Response to RC1: 'Comment on amt-2024-138', Anonymous Referee #2

Air ions promote new particle formation through ion-induced nucleation, so measuring air ions, especially small ones, is crucial. This manuscript describes a newly designed instrument, Cluster Ion Counter (CIC), which measures the number concentrations of air ions below 5 nm. Such a device could complement the family of instruments for studying the new particle formation. This manuscript is well written. I believe this manuscript could be published in AMT after addressing the following comments.

We appreciate the reviewer's positive and constructive feedback. Responses to each comment are provided individually below the respective comment, highlighted in blue text.

Major comments:

1. Neutral cluster and Air ion Spectrometer (NAIS), which was designed by same research group of this study, is widely used for the observation of air ions. I'm curious to know what differences or advantages the CIC has over NAIS. This study appears to have done a parallel comparison experiment of CIC and NAIS (Figure 5), but the results are not mentioned in the manuscript.

We understand the reviewer's interest in a direct comparison of NAIS and CIC using CERN CLOUD chamber data. However, such a comparison is not included in our study due to the unique inlet configurations required for sampling from the CLOUD chamber, which would introduce considerable variability and limit the reliability of a direct intercomparison. Specifically, the CLOUD chamber's outlet sizes (1/2 inch or 1 inch) required the use of different adaptors for each instrument (30 mm to 1/2 inch Y-splitter for CIC and 30 mm to 1 inch for NAIS). Additionally, the limited total flow available from the CLOUD chamber, necessitated by the demands of multiple instruments, forced instrument-specific flow rate adjustments. The CIC was operated at a reduced 14 lpm (7 lpm per analyzer), whereas the NAIS, with its fixed sampling rate at 54 lpm, drew 20 lpm from the chamber, with the remaining flow provided by a diluter. These disparities in inlet configurations and flow conditions, leading to potential variations in line losses and introducing uncertainties from either dilution (NAIS) or a potentially lower signal-to-noise ratio (CIC), make a direct and meaningful intercomparison of instrument performance within the CLOUD context difficult. We do, however, draw attention to a recent study by Kulmala (2024) that provides an intercomparison of these instruments under ambient conditions at the SMEAR II station in Finland.

The primary benefits of the CIC over a NAIS are lower weight, smaller dimensions, lower power consumption and better detection efficiency.

We added comments about that to the end of section "2.1 Instrument design":

> *Compared with earlier instruments developed at the University of Tartu, such as the NAIS or the Balanced Scanning Mobility Analyzer (BSMA; Tammet, 2006), the CIC features a simpler design. While it does not match the sensitivity of the BSMA or provide the detailed sizing information of the NAIS, the CIC offers several advantages over these more complex instruments. Notably, the CIC can operate at low sample flow rates that are unachievable by the BSMA. Compared with the NAIS, the CIC has a higher detection efficiency and a shorter inlet tract, allowing for more reliable measurement of small ions at higher time resolution and with a lower mobility diameter cut-off.*

2. CIC looks quite small compared to the NAIS. What is the weight of the CIC? Can mobile observation be an advantage for CIC?

The external dimensions of the CIC are 200 mm width, 130 mm height and 400 mm length. The weight of the instrument is 5 kg. The power consumption is 4-5 W at 30 lpm sample flow rate per analyzer. We added these details to section 2.1.

We added a comment to the summary:

> *Its low weight, small dimensions, and low power consumption open up new possibilities for aerial measurements with drones*

3. The authors state that CIC is capable of making precise and robust long-term measurements. Did the CIC operate under ambient conditions before? How does CIC perform in field measurements? I think it is important to make it clear that CIC can be used not only for chamber experiments but also for long-term field measurements.

We appreciate the reviewer's point regarding the broader applicability of the CIC beyond controlled laboratory settings. Indeed, multiple CIC instruments have been deployed for long-term measurements under diverse ambient conditions across various key field locations. For example, CICs have been integral to continuous long-term monitoring at prominent atmospheric research stations, including SMEAR Estonia, SMEAR II in Hyytiälä, Finland, Ny-Ålesund Research Station, and even the challenging and remote environment of Dome C, Antarctica. Kulmala et al. (2024) have already published the first CIC measurements from SMEAR II, covering two and a half months. Forthcoming publications will present measurements from Ny-Ålesund (Vaittinen et al., 2025, conference abstract) and other field sites.

Minor comments:

Abstract: I suggest adding a description of CIC application prospects to the abstract.

We added a short mention about CIC applications to the abstract.

> *The CIC is primarily designed as a robust, low-maintenance instrument prioritizing ease of operation and broad applicability, including laboratory experiments, long-term unattended field measurements, as well as mobile, airborne and battery-powered setups. The main application of the device is to study temporal development of total*

cluster ion concentrations while also providing some information about the ion mobility distribution.

Line 146: The full name of NAIS needs to be given here.

The full name was added.

References:

Kulmala, M., Tuovinen, S., Mirme, S., Koemets, P., Ahonen, L., Liu, Y., Junninen, H., Petäjä, T., and Kerminen, V.-M.: On the potential of the Cluster Ion Counter (CIC) to observe local new particle formation, condensation sink and growth rate of newly formed particles, Aerosol Research, 2, 291–301, https://doi.org/10.5194/ar-2-291-2024, 2024.

Vaittinen, A., Sarnela, N., Sipilä, M., Brasseur, Z., Boyer, M., Righi, C., Thakur, R., Mazzola, M., and Quéléver, L.: New Particle Formation and Condensable Vapours in an Arctic Site: Ny-Ålesund, EGU General Assembly 2025, Vienna, Austria, 27 Apr–2 May 2025, EGU25-18095, https://doi.org/10.5194/egusphere-egu25-18095, 2025.