The reviewer comments are listed in black below, while our replies are in *blue and italics.*

Table of content:

Other changes:

- *Acknowledgements and funding have been updated.*
- *On the request of the editor, we have updated the title to be more in accordance to the ACP guidelines (https://www.atmospheric-chemistry-and-physics.net/policies/guidelines_for_authors.html):*
    - *Process evaluation suggests models misrepresent the precipitation-driven replenishment of cloud condensation nuclei*
- *We have also edited the abstract and conclusions to more align with the ACP guidelines. For the abstract we have added a knowledge gap sentence as the third sentence ("[…] However, the ability of general circulation models (GCMs) to capture this precipitation-driven replenishment and size-dependent losses remains under-explored. […]") and shortened other sentences slightly. For the conclusion, we have added an implications paragraph at the end:*

  "The model deficiencies highlighted here have implications for climate projections in several ways. Firstly, a misrepresentation of CCN replenishment after rain is a symptom of a more general problem, i.e. that the path from NPF to CCN is not well represented. This matters because NPF becomes more important for the CCN budget in cleaner atmospheres, thus acting as a buffer for changes in other emissions Gordon et al. (2017), e.g. reductions in future climate projections. At ATTO station, our results suggest that two models (NorESM and EC-Earth) overestimate the impact of CCN replenishment after rain via NPF, likely due to an overestimation of organic aerosols. At the high latitude stations however, all the models underestimate this same impact. If high-latitude conditions are more representative of the global atmosphere, this bias would lead models to overestimate the climate impact of future changes in aerosol emissions; if ATTO-like conditions dominate, the opposite bias would result. Future research should therefore focus on including more stations and a global perspective as well as model development. Secondly, the poor performance of models in the cold season at Zeppelin station may lead to unrealistic feedback representations as the Arctic warms under global warming, due to shifts from glaciated, to mixed and liquid clouds. Ultimately, narrowing these process-level biases in the precipitation–NPF–CCN pathway will aid in constraining the magnitude of aerosol-driven climate forcing and feedbacks under continued emission reductions."

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Referee #1

I thank the authors for their additional work on this manuscript, which has addressed all of my previous comments. My only remaining concern is that the Supplement remains very long (more than 80 figures) with, as far as I can tell from a very quick search of the text, some figures which are not actually referenced in the main body. The authors could consider further condensing the amount of information in the Supplement to aid comprehension. However, since this is a very minor point which does not influence the overall quality of the article, I leave it to the authors to decide whether more information can reasonably be taken out. Other than this point I recommend that the article be published in its current form.

We would like to again thank referee 1 (Ruth Price) for the valuable work and comments.
About the supplement: We understand it seems like some figures are not referenced and we have indeed found 2 figures that were not referenced (these have been removed, see below), but mostly this is because some are referenced as whole sections or as Figs. X-Y. Note that in section S11 the section numbers have been changed (S11.2-11.4 are now 11.1.1-11.1.3).

- *Figures S26 and S27 were not referenced and have been removed.*
- *Section S10 was not referenced, but for completeness we would like to keep it and have added a reference to it now where Fig. 6 is discussed (L423). It contains the plots which are equivalent to Fig. 6, but for other stations and seasons.*
- *Section S11 is referenced in its entirety and 11.1 is needed for openness about the performance of XGBoost.*
- *Sections 11.2 and 11.3 contain figures that are not referenced, but we would like to keep the plots for completeness because if not we would show this analysis only for some stations (where it comes up in the main text).*
- *Section S11.4 is also referenced in its entirety and important for openness about the choices for XGBoost.*

Referee #2

Having reviewed the response and subsequent changes to the paper, following my initial review I am satisfied that the authors have addressed all concerns I had. I would like to thank the authors for their efforts in responding to my suggestions. I therefore believe that this paper should now be accepted for publication, pending minor changes outline below:

We would like to thank referees 2 (Carton-Kelly and Jones) again for their valuable feedback and help with this study. We have implemented all the suggestions.

[L159] "Sectional Aerosol module for Large Scale Applications" add (SALSA)

Thank you, this has been corrected.

[L163-165] This information is repeated in the "Nudging" section at [L185] so can be removed

Thank you, this has been changed accordingly.

[L201] "In-cloud impaction scavenging in stratiform clouds:" should start on a separate line

Thank you, this has been changed accordingly.

[L213] "applies scavenging" to "applies a scavenging"

Thank you, this has been changed accordingly.

[L259] "Global Data 5" I can't find where the 5 comes from, online or otherwise so I think it's a typo

Thank you, this has been changed accordingly.

[F9] There are two figure 9d's, the last plot should be (h)

Thank you, this has been changed accordingly.