INTERNATIONAL CONFERENCE ON
MOUNTAINS AND CLIMATE CHANGE

Wet deposition chemistry at a high elevation site in the Khumbu Valley (Nepal Himalaya): implications for the N biogeochemical cycle

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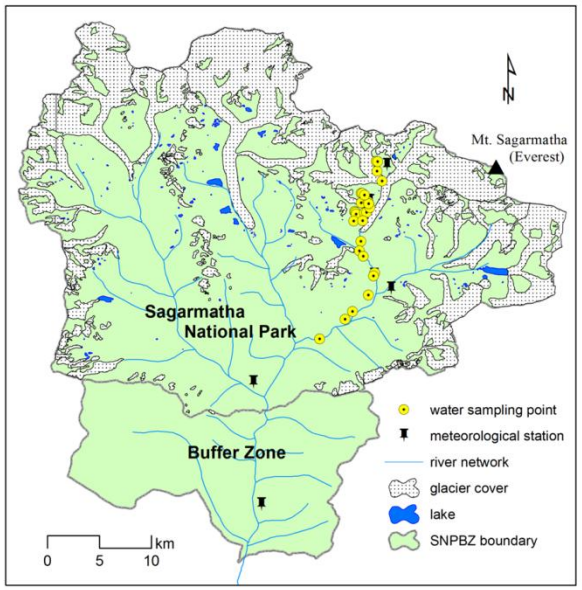
- Wet deposition is a crucial removal process for airborne gases and particulate matter returning to earth.
- Dissolved solutes in wet precipitation originate from diverse sources including natural sources and anthropogenic sources.
- The chemical composition of wet precipitation is influenced by the dynamics of the atmosphere, the atmospheric chemical reactions, and the removal processes in the atmosphere.
- Wet deposition is an important component of the biogeochemical cycles, especially for **nitrogen**.

Research activities 2007-2008, 2012-2013

SHARE
Stations at High Altitude for Research on the Environment

Pyramid international Laboratory Observatory (5050 m asl)

Sampling of wet deposition during 2007-2008



Sampling of surface waters at 4300 to 5500 m asl

Chemical and isotopic characterisation

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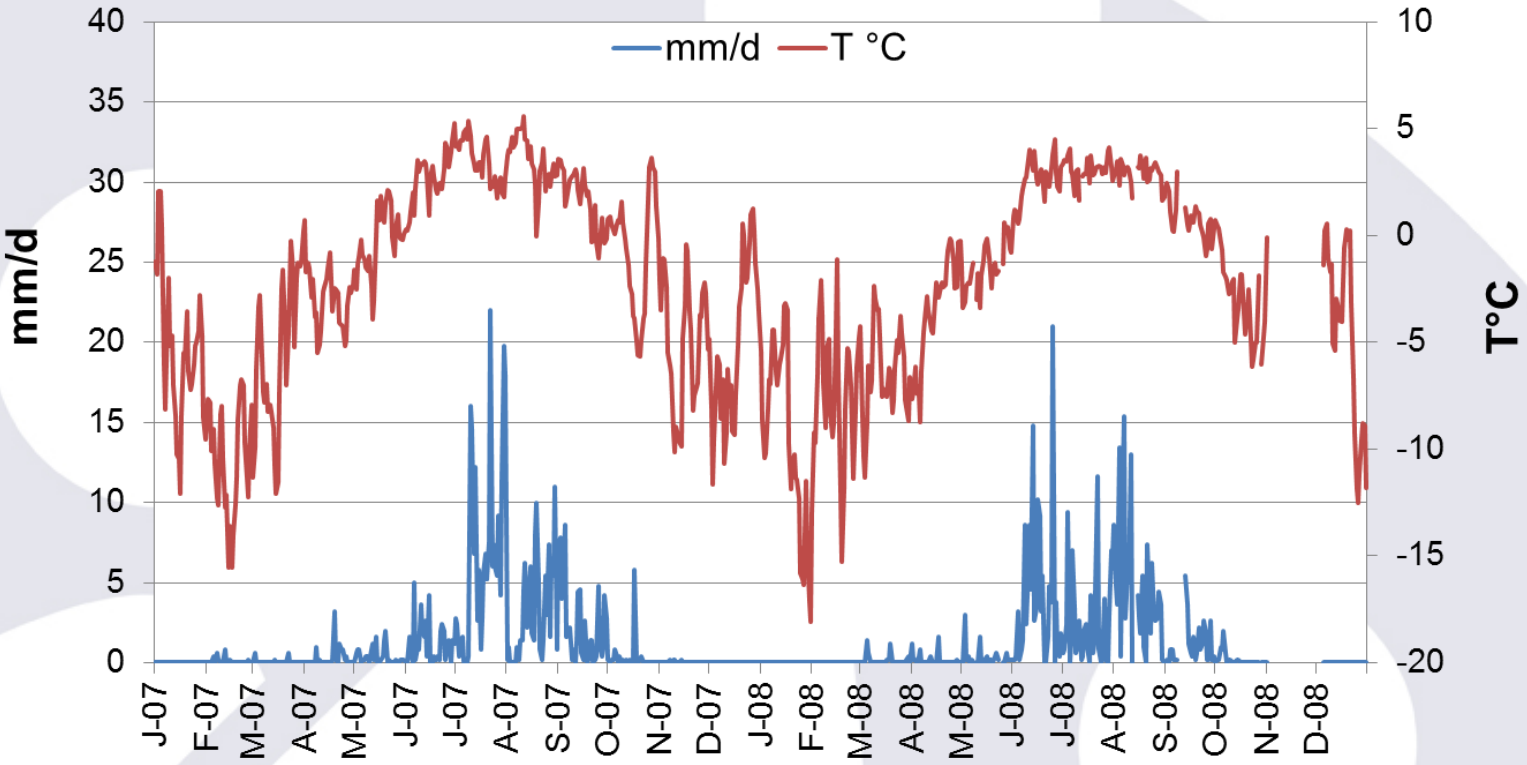
Pluviometric regime and temperature



2007: 446 mm
2008: 396 mm

June – September

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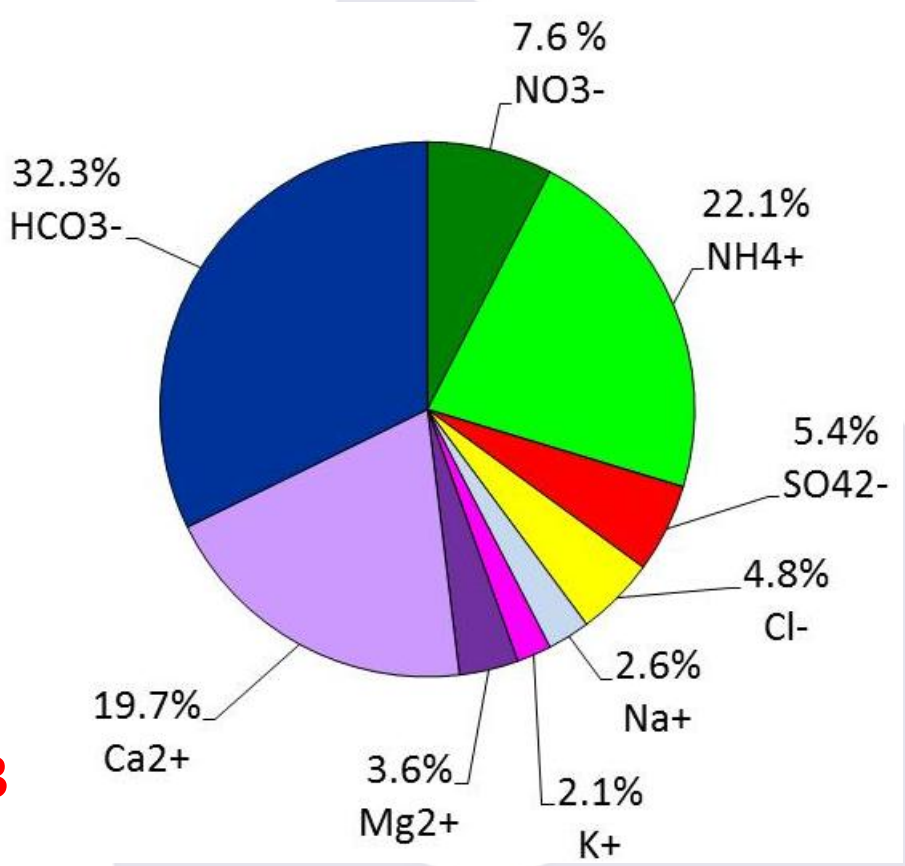
Chemical composition of rain water

Anions

$HCO_3^- > NO_3^- > SO_4^{2-} > Cl^-$

Cations

$NH_4^+ < Ca^{2+} < Mg^{2+} < Na^+ < K^+$



NH4 > NO3

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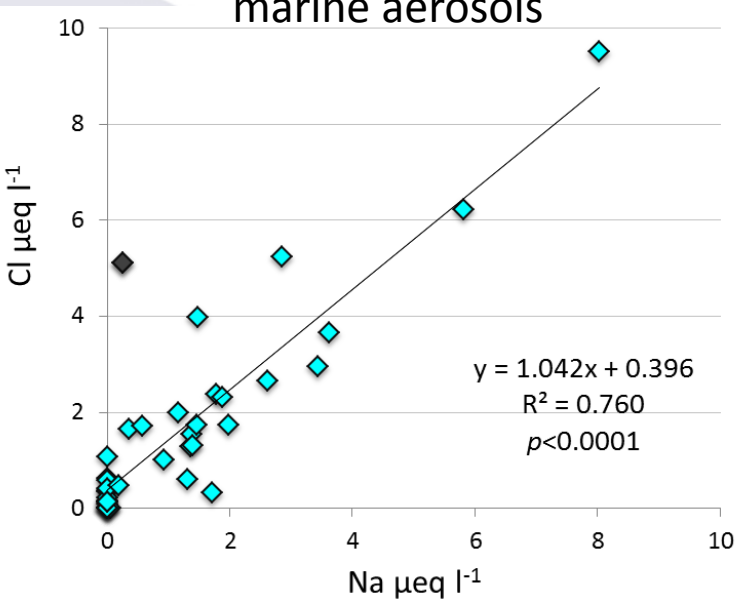
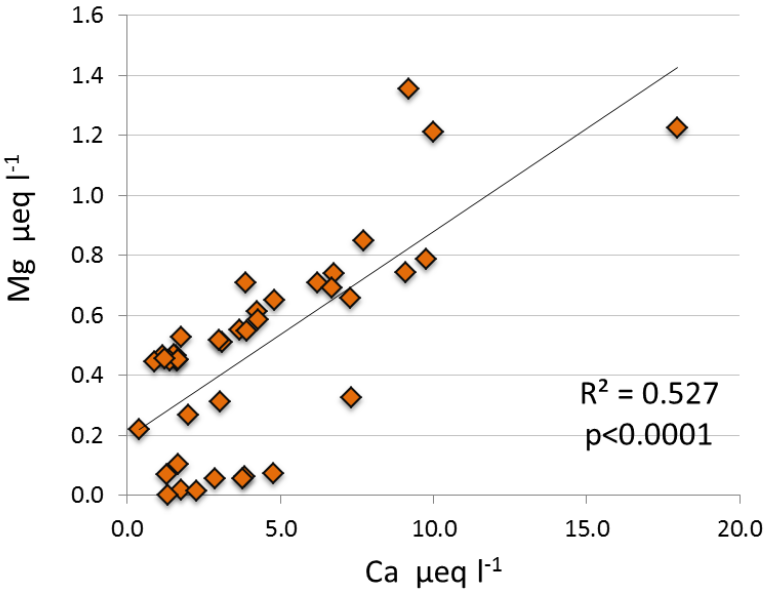
Potential precursors of ions

Sea salt			rain
Cl/Na	1.17	~	1.09
SO4/Na	0.12	<<	1.56
K/Na	0.02	<<	0.48
Mg/Na	0.23	<	0.61
Ca/Na	0.04	<<<	3.81

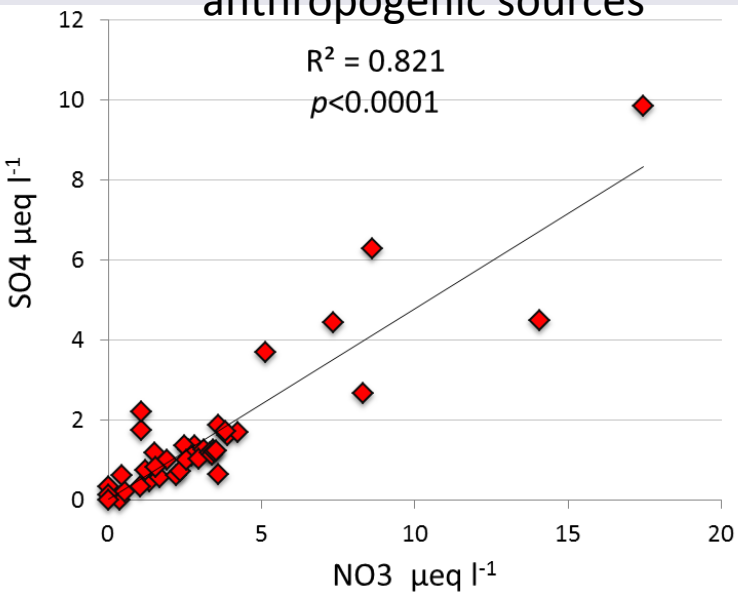
marine aerosols



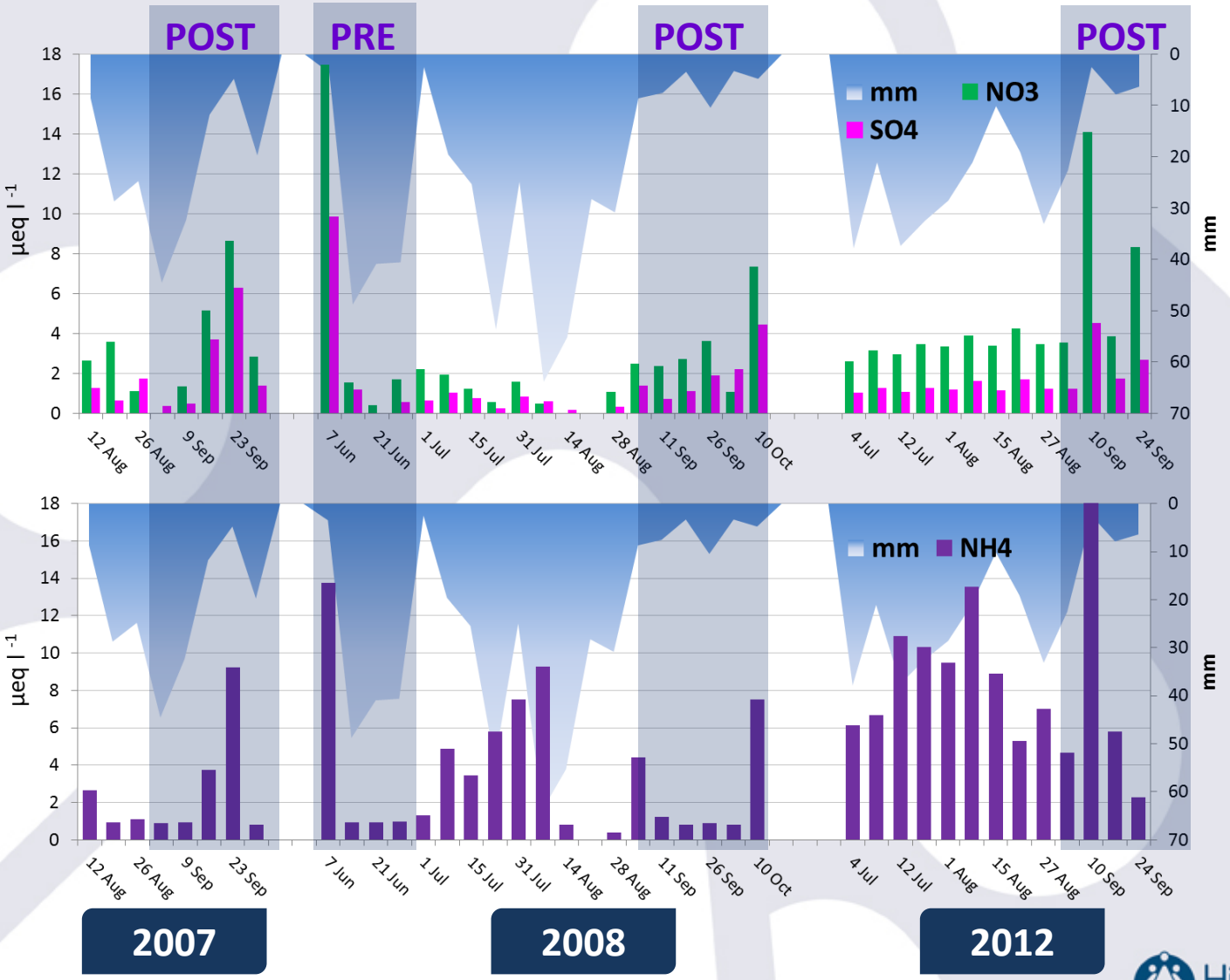
crust mineral and soil dust



anthropogenic sources



Temporal variations of ion species



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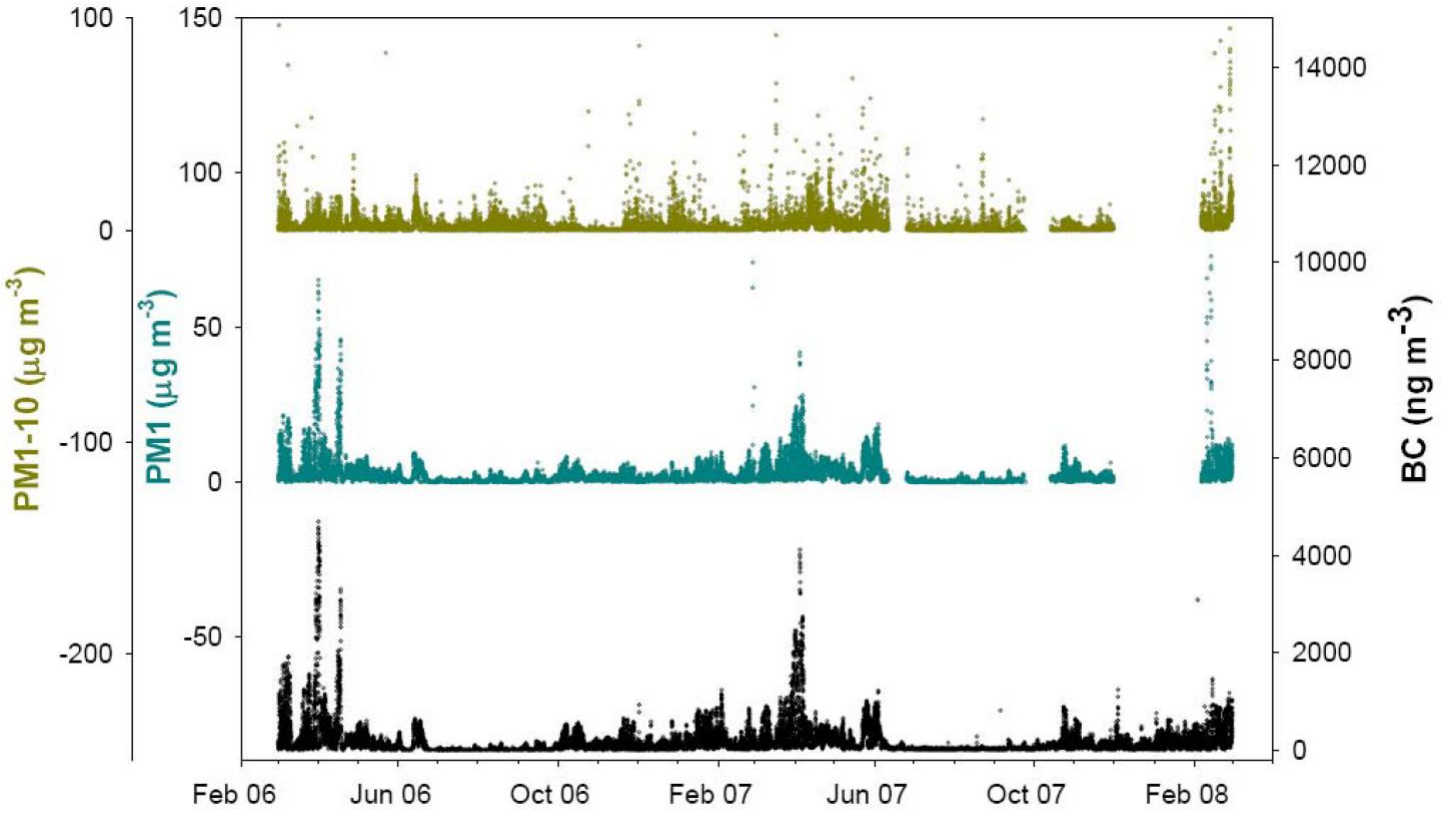
Temporal variations of aerosols concentrations



Time series of 30-min averaged BC (black), PM1 (cyan) and PM1−10 (brown) at NCO-P.
From Marinoni et al. 2010 Aerosol mass and black carbon concentrations, a two year record at NCO-P (5079 m, Southern Himalayas) Atmos. Chem. Phys., 10, 8551-8562, 2010

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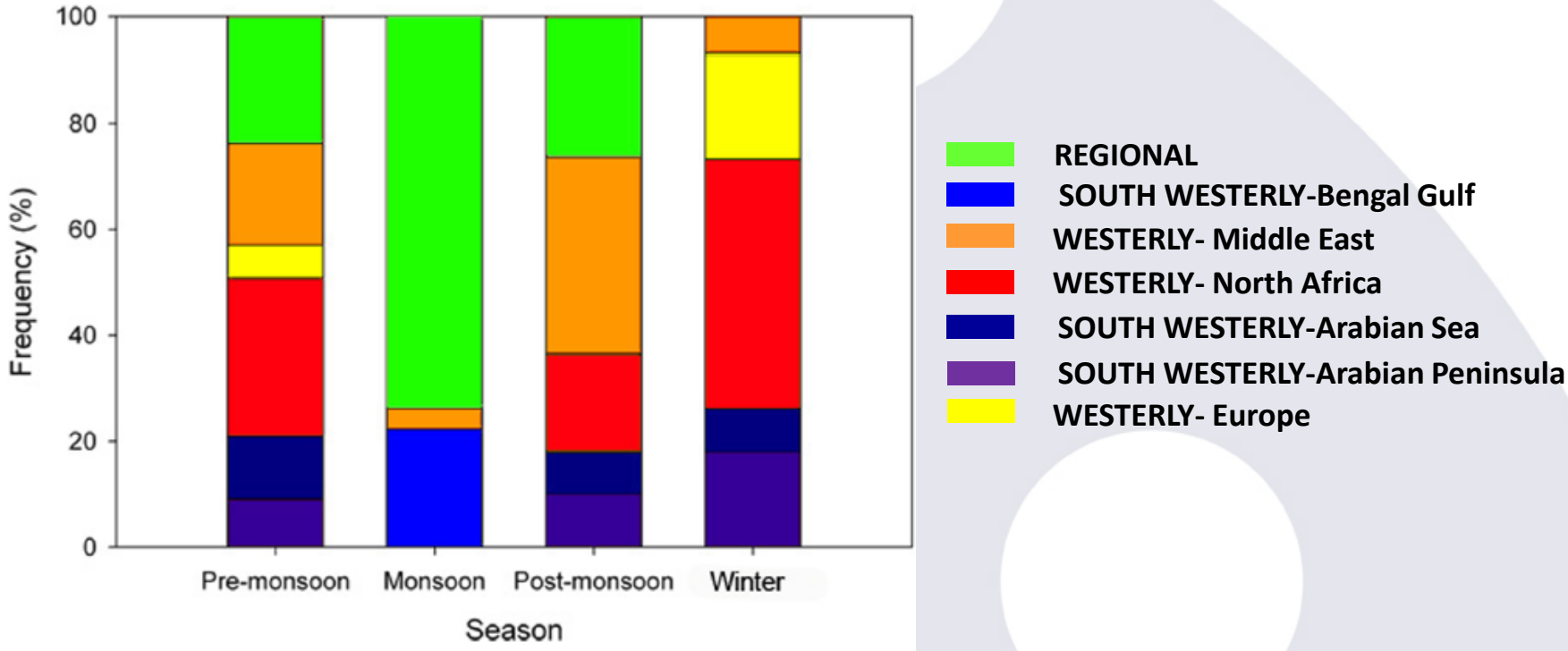
Seasonal weather regime

Seasonal cluster frequencies at NCO-P for the period March 2006–February 2008



From Bonasoni et al., 2010 Atmospheric Brown Clouds in the Himalayas: first two years of continuous observations at the Nepal Climate Observatory-Pyramid (5079 m) Atmos. Chem. Phys., 10, 7515-7531, 2010

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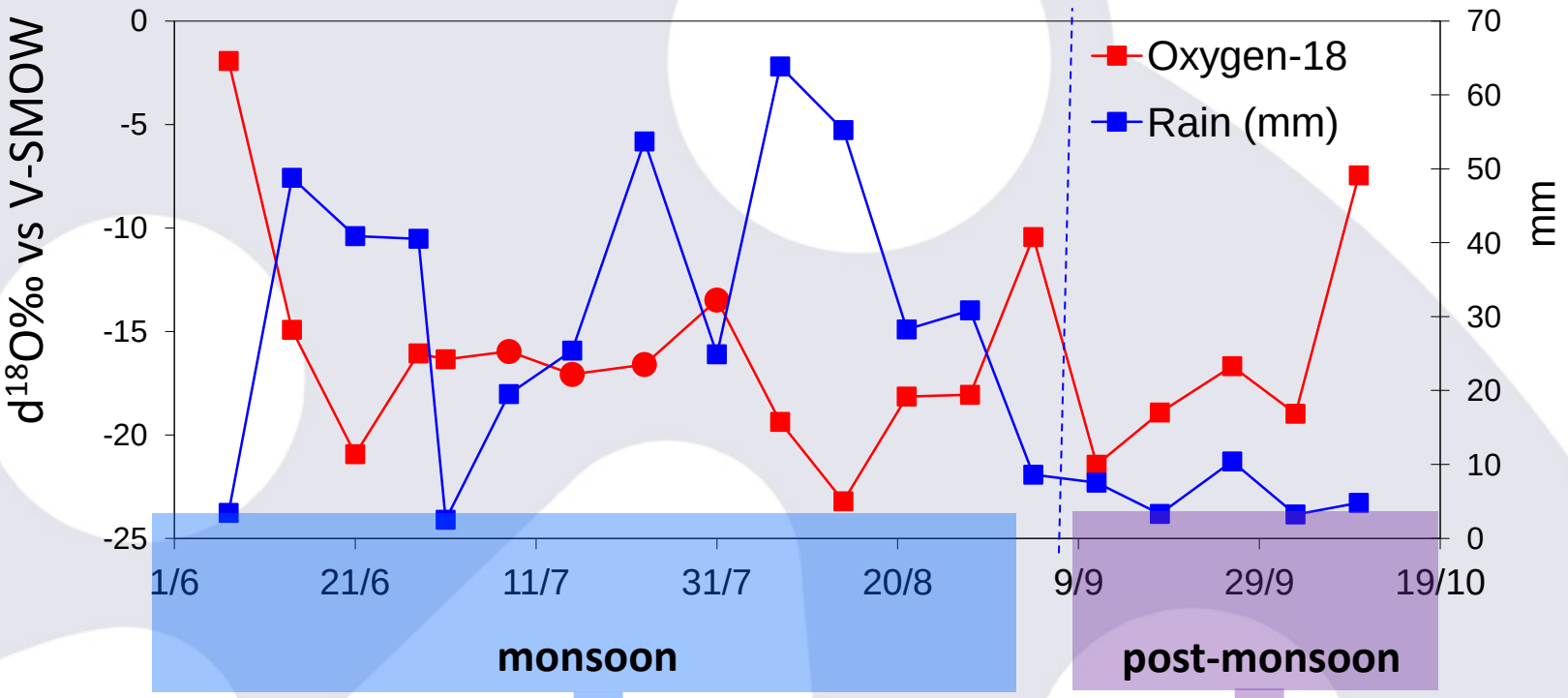
The isotopic composition of precipitation :δ18O and δ2H



"amount effect "

change in the air circulation patterns

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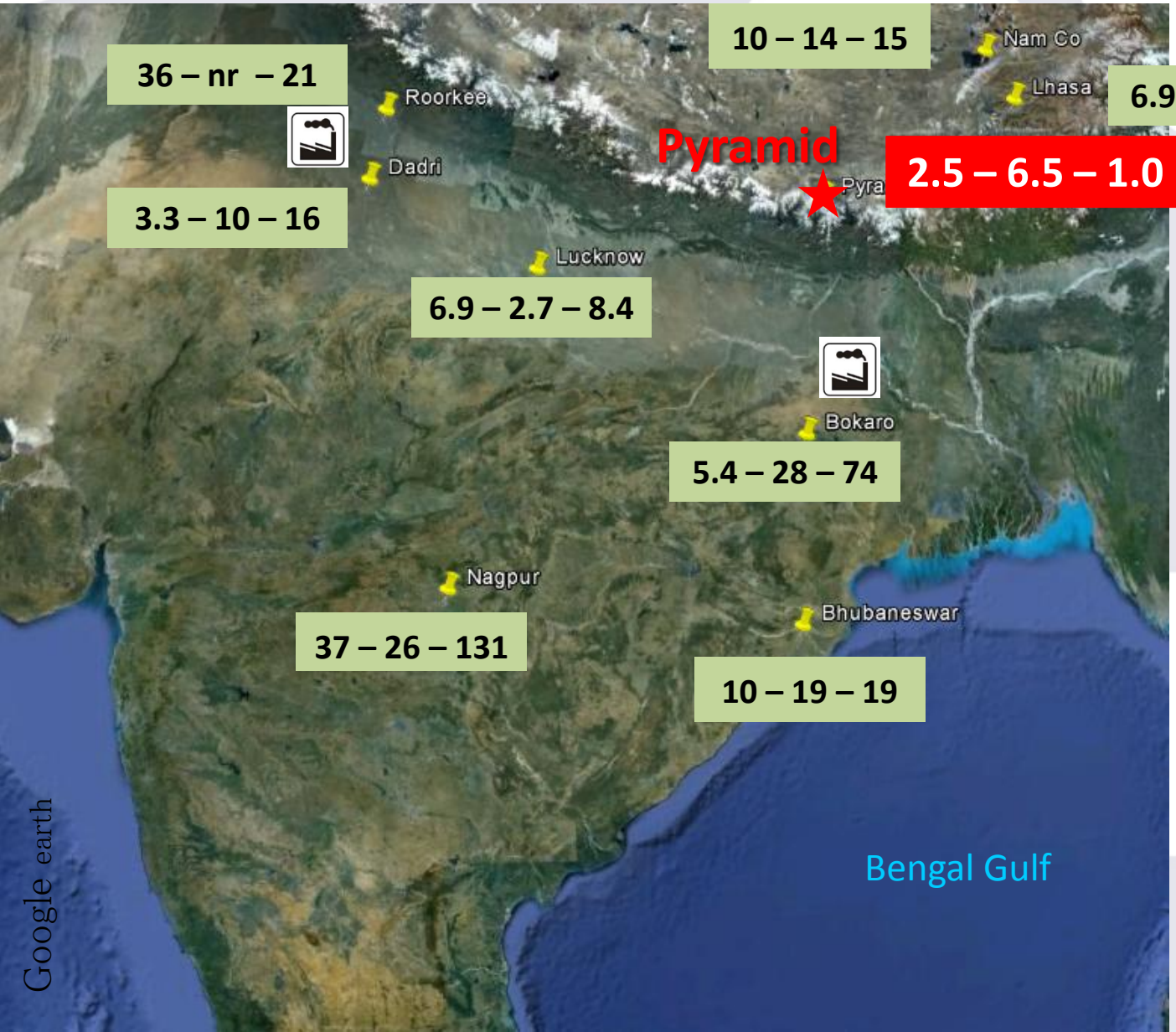
Comparison with other Asian sites

Concentration of NO_3^-, NH_4^+ and SO_4^{2-} µeq l^{-1}



Italian alpine site
(Val Masino)
21 – 20 – 22

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Nitrogen atmospheric loads

Khumbu valley

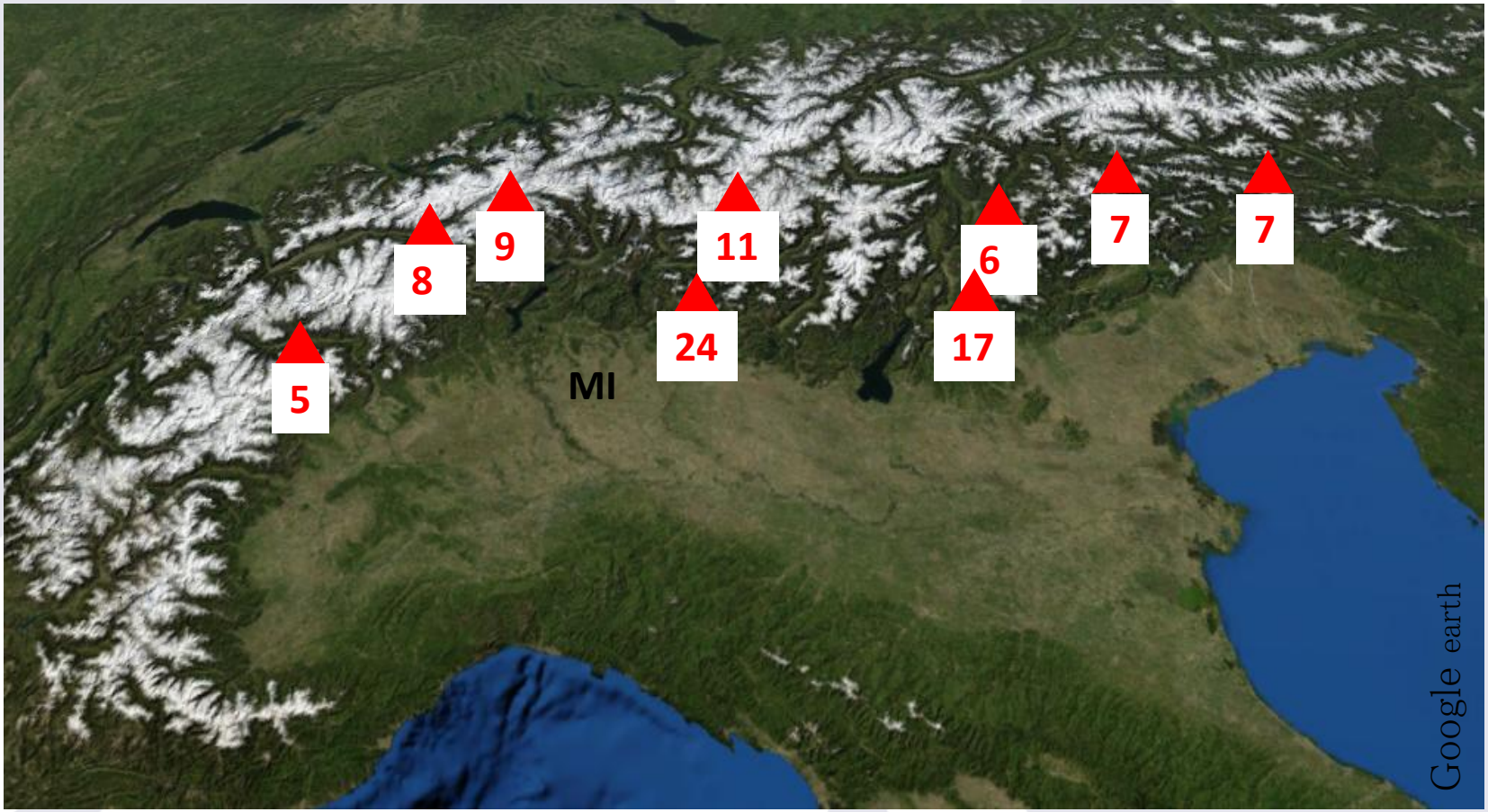
Nin annual load

0.30- 0.45 kg ha^{-1} yr^{-1}

Italian Alps

Nin annual load:

5 - 24 kg ha^{-1} yr^{-1}



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Comparison with remote ecosystems: Nitrogen load

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

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

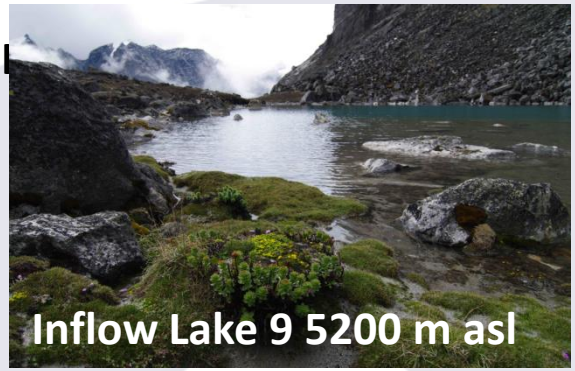
0.60 kg ha^{-1} yr^{-1}

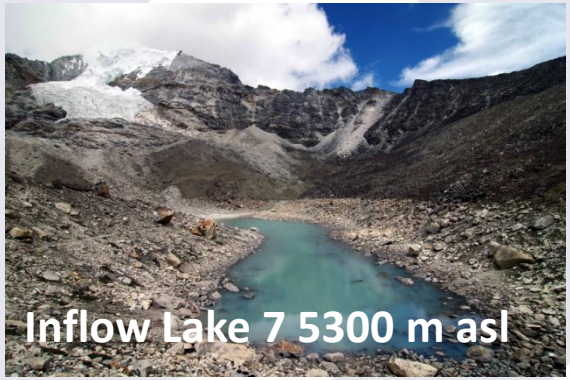
0.40 kg ha^{-1} yr^{-1}

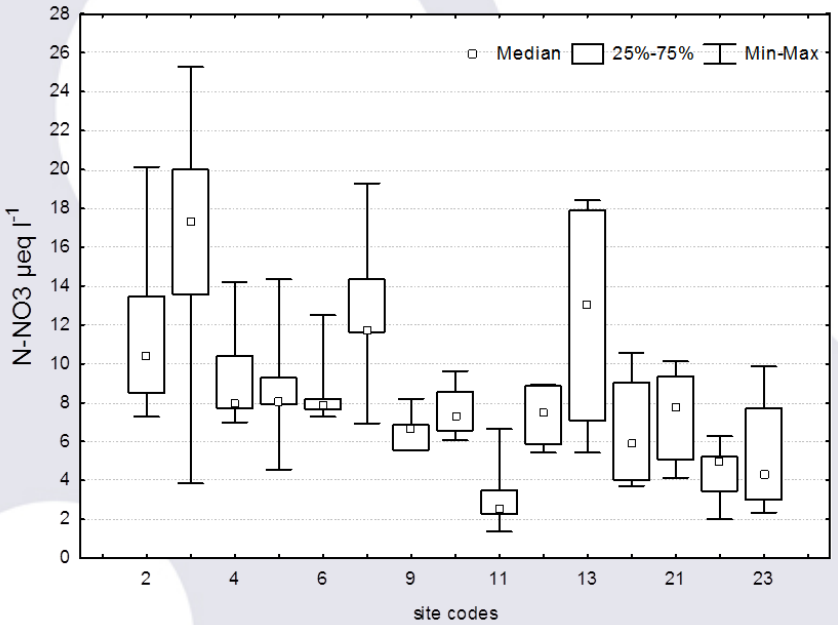
7.35 kg ha^{-1} yr^{-1}

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

Surface waters







NO_3 concentrations: 1-25 µeq l^{-1}

higher than expected!

Which is the origin of this N surplus?

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Conclusions

- During monsoon condition the depositions in the Khumbu valley are not substantially influenced by anthropogenic inputs.
- In pre and post monsoon seasons the Himalayas could not represent an effective barrier for pollutants coming from the southern urbanized and industrialized regions.
- These results are consistent with those obtained from the continuous monitoring of aerosols and black carbon at the same site and with other data available for the Himalayan region.
- The wet deposition fluxes measured at PIL were generally low, in particular the nitrogen load was one-tenth of the global terrestrial average reported for the mid-1990s.
- NO3 concentrations in running waters were not as low as expected from the N inputs. Why?
    - The wet deposition underestimates the total deposition as it does not take into account the contribution of dry deposition;
    - NO_3 may be stored in the snowpack and released as a pulse during spring melt;
    - N may have a biotic origin in microhabitats under talus.
- The results of recent activities (e.g. sampling of snow events, soil characterizations) will be useful to obtain further insights.

Thank you for your attention!

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