STATUS OF CERES CLOUD PRODUCTS

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CERES Science Team Meeting, Hampton, VA

November 1-3, 2005

CERES Cloud Products

- Terra MODIS processed as Edition 2b
  - through June 2005

- Aqua MODIS processed as Edition 1a
  - through March 2005

- TRMM VIRS processed through July 2001
  - plan to process all of it with latest edition & *faux flux*

- Edition 3 will start after V004 completes
  - expect beta runs in June 2006

CALIBRATION MONITORING

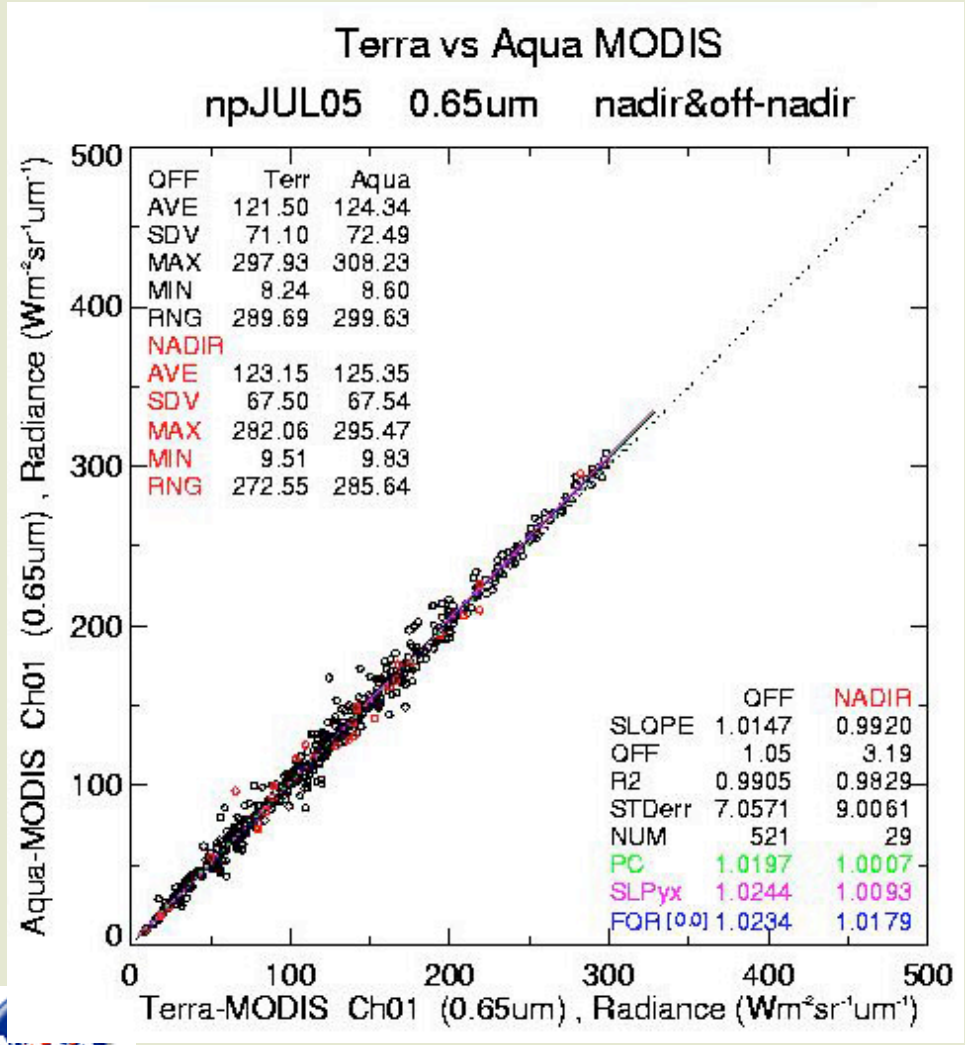
- Aqua vs Terra (match in polar regions only)
- MODIS vs CERES

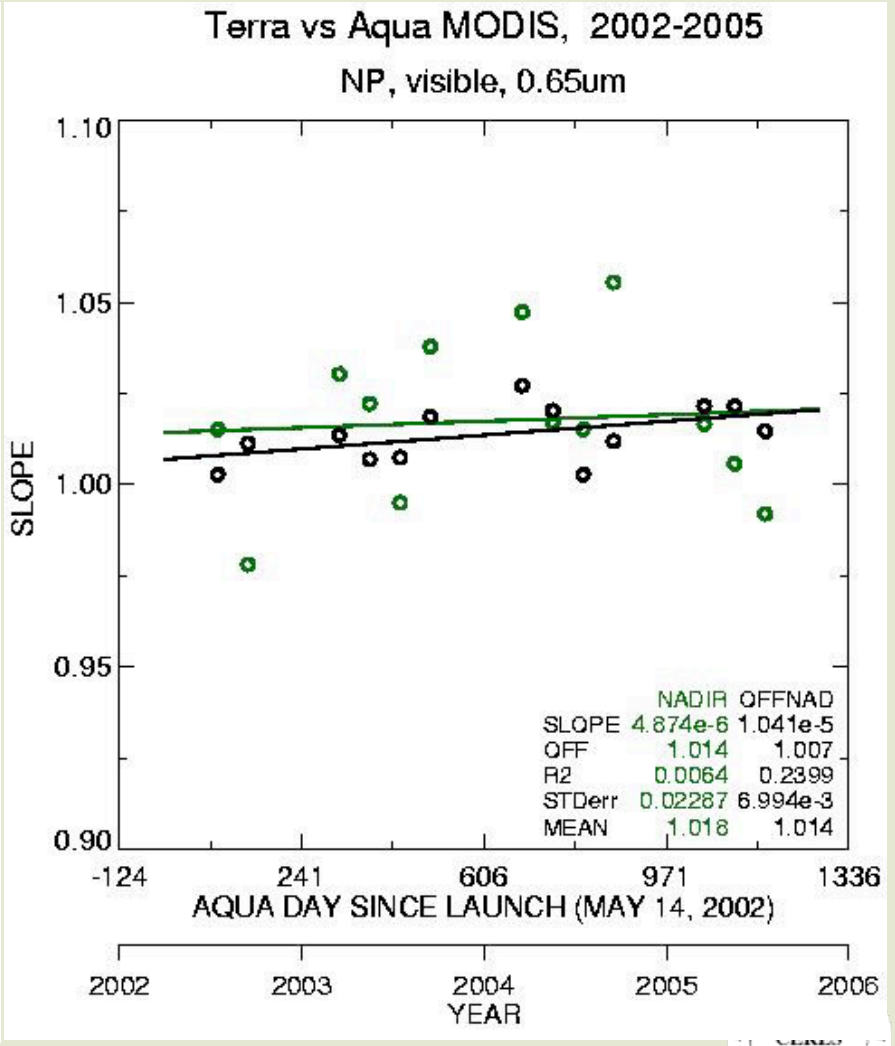
EXAMINE RELATIVE TRENDS IN IMAGER CHANNELS

VISIBLE

Compute slope for each month

Monitor slope variation

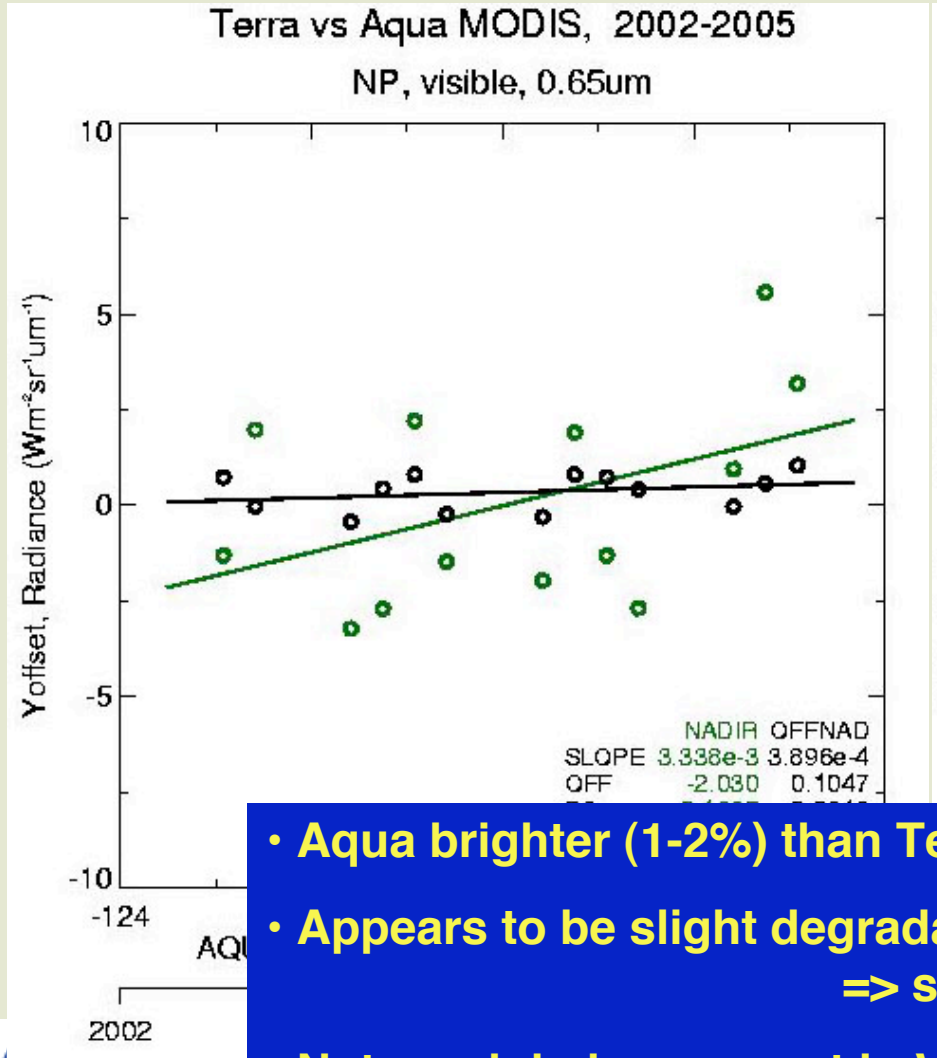




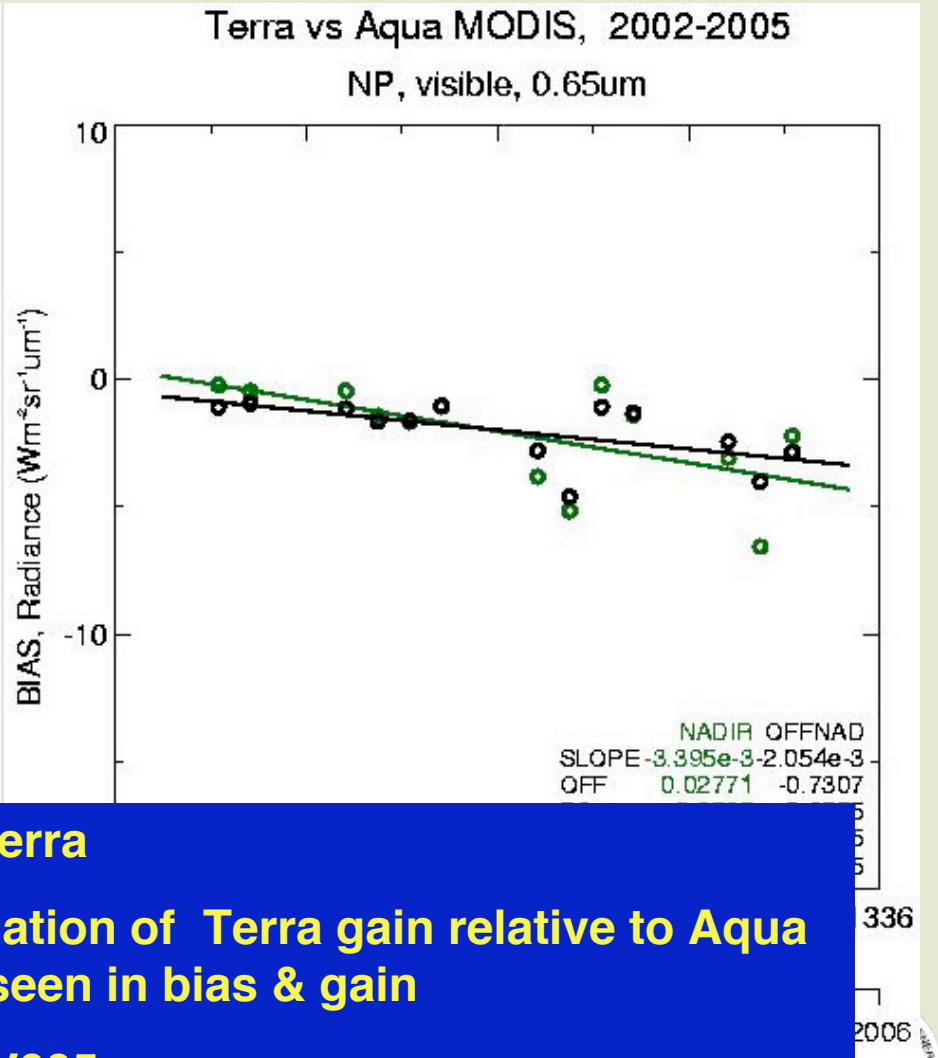
EXAMINE RELATIVE TRENDS IN IMAGER CHANNELS

VISIBLE

Monitor offset variation



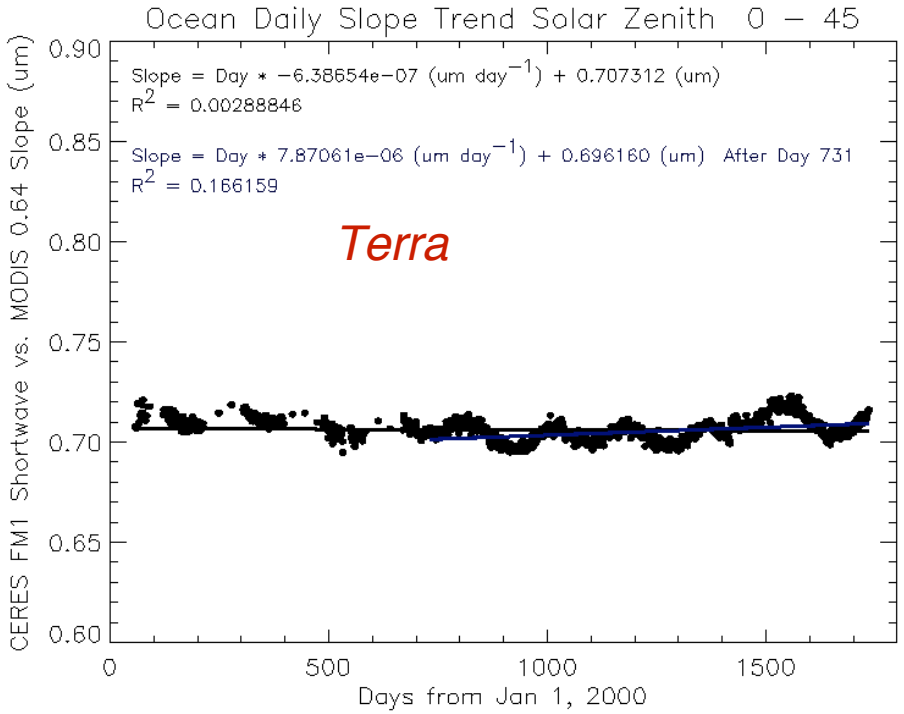
Monitor bias

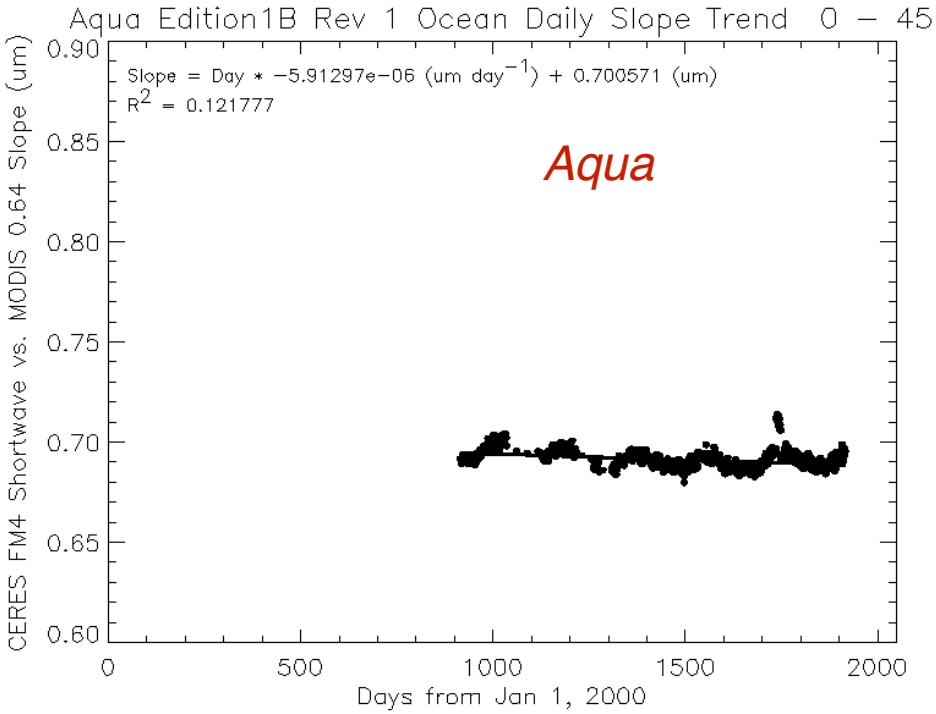


- Aqua brighter (1-2%) than Terra
- Appears to be slight degradation of Terra gain relative to Aqua
  => seen in bias & gain
- Not much help apparent in V005

INTERCALIBRATIONS
Comparison of CERES SW and *Aqua* MODIS
0.635 μm, July 2002 - Mar 2005

Slope of CERES vs MODIS: SW vs 0.64 μm



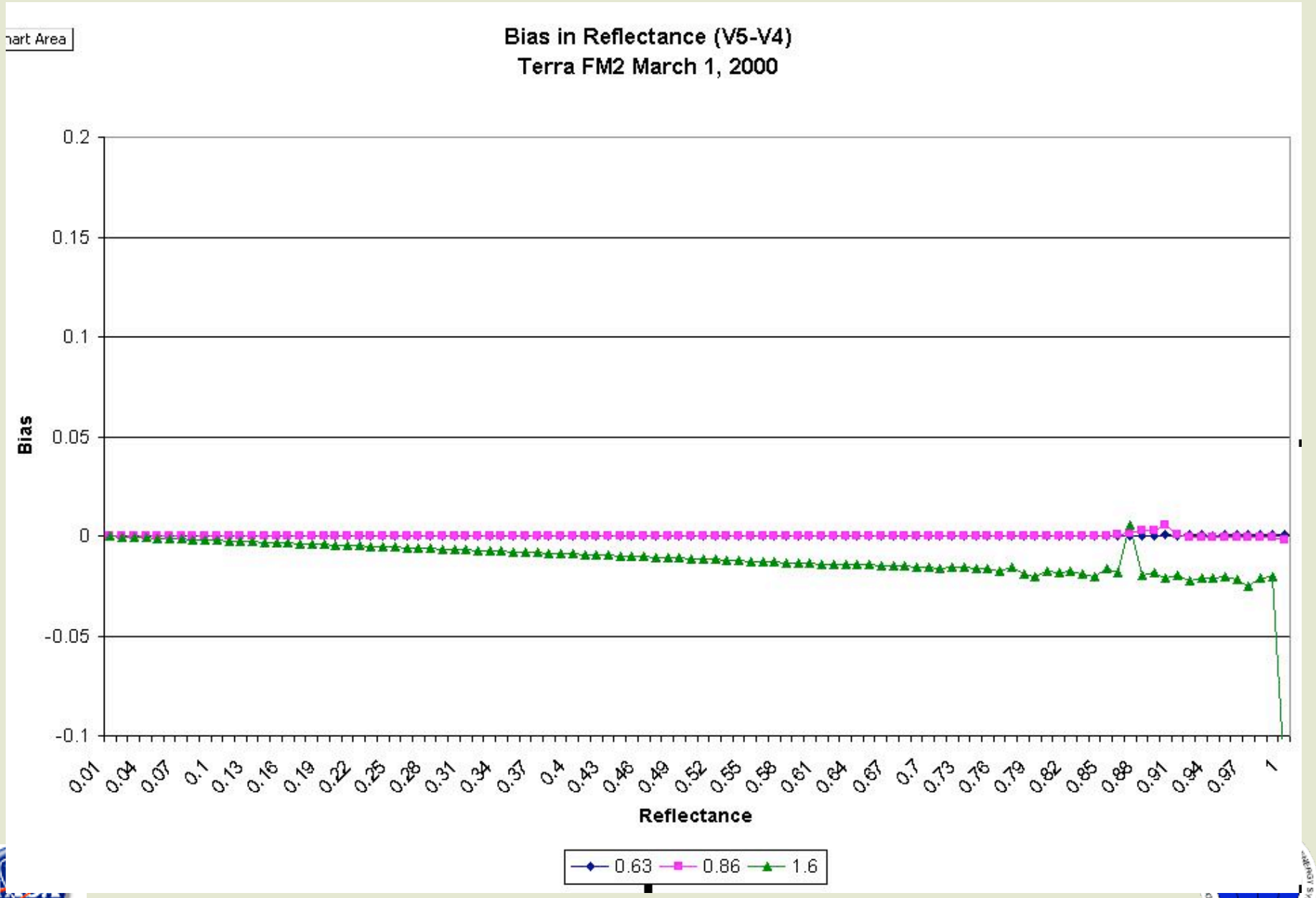


No trend for *Terra*; apparent trend for *Aqua*

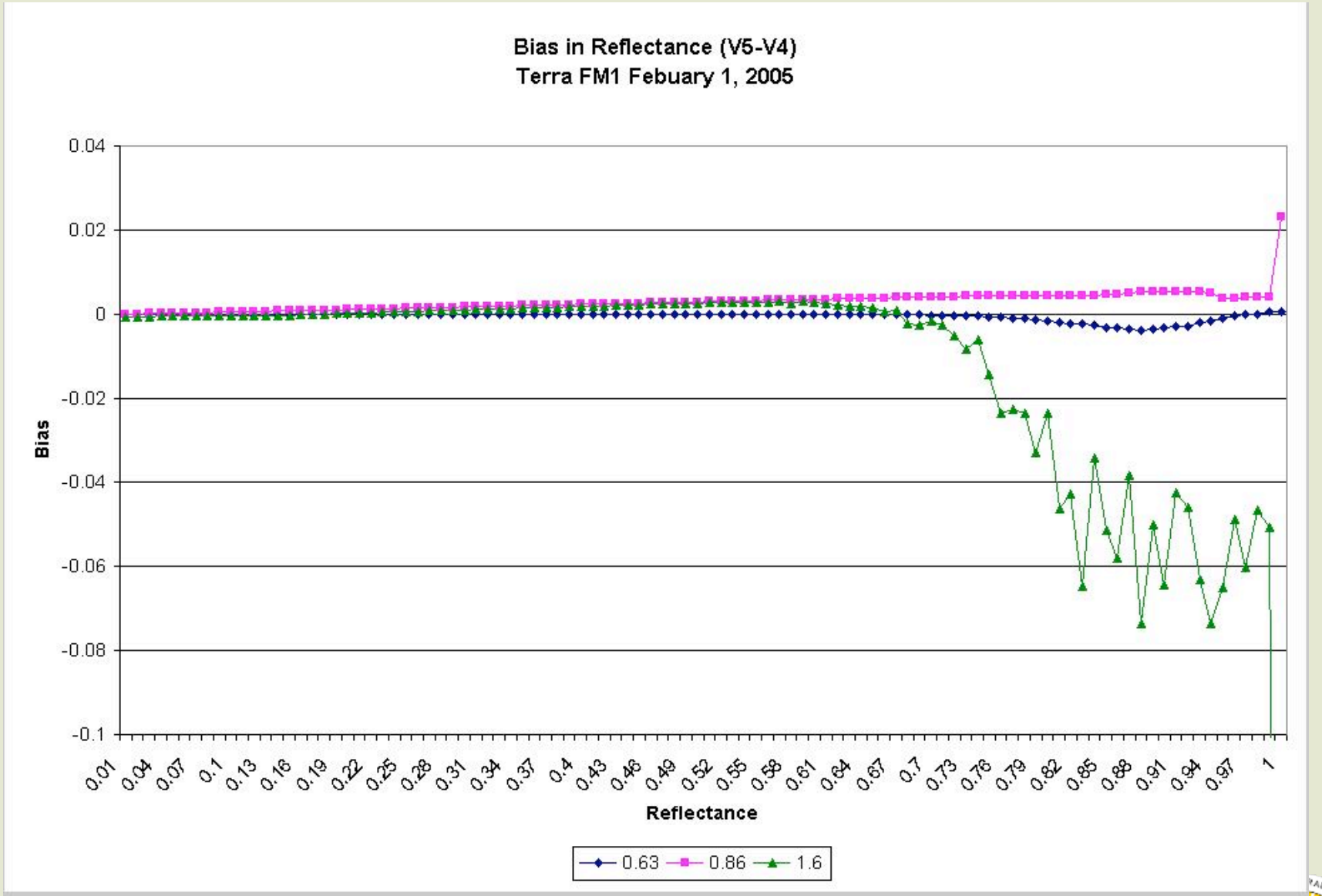
Terra & Aqua MODIS may trend relative to each other

***Terra* darker than *Aqua* by 1.2% at start of 2003**

Solar Reflectance Channels



Solar Reflectance Channels

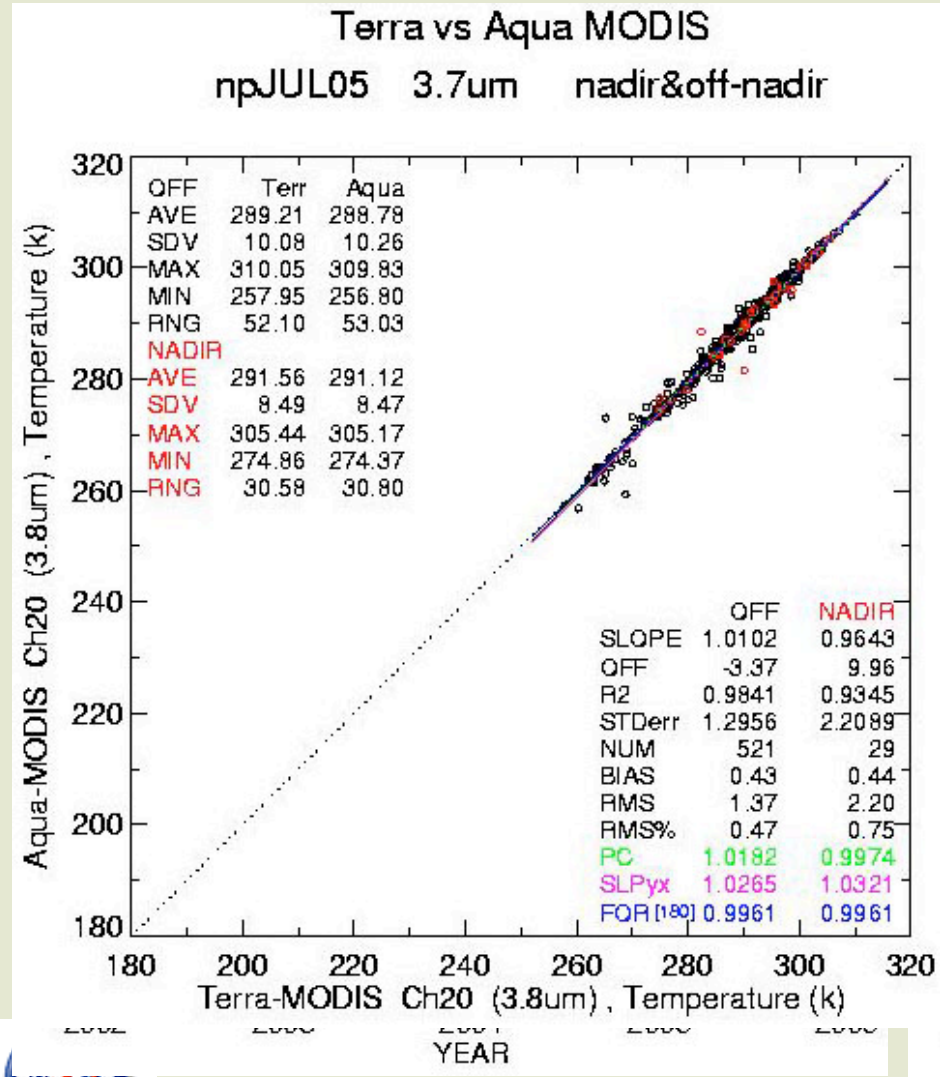


Changes vary with time

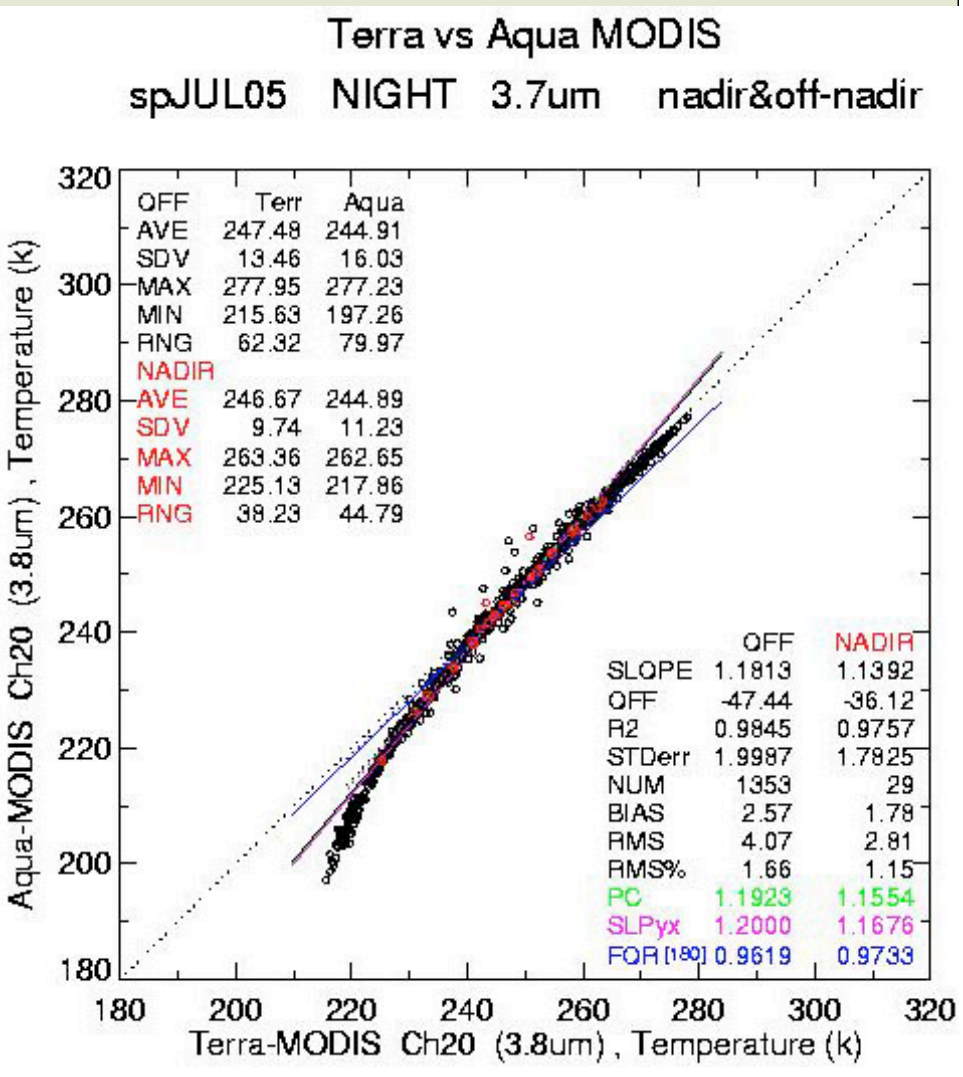
EXAMINE RELATIVE TRENDS IN IMAGER CHANNELS

3.8 μm

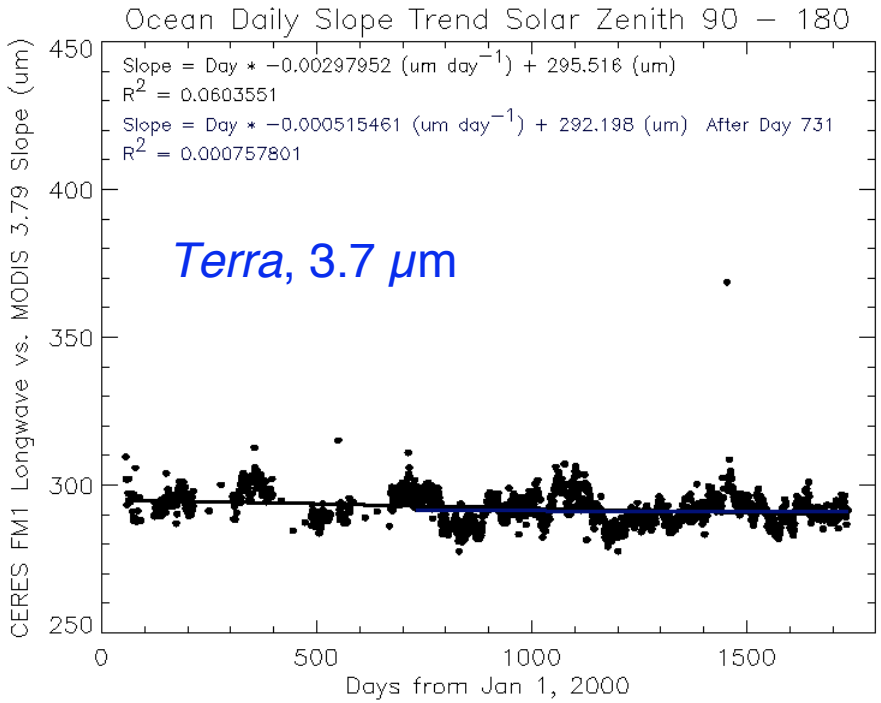
Daytime slope

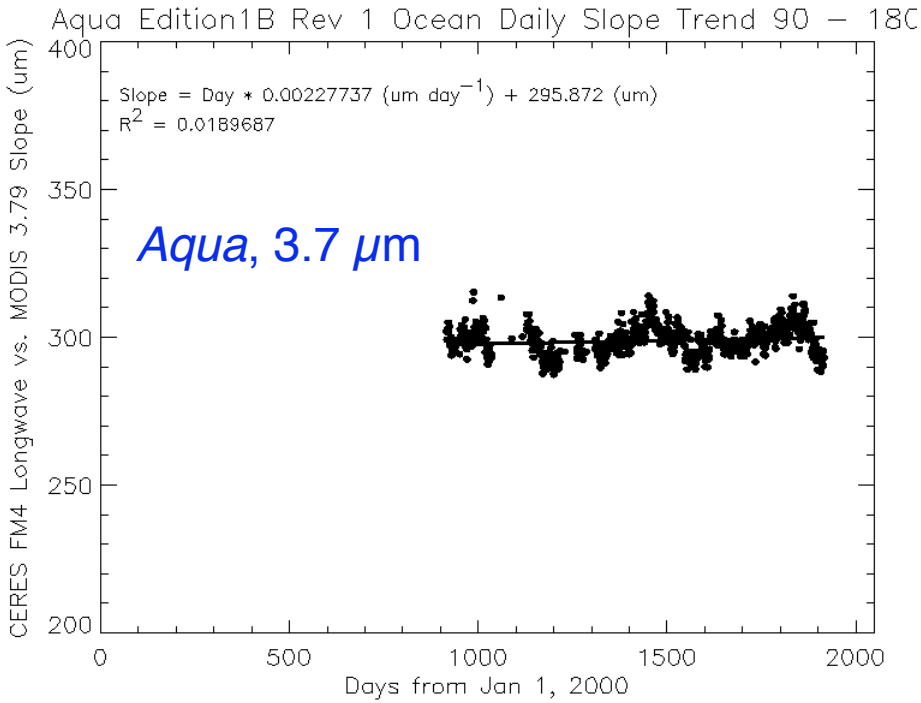


Night slope



Comparison of CERES LW and MODIS 3.78 μm, Night, 2000 - 2005



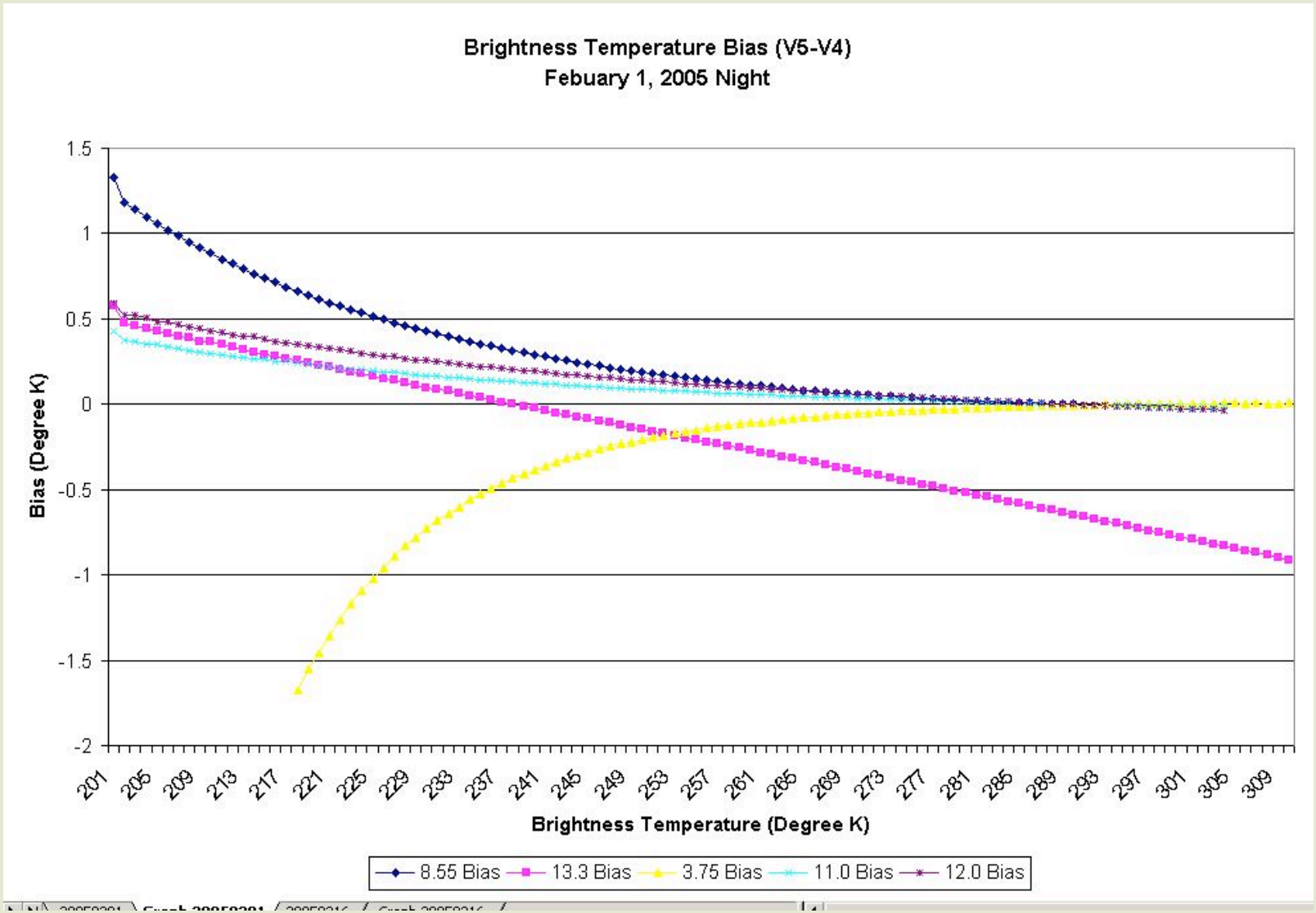


Terra FM1: suggestive of trend

Aqua FM4: no trend

***Aqua* colder than *Terra* => more LW for a given radiance**

Impact of Version 5 on Cloud Properties Using Current Algorithms

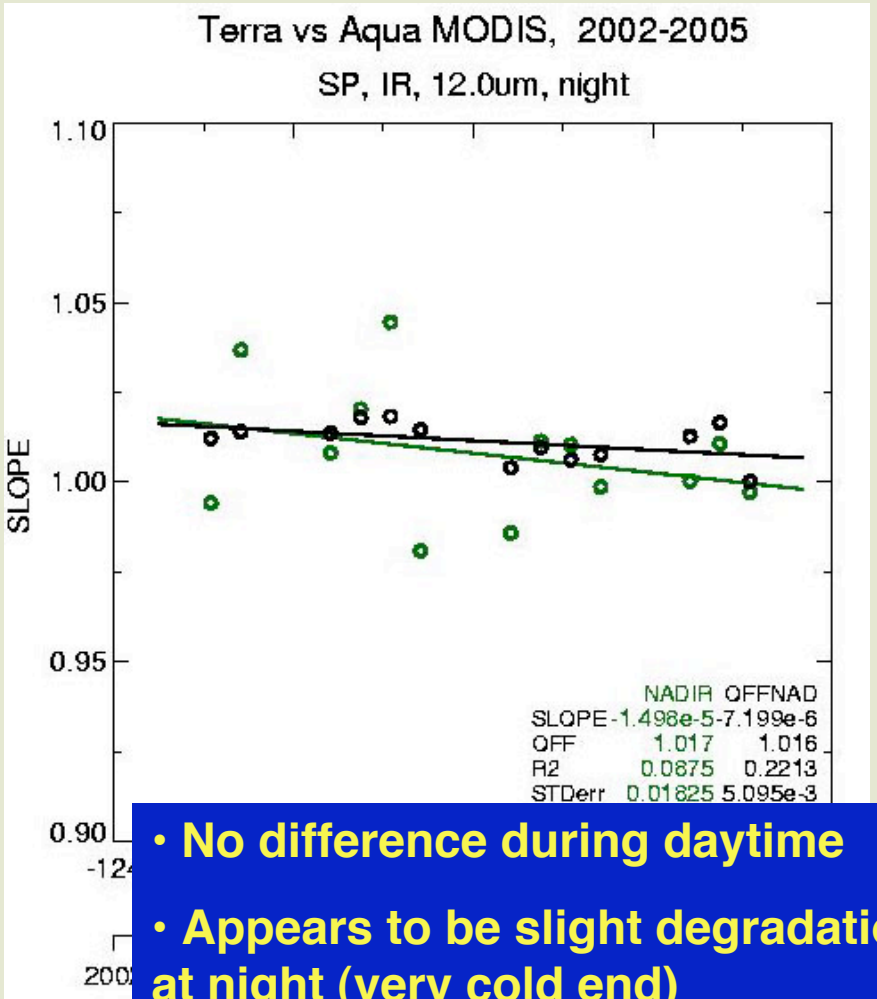


- 3.7 μm colder at T < 285 K: reduce droplet size (day), increase De
- 11, 12 μm warmer at T > 285 K: reduce polar night cloud

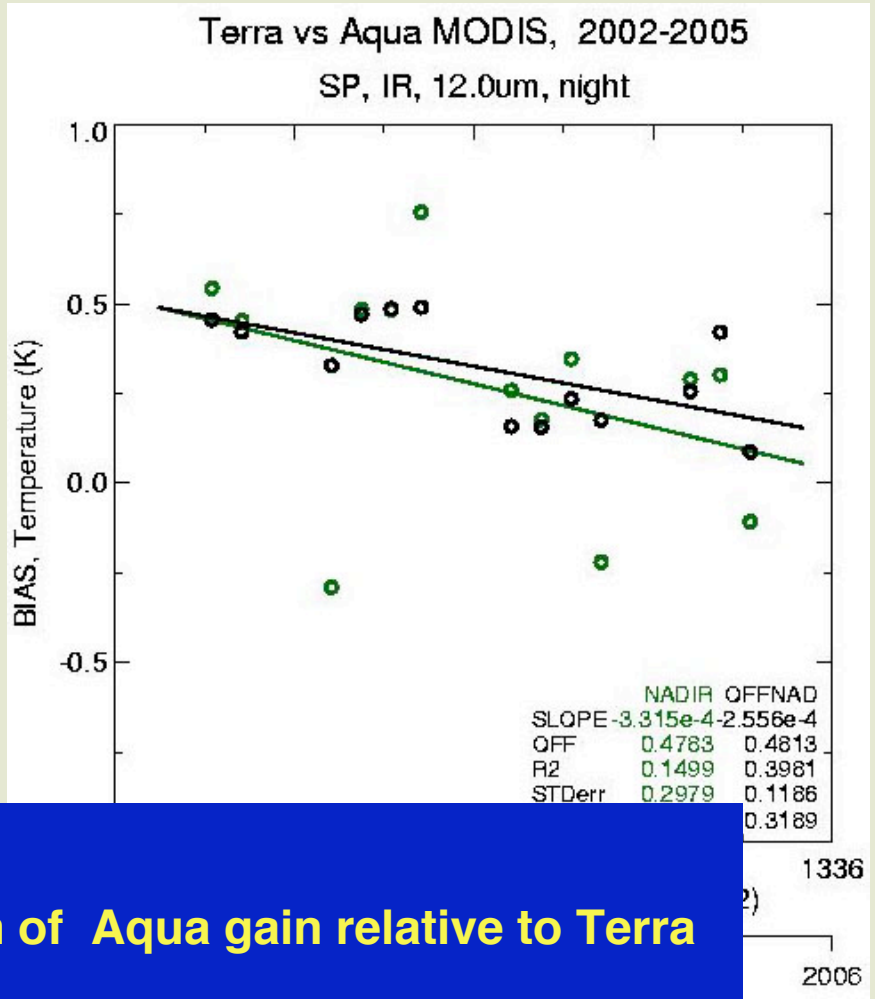
EXAMINE RELATIVE TRENDS IN IMAGER CHANNELS

12 μm

Night slope



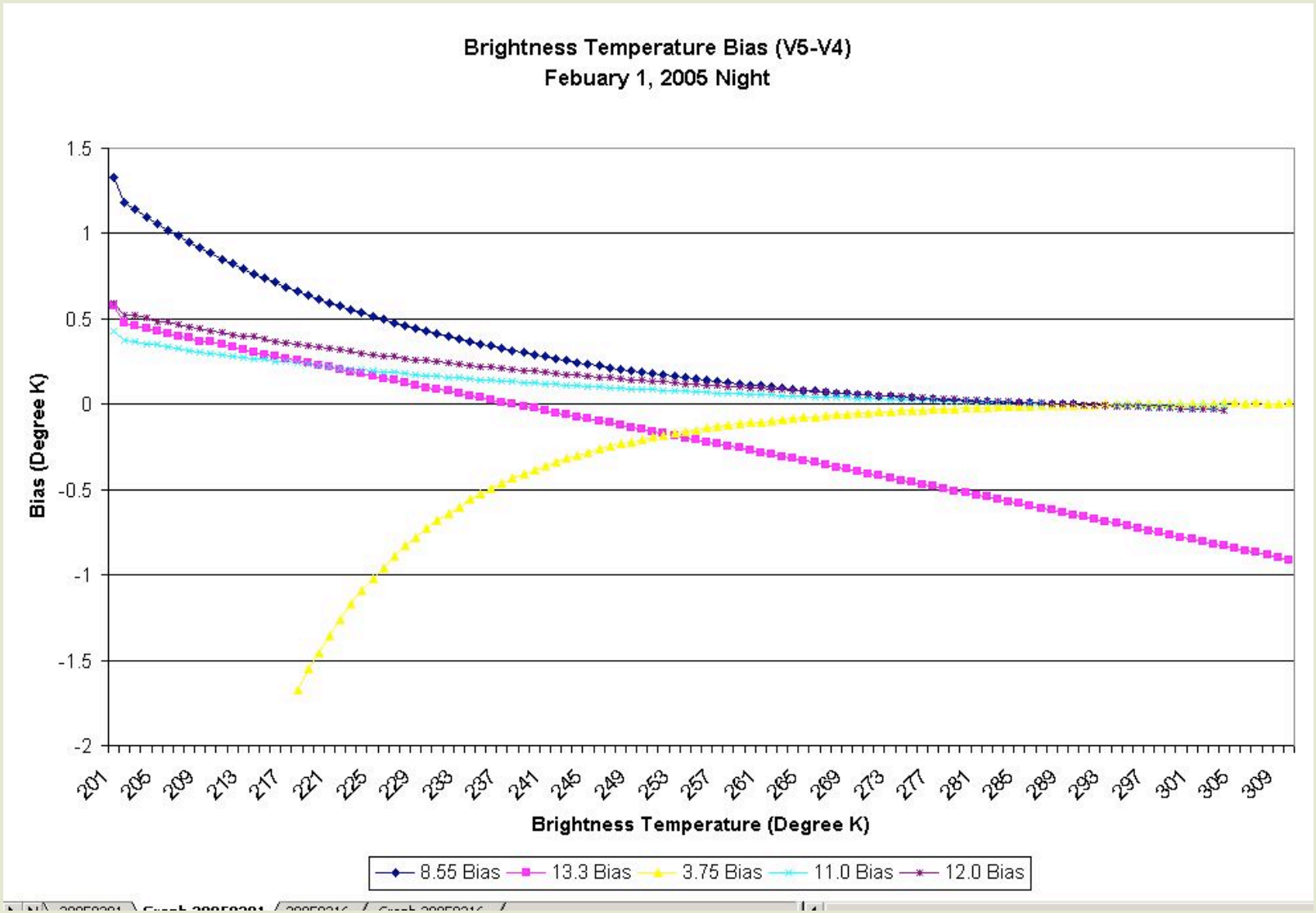
Night bias



- No difference during daytime
- Appears to be slight degradation of Aqua gain relative to Terra at night (very cold end)

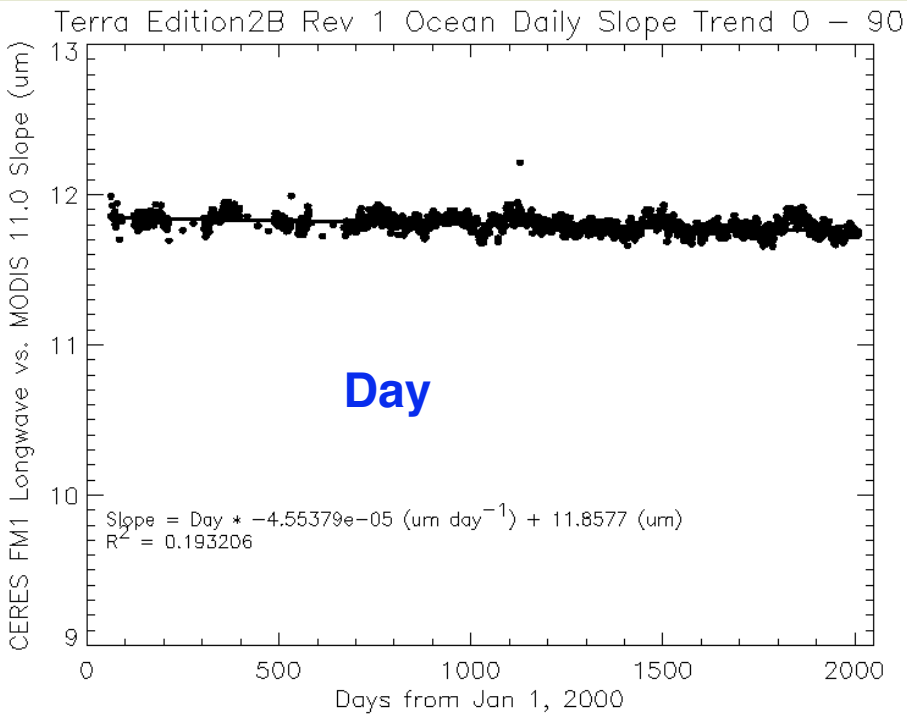
=> seen in bias & gain, collection 5 corrected

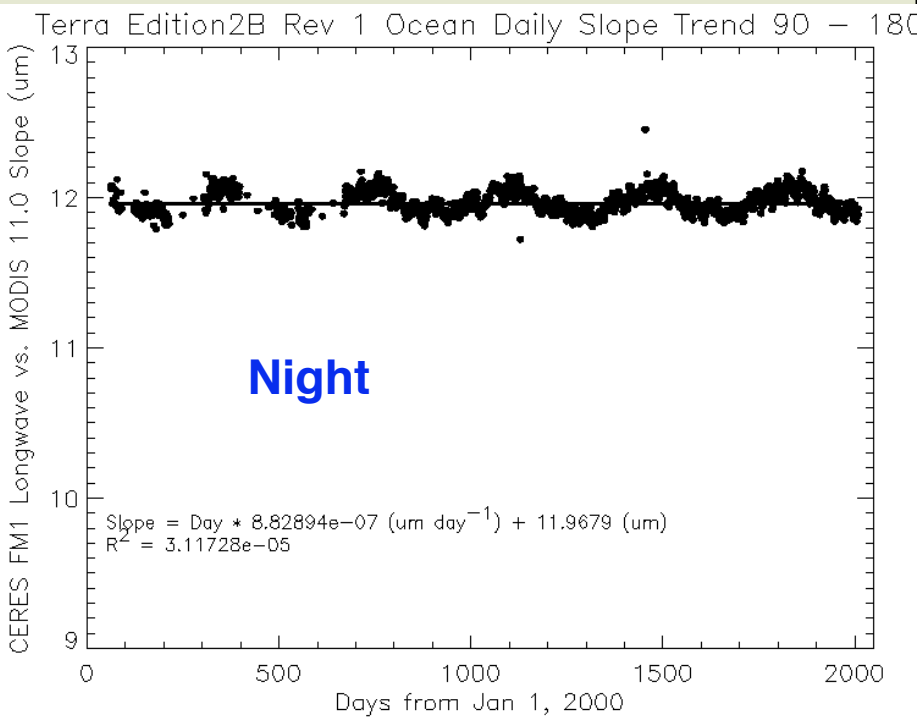
Impact of Version 5 on Cloud Properties Using Current Algorithms



- 3.7 μm colder at T < 285 K: reduce droplet size (day), increase De
- 11, 12 μm warmer at T > 285 K: reduce polar night cloud

Trend lines of 11μm vs LW/Window Regressions, *Terra*
Mar 2000 - Mar 2005





FM 1: => daytime decreasing trend, night flat

SW ?

Terra MODIS Version 5

- Each channel calibration slightly different than Version 4

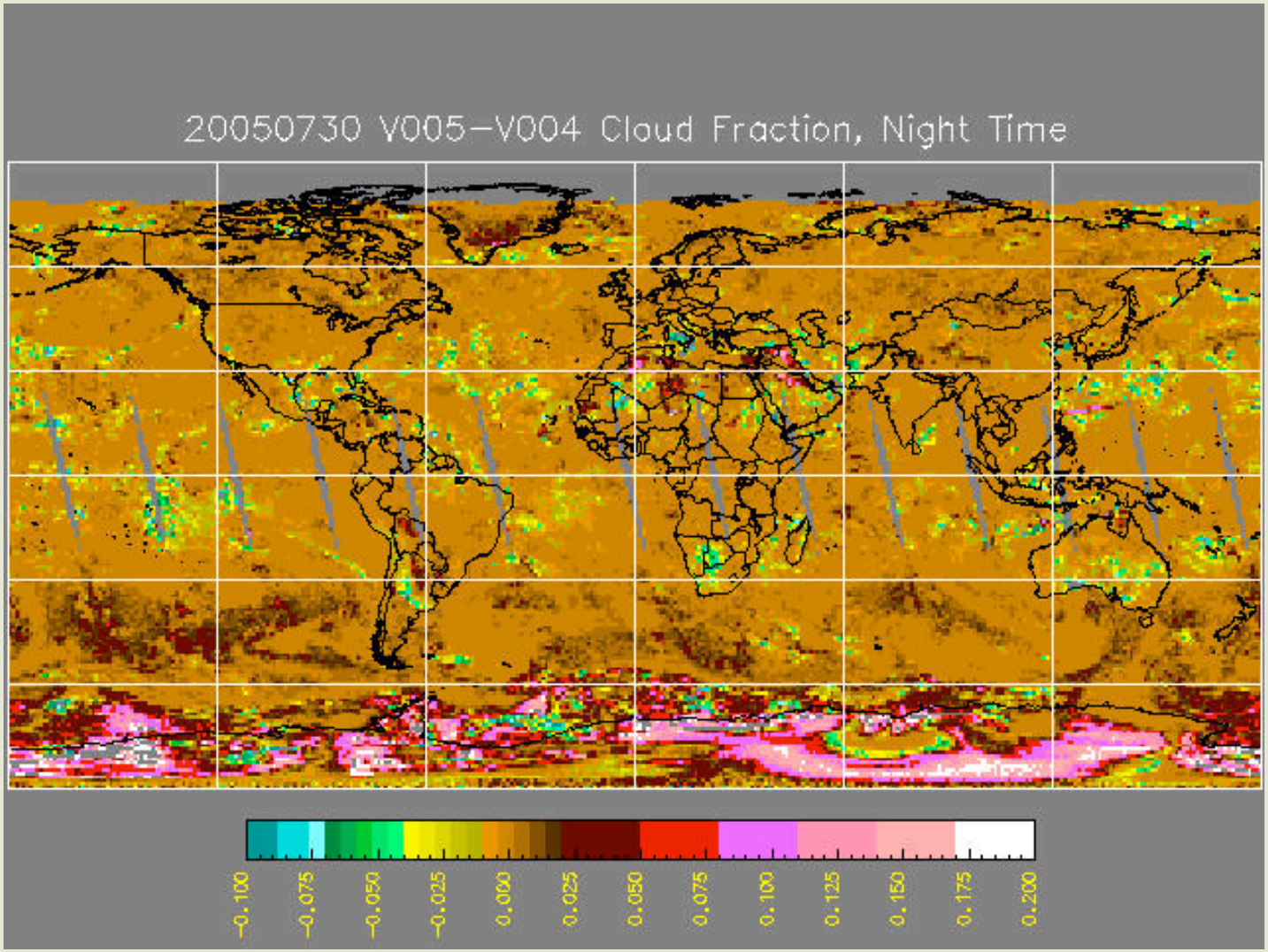
  - supposedly better

- Initial test run for several days for comparison with V004

Future for Version 005

- Complete analysis over all seasons
- Alter polar thresholds

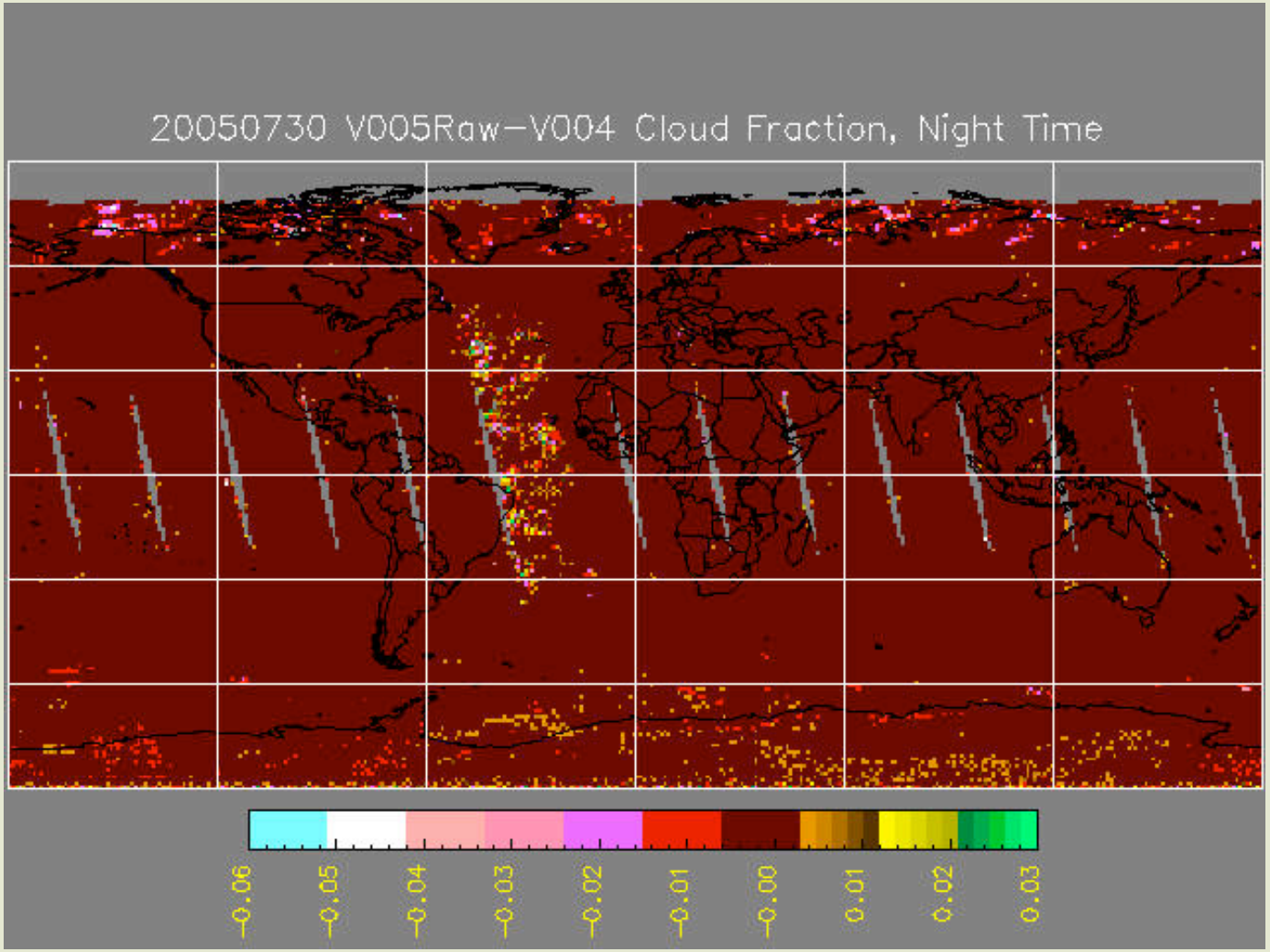
NIGHTTIME CLOUD AMOUNT, July 30, 2005



- **V005 corrections applied to make V005 look like V004**

  => large difference

NIGHTTIME CLOUD AMOUNT, July 30, 2005



- **No V005 corrections applied V004**

  => minimal difference: leave it alone?

SUMMARY OF TERRA-AQUA CONSISTENCY

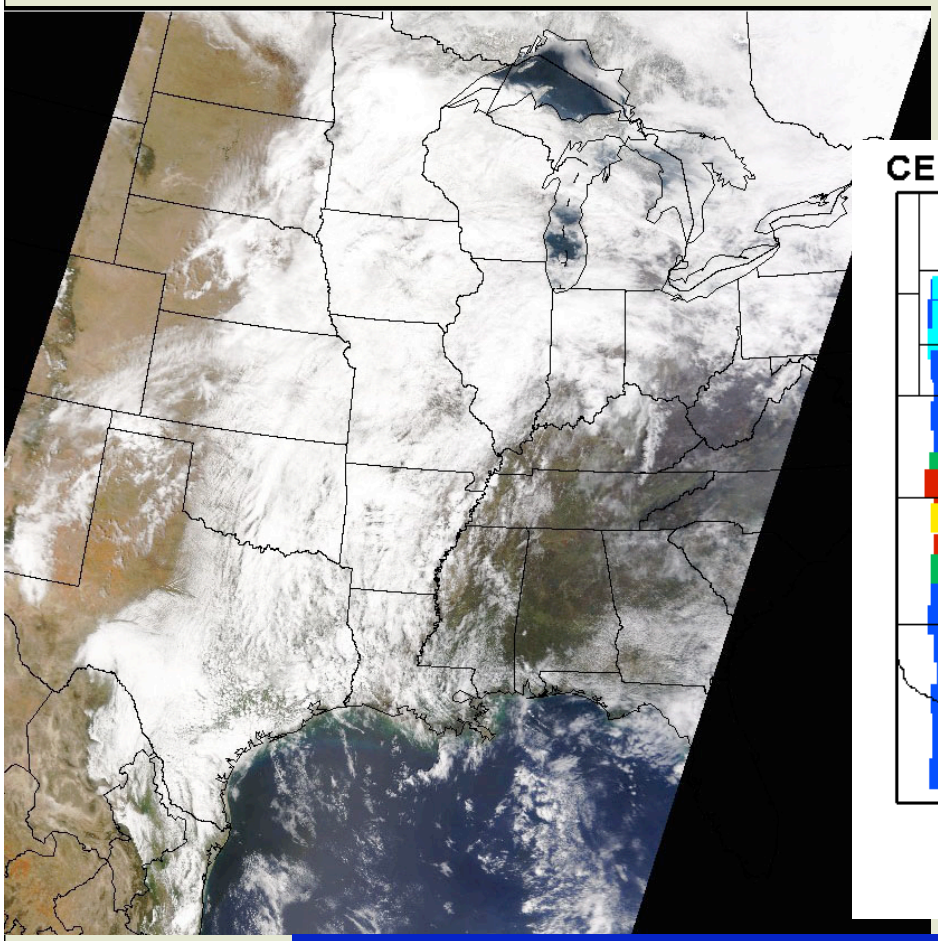
- Cloud fractions very consistent in pattern and magnitude
  - some differences over poles (2.13 vs 1.6 μm)
  - night most consistent
    - but decrease over polar plateaus hurts flux estimates
- More ice clouds from Aqua
  - probably thin cirrus and LBTM impact, some diurnal
  - lower ice OD, worse over poles
- Lower water cloud heights, higher ice cloud
  - some diurnal, some thin cirrus check
- Otherwise very consistent retrievals
  - thin cirrus check needs more investigation

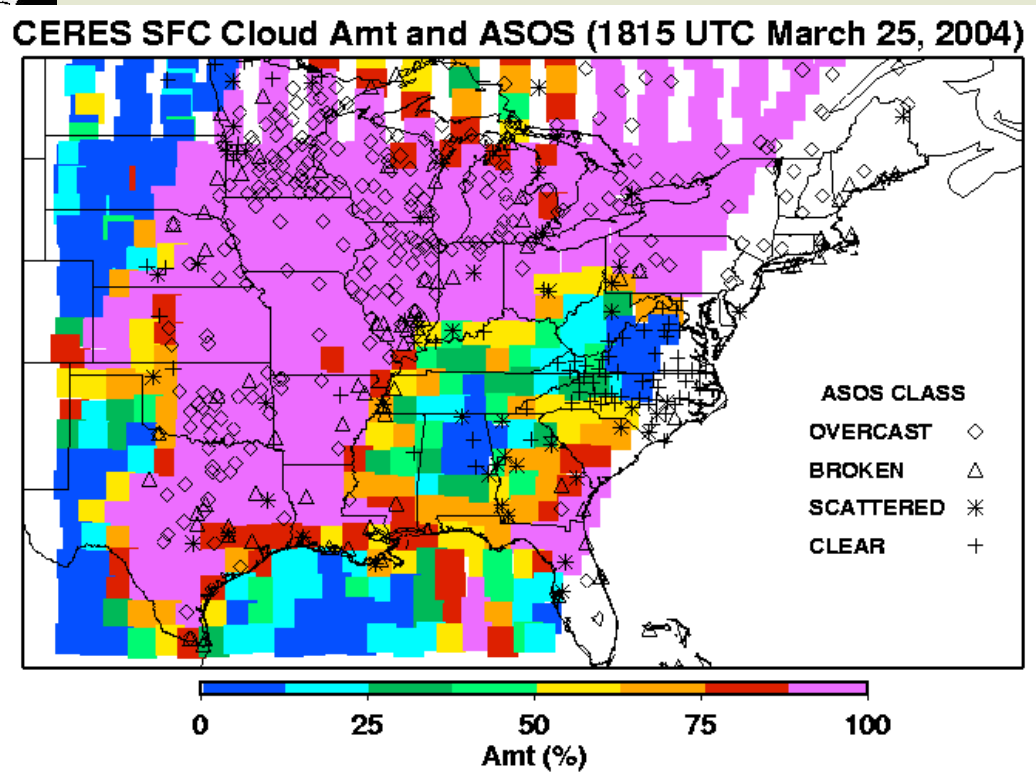
VALIDATION

- New Results for Aqua
- More GOES proxy comparisons

Validation of Cloud Amount (ASOS Comparisons)

Terra example





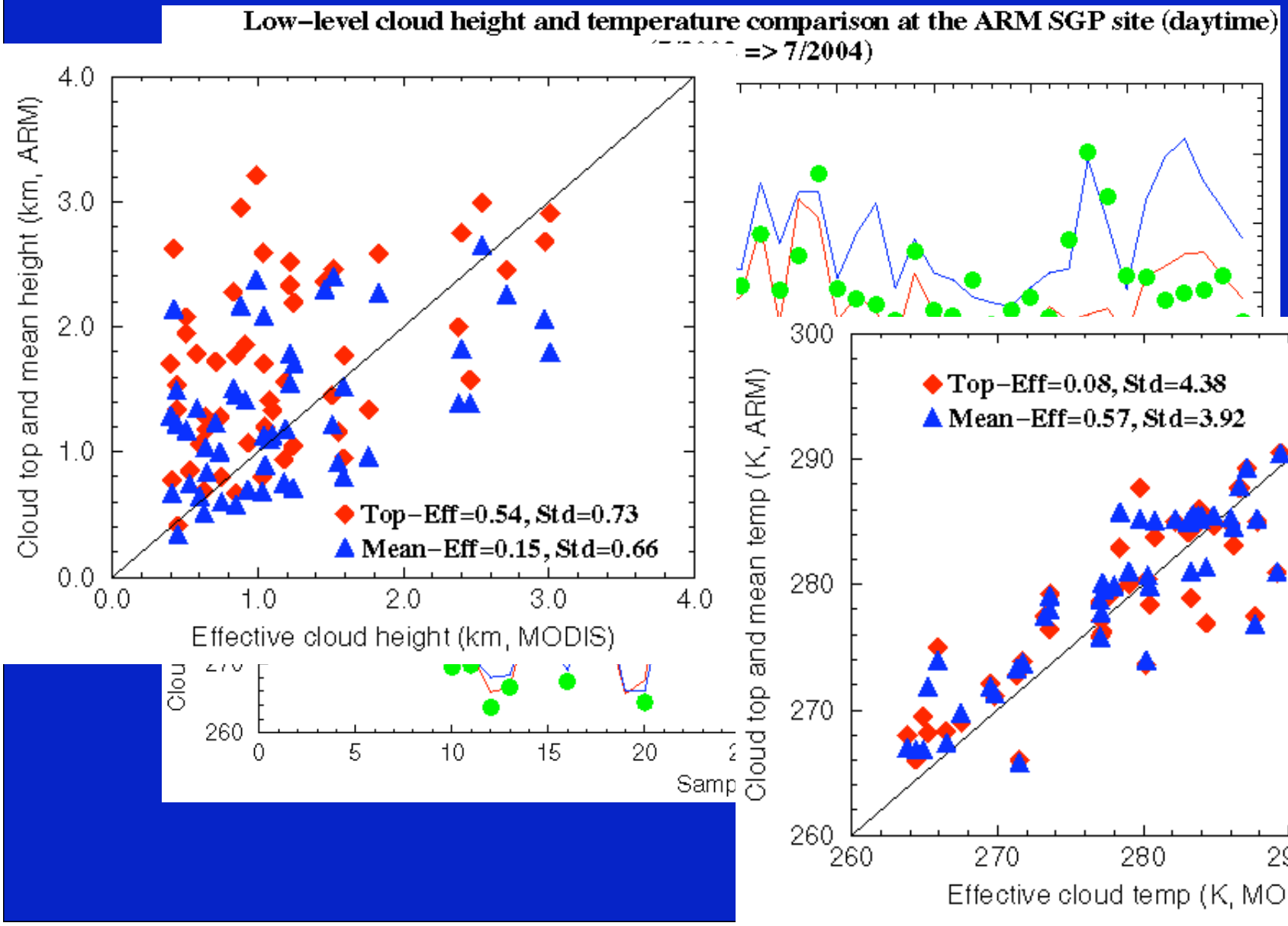
Well-matched in many areas, except near edges and when cirrus are the only cloud

May be possible only via statistics for mid-low level clouds

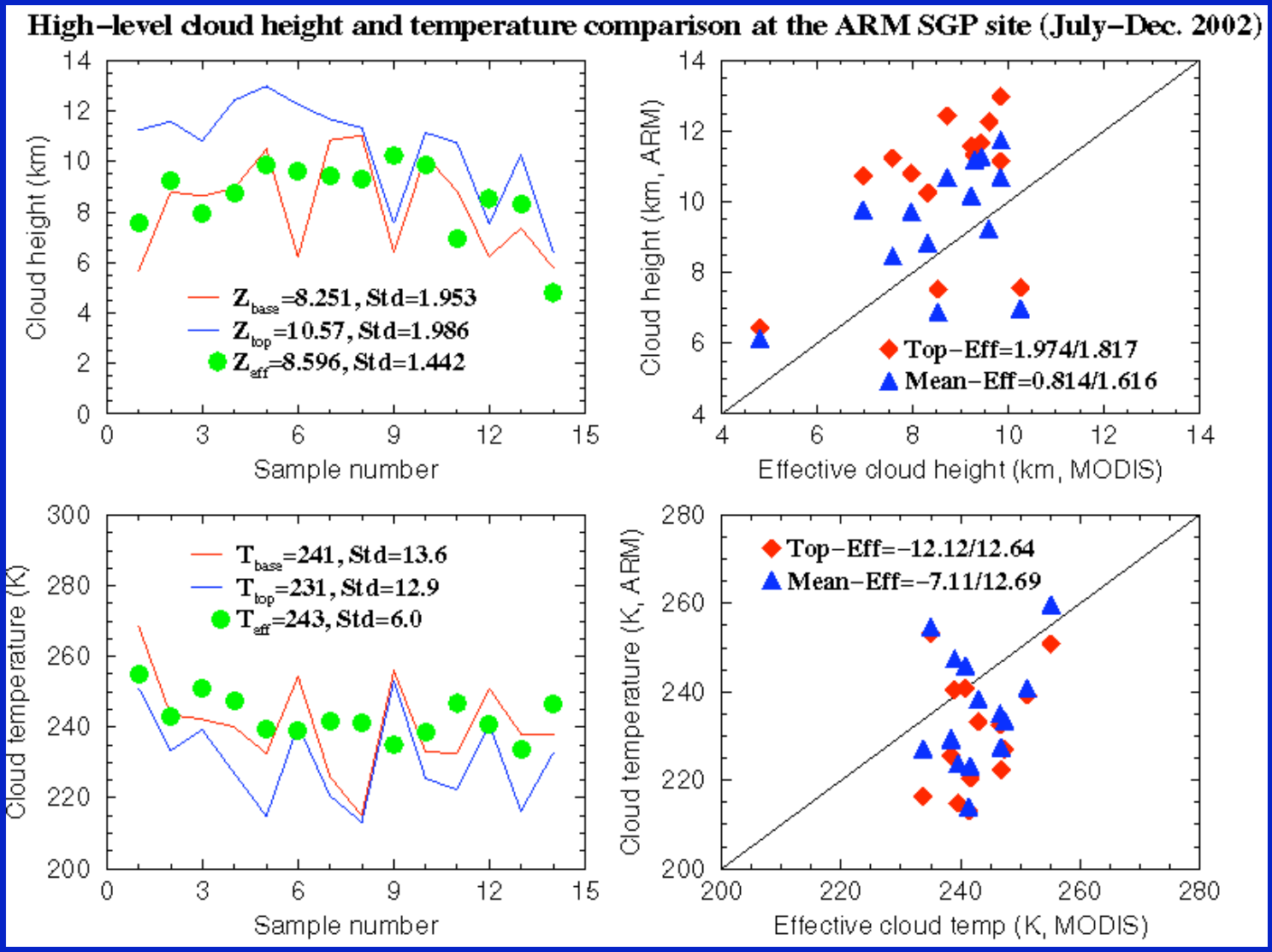
Comparison of Aqua Low Cloud Heights over SGP,

Cloud-top temperature is unbiased

so method for selecting height remains unsatisfactory!



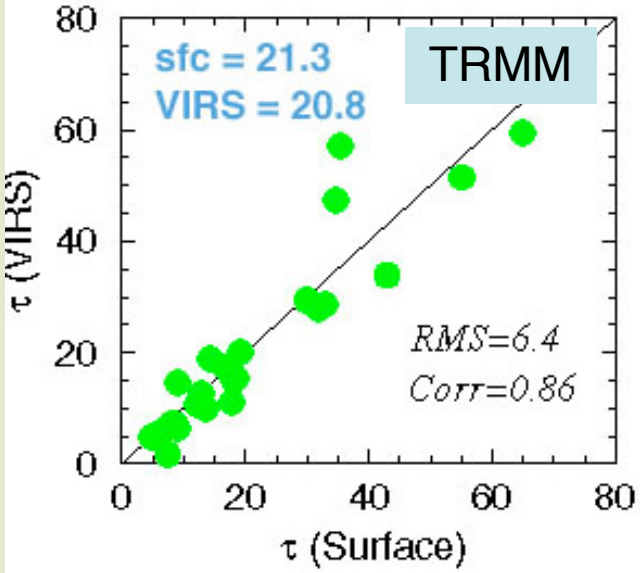
Aqua High Cloud Heights over the SGP

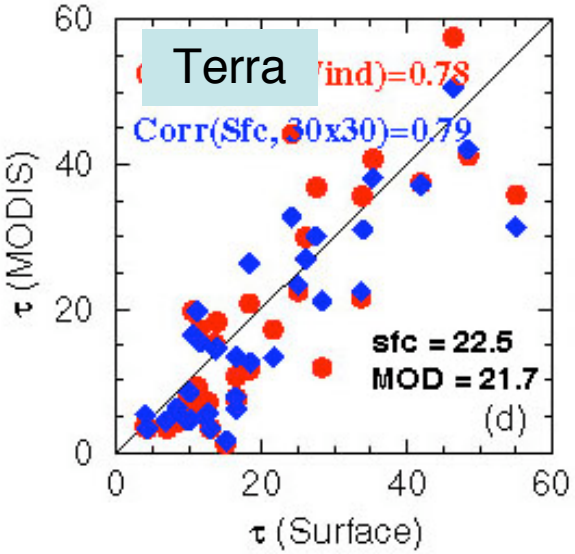


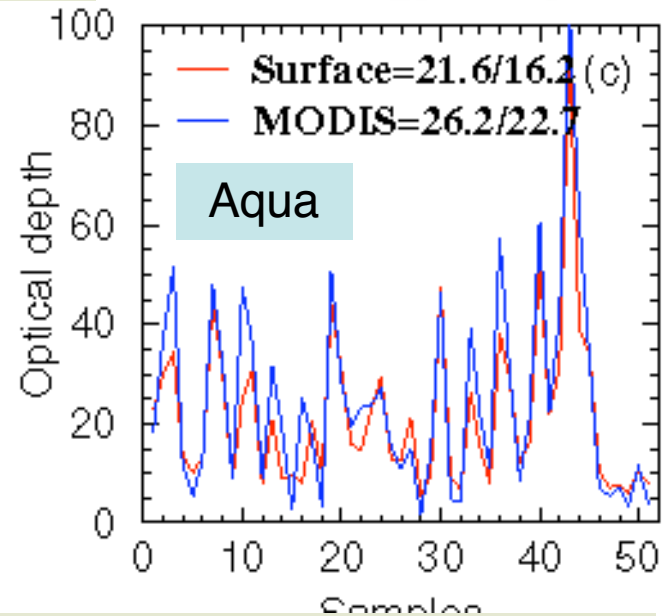
On average, Aqua cloud effective heights in thin cirrus fall between the base and center of the cloud

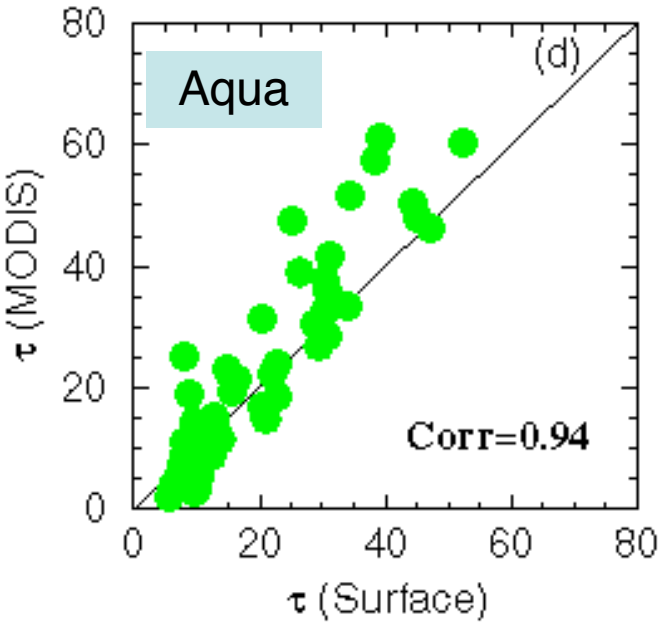
Validation of CERES Cloud Optical Depth (Stratus)

ARM SGP, VIRS 1998; MODIS 2000-2001





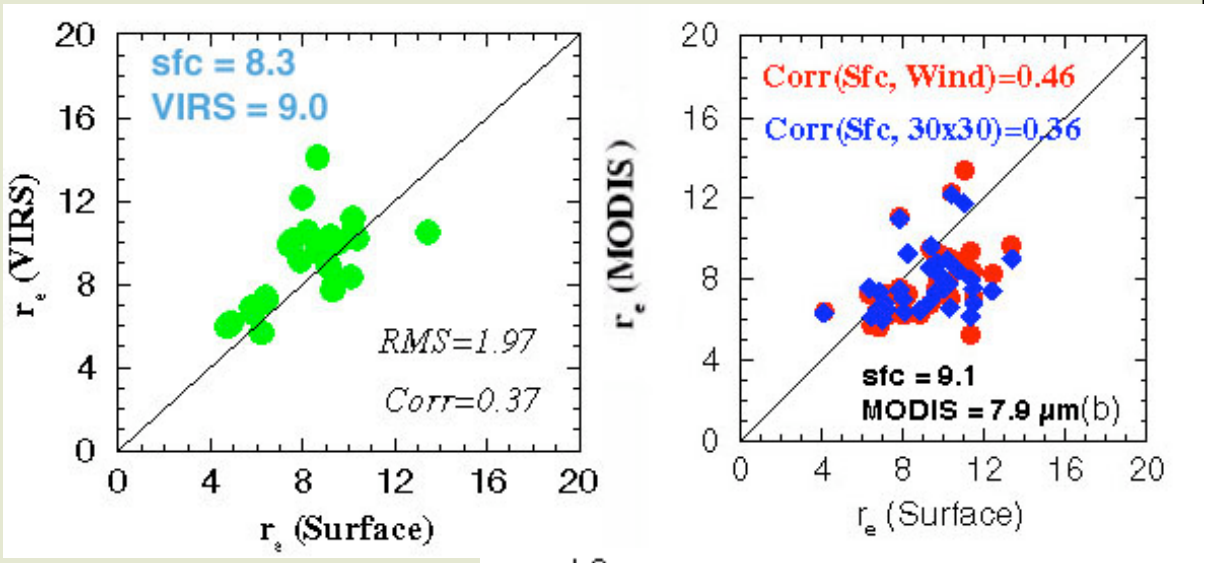


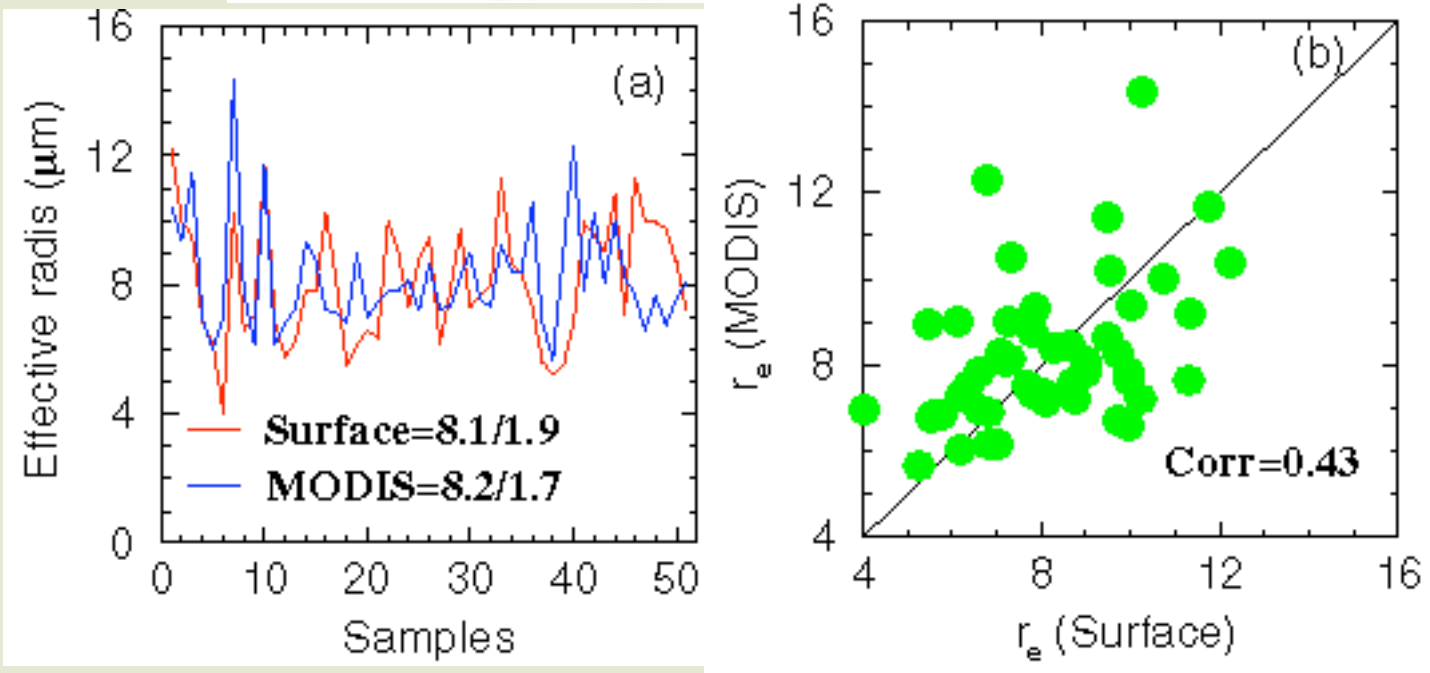


Excellent correspondence between CERES and surface-derived optical depths over ARM SGP site

Validation of CERES Cloud Droplet Size (Stratus)

ARM SGP, VIRS 1998; MODIS 2000-2001

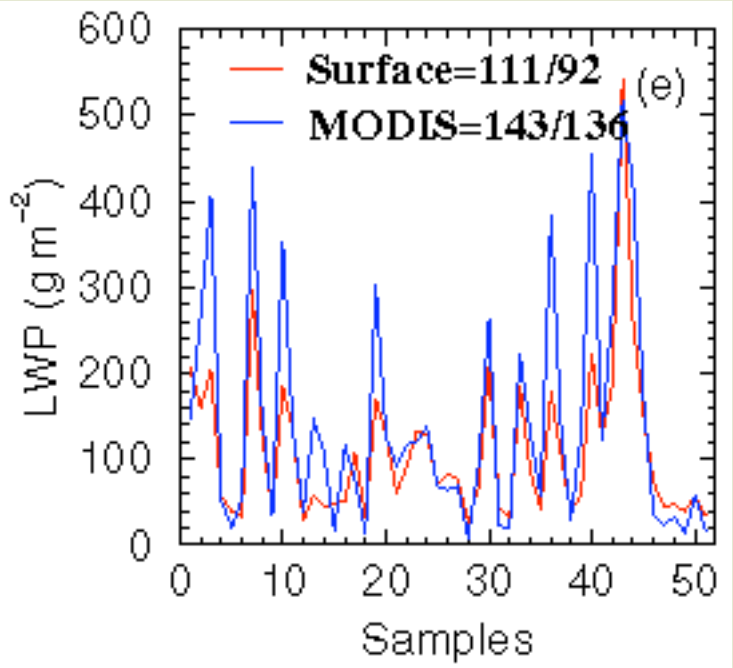


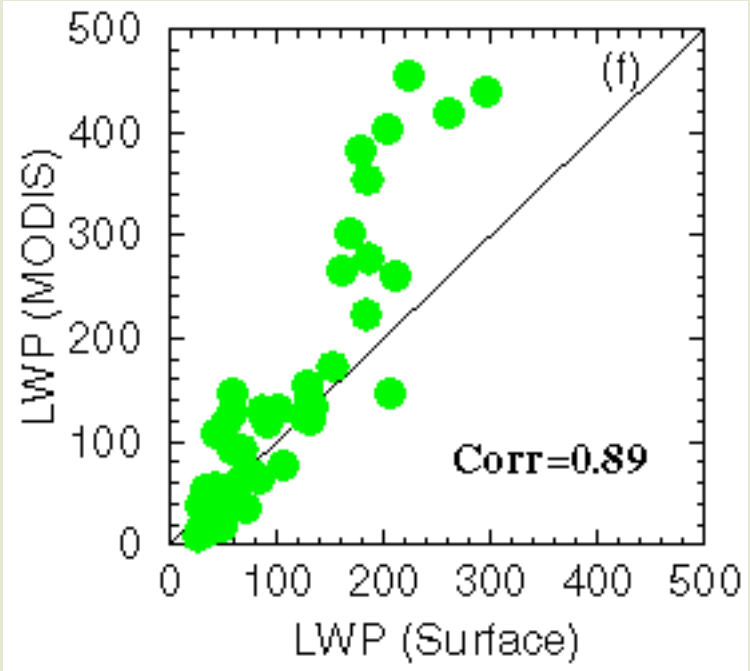


CERES average droplet sizes within ± 1 μm of surface-based values over ARM SGP site

Aqua Validation

LWP over ARM SGP site, July 2002-July 2004





- **LWP:** VIRS + 16% ($r^2 = 0.96$)

  Terra - 18% ($r^2 = 0.88$)

  Aqua + 28% ($r^2 = 0.89$) opt depth mainly

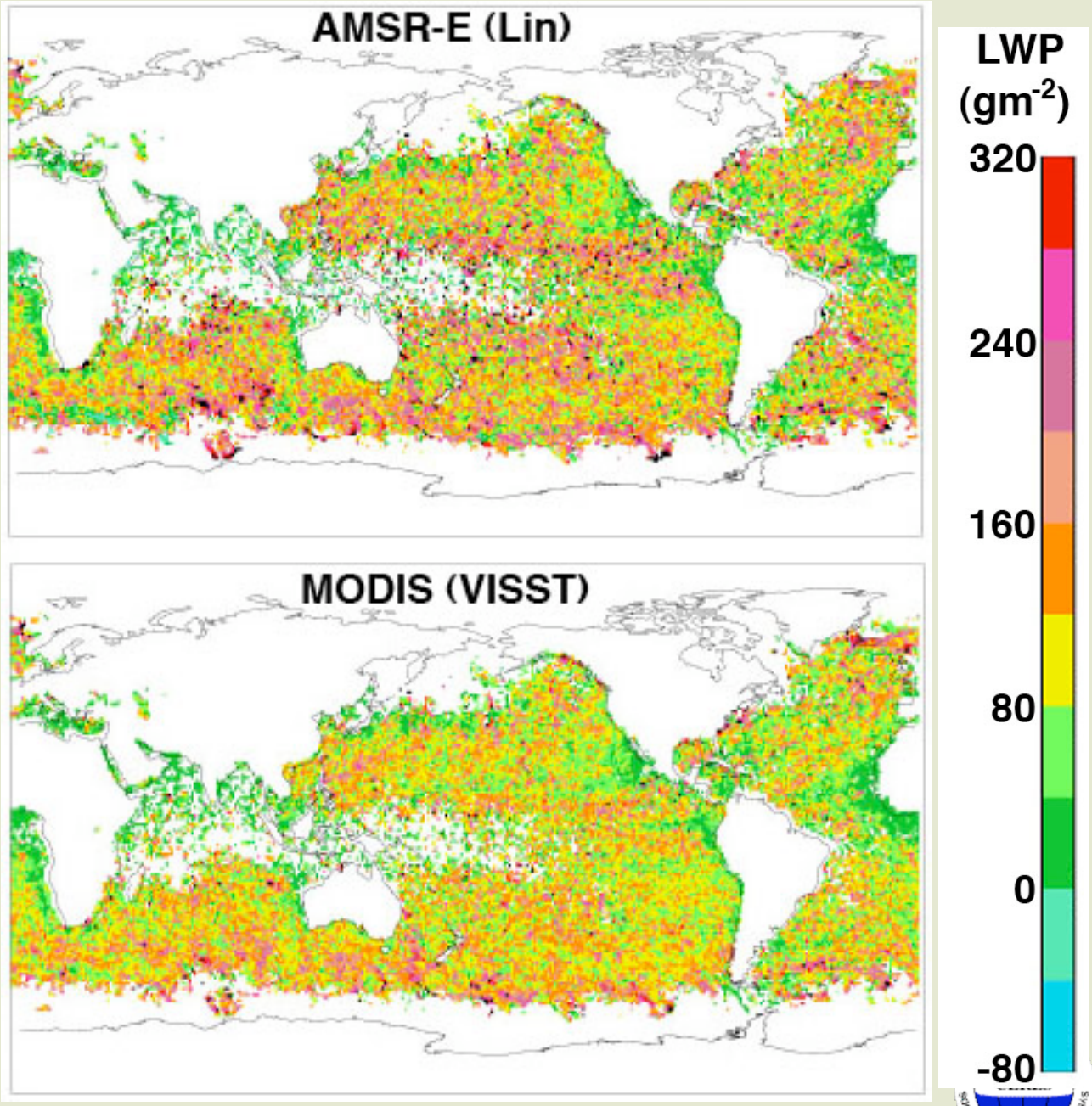
Standard errors ~ 50%

Aqua Validation

MODIS *vs* AMSR LWP

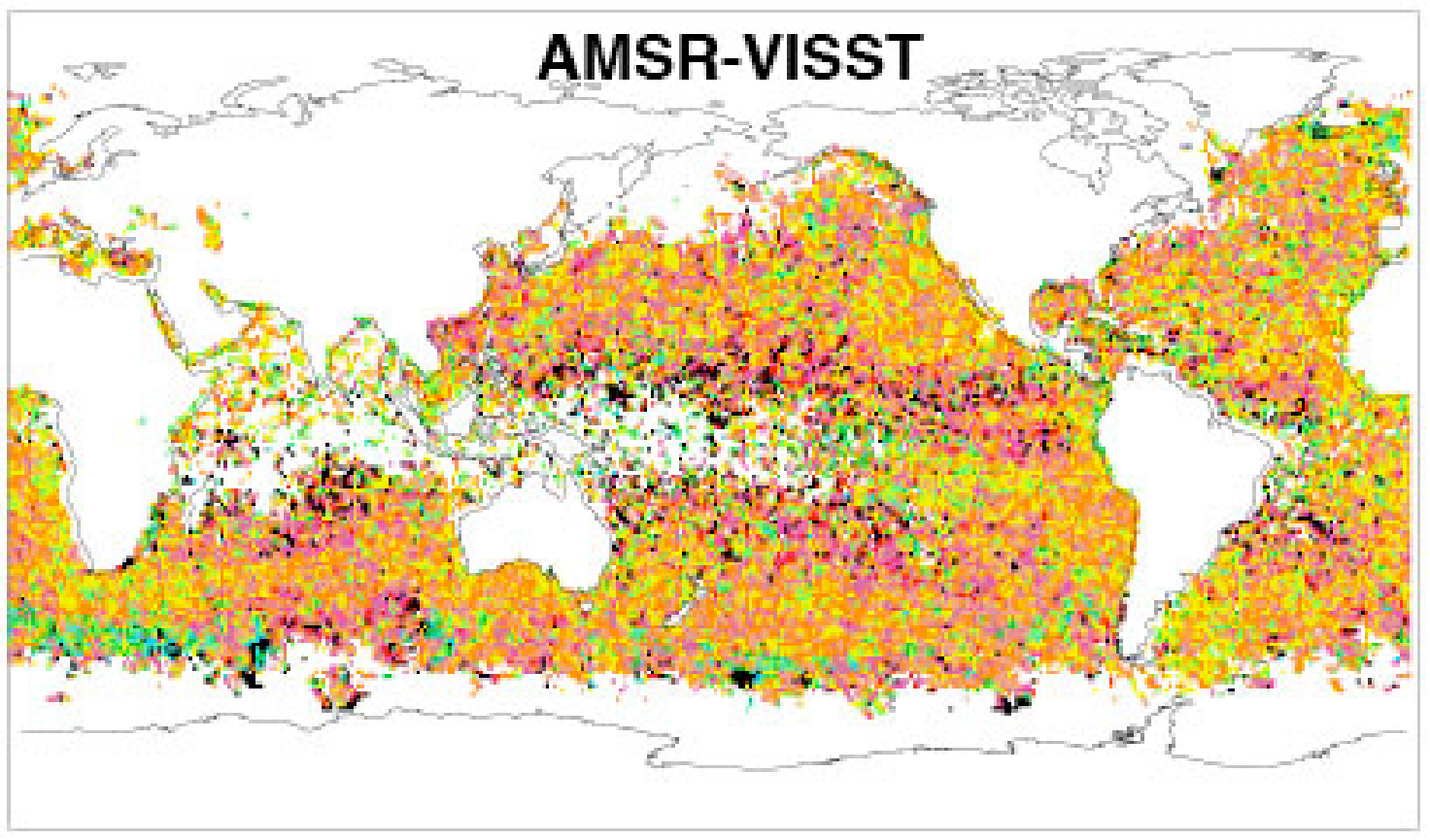
March 2005

Tc > 273 K



Aqua Validation

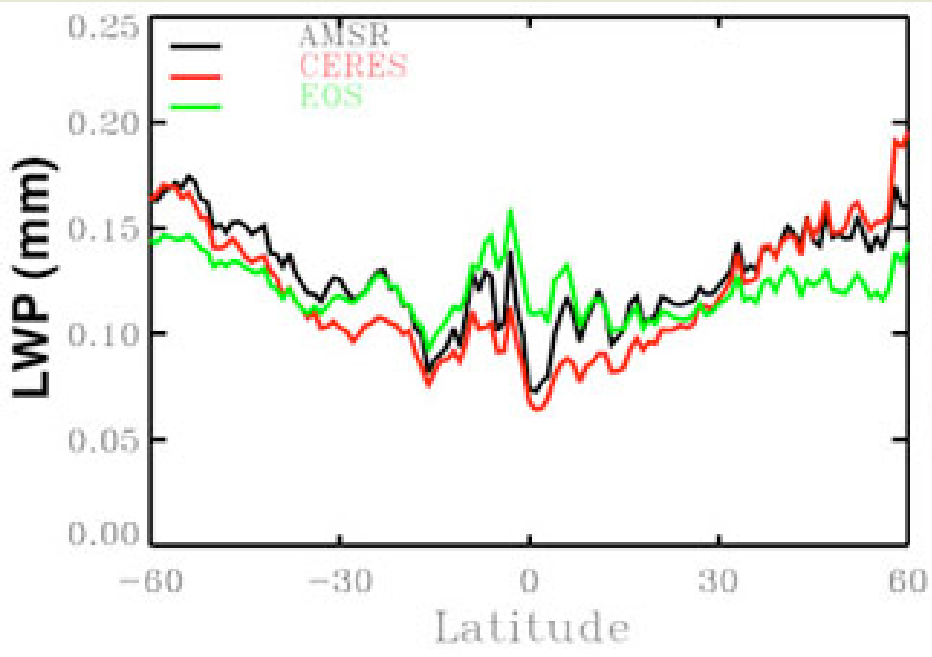
AMSR - VISST LWP March 2005, Tc > 273 K



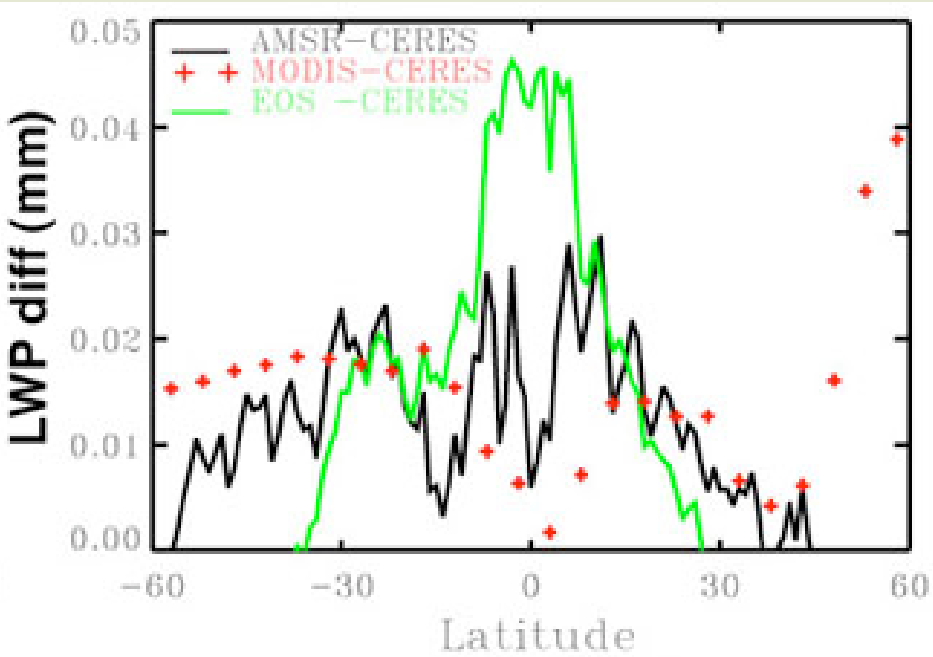
AMSR retrieving much larger values over open ocean

Aqua LWP Zonal Means
March 2005, Overcast Liquid Water

Monthly Means



Mean Differences



AMSR - Lin algo

EOS - AMSR Wentz algo

CERES - VISST

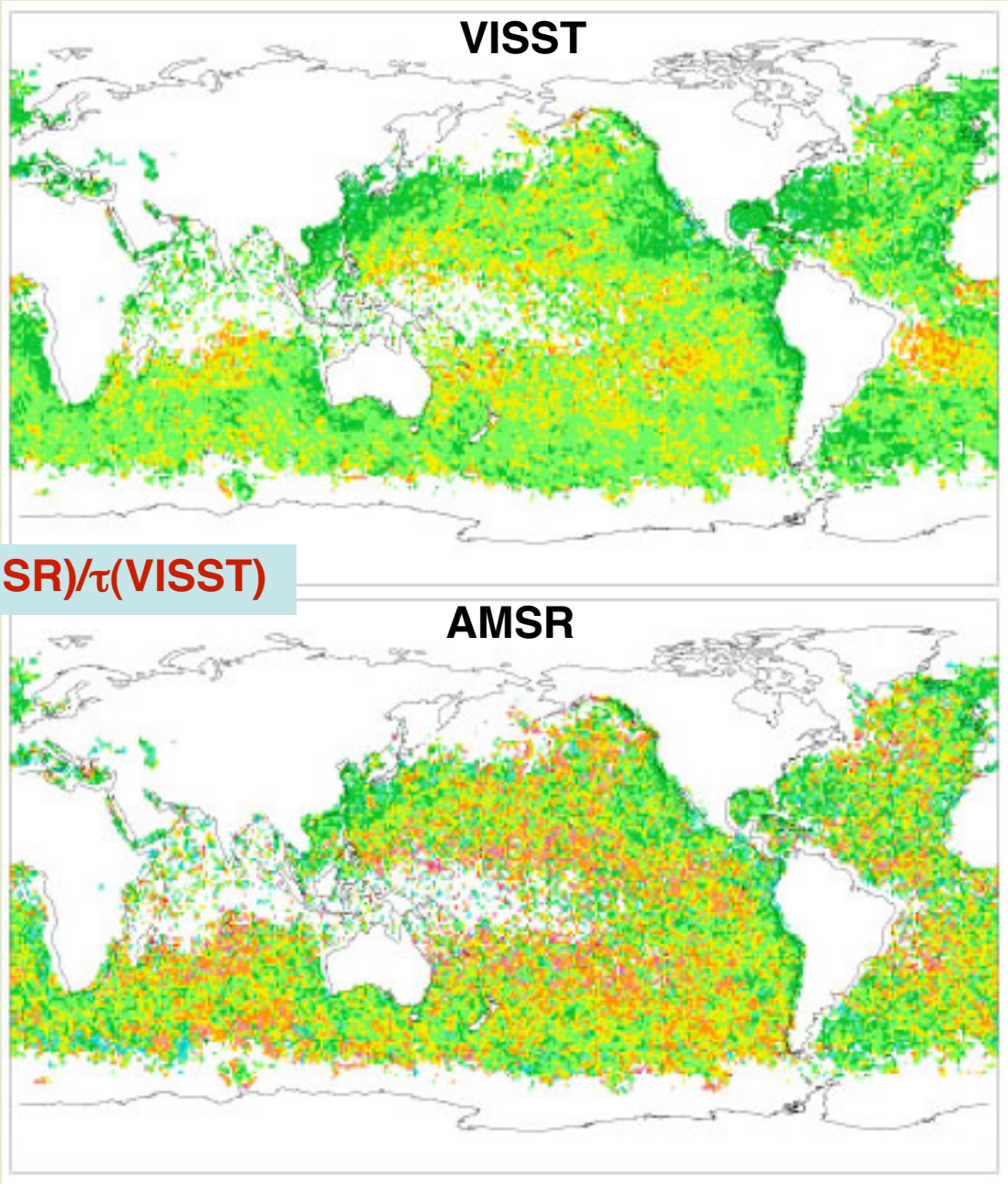
MODIS - MYD06

CERES < all others in Tropics

CERES < MYD06 everywhere, 10% solcon dif

Differences between MW algos as large as AMSR-VISST

Aqua Mean Effective Radius March 2005, Overcast Liquid Water

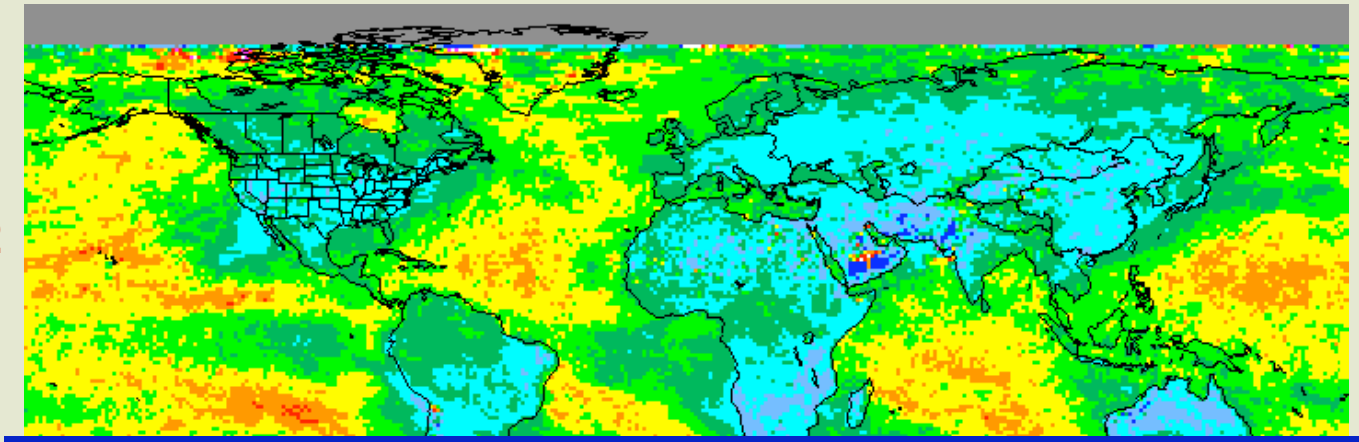


r_e(AMSR) = 0.75*LWP(AMSR)/τ(VISST)

Radius differences as large as 9 μm in some areas

WATER DROPLET EFFECTIVE RADIUS, *Terra*, October 2003

CERES Ed2



μm

4
6
8
10
12
14
16
18
20
22
24

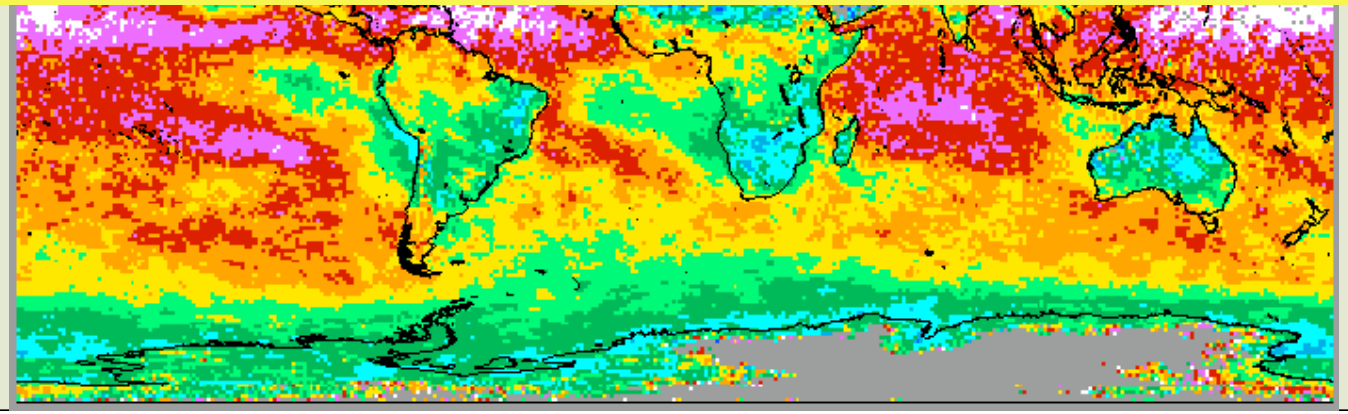
MODIS results resemble AMSR retrievals

Is $r_e > 18$ μm a typical monthly mean over open ocean?

Is AMSR biased?

Still some work left on AMSR calibrations

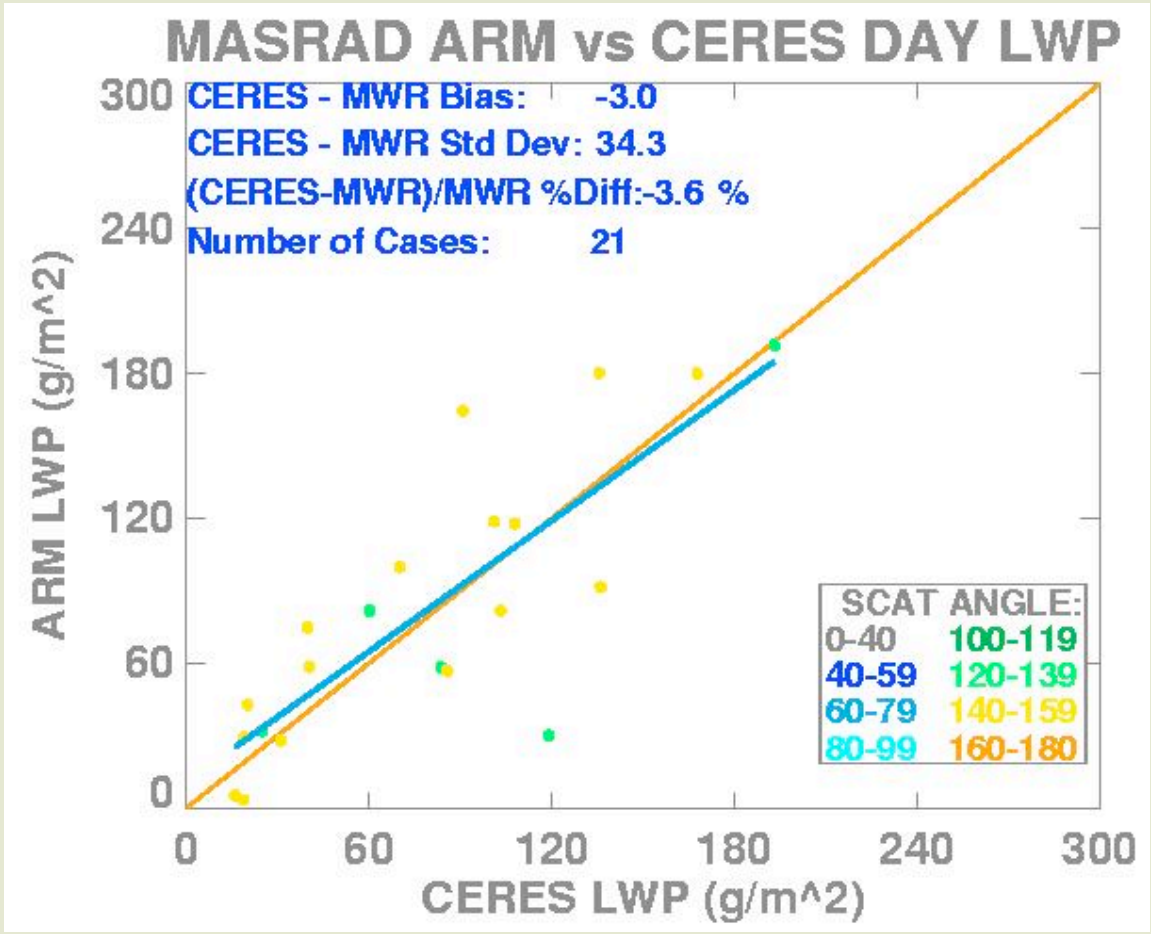
MOD08
MODIS Team



Terra Validation

LWP over ARM AMF site, Pt. Reyes, CA

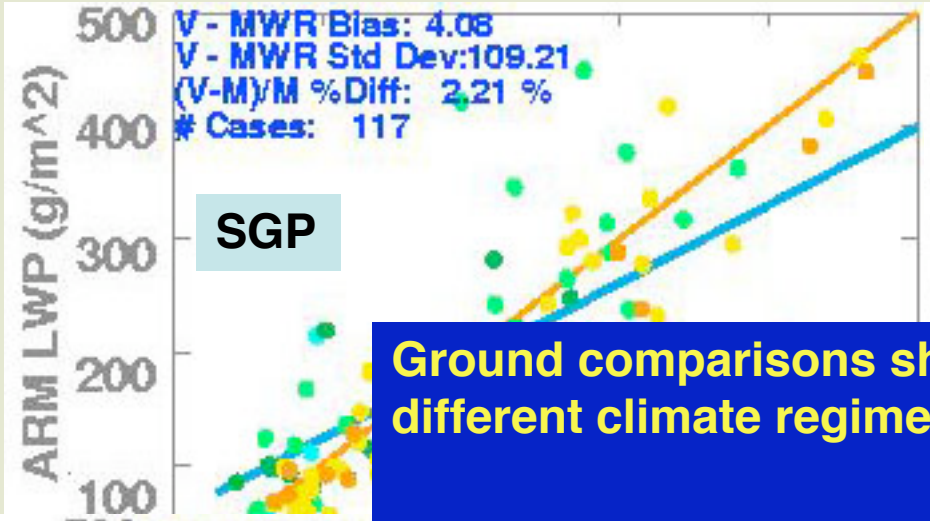
Feb 2005-June 2005

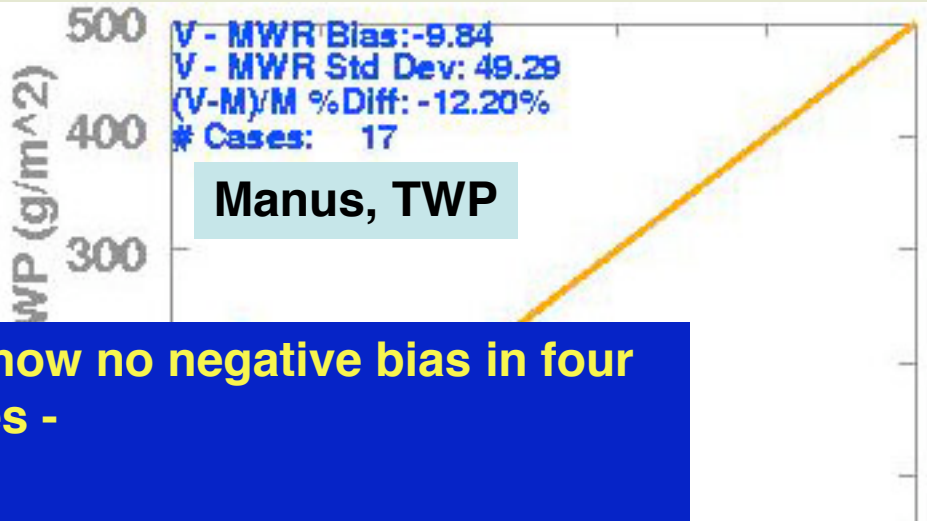


Expect Aqua to be greater than surface since r_e(Aqua) > r_e(Terra)

MODIS LWP Validation by GOES Proxy

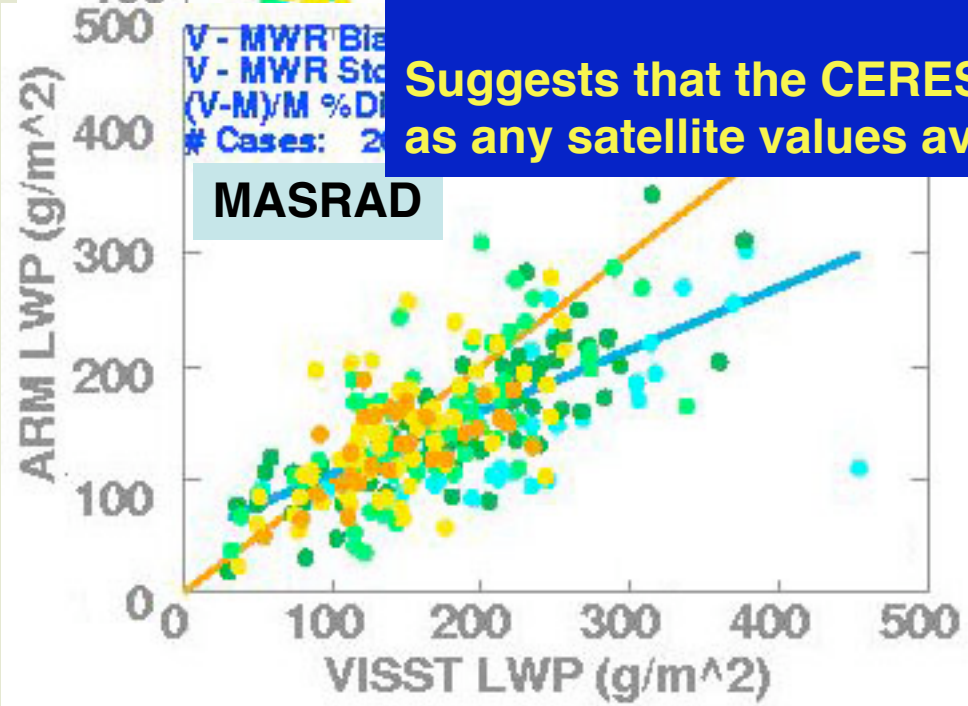
Using the same algorithms and GOES calibrated against MODIS, we obtain similar results over different areas:

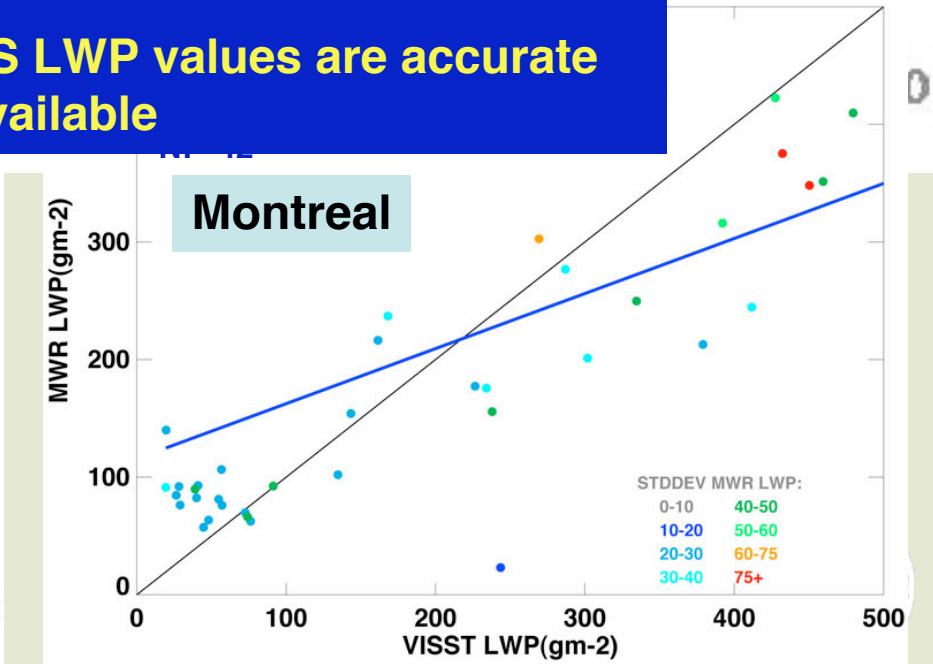




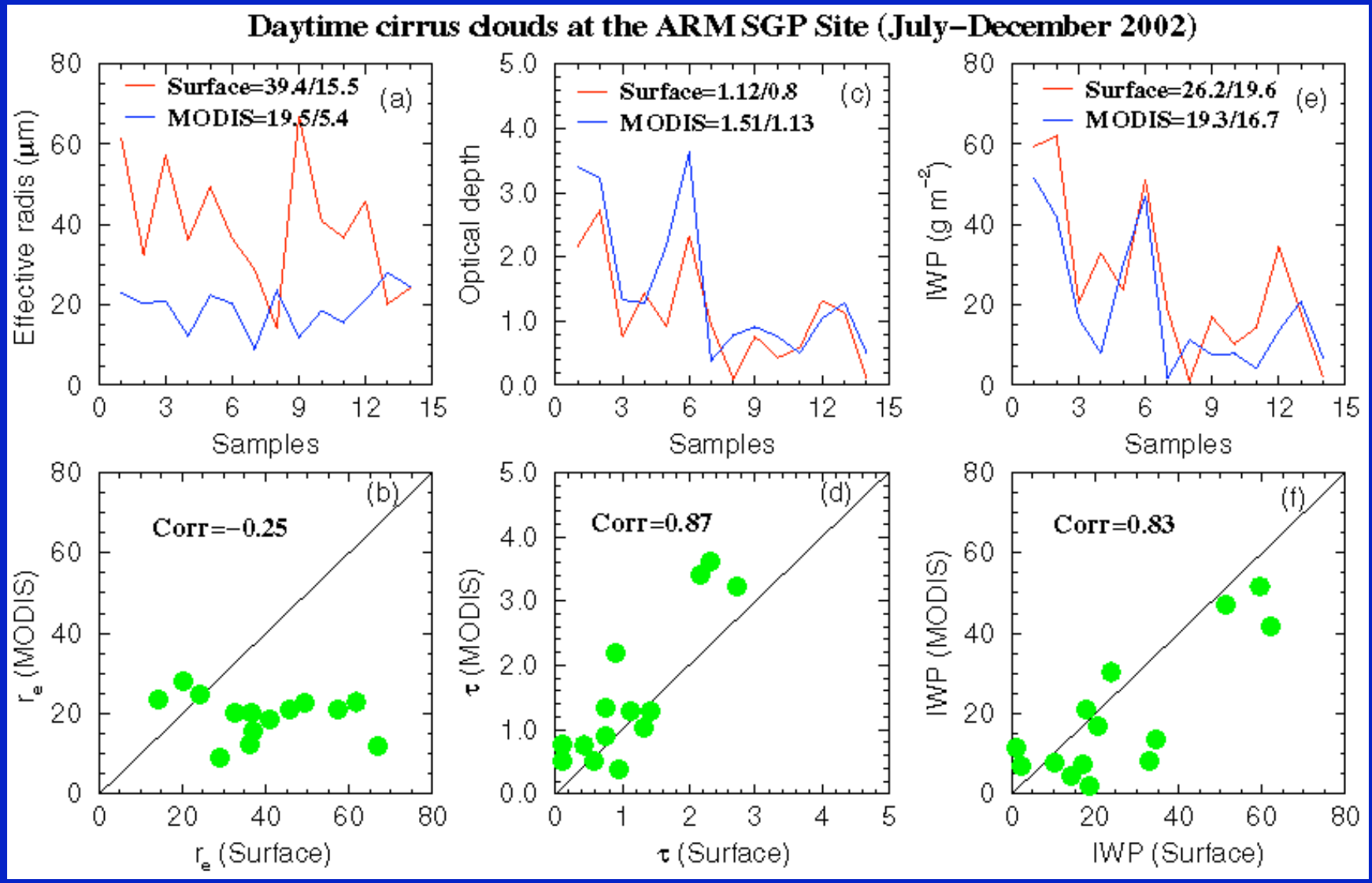
Ground comparisons show no negative bias in four different climate regimes -

Suggests that the CERES LWP values are accurate as any satellite values available





Aqua Cirrus at the ARM SGP, 2002



Apparent underestimate of particle size, overestimate of τ and IWP -

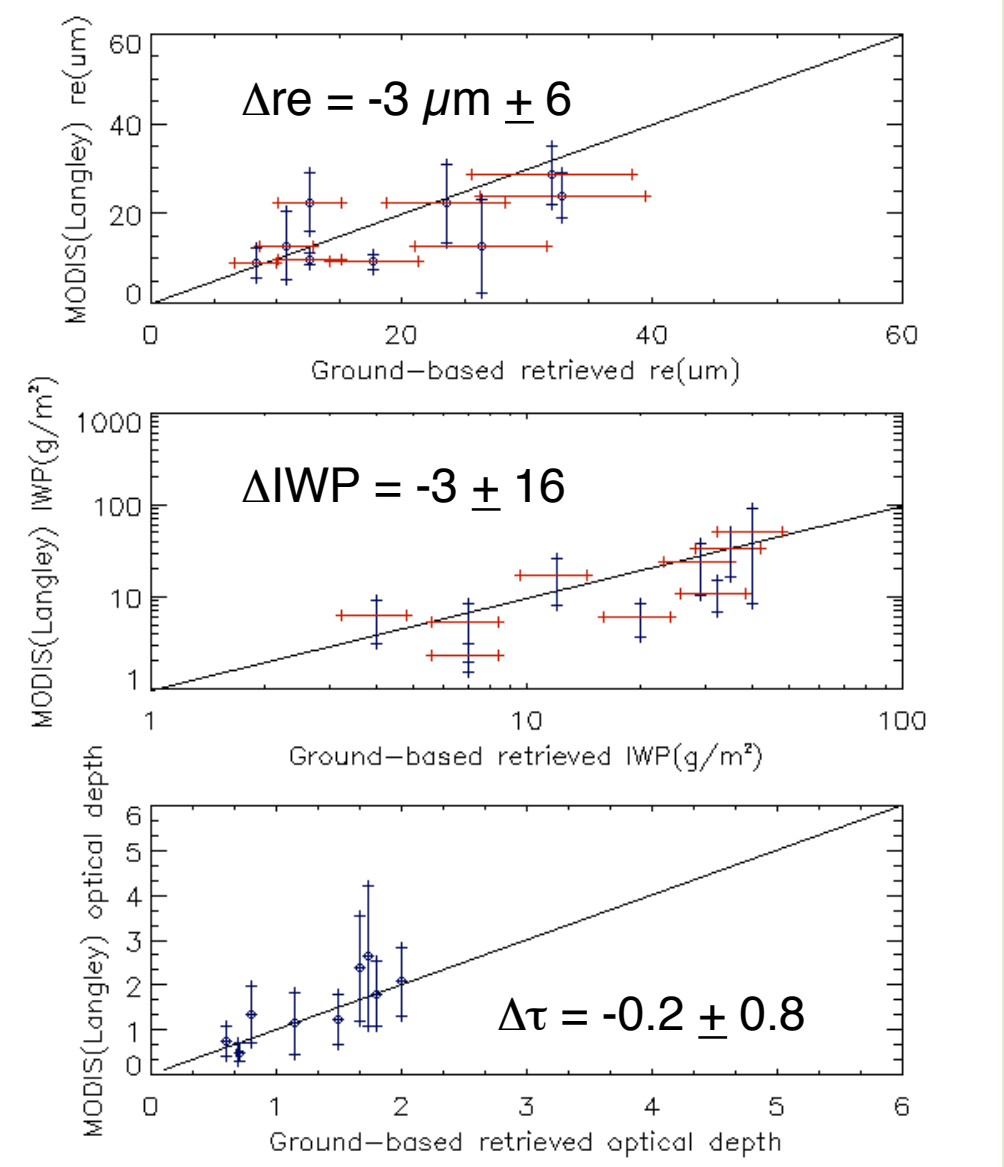
No attempt at parallax or wind strip

CERES

COMPARISON WITH SURFACE RADAR RETRIEVALS OF THIN CIRRUS

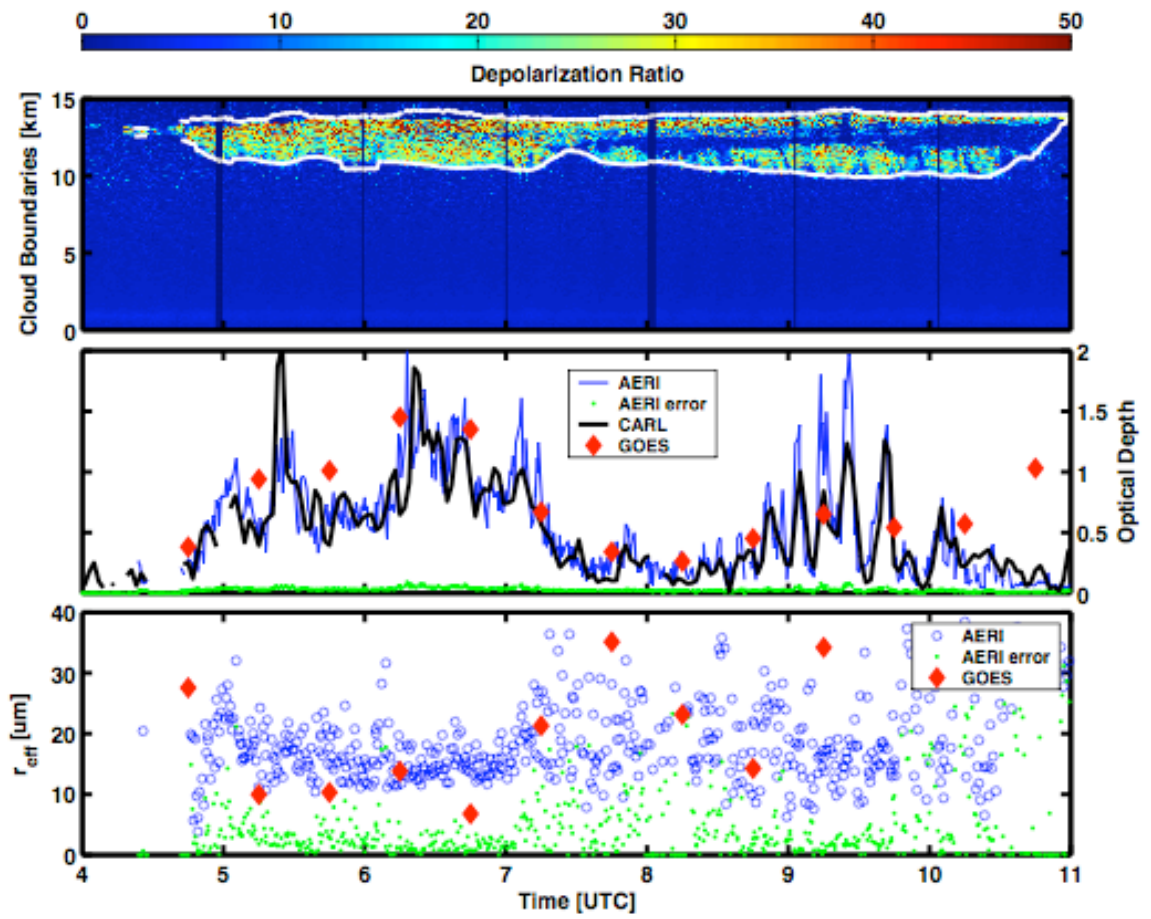
***Terra* MODIS, ARM SGP**

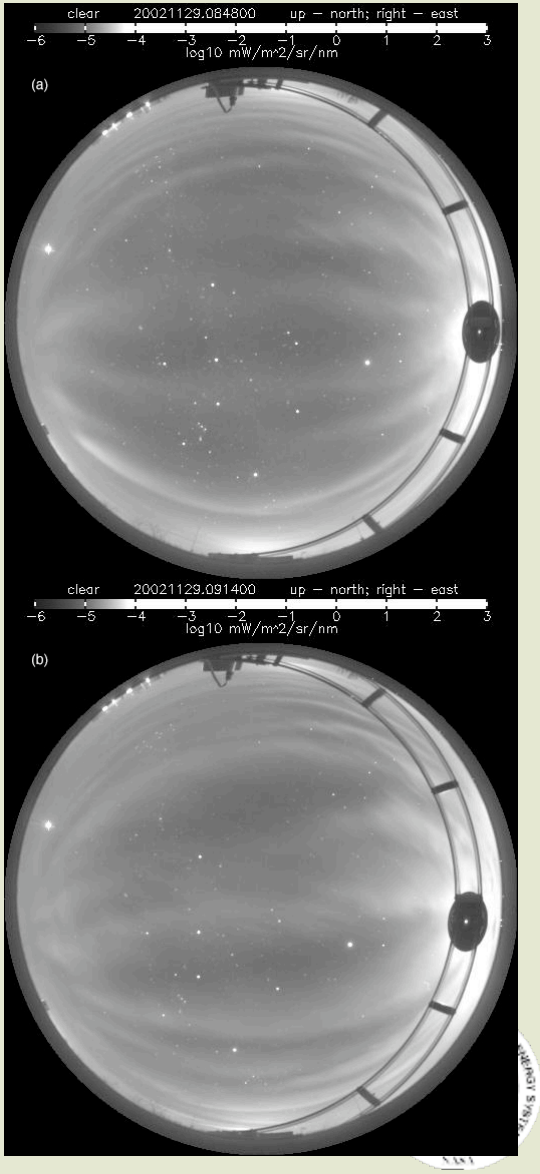
(see *Mace et al. 2005*)



Comparison of GOES Optical Depth Retrievals at Night Over SGP with Retrievals from AERI on Proteus,TX2002, 29 Nov 2002

DeSlover et al., JTech, 2005



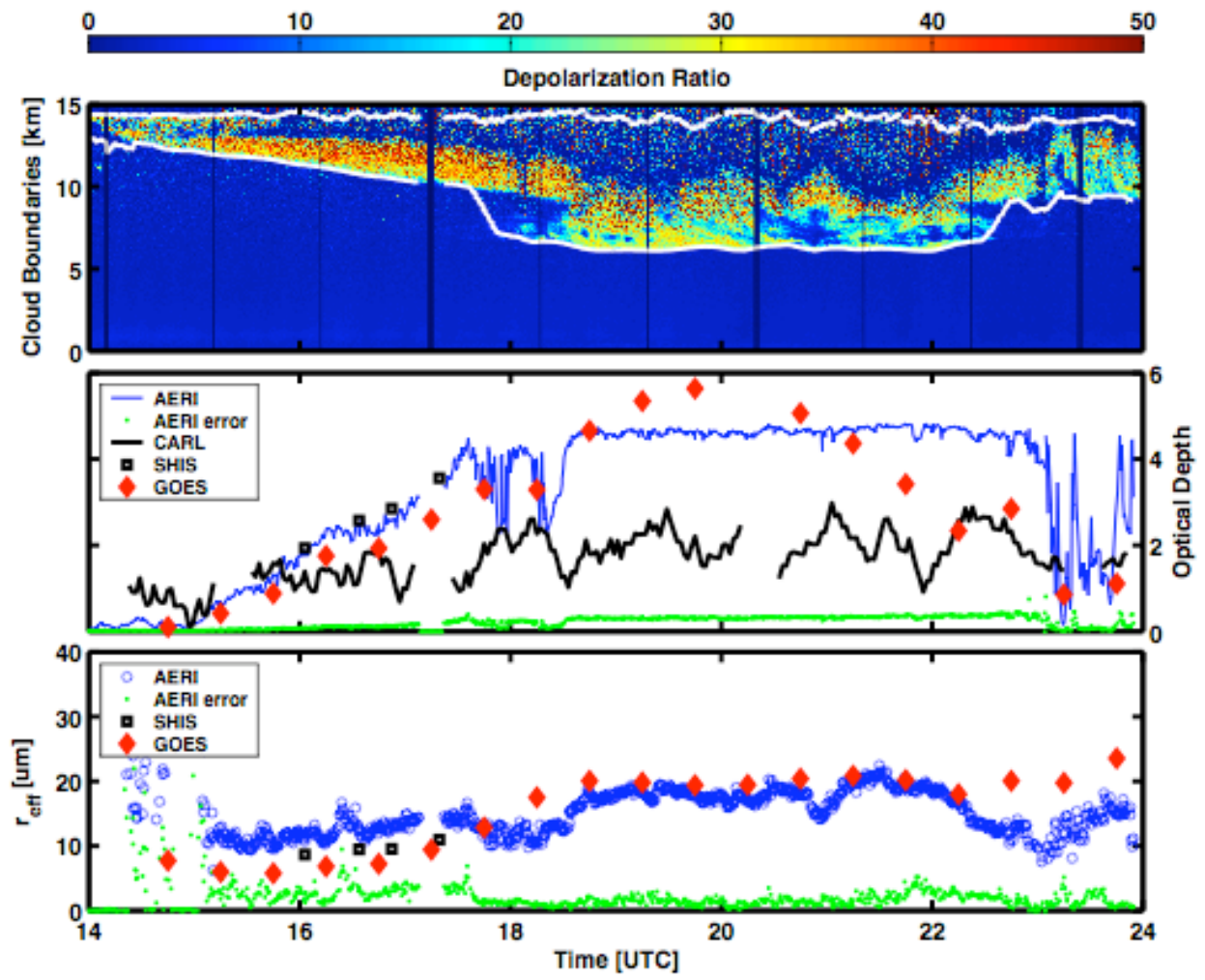


Excellent agreement in optical depth

Not bad in particle size

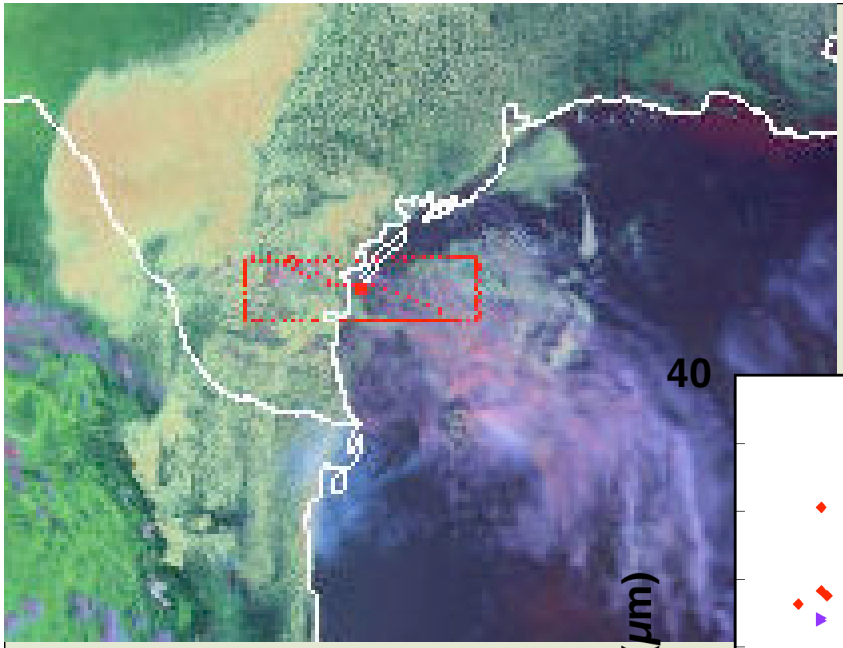
Comparison of GOES Daytime Cirrus Retrievals Over Texas with Retrievals from AERI & NAST-I on Proteus, AFWEX, 24 Dec 2004

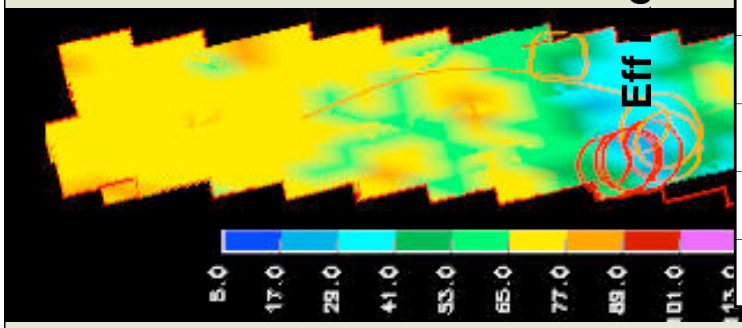
DeSlover et al., JTech, 2005

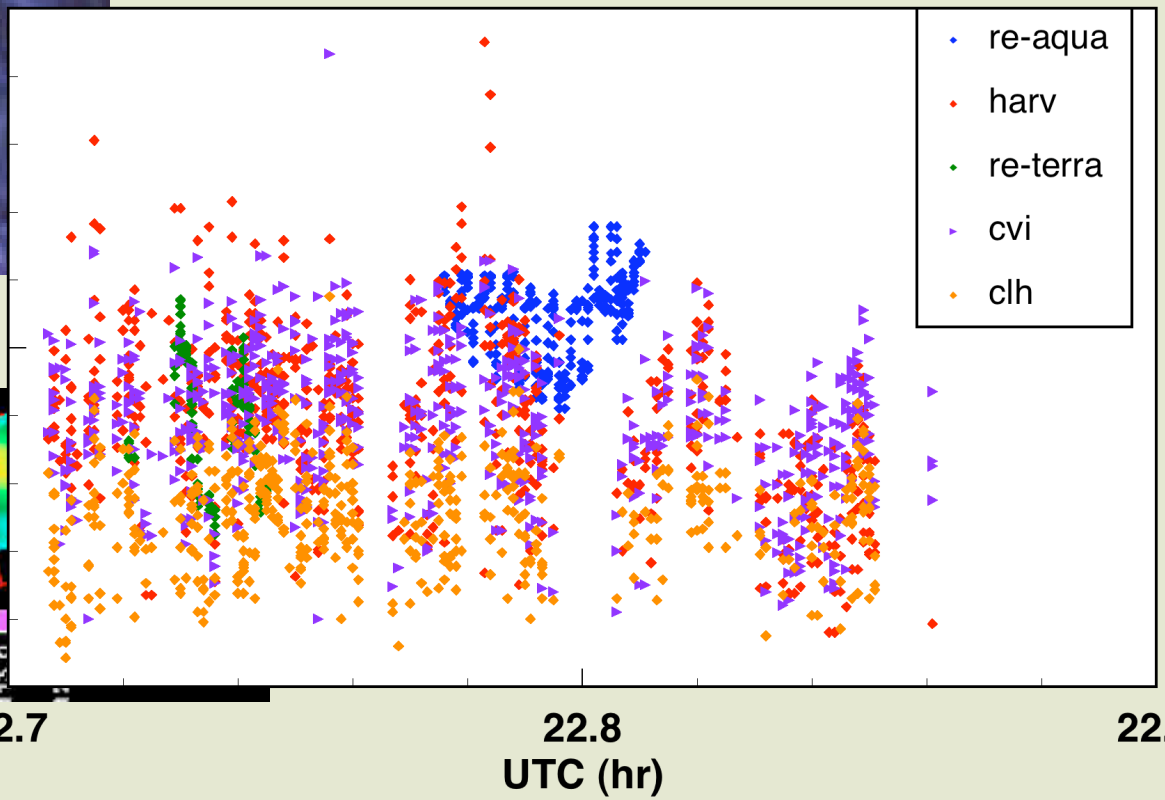


Excellent agreement in particle size and optical depth

Comparison of Ice Particle Sizes
WB-57 Flight, MidCiX, Apr 22

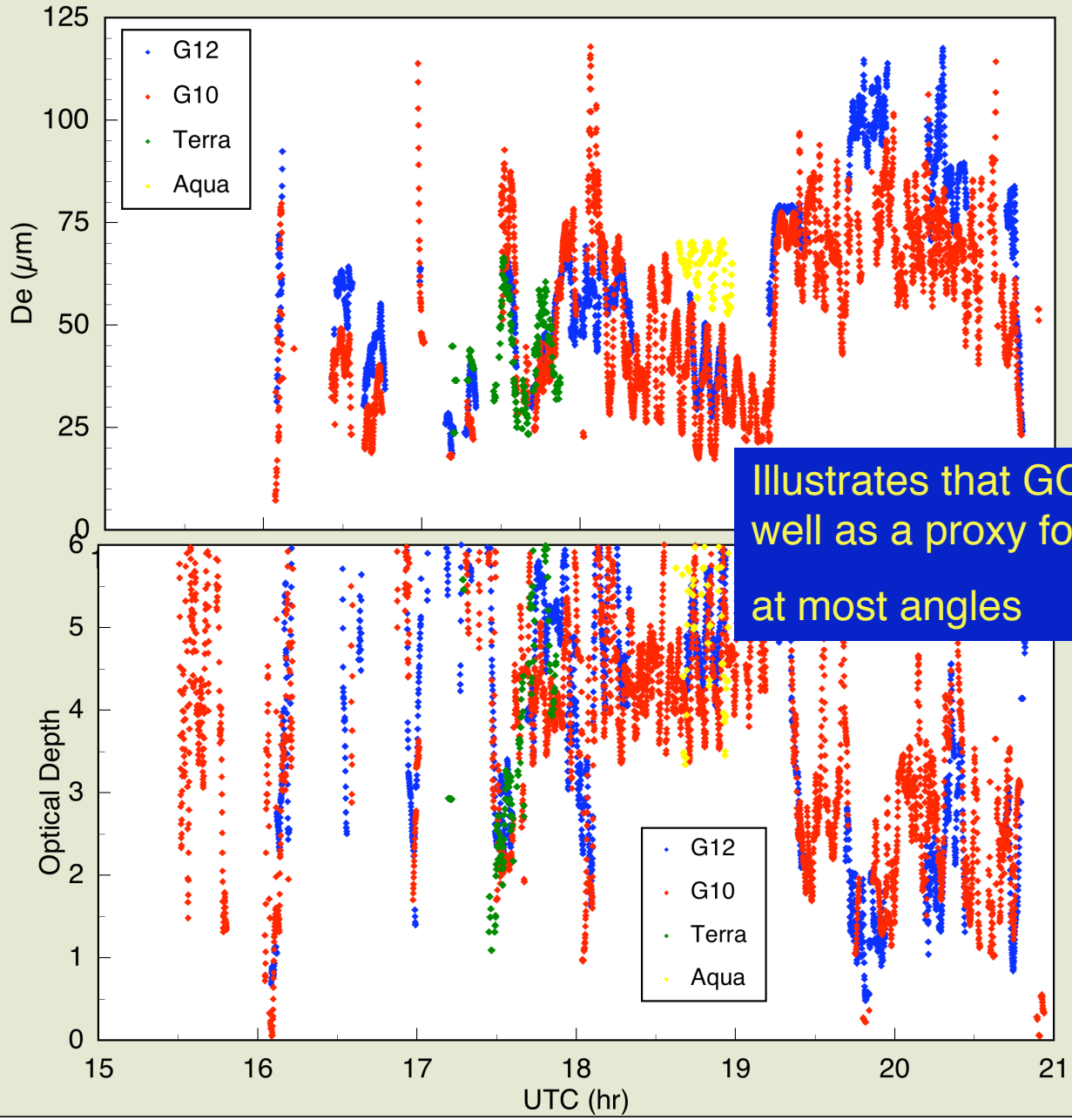






Need to average over time
Can find a dataset to agree with VISST

Comparison of Ice Particle Sizes & Optical Depth
WB-57 Flight During MidCiX, Apr 22, 2004



Illustrates that GOES serves well as a proxy for MODIS

at most angles

Summary of Preliminary In Situ - Satellite Cloud Opt Depth Retrievals, MidCiX

From Jay Mace, U Utah

Date	Time	CAS and CIP		CPI	CIN	GOES	MODIS	Remark
		Data	Fit					
4/19	1958-2002	5.38	7.22	5.33	8.46	40.4	None	Low Clouds
4/22	1828-1843	2.79	2.51	3.49	3.3	6.9	None	Low Clouds
	1849-1908	3.82	3.68	5.99	3.14	5.9	None	
4/27	1736-1741	4.07		14	4.75	3.41	1.9	Variable Clouds Clear Below No CIP
	1746-1756	2.34		9	2.42	3.54	1.4	
5/2	1910-1917	3.75		None	4.82	4.83	4.05	Clear Below No CIP down
	1919-1924	5.88	6.02	None	7.42	5.01	4.63	

- CAS/CIP in reasonable agreement with CIN

- Aircraft measurements agree reasonably with satellite optical depth - differences are consistent with low clouds and cloud field variability

Proposed Edition 3 Cloud Algorithm Changes

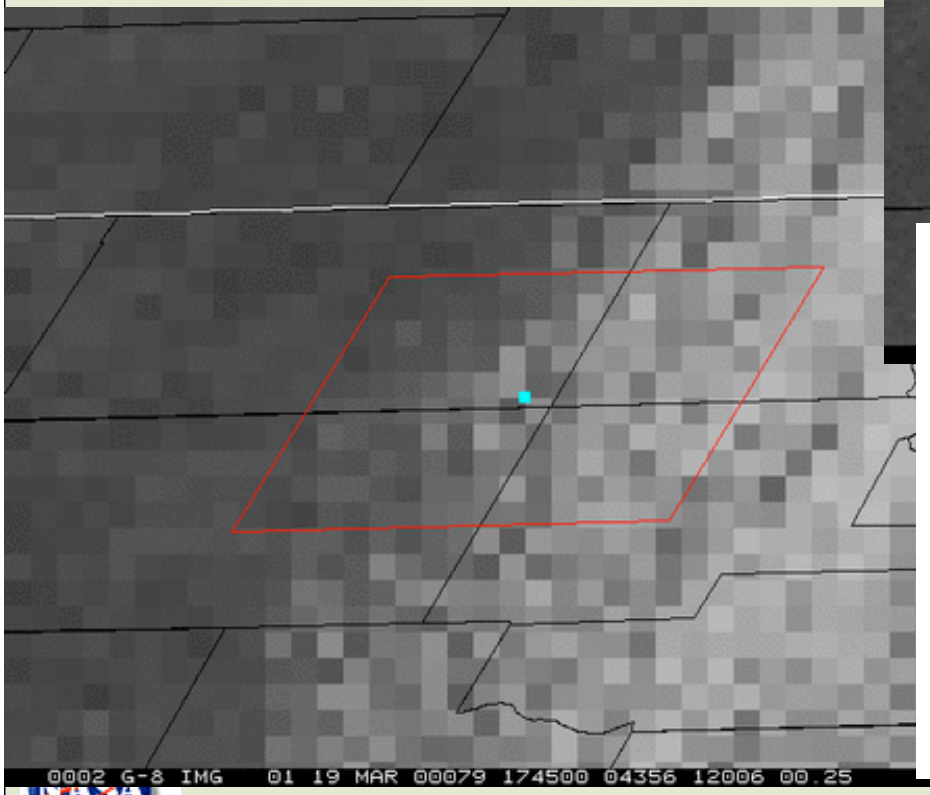
- Account for V005 changes, use calibration information
- Hi-res cloud detection and retrieval for low clouds (250-m into 1 km)
- Multilayer cloud detection & retrieval
- Smoother polar transition
- Improved thin cloud opt depth, phase, and heights
- Refined thin cirrus detection & dust/cloud discrimination
- Improved clear-sky maps & general mask/retrieval & calibration upgrades
  - *use of MODIS surface albedo & aerosols?*
  - *use of scene-dependent snow albedos*

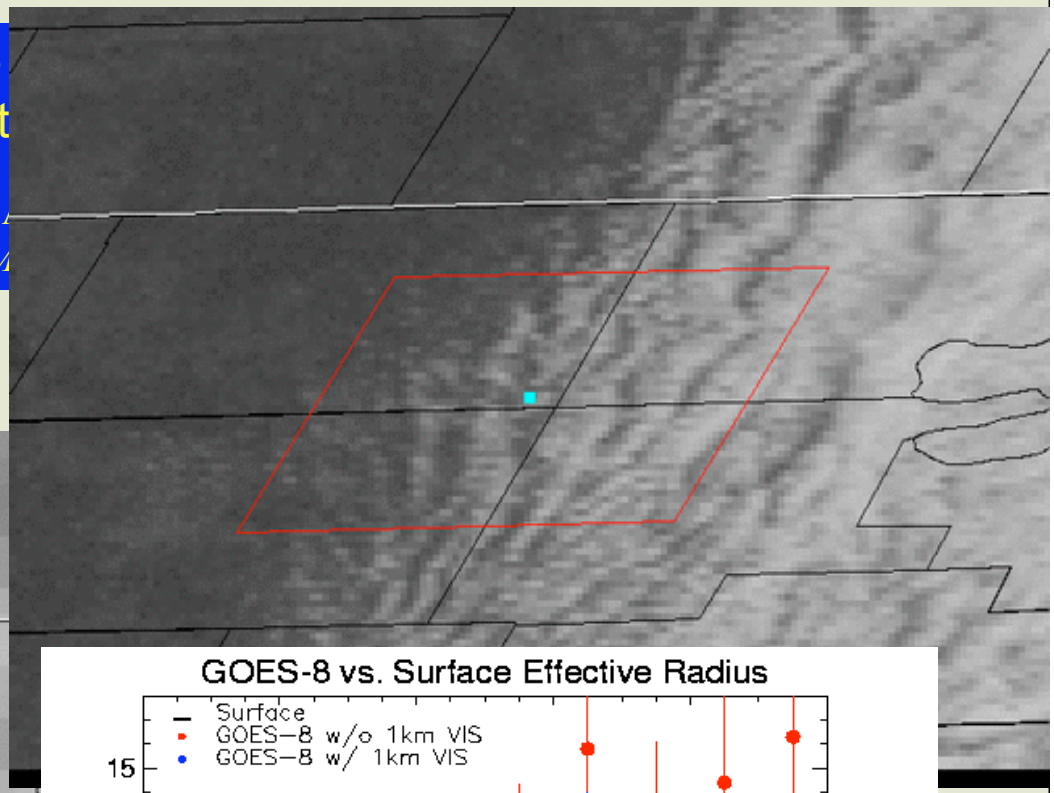
Hi-res cloud detection and retrieval for low clouds

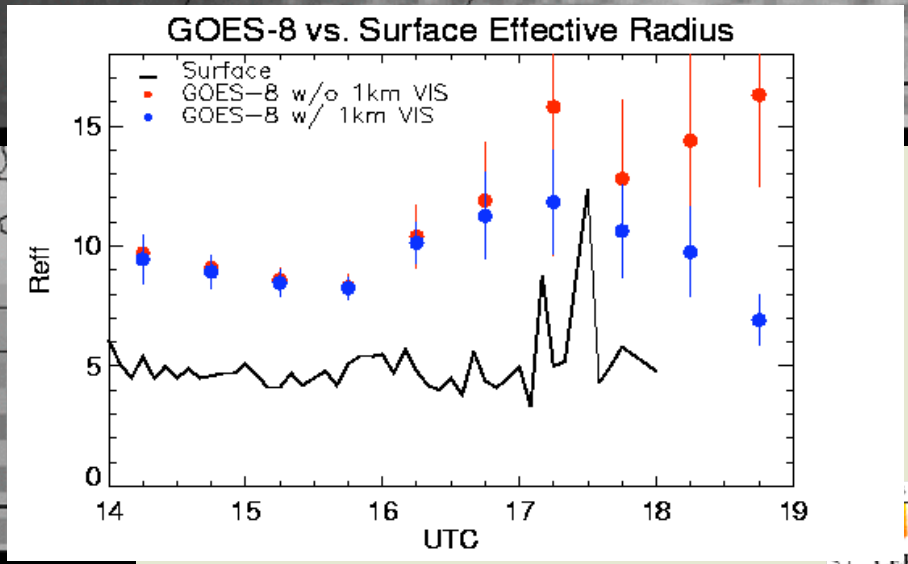
• Use 250-m VIS data to determine
clouds only to improve cumulus det

History: Nguyen, L., et al., 2002:
resolution imager data. *Proc. 11th AM*

GOES-8 4 and 1 -km pixels



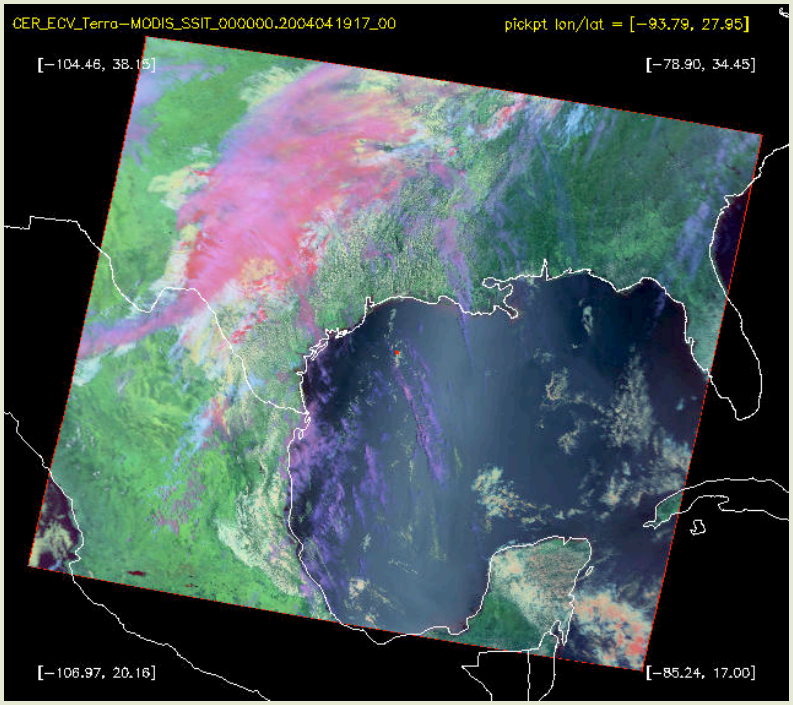


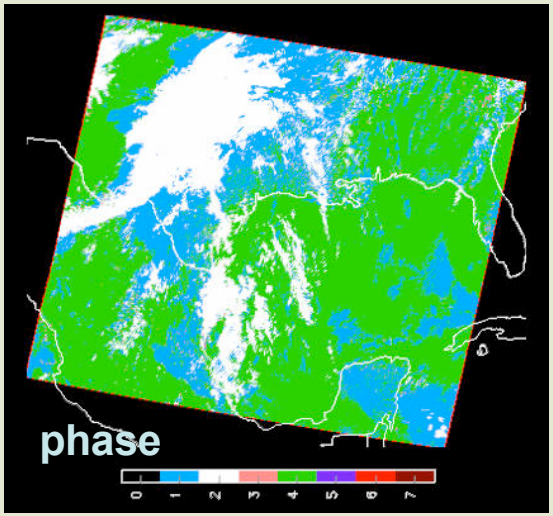


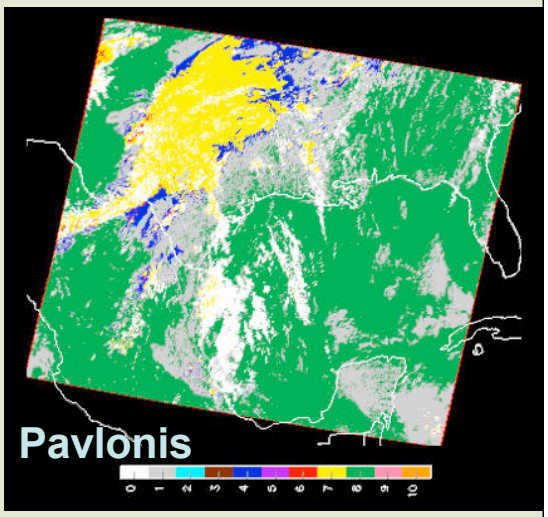
Multilayer cloud detection & retrieval

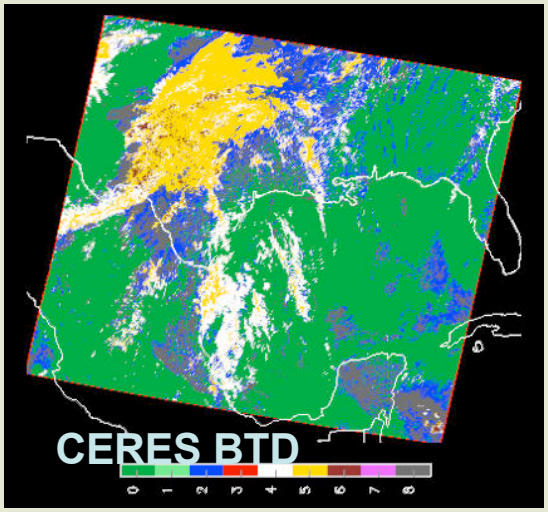
- Use MODIS channels to detect multilayer clouds & retrieve layer cloud properties

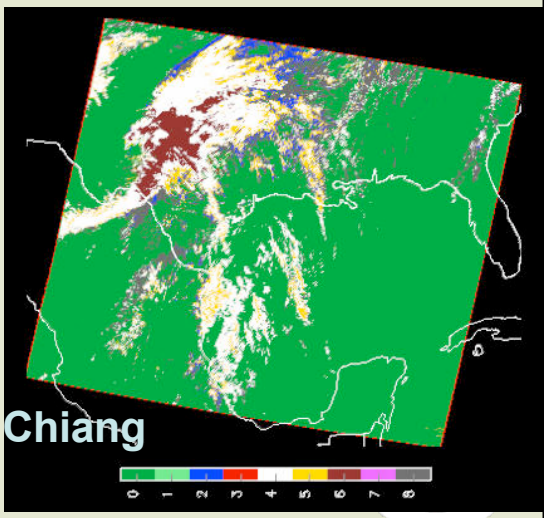
History: *Kawamoto et al. 2002; Pavlonis & Heidinger; Chiang & Li, 2005; Minnis et al.,2005; Fall 04/Spring 05 CERES STMs*





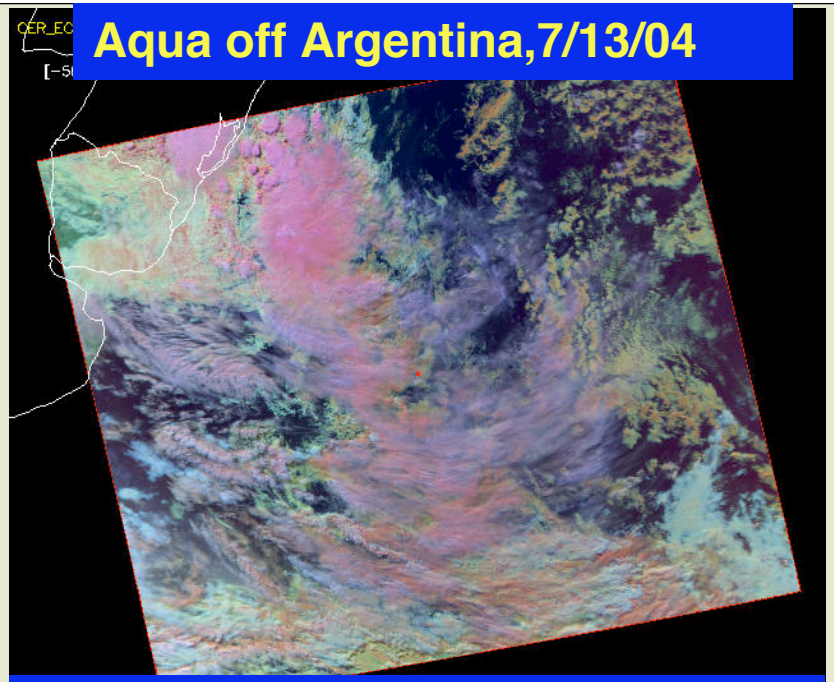






April 19, 2004 Terra

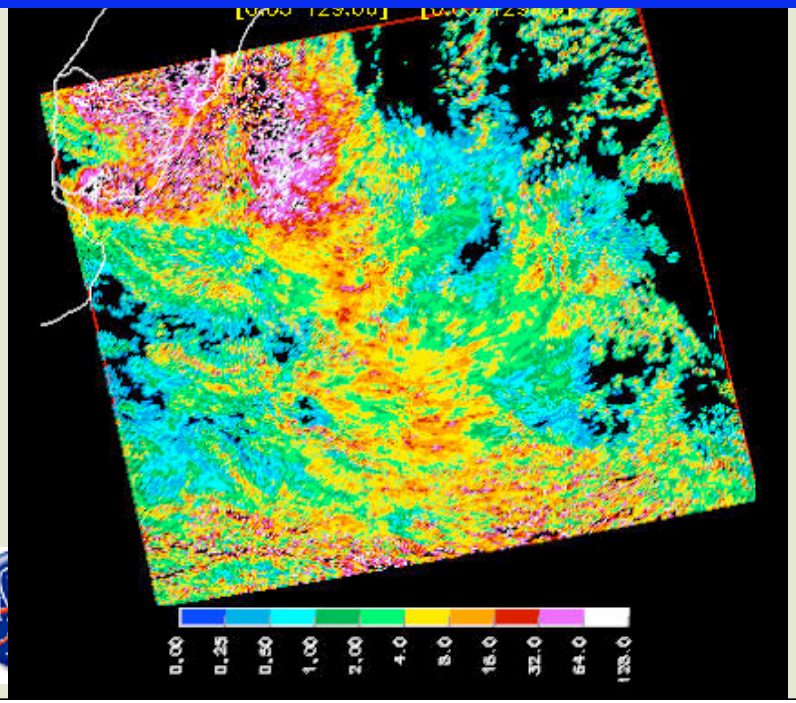
Aqua off Argentina,7/13/04



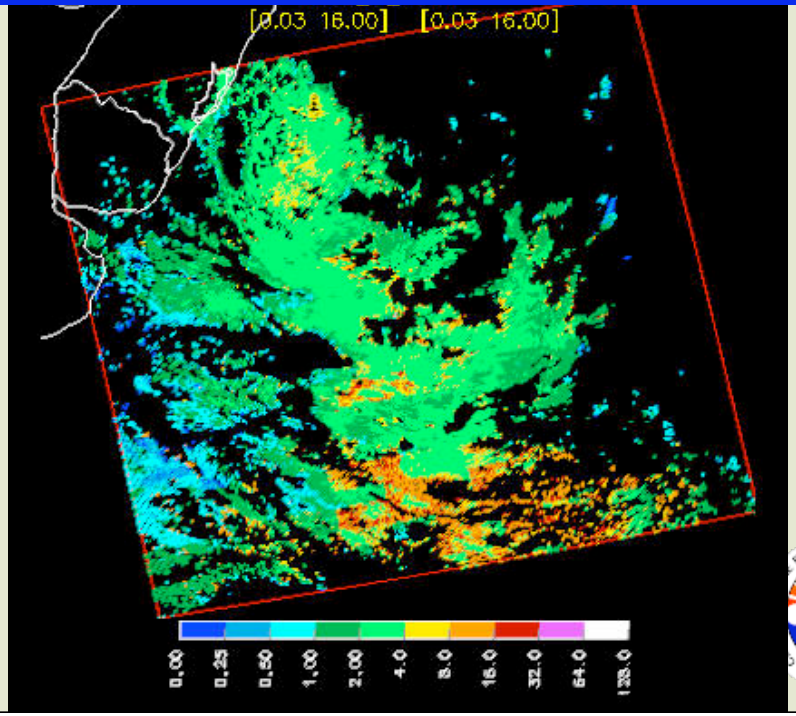
Use of nighttime algorithm to derive thin cloud optical depths

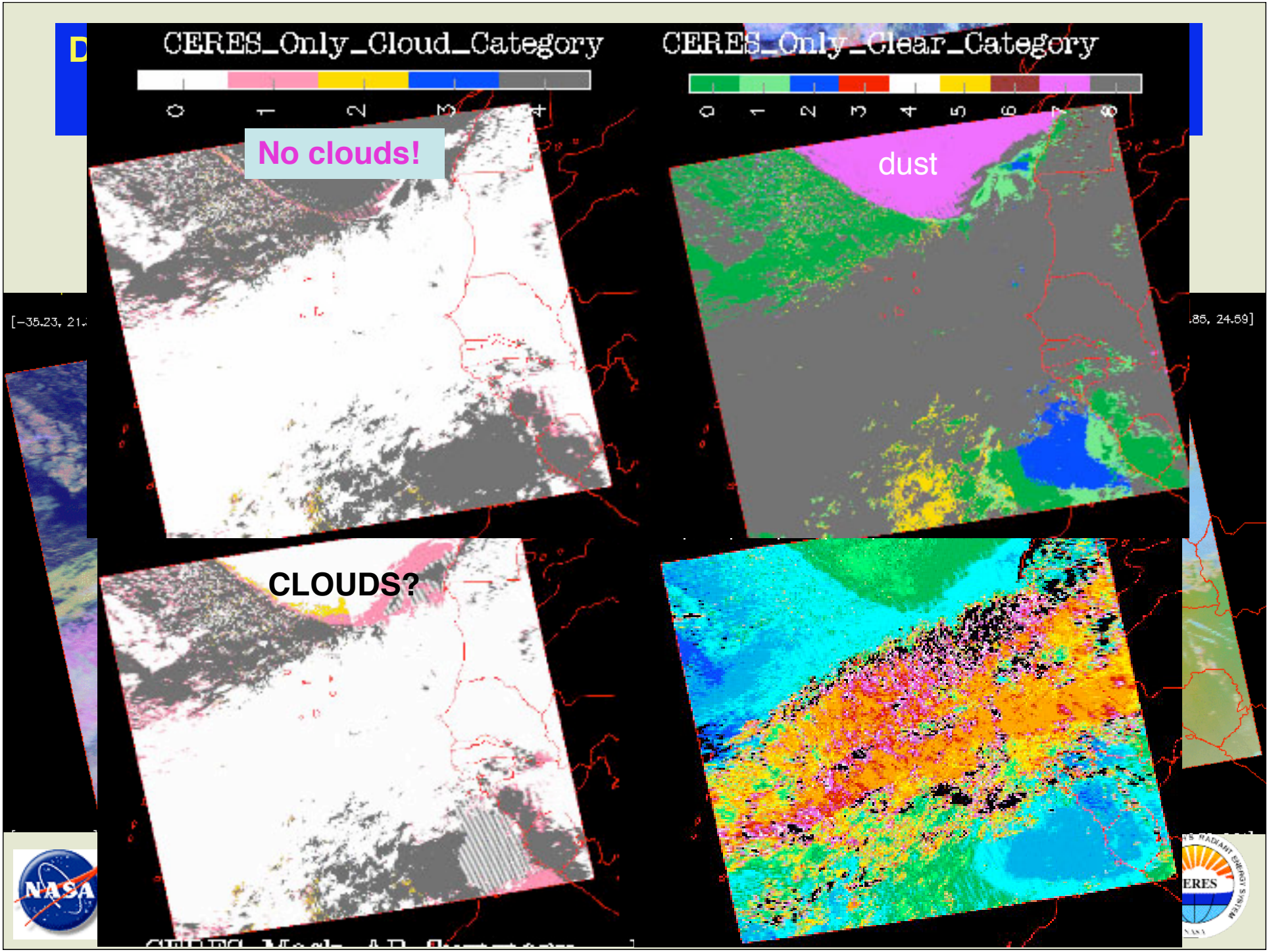
And refine VISST parameterization

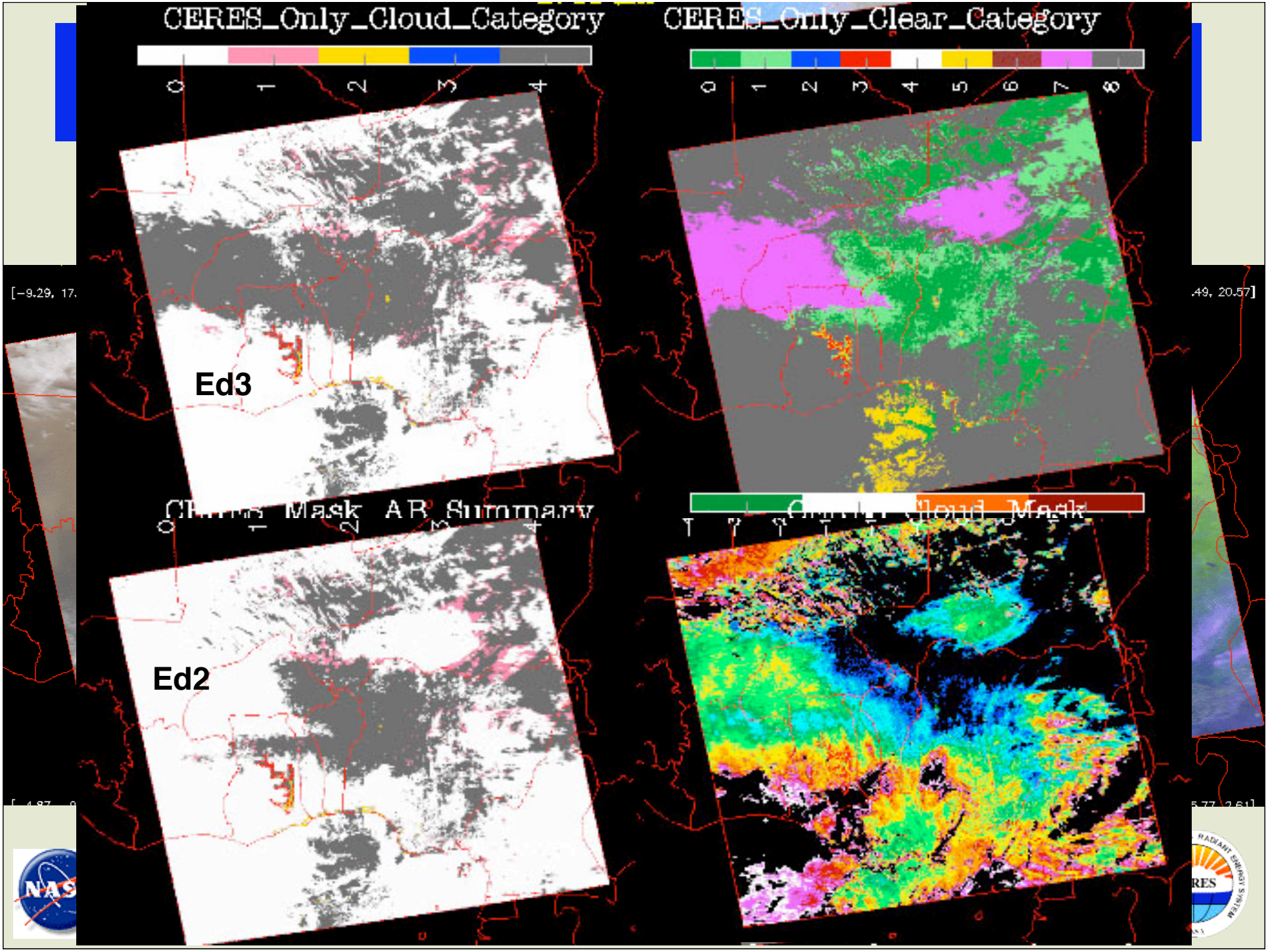
Cloud Opt Depth from VISST



High Cloud Opt Depth from SIST




CERES_Only_Cloud_Category
0
1
2
3
4
No clouds!
CERES_Only_Clear_Category
0
1
2
3
4
5
6
7
8
dust
CLOUDS?


CERES_Only_Cloud_Category
CERES_Only_Clear_Category
Ed3
Ed2

OTHER ISSUES TO BE HANDLED IN ED3

- Smoother polar transition
- Refined thin cirrus detection, new channels
- mixed phase clouds in Arctic (flag only)
- General mask/retrieval & calibration upgrades
- 1.6 vs 2.1 μm: 2.1 only?
- Improved clear-sky
  - Use MODIS clear-sky or our maps
    - code changes in VIS parameterization
- Streamline code=> faster
- Team's suggestions