On the discrimination between volcanic ash and desert dust leveraging photometer and depolarization lidar measurements

N. Papagiannopoulos, L. Mona, A. Amodeo, G. D'Amico, B. De Rosa, P. Gumà Claramunt, M. Mytilinaios, C.A Papanikolaou

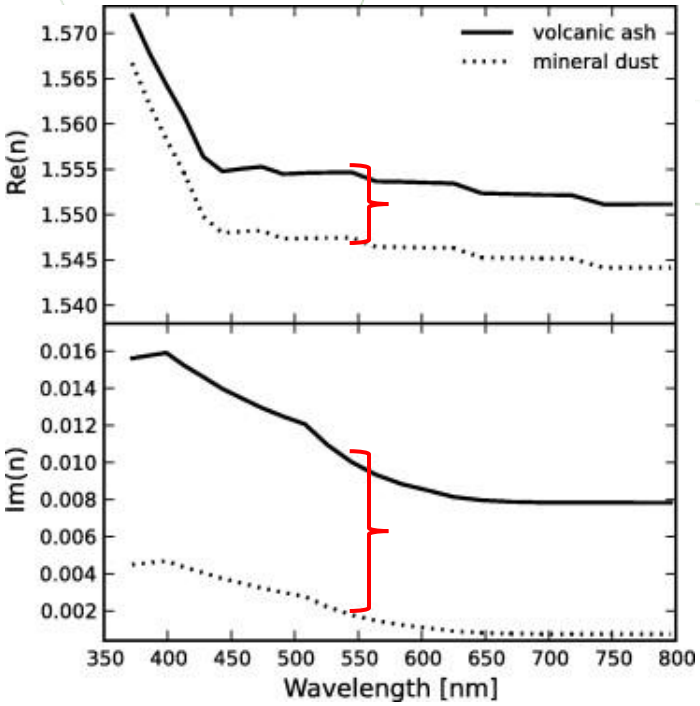
Consiglio Nazionale delle Ricerche | imaa ISTITUTO DI METODOLOGIE PER L'ANALISI AMBIENTALE

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 "Education and Research" - Component 2: "From research to business" - Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"

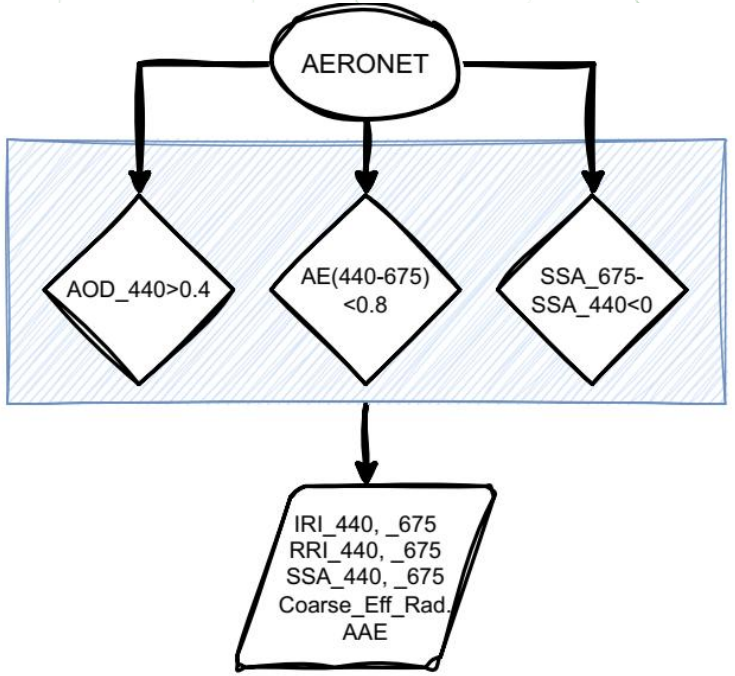
Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani

Motivation

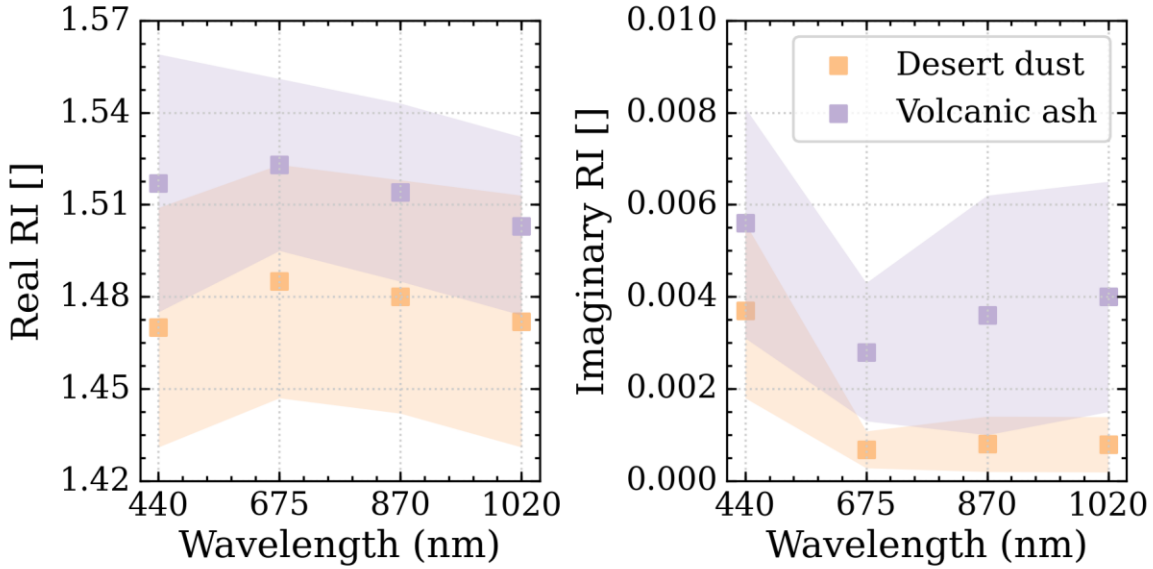
- Volcanic ash and desert dust are **non-spherical**, **coarse-mode** aerosols (e.g. Ansmann et al., 2011)
- Several studies discuss **slight differences** in particle depolarization ratio and lidar ratio among these two aerosol types
- It is therefore **challenging** for lidar-based aerosol typing to separate volcanic ash from desert dust
- Conversely, **microphysical properties** of volcanic ash and desert dust are shown to have significant differences.
- Weinzierl et al. (2012) showed a marked difference in the **complex refractive index** using airborne in situ



What does AERONET show?



- AERONET's global coverage and data quality allows for the compilation of a curated dataset of microphysical properties
- Standard filtering techniques were followed to identify ash/dust



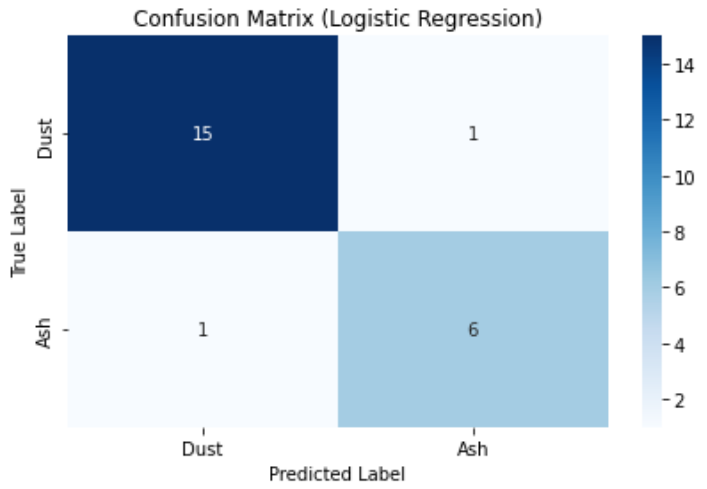
- **Volcanic ash:** 79 instances during the eruptions of Eyjafjallajokull in 2010 and La Palma 2021 were used
- **Desert dust:** 34 instances from the station of Potenza for the years 2017-2022

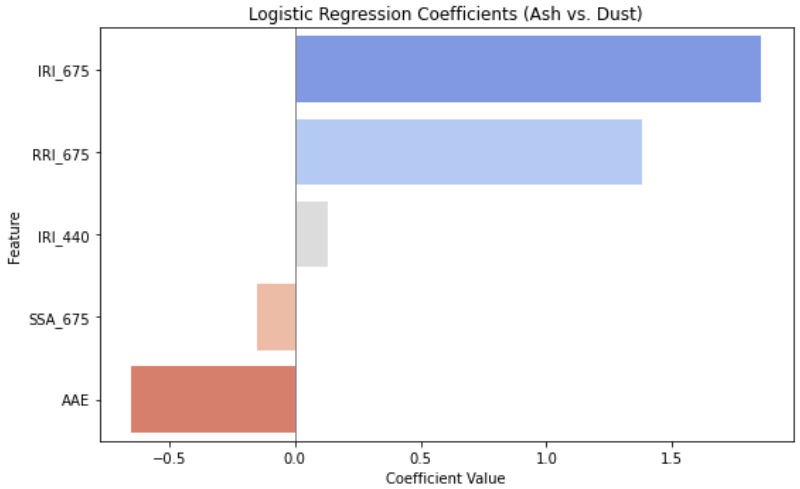
Machine learning classifier selection

- A set of key optical and microphysical features was used to train and evaluate several machine learning techniques.
- Need to be taken into account:
  - few training instances, class imbalance, non-linear feature relationships, overfitting

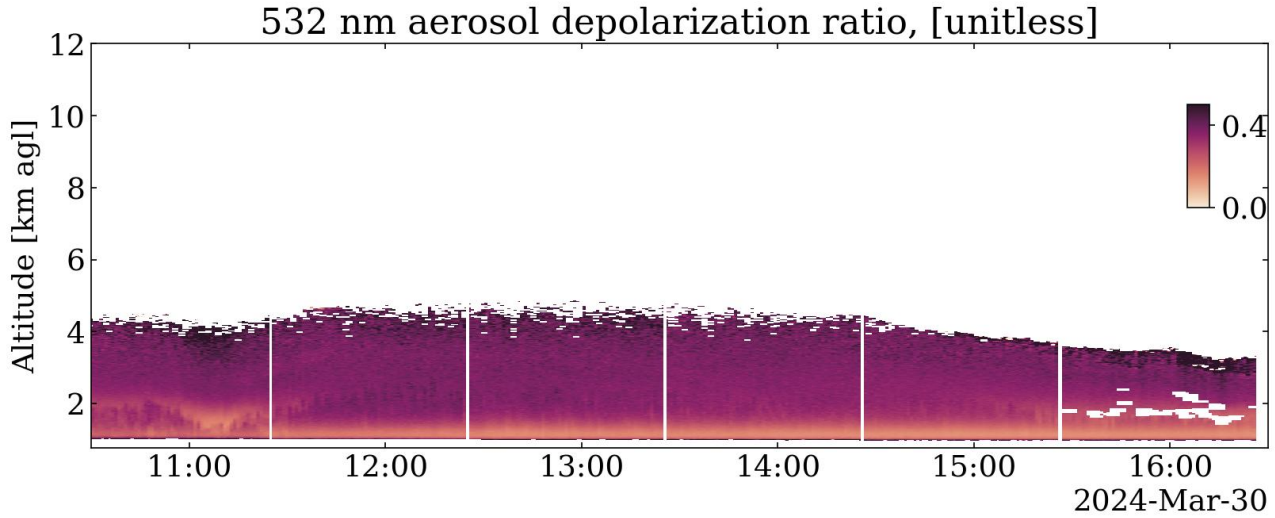
- Logistic regression
- Random Forest
- XGBoost
- SVM
- LightGBM

- Achieved the best balance between interpretability and accuracy (mean CV F1: 0.85±0.08 and strong recall on the–weak–ash class)

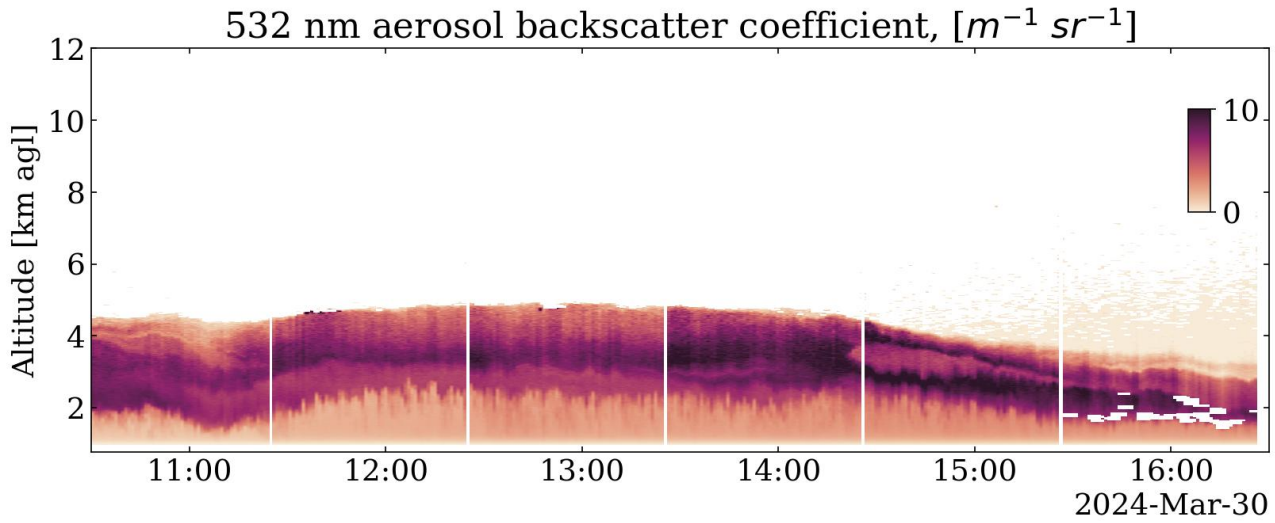


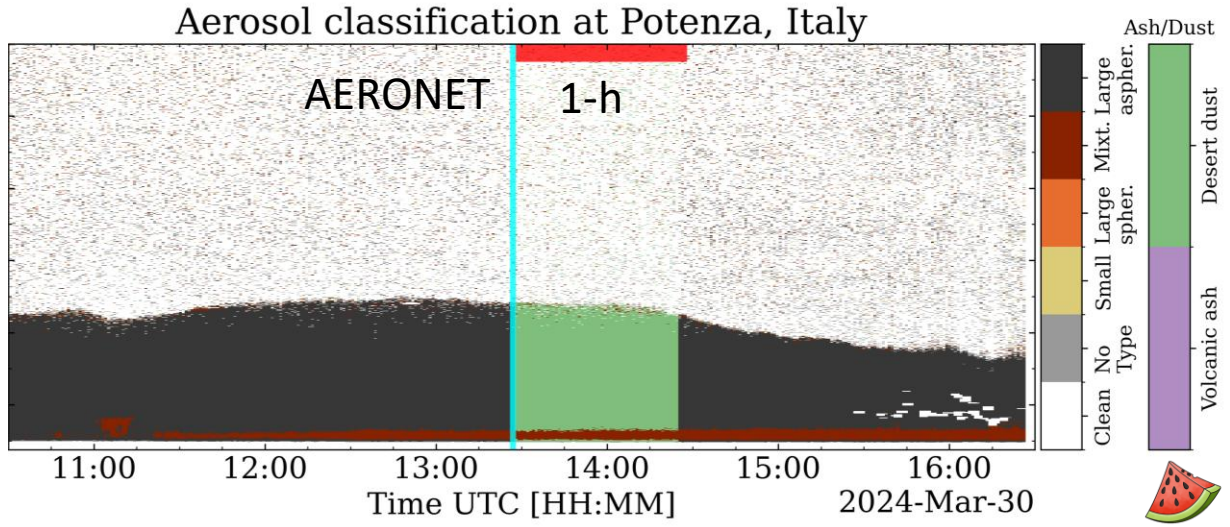


Application on lidar aerosol typing frameworks



- Activity linked to ITINERIS Task 4.11
- Methods and codes were fine-tuned during the campaign of Task 4.12
- 2 aerosol typing products are hosted in a post processing dedicated server and are routinely provided





Conclusions (so far)

This approach

- provides a promising avenue for integrating sun photometer data into aerosol typing frameworks
- offers insights into the most discriminative spectral features separating ash from dust.
- can/will be applied to lidar-based microphysical properties algorithms
- Shows the strength of synergies.

- The testing phase is on going (limited to dust cases)

THANKS!

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-Mission 4 “Education and Research” - Component 2: “From research to business” - Investment 3.1: “Fund for the realisation of an integrated system of research and innovation infrastructures”

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani