Long-Term Changes of Optical Properties of Mineral Dust And Its Mixtures Derived From Raman Polarization Water Vapor Lidar in Central Europe

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03. Atmospheric aerosol and clouds properties

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Poster P21

The 30th International Laser Radar Conference (ILRC) virtual conference, June 26th – July 1st, 2022.

→ The Earth's climate and its changes are one of the hot topics in nowadays science.

How and how fast is the climate changing?
Do the climate changes affect the aerosol loading within the atmosphere?
Are there any changes in the aerosol-climate feedback observed?

→ Desert dust – one of the major natural aerosols – was investigated over Warsaw (Central Europe).

→ Unique database of lidar-derived optical properties of mineral dust and its mixtures was derived and analyzed.

Figure 1: *Polly^{XT} lidar in the RS-Lab station in Warsaw, Poland. (photo: I. Stachlewska)*

Methodology

- Polly^{XT} lidar at the RS-Lab Warsaw, Poland (52.21 °N, 20.98 °E, 96 m a.s.l.) conducts 24h/7 automatic measurements at 1064, 532, and 355 nm (elastic), 532 and 355nm (elastic cross), 607 and 387 nm (Raman N_2) and 407 nm (Raman H_2O, Engelmann et al. 2016).
- Data between July 2013 and December 2020 were examined for long-range transport of mineral dust (high depolarization in the free troposphere and raised air temperatures).
- Mineral dust inflows identification based on models: backward trajectory model - HYSPLIT, mineral dust prediction model - BSC-DREAM8b, and aerosol prediction model - NAAPS.
- Data analyzed using the classical Raman approach, which enables obtaining the full sets of optical properties ($3\beta+2\alpha+2\delta$).

(*more details in Szczepanik et al. 2021*)

- Our study revealed **20 independent episodes** of mineral dust in free troposphere over Warsaw.
- For the identified cases, we obtained **120 sets of profiles** containing at least particle backscattering and depolarization.
- Three groups were classified: **pure mineral dust (MD), mineral dust with sulfates (MD+S), and mineral dust with biomass burning aerosols (MD+BB).**

In Warsaw, the δ values for clean mineral dust are lower than for the dust observed close to the source (*Mamouri & Ansmann, 2014*).

The mixed in additional aerosol affects the optical properties of mineral dust:

→ **sulfate's presence** slightly lowers values of all properties;

→ **Biomass burning** admixture increases α values significantly, while δ values are the lowest;

→ The amount of the additive may also play a role here, but it is hard to estimate it.

Table 1. *Average values of optical properties and layer height for: pure desert dust (MD) and its mixtures with sulfates (MD+S) and with aerosol originating from biomass combustion (MD+BB) observed over Warsaw in 2013-2020.*

Parameter	MD	MD+S	MD+BB
β 355 nm [$Mm^{-1}sr^{-1}$]	1.60 ± 0.76	1.32 ± 0.92	3.16 ± 0.85
β 532 nm [$Mm^{-1}sr^{-1}$]	1.22 ± 0.50	0.93 ± 0.53	1.80 ± 0.80
β 1064 nm [$Mm^{-1}sr^{-1}$]	0.82 ± 0.49	0.45 ± 0.31	1.08 ± 0.57
α 355 nm [Mm^{-1}]	69 ± 29	78 ± 41	248 ± 73
α 532 nm [Mm^{-1}]	48 ± 16	49 ± 28	173 ± 85
δ 355 nm [%]	10.53 ± 3.86	6.77 ± 2.99	2.23 ± 0.83
δ 532 nm [%]	15.46 ± 5.49	10.79 ± 3.22	4.49 ± 2.16

Frequency of dust occurences and its lenght analysis

- The number of dust inflows over Warsaw is increasing from 1-2 episodes per year before 2017 to even 6 cases in 2019;
- The length of the observed dust inflow is getting longer starting from 2016, reaching up to 36 h of mineral dust observations per event.

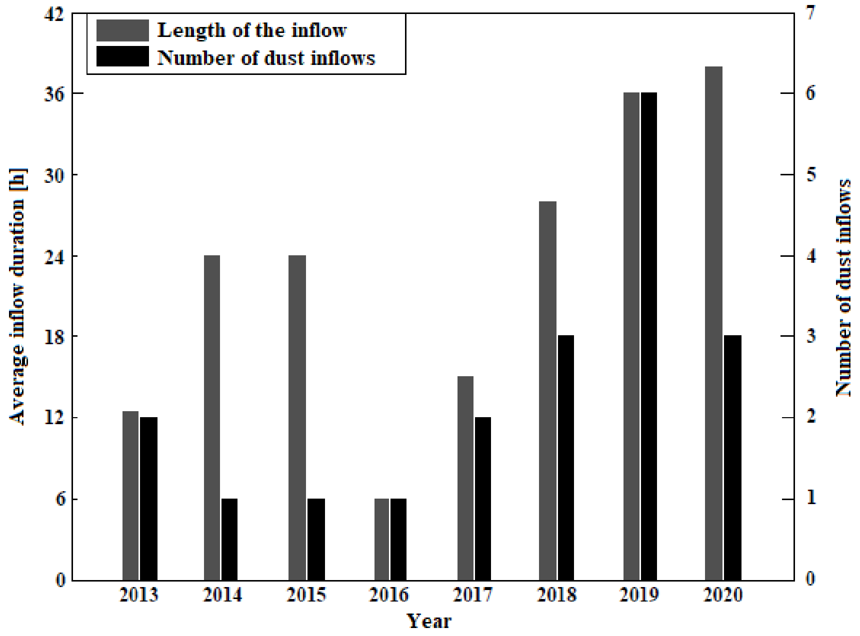

Figure 2: Histogram showing the number of inflows and their average duration for the identified episodes of the desert dust inflow over Warsaw.

Tracking the stage of inflow evolution

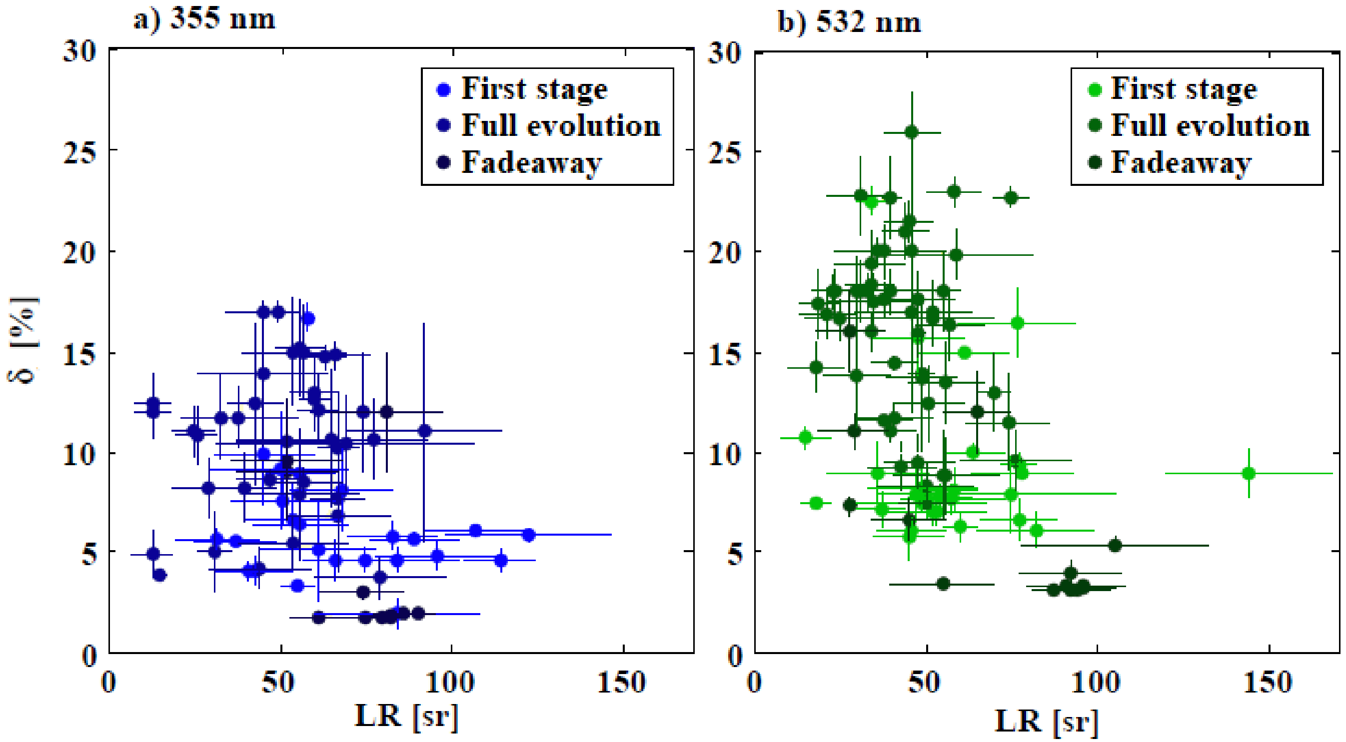

Figure 3: Values of δ and LR for 355 nm (left) and 532 nm (right) depending on dust inflow evolution (number of points is 83 for 355nm; 120 for 532nm).

- The highest δ values are during the full evolution of the dust inflow, while the lowest is for the fadeaway phase.
- Some outlying points stand for the cases of observation of a mixture of dust with another aerosol.

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