



Micro-Pulse Lidar Network (MPLNET): 10 Years of Trying to Imitate AERONET

Principal Investigator:

Judd Welton, NASA GSFC Code 613.1

Instrumentation & Network Management:

Sebastian Stewart, SSAI GSFC Code 613.1

Data Processing & Analysis:

Larry Belcher, UMBC GSFC Code 613.1

Tim Berkoff, UMBC GSFC Code 613.1

James Campbell, UCAR/Naval Research Lab

Administrative Support:

Sonia Cyrus, SSAI GSFC Code 613.1

GLAS Validation Activities:

Jim Spinhirne, formerly NASA GSFC Code 613.1

Judd Welton, Tim Berkoff

CALIPSO Validation Activities:

Judd Welton, Tim Berkoff, James Campbell

AERONET & Synergy Tool Partnership:

Brent Holben, NASA GSFC Code 614.4

Dave Giles, NASA GSFC Code 614.4

NASA SMART-COMMIT Field Deployments:

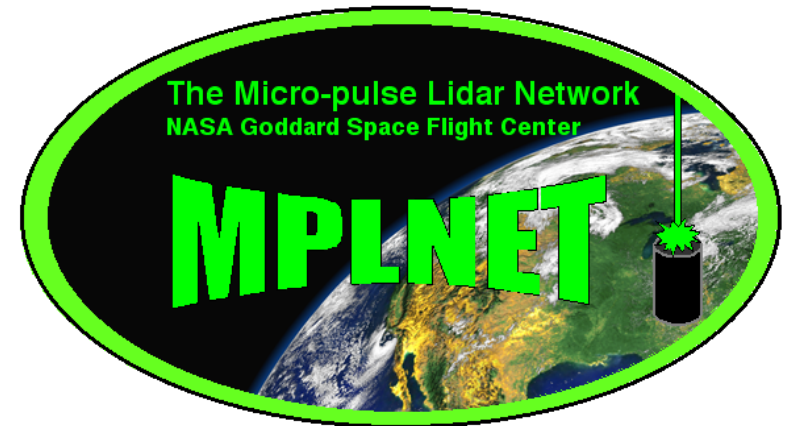
Si-Chee Tsay, NASA GSFC Code 613.2

Jack Ji, UMCP GSFC Code 613.2

Site Operations & Science Investigations

.... many network partners around the world

MPLNET is funded by the NASA Radiation Sciences Program and the Earth Observing System



MPLNET information and results shown here are the result of efforts by all of our network partners!

The Micro Pulse Lidar Network (MPLNET): Overview



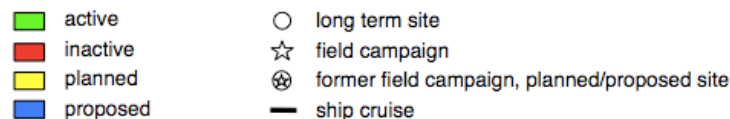
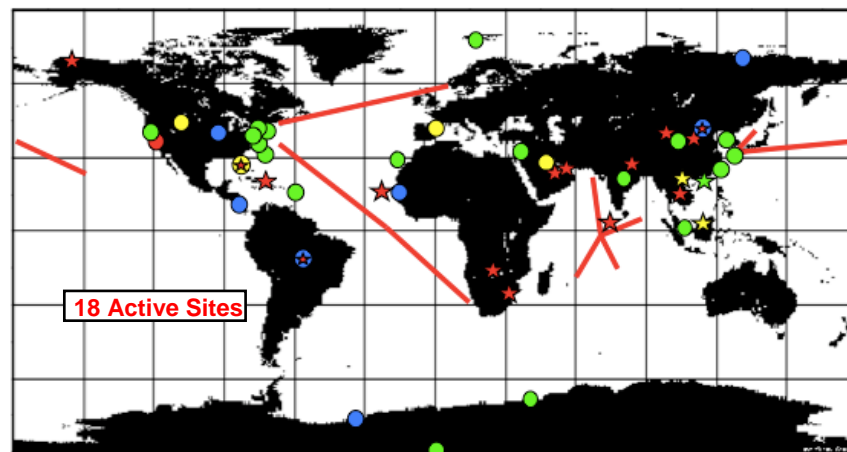
South Pole MPLNET Site:
1999-current



Micro Pulse Lidar
(GSFC Patent)



MPLNET Sites: 2000 - current



* most sites co-located with AERONET

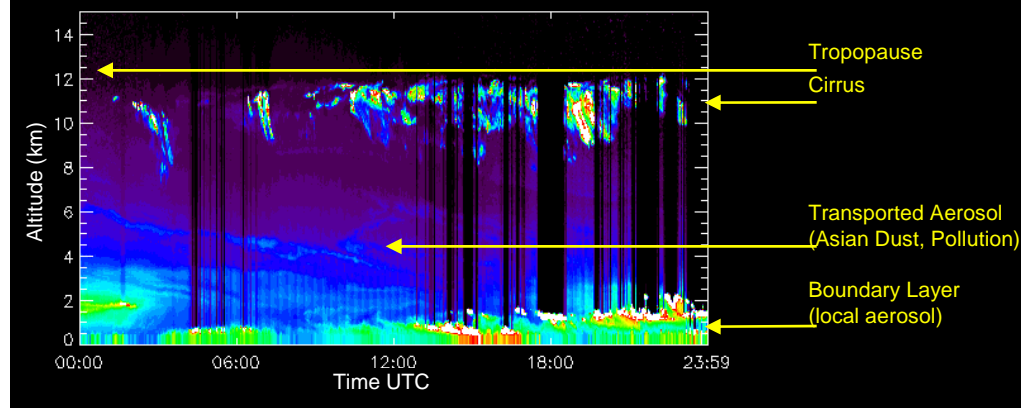
MPLNET:

- A federated network of micro pulse lidar sites around the world, coordinated and lead from Goddard Space Flight Center
- **Co-location with related networks, including NASA AERONET**
- Local, regional, and global scale contributions to atmospheric research
- Satellite validation
- Aerosol climate and air quality model validation
- Impact of aerosol & cloud heights on direct and indirect climate effects
- Support for wide variety of field campaigns

What's New?

- Version 2 products released 2008
- Continue active publication record (+40 papers since 2000)
- Barbados site activated in 2008
- IIT Kanpur and Singapore sites activated in 2009
- Dongsha Island temporary site Feb – March 2010, one or two more temporary sites in SE Asia in support of 7-SEAS campaign
- Other planned sites in 2010: Qatar, Spain, Miami, NYC

Example of MPLNET Level 1 Data: Atmospheric Structure

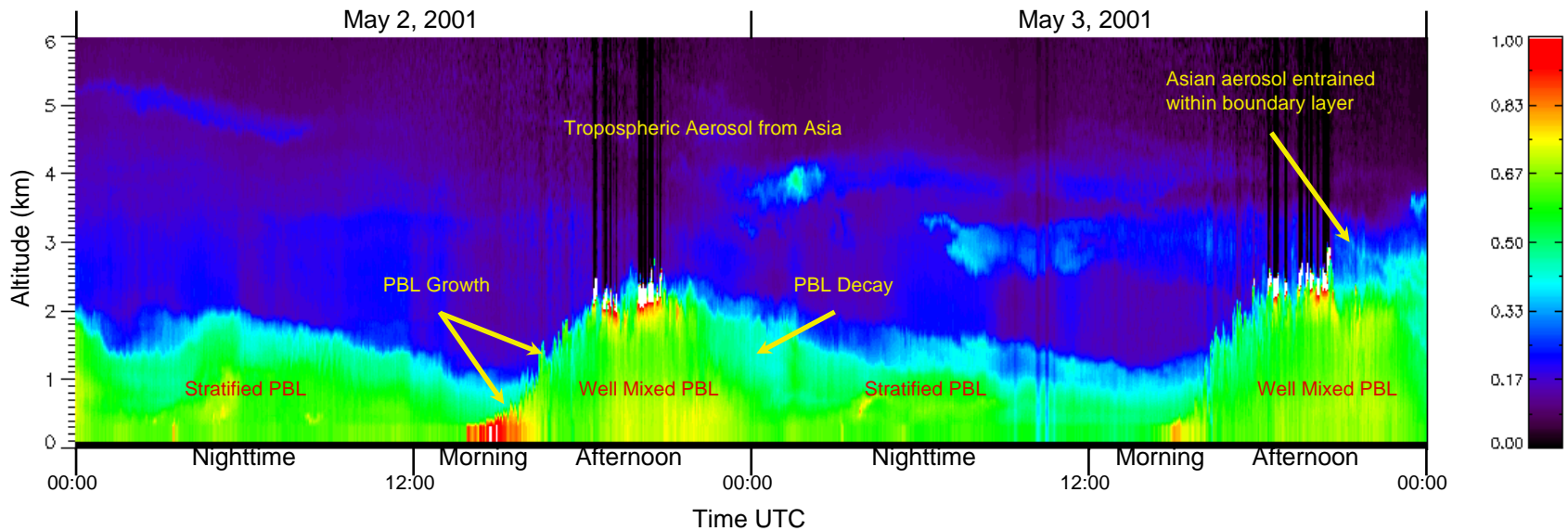


<http://mplnet.gsfc.nasa.gov>



MPLNET Data Products

Level 1 MPLNET Signals from NASA Goddard



MPLNET Data Products:

† near real time: 1 hour or 1 day

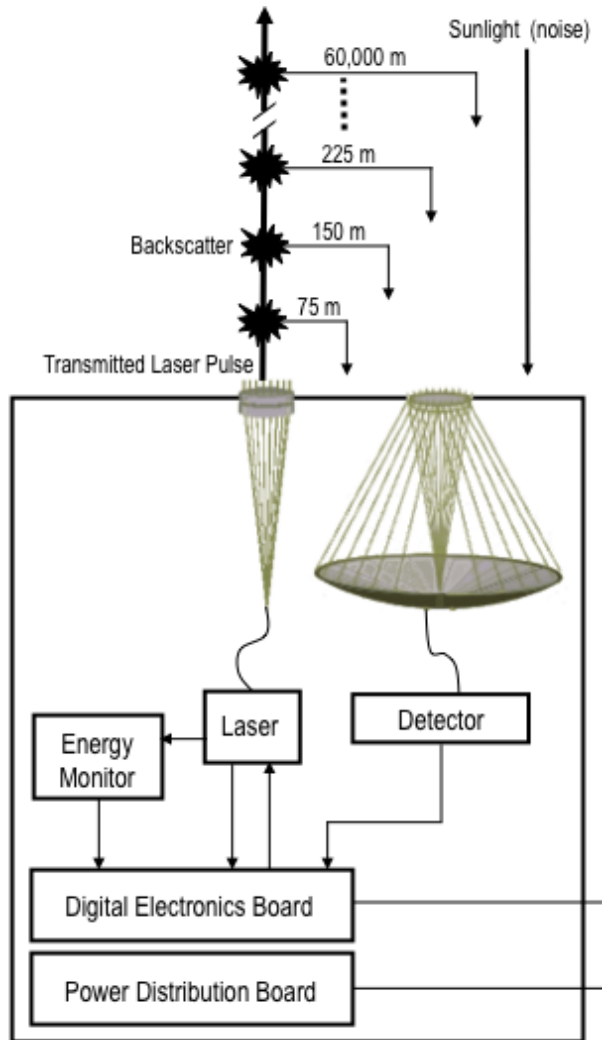
- Level 1 NRB Signals, Diagnostics
(near real time, no quality screening)
- Level 1.5 Level 1.5b: Aerosol, Cloud, PBL Heights and Vertical Feature Mask
Level 1.5a: Aerosol Backscatter, Extinction, Optical Depth Profiles and Lidar Ratio
(near real time, no quality screening)
- Level 2 Operational Products Under Development (beta data available upon request)
(not real time, quality assured)

All data are publicly available in netcdf format. Errors included for all data products.

Data policy same as AERONET. We are a federated network, individual site providers deserve credit.



Lidar Basics: Level 0 and Level 1 Data



Level 0, Raw Lidar Signal (counts/time):

$$P_{\text{RAW}}(r) = \left\{ \frac{O(r)E}{Dr^2} C\beta(r) e^{-2\int_0^z \sigma(r') dr'} \right\} + \frac{N_s + N_d}{D}$$

$$P_{\text{MPL}}(r) = \left\{ \frac{O(r)E}{Dr^2} C\beta(r) e^{-2\int_0^z \sigma(r') dr'} \right\} + \frac{A(r)}{D} + \frac{N_s + N_d}{D}$$

Overlap often insignificant for airborne and satellite lidar, not for ground-based lidar (especially the MPL)

Level 1 Signal:

$$P_{\text{NRB}}(r) = C(\beta_M(r) + \beta_P(r)) e^{-2\int_0^z \sigma_M(r') dr'} e^{-2\int_0^z \sigma_P(r') dr'}$$

$$P_{\text{ABS}}(r) = (\beta_M(r) + \beta_P(r)) e^{-2\int_0^z \sigma_M(r') dr'} e^{-2\int_0^z \sigma_P(r') dr'}$$

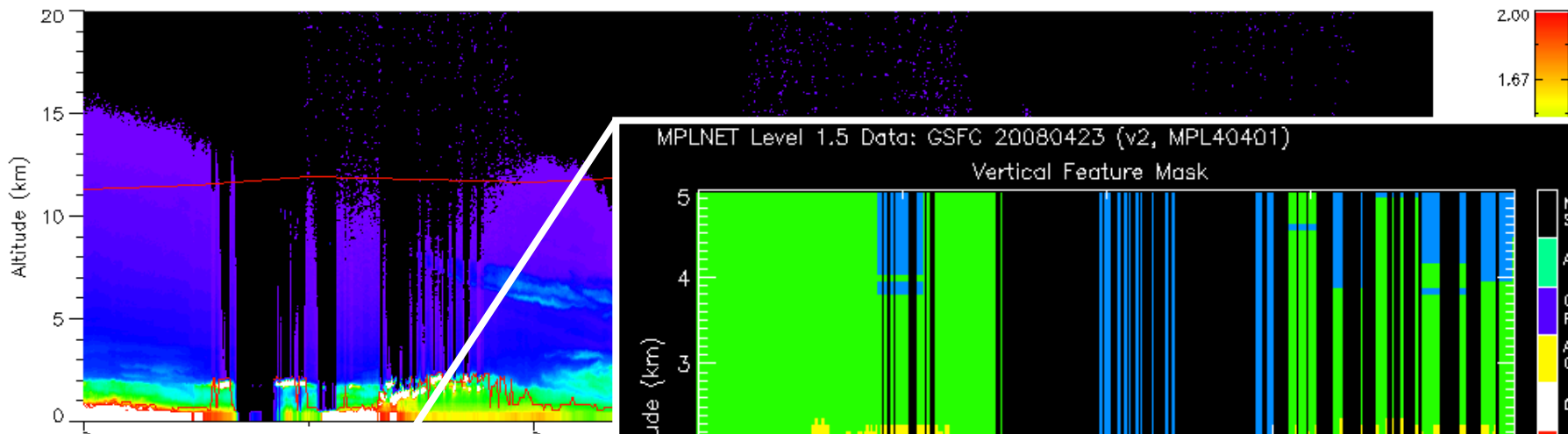
Level 1 data often reported as calibrated Attenuated Backscatter (km sr^{-1}) for airborne and satellite lidar

It is typically more challenging to calibrate (C) ground-based lidar because initial signal data are not acquired in the upper free trop (MPLNET level 1 data are NRB)

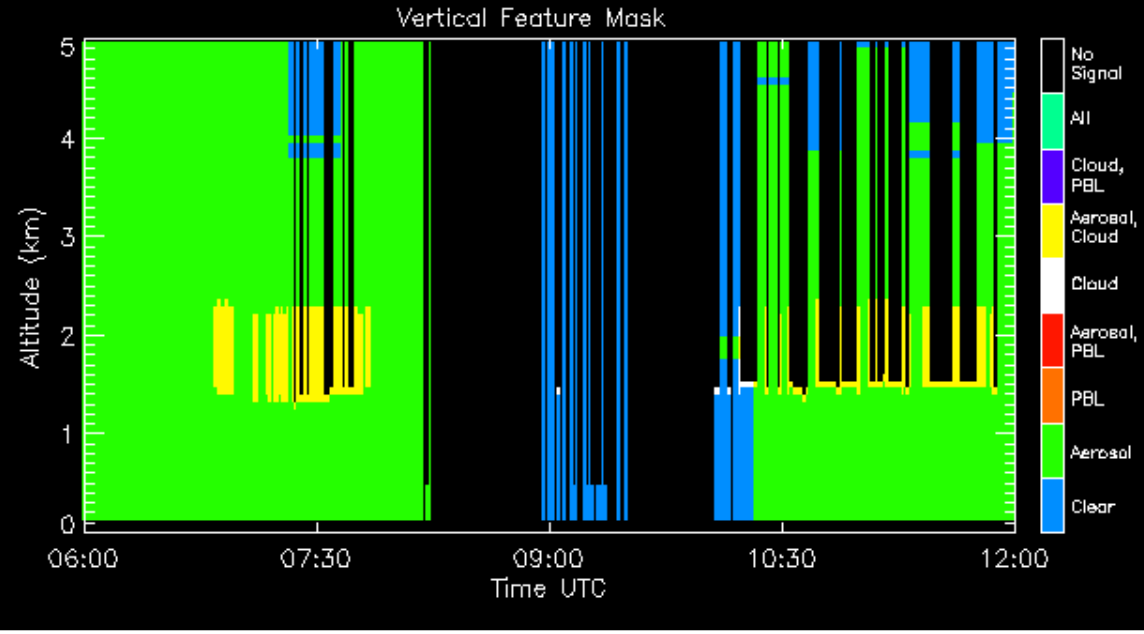


The Micro Pulse Lidar Network (MPLNET): Products

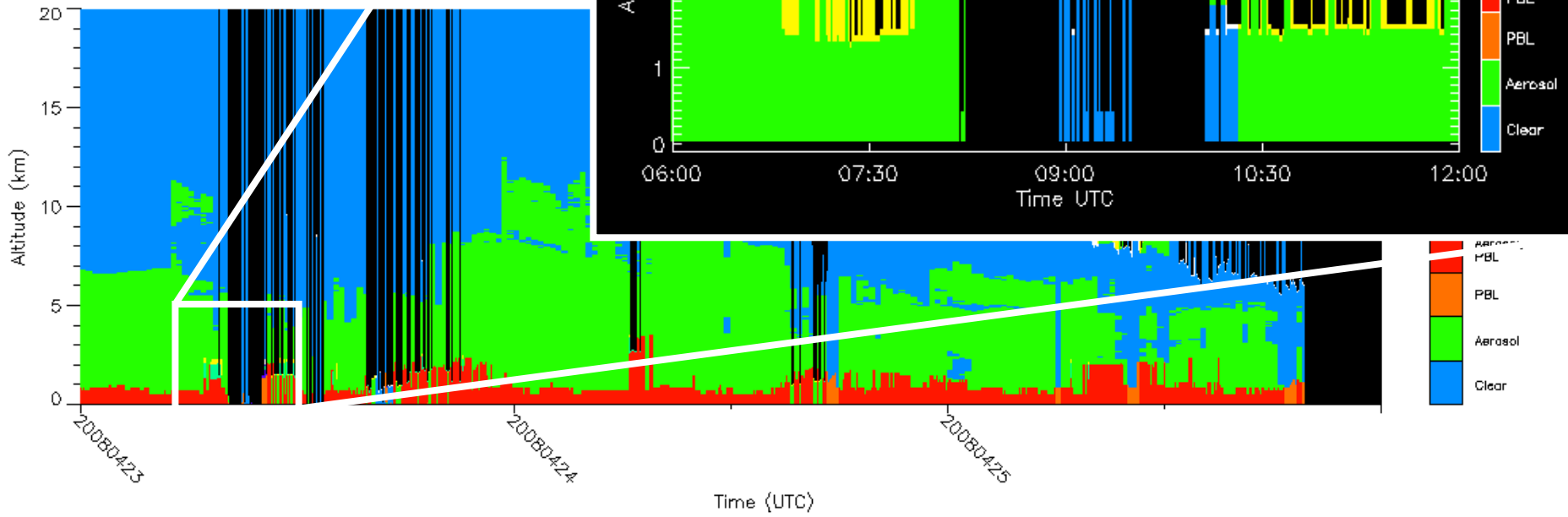
MPLNET Level 1.0 NRB: GSFC



MPLNET Level 1.5 Data: GSFC 20080423 (v2, MPL40401)



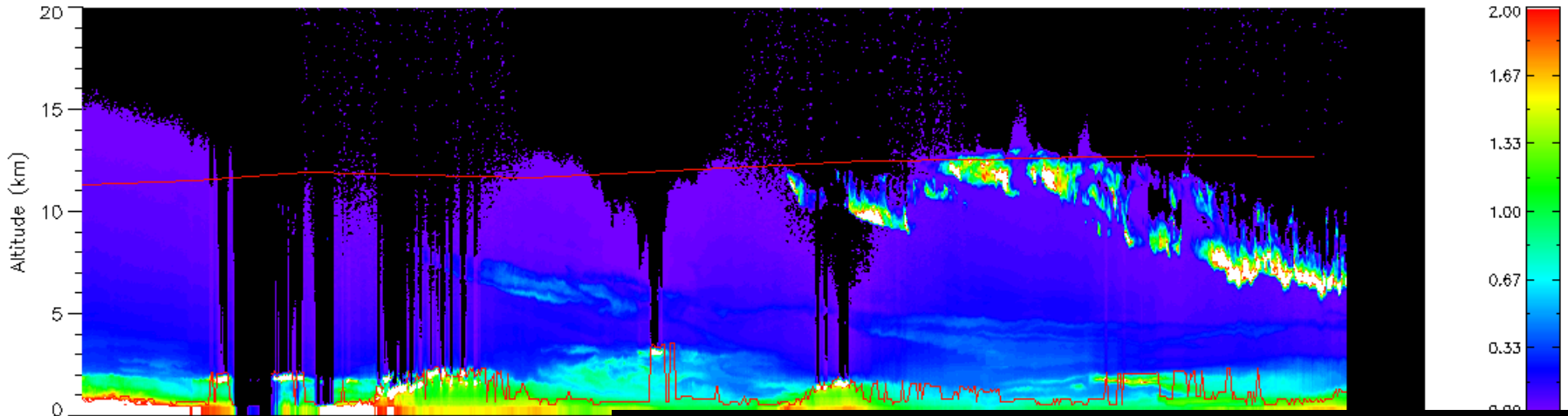
MPLNET Level 1.5b Vertical Feature Mask: GSFC





The Micro Pulse Lidar Network (MPLNET): Products

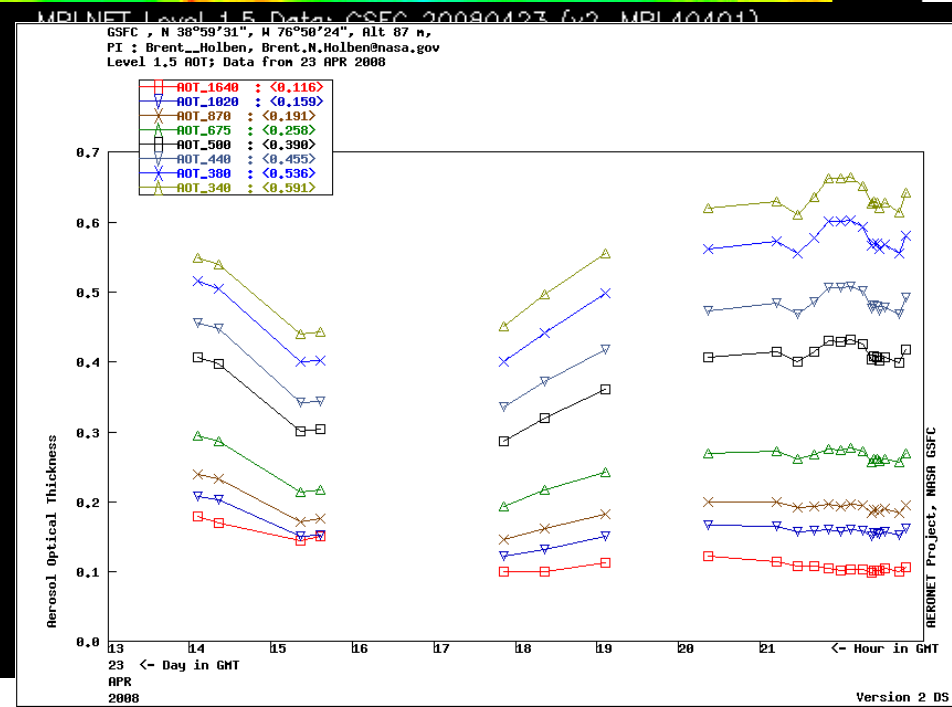
MPLNET Level 1.0 NRB: GSFC



Aerosol Properties:

1st Step: Retrievals at coincident AERONET AOD observations (daytime only)

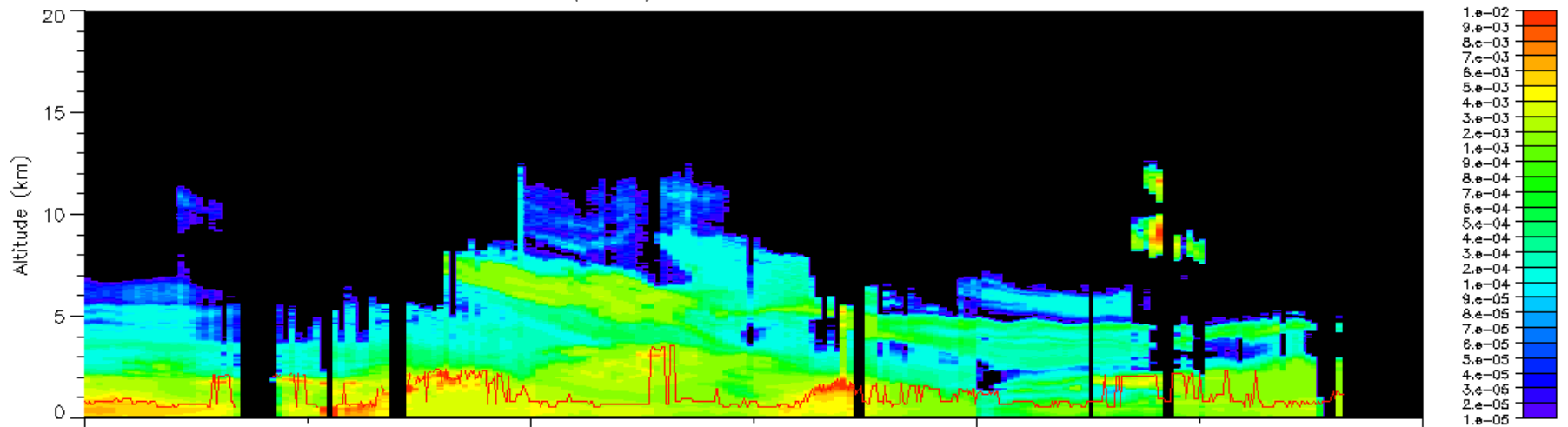
Using constrained Fernald solution (Welton et al. 2000)



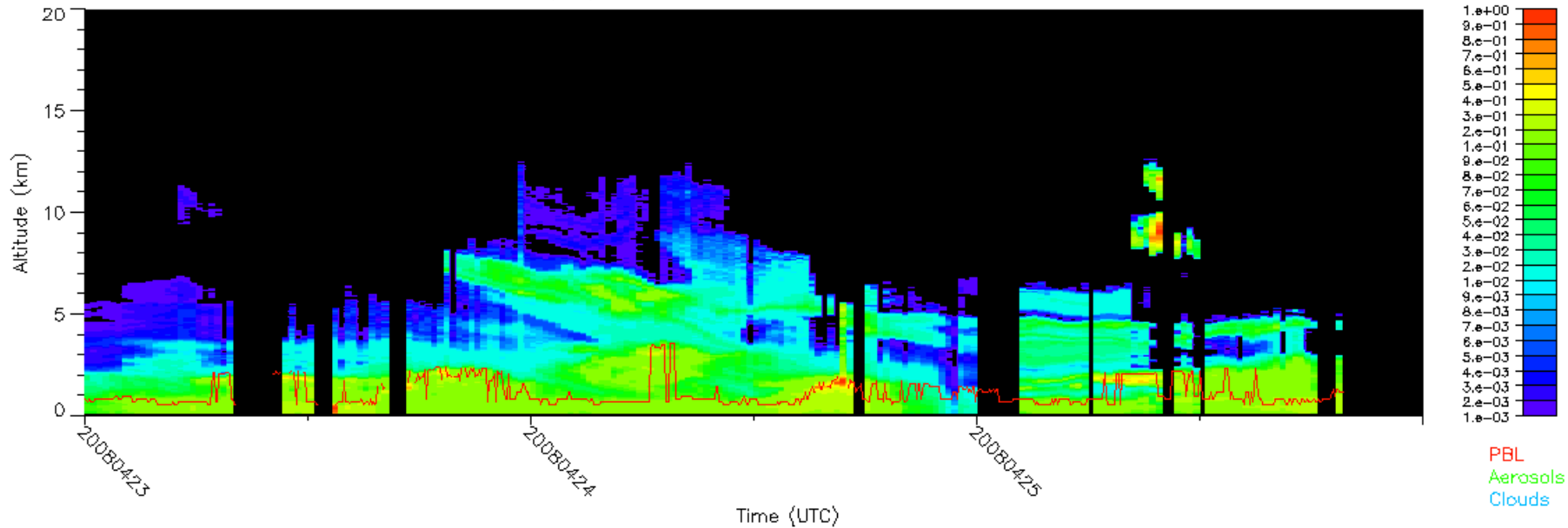


The Micro Pulse Lidar Network (MPLNET): Products

MPLNET Level 1.5a Aerosol Backscatter (km*sr)⁻¹: GSFC



MPLNET Level 1.5a Aerosol Extinction (km)⁻¹: GSFC

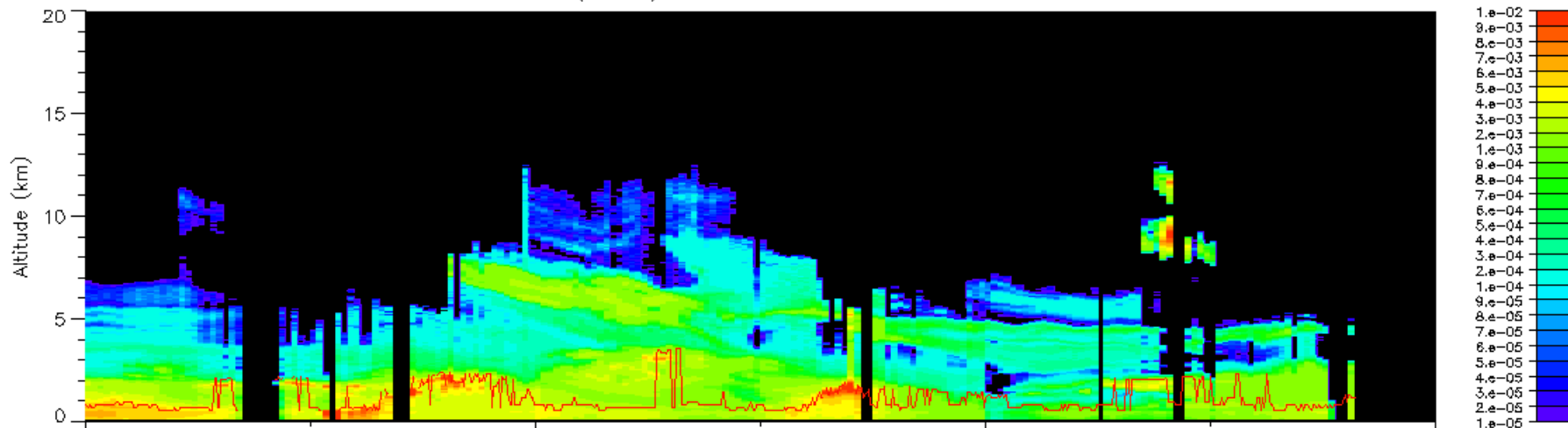


PBL
Aerosols
Clouds

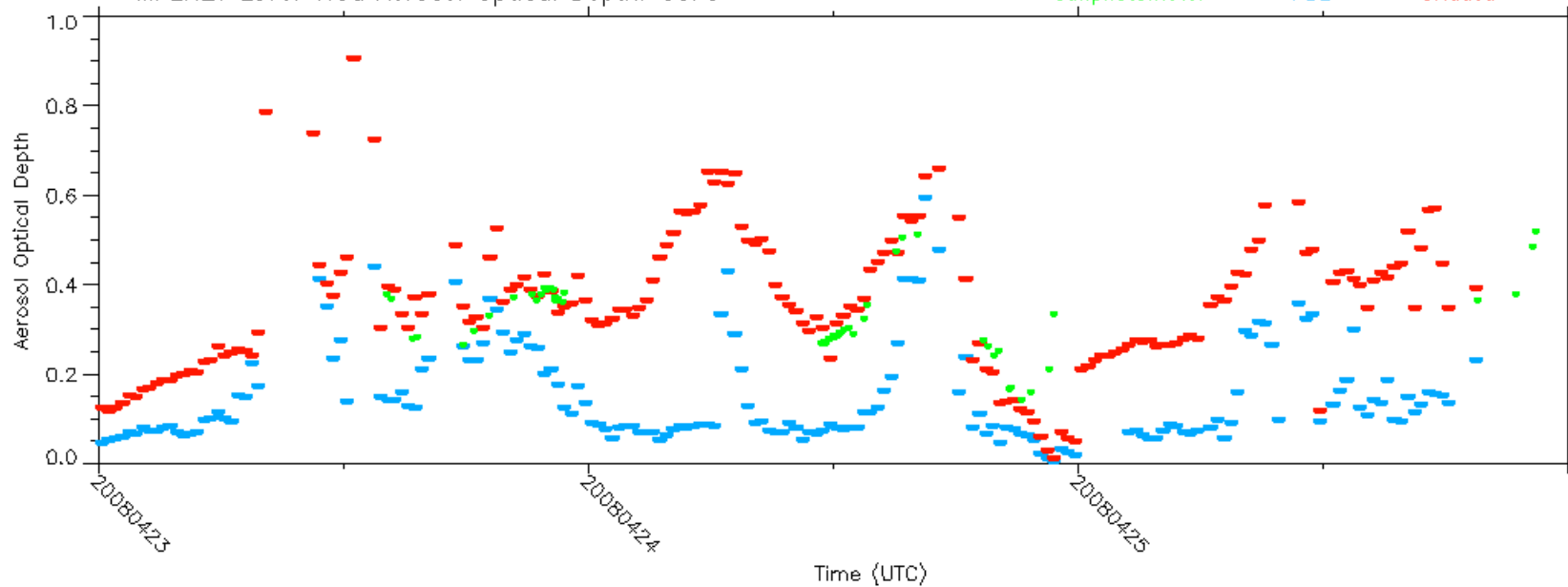


The Micro Pulse Lidar Network (MPLNET): Products

MPLNET Level 1.5a Aerosol Backscatter (km*sr)⁻¹: GSFC



MPLNET Level 1.5a Aerosol Optical Depth: GSFC





The Micro Pulse Lidar Network (MPLNET): Validation

Validation of MPLNET Aerosol Products

How well do state-of-the-art techniques measuring the vertical profile of tropospheric aerosol extinction compare?

B. Schmid, R. Ferrare, C. Flynn, R. Elleman, D. Covert, A. Strawa, E. Welton, D. Turner, H. Jonsson, J. Redemann, J. Eilers, K. Ricci, A. G. Hallar, M. Clayton, J. Michalsky, A. Smirnov, B. Holben, and J. Barnard, *J. Geophys. Res.*, 111, D05S07, doi:10.1029/2005JD005837, 2006.

Aerosol Extinction & Optical Depth profiles compared in comprehensive study:

- MPLNET (column AOT anchored to AERONET)
- MPL from ARM
- Airborne Ames Sunphotometer (AATS)
- Airborne in-situ (nephelometer & absorption photometer)
- Airborne cavity ring-down system (Cadenza)
- Ground-based Raman lidar (CARL)

AATS used as truth

- AATS is most direct measure of AOT profile
- AATS Column AOT within 2% of AERONET

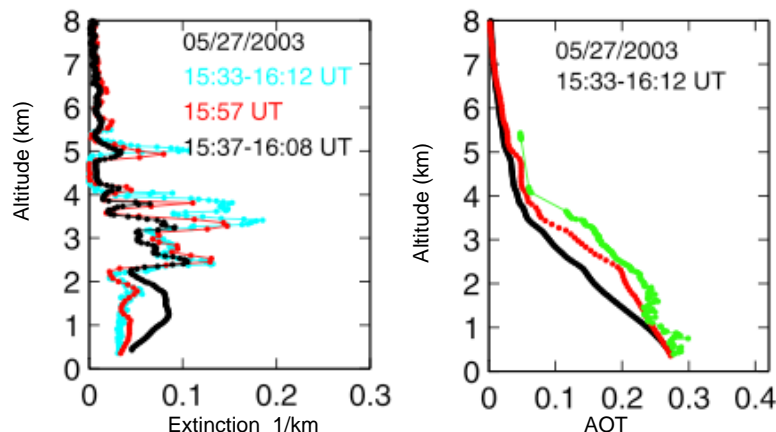


AATS-14 shown above

Example Comparisons from study (25 Days total).

Also surveyed past 7 field campaigns of such work.

MPLNET
MPL ARM
Neph/PSAP
AATS



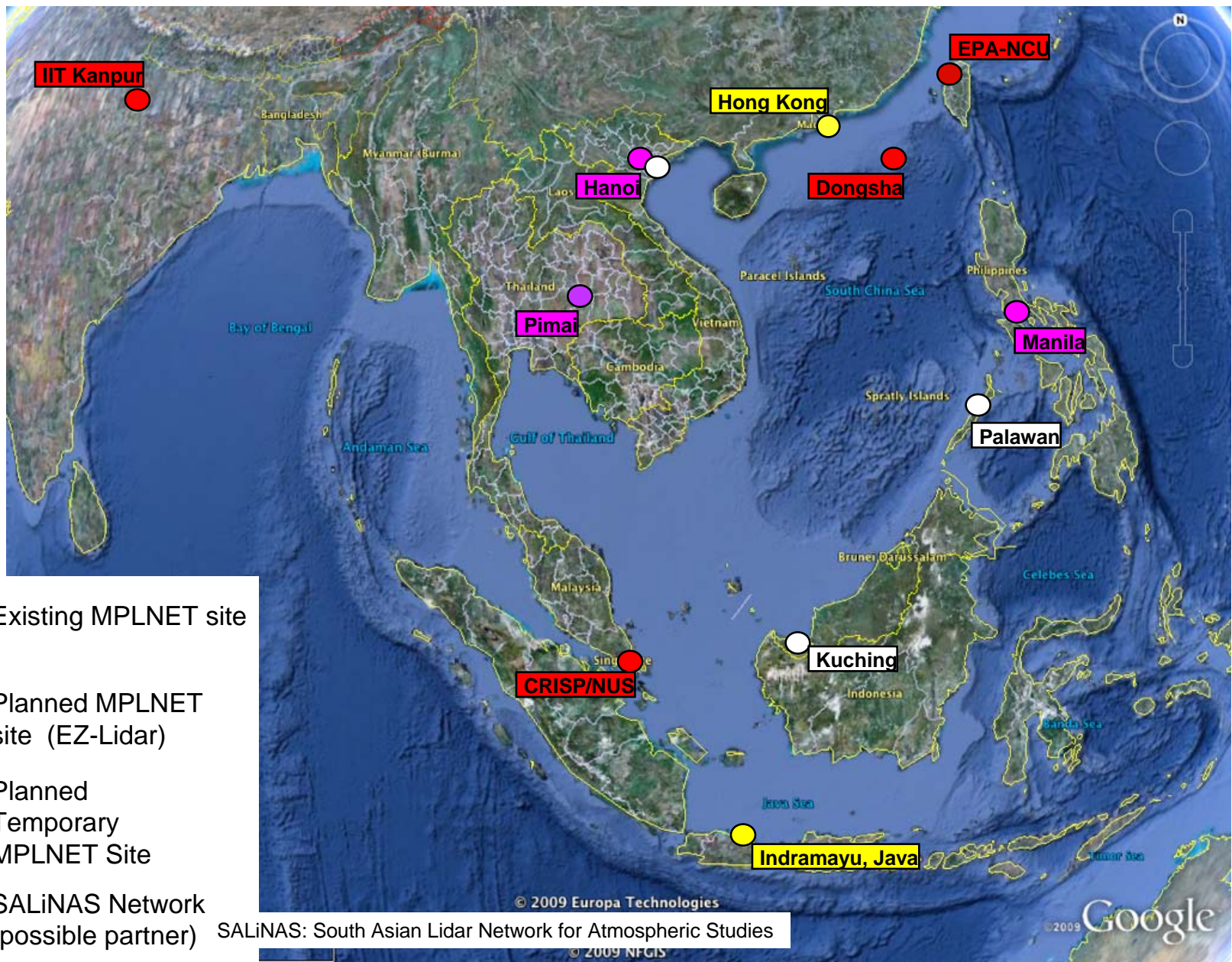
Summary of Study Results: MPLNET among best performers

Instrument (visible wavelengths, ~520 nm)	Bias Error relative to AATS
Cadenza	- 13%
Neph / PSAP	- 15%
MPLNET	+ 13%
MPL ARM	+ 24%
CARL (Raman)	+ 54%
Neph / PSAP Mean from 7 Campaigns	- 17%
Size Dist. Derived Mean from 3 Campaigns	- 18%
MPLNET Mean from 5 Campaigns	< + 20% (work in progress)

Conclusion: state-of-the-art techniques remain 15 - 20% uncertain

MPLNET meets or exceeds that target range

MPLNET: Future Plans 2010-2012 (AMY, 7-SEAS, and PAC³E)



● Existing MPLNET site

● Planned MPLNET site (EZ-Lidar)

○ Planned Temporary MPLNET Site

● SALiNAS Network (possible partner)

SALiNAS: South Asian Lidar Network for Atmospheric Studies

© 2009 Europa Technologies

© 2009 NFGIS

© 2009 Google

MPLNET: Website, Browse Tools, and Data Downloads



The Micro-pulse Lidar Network MPLNET

http://mplnet.gsfc.nasa.gov/data.html

Indramayu, West Java

NASA MPLNET CALIPSO AERONET Giovanni GLAS Quicklooks STRAT Welton Yahoo! Gmail Apple Google WBAL Traffic RT-295 News Apple

Sciences and Exploration Directorate
Earth Science Division

GODDARD SPACE FLIGHT CENTER
http://mplnet.gsfc.nasa.gov/cgi-bin/Mplnet/site_p...corr=no&idealtempmlider=0.0&thermalcorrscaler=1.0

The Micro Pulse Lidar Network
MPLNET

HOME

Data

- SITES
- PRODUCT INFO
- DATA POLICY
- DOWNLOADS

MPLNET Level 1.5 Data: GSFC 20080424 (v2, MPL40401)
Vertical Feature Mask

Altitude (km) vs Time UTC

Legend:

- No Signal
- All
- Cloud, PBL
- Aerosol, Cloud
- Cloud
- Aerosol, PBL
- PBL
- Aerosol
- Clear

2.00
1.67
1.33
1.00
0.67
0.33
0.00

View Products:

Level: 1.5 Signal: yes Mask: yes

Clouds: yes Aerosols: yes PBL: yes

Contour Controls:

Altitude (km): 0 to 20 Signal: 0.0 to 2.000

Times (HHMM): 0000 to 2359 Contour Levels: 80

Plot Buttons:

Contour Line

Cloud Properties

FIRSTGov

Privacy Policy and Important Notices

NASA

Curator: Larry R. Belcher
NASA Official: Elsworth J. Welton

MPLNET: Website, Browse Tools, and Data Downloads



The Micro-pulse Lidar Network MPLNET

http://mplnet.gsfc.nasa.gov/data.html

NASA MPLNET CALIPSO AERONET Giovanni GLAS Quicklooks STRAT Welton Yahoo! Gmail Apple Google WBAL Traffic RT-295 News Apple

Sciences and Exploration Directorate
Earth Sciences Division

http://mplnet.gsfc.nasa.gov/cgi-bin/Mplnet/site_p...2359&levels=80&staff=no&browse=safari&start=yes

MPLNET Level 1.5a Data: GSFC 20080424 (v2, MPL40401)
Aerosol Backscatter (km^*sr)-1 (527.0 nm)

Altitude (μm)

Time UTC

MPLNET Level 1.5a Data Products:

Product: Aerosol Backscatter (km^*sr)-1
 Aerosol Extinction km^{-1}
 Aerosol Optical Depth Profiles
 Aerosol Lidar Ratio (sr)
 Column Aerosol Optical Depth
 PBL Aerosol Optical Depth
 MPL Calibration Value

Altitude: _____

Max: _____

Times (HHMM): 0000 to 2359

Plot Buttons:

Plot

Aerosol Properties

Cloud Properties

SUNPHOTOMETER TIMES

- Sunphotometer Times
- 11:24 UTC
- 11:31 UTC
- 11:39 UTC
- 11:48 UTC
- 11:50 UTC
- 11:53 UTC
- 11:58 UTC
- 12:04 UTC
- 12:13 UTC
- 12:19 UTC
- 12:21 UTC
- 12:31 UTC
- 12:44 UTC
- 12:58 UTC
- 13:30 UTC

FIRSTGov | Privacy Policy and Important Notices | NASA

MPLNET: Website, Browse Tools, and Data Downloads



The Micro-pulse Lidar Network MPLNET

http://mplnet.gsfc.nasa.gov/data.html

NASA MPLNET CALIPSO AERONET Giovanni GLAS Quicklooks STRAT Welton Yahoo! Gmail Apple Google WBAL Traffic RT-295 News Apple

NASA GODDARD SPACE FLIGHT CENTER

- Sciences and Exploration Directorates
- Earth Sciences Division
- Laboratory for Atmospheres
- Mesoscale Atmospheric Processes Homepage

The Micro Pulse Lidar Network
MPLNET

HOME DATA OPERATIONS INSTRUMENTS PUBLICATIONS PEOPLE

Data

- SITES
- PRODUCT INFO
- DATA POLICY
- DOWNLOADS

GSFC

Latitude: 39.01667
Longitude: -76.86670
Elevation: 0.0500 km

Principal Investigator:
Judd Welton
Onsite Contact:
Sebastian Stewart

Email:
[E & Contact](#)

Site Description: [View](#)

Browse Data:

[Systems Tool](#) or Quicklooks:

Version: [what is this?](#)

Year:

Month:

Day:

Download Data:

MPLNET Level 1.0 Data: GSFC 20080424 (v2, MPL40401)
Normalized Relative Backscatter (527.0 nm)

MPLNET Data Products
Products Available: 1.0, 1.5a, 1.5b

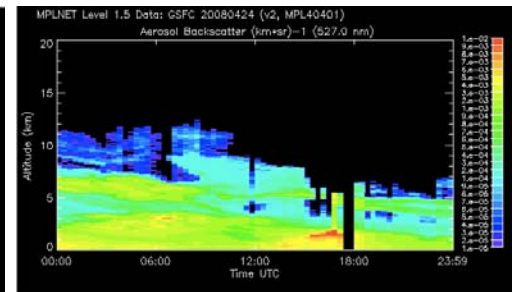
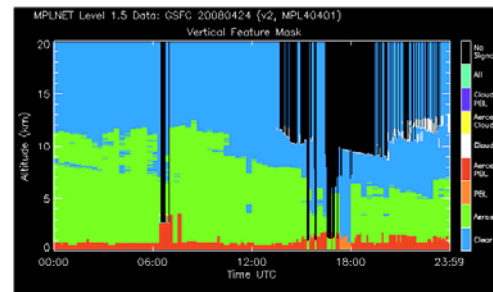
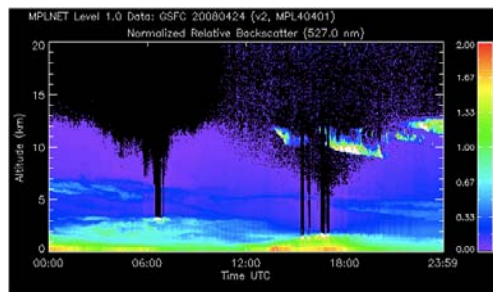
Signals & Diagnostics	<input type="button" value="Level 1.0"/>	<input type="button" value="Custom Plots"/>	<input type="button" value="Diagnostics"/>
Layer Heights & Classification	<input type="button" value="Level 1.5b"/>	<input type="button" value="Layers"/>	<input type="button" value="Feature Mask"/>
Aerosol Properties	Level 1.5a <input type="button" value="Sunphotometer Times"/>		
Cloud Properties	<input type="button" value="Gridded Data"/>		

FIRSTGOV [Privacy Policy and Important Notices](#) NASA Curator: Larry R. Belcher
NASA Official: Elsworth J. Welton

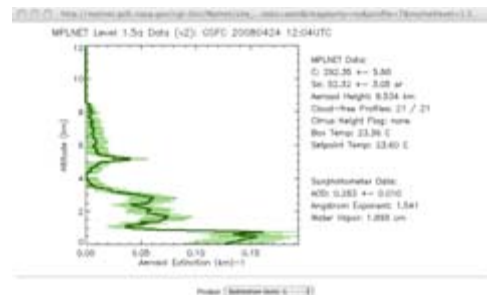


MPLNET: File Formats and Standardization

- All files in netcdf
- Daily archive per site
- Level 1 data rate: 1 minute, 75 meter vertical, 0 – 30 km
- Standard range grid for all data (Level 1 thru Level 2), site altitude provided to construct altitude array
- Level 1.5 temporal averaging required for layer heights and retrievals
 - clouds: 1 min, PBL: 5 min, aerosols: 20 min
 - Standard temporal array for Level 1, Level 1.5b VFM, and gridded Level 1.5a data
 - all data reported at 1 min regardless of data averaging for retrieval



- Varying temporal array for Level 1.5a sunphotometer constrained retrievals
 - all data represent 20 min averages about sunphotometer times





MPLNET: Large Data Requests

- Upon request, stage daily archive files on ftp server
 - Daily archive files not ideal for large requests
 - too many files, especially if request data from multiple sites
 - archive files contain all data products for given level (1, 1.5b, 1.5a) and various diagnostics
 - New user file format in development (also netcdf)
 - Turning point came after NCEP request for routine access to PBL heights, and
Paul Ginoux (GFDL) who asked for “everything”
 - Yearly data file containing one data product from all active sites that year
 - file updated daily or weekly (TBD)
 - e.g. One file containing all aerosol extinction profiles from all sites for 2009
 - only pertinent ancillary data and information added to file
 - all products conform to standard range grid
 - all products provided at native resolution (e.g. aerosol products at 20 minute intervals)
 - List of yearly product files in development
 - PBL height
 - aerosol top height
 - aerosol extinction profiles
 - aerosol backscatter profiles
 - aerosol lidar ratio
 - aerosol column AOD
 - aerosol PBL AOD
-



MPLNET: Conclusions

- MPLNET website: <http://mplnet.gsfc.nasa.gov>
 - MPLNET is part of the Synergy Tool, available through AERONET (and MPLNET) website
 - working to support EZ-Lidar sites in MPLNET framework, and synergy tool
 - future -> include independent lidar sites in synergy tool (added funding required)
 - plan to explore merged level 3 product using GEOS-5 aerosols (validation)
 - Other Lidar Networks
 - EARLINET, NIES, AD-NET, CISLiNET, REALM, CORALNet (regional focus), NDACC (global)
 - ALINE, SALINAS (new, mostly lidar enthusiasts, potential for coordinated operations)
 - WMO GAW effort to create a coordinated global lidar network of networks/stations
 - GAW Aerosol Lidar Observation Network (GALION)
 - Common ground based lidar issues for operational support
 - most sites are run by individuals contributing to a larger effort, coordinated at major center
 - network rep (ie, me for MPLNET) has difficulty offering network data to operational users unless consent provided by individual network partners
 - data policy conflicts... concern is that individual contributions lost in such large efforts
 - avoid lidar wow factor, define exactly what products/information you need from us (give me “everything” creates burden on us, and will likely create more problems for you than are solved)
 - do operational users want ground lidar for validation? assimilation? both?
 - JMA only presentation yesterday that used ground data for assimilation
-



Back Up Slides
