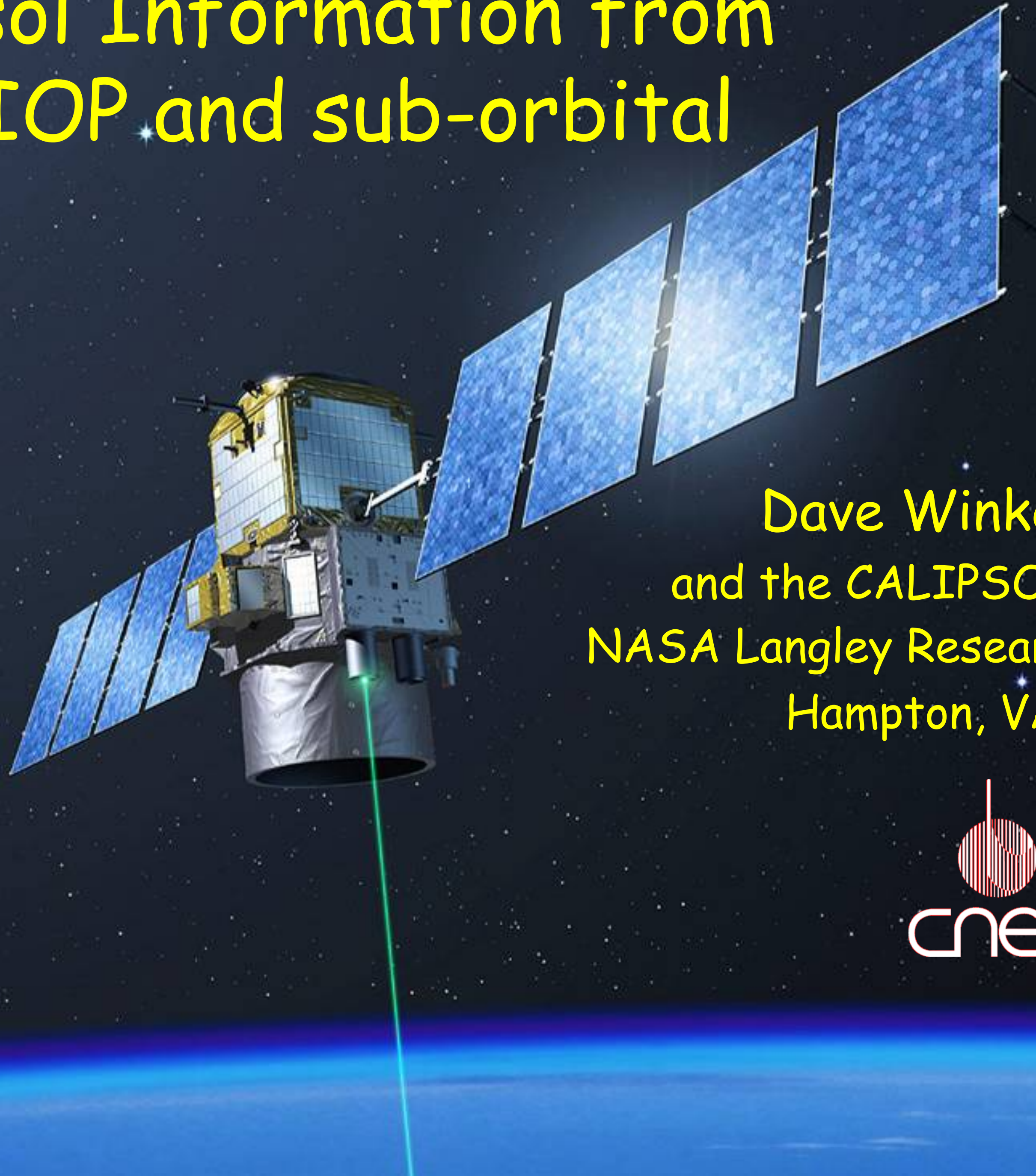
Aerosol Information from CALIOP and sub-orbital

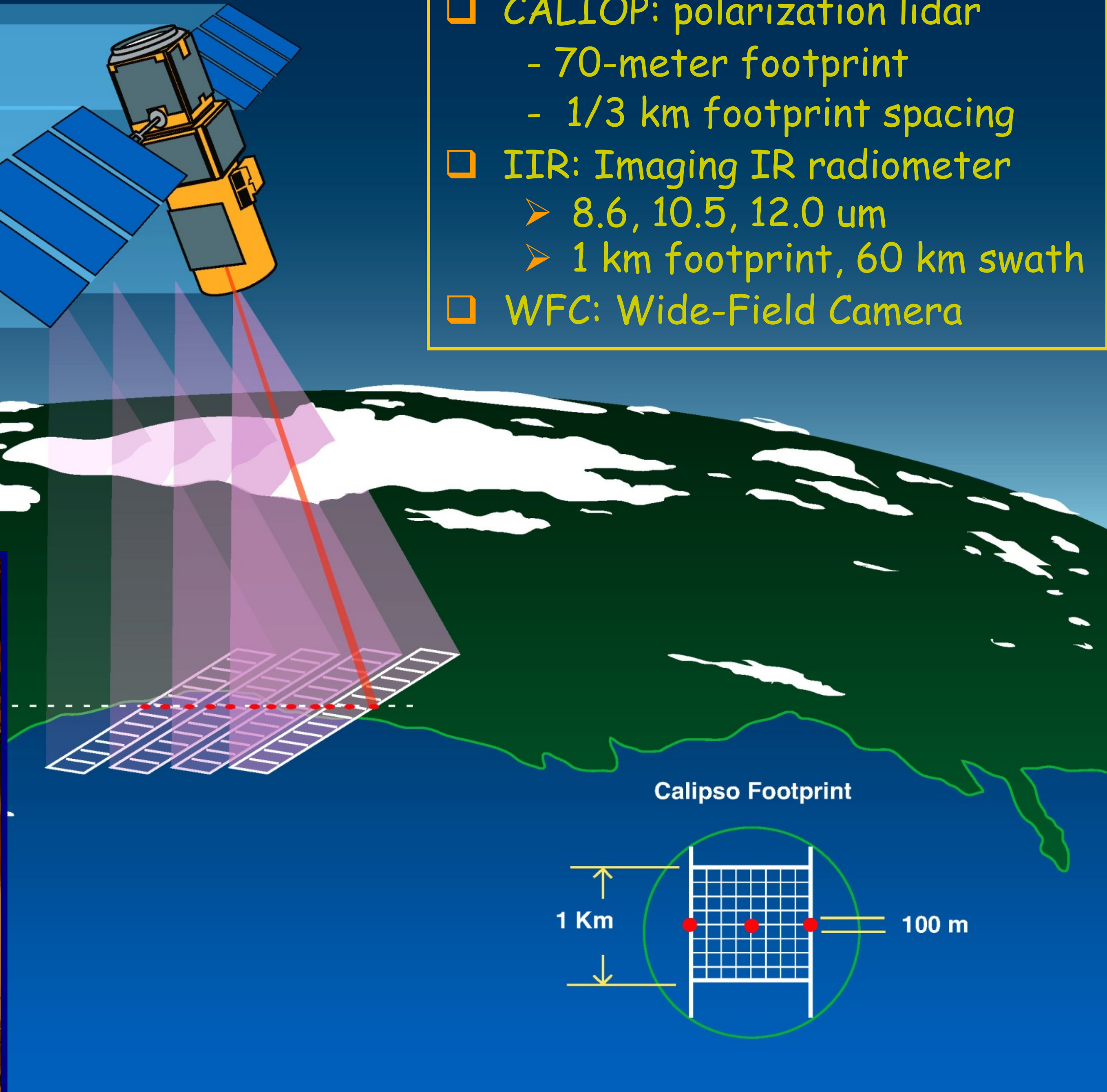


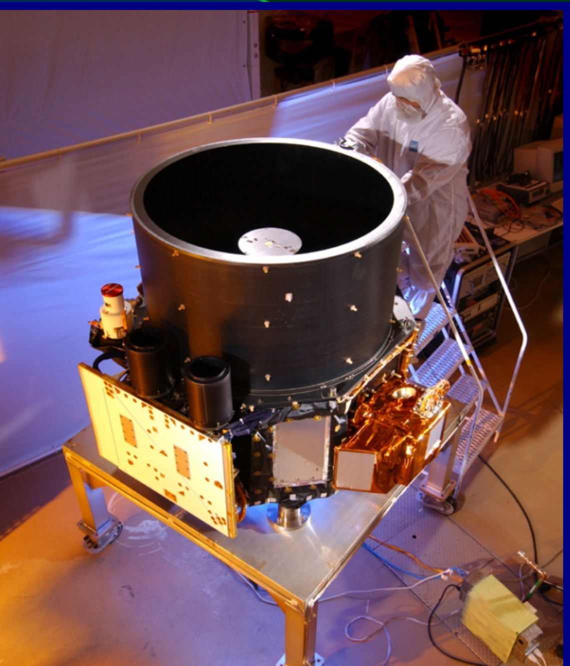
Dave Winker
and the CALIPSO Team
NASA Langley Research Center
Hampton, VA

First light: 7 June 2006

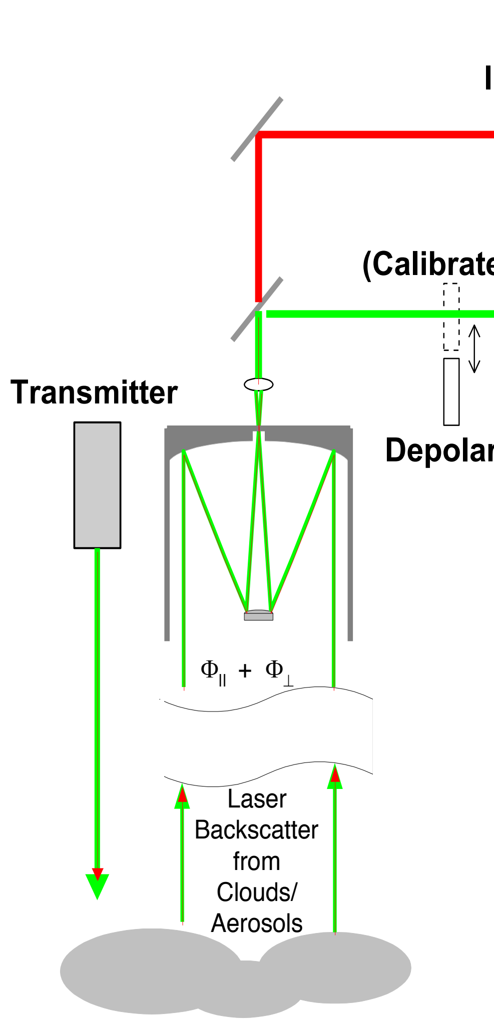
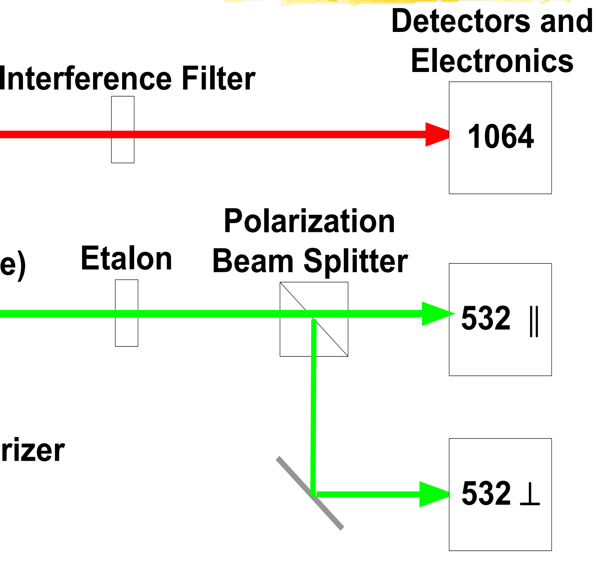
Three co-aligned instruments:

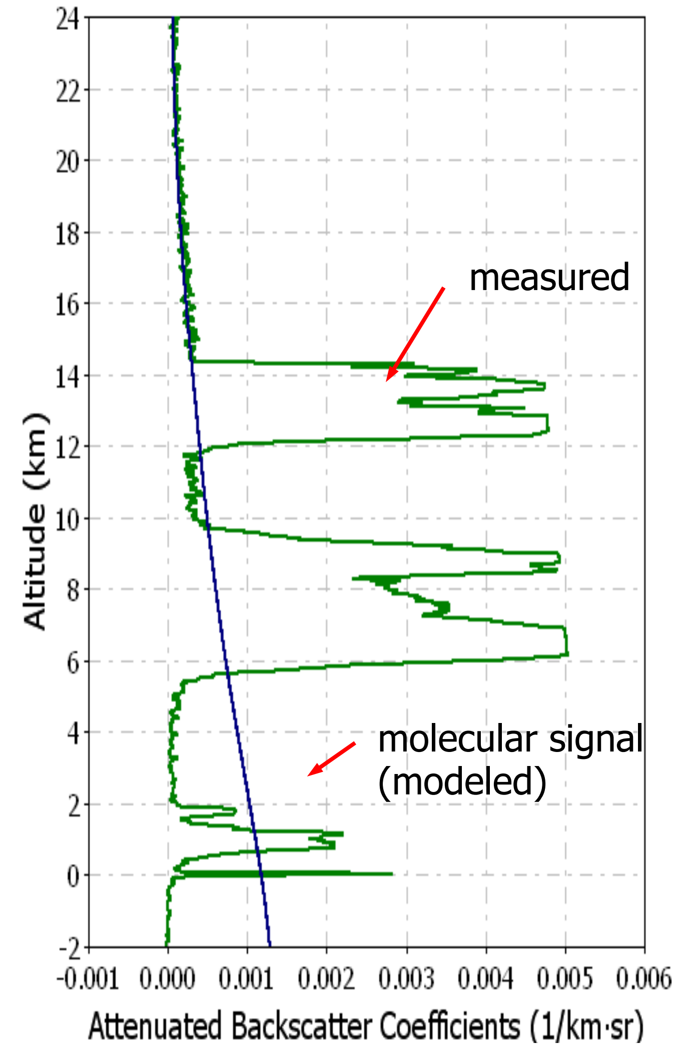
- CALIOP: polarization lidar
  - 70-meter footprint
  - 1/3 km footprint spacing
- IIR: Imaging IR radiometer
  - 8.6, 10.5, 12.0 um
  - 1 km footprint, 60 km swath
- WFC: Wide-Field Camera



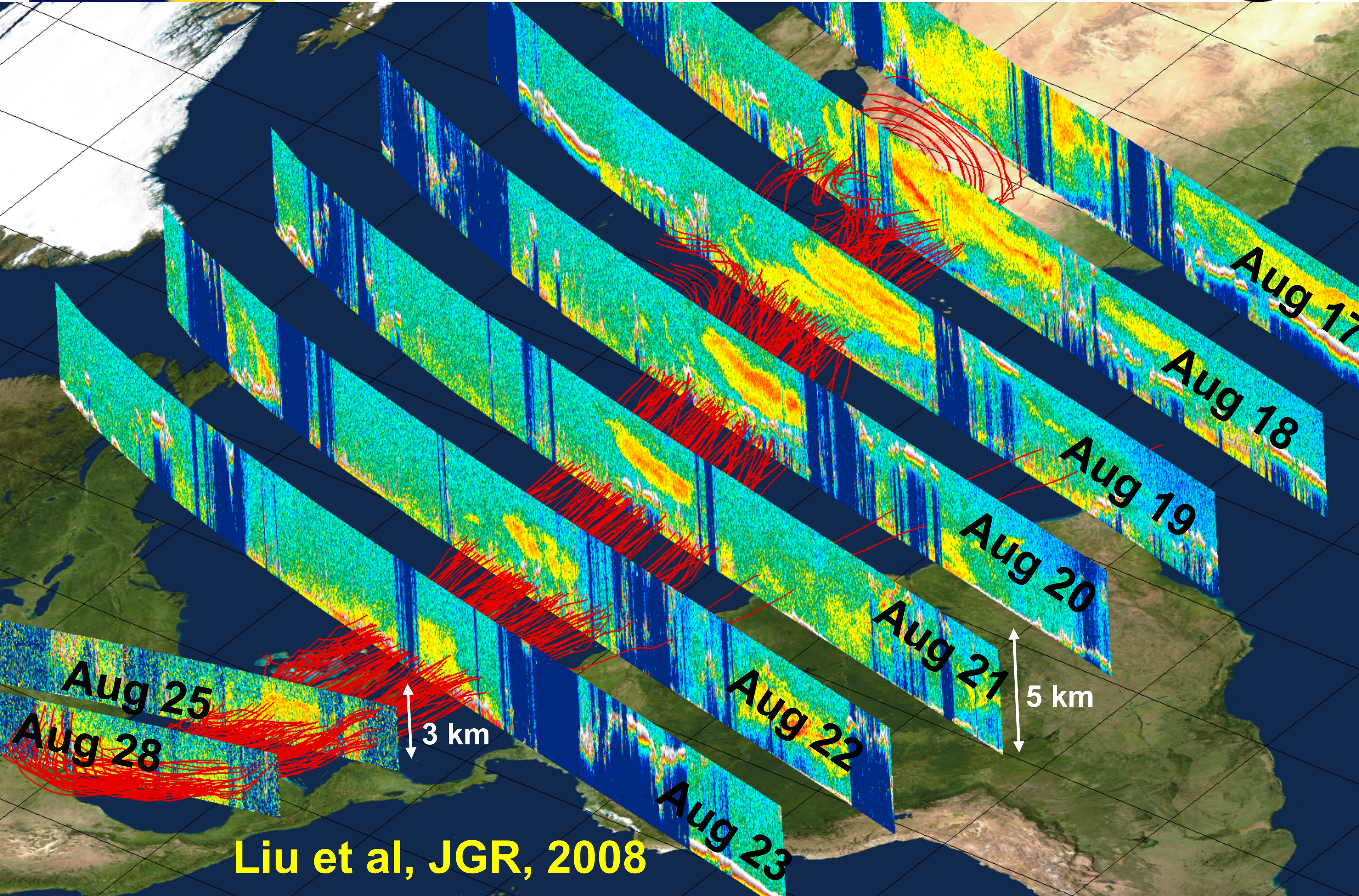


CALIOP Instrument Schematic



Case study of Sahara dust outbreak

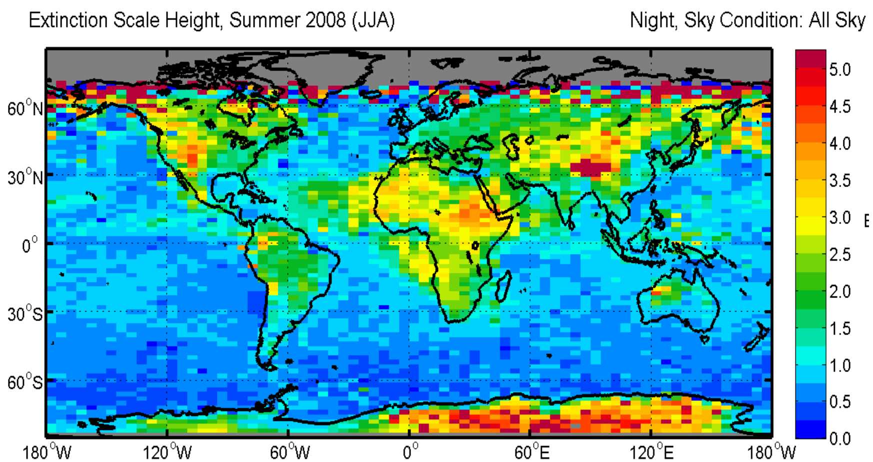


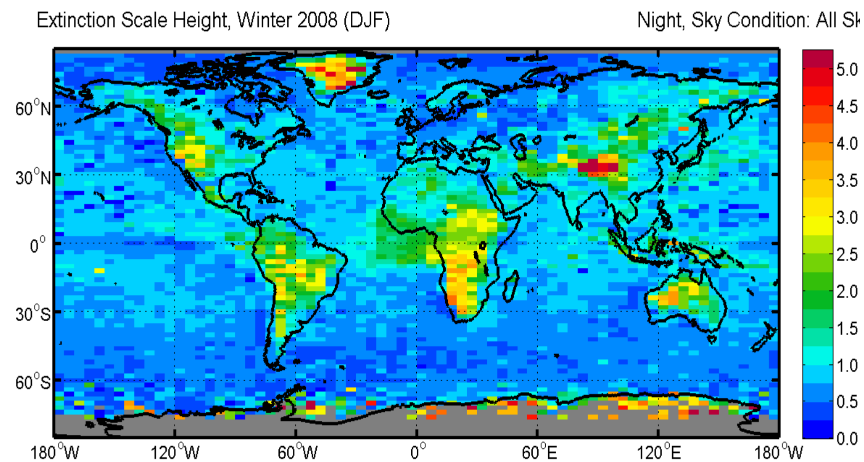
Liu et al, JGR, 2008

Aerosol Vertical Distribution from CALIOP

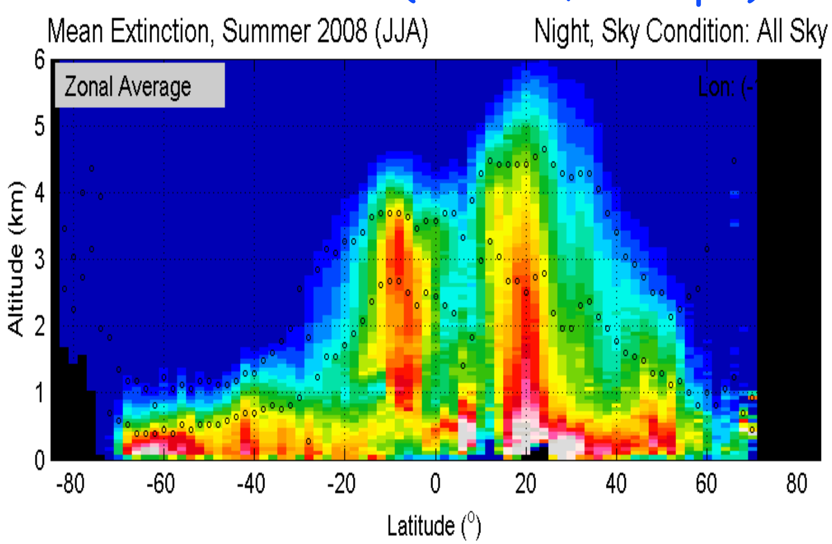
(Winker et al. 2013)

Aerosol extinction scale height, H (km, 63% of AOD below H)

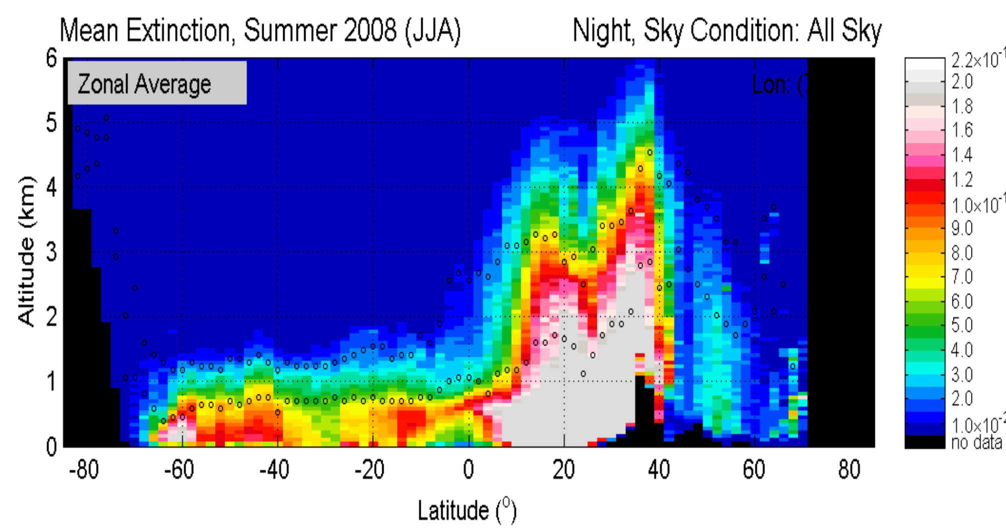




15W-30E (Africa, Europe)



70E-90E (India, Central Asia)



CALIPSO Technical Status

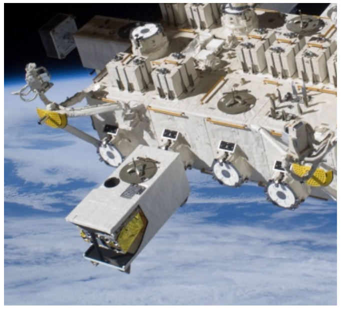
- CALIOP lidar continues to satisfy mission requirements
  - Continuous operation since June 2006
- Currently in a polar sun-sync orbit
  - 20 km below the A-train, but within the MODIS swath
- Spacecraft systems healthy
  - Sufficient power margins through mid-2023
  - But, no remaining propellant
    - Mean local time drifting ~15 minutes/year
- Remaining mission life unclear
  - Currently operating on backup laser (one of two), since 2009
  - Backup laser projected to operate only until early 2021
  - Will attempt to restart primary laser

Data Production Status

Product	Available ASDC	Available ICARE
CALIOP Level 1 (V3) Std	13 June 2006 - 17 April 2020	13 June 2006 - 16 April 2020
CALIOP Level 1 (V3) Expedited	Through 19 April 2020	Through 17 April 2020
CALIOP Level 1 (V4.10) Std	13 June 2006 - 31 January 2020	13 June 2006 - 31 January 2020
CALIOP Level 2 (V3) Std	13 June 2006 - 16 April 2020	13 June 2006 - 16 April 2020
CALIOP Level 2 (V3) Expedited	Through 19 April 2020	Through 17 April 2020
CALIOP Level 2 (V4.20) Std	13 June 2006 - 31 January 2020	13 June 2006 - 31 January 2020
CALIOP Level 2 (V3) PSC	13 June 2006 - 16 April 2020	13 June 2006 - 16 April 2020
CALIOP Level 2 Blow Snow–Antarctica (V1)	June 2006 – January 2020	June 2006 – January 2020
CALIOP Level 3 Aerosol (V4) Std	June 2006 – January 2020	June 2006 – January 2020
CALIOP Level 3 Strat. Aerosol (V1) Std	June 2006 – January 2020	June 2006 – January 2020
CALIOP Level 1.5 (V1) Std	13 June 2006 - 31 December 2019	13 June 2006 - 30 November 2019
CALIOP Level 1.5 (V3) Expedited	Through 19 April 2020	Through 17 April 2020
IIR Level 1 (V1; V2) Std	13 June 2006 - 18 April 2020	13 June 2006 - 16 April 2020
IIR Level 1 (V1) Expedited	Through 19 April 2020	Through 17 April 2020
IIR Level 2 (V3)	13 June 2006 - 14(nt),10(dy) April 2020	13 June 2006 - 14(nt),10(dy) April 2020
IIR Level 2 (V3) Expedited	Through 10 April 2020	Through 10 April 2020
IIR Level 2 (V4)	13 June 2006 - 2008 (on-going)	13 June 2006 - 2008 (on-going)
WFC Level 1 (V3)	13 June 2006 - 10 April 2020	13 June 2006 - 10 April 2020

Other Space Lidars

- CATS
  - 1064 nm backscatter lidar
  - Operated on ISS 2015-2017
  - McGill et al (2015)

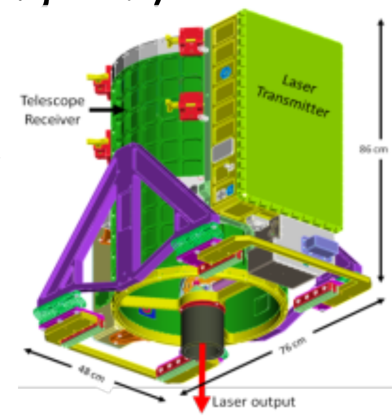


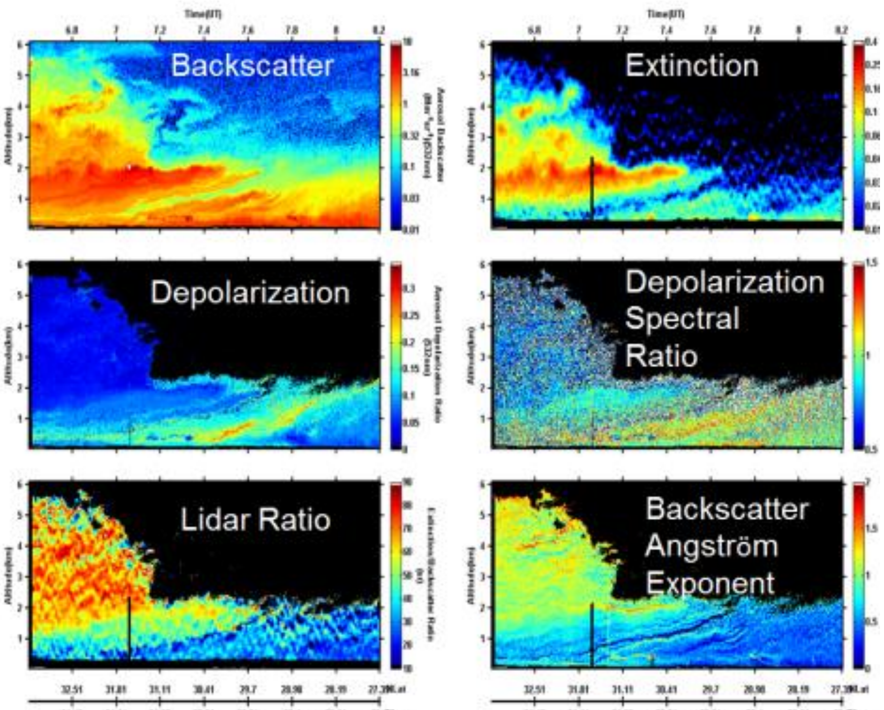
- ATLID on EarthCARE
  - 355 nm HSRL in polar orbit
  - Launch planned for mid-2022
  - Illingworth et al. (2015)

- NASA Aerosol-Cloud-Convection-Precipitation(ACCP) mission
  - Mission definition study underway
  - Will include a lidar – not yet defined
  - Launch foreseen in late 2020's

NASA Langley Airborne HSRL-1

- Flown on NASA/LaRC King Air, NASA P3,ER-2
- Nadir pointing lidar
- Flown in many campaigns
- see Hair et al. (2008)





HSRL Technique:

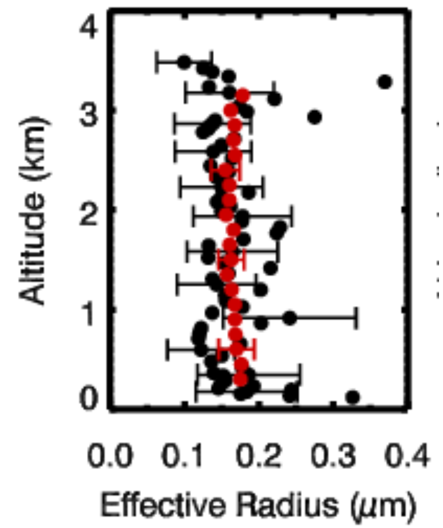
- Independently measures aerosol backscatter, extinction, and optical thickness

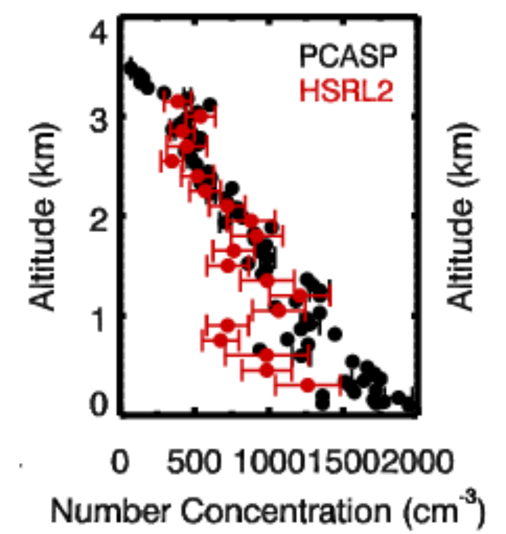
HSRL-1 Aerosol Data Products:

- Extinction Coefficient (532 nm)
- Optical Depth (AOD) (532 nm)
- Depolarization (532, 1064 nm)
- Mixed Layer Height
- Aerosol Type Classification
  - see Burton et al. (2013)

Second Generation Airborne HSRL-2

- HSRL capability at both 355 nm, 532 nm
- Provides "3β+2α" suite of measurements for aerosol microphysical retrievals
- Flying on King Air and other platforms



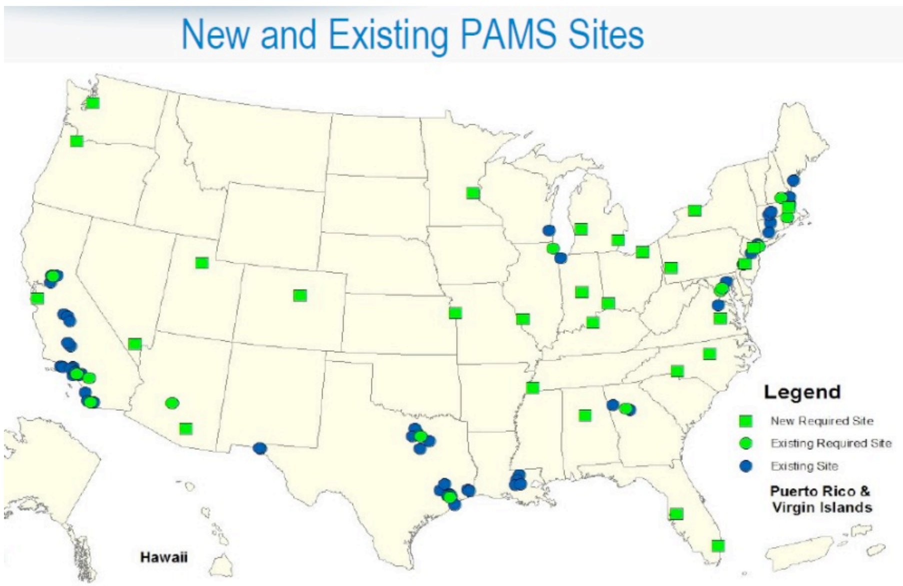


<u>Key additional products from HSRL-2</u>

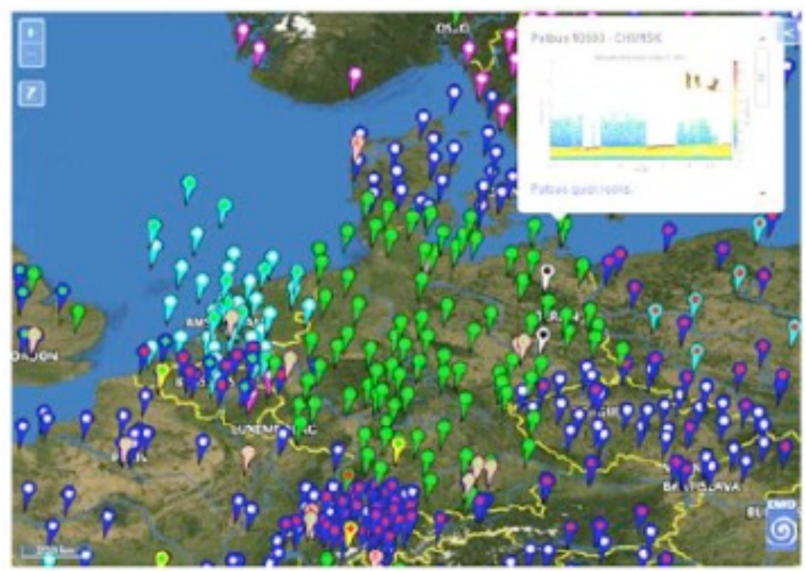
- Aerosol 355 nm Extinction profiles
- Enhanced type information
- Aerosol microphysical retrievals:
  - Effective radius
  - Number concentration

Ground-based Capabilities

- Emerging networks of operational ceilometers capable of aerosol profiling, identification of mixed layer height
- US: Enhanced PAMS
  - 40 sites operational by 10/21



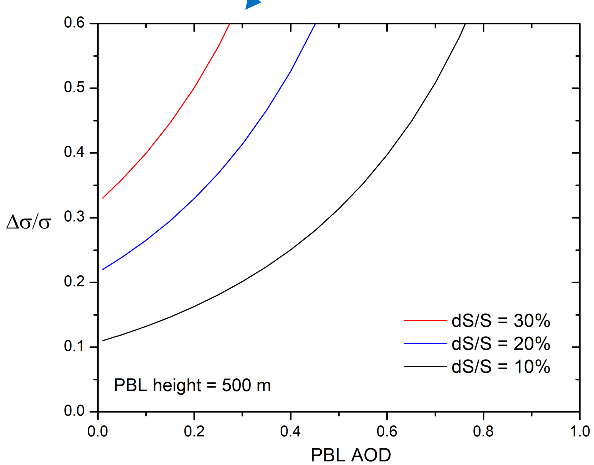
Europe: Copernicus
- Many sites operational today
- Data fed to NWP in real time



Aerosol Extinction Uncertainties

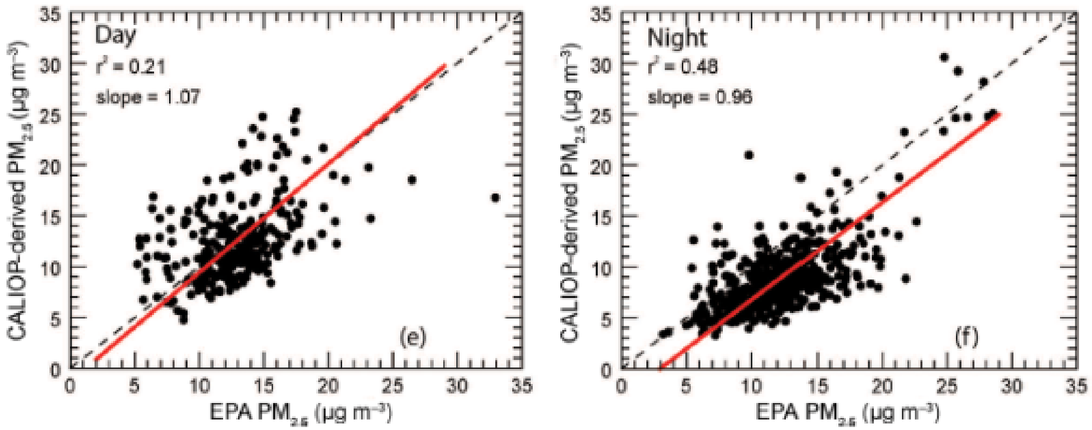
- CALIOP: aerosol extinction uncertainties are dominated by uncertainty in lidar ratio (extinction-to-backscatter ratio)
  - Error increases as lidar ratio uncertainty, dS/S, increases
- HSRL: direct measurement of extinction from measured molecular attenuation profile

Typical uncertainty for backscatter lidar



Relative error in near-surface aerosol extinction vs. AOD

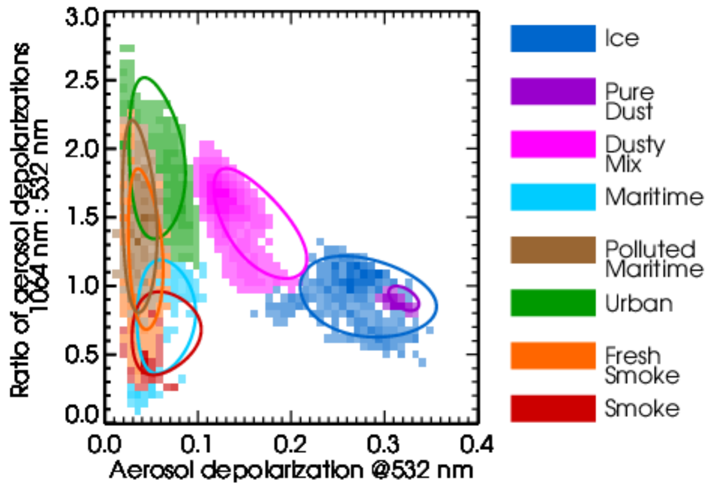
Lidar ratio uncertainties limit the accuracy of CALIOP PM2.5 estimates



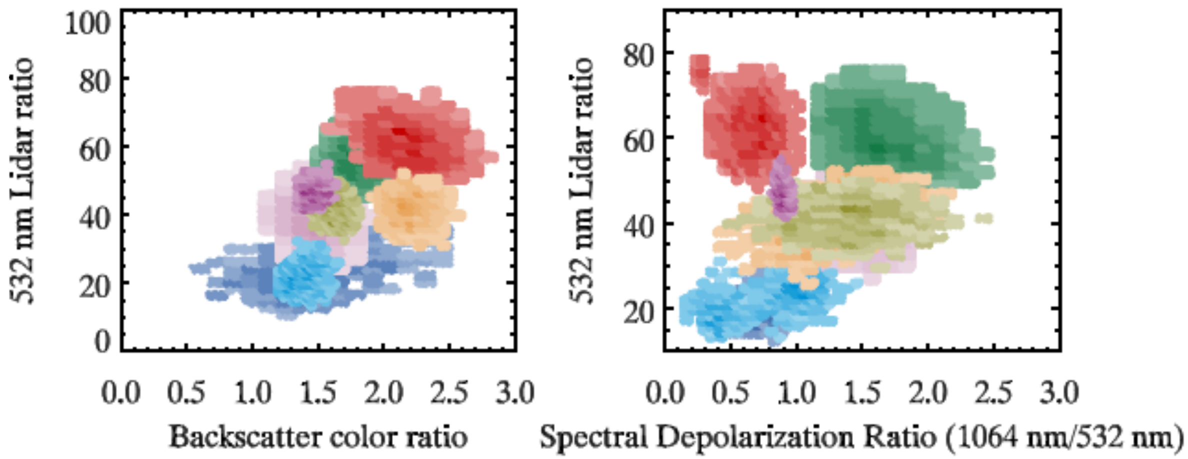
Mean PM2.5 concentration from near-surface CALIOP retrievals vs. ground-based EPA stations (Toth et al 2019)

Aerosol Type Information

CALIOP measures depolarization at 532 nm to distinguish dust from spherical aerosol particles:



HSRL measures additional intensive parameters, for better type discrimination ability:
(Burton et al. 2012)



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