Contributions to Air Quality Monitoring from the CALIPSO Lidar

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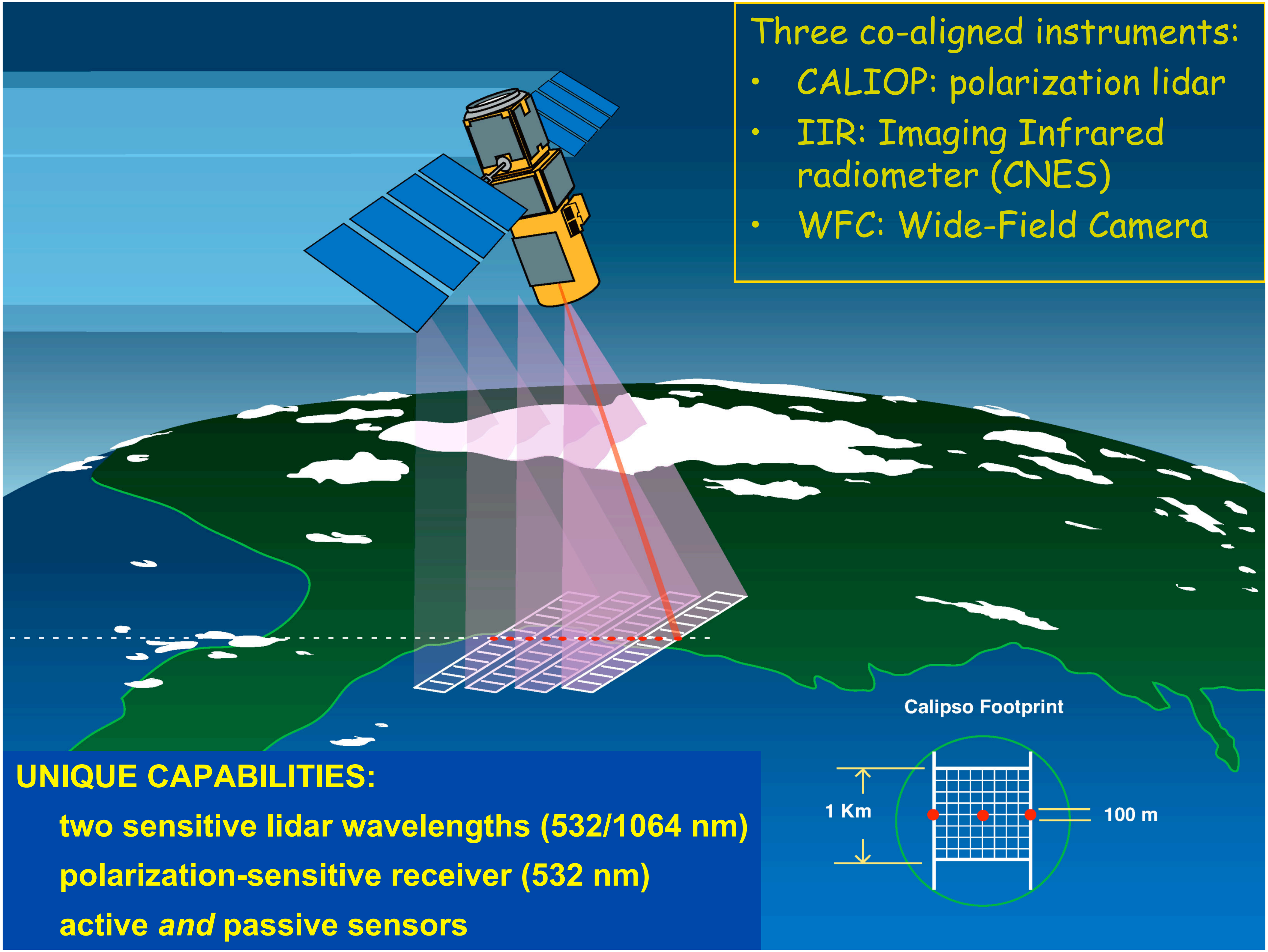
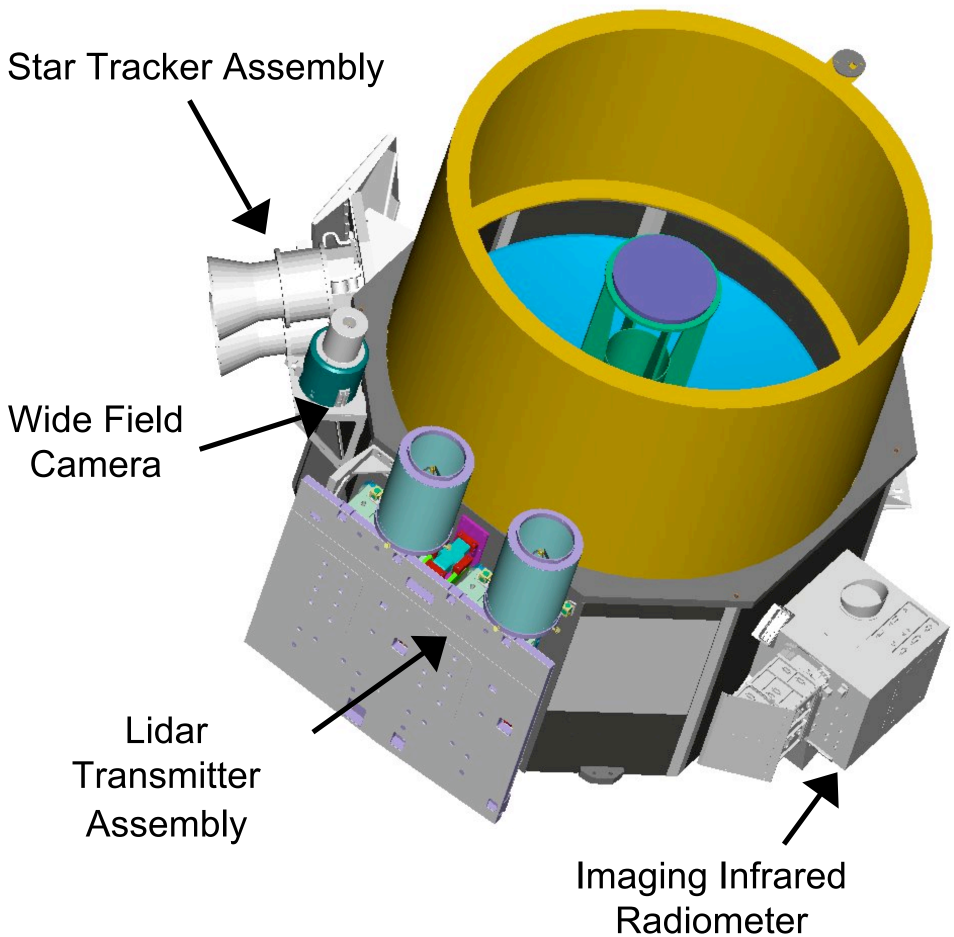
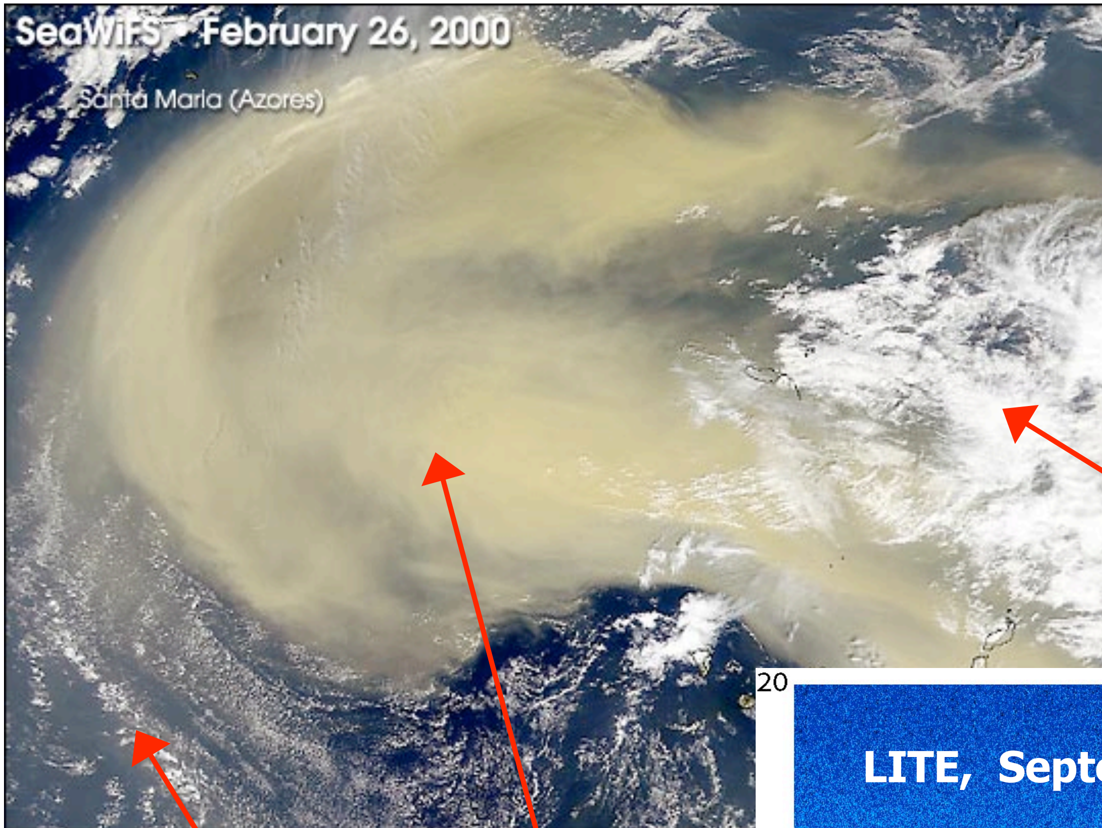
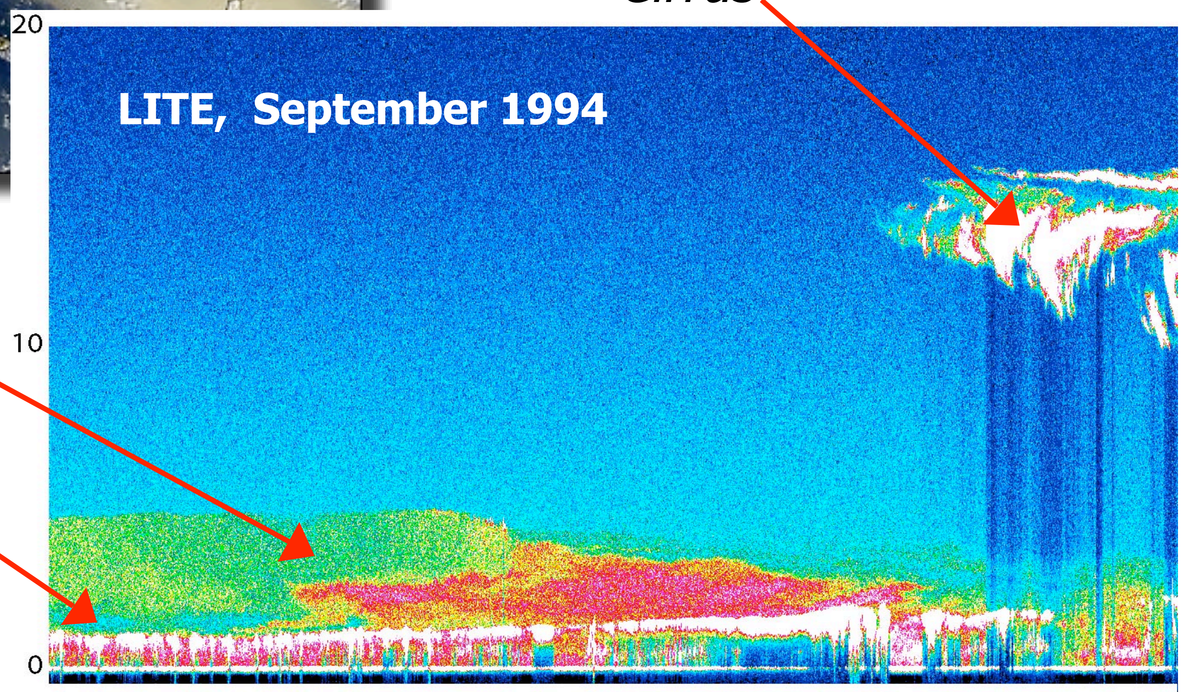

Three co-aligned instruments:
• CALIOP: polarization lidar
• IIR: Imaging Infrared radiometer (CNES)
• WFC: Wide-Field Camera
Calipso Footprint
1 Km
100 m
UNIQUE CAPABILITIES:
two sensitive lidar wavelengths (532/1064 nm)
polarization-sensitive receiver (532 nm)
active and passive sensors

CALIPSO Satellite

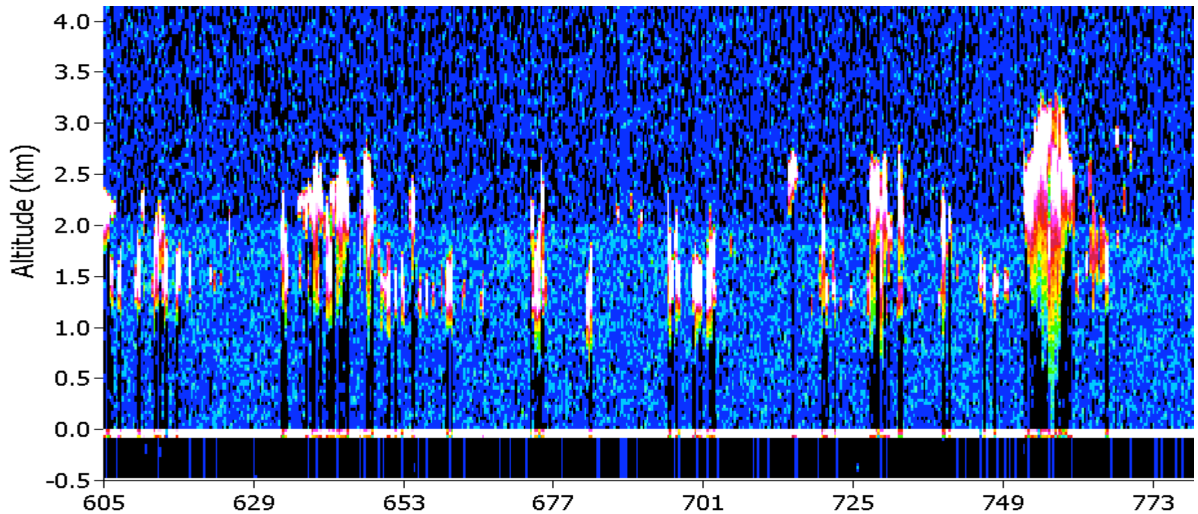


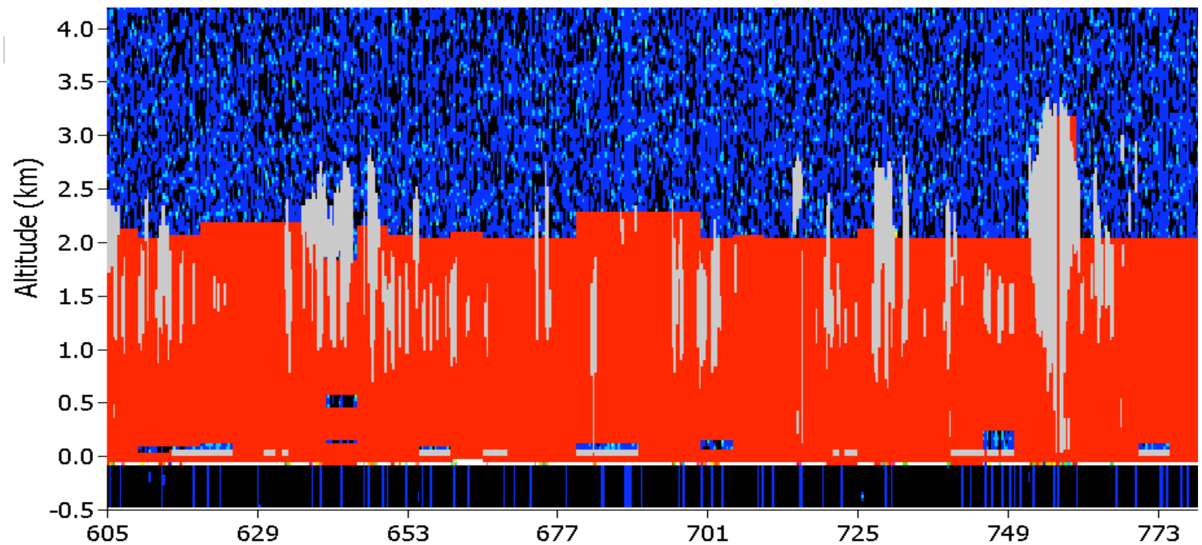


CALIPSO augments MODIS:
- aerosol profiles
- identifies heterogeneous columns
- aerosols beneath thin cirrus, in broken cloud fields, in sunglint
- and at night!



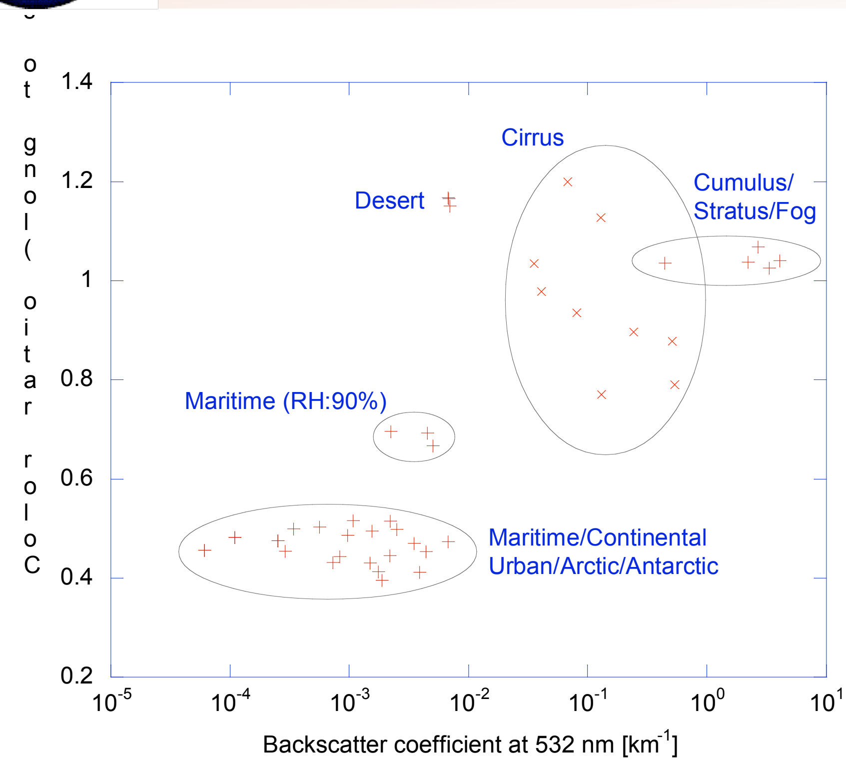
Improved cloud-clearing capability





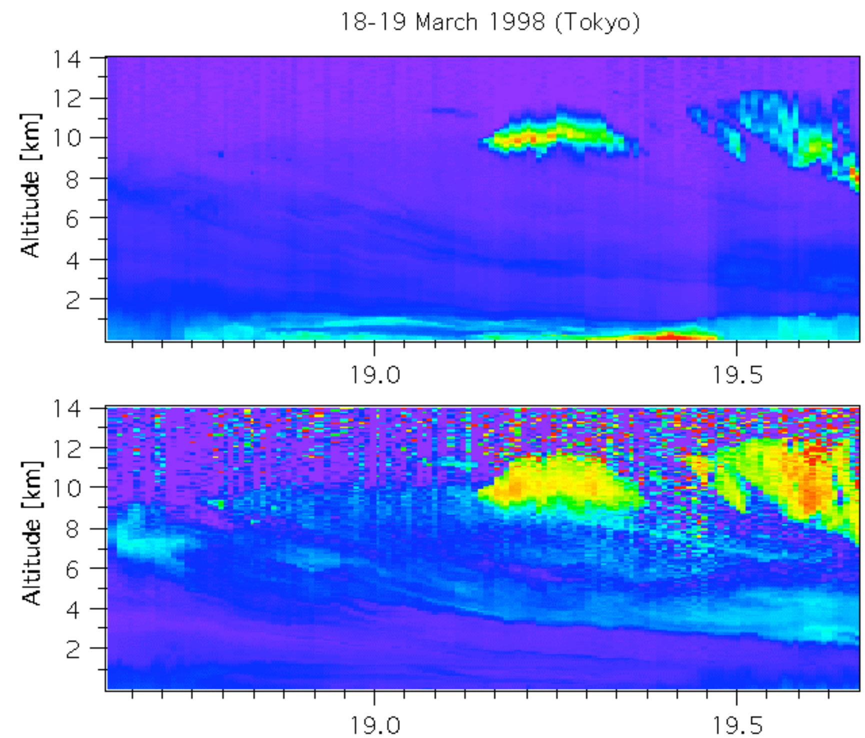
CALIPSO will observe aerosol in regions of broken clouds

CALIPSO Will Also Provide Aerosol "Type"



Lidar 2-wavelength data:

- **Aerosol-cloud separation**
- **Aerosol "size" (fine or coarse)**



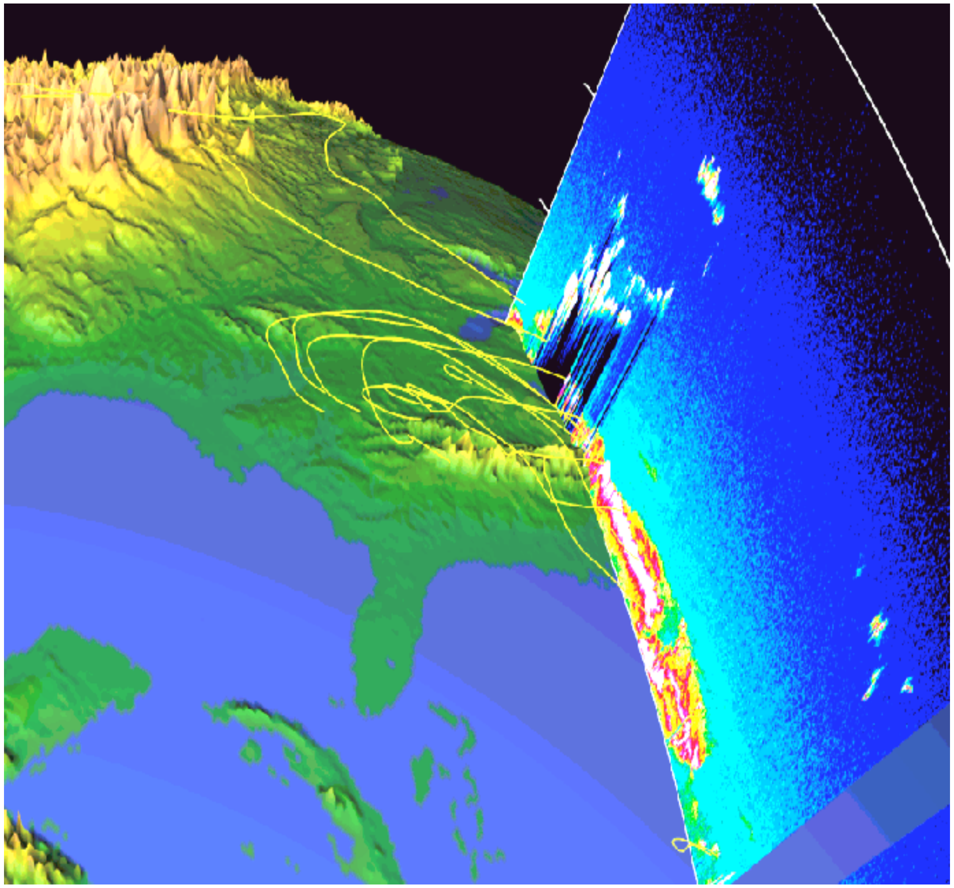
Lidar polarization signal indicates:

- **Solid or liquid aerosol**
- **Cloud ice/water phase**

Relevance to Modeling

- Aerosol profiles enable back-trajectories to aerosol sources
  - relate observed aerosols to sources
  - insight into aerosol composition and properties

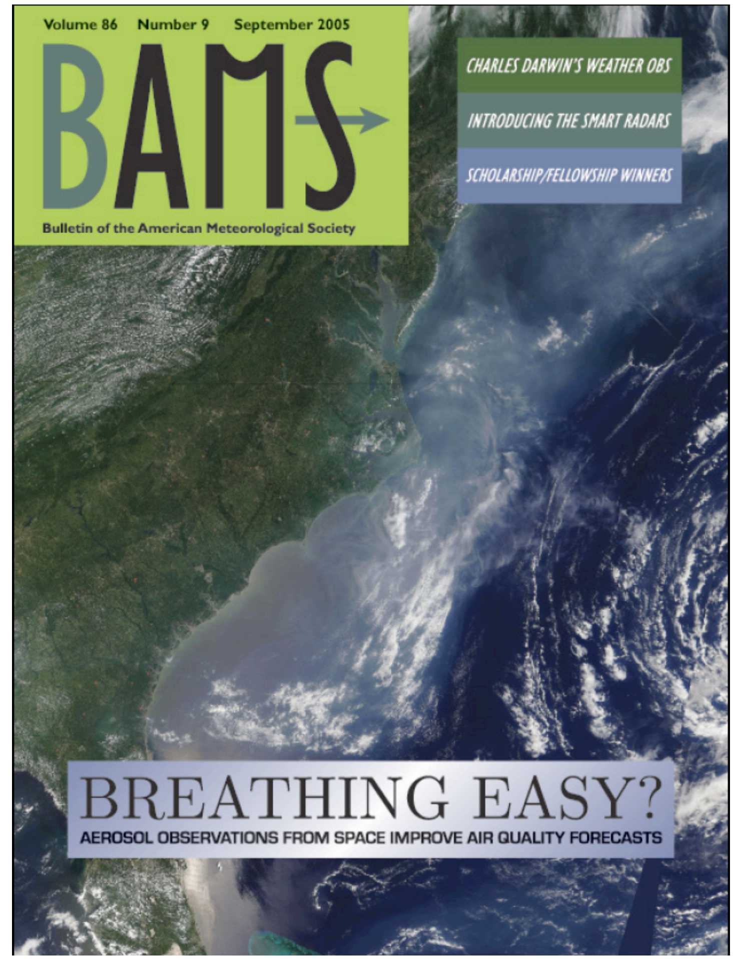
- Model initialization/assimilation
  - constrain aerosol vertical distribution
  - test/improve model performance



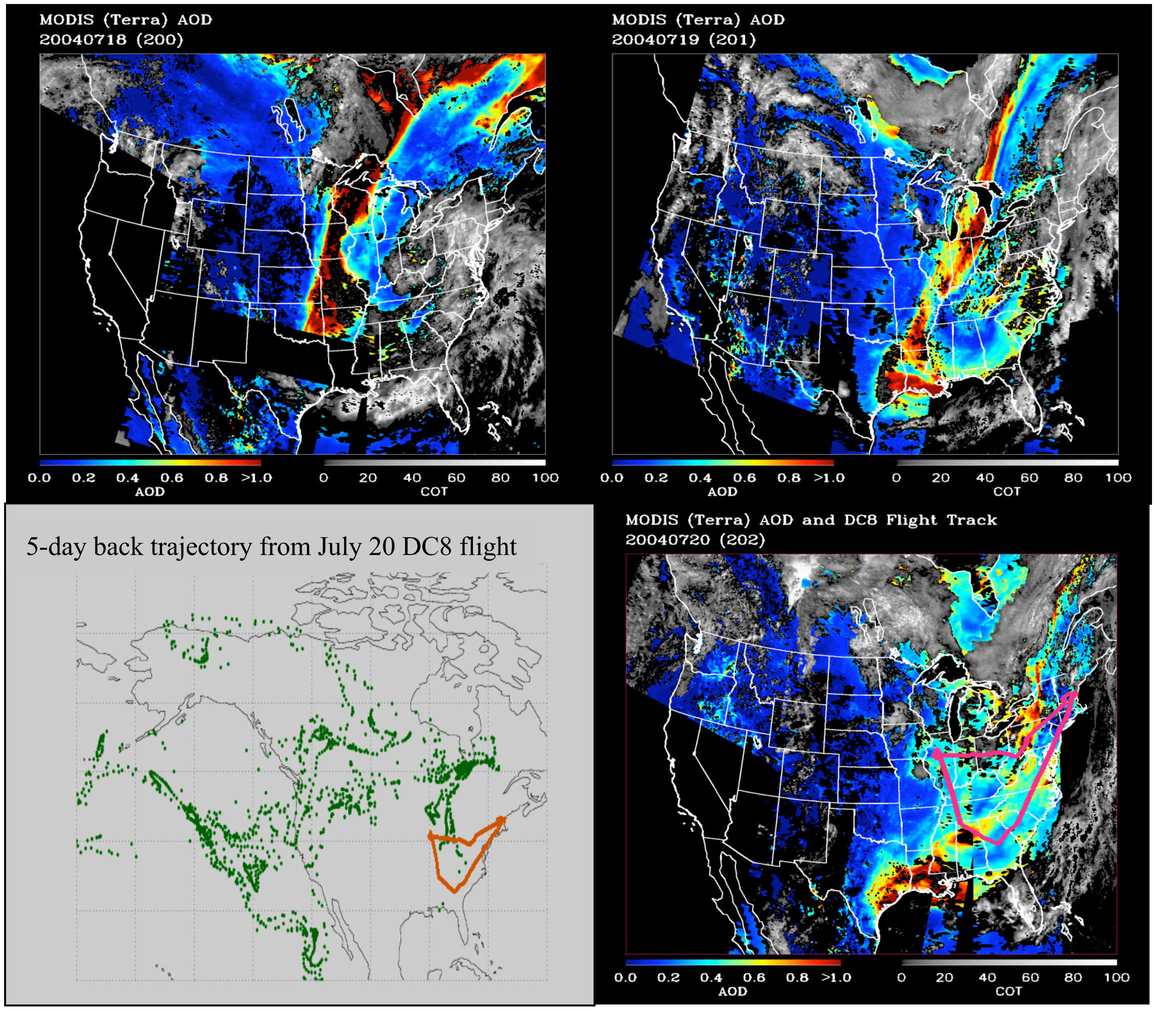
IDEA: Satellite based PM2.5 Forecasting and Assessment

Objective: Utilize NASA satellite measurements of column integrated *and height resolved* aerosol optical properties to improve our scientific understanding of the vertical distribution of aerosol loading, composition and transport, and demonstrate the capabilities of regional air quality prediction/assimilation systems

Precursor to the use of such systems for National air quality forecasting and assessment using aerosol optical measurements from future ground or space based lidar networks and operational satellite instruments such as the Visible/Infrared Imager/Radiometer Suite (VIIRS) on NPOESS.

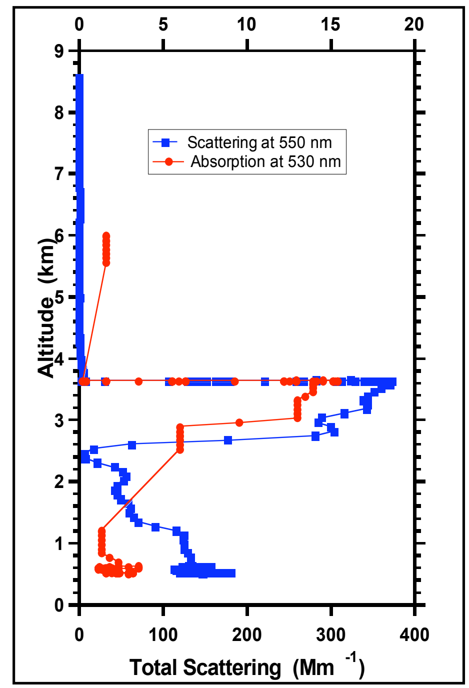


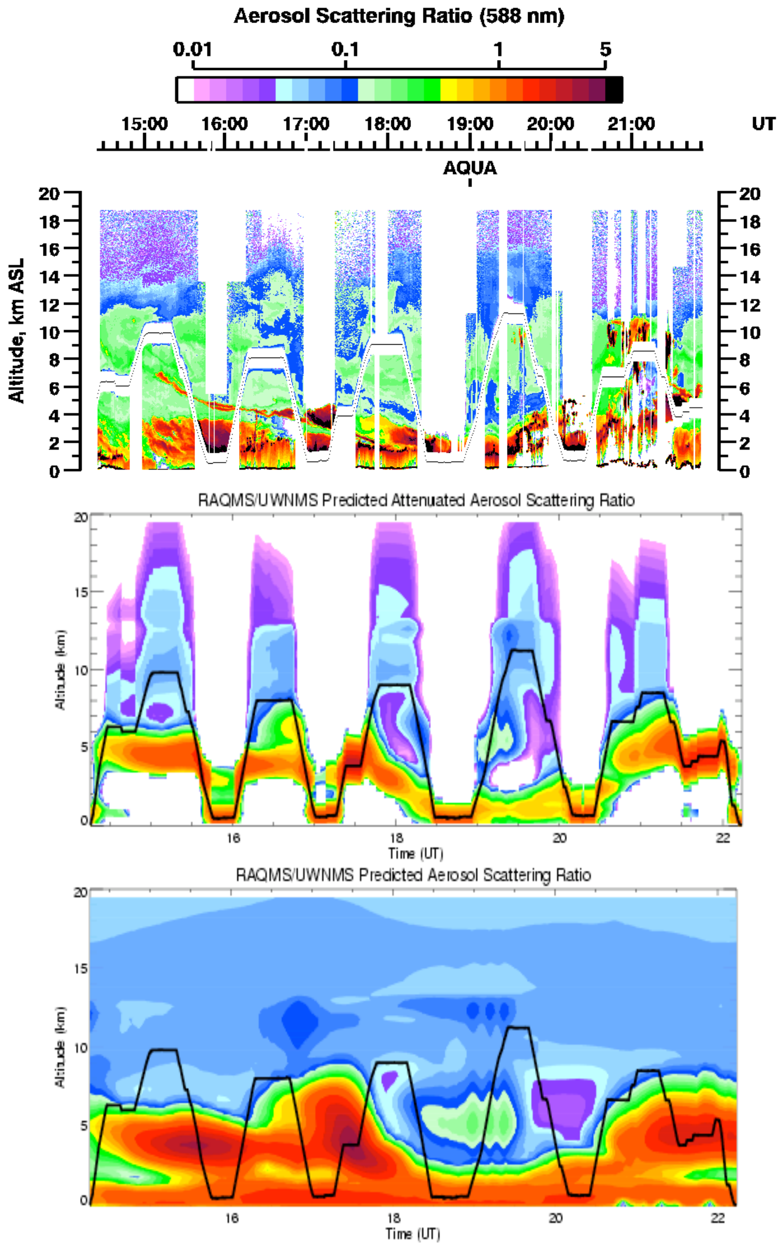
RAQMS July 15-19, 2004 Case Study



Clockwise from upper left: MODIS AOD on July 18, 19, 20 2004 (DC8 Flight Track on July 20 shown in pink) Lower left panel shows back trajectories originating along DC8 flight track between 700 and 400mb.

- A plume of high AOD associated with aerosols from Alaskan fires is evident extending from Hudson to Arkansas on July 18, 2004. This fire plume was sampled by instruments on the NASA DC8 on July 20, 2004.
- Aerosol optical depth (AOD) from MODIS-Terra
- Lidar aerosol profiles and in situ properties from the DC8 on 7/20/04





Comparison between DIAL 588nm (upper) and RAQMS 550nm (middle) Attenuated Aerosol Scattering Ratio for DC8 flight on July 20, 2004. Bottom: RAQMS 550nm Aerosol Scattering Ratio.

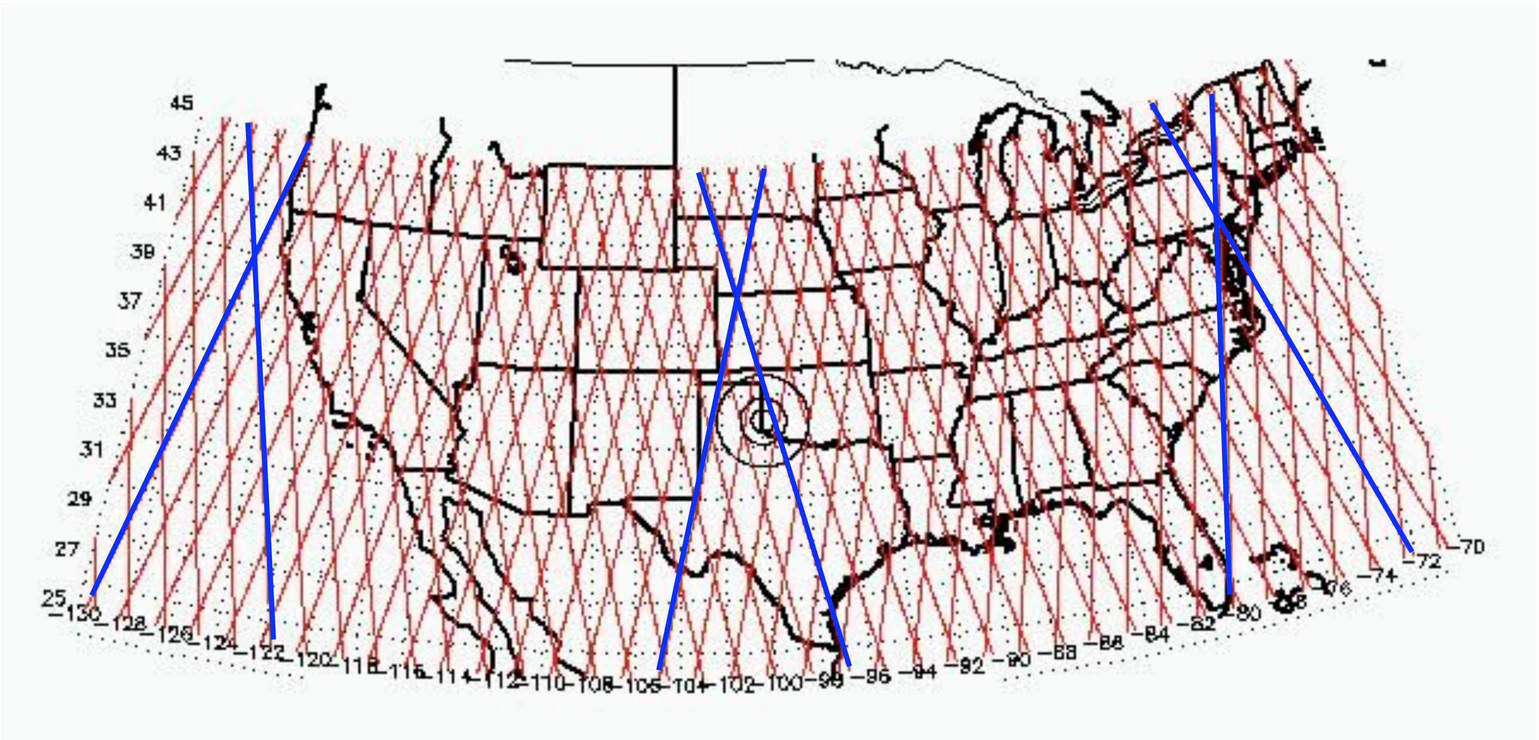
RAQMS aerosol predictions, initialized with an aerosol analysis that was constrained using lidar data and assimilated MODIS AOD, illustrates the advantages of combining high vertical resolution lidar data with high horizontal resolution column measurements.

The observed attenuated scattering ratios generally peak in the boundary layer (below ~3km) throughout most of the flight with an elevated scattering layer that slopes from ~8km at 15Z (beginning of the flight) down to the top of the boundary layer by ~18Z. DIAL depolarization measurements identify this layer as smoke.

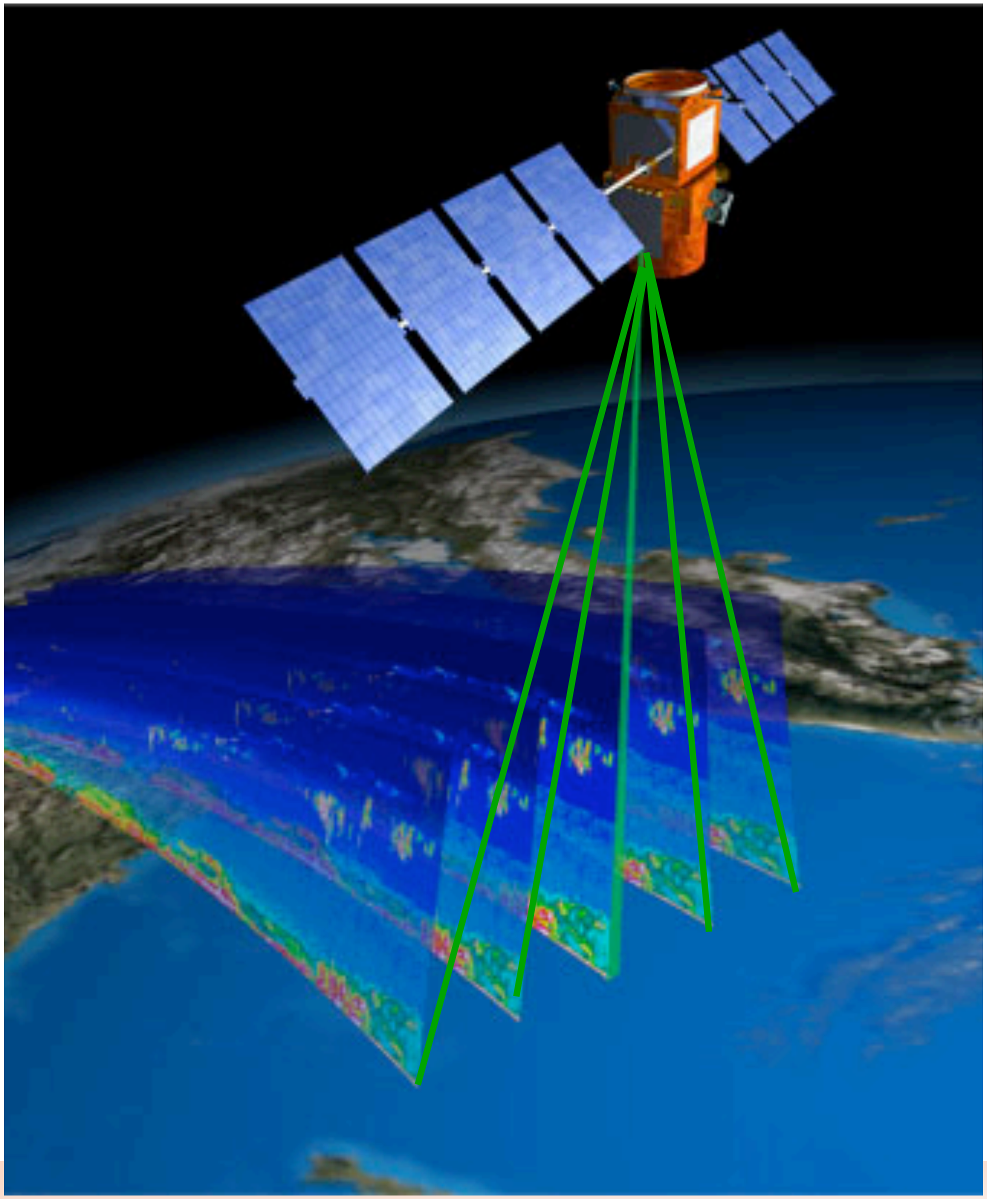
RAQMS does a good job of predicting the magnitude of the attenuated scattering ratios (because of the constraints provided by the MODIS AOD assimilation) except for within the boundary layer prior to 19Z where the predicted attenuated scattering ratio is very low. This occurs because overestimates in the thickness of the smoke layer prior to 19Z that lead to overestimates of the two-way transmittance and increased attenuation of the backscatter from the boundary layer aerosols when the DC8 is above the smoke layer.

CALIPSO 16-day Orbit Repeat Pattern

(same as ground track of MODIS-Aqua)



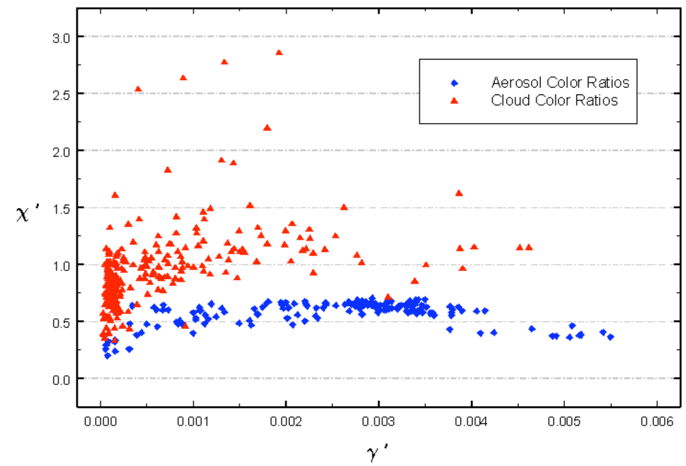
Next Generation System (Notional Concept)



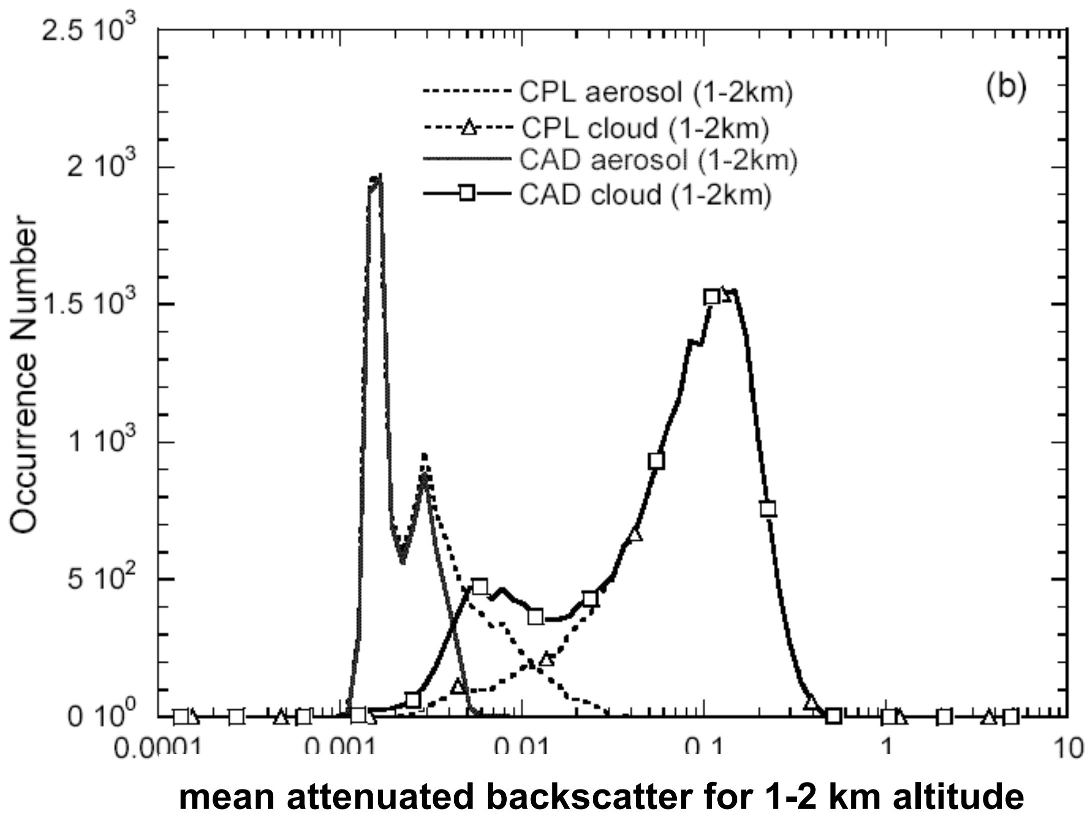
- Utility of nadir-viewing lidar is limited by sparse coverage
- Next-generation system: multiple beams for cross-track coverage
- Five beams provide quasi 1-day coverage of US

Backup Charts

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

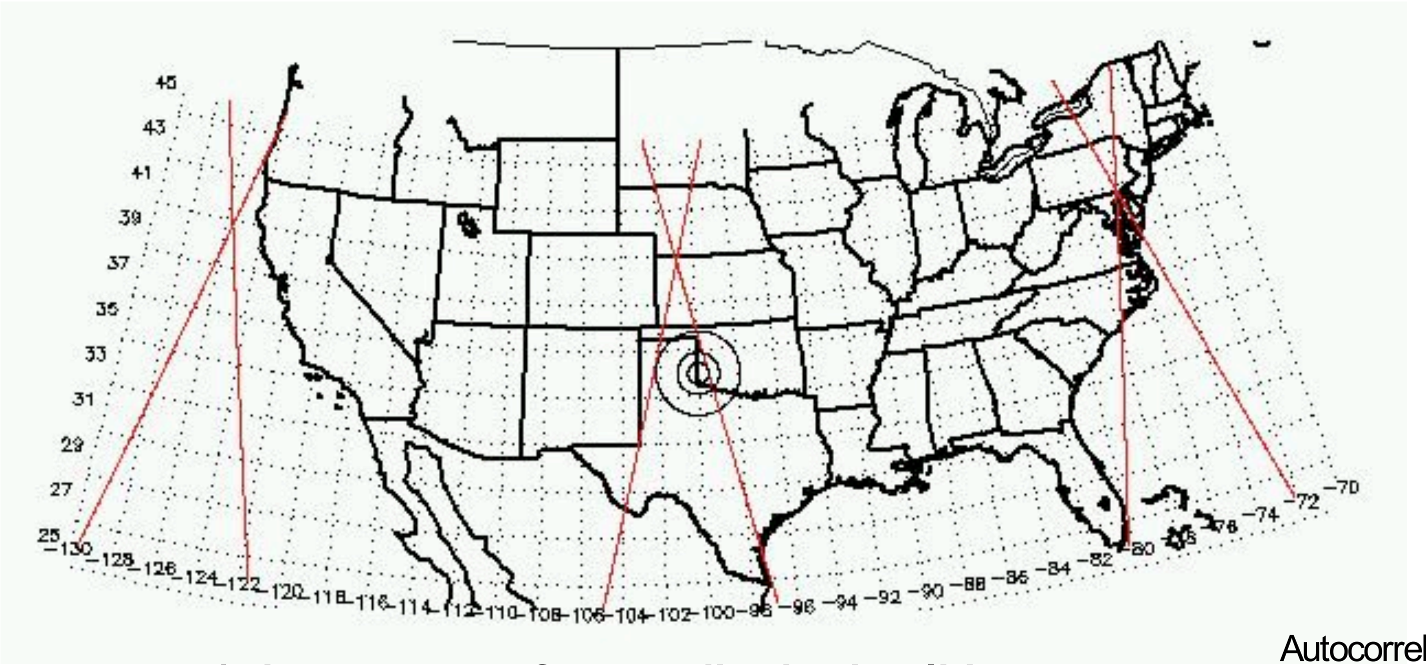


- The CALIPSO 2-λ algorithm (CAD) correctly identifies cloud and aerosol (note overlap).
- A 1-λ algorithm (CPL) misidentifies some cloud as aerosol, resulting in:
  - Biases in aerosol direct forcing
  - Ambiguities in assessing indirect forcing



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,

1-day nadir-viewing coverage



1-day coverage from nadir-viewing lidar

- **Nadir-viewing coverage is very sparse (> 2000 km path separation)**
- **Nadir measurement accounts for only 50% of the height variation 200 km away**
- **Aerosol height is essentially uncorrelated beyond 400 km**