Early Results from *CALIPSO*

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with help from:

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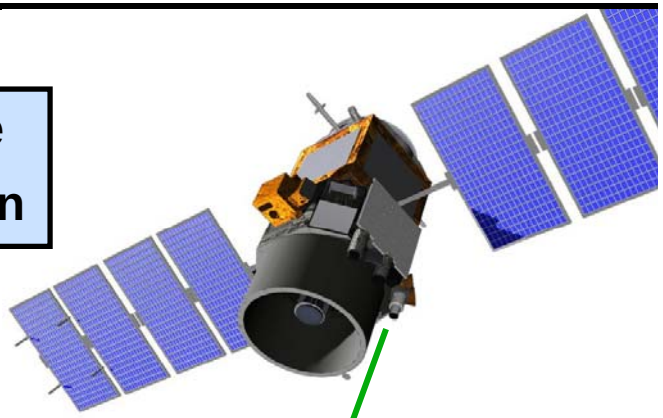
CALIPSO Mission Overview

First polarization lidar in space
Joint NASA-CNES collaboration



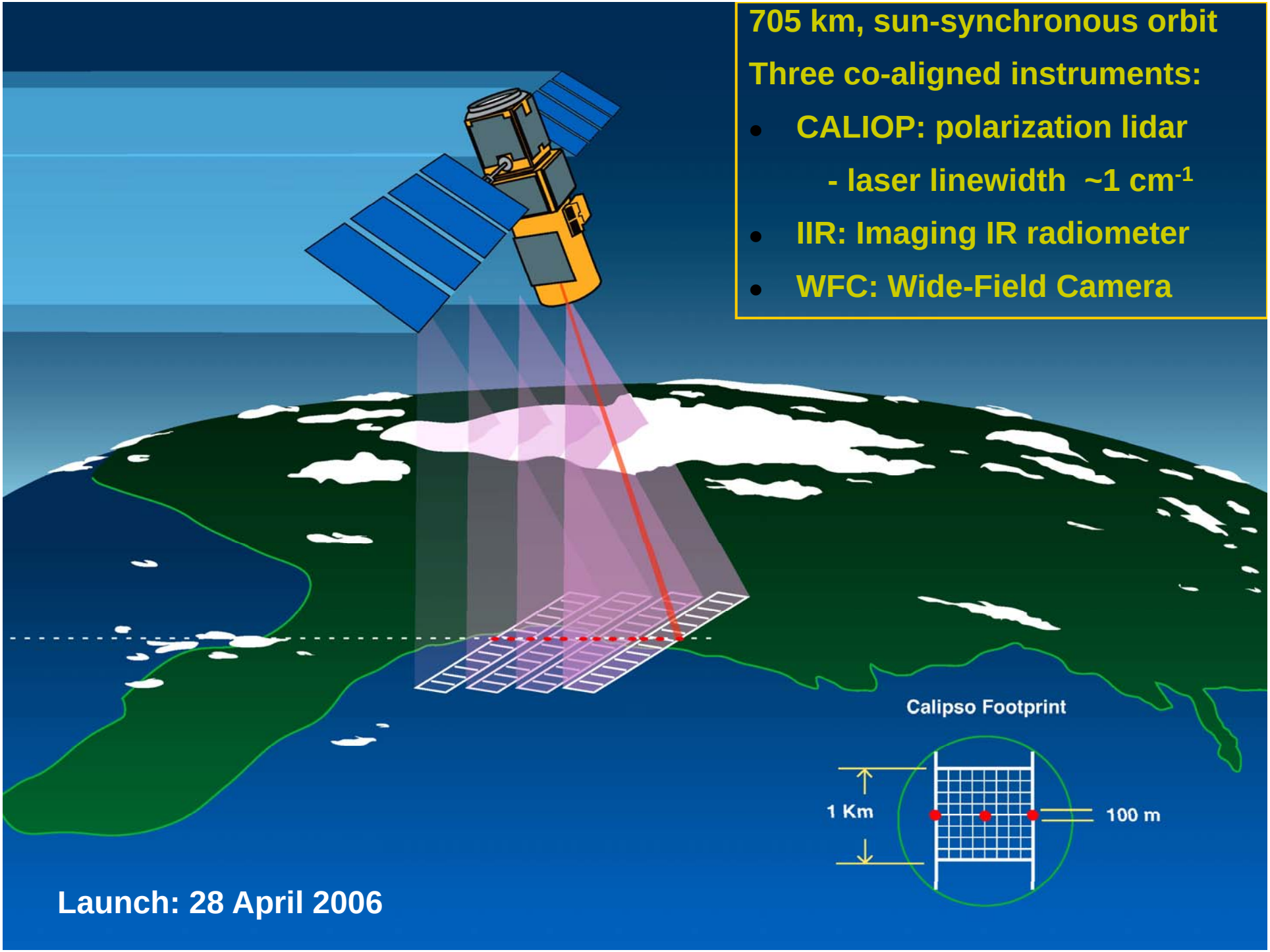
Proposed: 1998

Objectives:

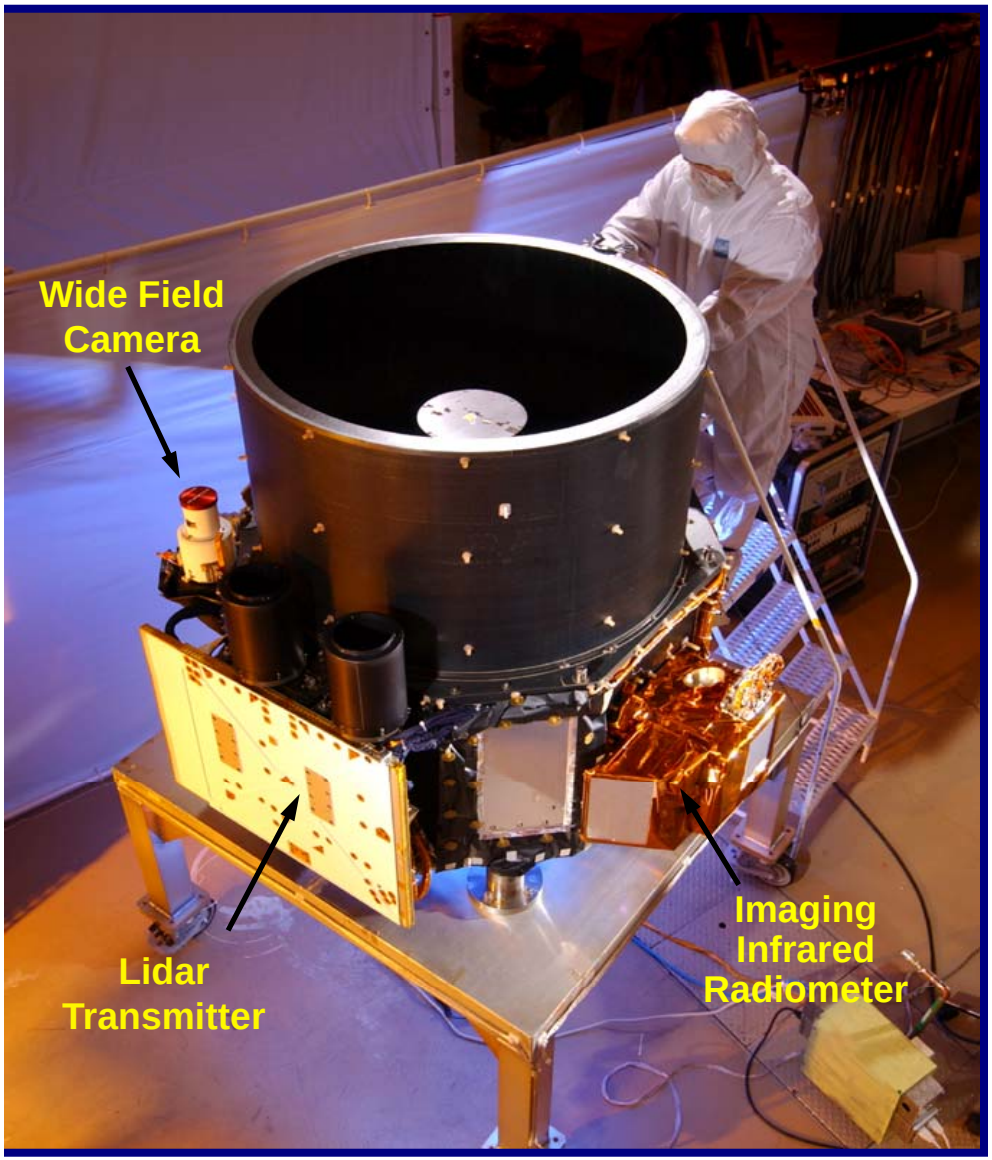
- **Improved understanding of aerosol and cloud effects on radiation budget**
- **Improved understanding of cloud-climate feedback processes**
- **Improve aerosol and cloud information from other A-Train sensors**
- **Improved predictive capability for climate, weather, and air quality**

Approach:

- **Produce a global aerosol and cloud dataset consisting of:**
  - **Profiles, optical properties, microphysical properties**
  - **Identify cloud ice-water phase, aerosol type**
- **Combine CALIPSO and other A-Train observations**


705 km, sun-synchronous orbit
Three co-aligned instruments:
• CALIOP: polarization lidar
- laser linewidth ~1 cm-1
• IIR: Imaging IR radiometer
• WFC: Wide-Field Camera
Calipso Footprint
1 Km
100 m
Launch: 28 April 2006

Payload Specifications



CALIOP

Laser	Nd: YAG, 2x110 mJ
Wavelength	532 nm, 1064 nm
Repetition rate	20.16 Hz
Receiver telescope	1.0 m diameter
Polarization	532 ∥ and ⊥
Footprint/FOV	100 m / 130 μrad
Vertical resolution	30 - 60 m
Horizontal resolution	333 m
Lin. dynamic range	22 bits

Wide-Field Camera (WFC)

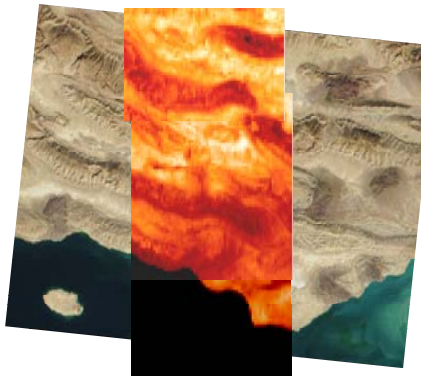
Wavelength	645 nm
Spectral bandwidth	50 nm
IFOV / Swath	125 m / 61 km

Imaging Infrared Radiometer (IIR)

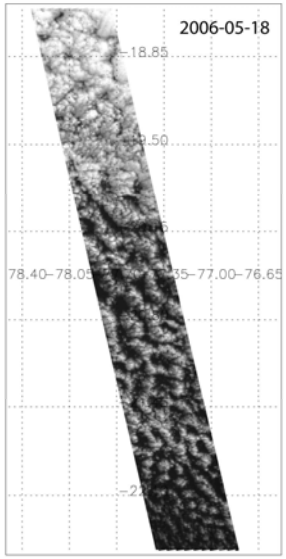
Wavelength	8.65, 10.6,12.05 μm
Spectral resolution	0.6-1.0 μm
IFOV / Swath	1 km / 64 km
NETD @ 210K	0.3 K
Calibration	±1 K

Post-Launch Chronology

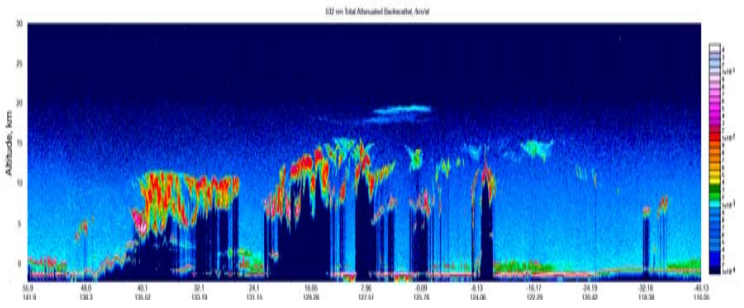
- 28 April – Launch
- 10 May – IIR *'First Light'*
- 15 May – WFC *'First Light'*
- 23-24 May – Initial laser tests (LOM 2)
- 7 June – CALIOP *'First Light'*
- 8-9 June – Laser tuning
- 22 Jul - Initial release of data to Science Team
- 5 Sep - Public release of browse images
- 3-5 Oct - Science Team meeting
- 8 Dec – First public release of science data



IIR First Light Image



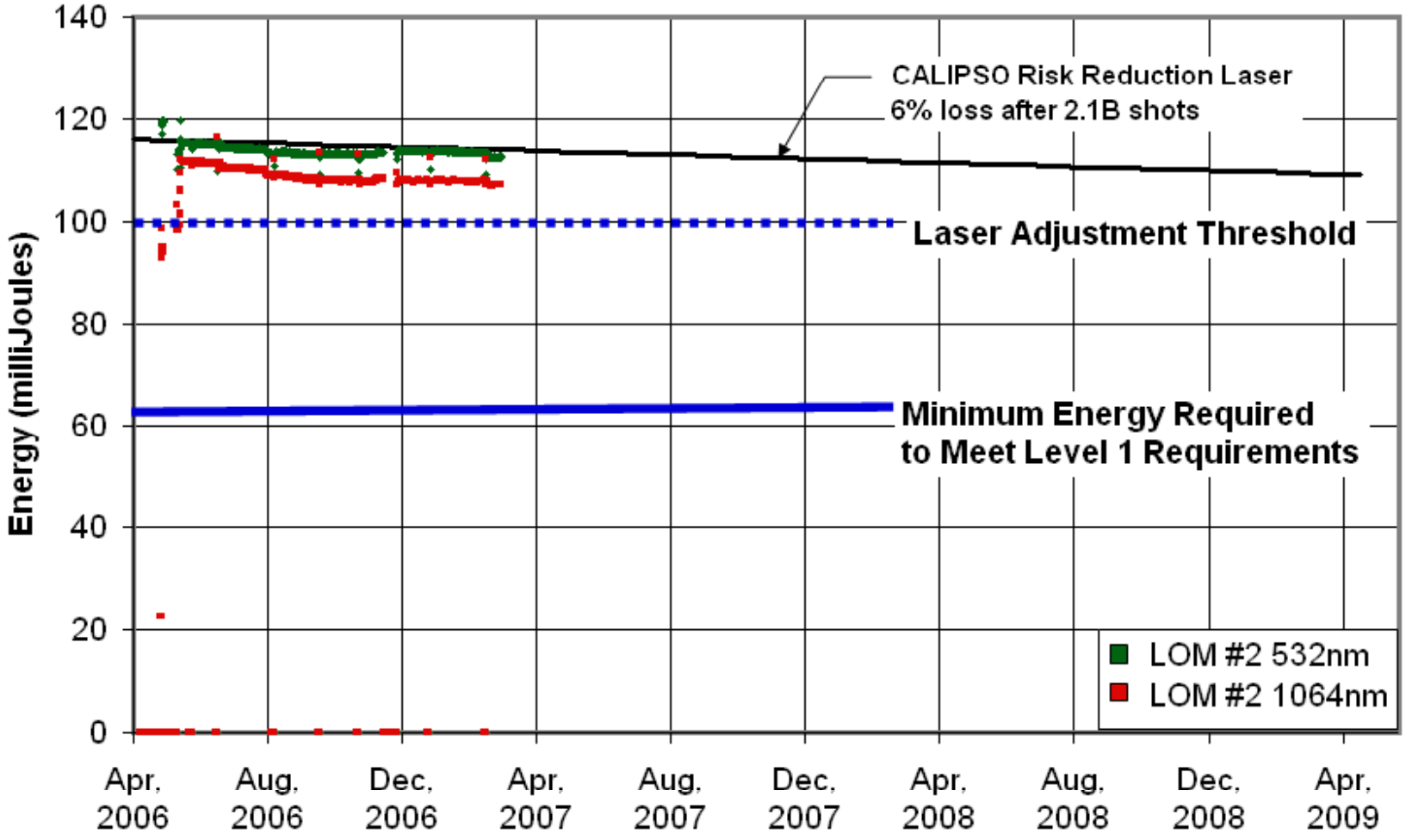
WFC First Light Image



CALIOP First Light Image

Laser #2 Pulse Energy through March 22

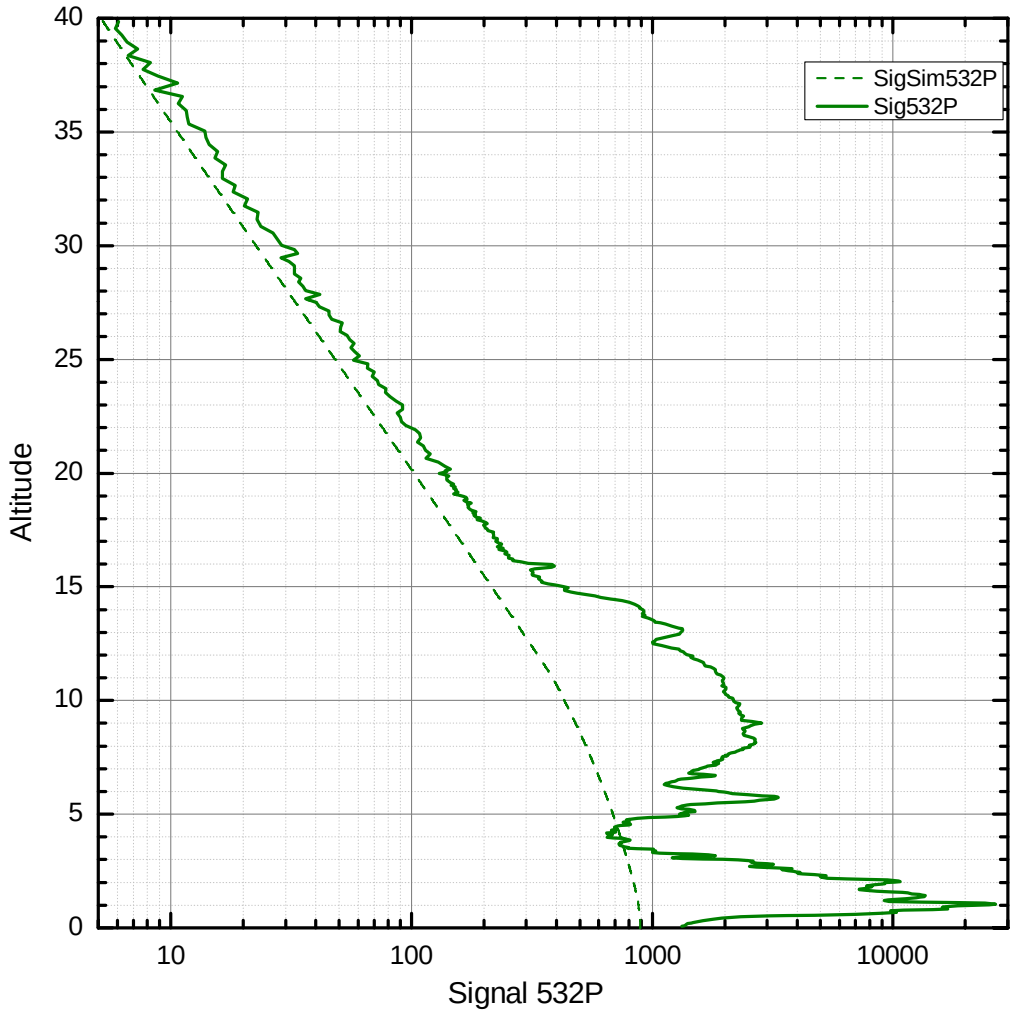
Laser continues to perform well



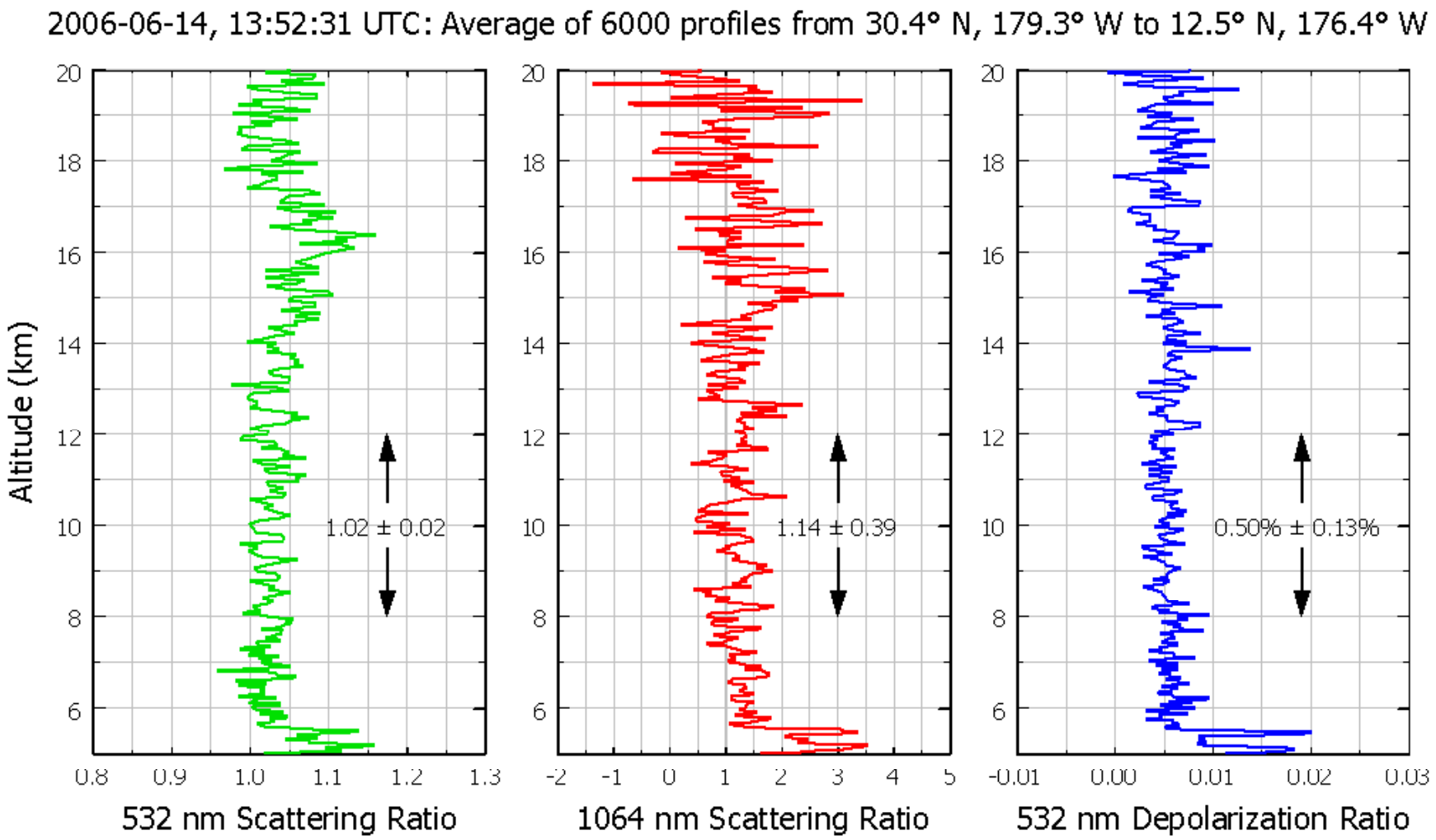
March 23, 2007

CALIOP Meeting/Exceeding Design Specifications

Signal strength and SNR ~50% greater than predicted

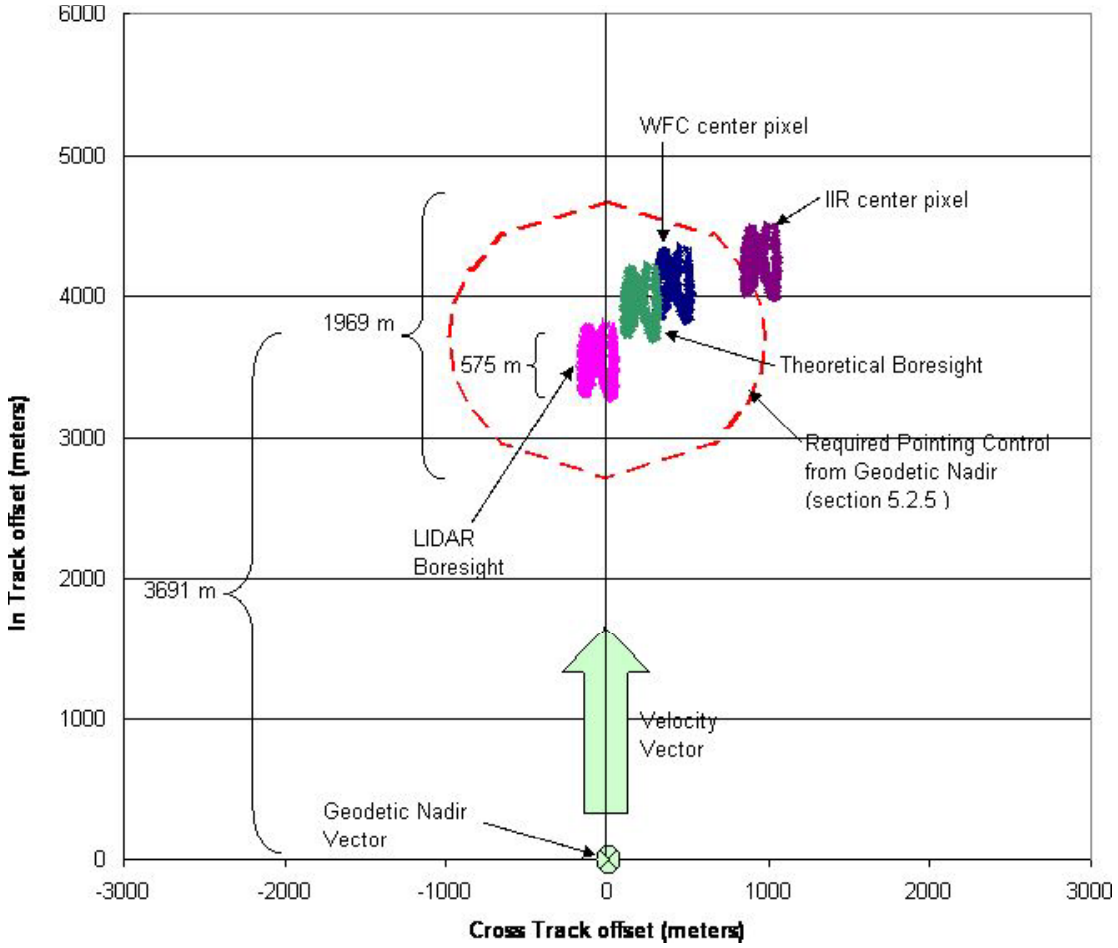


Clear-air Profiles



Pointing Biases and Uncertainties

Biases in relative pointing between star trackers and CALIOP/WFC/IIR have been identified and corrected



Relative to satellite geodetic nadir point:

Control (req't = ±1 km)

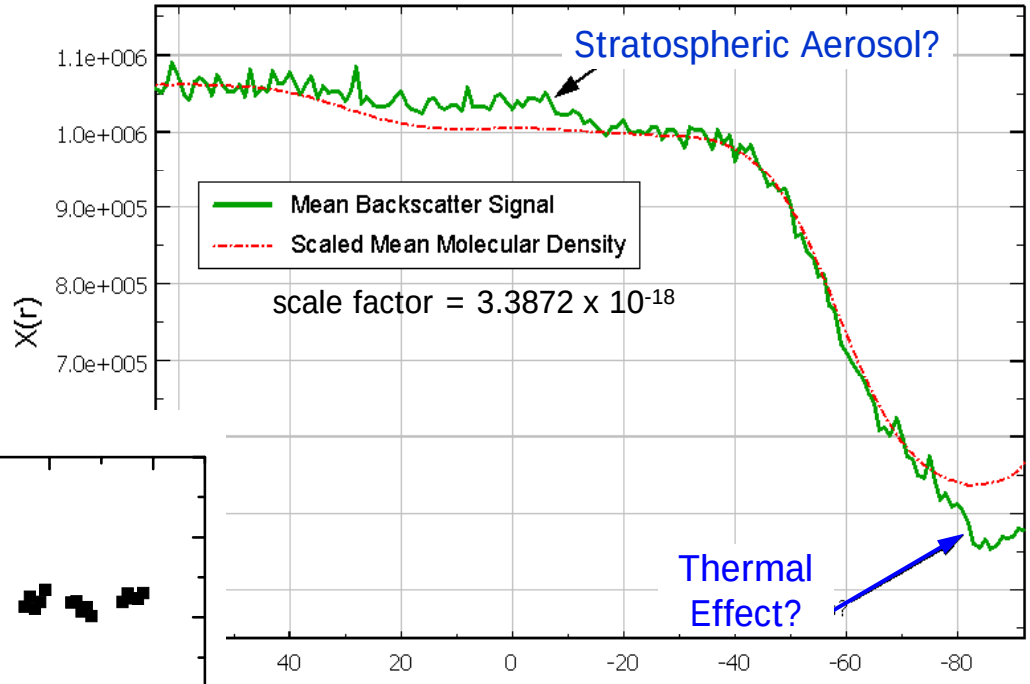
MEAN:	**Cross-track**	**Along-track**
CALIOP	**-55 m**	**- 428 m**
WFC	**372 m**	**126 m**
IIR	**270 m**	**500 m**

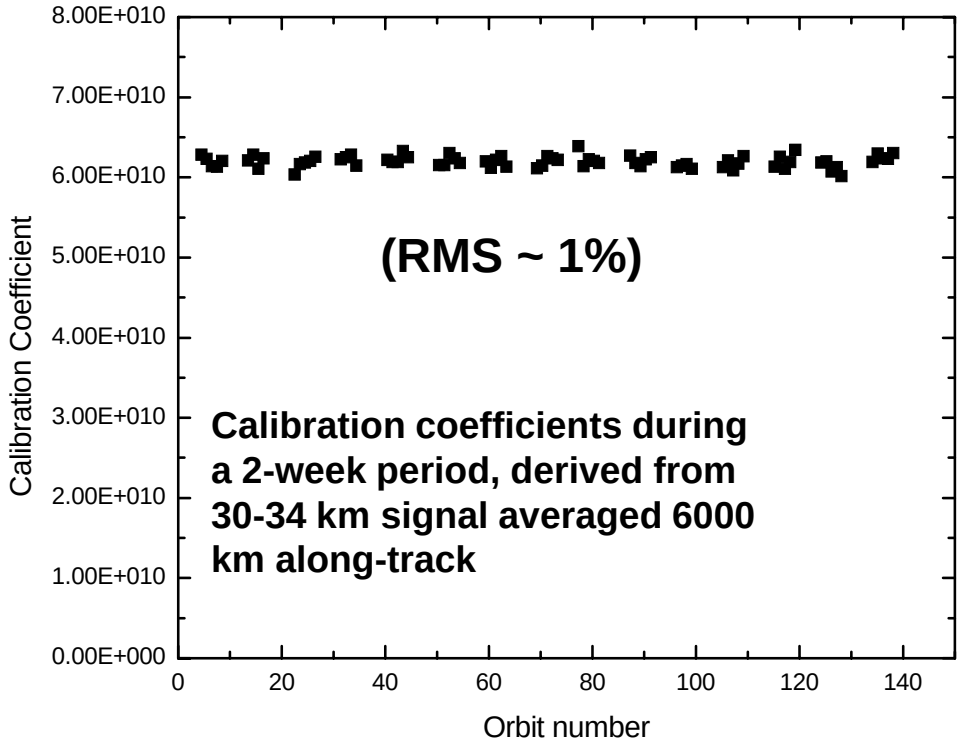
Knowledge:

RMS	**Cross-track**	**Along-track**
CALIOP	**29 m**	**26 m**
WFC	**35 m**	**40 m**
IIR	**100 m**	**100 m**

532-parallel calibration

532-parallel channel calibrated by normalization of high-altitude returns (30-34 km) to molecular density

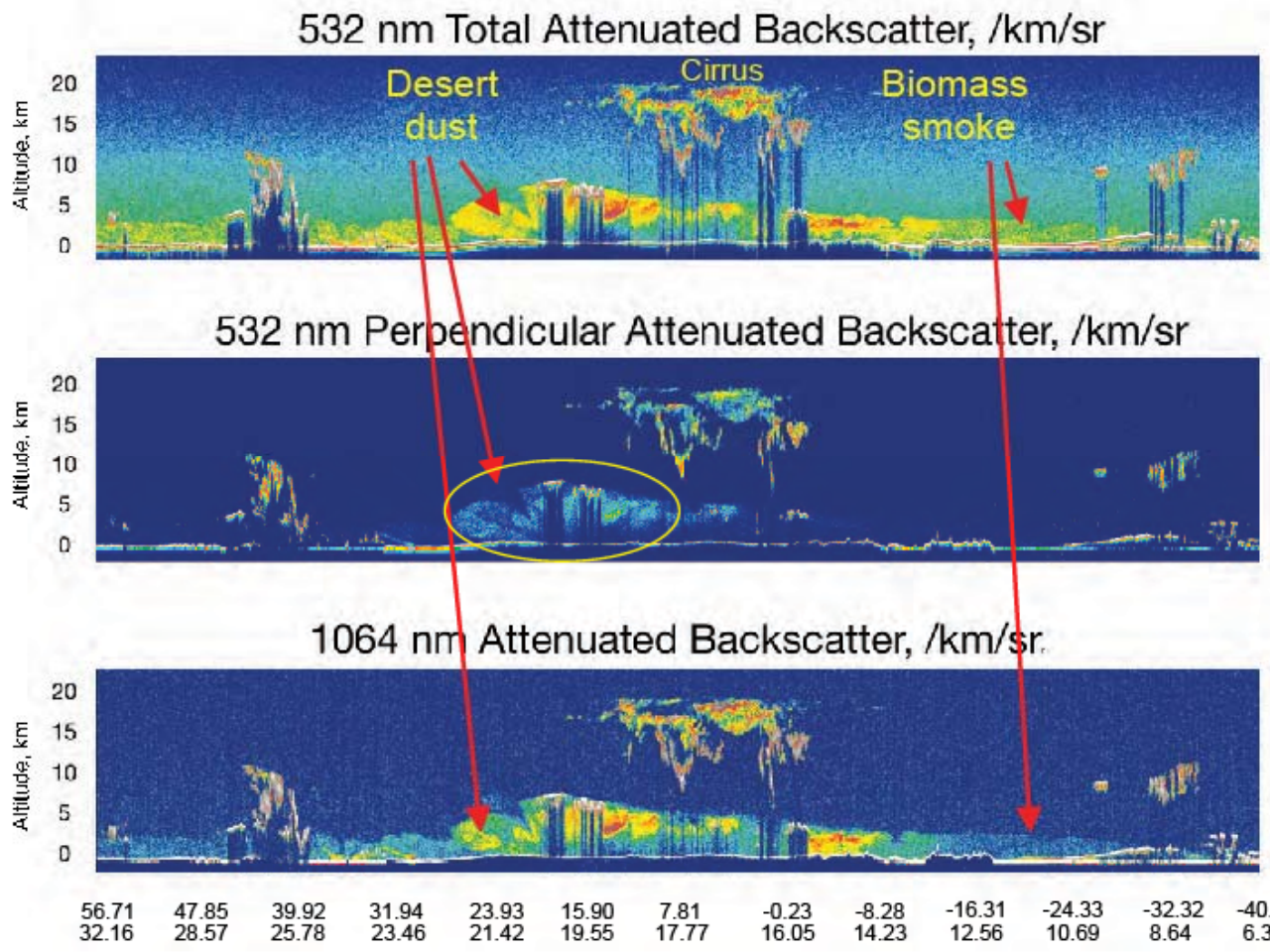


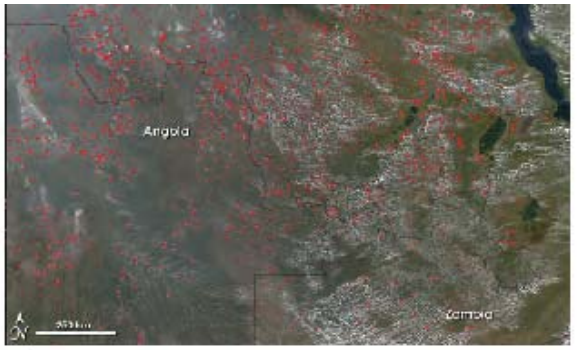


RMS variability of calibration coefficients slightly larger than expected from signal noise alone

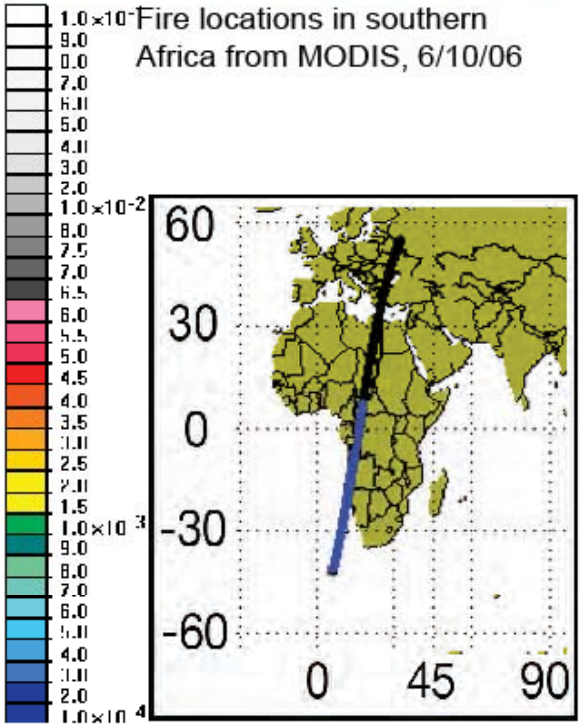
CALIPSO First Light Observations
(all 3 channels)

June 9, 2006





Fire locations in southern Africa from MODIS, 6/10/06



Validation Activities

Validation includes:

- Targeted aircraft campaigns
- International field campaigns
- Ground-based networks
- Satellite comparisons

Activities to date:

• Flights of LaRC HSRL	Jun-Sep 2006, Jan 2007
• CALIPSO-CloudSat Val Exp (Georgia)	Jul-Aug 2006
— CPL, CRS (ER-2), HSRL	
• Flights of CNES HSRL (Niger)	Jul 2006
• NASA AMMA (Cape Verde)	Aug 2006
• GoMACCS (Houston)	Aug-Sep 2006
• Canadian Cold Weather Study	Winter 2006/2007

Plans for 2007:

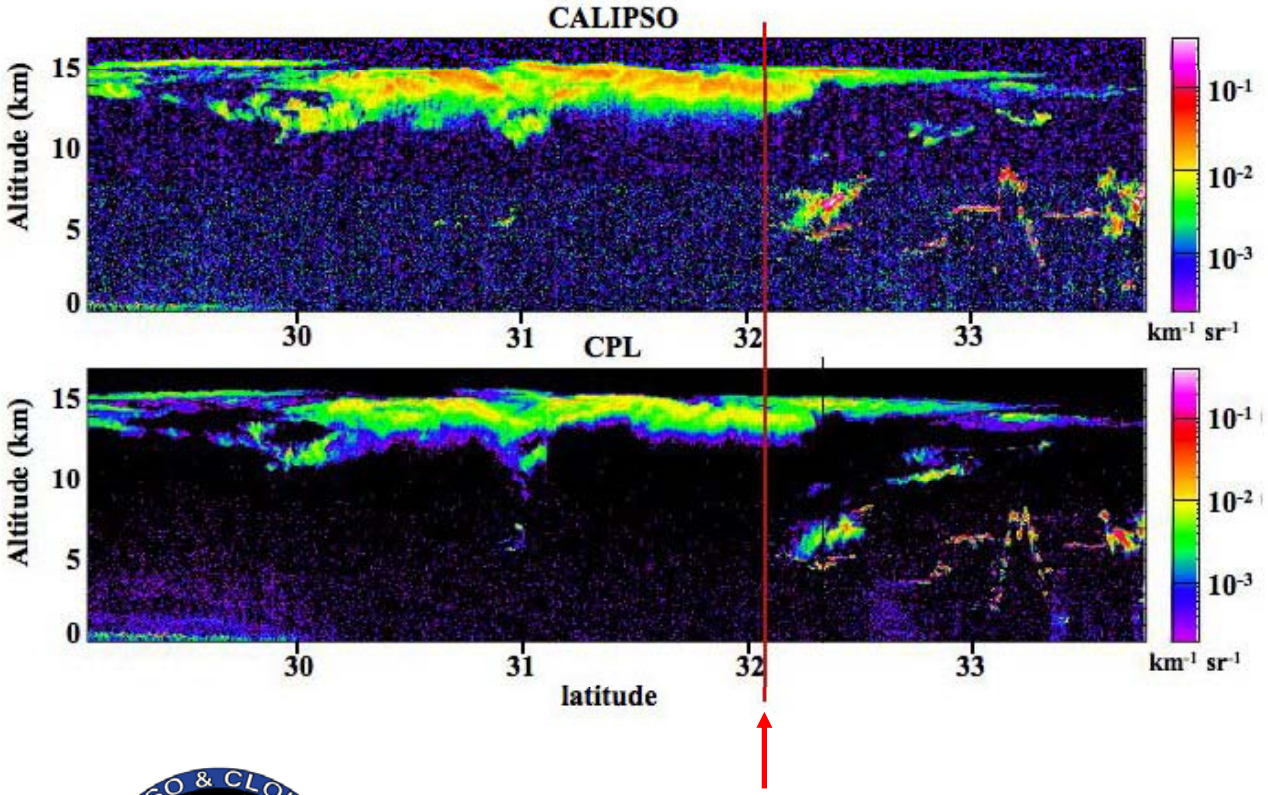
• DLR ASTAR (Svalbard)	Mar-Apr
• NASA TC^4 (Costa Rica)	Jul-Aug

- More comprehensive validation relying on ground-based instruments

Validation Intercomparisons: Clouds

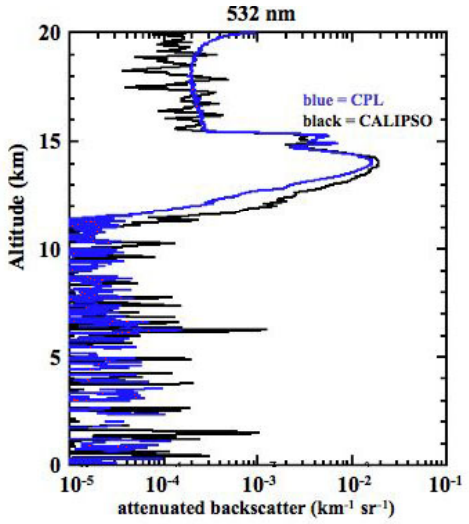
August 12, 2006

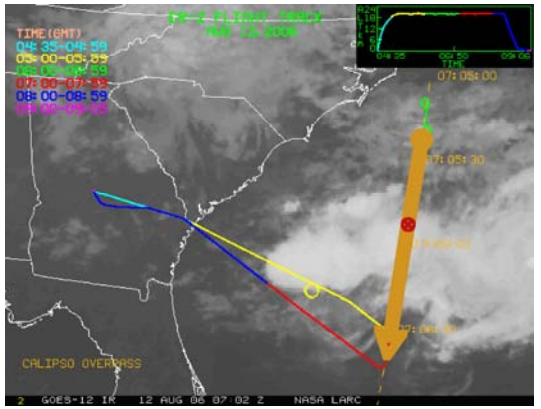
532 nm Calibrated Attenuated Backscatter



Coincidence

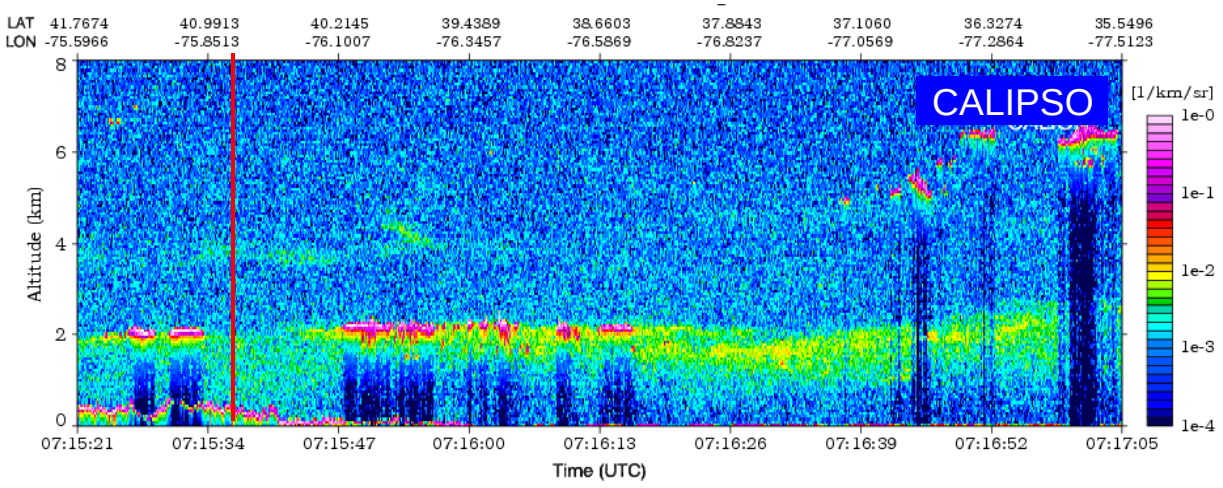
Coincidence

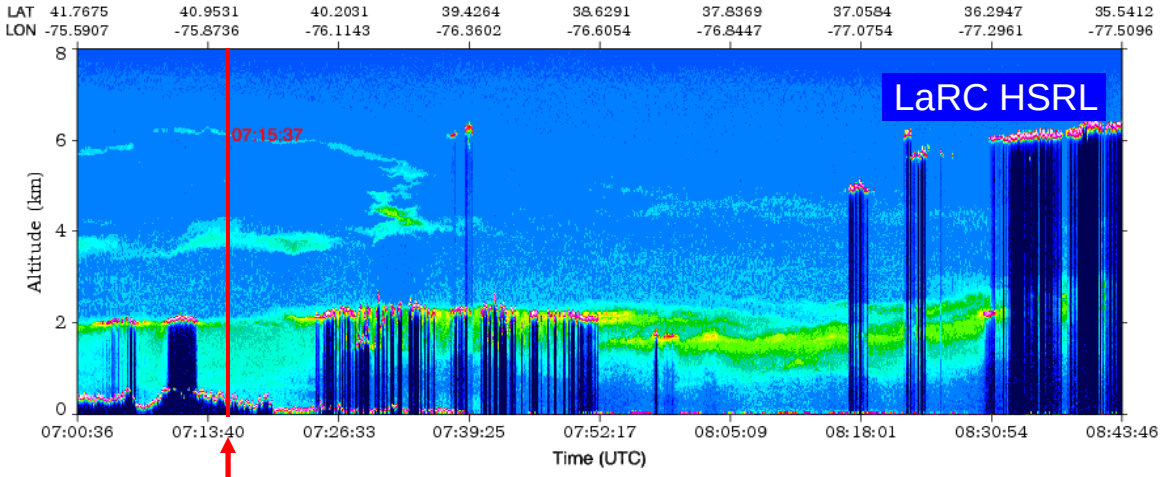




Validation Intercomparisons: Aerosols

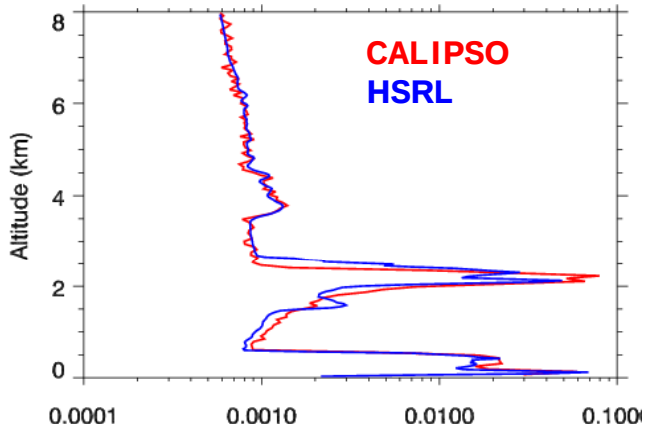
August 10, 2006



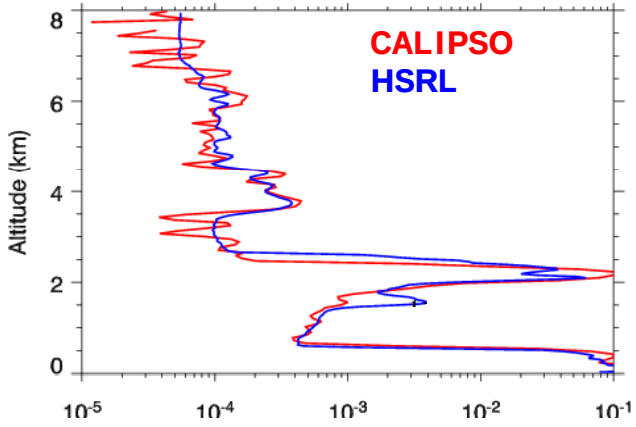


Coincidence

Coincidence



532 nm Attenuated Backscatter (km^{-1} sr^{-1})



1064 nm Attenuated Backscatter (km^{-1} sr^{-1})

Lidar Data Products*

Level 1 (geolocated and calibrated)

- DP 1.1 - profiles of attenuated lidar backscatter (532, $532_{\perp}$, 1064 nm)
- DP 1.2 – IR radiances (8.65, 10.6, 12.05 μm)
- DP 1.3 – Visible radiances (650 nm) (WFC)

Level 2

- DP 2.1A – Cloud/Aerosol layer product
  - layer base and top heights, layer-integrated properties
- DP 2.1B – Aerosol profile product
  - backscatter, extinction, depolarization profiles
- DP 2.1C – Cloud profile product
  - backscatter, extinction, depolarization, ice/water content profiles
- DP 2.1D – Vertical Feature mask
  - cloud/aerosol locations
- Also: products from IIR + CALIOP + WFC: cloud $T_B(\lambda)$, emissivity, r_e

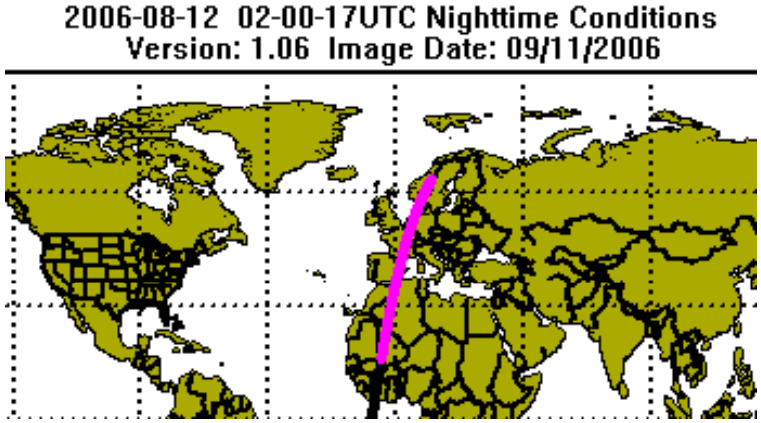
Level 3

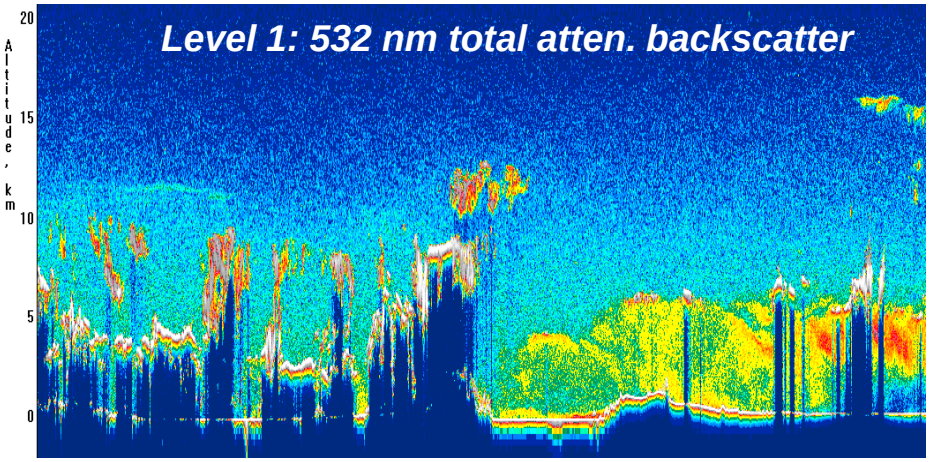
- Summary statistics on a global grid

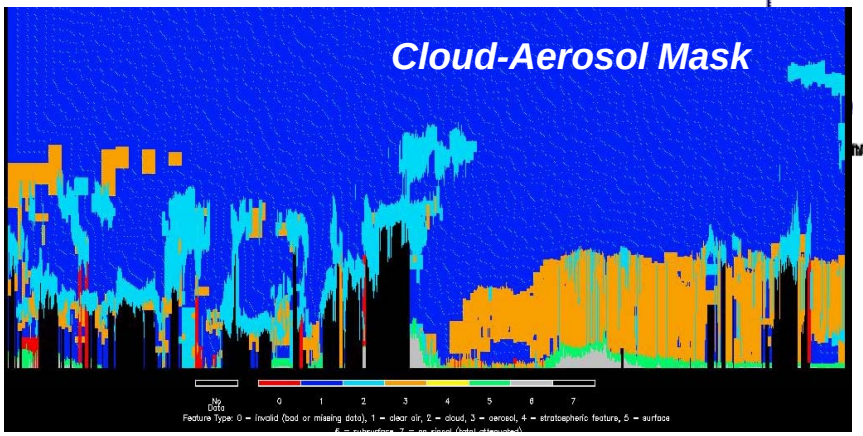
*Initial data release (Dec 8)

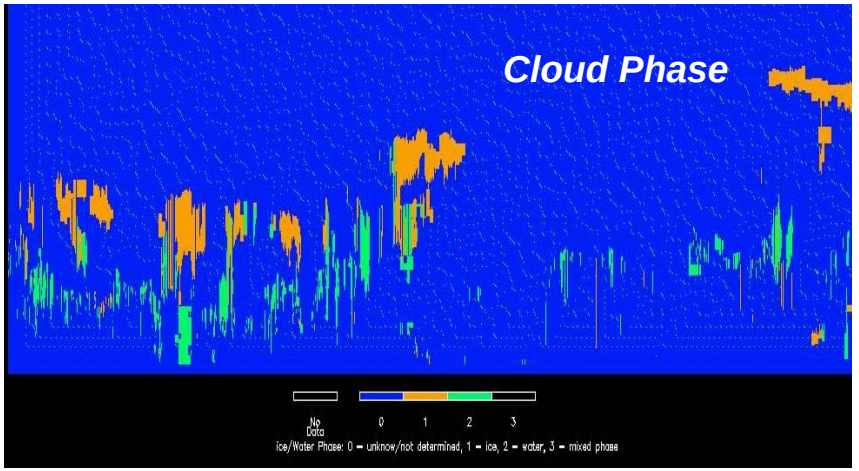
(available at http://eosweb.larc.nasa.gov)

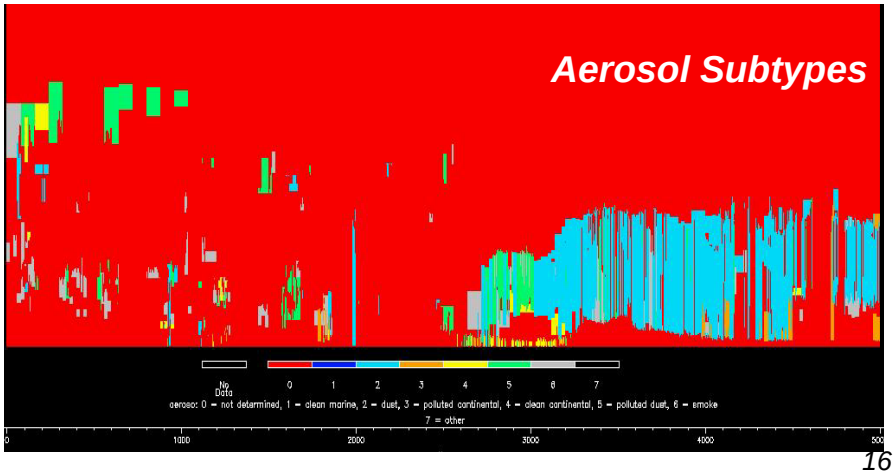
CALIPSO Data Products







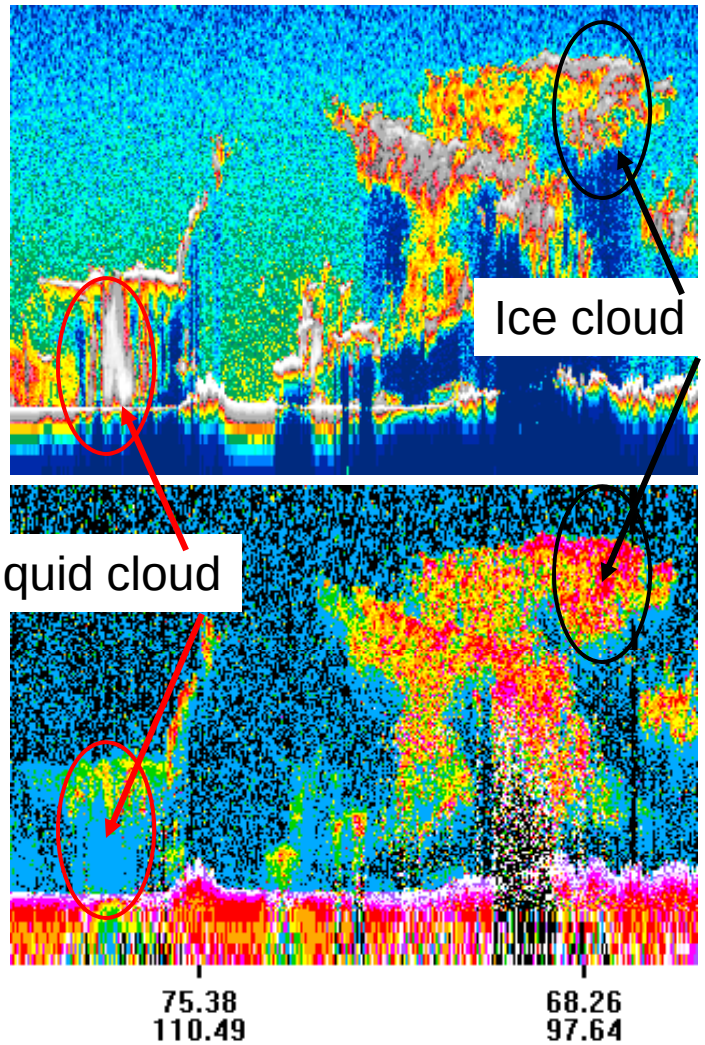




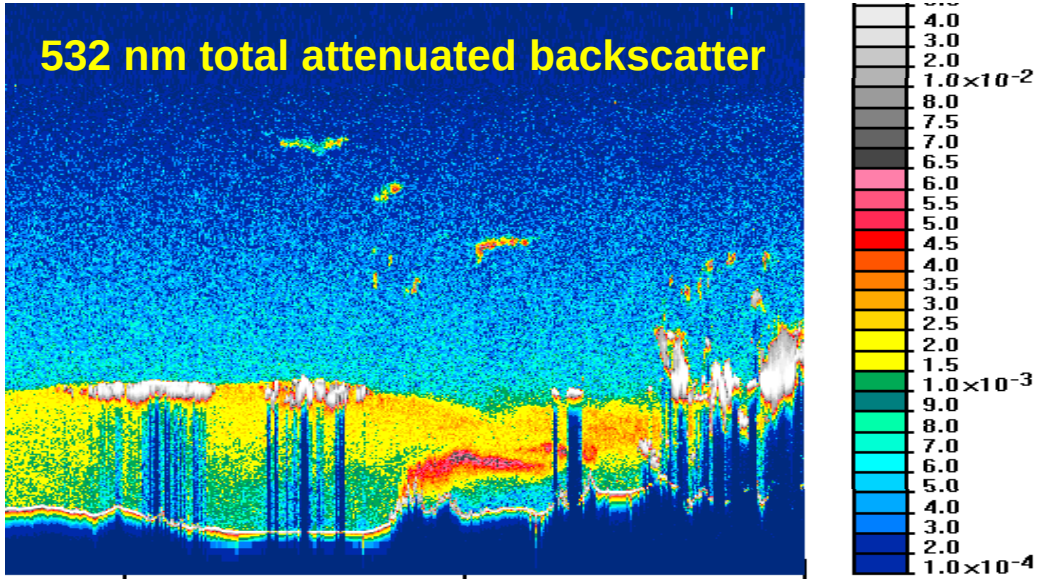
Information from Depolarization

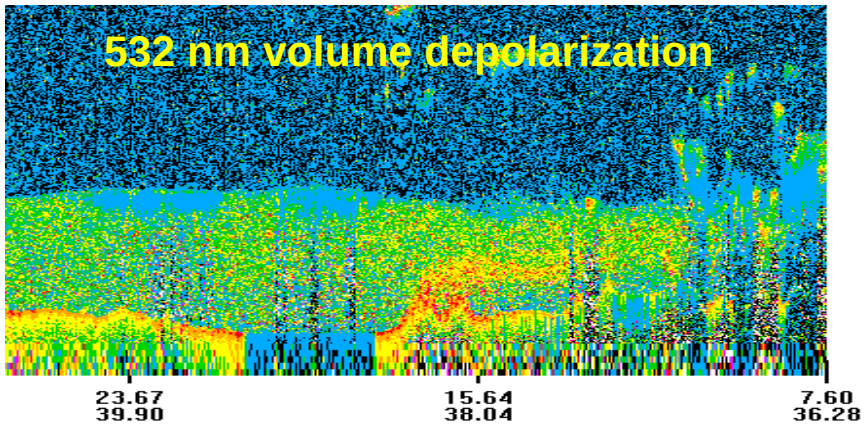
Arctic clouds

identification of water, and both random and oriented ice crystals



Sahara dust with embedded water clouds





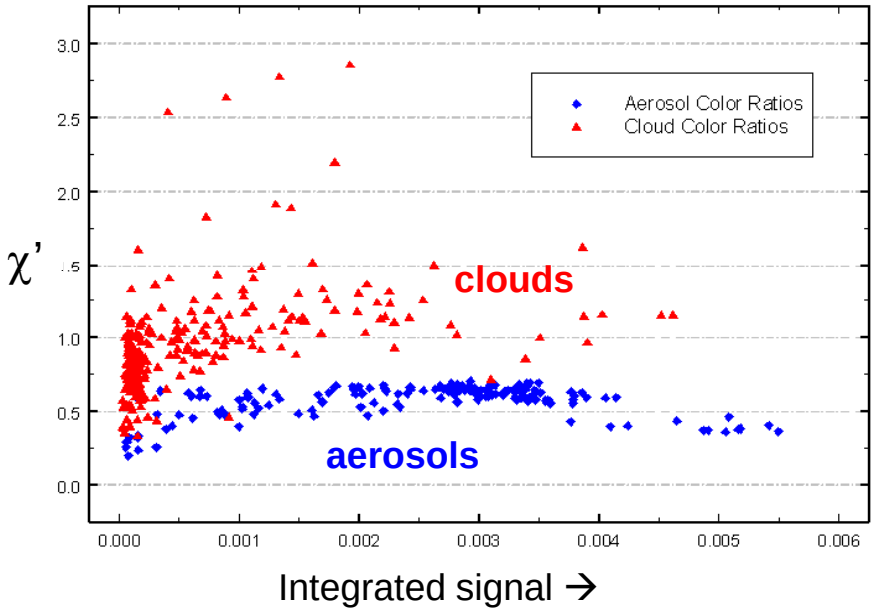
2-λ Cloud-Aerosol Discrimination

2-wavelength comparisons allow unambiguous discrimination of small aerosols from large cloud particles.

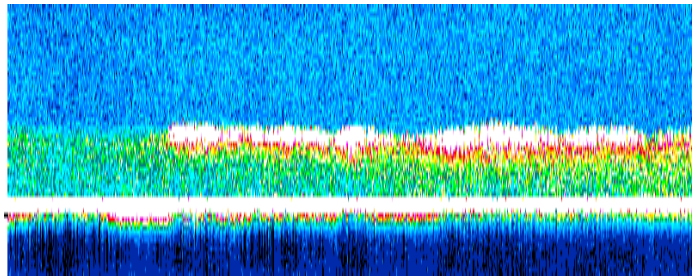
- **Cloud and aerosol can often be separated by scattering strength. But aerosol and cloud cannot be unambiguously discriminated using a single wavelength.**

- **Errors lead to biases in aerosol optical depth, and aerosol forcing.**

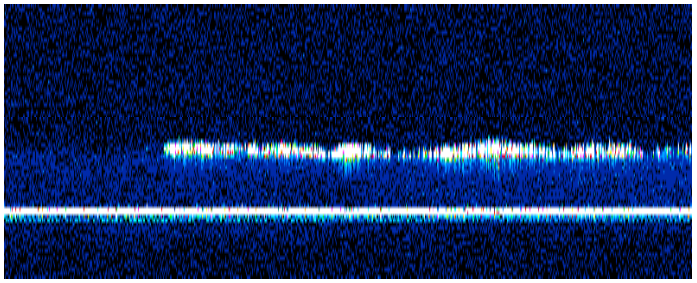
Separation of cloud and aerosol using $\chi' = \beta'_{1064}/\beta'_{532}$



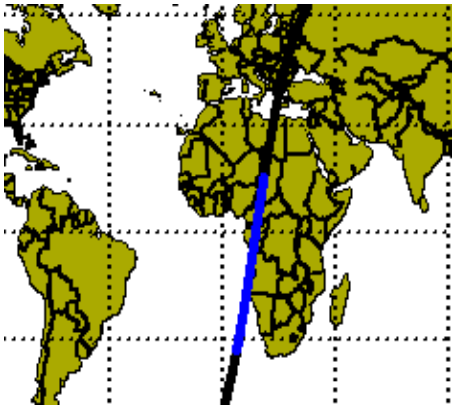
532 nm

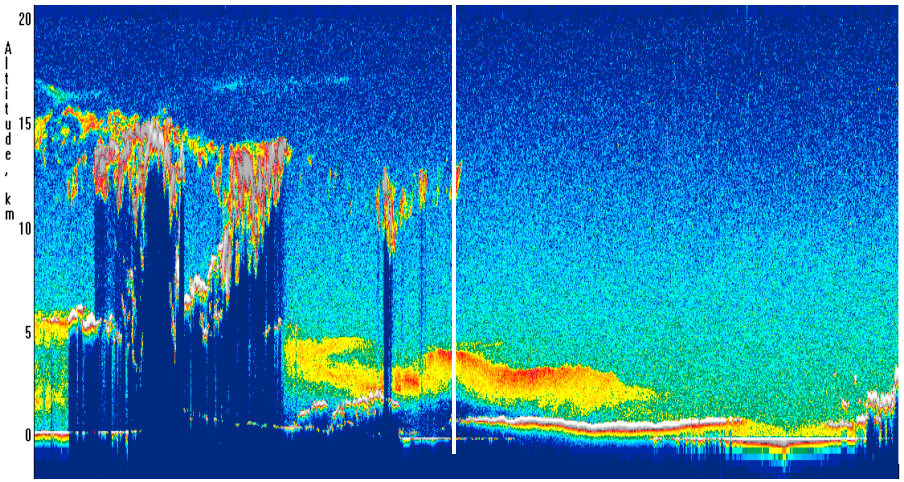


1064 nm

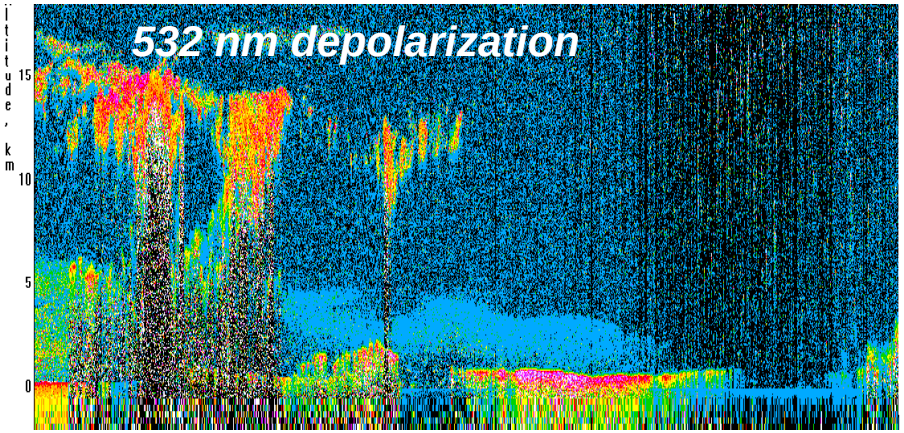


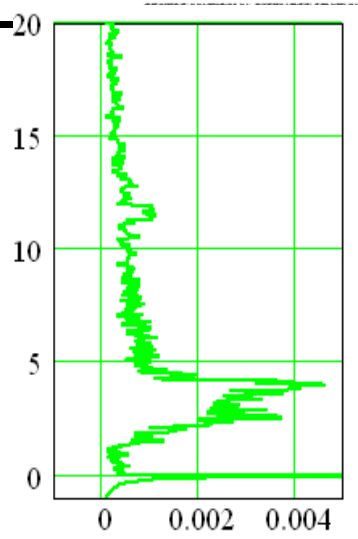
Impacts of smoke above cloud



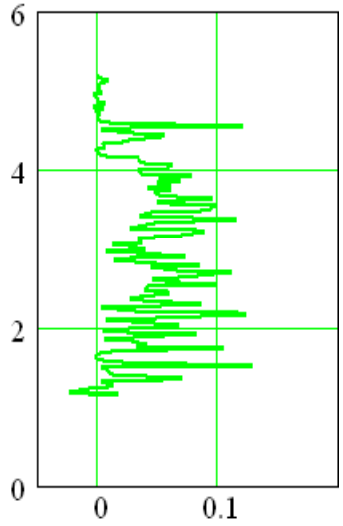


Observations on 10 August 2006





Attenuated Backscatter



Depolarization ratio

Retrieved smoke properties

AOD (532) = 0.69

avg depol = 0.04

Heating in smoke layer:

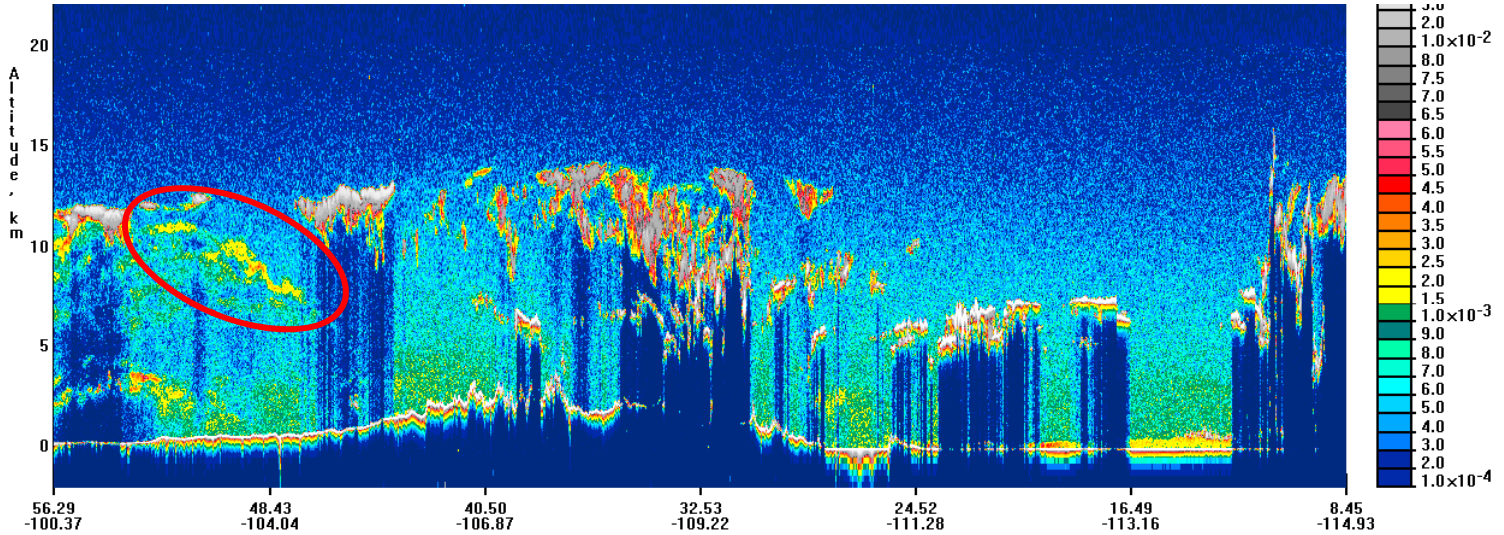
~70 W/m^2 (ω_o = 0.9)

Heating within the smoke layer stabilizes the atmosphere and traps the layer

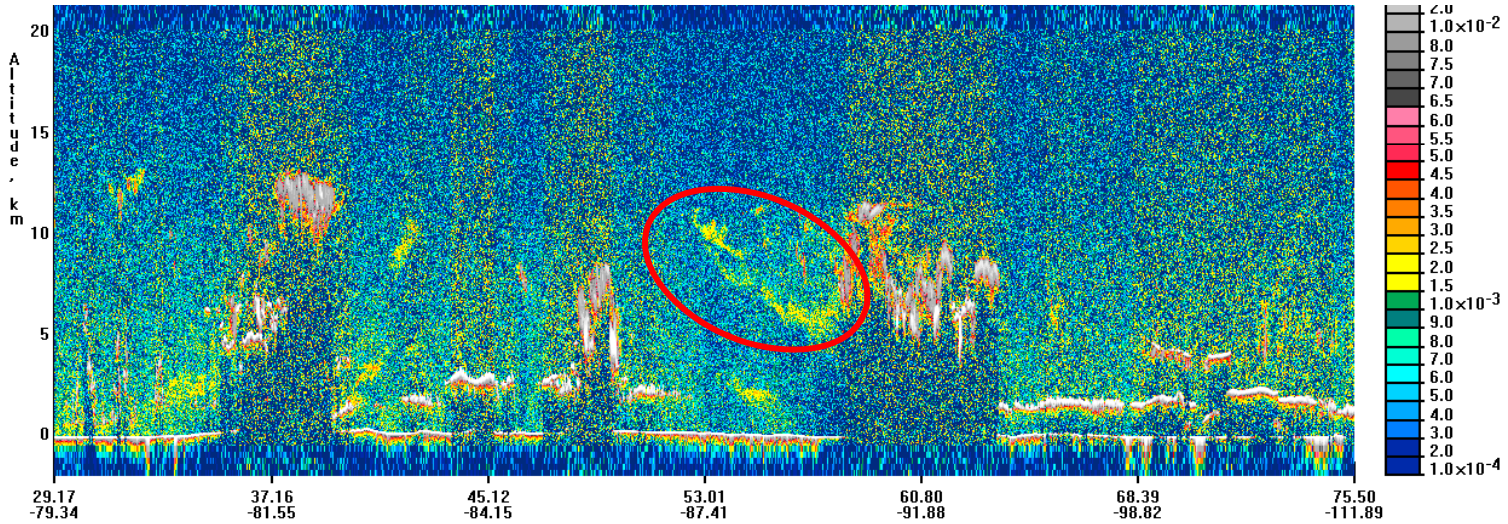
Smoke plumes over Canada – July 5th

CALIPSO observes plume injection height: model initialization, assessment

Night

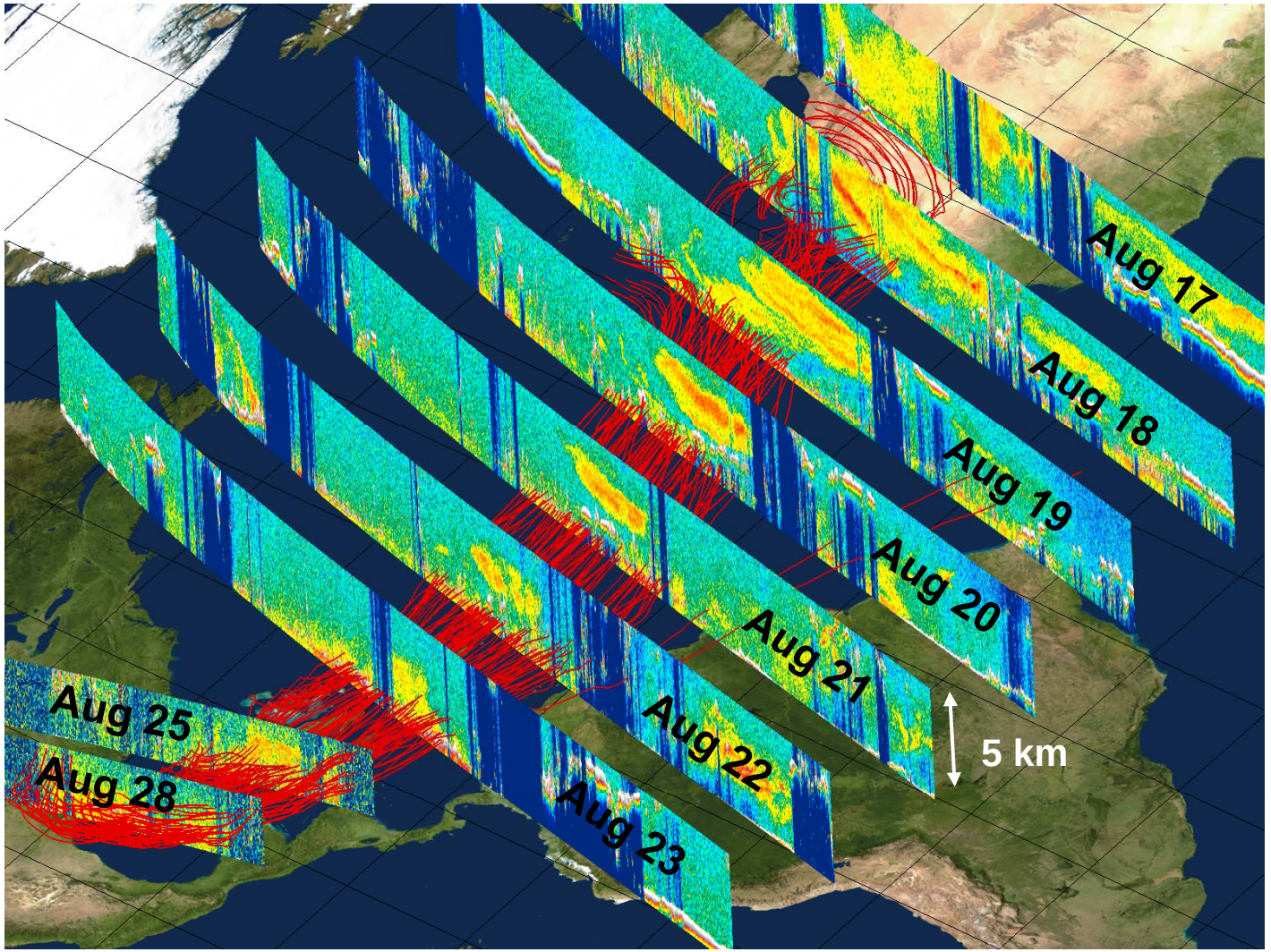


Daytime



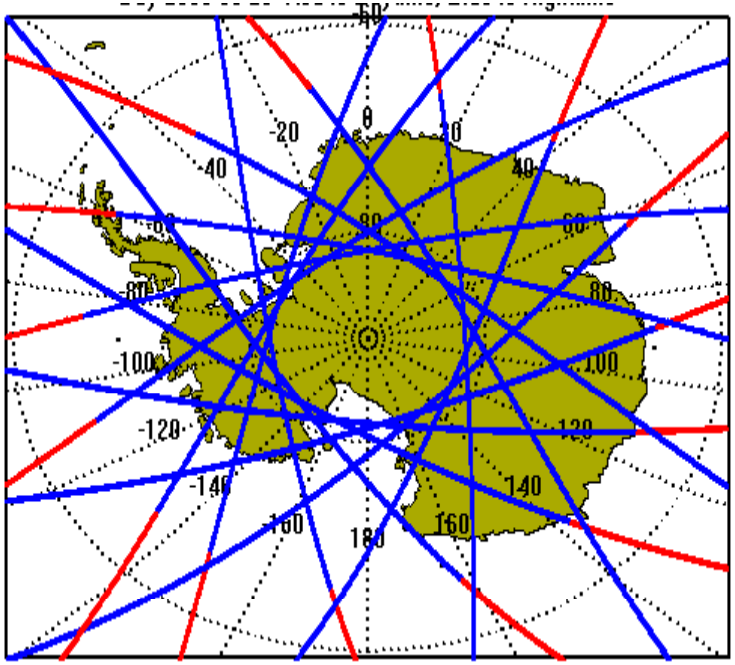
Major Saharan Dust Transport Event: Aug 17-28

CALIPSO can identify aerosol transport pathways and provide data to improve and verify models

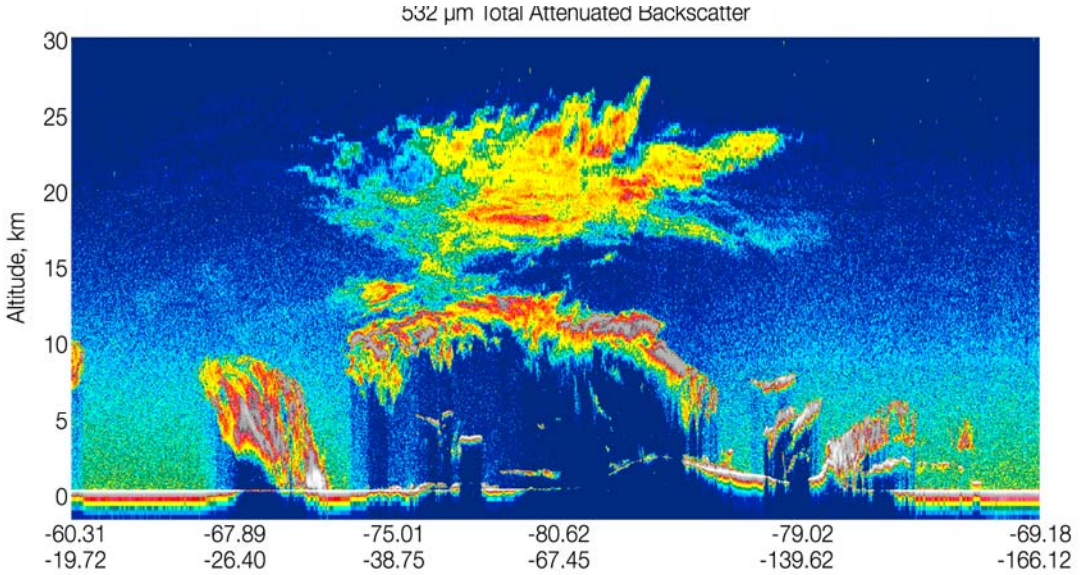


Antarctic Polar Stratospheric Clouds
July 24, 2006

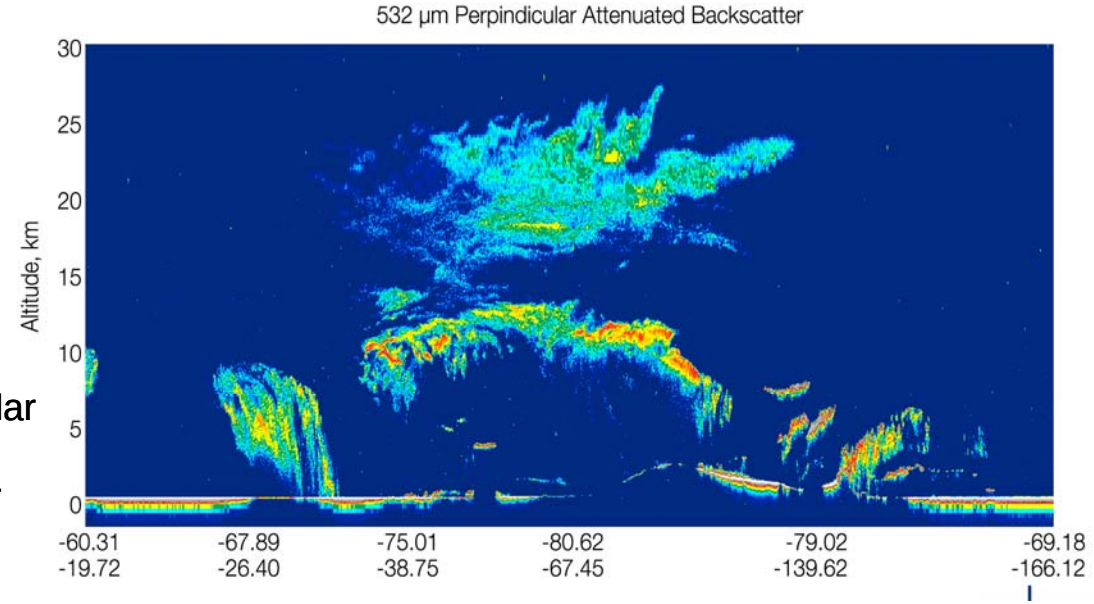
532 nm Total Attenuated Backscatter



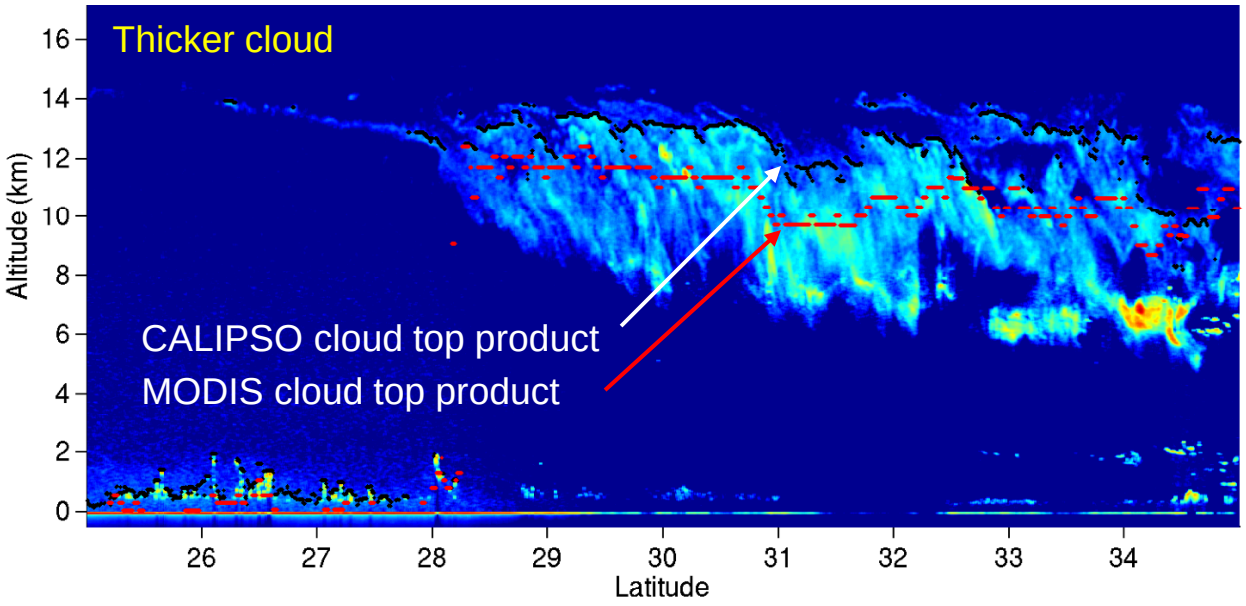
1-day coverage

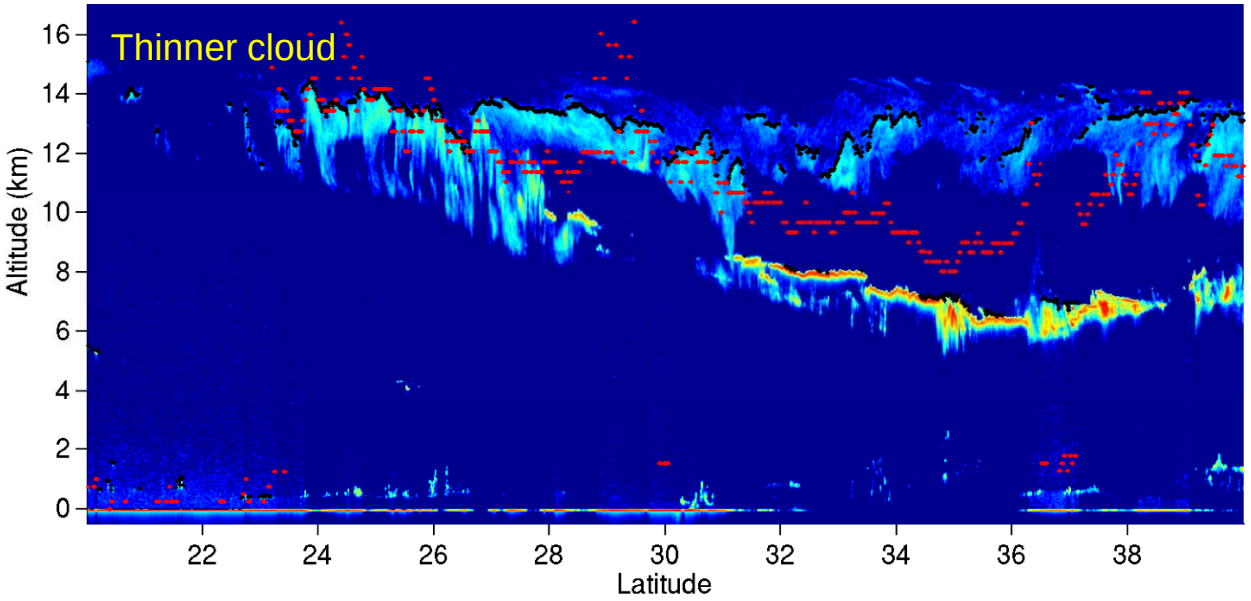


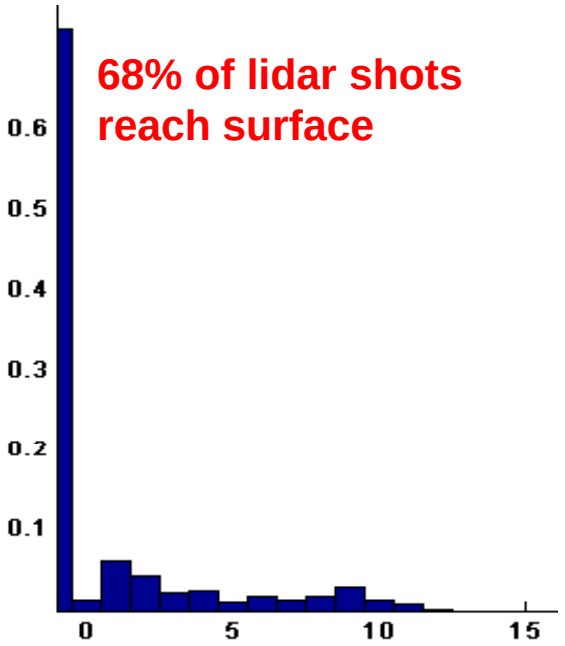
532 nm Perpendicular Attenuated Backscatter



Cloud Top Comparisons
CALIPSO vs. MODIS (June 15, 2006)



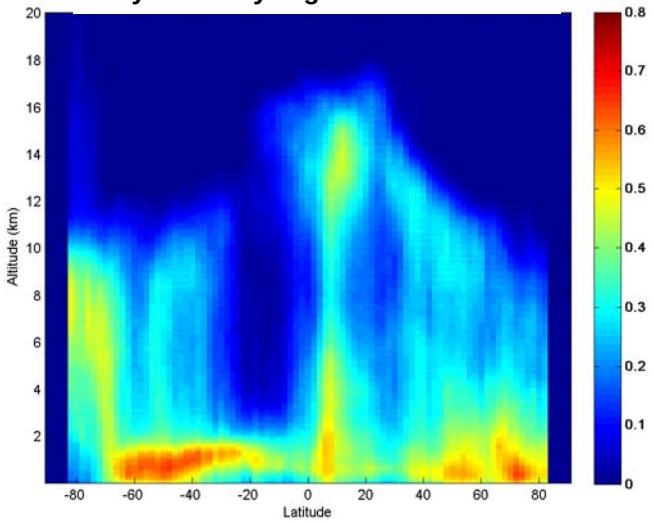




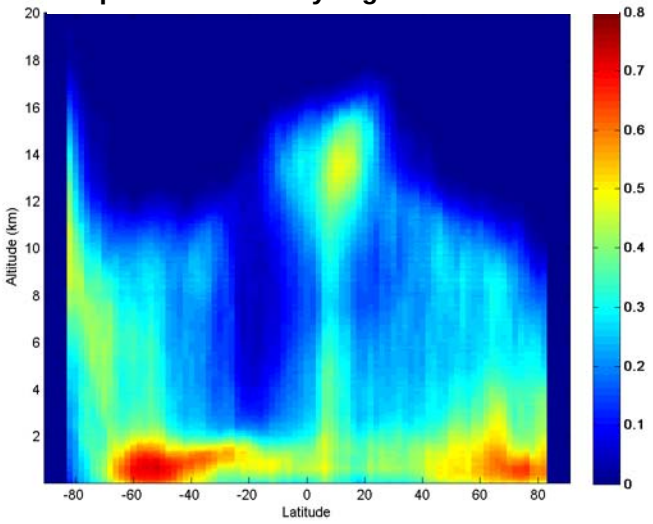
PDF of top height of lowest detected layer

CALIPSO Zonal Cloud Occurrence

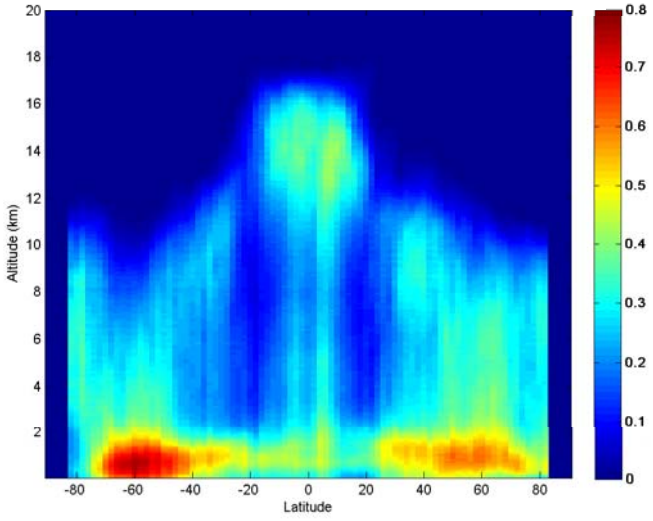
July 2006 Day-Night Cloud Fraction



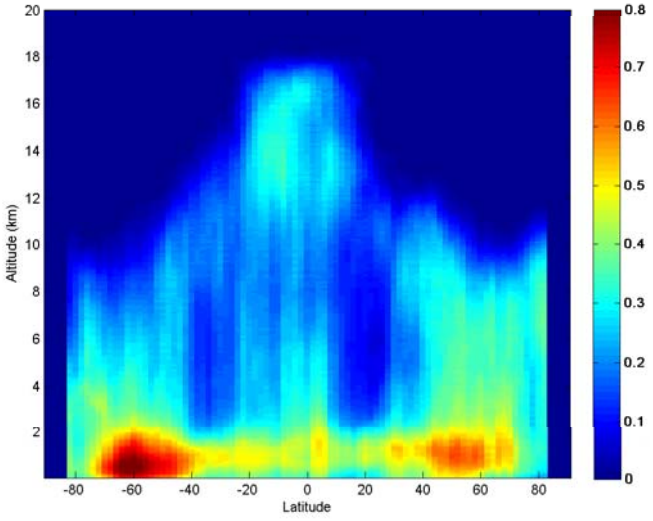
September 2006 Day-Night Cloud Fraction



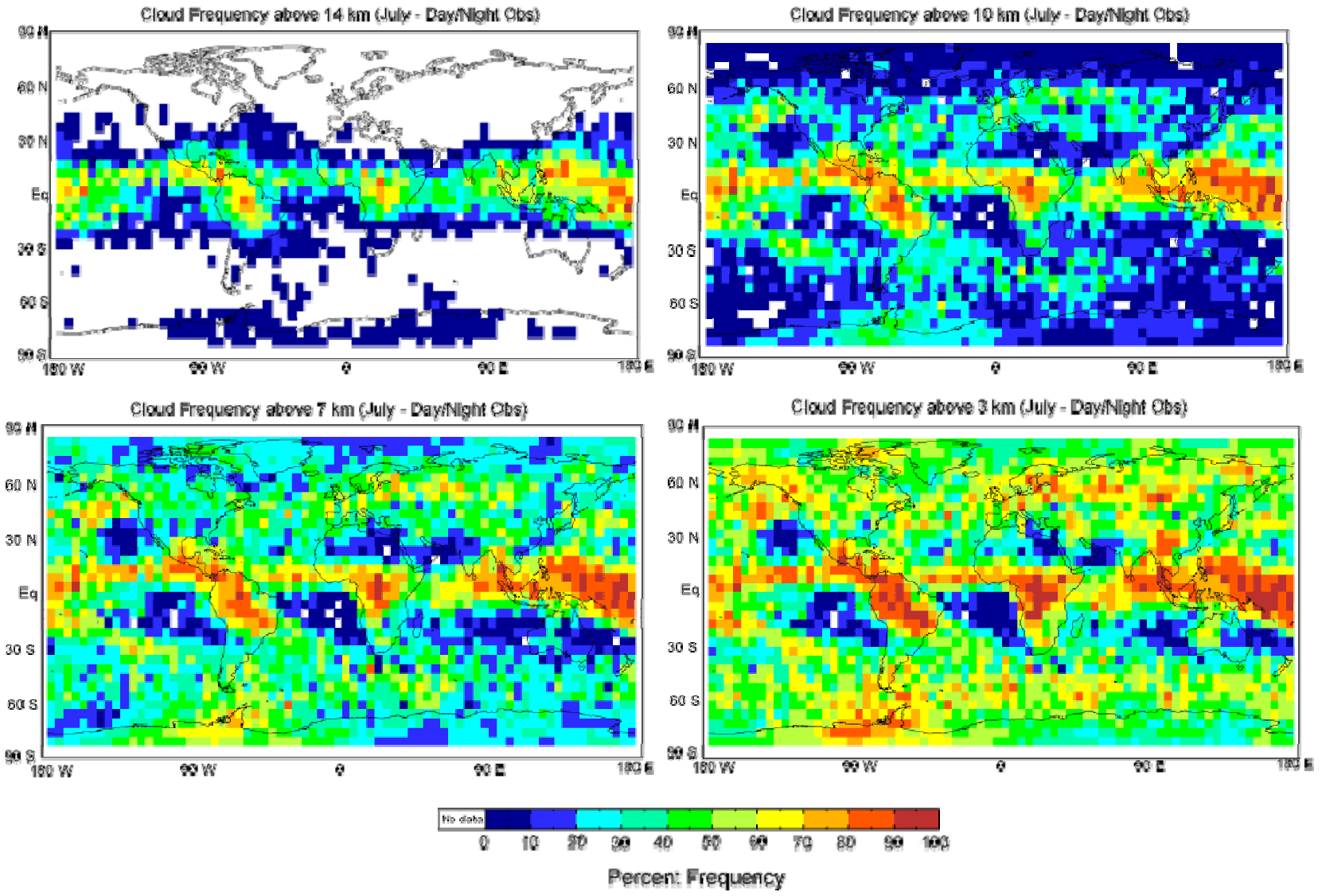
November 2006 Day-Night Cloud Fraction



January 2007 Day-Night Cloud Fraction

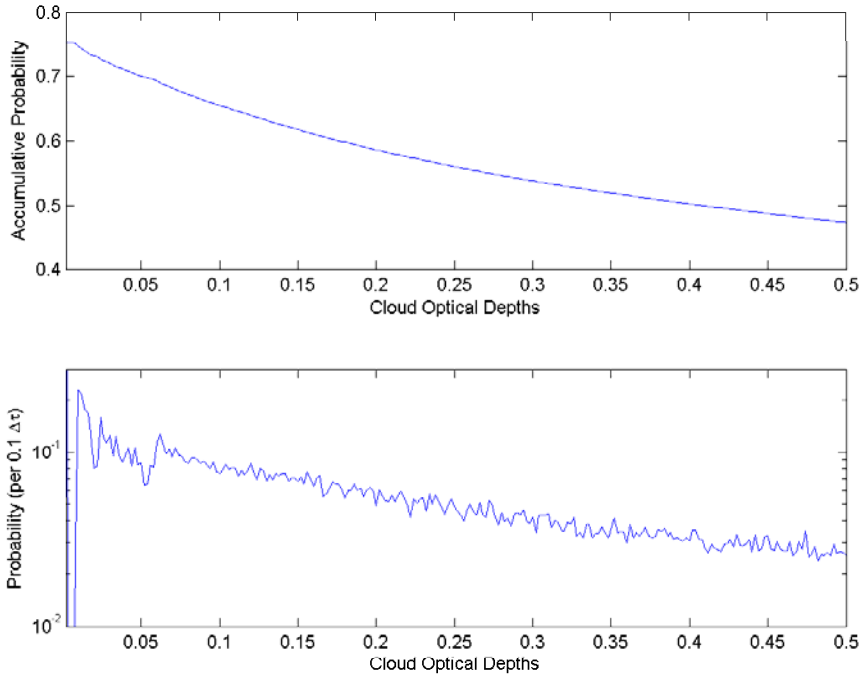


CALIPSO Geographical Cloud Occurrence

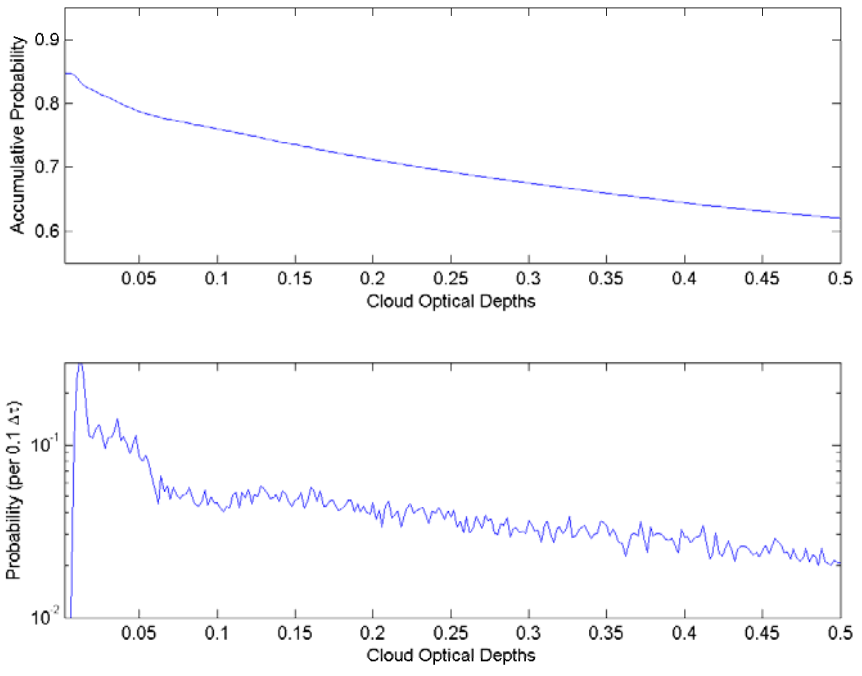


Tropical Subvisible Cirrus
Optical Depth Histograms

Daytime Jan 2007



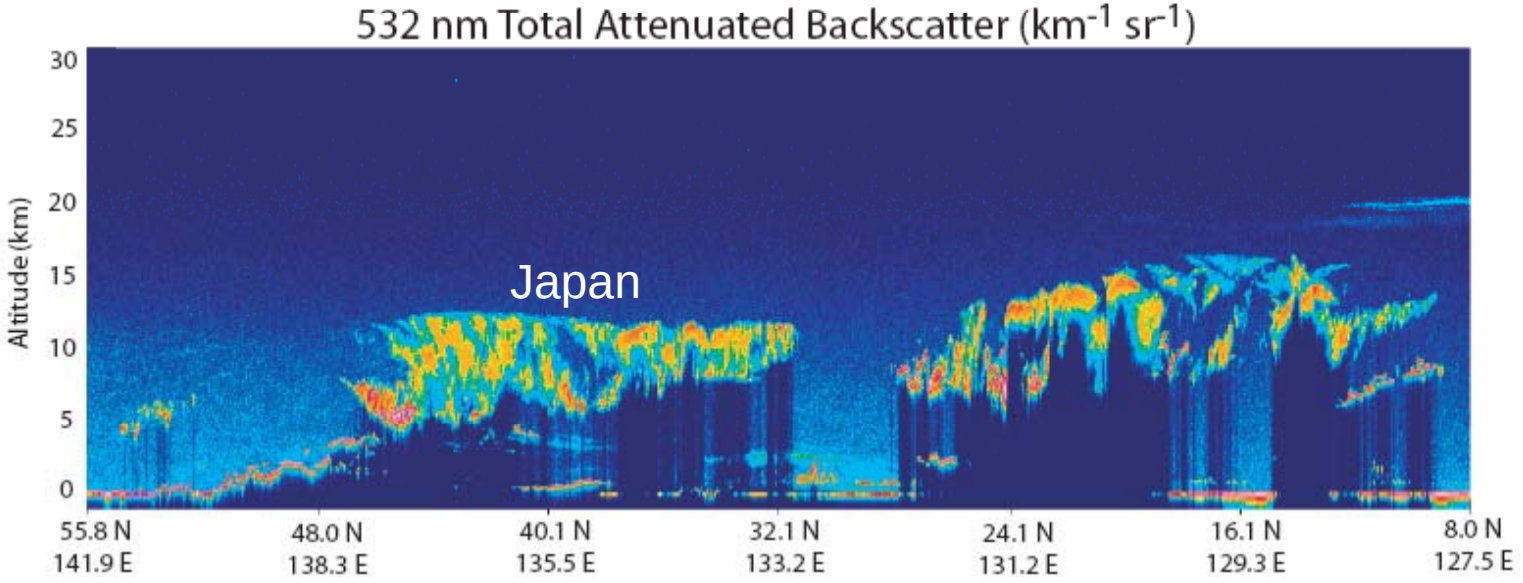
Nighttime Jan 2007



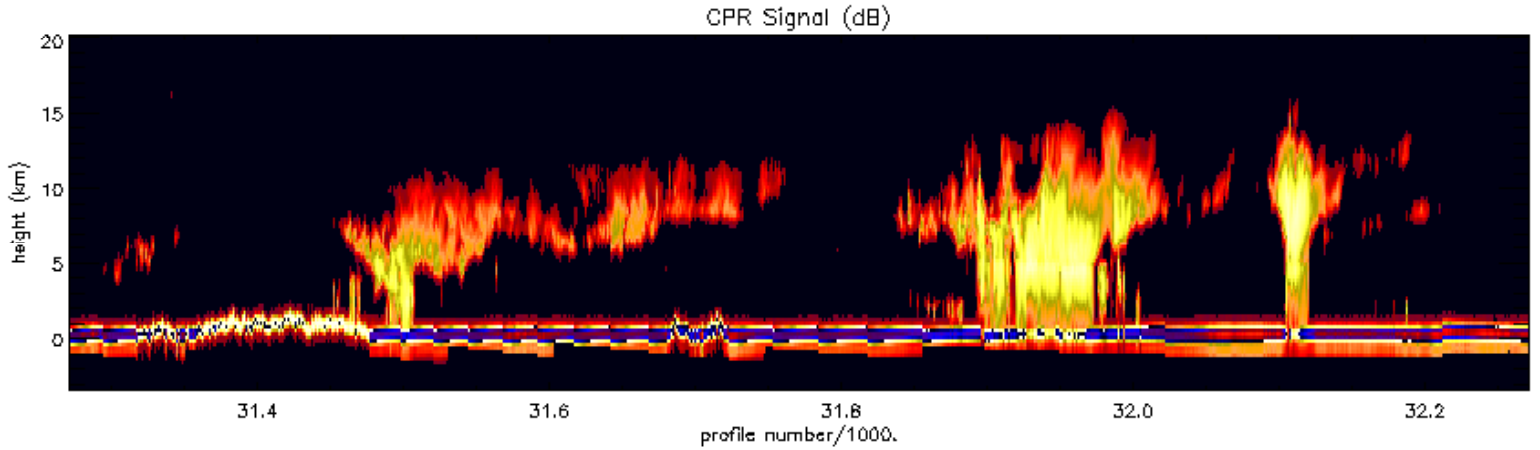
CALIPSO and CloudSat

Observations over the Western Pacific

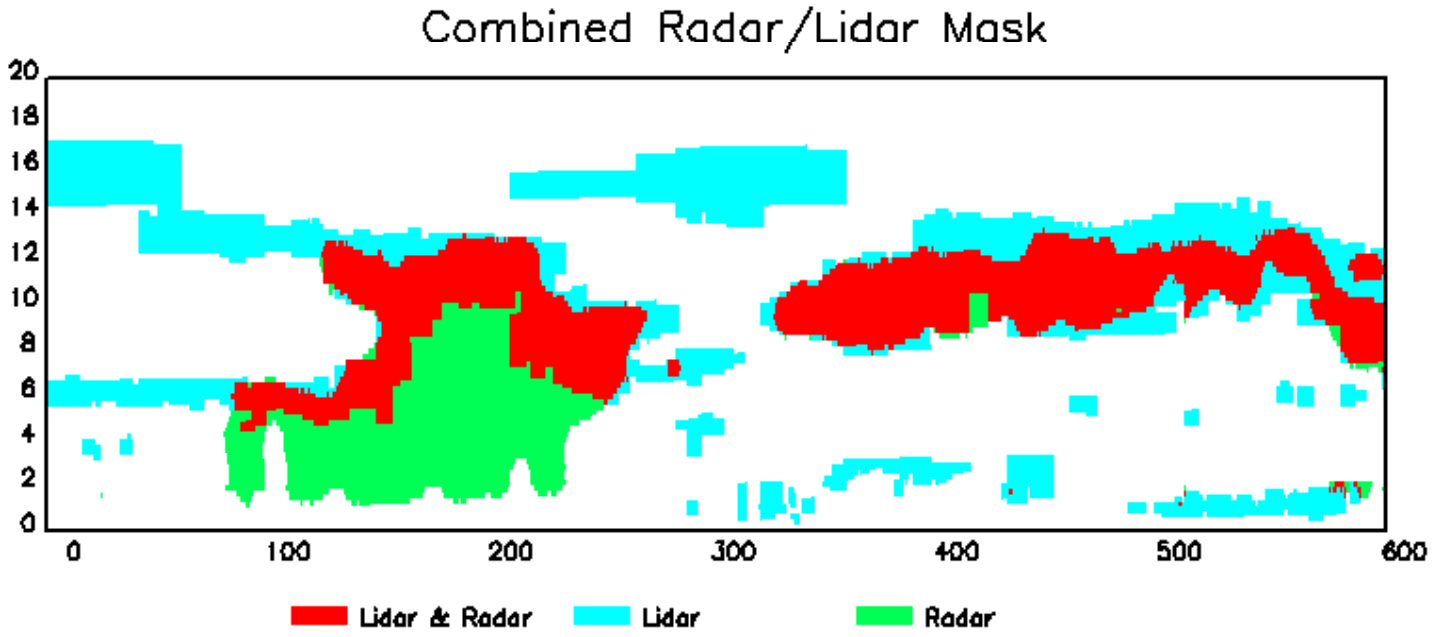
CALIPSO (532 nm)



CloudSat



CloudSat/CALIPSO Joint Cloud Mask



Produced by CloudSat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A cast of hundreds at NASA LaRC, CNES (Toulouse), Ball Aerospace (Boulder), SODERN (Paris), Alcatel (Cannes), and NASA GSFC
www-calipso.larc.nasa.gov