Developments, challenges, and the need for standards related to airborne bioaerosol measurements

Fiona Tummon – CCQM Workshop

25 October 2022

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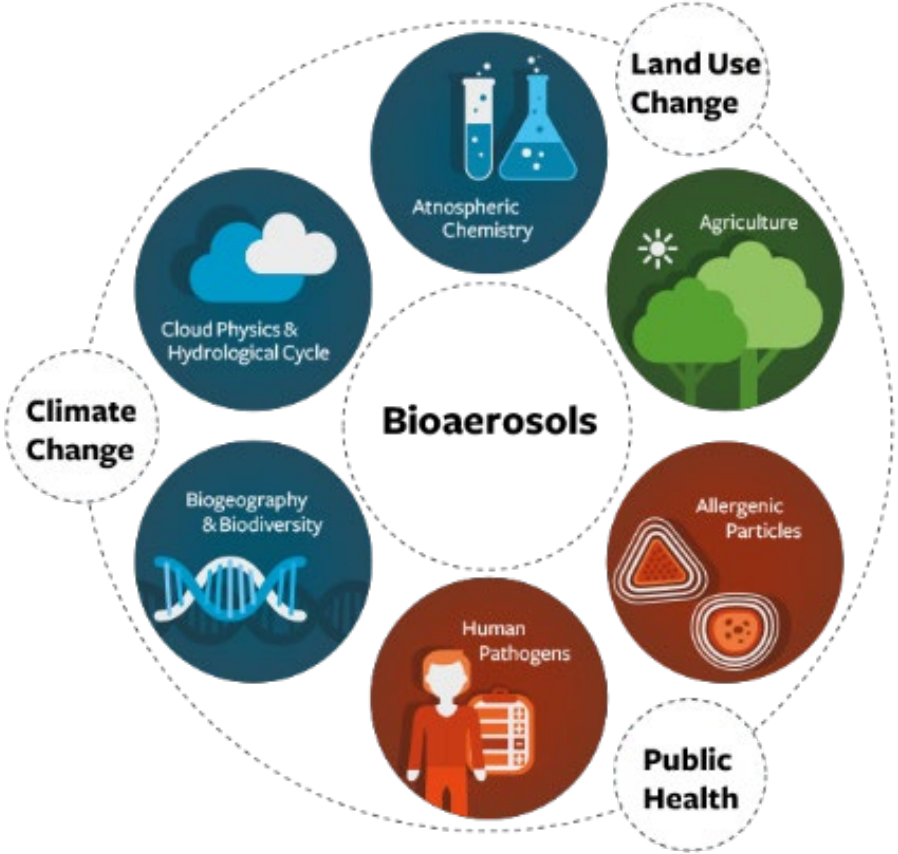
A little about bioaerosols…

Bioaerosol play an important role in many domains



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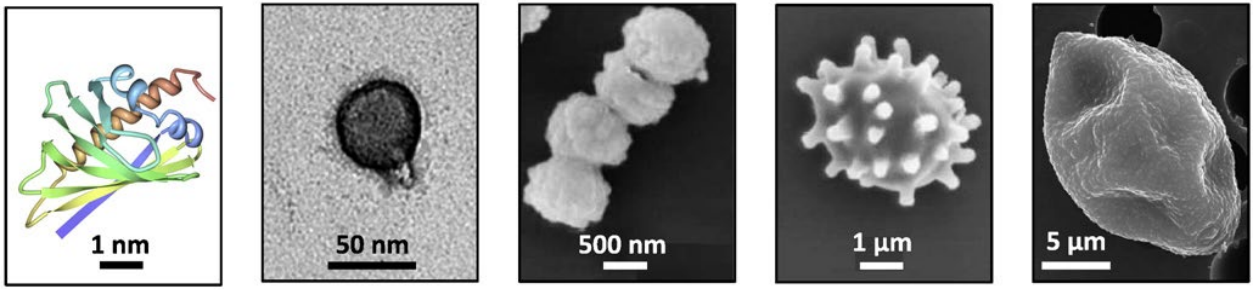
Bioaerosol cover a huge size spectrum



Proteins **Viruses** **Bacteria** **Spores** **Pollen**

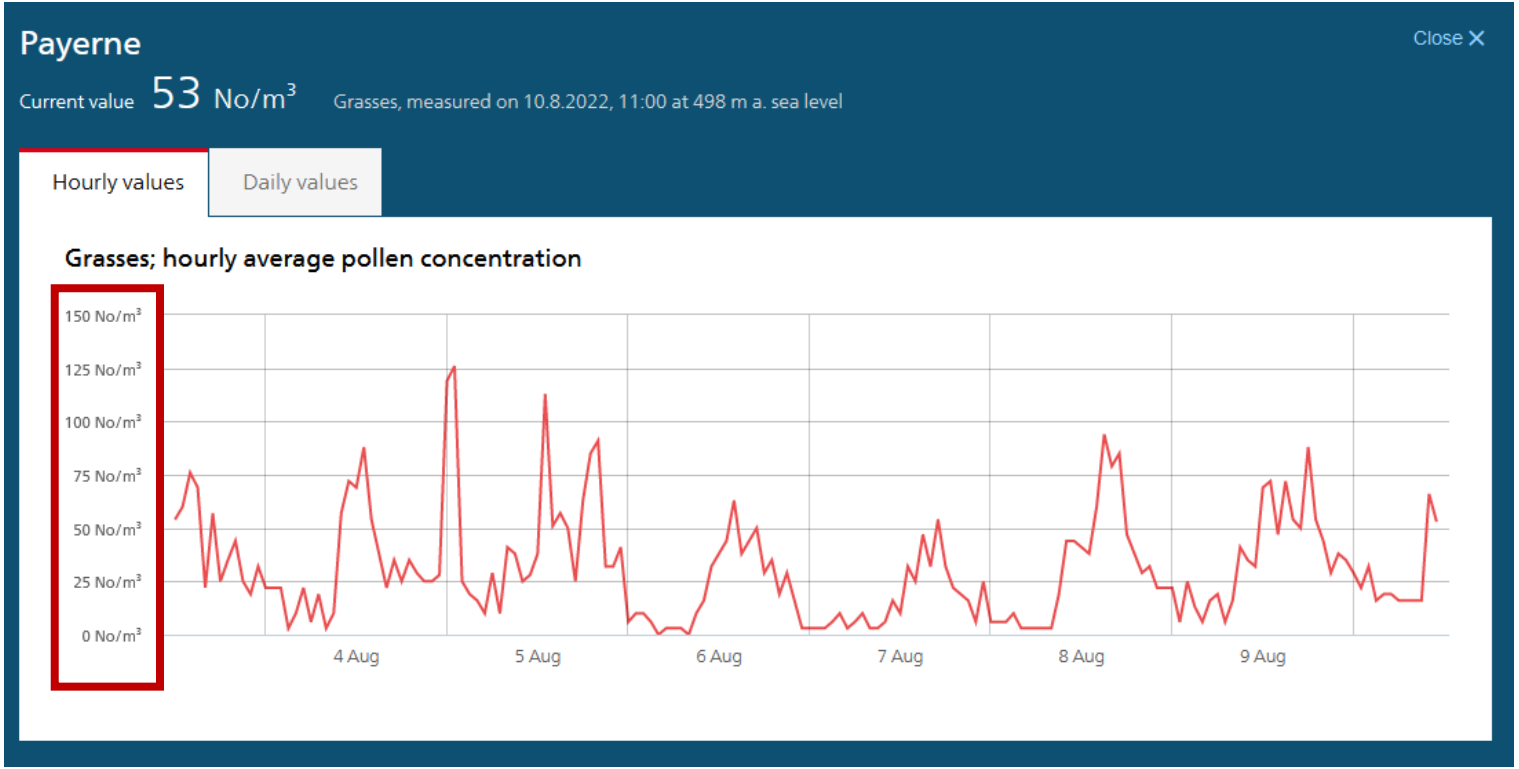
1.E-09 1.E-08 1.E-07 1.E-06 1.E-05 1.E-04

1 nm 10 nm 100 nm **1 µm** 10 µm **100 µm**

- ultrafine - *- fine -* *- coarse -*

Adapted from *Fröhlich-Nowoisky et al., 2016*

Bioaerosol concentrations are typically very low



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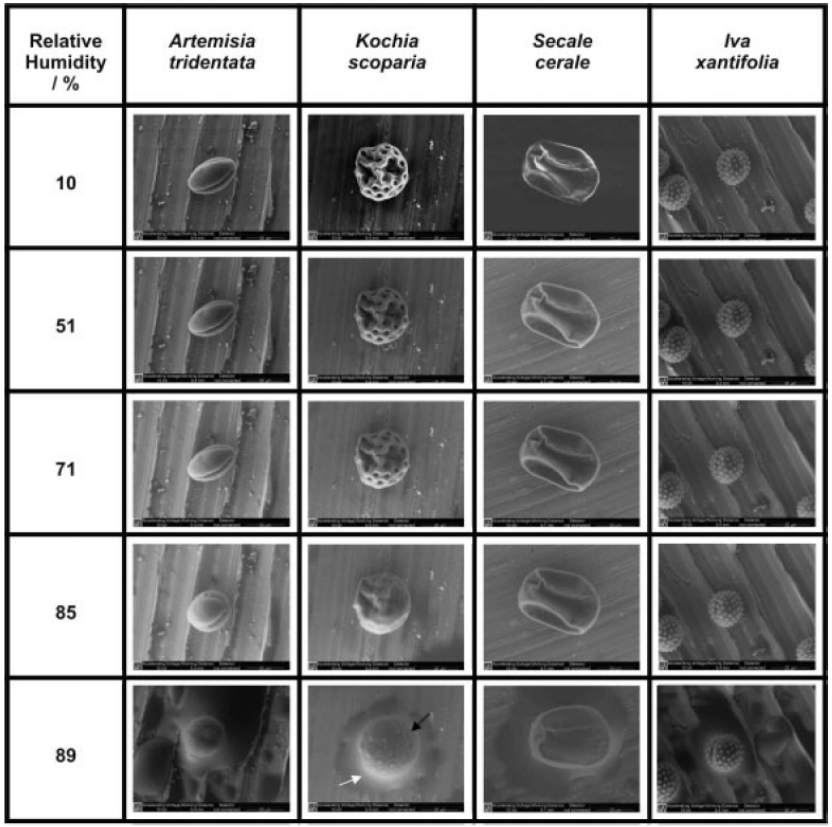
Certain bioaerosol characteristics depend on environmental conditions



Griffiths et al., 2012

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Calibration of bioaerosol monitors

…is a lot more challenging than traditional air quality monitors…

…because bioaerosol:

- Vary biologically within one particular species
- Are EXTREMELY large compared to “normal” aerosol
- Are fragile particles
- May age as they are transported through the atmosphere
- Probably vary under different weather conditions

Bioaerosol information is needed by many end user groups

Forecasts

(e.g. assimilating real-time observations)

Agriculture

(e.g. reducing pesticide use)

Climate Change

(e.g. tracking invasive species)

Health

(e.g. improving allergy diagnosis & treatment)

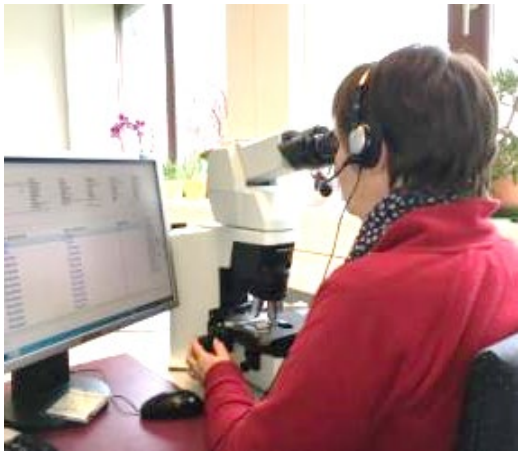
Research

(e.g. better understanding the hydrological cycle)

Developments so far

Traditional bioaerosol monitoring methods

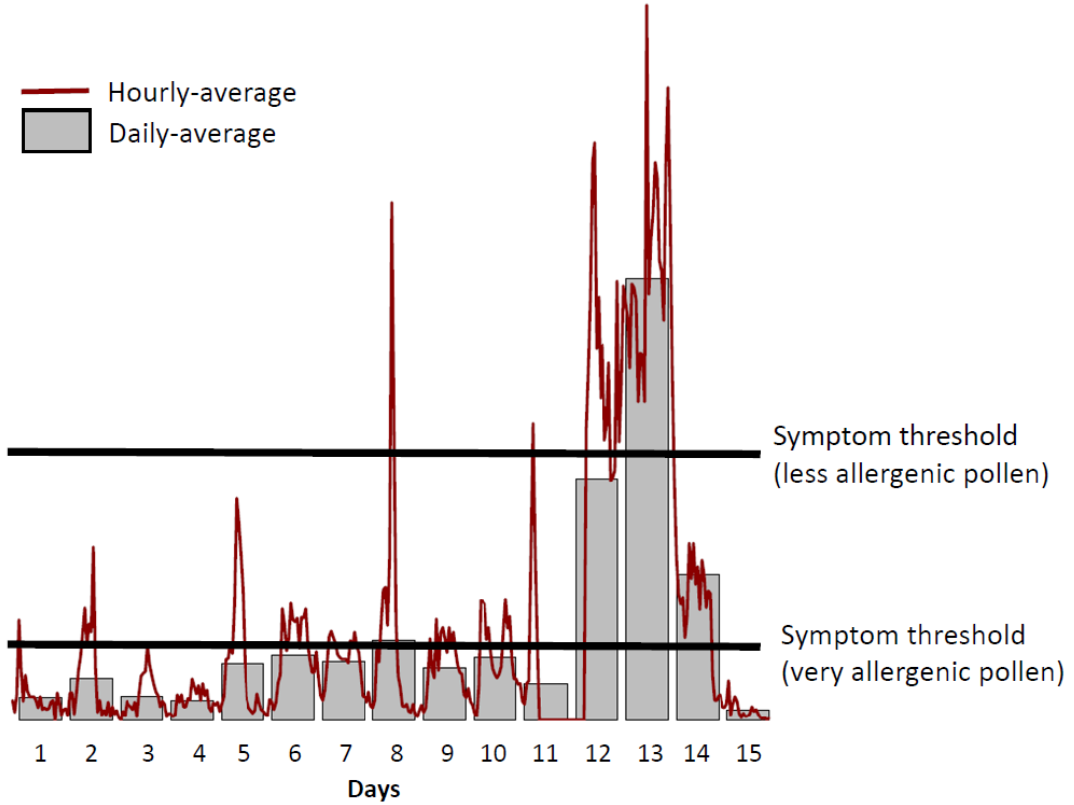
- Manual technique based on the Hirst trap
  - Time consuming counting
  - Low sampling volume (10L/min)
  - Large errors (due to flow variability, sampling, etc.)
  - Delayed data availability (3-9 days)



Real-time bioaerosol monitoring

A paradigm change!

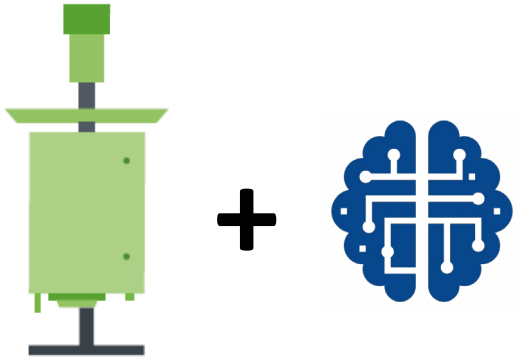
- Real-time measurements
- Higher sampling volumes
- Finer temporal resolution
- Massive impact on the quality and type of information available



Bioaerosol monitoring systems

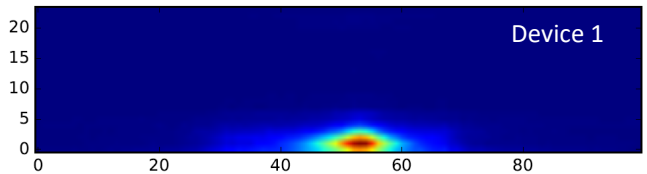
- Need to calibrate:
  - Instrument
  - Inlet [never been done before!]
  - Software (identification algorithm)

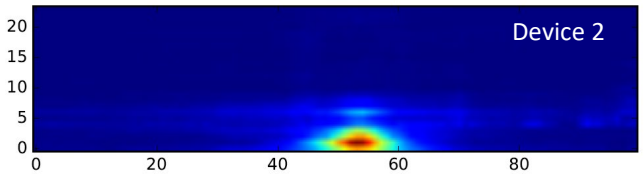
- May lead to the need to make:
  - Mechanical adjustments to the instrument
  - Adjustments to the software (internal to the instrument / identification algorithm)



Real-time bioaerosol monitors

- Nearly all are emerging technologies
  - Little is known about device stability – i.e. do they drift in time?
  - If they drift, what is it that drifts?
  - The instruments are not even airtight!
- Instruments are currently not delivered with a calibration report
- No certification process exists (since no CEN/ISO standard exists)
- Stability across devices is not always a given
- Monitoring networks require identical devices (or transparent correction procedures)





Real-time bioaerosol instruments

Plair Rapid-E

- 2.8 L/min
- 1-100 µm
- 1min resolution

DMT WIBS-NEO

- 0.3 L/min
- 0.5-30 µm
- 1min resolution

Swisens Poleno

- 40 L/min
- 1-300 µm
- 1min resolution

Hund BAA500

- 100 L/min
- 10-300 µm
- 3hr resolution

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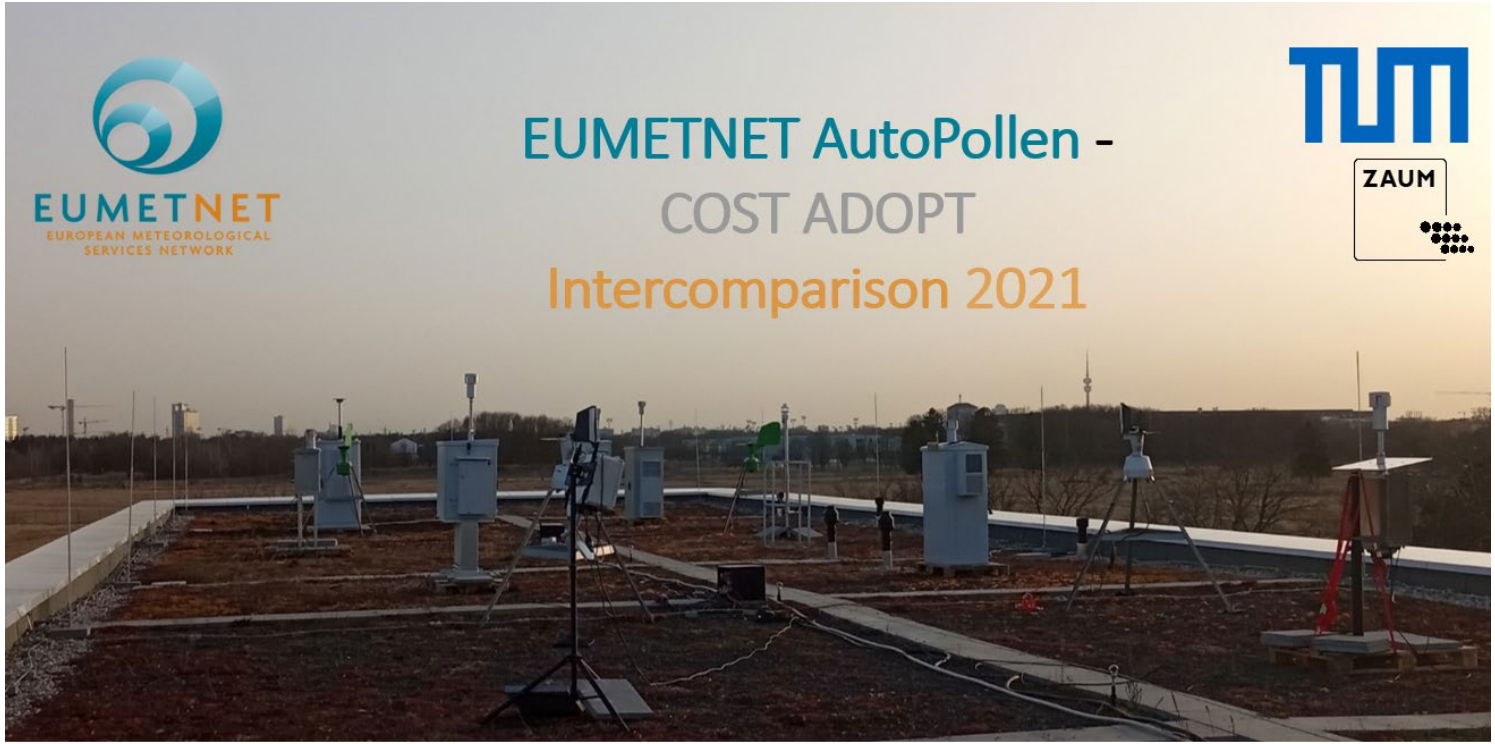
EUMETNET AutoPollen – COST ADOPT Intercomparison campaign 2021



cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

LGL Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit

HelmholtzZentrum münchen
Deutsches Forschungszentrum für Gesundheit und Umwelt

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EUMETNET AutoPollen – COST ADOPT Intercomparison campaign 2021

- Transparent intercomparison with independent operators
- Test and evaluate as many systems as possible at the same location and time
- Characterise each device with respect to their individual capabilites
- Compare automatic systems with present manual standard
- Recommend further development needs

A system = an instrument + a particle identification algorithm

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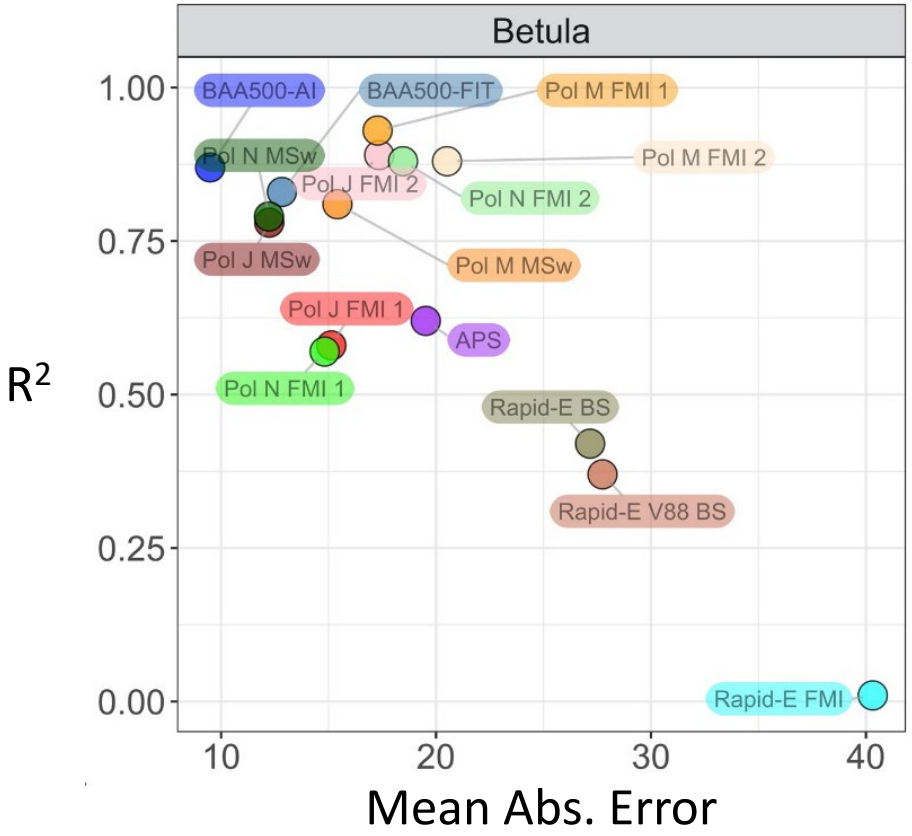
EUMETNET AutoPollen – COST ADOPT Intercomparison campaign 2021



See the results for yourself at:

https://autopollen-interactive.shinyapps.io/022_APP_AUTOPOLLEN

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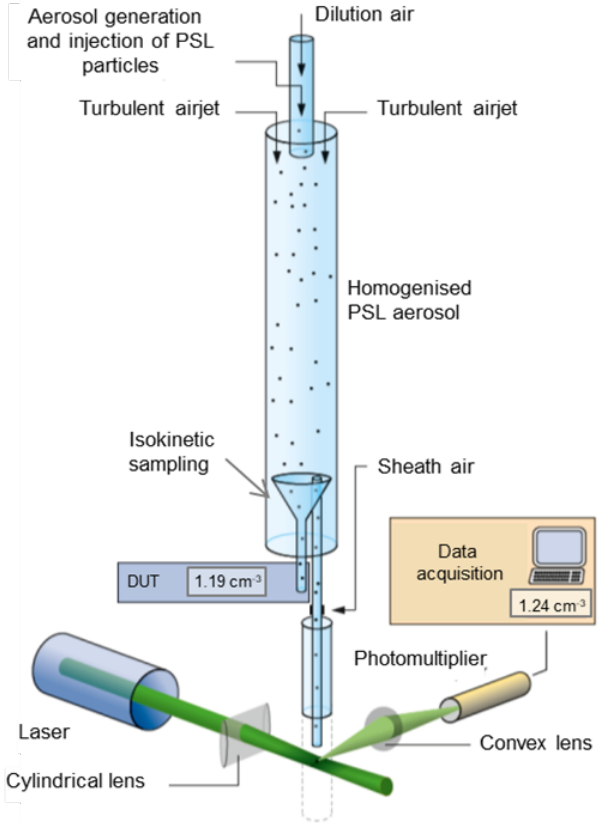
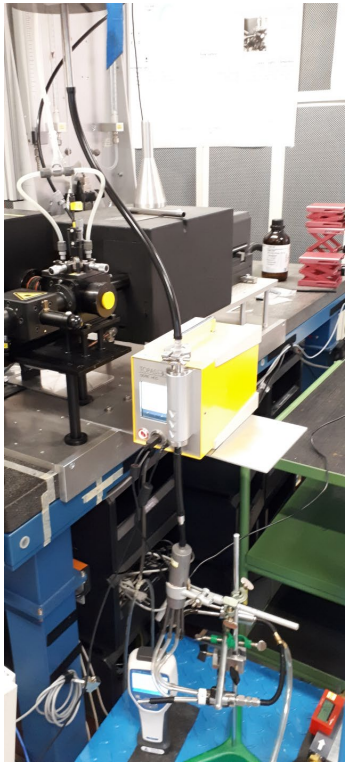
Aerosol Chamber Experiments





- Chamber usually for calibrations of particle number counters
- Uses an optical particle counter as a reference
- Diluter used for certain bioaerosol monitors

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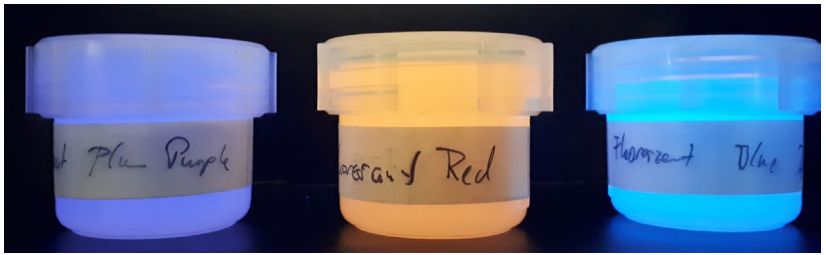
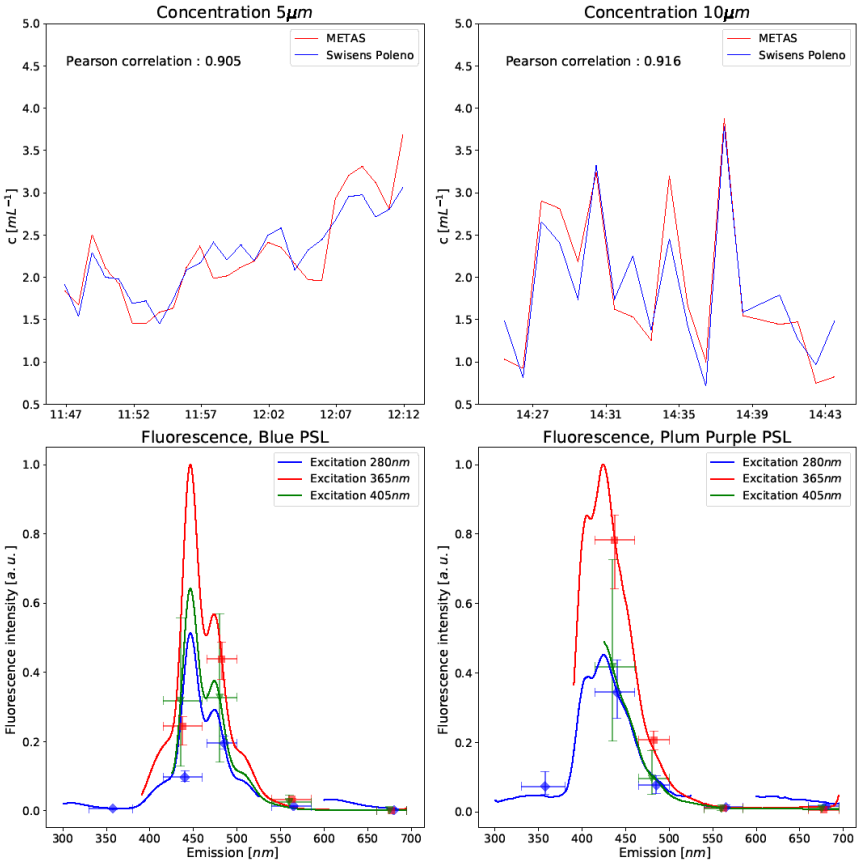
Aerosol Chamber Experiments

Primary standards are available for article number concentration calibrations:

- Tests have used PSL from 0.5-15 µm in size, also fluorescent particles
- Concentrations from 0.5/cm^3 to 1000/cm^3 are possible
- Typically 3-8% uncertainty in number concentration
- 2.5% uncertainty in PSL diameter



Aerosol Chamber Experiments



Swisens Poleno

Sauvageat et al., 2020

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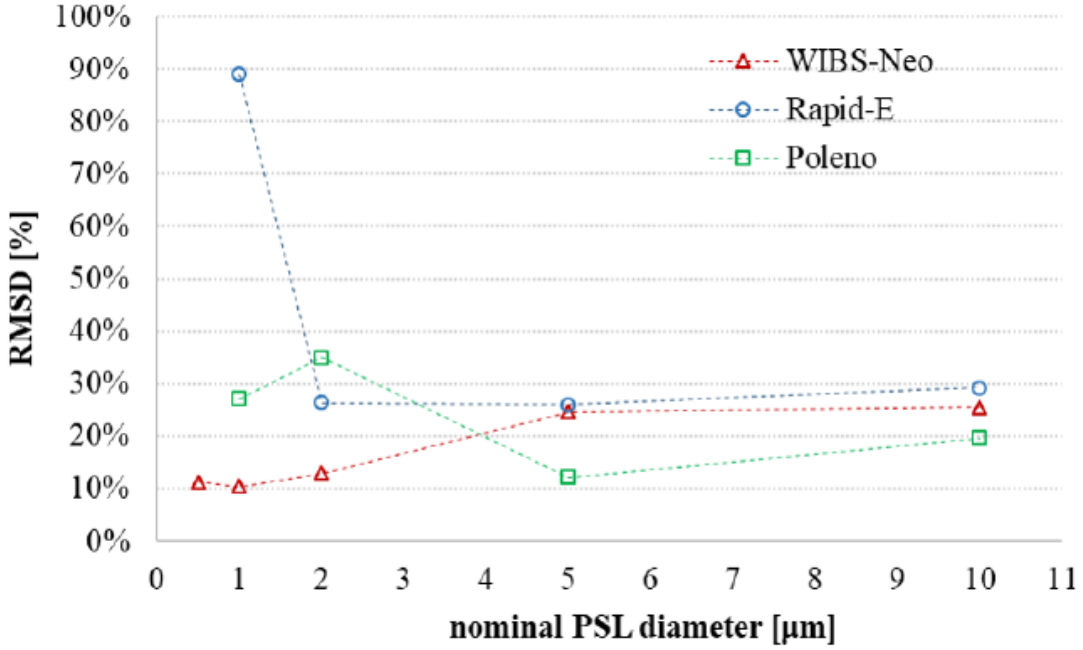
Aerosol Chamber Experiments



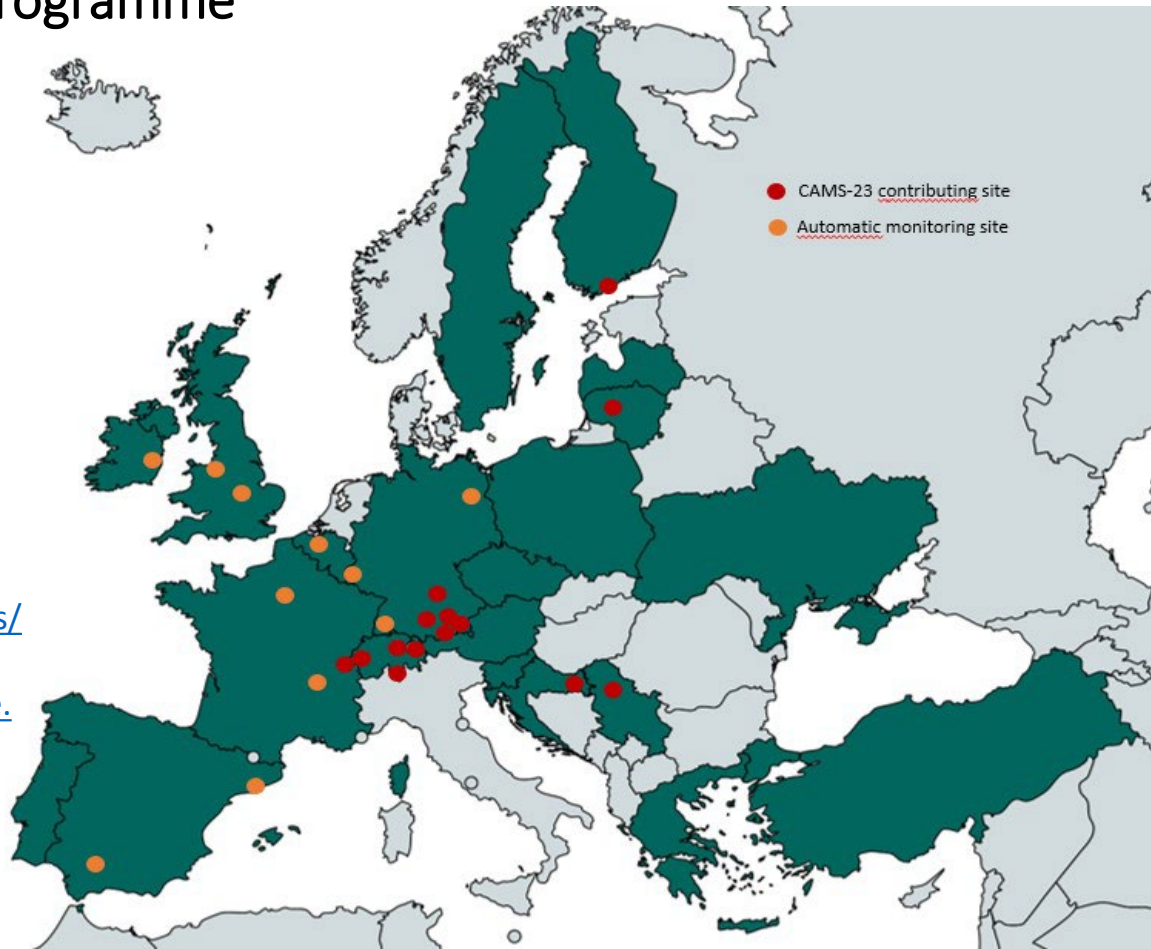
Particle Size RMSD

Lieberherr et al., 2021

Needs of the monitoring community

EUMETNET AutoPollen Programme

Bavaria, Germany:
https://epin.lgl.bayern.de/pollenflug-aktuell
Finland:
https://en.ilmatieteenlaitos.fi/atmospheric-bioaerosols-modelling
Lithuania:
https://miestoplauciai.vilnius.lt/ziedadulkes/
Manchester, UK:
www.urbanobservatory.manchester.ac.uk/uk-first-realtime-pollen-count-now-live
Serbia and Croatia:
www.realforall.com/language/en/measurements/
Switzerland:
www.meteoschweiz.admin.ch/home/messwerte.html?param=messwerte-pollen-graeser-1h



EUMETNET AutoPollen Programme

TC264/WG39

Aerobiologia
https://doi.org/10.1007/s10453-022-09755-6

SPECIAL ISSUE: AUTOPOLLEN

Towards standardisation of automatic pollen and fungal spore monitoring: best practises and guidelines

Fiona Tummon · Nicolas Bruffaerts · Sevcan Celenk · Marie Choël · Bernard Clot · Benoît Crouzy · Carmen Galán · Stefan Gilge · Lenka Hajkova · Vitalii Mokin · David O'Connor · Victoria Rodinkova · Ingrida Sauliene · Branko Sikoparija · Mikhail Sofiev · Olga Sozinova · Danijela Tesendic · Konstantina Vasilatou

EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

AEROMET-II Project

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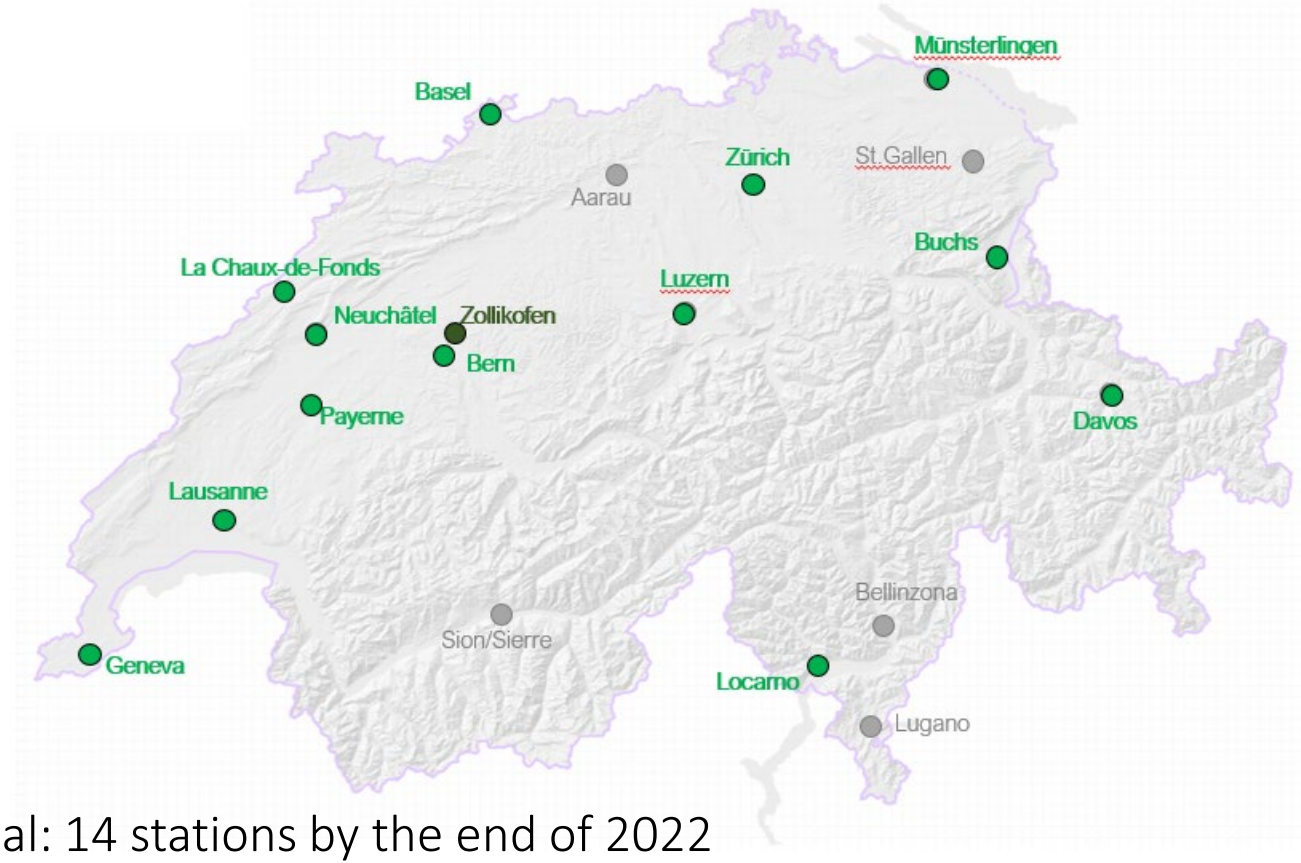
SwissPollen: An end-to-end real-time pollen monitoring network



Goal: 14 stations by the end of 2022

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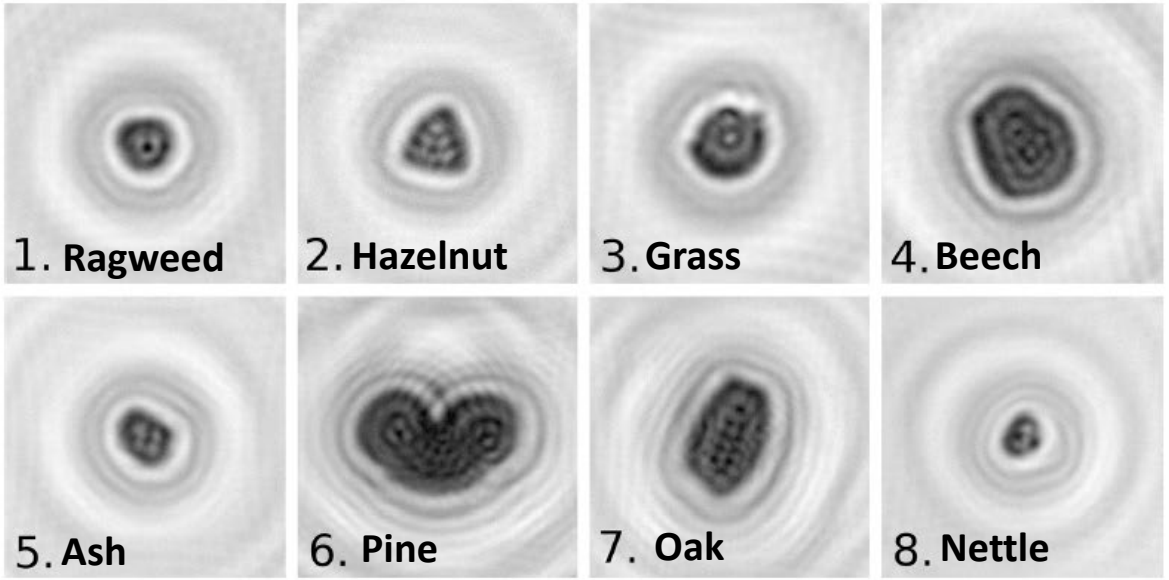
SwissPollen: An end-to-end real-time pollen monitoring network

Swisens Poleno

- Light scattering
- Fluorescence
- Holography

+ Artificial intelligence



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Challenges that lie ahead…

Reference Calibrations

- Provide the possibility for fully-traceable calibrations
- Low uncertainty is achievable (<5%)

- But…a lot of developments still need to be made:
  - *How can one aerosolise larger particles (e.g. up to 100µm)?*
  - *How can one obtain reference particle concentrations at levels relevant to bioaerosol (e.g. 1/m^3)?*
  - *How to aerosolise known quantities of real bioaerosol (e.g. pollen/fungal spores)?*
  - *Can we test under different environmental conditions?*
- And ultimately, can we have a portable instrument to do all of this?!

Challenges to the community

- Extend traceability to particles up to 100µm in size
- Generate reference pollen aerosol (single and multi-component) under controlled environmental conditions to calibrate instruments and train AI algorithms
- Generate reference mixtures of pollen internally/externally mixed with other ambient particles (e.g. dust or soot) to train AI algorithms (pollen can transport other particles)
- Develop methods to calibrate identification algorithms
- Establish a European/global standard for automatic bioaerosol measurements

The essential element to all of this is collaboration!

Thank you!