The MERMOSE project: characterization of particulates emissions of a commercial aircraft engine: from morphology to chemical composition

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Air transport commercial activities increase continuously trough the years (Airbus, 2013 ; Boeing, 2013). Their environmental impacts on air quality and global warming (Lee et al., 2010) are a main concern and still request nowadays some investigation.

In this framework, the French government funded some research projects in order to better understand the process that lead to the formation of condensation trails, to prevent and manage them. The MERMOSE project (http://sites.onera.fr/MERMOSE/) is the first brick to fill this gap. It aims to provide modern aircraft engine emission data and knowledge on emitted particles reactivity mainly with water.

During this project a field campaign has been performed behind a complete SaM 146 aircraft engine at Snecma test bench. Together, ONERA, IRSN, Snecma and CNRS (CINaM, PhLAM) made gas and particles measurements with a single hole probe that allowed sampling at 5 cm behind the engine exit. Cartographies through 16 points at various engine thrust has been done, from 30% engine maximum take-off thrust to 100%.

The experimental set-up has been composed of 4 lines, all connected to the same probe. The first one was dedicated to gas measurements following the certification guidelines (ICAO, 1993). One line dealt with sampling for laboratory characterizations, microscopy (TEM) and chemical analysis (EC/OC ratio, XREDS, FTIR, laser and ionic desorption mass spectrometry, Raman spectroscopy). Taking into account the SAE E-31 recommendations, two lines have been built to make on-line monitoring of size distributions (SMPS+C, SMPS+E, DMS 500), mass (MAAP, Pegasor, filters) and number (CPC, Pegasor) concentrations and particle surface area density (NSAM).

The modal diameter of the particles is ranging from 17 nm to 55 nm (increasing with the percentage of the maximum thrust), the particles denote a fractal morphology and are composed of nanoparticles of nearly 15 nm in diameter. They are mainly composed of carbon (with traces of O, S and Ca) and their EC/OC ratio increases as a function of the maximum thrust from 20/80 for 30% to 87/13 for 100%. This is confirmed by fine surface chemical composition mass spectrometry analysis performed using laser (L2MS) and ionic (SIMS) desorption. The maximum number of particles emitted has been detected for a 85% engine maximum thrust. Cartographies exhibit homogeneous size particle emission though engine plan exit. Some variations are observed for mass, number and surface area densities.

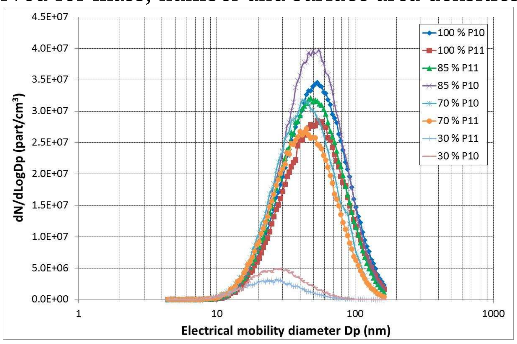

Figure 1. SMPS size distributions for various engine maximum thrusts at two different locations behind a SaM1 146 aircraft engine.

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References

Airbus, 2013, http://www.airbus.com/company/market/forecast/

Boeing, 2013, http://www.boeing.com/boeing/commercial/cmo/

ICAO, (1993). International Standards and Recommended practices, annex 16, volume II Aircraft engine emissions, 2sd edition.

Lee, D.S., G. Pitari, V. Grewe, K. Gierens, J.E. Penner, A. Petzold, M.J. Prather, U. Schumann, A. Bais, T. Berntsen, D. Iachetti, L.L. Lim, R. Sausen (2010). *Transport impacts on atmosphere and climate: Aviation. Atmospheric Environment*, **44**, 4678-4734.