CERES TRMM VIRS & TERRA MODIS CLOUD PROPERTIES

NASA : P. Minnis, D. F. Young, L. Nguyen

SAIC: S. Sun-Mack, Q. Trepte, Y. Chen, R. F. Arduini, S. Gibson, R. Brown

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

U. Utah: X. Dong, G. Mace -- Validation ARM SGP

NOAA/ETL: S. Matrosov, T. Uttal -- Validation ARM NSA

CERES Science Team Meeting

January 20, 2002

CLOUD PROPERTIES

- USED TO RELATE CLOUDS TO THE RADIATION BUDGET
  - TIES HYDROLOGICAL CYCLE TO RADIATION
  - ENABLES IMPROVEMENT OF ADMs => BETTER FLUXES

- FUNDAMENTAL CLIMATOLOGICAL DATA

- CLOUD AMOUNT, HEIGHT, TEMPERATURE, PHASE,
  OPTICAL DEPTH, PARTICLE SIZE, LIQUID & ICE WATER PATH

- PRODUCTS AT PIXEL LEVEL*, CERES FOOTPRINT
- ALGORITHMS CURRENTLY BEING APPLIED TO VIRS, MODIS, GOES

STATUS OF VIRS CLOUDS

- CONTINUOUS ANALYSES COMPLETED FROM JAN 1998 - JULY 1999
  - ADDITIONAL MONTH, MARCH 2000
  - WORKING ON AUG 1999
  - RESULTS LOOK VERY CONSISTENT,
  - AMOUNTS COMPARE WELL WITH SFC CLIMATOLOGY
  - LWP EXCELLENT (TRMM TMI & SGP)
  - OD: FEW % LOW, r_e: 0.7 μm GREATER THAN SFC RADAR

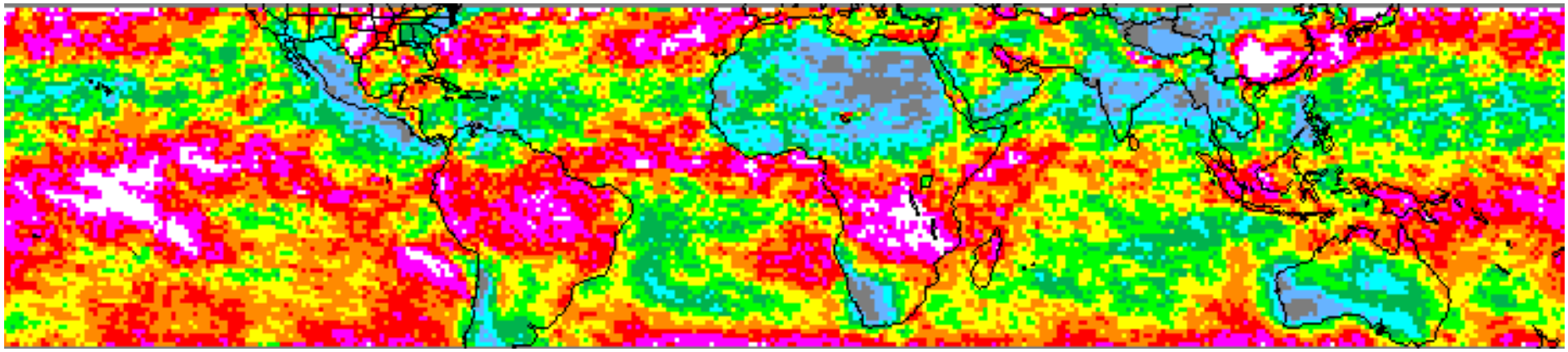
- VALIDATION PAPER (Dong et al.) NEARLY READY FOR SUBMISSION

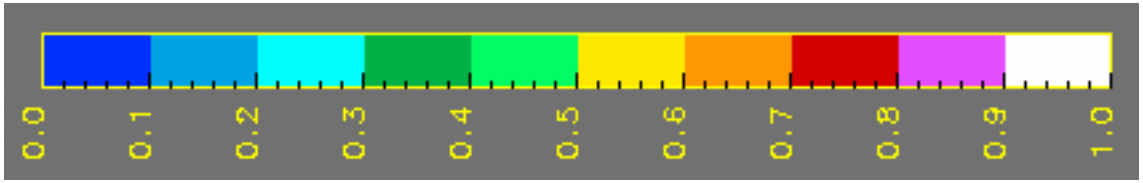
- CALIBRATION PAPERS ACCEPTED OR NEARLY COMPLETE

- WORKING ON DRAFTS FOR METHODOLOGY, RESULTS

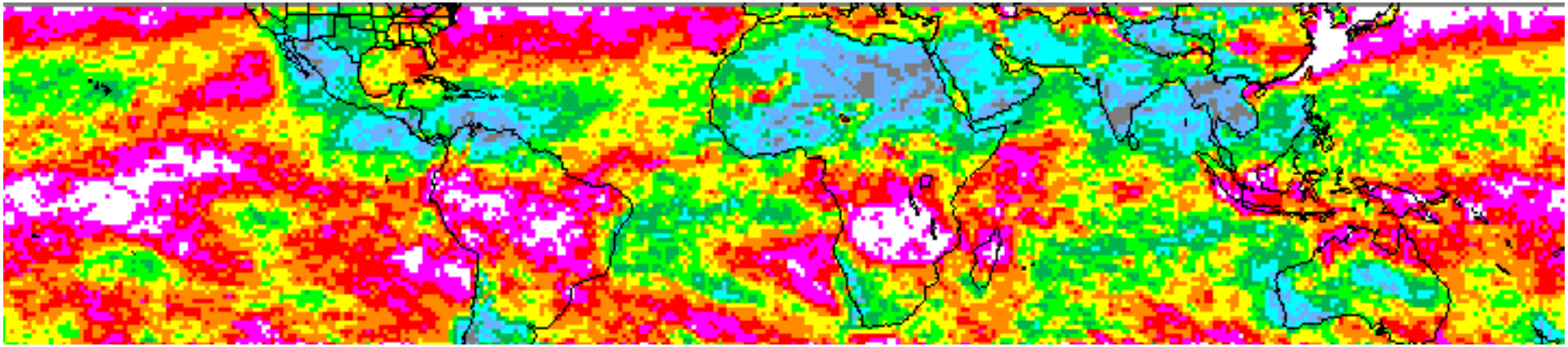
MEAN CLOUD COVER, VIRS, JAN 1998

DAYTIME



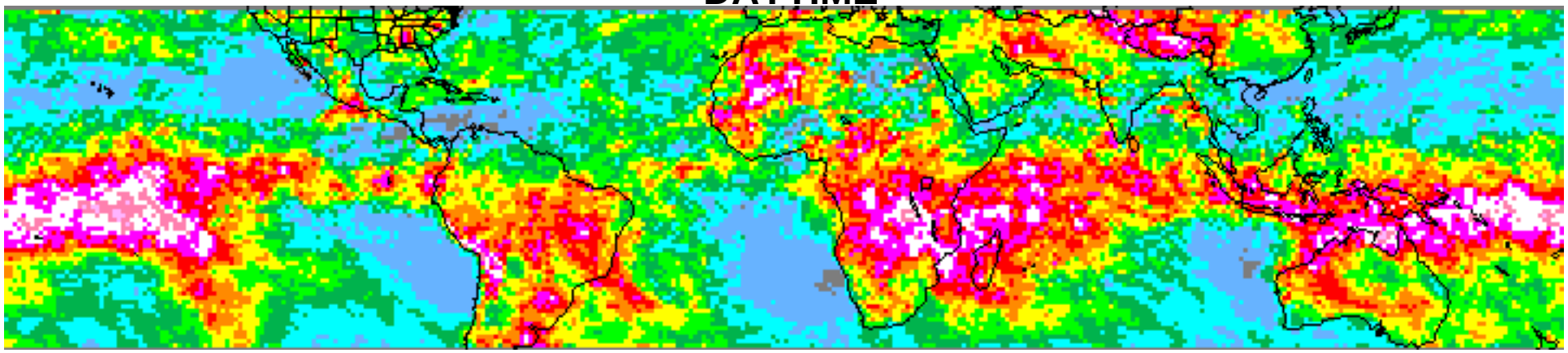


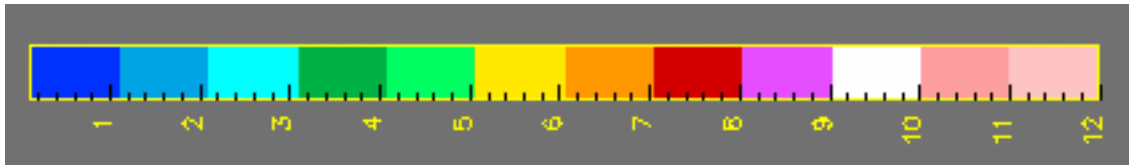
NIGHT



MEAN CLOUD HEIGHT, VIRS, JANUARY 1998

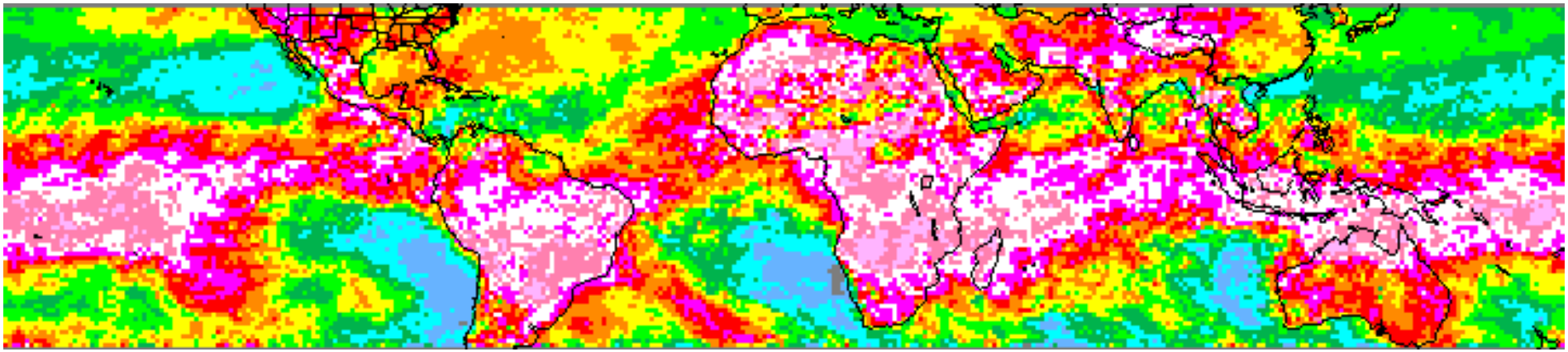
DAYTIME





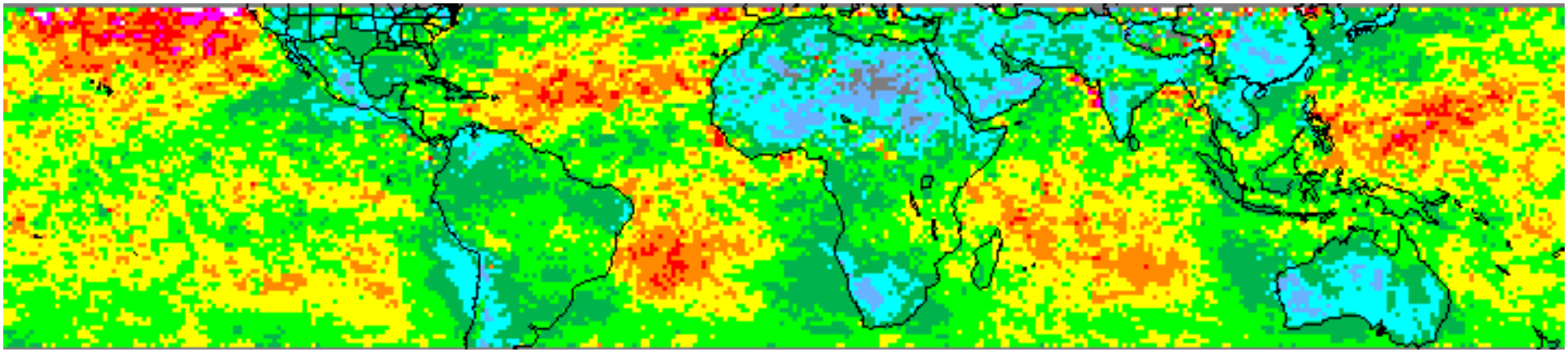
km

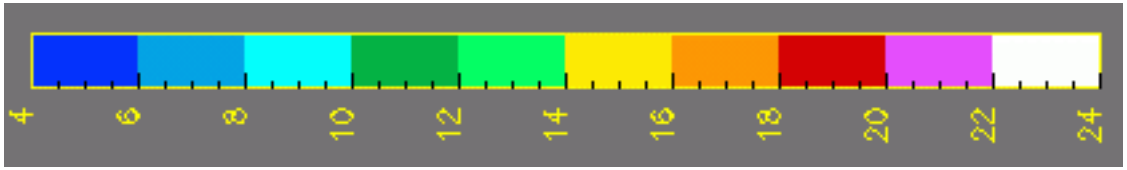
NIGHT



MEAN EFFECTIVE CLOUD WATER DROPLET SIZE, VIRS, JAN 1998

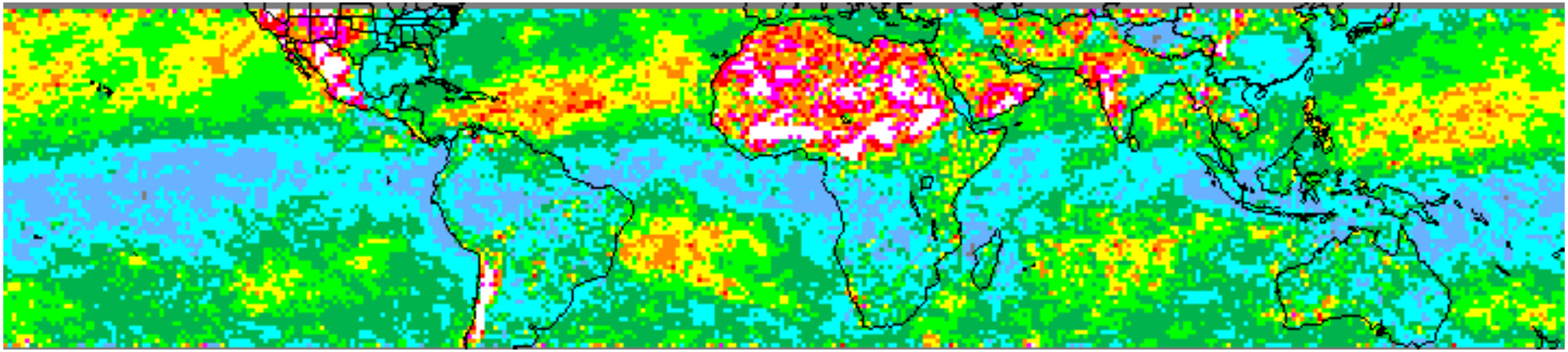
DAYTIME





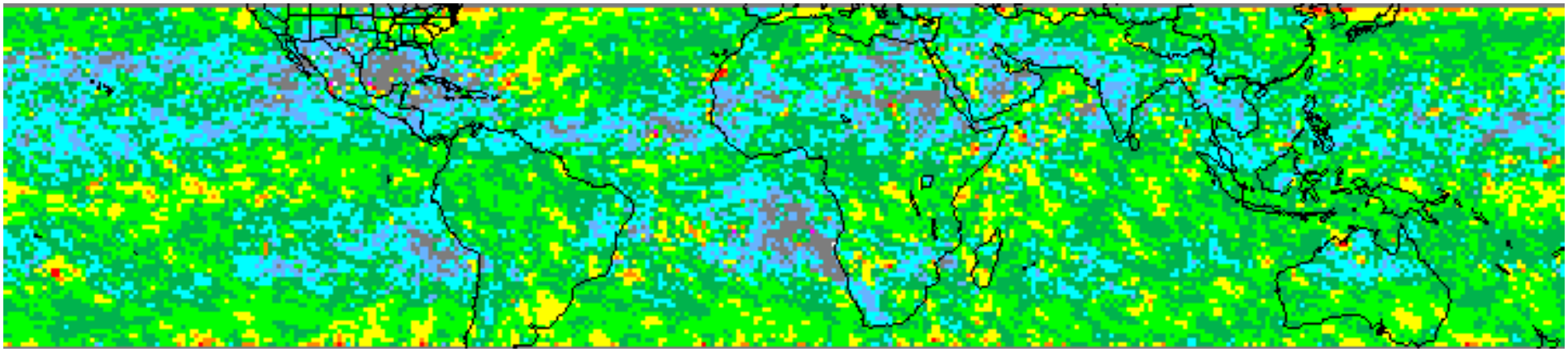
re, µm

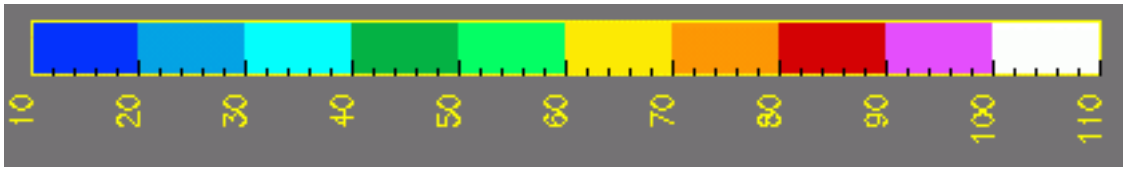
NIGHT



MEAN EFFECTIVE CLOUD ICE PARTICLE SIZE, DAY, VIRS 1998

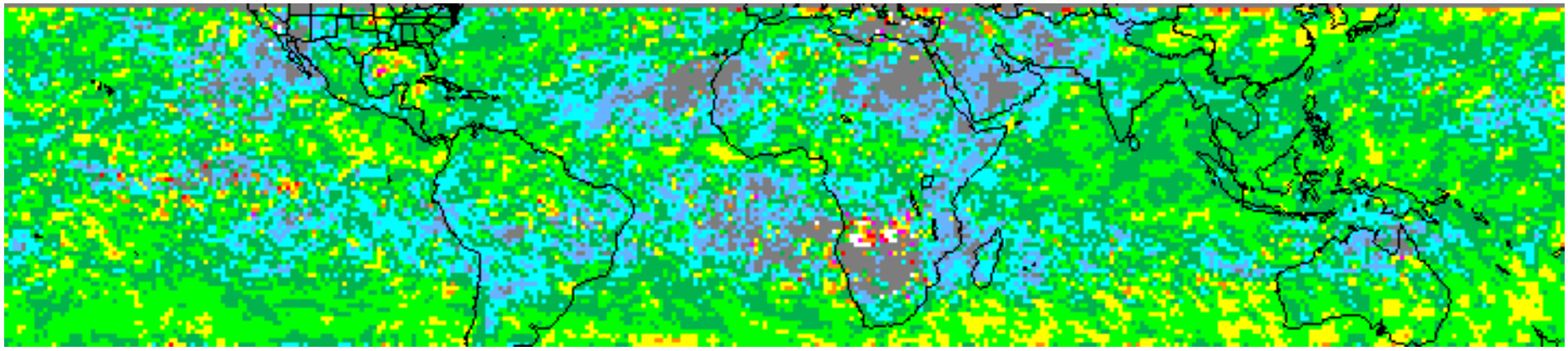
APRIL





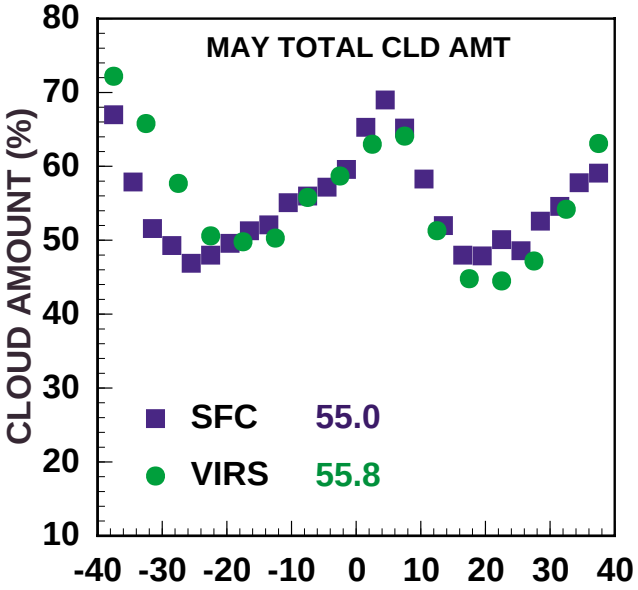
De, μm

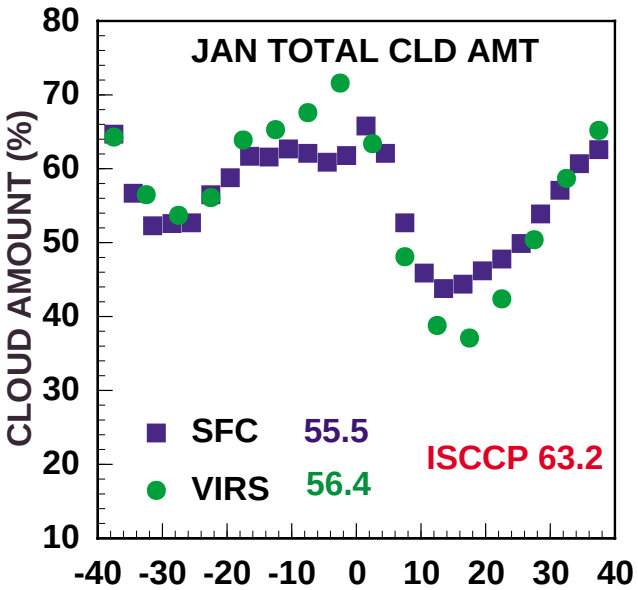
JUNE

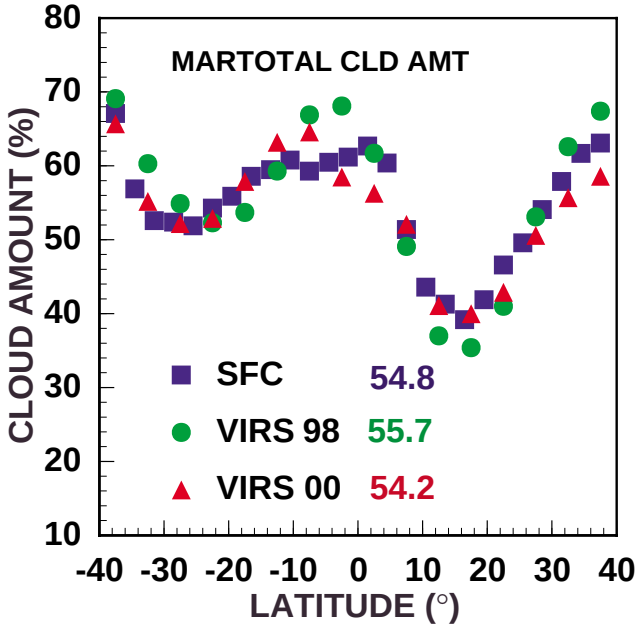


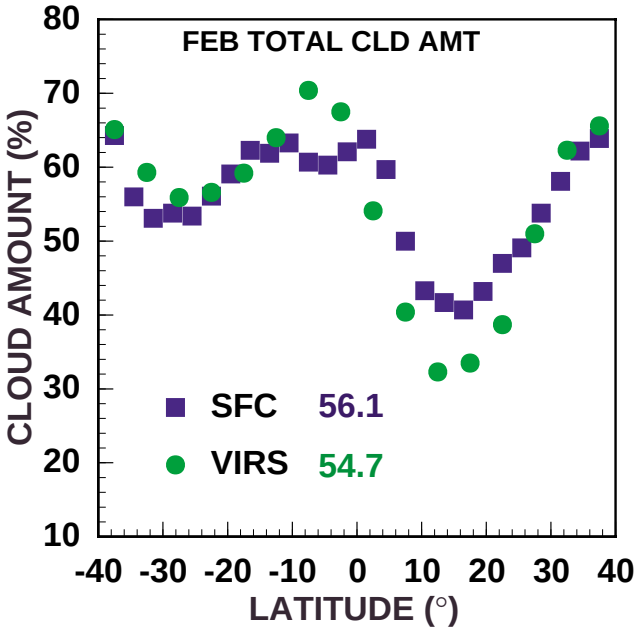
COMPARISON OF TOTAL CLOUD AMOUNTS

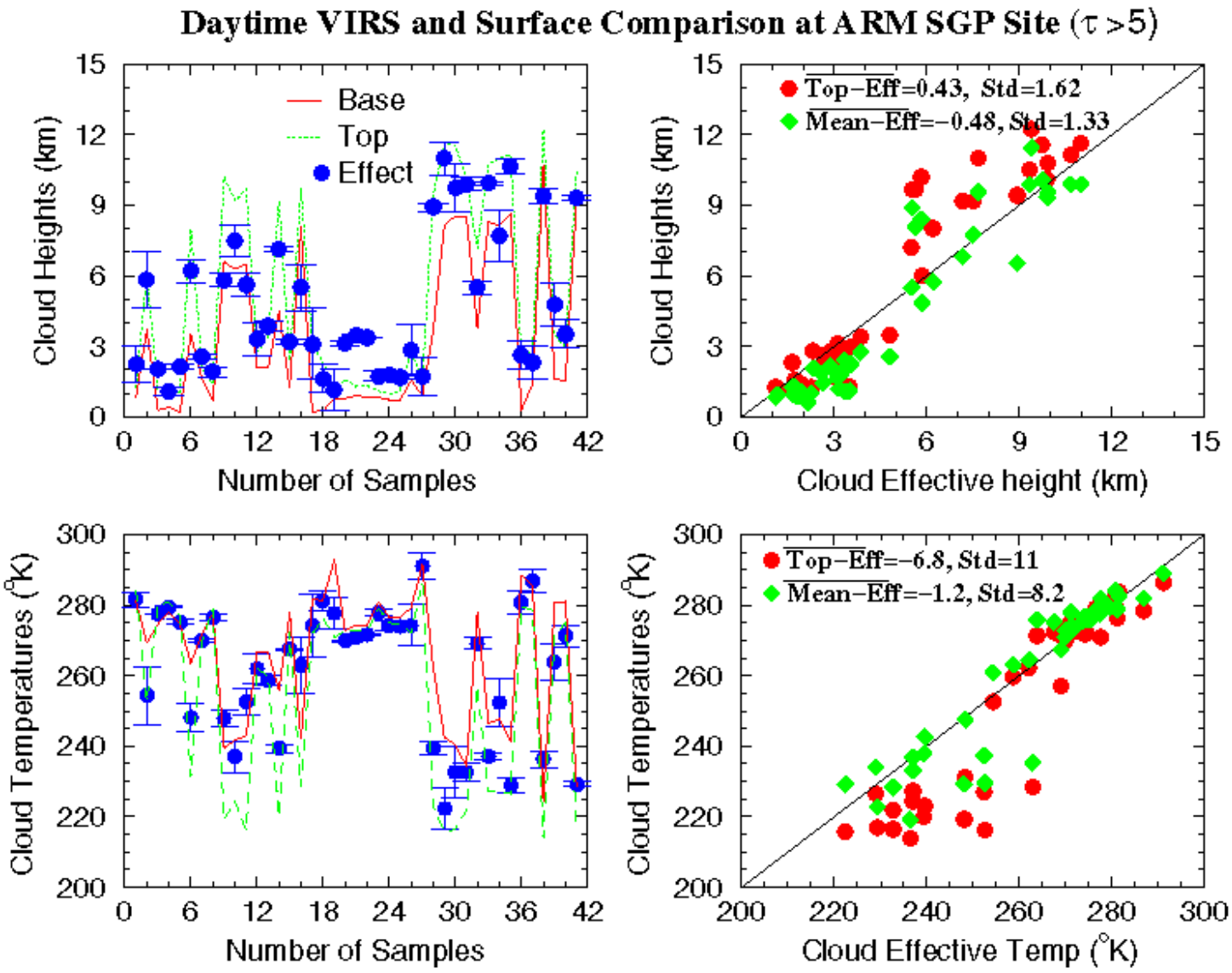
SURFACE (1971-1996) VIRS (1998) ISCCP (1984 - 1991)



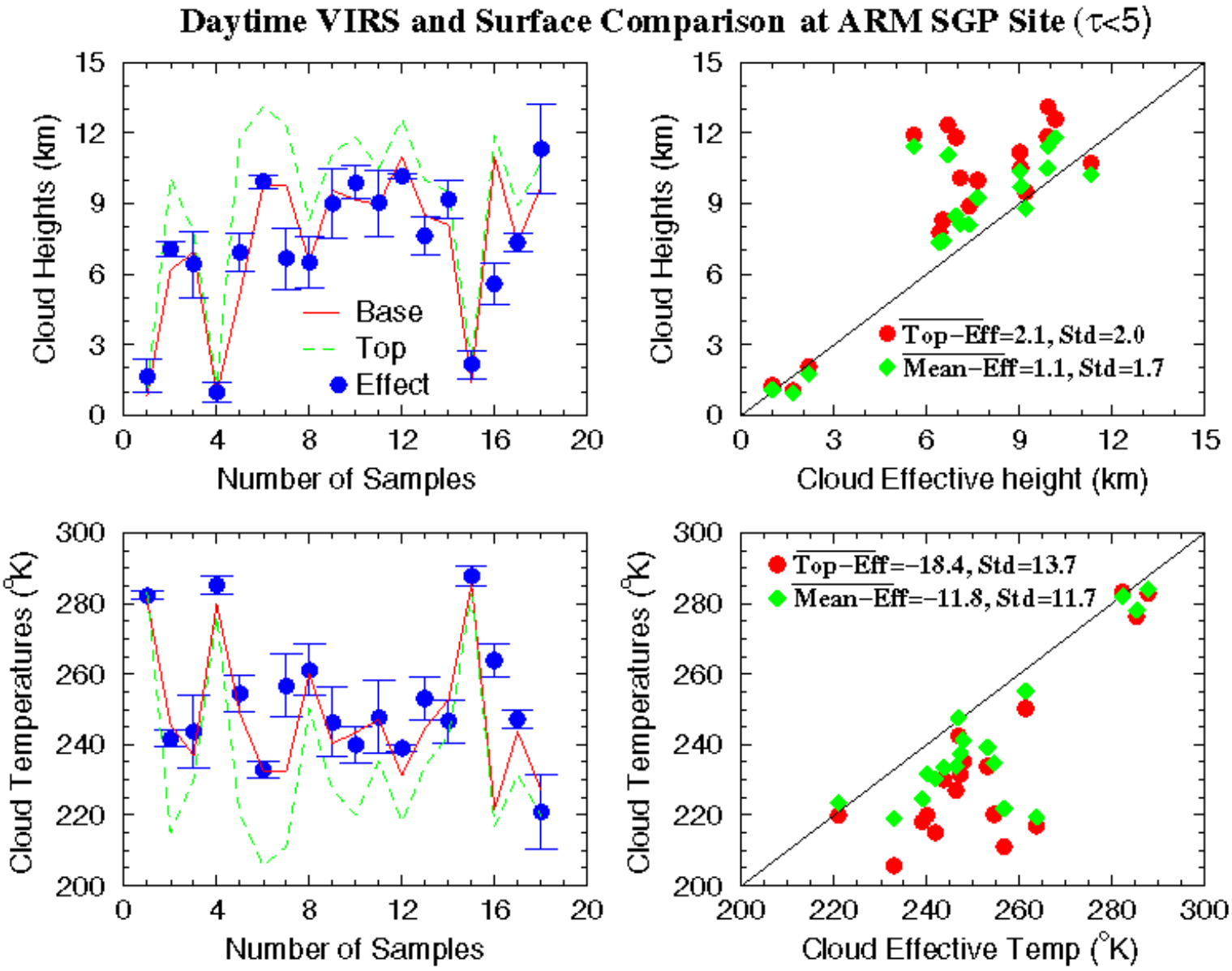




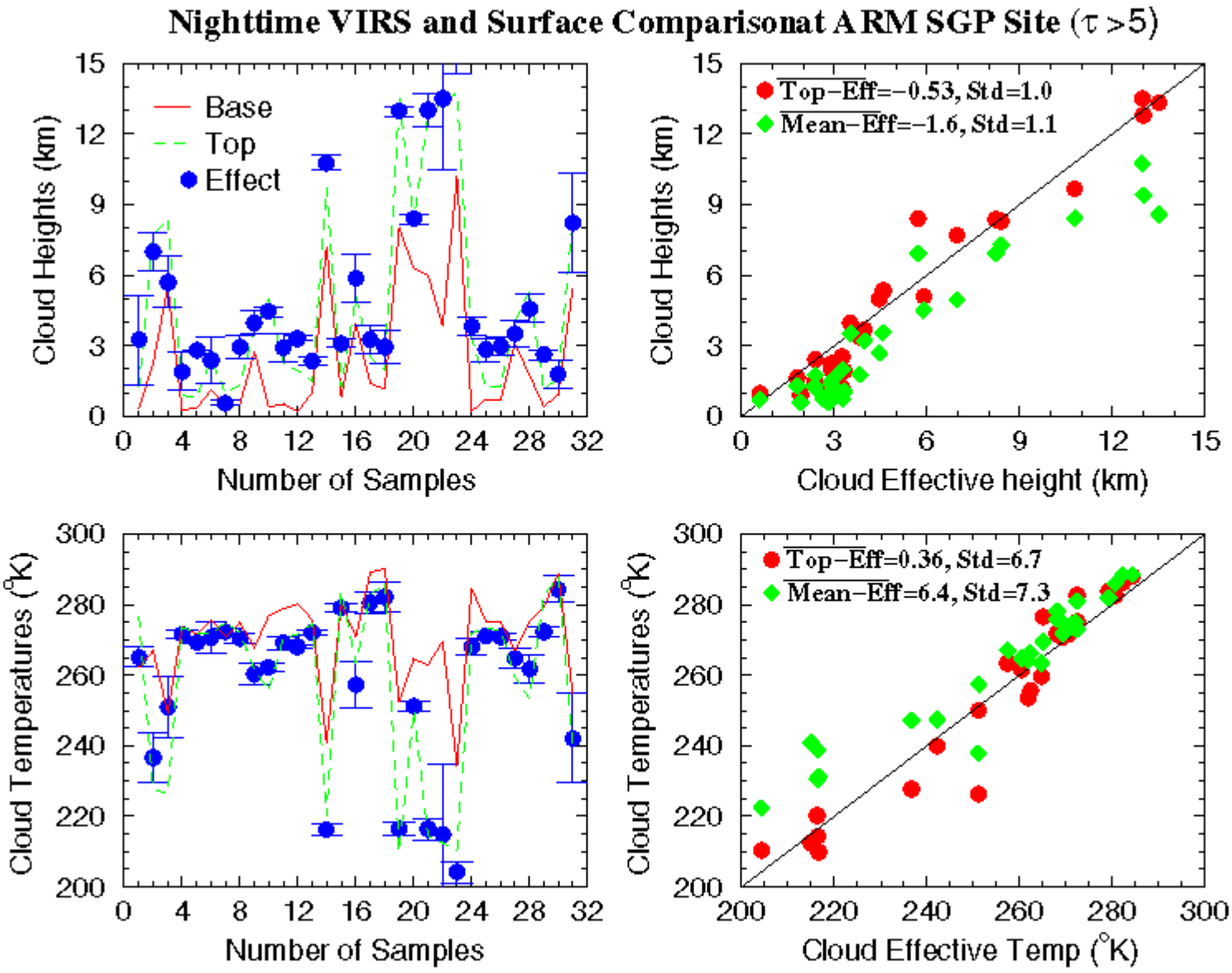




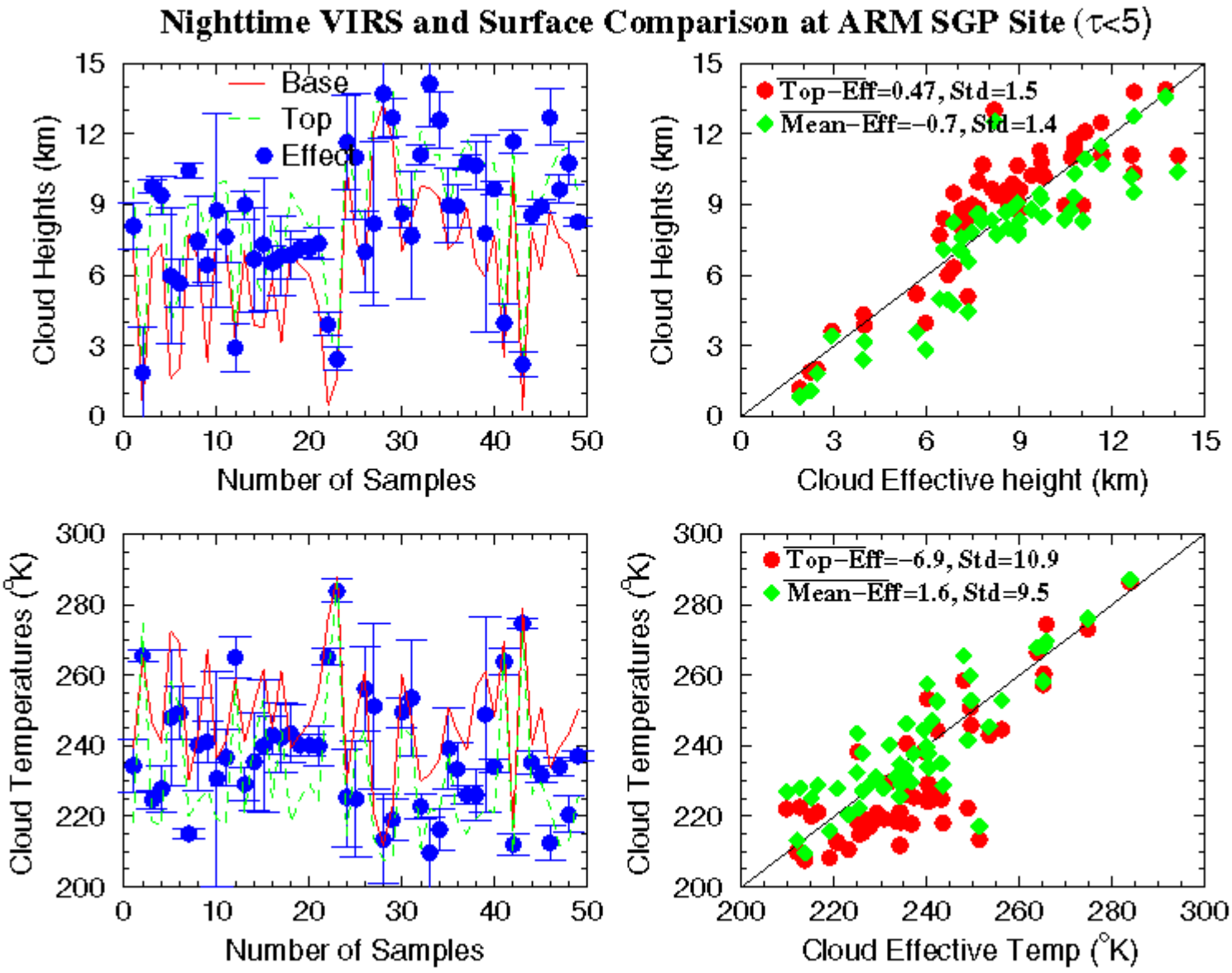
Daytime thick clouds: 5 stratus cloud tops outside of bounds, T(z) problem



Thin cloud daytime: 3 below cloud base, 1 above cloud top

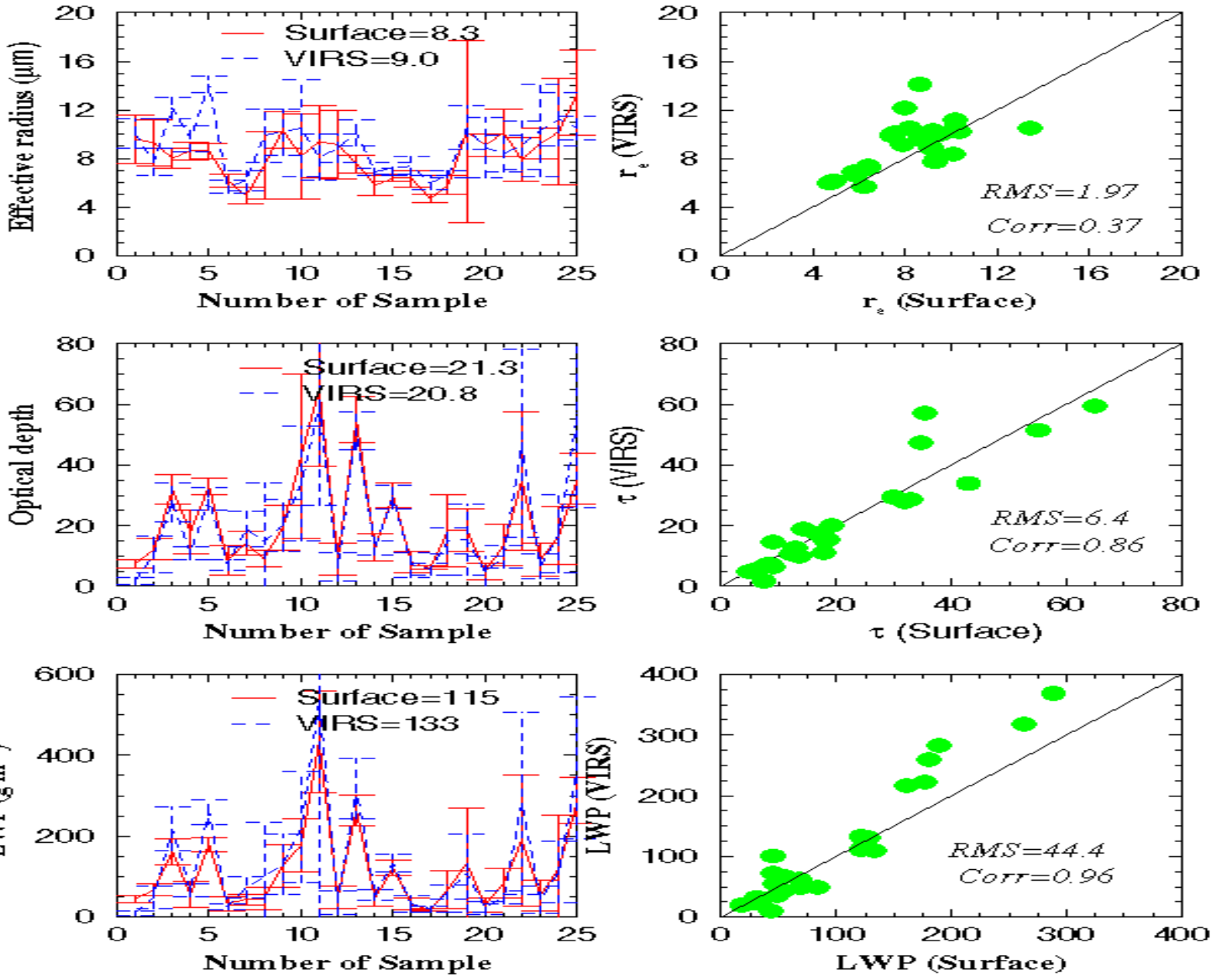


Nighttime thick: 2 cirrus too high, 3 stratus too high [T(z) again]

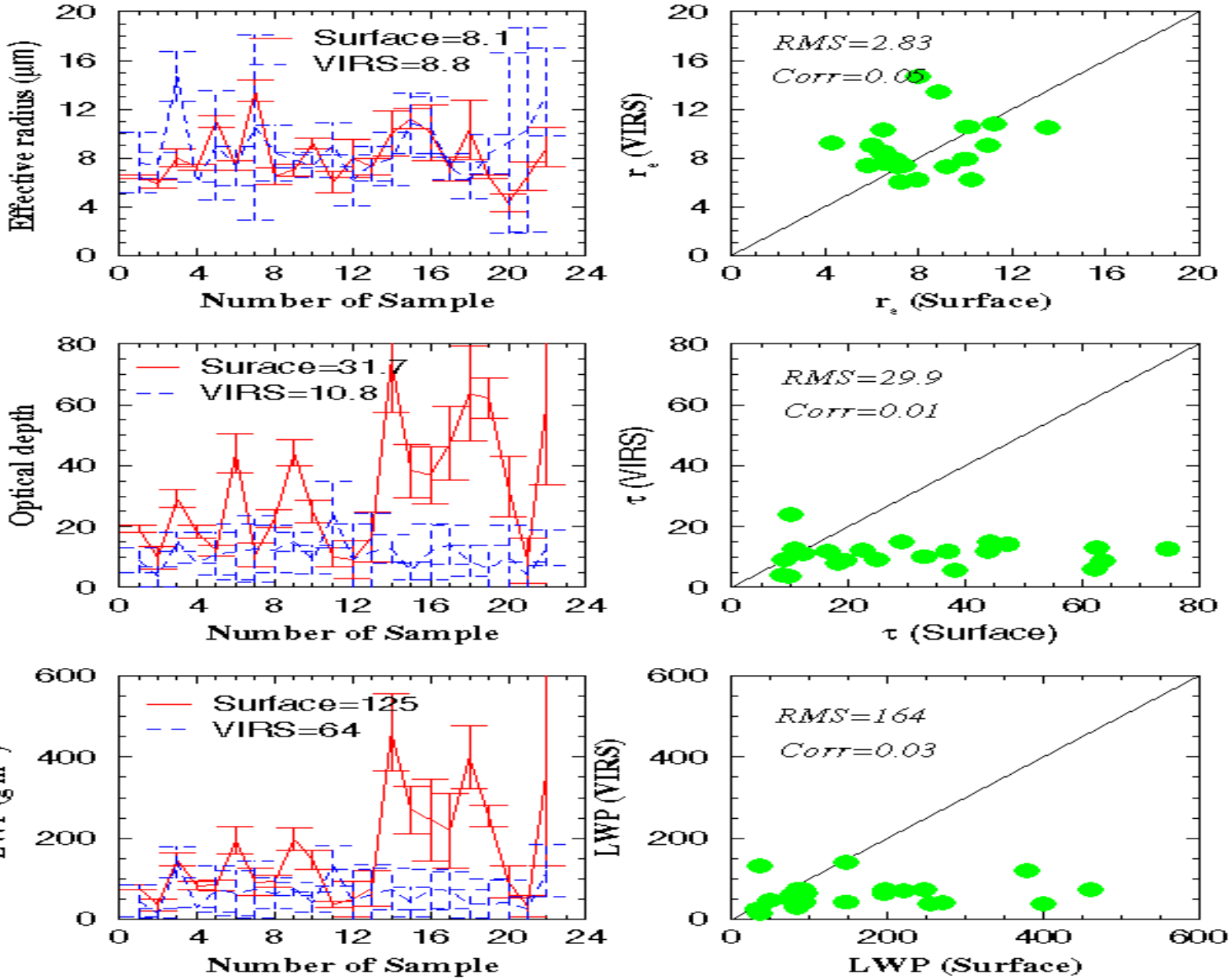


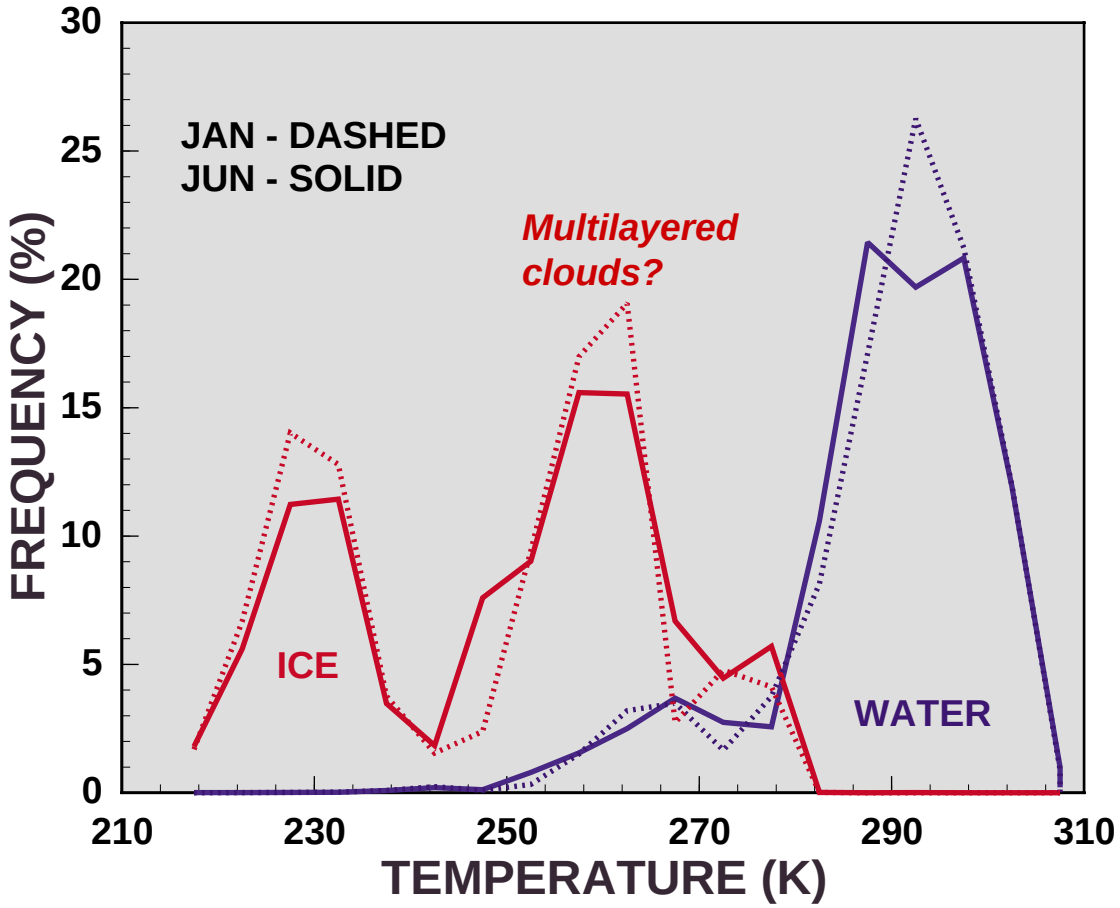
Nighttime thin: 4 Ci too high, 1 too low; best agreement

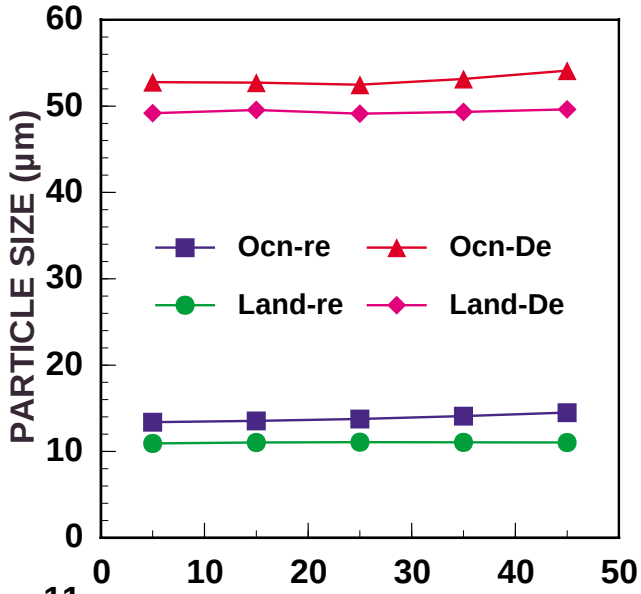
Daytime VIRS and Surface Comparison at ARM SGP Site

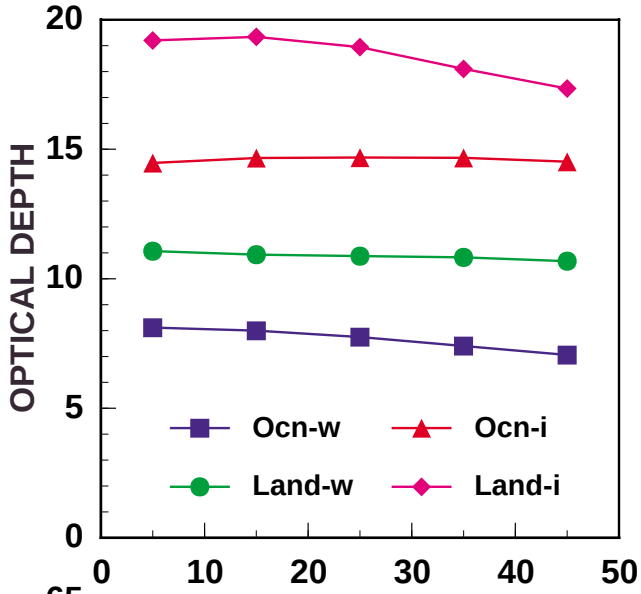


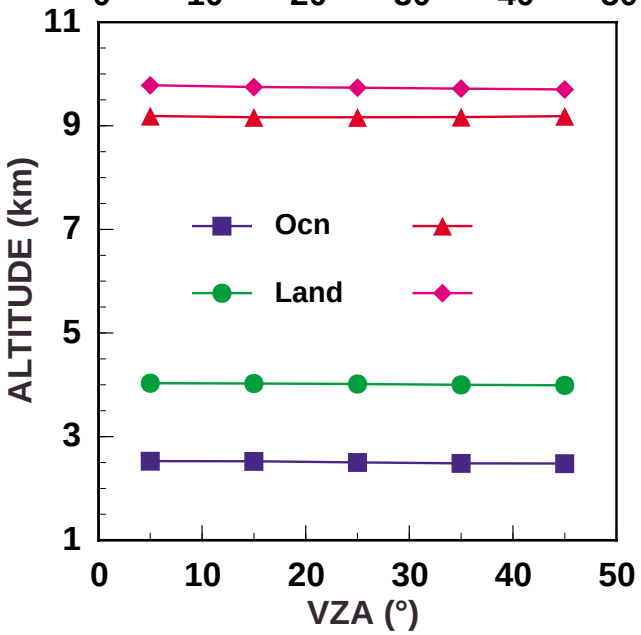
Nighttime VIRS and SurfaceComparison at ARM SGP Site

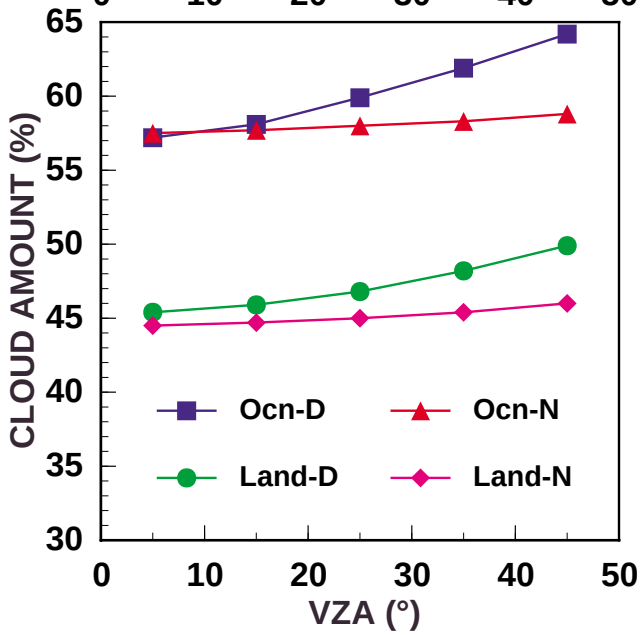


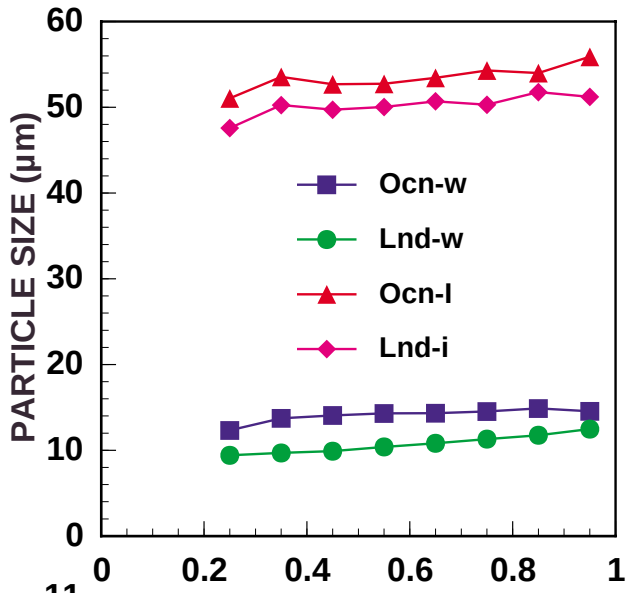

JAN - DASHED
JUN - SOLID
Multilayered clouds?
ICE
WATER
FREQUENCY (%)
TEMPERATURE (K)
0
5
10
15
20
25
30
210
230
250
270
290
310

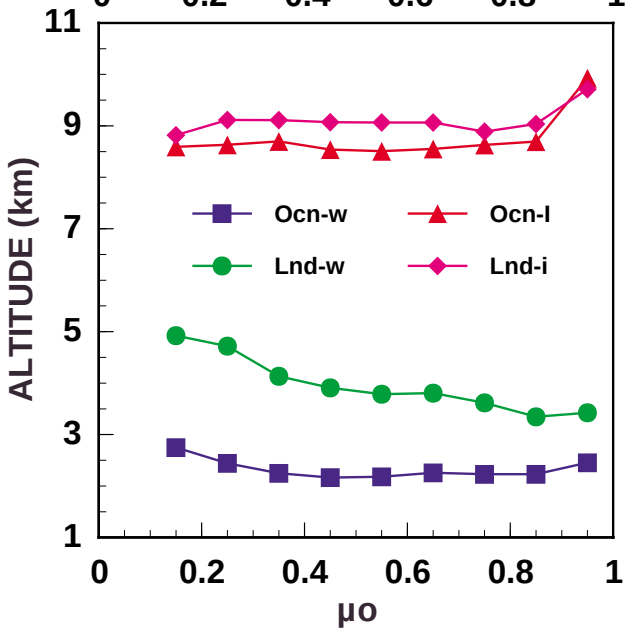

PARTICLE SIZE (μm)
60
50
40
30
20
10
0
0
10
20
30
40
50
Ocn-re
Ocn-De
Land-re
Land-De

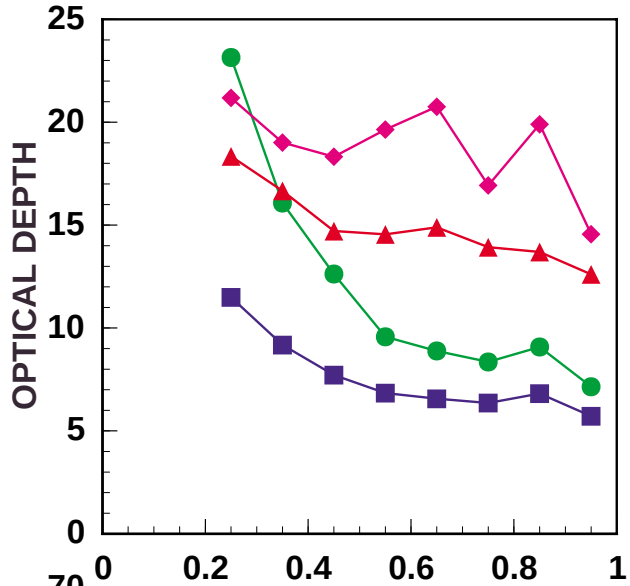

OPTICAL DEPTH
20
15
10
5
0
0
10
20
30
40
50
Ocn-w
Ocn-i
Land-w
Land-i

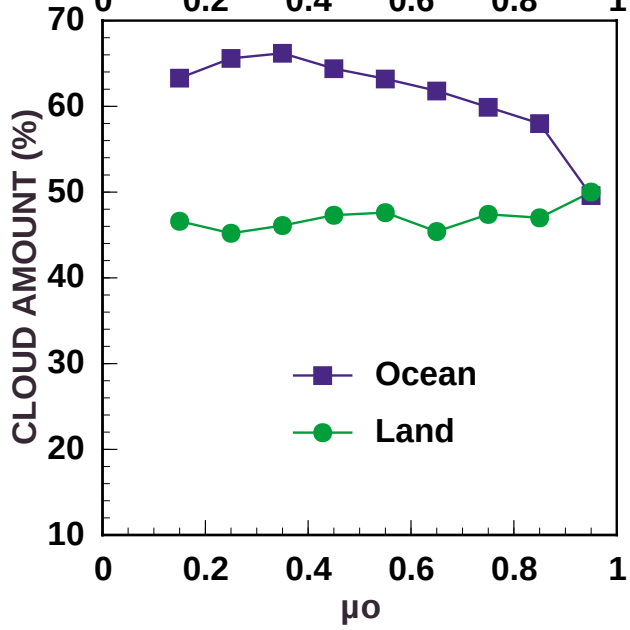

ALTITUDE (km)
11
9
7
5
3
1
0
10
20
30
40
50
VZA (°)
Ocn
Land


CLOUD AMOUNT (%)
65
60
55
50
45
40
35
30
0
10
20
30
40
50
VZA (°)
Ocn-D
Ocn-N
Land-D
Land-N


PARTICLE SIZE (μm)
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
Ocn-w
Lnd-w
Ocn-I
Lnd-i


ALTITUDE (km)
11
9
7
5
3
1
0
0.2
0.4
0.6
0.8
1
μo
Ocn-w
Ocn-I
Lnd-w
Lnd-i


OPTICAL DEPTH
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1


CLOUD AMOUNT (%)
70
60
50
40
30
20
10
0
0.2
0.4
0.6
0.8
1
μo
Ocean
Land

ECMWF vs DAO SFC TEMPS FOR VIRS JULY 1998

- COMPARISON OF DIFFERENCES BETWEEN MODEL & OBSERVED CLEAR-SKY TEMPERATURES: DIF = TMOD - TOBS
- DAO GEOS 3.3 & ECMWF (CERES PRODUCT)

	ECMWF	σ	DAO	σ
DAY	0.41 K	1.7 K	0.94 K	2.1 K
DAY LAND	-0.40	2.8 K	1.24 K	3.4 K
NIGHT	1.16 K	1.6 K	1.66 K	2.4 K
NIGHT LAND	1.62	2.3 K	3.13 K	3.8 K

- DAO VERSION 4 IN THE PIPELINE, NOT YET ANALYZED

STATUS OF CERES-MODIS CLOUD PROPERTIES

- **CALIBRATION**

  - **Provisional MODIS comparisons show good agreement for most channels, except for**

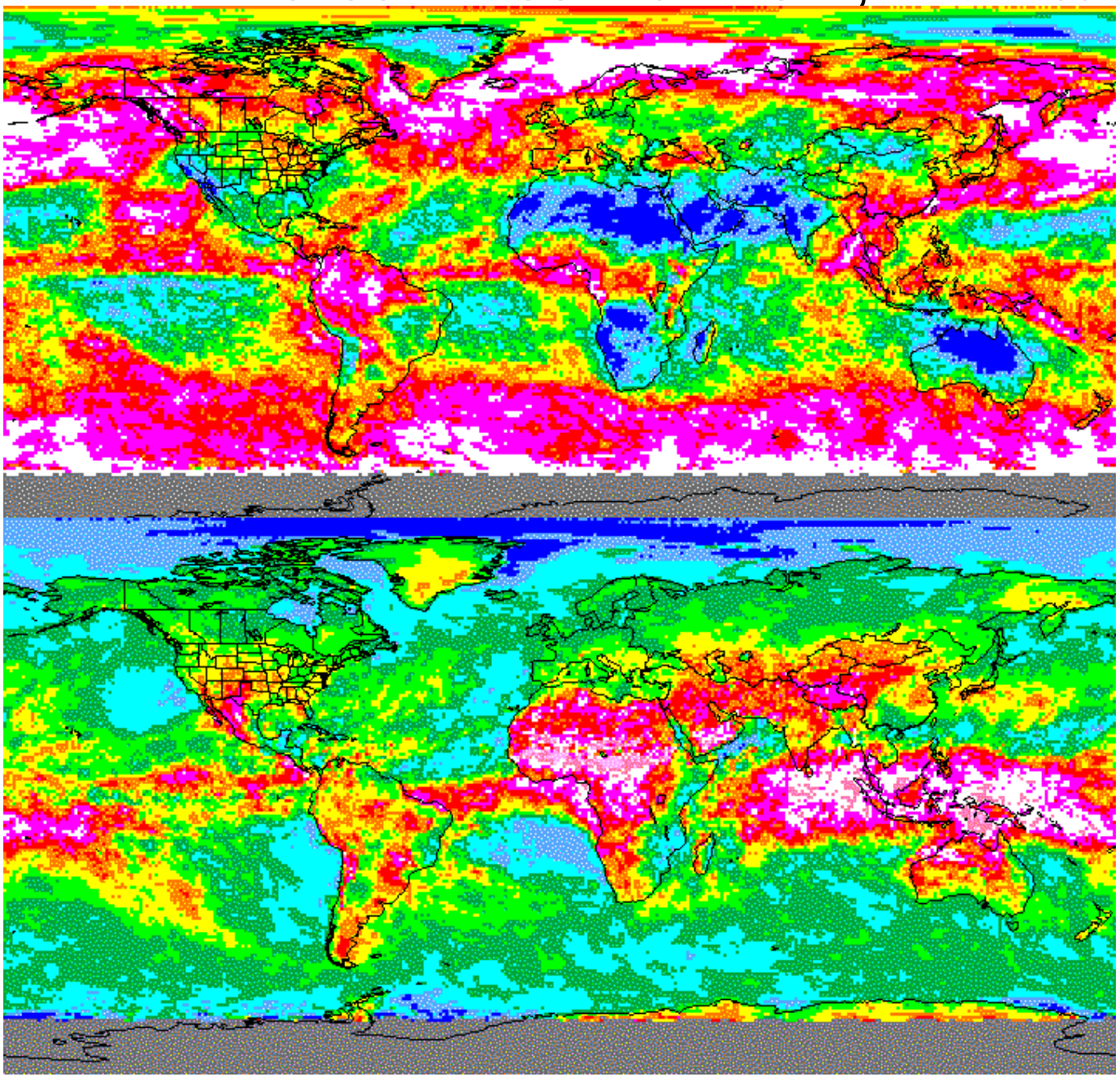
    - **MODIS 0.65 reflectance ~3% > VIRS at large albedos**
    - **MODIS 3.7 temps 0.5K > VIRS (day)**

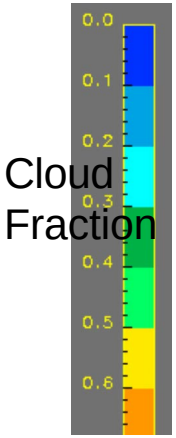
- **Betas in Archive**

  - **Beta1, March 2001**
  - **Beta2, April-May 2001**
  - **Beta1 & Beta2 used wrong 3.7-μm central wavelength**

    droplet sizes too small & night clouds too high

DAYTIME CLOUD AMOUNT & HEIGHT, APRIL 2001

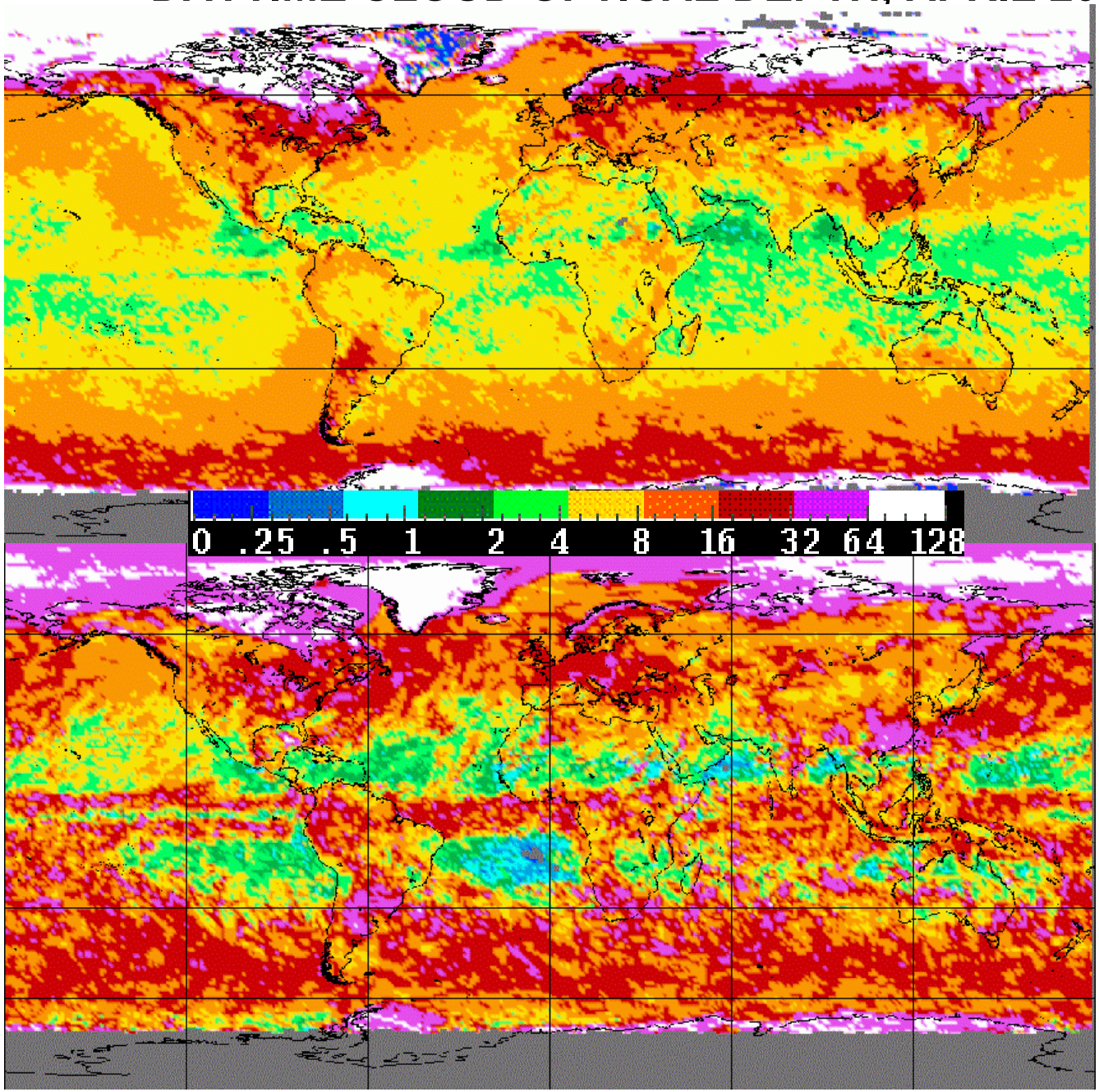




Cloud Fraction

Cloud Height (km)

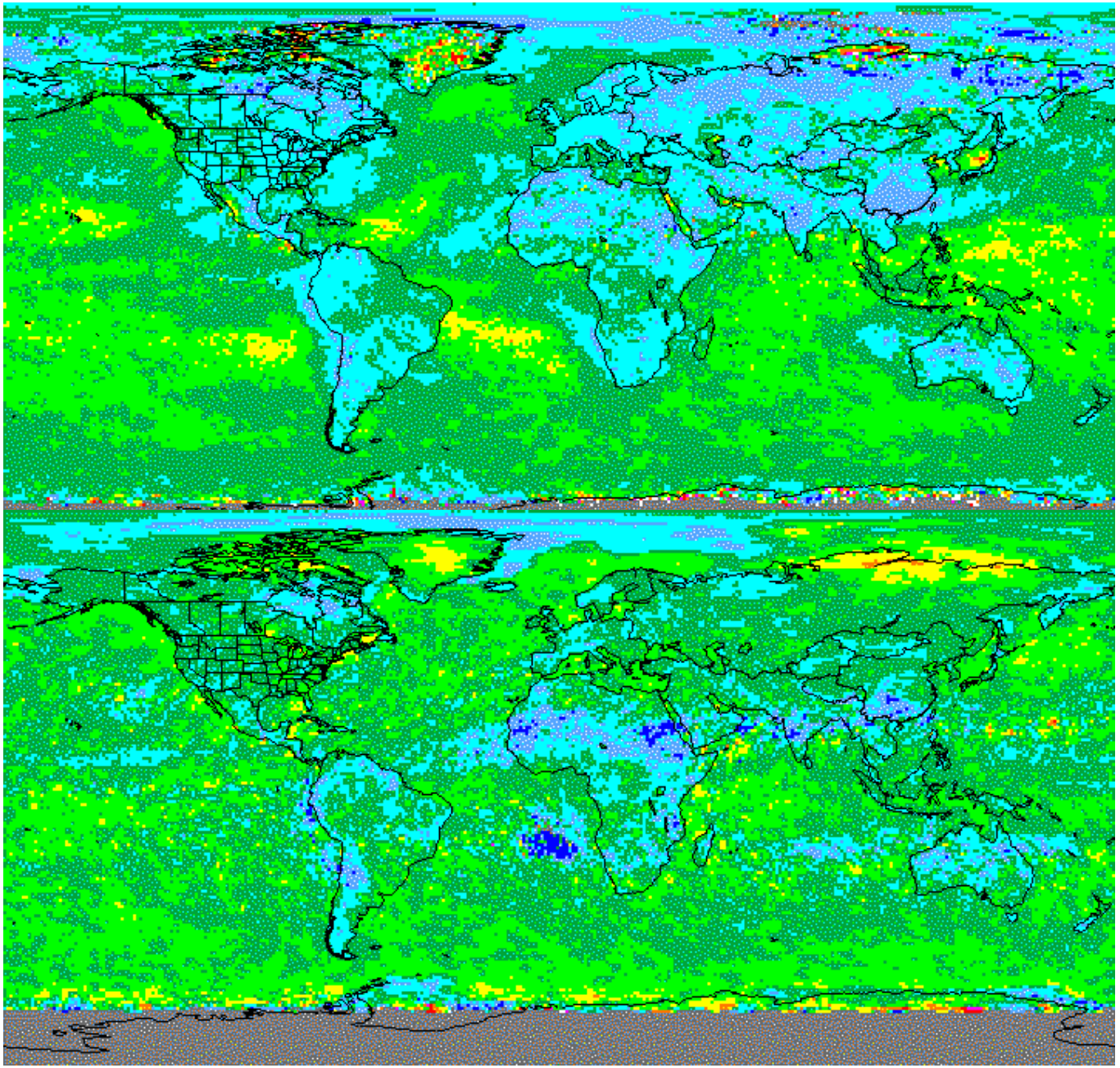
DAYTIME CLOUD OPTICAL DEPTH, APRIL 2001

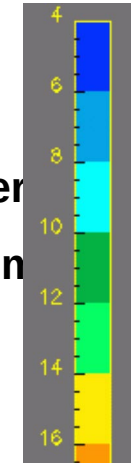


Water

Ice

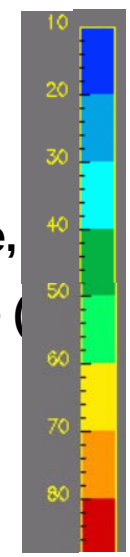
DAYTIME CLOUD EFFECTIVE PARTICLE SIZE, APRIL 2001





Water

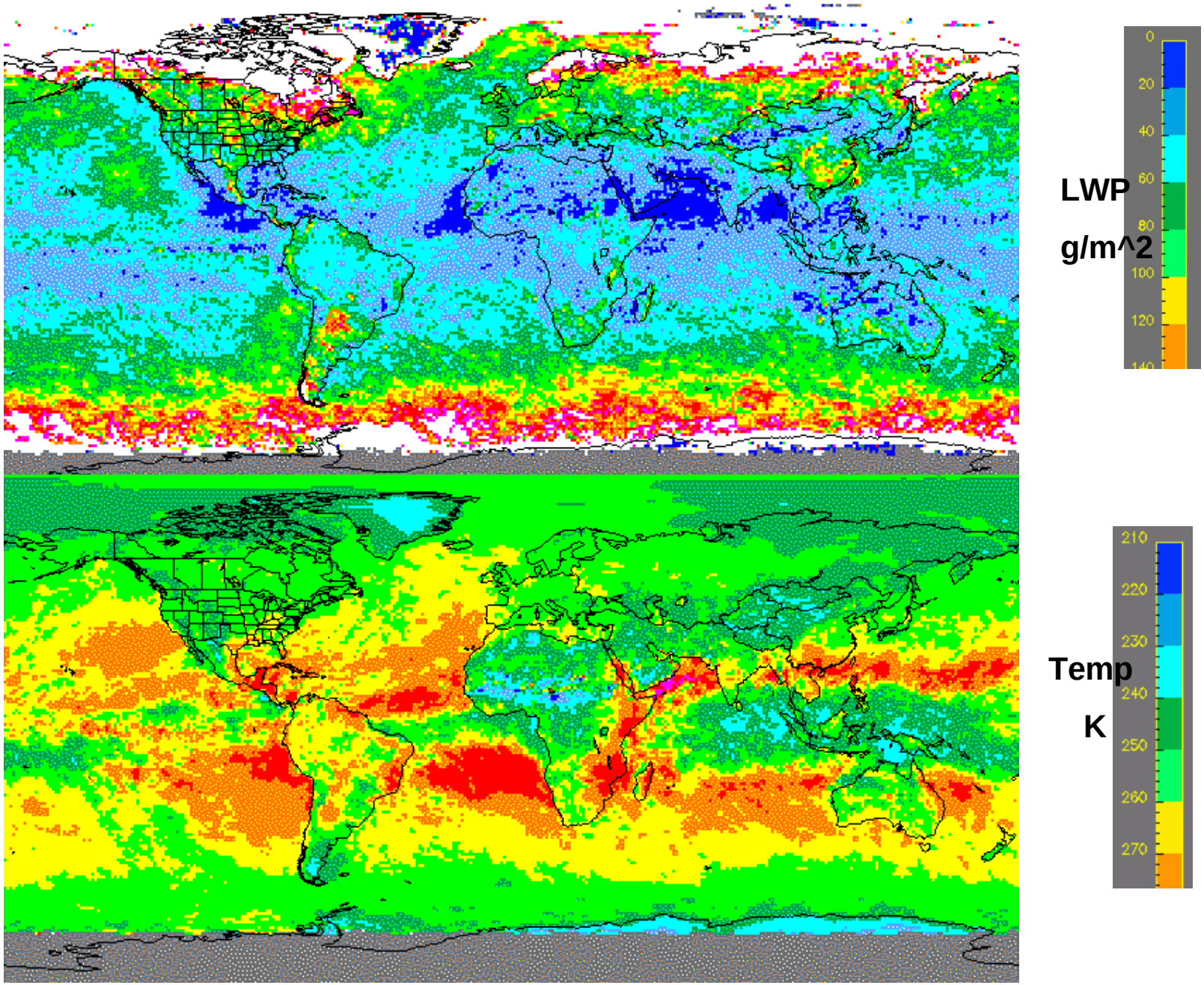
re (µn



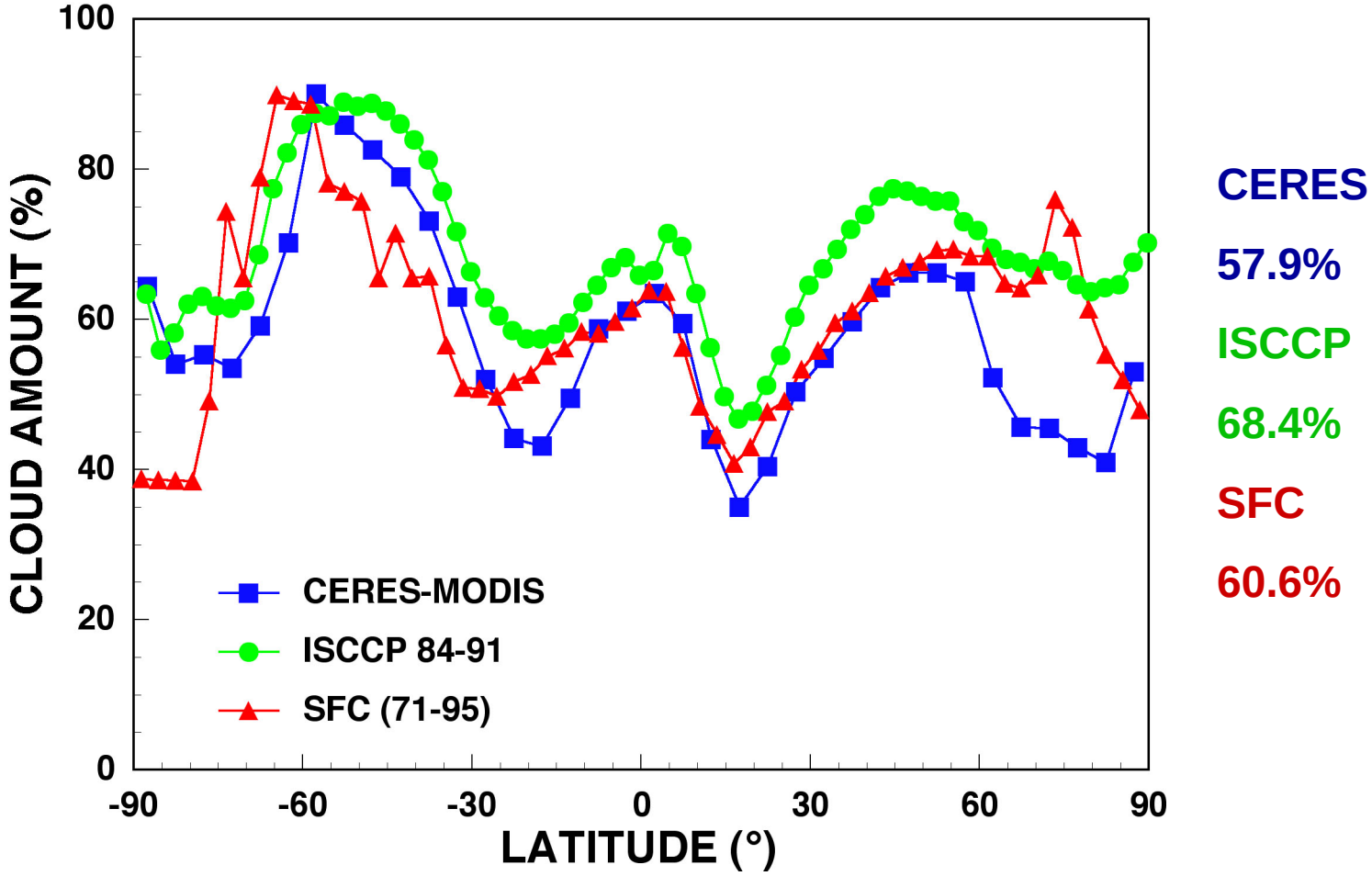
Ice,

De (

DAYTIME CLOUD LWP & TEMPERATURE, APRIL 2001

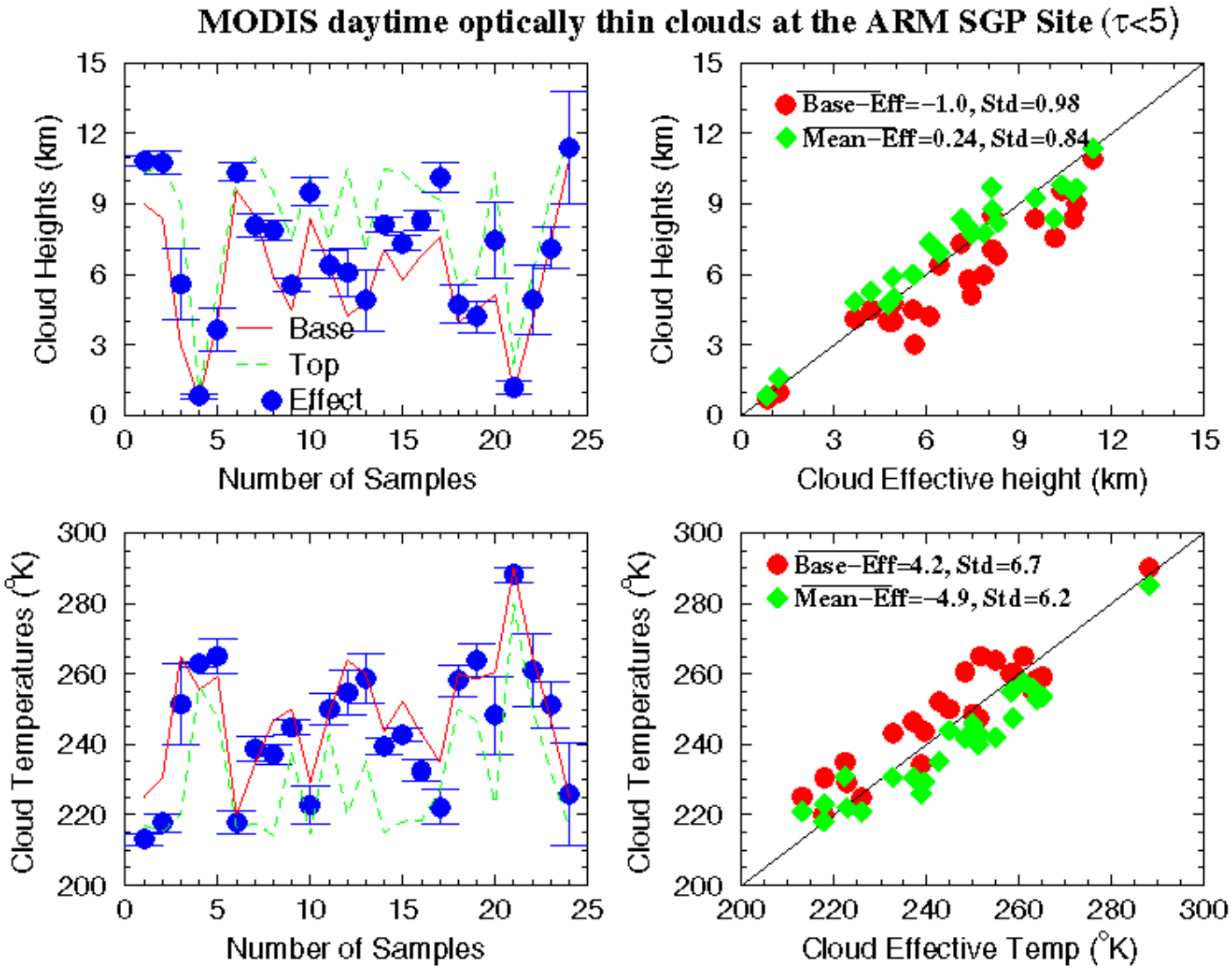


APRIL TOTAL CLOUD AMOUNTS
CERES 2001; ISCCP D2 (84-91); SFC (71-95)

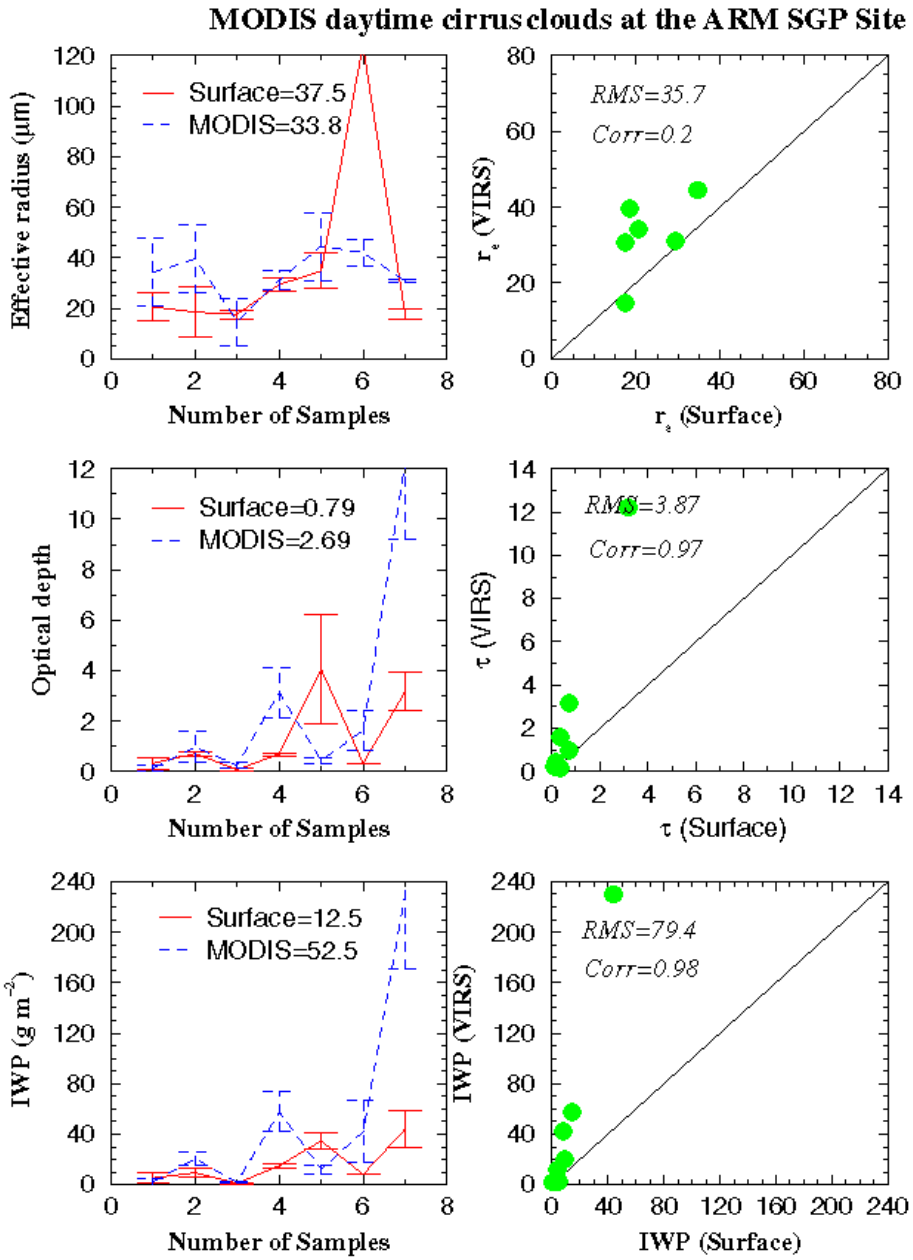


MODIS in twilight (SZA 78-90°) above 60°N; negates 3.7 μm impact on mask

THIN CLOUD HEIGHT VALIDATION CERES-MODIS, 11/00 - 5/01, BETA2



INITIAL CIRRUS PROPERTY VALIDATION CERES-MODIS 11/00 - 5/01 BETA2 100 x 100 km box vs 30 min avg



- 3.7-μm calibration reduces re
- OD outliers due to strong gradient in box

COMPARISON OF MODIS & CERES CLOUD MASK, JULY 4 OVER ALASKA

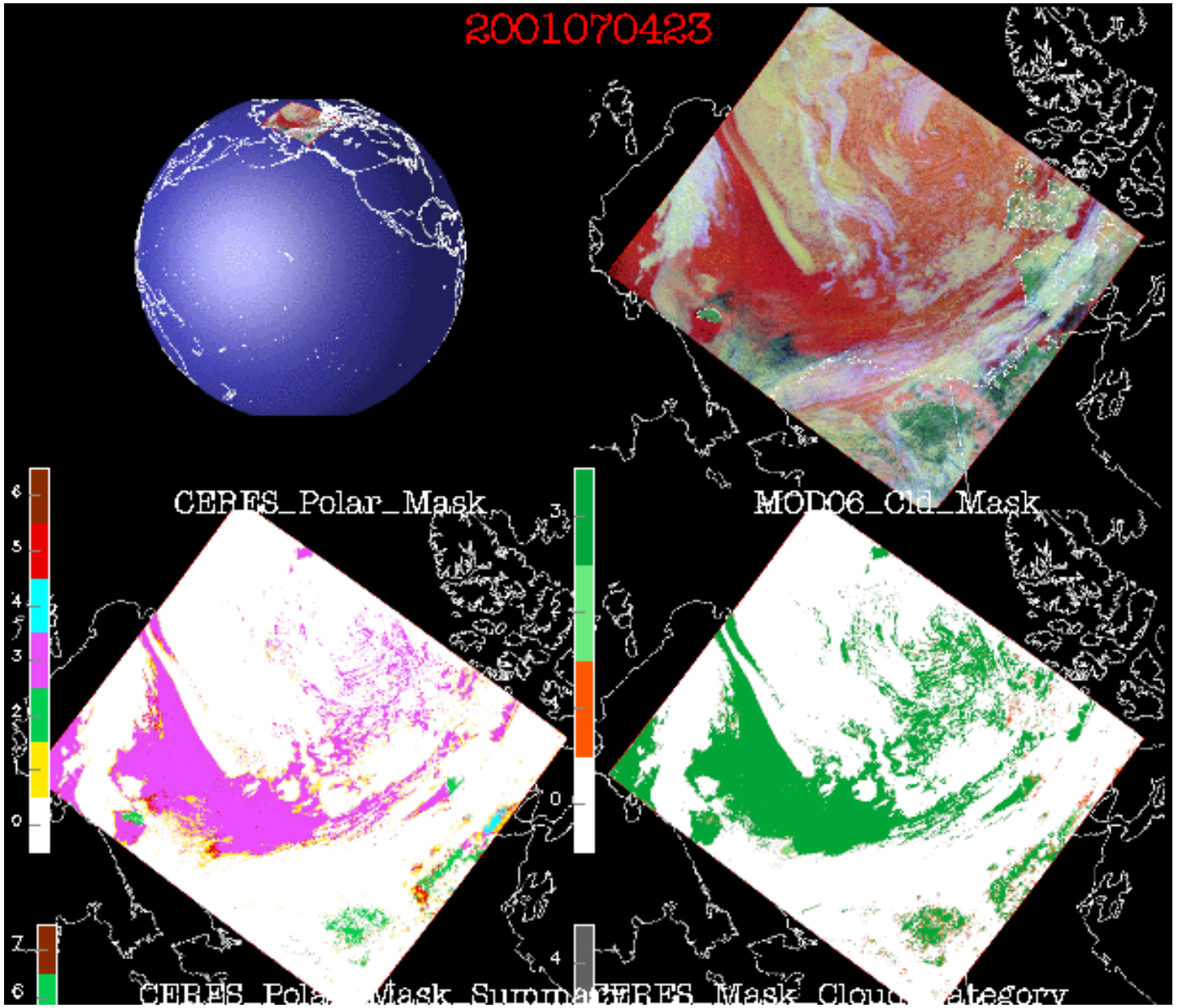
0 -cld

1 - noret

2 - clr land

3 - clr snow

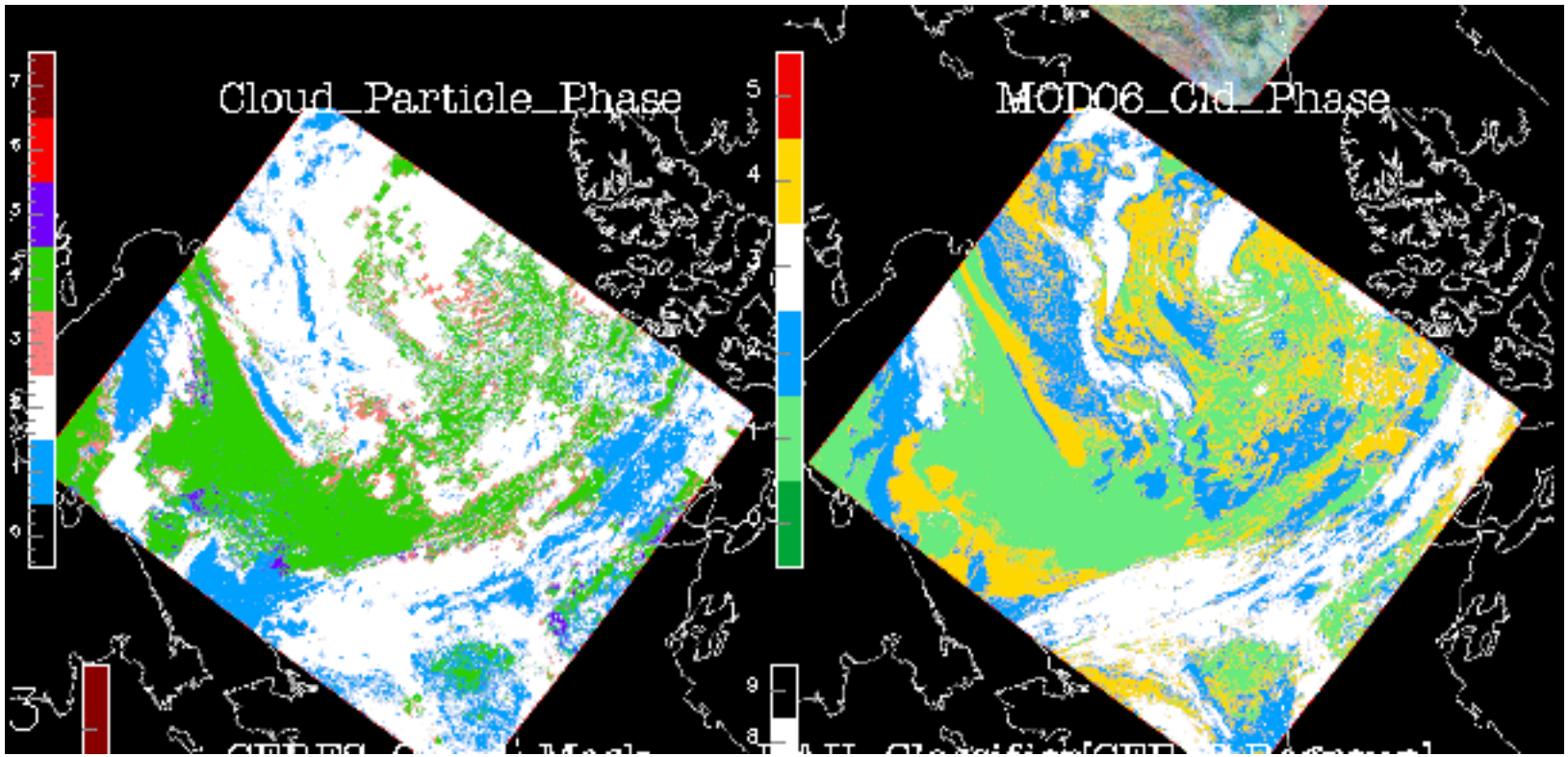
4 - clr ocn



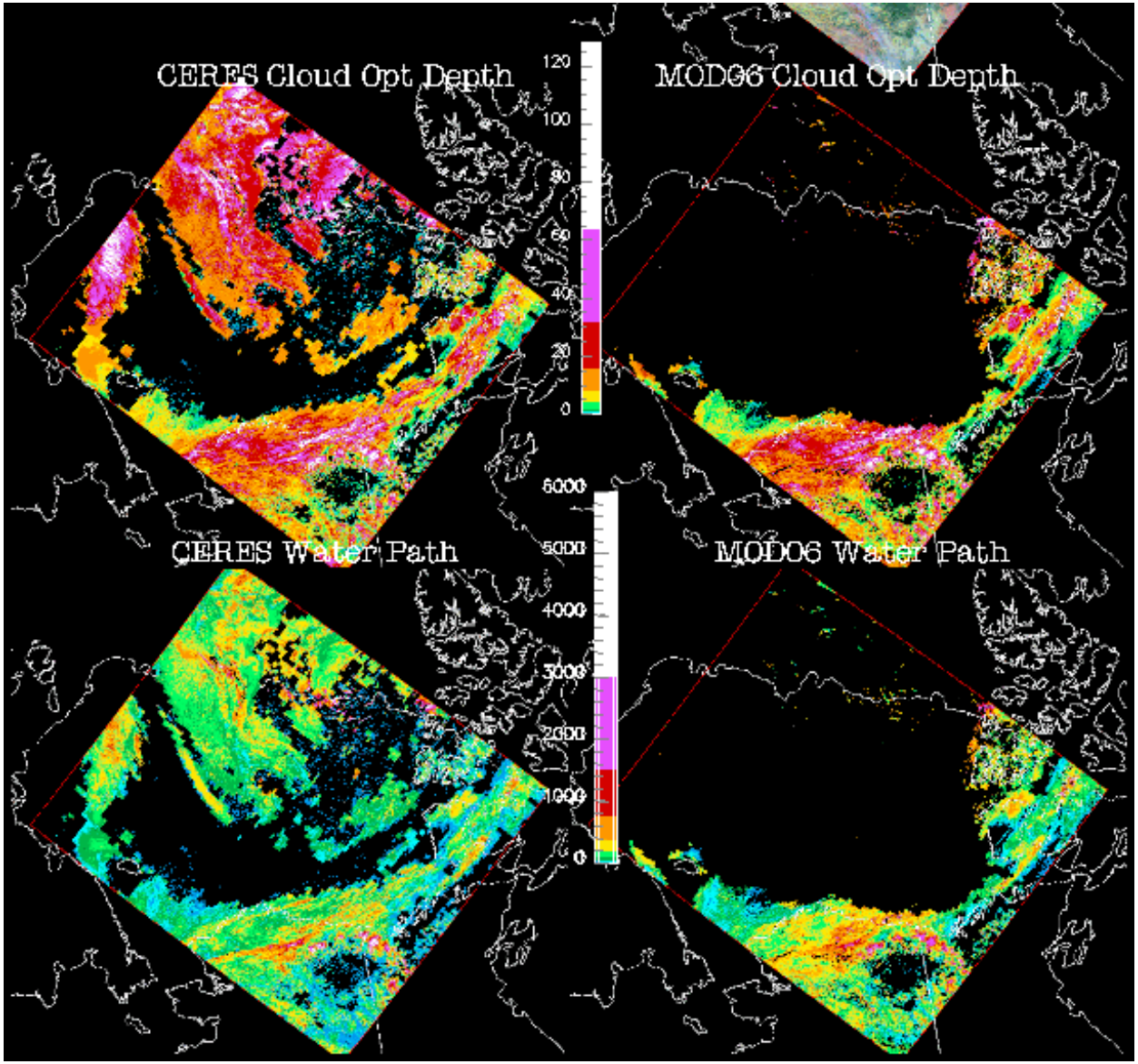
COMPARISON OF MODIS & CERES CLOUD PHASE, JULY 4 OVER ALASKA

GREEN - CLEAR; **BLUE - WATER**; **WHITE - ICE**

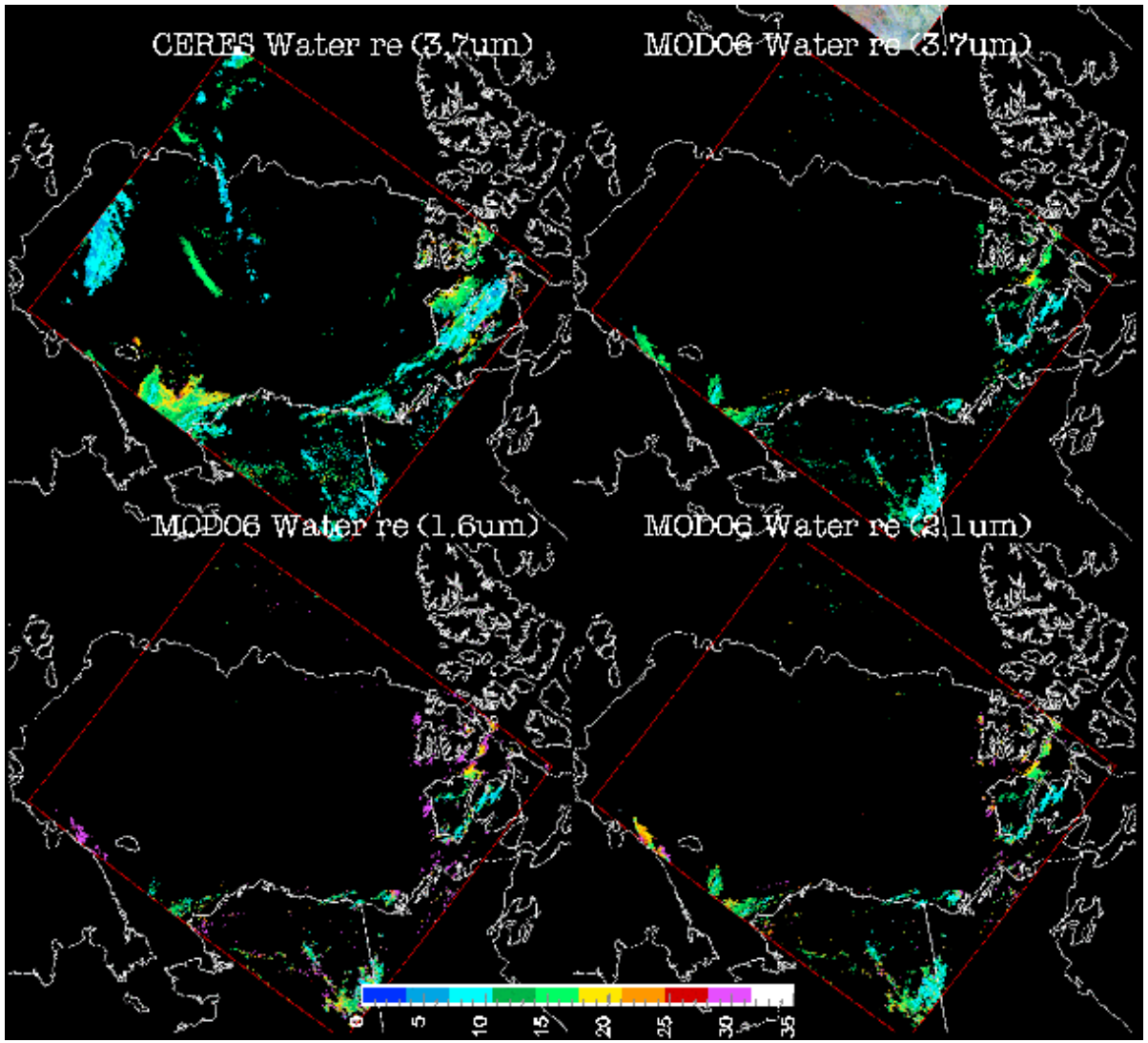
PINK - noret; **GOLD - no phase**



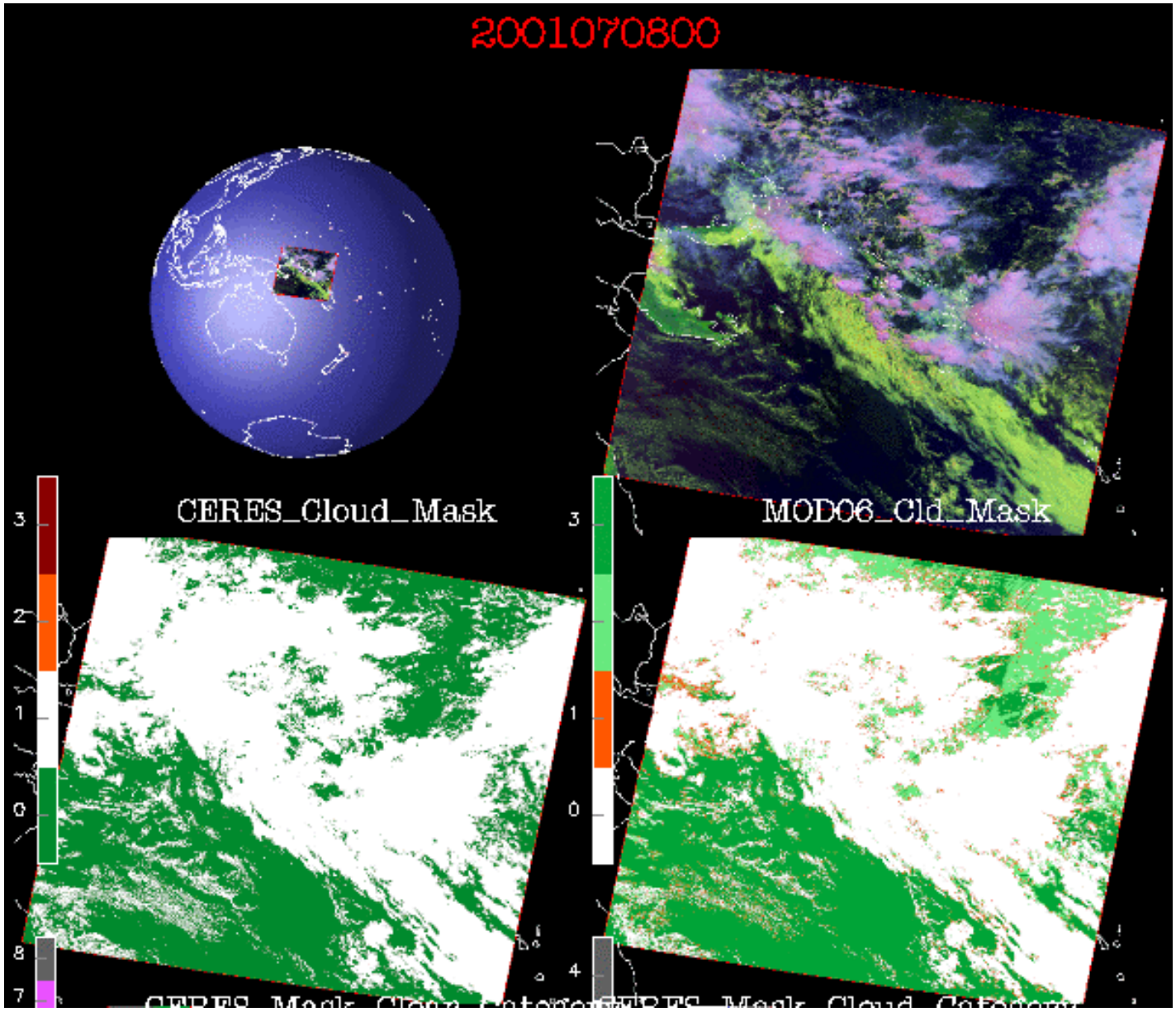
COMPARISON OF MODIS & CERES CLOUD OD, JULY 4 OVER ALASKA



COMPARISON OF MODIS & CERES CLOUD re, JULY 4 OVER ALASKA



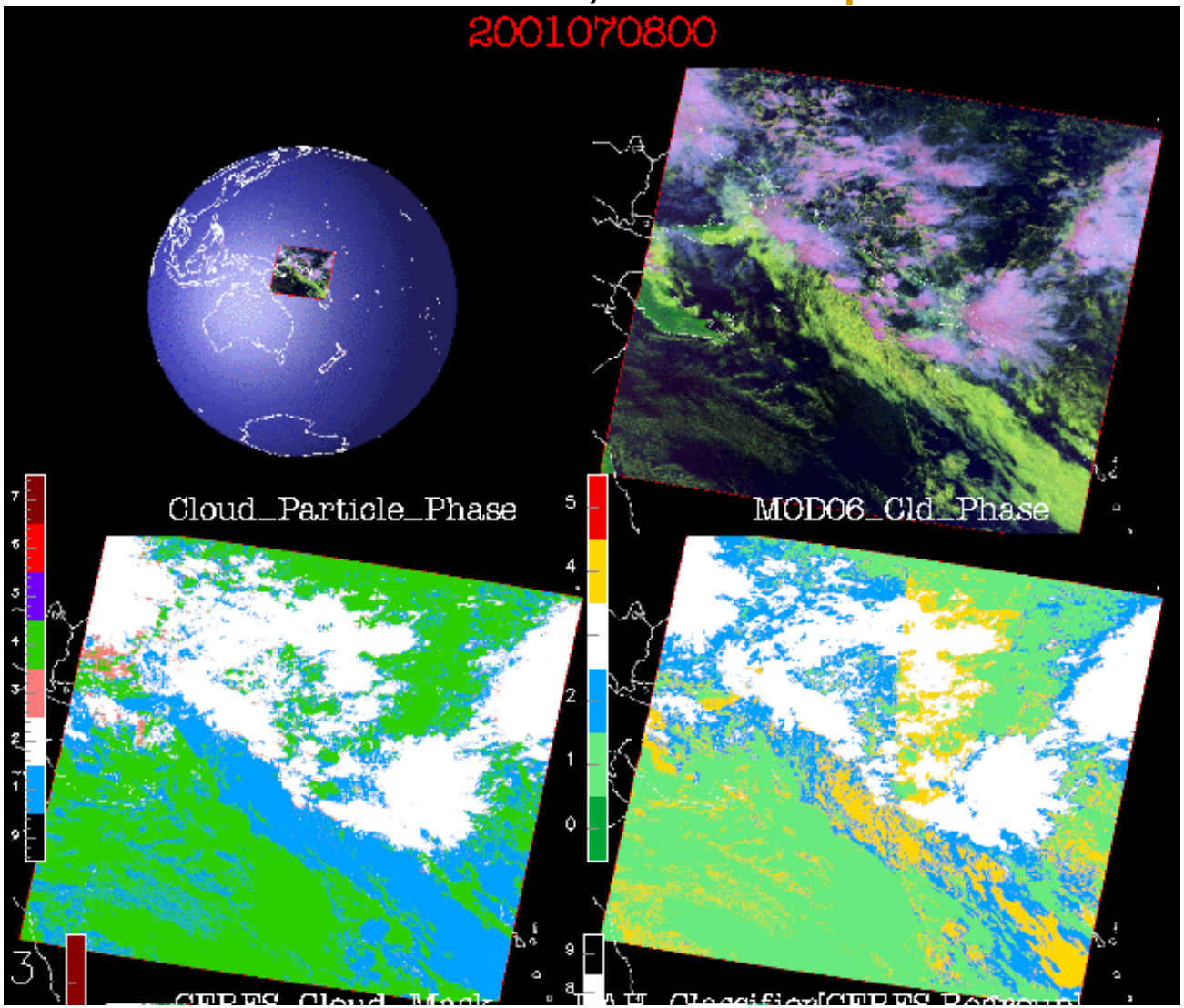
COMPARISON OF MODIS & CERES CLOUD MASK, JULY 8 OVER TWP



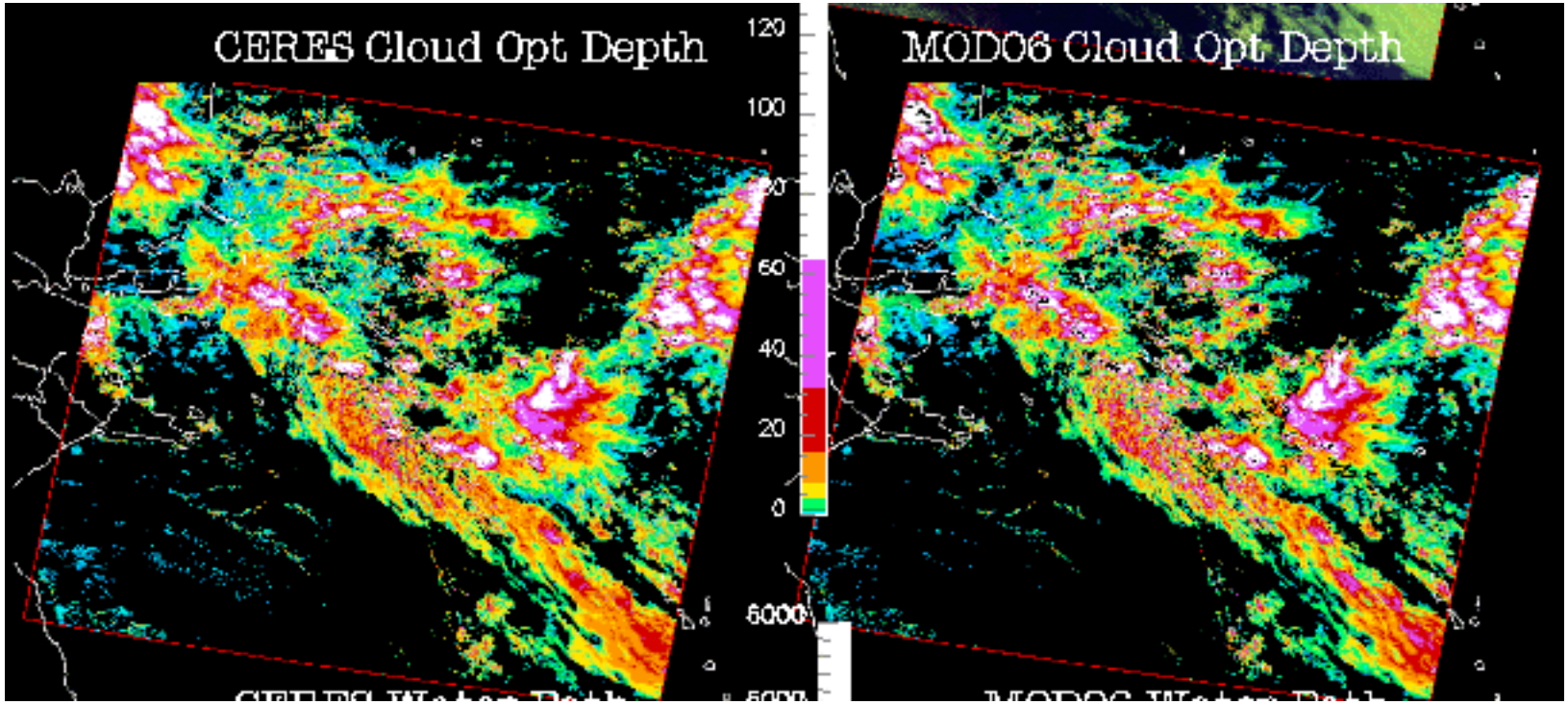
COMPARISON OF MODIS & CERES CLOUD MASK, JULY 8 OVER TWP

GREEN - CLEAR; **BLUE - WATER**; **WHITE - ICE**

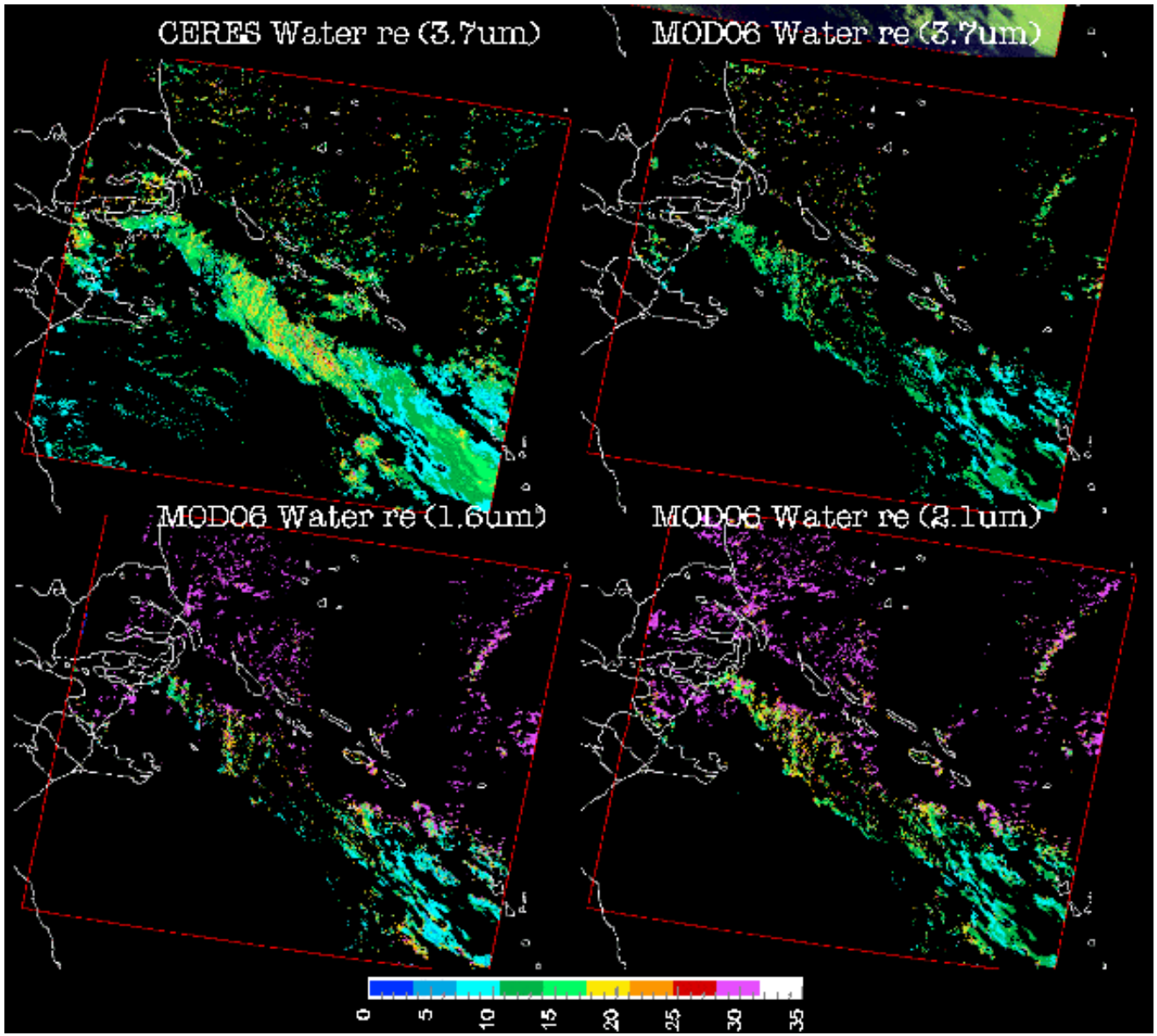
PINK - noret; **GOLD - no phase**

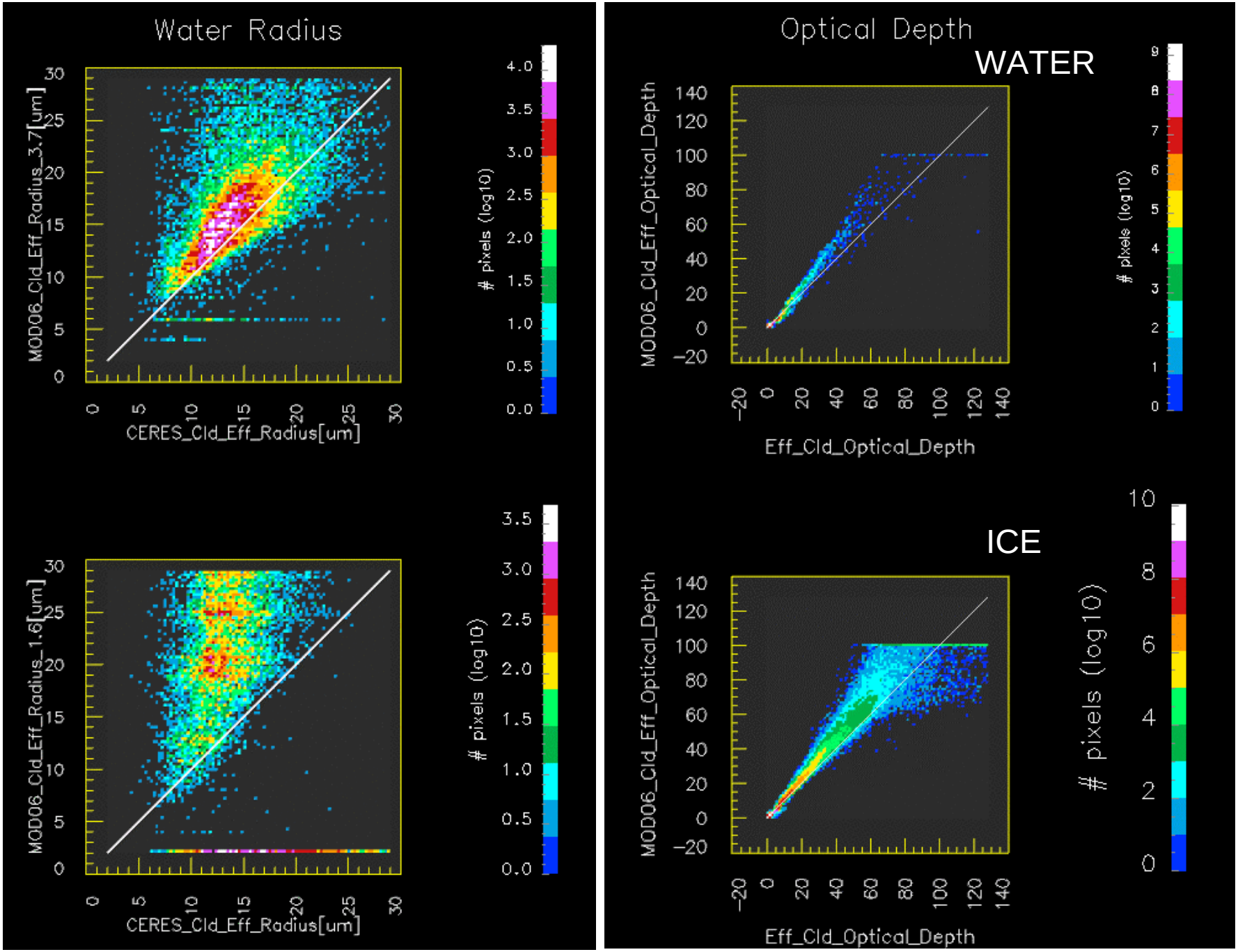


COMPARISON OF MODIS & CERES CLOUD OD, JULY 8 OVER TWP

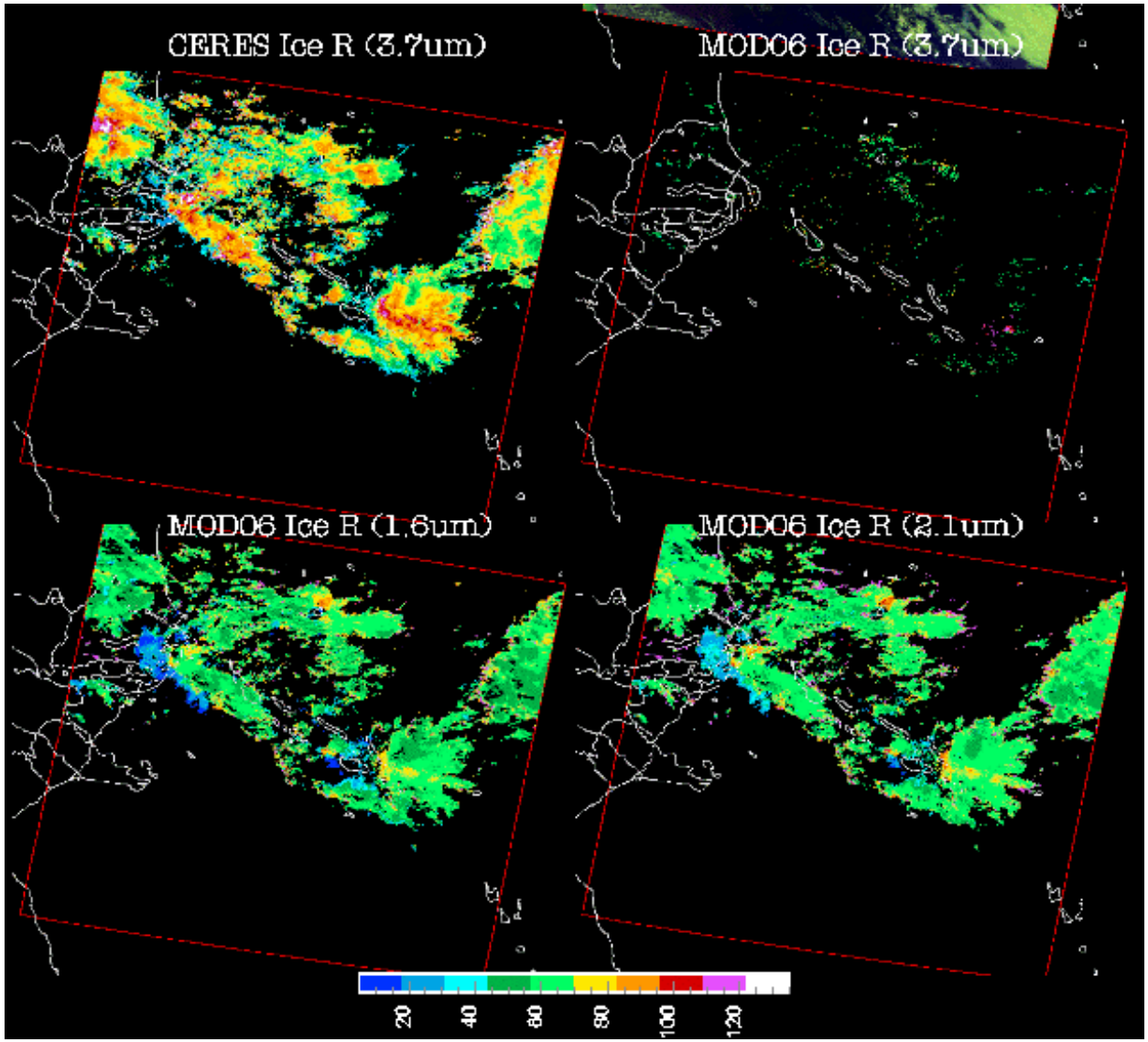


COMPARISON OF MODIS & CERES CLOUD re, JULY 8 OVER TWP

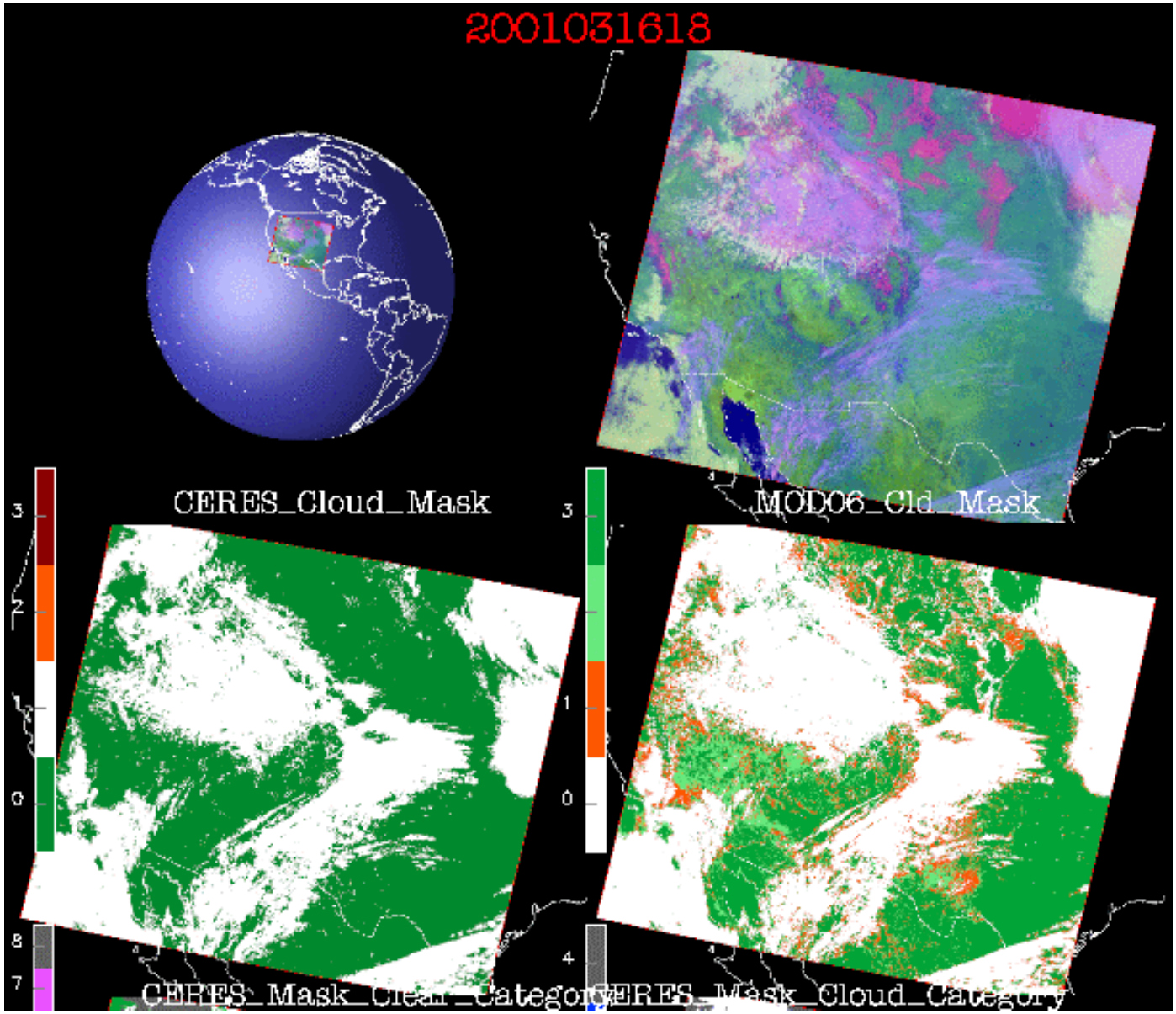



Water Radius
MOD06_Cld_Eff_Radius_3.7[um]
CERES_Cld_Eff_Radius[um]
pixels (log10)
Optical Depth
WATER
MOD06_Cld_Eff_Optical_Depth
Eff_Cld_Optical_Depth
pixels (log10)
MOD06_Cld_Eff_Radius_1.6[um]
CERES_Cld_Eff_Radius[um]
pixels (log10)
ICE
MOD06_Cld_Eff_Optical_Depth
Eff_Cld_Optical_Depth
pixels (log10)

COMPARISON OF MODIS & CERES CLOUD re, JULY 8 OVER TWP



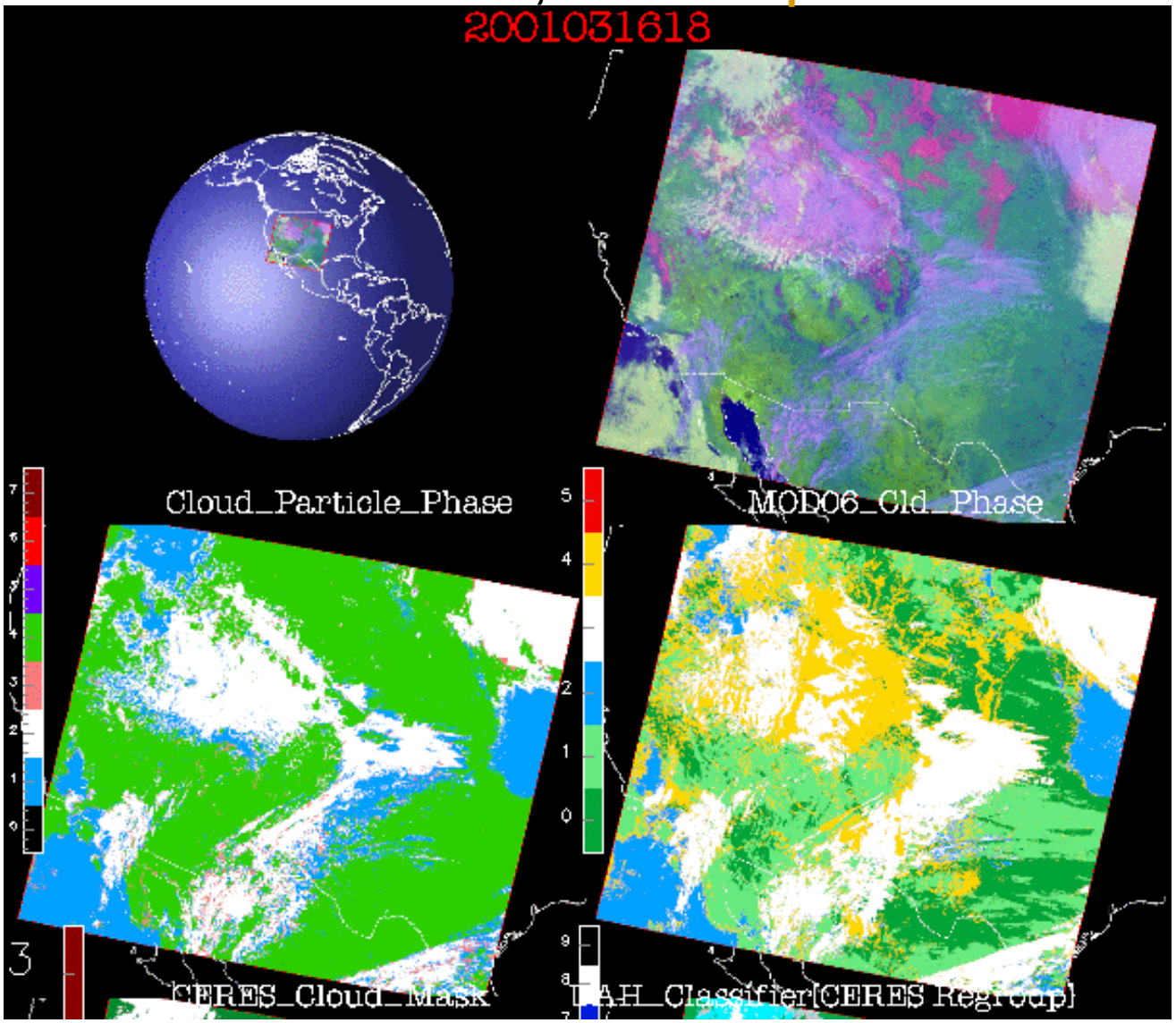
COMPARISON OF MODIS & CERES CLOUD MASK, MAR 16 OVER SGP



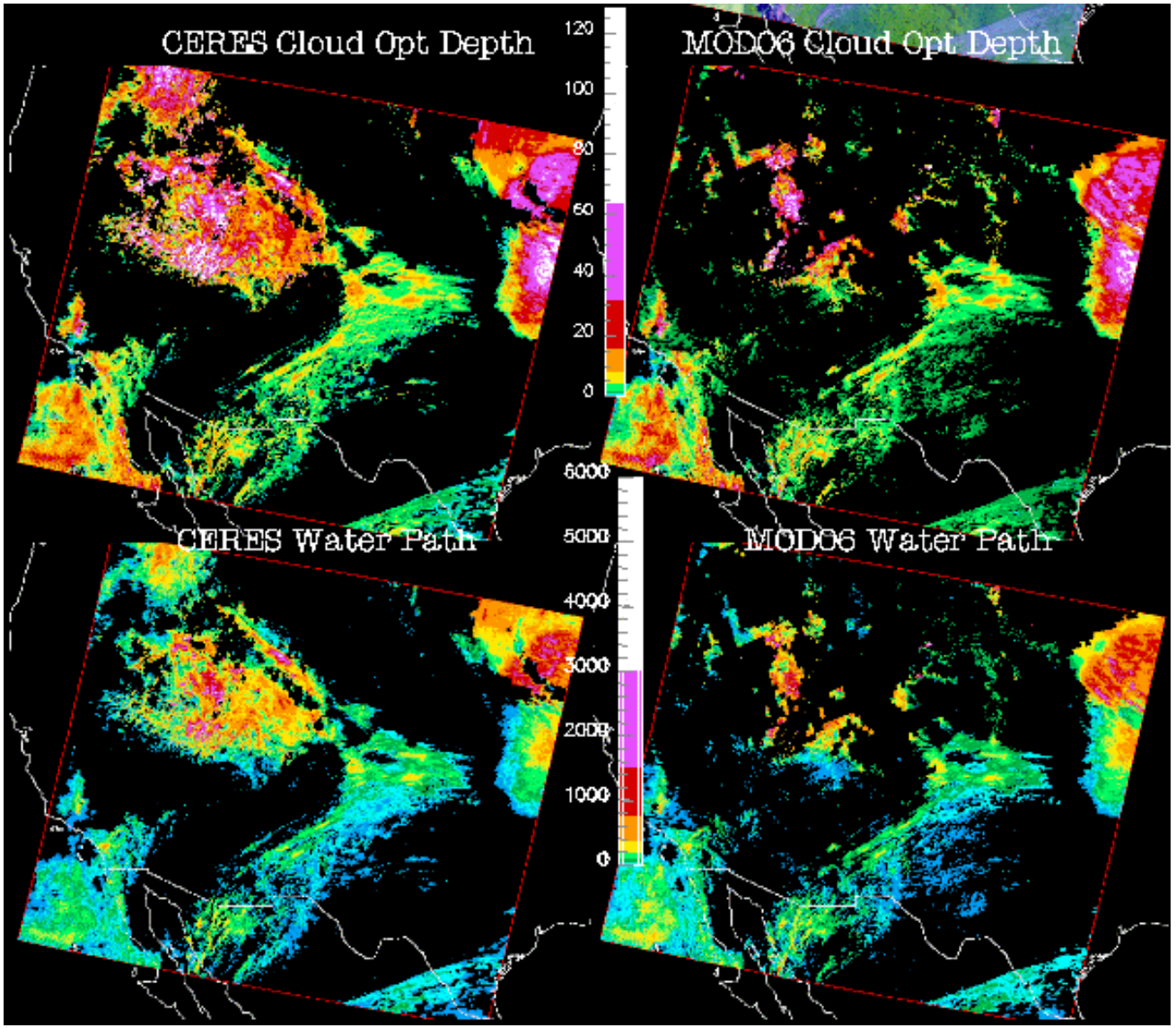
COMPARISON OF MODIS & CERES CLOUD PHASE, MAR 16 OVER SGP

GREEN - CLEAR; **BLUE - WATER**; **WHITE - ICE**

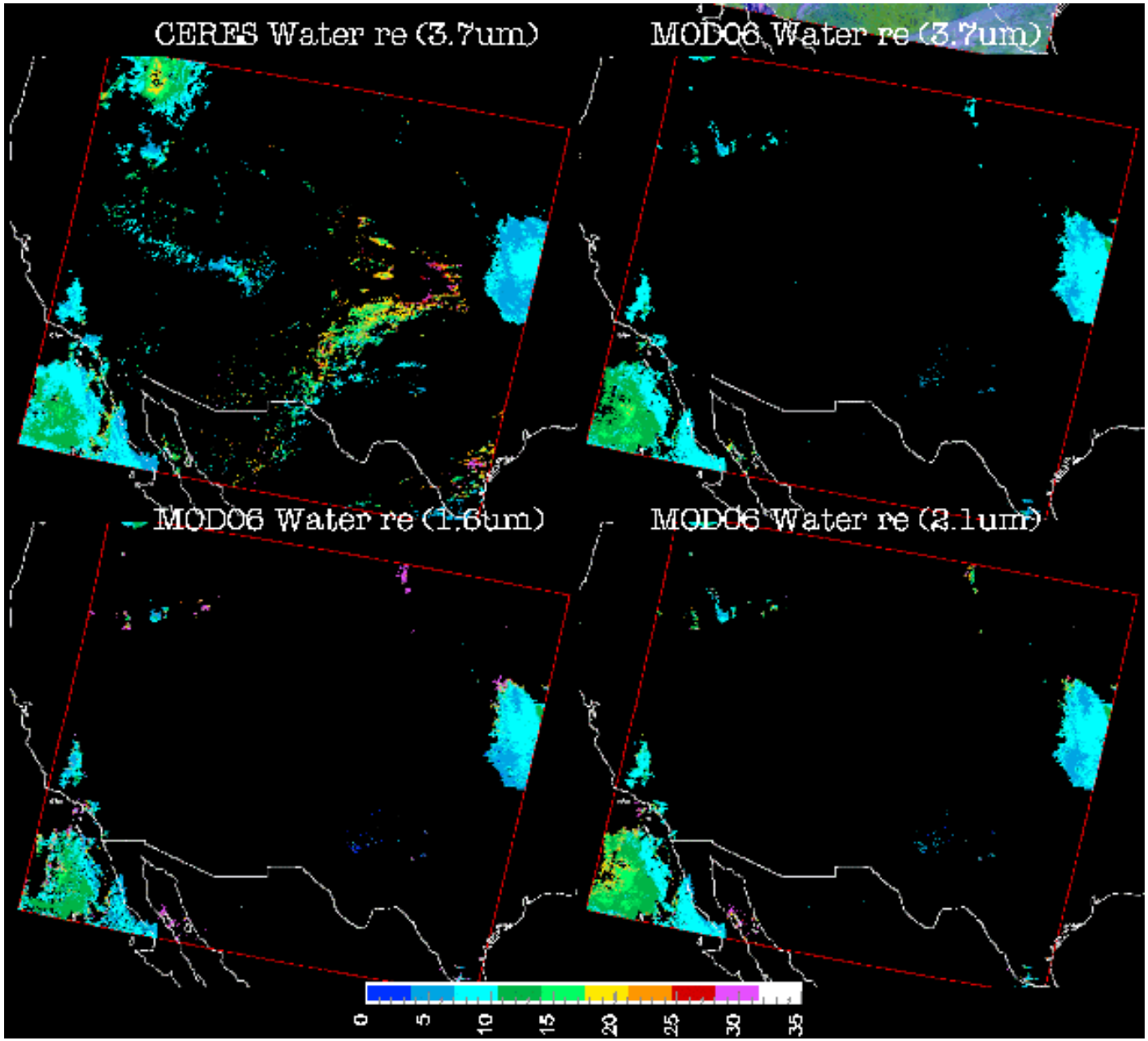
PINK - noret; **GOLD - no phase**

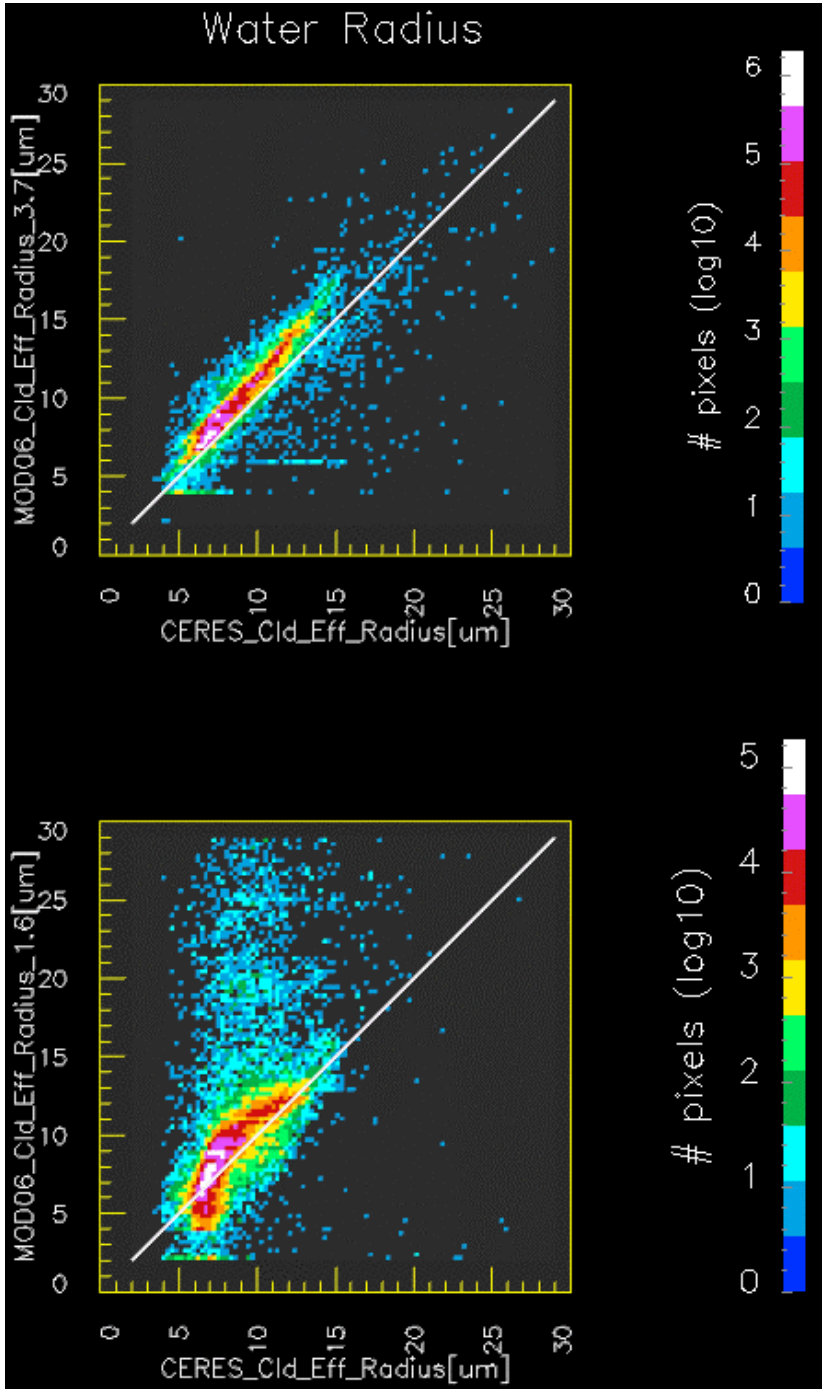


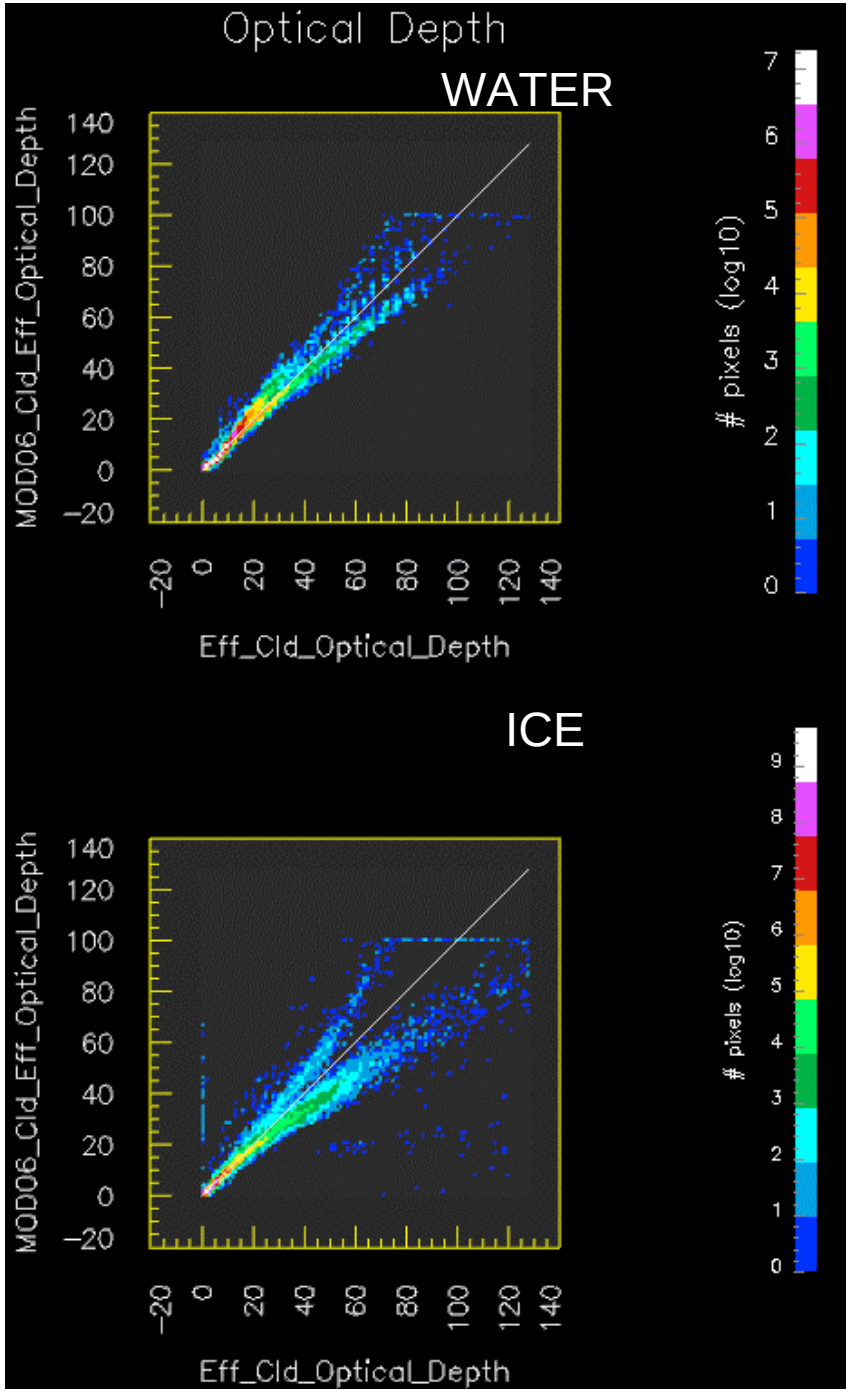
COMPARISON OF MODIS & CERES CLOUD OD, MAR 16 OVER SGP



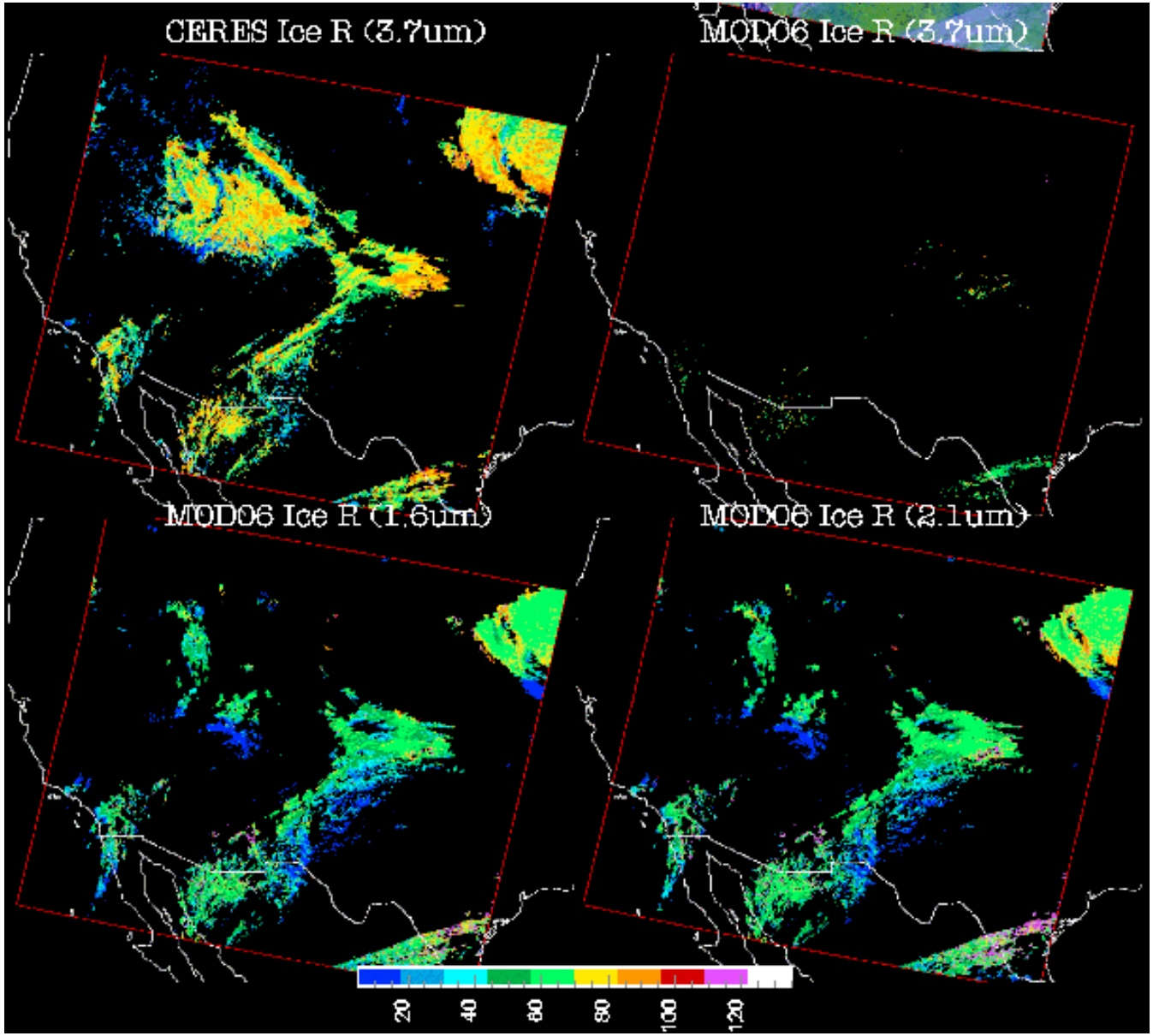
COMPARISON OF MODIS & CERES CLOUD re, MAR 16 OVER SGP



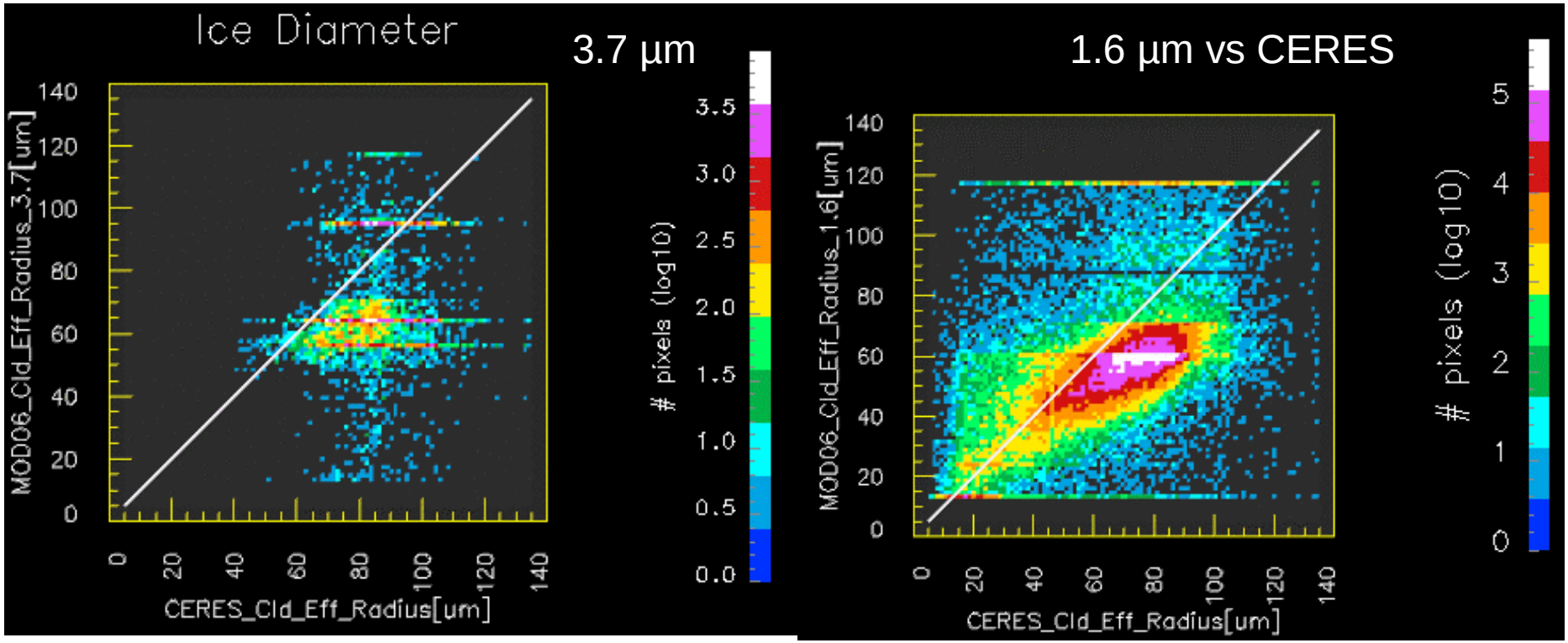

Water Radius
MOD06_Cld_Eff_Radius_3.7[um]
CERES_Cld_Eff_Radius[um]
pixels (log10)
MOD06_Cld_Eff_Radius_1.6[um]
CERES_Cld_Eff_Radius[um]
pixels (log10)


Optical Depth
WATER
MOD06_Cld_Eff_Optical_Depth
Eff_Cld_Optical_Depth
pixels (log10)
ICE
MOD06_Cld_Eff_Optical_Depth
Eff_Cld_Optical_Depth
pixels (log10)

COMPARISON OF MODIS & CERES CLOUD De, MAR 16 OVER SGP



COMPARISON OF MODIS & CERES CLOUD De, MAR 16 OVER SGP



SUMMARY OF DIFFERENCES BETWEEN CERES & MODIS MASK

GIVEN CERES CLASSIFICATION, IS MODIS THE SAME?

TWP

CLEAR: AGREE 34.8%	DISAGREE 6.6%
CLOUD: AGREE 56.8%	DISAGREE 2.4%
PHASE: AGREE: 35.0%	DISAGREE 8.1%
PHASE: MODIS NONE 13.6%	CERES NORET 0.7%

NSA

CLEAR: AGREE 19.2%	DISAGREE 0.9%
CLOUD: AGREE 64.1%	DISAGREE 13.0%
PHASE: AGREE 22.9%	DISAGREE 15.9%
PHASE: MODIS NONE 26.4%	CERES NORET 2.9%

SGP

CLEAR: AGREE 26.4%	DISAGREE 10.1%
CLOUD: AGREE 60.3%	DISAGREE 1.2%
PHASE: AGREE 42.3%	DISAGREE 11.0%
PHASE: MODIS NONE 7.4%	CERES NORET 1.4%

MEAN DIFFERENCES BETWEEN CERES & MODIS CLOUD PROPERTIES OVER NSA JULY 2001

BOTH CERES & MODIS MUST AGREE IN PHASE (SUBSET of 20 M-pixels)

(CERES- MODIS)

Particle size

3.7 Ret: re_Diff_Mean = **-0.67 ± 1.33 µm** *(with empirical cal correction)*
De_Diff_Mean = **5.88 ± 26.0 µm**

1.6 Ret: re_Diff_Mean = **-4.77 ± 6.29 µm**
De_Diff_Mean = **3.23 ± 20.1 µm**

2.1 Ret: re_Diff_Mean = **-2.98 ± 4.15 µm**
De_Diff_Mean = **-0.46 ± 18.6 µm**

Optical depth

re_OD_Diff_Mean = **0.53 ± 5.29**
De_OD_Diff_Mean = **2.83 ± 15.14**

MEAN DIFFERENCES BETWEEN CERES & MODIS CLOUD PROPERTIES OVER TWP JULY 2001

BOTH CERES & MODIS MUST AGREE IN PHASE (SUBSET of 12 M-pixels)

(CERES- MODIS)

Particle size

3.7 Ret: re_Diff_Mean = **-1.94 ± 3.39 µm** *(with empirical cal correction)*
De_Diff_Mean = **-2.78 ± 20.7 µm**

1.6 Ret: re_Diff_Mean = **-9.81 ± 7.05 µm**
De_Diff_Mean = **9.83 ± 18.71 µm**

2.1 Ret: re_Diff_Mean = **-9.20 ± 6.07 µm**
De_Diff_Mean = **5.42 ± 21.9 µm**

Optical depth

re_OD_Diff_Mean = **0.07 ± 2.06**
De_OD_Diff_Mean = **-0.87 ± 8.88**

MEAN DIFFERENCES BETWEEN CERES & MODIS CLOUD PROPERTIES
OVER SGP MARCH 2001

BOTH CERES & MODIS MUST AGREE IN PHASE (SUBSET of 5 M-pixels)

(CERES- MODIS)

Particle size

3.7 Ret: re_Diff_Mean = **-0.50 ± 1.10 µm** *(with empirical cal correction)*
De_Diff_Mean = **6.47 ± 19.6 µm**

1.6 Ret: re_Diff_Mean = **-2.49 ± 4.67 µm**
De_Diff_Mean = **10.5 ± 17.2 µm**

2.1 Ret: re_Diff_Mean = **-1.57 ± 2.60 µm**
De_Diff_Mean = **6.80 ± 15.1 µm**

Optical depth

re_OD_Diff_Mean = **0.37 ± 5.44**
De_OD_Diff_Mean = **4.07 ± 11.7**

CLOUD CODE IMPROVEMENTS FOR FINAL EDITION

- **Calibration resolution**
- **1.6-µm cloud retrieval test & validated, not implemented, reduce polar OD**

  VINT: Visible Infrared Near-infrared Technique for polar region
- **Improvement in twilight polar cloud mask**
- **Implementation of polar night mask**
- **Implement MODIS channel emittance models (improve cloud height at night)**
- **Update clear-sky reflectance maps for extratropical areas**

  beta2 used estimates from VIRS (IGBP averages)

FINAL NOTE RELATIVE TO *GERB*

- ***CERES*-LIKE ALGORITHMS BEING APPLIED TO *GOES-8* DATA**
  - **AVAILABLE AT http://www-pm.larc.nasa.gov/**
  - **NEAR REAL TIME OVER ARM SGP SITE**
    - **32°N - 42°N, 90°W - 114°W**
    - **VALIDATION PAPER ACCEPTED (*Dong et al.*)**
  - **CASE STUDIES OVER FLORIDA FOR CRYSTAL**
  - **3-HOURLY OVER SE PACIFIC (OCTOBER 1999-?)**

- **PLAN TO APPLY SAME ALGORTITHMS TO *MSG SEVIRI***
  - **IF NASA $$**