Study of the hydrogeochemistry of karst systems in the Andes

Origin and impact of climate and biological controls on carbonate weathering in the Peruvian Andes

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I. Introduction

Carbonates: 10-15% of the continental surface area
(Ford and Williams, 2007; *Chen et al., 2017*)

Carbonates weathering: 45 - 60% of dissolved elements transported to the ocean (80% Ca)
(Gaillardet et al., 1999; ; Meybeck, 2003)

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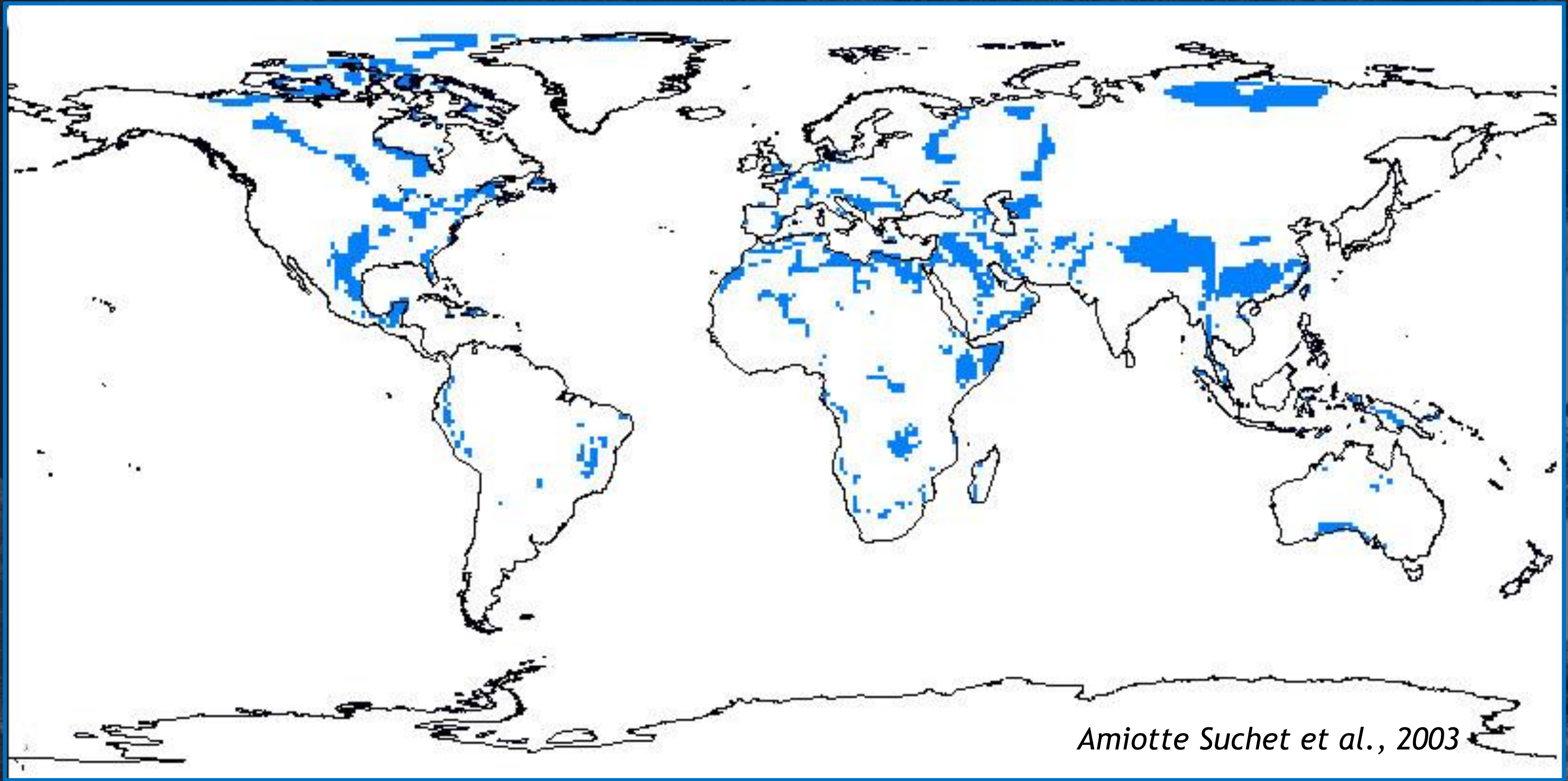
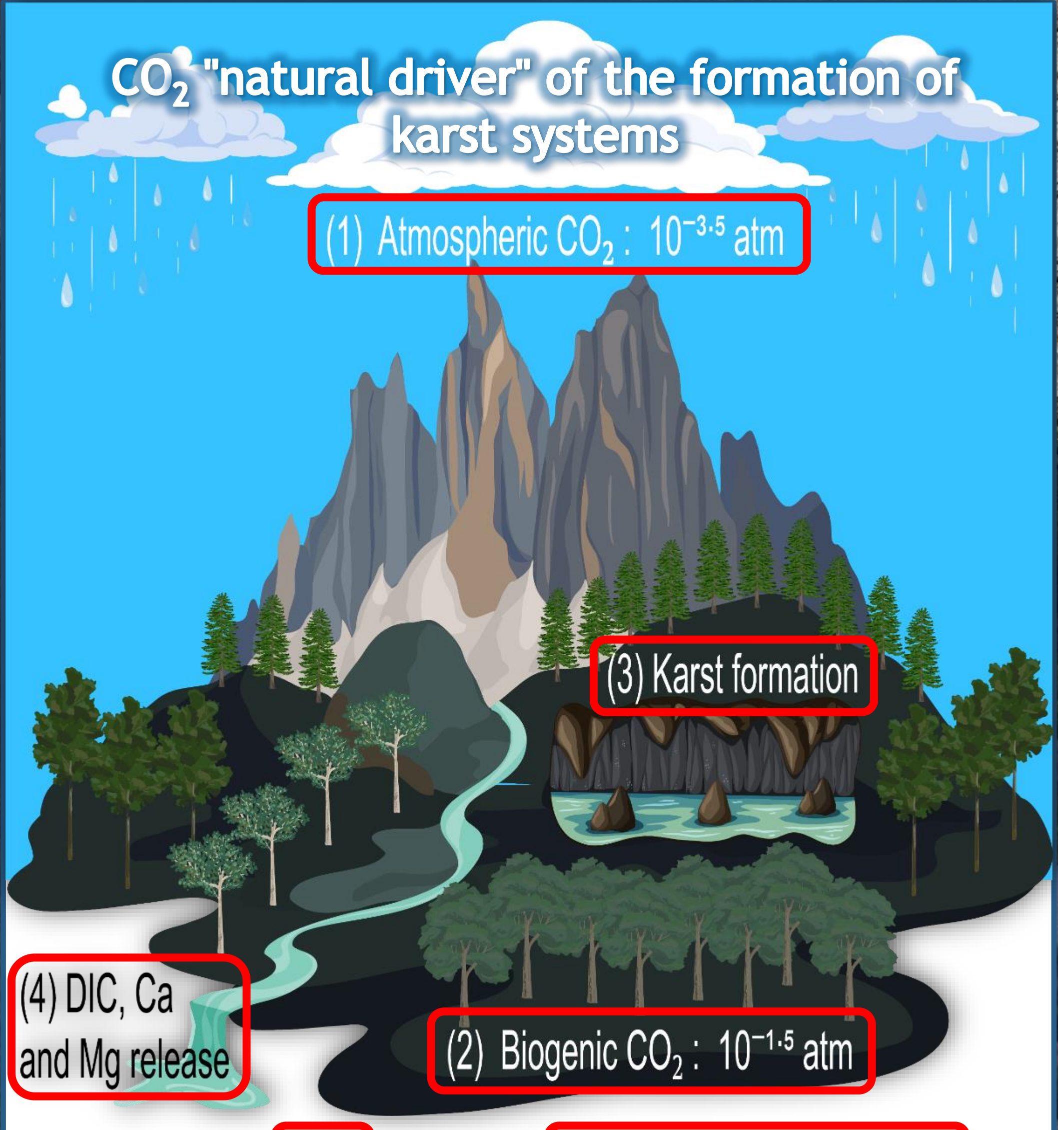
Major role in CO_2 transfer flows between the atmosphere and the critical zone
(Amiotte-Suchet et al., 2003; Hartmann et al., 2009)

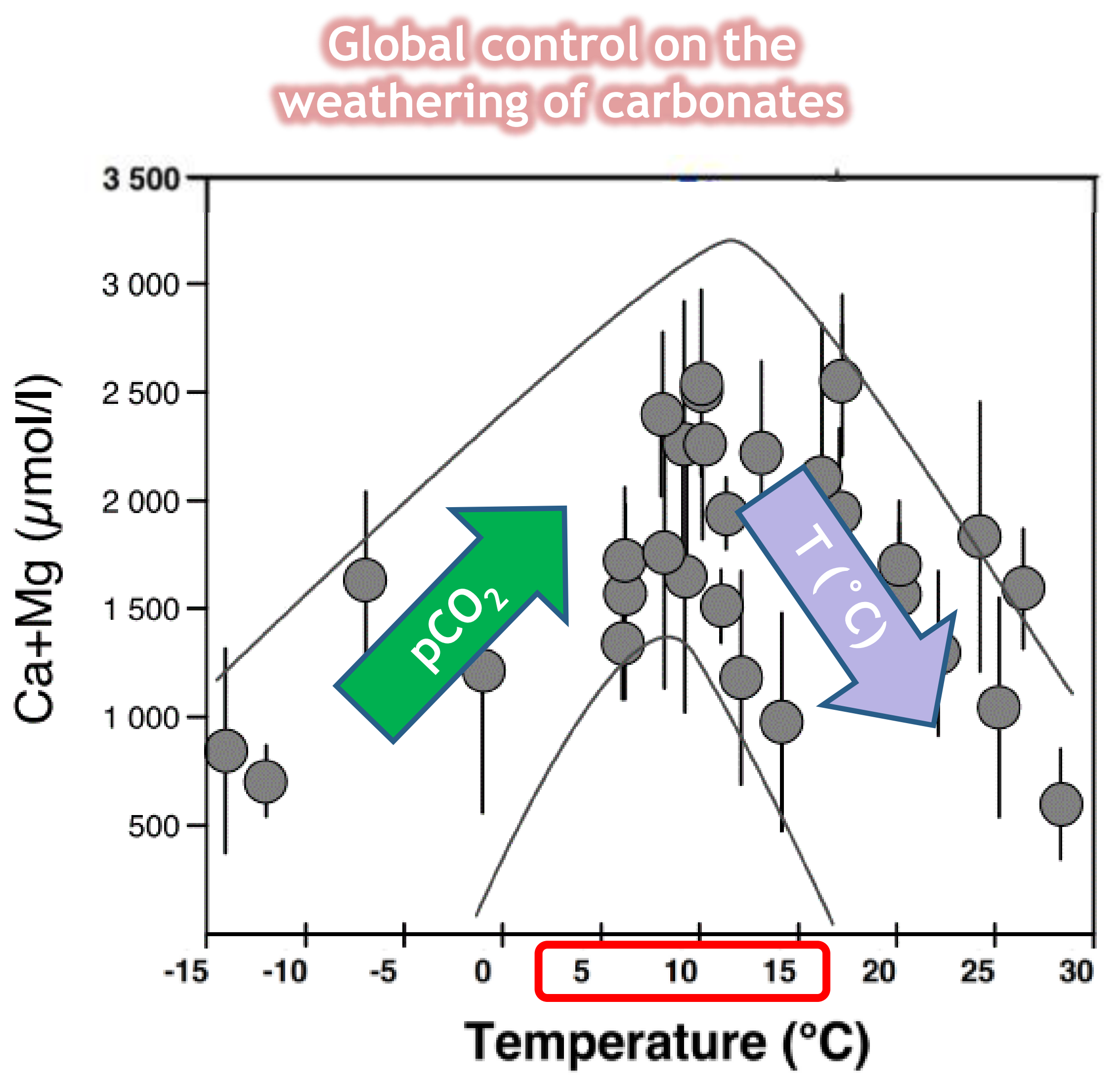


Amiotte Suchet et al., 2003

I. Introduction



$CaCO_3 + CO_2 + H_2O \Leftrightarrow Ca^{2+} + HCO_3^- + HCO_3^-$



Modified from Gaillardet et al., 2018

I. Introduction

Amazon

= 20% water supply to the ocean (200 000 m^3/s)

≈ 12% CWC (444 000 moles $CO_2/Km^2/an$)

(*Callède et al., 2010; Moquet et al., 2011; 2016a*)

Andes

≈ 13% Amazon surface (McClain and Naiman, 2008)

≈ 10% of water in the Amazon (Clark et al., 2014)

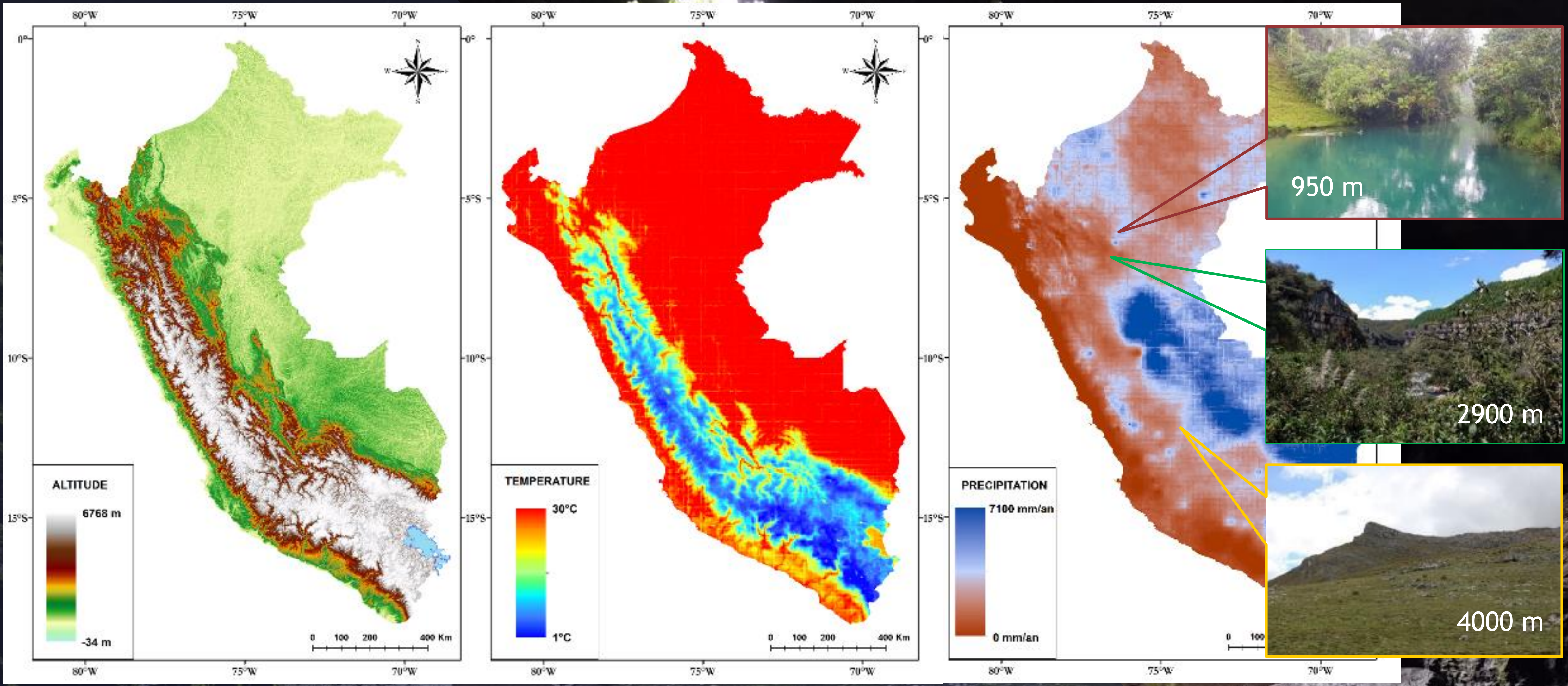
~90% of karst formations

> 70% of carbonate weathering flow

(Guyot et al., 1996; Hoorn et al., 2010)

I. Introduction

Peru: Strong Environmental Gradient



Objectives : (1) Relative weathering flow + CO_2 consumption + (2) Control of environmental parameters

II. Materials and methods

35 springs

16 February - 06 March 2018 (mission in Peru)

400 < H < et 4000 masl

A. Hydrological component:

Discharge, ETP(R).

B. Classic Hydrochemical Component:

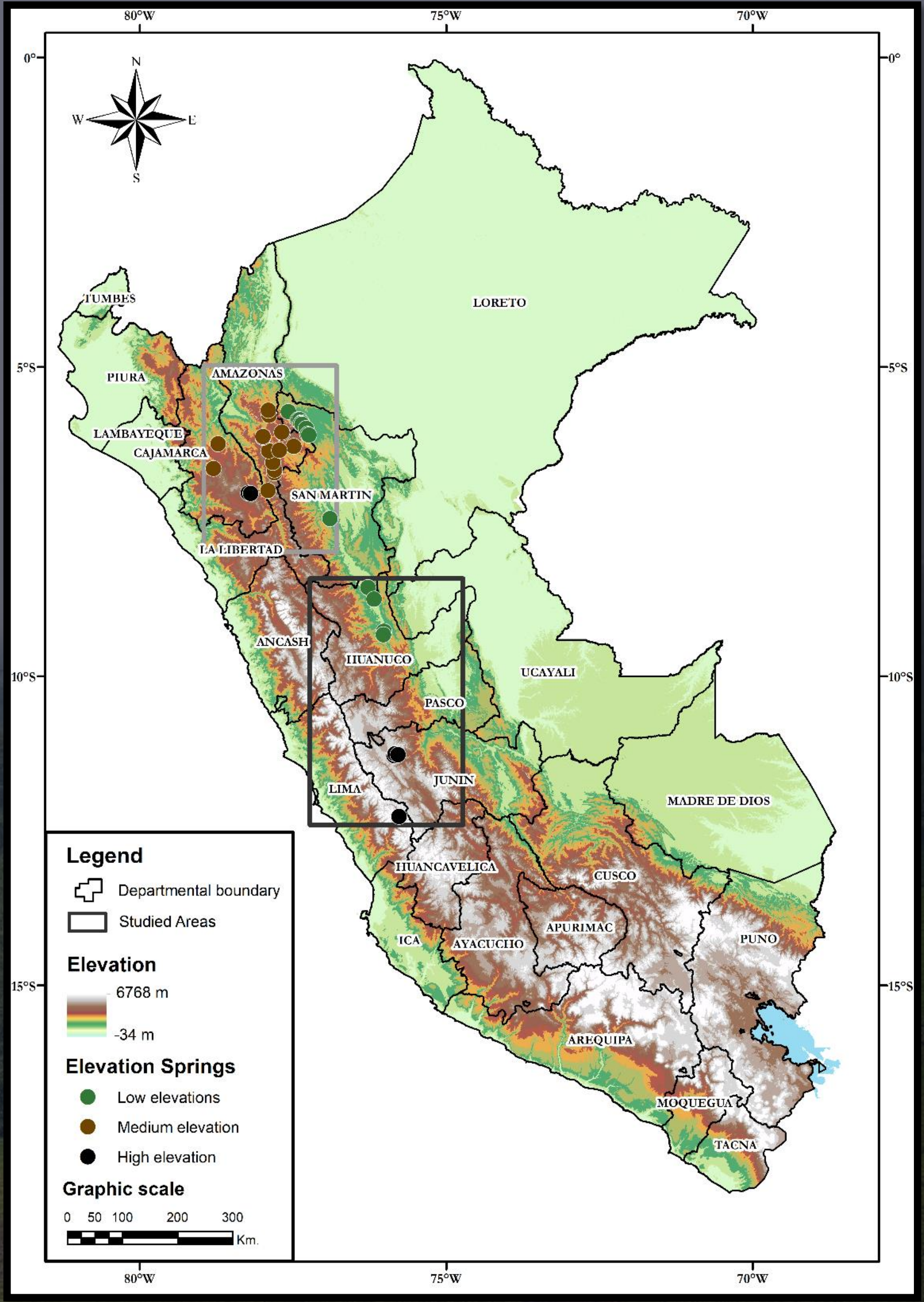
pH, conductivity, T_{water} alkalinity, major elements and traces, SIc, pCO_2.

C. Carbonate source component :

$\delta^{13}C$.

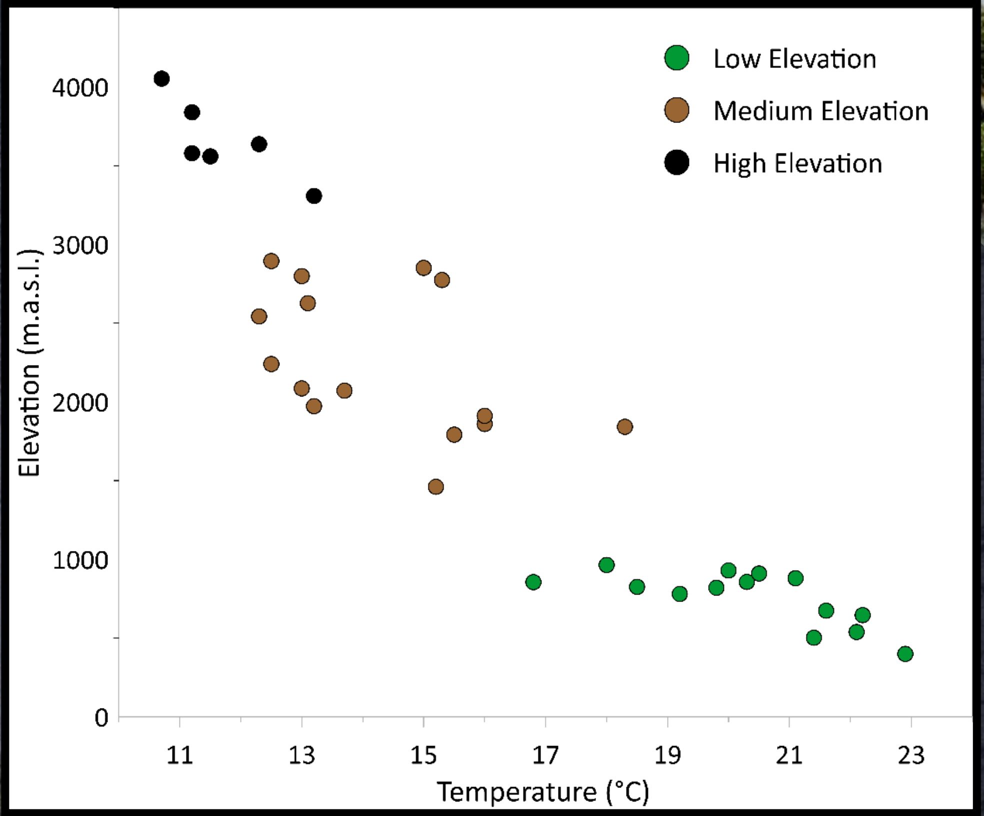
D. Hydroclimatic component (GIS) :

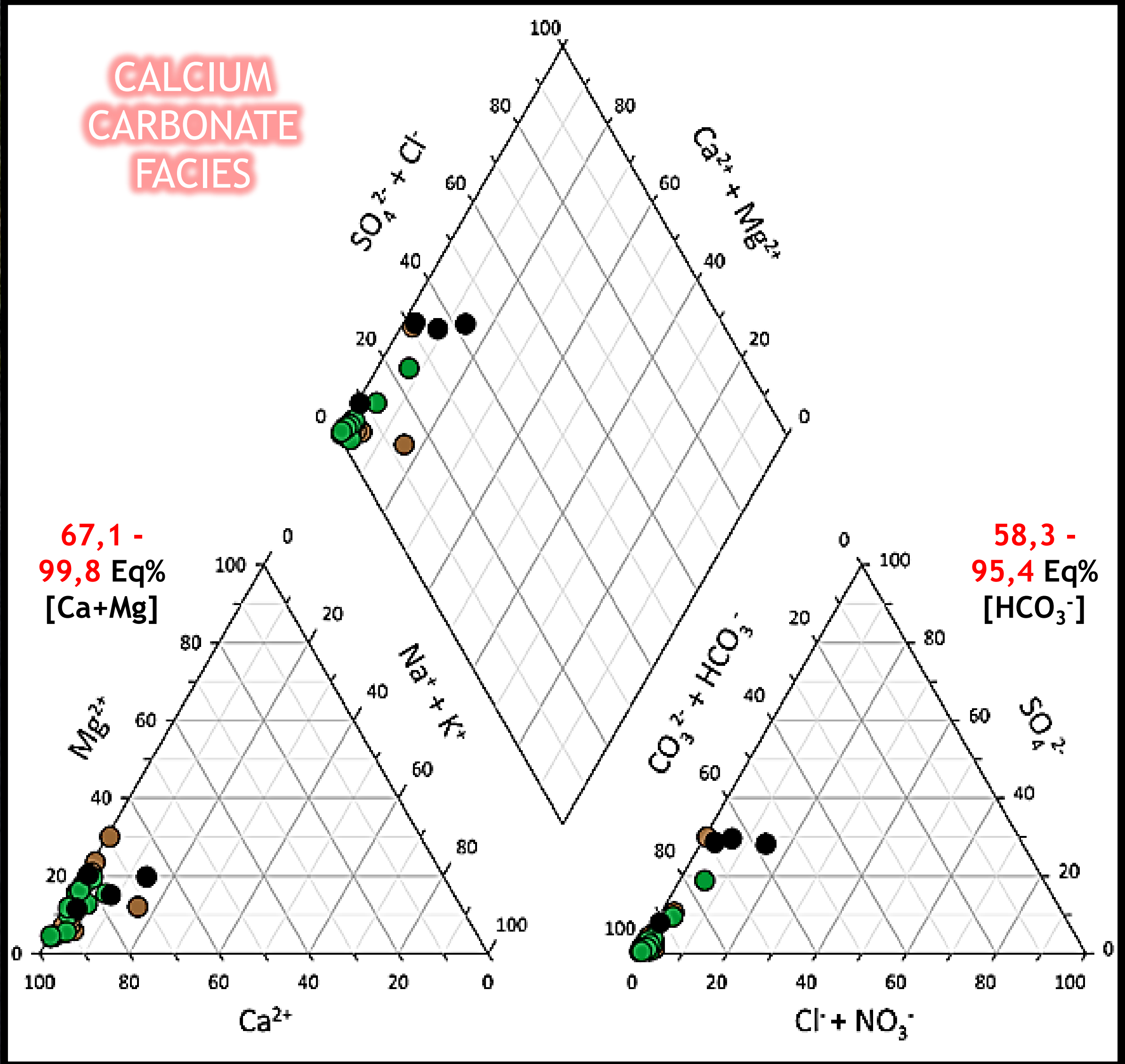
PISCO (P et T_{air}; *Aybar et al., 2017; Huerta et al., 2018*), delimitation BV_{topo}, Qs.



III. Results

11 < T_{water} < 23 °C 104 < C_{water} < 611 µS/cm 7,1 < pH < 8,4





-0,6 < SIc < 0,8 $10^{-3.41}$ < pCO_2 < $10^{-1,75}$ atm

IV. Discussion

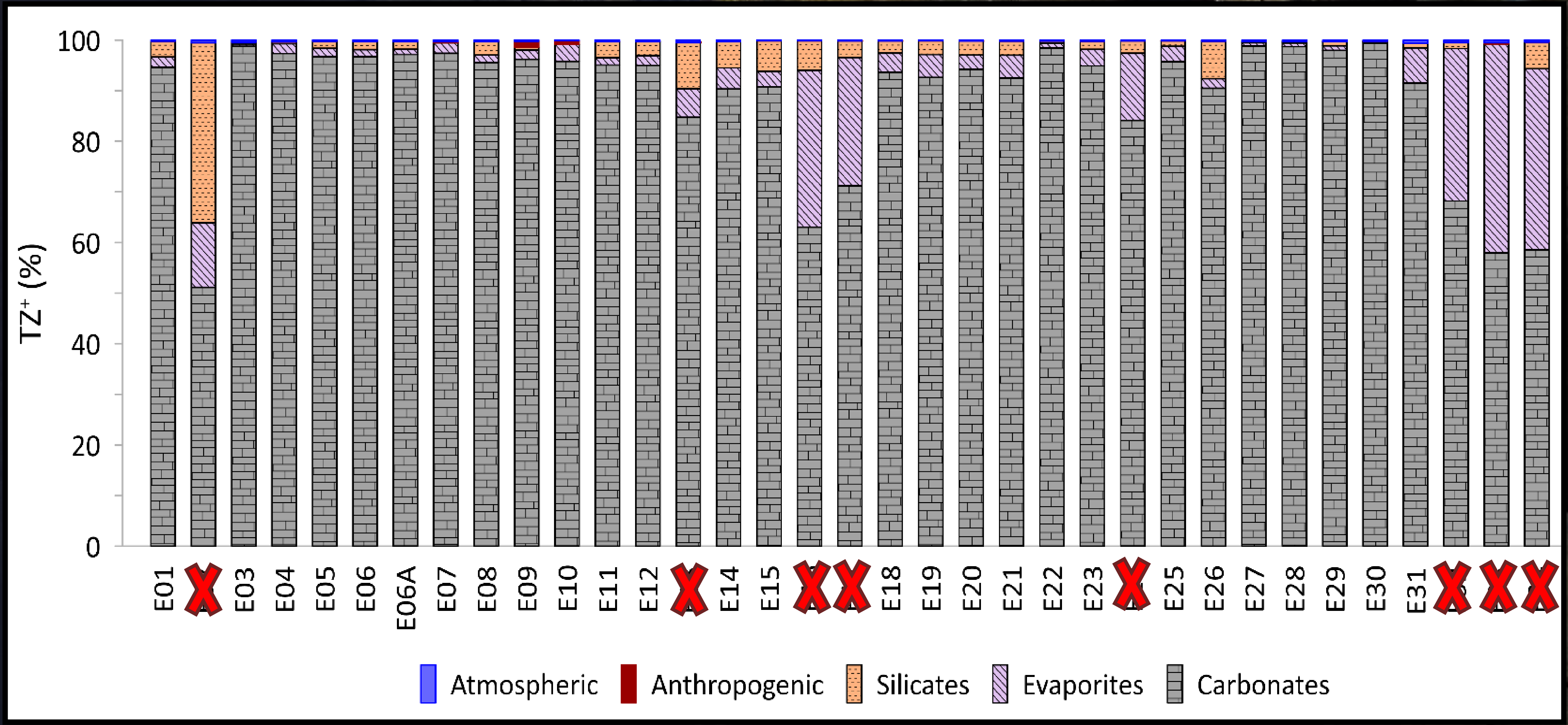
4.1. Hydrological parameters

$$F_{sp} = \frac{Q}{S} \, x \, C = (P - ET) \, x \, C$$

- ❑ $Q_{instantaneous} > Q_{annual\ average}$ (Logs of 5 springs)
- ❑ $BV_{topo} \neq BV_{drainage}$
- ❑ Underestimation of rainfall (Manz et al., 2016; Grandjouan et al., 2017; ≈ runoff)
- ❑ Temporal variation in concentration < 10% (temporal monitoring of 3 springs)

First approximation : RUNOFF ≈ P (HIGH UNCERTAINTY) → RELATIVE

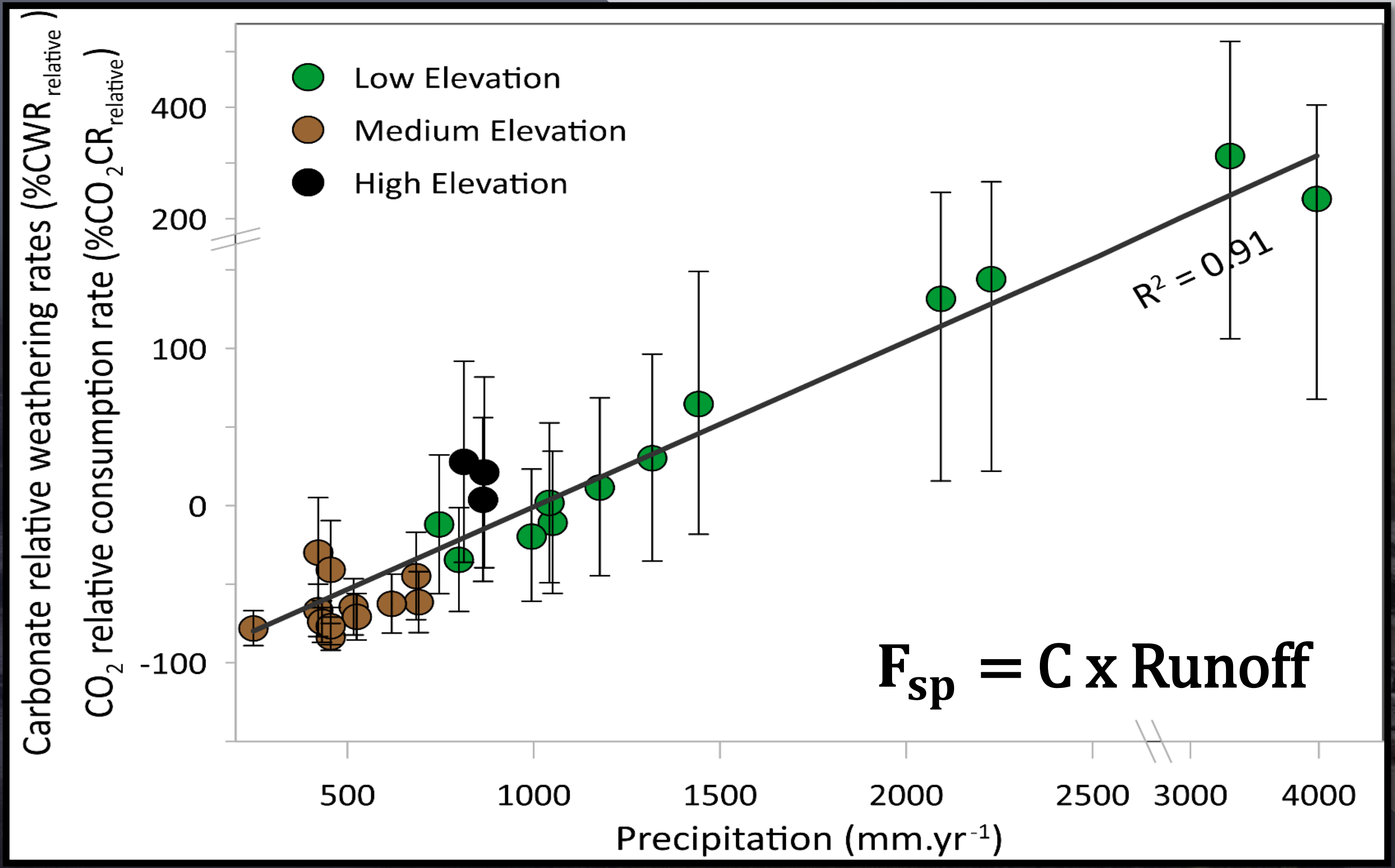
4.2. Sources of major elements



LIMESTONE + Influence « Evaporites and Silicates »

4.3. Weathering gradient of carbonates

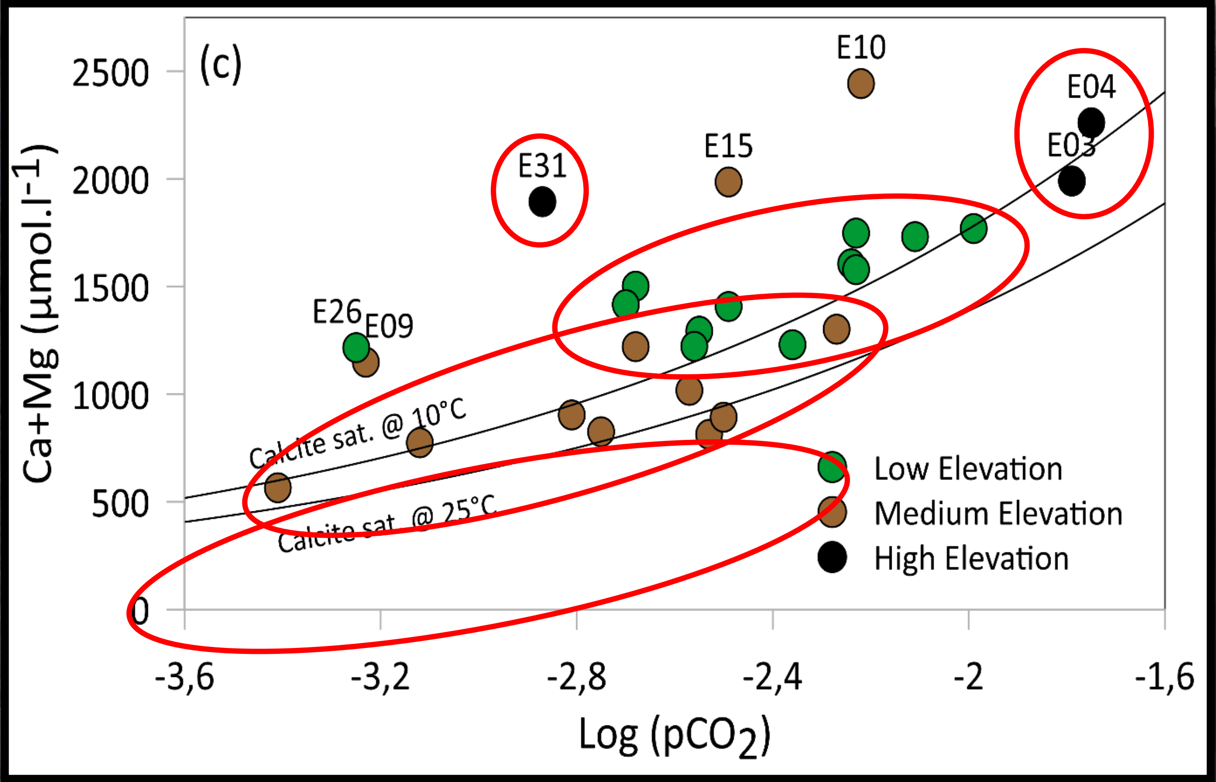
RELATIVE FLOW OF WEATHERING

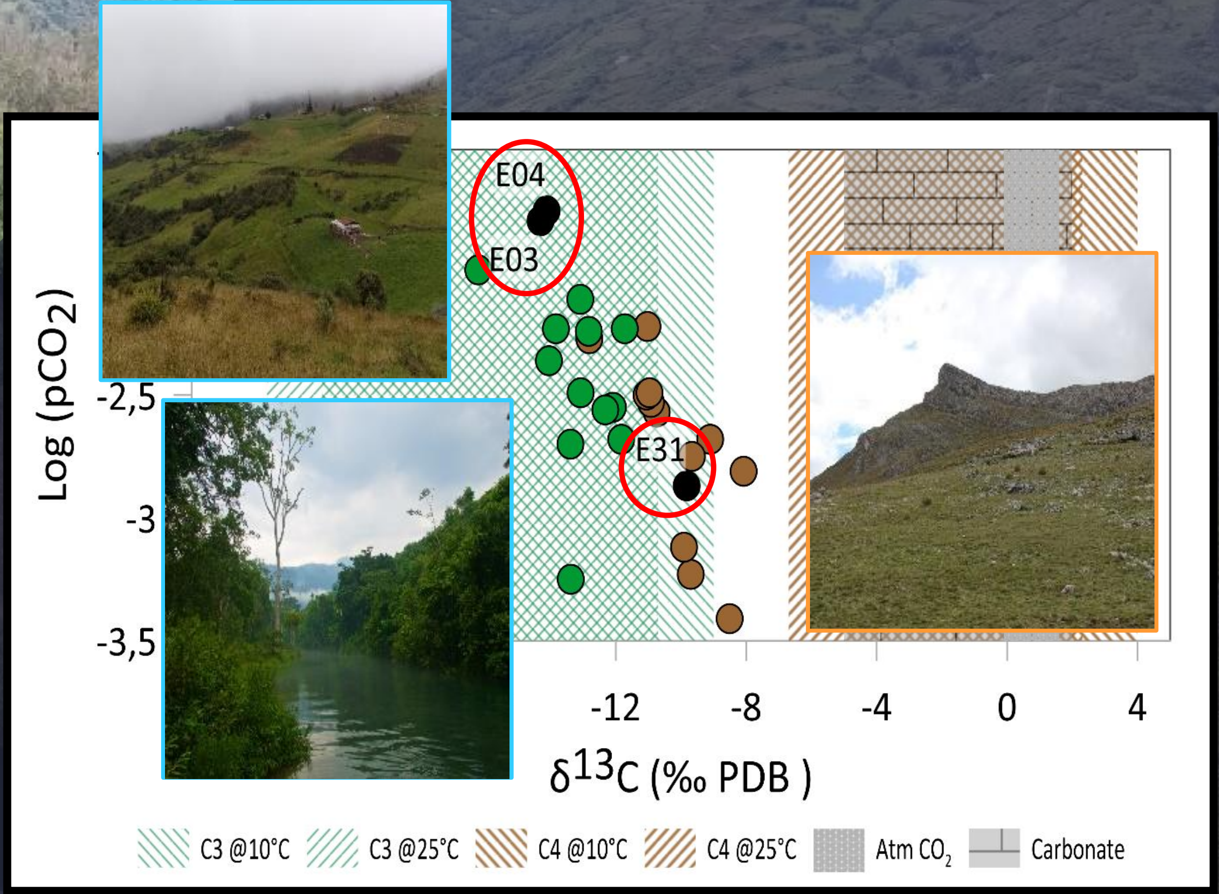


Spatial variability :
Rainfall >> Concentrations of Ca+Mg or HCO_3^-

First-order control of weathering flows:
Rainfall (Quantity of water)

4.3. Weathering gradient of carbonates





A. [Ca+Mg] High elevation « The highest »

Thermodynamic control

B. pCO_2 of low elevations >> medium altitude

Ecosystem type control

First order control on concentrations (weathering intensity): TEMPERATURE + VEGETATION

V. Conclusions

✓ Hydrological parameters =

high uncertainties

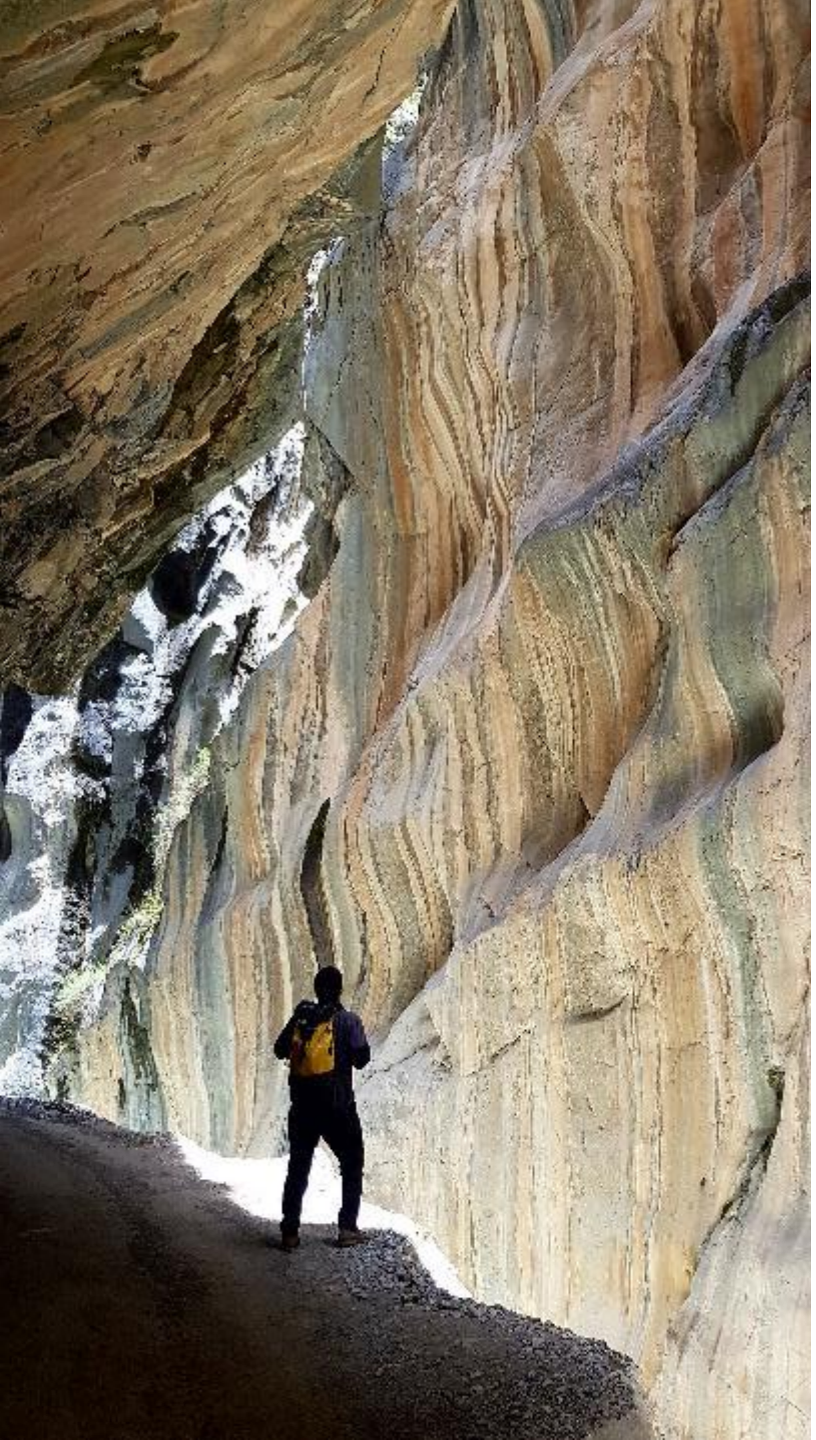
"lack of data + poorly known rainfall + karst region"

✓ Control on weathering flow =

Quantity of water

on concentrations =

Temperature + **Vegetation**



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