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Interactive comment on “Atmospheric black carbon and sulfate concentrations in Northeast Greenland” by A. Massling et al.

Anonymous Referee #3

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The manuscript entitled, “Atmospheric black carbon and sulfate concentrations in Northeast Greenland”, by A. Massling et al. is based on measurements of black carbon and sulfate north of Greenland at the high Arctic field site station Nord for 2011 to 2013 respectively. The measurements of black carbon were conducted by two instruments; Multi Angle Absorption Photometer (MAAP) at 670 nm wavelength and thermo-optical techniques. The aerosol sulfate was analyzed by using Ion Chromatography (IC). The measured concentrations of black carbon and sulfate were then compared with the output of Danish Hemispheric Model (DEHM) and found BC and sulfate modelled concentrations agreed well ($r^2=0.86$) with the measured aerosol values. Overall two years of results from Station Nord hold the merit on its own as the measurements in the high Arctic are very valuable and scarce. The measurement techniques used

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in this manuscript are sound and published (1) EUSAAR-2 protocol for Thermo-optical EC/OC analysis, (2) MAAP at 670 nm for optical measurements; mass absorption efficiency of 6.6 m²g⁻¹ used for conversion of light absorption to black carbon mass (3) IC technique for inorganic ions such as sulfate concentrations. Several points have been discussed regarding the accuracy of the optical data due to the mass absorption efficiency constant used for the conversion of absorption to black carbon mass. I recommend this manuscript suited for publication with a good standing as long as the changes listed in the below are incorporated into the manuscript. 1)When referring to any filter based measurements, these must be reported as EBC (equivalent black carbon , Petzold et al., 2013), along with the conversion scheme used to derive EBC from absorption coefficient. So pls replace BC by EBC everywhere in the manuscript. 2) Abstract is too generic, pls include specific details, lines 7-12“A correlation between BC and sulfate....”. Pls rephrase. This sentence is awkward. A strong correlation doesn’t state that transport of primary emitted BC particles is accompanied by aging....A strong correlation doesn’t state that all of these processes are happening....These correlations among BC and sulfate have been published before (Gong et al., 2010; Hopper et al., 1992). A strong correlation among two pollutant means they are released from the same sources or same region in case of primary source, including the similar depositions....Fossil fuel combustion releases BC as primary particle and also gaseous SO₂. The condensation of SO₂ on to the primary particles is a very quick process and conversion to sulfate also doesn’t require a lot of time in the source regions....En route from source regions to the receptor site, the aging of aerosol occurs with externally mixed aerosols converted to internally mixed aerosols. The other sources contribute to this mix, it could be biomass burning (for BC), biogenic aerosols from the ocean (DMS conversion to Sulfate and MSA)..and during summer, it could also be biogenic from the forest. 3) Lines 22-24 pls delete this sentence...“during winter and spring the Arctic atmosphere known to be impacted by....” .This is a known fact and should not be in the abstract.. 4) lines 25-26, Pls add flaring is also recognized as an important source (Stohl et al., 2013) 5) pg 11468

lines 1-4, What is the source of anthropogenic sulfate during the summer? Usually since the frequent transport from the south is slow down, sulfate is usually associated with the conversions of biogenically produced dimethyl sulfide emissions. Is the data screened for local contamination from the diesel generators? 6) line 8, pls add Sharma et al., 2013. 7) line 21-23, pls add Petzold et al., 2013 and use new recommendations as per this manuscript. Replacing BC with EBC (equivalent black carbon as previously suggested). 8) lines 23-25, “...is put into context of possible aging and transport...” It is extremely important to mention the same source region such fossil fuel...possible aging and transport mechanisms... 9) pg 11469, lines 5-10, EC/OC was collected at military station 2.5 km from the main sampling station. MAAP and sulfate were located at the main site hut 2.5 km southeast of the military camp. What is the predominant wind direction? Are the filter data sectored to stop sampling when the winds are from southeast sector? Does the weekly MAAP data screened out for military camp contamination? Pls comment. 10) lines 19-20, pls specify why used 6.6 m²g⁻¹ for conversion of light absorption of MAAP measurements to EBC mass and uncertainty associated with the measurement in the abstract where mention the MAAP measurements. 11) lines 22-25, pls replace uncertainty in black carbon to uncertainty in the light absorption coefficient measurements. Also suggest, uncertainty in equivalent black carbon could be as large as a factor of 2. 12) p 11473 line 21, ...”There are...sulfate and BC which is large and cannot be estimated for this study.” line 22-25, pls rephrase, “The anthropogenic emissions of SO₂ and BC...” to “the annual averaged emissions of SO₂ and BC were used in the model, not taken into account the seasonal variability in these emissions which could be about 20%”. Is this number correct? How did you get seasonal variation in BC emissions? These are usually listed as annually averaged values in the emissions database... 13)pg 11476, lines 24-30, pls cite Sharma et al., 2013 for seasonal pattern at Alert and Zeppelin Stations. 14) lines 6-10 all analytical systems have a detection limit for various components, pls determine the detection limits for MAAP and Thermo-optico method. How different are these measurements from detection limits especially during summer? Line 18 Pls replace “Minimum sulfate

concentrations were close to zero. . . .” With the detection limit value. . . . 15) pg 11477 lines 11-19, The lower ratio in the summer of sulfate to EC could be due to the fact that lower sulfate is present due to only biogenic impact and higher EC due to biomass burning. Do you also have measurements of potassium due to biomass burning to back up this statement. . . 16) pg 11479 Line 20 replace “dimethanesulfide” by “dimethyl sulfide”. Lines 19-21 “the results suggested that photo-oxidation of DMS. . . .” This is true only in the winter/spring time (30% is contributed from biogenic produced sulfate (Norman et al., 2002)). Summer time this fraction could be higher. Pls rephrase this statement. 17) lines 21-24, BC and SO₂ are released from the same fossil fuel sources and are long range transported. The conversion process occurs en-route from source regions to the receptor site. In lines, 304-307, you mentioned that Siberian smelters and other long-range transported anthropogenic pollution contribute to both. In the end, everything gets internally mixed as there is a long transport time from Siberia to Station Nord. 18) p 11480, Lines 6-12 How are BC and sulfate partly related to same combustion sources? Your hypothesis of sulfate particles as being transport containers is kind of misleading?? This is only true if the particles are internally mixed. If you consider sulfur dioxide and then sulfate coated black carbon shells coming from fossil fuel combustion source regions, the release and mixing of particles from the metal smelters will condense on the already existing black carbon particles coming from other source regions. . . .should that not be black carbon being containers for sulfate from smelters by condensing sulfur dioxide?? lines 14-22, during the summer, sulfate should have a large proportion of biogenic contribution. Anthropogenic influence should be minimal during the summer as clearly seen in the measurement at Alert, Nunavut location. Pls separate the Nov to May period from June to October in Figure 4 (a) and (b). The regression should fall apart during the summer as also clearly evident by the data at the lower end of the curve. If there is correspondence, it might be due to local influences. Also summertime increases in the precipitation in the source region and precipitation also resulted in lower sulfate and EBC. Is the deposition of the two a selective process as sulfate being much more soluble than EBC?

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19)pg 11482, lines 13-17, The regression plots of measurements of sulfate and EBC give a slope that is a factor of 4 lower than regression plots of model outputs for sulfate and EBC. Model output is overestimating sulfate and underestimating BC. That's the reason the slopes are so different with respect to measurements?? Pls include that.

20) The results from two black carbon techniques were compared although the two instruments were situated in laboratories 2 km apart and not having a common inlet.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 11465, 2015.

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