CERES CLOUD WORKING GROUP SUMMARY

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AS&M: P. W. Heck, D. R. Doelling

CERES STM, Newport News, VA, May 1, 2001

- CALIBRATION
  - CERES VS VIRS
  - VIRS VS ATSR-2
  - VIRS VS GOES
  - VIRS VS MODIS

- ALGORITHM STUDIES
  - CLOUD RETRIEVAL PARAMETERIZATION
  - CLOUD MASK CHANGES
    - VZA DEPENDENCE
    - DAYTIME POLAR

CHANGES TO CLOUD MASK

**. Further improved false cloud detection over barren using VIST no retrieval an
Velch tree.**

> **If weak clouds, VIST no retrieval, and Welch mask says clear, then thes
weak clouds --> clear.**

. Improved cloud detection over moderate and strong sun glint regions.

**. Added smoke tests over land (in C3) weak clear region using reflectance ratio o
.6 to 3.7.**

. In night time mask, added T4-T5 test to confirm strong cloud.

OTHER CLOUD CODE CHANGES

- **Included water absorption in 0.6µm**
- **New no-intercept 1.6-µm calibration**
- **Corrected 3.7-µm model (coding error correction)**
- **VISST code error fixed (jumps in τ)**
- **Implemented new tile size: 8 x 16 in VISST.**
- **New Calibration 1.6/0.6 ratio model for phase determination in VISST**
- **Introduced (40GP) higher resolution VIS reflectance model**
- **N2O absorption included in 3.7-µm calculations**

VIRS CALIBRATION

- **ALL CHANNELS APPEAR STABLE THROUGH MAR 2000 RELATIVE TO CERES BROADBAND (± 1%)**

  - **1.6 µm shows some possible drift (-2%)**

Use Welch Mask to Refine CERES Cloud M

CERES Cloud Mask	VISST	Welch Mask	Fina
weak clouds	no retrieval	clear	
weak clouds	no retrieval	aerosol	
weak clear		clear	
weak clear		aerosol	
weak clear		smoke, haze	

RESULTS

CLOUD MASK CLEAR STATISTICS, JANUARY 1998

Day: csz > 0.1

	Ocean	Land	Desert	Total
Clr Good	0.760	0.889	0.932	0.800
Clr Weak	0.016	0.036	0.032	0.022
Clr Smoke	0.033	0.029	0.013	0.031
Clr Fire	0.000	0.000	0.000	0.000
Clr Snow	0.000	0.031	0.014	0.008
Clr Glint	0.150	0.008	0.000	0.108
Clr Shadow	0.000	0.007	0.009	0.002
Clr Aerosol	0.041	0.001	0.001	0.029
Total	1.000	1.000	1.000	1.000

Night: csz < 0.1

	Ocean	Land	Desert	Total
Clr Good	0.817	0.522	0.065	0.646
Clr Weak	0.183	0.477	0.934	0.353
Clr Smoke	0.001	0.001	0.001	0.001
Total	1.000	1.000	1.000	1.000

CLOUD MASK CLOUD STATISTICS, JANUARY 1998

Day: csz > 0.1

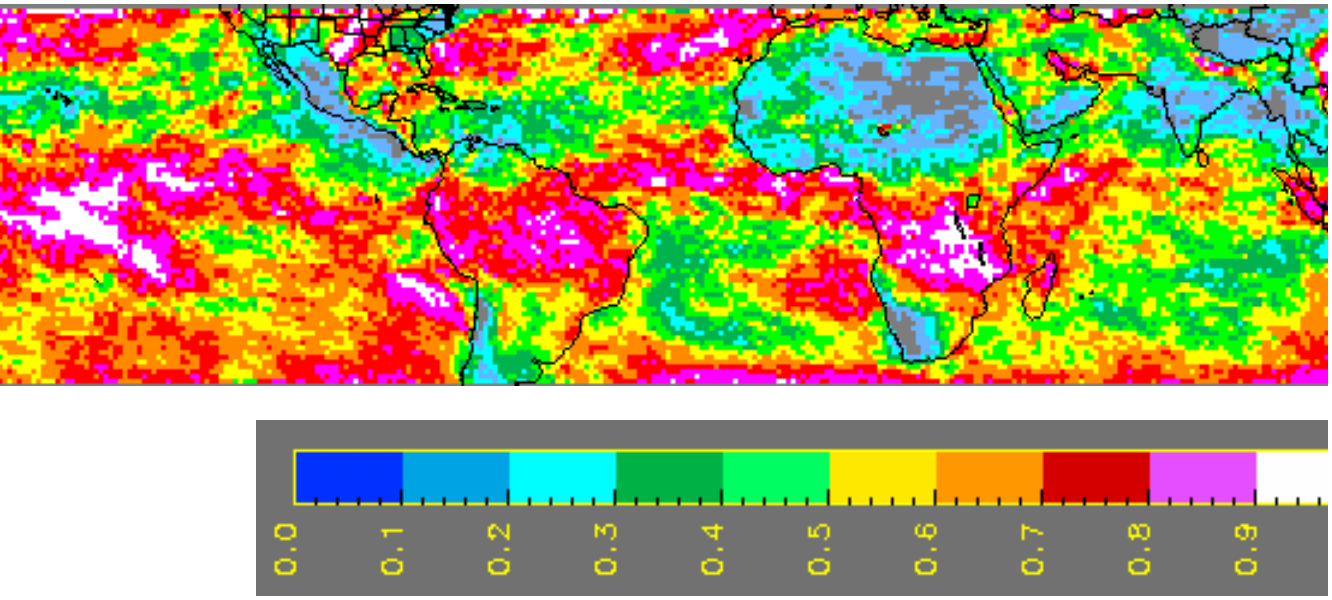
	Ocean	Land	Desert	Total
Cld Good	0.899	0.900	0.818	0.898
Cld Weak	0.046	0.045	0.090	0.047
Cld Glint	0.021	0.003	0.000	0.017
Cld VINT	0.033	0.053	0.093	0.038
Total	1.000	1.000	1.000	1.000

Night: csz < 0.1

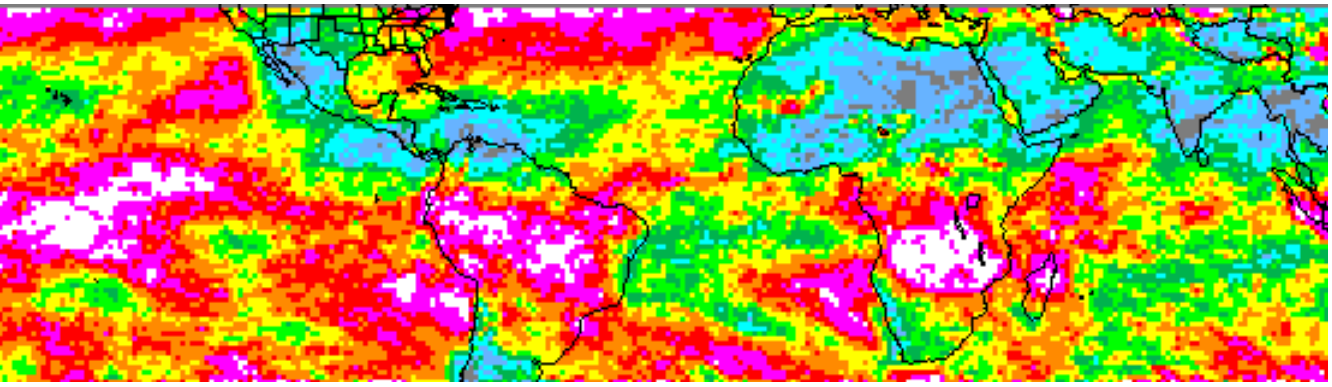
	Ocean	Land	Desert	Total
Cld Good	0.967	0.952	0.958	0.964
Cld Weak	0.019	0.039	0.014	0.023
Cld VINT	0.014	0.009	0.028	0.014
Total	1.000	1.000	1.000	1.000

MEAN EFFECTIVE CLOUD COVER, VIRS, JAN 1998

DAYTIME

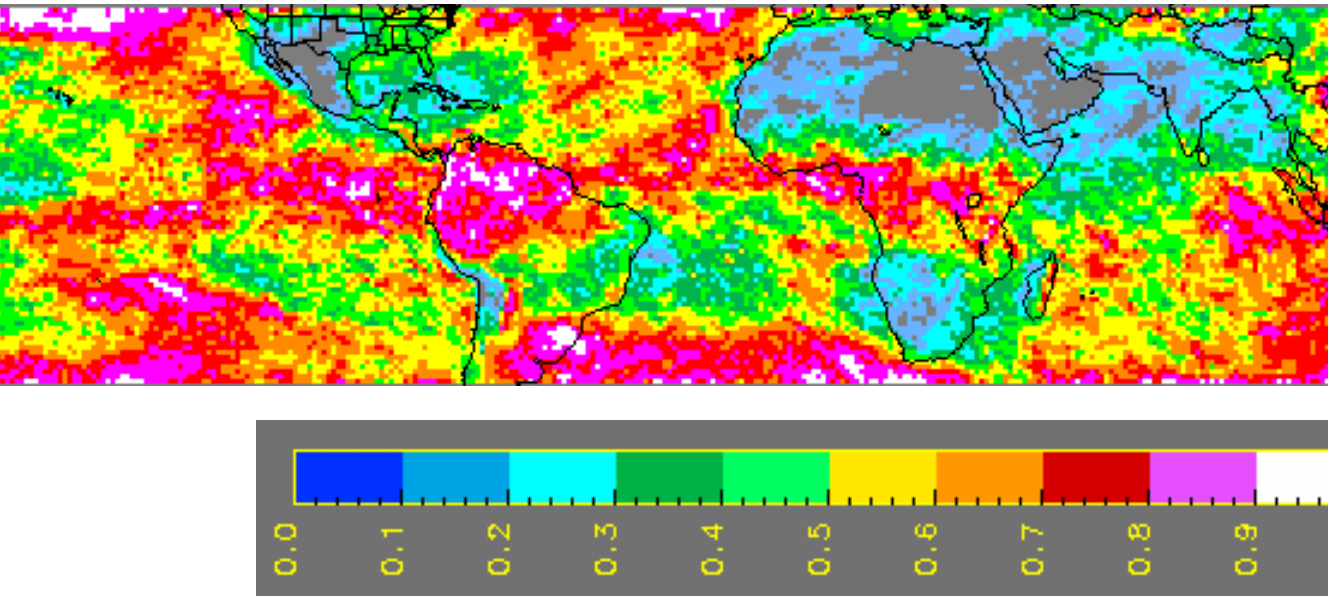


NIGHT



MEAN EFFECTIVE CLOUD COVER, VIRS, APRIL 1998

DAYTIME



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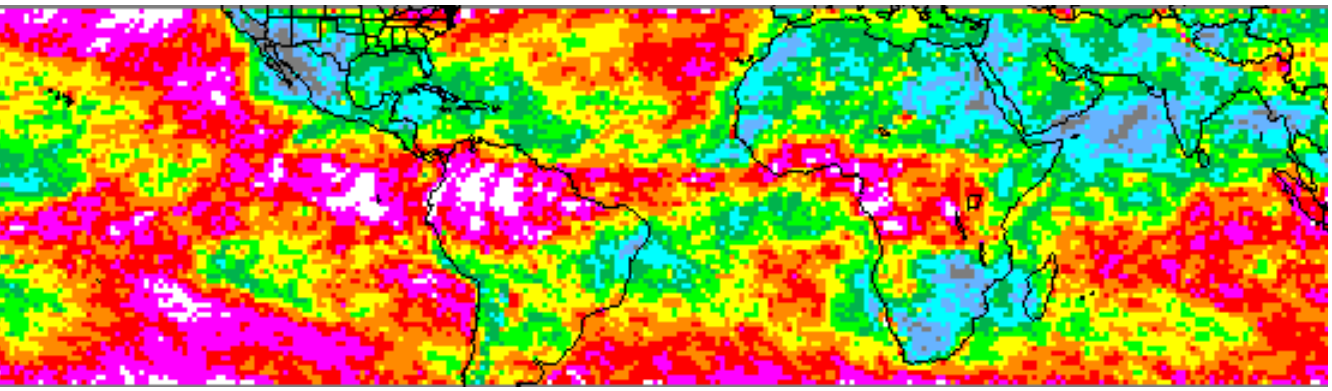
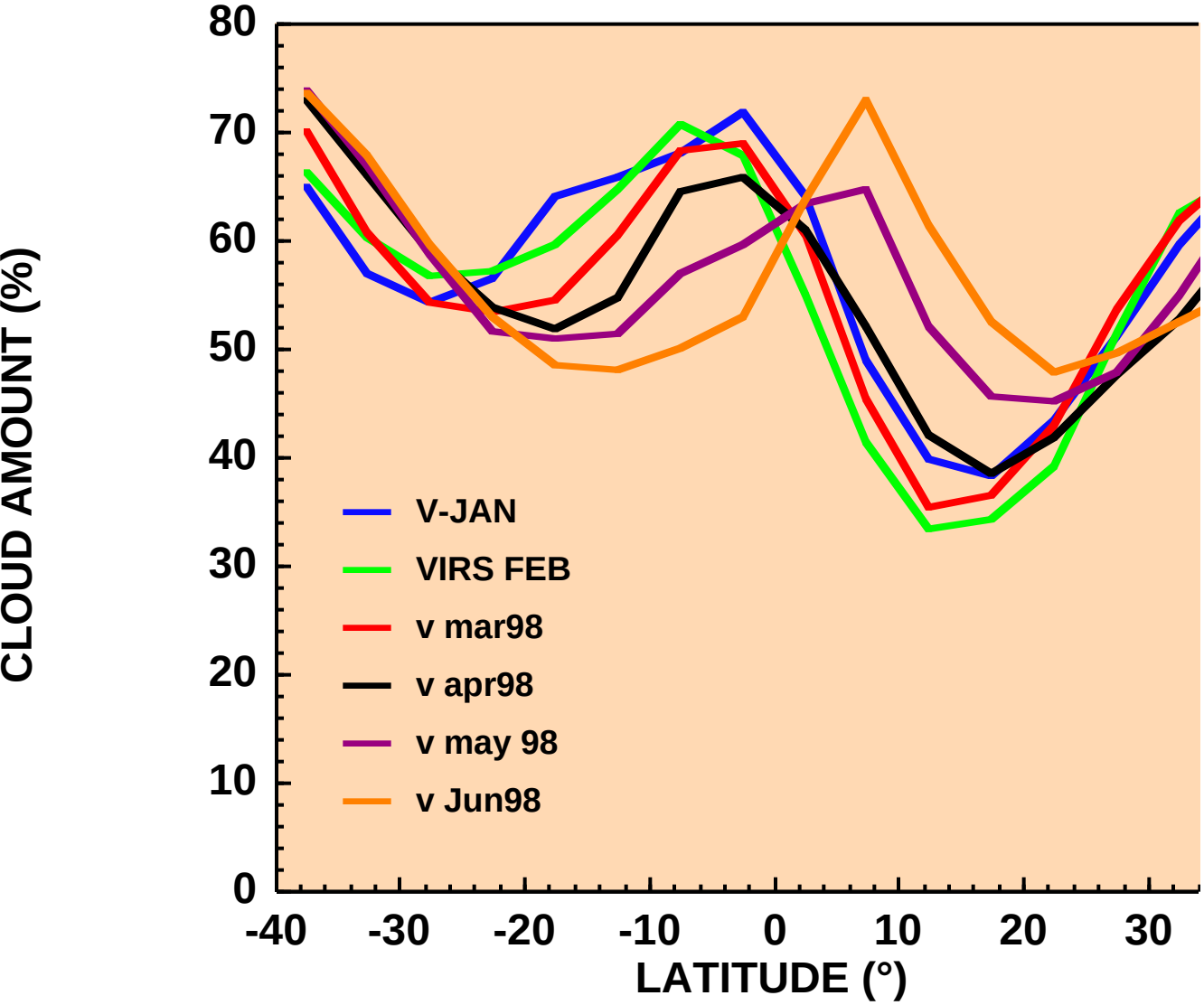


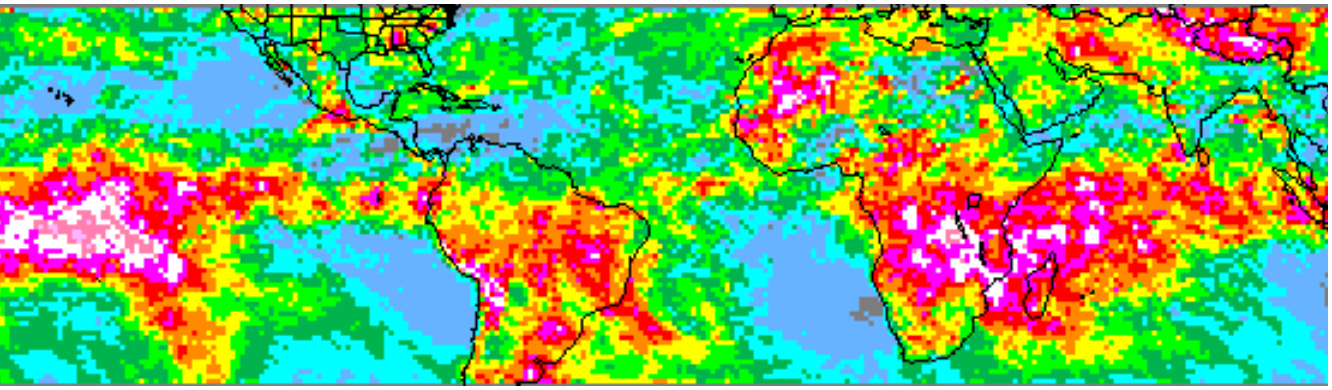
MONTHLY VARIATION OF TOTAL CLOUD AMOUNT

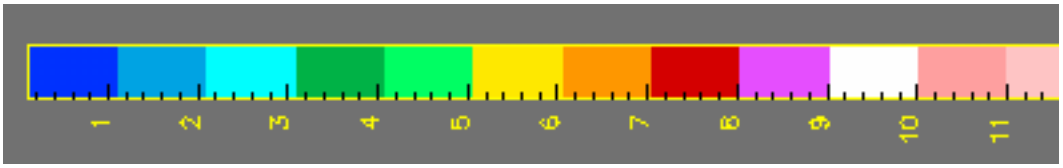
VIRS, 1998



MEAN EFFECTIVE CLOUD HEIGHT, VIRS, JANUARY 1998

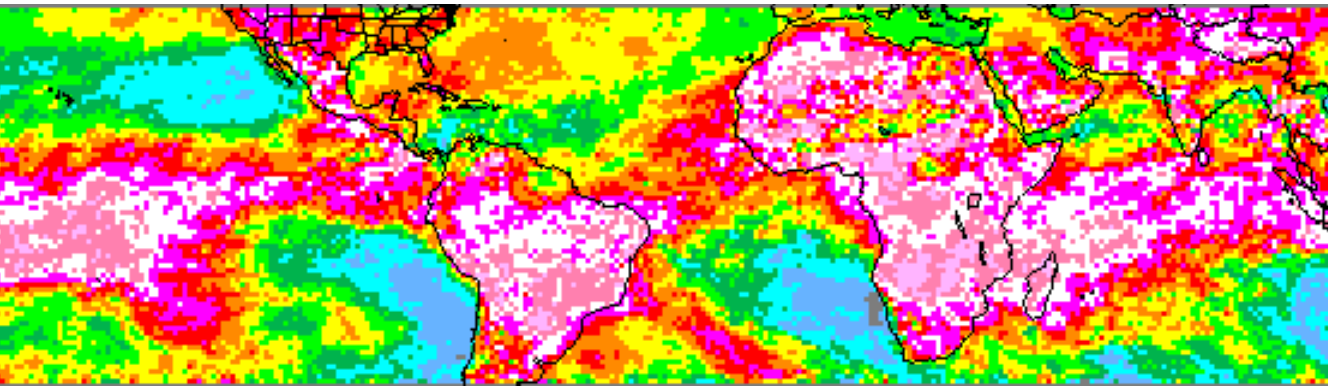
DAYTIME





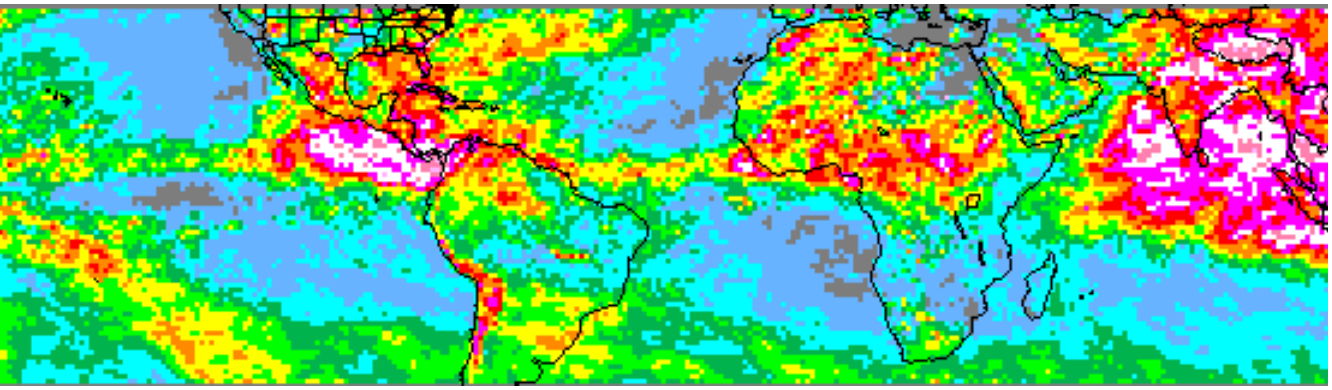
km

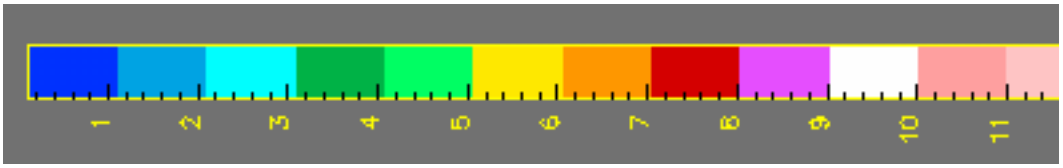
NIGHT



MEAN EFFECTIVE CLOUD HEIGHT, VIRS, JUNE 1998

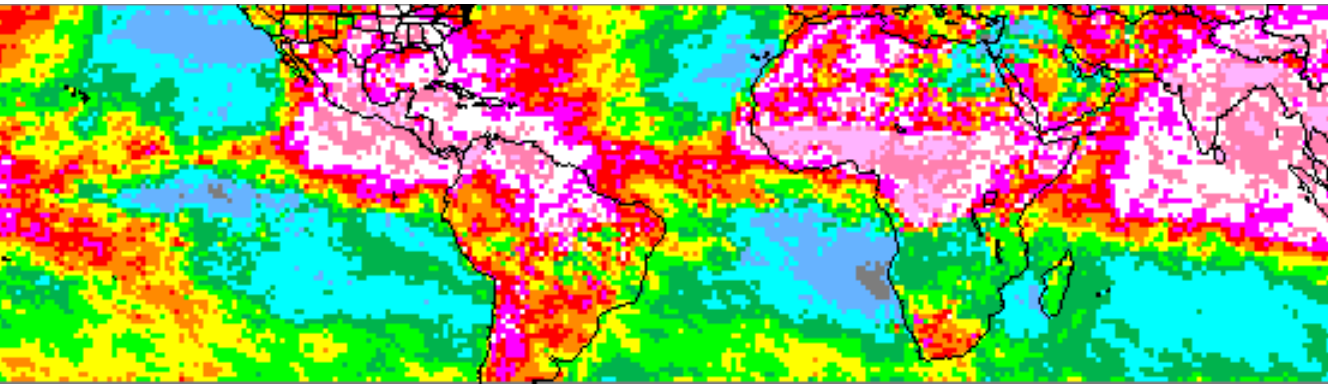
DAYTIME





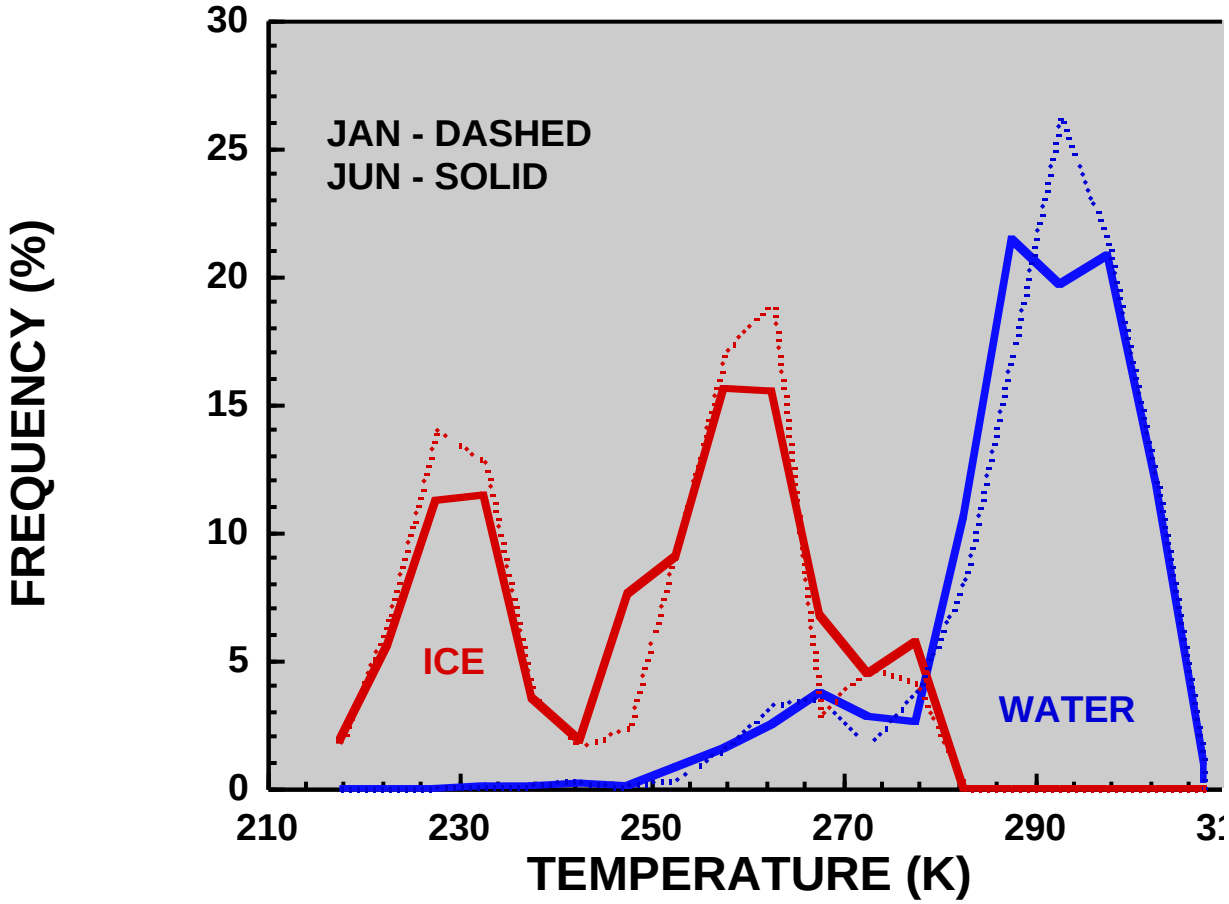
km

NIGHT

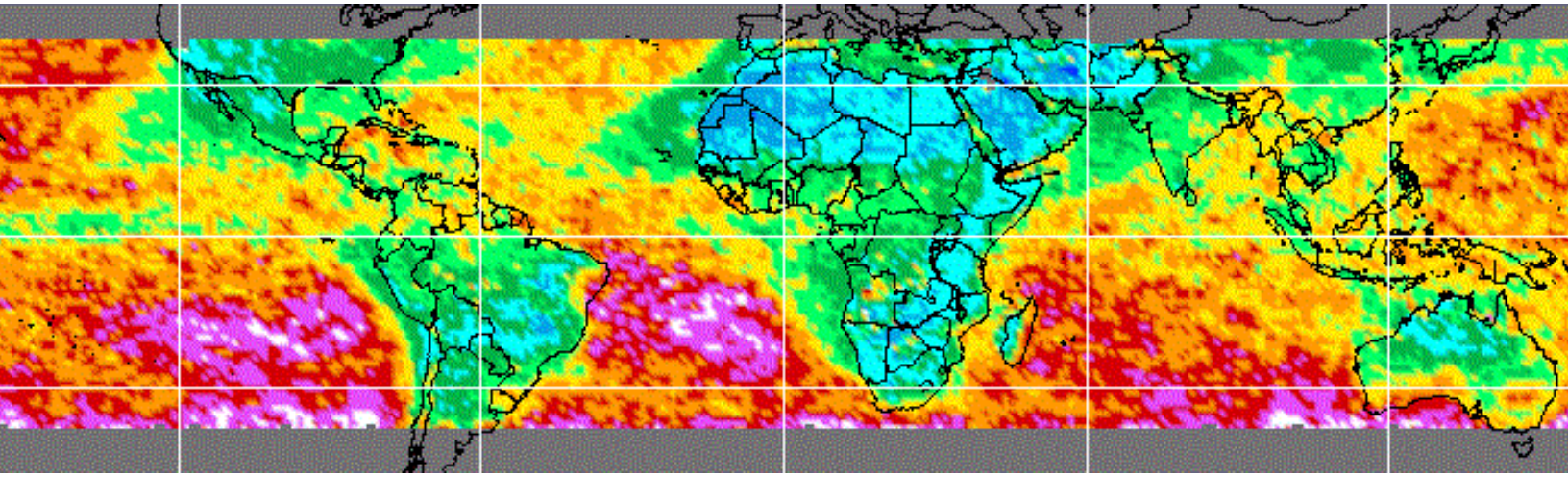


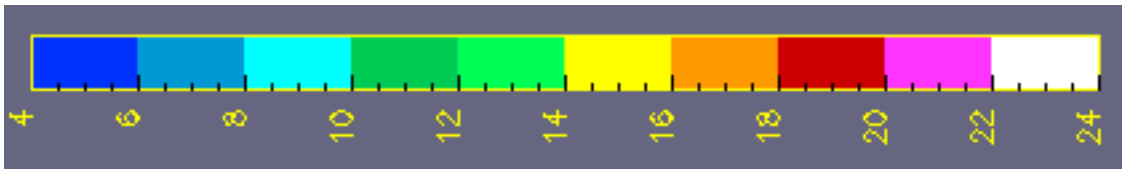
TEMPERATURE DISTRIBUTION OF PHASE

VIRS 1998



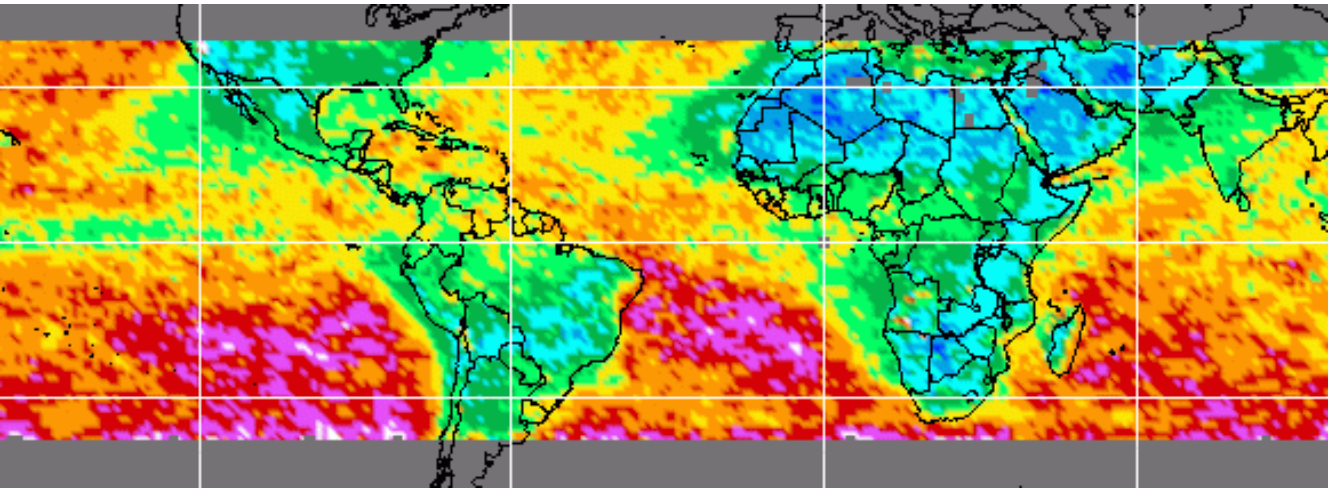
JULY 98 MEAN EFFECTIVE RADIUS FROM VIRS





OLD ^

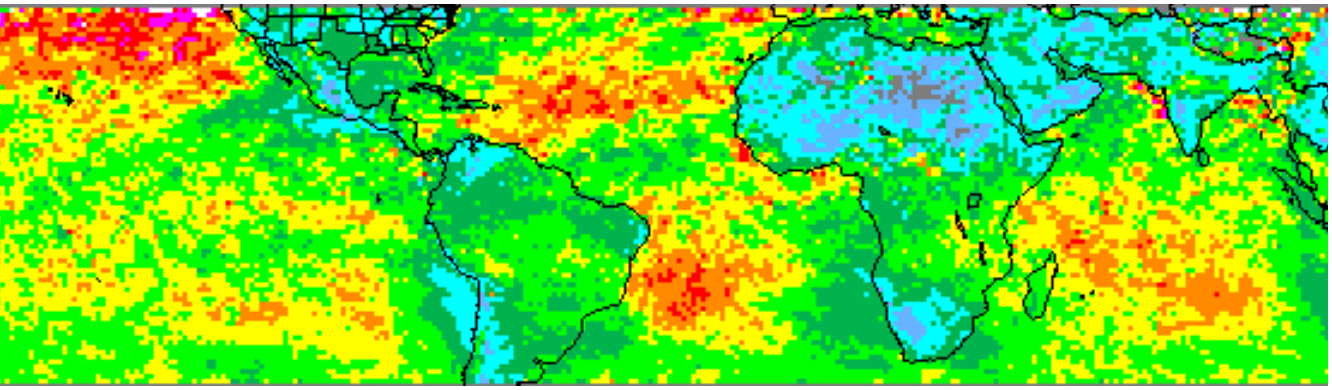
OLD

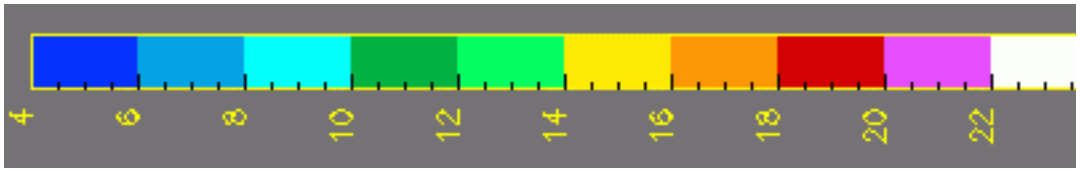


NEW ^

MEAN EFFECTIVE CLOUD DROPLET SIZE, VIRS, JAN 1998

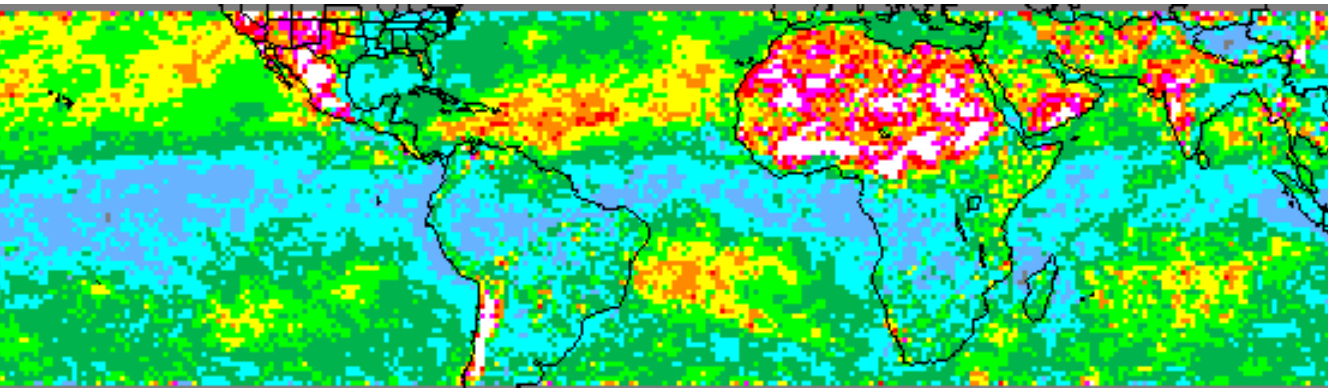
DAYTIME





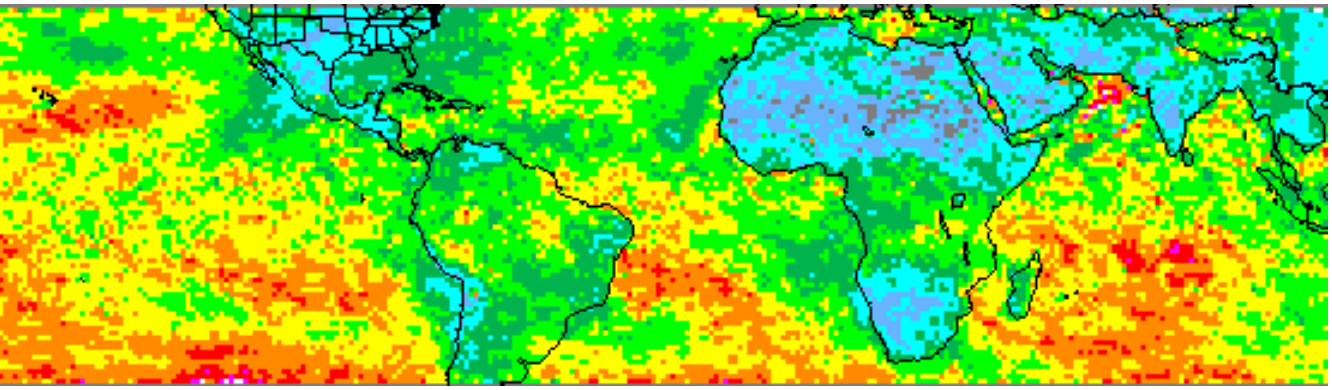
re, µm

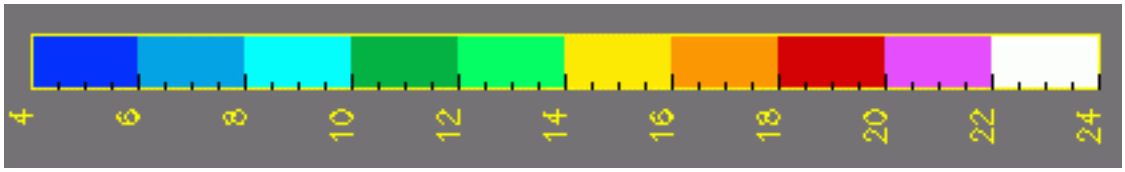
NIGHT



MEAN EFFECTIVE CLOUD DROPLET SIZE, DAY VIRS,1998

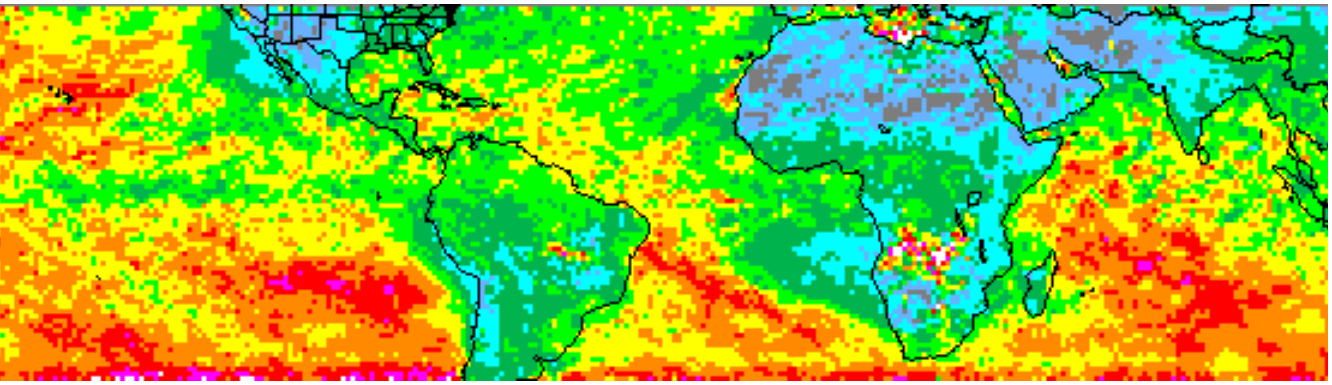
APRIL





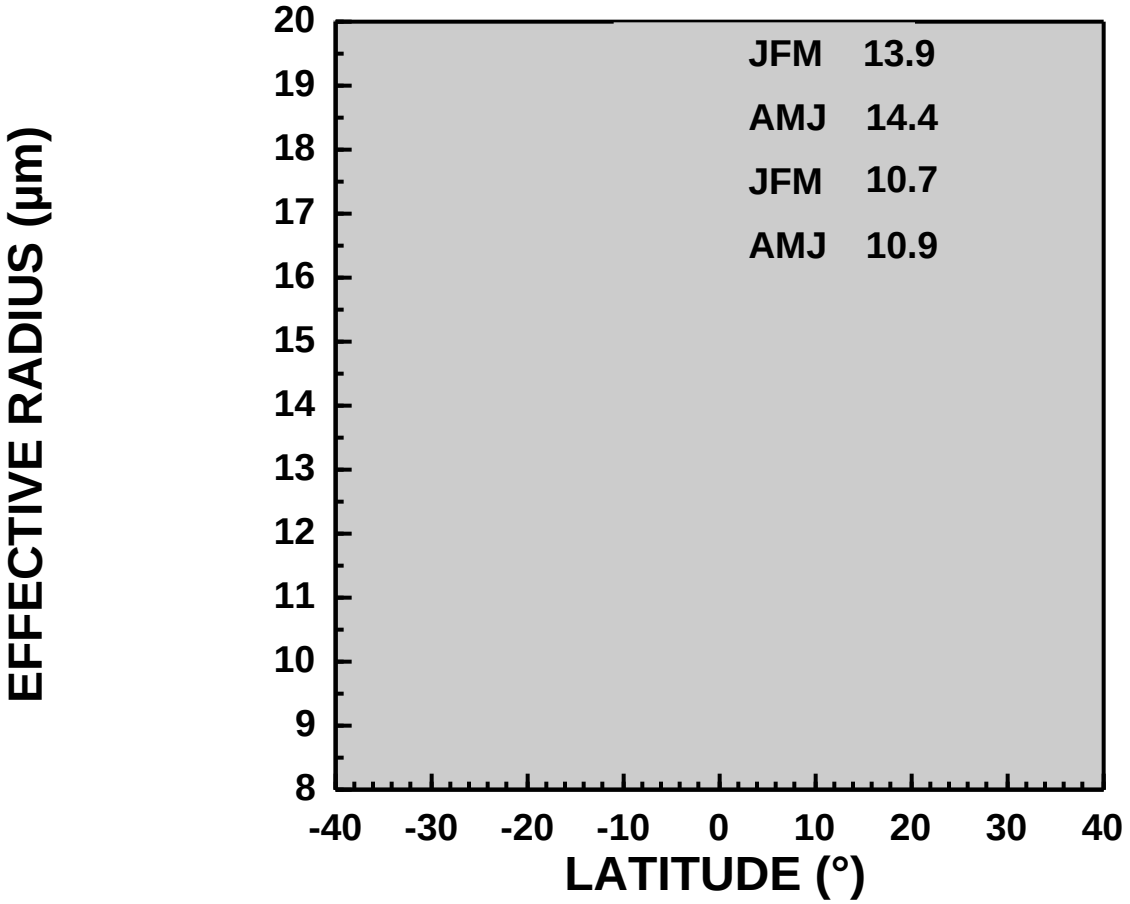
re, µm

JUNE



SEASONAL VARIATION OF CLOUD DROPLET RADIUS

VIRS 1998

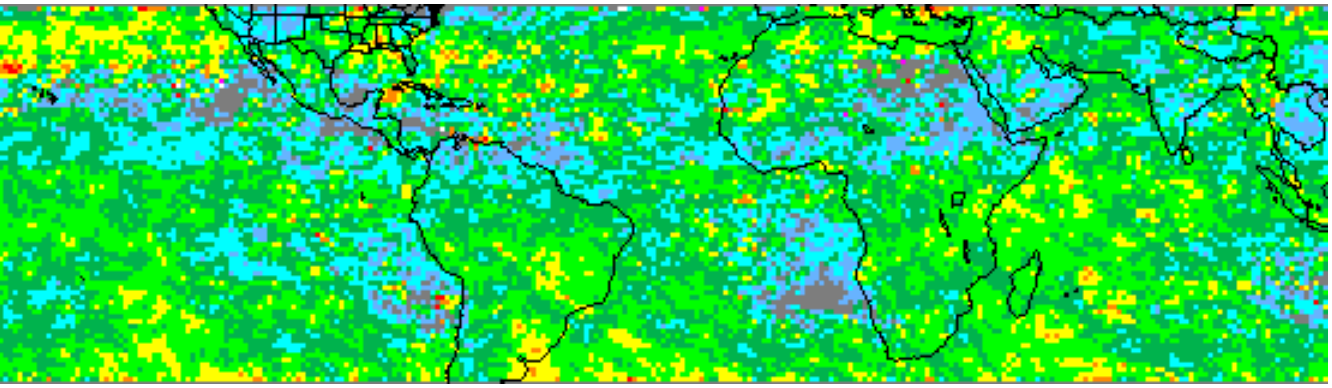


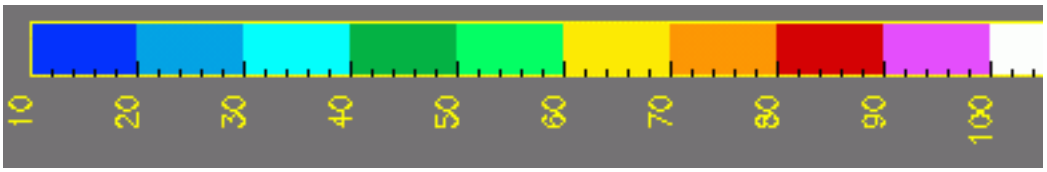
SOLID - OCEA

OPEN - LAND

MEAN EFFECTIVE CLOUD ICE PARTICLE SIZE, VIRS JAN1998

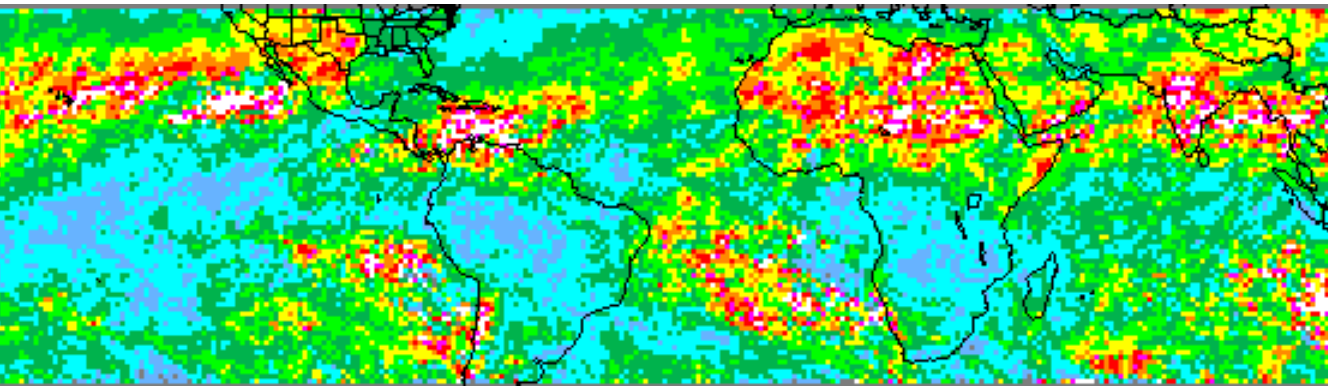
DAYTIME





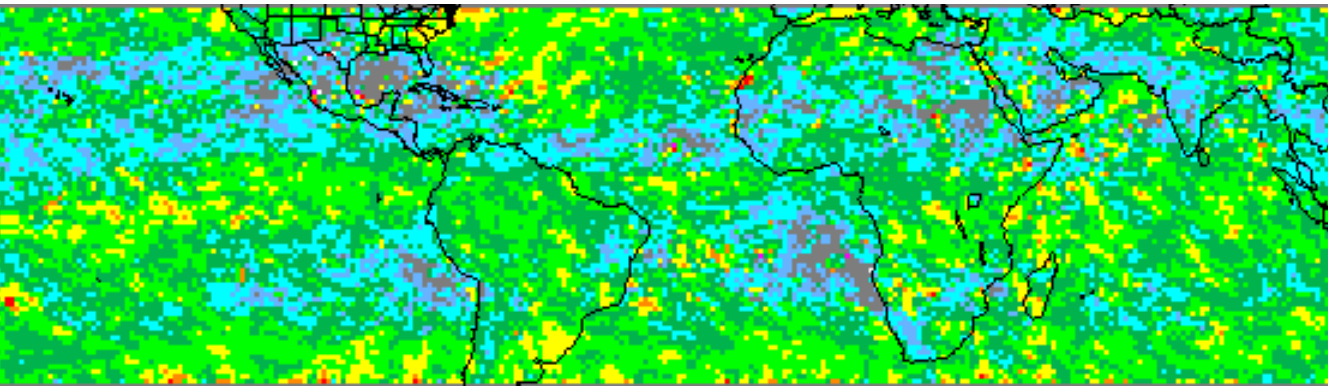
De, µm

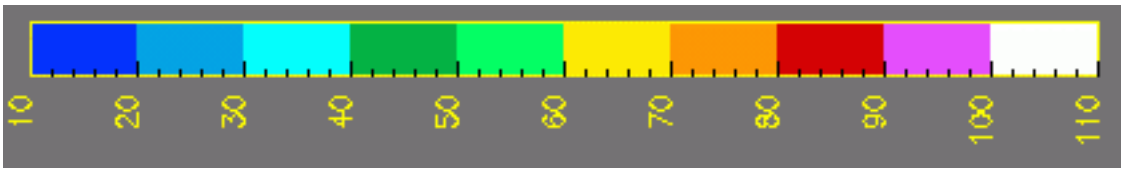
NIGHT



MEAN EFFECTIVE CLOUD ICE PARTICLE SIZE, DAY, VIRS 1998

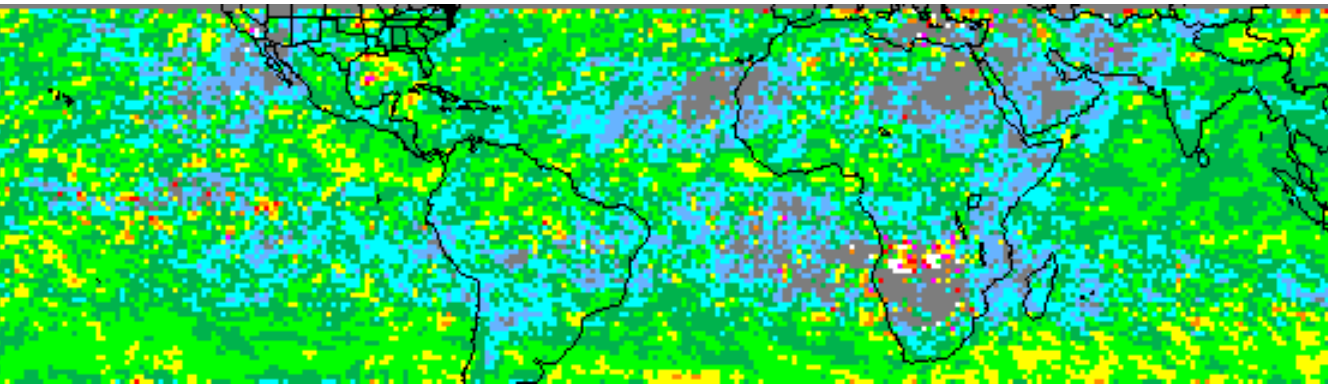
APRIL





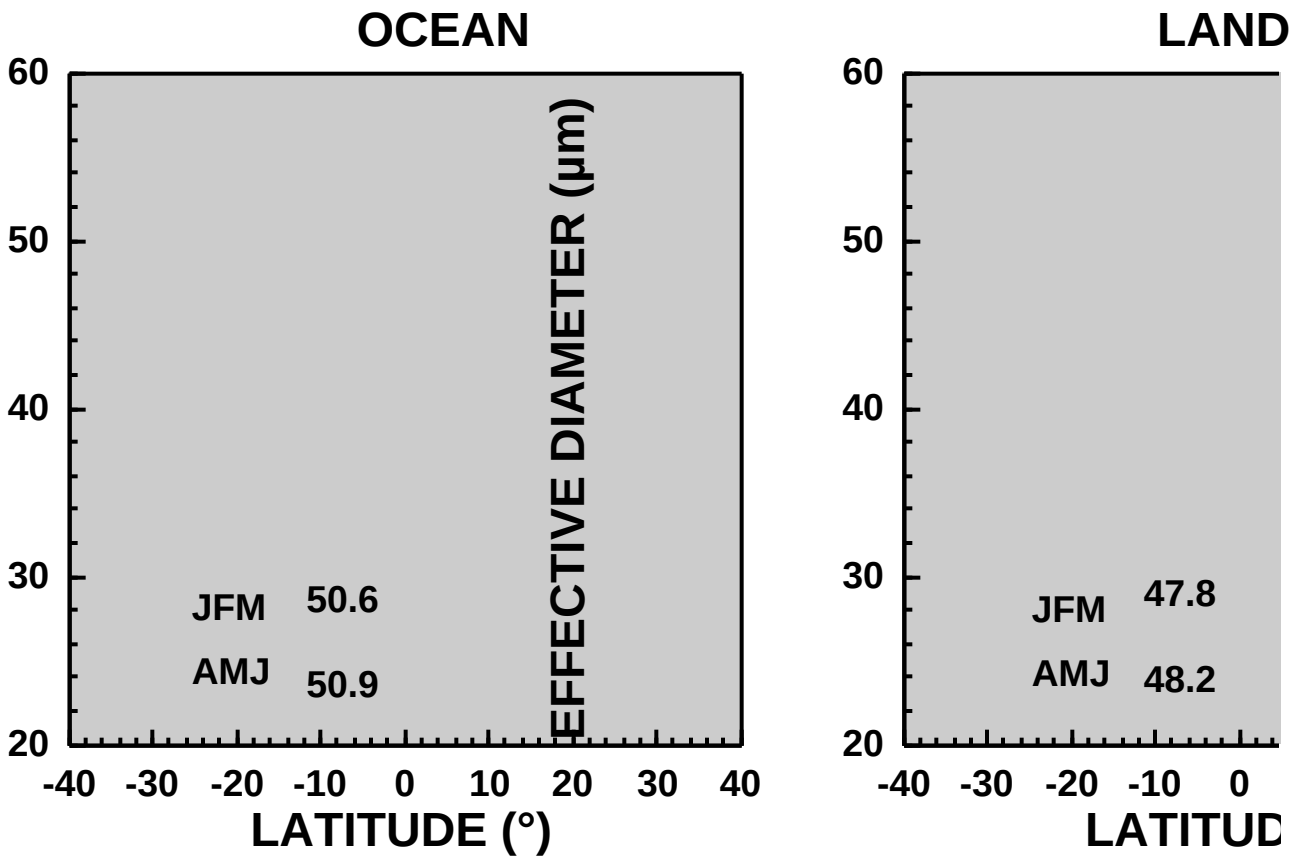
De, µm

JUNE



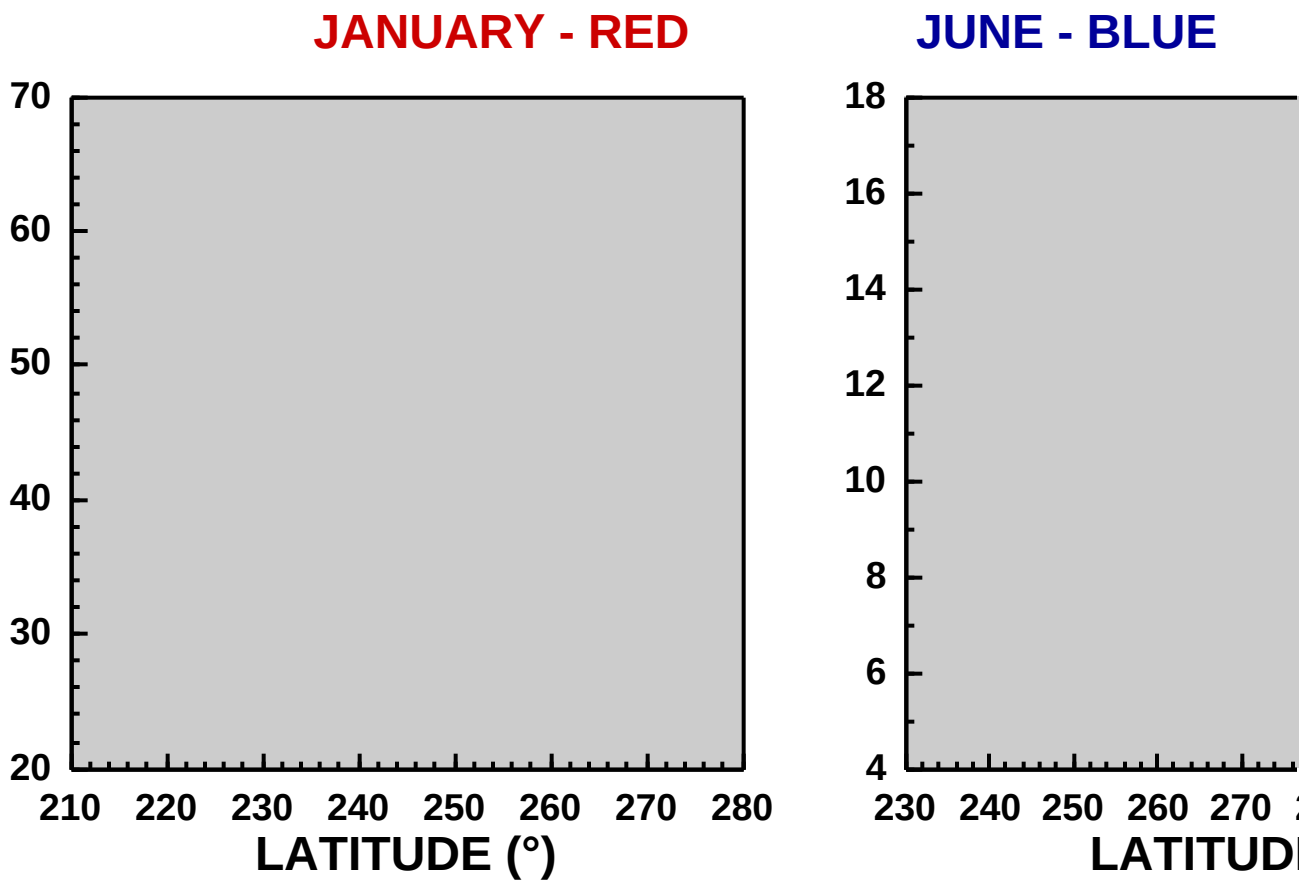
SEASONAL VARIATION OF ICE PARTICLE SIZES

VIRS, 1998



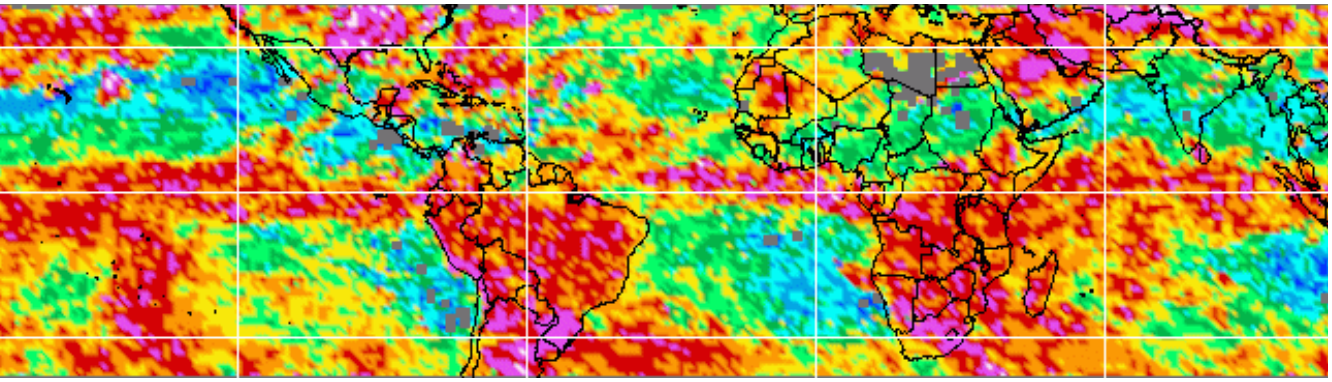
TEMPERATURE DEPENDENCE OF CLOUD PARTICLE SIZE

VIRS 1998



MEAN ICE CLOUD OPTICAL DEPTH, DAY, VIRS 1998

JANUARY



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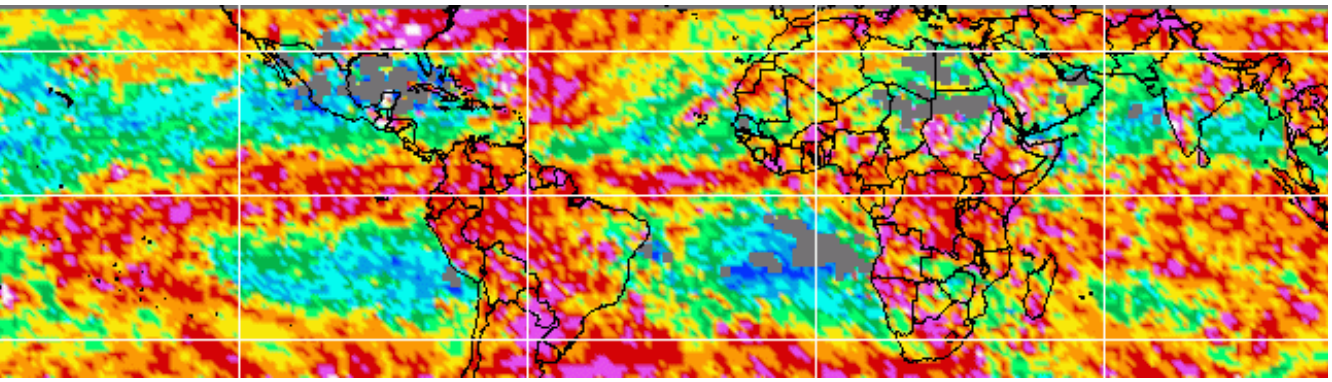
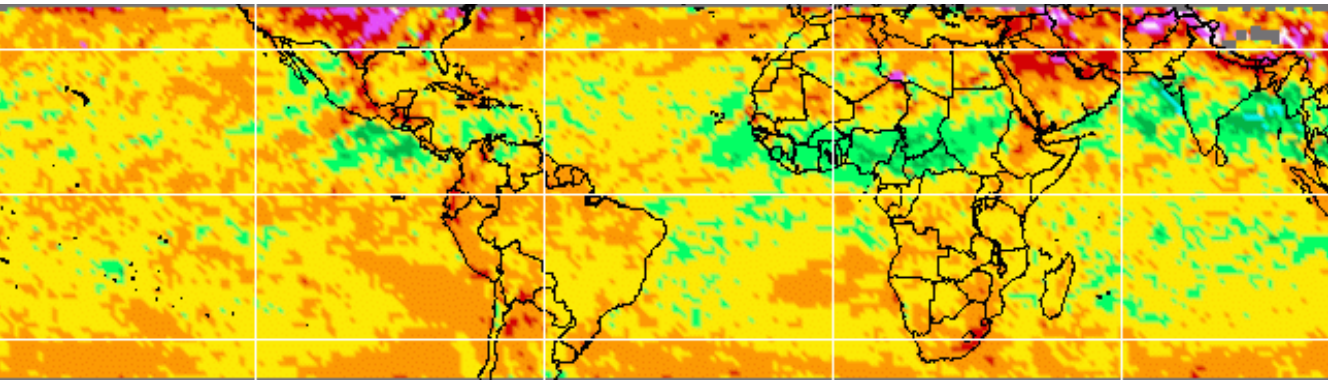


MEAN WATER CLOUD OPTICAL DEPTH, DAY, VIRS 1998

JANUARY



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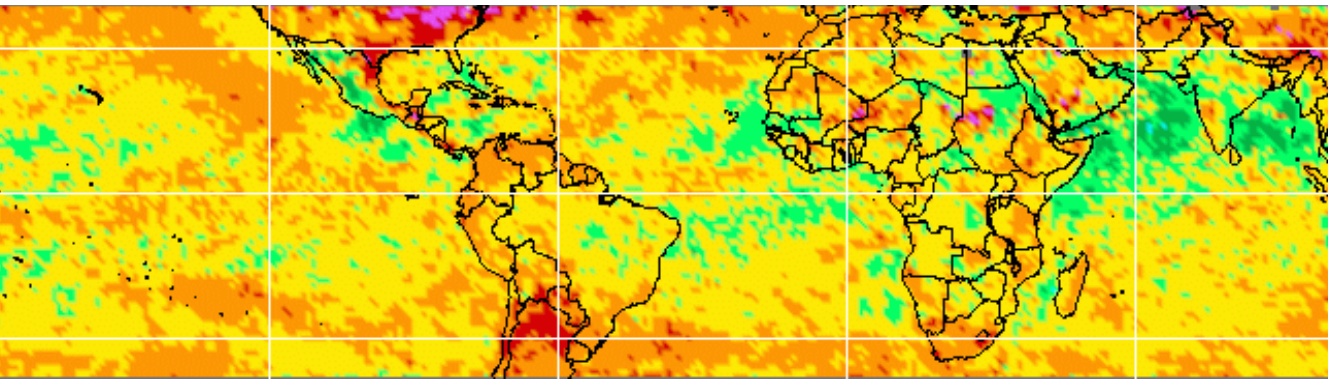
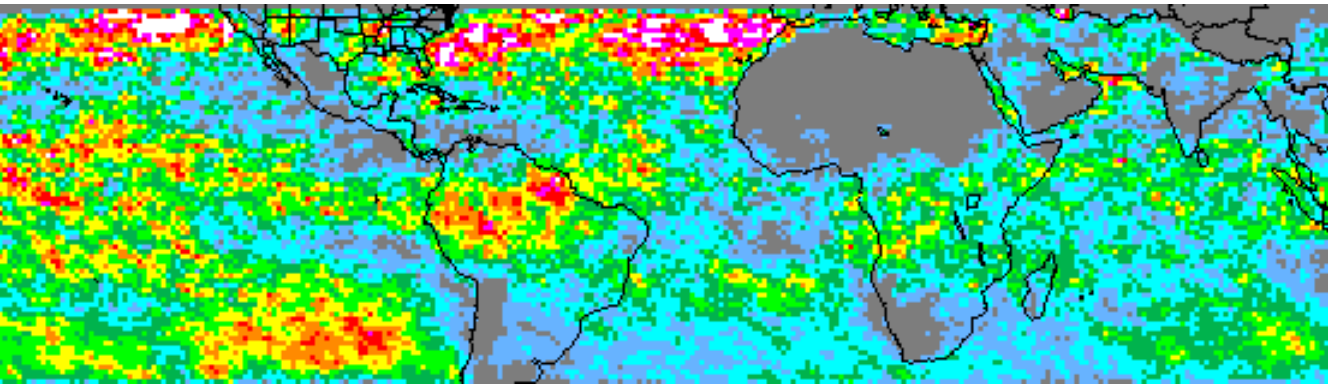
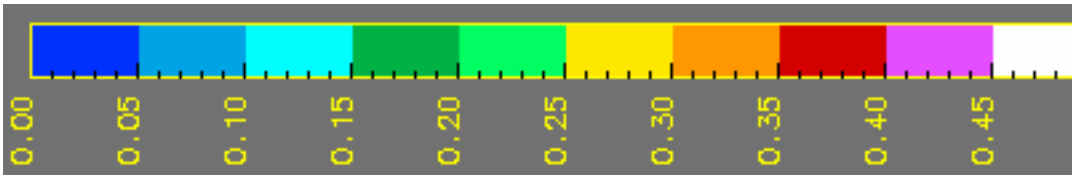


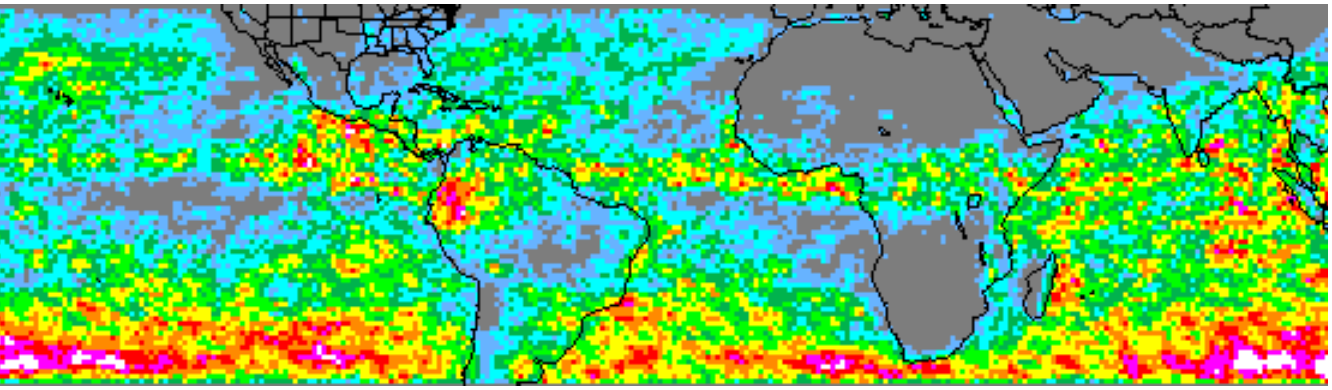
MEAN CLOUD OVERLAP FRACTION, DAY VIRS,1998

JANUARY



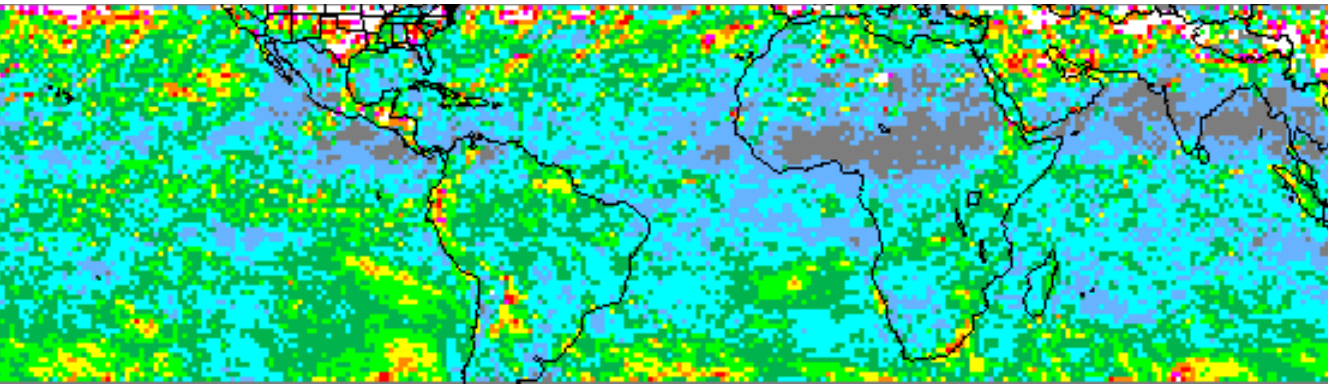


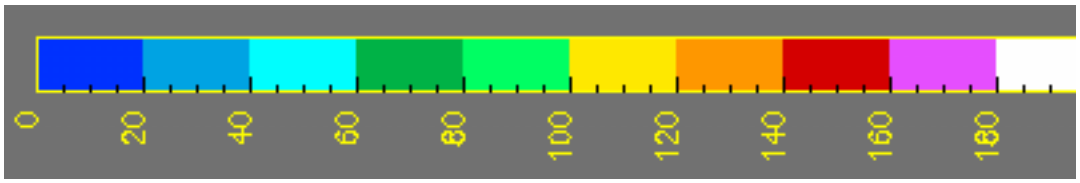
JUNE



MEAN CLOUD LIQUID WATER PATH, DAY VIRS,1998

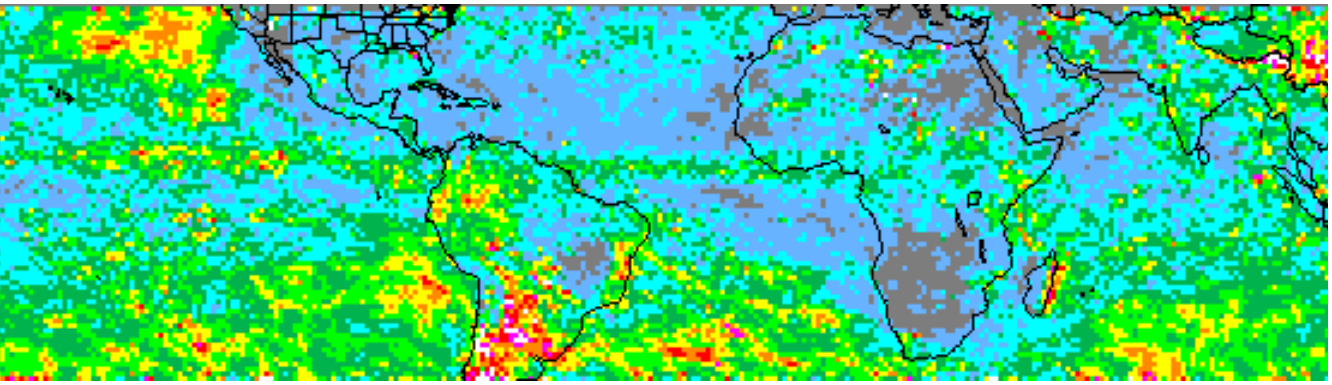
JANUARY





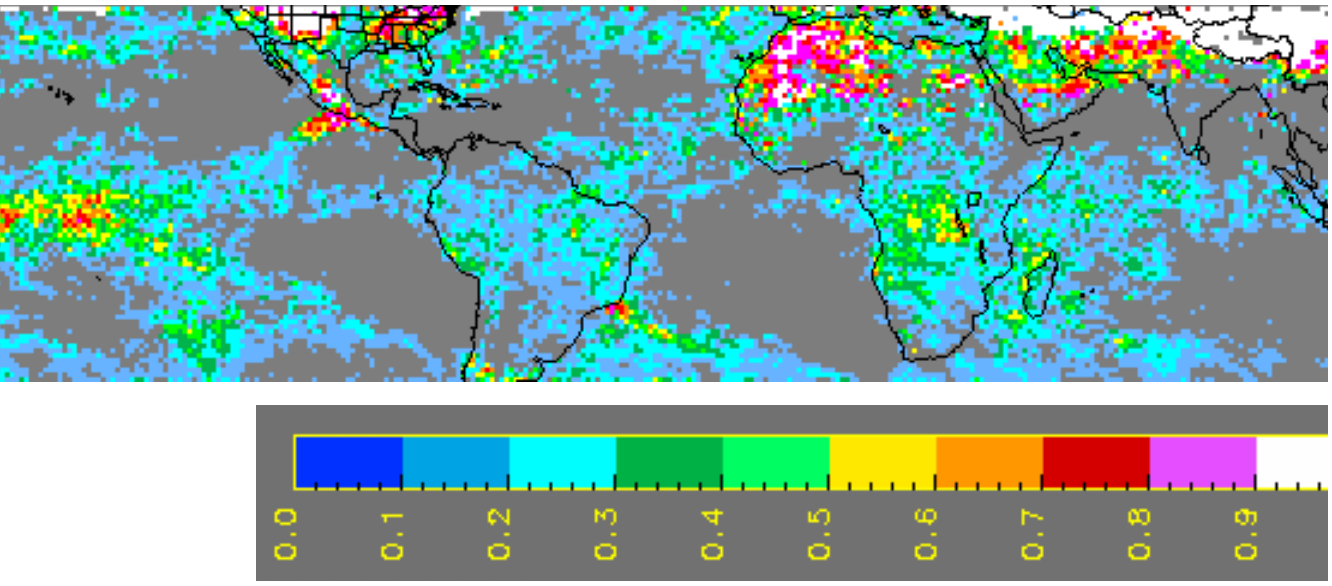
g/m^2

JUNE

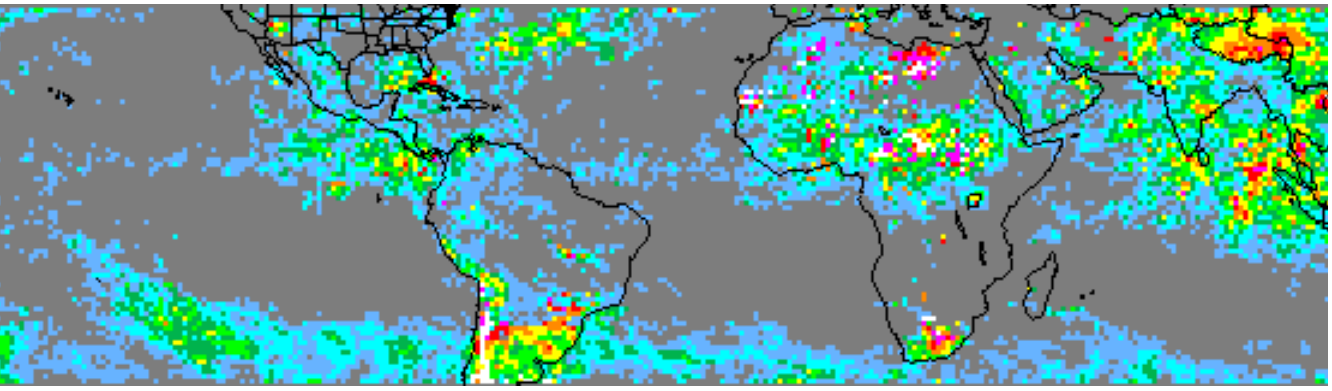


MEAN SUPERCOOLED CLOUD AMOUNT, DAY VIRS,1998

JANUARY

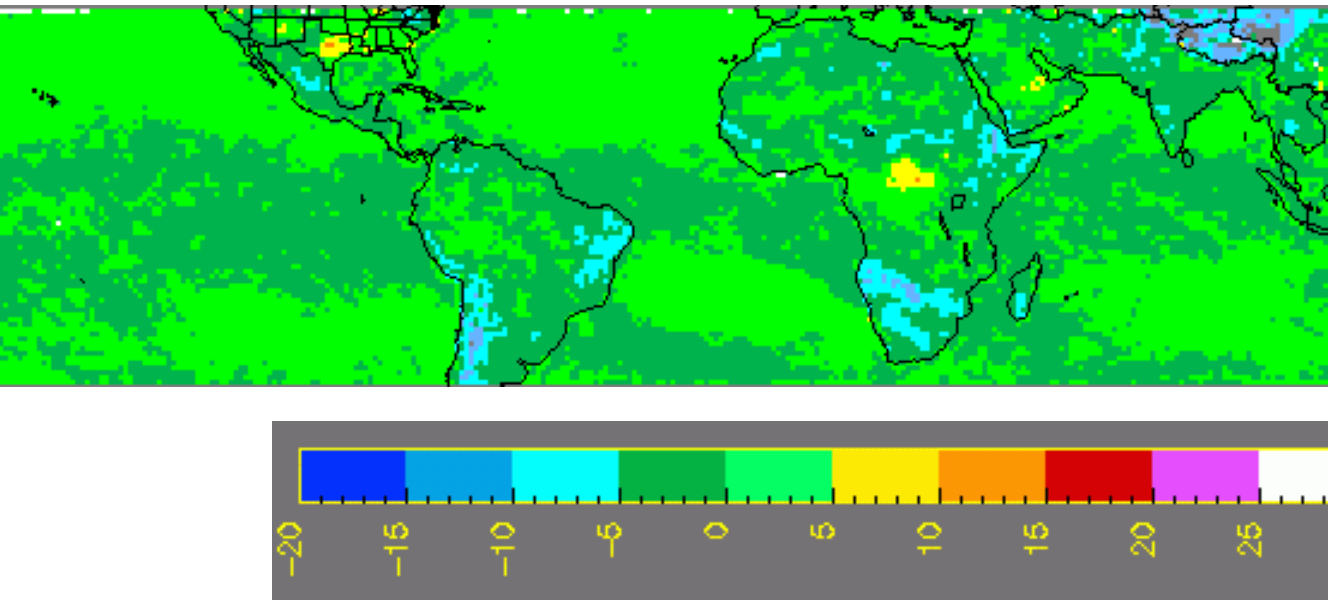


JUNE



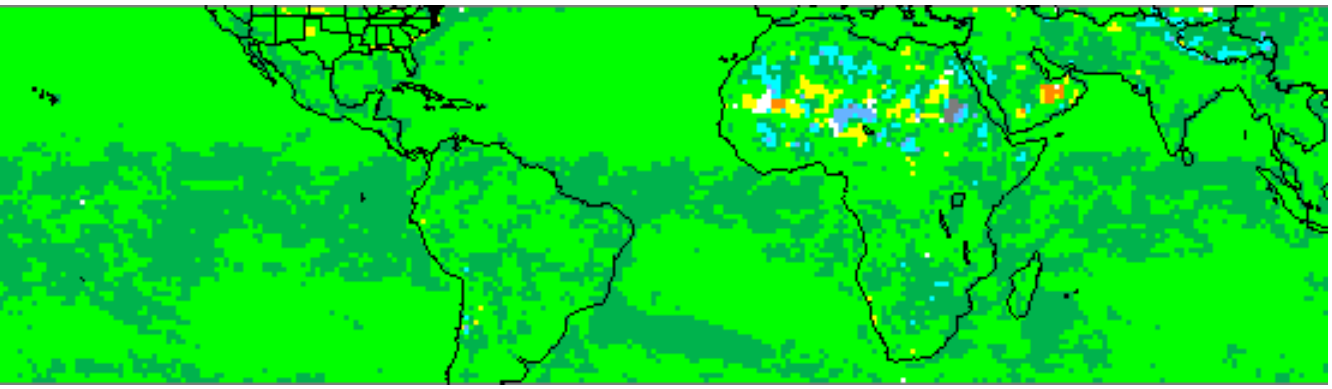
MOA - OBS CLEAR TEMPERATURE, VIRS, JANUARY 1998

DAYTIME



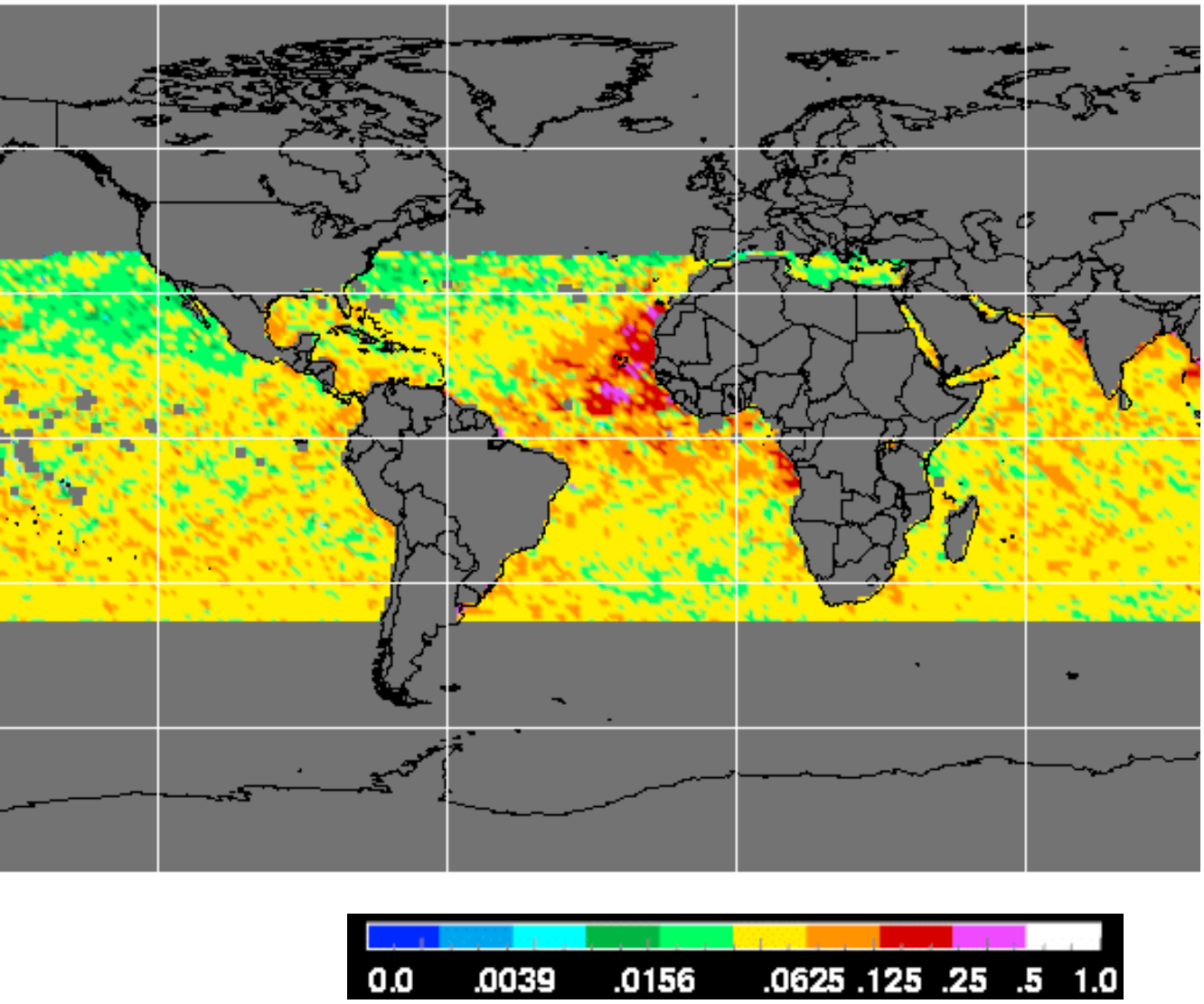
T (K)

NIGHT

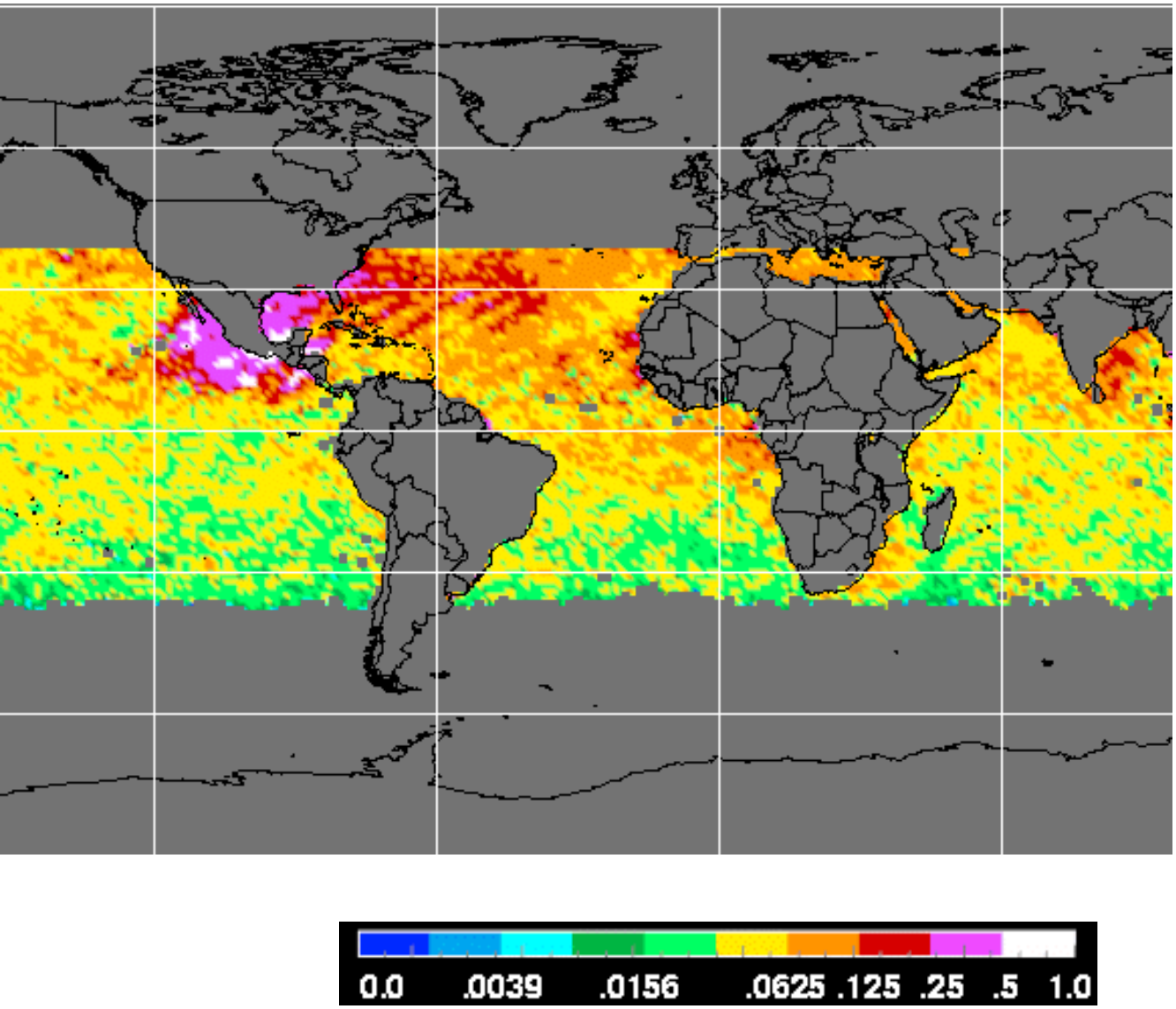


AEROSOL RETRIEVALS

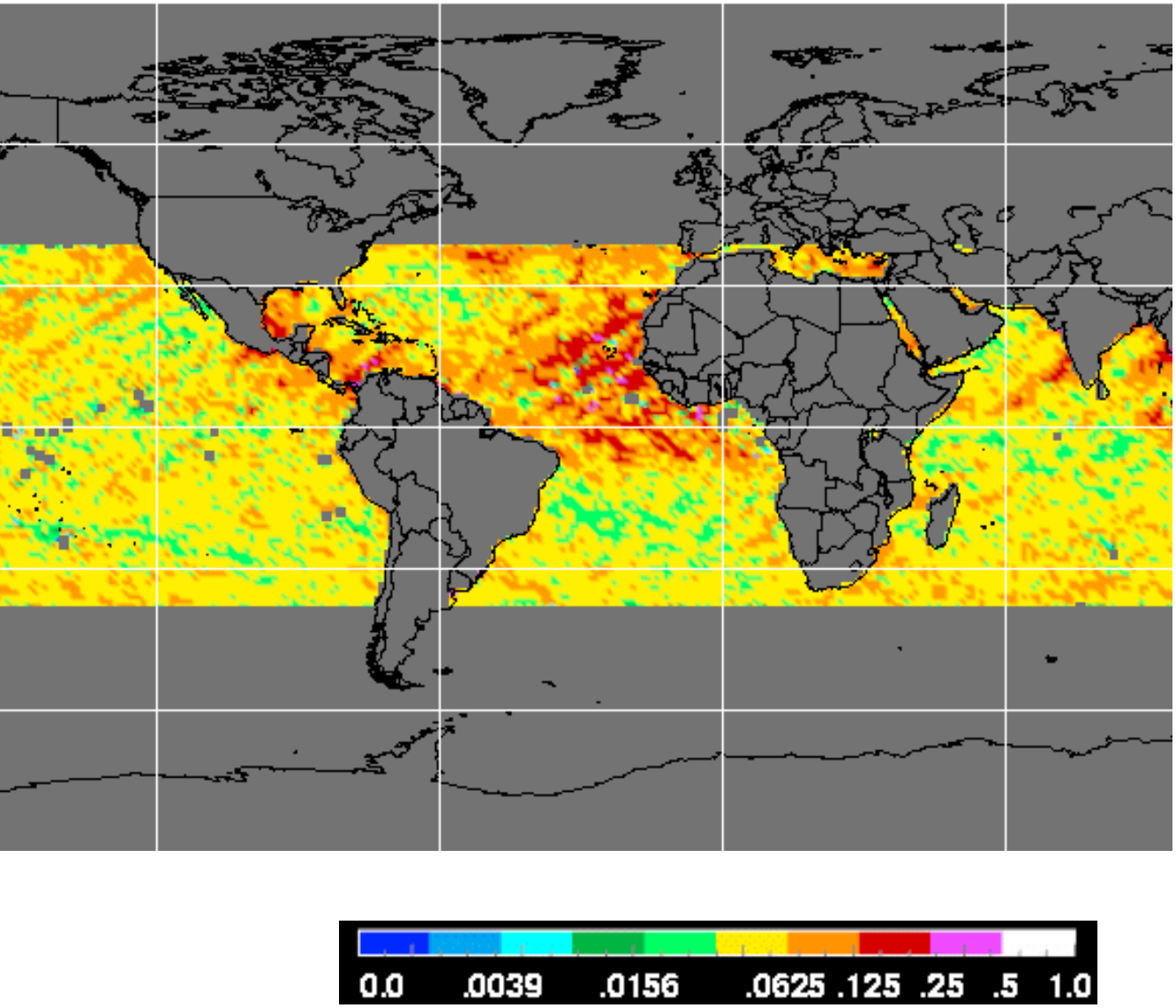
AOT, January 1998



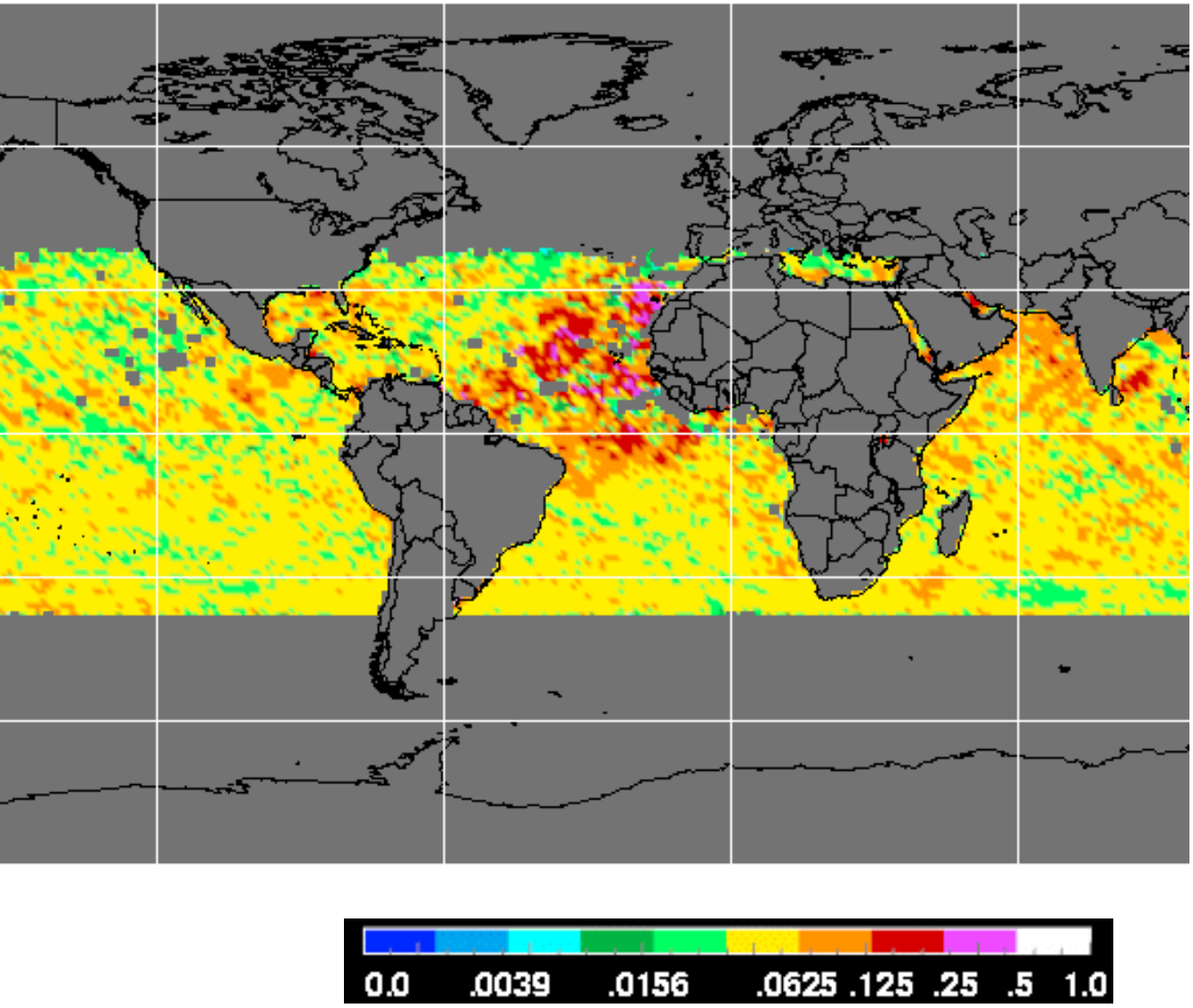
AOT, May 1998



AOT, March 1998



AOT, March 2000



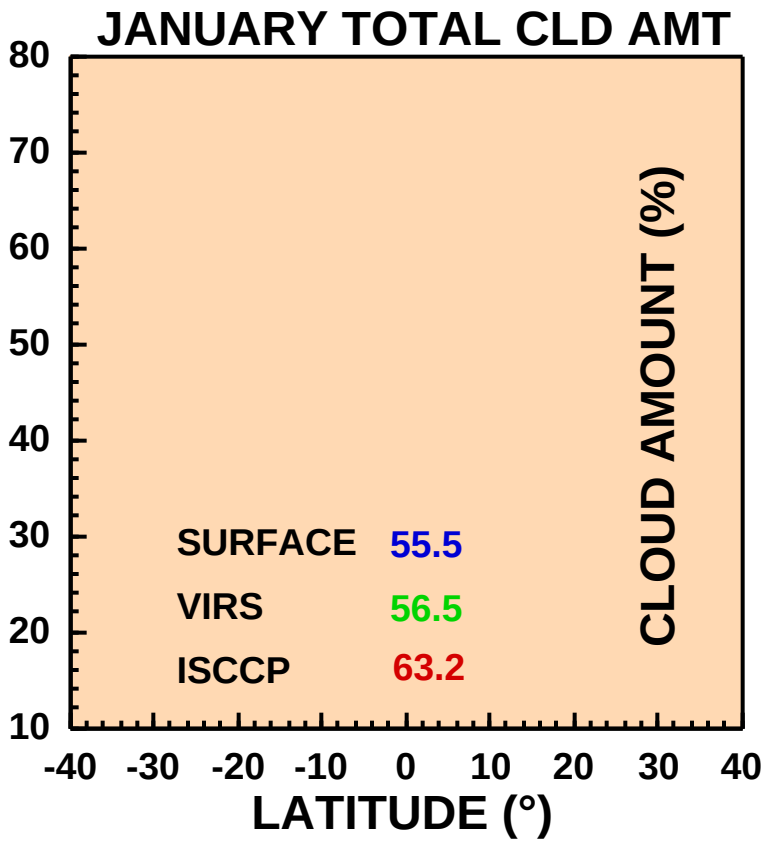
COMPARISONS WITH CLIMATOLOGY

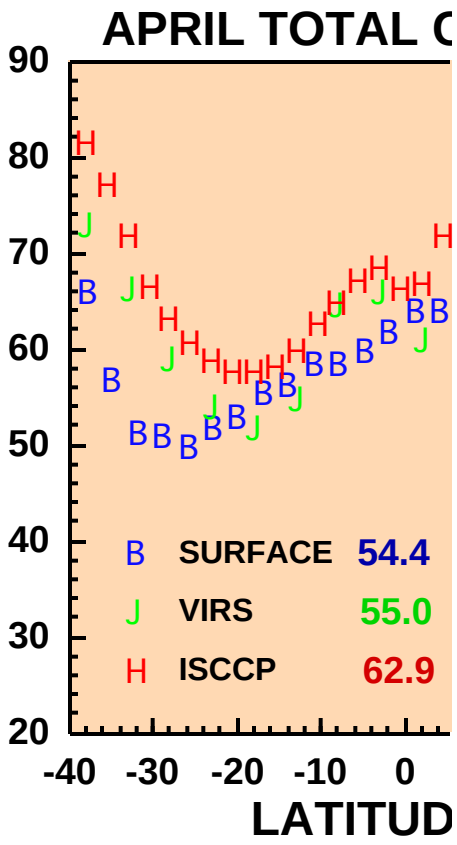
COMPARISON OF TOTAL CLOUD AMOUNTS

SURFACE (1971-1996)

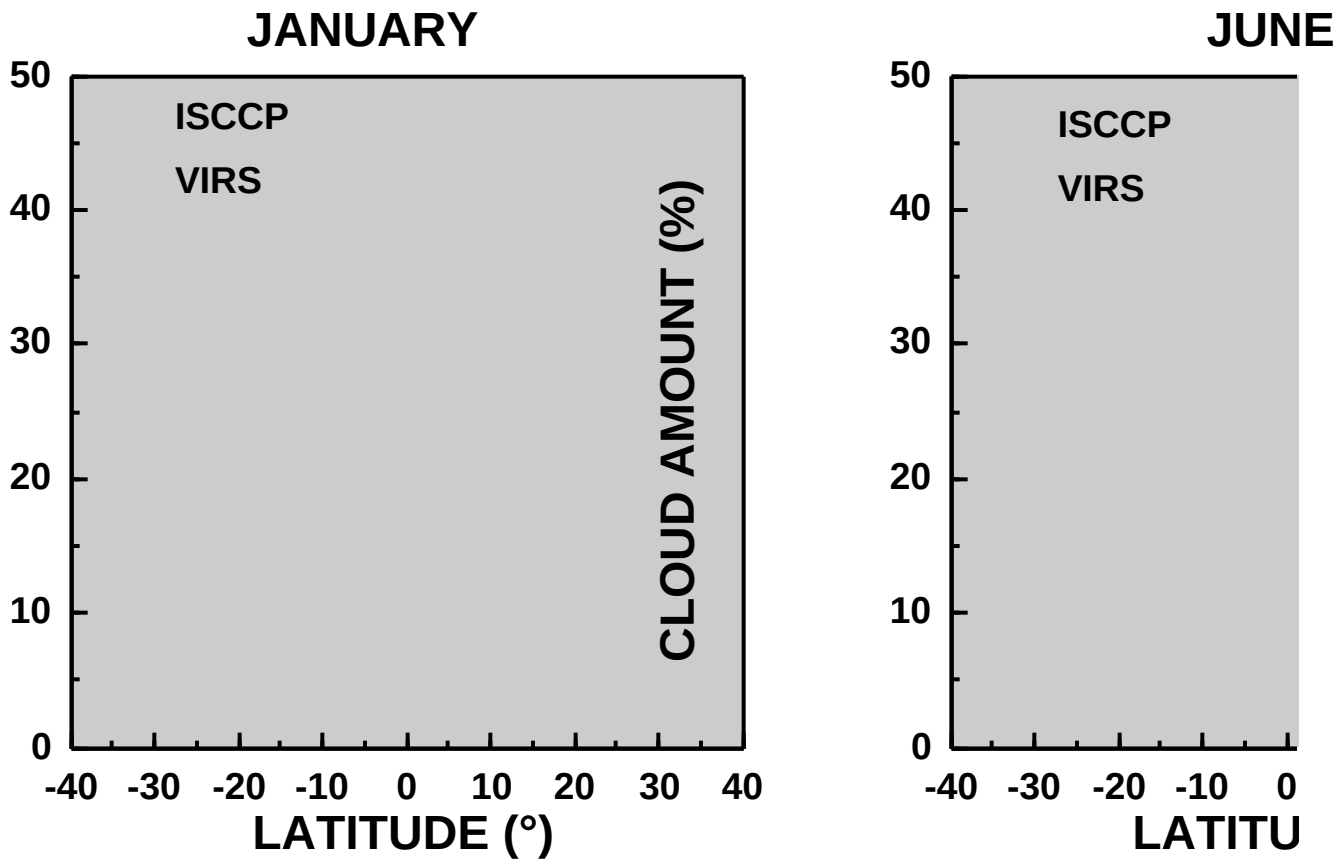
VIRS (1998)

ISCCP (1984 - 1991)

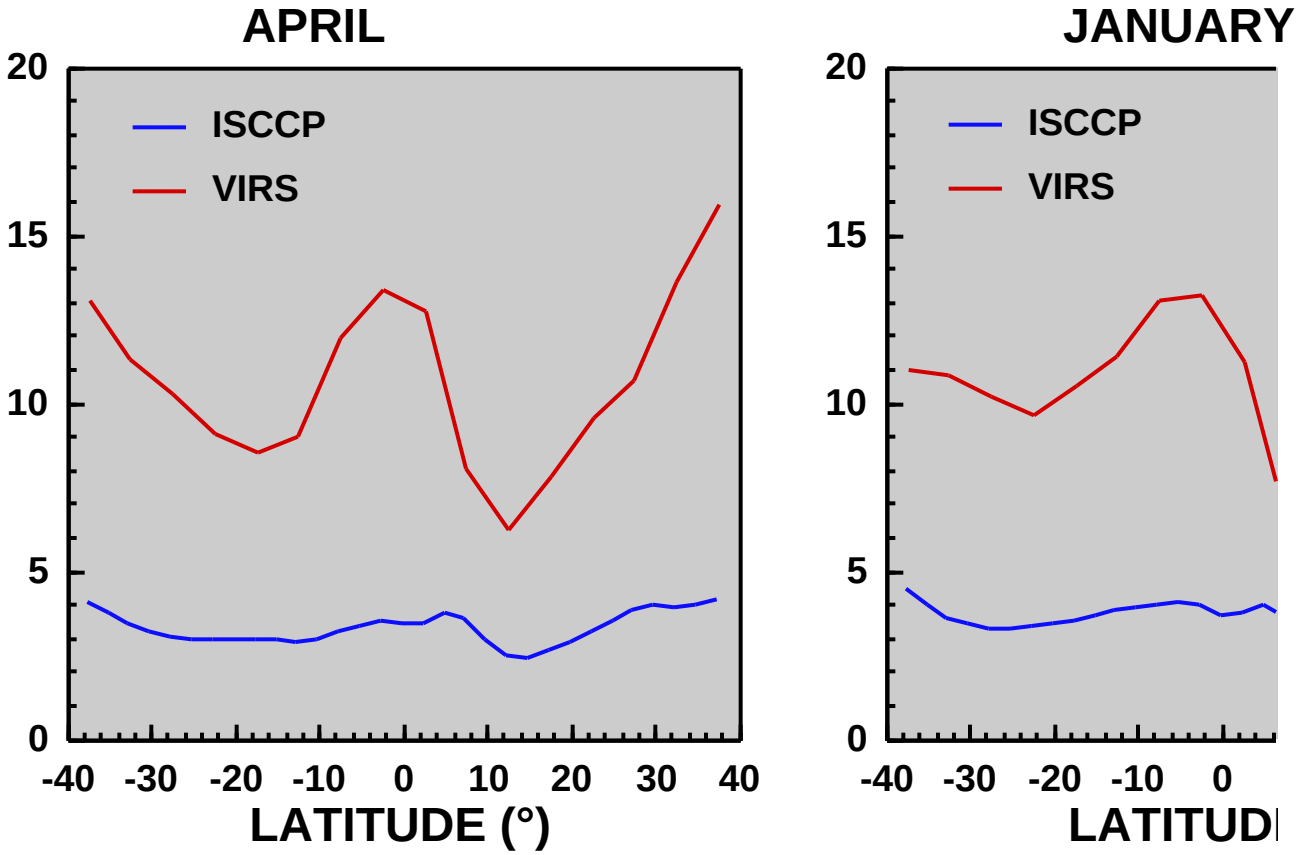




COMPARISON OF ISCCP HIGH & VIRS ICE CLOUD AMOUNTS

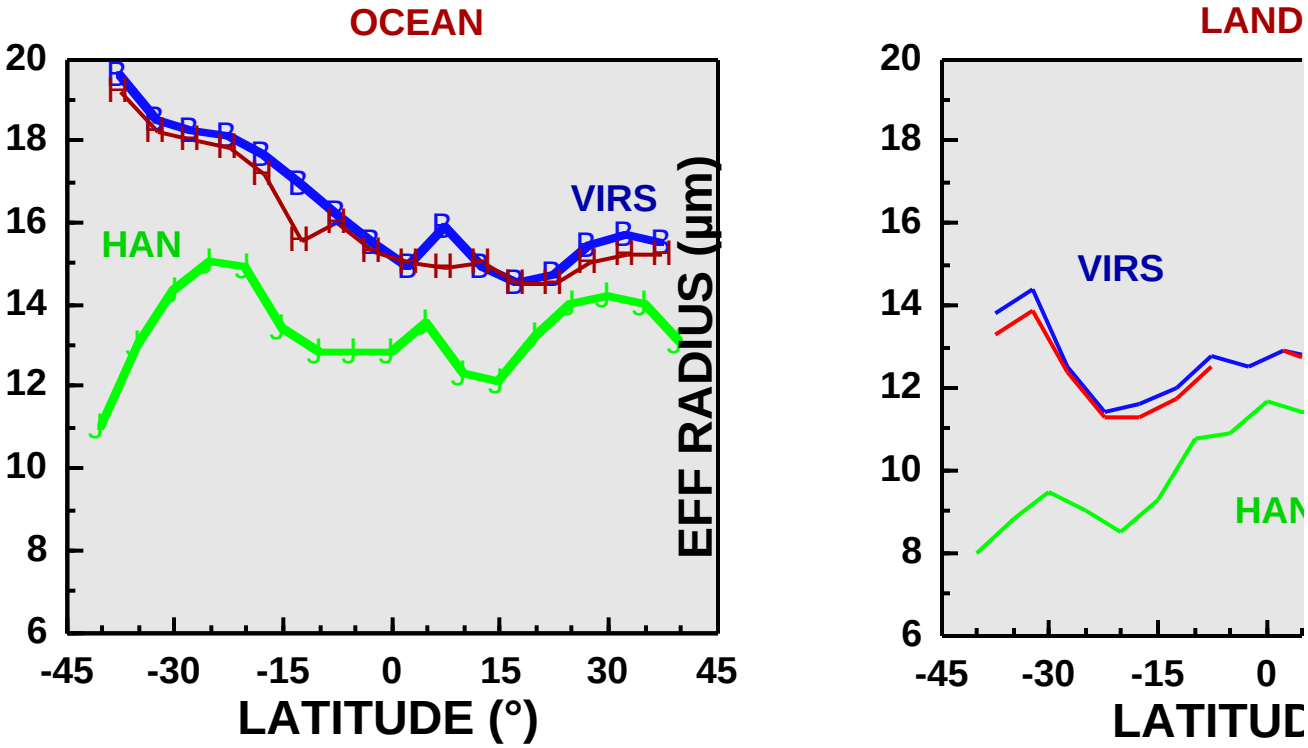


COMPARISON OF ISCCP & VIRS MEAN OPTICAL DEPTHS



OLD RESULTS

COMPARISON OF SATELLITE-DE
CLOUD PARTICLE SIZES, JULY M



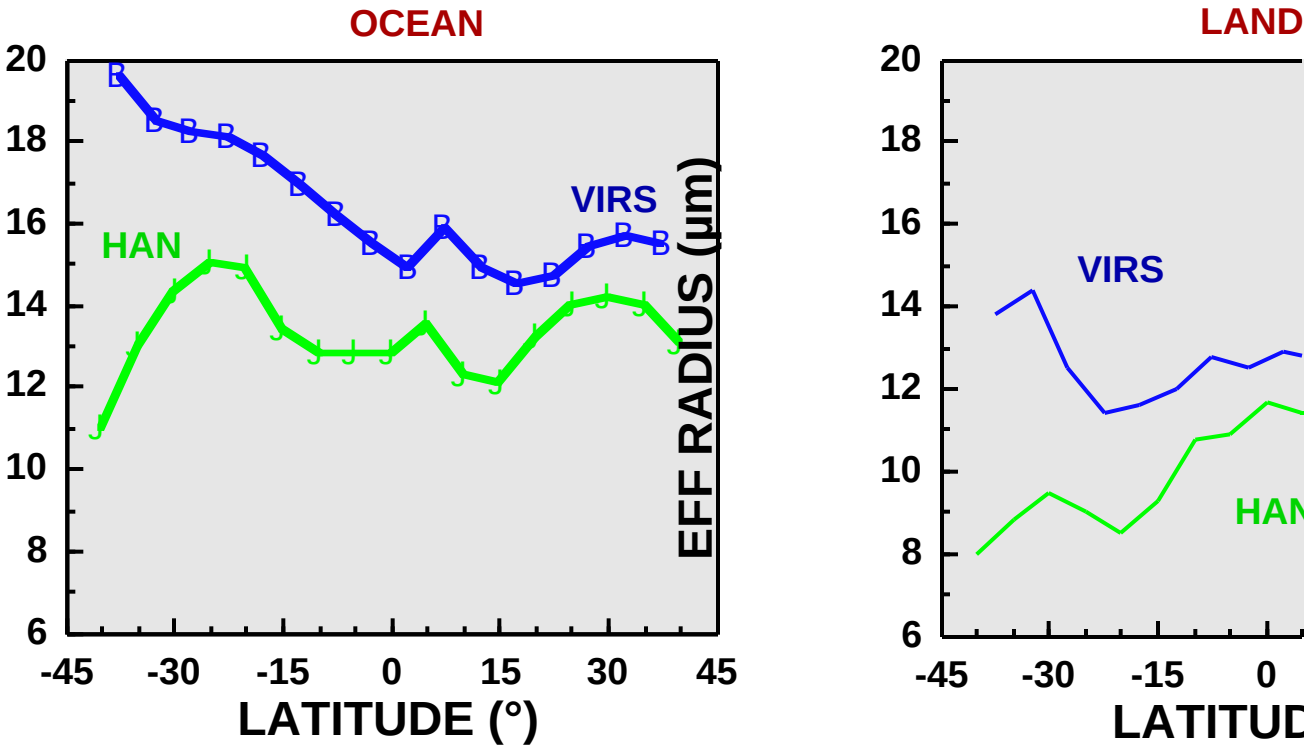
VIRS, 1998, TRMM

HAN et al. 1994, *J. Climate*, 1987 NOAA-9 AVHRR, T > 273K,

VIRS, 1998, new run

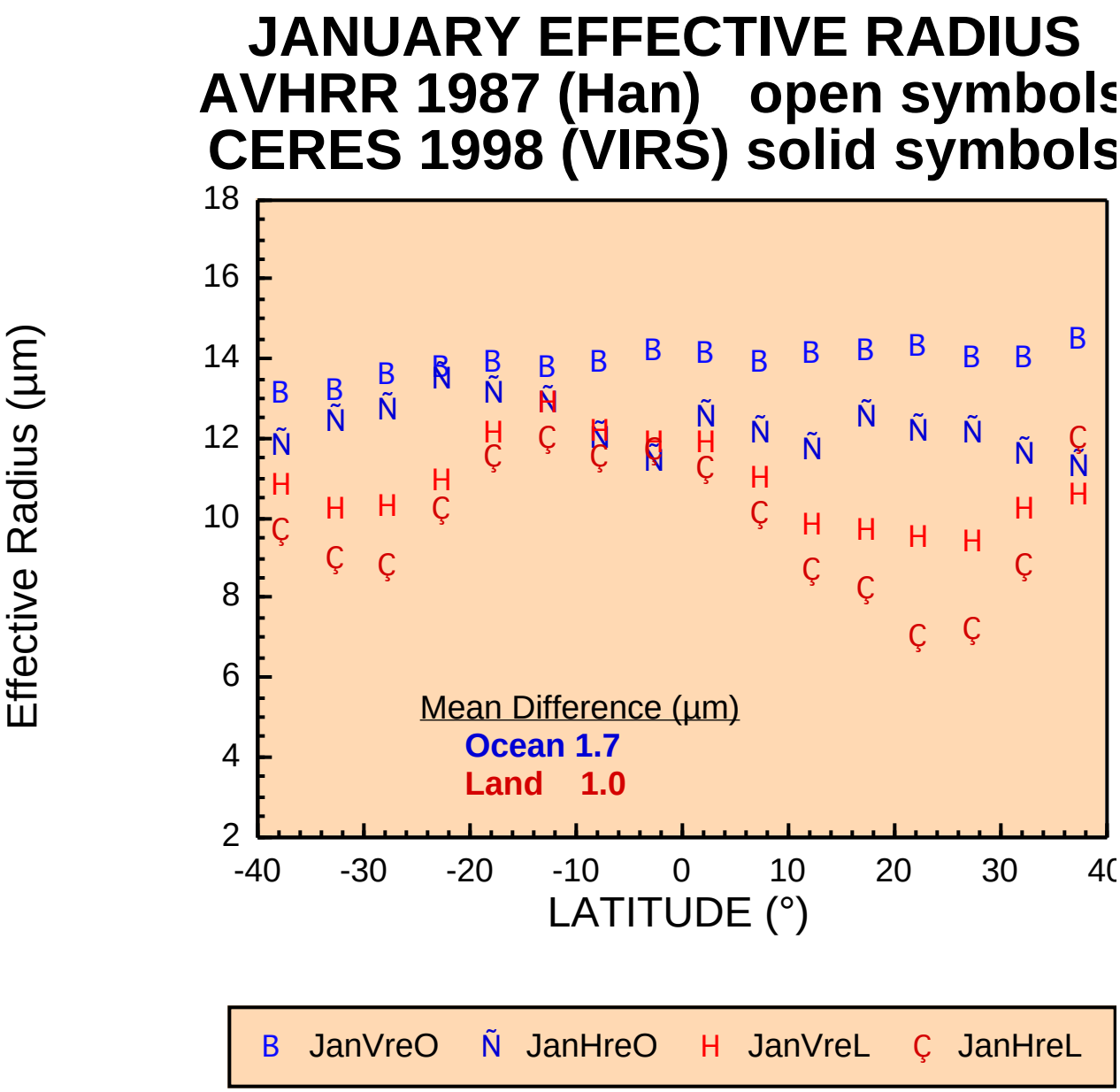
OLD RESULTS

COMPARISON OF SATELLITE-DE
CLOUD PARTICLE SIZES, JULY M

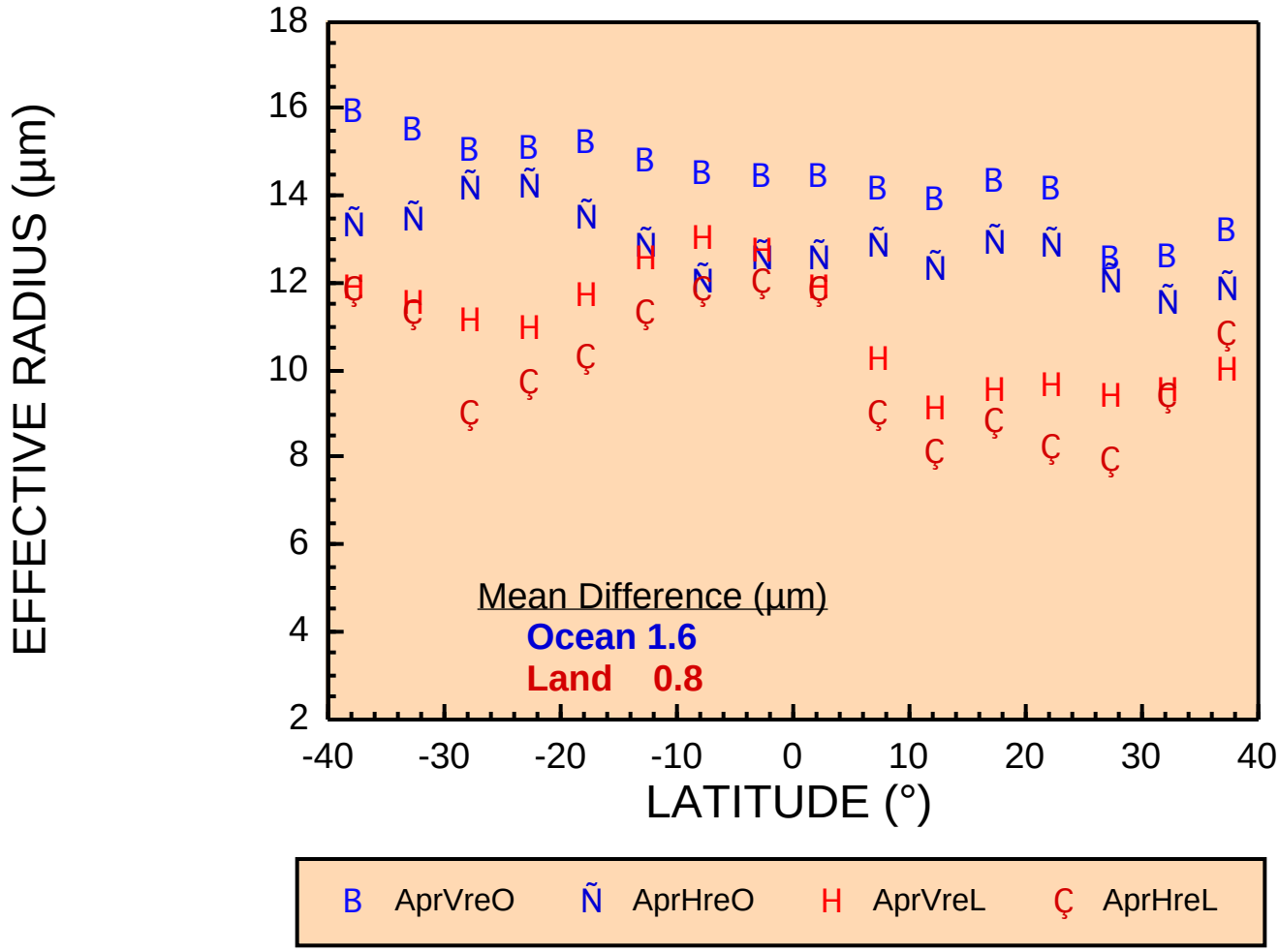


VIRS, 1998, TRMM

HAN et al. 1994, *J. Climate*, 1987 NOAA-9 AVHRR, T > 273K,


JANUARY EFFECTIVE RADIUS
AVHRR 1987 (Han) open symbols
CERES 1998 (VIRS) solid symbols
Effective Radius (µm)
LATITUDE (°)
Mean Difference (µm)
Ocean 1.7
Land 1.0
B JanVreO
Ñ JanHreO
H JanVreL
Ç JanHreL

APRIL EFFECTIVE RADIUS
AVHRR 1987 (Han) open symbols
CERES 1998 (VIRS) solid symbols



SOURCES OF DIFFERENCES

• MODEL INTERCOMPARISONS

- DIFFERENT ATMOSPHERIC ABSORPTION METHODS & PROFILES
- DIFFERENT TREATMENT OF CLOUD EMISSIVITY

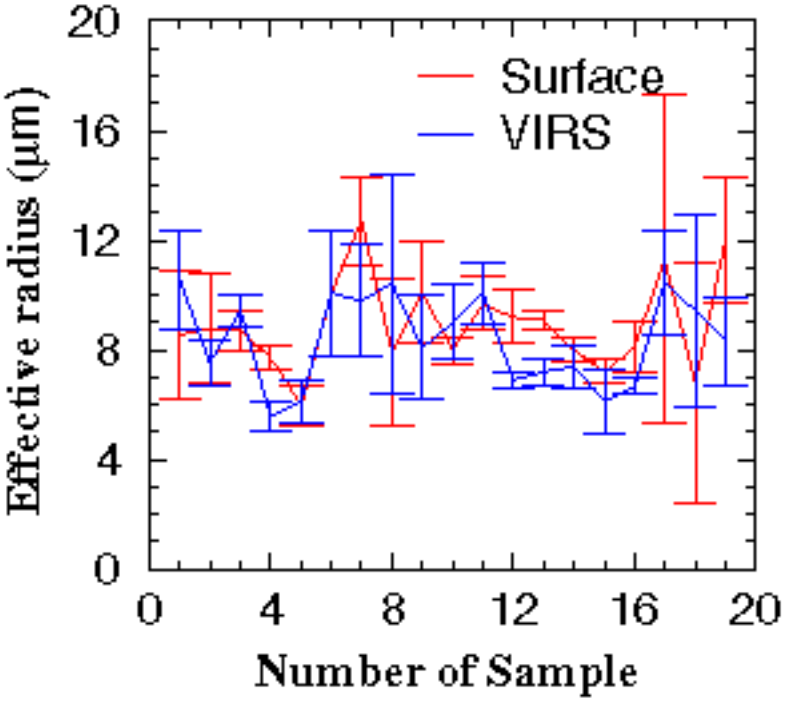
• ZONAL DEPENDENCE

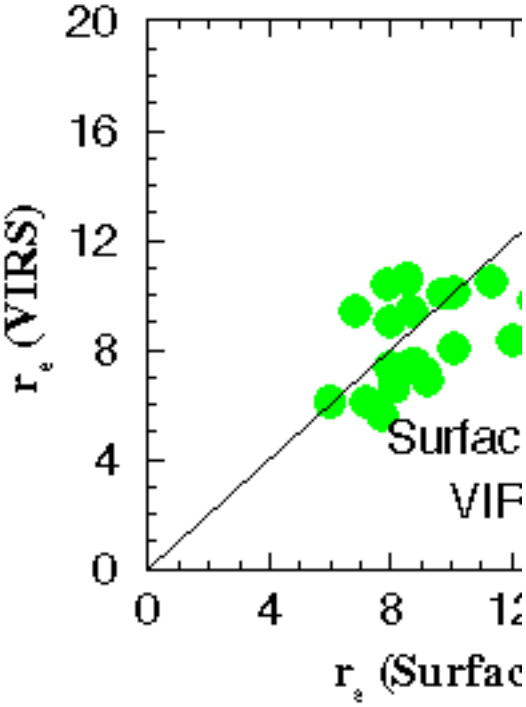
- CIRRUS CONTAMINATION
- LOW TAUS INCLUDED
- ANGLE DEPENDENCE

  HAN: NADIR ONLY, ZONAL SZA DEPENDENCE
- DIFFERENT ATMOSPHERIC PROFILES

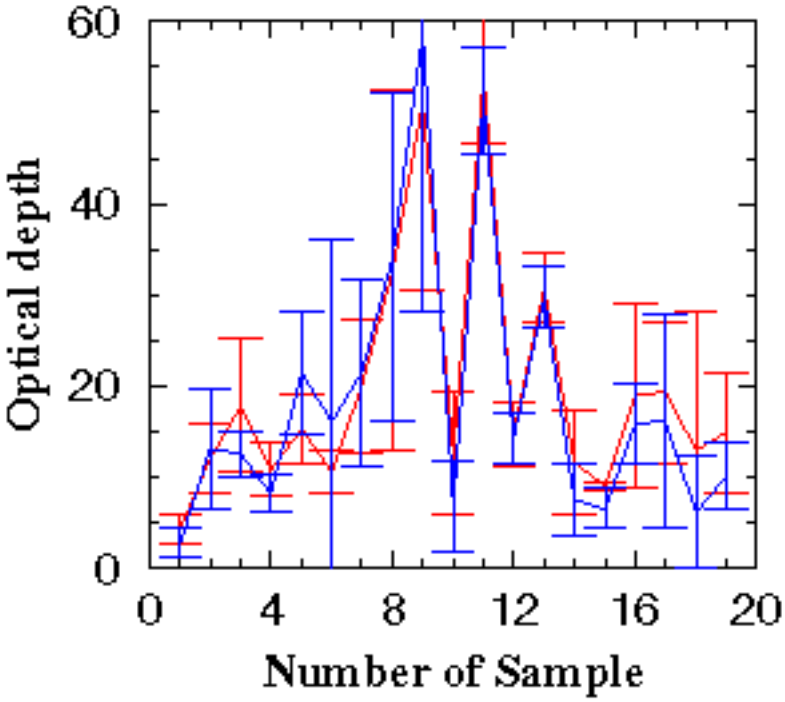
COMPARISONS WITH SURFACE DATA

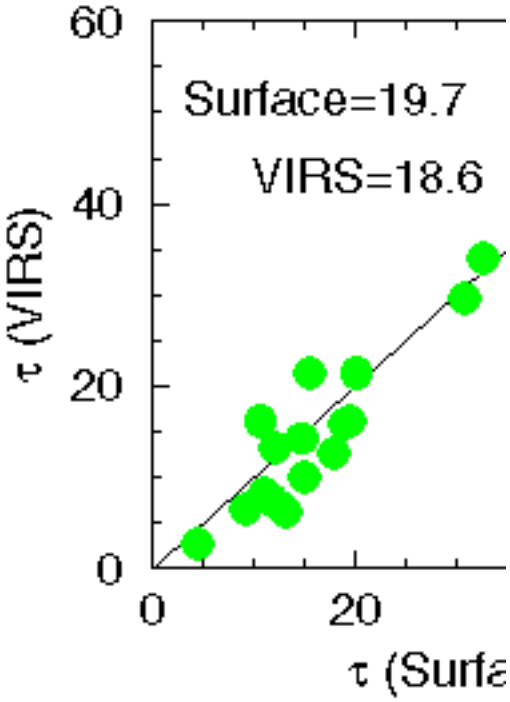
STRATUS CLOUD DROPLET SIZE COMPARISON
ARM SGP RADAR VS VIRS 1998



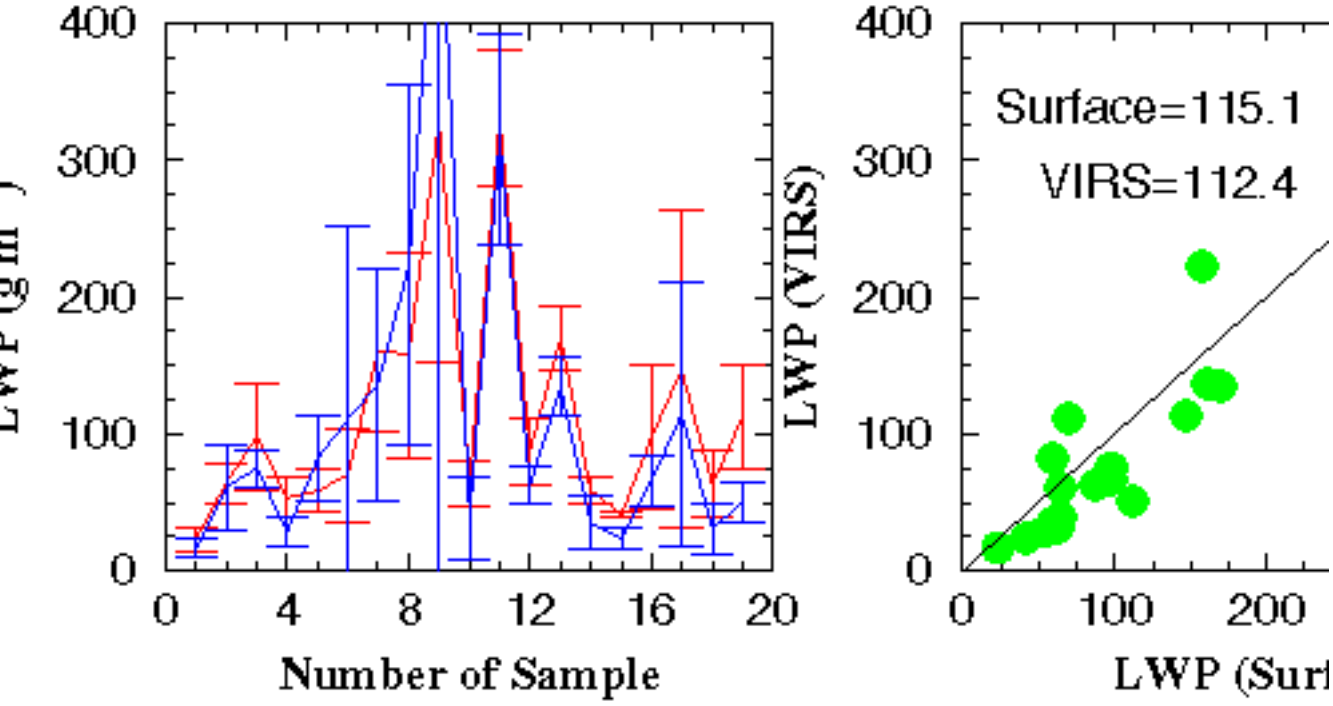


STRATUS CLOUD OPTICAL DEPTH COMPARISON
ARM SGP RADAR VS VIRS 1998

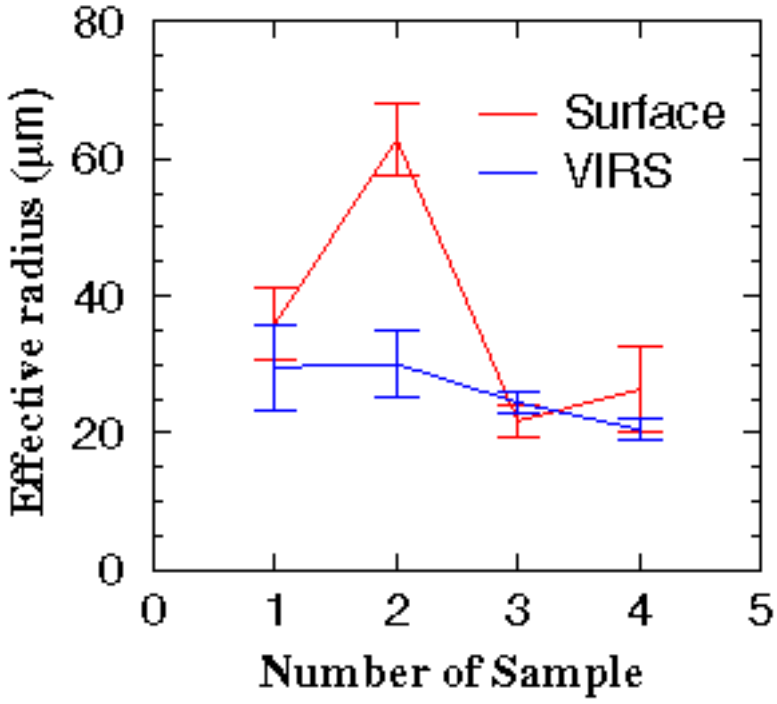


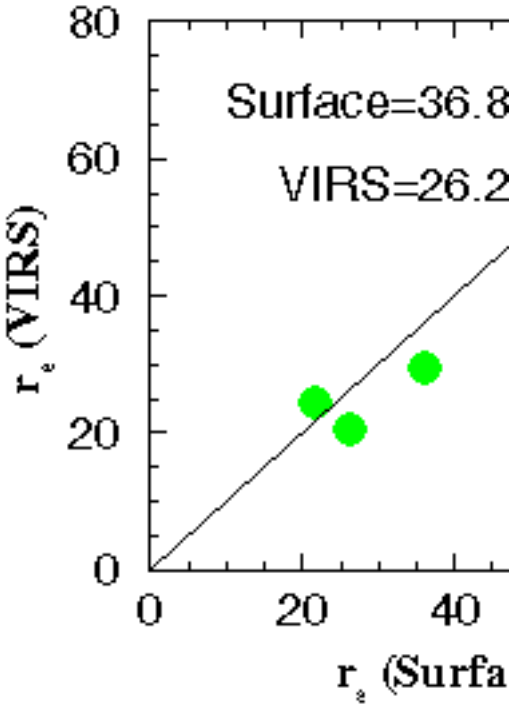


STRATUS CLOUD LWP COMPARISON
ARM SGP RADAR VS VIRS 1998

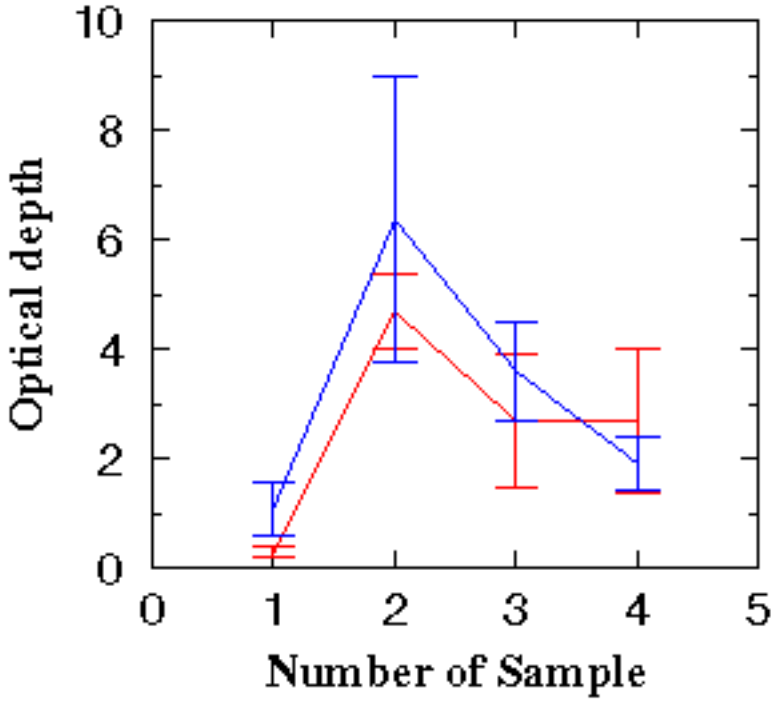


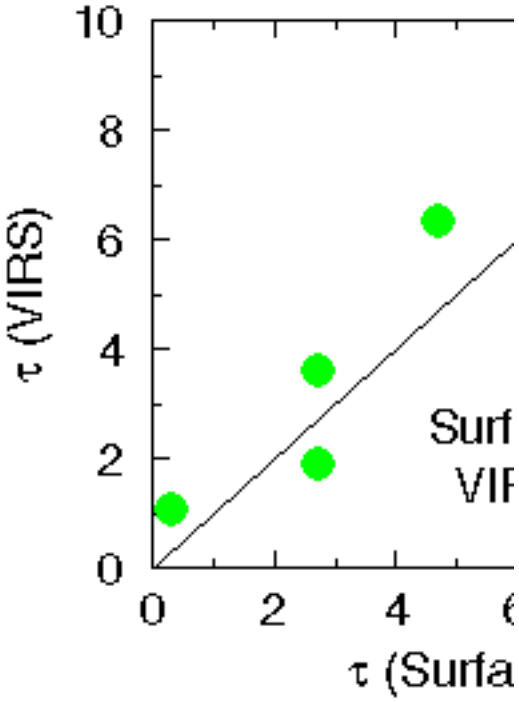
CIRRUS CLOUD CRYSTAL SIZE COMPARISON
ARM SGP RADAR VS VIRS 1998



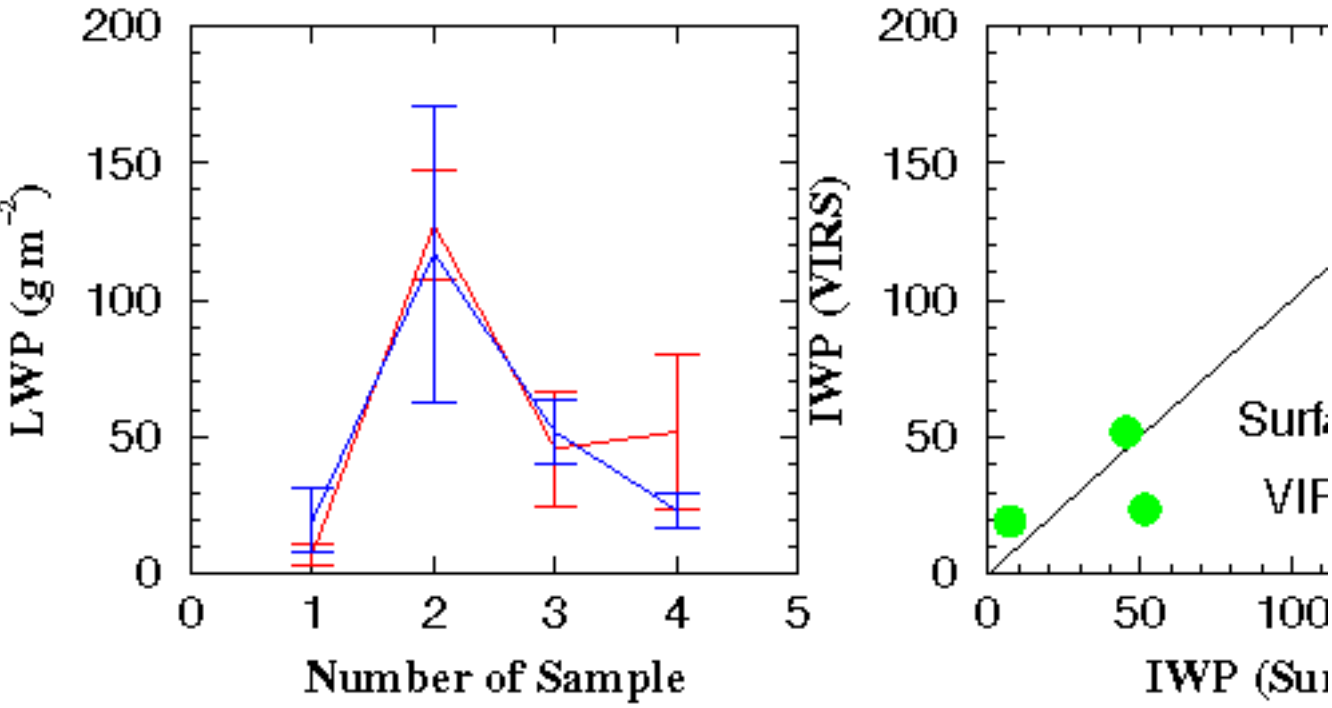


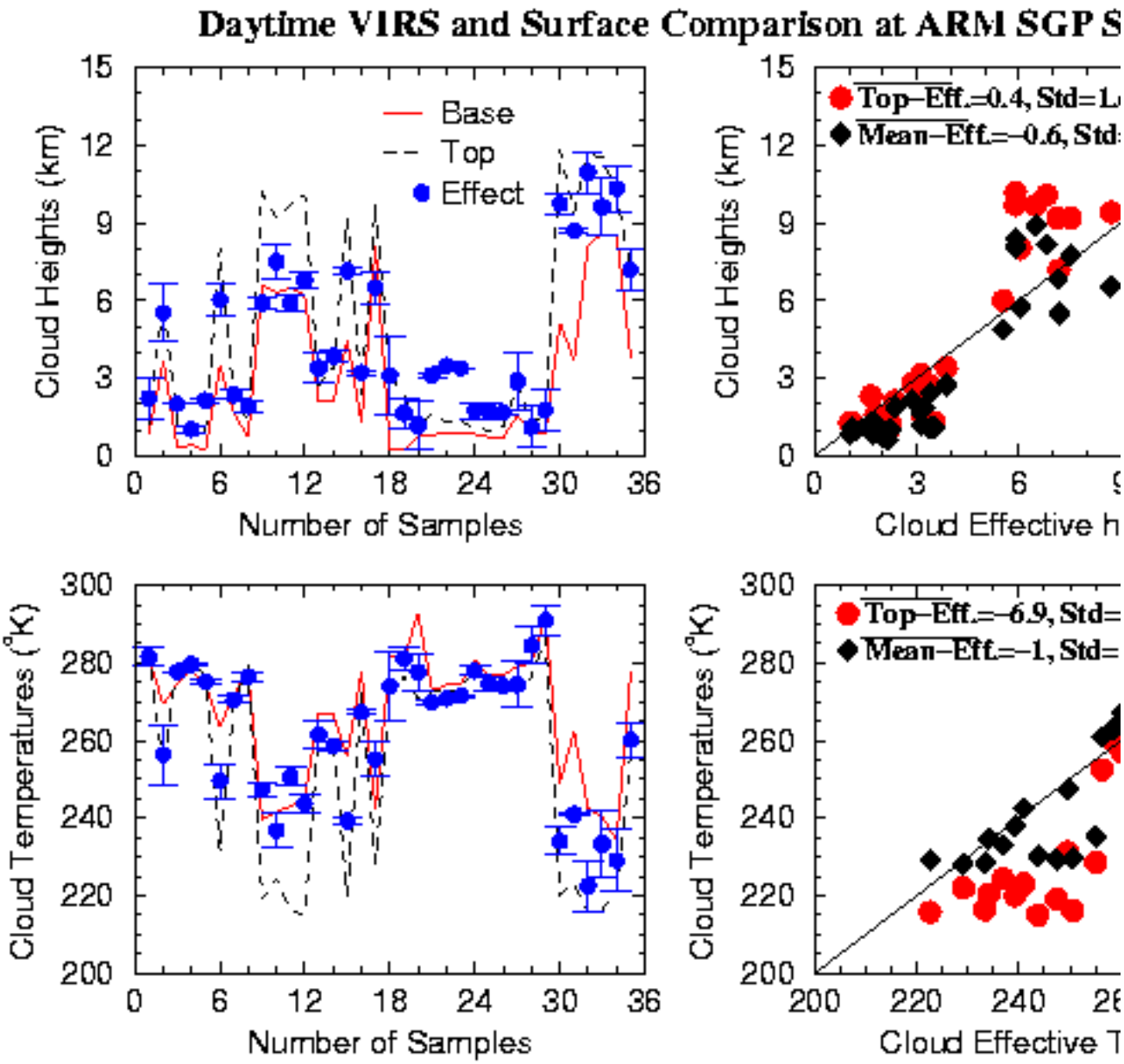
CIRRUS CLOUD OPTICAL DEPTH COMPARISON
ARM SGP RADAR VS VIRS 1998

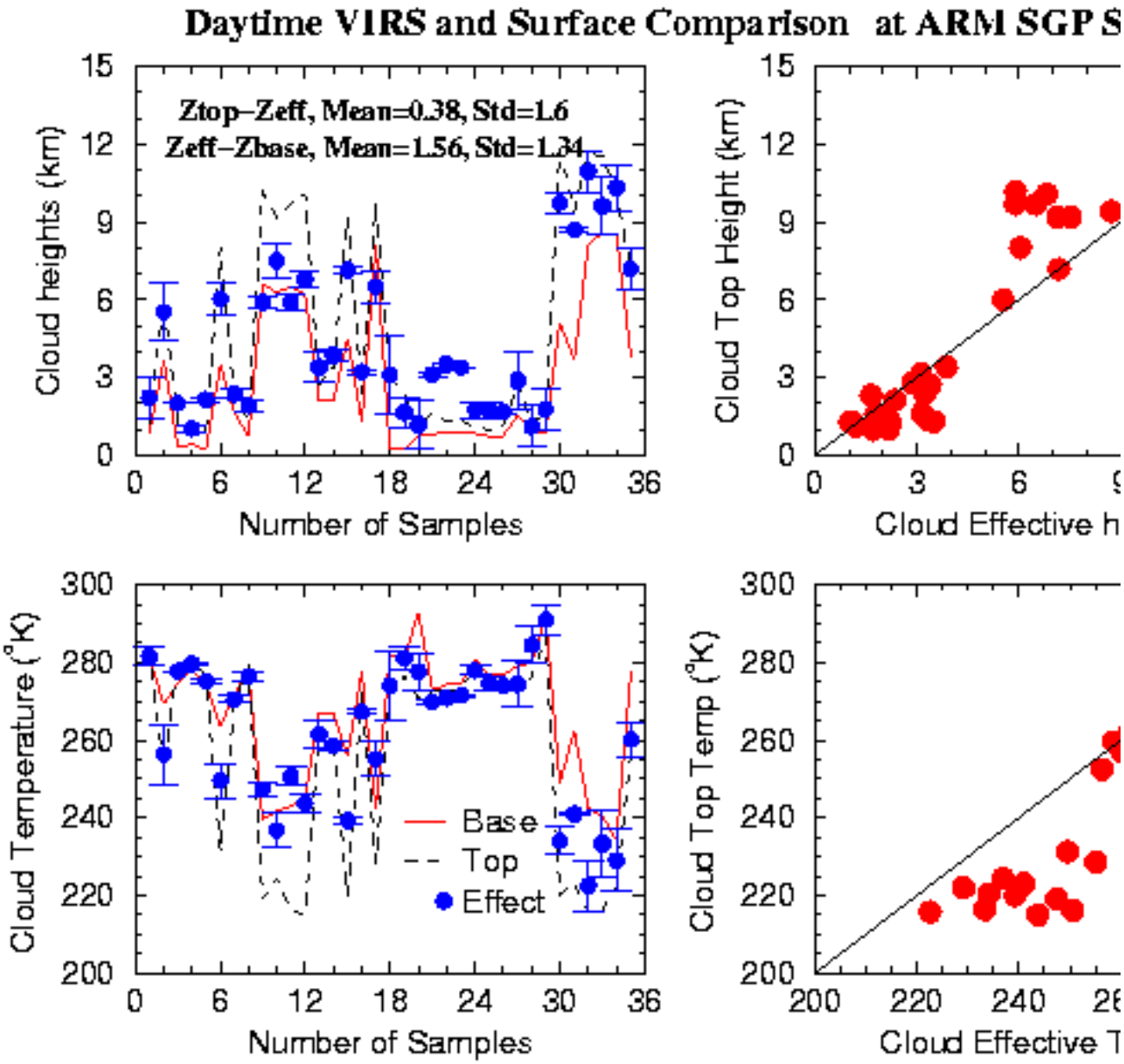


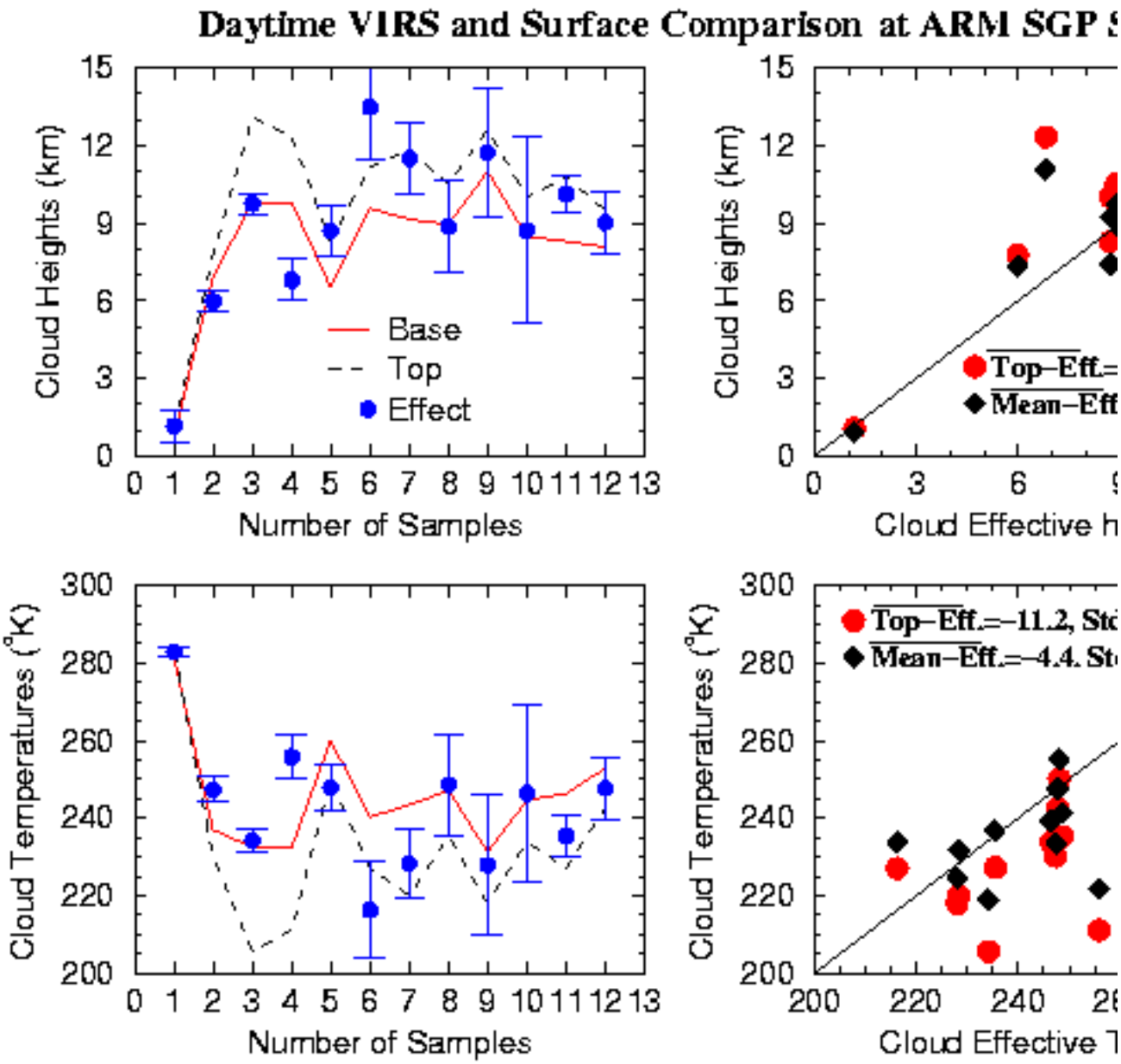


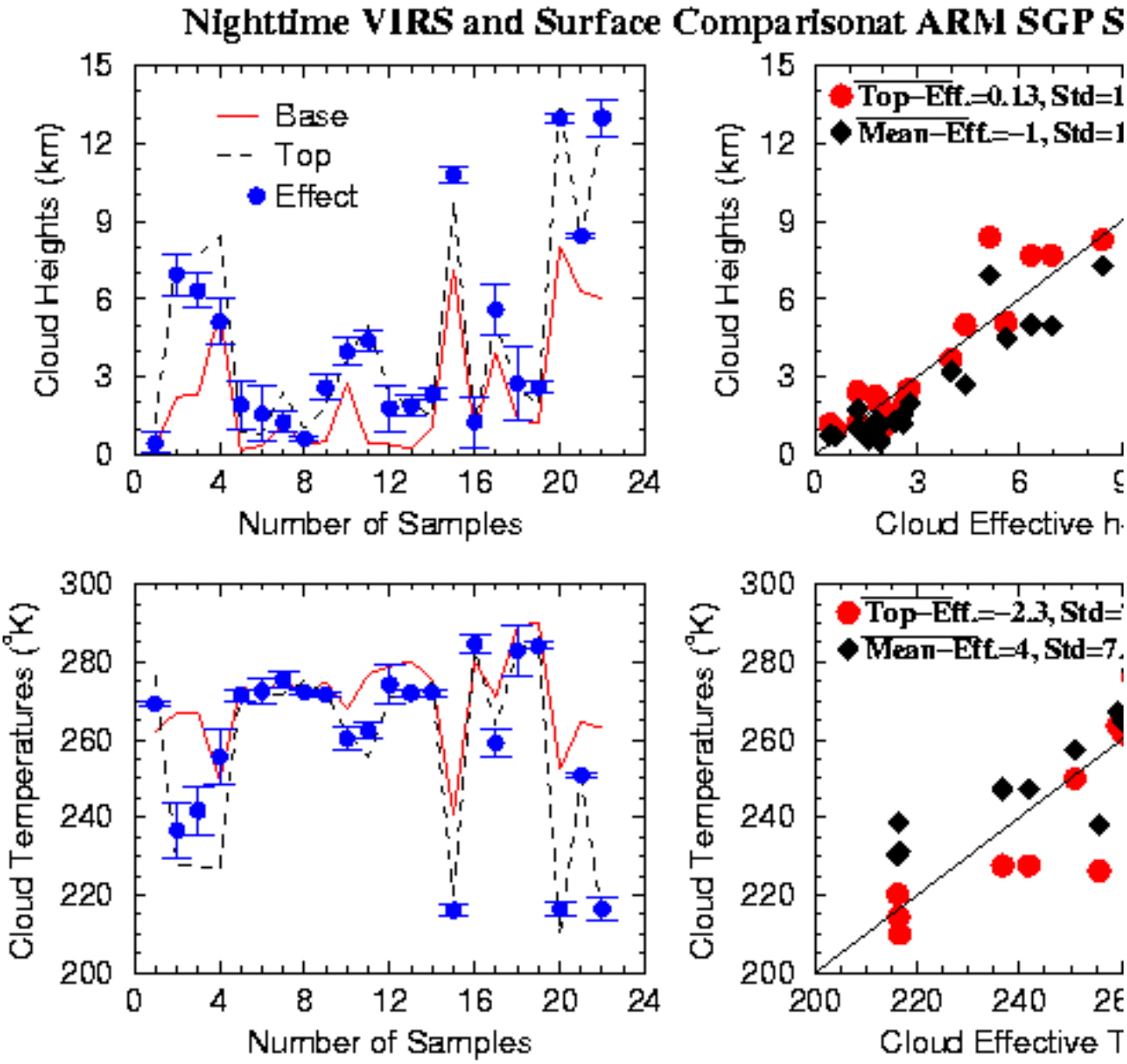
CIRRUS CLOUD IWP COMPARISON
ARM SGP RADAR VS VIRS 1998

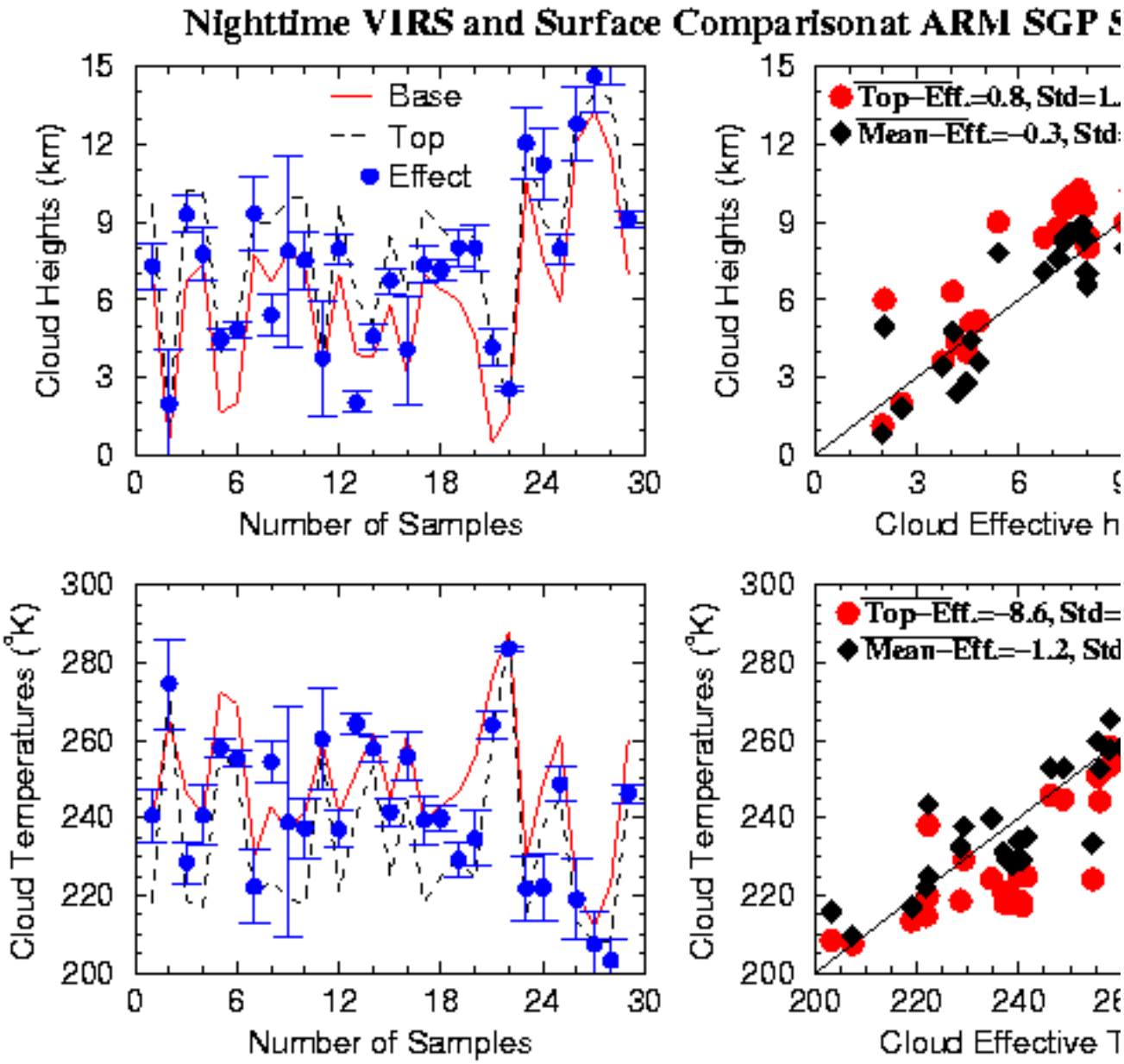



Daytime VIRS and Surface Comparison at ARM SGP S
Base
Top
Effect
Cloud Heights (km)
Number of Samples
Top–Eff.=0.4, Std=L
Mean–Eff.=–0.6, Std
Cloud Effective h
Cloud Temperatures (°K)
Top–Eff.=–6.9, Std=
Mean–Eff.=–1, Std=
Cloud Effective T

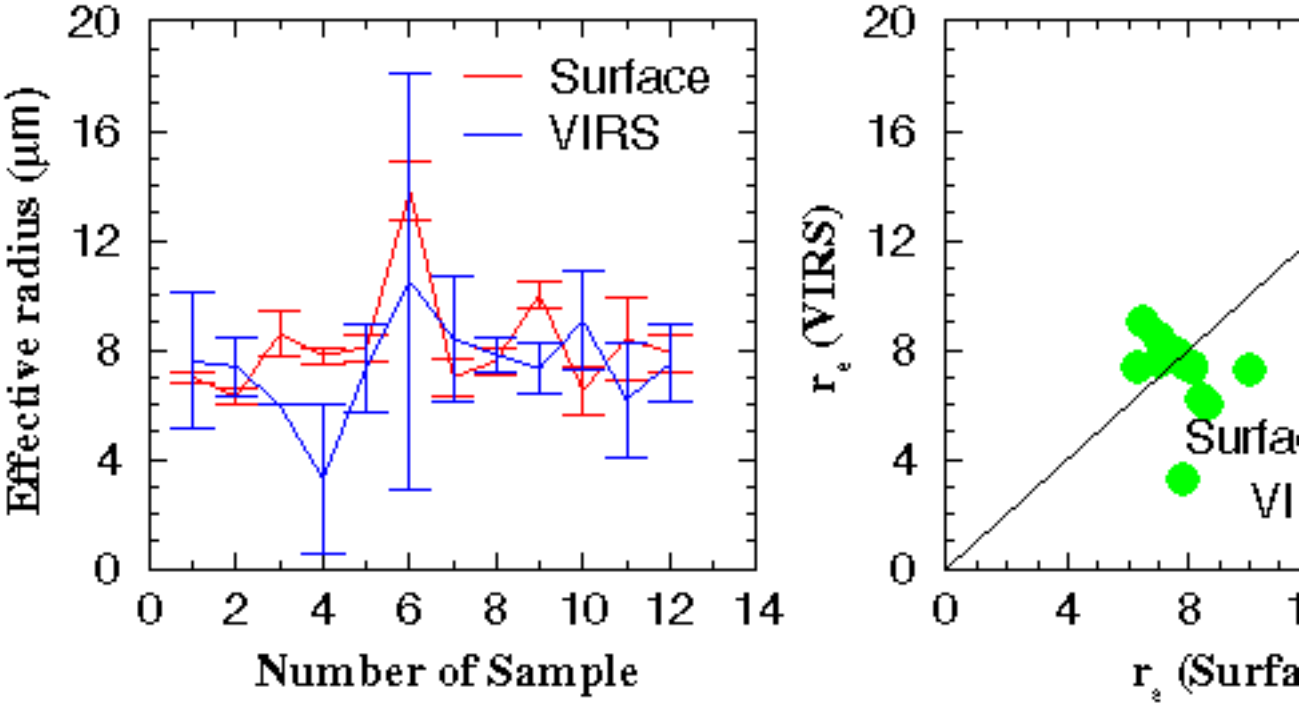

Daytime VIRS and Surface Comparison at ARM SGP S
Ztop−Zeff, Mean=0.38, Std=1.6
Zeff−Zbase, Mean=1.56, Std=1.34
Cloud heights (km)
Number of Samples
Cloud Top Height (km)
Cloud Effective h
Cloud Temperature (°K)
Base
Top
Effect
Number of Samples
Cloud Top Temp (°K)
Cloud Effective T


Daytime VIRS and Surface Comparison at ARM SGP S
Cloud Heights (km)
Number of Samples
Base
Top
Effect
Cloud Heights (km)
Top−Eff.=
Mean−Eff
Cloud Effective h
Cloud Temperatures (°K)
Number of Samples
Cloud Temperatures (°K)
Top−Eff.=−11.2, Sto
Mean−Eff.=−4.4. St
Cloud Effective T

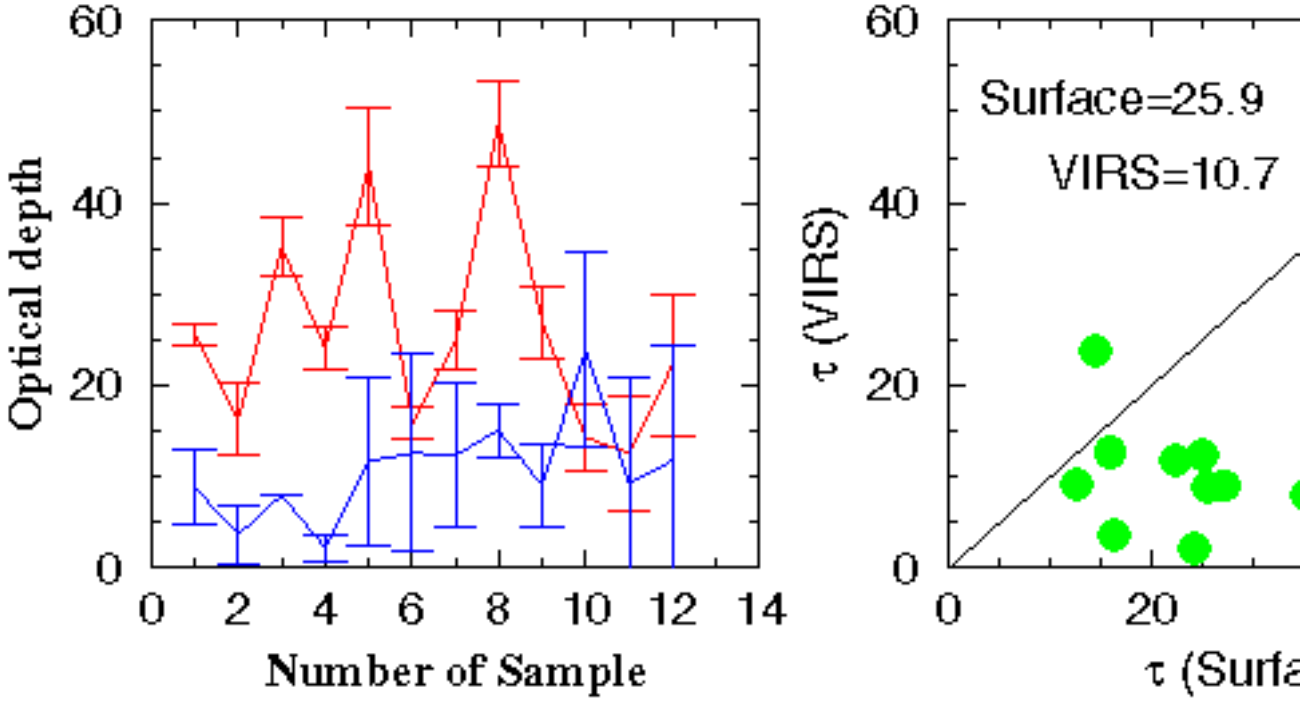

Nighttime VIRS and Surface Comparisonat ARM SGP S
Base
Top
Effect
Cloud Heights (km)
Number of Samples
Top–Eff.=0.13, Std=1
Mean–Eff.=–1, Std=1
Cloud Heights (km)
Cloud Effective h
Cloud Temperatures (°K)
Number of Samples
Top–Eff.=–2.3, Std=
Mean–Eff.=4, Std=7.
Cloud Temperatures (°K)
Cloud Effective T


Nighttime VIRS and Surface Comparison at ARM SGP S
Base
Top
Effect
Cloud Heights (km)
Number of Samples
Top−Eff.=0.8, Std=1.
Mean−Eff.=−0.3, Std
Cloud Effective h
Cloud Temperatures (°K)
Top−Eff.=−8.6, Std=
Mean−Eff.=−1.2, Std
Cloud Effective T

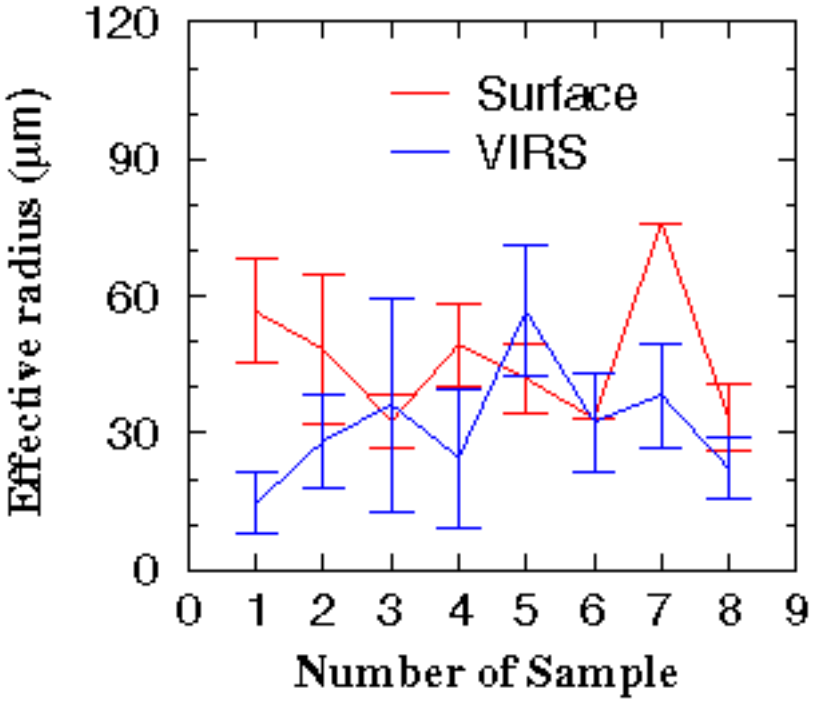
STRATUS CLOUD DROPLET SIZE COMPARISON
ARM SGP RADAR VS VIRS 1998
NIGHT

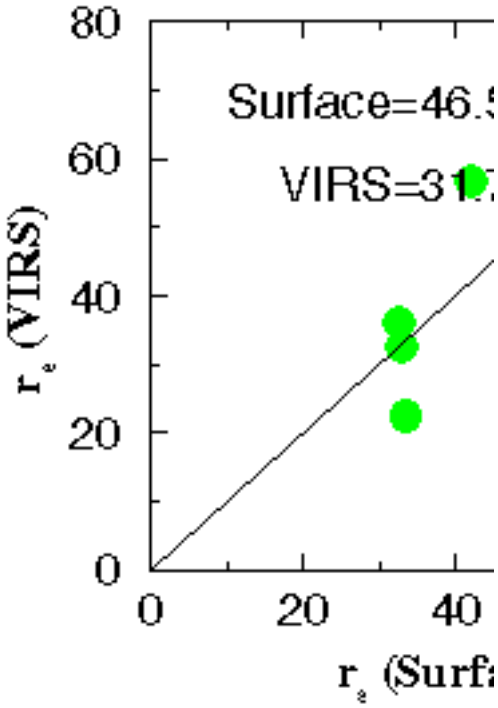


STRATUS CLOUD OPTICAL DEPTH COMPARISON
ARM SGP RADAR VS VIRS 1998
NIGHT

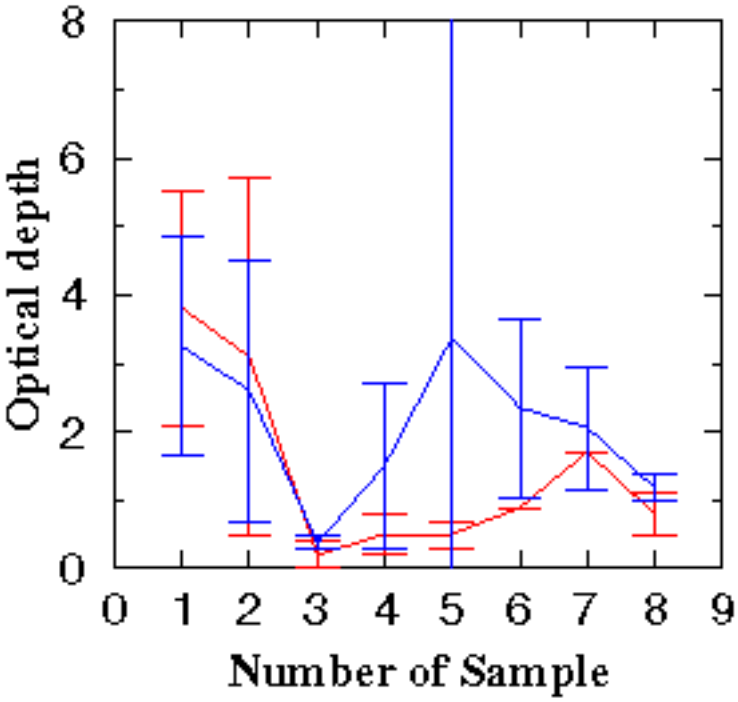


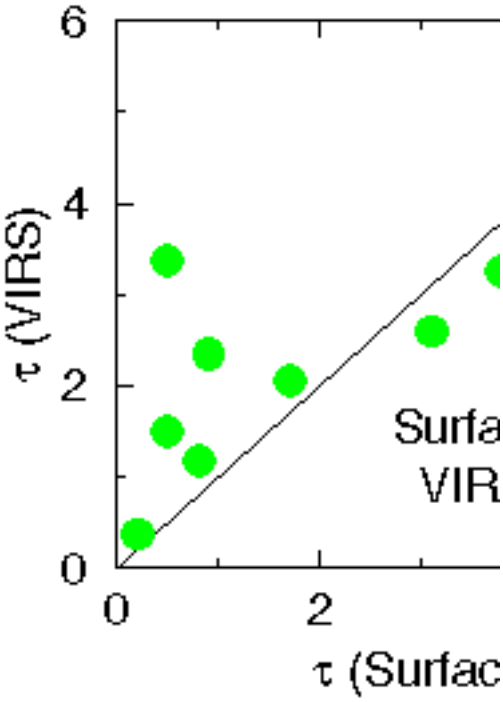
CIRRUS CLOUD CRYSTAL SIZE COMPARISON
ARM SGP RADAR VS VIRS 1998
NIGHT





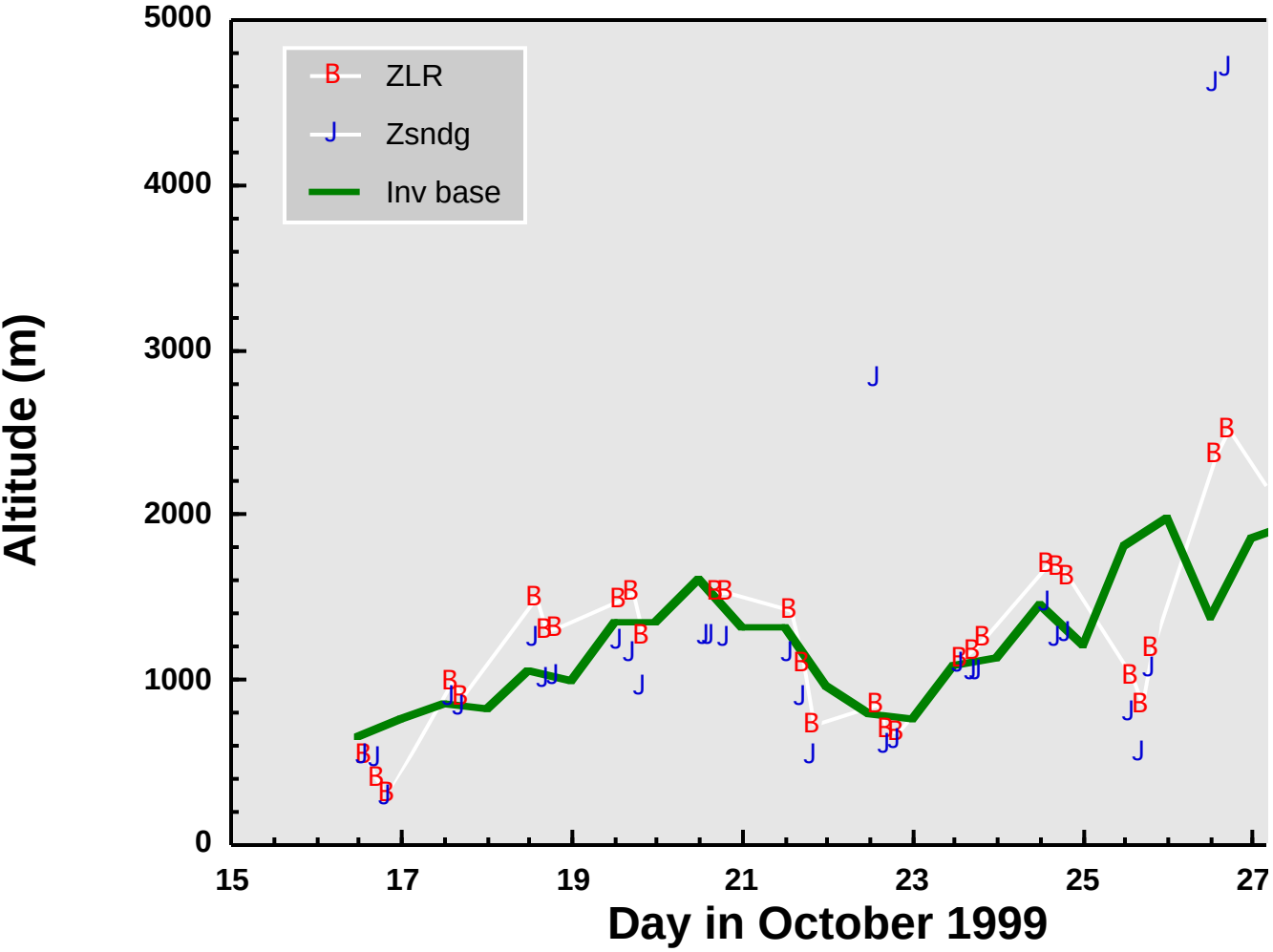
CIRRUS CLOUD OPTICAL DEPTH COMPARISON
ARM SGP RADAR VS VIRS 1998
NIGHT





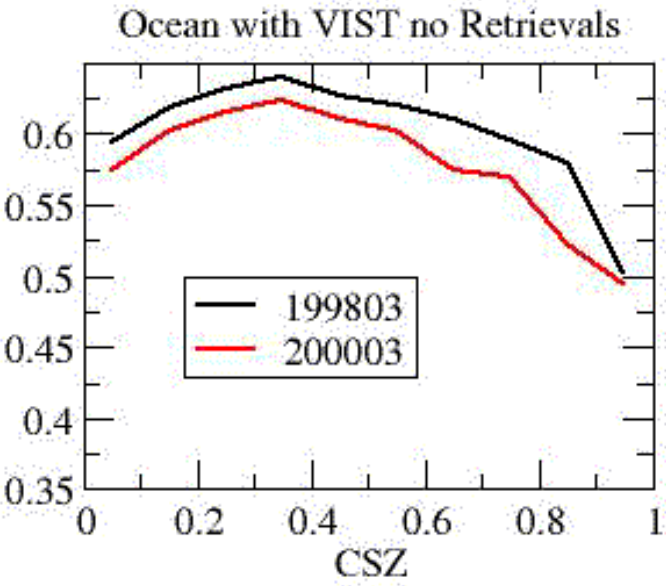
Comparison of cloud-top heights derived GOES-8 with inversion base heights from rawinsondes along transect of R/V Vidal Gormaz in SE Pacific.

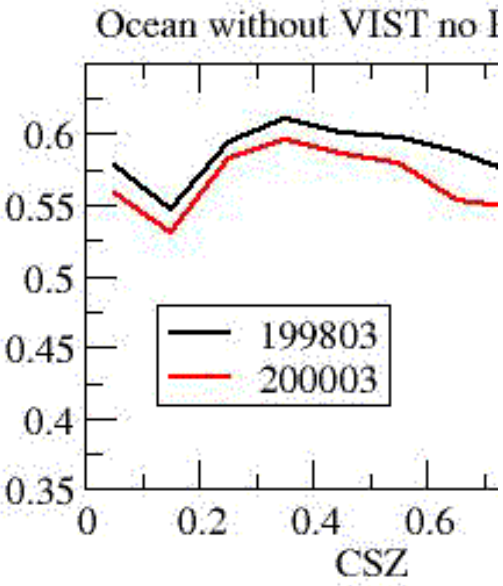
Asterisks denote observations of light rain.

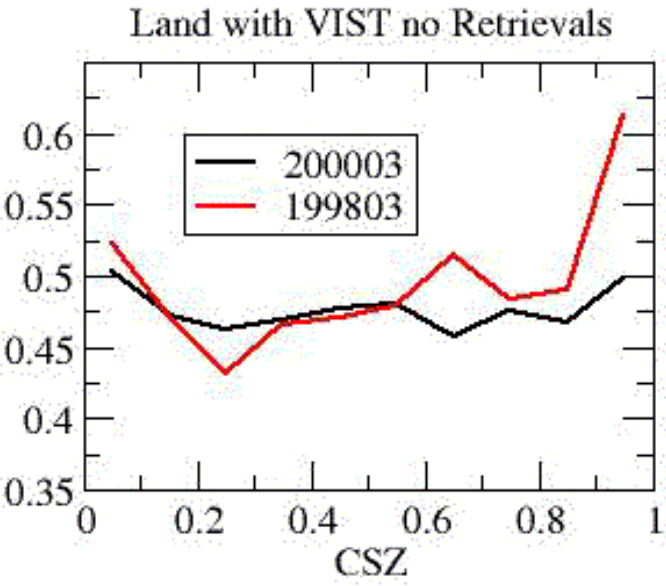


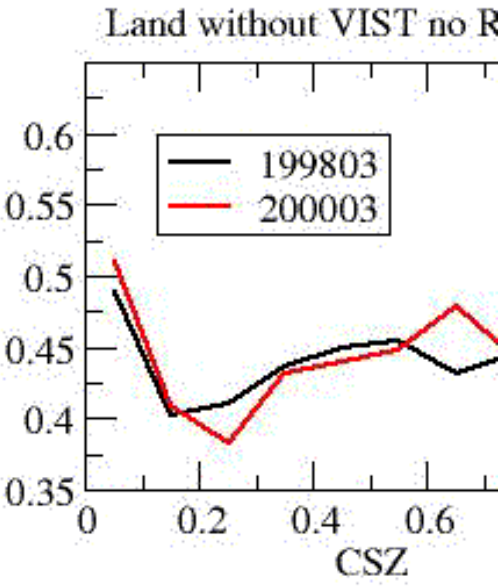
ANGULAR DEPENDENCE OF CLOUD PROPERTIES

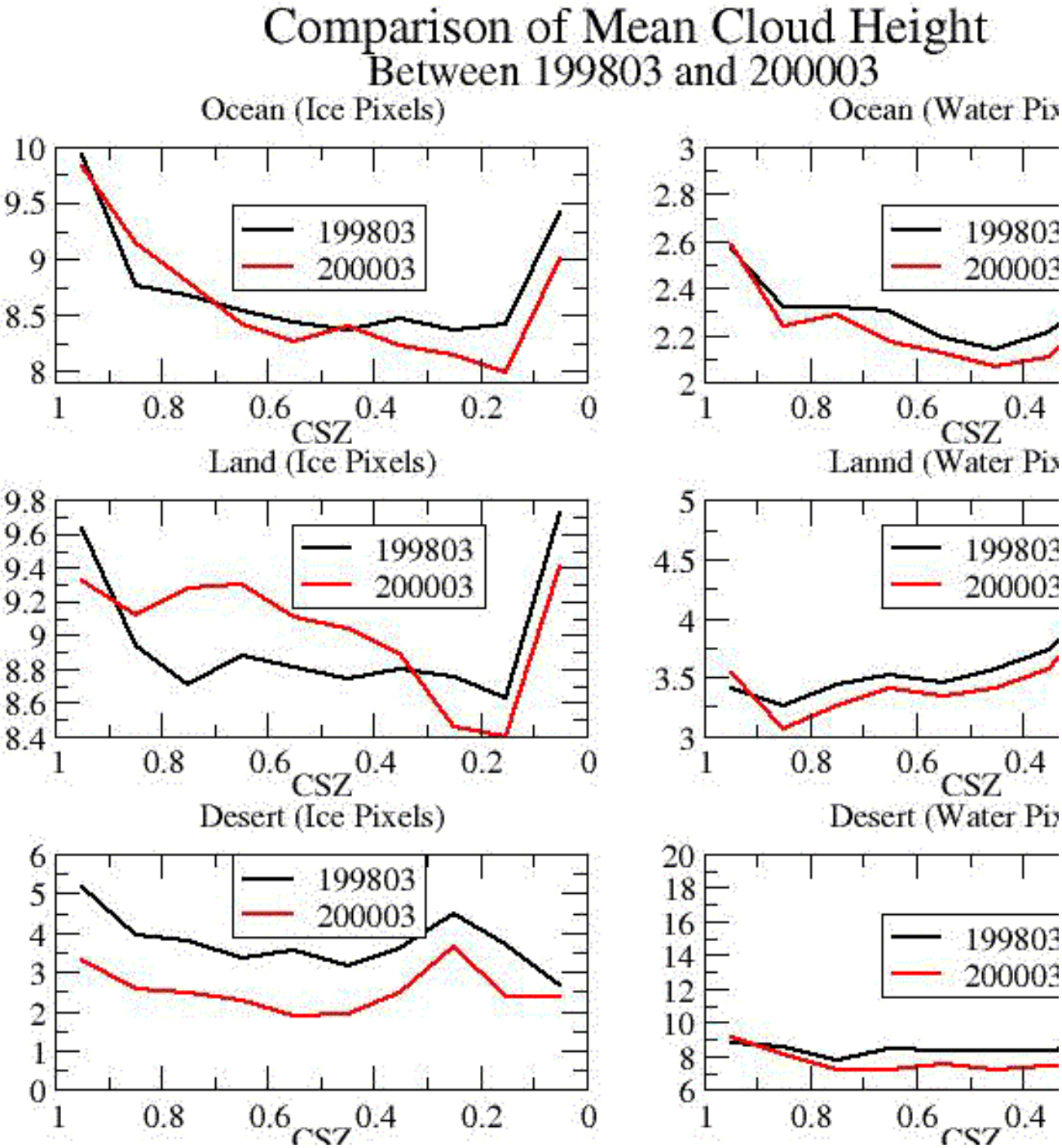
Comparison of Mean Cloud Fraction Between 199803 and 200003

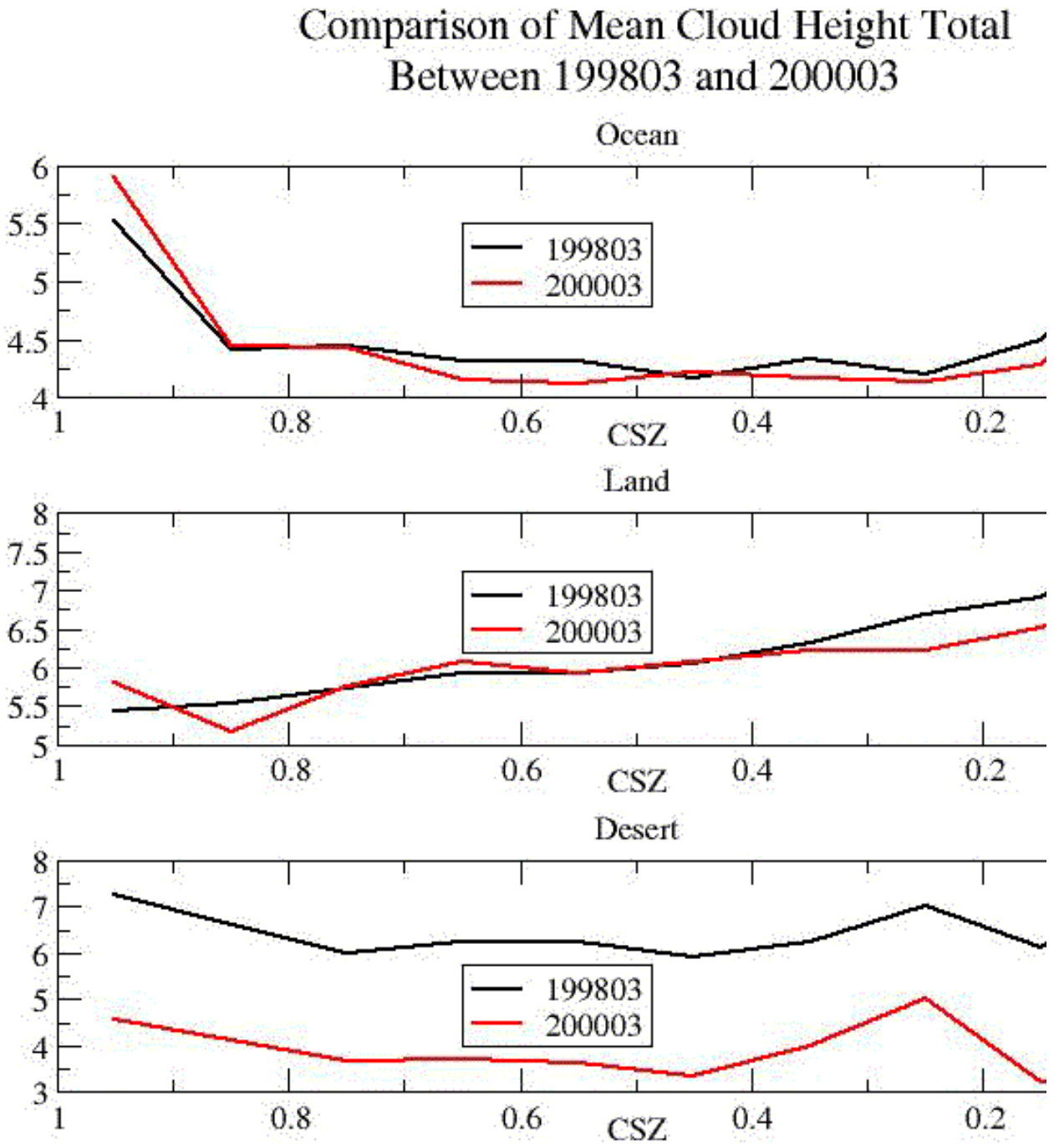




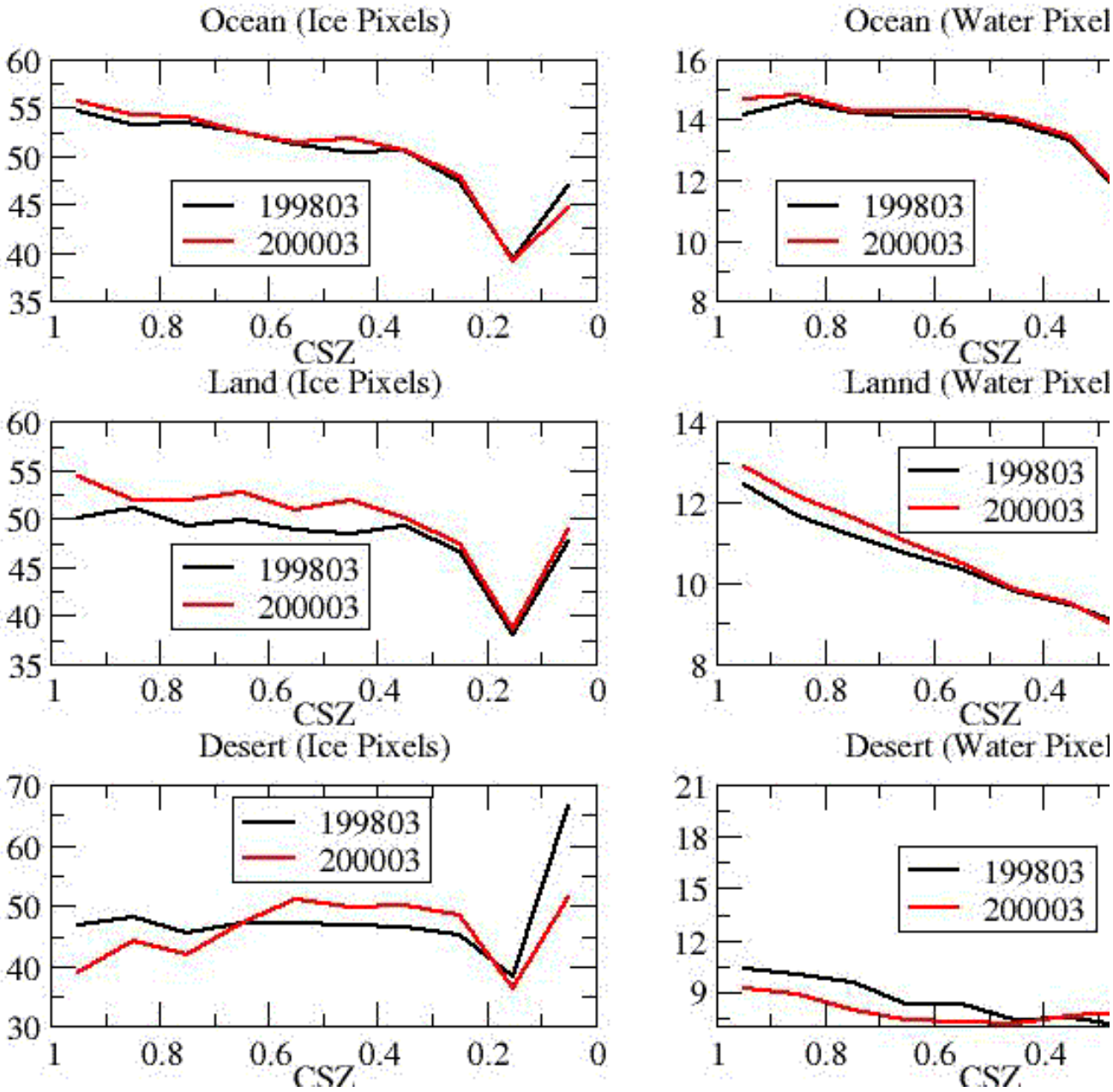




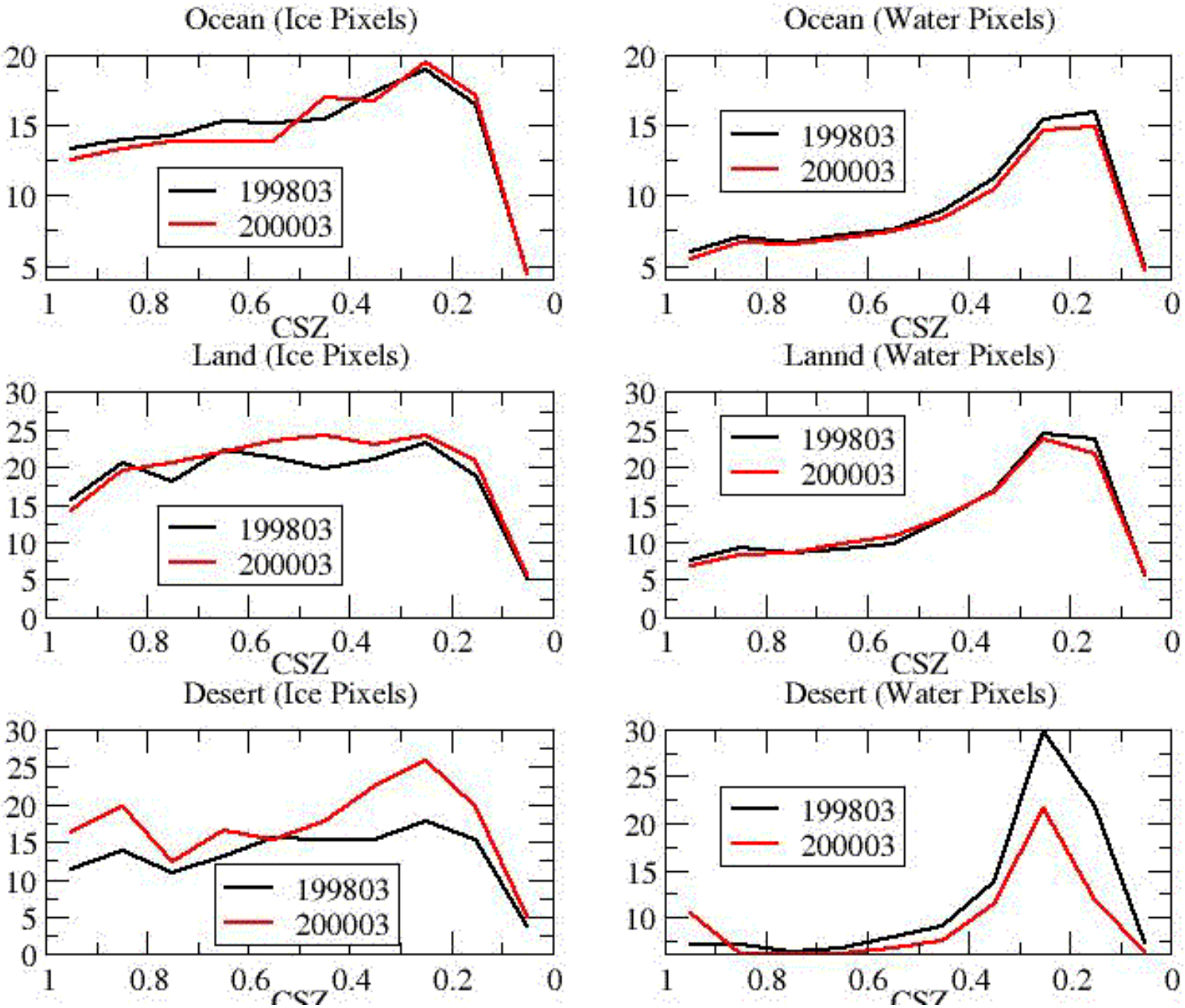

Comparison of Mean Cloud Height
Between 199803 and 200003
Ocean (Ice Pixels)
Ocean (Water Pix
Land (Ice Pixels)
Lannd (Water Pix
Desert (Ice Pixels)
Desert (Water Pix
199803
200003
CSZ

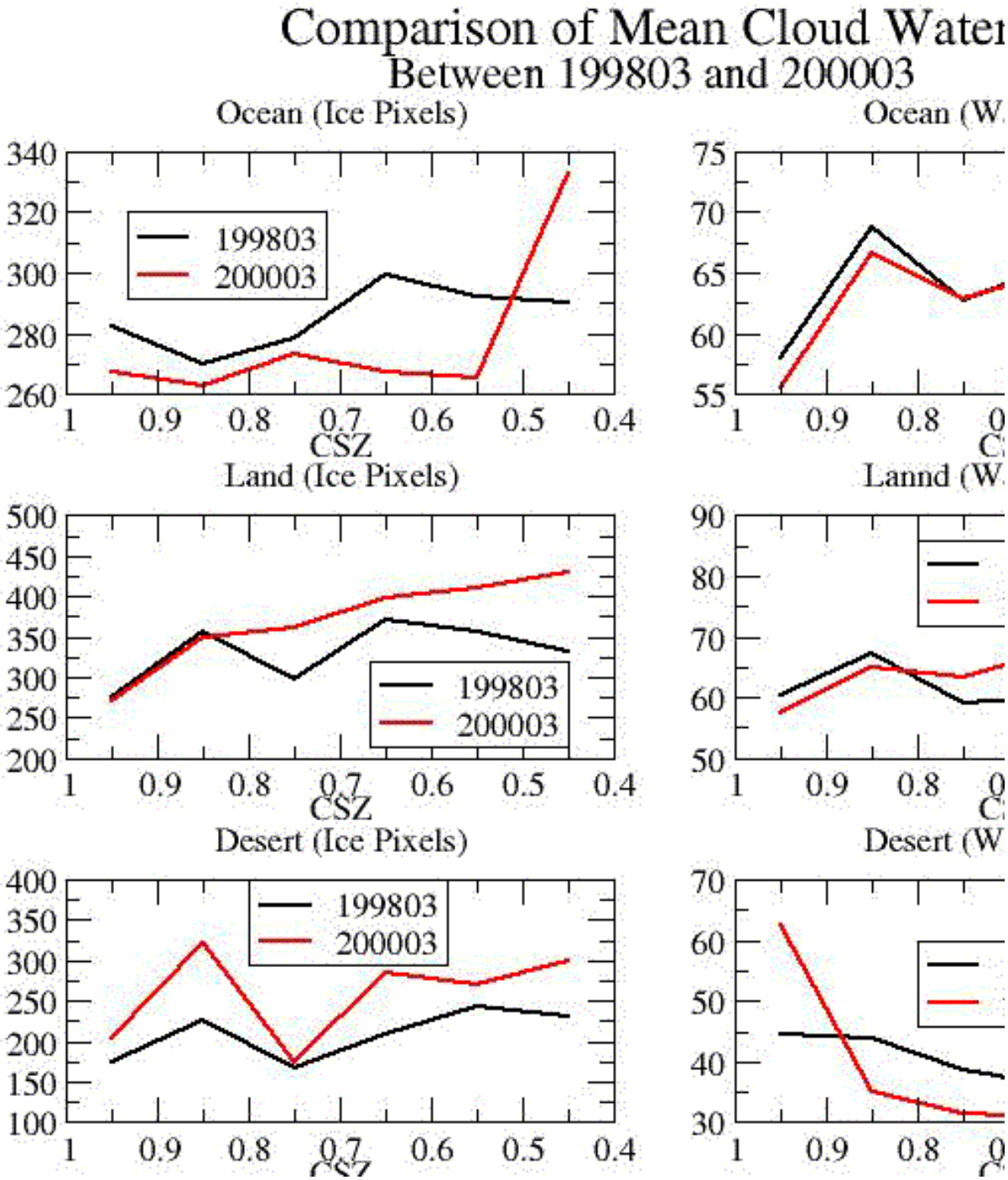

Comparison of Mean Cloud Height Total
Between 199803 and 200003
Ocean
6
5.5
5
4.5
4
1
0.8
0.6
0.4
0.2
CSZ
199803
200003
Land
8
7.5
7
6.5
6
5.5
5
1
0.8
0.6
0.4
0.2
CSZ
199803
200003
Desert
8
7
6
5
4
3
1
0.8
0.6
0.4
0.2
CSZ
199803
200003

Comparison of Mean Cloud Particle Size
Between 199803 and 200003

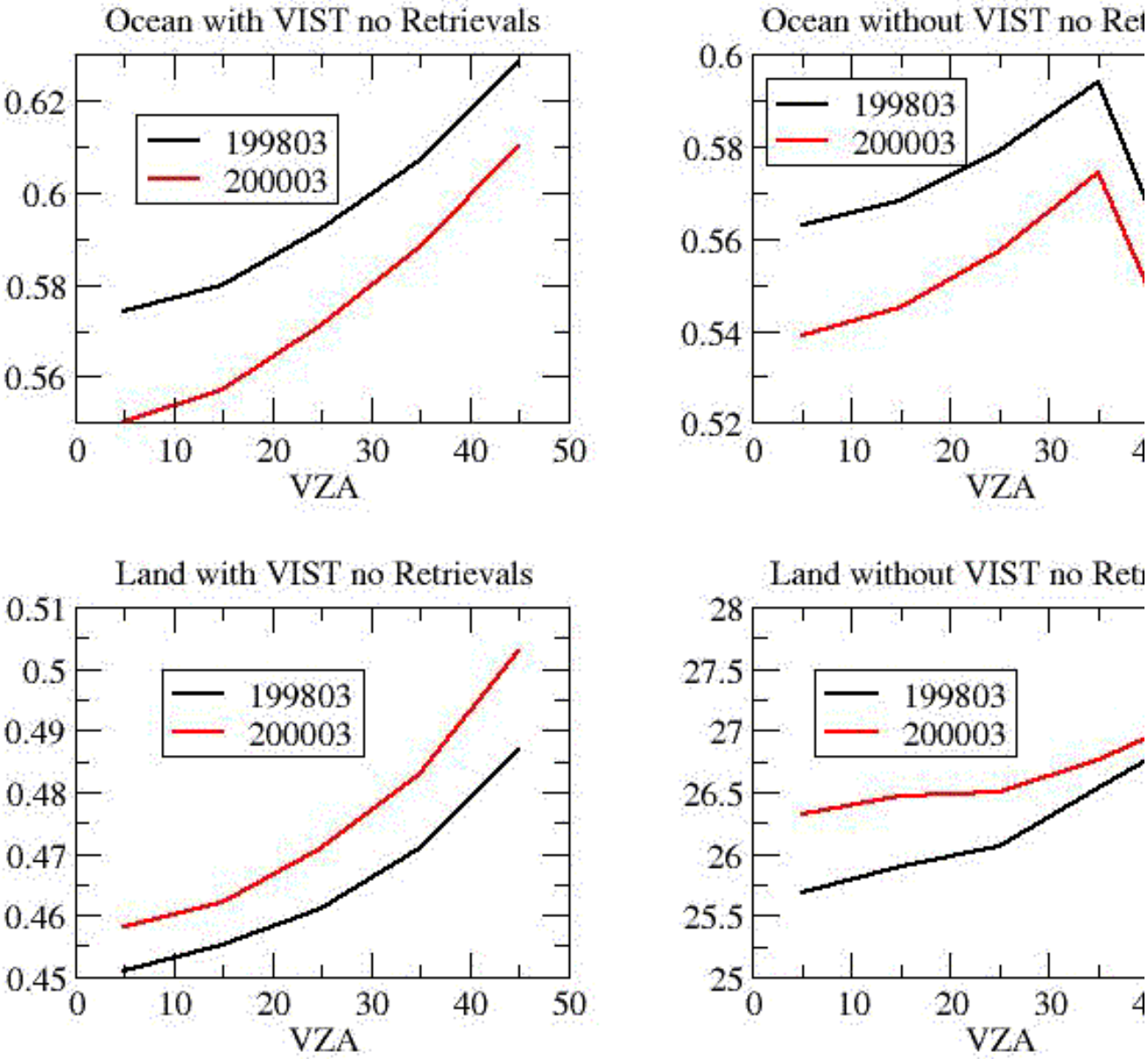


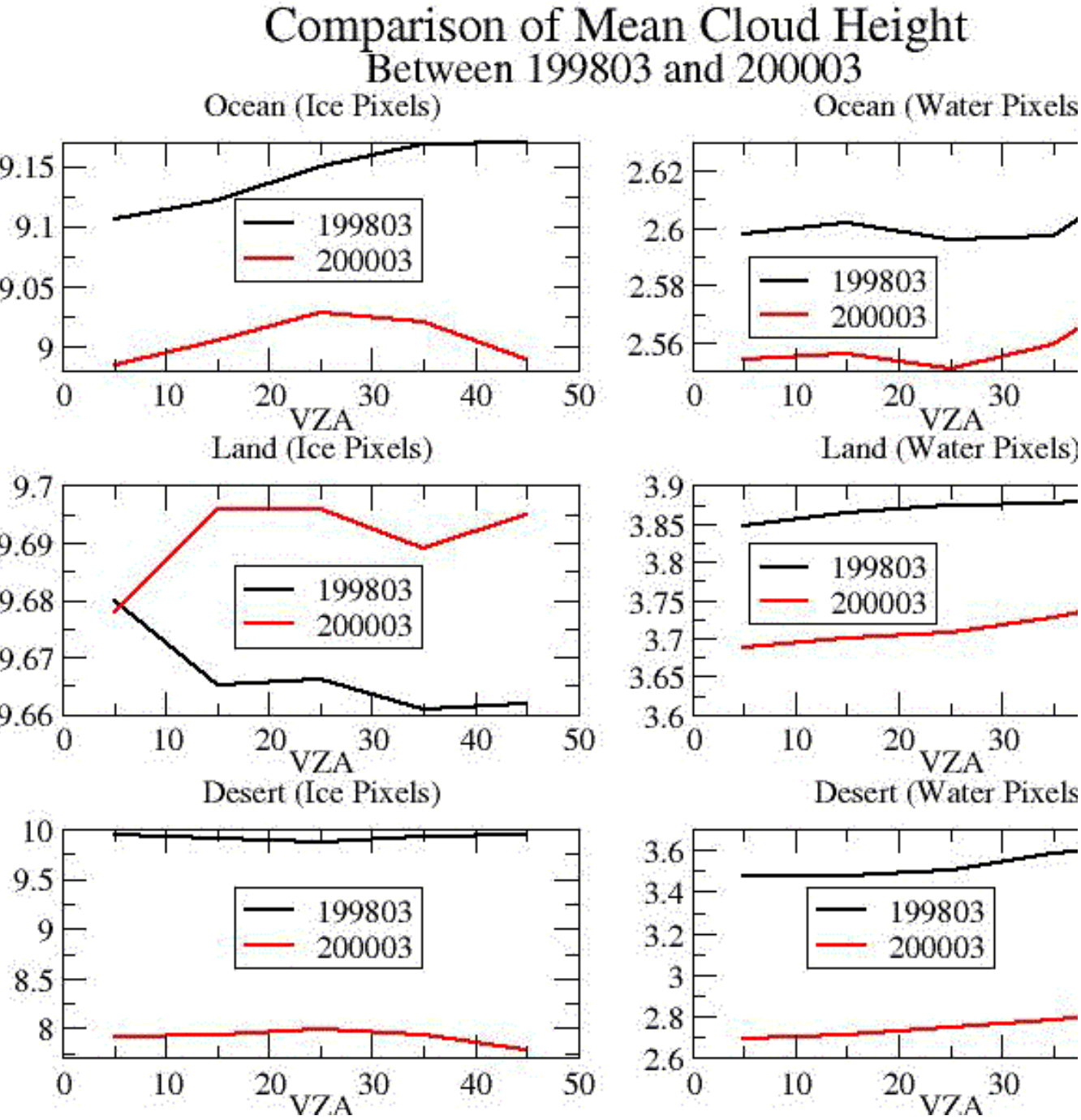
Comparison of Mean Cloud Optical Depth
Between 199803 and 200003



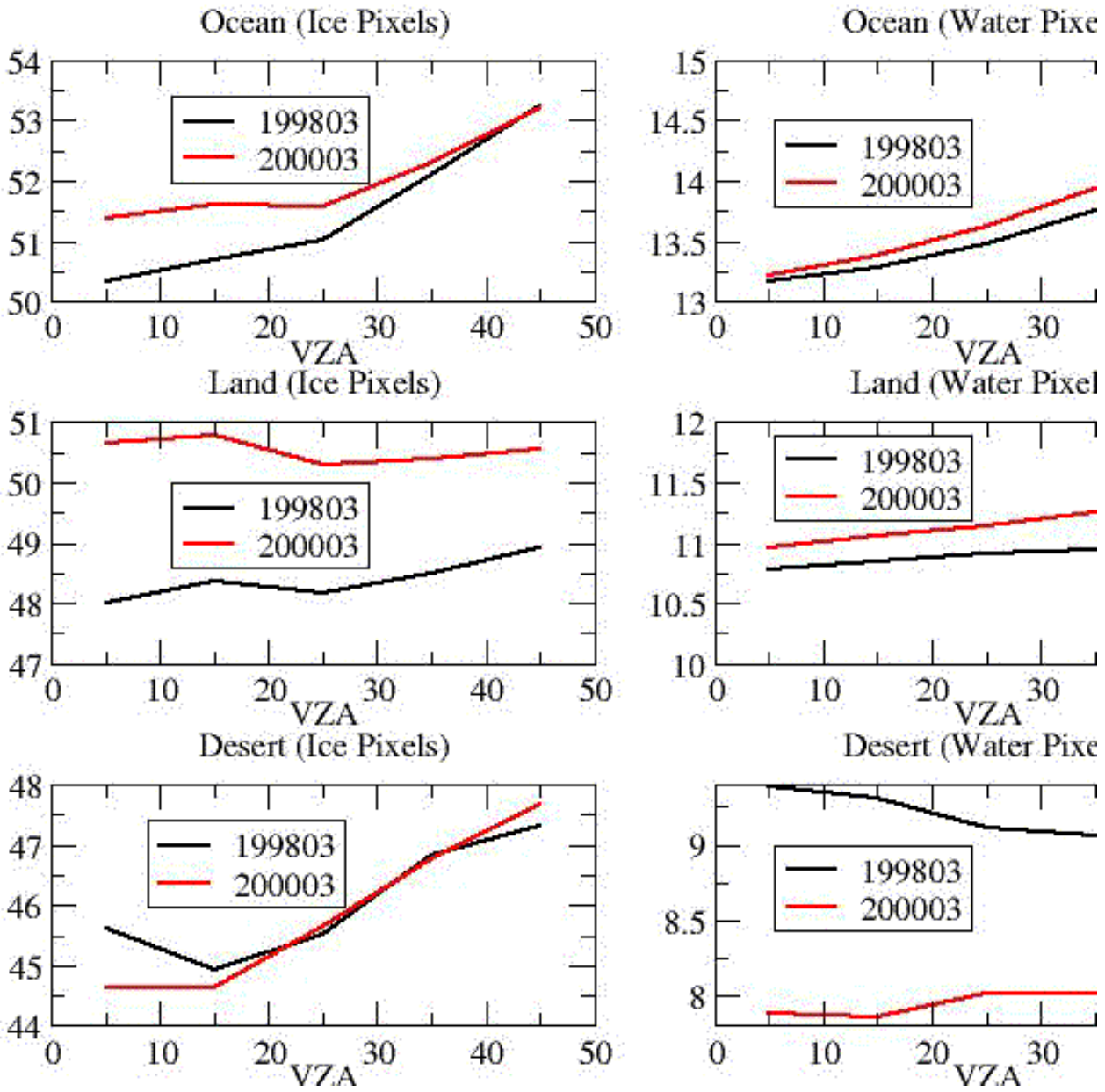

Comparison of Mean Cloud Water
Between 199803 and 200003
Ocean (Ice Pixels)
Ocean (W
Land (Ice Pixels)
Lannd (W
Desert (Ice Pixels)
Desert (W
199803
200003
CSZ

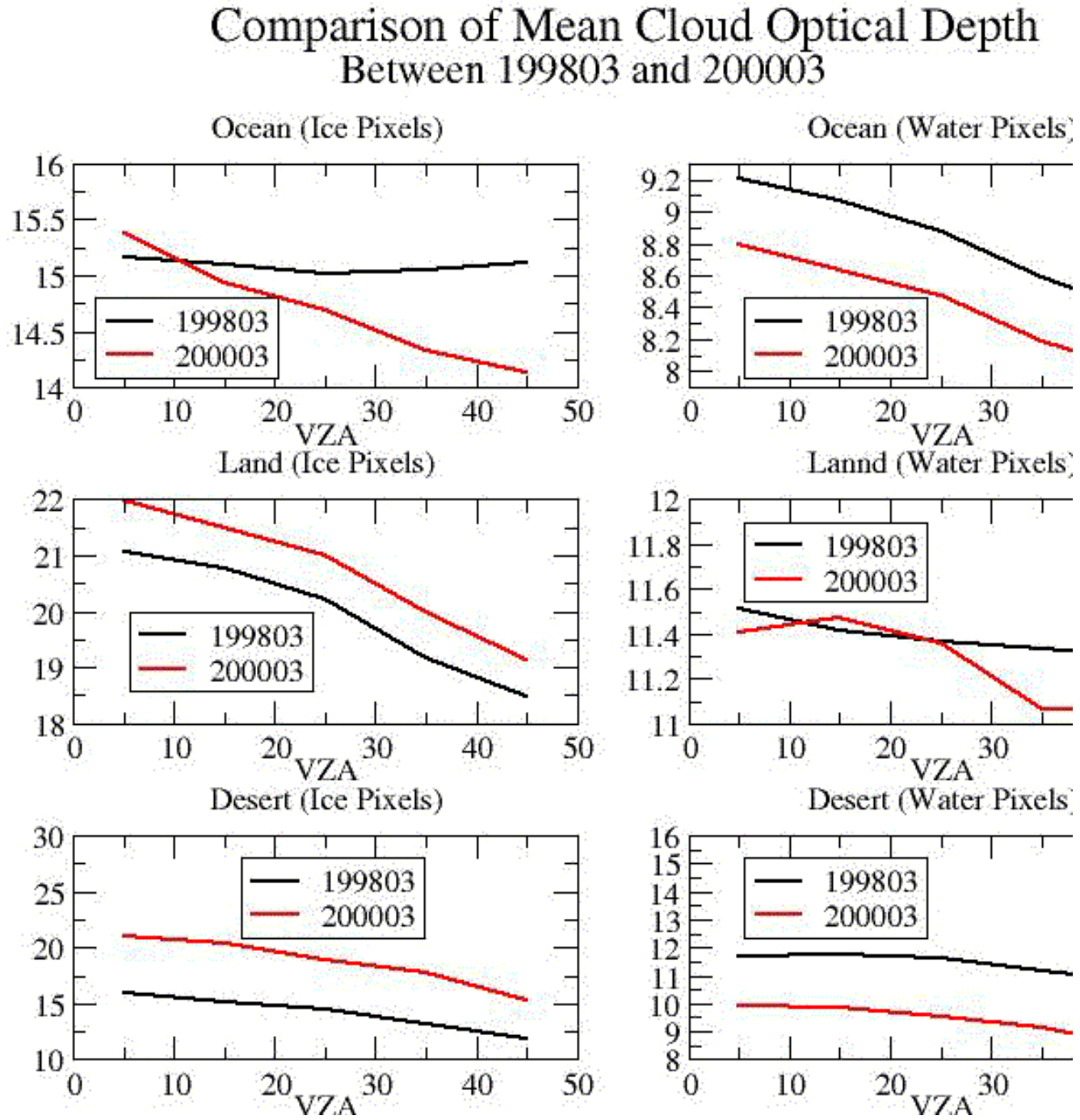
Comparison of Mean Cloud Fraction Between 199803 and 200003

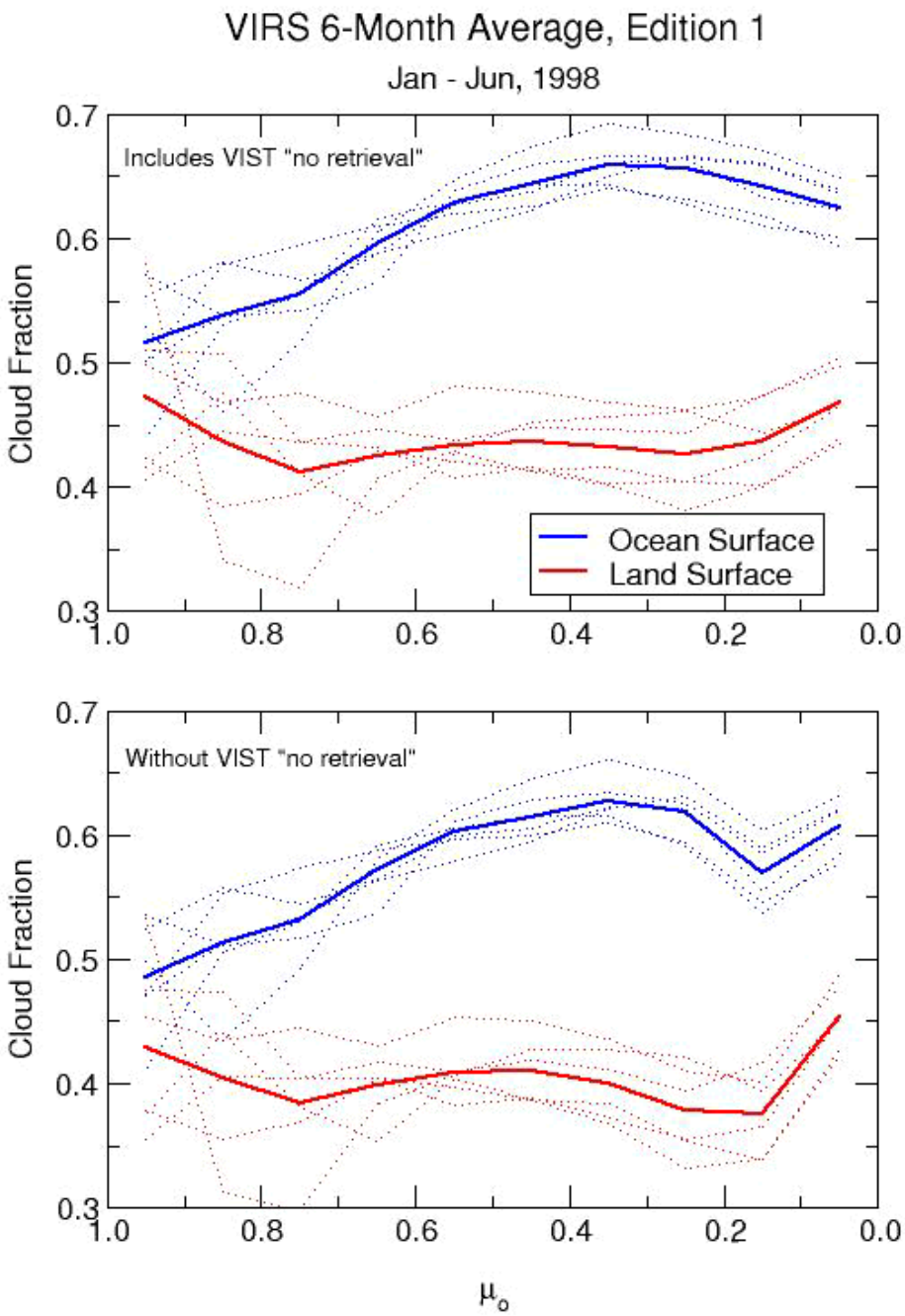



Comparison of Mean Cloud Height
Between 199803 and 200003
Ocean (Ice Pixels)
Ocean (Water Pixels
Land (Ice Pixels)
Land (Water Pixels)
Desert (Ice Pixels)
Desert (Water Pixels
199803
200003
VZA

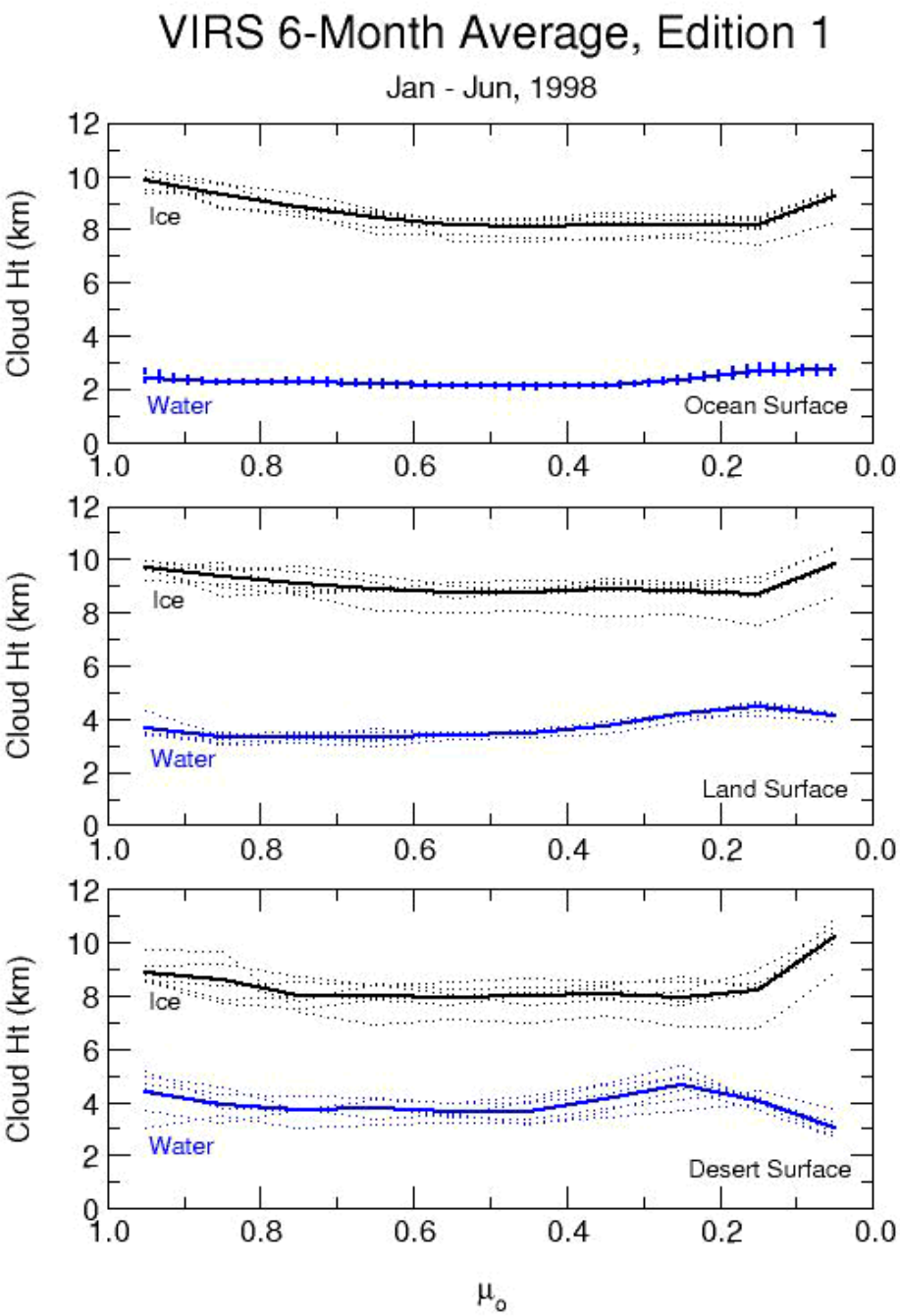
Comparison of Mean Cloud Particle Size
Between 199803 and 200003



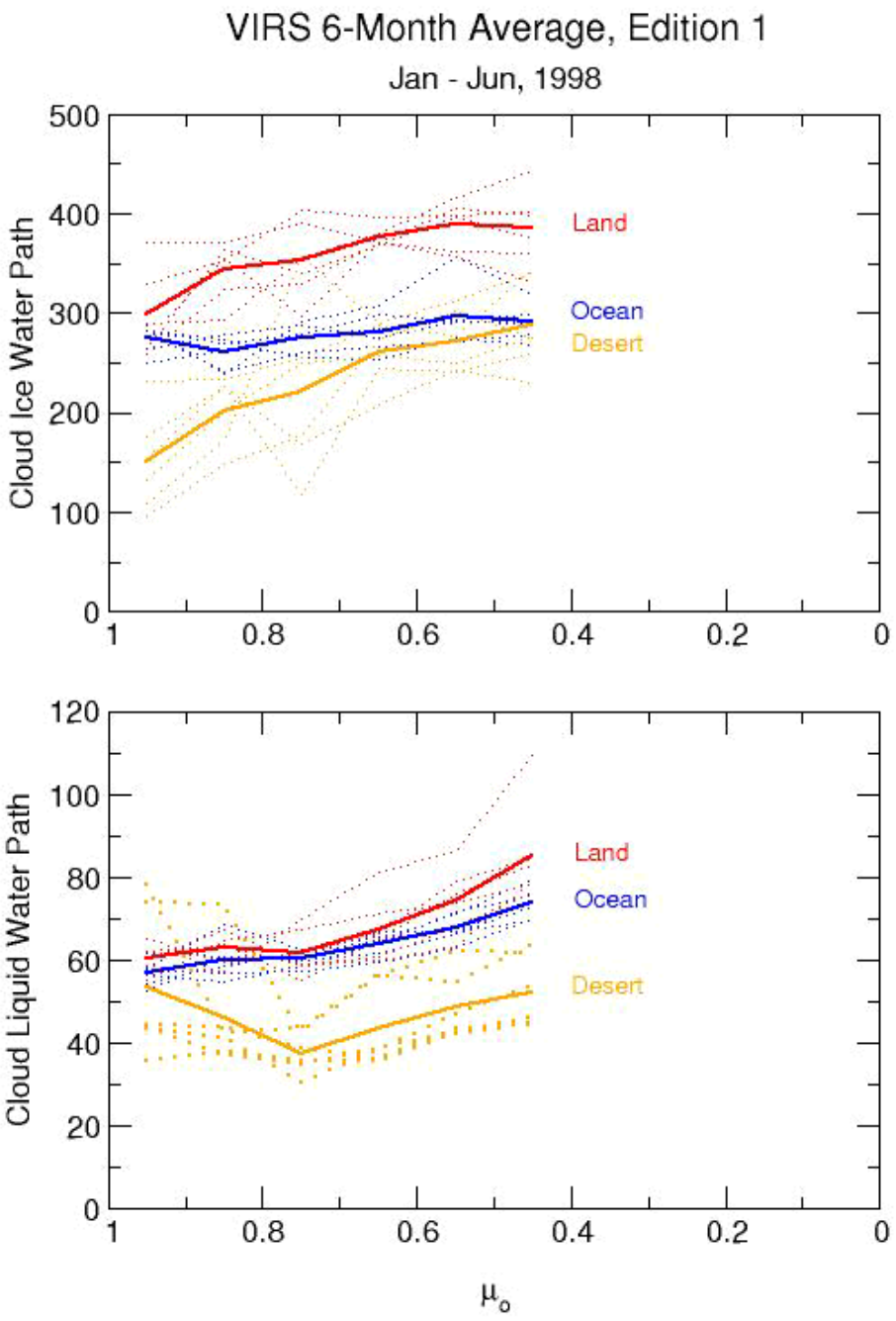

Comparison of Mean Cloud Optical Depth
Between 199803 and 200003
Ocean (Ice Pixels)
Ocean (Water Pixels)
Land (Ice Pixels)
Lannd (Water Pixels)
Desert (Ice Pixels)
Desert (Water Pixels)
199803
200003
VZA



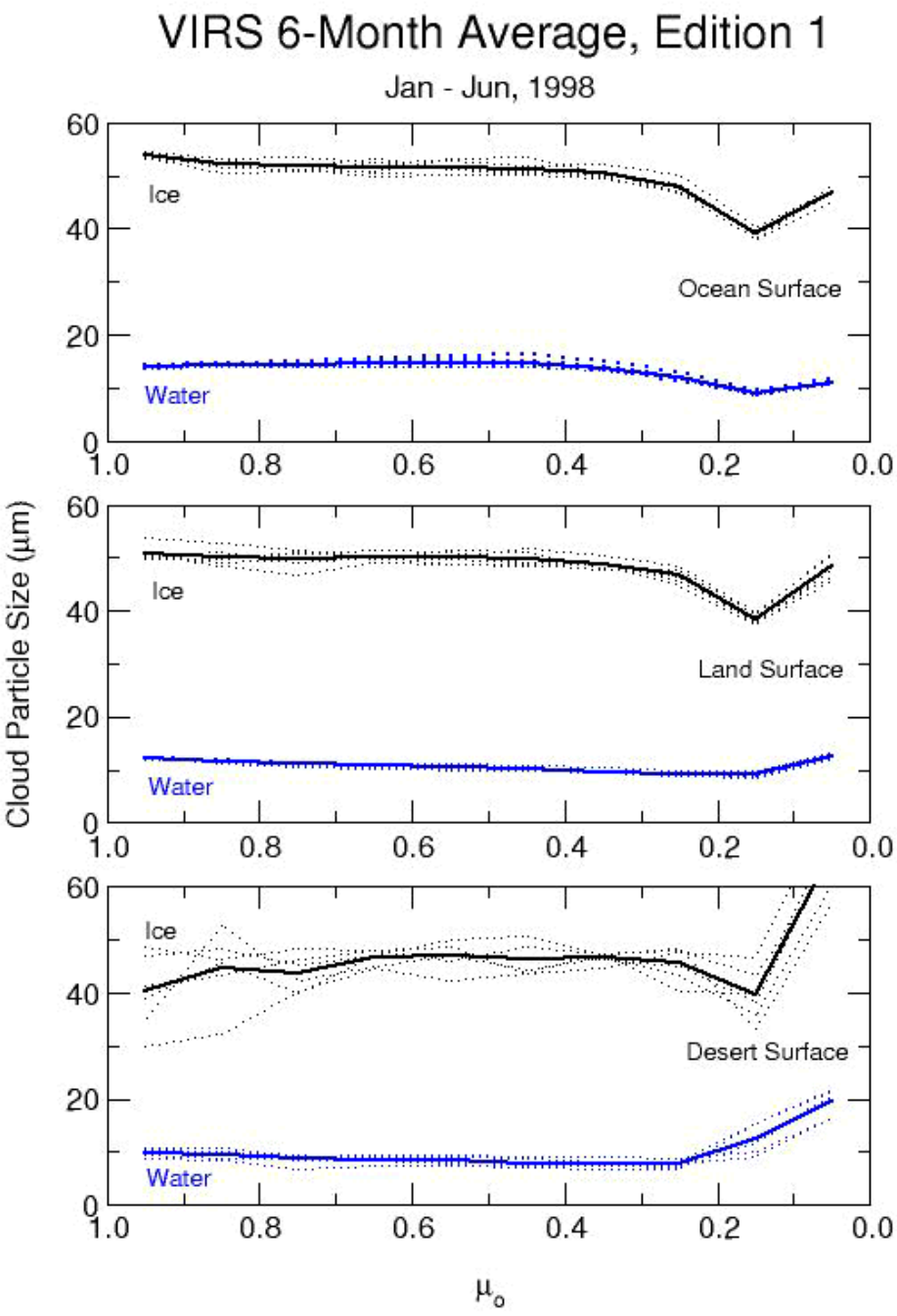
SOLAR ZENITH ANGLE DEPENDENCE OF CLOUD FRACTION



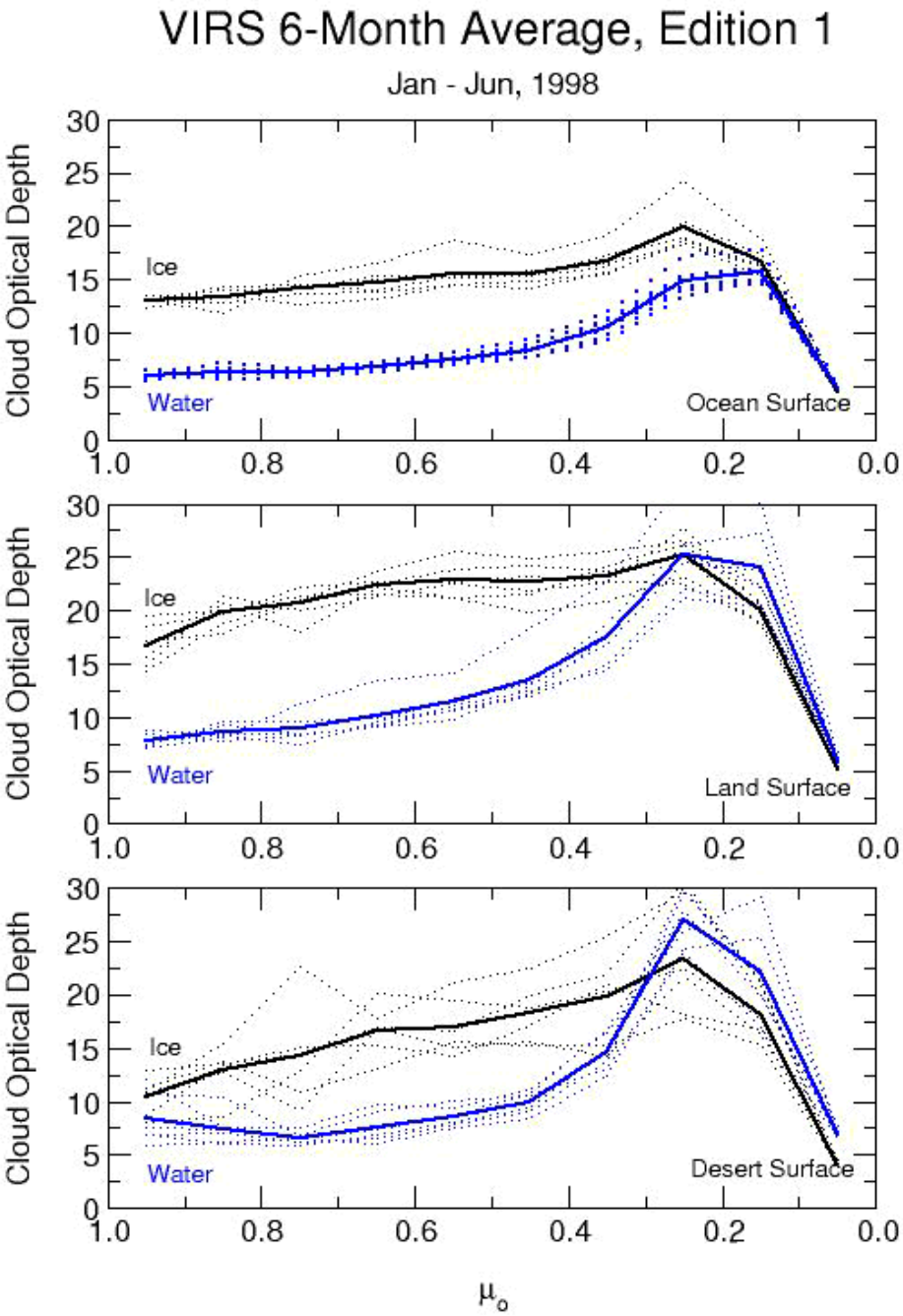
SOLAR ZENITH ANGLE DEPENDENCE OF CLOUD HEIGHT



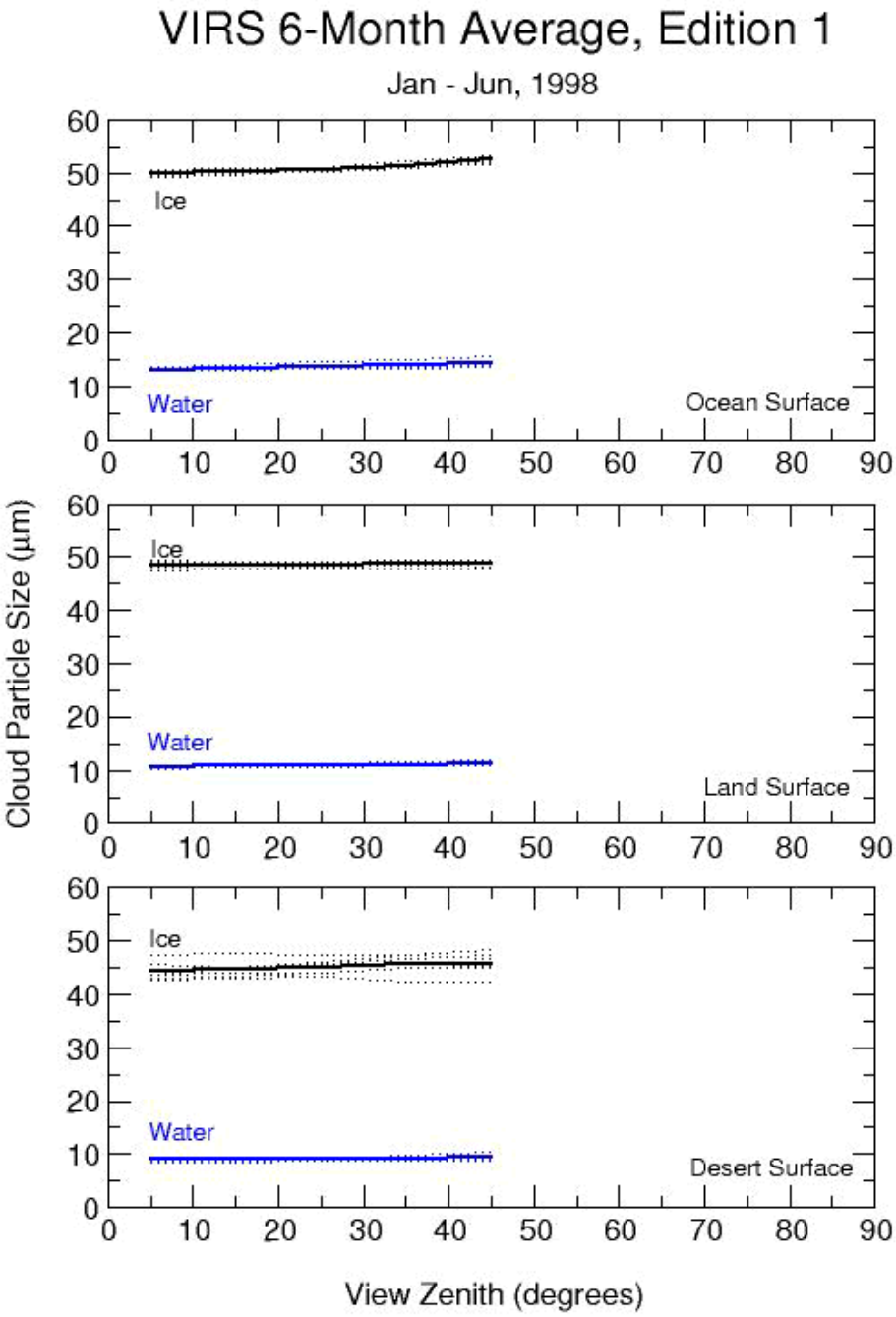
SOLAR ZENITH ANGLE DEPENDENCE OF CLOUD WATER PATH



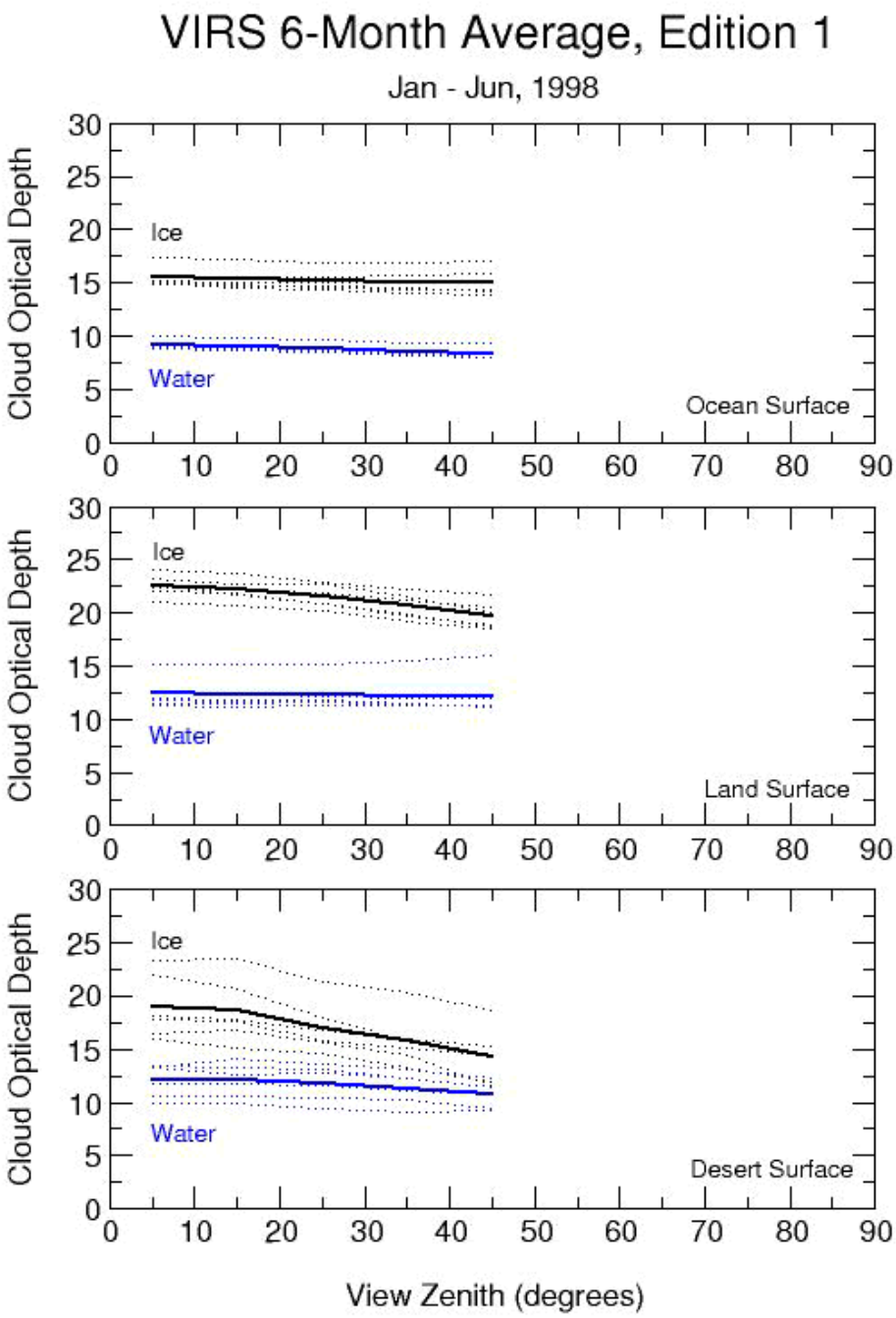
SOLAR ZENITH ANGLE DEPENDENCE OF CLOUD PARTICLE SIZE



SOLAR ZENITH ANGLE DEPENDENCE OF CLOUD OPTICAL DEPTH



VIEWING ZENITH ANGLE DEPENDENCE OF CLOUD PARTICLE SIZE



VIEWING ZENITH ANGLE DEPENDENCE OF CLOUD OPTICAL DEPTH

SUMMARY

• 7 MONTHS PROCESSED TO DATE

• CLOUD PARTICLE SIZES REDUCED

• DAYTIME SHOWS GOOD AGREEMENT IN STRATUS & CIRRUS

NIGHTTIME CLOUDS MAY BE A BIT HIGH, DON'T TRUST PROPERTI

• 3% OF CLOUDS- NO RETRIEVALS

• ANGULAR DEPENDENCE OF MOST PROPERTIES

• EXCELLENT AGREEMENT WITH SFC CLIMATOLOGY

* FEWER CLOUDS, MORE OD THAN ISCCP

• SEE *CERES DATA QUALITY SUMMARY REPORT*

MODIS STATUS

(Golden days are Sept 5,6,7,8; 3 days on system).

(1) MODIS reflectance code was modified to NOT take account for earth-sun distance since MODIS provided reflectance already normalized

(2) MODIS / VIRS intercomparisons for those orbits that MODIS/VIRS overpasses time < 4 min.

(3) Polar Mask is being examined

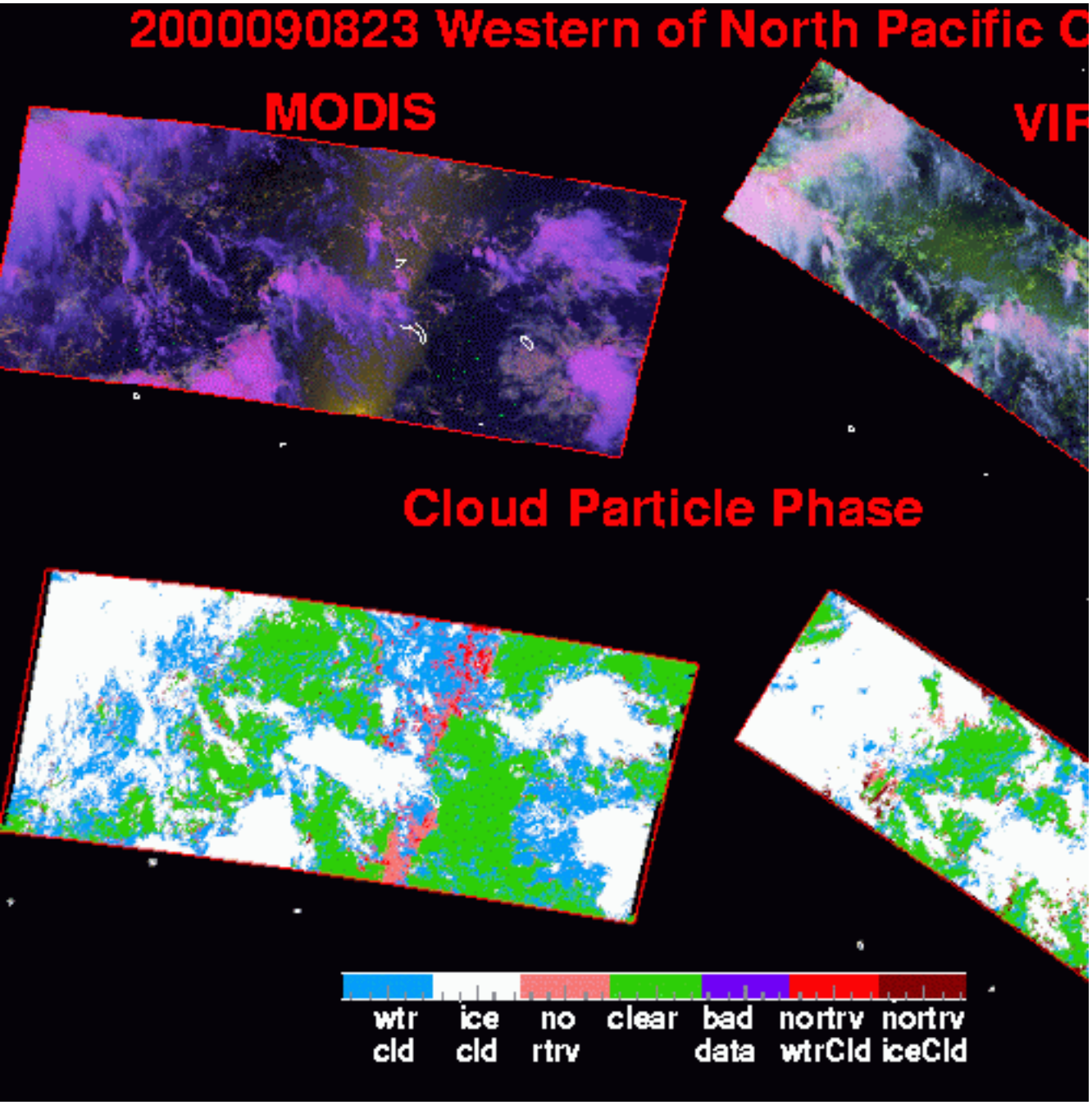
(4) MODIS data can be processed for every single pixel, every other pixel and every 5th pixel. The processing time is as following:

Every Single Pixel: 25h 45m per MODIS hour
Every Other Pixel: 6h 42m
Every 5th Pixel: 1h 20m

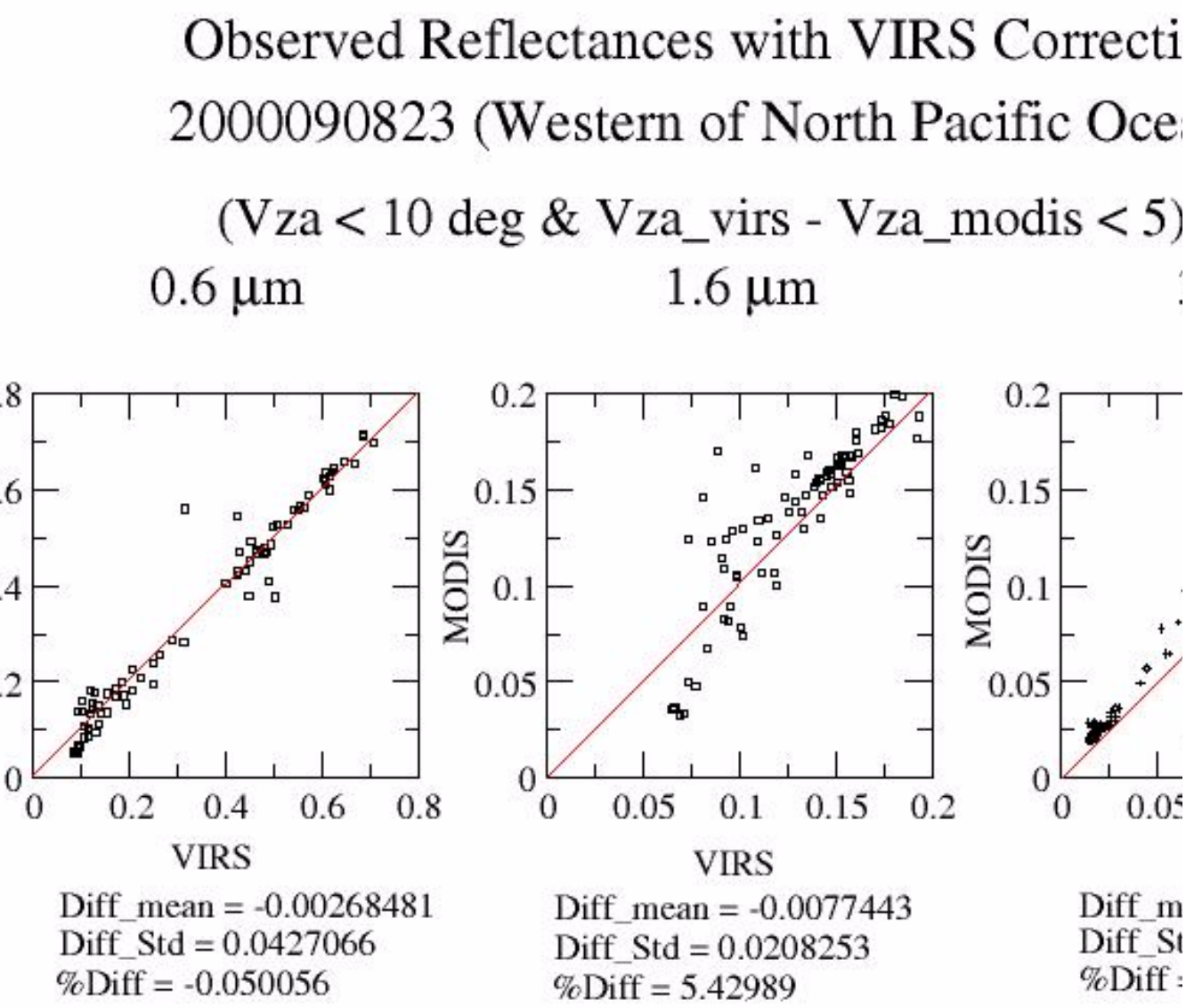
(5) Above is sub sample process. MOIDS sub region process is undergoing.

(6) MODIS Corr-k is coming and will be implemented after CERES STM.

(7) Initial comparisons with MODIS team results

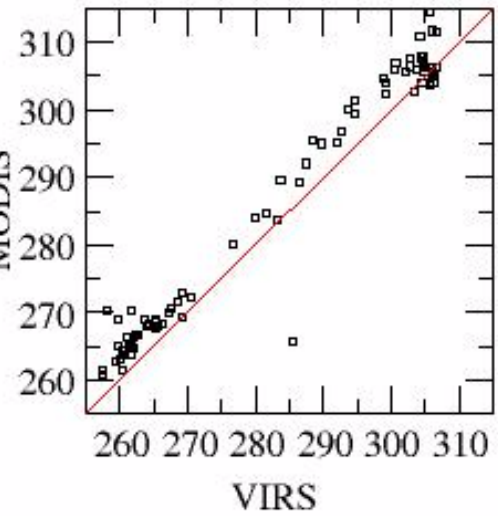

2000090823 Western of North Pacific C
MODIS
VIF
Cloud Particle Phase
wtr cld
ice cld
no rtrv
clear
bad data
nortrv wtrCld
nortrv iceCld

DAYTIME


Observed Reflectances with VIRS Correcti
2000090823 (Western of North Pacific Oce
(Vza < 10 deg & Vza_virs - Vza_modis < 5)
0.6 µm
1.6 µm
MODIS
VIRS
Diff_mean = -0.00268481
Diff_Std = 0.0427066
%Diff = -0.050056
Diff_mean = -0.0077443
Diff_Std = 0.0208253
%Diff = 5.42989

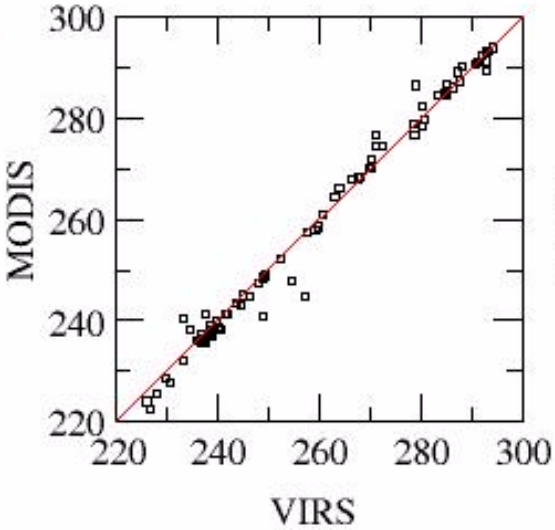
Observed Brightness Temperature (K)
2000090823 (Western of North Pacific Ocea
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

3.7 μm



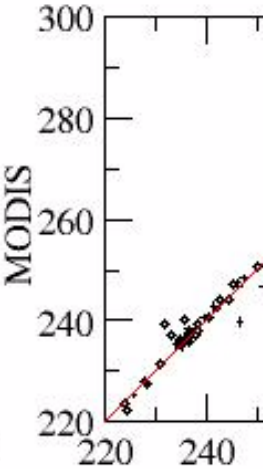
Diff_mean = -3.39841
Diff_Std = 3.79823

11 μm



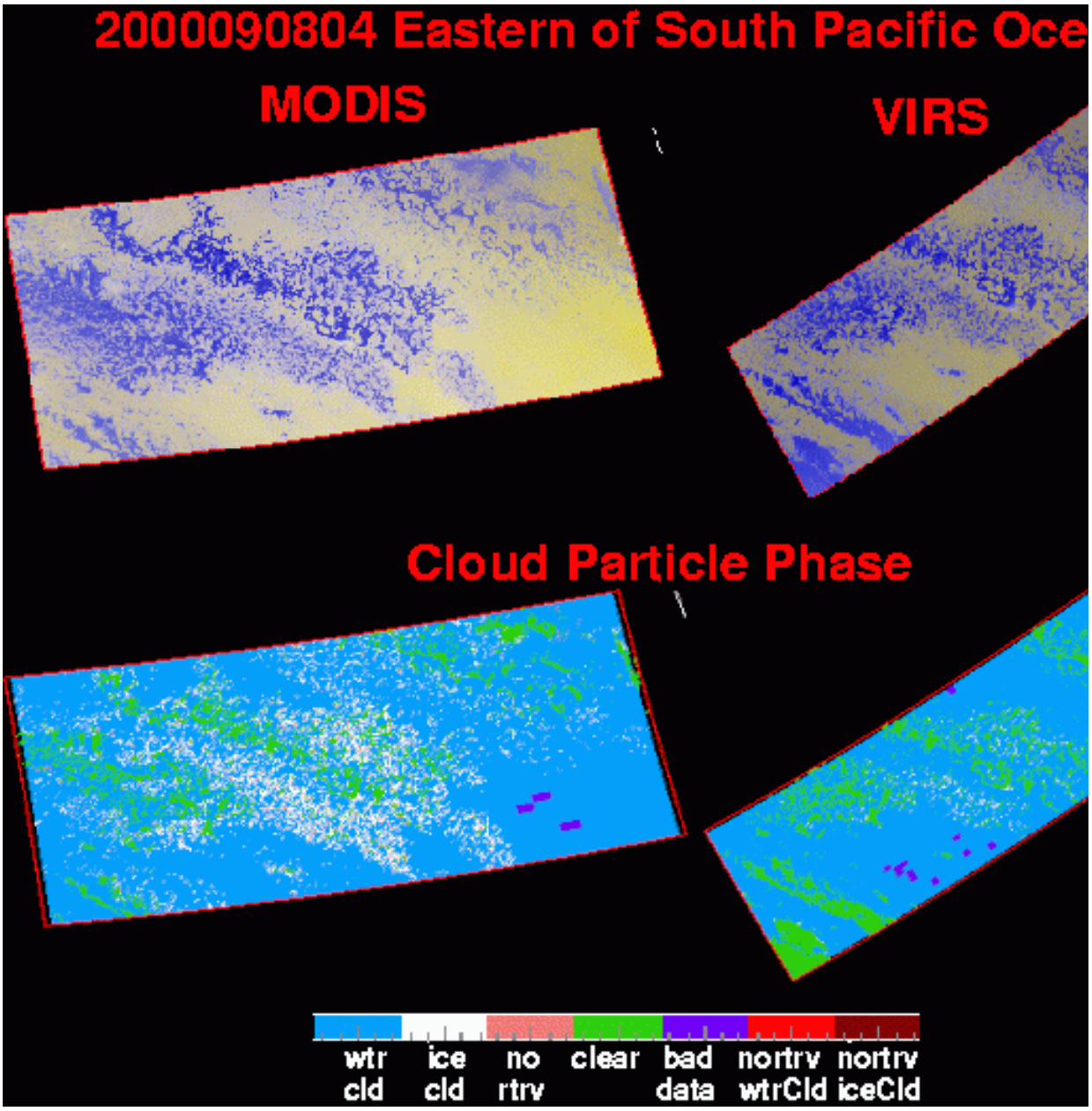
Diff_mean = 0.384652
Diff_Std = 2.64905

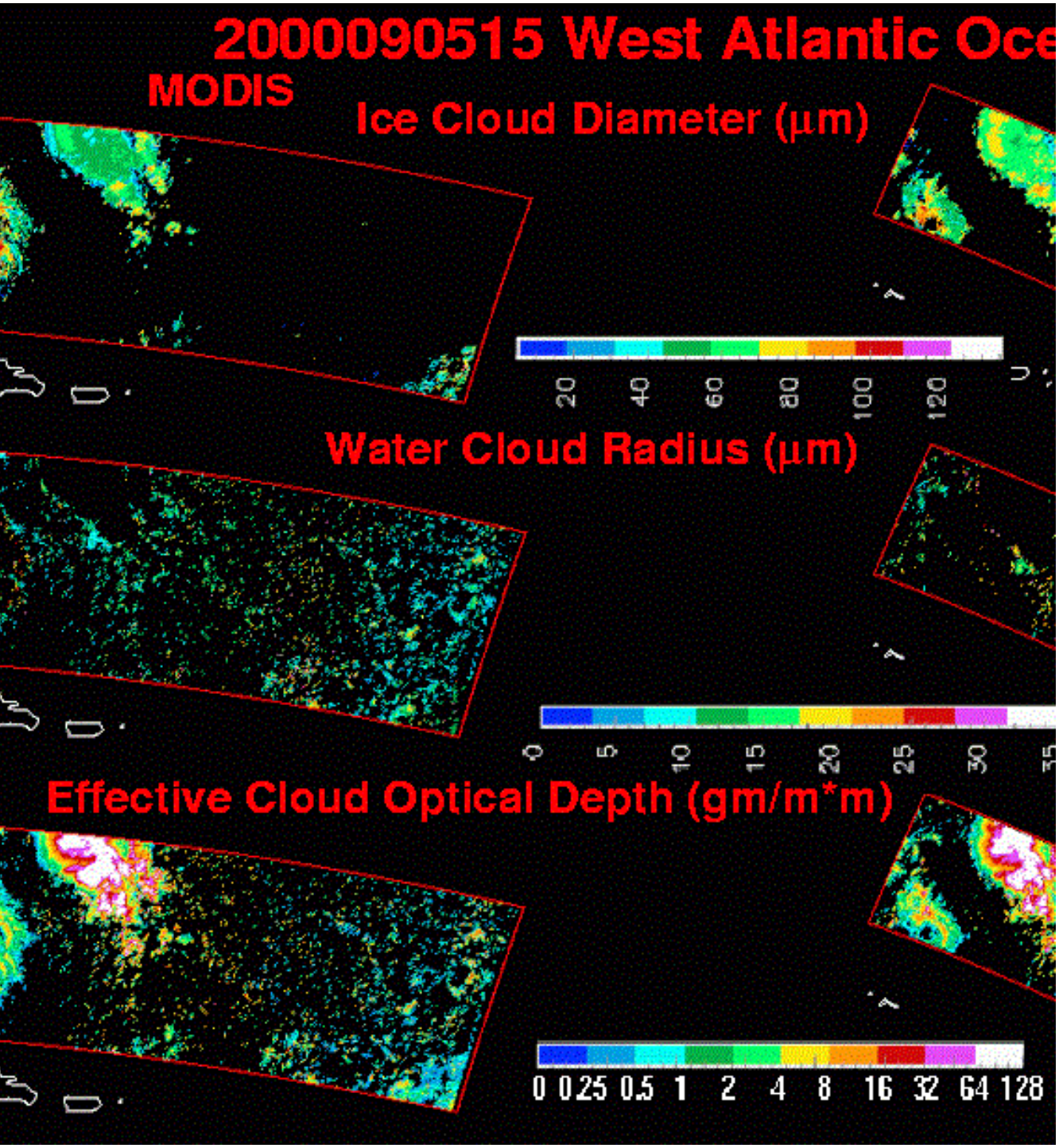
1



Diff_mea
Diff_Std

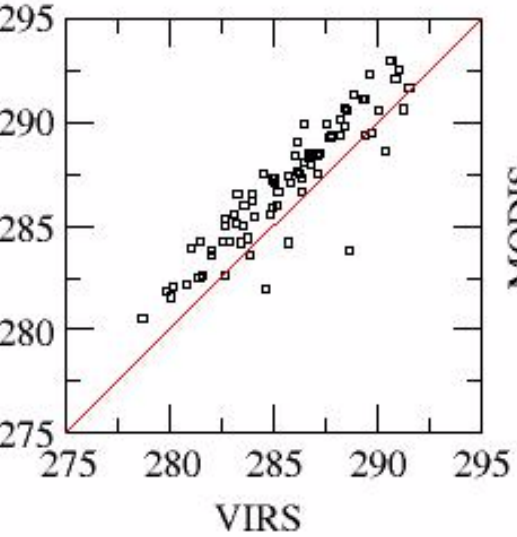
NIGHTTIME


2000090804 Eastern of South Pacific Oce
MODIS
VIRS
Cloud Particle Phase
wtr cld
ice cld
no rtrv
clear
bad data
nortrv wtrCld
nortrv iceCld


2000090515 West Atlantic Oce
MODIS
Ice Cloud Diameter (µm)
20 40 60 80 100 120
Water Cloud Radius (µm)
0 5 10 15 20 25 30 35
Effective Cloud Optical Depth (gm/m*m)
0 0.25 0.5 1 2 4 8 16 32 64 128

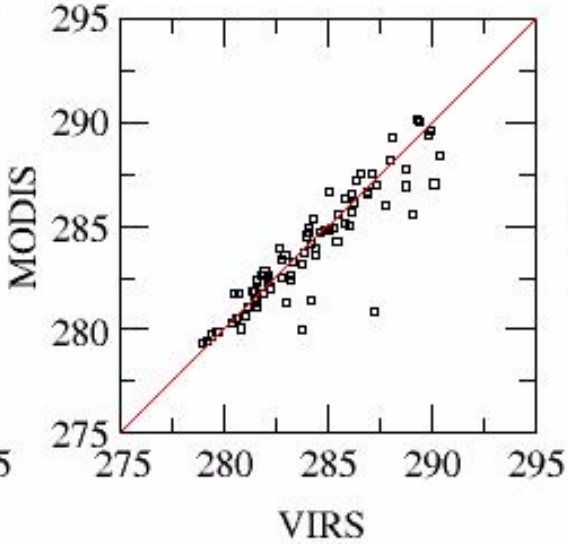
Observed Brightness Temperature (K)
2000090804 (Eastern of South Pacific Ocea
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

3.7 μm



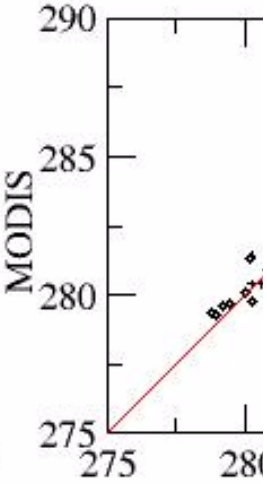
Diff_mean = -1.38722
Diff_Std = 1.29848

11 μm



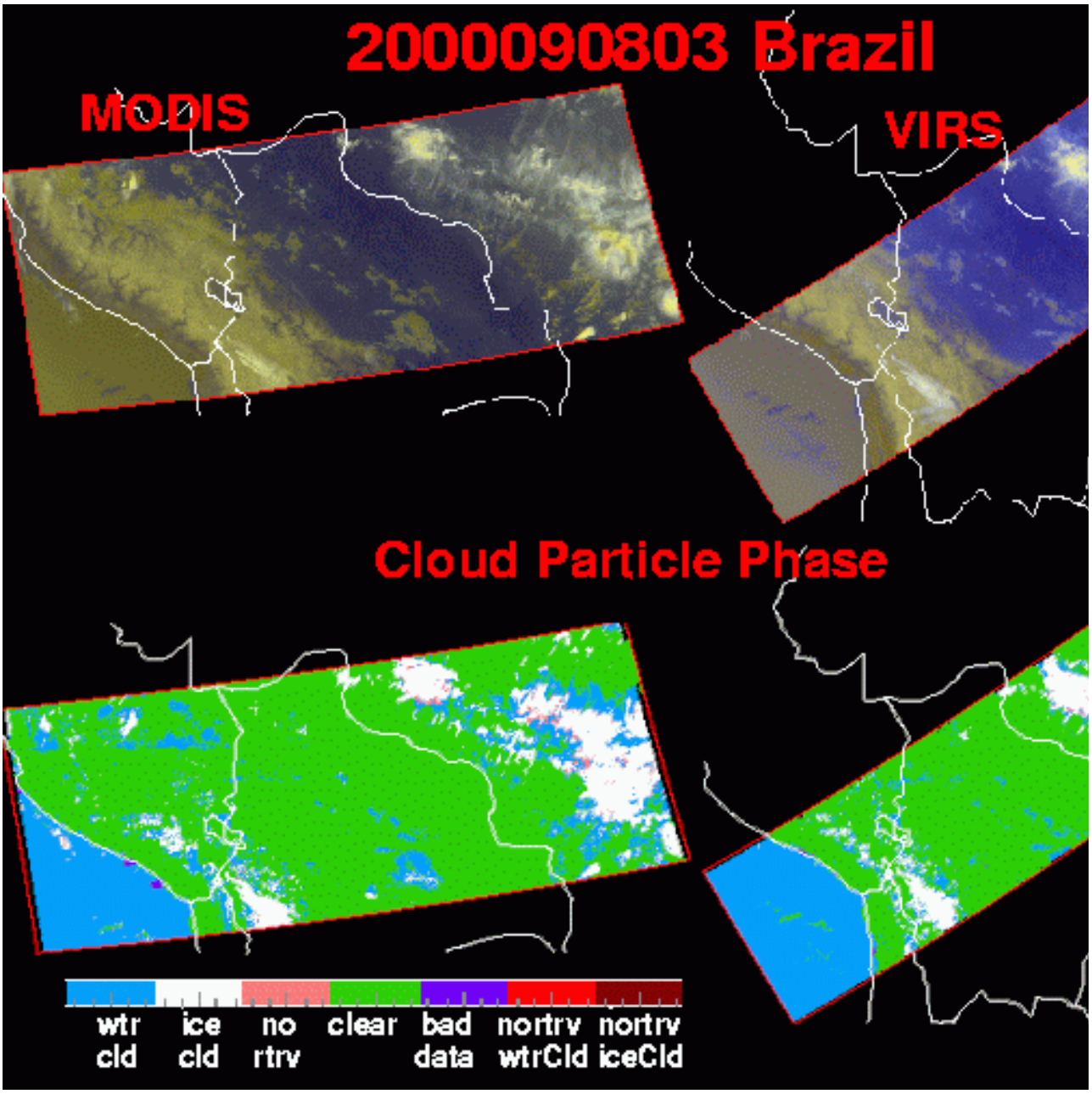
Diff_mean = 0.252932
Diff_Std = 1.2392

1



Diff_mea
Diff_Std

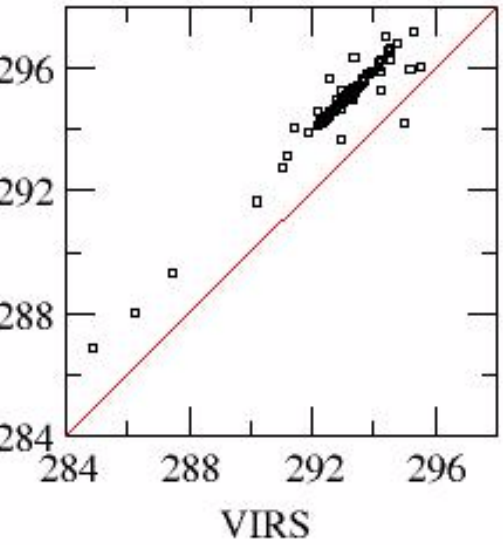
NIGHTTIME


2000090803 Brazil
MODIS
VIRS
Cloud Particle Phase
wtr cld
ice cld
no rtrv
clear
bad data
nortrv wtrCld
nortrv iceCld

Observed Brightness Temperature (K)
2000090803 (Brazil)

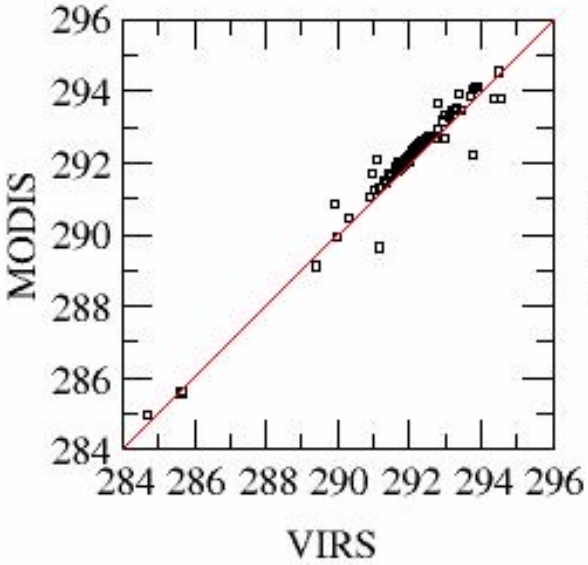
(Vza < 10 deg & Vza_virs - Vza_modis < 5

3.7 μm

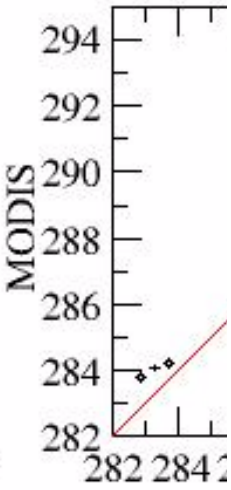


Diff_mean = -1.89737
Diff_Std = 0.466529

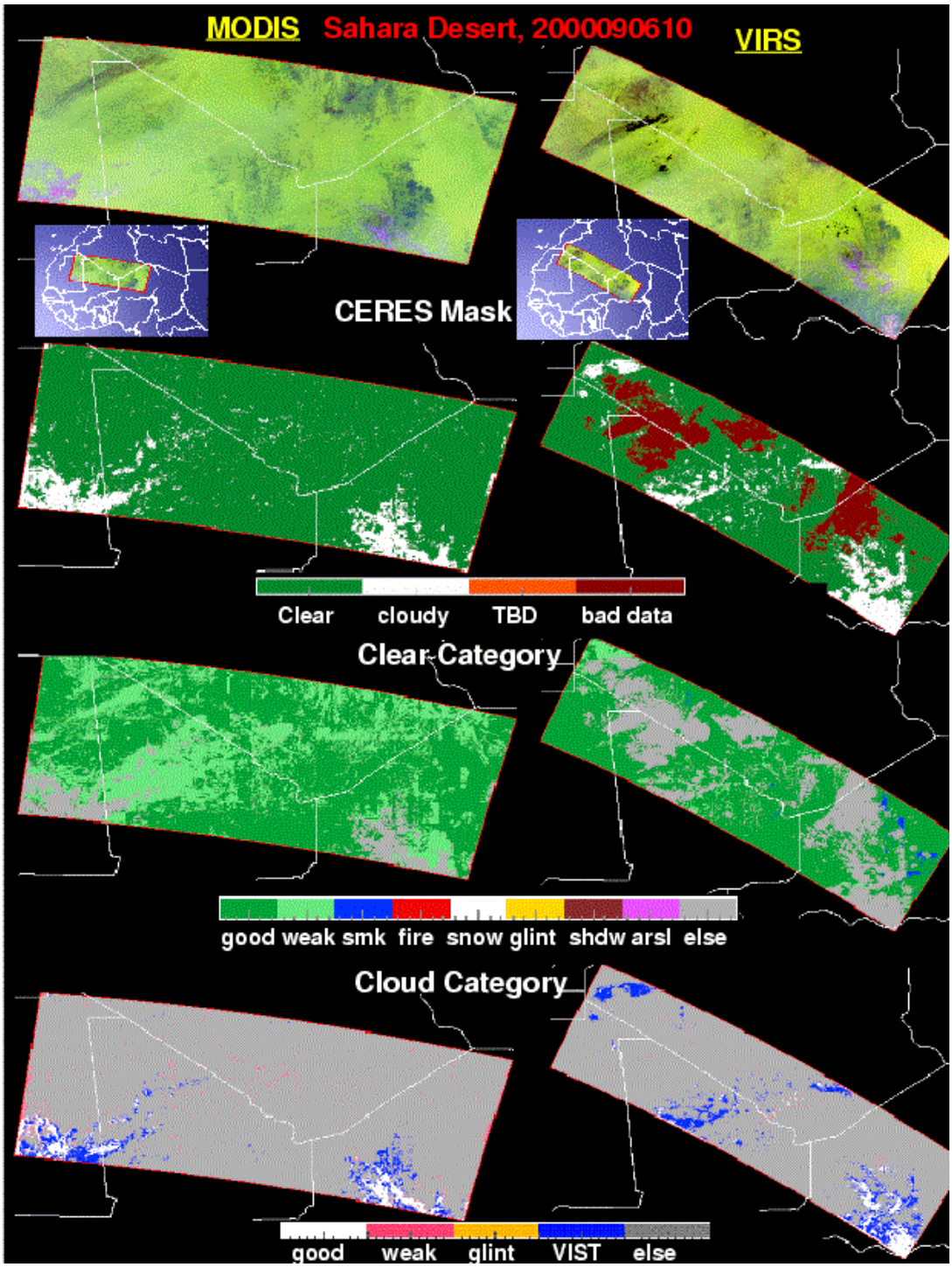
11 μm

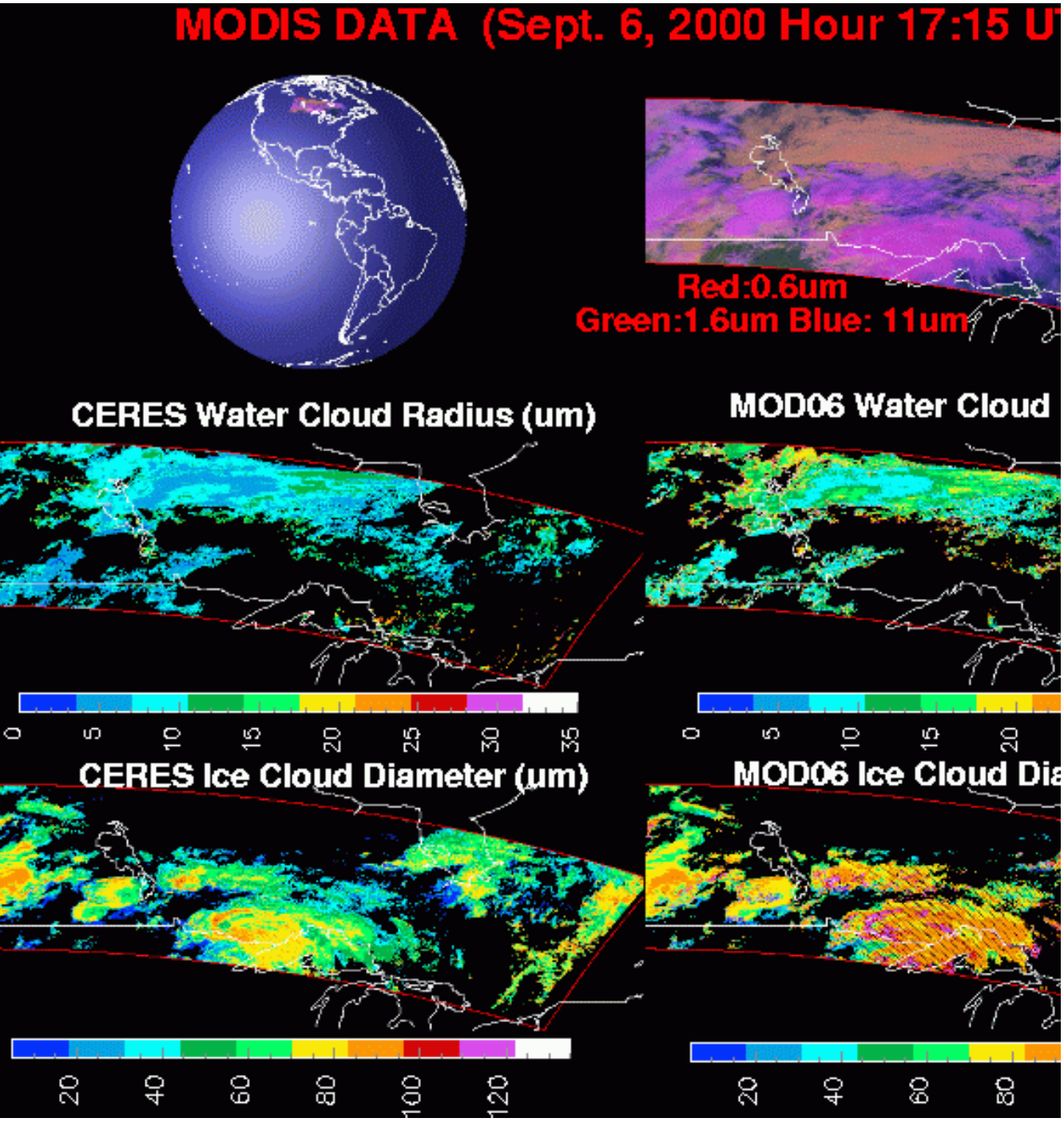


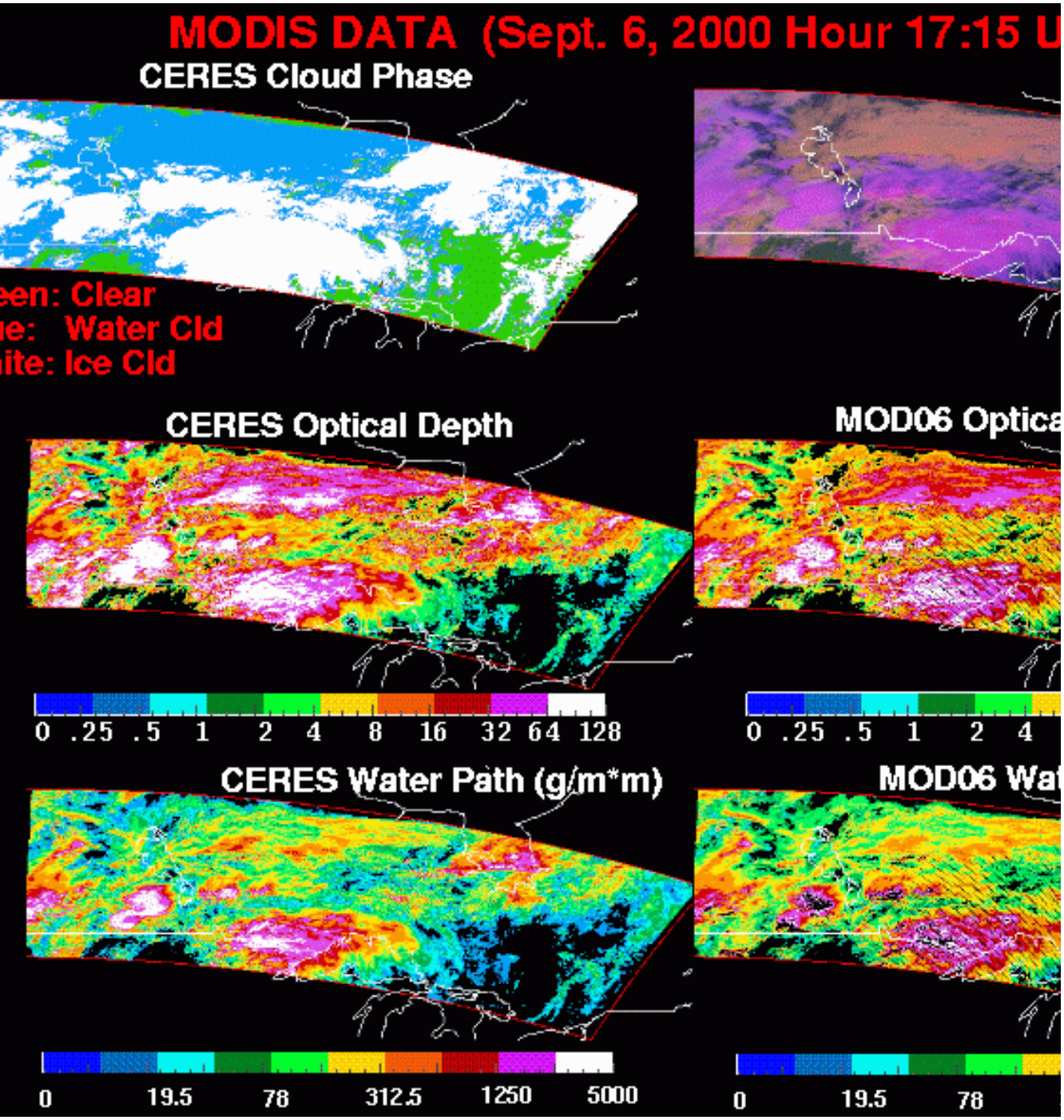
Diff_mean = -0.147864
Diff_Std = 0.355895

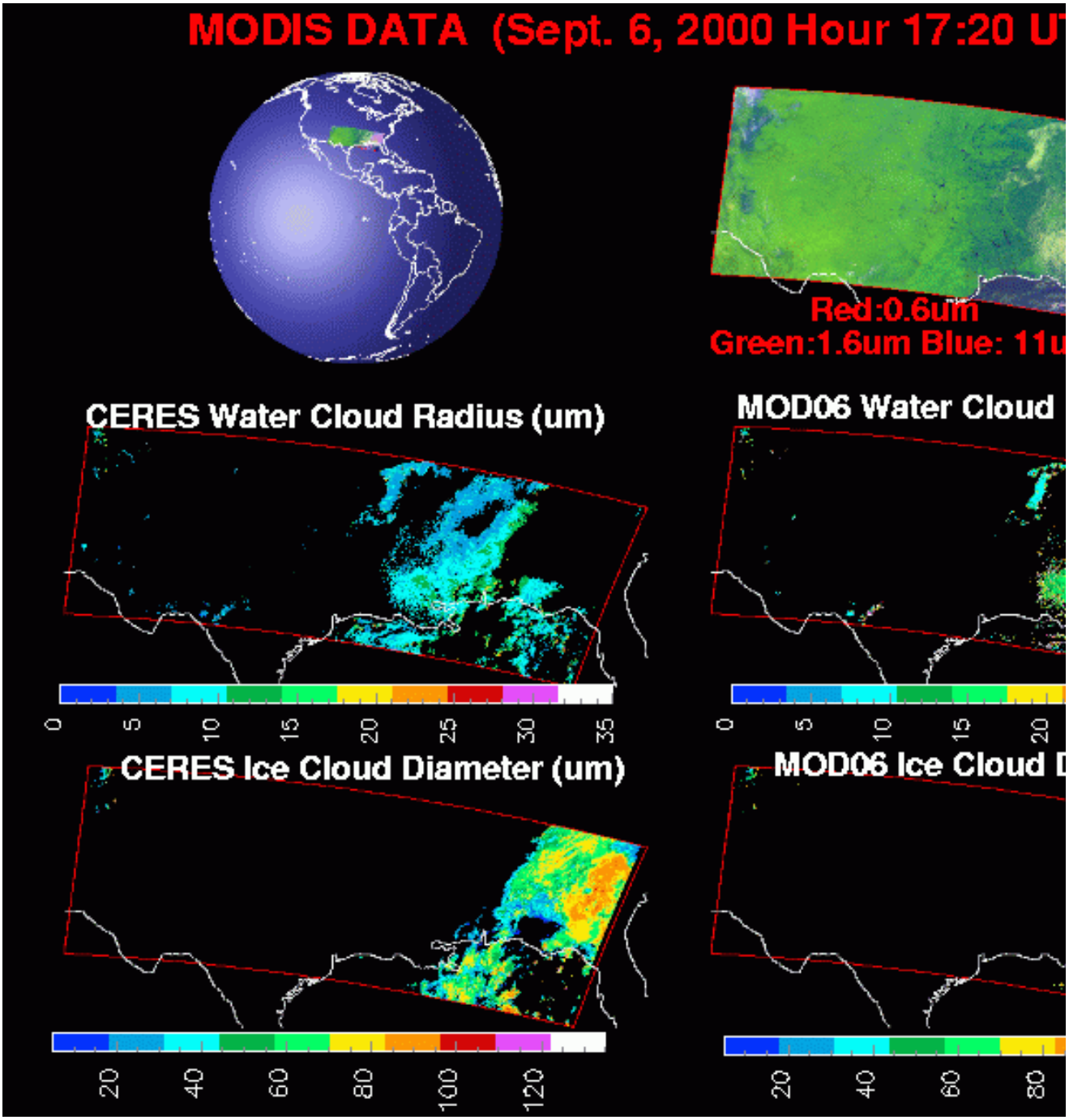


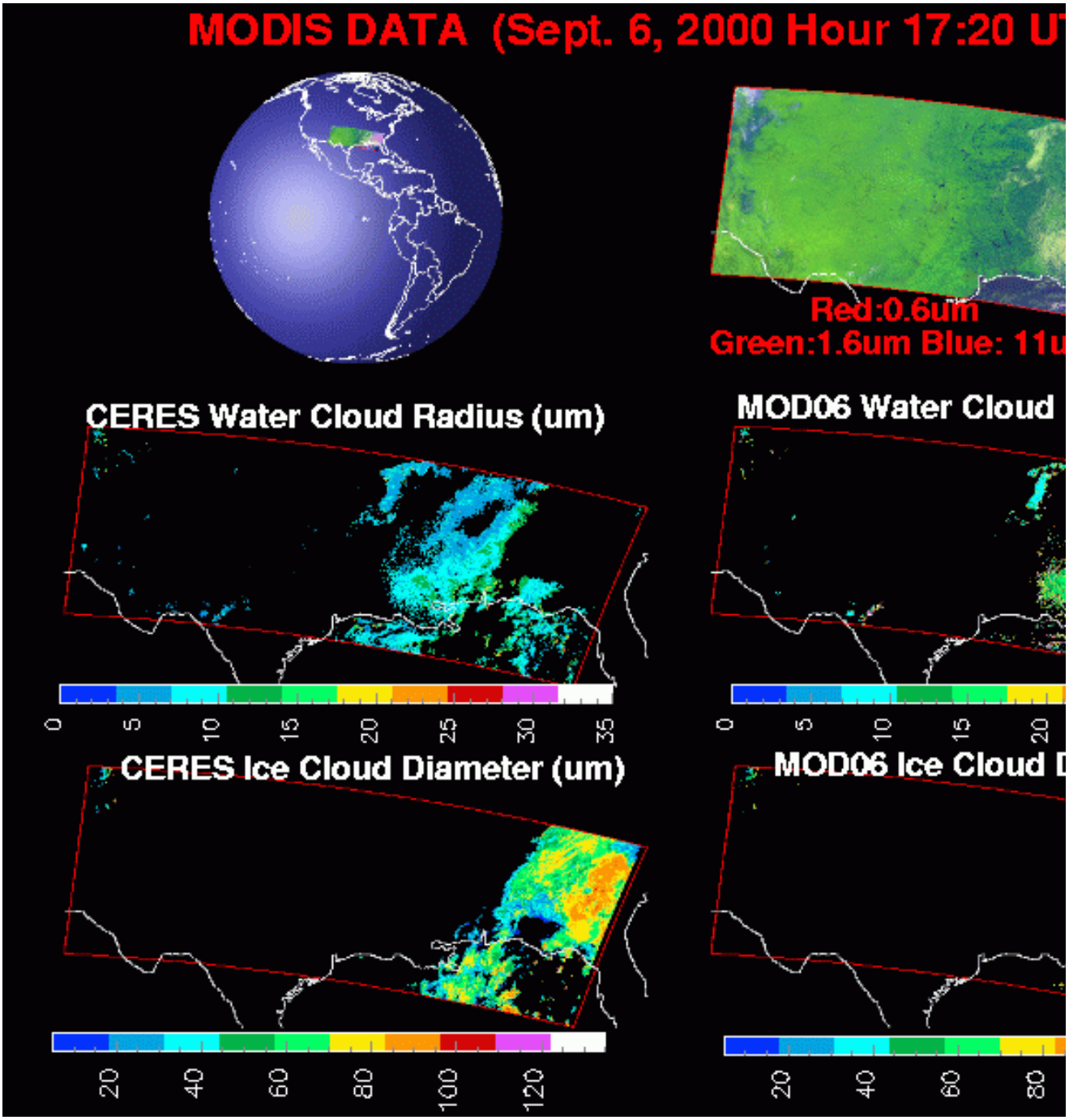
Diff_r
Diff_S

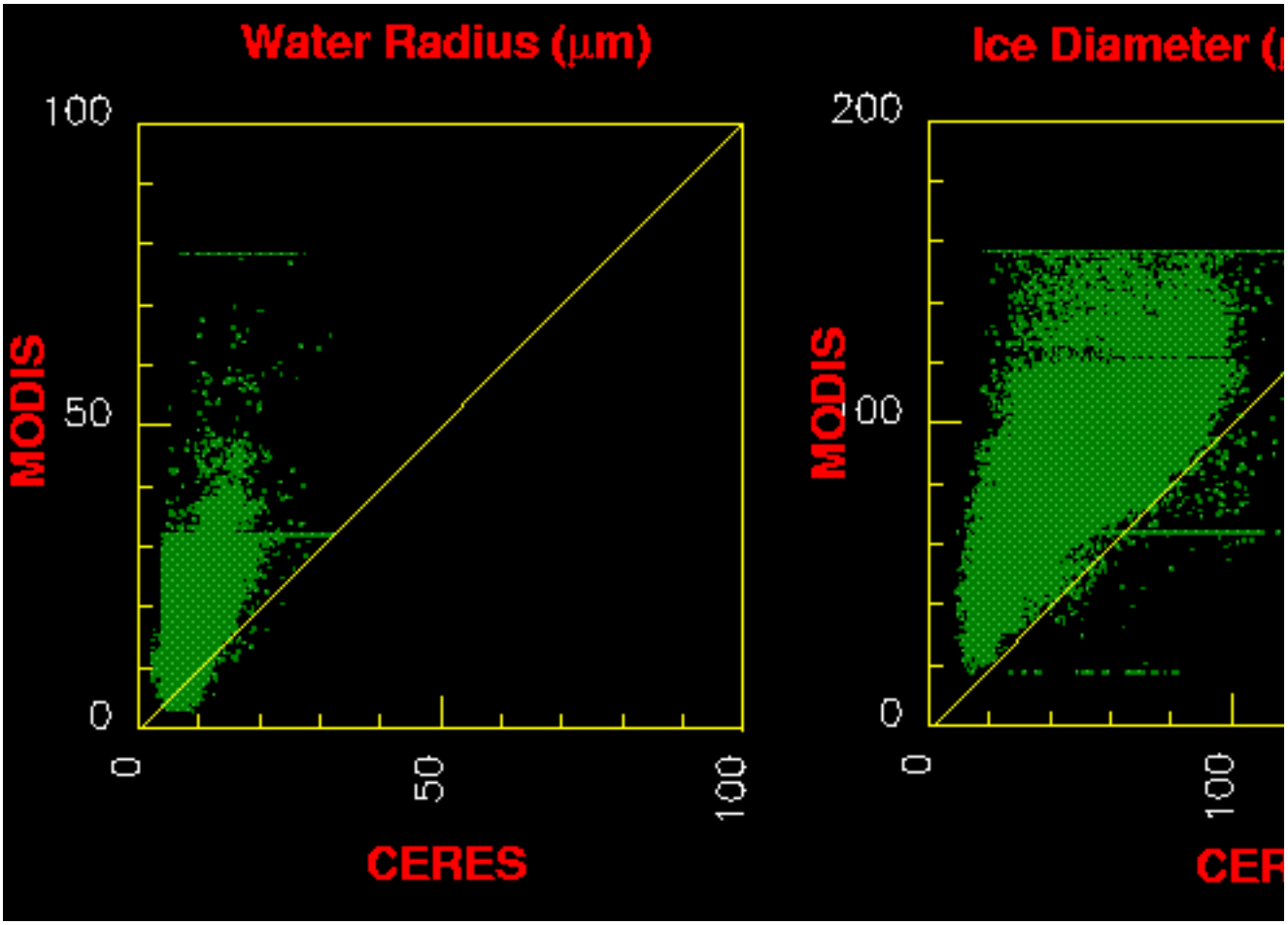

MODIS
Sahara Desert, 2000090610
VIRS
CERES Mask
Clear
cloudy
TBD
bad data
Clear Category
good weak smk fire snow glint shdw arsl else
Cloud Category
good
weak
glint
VIST
else

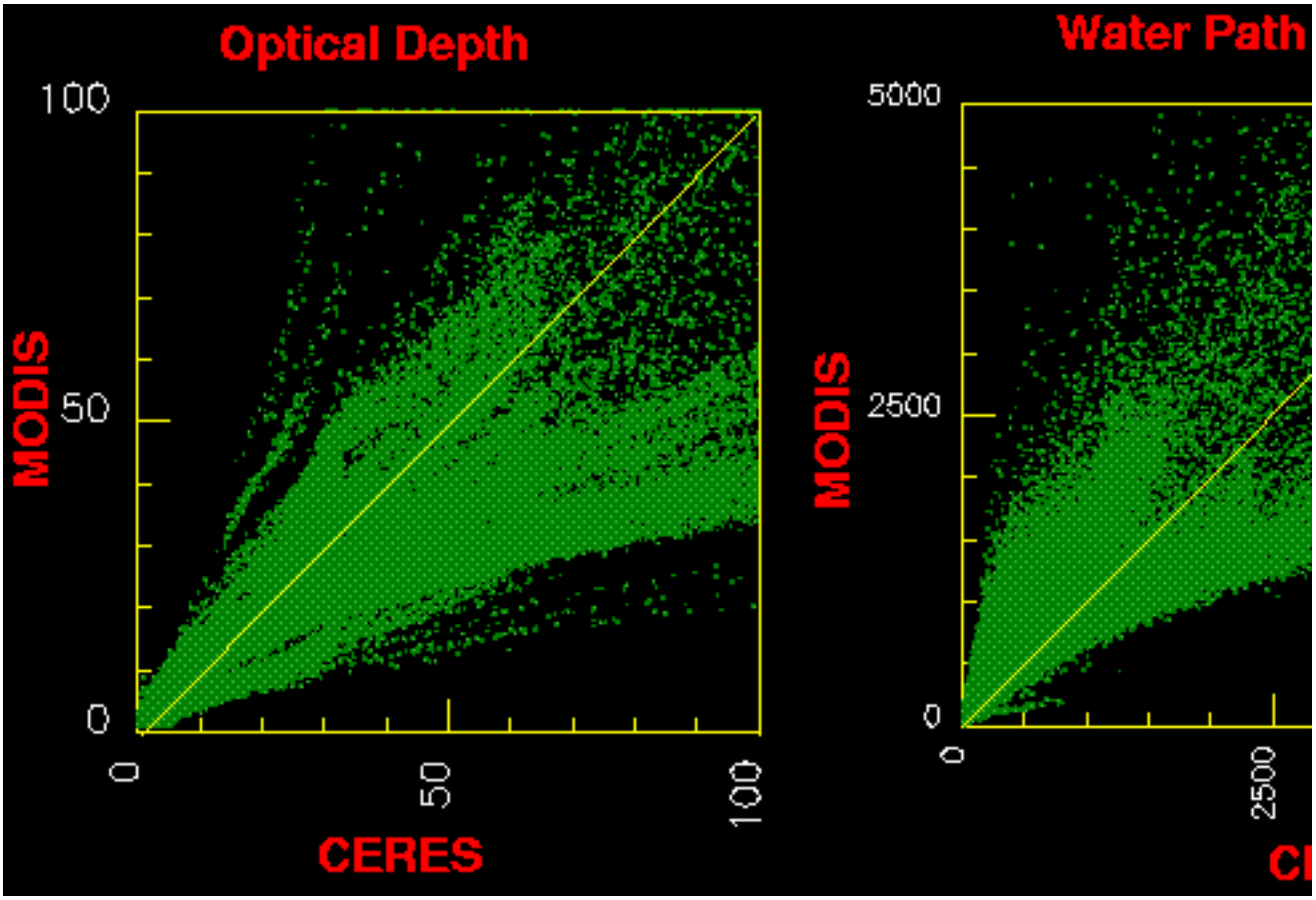

MODIS DATA (Sept. 6, 2000 Hour 17:15 U
Red:0.6um
Green:1.6um Blue: 11um
CERES Water Cloud Radius (um)
0
5
10
15
20
25
30
35
MOD06 Water Cloud
0
5
10
15
20
CERES Ice Cloud Diameter (um)
20
40
60
80
100
120
MOD06 Ice Cloud Dia
20
40
60
80

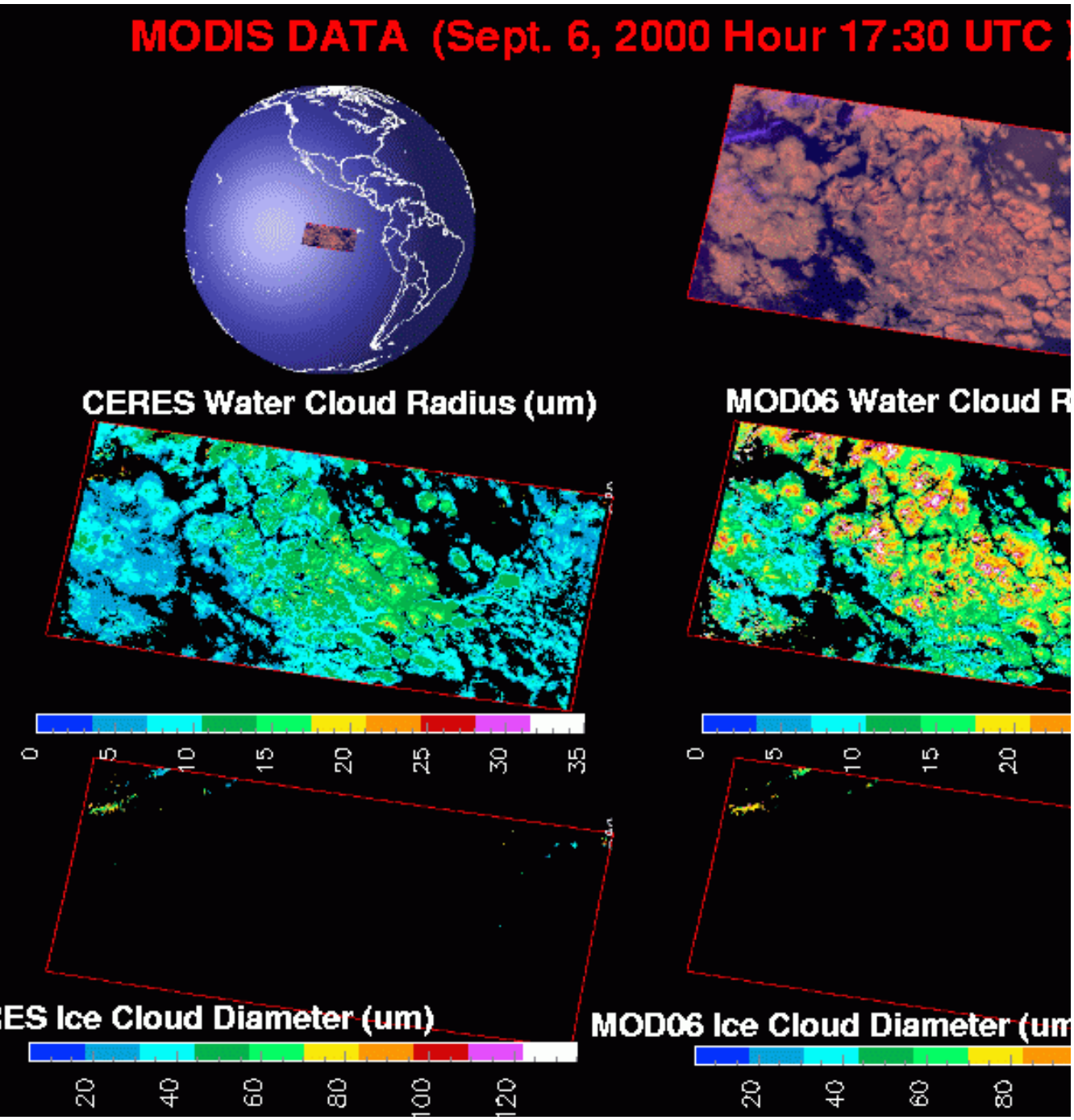

MODIS DATA (Sept. 6, 2000 Hour 17:15 U
CERES Cloud Phase
een: Clear
ue: Water Cld
hite: Ice Cld
CERES Optical Depth
0 .25 .5 1 2 4 8 16 32 64 128
MOD06 Optica
0 .25 .5 1 2 4
CERES Water Path (g/m*m)
0 19.5 78 312.5 1250 5000
MOD06 Wat
0 19.5 78

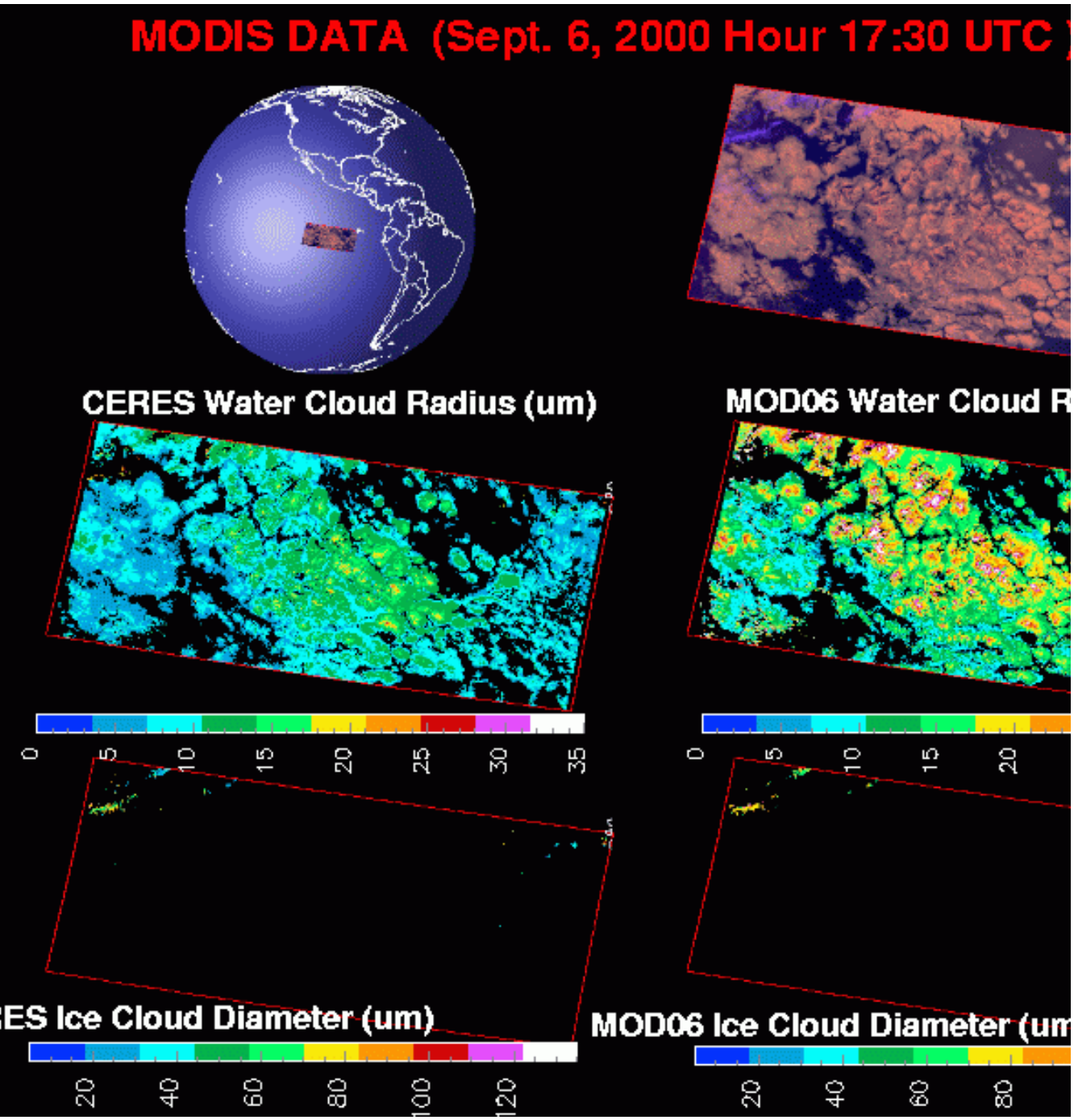

MODIS DATA (Sept. 6, 2000 Hour 17:20 U
Red:0.6um
Green:1.6um Blue: 11u
CERES Water Cloud Radius (um)
0
5
10
15
20
25
30
35
MOD06 Water Cloud
0
5
10
15
20
CERES Ice Cloud Diameter (um)
20
40
60
80
100
120
MOD06 Ice Cloud D
20
40
60
80

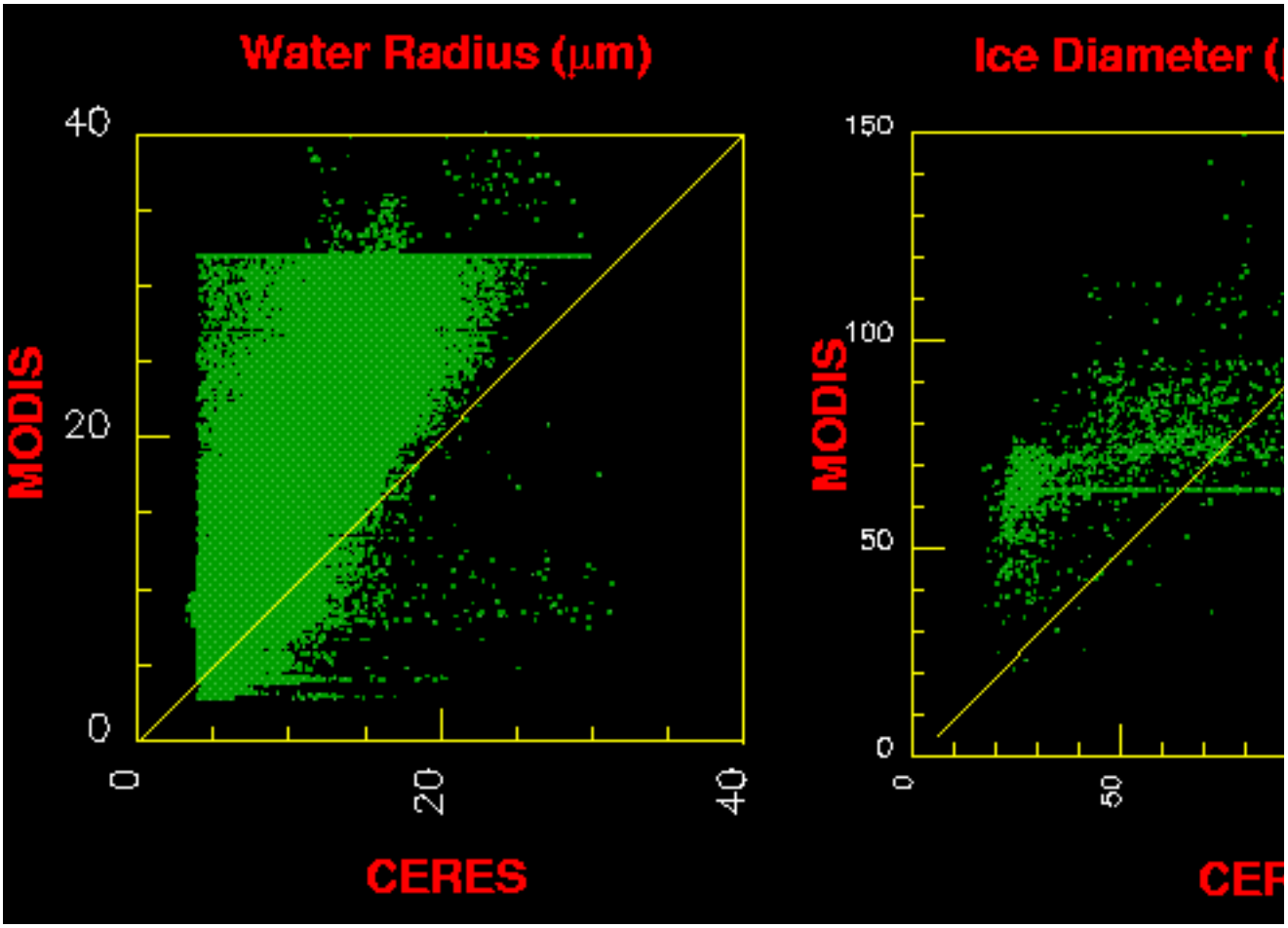

MODIS DATA (Sept. 6, 2000 Hour 17:20 U
Red:0.6um
Green:1.6um Blue: 11u
CERES Water Cloud Radius (um)
0
5
10
15
20
25
30
35
MOD06 Water Cloud
0
5
10
15
20
CERES Ice Cloud Diameter (um)
20
40
60
80
100
120
MOD06 Ice Cloud D
20
40
60
80

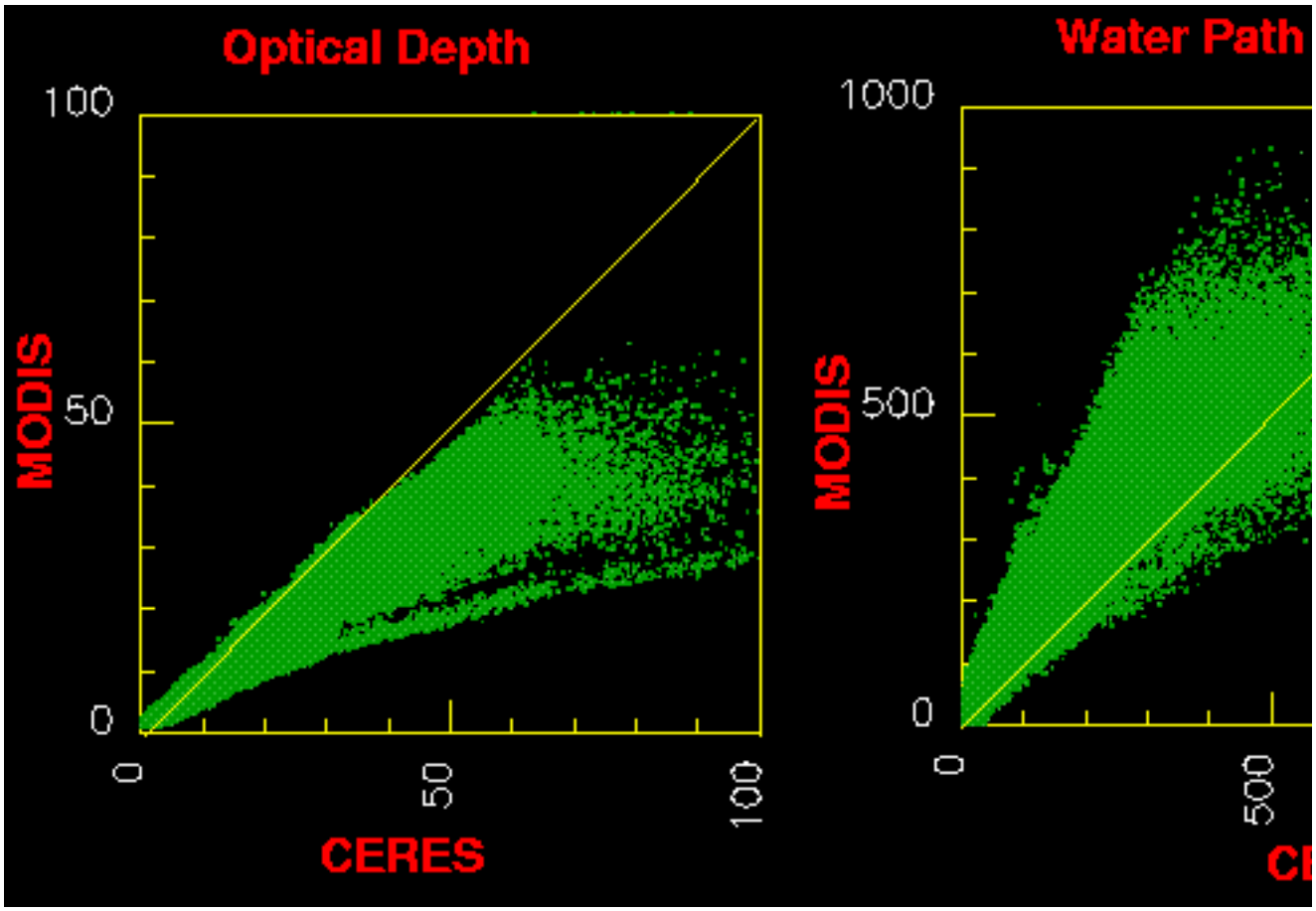

Water Radius (μm)
MODIS
CERES
0
50
100
0
50
100
Ice Diameter (
MODIS
CER
0
100
200
0
100


Optical Depth
100
50
0
MODIS
0
50
100
CERES
Water Path
5000
2500
0
MODIS
0
2500


MODIS DATA (Sept. 6, 2000 Hour 17:30 UTC
CERES Water Cloud Radius (um)
MOD06 Water Cloud R
0
5
10
15
20
25
30
35
0
5
10
15
20
ES Ice Cloud Diameter (um)
MOD06 Ice Cloud Diameter (um
20
40
60
80
100
120
20
40
60
80


MODIS DATA (Sept. 6, 2000 Hour 17:30 UTC
CERES Water Cloud Radius (um)
MOD06 Water Cloud R
0
5
10
15
20
25
30
35
0
5
10
15
20
ES Ice Cloud Diameter (um)
MOD06 Ice Cloud Diameter (um
20
40
60
80
100
120
20
40
60
80


Water Radius (μm)
MODIS
CERES
0
20
40
0
20
40
Ice Diameter (
MODIS
CER
0
50
100
150
0
50


Optical Depth
MODIS
CERES
0
50
100
0
50
100
Water Path
MODIS
0
500
1000
0
500

MODIS-CERES INITIAL COMPARISON SUMMARY

- Cloud amount: **CERES picks up slightly more cloudiness (small Cu, thin Ci)**

- Optical depth: **CERES has variable agreement with MODIS**

  - Very close for warm water clouds

  - CERES often larger in ice or supercooled conditions
  due to different ice models or different phase selection
  (no phase info available from MODIS 1 km)

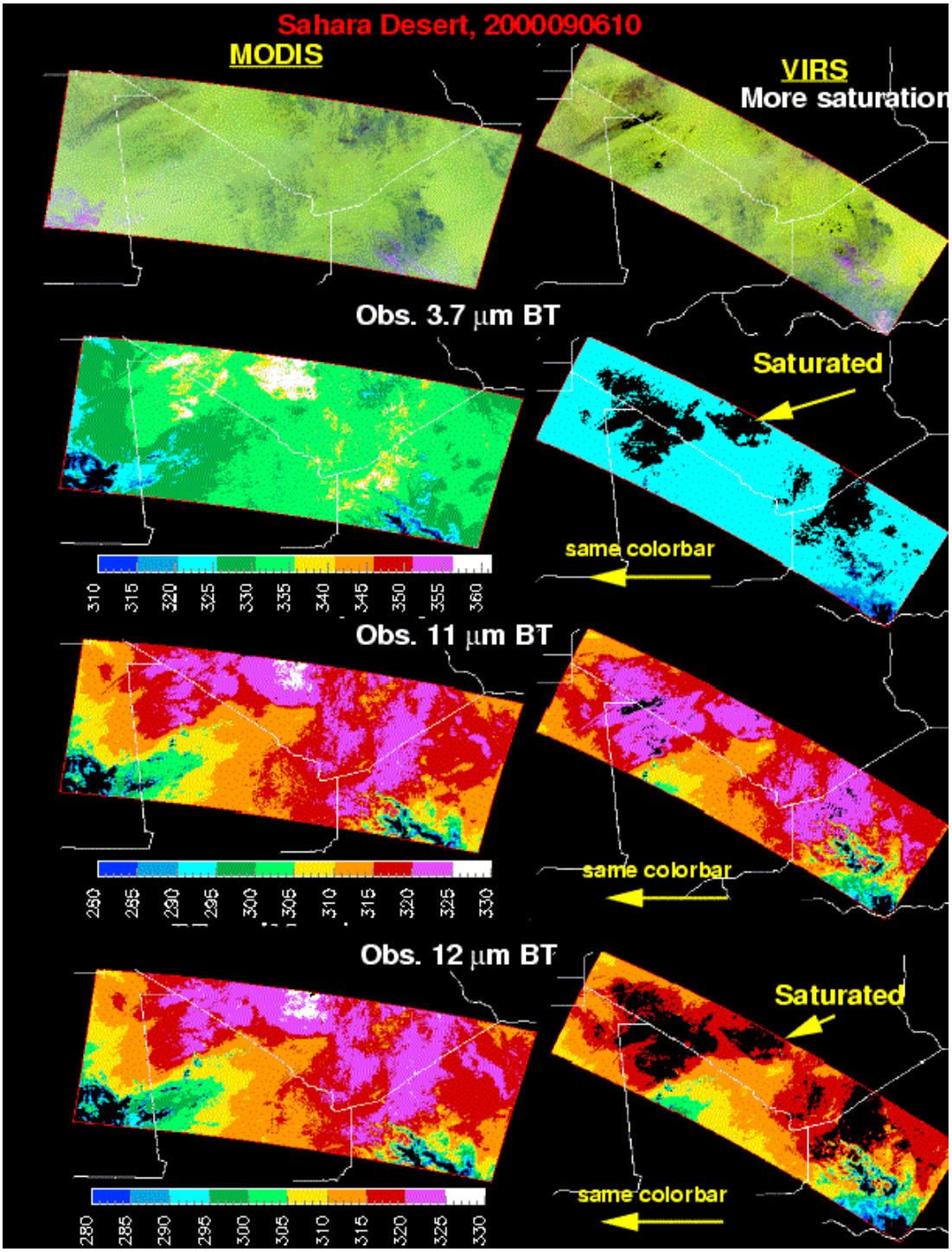
- Effective radius: **MODIS generally larger than CERES**

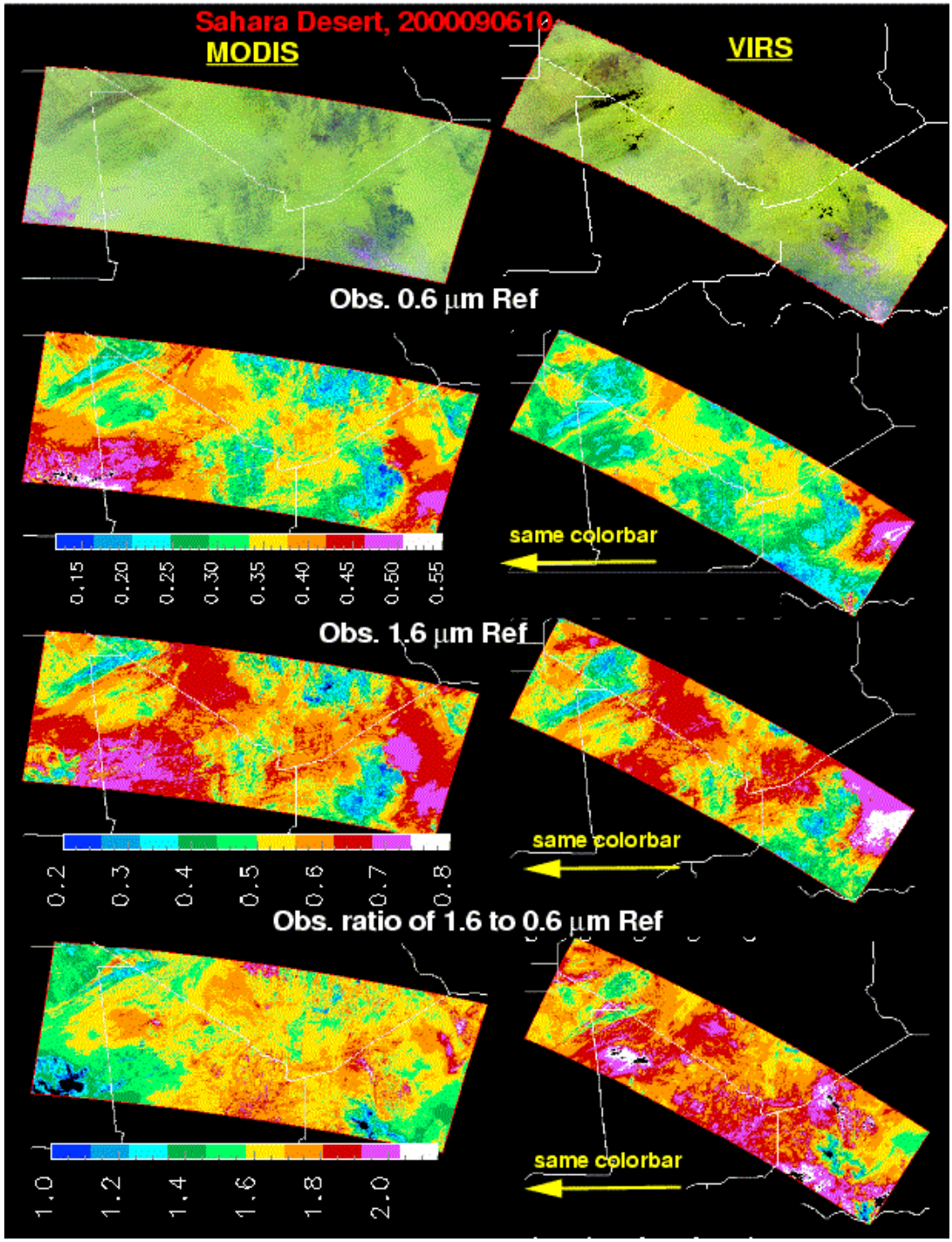
  - CERES using VIRS 3.7-µm models & atmos corrections

  - Phase and ice model differences

- Water path: **CERES smaller over warm clouds (re too low); greater over ice (τ)**

- FUTURE: **Height & phase comparisons; corrected 3.7 models, 1.6 re, global runs; ARM validations**


Sahara Desert, 2000090610
MODIS
VIRS
More saturation
Obs. 3.7 μm BT
Saturated
same colorbar
310 315 320 325 330 335 340 345 350 355 360
Obs. 11 μm BT
same colorbar
280 285 290 295 300 305 310 315 320 325 330
Obs. 12 μm BT
Saturated
same colorbar
280 285 290 295 300 305 310 315 320 325 330


Sahara Desert, 2000090610
MODIS
VIRS
Obs. 0.6 μm Ref
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
same colorbar
Obs. 1.6 μm Ref
0.2
0.3
0.4
0.5
0.6
0.7
0.8
same colorbar
Obs. ratio of 1.6 to 0.6 μm Ref
1.0
1.2
1.4
1.6
1.8
2.0
same colorbar

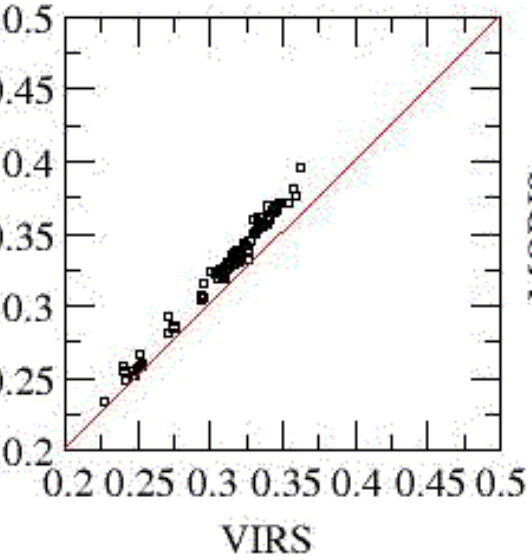
Observed Reflectances with VIRS Correction

Time Difference (TRMM - TERRA) = -1.4 min

2000090610 (SAHARA Desert)

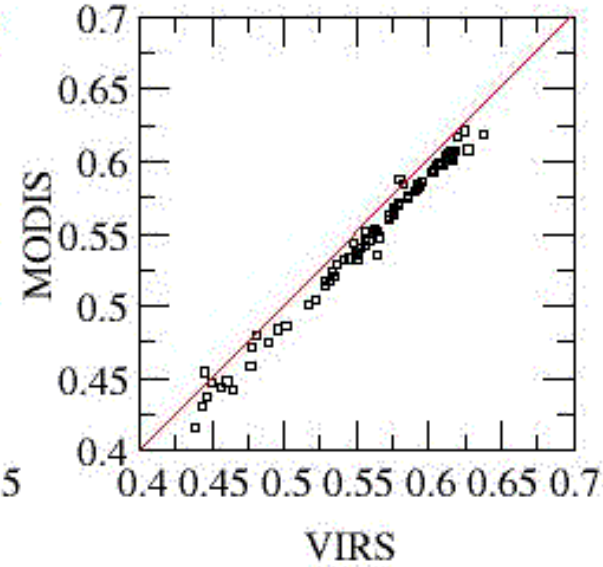
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

0.6 µm



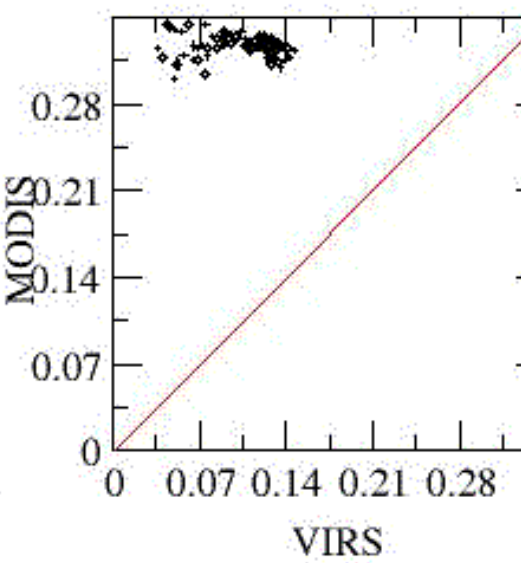
Diff_mean = -0.0174608
Diff_Std = 0.00567456
%Diff = 5.4996

1.6 µm



Diff_mean = 0.010557
Diff_Std = 0.00568931
%Diff = -1.91168

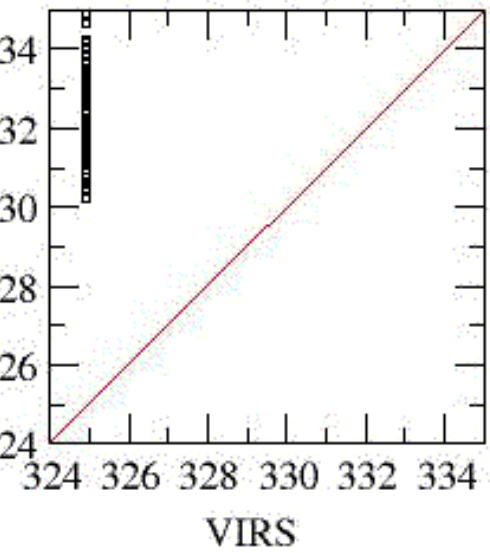
3.7 µm



Diff_mean =-0.223239
Diff_Std = 0.0320723
%Diff = 259.641

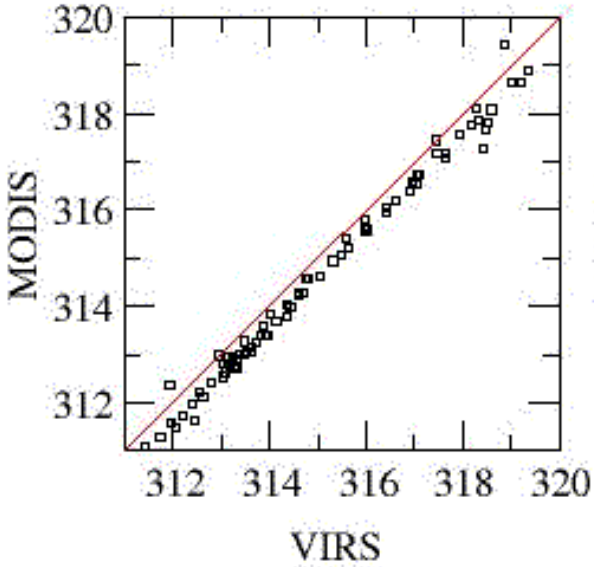
Observed Brightness Temperature (K)
2000090610 (SAHARA Desert)
(Vza < 10 deg & Vza_virs - Vza_modis < 5

3.7 μm

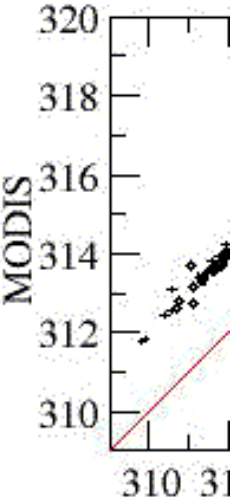


Diff_mean = -7.30654
Diff_Std = 1.04677

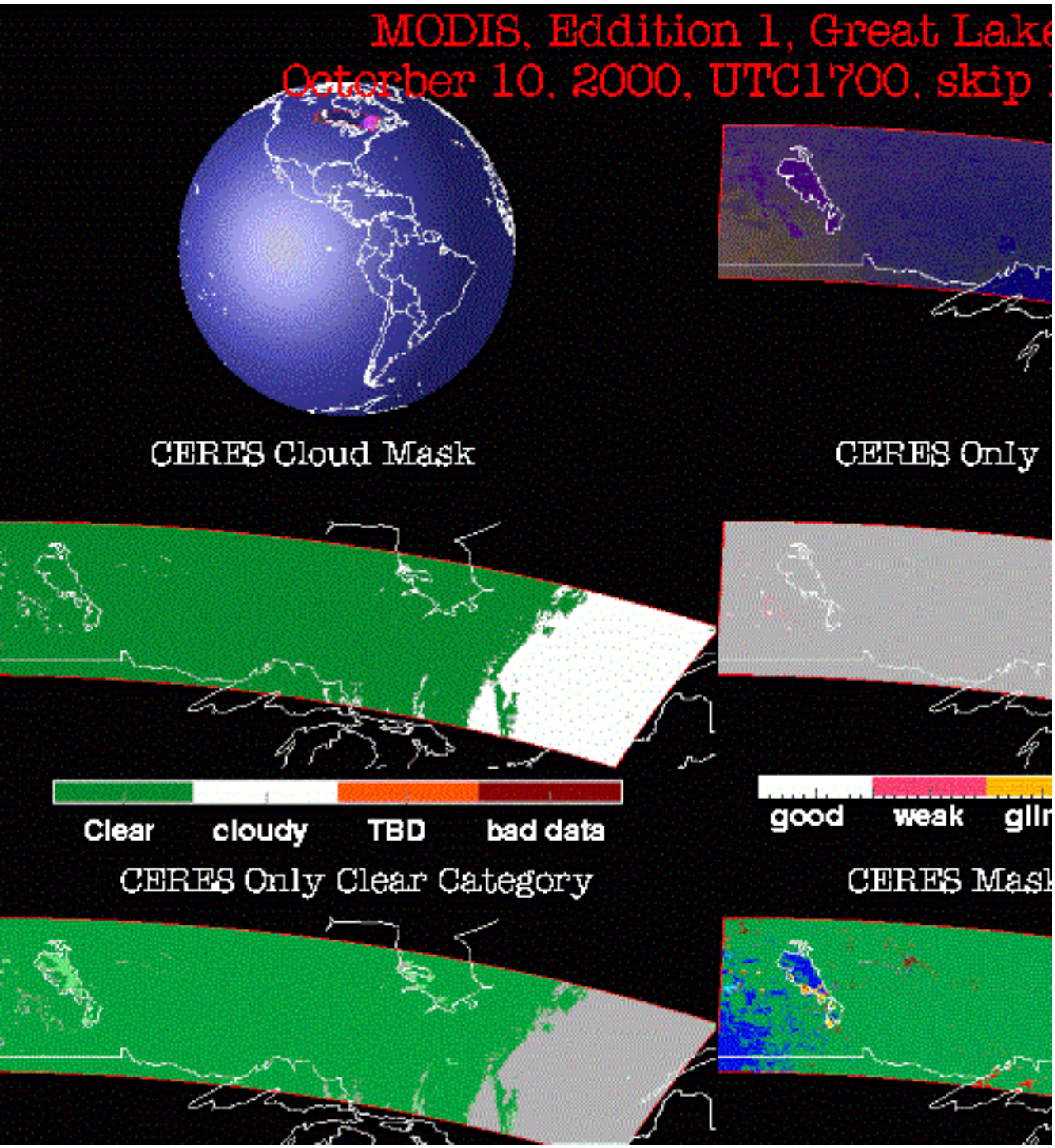
11 μm

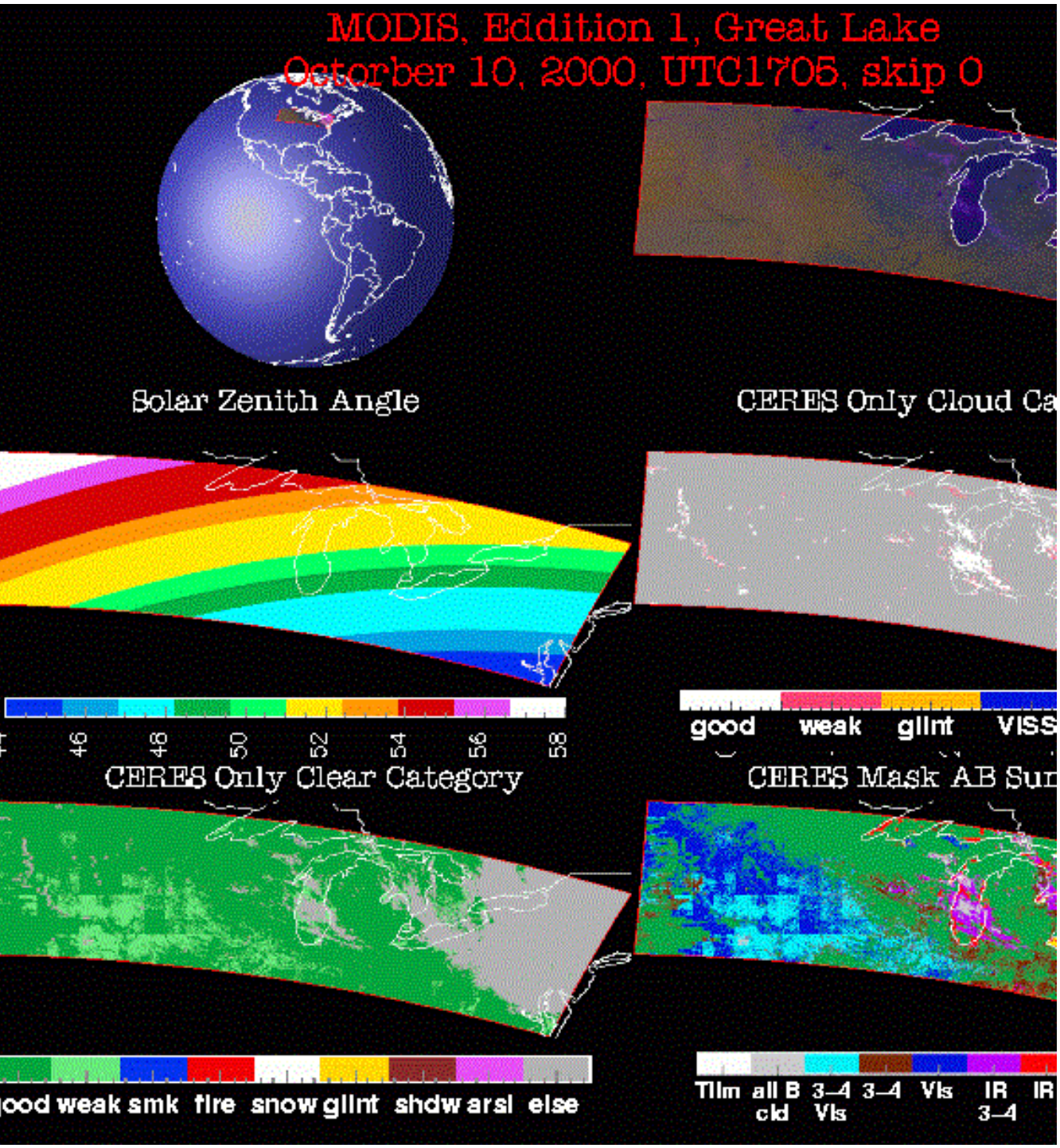


Diff_mean = 0.390541
Diff_Std = 0.217649



Diff_n
Diff_S


MODIS, Eddition 1, Great Lake
October 10, 2000, UTC1700, skip
CERES Cloud Mask
CERES Only
Clear
cloudy
TBD
bad data
good
weak
CERES Only Clear Category
CERES Mask


MODIS, Eddition 1, Great Lake
October 10, 2000, UTC1705, skip 0
Solar Zenith Angle
CERES Only Cloud Ca
46
48
50
52
54
56
58
good
weak
glint
VISS
CERES Only Clear Category
CERES Mask AB Sun
good weak smk fire snow glint shdw arsl else
Tlm all B cld
3–4 Vis
3–4
Vis
IR 3–4
IR

SUMMARY OF PRELIMINARY MODIS ANALYSES

VIRS & MODIS CALIBRATIONS FOR 0.65, 1.6, 10.8 µm ARE VERY CLOS

- 3.7-µm AVERAGES ABOUT 2K > VIRS

PART SPECTRAL, PART CALIBRATION?

- 11-µm POSSIBLE SCAN ANGLE VARIATION OF 1 OR 2K?
- 12-µm ~ 0.5K > VIRS

• VIRS & MODIS RETRIEVALS ARE GENERALLY CONSISTENT

- BIASES IN CLOUD AMT, re, DUE TO CALIBRATION