nvPM and Airport Air Quality – Evolution and State-of-the-Art of Methodologies and Possible Improvements

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Introduction

Particulate Matter (PM) emissions from aircraft engines adversely affect air quality in and around airports, contributing to public health concerns. RAPTOR project provides enhanced insights into PM within aircraft exhaust emissions in terms of new insights on emission/exhaust measurement and emission modelling uncertainties. RAPTOR will undertake an in-depth review of available literature to assess knowledge gaps.

This paper focus and describes the state-of-the-start of existing methodologies and standards for assessing aircraft PM emissions, including regulatory aspects, PM measurements and latest development in modeling.

Regulations

To protect human health, different standards regulate engine emissions and ambient air quality. ICAO developed different standards for nvPM aircraft's engine emissions. Those standards limiting the emissions of smoke, nvPM (as maximum mass concentration), nvPM mass and number LTO emissions. CAEP/10 nvPM mass concentration certification standard was agreed at the 10th ICAO-CAEP meeting in 2016 which also required the LTO mass nvPM and number nvPM emissions to be reported.

EU Directive 2008/50 is setting ambient air concentration limits for long-term (24-hour) and short-term (1-hour) exposure.

CAEP/11 new stringencies on nvPM LTO based emissions

Indicator	Standard	Rated Thrust (kN)	Limit
nvPM Mass Metric Value (mg/kN)	In-Production	< 200	$\frac{(3725.4 * (thrust - 200))}{-173.3} + 347.5$
		≥ 200	347.5
	New types	< 150	$\frac{(852.5 * (thrust - 150))}{-123.3} + 214.5$
		≥ 150	214.0
nvPM Number Metric Value (#/kN)	In-Production	< 200	$\frac{(1.95 * 10^{16} * (thrust - 200))}{-173.3} + 4.17 * 10^{15}$
		≥ 200 kN	$4.17 * 10^{15}$
	New types	< 150	$\frac{(9.92 * 10^{15} * (thrust - 150))}{-123.3} + 2.78 * 10^{15}$
		≥ 150	$2.78 * 10^{15}$

PM measurements

Two recent experimental measurement campaigns are analysed:

1) A-PRIDE 4 in 2012 was one of the first studies to analyse nvPM mass & number emissions using standardized method,

2) A study conducted in 2019 analysing PM toxicity using different aviation fuels.

In addition, two different Clean Sky 2 projects, AVIATIOR and RAPTOR, are conducting research on aircraft's PM and UFP emissions with the aim of better understanding this pollutant.

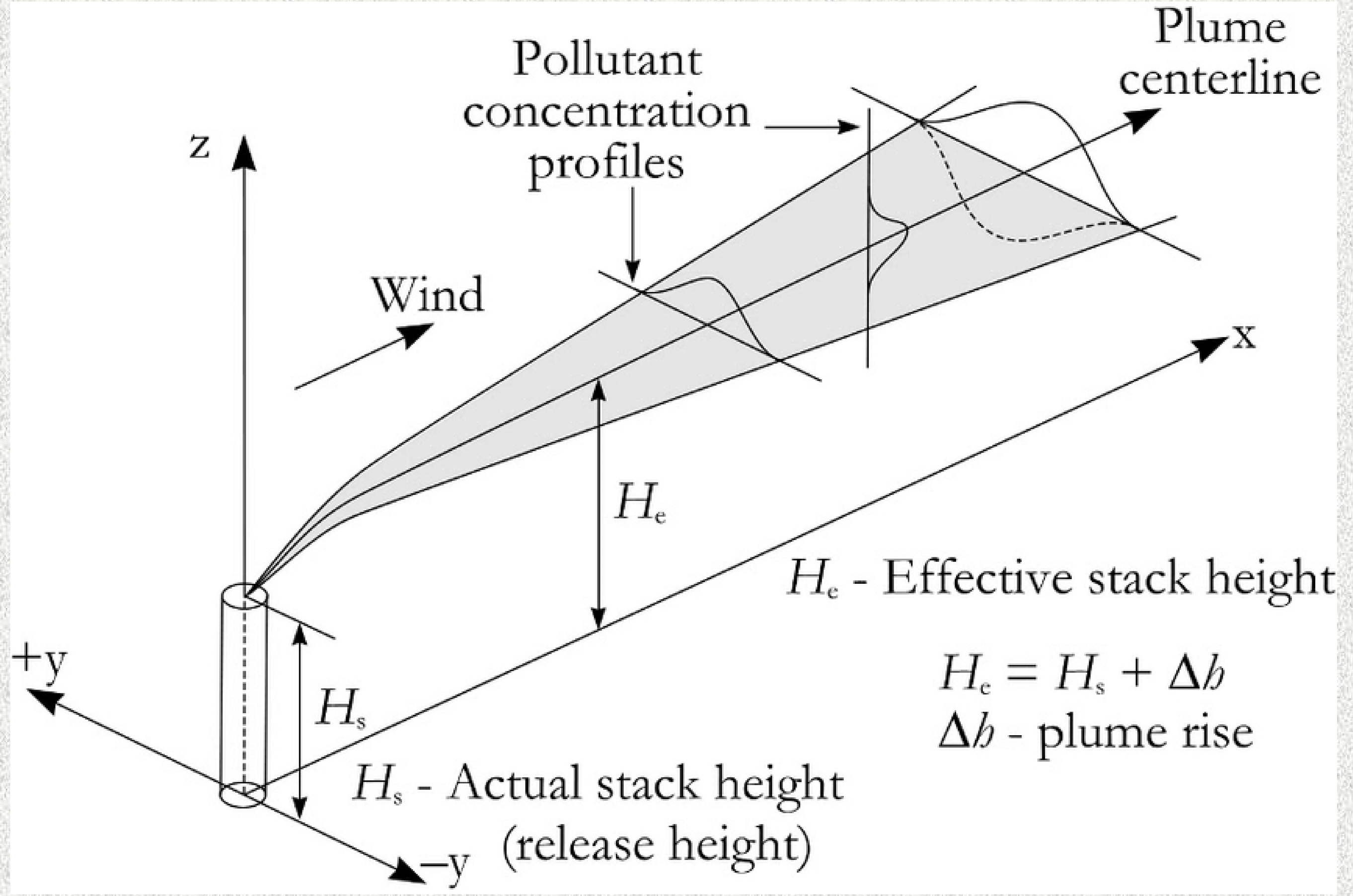
RAPTOR aims for measurement campaigns: Quantification of uncertainty associated with current and future ICAO standards using historic, contemporary and new PM data acquired from representative gas turbine sources. It aims to reduce the uncertainties (due to Humidity, Pressure & Temperature, Size measurement – line loss, sampling, calibration)

PM modelling

Different dispersion models allow to predict the PM concentration and dispersion from aircraft engines. Models are in general complex because it involves inter-relation between microphysical properties, mixing processes, and chemical reactions of the engine's exhaust plume with the ambient air.

These models are based on Gaussian Plumes or on Lagrangian dispersion models. More advanced models are the CFD solutions, which are still not use in industrial processes due to their high resources and computer's power consumption. Input parameters, and uncertainties in particular Emission indexes, need to be evaluated in detail through measurement campaigns.

In addition, estimated concentration will be directly related to the accuracy of input emissions estimates". Thus improving data collection of PM emissions and reducing uncertainties, will improve assessments.



Conclusions

While in recent past regulators and scientists made progress in developing standards and making prediction models, more research is needed.

Thus research in measurement techniques & corrections and their associated uncertainties (as these directly impact air quality modelling and inform aircraft-induced PM related toxicity and health effects) are important to carry out.

Studies including RAPTOR project, have found that nvPM emissions are also sensitive to fuel's sulphur and aromatic concentrations. Test measurements show that using a fuel containing less sulphur and aromatics, i.e. species organic species, leads to exhaust plumes with less nvPM.

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