ALICEnet
Automated LIdar-CEilometer network

The Alicenet Lidar Ceilometer Network: retrievals and long-term analyses of aerosol vertical profiles across Italy

Annachiara Bellini(1,2,*),Henri Diémoz(3), Luca Di Liberto(1), Alessandro Bracci(1), Gian Paolo Gobbi(1), Francesca Barnaba(1)
1-National Research Council-Institute of Atmospheric Science and Climate, CNR-ISAC, Rome, Italy
2-University 'La Sapienza', DIET, Rome, Italy; 3- ARPA Valle d'Aosta, Saint-Christophe, Italy *a.bellini@isac.cnr.it

Alicenet network

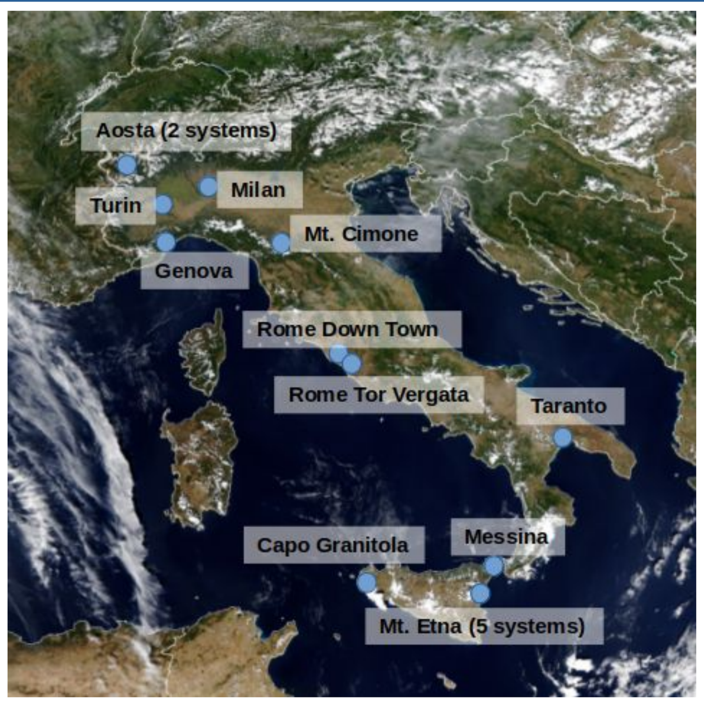

FIG.1: Alicenet network

Alicenet is the Italian network of Automated Lidar-Ceilometers (ALCs), active remote sensing instruments operationally (24/7) monitoring aerosol vertical profiles and clouds. It is a growing consortium coordinated by CNR-ISAC and involving different institutions. It also contributes to the European E-PROFILE program run by EUMETNET. The network (**FIG. 1**) extends from North to Southern Italy, thus covering a wide range of atmospheric and environmental conditions within the Mediterranean area. Alicenet data can be visualized in near real time on a dedicated web site (https://www.alice-net.eu/), and allow to study 4D atmospheric processes at different time (from minutes to years) and spatial (from local to regional/ national) scales.

Retrieval of Geophysical information

Alicenet has an homogeneous, automatic and centralized data processing performed at CNR-ISAC. The processing chain (**FIG. 2**) includes signal corrections, cloud screening and calibration procedures, followed by the quantitative retrieval of aerosol properties (optical properties, volume and mass concentration profiles) and aerosol layering (layer identification and associated loads). More details on the retrieval procedures and capabilities of Alicenet can be found in [1], [2], [3], [4], [5], [6].

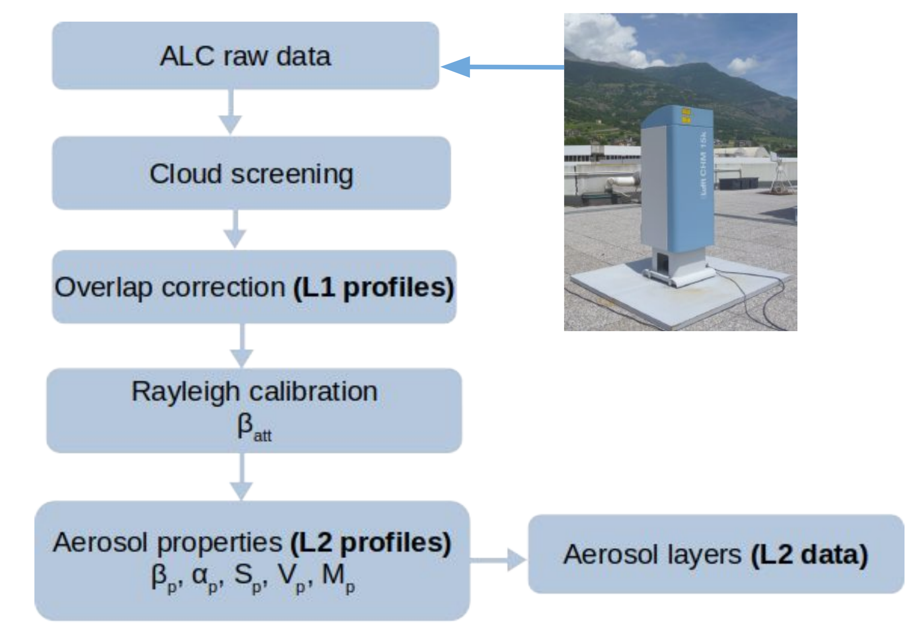

FIG. 2: Alicenet processing chain

Results

Examples of results from the analysis of the fully re-processed **7-year** (2016-2022) ALC dataset of **4 selected Alicenet stations** are shown here: **Aosta**, representative of an Alpine environment; two major urban centers, **Milan** within the Po valley, and **Rome**, in Central Italy; **Messina**, a maritime site in Sicily. ALC data have been also complemented by in-situ meteorological measurements (e.g., wind, RH, TKE) and modelled data (ERA5 [7], MERIDA [8]). The exploited Alicenet-derived information is grouped as follows:

(A) aerosol properties along the profile on the short- and long- term
(B) identification of aerosol layering on a daily or long-term scale (both near the surface **(B.1)** and in the middle-upper troposphere **(B.2)**)
(C) interplay of aerosol particles and meteorological parameters (wind and turbulence, humidity, radiation...)

ALICEnet Partners

Rome

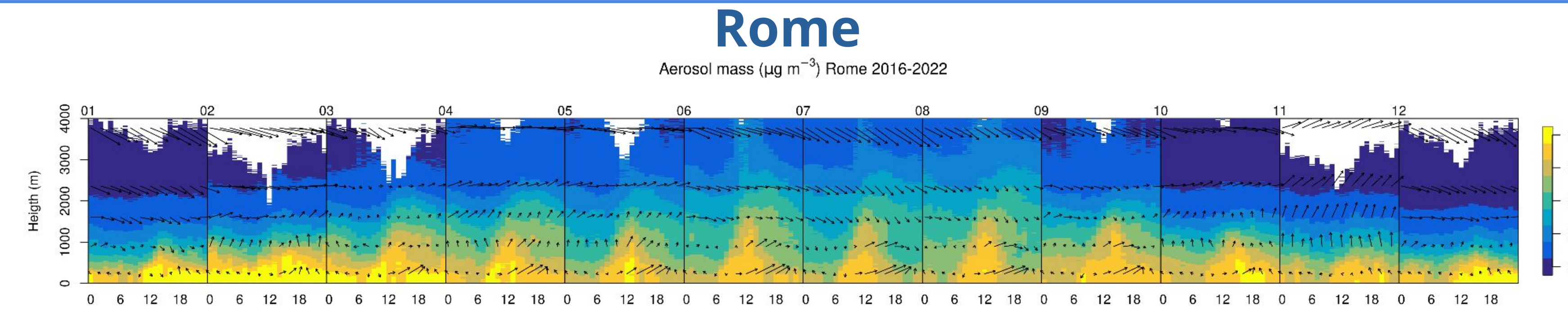

FIG.3: (A&C) Long-term (2016-2022) statistics of the monthly-resolved daily cycle of Alicenet-derived aerosol mass and wind (ERA5) vertical profiles over Rome. The evolution of the mixed aerosol layer, disturbed by sea-land breezes, is visible near the surface, while above the aerosol transport is dominated by mesoscale recirculation and synoptic flows.

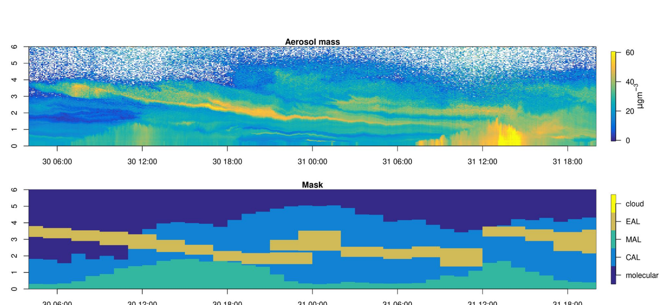

FIG.4: (A&B) TOP: aerosol mass profiles during a case of long-range transport of Saharan dust and fire plumes over Rome (30-31/07/2017). BOTTOM: corresponding aerosol layer mask: aerosol free (blue), low aerosol (Continuous Aerosol Layer, CAL, light blue), Mixed Aerosol Layer (MAL, green), Elevated Aerosol Layer (brown).

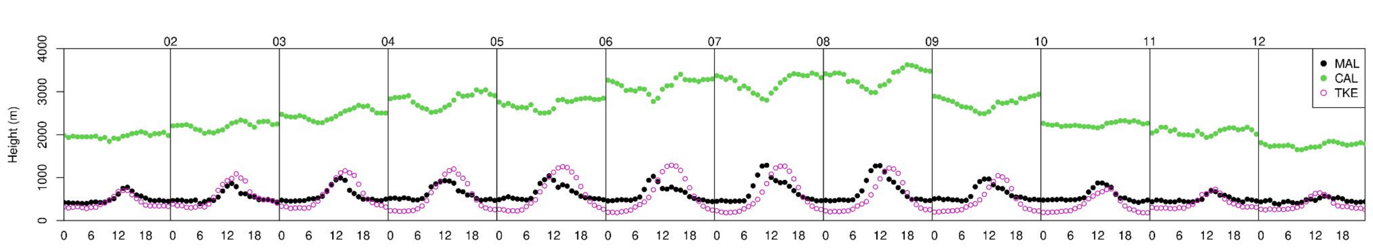

FIG.5: (B.1&C) Long-term (2016-2022) statistics of the monthly-resolved daily cycle of Alicenet-derived CAL and MAL, this latter compared with the same statistics of TKE, derived from a co-located ultrasonic anemometer.

Milan

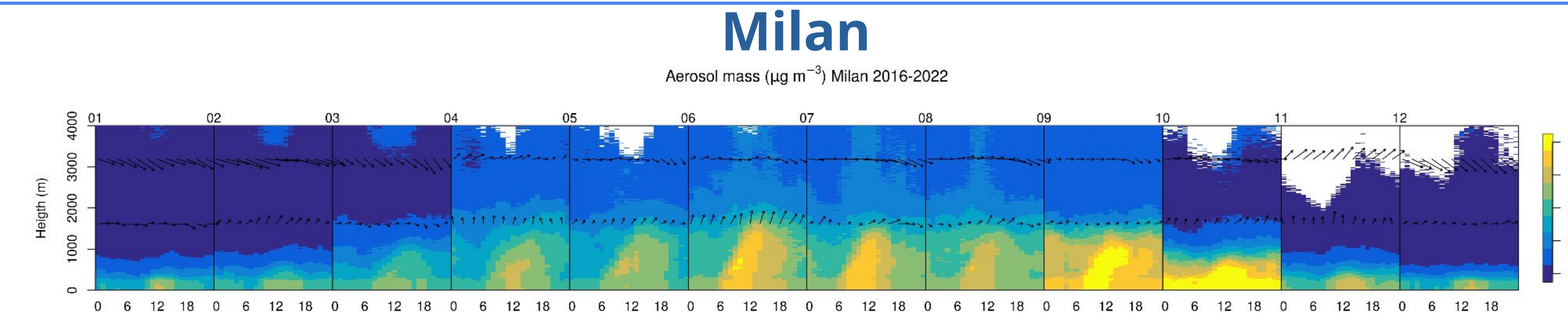

FIG. 6: (A&C) as in Fig. 3 but for Milan; wind vertical profiles are from MERIDA. The variability near the surface is influenced by turbulence and mesoscale circulations.

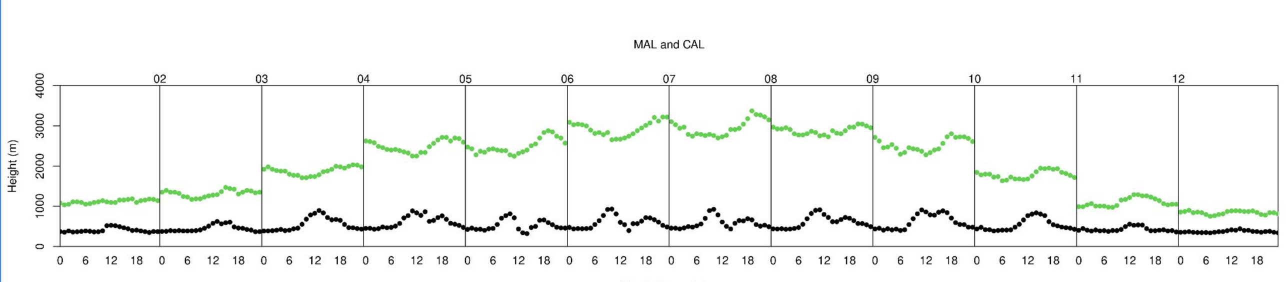

FIG. 7: (B.1) as in Fig. 5 but for Milan**.** The plain - mountain breezes remove boundary layer particles in the afternoon.

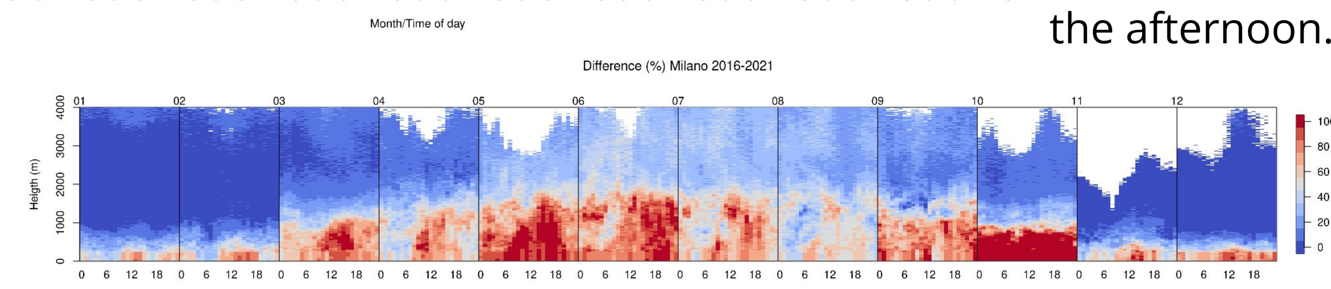

FIG. 8: (A&C) Estimated difference (%) between the Alicenet aerosol mass (ambient conditions) and the equivalent dry aerosol mass (as measured by e.g. PM in situ samplers).

Messina

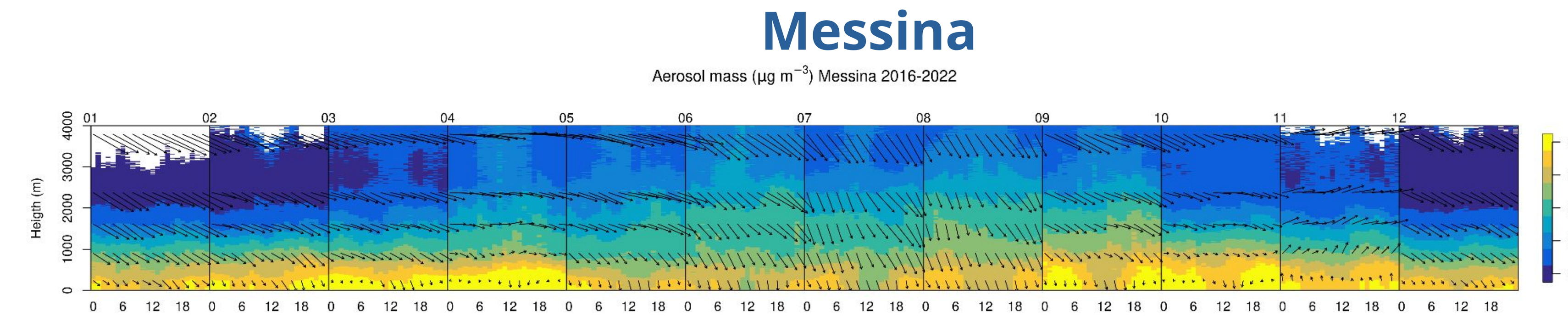

FIG. 9: (A&C) as in Fig. 3 but for Messina. Aerosols are confined within the thin maritime boundary layer. Above aerosols variability is dominated by long-range transport from S-SW.

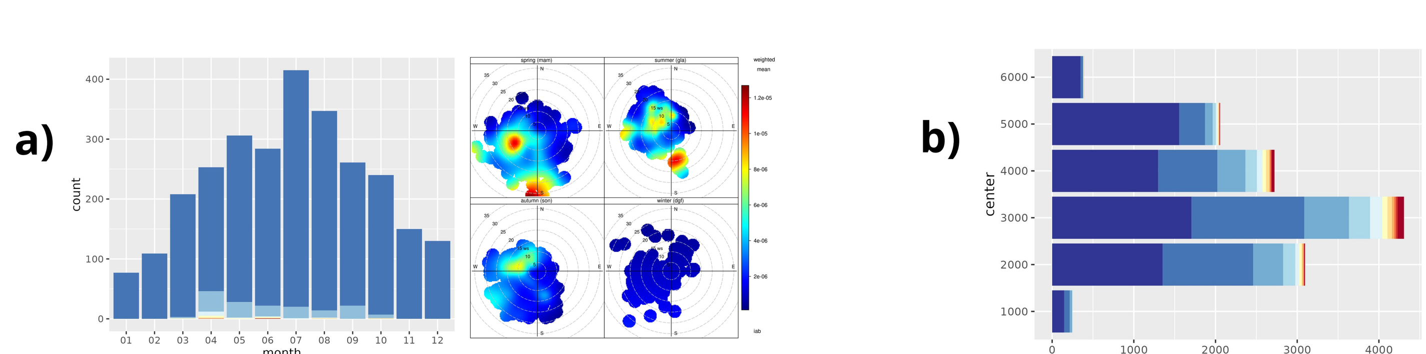

FIG.10: (B.2&C) Long-term (2016-2022) aerosol layer statistics: **a)** annual distribution of the occurrence of the elevated (2-to-5 km a.s.l.) aerosol layers over Messina, with corresponding seasonal polar plot of wind at 700 hPa (ERA5); **b)** vertical distribution of the elevated (1-to-6 km a.s.l.) aerosol layers. The colors (from red to blue) relate to aerosol loads.

Aosta

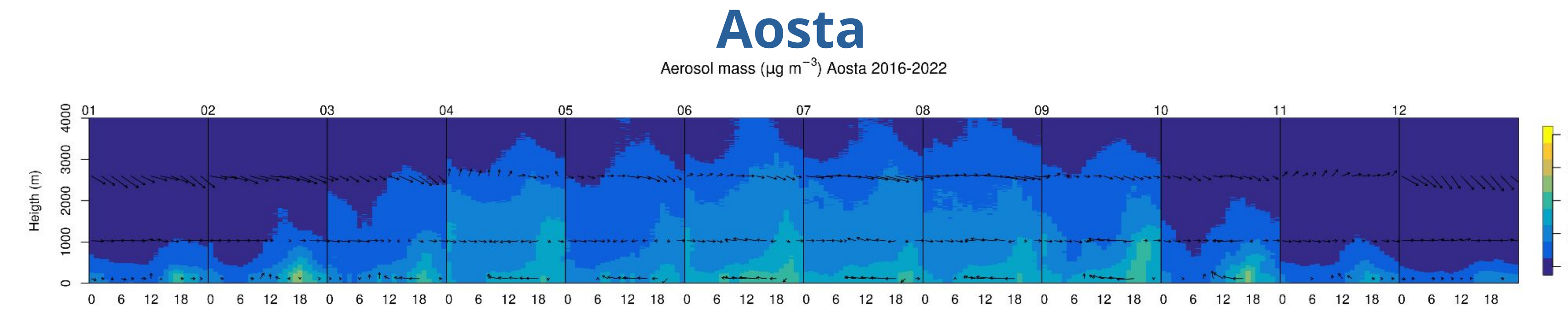

FIG. 11: (A&C) As in Fig. 3 but for Aosta; wind vertical profiles are from MERIDA plus surface measurements**.** The aerosol load in the lower troposphere is influenced by plain-mountain breezes from E-SE, by mountain venting and synoptic flows (crossing the Alps from W-SW) in the middle-upper troposphere.

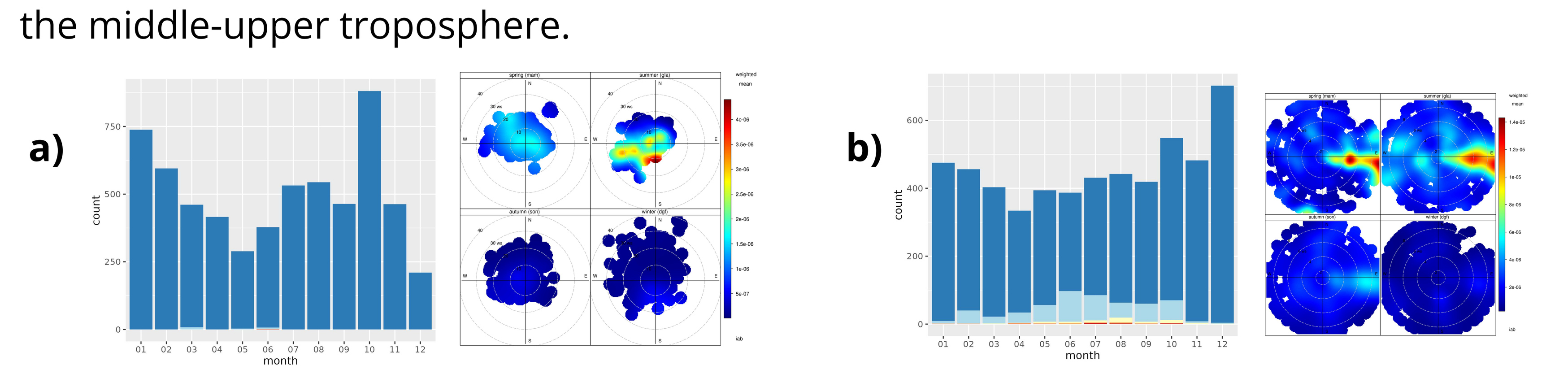

FIG.12: (B.2&C) Long-term (2016-2022) aerosol layer statistics: annual distribution of the occurrence of **a)** high level (3-to-7 km a.s.l.) and **b)** low level (1-to-3 km a.s.l.) aerosol layers, with corresponding seasonal polar plot of wind at 600 hPa (Novara Cameri soundings) and at the surface (co-located anemometer of ARPA Valle d'Aosta). The colors (from red to blue) relate to aerosol loads.

Summary

Alicenet provides continuous (24/7) monitoring of aerosol vertical profiles and cloud layers across the country. A centralized data processing collects and analyses the data. Level 0 aerosol data are currently visualized in near-real time on the Alicenet webpage. Taylored inversion algorithms also provide geophysical quantities (L1 and L2 data) for a 4D understanding of aerosol-related atmospheric processes at different spatio-temporal scales, with applications in air quality/human health, meteorology, aviation safety, solar energy production.

Acknowledgments

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[7] https://doi.org/10.24381/cds.bd0915c6 **[8] Bonanno et al., 2019** https://doi.org/10.1002/qj.3530