We appreciate all the reviewers for taking the time to read our paper and many helpful suggestions. We consider the comments very carefully and will revise the manuscript. Below we provide point-to-point answers to the comments of the two reviewers.

Dear Dr. Anders Svensson as Reviewer #1
[Reviewer comment]
General comment: To investigate the dust source, it would however be very helpful to have a few isotopic analyses of Sr or Nd that are probably more indicative of the dust origin than the mineralogy and certainly more informative than eg the roundness parameter. The argumentation and thus the conclusions concerning the dust source being at high, mid or low latitudes based on mineralogy are in my view somewhat weak without the isotopes. Likewise, the lack of isotopic analyses makes comparison to similar analyses from many other Greenland ice cores impossible. Indeed, it would be a surprise if we have substantial amounts of low latitude dust deposited in Northern Greenland today.
[Author reply]
We agree on the reviewer's comment that the Sr and Nd isotopes are one of the most useful tools to identify mineral dust sources. However, it is difficult to apply the isotope analyses for ice cores with low dust concentration because they need large amounts of dust samples. Indeed, previous studies on the isotope analyses have mostly targeted ice core dust from glacial periods characterized by high dust concentrations (e.g. Biscaye et al., 1997; Svensson et al., 2000). Although some studies analyzed the Sr and Nd isotopes of ice core dust from Holocene when dust concentrations are low, they needed to concentrate decades to thousand years of ice for each sample (e,g, Bory et al., 2003; Han et al., 2018; Simonsen et al 2019) Thus, we think the SEM-EDS analysis is a useful tool to provide a high-temporal-resolution record of composition and sources of ice core minerals during low dust concentration periods.

[Reviewer comment] General comment: I have my doubts about the trajectory analysis suggesting that none of the dust in the ice core originates from Asia. Large Asian dust clouds are observed on satellite images following the dominating westerly wind pattern. During the last glacial the majority of the Greenland dust had this source. Likewise, several tephra studies show that volcanic material of high-latitude Asian and Alaskan origin makes it to Greenland, whereas no tephra from Europe or lower latitudes ever made it to Greenland to my knowledge. Today the major Greenland dust source is less well-known and a more local dust contribution certainly is a possibility, but I would suspect a fraction of the dust still to originate in Asia today. Without the isotopic tracers, however, it is difficult to know, and trajectory analysis may not tell the complete story. Please compare your trajectory analysis to that made in Schüpbach et al., 2018, and comment on differences in methodology and results. In particular, Schüpbach et al., 2018, supplementary figure 1 may be relevant.

[Author reply]

The model (NOAA HYSPLIT) and datasets (ERA-Interim precipitation) used in our trajectory analysis are same as those of Schüpbach et al. (2018), but the initial height of air mass (50, 500, 1000, 1500 m a.g.l. vs. 100m a.g.l.), and the output figure descriptions (cumulative probability vs. endpoint) are different. We analyzed the 10-day back trajectory from the NEEM and SIGMA-D sites in the same setting for 1979-2014 (4 initial heights), and depicted the same trajectory map by following Schüpbach's supplementary figures (Figs. Reply 1 and 2). Our results show rather greater contribution from northwestern Canada than that of Schüpbach's, but the entire distributions for both sites are similar each other and to that of Schüpbach's map. Thus, we consider that the method and results of our trajectory analysis can be interpreted as same as those of Schüpbach et al. (2018). In addition, Schüpbach et al. (2018) addressed a limitation of the back-trajectory analysis that could not capture the Asian dust transportation through the upper troposphere.

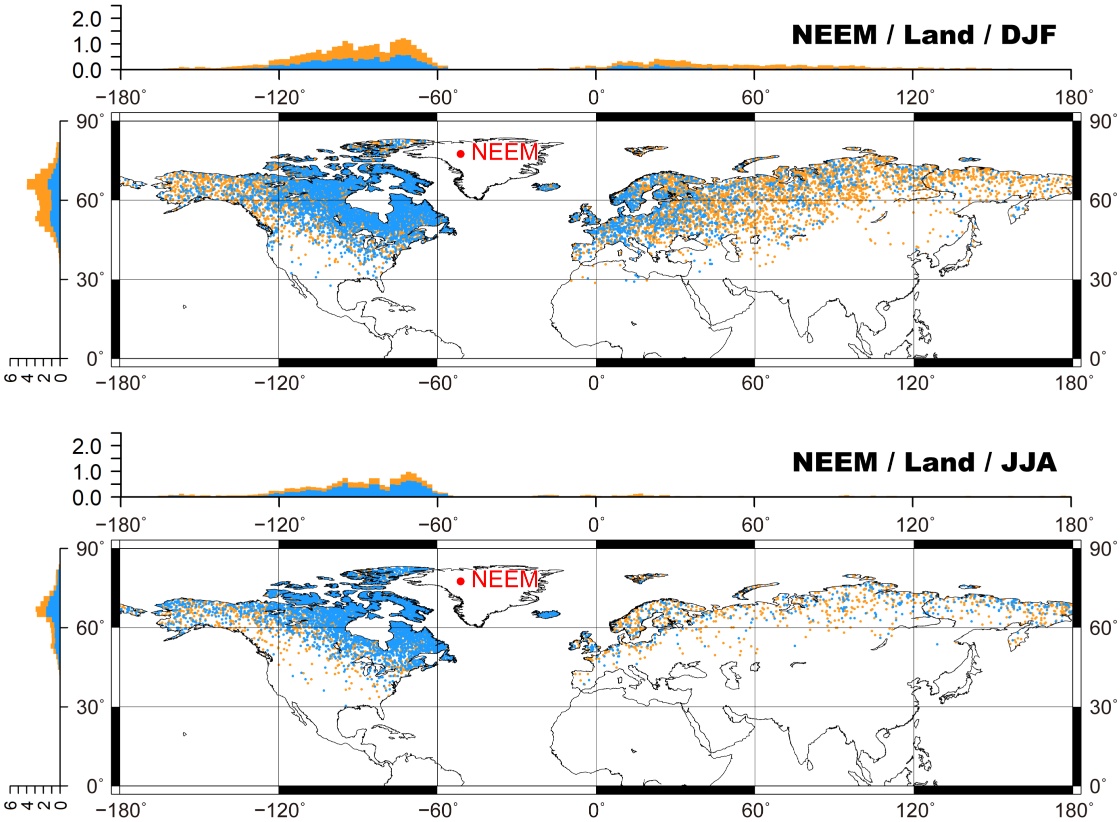


Figure Reply 1. Back trajectory analysis from the NEEM site. Endpoints of 10-day trajectory are plotted for winter (upper panels) and summer (lower panels) by the same manner of Schüpbach et al. (2018). Blue and orange dots denote wet and dry deposition at the NEEM site. Histogram axes indicate contribution to the all endpoints including ocean.

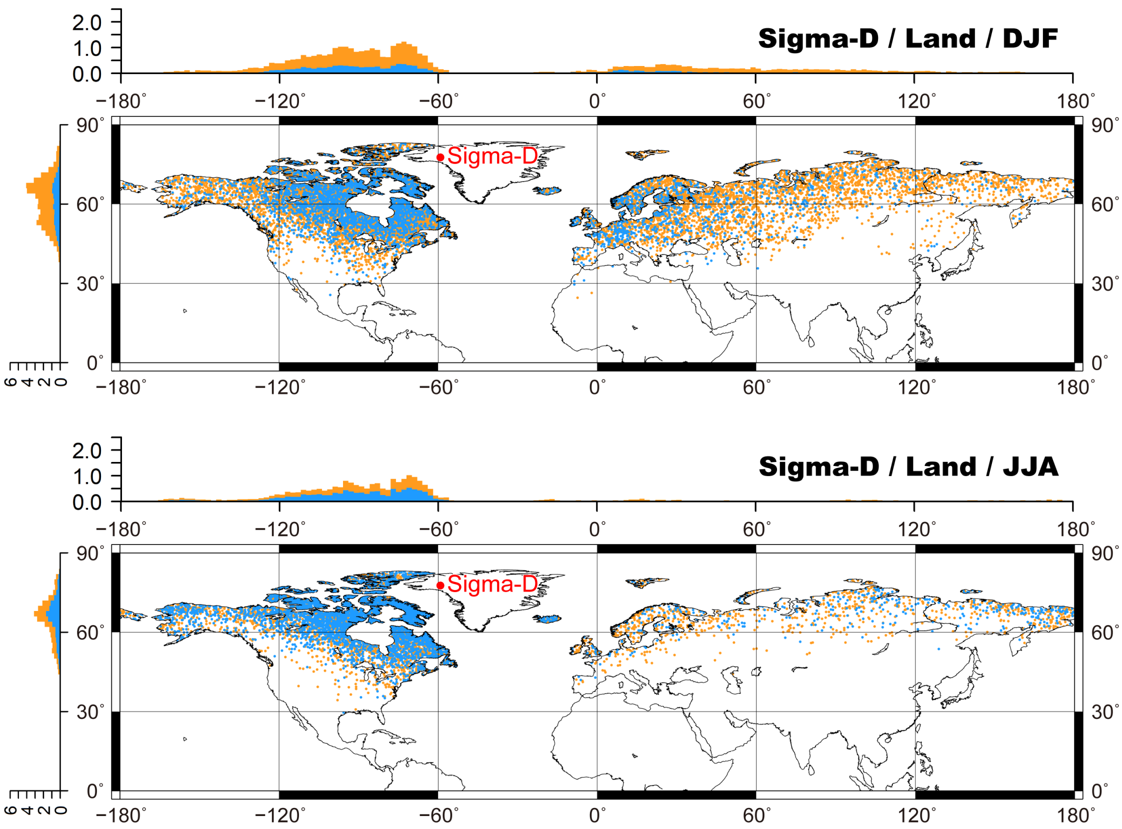


Figure Reply 2. As of Fig. Reply 1 but for Sigma-D site.

We also analyzed the 20-day back trajectories of air masses from the SIGMA-D site as well as the other six Greenland ice core sites at which Bory et al. (2003) revealed the dust sources by the Sr and Nd isotope ratios; the interior 4 sites (NGRIP, GRIP, Site-A, and Dye-3) contain more dust from eastern Asian deserts than the coastal 2 sites (Hans Tausen and Renland) (Fig. Reply 3). Our trajectory analysis shows the significantly low contribution of air masses from eastern Asia (less than 0.25%) and a similar temporal change among the ice core sites, whereas the air mass contribution from the Greenland coast is high (10-40%), especially for Hans Trausen and Renland, and followed by Sigma-D (Fig. Reply 4).

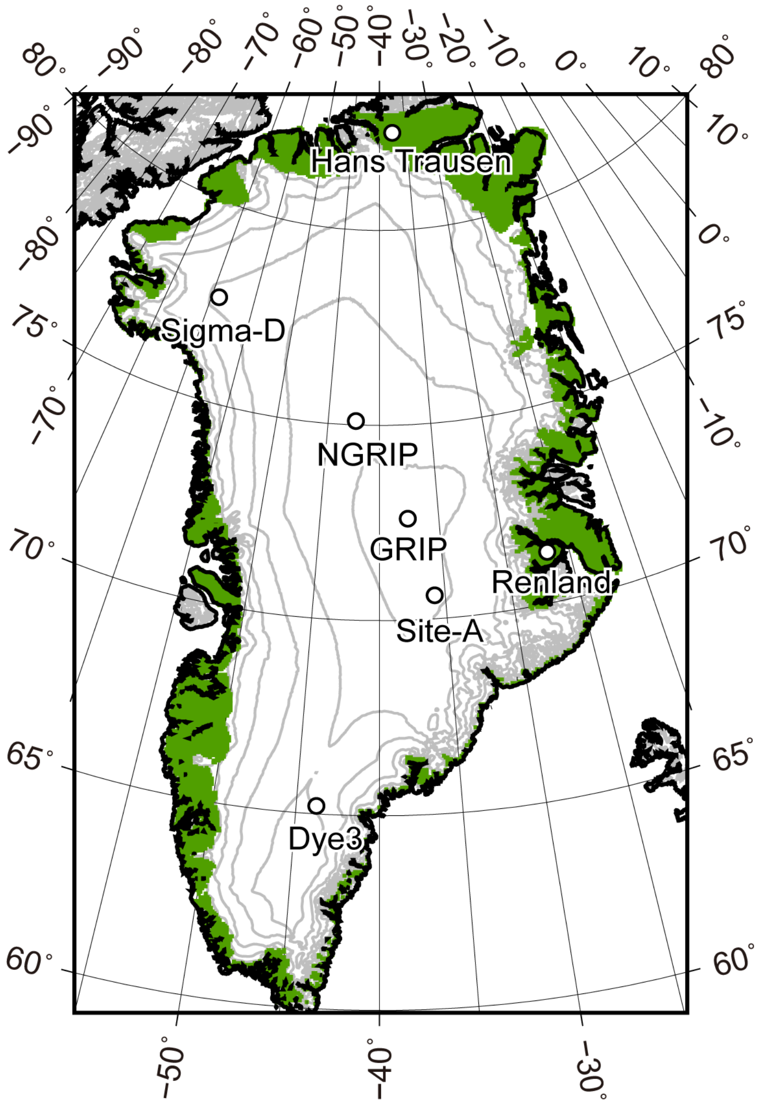


Figure Reply 3. Seven ice core sites for the back trajectory analysis.

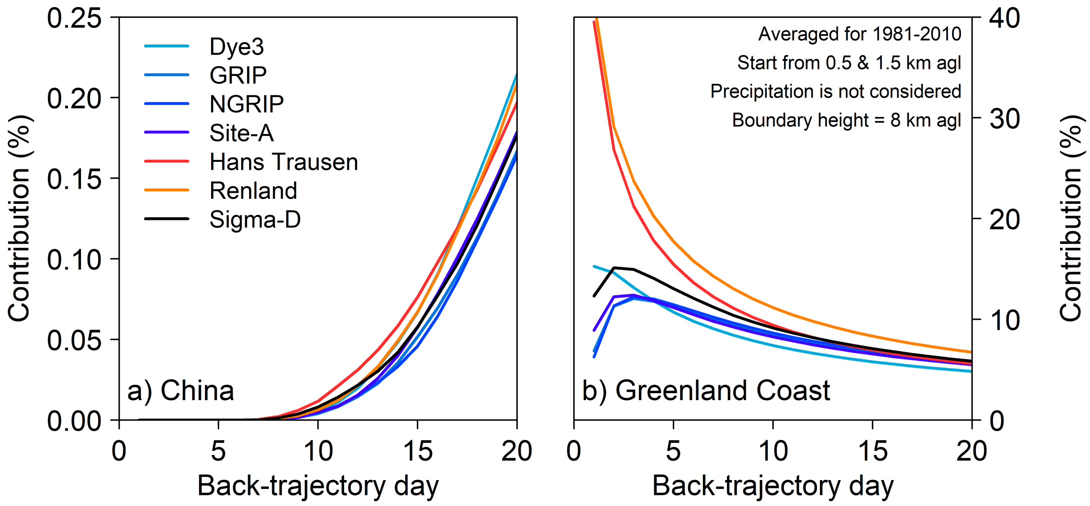


Figure Reply 4. Air mass contribution from (a) China region and (b) Greenland coast at the seven ice core sites on Greenland. The analysis setting is listed in (b).

Bory et al (2013) suggested that a discrimination between sources providing dust to an ice core site seems to occur with distance from the ice sheet margin and/or with altitude, and long-range transport from Asian deserts provides most of the dust deposited at interior sites, while local sources represent an additional and primary contributor at coastal sites in Greenland. Since the SIGMA-D lies between interior and coastal Greenland, the dust was likely derived from Asian dust sources as well as local sources. However, mineralogical composition of the SIGMA-D showed significantly lower proportion of illite and quartz and higher proportion of kaolinite (6-18%, 3-22%, 5-63%) than the other Greenland ice core dust originated from Asian deserts (e.g. GRIP: 23-35%, 31-48%, 4-16% (Svensson et al., 2000)). Thus, there is likely to be another main source for the ice core dust. The contributions of the 7-day back-trajectory suggest that north America likely differentiate the Sigma-D site from other sites (Fig. Reply 5).
We will revise our manuscript as described above.

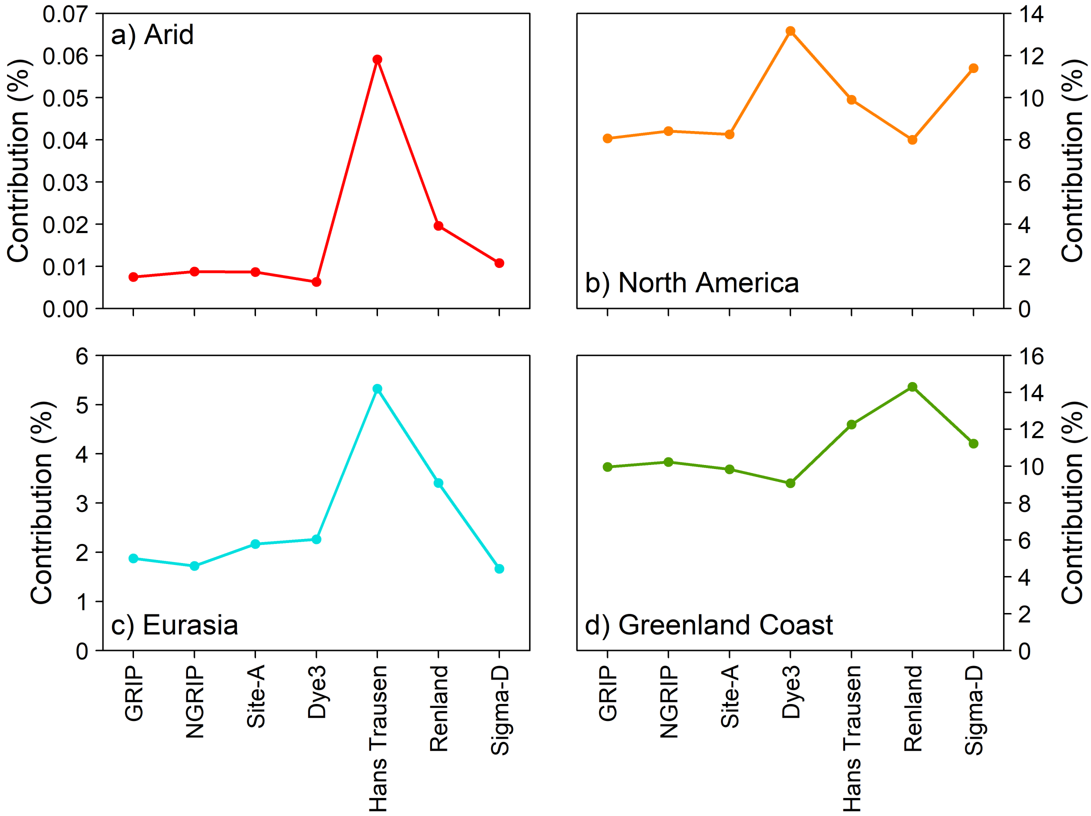


Figure Reply 5. Air mass contribution for the 7-day back trajectory from (a) Arid regions (China, Central Asia, and Middle East), (b) North America (Canada and US), (c) Eurasia (EU and Russia), and (d) Greenland coast at the seven ice core sites on Greenland. The analysis setting is same as Fig. Reply 4.

[Reviewer comment]

General comment: In Simonsen et al., 2019 (full reference below), the dust size distribution (or the contribution of large fraction particles) is seen as a strong indicator of local versus distant dust sources. Large particles cannot be transported over long distances, so the presence of large particles in the ice core is attributed to local dust sources. Does the dust size distributions in your study support your conclusions of local versus long-range dust source variations?

[Author reply]

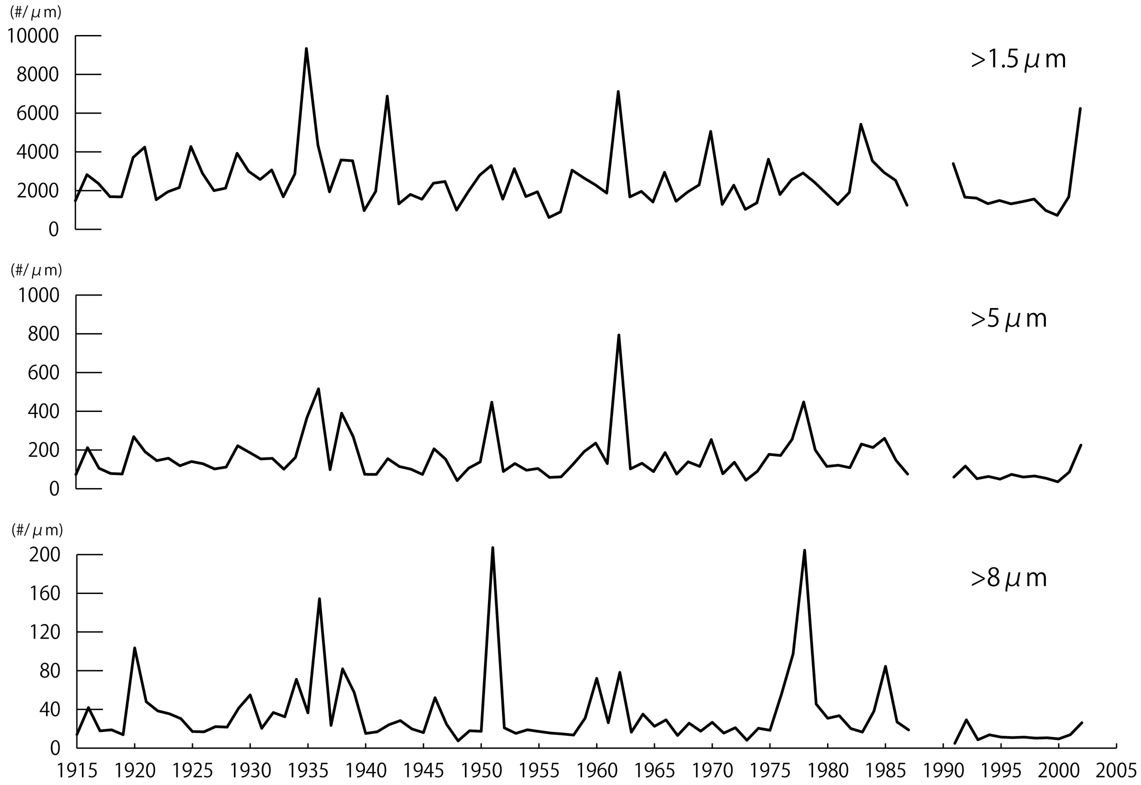
Yes. Simonssen et al., 2019 used particles with diameters of <2 μm and >8 μm as indicators of the distant and local dust sources for the RECAP ice core, respectively. Size distribution of the SIGAM-D ice core dust showed that the samples from the cold period (1960 to 1989) contained less particles with diameters of >8 μm (0-2 particles) than those from the warm periods (1915 to 1959 and from 1990 to 2013, 1-9 particles) when local dust supply increased. We will also add the profiles of the SIGMA-D ice core dust concentration from 1915 to 2002 measured by an Abakus laser particle sensor (Klots GmbH, Germany) on a continuous flow analysis (CFA) system as suggested by reviewer #2, showing higher concentration for the particles with diameters of > 1.5µm, 5µm, and >8µm in the warm period (1915-1950s) than the cold period (1950s-2000, except for a large peak in 1978, Fig. Reply 6). Furthermore, the Type A mineral that is abundant in the cold period contained lower amounts of particles with diameters of >2 µm (Fig.10). These results support our conclusions that the ice core dust was mainly transported from distant regions, and that the local dust supply increased in the warm periods when the snow/ice cover duration during the melt season in the Greenland coastal region was shortened. We will revise some sentences in the manuscript as described above.

[Reviewer comment]
General comment: I find the manuscript is generally well written with good figures and referencing, except the introduction that I think needs a rework both language-wise and concerning references. The cited papers appear not to be up to date; below I give some additional suggestions for recent work that I think should be referred to and possibly commented on.
[Author reply]
Many thanks for this suggestion. We will cite the papers as suggested by reviewers and get some English proofreading in the Introduction.

[Reviewer comment]
Mention the name of the analysed ice core in the title or in the abstract.
[Author reply]
We will add the name of the ice core in the abstract.

[Reviewer comment] It would be relevant to cite this recent paper in the introduction, since the idea of more local dust in Greenland ice cores is also discussed here although on a different time scale:
Simonsen, M. F., Baccolo, G., Blunier, T., Borunda, A., Delmonte, B., Frei, R., Goldstein, S., Grinsted, A., Kjær, H. A., Sowers, T., Svensson, A., Vinther, B., Vladimirova, D., Winckler, G., Winstrup, M., and Vallelonga, P.: East Greenland ice core dust record reveals timing of Greenland ice sheet advance and retreat, Nature Communications, 10, 10.1038/s41467-019-12546-2, 2019.
[Author reply] Many thanks for this suggestion. We will cite this paper in the Introduction.

(a)



(b)

	>1.5μm	>5μm	>8μm
1915-1954	2736.85	163.3	39.1
1955-1999	2086.65	139.0	29.6

Figure Reply 6. (a) number concentration of the SIGMA-D ice core dust particles with diameters of >1.5μm, >5μm, and >8μm from 1915 to 2002 measured by the Abakus, and (b) the averaged concentration from 1915 to 1954 and from 1955 to 1959.

[Reviewer comment] l. 19.: 'changed periodically' leaves the impression that the dust composition varies with a certain periodicity, ie with a certain frequency. Probably the authors mean to say that the dust had different composition in different periods?
[Author reply] We will revise the sentence that the ice core dust originated from different geological sources in different periods.

[Reviewer comment] l. 23.: 'This indicates...' -> 'Comparison to Greenland surface temperature records indicates. . .'
[Author reply] We will revise the sentence as suggested by reviewer.

[Reviewer comment] l. 24.: 'The trajectory . . .' -> 'A trajectory. . .' or 'Trajectory. . .'
[Author reply] We will revise the word as suggested by reviewer.

[Reviewer comment]
l. 30.: 'Past dust composition. . .' -> 'Past ice-core dust composition records have revealed substantial variations in the concentration...' It is unclear which time period you refer to here. Is this about glacial cycles (Antarctica), the last glacial cycle, the Holocene, historical times, or on a seasonal time scale? With this postulate you need to cite a reference.
[Author reply]
We will cite some papers and add sentences to refer to ice core dust variations on a geologic time scale (from the Eemian to the Holocene, e.g. Maggi et al., 1997; Steffensen, 1997; Ram and Koenig., 1997; Schüpbach et al., 2018; Simonsen et al., 2019) and a seasonal scale (e.g. Bory et al., 2002; Drab et al., 2002) in Greenland.

[Reviewer comment]
l. 31-32.: 'climate signals'. Are you referring to ice core water isotopes? 'atmospheric circulation', what is referred to here? Again the time period is not specified. Again you will need to cite published work for this statement.
[Author reply]
We will revise the words 'climate signals, such as temperature and atmospheric circulation' to 'temperature changes' and add sentences to refer ice core dust records covering geologic time period (from the Eemian to the Holocene).
We cited some papers to refer correlated variations between Greenland ice core dust and temperature variability indicated by $\delta^{18}O$ records (Line 32-35).

[Reviewer comment]
l. 29-40.: I think you also need to cite at least some of those classic studies:
Ruth, U., Wagenbach, D., Steffensen, J. P., and Bigler, M.: Continuous record of microparticle concentration and size distribution in the central Greenland NGRIP ice core during the last glacial period, Journal of Geophysical Research, 108, 10.1029/2002jd002376, 2003.
Petit, J. R., Mounier, L., Jouzel, J., Korotkevich, Y. S., Kotlyakov, V. I., and Lorius, C.: Palaeoclimatological and chronological implications of the Vostok core dust record,

Nature, 343, 56-58, 1990.
Lambert, F., Delmonte, B., Petit, J. R., Bigler, M., Kaufmann, P. R., Hutterli, M. A., Stocker, T. F., Ruth, U., Steffensen, J. P., and Maggi, V.: Dust-climate couplings over the past 800,000 years from the EPICA Dome C ice core, Nature, 452, 616-619, 2008.
[Author reply]
Many thanks for this suggestion. We will cite these papers in the Introduction.

[Reviewer comment]
l. 42.: What is meant by 'rarely'? Do you have evidence of changing isotopic rations during transport? If so, please cite relevant reference.
[Author reply]
We will use 'less alter' instead of 'rarely' in the sentence and cite some references (e.g. Capo et al., 1998; Faure, G. and Mensing, T.M., 2004).

[Reviewer comment]
l. 41-50.: You probably should cite some of the more recent papers as well:
Újvári, G., Stevens, T., Svensson, A., Klötzli, U. S., Manning, C., Németh, T., Kovács, J., Sweeney, M. R., Gocke, M., Wiesenberg, G. L. B., Markovic, S. B., and Zech, M.: Two possible source regions for central Greenland last glacial dust, Geophysical Research Letters, 42, 10399-10408, 10.1002/2015GL066153, 2015.
Han, C., S. D. Hur, Y. Han, K. Lee, S. Hong, T. Erhardt, H. Fischer, A. M. Svens- son, J. P. Steffensen, P. Vallelonga. High-resolution isotopic evidence for a potential Saharan provenance of Greenland glacial dust. Scientific Reports 8:15582 | DOI:10.1038/s41598-018-33859-0 3, 2018. l. 51-60.:
Probably you should cite this paper:
Obbard, R. W., Baker, I., and Prior, D. J. (2011). Instruments and Methods A scanning electron microscope technique for identifying the mineralogy of dust in ice cores. Journal of Glaciology 57, 511–514.
[Author reply]
Many thanks for this suggestion. We will cite these papers in the Introduction.

[Reviewer comment]
l. 63.: '... in the ice sheet' -> '... to the ice sheet'.
[Author reply]
We will revise the sentence as suggested by reviewer.

[Reviewer comment]
l. 61-72.: This recent paper would also be relevant for the introduction:

Zhang, P., Jeong, J.-H., Yoon, J.-H., Kim, H., Wang, S.-Y. S., Linderholm, H. W., Fang, K., Wu, X., and Chen, D.: Abrupt shift to hotter and drier climate over inner East Asia beyond the tipping point, Science, 370, 1095-1099, 10.1126/science.abb3368.
[Author reply]
Many thanks for this suggestion. We will cite these papers in the Introduction.

[Reviewer comment]
l. 179.: 'Dating of the SIGMA-D ice core, which was performed by annual layer counting of δ18O and Na+, showing obvious seasonal variations (Fig. A1).' -> 'Dating of the SIGMA-D ice core was performed by annual layer counting of δ18O and Na+ that show obvious seasonal variations (Fig. A1).'
[Author reply]
We will revise the sentence as suggested by reviewer.

[Reviewer comment]
l. 246.: 'cyclically' suggests a periodicity or frequency. What is the period or frequency on two different time scales referred to?
[Author reply]
We will revise the sentence that the ice core dust originated different geological sources in different periods.

[Reviewer comment]
l. 250.: Are you suggesting a major contribution of low to mid-latitude dust to Northern Greenland for the period 1950-2004? What is the potential source area and why should it be turned on in 1950 and off in 2004?
[Author reply]
The SEM-EDS results imply that the possible sources of the ice core dust in 1950-2004 are likely to be low/mid latitudes because Type A mineral (kaolinite) that is typical of humid tropical climatic zones such as modern-day Africa, south America and southeast Asia (Line 125 and 146) is abundant in the period. Although trajectory analysis cannot estimate contribution from distant sources as described above, it is unlikely that the large amounts of ice core dust was transported from such tropical regions. On the other hand, our trajectory analysis suggests that northern Canada can be also possible sources of the Type A mineral and some studies supported this argument (Line 326-335). Thus, we concluded that northern Canada seems to be best candidate for the ice core dust source during the period.
Higher proportion of the Type A mineral (more than 40 %) during the whole periods indicates that the ice core dust was constantly supplied from the distant source (northern

Canada) to the SIGMA-D site and the source areas have not changed over the past 100 years. However, the dust was additionally provided from local ice-free area in the warm periods (1915-1950, 2005-2013) and thus the relative proportion of the mineral from distant source was smaller in the two warm periods. We will revise the manuscript as described above.

[Reviewer comment]
l. 309.: ‘Previous studies. . .’ What are those previous studies and are they concerned with dust transport to Greenland in the last century?
[Author reply]
We will cite references showing dust transported from Asian deserts during the last century from Greenland snow pit samples (Bory et al., 2002; Drab e al., 2002).

Dear Dr. Laluraj C. M as Reviewer #2

[Reviewer comment]

General comment: The reporting of new dust mineral record observations in Greenland as well as attempts to identify the sources of dust during warmer/colder periods during 1915-2013 is worthy of publication. However, the report is not suitable for publication as it is. The strength of this work resides only in reporting a mineralogy record of a century time scale from Greenland; there have been no attempts to offer climatic reasons for recent changes in dust mineralogy/sources/production in source/deposition regions. Conversely, perhaps in the attempt to cover so much, the paper fails to go in-depth in a number of aspects of these important subjects and offer no insightful reasons for the possible causes in variation in dust mineralogy and sources changes during the recent colder/warmer periods of last century.

[Author reply]

We have discussed possible climatic reasons for the temporal variations in mineral composition and sources of the ice core dust, comparing historical records of silicate mineral proportions with those of the NAO index, surface temperature change, and snow cover fraction anomalies in Greenland in the manuscript (section 4.2).

Relatively higher proportion of the Type A mineral during the whole periods (Figures 7 and 9) indicates that the ice core dust was constantly supplied from the distant source (mainly northern Canada) to the SIGMA-D site and the source areas have not changed over the past 100 years. However, the dust was additionally provided from local ice-free area in the warm periods (1915-1950, 2005-2013) because the snow/ice cover duration in the Greenland coastal region was shortened by the recent warming during the melt season, and thus the relative proportion of the mineral from distant source was smaller in 1915-1950 and 2005-2013. We will revise the manuscript as described above.

[Reviewer comment]

General comment:

In particular, the authors omitted the potential methods (stable isotope ratio of Sr and Nd) to identify the sources of dust in different time scales as well as failing to consider high-resolution fractional dust estimates using water-insoluble particle counting (Coulter counter and laser-sensing particle detector) along with the estimated mineralogy data for dust sourcing/variation of dust mineralogy for strengthening the present argument.

[Author reply]

We recognize that the Sr and Nd isotopes are one of the most useful tools to identify mineral dust sources, and have used the isotope ratios to identify sources of mineral dust on Greenland glaciers (Nagatsuka et al., 2016). However, it is difficult to apply the isotope

analyses for ice cores with low dust concentration because they need large amounts of dust samples. Indeed, previous studies on the isotope analyses have mostly targeted ice core dust from glacial periods characterized by a high dust concentration (e.g. Biscaye et al., 1997; Svensson et al., 2000). Although some studies analyzed the Sr and Nd isotopes of ice core dust from Holocene when dust concentrations are low, they needed to concentrate decades to thousands years ice for each sample (e,g, Bory et al., 2003; Han et al., 2018; Simonsen et al 2019) . On the other hand, our study reveal that the SEM-EDS analysis can demonstrate a high-temporal-resolution record of composition and possible sources of the ice core minerals during recent low dust concentration periods as the last century. This is our strong point. We will emphasize it in the manuscript.
We will add the profiles of dust concentration from 1915 to 2002 measured by an Abakus laser particle sensor (Klots GmbH, Germany) on a continuous flow analysis (CFA) system (Fig. Reply 6). Since our Abakus detected particles with diameters between 1.5 and 15 µm, and the CFA analysis has not been carried out after 2003 (above 6.35m depth) due to poor core quality, we cannot compare the size distribution data with that measured by the SEM. However, the Abakus dust profiles showed higher concentration for the particles with diameters of > 1.5µm, 5µm, and >8µm in the warm period (1915-1950s) than the cold period (1950s-2000, except for a large peak in 1978), which supports an increase of local dust contribution from 1915 to 1950s as shown by the SEM results.

[Reviewer comment]
General comment:
Further, lack of trajectories observed from well-known dust sources reported in Greenland (eg:-North Africa/Middle East, and Eastern Asia eg;- Simonsen et al., 2019 and publication by Svensson & group), thereby doubting the uncertainties in using reanalysis data prior to 1979 CE.
[Author reply]
See the reply to Reviewer #1.

[Reviewer comment]
General comment: Additionally, I strongly encourage the authors to consider the full ice core mineralogy/dust records of 223 m or/at least 113 m (1660-2013 CE) for a better understating of variation in mineralogy records in Greenland during a longer period instead of considering the present firn part of the ice core (38 m) where most of the uncertainties are present. I believe that the above-mentioned issues can be addressed with reasonable additions and extra analysis. I leave it to the Editor to decide whether to recommend, to modify/drop one of the subject study (mineralogy variation in Greenland during the last century) or leave them all.

[Author reply]
This paper aims to describe temporal variations in sources of minerals in a Greenland ice core focusing on the past 100 years when the Arctic region was remarkably warming. Furthermore, it takes a lot of time for the high-temporal-resolution SEM analysis. Thus, we have no plan to analyze the rest of the ice core dust samples in this study. We will add the sentences to describe above in the introduction.

[Reviewer comment]
Line No. 23 - This indicates that the multi-decadal variation of the relative abundance of the minerals can be attributed to the local temperature changes in Greenland. The statement is quite arbitrary so may be re-written or removed.
[Author reply]
We will revise the sentences that the multi-decadal variation of the relative abundance of the minerals is likely to be affected by the local temperature changes in Greenland.

[Reviewer comment]
Maybe a statement on the overall implication of your study or future perspectives will be useful at the end of the abstract.
[Author reply]
We will add the sentence "Our results suggest that the SEM-EDS analysis of the ice core dust can demonstrate variations in the mineral dust sources during recent low dust concentration periods" at the end of the abstract.

[Reviewer comment]
The first paragraph of the introduction may be rewritten or adding a new paragraph by including recent studies (eg:- Zhang et al., 2020; Bory et al., 2002 & 2003) on dust sources dust in Greenland/mineralogy of dust in Greenland/implications in terms of climate changes may be included.
[Author reply]
Many thanks for this suggestion. We will cite the references as well as those suggested by Reviewer #1 for ice core dust sources in Greenland (e.g. Újvári et al., 2015; Han et al., 2018; Simonsen et al., 2019)/ mineralogy and size of dust in Greenland (e.g. Ruth et al., 2003)/ implications in terms of climate changes (e.g. Petit et al., 1990; Lambert et al., 2008) and rewrite some sentences in the introduction.

[Reviewer comment]
Line No. 103- How reliable the SEM analysis is to estimate the particle size and the number of particle counting from ice core used in the present study? May be

compared/clarified here using the different particle count estimate from other instruments
[Author reply]
We manually measured the two-dimensional area of the individual ice core dust on digital photographs with an image-processing application (ImageJ, National Institutes of Health, USA). Then, the equivalent circle diameter was calculated. The measurement error is about several ten nanometers.
Since our Abakus detected particles with diameters between 1.5 and 15 μm, we cannot compare the size distribution data with that measured by the SEM as described above. However, there was not so much difference in the size range of ice core dust between the SIGMA (mean: 0.97-2.60μm, mode: 0.35-1.15μm) and the other Greenland ice cores (e.g. GISP2 mean: 1.15-1.32μm Biscaye et al., 1997; NGRIP mode: 1.10-1.80μm, Ruth et al., 2003). Thus, we think the particle size of the ice core dust analyzed by the SEM is reliable. Furthermore, we chosen randomly 150 particles of the ice core minerals from the membrane filter for each sample, and thus we cannot estimate total number of the ice core minerals in each period.

[Reviewer comment]
Line No. 180- Since there are no other non-sea salt sulphate spikes of volcanic origin in the present time scale (1915-2013), Fig. A1 may be included with tritium spike data of chronology as a reference point
[Author reply]
We will add a tritium profile in Fig. A1 (also shown in this reply as Fig. Reply 7).

[Reviewer comment]
Line 245- Is the abundance of silicate minerals due to volcanic ash? There are several volcanic dusts reported in Greenland ice cores during the period between 1915-2013. Please include a discussion on it.
[Author reply]
The SEM observations did not identify ice core minerals exhibiting morphological characteristics of volcanic ash (Line 282-283). Furthermore, the mineral composition of the ice core dust was different from that of ash transported to the western ice sheet margins by Mt. Agung eruption in 1963, the Mt. St. Helens eruption in 1980, and the Mt. Pinatubo eruption in 1991. Since silicate minerals is the most abundant family of crustal minerals, we consider that the silicates in the ice core mainly originated from geological material.

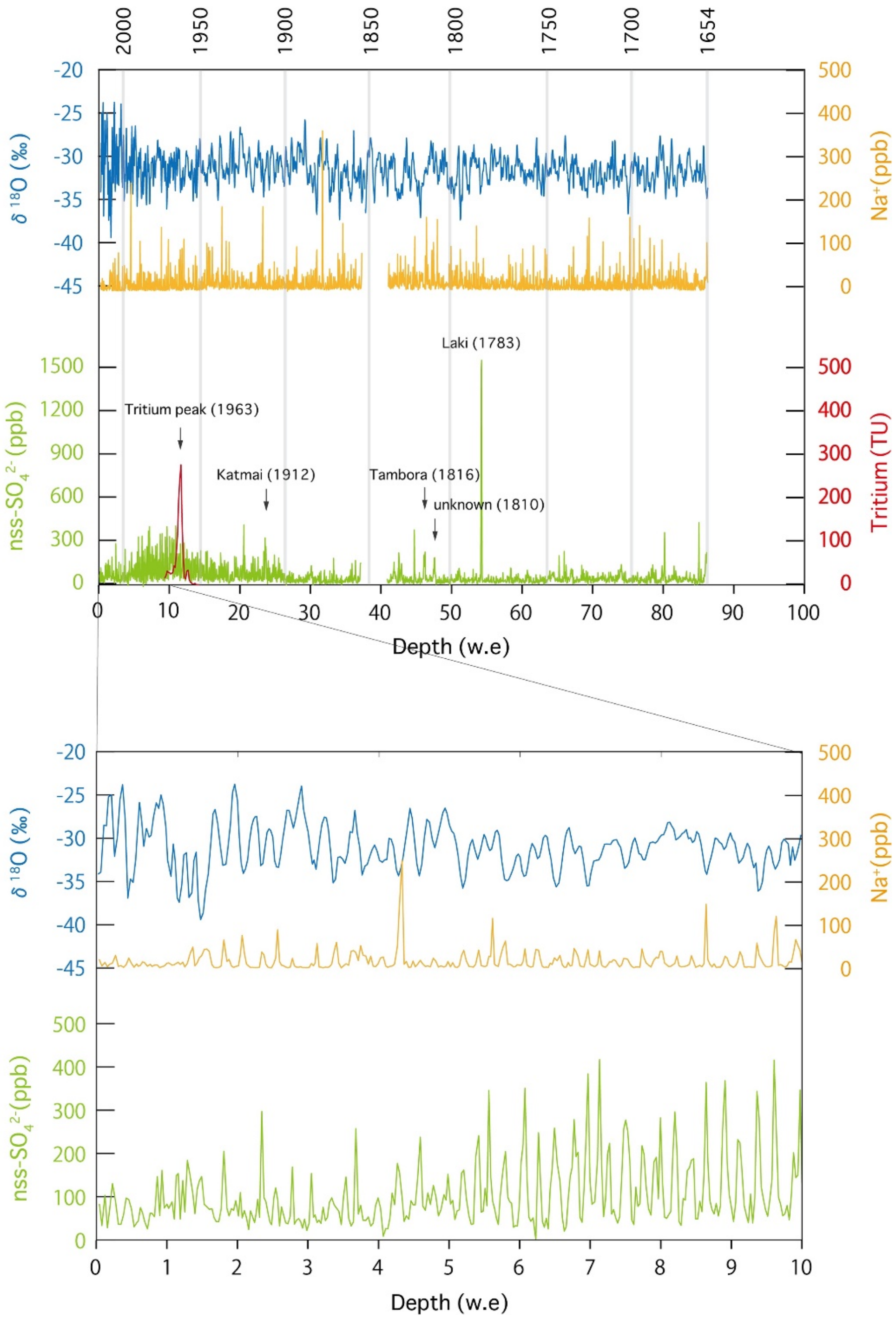


Figure Reply 7. ^{18}O, Na^+, nss SO_4^{2-}, and tritium records in the upper 112.87m (86.06m w.e.) of the SIGMA-D ice core. Major volcanic signals we identified are shown in SO_4^{2-} record. Bottom plots shows the enlarged record from 0 to 10 m w.e. (modified from Figure. A1).

[Reviewer comment]
Line No.310:-The choice of 07 days is not explained either and why the author considered only wet deposition?. At least this should be discussed.
[Author reply]
There was no strong reason for the choice of 7 days. But, Schüpbach et al. (2018), which was additionally discussed in the reply to the reviewer #1, estimated the modern atmospheric residence time for dust (Ca^{2+}) as 7.3 days so that our setting seems plausible. We will add air mass contribution by dry deposition as well as wet deposition to Figure 8 in the manuscript (also shown in this reply as Fig. Reply 8). The result shows that the air mass contribution from Greenland coast was larger in dry deposition than wet deposition during summer, which may cause an increase of dust sourced from local ice-free areas. However, there is no significant difference in the overall trend between the both deposition processes.

[Reviewer comment]
Trajectories also can never be discussed without cross-checking the results with the general synoptic situation(s) during the transport.
[Author reply]
We are not quite sure what the comment requires. Does this mean the probability map (Fig. 2b) should be superimposed by the long-term mean pressure pattern? We have not seen such a figure so far, and it would be so "noisy". If we discussed any "dust event" and its transportation, we would agree with the necessity of synoptic analysis. But our Fig. 2b is shown to depict the long-term mean condition. Further, the temporal fluctuation of contribution (Fig. 8) is shown to address "no significant trend/change of dust sources" so that we do not think of the necessity of synoptic analysis.

[Reviewer comment]
Trajectories with links, as shown in Fig. 2, are very unlikely to represent the real path of the air/dust particle.
[Author reply]
We are not quite sure why our backtrajectory expression is denied. Our probability map (Fig. 2b) is similar to that of Osman et al. (2019, Fig. 2b, also shown in this reply as Fig. Reply 9). Osman's figure represents the relative probability of (oceanic) airmass passing through a given atmospheric column en route to the GrIS. This is normalized on a 0-1 (least to most probable) scale while our scale is expressed as % (total sum is 100%).

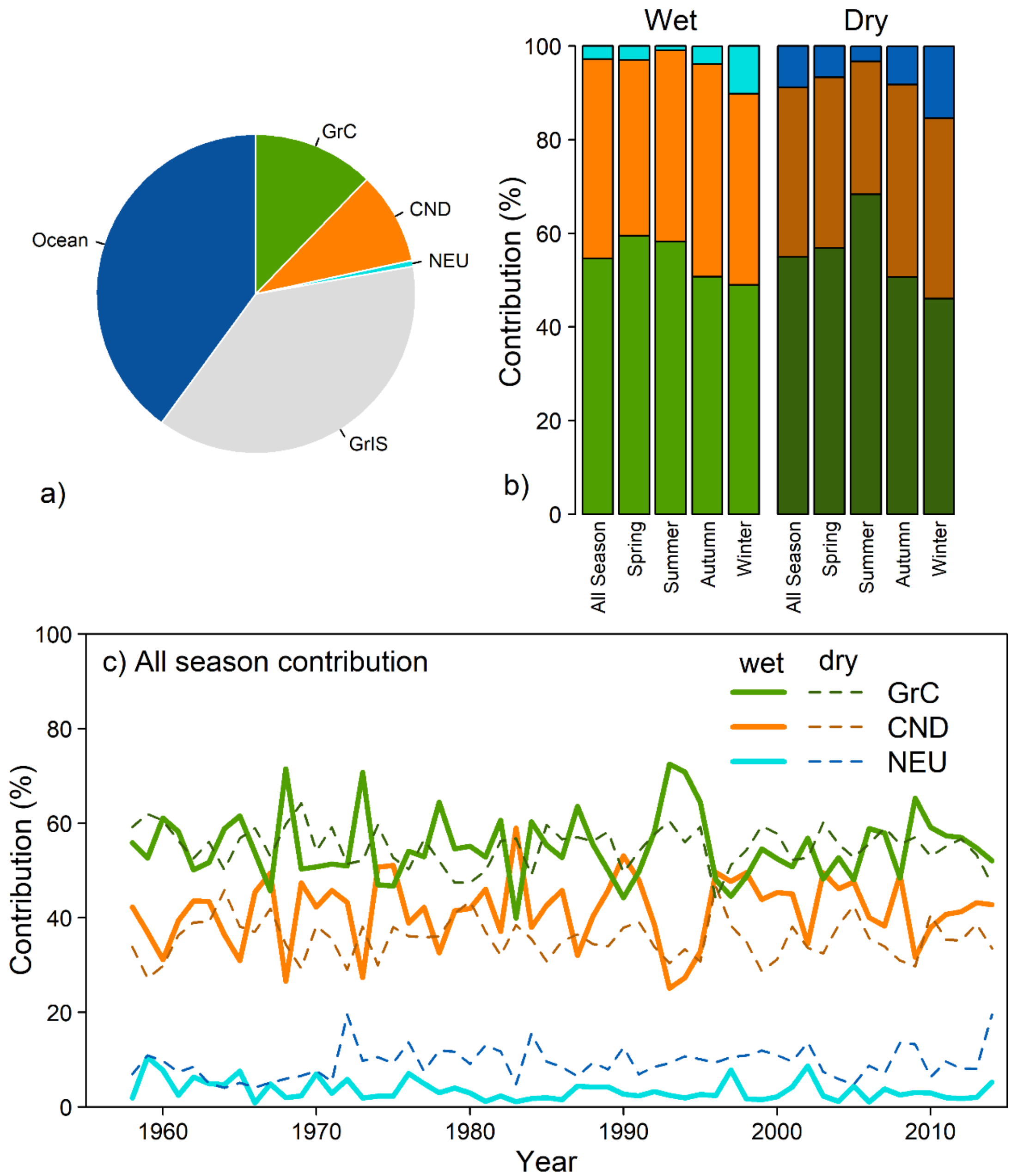


Figure Reply 8. (a) Contribution rate of an air mass from possible source areas during 1958 to 2013. (b) Seasonal and (c) annual variations in the regional contribution of wet and dry deposition to the SIGMA-D site excluding the ice sheet and ocean areas. GrC, GrIS, CND, NEU denote ice-free Greenland coastal region, Greenland Ice Sheet, Canada, and northern Eurasia, respectively (modified from Figure 8).

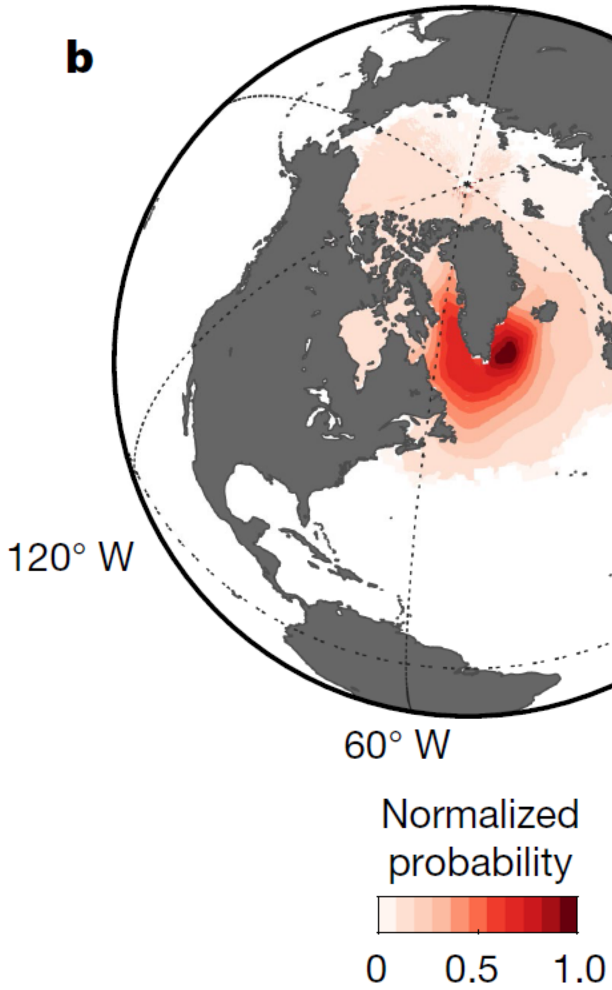


Figure Reply 9. Trajectory map of Osman et al. (2019, Fig. 2b) showing the relative probability of (oceanic) airmass passing through a given atmospheric column en route to the GRIS

[Reviewer comment]

What does it mean by a little contribution from Asia? please quantify it.

[Author reply]

This is addressed in the reply to reviewer #1.