Correlations of nonvolatile particulate matter mass and number emissions and particle size with smoke number determined for commercial aircraft jet engines

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Background

- Non-volatile PM (nvPM) emissions from aircraft engines worsen airport air quality and contribute to climate change.
- First aircraft engine nvPM emissions standard will be introduced in 2020 [1].
- The nvPM standard will replace the standard based on exhaust smoke visibility – smoke number (SN; figure).
- Certification SN data are available for most in-service commercial jet engines.
- Various methods approximate nvPM mass emissions from certification SN for the assessment of airport air quality and global emissions [1-4].
- The recommended method is the First Order Approximation v3 (FOA3) [2].
- We have developed correlations of nvPM emissions and particle size with SN from standardized emission measurements of five types of widely used commercial aircraft jet engines (figure).

NvPM mass and number concentrations

Particle size distribution parameters

Emission indices (emissions/kg fuel burned)

Conclusions

- Overall good correlation of all the parameters investigated with SN; especially mass-based emissions and GMD correlate strongly with SN.
- Mixed-flow engines (exhaust dilution with bypass air upstream of the sampling location) are outliers – the dilution ratio is unknown, but can be estimated from engine performance data.
- NvPM mass concentrations as a function of SN agree well with the recommended FOA3 [2].
- Up to a factor of ~3 lower nvPM mass concentrations and emission indices as a function of SN than recently proposed updated correlations [3,4].
- To estimate emissions from engines with ultra-low SN, we propose offsets in correlations, which may be significant for number-based emissions: the number concentration at SN ~0 reached well over 10^6 cm^-3.
- These data will contribute to more accurate assessments of aircraft engine nvPM emissions; further development will include more measurement data and correction for particle loss in the sampling system.

Methods

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References