CERES CLOUD WORKING GROUP STATUS

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

CERES Telecon, September 19, 2001

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

- CALIBRATION

  - Paper submitted to *J. Atmos. Oceanic Technol.* showing stability of VIRS using ATSR-2. CERES, and GOES data. Also includes comparison of provisional MODIS and VIRS. Day-night low temperature difference examined.

  - Paper in preparation showing calibration of VIRS 1.6 µm using ATSR-2, MODIS, MAS, and model calculations

- ALGORITHM STUDIES

  - CLOUD RETRIEVAL PARAMETERIZATION

  - CLOUD MASK CHANGES

    - VZA DEPENDENCE

    - DAYTIME POLAR

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

CHANGES TO CLOUD MASK (Ed 2)

DN1. Used VZA dependent thresholds to reduce VZA-dependence of cloud amount

D2. Improved low clouds detection over sun glint and non-glint ocean from C1, C3.

D3. Used ratio of 1.6 to 0.6 test to improve cloud detection over land from C1 and C3.

D4. Added elevation dependent snow tests and Ci-test thresholds.

D5. Improved the Welch tree: over non-glint water, if CERES cloud mask says weak clear and Welch mask says cloudy, overwrite CERES weak clear with strong clouds.

N1. Improved E2 test by adding T4-T5 test to reduce unreal weak clouds.

N2. Added thin Ci detection in E3 test for land and ocean.

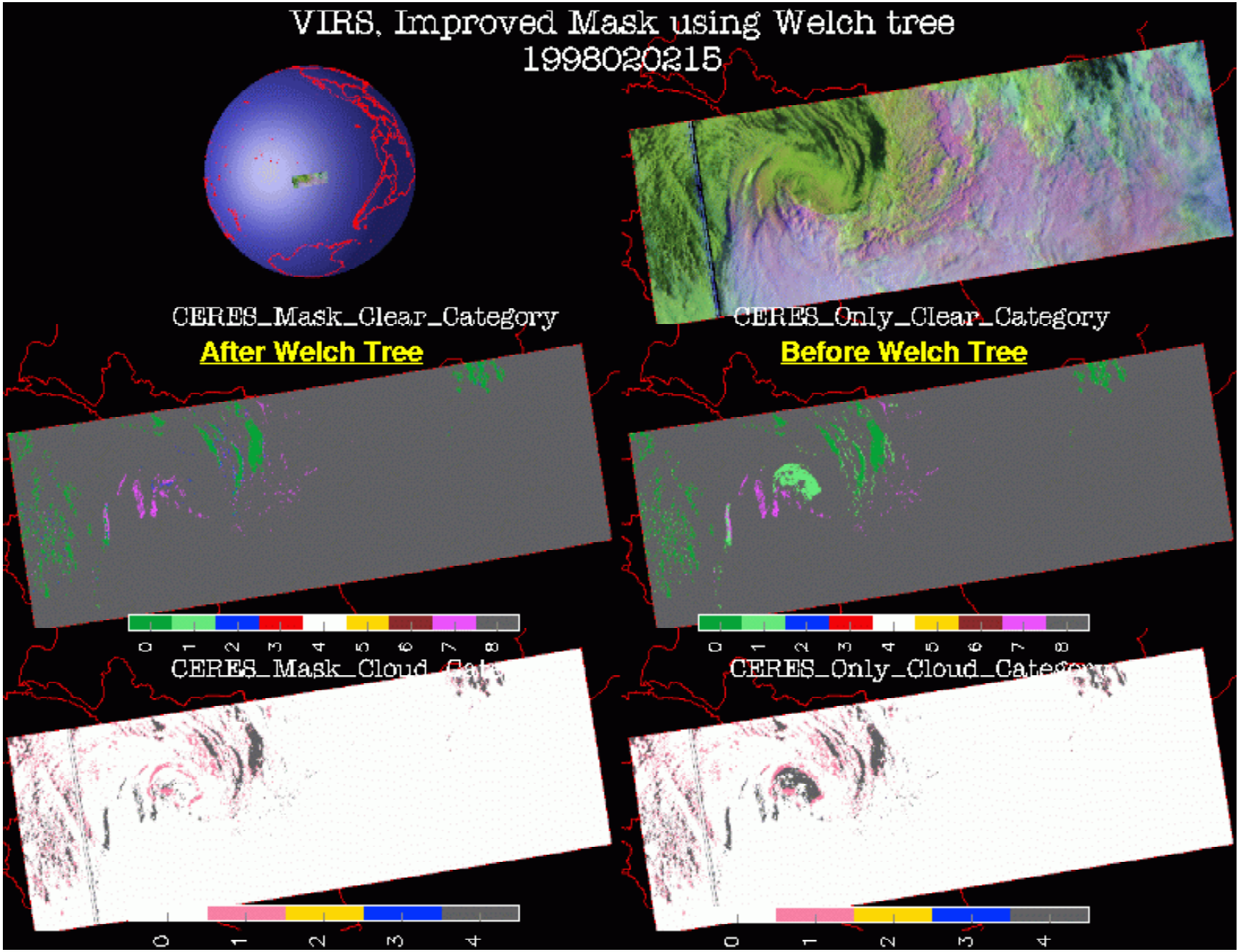
N3. Increased the ocean clear sky 3.7-11 micron standard deviation from 1.5 to 2.0.

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

Improved the Welch tree: over non-glint water
if CERES cloud mask says weak clear & Welch mask says cloudy,
overwrite CERES weak clear with strong clouds.

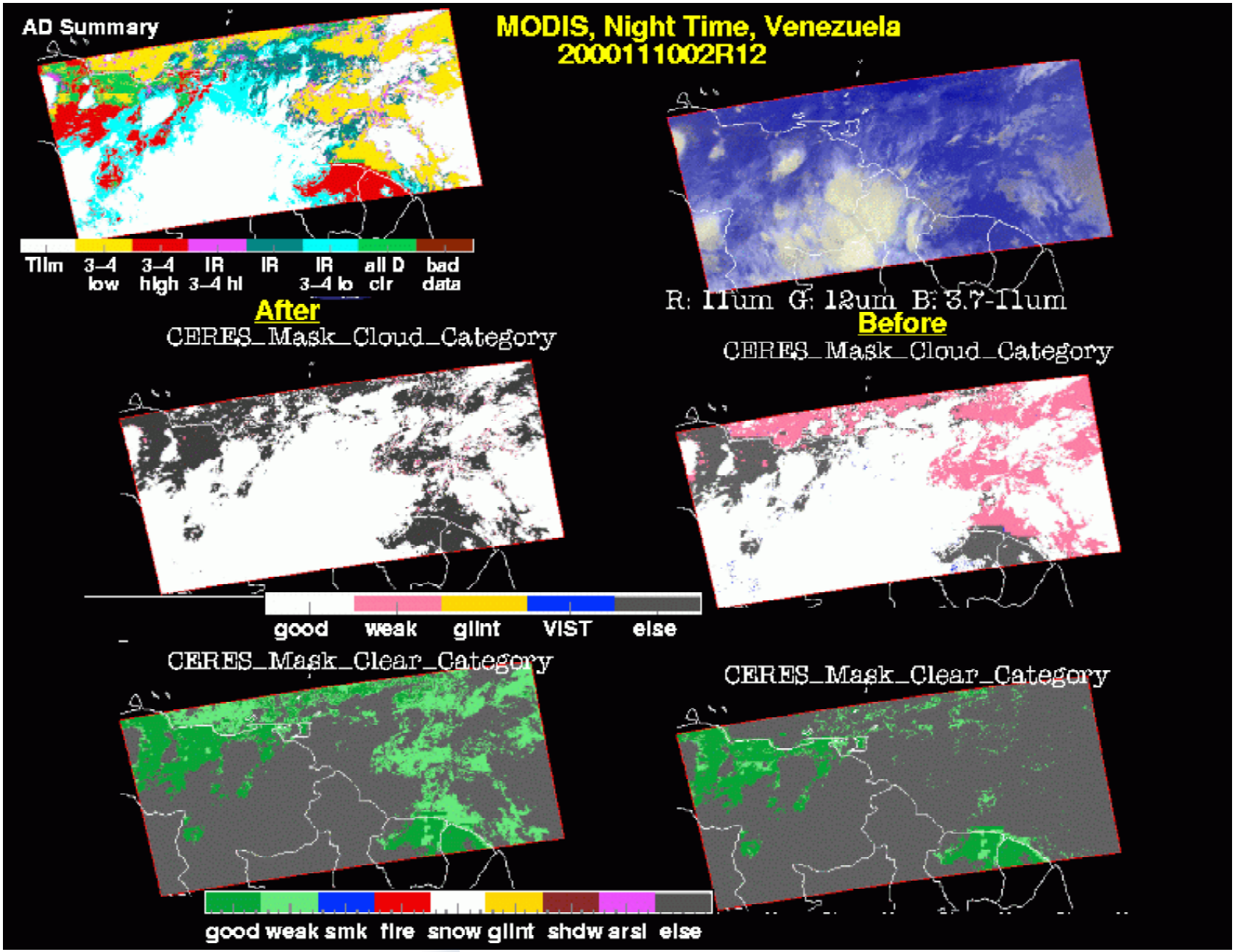
Use Welch Mask to Refine CERES Cloud Mask

CERES Cloud Mask	VISST	Welch Mask	Final Cloud Mask
weak clouds	no retrieval	clear	clear weak
weak clouds	no retrieval	aerosol	clear aerosol
weak clear		clear	clear strong
weak clear		aerosol	clear aerosol
weak clear		smoke, haze	clear smoke
weak clear over non–glint ocean, but at least one B tests say cloudy		cloudy (water, ice, or mixed)	strong cloud



Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

Improved E2 test by adding T4-T5 test to reduce unreal weak clouds.



POLAR MASK

P1. Improved the clear sky snow models for 0.6 , 1.6 and 3.7 micron using MODIS observations.

P2. Improved the clear land detection (after snow melts).

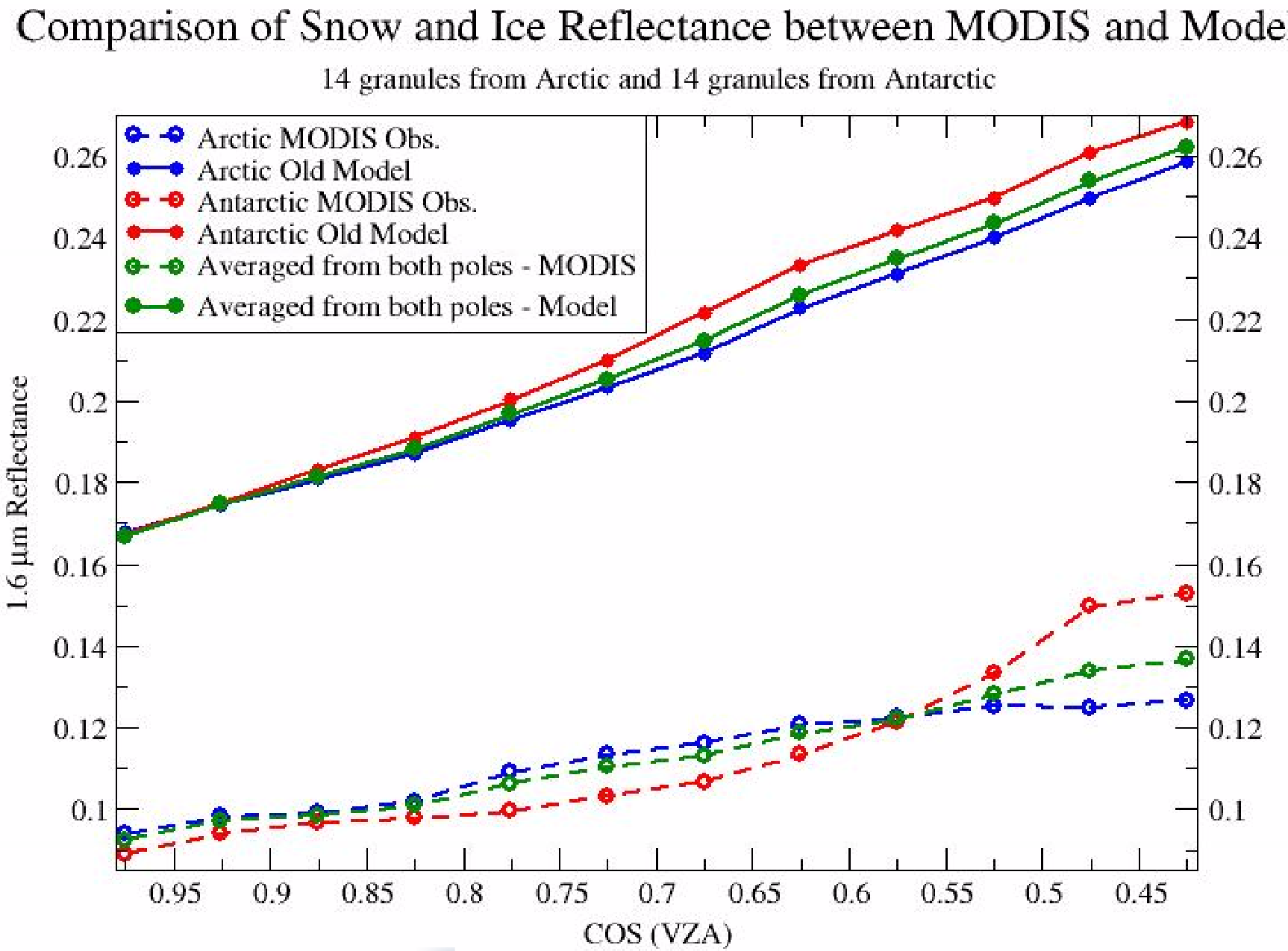
P3. Reduced the uncertain pixels at high sun angles and high view angles.

P4. Improved the ice clouds detection.

P5. Adjusted the thresholds for 3.7-11 micron BTD test and 3.7 reflectance test for the new MODIS calibrations.

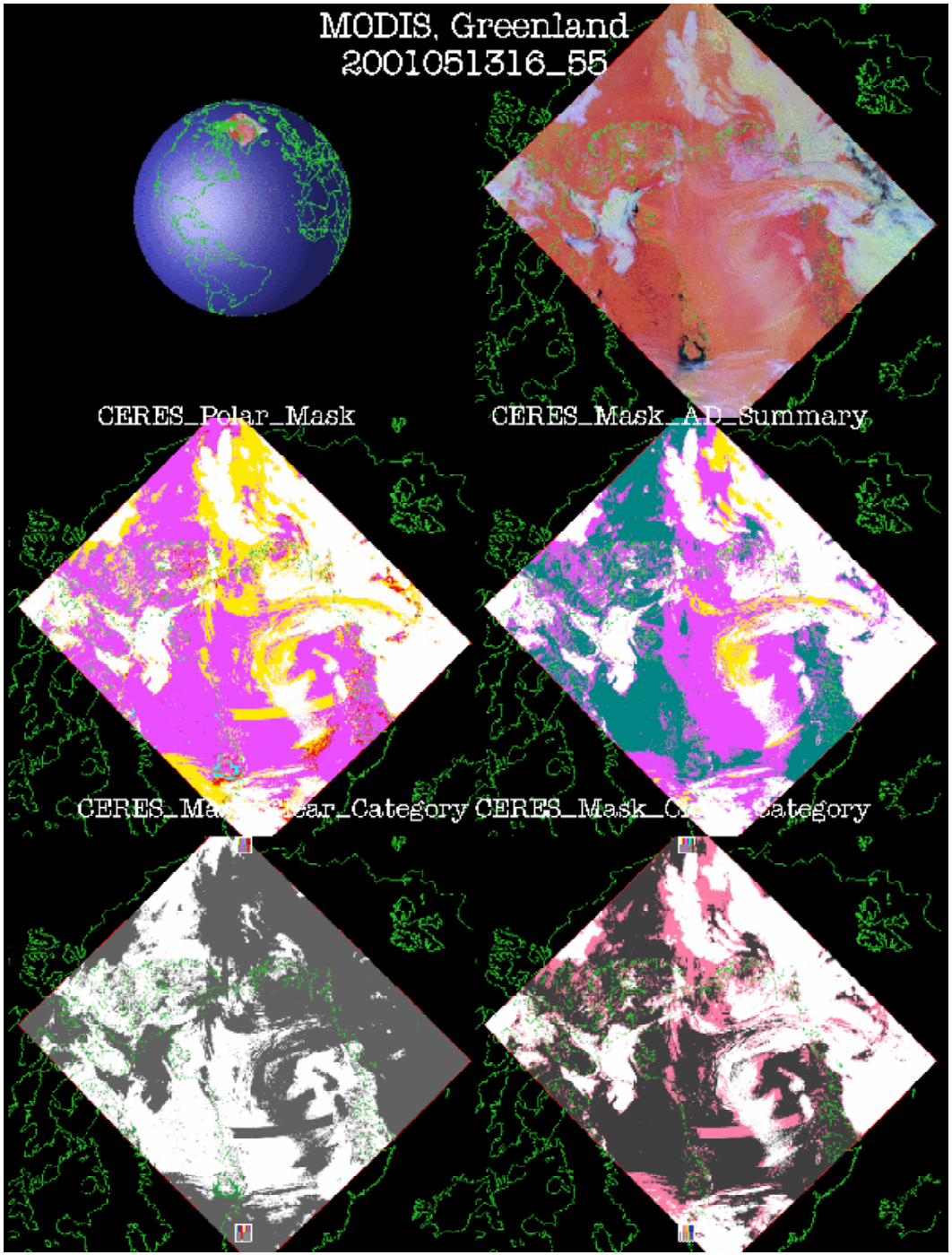
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

Improved clear sky-snow models for 0.6 , 1.6 and 3.7 µm using MODIS data.

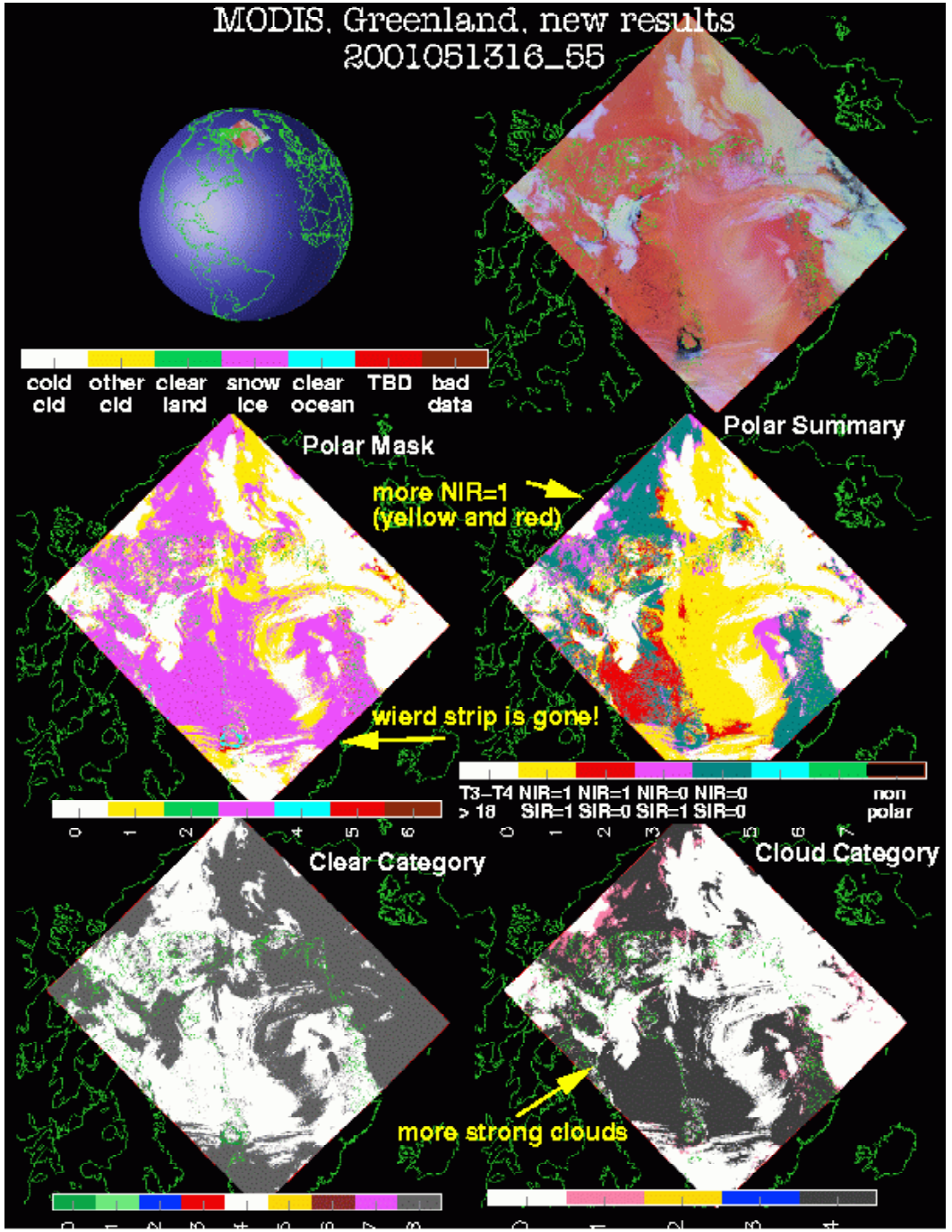


Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

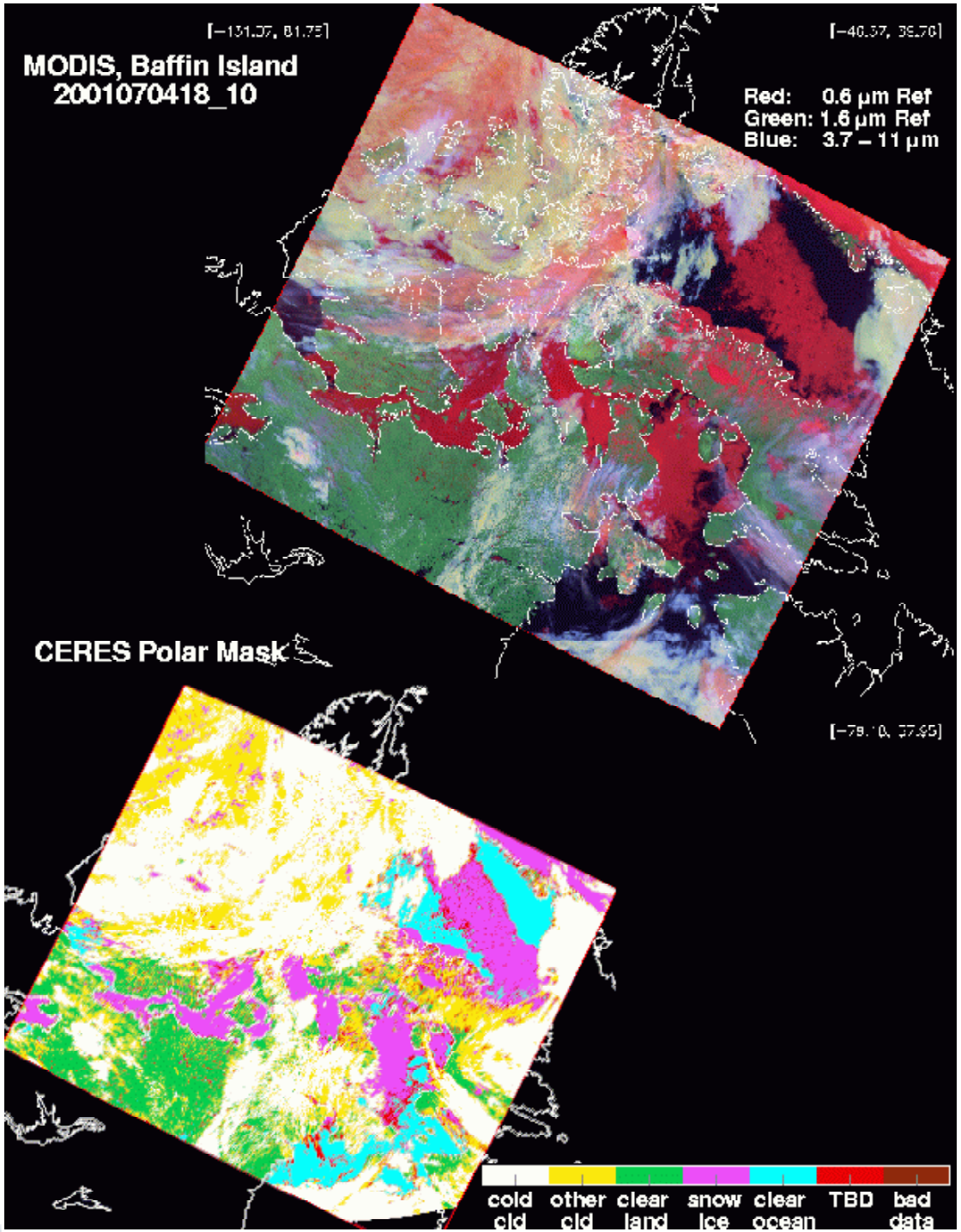
POLAR MASK USING OLD MODELS



POLAR MASK USING NEW MODELS



EXAMPLE OF IMPROVED DAYTIME POLAR MASK



OTHER CLOUD CODE CHANGES

- **Implemented hi-res cloud reflectance models (5° VZ & SZ, 21 RAZ nodes)**
- **1.6-µm cloud retrieval test & validated, not implemented**

VINT: Visible Infrared Near-infrared Technique

- **Corrected interpolation errors in marine strat cloud height estimation**
- **Used updated clear-sky albedo maps from Ed 1 in TRMM Ed 2**
- **Correct VIRS 1.6 um radiance due to temperature variations of the detector.**
- **Implemented Stowe's 3rd generation AOT algorithm**

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

MODIS-RELATED CHANGES TO CLOUD CODE

- **MODIS correlated *k* calculations used for atmospheric absorption**

- **Visible-free daytime retrieval algorithm for polar regions tested and validated, but not turned on yet (clear background is a problem)**

SINT: Solar-infrared Infrared Near-infrared Technique

- **Improved 0.6um, 1.6um, 3.7um clear-sky prediction over snow/ice.**

- **New MODIS reader to read subsetted MODIS radiance file (2x2) and match geolocation file (1x1). This reader can handle both versions (version 1 and version 3), where the difference is the channel selection.**

- **No 3.7μm calibration adjustment used for MODIS.**

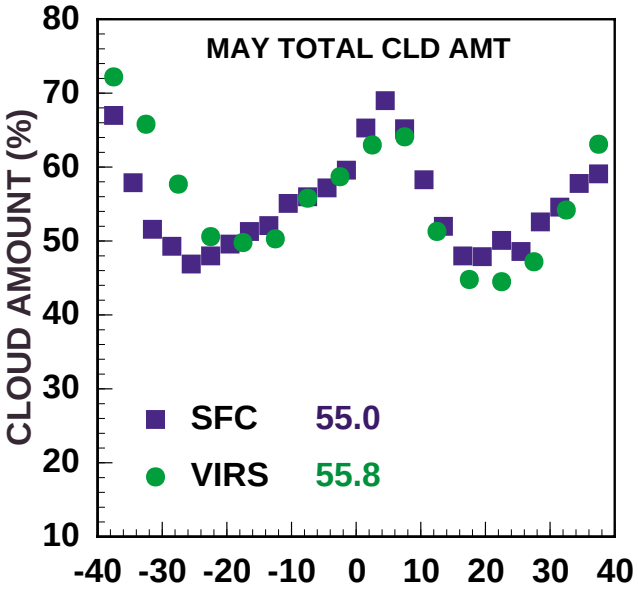
RESULTS

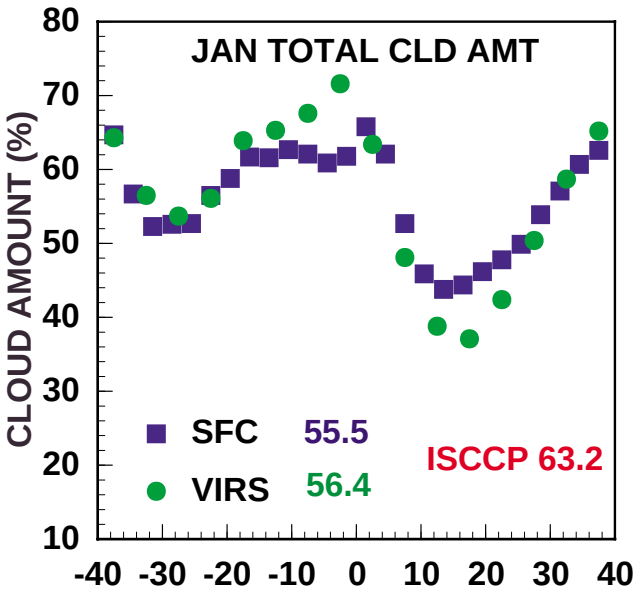
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

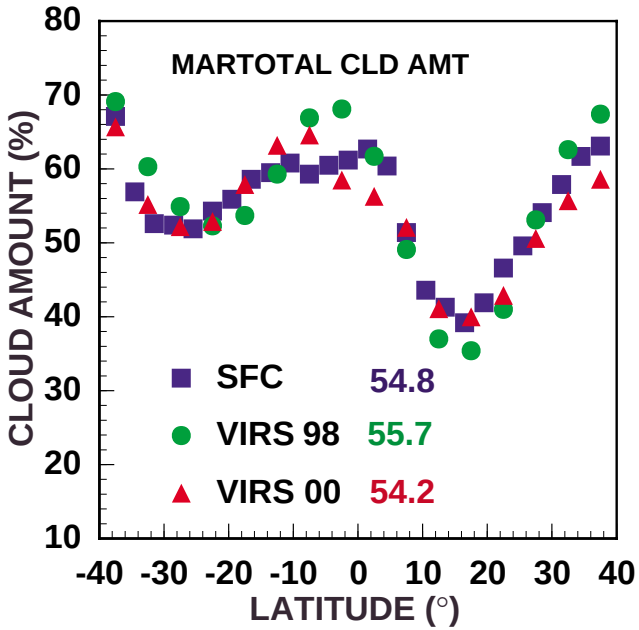
COMPARISONS WITH CLIMATOLOGY

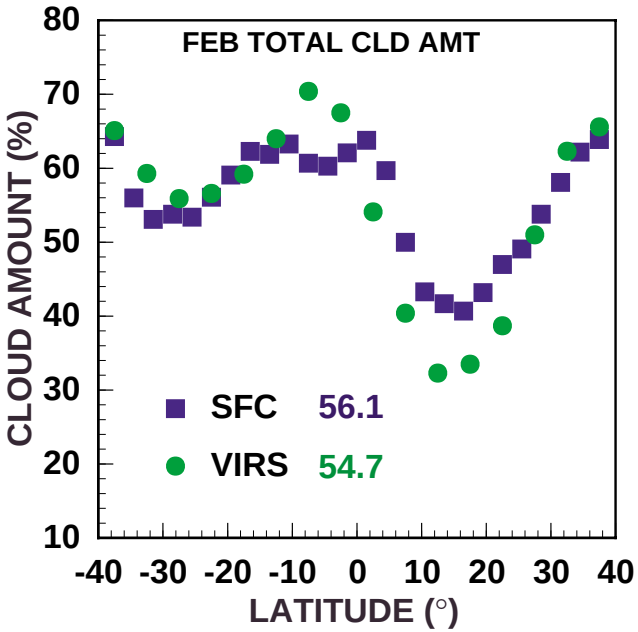
COMPARISON OF TOTAL CLOUD AMOUNTS

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

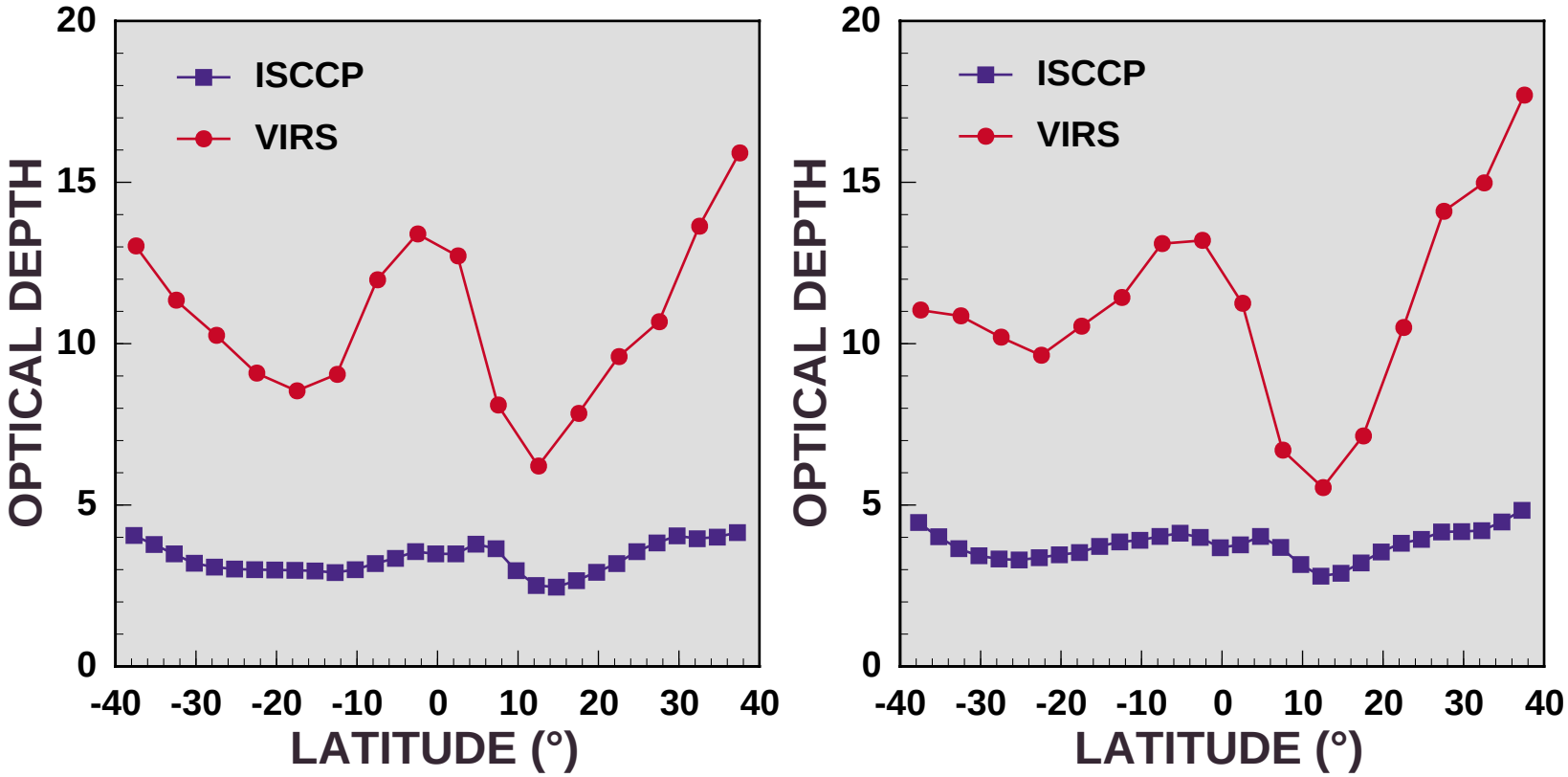








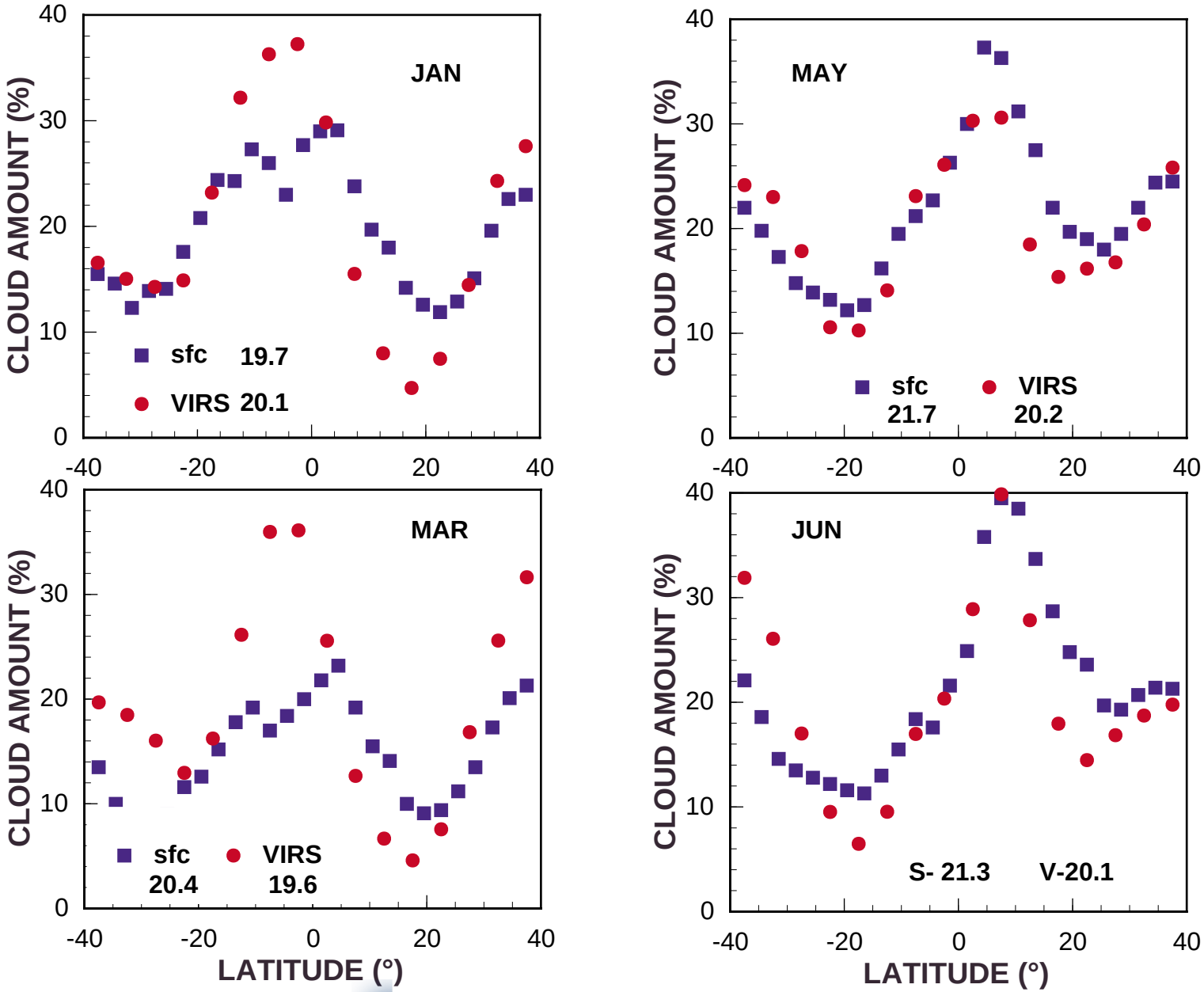
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov



Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

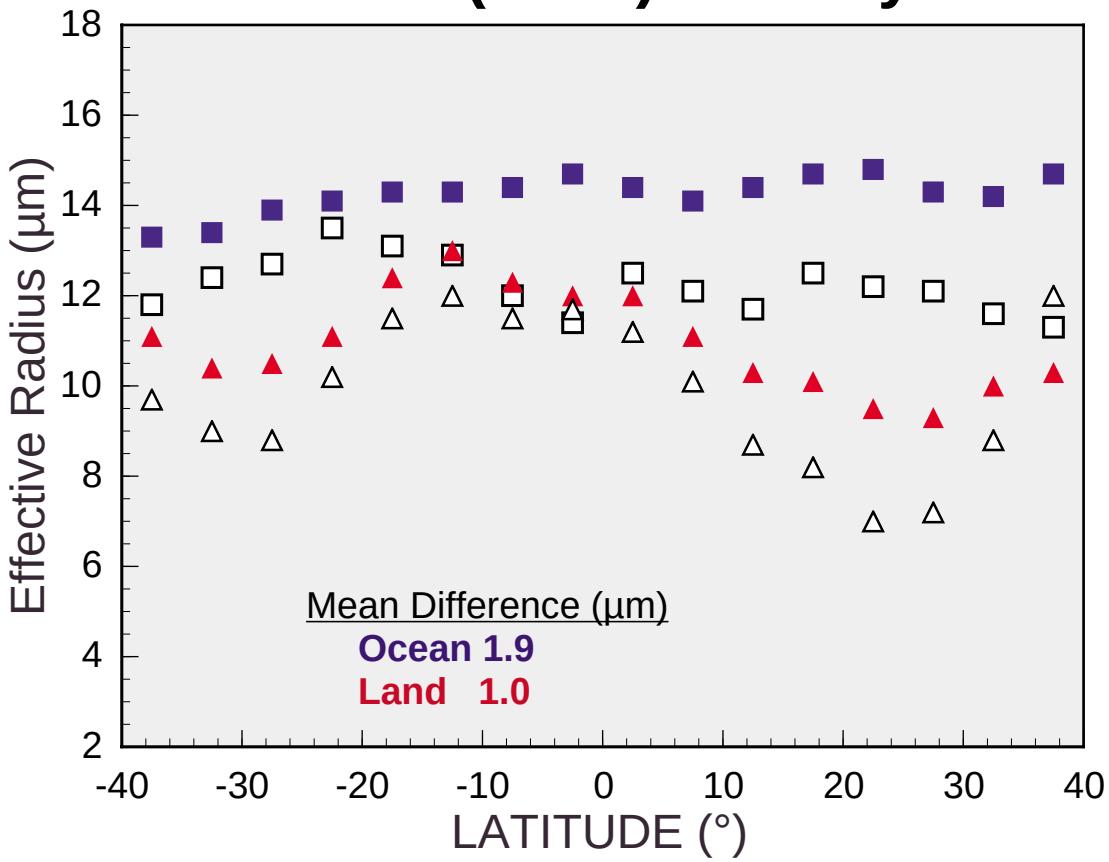
COMPARISON OF SFC-OBSERVED HIGH CLOUD AMOUNTS (1971-1996) AND VIRS-DERIVED COVERAGE BY ICE CLOUDS

VIRS sees 1% fewer ice clouds than SFC



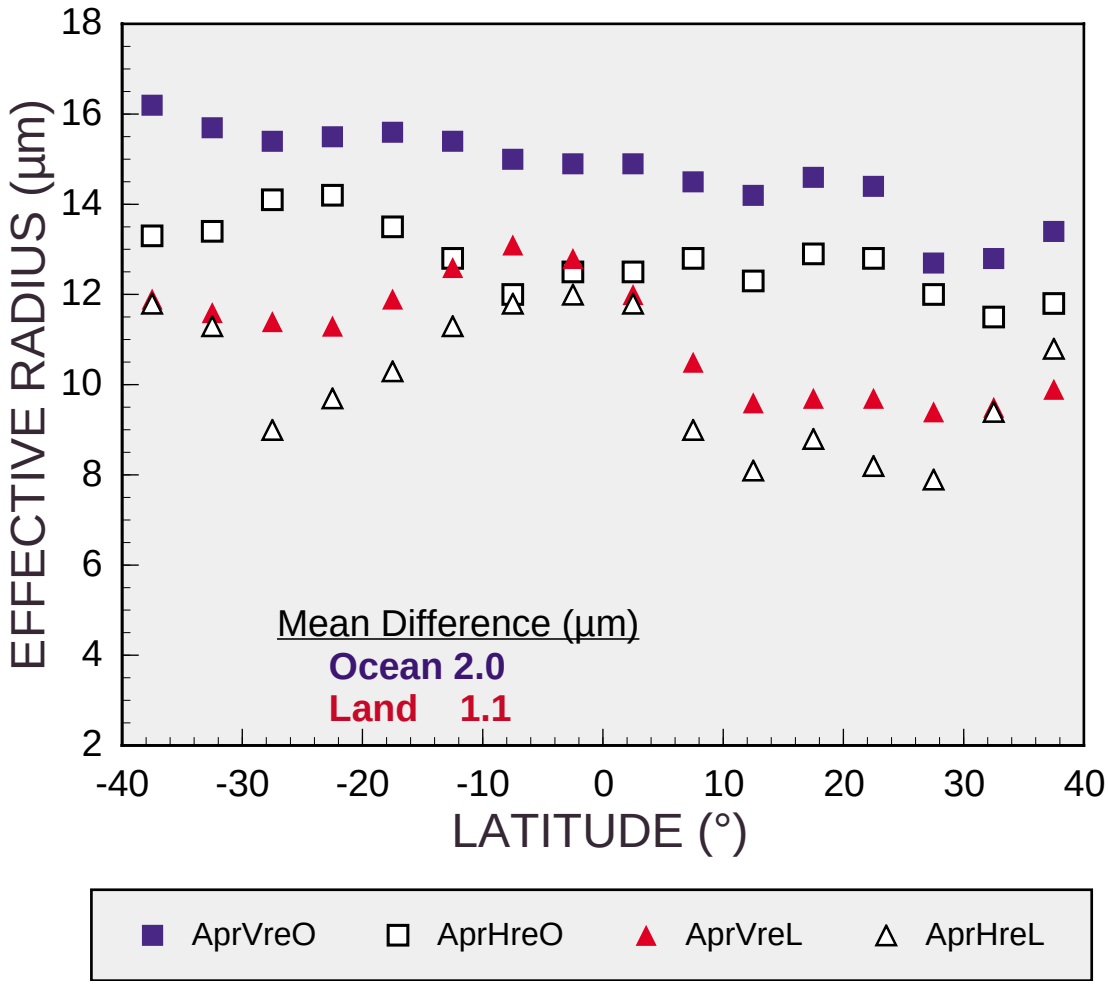
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

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



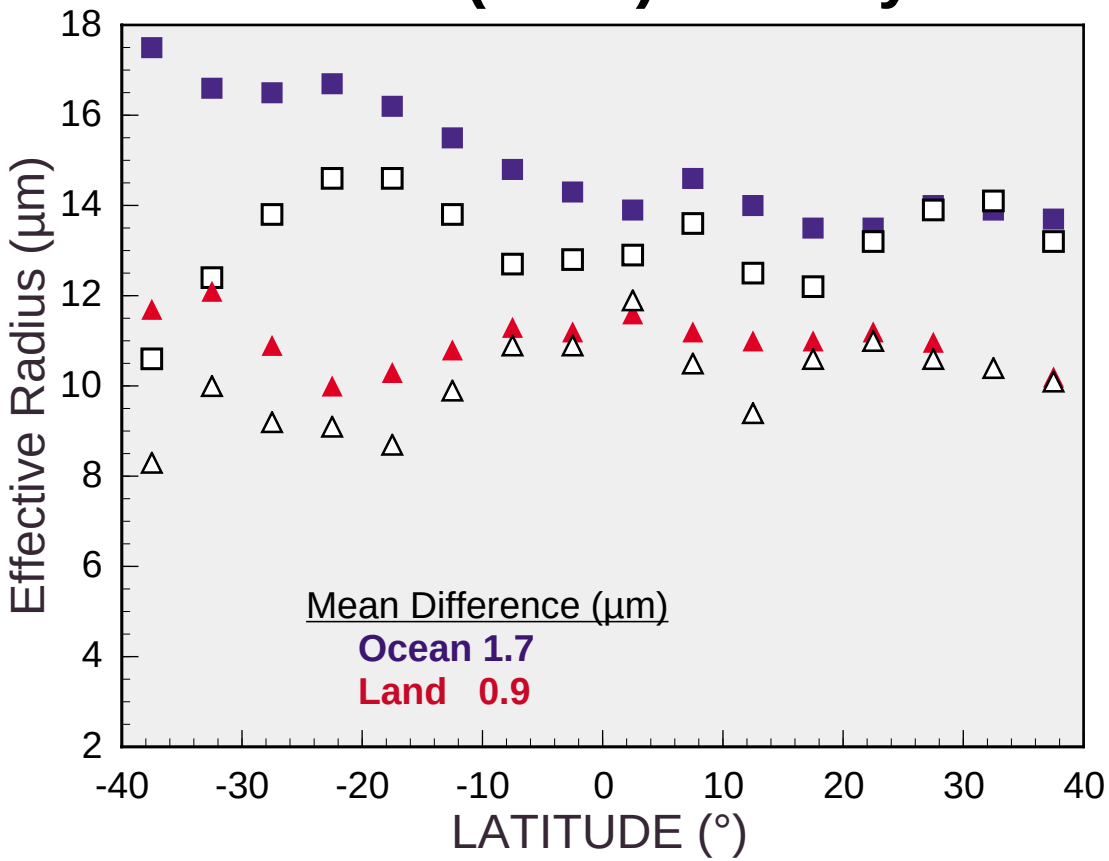
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

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



Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

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



Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

COMPARISONS WITH PREVIOUS DATA

- VIRS-derived r_e is greater than HAN NOAA-9 r_e by
  - ~ 1.9 μm over ocean
  - ~ 1.0 μm over land

- SEASONAL TRENDS SIMILAR

  ZONAL TREND DIFFERENCES VARIABLE

- DIFFERENCES MOST LIKELY DUE TO
  - Inclusion Of Overlapped Clouds, All taus
  - Inclusion Of Partially Filled Pixels
  - SZA Dependencies
  - Slight Errors In Emittance Parameterizations
  - Different atmospheric profiles/corrections

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

EFFECT OF MULTIPLE LAYERS ON RETRIEVED r_e

1 YEAR OF GOES-8 RETRIEVALS OVER ARM SITE

Clouds with a thin layer of cirrus above a low-level deck appear to have larger droplets than single-layer water clouds

A similar effect is realized for broken clouds

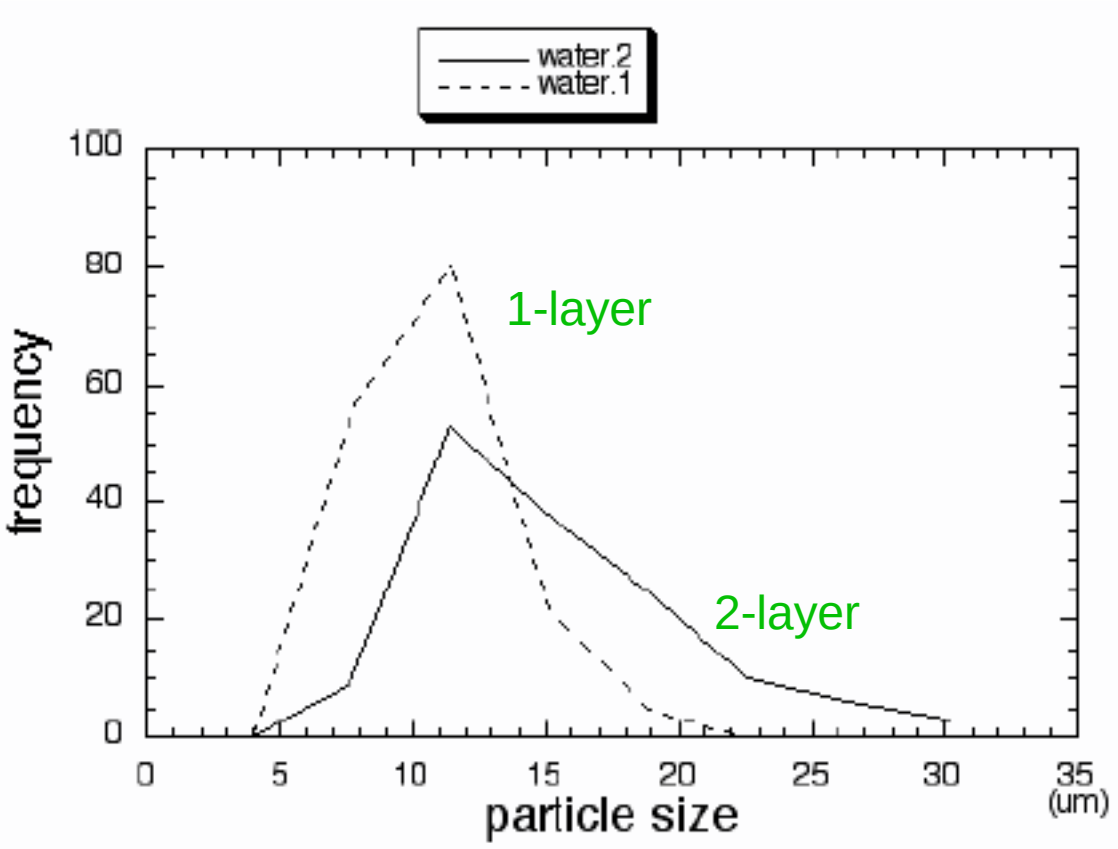


Figure 6. Histograms of cloud water droplet radius for single and multi-layered clouds.

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

EFFECT OF MULTIPLE LAYERS ON RETRIEVED D_e

1 YEAR OF GOES-8 RETRIEVALS OVER ARM SITE

Clouds with a thin layer of cirrus above a low-level deck appear to have smaller ice crystals than single-layer cirrus clouds

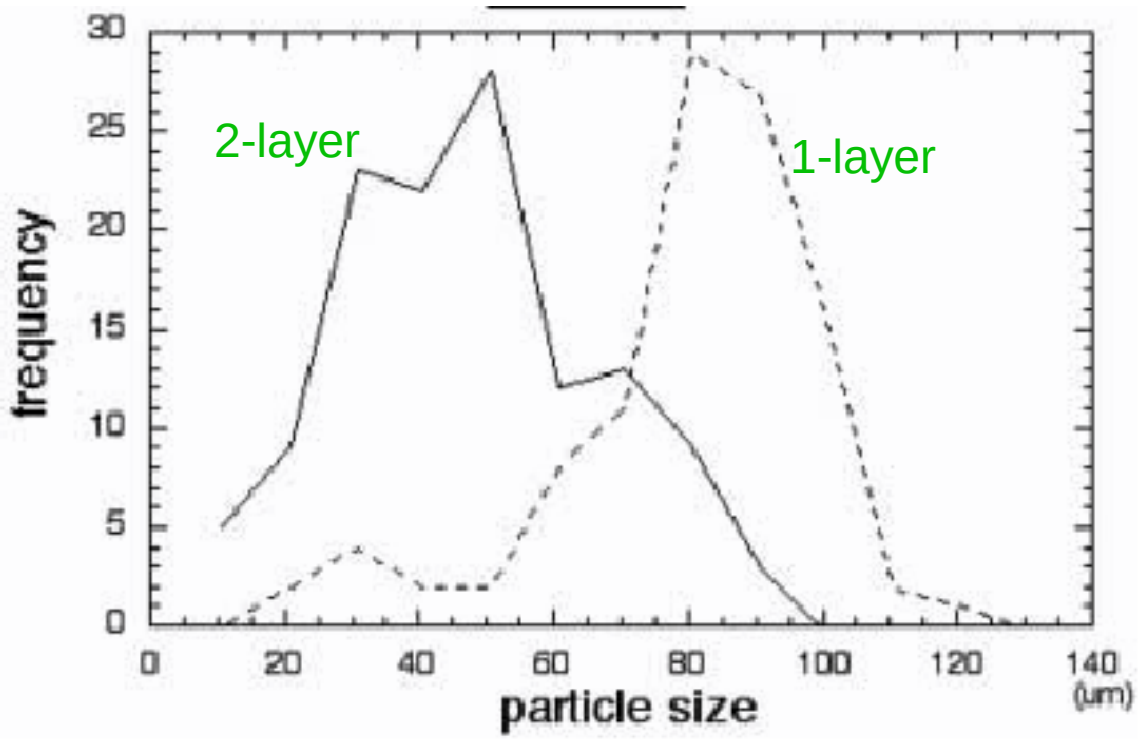


Figure 7. Same as Figure 6, except for cloud ice crystal diameter.

COMPARISONS WITH SURFACE DATA

A Year of Cloud Property Comparison Between CERES/VIRS and Surface Data at the ARM SGP

X. Dong, P.Minnis, S. Sun-Mack,
G.G. Mace, E.E. Clothiaux, and J. Liljegren

Contents:

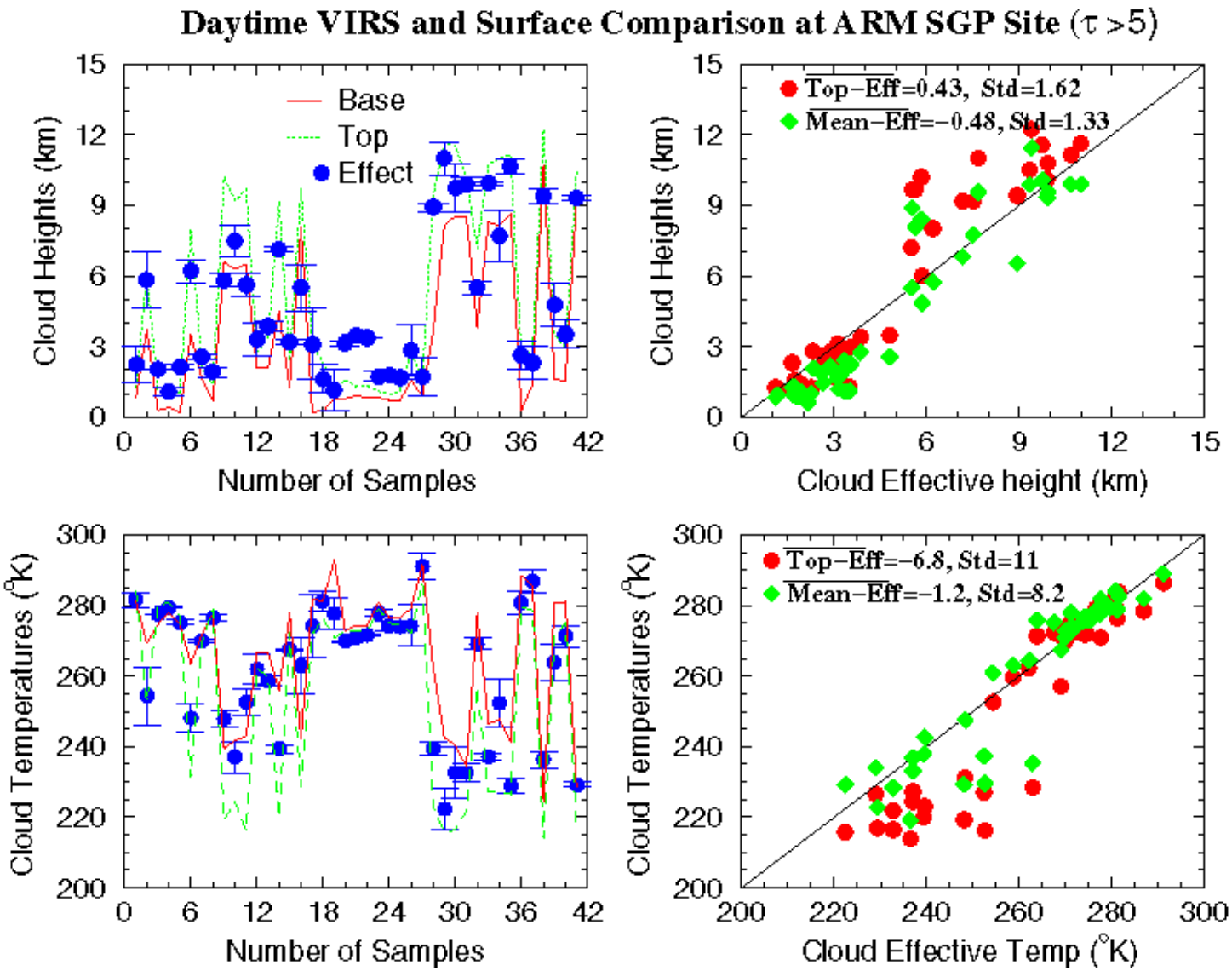
1. **To validate CERES/VIRS macrophysical and microphysical cloud properties using surface data (Updated)**
2. **Preliminary validation of MODIS results using surface data at the ARM SGP and NSA Sites**

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

What's New for VIRS validation ?

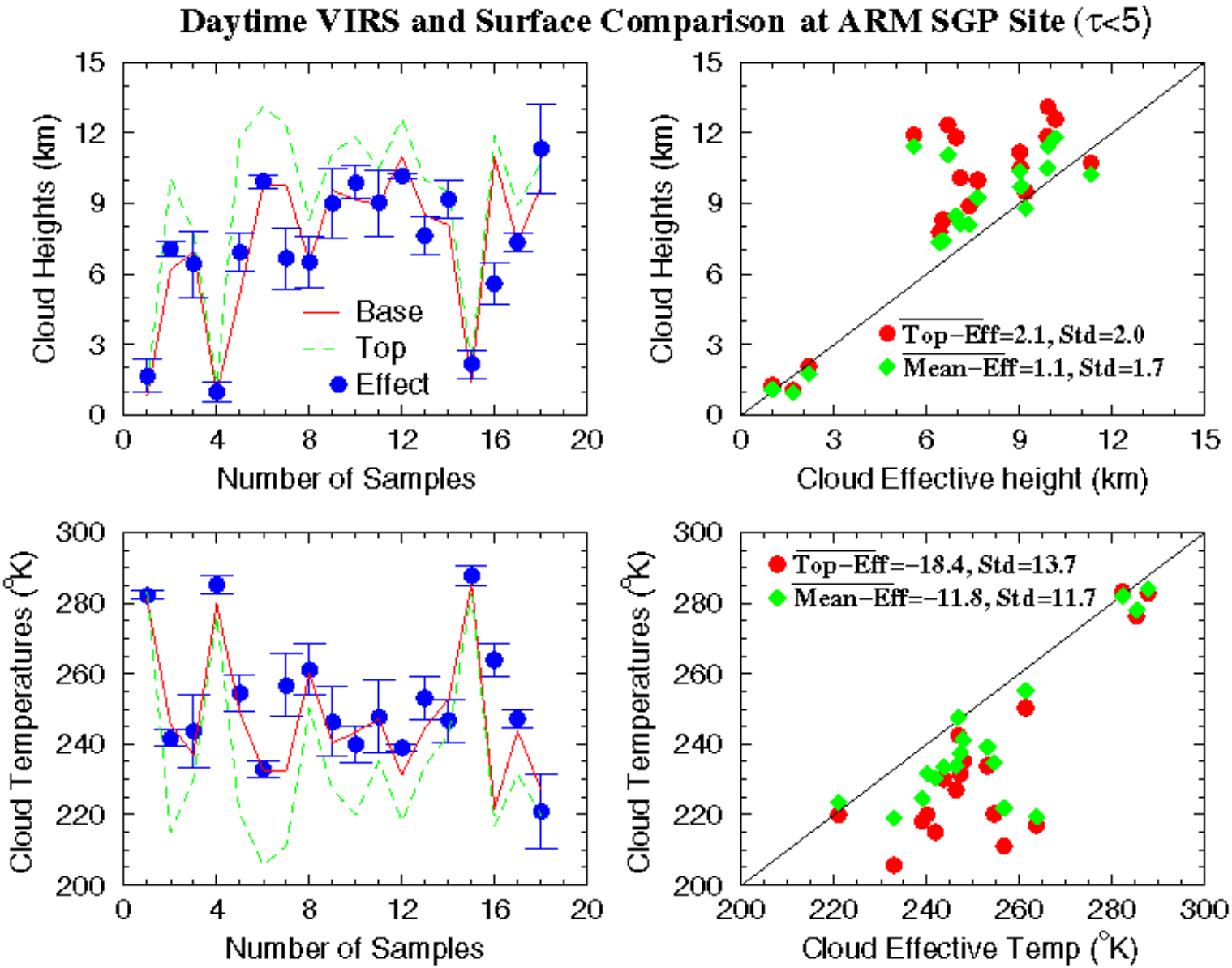
- **4 more months data (from Sept. to Dec. 1998)**
- **Total 59 cloud samples at Daytime, 80 samples at nighttime during 1998**
- **Updated CERES/VIRS retrievals**
- **Updated surface results**

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov



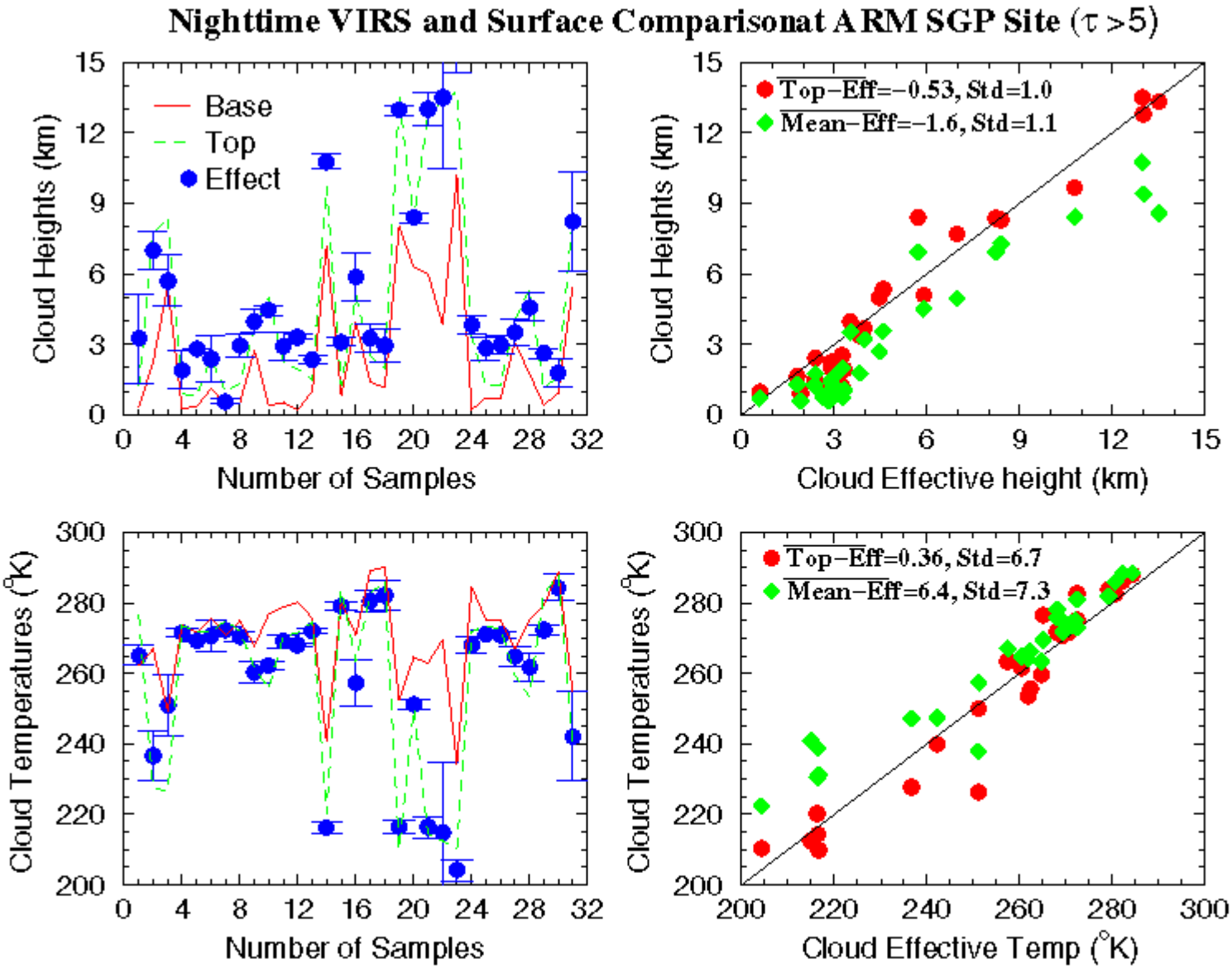
Daytime thick clouds: 5 stratus cloud tops outside of bounds, T(z) problem

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov



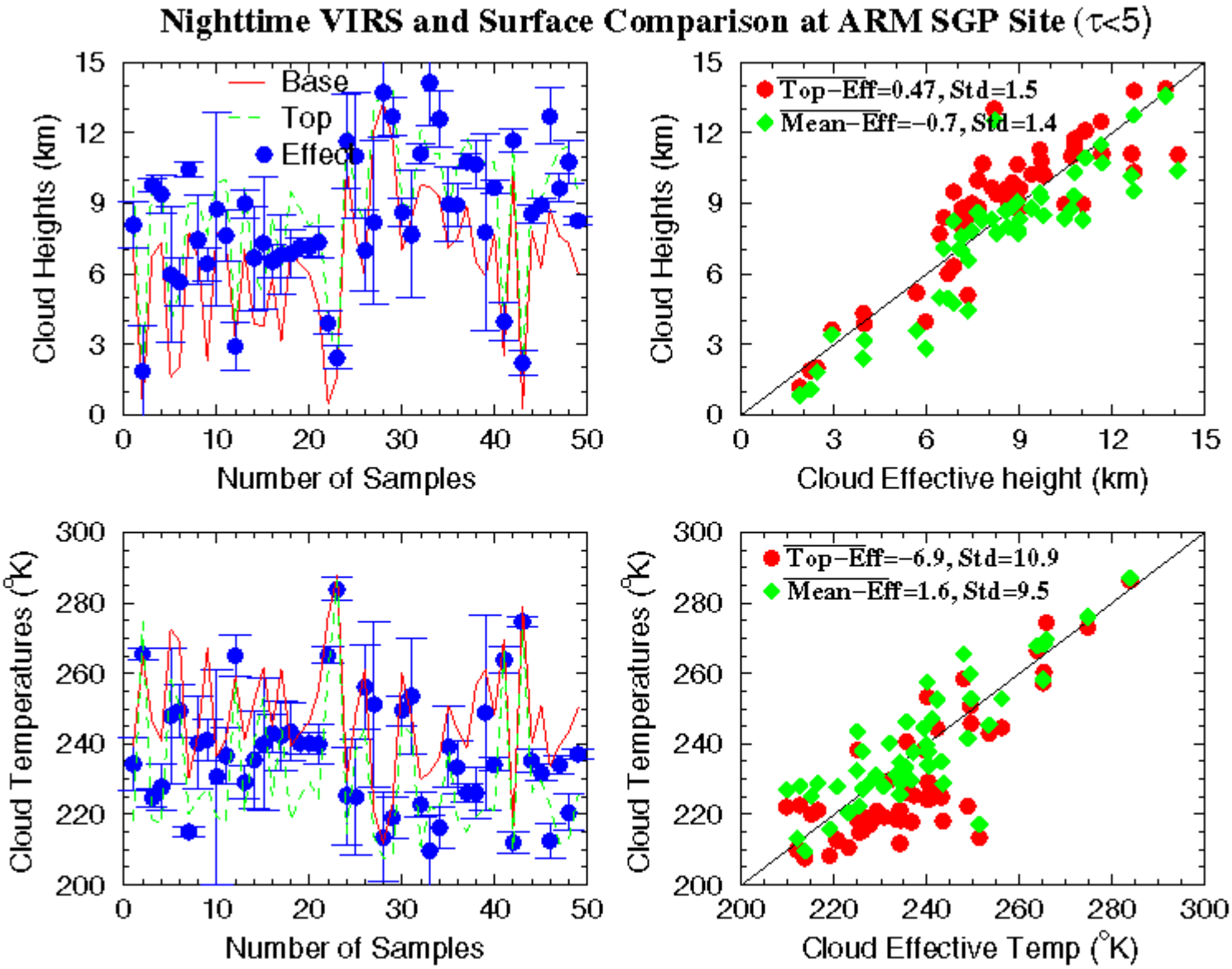
Thin cloud daytime: 3 below cloud base, 1 above cloud top

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov



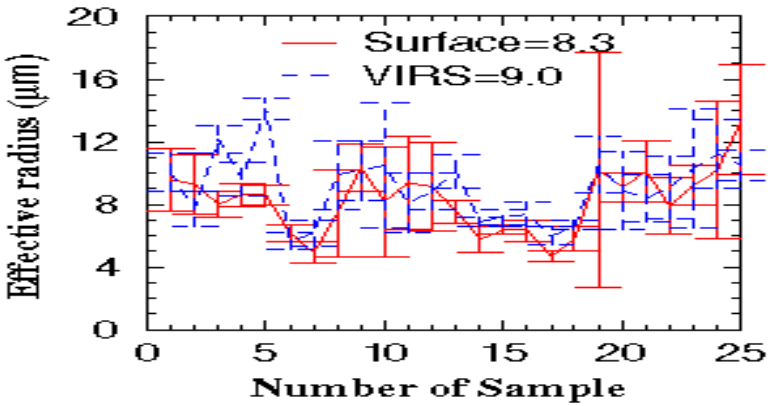
Nighttime thick: 2 cirrus too high, 3 stratus too high [T(z) again]

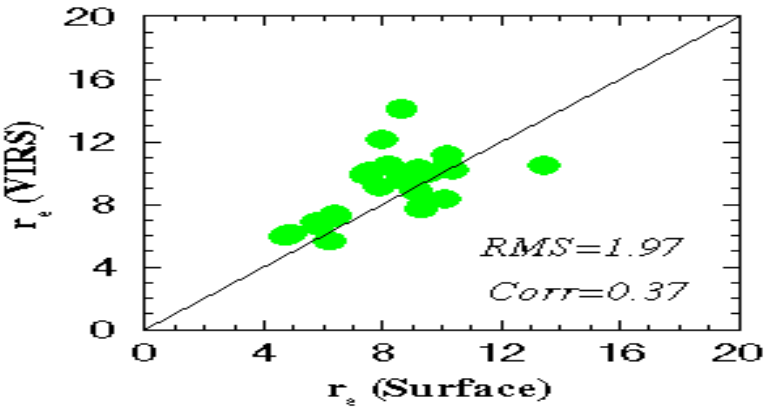
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov



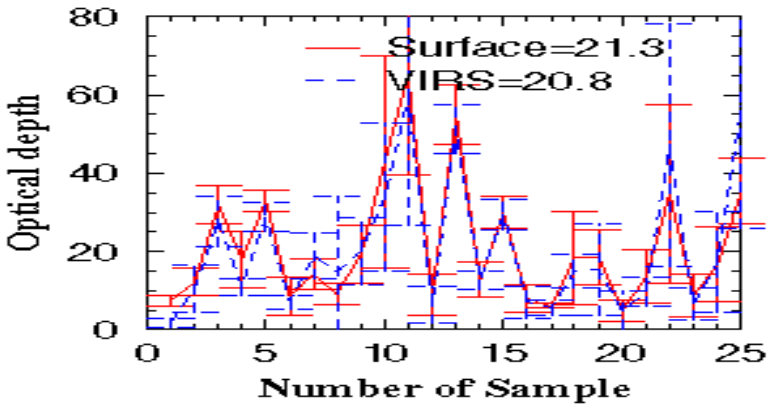
Nighttime thin: 4 Ci too high, 1 too low; best agreement

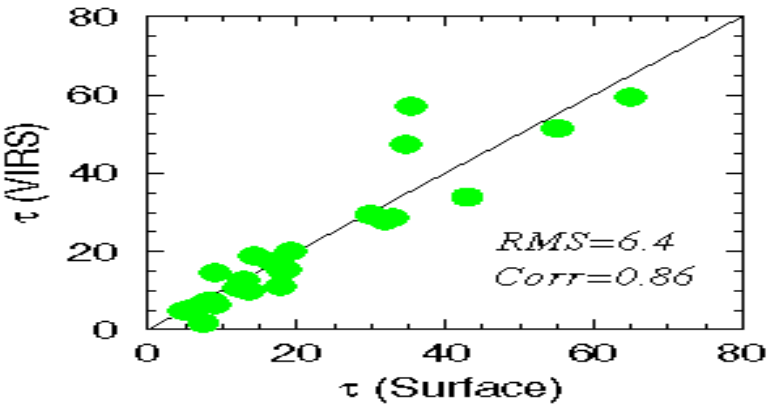
Daytime VIRS and Surface Comparison at ARM SGP Site



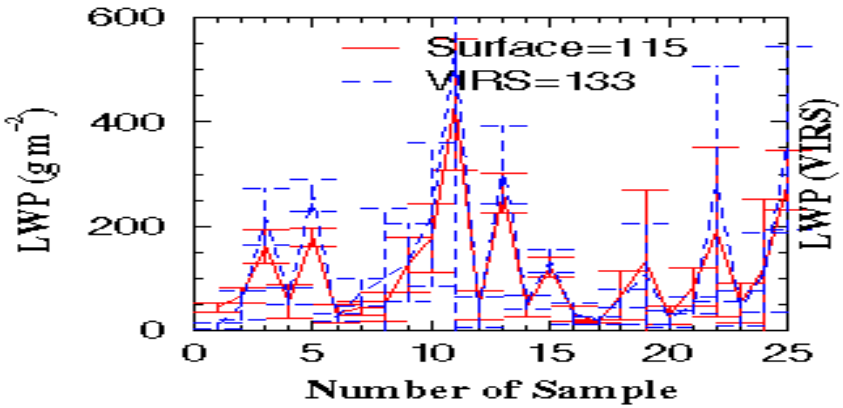


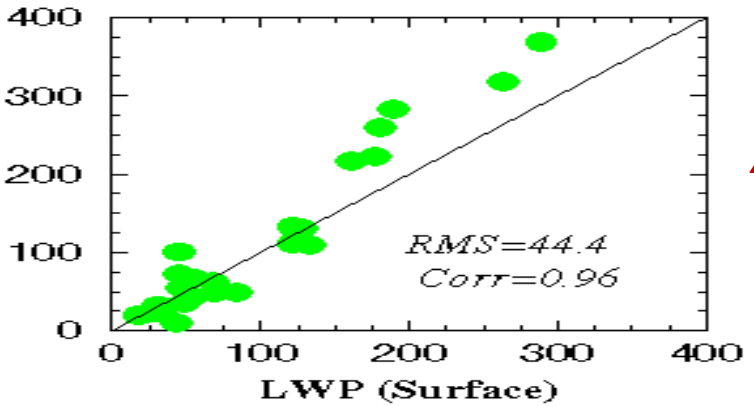
Δ = 8%





Δ = -2%

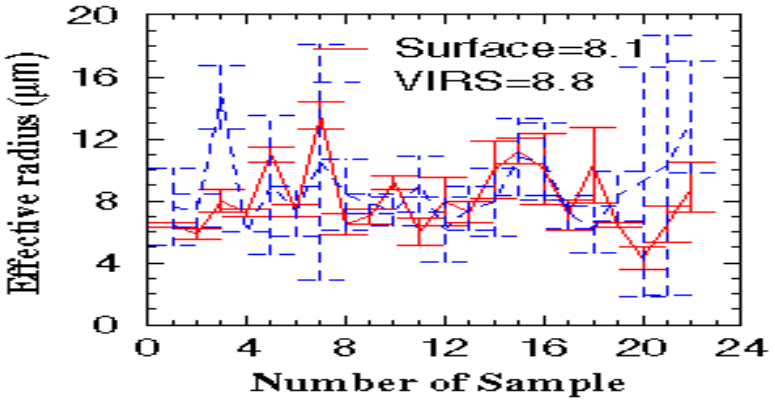


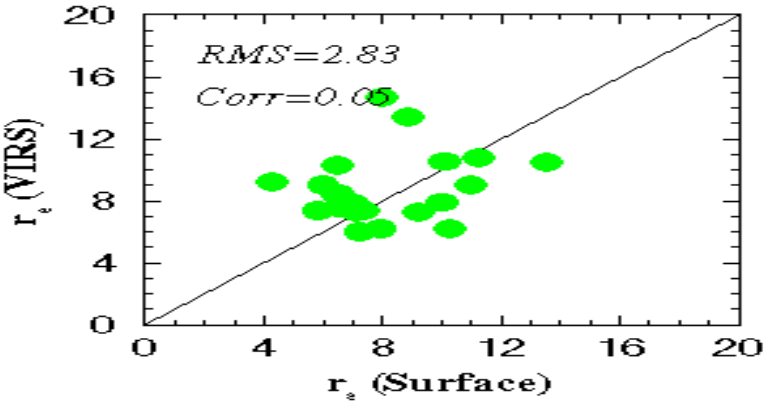


Δ = 16%

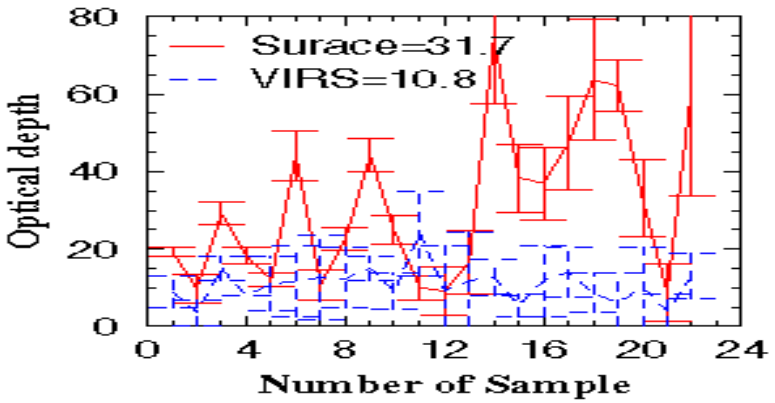
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

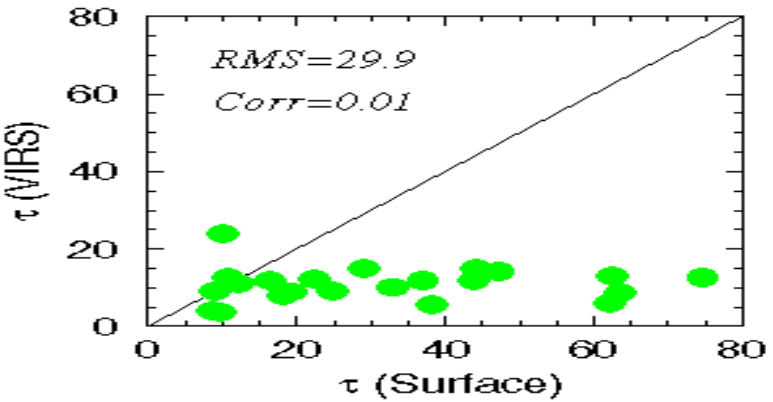
Nighttime VIRS and SurfaceComparison at ARM SGP Site

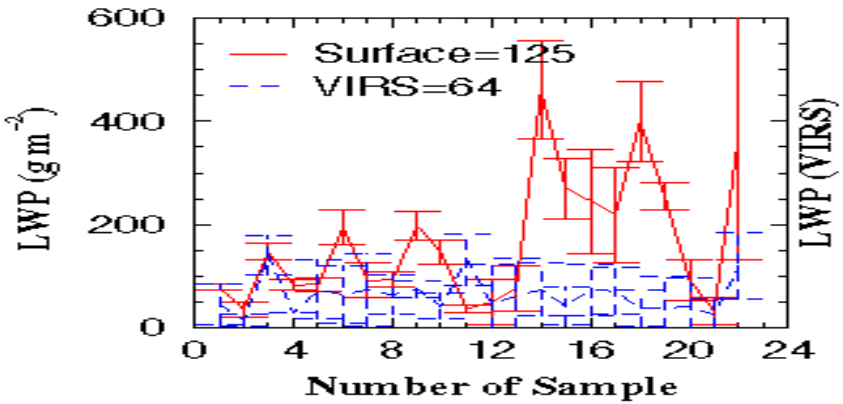


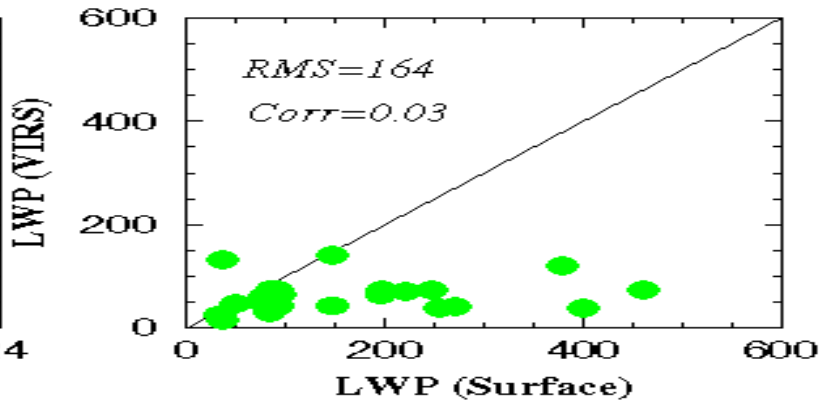


Δ = 9%



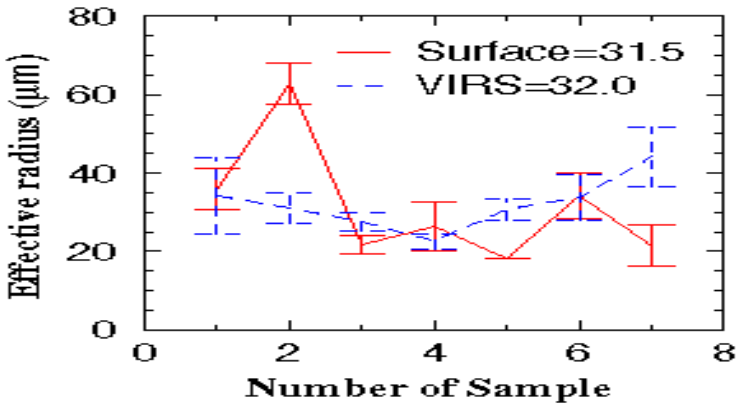


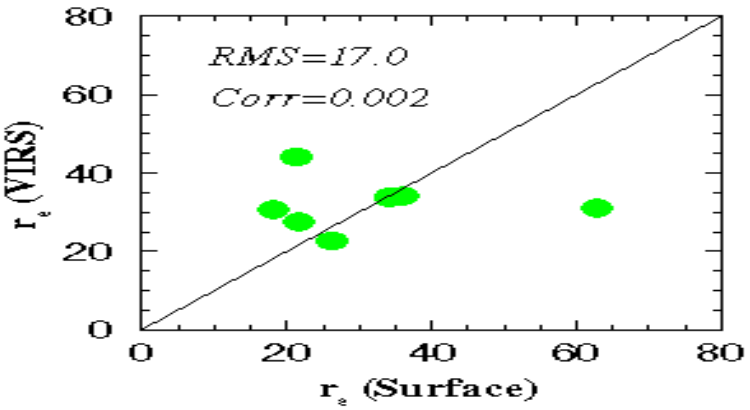




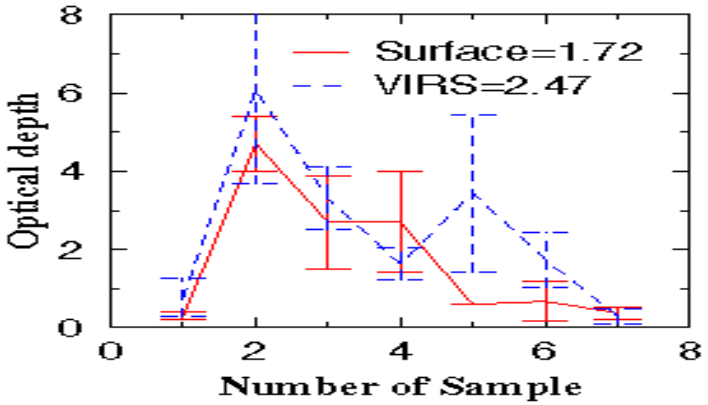
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

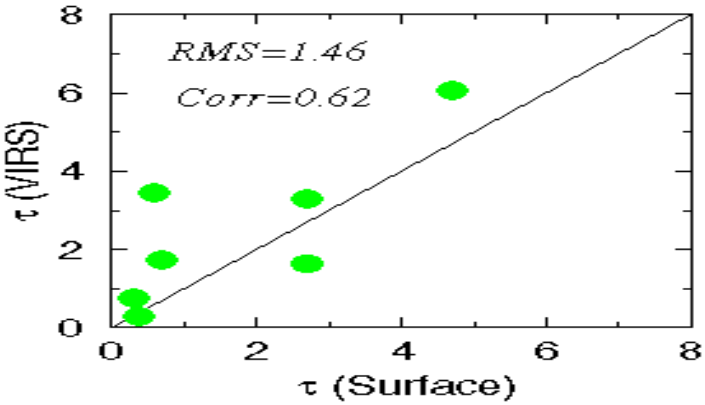
Daytime VIRS and Surface Comparison at ARM SGP Site



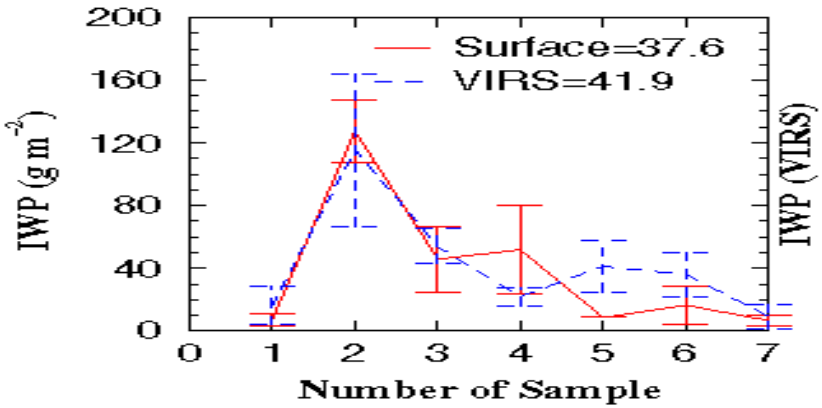


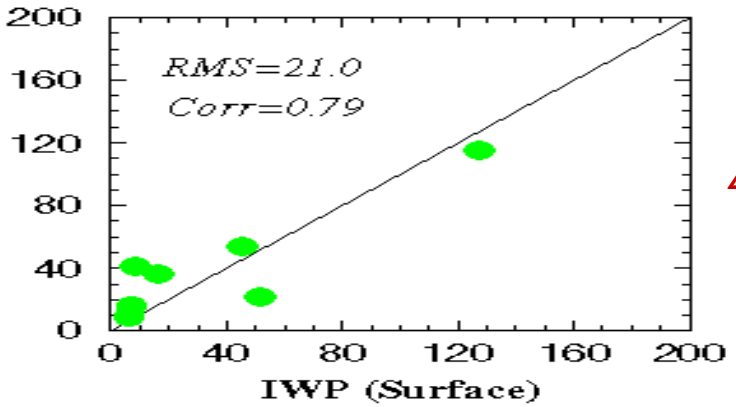
Δ = 2%





Δ = 44%

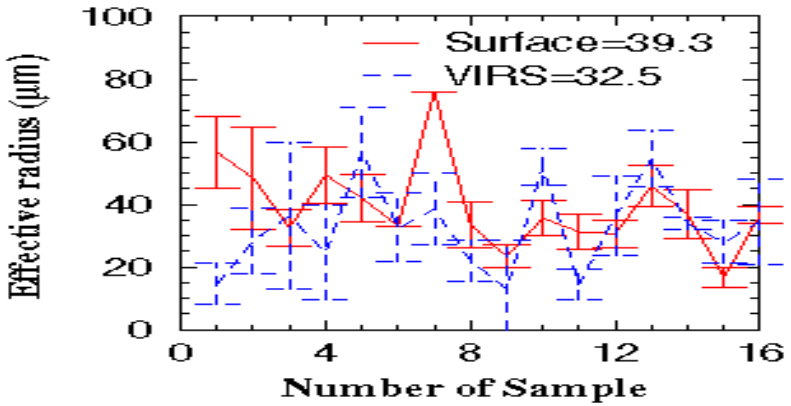


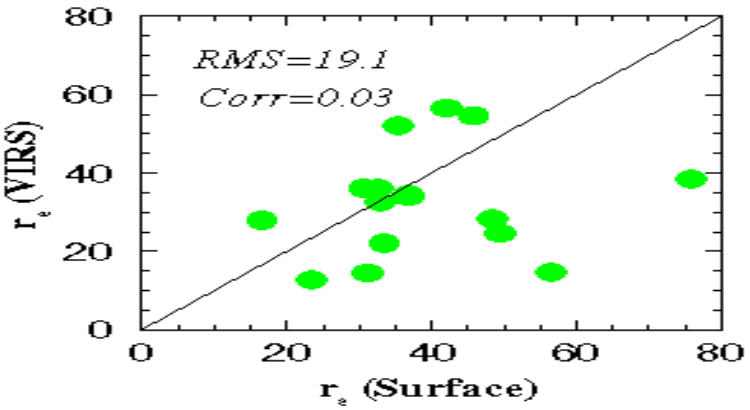


Δ = 11%

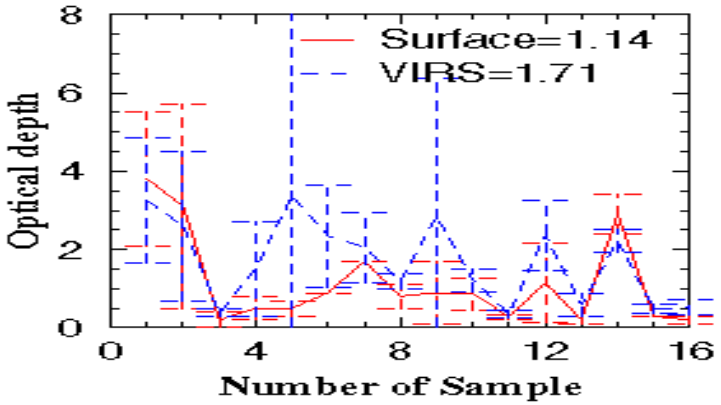
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

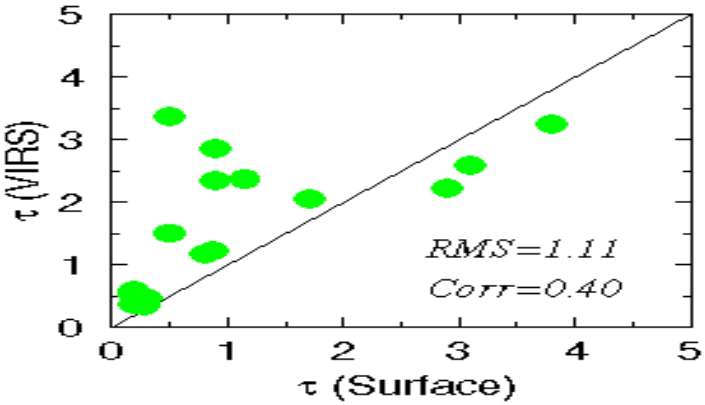
Nighttime VIRS and SurfaceComparison at ARM SGP Site



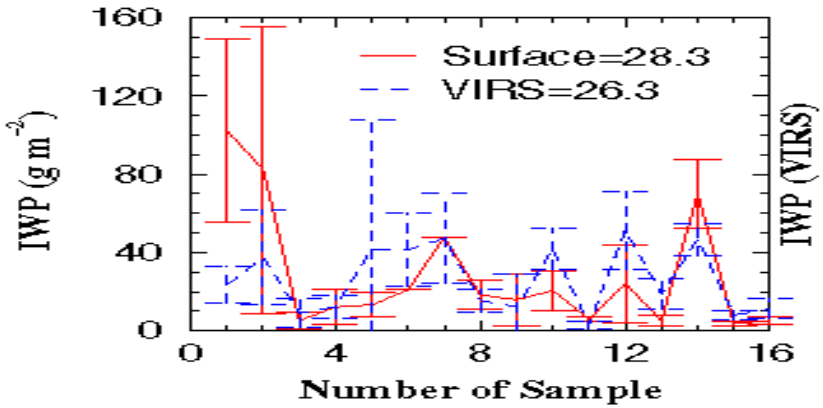


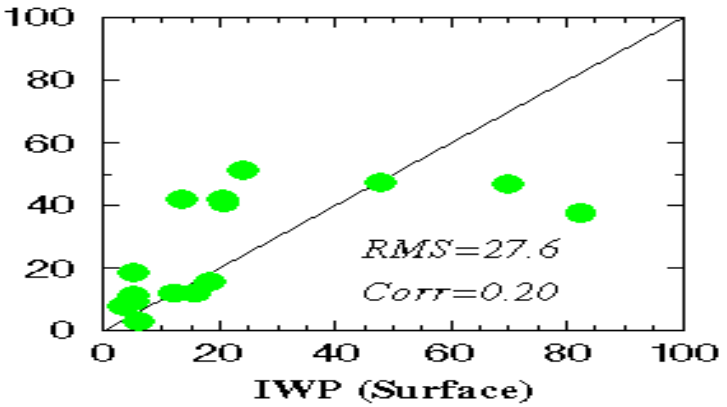
Δ = -17%





Δ = 50%





Δ = -7%

Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

Conclusions

1. VIRS cloud effective height

	Daytime	Night-time
For $\tau > 5$,	$z_{mean} < z_{eff} < z_{top}$	z_{eff} = top - 0.5 km
For $\tau < 5$,	$z_{base} < z_{eff} < z_{mean}$	z_{eff} = top + 0.5 km

2. VIRS microphysical properties:

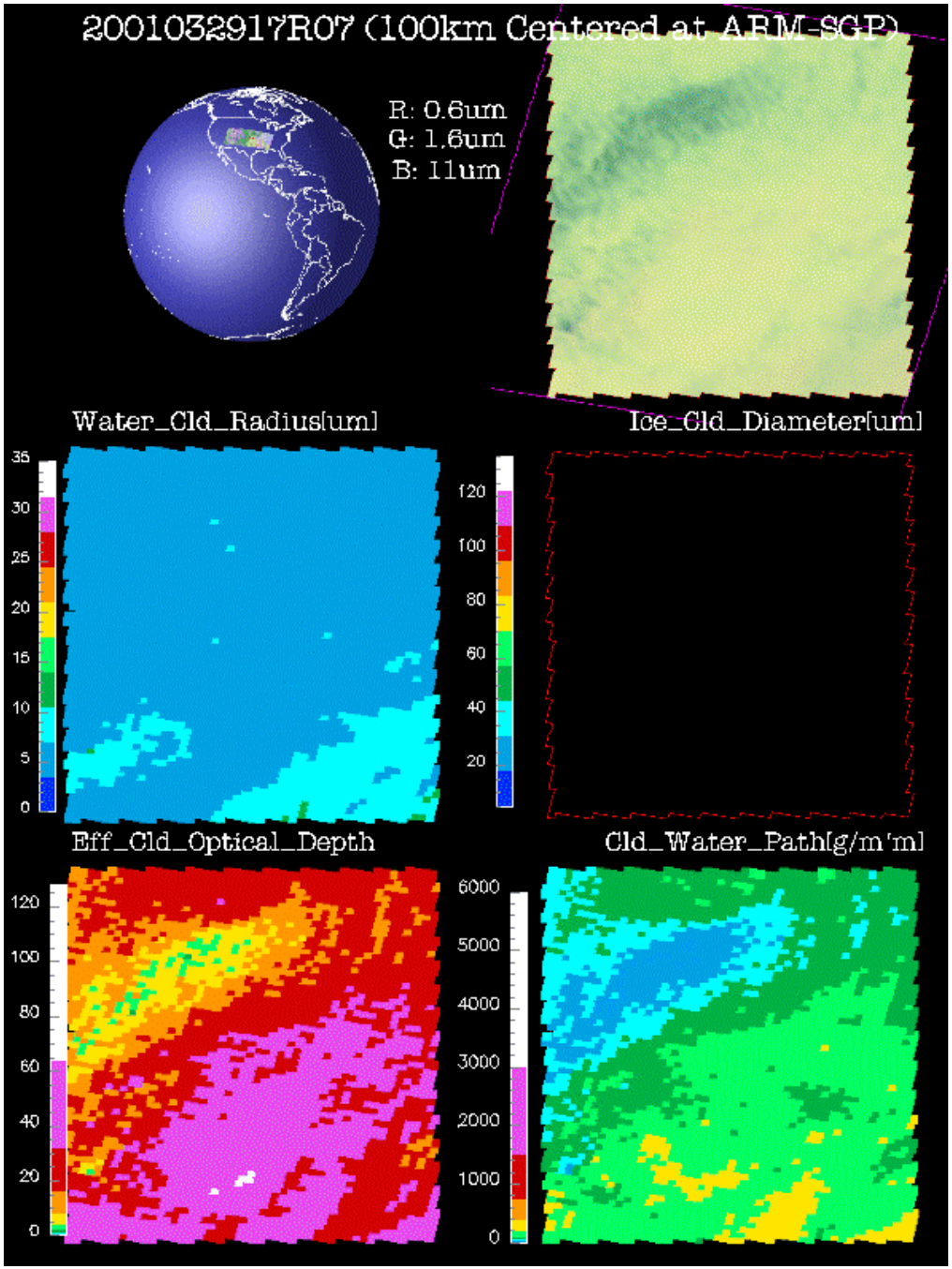
	Daytime	Night-time
For Stratus:	excellent with high corr	r_e is OK with low corr. τ and *lwp* underestimated
For cirrus:	overall agree well with a relative high corr. need more samples	overall good with a relative low corr. need more samples

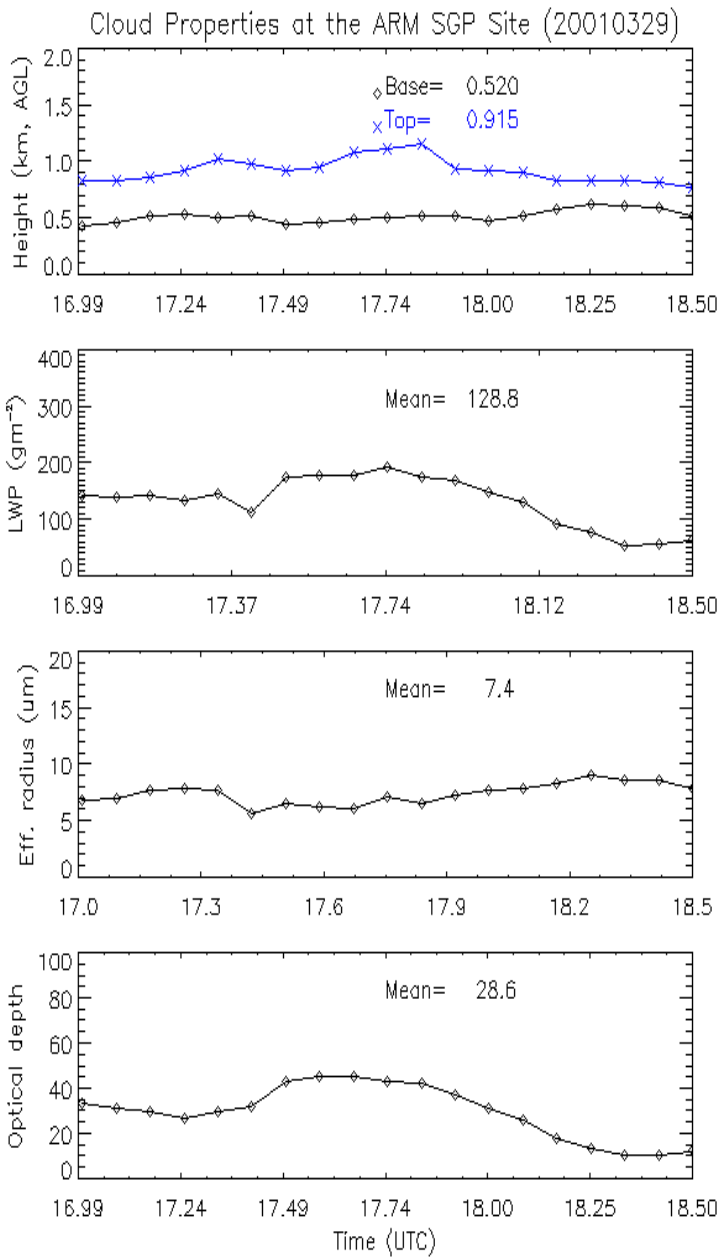
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

Validation of MODIS results at SGP

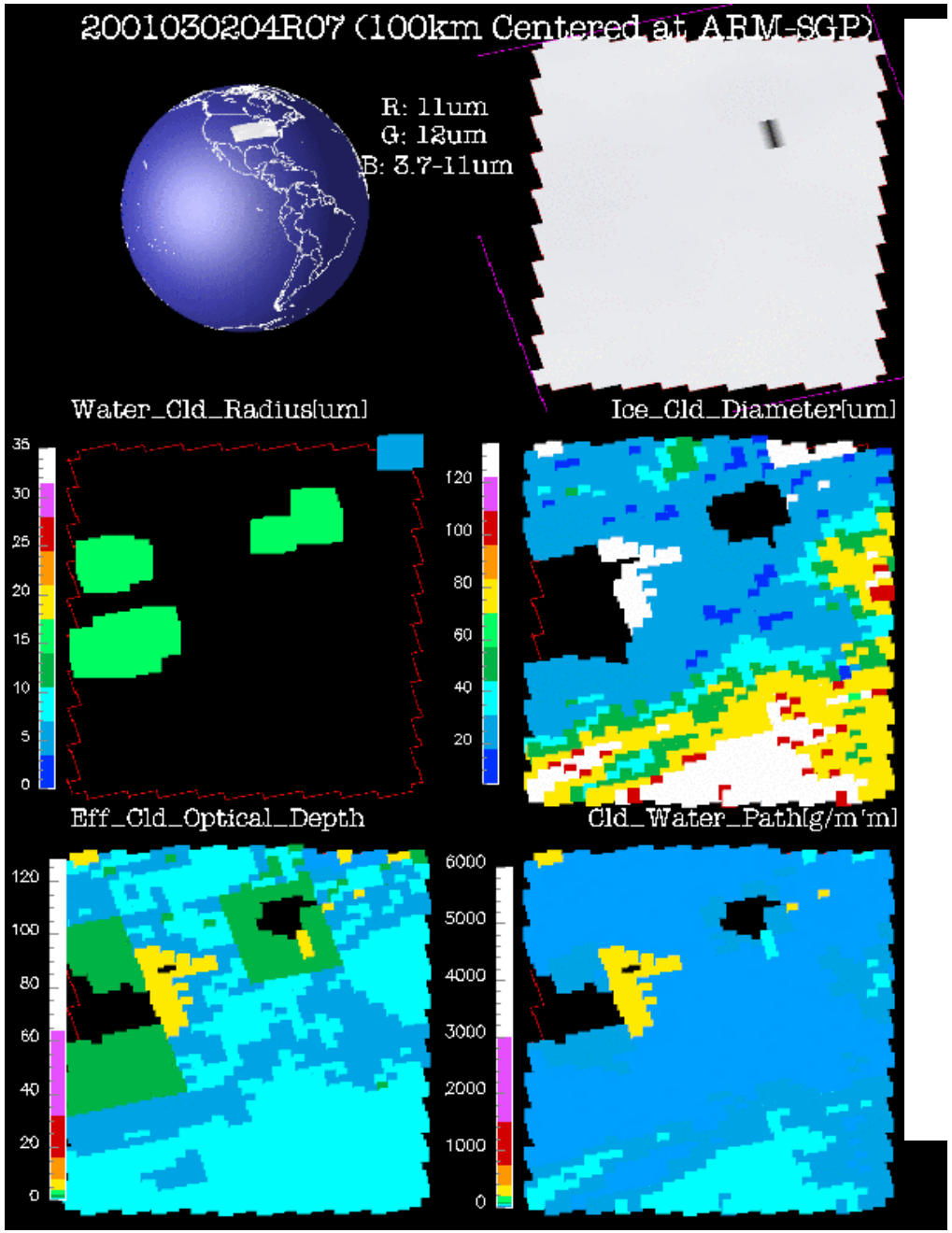
- **Sample 1: Daytime stratus on March 29, 2001**
- **Sample 2: Night-time cirrus on March 2, 2001**

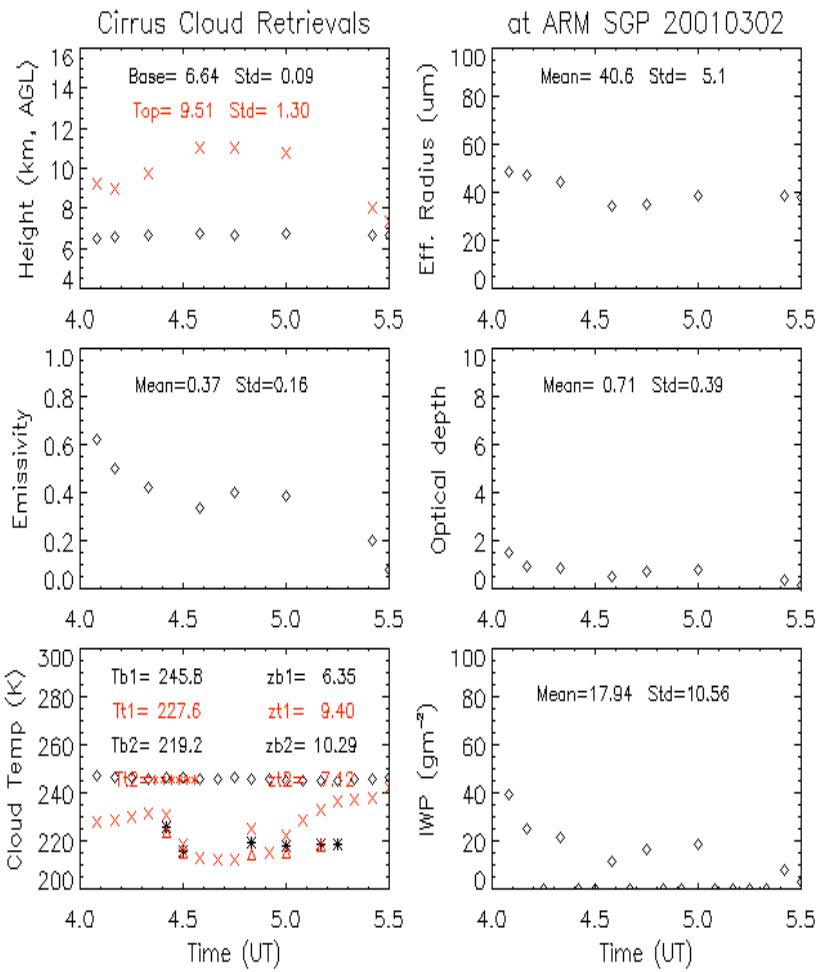
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov





Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov





Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

Validation of MODIS results at SGP

- **Sample 1: Surface VIRS**

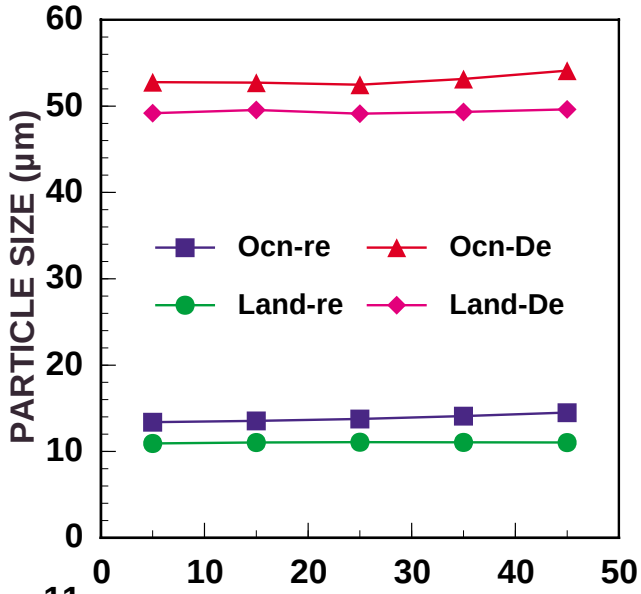
  Z_b=0.52 km, Z_t=0.92 km, Z_{eff}=1.9 km
  re=7.4 μm, re=5.3 μm
  τ=28.6 τ=33.2
  lwp=128.8 gm^{-2}, lwp=107.3

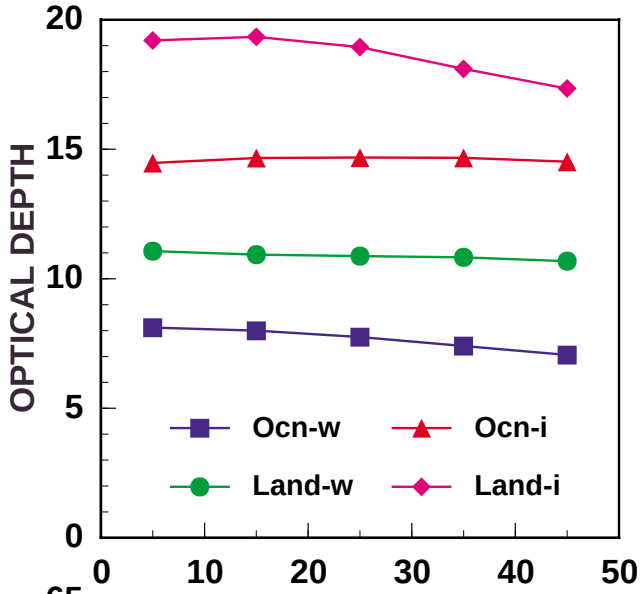
- **Sample 2: Surface VIRS**

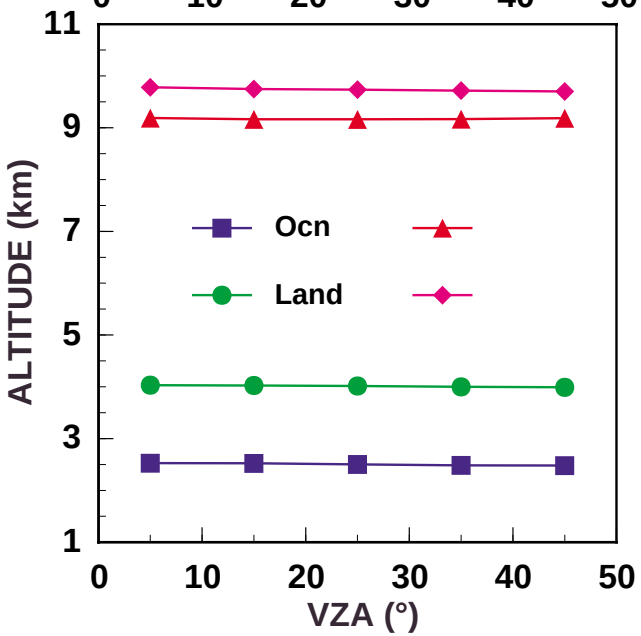
  Zb=6.64, Zt=9.51 km, Zeff=10.38 km
  re=40.6 μm, re=10.5 μm
  τ=0.71 τ=0.57
  IWP=17.9 gm^{-2} IWP=3.3

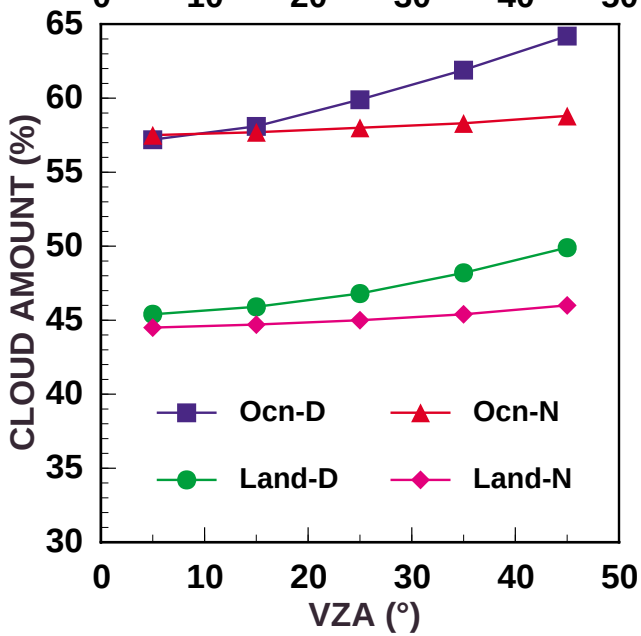
Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

ANGULAR DEPENDENCE OF CLOUD PROPERTIES

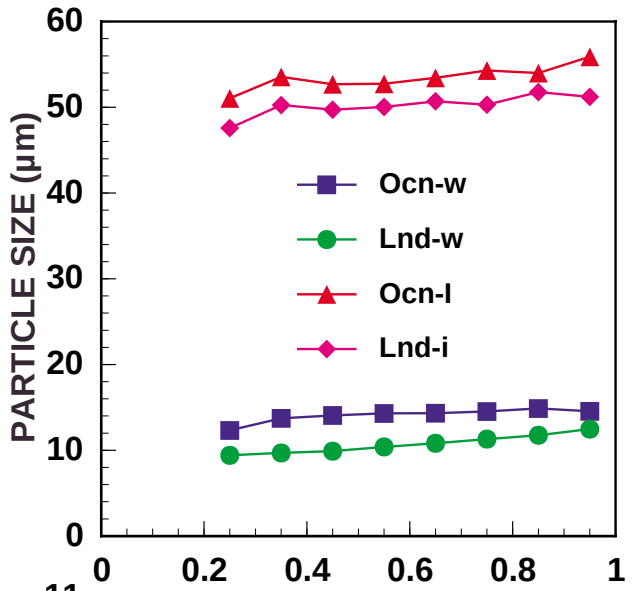


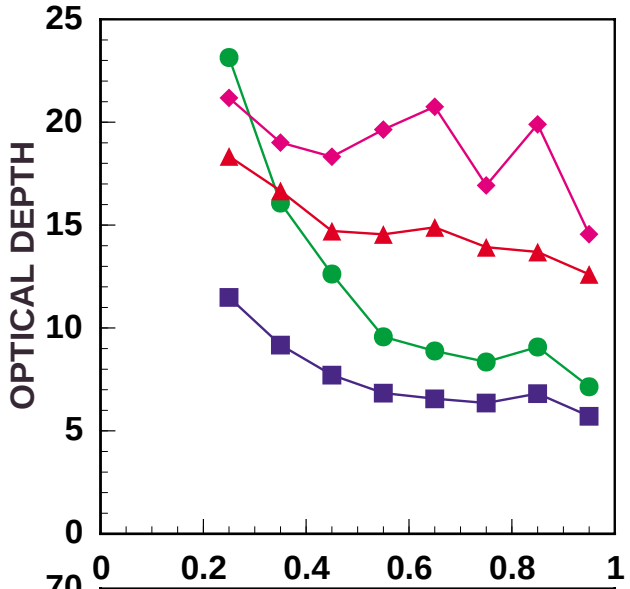


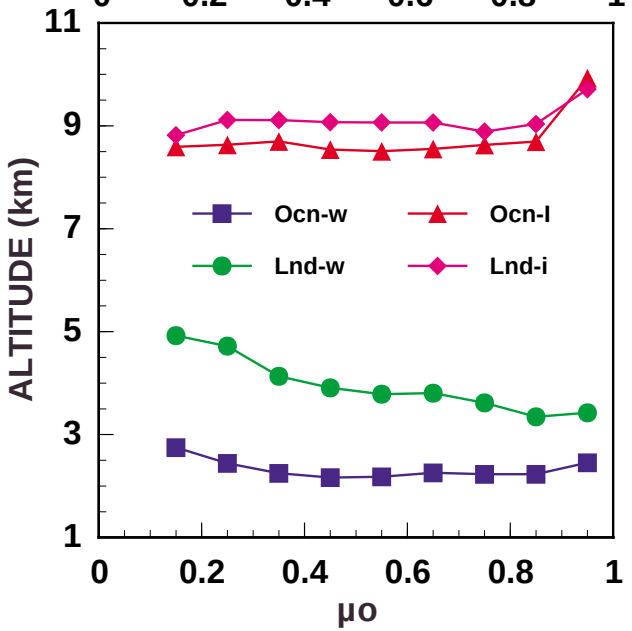


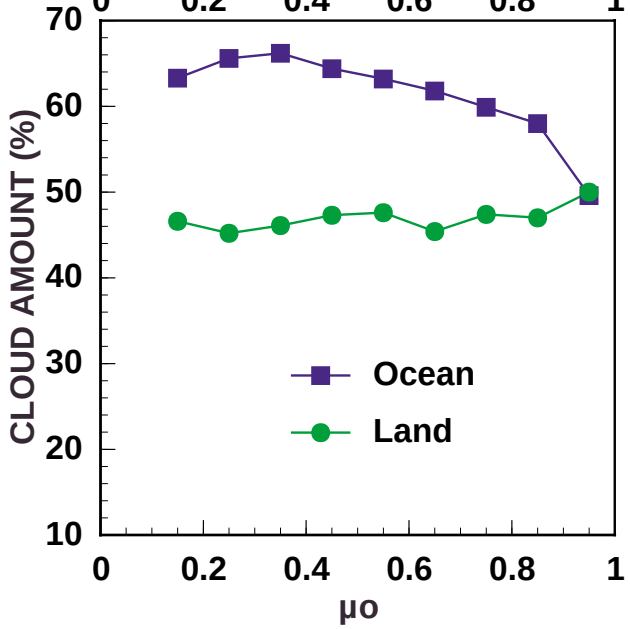


Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov





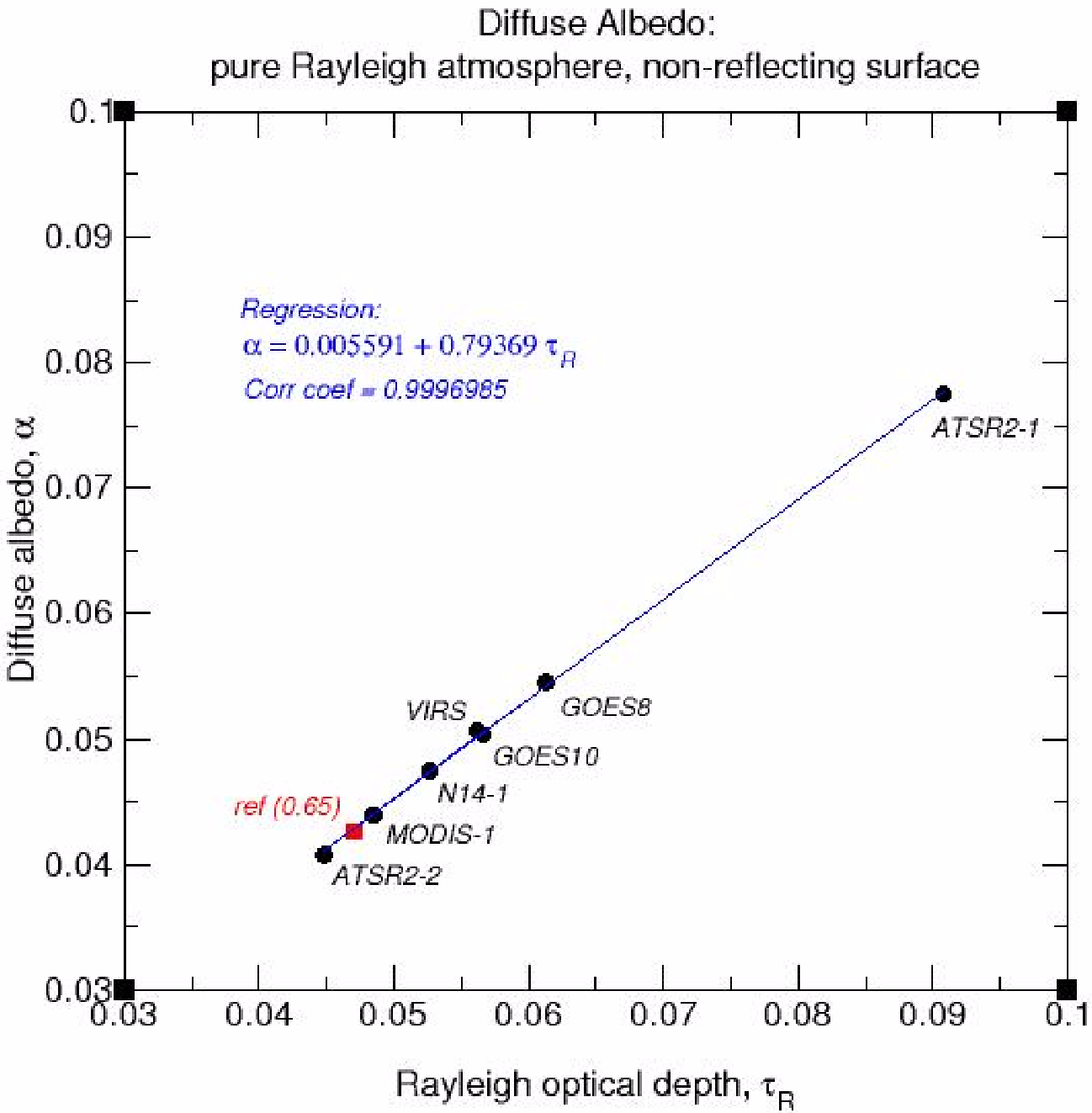




Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov

PLANNED IMPROVEMENTS

- VARIABLE RAYLEIGH SCATTERING DEPENDING ON SENSOR
- SENSOR-SPECIFIC CLOUD EMITTANCE MODELS
- SENSOR-SPECIFIC SURFACE EMITTANCE MODELS
- IMPROVED BLENDING OF POLAR AND REGULAR MASKS
- MULTI-LAYER ID
- CO2-SLICING



Distributed by the Atmospheric Science Data Center
http://eosweb.larc.nasa.gov