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Interactive Comment

Interactive comment on "Biotic stress accelerates formation of climate-relevant aerosols in boreal forests" *by* J. Joutsensaari et al.

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We thank the referee for valuable comments that we have used to improve our manuscript. We have considered the comments and have modified the manuscript accordingly. Our detailed responses to the referee's comments are below.

Referee's comment: 1) The authors used seedlings in the laboratory experiments. While this is certainly required to make the lab experiments tenable, could the authors comment on potential VOCs emissions difference between adult and juvenile trees? Does the VOC distribution or the total emission change as maturity is reached?

Authors' response, changes in MS: This is an important point. Therefore we have added the following sentence to the discussion (section 3.1).

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"We conducted our laboratory experiment with young seedlings due to practical restraints for a laboratory study, but these results should be representative of emissions of full grown forest trees because monoterpene composition of needles and wood of Scots pine are under strong genetic control. A 19-year monitoring study indicated that seedlings of Scots pine provenances at the age of four and twelve months has similar composition as the fresh cut stumps 19 years later (Kivimäenpää et al. 2012). "

Referee's comment: 2) The authors randomly selected insect-stressed areas for the model portion of the study (see Figure 6 figure caption). While the need for random selection is sensible for initial application, insect outbreaks are not random and are driven by local climate and geography (see Aukema, Ecography, 2008). Outbreak clustering could lead to concentration of VOCs in a more limited geographic range, in comparison to random outbreak, and this could lead to a different AOD distribution, causing local minima. How does the insect outbreak location impact the results of model?

Authors' response: We agree, but argue that such clustering would not have an impact on our main conclusion, i.e. that insect herbivory can affect aerosol forcing on a regional scale. Some indication on the impact of clustering can be seen in Fig. 6, where two or more model grid cells close to each other (over Siberia, Eastern Canada and Finland) are randomly selected to experience insect damage (Fig. 6a). Figure 6b clearly shows that over these areas the strong impact on aerosol mass is spread more uniformly over a larger region than over areas where only one model grid is impacted by insect damage. However, over most areas this effect disappears when looking at CCN concentrations (Fig. 6c). This is because the CCN concentration increase is strongly impacted by the background aerosol size distribution, which varies between the regions. We also note that given the coarse resolution of the model, each model grid cell is $2.8^{\circ} \times 2.8^{\circ}$ in area, and thus the simulated insect outbreaks are not highly localized.

Referee's comment: 3) The analytical precision of the measured values was likely overestimated in a few places. For example in Table 3, the average limonene emission from Neodiprion sertifer damaged was listed to six significant figures, and this level of precision is not practicable (or needed). In addition, the average alpha-terpineol emission was listed as zero, whereas a true zero cannot be reasonably measured, and instead "below detection limits" (with the detection limit listed) is a more commonly accepted practice.

Authors' response: We note that analytical precision of VOC emission rates (ng/g(DW)/h) is lower than values presented in tables (e.g., six digits). Due to large variation in concentrations, we have just presented all VOC values with one decimal. However, standard deviations (SD) of values are also presented so reader can estimate accuracy of results. If needed, we can present the values with 2 significant digits in the revised MS.

Referee's comment: In addition, the average alpha-terpineol emission was listed as zero, whereas a true zero cannot be reasonably measured, and instead "below detection limits" (with the detection limit listed) is a more commonly accepted practice.

Authors' response, changes in MS: Emission rates are calculated from VOC concentration, sample flow rates and needle dry masses so "detection limit" in VOC emission varies case by case. We estimated the average detection limit was around 0.1 ng/g(DW)/h. In the revised version of manuscript (Tables 3, 4 and 5), zero values have been replaced with the term "Not detected" (-) which indicated that values are zero or below detection limit (i.e., very low compared to the values of main compounds).

Referee's comment: Figure 3 and Figure 4, bottom panels: some of mass concentration and number concentration data points are connected by lines and some are not. What do the lines indicate? And why is this inconsistent–were some of the data points removed or averaged/smoothed?

Authors' response: The data points are connected with line in each series. However, zeros and not-a-number (NaN) values cannot plot in log scale and thus lines between

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those and previous/next values are not shown. Anyhow, the values are very low (near to zero) in control experiments so "missing" data points in the figures have not any effect on the results. The results are not averaged or smoothed.

Referee's comment: Suggested Typographical Corrections. . .

Authors' response, changes in MS: Typographical corrections suggested by the referee have been corrected in the revised version of manuscript.

References: Kivimäenpää, M., Magsarjav, N., Ghimire, R., Markkanen, J.M., Heijari, J., Vuorinen, M. & Holopainen, J.K. 2012. Influence of tree provenance on biogenic VOC emissions of Scots pine (Pinus sylvestris) stumps. Atmospheric Environment 60: 477-485.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 10853, 2015.