XI Convegno Nazionale sul Particolato Atmosferico, Torino 28-31 Maggio 2024

Caratterizzazione chimica ed isotopica delle deposizioni atmosferiche di azoto in un sito remoto ad alta quota (2900 m s.l.m.) nelle Alpi Occidentali.

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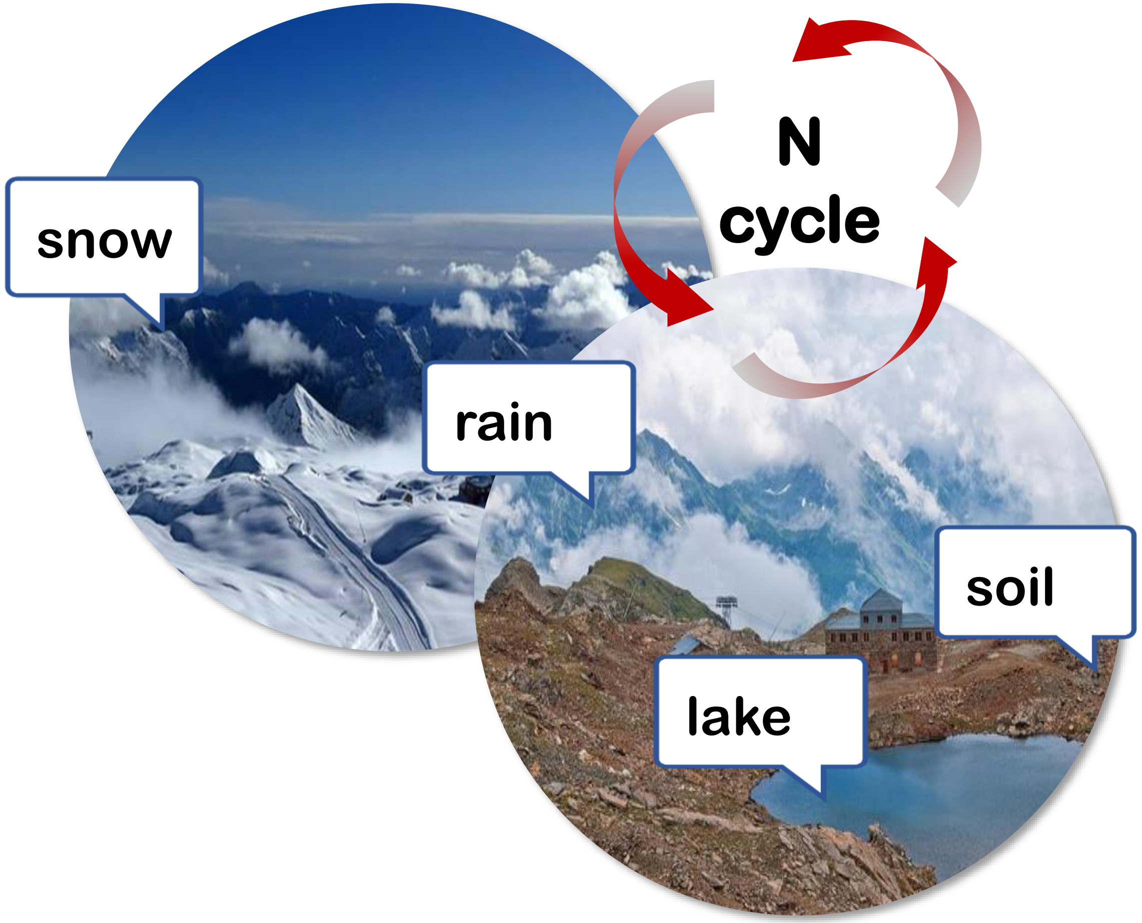
F32008 'Global Monitoring of Nitrogen Isotopes in Atmospheric Waters'

Objectives

LTER Italia
Italian Long-Term Ecological Research Network

Scientific Institute Angelo Mosso

- To integrate the role of **atmospheric deposition** in the long-term monitoring of **N cycle** in a LTER research area.
- to describe the seasonal variations of N concentrations and loads in **snow and rain.**
- To combine **N-isotopes** with deposition chemistry and hydrometeorological techniques to better understand the processes and the **sources** of inorganic N loads

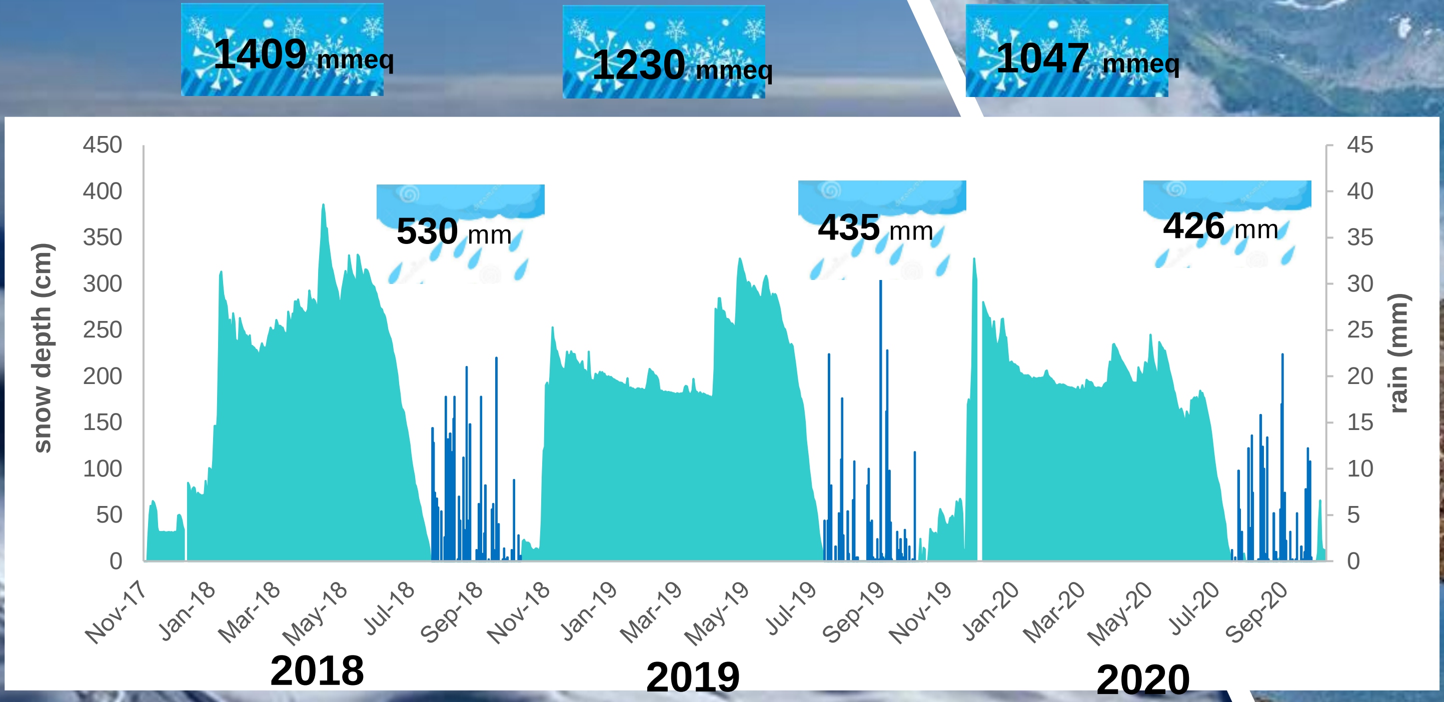


Scientific Institute "Angelo Mosso" 2900 m asl

LTER Italia
Italian Long-Term Ecological Research Network

November - June

July - October



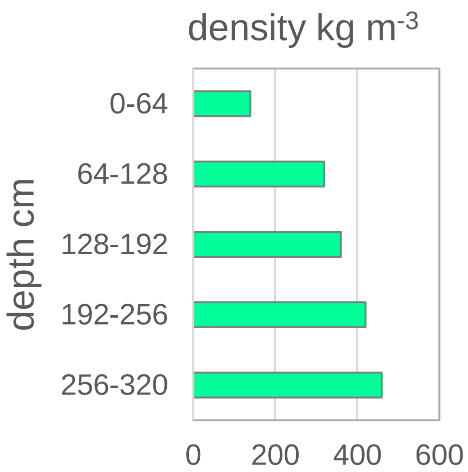
Methods

Rain and snow sampling

Weekly sampling

2018	2019	2020
10 17Jul – 5 Oct	12 8Jul – 1 Oct	10 17Jul – 28 Sep

Yearly sampling

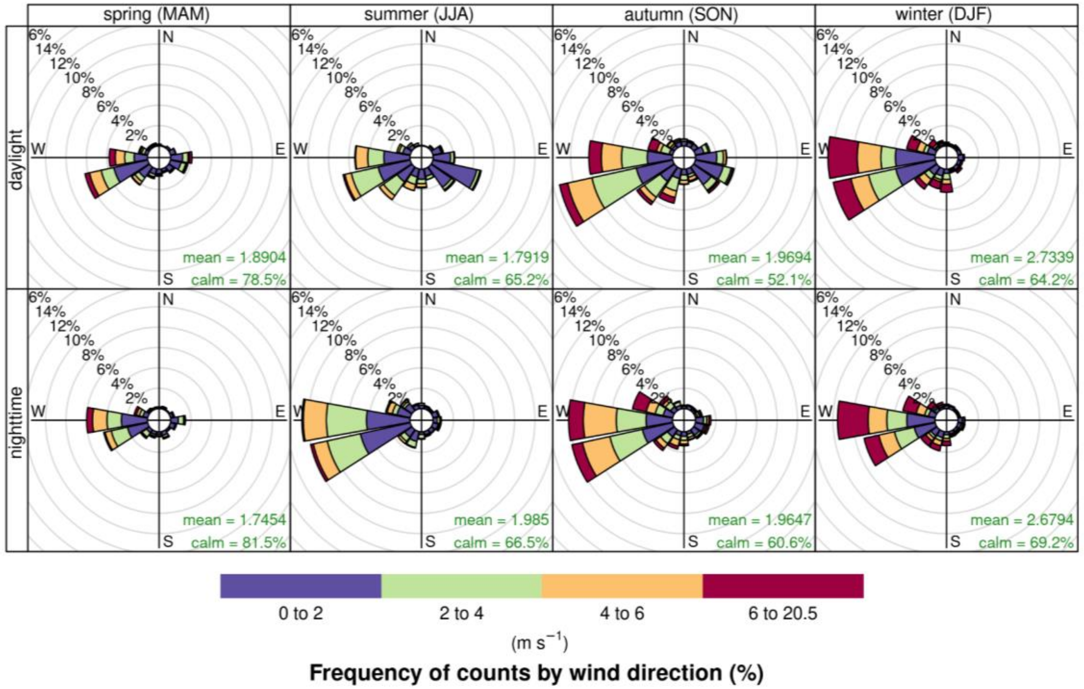


Ex.
5/4/2019
5 samples

Results

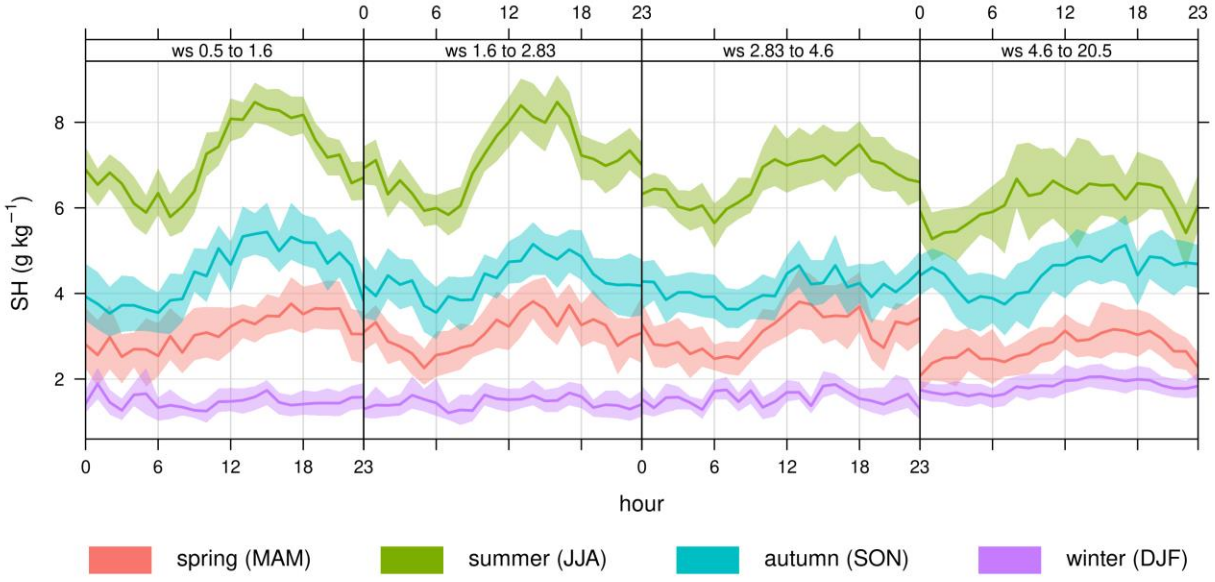
Local scale circulation

Wind speed and direction



Clouds from SE direction

Specific humidity

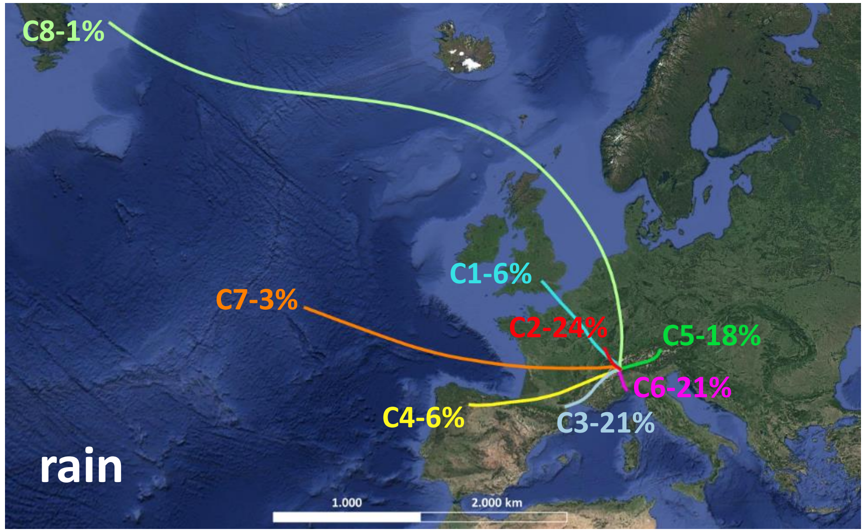


Results

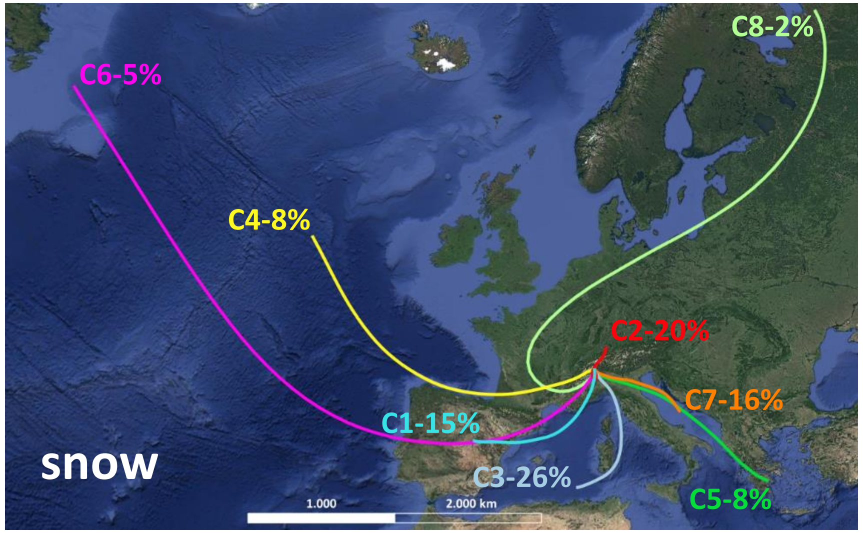
Large scale circulation

HYSPLIT model *(Stein et al., 2015)*

619 bwt



291 bwt



8 clusters

The most frequent are:

C2 : regional air masses, 200–300 km, from N **24%**

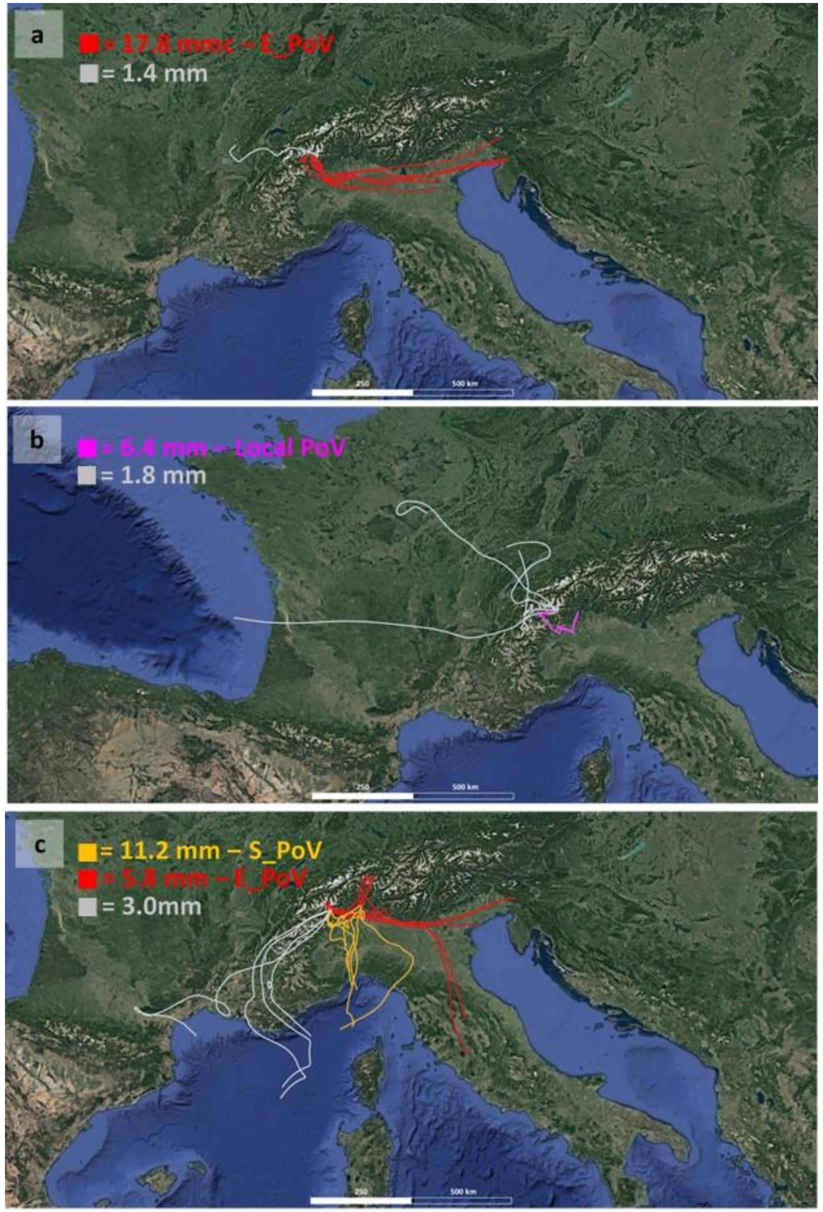
C6: regional air masses, 200–300 km from S and the Mediterranean Sea **21%**

C3: air masses of ~500 km length from W and SW **21%**

C5: regional air masses, 200–300 km from E (e.g. Po valley) and NE **18%**

Results

Large scale circulation



E_PoV group: air masses from E and crossing the entire Po valley up to 500 km in length.

11 ± 3 %

Local PoV group: included local air masses, i.e., short BWT of <100 km long

11 ± 2 %

S_PoV group: air masses from S Po valley

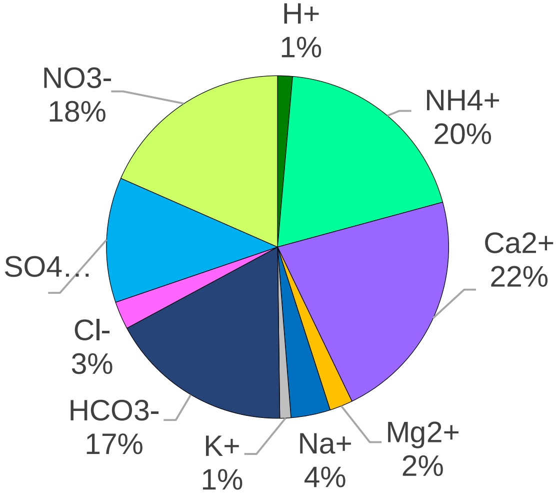
16 ± 5 %

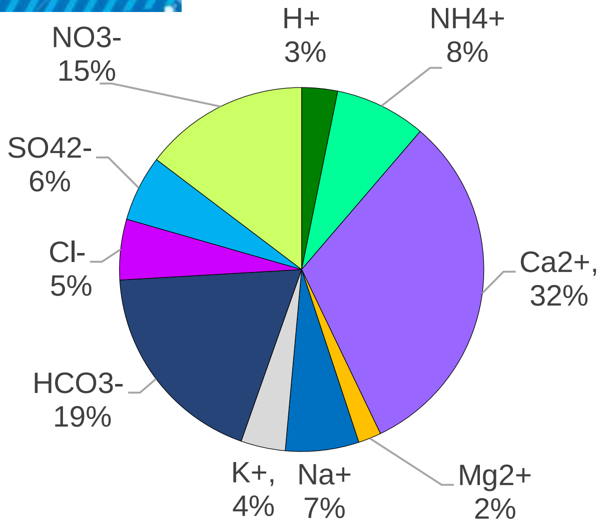
Total contribution coming from the Po valley:

38 ± 3 %

Results: chemistry

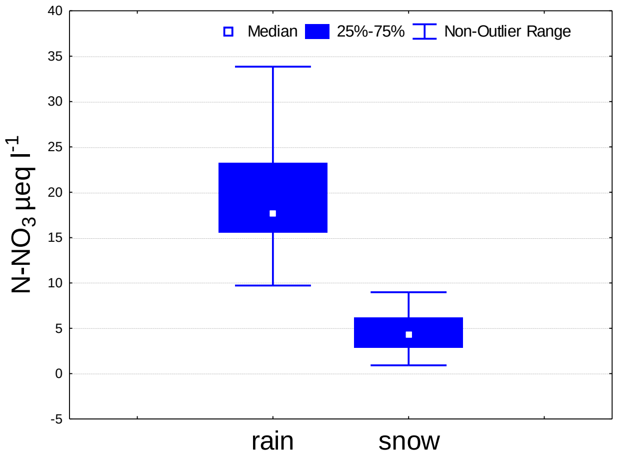
Chemical composition of rain and snow

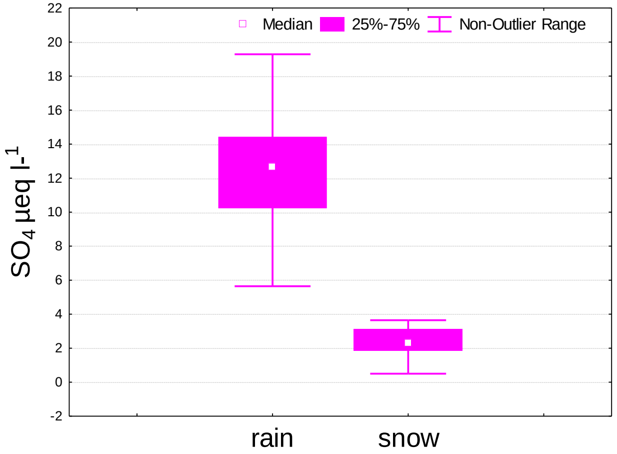


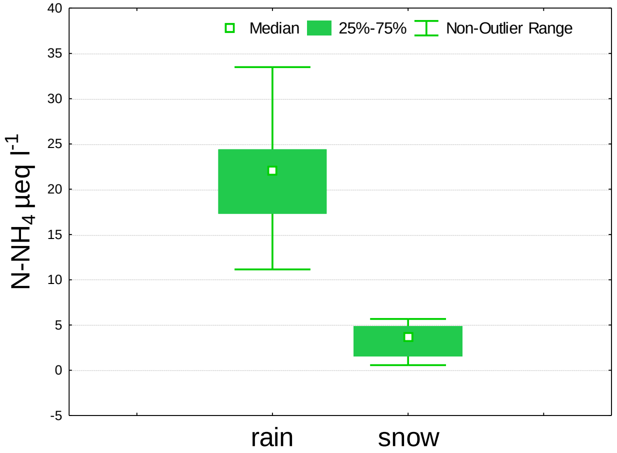


Rain:
$NH_4/NO_3 = 1.2$

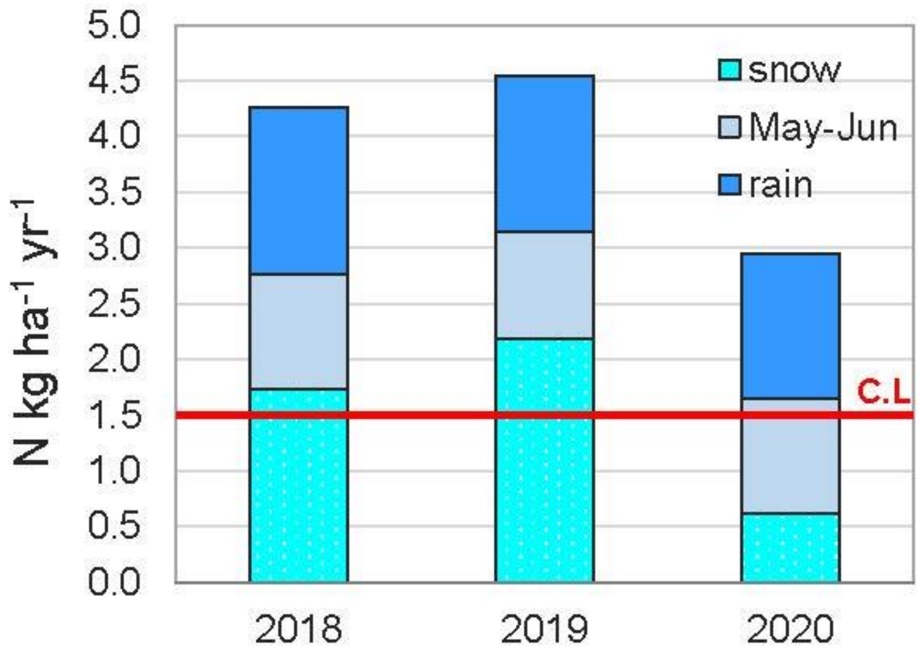
Snow:
$NH_4/NO_3 = 0.4$







Chemical loads: contribution of rain



Rain: 39 – 68% for N

The snowpack sampling underestimates the N input from wet deposition

“Critical load” is the amount of deposition of a given pollutant that an ecosystem can receive below which ecological effects are thought not to occur.

1.5 kg ha^{-1} yr^{-1}

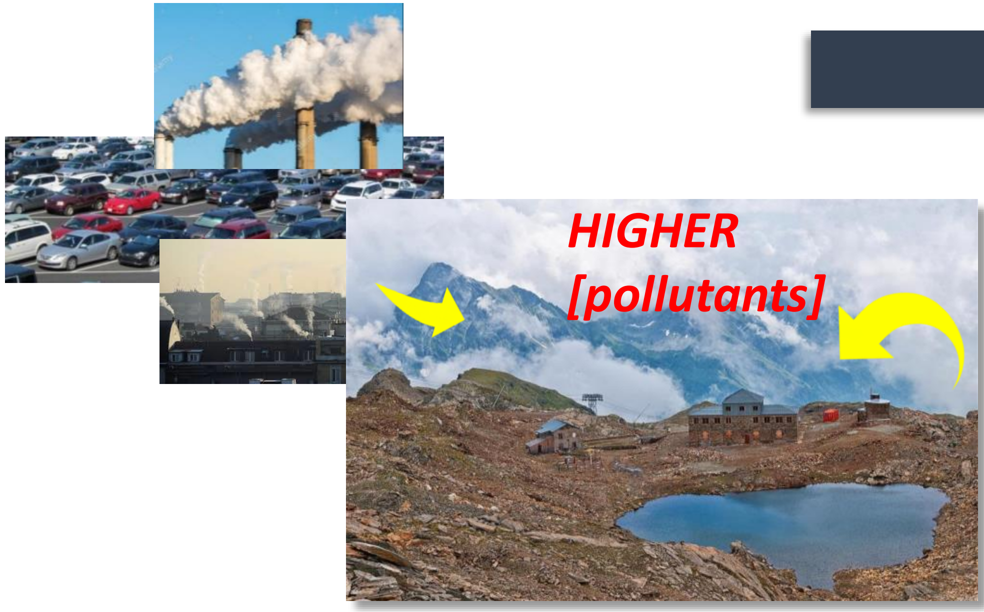
Critical N load for aquatic ecosystems in high-elevation basins with steep slopes, sparse vegetation, and an abundance of exposed bedrock and talus (*Nanus et al., 2012*).

Atmospheric N_{in} Load of N_{in} at Mosso:

3.9 kg ha^{-1} y^{-1}

Discussion: chemistry

Seasonal variations of nitrogen concentrations

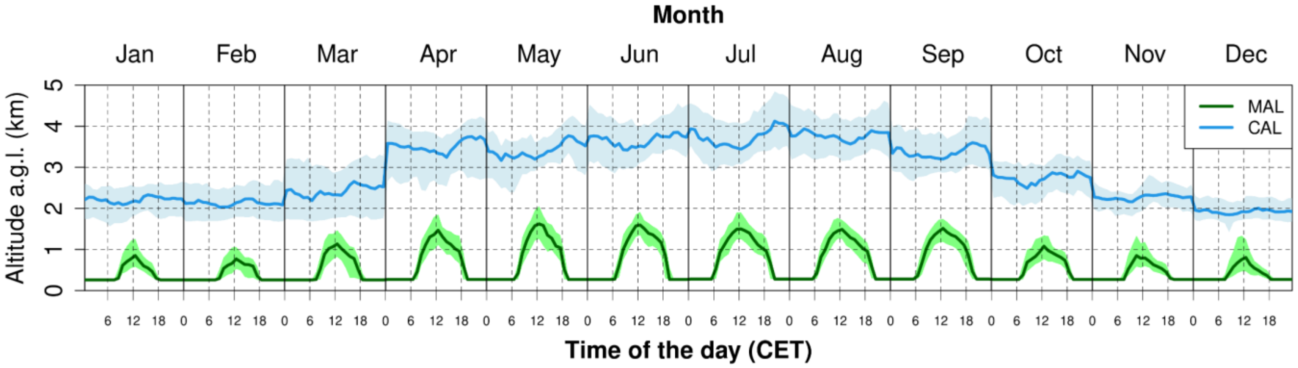


- **Thermal circulation** during summer favours:

i) the delivery of emissions from anthropized areas,

ii) the developing precipitation that can scavenge and deposit the pollutants

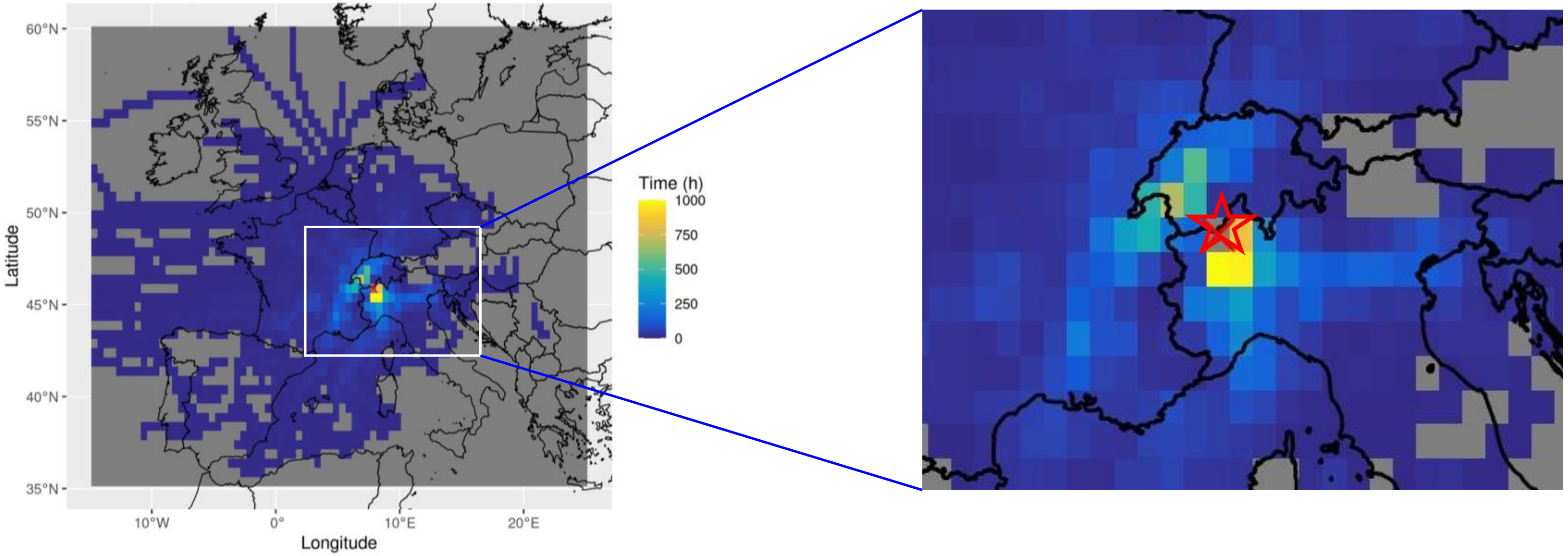
- **The greater height of the aerosol layer** in summer than in winter favours the dispersion and transport of pollutants from long distances.

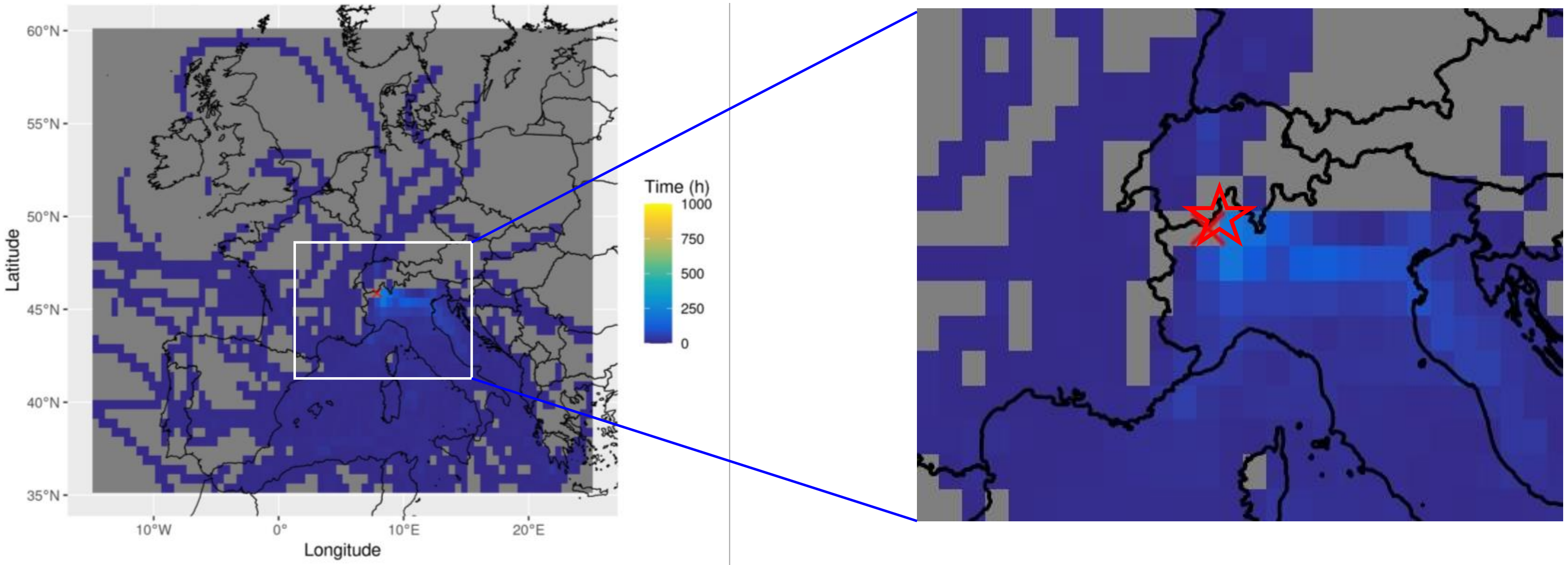


A. Bellini et al., 2024.

Discussion

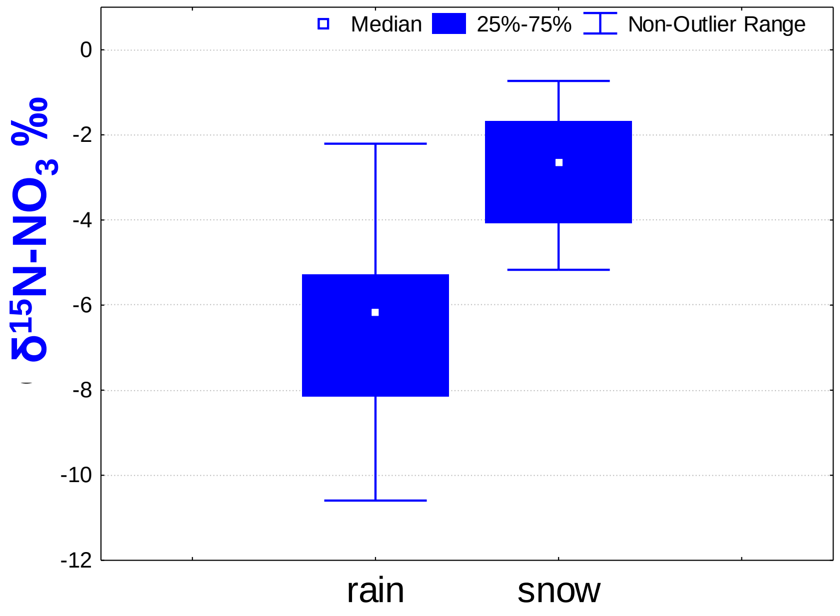
Total time spent in the continuous aerosol layer (CAL) by the calculated trajectories

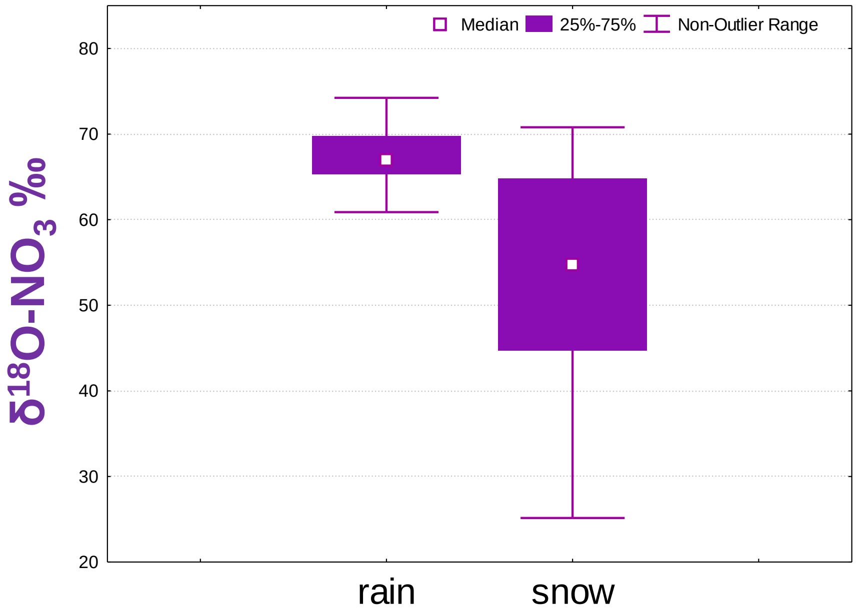




Results: nitrate isotopes

Nitrate molecule isotopes: 15N and 18O





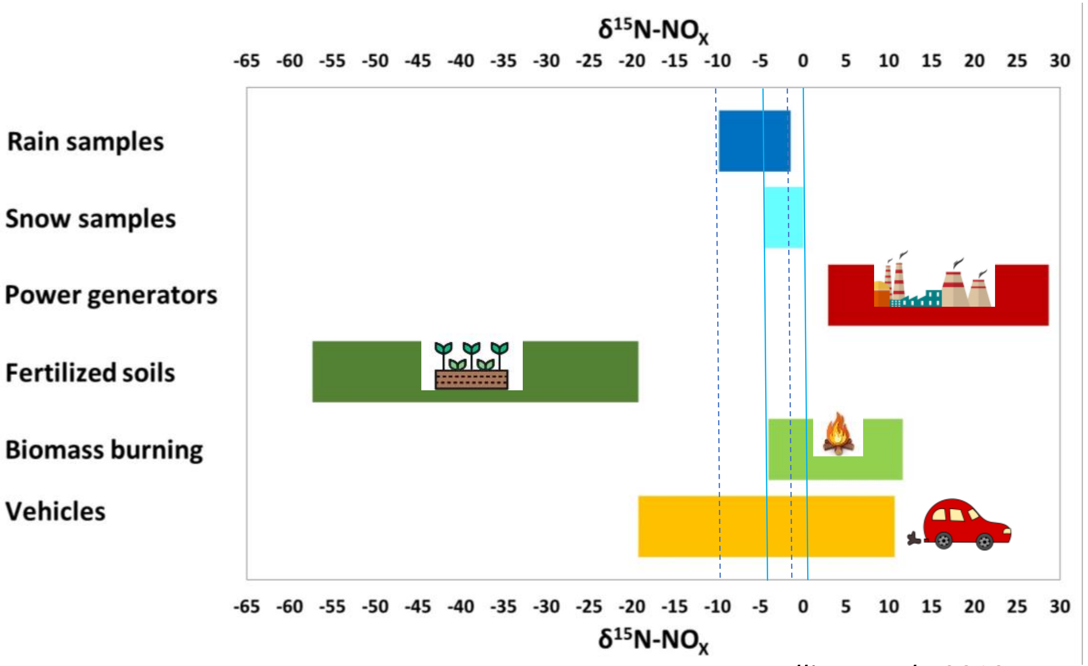
Post-depositional processes in snowpack?

HNO_3 re-evaporation, photolysis of NO3 → increase in the 15N/14N

Discussion: nitrate isotopes

Tracing the origin of nitrogen emissions

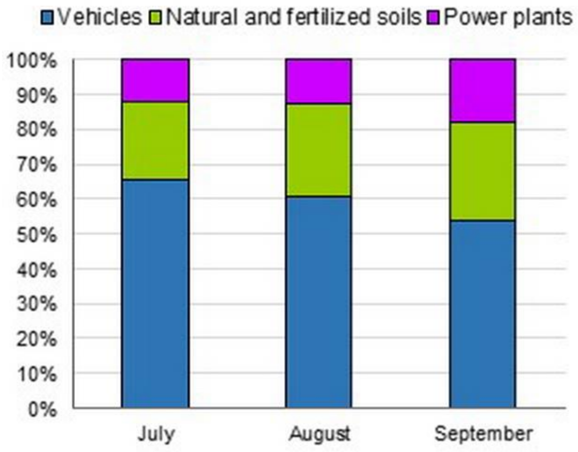
$\delta^{15}N\text{-}NO_3$‰ → NO_x sources



From Elliott et al., 2019

- -10.6 to -2.2‰
- -0.7 to -5.2‰
- 5 to 25‰
- -60 to - 20 ‰
- -10 to 10‰
- -20 to 10‰

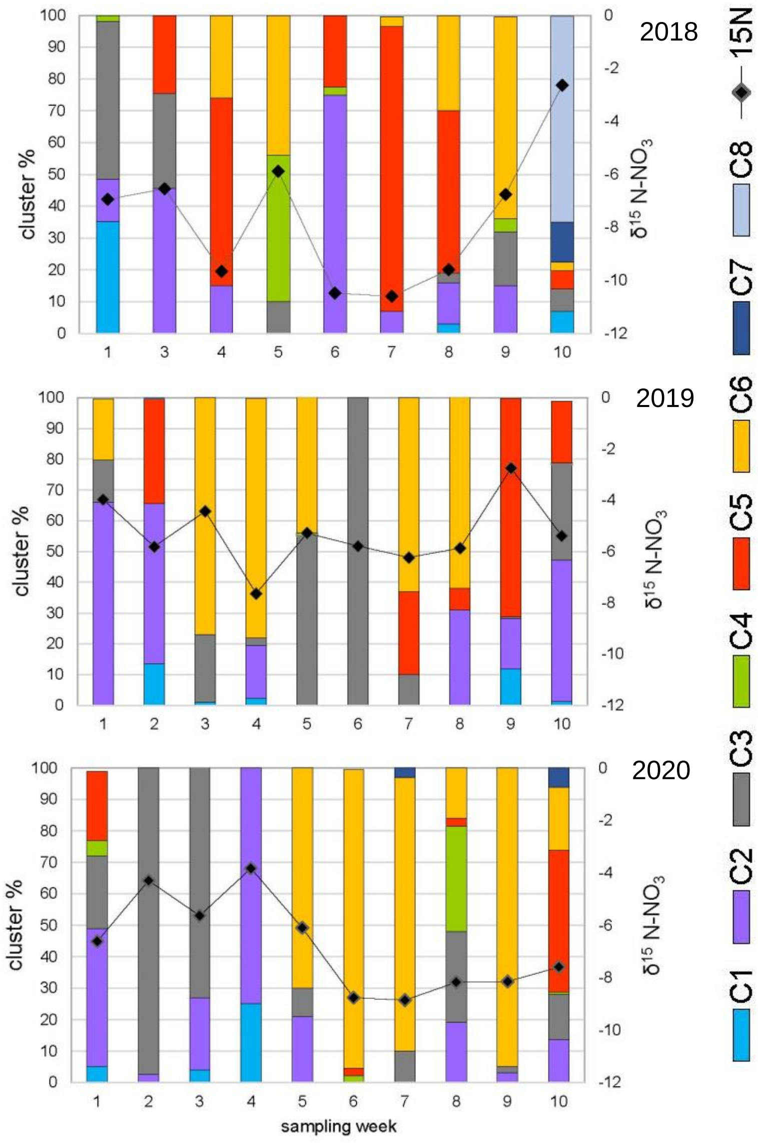
Bayesian isotope mixing model



Higher δ15N-NOx - - - - - - - - - - - → **Lower δ15N-NOx**

Discussion: nitrate isotopes

Back trajectory analysis and nitrate isotopes



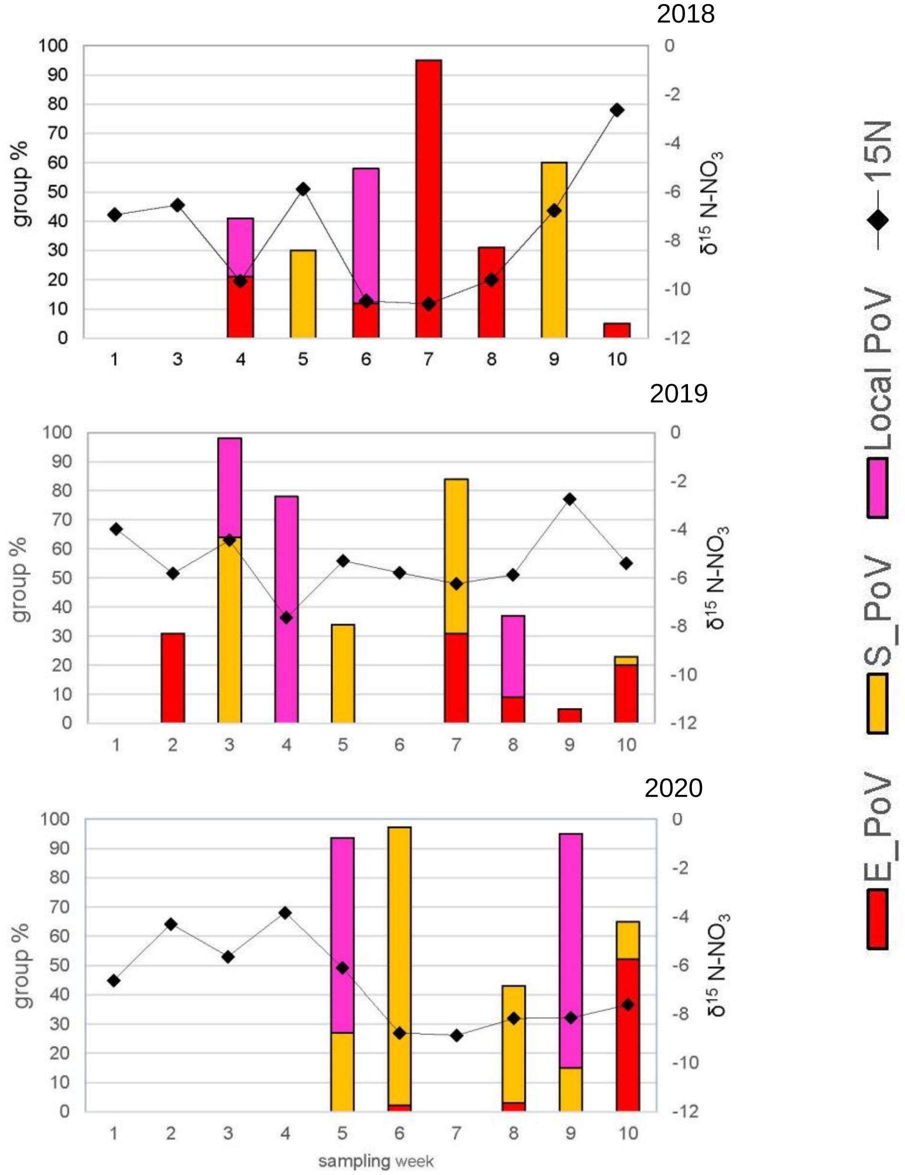
Regional clusters e.g. **C5 (from E and NE)** and **C6 (from S)**

Lower δ^{15}N-NOx

Long-range clusters eg. C3 and C8

Higher δ^{15}N-NOx

Back trajectory analysis and nitrate isotopes



Intermediate δ15N-NO_3 - 8.8 ‰

Mixture of sources

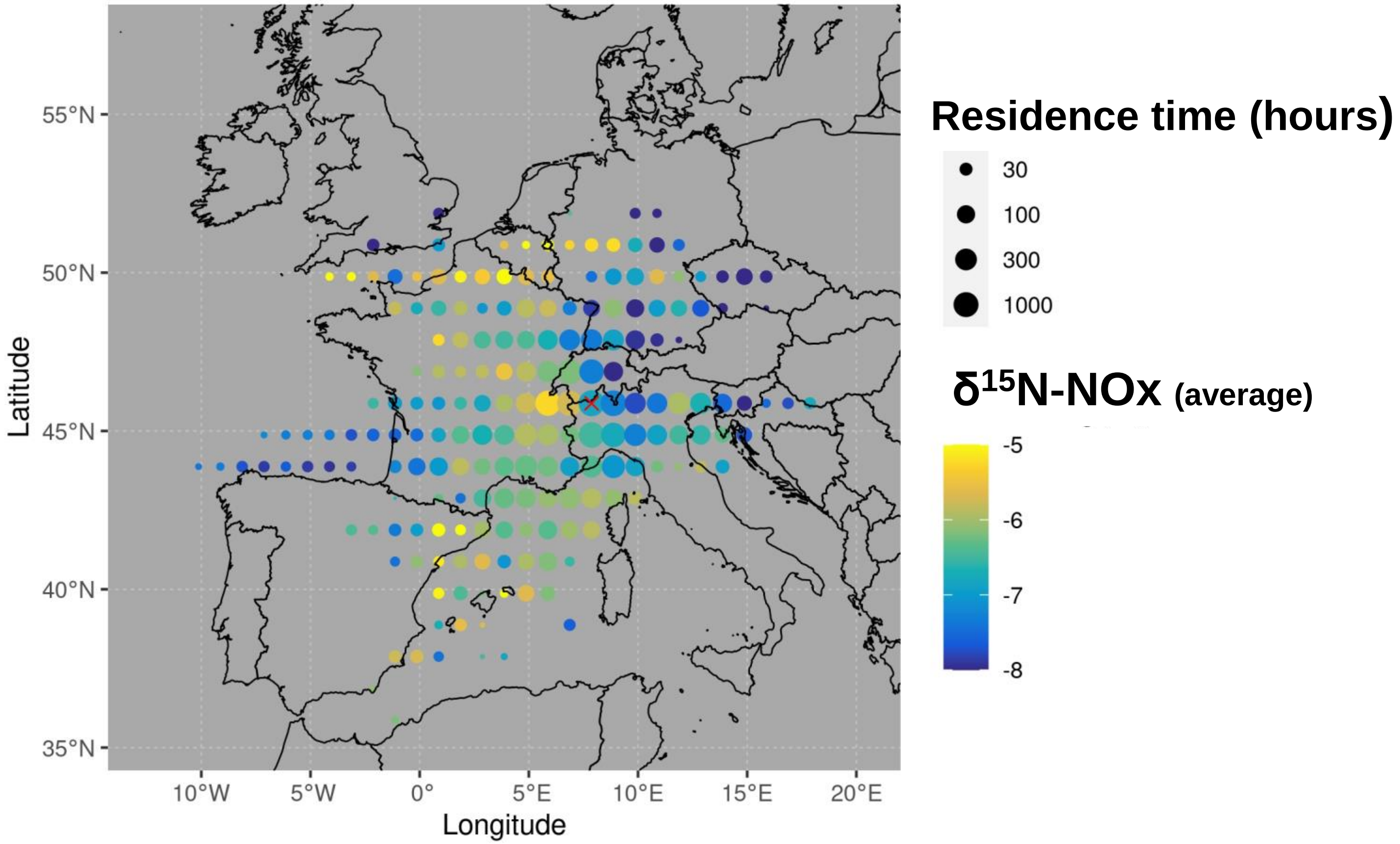
Higher δ15N-NO_3 - 6.8 ‰

Influence from combustion sources

Lower δ15N-NO_3 - 10.6 ‰

Agricultural activities and vehicle emissions

Discussion: nitrate isotopes



Concentration-weighted trajectories (CWT)

CONCLUSIONI

- Data set unico per gli ecosistemi al di sopra della tree-line nello scenario europeo.

- Sostanziale contributo della componente pioggia per ottenere un quadro completo del ruolo della deposizione atmosferica umida nel ciclo dell'N in ambienti di alta quota:
  - differenze stagionali nelle concentrazioni di molte specie chimiche in primis NO3 e NH4
  - stima corretta dei carichi di deposizione di N necessaria per valutare le eccedenze rispetto al carico critico.

- L'approccio metodologico utilizzato che ha combinato la chimica e le analisi isotopiche con tecniche idrometeorologiche e modellistiche (retro-traiettorie) ha dimostrato che:
  - nella stagione estiva l'area di studio è esposta a inquinanti che si originano da zone antropizzate come la Pianura Padana.
  - Le principali sorgenti di N in estate sono da attribuire alle emissioni derivanti dal traffico veicolare e dall'agricoltura.

- Le attività di ricerca in programma a breve termine prevedono indagini intensive che consentano campionamenti di pioggia con maggiore frequenza e durante l'inverno la raccolta di neve superficiale da confrontare con i campioni ottenuti con la procedura standard per valutare l'influenza dei processi post-deposizionali.

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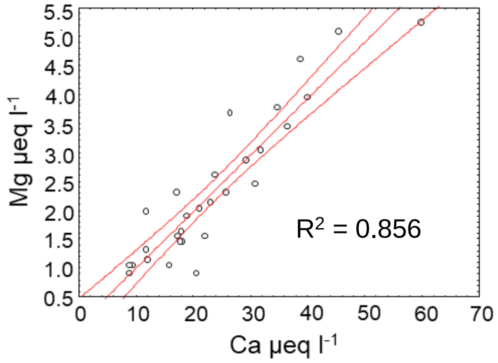
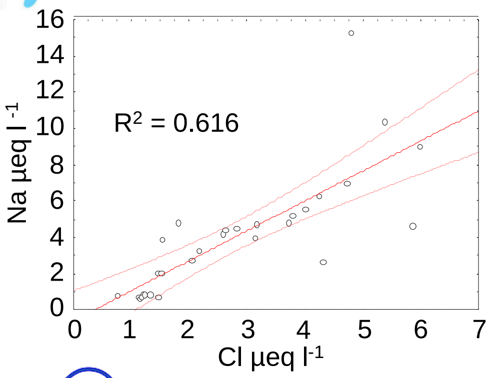
Grazie per l'attenzione!

Discussion: chemistry

Potential sources of ions

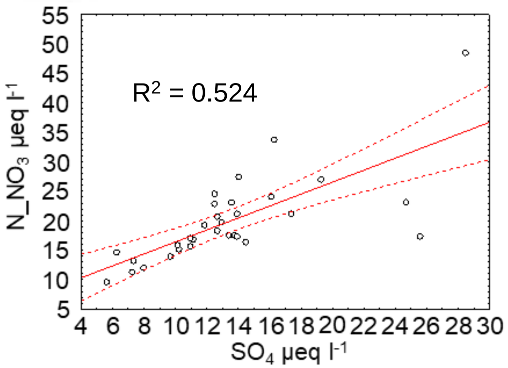
rain

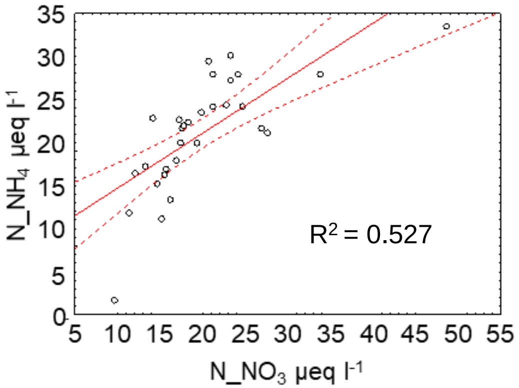




Crust and soil dust

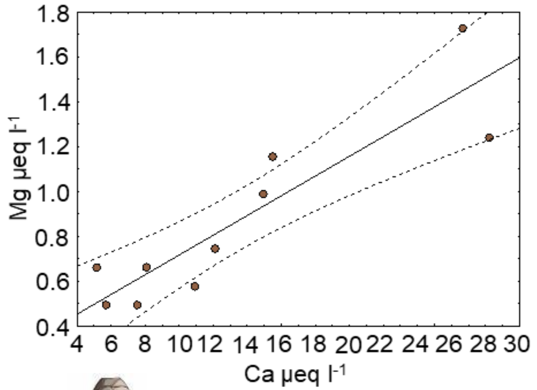
marine aerosols

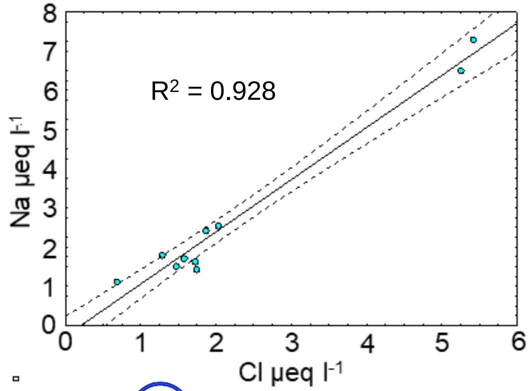




Anthropogenic source e.g. fossil fuels

snow





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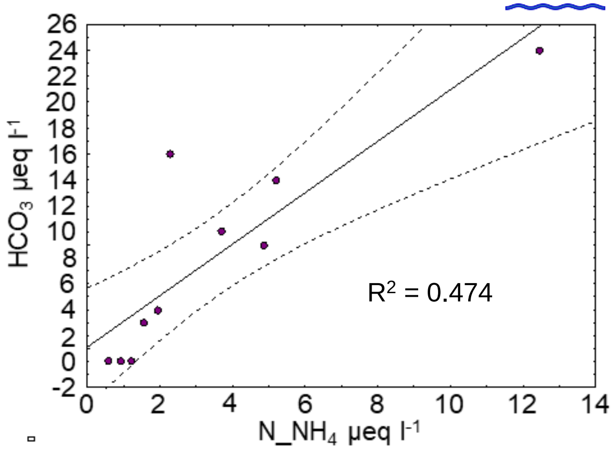


Results: isotopes

Nitrate molecule isotopes: 15N and 18O

Ranges

$\delta^{15}N‰\_NO_3$

Rain (n = 25)

-10.6 to -2.2‰

Snow (n = 9)

-0.7 to -5.2‰

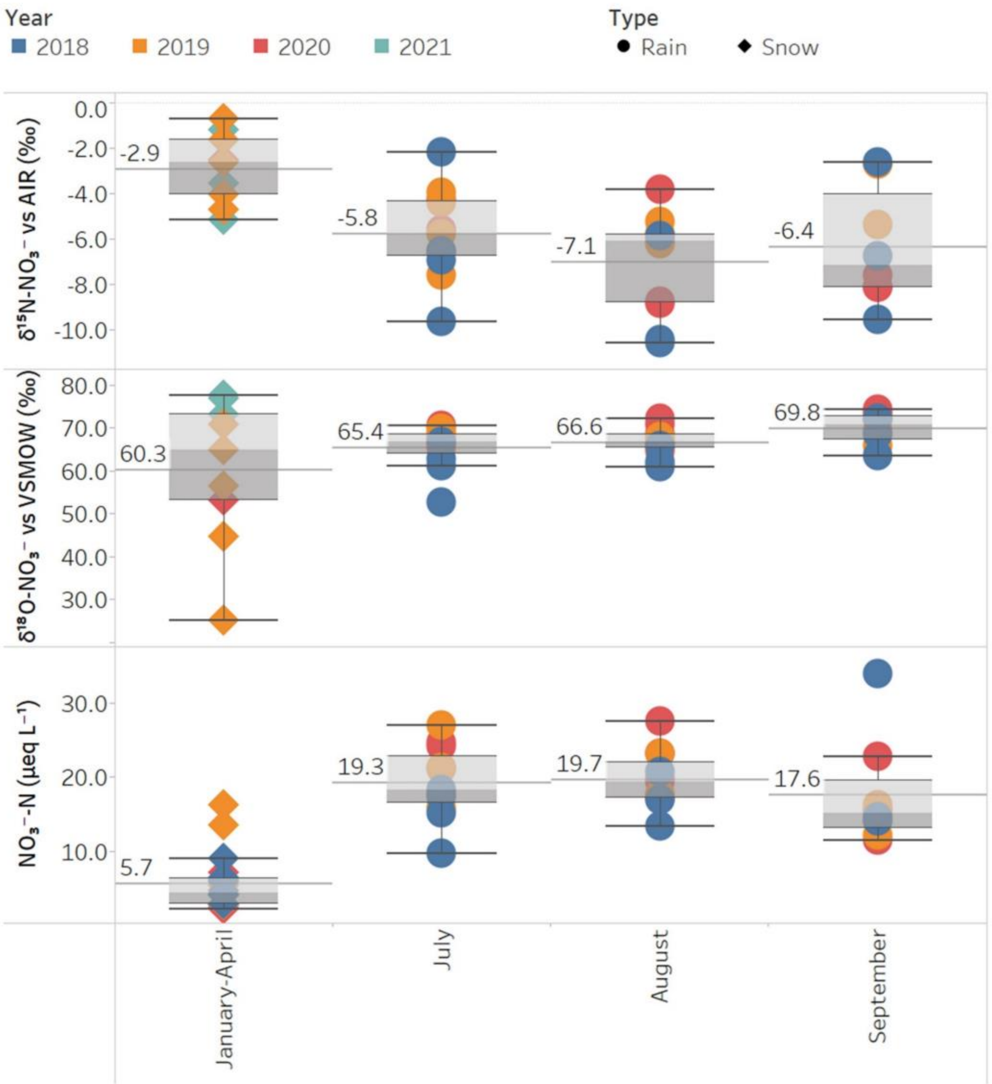
$\delta^{18}O‰\_NO_3$

Rain (n = 9)

+52.7 to +74.2 ‰

Snow (n = 9)

+25.2 to + 76.7‰



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