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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ion production rate in a boreal forest based on ion, particle and radiation measurements" *by* L. Laakso et al.

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Interactive comment on "Ion production rate in a boreal forest based on ion, particle and radiation measurements" by L. Laakso et al. Anonymous Referee #1

Received and published: 24 August 2004 This paper presents interesting results on measurements of the ion production rate in a boreal forest. This work is important for understanding the role of ion-induced nucleation (IIN) in forests. The authors compare ionization rates derived from measurements of cluster ion and particle concentrations and measurements of radiation and radon. This work is suitable for publication in ACP. Some specific comments that should be considered prior to publication:

Comment: In addition to comments below, also the language was checked and revised.

1. p. 3955, eqn (1). It is not clear from the text and symbols if equation (1) specifically includes the recombination of small cluster ions with charged aerosol. If not this could

lead to an underestimation of the cluster ion loss since the rate coefficients for cluster ion plus oppositely charged aerosol are significantly larger than those for cluster ion plus neutral aerosol.

Comment: All these processes are included. However, since our notations are less clear, we have changed the symbols.

2. p. 3955, eqn (2). Equation (2) applies "in case of charge equilibrium". Is this valid for all conditions, e.g. during nucleation? Some remarks regarding the validity of this assumption would be useful.

Comment: The phrase "in case of charge equilibrium" is not appropriate so we have changed it to “in the case of steady state”. The time constant of the transfer for steady state condition is about 1 minute for small ions in the continental boundary layer air. The “charge equilibrium” of large particles will be achieved after about 1 hour. Therefore, the particles in the size range of nucleation mode are certainly out of the “charge equilibrium” during nucleation burst events.

3. p. 3959, line 20. Presumably the mechanism of IIN is ion cluster growth followed by recombination to make new stable neutral particles that grow spontaneously. What is the specific mechanism for "the additional sink of small ions"? Are the authors referring to enhanced ion-ion recombination during nucleation? This would require an increase in the concentration of ions during nucleation, which seems unlikely. Note that this comment is also relevant to statements on p. 3948 line 14 (abstract), p. 3955 line 11 and on p. 3962 line 11 (conclusion).

Comment: The recombination of small ions (followed by the formation of particle above the critical size for nucleation) can be considered as one mechanism of IIN. "The additional sink of small ions" is the nucleation and the specific mechanism is not specified in the text in page 3959 line 20. The authors are not referring to enhanced ion-ion recombination during nucleation.

4. The consistent lower ion production rates derived from analysis of the cluster ion and particle concentrations are interesting. It may be very valuable to look more carefully over the whole measurement period at possible correlations between the discrepancy (the difference between the ion production rates derived from the two methods) and e.g. the concentration of 3 nm particles (a measure of nucleation), surface area, radon, temperature, RH, etc. This may help to reduce the number of possible explanations for the discrepancy.

Comment: The authors absolutely agree with referee. However, there are not really enough data for this purpose. We may do such investigations after one or two years when we have collected enough data.

5. What are the estimated uncertainties in the derived ionization rates? Are the differences between the two methods significant?

Comment: It is difficult to quantify the errors in indirect method. However, we think that factor of two is not too bad considering the many uncertainties in the method. Considering direct method, we have added the following text to the manuscript: The uncertainty of ionization rate caused by the external radiation is $\pm$ 10 \%.The uncertainty of ionization rate caused by radon varies between 3 and 20 \% depending on the radon activity concentration.

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Interactive Comment