Connecting model – observations aerosol typing

Lucia Mona
CNR-IMAA , Potenza, Italy

Thomas Popp, Ralph Kahn, Kostas Tsigaridis

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Aerosol Typing WG

IMPORTANCE

- **impact of the different aerosol sources on climate, precipitation and air quality**.
- **aerosol emissions policies**
- **local authorities and hazards**

The **inhomogeneity** among satellite (and not only) aerosol **typing schemes decreases** fundamental long-term datasets (multi sensors) **consistency**

Typing procedures - overview

- Confusing and misleading **nomenclature**
- Remote-sensing can provide **optical constraints** interpreted as **particle size, shape, and indices of refraction**
- A further **interpretative step**, entailing additional assumptions, reports particle **Source/Chemical Composition**
- **Validation Data** for aerosol type are very **limited**
- **Model** simulations and **in situ** measurements can help

Needs

- Making clear the variety of typing meanings, names, procedures
- Review the differences and try to explain them
- Identify gaps and further needs
- Comparing algorithms
- Overcoming limitation in reference datasets

Something else?

Reference database for aerosol typing (REDAT)

- **The idea: collecting information about aerosol typing from each sensor for each aerosol type and each algorithm.**

- **A set of pure aerosol components + their mixtures**
- **Labeled and identified with sensor typing procedures and grouping them in big categories.**

Its development could provide a common platform for in-depth investigation well beyond our current knowledge.

REDAT

- REDAT could provide the opportunity for

- ❑Finding matching / **translating rules** (which will be non-unique) between words belonging to a “controlled vocabulary”

- ❑Providing an indication of typing products **reliability**

- ❑Overcoming the “small” dataset limitation

- ❑Construction of a **multi-dimensional** and **multi-platform** space of characteristic optical properties

Design

- Indentified **needs**:

- ❑Hierarchical structure

- ❑Flexibility for accommodating substantially different data

- ❑Pointing to the specific typing algorithm and procedures

REDAT

Table1

Algorithm
ID
Sensor
Instrument type
…..

Table2

Aerosol type characteristics
ID
Algorithm ID
Type name
…..

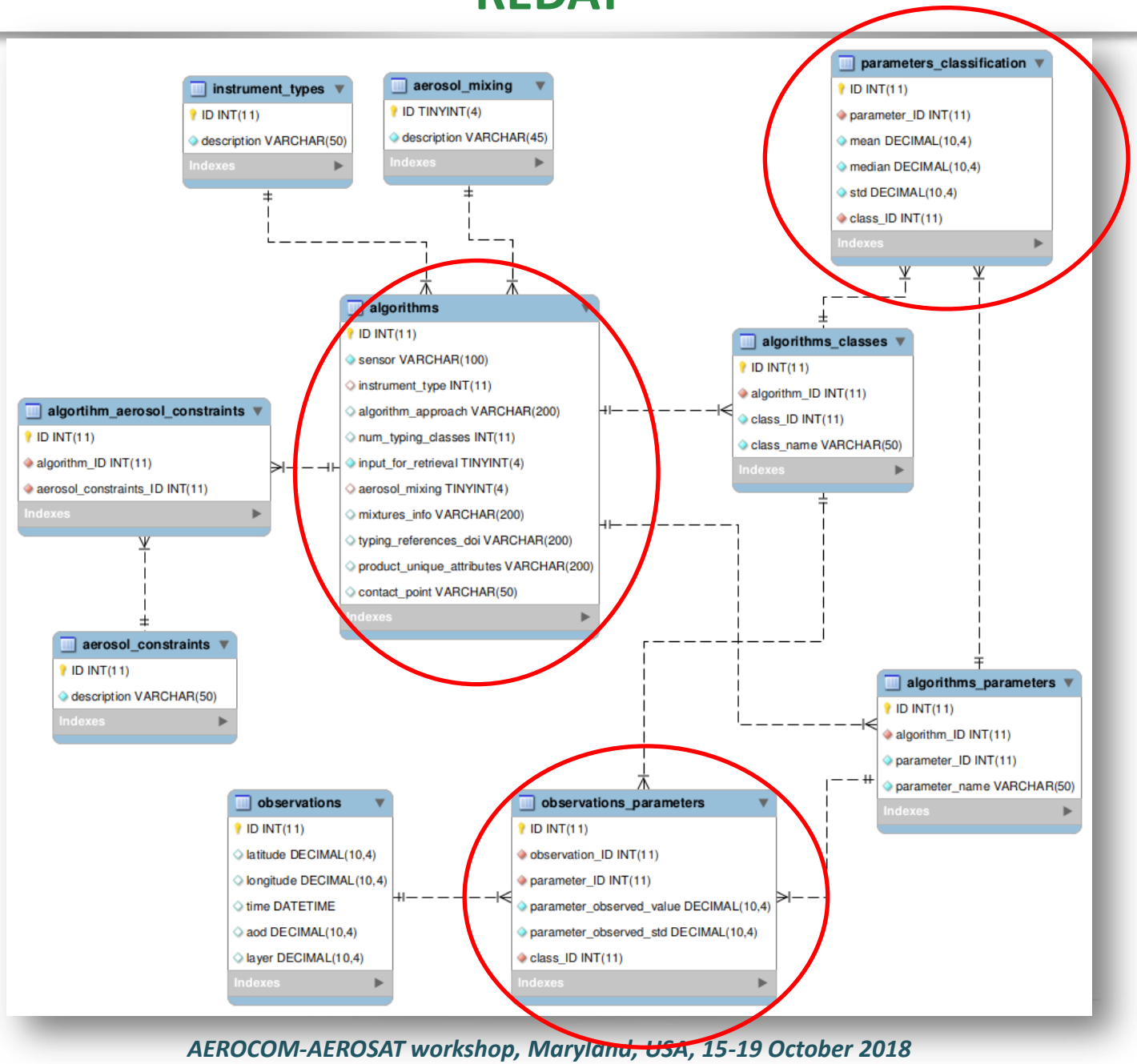
PostgreSQL database under development at CNR-IMAA

Table3

Reference Typing Data
ID
Algorithm ID
Location
…..

Simplified version…

REDAT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ID INT(11)
description VARCHAR(50)
Indexes
aerosol_mixing
ID TINYINT(4)
description VARCHAR(45)
Indexes
parameters_classification
ID INT(11)
parameter_ID INT(11)
mean DECIMAL(10,4)
median DECIMAL(10,4)
std DECIMAL(10,4)
class_ID INT(11)
Indexes
algorithms
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instrument_type INT(11)
algorithm_approach VARCHAR(200)
num_typing_classes INT(11)
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aerosol_mixing TINYINT(4)
mixtures_info VARCHAR(200)
typing_references_doi VARCHAR(200)
product_unique_attributes VARCHAR(200)
contact_point VARCHAR(50)
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algorithm_ID INT(11)
class_ID INT(11)
class_name VARCHAR(50)
Indexes
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algorithm_ID INT(11)
aerosol_constraints_ID INT(11)
Indexes
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description VARCHAR(50)
Indexes
algorithms_parameters
ID INT(11)
algorithm_ID INT(11)
parameter_ID INT(11)
parameter_name VARCHAR(50)
Indexes
observations
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longitude DECIMAL(10,4)
time DATETIME
aod DECIMAL(10,4)
layer DECIMAL(10,4)
Indexes
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observation_ID INT(11)
parameter_ID INT(11)
parameter_observed_value DECIMAL(10,4)
parameter_observed_std DECIMAL(10,4)
class_ID INT(11)
Indexes

REDAT

Table1

Algorithm
ID
Sensor
Instrument type
…..

Table2

Aerosol type characteristics
ID
Algorithm ID
Type name
…..

Inputs from community are needed

Table3

Reference Typing Data
ID
Algorithm ID
Location
…..

Database hosted at CNR & Linked to AEROSAT, AEROCOM, ACTRIS and relevant web site

Table 1

Database filled in with info coming for the overview of typing procedures

- **21 aerosol typing procedures included in the review**

To be checked and updated

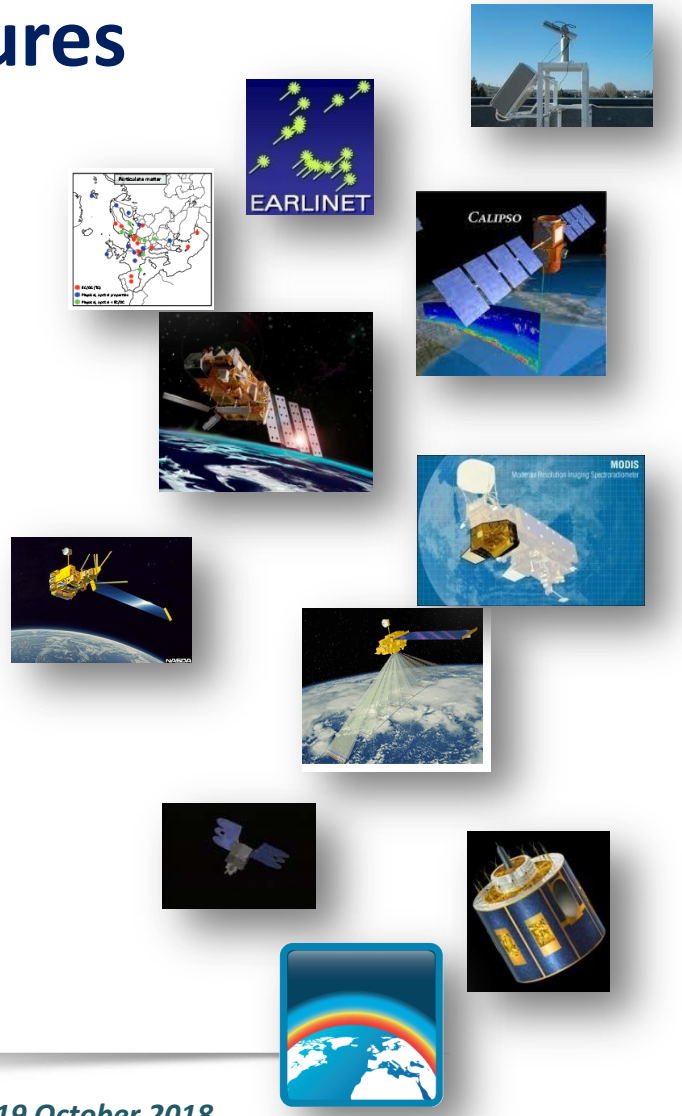
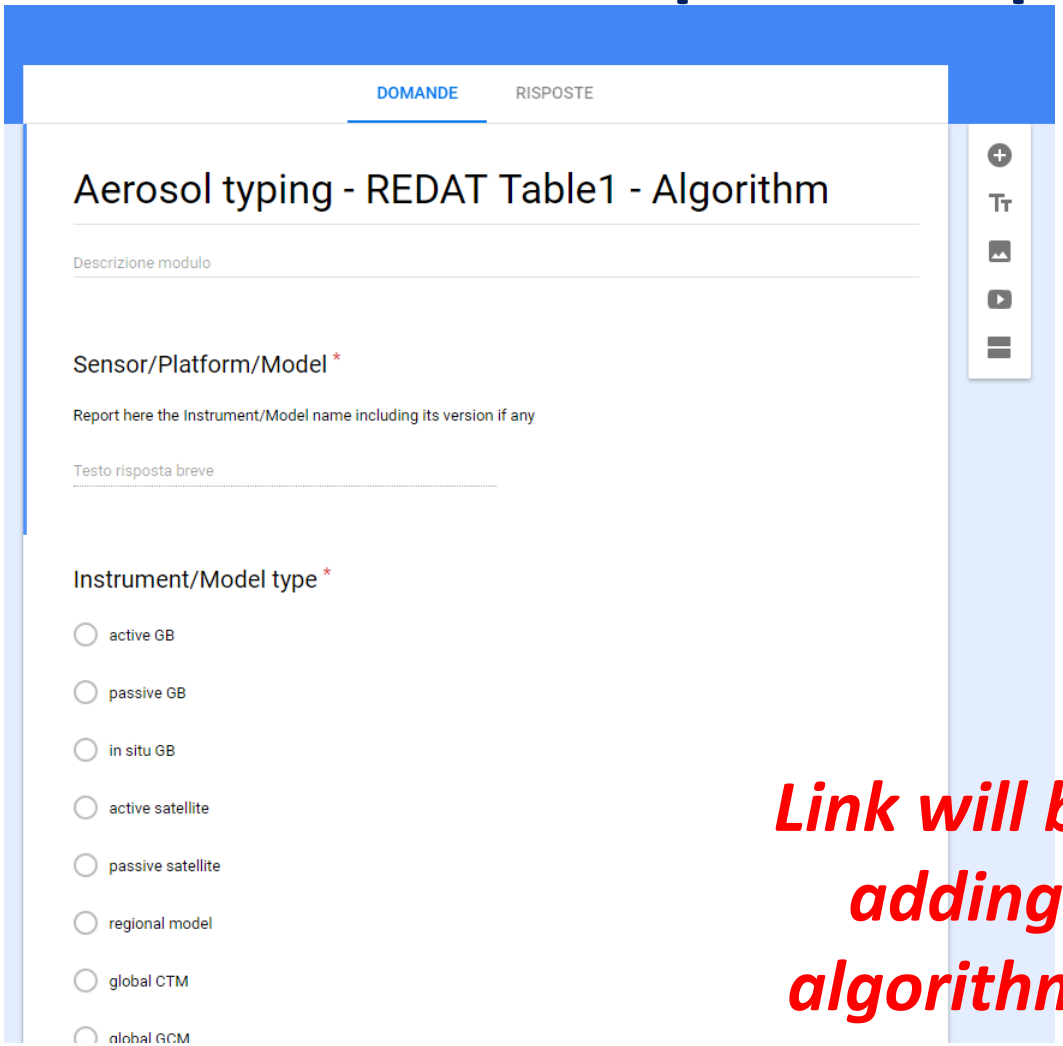


Table 1

Google form module set up for this purpose



Link will be sent for adding further algorithms by 10 Nov

Table 2

Definition of the properties for each class of each algorithm

- Aerosol class
- Characteristics of the class in term of each one of typing properties:

  Mean , std, median, 10-90 percentile

  or

  Thresholds used in the typing decision tree

- For models, source info used and which one

To be finalized by at least 1 representative for community:

GB, satellite, model

Lucia, Ralph, Kostas

To be checked and updated through a Google Module

sent to AEROSAT mailing list by 30 Nov

Core for BAMS paper

The problem of aerosol typing: its relevance

2 approaches: optical, interpretative scheme

Nomenclature

Classes

Aerosat initiative

Setting up a REDAT

The call for "external" contribution

The starting point

Structure and first sections by end of January

Table 3

Quantitative set of information and optical properties measurements for the different aerosol types/sensor/algorithm

This set could become a reference dataset for the whole community and will provide opportunities for:

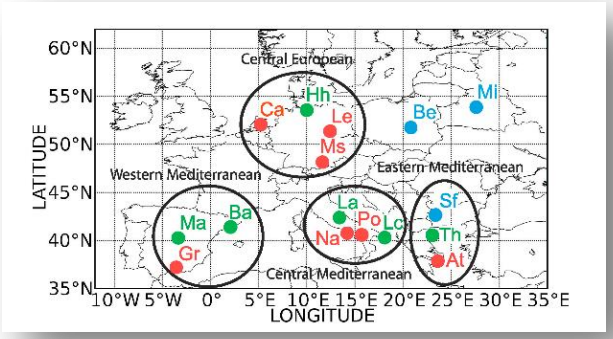
-Comparing typing procedures

-Providing a reference dataset and a link between observational and modeling community

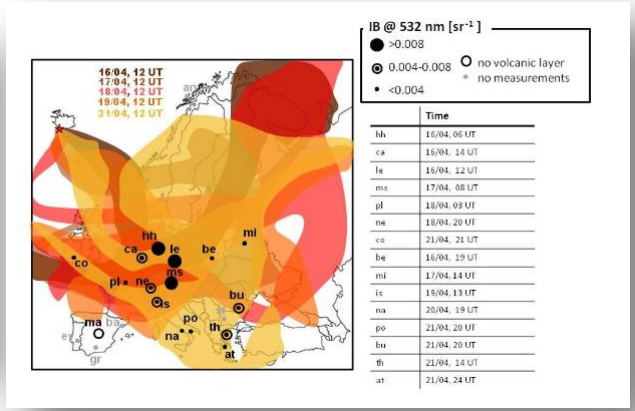
EARLINET/ACTRIS Reference dataset

Using published and full characterized data

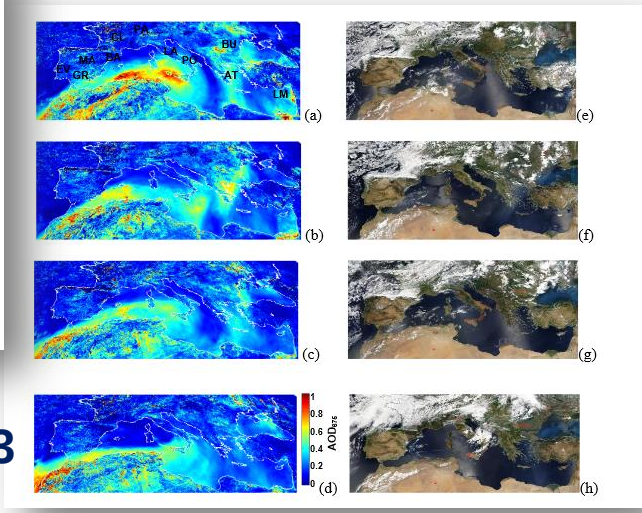
1. **CALIPSO- EARLINET dataset**
2. **Eyja volcanic eruption EARLINET dataset**
3. **ACTRIS summer 2012 campaign**



1. Pappalardo et al., JGR 2010



2. Pappalardo et al., ACP 2013



3. Sicard et al., AMT 2015

Aerosol typing within EARLINET/ACTRIS

A lidar stand-alone procedure has been realized in harmonization efforts with aerosol typing from HSRL lidar in US.

Method:
a distance-based multivariate analysis depending only on lidar intensive properties [Burton et al., 2012].

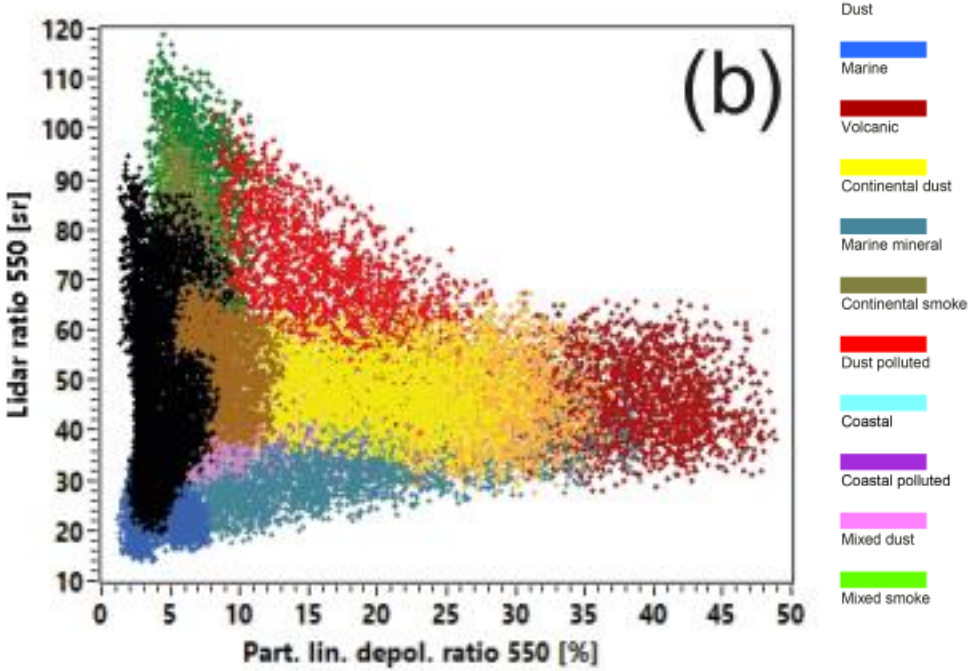
The method is set up using a training dataset and then results of the method are compared vs manual typing of the data (backtrajectories analysis + model inputs + satellite images).

Comparing Aerosol typing in EARLINET/ACTRIS

NATALI- Neural network aerosol typing algorithm based on aerosol lidar data

Neural network algorithm based on OPAC + RH,
GDAC microphysics
Mischenko spheroidal model
Linear mixing of different components

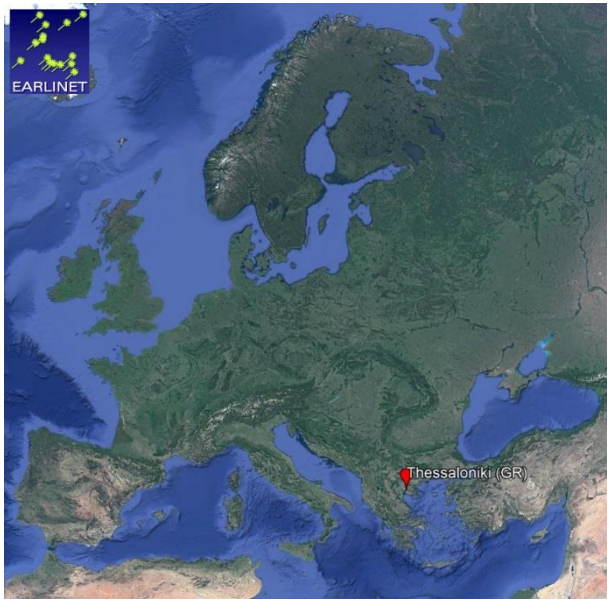
Nicolae et al., ACP 2018



Comparing Aerosol typing in EARLINET/ACTRIS

Systematic comparison of the 2 EARLINET algorithms on

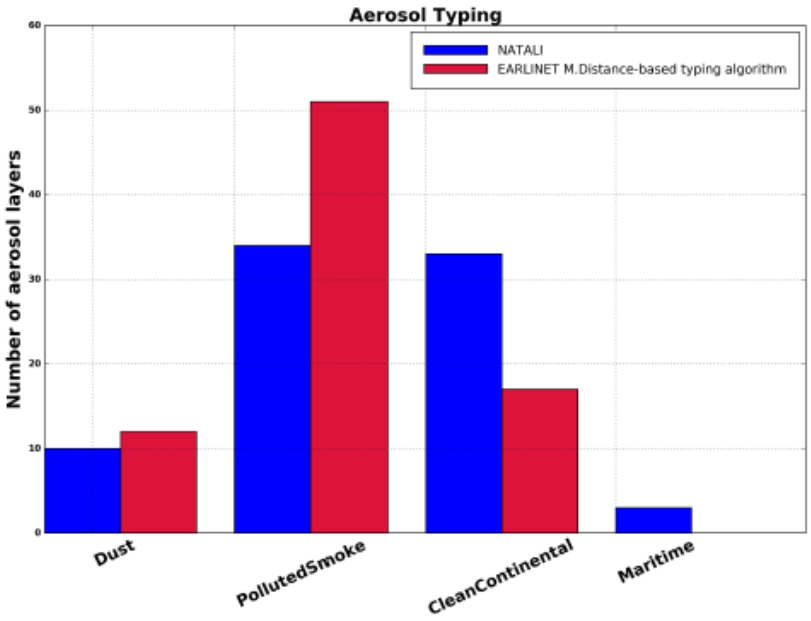
- 54 Raman lidar cases of aerosol measurements (backscatter coefficient profiles at 1064nm, 532nm and 355nm, as well as the extinction coefficient profiles at 532nm and 355nm)
- Thessaloniki
- period 2012-2015



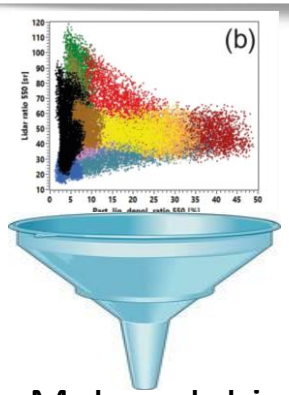
The 2 methodologies agree on the Thessaloniki characteristics in terms of typical aerosol content

Vodouri et al., submitted ACPD 2018

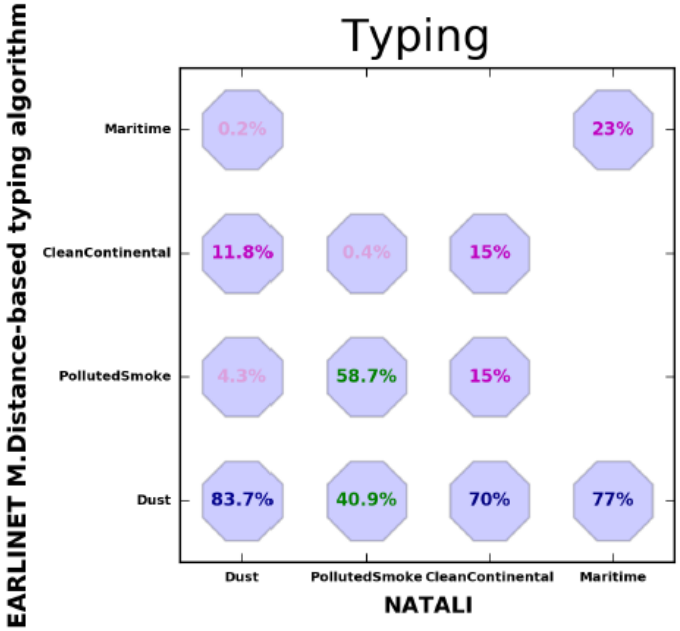
Classes rearranged for doing the "comparison"



Comparing Aerosol typing in EARLINET/ACTRIS



Mahanalobis method



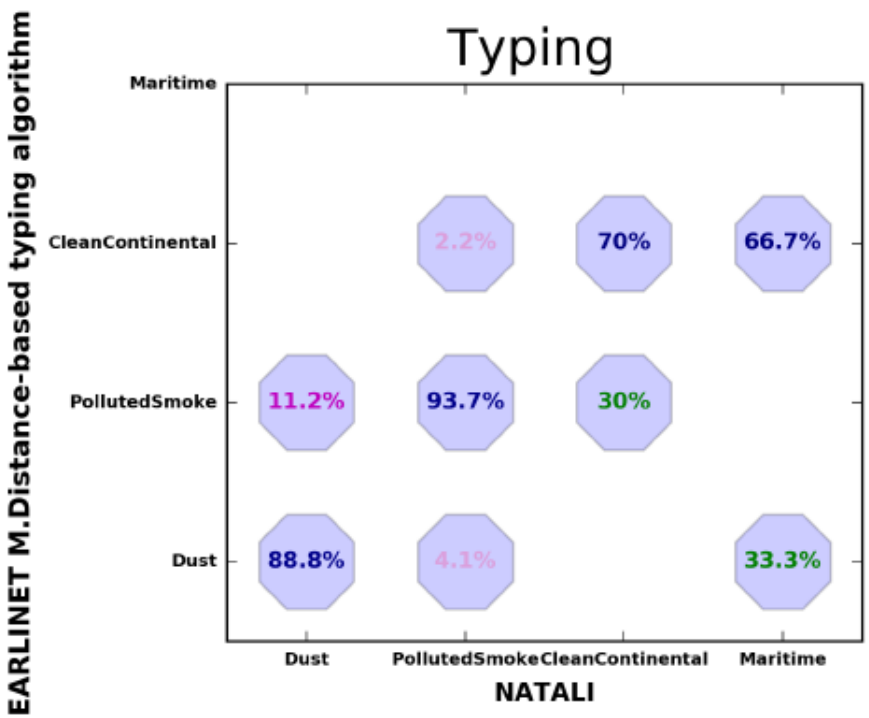
Synthetic data comparison

This potentially allows to understand the «sources» of different results when applied on the same datasets

Results:

- Dust-CleanContinental mismatch is probably due to the fact that rural conditions fall in CleanContinental type for NATALI while this is meant as background clean conditions in the EARLINET distance-based typing algorithm.
- NATALI considers pure marine layers while the EARLINET Mahalanobis distance based typing algorithm considers a mixture of marine with other aerosol types.
- NATALI modelled big particles are typed by the EARLINET distance method as Maritime but also as Dust category, probably because of the different range of large lidar ratio values allowed in the NATALI synthetic data

Comparing Aerosol typing in EARLINET/ACTRIS



When compared on real observations

Vodouri et al., submitted ACPD 2018

Results:

- Very good result on the most polluted classes
- A not satisfactory agreement is observed for the Maritime, which is the aerosol type less encountered over Thessaloniki. Dual interpretation is found for Maritime / Clear continental cases, this can be ascribed to the different aerosol type definition.

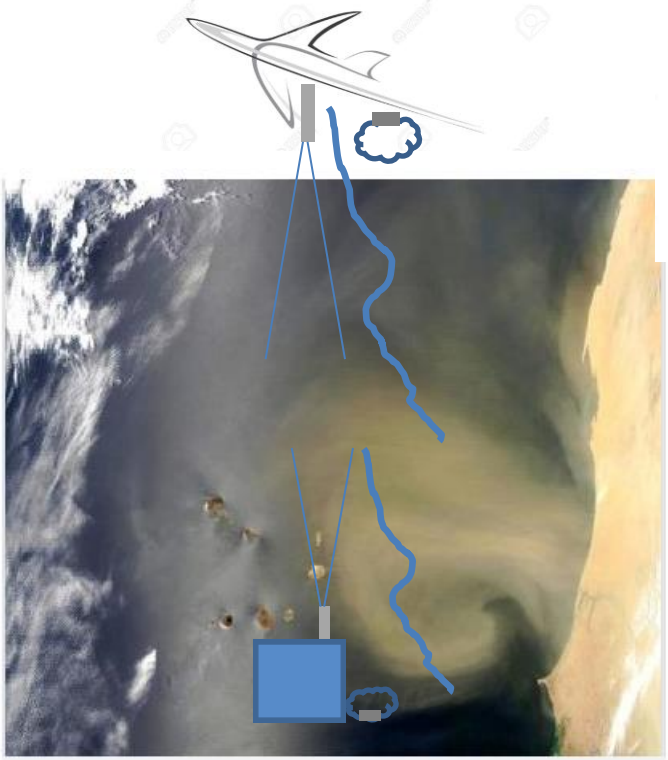
Working on first exercise for comparison/translating rules

1. **Select one common «type» to be explored**

2. **Identify experiments /campaigns as suitable for comparative study**

Working on first exercise for comparison/translating rules

A campaign is under preparation for summer 2020 for ADM Aeolus validation in Cape Verde, with special focus on dust.



Satellite picture of Saharan sand storm above the Cape Verde Islands.

Credit: NASA

Discussion points

- **Are we considering the main needs?**

- **Is a collaborative information database sustainable for such kind of not-funded initiative?**

- **Is the contribution requested to the AEROSAT community feasible as unfunded?**