EARLINET's ESA-CALIPSO project: Overview and results from correlative ground-based and spaceborne observations

Ulla Wandinger, Anja Hiebsch, Ina Mattis

Leibniz Institute for Tropospheric Research, Leipzig, Germany

Gelsomina Papparlardo, Lucia Mona, Fabio Madonna

Istituto di Metodologie per l'Analisi Ambientale, Potenza, Italy

With contributions from 16 EARLINET stations

This work has partly been presented at the

- EarthCARE Workshop, Kyoto, Japan, 10-12 June 2009
- CALIPSO/CloudSat Science Workshop, Madison, Wisconsin, 28 -31 July 2009

and in the

- manuscript for CALIPSO special issue in JGR by Pappalardo et al.

Outline

- Project overview
- News on CALIPSO Version 3 data
- Case study: Saharan dust outbreak 27-30 May 2008
- Conclusion and outlook

Anja will present aerosol classification in more detail

ESA–EARLINET activity

"Aerosols and Clouds:
Long-term Database from Spaceborne Lidar Measurements"

- ESA funded project
- since April 2008
- 16 EARLINET stations
- 18 month of correlative EARLINET-CALIPSO measurement
- development of a database on aerosol and cloud properties and correlative data sets

Objectives of the ESA–EARLINET activity

- provide a tool for homogenizing long-term space-borne observations conducted with different lidar instruments, operating at different wavelengths, on various platforms
- study the representativeness of the limited number of satellite lidar cross sections along an orbit against long-term lidar network observations on a continental scale

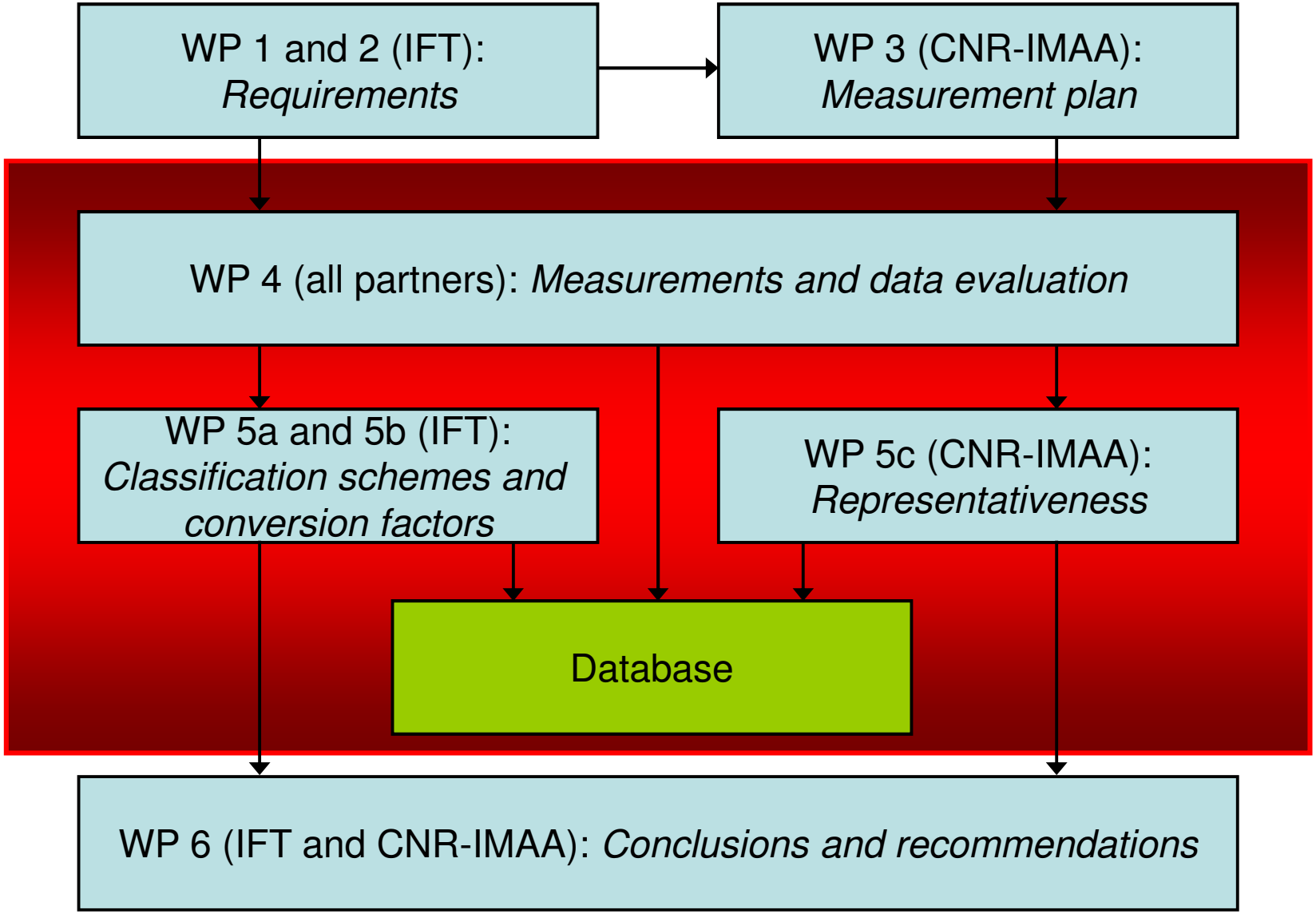
Specific tasks

⇨ develop common aerosol classification schemes

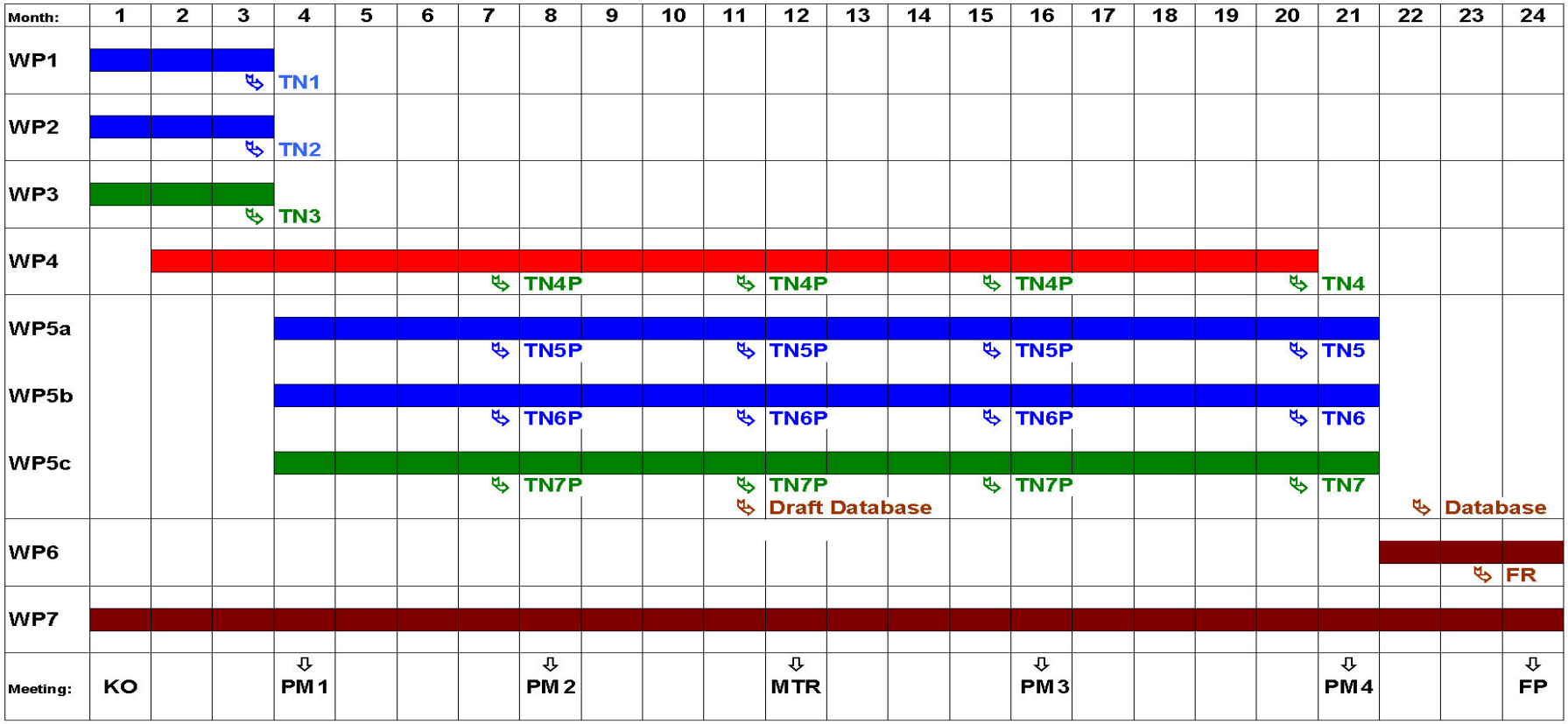
⇨ characterize the optical properties (lidar ratio, depolarization ratio, Ångström exponents) of major aerosol types

⇨ derive wavelength conversion schemes to harmonize space-borne observations

⇨ establish statistically significant datasets based on a correlative measurement strategy for verification/validation purposes and representativeness studies


WP 1 and 2 (IFT): *Requirements*
WP 3 (CNR-IMAA): *Measurement plan*
WP 4 (all partners): *Measurements and data evaluation*
WP 5a and 5b (IFT): *Classification schemes and conversion factors*
WP 5c (CNR-IMAA): *Representativeness*
Database
WP 6 (IFT and CNR-IMAA): *Conclusions and recommendations*

Time table of the study



Responsibilities

- IFT
- CNR-IMAA
- IFT and CNR-IMAA
- All partners

Currently, we negotiate a 6-month prolongation with ESA!

CALIPSO data status

- CALIPSO is running with the backup laser since March 2009
- NASA science team decided to use new Version 3 algorithm to evaluate the observations with the new laser
- All data since June 2006 will be re-evaluated with Version 3
- Level 1, Version 3 data available since June 2009
- Level 2, Version 3 data not available yet

⇨ no data for comparison/representativeness study since February 2009

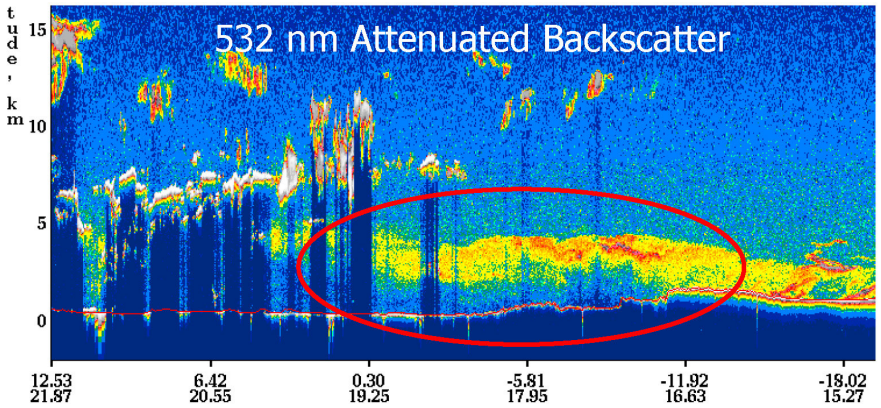
⇨ Version 3 data will be of better quality

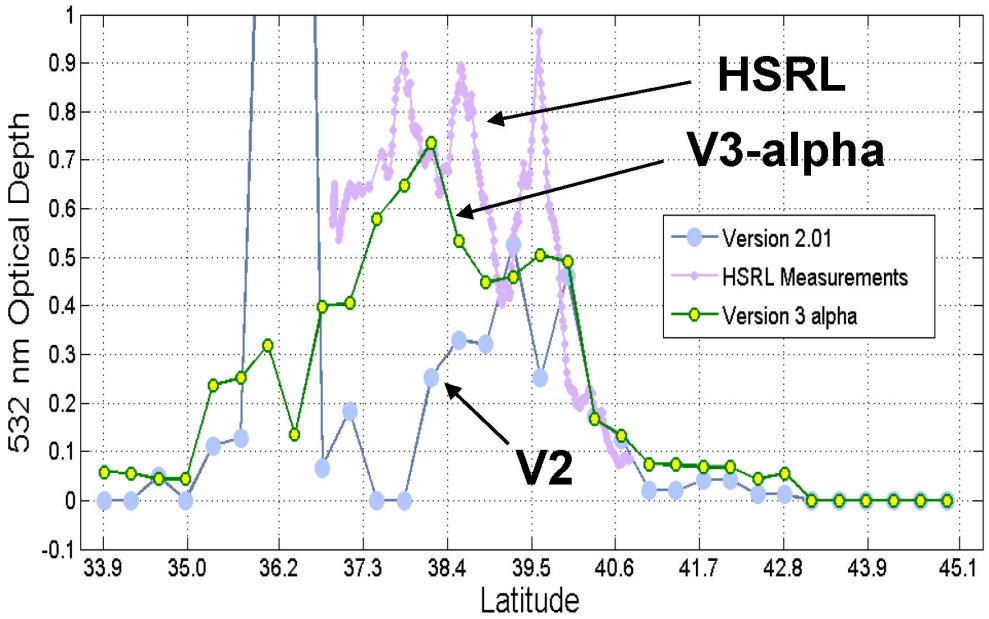
⇨ amount of data (size of files) will increase by at least a factor of 10

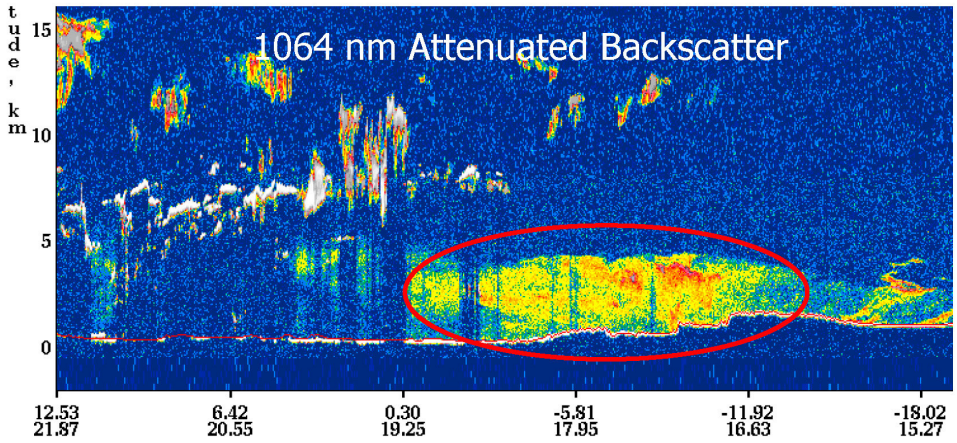
What will be new in Level 3 data products?

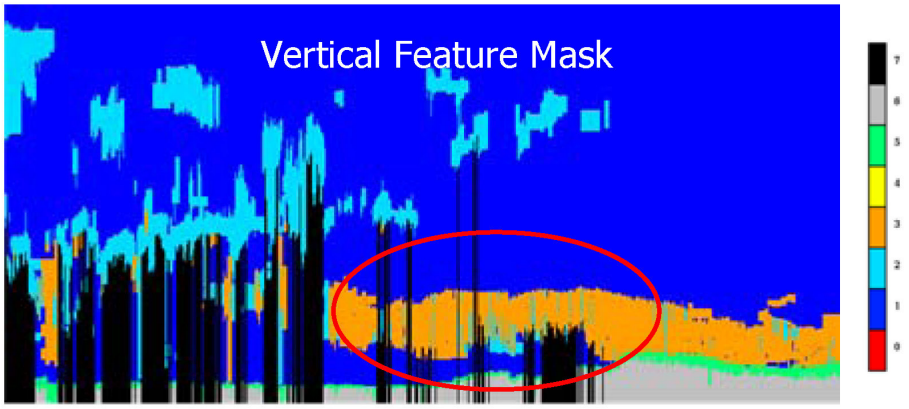
- Several significant bugs fixed (e.g. cloud removal in PBL)
- New resolution for aerosol products (5 km instead of 40 km)
- Improved daytime calibration, but biases remain at 1064 nm (color ratios biased)
- Improved CAD
- Improved aerosol typing
- Lidar ratio of dust at 1064 nm changed from 30 to 50 sr
- Extinction from lowest aerosol layer to ground = improved PBL profiles
- Column optical depth provided in aerosol and cloud profile data
- Particle depolarization ratio provided
- Particle color ratio provided
- New ice/water phase scheme, shape parameters of ice clouds provided
- Errors/uncertainties provided for most parameters
- More data quality flags (CAD, feature type, extinction)

Revised boundary layer aerosol retrieval

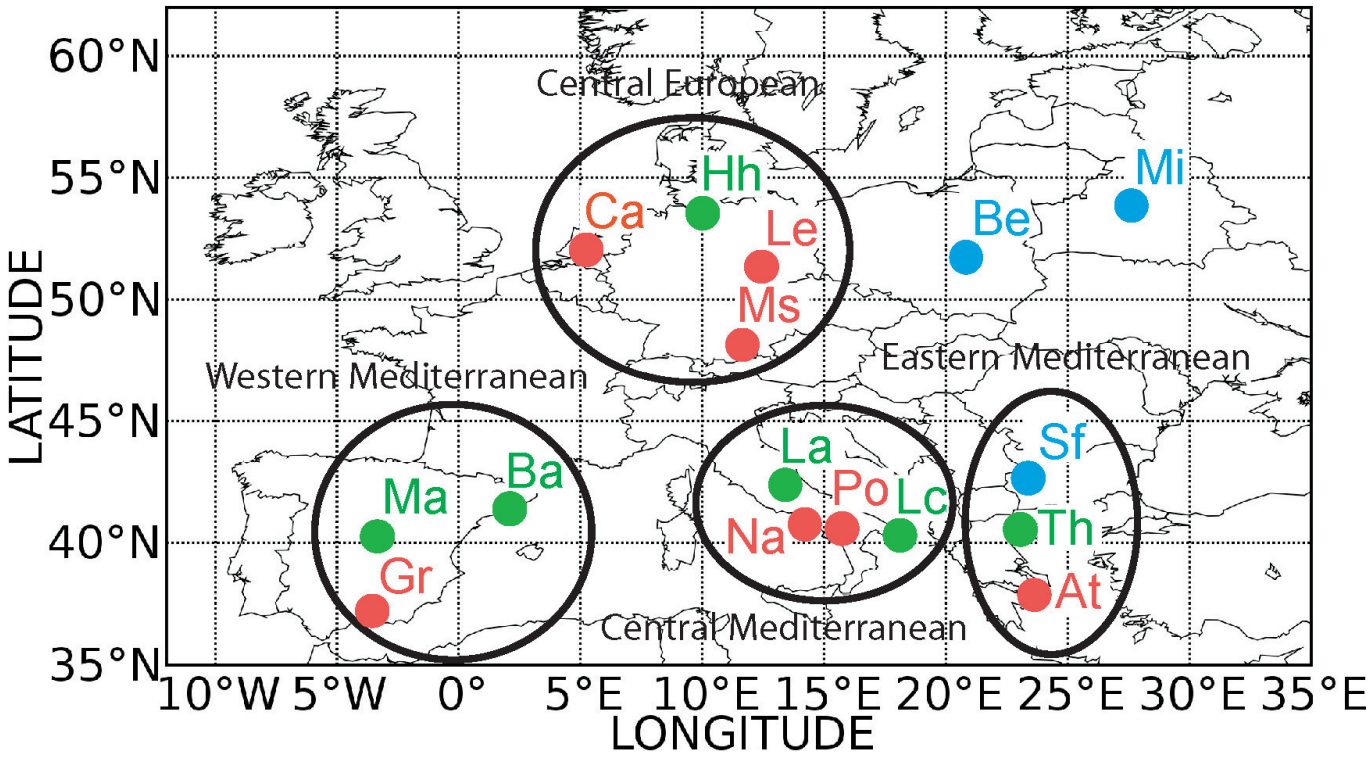








ESA–EARLINET network measurements



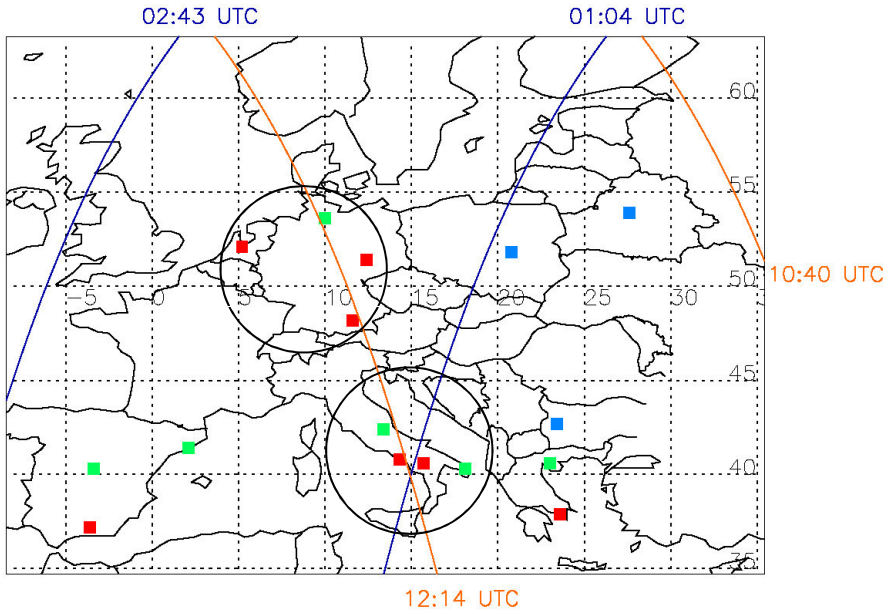
- high-performance stations = extinction and backscatter at 355 + 532 nm (+ backscatter at 1064 nm + depolarization)
- contributing stations = extinction and backscatter at one wavelength

Observational Strategy

CASE A:
Measurements within 100 km of the overpass

CASE B:
Simultaneous measurements of more than one station within the same cluster, when one station has a CASE A overpass

CASE C:
Measurements during special events (e.g., large Saharan dust intrusions, forest-fires smoke plumes, volcanic eruptions)



ESA–EARLINET study approach

→ 18 months of correlative measurements of EARLINET and CALIPSO

→ evaluation of the geometrical and optical properties of aerosols and clouds

→ rely on CALIPSO aerosol and cloud classification schemes

- **Marine aerosol**
- **Mineral dust**
- **Polluted continental aerosol**
- **Clean continental aerosol**
- **Polluted dust**
- **Biomass-burning smoke**

- **Ice clouds**
- **Water clouds**
- **Mixed-phase clouds**

+ dependence on source region
+ mixtures of different types
+ processing/aging during transport
+ humidity

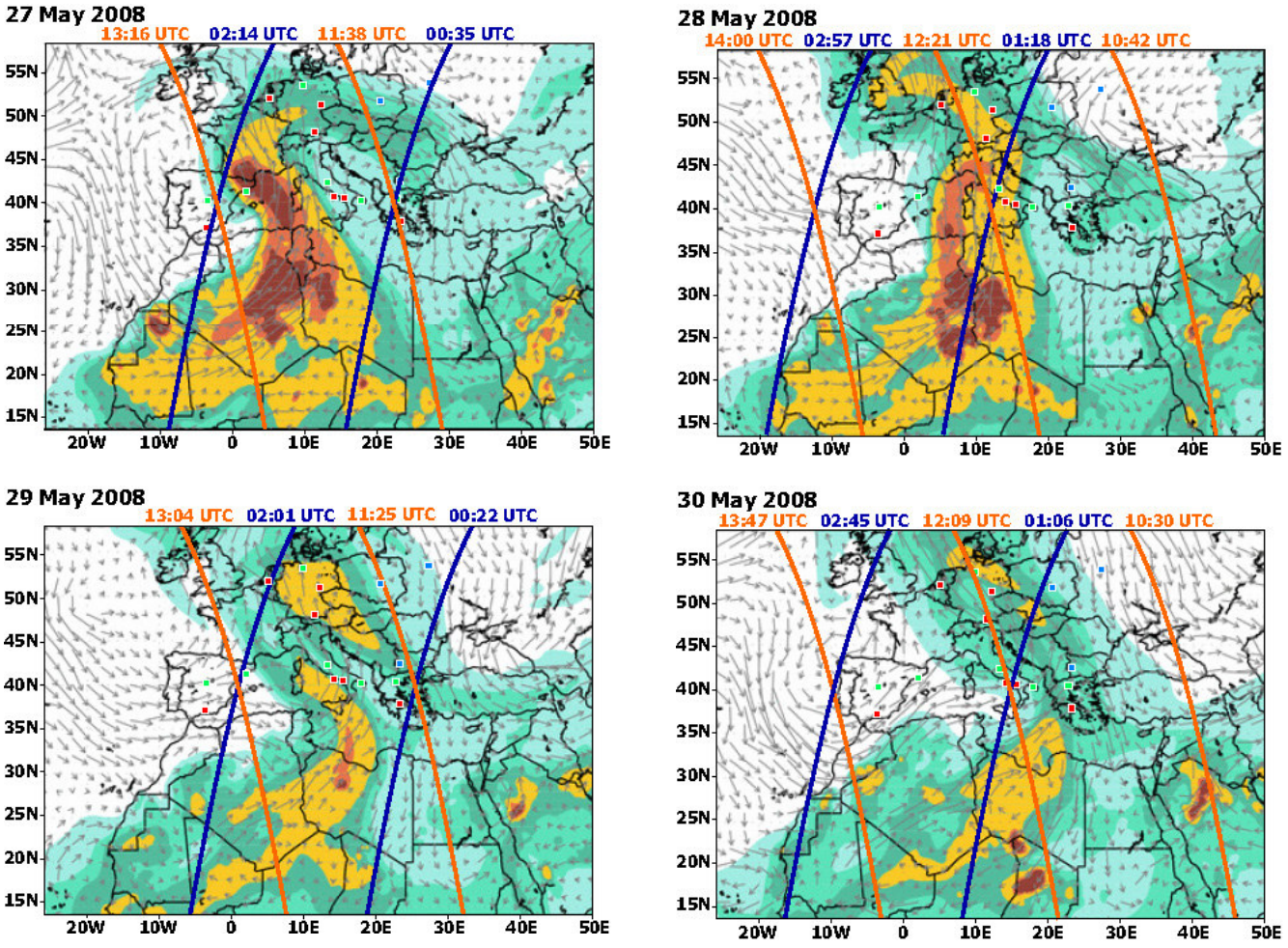
→ representativeness study

→ results stored in a long-term database for further use and extension during

→ can be continued during future missions

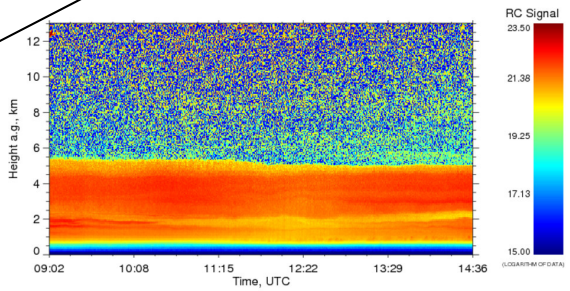
Case study: Saharan dust outbreak, 27-30 May 2009

DREAM Forecast and CALIPSO overpasses

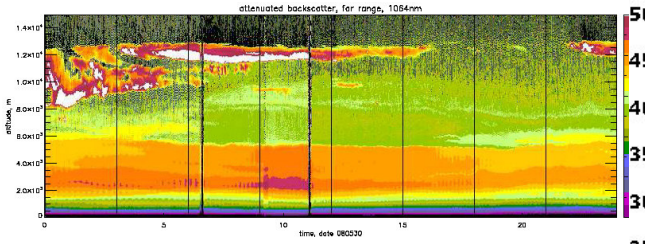


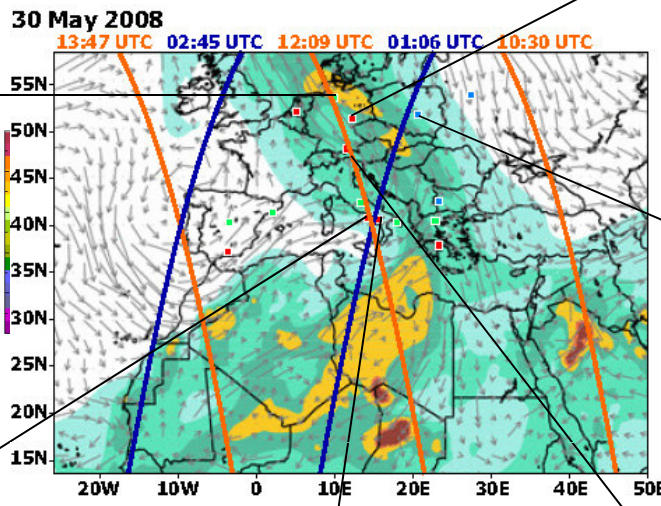
30 May 2008

Leipzig

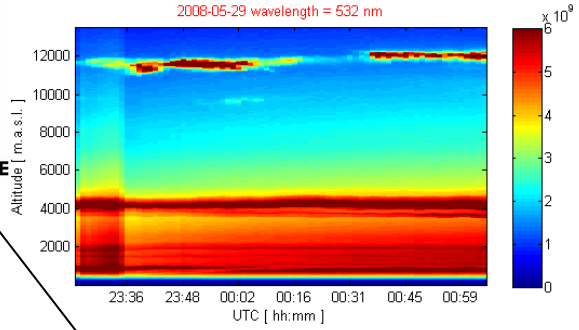


Hamburg

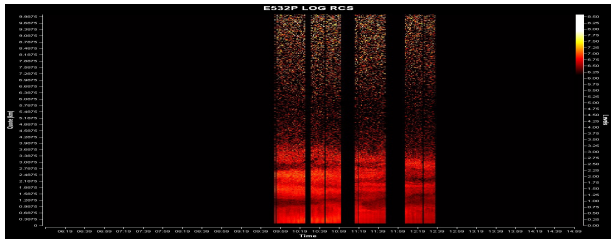




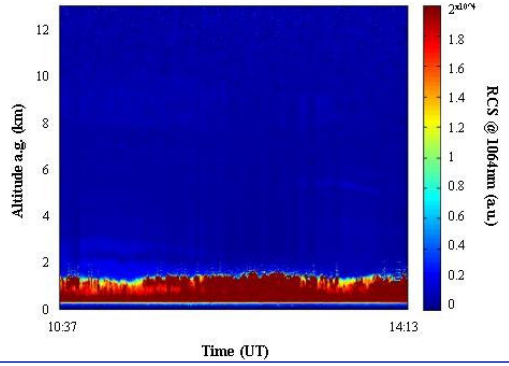
Belsk



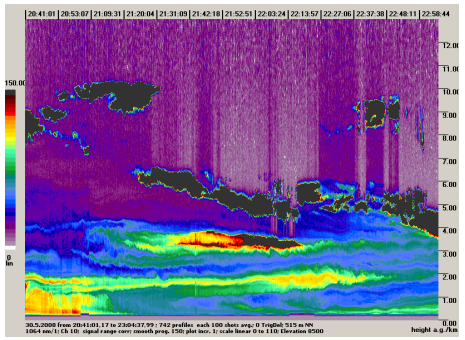
Naples



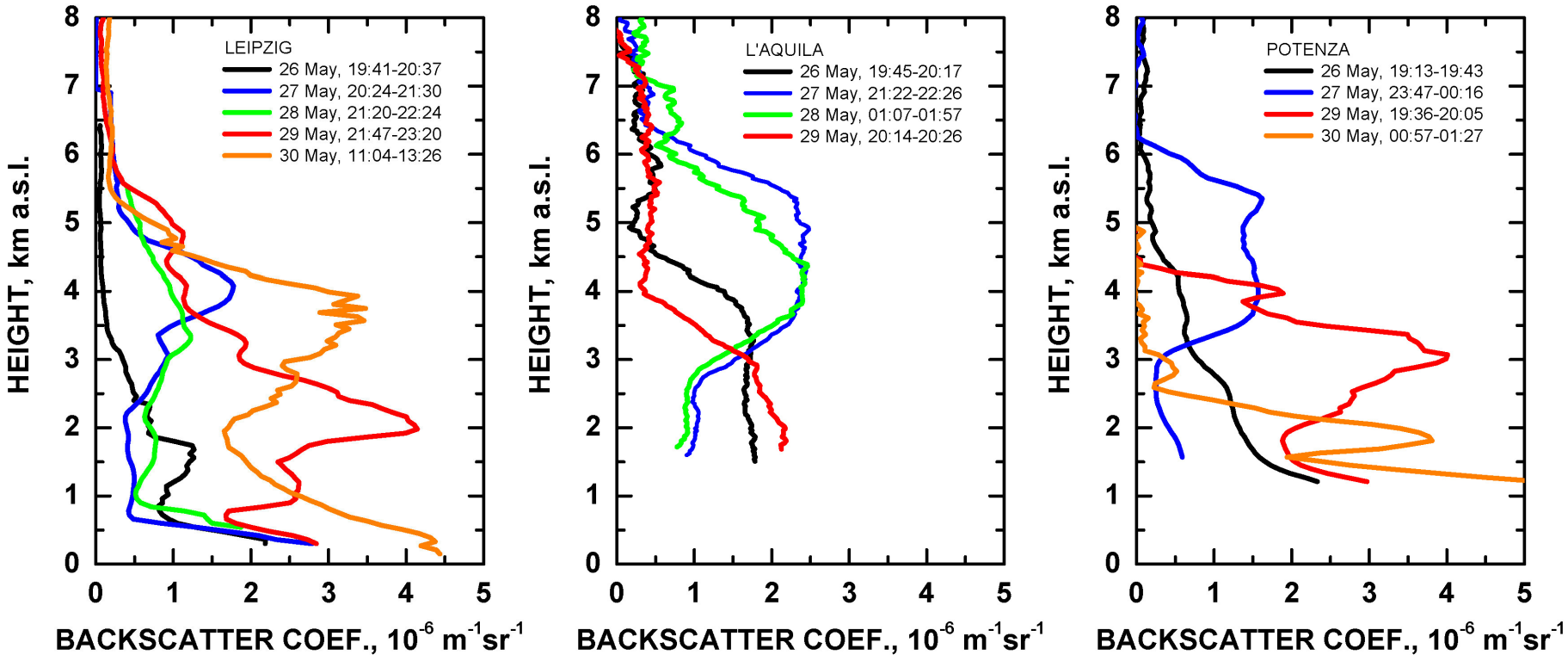
Potenza



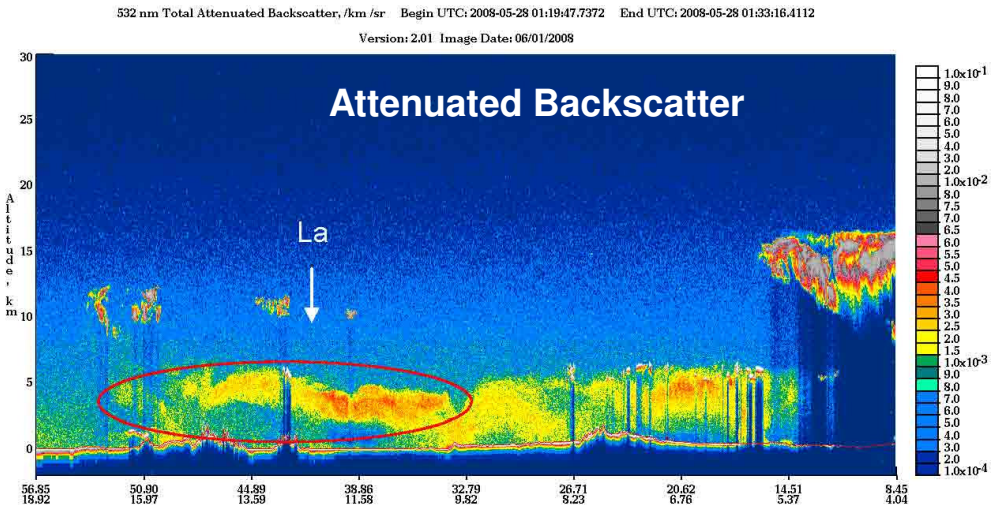
Munich

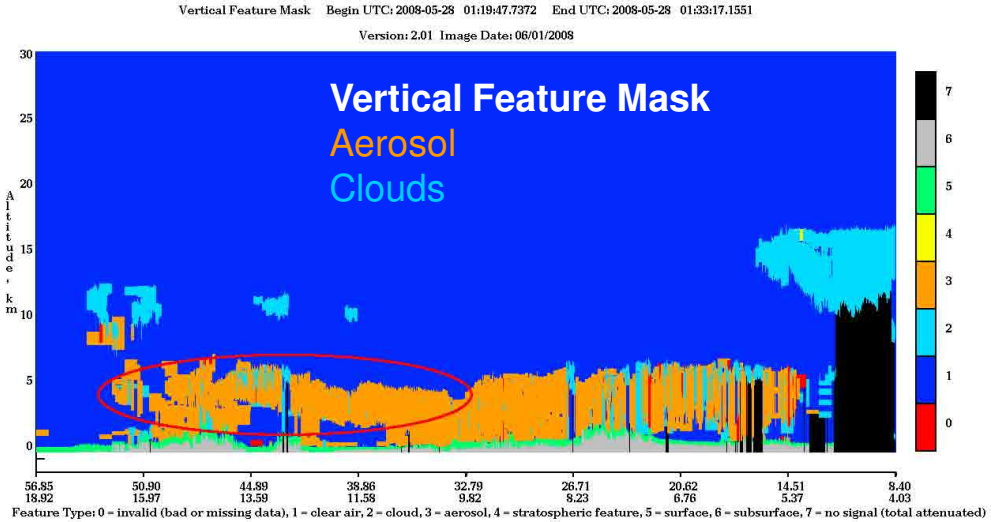


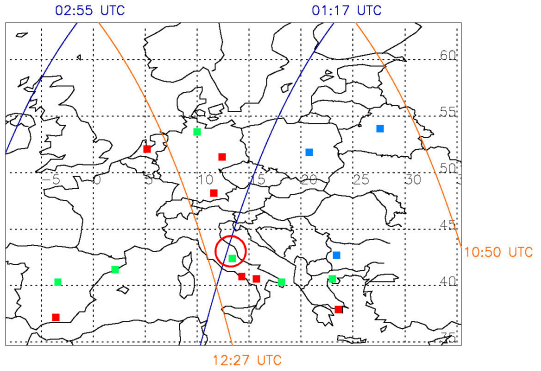
North-south and day-to-day variability of the dust load in terms of backscatter coefficient

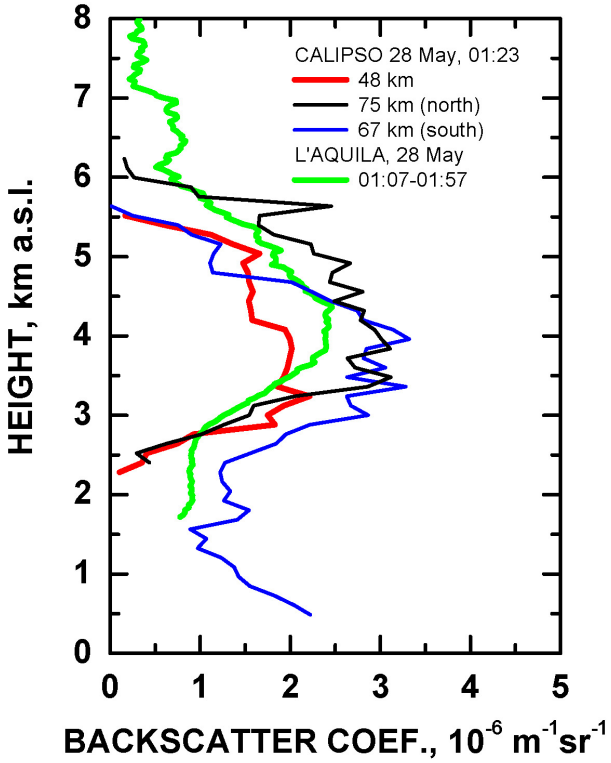


L2 product comparison: 28 May, night

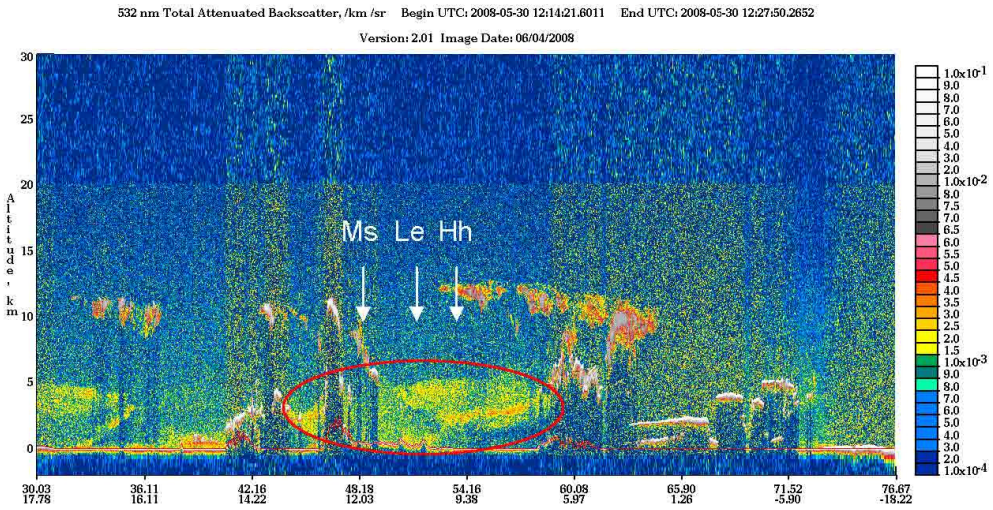


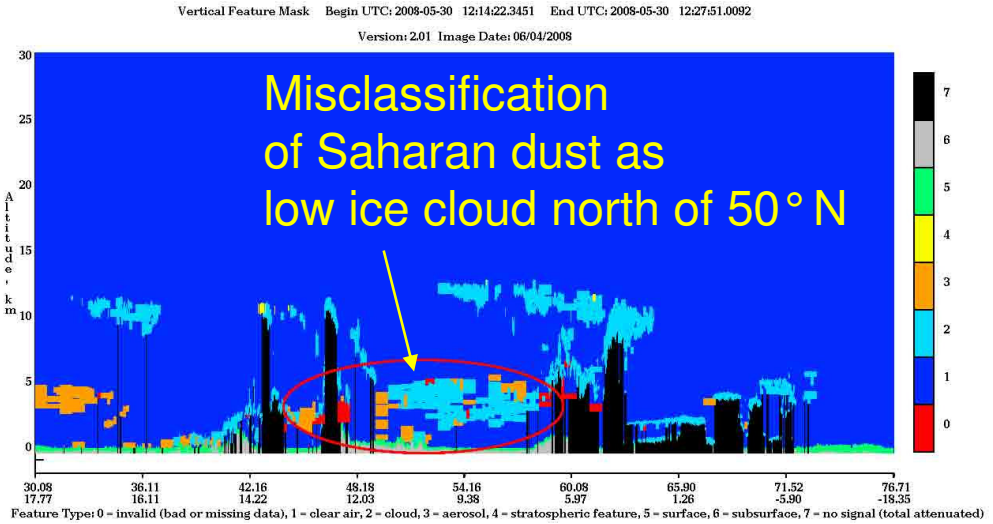


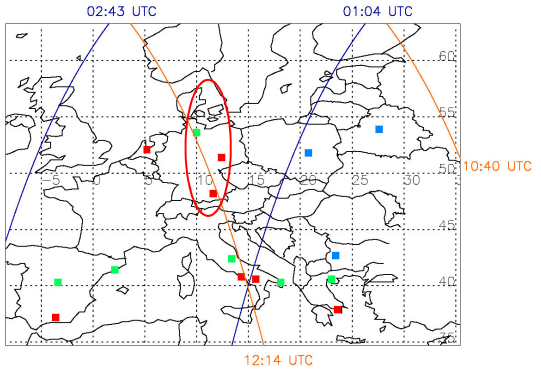


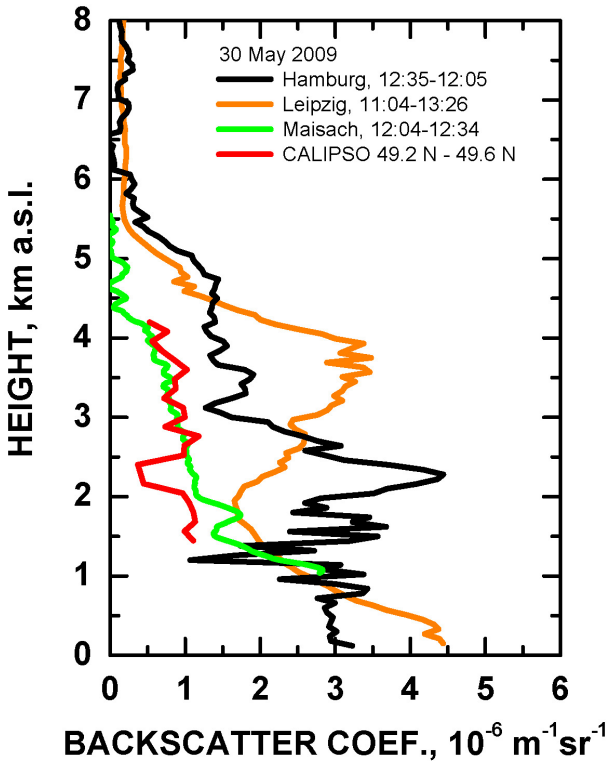


L2 product comparison: 30 May, day

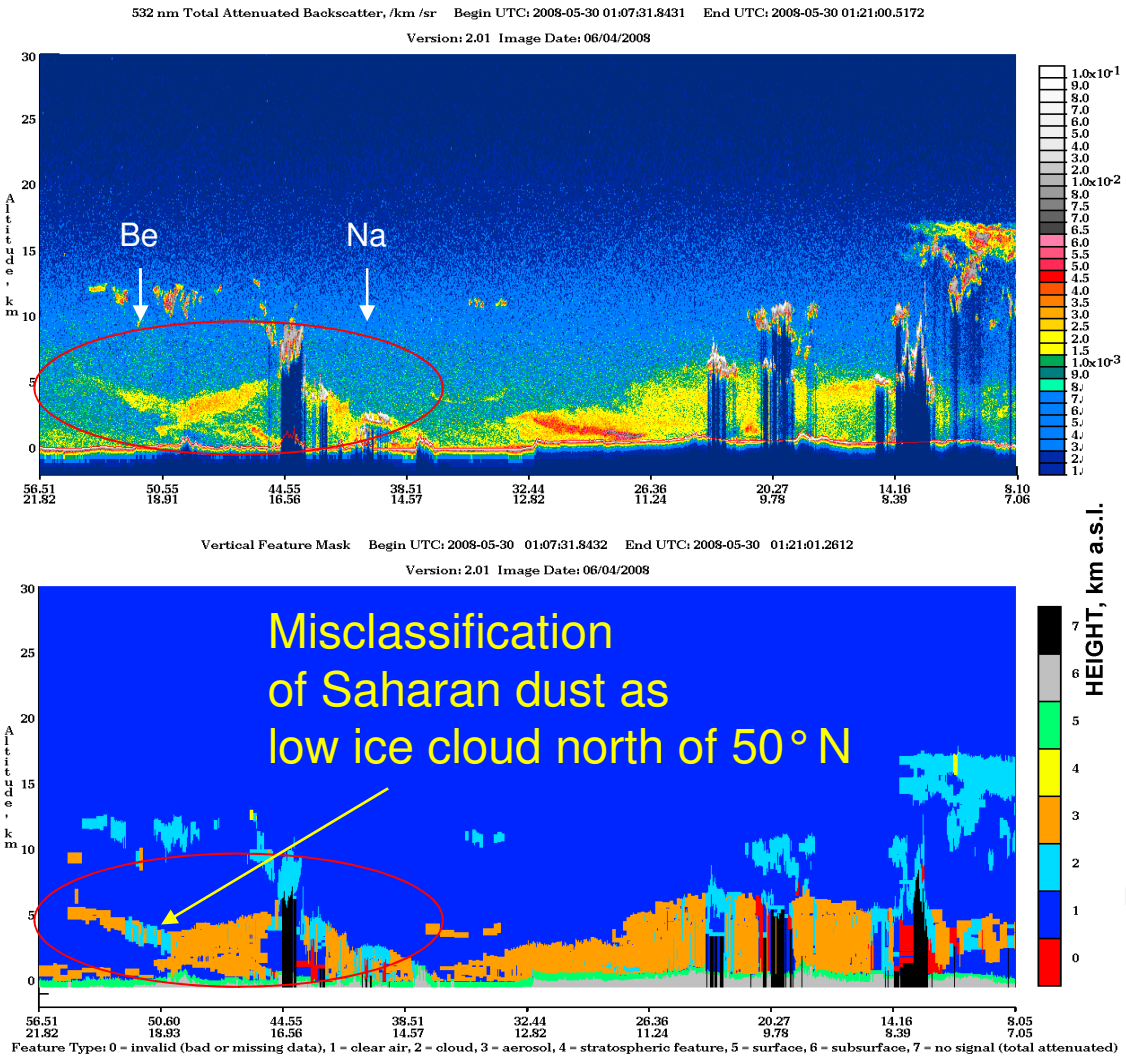


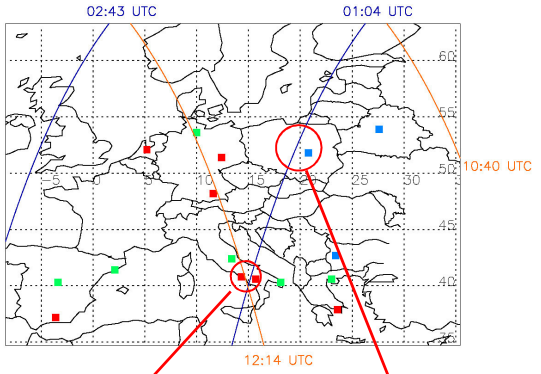


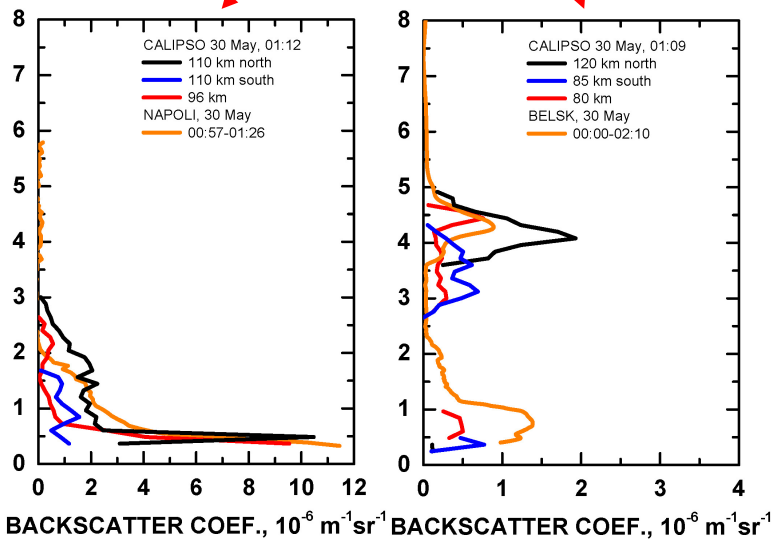




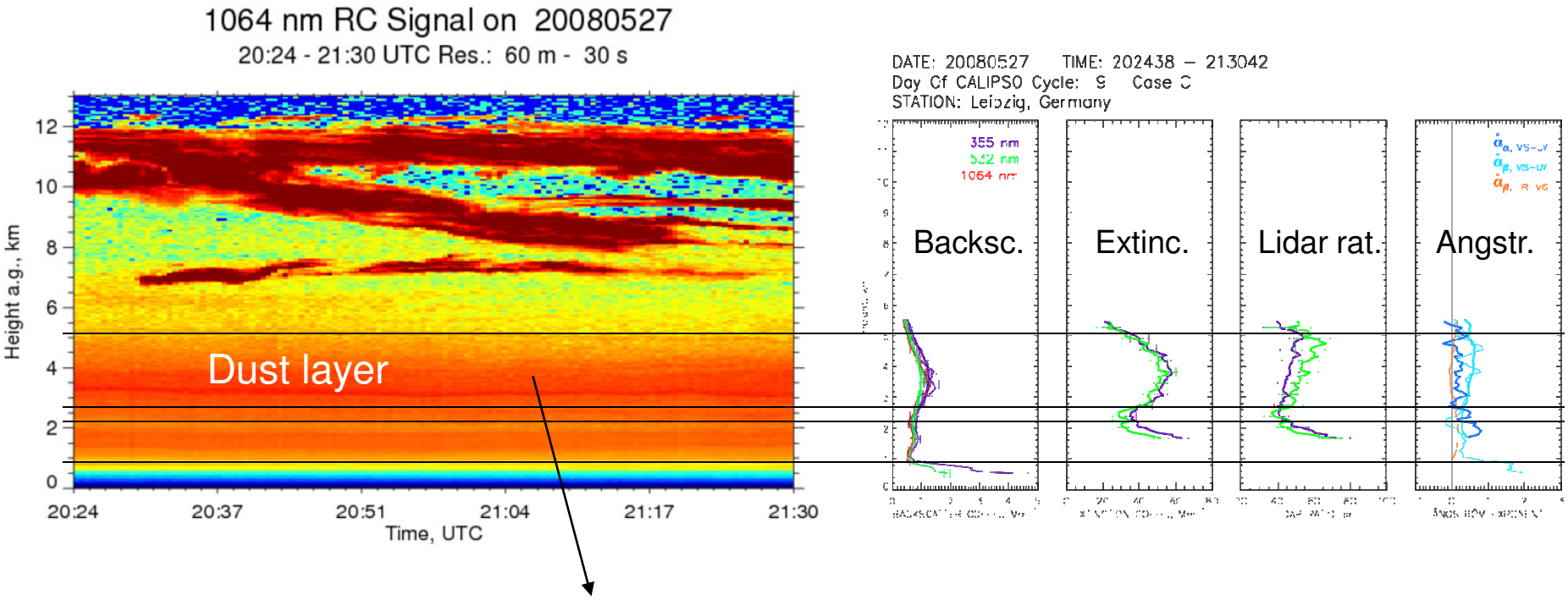
L2 product comparison: 30 May, night







Optical data products: Leipzig, 27 May 2008

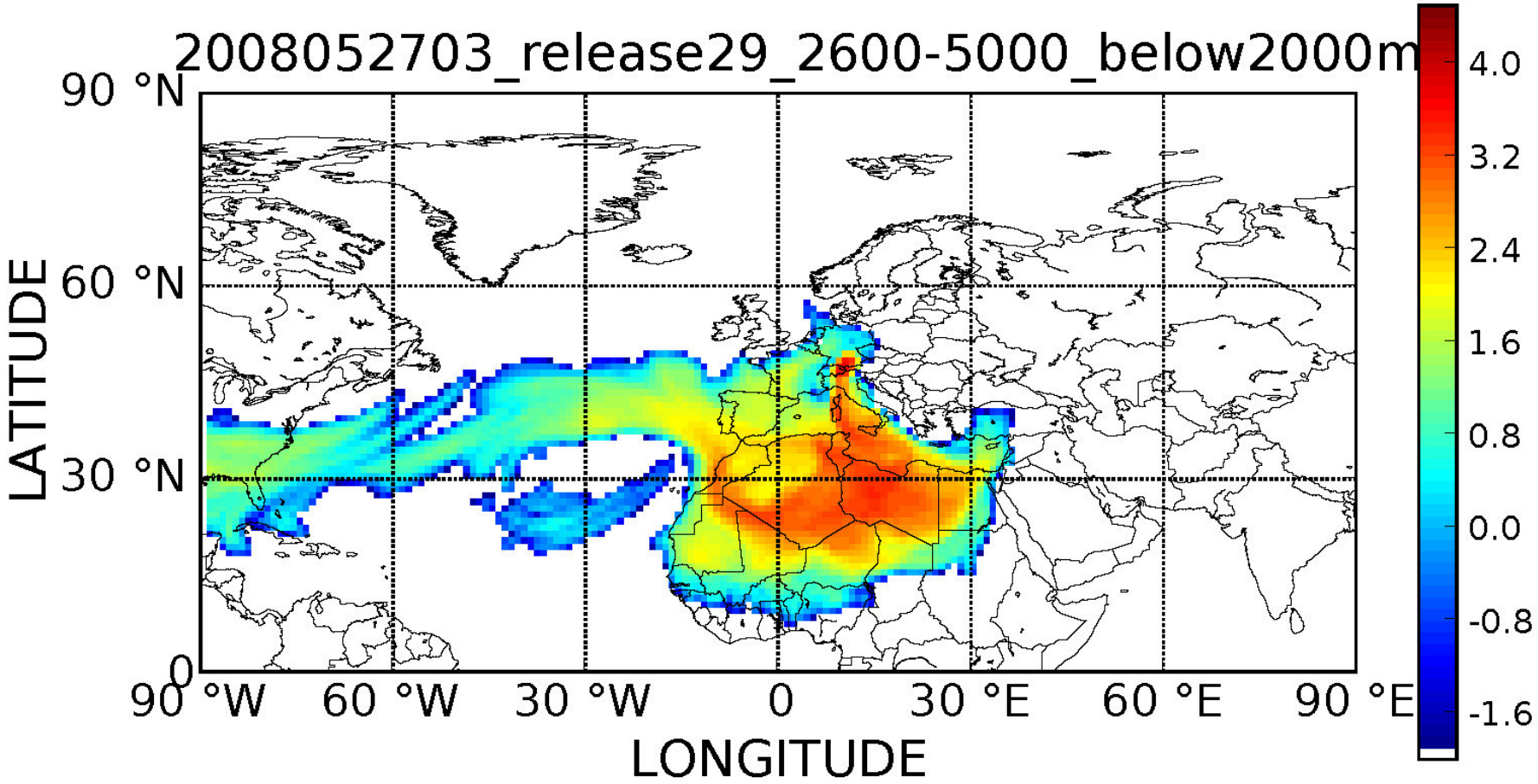


Layer-mean values

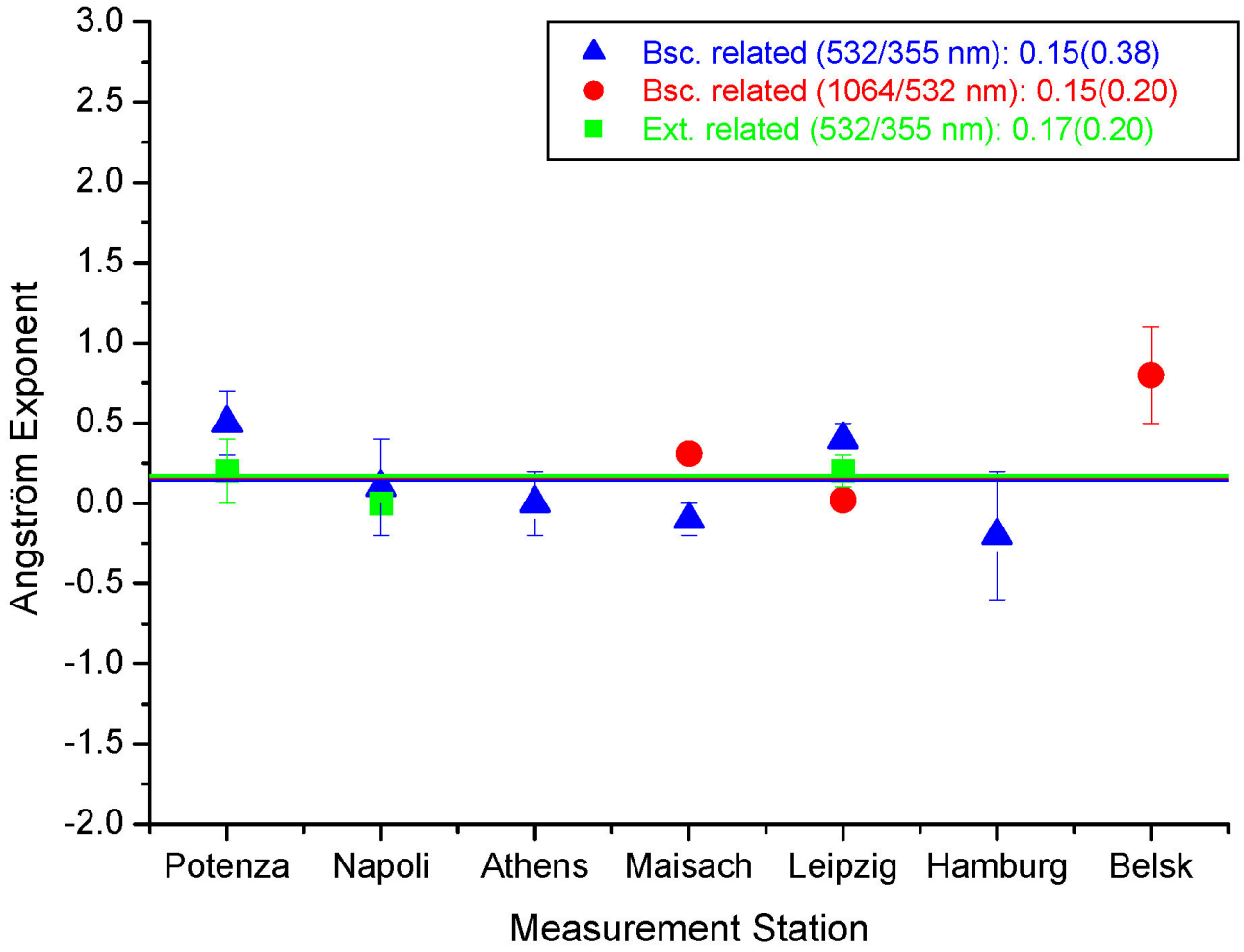
Backsc.	Extinc.	Lidar rat.	Angstr.
0.9±0.2	47±5	54±6	0.09±0.01
0.9±0.2	50±6	46±3	0.40±0.07
1.1±0.3			0.30±0.10

⇨ Statistics from 44 layers at 8 stations

Classification of aerosol with respect to source region: FLEXPART aerosol transport simulation (10 days backward)



Saharan dust – Angström exponents

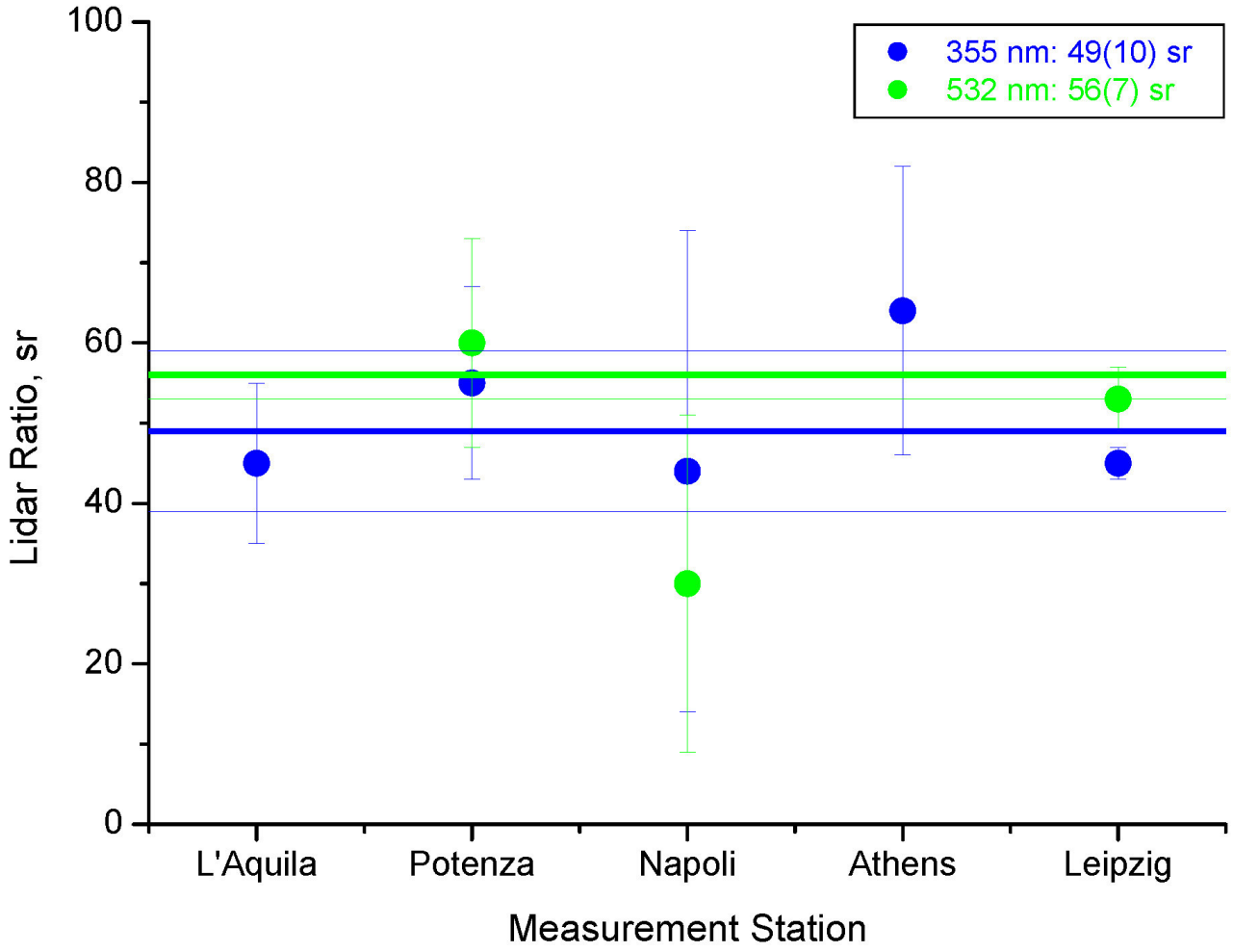


0.17 ± 0.20

0.15 ± 0.38

0.15 ± 0.20

Saharan dust – Lidar ratios



56 ± 7 sr

49 ± 10 sr

CALIPSO aerosol types and input lidar ratios

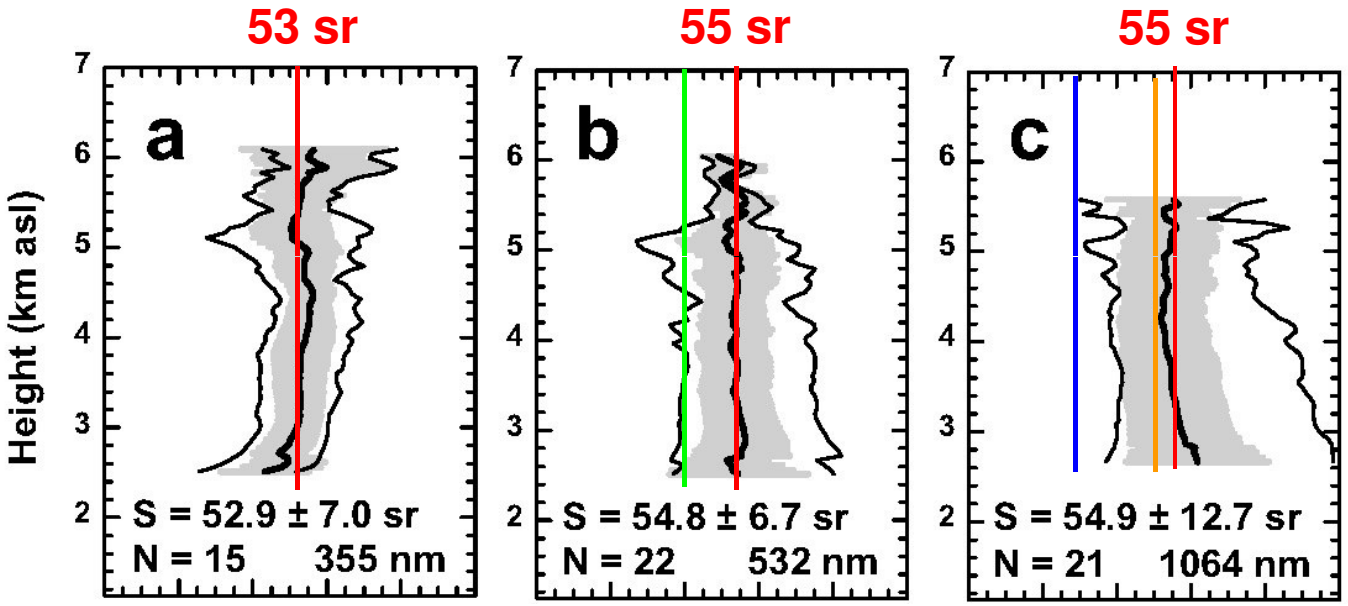
	532 nm	1064 nm
1 clean marine	20 sr	45 sr
2 dust	40 sr	~~30 sr~~ → 50 sr (Version 3)
3 polluted continental	70 sr	30 sr
4 clean continental	35 sr	30 sr
5 polluted dust	65 sr	30 sr
6 smoke	70 sr	40 sr

Based on Sun photometer observations and aerosol models
(size distribution and refractive index)

For dust a spheroid particle model is used to calculate scattering properties
(Mie scattering for the other types)

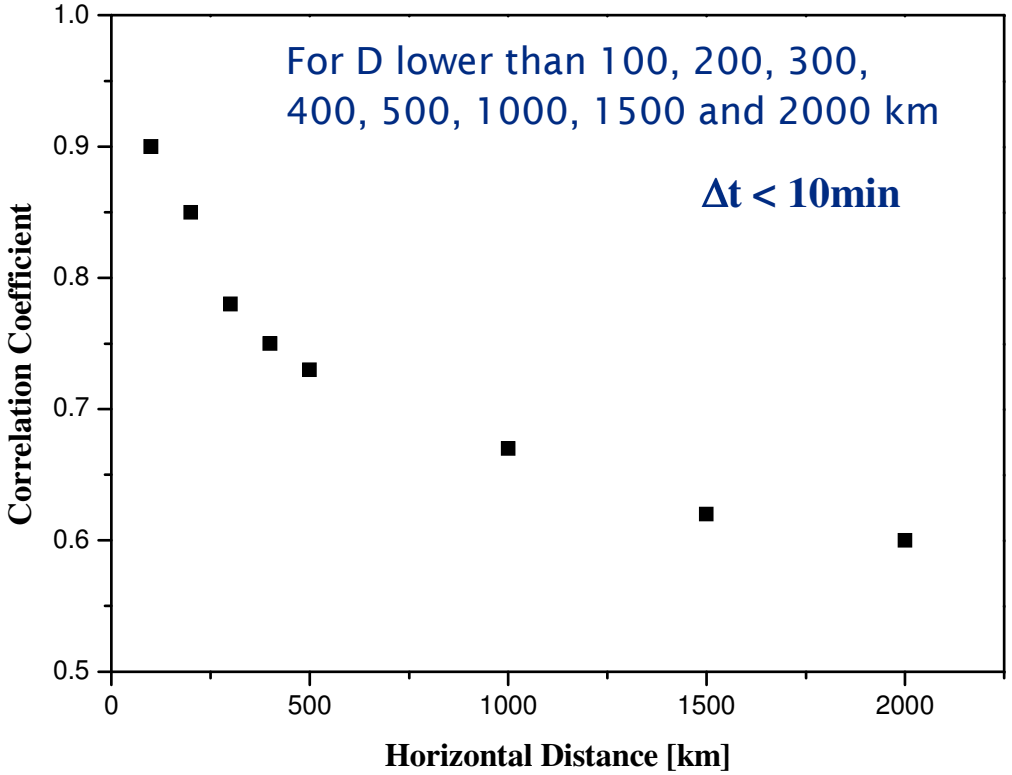
Lidar ratios of Saharan dust

measured in the source region at Ouarzazate, Morocco, 2006 during SAMUM-1



CALIPSO estimate: **40 sr** (V2 and V3) **30 sr** → **50 sr** V2 V3

Representativeness study



Comparisons within 10 minutes and different horizontal distances

Relational Database

on remote database server

PostgreSQL + pgAdmin III
(open source, platform independent)

Database tables

Basic definitions	EARLINET measurements	EARLINET-CALIPSO comparisons
• *EARLINET stations* • *Feature types* • *Feature properties* • *Optical data types* • *Source regions*	• *EARLINET measurements* • *EARLINET profiles* • *EARLINET features* • *Conversion factors*	• *CALIPSO data* • *EARLINET-CALIPSO feature comparisons* • *EARLINET-CALIPSO profile comparisons*

Conclusion and outlook

- **EARLINET is establishing a long-term database from correlative observations of ground-based instruments with CALIPSO.**
- **The database provides:**
  - **profiles of aerosol and cloud parameters at multiple wavelengths**
  - **layer-integrated optical properties per aerosol and cloud type**
  - **conversion factors to relate different space-borne missions**
  - **CALIPSO-EARLINET difference profiles and difference layer properties**
- **For the moment an 18-months observational period is foreseen, but this can be extended (continued during future missions).**
- **There is a strong need for such observations in other regions of the globe. GALION can contribute here in the future.**

→ Harmonization/validation of space-borne data sets of the next decade(s)