Ultrafine Particle exposure from individual aircraft approaching Innsbruck airport

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Experimental Overview

Introduction

We deployed a weather station, a microphone, two mobile UFP sensors and a fast CO_2 sensor on the roof of a school building located approximately 1 km from the runway of the Innsbruck airport (in the direction of the city center). The portable UFP sensors characterize PNC and size virtually in real time. We carried out long term measurements over several months to capture the diurnal and seasonal impact of real-world aircraft specific UFP emissions.

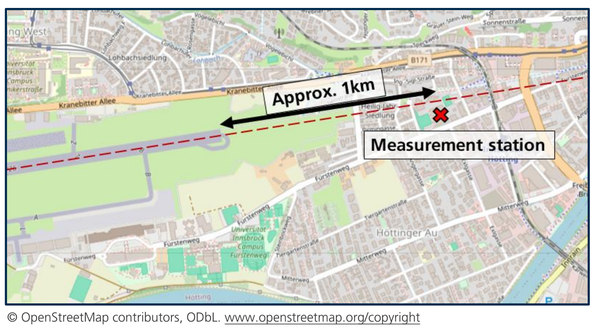


Figure 1: Location of measurement station.

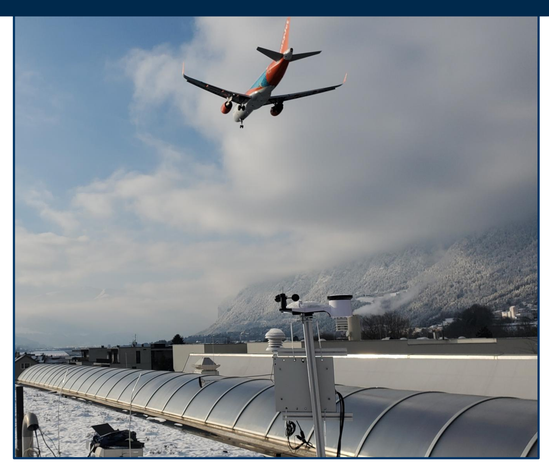


Figure 2: Airplane approaching Innsbruck airport from the east and measurement station in the foreground.

Instruments

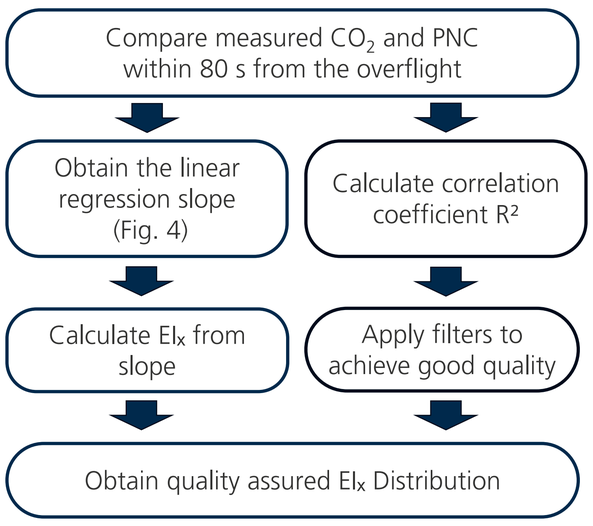
- Partector2 and Partector2 Pro (Naneos), PNC measurement every 1s and 4s, respectively
- LI-COR LI-850, CO_2 measurement every 1s
- Microphone
- Weather station
- Individual aircraft data from Flightaware

Airplane Particle Emissions

Introduction

Jet engines emit large amounts of UFP as quantified by the Particle number emission Index (EI_x) indicating the number of particles produced per kg fuel burned.
We used a conversion factor of 3.16 kg CO_2 per kg fuel.[1]
Studies have shown that exposure to UFPs can have adverse health effects, as these particles can enter the bloodstream and act as carriers of toxic substances.[2]

Methods



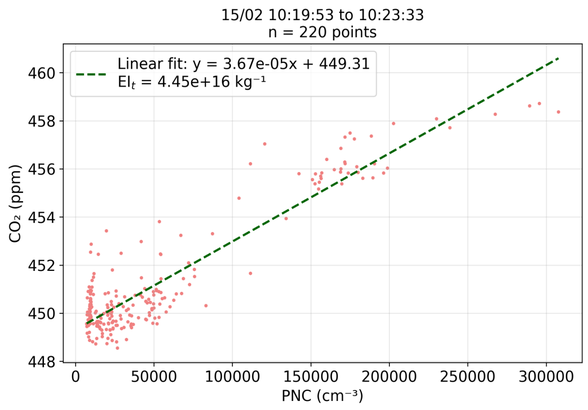


Figure 4: Linear regression (dashed line) of CO_2 vs PNC for the flight from Schiphol shown in Fig. 3B.

Results

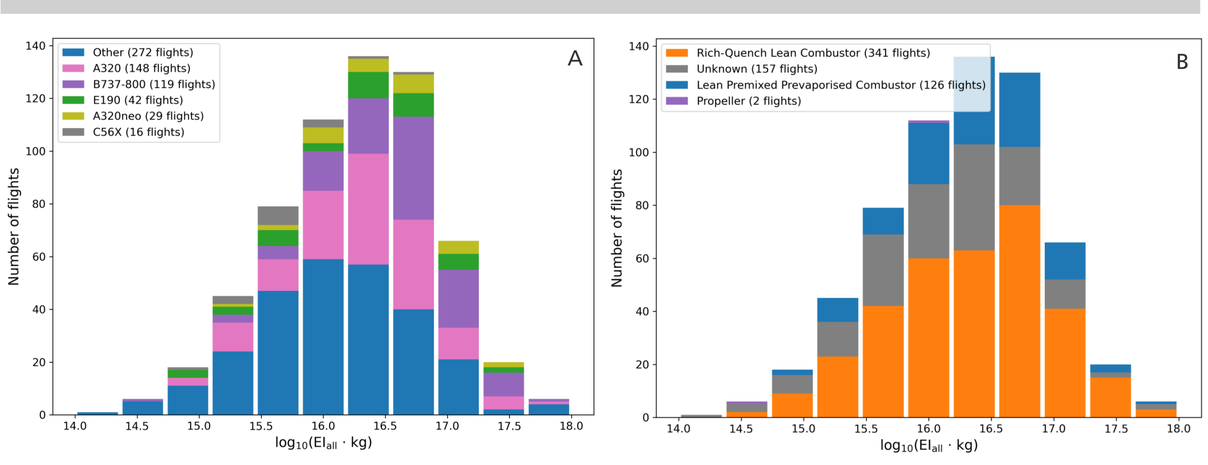


Figure 5: Estimated emission index EI_{all} for 626 arriving aircraft. **A)** coloured by aircraft type **B)** coloured by engine type

UFP exposure of landing aircraft driven by wake vortices

Overview of measurements over a weekend in February 2026.

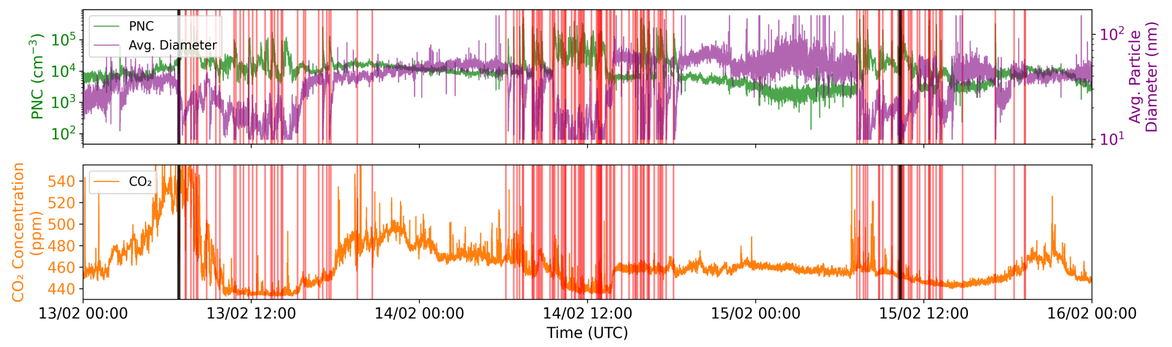


Figure 3: Red vertical lines indicate arriving airplanes. PNC (green), Average Particle Diameter (purple) and CO_2 concentration (orange) are shown. The two **black lines** indicate the windows shown in Fig. 4 and 5.

Particle Event in the early morning

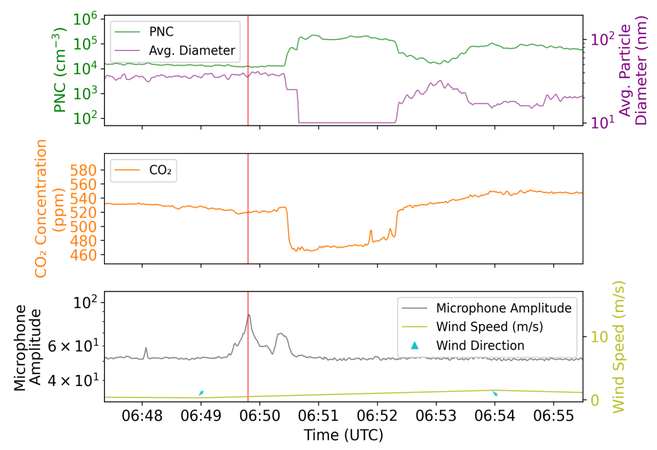


Figure 3A: Arriving flight from Hamburg (Airbus A320) on the 13th of February (red line).

- Nocturnal boundary layer with elevated CO_2 concentration
- Trajectory of approaching aircraft lies above the inversion layer
- Efficient downmixing of aircraft exhaust through wake vortices
- Exhaust plume reaches measurement station 40 s after aircraft passage

Particle Event later in the morning

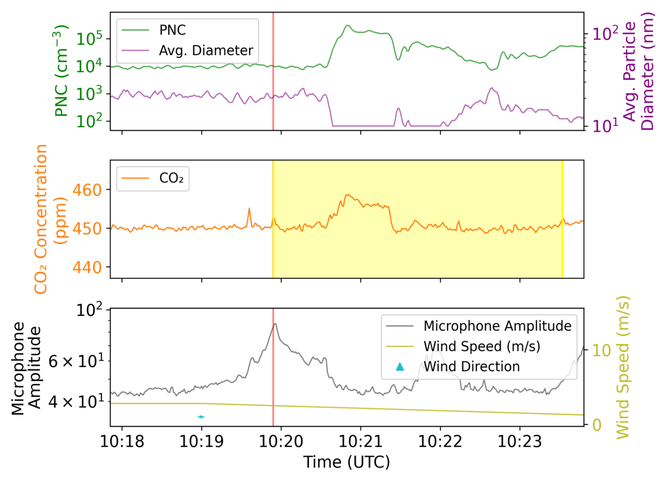
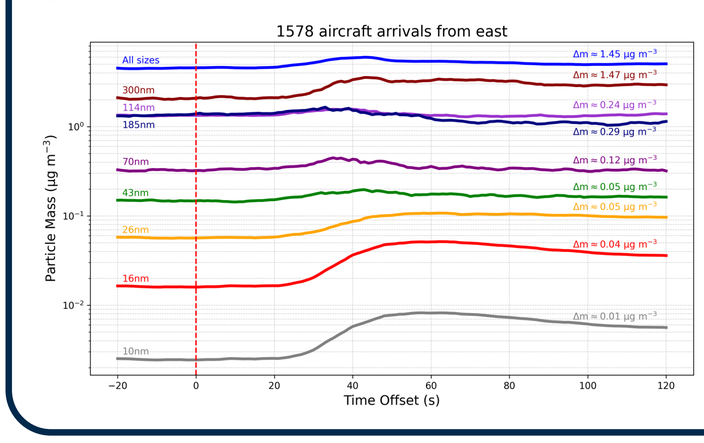


Figure 3B: Arriving flight from Schiphol (B737-800) on the 15th of February (red line). The yellow area is used for correlation analysis (see Fig. 4).

- A mixed layer develops during the sunny morning, removing the vertical CO_2 gradient between the measurement station and the approaching aircraft trajectory
- Exhaust plume reaches measurement station 35 s after aircraft passage
- Positive correlation between CO_2 and PNC

UFP Mass Emission from Airplanes



The size resolved UFP measurements allow to assign the individual contributions to the total UFP mass.

Figure 6: Average mass increase for each size bin measured by the Partector2 Pro. Δm describes the mass difference between the maximum and the background average - 20 s before to 20 s after closest approach (red dashed line).

Outlook

Real-time Chemical Analysis
While high PNC are a first indication of UFP exposure, a chemical analysis of individual plumes is needed. Due to the low mass load of UFP and the short plume duration real-time chemical characterization is challenging. High-resolution (Orbitrap) mass spectrometry seems feasible for real-time ambient measurements.

Acknowledgements

This Work was supported by OeAD Sparkling Science (Project Atemluft)

References

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