# The characterization of atmospheric trace metals input recorded in East GRIP snow pit


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## PURPOSE OF THIS RESEARCH

- Characterization of seasonal changes in atmospheric aerosols input into the Northeastern Greenland
- Identification of sources for atmospheric aerosols over the Northeastern Greenland
- Evaluation for natural/anthropogenic contributions to the atmospheric trace elements.

## SAMPLING

- In July, 2017, a series of 38 snow samples collected from 1.9 m deep snow pit at the Greenland EGRIP camp (75.623°N, 35.96°W).
- The snow pit was hand-dug by the researcher wearing full clean room garments and PE gloves using plastic shovel.
- The snow samples were collected at every 5 cm from the up-wind wall of the snow pit by pushing an acid clean cylindrical Teflon containers.

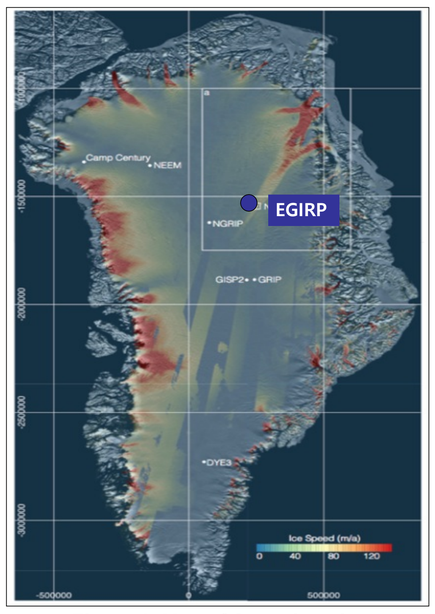



Figure 1. Map of Sampling site

Figure 2. EGRIP snow pit Sampling

## ANALYSIS

- All sample preparation and measurements except water stable isotopes measurement were performed in a Class 10 clean booth in a Class 1000 clean laboratory.
- Water stable isotope ratios ($\delta^{18}O$ and $\delta D$) of snow samples were measured by CRDS (2130-i, PICARRO Inc.).
- Ion species – $Na^+$, $Ca^{2+}$, $SO_4^{2-}$ and $Cl^-$ in snow samples were determined using ion chromatography (ICS 2100, Dionex) with CS12A(4 x 250 mm) and AS15(2x250 mm) columns.
- Trace metals and halogen in snow samples were analyzed using ICP-SF-MS (Element2, Thermo Fisher SCIENTIFIC, Germany) equipped with APEX_HF(Desolvation System, ESI, USA).

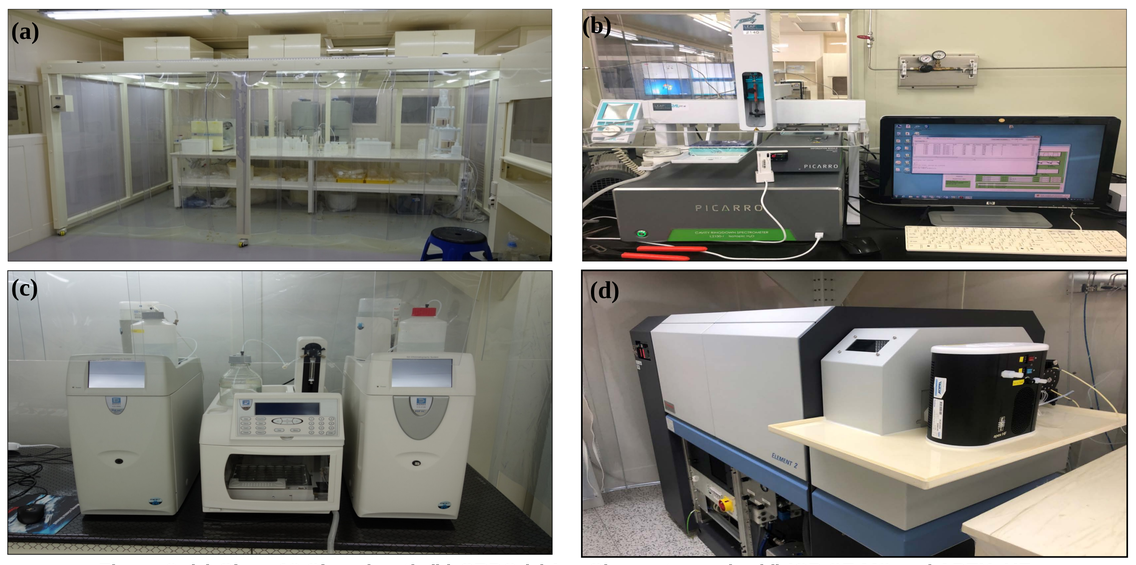
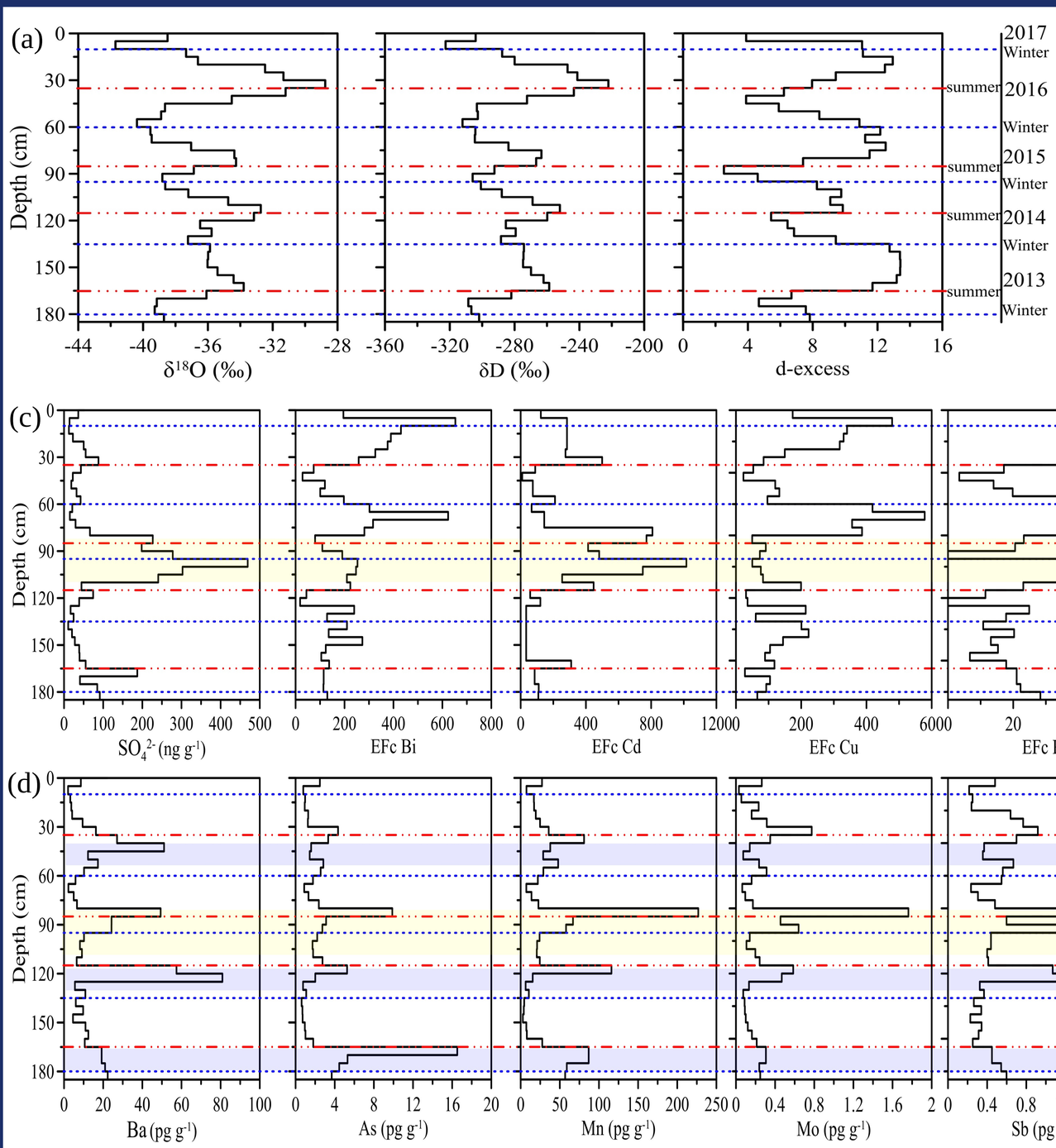



Figure 3. (a) Class 10 Clean booth (b) CRDS (c) Ion Chromatography (d) ICP-SF-MS and APEX_HF

## RESULTS



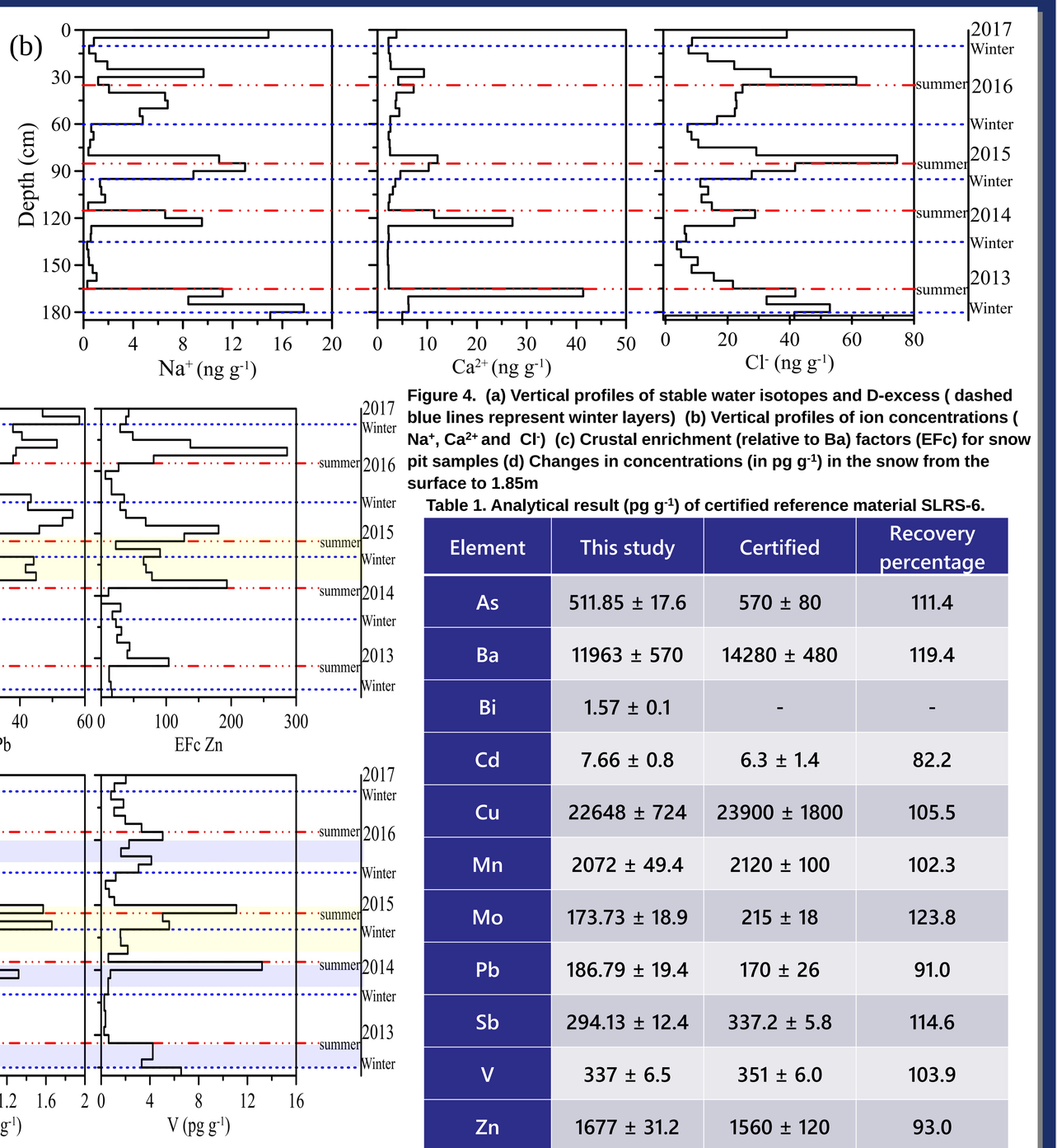










**Figure 4. (a) Vertical profiles of stable water isotopes and D-excess ( dashed blue lines represent winter layers) (b) Vertical profiles of ion concentrations ( $Na^+$, $Ca^{2+}$ and $Cl^-$) (c) Crustal enrichment (relative to Ba) factors (EFc) for snow pit samples (d) Changes in concentrations (in pg $g^{-1}$) in the snow from the surface to 1.85m**

**Table 1. Analytical result (pg $g^{-1}$) of certified reference material SLRS-6.**

| Element | This study | Certified | Recovery percentage |
|---|---|---|---|
| As | 511.85 ± 17.6 | 570 ± 80 | 111.4 |
| Ba | 11963 ± 570 | 14280 ± 480 | 119.4 |
| Bi | 1.57 ± 0.1 | - | - |
| Cd | 7.66 ± 0.8 | 6.3 ± 1.4 | 82.2 |
| Cu | 22648 ± 724 | 23900 ± 1800 | 105.5 |
| Mn | 2072 ± 49.4 | 2120 ± 100 | 102.3 |
| Mo | 173.73 ± 18.9 | 215 ± 18 | 123.8 |
| Pb | 186.79 ± 19.4 | 170 ± 26 | 91.0 |
| Sb | 294.13 ± 12.4 | 337.2 ± 5.8 | 114.6 |
| V | 337 ± 6.5 | 351 ± 6.0 | 103.9 |
| Zn | 1677 ± 31.2 | 1560 ± 120 | 93.0 |

## DISCUSSION

- The less negative values of $\delta^{18}O$ and $\delta D$ at 35, 85, 115, 165cm were assigned to summer season, while the more negative values at 10, 60, 95 and 135cm to winter season (Fig.4 (a)).
- $Ca^{2+}$ and Ba mainly originating from crust dust peaked during spring season implying the large influence from Asian dust (Fig.4 (b)).
- The high concentrations of $Na^+$ and $Cl^-$ during the spring season imply that enhanced westerly transport more sea-salt for that period. (Fig.4(b)).
- The nss$SO_4^{2-}$ layer at the depth of 85-120 cm is associated with an episode of increased Holuhraun eruption inputs. No significant changes in EF of As, Bi, Cd, and Mo for the period of Holuhraun volcanic eruption represent the contributions from anthropogenic emissions were much larger than the volcanic contributions. In additions, because Holuhraun eruption released much more gas($SO_2$) at the start of the event, the eruption was gas rich and ash poor. Yellow areas indicate when the volcanic eruption (Fig.4 (c)).
- Several of the metals have relative maxima in concentration during spring time. This may reflect inputs coming together with dust episodes originating from the Asian deserts or influence of industrial activities in North America. Blue areas indicate when spring season (Fig.4 (d)).

## Reference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# 일반세션 논문초록

## The characterization of atmospheric trace metals input recorded in East GRIP snow pit

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논문초록

On July 2017, a series of 38 snow samples were collected from the 1.9 m deep snow pit at the Greenland East GRIP deep ice core drilling camp in 5 cm interval. These samples were analyzed for As, Bi, Cd, Cu, Mo, Pb, Sc and Zn in order to characterize the relative contributions from anthropogenic and natural sources to the fallout of these elements in northeast Greenland. Also, for the age dating, we measured water stable isotope ratios and ions such as $Na^+$, $Ca^{2+}$ and $SO_4^{2-}$. The typical seasonal changes in water stable isotope ratios, $Na^+$ and $Ca^{2+}$ of the snow pit samples indicate that these samples covered the period from spring of 2013 to summer of 2017. On the other hand, nss-$SO_4^{2-}$ calculated with $SO_4^{2-}$ and $Na^+$ showed a large peak from 2014 fall to 2015 summer. This period corresponded to the Holuhraun volcanic eruption (31 August 2014) at Iceland, and thus it can be inferred that the large increase of nss-$SO_4^{2-}$ for that period was most likely due to the input of volcanogenic $SO_4^{2-}$.

A volcanic eruption is also well known for an important natural source for atmospheric trace metals. The high crustal enrichment factors (EFc) of As, Bi, Cd, Cu, Mo, Pb and Zn in the Greenland East GRIP snow pit implies the large contributions from additional sources other than wind born crust dust. However, differently from the remarkable peak of nss-$SO_4^{2-}$ corresponding to the Holuhraun eruption, High concentrations and EFc values of trace metals were found every year especially during fall and winter. This represents no particular contributions from that the Holuhraun eruption. This also well meets the gas rich-ash poor eruption of Holuhraun volcanoes. Considering this, the seasonal enrichments of trace metals in East GRIP seem to be significantly contributed by anthropogenic emissions.

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