Assessing the Impact of Emissions from Zürich Airport on Ultrafine Particles and Volatile Organic Compounds in a nearby Residential Area

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Introduction

Airports are important sources of **volatile organic compounds** (VOCs) and **ultrafine particles** (UFPs)[1]. The global air traffic is rising by ~6% every year, representing now > 300 passengers/s. Thus, assessing their **impact on the nearby air quality** is essential.

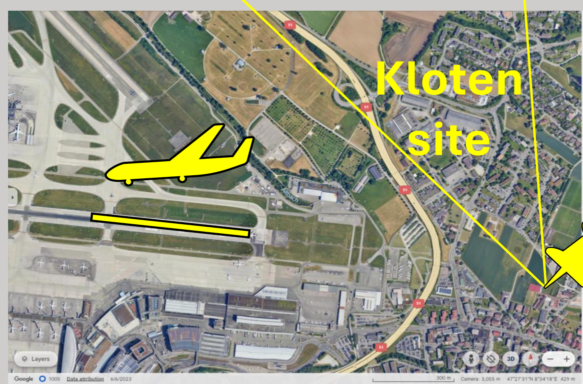
- The U.S. Environment Protection Agency has reported a list of **15 hazardous VOCs emitted by aircrafts**, such as benzene and several Hazardous Air Pollutants (HAPs).
- Gaseous emissions like total[2] and unburned hydrocarbons[3] are emitted more at low thrusts (idling and taxiing phases), when the combustion efficiency is lower.

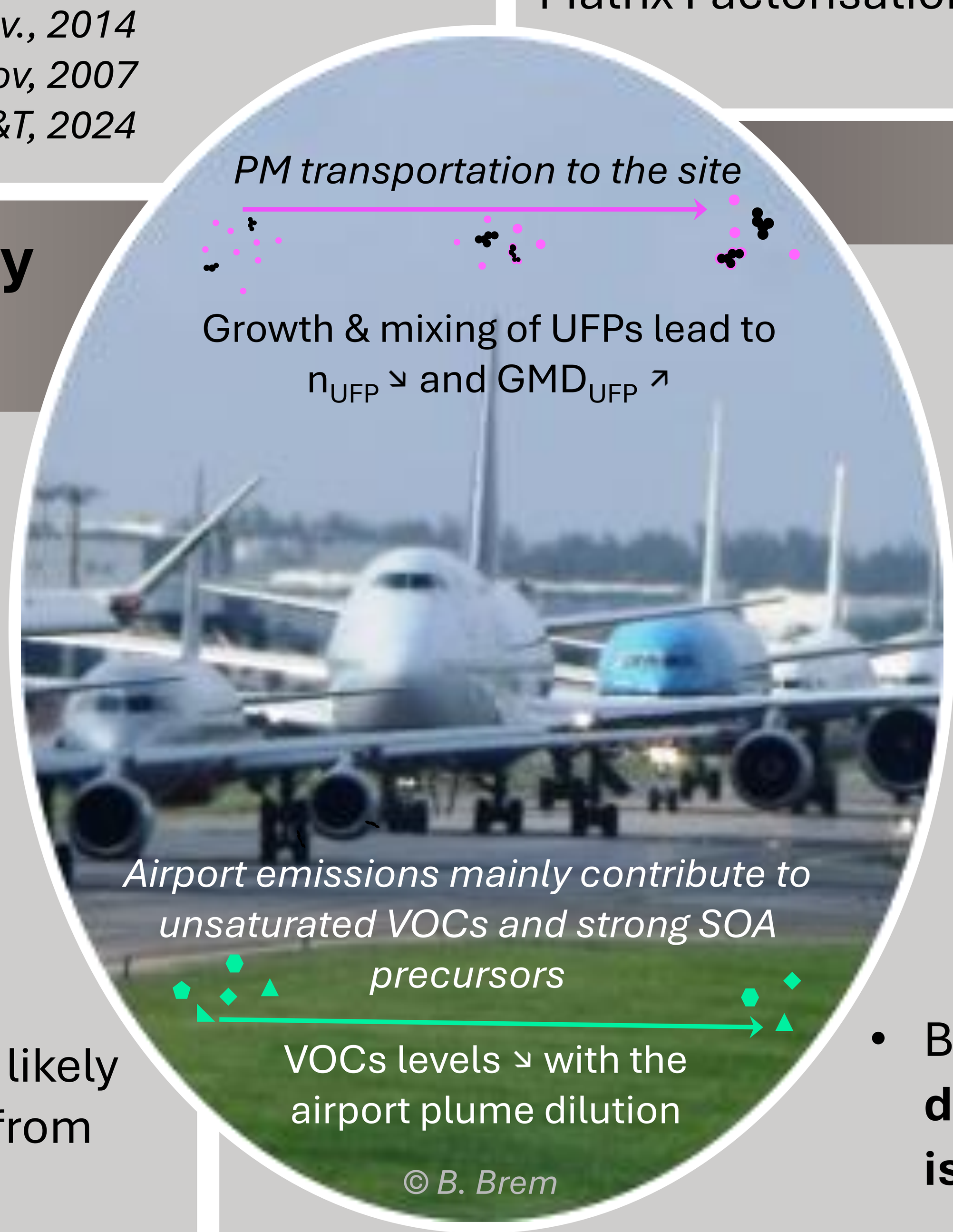
[1] *Masiol et al., Atm. Env., 2014*
[2] *Wey et al., ntsr.nasa.gov, 2007*
[3] *Heeb et al., ES&T, 2024*

Methodology

2 × 1-month measurement campaigns (Nov. 2022 and Aug. 2024) at Kloten **~ 1 km downwind of Zürich airport.**

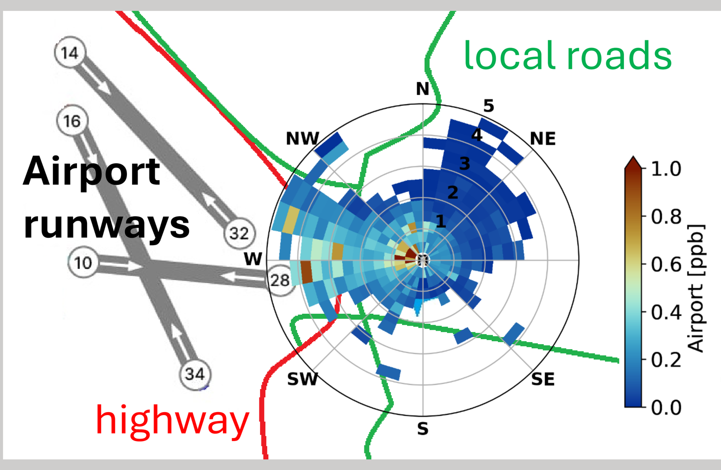
- CPCs (Condensation Particle Counters)
  → **Particle Number** (PN) **concentration**, *1 min*
- VOCUS PTR-MS (Proton Transfer Reactor MS)
  → **VOCs composition and mixing ratios**, *1 min*
- **VOCs source apportionment** using Positive Matrix Factorisation (PMF) with SoFi





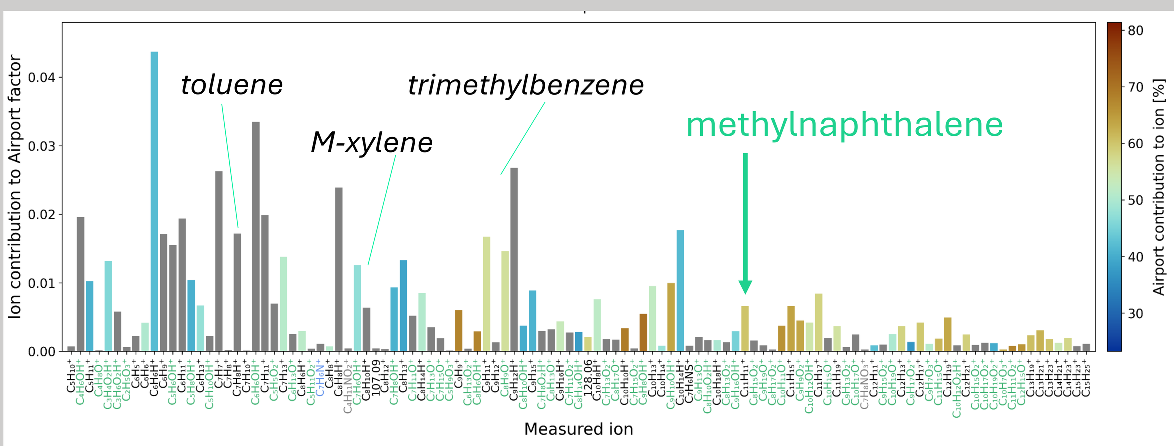
1. An airport-emission factor is revealed by source apportionment

- A **similar airport factor** was found for both Fall 2022 and Summer 2024.
- The airport factor profile **includes several HAPs**, such as methylnaphthalene.



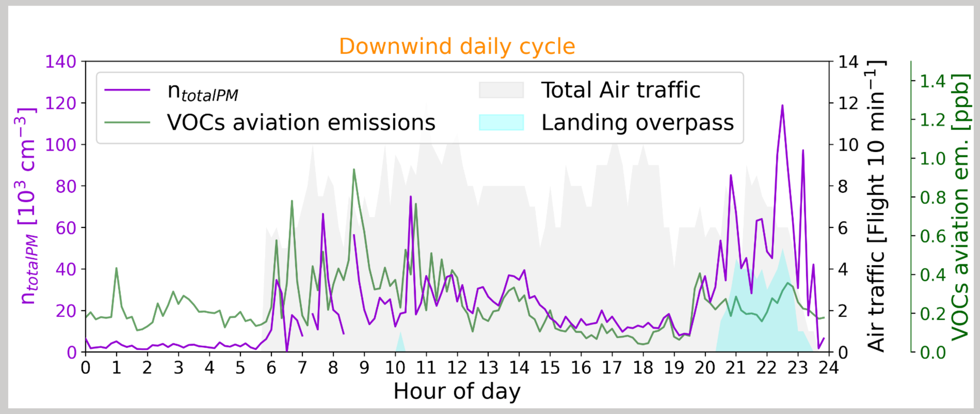
Polarplot of the airport factor at Kloten for the 2024 PMF.

- These compounds are likely **unburned Jet A1 fuel** from **low thrust** operations.



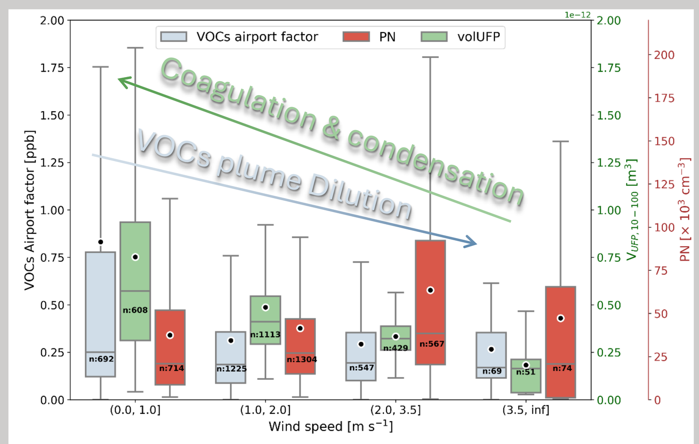
Airport factor profile retrieved by PMF on the Aug. 2024 VOCs data. Ions for which airport is the main contributor are coloured by contribution.

2. Co-emissions of UFPs and VOCs



Downwind diurnals of UFPs concentrations $n_{totalPM}$, air traffic and VOCs airport factor

- **High UFPs emissions** up to 300'000 cm^{-3} were measured **downwind** of the airport **AND** during **landing overpass**[4].
- By contrast, **VOC airport emissions** were **only** present **downwind** of the airport, suggesting the **main contribution is from low thrust** operations.
- The **VOC** aviation emissions were **increasing with decreasing wind speed**, suggesting a **lower dilution of the downwind plume**.
- Simultaneously, the **UFPs volume** concentration **increased**, reflecting **coagulation & condensation** processes **during the transport**, making the UFPs increase in diameter.

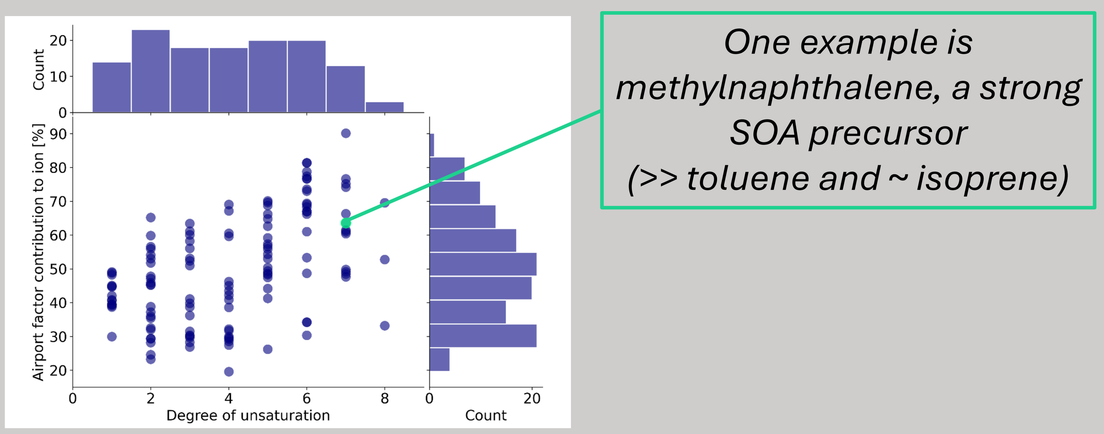


Airport factor ,UFPs number and volume concentrations as a function of the wind speed, measured downwind of the Airport

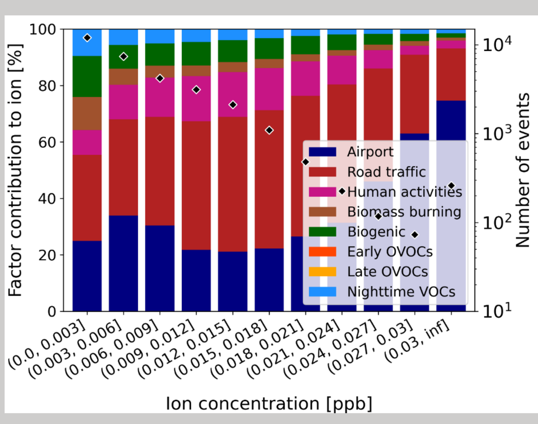
[4] Tinorua el al, ES&T, 2026 (check the QR-code ↓)

3. Health concerns due to the presence of strong SOA precursors

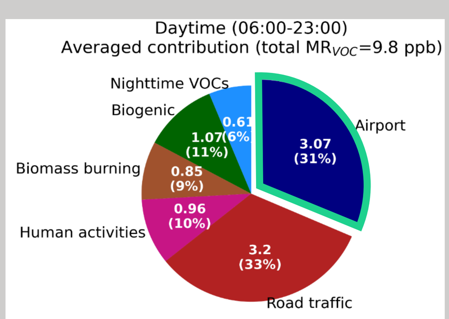
- The airport factor profile is the **main contributor of unsaturated** VOCs (Degree of unsaturation > 4), meaning :
  - lower volatility, which **increases their Secondary Organic Aerosol (SOA) formation** potential
  - Higher **ozone formation potential**



Airport factor contribution to individual ions as a function of their unsaturation degree.



Contribution of each PMF factor to methylnaphthalene



Factor contribution to methylnaphthalene, a HAP known to be emitted by aircraft engines for the 2024 PMF.

- **Traffic and airport** emissions are the dominant contributors to methylnaphthalene (~ ⅓ each on average).
- However, **peak** concentrations of methylnaphthalene are **clearly driven by the airport** factor.

Take-home messages

✓ About 1 km downwind of Zurich Airport, **VOC emissions from the airport activities** were measured together with **the highest UFP number concentrations.**

✓ **High UFP** levels were also measured during **landing** over the site, whereas **no VOCs** from the airport were measured. This highlights the **contribution of low thrust** aircraft operation to local VOCs.

✓ During its highest VOCs concentrations, the **airport** factor becomes **the main contributor of strong SOA precursors**, representing a concern for human health & the environment.

More on UFPs at Kloten !

Acknowledgements

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