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Atmospheric
Chemistry
and Physics
Discussions

Interactive comment on "Source apportionment of particles at Station Nord, North East Greenland during 2008–2010 using COPREM and PMF analysis" *by* Q. T. Nguyen et al.

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Response to Referee 1

General comments:

I am curious about the original chemistry data in general, which has not been presented in the paper – only the source apportionment results are there.

Reply: Table 2 with the actual concentrations of the analysed species was added together with a paragraph (section 3, right before section 3.1) describing the concentration in general.

Heidam et al. (2004) observed many time dependent trends in their concentrations – do the new results, nearly a decade later, still support these trends? In particular, trends in lead and sulfur were identified by Heidam. I believe this aspect deserves investigation.

Reply: We have been trying to focus on source apportionment in this paper and therefore the trend aspect is not fully covered. Long trend of Zn has been discussed. A review paper investigating concentration trends at Station Nord is also currently being prepared.

Related to the above, I was missing more discussion about this new source factor (the Zn source), which is required to characterize the data. The authors state that the sources must be different from those identified by Heidam et al. (2004). Is this visible in the original data chemistry data (e.g. Zn concentrations being higher than previously)?

Reply: The following sentence was added to Section 3 (where the decision to use 5 sources instead of 4 was discussed, in the ACPD version p24183 line 20): particularly with S, As, Pb and Br species in addition to unaccounted episodes of elevated concentration of Zn especially during summer 2009. Further investigation of long-term trend of Zn concentration also revealed a higher range of concentrations during our study period in comparison to the years 1991-2001 covered in Heidam et al. (2004).

Summer peaks in concentrations related to air masses from the Canadian Arctic are mentioned, has new industry or similar been built there between these two studies?

Reply: A paragraph has been added to the Zn source discussion in Section 3.2

Detailed comments:

Page 24184: same citation with different notation, which one is correct?: "Wang and Wilhelmy, 2009" and "Wang and Sañudo Wilhelmy, 2009".

Reply: "Wang and Sañudo Wilhelmy, 2009" is correct. Correction has been made accordingly.

References: Skov 2004 is often cited in the text, but does not appear in the reference list.

Reply: Correction has been made accordingly

Figure 2: please increase the font size on the legends and axis. Also, color scale is not explained.

Reply: The figure has been improved accordingly. The colour scale has now been explained in the figure caption.

Figure 6: please revise the figure caption, the first sentence gives an impression that the trajectory figures are some kind of averages from March 2008-February 2012.

Reply: The figure caption has been re-written.

Supplementary Table S1: please unify the format of the Soil and Marine profile values (some are scientific, others not).

Reply: Correction has been made accordingly.

Response to Referee 2

Geographic source regions were identified but little in depth discussion of the particular sources in those regions was offered. Based on research of industry/combustion sources and results of the back trajectory calculations, it would be helpful to add more information about potential sources in the Canadian Arctic responsible for the high Zn concentrations

Reply: this is similar to a general comment from Referee 1 which we have revised accordingly. A paragraph has been added to the Zn source discussion in Section 3.2

and specific industries in Siberia associated with the high Cu concentrations

Reply: a sentence was added at the beginning of section 3.2.

I agree with the first referee that it would enhance the paper to show data from the

time series (especially in combination with the earlier data from Nord) and not just the source apportionment results.

Reply: The actual concentration data of the species for the period 2008-2010 was shown in the newly added Table 2. A paragraph was added to describe how Zn increased during 2008-2010 compared to the previous years 1990-2001 covered in Heidam et al. (2004). We have tried to prepare a long time series figure for Zn, however we found that it was not illustrative and requires close examination to see the change. We thought this might confuse the readers and thus we chose to describe the trend of Zn instead.

p. 24175, line 5: What is meant by the “compositional change” of short-lived pollutants? The amounts of these species have changed in the Arctic atmosphere?

Reply: “compositional change” was changed to “the surface forcing and surface temperature response” (from Quinn 2008).

p. 24175, Lines 6 – 9: It should be made clear that model calculations suggest that BC contributes to Arctic warming. There are no measurements able to validate this claim.

Reply: Correction has been made accordingly

p. 24175, Lines 16 – 17: This sentence reads as if North America is part of Eurasia.

Reply: The sentence has been re-written.

p. 24175, Line 22: It would be more accurate to say that the deposition frequency during this time of year is low which limits the removal of Arctic haze through deposition.

Reply: Correction has been made accordingly

p. 24175, Line 24: A reference is needed for the statement that Arctic haze may add to warming of the Arctic through its potential to absorb thermal infrared radiation (e.g., Garrett and Zhao, Nature, 2006).

Reply: The reference of Garrett and Zhao (2006) was added accordingly

p. 24177, Line 25: As the text says, absorption is the measured parameter. Change to ": : :to derive black carbon mass concentrations from measurement of the absorption coefficient: : :."

Reply: Correction has been made accordingly

p. 24178, Line 7: Should be "particulate MATTER"

Reply: Correction has been made accordingly

p. 24178, Line 21: Should be "TRANSPORT modes"

Reply: Correction has been made accordingly

p. 24179, Line 3: Change to "the sources OF Arctic particulate matter"

Reply: Correction has been made accordingly

p. 24182, Line 26: Change to ": : :which may NOT ALLOW FOR the differentiation: : :"

Reply: Correction has been made accordingly

p. 24182, Line 27: What is meant here by "non-stationary conditions"? Is this referring to changing meteorology and transport pathways?

Reply: It was changed to "non-stationary meteorological conditions".

It is not clear how the examples given in the following text illustrate the effect of long sampling times on the ability to differentiate sources.

Reply: It was actually an example for the previous sentence on the limited number of sources in the Arctic. The sentence has been revised.

p. 24182, Sections 3.1 and 3.2: The figures in the supplementary material that show the dominant species in each source should be included in the main text. This would make the discussion in these sections easier to follow. The paper is short enough that

there is no need for them to be in the supplementary materials section.

Reply: Figures S1a and S1b have been merged together and moved to the main text. It is now Figure 4.

p. 24184, Line 19: Change to ": : :which also included K, Ca,: : :."

Reply: Correction has been made accordingly

p. 24185, Line 27: Can you describe more specifically what is included in "metal industry" relevant to sources to the Arctic?

Reply: Correction has been made accordingly

p. 24186, Lines 18 – 26: It is stated that "differences in the deposition velocities of SO2 (gas) and SO4 (particles) impose an error: : :.." Then the text goes on to provide examples to explain the imposed error. But the examples seem to have nothing to do with the impact of different deposition velocities.

Reply: The sentence has been re-written. We meant different scavenging rate of SO2 during different period of the year may affect the assignment of SOx = SO2 + SO42- as the source profiles are presumed constant. A reference has also been provided.

p. 24186, Lines 23 – 26: The presence of NO3 in the coarse mode and SO4 in the fine mode suggests different mechanisms of incorporation into the particulate phase and not necessarily co-varying sources. It is known that HNO3 condenses onto coarse mode sea salt and dust while fine mode SO4 results from oxidation of SO2 to SO4 and heterogeneous reactions.

Reply: Thank you for your suggestion. We have revised accordingly and added in some relevant references too.

p. 24187, lines 11 – 12: What does an absence of NO3 indicate about the combustion source?

Reply: Thank you for a very reasonable comment! We would indeed expect NO3, but it however was not assigned to the source by the models. We have added this sentence to discuss further: “NO3 which is the oxidation product of NOx is however absent from this Combustion source, which is possibly due to the smaller contribution of the species from this source compared to the other two anthropogenic Cu/Ni and Zn sources.”

p. 24188: lines 6 – 10: It seems the authors are saying that Br is coming from a local and/or marine source and not from distant anthropogenic sources. This should be made clear here. For example, say “Br is not likely to result from anthropogenic sources but instead, from marine or local sources.” What would the local sources be?

Reply: We meant “marine sources”. This was revised. A reference to Simpson et al., 2007 was also added.

p. 24188, lines 18 – 20: It is stated that the results presented here indicate that sources have changed since the time period analyzed by Heidem et al. Could it also be that the larger number of chemical parameters included in the study affected the assignment of sources compared to the results of Heidam et al.?

Reply: A COPREM test was actually performed with and without the new chemical parameters using Heidam et al. source profile. The result did indicate that the source has changed. This has been clarified further in text.

p. 24189, Lines 14 – 20: It is suggested that the trajectories calculations indicate that there is a source of Zn from the Canadian Arctic. Li and Cornett (2011) are cited as saying the Canadian source is not Arctic Zn smelters. A sentence should be added explaining why Li and Cornett discount smelters as a source of Zn. If not smelters, any idea of what else it could be?

Reply: A sentence has been added to explain the findings from Li and Cornett (2011) further. In the end it is still not clear what might cause a higher Zn concentration.

p. 24109, Line 5 – 8: What evidence is there that K is degraded in the atmosphere as

it undergoes long range transport? Maybe there are many sources of K in the Arctic (sea spray, dust, biomass burning) that prevent it from being a useful tracer when using week-long samples to differentiate sources.

Reply: Thank you for spotting this out, we have put the sentence where K is degraded in the atmosphere by mistake. This has been revised accordingly and relevant reference was also added.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 24173, 2012.