overcast Water Clouds
- Moderate Optical Depths Tau=~7 to ~20
- Large Cloud particles Re > 15 microns
- Regions of large aerosol optical depth
- Inhomogeneous clouds

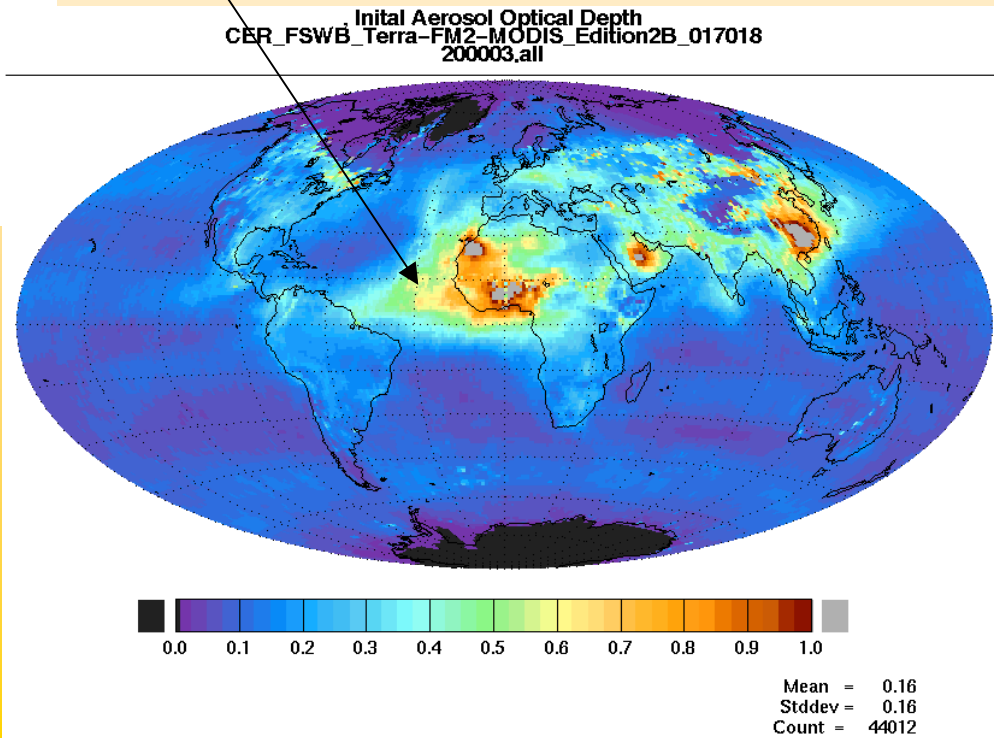
Toa Albedo Bias Causes

- Double treatment of aerosols
  - Large Tau Aerosols retrieved as “clouds”
  - while MATCH aerosols used during cloudy sky conditions.
- Multi-Layer clouds retrieved as single layer(?)
  - Thin “sub-visual” Cirrus (tau < 0.2) overlapping overcast stratus
  - Increases retrieved low cloud altitude, less H20 absorption
- Cloud 3D effects cloud top “bumps” (?)
  - Less reflectance at oblique angles not modeled well by PP RT.
- Broadband Cloud Optics(? small)
  - Correlation of cloud optics and gas absorption in some bands

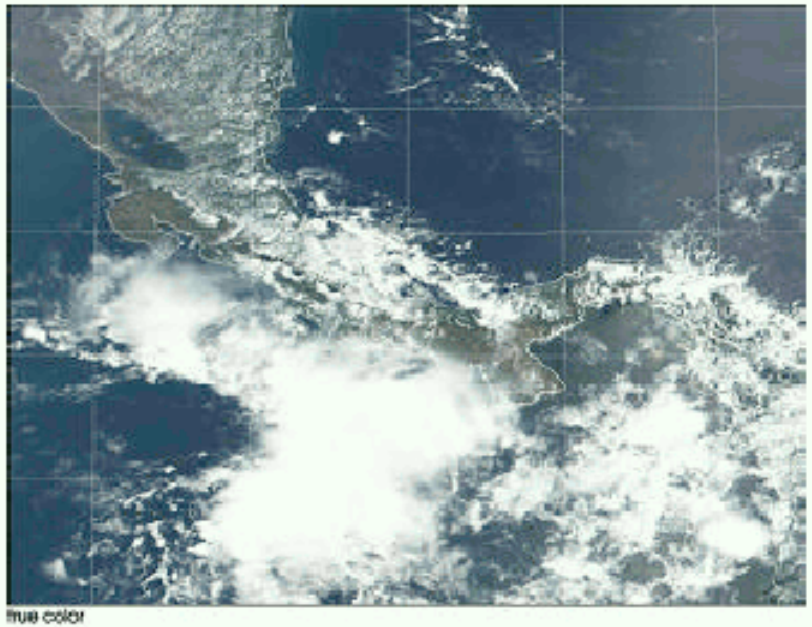
TOA SW Untuned-Observed and Aerosol



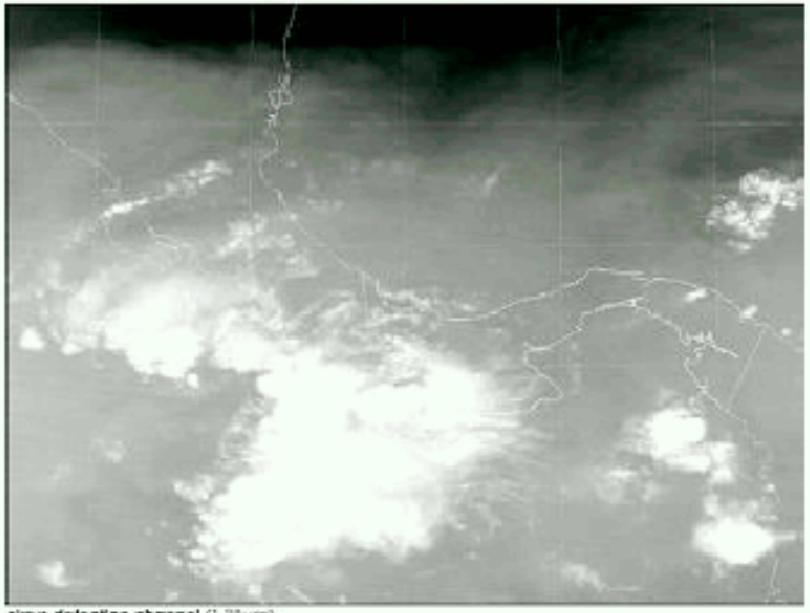
- Area of large positive SW bias off west coast of Africa coincides with Saharan Dust Aerosols over the Ocean with $\tau > 0.4$



Thin Cirrus Overlapping Overcast Water Clouds



true color



cirrus detection channel (1.38μm)

Missed Cirrus Effect

Mid-latitude Summer , Cos Sol= 0.80 , Ocean Surface Albedo

• Case 1: thin cirrus missed • No cirrus retrieved • Water Cloud – $\tau = 10.$ Re = 20 – **1:2 km** • OLR 264.9 • Albedo 0.3885	• Case 2: thin cirrus retrieved • Cirrus: **τ = 0.065** De=60 12:13km • Water Cloud – τ =10. Re = 20. – **0:1 km** • OLR 264.9 • Albedo 0.3812

1. Catching cirrus would lower underlying water cloud height
2. Compensates OLR decrease due to cirrus
3. Increased SW absorption
   due to increased water vapor lower in atmosphere

Result : Lower TOA albedo by (-0.007), same OLR

1D Vs 3D

- Monte Carlo simulations show decreased reflectance of overcast clouds for 3D compared to 1D
- Loeb & Coakley
  - Fig 19 J.Climate Feb 1998

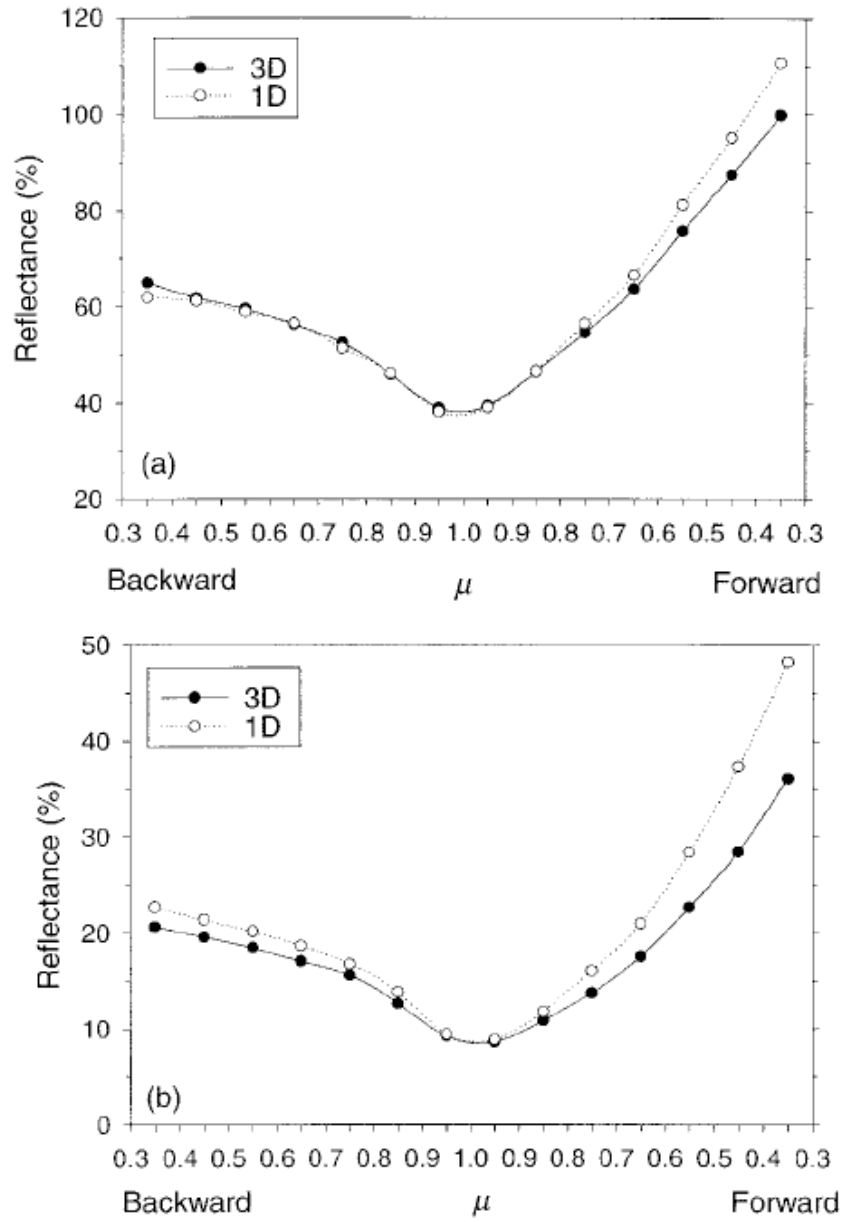
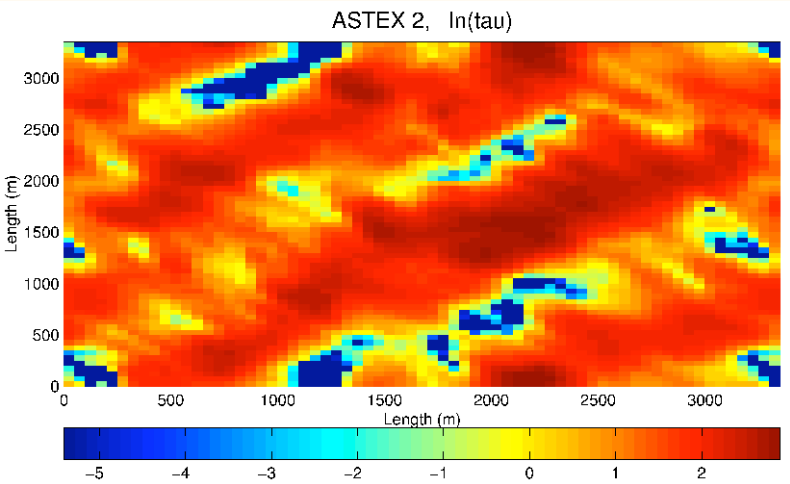
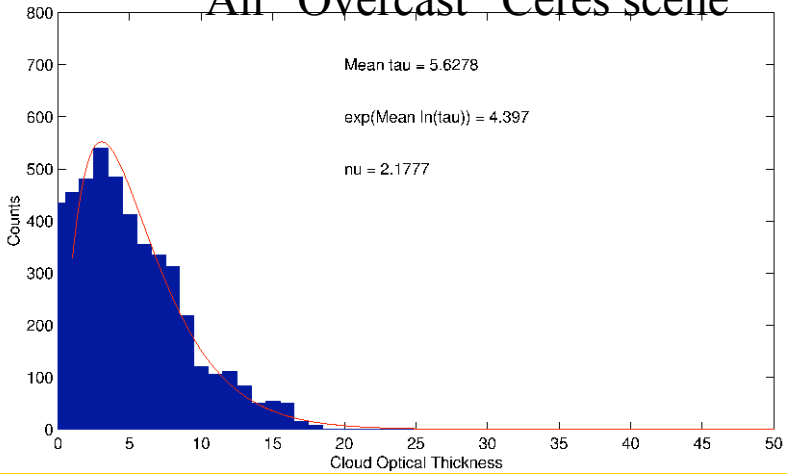


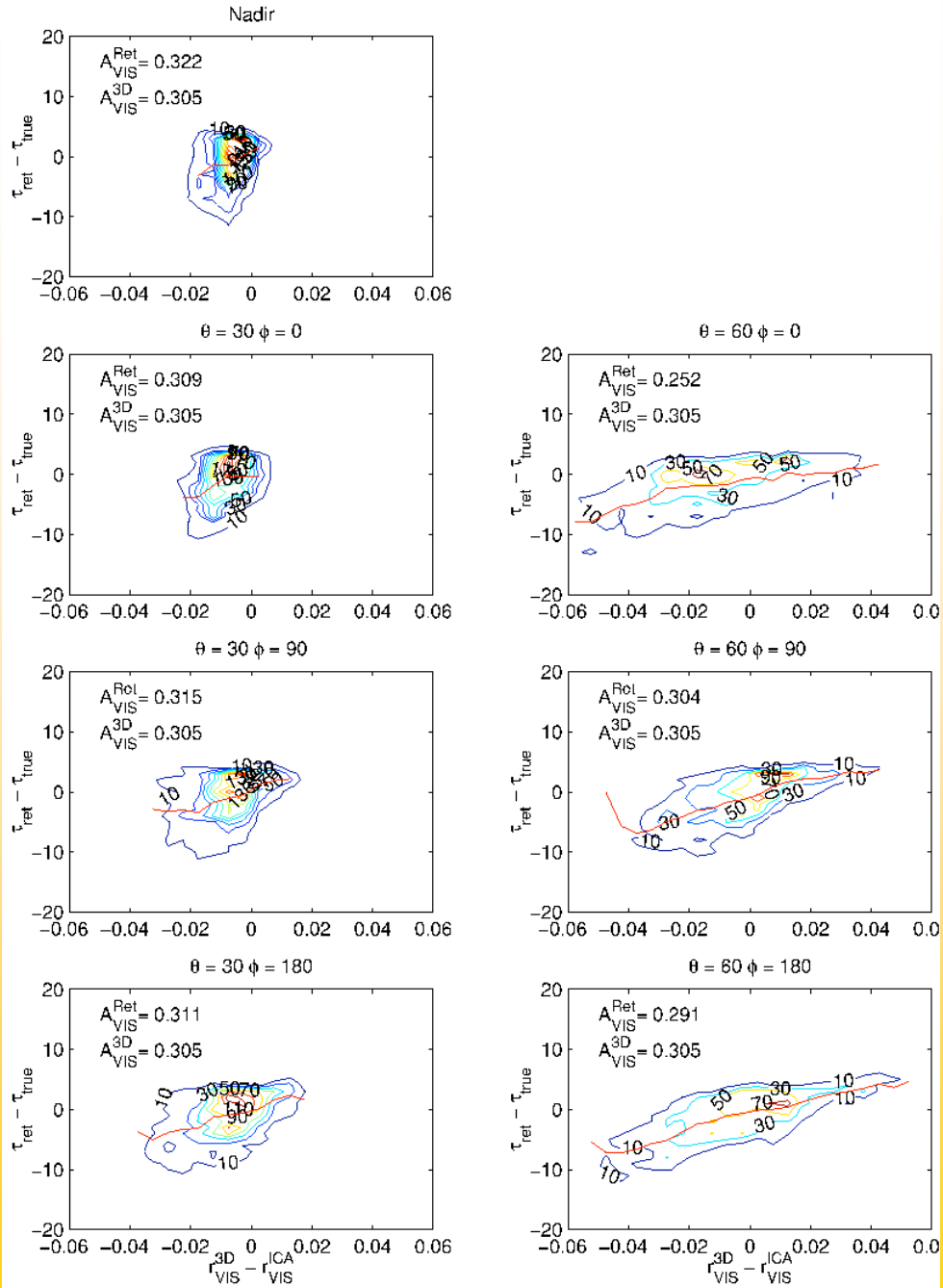
FIG. 19. Monte Carlo model simulations of 3D and 1D reflectances and μ for overcast cloud fields with single scattering albedos (ω_o) of (a) 1.0 and (b) 0.9.

3D Simulation
By S.Kato



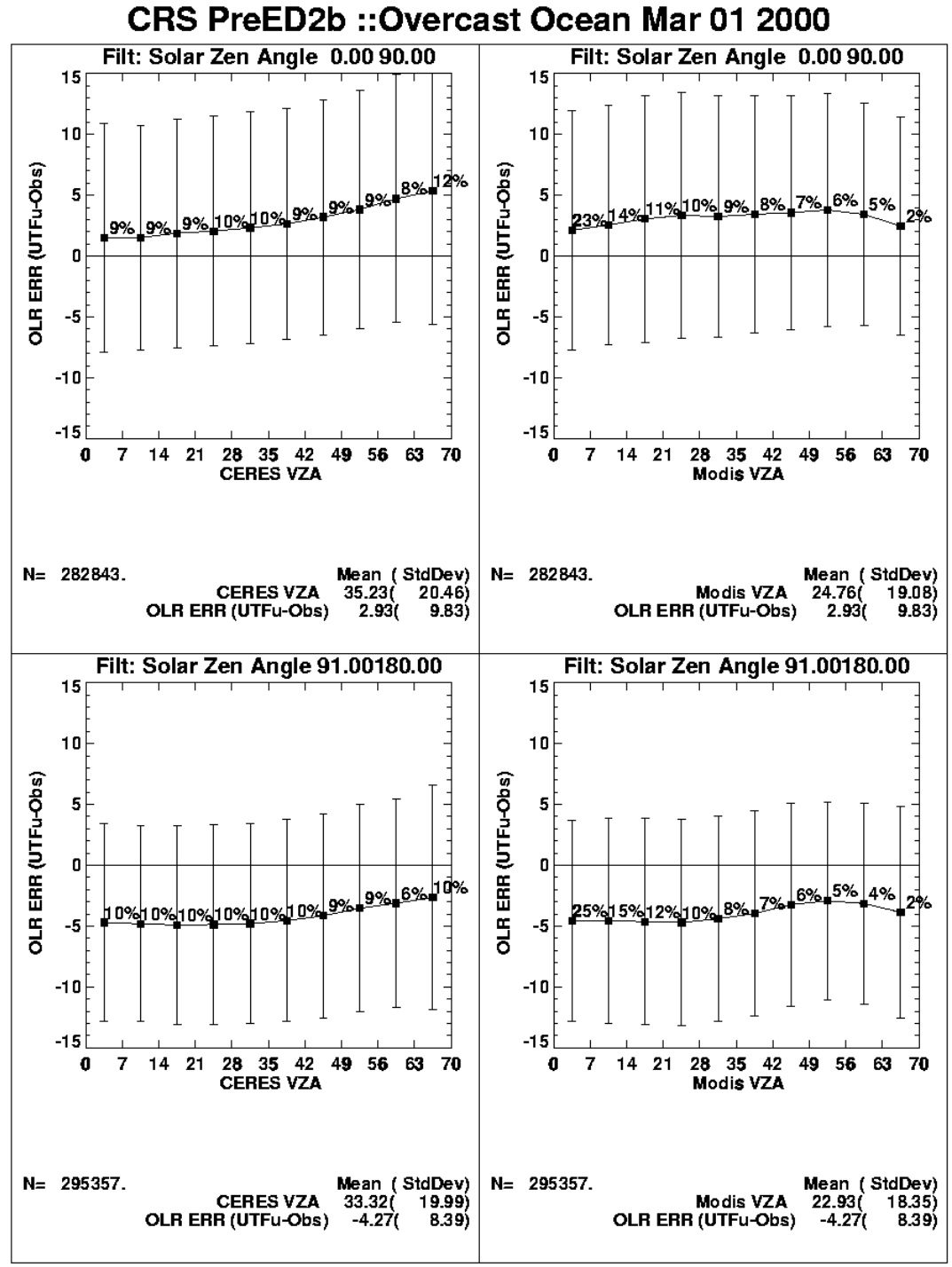
3.5 x 3.5 km Domain
An "Overcast" Ceres scene





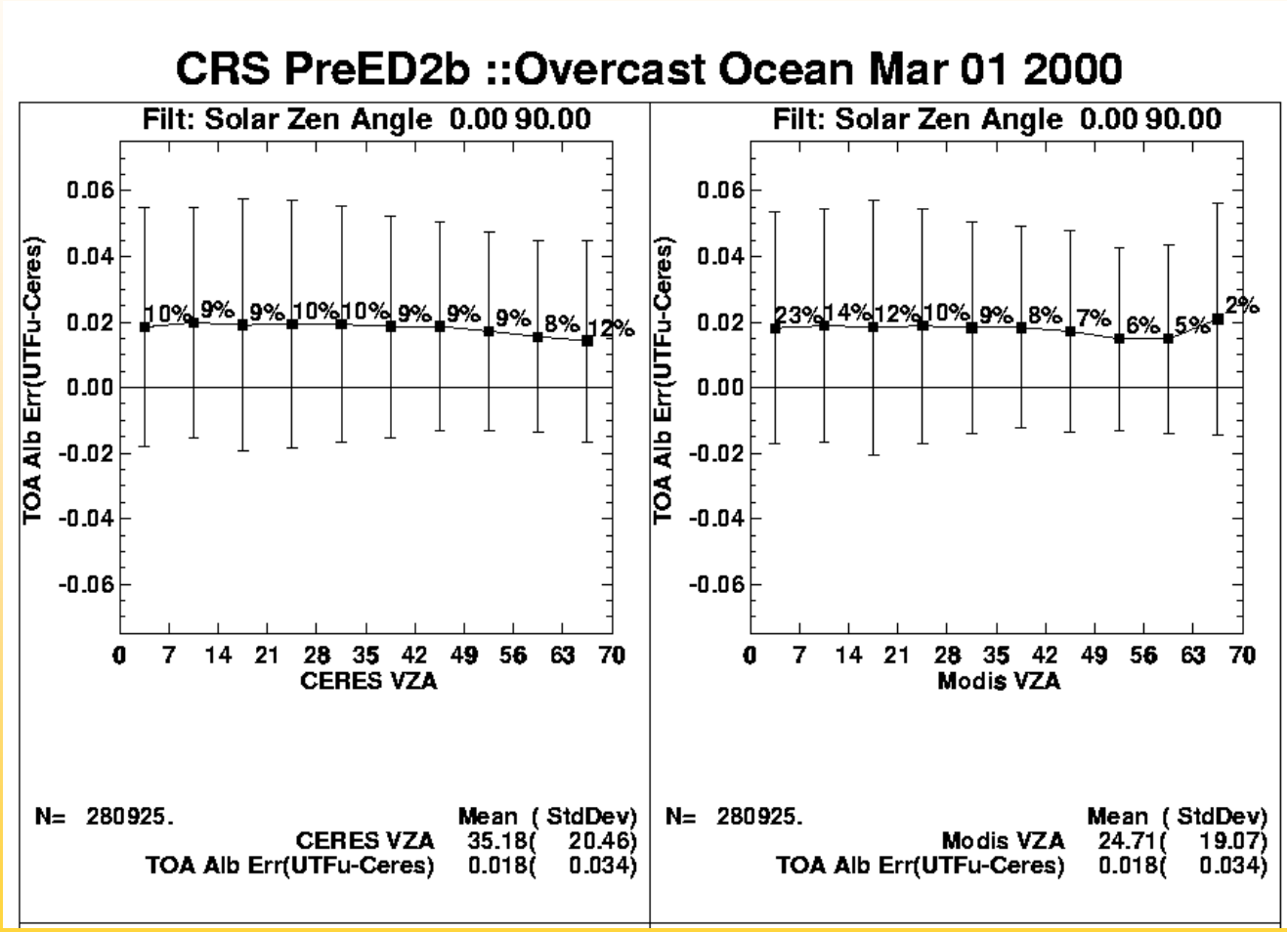
View Zenith Vs LW Flux Bias Untuned-Observed

- FM1 RAPS day
- Larger Positive error at oblique angle
  - Missing Cirrus?
  - UTRH too low?
- Less dependence too MODIS view angle
- Day Positive Bias
- Night Negative



View Zenith and TOA Albedo Bias

- FM1-RAPS
  - Single day
- Weak evidence consistent with:
  - Undetected cirrus?
  - Small scale 3D effects??



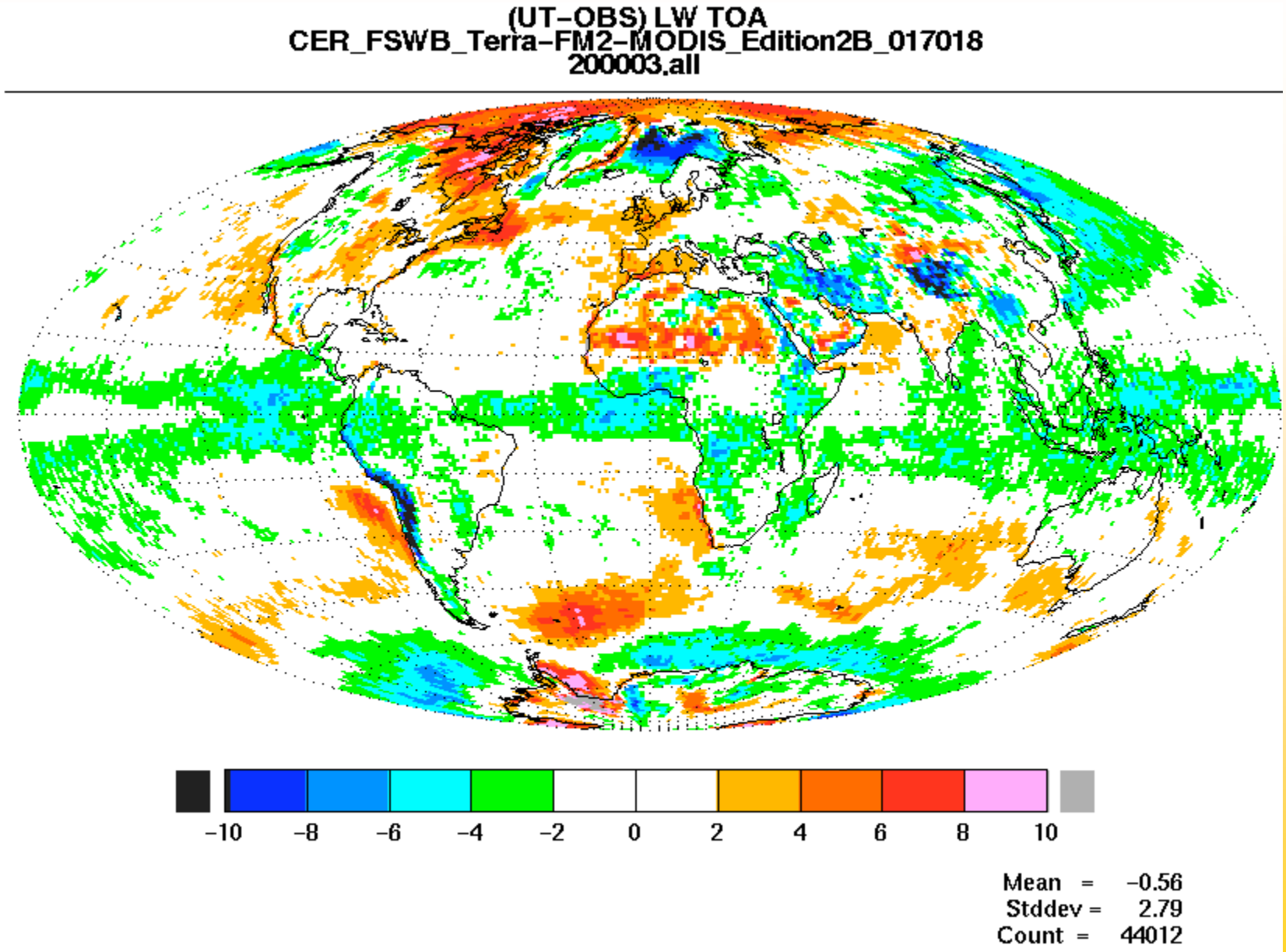
Conclusion

- Drift in Shortwave Toa bias
  - Consistent with CERES dimming
  - ~0.47 Wm-2 yr-1 or 0.37% yr-1
- Drift in Longwave Toa bias
  - ~0.38 Wm-2 yr-1 or 0.16 % yr-1
  - Mostly from Clear Sky Land.
- Untuned Shortwave Toa bias worst over Overcast Ocean.

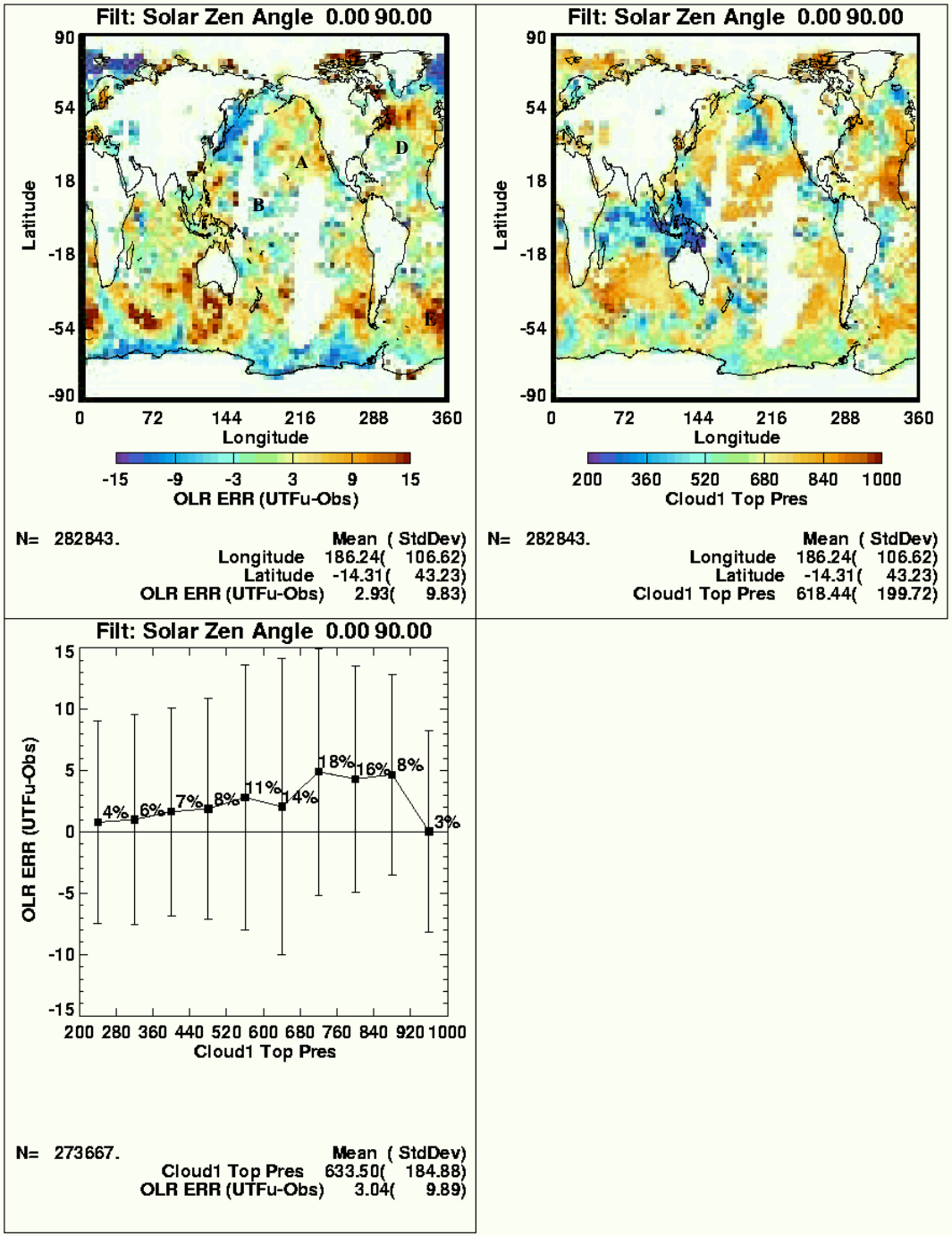
CRS Longwave TOA Bias

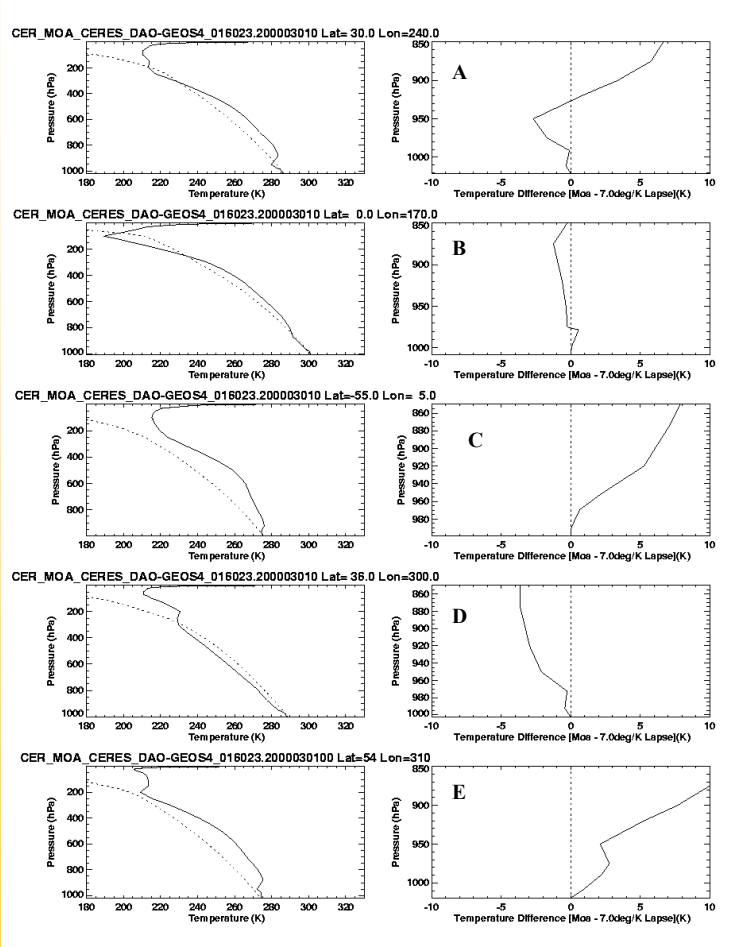
- Large day vs night differences
  - Cloud Fraction of High Cloud overestimated at night ?
- Inconsistency in regions where surface temperature inversions occur
  - Cloud retrieval assume ~7 K/km lapse rate
    - Near surface over ocean
  - Sarb RT calculations use Geos4 supplied temperature profiles

TOA LW Untuned-Observed

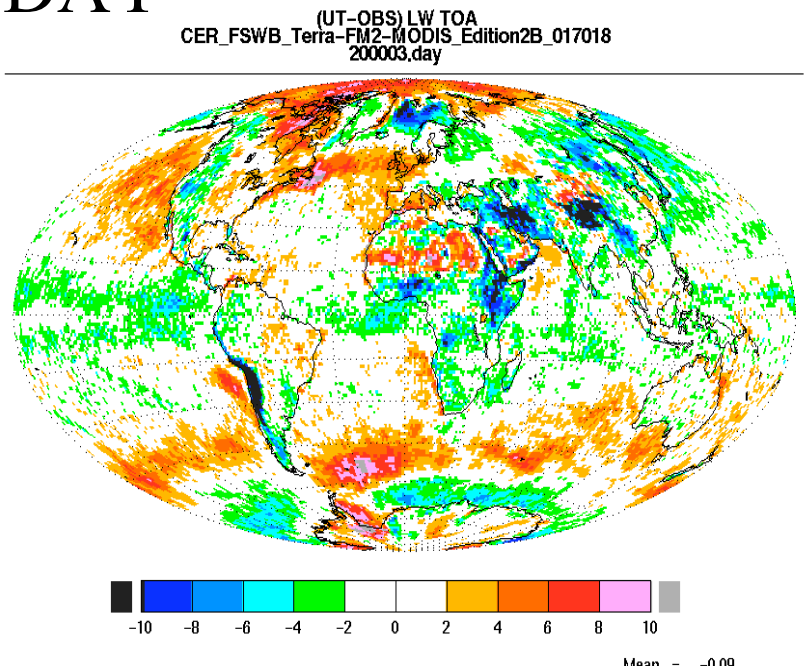


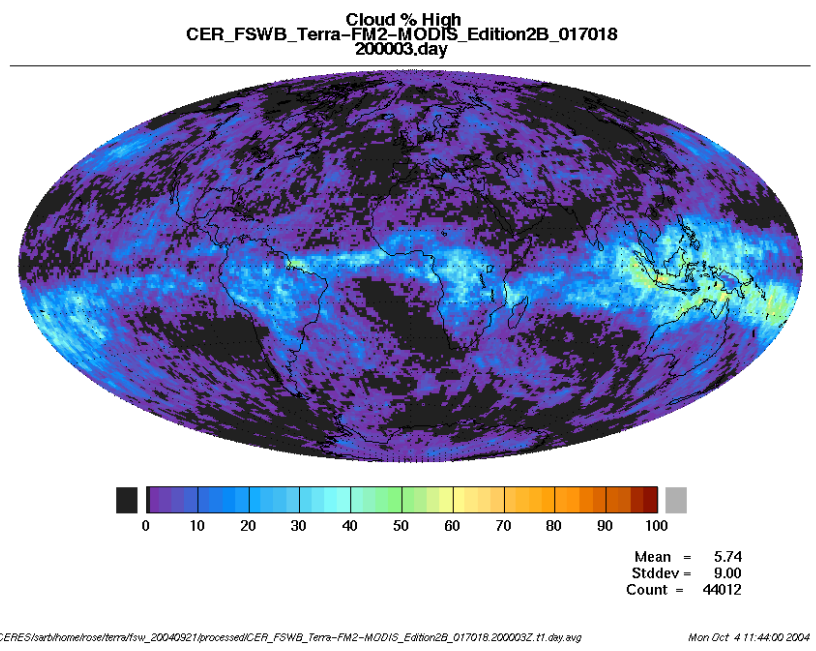
CRS PreED2b ::Overcast Ocean Mar 01 2000



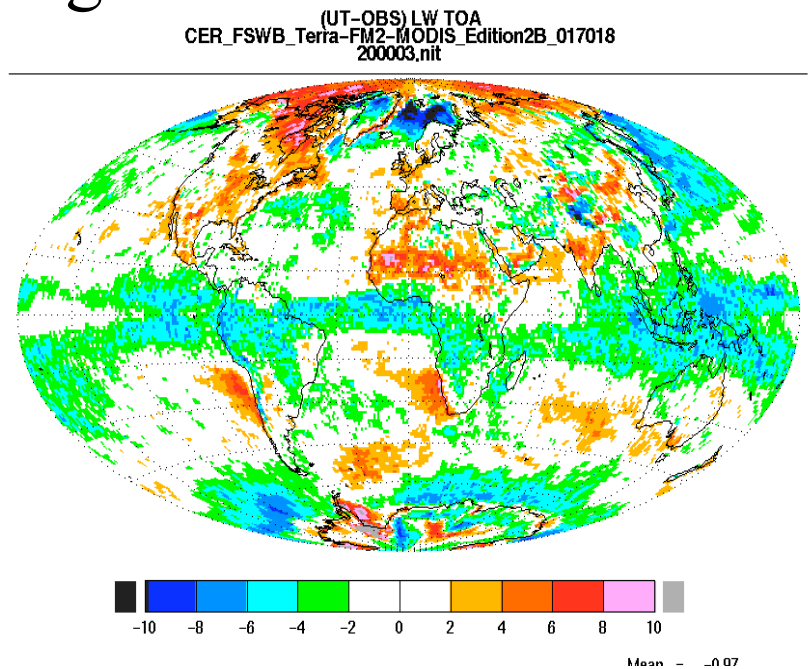


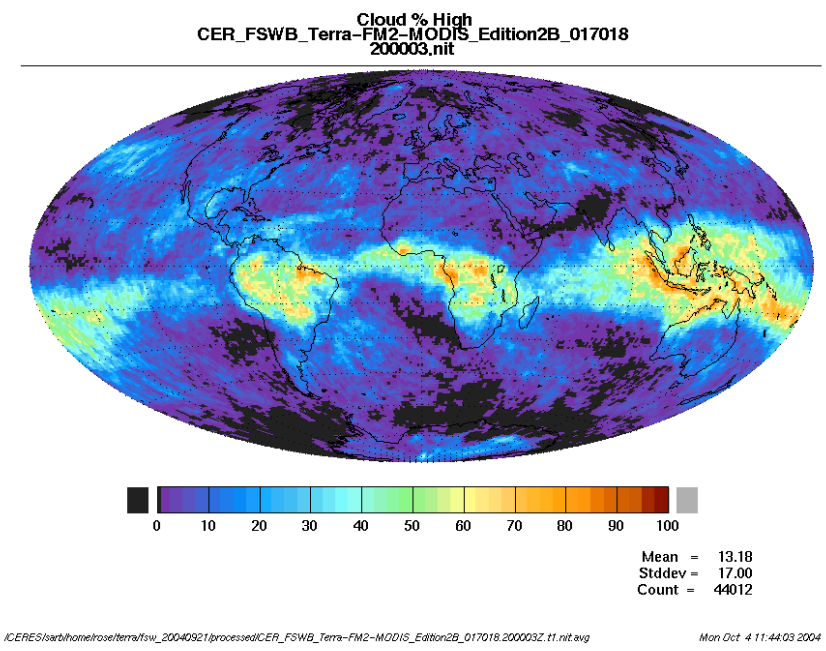
DAY


(UT-OBS) LW TOA
CER_FSWB_Terra-FM2-MODIS_Edition2B_017018
200003.day
-10 -8 -6 -4 -2 0 2 4 6 8 10


Cloud % High
CER_FSWB_Terra-FM2-MODIS_Edition2B_017018
200003.day
0 10 20 30 40 50 60 70 80 90 100
Mean = 5.74
Stddev = 9.00
Count = 44012
/CERES/sarb/home/rose/terra/fsw_20040921/processed/CER_FSWB_Terra-FM2-MODIS_Edition2B_017018.200003Z.t1.day.avg
Mon Oct 4 11:44:00 2004

Night


(UT-OBS) LW TOA
CER_FSWB_Terra-FM2-MODIS_Edition2B_017018
200003.nit
-10 -8 -6 -4 -2 0 2 4 6 8 10


Cloud % High
CER_FSWB_Terra-FM2-MODIS_Edition2B_017018
200003.nit
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Stddev = 17.00
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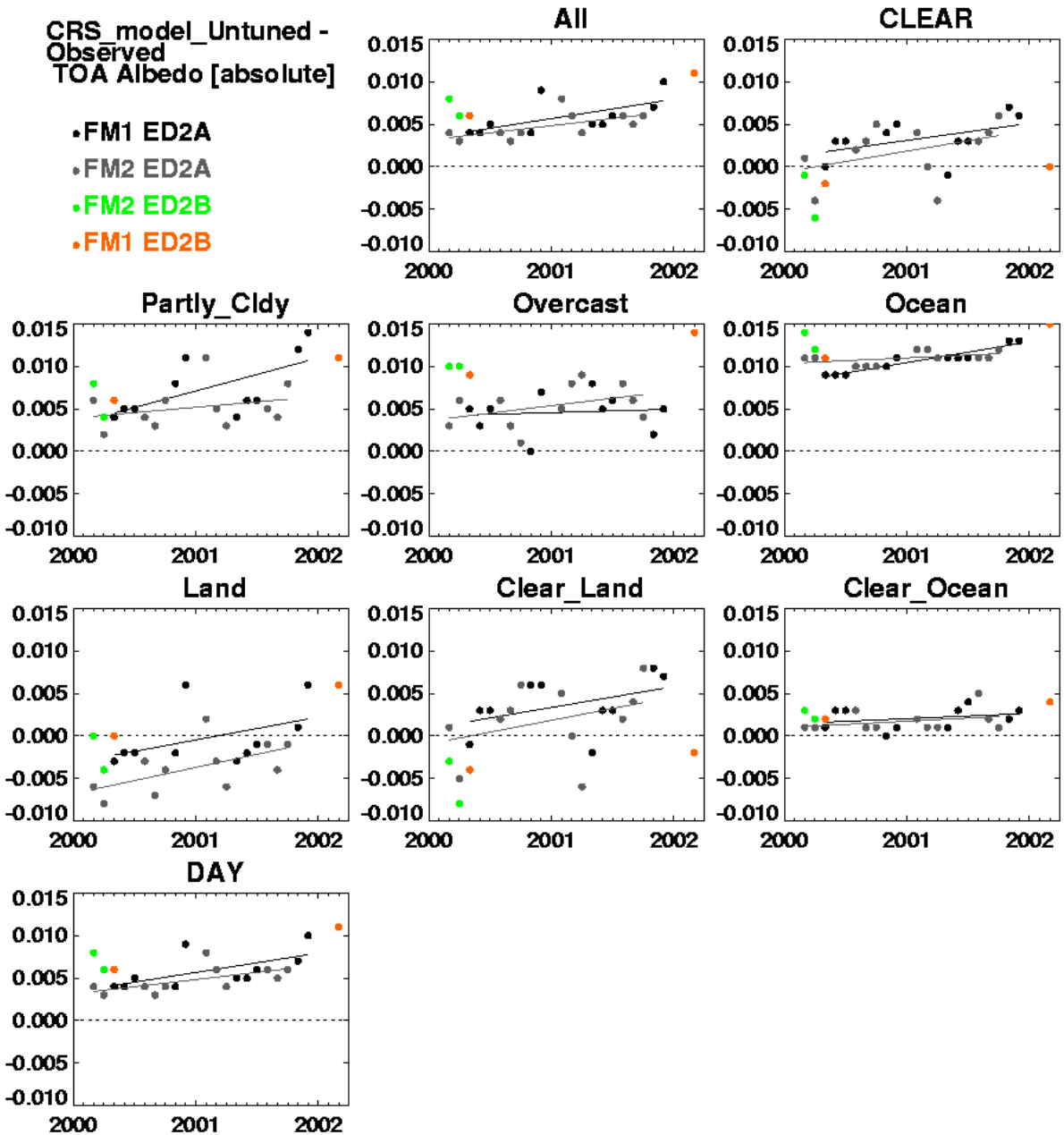
Mon Oct 4 11:44:03 2004

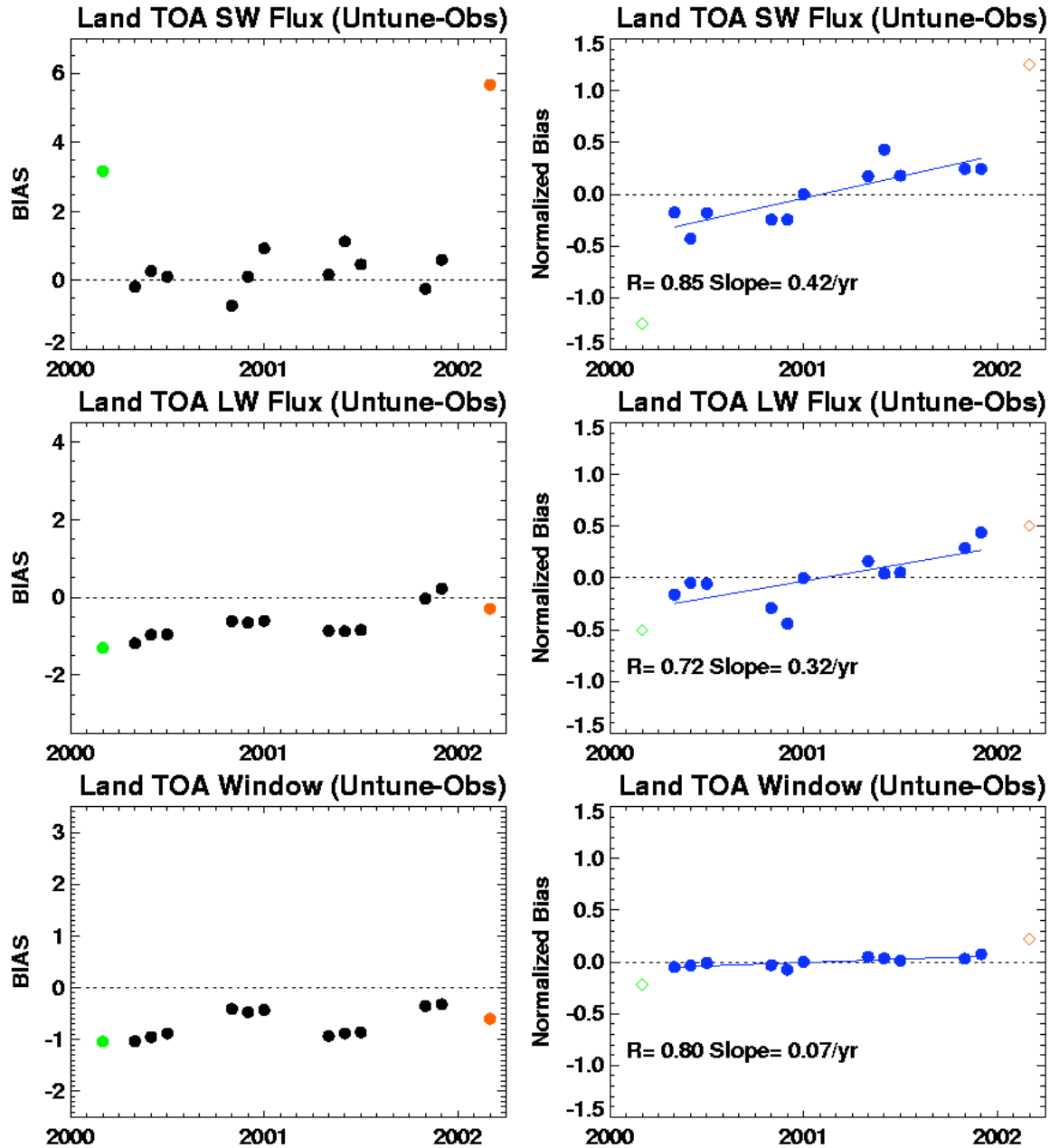
Spare Slides

SW Albedo


CRS_model_Untuned - Observed
TOA Albedo [absolute]
FM1 ED2A
FM2 ED2A
FM2 ED2B
FM1 ED2B
All
CLEAR
Partly_Cldy
Overcast
Ocean
Land
Clear_Land
Clear_Ocean
DAY
0.015
0.010
0.005
0.000
-0.005
-0.010
2000
2001
2002

Land

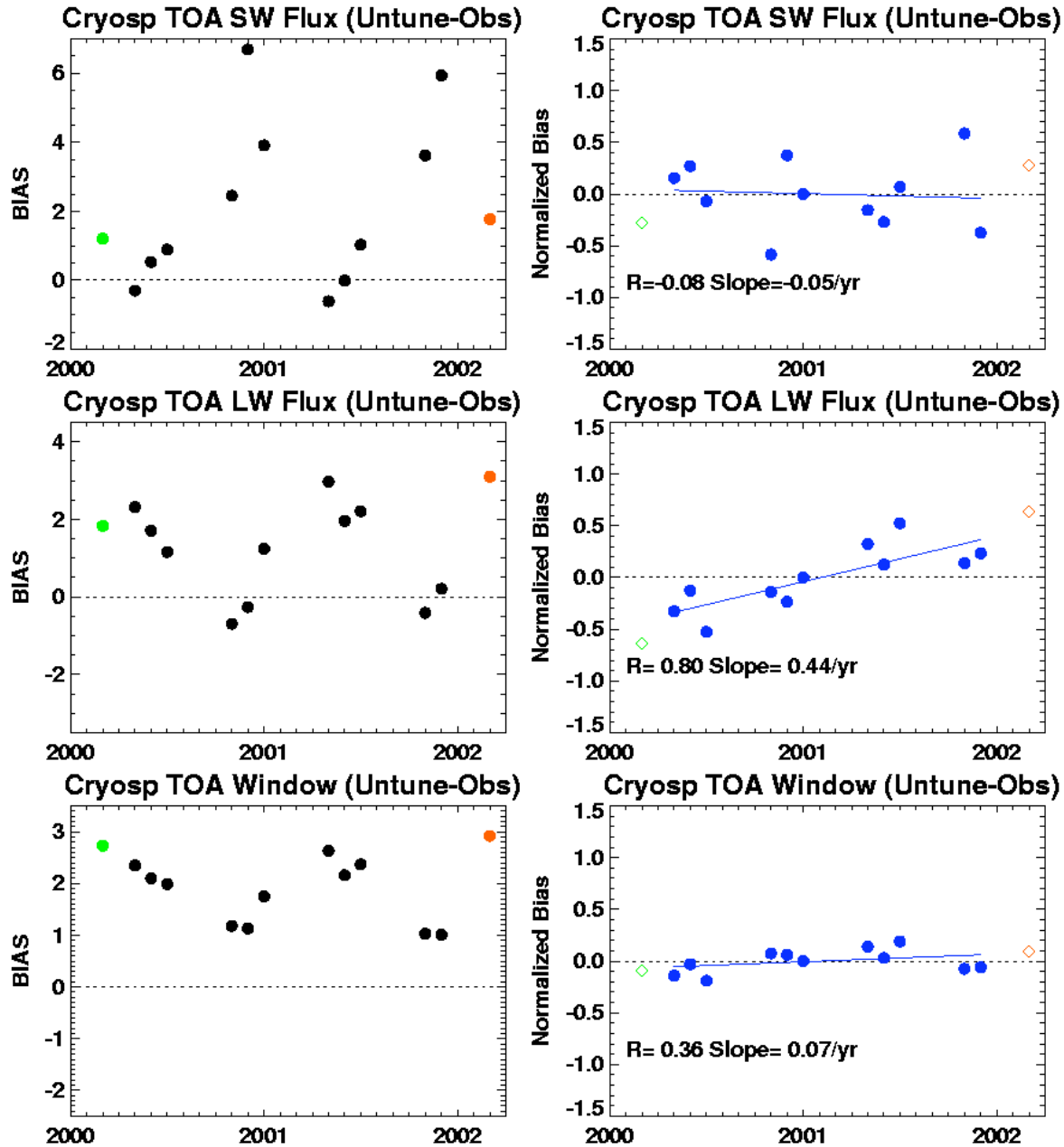
- FM1 ED2A
- FM2 ED2A
- FM2 ED2B
- FM1 ED2B



Normalized by multi-year monthly means

Cryosphere

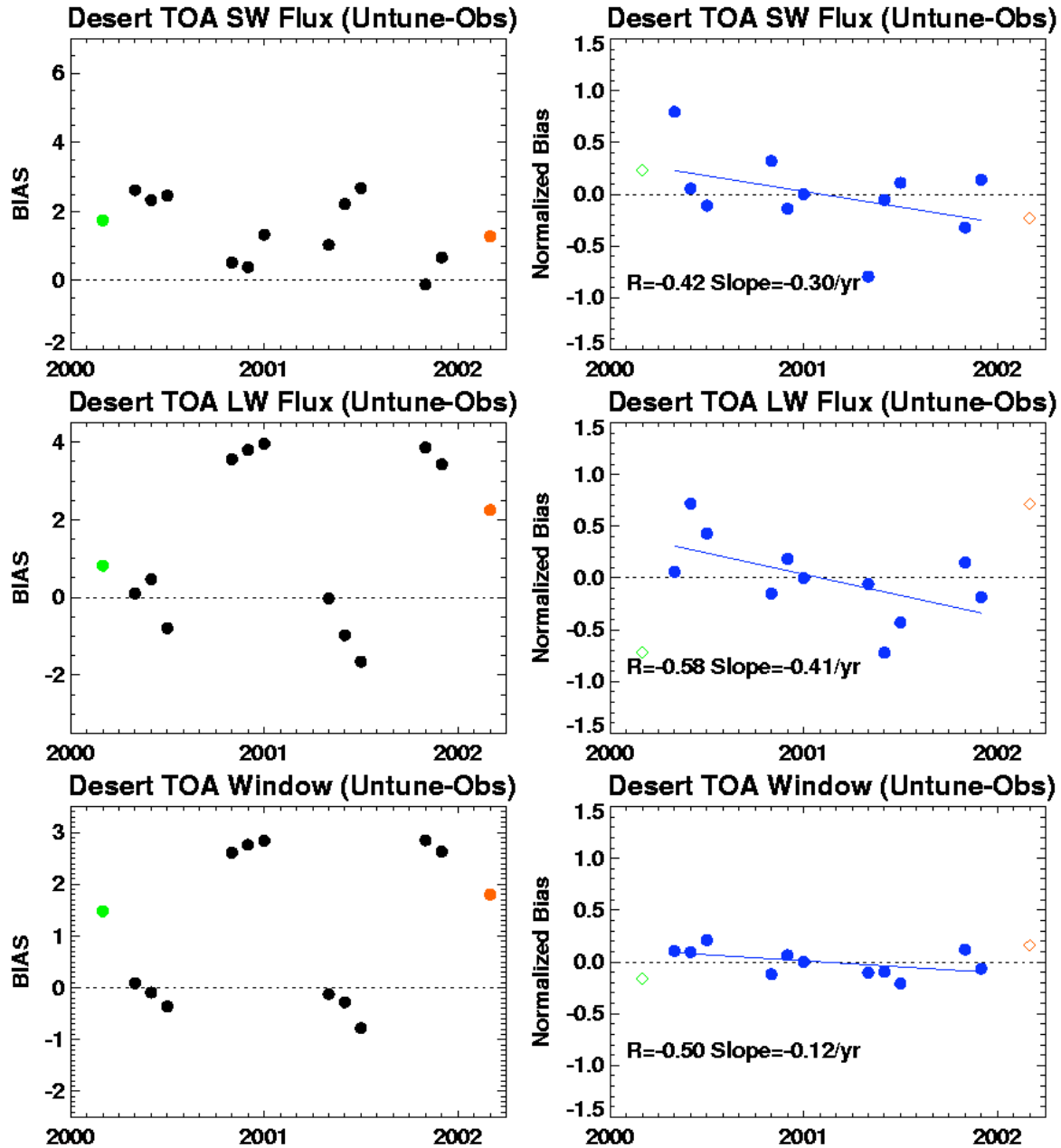
- FM1 ED2A
- FM2 ED2A
- FM2 ED2B
- FM1 ED2B



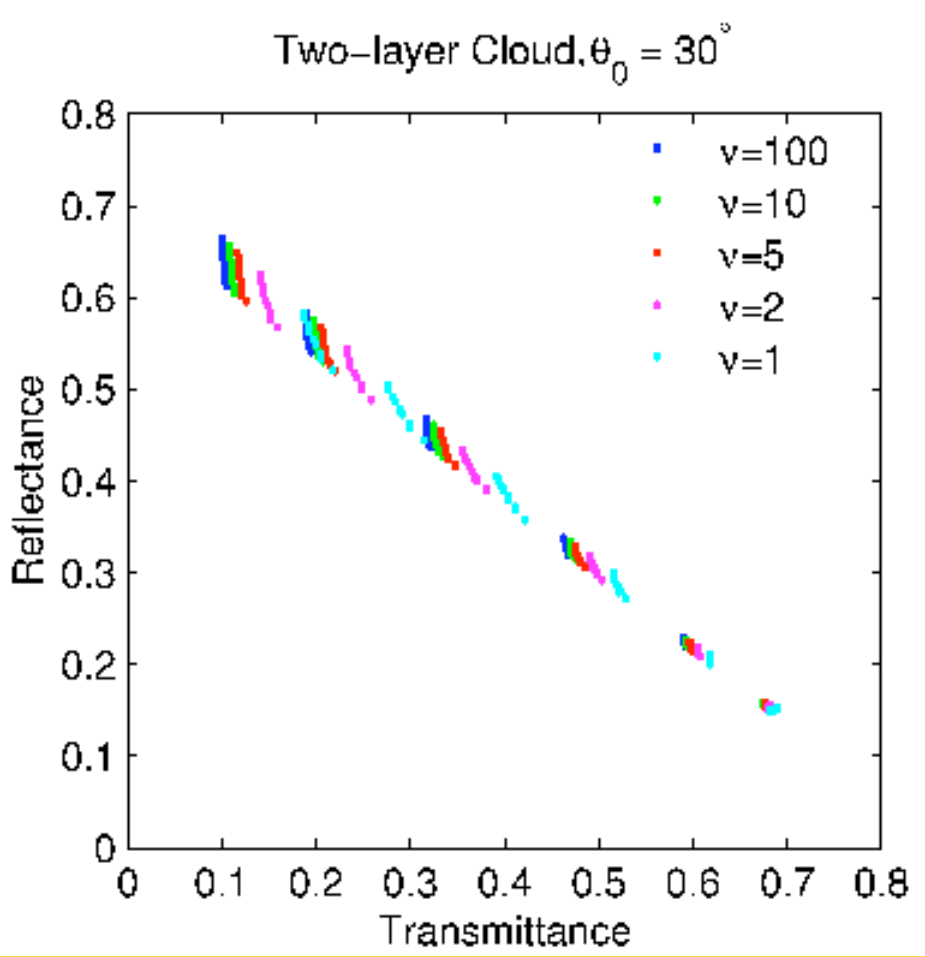
Normalized by multi-year monthly means

Desert

- FM1 ED2A
- FM2 ED2A
- FM2 ED2B
- FM1 ED2B



Normalized by multi-year monthly means


Two−layer Cloud, θ_0 = 30°
Reflectance
Transmittance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ν=100
ν=10
ν=5
ν=2
ν=1