

## ***Interactive comment on “Estimating the contribution of ion–ion recombination to sub-2 nm cluster concentrations from atmospheric measurements” by J. Kontkanen et al.***

**Anonymous Referee #1**

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### **General comments**

Contribution of ions in new particle formation has long been a topic of research and scientific debate. In earlier studies (e.g. Kulmala et al., 2013) neutral cluster production via ion-ion recombination has been described by simplified balance equation which takes into account ion-ion recombination and loss via coagulation. This work has completed the simplified balance equation by taking into account additional plausible processes, like growth of recombined clusters. In the manuscript, effect of cluster growth on neutral cluster concentration estimation was analyzed. This work fits well in the line of works which either experimentally or theoretically have tried to investigate

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neutral cluster formation via ion-ion recombination. This work can be published with minor corrections. In addition to comments by the other referee, following suggestions to further improve the manuscript should be considered.

### **Specific comments**

**Abstract, page 20810, lines 2-5:** At this point of the manuscript it is not clear to reader what is new in methods used here. One or two sentences of what was done and what is new should be added. Conclusions, page 20822, lines 25-26 should be revised accordingly.

**Abstract, page 20810, lines 12-15:** The observed small fraction of ion-ion recombination products from total neutral cluster concentration is consistent with earlier studies. However, I think that the authors should emphasize in the abstract and conclusions that taking into account growth of clusters has large influence on results (page 20822, lines 4-24). When cluster growth is included in the analysis the authors could estimate maximum production of neutral clusters from ion-ion recombination by deploying  $\lambda$  (maximum fraction of stable recombination products) equal to 1. If growth is not taken into account  $\lambda$  gets experimental values between 0.1 and 1 in order to provide reasonable estimates for recombination product concentrations. I think this is one of the most important results of this work but it is only shortly mentioned in the conclusions and not at all in the abstract.

**Page 20811, line 30–page 20812, line 1:** Methods to estimate growth rate and coagulation sink are from earlier studies. This sentence needs to be revised accordingly.

**Page 20816, line 9-11:** There are some inaccurate descriptions in the manuscript. As an example, the growth rate method needs to be explained a bit more clearly here since results depend strongly on growth rate. On page 20821, before discussing the last figure, first explanation of done growth rate analysis is finally given. Additionally, explain here why this method was chosen.

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**Page 20818, first paragraph:** This paragraph is difficult to follow and should be revised. The  $\lambda$  is one of the important variables which have large influence on results. Readers should not first have to go through other references before generally understanding what was done in this work.

**Page 20820 and 20835, Fig 4:** Add error bars based on concentration measurement and mobility/size interval uncertainties which can be large. There should be discussion in the text what is different in Fig. 4 and corresponding figure in Kulmala et al. (2013). I think that this is good point to clarify reason for different temporal evolution of total neutral cluster and recombination product concentrations. Similarly, short analysis based on Fig 5 should be given.

**Page 20824:** What is authors' recommendation which method should be used in other studies in future: the presented method with growth rates from new particle formation event periods or the simplified method used in earlier studies?

**Figures 1-3 and 6:** Are data from whole measurement period considered in these figures?

#### **Technical comments**

**Page 20811, line 20:** Work by Tammet et al. should be cited in the introduction.

**Page 20828:** remove reference from table caption.

**Page 20831, table 4:** round values are accurate enough for concentrations  $N_x$ .

**Page 20832:** Is error bar appropriate name for 5th and 95th percentiles?

#### **References**

Kulmala et al.: Direct observations of Atmospheric Aerosol Nucleation, Science, 339, 943-946, 2013.

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 20809, 2013.