Comparison of GLAS, CALIPSO, and Imager-Derived Cloud Properties

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ICESat Science Team Meeting
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Items since last science team meeting

• Yang, Y., A. Marshak, J. C. Cjiu, W. J. Wiscombe, S. P. Palm, A. B. Davis, D. A. Spangenberg, L. Nguyen, J. Spinhirne, and P. Minnis, 2008: Calibration of solar background signal for retrievals of cloud optical depth from the Geoscience Laser Altimetry System (GLAS). *J. Atmos. Sci.*, accepted.

• Minnis, P., S. Sun-Mack, Y. Chen, Q. Z. Trepte, and Y. Yi, 2008: Comparison of CERES-MODIS and ICESat GLAS cloud amounts. Submitted to *Geophys. Res. Lett.*

° Yi, Y., P. Minnis, S. Sun-Mack, and Y. Chen, 2007: Diurnal variations in cloud structure determined from CALISPO and ICESat lidar data. *A-Train-Lille 07 – Symposium*, Lille France, October 22-25.

• Nguyen, L., P. Minnis, D. A. Spangenberg, R. Palikonda, D. N. Phan, and M. L. Nordeen, 2008: Validation of real-time GOES products using GLAS and CALIPSO data. *AMS 5th GOES Users' Conference*, New Orleans, LA, January 23-24, CD-ROM, P1.63.

Objectives

- Compare cloud properties from GLAS and CALIPSO
  - differences & commonalities
  - can they be used together for passive retrieval validation?
    - important for GEO data especially

- Evaluate multilayer detection techniques applied to geostationary (GEO) satellite passive imager data
  - Examine relative accuracy of 1064-nm channel relative to 524 nm
  - Improve multilayer detection methods based on initial comparisons

Possible Means to Improve CERES Cloud Heights

- Multi-layer cloud detection & retrieval
- Adjust lapse rate method used for boundary layer clouds
  - *use moist layer in soundings*
  - *decrease the lapse rate*
- Develop new cloud thickness parameterizations to convert effective cloud height to physical cloud top
  - *Plotted results are for effective height, not physical height*
- Apply CO2-slicing method to pick up more thin clouds and discriminate at night between broken low level and high thin clouds
- Test new ice crystal models with smaller asymmetry factors to improve VISST retrievals during daytime

Validating GOES-Derived Cloud Properties over CONUS

- Cloud properties are derived each half hour from GOES-10 & 12 at 4 km
  - GOES-10: 0.65, 3.9, 10.8 & 12.0 μm radiances for cloud retrievals
  - GOES-12: 0.65, 3.9, 10.8 & 13.3 μm radiances for cloud retrievals
  - Cloud-top height estimated from OD and Teff
- Daytime: VISST (0.65, 3.9, 10.8 μm) used to perform single-layer retrievals
- Nighttime: SIST (3.9, 10.8 & 12.0 μm) used for single-layer retrievals
- Match closely with GLAS data for validation
- Two multilayer detection methods can be applied to GOES (BDM & COM)

Multilayered Cloud Detection & Retrieval

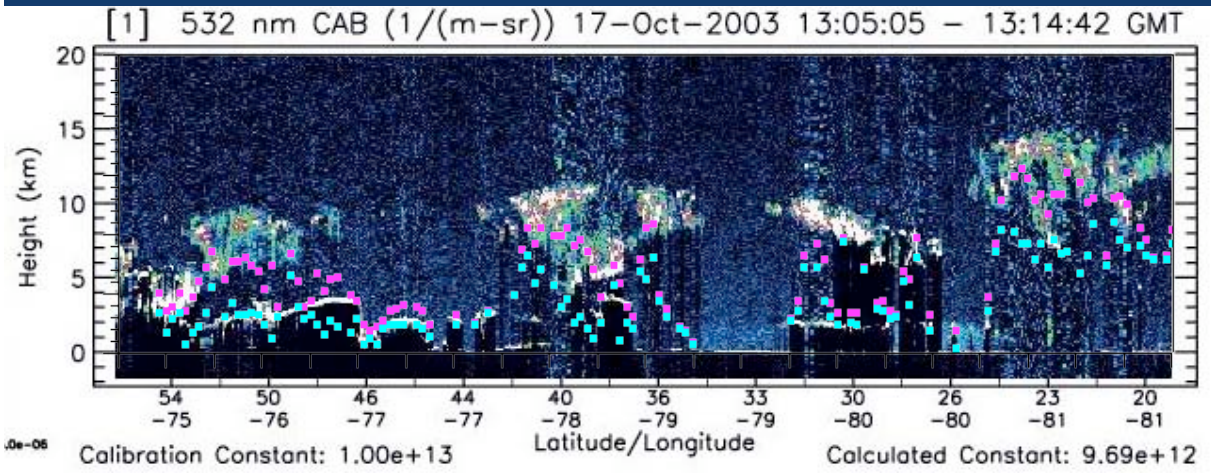
At least two different methods can be used for overlap detection & retrieval, but only one considered here

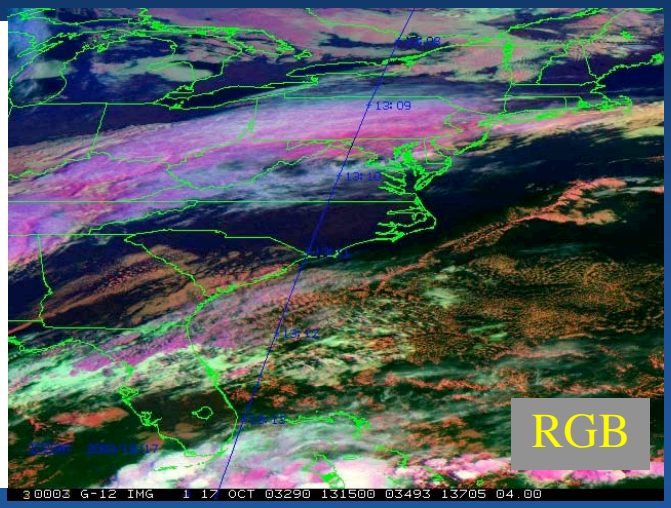
- CO2-slicing + VISST = COM Chang & Li (JGR 05)

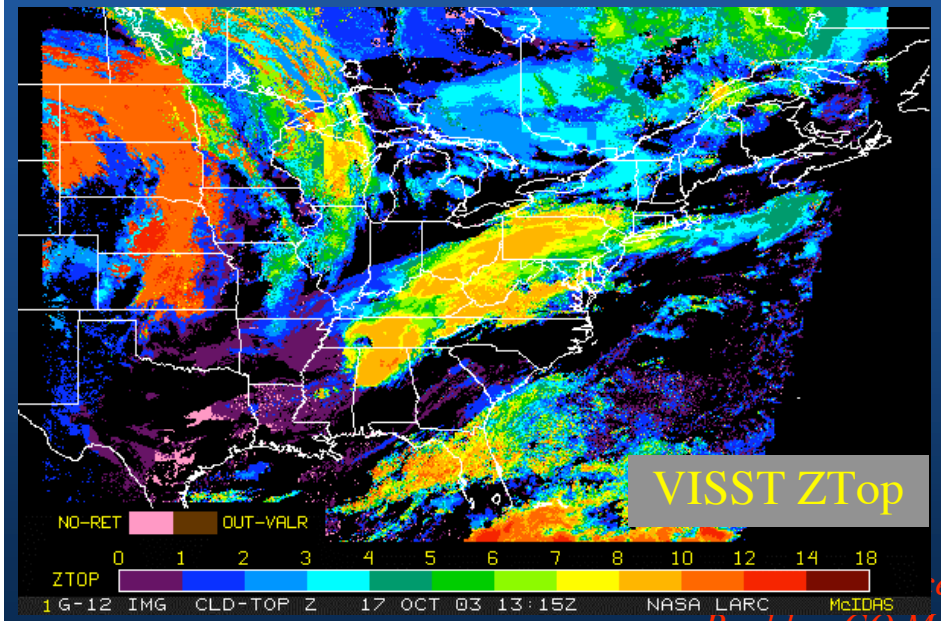
Cloud layering from GOES imagery, 1915 UTC, 5 May 2005

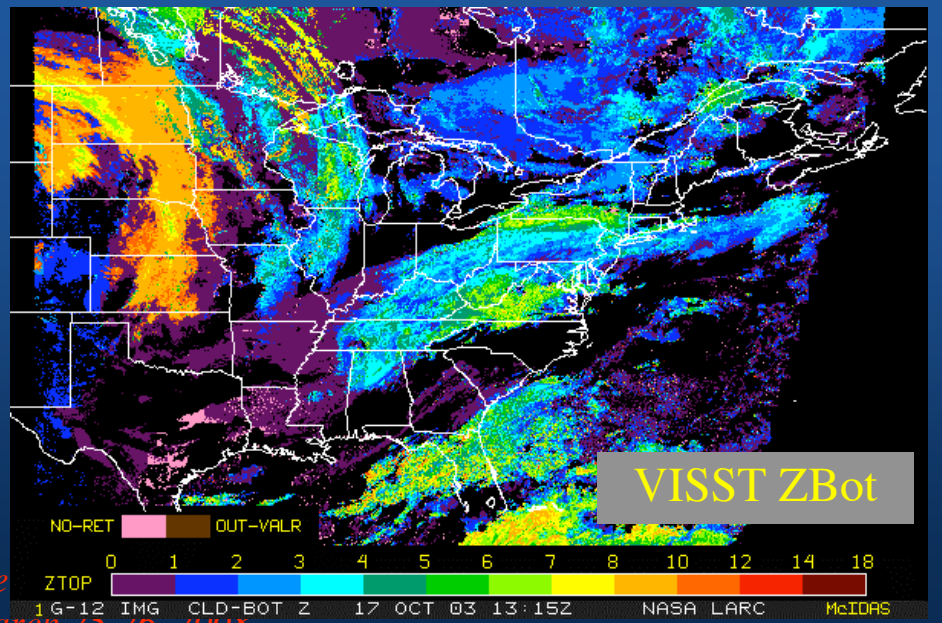
1-3: low single-layer
4-5: mid single-layer
7-9: multi-layer
10-12: high single-layer

Comparison of GOES/GLAS Cloud Heights
GOES-12 Oct 17, 2003 13:15 UTC



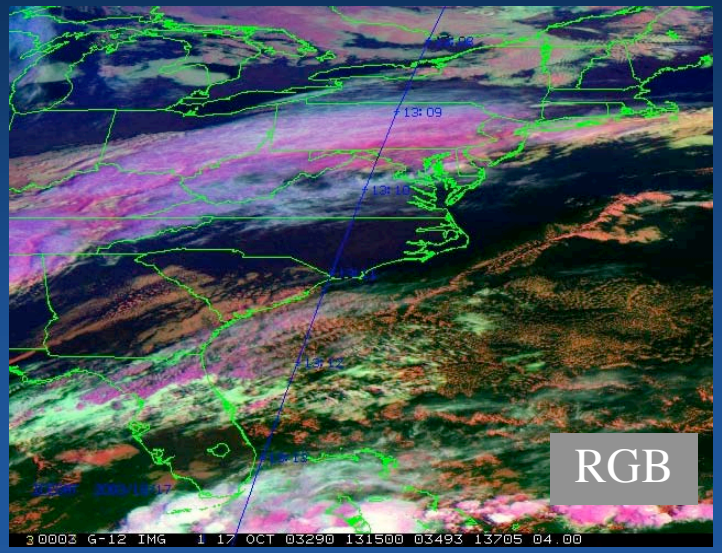




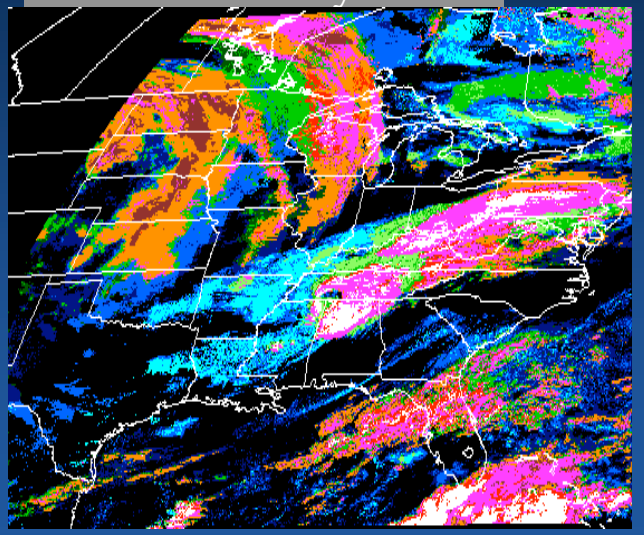


GOES-12 VISST vs GOES-12 CO2(13.4μm) Method

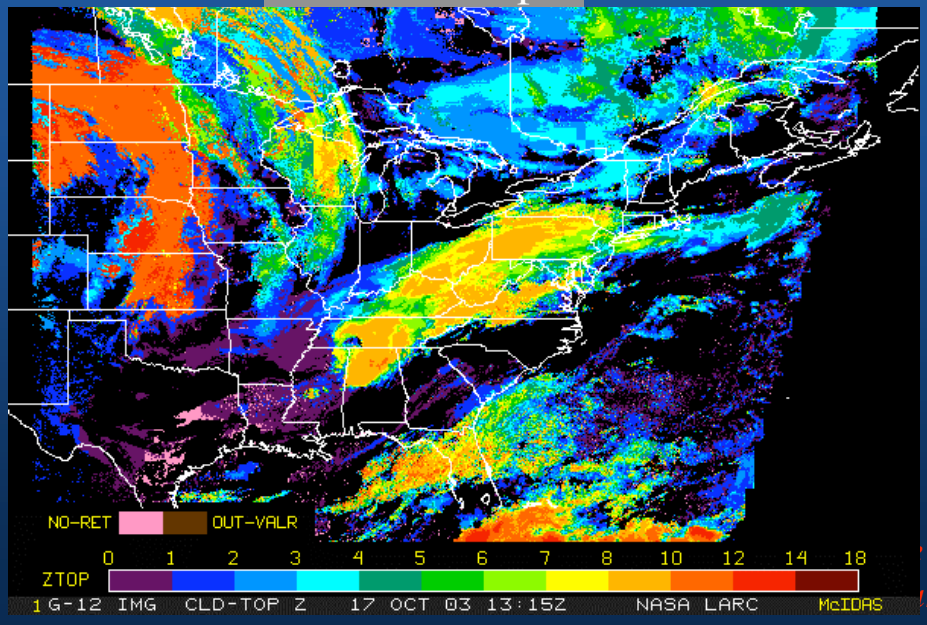
Oct 17, 2003 15:15 UTC



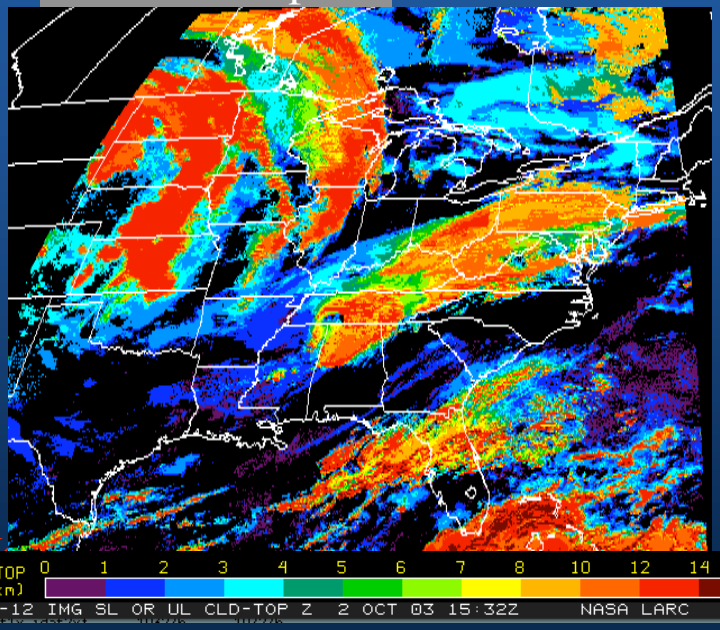
CO2 Multi-layer ID



VISST Ztop



CO2 Ztop

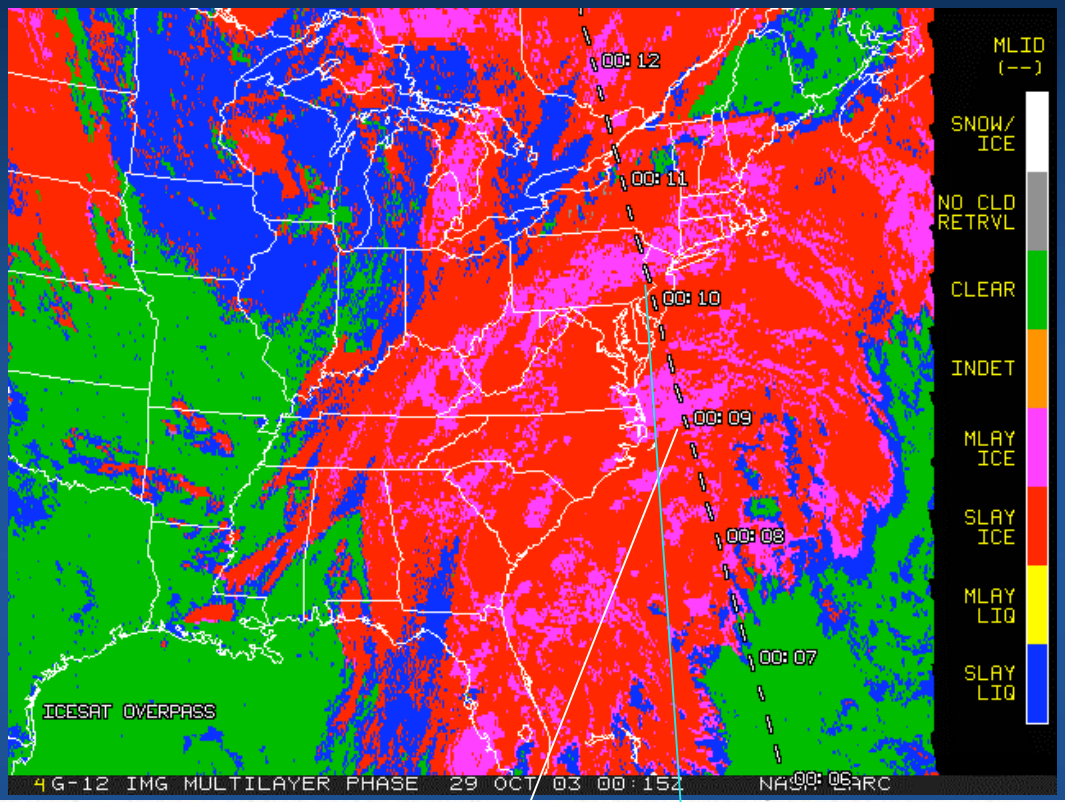


Multilayered Cloud Detection & CO2 Heights

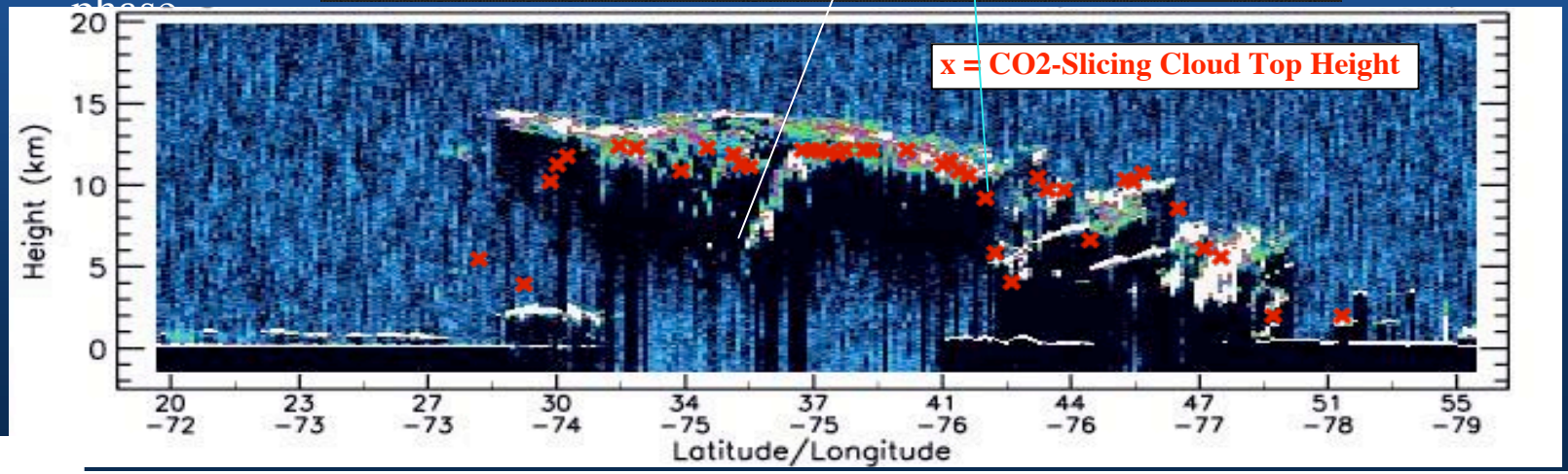
GOES-12, Oct. 29, 2003 0015 UTC

Multilayered cloud heights between base of upper cloud and top of low cloud

Multilayer detection reasonable in this case



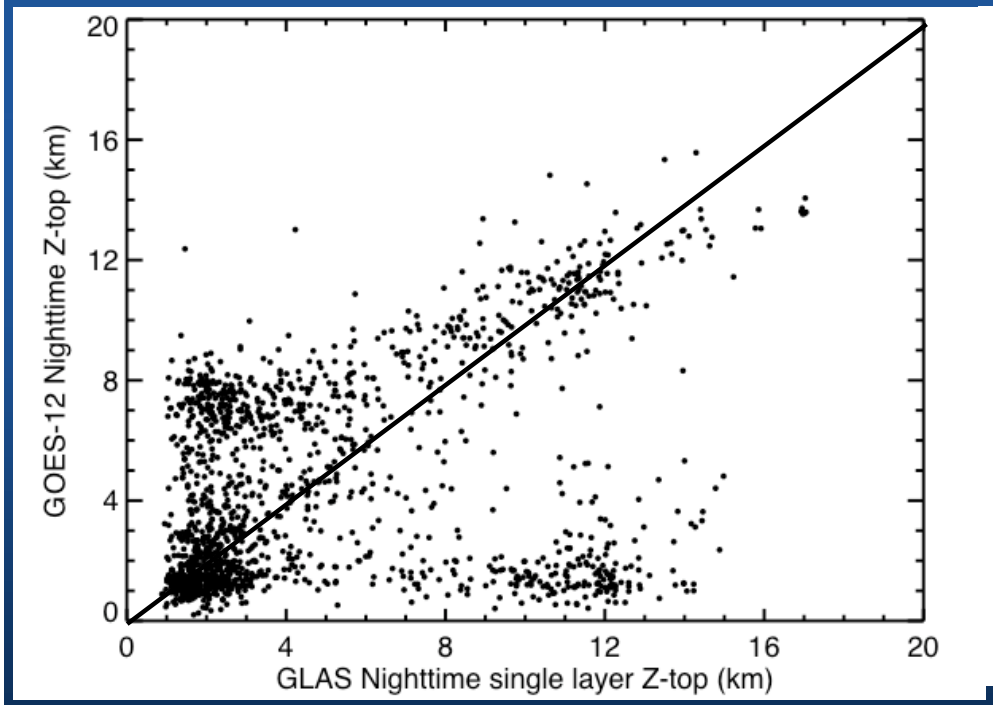
Single-layer cirrus heights 1-3 km below cloud-top height, similar to VISST heights



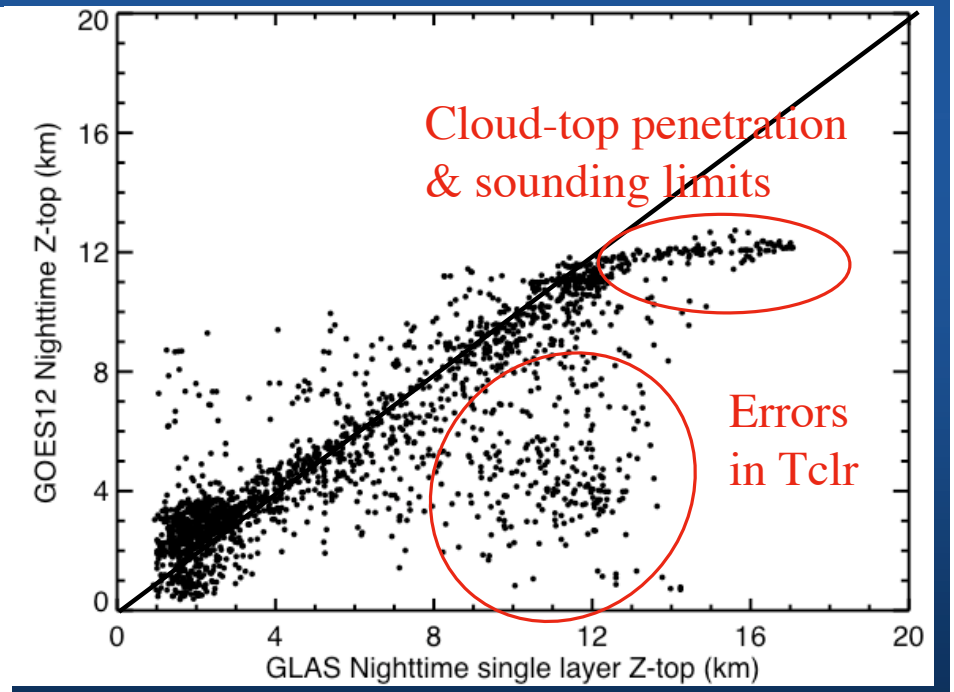
GLAS (1064nm) & GOES-12 Derived Cloud Top Heights
Oct. 21 - Nov. 23, 2005 (Single Layer - Night)

Validation Leads to Algorithm Improvements

VISST 2.1 + no CO2-slicing



VISST 3.0 + CO2 method



Daytime Single-layer Detection vs GLAS

G12/GLAS 532nm
Daytime, Fall '03

		GLAS Single-layer	
		YES	NO
G O E S	YES	797	189
	NO	28	58

pody=yy/(yy+ny) = 96.6
podn=nn/(yn+nn) = 23.5
Ntot= 1072

G12/GLAS 1064nm
Daytime, Fall '03 + 05

		GLAS Single-layer	
		YES	NO
G O E S	YES	1889	309
	NO	160	61

pody=yy/(yy+ny) = 92.2
podn=nn/(yn+nn) = 16.5
Ntot= 2419

- COM daytime algorithm has excellent skill in detecting SL clouds
- We can reliably use 1064-nm channel instead of 532 nm for determining skill of passive techniques (difference < 5% overall)

Nighttime Single-layer Detection vs GLAS

G12/GLAS 532nm
Daytime, Fall '03

		GLAS Single-layer	
		YES	NO
G O E S	YES	897	593
	NO	79	36

pody=yy/(yy+ny) = 91.1
podn=nn/(yn+nn) = 5.7
Ntot= 1072

G12/GLAS 1064nm
Daytime, Fall '03 + 05

		GLAS Single-layer	
		YES	NO
G O E S	YES	1889	309
	NO	160	61

pody=yy/(yy+ny) = 92.2
podn=nn/(yn+nn) = 16.5
Ntot= 2419

- COM nighttime algorithm has excellent skill in detecting SL clouds
- We can reliably use 1064-nm channel instead of 532 nm for determining skill of passive techniques (difference < 5% overall)

Status of Multi-layer Detection

• COM daytime & nighttime algorithms have excellent skill in detecting SL: > 90% accuracy

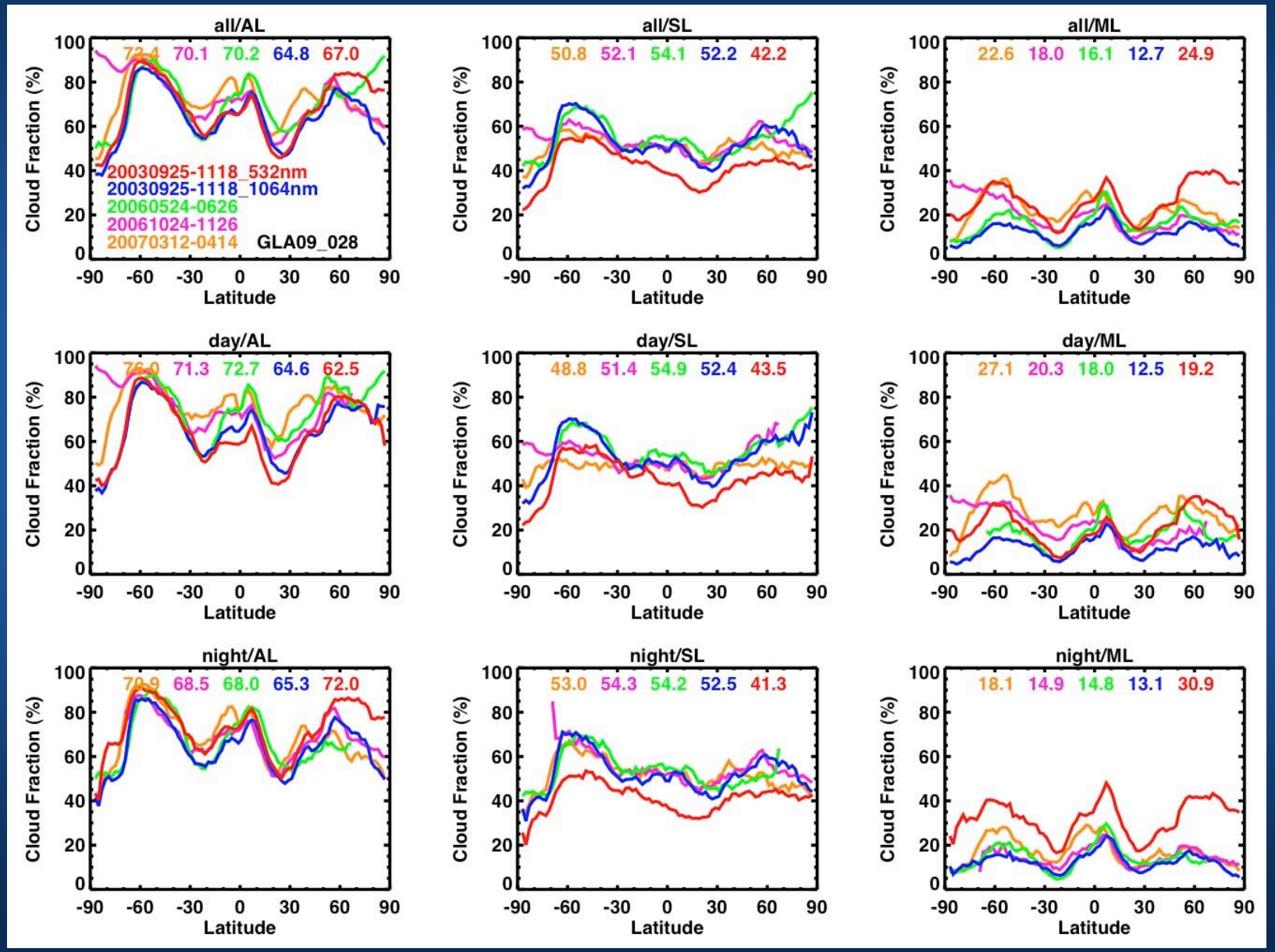
- when no multilayer detected, good chance it is single

• No skill so far in positively identifying multilayered clouds

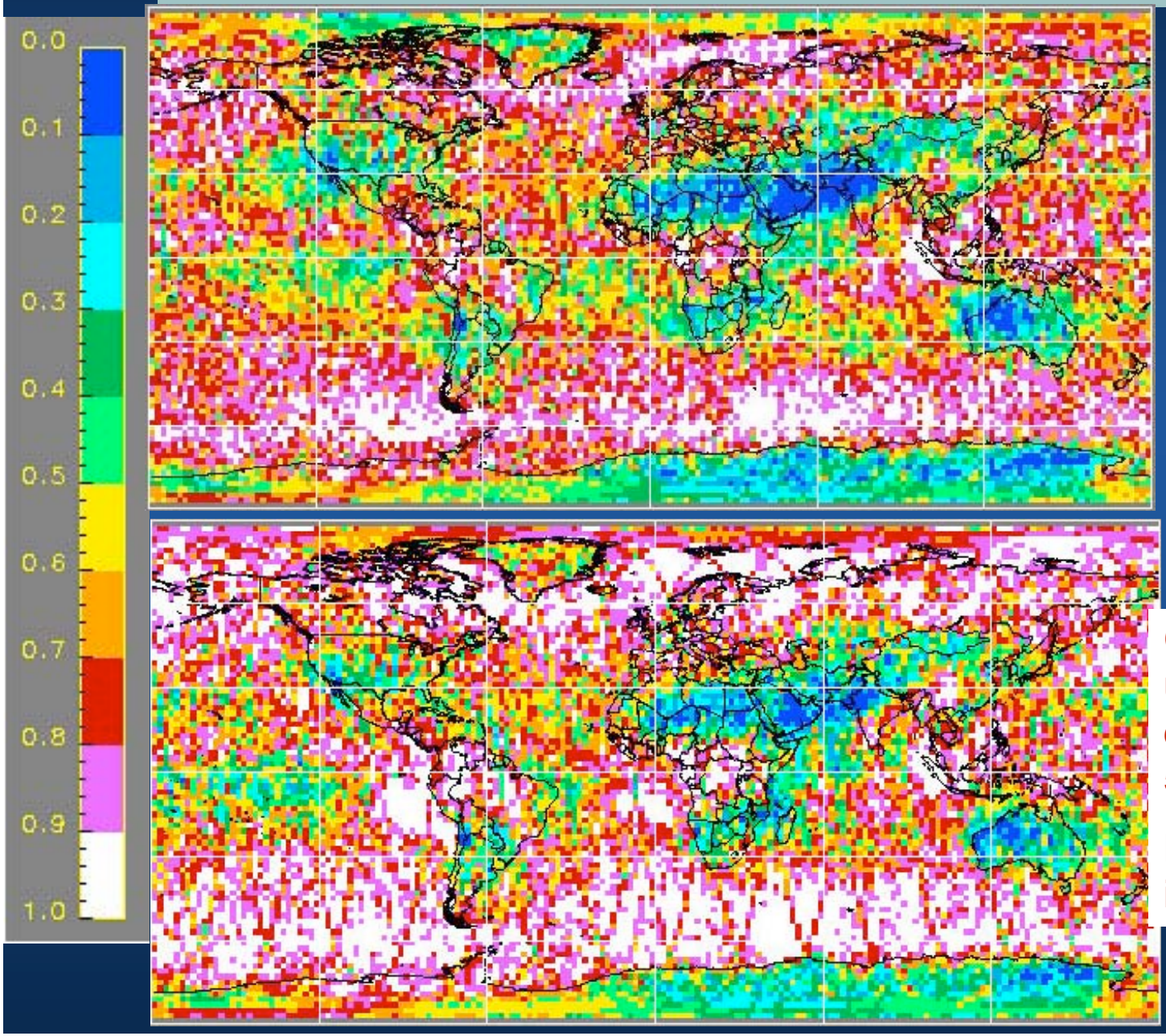
- more difficult using single CO2 channel on the imagers

- refinement will continue

Zonal Variation in Cloud Cover from GLAS seasonal & spectral



GLAS 1064 vs 532-nm Total Cloud Fraction 2-deg avg
October 2003 Mid-Res data, V026



1064 nm

532 nm

GLAS 1064 picks up less cloud cover than GLAS 532 in R026 -

But not so much in R028!

Comparisons of 1064 and 532, October 2003 R028

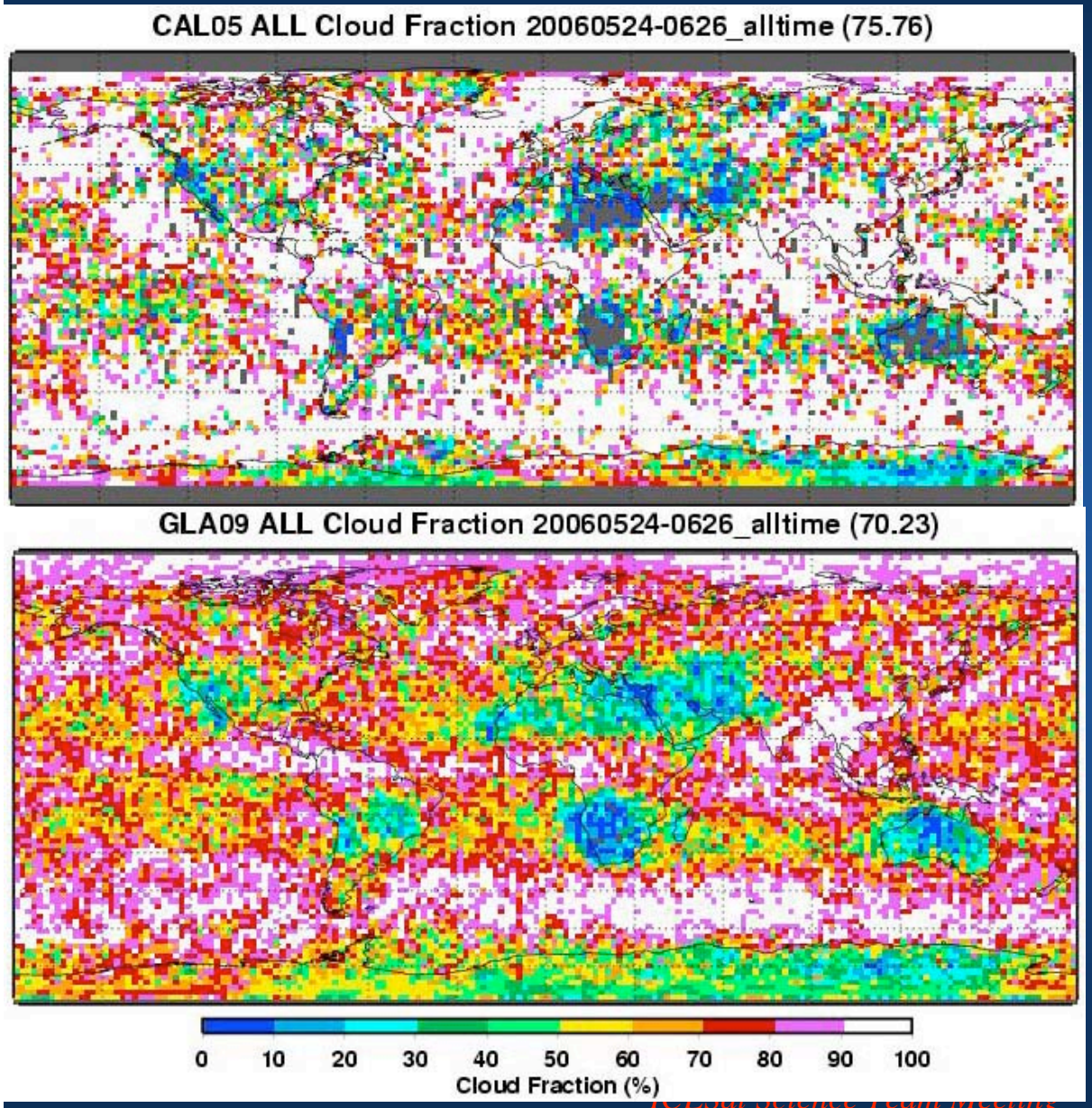
	Day	Night	Total
CERES Aqua	64.7	65.5	65.1
CERES Terra	61.6	64.5	63.8
G53mid	62.5	72.0	68.2
G10mid	64.6	65.3	64.8

1064 2% > 532 during daytime, but 8% less at night

These numbers are much smaller than other months from GLAS

- reprocessing?

Cloud Amounts from GLAS and CALIPSO, 5/24/06-6/26/06



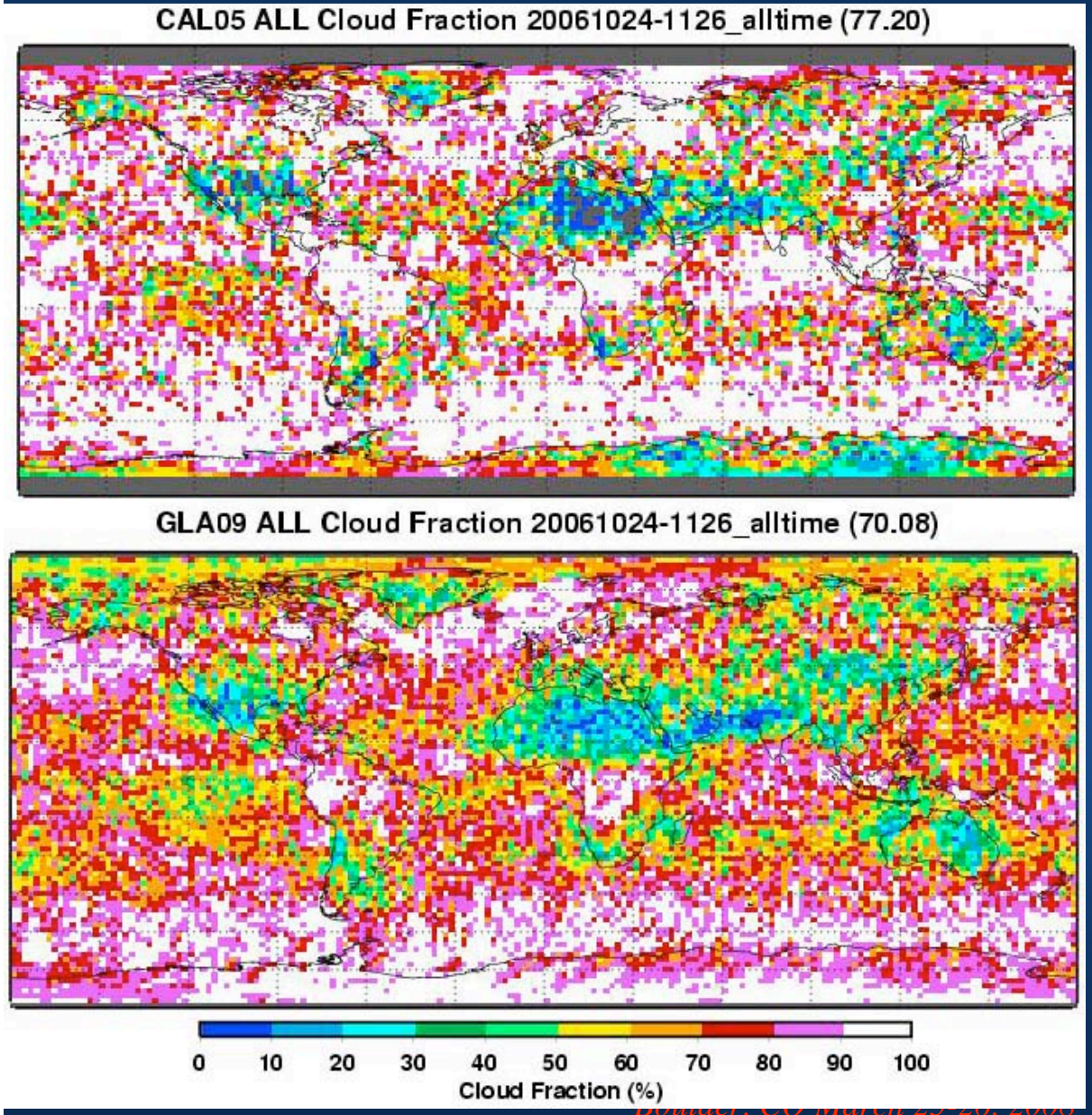
GLAS orbit ~ 0010/1300 LT
CALIPSO 0130/1330 LT

CALIPSO 2 weeks of data

CALIPSO detects more clouds in most areas except some deserts and parts of Antarctica
5% difference is comparable to 532 - 1064 difference

Algorithms differences Aerosol screening for CALIPSO? Blowing snow for GLAS?

Cloud Amounts from GLAS & CALIPSO, 10/24/06-11/26/06



GLAS orbit ~0800/2000 LT

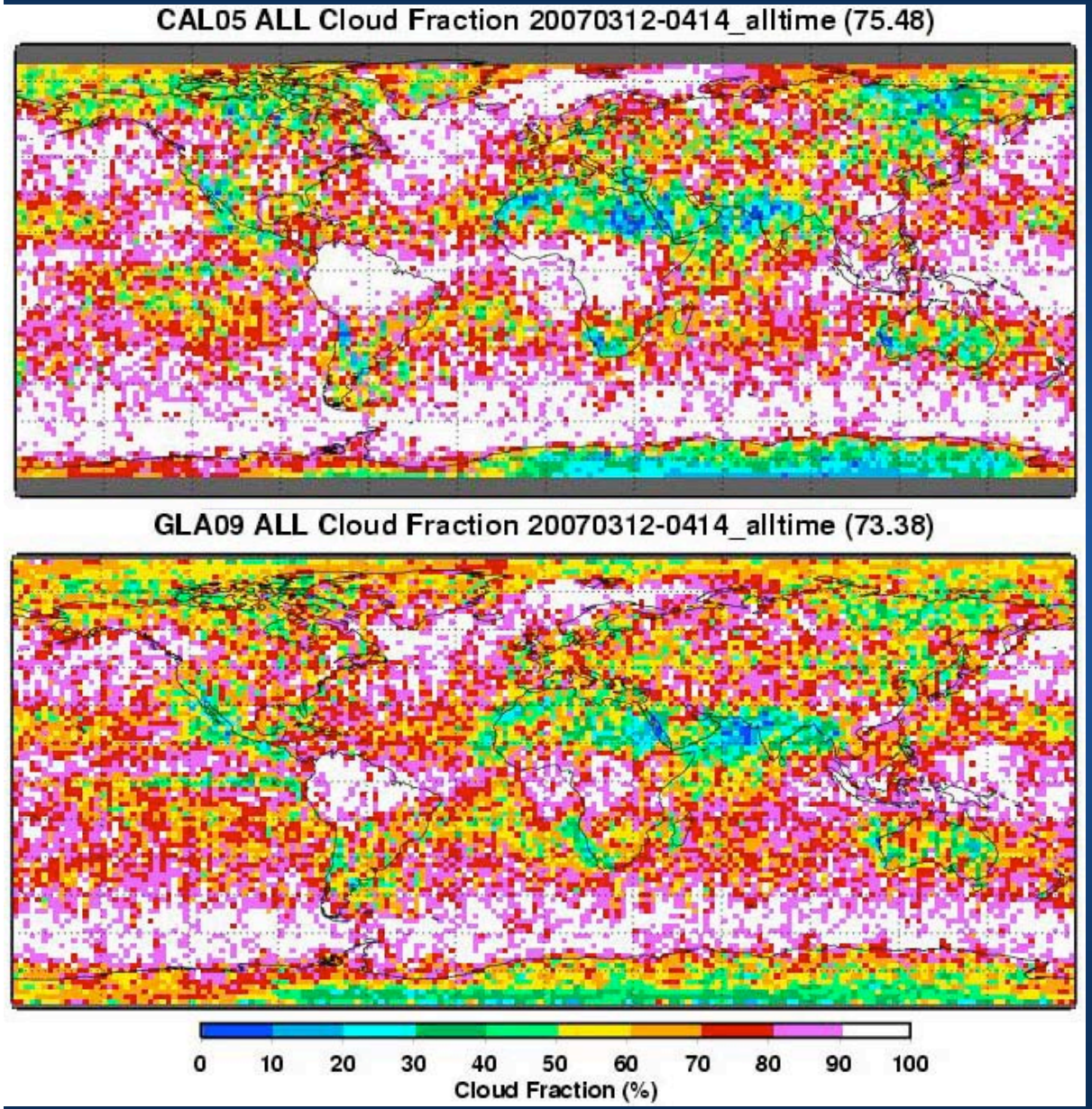
CALIPSO 0130/1330 LT

CALIPSO detects more clouds in most areas except some deserts, parts of Antarctica & TWP

7% difference may include some diurnal changes

Antarctic too cloudy from GLAS
Arctic much less than CALIPSO

Cloud Amounts from GLAS & CALIPSO, 3/12/07-4/14/07



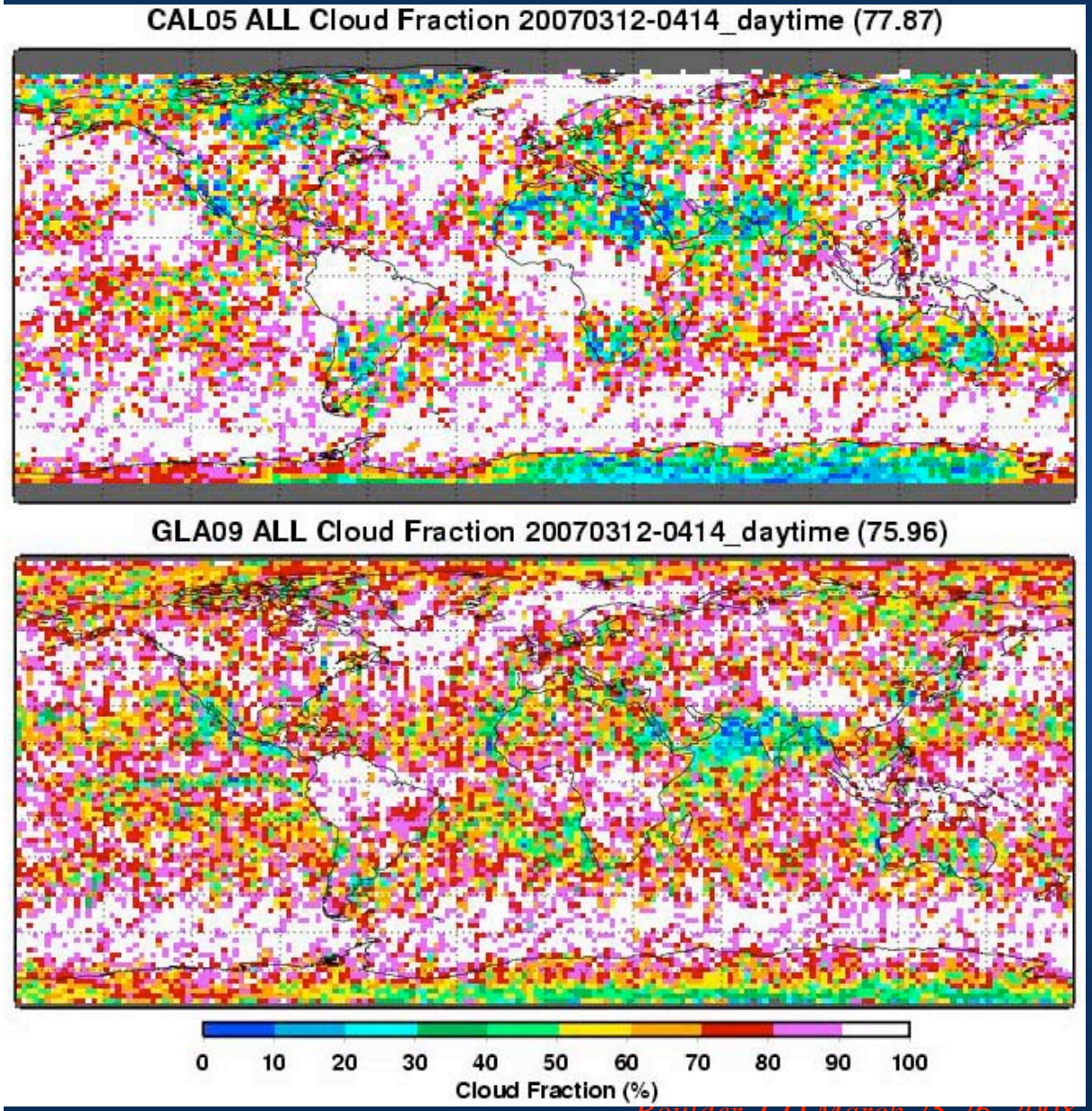
GLAS orbit ~0400/1600 LT

CALIPSO 0130/1330 LT

Similarities greatest for this period, 2% difference

East Antarctic & Greenland cloudier from GLAS
Arctic much less than CALIPSO
Expect some diurnal changes, e.g., increased tropical cirrus

Day Cloud Amounts from GLAS & CALIPSO, 3/12/07-4/14/07



GLAS orbit	1600 LT
CALIPSO	1330 LT

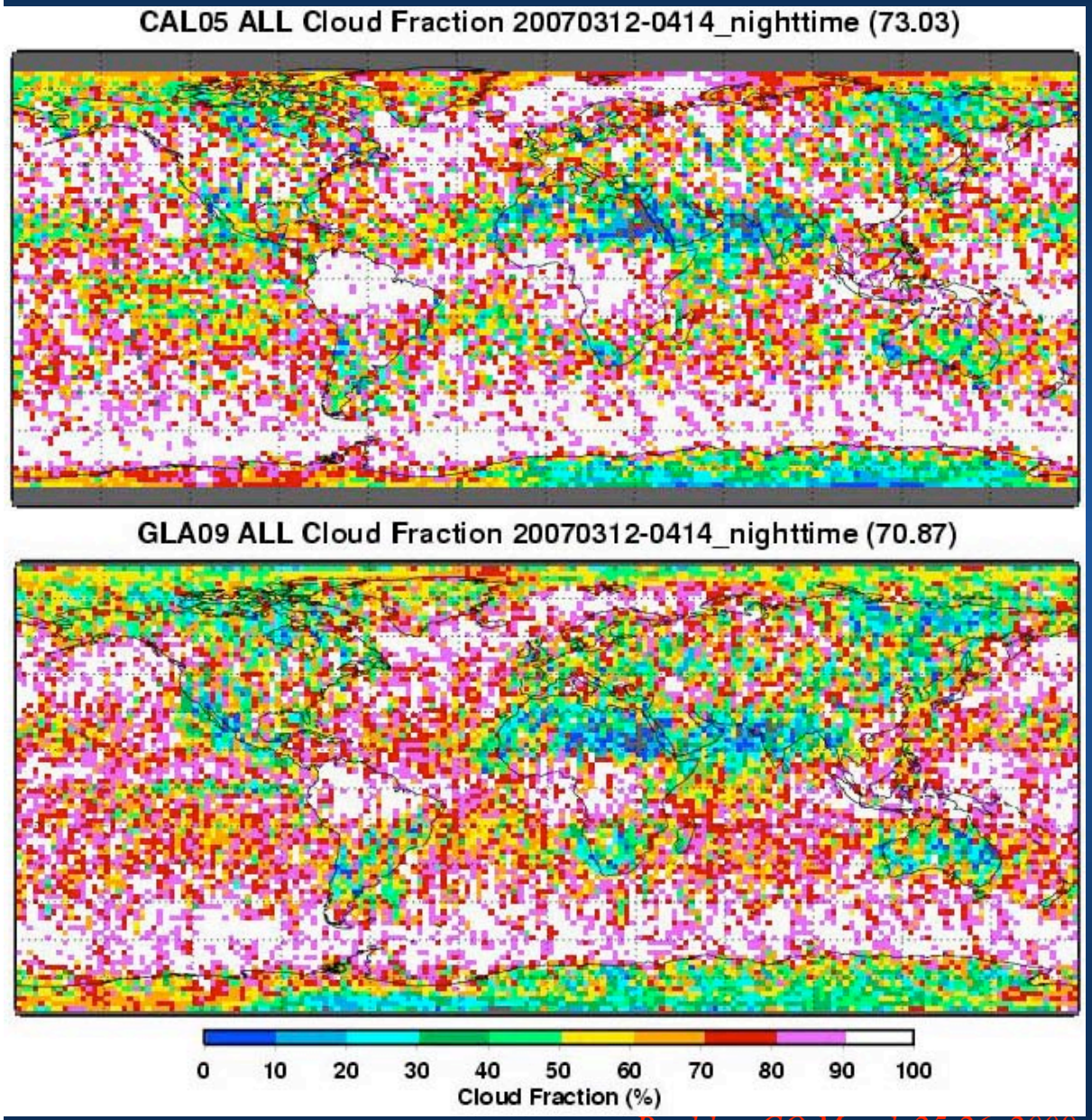
2% difference is result of compensations

Most land areas have more clouds from GLAS

Most ocean areas have more clouds from CALIPSO
Possible diurnal variations

GLAS has more clouds over Greenland and Antarctica

Night Cloud Amounts from GLAS & CALIPSO, 3/12/07-4/14/07



GLAS orbit ~0400 LT

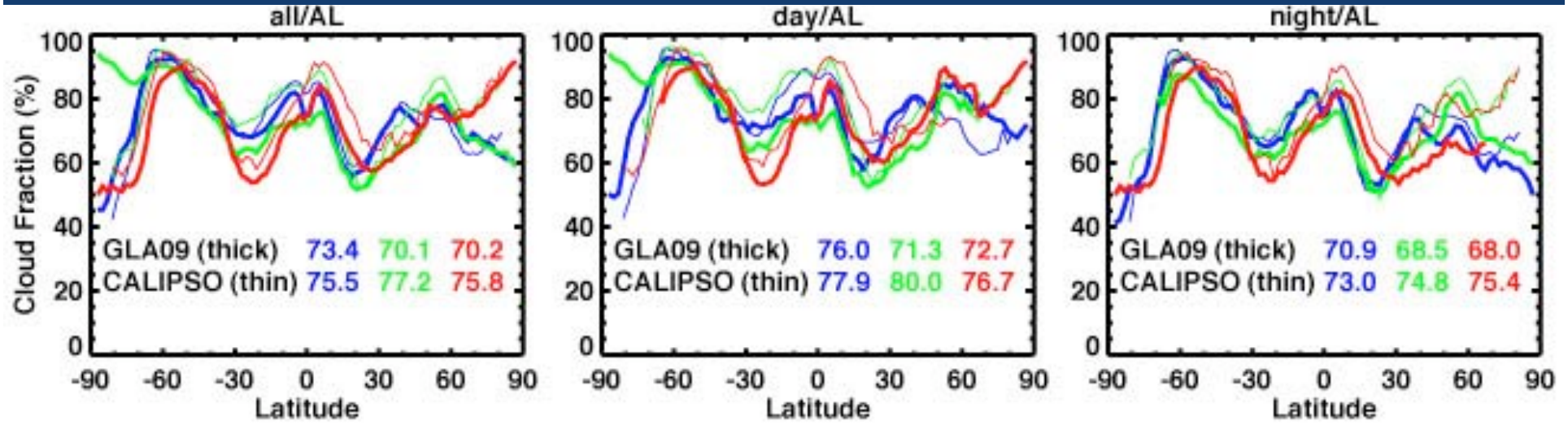
CALIPSO 0130 LT

Night results are remarkably similar, 2% difference

GLAS has more cloud cover over subtropical southern oceans
Probably diurnal changes

Zonal Mean Cloud Amounts, GLAS & CALIPSO

Blue:3/07 Green: 11/06 Red: 6/06



CALIPSO > GLAS in tropics

CALIPSO > GLAS in tropics

< GLAS in polar

CALIPSO > GLAS everywhere

CALIPSO > GLAS day & night, but more at night due to CALIPSO sensitivity. Are there differences in GLAS sensitivity month to month?

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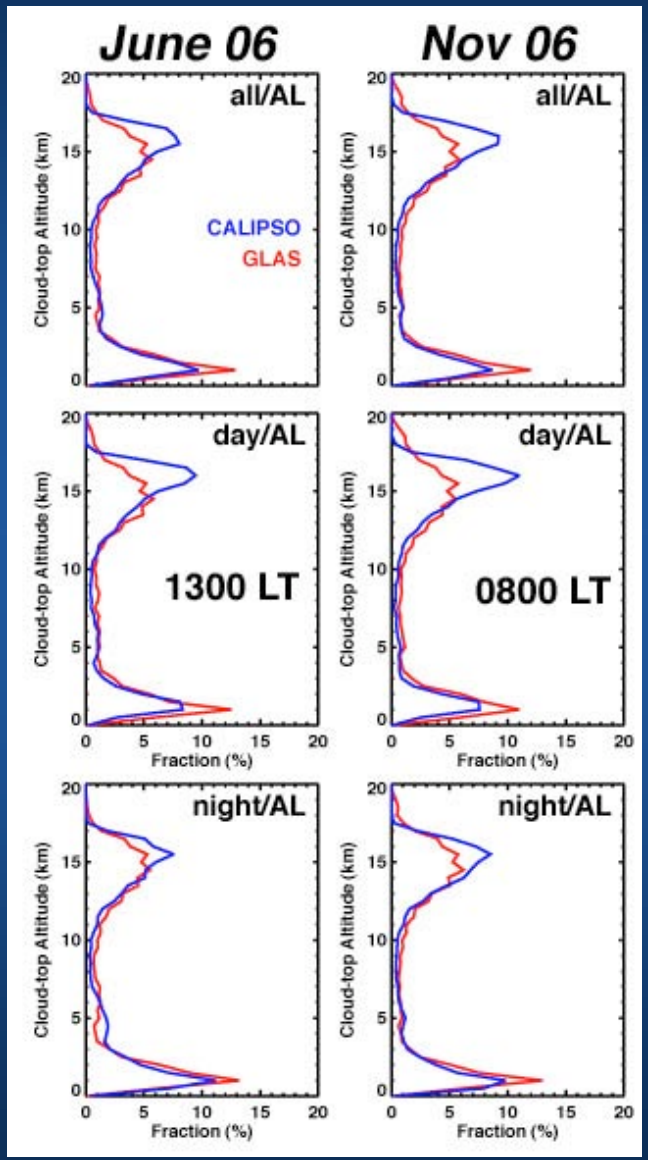
Boulder, CO March 25-26, 2008

Comparison of CALIPSO/GLAS Cloud Heights 20N-20S, 2006



- CALIPSO & GLAS detect more high clouds during November
- GLAS max cloud top freq lower than CALIPSO
- GLAS detects more cirrus above 18 km
- GLAS detects more midlevel & low clouds
- Low cloud detection nearly comparable at night in terms of relative proportions

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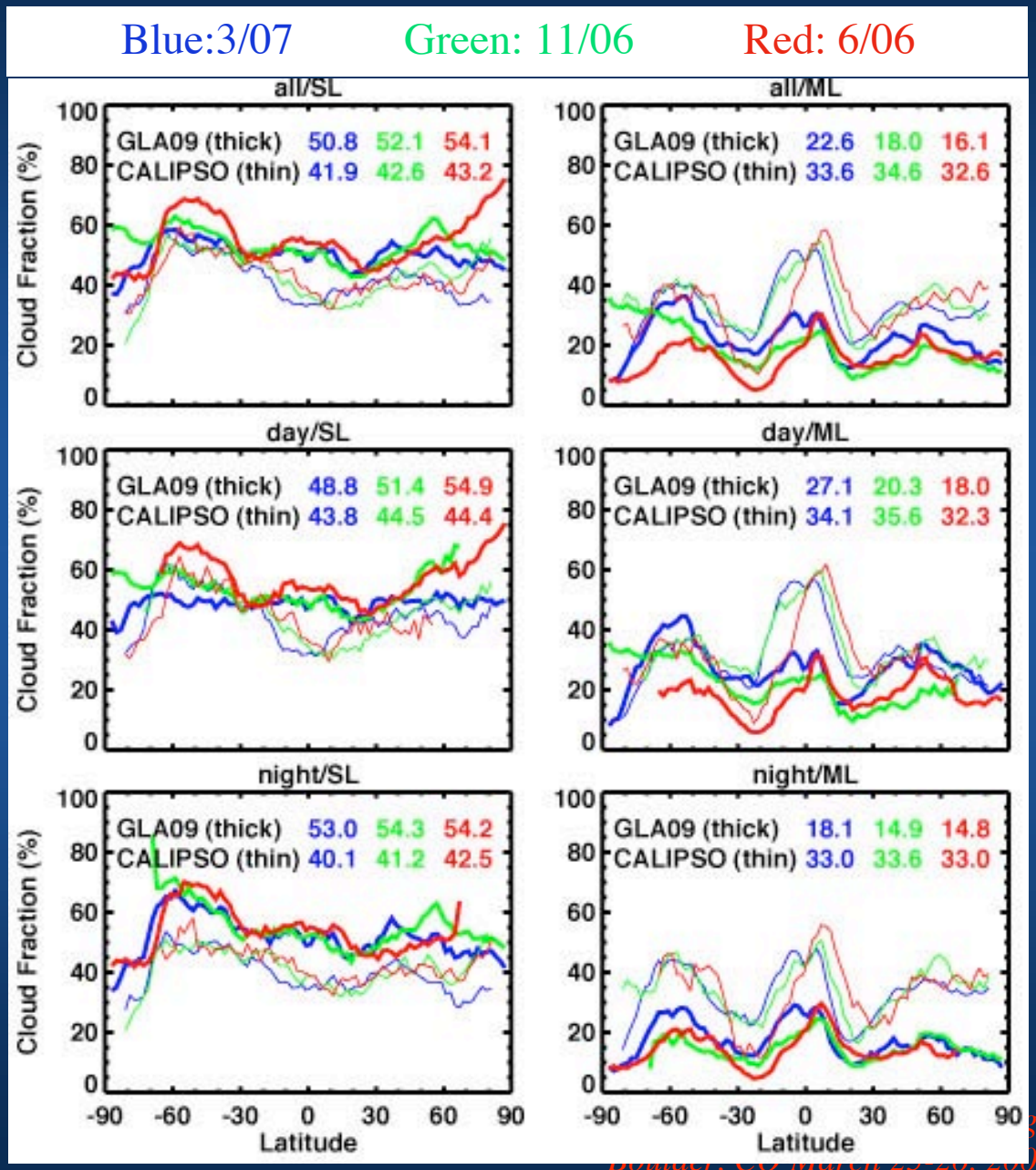
Zonal Mean Cloud Layering, GLAS & CALIPSO



Like the GLAS 532 results, CALIPSO detects 50-100% more multilayered clouds than GLAS 1064 nm

Future analyses will examine the optical depths of clouds missed by 1064 nm to determine if anything significant is lost in terms of radiatively important clouds

Summary

- GLAS validation has led to improvements in nighttime cloud heights from GOES
- Multilayer algorithm has also been improved
  - has high accuracy for single-layer cloud detection
  - more refinements needed to produce reliable multilayer detection
  - need to explore what types of clouds missed by 1064 nm
- GLAS 1064-nm clouds similar to, but less than CALIPSO
  - differences in polar regions
  - fewer clouds over ocean, greater proportion of low clouds detected
  - need to examine differences in algorithms & averaging techniques