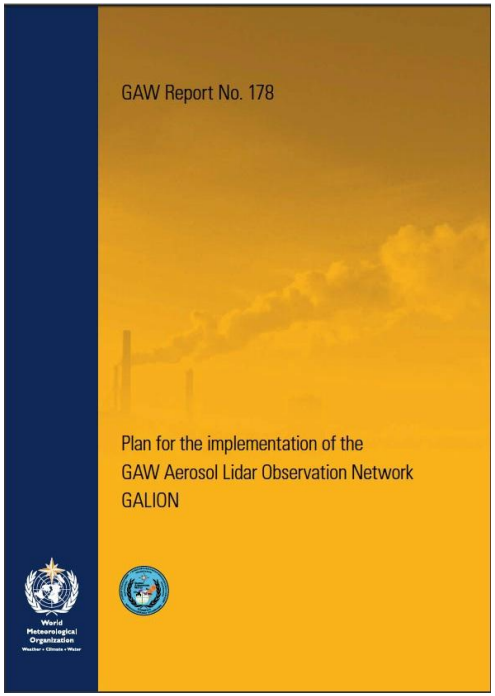
GAW Aerosol Lidar Observation Network (GALION)



First WMO Experts Meeting on the implementation of
the GAW Aerosol Lidar Observation Network: GALION
Held in March 2007, Hamburg Germany

2008 WMO Report:

ftp://ftp.wmo.int/Documents/PublicWeb/arep/gaw/gaw178-galion-27-Oct.pdf

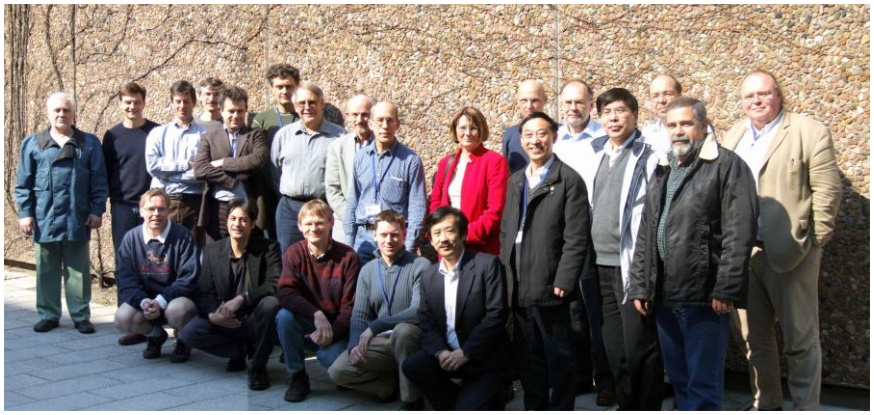
The Global Atmosphere Watch (GAW) aerosol program (GAW, 2007) strives "to determine the spatio-temporal distribution of aerosol properties related to climate forcing and air quality up to multidecadal time scales".

GALION goal: provide the vertical component of aerosol distributions through advanced laser remote sensing in a network of ground-based stations.

Ray Hoff (UMBC) and Gelsomina Pappalardo (CNR-IMAA) are the GALION Leads

http://alg.umbc.edu/galion/

1st Meeting: Hamburg, MPI
March 2007



2nd Meeting: Geneva, WMO
September 2010

Conceptually GALION fits GEOSS since it is a Network of Networks and GAW is GEOSS

Represented Networks:

Regional/Continental (Dense):

- EARLINET (EUROPE)
- AD-NET (E ASIA)
- CIS-LINET (CIS)
- CLN (NE United States)
- CORALNET (Canada)
- ALINE (Central & South America, Caribbean)

Global (Sparse):

- MPLNET
- NDACC

* Independent Sites

Implementation:

- Steering Group (GAW - network heads)
- Technical Working Groups
  - Technology & Methodology
  - QA/QC
  - Data Dissemination & Outreach
  - Model & Satellite Validation, Data Assimilation
- Capacity Building
  - Development into other regions
- Integration with Sunphotometer/Satellite Meas/Modeling
- Initial observation schedule based on EARLINET

  Minimum 1 obs at sunset on Mon, Thu

  If possible, 1 obs midday on Mon

Observational configuration	Bsc. cf.	Ext cf.	Lidar ratio	Opt. depth	Ang. exp.	Microphys
1-λ standard backscatter lidar	$\beta(z)$					
1-λ standard backscatter lidar + Sun photometer	$\beta(z)$,	$\alpha(z)$ estimate	$S_a(col)$	$\tau(\lambda)$	$Å_\tau(col)$	MPP(col)
m-λ standard backscatter lidar	$\beta(\lambda,z)$				$Å_\beta(z)$	
m-λ standard backscatter lidar + Sun photometer	$\beta(\lambda,z)$	$\alpha(\lambda,z)$ estimate	$S_a(\lambda,col)$	$\tau(\lambda)$	$Å_\beta(z)$, $Å_\tau(col)$	MPP(col)
1-λ Raman lidar/HSRL	$\beta(z)$	$\alpha(z)$	$S_a(z)$	τ		
1-λ Raman lidar/HSRL + Sun photometer	$\beta(z)$,	$\alpha(z)$	$S_a(z)$	$\tau(\lambda)$	$Å_\tau(col)$	MPP(col)
m-λ Raman lidar	$\beta(\lambda,z)$	$\alpha(\lambda,z)$	$S_a(\lambda,z)$	$\tau(\lambda)$	$Å_\beta(z)$, $Å_\alpha(z)$	MPP(z)
m-λ Raman lidar + Sun photometer	$\beta(\lambda,z)$	$\alpha(\lambda,z)$	$S_a(\lambda,z)$	$\tau(\lambda)$	$Å_\beta(z)$, $Å_\alpha(z)$, $Å_\tau(col)$	MPP(z), MPP(col)

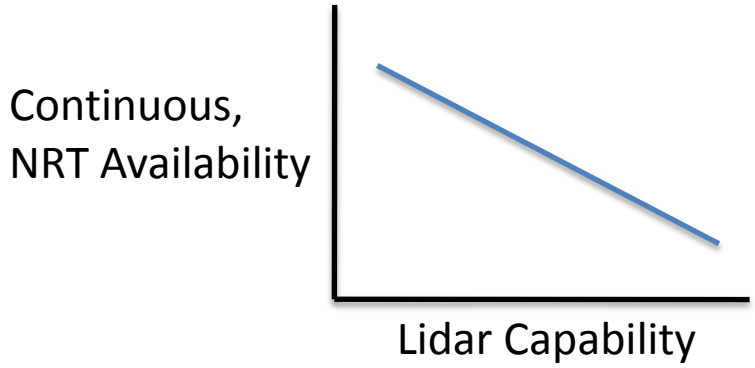
Parameter (product)	Basic lidar type
Range corrected signal (colour plots of aerosol and cloud distributions)	BL
Attenuated backscatter coefficient (calibrated range-corrected signal)	BL
PBL depth , cloud heights	BL
Aerosol backscatter coefficient	BL+SPM
Aerosol type discrimination (dust, anthropogenic)	BL+DL
Aerosol extinction coefficient (estimate), optical depth, column lidar ratio	BL+SPM
Aerosol extinction coefficient, optical depth, lidar ratio	RL or HSRL
Ångström exponent (backscatter-related)	MBL
Ångström exponent (extinction-related)	MRL
Aerosol type determination (dust, maritime, fire smoke, urban haze)	MRL+DL
Aerosol microphysical properties (volume and surface conc., refractive index)	MRL
Single scattering albedo (aerosol)	MRL

GALION sites are heterogeneous with respect to:

- Lidar capability (what can be retrieved from obs)
- Temporal resolution and sampling (continuous, episodic)
    - Vertical res varies also, but probably less of an issue
- NRT capability
- Standard automated processing

The following slides provide an overview of three established networks, all are now 10 years old. Example of the heterogeneous nature of GALION

Typically:



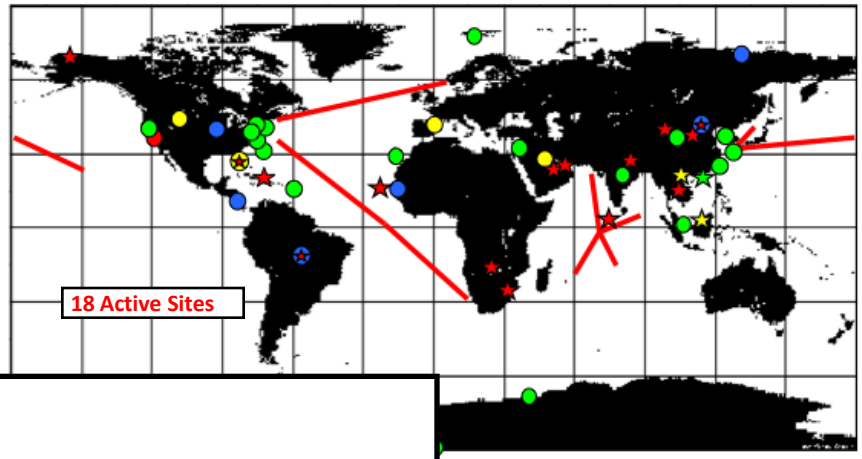
But not always….

The Micro Pulse Lidar Network (MPLNET): Overview

South Pole MPLNET Site:
1999-current

Micro Pulse Lidar
(GSFC Patent)

MPLNET Sites: 2000 - current



ng term site
eld campaign
rmer field campaign, planned/proposed site
hip cruise
ted with AERONET

MPLNET:

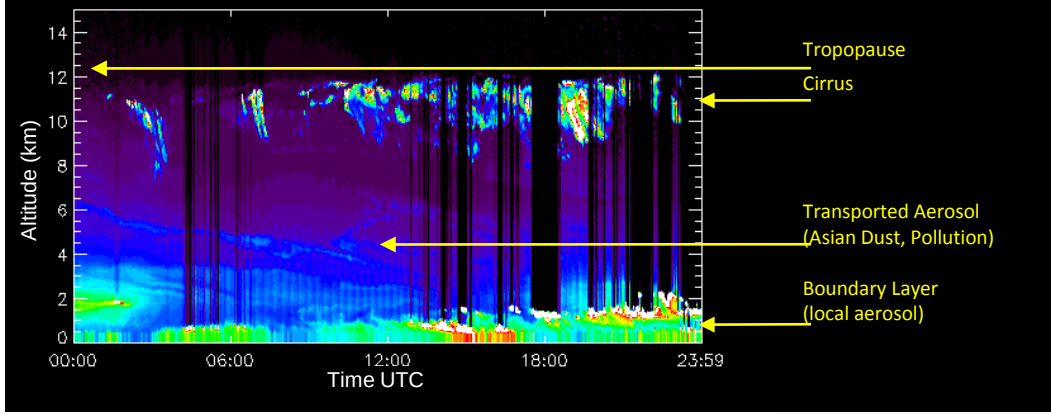
- A federated network of micro pulse lidar
  and lead from Goddard Space Flight Cent
- Co-location with related networks, includ
- Local, regional, and global scale contribu
- Satellite validation
- Aerosol climate and air quality model val
- Impact of aerosol & cloud heights on dir
- Support for wide variety of field campaig

4.9 Trillion Laser Shots,
and counting …..

What's New?

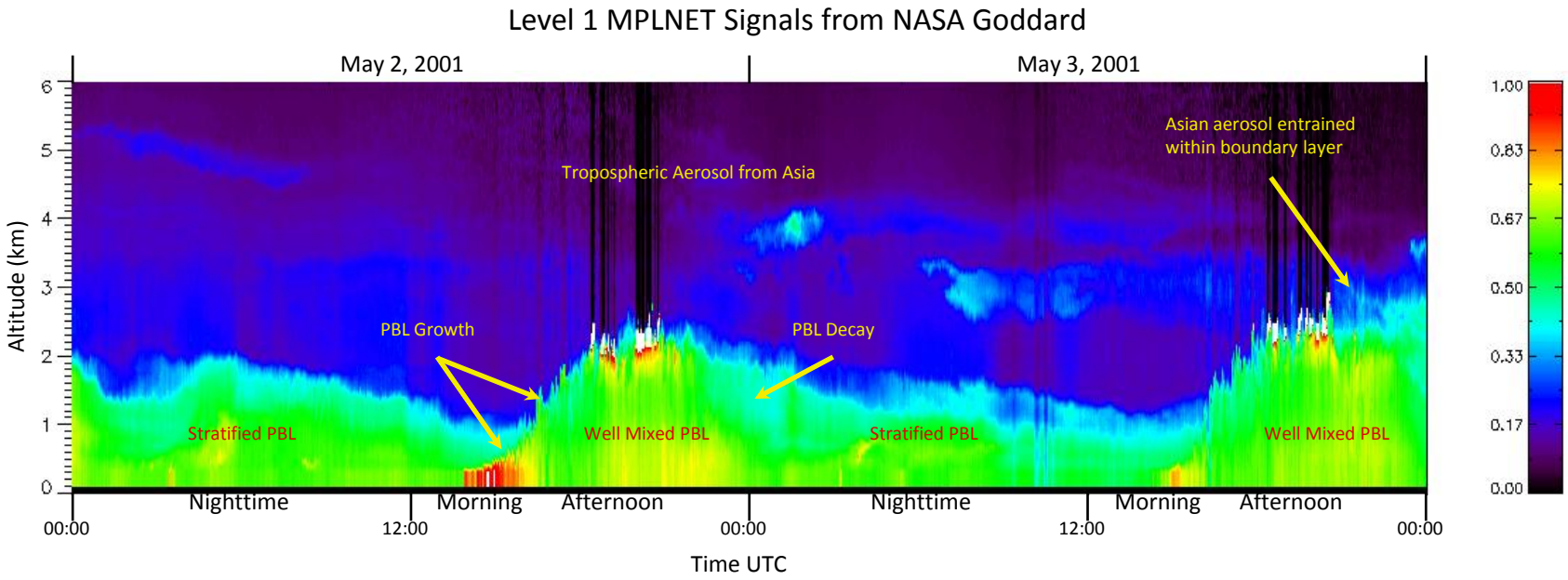
- Version 2 products released 2008
- Barbados site activated in 2008
- Kanpur, India and Singapore sites activated in 2009
- Dongsha Island temporary site Spring 2010
- Hanoi, Vietnam planned site by early 2011
- One or two additional sites in SE Asia in support of 7-SEAS
- Other planned sites over next year: Qatar, Spain, Miami, NYC, Montana

Atmospheric Structure



http://mplnet.gsfc.nasa.gov

MPLNET Data Products



MPLNET Data Products:

near real time: 1 hour or 1 day

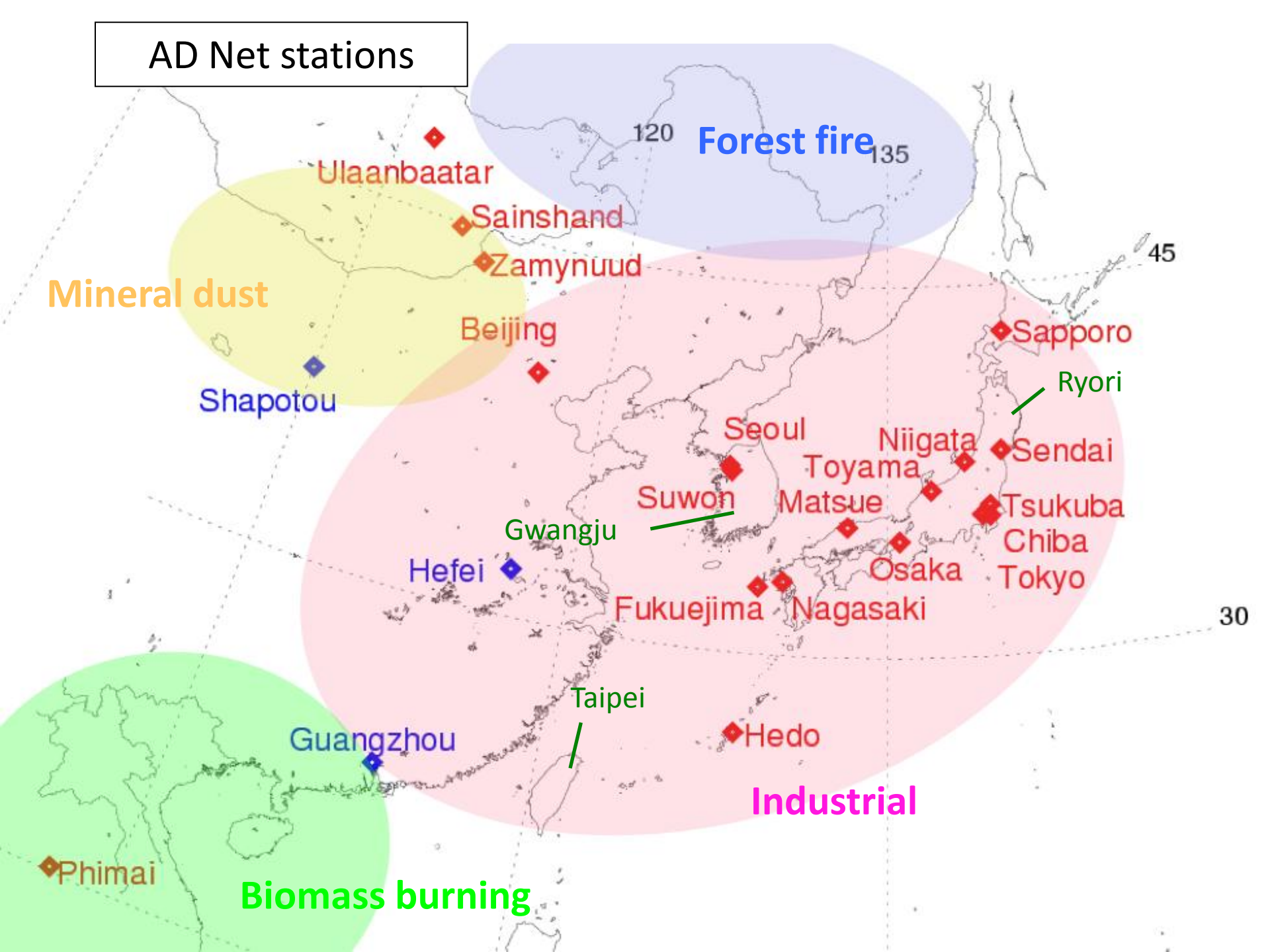
Level 1 NRB Signals, Diagnostics
(near real time, no quality screening)

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)

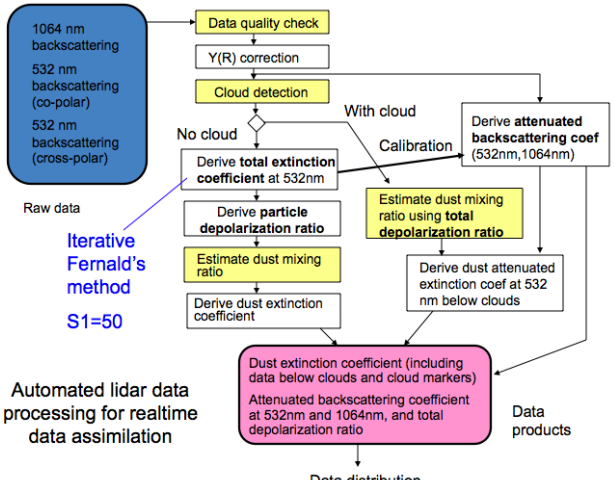
All data are publicly available in netcdf format. Errors included for all data products.

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

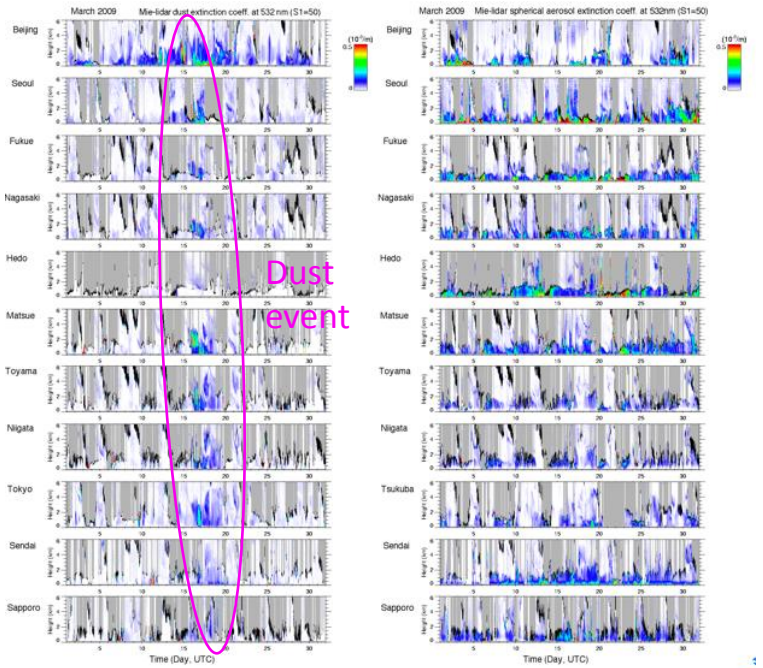

AD Net stations
120
135
45
30
Forest fire
Ulaanbaatar
Sainshand
Zamynuud
Mineral dust
Beijing
Shapotou
Sapporo
Ryori
Seoul
Niigata
Sendai
Toyama
Suwon
Matsue
Tsukuba
Gwangju
Chiba
Hefei
Osaka
Tokyo
Fukuejima
Nagasaki
Taipei
Guangzhou
Hedo
Industrial
Phimai
Biomass burning

(NIES Lidar Network)

Two-wavelength (1064nm, 532nm) Mie-scattering lidar with polarization channels at 532nm. (Raman receivers (607nm) are being added at several observation sites.)

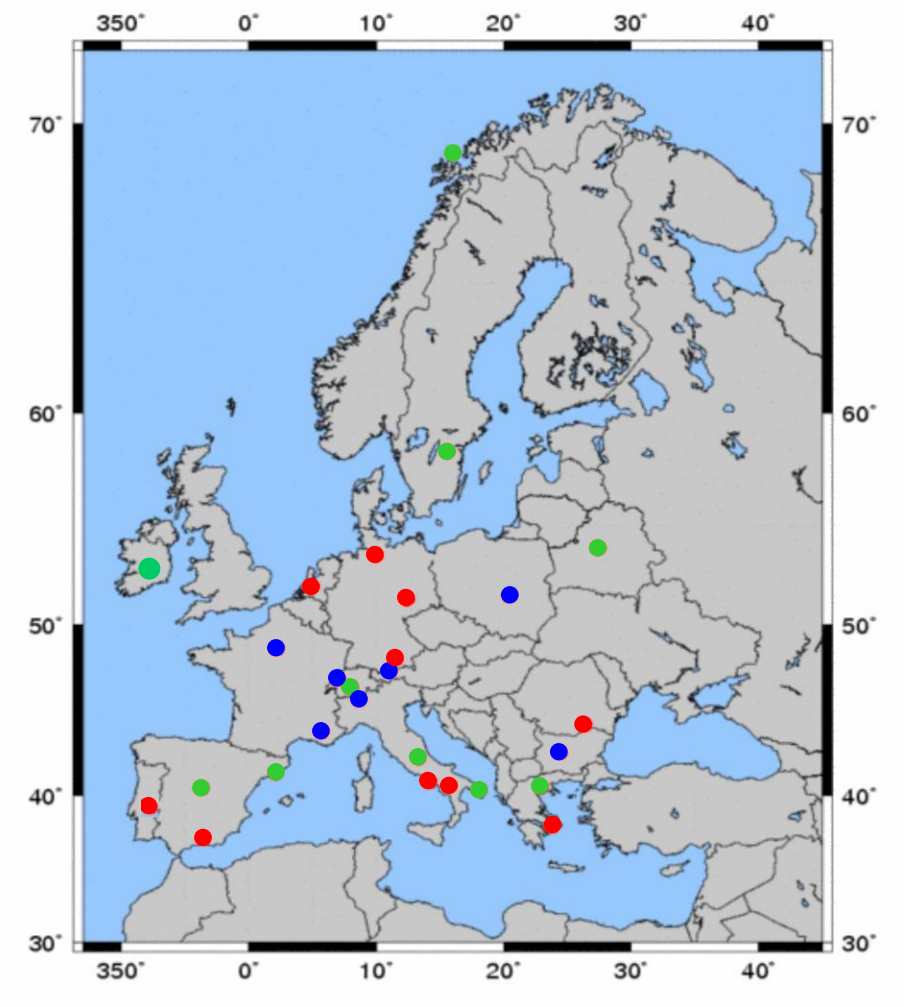


Realtime data processing system



Extinction coefficient estimates of dust (left) and spherical aerosols (right) for primary locations (April 2009).

European Aerosol Research Lidar Network (2010)



- 27 lidar stations

- 10 multiwavelength Raman lidar stations

backscatter (355, 532 and 1064 nm) + extinction (355 and 532 nm) + depol ratio (532 nm)

- 10 Raman lidar stations

- 7 single backscatter lidar stations

- comprehensive, quantitative, and statistically significant data base

- Continental and long-term scale

www.earlinet.org

EARLINET-ASOS
Sixth Framework Programme

EARLINET (for model evaluation/comparison)

Network: 27 lidar stations distributed over Europe (good coverage at continental scale)

Available lidar data (including error): extinction and backscatter profiles at 1, 2 or 3 different wavelengths plus aerosol depolarization profiles

Further products: Boundary Layer heigth, identification of layers, aerosol type classification and in some extent also the retrieval of microphysical properties for identified layers.

At present EARLINET data are not available in near real time.
A lot of work is in progress in order to establish a single calculus chain for all the instruments within the network (AERONET like).
This single calculus chain is at moment under test and it should be operational in early 2011.
This means that we will not have data in near real time in 2011 (within few hours), but that we could have a larger amount of available Quality Assured data in a much faster way. These data could be used for systematic data evaluation/comparison.

Representativeness studies are in progress using both satellite and sun-photometer data.

GALION Goals:

Ensure that users obtain lidar data that meets standards agreed upon lidar experts, with appropriate error

Facilitate cooperation and interaction among different networks to meet community needs

- one group can't do it all

Develop a system that allows users to visit one portal and:

- Effectively search for lidar data across otherwise disparate networks and individual stations
- Browse quicklooks of data
- Easily obtain data products in a standard, common format
- Help users navigate complicated data policies and protect data providers

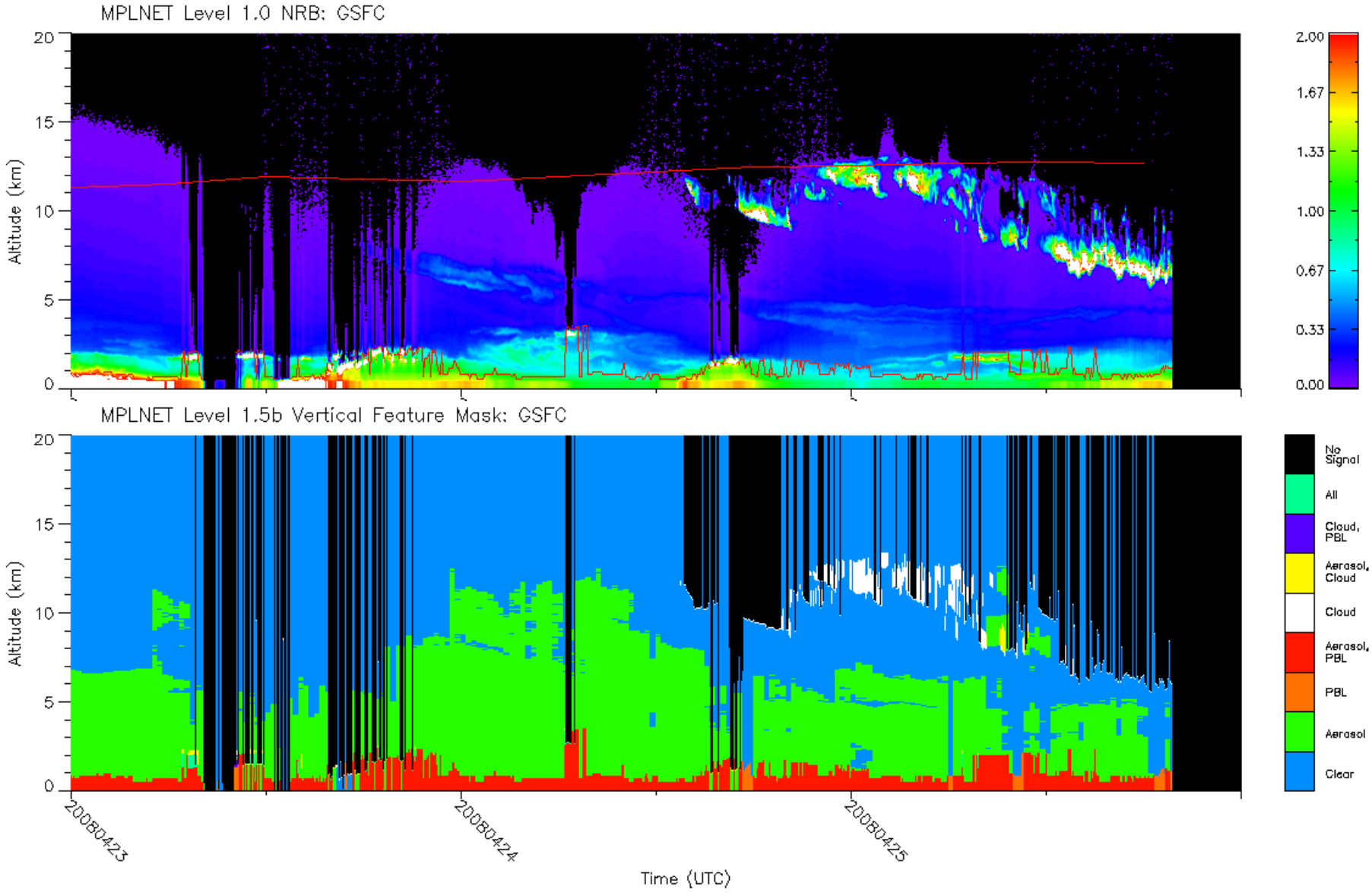
GALION has many challenges but we are confident this is possible

One important challenge:
Recognize that our heterogeneous nature is not a "problem", but an advantage. We need to focus on how to effectively provide ALL that we can from contributing stations, not settle on providing the bare minimum that every station can provide (eg backscatter).

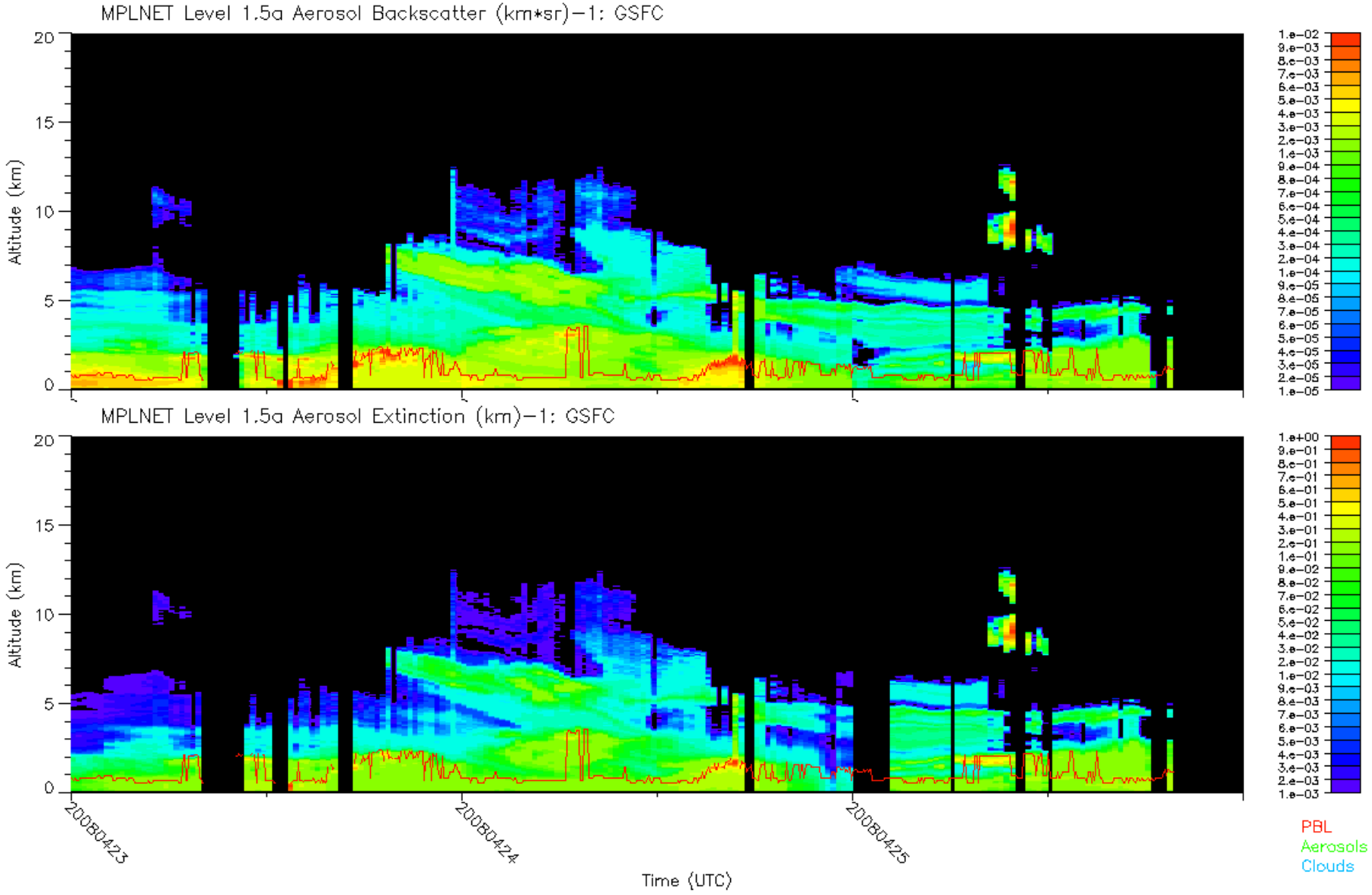
Most important challenge:
Money – what else? Funding levels vary widely across GALION contributors, most everyone is supported with research funding, not operational funding. That is a problem for ICAP users who want operational lidar data.

GALION Related Discussion Slides for ICAP

Simple systems contain much useful information on atmospheric structure….

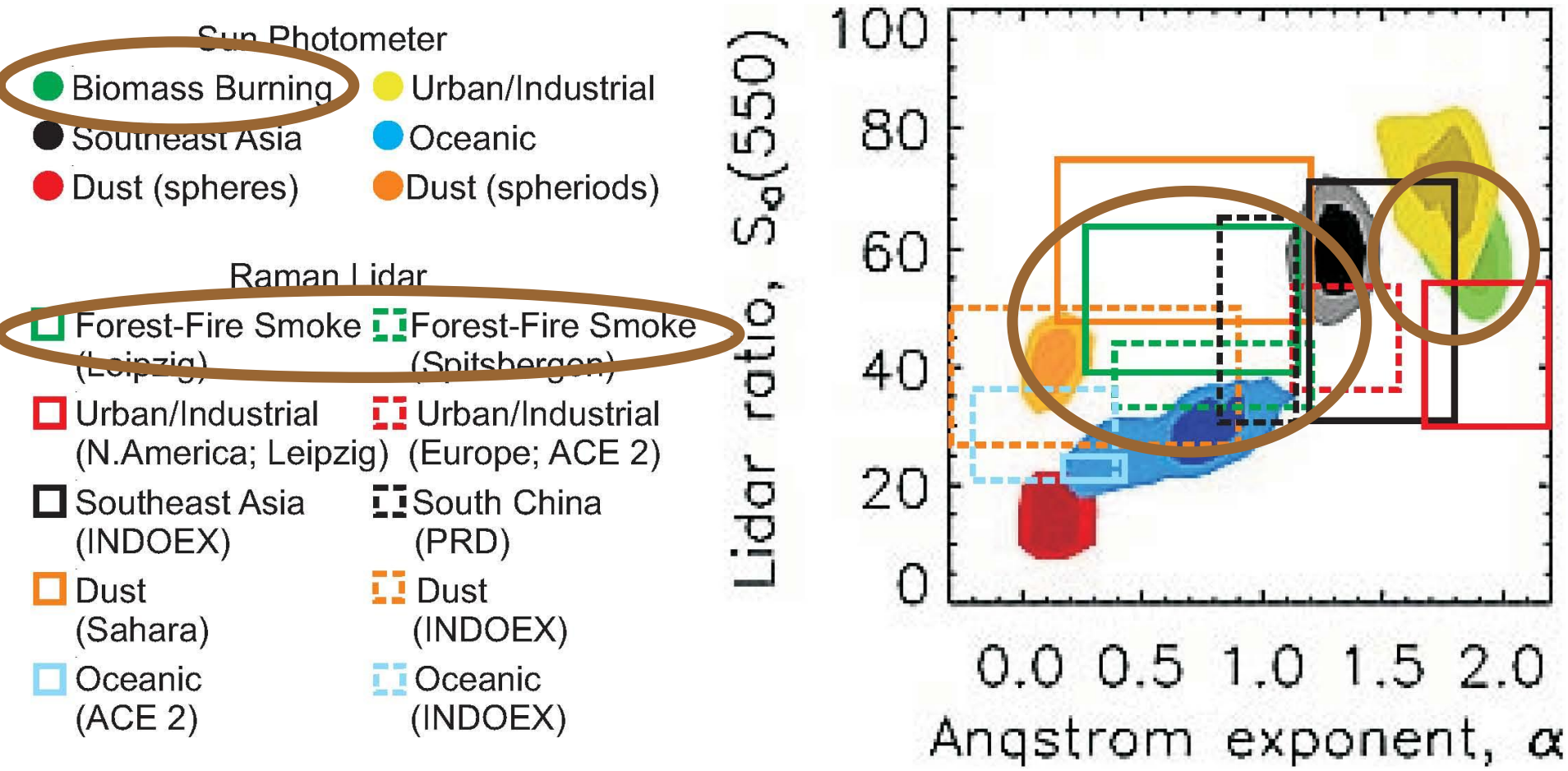


…. But cannot produce highly accurate extinction, or aerosol typing / microphysics



…. Because of the limited information available from observations

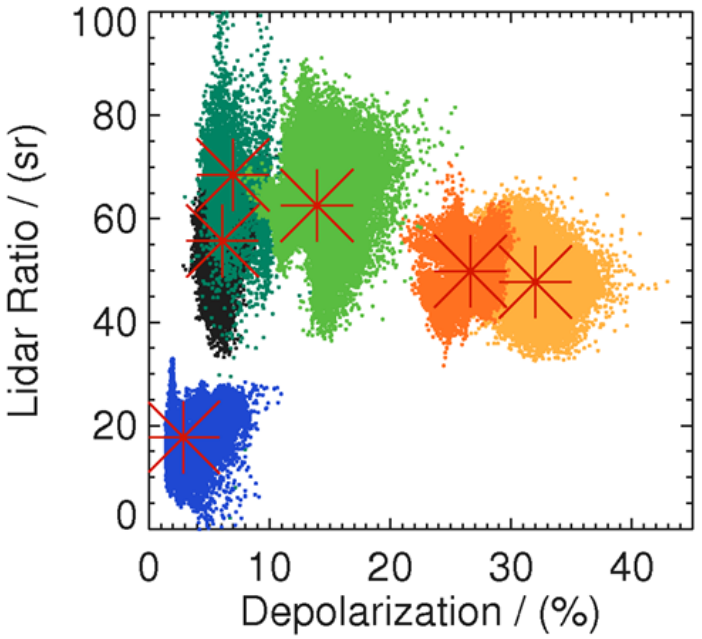
AERONET aerosol typing: column values



Slide from D. Müller, 2nd GALION Workshop

aerosol type classification

icarohs
support to science element



Pure Saharan Dust

Aged Saharan Dust

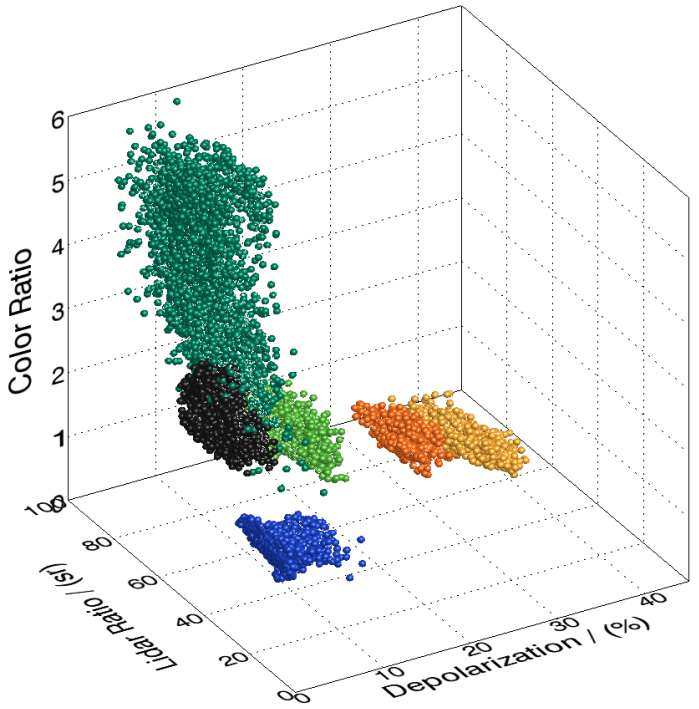
Biomass Burning Aerosol + Mineral Dust

Canadian Biomass Bui

Industrial Pollution Ae

Marine Aerosol

Slide from D. Müller, 2nd GALION Workshop

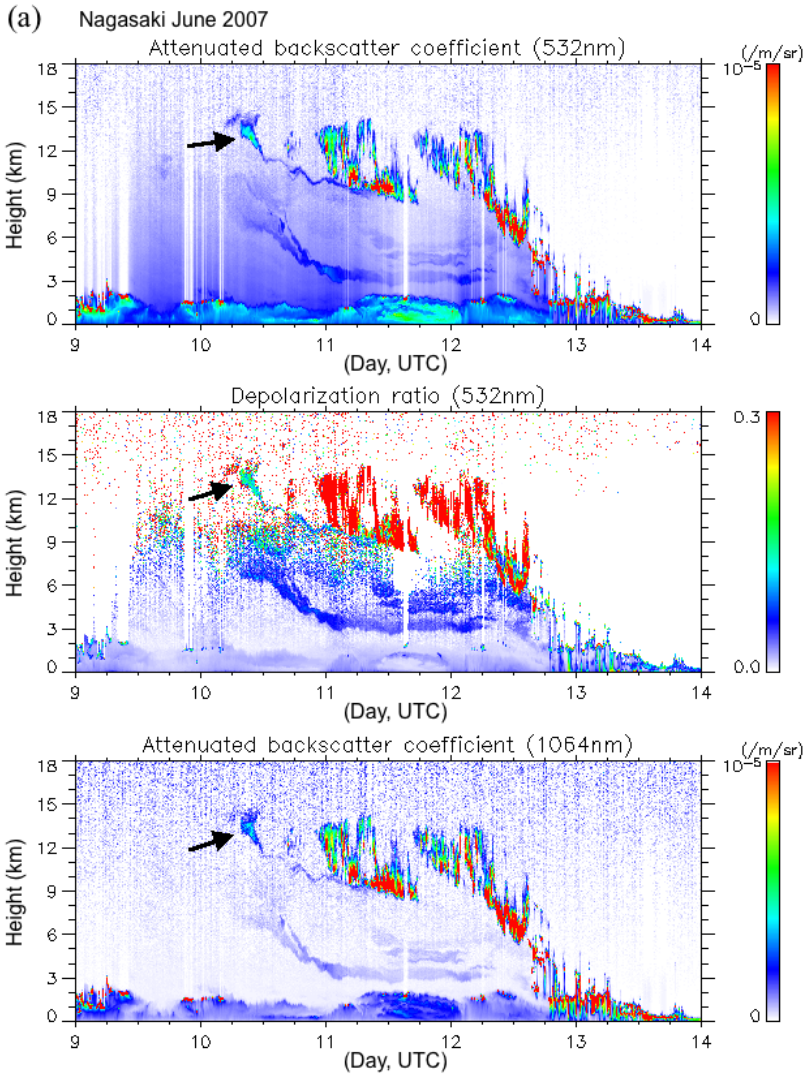


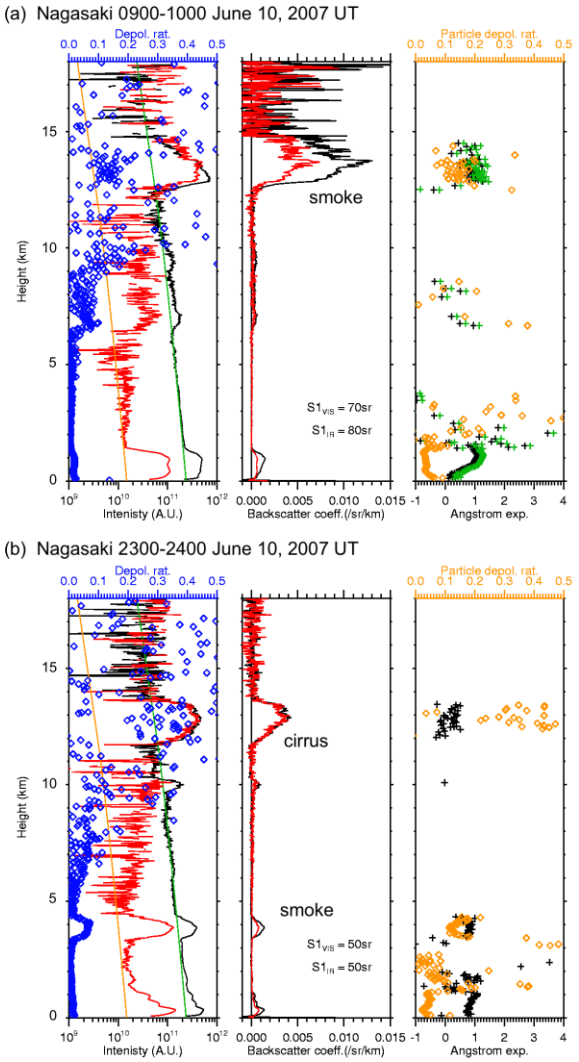
- different aerosol types cluster and can be distinguished
- spread of the clusters is limited by natural variations in the end

DLR

Petzold et al. ESA -ICAROHS, 2009
Esselborn et al., Appl. Opt., in preparation

~Mid-class lidar systems provide more information on aerosol type, and can still provide continuous, NRT capability (but more expensive and have eye-safety issues)



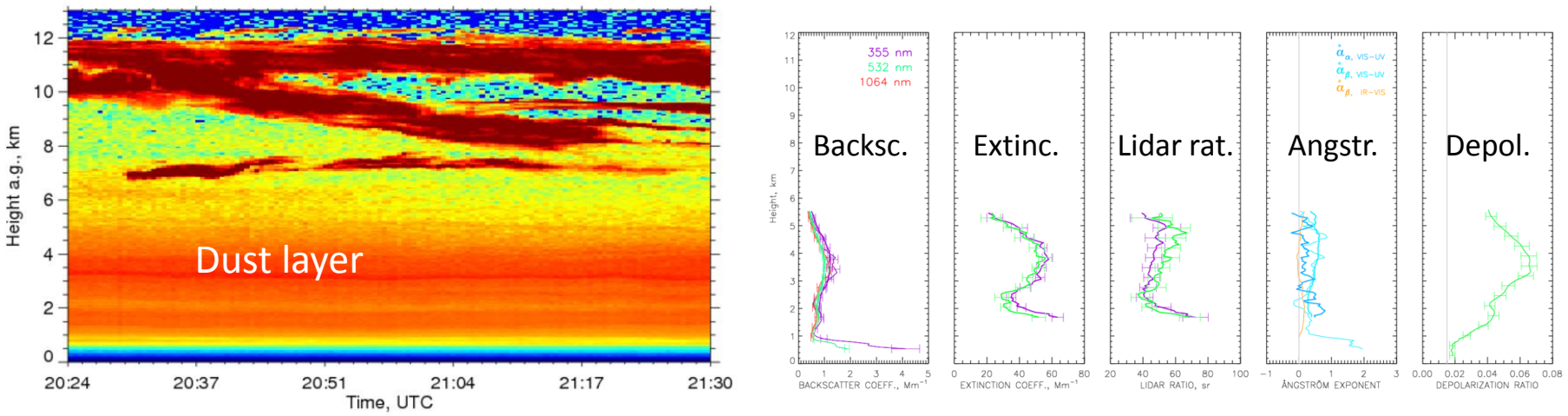


(Sugimoto et al., SOLA 2010)

Single wavelength Raman or HSRL systems can provide accurate extinction, But still have difficulty typing aerosols and cannot do microphysics

Multi-wavelength Raman or HSRL systems (3b+2a or better) can provide it all, but expensive, most have issues running continuously, and microphysical retrievals are complicated and difficult to run (at least now)

* note, some multiwavelength raman systems are running continuously

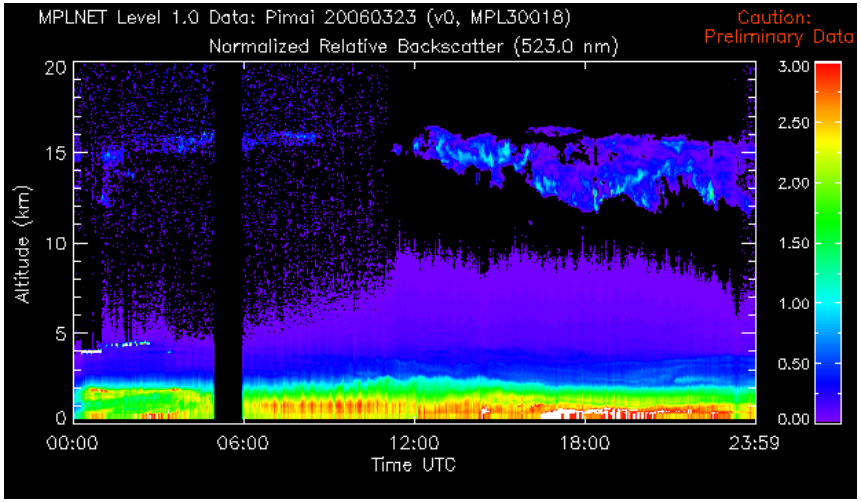


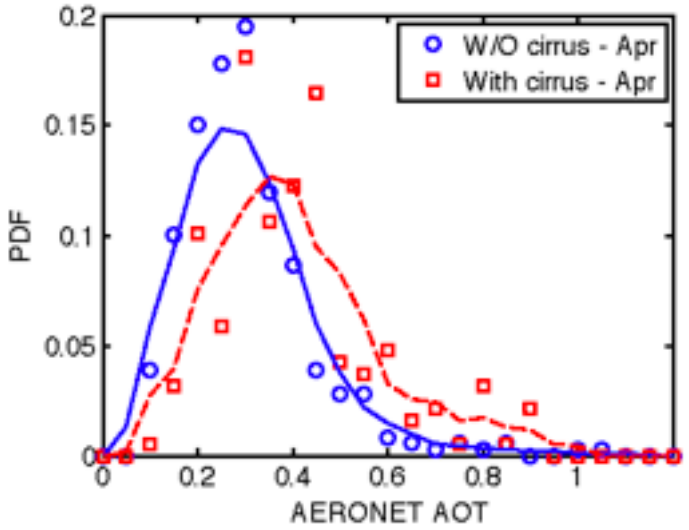
Slide Image from Ulla Wandinger, 2nd GALION Workshop

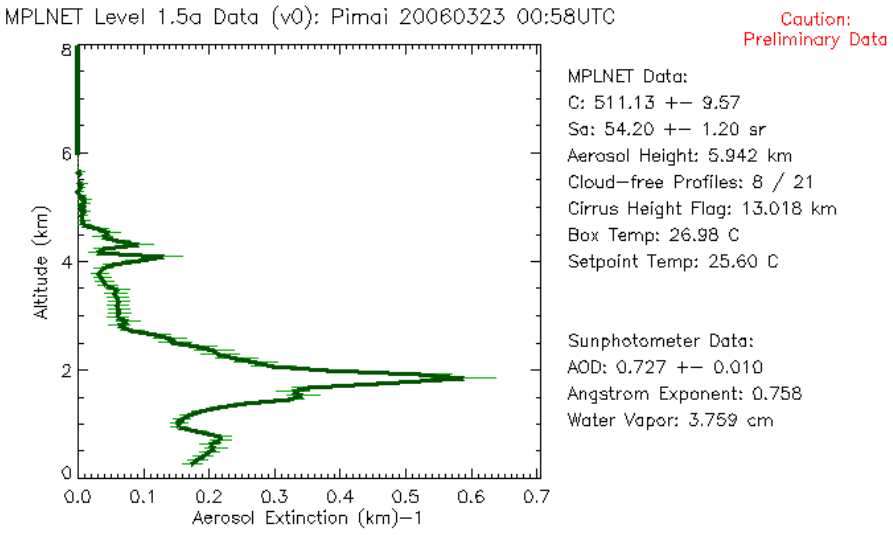
MPLNET Data Products: Cirrus Detection for AERONET AOD Evaluation

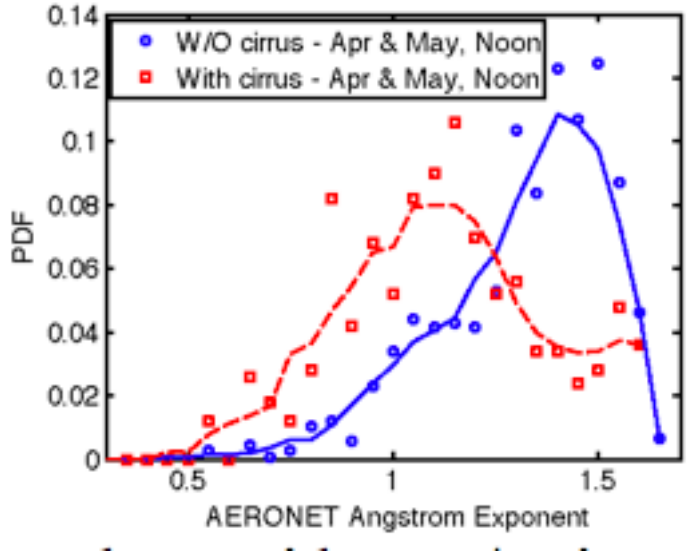
Susceptibility of Aerosol Optical Thickness Retrievals to Cirrus Contamination during the BASE-ASIA Campaign

J. Huang, N.C. Hsu, S.C. Tsay, M.-J. Jeong, B. Holben, E.J. Welton









Working Group Issues of Interest to ICAP:

Data archive and distribution still open.

- Metadata in GEOMs format, station entries should be placed in GAWSIS (problems with data there now)
- NETCDF or HDF
- Define common data descriptions: Level 0, 1, 1.5, 2 (GEOMS and MPLNET standards)
- Distributed vs centralized data center. Network heads favor distributed to maintain link to data use.
  - EARLINET, MPLNET, and AD-NET have well developed data centers, how to handle others?
- NRT Data needs connection to WIS backbone, method may have to be different than normal data

Networks cannot loose connection to data use! Need to justify our funding, and many sites within networks are run/funded independently.

- Perhaps easier to track research use of GALION data, but NRT for operational forecasting would be more difficult
  - Even if we put an expiration date on the NRT data for forecasting, still doesn't capture use of data by op center
  - Leverage off data providers for verification analysis? They have more time to look into the why (esp with students)

GALION Model & Satellite Validation, Data Assimilation Working Group:

Chairs: Judd Welton (NASA GSFC), Felicita Russo (CNR-ISAC)
Members: Stefan Kinne (MPI-Meteorology), Juan Carlos Antuña (Camaguey Met Center), Dave Winker (NASA LaRC), Thorsten Fehr (ESA), MariaRita Perrone (U Salento), Werner Thomas (?)

Define data products:

- Backscatter Profile
- Extinction Profile
- PBL Height
- Cloud Heights
- Clear
- No Signal
- Package co-located AOD data with lidar (eg MPLNET)
- Some will be periodic, others continuous
- Will require subsetting of sites by products available (and time) to avoid confusing users

Emphasize the following to GALION members:

- To avoid bias and misinterpretation by users: Must capture "no data/signal" information, and clouds
- Error/uncertainty is key for data assimilation
  - separate systematic from random if possible
  - consider reporting data even if fail internal GALION QA, or at least capture aerosol presence/location
  - report quality of error calculation… ie, backscatter+sunphoto derived extinction error contains potential bias due to use of constant lidar ratio, raman or HSRL technique can provide direct error calculation… Quality of error not standard across GALION!

Continuous data ideal, but not possible across GALION: modify existing minimum obs schedule to include sat overpass?

Our working group recommendation:
Select a past "golden" year to begin building GALION framework, avoids issues some groups have with generating new data products. Tie in with Aerocom hindcast effort, and might stimulate GALION members to contribute their data.

EARLINET (for data assimilation)

Near real time development possible in the future (1.5 level data not fully QA)

At moment EARLINET performs systematic observations, but not continuous 24hours/7 days a week measurements.

Continuous observations possible at 4 sites at moment (2010) and possible development for further stations in this direction can be made.

Continuous observations could be implemented but this implies a large difference in effort/ resources (in terms of man power and hardware/equipment). So before going for these continuos observations we have first to demostrate that these are really necessary.

A strong demand for continuous observations could help to find the necessary resources.

How many sites are necessary for continuous observations in order to be used for data assimilation at continental scale? **The answer to this question will help us in the implementation.**

For further info, please contact Gelsomina Pappalardo
pappalardo@imaa.cnr.it