CALIPSO

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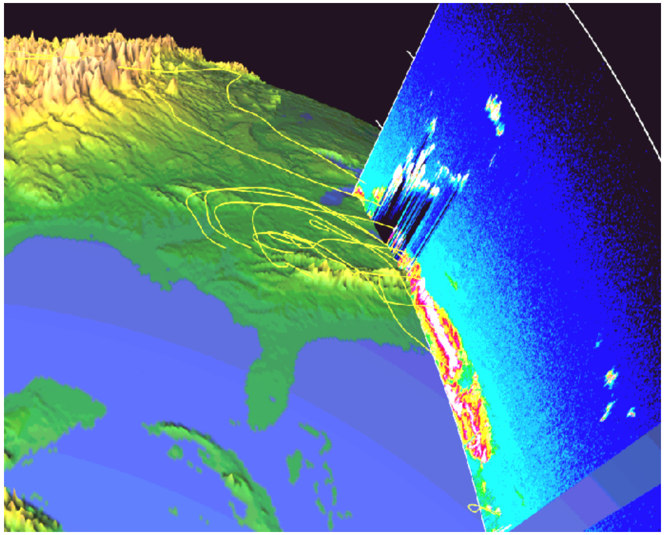
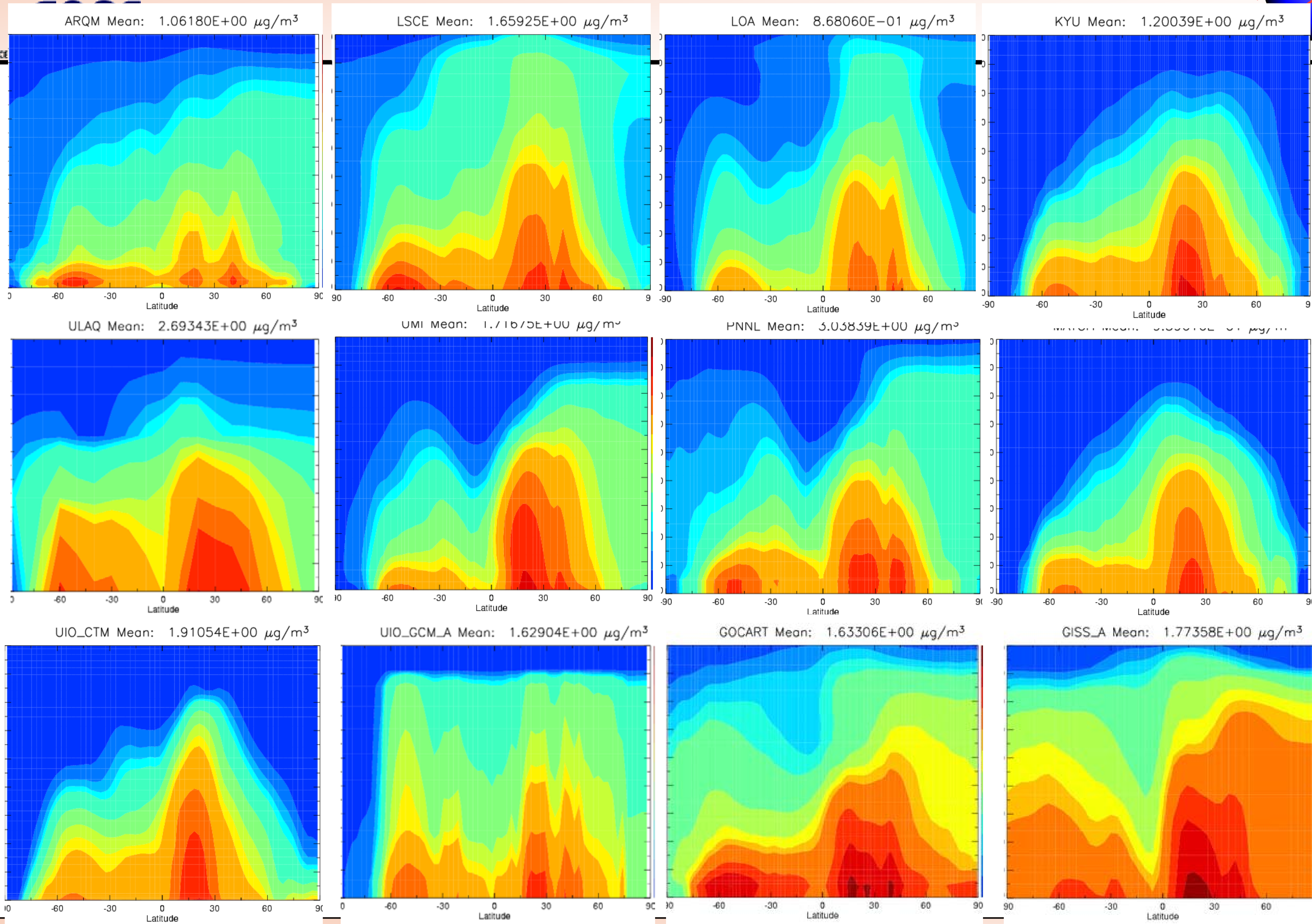
CALIPSO Mission Objectives

CALIPSO will fly as part of the Aqua constellation (A-train) to provide observations needed to:

- **Improve understanding of the role of aerosols and clouds in the processes that govern climate responses and feedbacks**
  - **Direct and indirect aerosol effects**
  - **Cloud forcing and feedbacks**



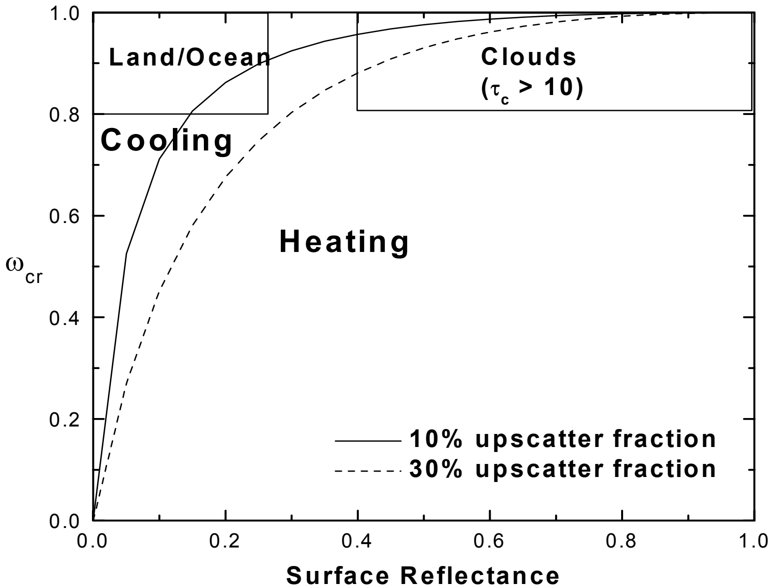
- Improve the representation of aerosols and clouds in models
  - Improved climate predictions
  - Improved models of atmospheric chemistry

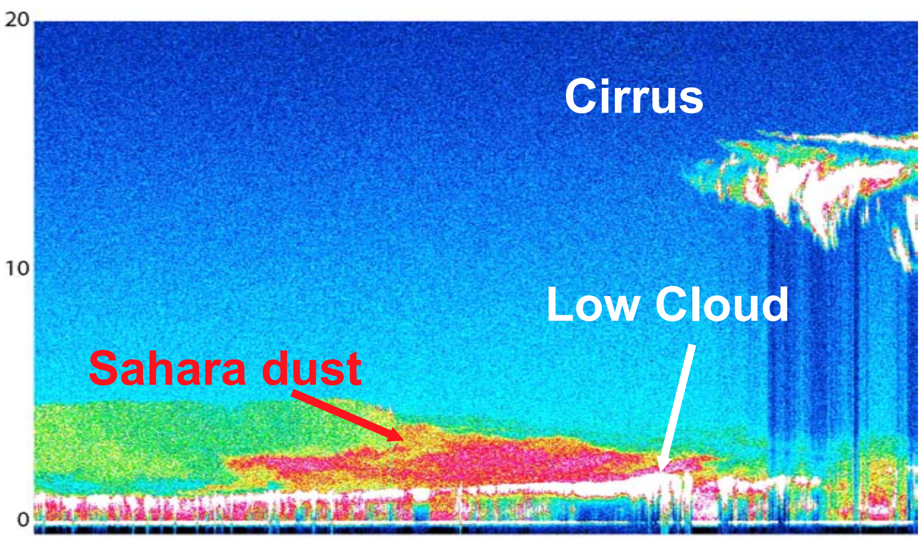

ARQM Mean: 1.06180E+00 μg/m³
LSCE Mean: 1.65925E+00 μg/m³
LOA Mean: 8.68060E−01 μg/m³
KYU Mean: 1.20039E+00 μg/m³
ULAQ Mean: 2.69343E+00 μg/m³
UMI Mean: 1.71675E+00 μg/m³
PNNL Mean: 3.03839E+00 μg/m³
UIO_CTM Mean: 1.91054E+00 μg/m³
UIO_GCM_A Mean: 1.62904E+00 μg/m³
GOCART Mean: 1.63306E+00 μg/m³
GISS_A Mean: 1.77358E+00 μg/m³
Latitude

The Vertical: CALIPSO Aerosol

Aerosol Direct Radiative Forcing

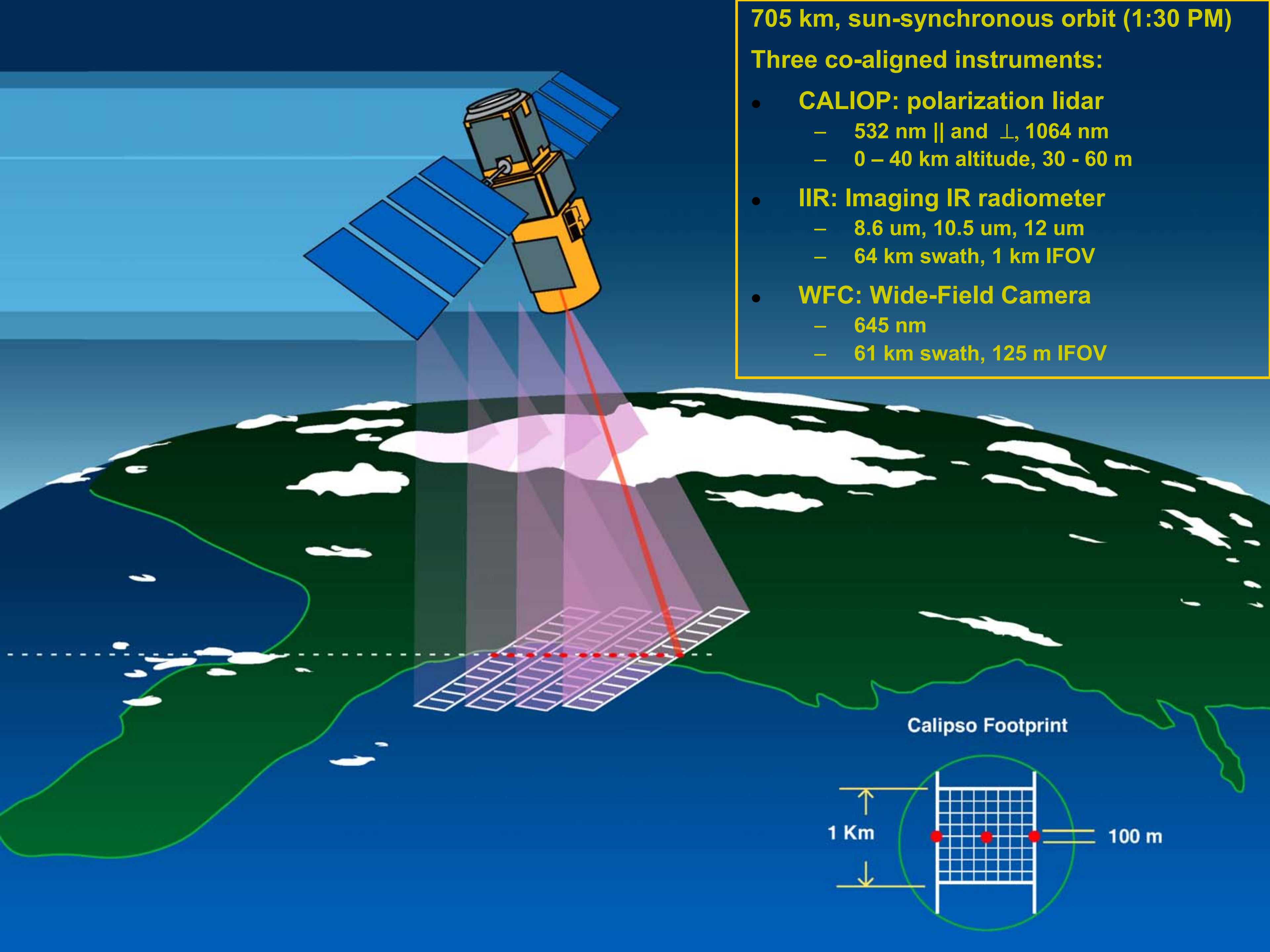
- CALIPSO aerosol profiles
  - aerosol lifetime dependent on height
  - radiative effects depend on underlying reflectance
  - observe aerosol above cloud, below thin cirrus
- A-train: CALIPSO + MODIS + CERES
  - improved characterization of direct forcing

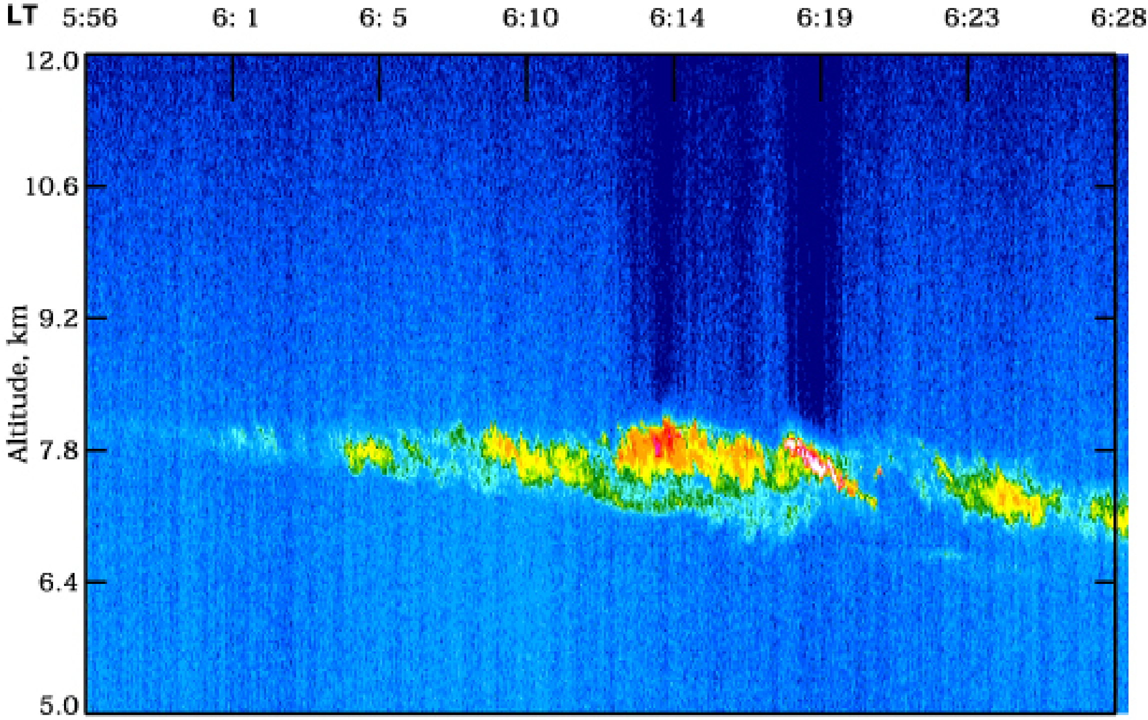




Aerosol Indirect Radiative Forcing

- CALIPSO cloud and aerosol profiles
  - unique ability to determine if cloud and aerosol are in the same layer.
- A-train: add MODIS + CERES
  - cloud microphysics, optics, radiation
- A-train: add AMSR, Cloudsat radar
  - adds LWP plus drizzle.


705 km, sun-synchronous orbit (1:30 PM)
Three co-aligned instruments:
• CALIOP: polarization lidar
– 532 nm || and ⊥, 1064 nm
– 0 – 40 km altitude, 30 - 60 m
• IIR: Imaging IR radiometer
– 8.6 um, 10.5 um, 12 um
– 64 km swath, 1 km IFOV
• WFC: Wide-Field Camera
– 645 nm
– 61 km swath, 125 m IFOV
Calipso Footprint
1 Km
100 m



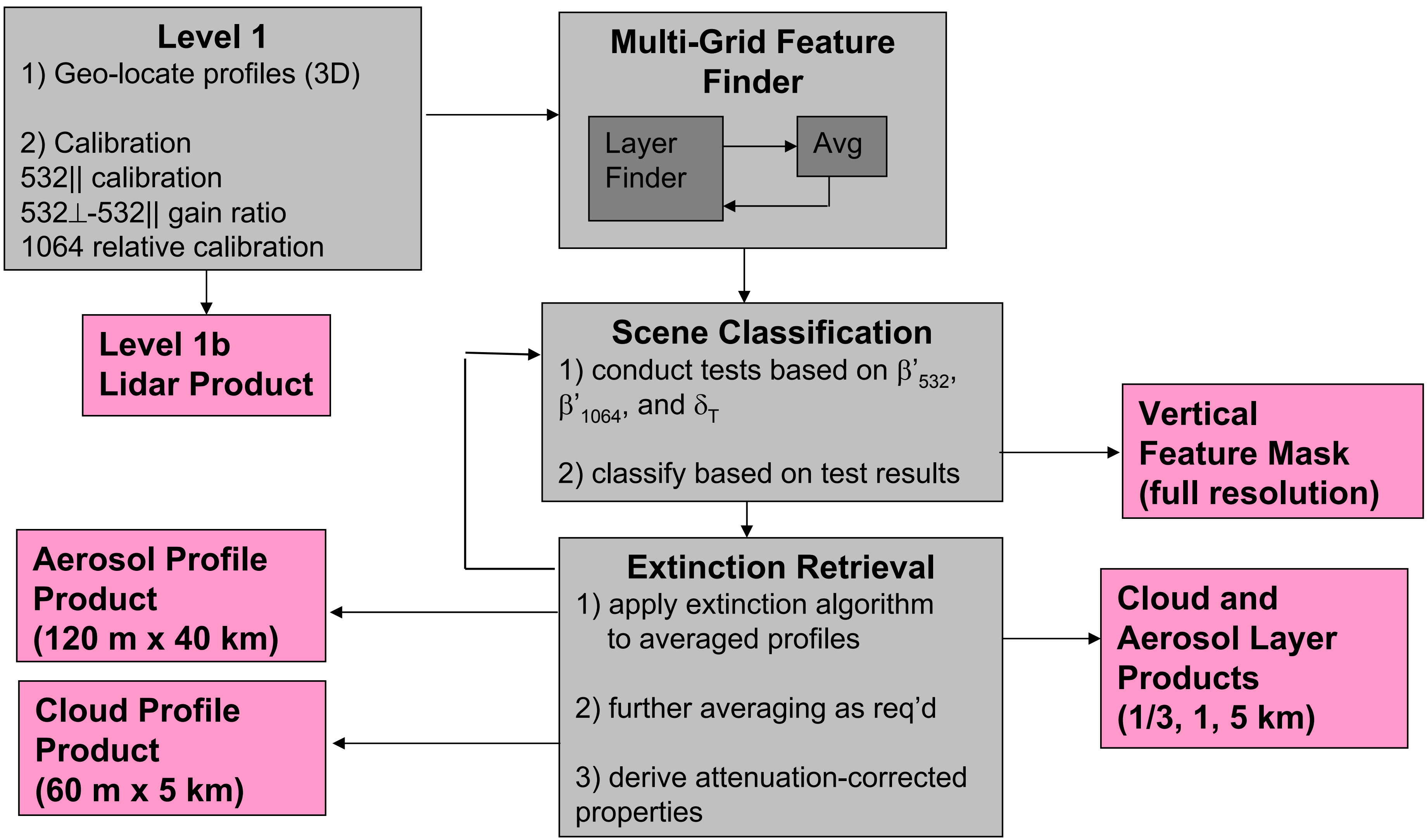
Cirrus Cloud Data - 12/08/03

Launch readiness: 26 May 2005

1st light: July '05

Release of β-data: fall '05

Lidar Algorithm Flow



Lidar Data Products

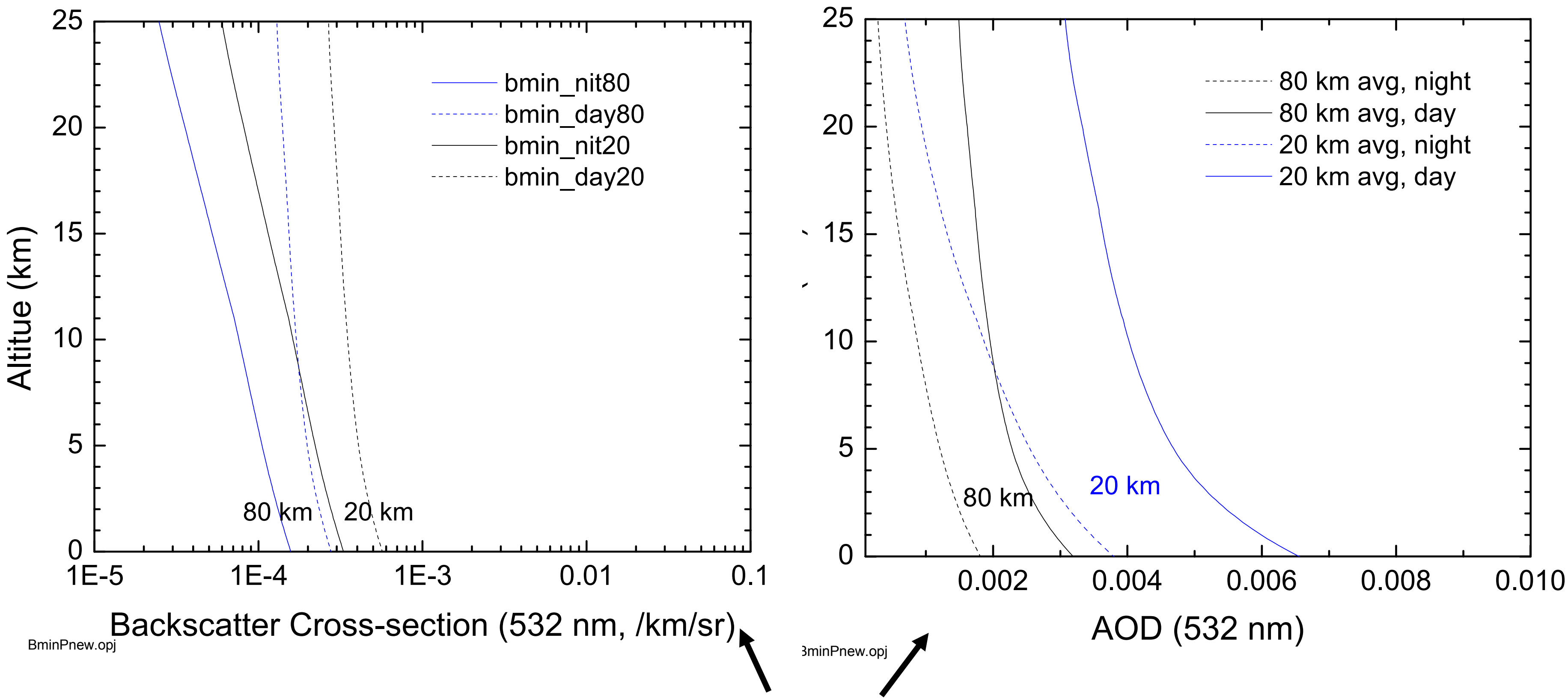
Data Product	Product Name	Primary Parameters	Maximum Altitude	Resolution	
				vertical	horizontal
DP 1.1	Level 1B Profiles	$532_{\perp+\parallel}$, $532_{\perp}$, 1064 attenuated backscatter	40 km	Full Resolution	
DP 2.1A	Cloud and Aerosol Layer Product	Cloud: base and top height, optical depth, I/W phase, IWP Aerosol: base and top height, optical depth, avg depolarization and color ratio, aerosol type	20 km 30 km	30 m 30 m	1/3, 1, 5 km 5 km
DP 2.1B	Aerosol Profile Product	532/1064 nm backscatter, extinction, depolarization	30 km	120 m	40 km
DP 2.1C	Cloud Profile Product	532 nm backscatter, extinction, depolarization, IWC	20 km	60 m	5 km
DP 2.1D	Vertical Feature Mask	cloud mask, ice/water phase aerosol mask, type	20 km	Full Resolution	

Layer Detection Sensitivity

β_m = minimum Detectable β_a

β_m converted to AOD

Dz = 500m, Sa = 23 (clean marine aerosol)

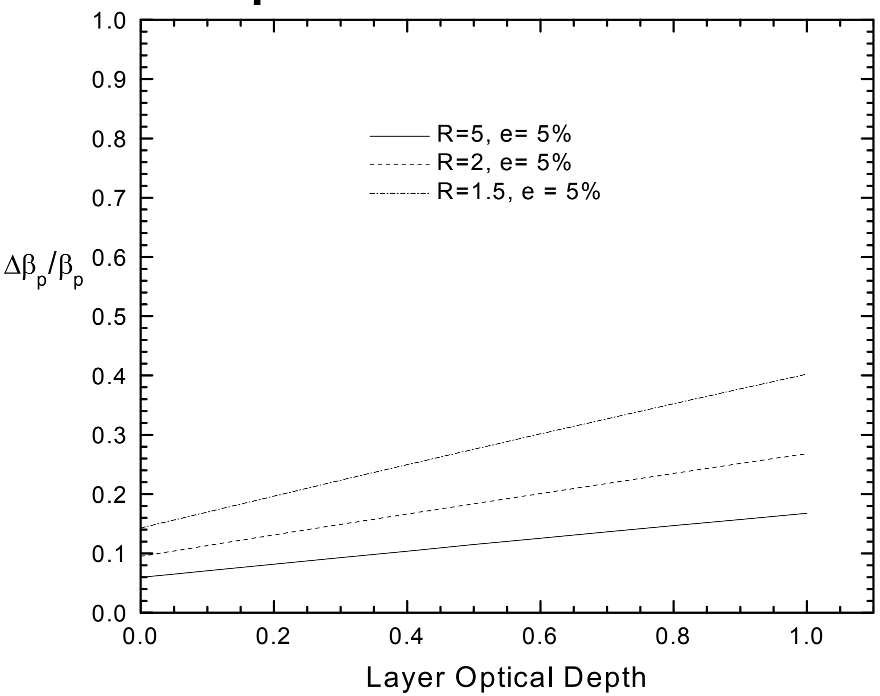


Note scale change

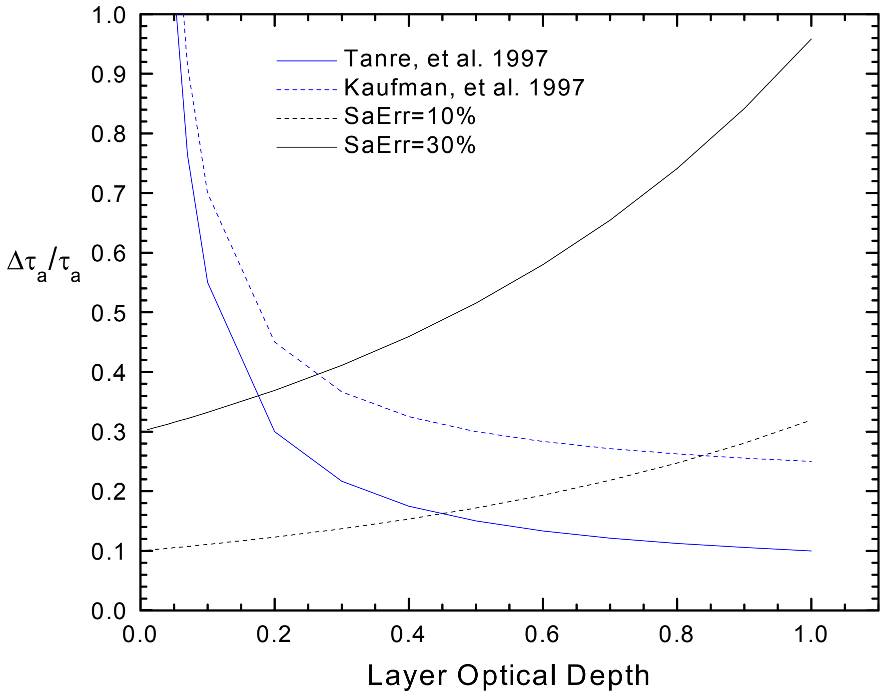
Aerosol Retrievals: MODIS vs. CALIOP

- Uncertainties in τ_a are due to S_a (mostly) and calibration (slightly)
  - Calibrate to ~2%
  - Constrain S_a to ~30%
- lidar excels at low optical depth: $\tau < 0.2$
  - complements passive capabilities

Impact of calibration error

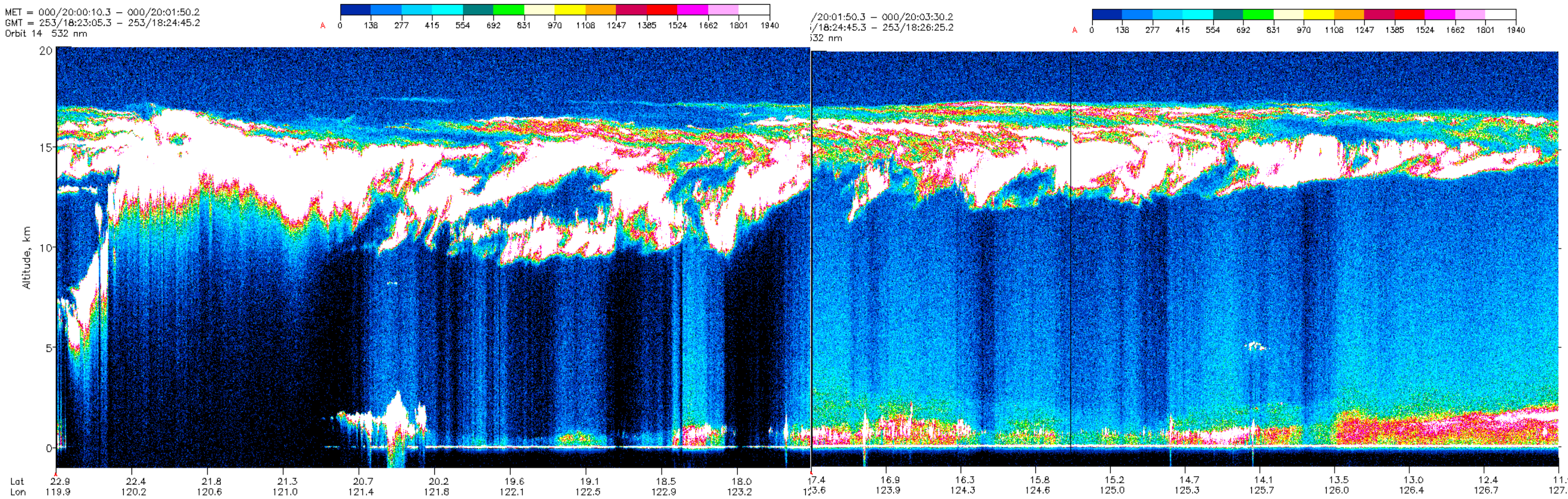


Impact of error in S_a

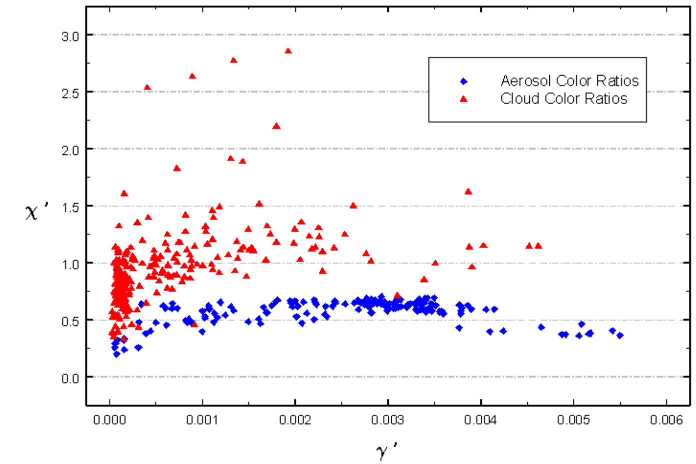


Deep cirrus layer, 20°N, western Pacific

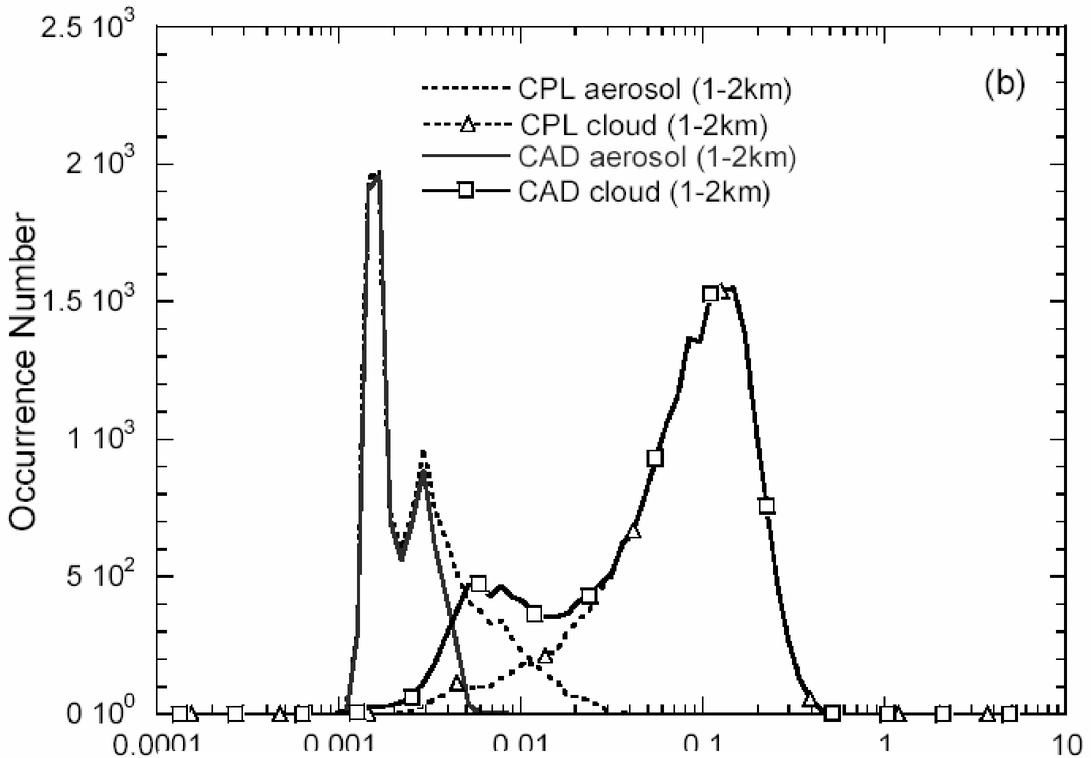
~ 1000 km



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

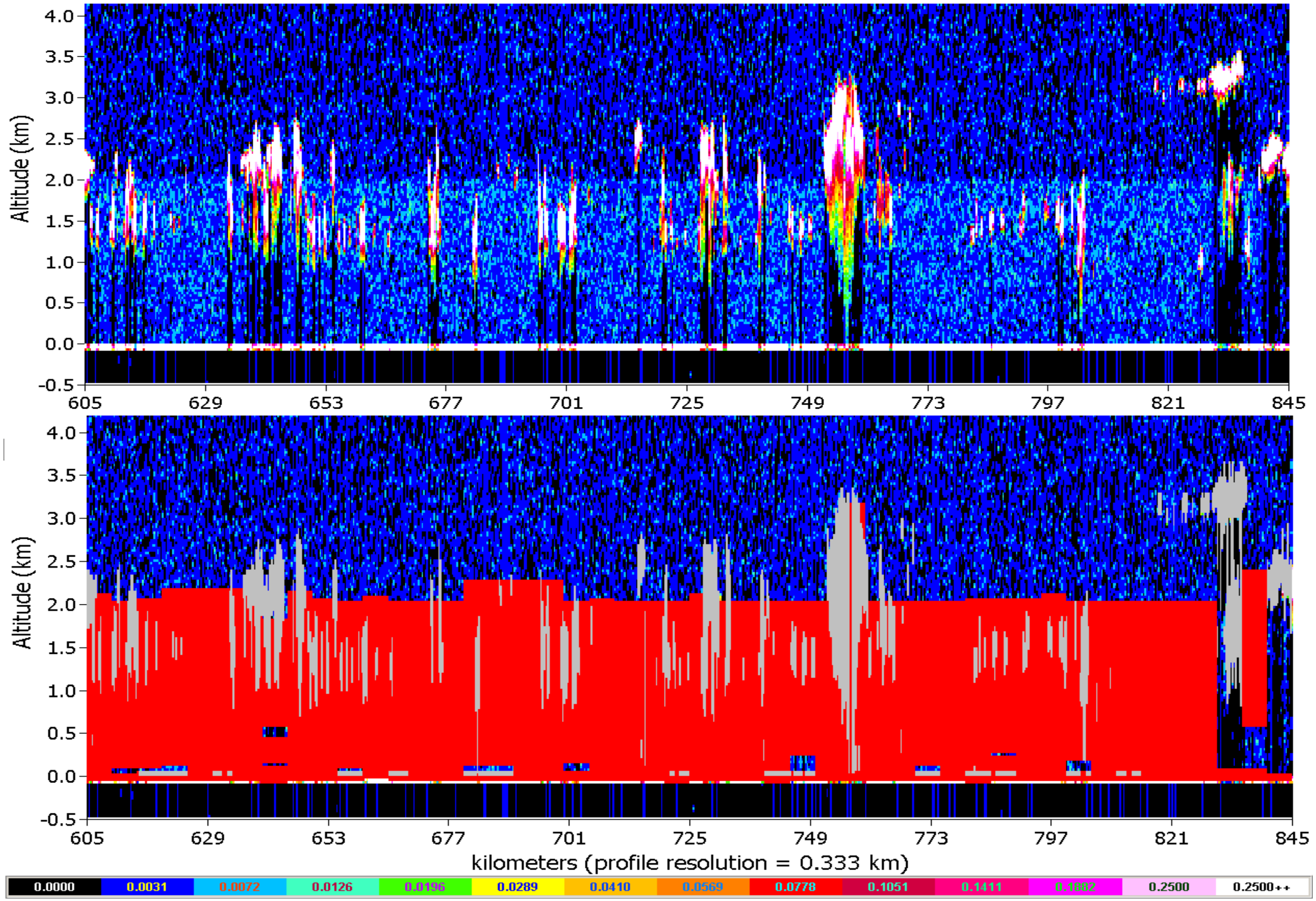


- The CALIPSO 2-λ algorithm (CAD) correctly identifies cloud and aerosol (note overlap).
- A 1-λ algorithm (CPL) misidentifies some cloud as aerosol, resulting in:
  - Biases in aerosol direct forcing
  - Ambiguities in assessing indirect forcing

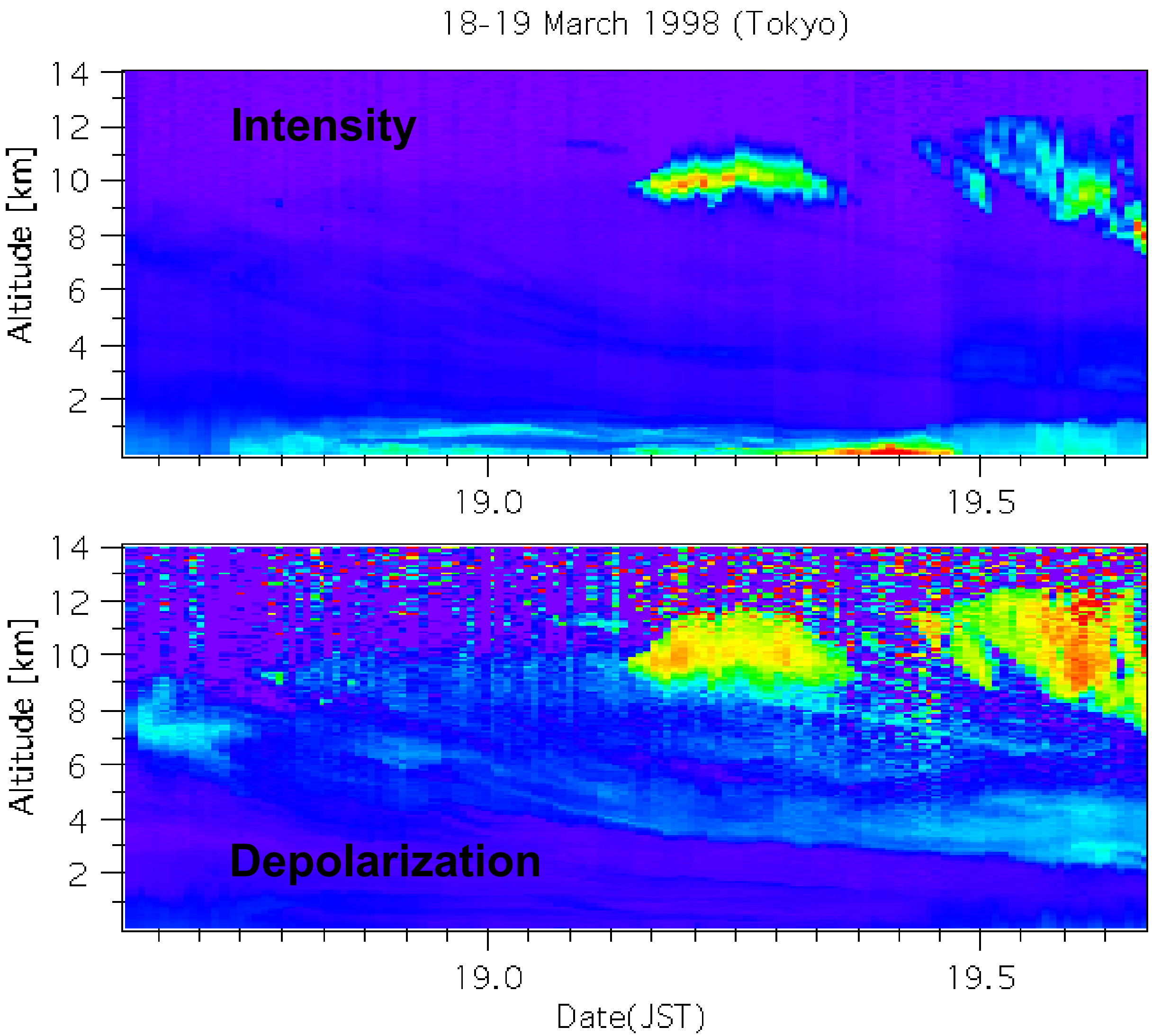


To a large degree, cloud and aerosol can be separated by scattering strength. There is a region of overlap, however, where 2-λ measurements are necessary. It is just this region which is critical to determining biases in aerosol direct forcing, to aerosol indirect forcing, and to aerosol-cloud interactions,

Boundary Layer Cloud Clearing



Aerosol sphericity profiles

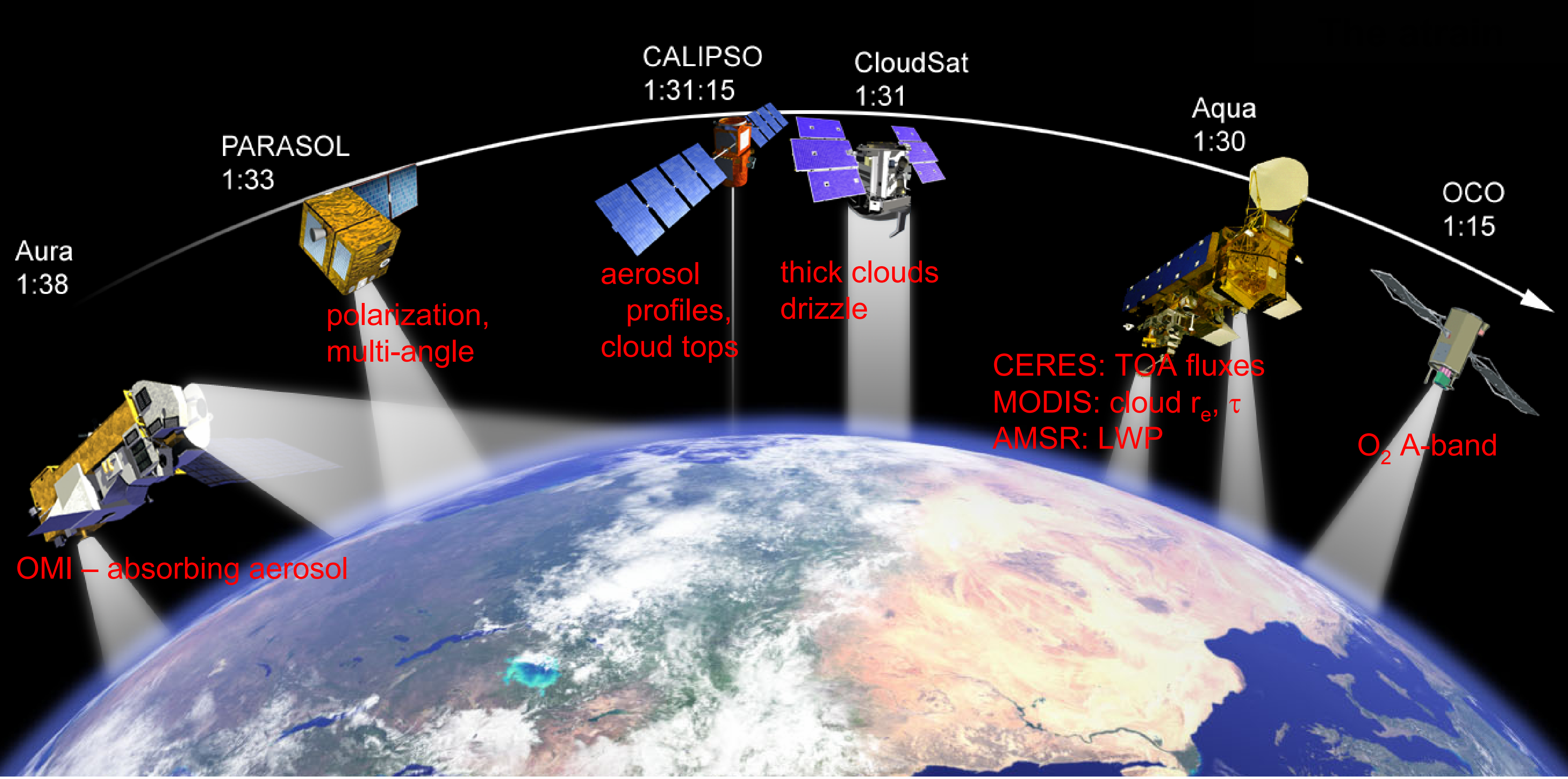


CALIPSO depolarization profiles:
- provide information on aerosol type
-- aid in discrimination of aerosol and cloud

Figure courtesy of T. Murayama

What can CALIPSO provide to AeroCom?

- **Vertical distribution/layering → constraints on transport**
- **Expands AOD available from passive, observations :**
  - **at night, polar regions, under thin cirrus**
- **Greater sensitivity to low AOD → constraints on removal mechanisms**
- **Better cloud masking**
  - **reduction of cloud biases**
  - **assessment of cloud proximity effects**
  - **assessment of biases from "invisible" cirrus**
- **Height, sphericity, size → information related to aerosol type**



Orbit: 705 km, 98° inclination, 1:30 PM equator crossing

A few A-train synergies:

CALIPSO + CloudSat: cloud profile product
CALIPSO + CERES + MODIS: surface radiative fluxes product
CALIPSO + MODIS + OMI + PARASOL + CERES: aerosol direct forcing
add: AMSR + CloudSat (LWP, drizzle): aerosol indirect forcing