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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Amines in Boreal Forest Air at SMEAR II Station in Finland" *by* Marja Hemmilä et al.

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We thank the reviewer for the helpful and constructive comments, which we address in detail below.

1. Please provide detailed information of the sampling period. What was the rationale to pick the 8 weeks during the 8 months? Since the study emphasizes seasonal variations, how confident can one be with measurements from relative short sampling periods in each month to make conclusions about seasonal changes?

Our plan was to measure from spring to autumn, and not only 8 weeks. Unfortunately, the instrument had failiers and leaks, and 8 weeks was only we could achieve. Our data includes 117 data points in March, 112 in April, 163 in May, 91 in July, 133 in

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August, 128 in November and 54 in December and we have included this information to the Table 4. This is much more data than has been published earlier.

2. Section 2.2: Authors simply use one sentence to cite previous work as Junninen et al. 2009 without a brief description of what this portal is. A bit more information is warranted. In addition, Junninen et al. 2009 is missing in the reference list. Please check and add in. In table 1, do environmental conditions have small or big variations during each month? please add standard deviations to each mean value. Also, it would be helpful to make statements of diurnal changes (i.e. day vs. night). Also, please provide information about rain, soil moisture, and soil temperature, as they are important environmental factors in the discussion.

"SmartSmear is the data portal for vizualisation and download of continuous atmospheric, flux, soil, tree, physiological and water quality measurements at SMEAR research stations of the University of Helsinki" sentence was added to section 2.2. We also added the missing reference to the list. Table 1 was moved to Supporting Material (Table S1), because Referee 2 asked. We added standard deviations to the Table S1. We also added information about rain, soil humidity and soil temperature to the Table S1, but the day and night means we did not find meaningful to add to the Table.

3. Misleading description at the very beginning of section 3.1: "Figure 1 shows the monthly means and medians of total amine concentrations (sum of gas and aerosol phases) ". Figure 1 only shows means. Correction is needed. It is confusing to claim monthly mean changes as seasonal variations (shown in figure 1) unless the authors define the seasons at first. In the figure, half of the species (EA, DEA, PA and BA) have different scales than the rest. Please consider using two different y-axis scale in one plot or having two separate plots in order to provide more clear trends for each species. Please clarify the meaning(s)/significance of showing the sum concentrations of gas and particle phases measurements (Figure 1 and 2). Tables 3 and 4 seem to de- liver similar cumulative results as Figures 1 and 2 but in separate phases, which are arguably better to understand.

The word “median” has been deleted. We have added which months refer to which season in chapter 2.1. Sentence “Total amine concentrations were used because we wanted to study amine sources and partitioning between aerosol and gas phase are dependent on environmental parameters.” was added to chapter 3.1. Figure 1 was moved to Supporting material because the Referee 2 asked.

4. Line 185-190: “The concentration increase in March is characterized with rain (Fig. 4) and the later increase in April took place during night with decreasing wind speed and higher temperature. This increase could be due to evaporation from melting snow and ground.” In Figure 4, the time scale on x-axis is too rough to provide ar vision of diurnal variation. Improvement is needed. It indicates rainfall is featured with high MMA concentration in March (Figure 4), which is mostly in the particle phase, as shown in Table 4. Does such high MMA relate to previous cloud processing? Except rainfall, do the other environmental conditions have potential influences? Authors should expand discussion here. No detailed information of wind speed and ambient temperature is provided to support the discussion. More explanations and possible references could assist the discussion about evaporation from melting snow and ground.

We have split the Figure 4 in three pieces to make it clearer. We also add wind speed and ambient temperature data in April to the figure.

5. For Section 3.1.4, the authors should include discussion to more extensive literature examining this species. There are a number of references in fact for all of the amines, but for DMA, at the minimum a couple of references with discussion of sources and behavior of DMA are the following: Youn, J. –S., et al. (2015). Dimethylamine as a major alkyl amine species in particles and cloud water: observations in semi-arid and coastal regions, Atmos. Environ., 122, 250-258, doi:10.1016/j.atmosenv.2015.09.061. Murphy, S. M., et al. (2007). Secondary aerosol formation from atmospheric reactions of aliphatic amines, Atmos. Chem. Phys., 7, 2313–2337.

We have added more discussion to Section 3.2.2 (former 3.1.4) with Youn et al. We

could not find much discussion about dimethylamine in Murphy et al, but the reference was valuable to Introduction.

6. Figure 5: Time scale on x-axis is too rough to tell diurnal circle. Improvement is needed.

More detailed time scale for x-axis was added.

7. Section 3.1.4: Authors emphasize DMA (and TMA) concentration higher in summer (i.e. August) due to biogenic sources. However, interpretations/discussion leading to that conclusion are not convincing in my opinion. It mentioned that DMA does not show correlation with biogenic tracer such as monoterpenes, while isoprene is noted as having light dependent emissions. Please provide supportive BVOC tracer information if the data is applicable. Are there BVOC tracers other than isoprene found related to variations of DMA and (or) TMA? In Figure 6, DMA shows strong diurnal cycle while TMA doesn't. Is the DMA diurnal circle found only during summer, especially August? Why is it that TMA does not have such a strong diurnal circle as it also mentioned in section 3.1.2? Authors should expand discussions here.

The DMA diurnal cycle is found only in summer. It is determined by the balance between emissions, reactivity and mixing in the atmosphere. Therefore the compounds emitting from the same sources can have different atmospheric concentrations. Usually the diurnal variation is mainly determined by mixing, causing daytime minima, but if emissions are light dependent or strongly temperature dependent, then the maxima is at daytime. This is mentioned in section 3.2.4. However, we have not mentioned in the text that higher summer time concentrations also indicate biogenic sources. This has been added to the text. Sources and source areas of DMA and TMA are not known, and different diurnal cycles can be caused by different balance between emissions, reactivity and mixing.

8. Figure 7: The current plot is hard to show the clear relationship between DMA and selected environmental factors, especially for data around July and December. Please

consider zooming in time scale on x-axis, for an example, using a discontinued time series.

We have made the Figure clearer according to the reviewers wish.

9. Line 295- 300: Does TMA negatively correlate with ambient temperature consistently or is this sensitive to season?

Yes, it is sensitive to season, we added a picture to Supplement (Figure S5).

Minor comments 1. Authors should consider adding a site map in section 2.1 in order to provide readers visualized information of study area.

We have added a site map to Supporting material.

2. Line 115: Why are the DL calculation methods for DMA and TMA different from the rest? In table 2, DMA shows different DLs in two time periods, while TMA doesn't. Please clarify the reason(s).

The DMA and TMA DLs were calculated from blank-values, because they had some blank, when the other compounds did not. We have added explanation to the text.

3. Table 1: What is the difference between "mean" and "average"? If they are same, please be consistent. Grey shade is not necessary if the color does not have meaning. Same comment applied to Table2.

We have changed "averages" to "means" and took the color off.

4. Table 2: Some species have a comma after their names while the others do not. Why NH3 and NH4+ are not mentioned in gas (particle) phase as the rest? Keep consistent style please.

We have added commas after every amine. We have added "gas" and "particle" after ammonia and ammonium.

5. Table 4: Typo for DMA median value (particle phase) in July. "4,9" should be "4.9".

We have changed it from “4,9” to “4.9”.

6. Figure 4: Add label for x axis. Same comment for Figure 5. The x-axis represents dates, but it is unclear. In contrast, Figure 7 has better x axis format. ase be consistent in plot style.

We have added the labels.

7. Figure 7: Units on y axis should be in parentheses.

We did this

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