CERES CLOUD ALGORITHM CHANGES

NASA : P. Minnis, D. F. Young

SAIC: S. Sun-Mack, Q. Trepte, Y. Chen, R. F. Arduini, T. D. Murray

AS&M: P. W. Heck

UAH: Q. Han

NOAA: L. Stowe

OSU: J. A. Coakley, M. Friedman

RMI: N. Clerbaux, S. DeWitte

CERES STM, Huntsville, AL, September 20, 2000

ACTION ITEMS FROM SPRING 2000 CERES STM

- **Change 1.6-μm calibration throughout the Clouds' code: DONE**

- **Minimize sub-pixel cloud contamination with spatial variability test for AOD retrievals: DONE**

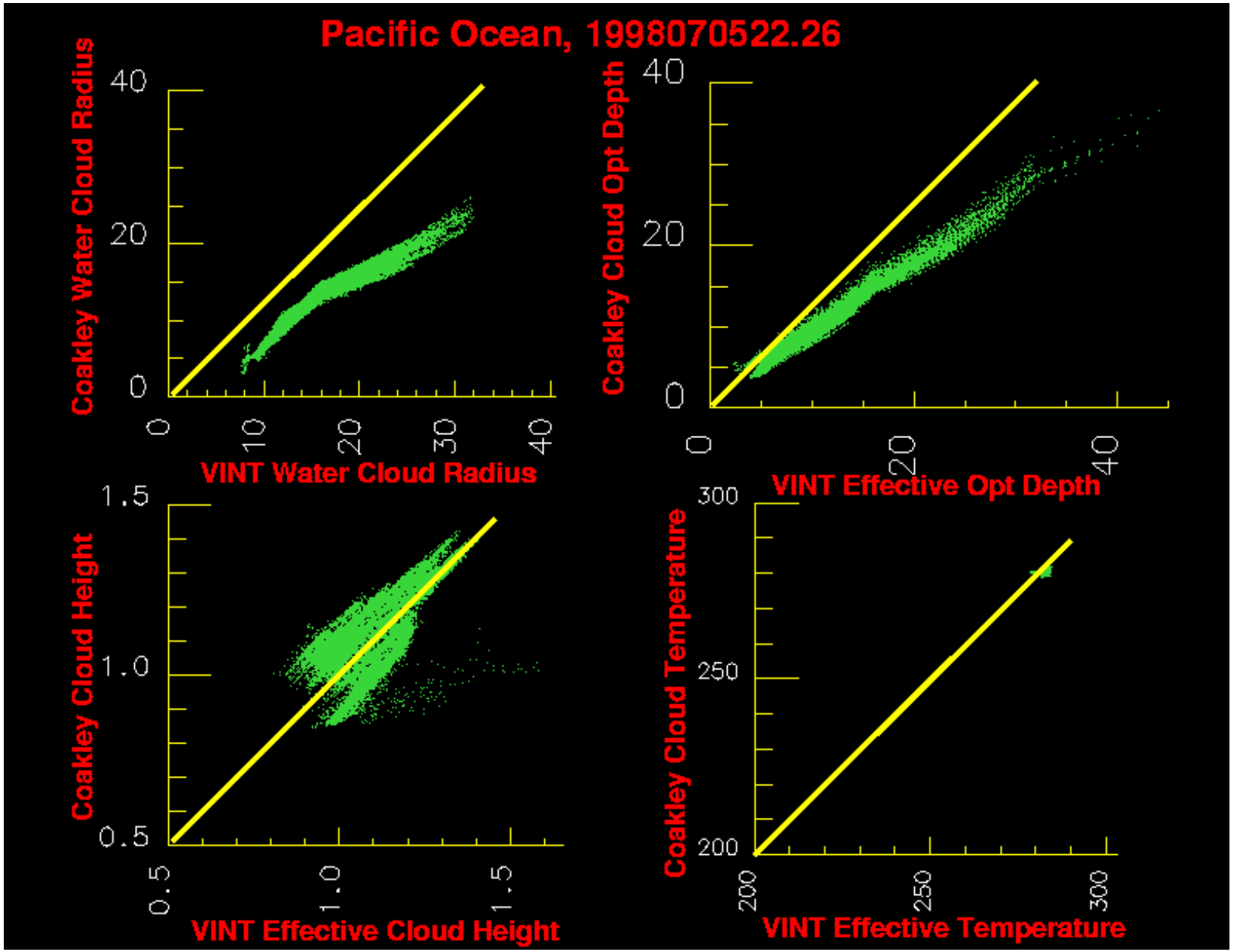
- **Use 10' land/water mask to allow more AOD retrievals: DONE**

- **Add 3 new parameters to SSF: DONE**

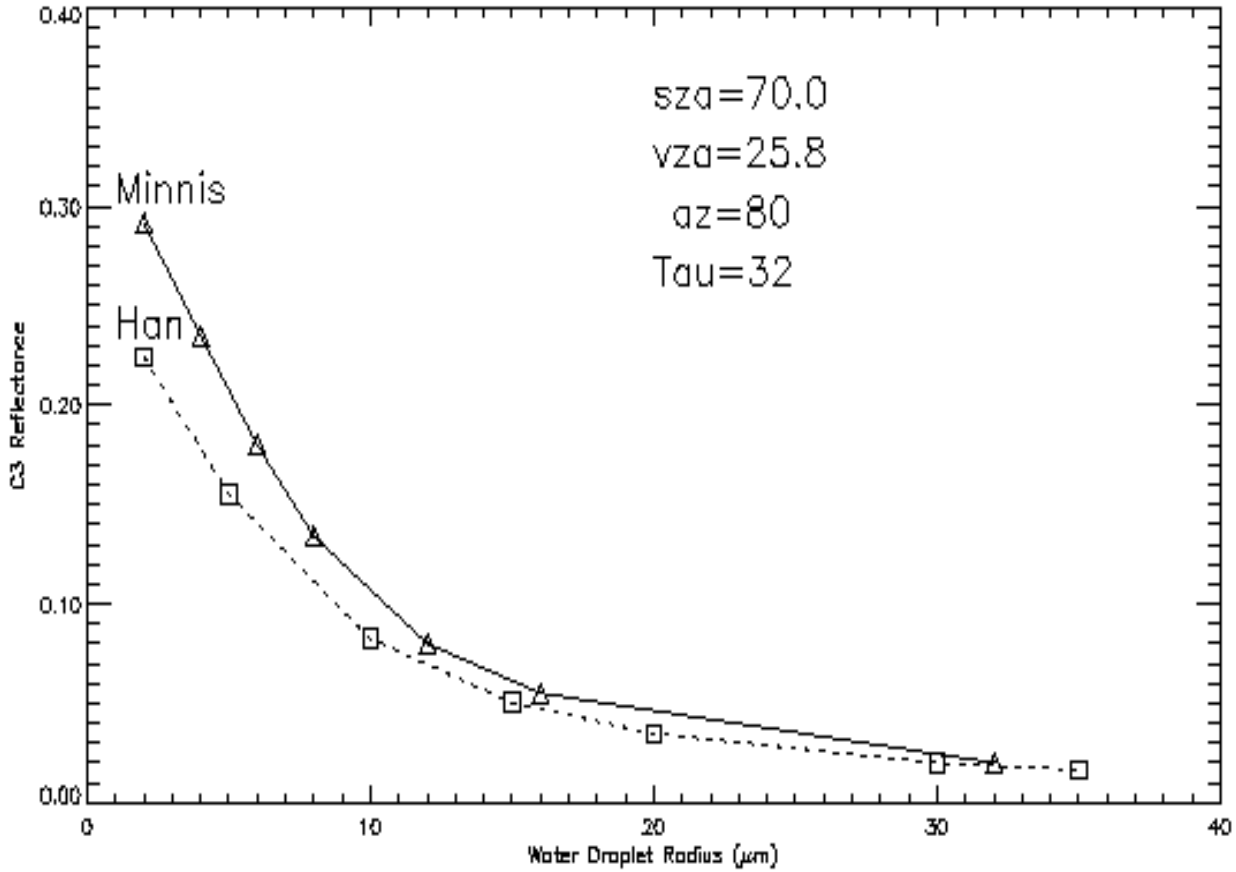
  frac of pixels, mean 0.6 and 1.6-μm reflectances used for AOD retrieval

- **Compare 3.7-μm reflectance models from Minnis, Han, & Coakley to help explain re differences: DONE**

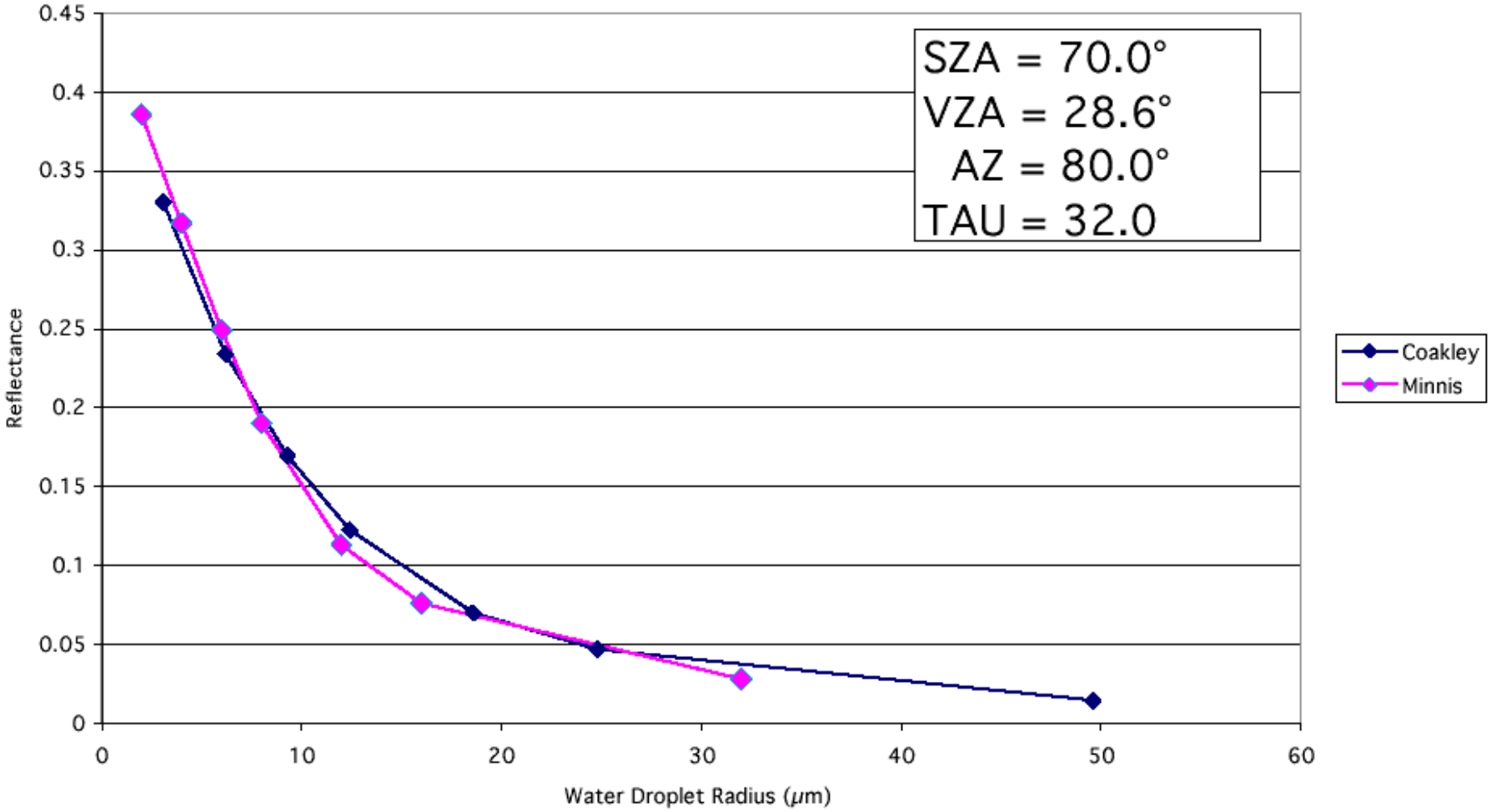
ORIGINAL COMPARISON OF CERES & COAKLEY RETRIEVALS OVER STCU

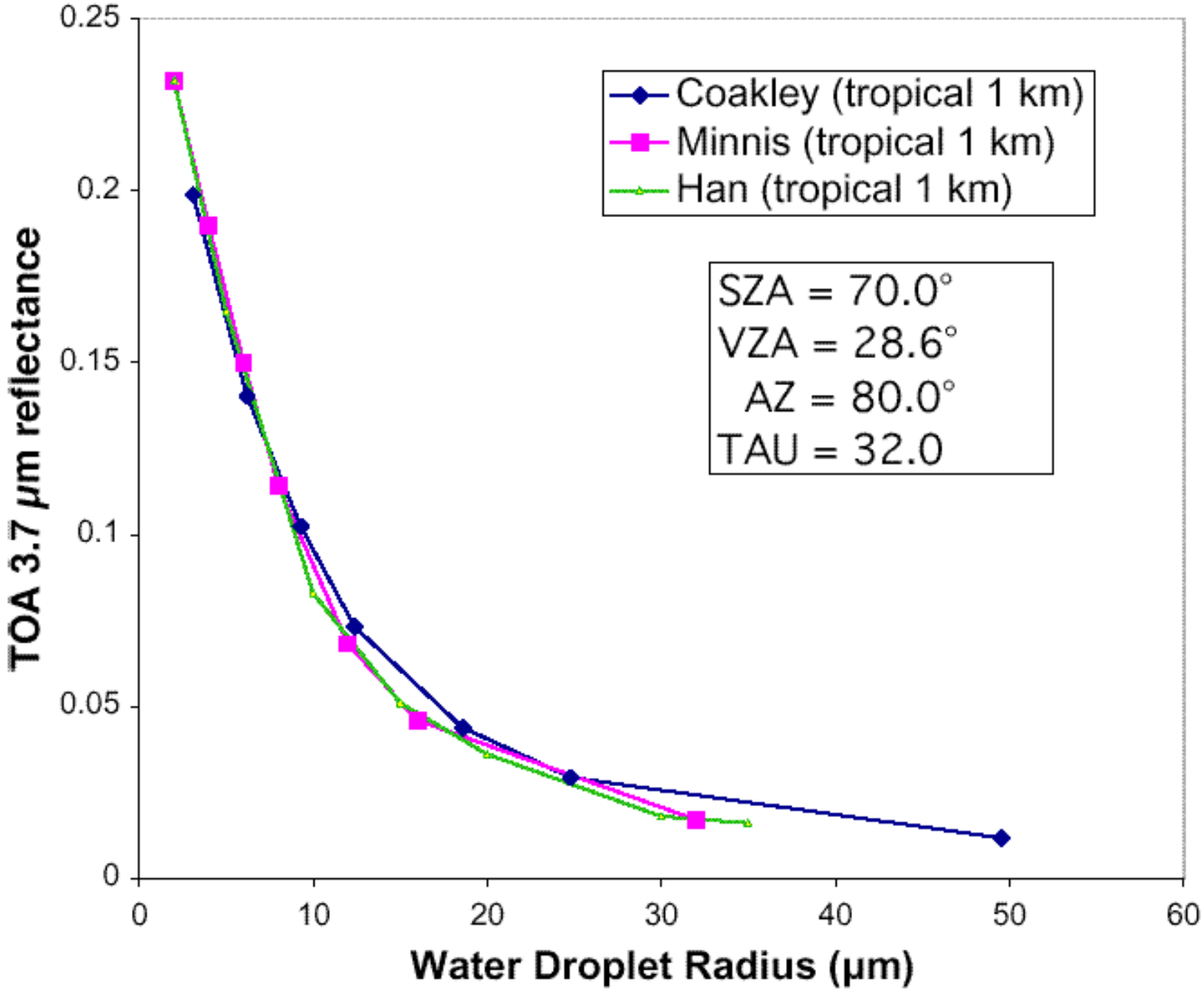


INITIAL COMPARISON OF re vs tau FROM CERES & ISCCP

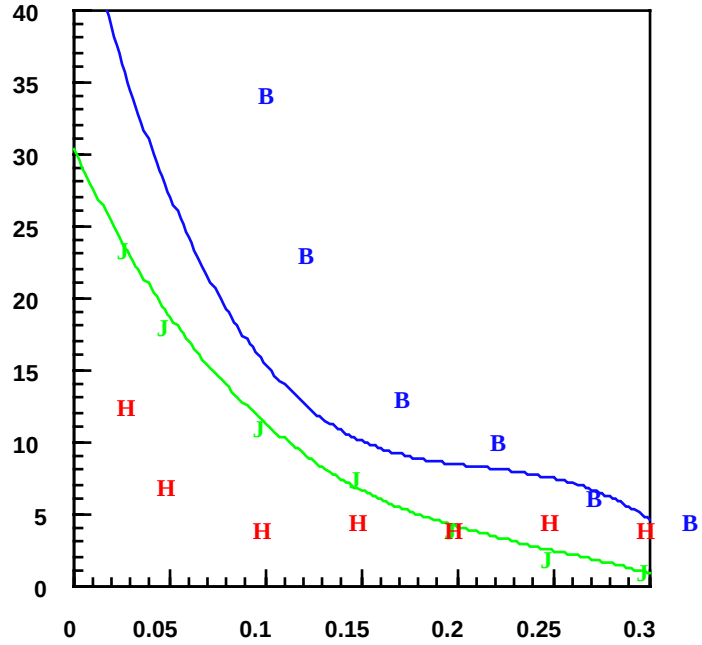


Water Cloud Reflectance Comparison
No Atmosphere




0.25
0.2
0.15
0.1
0.05
0
TOA 3.7 μm reflectance
0
10
20
30
40
50
60
Water Droplet Radius (μm)
Coakley (tropical 1 km)
Minnis (tropical 1 km)
Han (tropical 1 km)
SZA = 70.0°
VZA = 28.6°
AZ = 80.0°
TAU = 32.0

COMPARISON OF COAKLEY PARTICLE SIZES AS FUNCTION OF TOA 3.7-μm REFLECTANCE



B no atmo

J tropical 1 km

H diff

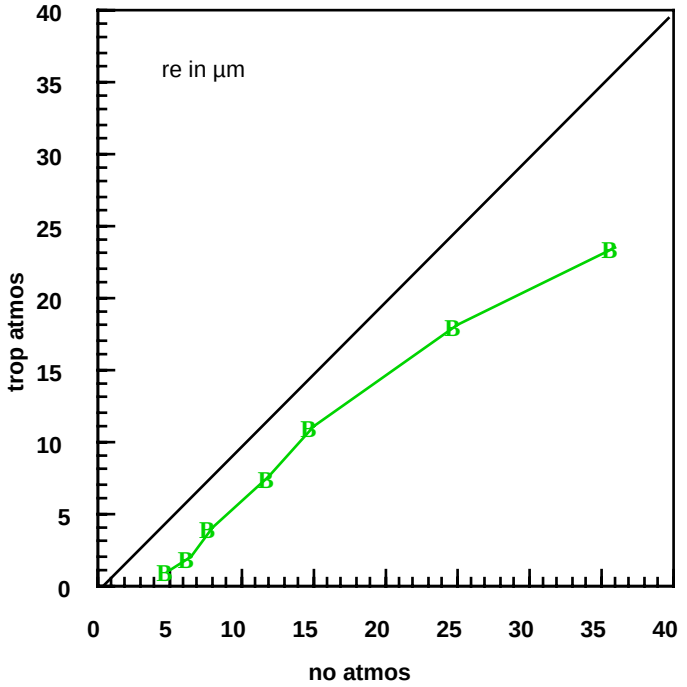
sza = 70

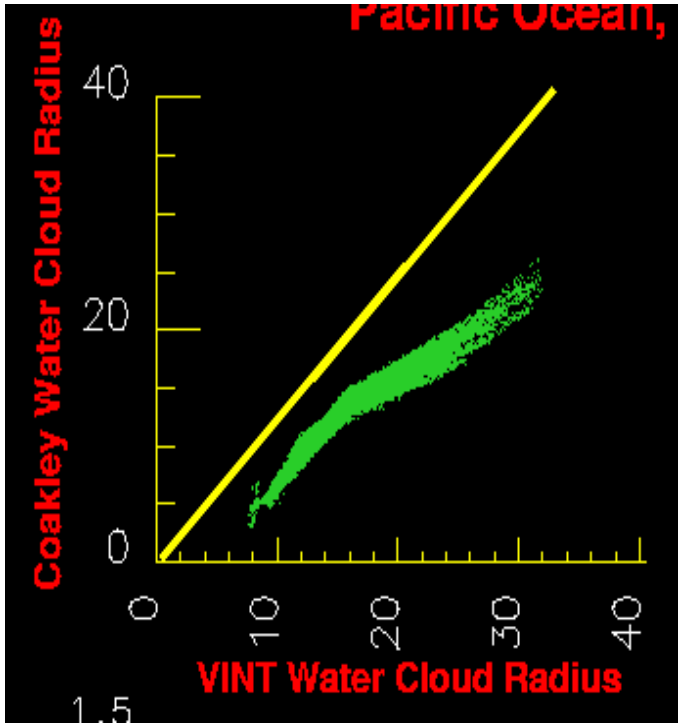
VZA = 28.6

RZ = 80

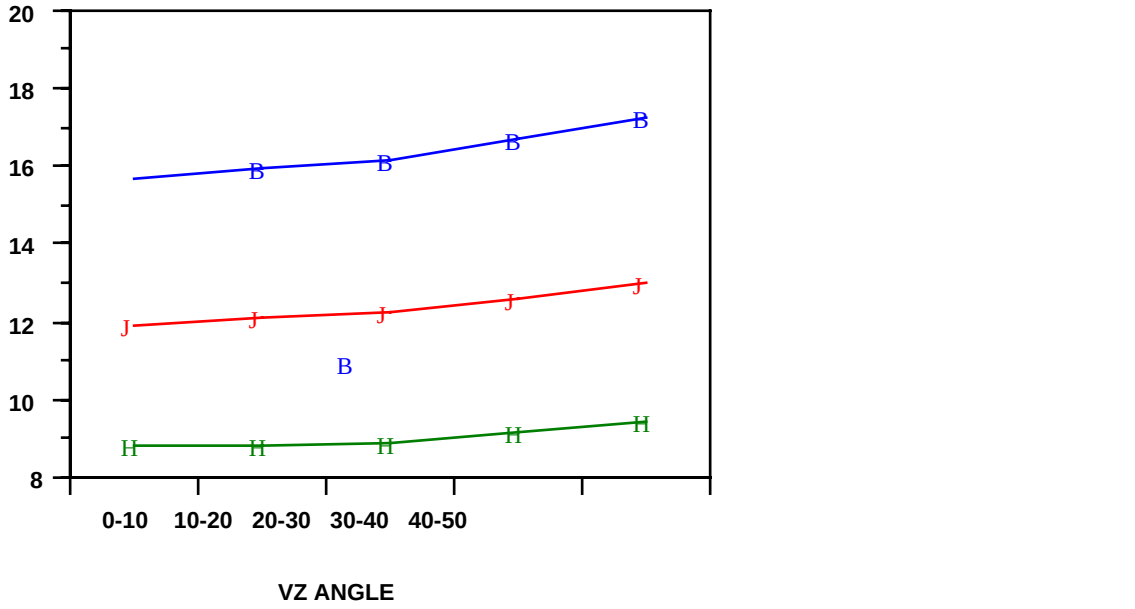
tau = 32

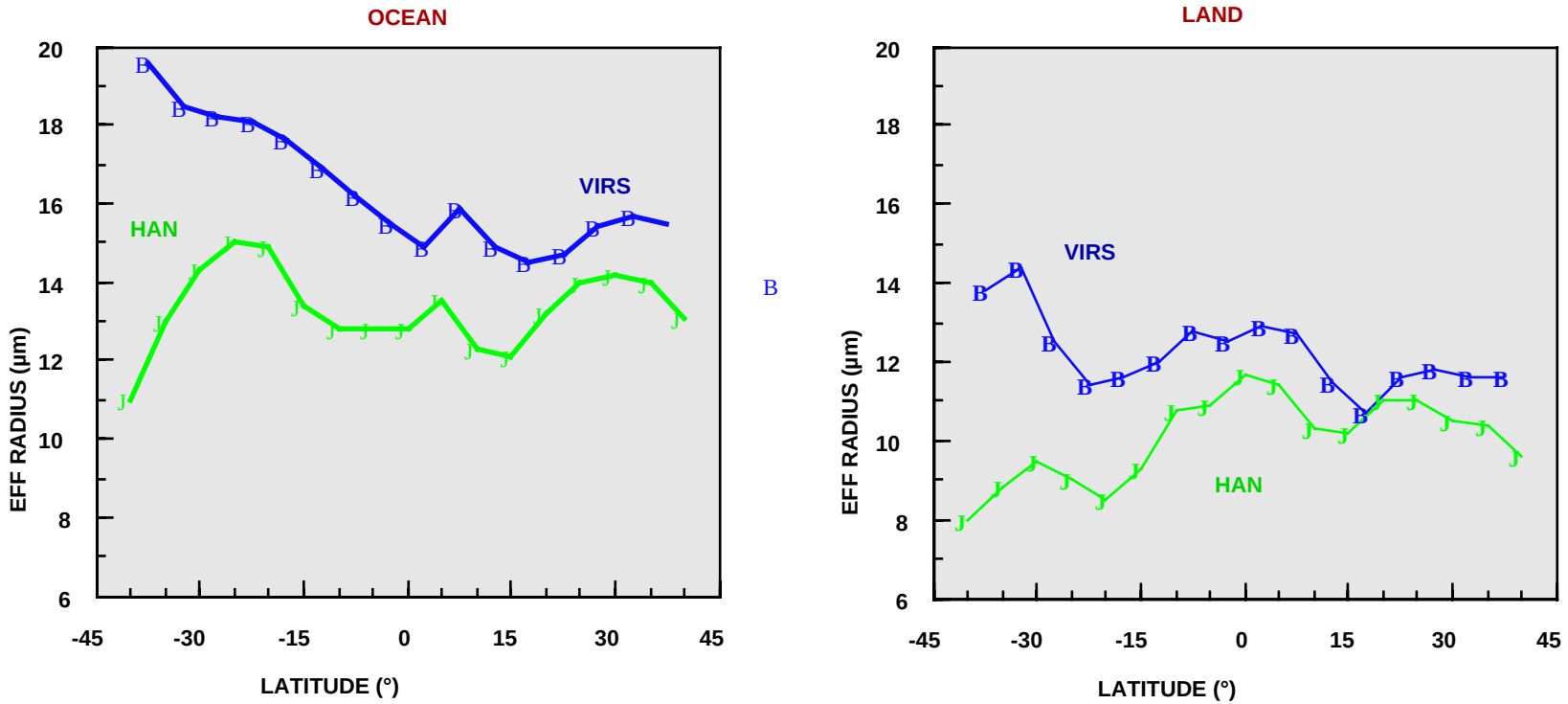
B





VARIATION OF re WITH VIEWING ZENITH ANGLE

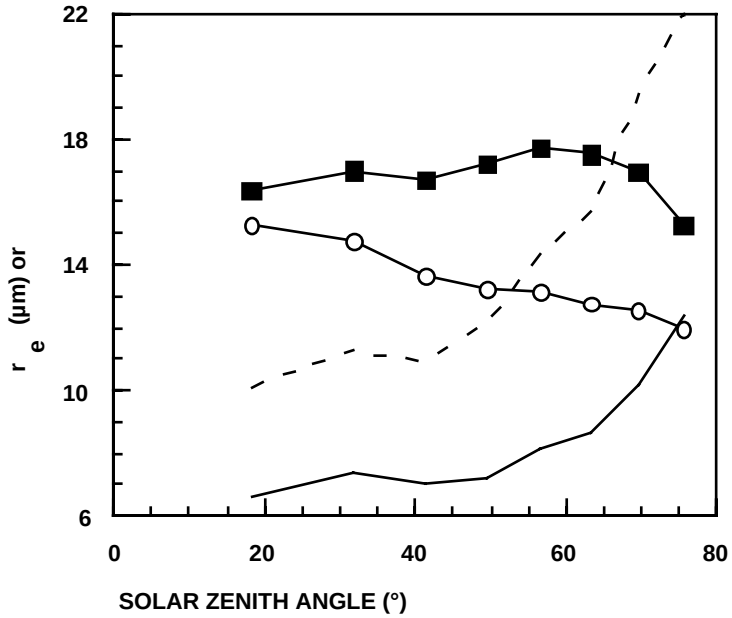




VIRS, 1998, TRMM

HAN et al. 1994, *J. Climate* , 1987 NOAA-9 AVHRR, T > 273K, tau > 3

VARIATION OF re WITH SOLAR ZENITH ANGLE



SOURCES OF DIFFERENCES

- **MODEL INTERCOMPARISONS**
  - DIFFERENT ATMOSPHERIC ABSORPTION METHODS & PROFILES
  - DIFFERENT TREATMENT OF CLOUD EMISSIVITY

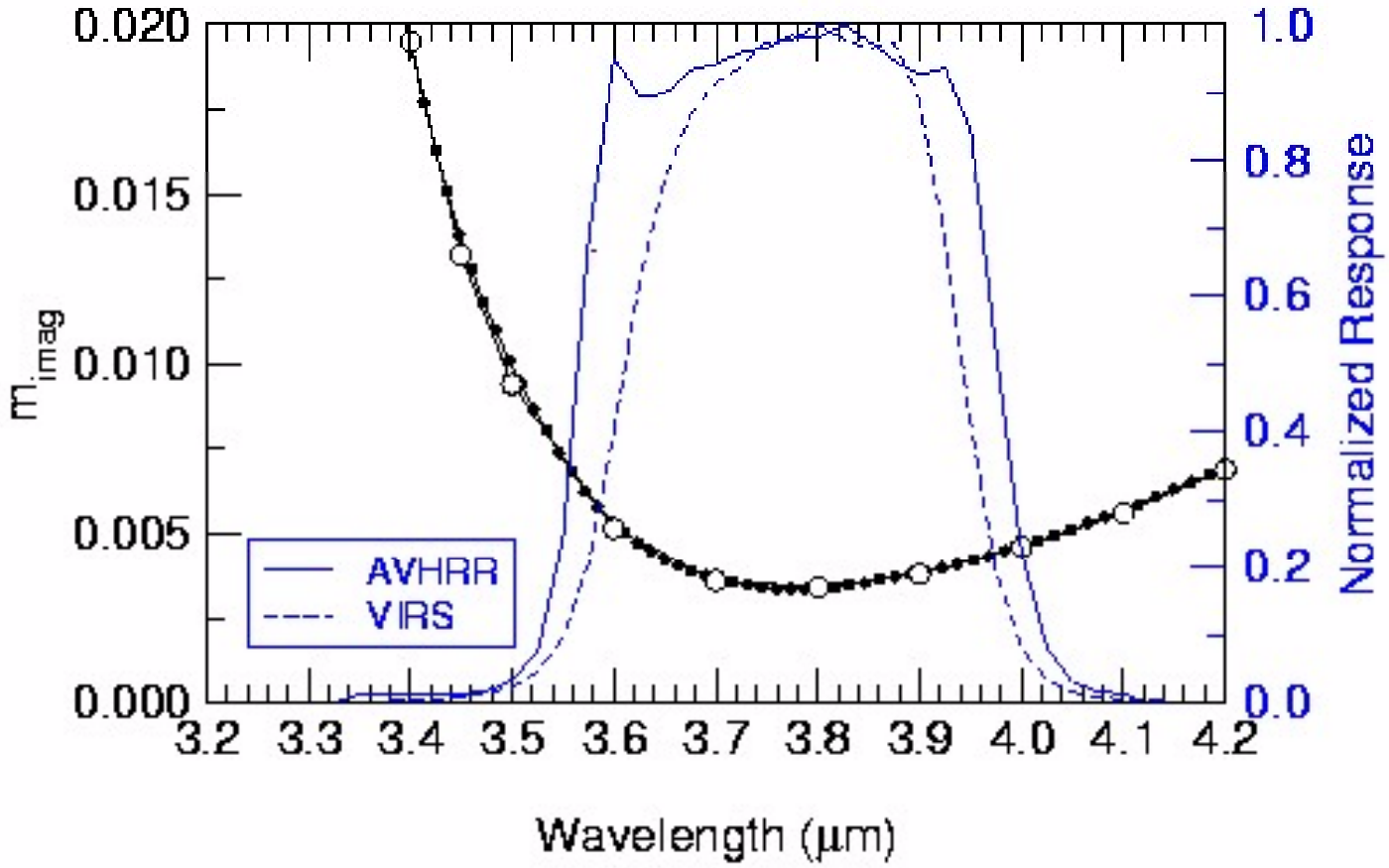
- **ZONAL DEPENDENCE**
  - CIRRUS CONTAMINATION
  - LOW TAUS INCLUDED
  - ANGLE DEPENDENCE

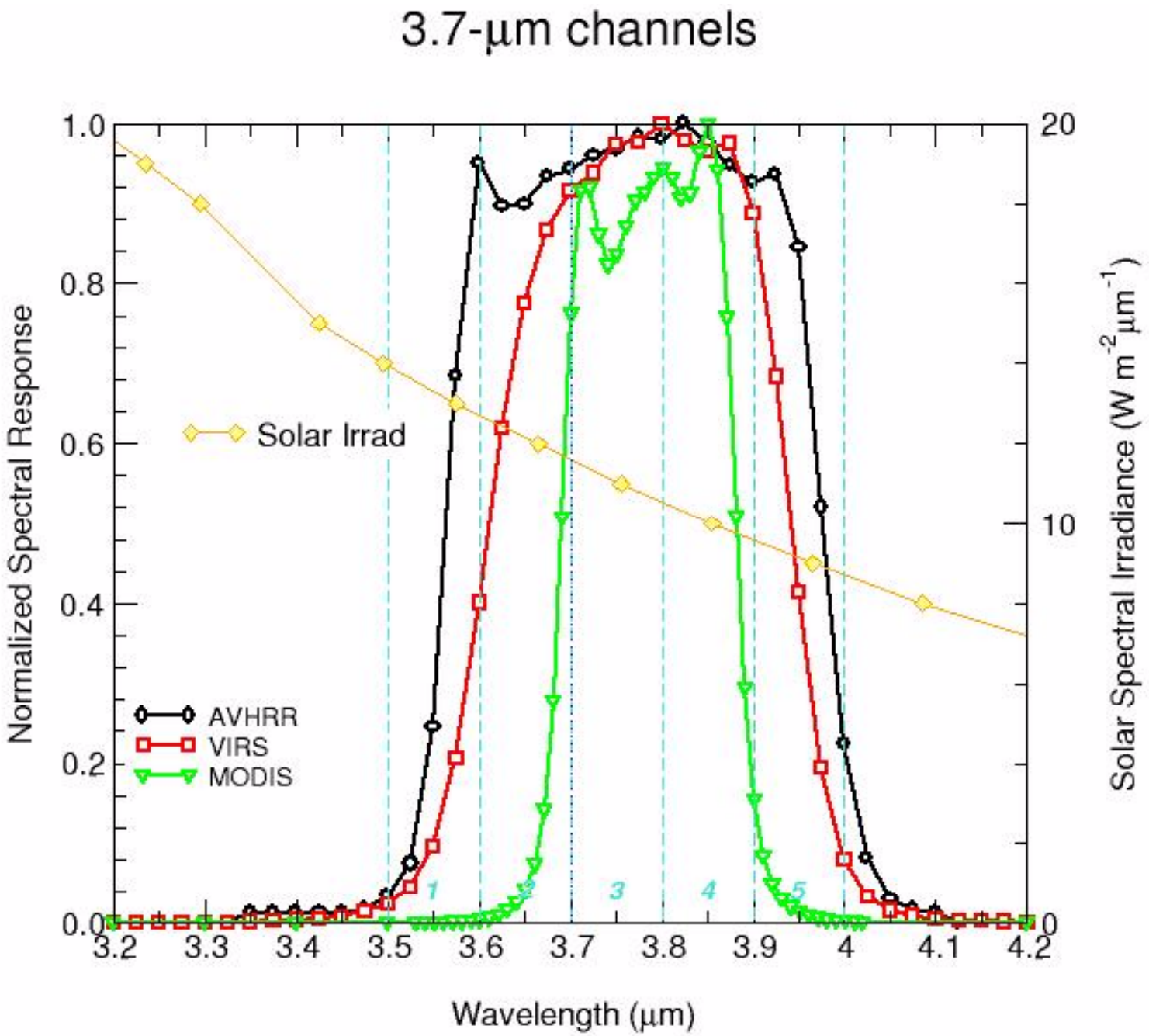
    ISCCP: NADIR ONLY, ZONAL SZA DEPENDENCE
  - DIFFERENT ATMOSPHERIC PROFILES

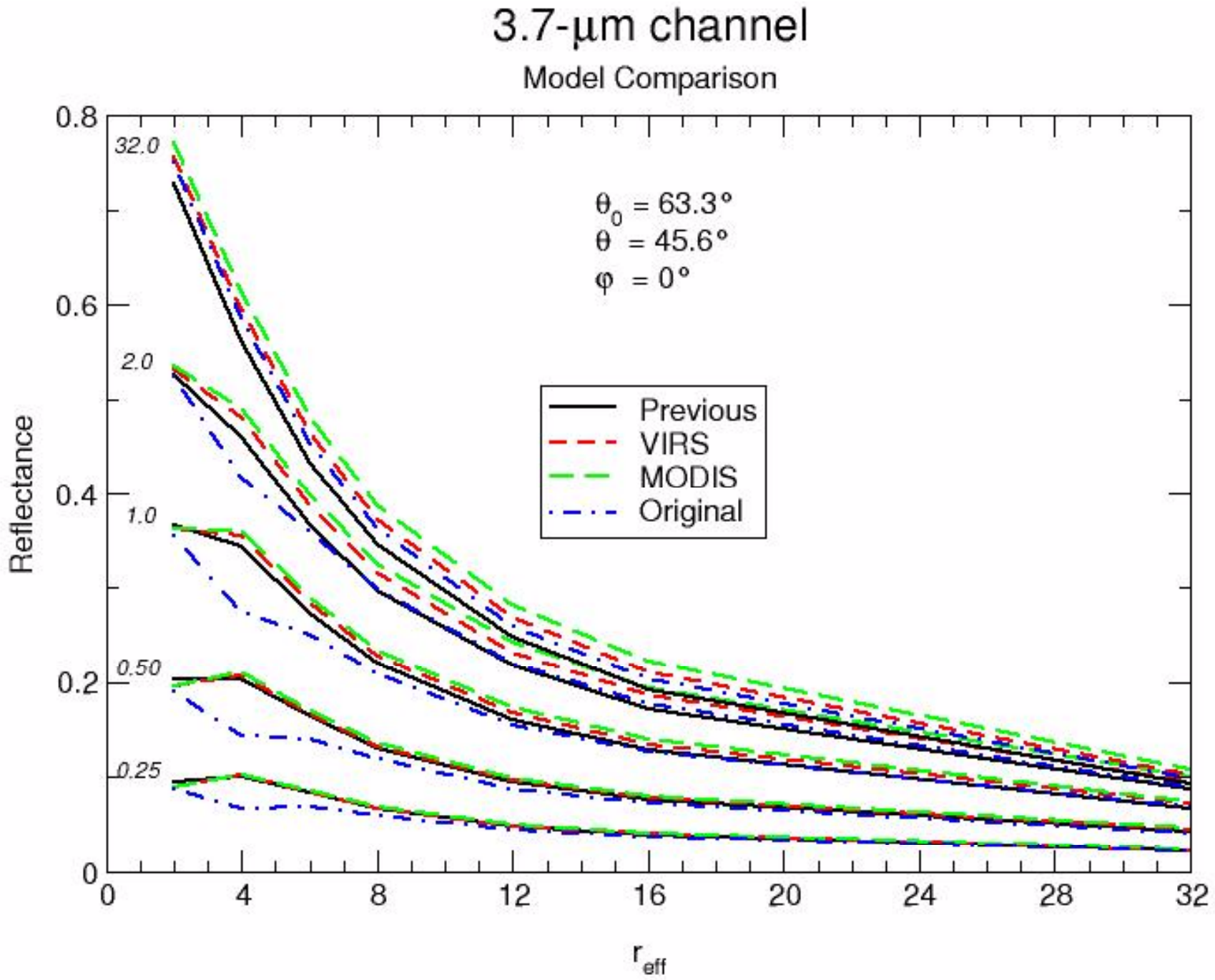
ADDITIONAL CHANGES TO CLOUD CODE

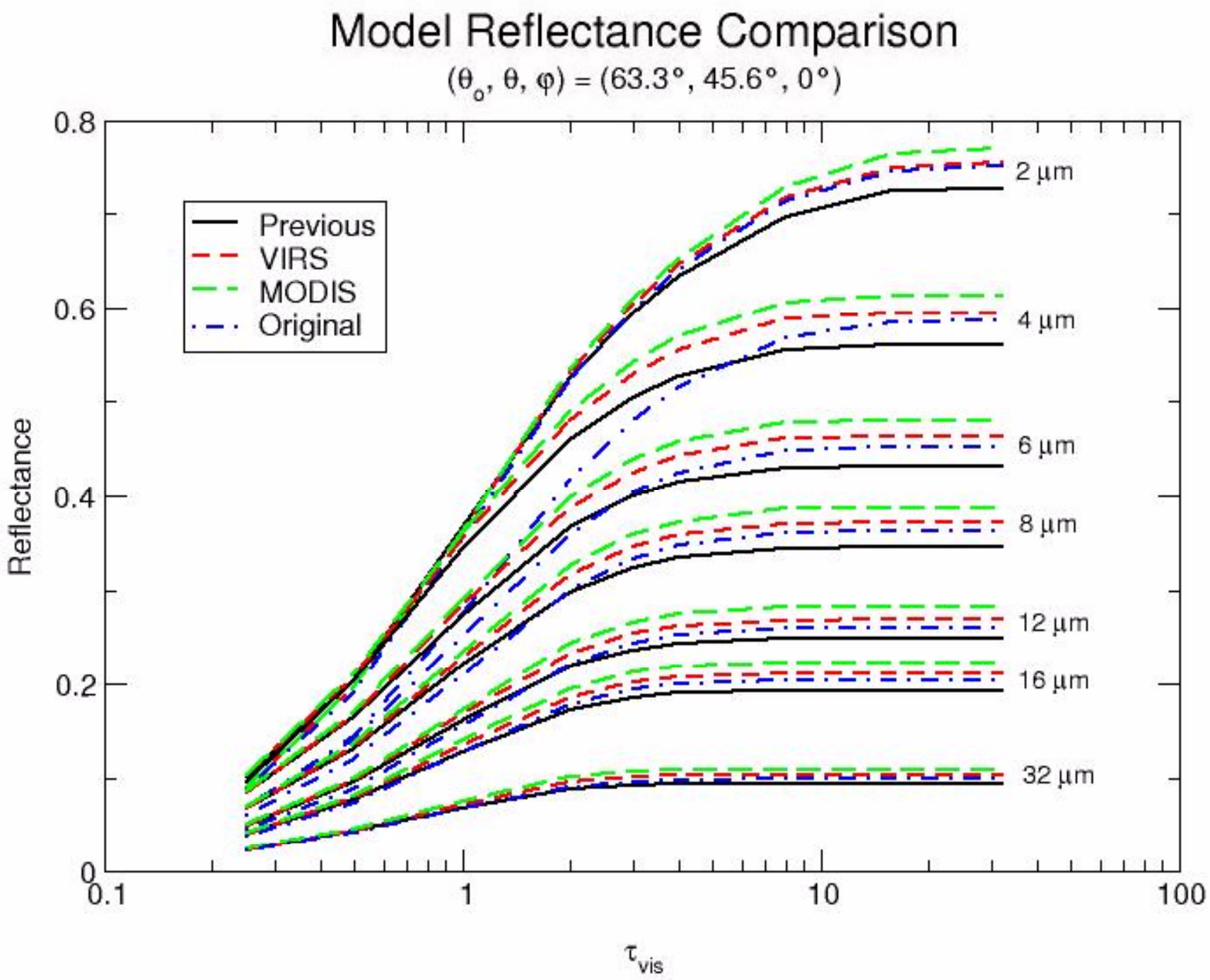
- **Interpolation between *re* models uses *Akima Spline***
- **Atmospheric absorption now includes layer containing cloud**
- **Different weighting of SI bands to compute mean 3.7 reflectance**
- **VIS atmospheric absorption reformulated for specific bandwidths including ozone & H2O**
- **Optical depth interpolation error fixed**

IMAGINARY INDEX OF REFRACTION FOR SOLAR-INFRARED BAND




3.7-µm channels
Normalized Spectral Response
Solar Spectral Irradiance (W m-2µm-1)
Wavelength (µm)
Solar Irrad
AVHRR
VIRS
MODIS
1
2
3
4
5
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
4.1
4.2

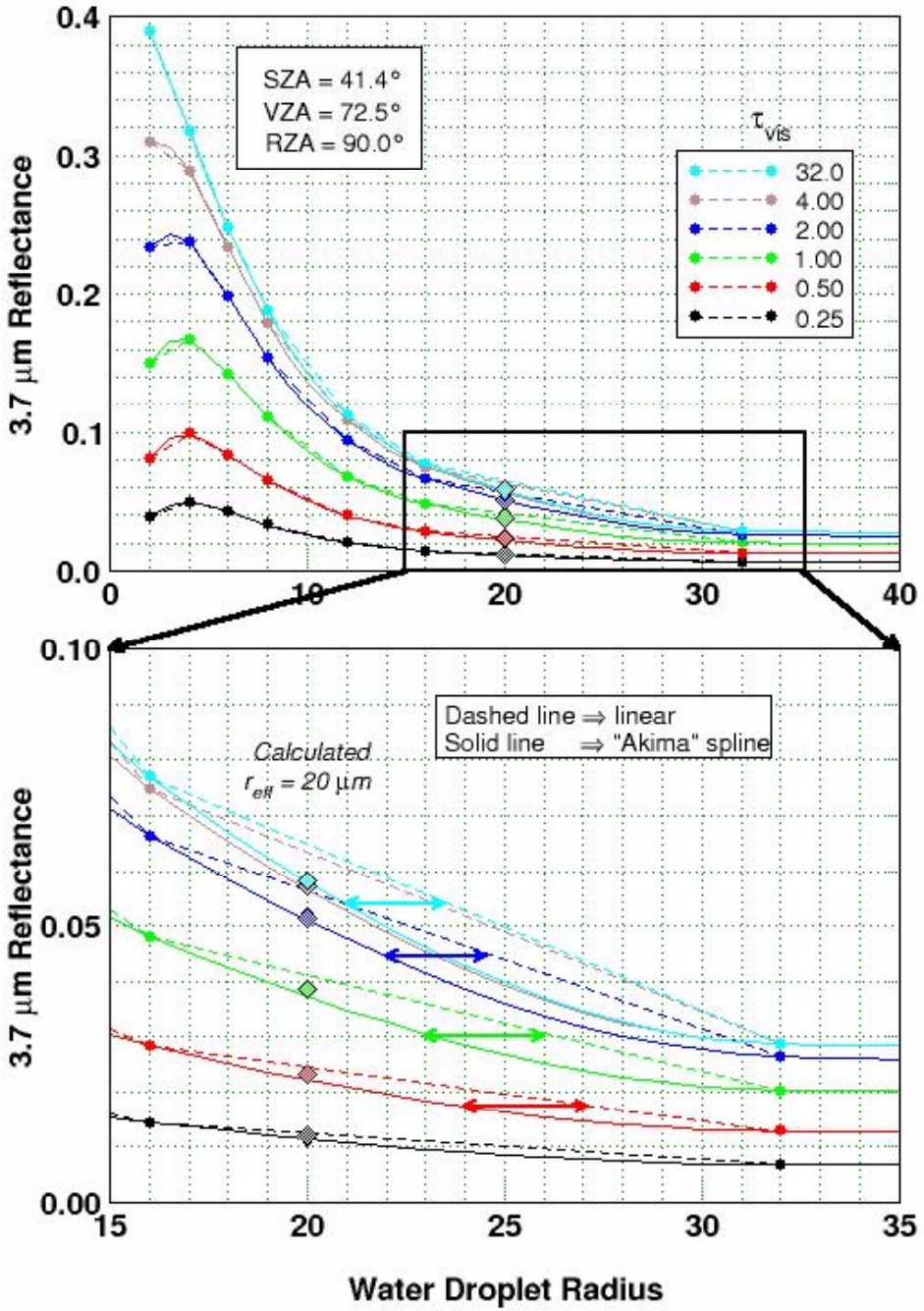

3.7-μm channel
Model Comparison
θ0 = 63.3°
θ = 45.6°
φ = 0°
Previous
VIRS
MODIS
Original
32.0
2.0
1.0
0.50
0.25
Reflectance
reff
0
0.2
0.4
0.6
0.8
0
4
8
12
16
20
24
28
32


Model Reflectance Comparison
(θo, θ, φ) = (63.3°, 45.6°, 0°)
Reflectance
τvis
0.8
0.6
0.4
0.2
0
0.1
1
10
100
Previous
VIRS
MODIS
Original
2 μm
4 μm
6 μm
8 μm
12 μm
16 μm
32 μm

INTERPOLATION OF *re*

FROM MODEL NODE POINTS

Linear vs. *Akima Spline*



INTERPOLATION OF *re*

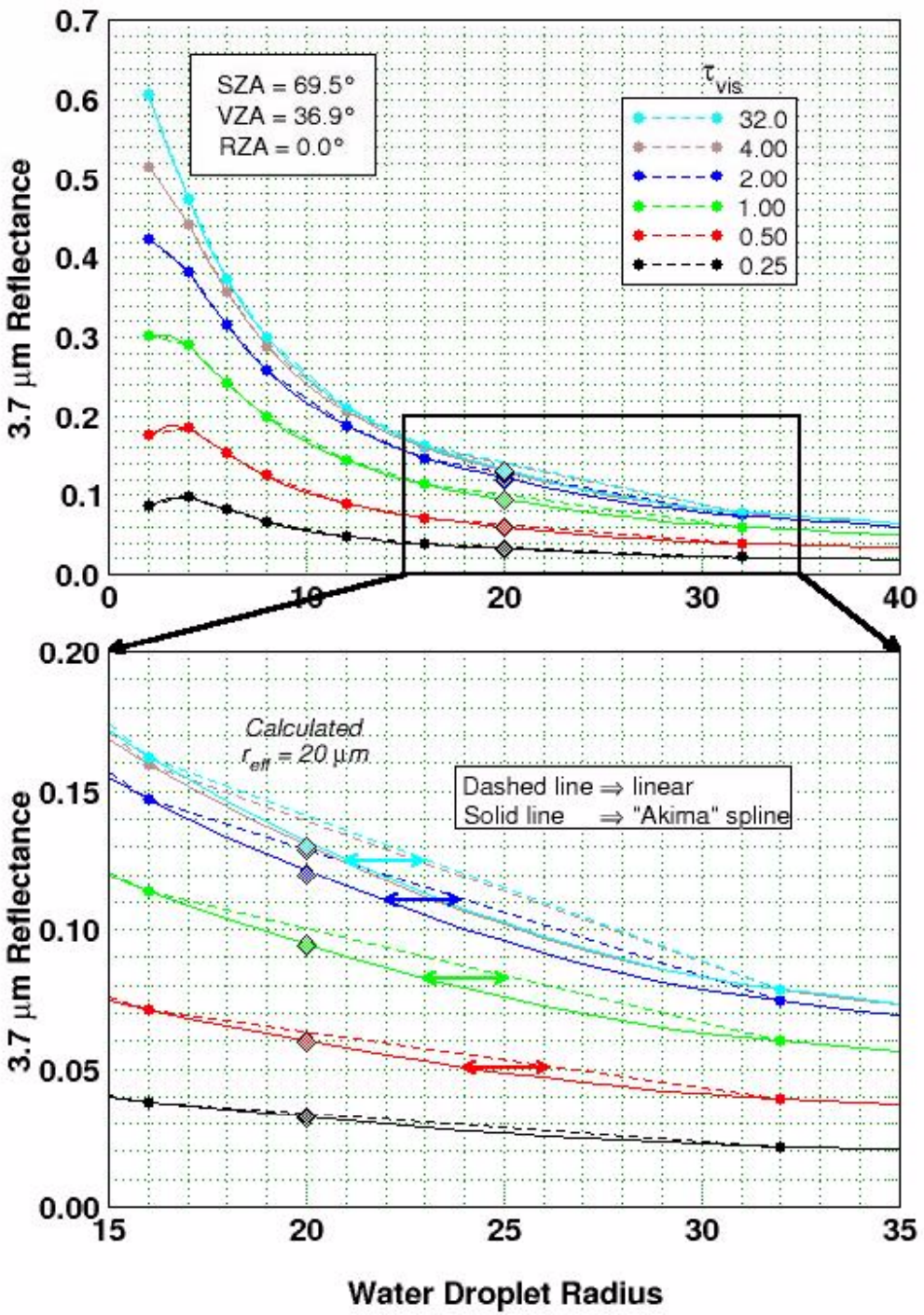
FROM MODEL NODE POINTS

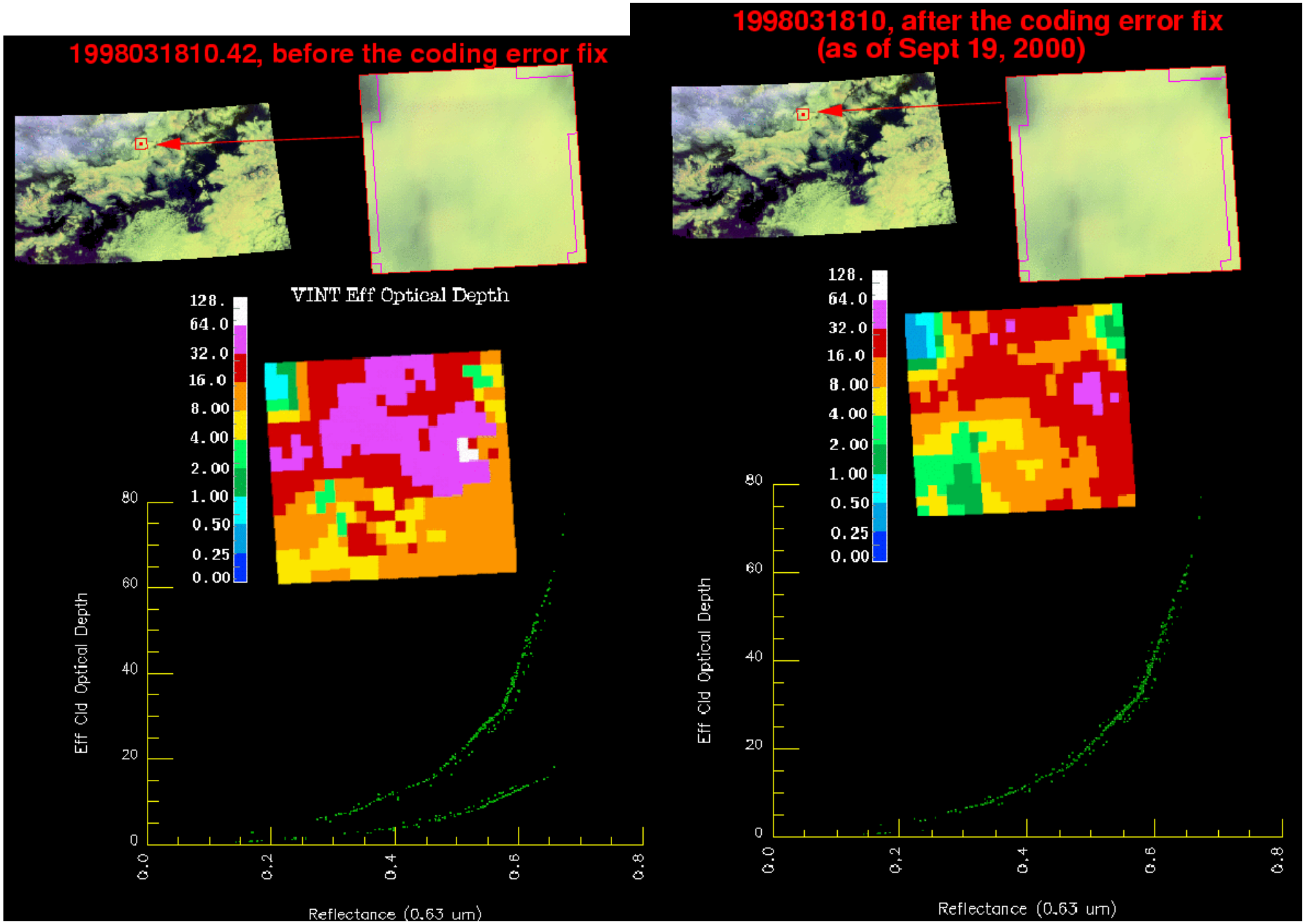
Linear vs. *Akima Spline*

Linear overestimates *re* at large *re*

Akima yields very accurate fit,

No time loss

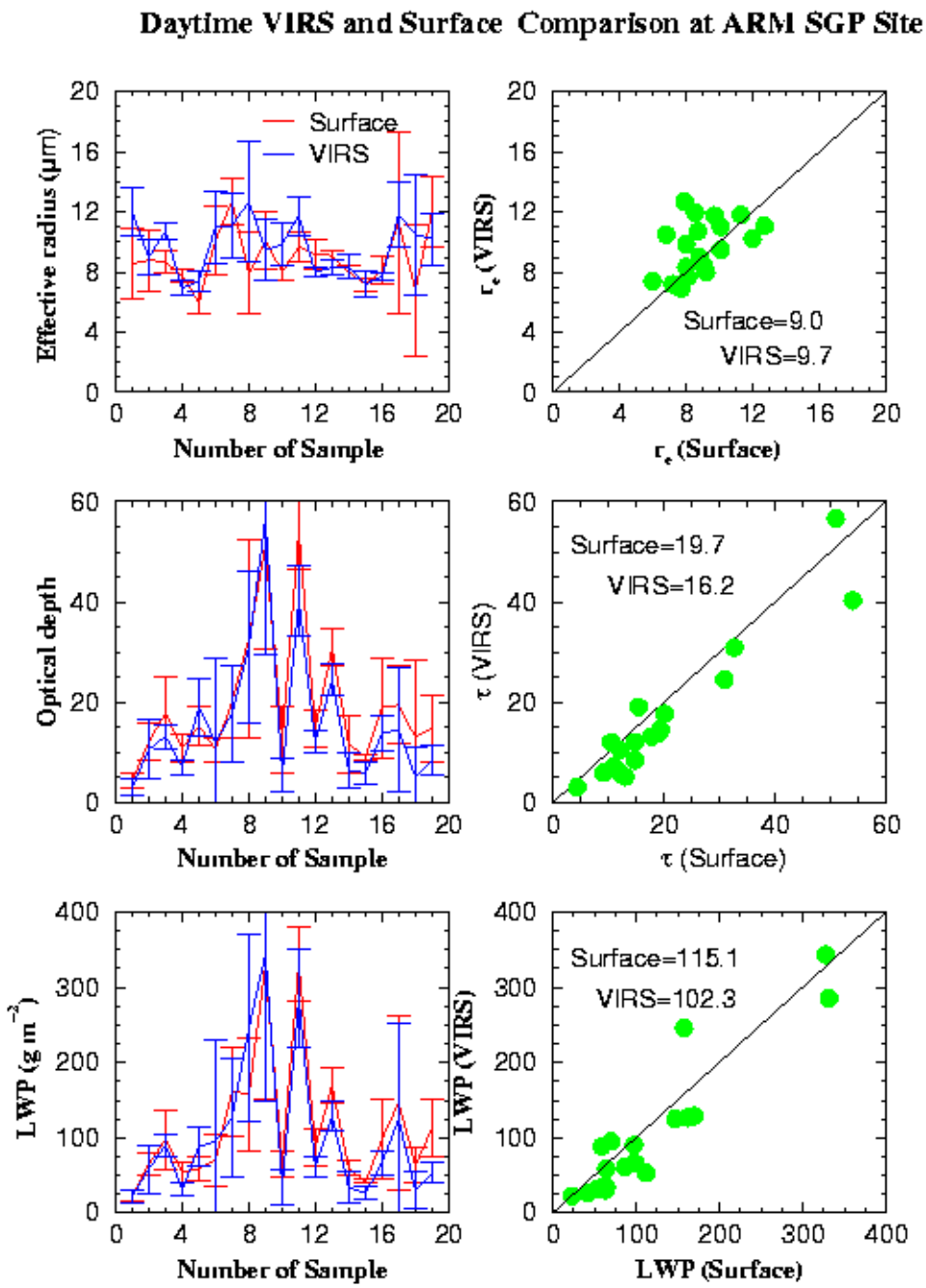



1998031810.42, before the coding error fix
VINT Eff Optical Depth
128.
64.0
32.0
16.0
8.00
4.00
2.00
1.00
0.50
0.25
0.00
Eff Cld Optical Depth
0
20
40
60
80
0.0
0.2
0.4
0.6
0.8
Reflectance (0.63 um)
1998031810, after the coding error fix
(as of Sept 19, 2000)
128.
64.0
32.0
16.0
8.00
4.00
2.00
1.00
0.50
0.25
0.00
Eff Cld Optical Depth
0
20
40
60
80
0.0
0.2
0.4
0.6
0.8
Reflectance (0.63 um)

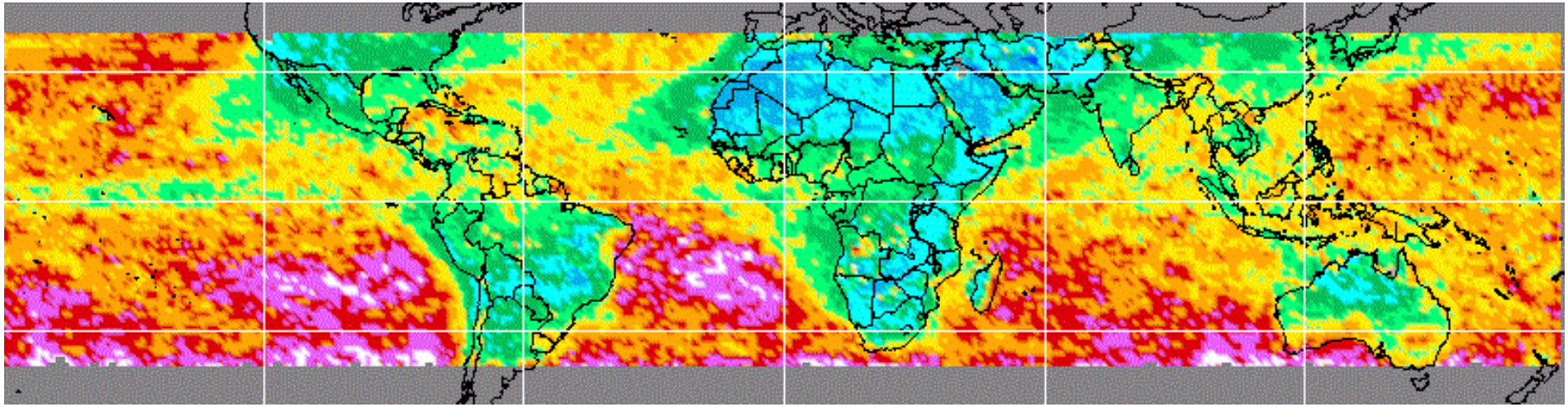
RADAR COMPARISONS OVER ARM SGP, STRATUS

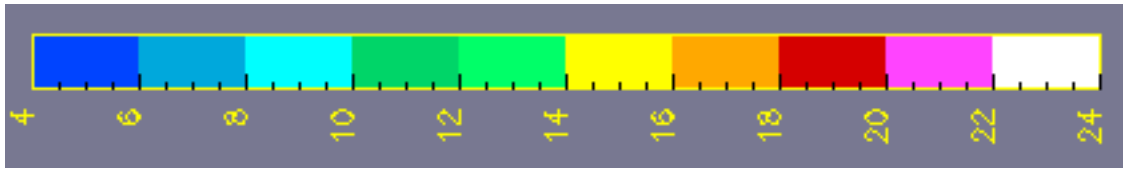
Radii from VIRS are only 0.9 µm (10%) greater than the radar values. Optical depths match much better than before with only 15% underestimate relative to the surface.

The resulting LWP is 11% smaller than the surface-derived values. A reduction in the value of re would increase the discrepancy in LWP.

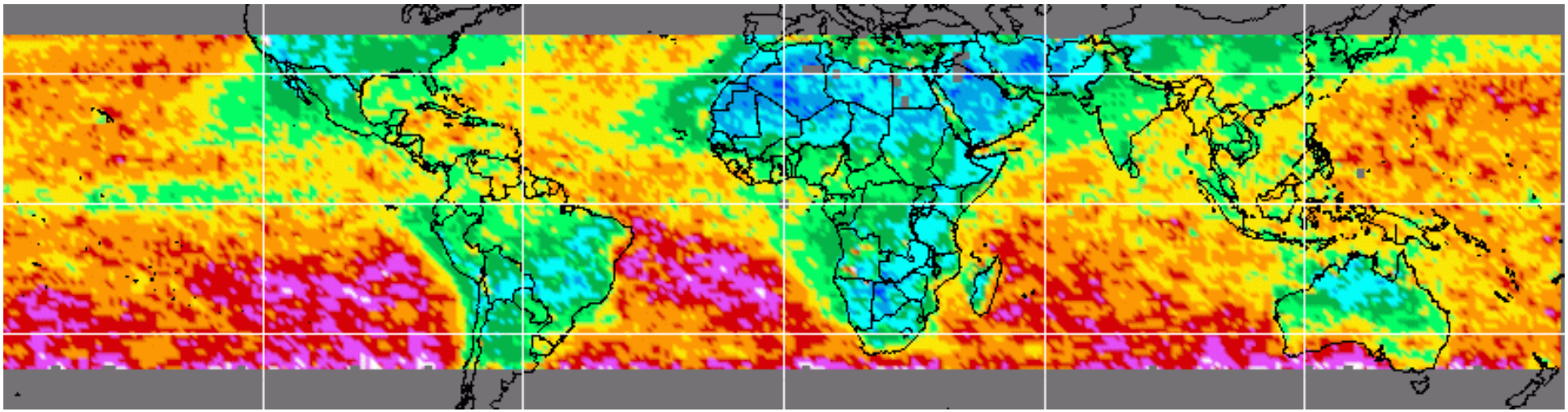


JULY 98 MEAN EFFECTIVE RADIUS FROM VIRS

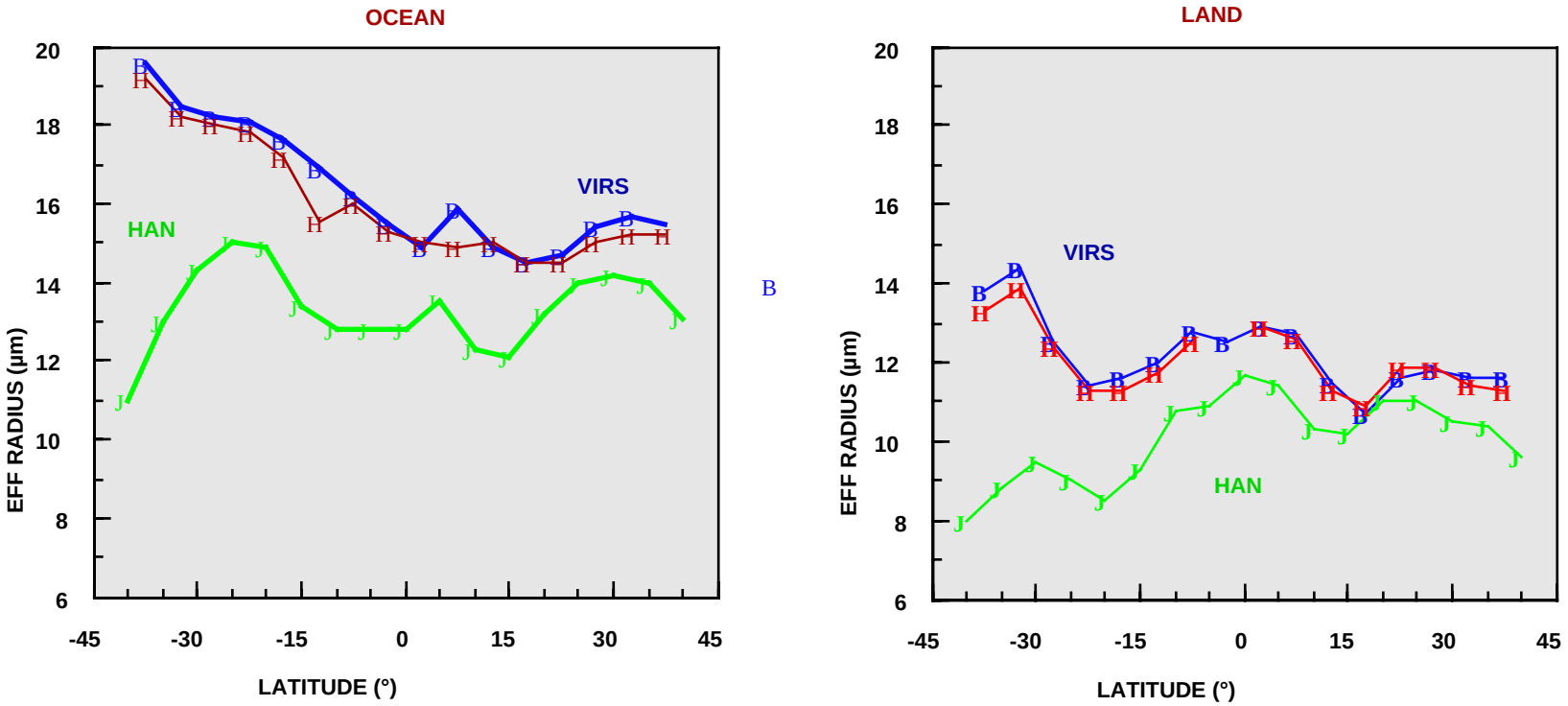




OLD ^



NEW ^



VIRS, 1998, TRMM

HAN et al. 1994, *J. Climate* , 1987 NOAA-9 AVHRR, T > 273K, tau > 3

VIRS, 1998, new run

PROPOSED CHANGES FOR CERES CLOUD CODE

- **INCLUDE N20 ABSORPTION IN CORR-K CALCULATIONS**

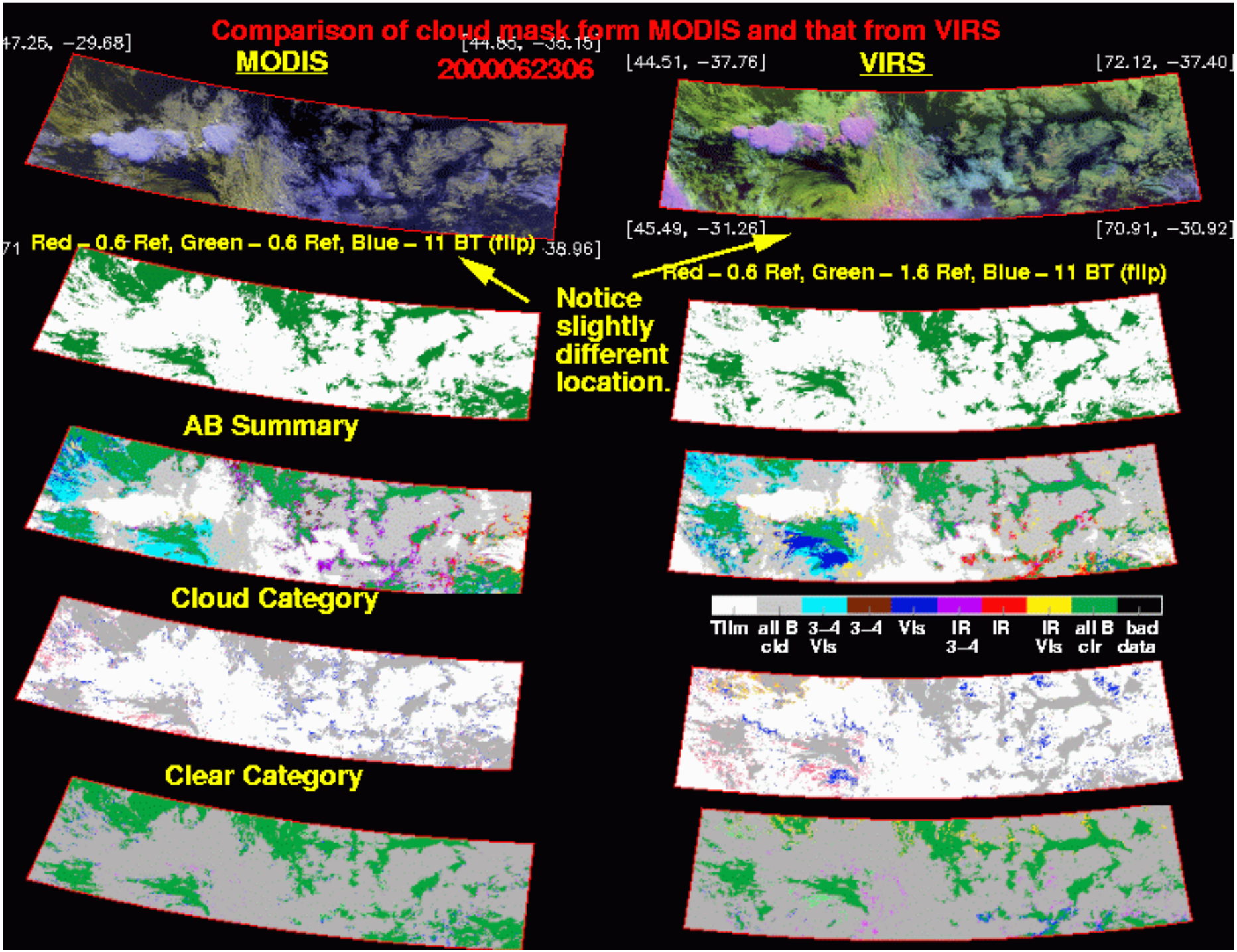
- **REDUCE VIRS TILE SIZE TO 8X16 PIXELS TO REDUCE VZA RANGE IN MODEL CALCULATIONS**

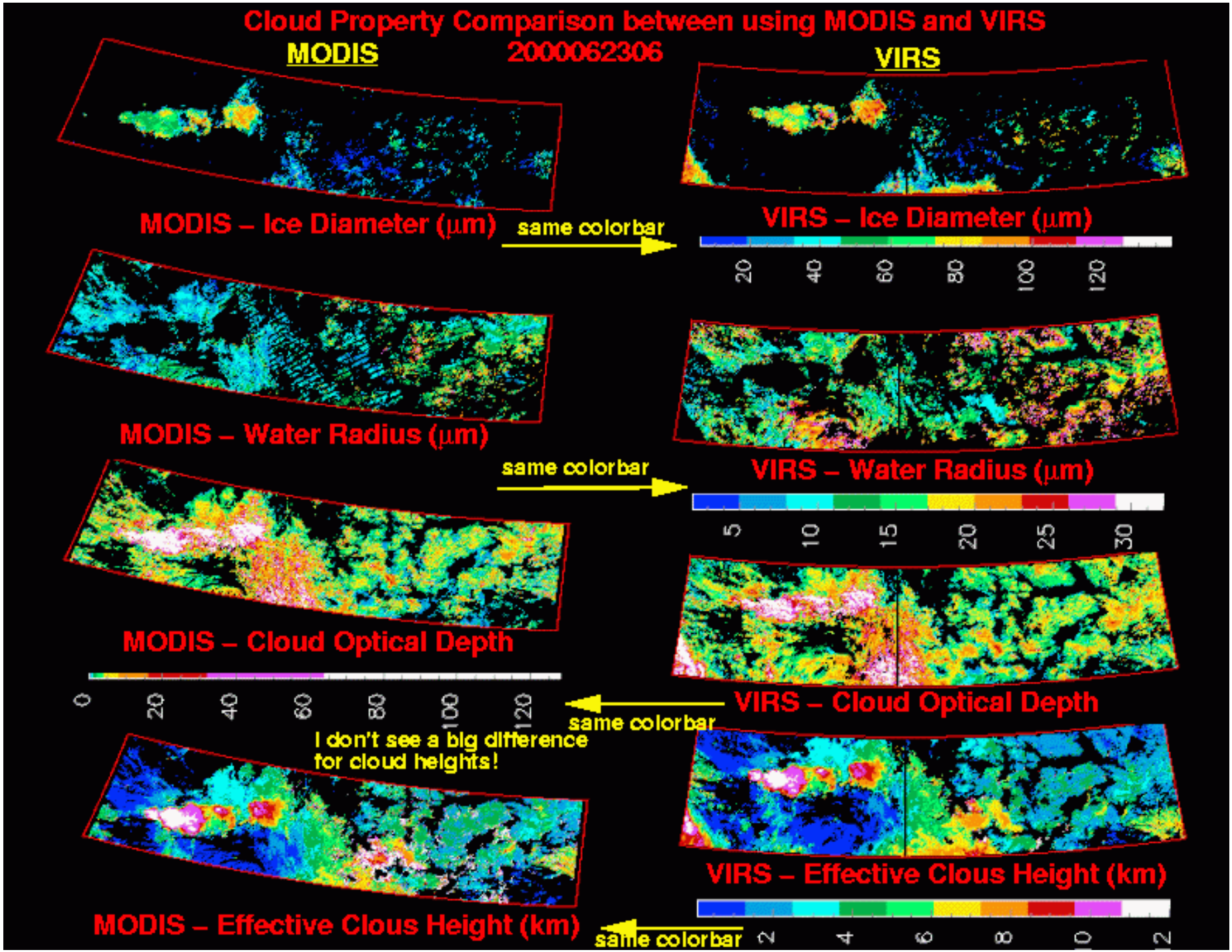
  - ΔVZA IS ~ 6°; DECREASE TO 3°

FIRST MODIS RETRIEVALS

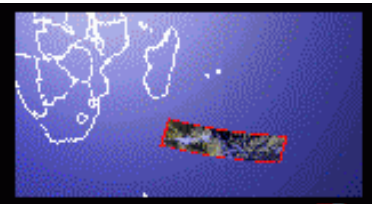
NASA : P. Minnis

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


Comparison of cloud mask form MODIS and that from VIRS
47.25, −29.68]
MODIS
[44.85, −36.15]
2000062306
[44.51, −37.76]
VIRS
[72.12, −37.40]
[45.49, −31.26]
[70.91, −30.92]
71 Red – 0.6 Ref, Green – 0.6 Ref, Blue – 11 BT (flip) 38.96]
Red – 0.6 Ref, Green – 1.6 Ref, Blue – 11 BT (flip)
Notice slightly different location.
AB Summary
Cloud Category
Clear Category
Tlim
all B cld
3–4 Vis
3–4
Vis
IR 3–4
IR
IR Vis
all B clr
bad data

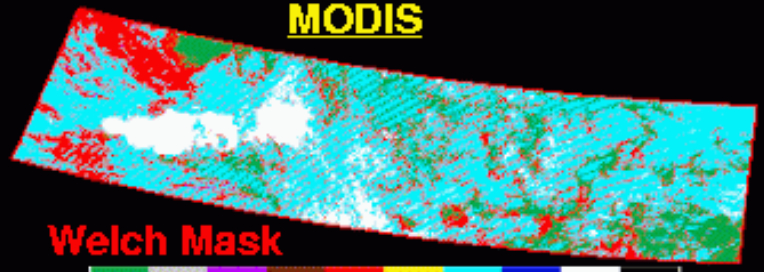

Cloud Property Comparison between using MODIS and VIRS
MODIS
2000062306
VIRS
MODIS – Ice Diameter (μm)
same colorbar
VIRS – Ice Diameter (μm)
20
40
60
80
100
120
MODIS – Water Radius (μm)
VIRS – Water Radius (μm)
same colorbar
5
10
15
20
25
30
MODIS – Cloud Optical Depth
0
20
40
60
80
100
120
same colorbar
VIRS – Cloud Optical Depth
I don't see a big difference
for cloud heights!
VIRS – Effective Clous Height (km)
MODIS – Effective Clous Height (km)
same colorbar
2
4
6
8
10
12

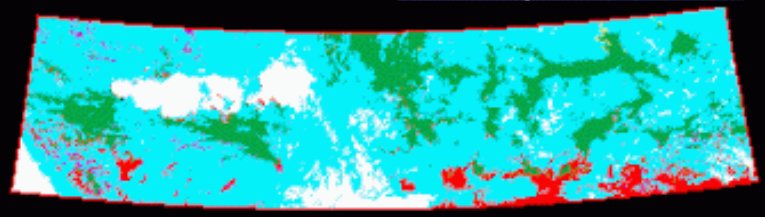
Algorithem results comparison between MODIS and VIRS
2000062306



MODIS

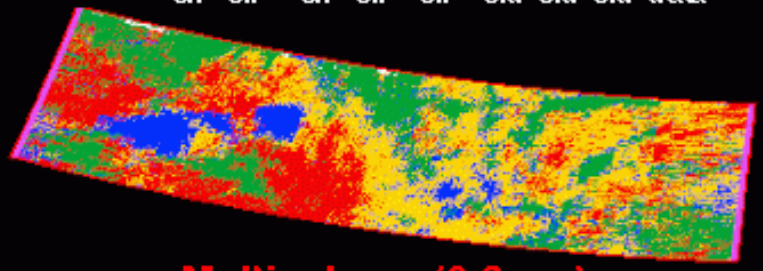
VIRS

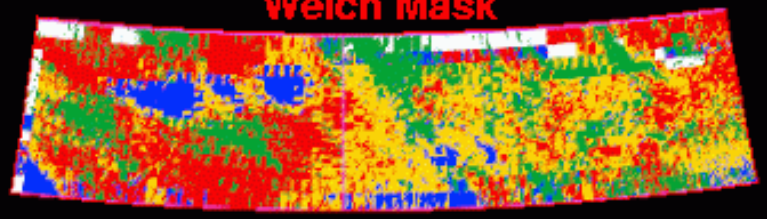




Welch Mask

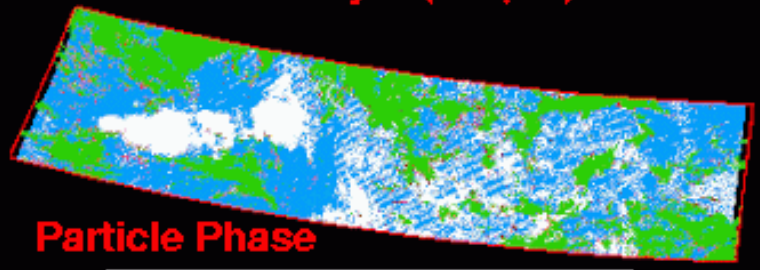
clr snw clr | arsl clr | sdw clr | smk clr | glnt clr | wtr cld | mix cld | ice cld | bad data





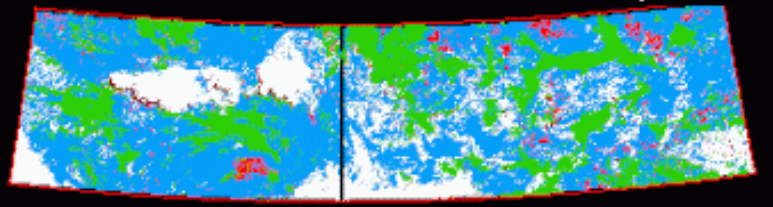
Welch Mask

Multi – layer (0.6 μm)



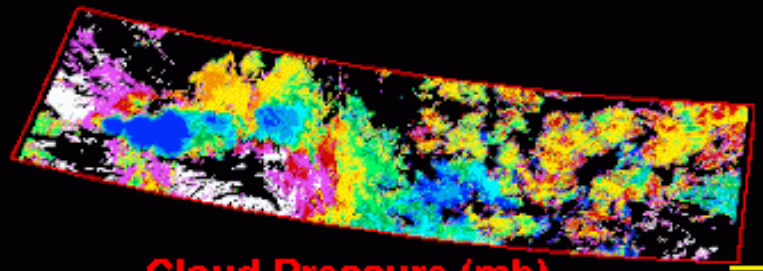
clr | sigl | high low | mult shdw | not use | bad data | not proc

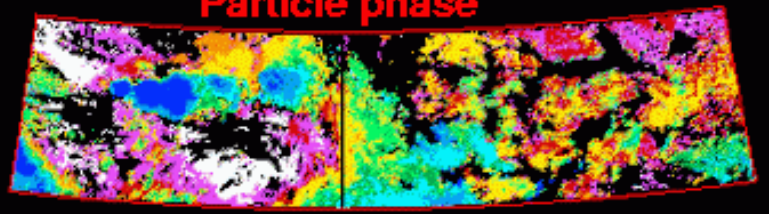
Particle Phase



wtr cld | ice cld | no rtrvl | clear | bad data

Particle phase

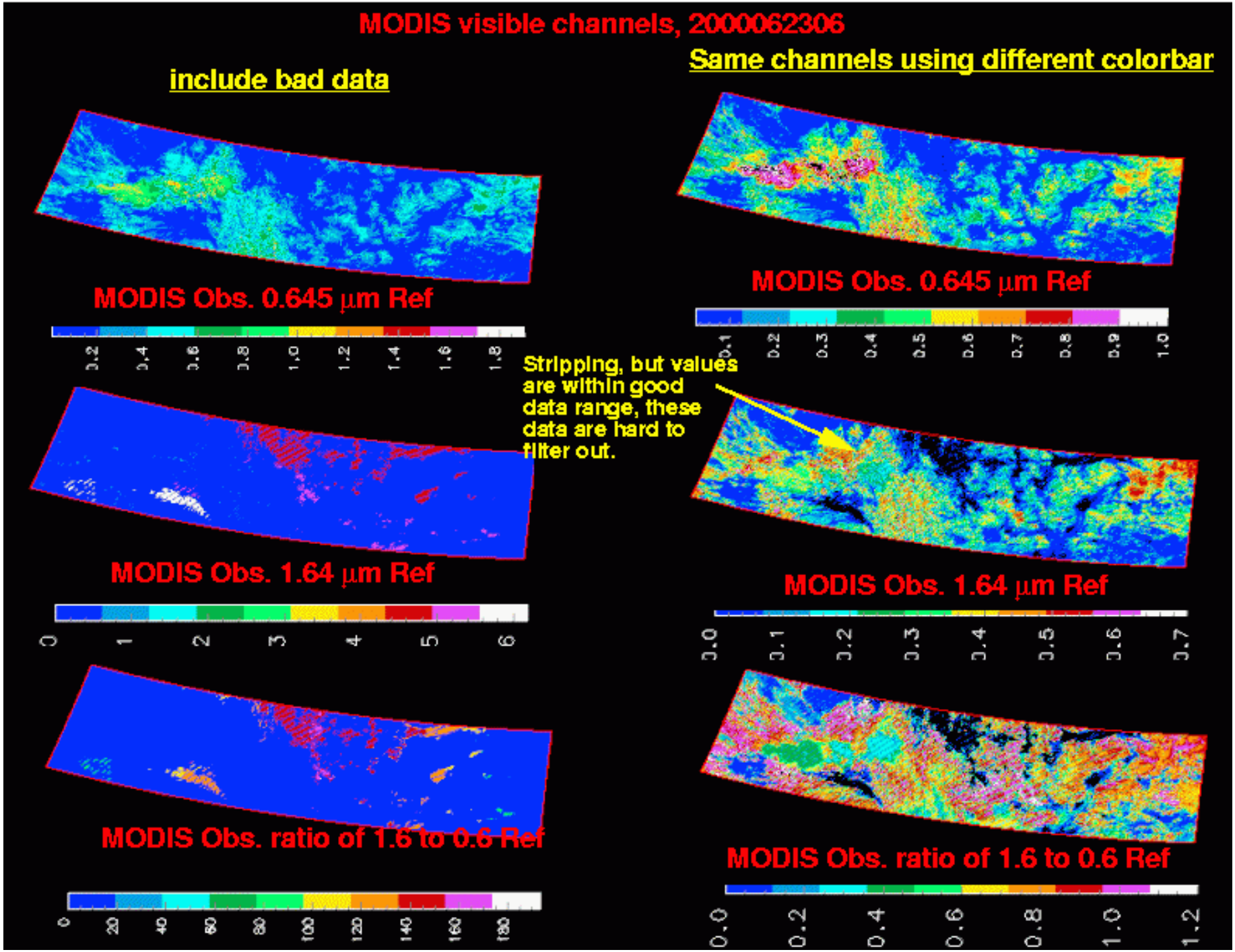


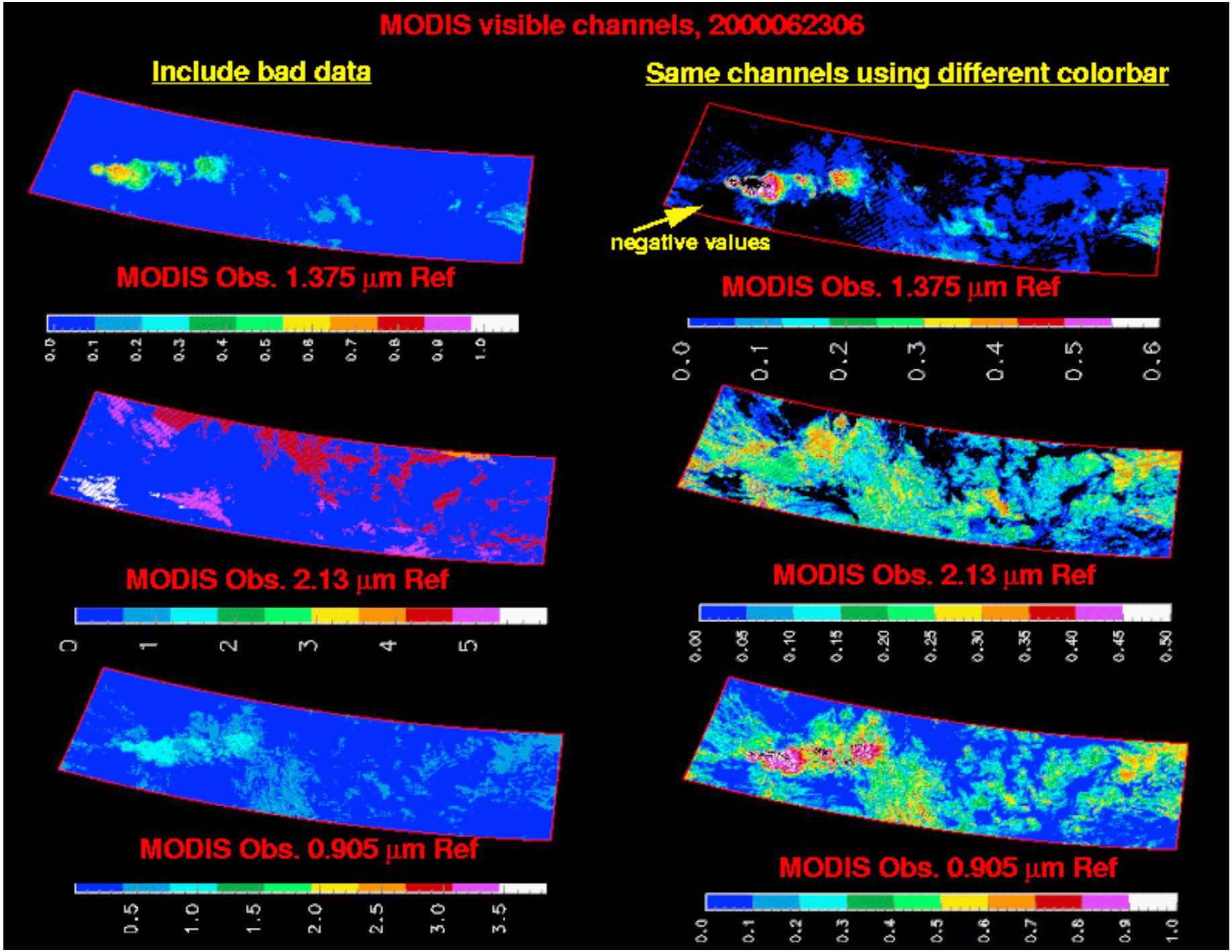


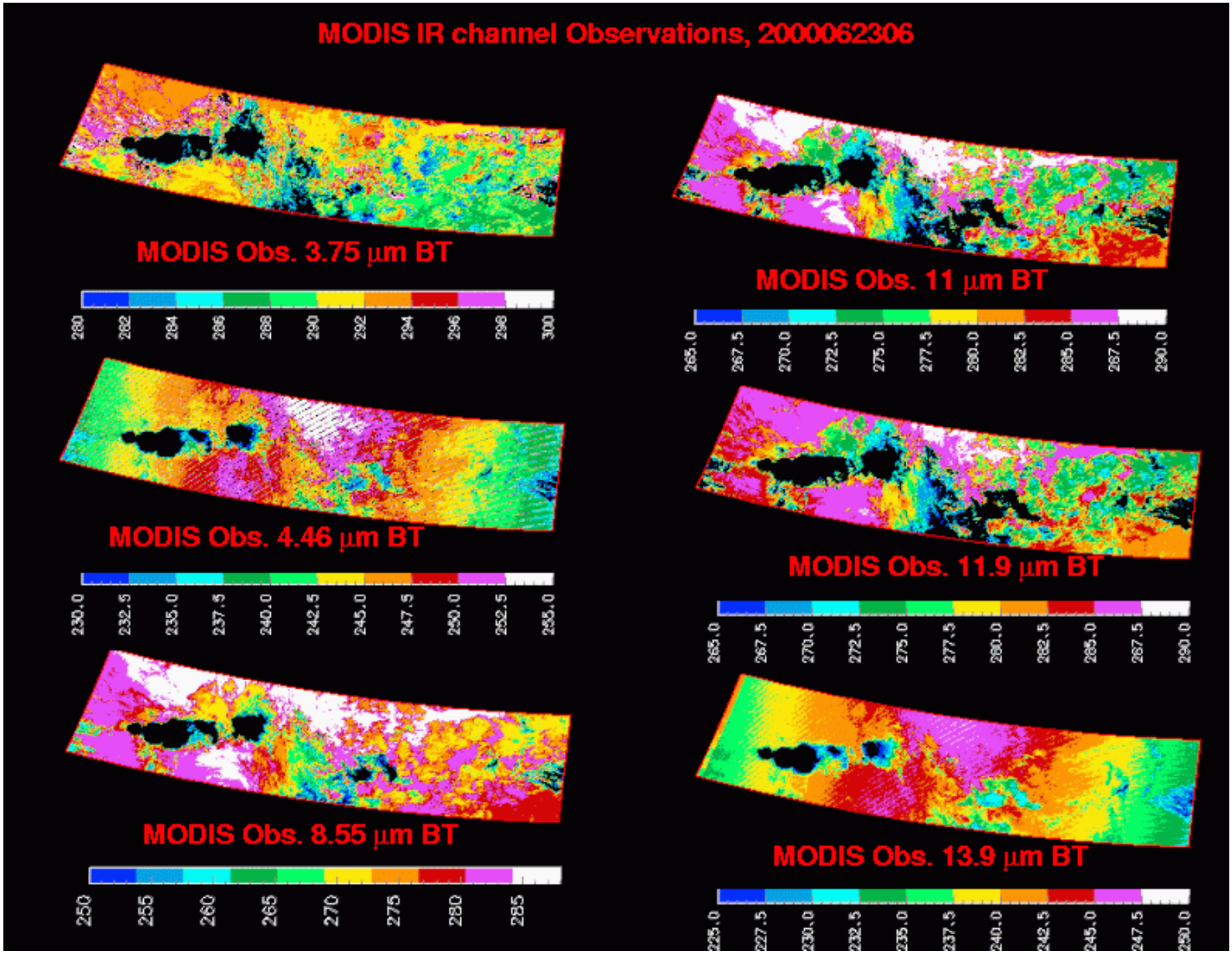
Cloud Pressure (mb)

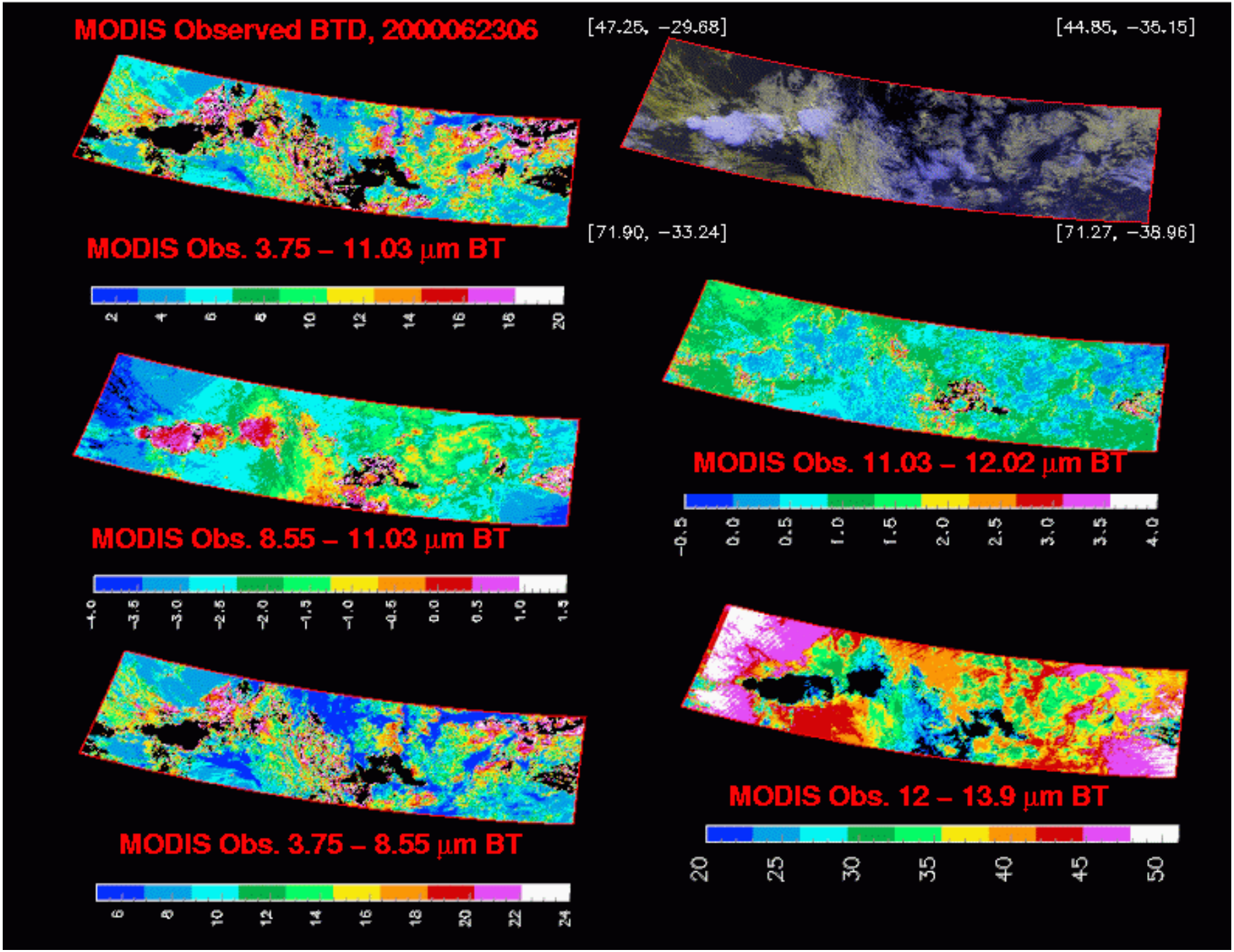
Cloud Pressure (mb)

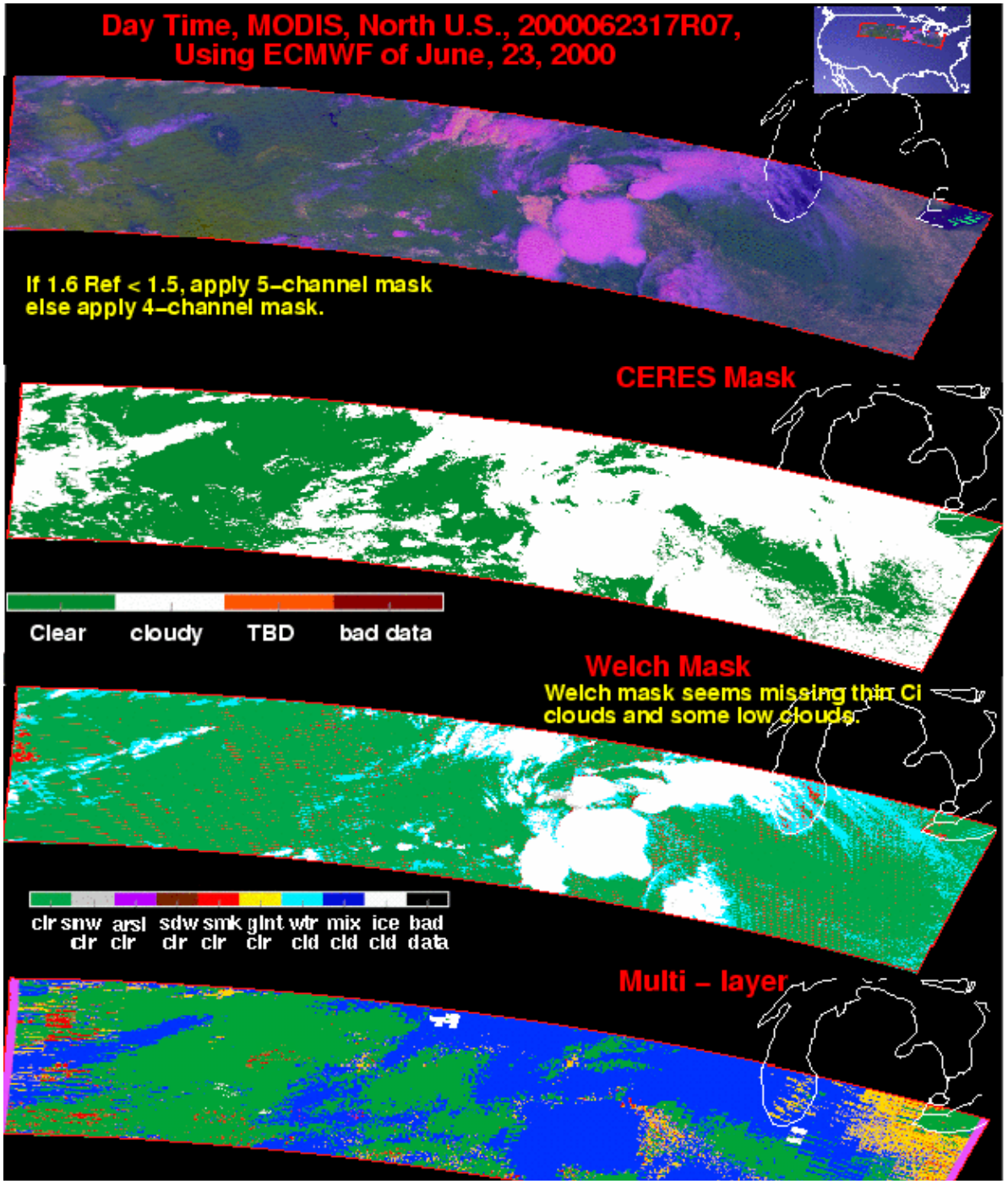
same colorbar


MODIS visible channels, 2000062306
include bad data
Same channels using different colorbar
MODIS Obs. 0.645 μm Ref
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8
MODIS Obs. 0.645 μm Ref
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Stripping, but values are within good data range, these data are hard to filter out.
MODIS Obs. 1.64 μm Ref
0 1 2 3 4 5 6
MODIS Obs. 1.64 μm Ref
3.0 3.1 3.2 3.3 3.4 3.5 3.6 3.7
MODIS Obs. ratio of 1.6 to 0.6 Ref
0 20 40 60 80 100 120 140 160 180
MODIS Obs. ratio of 1.6 to 0.6 Ref
0.0 0.2 0.4 0.6 0.8 1.0 1.2


MODIS visible channels, 2000062306
Include bad data
Same channels using different colorbar
negative values
MODIS Obs. 1.375 μm Ref
MODIS Obs. 1.375 μm Ref
MODIS Obs. 2.13 μm Ref
MODIS Obs. 2.13 μm Ref
MODIS Obs. 0.905 μm Ref
MODIS Obs. 0.905 μm Ref

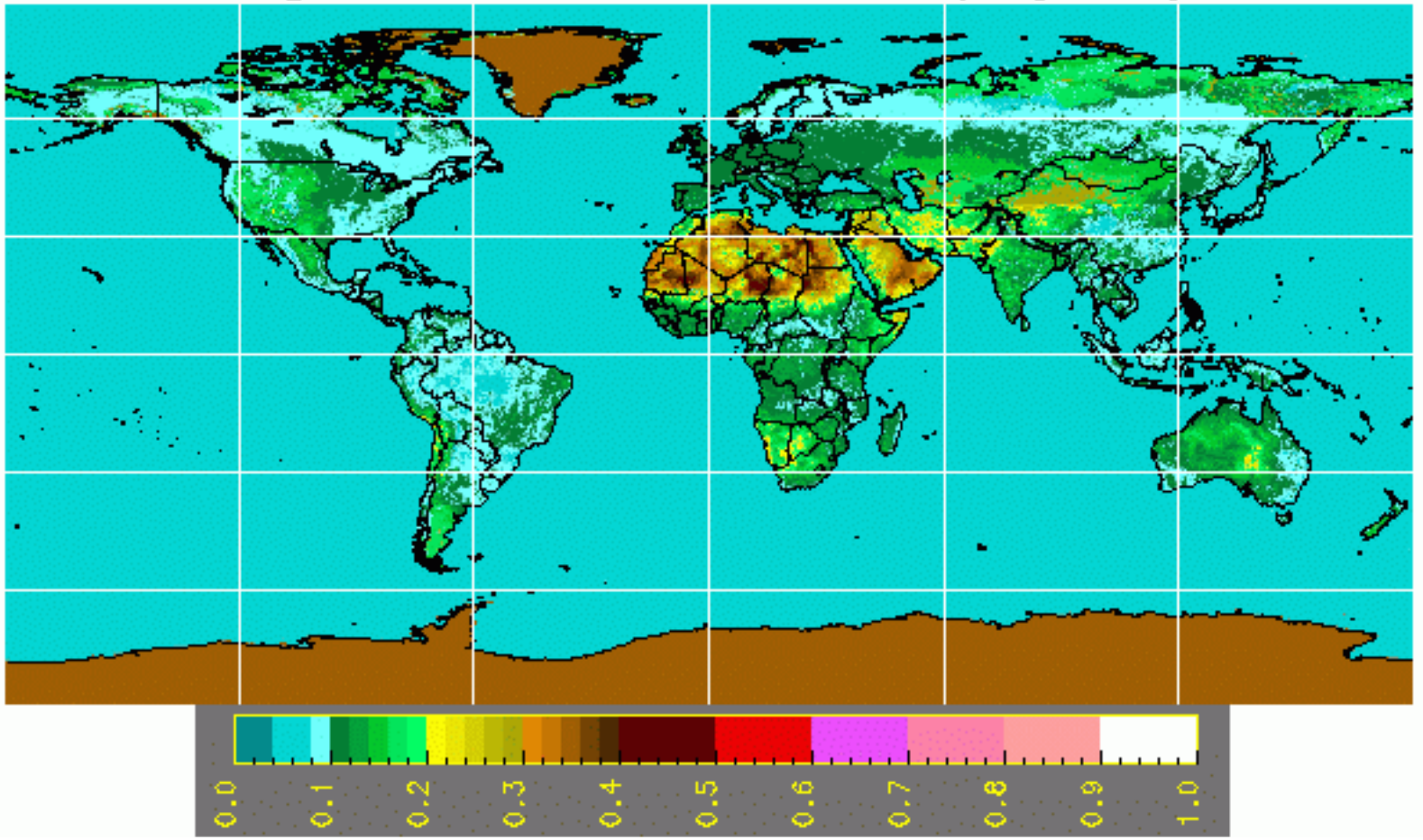

MODIS IR channel Observations, 2000062306
MODIS Obs. 3.75 μm BT
280 282 284 286 288 290 292 294 296 298 300
MODIS Obs. 11 μm BT
265.0 267.5 270.0 272.5 275.0 277.5 280.0 282.5 285.0 287.5 290.0
MODIS Obs. 4.46 μm BT
230.0 232.5 235.0 237.5 240.0 242.5 245.0 247.5 250.0 252.5 255.0
MODIS Obs. 11.9 μm BT
265.0 267.5 270.0 272.5 275.0 277.5 280.0 282.5 285.0 287.5 290.0
MODIS Obs. 8.55 μm BT
250 255 260 265 270 275 280 285
MODIS Obs. 13.9 μm BT
225.0 227.5 230.0 232.5 235.0 237.5 240.0 242.5 245.0 247.5 250.0


MODIS Observed BTD, 2000062306
[47.25, −29.68]
[44.85, −35.15]
[71.90, −33.24]
[71.27, −38.96]
MODIS Obs. 3.75 – 11.03 μm BT
2 4 6 8 10 12 14 16 18 20
MODIS Obs. 11.03 – 12.02 μm BT
−0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
MODIS Obs. 8.55 – 11.03 μm BT
−4.0 −3.5 −3.0 −2.5 −2.0 −1.5 −1.0 −0.5 0.0 0.5 1.0 1.5
MODIS Obs. 12 – 13.9 μm BT
20 25 30 35 40 45 50
MODIS Obs. 3.75 – 8.55 μm BT
6 8 10 12 14 16 18 20 22 24


Day Time, MODIS, North U.S., 2000062317R07,
Using ECMWF of June, 23, 2000
If 1.6 Ref < 1.5, apply 5–channel mask
else apply 4–channel mask.
CERES Mask
Clear
cloudy
TBD
bad data
Welch Mask
Welch mask seems missing thin Ci
clouds and some low clouds.
clr snw clr
arsl clr
sdw clr
smk clr
glnt clr
wtr cld
mix cld
ice cld
bad data
Multi – layer

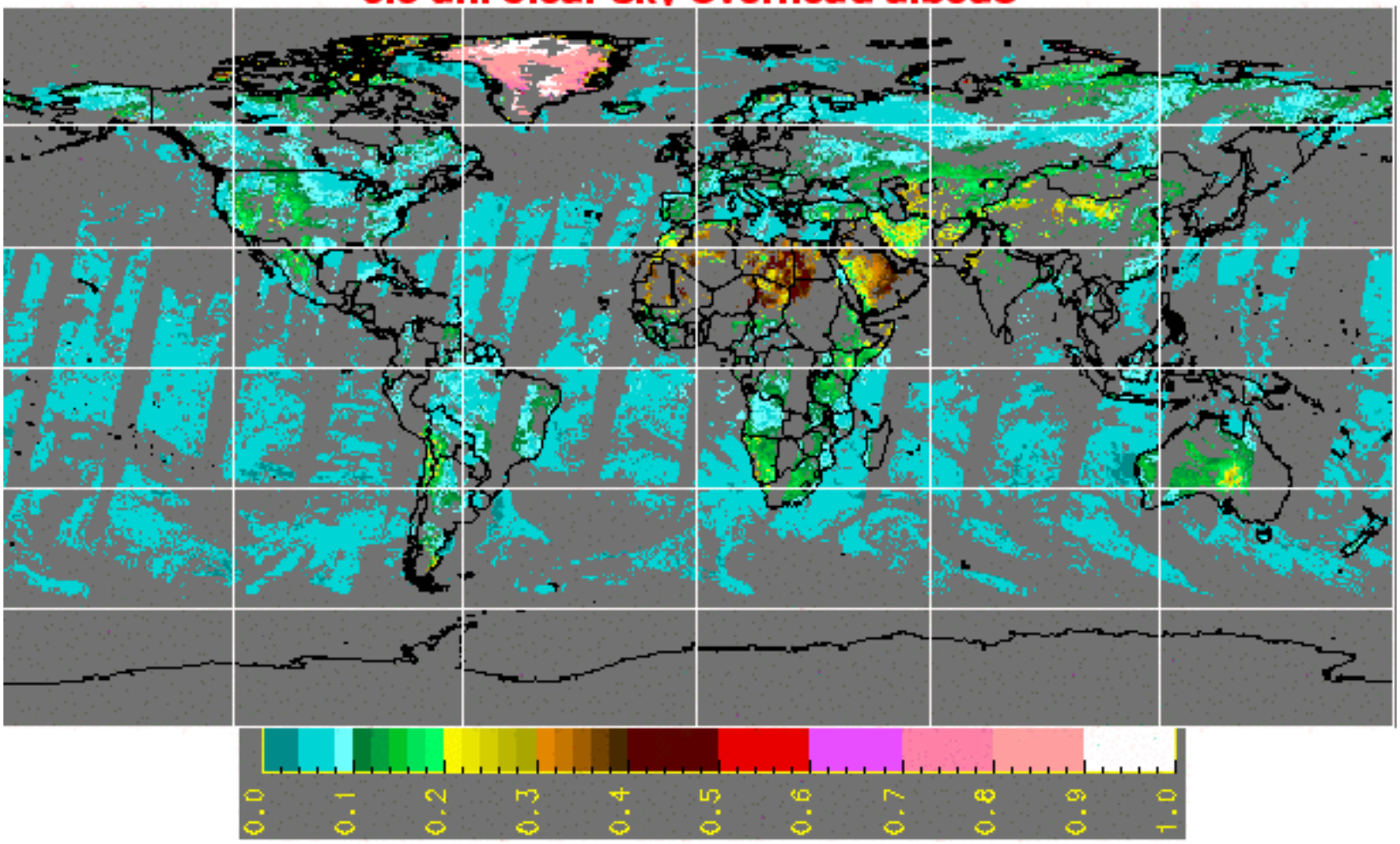
Clear Sky Overhead Albedo

Using VIRS data and CERES MASK (July 1998)

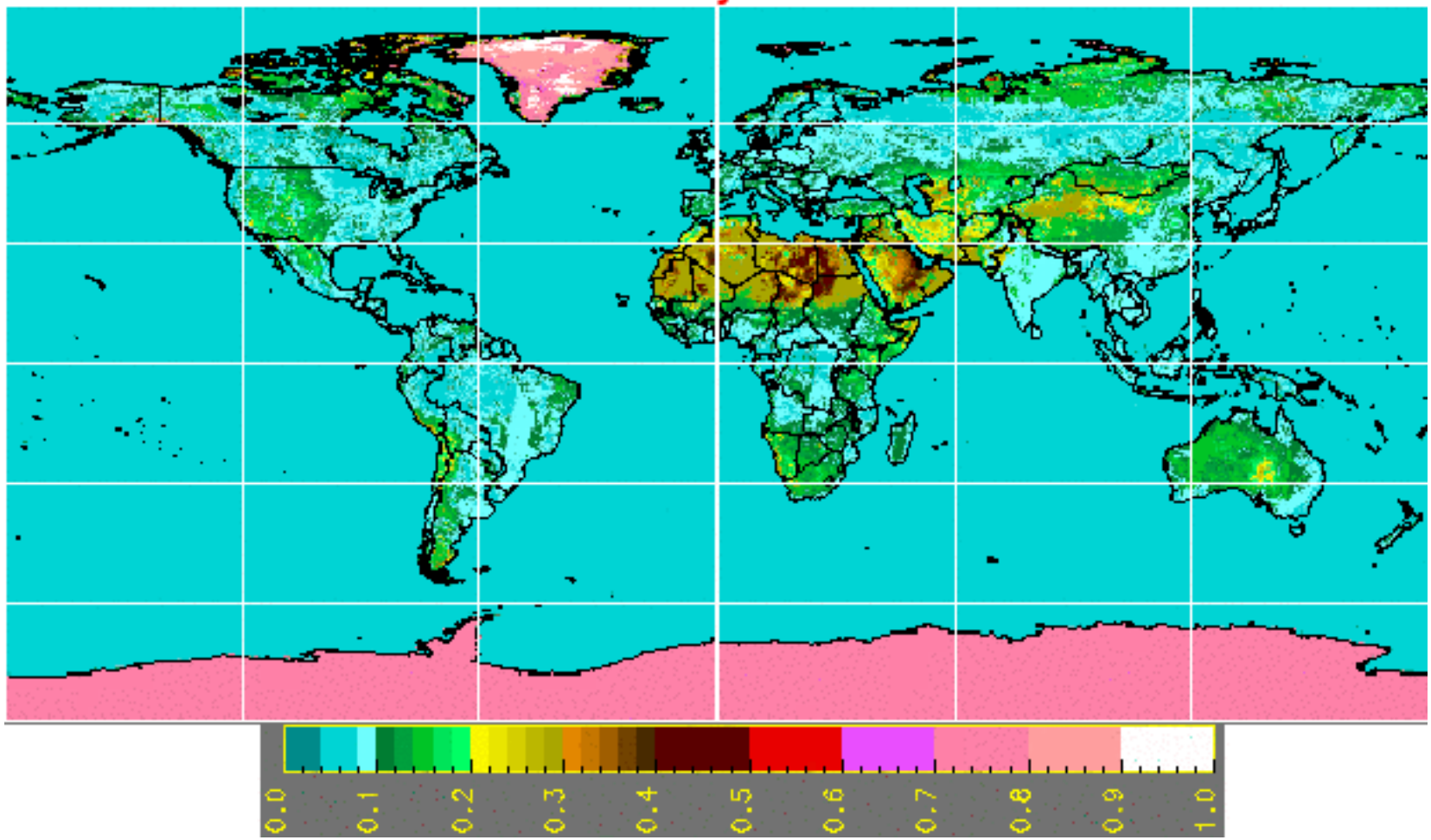


MODIS 20000630 (10 min grid daily average)

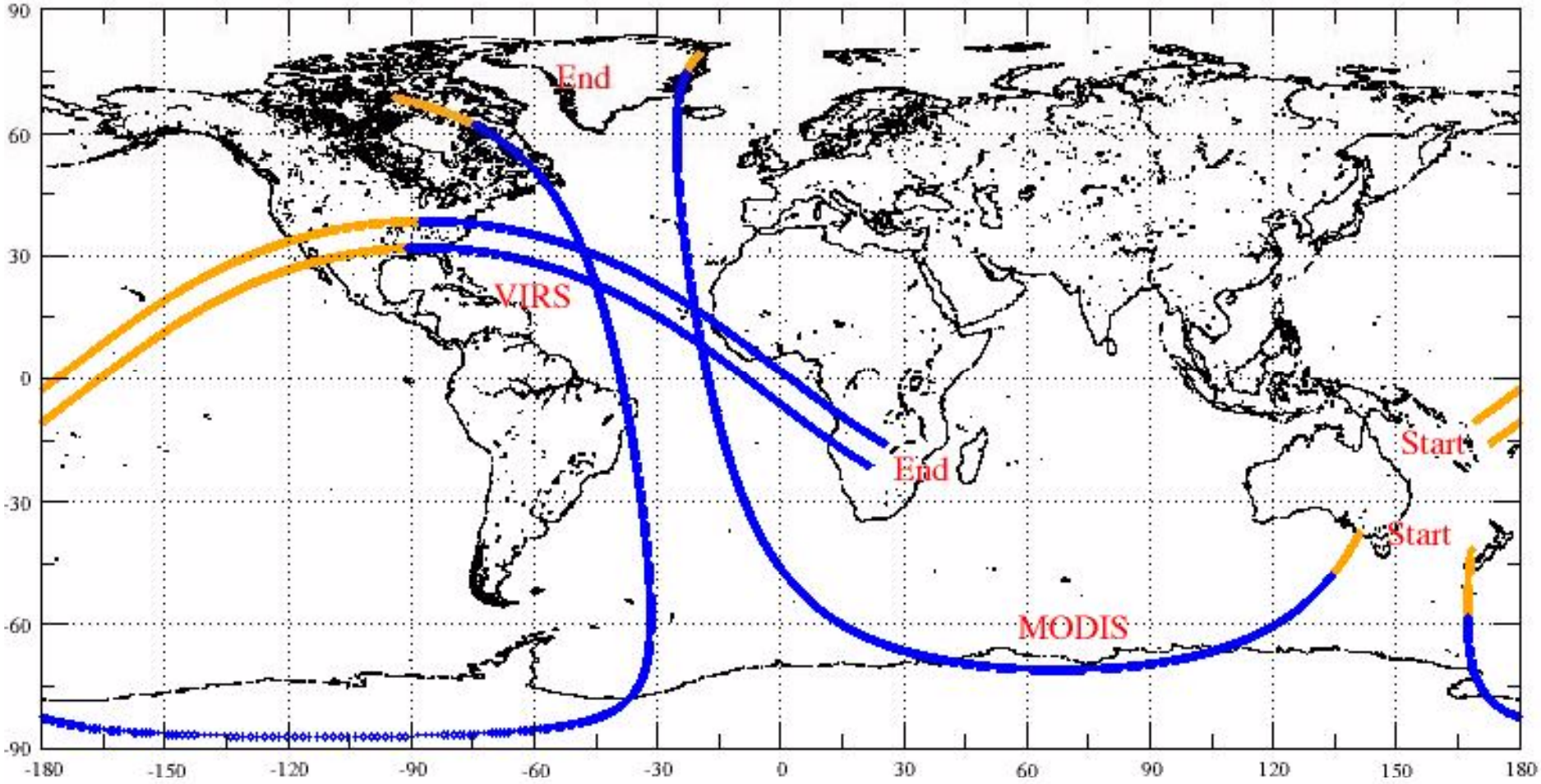
0.6 um clear sky overhead albedo



MODIS 20000630 (10 min grid daily average)
(IGBP Type Filled for Missing Data and Water Data)
0.6 um clear sky overhead albedo



2000063000


End
VIRS
End
Start
Start
MODIS
90
60
30
0
-30
-60
-90
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180

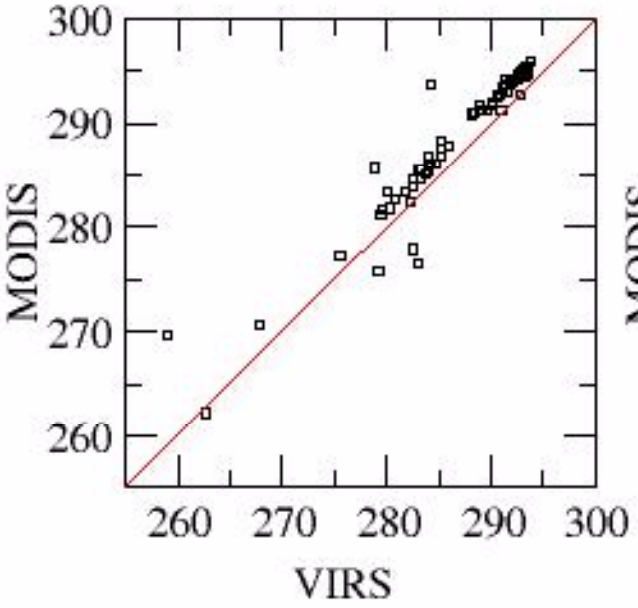
DAYTIME

Observed Brightness Temperature (K)

2000063000

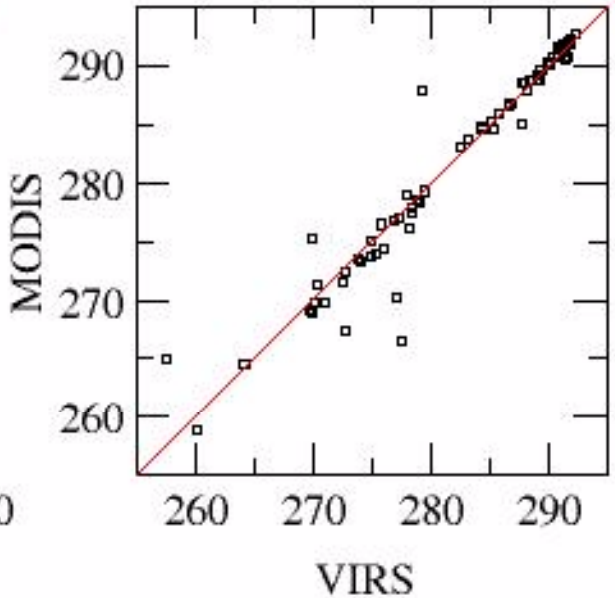
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

3.7 μm



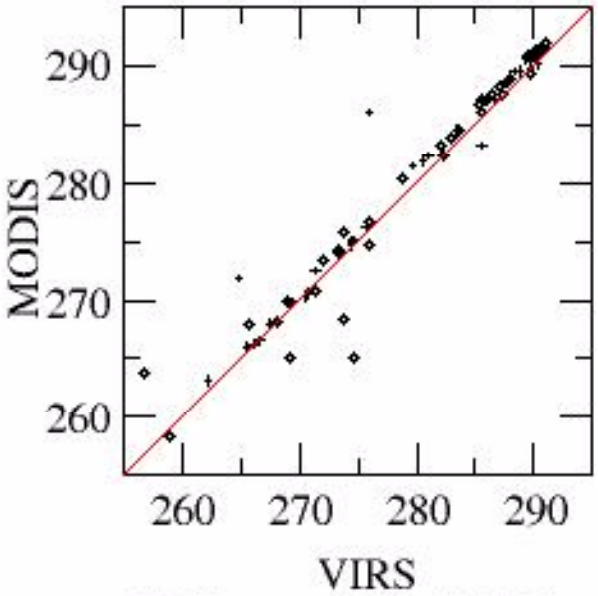
Diff_mean = -1.89438
Diff_Std = 1.99094

11 μm



Diff_mean = 0.174443
Diff_Std = 2.18721

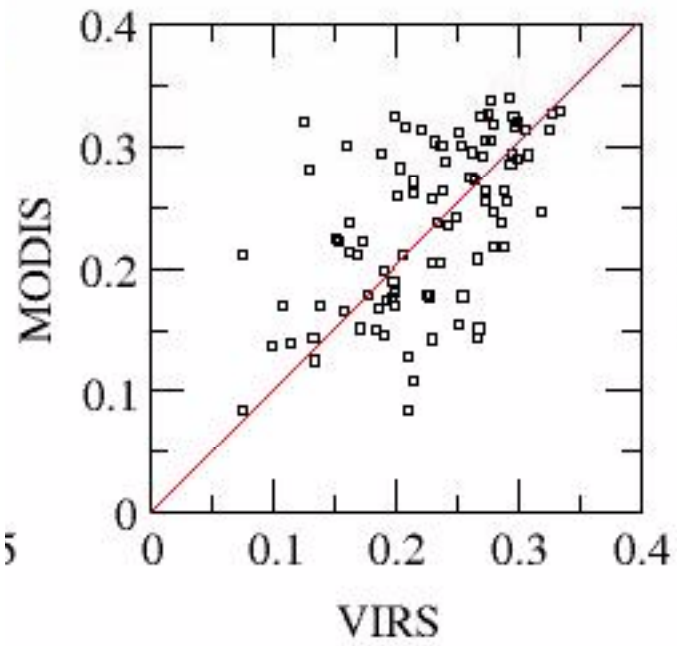
12 μm



Diff_mean = -0.696126
Diff_Std = 2.10621

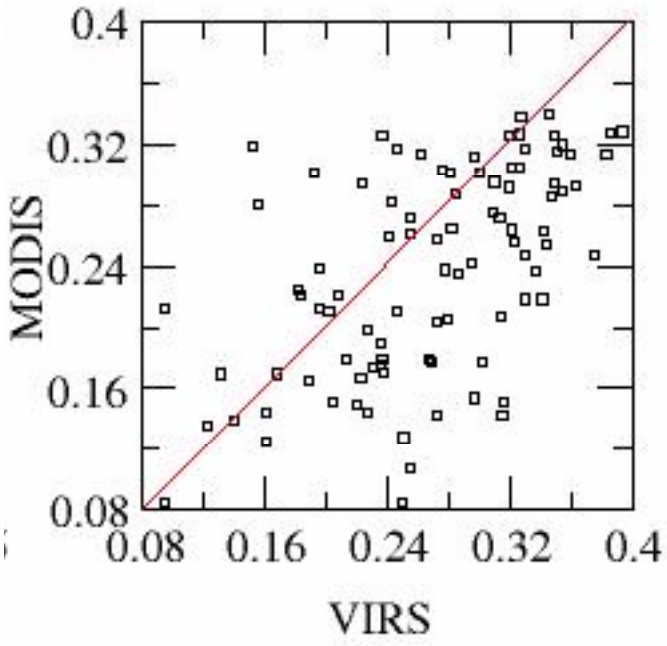
VIRS/MODIS COMPARISONS OF 1.6 REFLECTANCE WITH & WITHOUT THE ATSR-2/VIRS CALIBRATION CORRECTION, 2100 UTC, 23 JUNE

No correction



Diff_mean = -0.010338
Diff_Std = 0.0608439

Correction



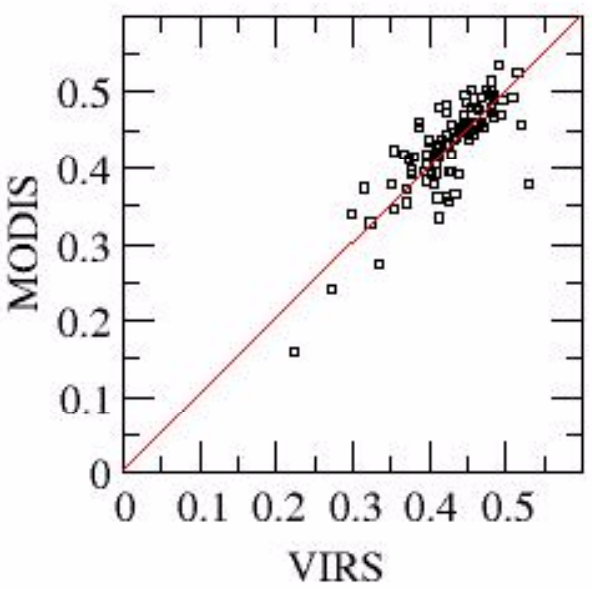
Diff_mean = 0.0320761
Diff_Std = 0.0648966

Observed Reflectances with VIRS Correction

2000062303

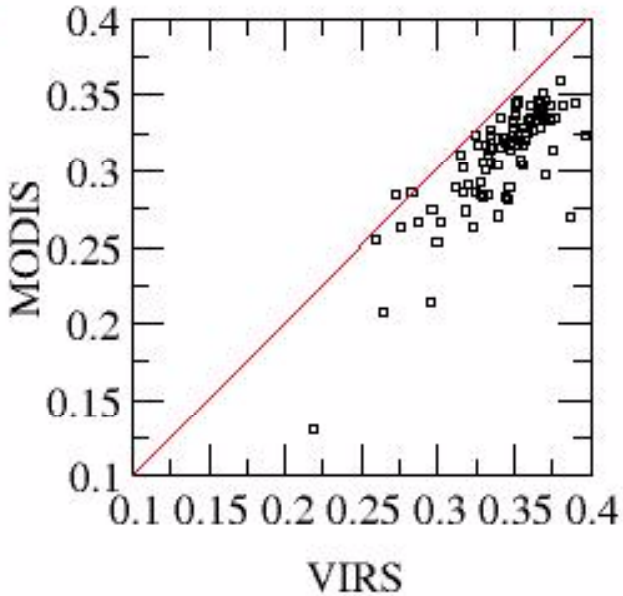
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

0.6 μm



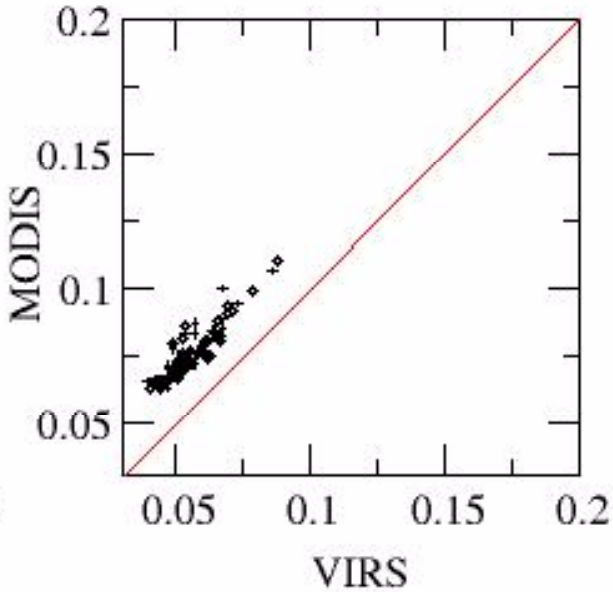
Diff_mean = -0.00404457
Diff_Std = 0.0363387

1.6 μm



Diff_mean = 0.0317326
Diff_Std = 0.0203439

3.7 μm



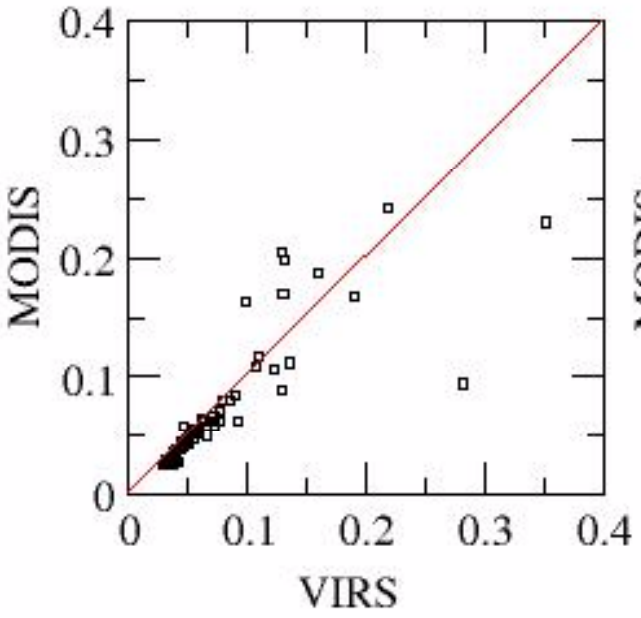
Diff_mean =-0.0203043
Diff_Std = 0.00397604

Observed Reflectances with VIRS Correction

2000070118

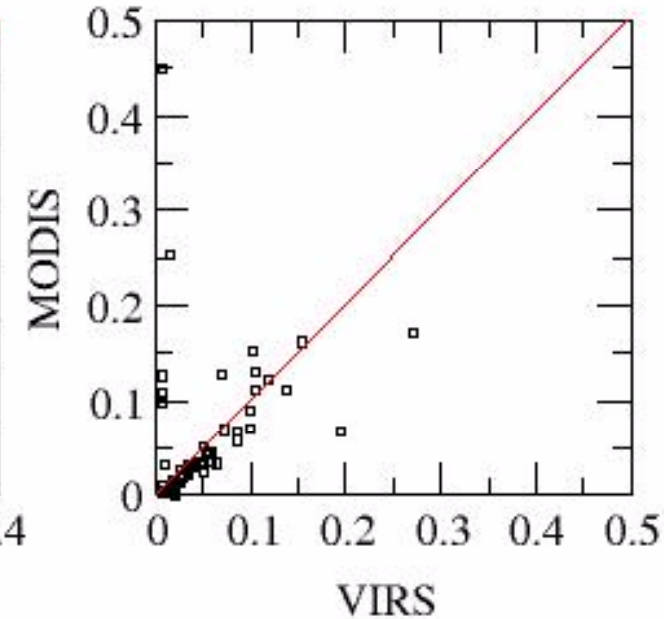
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

0.6 μm



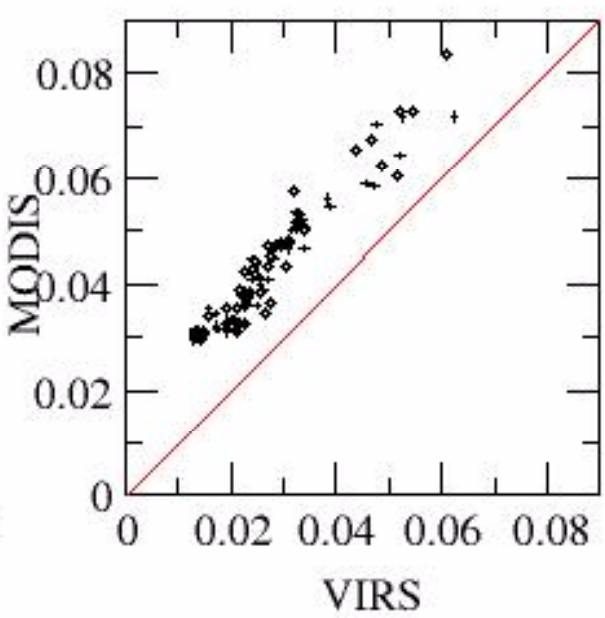
Diff_mean = 0.00497573
Diff_Std = 0.0262765
%Diff = -8.817

1.6 μm



Diff_mean = -0.00156177
Diff_Std = 0.0572435
%Diff = 93.8522

3.7 μm



Diff_mean =-0.0158786
Diff_Std = 0.00339853
%Diff = 66.987

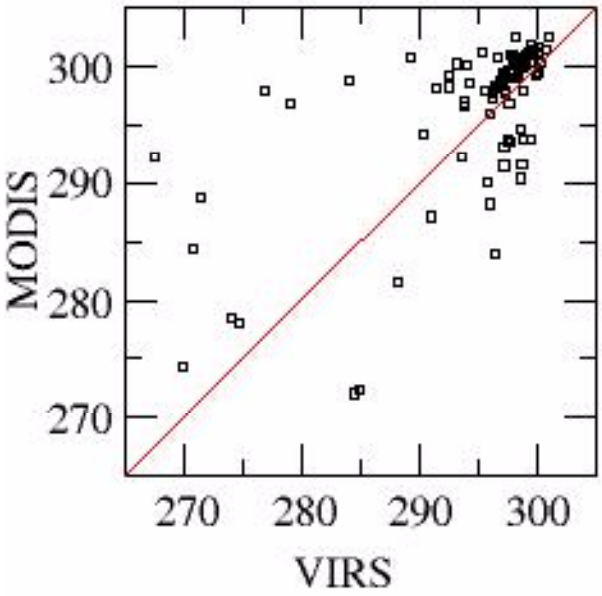
NIGHTTIME

Observed Brightness Temperature (K)

2000070122

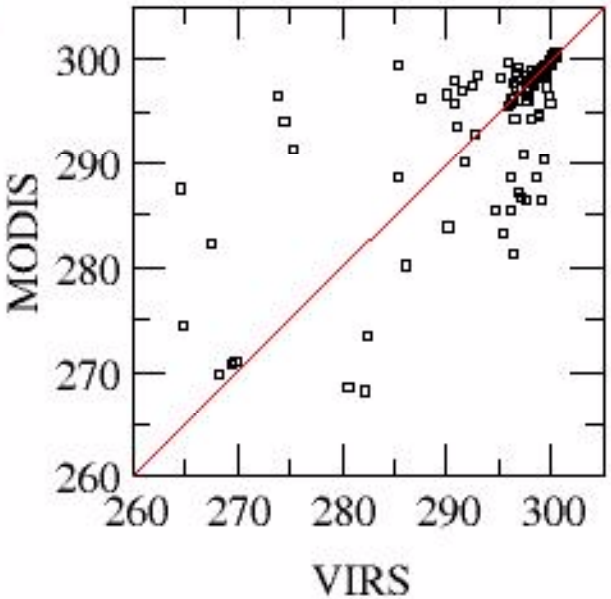
(Vza < 10 deg & Vza_virs - Vza_modis < 5)

3.7 μm



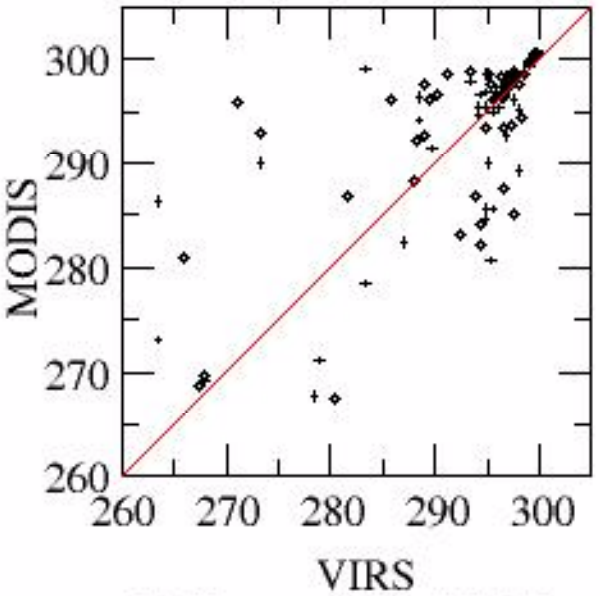
Diff_mean = -1.65478
Diff_Std = 5.6607

11 μm



Diff_mean = 0.21422
Diff_Std = 6.53555

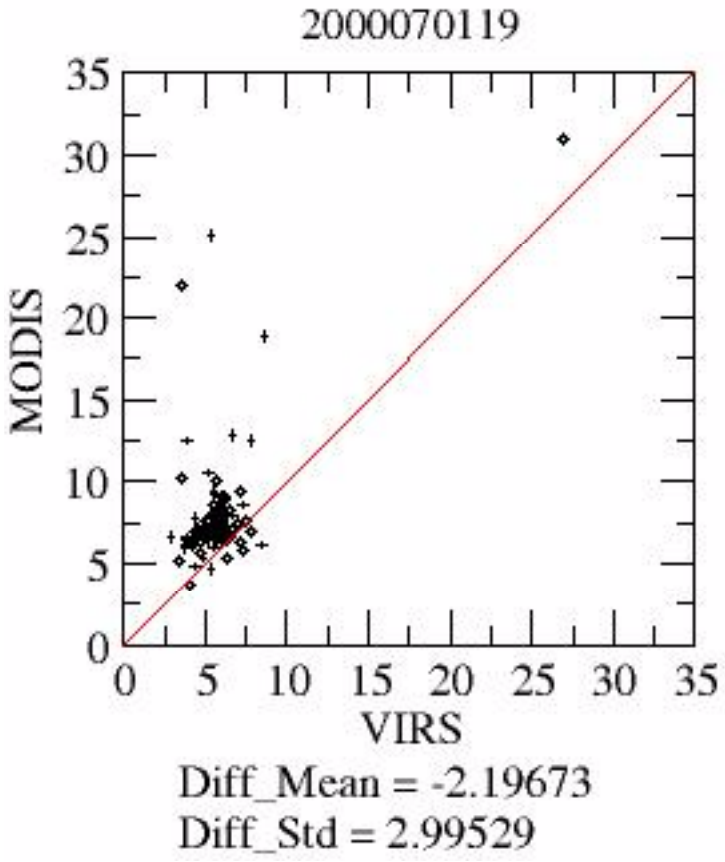
12 μm

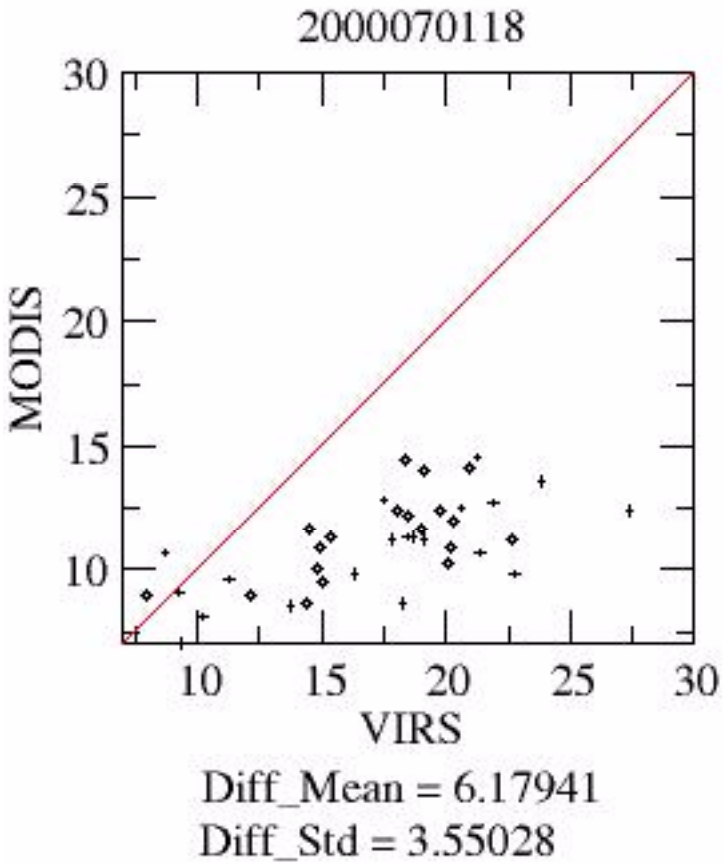


Diff_mean = -0.668743
Diff_Std = 6.63106

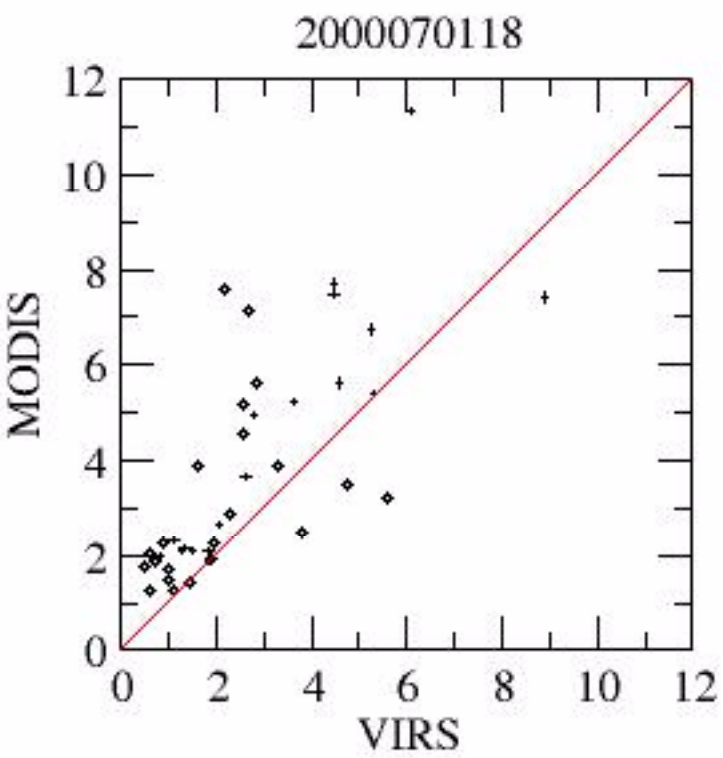
EFFECTIVE RADIUS COMPARISONS (μm)

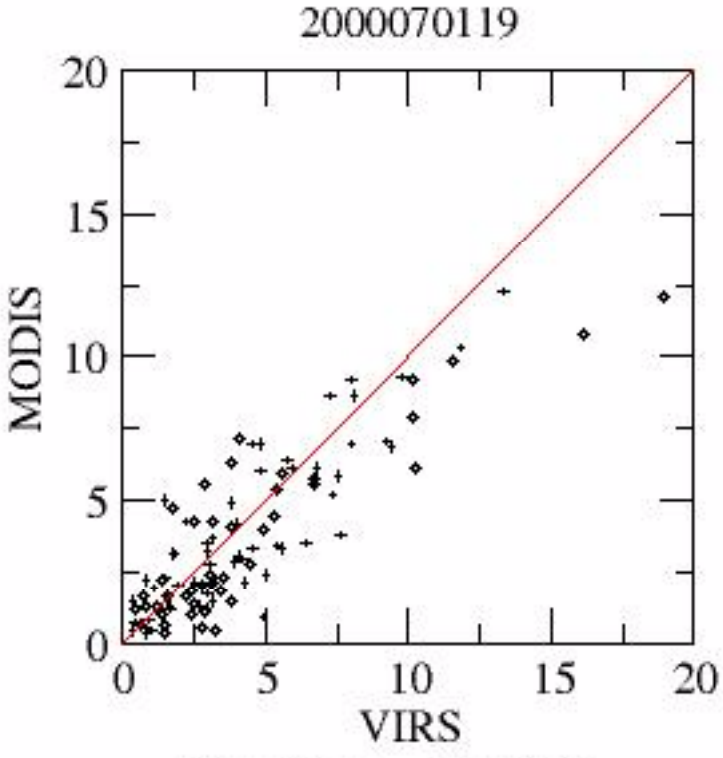
AFTER NEW MODELS



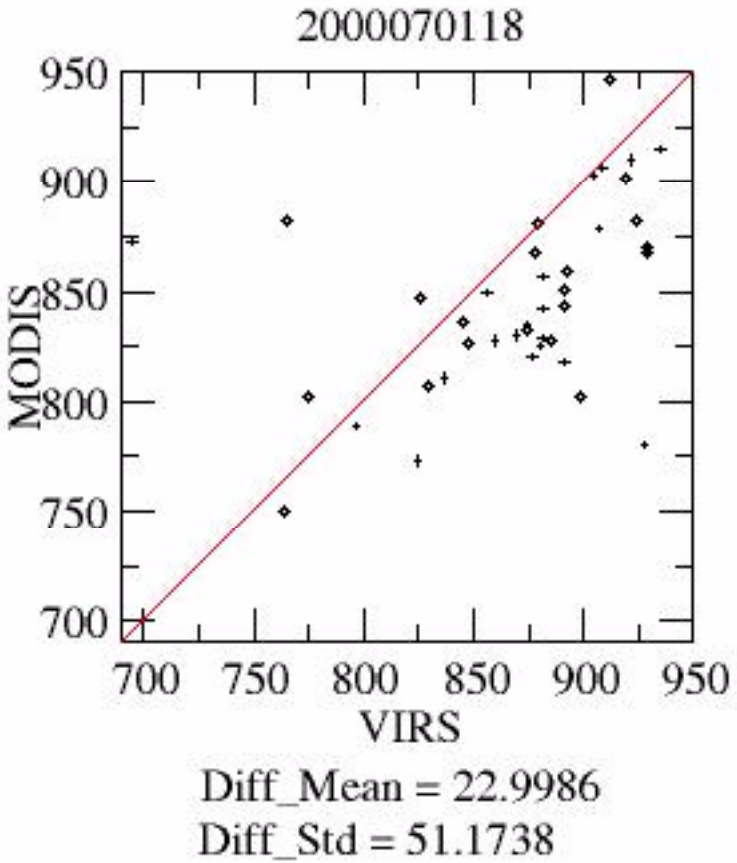


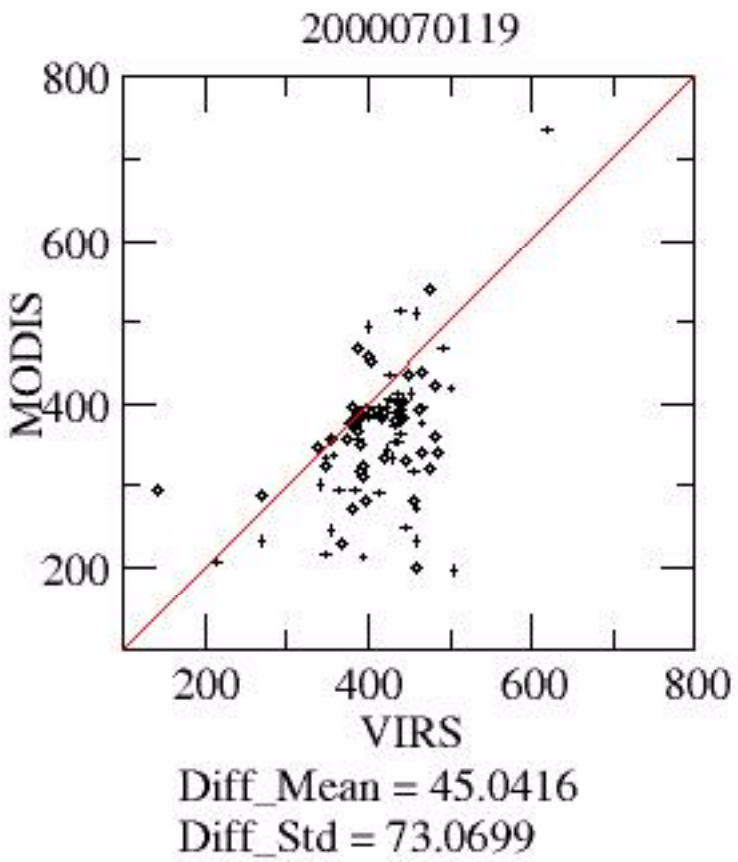
OPTICAL DEPTH COMPARISONS

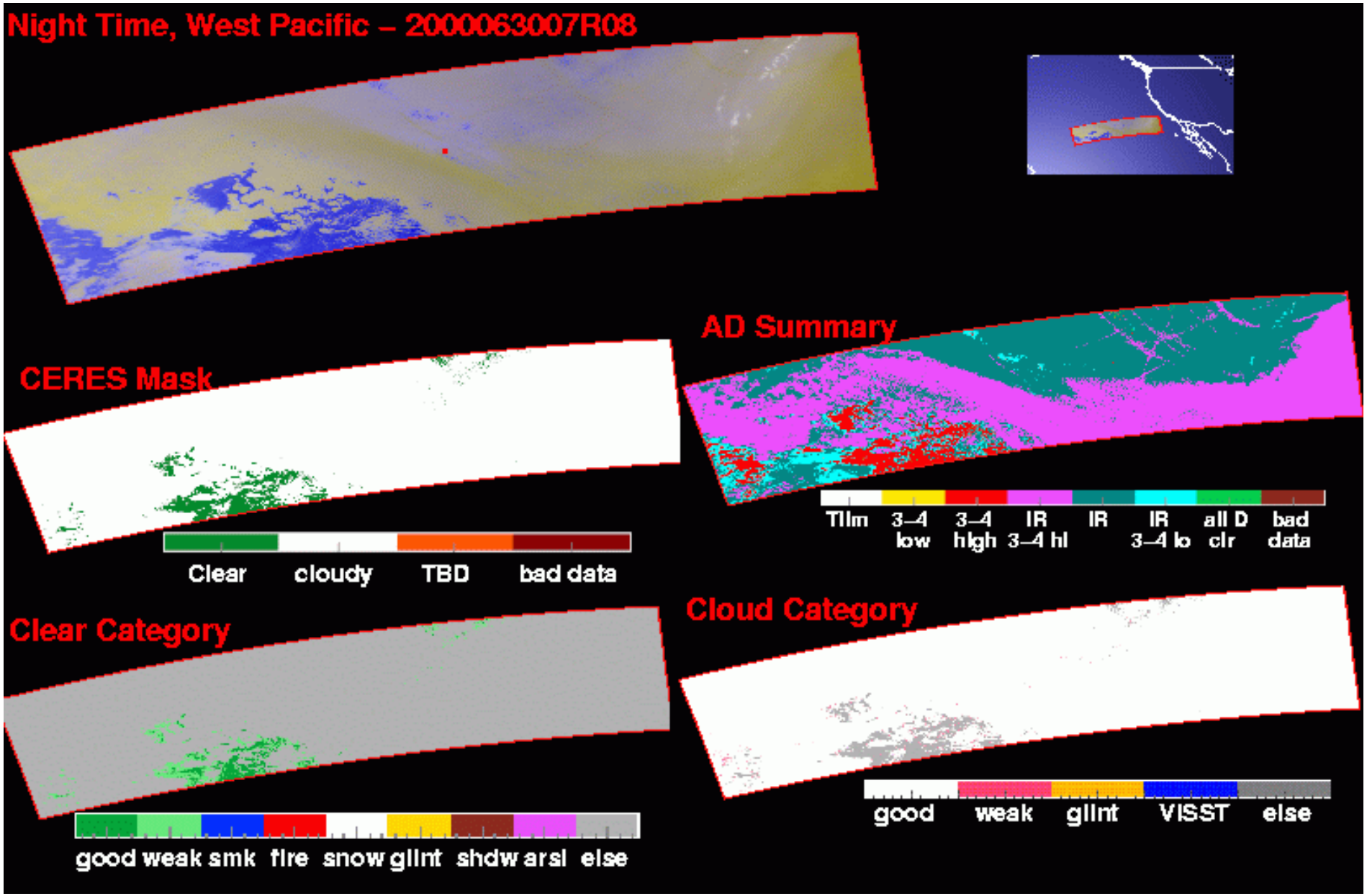


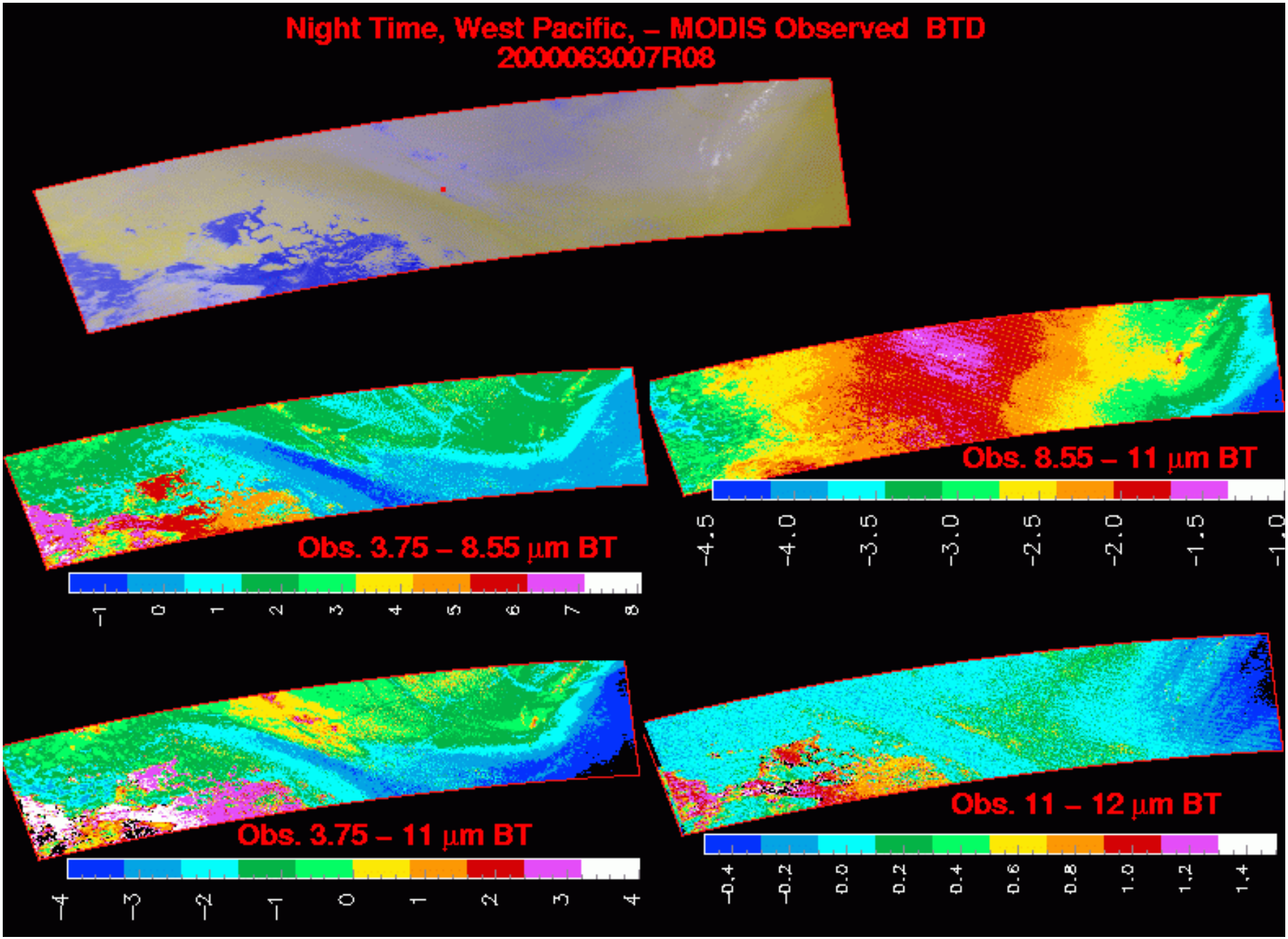


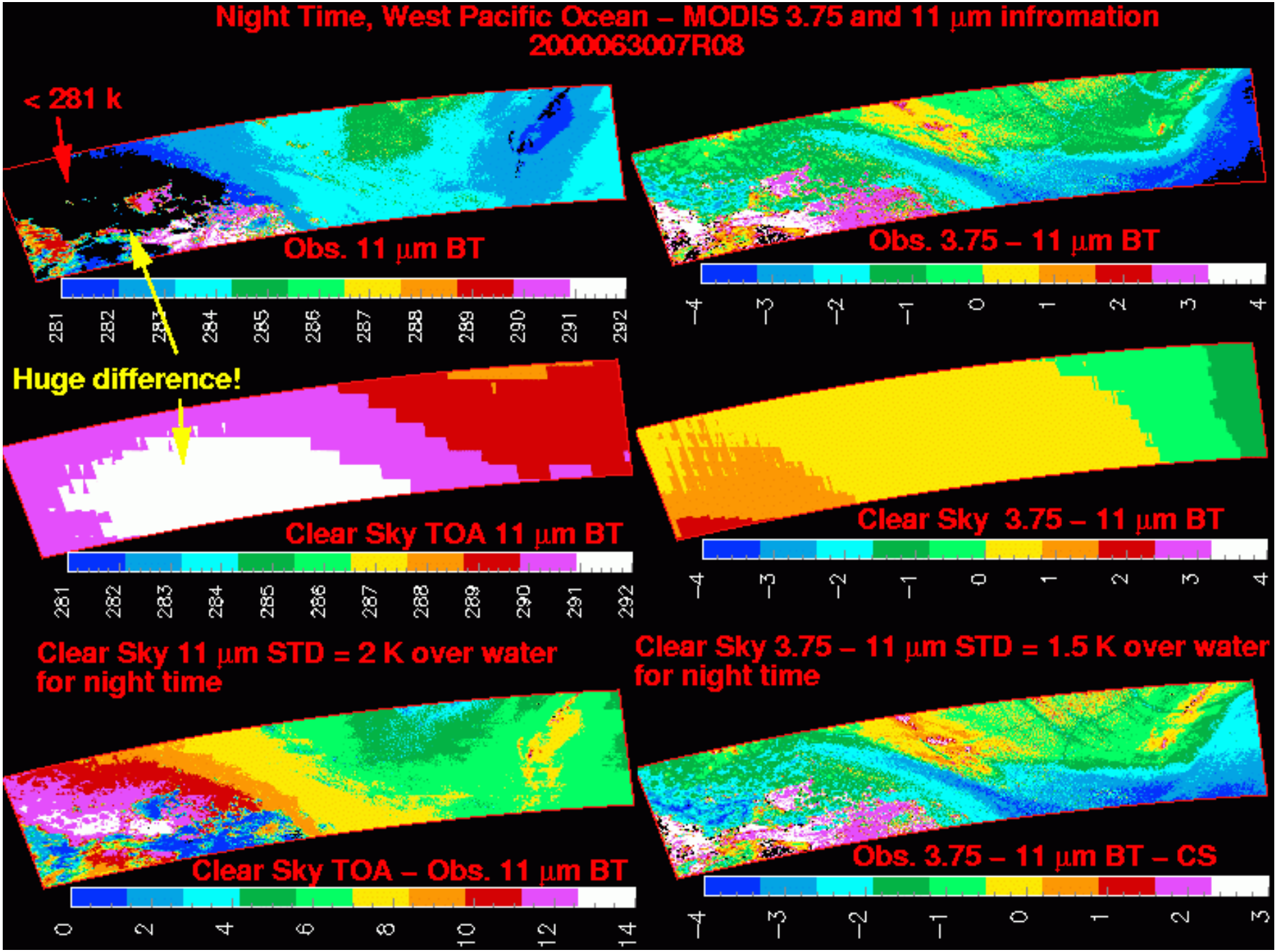
CLOUD PRESSURE COMPARISONS

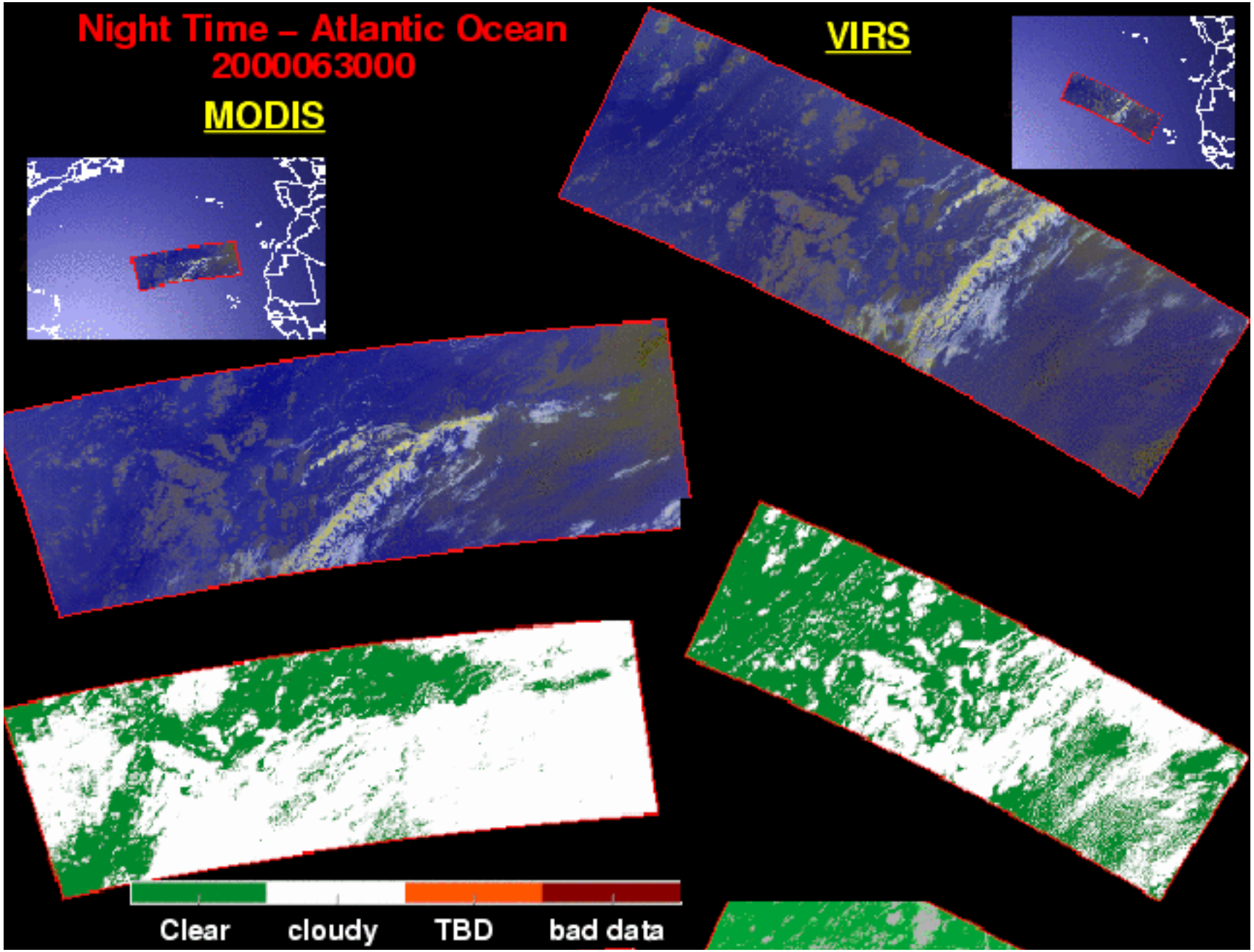


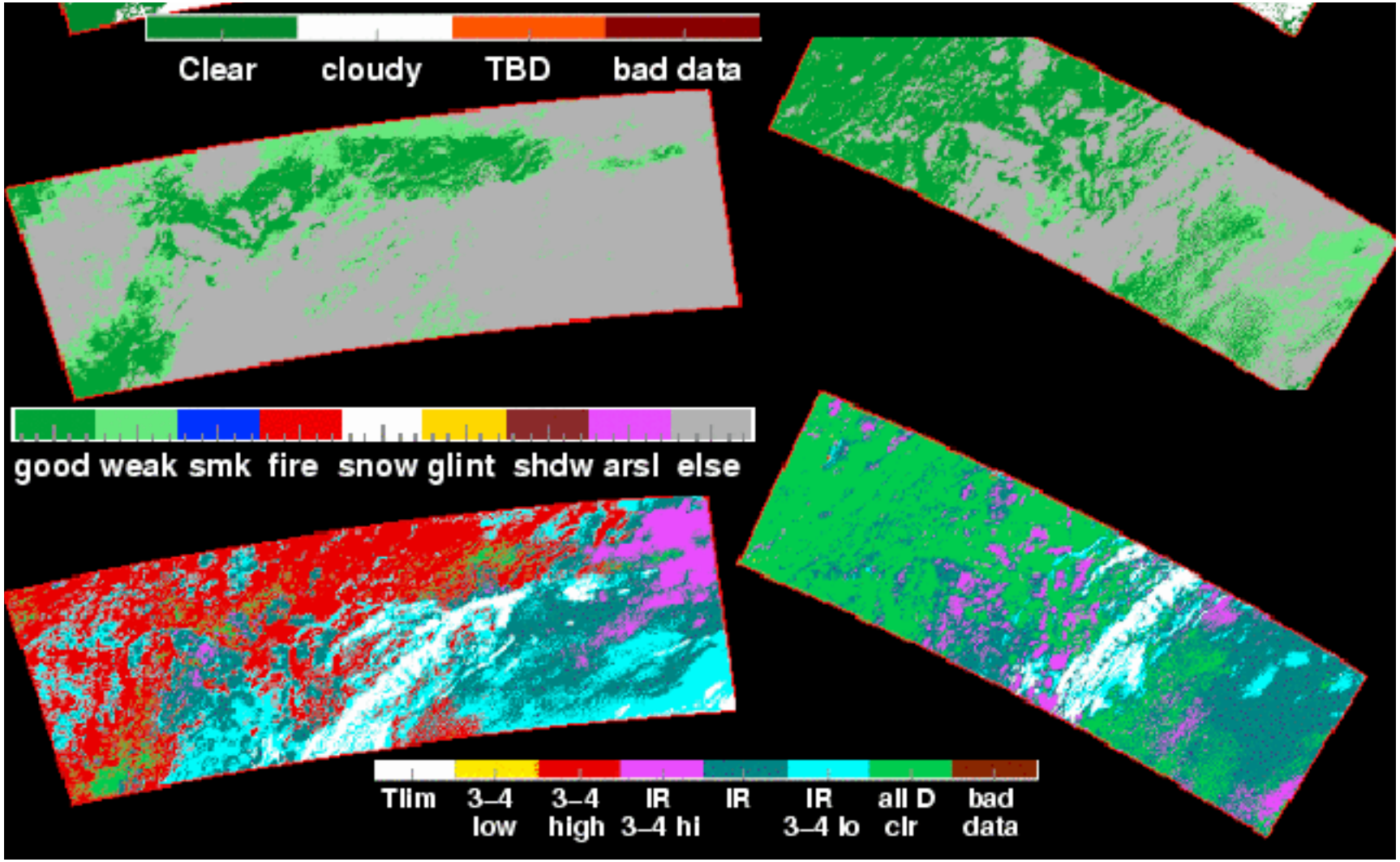


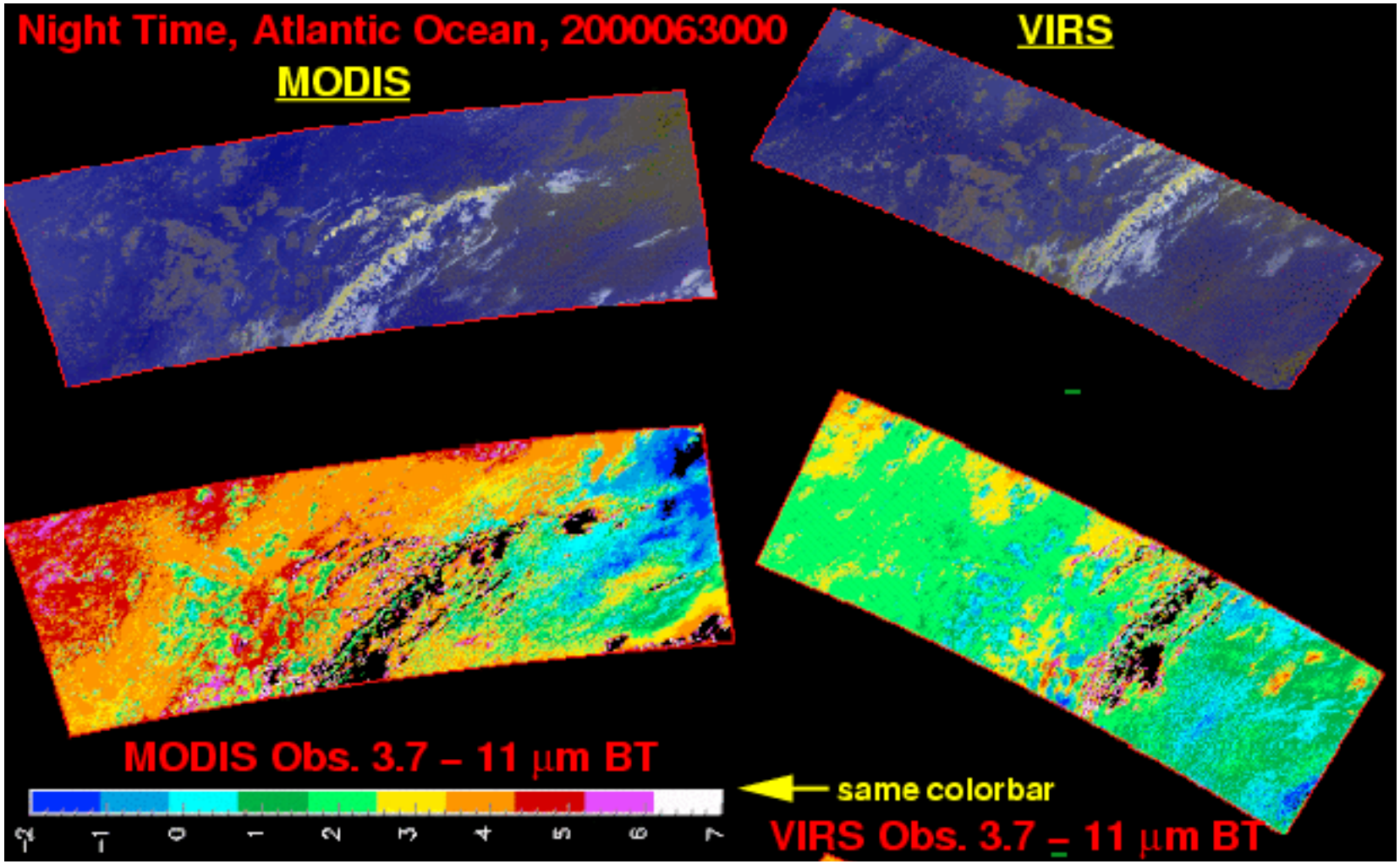

Night Time, West Pacific – 2000063007R08
CERES Mask
Clear
cloudy
TBD
bad data
AD Summary
Tllm
3–4 low
3–4 high
IR 3–4 hl
IR
IR 3–4 lo
all D clr
bad data
Clear Category
good
weak
smk
fire
snow
glint
shdw
arsl
else
Cloud Category
good
weak
glint
VISST
else

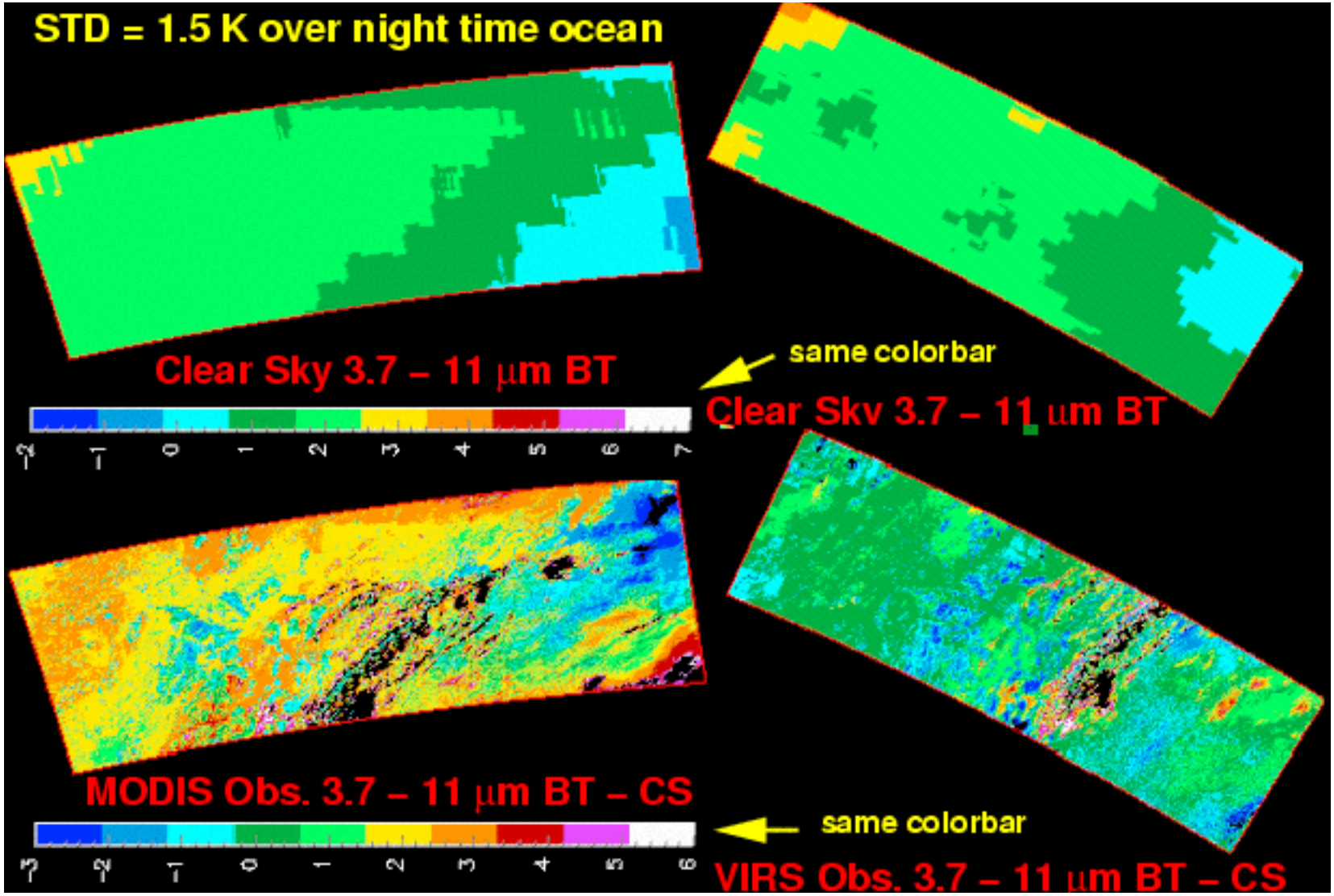

Night Time, West Pacific, – MODIS Observed BTD
2000063007R08
Obs. 3.75 – 8.55 μm BT
-1 0 1 2 3 4 5 6 7 8
Obs. 8.55 – 11 μm BT
-4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0
Obs. 3.75 – 11 μm BT
-4 -3 -2 -1 0 1 2 3 4
Obs. 11 – 12 μm BT
-0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

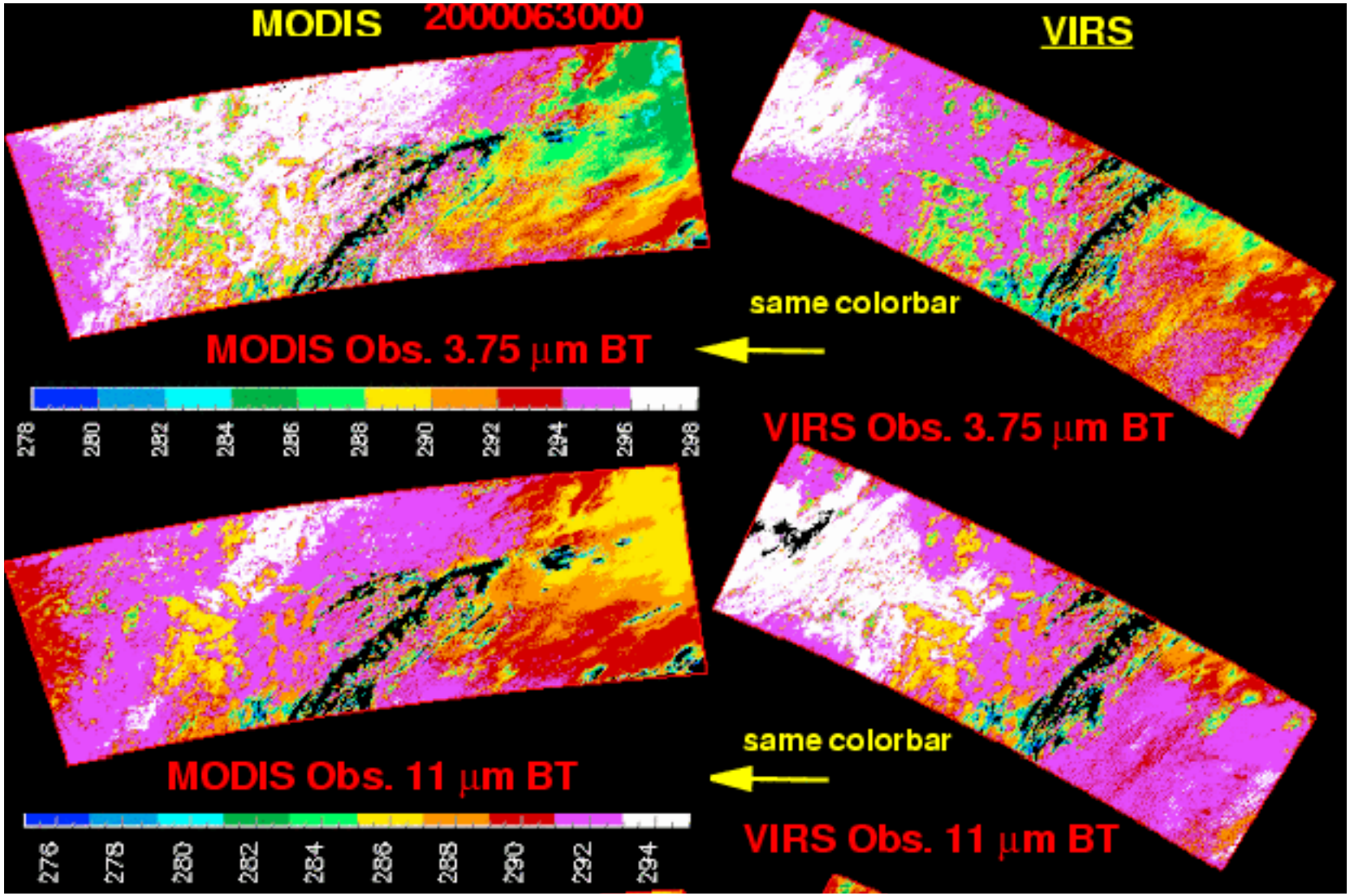

Night Time, West Pacific Ocean – MODIS 3.75 and 11 μm infromation
2000063007R08
< 281 k
Obs. 11 μm BT
281 282 283 284 285 286 287 288 289 290 291 292
Obs. 3.75 – 11 μm BT
−4 −3 −2 −1 0 1 2 3 4
Huge difference!
Clear Sky TOA 11 μm BT
281 282 283 284 285 286 287 288 289 290 291 292
Clear Sky 3.75 – 11 μm BT
−4 −3 −2 −1 0 1 2 3 4
Clear Sky 11 μm STD = 2 K over water
for night time
Clear Sky TOA – Obs. 11 μm BT
0 2 4 6 8 10 12 14
Clear Sky 3.75 – 11 μm STD = 1.5 K over water
for night time
Obs. 3.75 – 11 μm BT – CS
−4 −3 −2 −1 0 1 2 3

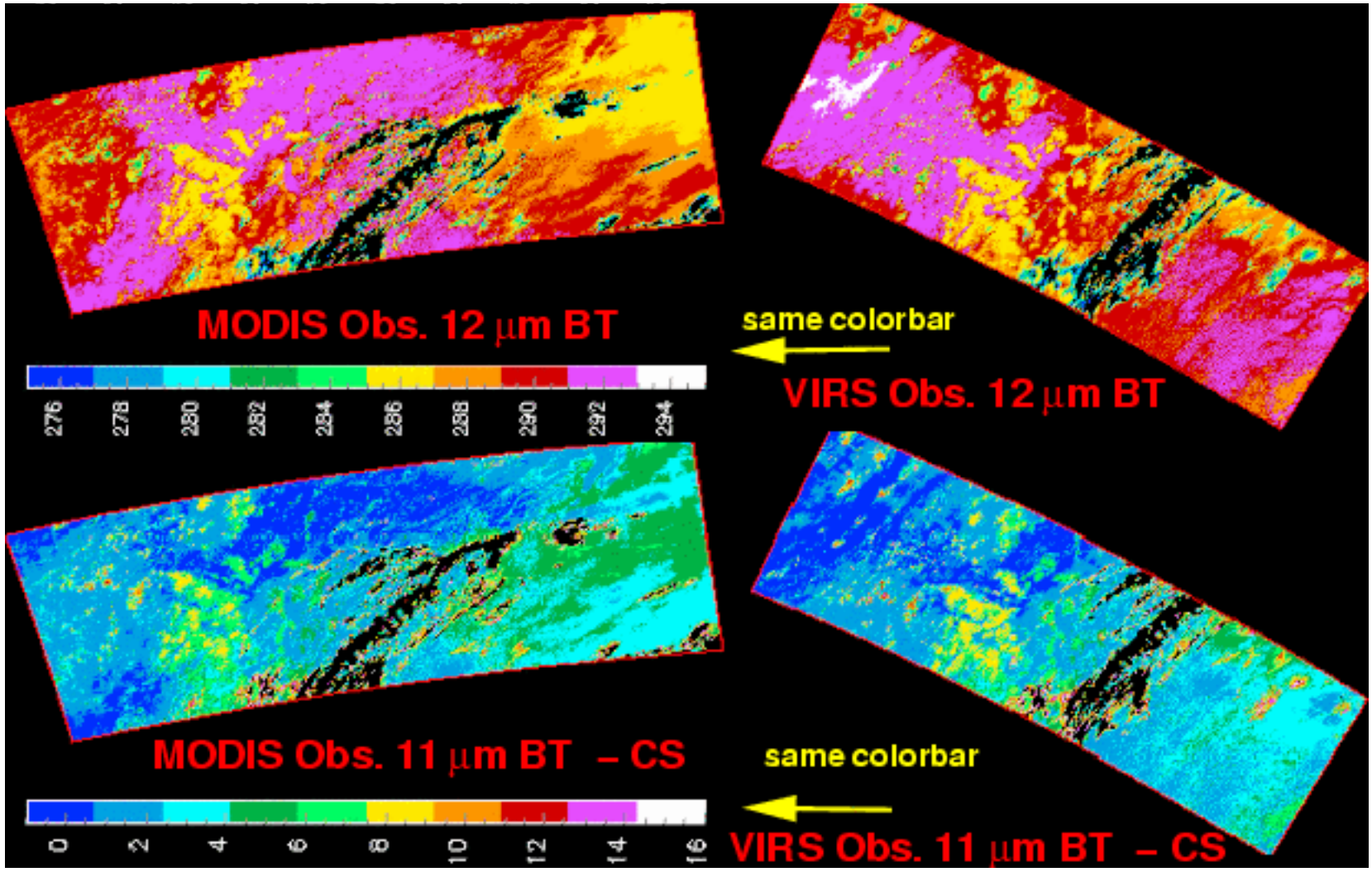

Night Time – Atlantic Ocean
2000063000
MODIS
VIRS
Clear
cloudy
TBD
bad data

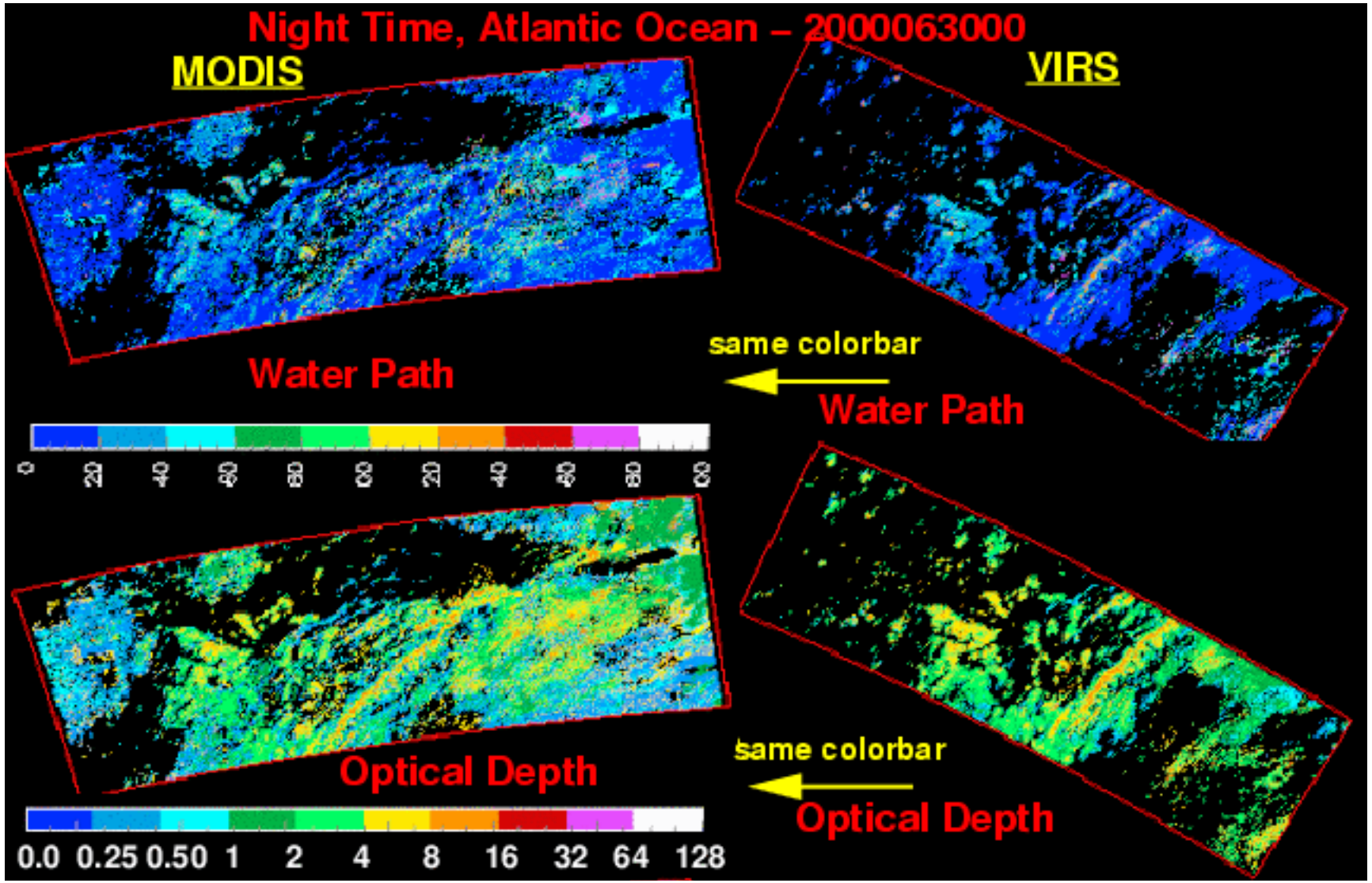

Clear
cloudy
TBD
bad data
good
weak smk
fire
snow
glint
shdw
arsl
else
Tlim
3–4 low
3–4 high
IR 3–4 hi
IR
IR 3–4 lo
all D clr
bad data

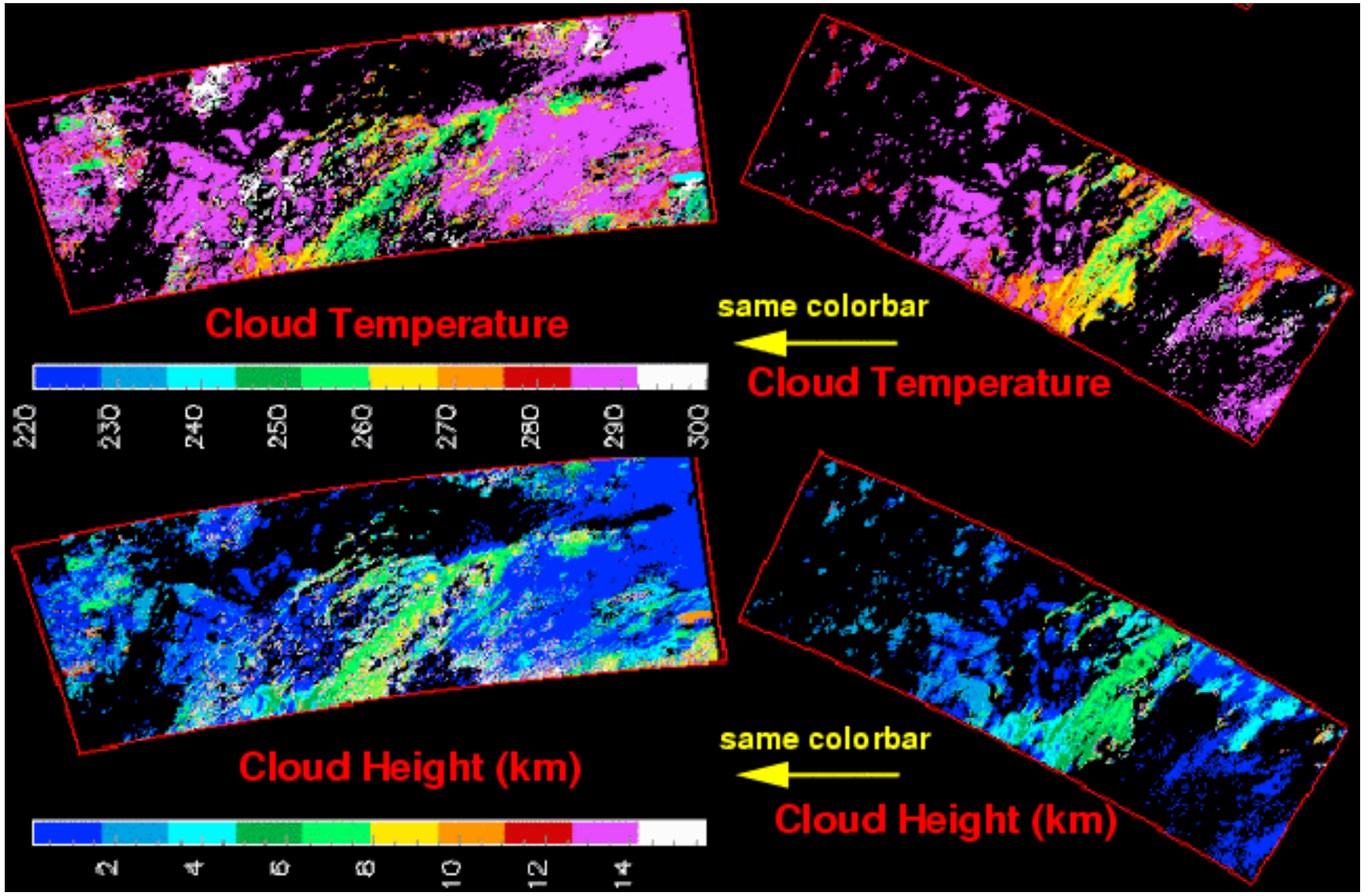

Night Time, Atlantic Ocean, 2000063000
MODIS
VIRS
MODIS Obs. 3.7 – 11 μm BT
same colorbar
VIRS Obs. 3.7 – 11 μm BT


STD = 1.5 K over night time ocean
Clear Sky 3.7 – 11 μm BT
same colorbar
Clear Sky 3.7 – 11 μm BT
MODIS Obs. 3.7 – 11 μm BT – CS
same colorbar
VIRS Obs. 3.7 – 11 μm BT – CS


MODIS 2000063000
VIRS
same colorbar
MODIS Obs. 3.75 μm BT
278 280 282 284 286 288 290 292 294 296 298
VIRS Obs. 3.75 μm BT
same colorbar
MODIS Obs. 11 μm BT
276 278 280 282 284 286 288 290 292 294
VIRS Obs. 11 μm BT


MODIS Obs. 12 μm BT
same colorbar
VIRS Obs. 12 μm BT
276
278
280
282
284
286
288
290
292
294
MODIS Obs. 11 μm BT – CS
same colorbar
VIRS Obs. 11 μm BT – CS
0
2
4
6
8
10
12
14
16


Night Time, Atlantic Ocean – 2000063000
MODIS
VIRS
same colorbar
Water Path
Water Path
0 16 32 48 64 80 96 112 128 144
same colorbar
Optical Depth
Optical Depth
0.0 0.25 0.50 1 2 4 8 16 32 64 128


Cloud Temperature
220
230
240
250
260
270
280
290
300
same colorbar
Cloud Temperature
Cloud Height (km)
2
4
6
8
10
12
14
same colorbar
Cloud Height (km)

SUMMARY OF PRELIMINARY MODIS ANALYSES

- **VIRS & MODIS CALIBRATIONS FOR 0.65, 1.6, 10.8 μm ARE VERY CLOSE**
  - 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

- **MODIS CHANNELS 1.38, 8.55, and 13.9 μm LOOK VERY PROMISING**

- **VIRS & MODIS RETRIEVALS ARE GENERALLY CONSISTENT**
  - BIASES IN CLOUD AMT, re, DUE TO CALIBRATION