RESPONSE TO REVIEWER COMMENTS

Title: Aircraft-derived particle fluxes distinguish entrainment zone and decoupled layer nucleation in marine boundary layers

Journal: Atmospheric Chemistry and Physics

Ref: egusphere-2026-61

Editor's Comments in 12-point italicized font

Authors' Response in indented, 12-point normal font.

Changes to the manuscript in quotes, 12-point blue font.

#1. *Please address this reviewer comment correctly: 2. Line 168: Please provide numbers instead of vague statements like "…with signal-to-noise characteristics suitable for detecting both remote continental and clean marine aerosol concentrations.." Furthermore, this should be a question of absolute particle numbers due to Poisson statistics – right? The reviewer asked for numbers and you have provided just generic formula how to obtain them.*

> **Response:** We agree with the editor that invoking the $\sqrt{C}$ signal-to-noise formula without providing study-specific values was misleading. Since the raw count data are not accessible to us – all quality control is applied by the ARM instrument mentors prior to data release – we are not in a position to calculate per-bin SNR values. We have therefore revised the text to remove the SNR clause and instead rely on the published aircraft-based deployment references (Kulkarni and Wang, 2006a, b; Olfert et al., 2008) to establish the instrument's suitability for clean marine conditions.

Revised manuscript text: "Aerosol size distributions from 10 nm to 600 nm were characterized using a Fast Integrated Mobility Spectrometer (FIMS) (Kulkarni and Wang, 2006a, b).The FIMS provides size distribution measurements at 1-second temporal resolution suitable for detecting both remote continental and clean marine aerosol concentrations, as demonstrated in aircraft-based deployments (Kulkarni and Wang, 2006a, b; Olfert et al., 2008). Particles are charged within the instrument and separated by electrical mobility using an applied electric field."

#2. *Your statement indicates that there can be significant discrepancies in performance of the CPC and FIMS Line 180: IMS-derived number concentration also served as a quality control flag for the CPC 3772. Since both instruments share an overlapping detection size range (10–600 nm for FIMS;>10 nm for CPC 3772), their total number concentrations should be broadly comparable (with CPC showing a higher. The FIMS provides high temporal resolution measurements with excellent sensitivity and counting statistics required for aircraft-based studies (Olfert et al., 2008) total number concentration than FIMS) under a laboratory setting where all the variables are controlled. But the CPC concentration was found to be suspect at times, likely because of issues with the working fluid, or a change in flow rate that is controlled using a critical orifice.*

How does it correspond to your earlier statement starting at Line # 157. Both flow rates remained stable across the sampling altitude range (Zheng et al., 2021). The airborne CPC configuration was validated for operation up to 4000 m altitude and across ambient relative humidity conditions of 0–90% RH. For a typical polluted environment (~ 5000 cm−3), CPC concentration measurements had an accuracy of 0.3 % (Kuang and Mei, 2019). All data used in this study passed instrument mentor specified quality control filters, which are distributed alongside the data. Based on this, your instruments should perform much better than 10% margin.

Can you please provide histogram distribution of the difference between integral FIMS and total CPC?

Response: We thank the editor for this important clarification request. The apparent contradiction between the stated CPC accuracy (0.3%) and the 10% QC threshold requires explanation.

The 0.3% accuracy figure (Kuang and Mei, 2019) characterizes CPC performance under stable, controlled laboratory conditions with a typical polluted environment concentration of ~5000 cm^{-3}. The 10% threshold is not a statement about typical instrument accuracy – it is designed specifically to catch episodic malfunctions, namely working fluid depletion or critical orifice blockage events. These malfunctions produce large sustained negative deviations in CPC concentration that are physically impossible given the overlapping size ranges of the two instruments (CPC >10 nm; FIMS 10–600 nm). Under normal operating conditions, the CPC concentration must always exceed the integral FIMS concentration, since the CPC detects all particles above 10 nm while FIMS is bounded at 600 nm.

The histogram of CPC minus integral FIMS differences (Figure S1) confirms this interpretation. The distribution is sharply peaked near zero with a slight negative skew, consistent with good agreement during normal operation. The negative tail represents the episodic malfunction periods the 10% threshold is intended to exclude. The 10% threshold was chosen conservatively to flag only those periods where the discrepancy is large enough to be unambiguously attributable to instrument malfunction rather than natural atmospheric variability. The vast majority of data points fall well within physically plausible bounds.

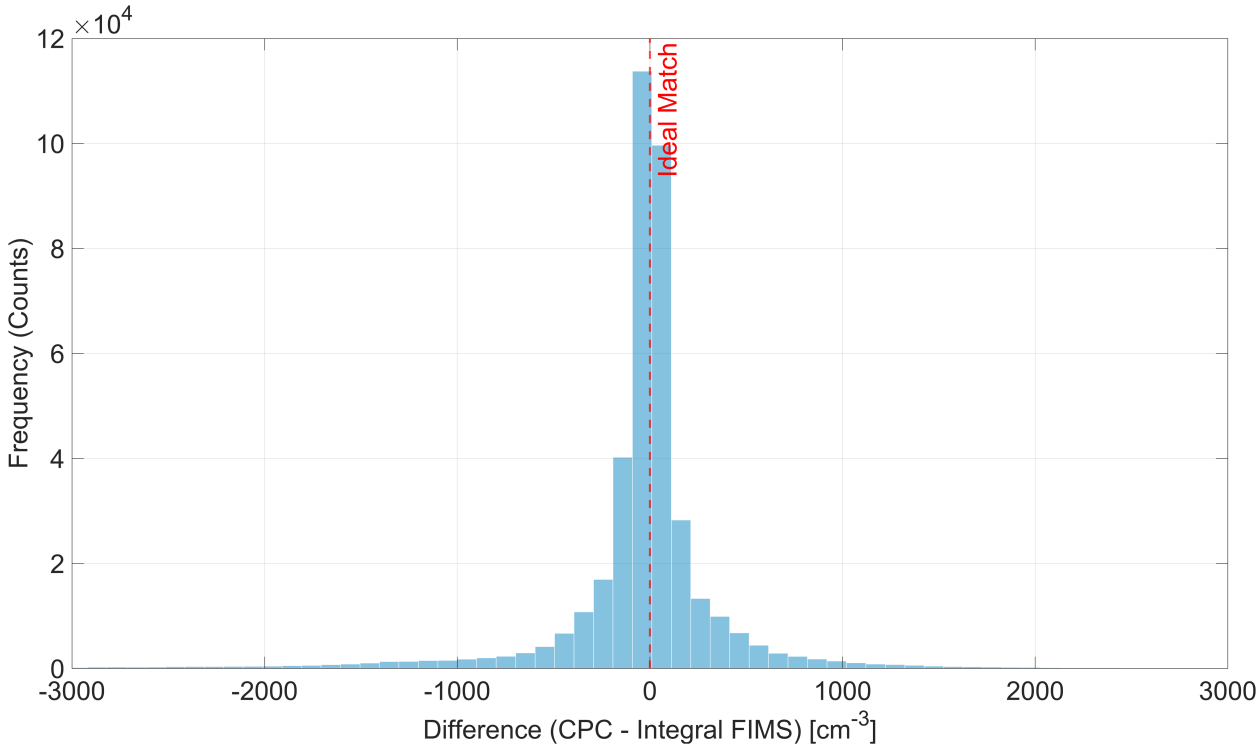

Figure S1. Histogram of the difference between total particle number concentration measured by CPC model 3772 and integral FIMS concentration (CPC − integral FIMS) across all campaign data. Positive values indicate CPC exceeding integral FIMS, as expected under normal operating conditions. Negative values reflect episodic periods of CPC malfunction used to define the 10% quality control threshold.

Revised manuscript text: "FIMS-derived number concentration also served as a quality control flag for the CPC 3772. Since both instruments share an overlapping detection size range (10–600 nm for FIMS; >10 nm for CPC 3772), their total number concentrations should be broadly comparable, with CPC showing a higher total number concentration than FIMS under normal operating conditions, as the CPC detects all particles above 10 nm while FIMS is bounded at 600 nm. The histogram of differences between CPC and integral FIMS concentrations (Fig. S1) shows a distribution sharply peaked near zero with a slight negative skew, confirming good agreement during normal operation. The dashed red line indicates zero difference, below which CPC concentrations are physically implausible given the instruments' overlapping but non-identical size ranges. The negative tail reflects episodic periods when the CPC concentration was found to be suspect, likely due to working fluid depletion or a change in flow rate controlled by a critical orifice, producing sustained negative deviations that are physically implausible given the instruments' overlapping size ranges. These episodic malfunctions are distinct from the instrument's typical 0.3% measurement accuracy under stable conditions (Kuang and Mei, 2019). Hence, a conservative threshold was set with CPC concentrations falling below 10% of the simultaneously measured FIMS concentration, indicating a physically implausible discrepancy inconsistent with real atmospheric variability, and were therefore excluded from analysis as likely instrument malfunctions."