CALIPSO and LITE data for space-based DWL design and Data utility studies: Research plans

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WG on Space-Based Lidar Winds

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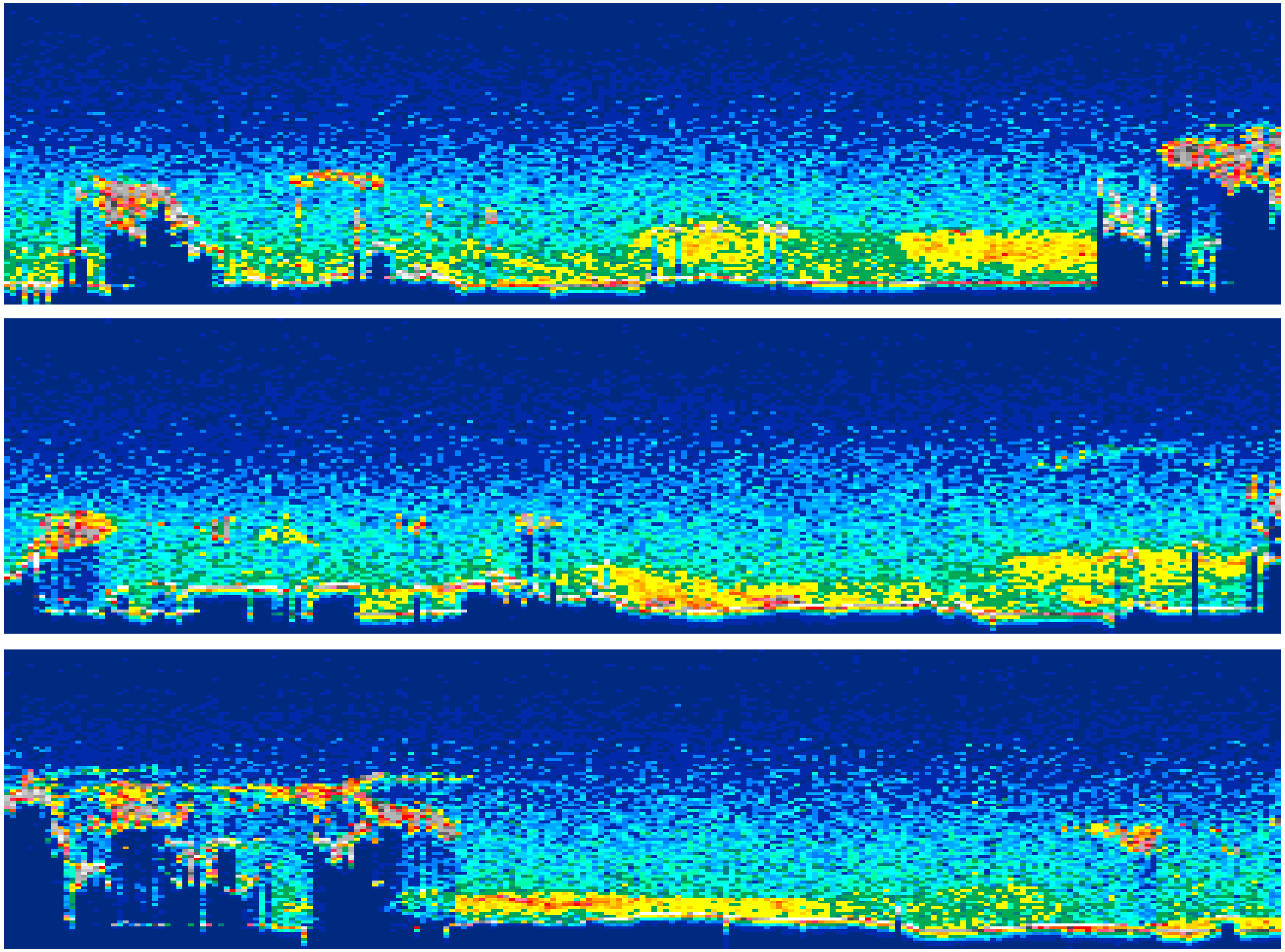
Clouds can be both targets and confounders for space-based lidars. Based upon various cloud studies, global cloud coverage varies from ~ 65% to >80% depending upon the threshold of optical depth chosen for defining a cloud and the “pixel” size.

CALIPSO



http://www-calipso.larc.nasa.gov/products/lidar/browse_images/show_calendar.php

CALIPSO/LITE ROSES07 study

The proposed study will use both LITE and CALIPSO data to address the following four major issues:

- Cloud free line-of-sight (CFLOS) statistics for laser beam footprints (with particular interest in contiguous laser shot integration intervals),
- Global aerosol backscatter distributions with particular interest in their correlation with cloud and atmospheric dynamics,
- Conversion of observations at CALIPSO wavelengths to those pertinent to GWOS, the hybrid wind lidar (.355 and 2.01 microns); validation of aerosol backscatter distributions being used in NASA/NOAA OSSEs.
- Instrument trade studies relevant to the GWOS instrument concept using an existing Doppler Lidar Simulation Model

Overview

- Develop a state-of-the-art set of *cloud free line-of-sight (CFLOS) statistics and atmospheric optical properties for space-based Doppler Wind Lidar (DWL)* design using both LITE and CALIPSO data and use the Doppler Lidar Simulation Model (DLSM) to conduct basic trade studies that relate directly to laser design and scanning options.
- Effort is focused upon issues that are unique to the *hybrid (coherent and direct detection combined) Doppler Wind Lidar* being considered for the first USA mission. In particular, deriving 2 micron coherent performance from .532/1.06 µm CALIPSO data is non-trivial and will require some modeling.
- Our revisit to the LITE data is in recognition of the fact that *LITE was the most powerful backscatter lidar ever flown* in space. If the weak aerosol distributions are to be investigated, it will probably be the LITE data that is most useful.
- Simpson Weather Associates' (SWA) recent study of the CFLOS statistics from the ICESat GLAS (Geosciences Laser Altimeter System) data sets provides both the motivation and methodology behind this work

LITE CFLOS study

The general conclusions of the LITE data analyses of cloud porosity for lasers were that:

- The 532nm beam provided a ground return more often (~60 - 65%) than the current cloud climatologies based upon passive imagers suggested (~30-40%).

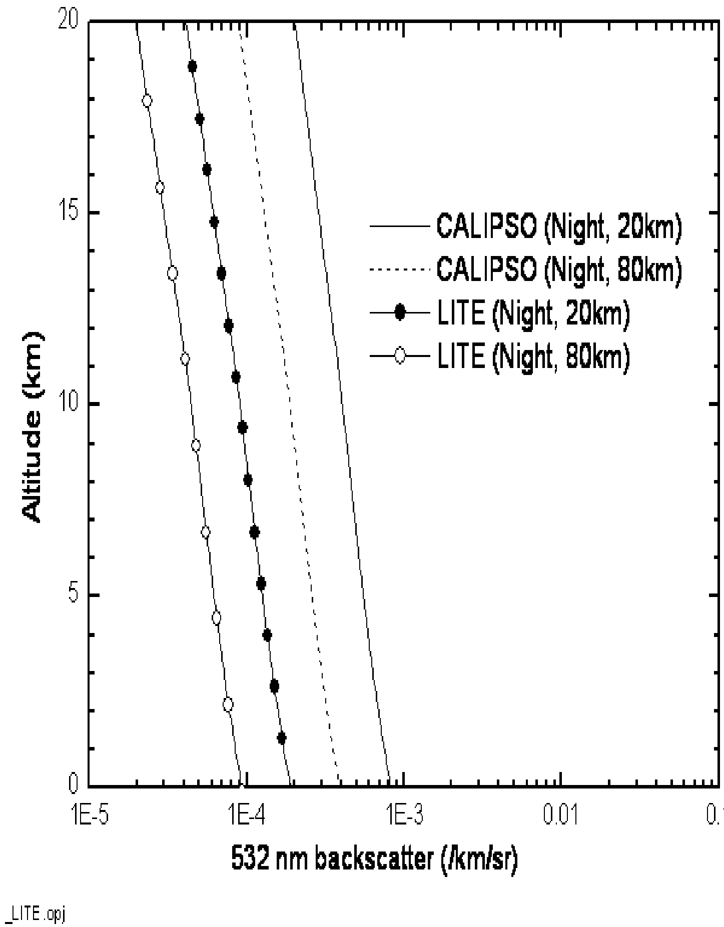
- More than 50% of the time that the lidar beam intercepted a cloud it also provided a ground return. In other words the porosity of the clouds to the LITE beams was on the order of 50%.

GLAS study summary

- 70 - 80% of the GLAS lidar samples involved some return from clouds (assumed that “no cloud/no ground returns” intercepted thick layers of optically thin clouds)
- 75 - 80% of the GLAS lidar samples detected the earth’s surface (adjusted for smooth water returns)
- When clouds were present, 25 – 40% of the time at least two layers were detected.
- Details on the ESTO GLAS study can be found at the following web site : (http://esto.nasa.gov/adv_planning_studies_archive.html).

Minimum Detectable Backscatter

LITE vs. CALIPSO (532 nm, night, averaging to 20 km, 80 km)



At night, LITE 532 nm is more sensitive than CALIPSO 532 nm. Due to larger LITE FOV and filter passband, daytime performance is similar.

CALIPSO 1064 detector is better than LITE 1064 detector, so advantage of LITE is less than at 532 nm.

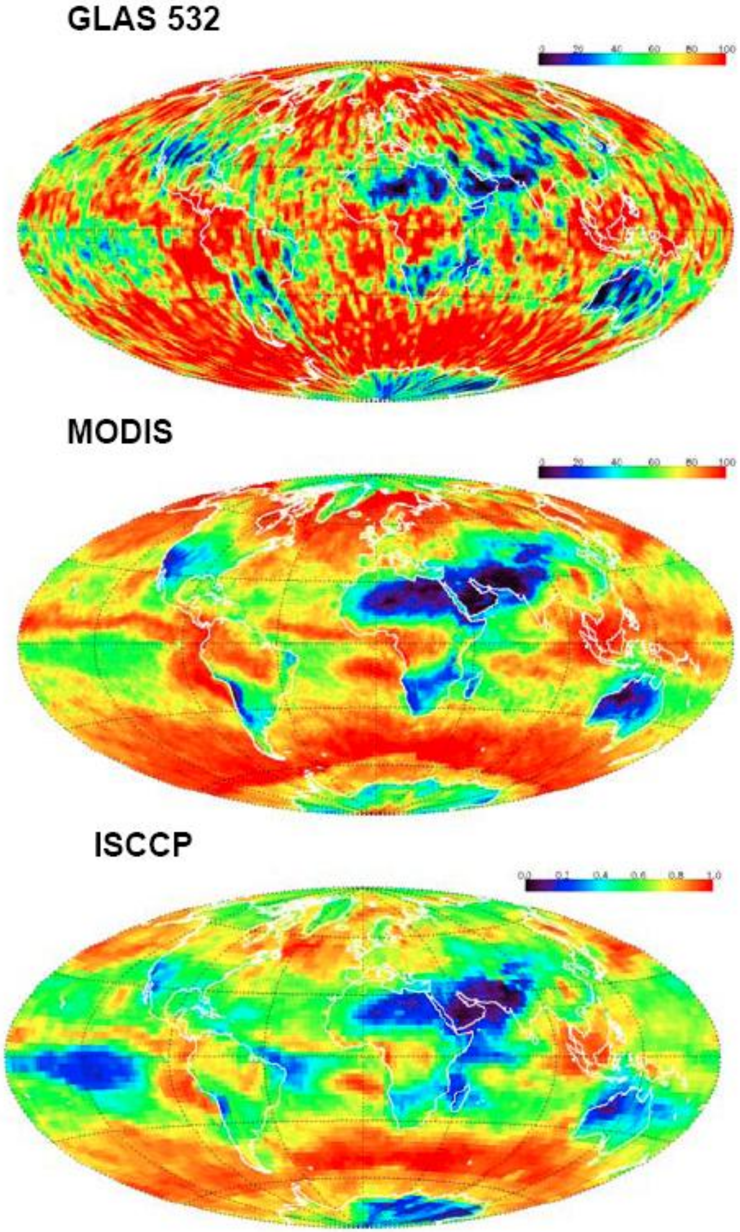


Figure 2A: Global maps of cloud frequency for GLAS, MODIS, ISCCP for October. 2003.

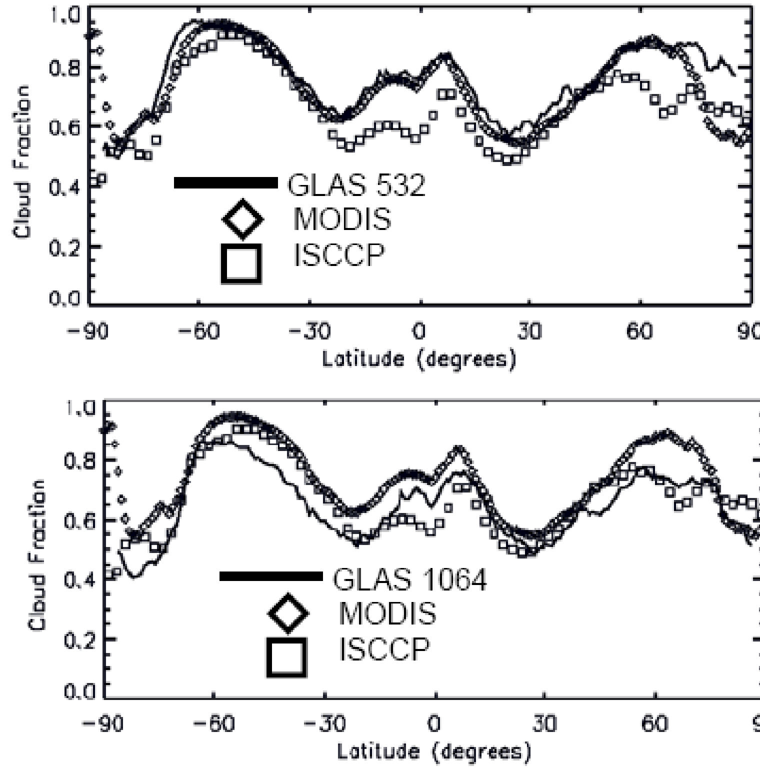
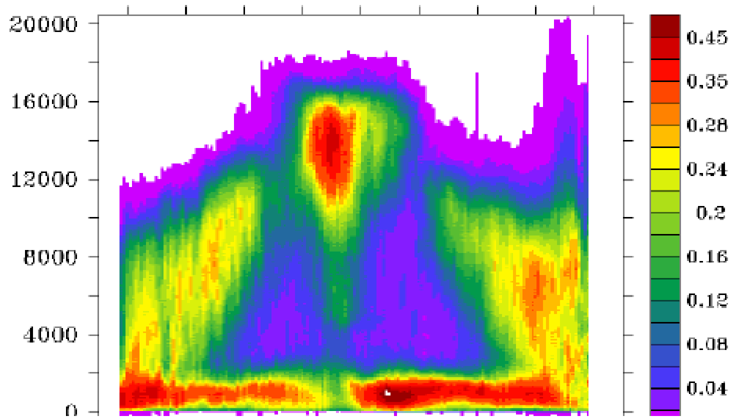
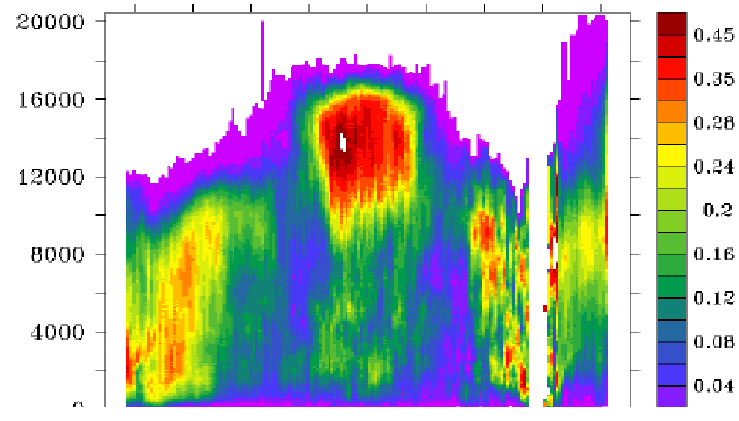


Fig. 3. Zonal cloud fraction for GLAS, ISCCP, and MODIS for October, 2003.

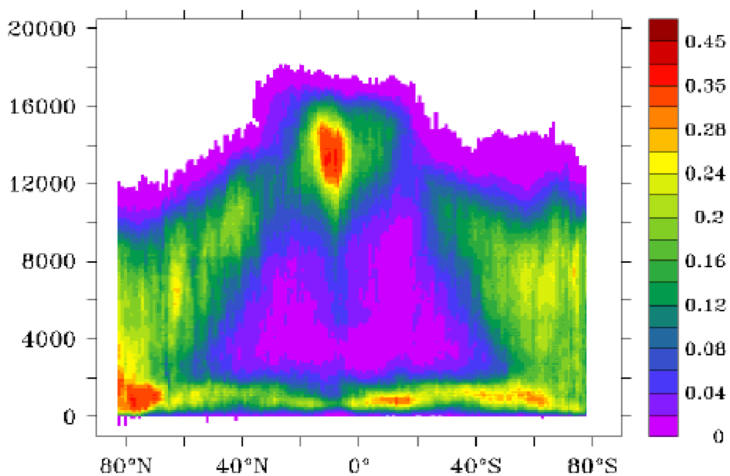
WHAT IS OBTAINED From CALIOP/CALIPSO October 2006

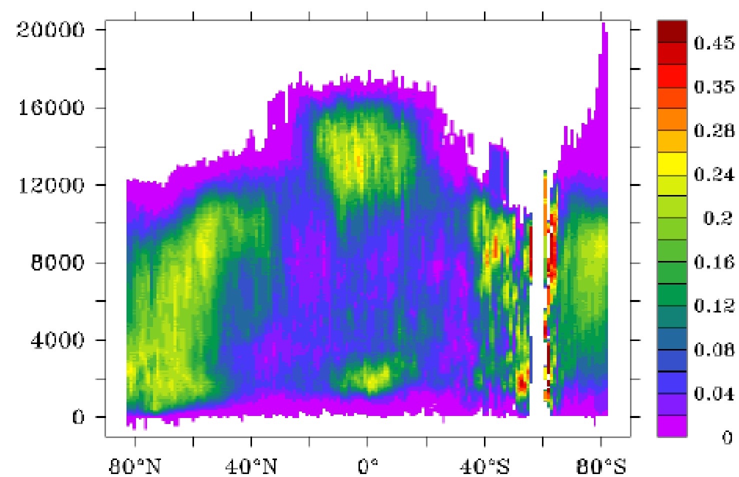
Night Ocean Land





Day Calipso data v1.10





Earthcare workshop, ESTEC, 8 May 2007

Seze, Pelon, Flamant, Vaughn, Trepte and Winker

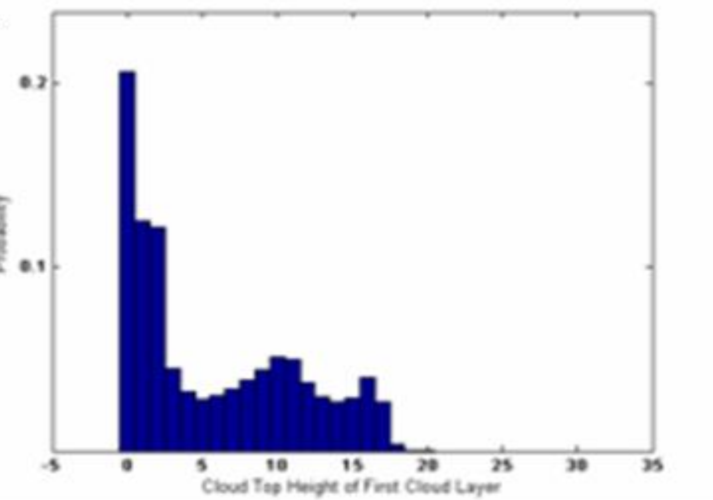
Night and day cloud cover

GLAS 50 days during the 2003 fall, CALIOP August and October 2006

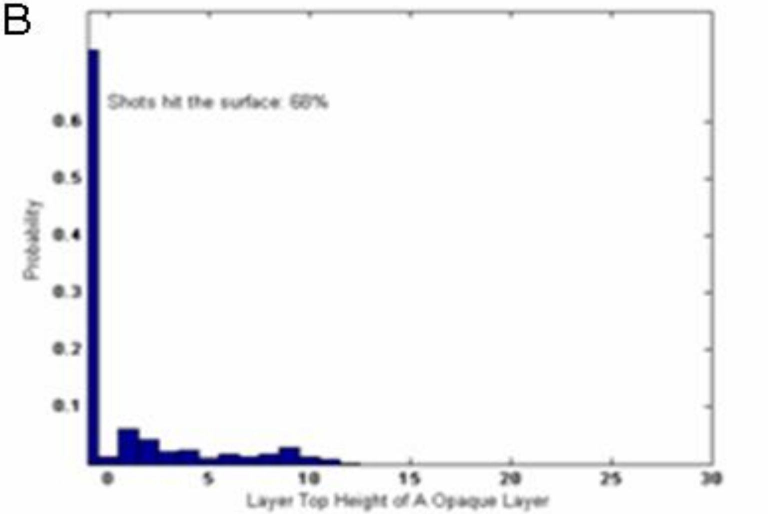
	Night				Day		
	GLAS	CALIPSO			GLAS	CALIPSO	
	2003	*Oct*	*Aug*		*2003*	*Oct*	*Aug*
Total cloud cover	78%	79%	76%		65%	75%	78%
high cloud	21%	23%	29%		20%	23%	20%
middle cloud	19%	12%	11%		23%	13%	15%
high + middle	10%	11%	13%		8%	12%	11%
low cloud	30%	34%	29%		37%	35%	36%
low cloud with other	20%	20%	18%		11%	17%	18%

Low < 700 hPa **Middle : 700-400 hPa** **High > 400 hPa**

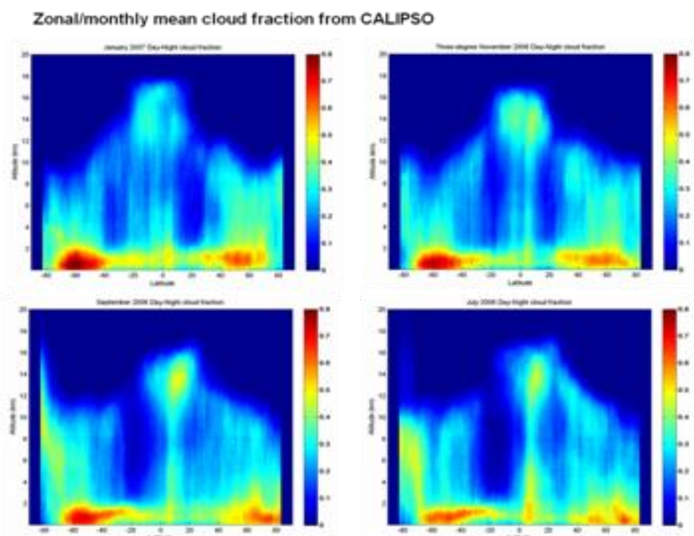
A



B



C



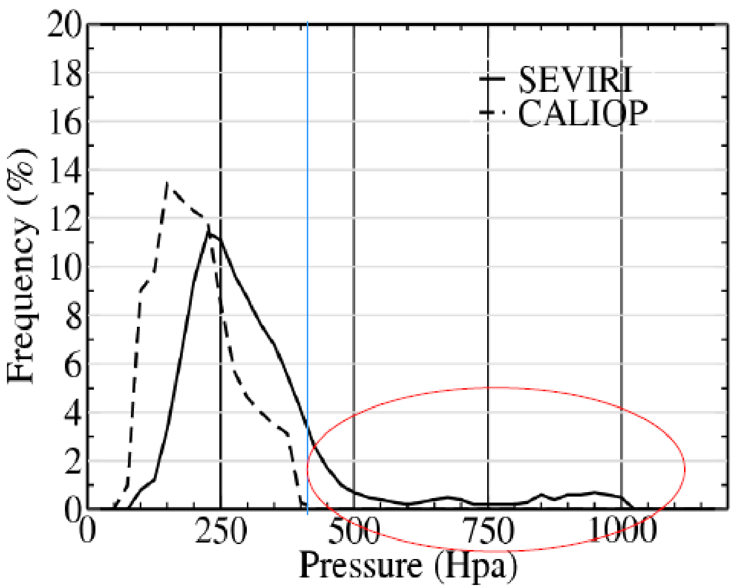
A:Cloud top height of the first cloud layer CALIPSO detects

B:Cloud top height of opaque cloud Layer: non-opaque shots are about 68%

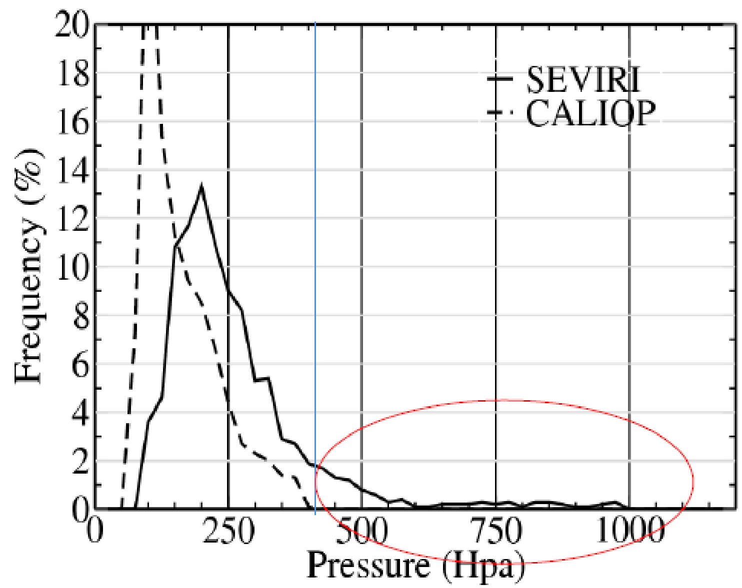
C: Zonal/monthly mean cloud fraction from CALIPSO

DISTRIBUTION OF SEVIRI CLOUD TOPS

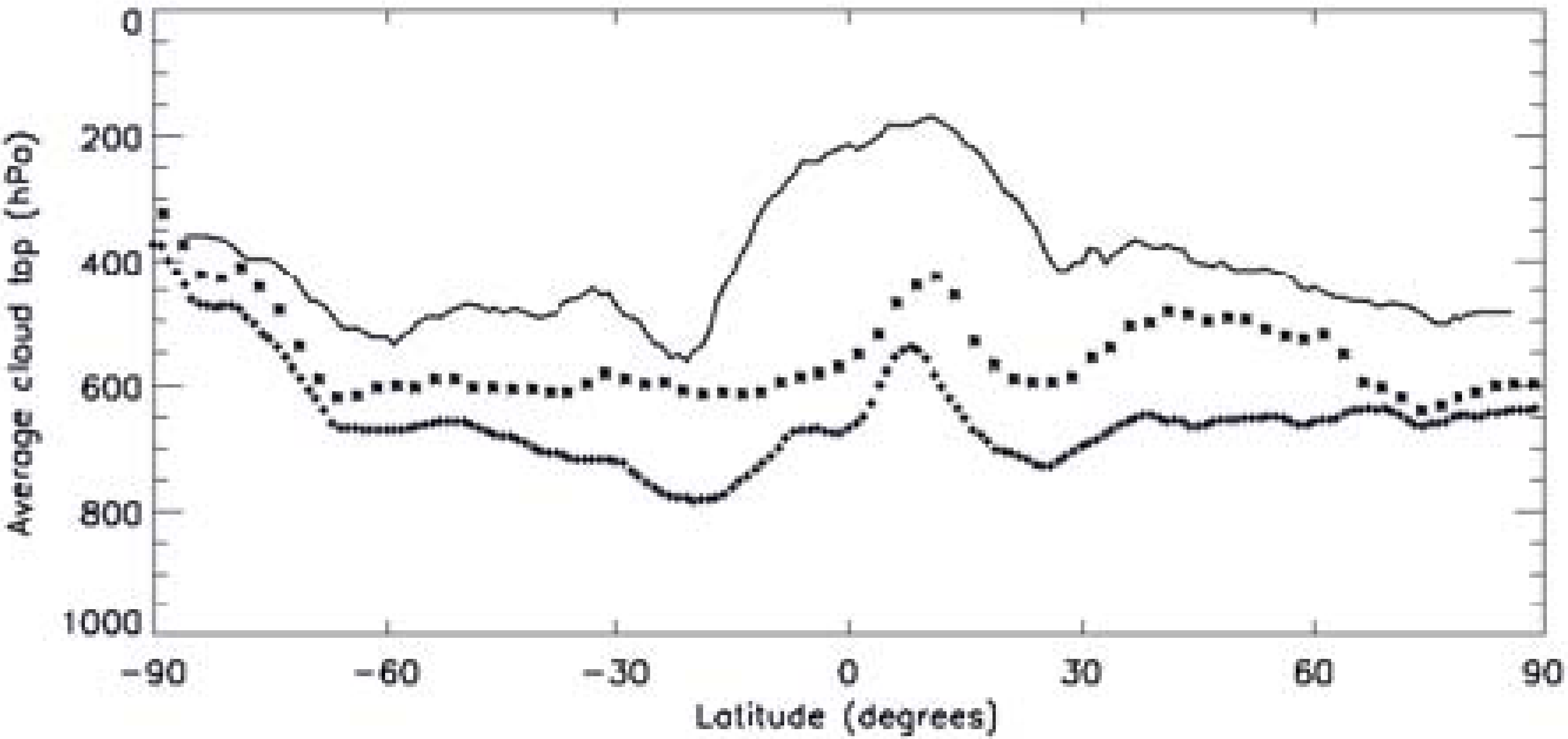
FOR CALIOP high clouds tops below 400 hPa Night data



OCEAN



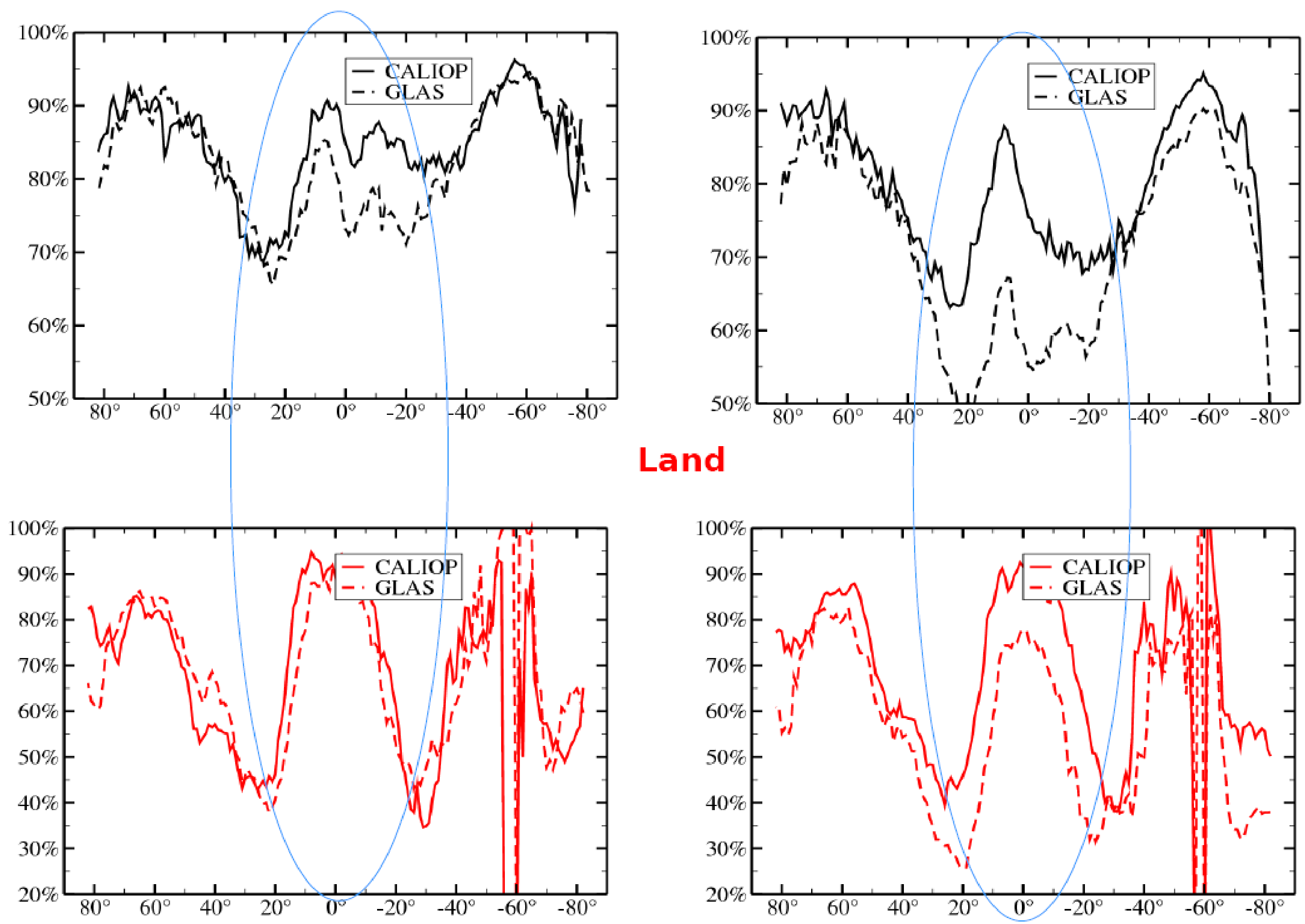
Land



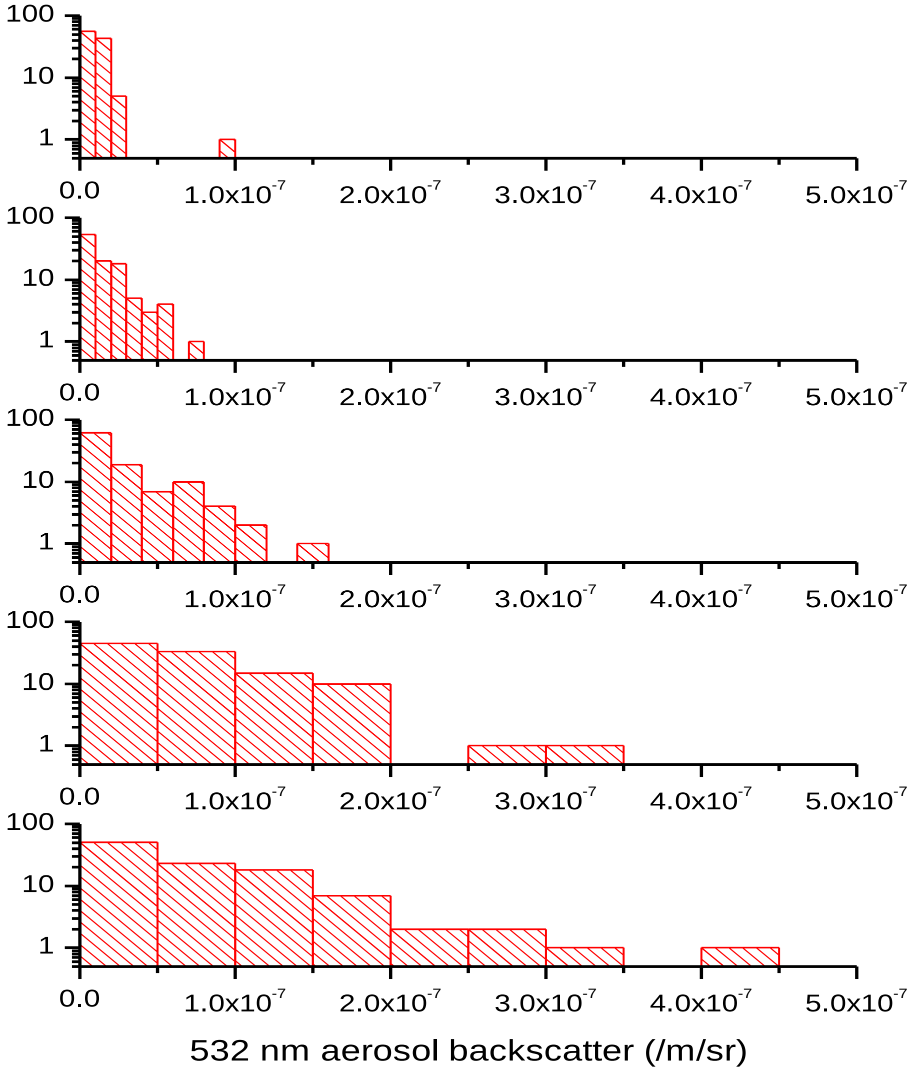
Zonal average cloud top for GLAS,ISCCP, and MODIS for October, 2003.

Taken from: William D. Hart*, Stephen P. Palm, James D. Spinhirne and Dennis L. Hlavka Global and polar cloud cover from the Geoscience Laser Altimeter System, observations and implications

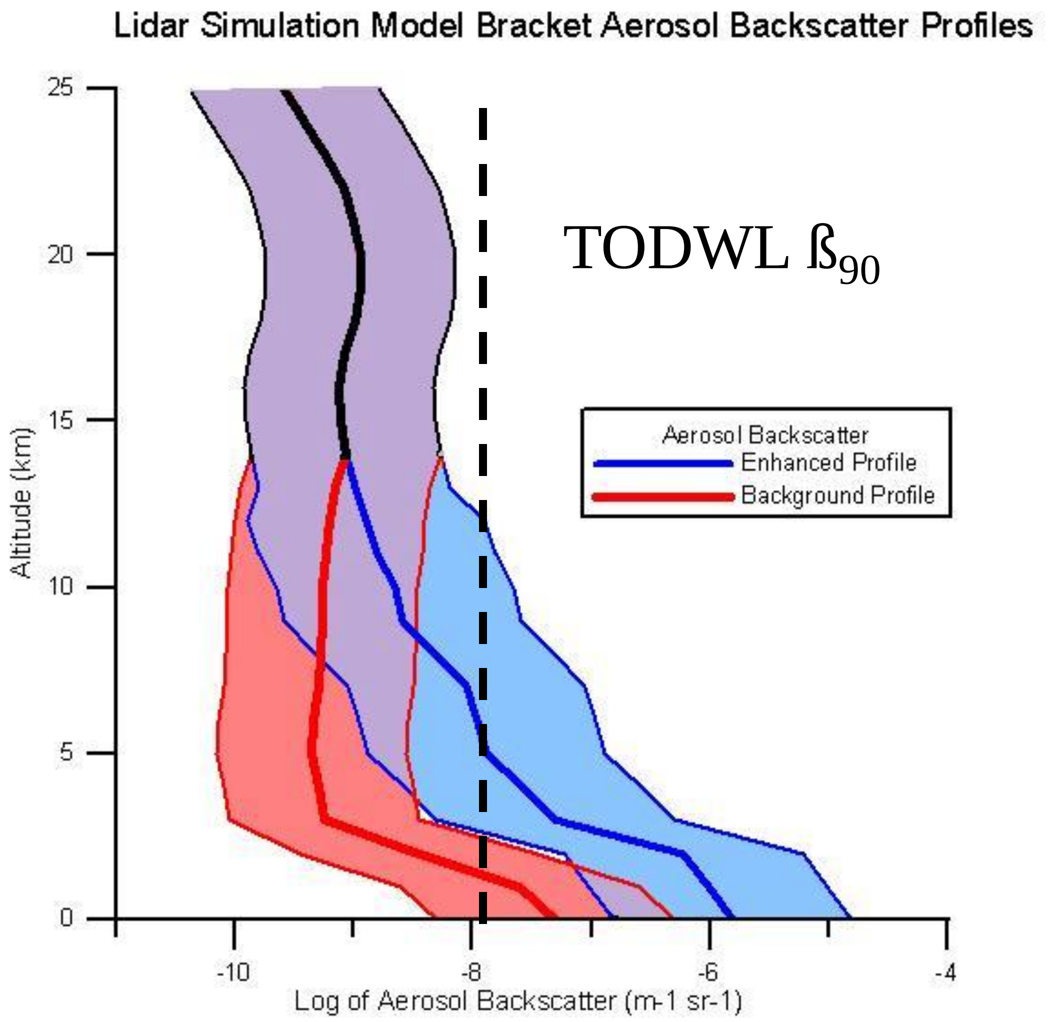
Night **Ocean** **Day**



GLAS october 2003 – CALIOP october 2006



Frequency distributions of 532 nm aerosol backscatter
in the tropics (5oS- 25oS) September 1994.
From top to bottom: 14-16 km, 12-14 km, 10-12 km, 8-10 km, and 6-10 km.


Lidar Simulation Model Bracket Aerosol Backscatter Profiles
TODWL ß90
Aerosol Backscatter
Enhanced Profile
Background Profile
Altitude (km)
25
20
15
10
5
0
-10
-8
-6
-4
Log of Aerosol Backscatter (m-1 sr-1)

Natural Variability of 2 μm Backscatter