Reviewer #1

The manuscript by Li et al. investigates the roles of oxygenated organic molecules (OOMs) and sulfuric acid (H_2SO_4) in explaining atmospheric nanoparticle growth. To isolate condensational growth from coagulation, the authors developed a laminar flow reactor that enables the independent quantification of these two processes. The study combines laboratory experiments using both biogenic and anthropogenic precursors with field observations, providing a comprehensive assessment of particle growth under controlled and ambient conditions. The measurements employ three complementary mass spectrometers to maximize the detection of condensable organic vapours. My expertise lies primarily in atmospheric measurements and modelling, and therefore my comments focus on these aspects rather than on the design and characterization of the newly developed reactor.

Overall, the laboratory and field measurements are comprehensive, the methodology is robust, and the manuscript is well organized and easy to follow. The authors compare several published volatility parameterizations and demonstrate that six of the seven overestimate condensational growth. They attribute this primarily to parameterizations developed for biogenic environments that predict lower OOM volatilities, particularly under high-NO_x conditions. I believe this is an important contribution to the field and recommend publication after addressing the following minor comments.

Response:

We sincerely appreciate *Reviewer #1's* careful evaluation and positive assessment of our work and constructive comments, which have significantly improved the clarity and quality of our manuscript.

Minor comments

Comments #1. *A summary table comparing the seven volatility parameterizations would greatly improve readability. In particular, it would be useful to summarize the required input variables and intended application of each parameterization. Since the Zhang et al. parameterization is the only one that underestimates condensational growth, the authors should also briefly discuss the key differences that distinguish it from the others.*

Response: We thank *Reviewer #1* for this helpful suggestion. We have added Table R1 (also as Table S2 in our revised SI), which summarizes the seven parameterizations, the reaction systems or chemicals from which they were derived, and their required molecular descriptors, intended application, and behaviour in our experiments. Besides, we have also added statements in the Section "Evaluation of volatility parametrizations" to elucidate the feature that distinguishes the scheme of Zhang et al. (2026) (Line 253-262 in our revised manuscript) from

the others. The scheme of Zhang et al. (2026) was the only one calibrated via volatilities measured directly from ambient particulate OOMs in the presence of NO_x, whereas the other six parametrizations were mainly built on chamber-generated and CHO-dominated oxidation products from biogenic precursors.

Line 253-262 in our revised manuscript:

"Table S2 summarizes the seven parameterizations including the reaction systems or chemicals from which they were derived, and their required molecular descriptors and intended applications. The seven schemes mainly differ in the volatility datasets upon which they were built. Six of them rest mainly on chamber-generated oxidation oxygenated products from biogenic precursors, which are dominated by CHO compounds. In contrast, the scheme of Zhang et al. (2026) was calibrated against the volatilities measured directly from ambient particulate OOMs at urban and suburban sites. These OOMs are formed in the presence of NO_x and include N-containing species, so that the scheme is constrained over a wider part of formula space whereas the other schemes sample only weakly. In a comparison with the scheme derived from the National Cancer Institute (NCI) open database, this scheme performed comparably to the other schemes for CHO compounds and better than others for CHON compounds. Therefore, it can be expected to more realistically describe the volatility of OOMs formed under high-NOx conditions, consistent with its closer agreement with our laboratory growth experiments (Sect. 3.2)."

Table R1 (Table S2 in our revised SI). Inter-comparison of the seven OOM volatility parameterizations evaluated in our study. *n*C, *n*O and *n*N denote the numbers of carbon, oxygen and nitrogen atoms in the molecular formulas of OOMs.

Parameterization	Derivation basis	Required inputs	Intended application	Behaviour in this study
Li et al. (2016)	Large dataset of organic compounds (>3×10^4 species) spanning CH, CHO, CHN, CHON and CHOS classes, with vapour pressures from measurements and group-contribution estimates; not specific to autoxidation products	*n*C, *n*O, *n*N (class-specific coefficient sets)	General volatility estimation across a broad SOA compound space ("molecular corridors")	Reproduced GRs under low NOx; overpredicted under high NO_x, most strongly for toluene + OH
Stolzenburg et al. (2018)	α-Pinene-derived HOMs generated in the CLOUD chamber; formulation adjusted to reproduce nanoparticle growth between −50 and +25 °C	*n*C, *n*O; explicit temperature dependence	Biogenic nucleation and early growth across a wide tropospheric temperature range	Reproduced GRs under low NO_x; overpredicted under high NOx
Mohr et al. (2019)	FIGAERO-CIMS measurements-derived volatilities of α-pinene oxidation products (boreal forest and chamber measurements); revision of Donahue et al. (2011)'s formulation with a modified oxygen term	*n*C, *n*O	HOMs-driven nanoparticle growth in BVOCs-dominated boreal environments	Reproduced GRs under low NO_x; overpredicted under high NOx
Qiao et al. (2021)	Revision from Mohr et al. (2019), extended to the OOM population observed in urban Beijing, including N-containing species	*n*C, *n*O, *n*N	OOM contribution to the growth of newly formed particles in urban environments	Systematically overpredicted growth across all precursor and NOx conditions
Dada et al. (2023)	Sesquiterpene ($C_{15}H_{24}$) and monoterpene oxidation products generated at CLOUD chamber	*n*C, *n*O, *n*N	Biogenic new particle formation including sesquiterpene oxidation	Reproduced GRs under low NOx; overpredicted under high NOx
Stolzenburg et al. (2025)	Formulation refined against autoxidation products from biogenic VOCs, developed in the context of nanoparticle mass-closure analysis	*n*C, *n*O, *n*N	Mass closure of nanoparticle growth in BVOC-dominated environments	Systematically overpredicted growth across all precursor and NOx conditions
Zhang et al. (2026)	Volatility measurements by FIGAERO-iodide-CIMS of ambient particulate OOMs from urban and suburban sites in eastern China (mixed anthropogenic–biogenic environment with high NOx)	*n*C, *n*O, *n*N	Ambient OOMs in polluted, NOx-influenced environments	Best agreement with measured GRs in all laboratory experiments; slight underprediction of ambient GR at Lake Tai

Comments #2. *The title, abstract, and conclusions attribute the remaining unexplained particle growth to additional processes that are not represented in the current framework. While this is certainly a plausible interpretation, the manuscript should more explicitly acknowledge other sources of uncertainty, including incomplete detection of condensable vapours by current instrumentation, uncertainties in particle size distribution and growth-rate measurements, and uncertainties within the modelling framework itself. I therefore encourage the authors to slightly soften the title and conclusions to better reflect these remaining uncertainties.*

Response: We thank *Reviewer #1* for this helpful comment. We agree that more attention should be paid to our main findings and the associated uncertainties from our measurements and the modelling framework, instead of emphasizing on the additional processes (e.g., heterogenous reactions) responsible for the remaining unexplained particle growth. Therefore, we have modified our statements to better reflect these remaining uncertainties.

The title has been changed from "Overestimated organic condensation reveals an underperformance in estimation of ambient nanoparticle growth" to "**Organic condensation derived from different volatility parameterizations and its implications for ambient nanoparticle growth**", so that the title now precisely describe our results, i.e., the condition-dependent overestimation by existing volatility parameterizations, rather than an inference about the growth closure of ambient nano-particles with diameters less than 15 nm. Besides, the statements describing our results as a strong evidence that coagulation and condensation alone cannot account for ambient particle growth have been removed and the closing sentences of the abstract have likewise been rewritten (lines 25-26 in our revised manuscript): we now report that coagulation together with H_2SO_4 and OOM condensation accounts for on average about 53% of the observed 3-15 nm growth rate, and roughly 86% at the upper limit of the estimated uncertainty in OOM concentrations, and we present the unexplained gap as a lower limit and was attributed to additional processes absent from our present framework.

The discussion section (Sect. 4) has been modified to treat the three sources the reviewer identifies explicitly, and to state the direction in which each acts:

(i) Incomplete detection of condensable vapours. To the best of our knowledge, the instrument combination of Vocus-PTR, Iodine-CIMS and Nitrate-CIMS can detect almost all condensable vapours in our laboratory experiments and ambient observations. However, certain species could be missed, likely species with few hydrogen-bond-donating groups, weakly iodide-binding compounds, peroxides and organic nitrates subject to fragmentation in the Vocus-PTR, and condensable species outside our elemental definition of OOMs.

(ii) Size-distribution and growth-rate measurement. The observed GR was derived from a linear

fit to the mode diameters of the growing nucleation mode between 3 and 15 nm (Fig. R1, also as Fig.S19 in our revised SI). The fitted $GR_{3\text{-}15}$ was 12.03, 11.84, 11.77 and 9.69 nm h^{-1} for the four NPF events, with standard errors of 1.49, 1.24, 0.54 and 1.06 nm h^{-1}, respectively, i.e. 5-12% of the fitted values. These errors reflect only the scatter of the mode diameters about the fitted line during the growth period. Also, further contributions may arise from counting statistics, the size-dependent transfer function and detection efficiency of the 1-nm SMPS and the PSM, and the choice of mode-fitting and growth-rate retrieval. Although the uncertainties from the instruments and methods may have an effect on our estimations, their contributions could be minor.

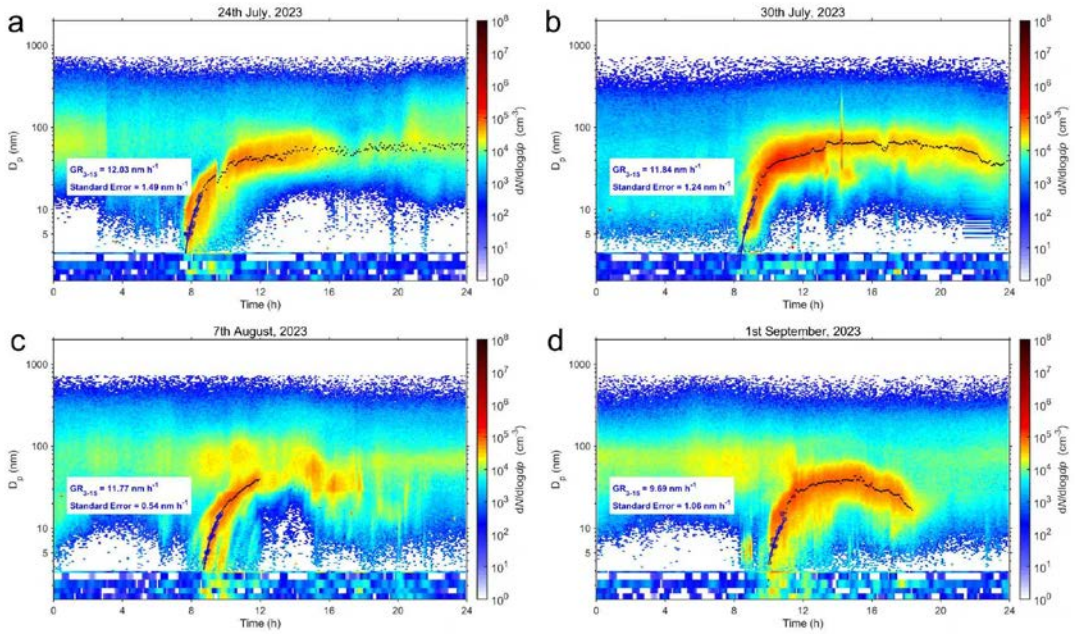


Fig. R1 (Fig.S19 in our revised SI). **Observed growth of newly formed particles.** Particle number size distributions on (a) 24th July, (b) 30th July, (c) 7th August and (d) 1st September 2023. Blue circles mark the mode diameters used for the fit, and the blue line shows the linear fit between 3 and 15 nm. The fitted $GR_{3\text{-}15}$ and its standard error are given in each panel.

(iii) The growth model. We now explicitly state that the model assumes internally well-mixed, spherical particles with unit activity coefficients, and that it neglects particle-phase reactions and possible viscosity limitations to bulk diffusion. Non-ideal mixing, a reduced effective surface tension for organic-rich nanoparticles, or particle-phase reactive uptake would lead to the increasing of the simulated condensational growth.

Regarding to these concerns, we took the uncertainties from both measurements and calculations into account, and the unexplained “gap” was treated as a lower limit, due to the simulated growth was obtained at the upper limit of uncertainties from our measurements. An

unexplained gap is still about 14% even under these favourable simulation conditions, indicating that the missing of some growth mechanisms from the current framework. We now state that this gap cannot be attributed to a specific process, and heterogeneous chemistry on the particle surfaces is proposed as one plausible candidate among these processes rather than as a conclusion.

It should be noted that this softening only applies to the interpretation of the unexplained gap between simulated and observed ambient growth, and not the laboratory results (i.e., volatility parameterizations trained predominantly on the products of oxidation of biogenic VOCs systematically overestimate OOM condensation under NO_x-rich conditions, and correcting this bias is a prerequisite for any meaningful attribution for the remaining nanoparticle growth gap), which remain firmly supported.

The corresponding revisions read (Sect. 4, lines 371-380):

"On the other hand, several sources of uncertainty besides unrepresented mechanisms could contribute to the gap. First, the detection of condensable vapours is not necessarily complete: although three complementary mass spectrometers were deployed, it is likely that no combination of ionization schemes captures the entire condensable vapour population. In addition, species with low ionization efficiency towards NO_3^-, I^- and H_3O^+, thermally labile or strongly wall-adsorbing compounds, and condensable species falling outside our OOM definition would be missed. Second, the observed size distributions and growth rates also carry a potential uncertainty. Below 15 nm, this comes from low particle counts, the size-dependent efficiency of the 1-nm SMPS and PSM, and charging corrections. The method used to retrieve the growth rate adds further uncertainty (Cai et al., 2020). Third, the growth model is simplified. It assumes that particles are spherical and internally well mixed, with unit activity coefficients, and it neglects particle-phase reactions (such as oligomerization and chemical aging) and possible viscosity limitations to diffusion in freshly formed particles. "

Comments #3. *The discussion would also benefit from placing the results within the context of other recent studies on condensational growth. In addition, it would be interesting to comment on the broader applicability of the conclusions beyond Lake Tai. For example, would the Zhang et al. parameterization also underestimate particle growth under low-NOx, biogenic environments such as Hyytiälä, Finland, or is its performance expected to be location dependent?*

Response: We thank *Reviewer #1* for this suggestion. Because we have no such comprehensive field datasets from other environments such as low-NO_x, biogenic atmospheres,

we have extended the discussion by published studies. Nevertheless, our discussion is based on existing results from previous studies that used other volatility parameterizations. In boreal forest site (e.g., Hyytiälä, Finland), the simulated growth rates based on HOM condensation have been reported to either agree with ambient observations (Mohr et al., 2019) or, in a more comprehensive later analysis, exceed observations (Stolzenburg et al., 2025), with the latter discrepancy attributed to evaporation of particulate organics. Our laboratory evaluation suggests that at least part of such an overprediction may originate from the volatility parameterization. In urban Beijing, OOM condensation was found insufficient to explain the observed growth of sub-10 nm particles (Qiao et al., 2021), whereas at a roadside site in Leipzig, traffic-related vapours were sufficient to explain the observed rapid growth (Brean et al., 2024). These studies differ in how completely the condensable vapours were measured and in how particle-phase processes were treated, so that the closure result at a given site reflects more than the volatility parameterization alone. Our laboratory experiments isolate the volatility parameterization from these factors, because the vapours are measured and the growth is observed under controlled conditions.

On a broader applicability, our approach is not specific to Lake Tai. The laboratory experiments cover biogenic (α-pinene + O_3) and anthropogenic (toluene + OH) precursors under both low- and high-NOx conditions, and the Zhang et al. (2026) scheme, which is based on a wide range of OOM species, gave the closest agreement with the measured growth. In the low-NO_x α-pinene + O_3 experiments, which resemble biogenic environments such as Hyytiälä, it slightly overpredicted growth (Fig. 3a and 3c), consistent with the overprediction reported for Hyytiälä (Stolzenburg et al., 2025). The growth gap at Lake Tai more plausibly reflects factors that the laboratory experiments exclude, namely growth processes not represented in the model, condensable vapours not detected by our instruments, and measurement uncertainties (Sect. 3.3). Whether a similar gap exists elsewhere can be tested in future closure studies that combine complete vapour measurements with growth observations.

Technical comments.

• *Line 135: "limited resolution" is missing a unit.*

• *Figure 4 legend panel c: "Zhang (2025)" should be updated to "Zhang (2026)."*

• *Supplementary Figure 13: "Fig." should read "Fig. S13."*

Response:

Line 135: we thank *Reviewer #1* for noting the ambiguity. The quantity is the resolving power $R = Z/\Delta Z$, which is dimensionless; we have made this explicit in both the main text and

the Methods.

Figure 4c has been regenerated with the corrected label “Zhang (2026)”.

The supplementary figure caption has been corrected to “Fig. S13.”, and we have taken the opportunity to correct several further cross-reference and typographical errors identified during revision.

References

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