School of Engineering

Impact of Seasonal Variations on Jet Engine Emissions from a Business Jet Running on Fossil and Sustainable Aviation Fuels

Tobias Schripp[1], Mauro Alig[1], David Bell[2], Jon Bell[1], Jacinta Edebeli[1], Lorenzo Finocchiaro[3], Jacopo Franzetti[3], Simon Hofstetter[4], Yiheng Liang[1], Oliver Lipp[5], Anastasios Melas[3], Samo Smrke[5], Ricardo Suarez-Bertoa[3], Matteo Stähelin[1], Yuantao Wang[2], Tobias Grein[6] and Urs Thomann[4]

[1]Center for Aviation, Zurich University for Applied Sciences (ZHAW)
[2]Laboratory of Atmospheric Chemistry (PSI)
[3]European Commission, Joint Research Centre (JRC)
[4]Pilatus Aircraft Ltd.
[5]Institute of Chemistry and Biotechnology (ZHAW)
[6]German Aerospace Center (DLR)

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Project DVISAR (2023 – 2026)

"Addressing feasibility studies towards cleaner aviation and environmental impacts research with SAF on unregulated engines"

- Emission measurements on unregulated engines (< 26.7 kN) with special emphasis on SAF usage and ambient conditions

- Effect of 35% SAF blend on nvPM emissions
- Effect of winter/summer on the engine emissions

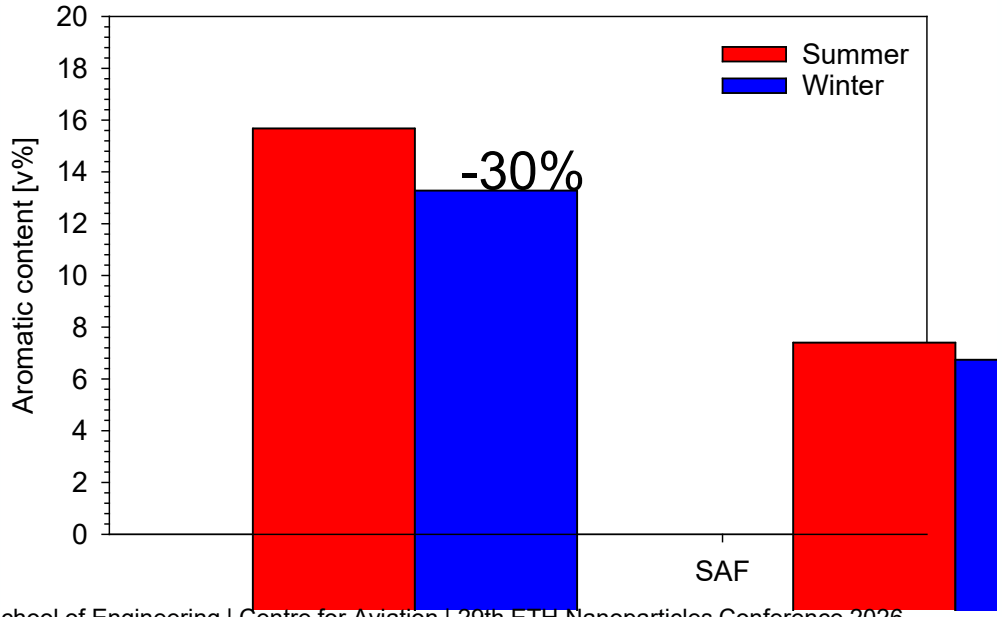
Funded by the Swiss Federal Office of Civil Aviation (FOCA)

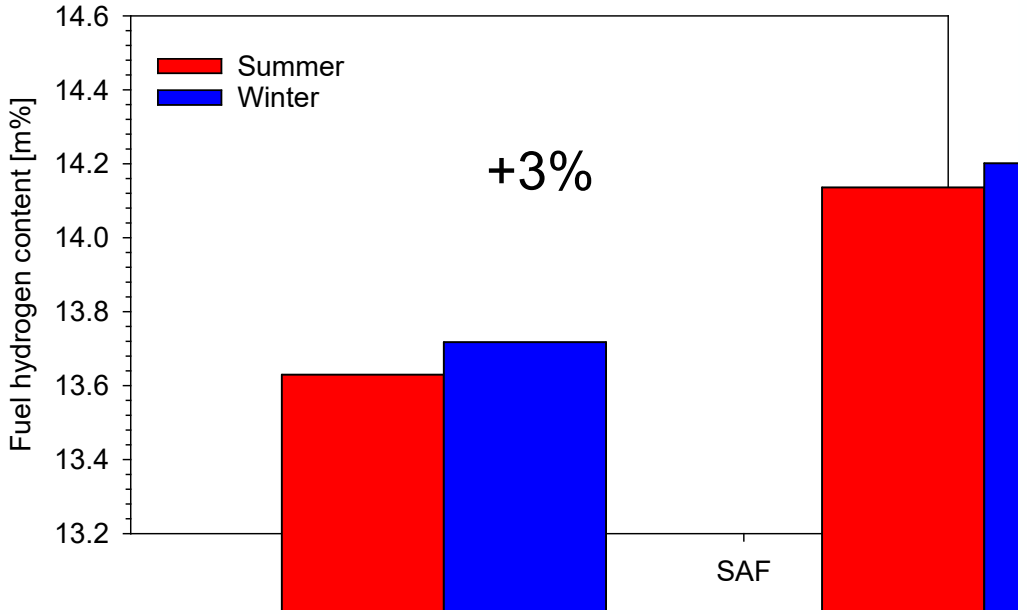
Supported by

Experimental Strategy

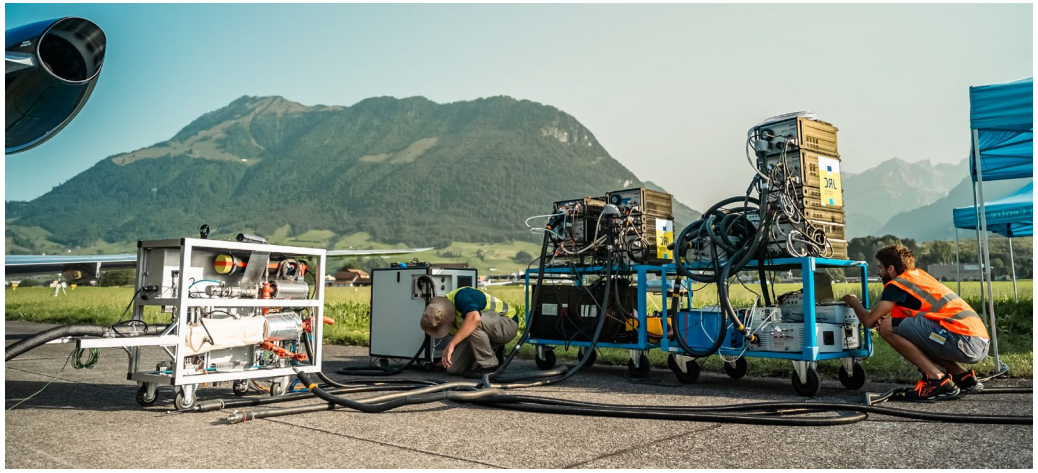
- Similar experimental setup for summer (August) and winter (January/February) campaign
  - Summer: 24.7°C – 31.4°C and 38 % - 61 % RH, low wind, no precipitation
  - Winter: 3.7°C – 7.9°C and 51 % - 74 % RH, low wind, low precipitation

- PC-24 with Williams FJ44-4A turbofan engines (15.3 kN MCT) – not the same aircraft though
- Comparison between a reference Jet A-1 and a blend with 35% HEFA
- Test matrix with 10 test points ranging from ground idle to high thrust, incl. “Quiet-Power-Mode”



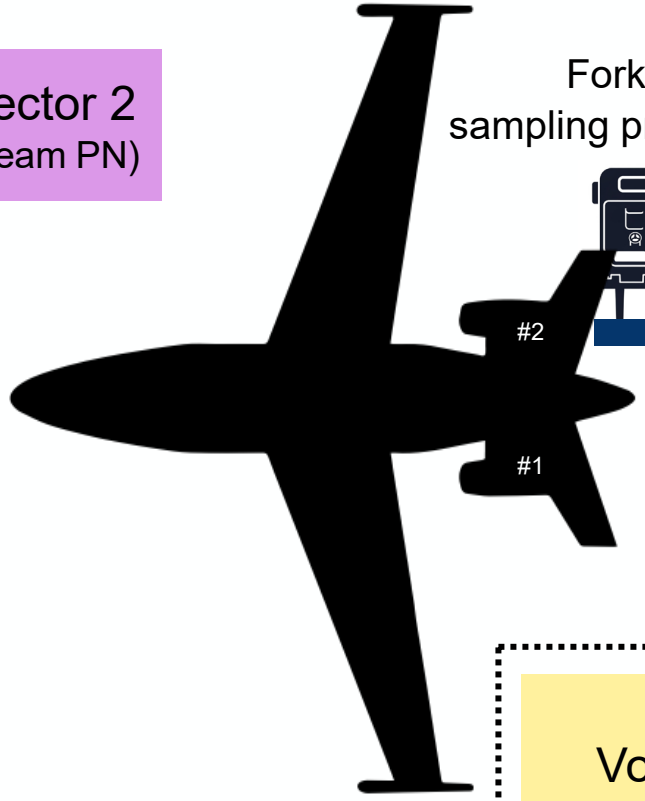


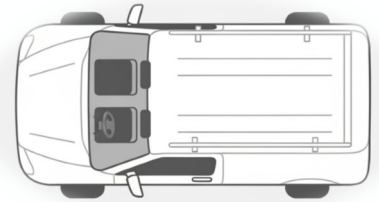
Experimental Setup



Partector 2
(upstream PN)

Forklift &
sampling probe





PSI MOSQUITA

Distribution & dilution

25 m

25 m, raw

Volatile organic compounds
PTR-TOF-MS

PEMS Gases
FT-IR

Soot mass, number and size distribution
CO_2

CO_2
CO
UHC (FID)
SO_2
NO_x
VVOC (DNPH)

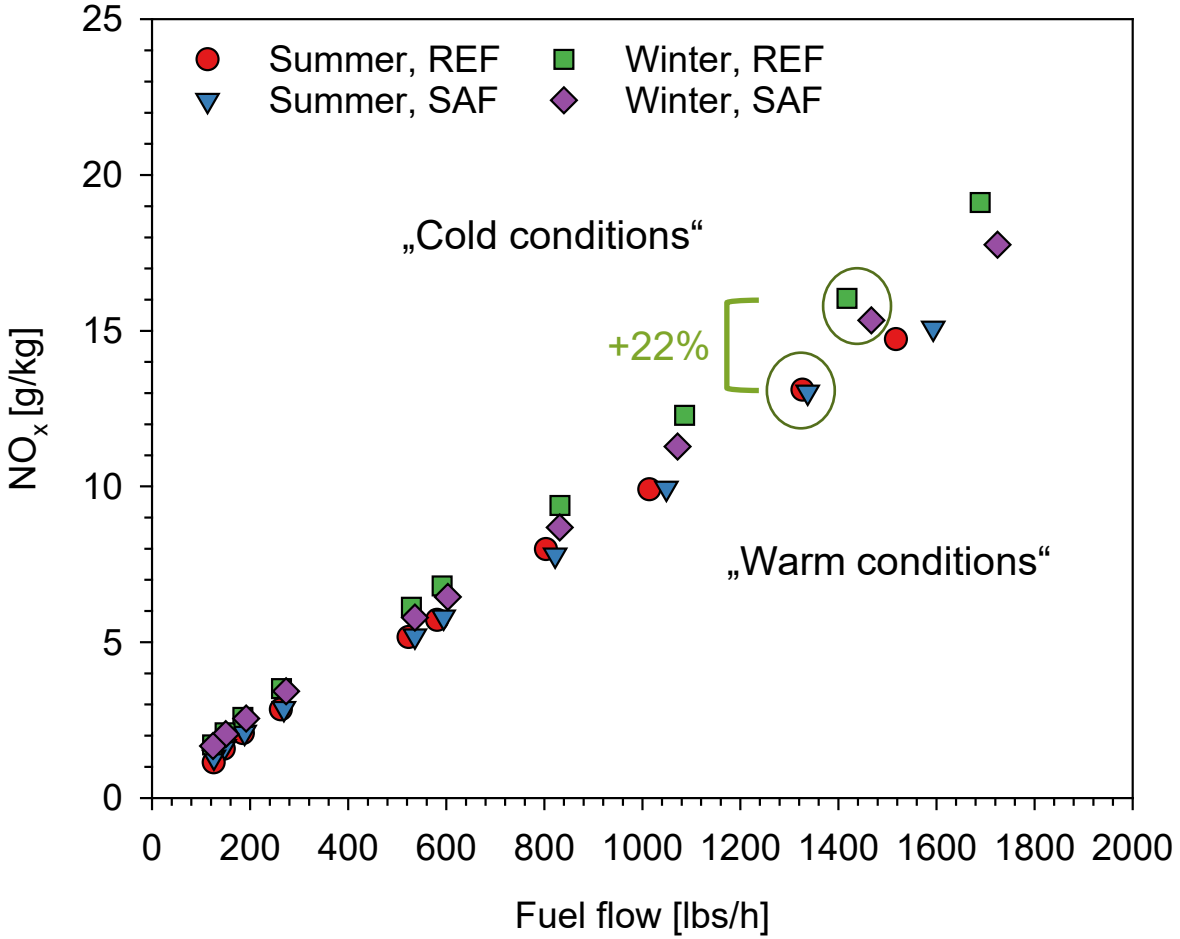
VOCUS-PTR-TOF-MS
NAIS
(aerosol charge)
MIRO
(gas analyzer)

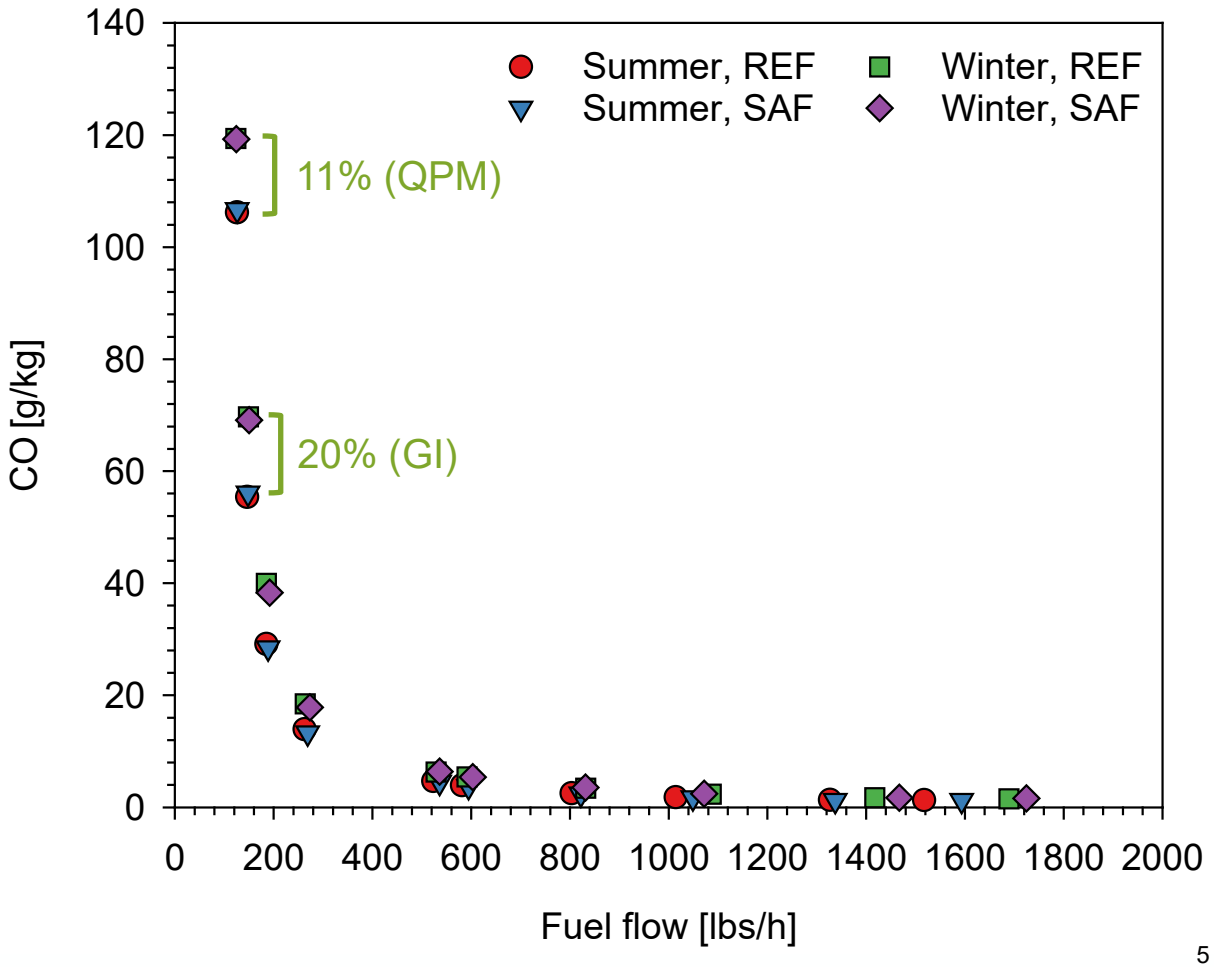
„near“ to aircraft

„far“ from aircraft

Gaseous Emissions – NOx & CO

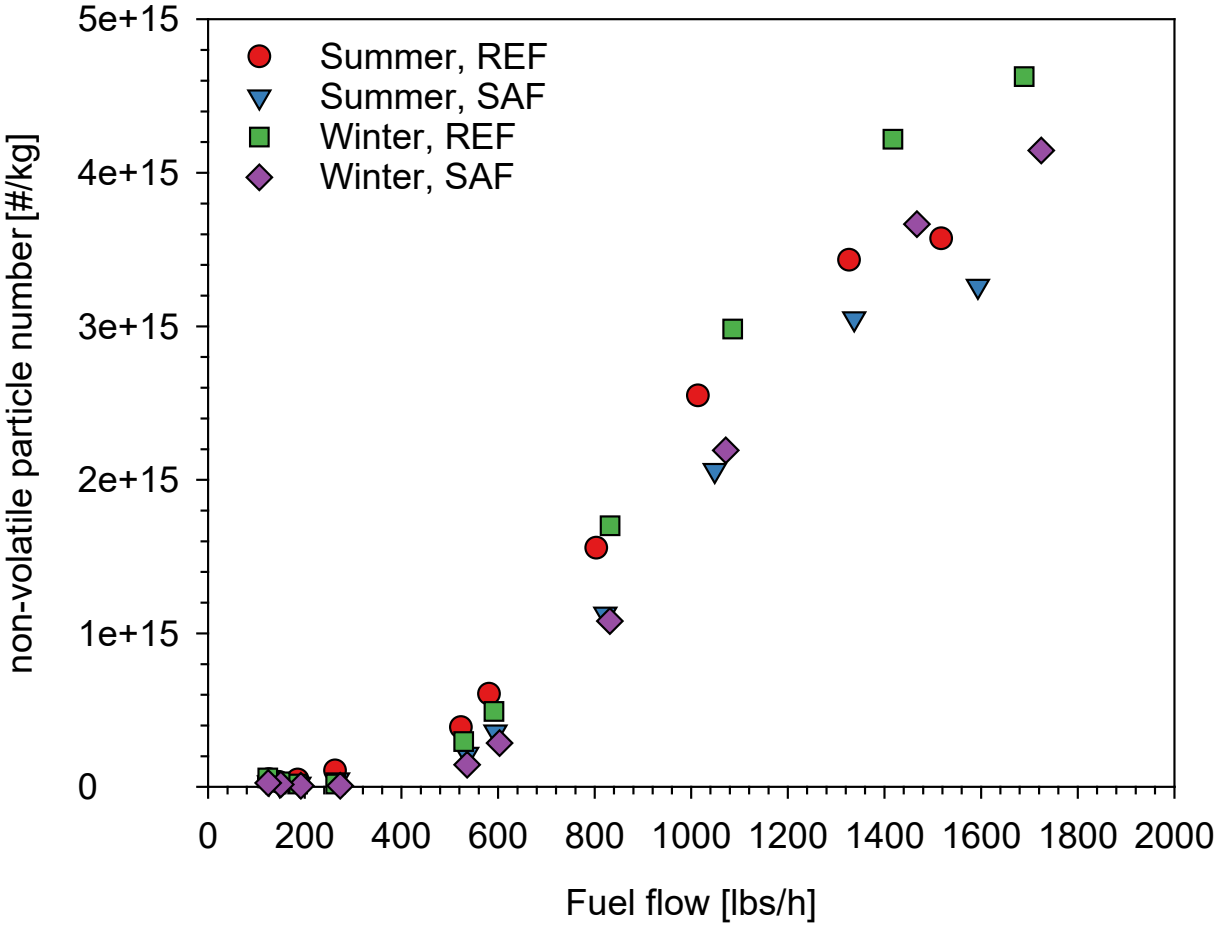
- Summer → Winter: Lower NOx emission (high power); lower CO emission (low power)
- Fuel composition has no significant impact on CO and NO_x

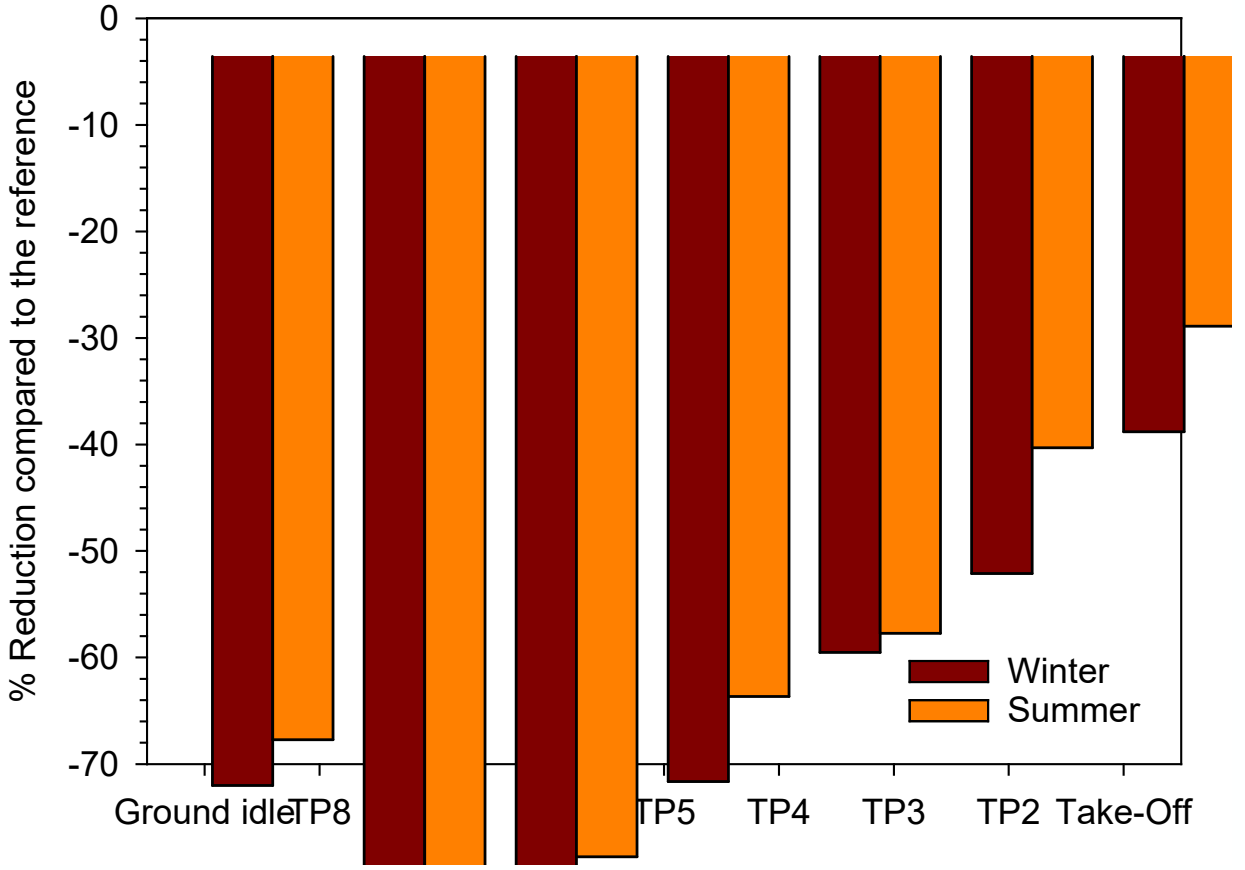




Particle Emission – Particle number

- The particle number emission is affected by the fuel composition
- The mitigation effect is higher at lower power settings





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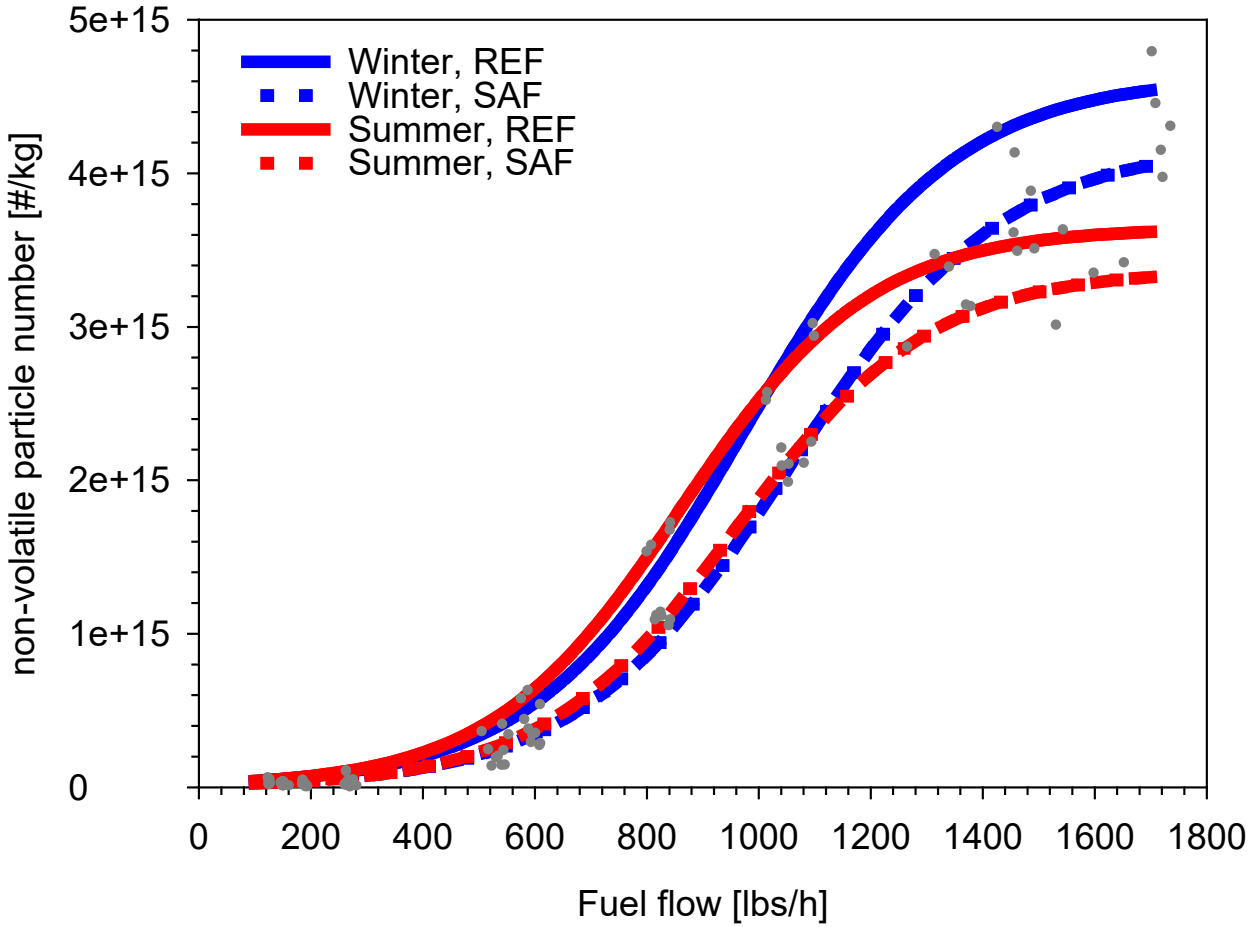
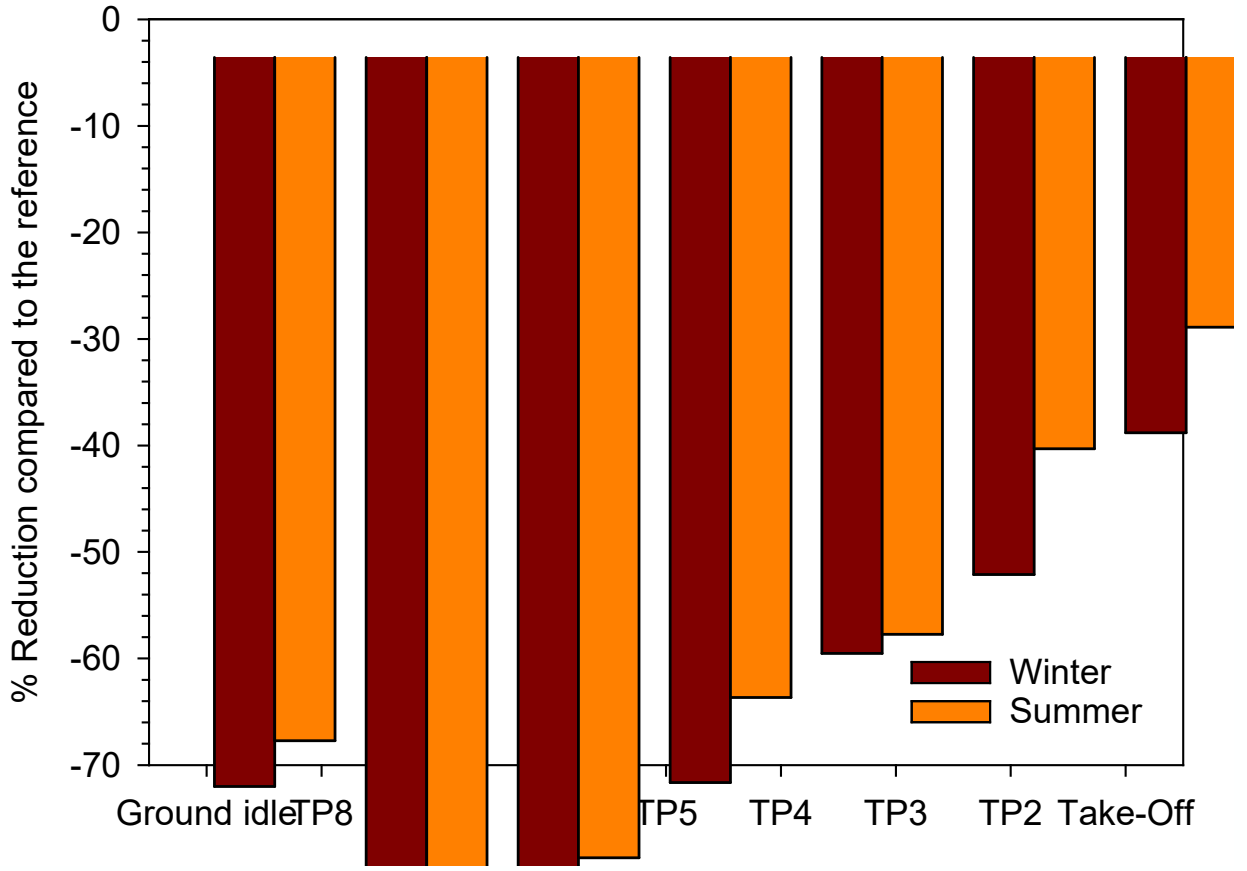
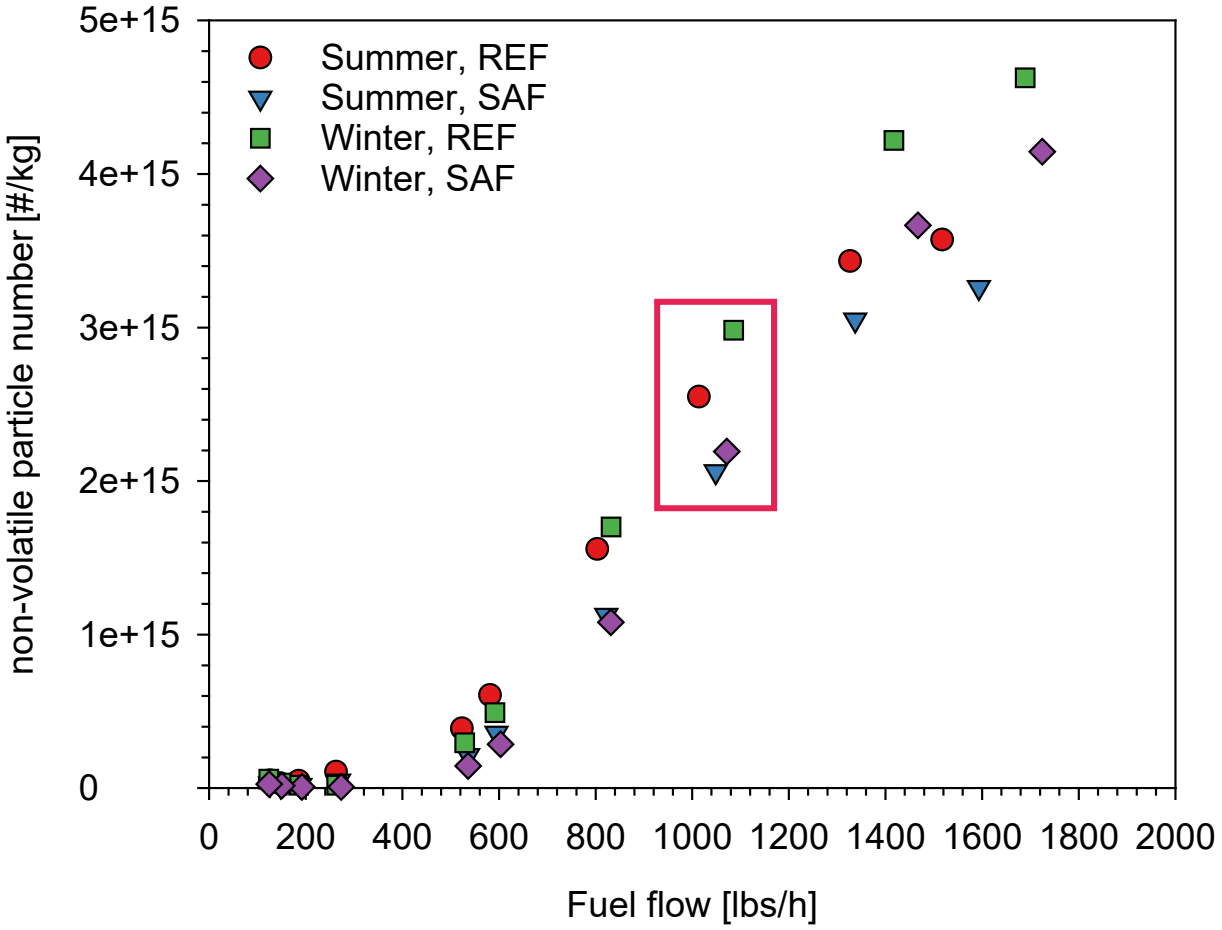
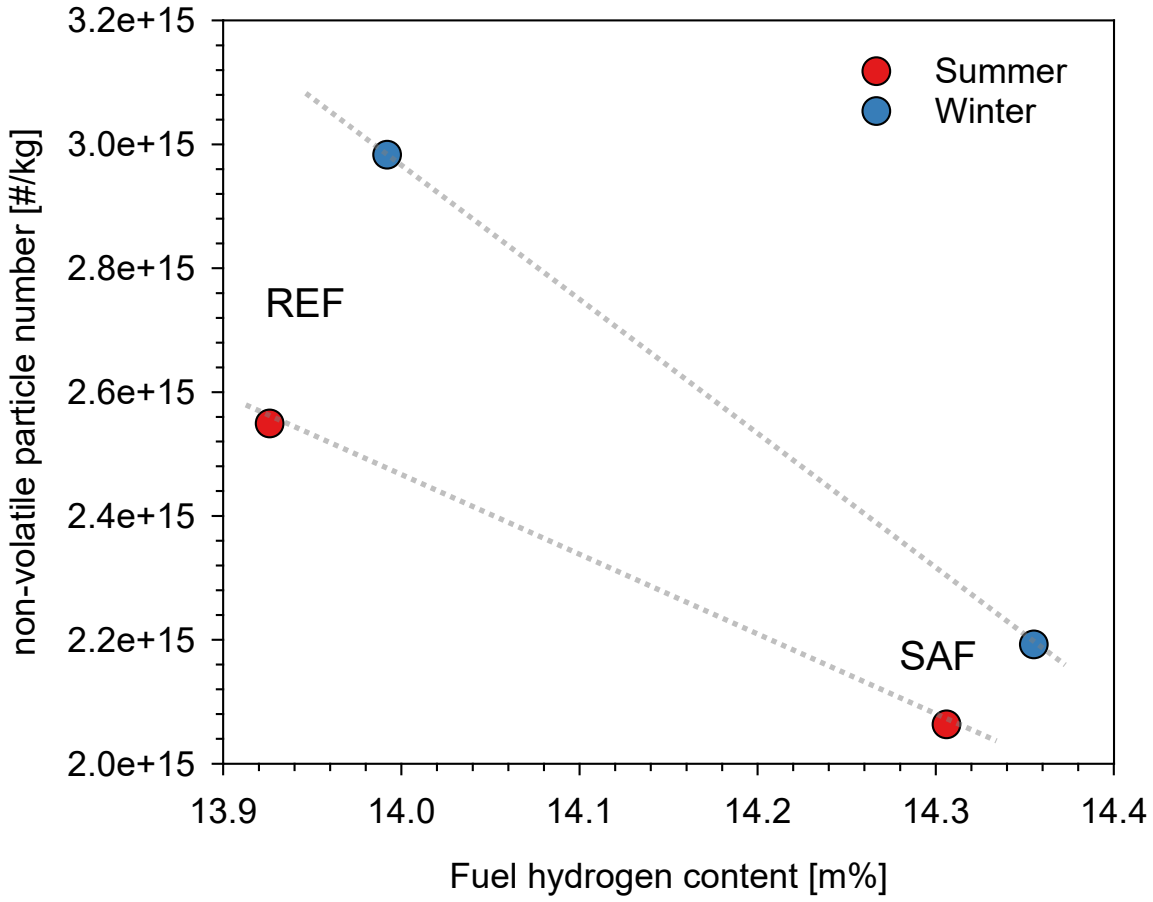




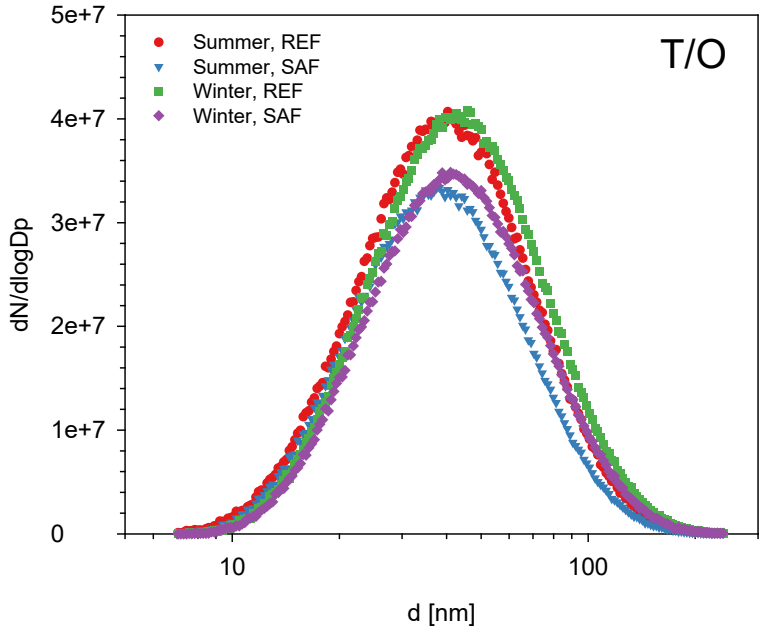
Particle Emission – Particle number

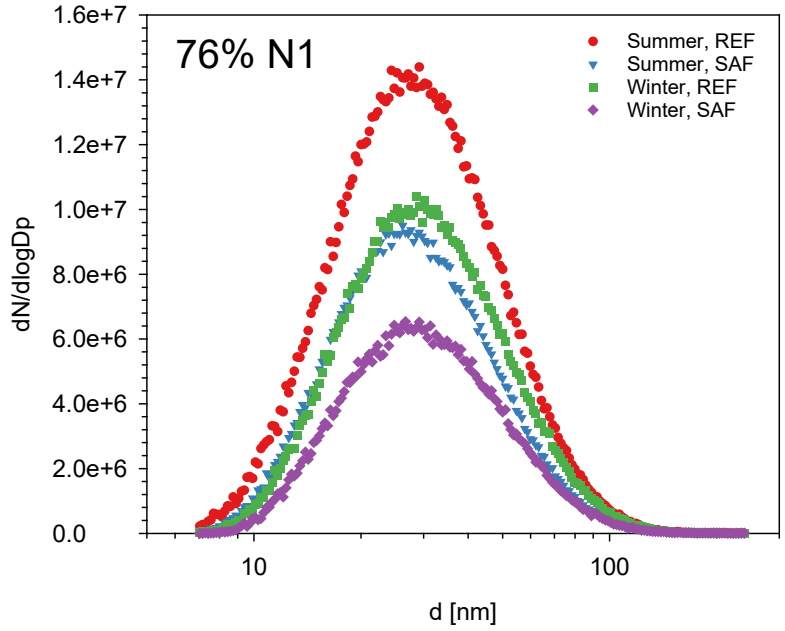
- The particle number emission is affected by the fuel composition
- The fuel hydrogen content (FHC) is a good predictor but the ambient conditions have an influence too

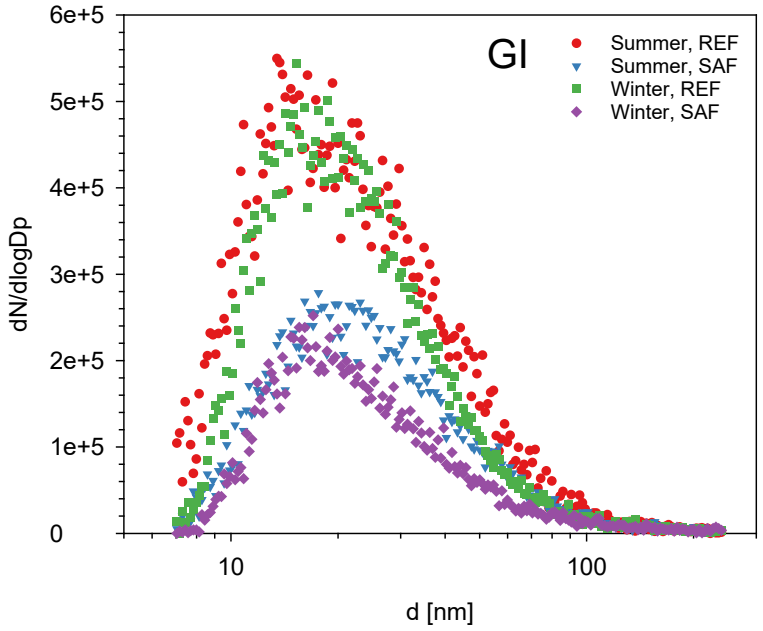




Particle Emission – Particle size

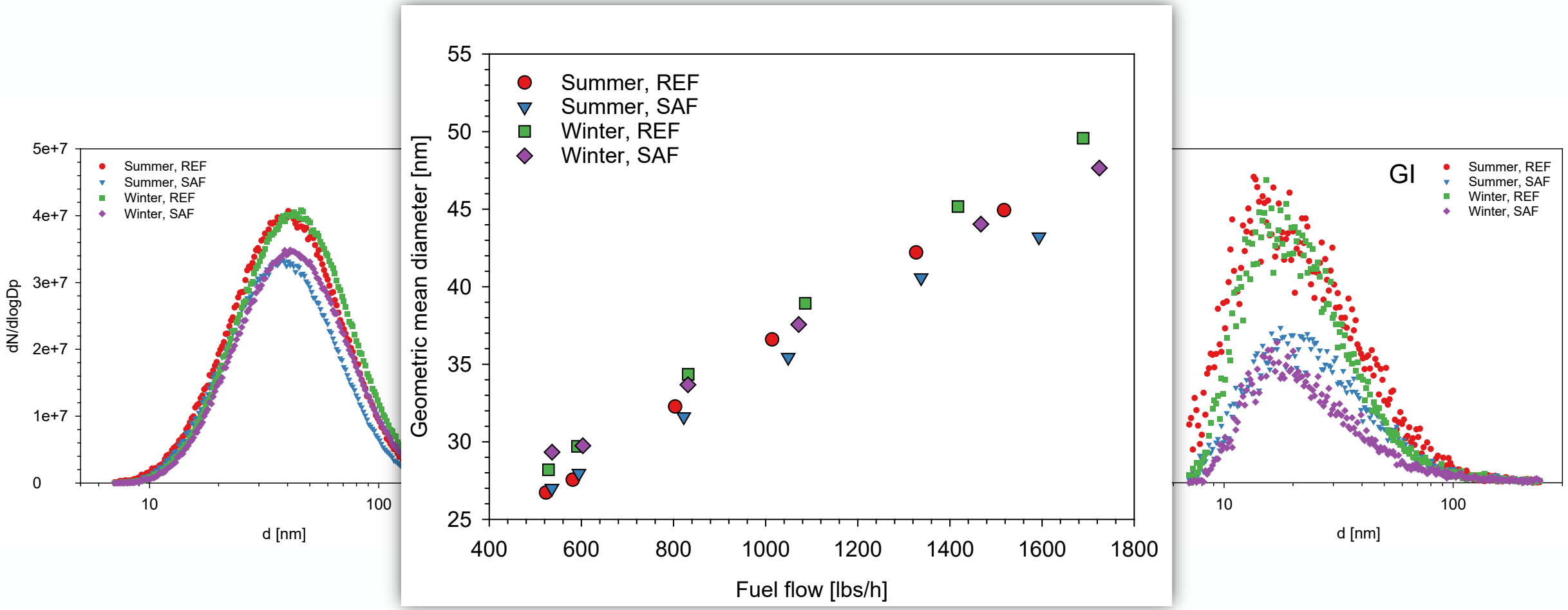






- The particle number emission is affected by the fuel composition but not the particle size
- The ambient conditions have an impact on the particle formation / particle size

Particle Emission – Particle size



- The particle number emission is affected by the fuel composition but not the particle size
- The ambient conditions have an impact on the particle formation / particle size

Summary

- The application of a 35% HEFA blend has significant positive impact on the emissions of a PC-24 (up to 60% lower soot number and 48% lower soot mass emission) without trade-off effects (e.g. different NO_x emissions)

- The ambient conditions have a significant impact on non-CO_2 emissions – in particular at high power settings; correction factors need to be investigated further (thrust-based evaluation)

- Relative fuel studies need to maintain similar ambient conditions to get reliable mitigation factors

- Next: Analysis of the plume aging at different ambient conditions, feasibility of measurement systems from the automotive industry, and a detailed analysis of the organic emissions.

Thank you for your attention!

See also: Poster 10C (Tue)
Assessment of aircraft engine exhaust toxicity using an on-site air–liquid interface cell exposure system (Ruiwen He, AMI)

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