Aerosol Information from CALIOP and sub-orbital

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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

Calipso Footprint

1 km
100 m
CALIOP Instrument Schematic

- Transmitter
  - Laser Backscatter from Clouds/Aerosols
- Depolarizer
- Interference Filter
  - Etalon
- Polarization Beam Splitter
- Detectors and Electronics
  - 1064 nm
  - 532 nm
- Interference Filter
- Measured molecular signal
- Modeled molecular signal
- Attenuated Backscatter Coefficients (1/km sr)
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)
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
<table>
<thead>
<tr>
<th>Product</th>
<th>Available ASDC</th>
<th>Available ICARE</th>
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<td>CALIOP Level 1 (V3) Std</td>
<td>13 June 2006 - 17 April 2020</td>
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<tr>
<td>CALIOP Level 1 (V3) Expedited</td>
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<td>CALIOP Level 2 (V3) Std</td>
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<td>CALIOP Level 2 (V3) PSC</td>
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<td>CALIOP Level 1.5 (V1) Std</td>
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<td>IIR Level 1 (V1; V2) Std</td>
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<td>IIR Level 2 (V3)</td>
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<td>IIR Level 2 (V3) Expedited</td>
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<td>IIR Level 2 (V4)</td>
<td>13 June 2006 - 2008 (on-going)</td>
<td>13 June 2006 - 2008 (on-going)</td>
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<td>WFC Level 1 (V3)</td>
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Winker, CEOS AC-VC, June 2020
Other Space Lidars

- **CATS**
  - 1064 nm backscatter lidar
  - Operated on ISS 2015-2017

- **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

Key additional products from HSRL-2
- 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**

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

**Relative error in near-surface aerosol extinction vs. AOD**

**Mean PM2.5 concentration from near-surface CALIOP retrievals vs. ground-based EPA stations (Toth et al 2019)**
HSRL measures additional intensive parameters, for better type discrimination ability: (Burton et al. 2012)
References


Additional references

- Kaku et al., 2018: Assessing the challenges of surface-level aerosol mass estimates from remote sensing during the SEAC4RS and SEARCH campaigns: JGR, 7530 - 7562. doi:10.1029/2017JD028074