

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

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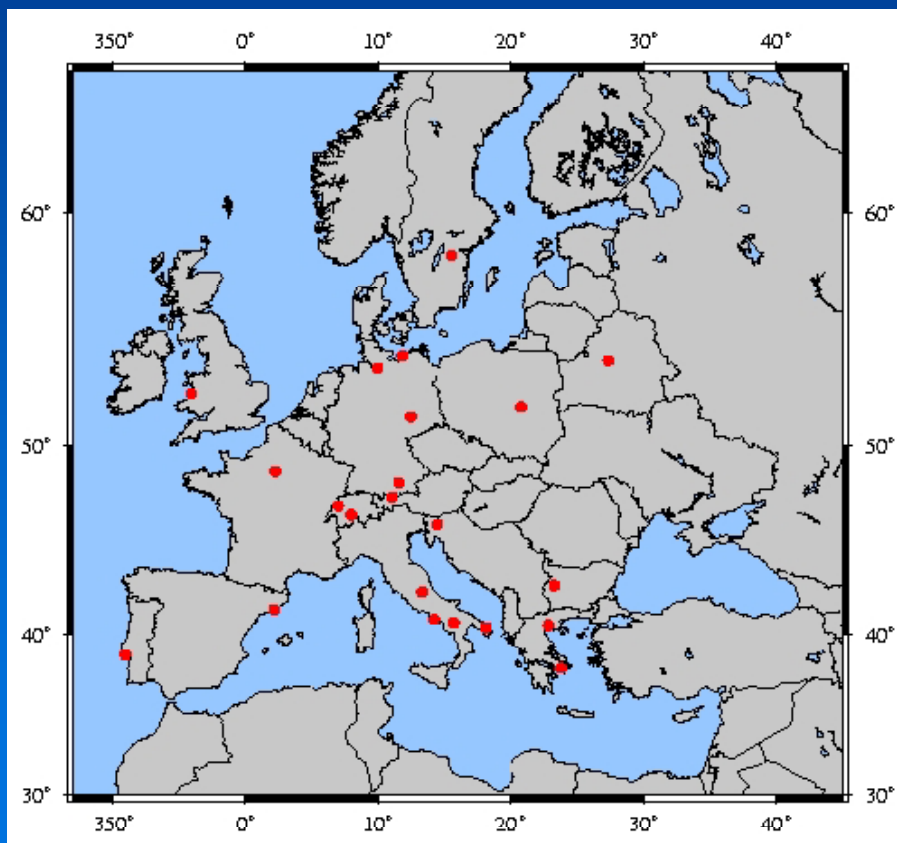
The present knowledge of the aerosol distribution is far from sufficient to properly estimate the role of aerosols in changes of the global and regional environmental conditions and climate.

The complexity of the problem requires a synergistic approach of satellite and ground-based observations together with models.

EARLINET

European Aerosol Research Lidar NETwork

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 algorithms intercomparisons*

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*



EARLINET ASOS

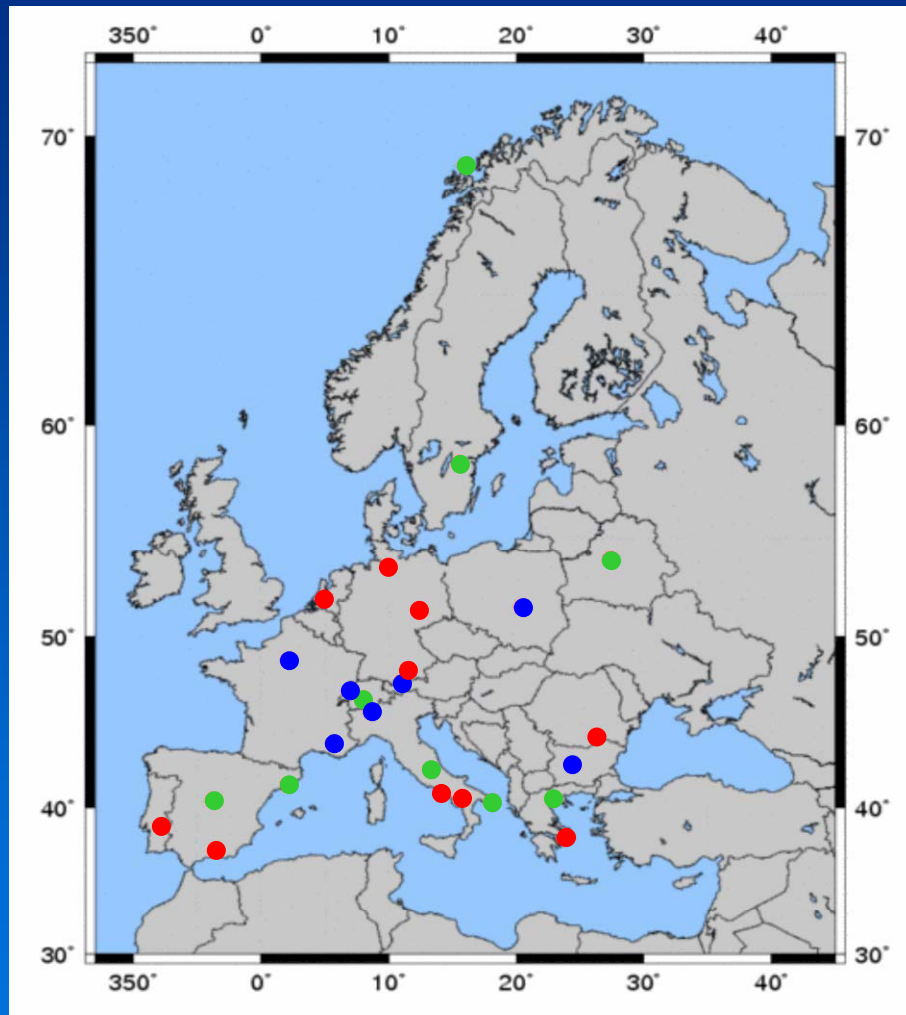
European Aerosol Research Lidar Network: Advanced Sustainable Observation System

EC Infrastructure Project Started on 1st March 2006

The overall objectives are:

- To extend the development of the European Aerosol Research Lidar Network as a world-leading instrument for the observation of the 4-dimensional spatio-temporal distribution of aerosols on a continental scale, resulting in accurate, well-defined, and easily accessible data products for use in science and environmental services.
- To enhance the operation of this instrument to foster aerosol-related process studies, validation of satellite sensors, model development and validation, assimilation of aerosol data into operational models, and to build a comprehensive climatology of the aerosol distribution.
- To play a leading role in the development of a global observation network for the aerosol vertical distribution as a major innovative element of GEOSS, by setting the standards for instruments, methodology, and organization in this specific area.

EARLINET 2010



26 lidar stations

- 10 multiwavelength Raman lidar stations

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

- 9 Raman lidar stations

- 7 single backscatter lidar stations

EARLINET stations
operational in the next future

- Georgia
- Ireland
- Israel

www.earlinet.org

EARLINET within an integrated observation system

- integration with other remote sensing observations from the ground
- integration with in-situ measurements
- integrations with satellite observations
- model evaluation and data assimilation
- aerosol – other species
- aerosol – clouds interactions

EARLINET in GEOmon

- EARLINET- AERONET



ENAN

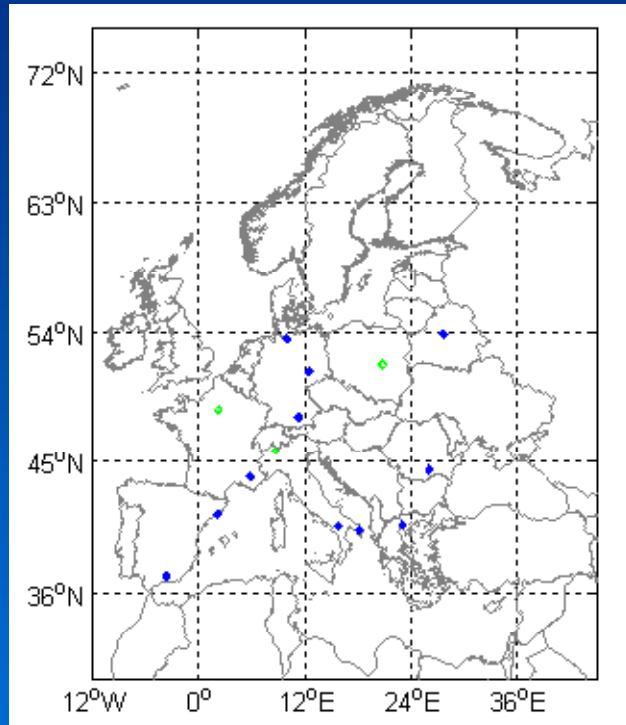
- EARLINET - CALIPSO



Satellite

EARLINET – AERONET/PHOTONS comparison and integration

EARLINET - AERONET co-located stations



Green = backscatter lidars
Blue = Raman lidars

- only climatologic EARLINET measurements are considered in order to avoid bias due to the large AOD values observed during special events

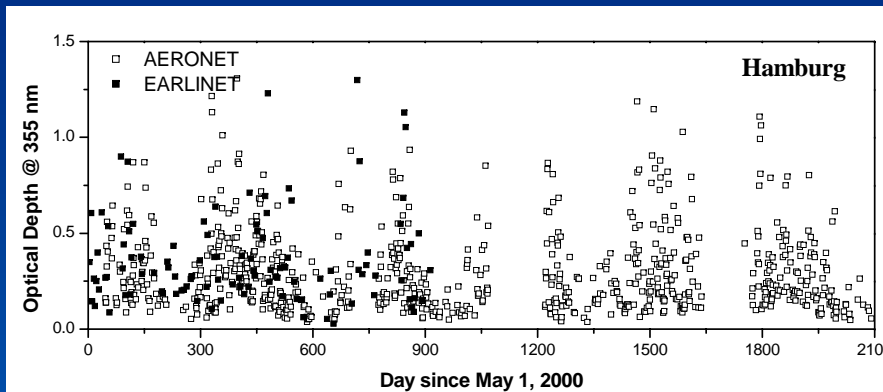
- for a statistically significant comparison database, only stations with more than 100 extinction profiles retrieved

In this way, the following stations are selected:

Hamburg and Leipzig in Germany, Potenza and Lecce in Italy and Thessaloniki in Greece.

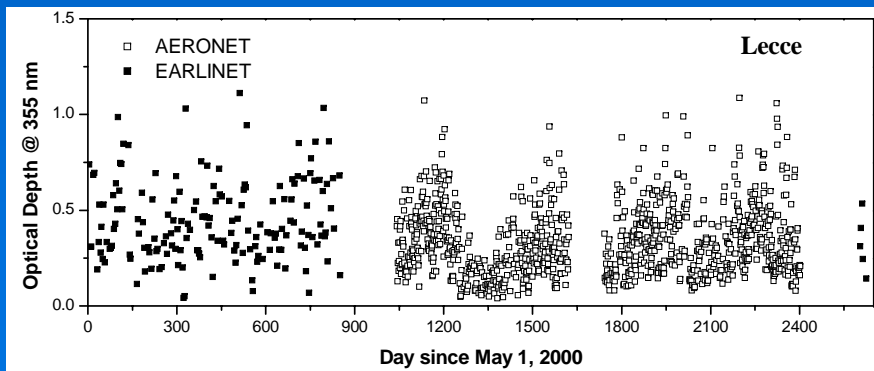
For all these sites, EARLINET lidar systems provide vertical profiles of the aerosol extinction coefficient at 355 (or 351) nm and therefore are able to directly measure the AOD at this wavelength calculated over all the atmospheric column as well as in different atmospheric layers.

EARLINET – AERONET/PHOTONS comparison and integration



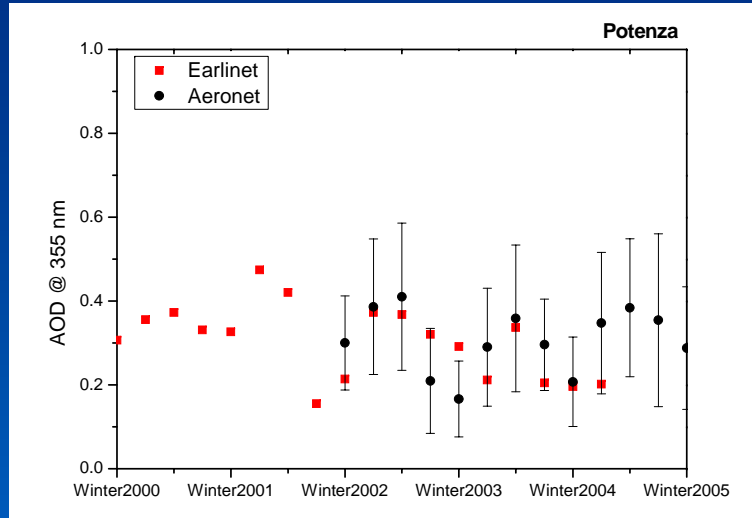
A good agreement is found for the 5 selected stations.
The temporal behaviour and the annual cycle is captured by both lidar and Sun-photometer measurements.

	AERONET	EARLINET
Hamburg 355nm	0.30 ± 0.23	0.36 ± 0.24
Leipzig 355nm	0.35 ± 0.22	0.38 ± 0.26
Leipzig 532nm	0.22 ± 0.15	0.22 ± 0.15
Potenza 355 nm	0.33 ± 0.18	0.35 ± 0.18
Lecce 355 nm	0.33 ± 0.18	0.44 ± 0.21
Thessaloniki 355 nm	0.43 ± 0.23	0.71 ± 0.46

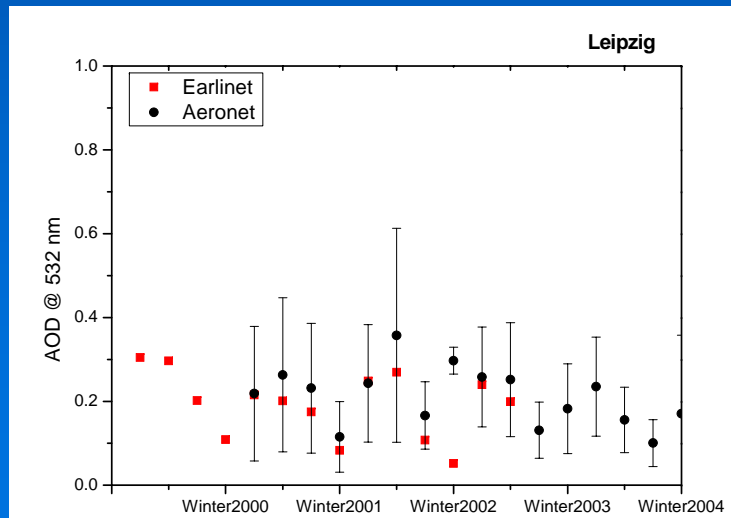


Good agreement for mean and standard deviation values is generally observed.

EARLINET – AERONET/PHOTONS comparison and integration



A good agreement is observed between EARLINET and AERONET AOD seasonal averages and it is almost perfect for the annual ones for all the stations apart from Thessaloniki.



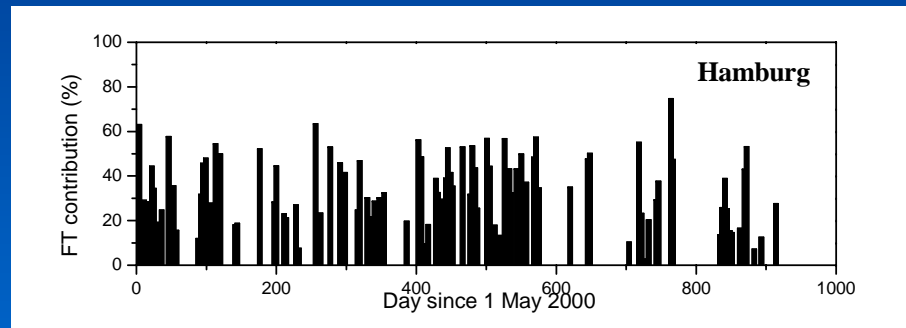
EARLINET systematic measurements are representative for seasonal and climatological analysis.

The discrepancy found for Thessaloniki could be related to large variability in AOD values.

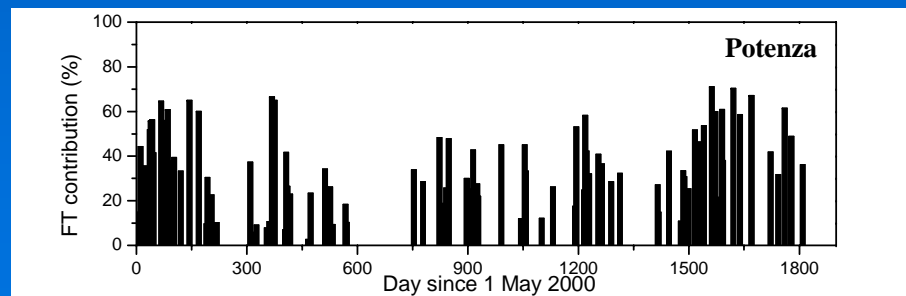
EARLINET – AERONET/PHOTONS comparison and integration

The vertical profiling capability of lidar techniques allow to investigate the vertical distribution of the aerosol providing high vertical resolution profiles of the aerosol optical properties.

In particular, PBL height is typically provided in the EARLINET database for each observation as additional information. Starting from it, it is possible to calculate the free troposphere (FT) contribution to the aerosol load.



The FT contribution to the total aerosol load ranges between 24 up to 37%.



For Southern stations it is evident an annual behaviour, that is mainly due to the arrival of desert dust from the close Africa continent [*Mona et al., 2006; Papayannis et al., 2008*] and to the biomass burning that largely affect Greece and Italy during warm seasons [*Balis et al., 2003*].

EARLINET – AERONET/PHOTONS comparison and integration

Angstrom exponent

For what concerns EARLINET for this study (2000-2005), Angstrom exponent is available only for Leipzig.

Leipzig Angstrom exponent: 1.5 ± 0.8 @ 355-532 nm (EARLINET)

1.2 ± 0.3 @ 340-500 nm (AERONET)

10 EARLINET stations have currently the capability to obtain simultaneously extinction profiles at 355 and 532 nm

Lidar Ratio

AERONET overestimates lidar ratio measured by lidars, in particular for the sites largely affected by Saharan dust events, Lecce, Potenza and Thessaloniki.

A larger geographical variability is observed in EARLINET data reflecting the variability of aerosol microphysical properties over the European continent.

Possible reasons of observed differences:

- particle backscatter coefficient is not measured but estimated from products of inversions by Sun-photometers
- columnar comparisons are affected by the large vertical variability observed
- daytime and night-time measurements are compared in which humidity and microphysical properties, and therefore lidar ratio, can strongly change.

	AERONET @ 440 nm (sr)	EARLINET @ 355 nm (sr)	Vertical Variability (sr)
Hamburg	83 ± 16	61 ± 23	90
Leipzig	83 ± 19	56 ± 15	10
Potenza	70 ± 14	39 ± 12	16
Lecce	74 ± 13	48 ± 24	27
Thessaloniki	90 ± 14	45 ± 31	40
	AERONET (sr)	EARLINET (sr)	Vertical Variability (sr)
Leipzig 532nm	73 ± 17	57 ± 18	14

EARLINET – AERONET/PHOTONS comparison and integration

A climatological analysis of the aerosol optical depth at EARLINET stations has been performed.

This allows to investigate the Europe aerosol content on the base of the reference network for aerosol profiling.

The integration of EARLINET and AERONET/PHOTONS data will allow us to overcome limits of both techniques and to take the most from their advantages. A better insight of the Europe aerosol content will be obtained by a combined use of EARLINET and AERONET/PHOTONS databases.

In particular, a good characterization of the aerosol content over Europe would be possible through analysis of the aerosol variability and of the free troposphere aerosol load. EARLINET – AERONET database harmonization process started within GEOMON.

More studies are necessary, in particular for the microphysical properties.

The EARLINET-CALIPSO experience

EARLINET represents an optimal tool to validate CALIPSO lidar data and to provide the necessary information to fully exploit the information from that mission

- A ground based lidar network with advanced instrumentation can enhance the value of satellite retrievals. This relates to independent extinction measurements as well as to additional information, e.g. multi-wavelength, depolarisation
- To learn about the spatial and temporal representativeness of ground-based or spaceborne measurements, the latter in particular with respect to the sun-synchronous orbit and the revisit-time
- CALIPSO and EARLINET data together can be used for a very detailed study of the aerosol distribution over Europe

EARLINET correlative measurements for CALIPSO

EARLINET strategy for correlative measurements for CALIPSO:

- Case A (CALIPSO overpass within 100 km)
 - Case B (more stations of the same European region perform contemporary measurements)
 - Case C (interesting additional cases like Saharan dust intrusions, forest fires etc..)
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- EARLINET started correlative measurements for CALIPSO on 14 June 2006
 - Correlative measurements are continuing

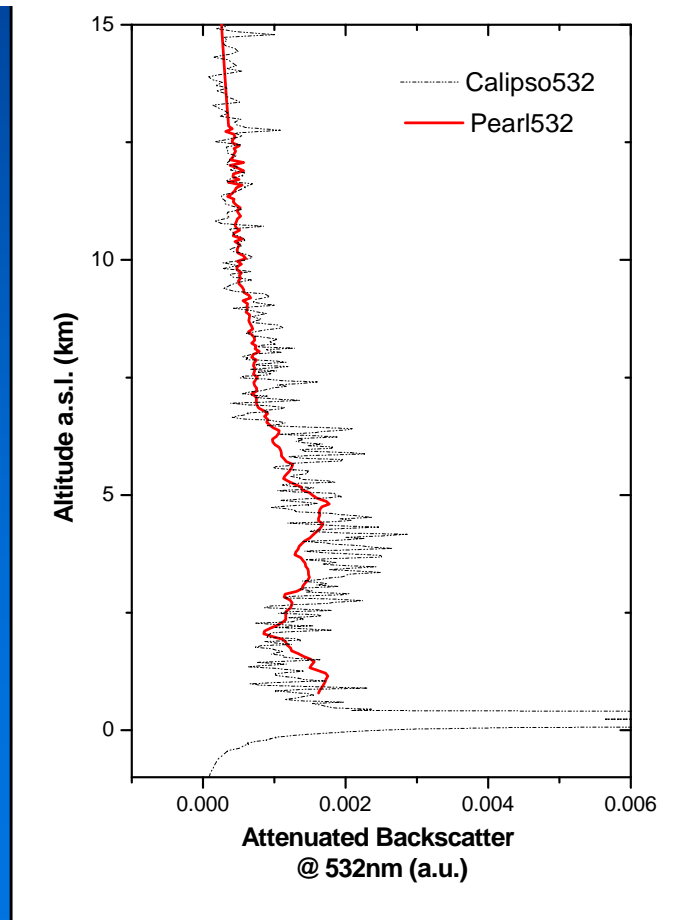
ESA-CALIPSO project

Comparison with CALIPSO level 1 data: attenuated backscatter

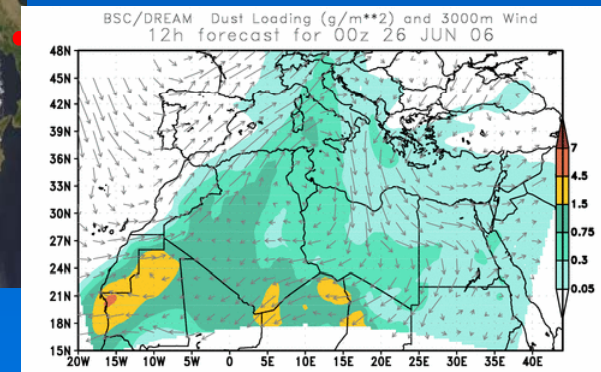
CALIPSO-like attenuated backscatter at 532 nm can be calculated by means of EARLINET Raman measurements at 532 nm without assumptions.

Their comparison with CALIPSO attenuated backscatter allows to check the quality of CALIPSO Level 1 data and to find out possible problems

Pearl (Potenza EARlinet Lidar) 00:56-01:26 UT
Calipso 01:10:22-01:10:23 UT - 5 km Horizontal Resolution



Saharan dust layer extends between 2 and 9 km a.s.l.



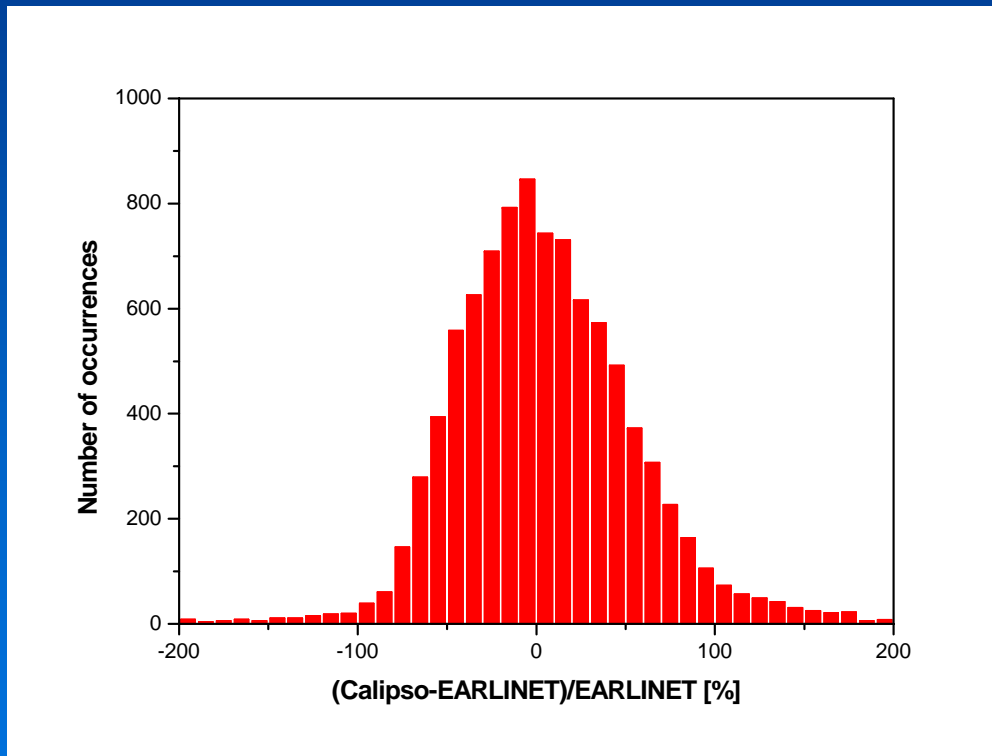
Mona et al. ACP 2009

GEOmon General Assembly, London UK, 18 - 20 January 2010

Comparison with CALIPSO level 1 data: attenuated backscatter

Distribution of the mean relative differences between CALIPSO Level 1 and corresponding EARLINET attenuated backscatter measurements.

The calculation has been performed using data provided by the 3+2 stations of Leipzig, Napoli, Potenza, Madrid and Barcelona.



Relative mean difference = 4.6%

Relative standard deviation = 50%

Relative median value = 0.6%

Pappalardo et al., JGR 2010

Model evaluation – data assimilation

EARLINET observations were included in the AEROCOM tool for model/observation comparison (*Guibert et al. - The vertical distribution of aerosol over Europe - synthesis of one year of EARLINET aerosol lidar measurements and aerosol transport modeling with LMDzT-INCA - Atm. Env.2005*)

A cooperation between EARLINET and the Barcelona Supercomputing Center has been established for Saharan dust intrusions study (EARLINET and DREAM) [WMO SDSWAS]

A study of comparison with the ECMWF model for aerosol is actually in developing phase

Summary and perspectives

- Strong need for integrated long term aerosol observations*
- cooperation and coordination with the relevant observation and user communities*
- continuing integrated observations*
- scientific projects*
- global scale: GALION, the GAW Aerosol Lidar Observation Network*



ACKNOWLEDGEMENT

WMO - GAW

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European Space Agency

AERONET data available from <http://aeronet.gsfc.nasa.gov>

German Weather Service for the air mass back-trajectory analysis

NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT
backtrajectory analysis

NASA for MODIS images

Maltese Euromediterranean Center (ICoD) and Barcelona Supercomputing
Center for Dust Regional Atmospheric Model (DREAM)

The CALIPSO team of the NASA Langley Research Center for the provision of
the CALIPSO ground track data

CALIPSO data were obtained from the NASA Langley Research Center
Atmospheric Science Data Center