ACTRIS aerosol vertical profiles: advanced data and their potential use in a aerosol observations/models combined approach

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and

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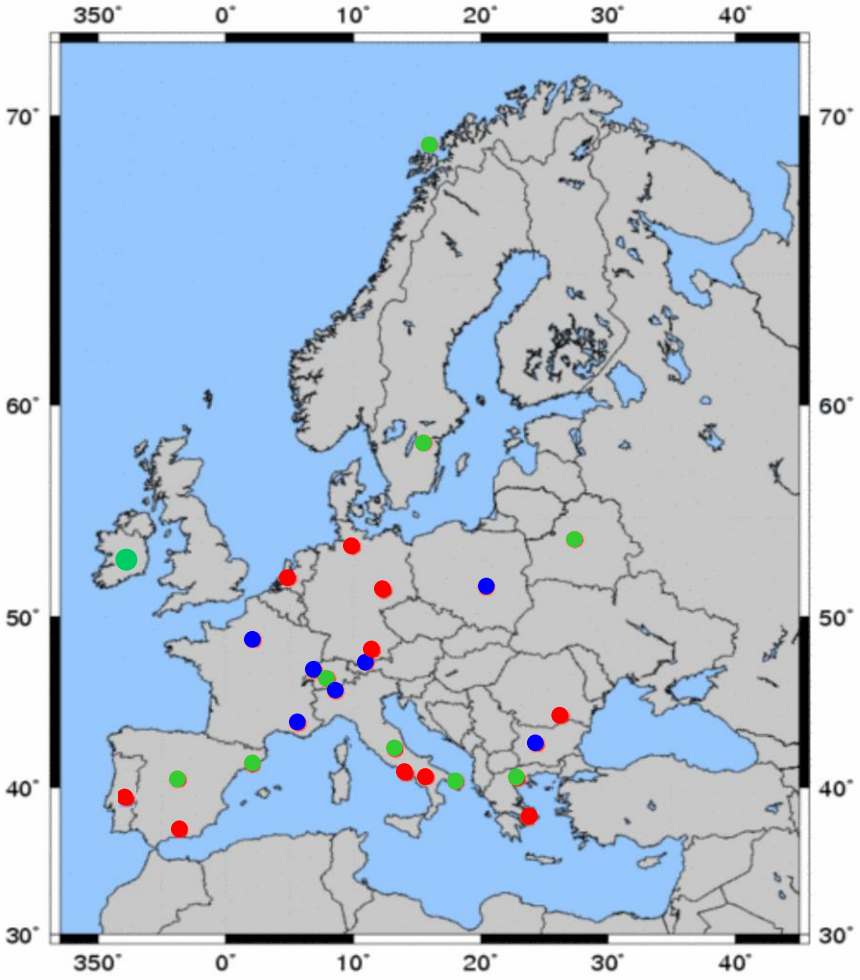
OUTLINE

- EARLINET infrastructure
- EARLINET measurements
- EARLINET database and advanced products
- Climatological results (AOD, FT contribution)
- Measurements representativeness in terms of
  - Columnar content
  - Vertical profiling
- An example of systematic comparison with a model
- Summary and conclusions

EARLINET



- since 2000
- 27 lidar stations

-10 multiwavelength Raman lidar stations

-10 Raman lidar stations

- 7 single backscatter lidar stations

- comprehensive, quantitative, and statistically significant data base
- Continental and long-term scale

www.earlinet.org

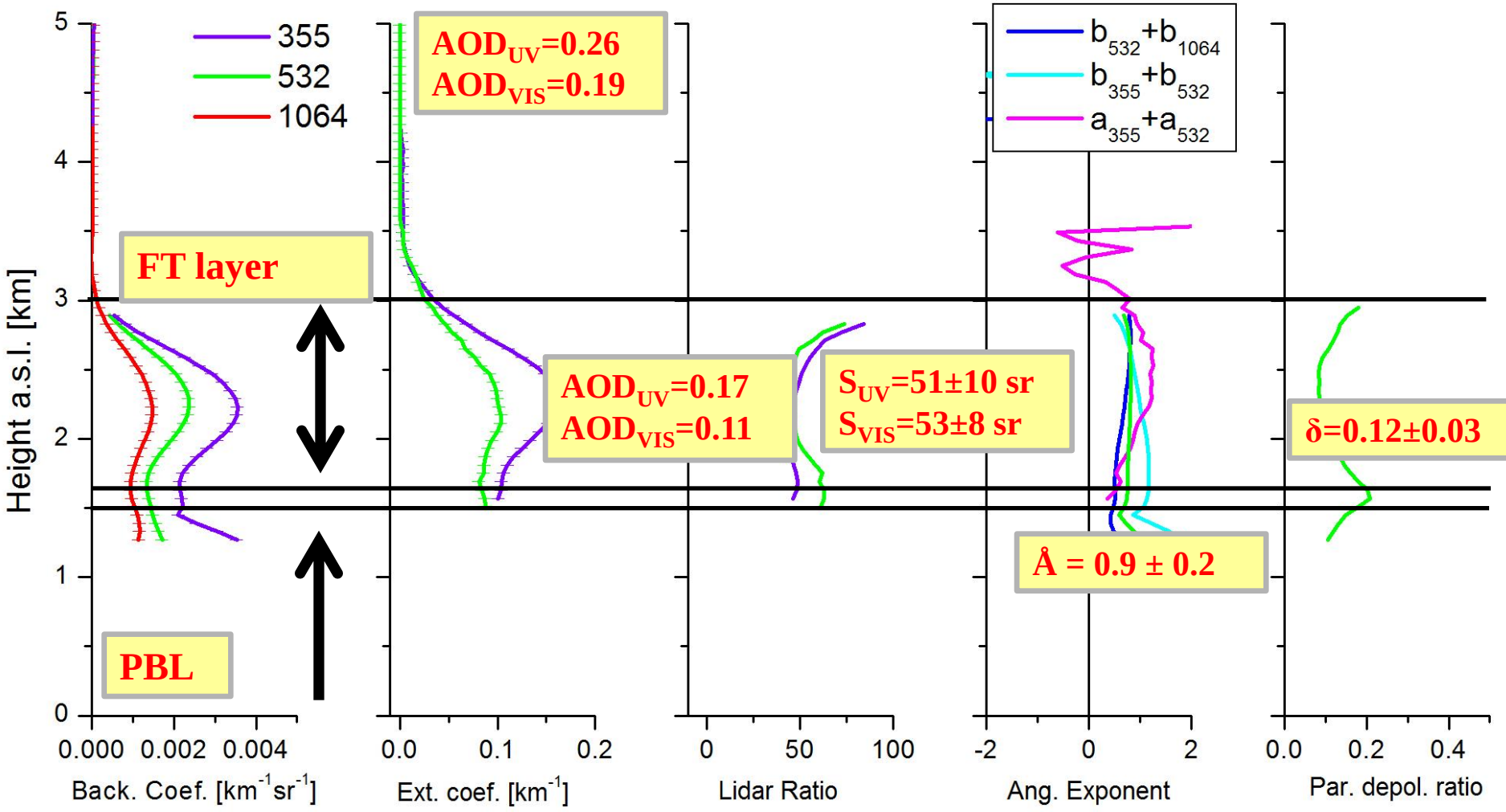
EARLINET

ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network) is a research infrastructure that aims at integrating European ground-based stations equipped with advanced atmospheric probing instrumentation for aerosols, clouds and short-lived gas-phase species (based on EUSAAR, EARLINET, CLOUDNET infrastructures and a new trace gas network).

EARLINET vertical profiling is the ideal bridge between in situ and satellite/ground-based columnar measurements and for cloud-aerosol interaction studies.

Example of EARLINET measurements

Potenza, Italy, (40.60°N, 15.73°E), 05 July 2012, 19:43- 21:31 UTC



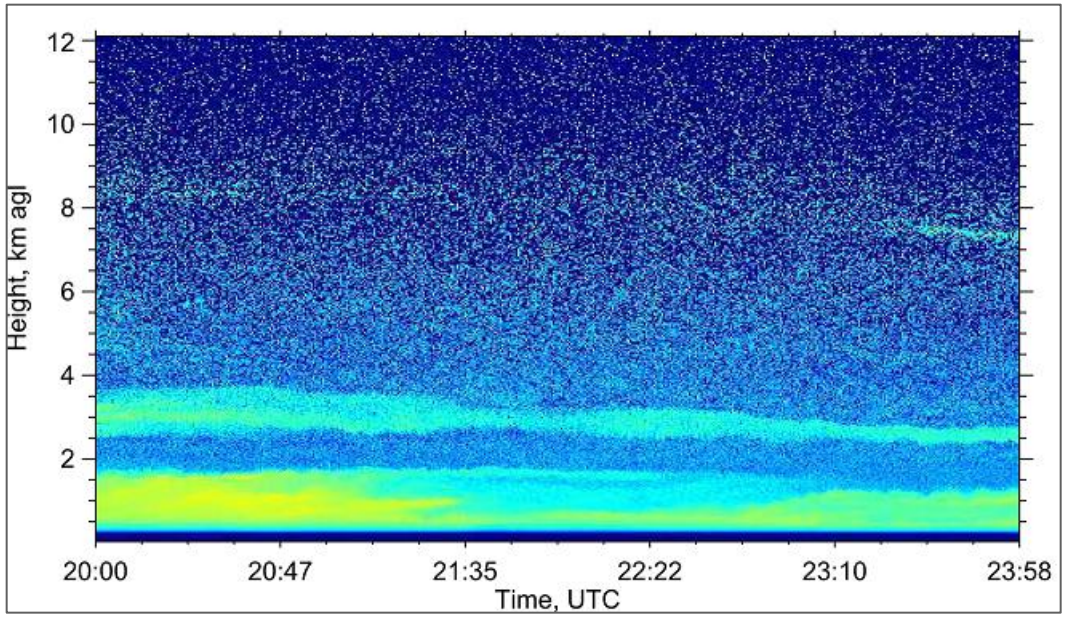
All these info can be used for microphysical properties retrieval (Wandinger presentation)

EARLINET measurements

Climatological schedule

Measurements are performed almost simultaneously at all EARLINET stations 3 times per week on the base of a fixed time schedule:

- **one daytime measurement per week around noon (on Monday, 14:00 LST ± 1 hour.), when the boundary layer is usually well developed,**
- **two night-time measurements per week (on Monday and Thursday at sunset -2h +3h), with low background light, in order to perform Raman extinction measurements.**



Example of Quicklook
Evora- 30 june 2012
RCSsignal at 1064nm

Quicklooks are typically reachable for each EARLINET station in NRT at http://www.earlinet.org/quicklook

EARLINET measurements

Saharan dust

A suitable observing methodology has been established within the network for studying Saharan dust events.

Measurements are performed in correspondence of alerts based on the operational outputs of the DREAM (Dust REgional Atmospheric Model), and the Skiron models distributed to all EARLINET stations by the NTUA (National Technical University of Athens) group

The alerts are diffused 24 to 36 hours prior to the arrival of dust aerosols over the EARLINET sites.

Typically runs of measurements longer than the typical 3-hour observations performed for the EARLINET systematic measurements are performed at the EARLINET stations in order to investigate the temporal evolution of the dust events.

Papayannis et al., JGR 2008

Calipso

EARLINET measurements

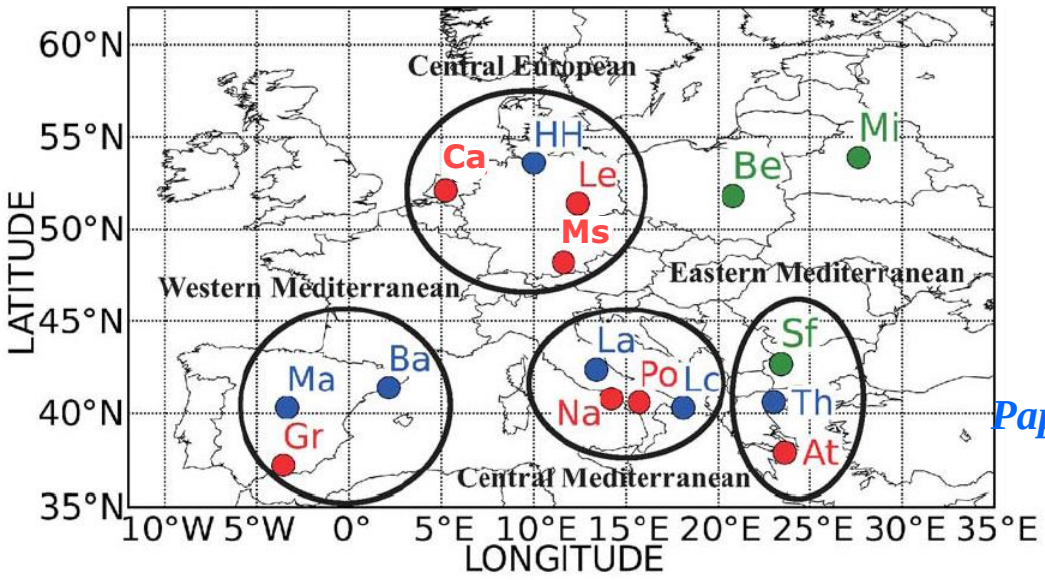
Measurements performed following a devoted measurement strategy realized and optimised by the CNR-IMAA group

Case A: when CALIPSO overpasses within 100 km

Case B: contemporary measurements at several EARLINET stations of the same geographic cluster

Case C: in cases special events like Saharan dust outbreaks and forest-fire events

• High performance stations / • contributing stations / • contributing non-funded stations



Pappalardo et al., JGR 2010

EARLINET measurements

Volcanic eruptions

Measurements based on alerting system.

UTLS layers related to eruptions in the North Pacific ring (2008-2010)

Etna 2001 /Etna 2002 ***Pappalardo et al., GRL 2004***

Eyjafjallajökull 2010

Grimsvotn 2011

Nabro 2011 ***Sawamura et al.,, 2012***

Relational database about identified volcanic layers is freely available at:

www.earlinet.org

Pappalardo et al., ACP 2013

Special measurements campaigns

ICARTT

SAMUM-2

ACTRIS summer 2012

EARLINET database

Devoted database in a standardized NetCDF format (CF compliant dataformat).

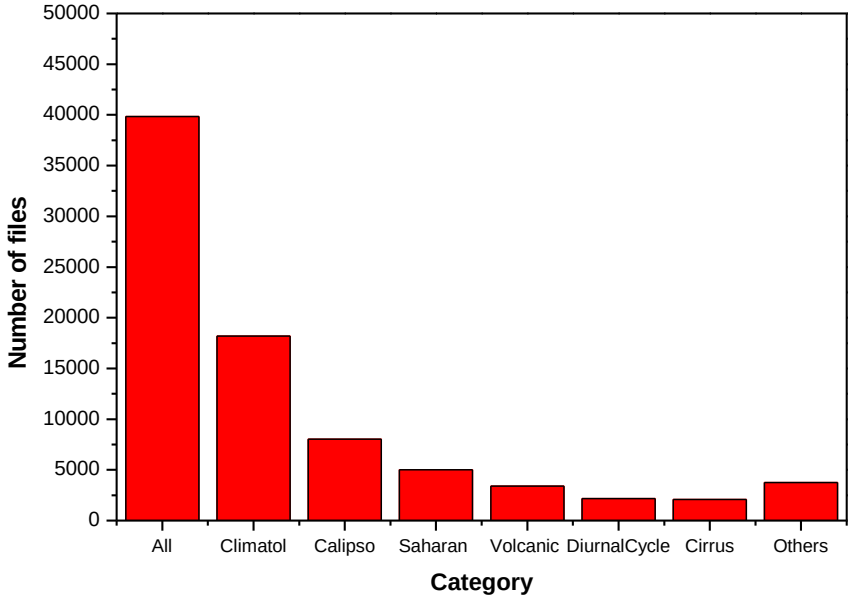
EARLINET database is organised into 10 categories (climatology, saharan, volcanic, forest fires , calipso, etc)

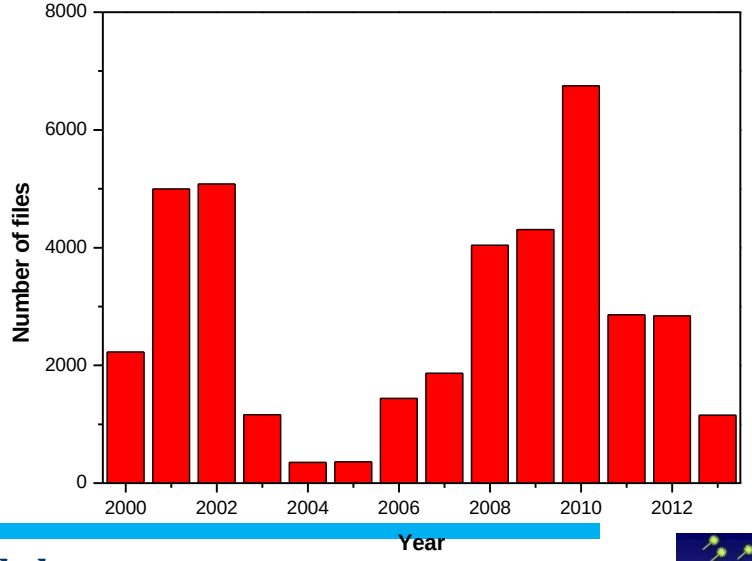
3 level of data availability: internal (1 year From data acquisition)

External freely available www.earlinet.org and ACTRIS data portal

DOI database with quality checked files

First volume in preparation





Workshop

Hamburg, Germany

EARLINET climatology

For this climatological analysis, only measurements from climatological category are considered.

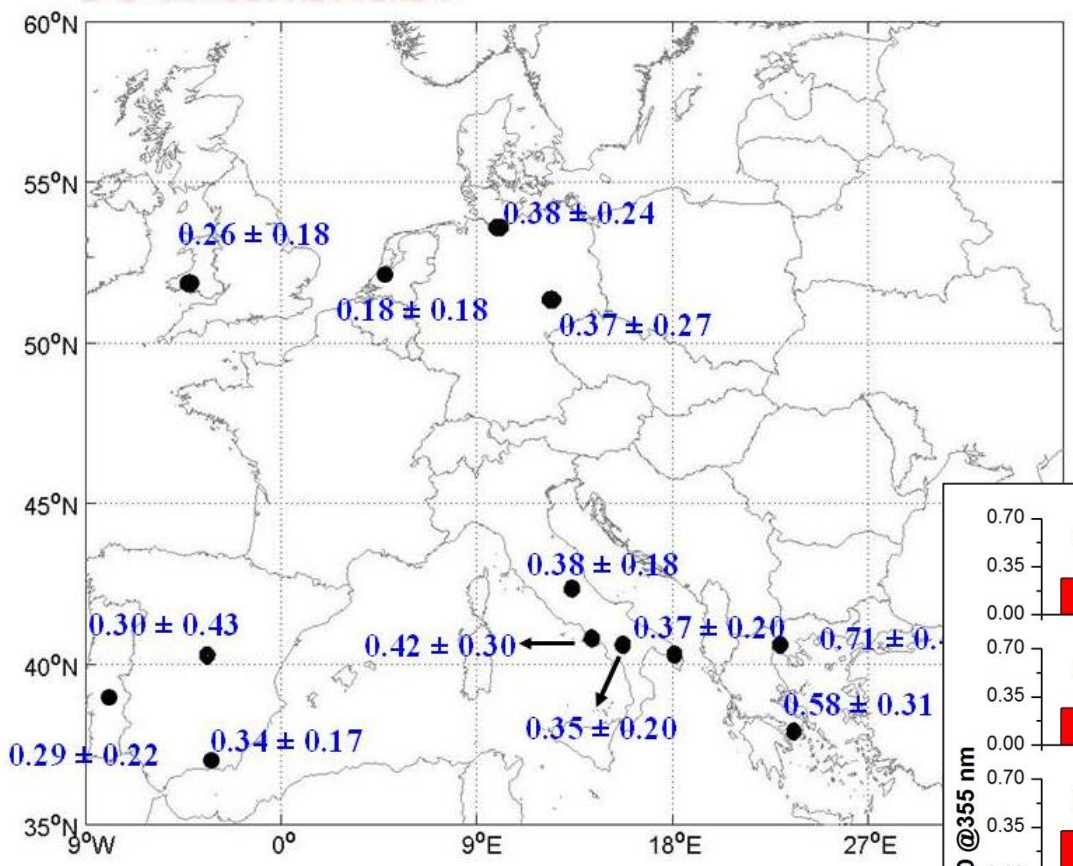
Climatological category contains also some profiles belonging to other categories and on a sufficient large number of profiles these data will be representative of the natural variability and occurrences of special events at each station.

Only Raman stations are considered because able to measure directly the AOD.

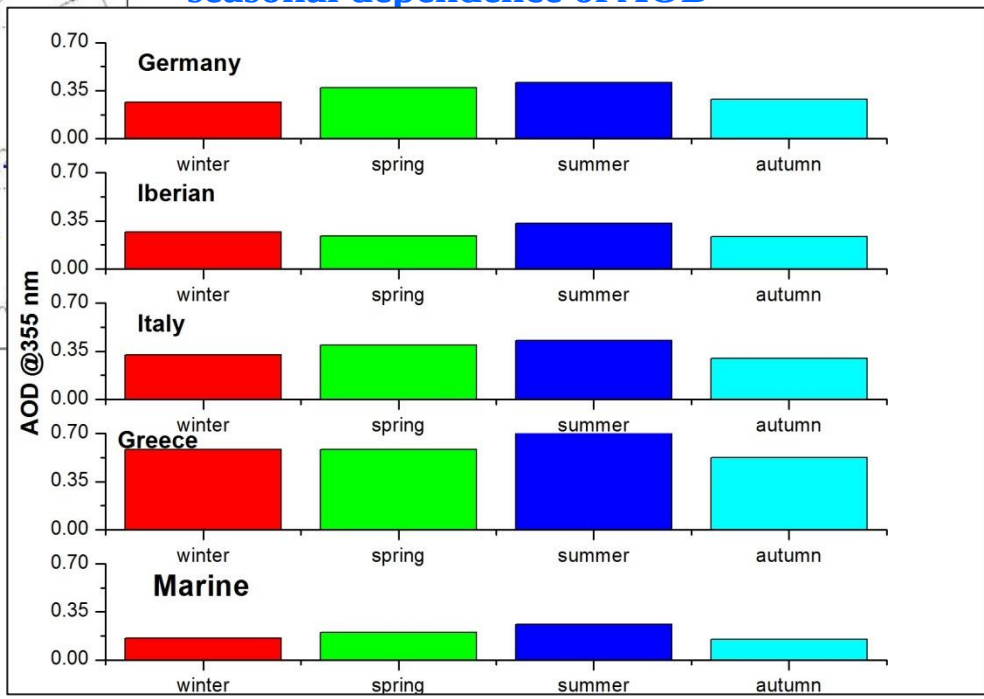
Only QA EARLINET data are considered: May 2000-December 2011 period

Mona et al., in preparation 2013

Averaged AOD at 355/351 nm



- higher AOD in the South
- Highest aOD values toward East
- lowest values at maritime sites
- smaller variability during Autumn -Winter
- seasonal dependence of AOD



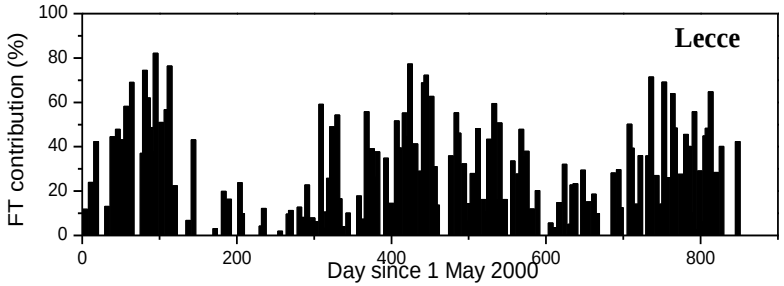
Multi-years behaviour

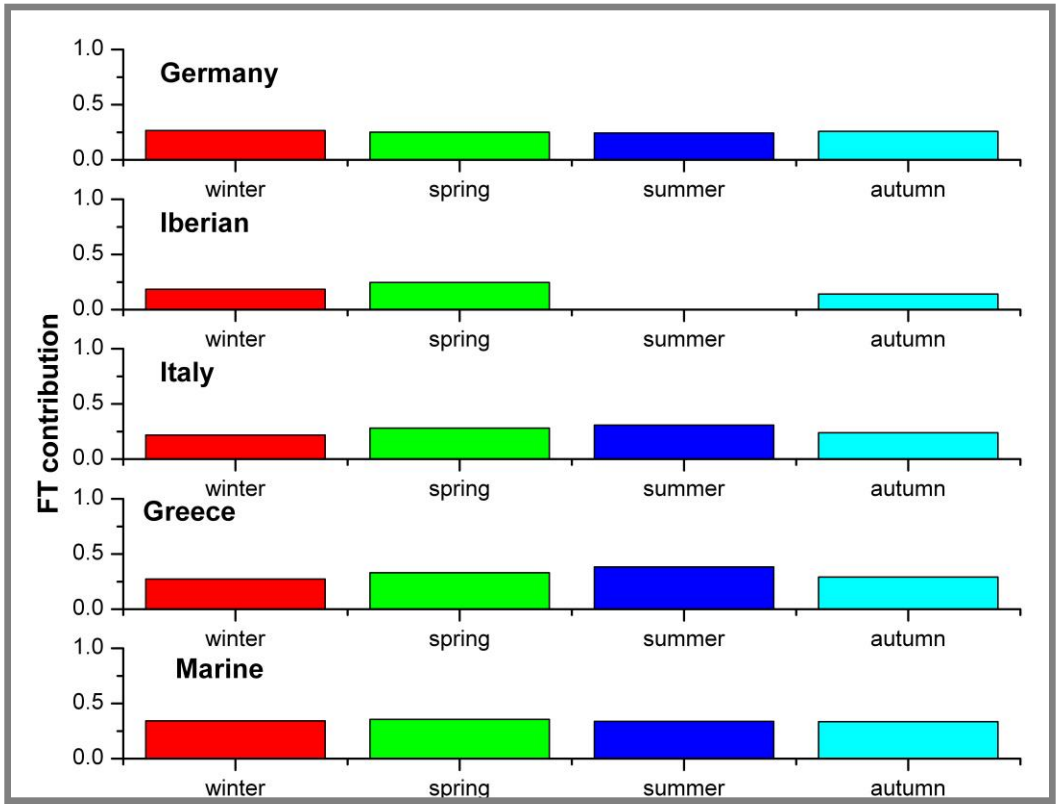
Annual averages are considered only if data are available for each season (black). Averages are reported in red for cases with 1 season missing.

A slightly decrease in AOD is observed from 2006-2007 until 2011 period.

Free Troposphere contribution

Free troposphere contribution (FT) to the total aerosol load is calculated in percentage to the total AOD starting from information provided by lidar about the PBL top height





- **FT on average 30-35% for all the stations**
- **Seasonal behavior due to Saharan dust episodes evident in Southern Europe stations**
- **FT largely varies in Southern Europe**
- **FT almost constant during the year at maritime sites**
- **FT higher at maritime sites**

From EARLINET climatological database we have long-term aerosol observations.

Mean values for months, seasons, 6-months and year are available for investigating how aerosol content is changing over Europe

Are these values representative ?

Is the 2 times per week sampling sufficient for climatological studies?

Are punctual measurements representative of a larger area? In which sense?

Comparison and integration with other data is fundamental for addressing these points.

Mona et al., in preparation 2013

EARLINET-AERONET comparison

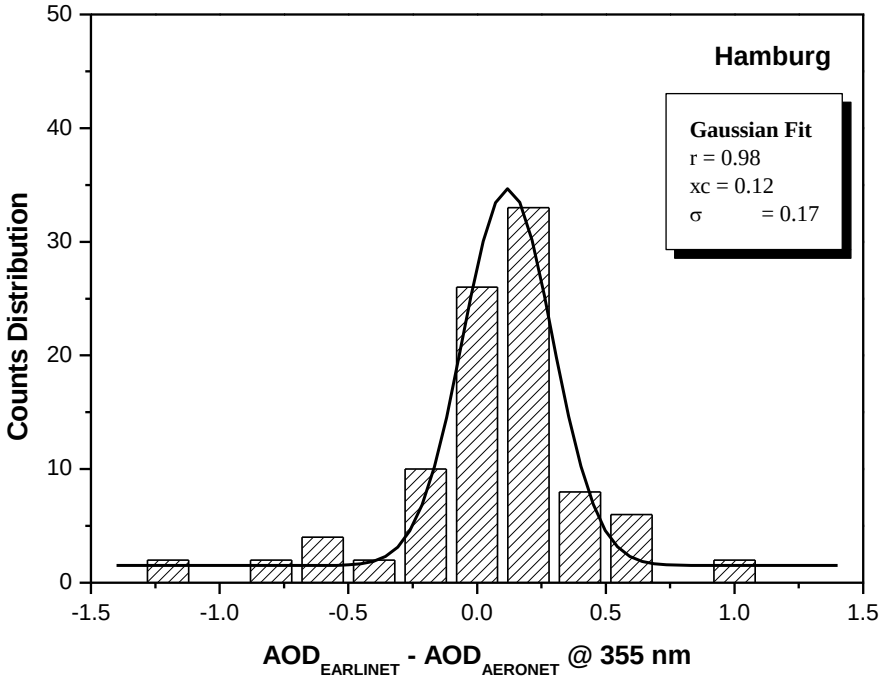
Co-located stations are considered.

Daily average of AERONET data are compared to the same day EARLINET measurements for checking the consistency of data.

AERONET AOD values are scaled to the lidar observation wavelength through the mean Ångström exponent measured by AERONET at the same station.

For this comparison, only stations with more than 100 extinction profiles retrieved during regular measurements have been selected.

Difference of same-day measurements



Differences are on averages in agreement with zero, even if also large differences are observed.

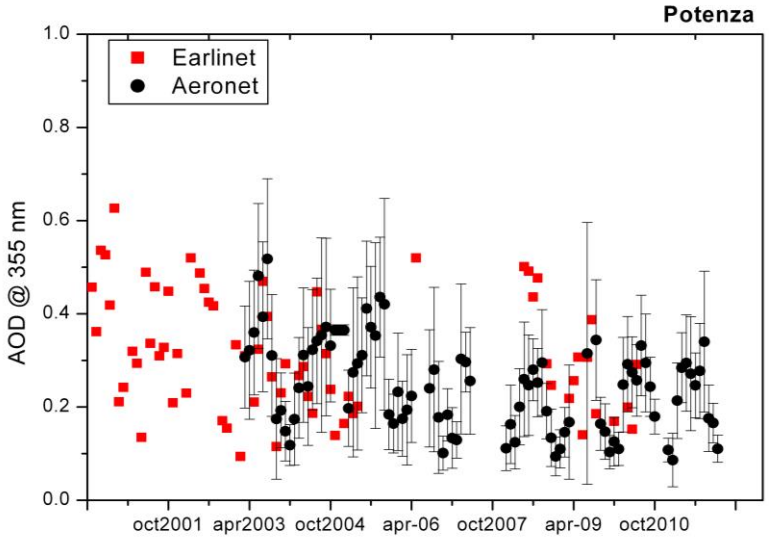
Distributions are typically well fitted by Gaussian distribution centered around zero.

Some large difference values observed can be related to:
-no really simultaneous measurements
-presence of free troposphere layers

Station	$AOD_{EAR} - AOD_{AER}$	Cases number	Correlation coefficient	Center of fitting curve	Half width of fitting curve
Hamburg	0.05 ± 0.35	95	0.98	0.12	0.17
Leipzig	0.05 ± 0.20	44	0.93	0.04	0.16
Leipzig (532nm)	-0.001 ± 0.12	45	0.9	-0.005	0.13
Potenza	0.009 ± 0.22	41	0.94	0.023	0.14
Thessaloniki	0.15 ± 0.09	12	0.97	0.17	0.05

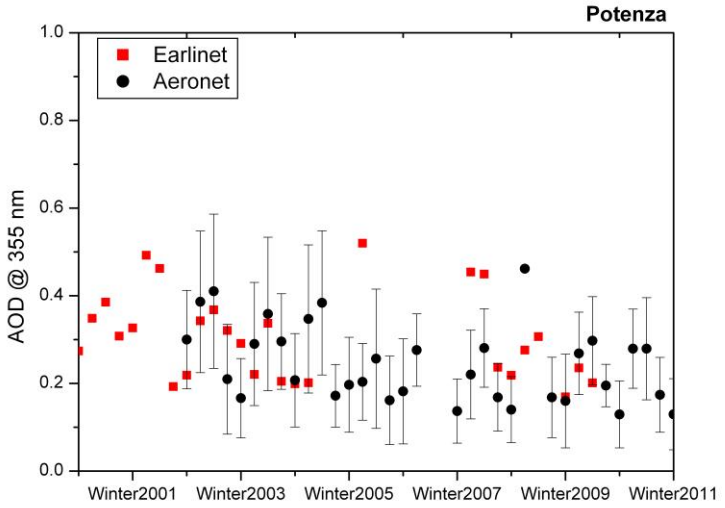
Is the regular schedule sufficient for climatological purposes?

For the climatological comparisons, only climatological EARLINET measurements are considered in order to avoid possible biases due to intense measurement periods related to special events observations.



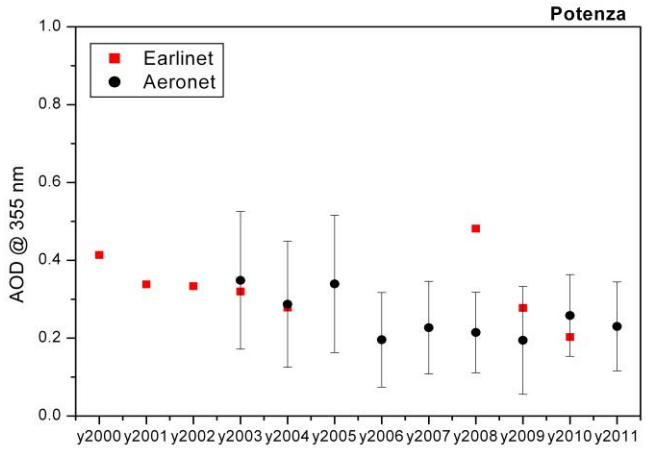
Monthly averages: partially ok.

Seasonal averages: ok for n. >4



Is the regular schedule sufficient for climatological purposes?

Annual averages: ok for n. >8



Station	AERONET	EARLINET
Hamburg	0.30 ± 0.23	0.36 ± 0.24
Leipzig	0.35 ± 0.22	0.39 ± 0.26
Lecce	0.33 ± 0.18	0.39 ± 0.20
Potenza	0.33 ± 0.18	0.35 ± 0.18
Thessaloniki	0.43 ± 0.23	0.46 ± 0.13
Leipzig 532nm	0.22 ± 0.15	0.22 ± 0.15

Long-term averages: ok

Good representativeness of EARLINET regular measurements (typically 50% of scheduled measurements are performed)

Are punctual measurements representative of a larger area?

MODIS daily time series of aerosol optical depth at 550 nm of the collection 5 with a resolution of 1° × 1° data are considered.

Measurements performed on the same day are compared.

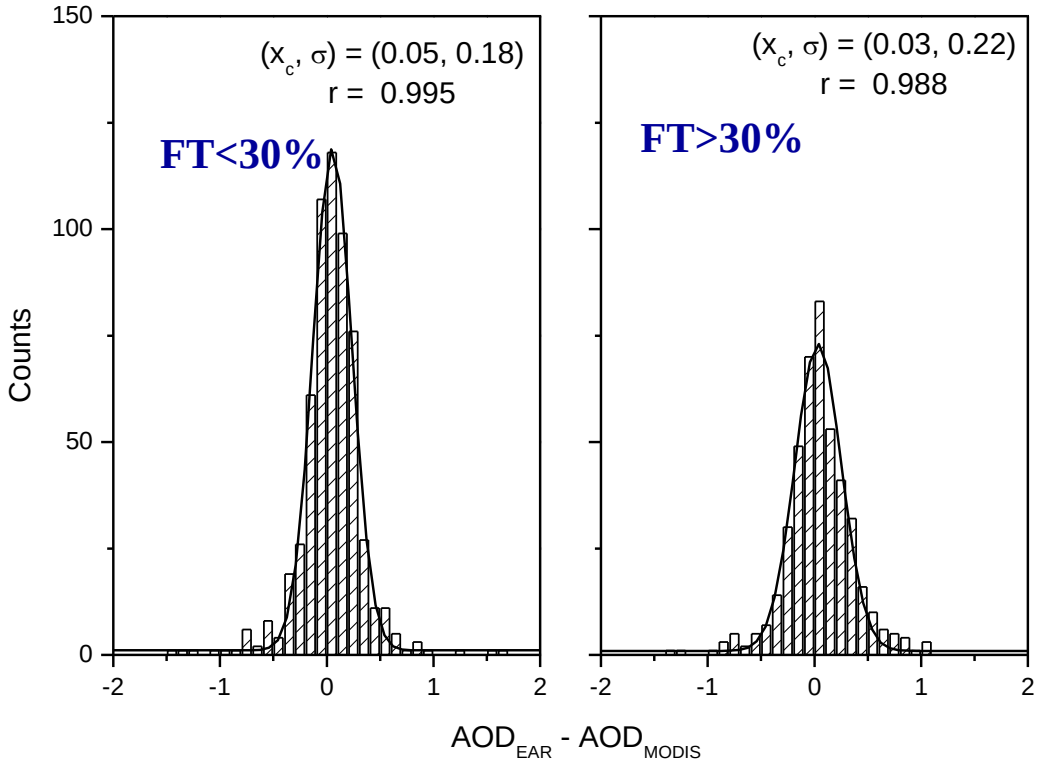
Measurements collocation in time is not possible:MODIS are daytime data and EARLINET Raman data are only night time data.

MODIS data are scaled to the EARLINET measurement wavelength using the mean Ångström exponent measured at the closest AERONET station.

Difference of same-day measurements

Differences between EARLINET and MODIS AOD measured on the same day are calculated for each station.

- **differences distribution approximated by a Gaussian distribution centered around 0.04 with a standard deviation of 0.2.**



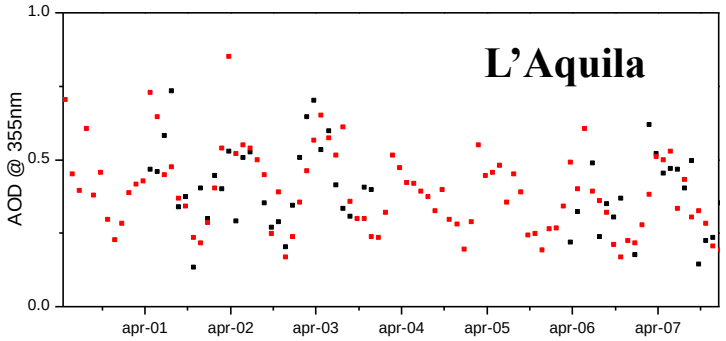
FT =Free Troposphere contribution to AOD

evaluated from EARLINET profiles

High FT contribution, which typically indicates large scale processes, differences between satellites 1° × 1° measurements and punctual measurements of the AOD are typically more spread than for small FT contributions

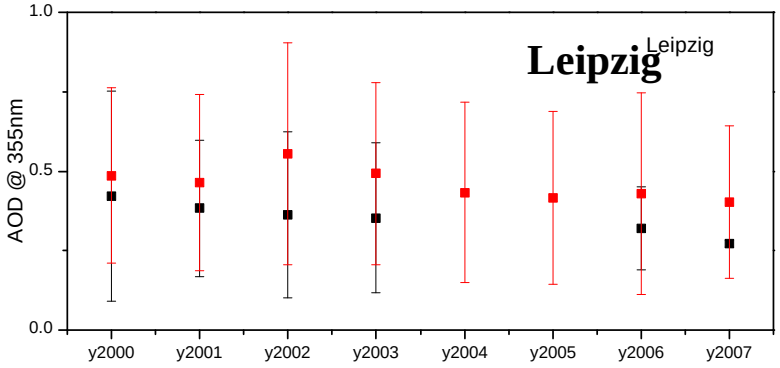
Are punctual measurements representative of a larger area?

MODIS
EARLINET



Monthly averages

- General agreement
- Seasonal behavior well seen by both sensors



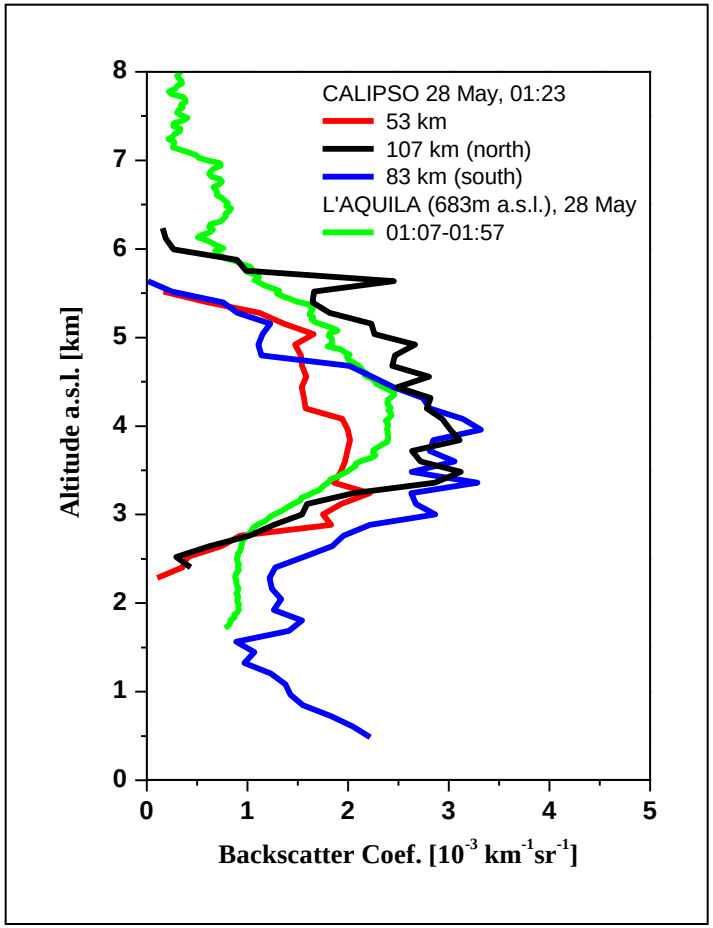
Annual averages

- Also at this 1°x1° scale , good agreement

EARLINET / CALIPSO study for representativeness

Representativeness in the vertical dimension is even more complex.

A case of dust intrusion over Europe: May 2008 many EARLINET measurements



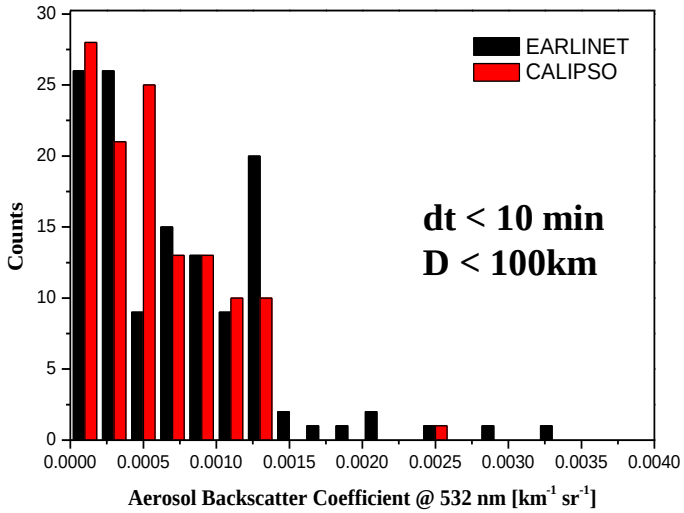
Level 2 data are in good agreement with EARLINET observations.

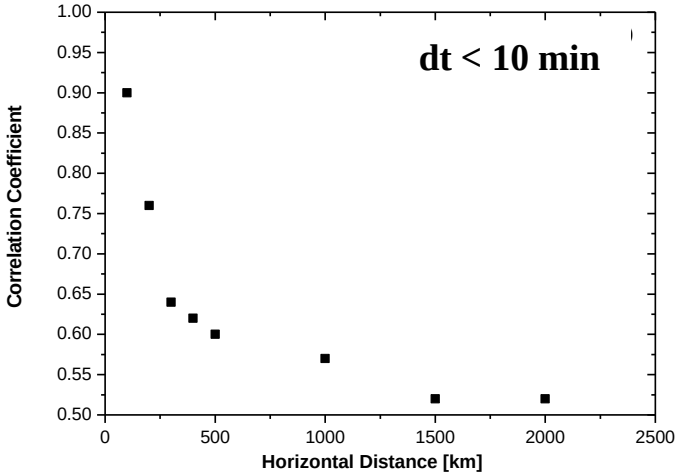
The count distributions of CALIPSO and EARLINET backscatter-coefficient measurements for different time shifts and distances are investigated.

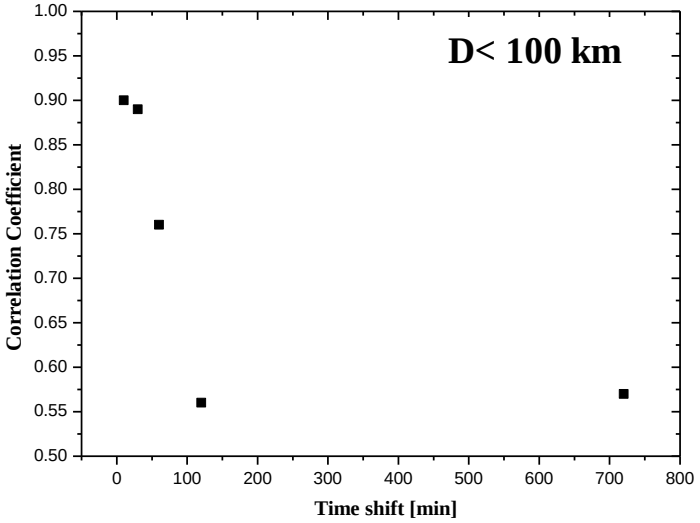
Pappalardo et al., JGR 2010

EARLINET / CALIPSO study for representativeness

At short distances good correlation (>0.9).







There is a loosing of correlation moving far from the EARLINET observations.

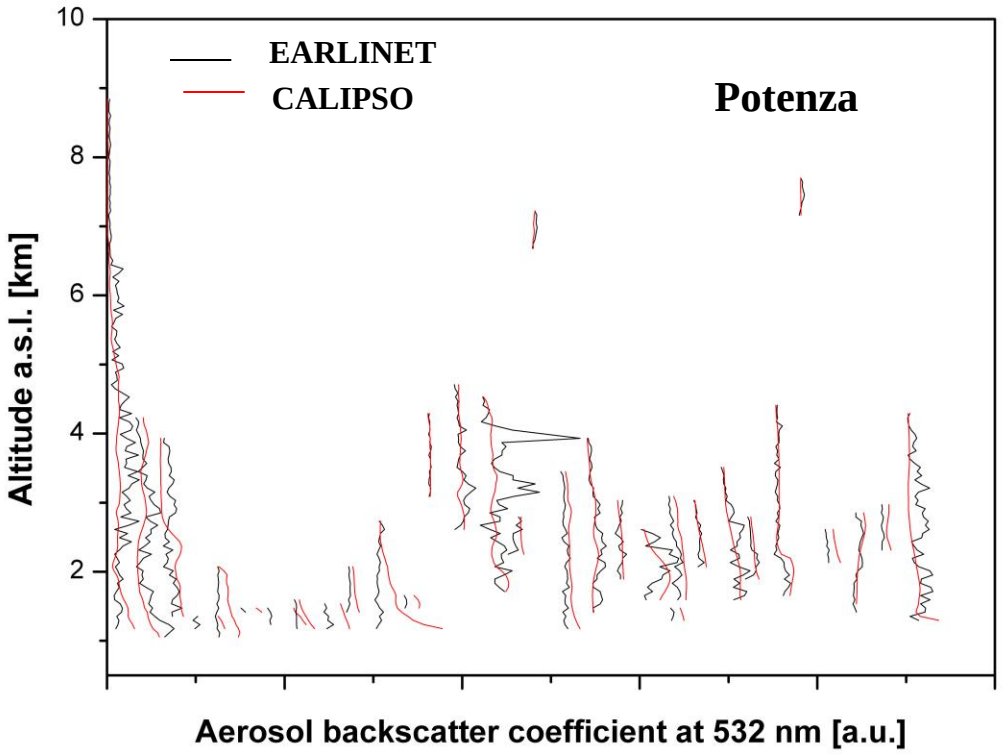
This analysis shows a spatio-temporal scale of 300 km and 30 m

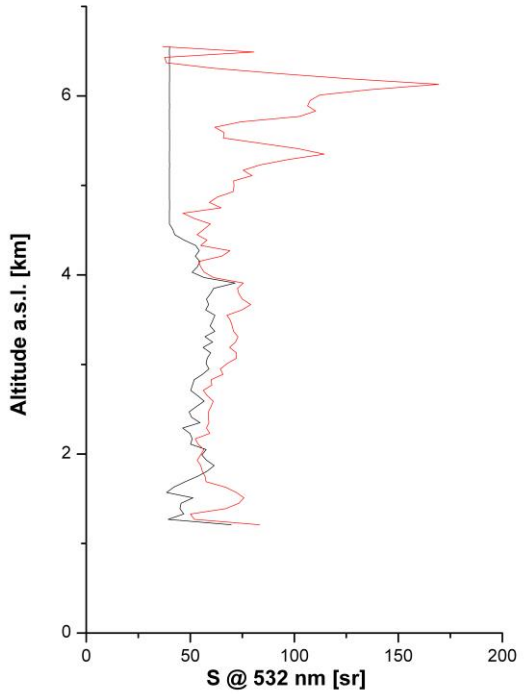
Pappalardo et al., JGR 2010

EARLINET / CALIPSO study for representativeness

Are EARLINET profiles representative for a larger area also in terms of profiles?

Long-tem comparison with CALIPSO Lev 2 database





- Typically good agreement in backscatter
- Discrepancies in the low range (below 2 km)
- CALIPSO S is significantly lower than EARLINET measured one (bias ≈ 10sr)

Mona et al., in preparation 2013b

A first systematic comparison with a forecast model

Comparison for dust event :

Location: Potenza EARLINET site

Period: May 2000 – June 2012

Data: EARLINET vertical profiles

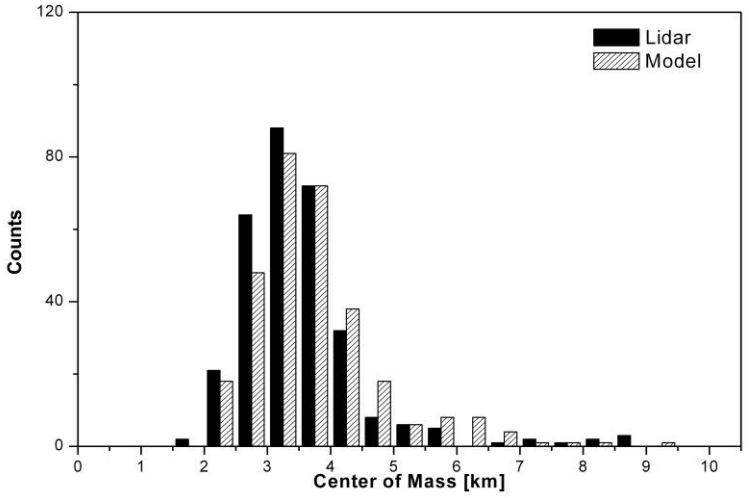
BSC-DREAM8b model

Comparison performed in terms of

- **dust layer geometrical properties (base, top, extension and center of mass)**
- **dust optical properties**

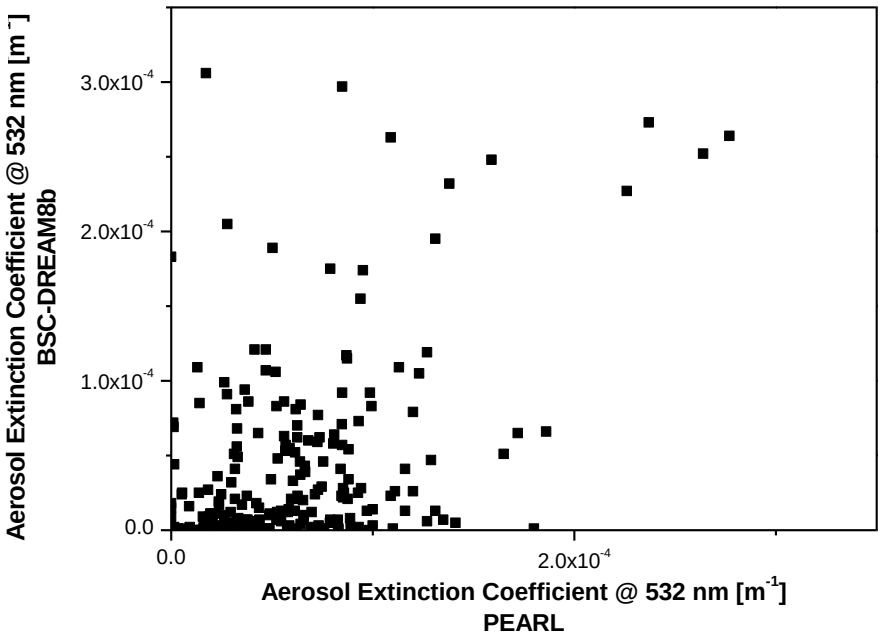
Mona et al., submitted ACP 2013

A first systematic comparison with a forecast model



The model well reconstructs the measured layering: profiles are correlated within 5% of significance for 60% of the cases and the dust layer center of mass as measured by lidar and modeled by BSC-DREAM8b differ on average 0.3 ± 1.0 km

BSC-DREAM8b typically underestimates the dust extinction coefficient in particular below 3.5 km and for low concentrations



Mona et al., submitted ACP 2013

Summary and conclusions

- EARLINET database is freely available

- Advanced datasets are already available

- Other info are available in the database besides optical properties profiles

- Climatological measurements scheduling significant for climatological investigations

- EARLINET AOD punctual measurements could represent 1°x1° horizontal scale

-A 300 km-30min scale length is found for vertical profiling during long-range transport case

-Above 2 km EARLINET vertical profiles are typically representative for a larger area (around 80km).

-First example of systematic comparison with forecast model

Future plans

- Systematic comparison with CALIPSO level3 data is in progress

- Systematic comparisons with AEROCOM and MACC models

-Making available advanced data from these studies