cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL

ACTRiS

Unpublished results

European Overview for Source Apportionment of Organic Aerosol

Chen et al.

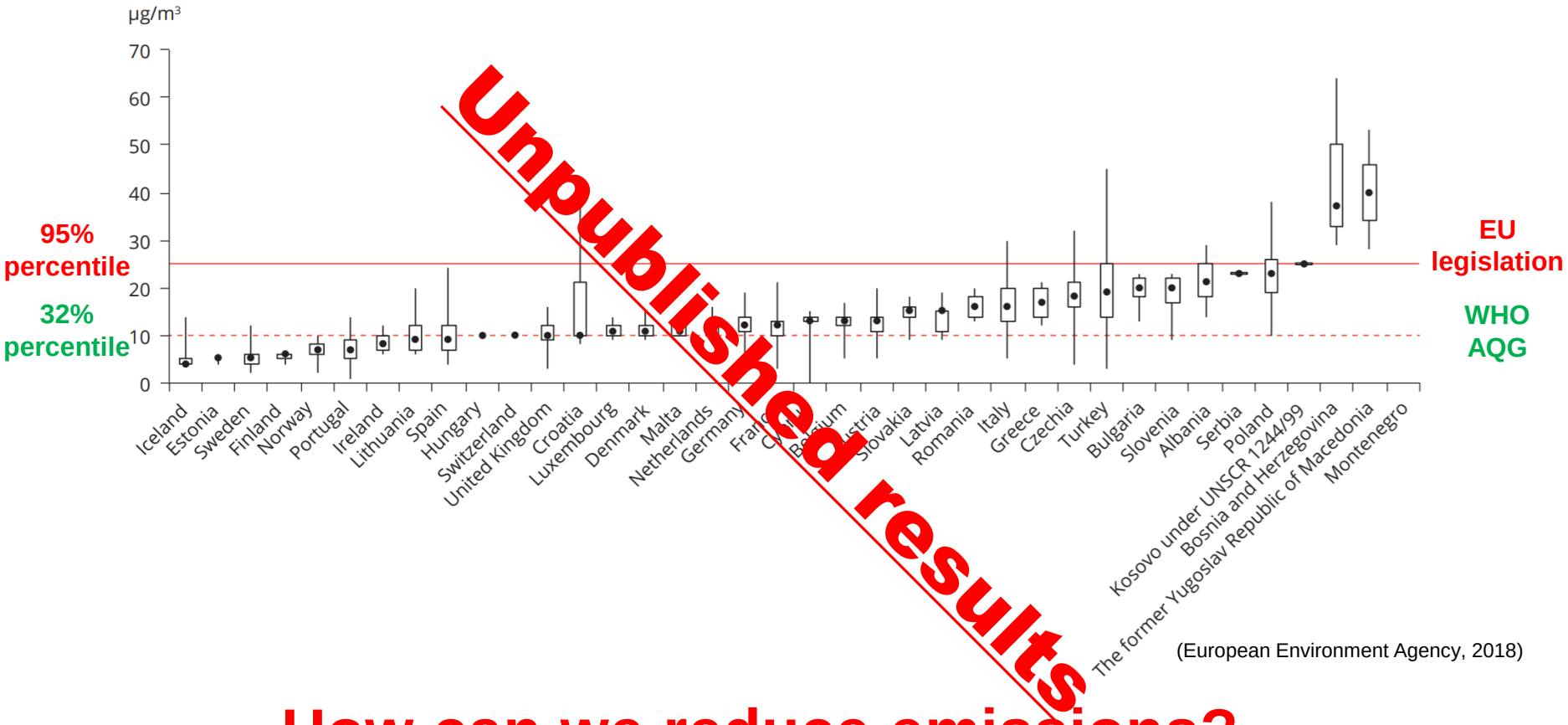
21th Task Force on Measurement and Modelling Meeting May 12th, 2020

Motivations

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL

$PM_{2.5}$ concentrations in relation to the annual limit value in 2016



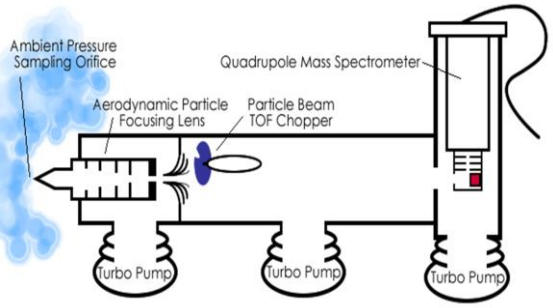
Unpublished results

(European Environment Agency, 2018)

How can we reduce emissions?

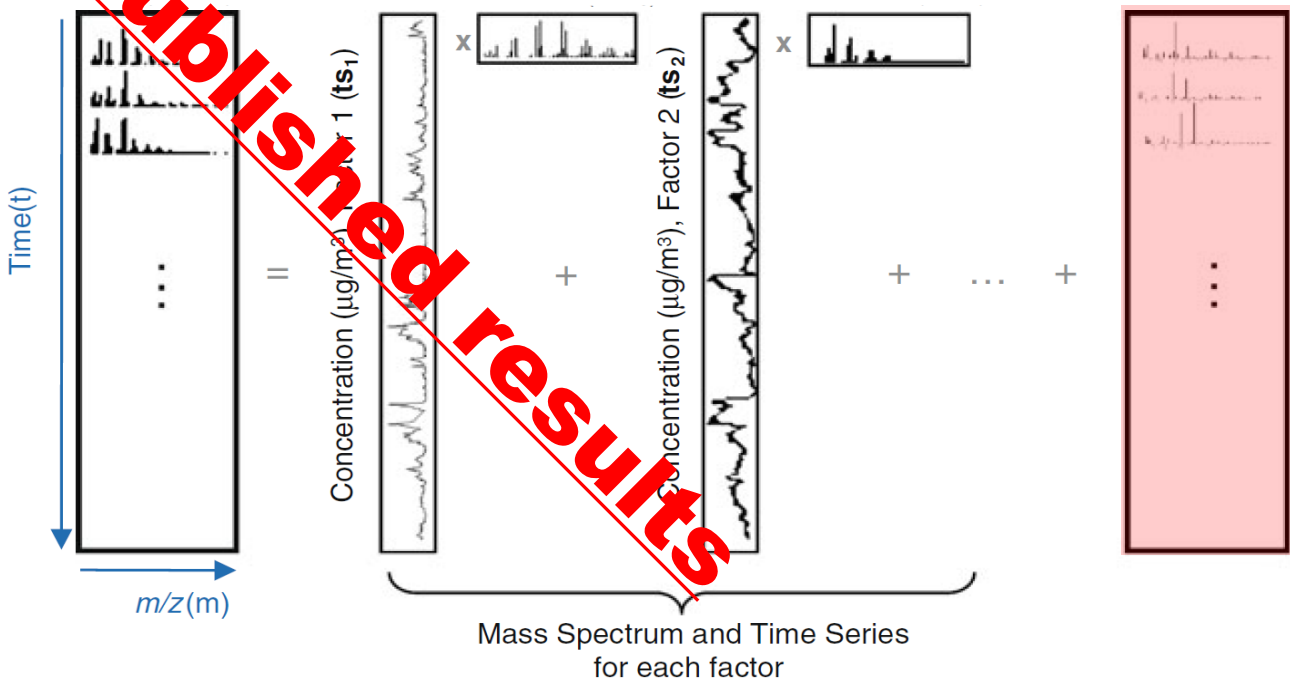
The sources of organic aerosol (**20-90%** of total submicron aerosol) need to be characterized

Positive Matrix Factorization (PMF)



On-line determination of chemical composition: The Aerodyne Aerosol Mass Spectrometer (AMS)

$$\underbrace{X_{measured}}_{\text{Mass spectral matrix (m×n)}} = \sum_{k=1}^{p} \underbrace{ts_{ik}}_{\text{Time series}} \times \underbrace{f_{kj}}_{\text{Factor profile}} + \underbrace{e_{ij}}_{\text{Residual matrix (m×n)}}$$



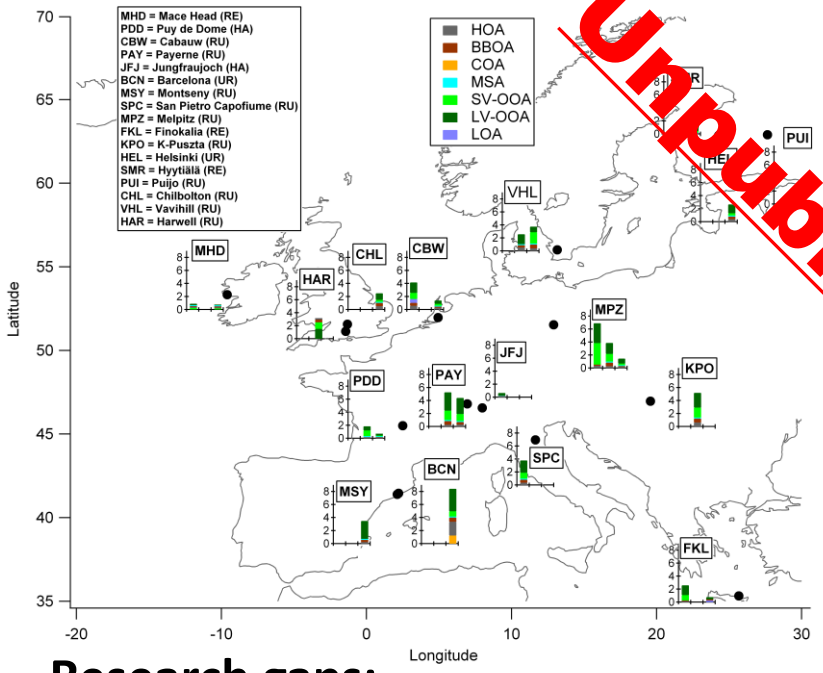
Adapted from Zhang et al., (2011)

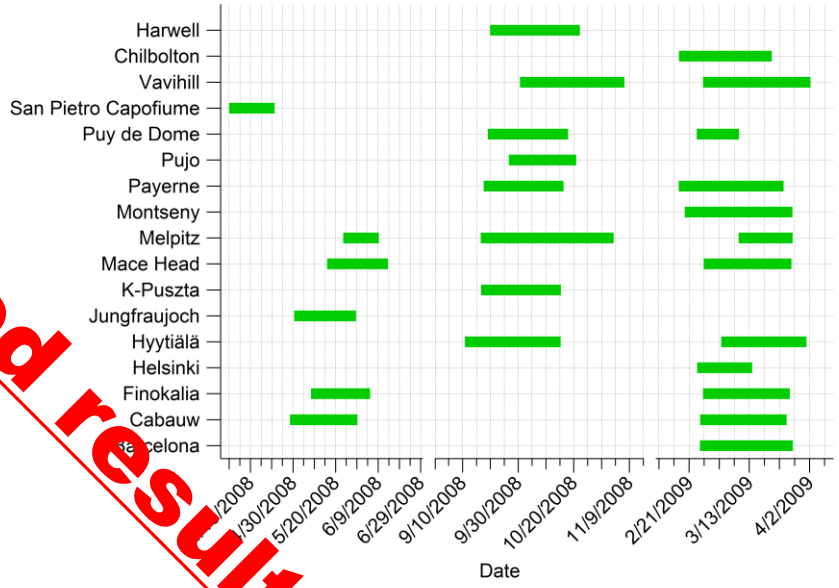
$$Q = \sum_{i=1}^{m} \sum_{j=1}^{n} \left(\frac{e_{ij}}{\sigma_{ij}} \right)^2$$

measurement uncertainties

Most-recent European Overview work

Crippa et. al., (2014) presents a spatial variabilities of organic aerosol (OA) sources with a consistent source apportionment (SA) guideline for 25 datasets collected using the Aerodyne aerosol mass spectrometer (AMS)





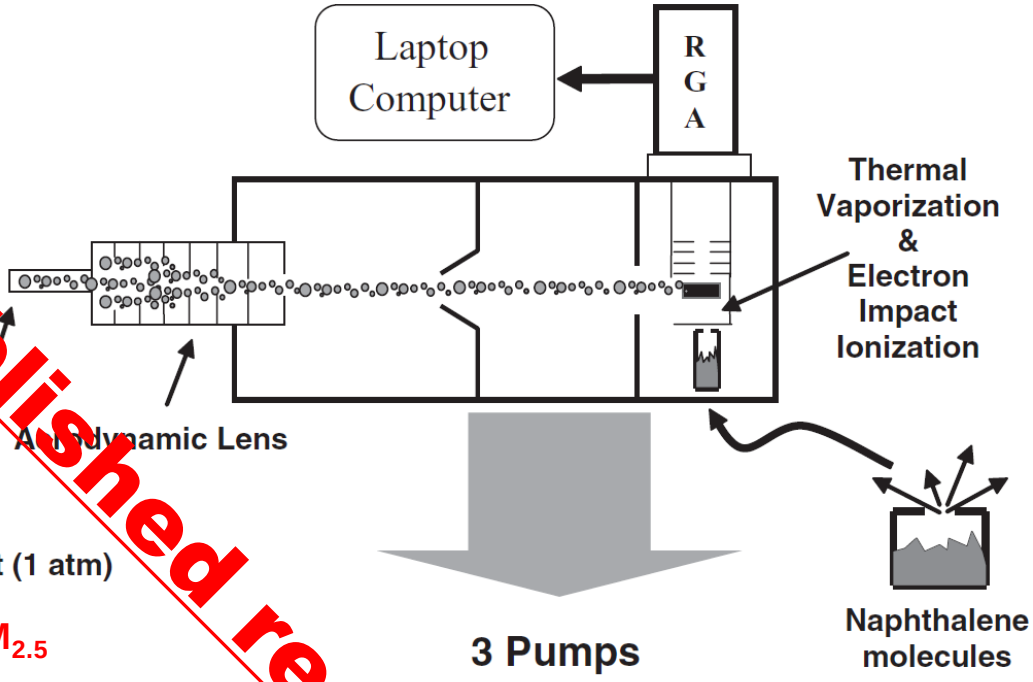
(Crippa, et. al., 2014)

Research gaps:

1. PMF suffers from **rotational ambiguity** and requires **subjective** judgements;
2. The conventional PMF does not consider the **evolutions of OA source** profiles;
3. AMS is a labor-intense and expensive instrument, not desirable for long-term monitoring;
4. **Seasonal variations** of OA sources are still poorly understood without long-term datasets.

Aerosol Chemical Speciation Monitor (ACSM)

（Aerodyne, 2014）



（Ng et al., 2011）

- Report mass concentration of OA, ammonium, sulphate, chloride, and nitrate with a 10-min resolution
- More **stable** for long-term measurement with less maintenance
- Low-cost and suitable for monitoring purpose

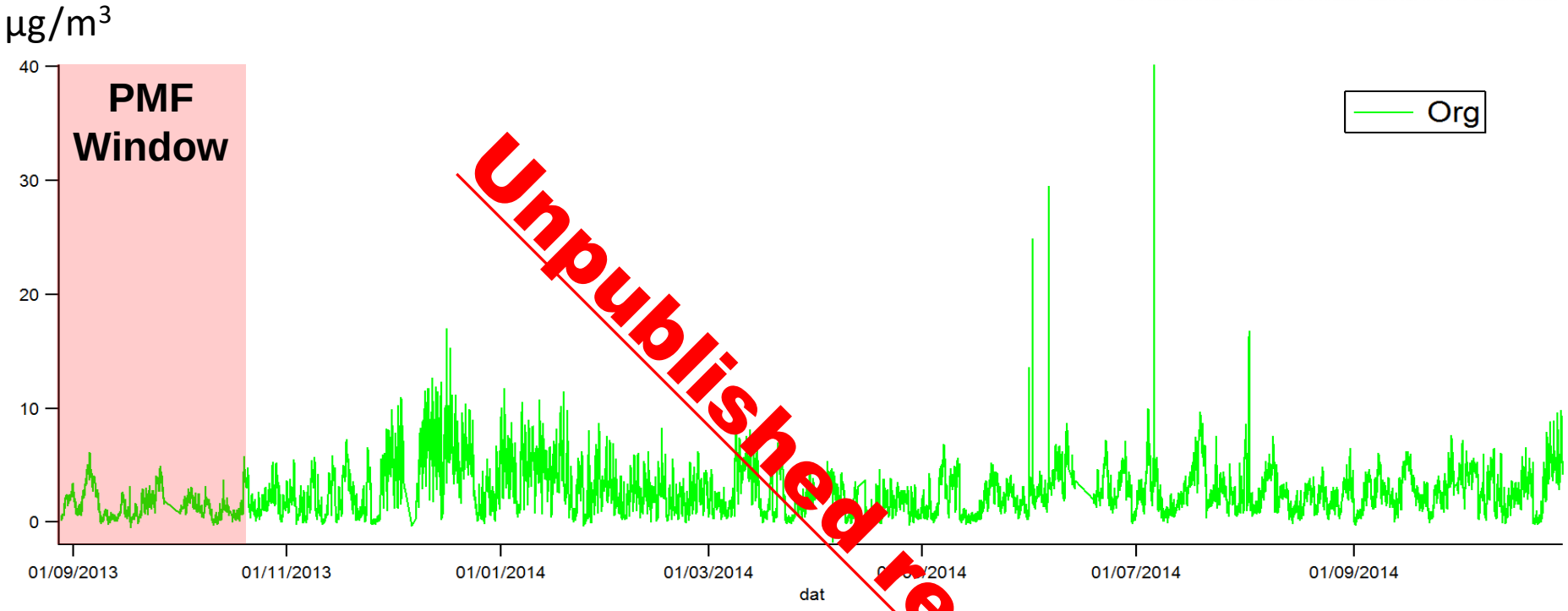
But…

- Only provide a mass spectrum with unit mass resolution (UMR)

Data Coverage

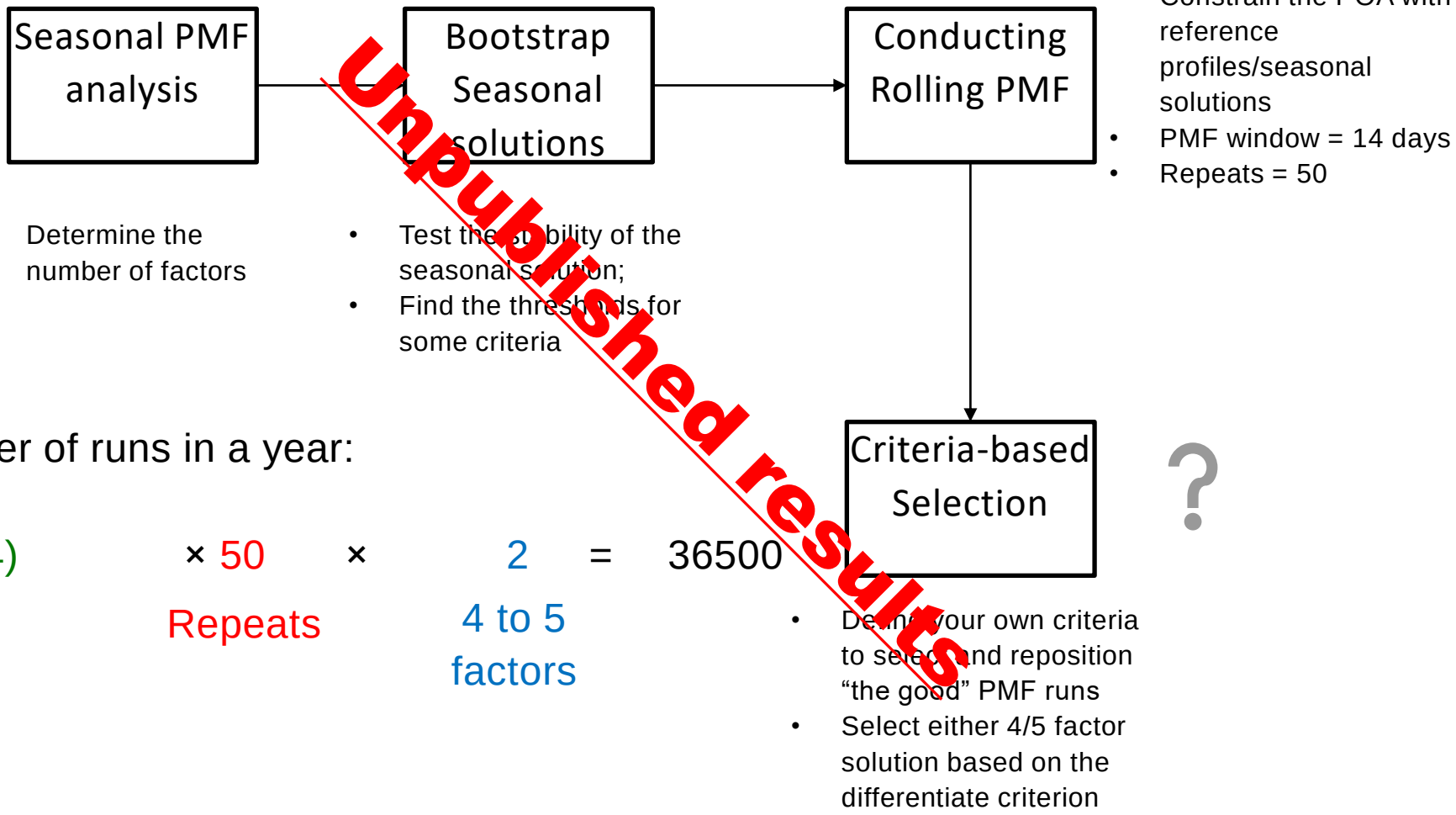
24 long-term datasets with some overlaps

What is rolling PMF?



- PMF window can **shift** over the whole PMF input (>1 year) with a step of one day (or user defined) for many (e.g., 50) repeats
- Take the **temporal variations** of OA sources into account
- PMF runs can be assessed by using criteria-based selection, such as correlation with external tracers

Standard procedures for rolling PMF



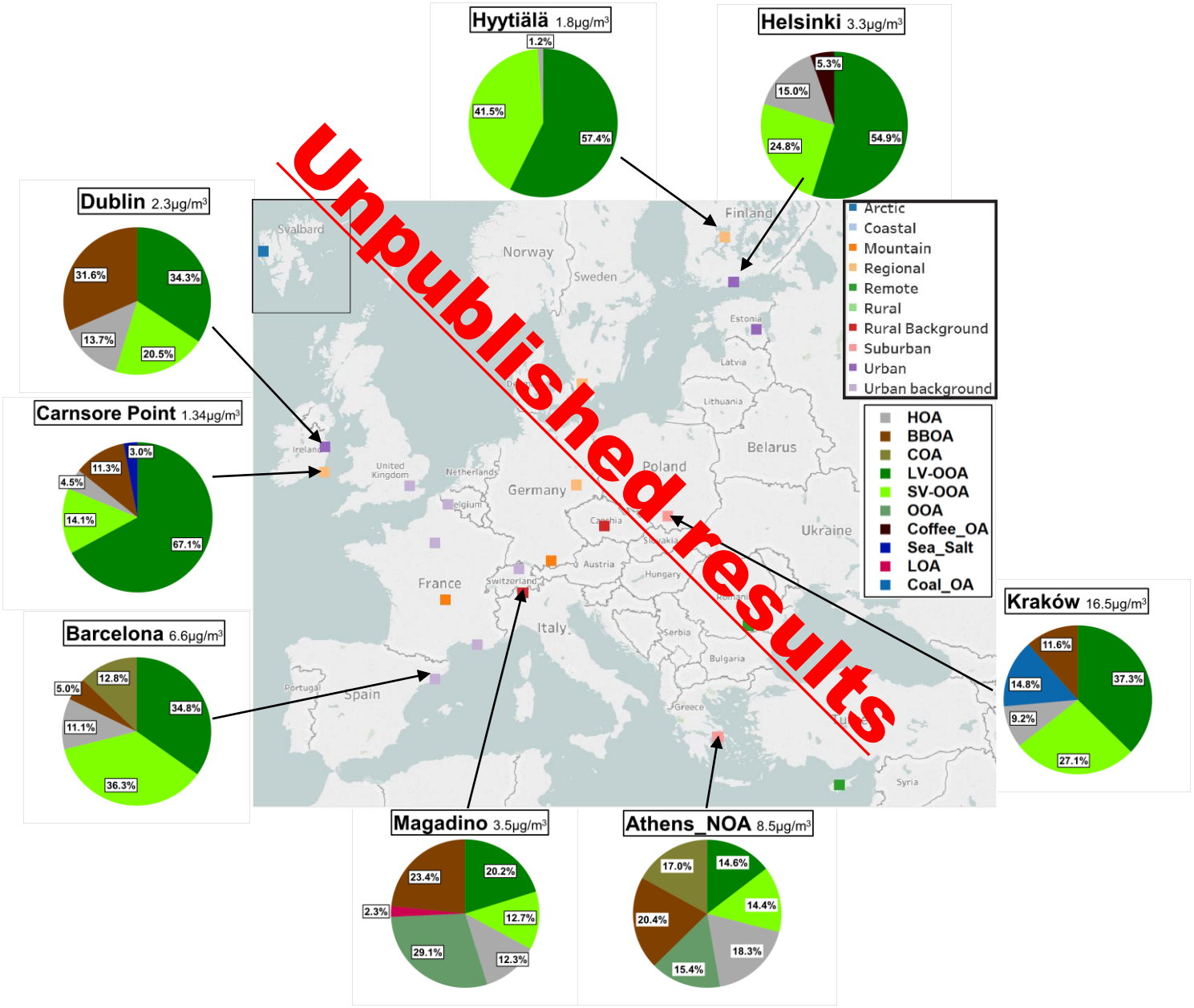
Number of runs in a year:

(365-14) days × 50 Repeats × 2 4 to 5 factors = 36500

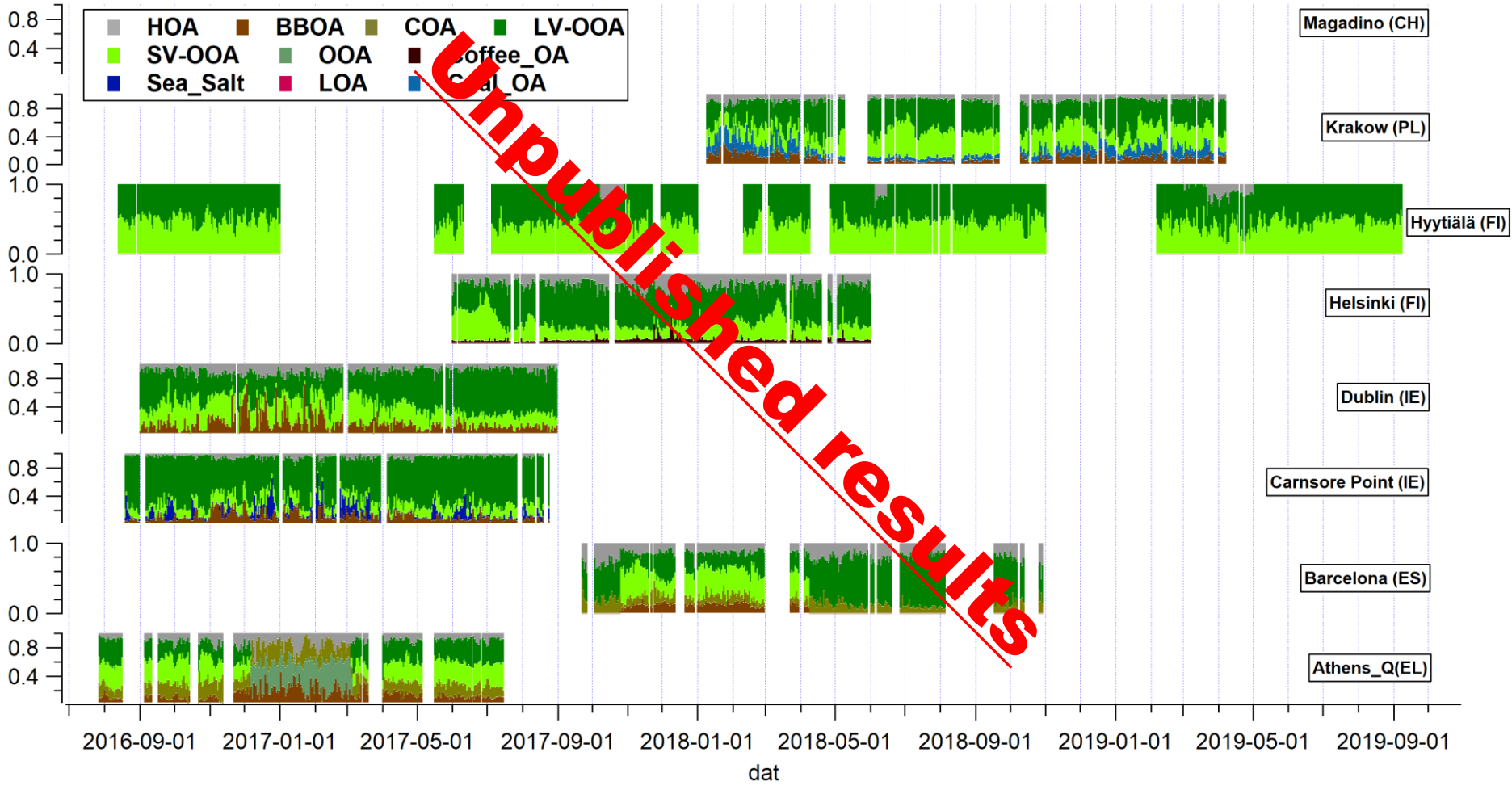
Overview

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL



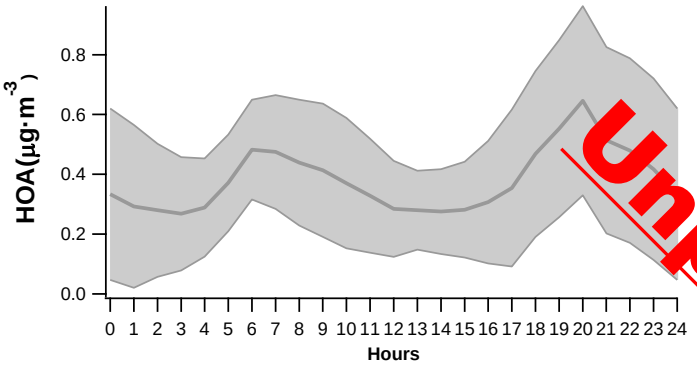
Relative Contribution

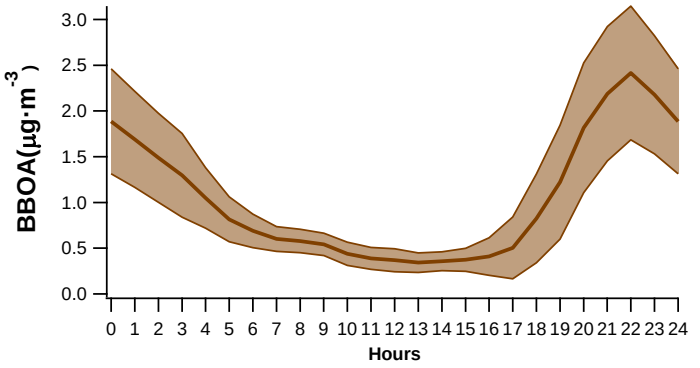


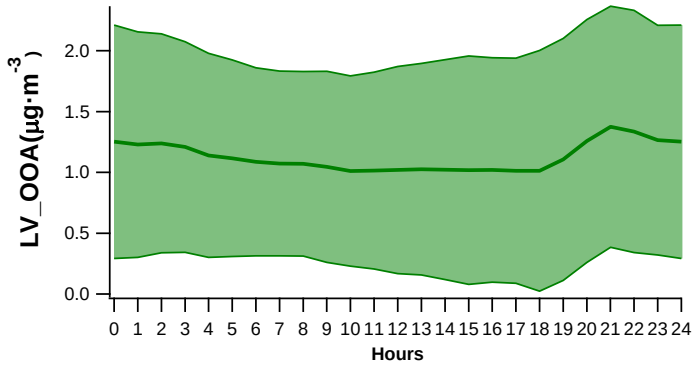
Yearly averaged diurnals

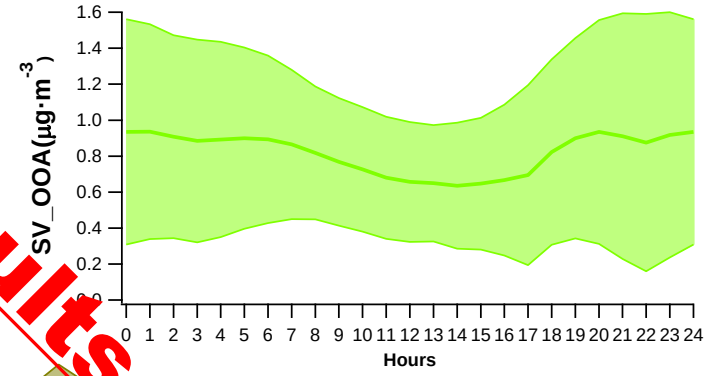
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

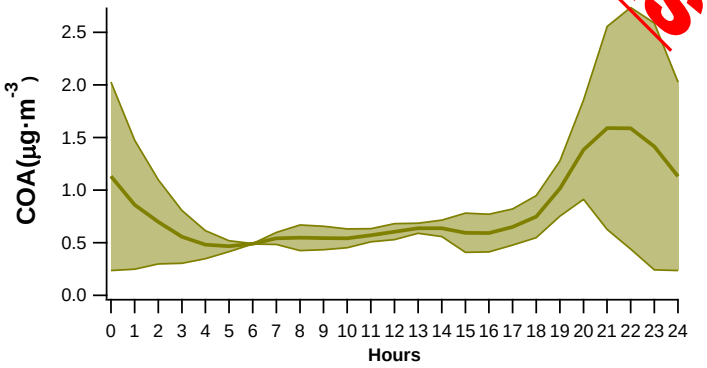
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL











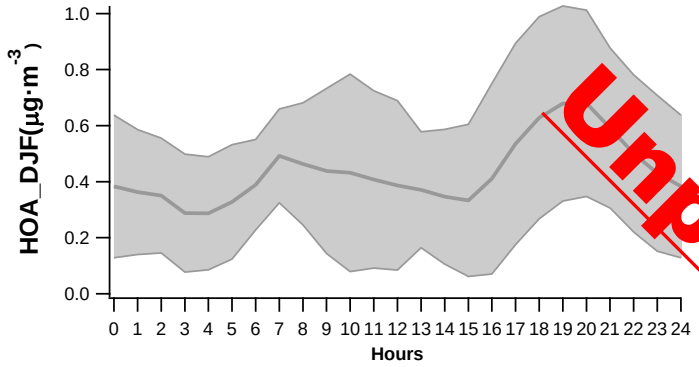
Unpublished results

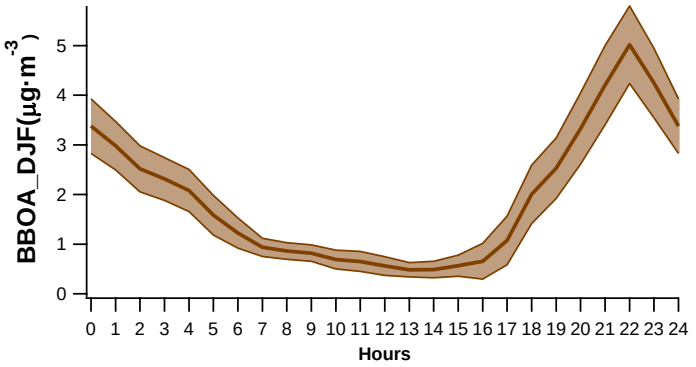
Barcelona and Athens Only

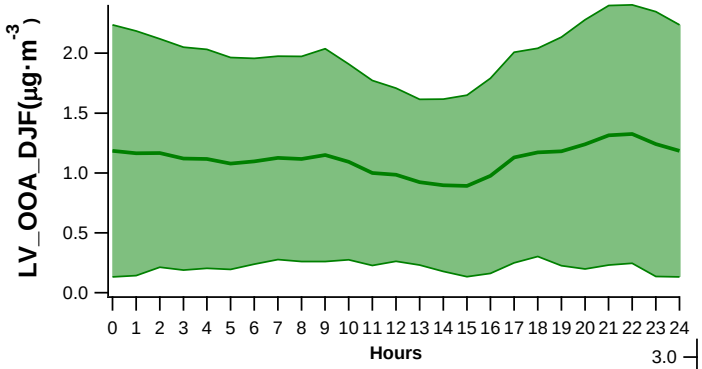
DJF averaged diurnals

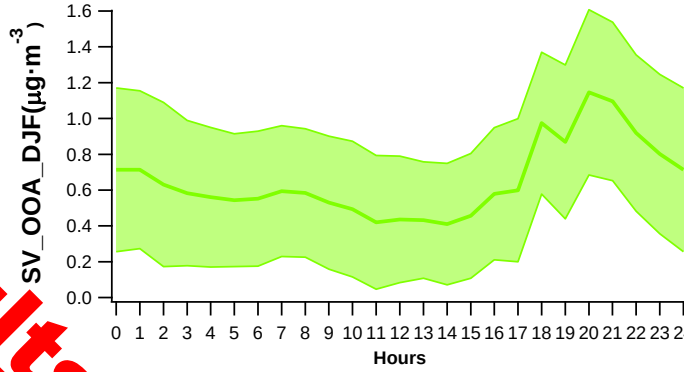
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

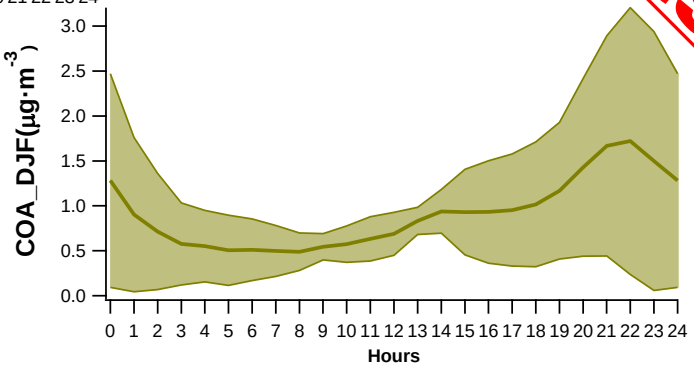
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL









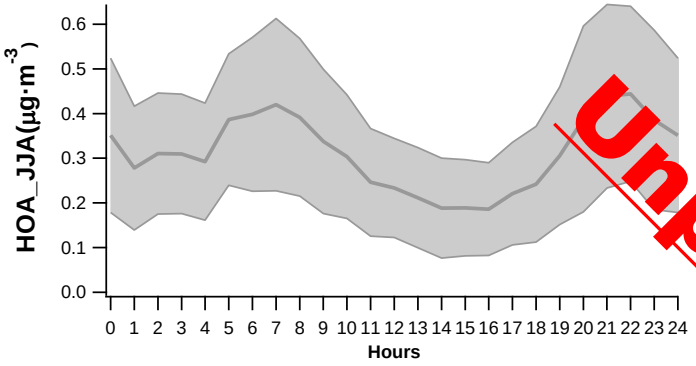


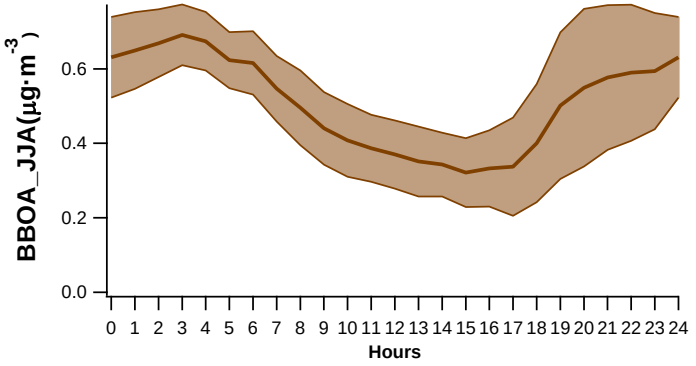
Barcelona and Athens Only

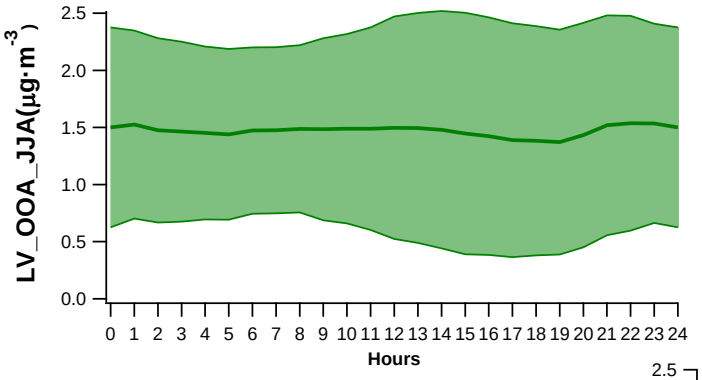
JJA averaged diurnals

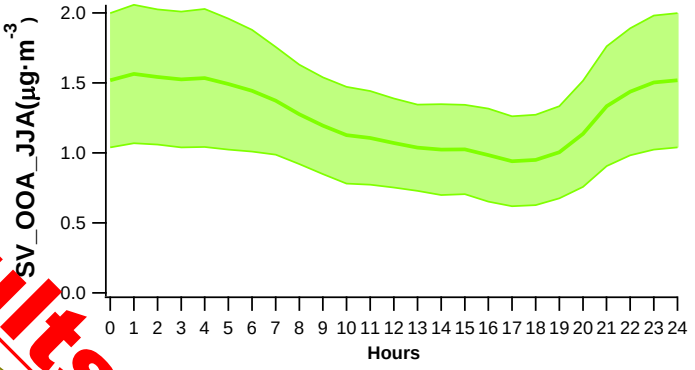
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

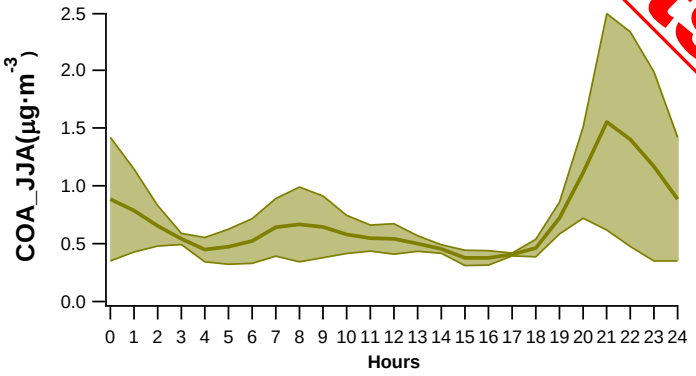
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL











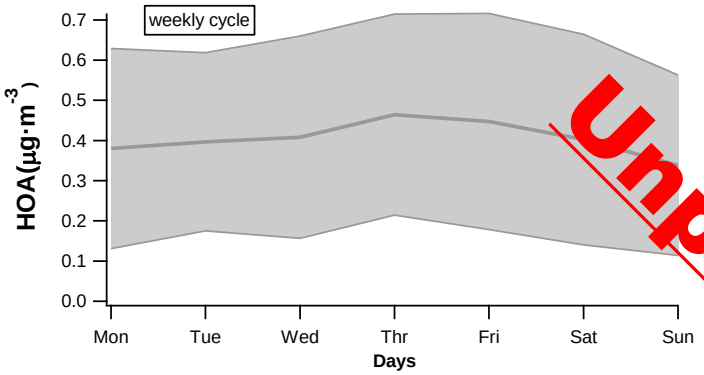
Unpublished results

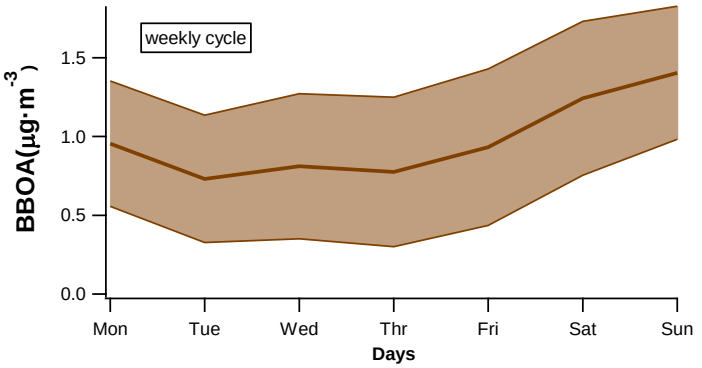
Barcelona and Athens Only

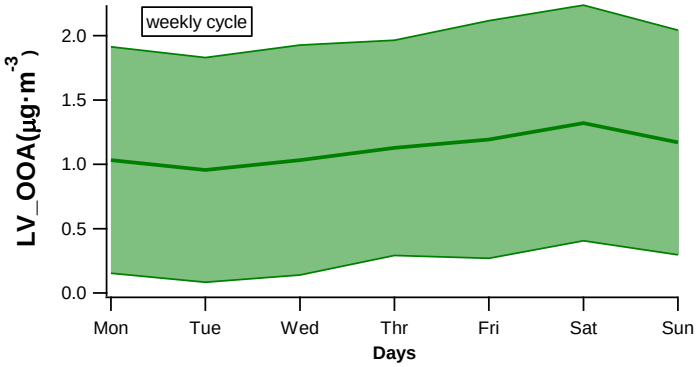
Yearly averaged weekly cycle

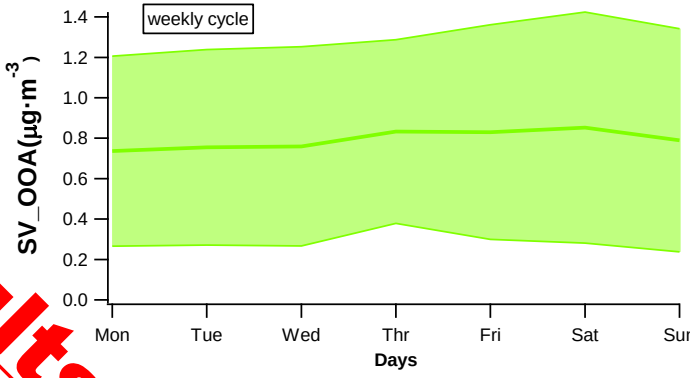
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

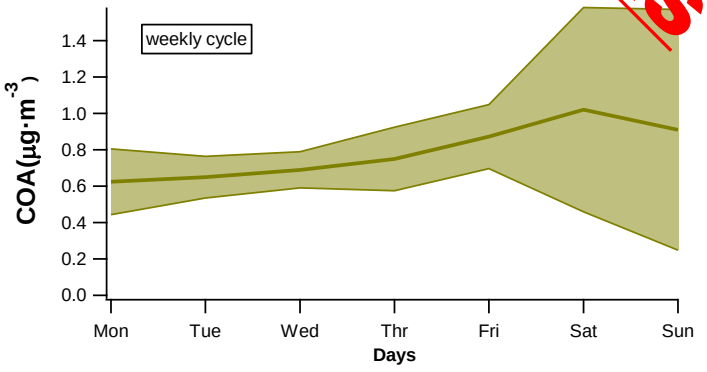
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL











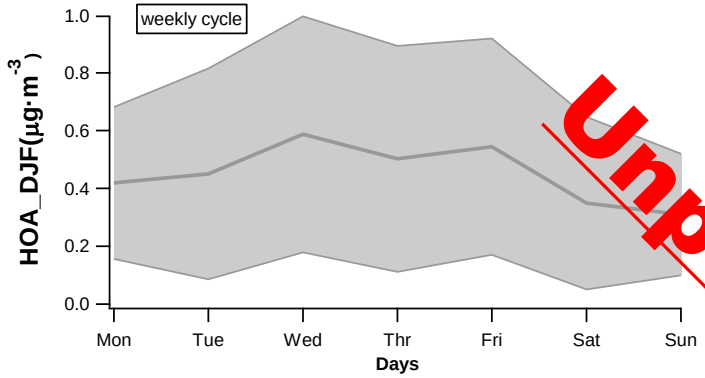
Unpublished results

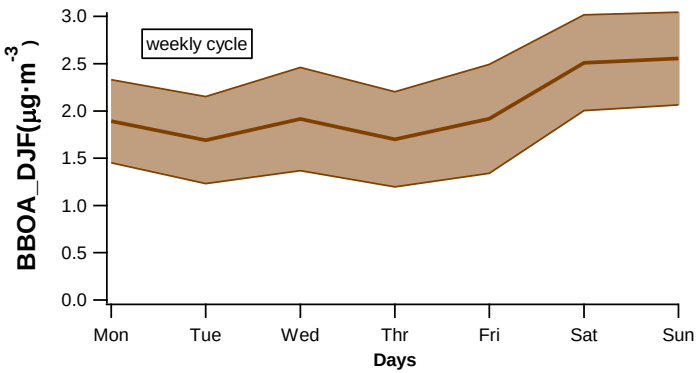
Barcelona and Athens Only

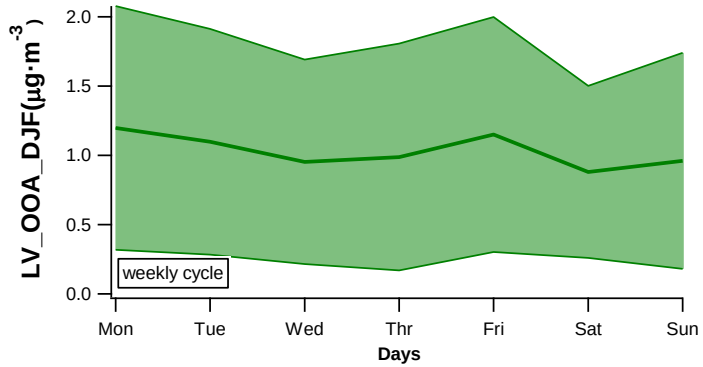
DJF averaged weekly cycle

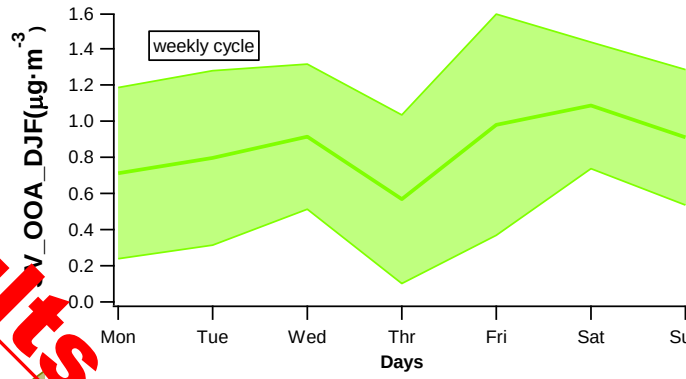
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

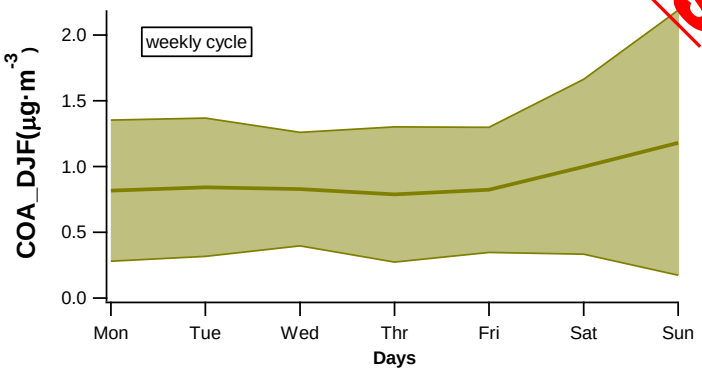
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL











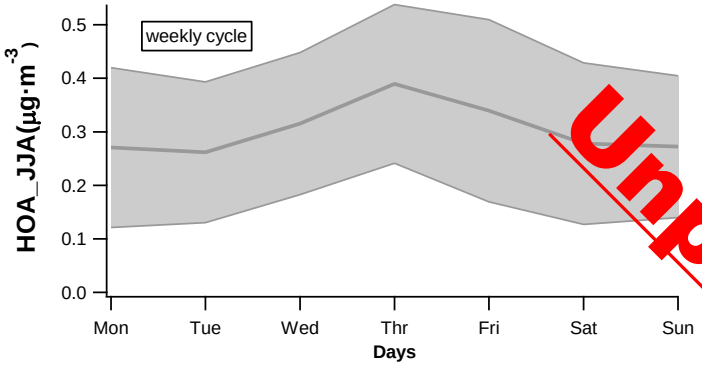
Unpublished results

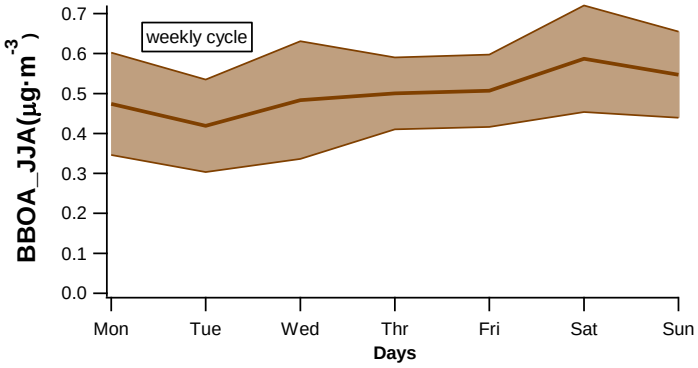
Barcelona and Athens Only

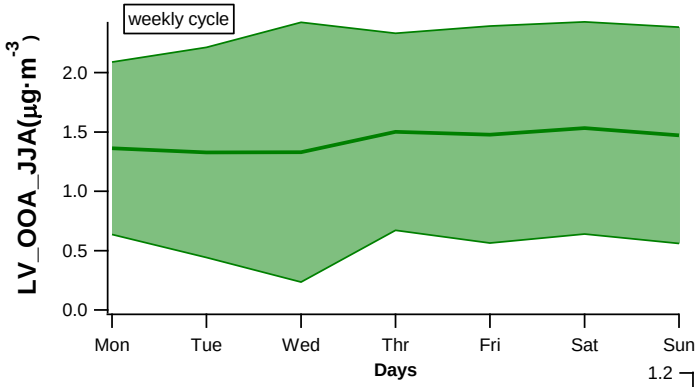
JJA averaged weekly cycle

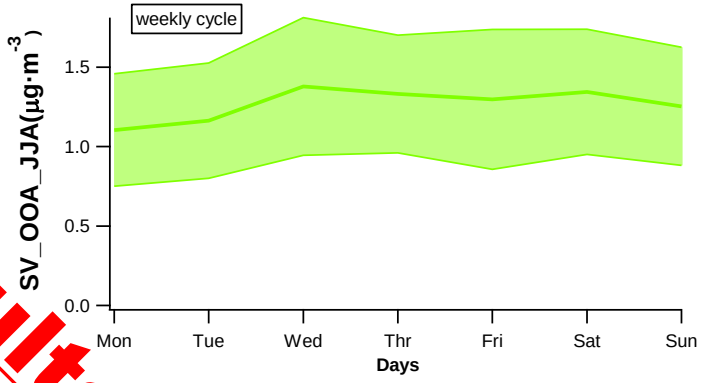
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

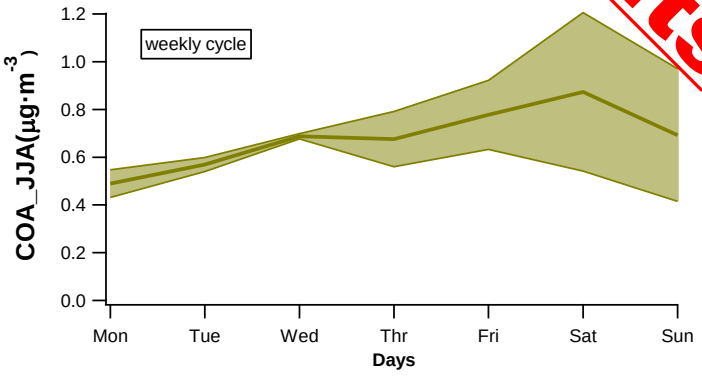
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL











Unpublished results

Barcelona and Athens Only

Summary and Outlook

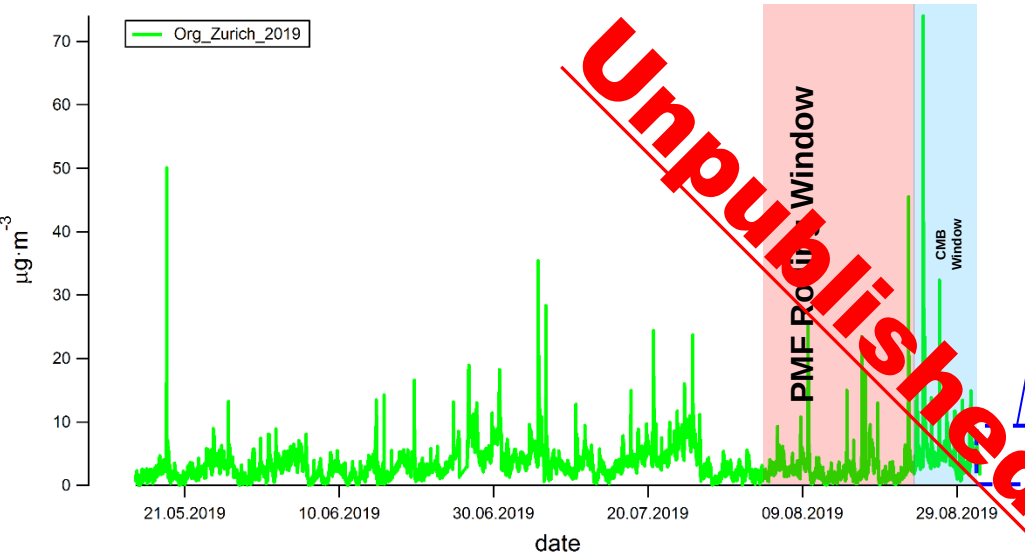
cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

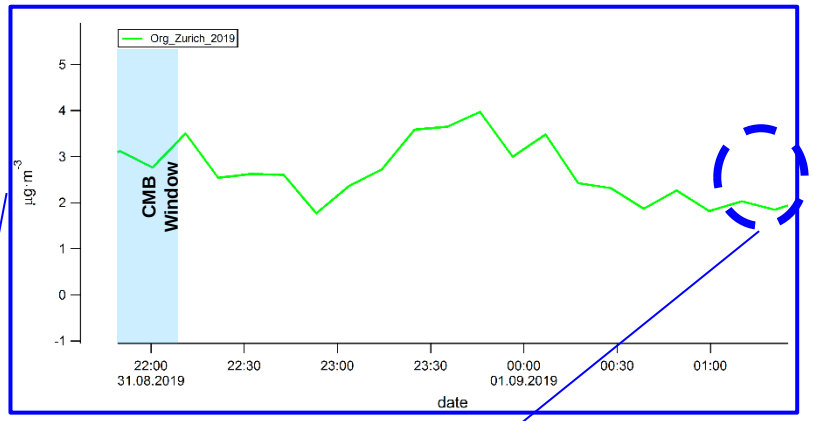
COLOSSAL
CA16109 Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL

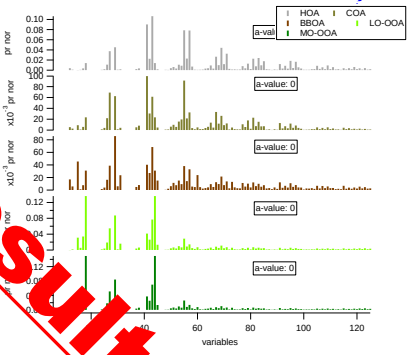
- 8/24 datasets have preliminary results so far;
- OOA is still the largest contributor over the Europe;
- Biomass burning is a considerable sources in most of the stations, especially during the cold period

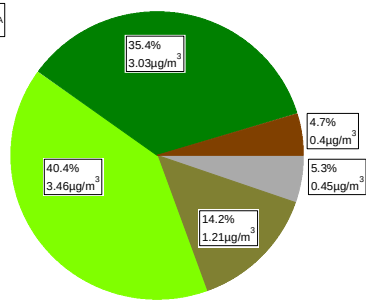
- This study provides a standardized protocol to analyzing long-term ACSM data using SoFi Pro;
- It could provide a comprehensive overview of the temporal/spatial variabilities of the OA sources in Europe;
- With the overlap from 2016 to 2017, the origin of long-range transport aerosols could be determined;
- With highly time resolved OA sources, it could provide additional constrains for air quality models;
- On top of the success of this project could potentially leads to the possibilities of **Real-time source apportionment**

Real-time Source Apportionment









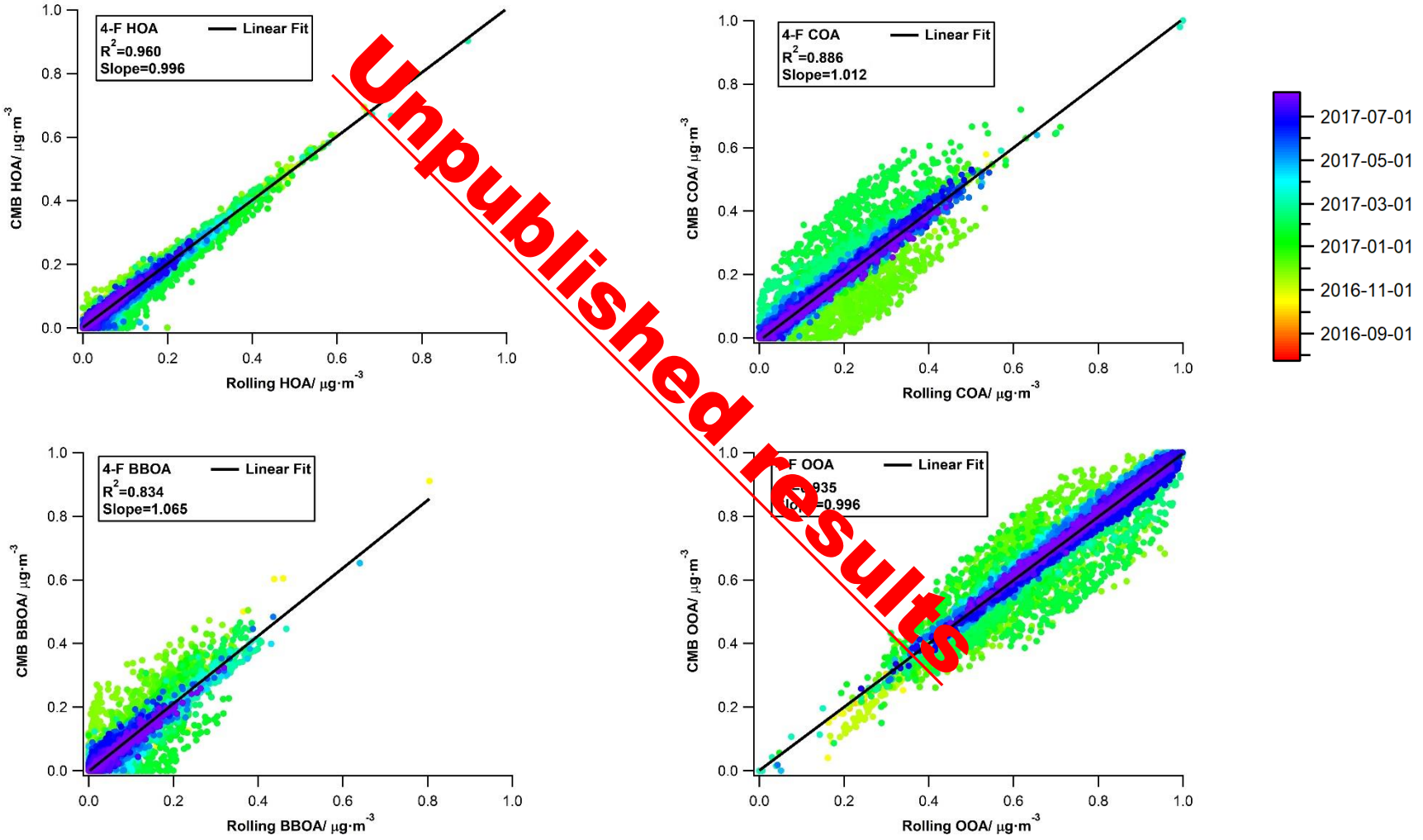
Assumptions:

Source profiles are consistent within PMF window and the next data point

Concept:

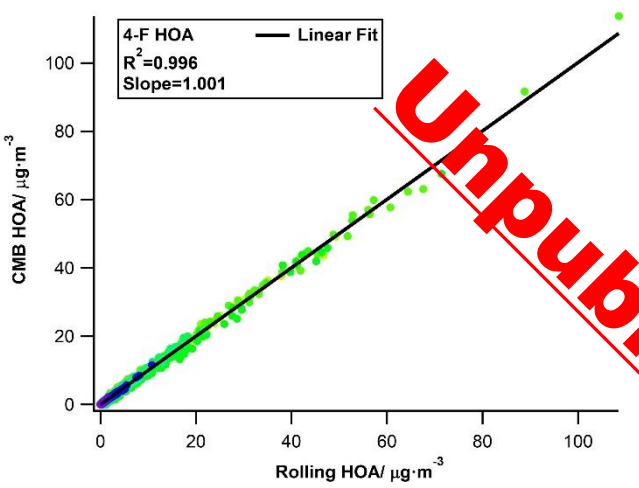
Run the rolling PMF with a small step (e.g., 1 day), using the source profiles from the most-recent solution to run chemical mass balance (CMB) for the next data point to retrieve the real-time OA sources.

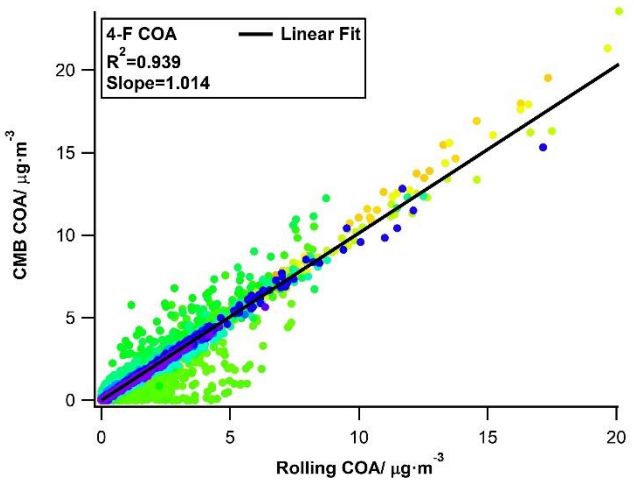
Comparison in relative contributions

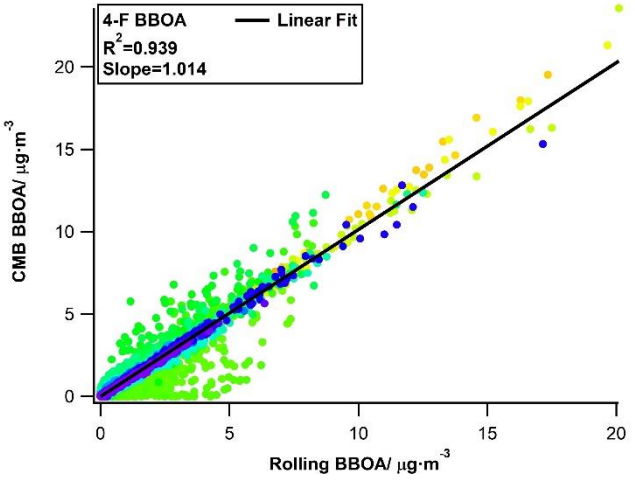


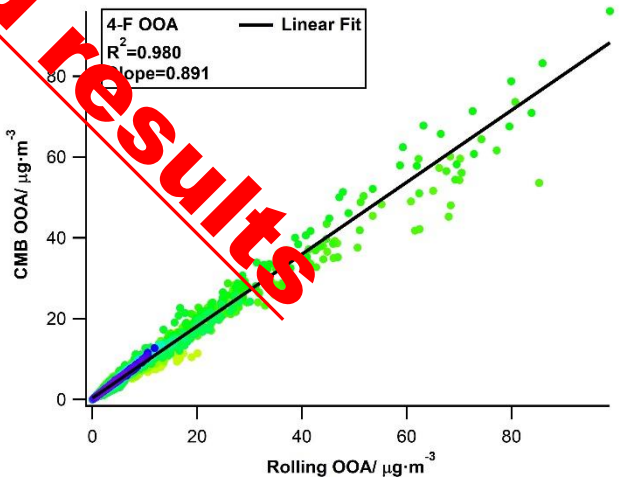
4-factor, 7-day window, 10 repeats/window

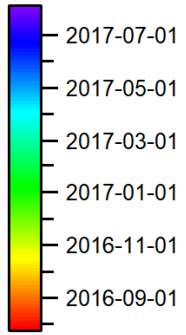
Comparison in mass concentration



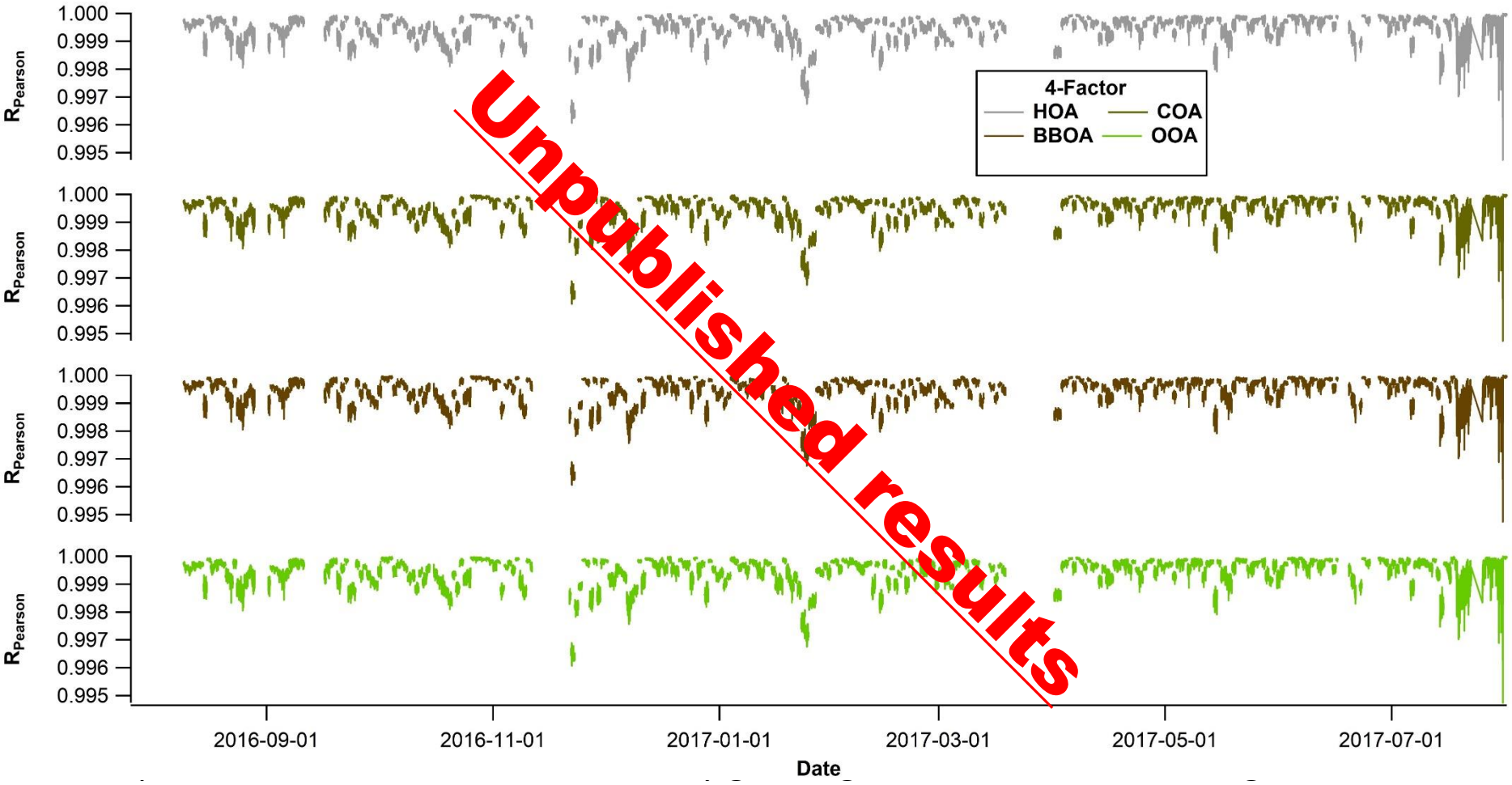








Correlation b/w factor profiles



profiles from the rolling results.

The factor profiles are rather static within 14-day rolling PMF window