GALION: The GAW Aerosol Lidar Observation Network.

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- Motivation
- Examples
- Lidar methods
- Networking
- Status
Why Aerosol Research?

Aerosols have important effects on human life:

- Aerosols can be toxic, by composition or by structure (size or shape).
  Many aerosol-induced diseases have been identified.

- Aerosols deteriorate visibility.
  Haze and fog occurrence depends on aerosols.

- Ecosystems are affected by significant mass transport.
  Eutrophication of lakes and seas.

- Aerosols influence atmospheric chemistry by providing reactive surfaces.
  Stratospheric ozone depletion, summer smog.

- Aerosols affect the radiation budget and hence temperature distribution within the atmosphere and on the ground, including change in spectral distribution.
  The details depend strongly on type and vertical distribution.

- IPCC has identified the effect of aerosols on climate as one of the most uncertain contributions:
  Climate is affected directly by scattering and absorption
  Climate is affected indirectly by changing cloud formation and properties

- Aerosols disturb satellite imagery.
  Aerosol interference often deteriorates or prohibits the retrieval of surface properties from space.
Why lidar observation network?

Why measurements?
Aerosols are very difficult to handle in models:
- Aerosols are produced by many different processes, some sources are localized, others are distributed over large volumes.
- Aerosols interact dynamically in a nonlinear way (nucleation, condensation, coagulation, deposition).
- Aerosols can be transported over large distances.
Measurements are needed to assess and improve understanding of aerosol processes and their treatment in models!

Why lidar?
- Transport, and in particular long-range transport, occurs at elevated layers!
- The exact altitude of any aerosol layer is required to trace it back to the source.
- Lidar provides excellent information about the vertical structure of aerosol layers.
- Advanced lidar methods provide very good information about aerosol optical properties (extinction, backscatter, optical depth).
- Advanced lidar plus advanced retrieval methods provide important information about microphysical properties of aerosols.

Why 4-D?
- Aerosol distribution is highly variable in space and time.
- Long range transport of aerosols and precursors makes the system non-localised.
- Global or at least hemispheric coverage is needed for the assessment of source-receptor relations, climate impact studies, or comparative statistics.
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lnPr² @ 820 nm, channel 3, location Met. Obs. Lindenberg
 Courtesy I. Mattis, IfT Leipzig
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• Backscatter lidar can retrieve the spatial distribution of aerosols
  – with high sensitivity and resolution
  – on temporal scales from turbulence to climatology
  – on vertical scales from turbulence to tropospheric coverage
  – unattended and automated
  – from various platforms, ground-based to spaceborne

• Layer structure and precise height information helps to trace aerosol plumes back to their origin.

• Lidar measurements cover the 2 dimensions generally neglected in satellite retrievals from passive sensors: *vertical and time!*
Methods

Quantitative retrieval of aerosol parameters from lidar measurements.

Lidar equation: \[ P \cdot R^2 = c(\beta_p + \beta_m)e^{-2\int_0^R (\alpha_p + \alpha_m) \, dr} \]

Backscatter lidar: \[ \frac{d}{dR} \ln (P \cdot R^2) = \frac{d}{dR} \ln \beta - 2\alpha \] Is NOT quantitative!
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Raman lidar: \[ \frac{d}{dR} \ln(P \cdot R^2) = \frac{d}{dR} \ln \beta_R - 2\alpha \] Now widely used!

HSR lidar: \[ \frac{d}{dR} \ln(P \cdot R^2) = \frac{d}{dR} \ln \beta_m - 2\alpha \] Challenging!
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Polarisation allows to distinguish spherical from nonspherical particles!
Diurnal cycle

Hamburg, 18 Oct 2000

Measured aerosol extinction coefficient (Mm$^{-1}$)

Modeled aerosol extinction coefficient, (Mm$^{-1}$)
Ground-based lidar can retrieve

- **Vertical distribution** of aerosols from backscatter lidar on all relevant scales in 4-D
- **Optical properties** from Raman or HSR lidar
- **Microphysical parameters** from multi-wavelengths systems plus advanced retrieval methods.

Long-term automated operation

- achieved for backscatter lidar
- at few sites for Raman lidar
- systems for day+night microphysical retrieval under development

Quantitative methods permit network operation:

- to study large scale processes, e.g., long range transport
- to establish aerosol climatology on continental (global?) scale, covering 4 dimensions
- to provide excellent ground truth
- to provide key information for improved interpretation of satellite measurements
- to provide key information for model validation
GALION organisation

GALION is organised as a network of aerosol lidar networks, to be amended by selected stations, with commitment to long-term operation. Participating networks are:

- ALINE, Latin America
- AD-Net, East Asia
- CIS-LINET, Commonwealth of Independent States
- EARLINET, Europe
- NDACC, Global Stratosphere
- REALM, Eastern North America
- MPLNET, Global, Micropulse Lidar

Tasks for coordination:

- Harmonise operational scheme
- Harmonise data products and name conventions
- Provide homogeneous documentation for systems and data
- Establish common access point for data
Initial scheme of operation:

- Routine measurements at fixed dates, 3 per week (on 2 days)
- Special measurements on alert (e.g., desert dust outbreaks, biomass burning plumes, volcano eruptions)
- Aerosol and cloud layer identification and characterisation
- Compilation of aerosol profile data, extinction and backscatter

Two subnets:

- Small number of advanced stations
  - independent extinction measurements, 2 or more wavelengths
  - backscatter measurements at 3 or more wavelengths
  - depolarisation measurements
  - characterisation of aerosol microphysical properties

- Large network with backscatter lidar
  - layer identification
  - aerosol backscatter at single wavelength
  - extinction estimates
GALION vs. CALIPSO

Why not leave aerosol profiling to spaceborne lidar?

GALION advantages:

- temporal coverage and resolution (e.g., diurnal cycle!)
- advanced observation methods: multiple wavelengths, Raman
- can support satellite lidar evaluation by providing
  - extinction/backscatter ratio
  - Ångström coefficients
- observations below clouds
- calibration capabilities
- long term stability
- reference between different satellite systems

GALION and spaceborne lidars are complementing, not excluding!
Status

- WMO/GAW experts meeting held in Hamburg, March 27-29, 2007
- Cooperation between networks resolved
- Main scheme of operation resolved
- White Paper in preparation (to be submitted to WMO/GAW)
- Endorsed by WMO/GAW SAG Aerosol

GALION exists!

For data over Europe consider EARLINET!