Consiglio Nazionale delle Ricerche

CIAO activities for satellite validation and model evaluation using ground based measurements

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Why useful for satellite validation & model evalutaion

- multi-instruments measurements for several atmospheric parameters
- long-term observations
- CALIPSO dataset archive available
- high quality data garantueed by the involvment in International networks
- CIAO reference lidar system for aerosol measurements

Why useful for satellite validation & model evalutaion

At network level:

- ❑ coordination of computation and distribution of CALIPSO overpasses
- ❑ Coordination of special event alerts for EARLINET
- ❑ quality check of the network data
- ❑ SCC developed at CNRIMAA
- ❑ EARLINET database is going to be host at CNRIMAA

The main content

Satellite validation activities

Models evaluation activities

H_2O, T
aerosol
clouds

- ❑ PAST
- ❑PRESENT
- ❑ FUTURE

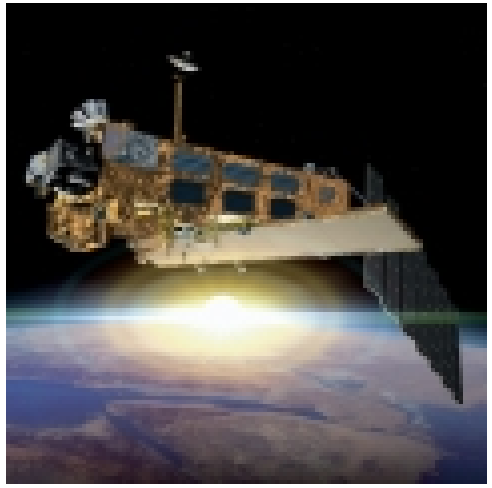
H_2O, T

Satellite validation – PAST

- Mipas sensor aboard ENVISAT
  (Michelson Interferometer for PassiveAtmospheric Sounding),
  vertical profiles of T and H_2O - radiosoundings
  vertical profiles of H_2O - water vapour Raman lidar

  Wetzel et al., ACP, 2013
  Ridolfi et al., ACP, 2007

- GOMOS sensor aboard ENVISAT
  (Global Ozone Measurement by the Occultation of Stars)
  vertical profiles of H_2O - radiosoundings



H_2O, T

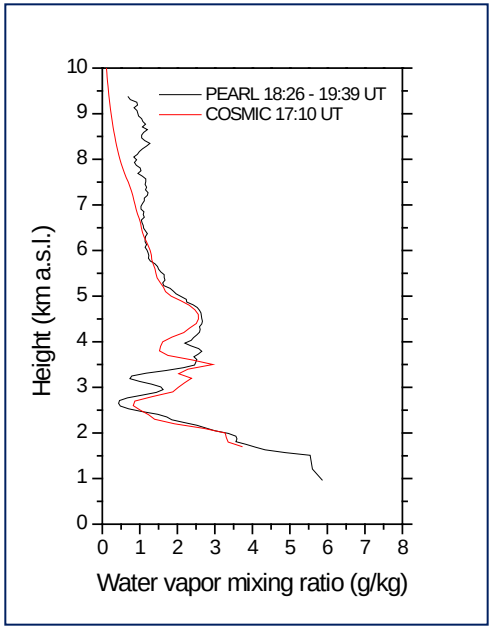
Satellite validation – PAST

- AIRS on Aqua satellite
  (Atmospheric InfraRed Sounde),
  vertical profiles of T and H_2O - radiosoundings
  vertical profiles of H_2O - water vapour Raman lidar

Zhou et al., Q.J.R.Met. Soc, 2007
Taylor et al., BAMS, 2008

Satellite validation – PRESENT

- COSMIC program
  (Constellation Observing System for Meteorology, Ionosphere, and Climate)
  vertical profiles of H_2O – water vapour Raman lidar



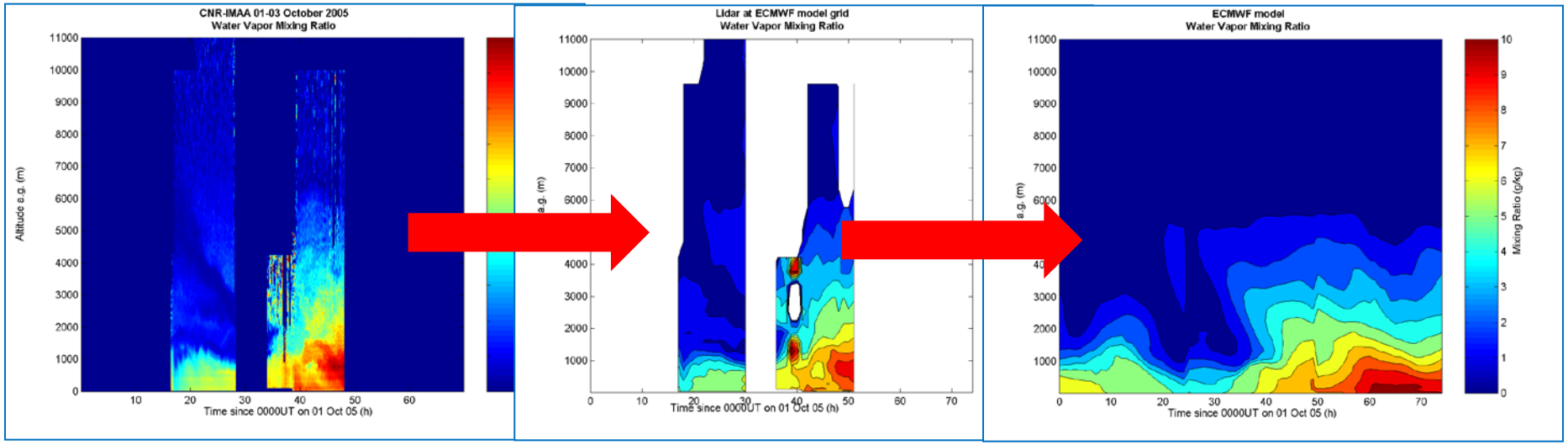
H_2O, T

Model Evaluation – PAST

- Systematic comparison with models available within Cloudnet (DWD, ECMWF, KNMI, MetOffice, MeteoFrance),
  vertical profiles of H_2O - water vapour Raman lidar

Mona et al., AMS, 2007

Obs **Obs to mod resolution** **Mod**

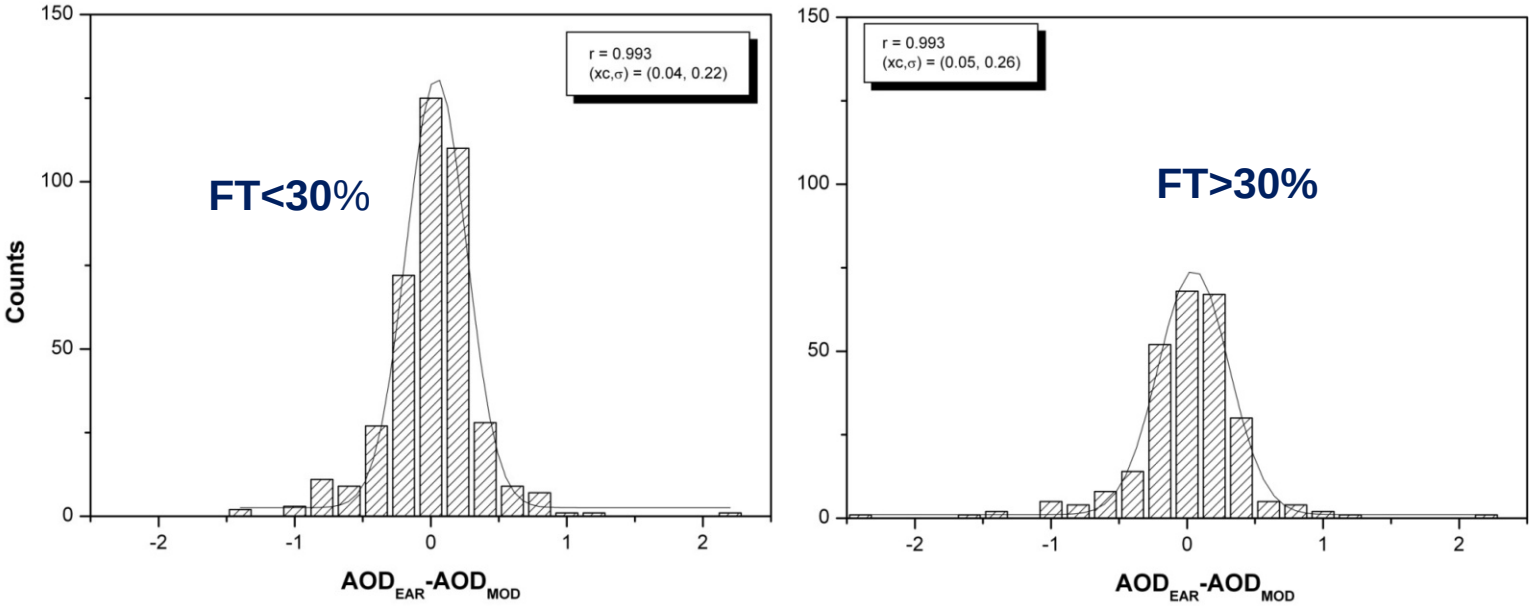


Lidar and models pdf are compared for 0-2 km, 2-4 km, 4-6 km, 6-8 km altitude ranges for the longest record of data for each month.

Aerosol

Satellite Validation – PAST

- MODIS collection 5 daily AOD @ 550 nm
  - Integrated profiles of extinction profiles by EARLINET Raman lidars
  - MODIS 1° × 1° centered on EARLINET sites
  - data acquired on same day (MODIS daytime, EARLINET nighttime)



- No bias is evident: differences well fitted by Gaussian distribution centered at 0.04 ±0.2.
- Distribution for cases with high free troposphere (**FT**) contribution more spread

Aerosol

Satellite Validation – PAST

- **CALIPSO related efforts**
  EARLINET Raman lidars

EARLINET started correlative measurements for CALIPSO on 14 June 2006, i.e. at the beginning of the CALIPSO operation.

A strategy for correlative measurements has been defined on the base of the analysis of the ground-track data provided by NASA.

The majority of EARLINET stations contributed on a voluntary basis to this measurement program in the first two years of the mission.

A dedicated ESA activity supports correlative EARLINET-CALIPSO observations at 16 selected EARLINET stations since April 1, 2008.

Aerosol

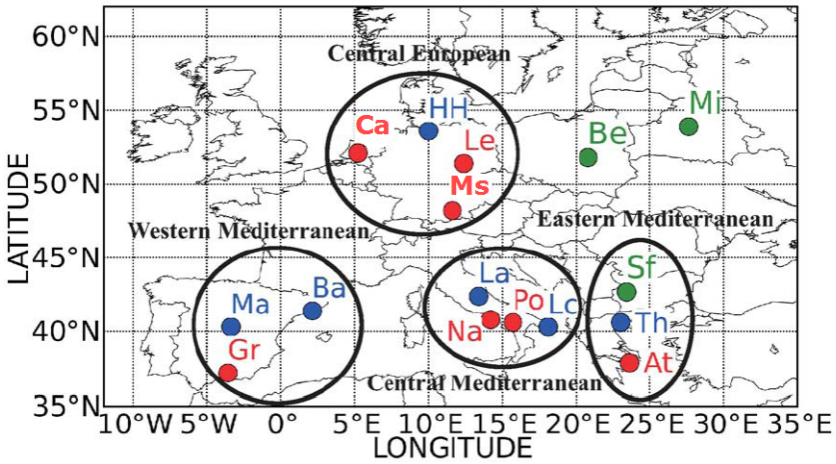
Satellite Validation – PAST

EARLINET correlative measurements are performed:

- by a single station for CALIPSO overpasses within 100 km (Case A measurements)

- simultaneously at more stations of the same cluster (Case B measurements)

- simultaneously at large scales by stations of different clusters during interesting additional cases like Saharan dust intrusions and forest fires (Case C measurements).



Aerosol

Satellite Validation – PAST

Level 1 data comparisons

Methodology developed for retrieving CALIPSO-like Level1 data from ground-based elastic/Raman technique

Mona et al., ACP , 2009

Systematic comparison demonstrates the absence of biases and main problems in CALIPSO detected signals

Pappalardo et al., JGR, 2010

Level 2 data comparisons

CALIPSO Level 2 data generally perform well for intense layers presence both in terms of optical profiles and layer identification.

Some critical points:
- cloud-aerosol discrimination
- lidar ratio assumptions
- multiple scattering for aerosol below cirrus and large dust particles

Pappalardo et al., JGR, 2010

Aerosol

Satellite Validation – PRESENT

Level 3 data comparisons

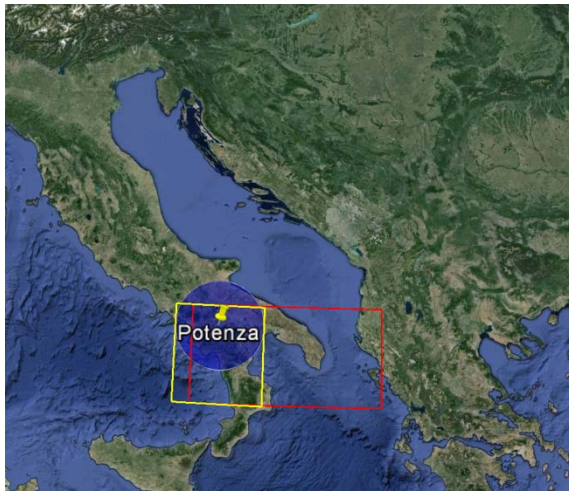
CALIPSO Lev3 monthly mean profiles of aerosol extinction at 2°x5° grid

EARLINET monthly averages evaluated considering only measurements performed in coincidence with CALIPSO overpass (within 100km)

Comparison not trivial for spatio-temporal consideration

Reproducing Level 3 statistics – Level 3*

- some data screening applied for Lev3
- 1°x1° grid
- only Lev2 data corresponding to available EARLINET coincident measurements



Papagiannopoulos PhD thesis, 2014

Aerosol

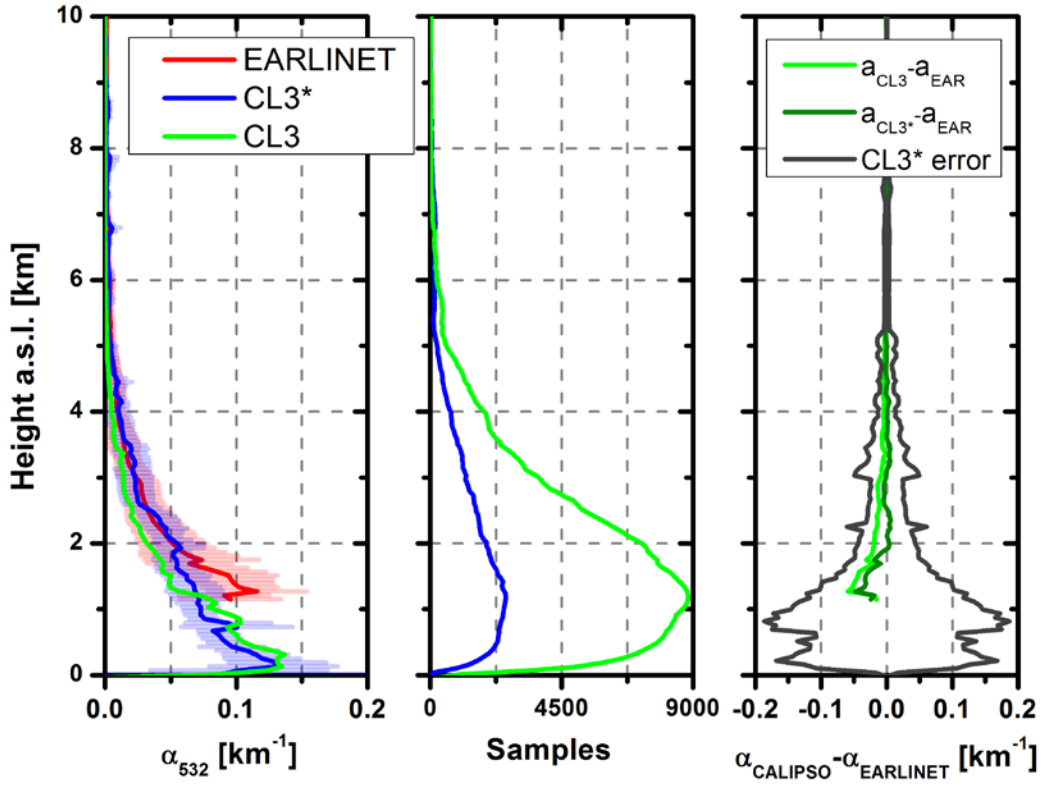
Satellite Validation – PRESENT

Level 3 data comparisons

Comparison performed in terms of:

- aerosol extinction profiles
- aerosol backscatter profiles
- aerosol typing
- lidar ratio value

Aerosol



Level 3

272 overpasses

Level 3*

96 overpasses

EARLINET

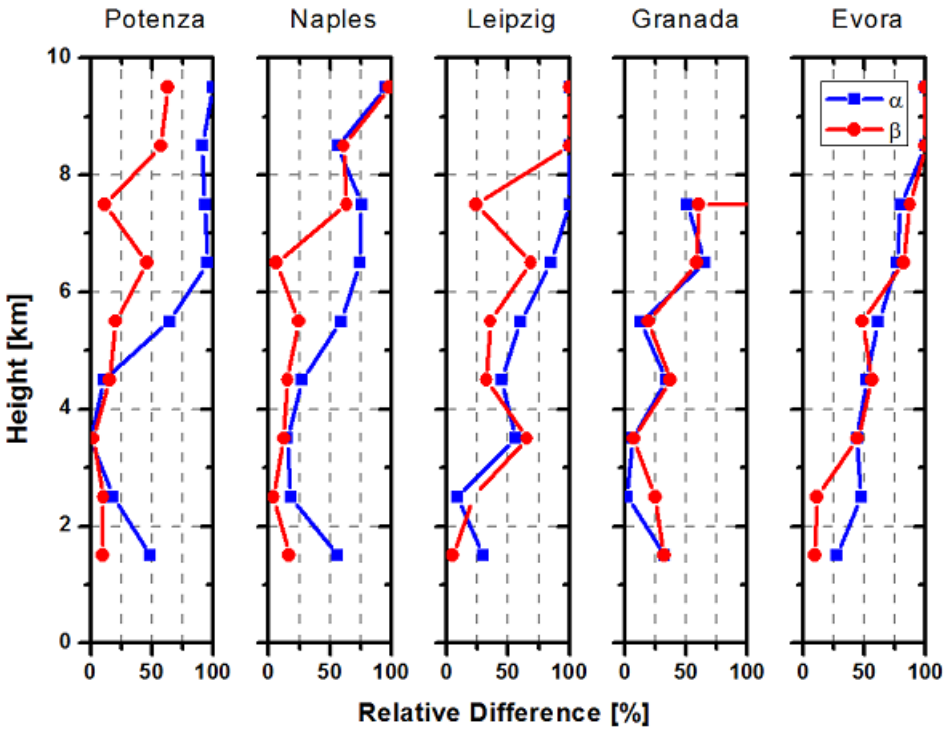
96 observations

- The Level 3* comparison improved in height range 1 – 4 km, and almost any discrepancy diminished in the range 2 – 4 km.
- Negative bias!!!

Papagiannopoulos PhD thesis, 2014

Aerosol

Satellite Validation – PRESENT



- The backscatter comparison showed improvement

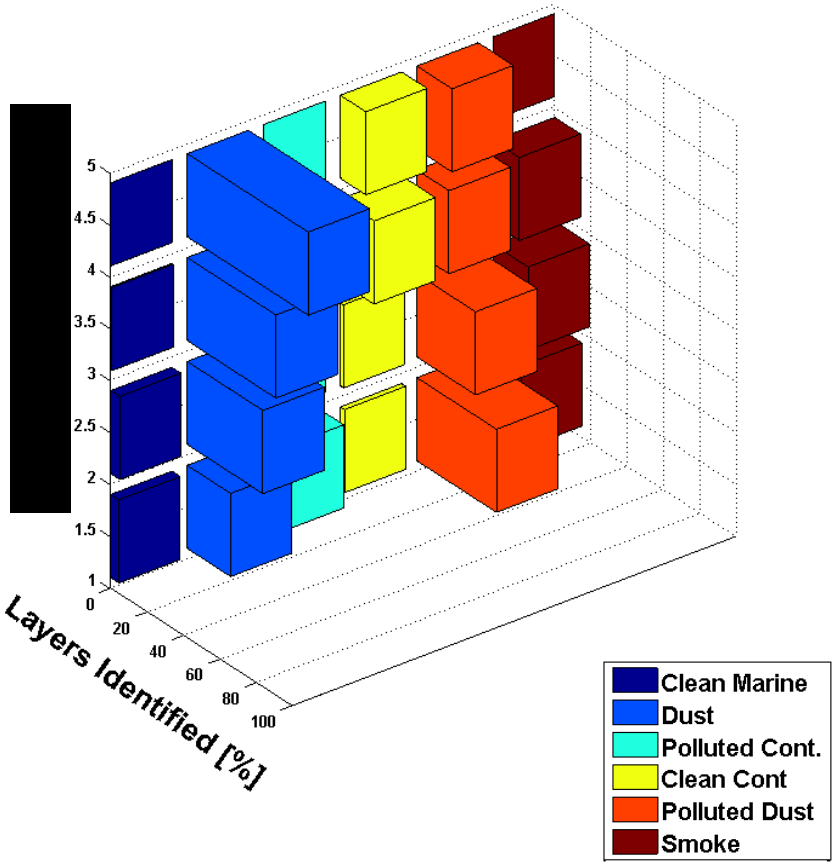
- Backscatter could be included in the product, less affected by the ldiar ratio (S) assumptions

Papagiannopoulos PhD thesis, 2014

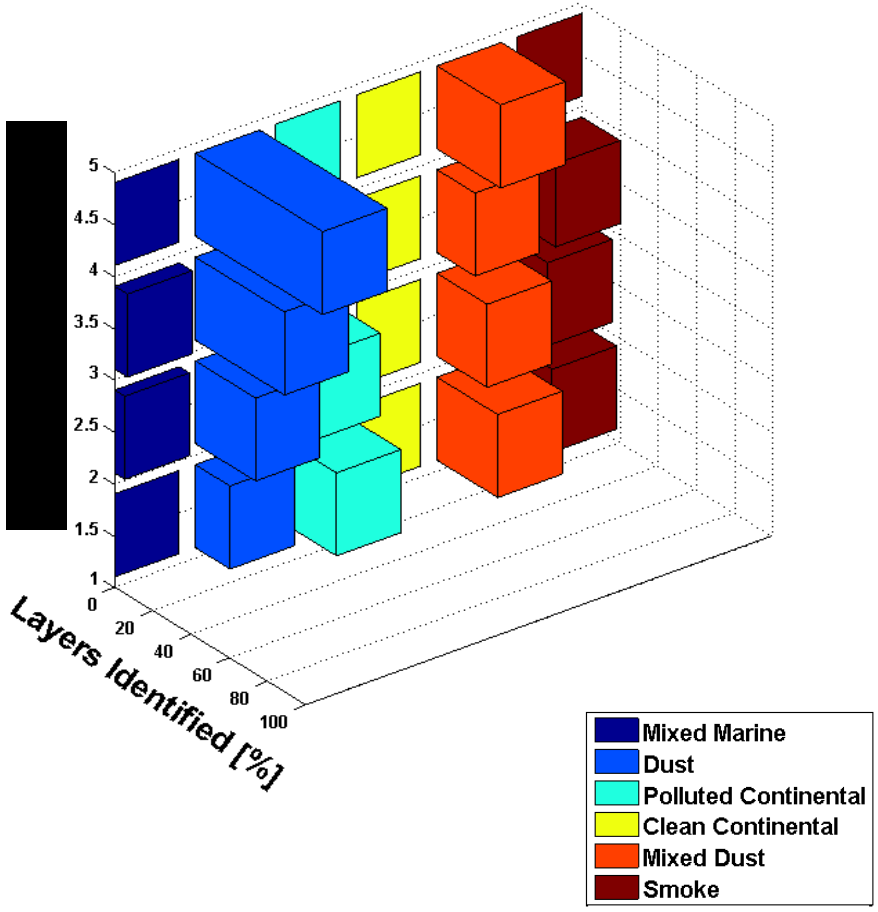
Aerosol

Satellite Validation – PRESENT

CALIPSO



EARLINET



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Aerosol

Satellite Validation – PRESENT

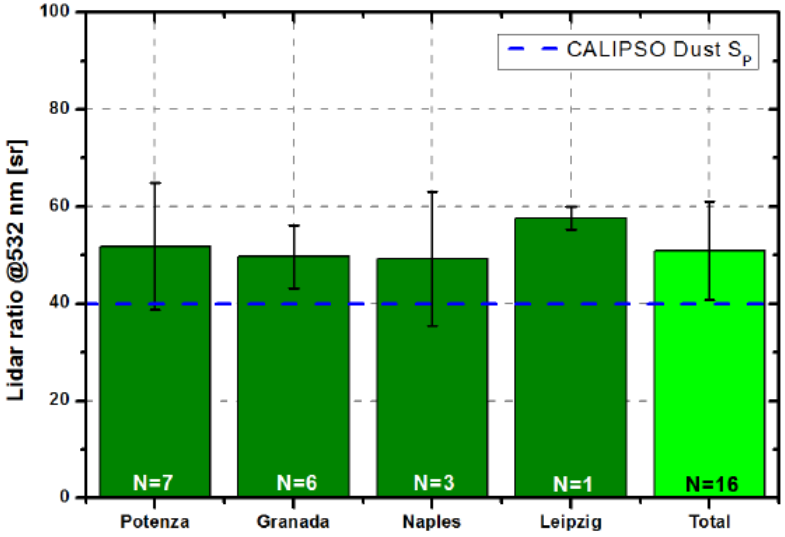
Summary of aerosol typing comparison

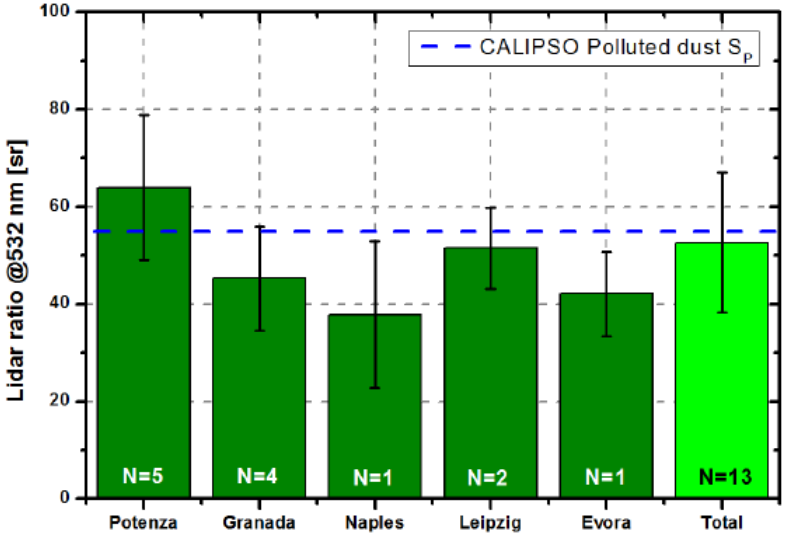
- D and PD components well captured, even if CALIPSO tends to overuse the aerosol type close to the surface
- S well captured
- CC and PC poor agreement
- CM is not observed over continental grids
- No PC over marine locations

Aerosol

Lidar Ratio (S) type-by-type comparison

- CALIPSO value for D lower than EARLINET measurements
- PD too high over Mediterranean sites for the influence of marine particles.





- Even if based on a low number of EARLINET measurements, the CC subtype reveals higher value than assumed one.

Papagiannopoulos PhD thesis, 2014

Aerosol

Adjusting the lidar ratio

- A first estimation of the impact inserting mean observed values for D, PD and CC (51sr, 47sr, 45 sr)

CALIPSO cell	CC [45 sr]	Dust [51 sr]	PD [47 sr]	Combined [45+51+47 sr]
Potenza	0.51%	5.75%	-6.46%	0.04%
Naples	0.33%	7.97%	-5.30%	3.12%
Leipzig	0.98%	1.99%	-	2.90%
Granada	0.14%	8.47%	-7.85%	1.20%
Evora	0.88%	2.26%	-5.97%	-2.80%
Total	0.62%	5%	-6.39%	0.21%

Latitudinal-, seasonal-, source-based Dust Lidar Ratio should be coupled in the CALIOP retrieval scheme.

Aerosol

Models evaluation

- Transport model evaluation for case studies e.g. the Etna 2002 volcanic eruption

Villani et al., JGR, 2006

- First example of assimilation of NRT aerosol lidar data from 72h exercise based on the SCC use

Polair3D chemistry transport model (CTM) ***Wang et al., ACP 2014***

- Comparison of ACTRIS Summer 2012 campaign extinction profiles with EMEP/MSC-W model

Tsyro et al, DUST2014 conf , 2014

Aerosol

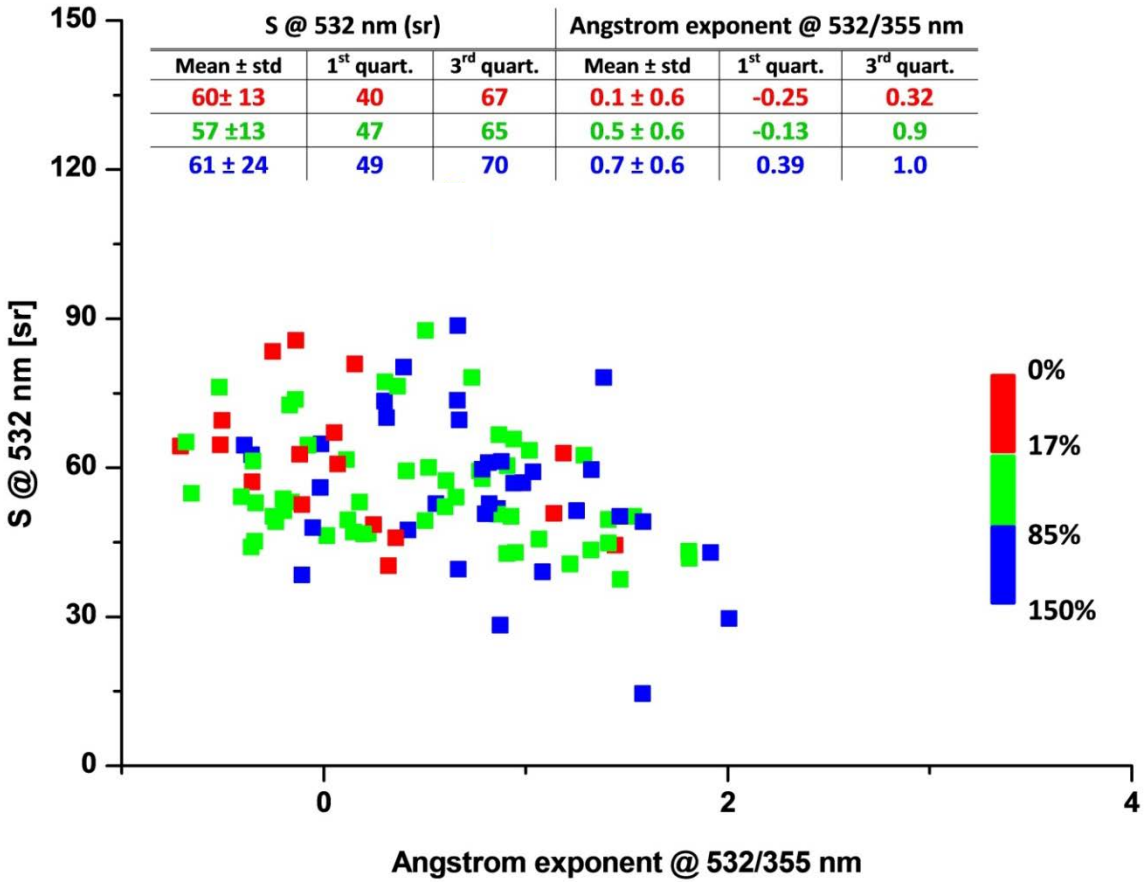
12-year-long systematic comparison EARLINET Potenza data vs BSC-DREAM8b

- Geometrical features of dust layer are well described by the model in terms of center of mass.
- Good correlation between profiles for cases with AOD layer >0.1

The level of agreement decreases with increasing of mixing/modification processes.

Mona et al., ACP, 2014

S @ 532 nm (sr)			Angstrom exponent @ 532/355 nm		
Mean ± std	1st quart.	3rd quart.	Mean ± std	1st quart.	3rd quart.
60± 13	40	67	0.1 ± 0.6	-0.25	0.32
57 ±13	47	65	0.5 ± 0.6	-0.13	0.9
61 ± 24	49	70	0.7 ± 0.6	0.39	1.0



Aerosol

Models evaluation - PRESENT

- SDSWAS model vs 3α+2β+dep profiles at network level
- Systematic comparison of dust profiles with BSC-DREAM8b and SEEVCC models
- Long term comparison of aerosol extinction profiles from the EMEP model and EARLINET

FUTURE PLANS

Approved projects:

Aeolus L2A aerosol and cloud product validation using the European Aerosol Research Lidar Network EARLINET

EC-ACTS: Earlinet and Cloudnet - Aerosol and Clouds Teams for Sentinel-5P Validation

Model evaluation, assimilation and trend studies – JRA3 in ACTRIS2

Further actviities:

EarthCare and Copernicus data validation/evaluation