

EGU25-2115 | PICO | AS4.17

Fri, 02 May, 08:41–08:43 (CEST) PICO

spot 3 | PICO3.4



# Temporal and spatial dynamics of bioaerosol particles through integrated monitoring approach of local air distribution patterns

Abstract QR code



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Abstract QR code



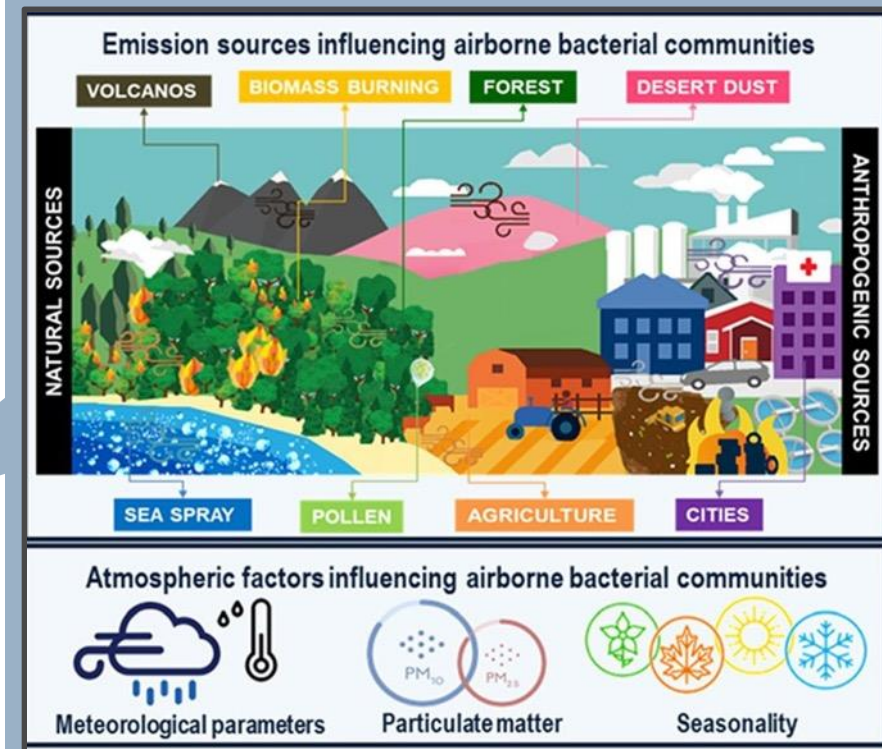
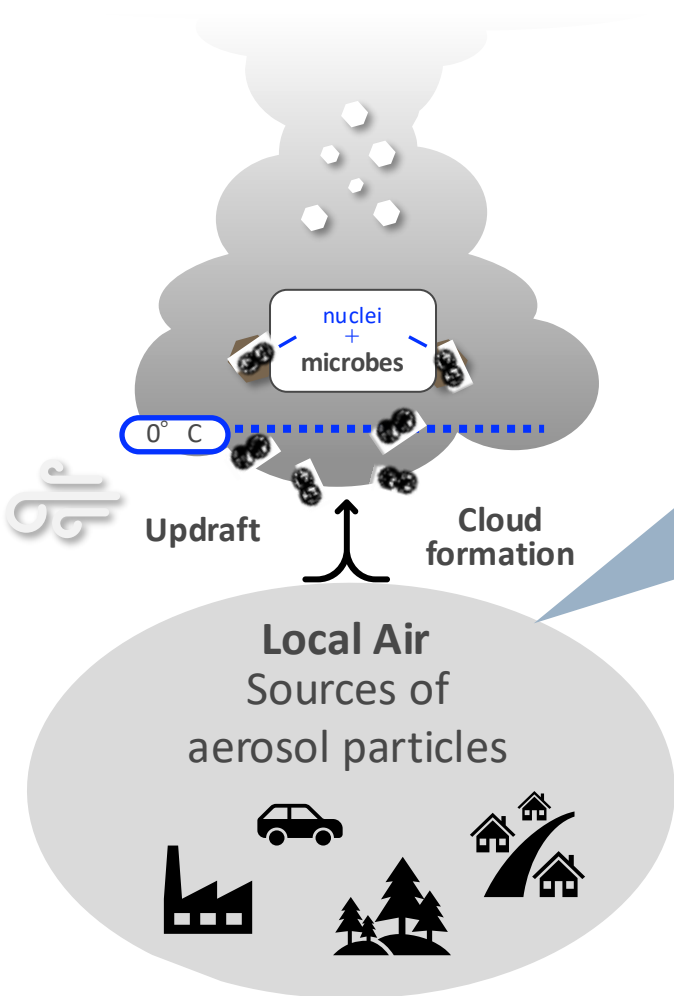
|                      |  |
|----------------------|--|
| Introduction         | Importance of bioaerosol research                                |
| Real-time monitoring | Monitoring setup   |
|                      | Community analysis   |
|                      | Diurnal pattern  |
|                      | Ice Nucleation Activity  |
| Light-plane sampling | Orientation of a sampler:<br>DNA conc. and no. of particles/size |
| Summary              | Contact/Acknowledgement  |
|                      | Appendix   |



# Bioaerosol monitoring

## Bioaerosols that act as cloud condensation nuclei or ice crystal nuclei:

- What kind of particles?
- What kind of particles have the ability to form nuclei?



Ruiz-Gil T, et al. Environ Int. 2020;145:106156.

## Difficulties of bioaerosol research

- No Standardized protocol
- Low biomass = Contamination
- Affected by many factors

## Questions:

- What is the variability of (micro)biological particles?
- Are there any annual, monthly, or daily variability?

If Yes, what factors are associated with them?

# Bioaerosol monitoring

## On-going projects

### Particle and microbial community monitoring

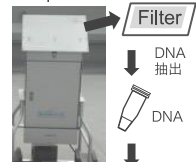


BioTrak,  
TSI

- Total number of particles
- Number of biological particles

Operating environment  
5° C to 30° C  
20% to 85%RH

High volume air  
sampler



微生物群集構造解析  
(16S rRNA, 18S rRNA)



Culture and  
Ice Nucleus  
Activity

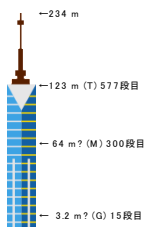
## Connect ground to high-altitude

Ultralight plane

Max.  
1 hour  
Once a  
month or  
more



Max.  
123 m Tower



## Monitoring of current airborne viable particles



Like a snapshot!

Hard to understand the relationship between meteorological factors

### 1. Conduct real-time bioaerosol monitoring



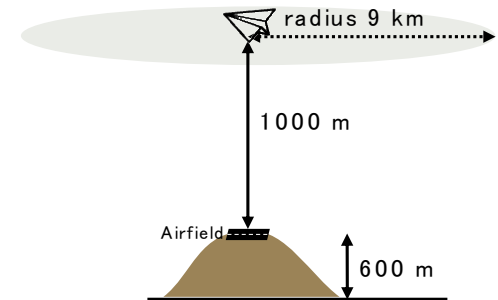
BioTrak,TSI

- Total number of particles
- The number of biological particles

### 2. Examine the relationship between high-altitude and ground

Max. 1 hour sampling, at 1600 m above  
the ground

Once a month or more



# Real-time monitoring of Viable particle counts



Usually used in clean room

Particle counter

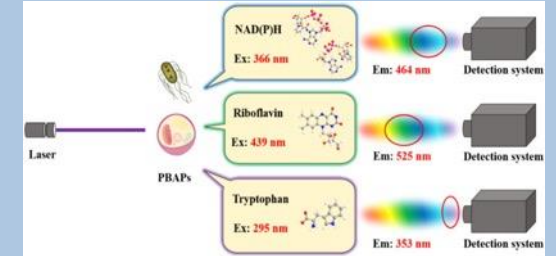
OPC total: six channels  $0.5\ \mu\text{m} < dp < 25\ \mu\text{m}$

Viable particles: 4 channels  $2\ \mu\text{m} < dp < 25\ \mu\text{m}$

Laser-induced fluorescence (NADH, Flavin et tryptophan)

TCNT= Viable particle+Non-viable particle

VCNT = Viable particle



BioTrak, TSI

Maximum number of particles:

29,000,000/m<sup>3</sup>

→ 29,000/L

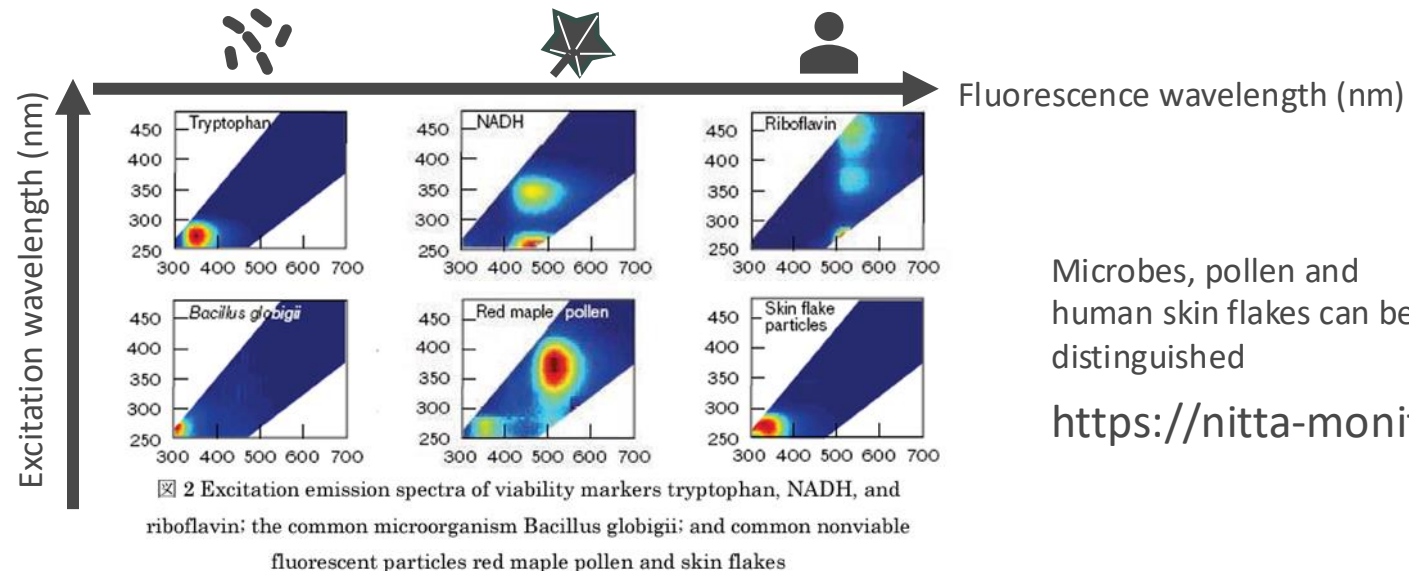
Speed :

28.3 L/min

Operating

5° C to 30° C

20% to 85% RH



Microbes, pollen and human skin flakes can be distinguished

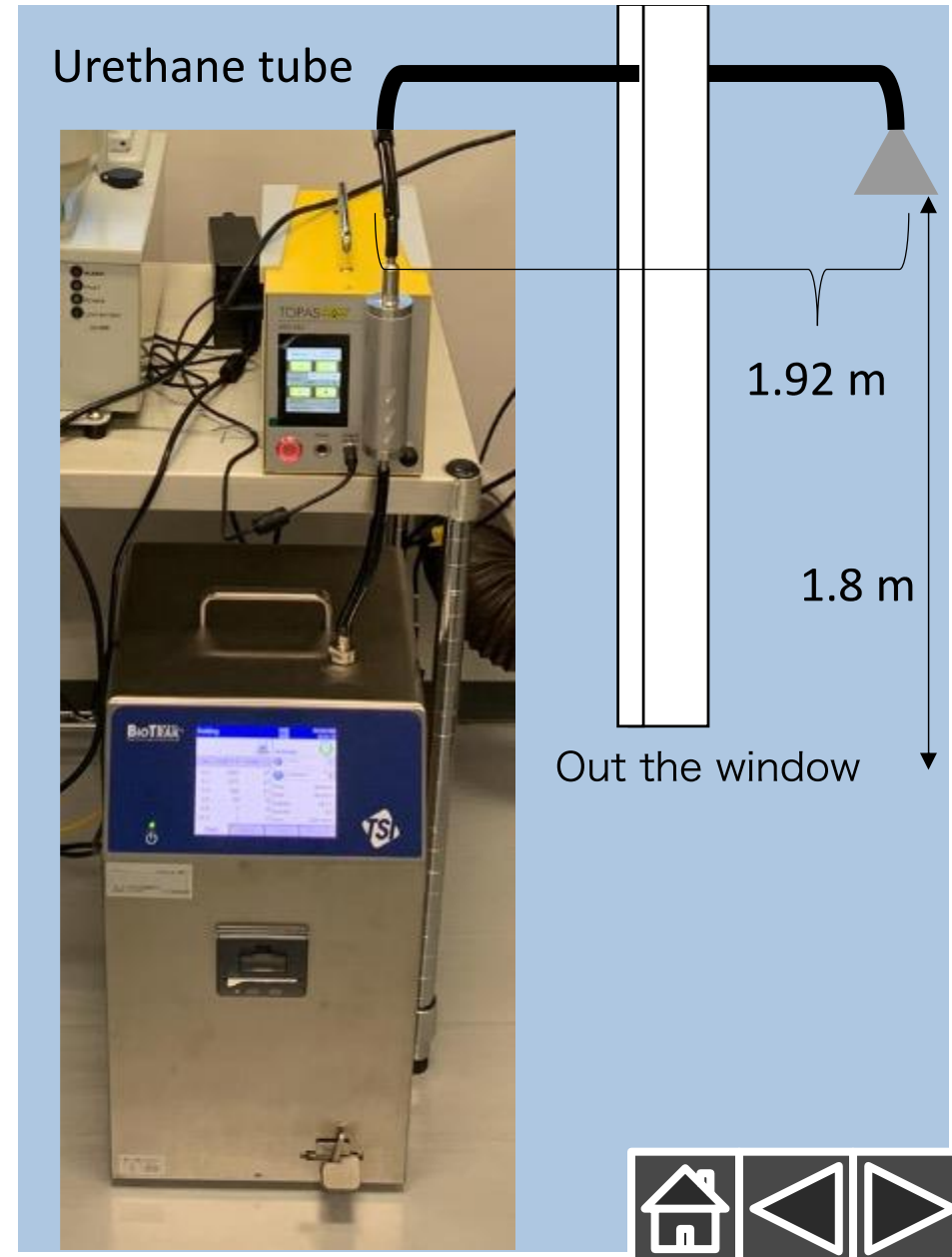
<https://nitta-monitoring.com/biotrak/>





# Real-time monitoring of Viable particle counts

Set up: July, 2023 ~

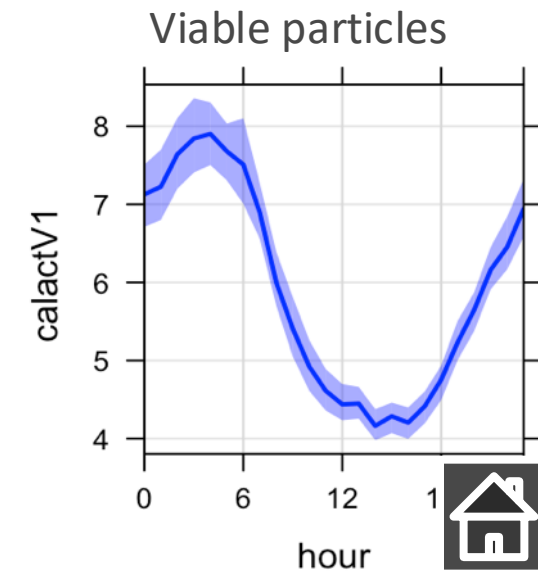
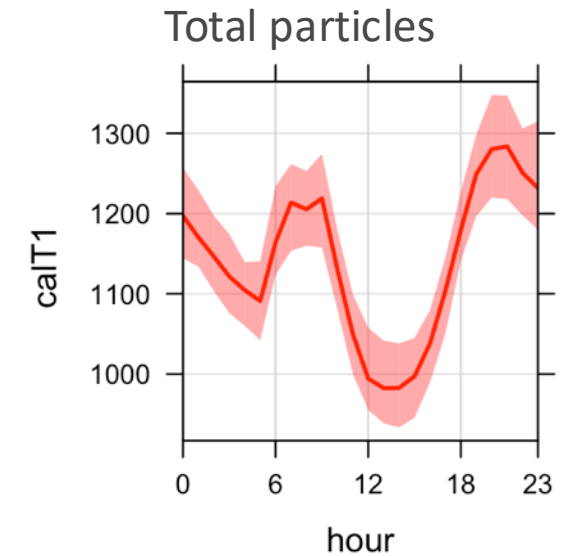
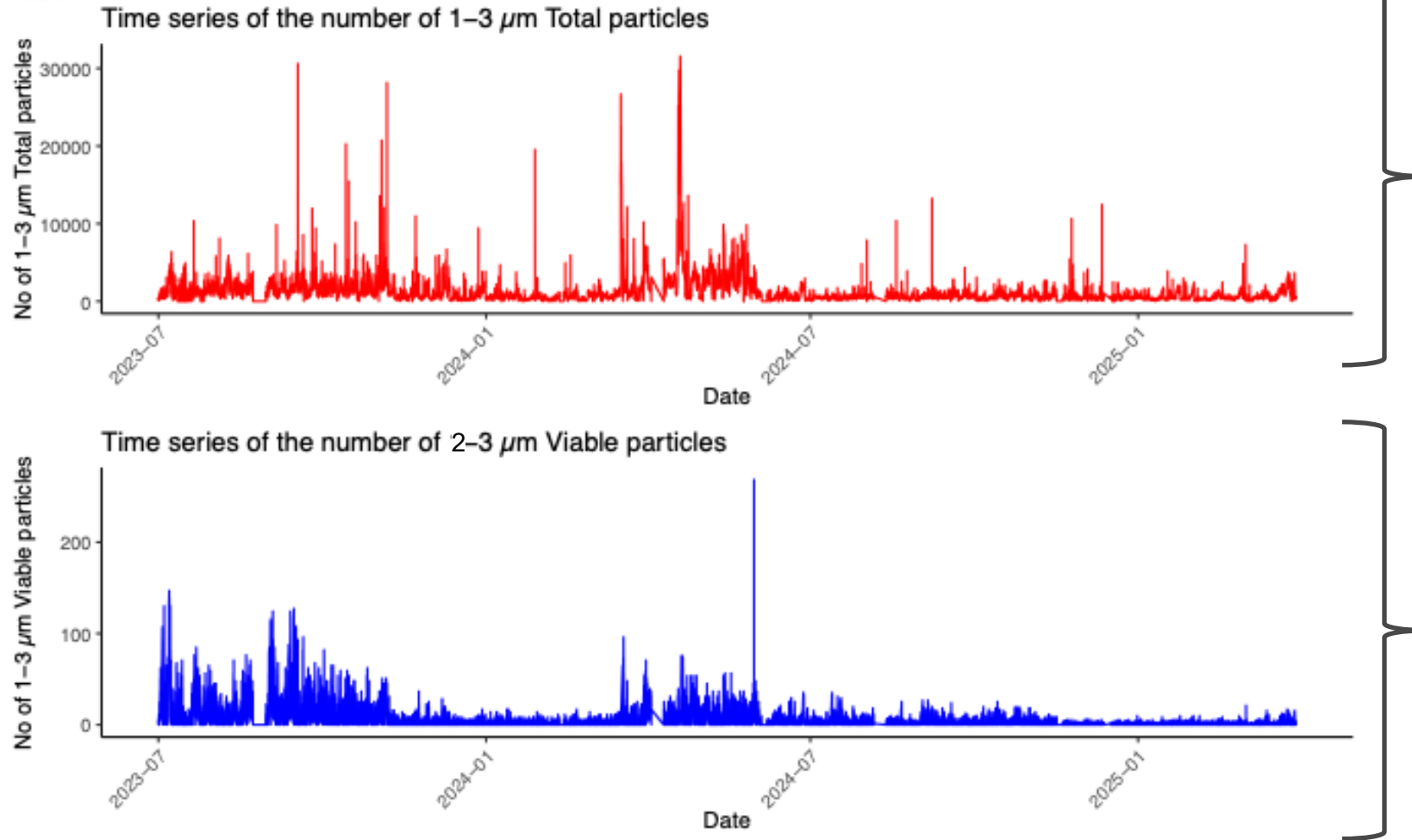


# Real-time monitoring of Viable particle counts



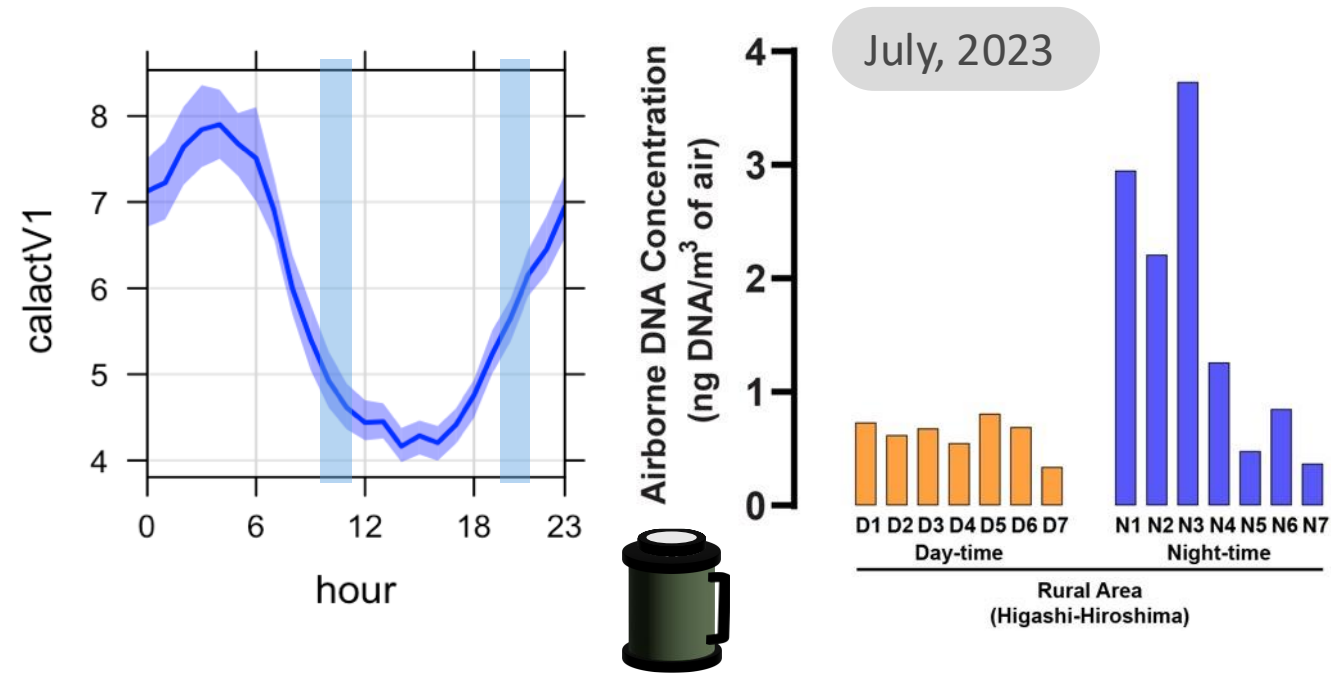
July 2023 ~ March 2025

Bioparticles appear to have diurnal patterns

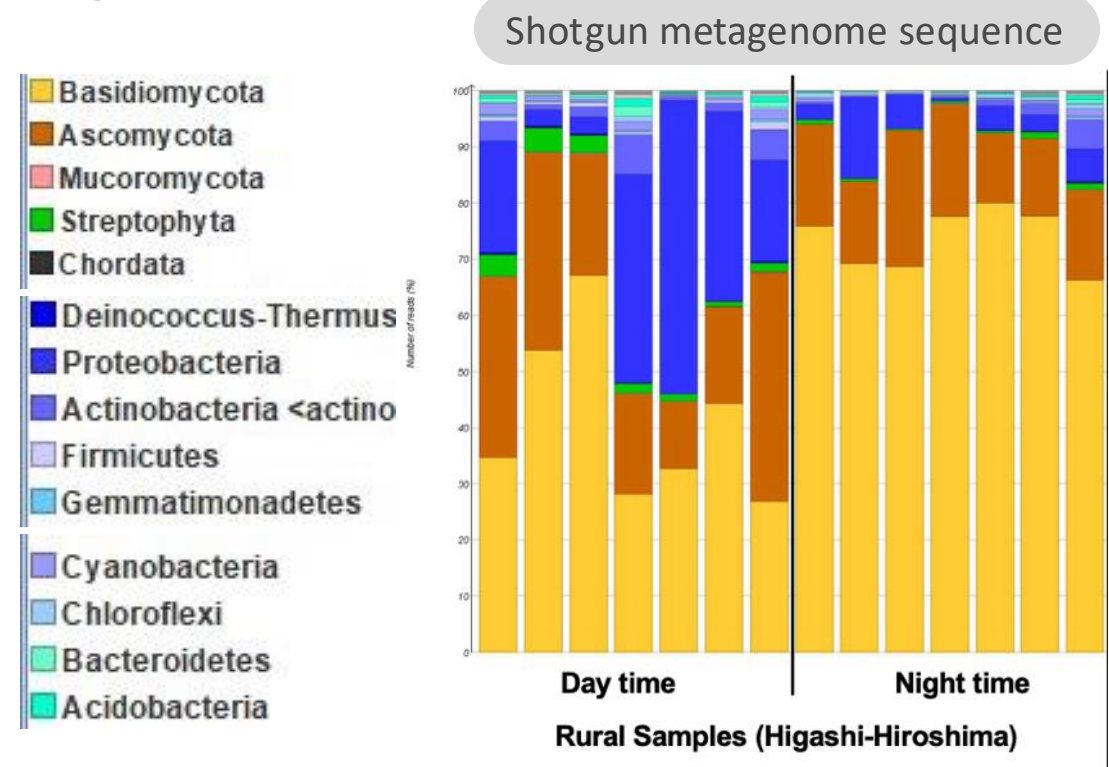


# Real-time monitoring of Viable particle counts

Bioaerosol DNA concentration:  
Diurnal cycle may exist



Higher percentage of fungi at night



Bioaerosol DNA concentration was high at night.  
The percentage of fungi was higher at night than during the day.

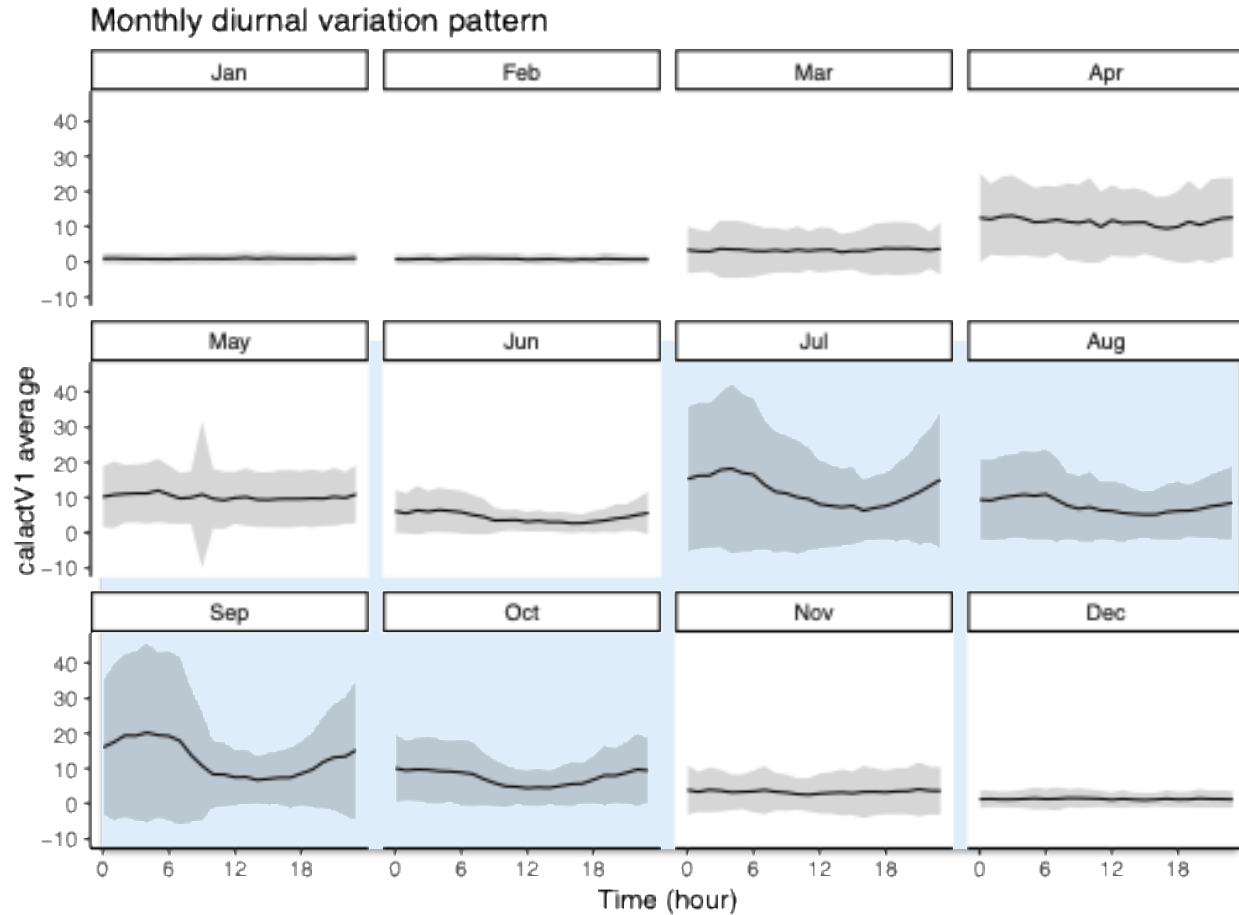
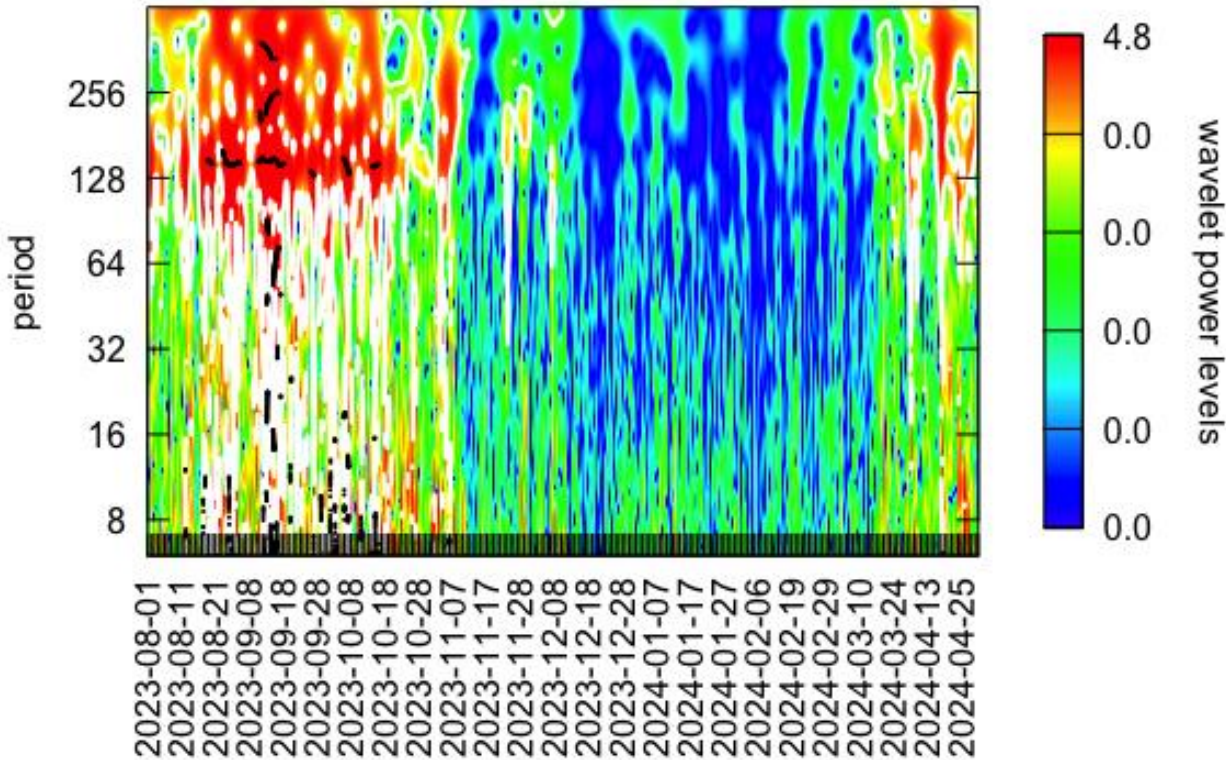




# Real-time monitoring of Viable particle counts

wavelet transformation

**Viable particle count diurnal variation**



Biological particle counts exhibited pronounced daily pattern during the late summer and early autumn months (July-October), with this pattern notably absent during the winter period (November-March)

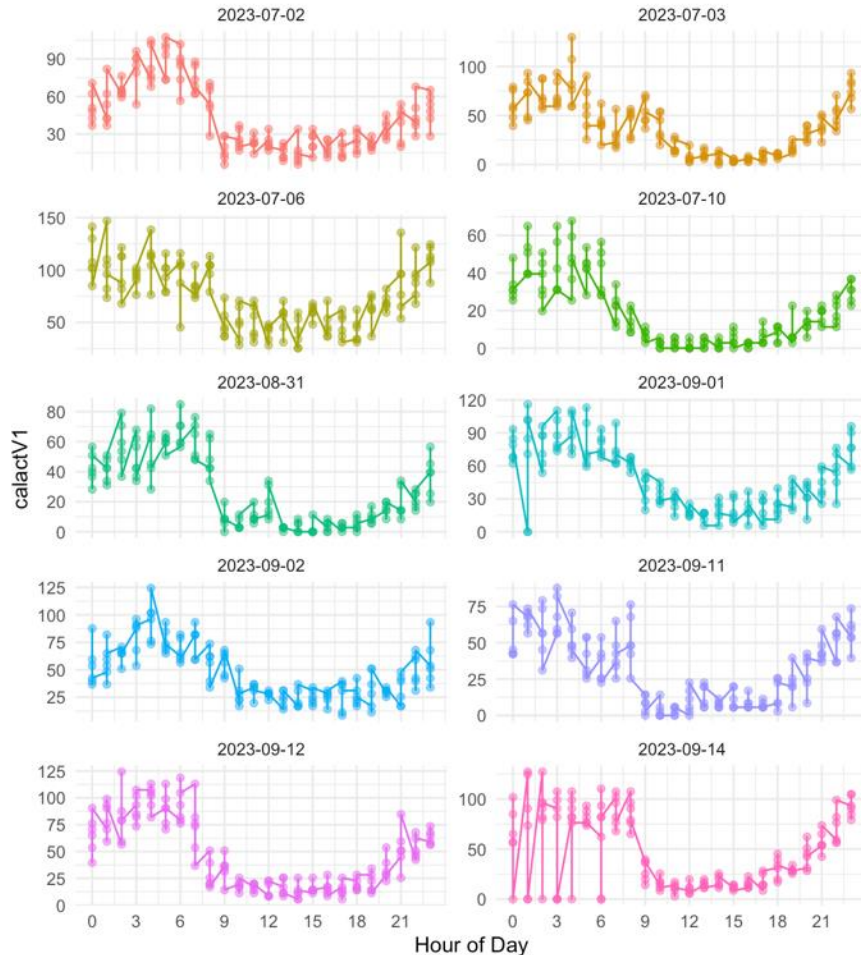


# Real-time monitoring of Viable particle counts

Viable particles

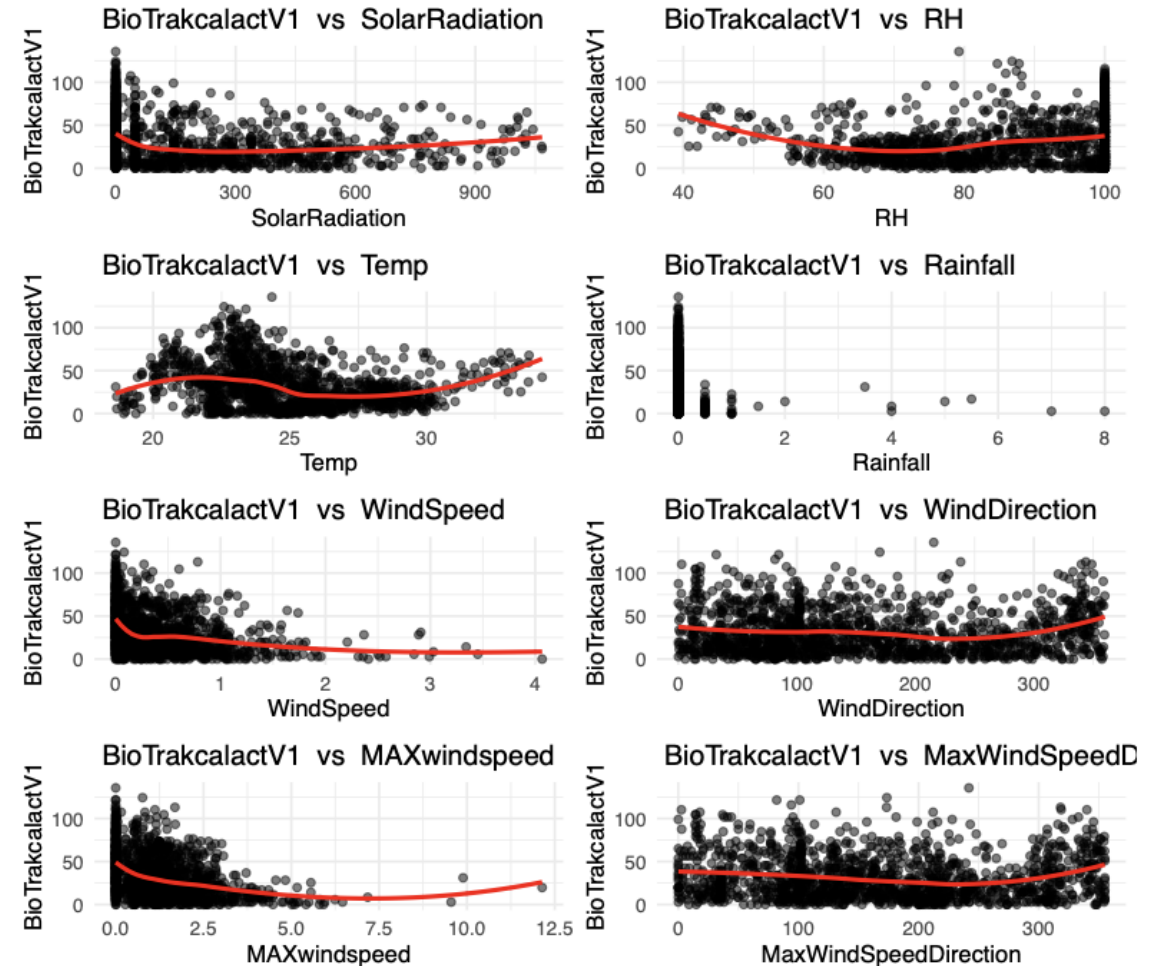
Data with daily variation\*

Top 10 Days with Strongest Night-High Day-Low Pattern  
Based on days with at least 90% data completeness



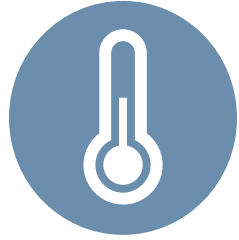
\*Data where nighttime is defined as the period from 10 p.m. to less than 6 a.m., and where the nighttime average is higher than the daytime average, are defined as having a daily variation.

Relationship between meteorological factors is **NOT** linear

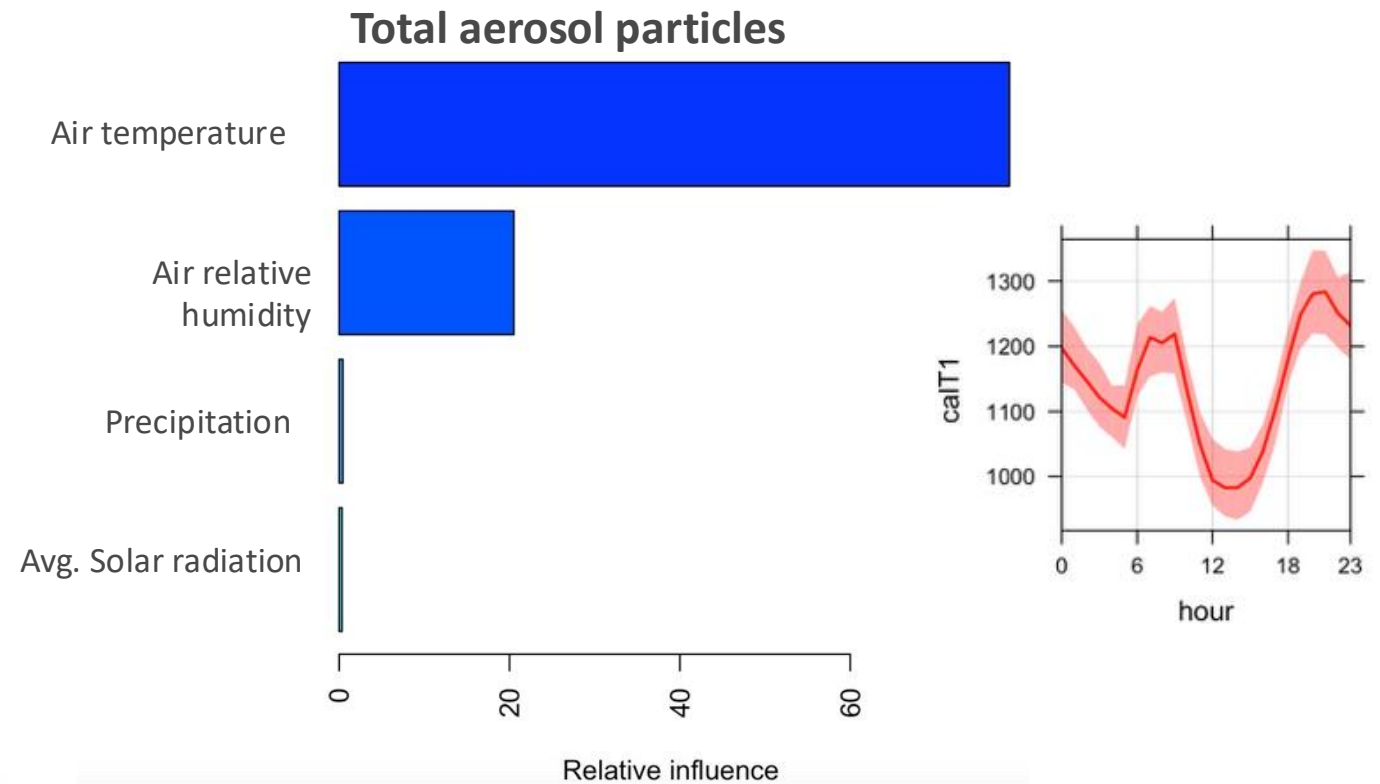
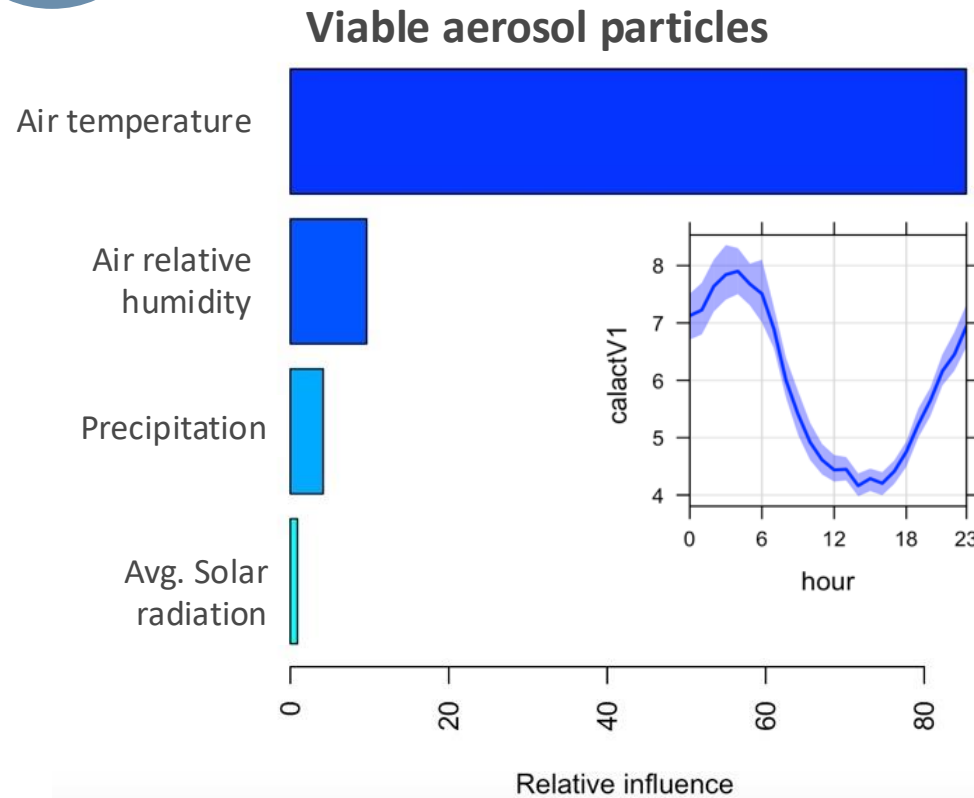


# Real-time monitoring of Viable particle counts

Effect of other environmental parameters on Viable and Total aerosol particles



Air temperature had the highest influence on Viable and Total particles



Aggregated boosted trees were used to determine the relative influence of environmental factors on the proportions of VCNT and TCNT



# Real-time monitoring of Viable particle counts

## Relationship between Viable particles and weather factors



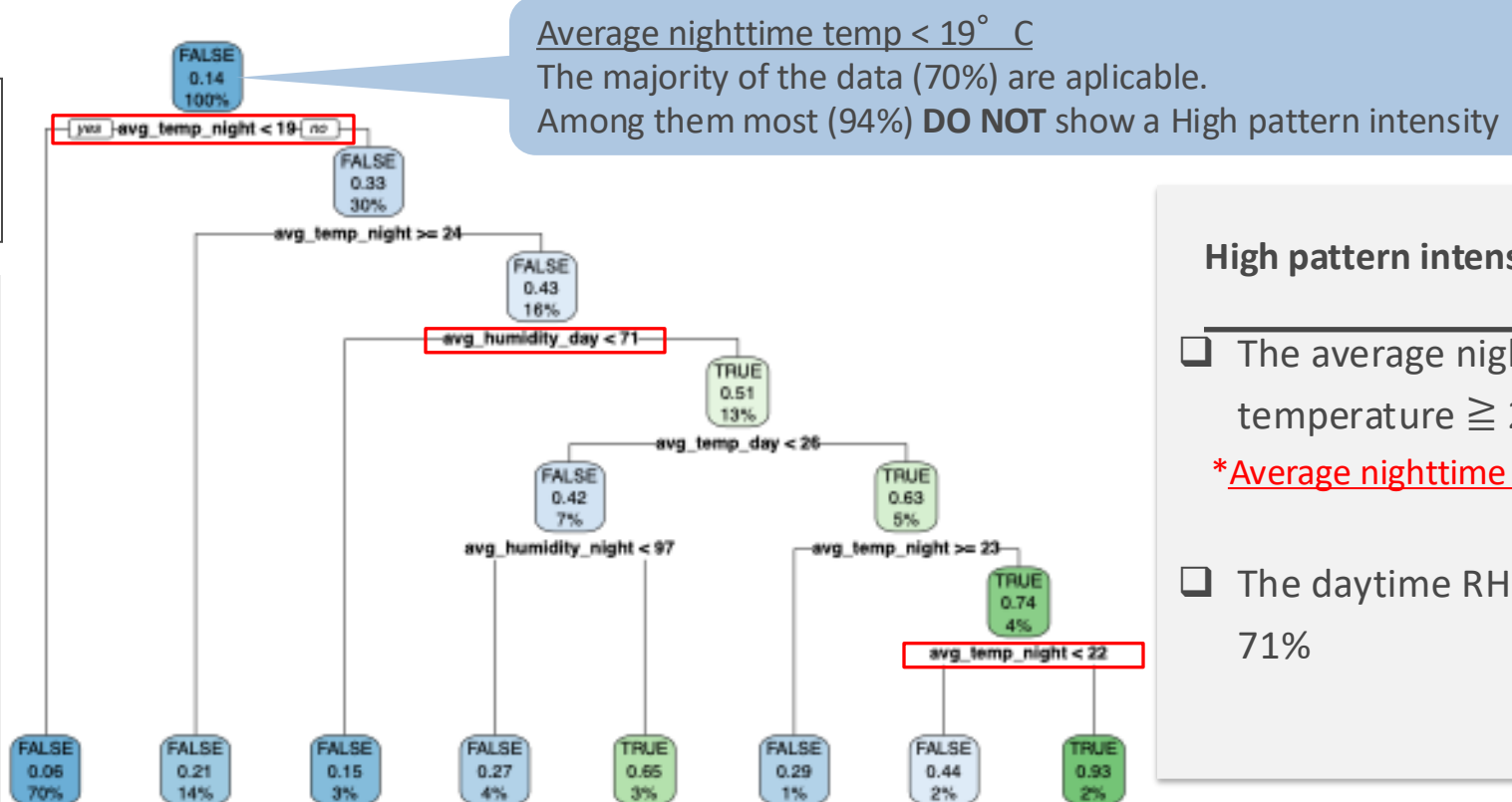
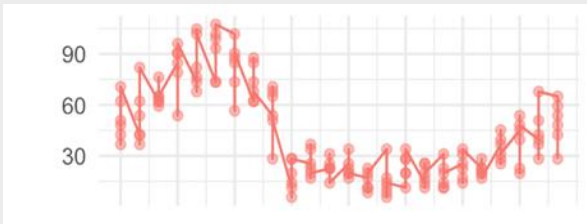
Decision Tree Analysis (DCA)

Explore threshold values from comparison of high and low patterns

Combined conditions of temperature and humidity is important for Viable aerosol particles

pattern\_intensity =  
avg\_Viableparticle\_night -  
avg\_Viableparticle\_day

Ex:  
avg\_Viableparticle\_night >  
avg\_Viableparticle\_day  
Pattern intensity is **High**



### High pattern intensity conditions

- ☐ The average nighttime temperature  $\geq 22^{\circ}\text{C}$   
*\*Average nighttime temp  $\geq 19^{\circ}\text{C}$*
- ☐ The daytime RH conditions  $\geq 71\%$





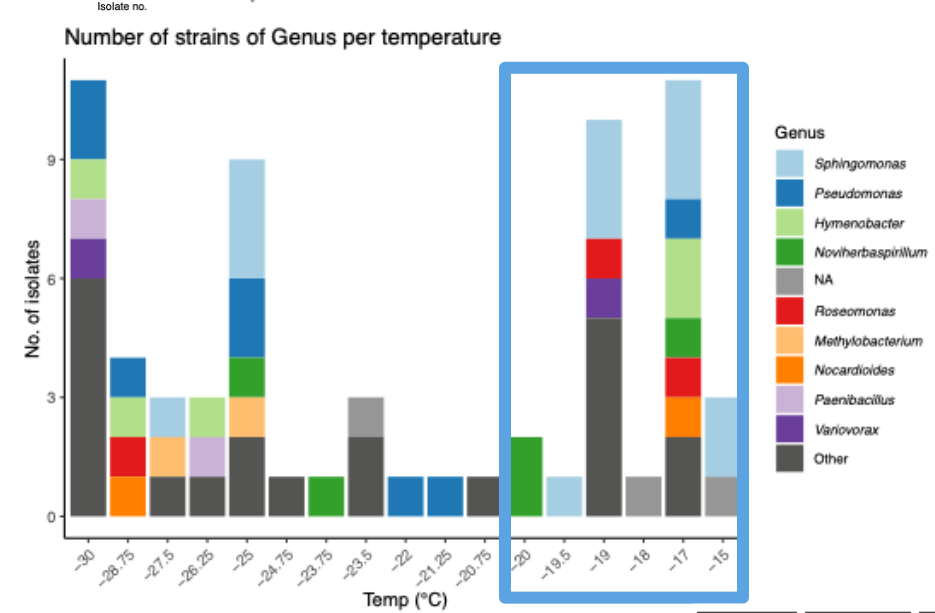
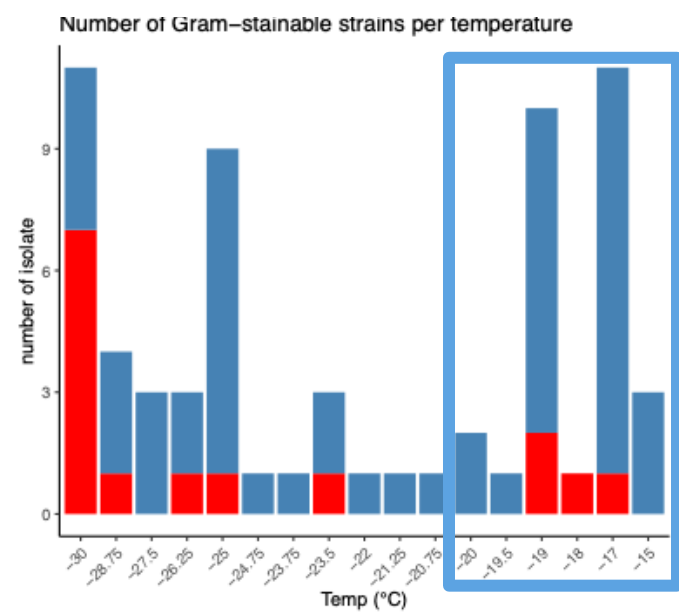
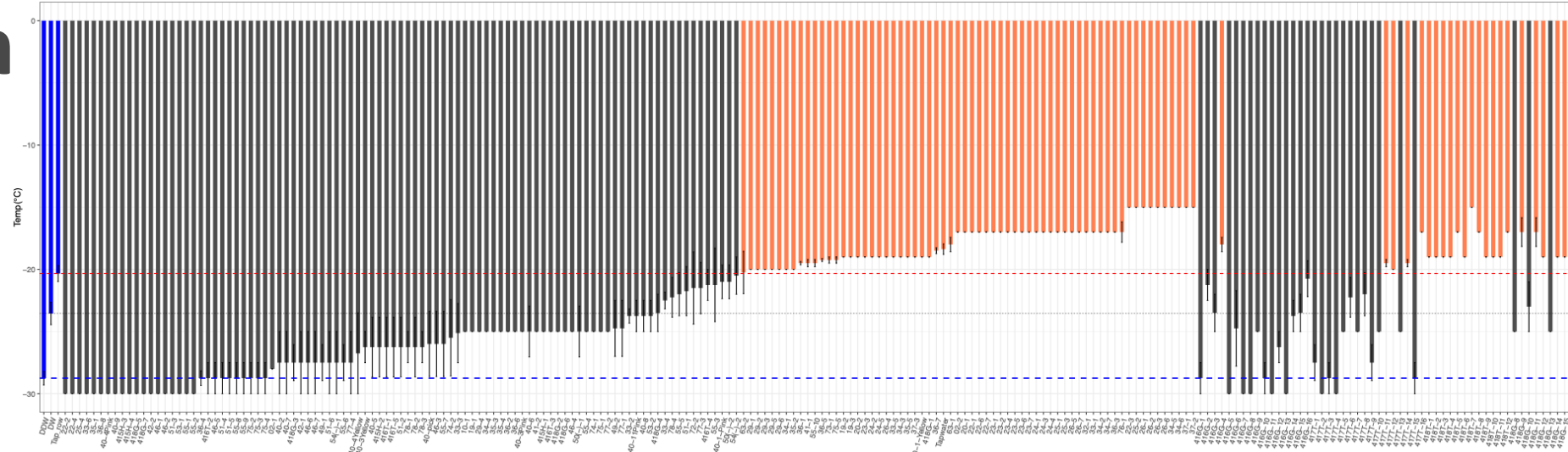
## Ice nucleation activity

Totally  
**40%** out of 211  
isolates has ice  
nucleation activity

Some G+ have the  
activity, too

*Microbacterium* (-19°C)  
*Labedella* sp. (-19°C)  
*Nocardiodes hwasunensis* (-17°C)

Sterile water freezes at an average of -28.8° C



## Microlight plane (Ultralight plane)

Lightweight: 100 kg - 230 kg

Simple structure: aluminum alloy  
tubing and wires

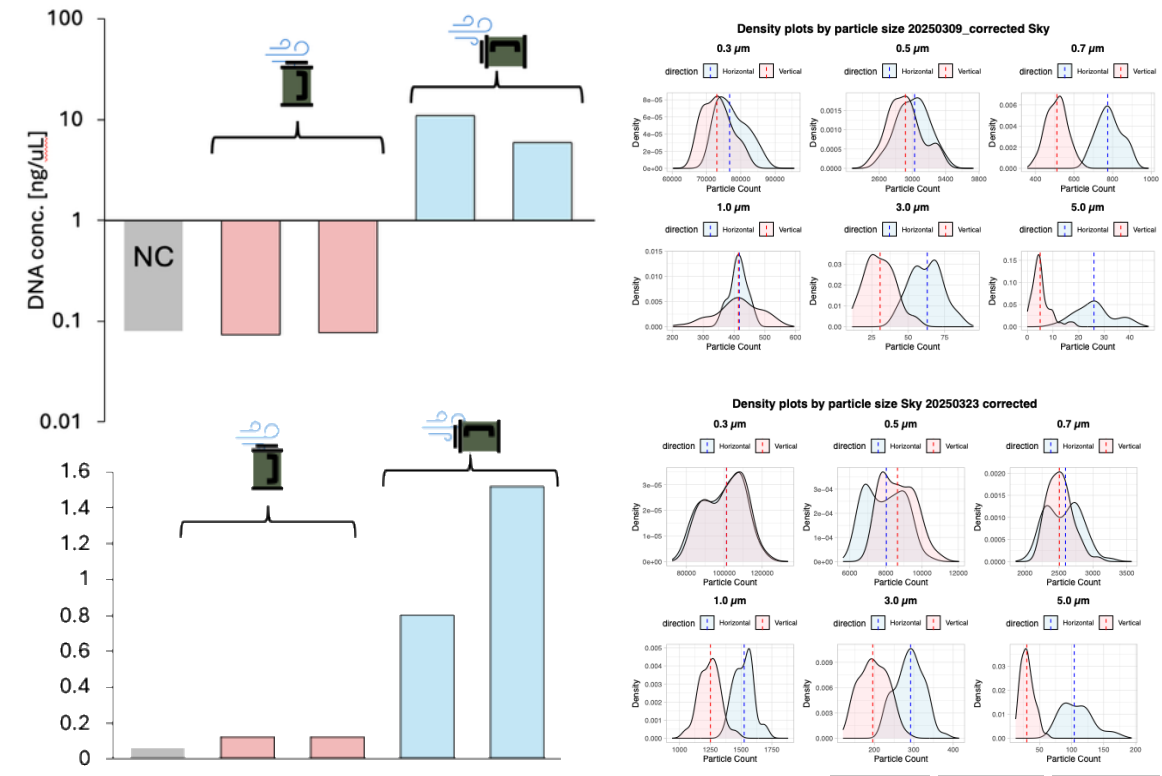
Speed: Average: 60-80 km/h

High: ~ 1600 m



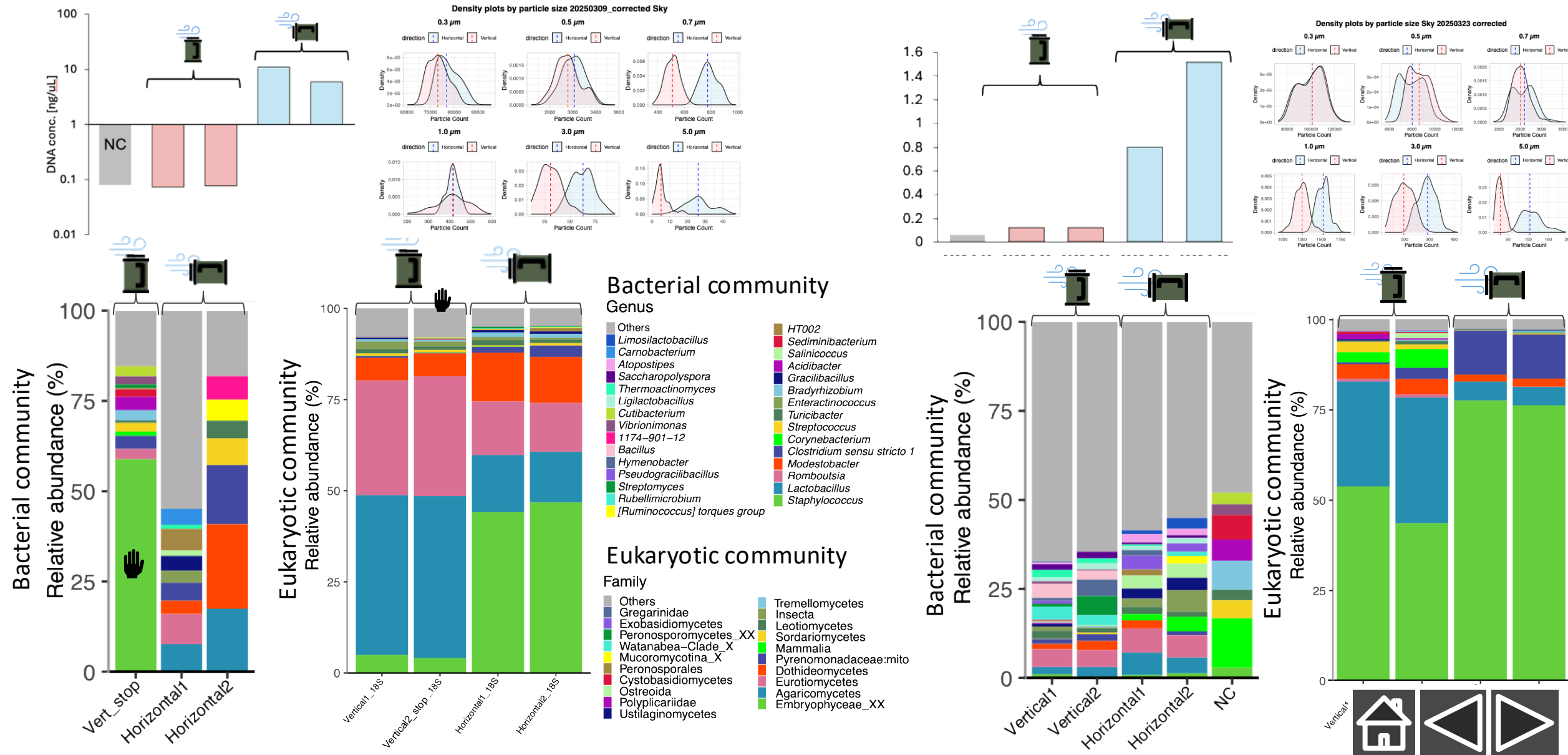
## Direction of sampler installation

Samplers placed horizontally have a higher number of particles and higher DNA concentration than those placed vertically



# Light plane sampling

## Direction of sampler installation and Microbial community



# Summary


## Difficulties of bioaerosol research

- No Standardized protocol
- Low biomass = Contamination
- Affected by many factors
- Monitoring of current airborne viable particles is like a snapshot (low resolution)

## Patterns of viable particles

- **Daily and seasonal variations**
- Higher percentage of fungi at night
- No linear correlation was detected
- **BUT**
- Nighttime **Air temperature** and Daytime RH influenced on **VCNT diurnal pattern**

## Effect of sampler placement orientation

Vertical  vs  Horizontal

- **DNA concentration:  $V \ll H$**
- **No of Particles:  $V \ll H$**
- Bacterial community was not so different
- Eukaryotic community was affected





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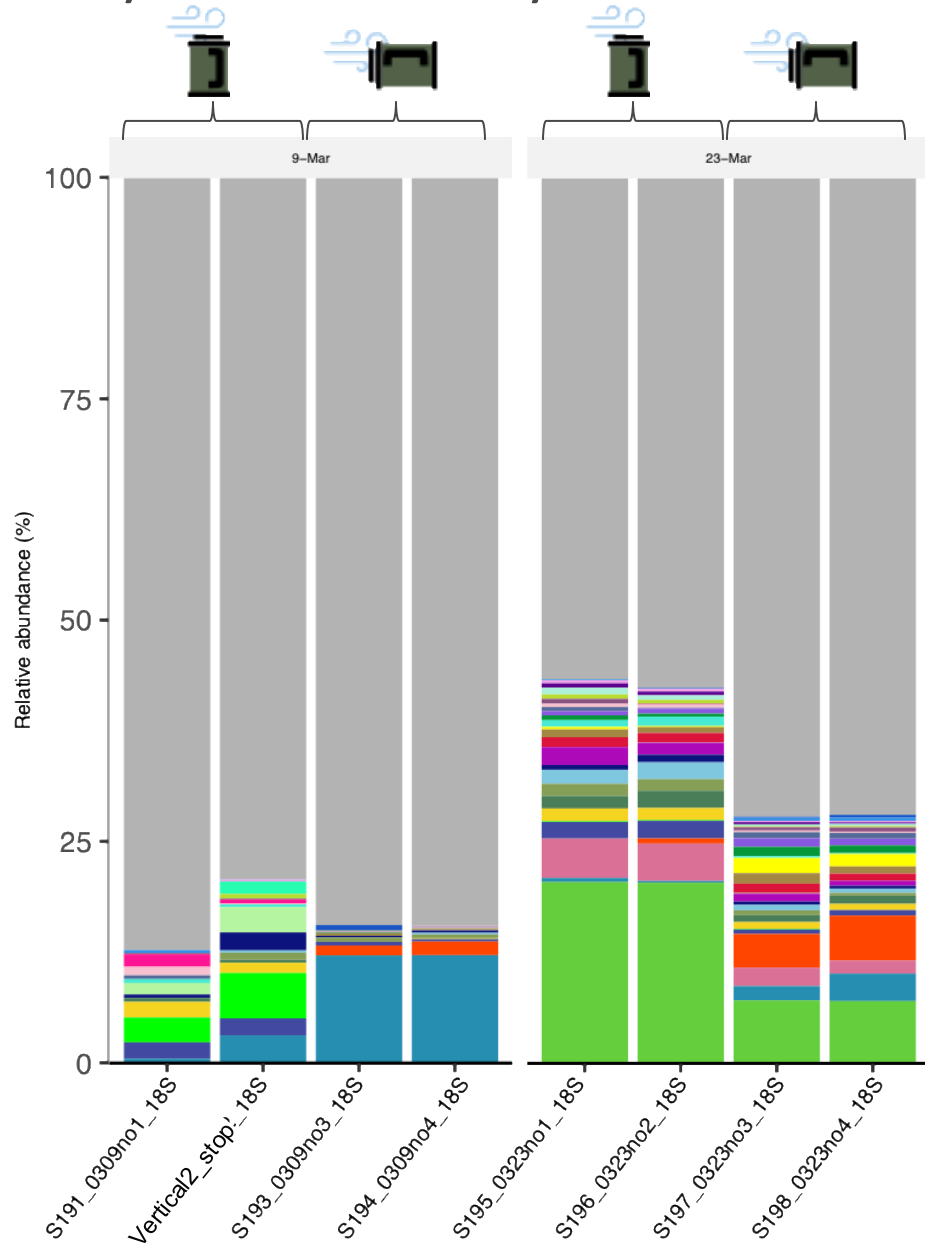
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# Appendix.

## Eukaryotic community



## Bacterial community

