Supplement of Atmos. Meas. Tech., 18, 6795–6816, 2025
https://doi.org/10.5194/amt-18-6795-2025-supplement

Atmospheric Measurement Techniques
Open Access

Supplement of

In-flight emission measurements with an autonomous payload behind a turboprop aircraft

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We examine the impact of age on the ratio of nvPMs to tPM. Figure S1 provides the number concentration of nvPM (blue) and tPM (red) particles measured at FL250 over the plume from approximately 1 s up to 12.5 s of age. Unfortunately, not all plume ages were sampled sufficiently well, e.g., between 8 and 12 s, no plume data are available. The number concentrations are mainly governed by dilution in axial but also in radial direction (Lottermoser and Unterstrasser, 2025). The higher peak values at a plume age of 12 s compared to those of 8 s suggest that the center of the plume has not been sampled adequately at the plume age of 8 s. The data is compared here to two concentration values calculated using mean dilution curves for turbofan engines (Schumann et al., 1998; Zink and Unterstrasser, 2025). Both curves generally represent the highest number concentrations, corresponding to the plume center, found for different plume ages. While the dilution curve with the exponent of 1.15 describes the upper concentrations somewhat better, no conclusion can be drawn which of the two curves provides a better representation of the data. To examine the evolution of tPM and nvPM dilution-independent, we show the $\mathrm{EI}_{\mathrm{tPM}}$ (panel b) and $\mathrm{EI}_{\mathrm{nvPM}}$ (panel c) and their ratio (panel d) over plume age. Within the first 4 s, the EI show a large scatter by almost a factor of two, with the highest and lowest data points found at this plume age. We attribute this large scatter to the rather large variability in the early jet phase, where particle evolution and distribution are governed by the turbulent conditions of the plume. Towards higher ages, the data become very sparse and integration over single plumes only provides single data points, which are in good agreement with the median value. The ratio $\mathrm{EI}_{\mathrm{nvPM}}$ / $\mathrm{EI}_{\mathrm{tPM}}$ remains, on average, at 0.77 with a larger scatter in the early turbulent phase. A decrease in this ratio with larger plume ages is evident, but the lack of statistics leaves a high uncertainty in this observation. Due to the limited data, no final conclusion can be drawn on the evolution of the nvPM and tPM particle ratio (here provided as $\mathrm{EI}_{\mathrm{nvPM}}$ over $\mathrm{EI}_{\mathrm{tPM}}$ in the aging plume. The average of all data suggests a ratio of 0.77 with a standard deviation of 0.04. In the future, we encourage this strategy of sampling and data analysis to provide evidence of volatile particle formation and growth, or effects of mixing on this ratio, covering the full distance and age spectrum.

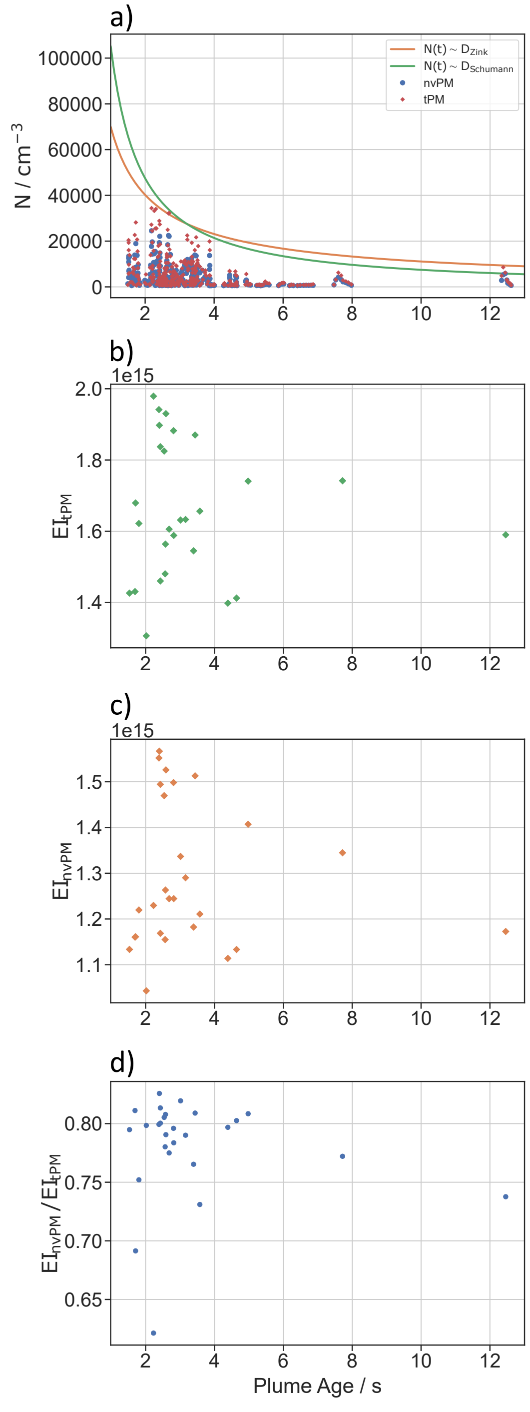

Figure S1. (a) Number concentration of nvPM and tPM over the plume age from data obtained at FL250 during flight 5. In addition, and for comparison, the concentrations calculated using the dilution according to (Schumann et al., 1998; Kärcher et al., 2015). (b) EI_{tPM} and (c) EI_{nvPM} over plume age. (d) EI_{nvPM} / EI_{tPM} over plume age.

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