

Review of Yan et al. acp-2018-187

The manuscript analyzes cluster ion data from the SMEAR station in Hyytiälä, Finland, from three springtime measurement periods. Data from anion measurements with an API-TOF mass spectrometer and an NAIS instrument are analyzed. The focus of the analysis is on H₂SO₄-NH₃ cluster ions in comparison to HOM ions and their relation to aerosol nucleation events. It is found that the ratio between [HOMs] and [H₂SO₄] controls the presence of large H₂SO₄-NH₃ clusters. Furthermore, the probability for IIN to occur is largest and reaching almost 100% when clusters containing 6 or more H₂SO₄ molecules are present. The contribution of IIN to the total nucleation is reported to range between 4 and 45%, with an average of 12% contribution for cases that are dominated by H₂SO₄-NH₃ nucleation and 18% in HOM-driven events.

The manuscript is an extension of a series of papers focusing on results from the API-TOF measurements in Hyytiälä (e.g. Ehn et al., 2010 and 2011, Schobesberger et al., 2013 and 2015; Yan et al., 2016; Bianchi et al., 2017). The previous papers focused mostly on the role of HOMs while this one focuses on the role of H₂SO₄-NH₃ anion clusters, therefore the paper presents sufficient new material to warrant publication in ACP.

There is a number of minor points and technical corrections to consider before publication in ACP:

Minor points

line 43: The paper by Dunne et al., Science, 2016 should be referenced here as well.

136: quantification of the API-TOF results. Was the transmission of the API-TOF characterized as described by Heinritzi et al., AMT, 2016? Can you be sure that the transmission did not change due to the changes in tuning (l 139)?

181: What about recombination with ions larger than 3.5 nm?

Figure 2: panel B is as important as panel A. Why is B just shown as a small inset? Please show B as a separate panel of the same size as A, or even as a separate Figure.

347: Please explain in detail how J_{IIN} for 2.5 nm particles was calculated (here, or in Section 2).

404-575: **Please check all references carefully:** In many cases there are co-authors missing (and no "et al." is included), e.g. Bianchi et al., 2017, Dada et al., 2017, Ehn et al., 2010, Ehn et al., 2011, Kulmala et al., 2004, Schobesberger et al., 2013 and 2015, and even in Yan et al., 2016, and many others.

General comment on choice of cited references: There is no doubt that the Kulmala group has produced lots of important research with respect to ground-based cluster ion composition measurements with the API-TOF in Hyytiälä, and it is therefore ok to reference the previous work of your own group frequently. Nevertheless, there have been various contributions to the field of H₂SO₄-NH₃-IIN by other groups and the choice of references discussed for example in the introduction seems somewhat unbalanced. Out of the 34 references listed in the references section, 29 are from the Kulmala group or co-authored by the Kulmala group (and the 5 remaining references are mainly general ones such as reviews or the IPCC report). It is expected in scientific publications to give reference also to the previous work by others that is relevant for your work. Therefore I suggest to mention/discuss also work from other groups, e.g. Eisele et al., JGR, 2006; Iida et al., JGR 2006, Tammet et al., Atm. Res. 2014; Rose et al., ACP, 2013; Boulon et al., ACP 2010; Kurten et al., JGR, 2016; Froyd and Lovejoy, JPC, 2011, etc. to give some credit also to the rest of the scientific world

that performed measurements of H₂SO₄-NH₃ ion induced nucleation and other ion clusters. Also Bianchi et al., Science, 2016; Dunne et al., Science, 2016, and Wagner et al., ACP, 2018, should be included and discussed in the context of this paper (I recognize that these are also co-authored/authored by the Helsinki group).

Technical corrections:

line 65 and 67. Bianchi et al. is referenced twice, one time within a sentence is sufficient.

75: understandings → understanding

92: insert space between semicolon and Ehn, as well as between semicolon and Yan

111: “daytime spectrum in the daytime...” → avoid duplication

113: “of an ion in *the* APi-TOF...”

115: “note that *the* APi-TOF...”

119: instruments → instrument

120: “is a best instrument” → “is a good...” or “is a well-suited...”

127: not the same in *the three* years...

129: “clusters contained 6 clusters” → “clusters contained 6 SA molecules”

130: “in the clusters were observed” → were observed in the clusters

131: larger than 700 Th *for the measurements in 2011*.

133: Figure 3 is called here before Figure 2 is called. → Change order of Figures 2 and 3.

139: tunings of CI-APi-TOF → *tuning of the* CI-APi-TOF

181, 184: “Eq. S2” → change numbering of the Equation to “Eq. 2”

197: *A similar* approach

204: measurements → measurement

204: dependant → dependent

242: prevents → suppresses

261: “by observing an increase...” (delete “of”)

262: “sub-2nm ions”, I think you mean “ions *larger* than 2 nm” here?

279: “...unclear is IIN occurred was counted...” → “...unclear *if* IIN occurred *were* counted...”

289: permanence → continuity

319 and 324: *the* other type of events

321: less → lower

322: clusters at high temperatures that *can evaporate* NH₃ back to the atmosphere.

340: Figure 5, panel B: “cloudiness parameter” should probably be “clear-sky parameter”, or it should be explained that 1 = clear-sky = 0% cloudiness; and 0 = 100% cloudiness

349: This *indicates*

361: Figure 6, panels B and C could be depicted with identical y-range (e.g. 10^{-2} to 20), then a comparison would be easier. At least some tick marks should be added to panels B and C.

368 “Summary and Conclusions” → “Summary” (there are no new conclusions, it is just a summary of the findings presented previously)

380: from → for

382: *on* other days

385: *a* mechanism

385: at least responsible for → responsible for at least

404: Reference → References