INTEGRATED LONG TERM OBSERVATIONS FOR ASSESSING THE IMPACT OF ATMOSPHERIC AEROSOL ON CLIMATE AND ENVIRONMENT

Gelsomina Pappalardo
Consiglio Nazionale delle Ricerche – Istituto di Metodologie per l’Analisi Ambientale (CNR-IMAA), Potenza, Italy

pappalardo@imaa.cnr.it

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Outline

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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!

- in situ measurements
- Ground based remote sensing measurements
- Satellite measurements

PARAGON: An Integrated Approach for Characterizing Aerosol Climate Impacts and Environmental Interactions (Diner, BAMS 2004)
Lidar measurements

It is in particular the information about the vertical distribution of aerosols that is missing!

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.

Lidar Network

Aerosol distribution is highly variable, single point measurements are insufficient for characterization.

At least continental scale coverage is needed for, e.g., climate impact studies, source localization, comparative statistics.

It helps to build a community with common understanding of aerosol related processes and observation techniques!

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Aerosol profiling for climate and air quality research

Lidar measurements
Long term measurements
Distributed measurements
Advanced lidar systems for microphysical properties

EARLINET

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EARLINET was established in February, 2000 as a research project supported by the European Commission under the Fifth Framework Programme within the Energy, Environment and Sustainable Development Programme, contract No EVR1-CT-1999-40003.

- 22 lidar stations distributed over 14 European countries
- main objective: to establish a qualitatively and quantitatively significant database for the horizontal and vertical distributions of atmospheric aerosols over Europe
- 3 systematic regular aerosol lidar measurements per week
- special measurement campaigns to study special events (Saharan dust outbreaks, volcanic eruptions, forest fires)
- system level and retrieval alghoritms intercomparisons

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After the end of the FP5 EC-project EARLINET continues to operate as a voluntary association of research institutions with specific interest in atmospheric aerosol research.

**EARLINET organisation**

Main common tasks:
- Routine measurements at fixed dates, 3 per week (on 2 days)
- Compilation of aerosol profile data, extinction and backscatter
- Compilation of back-trajectory data

Task groups for special investigations:
- Quality assurance (instruments)
- Quality assurance (algorithms)
- Observation of special events (Saharan dust, forest fires)
- Statistical/climatological analysis
- Microphysical retrieval algorithms
- Synergy and Integration (models/observations)
- Support to satellite missions

The improvement of the EARLINET infrastructure is supported through the FP6 EC-project EARLINET-ASOS (Advanced Sustainable Observation System) (2006-2011)

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25 lidar stations
- 8 multiwavelength Raman lidar stations $3\beta + 2\alpha + \delta$ (○)
- 9 Raman lidar stations (●)
- 8 single backscatter lidar stations (●)

EARLINET stations operational in the next future
- Israel
- Georgia
- Ireland
- Portugal

www.earlinet.org

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EARLINET database

EARLINET measurements started in May 2000

The EARLINET database represents the largest database for the aerosol distribution on a continental scale

All the files are divided in different categories related to regular and special conditions:

- Climatology
- Cirrus
- Diurnal cycles
- Volcanic eruptions
- Forest Fires
- Photosmog
- Rural/urban
- Saharan dust
- Stratosphere

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26 June 2006 Saharan dust observed over Potenza EARLINET lidar station (PEARL)

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Saharan dust event 26-30 May 2008

28 May 2008 Range corrected signal @ 1064 nm

Potenza, Italy

Bucharest, Romania

Hamburg, Germany

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Evolution of Volcanic Aerosol Layer

Potenza, 1 November, 13:20 UTC– 2 November, 2002    22:00 UTC

AVHRR images

Pappalardo et al., GRL 2004

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ESA’s wind mission ADM-Aeolus

Doppler Wind Lidar (DWL)

- Wind
- Cloud top heights
- Vertical distribution of clouds
- Aerosol properties

Launch expected in 2010

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EarthCARE

Earth Clouds, Aerosols and Radiation Explorer

High Spectral Resolution Lidar

Rayleigh scattering contribution

Mie scattering peak

High Resolution Filter

Wavelength

ESA-JAXA
Launch 2013

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Lidar on board CALIPSO (NASA/CNES), ADM-Aeolus (ESA) and EarthCARE (ESA/JAXA) will provide a unique, long term, global, 4-dim dataset on aerosol and clouds

- Different instruments/wavelength:
  CALIOP: 532/1064 nm (backscatter)
  ALADIN/ATLID: 355 nm (backscatter+extinction)

- Polar orbiting satellite revisit time

**Ground based lidar networks:**

- Provide proper conversion factors for a consistent long-term dataset
- Verify satellite-based cloud/aerosol discrimination and classification/typing
- Study representativeness of cross-sections along an orbit with observations at multiple points
GALION – the GAW Aerosol Lidar Observation Network

The objective:
The GAW aerosol program strives "to determine the spatio-temporal distribution of aerosol properties related to climate forcing and air quality up to multidecadal time scales".

The specific objective of GALION is to provide the vertical component of this distribution through advanced laser remote sensing in a network of ground-based stations.

The aerosol properties to be observed include the identification of aerosol layers, profiles of optical properties (backscatter and extinction coefficients at selected wavelengths, lidar ratio, Ångström coefficients), aerosol type (e.g. dust, maritime, fire smoke, urban haze), and microphysical properties (e.g., volume and surface concentrations, size distribution parameters, refractive index).
The operation will be designed to serve the following main areas:

1. Climate research and assessment
   1.1 Global climatology
   1.2 Model evaluation
   1.3 Aerosol transport and tracers
   1.4 Impact on radiation, particularly UV

2. Air quality
   2.1 Air quality assessment
   2.2 Air quality forecast

3. Plumes from special events

4. Support for spaceborne observations
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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

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CALIPSO

~24 hours after eruption, CALIPSO detects stratospheric feature over northern British Columbia (59.6N, 133.5W)

26 March 2009
Redoubt Eruption

27 March 2009
Madison, WI, USA
Ed Eloranta

2 April 2009
Potenza, Italy

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Summary and perspectives

- Strong need for integrated long term aerosol observations
- 4-dimensional space-time distribution of aerosols
- Aerosol profiling → LIDAR
- the EARLINET example
- Cooperation and coordination with the relevant observation and user communities
- Support to current and future satellite missions with lidar onboard
- GALION at global scale

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