Source apportionment of carbonaceous fine aerosols in near-real time (NRT)

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in close collaboration with:

Datalystica (F. Canonaco and A. Tobler)

Paul Scherrer Institute (Gang Chen, K. Daellenbach, et al.)

AERIS/Icare (N. Pascal, A. Chauvigné, et al.)

Tropos/CAIS-ECAC (T. Müller et al.)

NILU/ACTRIS AIS DC (M. Fiebig, P. Eckhardt, et al.)

RI-URBANS (101036245)

Science meeting – 19-20 Oct. 202

This task is about: Source Apportionment ST

Sampling sites

Data collection

Main PM components

Tracers

Data analysis

Tools

Tools

Epidemiological and/or toxicological data

e.g., combustion sources, road dust, secondary organic aerosols (SOA)

Sources identification

Air quality plans

Long-term trends

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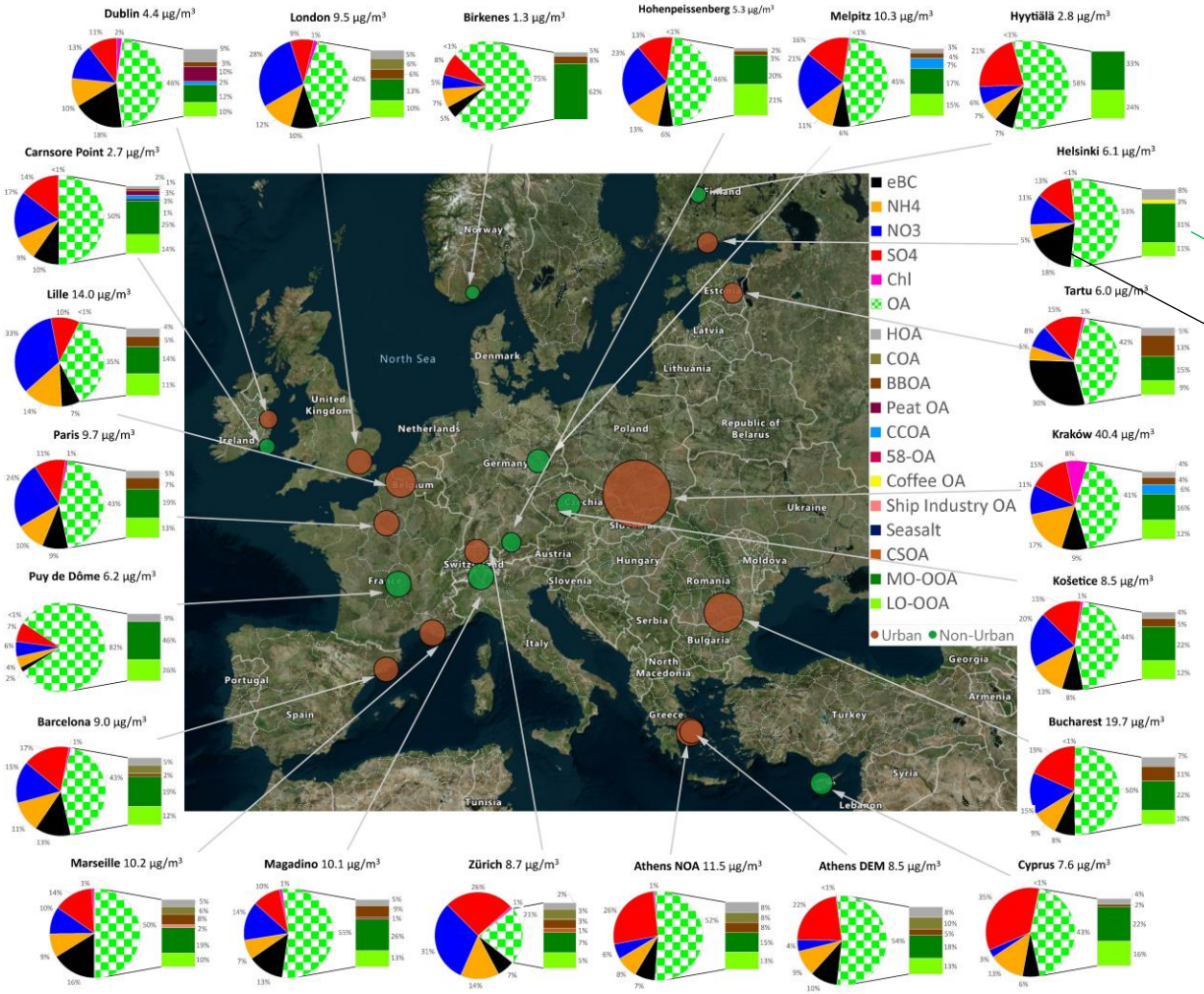
Predominance of carbonaceous aerosols in PM_1



Main PM_1 components at various European sites (Chen et al., 2022)

Organic Aerosol (OA) sub-fractions

Black carbon (BC)

Various sources, to be apportioned:

- Different type of combustion sources
- Primary vs.sceondary OA (POA vs. SOA)
- SOA from mainly from anthropogenic or biogenic precursors ?

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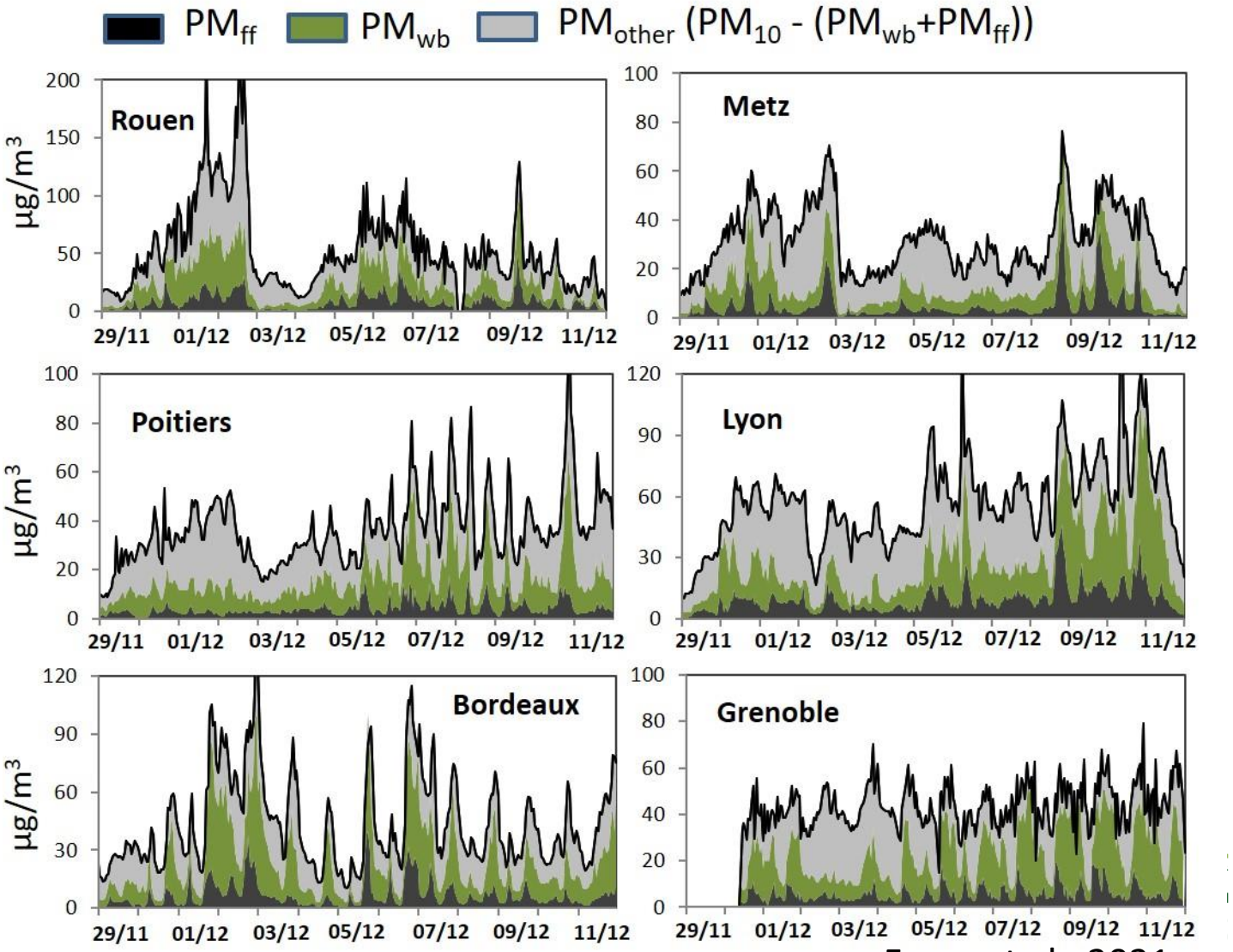
Black Carbon NRT Source Apportionment (liquid fuel vs. Solid fuel burning)

Using multi-wavelength light absorption measurements (filter-based photometers)

Ex. at various AQMN stations France, Dec. 2016

- PM_{ff} due to liquid fuel burning (e.g., traffic exhaust)

- PM_{wb} due to solid fuel burning (e.g., biomass burning)



Favez et al., 2021

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Black Carbon NRT Source Apportionment (liquid fuel vs. Solid fuel burning)

Using multi-wavelength light absorption measurements (filter-based photometers)

Using the Beer–Lambert's Law, we obtain the equations relating the absorption coefficients (b_{abs}), the wavelengths, and the absorption exponents for conditions of pure traffic and pure woodburning (wb).

$$\frac{b_{abs}(470\ nm)_{traffic}}{b_{abs}(950\ nm)_{traffic}} = \left(\frac{470}{950}\right)^{-\alpha_{traffic}} \quad (1)$$

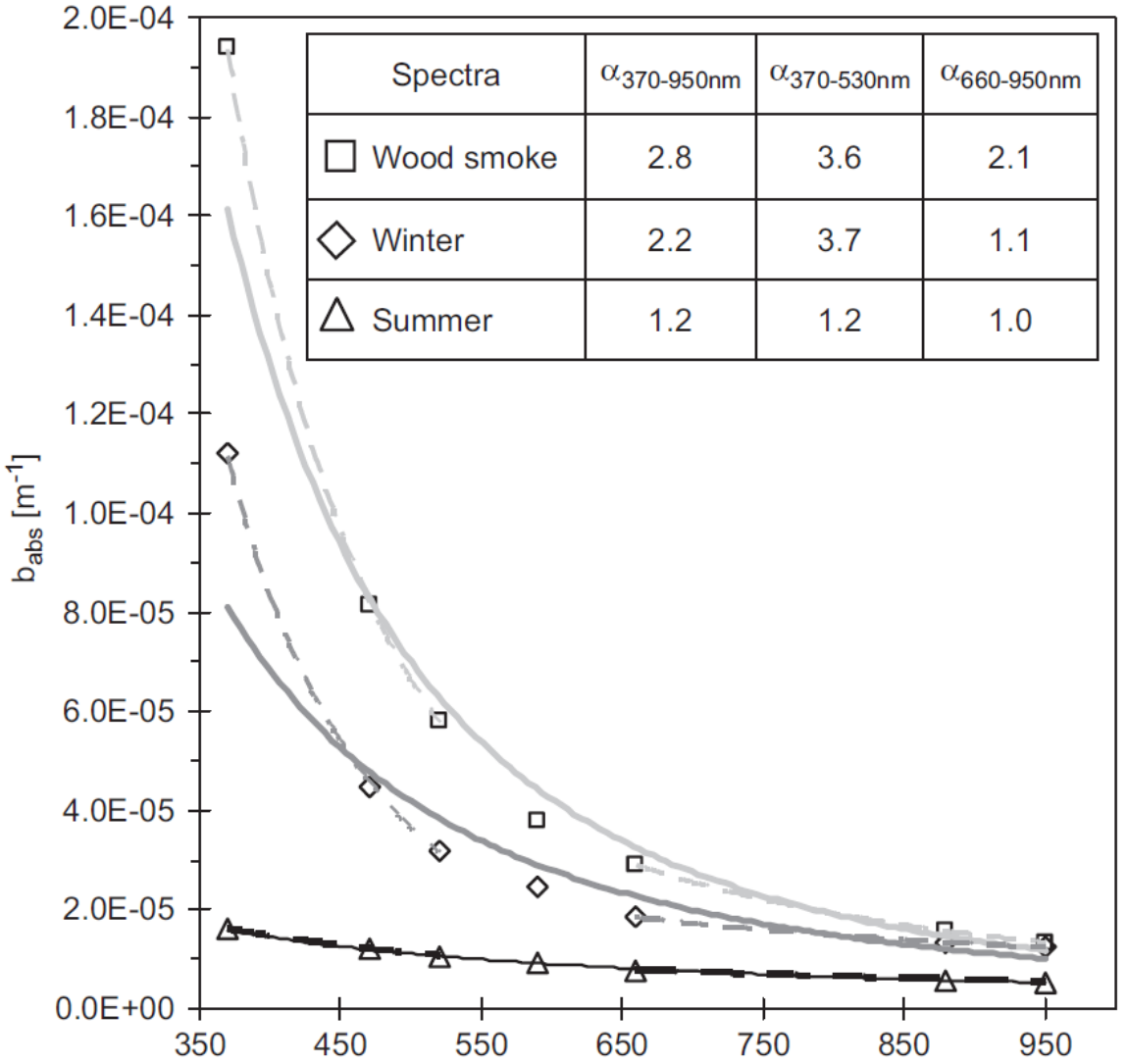
$$\frac{b_{abs}(470\ nm)_{wb}}{b_{abs}(950\ nm)_{wb}} = \left(\frac{470}{950}\right)^{-\alpha_{wb}} \quad (2)$$

$$b_{abs}(\lambda) = b_{abs}(\lambda)_{traffic} + b_{abs}(\lambda)_{wb} \quad (3)$$

For given $\alpha_{traffic}$ and α_{wb} values and using the field data of the light absorption measurements at 470 and 950 nm, the values for $b_{abs}(470nm)_{traffic}$, $b_{abs}(950nm)_{traffic}$, $b_{abs}(470nm)_{wb}$, and $b_{abs}(950nm)_{wb}$ can be computed with eqs 1−3. In this study,

Sandradewi et al., 2008

Spectra	$\alpha_{370\text{-}950nm}$	$\alpha_{370\text{-}530nm}$	$\alpha_{660\text{-}950nm}$
□ Wood smoke	2.8	3.6	2.1
◇ Winter	2.2	3.7	1.1
△ Summer	1.2	1.2	1.0



Sandradewi et al., 2007

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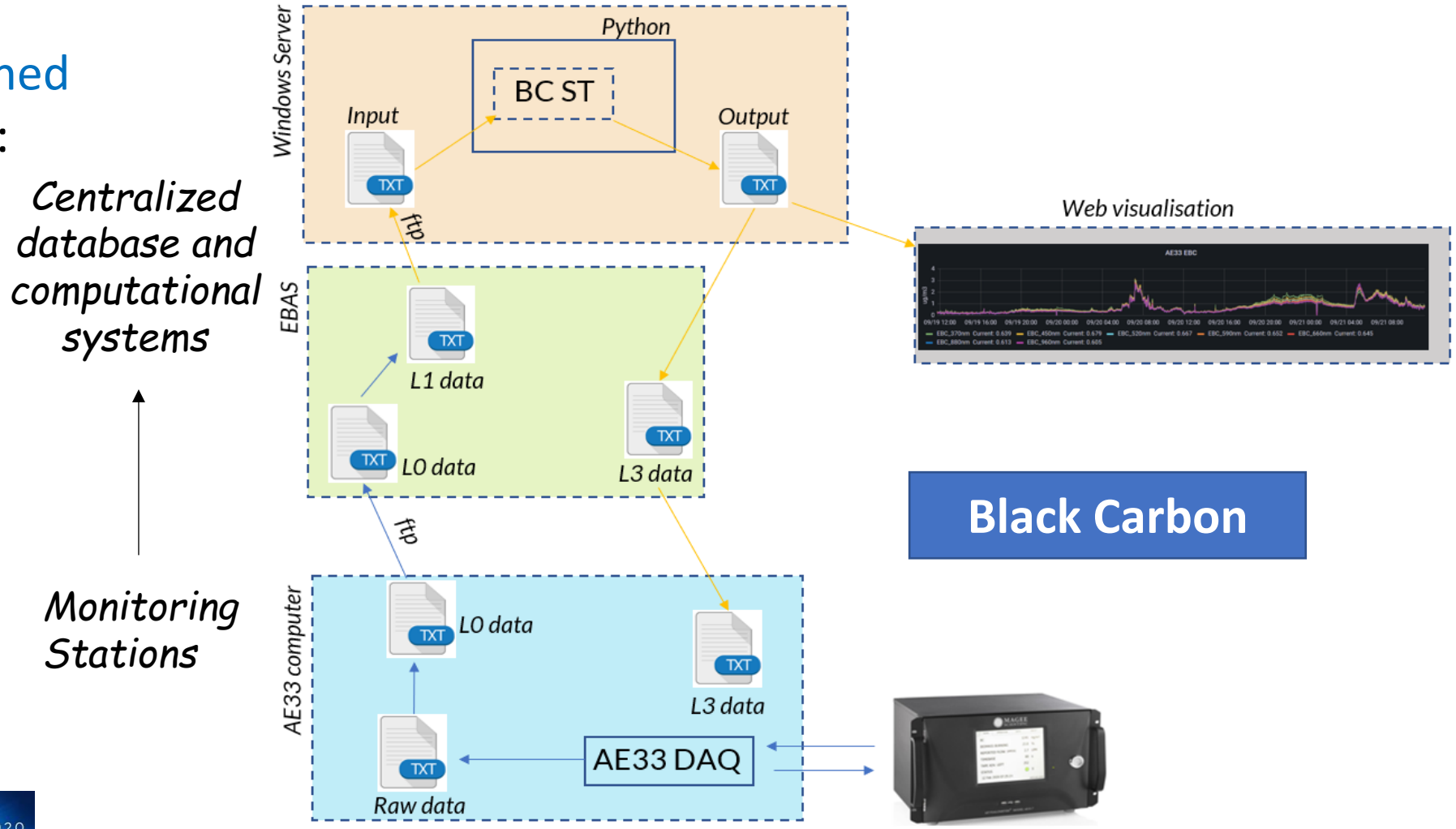
Black Carbon NRT Source Apportionment (liquid fuel vs. Solid fuel burning)

Data workflow designed for this RI-Urbans Task:



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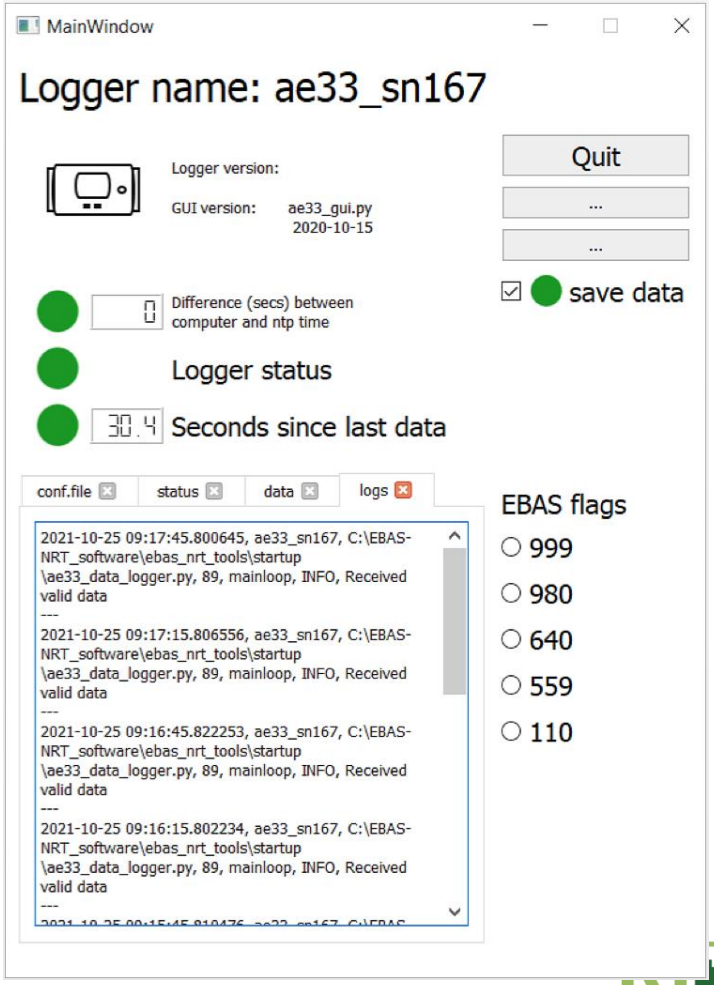
Black Carbon NRT Source Apportionment (liquid fuel vs. Solid fuel burning)

Data logger for NRT data transmission to EBAS

Taking advantage from **NRT data transfer procedures** also developped in the frame of CAMS21a projects (ECMWF-ACTRIS contracts)

- Fully configurable via configuration file for automatic startup after boot
- Similar and simple GUIs for all data loggers
- Setting EBAS flags
- Generation of Nasa-ames files
- Error detection and troubleshooting
  - Reinitialization of device connections, software & hardware restart if required
  - Saving all activities, status and error messages
- Saving data in various formats for
  - Debugging (text file)
  - Long-term data storage (text file)
  - Direct and fast access for visualisation and data processing (database)



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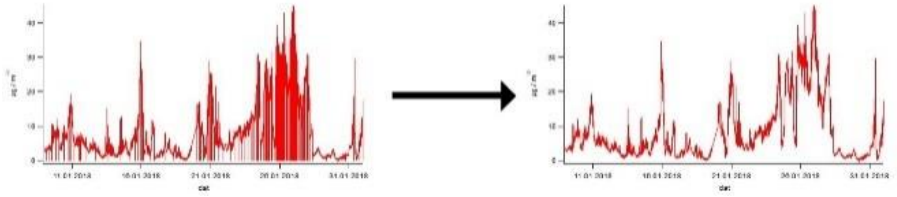
Black Carbon NRT Source Apportionment (liquid fuel vs. Solid fuel burning)

Improving the Aethalometer Model calculation chain:



- Increasing signal-to-noise ratio in the retrieval of 15-min average data
- Reinforcing data qualification procedures, e.g., comprehensive qualification of the whole set of multi-wavelength measurements
- Checking for the validity of automated firmware correction procedures
- Determining and computing site-specific parameters (source-dependent Angström absorption exponents)

Zotter et al., 2017

Station	α_{WB} range	α_{WB} mean ± standard deviation
SIS	1.23–1.84	1.55 ± 0.21 ($n = 9$)
ZUR (winter)	1.47–1.80	1.67 ± 0.11 ($n = 14$)
ZUR (summer)	1.34–1.90	1.60 ± 0.14 ($n = 8$)
MAG	1.53–1.85	1.69 ± 0.09 ($n = 19$)
PAY	1.42–1.80	1.63 ± 0.10 ($n = 19$)
MOL	1.85–2.17	1.93 ± 0.16 ($n = 4$)
ROV	1.43–1.85	1.68 ± 0.11 ($n = 13$)
REI	1.70–1.86	1.81 ± 0.06 ($n = 5$)
MAS	1.46–1.65	1.56 ± 0.06 ($n = 8$)

D1.4-5 Service tool for NRT source apportionment of carbonaceous matter:

Black Carbon ($PM_{2.5}$)

AE33, Aerosol d.o.o.

ACTRIS Level0b data

TXT

Treatment
Data curation
Formatting

Open-source software (Python)

BC Source App. results

+ Visualization tool

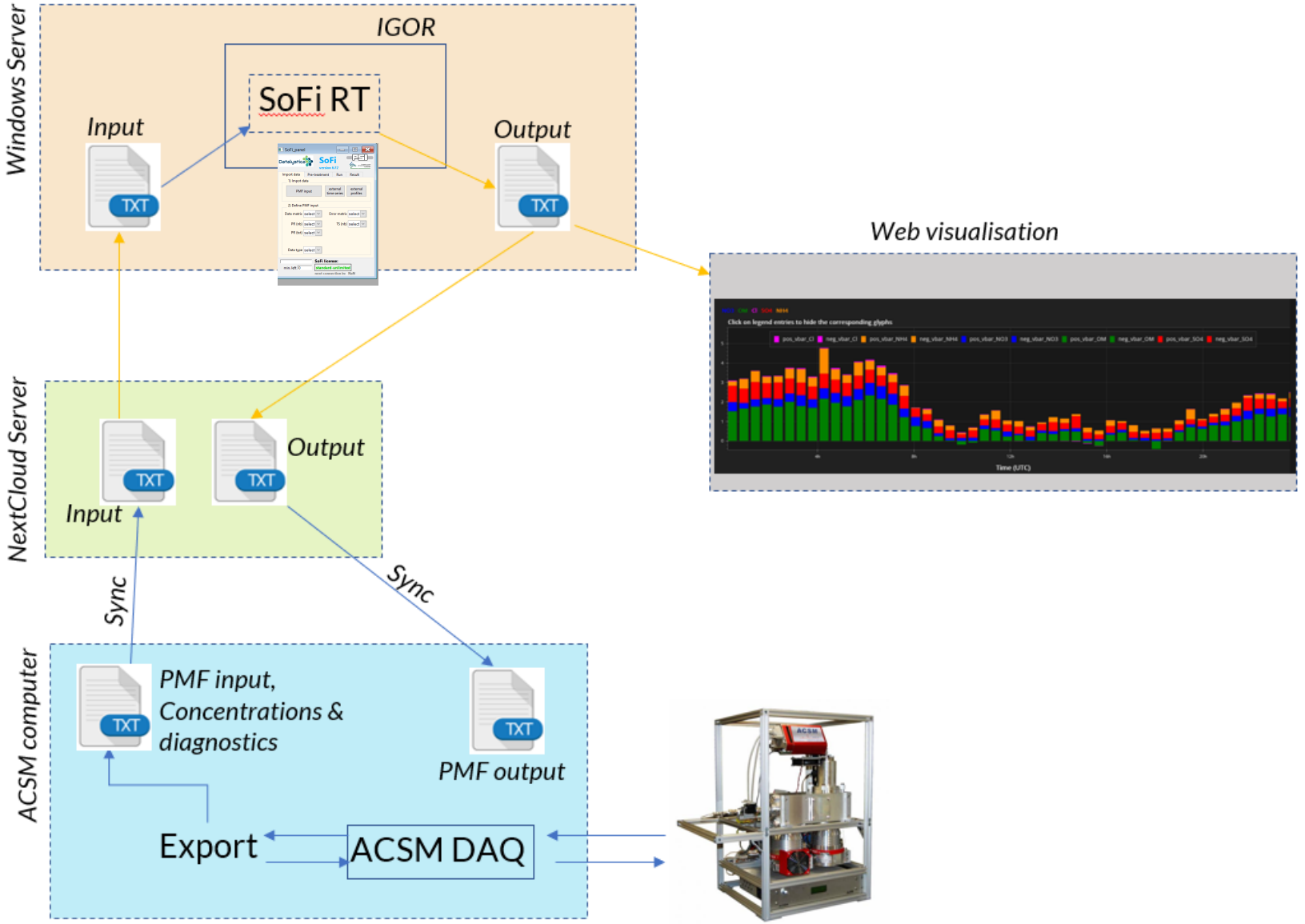
Already installed at most of the pilot sites

Server is ready to host software still under development

Organic Aerosols NRT Source Apportionment

Centralized database and computational systems

Monitoring Stations



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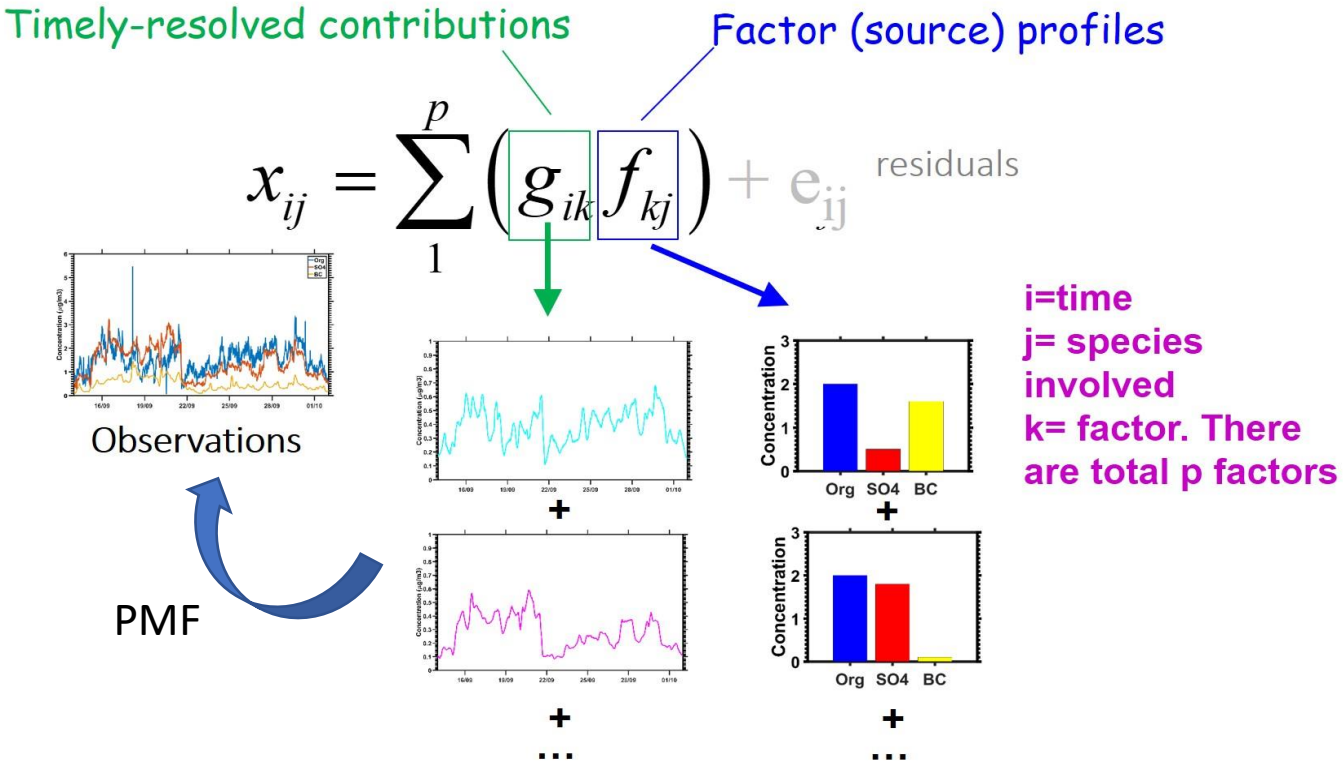
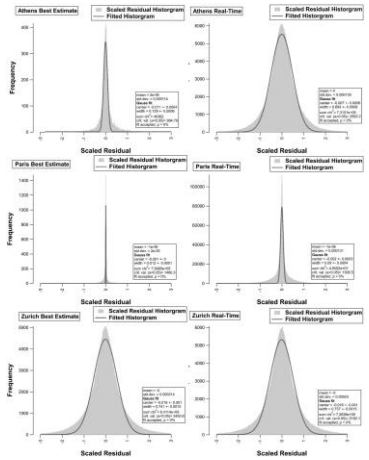
Positive Matrix Factorization (PMF)

Standard PMF: **No a priori information about the sources** (number, profiles, ..) are needed



Q represents the difference between PMF outputs and measurements, which should be minimized by the model

$$Q = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{\left(x_{ij} - \sum_{k=1}^{p} g_{ik} f_{jk} \right)^2}{\sigma_{ij}^2}$$



Positive Matrix Factorization (PMF)

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1st step of PMF

$$Q = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{\left(x_{ij} - \sum_{k=1}^{p} g_{ik} f_{jk} \right)^2}{\sigma_{ij}^2}$$

Enhanced PMF: Introduce some information about sources

E.g., Implementing target emission profiles

Enhanced PMF

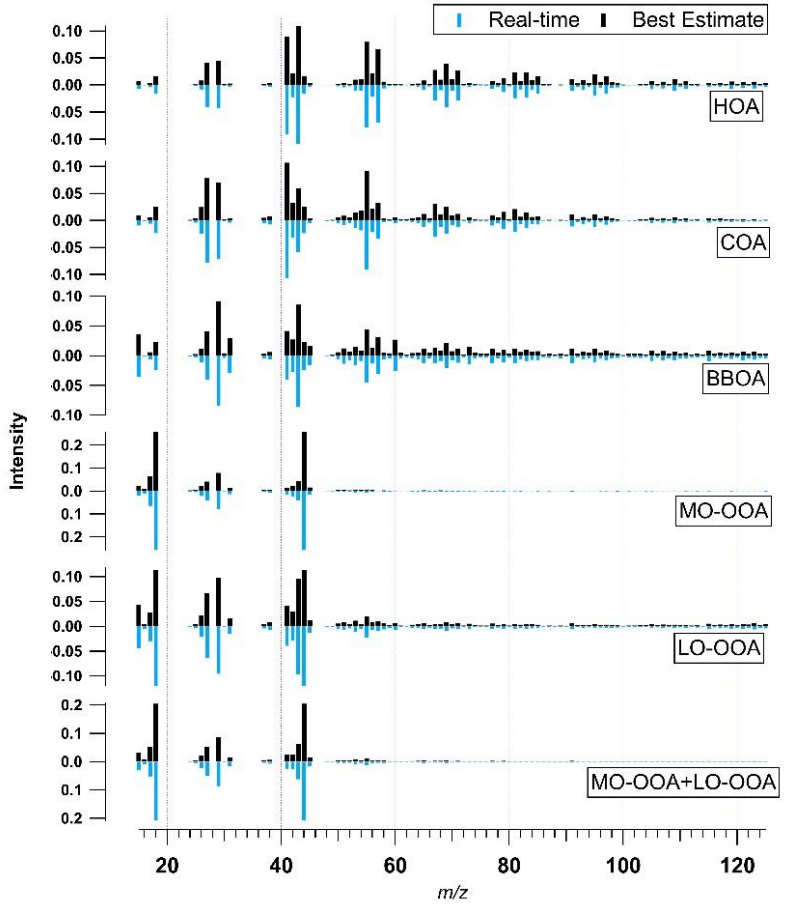
$$Q_{aux} = \frac{\left(f_{jk} - a_{jk} \right)^2}{\sigma_{jk}^{aux^2}}$$

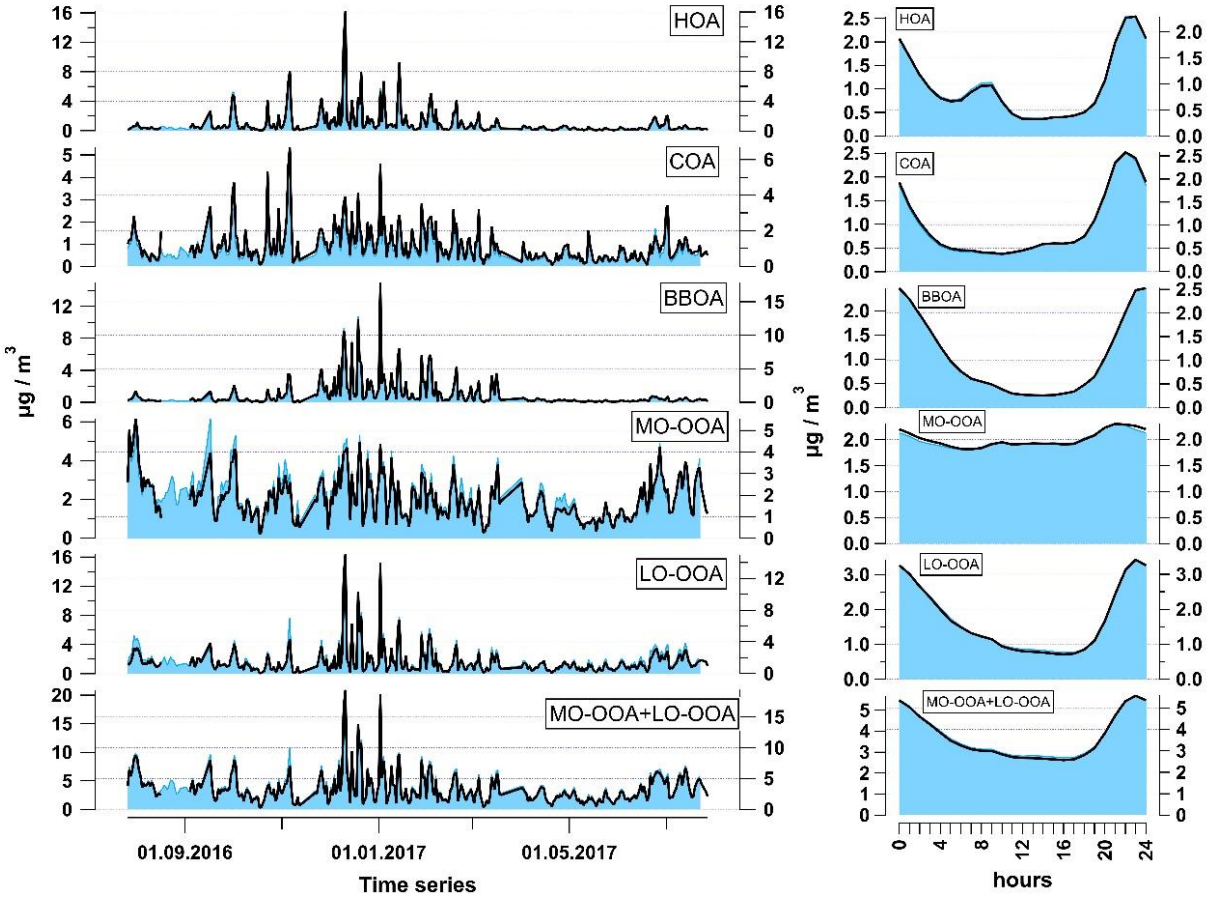
$$Q_{enh} = Q + Q_{aux}$$

Organic Aerosols NRT Source Apportionment

Based on mass spectral signatures and time variations:

Chen et al., EST, in press





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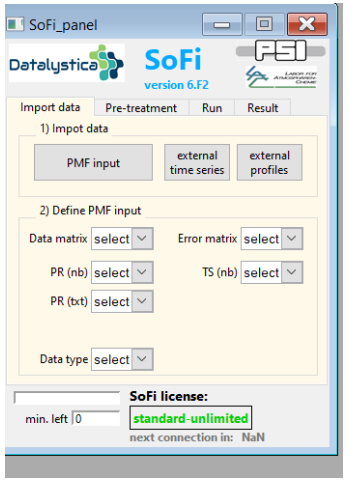
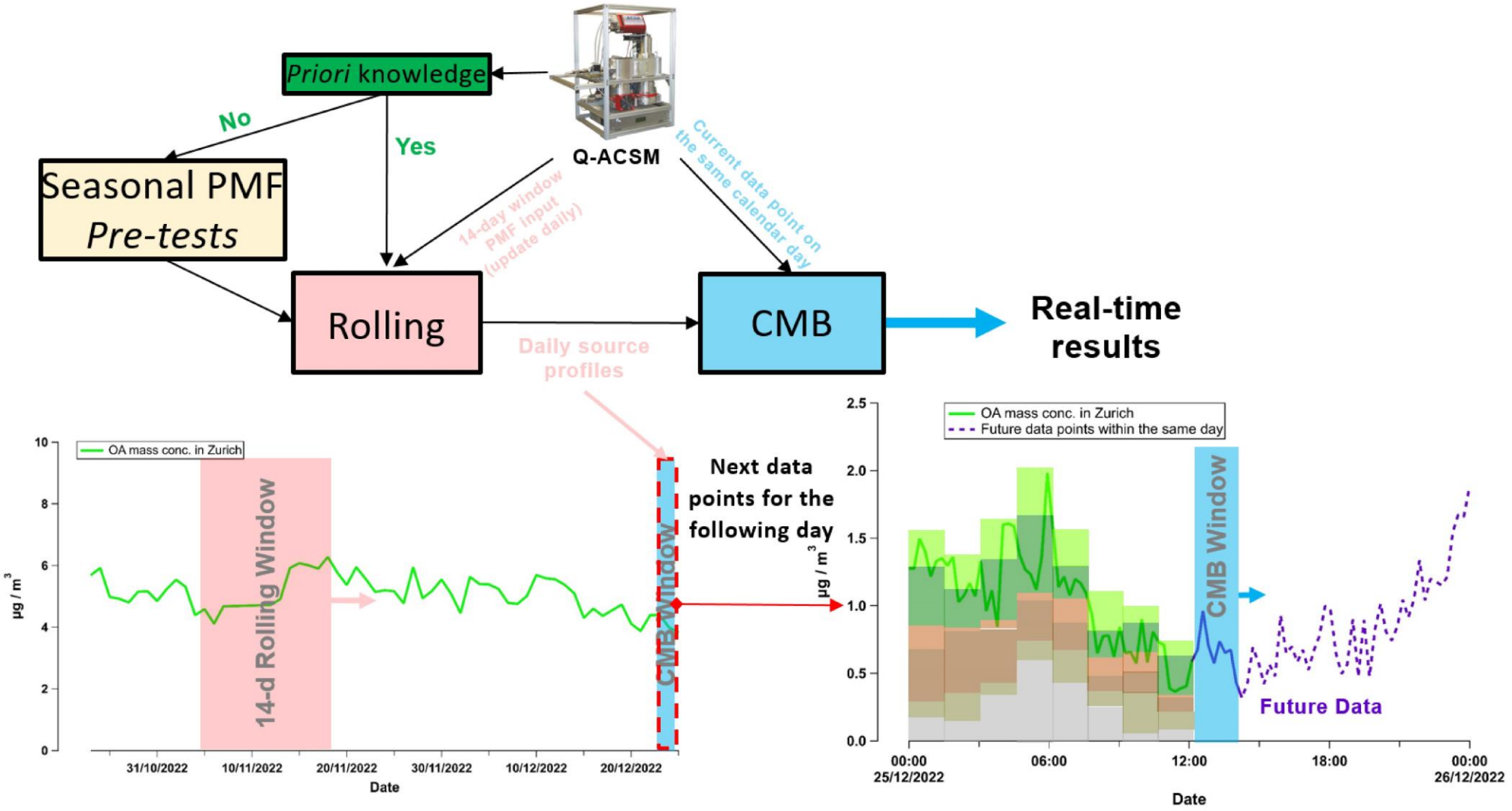
Organic Aerosols NRT Source Apportionment





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Chen et al., EST, in press

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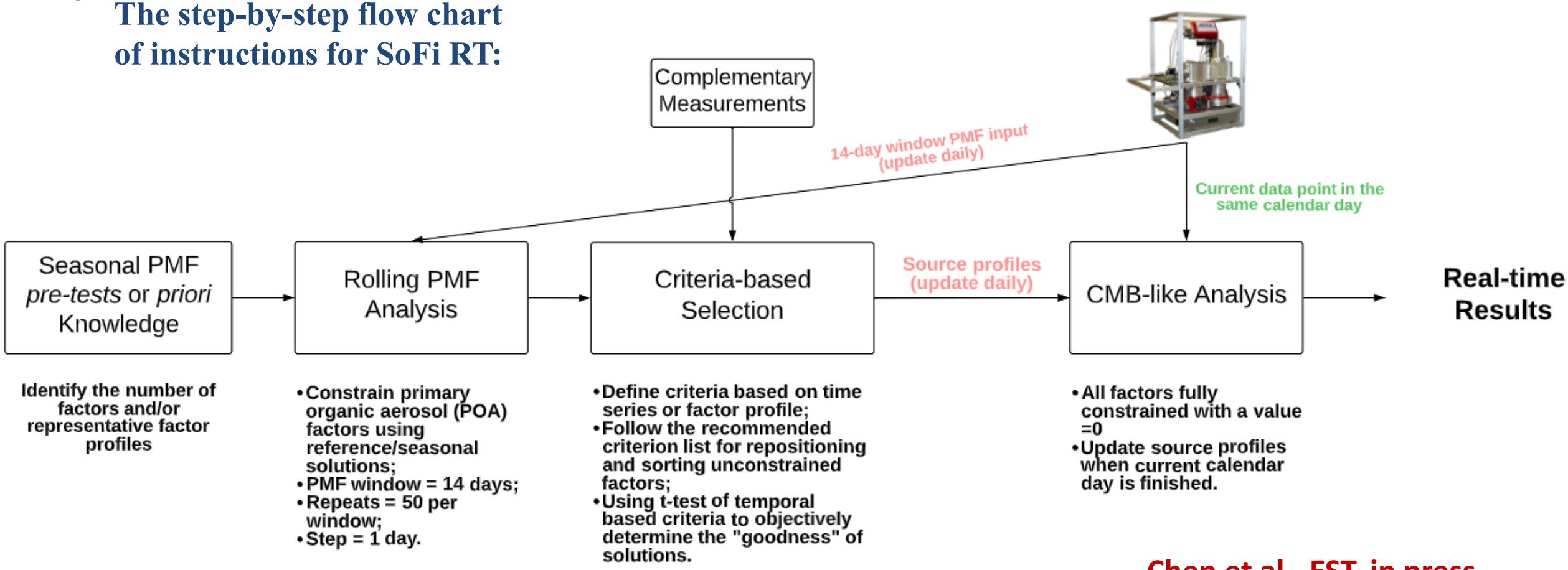
Organic Aerosols NRT Source Apportionment

The step-by-step flow chart of instructions for SoFi RT:



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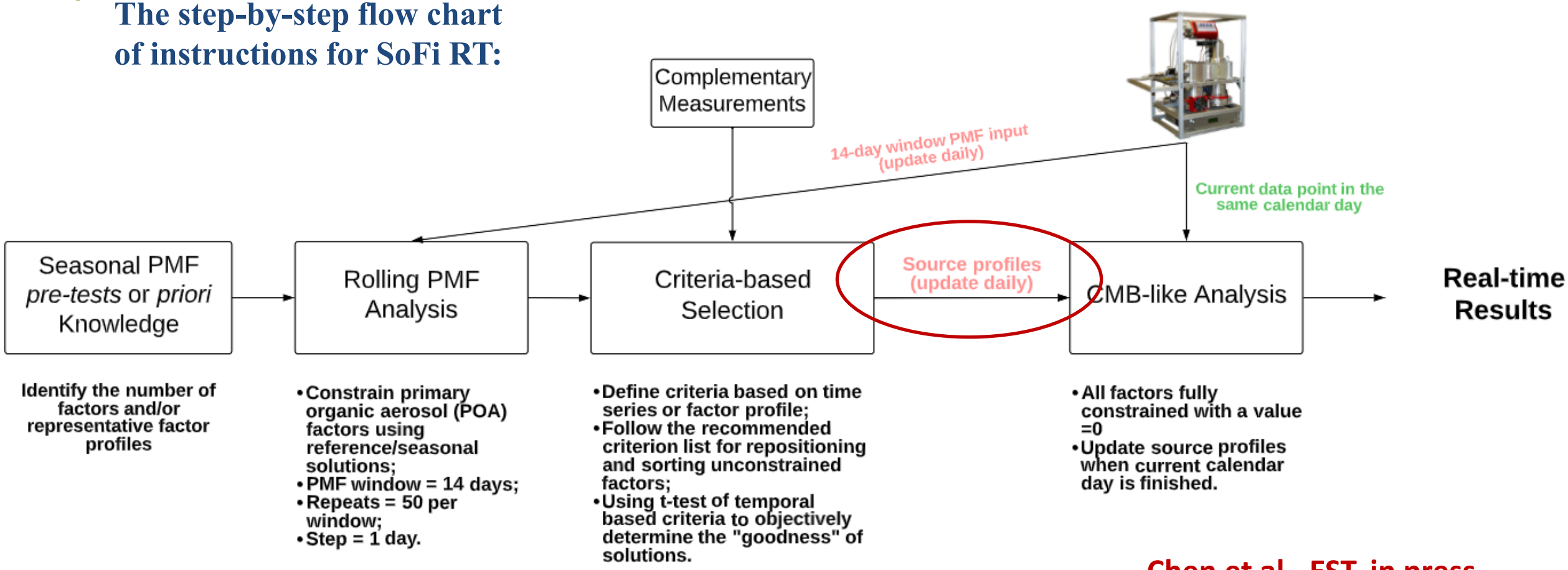

Chen et al., EST, in press

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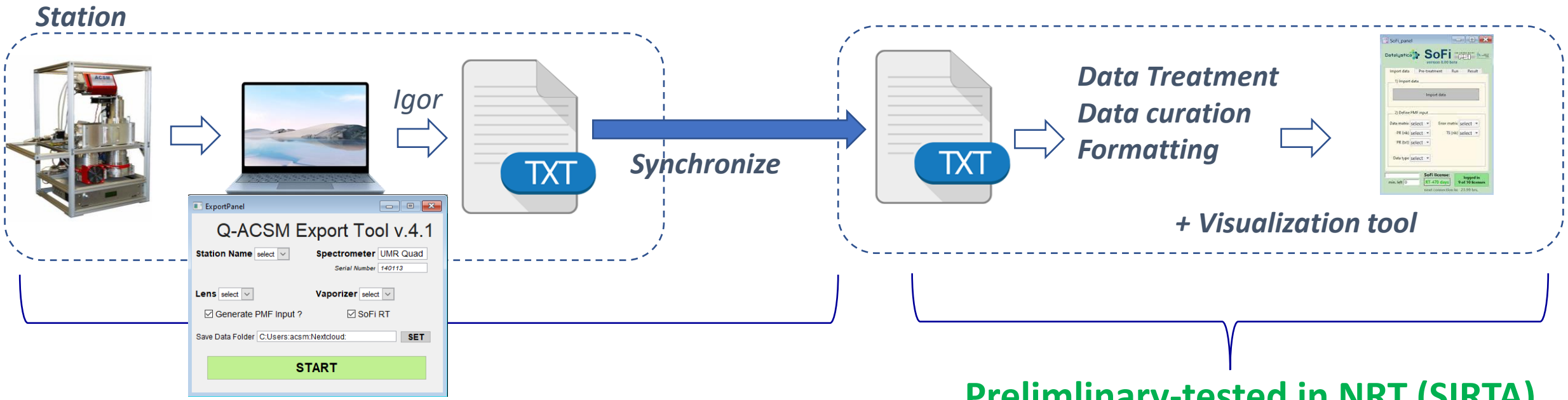
D1.4-5 Service tool for NRT source apportionment of carbonaceous matter:

Submicron OA



Developped and installed on pilot Quad-ACSM

Prelimlinary-tested in NRT (SIRTA)

Central server is ready to host

SoFi RT multisites computation

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Thank you very much for your attention

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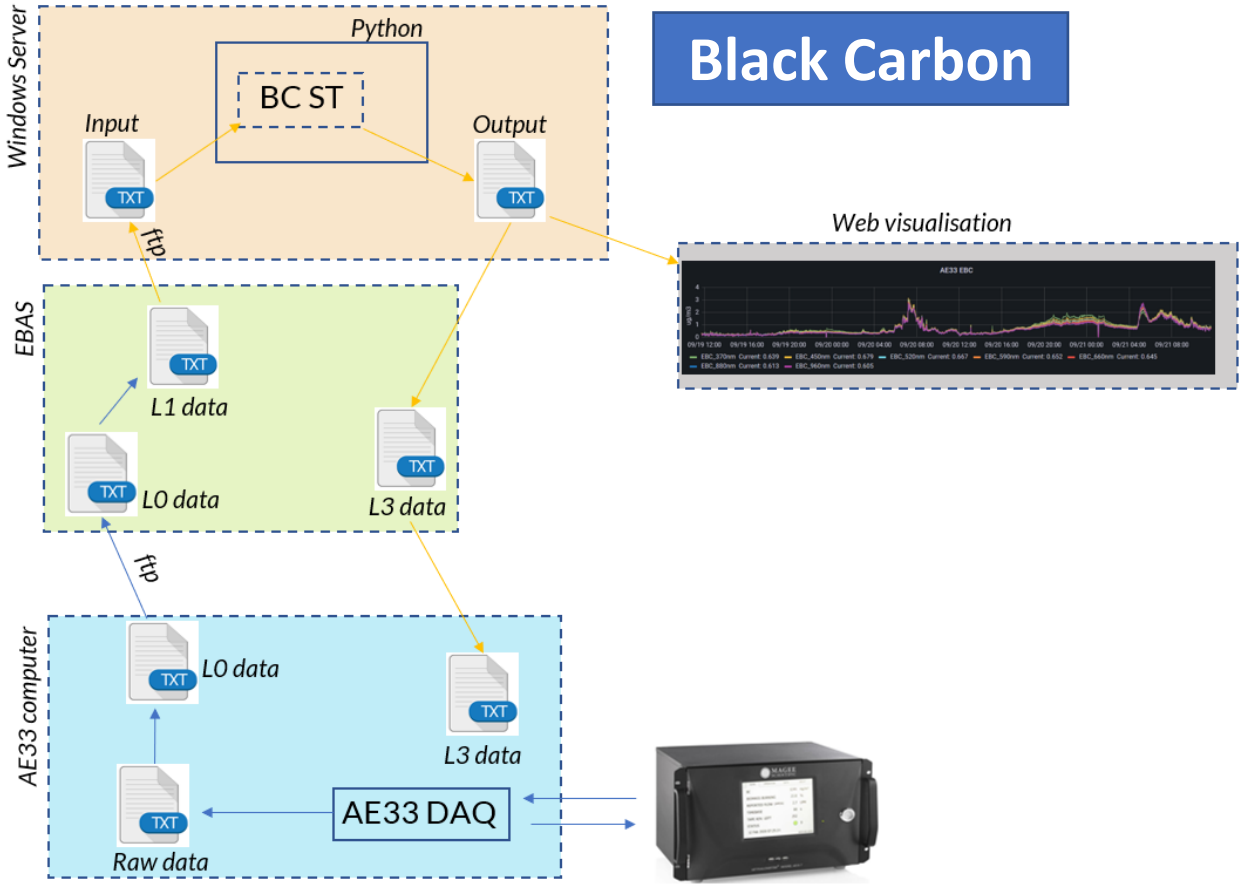

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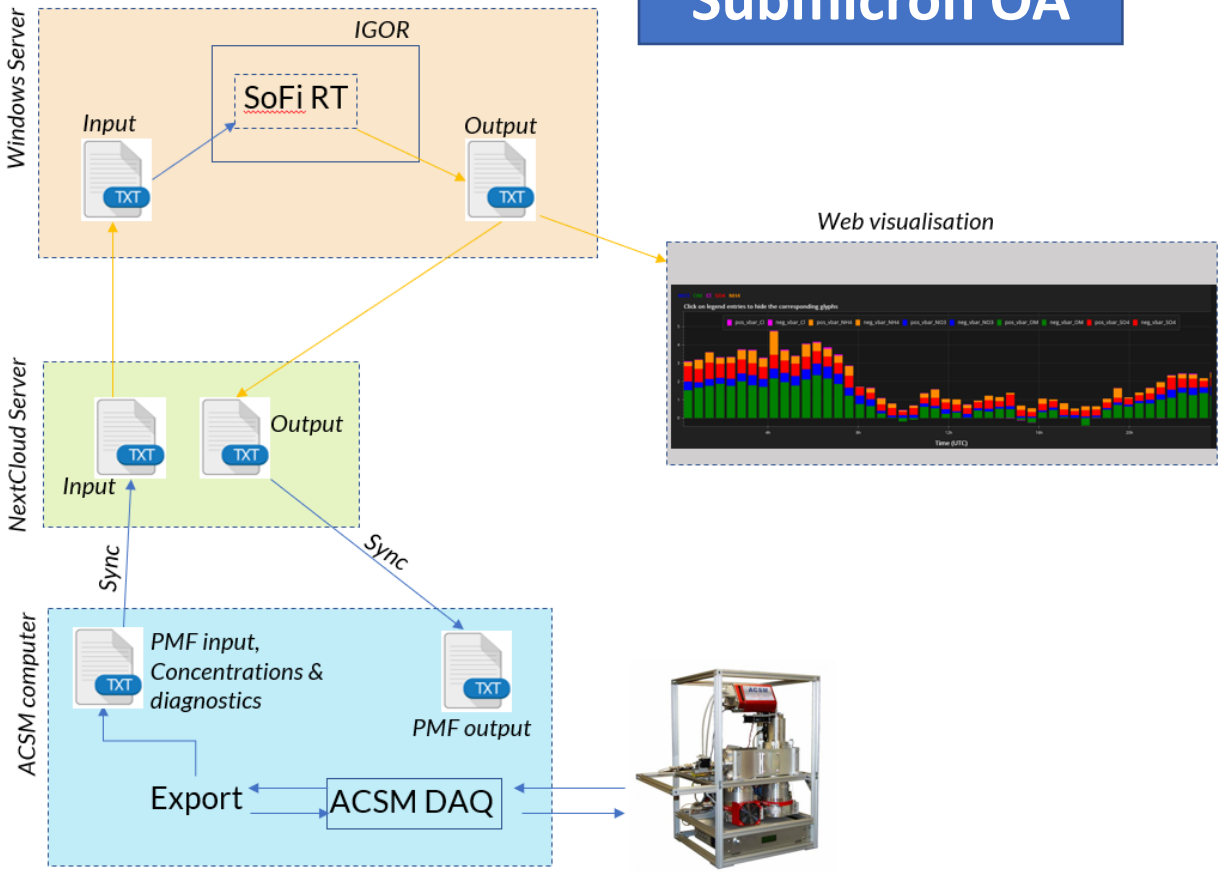

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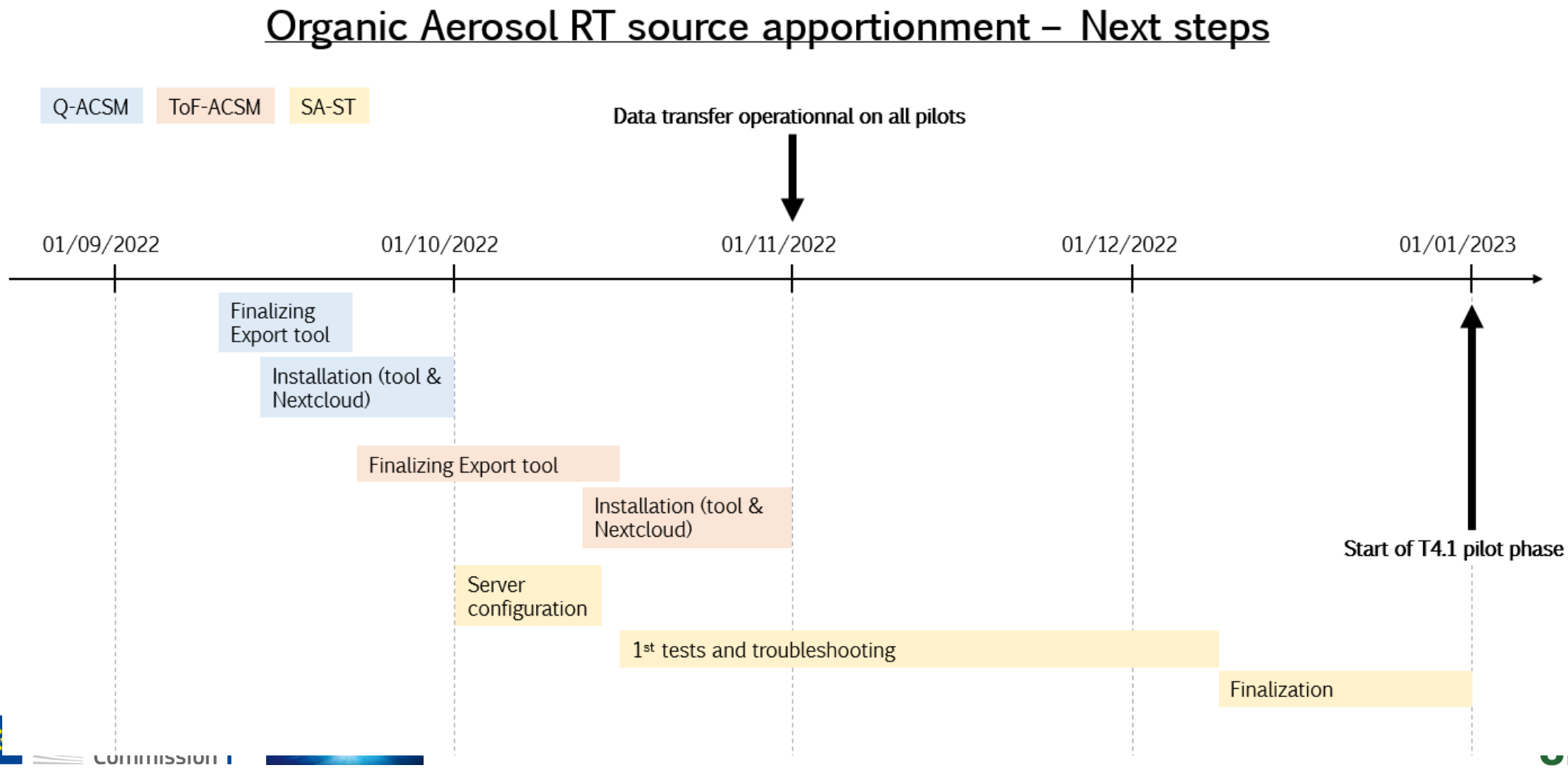

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