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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.

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The referee raised a few points regarding the manuscript. These points are well taken and we appreciate the comments. The manuscript has been modified to take them into account. The Referee comment is in italics and our response is in a normal font.

Page 2, Line 20-24: Please refer that this point has been extensively addressed in Legrand et al. (2006) and it was concluded that "for Greenland ice, ammonium, formate, OC (DOC or TOC), BC, as well as vanillic and glycolic acids were enhanced well above their background values during fire events."

Revision, page 2, line 28: "Black carbon in ice cores has been used as a tracer for

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preindustrial biomass burning (Chýlek et al., 1995; Legrand et al., 2016; McConnell et al., 2007; Rubino et al., 2015; Zennaro et al., 2014). Ammonium, formate, black carbon, and organic carbon (dissolved organic carbon or total organic carbon) were enriched substantially relative to background levels during fire events in Greenland ice (Legrand et al., 2016)."

Line 24-29, Page 9 (also lines 15-18, page 10): This paragraph needs to be reworded since, as it stands, it gives to the reader the overall impression that only levoglucosan records in Greenland ice are available and useful to discuss past biomass burning activity, which is not correct. In fact, the NEEM record (5-year average) of levoglucosan (Zennaro et al., 2014) suggests an outstanding maximum around 1600 (not revealed by the sub-annual BC and ammonium profiles).

Revision: "Historical changes in biomass burning have also been reconstructed from ammonium spikes in the NEEM and Summit Greenland ice core records. Variations in the frequency of ammonium peaks for the past 1,000 years suggest elevated burning from 1200 to 1500 CE and low burning from 1600-1800 CE (Legrand et al., 2016; Fischer et al., 2015). This pattern of preindustrial burning is different from the Akademii Nauk record, which is not surprising given that Greenland is primarily influenced by transport from North America, rather than Eurasia. These trends are generally consistent with charcoal records from northeastern Canada (Power et al., 2013). Zennaro et al. (2014) presented a 2,000-year NEEM record of levoglucosan and black carbon. They show four preindustrial maxima in levoglucosan, around 100 BCE-100 CE, 200-600 CE, 1000-1200 CE, and 1500-1700 CE. The last of these maxima is strongest and coincident with the 1400-1600 peak in Akademii Nauk aromatic acids. Interestingly, the same feature is not the largest peak for NEEM black carbon. There are clearly unresolved differences between various Greenland ice core proxy records, particularly for the period around 1500 CE."

Revision: "Climate reconstructions based on Northern Hemisphere proxy records show a long-term cooling trend over the past 2,000 years (Fig. 8; PAGES 2k Consortium,

2013; Hegerl et al., 2006; Ljungqvist., 2010; Mann et al., 2008; Moberg et al., 2005). Centennial-scale climate variability, most notably the Medieval Climate Anomaly (830-1100 CE) and Little Ice Age (1580-1880), is superimposed on this trend (PAGES 2k Consortium, 2013; Büntgen et al., 2016; Lamb, 1965; Mann et al., 2009). Akademii Nauk VA and p-HBA levels do not exhibit a trend following the long-term cooling trend in temperature, but they do appear to correlate with some centennial-scale climate variability. Akademii Nauk VA and p-HBA levels are elevated from 380-660 CE, prior to and during the Late Antique Little Ice Age (536-660 CE; Büntgen et al., 2016). The Akademii Nauk aromatic acids are low during the early part of the Medieval Climate Anomaly (prior to 1050 CE). They are slightly elevated during the latter part of the Medieval Climate Anomaly. Tree ring reconstructions suggest that the Medieval Climate Anomaly was humid in Northern Siberia (Siorova et al., 2013). Akademii Nauk VA and p-HBA are elevated from 1460-1660 CE during the Little Ice Age. The Akademii Nauk aromatic acid trends are different from those in composite Northern Hemisphere sedimentary charcoal records, which show an overall decline over the past 2,000 years, with a maximum during the Medieval Climate Anomaly and minimum during the Little Ice Age (Marlon et al., 2008; Power et al., 2013)."

Revision: Ammonium has been added to Fig. 7.

Revised Fig. 7 caption: "Timeline of elevated burning periods in Northern Hemisphere ice core studies. From top: Akademii Nauk vanillic acid and parahydroxybenzoic acid (this study); Belukha glacier nitrate, potassium, and charcoal (Eichler et al., 2011); NEEM levoglucosan and black carbon (Zennaro et al., 2014); NEEM and Summit ammonium (Legrand et al., 2016; Zennaro et al., 2014); and Kamchatka Peninsula parahydroxybenzoic acid, vanillic acid, dehydroabietic acid, and levoglucosan (Kawamura et al., 2012). Lines indicate periods of elevated burning. Grey bars mark the time range analysed in each core."

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