EARLINET correlative measurements for CALIPSO

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Correlative measurements

EARLINET, the European Aerosol Research Lidar Network, offers a unique opportunity for the validation and full exploitation of the CALIPSO mission because of its geographic coverage and the deployment of advanced Raman aerosol lidars. EARLINET provides long-term, quality-assured aerosol data, which allows us to investigate a large variety of different aerosol situations with respect to layering, aerosol type, mixing state, and properties both in the free troposphere and the local planetary boundary layer.
EARLINET started correlative measurements for CALIPSO since 14 June 2006, at the beginning of the operativity of CALIOP. A strategy for correlative measurements has been defined on the base of the analysis of the ground track data provided by NASA. Based on the experience of the first 18 months of correlative observations, the strategy of correlative measurements has been consolidated in the frame of a dedicated ESA study aiming at a long-term aerosol and cloud data base from ground-based and satellite-borne lidars. Within this study, correlative measurements have been intensified especially taking into account the geographical distribution of participating stations. EARLINET correlative measurements are still in progress.
After about 3 years of correlative observations, more than 6500 hours of correlative measurements have been performed and about 3100 correlative files are available for comparisons.
A number of modelling tools is used for the aerosol type and source identification in addition to the information derived from the multi-wavelength lidar observations.
The first results in terms of comparisons between EARLINET and available CALIPSO products (both level 1 and level 2 data) are presented.

25 lidar stations

- 9 multiwavelength Raman lidar stations 3β (backscatter) + 2α (extinction) + δ (depolarization ratio) (●)
- 9 Raman lidar stations (●)
- 7 single backscatter lidar stations (●)

EARLINET stations operational in the next future

- Israel
- Ireland
- Portugal

Following the measurement strategy established for the ESA-CALIPSO study, horizontal distance between CALIPSO and EARLINET selected stations covers a large interval:
• 0-100 km for Case A (almost 60% of the cases within 50 km)
• 120-750 km for Case B (almost 70% of the cases within 500 km)
• also larger distances for Case C measurements
This allows us to investigate the horizontal variability on different scales, from regional to continental one. The temporal variability of aerosol/clouds fields can be investigated with the 150 minutes lasting records of measurements (centered around the overpass)

The validation strategy foresees the following mandatory measurements:
• Case A measurements – CALIPSO overpass within 100 km
• Case B measurements – more stations of the same cluster perform simultaneous measurements
• Case C measurements – interesting additional cases like Saharan dust intrusions and forest fires

Four clusters have been identified for studying the aerosol/cloud fields on European continent: Central European (hh - Hamburg, ca - Cabauw, le - Leipzig, mu - Munich), Western Mediterranean (ba - Barcellona, ma - Madrid, gr -Granada), Central Mediterranean (la – l'Aquila, na - Napoli, po - Potenza, lc - Lecce) and Eastern Mediterranean (sf - Sofia, th - Thessaloniki, at - Athens). Each one of identified cluster includes at least one multiwavelength Raman lidar station.

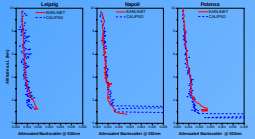
Comparison EARLINET – CALIPSO (lev1)

Comparison with CALIPSO level 1 data: attenuated backscatte

Comparison in terms of CALIPSO Level 1 product is needed for identifying any potential problem and bias contained in the calibrated CALIPSO lidar signals (lev1). Only after a check of the unprocessed CALIPSO data, the comparison in terms of Level 2 products will allow to check and improve CALIPSO retrieval algorithms and assumptions. From simultaneous and independent measurements of aerosol backscatter and extinction profiles measured by EARLINET, it is possible to calculate without any assumptions the CALIPSO-like attenuated backscatter (CLAB) profile at 532 nm, to be compared to CALIPSO Level 1 data [Mona et al., 2009].

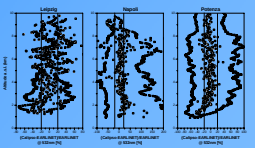
First preliminary results are obtained considering:

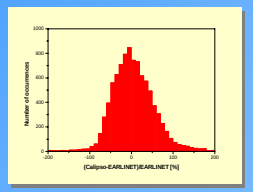
- Independent extinction and backscatter profiles
- Case A measurements
- Night time measurements
- No clouds



On average, the agreement is good demonstrating the good performance of CALIPSO and the absence of evident biases in the CALIPSO raw signals.

Disagreements at low altitudes are observed, because of imperfect spatial coincidence and high variability in the aerosol content at these altitude.





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.

Good agreement with a relative mean difference of 4.6%, a relative standard deviation of 50% and a relative median value of 0.6%.

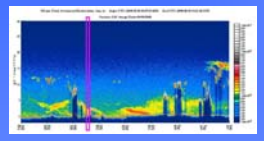
Comparison EARLINET – CALIPSO (lev2)

Comparison with CALIPSO level 2 data: aerosol backscatter and extinction coefficient

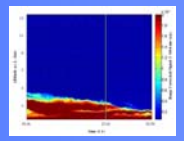
30 May 2008

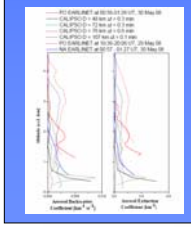
- Case C measurements
- Night time measurements
- Saharan dust

Cross section of the total attenuated backscatter measured by CALIPSO at 532 nm on 30 May 2008. The purple box highlights the overpass at Potenza



Temporal evolution of the lidar range-corrected signal at 1064 nm measured at Potenza on 29-30 May 2008.





Aerosol backscatter (left panel) and extinction (right panel) coefficient at 532 nm measured at Potenza (PO) and Naples (NA) EARLINET stations and obtained from CALIPSO observations at different horizontal distance from Potenza lidar station for the 29-30 May 2008 night-time case.

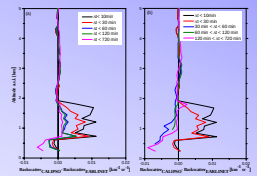
Good agreement for Potenza aerosol backscattering measurements on 29 May (107 km distance).

No similar agreement for the aerosol extinction measurements probably due to CALIPSO assumptions on lidar ratio.

Representativeness study

Comparisons within 100 km and different time shifts

All differences profiles related to space-borne vs ground-based lidar horizontal distance below 100 km (Case A measurements) are selected and classified in classes on the basis of the time shift (dt) between the 2 observations.

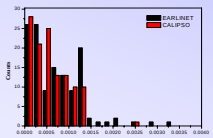


Count distributions of EARLINET and CALIPSO measured values of aerosol backscatter coefficient at 532 nm for space-borne vs ground-based lidar horizontal distances lower than 100 km and 10 minutes for maximum time shift between the two observations

Mean Values
CALIPSO = 0.004 km $^{-1}$sr^{1}
EARLINET = 0.0008 km $^{-1}$sr^{1}

Median Values
CALIPSO = 0.0005 km $^{-1}$sr^{1}
EARLINET = 0.0006 km $^{-1}$sr^{1}

Correlation Coefficient = 0.9

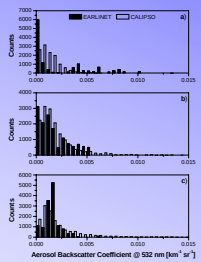


For time shifts larger than 30 minutes the two observations are not correlated. This implies that on a spatial scale of 100 km the aerosol time variability for this event is of the order of 30 minutes

The observational period of ***26-31 May 2008*** has been chosen for a first correlation analysis for both single and multiple point observations as a period with a large number of performed measurements.

In fact, during these days 15 Case A, 7 additional Case B measurements and 56 additional Case C measurements were performed because of the Saharan dust alert distributed to the EARLINET station At the moment, ***420*** **EARLINET files** are on the database for this period

Comparisons with different time and space distances



Count distribution of aerosol backscatter measured by CALIPSO and EARLINET within 12 hours and 2000 km are studied for different altitudes

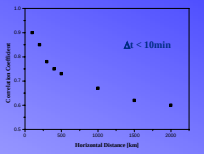
• 0-1 km, the two distributions are not so similar because of the more significant influence of the local boundary layer aerosol

•2-3 km, a much better agreement is observed with a correlation coefficient of 0.92. This result is consistent with the expected behaviour of such major Saharan dust event extended on a continental scale

•4-5 km, we observe differences in both shape and values of the distributions

Comparisons within 10 minutes and different horizontal distances

Correlation coefficient between CALIPSO and EARLINET backscatter counts distributions for time shifts lower than 10 minutes reported as a function of the maximum considered horizontal distances between the two observations.



Strong dependence on the horizontal distance over 10 minutes as timescales.

The correlation coefficient decreases with the horizontal distance following an exponential decay law (r=0.993)

Conclusions and outlook

The development of cloud and aerosol-type classification schemes and of conversion algorithms to relate space-borne lidar observations made with different instruments onboard the CALIPSO, ADM-Aeolus, and EarthCARE missions is an important task to establish a harmonized long-term, global, 4- dimensional aerosol and cloud data set. This task requires the long-term, ground-based support of space-borne missions with multiwavelength lidar instruments at different locations in order to build up a comprehensive database of ground-truth information. EARLINET as a continental lidar observation network is an optimum tool in this context. Consequently, ESA and EARLINET have initiated a correlative EARLINET-CALIPSO measurement program and a corresponding long-term aerosol and cloud database. There is a strong need to continue such kind of activities during future space-borne lidar missions. In addition, the currently established global aerosol lidar network GALION (Global Atmosphere Watch Aerosol Lidar Observation Network) will allow us to extend the ground-based observations from the continental to the global scale and to improve our understanding of the variety of natural and anthropogenic aerosol sources.

Reference

- Wandinger, U., Pappalardo G., Hiebsch A., Mattis I., Mona L., and Madonna F. (2009), Long-term aerosol and cloud database from correlative CALIPSO and EARLINET observations, this workshop.
- Mona, L. , Pappalardo G. , Amodeo A., D'Amico G., Madonna F., Boselli A., Giunta A., Russo F., and Cuomo V. (2009), One year of CNR-IMAA multi-wavelength Raman lidar measurements in correspondence of CALIPSO overpass: Level 1 products comparison, vol. 9, N. 2, pp. 8429-8468.
- Pappalardo et al. (2009), EARLINET correlative measurements for CALIPSO: first intercomparison results, Journal of Geophysical Research (submitted).

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