Answer to reviewer comment 2

Review for Du et al. ESSD by Cécile Blanchet

Potsdam, April 19 th 2022

The authors present a data compilation for neodymium and strontium isotopes to trace dust deposition in the "three poles". In order to do that, the authors have assembled data from the literature as well as new measurements. I would recommend to reorganize the manuscript and better define the objectives of the study before this can be published. I have several comments, which I hope will help to improve the manuscript.

Reply: The authors greatly appreciate Prof. Cécile Blanchet for the very helpful and constructive comments in suggesting improvements on our first submission.

Please see our responses below, we have made major revisions to the manuscript, including significant additions for Sr-Nd data. We hope that this version addresses the comments of the referee.

Main comments:

1) I am not entirely sure what the main goal of the paper is: is it to determine where dust deposited on the three poles comes from? Is it to determine how the three poles act as sources and/or sinks through time? Is it to determine the role of local dust sources to the sinks on the three poles? On line 106, it is not clear which are the "questions" the authors are aiming to answer. Clarifying the aim will help to understand the rationale of compiling data from soil surfaces, glacier, snow, and marine sediment cores, but not using more global databases that would allow to determine the contribution from other potential source areas.

Reply: Thanks for your comments. We agreed that the main goal of the paper is not clear. First, the previous datasets (Blanchet et al., 2019; Robinson et al., 2021) had covered the most of regions in global scale. Therefore, the data was mainly compiled in the three poles. In this dataset, we defined the area of three poles based on the previous study (Li et al., 2021). Because the dust transport is complicated in Arctic, we did not use the PSAs at a global database. Second, for the remote three poles, which almost cover by the snow or ice. The long/short distance dust is transported and preserved into snow or ice by the atmospheric wet and dry depositions. Therefore, snow or ice from the three poles is the sink for the aeolian dust. And the deserts in arid areas of mid and low latitudes are the main source of dust. Third, as global warming, the exposed bedrock will be the dust source of snow and ice by physical or chemical weathering, which will become the new dust source. In addition, the sediment from Arctic Ocean and Southern Ocean will mix the aeolian dust and continental shelf material, which would be the sink. The age of samples was limited to the Quaternary period (2.5 Ma) because of the oldest ice core is about 800 000 years. The most of samples are collected from the surface deposits. Therefore, the aim of this manuscript is focused on the source and sink relationships between snow, ice and sediment records and potential source areas in this study. In the revised version, we reorganized the Introduction, the scientific topic of this work are further explained in this part.

2) If the aim of the paper is to describe the dataset, the authors need to spend more time explaining their strategy for data collection. Literature search? Use of previous compilations? Number of data from the literature versus samples measured and

published in this paper. Needs to be clarified, esp. in lines 175-190, where it is quite confusing (although it is clearer in the abstract). Please separate in the methods the literature search from the sample collection and measurements.

Reply: Yes, the describe dataset is the topic in this paper. In revised version, we recompiled much more Sr-Nd data and references. We presented the dataset information in Table 1. Because this strategy for data collection is the same with Blanchet (2019), we simplified this detail process, and as the examples, we try to list the patterns or characteristics in the three poles. The sample collection and measurements were separated in revised version.

3) Data file (excel spreadsheet): I struggle with the way the data are presented: I would recommend to use one template for all the data. In the attached spreadsheet, there are four different sheets with each a different template. For the sake of being able to compare the data with each other, please follow a strict (and similar) order and include "NA"s when an information is missing. If you want your data to be used by others, why not using the template that we published last year (version 3.0 of my database: https://dataservices.gfzpotsdam.de/panmetaworks/showshort.php?id=7124101c-d2a2-11eb-9603497c92695674), with perhaps modifying the "water depth (m)" column into an "elevation (m)" column (with changing signs whether it is altitude (+, masl) or bathymetry (-, mbsl)? Also please provide the locations in decimal degrees as it allows most programs to plot the data (it is more difficult with locations in minute/second). Also please provide the metadata in the downloadable spreadsheet.

Reply: Thanks for your concern. We are aware of it and used one template for all the

data as your version 3.0 database. The information of altitude or bathymetry and the locations were added in revised manuscript. The coordinates of locations were transferred in decimal degrees, and the metadata was also provided in revised manuscript.

4) Data visualisation: I think that one of the powerful possibilities of compiling data and attributing precise locations is to explore the spatial variability of certain variables by plotting isoscapes (instead of plotting numbers on locations like in Fig. 5). You're your case, it would be very interesting to compare the changes in Nd and Sr isotopes spatially in the three poles for the source material (soils) and for the sinks (snow, sediments). In general, the authors need to better separate sources and sinks throughout the manuscript.

Reply: Thanks, we agreed it. The Fig. 5 was replaced, however, we do not by plotting isoscapes for two reasons. First, few Sr-Nd data (including deep ice core) from snow or ice are collected from the Greenland ice sheet, which will result in the much uncertainty; Second, the Sr-Nd data from the Third Pole are multi-types, the geological unit is complicated, which are difficult to express with plotting isoscapes, and Sr-Nd data from the Antarctica are not uniformly distributed. As a case, we presented the Holocene samples for Antarctica with by inverse distance weighted interpolation using ArcGIS. We tried to identify the source or sink characteristics of Sr-Nd in dataset. However, for example, for loess samples from the deserts, Sr-Nd data may represent the source, but it may be sink in Chinese Loess Plateau because this material produced from the deserts and then deposited in this region. We try to separate sources and sinks in revised

manuscript as you suggestion.

5) Box and whiskers plots (Fig. 3 and 6): please indicate the number of samples used for each category. Please note that these analyses are best suited for >5 samples.

Reply: Thanks, we checked the box and whiskers plots in Figs. 3 and 6, the number of samples are all >5 samples, which were added in Figs.

6) In general, the isotopic signature needs to be discussed in terms of lithologicak context, which is seldom mentioned in the manuscript. Perhaps use geological maps to contextualise the varying signatures observed?

Reply: Agreed. Indeed, the lithological concentration for marine sediment can effect Nd values, we added the part of discussion about lithologicak context in lines 209-217. However, the geological conditions for the three poles are very complicated because of the areas of the three poles covering by snow or ice, and the resolutions of lithologicak data in Arctic Ocean and Southern Ocean are low, therefore, we did not contextualise it into the geological maps.

7) There are way too many abbreviations and I must say, I got lost. Please use abbreviations only when necessary but otherwise use the full names.

Reply: Sorry, we checked and corrected them in revised manuscript.

Minor comments:

L. 29-30: "recognized and introduced": what do you mean here?

Reply: We revised these word in revised manuscript.

L. 115: what is "data augmentation"?

Reply: We deleted it.

L. 122-123: it might be useful to clarify the expression "three poles" for the readers who might not be familiar with it. I knew the expression "third pole" but not "three poles". In lines124-125, you cite Australia, Southern south America, Southern Africa and New Zealand: are these regions part of the three poles? I thought the third pole refers to the Himalayas? Please clarify.

Reply: Thanks, we gave the "three poles" areas in Fig. 1. The areas of Australia, South America, Southern Africa and New Zealand are not the parts of the three poles. We collected the Sr-Nd data from the Himalayas and added it.

L. 126: I don't think that the abbreviation TP has been introduced before.

Reply: Changed.

L. 131: Please explain what a cryoconite sample is.

Reply: Explained it in lines 117-119.

l. 182: Very pleased that you used the scheme I developed: it will be very useful to compare and compile datasets!

Reply: We used the template as you developed it.

L. 218-219: I do not understand this sentence. The "acid leaching method" used is not given in the spreadsheets.

Reply: As you know, the gran sizes and acid leaching can effect Sr and Nd isotopic ration, therefore, we attempts to build a database that includes the different gran sizes and acid leaching methods (See dataset).

l. 220: "This feature validates" is a strange formulation, please clarify.

Reply: We deleted it for avoiding the misinterpretation.

L. 221-222: how did you determine PSAs exactly? Based on which criteria?

Reply: We determined the PSAs based on two criteria. First, the geographic location of deserts usually can be divided into the different geologic units. Such as, the arid regions from the western China, Sahara, Australian, South Africa and South America. In general, the PSAs mostly distributed in arid regions of low-mid latitudes in the northern Hemisphere. Second, a number of previous studies have identified the PSAs based on Sr-Nd data or dust transport model at a global scale (Chen et al., 2007; Li et al., 2008; Du et al., 2019; Zwaaftink et al., 2016; Dong et al., 2021). Therefore, Sr-Nd data will further demonstrate these identified PSAs, and try to link the relationship between PSAs and glaciers, and Sr-Nd data also can provide the new information for further finding the others possible PSAs.

L. 224-253: are these six regions the PSAs? How were they determined?

Reply: Yes. In general, these six region were determined by the high mountains (> 4000 m msl). Such as, Tienshan Mountain, Kunlong Mountain, Qilian Mountain, Hengduan Mountain, Himalayas and interior Tibet Plateau. In revised manuscript, we plotted the Mountains in Fig. 2. Sr-Nd data in each PSAs were the unique characteristics.

L. 301-306: belong to the methods. This happens repeatedly throughout the manuscript. Please all technical considerations should be put in the methods. However, the authors are often describing how other teams have sampled, which seems not really necessary. It might be advisable to the authors to edit the paper: there are often redundancies or unclear sentences, which hinder a smooth reading and a comprehension of the paper.

Reply: Thank you for your suggestion. These sentences were deleted. We also reedit

L. 374-376: I do not understand this sentence. I cannot see any homogeneity/heterogeneity from Fig. 6. Please clarify or modify Fig. 6.

Reply: Sorry, we explain it in revised manuscript.

L. 377. Antarctica: there are a lot of new data for Antarctica assembled in the paper of Robinson et al. (2021) in Chemical Geology (Open Access, https://doi.org/10.1016/j.chemgeo.2021.120119). The accompanying database version is V3.0: https://dataservices.gfz-potsdam.de/panmetaworks/showshort.php?id=7124101c-d2a2-11eb-9603-497c92695674)

Reply: Thanks, we updated some data from Robinson et al. (2021) for Antarctica.

L. 429-438: the separation in these different areas seems quite arbitrary. What is it based on? The authors mix sources and sink and it is not very helpful to understand the processes driving dust transportation I think.

Reply: There different areas were divided based on Sr-Nd data. We agreed that the sources and sinks are not clear. We gave some explanation in revised manuscript based on your suggestions, such as, lines 161-167, 238-241, 313-316.

L530-556. Conclusions

L. 540-543: I find this claim not really supported by the manuscript. The criteria were not used to determine which dust source was contributing to which sink. This needs to be better demonstrated, e.g., by separating sources and sink in the database or in the figures.

Reply: Thanks, we revised these sentences in lines 523-525, 533-535 and 538-540. As mentioned before, because the source or sink may be uncertain for the different region. We just separated sources and sink in the database.

L. 554. A PSA should be defined based on present-day knowledge of dust generation, e.g., based on remote sensing or geomorphological evidence. At minima it needs to be defined by the dust produced: grain-size distribution, mineralogy, isotope signature as well as by its geographical location.

Reply: Thanks, it is clear that PSAs in Antarctica are identified by remote sensing or geomorphological evidence. We revised this sentence in lines 541-545.

Figures:

I would encourage the authors to revise their figures to make them more informative.

Fig. 2: The numbers on the map (glaciers and deserts) need to be related to the names in a legend or in the caption.

Reply: We added these names of glacier in the caption.

Fig. 3: see my previous comment on box and whiskers plots.

Reply: Thanks, we checked it and added the explanations.

Fig. 4: There needs to be a legend on this map to help the reader to identify the different sample sets.

Reply: Done.

Fig. 5: This figure would be much better is plotted as an isoscape (using interpolation between known values), and with maps for sources and maps for sinks. Actually, I think that Fig. 4 and 5 could be combined in isoscapes.

Reply: Yes, we agreed. However, as the readers and editors' concern, we should introduce the data characteristics. Besides, the sources or sinks are very different for the different age samples. Therefore, we just compared Sr-Nd data in 12 sub-regions with the modern samples (surface samples from sediment), which give the patterns of Sr-Nd in the Arctic.

Fig. 6. See Fig.3. I struggle with the abbreviations: please put the full names.

Reply: Sorry, added them.

Fig. 7: same as comment for Fig. 5.

Reply: Done.

Fig. 8: What are the A, B, C and D areas? Perhaps choose colour codes to distinguish the main areas?

Reply: We changed it with Fig. 7

Data: See main comment 3)

Reply: Thanks, we added in the major revisions.