Technical quantitative monitoring, modelling and classification of different agri-bioaerosol emissions

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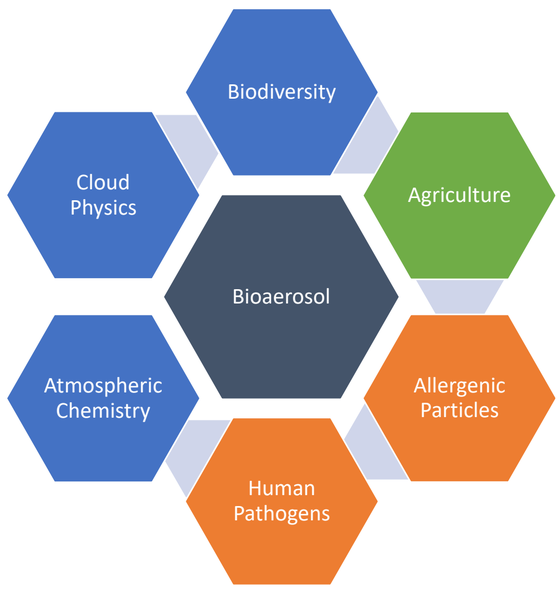
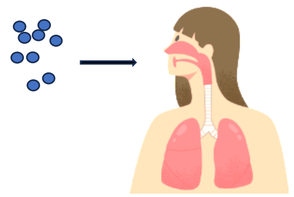
Bioaerosol Background

Bioaerosols, also known as primary biological aerosol particles (PBAP) Defined as suspended airborne particles that are emitted by living organisms. Contain diverse microorganisms such as pollen (10-100 μm), bacteria (0.2-10 μm), fungal spores (2-50 μm), viruses (< 0.2 μm), etc.
Through their extensive involvement in surface-atmosphere physic-chemical reactions affect the stability of the biosphere, climate change, and animal and human health.

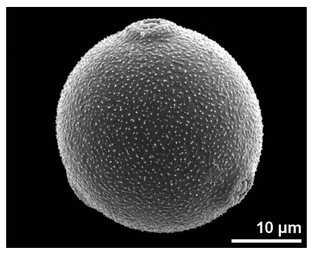


Research Motivations

Crops and different agricultural activities can be sources of Bioaerosols.



Pollen and other bioaerosols can be inhaled by human respiratory system, causing allergic reactions, etc.



Betula pollen SEM photo. From https://www.paldat.org/search/genus/Betula

Quantitative measurements of bioaerosol emissions can help farmers to set exposure standards and reduce the risk of hay fever. Also, monitoring bioaerosols for changes in distribution can guide land-use policies.

Challenges

Challengs in this experiment centred on methodological uncertainties, instrument construction and meteorological conditions:

- Low pollen and fungal spores concentration in the air >>> may not satisfy the resolution criteria for flux measurements.
- Varying atmospheric conditions, near-surface turbulence, etc., affecting data collection.
- Expensive detect sensors.

Aims

1. Determination of bioaerosol emission fluxes from agricultural crops using the Gradient-Flux and eddy-covariance methodology.
2. Measurement of the concentration of bioaerosols that may be generated during different agricultural activities as well as natural emissions during the growing seasonal.
3. Combining upon points, assessment of the accuracy of bioaerosol emissions will be conducted based on different meteorological case studies using the collected data.

Flux Calculation Theory

Aerosol flux measurements consist of two main methods, the Flux-Gradient measurement and Eddy Covariance measurement.

Flux-Gradient technique is a bottom-up measurement. Two aerosol monitoring instruments are fixed at two different heights. Equations below:

$$F = -K\frac{\Delta C}{\Delta z}$$

$$\begin{cases} \left(1 - 15\frac{z}{L}\right)^{-0.5} & L < 0 \\ \left(1 + 5\frac{z}{L}\right) & L > 0 \end{cases}$$

$$K = \frac{\kappa Z_m u_*}{\emptyset}$$

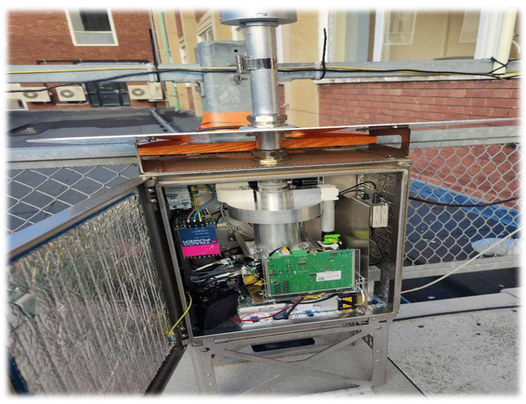
$$L = -\frac{{u_*}^3 \bar{T}}{\kappa g \overline{w'T'}}$$

The eddy-covariance method is the direct way to measure the turbulent fluxes of momentum, temperature, trace gases, and particles between the land surface and the atmosphere.

$$F_x = \overline{w'c'}$$

By combining 3D sonic anemometers and pollen detect sensor, can calculate F_x through tools such as software EddyPro, Version7.

Instruments



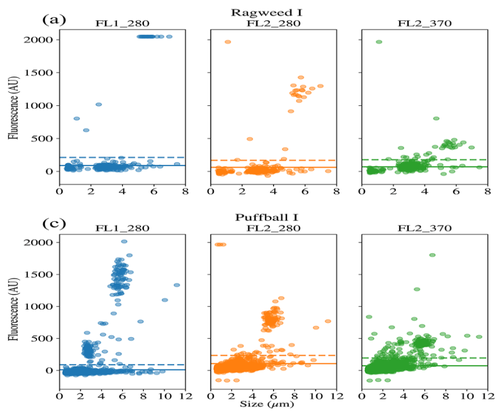
Swisens Poleno: Real time, speciated pollen concentration measurements. Using UV-LIF and holography camera to classification pollen species.

DMT WIBS-NEO: real-time, single particle measurement.
UV-LIF technology.

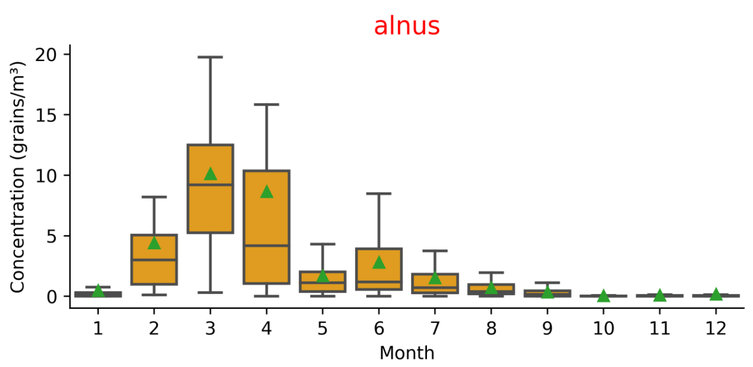
Plair Rapid-E+: Real time, single particle measurement.
Sigma-2 inlet; UV-LIF technology; GPU acceleration.

Research Innovations

For aerosol measurement fields, the real-time, high-temporal-resolution device allows capture of aerosol release processes in shorter time intervals. Bioaerosol identification of single particles is possible with UV-LIF technology(analysis of fluorescence spectra of bioaerosols). It can provide insights into previously poorly understood phenomena, such as wind–stamen interactions and the forces delivering pollen grains into airflows including rainfall events that generate sub PM2.5 pollen fragments and enhance certain fungal spore emissions.



An example of bioaerosols fluorescence response under different wavelengths.



After capture pollen emission we can draw plots like this to predict pollen seasons and provide guidance for farmers and other allergic group.

References
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