Summary of Micro-Pulse Lidar Data Obtained During NASA's DISCOVER-AQ field missions

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DISCOVER-AQ (DAQ), a NASA Earth Venture program funded mission, stands for Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality.

- Ground-based & aircraft measurements at four different regions:
  - Baltimore-Washington & GEO-Cape ship, MDE aircraft (July/Aug 2011)
  - California (Jan/Feb 2013)
  - Houston (Sept 2013) w/SEAC4RS
  - Denver (July/Aug 2014) w/FRAPPE

- Two key aircraft: Wallops P3 & Langley King Air

- MPL systems present in all four campaigns at different ground sites, but do not represent all lidars in the field campaign, many other systems (wind, HSRL, ceilometers, etc)

- Typically located at critical P3 aircraft “spiral” locations

- MPL data systems auto-linked together via Dropbox, to provide real-time display of data during field operations and instrument monitoring.

Image courtesy of Timothy Marvel.
Micro-Pulse Lidar Systems

- Manufactured by Sigma Space
  http://www.sigmaspace.com/
- Portable & meets ANSI Class 2 “eye-safe” standard
- Unattended, continuous (24-7) aerosol and cloud profiling during DAQ
- Systems loaned by Sigma or owned by DAQ research groups (UMBC or Millersville)
- Two different model types: Regular MPL & “MiniMPL”
- Single wavelength 532 or 527 nm, for DAQ operated at 30 m vertical and 1 minute time resolutions

Photo credit: Sigma Space
MPLs in the field for DISCOVER-AQ

- Ft. Collins
- Porterville, CA
- Essex, MD
- Fairhill, MD
- NOAA ship, Chesapeake Bay
- Huron, CA
### Summary of DISCOVER-AQ MPL Sites

- 30 meter vertical, 1 minute time resolution
- Typically located at P3 spiral locations
- Geo-CAPE NOAA ship in 2011 (see Tzortziou et al., Journal of Atmospheric Chemistry, April 2013)
- Additional wide-field receiver used in-field for California 2013, Houston 2013, Denver 2014 to help with near-range signal and calibration
- Sites are not part of NASA’s MPLNET network, data available in DISCOVER-AQ archive
- Eleven different sites, ~600 hours of data/site, ~360,000 profiles

### DISCOVER-AQ MPL sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Lat/Lon</th>
<th>Owner/Model/Serial</th>
<th>Dates of operation</th>
<th>Depol?</th>
<th>Host</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baltimore-Washington 2011</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Beltsville</td>
<td>39.0562, -76.87540</td>
<td>Sigma Space/MiniMPL/5004</td>
<td>July 11 to Aug 2</td>
<td>Y</td>
<td>Howard Univ.</td>
</tr>
<tr>
<td>Essex</td>
<td>39.31095, -76.47449</td>
<td>Sigma Space/MiniMPL/5003</td>
<td>July 21 to Aug 3</td>
<td>Y</td>
<td>MDE</td>
</tr>
<tr>
<td>Edgewood</td>
<td>39.41014, -76.29682</td>
<td>Sigma Space/MiniMPL/5002</td>
<td>June 28 to Aug 15</td>
<td>Y</td>
<td>Penn State</td>
</tr>
<tr>
<td>Fairhill</td>
<td>39.70140, -75.85995</td>
<td>Sigma Space/MPL/4111</td>
<td>June 29 to July 31</td>
<td>Y</td>
<td>NASA GSFC SMART trailer</td>
</tr>
<tr>
<td><strong>NOAA ship/Chesapeake Bay</strong></td>
<td>Misc</td>
<td>Sigma Space/MiniMPL/5003</td>
<td>July 14 to July 20</td>
<td>Y</td>
<td>NOAA Vessel SRVx</td>
</tr>
<tr>
<td><strong>California 2013</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Porterville</td>
<td>36.0319, -119.0551</td>
<td>UMBC/MPL/4021/Inc. extra near-range channel</td>
<td>Jan 11 to Feb 7</td>
<td>N</td>
<td>Penn State</td>
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<tr>
<td>Huron</td>
<td>36.2062, -120.1046</td>
<td>Millersville/MPL/111</td>
<td>Jan 14 to Feb 8</td>
<td>N</td>
<td>Millersville</td>
</tr>
<tr>
<td><strong>Houston 2013</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Smith Point</td>
<td>29.546, -94.7799</td>
<td>Millersville/MPL/111/Inc. extra near-range channel</td>
<td>Sept 1 to Sept 27</td>
<td>N</td>
<td>Millersville</td>
</tr>
<tr>
<td><strong>Denver 2014</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Ft. Collins</td>
<td>40.5930, -105.1414</td>
<td>Millersville/MPL/411</td>
<td>July 16 to Aug 9</td>
<td>Y</td>
<td>Millersville</td>
</tr>
<tr>
<td>Platteville</td>
<td>40.1828, -104.7261</td>
<td>Sigma Space/MPL/5002</td>
<td>July 18 to Aug 11</td>
<td>Y</td>
<td>Penn State</td>
</tr>
<tr>
<td>NREL-Golden</td>
<td></td>
<td>UMBC/MPL/4021</td>
<td>July 16 to Aug 11</td>
<td>N</td>
<td>UMBC</td>
</tr>
</tbody>
</table>
How to Find DISCOVER-AQ MPL Data

Select campaign region
To find MPL data need to know specific site name
Then under BERKOFF.TIM/

All files are publicly available, except Colorado 2014, expected public release in early 2015

Data format is H5, daily quicklook images in .png

Archive Website: http://www-air.larc.nasa.gov/missions/discover-aq/discover-aq.html
Overlap and afterpulse for each MPL system are different, require careful calibration and validation to obtain quantitative boundary layer aerosol information.
MPL Data for DISCOVER-AQ

Post-campaign NRBs re-processed with updated overlap calibrations and placed in the archive, H5 format. Daily images also uploaded to archive.

For the lidars with depolarization, raw cross-pol data was placed in the archive, but not converted quality checked data product.

From the NRB data, it is possible to:
- Generate mixed layer height, an indicator of PBL height during daytime (see Compton et al., Scarino et al.)
- Use Fernald-Klett inversion with co-located AERONET AOD to get average S-ratio and generate aerosol backscatter $\beta(r)$ & aerosol extinction $T(r)$ profiles.

For descrip. of lidar inversion methods see:
Multi-site Data Example from July 19, 2011

AERONET July 19 AOD map

NOAA Vessel SRVx - National Marine 501

MPL ship data is also available in KMZ format
Recovery of near-surface signal with wide field-of-view (WFOV) receiver

- San Joaquin Valley has extremely low PBL, so low that standard MPL channel would not ordinarily capture aerosol dynamics
- WFOV overlap very short
- WFOV implemented at some DAQ sites in California, Houston, & Denver to enable on-site cals and better retrievals of near-field (< 1 km) aerosols
Airborne HSRL
Aerosol Measurements

HSRL Technique:
- Independently measures aerosol backscatter, extinction, and optical thickness

DISCOVER-AQ (July 2011)
- 25 science flights
- ~100 science hours
- HSRL “curtains” provide:
  - measurement of horizontal and vertical variability over domain
  - vertical context for surface and satellite column measurements

HSRL Aerosol Data Products:
- Backscatter coefficient (532, 1064 nm)
- Depolarization (532, 1064 nm)
- Extinction Coefficient (532 nm)
- Optical Depth (AOD) (532 nm)
- Planetary Boundary Layer (PBL) Height
Comparisons to NASA’s HSRL airborne data
Aerosol Extinction Retrieval for July 5 Edgewood “MiniMPL”

Example Aerosol Extinction Comparisons with LARC Airborne HSRL
Example MPL Comparisons to NASA’s airborne HSRL spatially coincident (< 5 km) extinction profiles

Edgewood MPL (green) & airborne HSRL (blue) coincident profiles

Altitude 0 to 6 [km]

Extinction coefficient, 0 to 0.25 [km\(^{-1}\)]
MPL Determination of Daytime PBL growth

From Compton et al., *J. Atmos. Oceanic Technol.*, **30**, 1566–1575

\[
y = (0.83 \pm 0.06)x + (0.21 \pm 0.09)
\]

\[
R^2 = 0.92 \quad \text{Bias} = -0.02 \pm 0.18
\]

\[N = 17\]
Smoke Transport Case July 17-20, 2014

July 17
Millersville MPL at Ft. Collins West
2014-07-17 to 2014-07-18 UTC

July 18
Millersville MPL at Ft. Collins West
2014-07-18 to 2014-07-19 UTC

July 19
Millersville MPL at Ft. Collins West
2014-07-19 to 2014-07-20 UTC

July 20
Millersville MPL at Ft. Collins West
2014-07-20 to 2014-07-21 UTC

NOAA HYSPLIT MODEL
Backward trajectories ending at 0000 UTC 18 Jul 14
GDAS Meteorological Data

NOAA HYSPLIT MODEL
Backward trajectories ending at 0600 UTC 18 Jul 14
GDAS Meteorological Data

Smoke? smoke?
- Depicts a defined LLJ “core” from 04-08 UTC of >10 m/s from the surface to near 1500 m AGL. Red arrow estimates center of core.
- The dramatic turning of the winds is also apparent.
MPL Backscatter with HRDL Overlay

July 19, 2014: Porterville MPL Backscatter W/ HDRL winds
Studies using DISCOVER-AQ MPL data


- Hoff et al., Evaluation of Extinction Profiles and Aerosol Optical Depth from Multisensor Data in the Baltimore-Washington DISCOVER-AQ Experiment and Comparison with WRF/CHEM, In prep

- Scarino et al., Mixed Layer Heights and Aerosol Products derived for the NASA LaRC Airborne High Spectral Resolution Lidar during the 2011 DISCOVER-AQ Field Campaign, In prep
During DAQ, MPLs collected data at eleven different sites resulting in ~250 days of data, ~360,000 vertical backscatter profiles.

Complimented by many other ground and aircraft trace-gas and aerosol measurements at four different DAQ regions in the U.S.


MPL 2011 data also have aerosol extinction retrievals & mixed-layer height products, with further processing same could also be generated for remaining data (California, Houston, & Denver)

Contributed to a range of studies including: PBL heights, cloud-aerosol interactions, trace gas, aerosol models & transport

To ensure best use of data please contact:

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