Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-139-AC2, 2019
© Author(s) 2019. This work is distributed under
the Creative Commons Attribution 4.0 License.

Atmospheric Chemistry and Physics Discussions
Open Access



# *Interactive comment on* "Ice core records of biomass burning tracers (levoglucosan, dehydroabietic and vanillic acids) from Aurora Peak in Alaska since 1660s: A new dimension of forest fire activities in the Northern Hemisphere" *by* Ambarish Pokhrel et al.

**Ambarish Pokhrel et al.**

pokhrel@pop.lowtem.hokudai.ac.jp

Received and published: 12 September 2019

# Reviewer 2 "Ice core records of biomass burning tracers (levoglucosan, dehydroabietic and vanillic acids) from Aurora Peak in Alaska since 1660s: A new dimension of forest fire activities in the Northern Hemisphere" by Ambarish Pokhrel and co-workers.
Overall evaluation:

The topics is of importance since fires are a major source of gases and aerosols that



Printer-friendly version

Discussion paper

CC BY

strongly impact chemical composition of the atmosphere and the radiation balance. In turn, climate changes directly disturb the fire regime, for instance through the duration of fire weather conditions and changes in vegetation, particularly in the boreal regions. In addition to this overall interest, the data presented in this paper would be useful to discuss the consistency between these three organic markers (levoglucosan, dehydroabietic and vanillic acids) and other potential proxy including ammonium. However, as it stands, the paper suffers from too many weaknesses to be recommended for publication at the ACP journal. I recommend to the authors to take time to revisit the existing literature and their data. Major weaknesses:

1. Quality of the Aurora ice record: Some key information are missed in the manuscript for the reader to evaluate the quality Aurora ice core record. Indeed, when using an ice core record to infer atmospheric information, the reader (and the reviewers) needs to have some basic information that are not given in section 2 (Materials and Methods). I think that, given the rather low elevation (2850 m) of the Aurora site, we may expect frequent melting. If, so that has to be clearly stated in the manuscript and the authors would discuss the possible consequence for the quality of the ice record in terms of atmospheric signal. Since the effect of melting is not well know for organics, it would be nice to show the record of major ions (including ammonium, nitrate, and sulfate). Checking your Figure 4, i am very surprised by the nitrate levels that are shown to range between 0 and 34 ppb (i.e., very low levels). At the opposite, the nss-K level (ranging from 0 to around 50 ppb) exhibits several values exceeding 15 ppb (which is a lot): how much abundant is calcium in this core? (see my further comments on the use of fine potassium). Responsse: Thank you very much. The annual snow accumulation rate is 8 mm yr-1 since 1900 to onwards and drastically accumulated at a rate of 23 mm yr-1 after the Great Pacific Climate Shift. Meanwhile, the average temperature anomalies for 1923-1942, 1943-1945, and 1976-2007 were +0.73, -0.65 and +0.55ïĆřC, respectively (Tsushima et al., 2015).

We assumed that there was not 100 percent melting of snowfall in the saddle of the

Aurora. The correlations of ïĄďD record of this ice core and detrended annual accumulation rates of snowfall are well correlated with air temperature and precipitation amount of Aurora.

The average annual amplitude of ïĄďD from this ice core is 30.9%. This high amplitude (more than 30%) cannot be maintained, if there was intensive melting (100%) in the past (Tsushima et al., 2015). Please see lines 54136-54550.

We are preparing a separate manuscript of ions. We are very sorry to say that we would like to remove Fig. 4 and explanation of this figure. Hence, this time we have deleted these two paragraphs and Fig.4.

2. Inconsistencies: Since you will discuss in section 3 (as also mentioned in the abstract) the correlations of levoglucosan with NO2-, NO3-, nss-SO42-, nss-K+, and NH4+ that are all insignificant (suggesting that these anions and cations do not represent a gleaming signal of biomass burning activities in the source regions for southern Alaska)), it would be nice to show the profiles. This need to report these profiles also comes from the fact this observed absence of correlations contrasts with the statement that I find in the paper from Tsushima et al. (2005) stating "To confirm the dating based on D and Na+ seasonal cycles, we compared the dating of the ice core with reference horizons of known age (Fig. 3). We found a large peak of NO3 and NH4+ and a visible dirty layer at 8.55 m w.eq., which we ascribed to the year 2004. Generally, NO3 and NH4+ are released by forest fires (e.g., Legrand and Mayewski, 1997; Eichler et al., 2011). Âż This point clearly needs to be discussed showing all the records, i think. Since, as also suggested by your figure 5, the 2004 year was characterized by large fires in Alaska, please also comment your organic records for this year ? Response: Thank you very much. This time we have removed that ionic part in the revised MS. We are preparing another paper for ions.

We did not obtain high value of levoglucosan (95.3 ng/Lkg-ice) compared to its average (543). But dehydroabietic (309.7) and vanillic (2.70) acids showed higher concentra-





CC BY

tions compared to their average (62 and 1.6 ng/kgL-ice, respectively). Hence, there is more local influence for dehydroabeitic and vanillic acids. Please also see Figure 6e in the revised MS.

3. Numerous previous works are not cited or adequately cited in the manuscript: In the introduction and at several places in the text, the previous works done on fire records in ice cores are not adequately cited, and some important references are missed including two reviews papers (see the list below). For example, you extensively cited the paper from Whitlow et al. (1994) for ammonium and nitrate biomass burning events that just follows the pioneering study from Legrand et al. (1992) for ammonium, nitrate and carboxylates. After the publication of these two papers, it becomes clear that, although some ammonium spikes are sometimes accompanied by nitrate peaks, it is not a general rule (Savarino and Legrand, 1998). This point was extensively discussed in the review from Legrand et al. (2016). The same is true for the non-sea-salt and non-dust potassium fraction. On this topic, in your manuscript I would recommend to report nss-non-dust-potassium (calculated by using your calcium data). Finally, none of the Greenland ice core studies reported a sulfate perturbation with biomass burning peaks. So I will be more careful about that at line 246. Response: Thank you very much. By taking the reviewer's comment, we have cited all these research papers in the revised MS.

We are preparing another paper by focusing on ions. Nss-non-dust K+ calculation is of great interest. We will certainly report nss-non-dust K fraction in another paper. Hence, we have decided to delete all the ionic parts of this ice core on thisfrom this MS.

Legrand M., M. De Angelis, T. Staffelbach, A. Neftel, and B. Stauffer, Large perturbations of ammonium and organic acids content in the Summit Greenland ice core, fingerprint from forest fires ?, Geophys. Res. Lett., 19, 473-475, 1992. Legrand M., and M. De Angelis, Light carboxylic acids in Greenland ice: A record of past forest fires and vegetation emissions from the boreal zone, J. Geophys. Res., 101, 4129-4145, 1996. Savarino, J., and M. Legrand, High northern latitude forest fires and





CC BY

vegetation emissions over the last millenium inferred from the chemistry of a central Greenland ice core, J. Geophys. Res., 103, 8267-8279, 1998. Legrand, M., McConnell, J., Fischer, H., Wolff, E. W., Preunkert, S., Arienzo, M., Chellman, N., Leuenberger, D., Maselli, D., Place, P., Sigl, M., Schüpbach, S., and Flannigan, M.: Boreal fire records in Northern Hemisphere ice cores: A review, Clim. Past, 12, 2033-2059, doi:10.5194/cp-12-2033-2016, 2016. Rubino, M., D'Onofrio, A., Seki, O., and Bendle, J.A., Ice-core records of biomass burning, The Anthropocene Review, vol. 3(2), 140-162, DOI: 10.1177/2053019615605117, 2016. Grieman, M. M., Aydin, M., Isaksson, E., Schwikowski, M., and Saltzman, E. S.:Aromatic acids in an Arctic ice core from Svalbard: a proxy record of biomass burning, Clim. Past, 14, 637-651, https://doi.org/10.5194/cp-14-637-2018, 2018.

4. The wording is sometimes too vague or unclear, figures are unclear: I don't understand the meaning of "A new dimension of forest fire activities in the Northern Hemisphere" in the title. Response: Thank you, we have changed the title. Please see lines 1-4 in the revised MS.

Line 29: what do you mean with "different ice core studies": Please specify from where ?, with which proxy ?, which time period ? Response: Thank you for the question. We have improved this line and mentioned clearly Kamchatka (Kawamura et al., 2012), Mt. Logan (Robock et al., 1991), Svalbard, Akademii Nauk and Tunu (Grieman et al., 2018a,b; 2017), and Greenland (Whitlow et al., 1994) ice core studies in the revised MS. Please see Figures 6 (a-e). Please see lines 34-36.

Lines 236 and 239: what are these numbers: concentrations of ammonium ? of levoglucosan ? Why figure 3 reports levoglucosan only up to 600 ng L-1 and Figure 4 only up to 1200 ng L-1 while Figure 2 indicates levo as high as 20802 ng L-1 ? Please show satellite data for Siberia as well in Figure 5. Response: Thank you. Figure 3 is the correlation analysis for the period of 1977-2007 (i.e., after the Great Pacific Climate Shift). Concentrations of these compounds are within 600 ng/kgL-ice. We can see in the figure caption too. We have prepared air mas backward trajectories (500 hPa) in





CC BY

the revised MS. Please Figure 7a-f. Please see lines 160-173.

5. Information derived from Back-ward trajectories: I think you may address more details on the origin of air mass reaching the Aurora site. In the present manuscript you stated at the end of the introduction: “Particularly, 10 day backward trajectory from 1992-2002 showed that southern Alaska can receive air masses from the North Pacific Regions, East Asia, Eastern Russia-Siberia, higher latitudes of Alaskan regions, Japan, and Canadian regions in the troposphere (>300 hPa) (Yasunari and Yamazaki, 2009).” I here recommend to address the following points (that would need new calculations): (1) focus on the fire season (from June to August), (2) I think 300 hPa is too high (it is the upper troposphere) and 500 hPa (around 5 km elevation) is likely more relevant for the travel of plumes. Also check the sensitivity between 5 and 10 days. Response: Thank you. By taking reviewer comments, we have added Air mass Backward trajectories (500 hPa) with fire counts for the fire seasons whole year. (June to August). Please see Figure 7a-f.

6. Discussion with previous records (section 3.4): Why do you extensively discuss your organics with ammonium records from 20D (Greenland) ? This discussion is not very useful since the records were obtained with different proxy and are expected to be influenced by different source regions (Canada for Greenland versus Alaska and may be Siberia for Aurora). Instead, again please show your own (Aurora) data on ammonium, nitrate, potassium, sulfate etc. Response: Thank you. We have deleted ionic parts from this section of 3.4 (i.e., comparison with ammonium, nitrite, nitrate and sulphate of same ice core) as mentioned above.

This time, we compared this study with other ice core studies of biomass burning tracers in the section 3.4 (i.e., Biomass burning tracers, Temperature, and Climate variability: Atmospheric consequences) in the revised MS. Please see section 3.4.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-139, 2019.





Printer-friendly version

Discussion paper