EGU General Assembly 2022

ALICEnet Automated LIdar-CEilometer network

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ALICEnet: the Italian Automated LIdar-CEilometer Network

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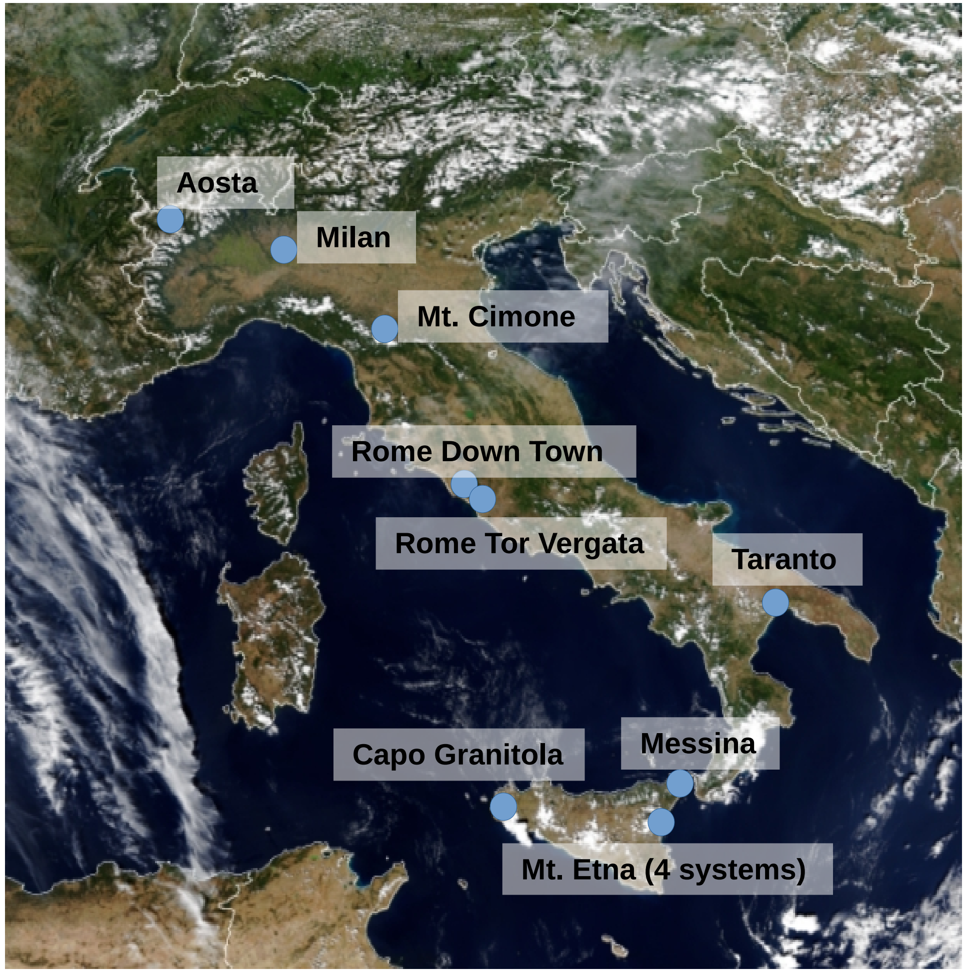
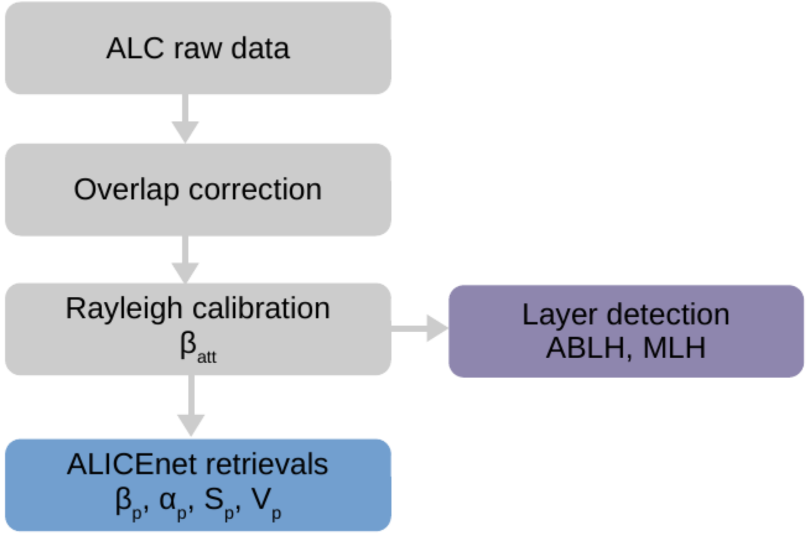
Network

- Italian network of **Automated Lidar-Ceilometers** (ALCs) operationally (**24/7**) monitoring **aerosol profiles and clouds**
- Wide range of atmospheric and environmental conditions: Saharan dust advections (Barnaba et al., 2017, Barnaba et al., 2022, Gobbi et al., 2019), volcanic ash eruptions, anthropogenic aerosol production (Diémoz et al., 2019a, b)
- CHM15k systems (in some stations co-located polarization-sensitive lidar-ceilometers, solar/lunar radiometers, in-situ aerosol observations)
- Most of the systems already have multiannual records
- Coordinated by CNR-ISAC with collaboration of several regional EPAs (ARPAs) and Research Institutions
- Contributor to the EUMETNET program E-PROFILE EUMETNET
- **Centralized data processing** at CNR-ISAC, including data quality controls and inversions ➡ homogeneous quantitative information on aerosol properties across the country



Location of the ALICEnet ALC instruments (2022).

Retrievals and products



Flowchart of the ALICENET data processing.

- Overlap correction: Hervo et al., 2016
- Calibration: automatic Rayleigh procedure
- **ALICEnet retrievals**:
  - aerosol backscatter β_p: forward solution of the Klett inversion (Wiegner and Geiβ, 2014) with an iterative technique to derive the lidar ratio
  - aerosol extinction α_p, surface area S_p, and volume V_p: mean functional relationships based on a large set of numerical simulations (Dionisi et al., 2018) linking aerosol backscatter to extinction, surface area, and volume (and, via assumption of a particle density, mass)
- **Mixing layer and atmospheric boundary layer heights detection**: STRATfinder algorithm (Kotthaus et al., 2020)

- Vertical profiles of the range-corrected ALC signals (**Level 1 profiles**, resolution of 15 m up to an altitude of 15 km) provided in near real time in https://www.alice-net.eu/
- ALICEnet retrievals (**Level 2 profiles**) evaluated against independent data from both long term observations and field campaigns. **Near real time** dissemination of Level 2 profiles and of products on aerosol stratification (Level 3 data) currently under development
- Efforts to upgrade ALICEnet algorithms and tailor its products to user needs constantly made in collaboration with EU Initiatives and Projects

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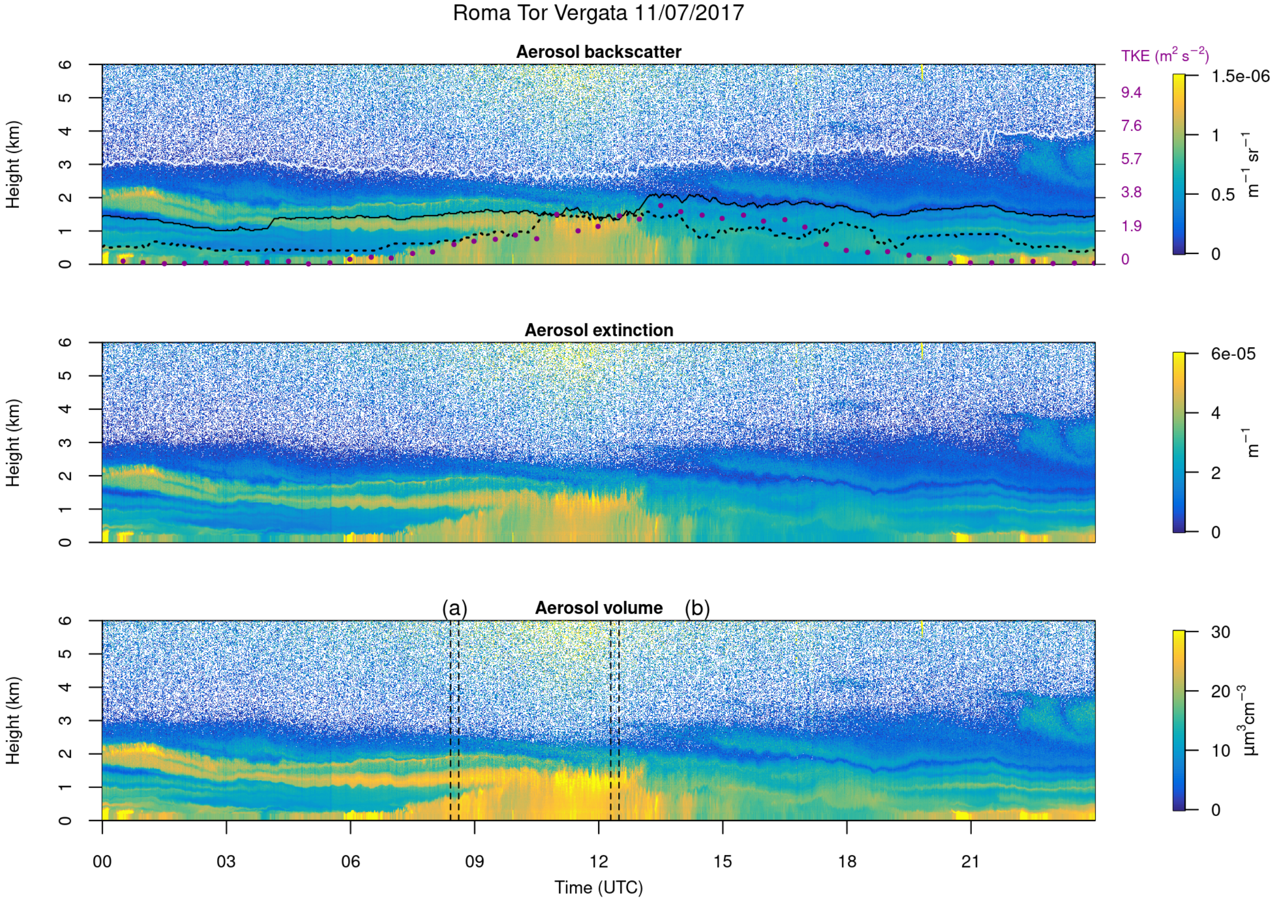
Applications: Aerosol transport episodes

Characterization of the vertical distribution of aerosol physical and optical properties, and of atmospheric processes

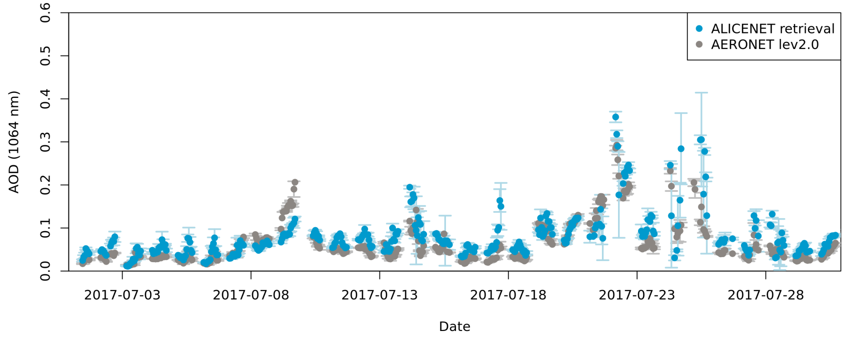


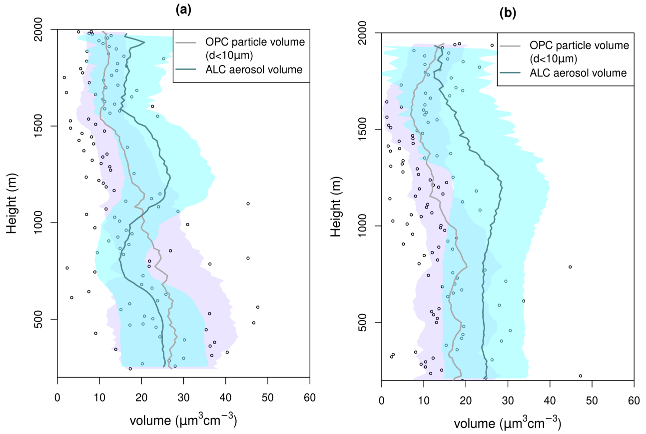
Aerosol backscatter, extinction, and volume profiles in Rome Tor Vergata derived during the EMERGE campaign. The mixing layer (dotted black line), the atmospheric boundary layer (black line), and the top of the aerosol layer (white line) heights detected by STRATfinder are superimposed on the backscatter profiles, together with the turbulent kinetic energy time series (violet dots).

11 July 2017: example of advection of Saharan dust and fires plumes over Rome, entrained and mixed into the atmospheric boundary layer, as observed during the EMERGE campaign (Andrés Hernandez et al., 2022)

Comparison between the **ALICEnet Level 2 AOD** retrieval and the relevant reference **AERONET Level 2 AOD** data in Rome Tor Vergata, July 2017.

Aerosol optical depth (1064 nm), Rome Tor Vergata July 2017



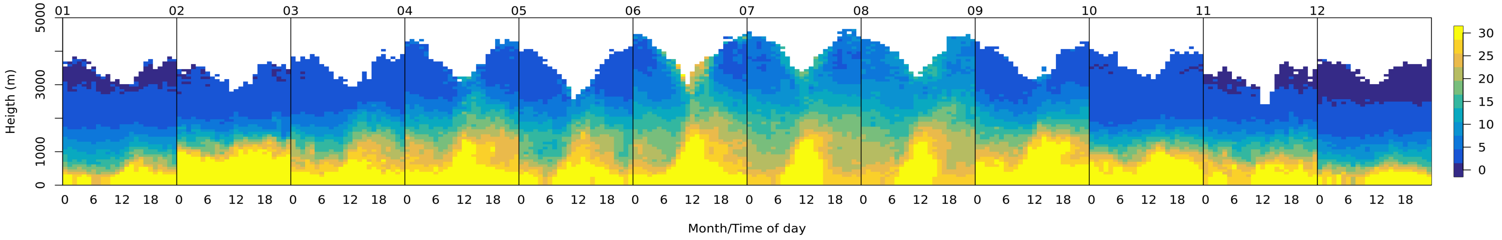


Comparison of **ALICEnet aerosol volume profiles** with relevant data from **in situ aircraft measurements** performed during the EMERGE campaign, time windows (a) and (b) superimposed on 11/07/2017 volume profiles.

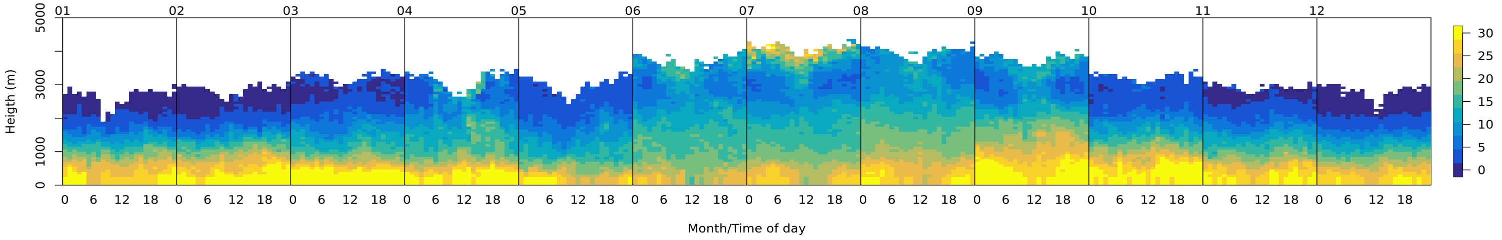
Applications: Aerosol climatologies

Aerosol mass profiles (µg m^{-3}) 2016-2021 climatology

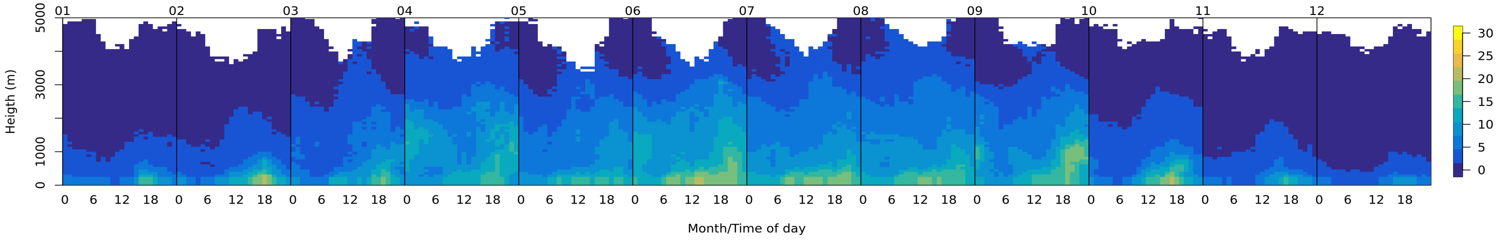
Rome Tor Vergata



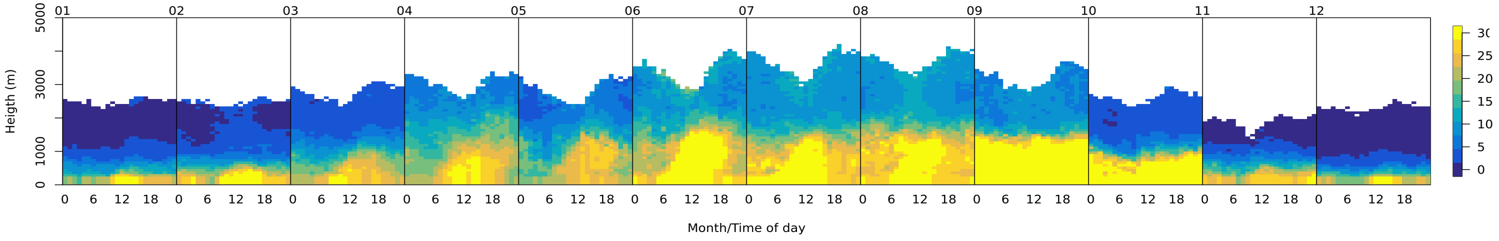
Messina



Aosta

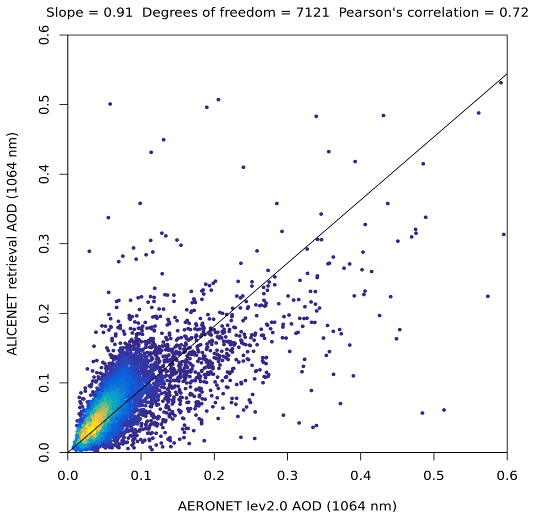


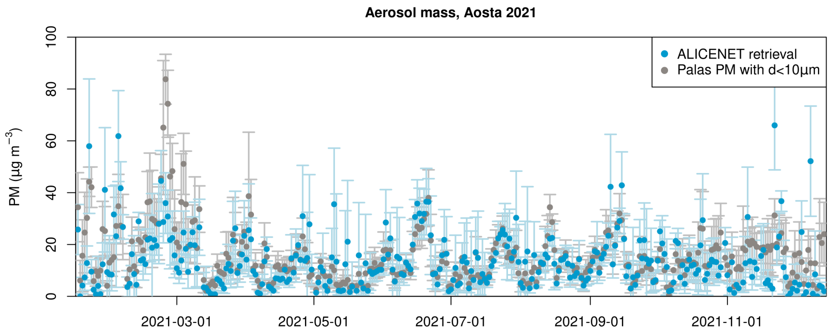
Milan



Left: **6-year (2016-2021) Climatology of the ALICEnet-derived aerosol mass vertical profiles** (Monthly and daily resolved) at 4 sites of the ALICEnet network (from top to bottom: Rome, Messina, Aosta, Milan). Right: scatter plot of **ALICEnet and AERONET Level 2 AODs** in Rome with data in the period **2016-2021**.

Aerosol optical depth (1064 nm) Rome Tor Vergata 2016-2021





Above: comparison between **surface PM concentrations** (ALICEnet retrieval and Palas OPC) in Aosta over the year 2021.

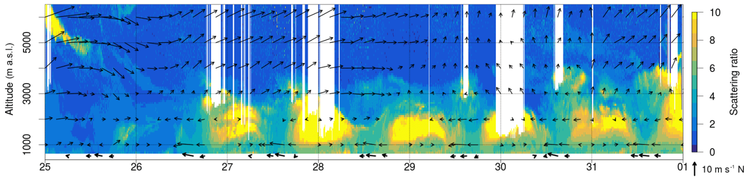
Reprocessed database already available for the main sites (e.g. Milan)

Conclusions

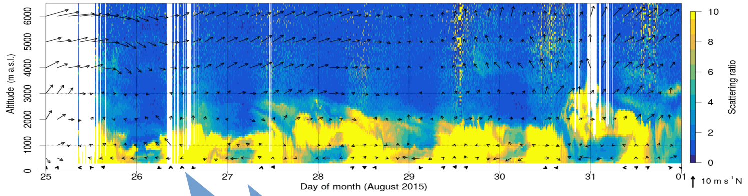
- ALICEnet allows continuous monitoring (**24/7**) of **aerosol vertical distribution across Italy**
- The **long-term database** (≥ 6 years) already available in some ALICEnet sites allows climatological analysis as well as the investigation of aerosol processes at different spatial and temporal scales
- The **geophysical information** retrieved within the network can be tailored to a wide range of stakeholder communities, such as meteorology, air quality and aviation control agencies
- The **synergy** with others remote sensing instruments and atmospheric chemistry models will be explored ➡ identification of local/advected aerosol layers, radiative impacts, evaluation of ABL physical and chemical processes impacting air quality

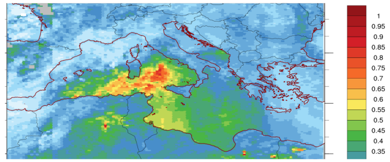
From top to bottom: **aerosol pollution over the Po Basin**, 25-31 August 2015 (ALICEnet scattering ratio profiles in Aosta and Milan and SUOMI NPP VIIRS true color), **Saharan dust advection** over Italy, 18-23 June 2021 (MAIAC AOD at 500 nm and ALICEnet aerosol extinction profiles in Rome and Capo Granitola), **Etna eruption**, 21 February 2022 (camera and ALICEnet Level 1 profiles in Mt. Etna).

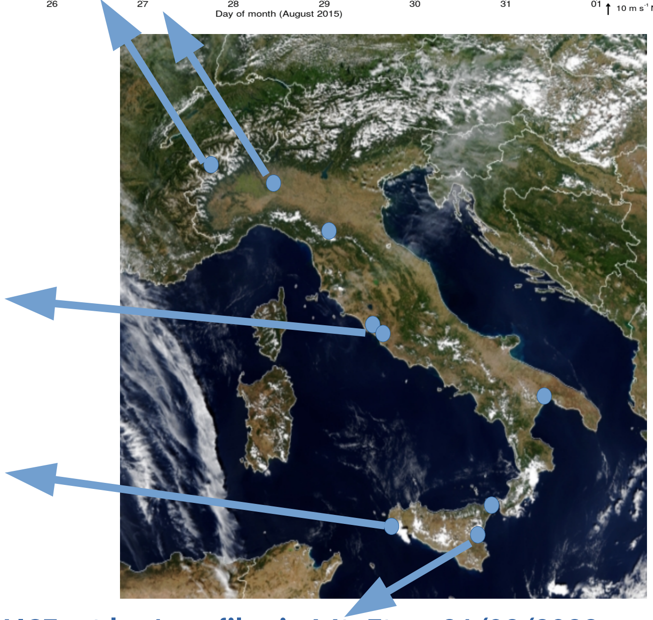
ALICEnet lev2 profiles in Aosta



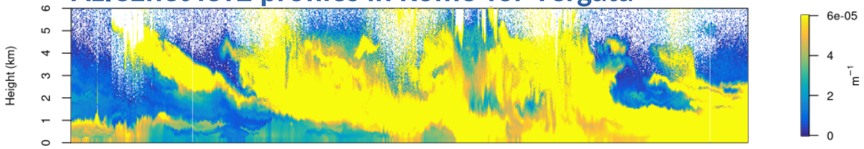
ALICEnet lev2 profiles in Milan



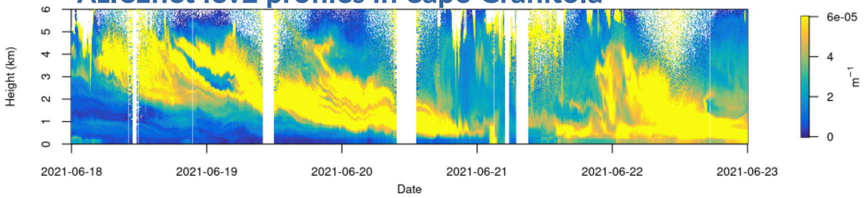




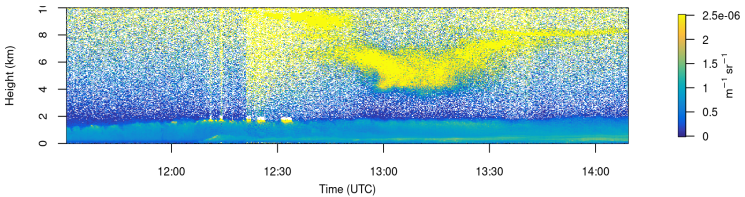
ALICEnet lev2 profiles in Rome Tor Vergata



ALICEnet lev2 profiles in Capo Granitola



ALICEnet lev1 profiles in Mt. Etna, 21/02/2022



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Consiglio Nazionale delle Ricerche ISAC ARPA Valle d'Aosta

Thank you!

References

- Barnaba, F., Bolignano, A., Di Liberto, L., Morelli, M., Lucarelli, F., Nava, S., Perrino, C., Canepari, S.,Basart, S., Costabile, F., Dionisi, D., Ciampichetti, S., Sozzi, R., Gobbi, G. P., Desert dustcontribution to PM10 loads in Italy: Methods and recommendations addressing the relevantEuropean Commission Guidelines in support to the Air Quality Directive 2008/50, Atmospheric Environment, Volume 161,2017, Pages288-305, ISSN1352-2310, https://doi.org/10.1016/j.atmosenv.2017.04.038, 2017
- Barnaba, F., Romero, N. A., Bolignano A., Basart, S., Renzi, M. and Stafoggia, Multiannual assessment of the desert dust impact on air quality in Italy combining PM10 data with physics-based and geostatistical models, Environment International, Volume 163, 2022, 107204, ISSN 0160-4120, https://doi.org/10.1016/j.envint.2022.107204, 2022
- Bellini, A., Diémoz, H., Di Liberto, L., Gobbi, G.P., Barnaba, F., The Italian Automated Lidar-Ceilometer Network (ALICEnet): infrastructure, algorithms and applications, (in preparation)
- Diémoz, H., Barnaba, F., Magri, T., Pession, G., Dionisi, D., Pittavino, S., Tombolato, I. K. F., Campanelli, M., Della Ceca, L. S., Hervo, M., Di Liberto, L., Ferrero, L., and Gobbi, G. P.:Transport of Po Valley aerosol pollution to the northwestern Alps – Part 1: Phenomenology, Atmos. Chem. Phys., 19, 3065–3095, https://doi.org/10.5194/acp-19-3065-2019, 2019
- Diémoz, H., Gobbi, G. P., Magri, T., Pession, G., Pittavino, S., Tombolato, I. K. F., Campanelli, M., andBarnaba, F.: Transport of Po Valley aerosol pollution to the northwestern Alps – Part 2: Long-termimpact on air quality, Atmos. Chem. Phys., 19, 10129–10160, https://doi.org/10.5194/acp-19-10129-2019, 2019
- Dionisi, D., Barnaba, F., Diémoz, H., Di Liberto, L., and Gobbi, G. P.: A multiwavelength numericalmodel in support of quantitative retrievals of aerosol properties from automated lidar ceilometersand test applications for AOT and PM 10 estimation, Atmos. Meas. Tech., 11, 6013–6042,https://doi.org/10.5194/amt-11-6013-2018, 2018
- Gobbi G.P., Barnaba F., Di Liberto L., Bolignano A., Lucarelli F., Nava S., Perrino C., Pietrodangelo A.,Basart S., Costabile F., Dionisi D., Rizza U., Canepari S., Sozzi R., Morelli M., Manigrasso M.,Drewnick F., Struckmeier C., Poenitz K., Wille H.: An inclusive view of Saharan dust advectionsto Italy and the Central Mediterranean, Atmospheric Environment, Volume 201, 2019, Pages 242-256, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2019.01.002, 2019
- Hernández, A. M. D., Hilboll, A., Ziereis, H., Förster, E., Krüger, O. O., Kaiser, K., Schneider, J.,Barnaba, F., Vrekoussis, M., Schmidt, J., Huntrieser, H., Blechschmidt, A.-M., George, M.,Nenakhov, V., Klausner, T., Holanda, B. A., Wolf, J., Eirenschmalz, L., Krebsbach, M., Pöhlker,M. L., Hedegaard, A. B., Mei, L., Pfeilsticker, K., Liu, Y., Koppmann, R., Schlager, H., Bohn, B.,Schumann, U., Richter, A., Schreiner, B., Sauer, D., Baumann, R., Mertens, M., Jöckel, P., Kilian,M., Stratmann, G., Pöhlker, C., Campanelli, M., Pandolfi, M., Sicard, M., Gomez-Amo, J. L.,Pujadas, M., Bigge, K., Kluge, F., Schwarz, A., Daskalakis, N., Walter, D., Zahn, A., Pöschl, U.,Bönisch, H., Borrmann, S., Platt, U., and Burrows, J. P.: Overview: On the transport andtransformation of pollutants in the outflow of major population centres – observational data fromthe EMeRGe European intensive operational period in summer 2017, Atmos. Chem. Phys., 2022, https://doi.org/10.5194/acp-22-5877-2022, 2022
- Hervo, M., Poltera, Y., and Haefele, A.: An empirical method to correct for temperature-dependent variations in the overlap function of CHM15k ceilometers, Atmos. Meas. Tech., 9, 2947–2959, https://doi.org/10.5194/amt-9-2947-2016, 2016
- Kotthaus, S.; Haeffelin, M.; Drouin, M.-A.; Dupont, J.-C.; Grimmond, S.; Haefele, A.; Hervo, M.; Poltera, Y.; Wiegner, M. Tailored Algorithms for the Detection of the Atmospheric Boundary Layer Height from Common Automatic Lidars and Ceilometers (ALC). Remote Sens. 2020, 12, 3259. https://doi.org/10.3390/rs12193259, 2020
- Wiegner, M., Madonna, F., Binietoglou, I., Forkel, R., Gasteiger, J., Geiß, A., Pappalardo, G., Schäfer, K., and Thomas, W.: What is the benefit of ceilometers for aerosol remote sensing? An answer from EARLINET, Atmos. Meas. Tech., 7, 1979–1997, https://doi.org/10.5194/amt-7-1979-2014, 2014

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