UAV-based aerosol and VOC measurements above a spruce forest canopy in Lower Austria

Florian Wieland[1], Matthäus Rupprecht[1], Peter J. Wlasits[1,2], Jürgen Gratzl[1], Pascal Langer[1], Vanessa Treml[1], Jordan Horral[3], Cayden Smedley[3], Regina Hanlon[3], David Schmale III[3], Hinrich Grothe[1]

[1]Institute of Materials Chemistry, TU Wien, Vienna, 1060, Austria
[2]Faculty of Physics, University of Vienna, Vienna, Austria
[3]School of Plant and Environmental Sciences, Virginia Tech, Blacksburg, Virginia, 24061-0390, USA
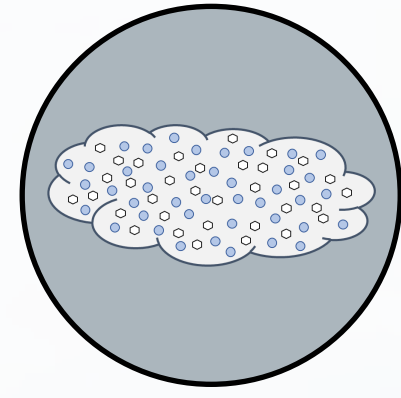
Introduction

Primary Biological Aerosol Particles (PBAPs)—a diverse group including pollen, fungal spores, and bacteria—are ubiquitous in the atmosphere. Despite their importance, quantifying their emission sources is challenging, particularly due to their heterogeneity.

Why study PBAPs?

Climate & Weather Influence: They act as highly efficient Cloud Condensation Nuclei (CCN) and Ice Nuclei (IN), directly influencing cloud formation, radiative properties, precipitation, and overall climate dynamics.
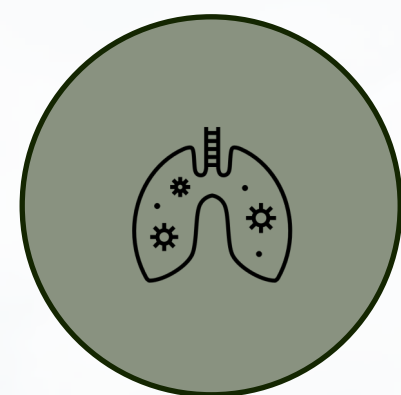
Health Impacts: PBAPs are major contributors to airborne allergens, triggering respiratory issues and impacting public health.

Methodology

Platform: Utilized a novel sensor suite mounted on an Uncrewed Aerial Vehicle (UAV).
Campaign: Two-week field campaign in a protected forest northwest of Vienna.
Measurements:

- Performed vertical profiles and targeted flight patterns to measure PBAP emissions.
- Concurrently measured Volatile Organic Compounds (VOCs) as indicators of biological activity and ecosystem processes driving particle release.
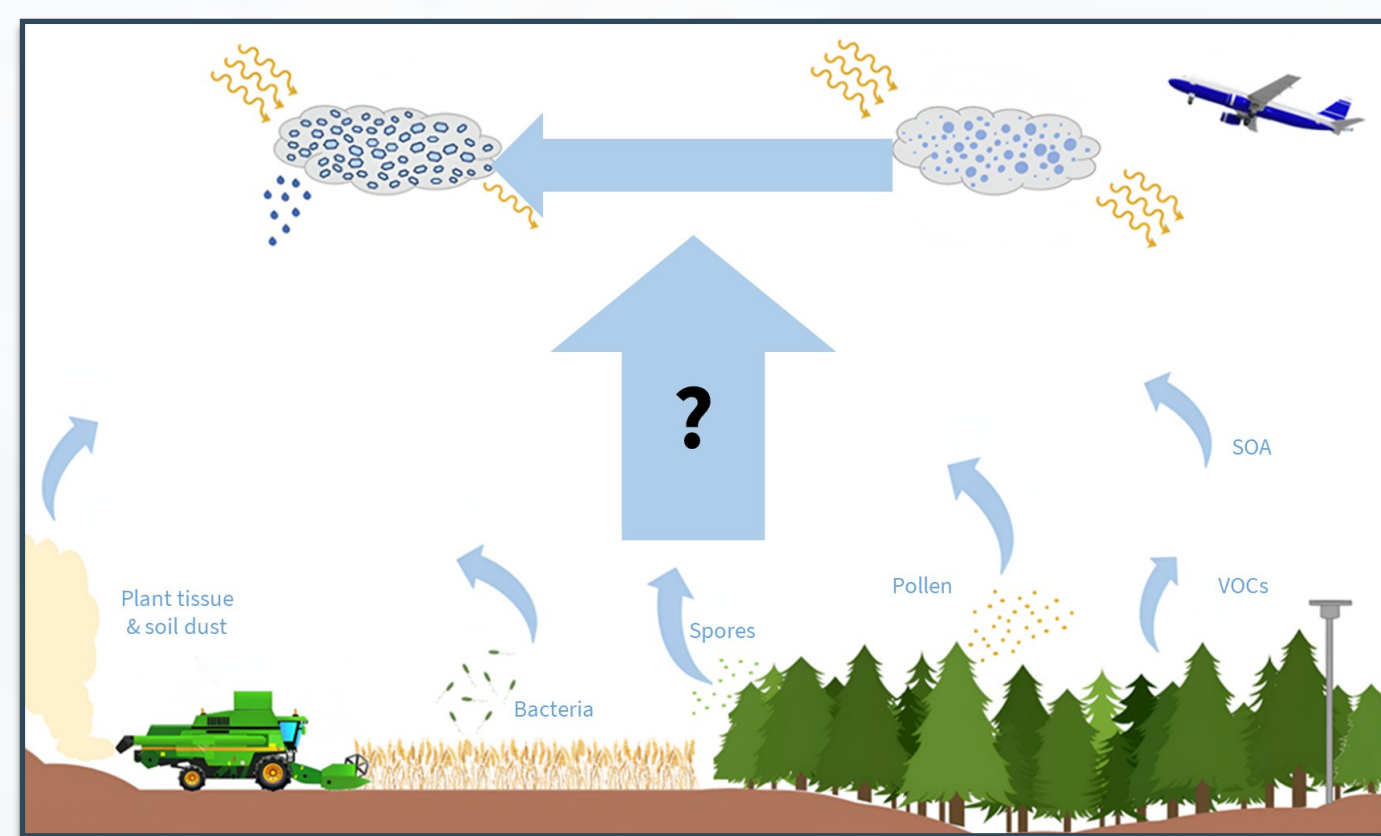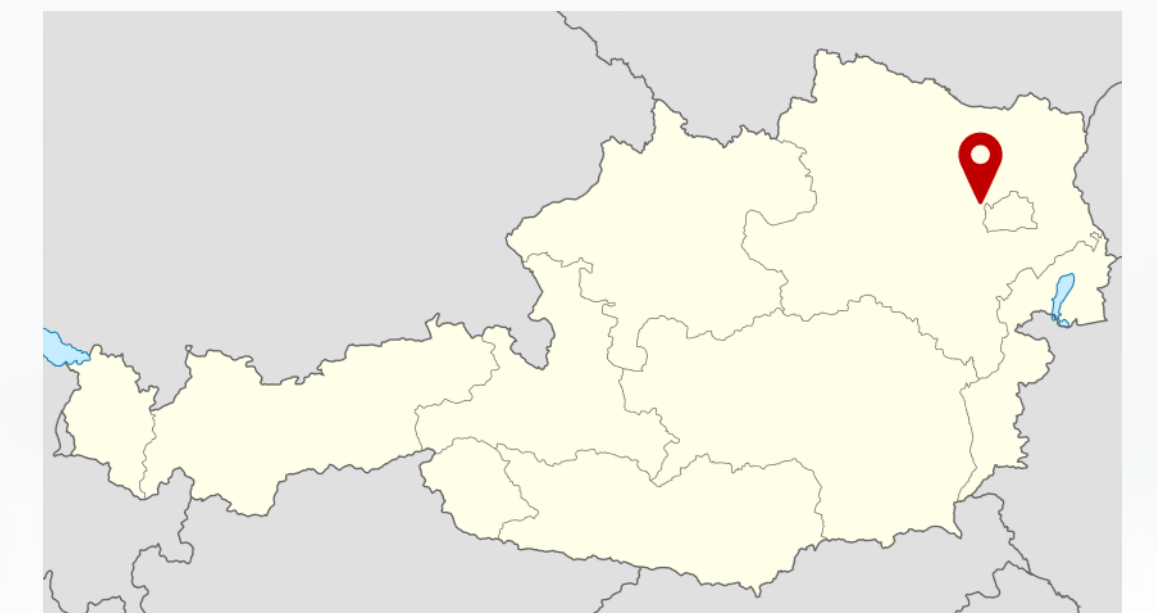
Field Campaign Details

2 ... weeks of measurements in **Mauerbach, Austria**
11th - 14th June and 08th - 11th July
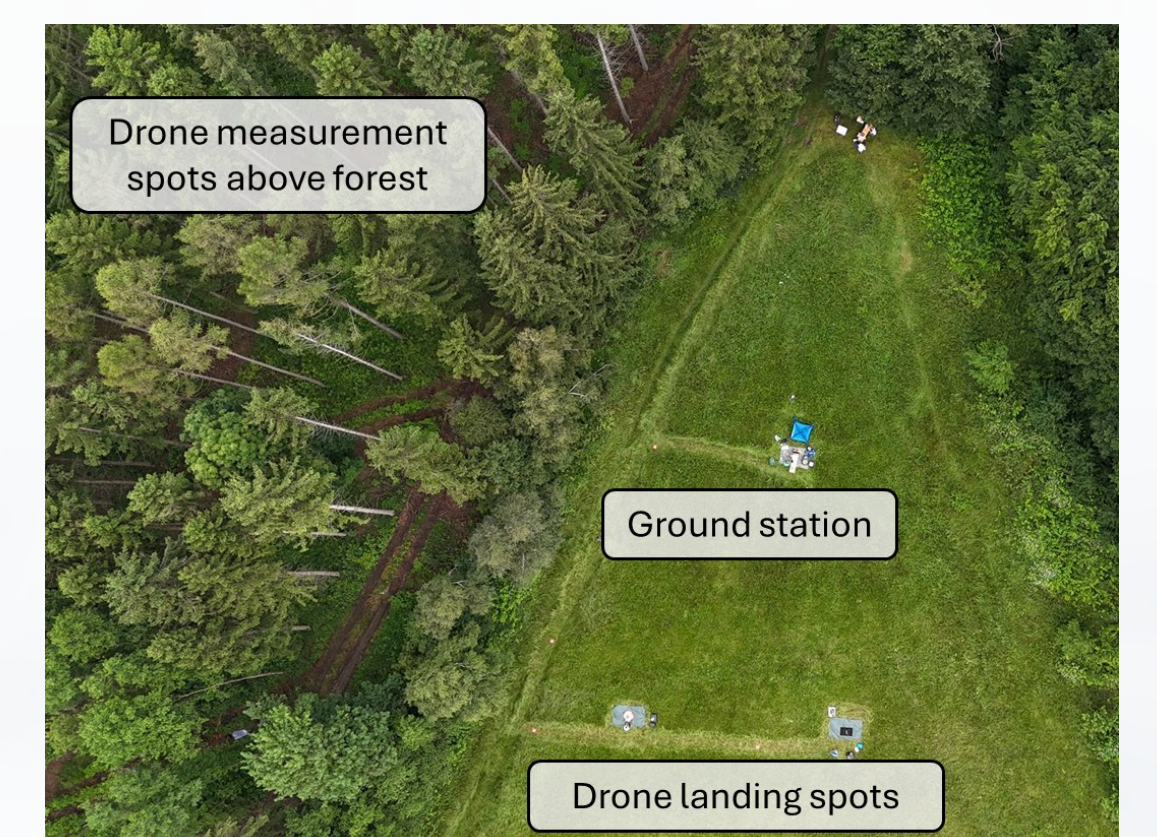protected forest, mainly spruce trees

... UAVs

UAV TU Vienna
- Particle size distribution (POPS, SMPS)
- Air quality sensors (T, RH, p, TVOC, NOx, PM)
  *TVOC… total volatile organic compounds
- VOC sampling

UAV VT
- Particle size distribution (PM sensor)
- Aerosol sampling (Impinger)

... ground stations

Main Station
- Single particle fluorescence measurements (WIBS)
- Particle size distribution (WIBS, Optical particle counter)
- Aerosol sampling (Impactor, Impinger)
- Air quality sensors (T, RH, p, TVOC, NOx, etc.)

Portable station
- Particle size distribution (PM Sensor)
- Aerosol sampling (Impinger)

Case study — 11th July 2024

Height profile measurements from July 11th show clear trends:

1. Total particle concentration (0.115 – 3.370 µm) increases with height, above meadow and above canopy
2. PM2.5 concentrations show a similar trend
3. TVOC concentrations decrease strongly over meadow with increasing height, while above canopy low TVOC concentrations can still be detected

Fig 1. Overview of parts of the UAV sensors collected data.
5 flights focusing on height profile measurements above meadow and canopy
- Stationary periods at 15, 40, 80m AGL
- Tree height approx. 21m (dashed line)

Top: Height AGL & total part. concentration (POPS)
Middle: Temperature & relative humidity (BME680)
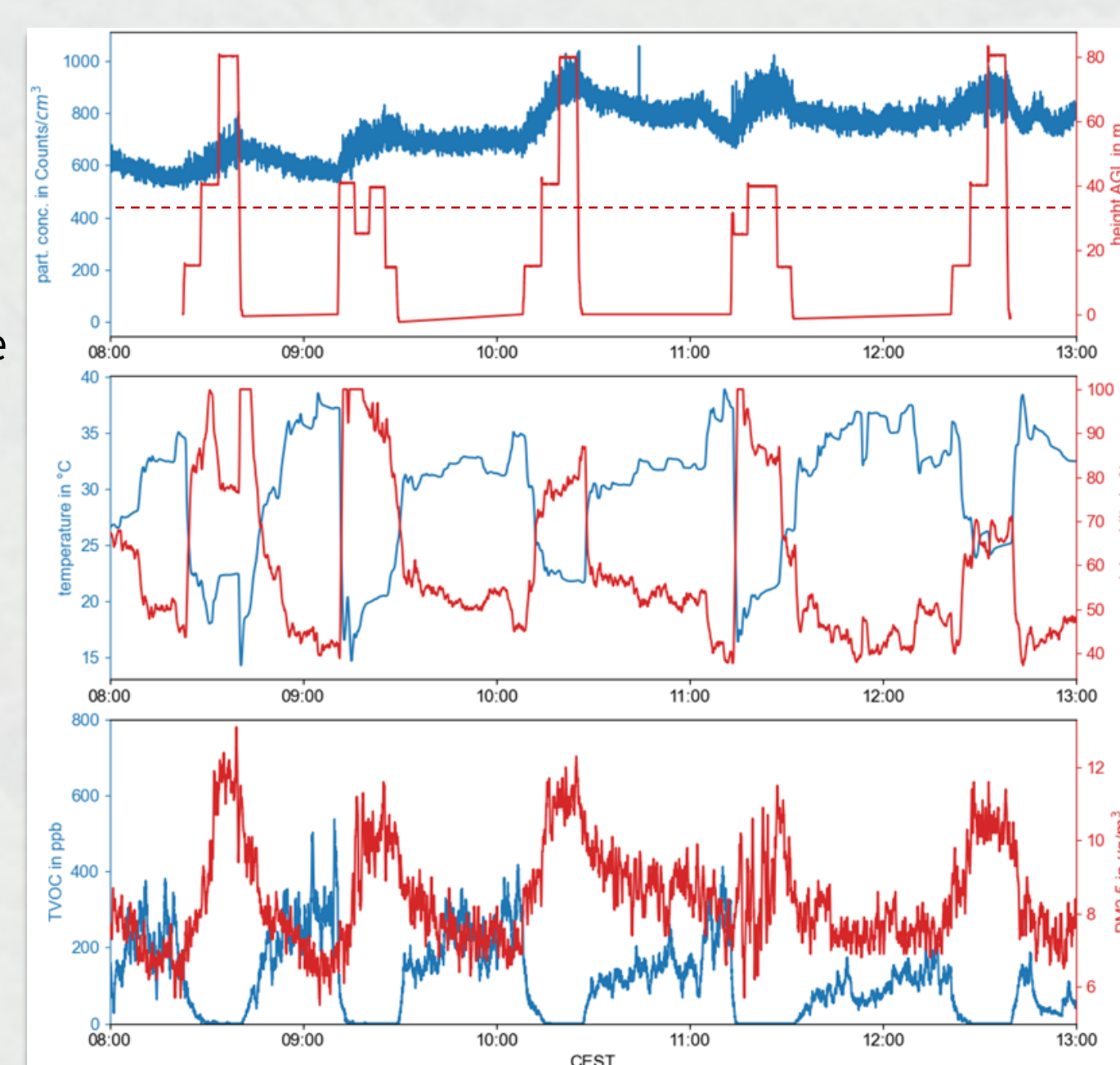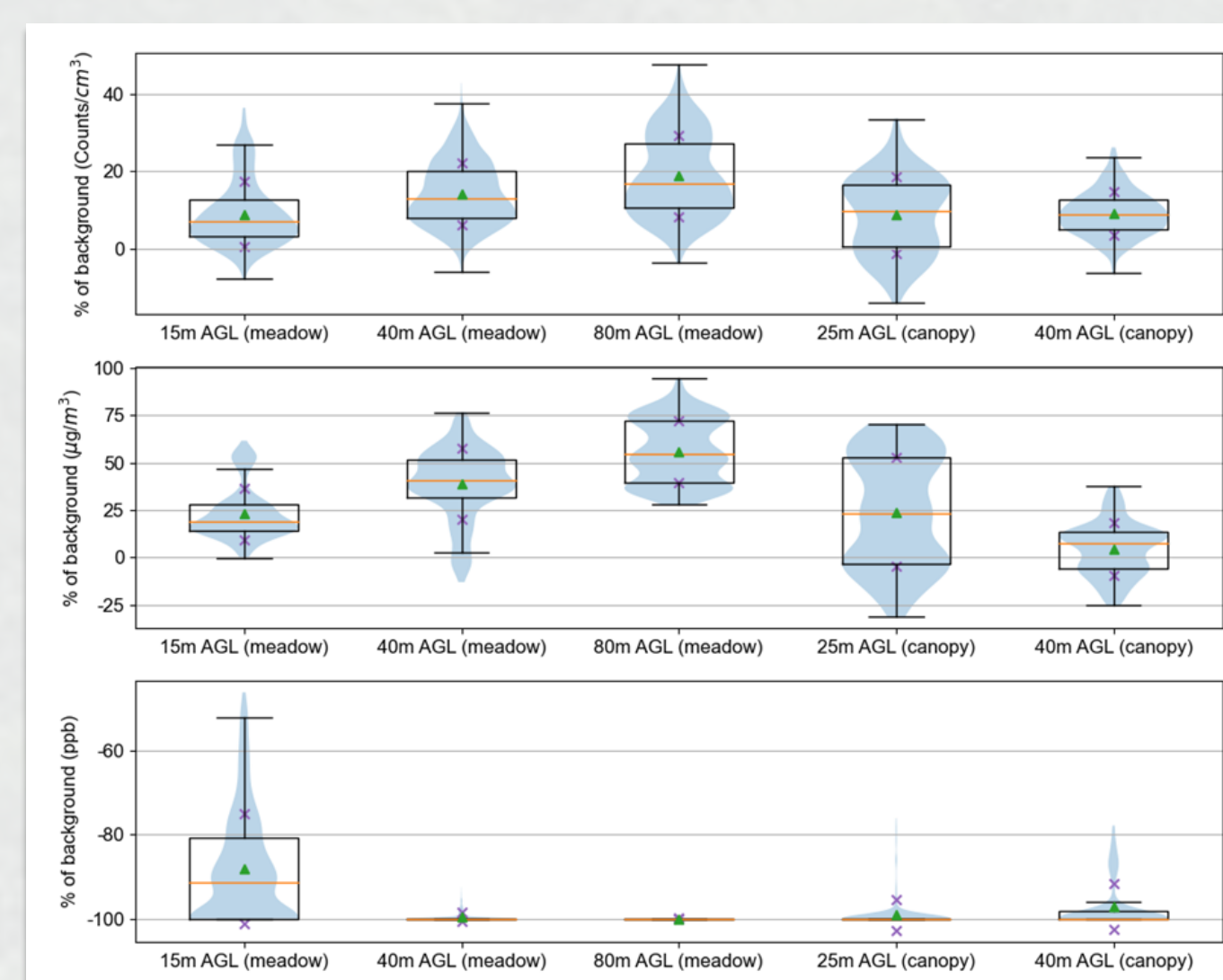Bottom: TVOC (CCS811) & PM2.5 (SEN55)

Fig 2. Comparison of in-flight measurements to a 10 min pre flight period (termed here as background) of all flights from July 11th
Top: total particle concentration (POPS)
Middle: PM2.5 (SEN55)
Bottom: TVOC (CCS811)

Conclusion

Trends at 40m over the course of all 34 flights show the same trends as the case study:

1. Total particle concentrations and PM2.5 slightly increased with height compared to ground
2. TVOC concentration strongly decreased with height

Fig 3. Comparison of total particle concentration (POPS), PM2.5 (SEN55), TVOC (CCS811) to a pre-flight period over all flights

Canopy — 12
Canopy & Meadow — 5
Meadow — 9
Instrument Malfunction — 8
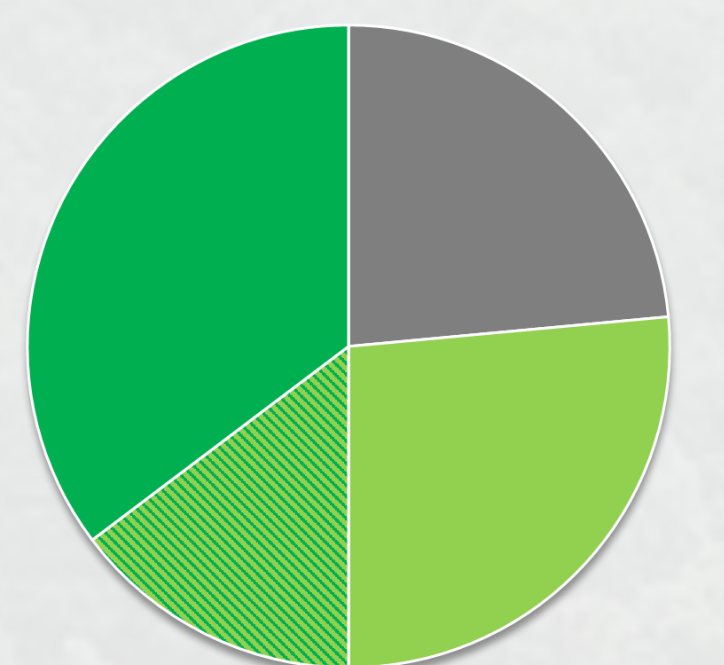
Outlook

- Data analysis of ground based measurements still to come
- Analysis of Particle size distribution of ground based OPC & WIBS vs UAV-based POPS could reveal more insights on types of (bio-)aerosols
- GC-MS analysis of sampled VOCs can give more insights to the measured VOCs