Export of aircraft exhaust ultrafine particles from Tokyo International (Haneda) Airport

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High concentrations of ultrafine particles (UFPs; diameter < 100 nm) have adverse effects on human health [1]. Jet aircraft emissions are significant sources of UFPs around airports and in the upper troposphere. However, the emissions and dispersion of UFPs originating from jet aircraft under real-world operating conditions are not well understood. The purpose of this study was to estimate the number flux of UFPs exported from Tokyo International (Haneda) Airport (HND) using mobile measurement data.

Mobile measurements were performed in the vicinity of HND on March 7 and 10 of 2022, February 18 and 19 of 2023, October 17 of 2024, and March 4 of 2025. A portable CPC (Model 3007, TSI) was mainly used for the measurements of polydisperse particle number concentrations (>10 nm). The basic performance of the CPC 3007 has been extensively evaluated using field measurement data obtained at Kobe Airport [2, 3]. A portable scanning mobility particle sizer (NanoScan, Model 3910, TSI) and an optical particle counter (HHPC 6+, Beckman Coulter) were temporarily used to estimate the particle number concentrations above the UFP size range. Furthermore, a carbon dioxide (CO_2) sensor (LI-840, Li-Cor) was temporarily used to derive the effective particle number emission indices (EIs). Here, the term “effective” includes the spatially and temporally averaged nonvolatile (combustion-generated) particles and volatile particles formed during plume expansion. The number flux of UFPs exported from HND can be estimated using the effective number EIs of UFPs and an emission inventory for CO_2.

Figure 1 shows an example time series of the number concentrations and size distributions of aerosol particles. The distance from the nearest runway to the observation point along the wind direction was ~1 km. The high particle number concentrations measured by the CPC were associated with the enhanced fraction of the smallest three size bins of the NanoScan (< 20 nm), indicating the significance of sub-20 nm particles in aircraft exhaust plumes exported from airports. The variability in the particle number concentrations and estimates of the number flux of UFPs are discussed in detail in the presentation.

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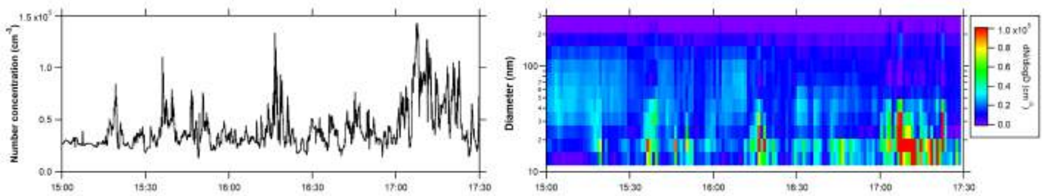

Fig. 1. Example time series of the number concentrations and size distributions of aerosol particles obtained in the vicinity of Haneda Airport on March 10, 2022.

[1] WHO global air quality guidelines, https://iris.who.int/handle/10665/345329; [2] N. Takegawa, *Aerosol Sci. Technol.*, **2023**, 57, 1087–1097; [3] N. Takegawa, Y. Murashima, and H. Sakurai, *Aerosol Air Qual. Res.*, **2025**, 25, 43.

Session 1: Aircraft emissions (Part 1), Talk

Dispersion of ultrafine particles originated from a medium-large international airport

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Ultrafine particles (UFPs), i.e. aerosol particles with a diameter smaller than 100 nm, are harmful to human health. As the emission and air quality regulations have mainly based on particle mass (e.g., $PM_{2.5}$), exposure to UFPs can still be high especially in urban areas. UFPs are suggested to be the most important contributor on premature deaths from air pollution in Europe in 2030 [1], highlighting the need to understand the sources and concentrations of UFPs in urban areas. Airports have been noted as important sources of UFPs (e.g. [2]). Long-term air quality impacts of airports as well as the characteristics and dispersion of the airport-originated UFPs are, however, not well understood: For example, the contribution of airports on 1–10 nm particles. Here [3], we measured airport-originated particles with the Aerosol and Trace-gas Mobile Laboratory (ATMo-Lab) near an international airport in Helsinki, Finland, February 2025. The ATMo-Lab was equipped with four condensation particle counters (CPC) with cut-off sizes of 2.5 nm, 4 nm, 10 nm and 23 nm, an electrical low pressure impactor (ELPI+), an AE33 Aethalometer, a Partector 2.1 Pro and CO_2 measurement. Driving measurement routes perpendicular to the airport (approx. 1–10 km) were driven so that the wind was blowing from the airport to the direction of the measurement routes. In addition, data from stationary air quality measurement sites 1-15 km away from the airport were utilised. At a site 1 km away, the particle size distribution was measured down to the size of 1.2 nm.

In the driving measurements [3], the downwind particle number concentration (PNC) exponentially increased when the distance to the airport decreased, and elevated PNC was still clearly observable 10 km away from the airport (Figure). The downwind PNC (> 2.5 nm) exceeded the WHO's definition for high short-term concentration (20 000 1/cm^3) 7–8 km away from the airport. Roughly 30 % of the airport-originated particles were smaller than 10 nm, and 70 % smaller than 23 nm. The effect of airport on black carbon or $PM_{2.5}$ was minimal. The airport was estimated to contribute to 500–5 000 1/cm^3 yearly increases of PNC (> 10 nm) 2–5 km away from the airport, showing the importance of UFPs near airports.

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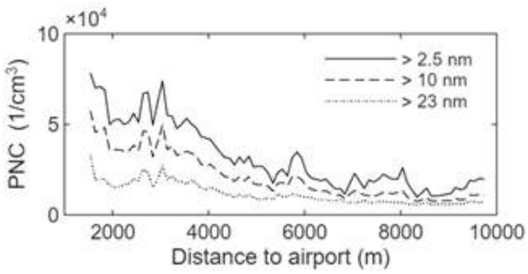

[1] Hänninen, et al. (2025), Environment International. DOI: 10.1016/j.envint.2025.109657
[2] Keuken, et al. (2015): Atmospheric Environment, 104. DOI: 10.1016/j.atmosenv.2015.01.015
[3] Lepistö et al., in review (Environmental International).

Ultrafine particle exposure from individual aircrafts approaching Innsbruck airport

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Aircraft engines produce emissions similar to those from other fossil fuel combustion sources, contributing to air pollution. In addition, they emit large numbers of ultrafine particles (UFPs) across a wide range of operating conditions. 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 (1). While there is no guideline level for UFP by WHO, an hourly Particle Number Concentration (PNC) above 20 000 particles/ccm is considered “high” (2). In this work we deployed a weather station, a microphone, two mobile UFP sensors and recently a fast CO2 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 to the East). The portable UFP sensors (Partector2 an Partector2 Pro from Naneos Particle Solutions GmbH, Switzerland) allows characterizing particle concentration and size virtually in real time. We carried out long term measurements over more than a year to capture the diurnal and seasonal impact of real-world aircraft specific UFP emissions. We observe UFP plumes with PNC of several hundred thousand particles/ccm of individual aircrafts approaching the airport prevailingly from the East as shown in Figure 1. As an example, in February 2024 PNC concentrations during the day exceeded the WHO “high” classification limit almost every day when wind speeds are less than 10 m/s. A comprehensive real-world dataset on aircraft-specific emissions will be presented, providing critical insights into plume dispersion during landing and take-off. This work was supported by OeAD Sparkling Science (Project Atemluft).

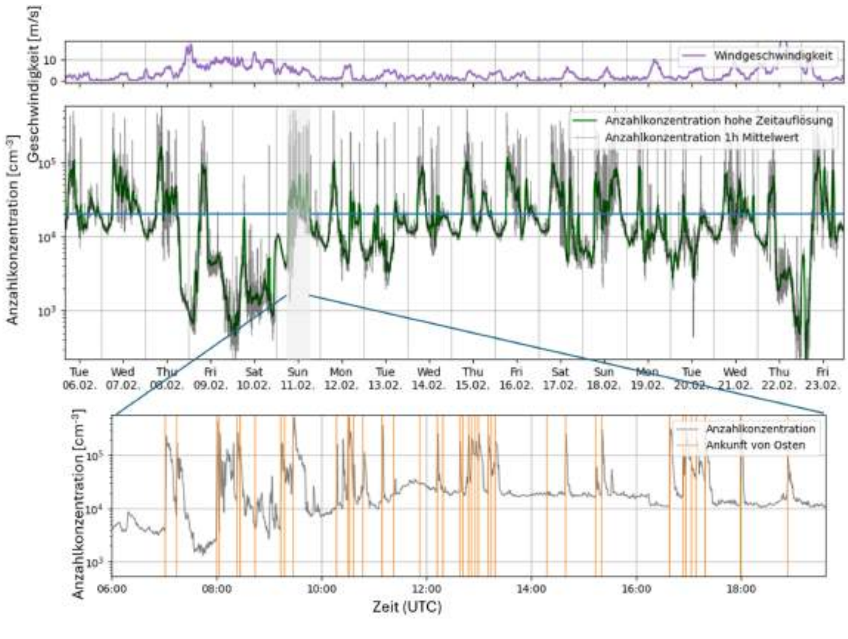

Figure 1: In-situ observations of PNC. Inset shows individual plumes associated with aircraft landing operations (1) European Aviation Environmental Report 2025, Doi: 10.2822/1537033 and references therein. (2) WMO (2021) WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.