We provide detailed responses to all comments below; the responses are shown in blue, and all revisions in the manuscript are highlighted in red, with specific changes bolded.

This manuscript demonstrates that atmospheric new particle formation (NPF) is governed not by ozone (O_3) levels alone, but by the temporal synchronization between precursor production and background aerosol removal. The authors show that such synchronization is primarily controlled by the evolution of the planetary boundary layer, with NPF occurring when post-sunrise boundary-layer development simultaneously enhances near-surface oxidation capacity through mixing of O_3 from above and reduces the condensation sink. On the other hand, stable PBL conditions can either lead to low O_3 levels or high background aerosol concentations leading to low low source rate or high sink of newly formed particles.

In my opinion, methodological strength of this work is the combination of NPF classification with interpretable machine-learning tools. By integrating generalized additive models with SHAP analysis and vertical observational data, the authors quantitatively attribute nucleation-mode particle variability to individual meteorological, chemical, and aerosol parameters under different pollution regimes. This approach represents an advance over traditional correlation analyses and offers a clear framework for diagnosing nonlinear source–sink competition in NPF studies.

In addition to the comments provided by Referee #2, I suggest adding a short discussion on how the authors think the identified source–sink mechanisms would be expected to generalize to other regions, seasons, or pollution regimes. Since this study is based on an intensive observation period of roughly two weeks at a single site, it would help setting this study into broader context and to prevent overinterpretation of the results obtained here.

I recommend the manuscript to be accepted for publication.

Response: We sincerely thank the reviewer for the very positive overall assessment of our work and for this constructive and important suggestion. We fully agree that placing the present results in a broader spatial, seasonal, and chemical context is essential, both to underscore the wider relevance of the proposed mechanism and to avoid overinterpretation given the limited duration and single-site nature of our observations.

Following the referee's suggestion, we have added a short discussion at the end of the Conclusion section that explicitly acknowledges the observational constraints of the present dataset and outlines how the identified source–sink synchronization mechanism may be expected to generalize to other regions, seasons, and pollution regimes.

Modified content (Section 4, Lines 364-380): It should be noted that the data utilized in this study were derived from a 25-day intensive observations conducted at a suburban site within

the Yangtze River Delta region. Consequently, the source-sink synchronization framework proposed herein is best regarded as a mechanistic insight at the process level, rather than as a strictly quantitative law. Nevertheless, we believe that this framework can still provide a useful reference for understanding NPF processes in other atmospheric environments, because the temporal synchronization of source enhancement and sink weakening driven by boundary layer development does not depend on the specific emission characteristics or meteorological conditions of this study site. Naturally, the specific forms of the source and sink terms will vary with changing environmental conditions. For instance, in coastal or forested regions, source terms may be dominated by biogenic volatile organic compounds (BVOCs) and their oxidation products, while condensation sinks may be more heavily influenced by sea salt or natural organic aerosols. Conversely, during winter, when photochemical activity is attenuated and stable boundary layers are more prone to persistence, the process of source-sink synchronization becomes more difficult to establish. Furthermore, we hypothesize that this framework holds the greatest explanatory power under conditions of compound O_3-$PM_{2.5}$ pollution; in cleaner atmospheric environments, however, NPF may be more constrained by weak source conditions. Thus, these contextual variations do not negate the applicability of the framework; rather, they indicate that when applying it across different regions or seasons, the specific source and sink terms must be re-identified in accordance with the prevailing atmospheric environment. Therefore, further research is needed to assess the universality of this mechanism based on data from multiple sites and long-term observations, and to quantitatively test its applicability under different atmospheric conditions.