Clim. Past Discuss.,
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Climate of the Past Discussions

Interactive comment on "Boreal fire records in Northern Hemisphere ice cores: A review" *by* Michel Legrand et al.

Anonymous Referee #2

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The authors aim to determine if fire records vary spatially between northern versus central Greenland sites as well as if transport patterns of the various biomass burning markers affected the fire records. Such a comparison of different fire markers in Greenland ice cores is a worthwhile goal, although the authors should highlight that some of their assumptions and conclusions are specific to Greenland. The first two-thirds of the paper are detailed and provide well-rounded explanations, while the final third feels rushed with a conclusion of the necessity of extracting more ice cores across Greenland for better spatial representation of these markers.

The current studies of biomass burning in ice cores are exponentially increasing. I applaud the authors for systematically investigating the differences between these proxies in a specific region as such comparisons help the ice core and fire science communities as a whole. This paper adds a beneficial review to the literature.

General comments:

The authors have extensive knowledge and a corresponding publication record of investigating ammonium in Greenland ice cores. The authors therefore strongly emphasize ammonium throughout this investigation of biomass burning proxies in Greenland ice cores and compare every other chemical fire marker to ammonium (e.g. Figure 2 and all sections of 3.2). However, the authors should justify why they use ammonium as the marker against which they compare every other record. The paper circuitously mentions (but not until section 3.3) that ammonium is mainly a viable fire marker in the poles as these regions are located far enough away from biogenic sources of ammonium, but this important point should be mentioned very early in the introduction. The authors could strengthen the entire paper if they are able to demonstrate that biogenic ammonium does not influence the ammonium record in Greenland.

Although the authors provide an overview on the known atmospheric lifetime of many of the species, the authors assume that each proxy will follow the same back trajectory. Some markers (ie vanillic acid) may be able to be injected higher into the atmosphere than heavier particles such as BC. These different injection heights can influence their transport and thereby also influence their atmospheric lifetime. The authors mention the difference in plume altitude with respect to the relative abundance of NO compared to NH3, but (page 8) but do not mention this important parameter when investigating the contributions of the other biomass burning markers. A discussion on injection heights and depositional differences between markers should be included in the paper.

Section 4.1.2 distracts the reader from the central aims of the paper as the level of detail included in this section is much greater than that provided in other sections, and as the evidence for or against the Tunguska asteroid impact is only obliquely related to biomass burning. Significantly shortening or even omitting this section will help "tighten" the manuscript.

Specific comments:

Page 2, Lines 4 and 5: What spatial and temporal differences occurred since 1900?

Page 2, Lines 9 and 10: The first known human-origin fires occurred 1 million years ago (Berna et al., PNAS, 2012). Although he scientific community is actively seeking 1 million year old ice, currently the record of human-origin fires is longer than any ice core record. Please revise or omit this statement.

Page 2, Lines 20-23: Mentioning that paleo-fire records are available for these distinct regions of North America is somewhat misleading. Using the publicly-available R paleofire package (Blarquez et al., Computers & Geosciences, 2014), scientists are able to compile charcoal data into any regions of their choosing.

Page 3, Lines 15-17: Do you mean that high-resolution records are limited form the present day until the last millennium OR that these high resolution records only exist for the past millennium?

Page 5, Lines 37-29: Please state why it is important that nitrogen emissions are dominated by ammonia and not NOx.

Page 6, Line 6-10: Do you mean that burning is not expected to produce levoglucosan in flaming conditions regardless of the vegetation type?

Page 8, Line 1-6. If the R2 of formate versus ammonium is higher than the R2 of vanillic acid versus ammonium, why then use vanillic acid? Do you prefer vanillic acid because formic acid is produced during smoke plume aging (page 7)? Why do you not show formate in Figure 6?

Section 3.2.5. The authors state studies that are towards the low end of the spectrum of atmospheric lifetimes for levoglucosan. Slade and Knopf, 2013 mention that under atmospheric background conditions, levoglucosan likely has an atmospheric lifetime of 2 weeks, while Bai et al., 2013 suggest that levoglucosan may have a mean atmospheric lifetime of 26 days.

Section 3.2.6: Why do you designate these different groups if you do not use them

later in the paper? Mentioning that certain markers are “grouped” or “similar” rather then designating specific groups (ie Group 1) may help the reader.

Section 3.3: Why do you not include the Akedemii Nauk (Siberia) ice core? This core may provide a link between the Greenland cores and the more temperate Siberian and Alaskan core that you include in the paper.

Page 13: If there is little difference between the 0, 250 and 500 m above ground level back trajectories, why do you choose the 500 m trajectories? You are investigating material that is deposited at the surface (0 m above ground level).

Figures 11 and 12: Although you mention the source of your data in the paper, please also mention this data source in the figure captions.

Page 16 Lines 34-39: The authors spent multiple pages in the beginning of the paper outlining differences between what individual proxies record (ie BC results from flaming fires and/or fossil fuel burning while levoglucosan is produced from smoldering fires and where ammonium contains a biogenic emissions source). I agree that “more work is needed to elucidate why levoglucosan (and neither BC nor ammonium) would be able to record Siberian fire activity in Greenland ice “ is necessary, but the authors themselves provide plausible explanations earlier in the paper. In Section 4.3 the authors mention that levoglucosan may “mirror changes of fire activity at a larger scale. . .. than ammonium records” which is another explanation for these differences. The authors should include these possibilities during the discussion in Section 4.2 (lines 34-39).

I completely understand the difficulties in writing an academic manuscript in another language. However, in many locations in the paper the writing style gets in the way of understanding the science (e.g. page 5). Multiple co-authors are native English speakers and I strongly urge these co-authors to carefully edit the paper to remove instances of passive voice, flipped clauses and noun-adjective pair placements.

Technical corrections:

Page 3, Line 3: Place “biomass burning source” or some equivalent after “this”.

Page 3, Line 39: Place “comparison” after “this”.

Sometimes temperatures are recorded in degrees C and sometimes in degrees K. Please be consistent throughout the paper.

Page 8, Line 17: Replace “unit” with “unity”

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