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Bioaerosols: a forgotten component of atmospheric aerosols?

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SILAM team

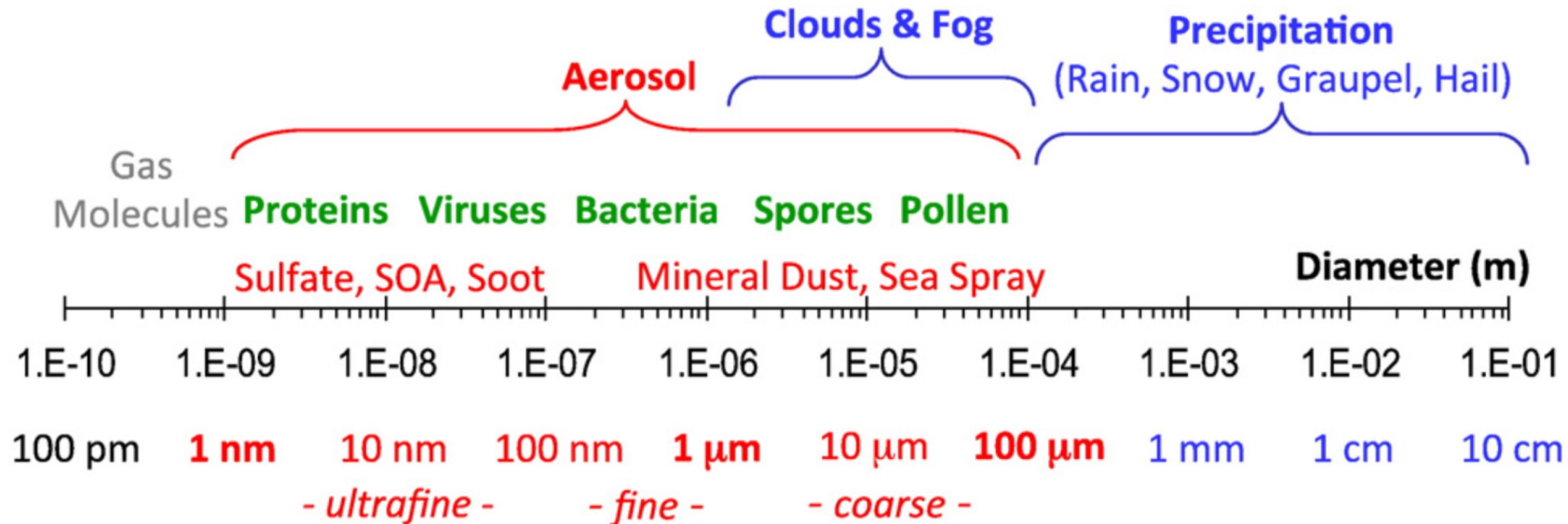
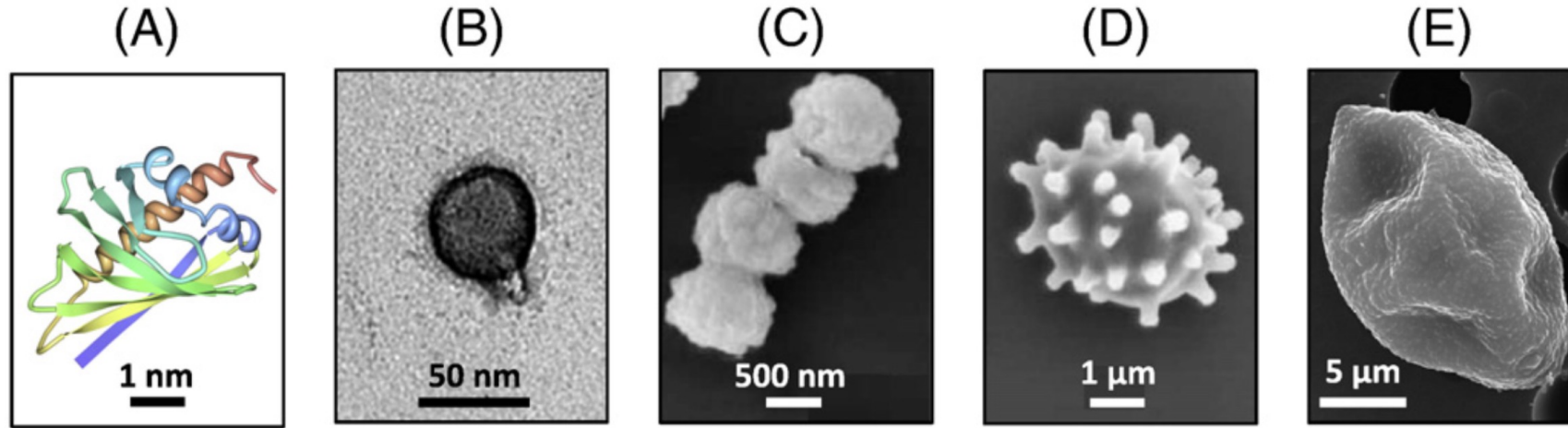
SYLVA project team



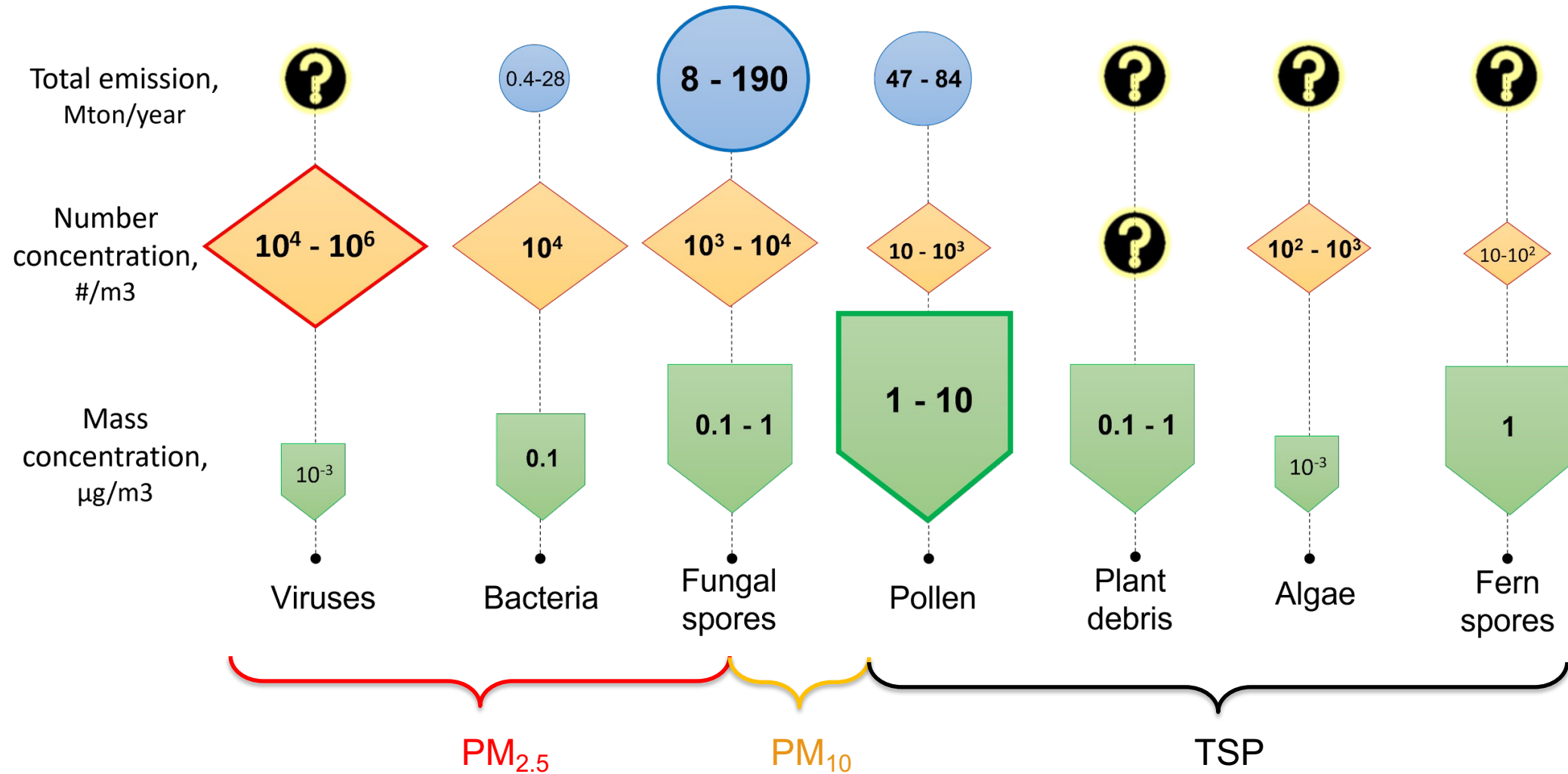
Outlook

- Introduction
 - bioaerosols: what are they?
 - what we (do not) know about bioaerosols
- Roles of bioaerosols in the air
- Means of bioaerosol measurements
- Means of bioaerosol modelling
- Example: a recent bioaerosol campaign
- SYLVA Horizon project

Bioaerosols: who are they?



Bioaerosols in the atmosphere

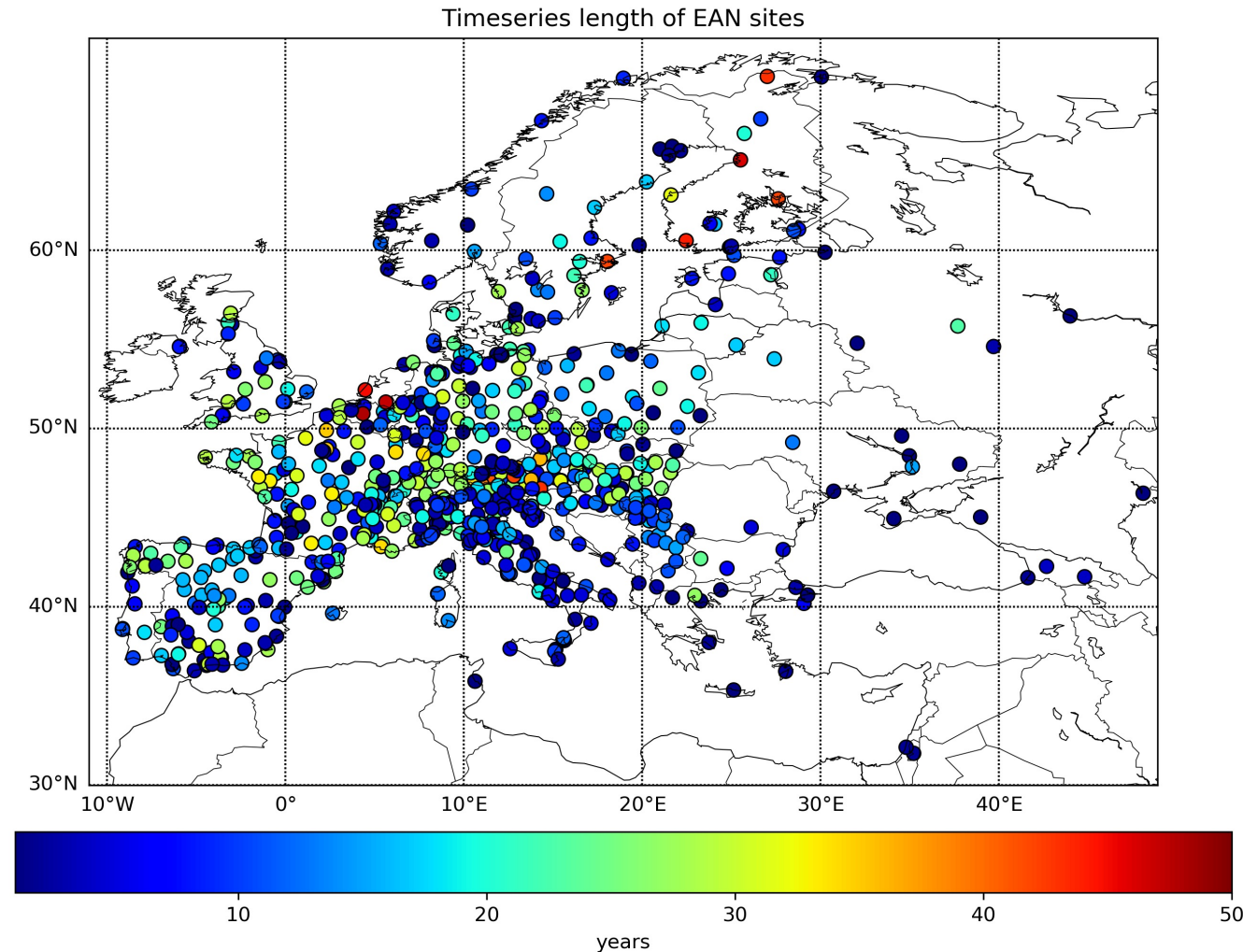


Role of bioaerosols in the environment

- Atmosphere is the key transport media for other environmental compartments, via bioaerosols
 - vital role for the biosphere
 - spread of various organisms across ecosystems
 - short cycling period (< 1 year): an adaptation mechanism for climate change
 - also spreads pathogens (plants, animals, humans)
- Bioaerosols are heavily affected by atmospheric processes and sensitive to climate...
 - plants are sensitive to weather, both in short- (synoptic) and long-term (climate)
 - every insect & animal related to plants is also affected
- ...and can themselves affect the atmosphere and climate
 - cloud condensation nuclei
 - ice nuclei

Data: European Aeroallergen Network

- The only regular dataset
 - Europe: 1974-c.m.; ~300 sites
 - World: individual sites
- Data are:
 - daily (few sites: bi-hourly)
 - ~20 pollen types
 - some sites: 1-2 spore types
 - not shared
 - 70yrs-old manual technique
 - large uncertainties
 - few sites survive for long
- Models and species:
 - SILAM (12), COSMO-ART (4)
 - + Copernicus (10 from SILAM)



Note: all sites included regardless the current state

Breakthrough: new technology

- Multitude of bioaerosols
- Suitable for regular monitoring (efficiency, availability)
- Key challenge: recognition of particle type
 - improved and automated good-old principle: impaction on a transparent sticky tape followed by microscopic analysis: counting & recognition
 - flow cytometers (real-time particle counters) with recognition based on scatterometry, holography, fluorescence
 - sampling on filters followed by eDNA 3rd generation sequencing (not real-time but ultimate recognition)
- Connection to models
 - real-time evaluation
 - data assimilation (but not model state)

Bioaerosol campaign, 2021

- Motivation
 - scientific: biological composition of the air is poorly known
 - practical: check the flow cytometers in real conditions
- Goals
 - to obtain time-resolving speciation of bioaerosols in Northern Europe
 - to verify feasibility and means of regular bioaerosol observations
- Idea
 - combine classic and new devices
 - include an ultimate solution: 3rd generation DNA sequencer
 - bring together with models
 - complement another bioaerosol campaign (also 2021) comparing many devices

Air-flow cytometers

10 slides per day

❖ Rapid-E



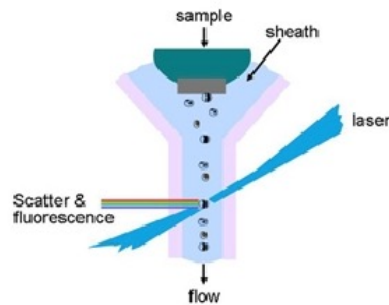
Siauliai:

sticky glass slides
(diameter 20 mm)

- scattering
- light induced fluorescence

hourly timeseries

❖ Poleno

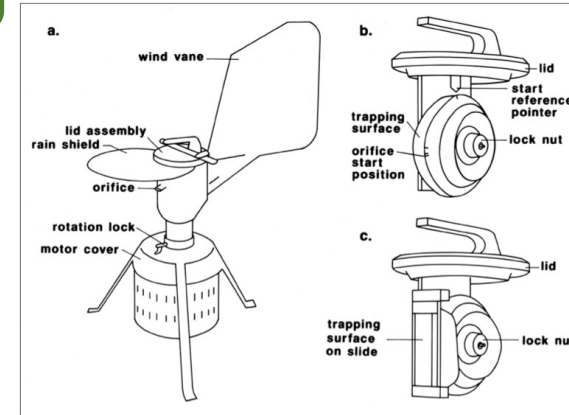


- holographic image
- scattering
- depolarization
- fluorescence

Volumetric spore traps

time dependent number of tape cuts

❖ Burkard



(2006). Using a Burkard Trap. In: Lacey, M.E., West, J.S. (eds) *The Air Spora*. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-30253-9_4

❖ Lanzoni



- continuously collected samples by the rotating drum covered with sticky tape
- manual identification and counting of biological particles with the optical microscopes

7-day clock – first 2 weeks (28 pcs of 6 hrs collection)

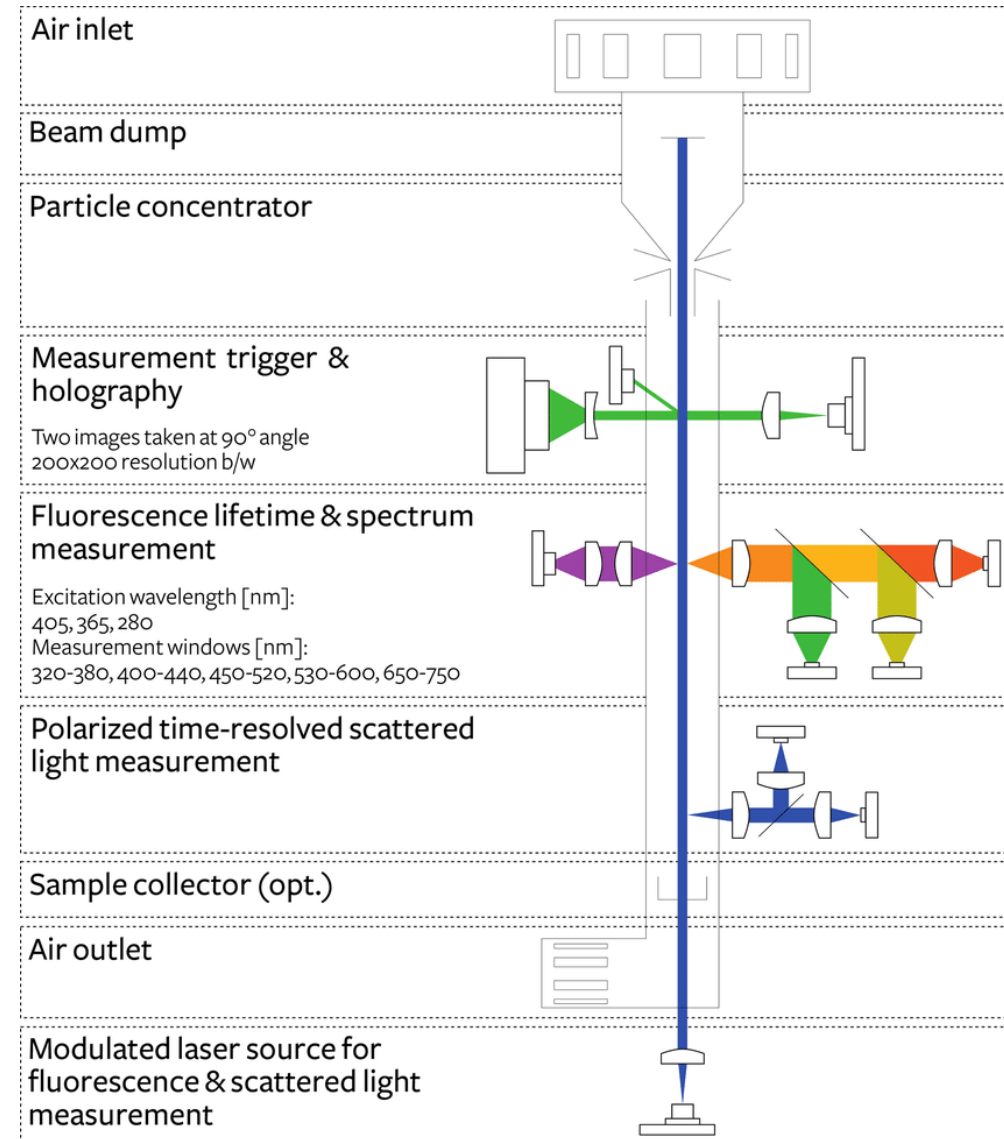
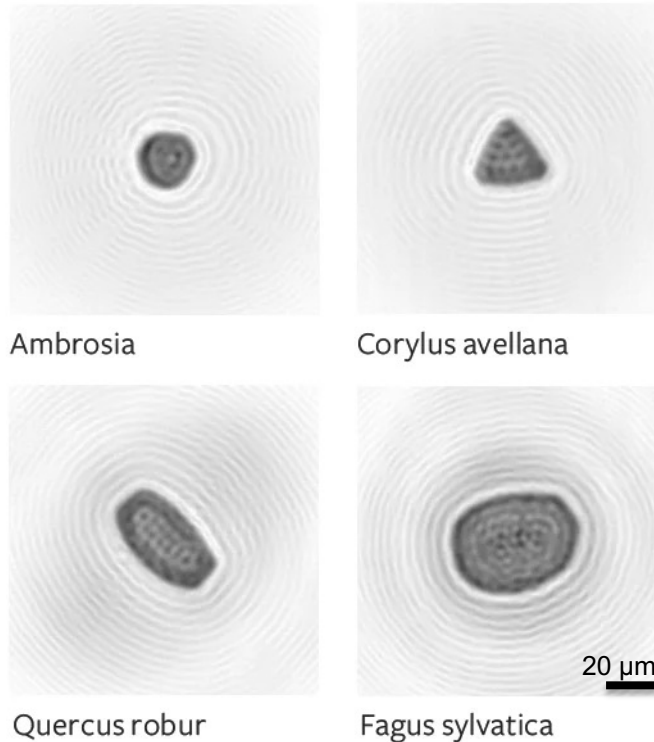
24-hrs clock – rest of the campaign, 1 tape per day cut to 12 pcs of 6-hrs collection



Filters were changed in the evening to minimize contacts within FMI

Swisens Poleno particle counter

- Real-time particle counter
- Particle range: 1 μm -100 μm
- Flow rate: 40 l / min
- Particle registration
 - holographic images
 - scattering patterns
 - depolarization
 - fluorescence wavelengths
- Particle recognition
 - external machine learning



Nanopore: 3rd generation DNA sequencer

- Key features compare to earlier next-generation technology
 - much larger part of genome sequenced (up to 5-10k basepairs)
 - small sample needed (few tens of ng of DNA)
 - fast (3 -12 hours for up to 60 samples)
 - cheap (potentially 20-30 Euro/sample)
- Accuracy: 97-99% depending on software

Collection outcome

- Collection periods:
 - Siauliai: 1 March – 30 April 2021
 - Helsinki: 15 March – 31 May 2021
- Total samples: 1524
- Data loss at collection: 1 day in Helsinki
- Amount of biological material
 - ~30% are suitable for direct DNA sequencing
 - rest requires PCR to boost the DNA amount, at a price of disruption of quantitative composition fractions

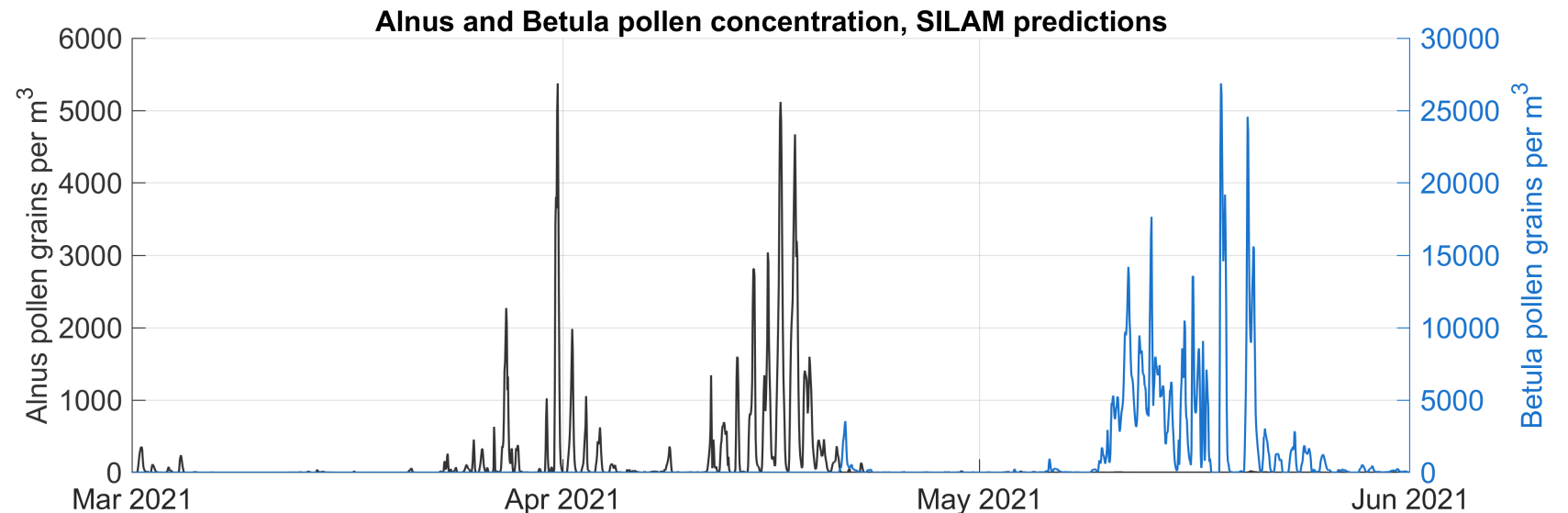
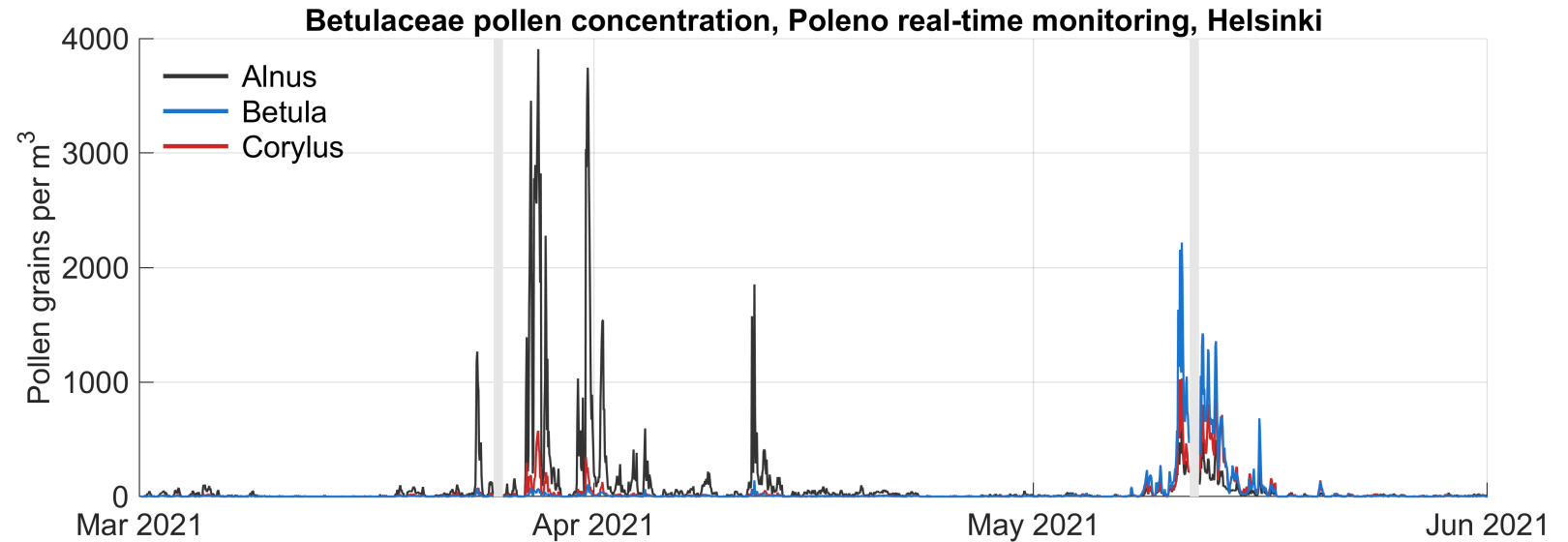
Spring 2021, Helsinki: Poleno, SILAM

Poleno Recognition skills

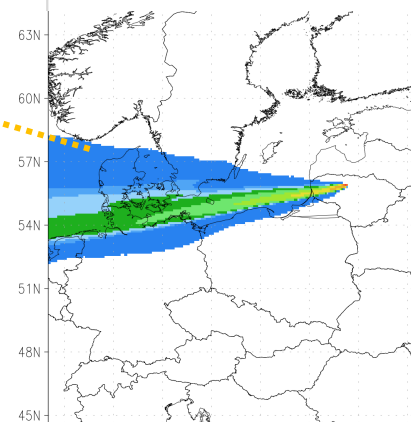
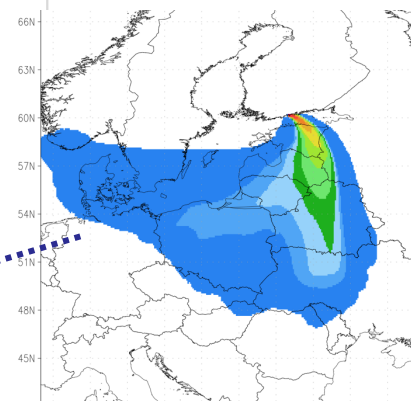
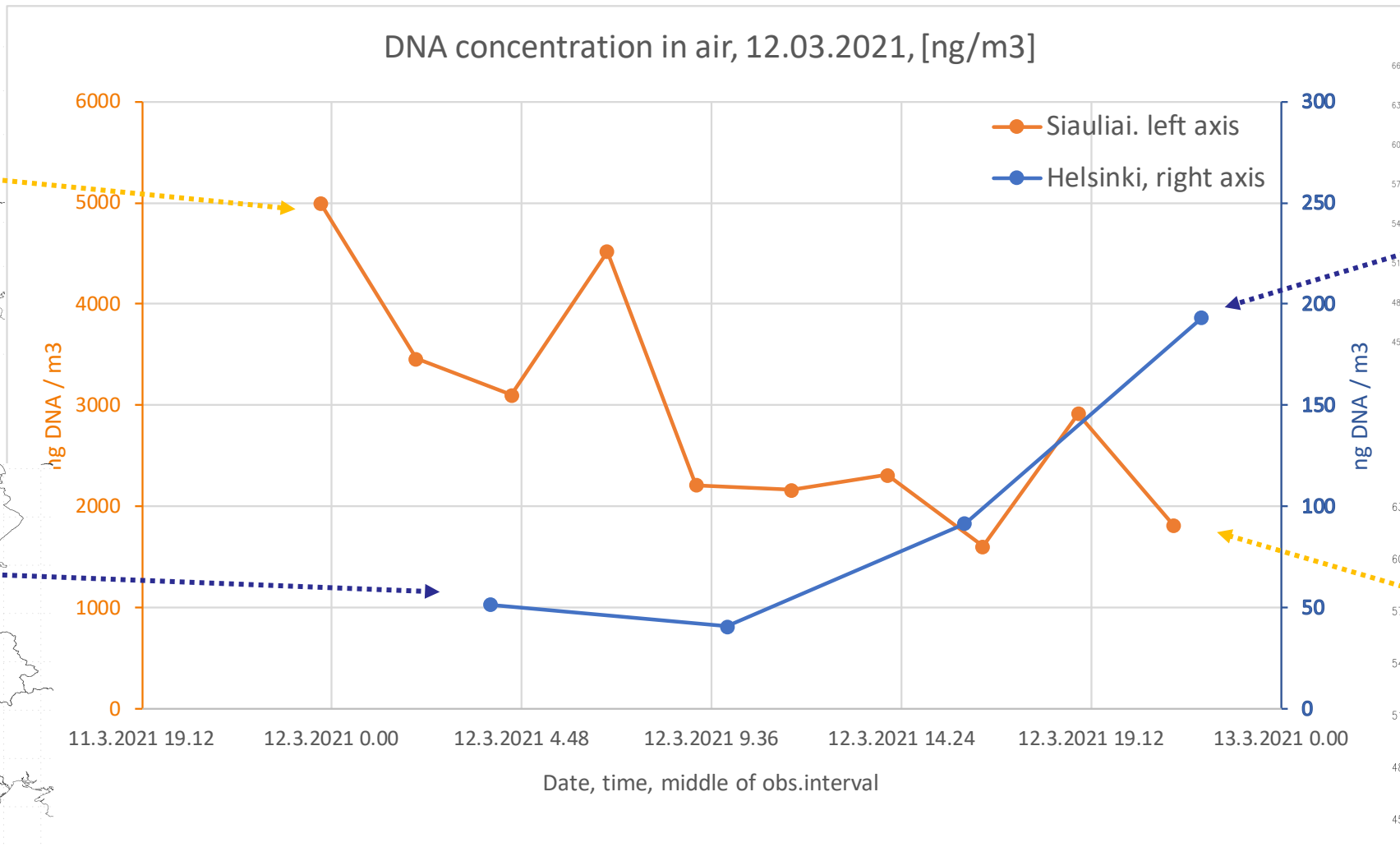
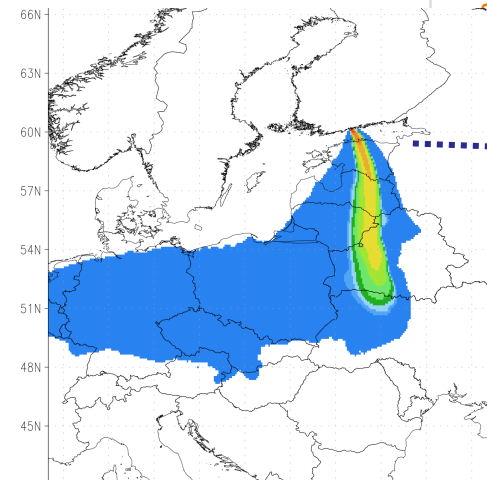
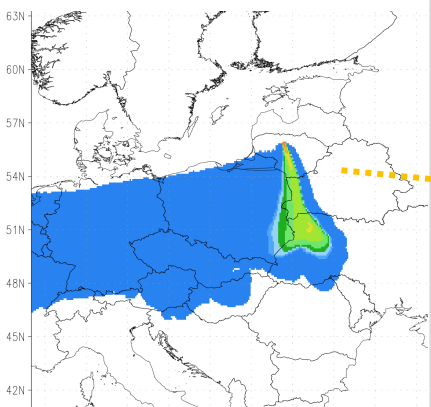
- Significant asymmetric confusion for *Betulaceae*: correct *Alnus* and *Corylus* but half of *Betula* is misinterpreted
- Discrepancy for *Betula* absolute values: about half of *Betulaceae* concentration is missing in May

SILAM predictions skills

- SILAM accurately predicted start of the season while slightly overestimating its duration

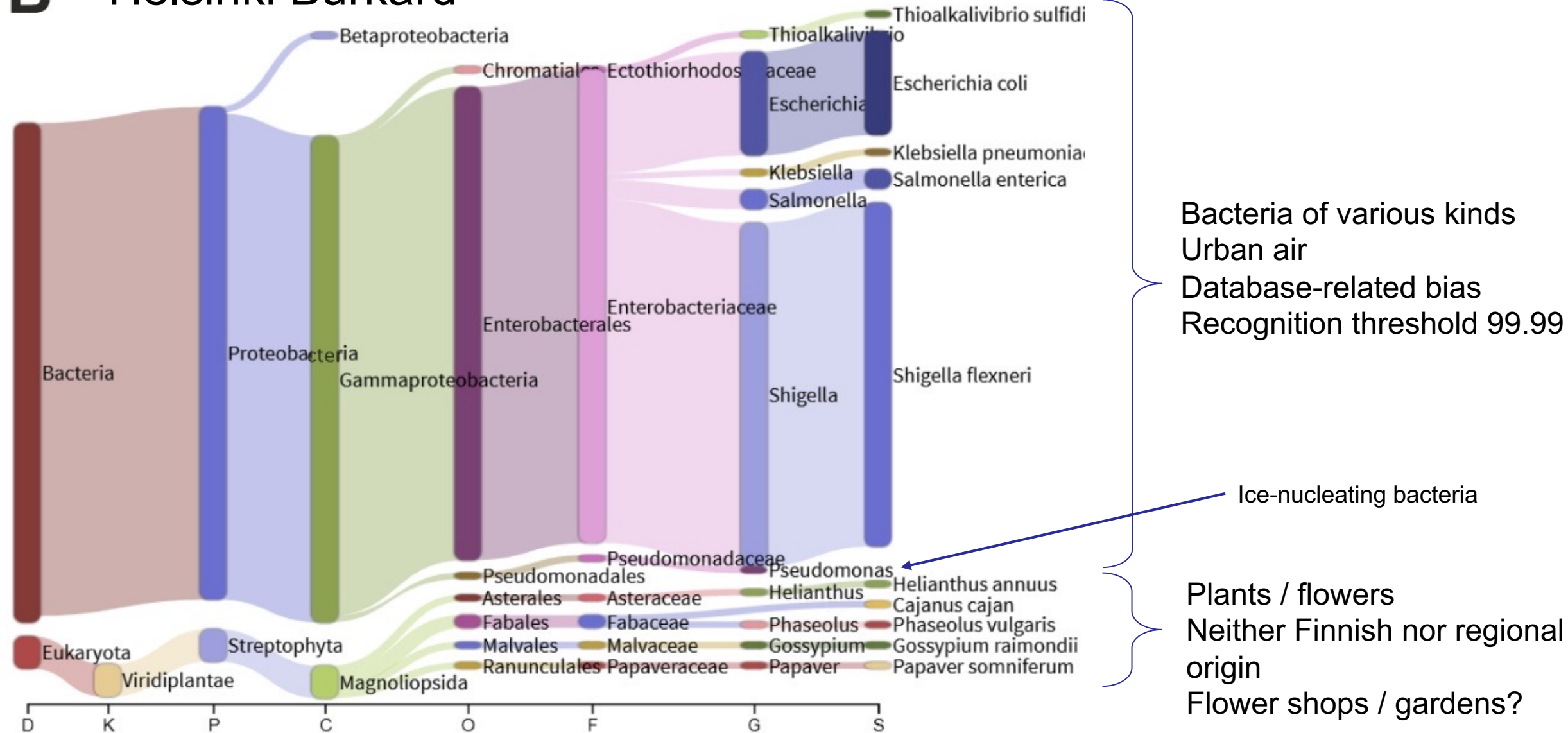


DNA yield, 12.03 [ng DNA / m³]



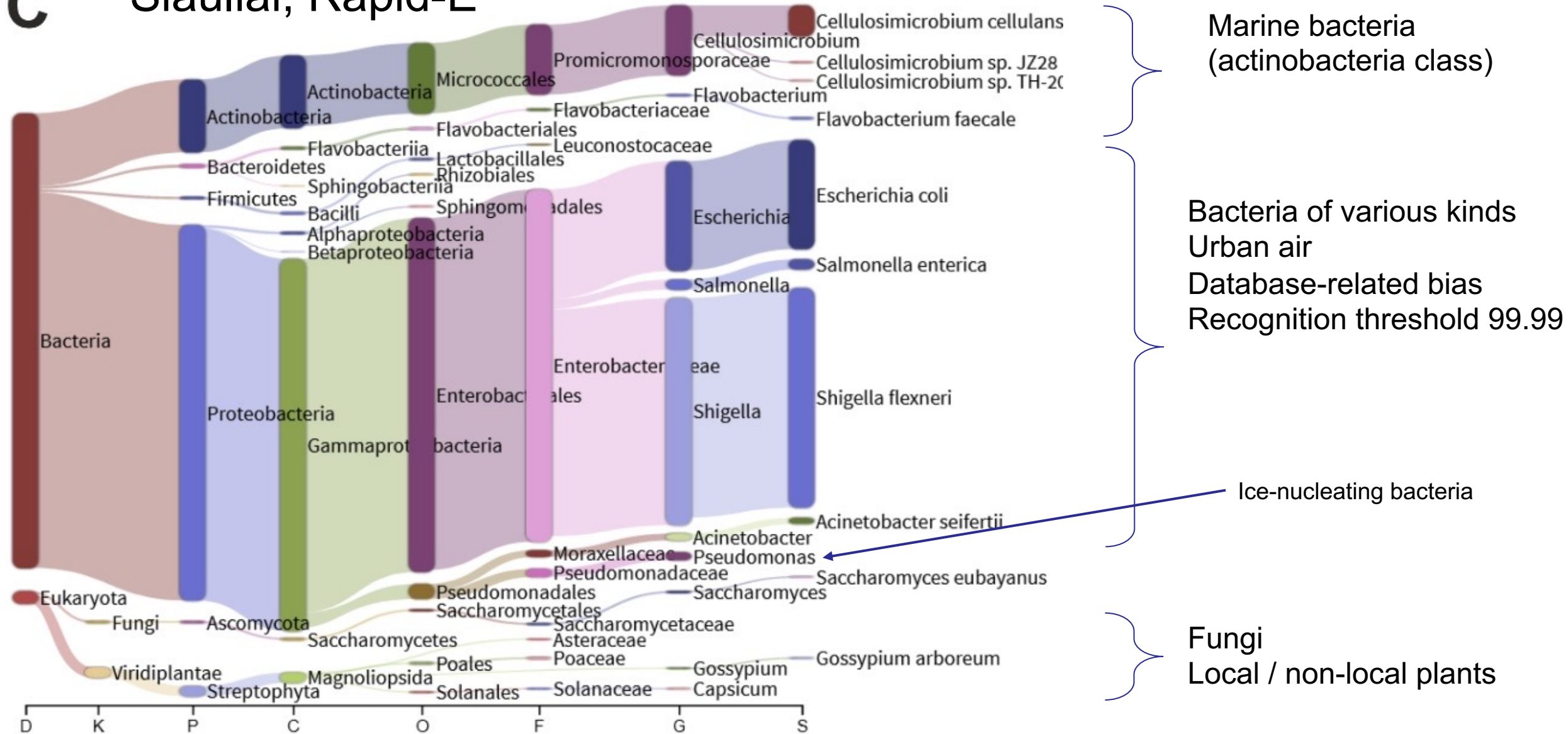
Classification Helsinki, 12.03 full day

B Helsinki Burkard

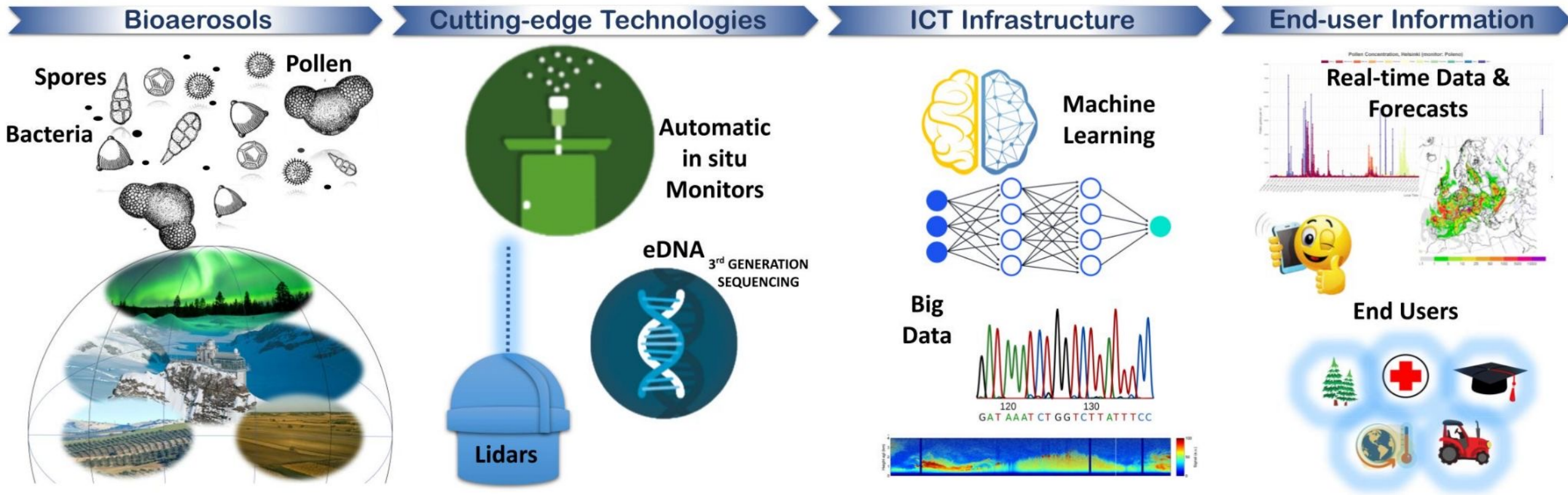


Classification Siauliai 12.03 full day

C Siauliai, Rapid-E



SYLVA: advancing the technology



SYLVA: SYstem for reaL-time obserVations of Aeroallergens,
a Horizon project, 2023-2026

Summary

- Bioaerosols are present in the air in significant amounts
- Emission is highly specific
- Apart from self-evident role in biosphere, there is a proven record of interaction with clouds as cloud condensation nuclei and ice nuclei
- Monitoring and modelling are emerging, in several cases approaching service-level maturity (e.g., CAMS pollen service, MASK-Air personal allergy app, ...)