PSI Center for Energy and Environmental Sciences

Characterizing Aviation Contributions to Particulate Matter near Zürich Airport using Chemical Composition and Source Apportionment

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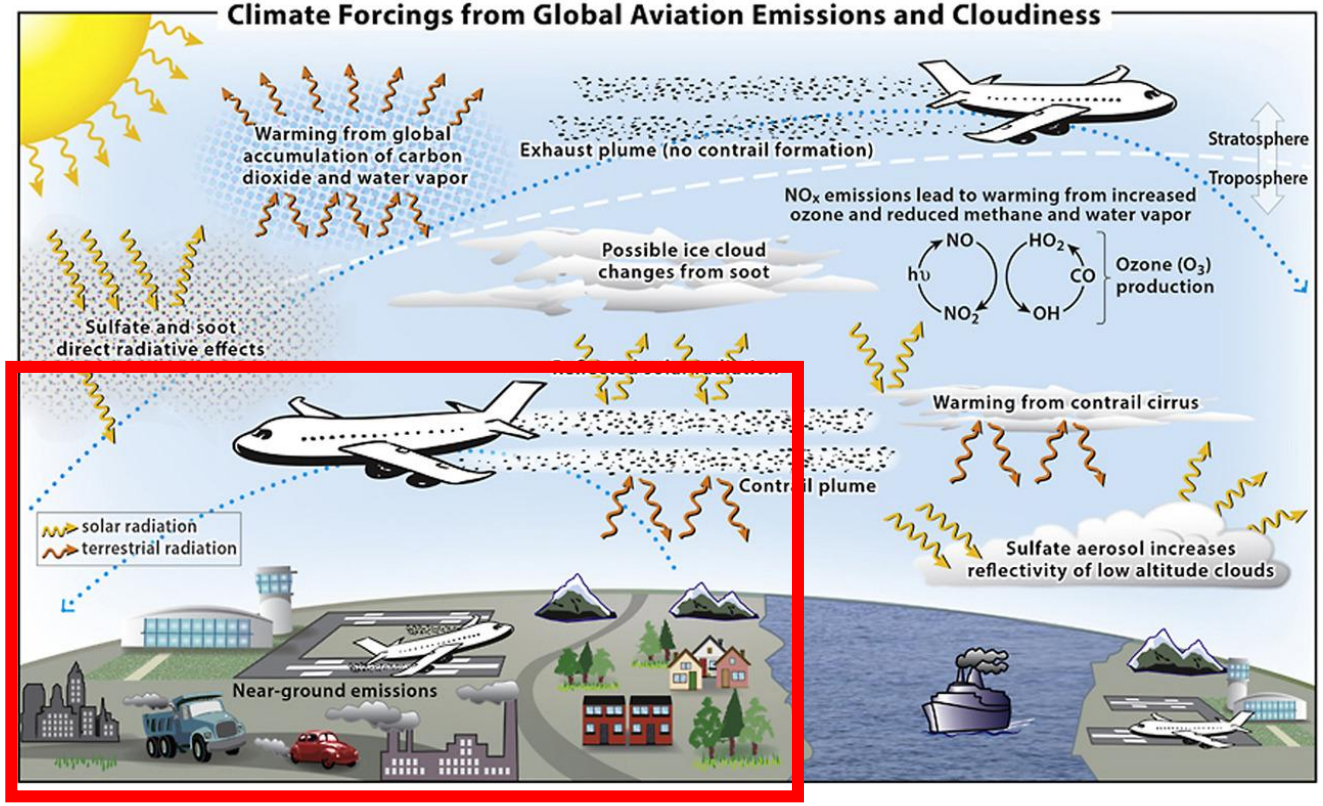
NPC 2026

Zürich, *Switzerland - 01 June 2026*

Introduction

Airports are major hotspots of degraded air quality and health risks 😩

- Aircraft emit large amounts of PM and UFP, degrading air quality near airports.
- Aircraft activity elevates PM and UFP, peaking at take-off/landing, spreading kilometers downwind, producing secondary aerosols (Chung et al., 2023; Ridolfo et al., 2024).
- Aircraft emissions release ultrafine particles and lubrication oil compounds that are prevalent near airports and can induce oxidative stress in bronchial cells (Jonsdottir et al., 2019, Tinorua et al.,2026)

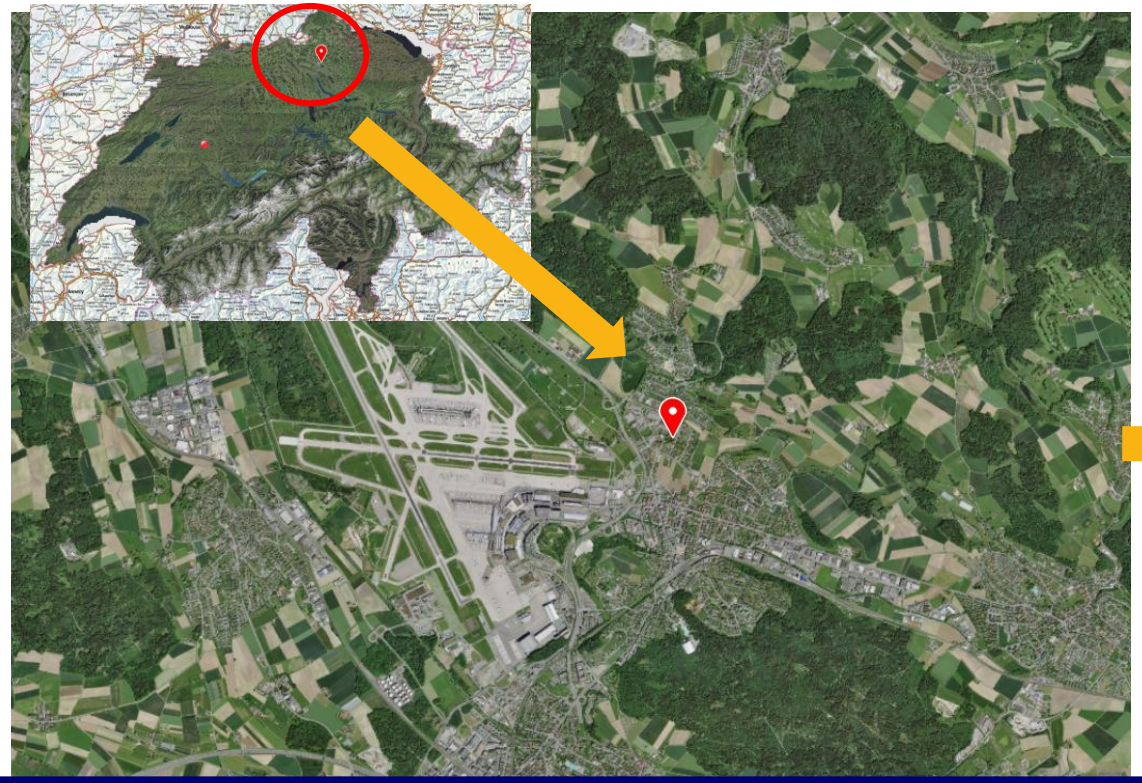


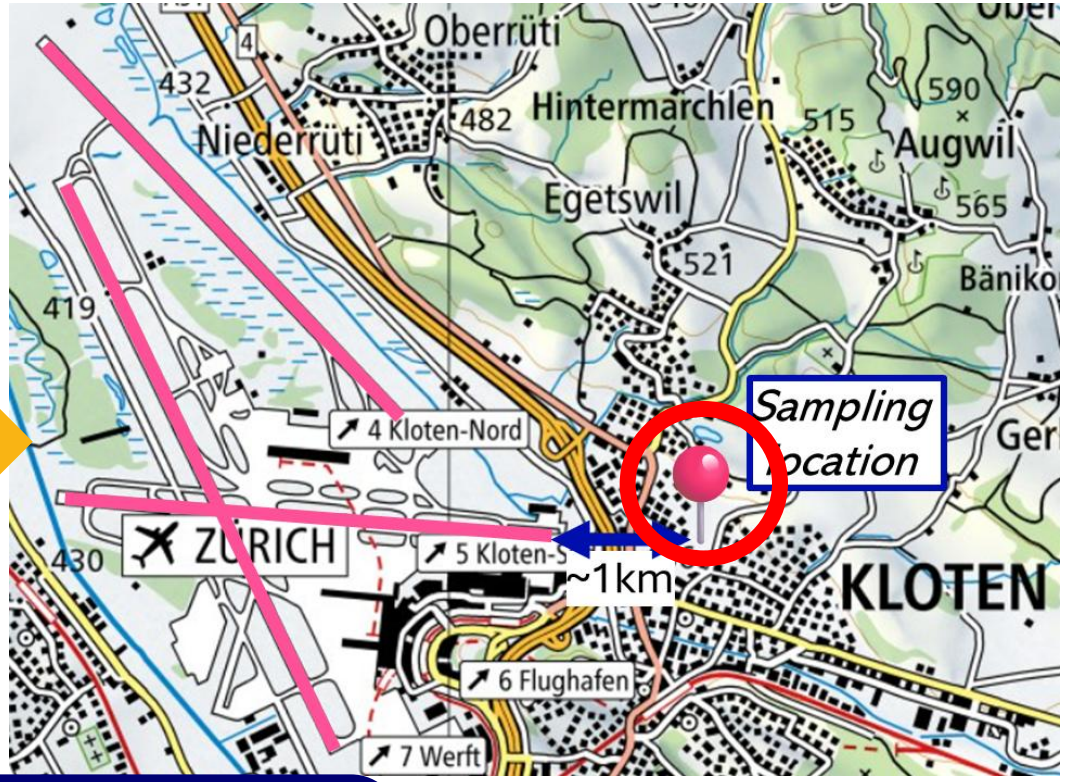
Source : Lee et al., 2021

Research gap

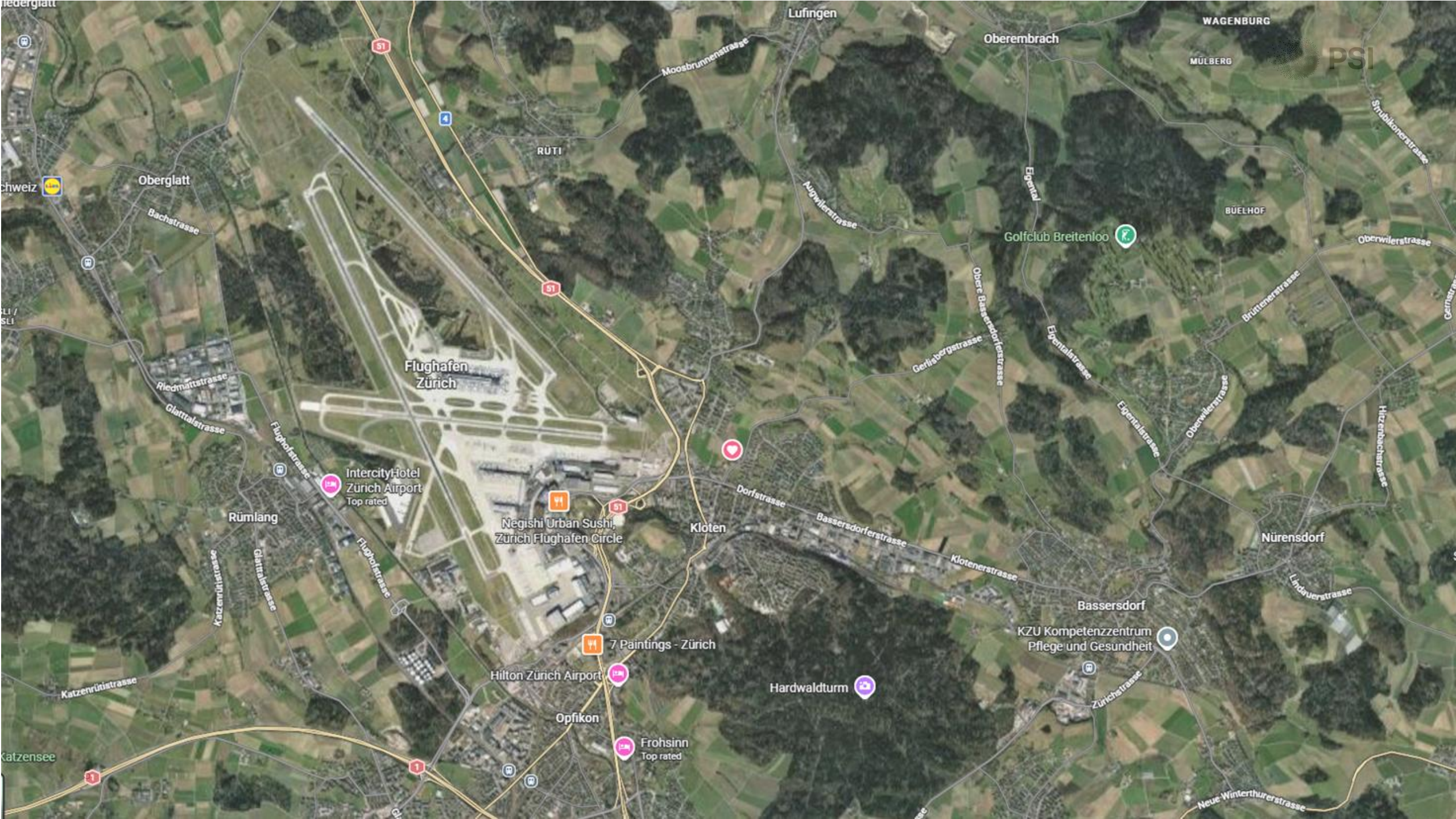
- The contribution of gases, VOCs, and UFPs are well-studied but the contribution to particulate mass remains poorly understood.
- Can we identify and quantify the fraction of Non refractory PM_1 originating from airport emissions at the nearby downwind site?
- Do we find any evidence of near-field secondary organic aerosol formation from airport related precursor gases?

Study location



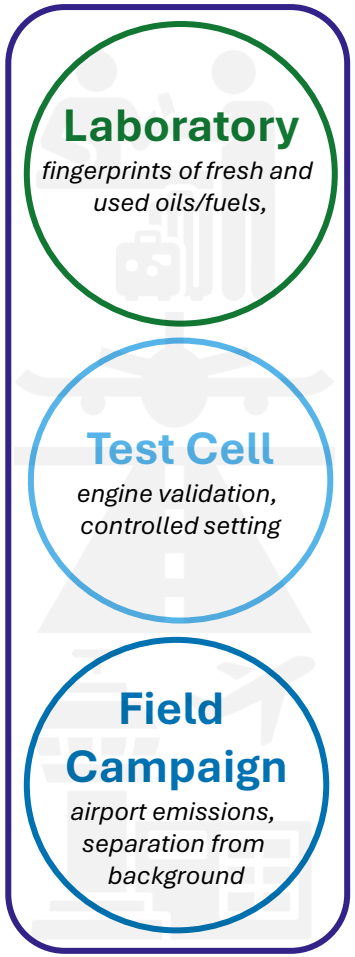


- Kloten is located about 10 km northeast of the centre of the city of Zurich (2.1 million people) in the plain of the Glatt valley
- The sampling site is ~1 km downwind from Runway 28.
- Residential and school buildings, main roads and restaurants nearby.


Lufingen
Oberembrach
WAGENBURG
MÜLBERG
PSI
Moosbrunnenstrasse
RÜTI
Oberglatt
Bachstrasse
Aufwilerstrasse
Eigental
BÜELHOF
Golfclub Breitenloo
Oberwilerstrasse
Strubikonerstrasse
Obere Bassersdorferstrasse
Gerlisbergstrasse
Eigentalstrasse
Brüttenerstrasse
Flughafen Zürich
Riedmattstrasse
Glattalstrasse
Flughofstrasse
IntercityHotel Zürich Airport
Top rated
Negishi Urban Sushi, Zürich Flughafen Circle
Dorfstrasse
Bassersdorferstrasse
Klotenerstrasse
Kloten
Nürensdorf
Hitzenbachstrasse
Rümlang
Katzenrütistrasse
Glattalstrasse
Flughofstrasse
Bassersdorf
Lindauerstrasse
KZU Kompetenzzentrum Pflege und Gesundheit
7 Paintings - Zürich
Hilton Zürich Airport
Hardwaldturm
Zürichstrasse
Katzenrütistrasse
Opfikon
Frohsinn
Top rated
Katzensee
Neue Winterthurerstrasse

Project & Methods

APPROPRIATE



Project & Methods

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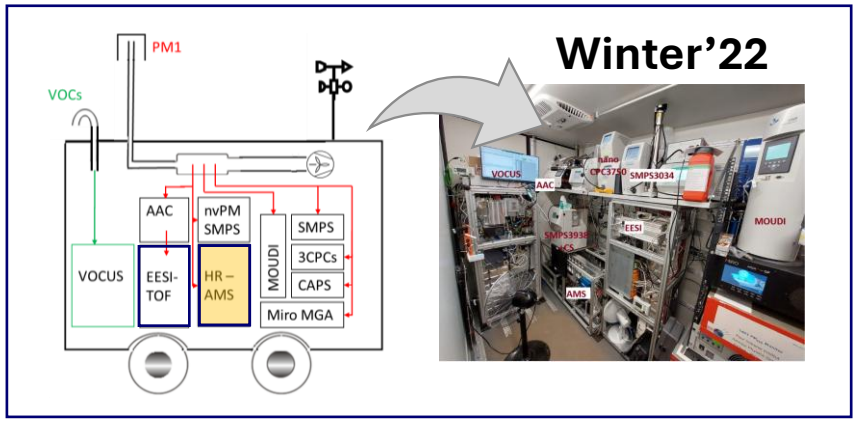
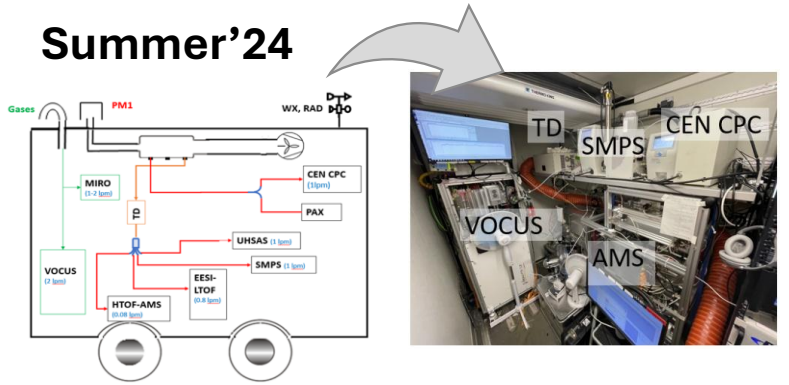
APPROPRIATE

Laboratory
fingerprints of oils/fuels, chemistry

Test Cell
engine validation, controlled setting

Field Campaign
airport emissions, separation from background





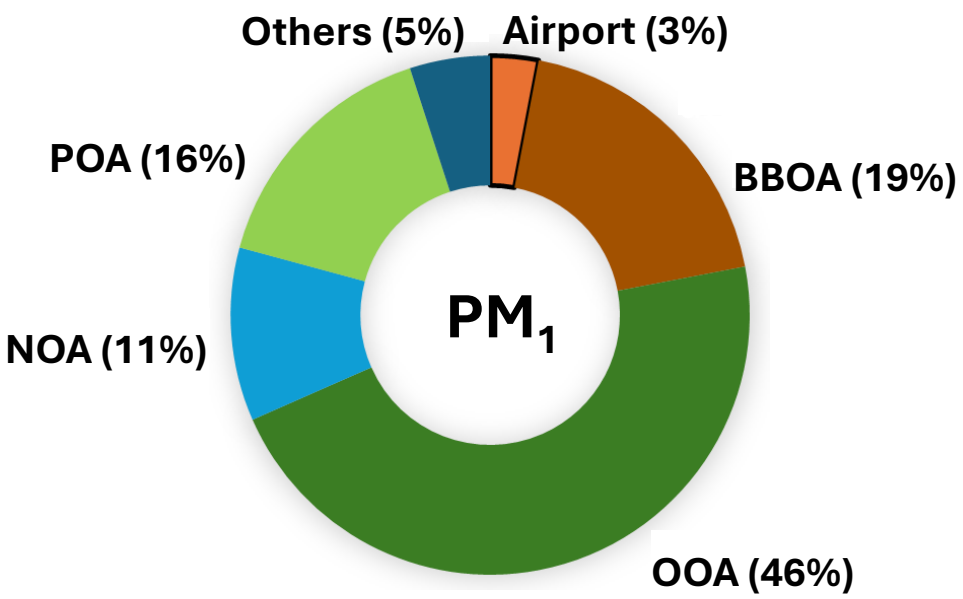
PM→sources: Positive Matrix Factorization (PMF)

$$x_{i,j} = \sum_{k=1}^{p} (g_{i,k} \cdot f_{k,j}) + e_{i,j}$$

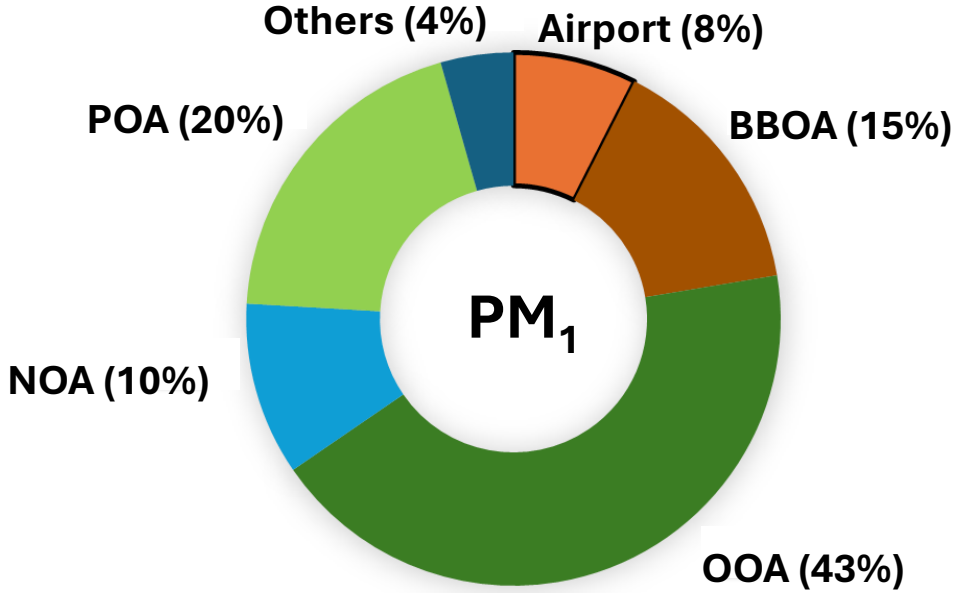
- p: Number of sources
- $x_{i,j}$: Input matrix
- $g_{i,k}$: Factor timeseries
- $f_{k,j}$: Factor profiles
- $e_{i,j}$: Residual matrix

Contribution of PM from the airport

Factors contributing to PM



Average contribution from 5th Nov-2nd Dec 2022 overall



Average contribution from 5th Nov-2nd Dec 2022 during airport operation

Biomass Burning organic aerosols (BBOA)

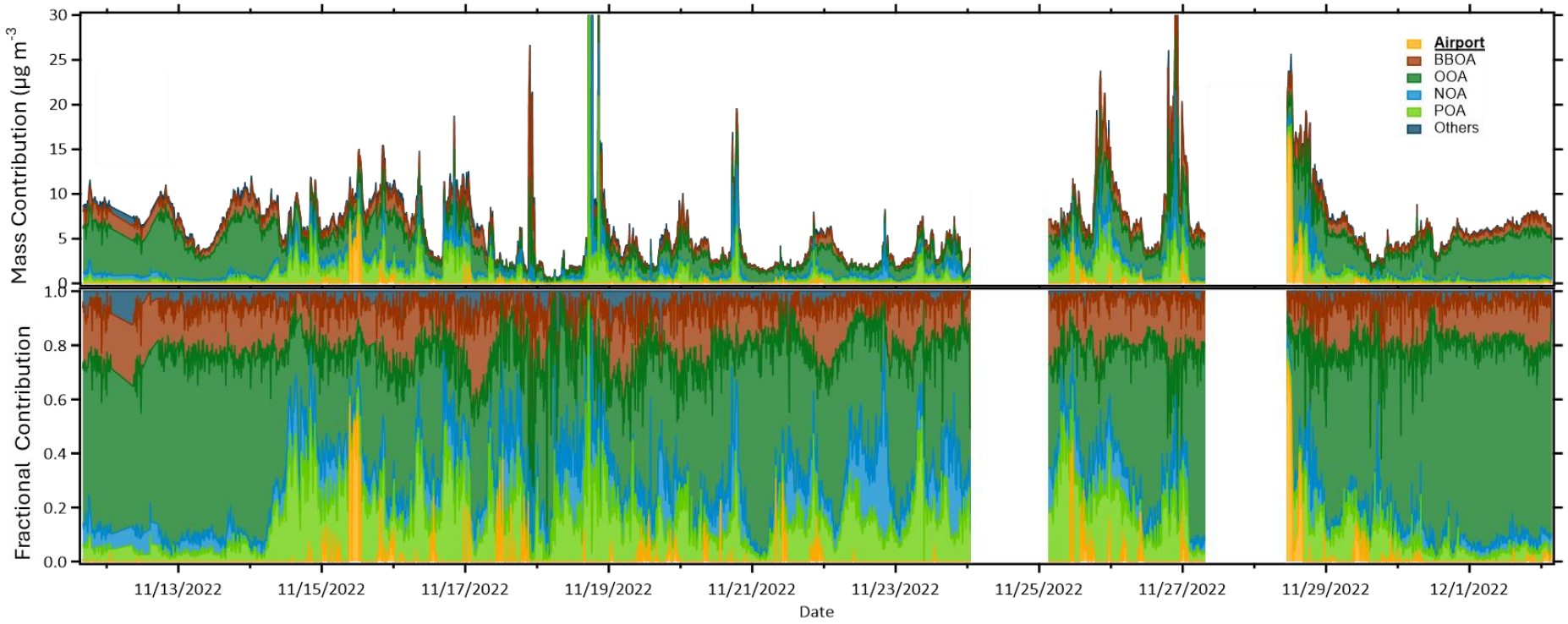
Primary hydrocarbons (POA)

Oxygenated organic aerosols (OOA)

Nitrogen-containing organic aerosol (NOA)

Airport factor

Factors contributing to PM

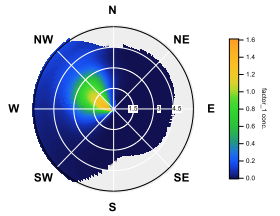


Time series and fractional contribution of the organic factors showing the changes in the airport influence episodically.

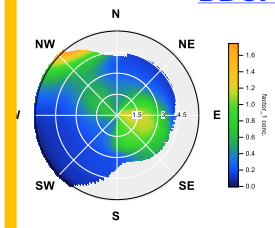
Effect of airport operations

During airport operation (6:00 am- 11:00 pm)

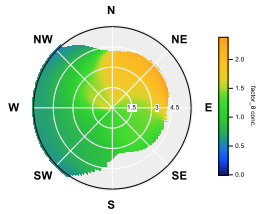
Airport



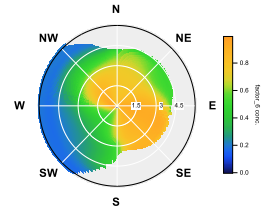
BBOA



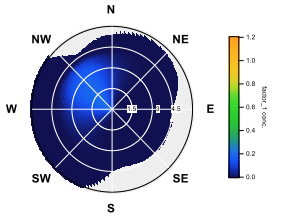
OOA

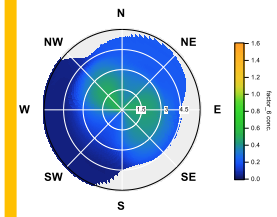


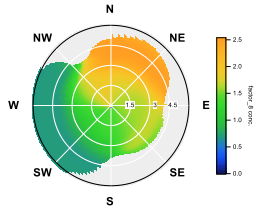
POA

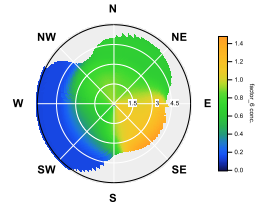


No airport operation (00:00 am- 06:00 am)





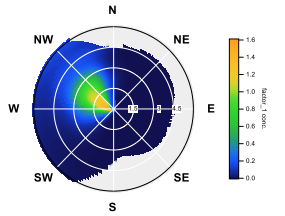




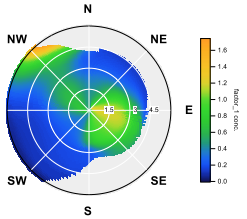
Effect of airport operations 6 am- 5 pm

During airport operation (6:00 am- 11:00 pm)

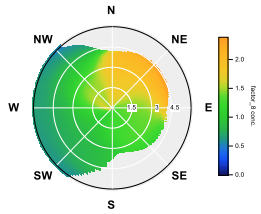
Airport



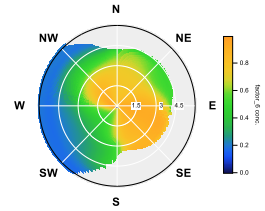
BBOA



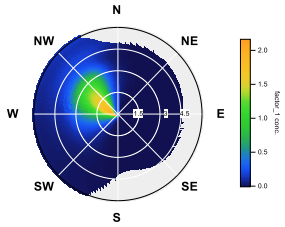
OOA

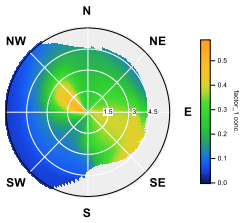


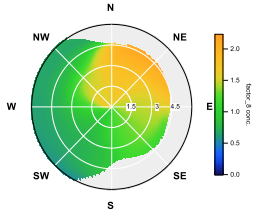
POA

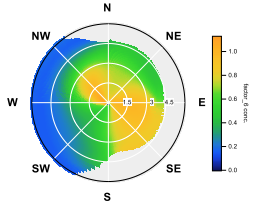


Excluding landings over the site: airport operation (06:00 am- 05:00 pm)









This factor intensifies during 6-5 window

Airport factor correlation

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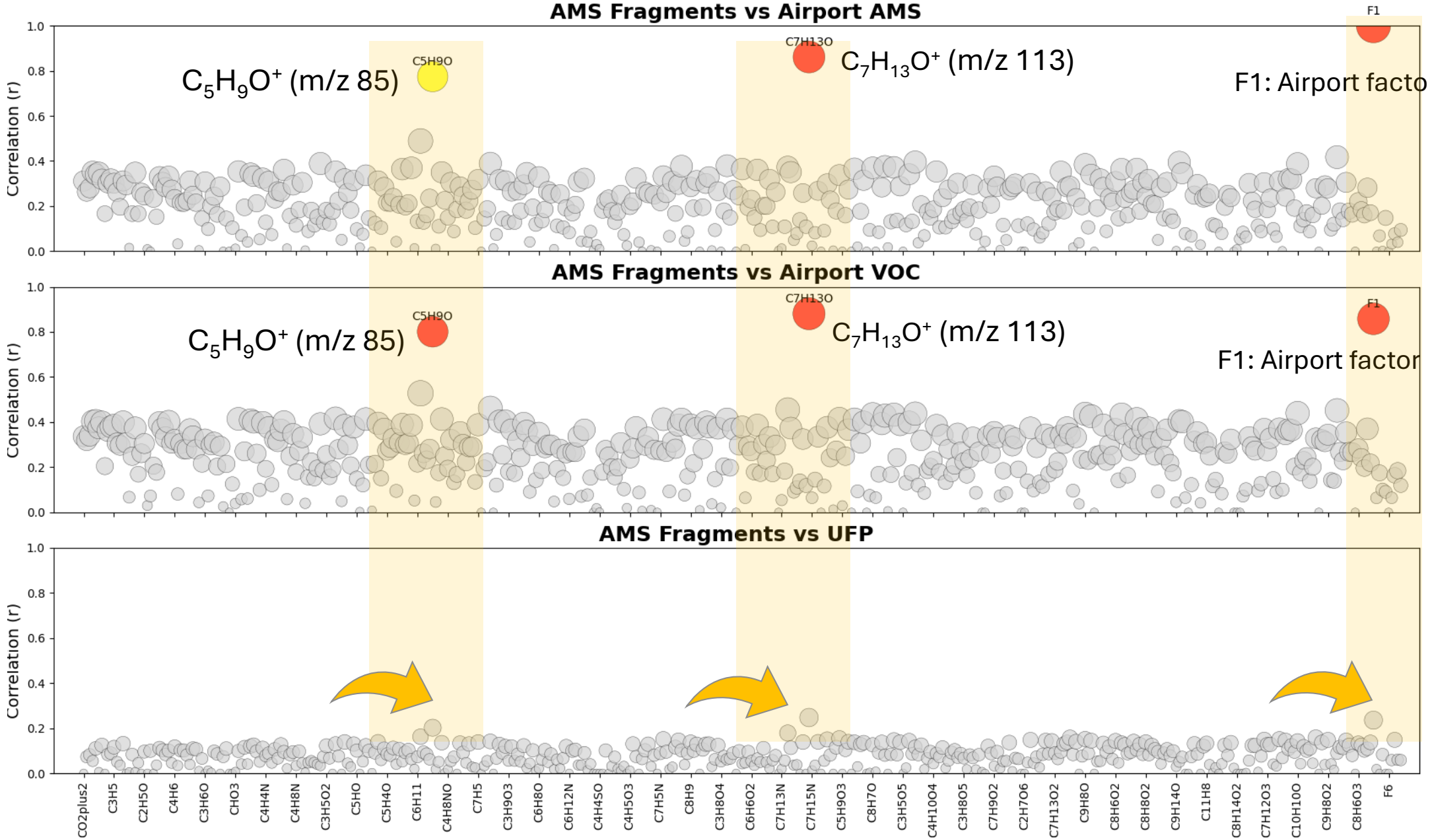

Take home messages

Winter-time PMF resolved airport factor around Zürich Airport

Oil-related emissions detected, while several factors influenced by airport activity

Together, contribution from airport-related sources of particulate mass is >8%

Airport emissions contribute >8% of particulate organic mass, a non-negligible fraction at regional scale, while simultaneously acting as a key source of ultrafine particles, warranting complementary UFP-specific regulatory attention due to their distinct health relevance.

PSI Center for Energy and Environmental Sciences

Labor für Atmosphären-Chemie

Stadt Kloten
WELTOFFEN UND BÜRGERNAH

SR Technics

Kanton Zürich
Baudirektion
Amt für Abfall, Wasser, Energie und Luft

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Funded by:

Swiss Federal Office of Civil Aviation (FOCA) SFLV 2020-080
Aviation Plume PROPeRtIes AT point of Exposure (APPROPRIATE)
and *AGEAIR 2 (SFLV 2018-048*).

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Thank you for your time and attention