

Interactive comment on “Aromatic acids in a Eurasian Arctic ice core: a 3000-year proxy record of biomass burning” by Mackenzie M. Grieman et al.

Anonymous Referee #3

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General comments:

The manuscript by Grieman et al. presents a 3000 year record of concentration of vanillic acid and para-hydroxybenzoic acid in an ice core from the Eurasian Arctic. These two aromatic acids derive from combustion of lignin and are considered tracers of biomass burning. In the past, several authors have measured their concentrations in ice cores (McConnell et al., 2007; Kawamura et al., 2012; Müller-Tautges et al., 2016), as acknowledged by Grieman et al. However, Grieman et al. provide longer records, characterised by very high resolution, and measured with a different technique (Ion Chromatography-Mass Spectrometry) than the most commonly used ones (High Performance Liquid Chromatography-MS or Gas Chromatography-MS). For these reasons,

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I think the manuscript represents a substantial contribution to scientific progress. It is certainly within the scope of Climate of the Past, since biomass burning emissions contribute significantly to land carbon emissions, and fire has an important influence on ecosystems dynamics. The scientific approach and the methods are valid and the results are properly discussed. Therefore, I recommend the manuscript for publication. However, there are a few points that need revision/explanation, including the ice dating and the back-trajectories analysis. I would like the authors to answer the following points, before the manuscript is published.

Specific comments:

Page 1, line 7: Could you provide the concentrations in [ng/l] as well (e.g.: 1 ppb=...ng/l)? I feel like [ng/l] is more widely used.

Page 1, line 10: "The timing of these periods coincides with the episodic pulsing of ice-rafted debris in the North Atlantic known as Bond events.". I would add "suggesting a link between fires and large-scale climate variability on millennial time scales"

Page 2, line 25-26: I suggest you delete "because ammonium could be derived from these other sources", as you have already explained it a few lines above.

Page 2, line 27: I would add "... while it can also originate from fossil fuel combustion during industrial times".

Page 3, line 11: You could also mention dehydroabietic acid when citing burning of conifer.

Page 3, line 16-17: In the Introduction, you have discussed the effects of emissions, transport and transformations, but I feel that you should discuss depositional and post-depositional processes more in details. What do we know about possible post-depositional processes?

Page 3 line 27: I suggest you call them "back-trajectories".

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Page 4, line 24-25: Are there blanks to test any possible contamination from the melter?

Page 4, line 28-30: Why did you decide to opt for this second ice age scale? Do you consider it more accurate? If so, why? How older do you mean when you say "substantially older"? Please, provide numbers.

Page 6, line 4: A subset of how many samples were analysed using HPLC-ESI/MS/MS?

Page 6, line 26: "We are not aware of any laboratory combustion studies of the larch typically comprising the likely source regions". This sentence is not clear to me. What do you exactly mean?

Page 6, line 29: From figure 3, I would not say that the levels of VA are generally higher than those of p-HBA in the PILH. Could you specify how you have compared the levels of the two molecules (average, maxima, ...) and possibly provide the numbers for them?

Page 7, line 3-4: How did you quantify the percentage of melt layer in figure S4? Is this already published data?

Page 7, line 7: I would like you to give a definition of the LOESS smoothing either in the Methods section or here.

Page 7, line 14: I would write the periods here

Page 7, line 23: Together with the period 180-220 CE?

Page 7, line 30: If recent VA and p-HBA observations in Arctic snow and atmosphere were available, you could go one step further and use first-order assumptions on transport, transformations and post-depositional processes to estimate the atmospheric aerosol concentration of VA and p-HBA in the region of the Nauk ice core and in the source region, similarly to what done by Fischer et al. (2015) for ammonium. I don't

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know whether recent VA and p-HBA observations are available, but you might want to cite Fischer et al. (2015) anyway, saying that it provides a method to estimate atmospheric concentrations in the source regions, provided that recent observations are available.

Page 8, line 12-16: There is an assumption here that you should discuss: atmospheric circulation has not changed over the past 3000 years. How likely is that assumption to be valid? Is there no evidence of changes of atmospheric circulation over the last millennia, especially over climatically relevant periods, such as the Medieval Climate Anomaly and the Little Ice Age? Some discussion is needed.

Page 10, line 4: I guess you do not mention anthropogenic influence on biomass burning because the human presence in Siberia is negligible. If so, I would spell it out, stating that the lack of significant anthropogenic activity allows you to interpret variations in biomass burning proxies and climate with a cause-effect relationship.

Page 10, line 5-7: See also Seki et al. (2015), Scientific Report

Page 10: line 32: I would add "Figure 8, bottom plot"

Supplementary Figure S1: What do red lines/letters mean? Do they refer to the typical fragmentation in the Mass Spectrometer, as explained at page 5, line 22 of the main text? I would add some explanation in the figure's caption.

Technical comments:

Page 2, line 3: replace "difference" with "different"

Page 6, line 23: replace "gasses" with "grasses"

Page 9, line 19: there is a comma missing between p-HBA and VA: "In that study, elevated p-HBA VA,...."

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