The MERMOSE project: Characterization of particulates emissions of a commercial aircraft engine: from combustion chamber to complete engine

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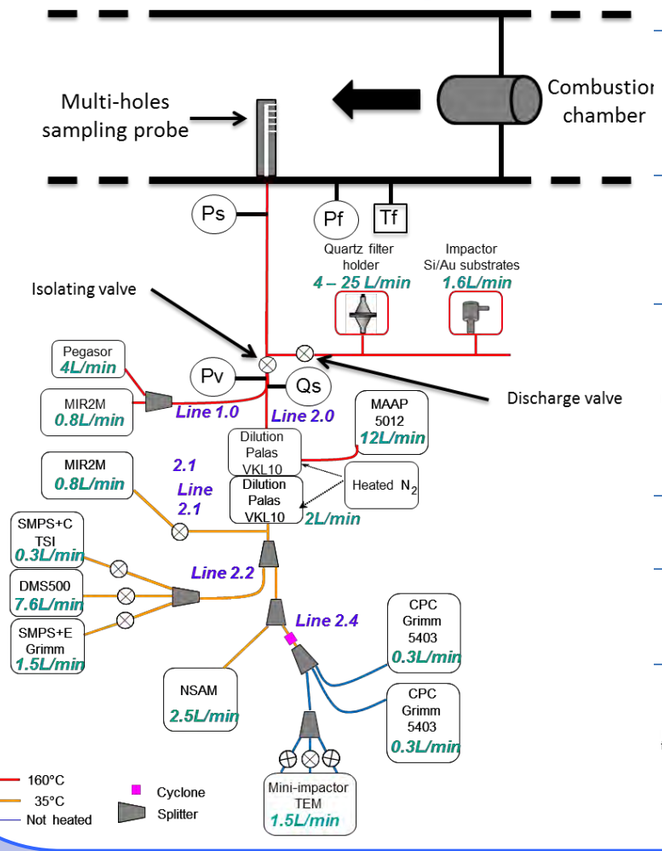
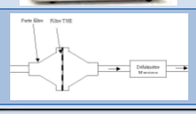
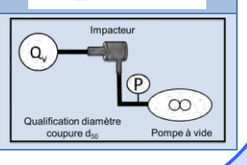
INTRODUCTION & GOALS

Visible contrails over Paris (Notre-Dame)

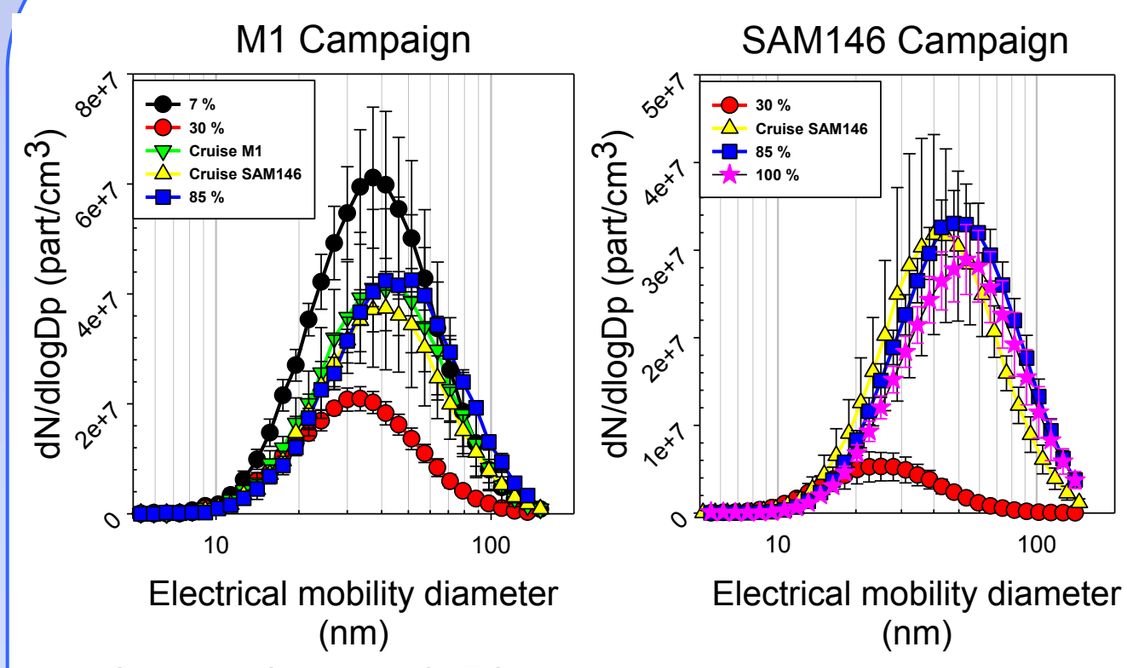
- MERMOSE is part of a 6 projects framework proposal that aims to understand the contrails formation, their impact on the climate and how to prevent or manage them regarding civil aircraft commercial activities. This batch of projects will be founded by the French Civil Aviation (DGAC).
- Our study is divided into 2 activities: Measurement behind a real turboreactor and understanding the contrails formation processes (not shown here).
- Our goals are to give experimental data on emission and better understanding of the fundamental process that leads to the contrail formation. After a first campaign of sampling behind the SAM146 engine [1], similar experiments have been carried out behind a combustion chamber of this engine mounted on the M1 test bench and for various engine thrust from 7% engine maximum take-off thrust to 100% including real cruise setting.

Experimental Set-up



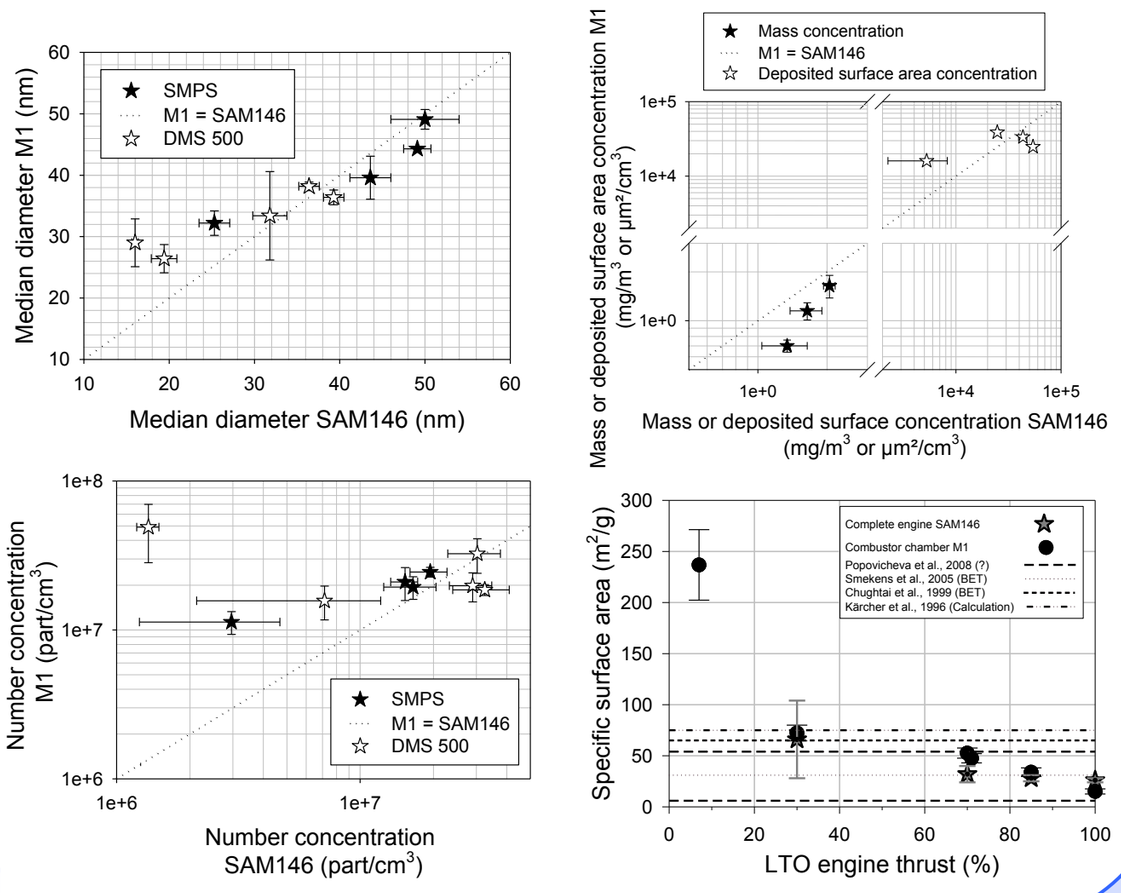
Tool	Parameter	Principle	Illustration
CPC 5403 Grimm	Number concentration	Butanol vapor condensation on particle plus optical counting	
SMPS 3936N	Size distribution	DMA 3085 + CPC 3025A	
DMS 500	Real time size distribution	Electrical charging and real time measurement in an electrostatic precipitator using several electrometers	
NSAM 3550	Deposited surface concentration	Diffusion charging of particle	
HEPA filters	Elemental to organic carbon ratio	Quartz fibers filter sampling + thermo-optical analysis (Improve)	
Low pressure impactor	Surface composition Elemental composition Morphology	Impaction on Si/Au substrates or TEM grids + XPS/NEXAFS Raman/SIMS TEM/HRTEM XREDS	

SMPS size distributions vs LTO's points

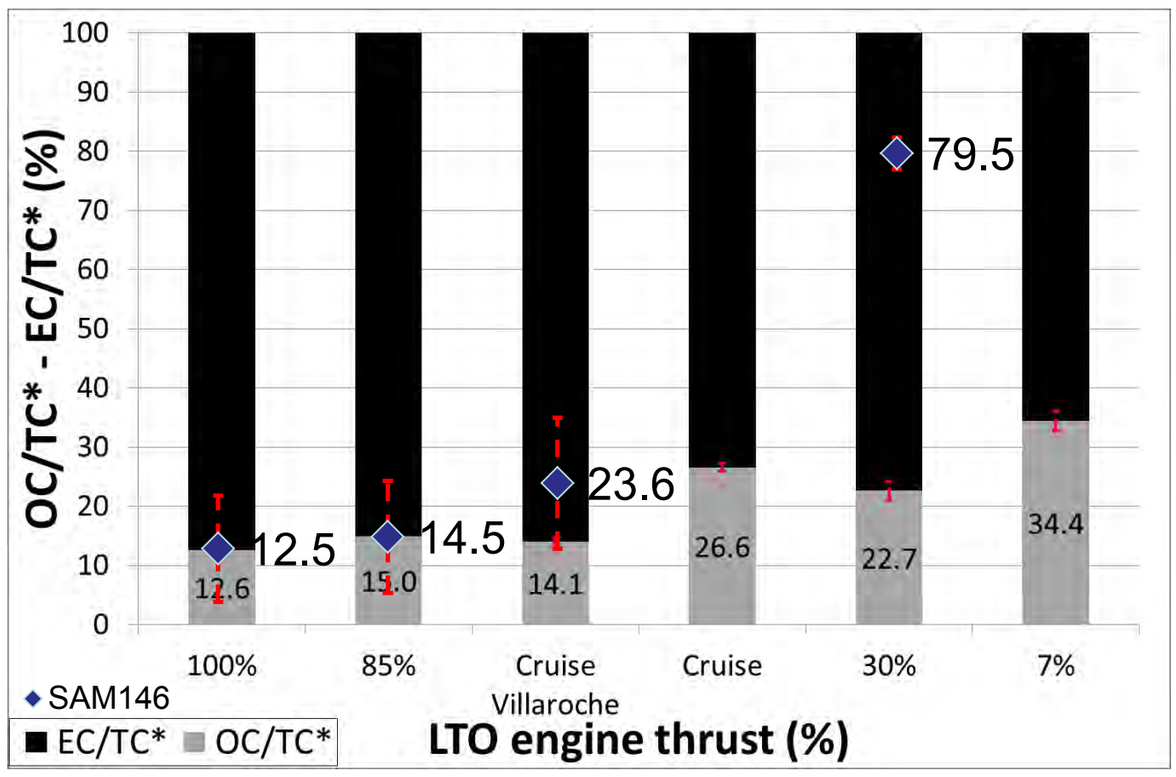


- Strong influence of LTO's regimes.
- Good agreement between M1 and SAM146 campaigns (despite 7% for M1).

Combustion chamber M1 vs SAM146



Organic to total carbon ratio (OC/TC)



- Thermo-optical analysis (Sunset Lab) of the EC/OC ratio according to the IMPROVE protocol (background subtracted).

Results of the M1 campaign

- Good agreement between results obtained behind a combustion chamber of the SAM 146 engine and during a field campaign performed on the complete SAM146 engine [1].
- Characterization of the particle matter: size, chemical composition [2], surface area, morphology [3].
- Size distribution, specific surface area, mass and number concentrations and OC/TC are strongly affected by LTO, not the case for morphology and structure.

Reference:

[1] Ouf F.X. et al. *The MERMOSE project: characterization of particulate emissions of a commercial aircraft engine*, Aerosol Technology, Karlsruhe, Germany, 2014.

[2] Ouf F.X. et al. *Effective density measurements of aircraft soot particles and surrogates*, Aerosol Technology, Tampere, Finland, 2015.

[3] Ortega I.K. et al. *Structural and chemical characterization of soot particles*, Aerosol Technology, Tampere, Finland, 2015.

Website of the MERMOSE project: ***http://mermose.onera.fr/***

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