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Size distribution and seasonal evolution of airborne metals in Antarctic atmospheric particulate matter

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INTRODUCTION & AIM

Aerosols are key climate drivers, affecting Earth's radiation balance and cloud properties (Nielsen, 2019). Antarctica, apparently remote from major anthropogenic sources, offers an ideal setting to study background aerosol concentrations and natural processes, aiding in understanding human impacts and long-range aerosol transport (Weller, 2008). This research focuses on: (1) the determination of size-segregated elements in aerosol; (2) the evaluation of size distributions and seasonal variations; and (3) the assessment of potential sources of elements in the Antarctic aerosol.

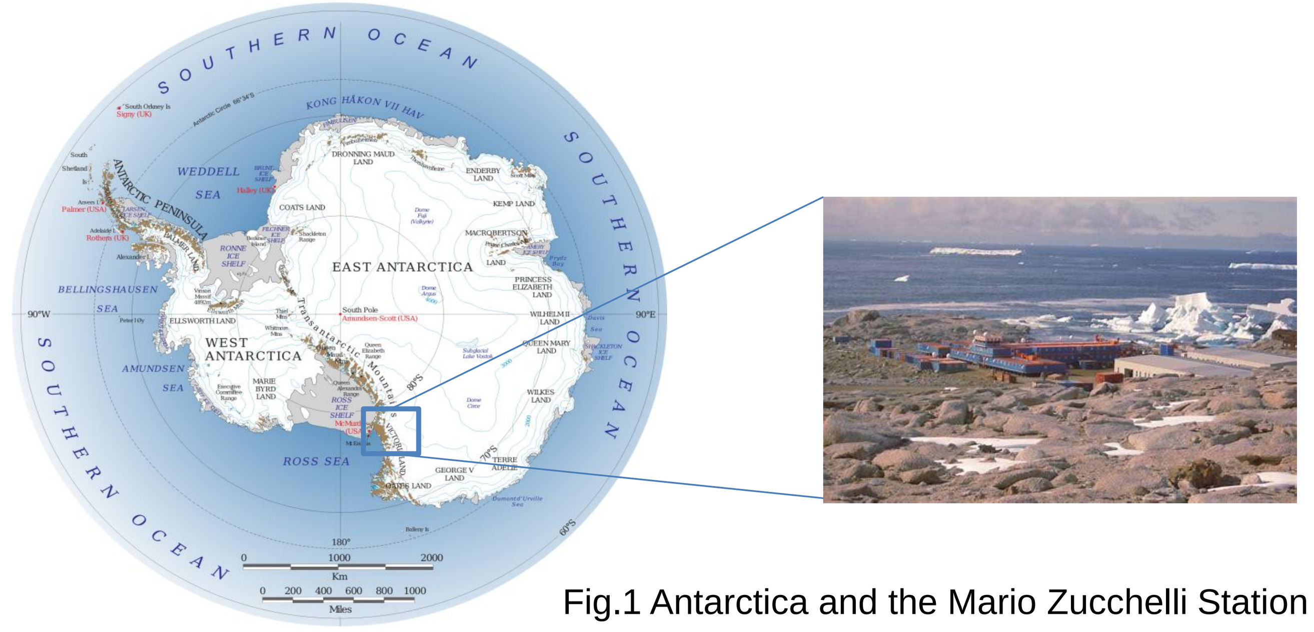


Fig.1 Antarctica and the Mario Zucchelli Station

METHOD

Sampling was conducted at M. Zucchelli Station, located in Terra Nova Bay (Ross Sea), 57 meters above sea level and 250 meters from the sea. The Antarctic campaign took place from November 12, 2019, to January 20, 2020. A PM10 high-volume sampler equipped with a 6-stage cascade impactor operated at a flow rate of 1.13 m³/min was used. Sampling followed a 10-day interval strategy using PTFE fiber filters, resulting in a total of seven collected samples, along with three field blank samples.

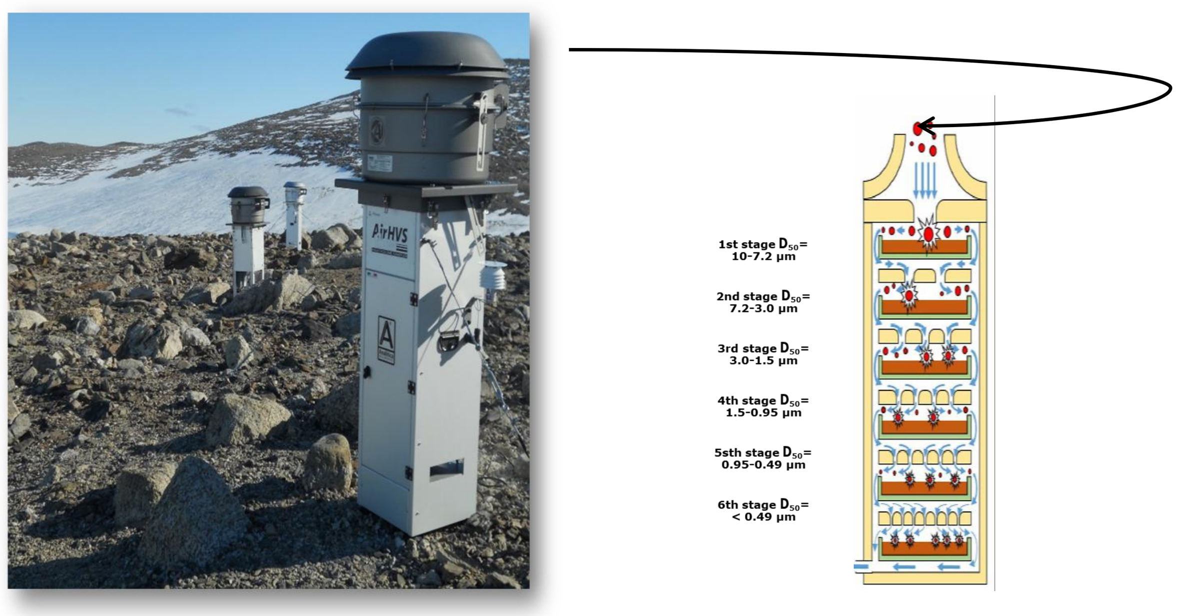


Fig.2 High Volume multi-stage Cascade Impactor

All analytical steps were performed in an ISO 5 clean room laboratory

For DMA-1 analysis, an aliquot (1/64) of each original PTFE fiber filters, no sampling preparation was required

For ICP-OES and GF-AAS analysis, an aliquot (1/8) of each original PTFE fiber filters were subjected to microwave acid digestion (5 mL HNO_3 / 1 mL HF/ 1 mL H_2O_2)

ICP - OES

Cd, V, Cr, Ni and Cu

GF - AAS

Al, Ca, Cd, V, Cr, Ni and Cu

DMA

Particulate Hg

CONCLUSION

The seasonal evolution of size-segregated PM10 was element-specific and strongly affected by the catabatic wind events and pack-ice melting. These preliminary results highlighted the importance of monitoring aerosols in Antarctic to better understand their contribution and impact on polar ecosystems.

Three different concentration trends were observed during the campaign:

- Constant Trend → K, Na, Al, Ca, Mn, V, Cd
- Increasing Trend → Ni (unique behavior)
- Decreasing Trend → Mg, Fe, Cr, Cu, Hg

Enrichment Factor (EF) Analysis:

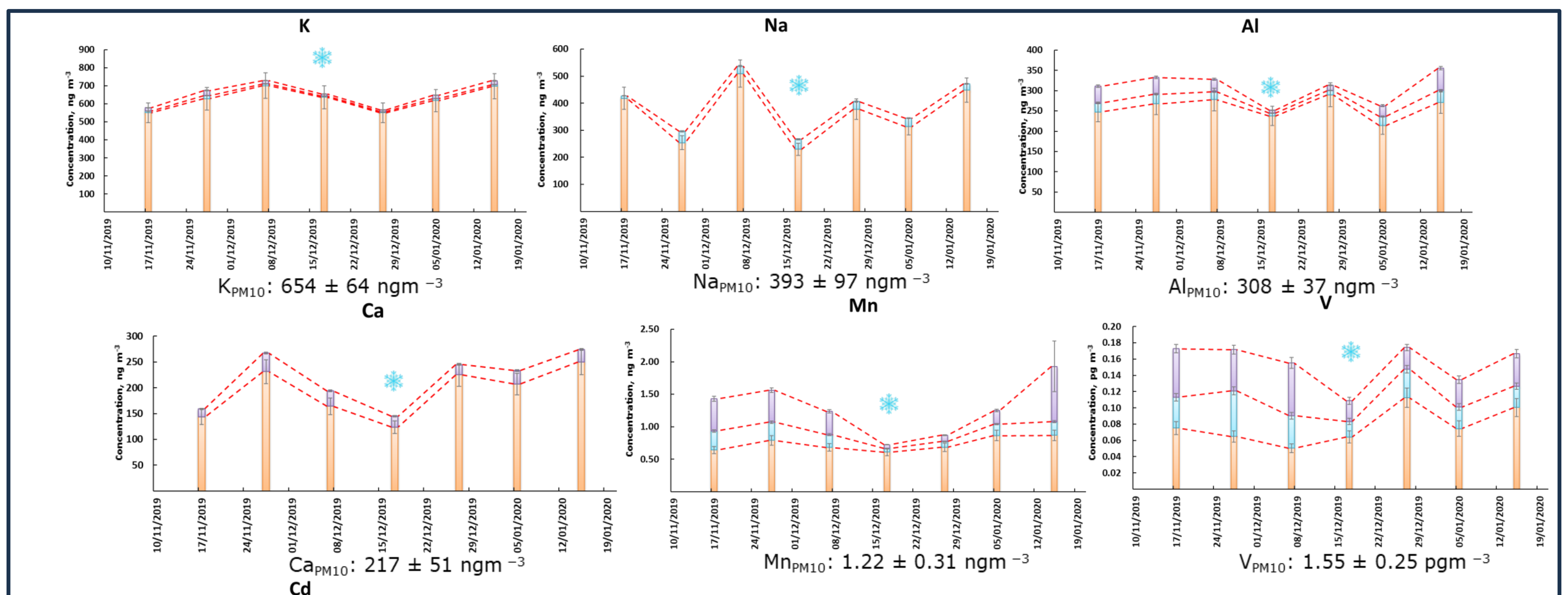
- Cd and Hg → Possible anthropogenic influence

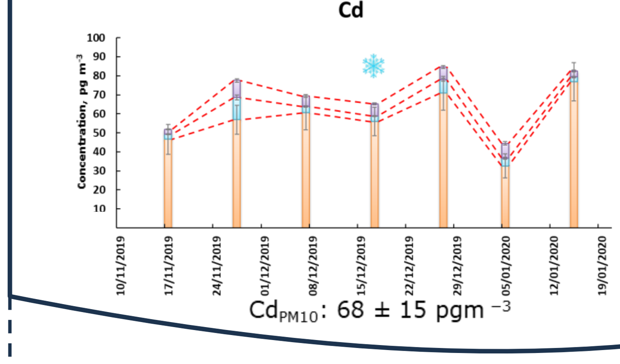
The Size Distribution Patterns :

- Trimodal distribution → Al, Fe, K, Mn, Cu, Cd, Cr and V
- Bimodal distribution → Ca, Mg, Na and Ni
- Unimodal distribution → Hg

RESULTS & DISCUSSION

Metals (Metalloids) - Decreasing order : K > Na ≃ Al > Ca > Mg ≃ Fe > Mn >Cr > Ni > Cu > V > Cd > Hg

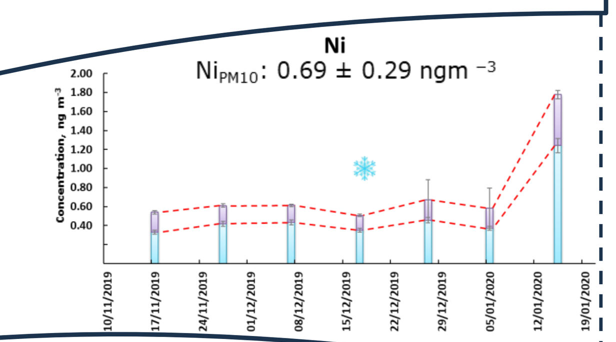




I - Constant trend - Elemental concentrations in total Antarctic PM10 follow a constant trend over the sampling period.

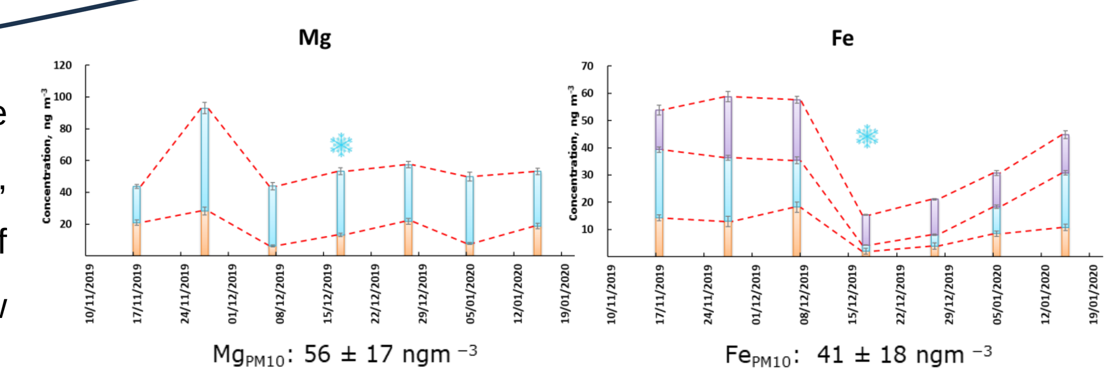
Snowfall characterized the study area from the 12 of December to the 22 of December

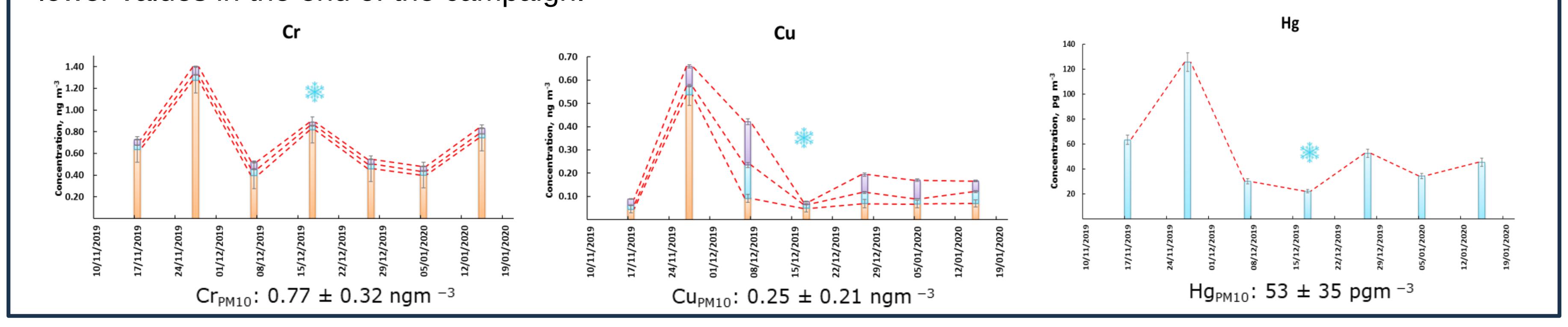
Source Meteo-Climatological Observatory



II - Increasing trend - After the halfway point of the campaign, a progressive rise is detected, in contrast to the previous trends exhibited by the other elements

III - Decreasing trend - as a result of ice melting and the sea spray emission, elements peak at the end of November/mid-December and then show lower values in the end of the campaign.





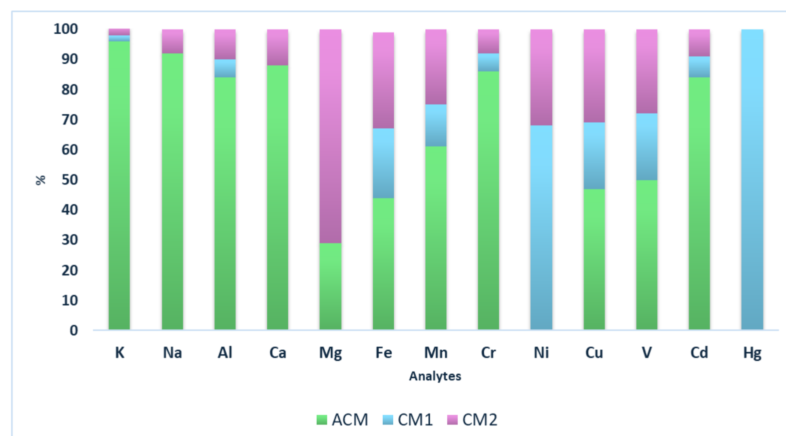
Size Distribution

Al, Fe, K, Mn, Cu, Cd, Crand V have a Trimodal distribution

Ca, Mg, Na, and Ni have a bimodal distribution

Hg has a unimodal distribution

ACM → 0.1 < Dp < 1.0 µm
CM1 → 1.0 < Dp < 3.0 µm
CM2 → 3.0 < Dp < 10 µm



Source Evaluation: Enrichment Factors

POTENTIAL ANTHROPOGENIC

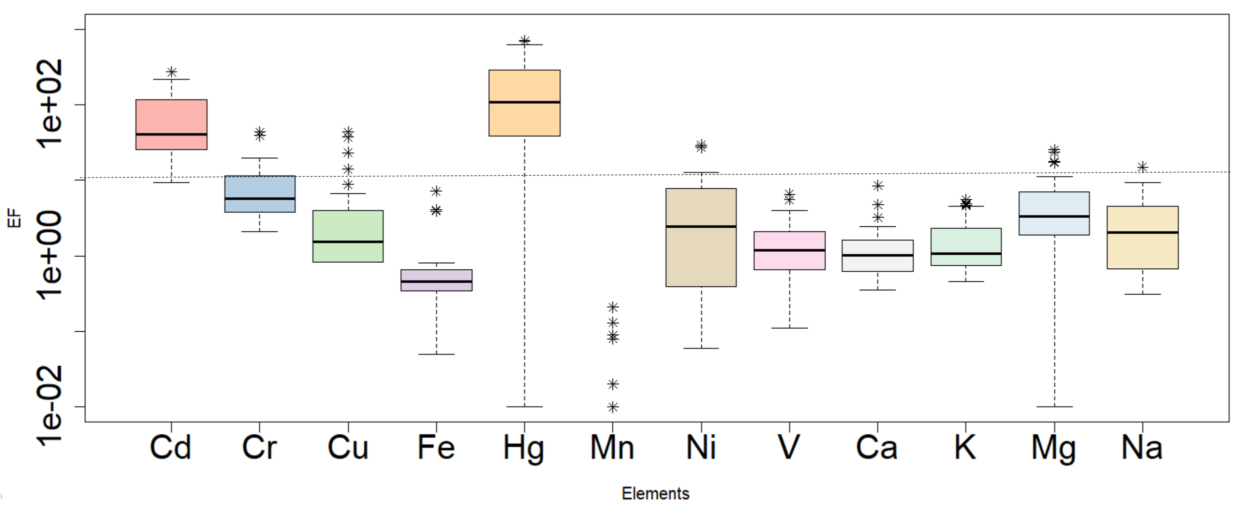
$$EF_m = \frac{\left(C_m / C_{Al}\right)_{PM}}{\left(C_m / C_{Al}\right)_{UCC}}$$

EF<10 No Enrichment

10<EF<100 Moderate Enrichment

EF>100 Severe Enrichment

Aluminium as reference element (We



FUTURE WORK / REFERENCES

- Integrate this approach for Mario Zucchelli's Campaigns 2017-2018 and 2018-2019
- Application of statistical analysis (PMF) and air mass back-trajectories model HYSPLIT

Nielsen, I.E., et al. (2019) Atmospheric Chemistry and Physics, 19(15), 10239–10256.

Weller, R., et al. (2008) Tellus B: Chemical and Physical Meteorology, 60(B), 742–752.

Wedepohl, K. H. (1995). Geochimica et cosmochimica Acta, 59(7), 1217-1232.