Focus on the Space-Based Lidar Data
CALIOP: Cloud and Aerosol Lidar with Orthogonal Polarization

1. Basic lidar info
2. ATTREX 2014 – Aircraft data comparisons
3. ATTREX Regional Overview
4. Regional Characteristics and Time Series

- Is it sensitive?
- Is it representative?
- What are we looking at?

What can we learn with it?
Lidar Signal Interpretation is a Multiple Step Process:

Range-Resolved, Normalized Signal
Calibrated Attenuated Backscatter Profiles; 532 P, 532 S, 1064

Atmospheric “Features” located
\( dH = 333m, 1\text{km}, 5\text{km}, 20\text{km}, 80\text{km} \)

Atmospheric Features Identified
Layer-Integrated properties:
Attenuated Backscatter, 532 nm
Depolarization, 1064/532 nm ratio

Extinction, Particulate Backscatter
Coefficients Retrieved

IWC parameterized from Extinction Aircraft Data

**Calibration**

\( L_1 \)
Volume backscatter coefficients, integrated attenuated backscatter, volume depolarization, volume CR

**Feature Detection**

Vaughan, 2009

**Feature Identification**

Liu, 2009; Hu, 2009 (cloud phase)
Omar, 2009 (aerosol type)

\( L_2 \)
Profiles at 1km, 5km, 60m vertical resolution in the UT/LS;
Layer-Integrated quantities, stats

Young and Vaughan 2009, Young, 2012

**TTL cirrus IWC**
Heymsfield, 2014
CALIOP 532 nm Nighttime channel clear air scattering ratios show that in the Tropics, CALIOP sees volcanic aerosols and ice particles with particle concentrations too small to detect as layers.
Clear Air Scattering Ratio – Before and After Kelud Eruption

Plot provided by Jason Tackett
ATTREX – Guam
February, March 2014
Comparisons with Aircraft Observations
ATTREX 2014 Instruments and Measurements

**Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP)**
- Ice Water Content (IWC)
- Extinction (Ext)
- 532 nm Depolarization
- 1064/532 BS Ratio

**Imaging Infrared Radiometer (IIR)**
- Ice Water Path (IWP)
- Optical Depth (OD)
- Effective Particle Size
- Microphysical Param.

**NOAA Water**
- Water vapor
- Cloud IWC

**SPEC, Inc. Hawkeye**
- 2D-S (PSD, Ext, IWC)
- CPI images
- FCDP (PSD, Ext, IWC)

**Cloud Physics Lidar (CPL)**
- 3 wavelengths
- Extinction
- 1064 nm Depolarization
- BS Ratios
February 10 – March 14, 2014
8.2 – 20.2 km (mainly above $\theta = 355$ K), Cold ice clouds (cloud base < -40)

Data Coverage during ATTREX 2014
Integrated attenuated backscatter (IAB) shows two modes of cloud optical thickness. IAB of \~0.028 \text{ sr}^{-1} are opaque to CALIOP with OD \~3 and are likely to be associated with convection. Many transparent layers have IAB \<0.005 \text{ sr}^{-1}.
2D-S and CPL Extinctions

Example Flight on March 9

Aircraft Trace colored by 2D-S bulk extinction coefficient

CPL 532 nm Extinction Coefficients 09mar14 km⁻¹

GH level legs at 14.5 km create more sampling at -68°

CPL extinction coefficients

Time (Elapsed Sec)
TC\textsuperscript{4} CPL and CALIOP OD Comparison, Cloud Bases 15-18 km

**ATTREX – 2014, Guam OD Comparison, Cloud Bases 15-18 km**

**Reproduced from Davis et al., 2010**
IWC Distribution Comparison

Level legs of GH at -68 °C
Regional Climatology from CALIOP

DJF, Mean UT Ice Mass, Z > 12 km

JJA, Mean UT Ice Mass, Z > 12 km

DJF, Mean UT Ice Mass, Z > 15 km

JJA, Mean UT Ice Mass, Z > 15 km
Time Series  Asian Monsoon IWC  IWC (mg/m³)
Summary

• CALIOP Version 4 calibration is helpful for better TTL observations
• Lidar sensitivity down to ~0.003 OD in the TTL
• Layers provide convenient information, but miss some features because of orientation
• Scattering ratios averaged over enough time may provide more information (with caution because depolarization has a relatively low signal to noise ratio)
• For extinction retrievals, we need to know the extinction to backscatter ratio.
• Working on extinction comparison from ATTREX ($\sigma=2A$).
• Particle area to mass power law derived by NOAA group (Troy Thornberry, poster yesterday).
• Error estimate in the TTL is a work in progress, due to extra challenges in the TTL.