



ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))



EARLINET – European Aerosol Research Lidar NETWORK ([www.earlinet.org](http://www.earlinet.org))

# EARLINET/ACTRIS analysis of aerosol profiles during the COVID-19 lock-down and relaxation period

## About EARLINET/ACTRIS

The [European Aerosol Research Lidar Network](http://www.earlinet.org), EARLINET, was established in 2000 as a research project with the goal of creating a quantitative, comprehensive, and statistically significant database for the horizontal, vertical, and temporal distribution of aerosols on a continental scale. Since then EARLINET has continued to provide the most extensive collection of ground-based data for the aerosol vertical distribution over Europe.

EARLINET is part of ACTRIS ([Aerosols, Clouds and Trace gases Research Infrastructure](http://www.actris.eu)). ACTRIS is a pan-European initiative consolidating actions amongst European partners producing high-quality observations of aerosols, clouds and trace gases. ACTRIS was accepted into ESFRI Roadmap in 2016 and is now in the implementation phase.

## The NRT Campaign in May 2020

This campaign is organized as part of the ACTRIS initiative for studying the changes in the atmosphere during the COVID-19 lockdown. The scope of the campaign is twofold: a) to monitor the atmosphere's structure during the lockdown and early relaxation period in Europe; b) to identify possible changes due to decreased emissions, by comparison to the aerosol climatology in Europe.

Lidars measure at least two-times per day (minimum two hours at noon, and minimum two hours after sunset). Depending on the setup of the instrument, various data products are produced by a centralized processing system (Single Calculus Chain)<sup>1</sup>: vertical profiles of the aerosol backscatter and extinction coefficients, and of the linear depolarization ratios. With their high temporal and vertical resolution, lidars give comprehensive information on the atmospheric structure, its dynamics, and its optical properties.

In this study the near-real time (NRT) is used. Measurements are submitted and processed in maximum 12h after the end of the mandatory noon and nighttime measurements. Quality control of the

---

<sup>1</sup> D'Amico, G., Amodeo, A., Baars, H., Biniotoglou, I., Freudenthaler, V., Mattis, I., Wandinger, U., and Pappalardo, G.: EARLINET Single Calculus Chain – overview on methodology and strategy, *Atmos. Meas. Tech.*, 8, 4891–4916, <https://doi.org/10.5194/amt-8-4891-2015>, 2015



ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))



EARLINET – European Aerosol Research Lidar NETWORK ([www.earlinet.org](http://www.earlinet.org))

measurement is performed by each station, while the SCC embeds subroutines for automatic quality control of the processed data. However, this is still preliminary data until the full set of QA/QC procedures is applied and the re-analysis is done.

## Contacts

- [Doina Nicolae](#), ACTRIS Centre for Aerosol Remote Sensing (CARS)
- [Lucia Mona](#), ACTRIS Data Centre, Aerosol Remote Sensing Unit (ARES)

## Participating lidar stations

EARLINET currently has 31 active stations. Out of these, 21 participate in this campaign, covering different regions over Europe. These stations operate either automatic / remotely controlled instruments, or are located in regions where complete lock-down is not effective.



*Lidar stations providing measurements of the aerosol profiles daily: a) in yellow, stations measuring 2 times per day; b) in red, stations providing quasi-continuous measurements. No measurements are performed during precipitation.*

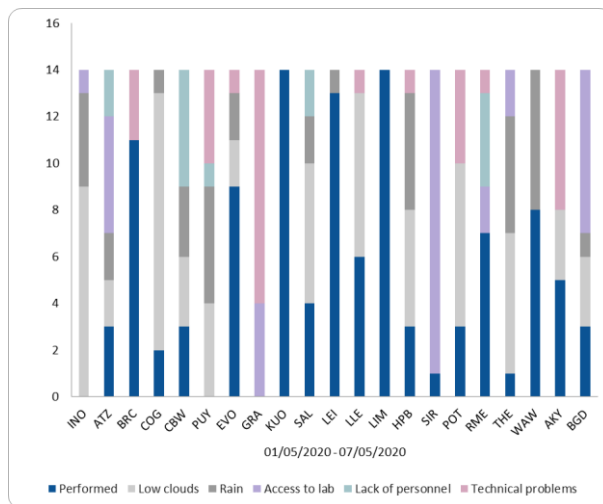
Location	Coordinates
Athens	37.9600 N, 23.7800 E, 212 m
Barcelona	41.3930 N, 2.1200 E, 115 m
Belsk	51.8300 N, 20.7800 E, 180 m
Bucharest	44.3480 N, 26.0290 E, 93 m
Cabauw	51.9700 N, 4.9300 E, 0 m
Clermont-Ferrand	45.7610 N, 3.1110 E, 420 m
Evora	38.5678 N, -7.9115 E, 293 m
Granada	37.1640 N, -3.6050 E, 680 m
Kuopio	62.7333 N, 27.5500 E, 190 m
Lecce	40.3330 N, 18.1000 E, 30 m
Leipzig	51.3527 N, 12.4339 E, 125 m
Lille	50.6117 N, 3.1417 E, 60 m
Limassol	34.6700 N, 33.0400 E, 10 m
Hohenpeissenberg	47.8019 N, 11.0119 E, 974 m
Palaiseau	48.7130 N, 2.2080 E, 156 m
Potenza	40.6000 N, 15.7200 E, 760 m
Roma-Tor Vergata	41.8330 N, 12.6500 E, 110 m
Thessaloniki	40.6300 N, 22.9500 E, 50 m
Warsaw	52.2100 N, 20.9800 E, 112 m
Antikythera	35.8600 N, 23.3100 E, 193 m
Belgrade	44.8557 N, 20.3913 E, 89 m

# Report for 1 – 7 May 2020

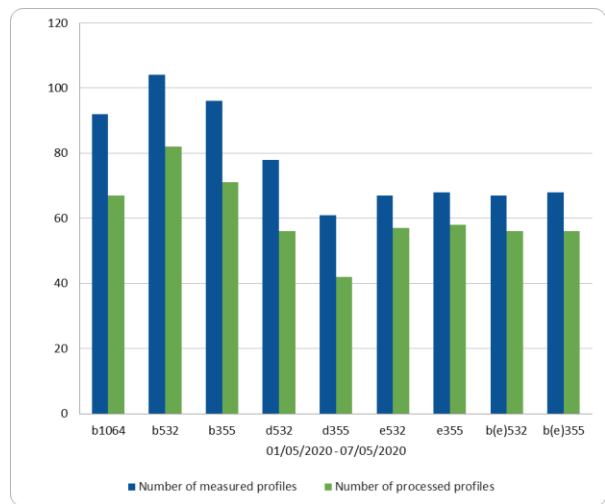
The first week of the campaign was dedicated to the adjustment of the instruments, performance of the quality assurance tests, and implementation of the specific measurement and data processing procedures.

During this week, low clouds were generally present above Europe, therefore only part of the scheduled measurements has been performed and processed. Due to the small number of processed files, no detailed analysis of the resulting data is possible. Several examples are presented below.

## Statistics of the week



Measurement statistics



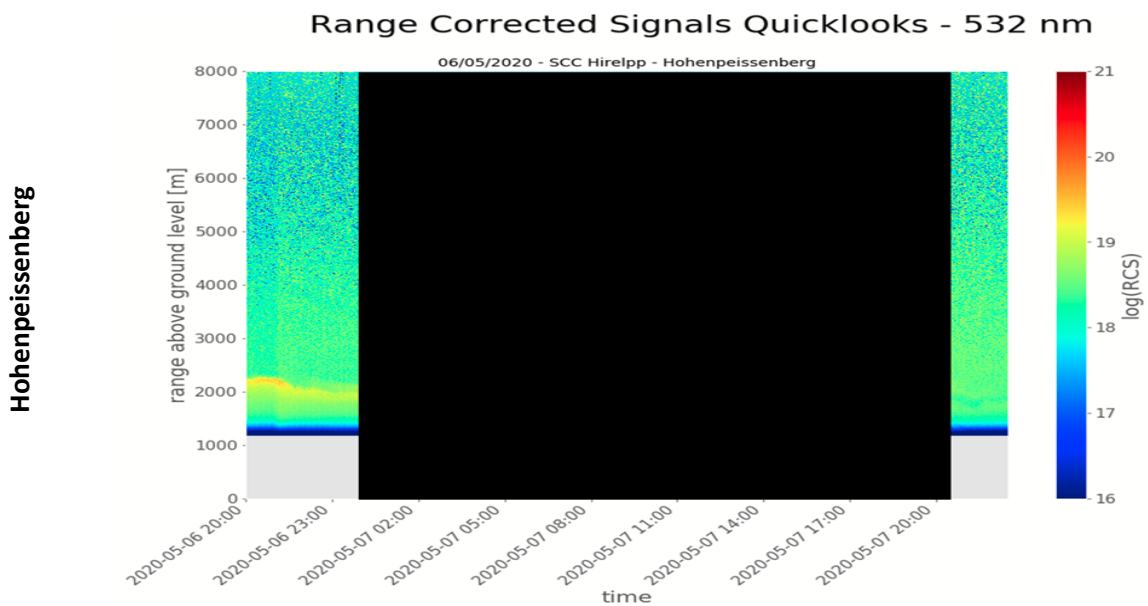
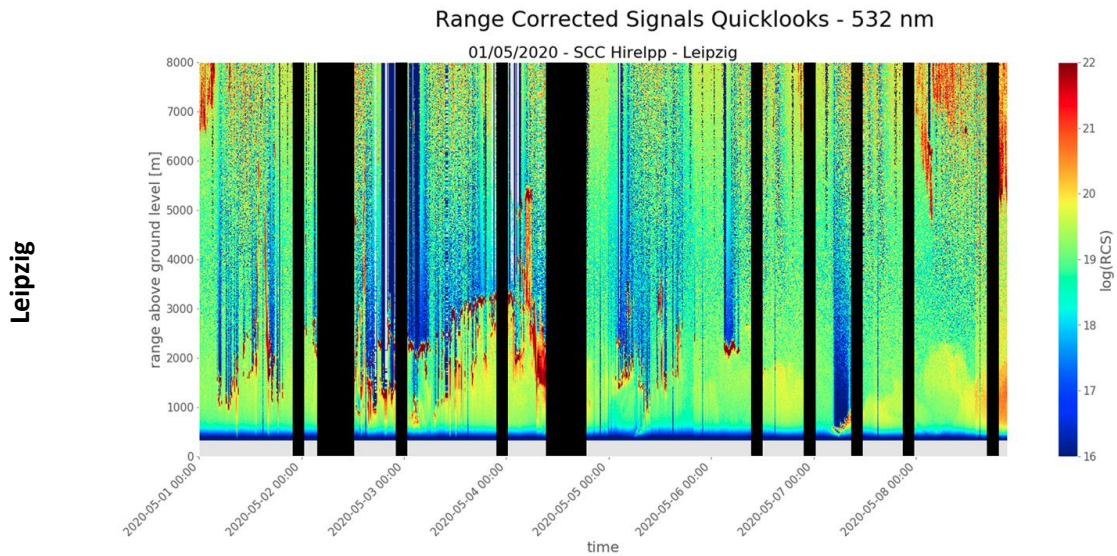
Data products statistics

During this week, 37% of the total number of scheduled measurements were performed. In 36% of the cases, measurements could not be performed due to the weather conditions (rain or very low clouds), access to the laboratory and lack of personnel made the measurements impossible in 16% of the cases, while 11% of the measurements could not be performed due to instrument setting and check-ups.

More than 77% of the collected datasets were successfully processed by the Single Calculus Chain. Most of the missing data products are due to the presence of low clouds in the measurements, which are screened out by the Cloud Masking module.

## Quicklooks of the week

Quicklooks below show the temporal variability of the aerosol layers in the vertical. Regions in the atmosphere with high content of aerosols or clouds are identified in red colors, while “clean” regions are shown in blue. Black color indicates lack of measurement due to low clouds or precipitation.



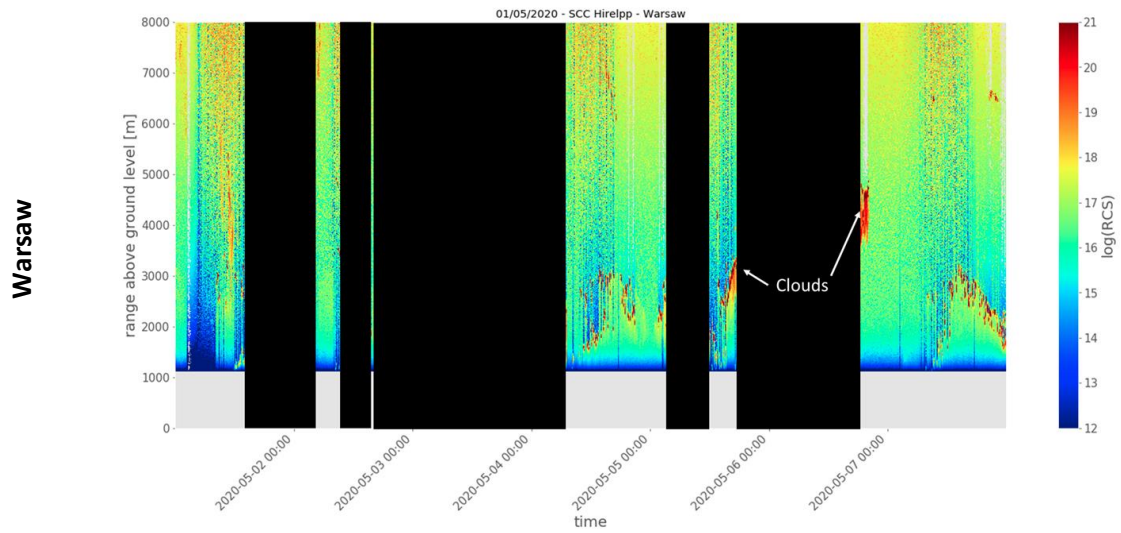


ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))

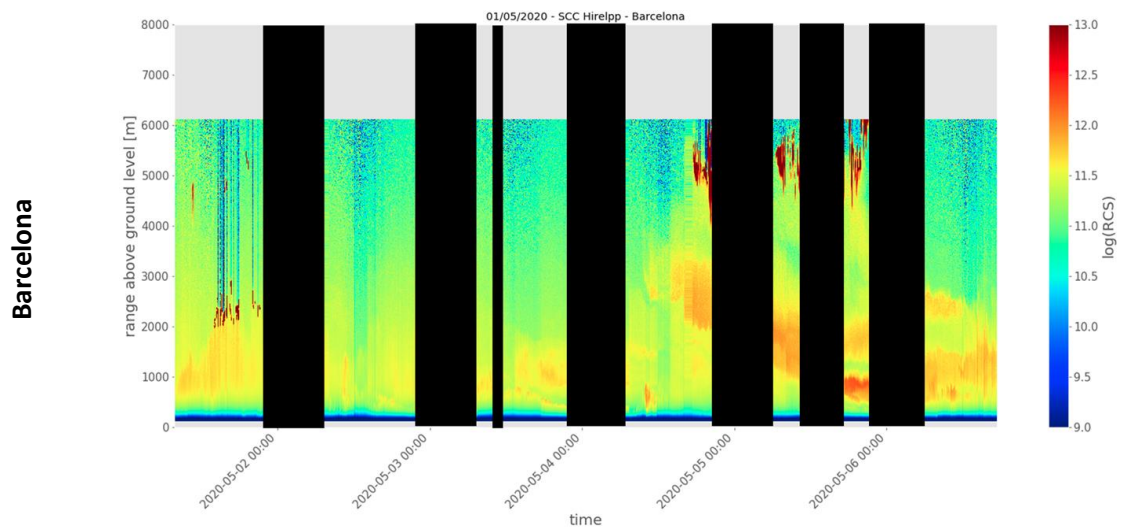


EARLINET – European Aerosol Research Lidar Network ([www.earlinet.org](http://www.earlinet.org))

### Range Corrected Signals Quicklooks - 532 nm

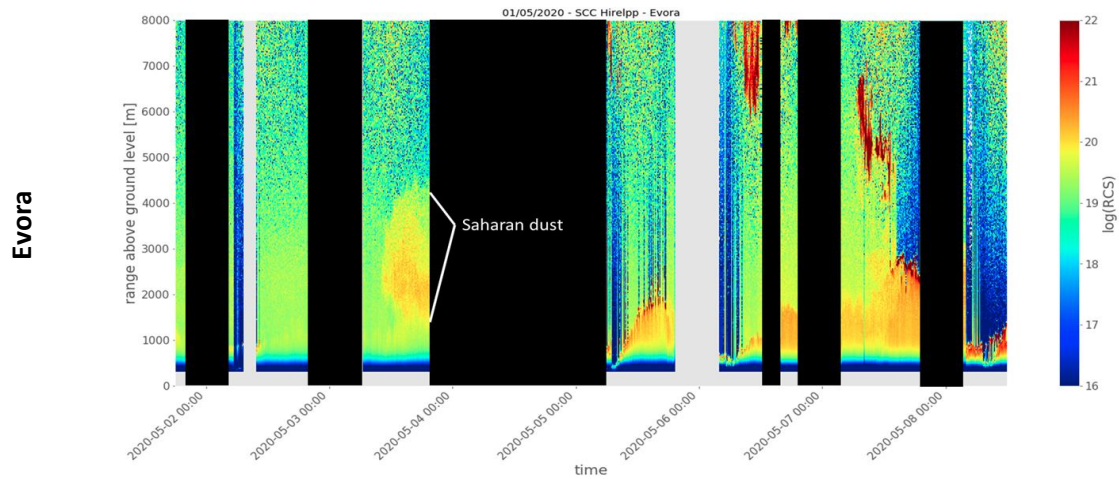


### Range Corrected Signals Quicklooks - 532 nm

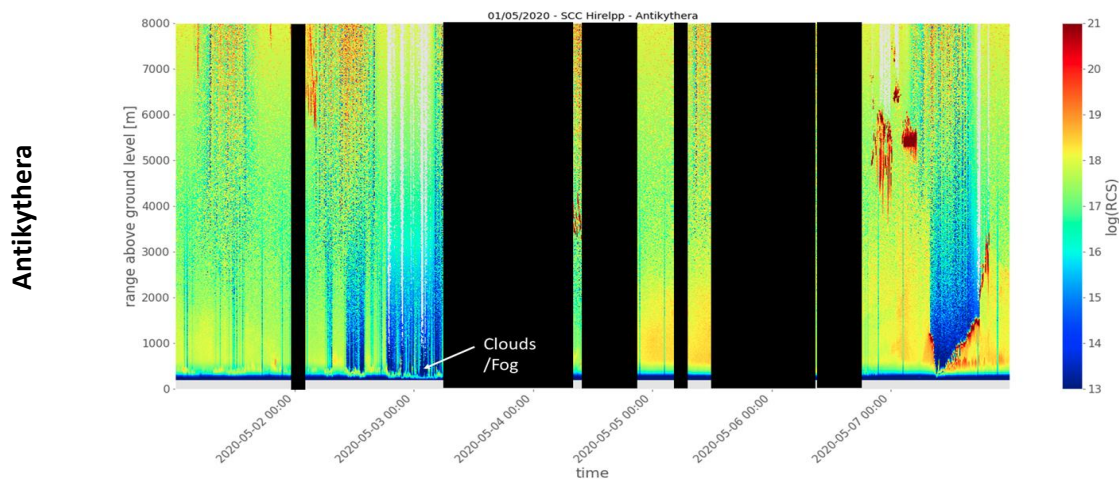




Range Corrected Signals Quicklooks - 532 nm



Range Corrected Signals Quicklooks - 532 nm



For the lidar stations in central Europe (Warsaw, Leipzig, Hohenpeissenberg), the week of 1 to 7 May was dominated by low-level clouds with rain events. The cloud bottom height varied from 1 to 3 km in Warsaw and thus was mostly connected to the local PBL. A similar pattern was observed in Leipzig, but in the end of the week, low-level clouds dissolved and aerosols were observed up to 2.5 km. Above 7 km, mainly Cirrus clouds were present. The aerosol load was significantly intensified from afternoon to the night of 7 May. In the Western Mediterranean - Evora - the week started under clear sky conditions with low aerosol load. In the middle of the week, a dense Saharan dust plume was observed between 1.5 and 4.5 km. This plume was observed later in the week in Barcelona up to 6 km with clouds forming on its top. After the mid of the week it started to get cloudier in Evora and aerosols coupled to the PBL were observed up to 2.5 km. Similar observations were made in Barcelona.



ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))



EARLINET – European Aerosol Research Lidar Network ([www.earlinet.org](http://www.earlinet.org))

A different picture was drawn in the Eastern Mediterranean on the island of Antikythera. There, the first half of the week was dominated by low-level clouds and/or fog. During clear sky conditions in the middle of the week, aerosols most probably coupled to the PBL were observed up to 2.5 km. The end of the observing week was again dominated by a frontal passage with low clouds and probably a bit of precipitation.

In contrast to April 2020, in which high pressure over central Europe led to clear sky conditions and the occurrence of multiple aerosol layers in the troposphere (most probably caused by biomass burning in Eastern Europe), the first week of May 2020 was characterized by changing weather patterns with significant low clouds and rain, but also some dust from the Saharan desert reaching the Iberian Peninsula.

## Weekly means

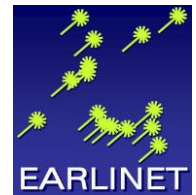
Aerosol backscatter coefficient is a measure of the aerosol load. Linear particle depolarization is a measure of the aerosol non-sphericity. Low troposphere is here defined up to 3 km altitude, where local influences are still possible. High troposphere is defined from 3 km up to 7 km, where typically long-range transport of aerosols occurs and no local influences are present. For sites for which only backscatter at 355 nm was available, the values were scaled to 532 nm considering a backscatter Angstrom exponent of 1. No wavelength dependence has been considered for the particle depolarization ratio.

Being an intensive parameter, the particle depolarization values are considered significant only when the aerosol load is such to allow the depolarization characterization. Specifically, the depolarization values satisfying the following criteria, satisfied simultaneously, are considered for the averaging procedures:  $\text{backscatter} > 5 \times 10^{-7} \text{ m}^{-1}\text{sr}^{-1}$  and  $\text{error\_backscatter}/\text{abs}(\text{backscatter}) < 50\%$  and  $\text{error\_depolarization}/\text{abs}(\text{depolarization}) < 50\%$ .

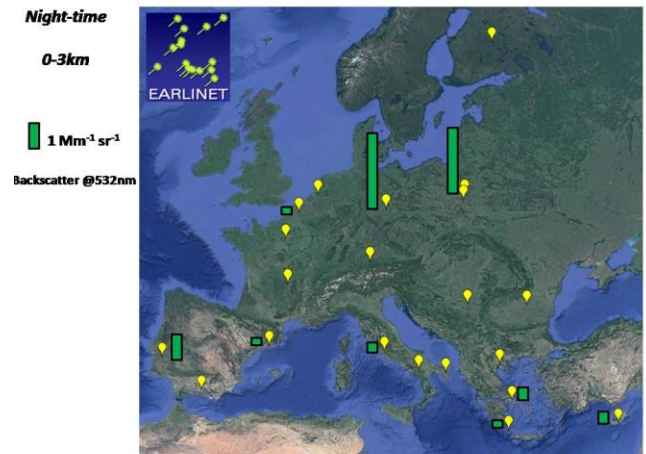
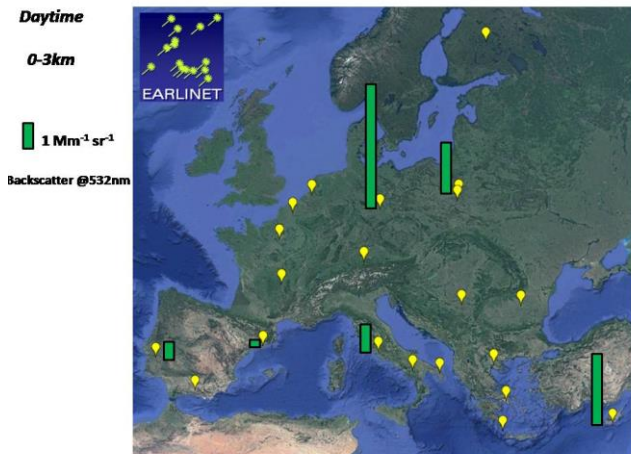
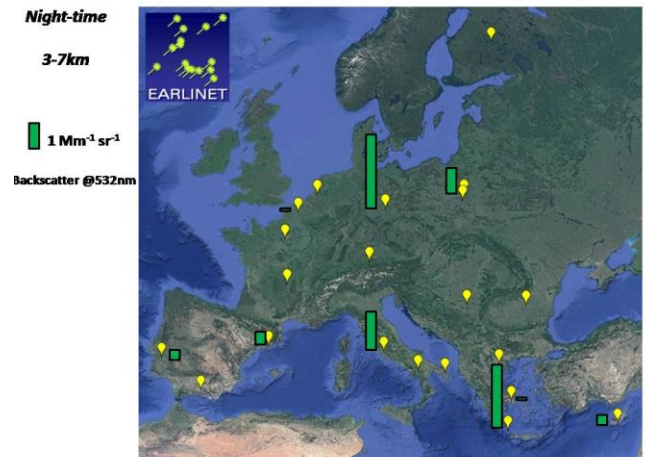
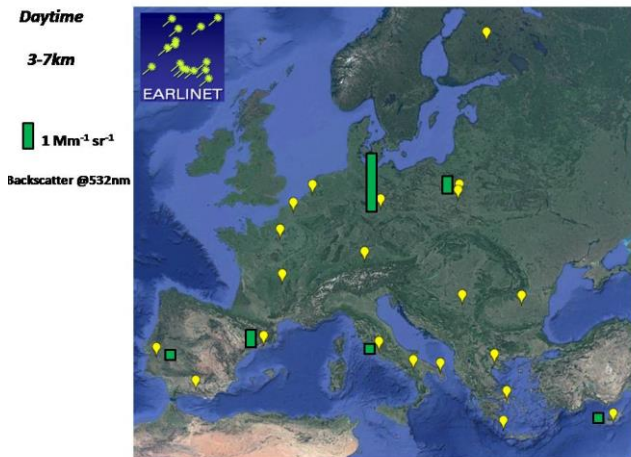
Weekly means are reported only for parameters measured at least 3 times for the considered slot of measurement.



ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))



EARLINET – European Aerosol Research Lidar NETWORK ([www.earlinet.org](http://www.earlinet.org))



*Weekly mean values of the aerosol backscatter coefficient (532 nm) for low troposphere (bottom panel) and high troposphere (upper panel) during daytime*

*Weekly mean values of the aerosol backscatter coefficient (532 nm) for low troposphere (bottom panel) and high troposphere (upper panel) during nighttime*

Backscatter values below 3 km are typically higher than those in the upper part of the troposphere and values are also typically higher in daytime than in nighttime. However, significant differences between regions are also visible. Systematic high values are measured in Central-North Europe (Leipzig and Warsaw) both at night and day, in the low and in the high troposphere. For the Southern stations the pattern changes from day to night: higher values in the low troposphere during daytime, and higher values in the high troposphere during nighttime.

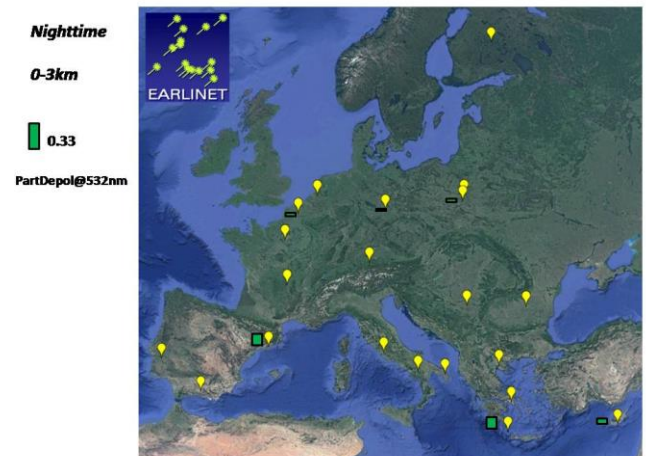
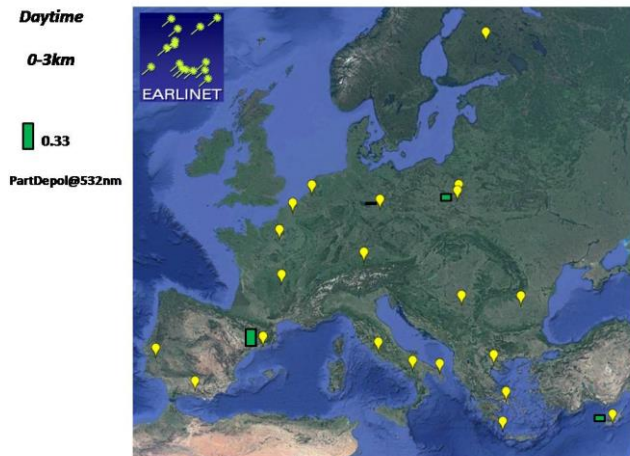
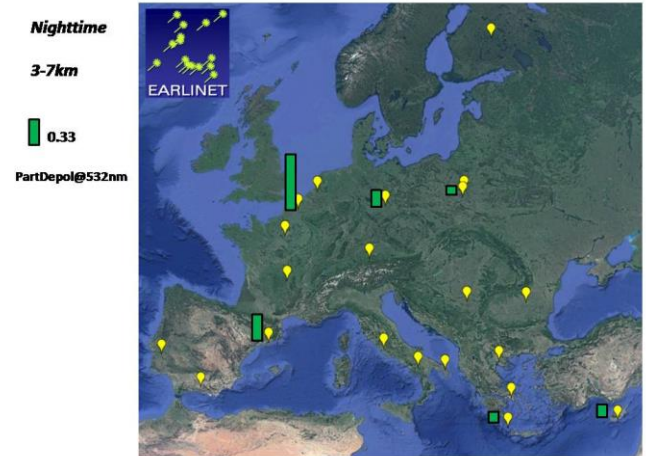
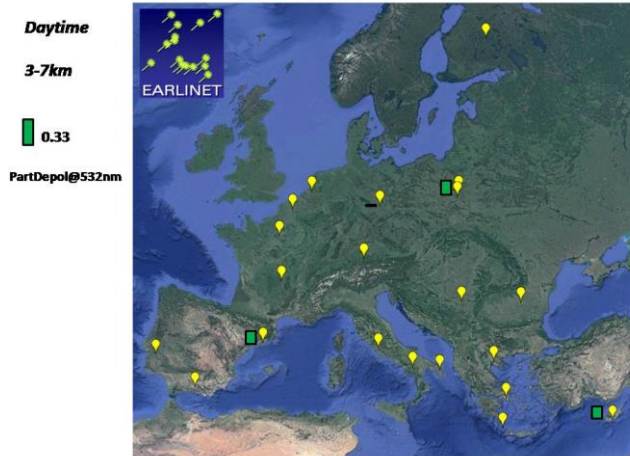




ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))



EARLINET – European Aerosol Research Lidar NETWORK ([www.earlinet.org](http://www.earlinet.org))



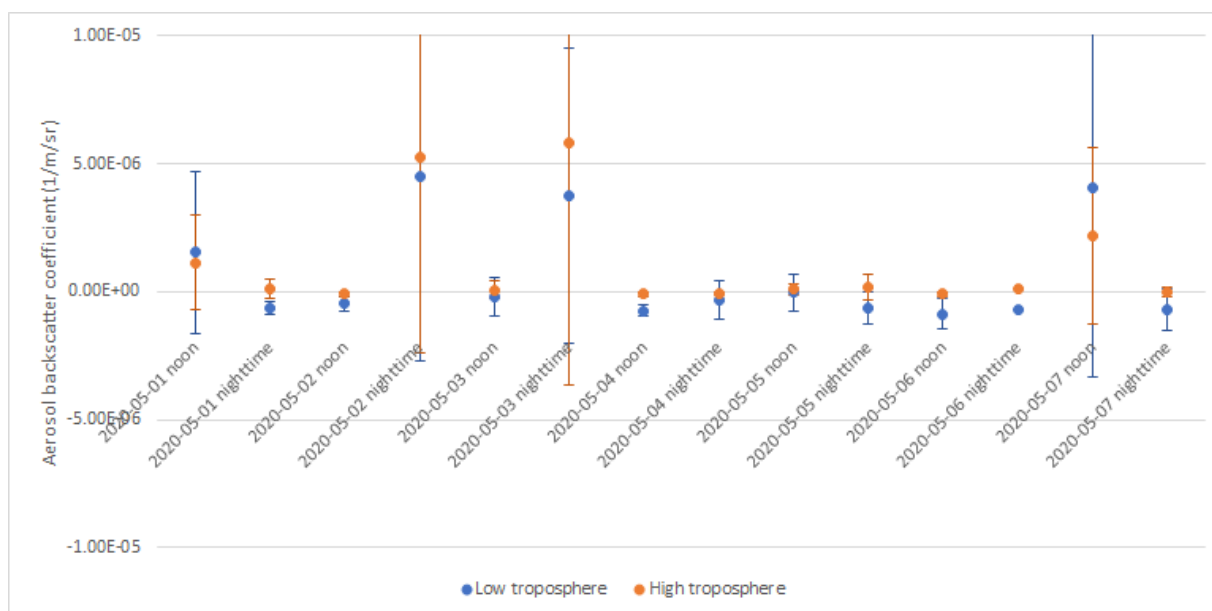
*Weekly mean values of the particle linear depolarization ratio (532 nm) for low troposphere (bottom panel) and high troposphere (upper panel) during daytime*

*Weekly mean values of the particle linear depolarization ratio (532 nm) for low troposphere (bottom panel) and high troposphere (upper panel) during nighttime*

In the low troposphere, the values of the linear particle depolarization ratio are relatively low in all regions typical for continental aerosols, with slightly higher values in Southern Europe. In the high troposphere, the values of the linear particle depolarization ratio are higher for Central-North stations, as well as for Barcelona. This may be related to an episode of long-range transport of dust particles at altitudes higher than 3km.

## Evolution with time

The graphs below show the changes during the week of the aerosol backscatter coefficient in the low and high troposphere, as a difference to the climatological values for May between 2000 – 2015<sup>2</sup>.



*Time evolution of the aerosol backscatter coefficient (532 nm) in the low and high troposphere; average for all stations*

Generally, in Europe a small decrease of the aerosol backscatter coefficient in the lower troposphere and a more significant decrease in the high troposphere can be seen. However, the day to day variability is high, especially for the lower troposphere, due to particular meteorology during Spring time. Measurements on 2<sup>nd</sup>, 3<sup>rd</sup> and 7<sup>th</sup> of May show especially high values for both vertical regions, probably associated to long range transport of aerosols in Central-North Europe.

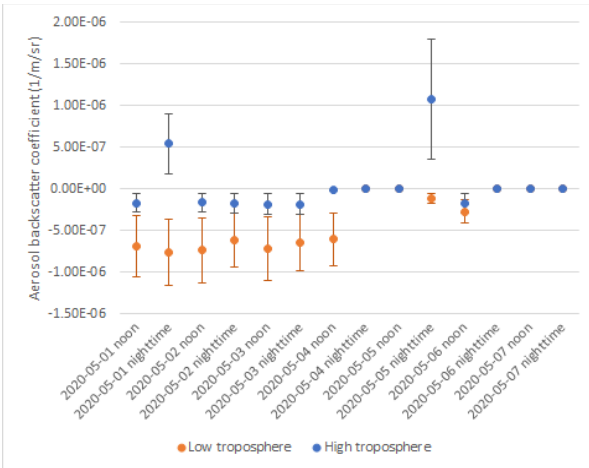
<sup>2</sup> Climatological values and profiles are evaluated on the base of 15 years of data ([https://doi.org/10.1594/WDCC/EARLINET All 2000-2015](https://doi.org/10.1594/WDCC/EARLINET_All_2000-2015)) and are provided as the first release of ACTRIS/EARLINET Level 3 dataset available at <https://www.earlinet.org/index.php?id=125>.



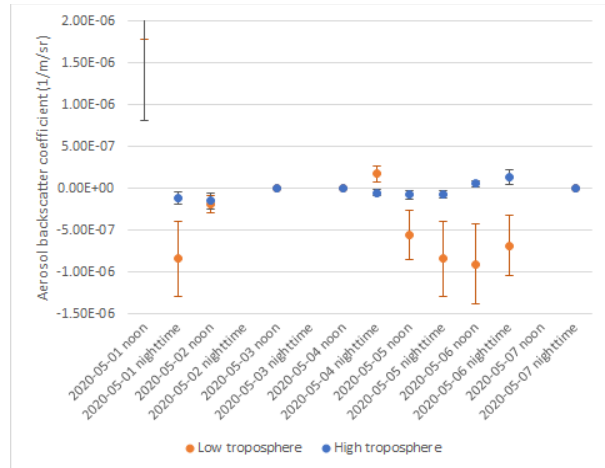
ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure ([www.actris.eu](http://www.actris.eu))



EARLINET – European Aerosol Research Lidar NETWORK ([www.earlinet.org](http://www.earlinet.org))



*Time evolution of the aerosol backscatter coefficient (532 nm) in the low and high troposphere; Barcelona station (South-West Europe)*



*Time evolution of the aerosol backscatter coefficient (532 nm) in the low and high troposphere; Leipzig station (Central-North Europe)*

As shown in the examples above, the values of the aerosol backscatter coefficient in the low troposphere are lower than the climatological values for almost the entire time interval presented, both in South-West and in Central-North Europe. The high troposphere, however, shows some time intervals with increased values of the aerosol backscatter coefficient, different for South-West Europe (1<sup>st</sup> May nighttime, 5<sup>th</sup> of May nighttime) and Central-North respectively (1<sup>st</sup> May noon). This may be associated to the specific patterns of the long range transported aerosols in the free troposphere.

## Preliminary conclusions on the week

In contrast to April 2020, the first week of May 2020 was characterized by changing weather pattern with significant low clouds and rain, but also some dust from Sahara reaching the Iberian Peninsula.

Generally, in Europe a small decrease of the aerosol backscatter coefficient in the lower troposphere and a more significant decrease in the high troposphere was noticed by comparison with the climatological values (2000-2015).

Significant differences between values of the aerosol backscatter coefficient and linear particle depolarization ratios in the low troposphere and high troposphere were noticed at all lidar stations.