2020 EGU General Assembly, Online, 4 – 8 May 2020

# Water isotope and chemical records in a recent snow pit from Hercules Neve, northern Victoria Land, Antarctica

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EGU General Assembly 2020
Vienna | Austria | 3-8 May 2020

# Mineral dust effect

**MINERAL DUST**

### Climate
- Direct: the absorption of thermal radiation
- Indirect: the global carbon cycle and green gas content

### Chemistry
- Chemical balance of the atmosphere through surface absorption and reaction

### Biogeochemical Cycle
- Providing nutrients on terrestrial and marine ecosystem

### Health
- Mineral dust in the respirable size can cause health problem


➢ Polar ice cores archive mineral aerosol exclusively of aeolian origin

➢Since dust in snow does no weathering after deposition, it can give information about the past climate system.

# The importance of local source

Aarons et al.,2016

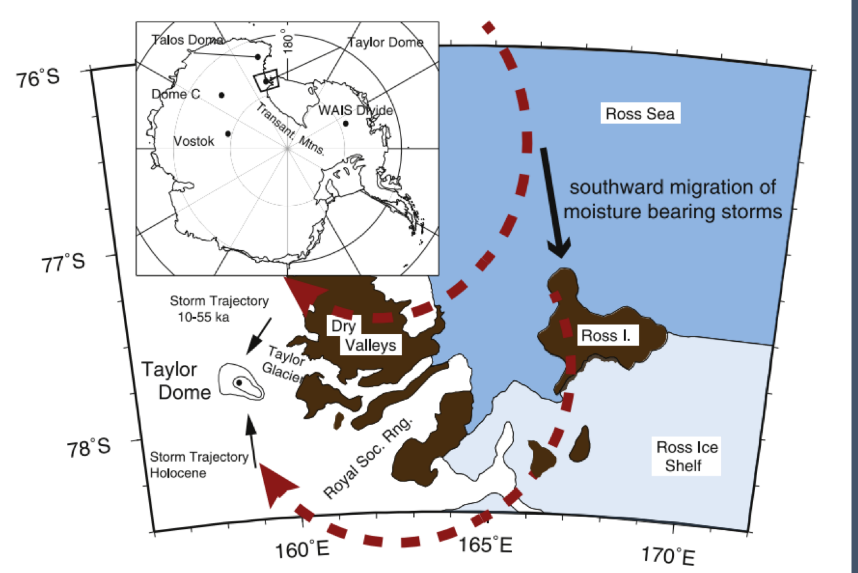



**Fig. 1.** Map of Taylor Dome and surrounding area, with major ice core drilling sites and the hypothesized Last Glacial Maximum (top dashed arrow) and current Holocene (bottom dashed arrow) storm trajectory (figure adapted from Morse et al., 1998).

- During late Quaternary glacial periods on central and coastal east Antarctic ice cores identify southern South America (SSA) as the most likely source of mineral dust

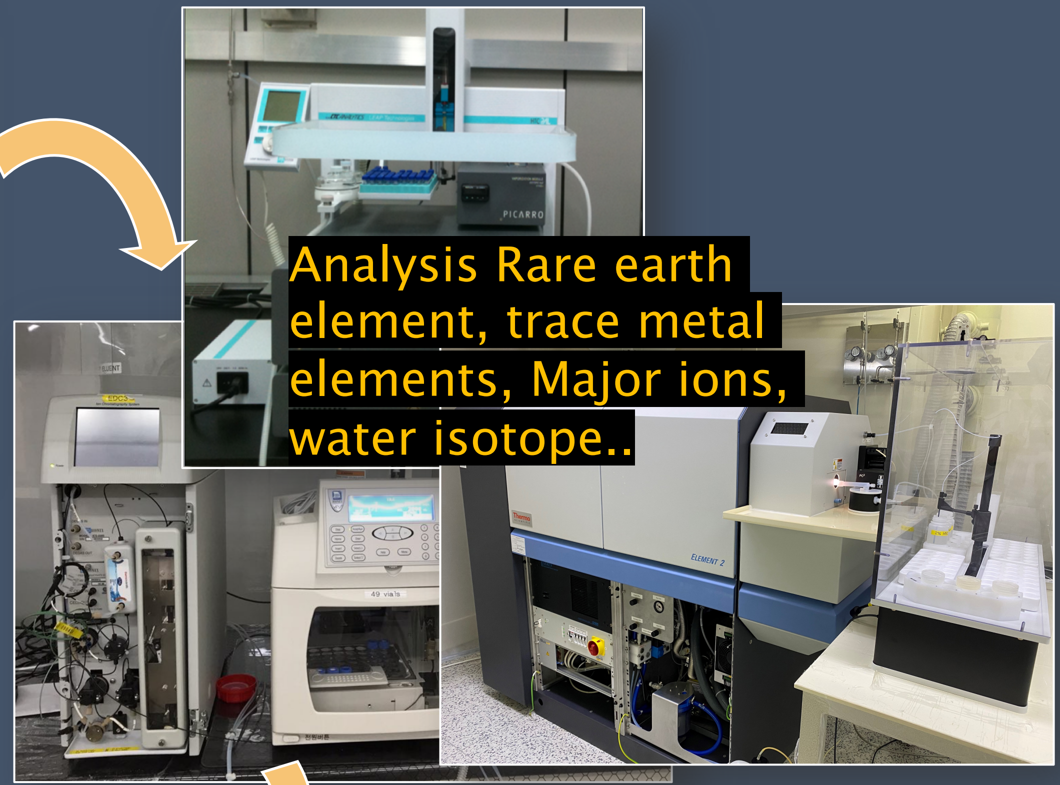
- During interglacial periods in coastal ice cores may potentially originate from local sources (Delmonte et al., 2007, 2010; Gabrielli et al., 2010; Aarons et al., 2016).

# Hercules Neve

- Sampling date: Dec. 15, 2015
- Location: 73°03'S, 165°24'E
- Altitude: ~2900 m
- Distance from the sea: ~75 km
- Accumulation: 119~145 kg $m^{-2}$ $a^{-1}$ (Stenni et al., 1999; 2000)


- Hercules neve is surrounded by the mountains and close to the coastal.
- HN region in glacier ice also has the potential to provide information about the sources of aeolian dust reaching the Antarctic ice sheet at past climatic cycles

# Research proposal


Identification of source

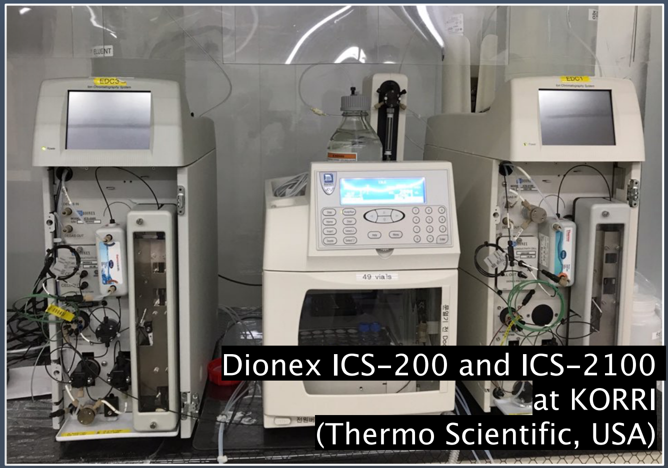
# Snowpit sampling

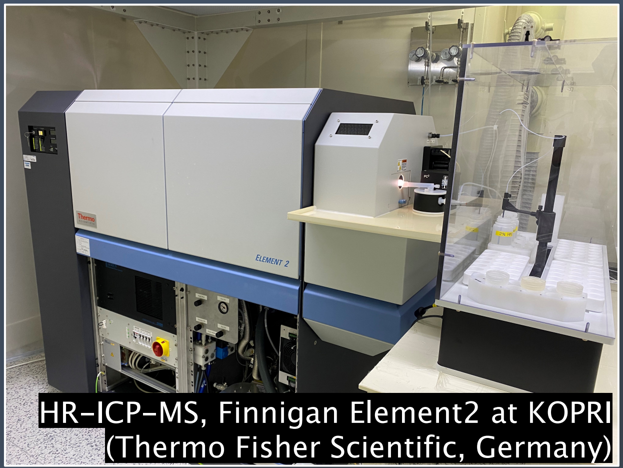
Source: 2014/15 Antarctic campaign by KOPRI

- Depth: 2 m
- Sampling resolution: 5 cm
- Pre-cleaned equipment: polyethylene bottle, stain-less steel shovel, polyethylene gloves, Teflon cylinder, hammer, clean-suit, mask

# Experimental method


Isotopic liquid water analyzer at KOPRI, L2130-I (Picarro, USA)


Dionex ICS-200 and ICS-2100 at KORRI (Thermo Scientific, USA)


HR-ICP-MS, Finnigan Element2 at KOPRI (Thermo Fisher Scientific, Germany)

| | Precision | Number of sample | Standard |
|---|---|---|---|
| Water isotope ($\delta^{18}O$ and $\delta D$) | $\delta^{18}O$: 0.07 ‰<br>$\delta D$: 0.6 ‰ | 40 | VSMOW, GISP, SLAP and Lab-made standard |
| Major ion ($Na^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, MSA, $Cl^-$, $F^-$, and $SO_4^{2-}$ ) | <10 % | 40 | Cation; Product # 46070, Anion, Product # 57590 |
| REE (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Yb, Lu), Trace metal (Y, Sb, Ba, Tl, Bi,Th) | <15 % | 40 | IV-ICPMS-71A, 71B, 71D |

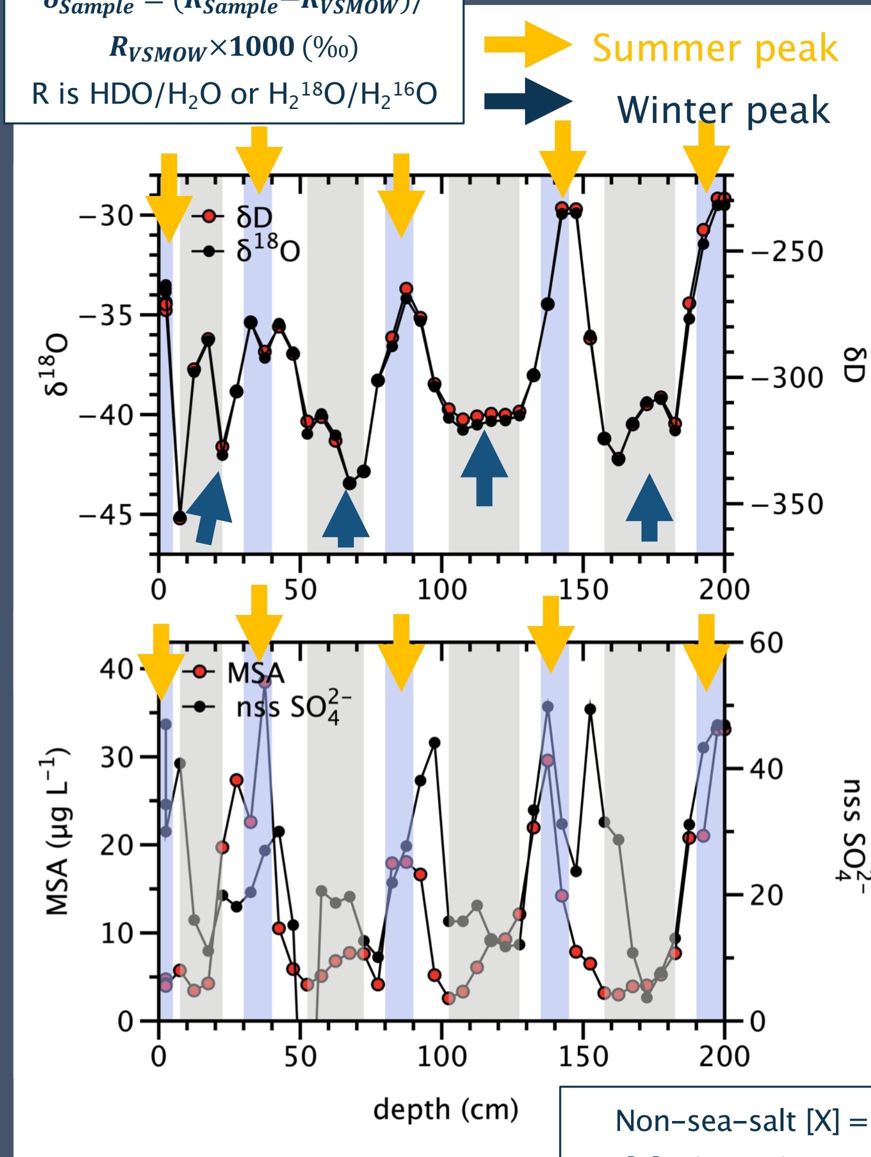
# 1.1 Temporal variation of water isotopes, MSA

$$\delta_{Sample} = (R_{Sample} - R_{VSMOW}) / R_{VSMOW} \times 1000 \ (‰)$$

R is $HDO/H_2O$ or $H_2{}^{18}O/H_2{}^{16}O$

- ❖ Water isotopes in snow -> temperature proxy
  - – Oxygen and hydrogen isotopes (water isotope ratios) are temperature related and can be used to confirm seasonality.
  - – Summer enriched ratio, winter depleted ratio

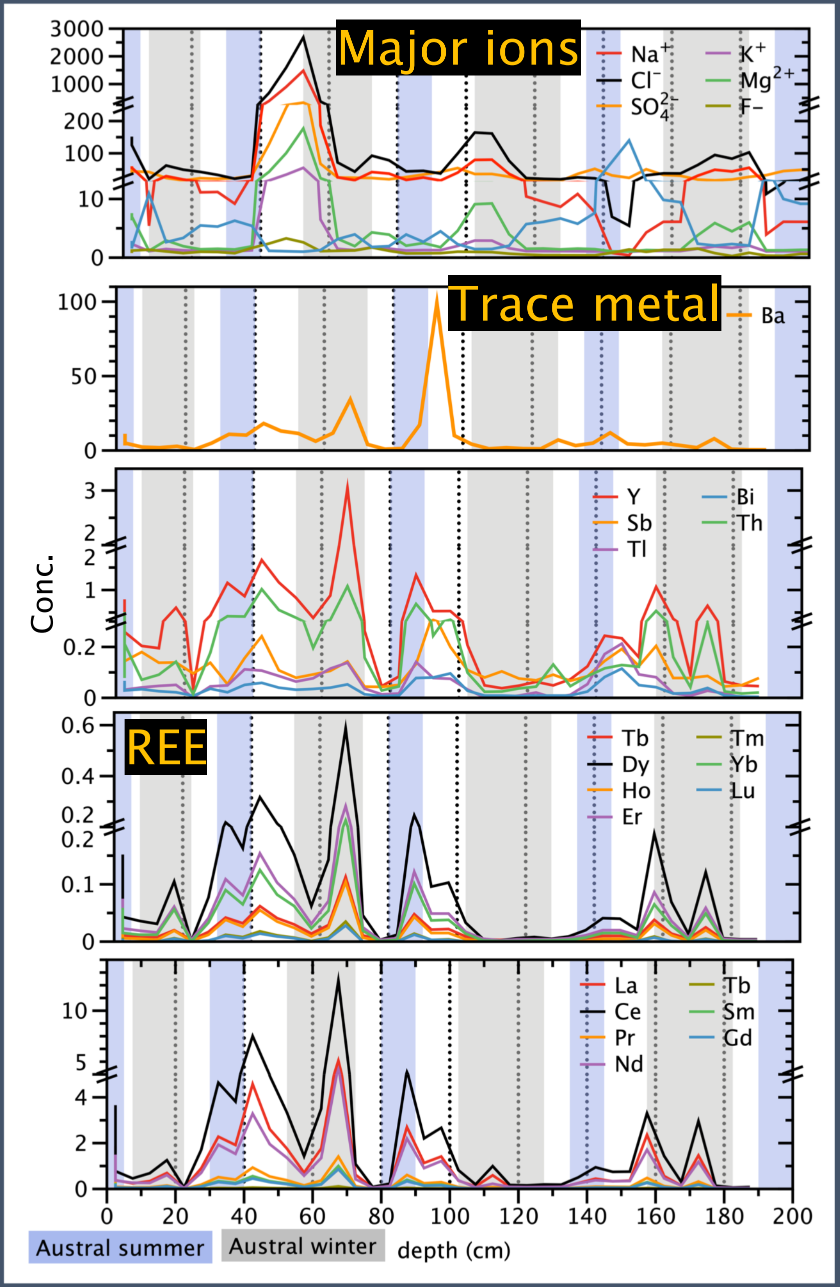
- ❖ MSA and non-sea salt $SO_4{}^{2-}$ -> seasonality proxy
  - – MSA (Methanesulfonic Acid), non-sea salt $SO_4{}^{2-}$ is a by-product of marine biological activity and can be used as a seasonal proxy because it has high activity in summer and shows high concentration in snow.




$$\text{Non-sea-salt } [X] = \text{tot}[X] - (X/Na^+)_{sw} \times Na^+$$

# 1.2 Temporal variation of major ions, REE and trace metal

Depth profile of the major ions, REE, and trace metal




The major ions, REE, and trace metal

- No consistent pattern indicate the various sources
  - Marine source (sea salt)
  - Terrestrial source (crust-derive dust)
  - Anthropogenic source
  - Volcanic source
- Sea salt ions ($Na^+$, $Cl^-$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $SO_4^{2-}$) show high correlations each others
- High correlation in REE and trace metal (except Ba, Bi, Sb)

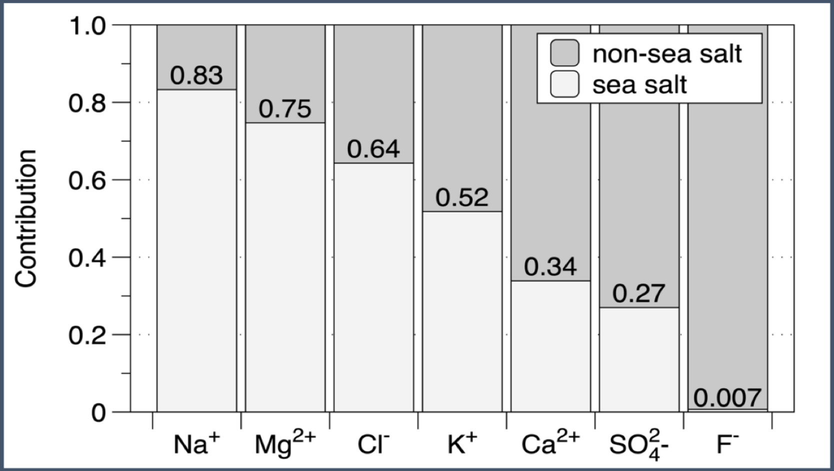
# 2.1 Effect of Marine source (sea salt)

**Fraction of major ions, REE and trace metal**

1) *Non-sea-salt [X] = tot[X] – (X/Na⁺)* $_{seawater}$ *× Na⁺*

2) *Contribution of Non-sea salt [X] = nss[X]/tot[X]*

**Major ions**

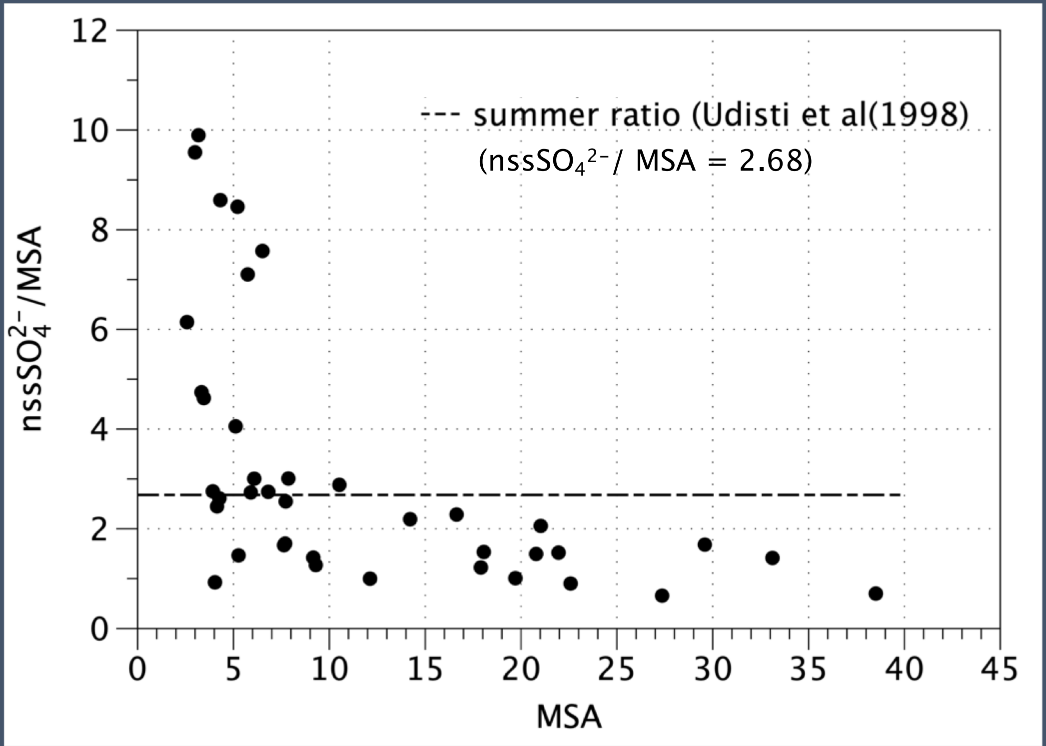



- Sea salt contribution was higher (>60 %) in $Na^+$, $Mg^{2+}$, $Cl^-$
- Contributions of other sources (not only sea salt) shown in $K^+$, Ca2+, and $SO_4^{2-}$
- $F^-$ no sea salt

**REE & Trace metal**

- Sea salt sourced REE is negligible, thus crustal and terrestrial sources were considered

# 2.2 Marine biogenic source (corr. nss $SO_4^{2-}$ with MSA)




- Biogenic sulfur enhancement in spring and summer was detected in nss$SO_4^{2-}$ and MSA (r = 0.39)
- Minor contribution of other sources (e.g. crust, volcanic) can be observed in nss$SO_4^{2-}$ during winter (MSA conc. is low)

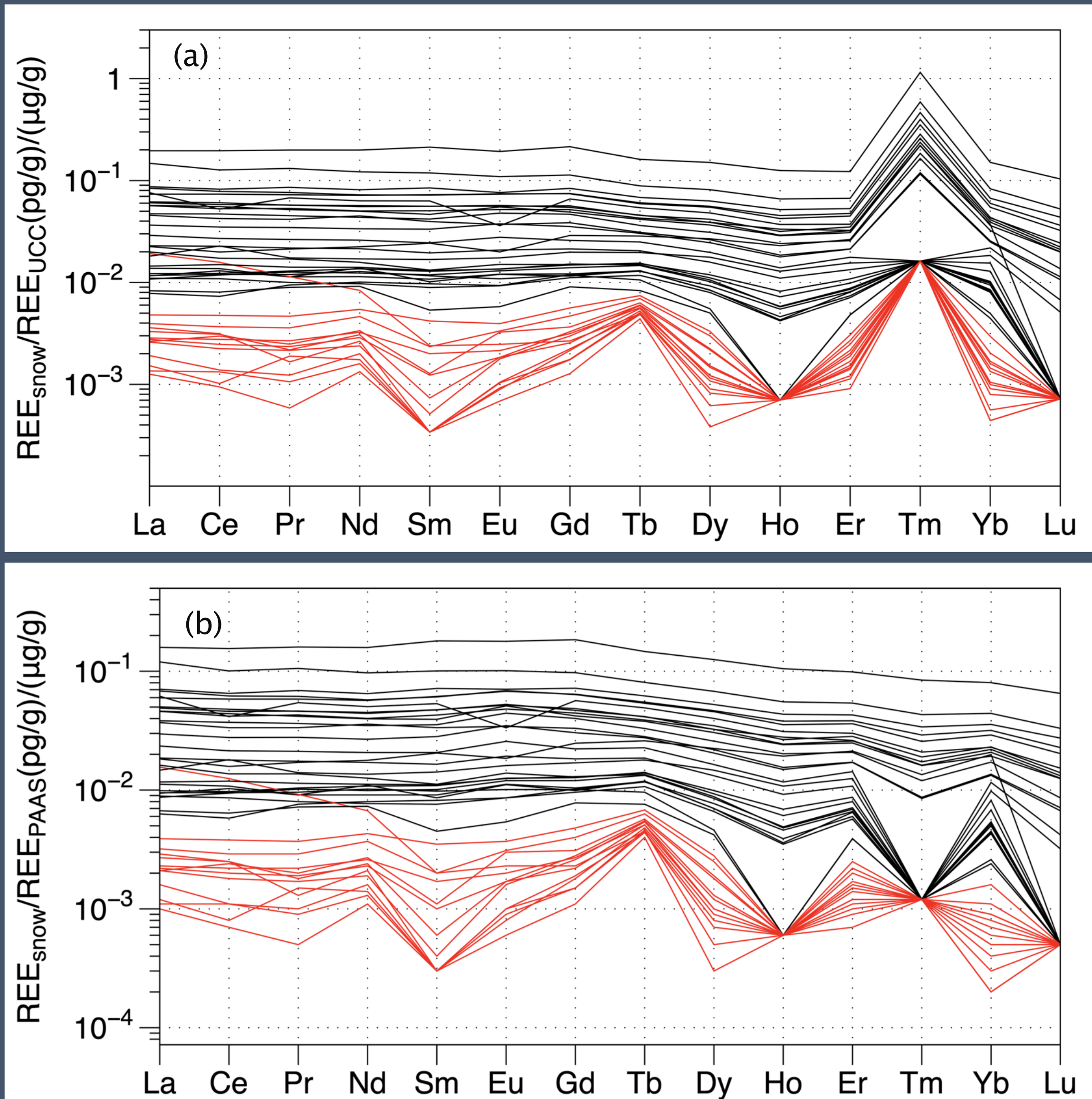
# 2.3 Potential Source – Trace metal

- ❖ Y and Th show high correlation ($r^2$ = 0.99) with the REE (La), while this correlation was not observed with the others including Sb, Ba, Bi, and Tl (0.27<$R^2$).
- ❖ It can be considered the different sources for Sb, Ba, Bi, and Tl compared to potential sources of REE.
- ❖ Sb, Bi, Ba and Tl correlation ($R^2$)

| | Sb | Bi | Tl | Ba |
|---|---|---|---|---|
| **Sb** | 1 | | | |
| **Bi** | 0.36 | 1 | | |
| **Tl** | 0.16 | 0.74 | 1 | |
| **Ba** | 0.22 | 0.10 | 0.10 | 1 |

- Bi show relation with Sb and Tl
- Sb, Bi and Tl were assumed to be sourced from other sources (e.g. anthropogenic)

# 2.4 Terrestrial Source – REE




- $REE_{snowpit}/REE_{UCC\ or\ PAAS}$
  - The converging points of Ho, Tm, and Lu indicate the detection limit values (due to very low values).
  - The anomalies of Sm and Tb were commonly seen in the low concentration section (red line) in (a) and (b), and the anomaly of the positive Tm in the high concentration part (black line)is observed in (a).
  - It seems that there are at least two snow REE sources, continental sources, not marine or anthropogenic pollution.

# Summary

- No consistent pattern (seasonal) was observed in major ions, REE, and trace metal
- The patterns of Sb, Tl and Bi are different from REE and are considered to be anthropogenic source as in previous studies.
- Considering concentration of REE, there are two crust-derived potential sources (maybe not marine and anthropogenic source)
- More records (long-term record (e.g. ice core)) in local scale are needed in the further research

Thank you.