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Climate of the Past Discussions

Interactive comment on "Burning-derived vanillic acid in an Arctic ice core from Tunu, Northeastern Greenland" *by* Mackenzie M. Grieman

Anonymous Referee #2

Received and published: 14 June 2018

This study presents new interesting measurements of vanillic acid as a proxy for biomass burning from an ice core record in northeastern Greenland spanning the past 1700 years. The authors examine the variability in the measurements in light of previously identified changes in climate and fire activity. Questions are posed about the source area of the VA, and the controls on its variability; these are addressed through air mass back trajectory analysis and through comparisons with data from other records and proxies.

The new study represents an important contribution to the literature and the paper is generally clear. Various sections, however, need more careful attention, especially because the data and analyses tend to raise more questions than they answer (although this is often the case, and especially when developing new proxies for environmental

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changes). However, in this case there should be some discussion of what in particular might be most informative/useful going forward in terms of new proxy comparisons, or modeling, etc. Nor is there discussion of the more recent variations and how they compare with historical data, which is a large omission that needs to be addressed, especially given the 2.5-year temporal resolution of the ice core record noted in Section 2.1. Furthermore, how might we better understand the source areas or relationships between VA and other fire proxies from ice (e.g. what benefits does VA provide in comparison with BC, ammonium, levoglucosan, etc.)? Where are the greatest sources of uncertainty? Clarifying the limitations of the existing study and adding some thoughts about 'next steps' would be helpful for those outside the ice core community in particular.

In general, the conclusions are cautious and generally aligned with the data presented. VA holds some promise insofar as it appears consistent with other proxies in showing high fire activity during the RWP and MCA in particular, and low during the LILIA and LIA. With more careful attention to detail, some reorganizing, and some figure clean-up this will make a useful contribution to our understanding of how fire has changed on long time scales and what can be inferred from different proxies.

A few sections in particular need attention.

Section 3.3 – This section is describing methods but is located in the Results section – it seems more appropriate to methods. In addition, the 17% of the summer back trajectories reaching North America is quite low – where do all the trajectories that are not accounted for come from?

Section 3.6 also needs work. The methods referenced are entirely absent from the "Methods" section again and need to be moved and expanded there to understand what exactly was done (Pg. 7 line 19 is insufficient). Moreover, the influence of different modes of climate variability on the VA record are nearly impossible to disentangle given that the decadal-scale variability in the VA record raises more questions than it

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addresses – it seems unclear still what exactly is producing the short-term variability in VA (in terms of fire), let alone what would cause the variations in fire themselves IF that is what the VA variations are reflecting. Furthermore, the features that are most robust in the VA record – high values during the RWP and MCA, and low values during the LALIA and LIA – are still not well understood. The RWP itself is not a well-known or widespread climate feature, so more information and background about that could be provided instead of discussion of possible climate modes that might control fire. I would rather see more investigation into understanding the potential relationships between the VA record and other fire proxies than a detailed investigation into the interannual climate controls on a very uncertain biomass burning reconstruction.

Detailed comments:

Pg 2. VA is described as resulting from the combustion of lignin. McConnell et al. (2007) indicated that conifers in particular are expected to be the primary source of VA – it seems worth noting this again, and also providing more information that might be useful based on the extensive previous research on VA that is cited. E.g. what is the expected atmospheric residence time of VA?

Pg 4 Line 6: Were higher thresholds tried? Would thresholds in the 80s or 90s produce very different results? Why did you choose this range?

Pg 4 Line 8: remove “Clearly” and explain what “these” refers to.

Pg 4 Line 12: should say “fires”

Pg 4 line 20: define the terms in the equation and make your words consistent with the equation.

Pg 4 Lines 26-80 – the equation and its description are not rendering properly (esp. check the capitalization and subscripting; vd, rscav).

Fig. 4 – Please discuss this figure and how it relates to the known fire history of NA. Fire history data are available from tree-ring (e.g. Giardin’s papers, the Canadian

Large Fire Database) and historical studies and the data raise important concerns that warrant more discussion. Specifically, the high VA values in the 1960's and 70's are puzzling given that this pattern is directly opposite what historical records show (e.g. Mouillot and Field, 2005; Mouillot et al. 2006), where burning was very low in the middle part of the century. Many more recent NA fire records generally show that burning has increased most rapidly from low levels since the 1980's (NIFC, Littell et al. 2009). Is it possible that VA could at times have been influenced by some intensive industrial or lumber/logging-related processes that might have been occurring during this time in NA? In any case, in light of these data it is good that the authors state that VA is best considered a qualitative proxy at this stage and requires further exploration – this acknowledgement is appreciated.

The first reviewer raised many good concerns about the correlations presented, I trust those will also be addressed.

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