



# The NASA Micro-Pulse Lidar Network (MPLNET)

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## CALIPSO Validation Activities:

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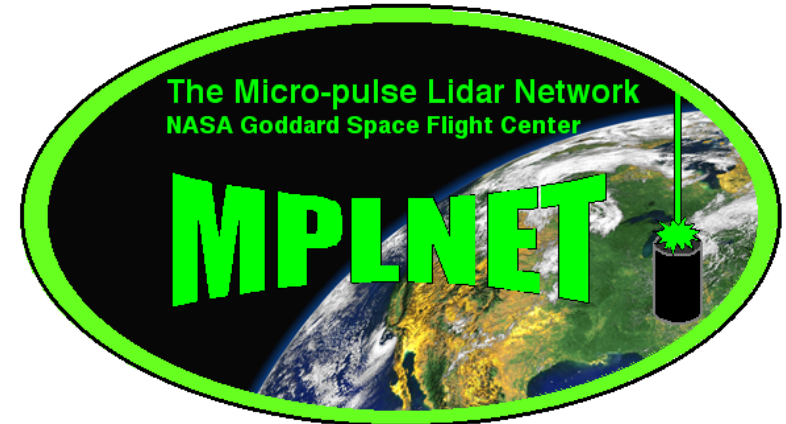
## NASA SMARTLABS Field Deployments:

Si-Chee Tsay, NASA GSFC Code 613

## Site Operations & Science Investigations

.... many network partners around the world

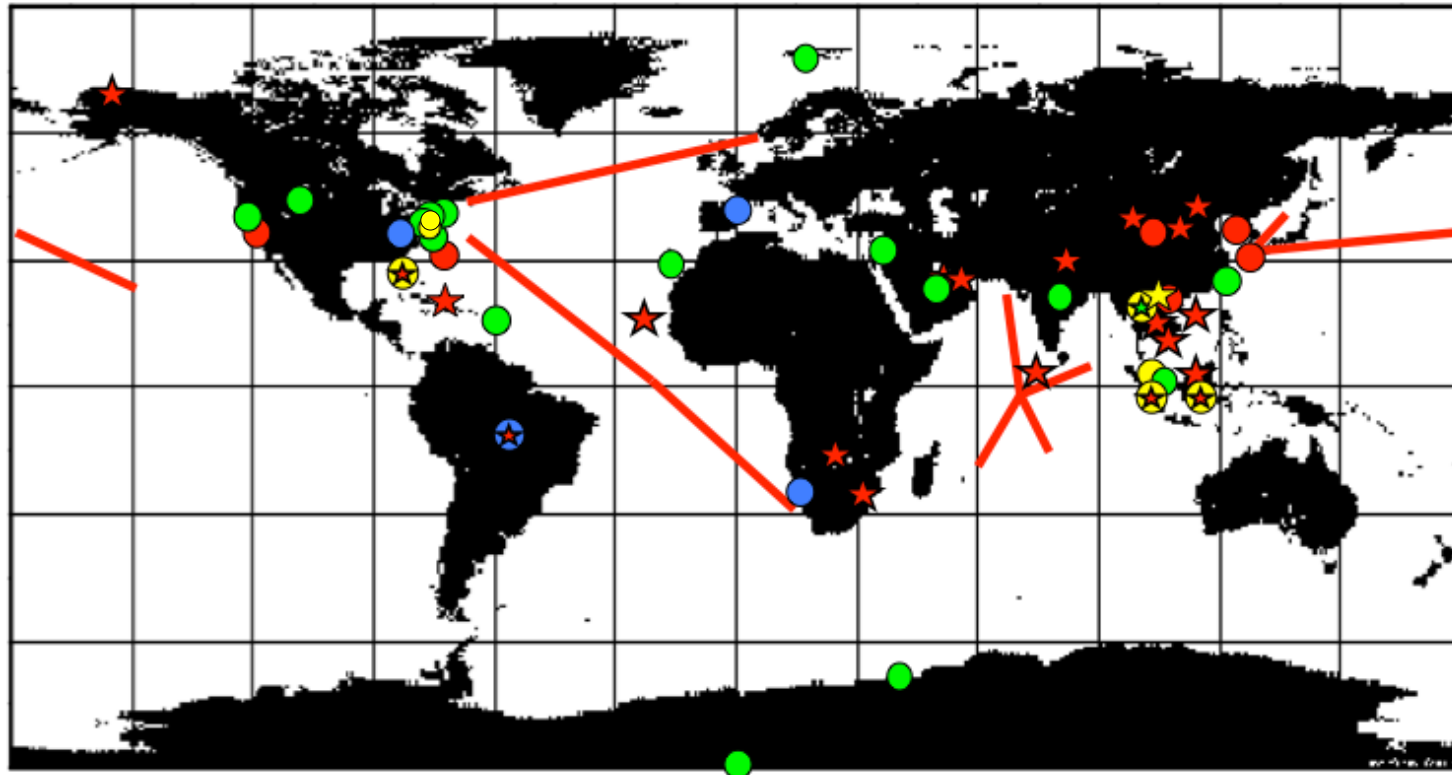
MPLNET is funded by the NASA Radiation Sciences Program and the Earth Observing System











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



## All MPLNET Sites: 2000 - current

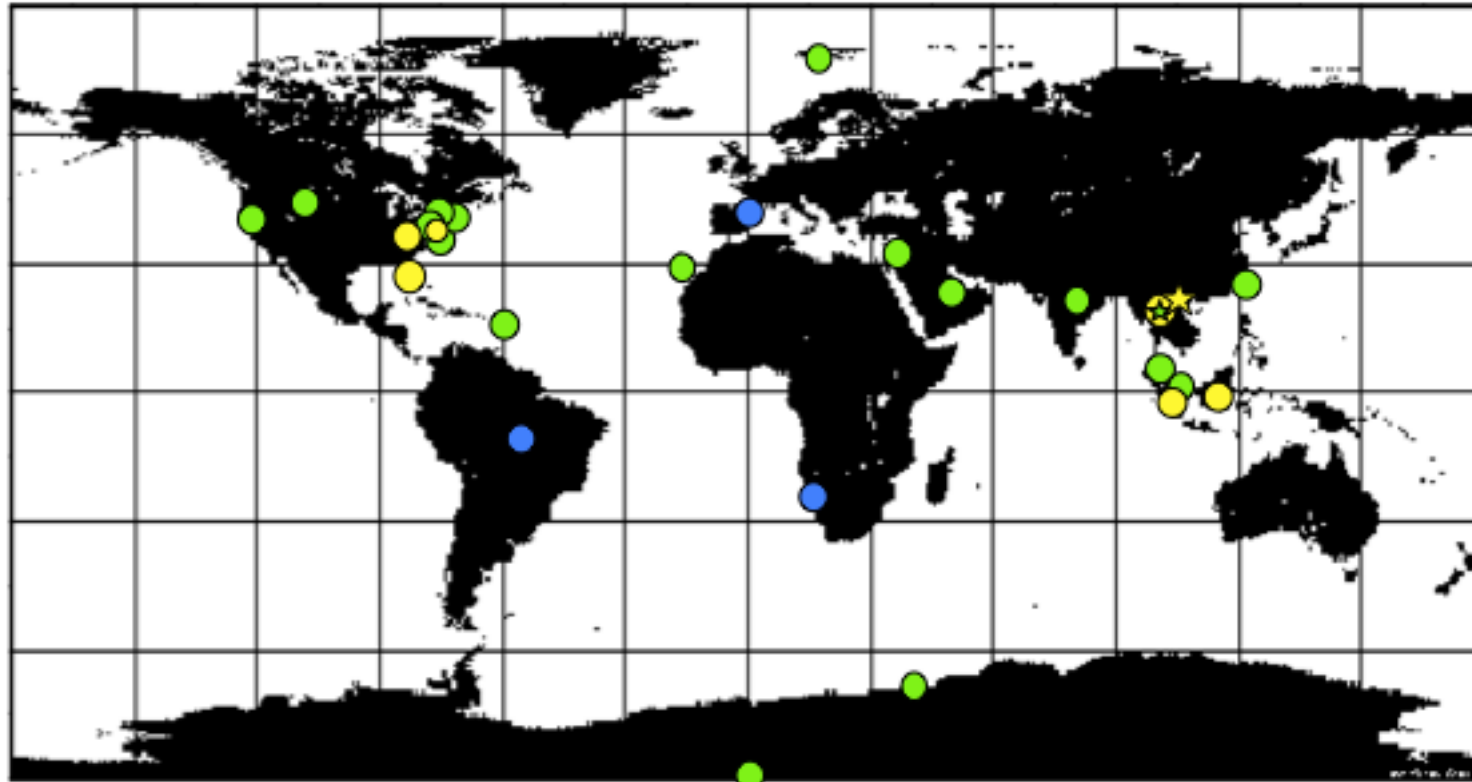


- |   |          |   |  |
|---|----------|---|--|
|  | active   |  | long term site                               |
|  | inactive |  | field campaign                               |
|  | planned  |  | former field campaign, planned/proposed site |
|  | proposed |  | ship cruise                                  |

\* most sites co-located with AERONET



## Active, Planned, & Proposed MPLNET Sites: 2000 - current



- active
- inactive
- planned
- proposed

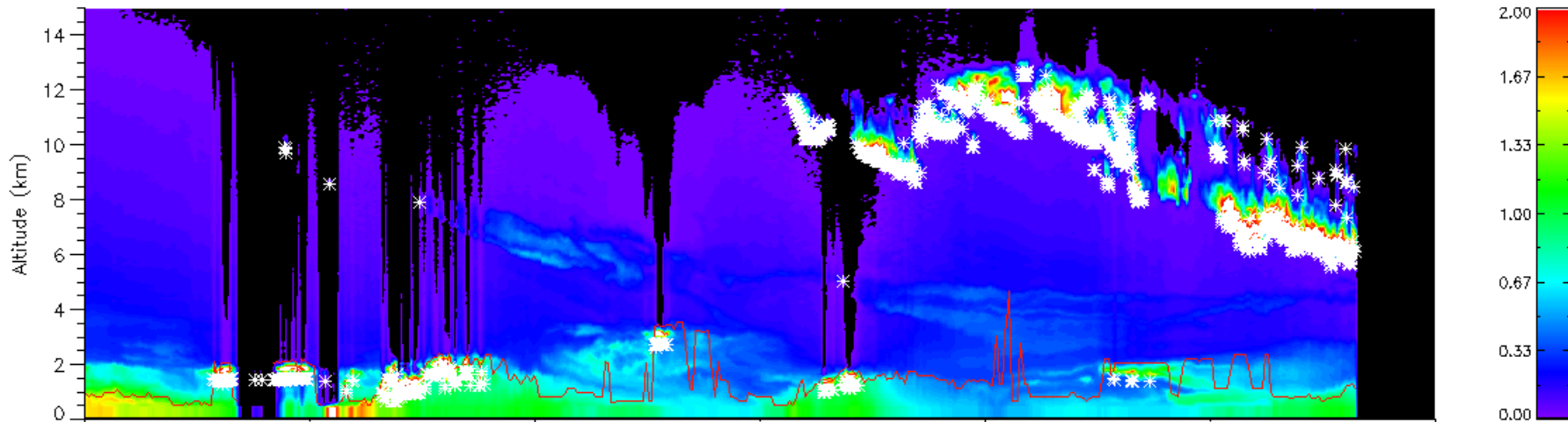
17 Active Long-term sites  
6 Planned sites, USA & Thailand by Spring 2015  
    3 in USA (Wallops VA, Miami FL, ASU NC)  
    1 Thailand (Om Koi)  
    2 Indonesia (Sumatra & Kalimantan Borneo)  
3 Proposed sites, others in discussion

\* most sites co-located with AERONET



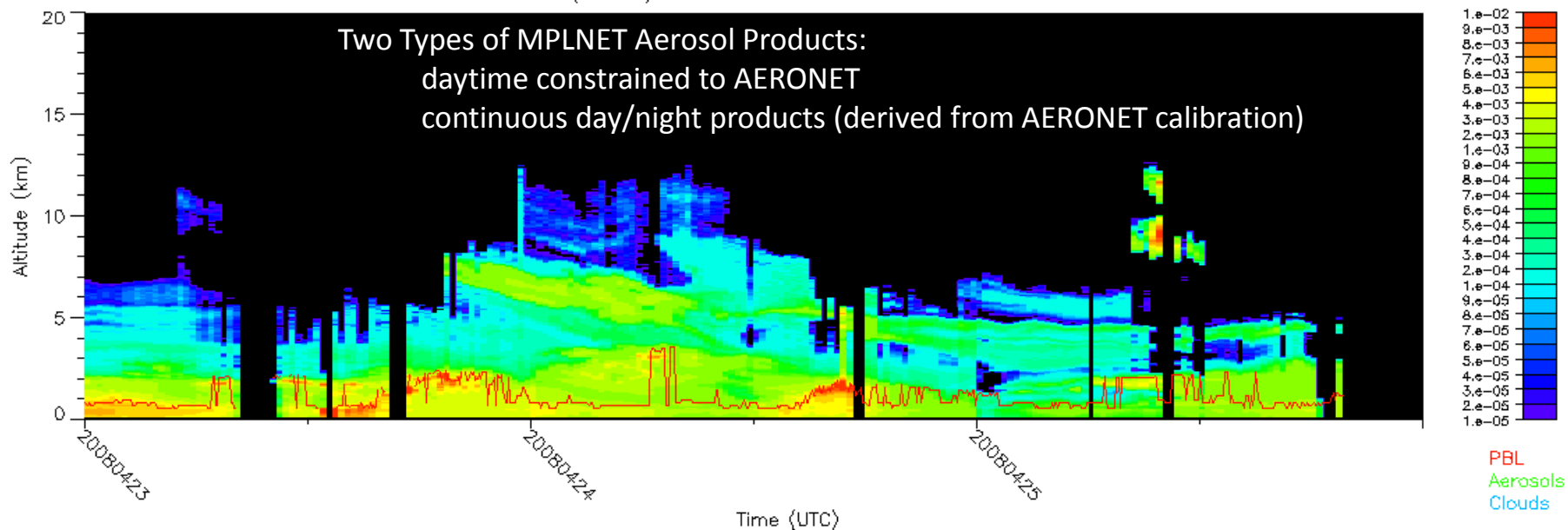
# MPLNET Version 2 Data Products: Quick Summary

MPLNET Level 1.0 NRB: GSFC



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

Two Types of MPLNET Aerosol Products:  
daytime constrained to AERONET  
continuous day/night products (derived from AERONET calibration)





## The Micro Pulse Lidar Network (MPLNET): Ongoing Activities

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1. Version 2 is still running. Level 1, 1.5, and 2 products avail.  
error bars for all products, ncdf 3, no online ordering
  2. We are currently developing our Version 3 MPLNET Data System:
    - a. Version 3 Data release (with new website)
      - Reprocessing all Level 1 data to improve error product (error will increase)
      - new PBL height, depolarization ratio, improved high cloud/cirrus retrievals, with estimated optical depth
      - Switch to GEOS-5 met data for near real time and standard processing
      - New Website, more efficient data file search, request, delivery
      - More online tools for data visualization & ordering
      - CF compliant Netcdf 4
    - b. Adding Polarized Micro Pulse Lidars (P-MPL) to MPLNET
  3. Working with op centers (thru ICAP) to develop MPLNET verification tools/methods. Prototype NRT aerosol extinction product now available (ECMWF testing).
  4. Network expansion phase for next several years (baseline 1-2 new NASA sites per year)
    - a. Working to complete final sites in SE Asia
    - b. Expand USA, Southern Hemisphere burning sites next (S Africa, S America)
  5. COTR on an fiber-laser based HSRL development contract with Fibertek (~HSRL-MPL)
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## Version 3 MPLNET Development



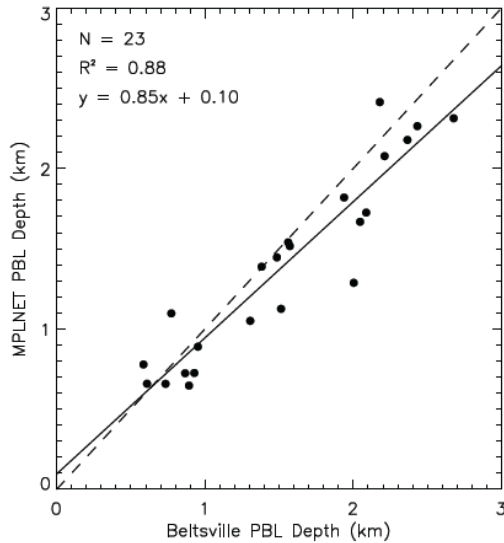
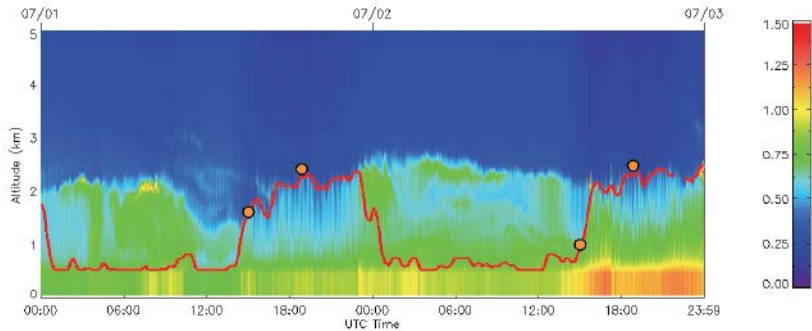


# New MPLNET Mixed Layer Depth (PBL) Product: Jasper Lewis

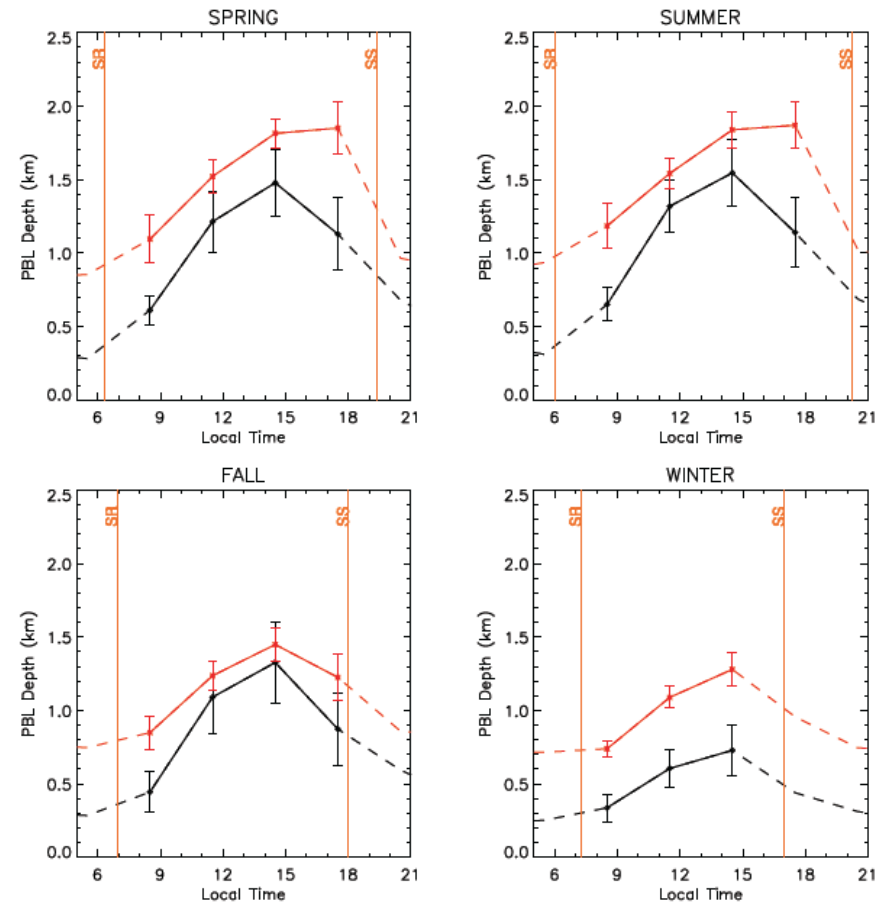


A new MPLNET boundary layer depth algorithm has been developed, vast improvement over the current product.

Lewis, J.R. E.J. Welton, A.M. Molod, and E. Joseph, Improved boundary layer depth retrievals from MPLNET, JGR, final revision, 2013.



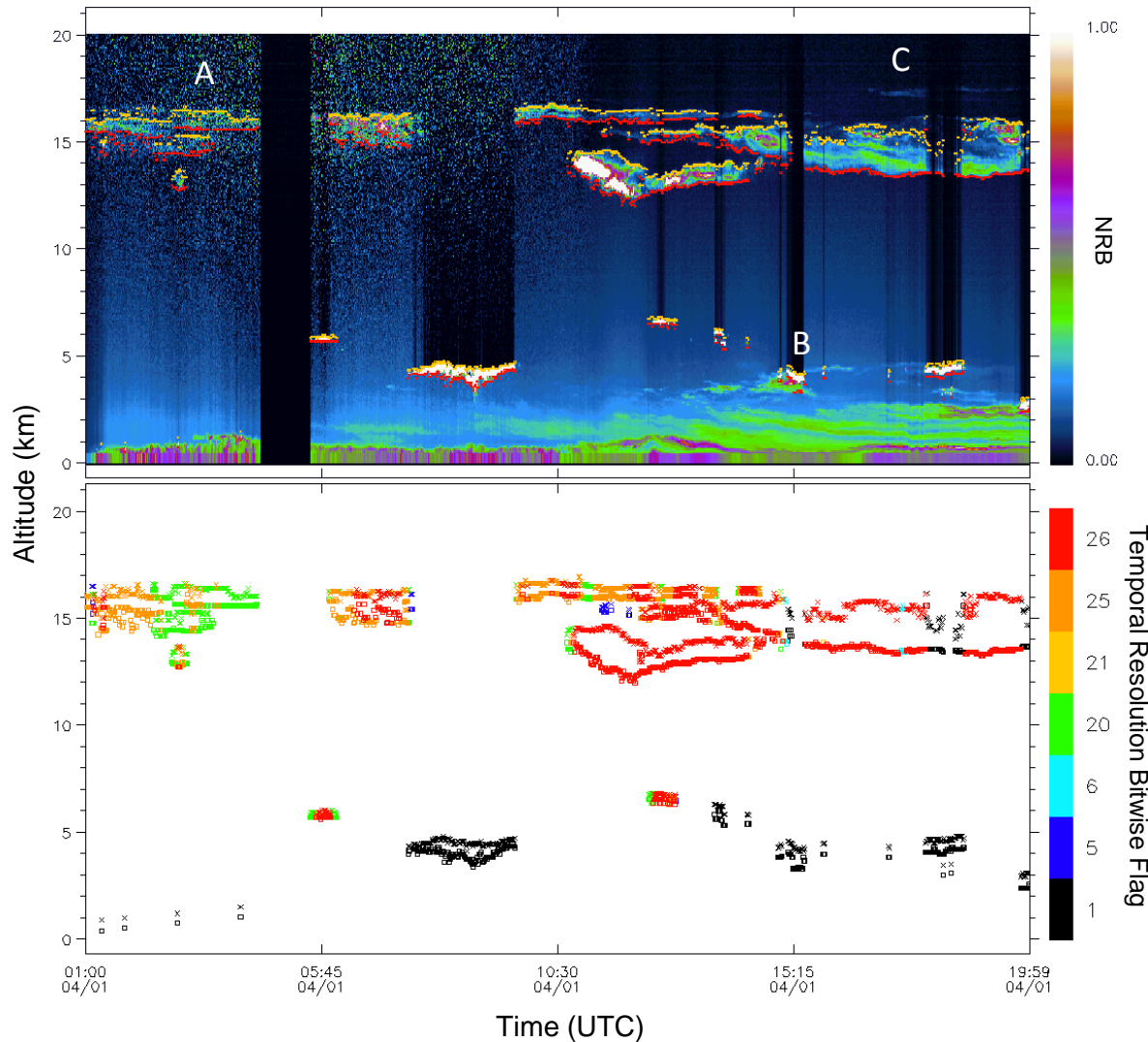
**Figure 1:** (top) Example of MPLNET signals from GSFC July 1-2, 2011. New PBL product shown as red line, circles indicate PBL height retrievals from HU-Beltville radiosonde. (bottom) All comparisons between MPLNET and HU-Beltville PBL heights.



**Figure 2:** Comparison of seasonal diurnal cycles of the PBL height at GSFC for 2001-2008 using the new MPLNET algorithm (red) and GEOS-5 model (black). Orange vertical lines indicate the mean times for sunrise (SR) and sunset (SS).



Singapore, 01 April 2012



- A multi-temporal averaging scheme is used to improve performance in weak signal-to-noise.
- Data flags will indicate the temporal resolution used as well as the number of 1-minute profiles included in the average.
- Other data flags indicate:
  - Cirrus (Ice) clouds
  - Day/Night retrievals
  - Data quality
  - Attenuation limit
  - Retrieval Method (GCDM or UCDM)



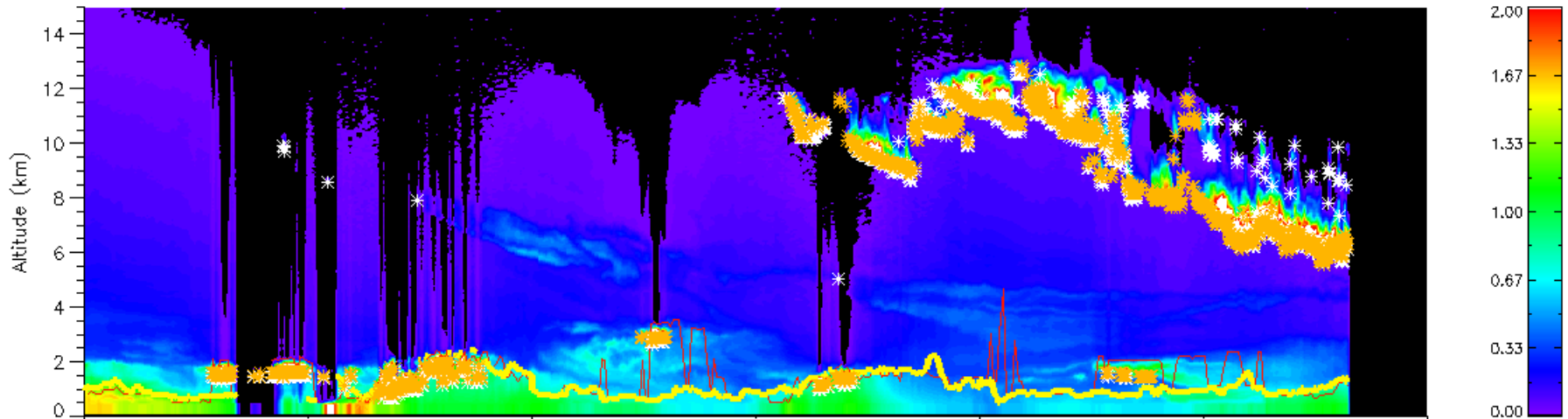


# MPLNET New Version 3 Data Products: Overview

New mixed layer depth/PBL (Lewis et al, 2013), New Cloud products (Lewis et al, in prep)

Cirrus typing/discrimination (Campbell et al, in prep)

MPLNET Level 1.0 NRB: GSFC

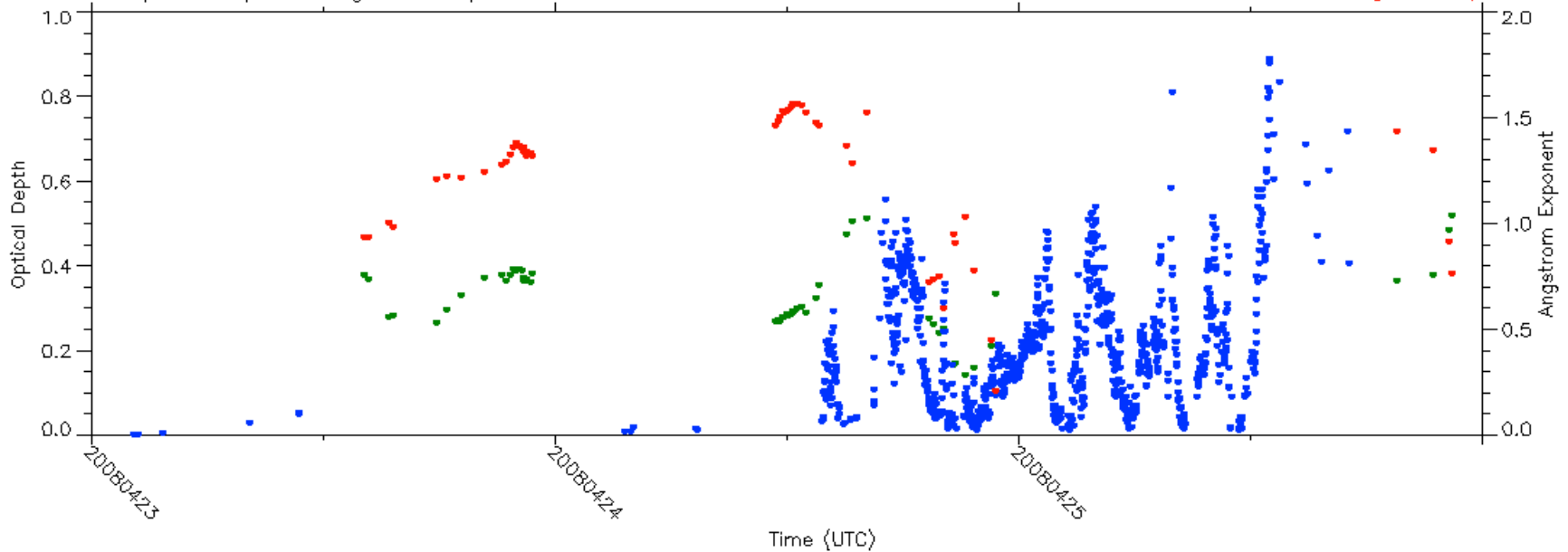


Optical Depth & Angstrom Exponent: GSFC

AERONET AOD

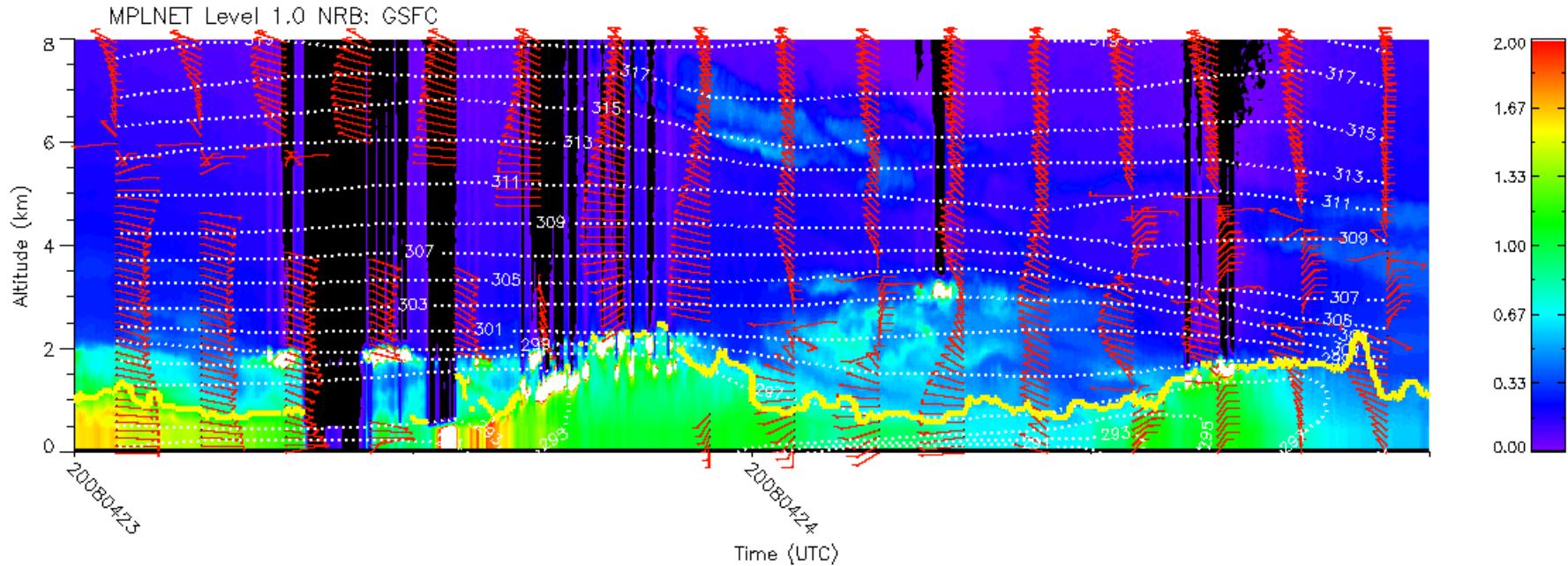
MPLNET Thin Cloud OD

AERONET Angstrom Exponent





# MPLNET New Version 3 Data Products: Switch to GEOS5 Met Aux Data



Standard L1.5 and L2 MPLNET Products: GEOS5 Instrument Team (IT) Product (model fixed, assimilated)

L1.5 latency: next day (~14:00 UTC)

L2 latency: pending AERONET availability + X weeks

New MPLNET L1.5v (validation) Products: GEOS5 Forecast (FP) Product

L1.5v latency: < 1.5 hours

Product suite is the same for L1.5 and L2, and L1.5v

All L1.5 and L2 data online for browsing and file downloads

L1.5v data: browse online, but data files only available to approved users (ie ICAP)



# MPLNET New Version 3 Data Products: Aerosols

MPLNET Level 1.0 NRR - GSFC

Changes to aerosol products in Version 3 are more subtle, but products improve by using GEOS5 met data:

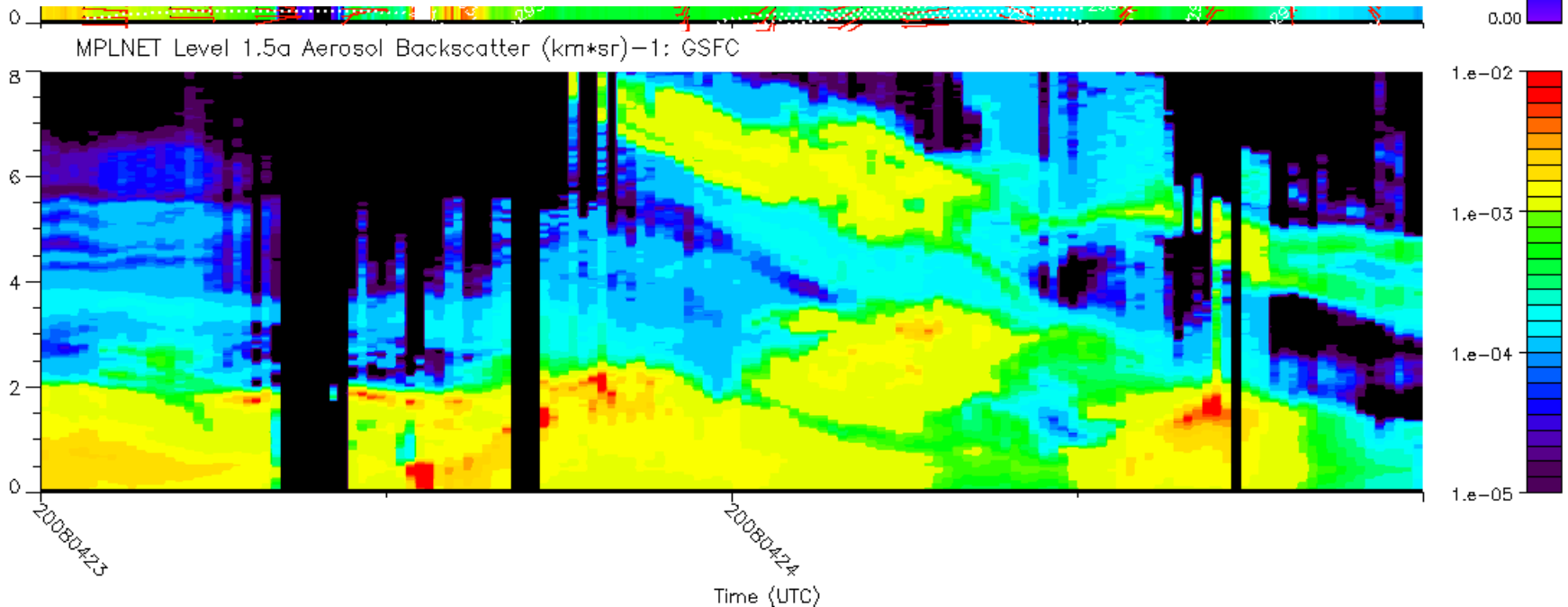
Improves Molecular Profile calculations, better aerosol detection, expanded analysis options

L1.5 data quality increases. Closer to L2, only missing elements are human inspection & data screening.

Version 2: continuous aerosol products were not provided to users (quality too poor)

Version 3 aerosol products will now include continuous day/night retrievals.

Altitude (km)





# Version 2 MPLNET Level 2 vs Level 1.5 Data: All GSFC 2009

Summary:

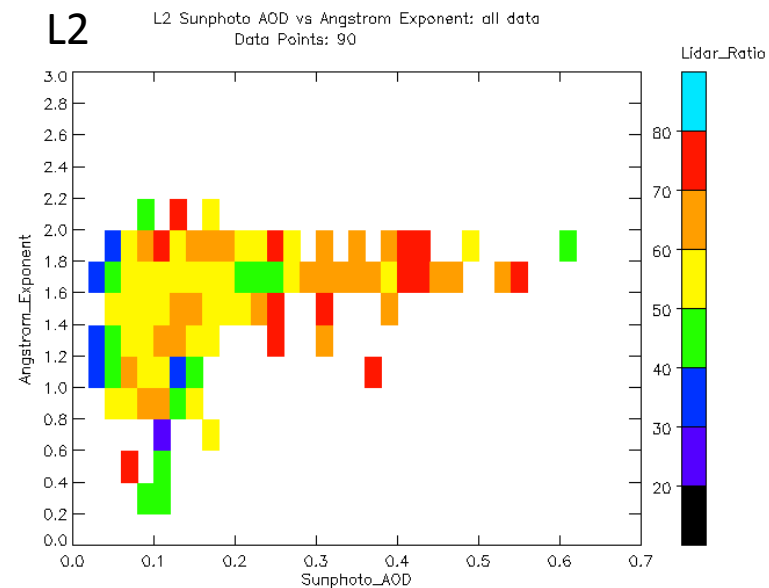
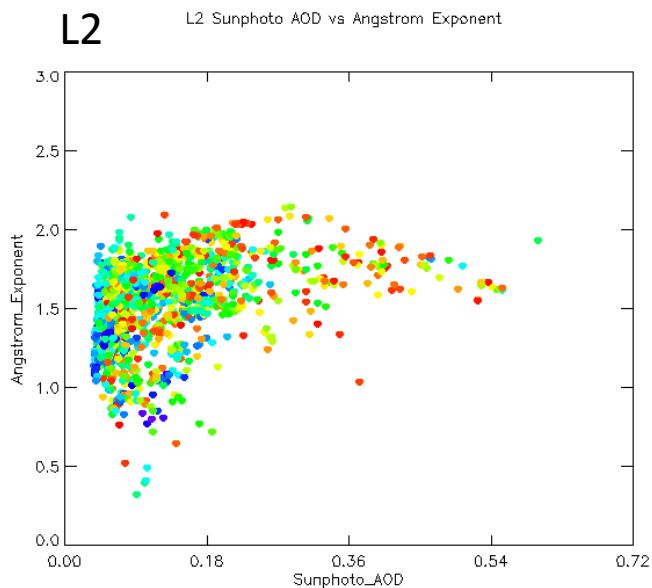
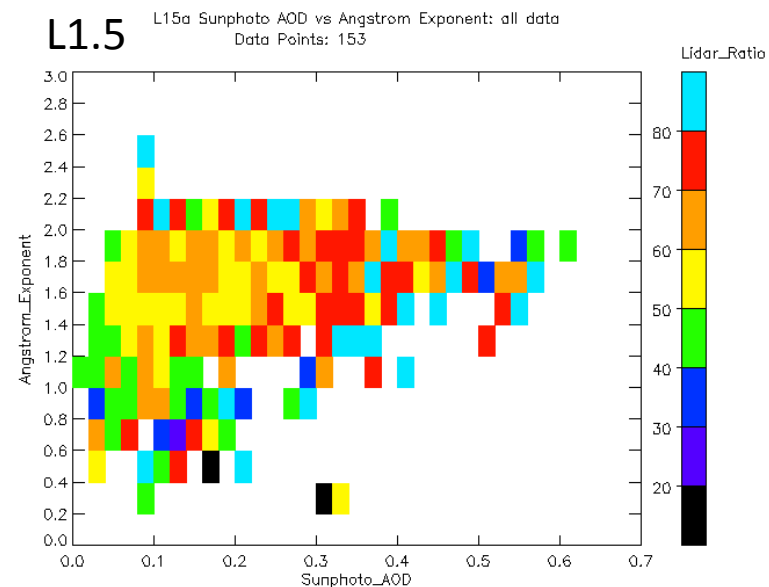
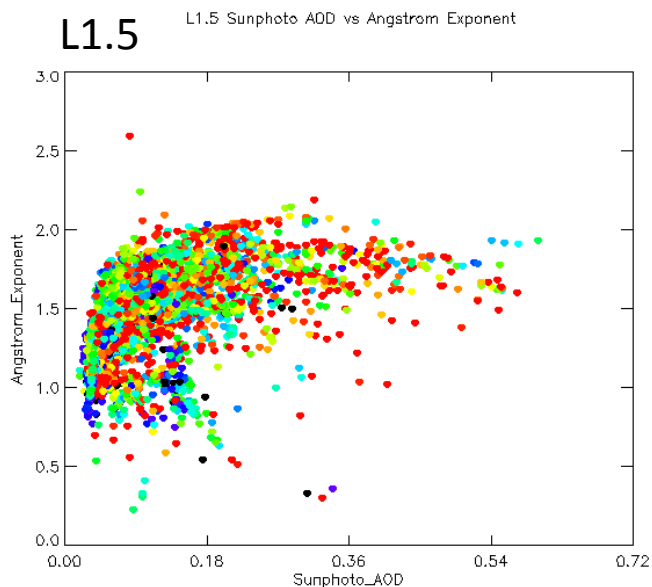
36% Data pass Level 2 Screen

Version 2 Level 2 Data:

- Only AERONET constrained data available
- Gridded day/night product results not good enough to distribute (working on this)

Version 2 Level 2 Data not only screened version of L1.5, but data are more accurate:

- Uses L2 AERONET AOD
- NCEP met data used for molecular profile, large improvement in aerosol height product

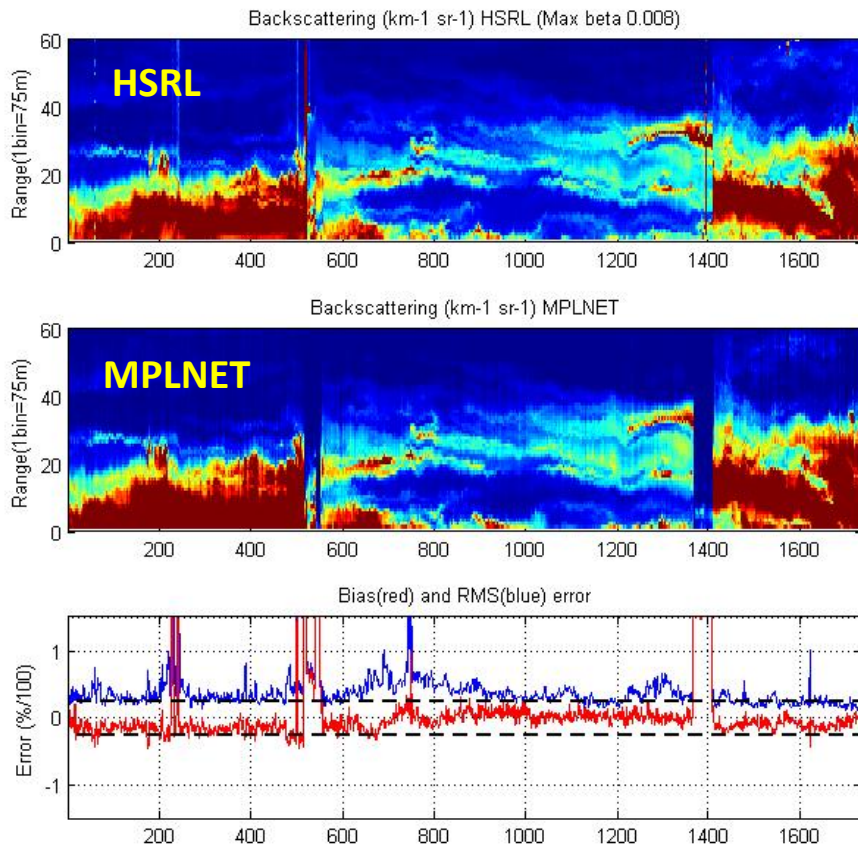




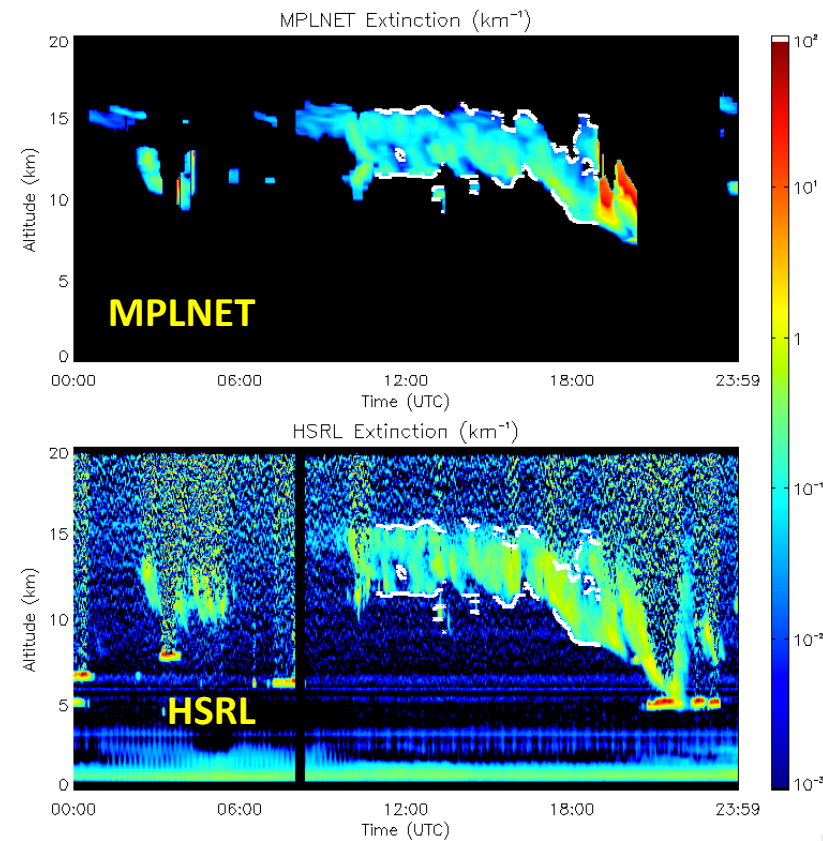
# MPLNET Validation: New Study Underway Using UW HSRL at Singapore 2012

Five published studies demonstrating MPL/MPLNET instrument performance and aerosol retrieval capability. The last was Schmid et al (2006): a comprehensive analysis of different aerosol extinction techniques. MPLNET: aerosol extinction error within 20% (does not include potential bias for column lidar ratio technique)

HSRL vs MPLNET: Aerosol Products (Lolli et al, in prep)



HSRL vs MPLNET: Cloud Products (Lewis et al, in prep)



HSRL Data Courtesy UW Lidar Group: <http://hsrl.ssec.wisc.edu>

# New Version 3 Data Processing System & Website are Functional:

## Compliant with new IT Security Protocols & IPv6



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### MPLNET Data for Singapore:

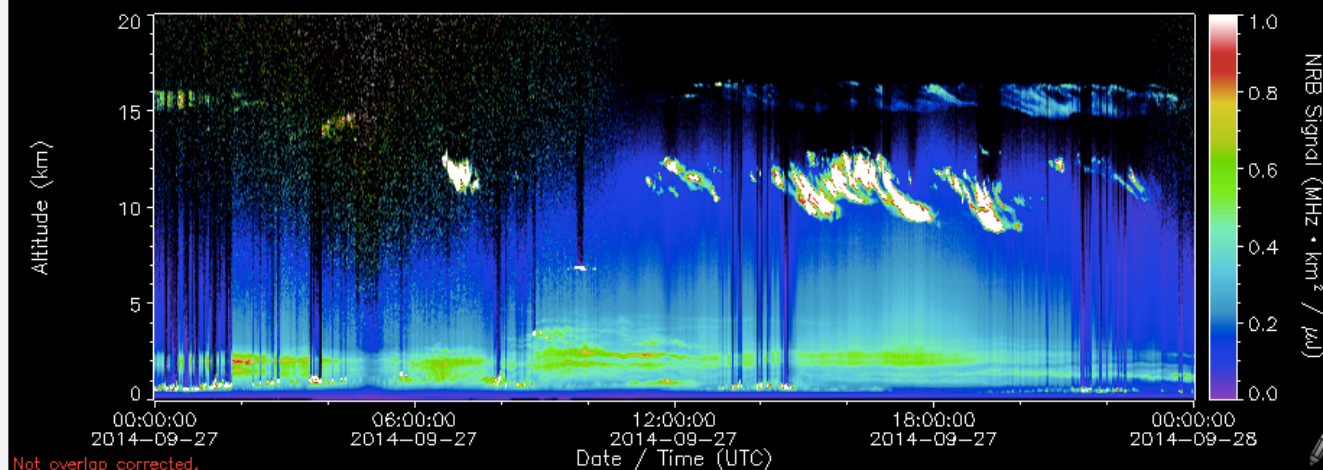
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Color-Table: <input type="text"/>		Min-Color: <input type="text"/>	
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Background-Color: <input type="text"/>		Padding: <input type="text"/>	
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Hide Title:  Hide Axes:

MPLNET NRB Plot for Singapore on 2014-09-27 (MPL44235)



Background/Temps Plot for Singapore on 2014-09-27 (MPL44235)



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## **New Polarized MPL (P-MPL) and Lidar Enclosures**





# Polarized MPL (P-MPL) and new Lidar Enclosures/Shipping boxes:

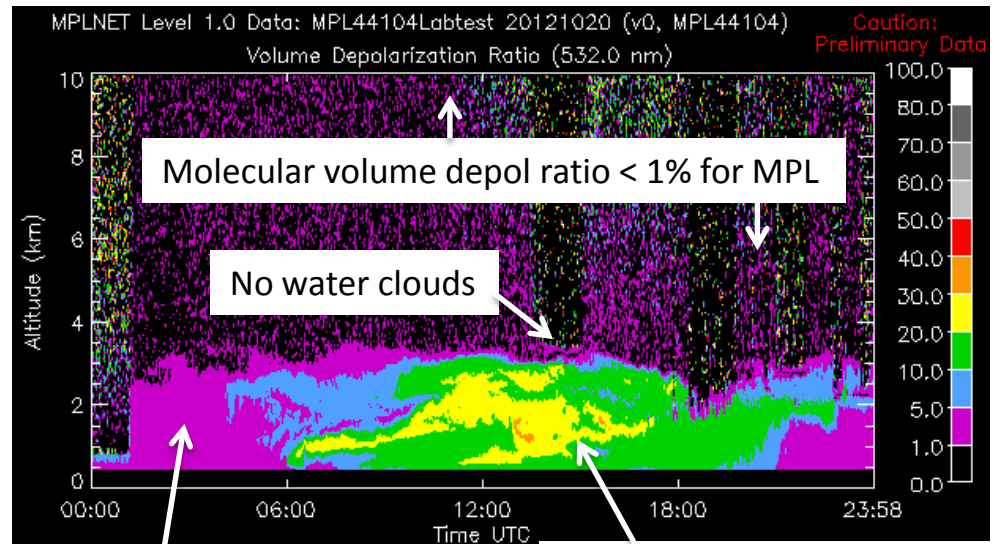
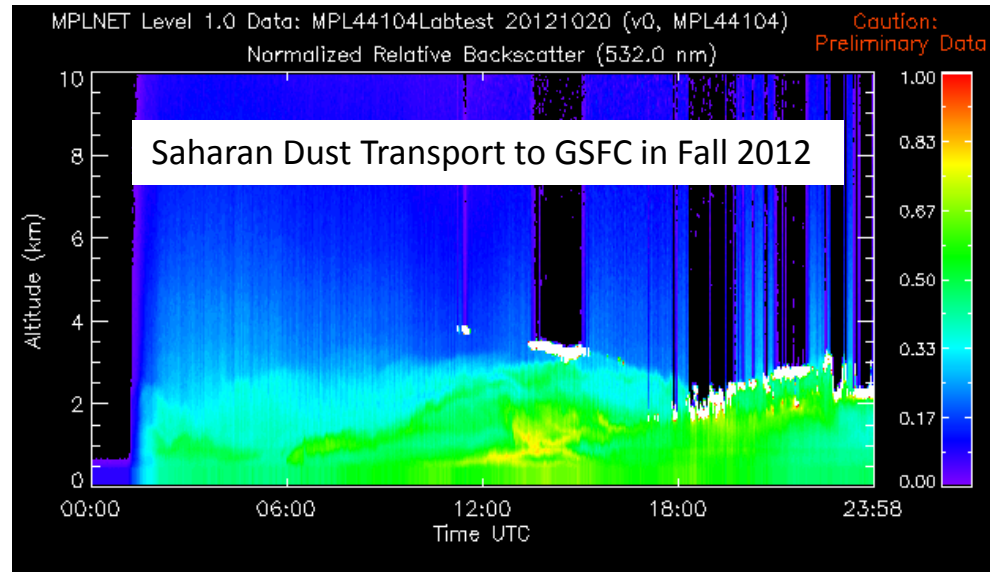
## Polarization MPL Approved for use in MPLNET

Original P-MPL developed at ARM/Sigma Space years ago. However it had slow switching between co and cross polarization and the system characterization, calibration, and accuracy studies were never completed.

New P-MPL product developed thru interaction with GSFC/Sigma includes fast switching.

Unique transceiver design with Ferroelectric Liquid Crystal Polarization Rotator:

- no gain ratio calibration
- possibility of cross-talk greatly reduced
- no overlap issue (ratio of signals)



Urban aerosol vol depol < 5%

Saharan dust vol depol ~ 20%

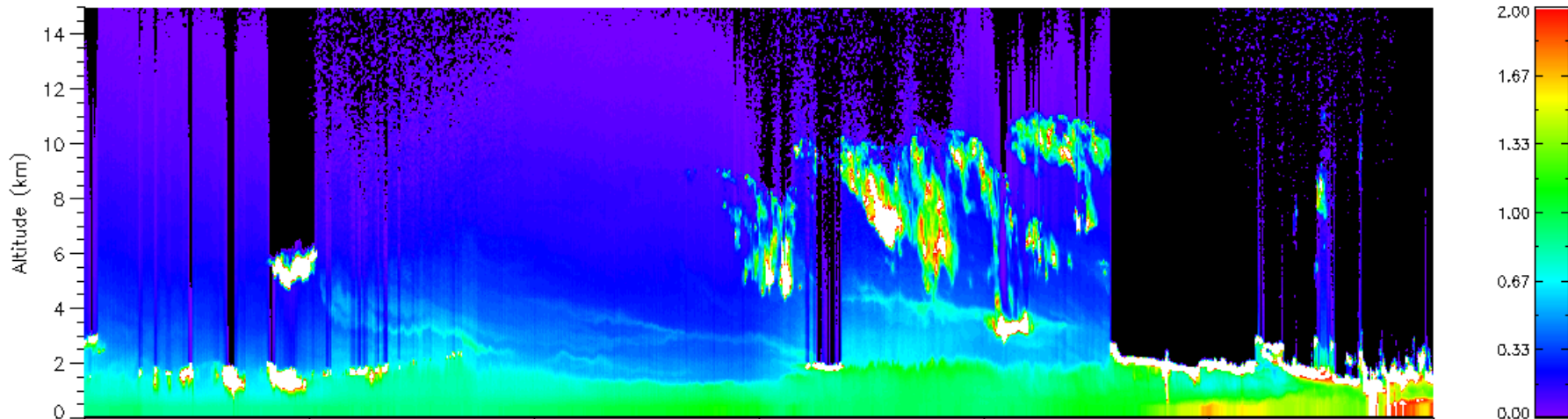




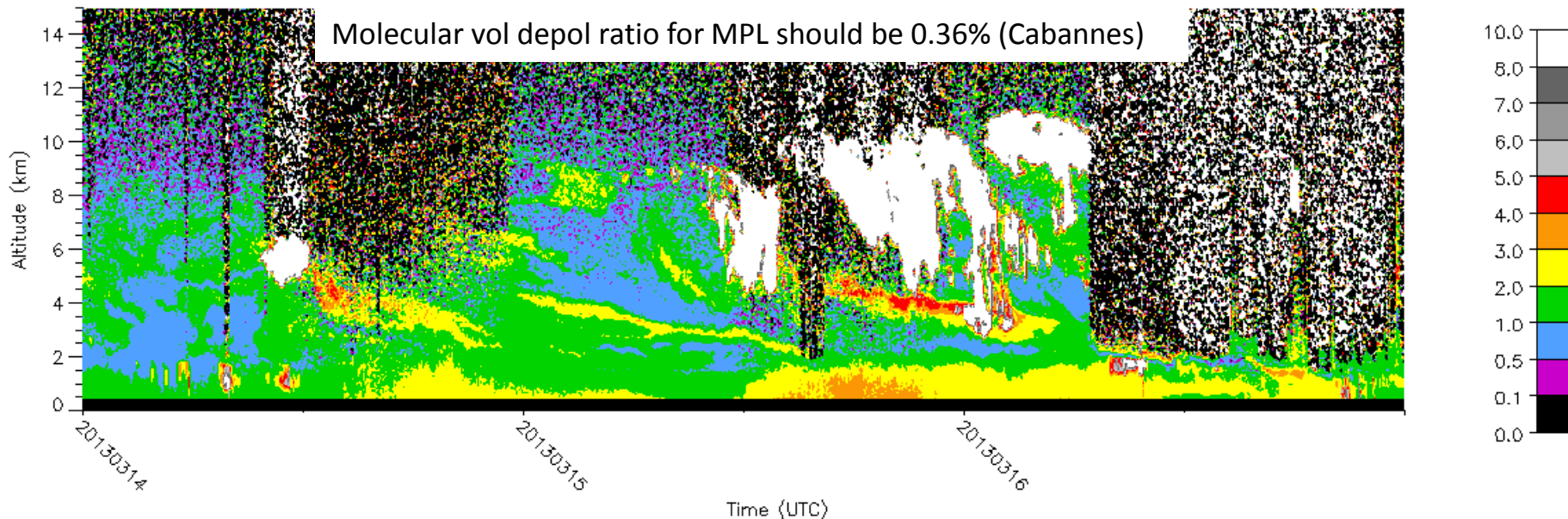
# MPLNET Instrumentation: New P-MPL

Volume depol MPL accuracy:  $< 1\%$ . Discriminate aerosol features even  $< 5\%$  volume depol ratio  
**When the MPL is aligned and calibrated properly!**

MPLNET Level 1.0 NRB: MPL44217Lab

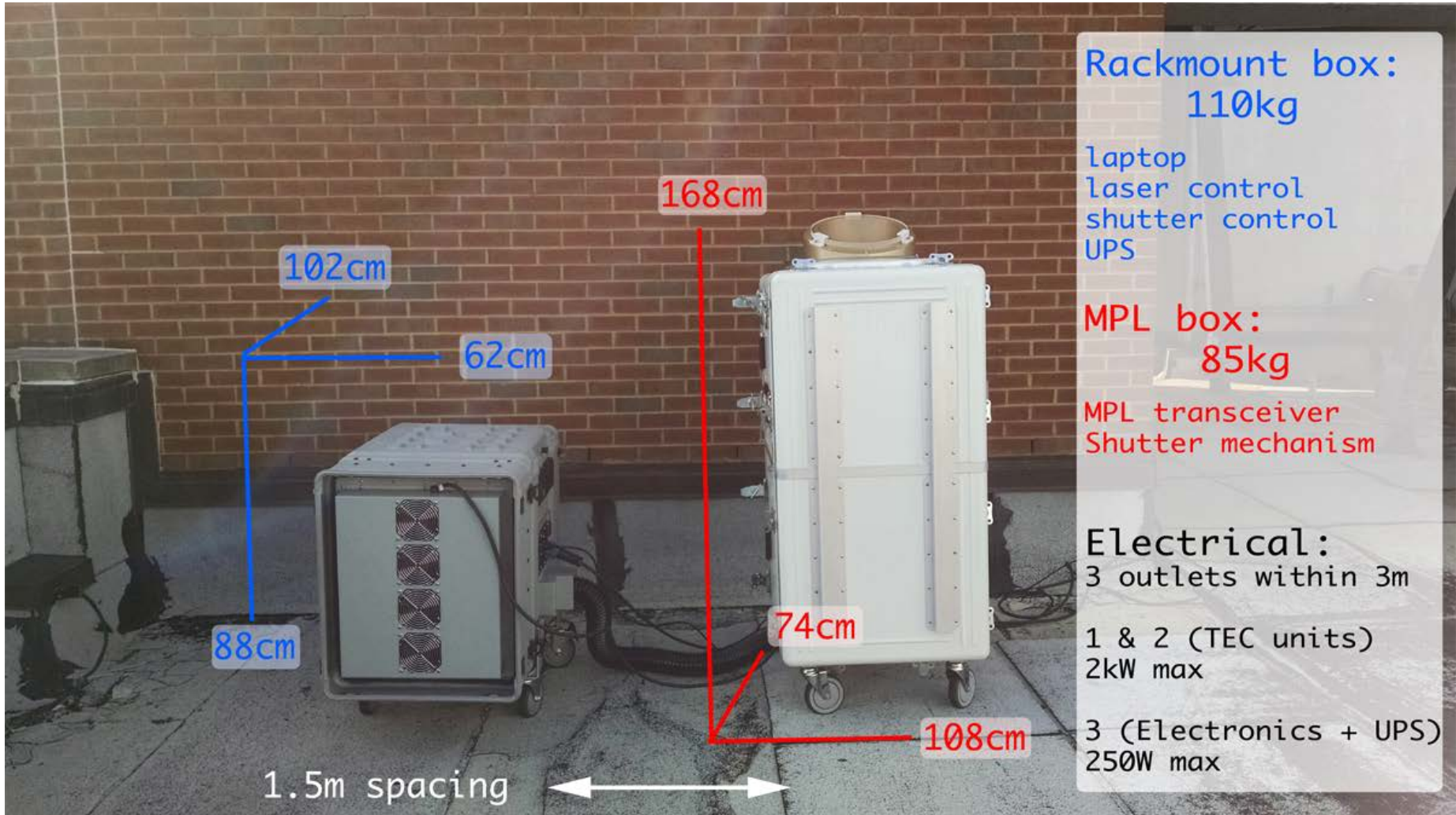


MPLNET Volume Depolarization Ratio: MPL44217Lab





# MPLNET Instrumentation: New MPL Enclosures (shipping & ops)



Prototype is shown here (Dor Ang Khang, Thailand)

Data:	Original MPL	Polarized MPL
	195KB/hour	392KB/hour
	4.68MB/day	9.41MB/day



## Polarized MPL (P-MPL): Performance

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End of 2013: I approved Polarized MPL (P-MPL) for use in MPLNET. Based on first 3 prototypes.

Purchased 4 new Polarized MPLs, delivered early spring 2014.

All 4 had serious vol depol ratio bias problems. Yet the total lidar signal was reasonable.  
I halted entire P-MPL program.

Developed fully polarized model (I,Q,U,V) of the MPL system (transmitter to receiver)

Original MPL was depolarized (not sensitive to polarization)

P-MPL: complicated switching process between linear & elliptical transmitted laser pulses  
using a polarization rotator

Results of study indicated P-MPL problems were easy to fix, caused by poor QC at company

Most critical calibration was alignment of the rotator to the laser polarization plane

MPL company QC process was improved as a result

Difficult exercise but have better understanding of P-MPL now than before

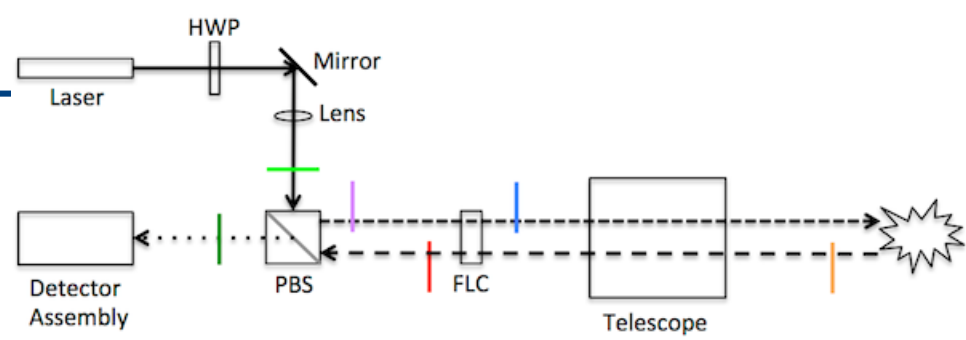
Also determined more subtle sources of bias in the P-MPL data

This may be very technically detailed, but I think its important to present for this group

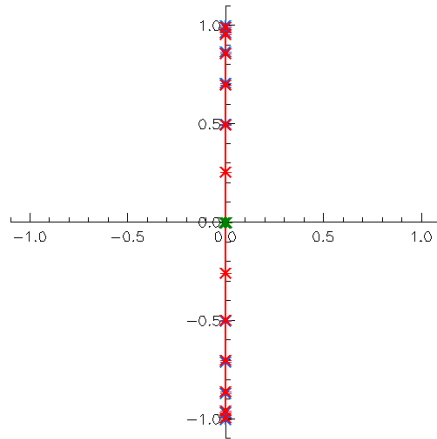
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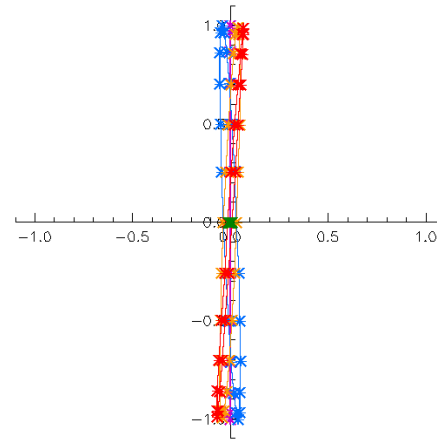
# Polarized MPL Simulation



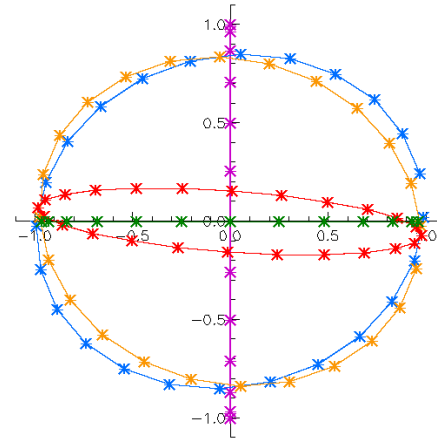
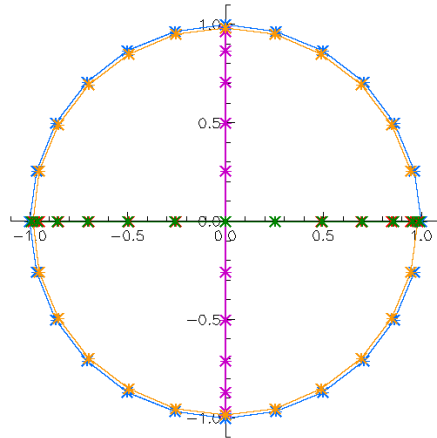
### Ideal P-MPL



### Perturbed Optics



### Channel 1 (FLC: Linear Light)

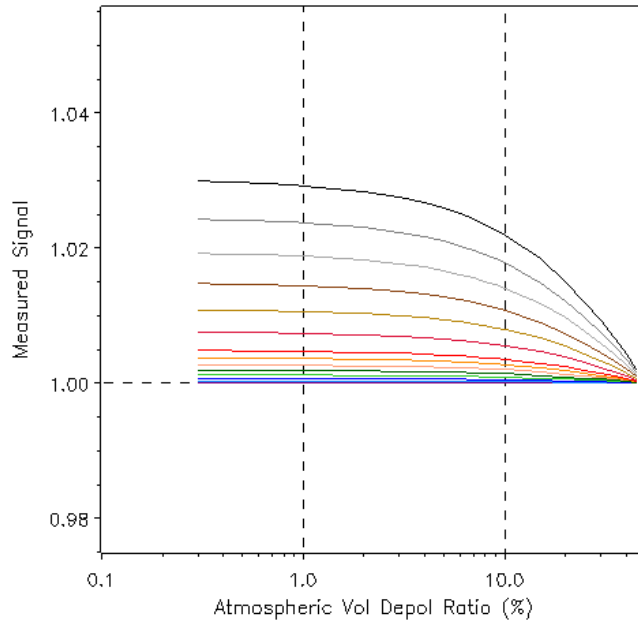
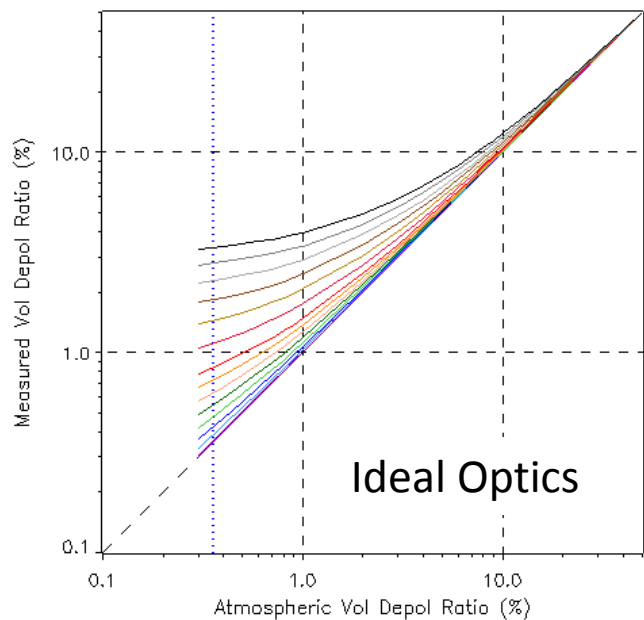


### Channel 2 (FLC: Circular Light)



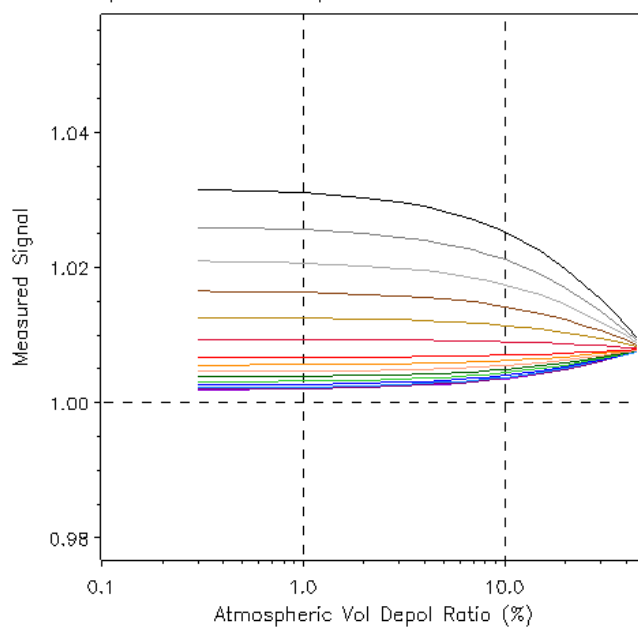
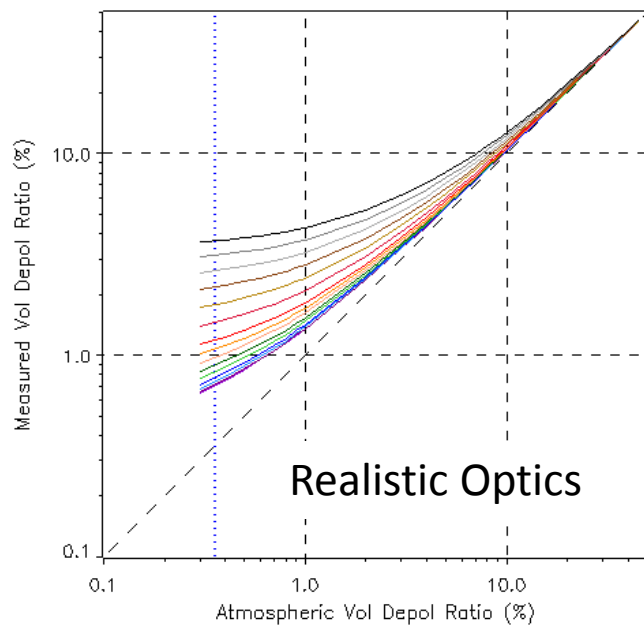


Atmospheric vs Measured Vol Depol Ratio Atmospheric Vol Depol Ratios vs Measured Signal



- FLC Position Dev:
- 0.00 deg
  - 0.25 deg
  - 0.50 deg
  - 0.75 deg
  - 1.00 deg
  - 1.25 deg
  - 1.50 deg
  - 1.75 deg
  - 2.00 deg
  - 2.50 deg
  - 3.00 deg
  - 3.50 deg
  - 4.00 deg
  - 4.50 deg
  - 5.00 deg
- FLC Rotation Dev: 0.000 deg  
 FLC Retardation Dev: 0.000 waves  
 FLC Ext-Ratio: 1.00000  
 FLC Depolarization: 0.000 %
- PBS Trans Ext-Ratio: 1.00000e+12  
 PBS Rec Ext-Ratio: 1.00000e+12  
 PBS Trans Position Dev: 0.00 deg  
 PBS Rec Position Dev: 0.00 deg  
 PBS Depolarization: 0.000 %

Atmospheric vs Measured Vol Depol Ratio Atmospheric Vol Depol Ratios vs Measured Signal

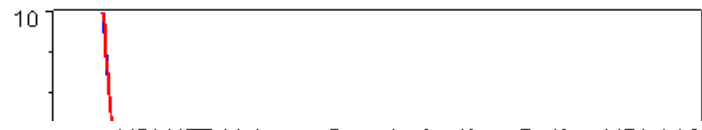


- FLC Position Dev:
- 0.00 deg
  - 0.25 deg
  - 0.50 deg
  - 0.75 deg
  - 1.00 deg
  - 1.25 deg
  - 1.50 deg
  - 1.75 deg
  - 2.00 deg
  - 2.50 deg
  - 3.00 deg
  - 3.50 deg
  - 4.00 deg
  - 4.50 deg
  - 5.00 deg
- FLC Rotation Dev: 0.000 deg  
 FLC Retardation Dev: 0.013 waves  
 FLC Ext-Ratio: 1.00000  
 FLC Depolarization: 0.000 %
- PBS Trans Ext-Ratio: 500.000  
 PBS Rec Ext-Ratio: 500.000  
 PBS Trans Position Dev: 0.00 deg  
 PBS Rec Position Dev: 0.00 deg  
 PBS Depolarization: 0.000 %

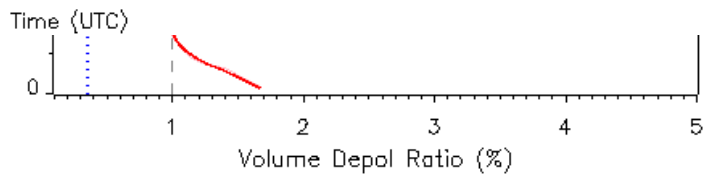
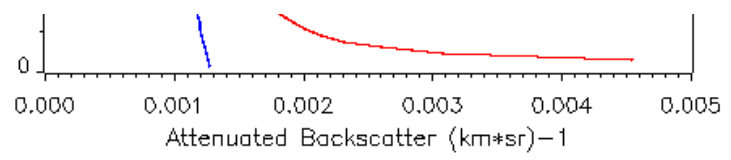
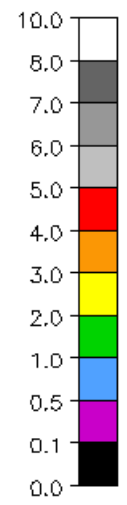
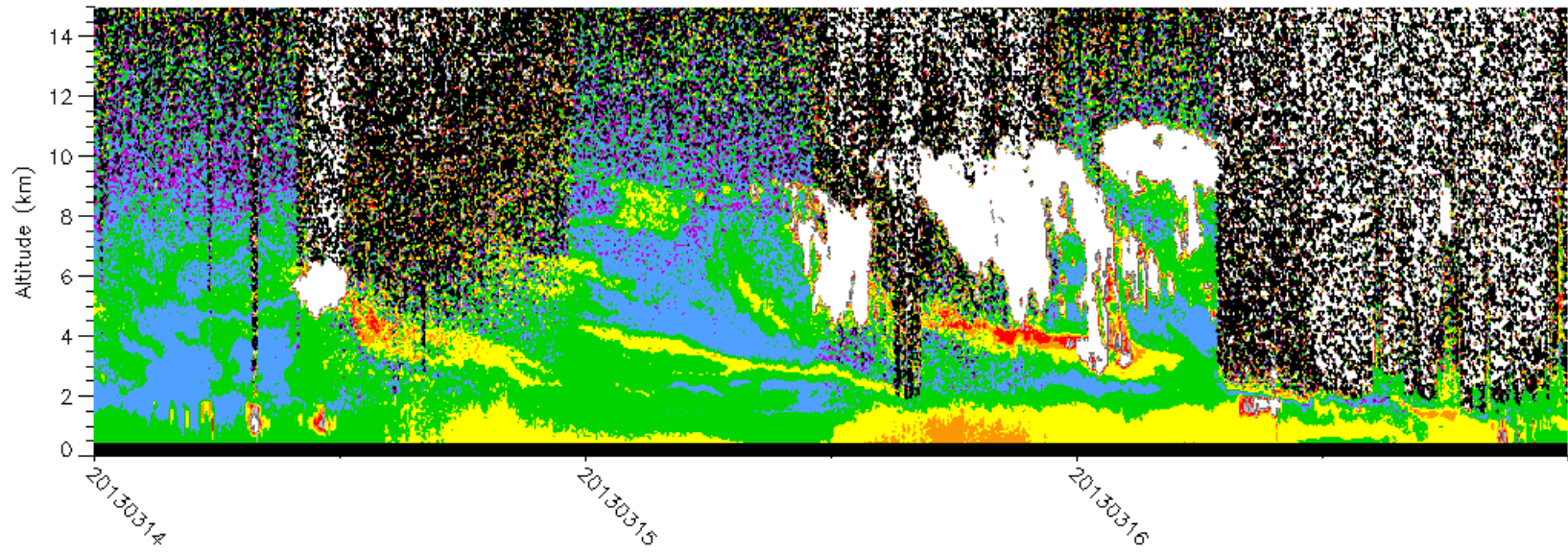


Attenuated Backscatter:

Vol Depol Ratio:

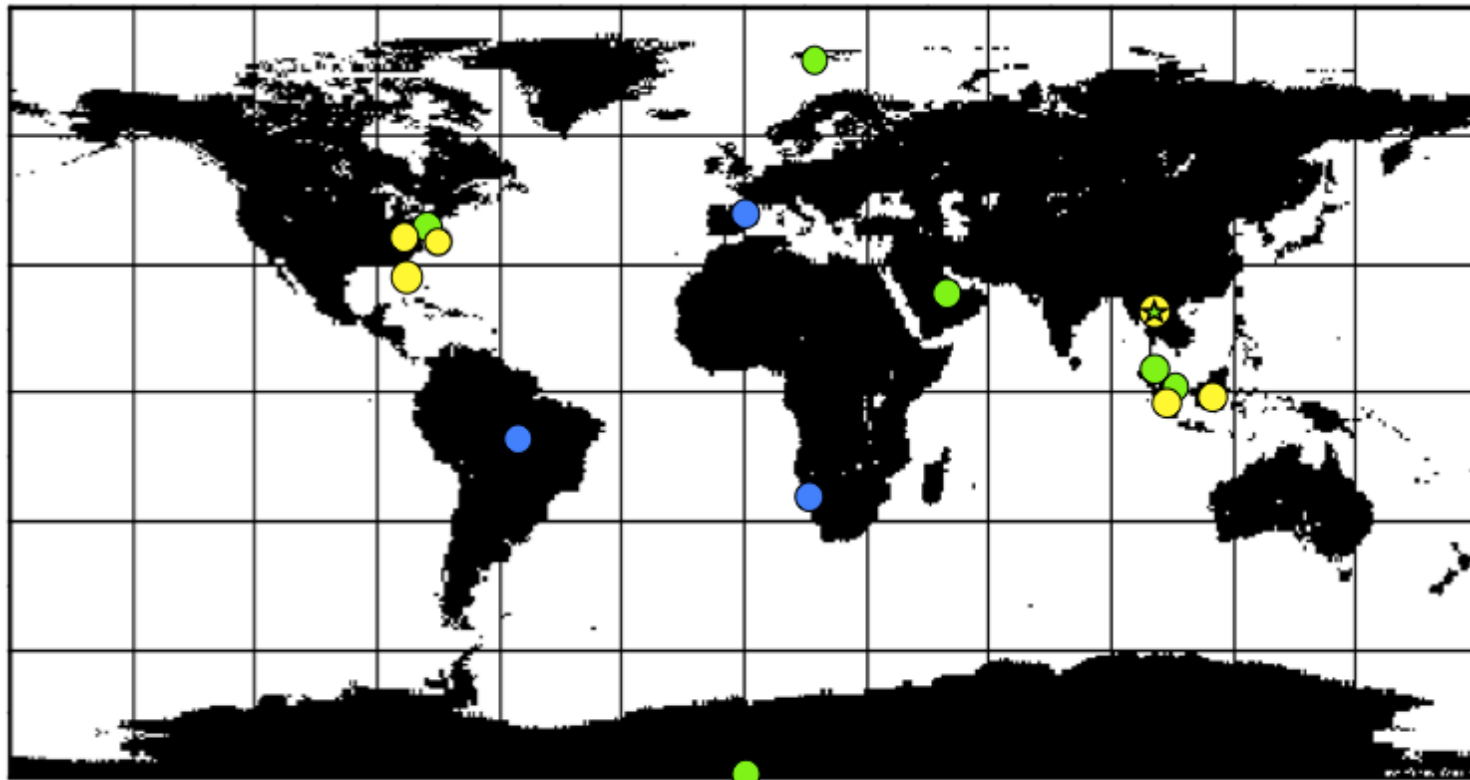


MPLNET Volume Depolarization Ratio: MPL44217Lab





## MPLNET Sites with new Polarized MPL



- active
- inactive
- planned
- proposed

Sites with New Polarized MPL:  
GSFC, South Pole, Ny Alesund, KAUST, Singapore, Penang  
All planned and proposed sites

Planning underway to replace many older sites

\* most sites co-located with AERONET



Developed MPLNET Verification Product (L1.5v) for Models:

First test products implemented in V2, available at:

PBL Height product was produced for NCEP several years ago (J. McQueen)  
(discontinued till V3)

Aerosol Extinction Profile Product:

[http://mplnet.gsfc.nasa.gov/data/ML15V2SAEXT/mplnet\\_l15\\_v2\\_s\\_aext\\_daily.nc](http://mplnet.gsfc.nasa.gov/data/ML15V2SAEXT/mplnet_l15_v2_s_aext_daily.nc)

Latency: files available next day, 08:00 EST every morning.

Product will be refined for V3:

nc4, CF compliance, full suite of products will be added

Latency: < 1.5 hours

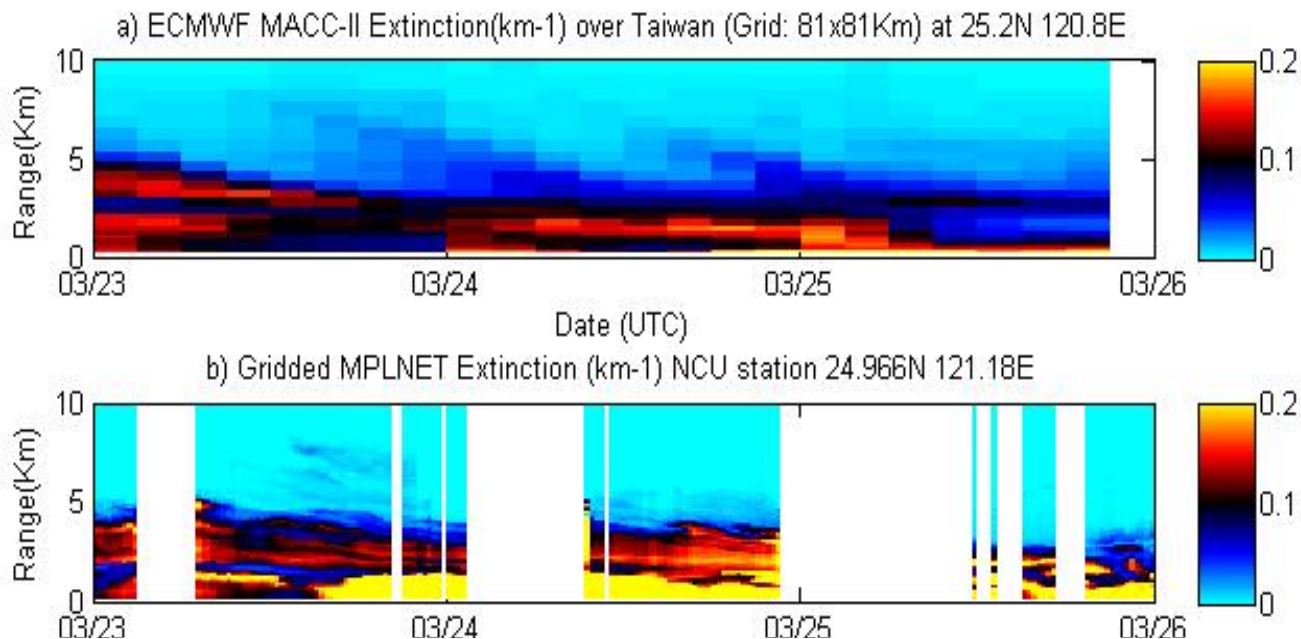
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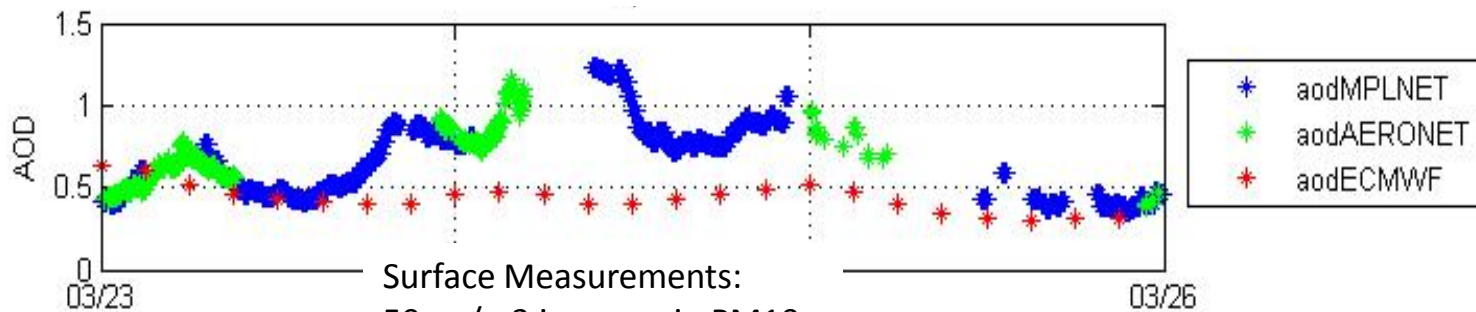


# Aerosol Model Evaluation: ECMWF MACC-II vs AERONET/MPLNET

Simone Lolli (MPLNET Staff) has a poster evaluating MACC-II at Taiwan AERONET/MPLNET Site



MPLNET 24hr AOD useful for model verification, inherently less affected by thin cirrus



Surface Measurements:  
50 ug/m3 increase in PM10  
Correlated to increased PBL  
extinction from lidar

# Summary of Current Activities:

- Continue network expansion: site suggestions welcome
- Version 3 MPLNET Development: Engineered to use non-MPL (GALION)
- Finalize P-MPL instrument & protocol
- Develop Model Verification Products
  - Aerosol Extinction product
  - Will produce lidar AOD product for 24 hr verification
  - Other Products? Attenuated Backscatter, Clouds, PBL, PBL-AOD

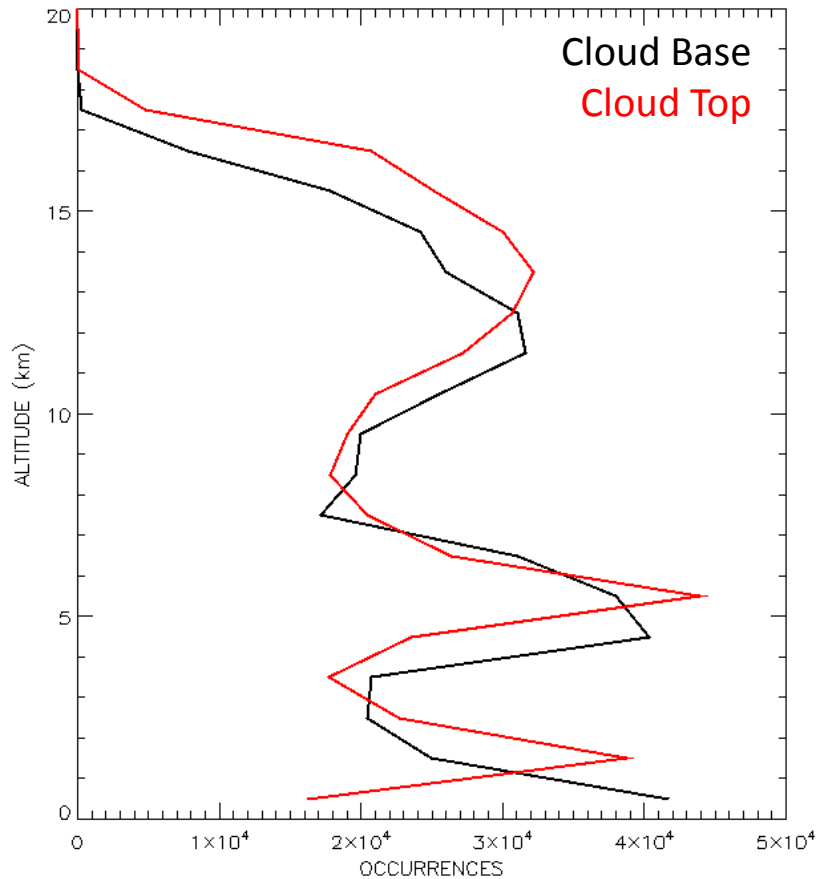




## Cloud Statistics for Singapore: 2012

Climatology for GSFC (10 yrs) underway (Lewis et al, in prep)

### All Clouds



### Cirrus Clouds

