Long term analysis of aerosol optical properties and dominant types over Europe

-Aerosol typing-

G. Ciocan [1,2], A. Nemuc[1] , D. Nicolae[1]

[1]National Institute of Research and Development for Optoelectronics INOE 2000, Magurele, 077125, Romania

[2] Faculty of Physics, University of Bucharest, Magurele, 077125, Romania

Presenting author email: gabriela.ciocan@inoe.ro

Contents

- Introduction
- Clustering
- Fingerprints
- Conclusions

Introduction

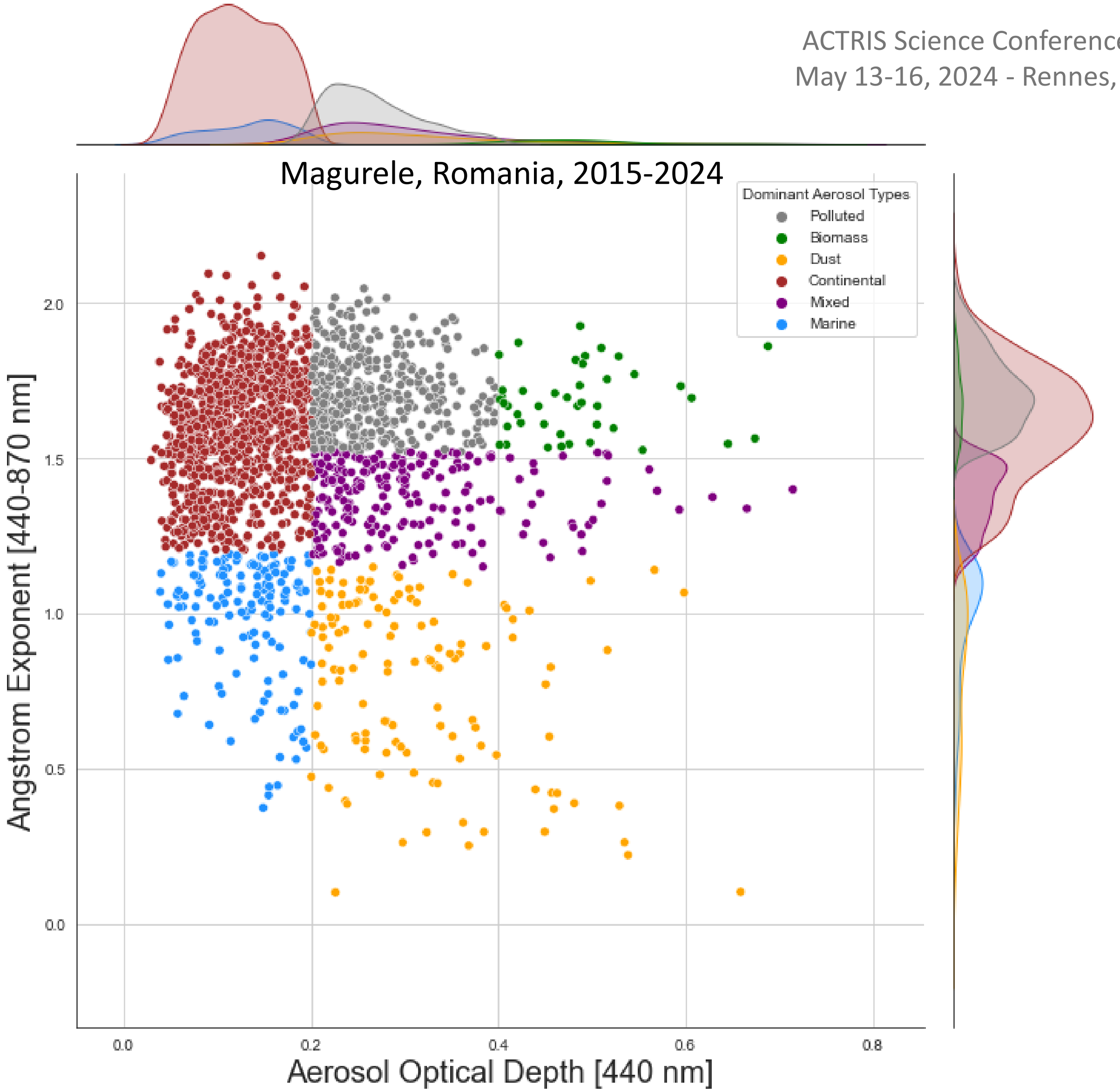
- Main objective
  - Comprehensive view of dominant aerosols across Europe
- Motivation
  - Different aerosols impact our lives in different ways
- Data set
  - AERONET level 1.5 daily averages of both direct and inverse sunphotometer products
  - More than 5 years of continuous data
- Number of countries & sites
  - 27 countries
  - 30 sites

Clustering

Method 1

Dubovik et. al (2002)[1]
Toledano et. al (2007)[2]

Aerosol Type	AE [440-870] nm	AOD 440 nm
Marine	<1.2	<0.2
Dust	<1.15	>0.2
Continental	>1.2	<0.2
Mixed	1.15< - <1.52	>0.2
Polluted	>1.52	0.2< - < 0.4
Biomass Burning	>1.52	>0.4



[1]*Dubovik, O., Holben, B., Eck, T. F., Smirnov, A., Kaufman, Y. J., King, M. D., Tanré, D., & Slutsker, I. (2002). Variability of Absorption and Optical Properties of Key Aerosol Types Observed in Worldwide Locations. Journal of the Atmospheric Sciences, 59(3), 590-608.* https://doi.org/10.1175/1520-0469(2002)059<0590:VOAAOP>2.0.CO;2

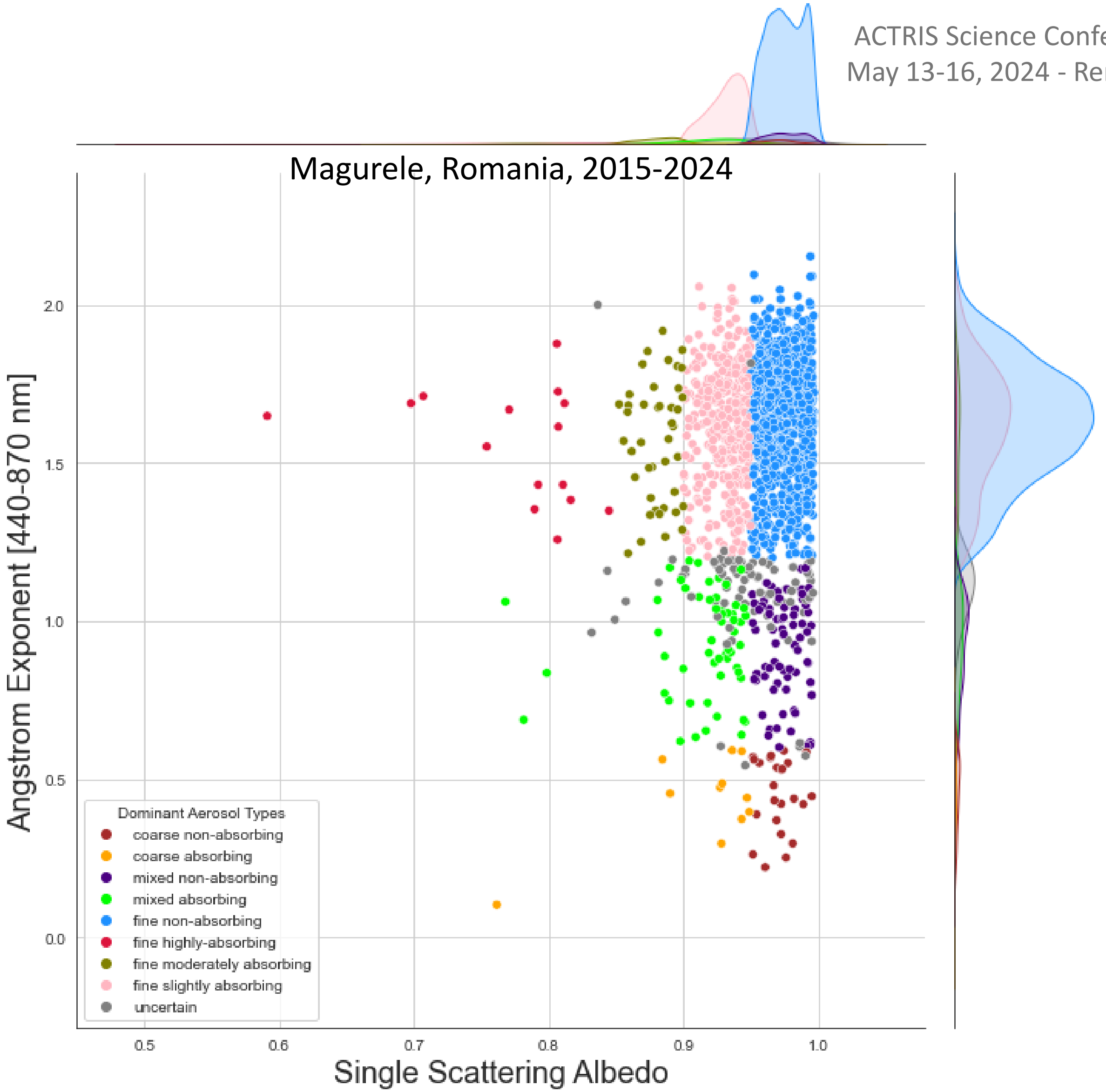
[2]*Toledano, C. & Cachorro, Victoria & Berjón, Alberto & Frutos Baraja, A. & Sorribas, Mar & Morena, Benito & Goloub, P. Aerosol optical depth and Ångström exponent climatology at El Arenosillo AERONET site (Huelva, Spain). Quarterly Journal of the Royal Meteorological Society. 133. 795 - 807. 10.1002/qj.54. (2007).*

Clustering

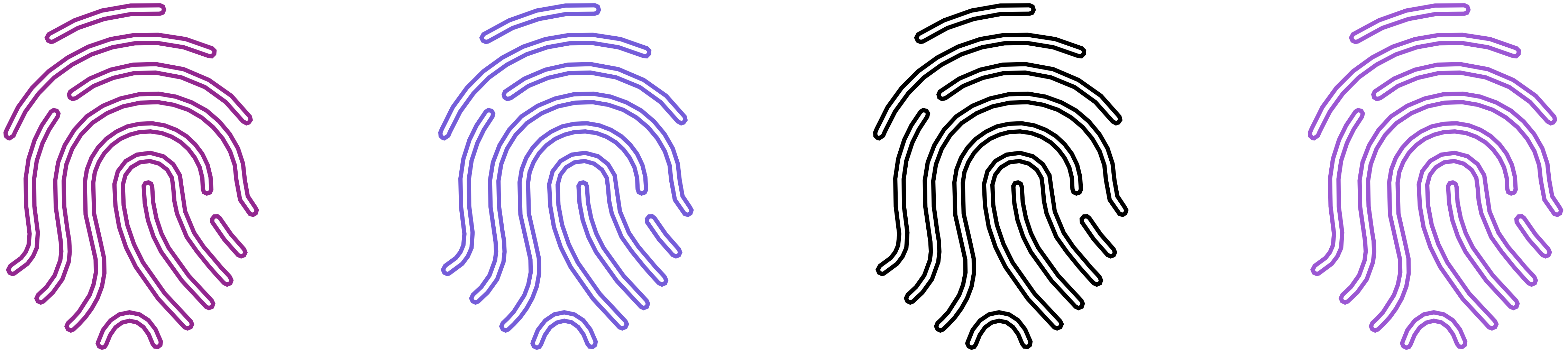
Method 2

Lee et. al (2010)[3]

Aerosol Type	SSA 440 nm	FMF 500 nm	AE [440-870 nm]
Coarse non-absorbing	>0.95	≤ 0.4	≤ 0.6
Coarse absorbing	≤ 0.95	≤ 0.4	≤ 0.6
Mixed non-absorbing	> 0.95	0.4 ≤ - < 0.6	0.6 ≤ - < 1.2
Mixed absorbing	≤0.95	0.4 ≤ - < 0.6	0.6 ≤ - < 1.2
Fine non-absorbing	> 0.95	> 0.6	> 1.2
Fine highly-absorbing	≤0.85	> 0.6	> 1.2
Fine moderately -absorbing	0.85 ≤ - <0.9	> 0.6	> 1.2
Fine slightly-absorbing	0.9 ≤ - 0.95	> 0.6	> 1.2



[3] *Lee, Jaidan & Kim, Jhoon & Song, C.H. & Kim, S.B. & Chun, Y. & Sohn, B.J. & Holben, Brent. (2010). Characteristics of aerosol types from AERONET sunphotometer measurements. Atmospheric Environment. 44. 3110-3117. 10.1016/j.atmosenv.2010.05.035.*

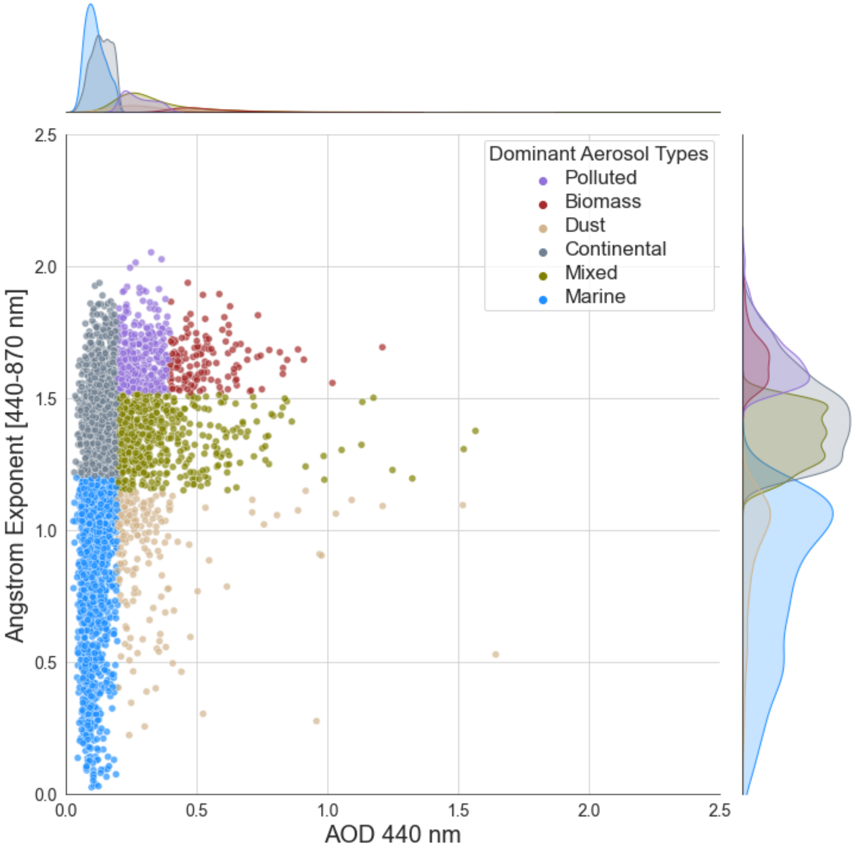


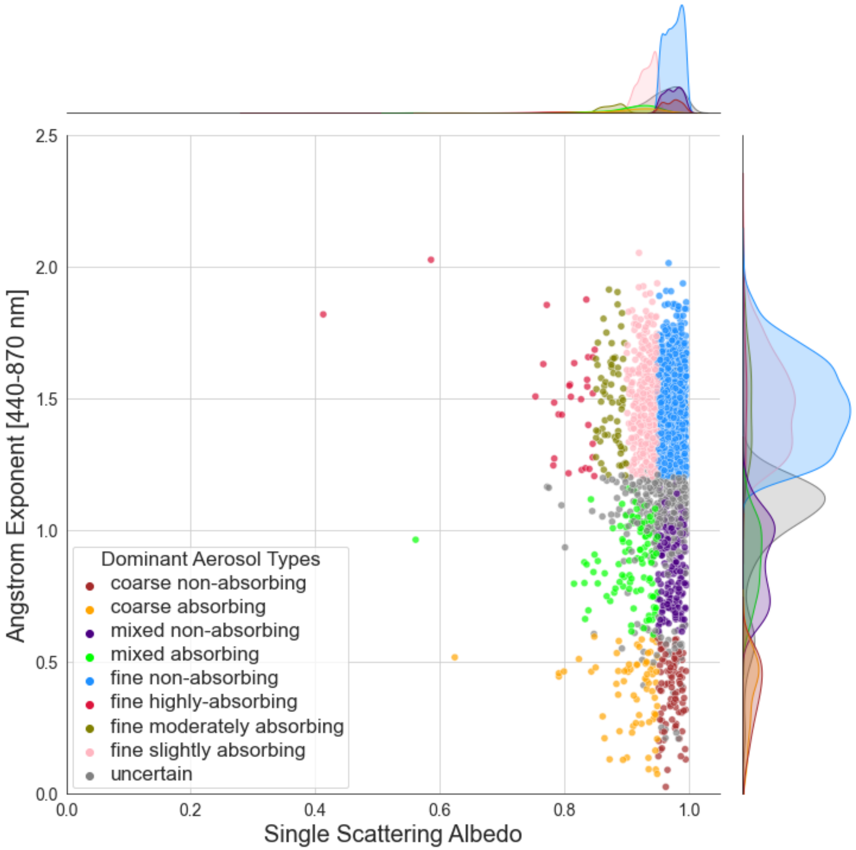
Fingerprints

Aerosol typing from passive remote sensing measurements

Costal sites

- Tight clusters for low values of AOD
- Tight clusters of mixed and coarse non-absorbing aerosols
- Dispersed cluster of other types
- Top or bottom heavy distribution according to the first representation depending on the location of the site

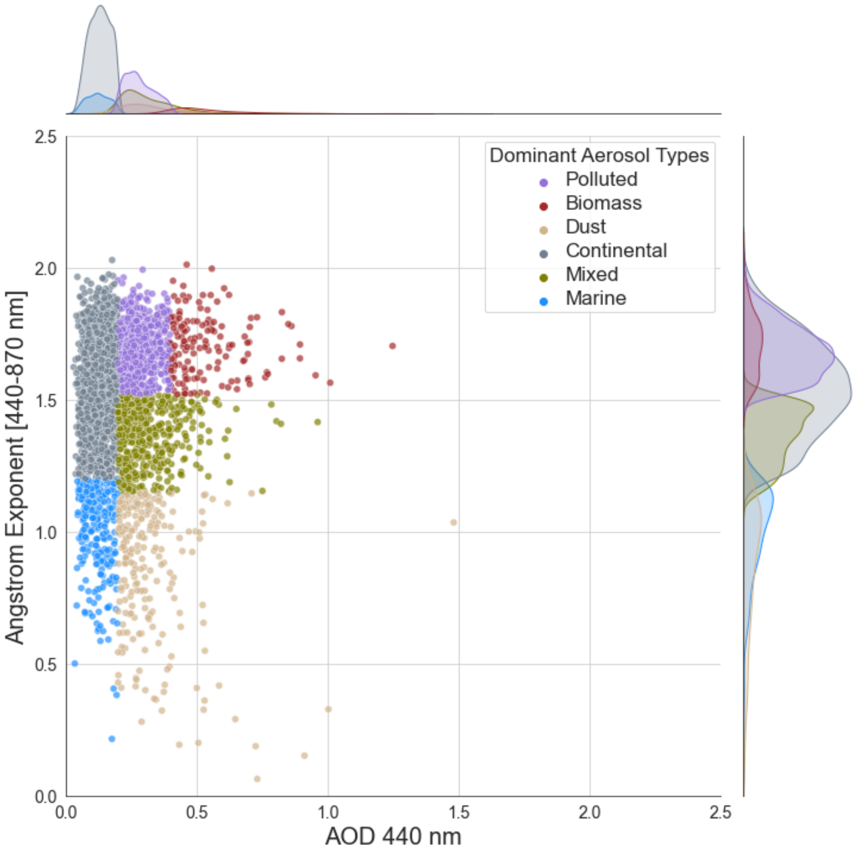


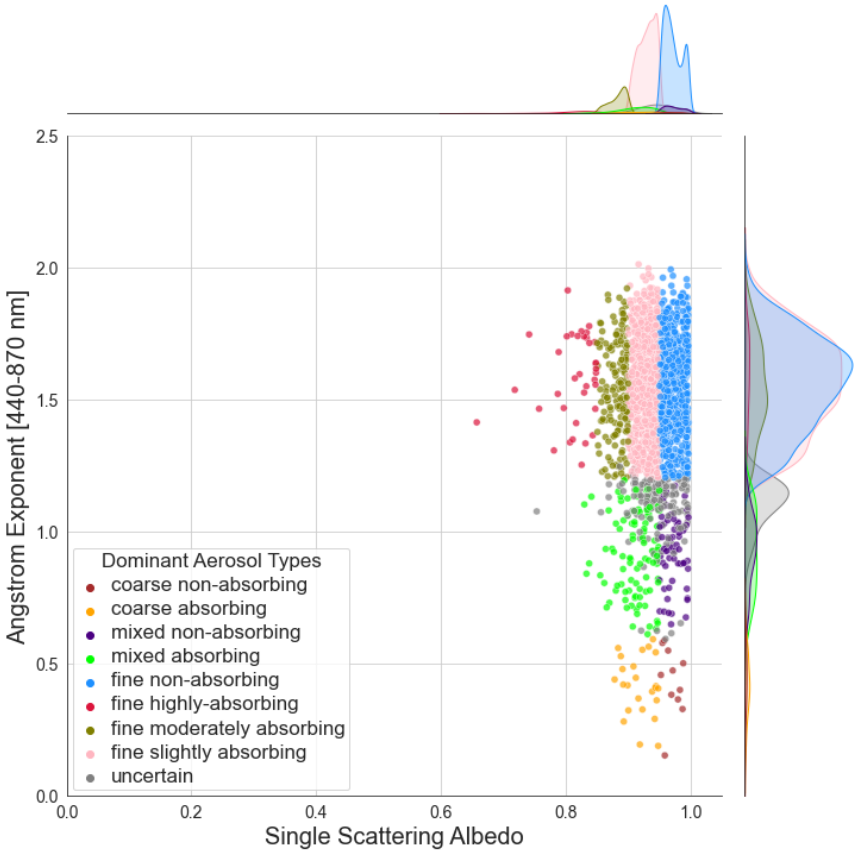


Method 1	
Marine	34%
Continental	30%
Mixed	17%
Polluted	10%
Dust	6%
Biomass	4%
Method 2	
uncertain	53%
fine non-absorbing	21%
mixed non-absorbing	10%
coarse non-absorbing	5%
fine slightly absorbing	3%
mixed absorbing	3%
coarse absorbing	2%
fine moderately absorbing	2%
fine highly-absorbing	1%

Inland sites

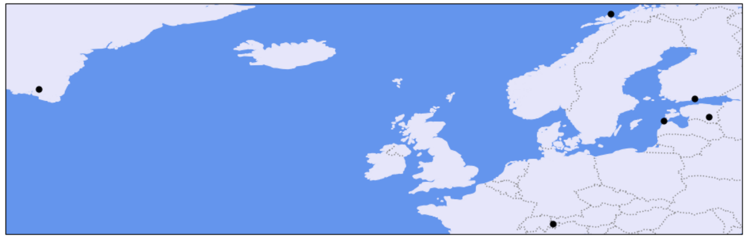
- Tight clustering for the continental, polluted and mixed aerosol types
- Dispersed marine and dust of low angstrom exponent
- Tight clustering around low AOD and angstrom exponent of biomass
- Tight clustering of fine slightly and non-absorbing aerosols



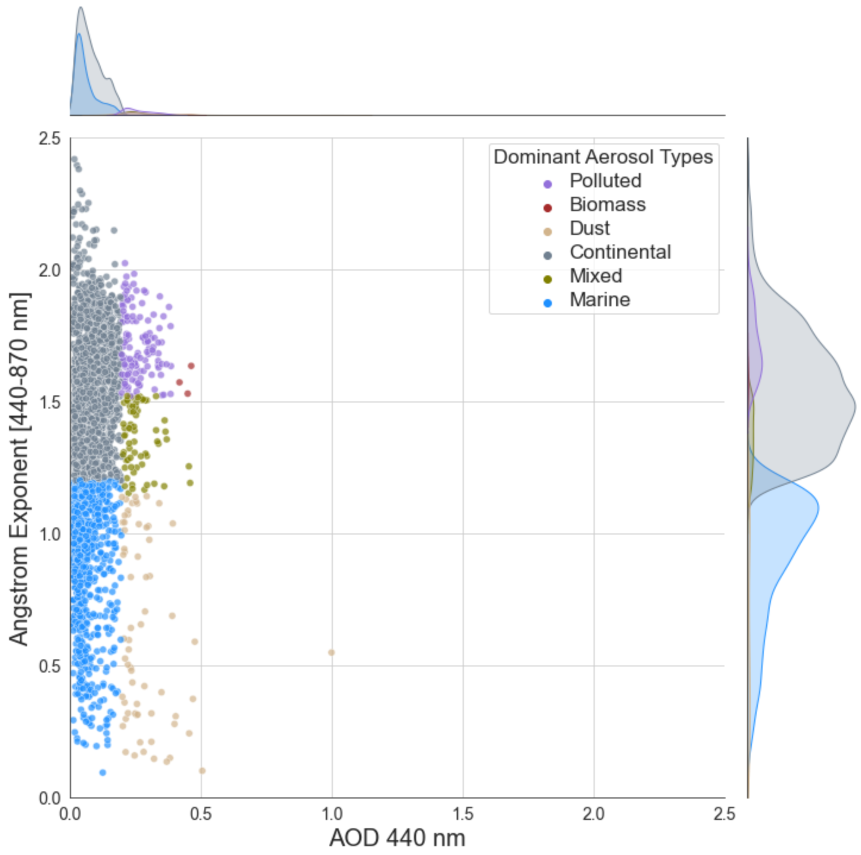


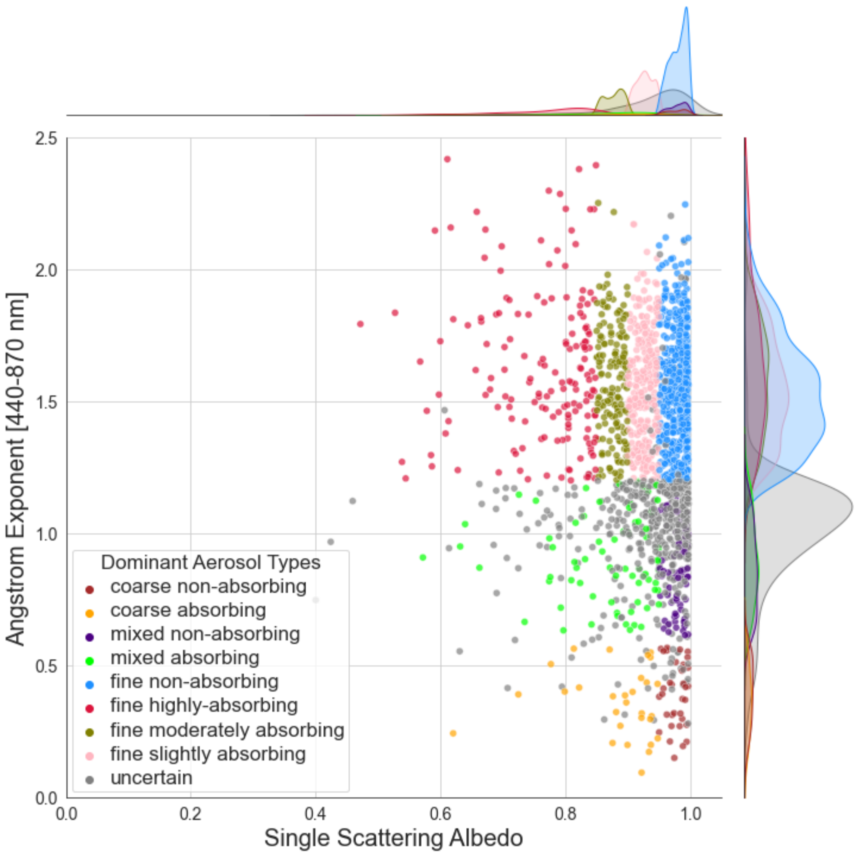
Method 1	
Continental	44%
Polluted	20%
Mixed	15%
Marine	8%
Dust	7%
Biomass	5%
Method 2	
uncertain	33%
fine slightly absorbing	27%
fine non-absorbing	26%
fine moderately absorbing	6%
mixed absorbing	3%
mixed non-absorbing	2%
fine highly-absorbing	1%
coarse absorbing	1%
coarse non-absorbing	0%

Cold region sites



- Highest contribution comes from low AOD and high Angstrom Exponent marine aerosols, together with low AOD and Angstrom Exponent continental aerosols
- Very dispersed clusters

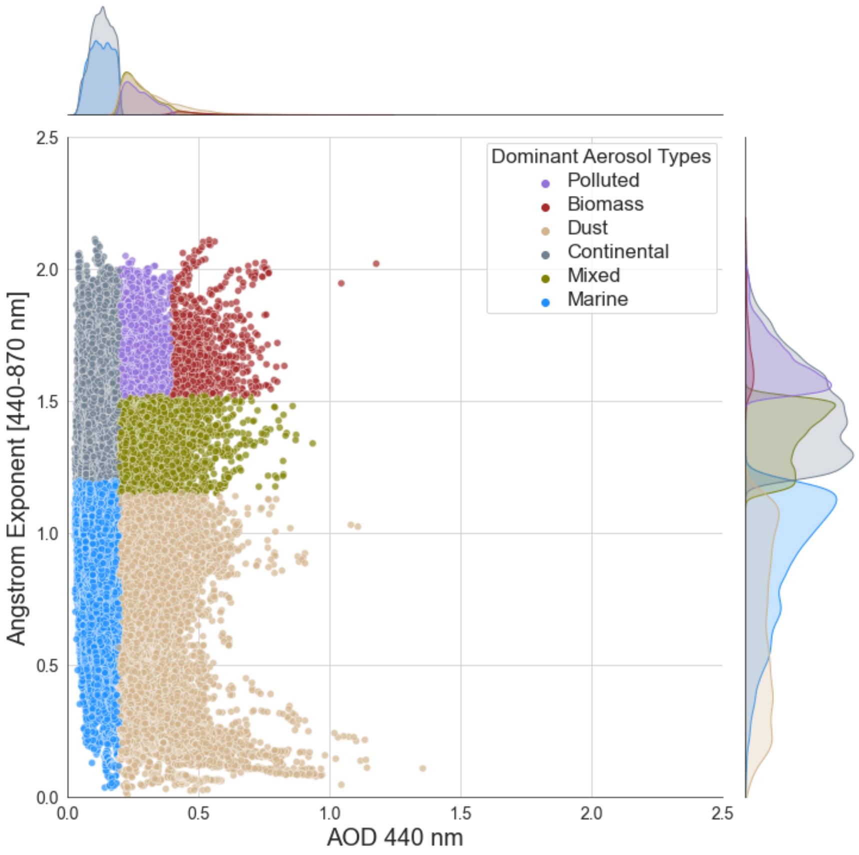


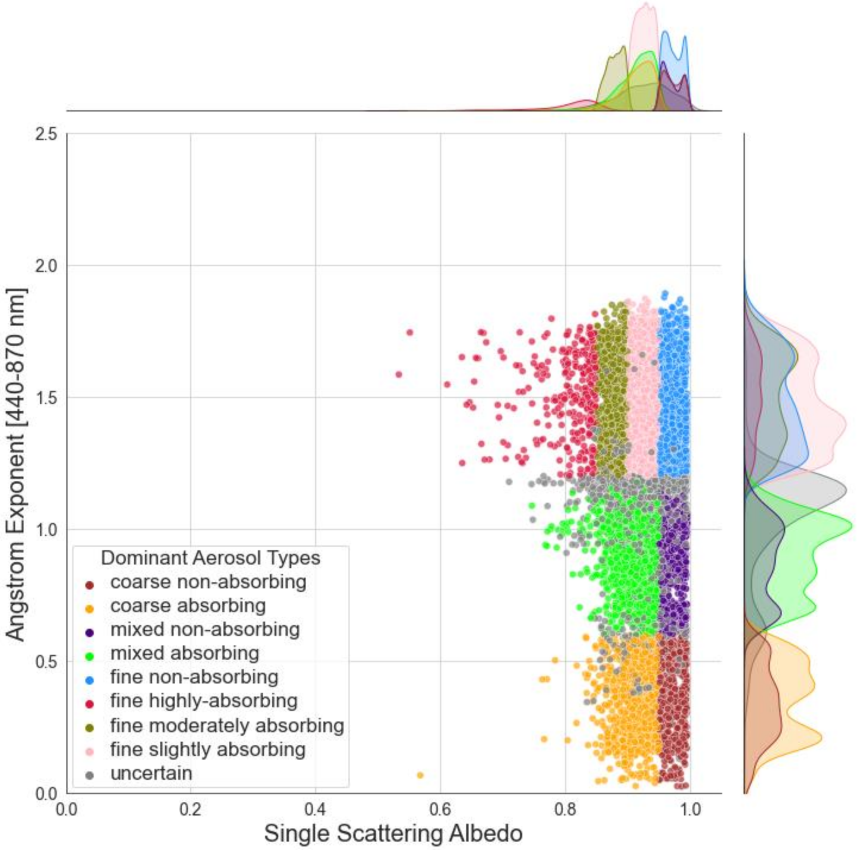


Method 1	
Continental	60%
Marine	31%
Polluted	4%
Dust	2%
Mixed	2%
Biomass	0%
Method 2	
uncertain	55%
fine non-absorbing	17%
fine slightly absorbing	10%
fine highly-absorbing	6%
fine moderately absorbing	6%
mixed non-absorbing	2%
mixed absorbing	2%
coarse non-absorbing	1%
coarse absorbing	1%

Sea-Centered Sites

- Tight clustering overall
- Flat distribution of dust in regards with the angstrom exponent





Method 1	
Continental	32%
Marine	25%
Dust	17%
Mixed	14%
Polluted	10%
Biomass	1%
Method 2	
uncertain	23%
fine slightly absorbing	17%
mixed absorbing	14%
fine non-absorbing	14%
coarse absorbing	11%
fine moderately absorbing	7%
mixed non-absorbing	7%
coarse non-absorbing	4%
fine highly-absorbing	3%

Conclusions

Analysis of aerosol optical properties and dominant types over Europe using passive remote sensing measurements

- **Dominance of Continental and Fine Non-Absorbing Aerosols**
  - Across all sites, the highest percentage of aerosols observed were Continental and Fine Non-Absorbing types
- **Differential Impact on Sea-Centered and Cold Regions Sites**
  - Sea-centered sites demonstrated a pronounced susceptibility to various aerosol types, contrasting starkly with cold region sites that exhibited minimal presence of aerosols other than Continental, Marine, and Fine Non-Absorbing varieties.
- **Similar Distribution in Inland and Coastal Sites**
  - Inland and coastal sites exhibited comparable aerosol distributions, with coastal sites notably characterized by a higher prevalence of Low Aerosol Optical Depth (AOD) and Angstrom Exponent Marine Aerosols
- **Future plans**
  - To investigate worldwide and also seasonal using the same methodology for aerosol characterization
  - To introduce lidar aerosol typing for the analysis of some of the sites

Thank you for your attention!

gabriela.ciocan@inoe.ro

This work is part of a project that is supported by the European Commission under the Horizon 2020 – Research and Innovation Framework Programme, through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004, by the Core Program within the National Research Development and Innovation Plan 2022- 2027, carried out with the support of MCID, project no. PN 23 05 and through Program 1- Development of the national research development system, Subprogram 1.2 - Institutional performance - Projects to finance the excellent RDI, Contract no.18PFE/30.12.2021,

We thank all AERONET PI investigators and their staff for establishing and maintaining all sites used in this investigation.

Authors acknowledge AERONET-Europe/ACTRIS for calibration and maintenance services.

The main author received financial support (ITC conference grant) from the COST (European Cooperation in Science and Technology) under the Action CA21119 HARMONIA (International network for harmonization of atmospheric aerosol retrievals from ground-based photometers).

COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

Funded by the European Union

EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY