Status and Update on the WMO GAW Aerosol Lidar Observation Network (GALION)

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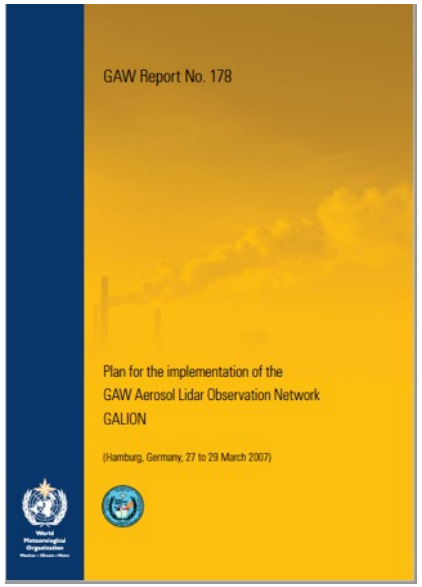
World Meteorological Organization
Global Atmosphere
Watch Program

GALION The GAW Aerosol Lidar Observation Network

GALION is a lidar network of networks organized through the WMO Global Atmospheric Watch (GAW) program.

Judd Welton (NASA, USA) and Lucia Mona (CNR, Italy) are co-chairs
Guidance and direction provided by steering committee (network heads) and GAW Aerosol SAG

See GAW Report 178 (2008)



Original GALION Networks:

- AD-Net
- EARLINET
- CIS-LINET
- LALINET
- CORALNET
- CREST

regional

- MPLNET
- NDACC Lidar

global

active GALION members, signed agreements with WMO as contributing networks

Objectives: provide long term, coordinated lidar network profiling of aerosol properties to support the following

1. climate research and assessment
2. air quality assessment and forecasting
3. Plume monitoring for special events
4. Satellite cal/val and synergistic research

Global coverage is only achievable by combining efforts of individual lidar networks. We have to work together.

Other Motivation: Satellite lidar profiling gaps

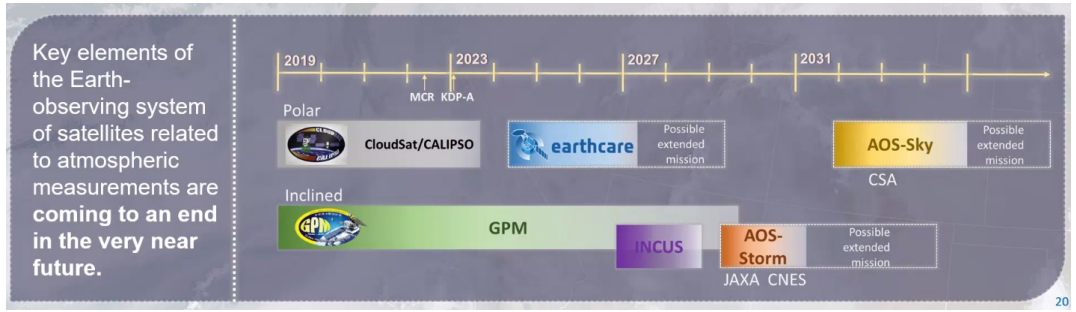


Image from NASA AOS team

Motivation for ICAP:

For most of you aerosol vertical distribution (especially operational use) has been on your future work slide since ICAP 1
Goal is to help move that to your current work slides by providing easier and more informative access to our data

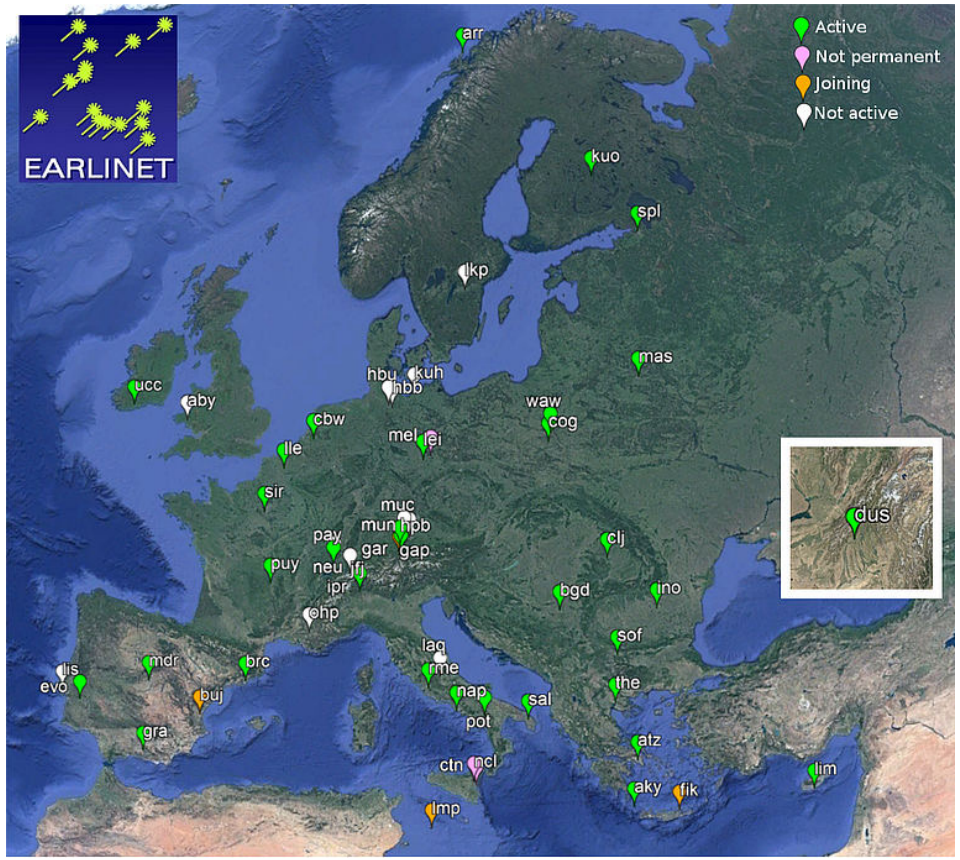
Asian dust and aerosol lidar observation network – AD-Net

#Realtime data sharing is not applicable to lidars in China

- 96 profiles / day, vertical resolution = 30 m
- 532 nm attenuated backscatter coefficient + depolarization ratio (up to 18 km) & extinction coefficient (with fixed lidar ratio S1 = 50sr, up to 9 km)
- Available in figures and netCDF at: https://www-lidar.nies.go.jp/AD-Net/
- References: Shimizu et al., Opt. Eng. (2017) doi:10.1117/1.OE.56.3.031219
- Contact: shimizua@nies.go.jp

* Last updated March 2022

European Aerosol Research LIdar NETwork – EARLINET/ACTRIS



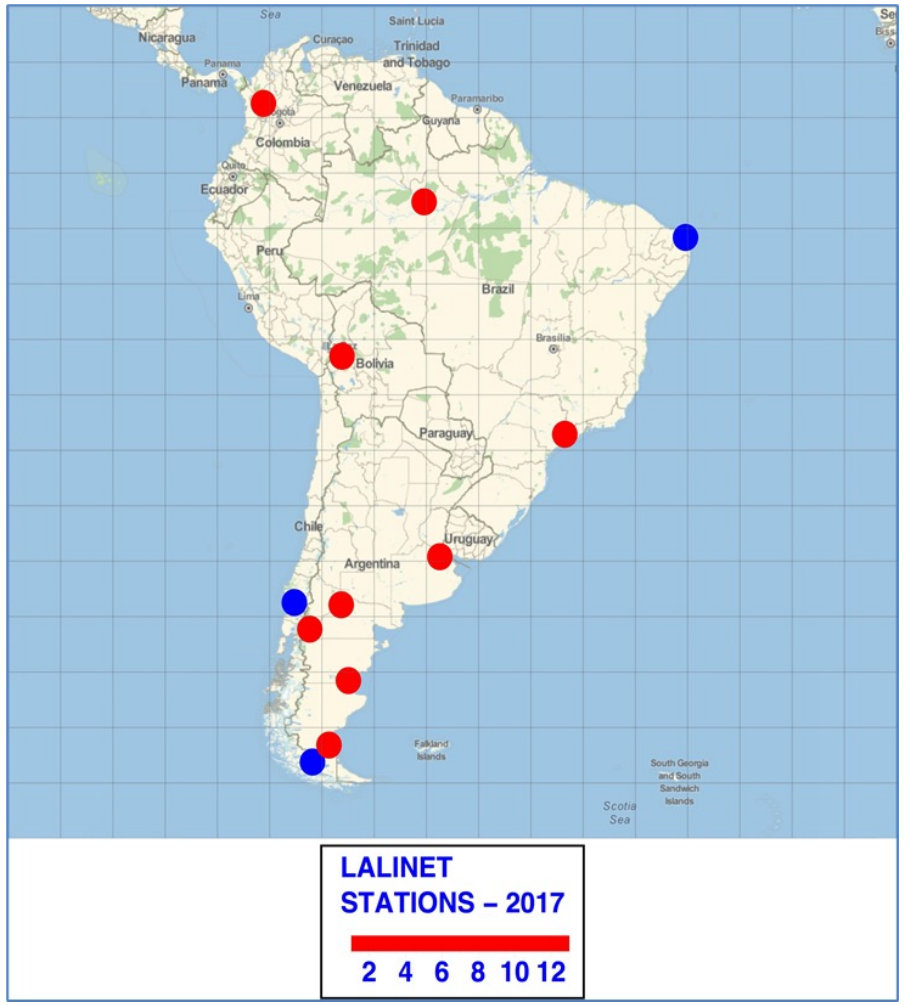
https://www.earlinet.org/

- mainly based on **Raman** lidar systems, able to provide vertical **profiles** of **aerosol extinction** and **backscatter** coefficients without significant assumptions.
- most of the stations at **different wavelengths**
- currently most of the sites provides also **linear particle depolarization ratio**
- most of the sites have **co-located photometers**

EARLINET is since 2011 integrated in **ACTRIS (Aerosol, Clouds, and Trace gases Research Infrastructure)**

Pappalardo, G., et al., EARLINET: towards an advanced sustainable European aerosol lidar network, Atmos. Meas. Tech., 7, 2389–2409, https://doi.org/10.5194/amt-7-2389-2014, 2014.

Latin America LIdar NETwork – LALINET



ST.	ID	LAT(S) LON(W)	Channels (nm)
Buenos Aires	*AEP*	34.56°S 58.42°W	*1064, 532P & 355P*
Buenos Aires	*VMA*	34.56°S 58.51°W	*1064, 607, 532P, 387 & 355P*
Neuquen	*NQN*	38.95°S 68.13°W	*1064, 532P & 355P*
Barilo-che	*BRC*	41.15°S 71.16°W	*1064, 607, 532, 387 & 355*
Commo doro	*CDR*	45.79°S 67.46°W	*1064, 532 & 355*
Gal-legos	*RGL*	51.61°S 69.31°W	*1064, 532P & 355P*
Punta Arenas	*PAR**	53.13°S 70.88°W	*1064, 607, 532P, 408, 387 & 355P*
S. Paulo	*SPU*	23°13′ 46°28′	*1064, 607, 532, 408, 387 & 355*
S. Paulo	*SPT*	*VAR*	*607, 532*
Man-aus	*MAO*	02.60°S 60.21°W	*408, 387, 355*
Natal	*NAT*	05.82°S 35.20°W	*1064, 532P & 355P*
*Temuco**	*TMU**	38.74°S 72.62°W	*1064, 532P & 355P*
Medellin	*MED*	06.26°N 75.58°W	*532 & 355*
La Paz	*LPZ*	16.54°S 68.07°W	*1064, 532P & 355P*

https://lalinet.org

Measurements of 1064 nm, 532 nm and 355 nm from elastic and multi-wavelength lidar systems in order to retrieve backscatter, extinction, lidar ratio profiles, plus backscatter and extinction Angstrom Exponent and Color ratio.

LALINET: The First Latin American–Born Regional Atmospheric Observational Network
https://doi.org/10.1175/BAMS-D-15-00228.1

* Last updated March 2022

NASA Micro Pulse Lidar Network – MPLNET

Global Backscatter Lidar Network: 2000 - current

- 82 sites total (25 operational, 57 closed): 28 countries
- 12 more sites in planning
- Continuous (day/night) operations, colocation with AERONET

Instrumentation:

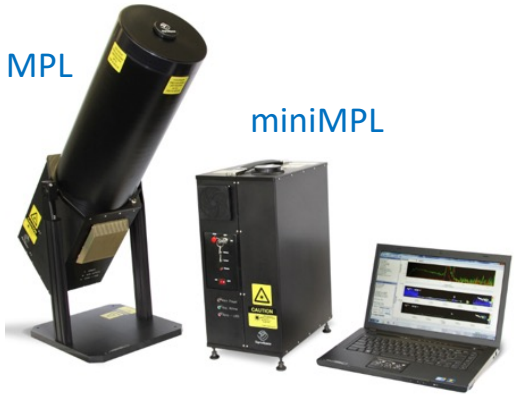
- Micro Pulse Lidar, miniMPL
- Eye safe, green backscatter lidar. Polarized in early 2000s
- Entire network has polarized MPL since ~2016

MPLNET History:

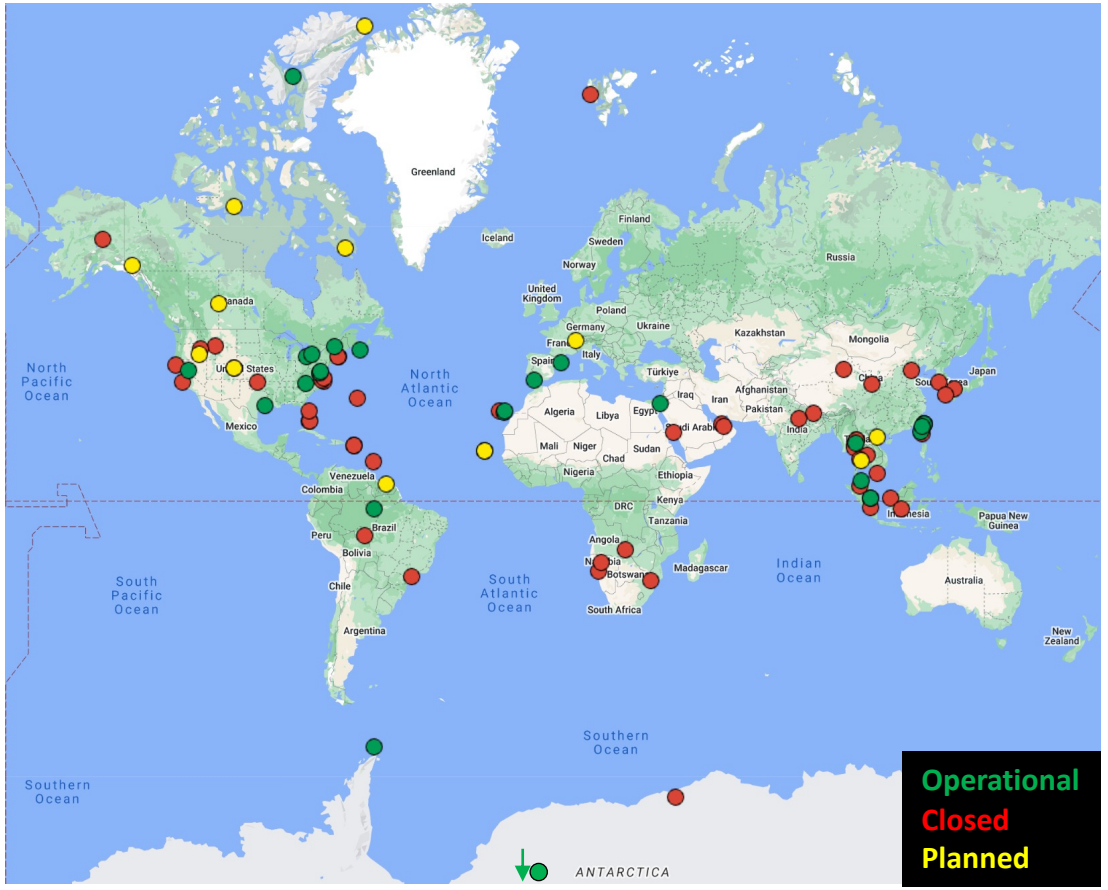
- Three Version Releases: V1 and V2 (2000 – 2021)
- Version 3 Released in Nov 2021

Updates Since ICAP 2022:

- More sites installed, many more in final planning stages (ops by 2024)
- Focus on new sites in western North America near fire sources
- Ongoing V3 reprocessing of older data back to 2000



https://mplnet.gsfc.nasa.gov



Data Products:

- NRB: Lidar signals; volume depolarization ratios; diagnostics
- CLD: Cloud heights; thin cloud extinction and optical depths; cloud phase
- AER: Aerosol heights; extinction, backscatter, and depolarization ratio profiles; lidar ratio
- PBL: Mixed Layer Top and estimated AOD
- L1 and L1.5 products available in NRT, QA screen applied at L1.5 and L2
- L3 products in development (created from L2 data)

Network for the Detection of Atmospheric Composition Change – NDACC

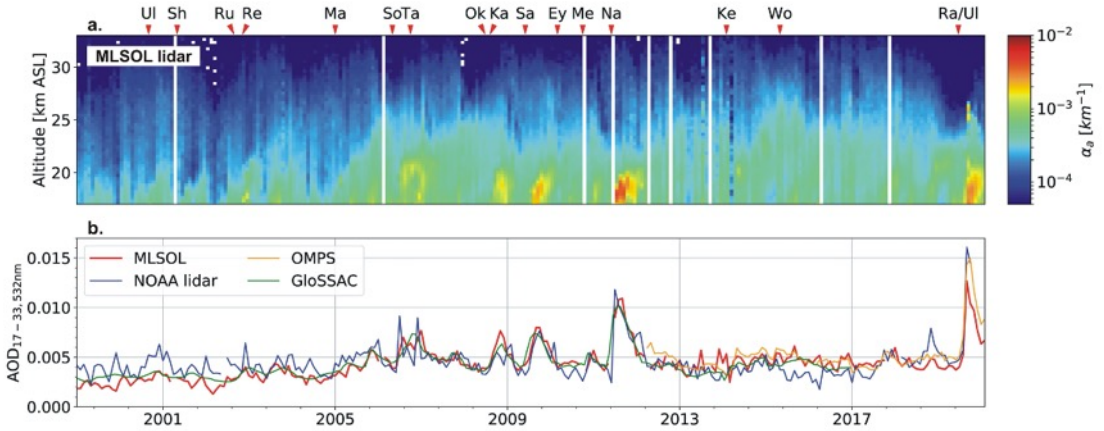
NDACC Sites	Aerosols	Ozone	Temperature	Water Vapor	Wind
All times (active and inactive)	20	15	15	15	1
In operation today (active)	10	10	10	10	1

Courtesy of Thierry Leblanc,
Jet propulsion Laboratory,
California Intitue of Technology

Long-term monitoring of atmospheric composition

http://www.ndacc.org

NDACC provides a measure of stratospheric AOD contribution to total column



Top: Long term time series of Aerosol Extinction by MLSO
Bottom: Stratospheric AOD from MLSOL and NOAA-MLO lidar, OMPS, and GloSSAC

Chouza et al. ACP (2020): Long-term (1999–2019) variability of stratospheric aerosol over Mauna Loa, Hawaii, as seen by two co-located lidars and satellite measurements, ACP, 20(11), 6821-6839

Leblanc et al., BAMS, State of the Climate 2020, Chapter 2, Sidebar 2.2

* Last updated March 2022

GALION: Operations and Working Groups

GALION operations: from 2008 original report

Due to the variety of lidar instruments and processing systems throughout the contributing networks, it was decided to target a minimum of 2 observations per week.

- Monday and Thursday around sunset
- Some networks continuous 24/7, number growing

Products provided from a given site are dependent upon the capability of the onsite lidar and network.

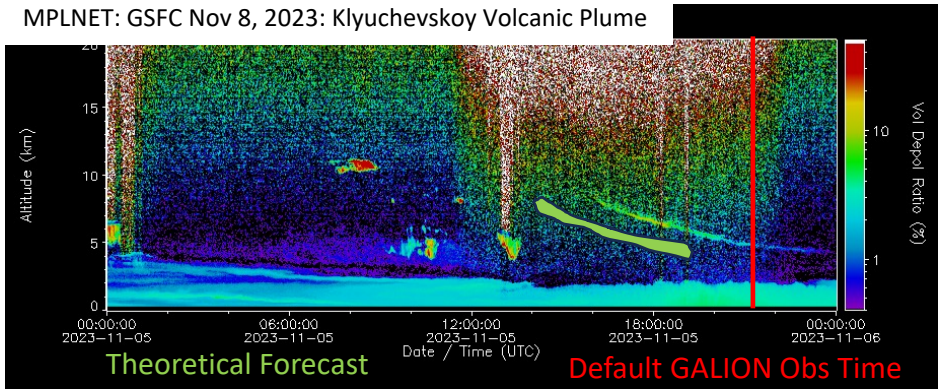
This system accommodates a tiered approach to data quality based on lidar capability and external observations.

Working groups:

- Methodology
- Technologies
- Quality Assurance
- Applications
- Data Center

Data Center Working Group formed in Dec 2021
Welton Lead. Representatives from each network

MPLNET: GSFC Nov 8, 2023: Klyuchevskoy Volcanic Plume



Continuous data are important for surface obs:

- Inherently limited spatial information
- We can provide better temporal vs satellite
- More helpful for forecast validation

Methods, Technology, Data Quality

- GALION has established standards and each network has traceable history of peer reviewed calibration and processing methods.

Aerosol Observation Requirements and Data Variables

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	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

BL: Backscatter lidar
DL: Depolarization
HSRL: High Spectral Resolution Lidar
SP: Sunphotometer
RL: Raman lidar
M: Multi-wavelength

GALION Data Center Working Group: Metadata & Vocabularies

Standardize and Codify Variables, Instruments, etc

Lidar Variables:
Relative_Attenuated_Backscatter
Attenuated_Backscatter
Volume_Depolarization_Ratio
Scattering Ratio

Cloud Variables:
Cloud_Base_Height
Cloud_Top_Height
Cloud_Backscatter
Cloud_Extinction
Cloud_Lidar_Ratio
Cloud_Optical_Depth
Cloud_Effective_Radius_Estimate
Cloud_Depolarization_Ratio
Cloud_Phase

Mixed Layer Variables:
Mixed_Layer_Height
Mixed_Layer_Aerosol_Optical_Depth_Estimate
Mixed_Layer_Aerosol_Optical_Depth

Aerosol Variables:
Aerosol_Layer_Height
Aerosol_Backscatter
Aerosol_Extinction_Estimate
Aerosol_Extinction
Aerosol_Lidar_Ratio_Estimate
Aerosol_Lidar_Ratio
Aerosol_Optical_Depth_Estimate
Aerosol_Optical_Depth
Aerosol_Angstrom_Exponent_Estimated
Aerosol_Angstrom_Exponent
Aerosol_Effective_Radius_Estimate
Aerosol_Single_Scatter_Albedo_Estimate
Aerosol_Volume_Concentration_Estimate
Aerosol_Surface_Concentration_Estimate
Aerosol_Refractive_Index_Estimate
Aerosol_Effective_Radius
Aerosol_Single_Scatter_Albedo
Aerosol_Volume_Concentration
Aerosol_Surface_Concentration
Aerosol_Refractive_Index
Aerosol_Depolarization_Ratio
Aerosol_Type

Instrumentation:

instrument	code	wigos	wigos_name
Backscatter Lidar	BL	341	Backscatter lidar
Raman Lidar	RL	143	Raman lidar
High Spectral Resolution Lidar	HSRL	342	High spectral resolution (HSR) lidar
Doppler Wind Lidar	DWL	142	Doppler wind lidar
Differential Absorption Lidar	DIAL	335	Differential absorption lidar (DIAL)
Integrated Path Differential Absorption Lidar	IPDIAL	320	Integrated path differential absorption (IPDA) lidar
Polarized Lidar	PL	pending	pending
Multi-Wavelength Backscatter Lidar	MWBL	341	Backscatter lidar
Multi-Wavelength Raman Lidar	MWRL	143	Raman lidar
Multi-Wavelength High Spectral Resolution Lidar	MWHSRL	342	High spectral resolution (HSR) lidar
Multi-Wavelength Polarized Lidar	MWPL	pending	pending
Sunphotometer or Sun-Sky Photometer	SP	244	Sun-tracking photometry

GALION Data Center Working Group: Metadata & Vocabularies

Standard Variables Mapped to Instrumentation and other parameters, including WIGOS OSCAR

No map to WIGOS/OSCAR,
Some variables are in process of begin added,
Some may not ever be added to WIGOS.

Specifies instrument requirements for variables,
Units, Atmospheric Layers (PBL – Stratosphere),
and mapping to WIGOS/OSCAR

variable	description	unit	instrumentation	layer	level	wigos	wigos_name	application_area
Relative_Attenuated_Backscatter	uncalibrated lidar signal	1	BL RL HSRL DWL DIAL IPDIAL MWBL MWRL MWHSRL	PBL freeTroposphere UTLS MUS	1	12251	Relative attenuated backscatter	no
	calibrated lidar signal	m-1 sr-1	BL MWHSRL	PBL	1	12248	Attenuated backscatter	no
Volume_Depolarization_Ratio	volume depolarization ratio	percent	PL MWPL	PBL freeTroposphere UTLS MUS	1	no	no	no
Aerosol_Layer_Height	Aerosol layer height	m km	BL RL HSRL DWL DIAL IPDIAL MWBL MWRL MWHSRL	PBL freeTroposphere UTLS MUS	1.5 2	12162	Aerosol layer height	climateMonitoring
Aerosol_Extinction_Estimate	Aerosol Extinction Coefficient	m-1 km-1 Mm-1	BL BL_SP MWBL MWBL_SP	PBL freeTroposphere UTLS MUS	1.5 2	12145	Particle light extinction coefficient	climateMonitoring aeronauticalMeteorology atmosphericCompositionForecasting atmosphericCompositionMonitoring
Aerosol_Extinction	Aerosol Extinction Coefficient	m-1 km-1 Mm-1	RL HSRL MWRL MWHSRL	PBL freeTroposphere UTLS MUS	1.5 2	12145	Particle light extinction coefficient	climateMonitoring aeronauticalMeteorology atmosphericCompositionForecasting atmosphericCompositionMonitoring
Aerosol_Lidar_Ratio_Estimate	Aerosol lidar ratio	sr	BL_SP MWBL_SP	PBL freeTroposphere UTLS MUS	1.5 2	no	no	no
Aerosol_Lidar_Ratio	Aerosol lidar ratio	sr	RL HSRL	PBL freeTroposphere	1.5 2	no	no	no

GALION Data Center Working Group: Common Data Files

We are working with the EarthCARE validation team to harmonize vocabularies and definitions with pre-existing GALION values

- The EarthCARE EVDC team* is developing a common GEOMS format for L2 aerosol and cloud, tag up meeting next week
- Results of this effort will hopefully lead to common lidar formats, for use by future missions (NASA AOS validation, etc)

Draft Aerosol File (GEOMS): Refinements/mods next week

Variable Name	Unit	Type	Definition	Require (x=mandatory, o=optional, x=conditional)
LATITUDE.INSTRUMENT	deg	REAL	Inst. geolocation (+ for north; - for south)	x
LONGITUDE.INSTRUMENT	deg	REAL	Inst. geolocation; (+ for east; - for west)	x
ALTITUDE.INSTRUMENT	m	REAL	Inst. geolocation	x
DATETIME	MJD2K	DOUBLE	weighted mean meas. Time	x
DATETIME.START	MJD2K	DOUBLE	Meas. start	x
DATETIME.STOP	MJD2K	DOUBLE	Meas. stop	x
INTEGRATION.TIME	h	REAL	Actual integration time (could be smaller than DATETIME.STOP - DATETIME.START e.g. due to breaks; clouds ...)	x
WAVELENGTH_EMISSION	nm	REAL	Wavelength(s) of the transmitted laser pulse	x
WAVELENGTH_DETECTION	nm	REAL	Detection wavelength(s) (may or may not be the same as emission)	x
ANGLE.VIEW_ZENITH	deg	REAL	pointing of lidar beam(s) e.g. 10 degrees off zenith to avoid specular reflection from cirrus clouds	x
ACCUMULATED.LASER.SHOTS	1	REAL	Total number of laser shots	o
ALTITUDE	m	REAL	Actual measurement altitude grid (increasing)	x
AEROSOL.RETRIEVAL.METHOD	[empty]	STRING	Use NDACC standards TBD	x
AEROSOL.RETRIEVAL.PRODUCT.TYPE	[empty]	STRING	Use EARLINET standards: entries can be e0355 b0355 e0351 b0351 e0532 b0532 e1064 b1064 b0253 b0313 b0335 b0510 b0694 b0817	o
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER	1	REAL	Backcatter ratio at corresponding wavelength	x
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER_UNCERTAINTY.COMBINED.STANDARD	1	REAL	Combined Uncertainty: NDACC-lidar-standardized definition usually mean square root of random and systematic uncertainty	x
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER_UNCERTAINTY.RANDOM.STANDARD	1	REAL	Random uncertainty: NDACC-lidar-standardized definition	x
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER_UNCERTAINTY.SYSTEMATIC.STANDARD	1	REAL	Systematic uncertainty: NDACC-lidar-standardized definition	x
ALTITUDE_RESOLUTION.ALTITUDE.IMPULSE.RESPONSE.FWHM	m	REAL	Vertical resolution: Full-width at half-maximum (FWHM) of delta impulse response; NDACC-lidar-standardized	x
RANGE_INDEPENDENT_NORMALIZATION	m	REAL	Bottom and top altitudes of the normalization layer (a 2 element vector: [zbot;ztop])	x
AEROSOL.TYPE_DERIVED	[empty]	STRING	text describing the aerosol at the different altitudes e.g. cloud; cirrus; volcanic; PSC; PSC type1; PSC type2;	o
AEROSOL.BACKSCATTER.COEFFICIENT_DERIVED	m-1 sr-1	REAL	Backscatter coefficient derived from measured backscatter ratio	x
AEROSOL.BACKSCATTER.COEFFICIENT_DERIVED_UNCERTAINTY.COMBINED.STANDARD	m-1 sr-1	REAL	Combined Uncertainty: NDACC-lidar-standardized definition usually mean square root of random and systematic uncertainty	x
AEROSOL.BACKSCATTER.COEFFICIENT_DERIVED_UNCERTAINTY.RANDOM.STANDARD	m-1 sr-1	REAL	Random uncertainty: NDACC-lidar-standardized definition	x
AEROSOL.BACKSCATTER.COEFFICIENT_DERIVED_UNCERTAINTY.SYSTEMATIC.STANDARD	m-1 sr-1	REAL	Systematic uncertainty: NDACC-lidar-standardized definition	x
NUMBER.DENSITY_INDEPENDENT	molec m-3	REAL	Air number density profile used to derive backscatter coefficient	x
PRESSURE_INDEPENDENT	hPa	REAL	Pressure profile used to derive backscatter coefficient	x
TEMPERATURE_INDEPENDENT	K	REAL	Temperature profile used to derive backscatter coefficient	x
NUMBER.DENSITY_INDEPENDENT_SOURCE	[empty]	STRING	Air number density profile source (e.g. Lidar; NCEP; Sonde; ECMWF etc.)	x
PRESSURE_INDEPENDENT_SOURCE	[empty]	STRING	Pressure profile source (e.g. Lidar; NCEP; Sonde; ECMWF etc.)	x
TEMPERATURE_INDEPENDENT_SOURCE	[empty]	STRING	Temperature profile source (e.g. Lidar; NCEP; Sonde; ECMWF etc.)	x
AEROSOL.EXTINCTION.COEFFICIENT_DERIVED	m-1	REAL	aerosol extinction coefficient e.g. derived from backscatter coefficient and lidar ratio or derived from Raman return signal	o
AEROSOL.EXTINCTION.COEFFICIENT_DERIVED_UNCERTAINTY.COMBINED.STANDARD	m-1	REAL	Combined Uncertainty: NDACC-lidar-standardized definition usually mean square root of random and systematic uncertainty	x if AEROSOL.EXTINCTION.COEFFICIENT is provided
AEROSOL.EXTINCTION.COEFFICIENT_DERIVED_UNCERTAINTY.RANDOM.STANDARD	m-1	REAL	Random uncertainty: NDACC-lidar-standardized definition	x if AEROSOL.EXTINCTION.COEFFICIENT is provided
AEROSOL.EXTINCTION.COEFFICIENT_DERIVED_UNCERTAINTY.SYSTEMATIC.STANDARD	m-1	REAL	Systematic uncertainty: NDACC-lidar-standardized definition	x if AEROSOL.EXTINCTION.COEFFICIENT is provided
AEROSOL.LIDAR.RATIO_INDEPENDENT	sr	REAL	Aerosol extinction-to-backscatter ratio	o
AEROSOL.ANGSTROM.EXPONENT_INDEPENDENT	1	REAL	exponent e in wavelength to the e power law used to convert aerosol extinction from one wavelenght to another	o
AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED	1	REAL	derived depolarization ratio for aerosol scattering	o
AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED_UNCERTAINTY.COMBINED.STANDARD	1	REAL	Combined Uncertainty: NDACC-lidar-standardized definition usually mean square root of random and systematic uncertainty	x if AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED is provided
AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED_UNCERTAINTY.RANDOM.STANDARD	1	REAL	Random uncertainty: NDACC-lidar-standardized definition	x if AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED is provided
AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED_UNCERTAINTY.SYSTEMATIC.STANDARD	1	REAL	Systematic uncertainty: NDACC-lidar-standardized definition see also Freudenthaler; V.: Atmos. Meas. Tech. doi:10.5194/9-4181-2016; 201	x if AEROSOL.LINEAR.DEPOLARIZATION.RATIO_DERIVED is provided
VOLUME.LINEAR.DEPOLARIZATION.RATIO	1	REAL	measured Volume depolarization ratio arising from Rayleigh(+ rotational Raman) scattering and aerosol scattering	o
VOLUME.LINEAR.DEPOLARIZATION.RATIO_UNCERTAINTY.COMBINED.STANDARD	1	REAL	Combined Uncertainty: NDACC-lidar-standardized definition usually mean square root of random and systematic uncertainty	x if VOLUME.LINEAR.DEPOLARIZATION.RATIO is provided
VOLUME.LINEAR.DEPOLARIZATION.RATIO_UNCERTAINTY.RANDOM.STANDARD	1	REAL	Random uncertainty: NDACC-lidar-standardized definition	x if VOLUME.LINEAR.DEPOLARIZATION.RATIO is provided
VOLUME.LINEAR.DEPOLARIZATION.RATIO_UNCERTAINTY.SYSTEMATIC.STANDARD	1	REAL	Systematic uncertainty: NDACC-lidar-standardized definition	x if VOLUME.LINEAR.DEPOLARIZATION.RATIO is provided
LAYER.INDEX	1	SHORT	array of size n equal to the number of layers being reported e.g. 1 2 3	o
ALTITUDE_AEROSOL_LAYER.BASE	m	REAL	Base of aerosol layer above sea level	o
ALTITUDE_AEROSOL_LAYER.TOP	m	REAL	Top of aerosol layer above sea level	o
ALTITUDE_MIXING.LAYER.BASE	m	REAL	Base of mixing layer above sea level	o
ALTITUDE_MIXING.LAYER.TOP	m	REAL	Top of mixing layer above sea level	o
ALTITUDE.TROPOPAUSE_INDEPENDENT	m	REAL	Tropopause height	o
ALTITUDE.TROPOPAUSE_INDEPENDENT_SOURCE	[empty]	STRING	Tropopause height source e.g. radiosonde; MERRA	x if ALTITUDE.TROPOPAUSE_INDEPENDENT is provided
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER_RESOLUTION.ALTITUDE.DF.NORMALIZED.FREQUENCY	1	DOUBLE	Normalized frequency grid to use with the Transfer Functions in bins to the power of -1 (Nyquist=0.5)	o
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER_RESOLUTION.ALTITUDE.DF.TRANSFER.FUNCTION	1	DOUBLE	Transfer Function of Digital Filter used	o
ALTITUDE_RESOLUTION.ALTITUDE.DF.CUTOFF	m	DOUBLE	Vertical resolution: NDACC-lidar-standardized = digital filter cut-off frequency	o
AEROSOL.BACKSCATTER.RATIO_BACKSCATTER_RESOLUTION.ALTITUDE.IMPULSE.RESPONSE	1	DOUBLE	Vertical resolution: impulse response matrix	o
AEROSOL.BACKSCATTER.COEFFICIENT_DERIVED_RESOLUTION.ALTITUDE.DF.TRANSFER.FUNCTION	1	DOUBLE	Transfer Function of Digital Filter used	o
AEROSOL.BACKSCATTER.COEFFICIENT_DERIVED_RESOLUTION.ALTITUDE.IMPULSE.RESPONSE	1	DOUBLE	Vertical resolution: impulse response matrix	o
AEROSOL.EXTINCTION.COEFFICIENT_DERIVED_RESOLUTION.ALTITUDE.DF.TRANSFER.FUNCTION	1	DOUBLE	Transfer Function of Digital Filter used	o
AEROSOL.EXTINCTION.COEFFICIENT_DERIVED_RESOLUTION.ALTITUDE.IMPULSE.RESPONSE	1	DOUBLE	Vertical resolution: impulse response matrix	o
AEROSOL.DEPOLARIZATION.RATIO_DERIVED_RESOLUTION.ALTITUDE.DF.TRANSFER.FUNCTION	1	DOUBLE	Transfer Function of Digital Filter used	o
AEROSOL.DEPOLARIZATION.RATIO_DERIVED_RESOLUTION.ALTITUDE.IMPULSE.RESPONSE	1	DOUBLE	Vertical resolution: impulse response matrix	o
SOURCE.PRODUCT	[empty]	STRING	Information relevant to the source history of the Metadata and Data	o

* The EarthCARE EVDC is also working on formats for L3 data and airborne data.

World Meteorological Organization
Global Atmosphere
Watch Program

GAW

GALION The GAW

GALION Data Center Working Group:

New Data Center and Website

https://galion.world

NASA AWS Contract to Support GALION Data Center
Django and Python development

Capabilities

GALION information and search and discovery
Automated handshakes with WMO OSCAR database
Metadata APIs

- Upload from GALION networks (Push)
- Developing upload Pull capability (easier maintenance)

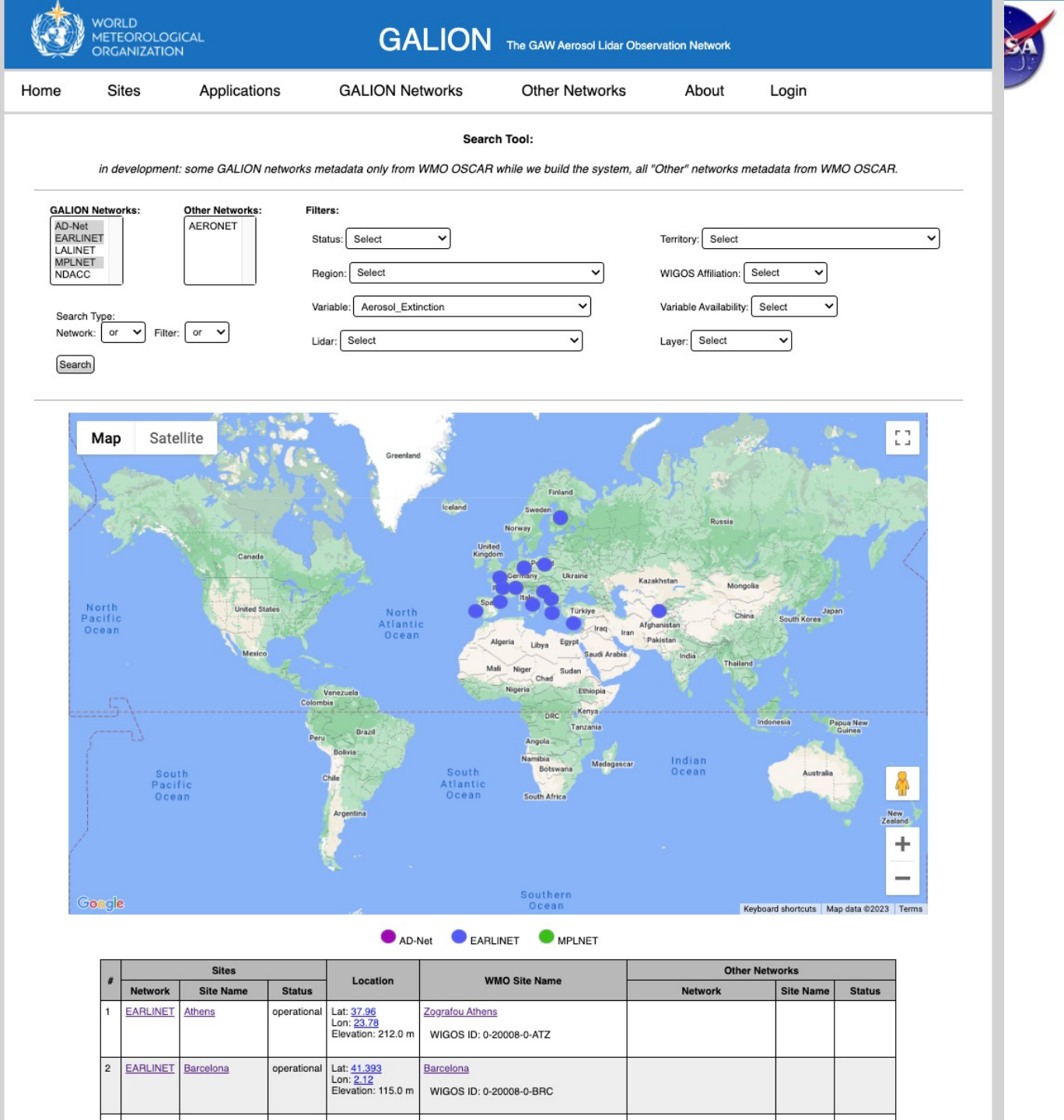
Tools in development (functional but not public*)

- Metadata Downloads
- Trajectory analysis

Future Tools

- Quicklook Imagery
- API Data Downloads (current and common formats)
- Volcanic Alerts and Monitoring
- PyroCb/Smoke Alerts and Monitoring
- AQ Support

* Some networks do not have full metadata submissions yet. We are using OSCAR metadata in place of, which lacks some information and is currently out of date. Tools in development and future will not be implemented until metadata archive is complete.



#	Sites			Location	WMO Site Name	Other Networks		
	Network	Site Name	Status			Network	Site Name	Status
1	EARLINET	Athens	operational	Lat: 37.96 Lon: 23.78 Elevation: 212.0 m	Zografou Athens WIGOS ID: 0-20008-0-ATZ			
2	EARLINET	Barcelona	operational	Lat: 41.393 Lon: 2.12 Elevation: 115.0 m	Barcelona WIGOS ID: 0-20008-0-BRC			

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Case Study: Alberta Fires May 2023
Back Trajectory May 13
Observed Smoke Heights
El_Arenosillo, Spain MPLNET site

(trajectory analysis from GSFC 3 days earlier show origin over Alberta, CA)

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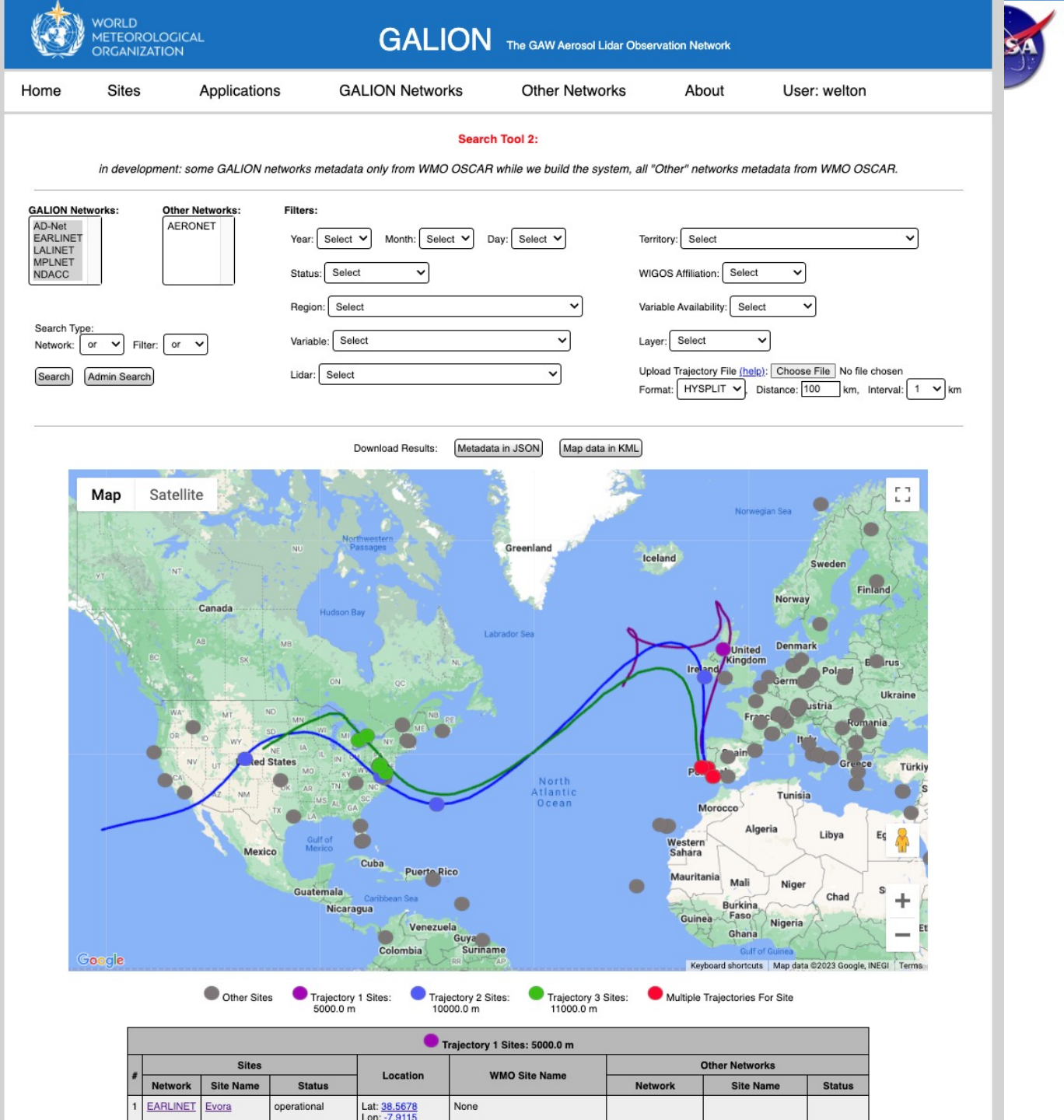

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GALION JSON Metadata: file snippets

AD-Net


```
    "level": "1.5",
    "instrumentation": "MWBL",
    "wavelength": "532",
    "wavelength_unit": "nm",
    "range_resolution": "30",
    "range_unit": "m",
    "layer": "troposphere",
    "url_browse": [
      "https://www-lidar.nies.go.jp/AD-Net/fig/Tsukuba2-230401-230430.png"
    ],
    "url_file": [
      "https://www-lidar.nies.go.jp/AD-Net/ncdf/TKB/TKB230420.nc"
    ],
    "observation_schedule": "1;12;1;7;0;23;0;59;00:00:00Z",
    "observation_temporal_reporting_interval": "PT15M",
    "wigos": true,
    "wigos_observation_variable": "12145",
    "wigos_observation_geometry": "verticalProfile",
    "wigos_observation_application_area": "climateMonitoring;aeronauticalMeteorology;atmosphericCompositionFore
    "wigos_observation_instrument": "341",
    "wigos_observation_data_level": "level2",
    "wigos_observation_layer": "troposphere",
    "wigos_observation_wavelength": "532",
    "wigos_observation_frequency": "563.5196578947368",
    "wigos_observation_range_resolution": "30",
    "wigos_observation_variable_unit": "m-1",
    "wigos_observation_wavelength_unit": "nm",
    "wigos_observation_frequency_unit": "thz",
    "wigos_observation_range_resolution_unit": "m",
    "wigos_observation_schedule": "",
    "wigos_observation_temporal_reporting_interval": ""
  }
```


EARLINET


```
    "level": "2",
    "instrumentation": "RL",
    "wavelength": "355.0;532.0",
    "wavelength_unit": "nm",
    "range_resolution": "",
    "range_unit": "m",
    "layer": "PBL;freeTroposphere;UTLS",
    "url_browse": [
      "https://quicklooks.earlinet.org/"
    ],
    "url_file": [
      "https://data.earlinet.org/api/services/restapi/opticalproducts/filename/EARLINET_AerRemSen_pot_Lev01_e0
      "https://data.earlinet.org/api/services/restapi/opticalproducts/filename/EARLINET_AerRemSen_pot_Lev01_e0
      "https://data.earlinet.org/api/services/restapi/opticalproducts/filename/EARLINET_AerRemSen_pot_Lev01_e0
      "https://data.earlinet.org/api/services/restapi/opticalproducts/filename/EARLINET_AerRemSen_pot_Lev01_e0
    ],
    "observation_schedule": "1;12;1;7;0;23;0;59;00:00:00Z",
    "observation_temporal_reporting_interval": "PT1H",
    "wigos": true,
    "wigos_observation_variable": "12145",
    "wigos_observation_geometry": "verticalProfile",
    "wigos_observation_application_area": "climateMonitoring;aeronauticalMeteorology;atmosphericCompositionFore
    "wigos_observation_instrument": "143",
    "wigos_observation_data_level": "level2",
    "wigos_observation_layer": "PBL;freeTroposphere;UTLS",
    "wigos_observation_wavelength": "355.0;532.0",
    "wigos_observation_frequency": "844.4857971830986;563.5196578947368",
    "wigos_observation_range_resolution": "",
    "wigos_observation_variable_unit": "m-1",
    "wigos_observation_wavelength_unit": "nm",
    "wigos_observation_frequency_unit": "thz",
    "wigos_observation_range_resolution_unit": "m",
    "wigos_observation_schedule": "",
    "wigos_observation_temporal_reporting_interval": ""
  },
```


MPLNET


```
    "level": "1.5;2",
    "instrumentation": "BL_SP",
    "wavelength": "532.0",
    "wavelength_unit": "nm",
    "range_resolution": "74.9481",
    "range_unit": "m",
    "layer": "PBL;freeTroposphere;UTLS;MUS",
    "url_browse": [
      "https://mplnet.gsfc.nasa.gov/data.cgi?s=GSFC&t=20230201"
    ],
    "url_file": [
      "https://mplnet.gsfc.nasa.gov/download?version=V3&level=L1&product=AER&site=GSFC&year=2023&month=02&day=
      "https://mplnet.gsfc.nasa.gov/download?version=V3&level=L15&product=AER&site=GSFC&year=2023&month=02&day
      "https://mplnet.gsfc.nasa.gov/download?version=V3&level=L2&product=AER&site=GSFC&year=2023&month=02&day=
    ],
    "observation_schedule": "1;12;1;7;0;23;0;59;00:00:00Z",
    "observation_temporal_reporting_interval": "PT1M",
    "wigos": true,
    "wigos_observation_variable": "12145",
    "wigos_observation_geometry": "verticalProfile",
    "wigos_observation_application_area": "climateMonitoring;aeronauticalMeteorology;atmosphericCompositionFore
    "wigos_observation_instrument": "341",
    "wigos_observation_data_level": "level2",
    "wigos_observation_layer": "PBL;freeTroposphere;UTLS;MUS",
    "wigos_observation_wavelength": "532.0",
    "wigos_observation_frequency": "563.5196578947368",
    "wigos_observation_range_resolution": "74.9481",
    "wigos_observation_variable_unit": "km-1",
    "wigos_observation_wavelength_unit": "nm",
    "wigos_observation_frequency_unit": "thz",
    "wigos_observation_range_resolution_unit": "m",
    "wigos_observation_schedule": "1;12;1;7;0;23;0;59;00:00:00Z",
    "wigos_observation_temporal_reporting_interval": "PT1M"
  },
```


Links to network data:
- Quicklooks (static images or API)
- Files (FTP/SFTP or API)

Issues to consider:
- Data Policy & DOI/License
- Common image and file formats
- Open Access or Authentication
  - AD-Net and MPLNET open
  - EARLINET just opened

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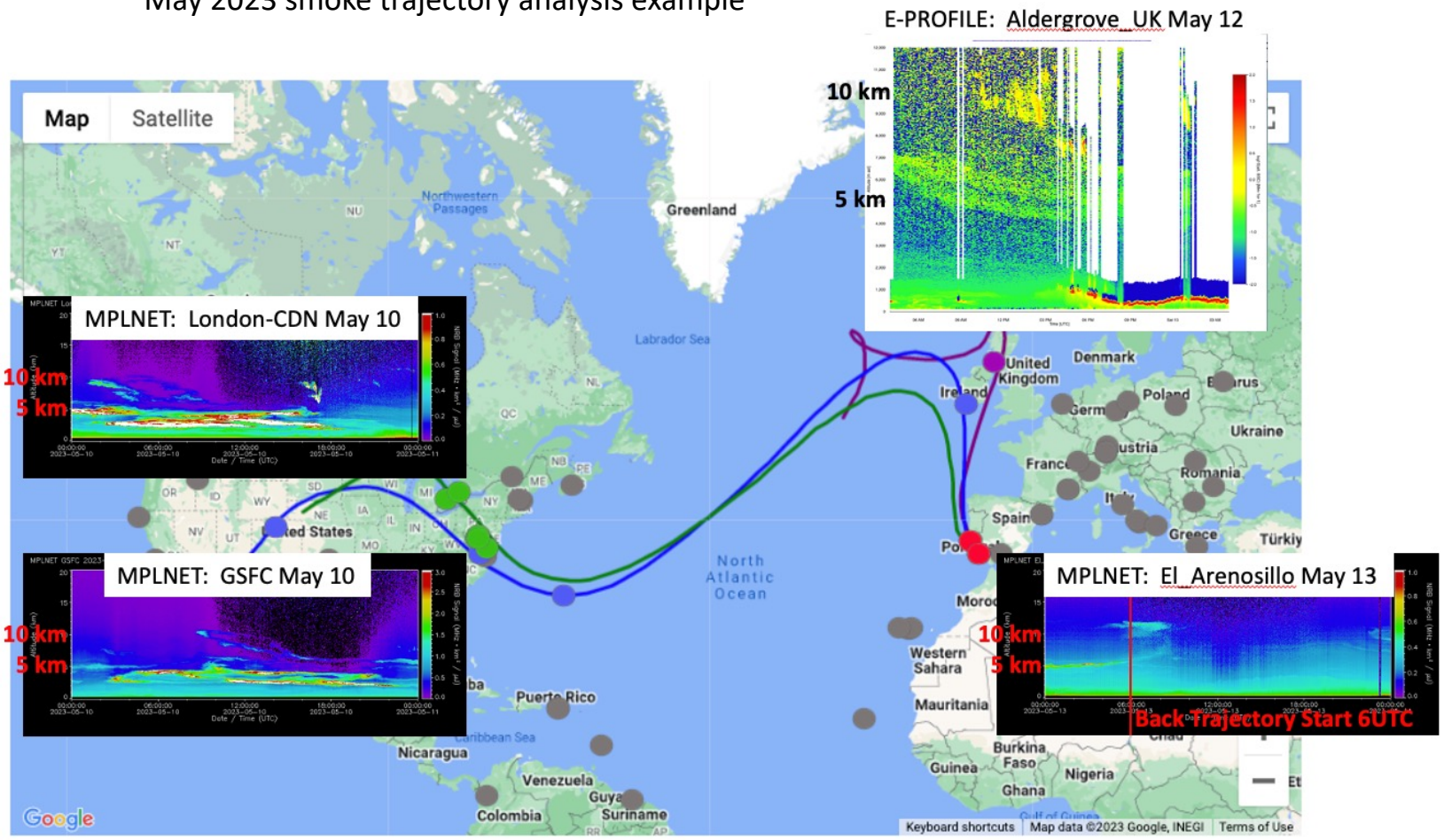
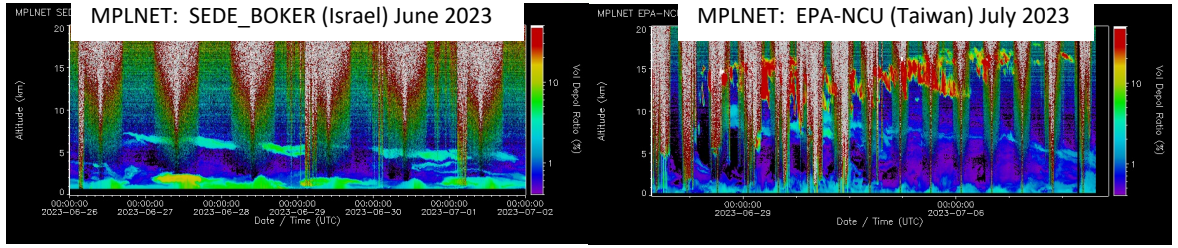
Conceptual graphic of quicklook imagery:
May 2023 smoke trajectory analysis example





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Challenge going forward: PyroCb
Dealing with annual smoke distribution in FT – UTLS across NH

Conclusion: Infrastructure and New Data Center

Information and search and discovery. Centralized coordination with WMO OSCAR

- Better programmatic planning of observations, within GALION and beyond (other networks)
- Easier to find data, automate with APIs
- Continue working on common data browse, data format & download capabilities

Develop applications

- Back trajectory analysis tool (done, testing)
- Future: Coordinated support for WMO SDS-WAS, Volcanic and fire/smoke alerts and monitoring
  - Some networks already contributing to such work, experience & blue prints for future action
- GALION networks are part of EarthCARE Validation Team (meeting next week)
  - Coordinated support for Future Satellite Validation based on EarthCARE experience

- FAIR Data Support and Integration
  - Data policies and licenses must be handled appropriately if we merge data across networks
  - Consider integration with WMO Information System (WIS) 2.0 (in dev/testing now)
    - I will talk more about WIS 2.0 during the WMO Synergy Discussion later this afternoon

Conclusion: GALION Activities

Intercomparisons and Coordination Between GALION members

- MPLNET – EARLINET
  - Intercomparisons in 2024 at collocated sites at Barcelona and Payerne
  - CARGO-ACT: new project starts March 2024 (EU ACTRIS and USA university and gov members)
    - Develop roadmap for cooperation between EU and USA research infrastructures, including lidar & ceilometer (Mona, Welton)
- EARLINET – LALINET: Heterogeneous network processing
  - EARLINET Single Calculus Chain (SCC) well established. LALINET new Lidar Processing Pipeline (LPP) in development
  - Argentina Weather Service using EARLINET/SCC to process and distribute data
  - Harmonization campaign 2025: comparison of new LPP to SCC processing of LALINET data

Ceilometer Networks: inclusion in GALION (or at least collaboration)

- E-PROFILE: talks underway
- US ASOS (met observation sites): ceilometer profile data (100s of sites) may soon be available. Initial discussions starting.
- US Unified Ceilometer Network (UCN): ceilometers at EPA-PAMS sites (~50). UCN in transition at the moment, talks stalled.

Other Activities

- MPLNET – GRASP: Comparison of MPLNET aerosol retrievals to those from GRASP using the same lidar signal input (MPLNET L1). Paper in prep.
- Next opportunity for GALION-wide meeting is ILRC June 2024