

PAUL SCHERRER INSTITUT



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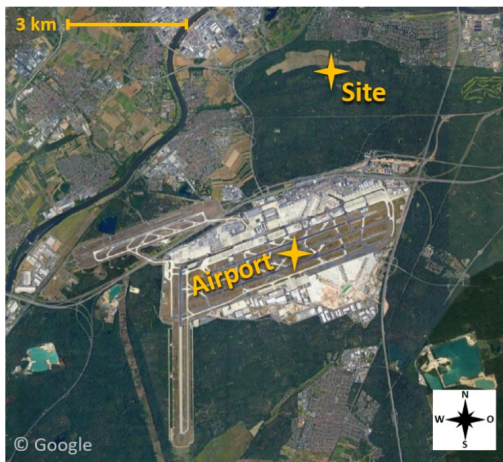
Investigating the chemical composition of oil-containing ultrafine particle emissions from aircraft engines

26th ETH Nanoparticle Conference

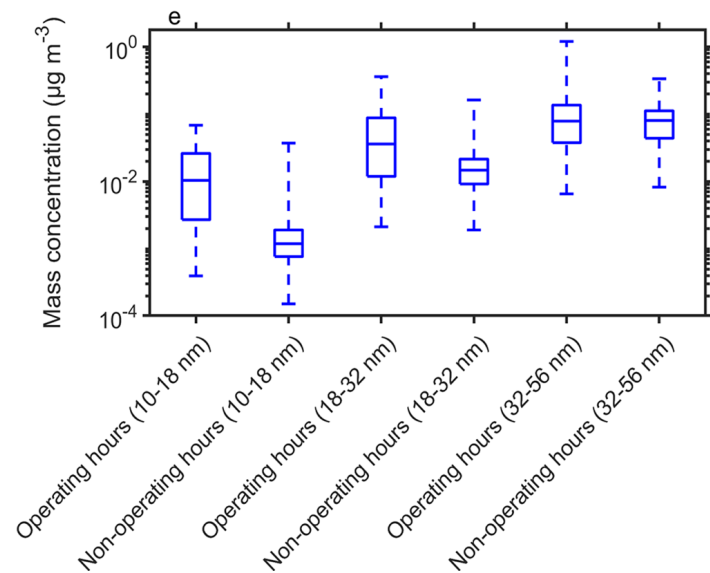
UFPs are observed near airports

1

UFPs are consistently detected near airports



Ungeheuer, et al. (2021) *Atmos. Chem. Phys.*



Ungeheuer, et al. (2022) *Comm. Earth. Env.*

Airport UFPs may originate from oil

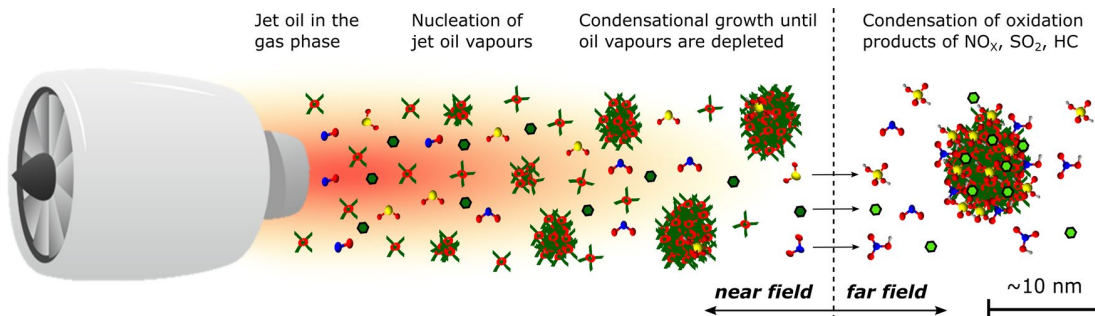
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UFPs are consistently detected near airports

2

UFPs originate from aircraft engines

- UFPs contain aircraft oil components
- One group proposes that UFPs are nucleated by oil esters in the exhaust flow



UFP exposure has serious health effects

1

UFPs are consistently detected near airports

2

UFPs originate from aircraft engines

3

UFPs are transported to residential areas nearby

UFPs effectively permeate the lower-respiratory tract and the blood-brain barrier.¹

Aircraft UFPs are linked to increased risk of brain tumors.^{2,3}

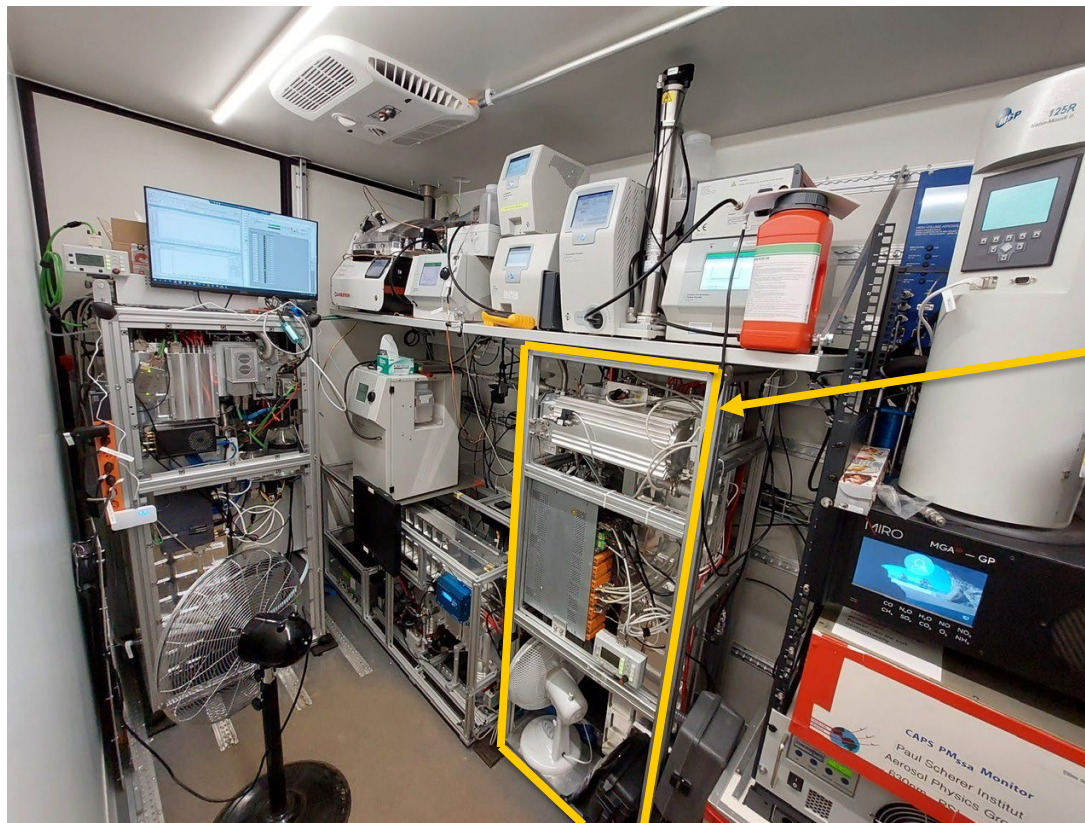
The chemical composition of aircraft UFPs are mostly unknown.

1. Hudda, N., et al. (2020) *Environ. Sci. & Technol.* **54**, 8580 – 8588.
2. Weichenthal, S. et al. (2020) *Epidemiology* **31**, 177 – 183.
3. Wu, A. H. et al. (2021) *Cancer Res.* **81**, 4360 – 4369.

APPROPRIATE investigation: *Aviation Plume PROPeRtIes AT point of Exposure*

One goal I will discuss today is probing the chemical composition of aircraft engine UFPs to better understand their origin

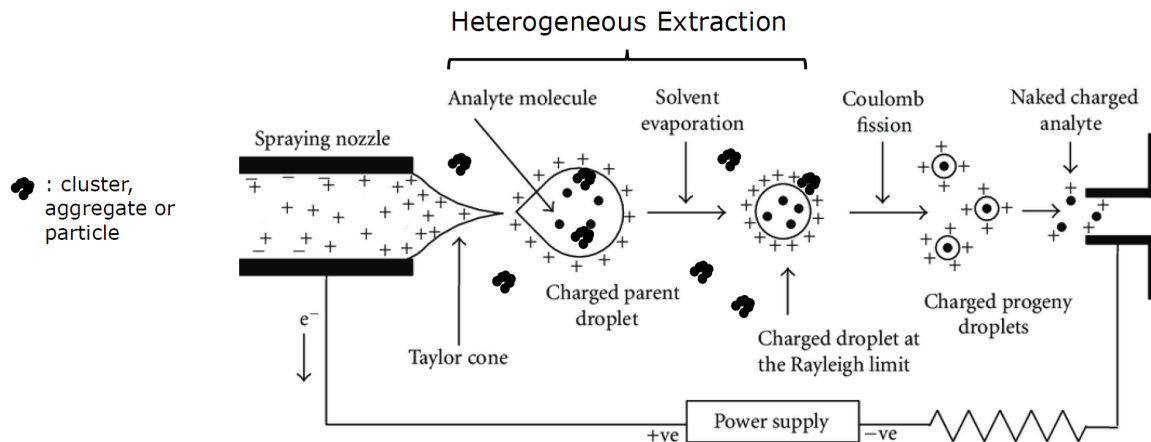
We use the APPROPRIATE instrumentation



EESI

Particle-phase molecular composition by EESI mass spectrometry

- Extractive ElectroSpray Ionization (EESI)
- Measurement of aerosol chemical composition
- Captures whole molecules, in contrast to Aerosol Mass Spectrometry
- High mass resolution ($m/\Delta m > 8000$)
- High time resolution (1 Hz)



Banerjee et al. *I. J. of Anal. Chem.* 2012

APPROPRIATE investigation: *Aviation Plume PROPeRtIes AT point of Exposure*



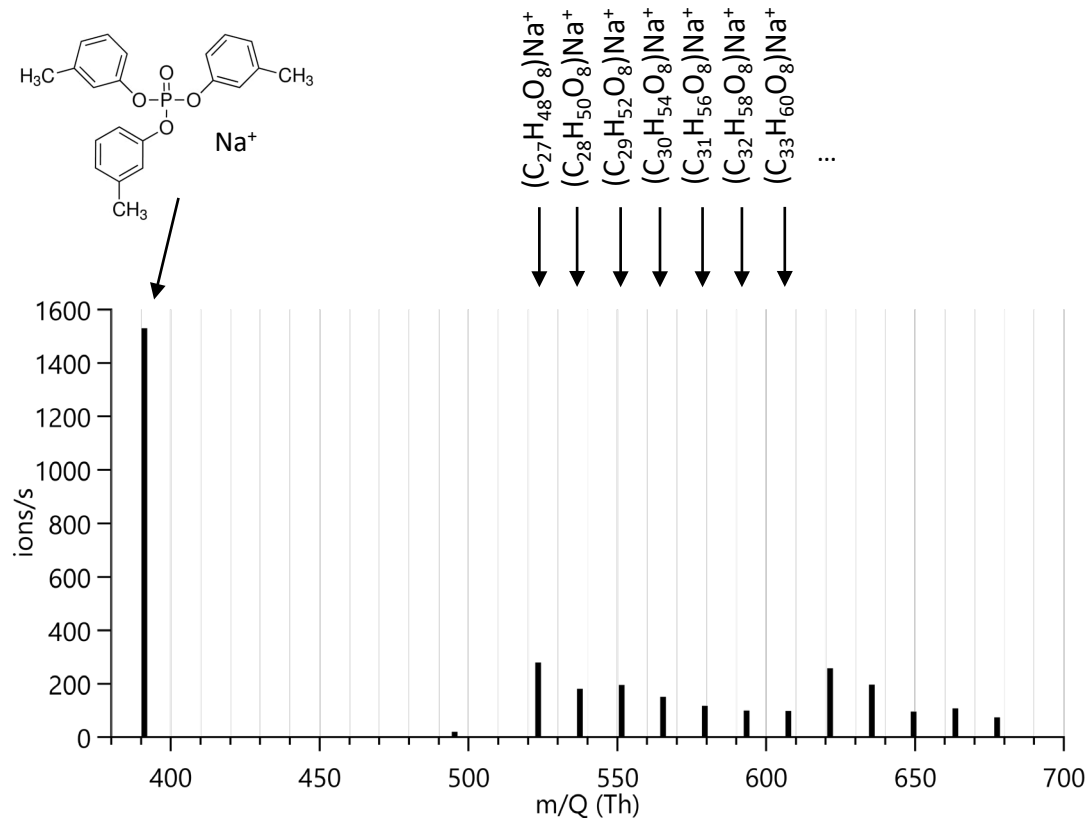
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Sample the aerosolized and gas-phase chemical composition of new and used aircraft oils.



EESI MS detects oil building blocks in aerosolized oil

We detect several esters known to be in aircraft oils



APPROPRIATE investigation: *Aviation Plume PROPeRtIes AT point of Exposure*

2

Measurements of exhaust from recently overhauled engines at an Engine Test Facility (SR Technics Zürich)

PSI Measurement Container at SR Technics



Engine Test Cell at SRT

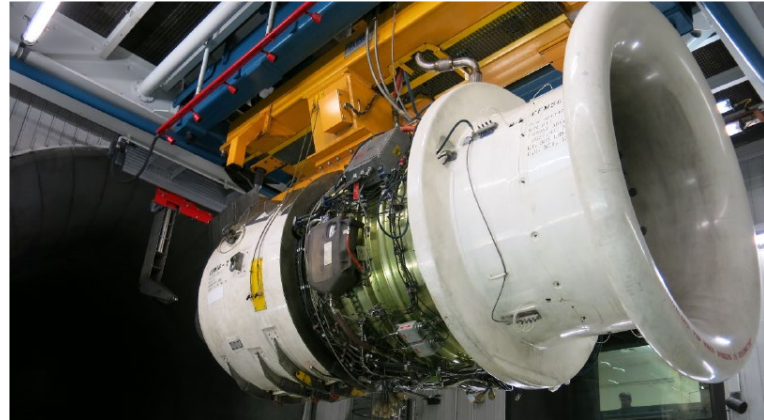
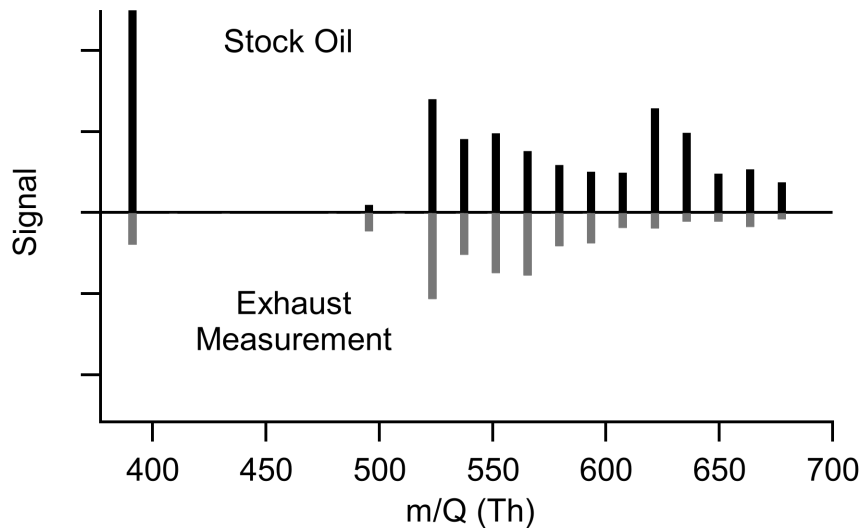
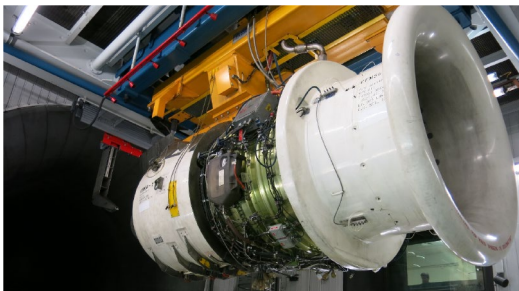


Photo courtesy of SR Technics

Aircraft oil aerosol is present in engine exhaust

Aircraft exhaust clearly emits aircraft oil building blocks – aerythritol esters.

But not the difference in the relative intensity.



Oil emissions are continuous

High mass esters increase,
mostly linearly, with increasing
engine thrust.

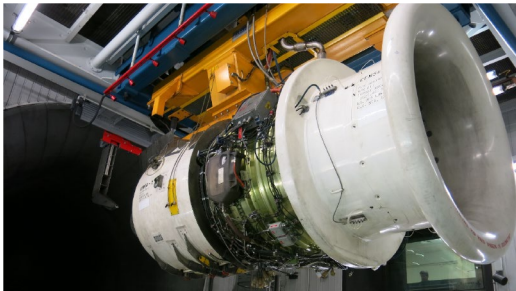
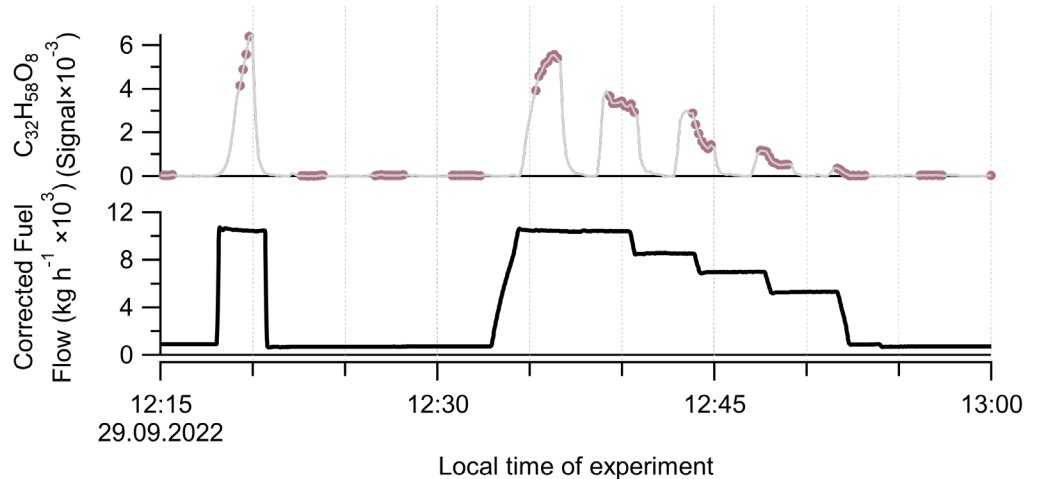


Photo courtesy of SR Technics



Oil emissions are continuous

High mass esters increase, mostly linearly, with increasing engine thrust.

However, low mass ester emissions are non-linear.

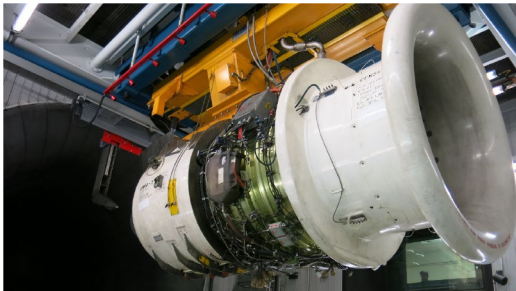
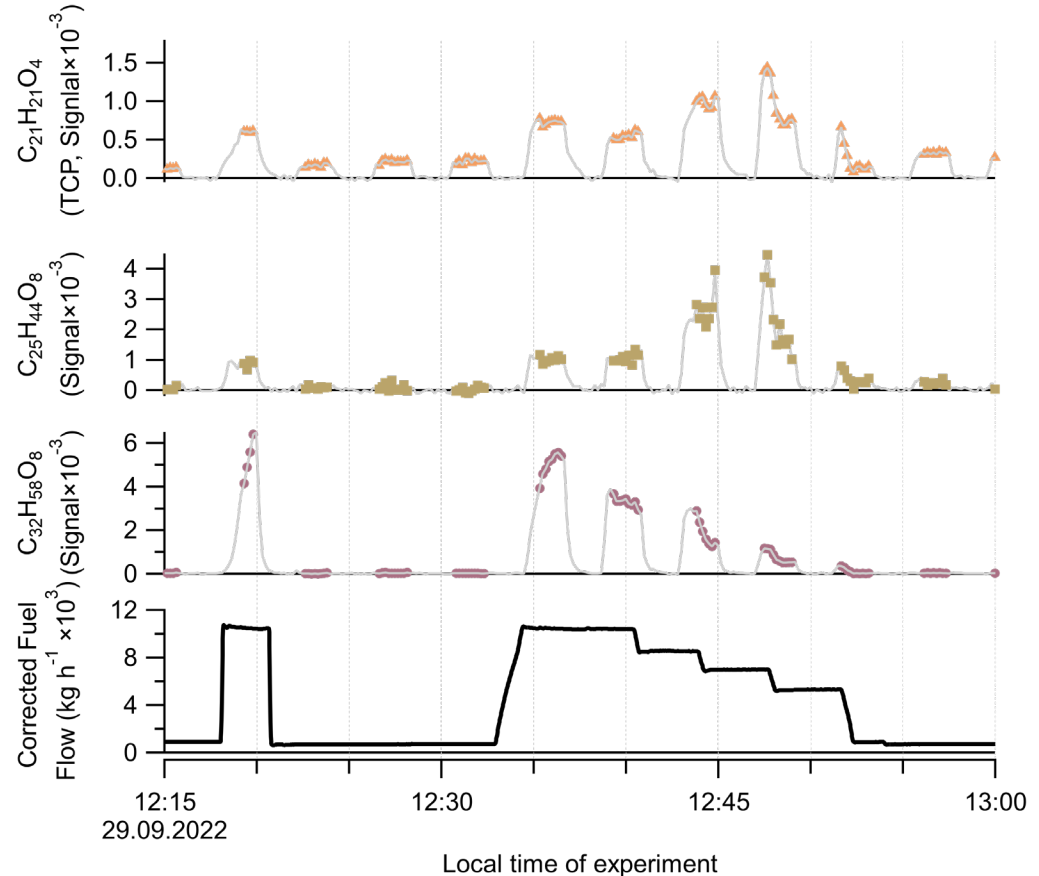


Photo courtesy of SR Technics



APPROPRIATE investigation: *Aviation Plume PROPeRtIes AT point of Exposure*

3

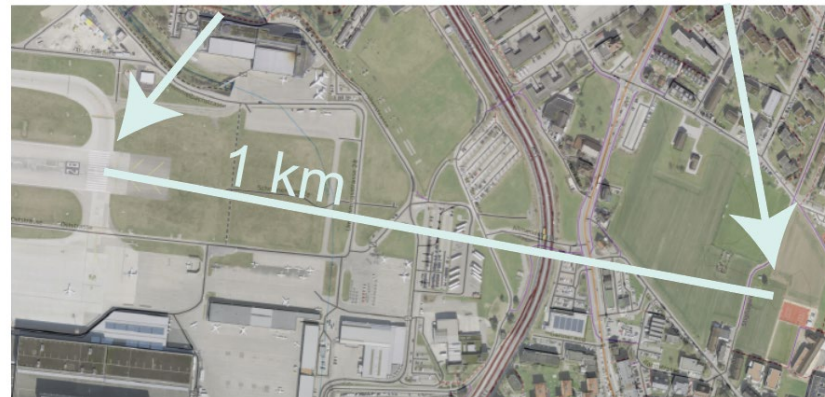
Measurements of ambient aircraft plumes near a major airport - (Six Weeks Oct – Nov 2022)

PSI Measurement Trailer outside the Zürich airport



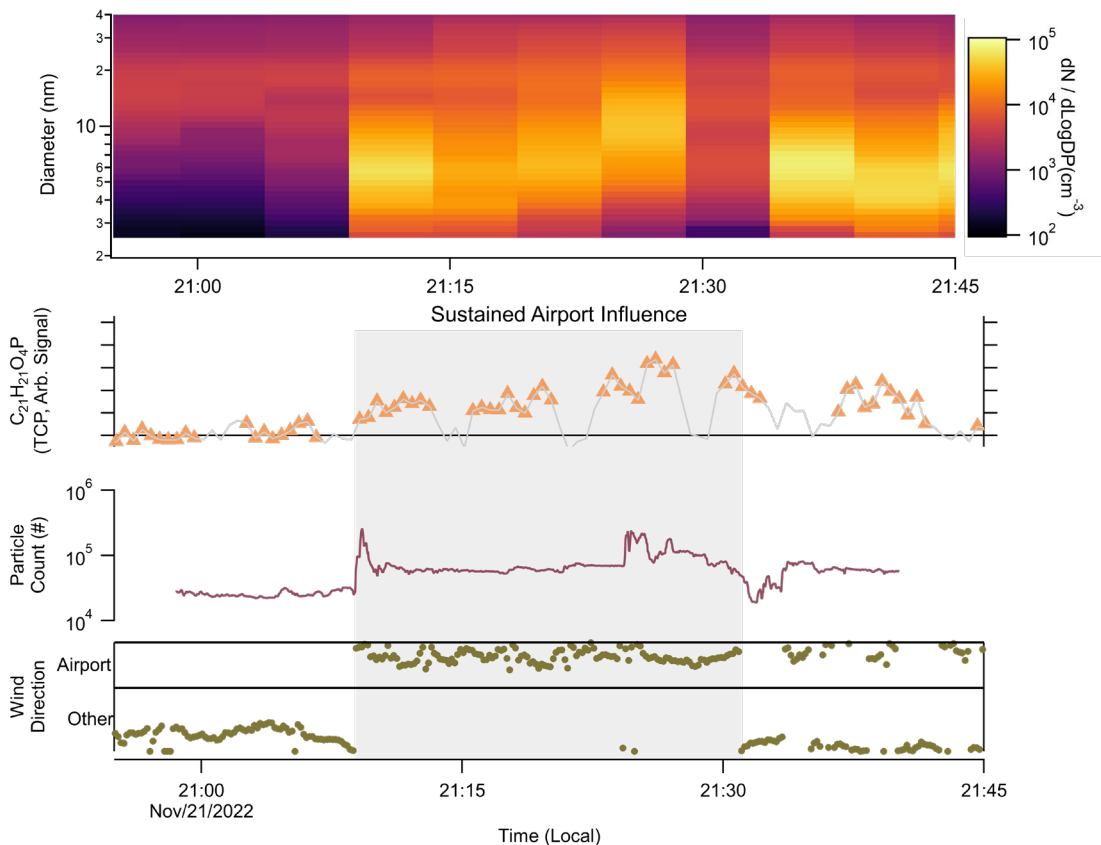
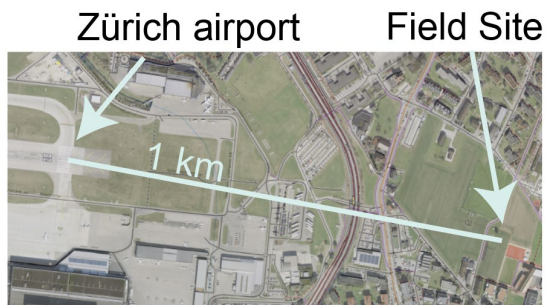
Zürich airport

Field Site



We detect aircraft oil UFPs in ambient air

Clear enhancement of
tricresylphosphate
observed when the Zürich
airport is upwind



- Engine exhaust measurements of Sustainable Aviation Fuels



Thank you to all of our collaborators

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