Análisis del origen de agua en dos cuencas andinas con trazadores de isótopos estables y otros parámetros hidro-químicos para apoyar la parametrización de modelos hidrológicos

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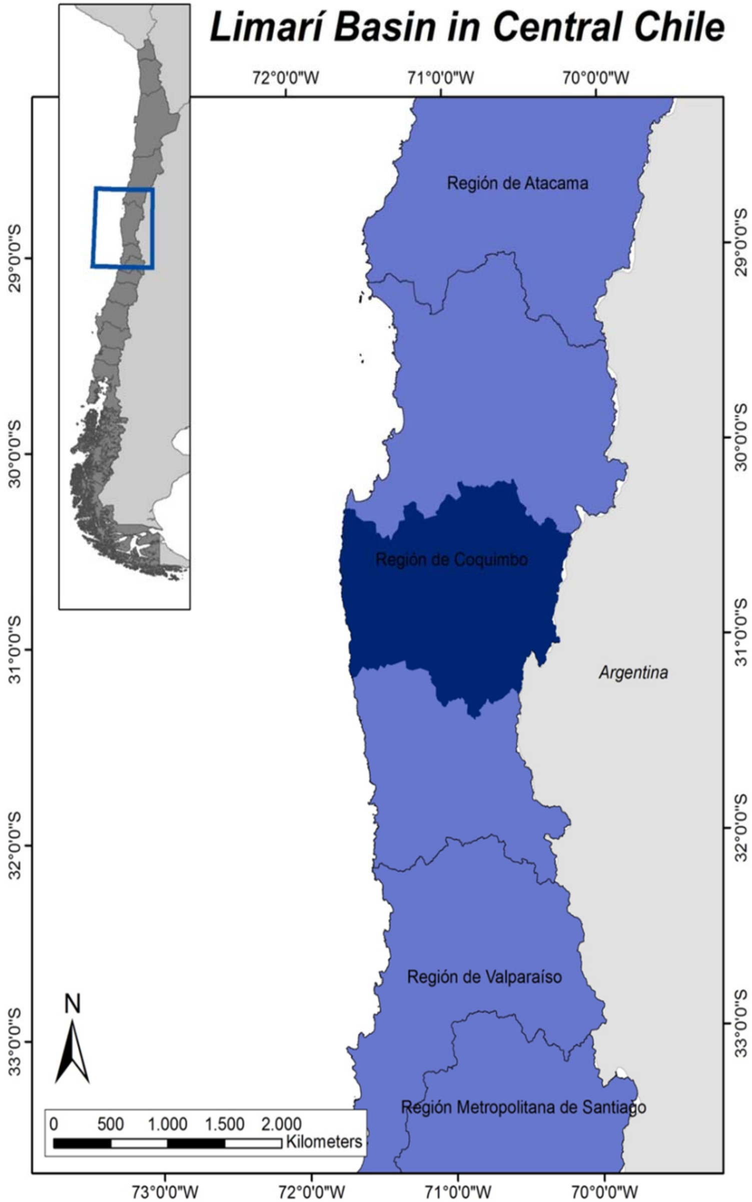
Contenido:

- Región de estudio, cuencas Rio Grande y Tascadero
- Variabilidad de clima y hidrología
- Muestreo de isótopos estables y análisis hidro-químico
- Resultados y demanda de investigación

Región de estudio

Assessment of runoff generation from high elevation Andean catchments to predict water availability under climate variability and change



Limarí Basin, size 11.696 km

- Elevation: Pacific coast to the Andes: 0-6000 m
- Average annual rainfall: 120 mm
- strong Precipitation gradient from North to South

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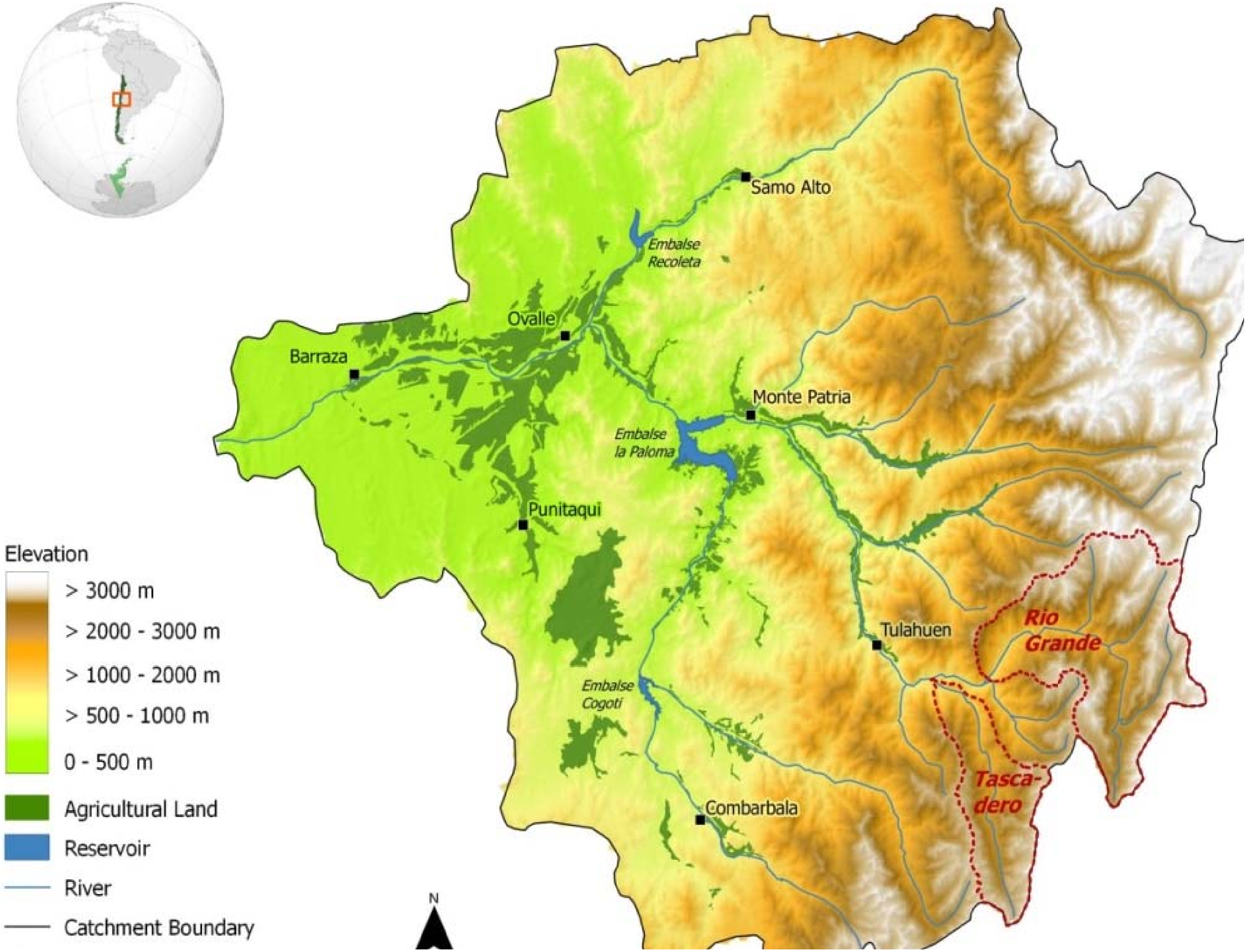

- Strong spatial and temporal variability of precipitation,
- average rainfall 120mm per year
- Pot Evapo-traspiration
- > 1000mm
- Hydrological year May to April

Limarí Basin, Rio Grande (544km²) and Tascasdero (254 km²), total size 11.696 km,

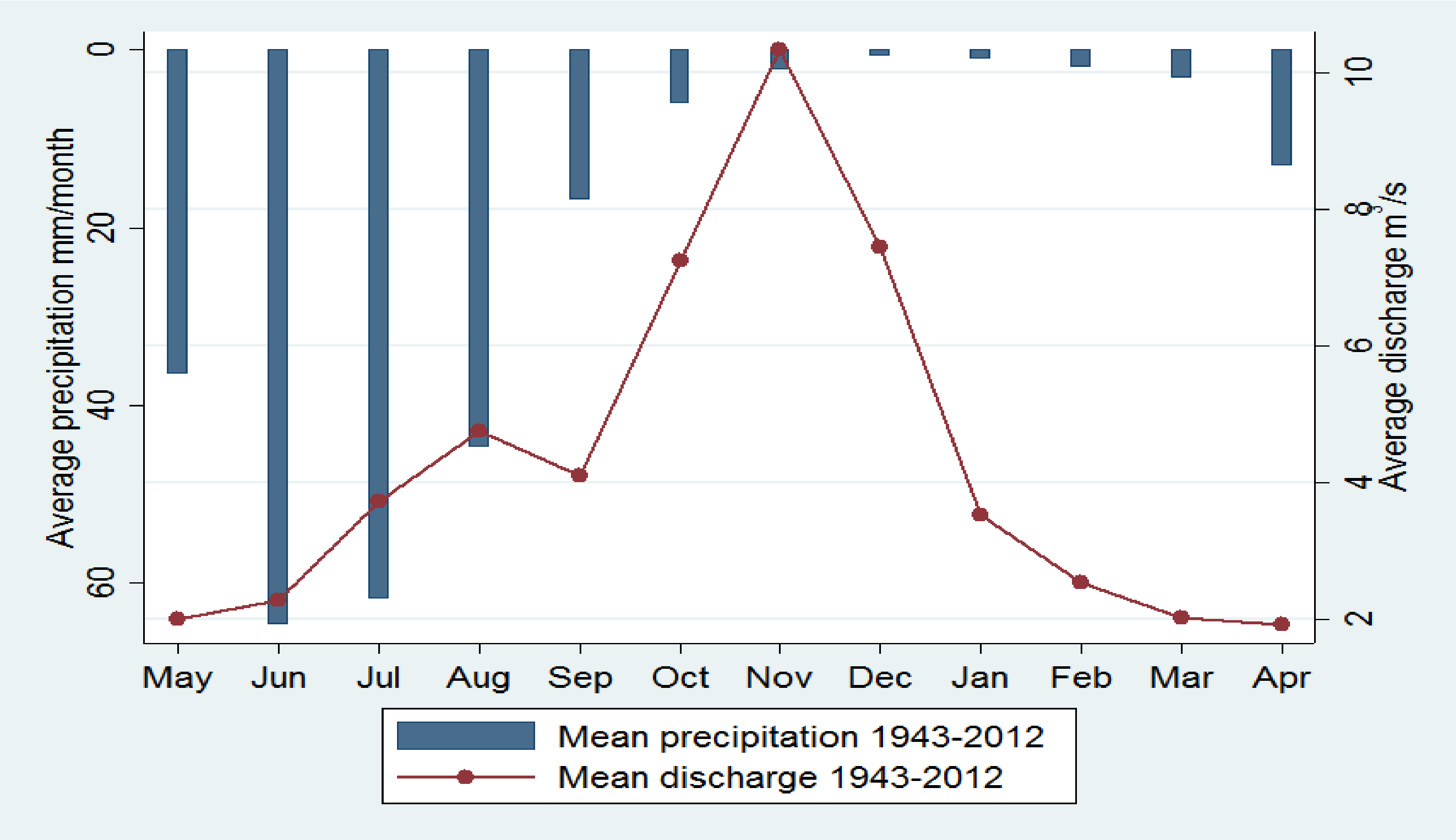

Fig: Intra-annual Precipitation-discharge distribution at Las Ramadas station – averages from 1943 to 2012

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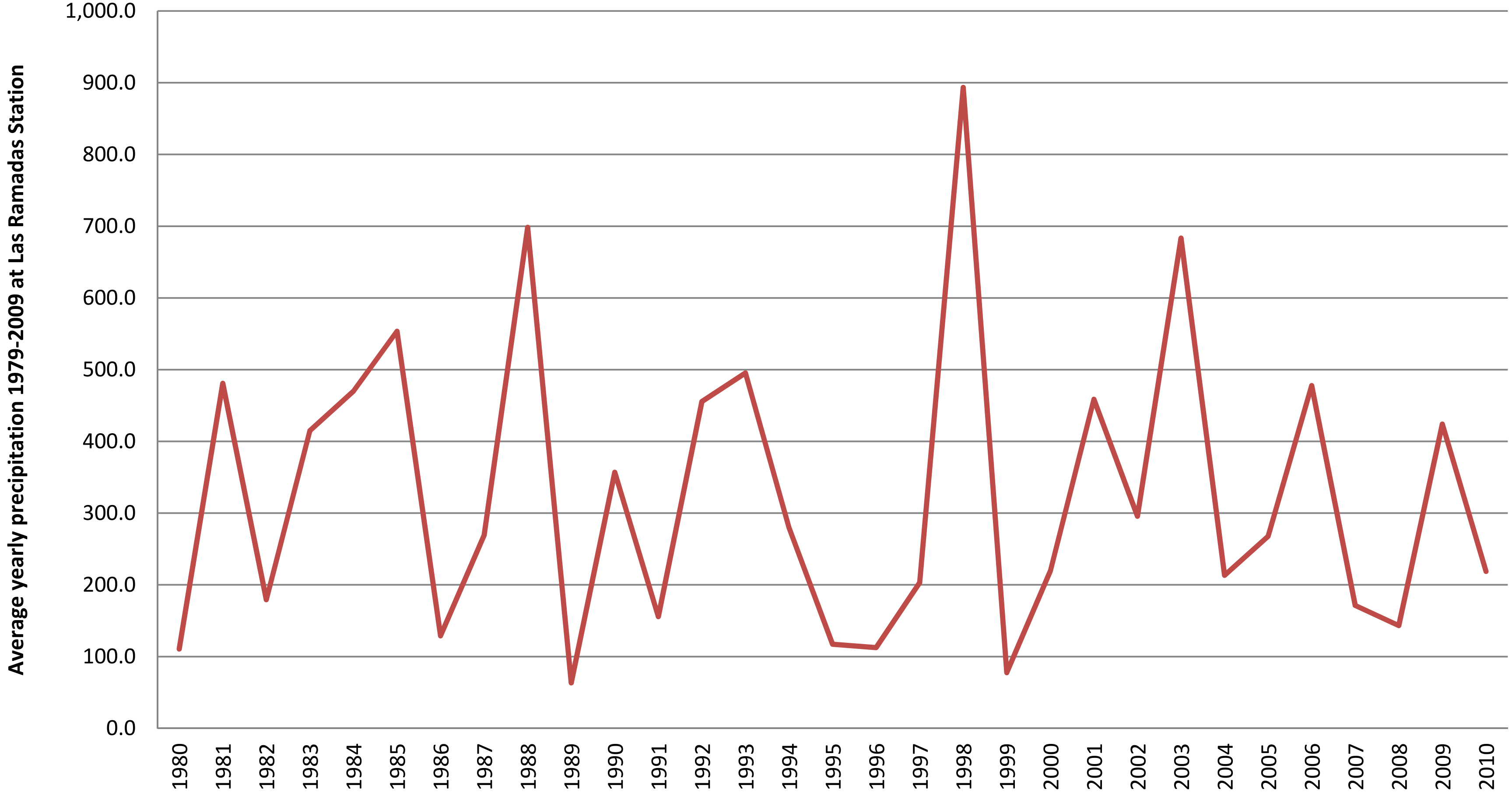

Figure: Average yearly precipitation in the Limarí River Basin at Las Ramadas climate station 1979-2009, Data source: DGA 2010

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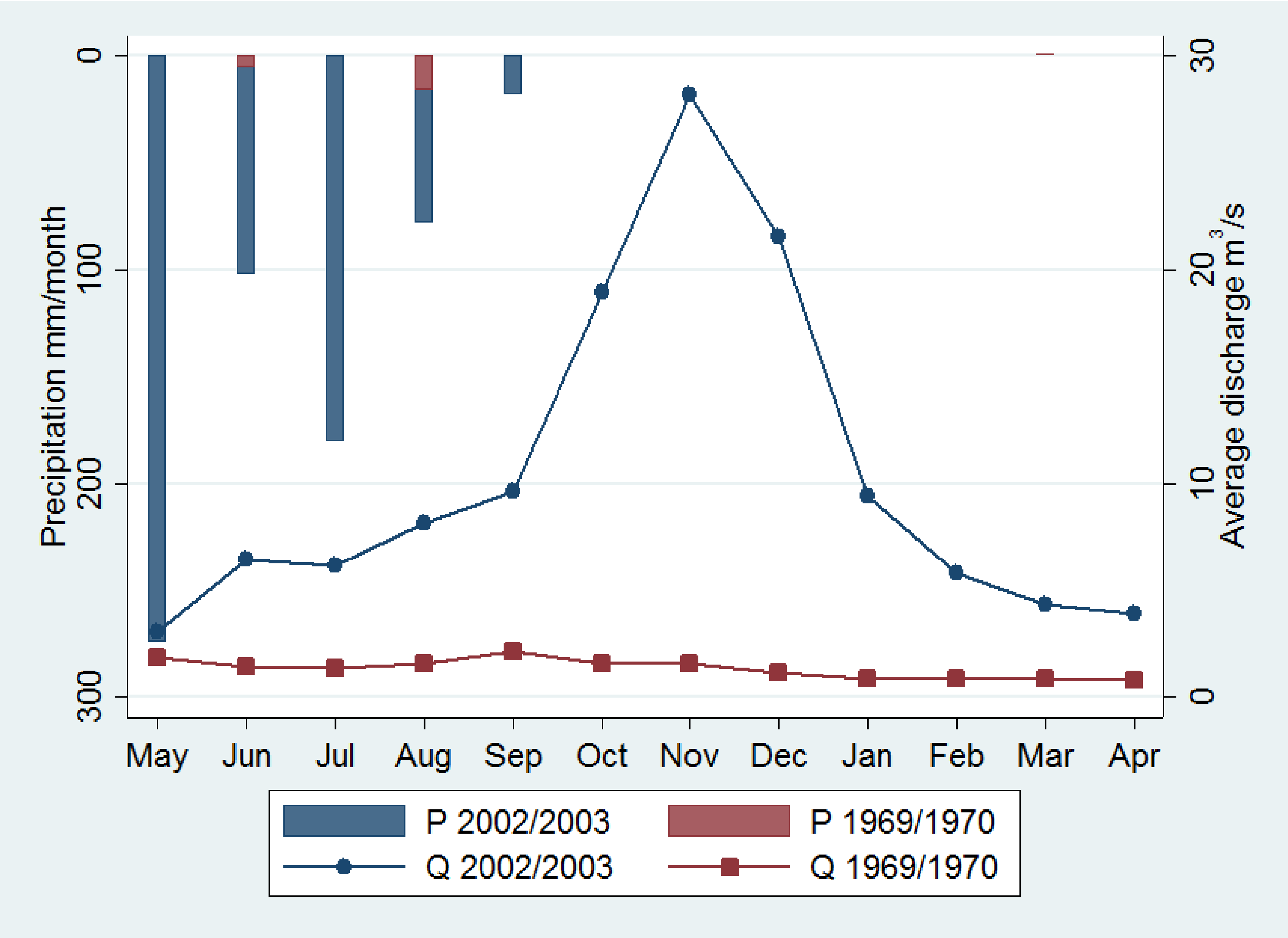

Fig: Two extreme years of Precipitation-discharge


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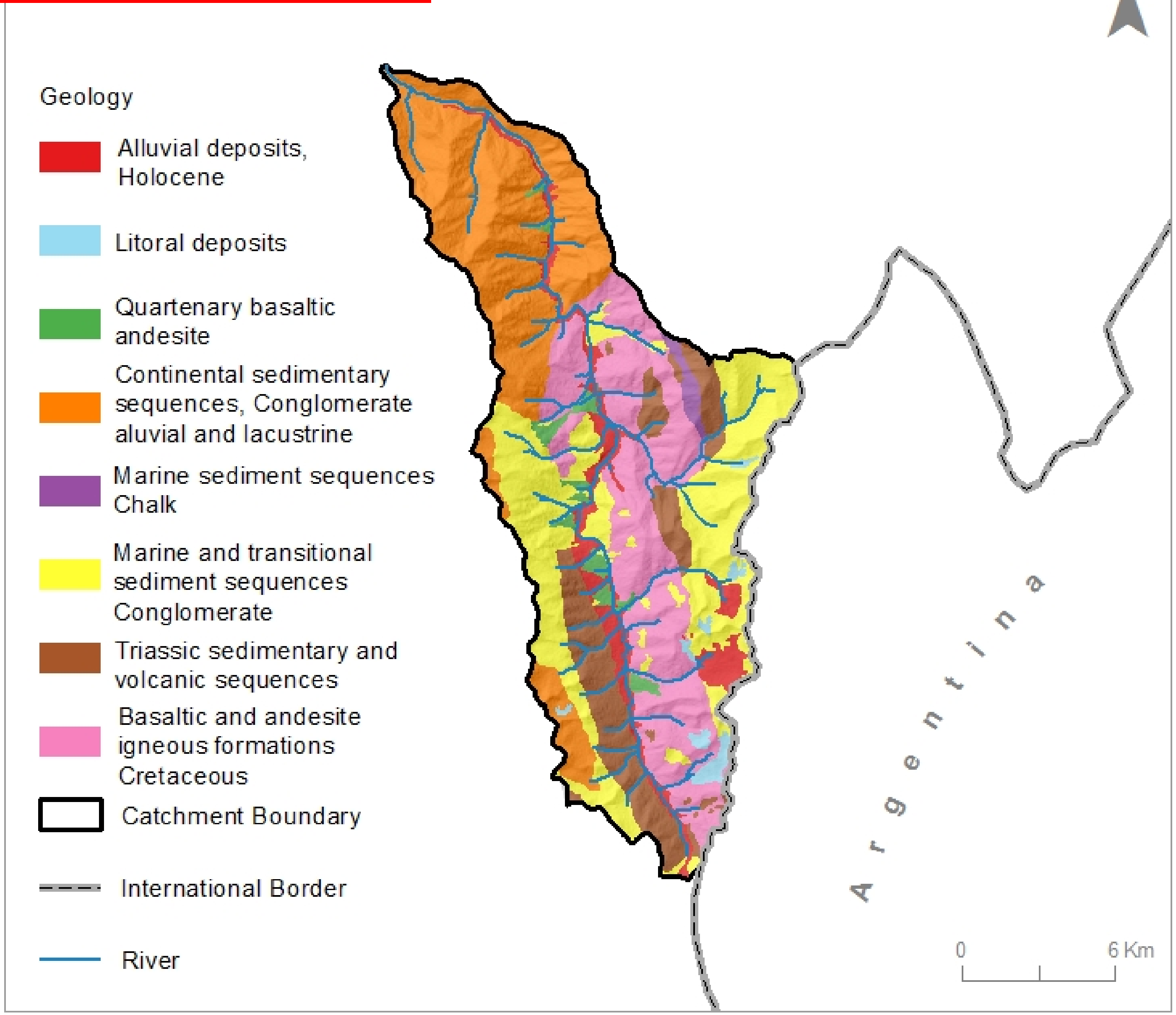
WRONG!!!!!!



Preliminary map of Geology of Tascadero based on Goat study and Geological map of Chile


MOP
ESTACION FLUVIOMETRICA
RIO TASCADERO
EN DESEMBOCADURA
AREA CUENCA 238 km²
ALTURA 1370 msnm

Objetivo:

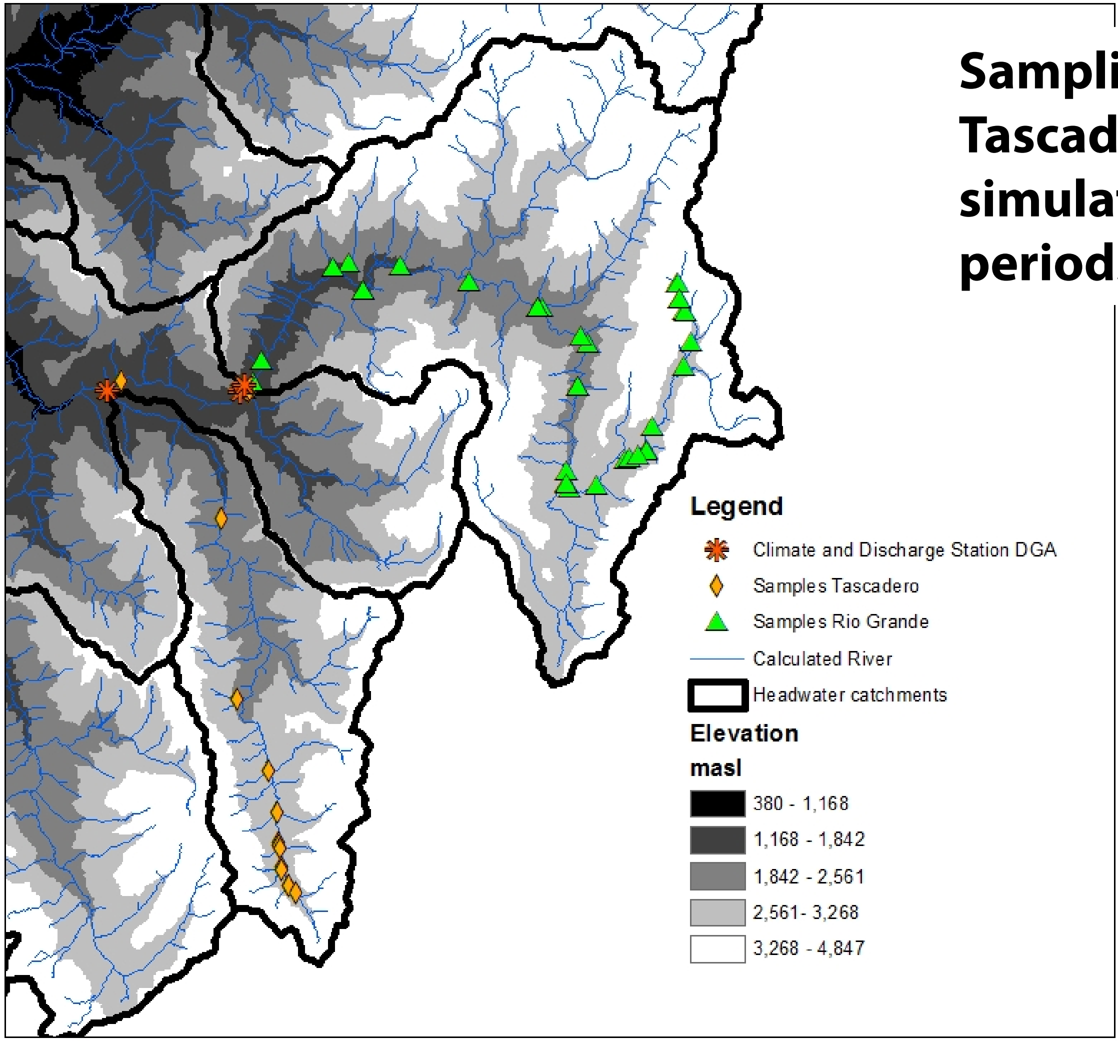
Mejorar los conocimientos sobre la interacción clima-agua superficial-agua subterránea

Objetivos detallados:

- Analizar el origen de las aguas y su tiempo de residencia
- Mejorar los conocimientos sobre el entorno geológico y hidrogeológico
- Flujos de agua subterránea
- Apoyar la validación y calibración de modelos hidrológicos

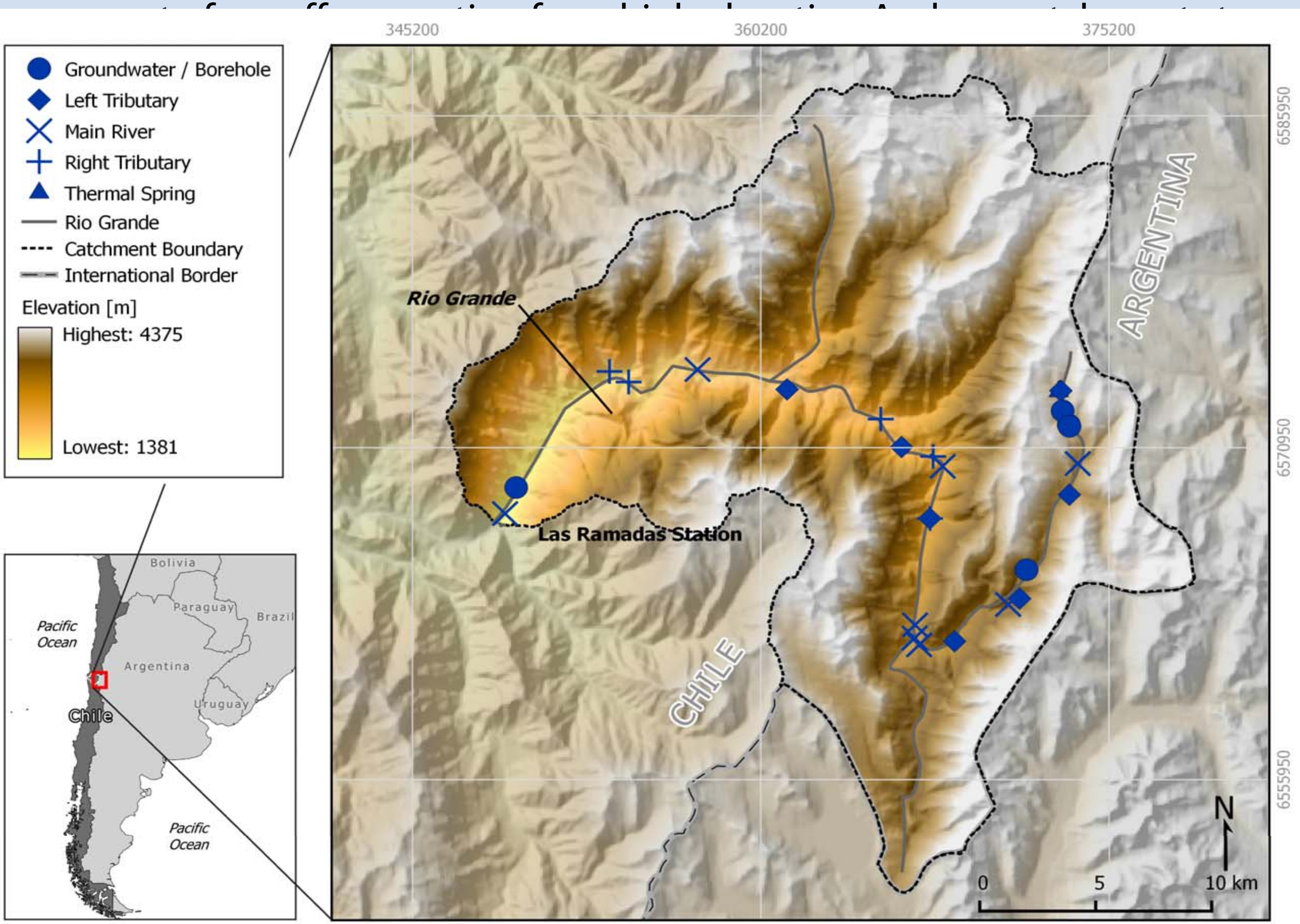
Muestreo estacional de isótopos estables y parámetros hidro-químicos en Diciembre, Mayo, Septiembre, Enero

- Sampling $\delta^{18}O$ and $\delta^{2}H$ in Rio Grande and Tascadero streams + Precipitation, snow to assess the residence time and origin of stream water
- geochemical analysis: cations: Na^{++}, K^{+}, Ca^{2+}, Mg^{2+} and anions: Cl^{-}, SO_4^{2-}, HCO_3^{-}, CO_3^{2-} to assess the characteristics of the source and aquifers of origin
- Runoff measurements in headwater contribution streams, conductivity, stream temperature



Sampling locations in Rio Grande and Tascadero headwater catchments, simulated streams for water rich periods

- No glaciers
- Heterogeneous geology



345200
360200
375200
6585950
6570950
6555950
Groundwater / Borehole
Left Tributary
Main River
Right Tributary
Thermal Spring
Rio Grande
Catchment Boundary
International Border
Elevation [m]
Highest: 4375
Lowest: 1381
Rio Grande
Las Ramadas Station
ARGENTINA
CHILE
N
0
5
10 km
Bolivia
Paraguay
Brazil
Pacific Ocean
Argentina
Uruguay
Chile
Pacific Ocean

Assessment of runoff generation from high elevation Andean catchments to predict water availability under climate variability and change

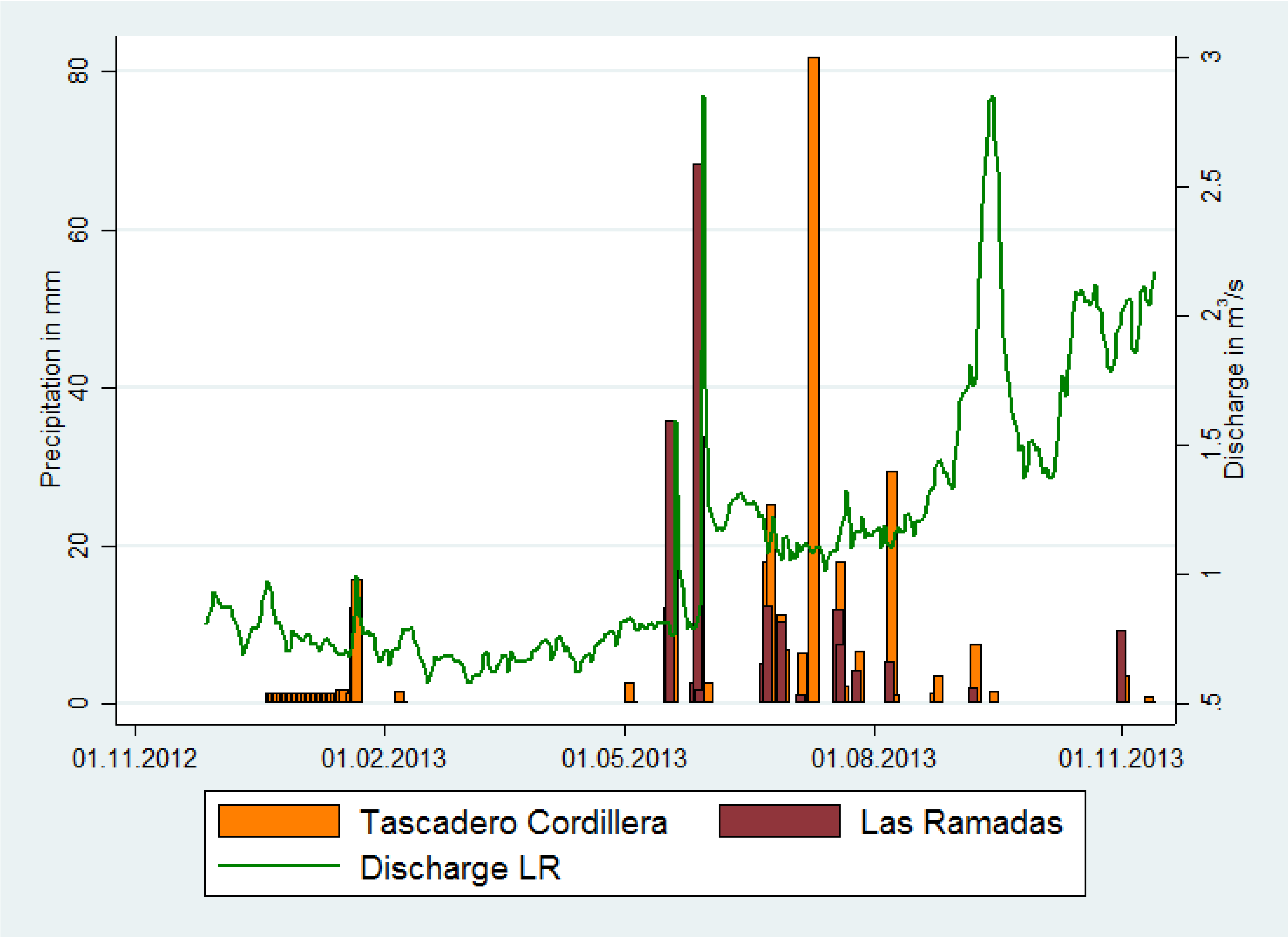


Figure 8: Precipitation recorded in the Cordillera (Tascadero station at 3500m) in 2013 compared to precipitation in Las Ramadas and discharge in Las Ramadas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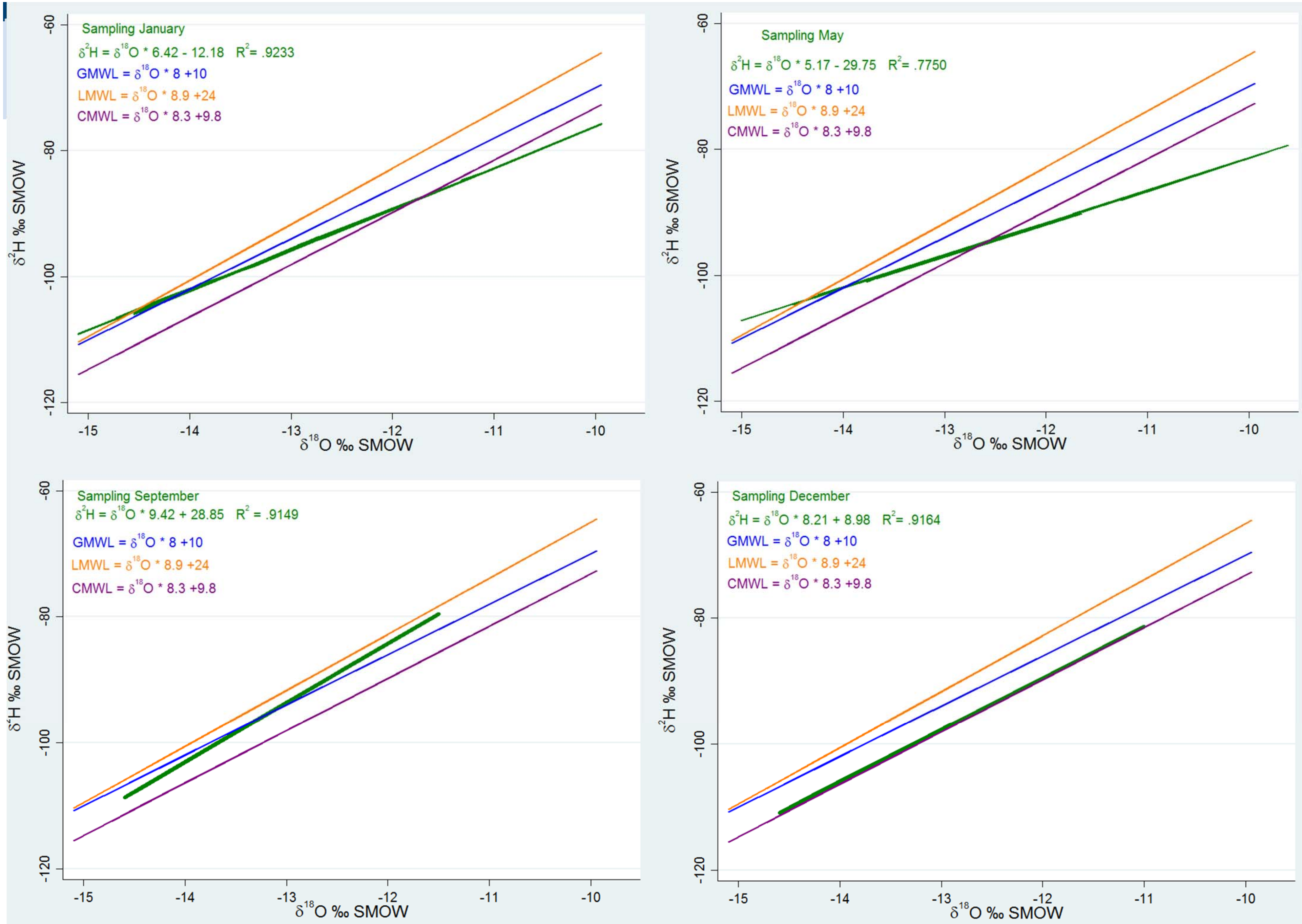
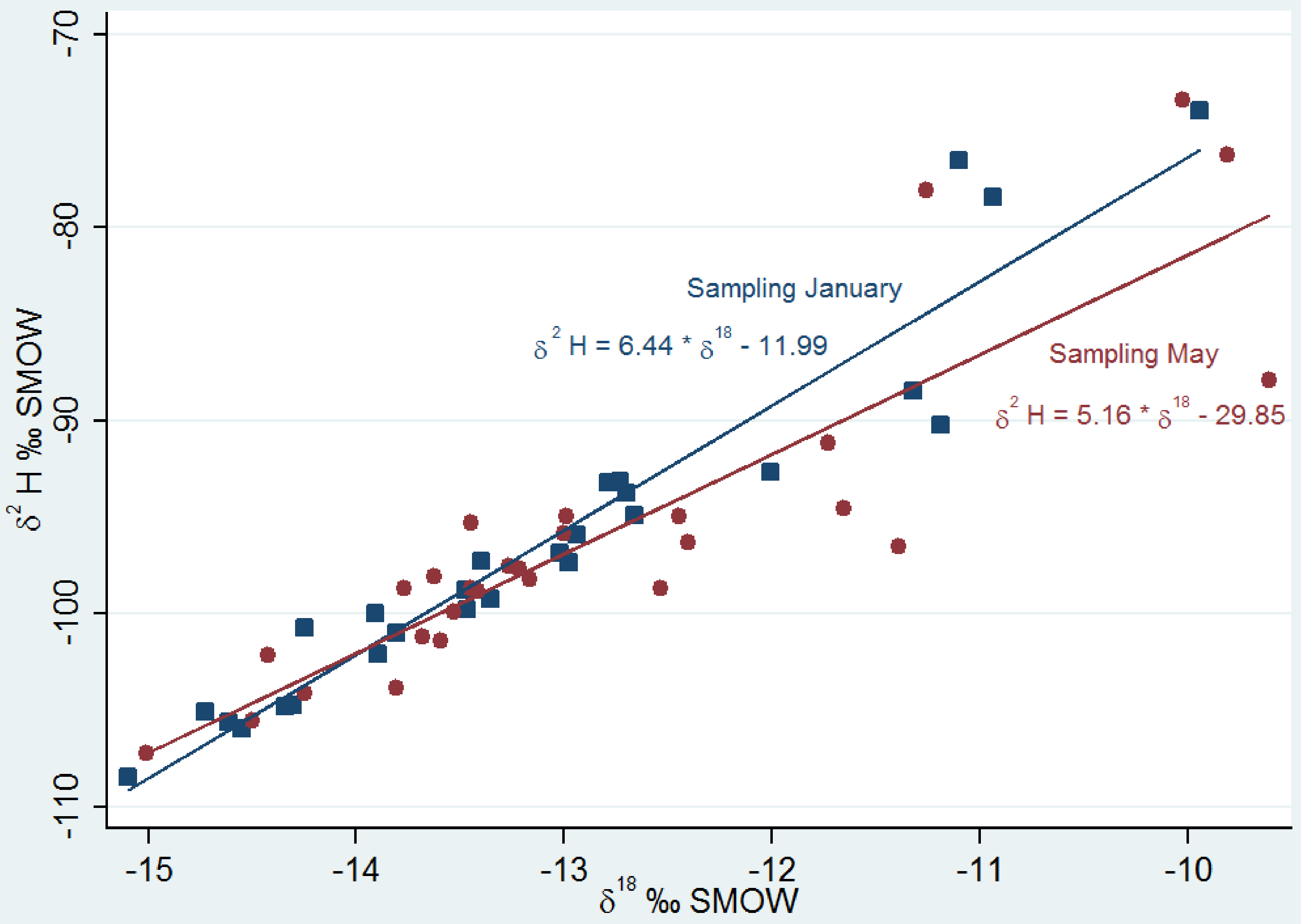


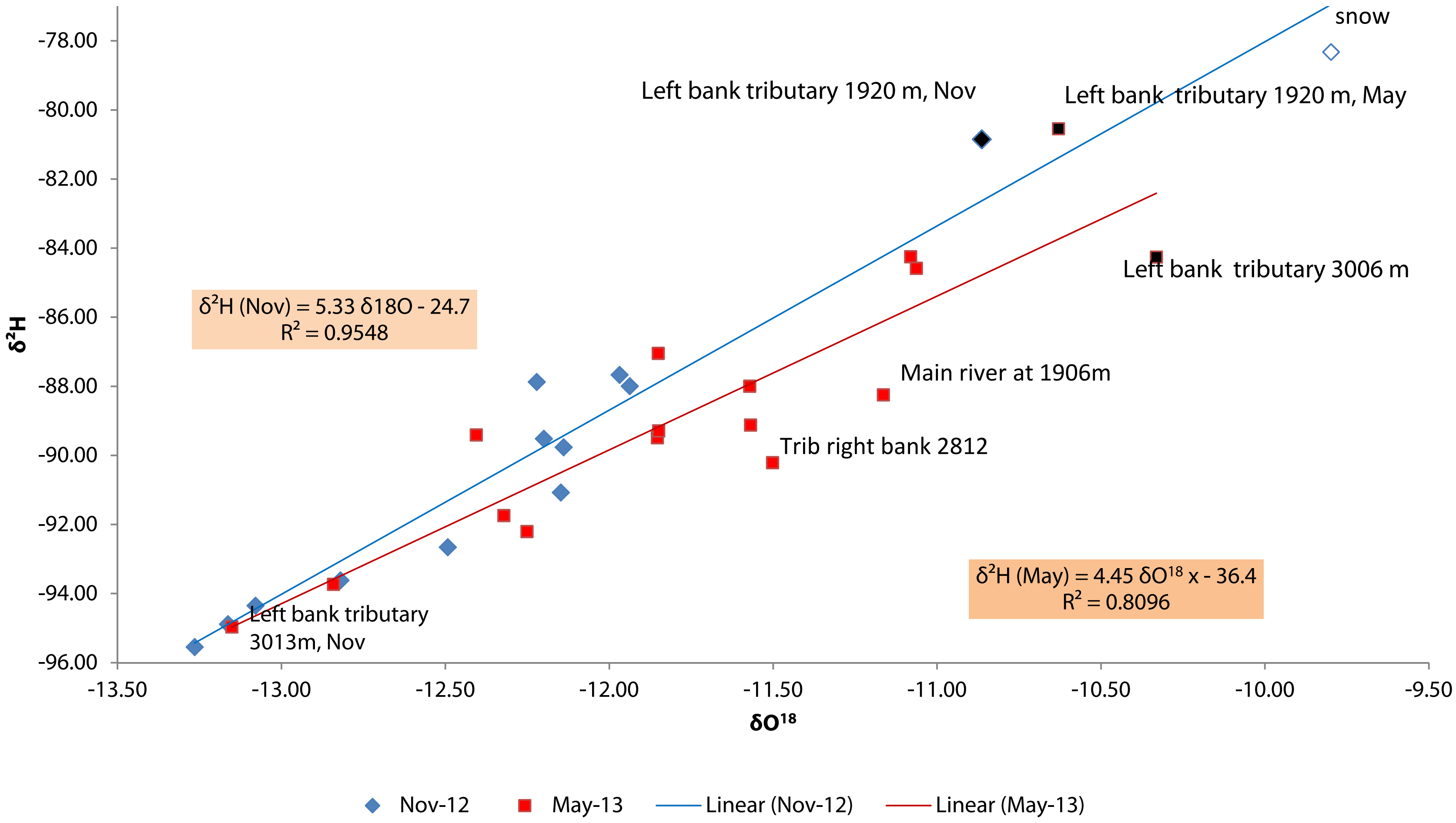
Figure 3: Comparison of the sampling regression lines in Rio Grande in summer and autumn with relevant meteoric water lines: the Global Meteoric W ater Line $\delta^2H=8* \delta^{18}O+10$, the Chilean Meteoric Water Line: $\delta^2H=8.3* \delta^{18}O+9.8$ (Spangenberg et.al., 2007) and a Local meteoric Water Line $\delta^2H=8.9* \delta^{18}O+24$ for the lower part of the Limarí basin (calculated by

Assessment of runoff generation from high elevation Andean catchments to predict water availability under climate variability and change



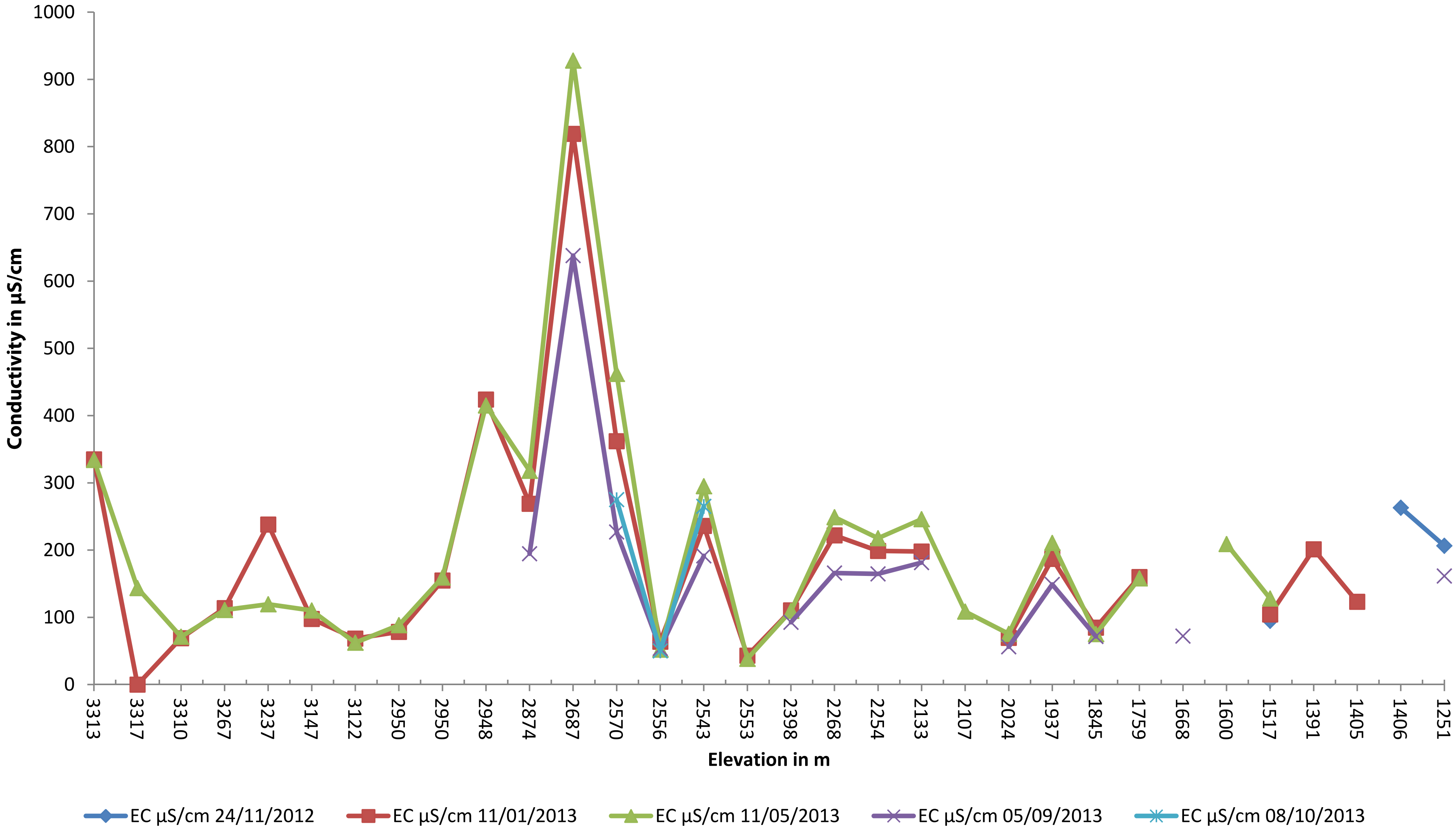
δ18 O ‰ values against 2H in Rio Grande, January 2013 + May 2013

Assessment of runoff generation from high elevation Andean catchments to predict water availability under climate variability and change



δ18 O ‰ values against 2H in Tascadero, November 2012 (spring) + May 2013 (autumn)

Assessment of runoff generation from high elevation Andean catchments to predict water availability under climate variability and change



Seasonal Conductivity measurements against elevation

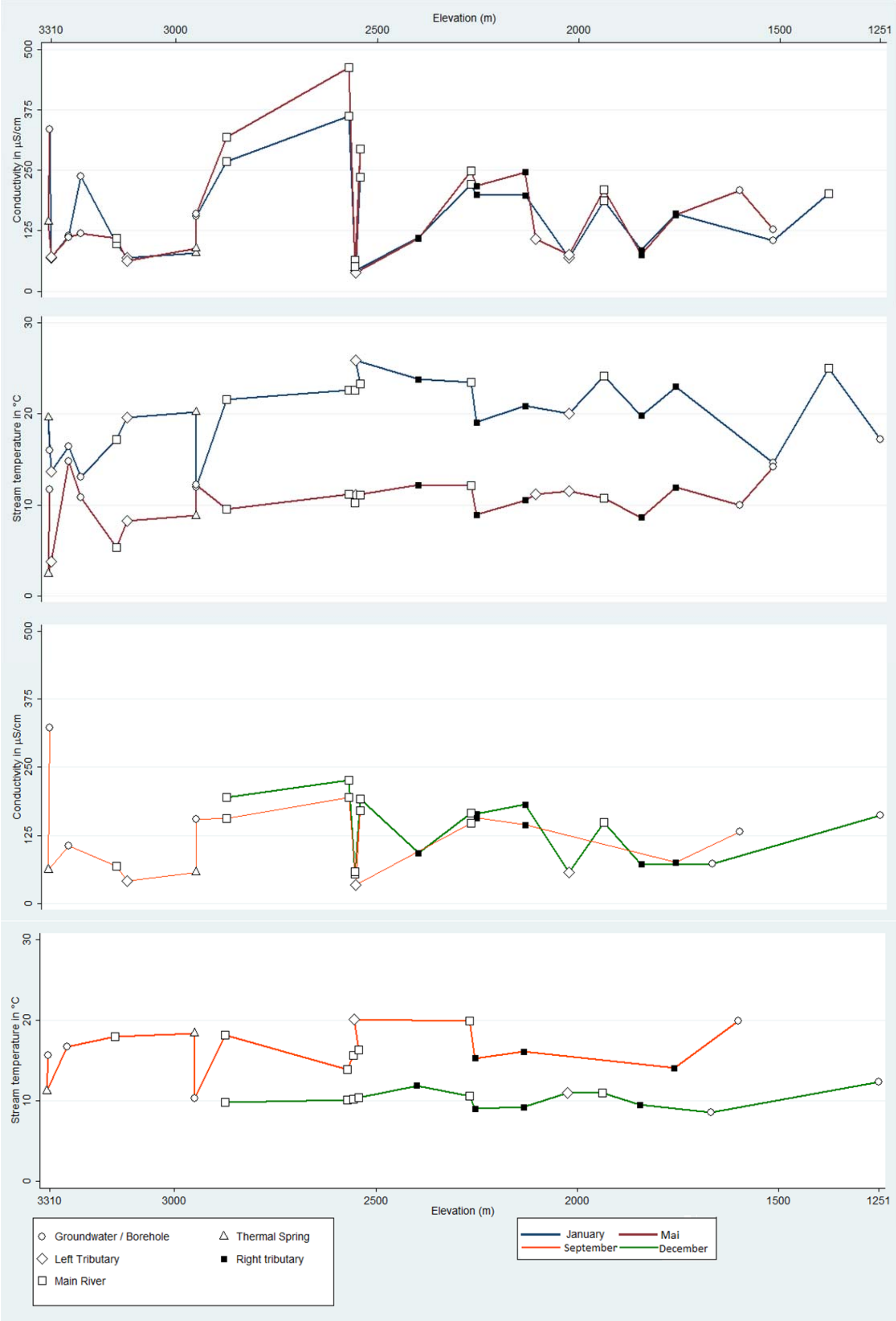


Figure: Variation of conductivity and stream temperature values, thermal spring values were excluded from the graph

Asses nts to
predi

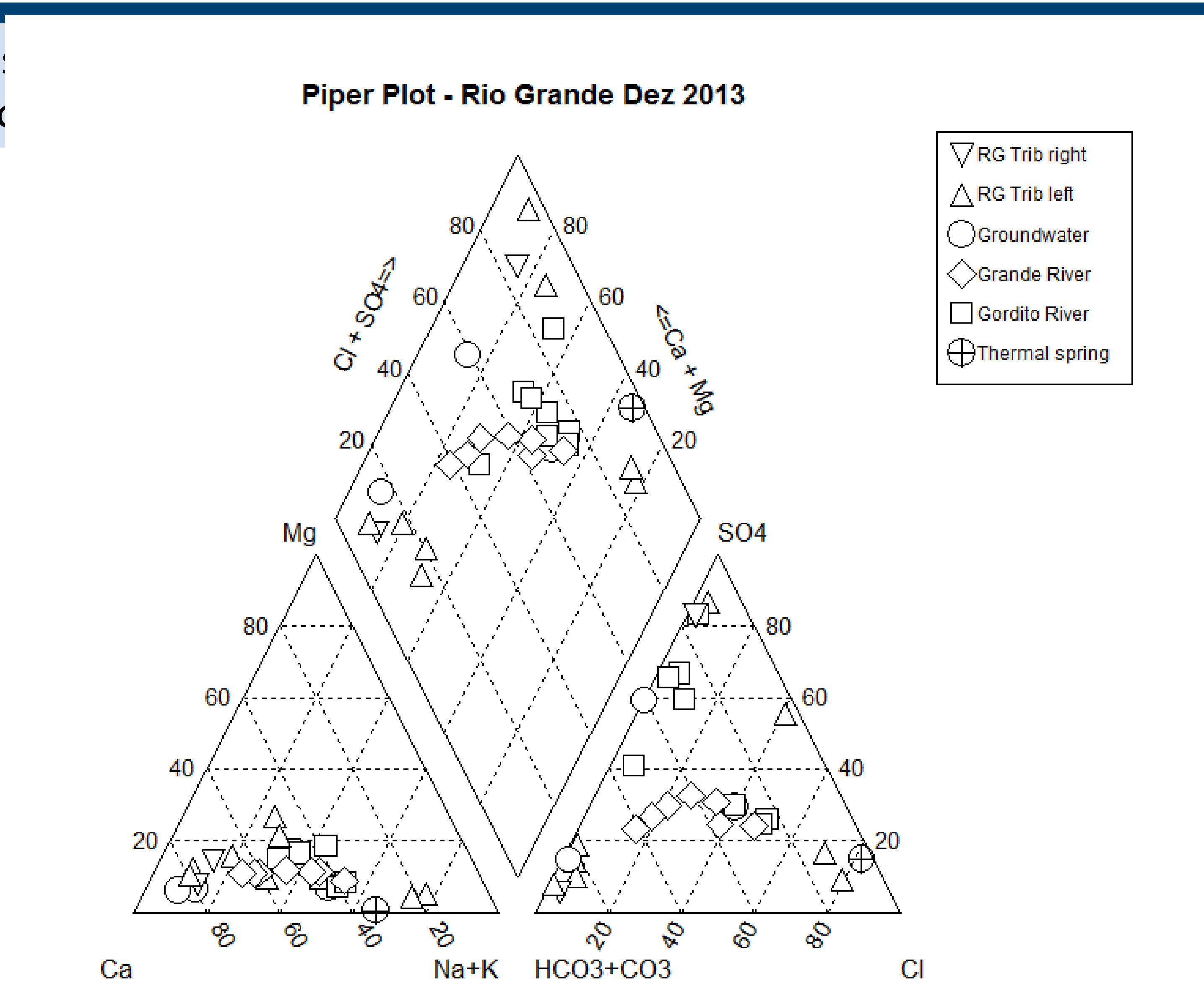


Figure Piper plot showing the distribution of anions and cations
in the December water samples of the Grande catchment.

(1) low mineralized calcium-sulfate and bicarbonate dominated streams at the headwaters, showing a strong relationship to precipitation and snow melt;

(2) main rivers with a moderate level of mineral contents, showing rock weathering as predominant effect and various ion species as majority;

(3) groundwater-fed boreholes as well as tributaries with high ion contents and varying hydrochemistry and origin;

(4) chloride waters of a hot spring with very high mineral contents.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Assessme ments to
predict w

Resultados:

- Isótopos estables en agua superficial demuestran un efecto fuerte altitudinal con enriquecimiento en la ratio de δ^2H y $\delta^{18}O$ aguas abajo indicando que tienen su origen en flujo subterráneo de recarga de nieve intraanual
- Variación espacial en isótopos está reducida en Septiembre, periodo de derretimiento gracias a más influencia nival
- Conductividad eléctrica y concentraciones de mayores iones y cationes indican que no hay contribuciones de agua subterránea más mineralizada al caudal

Demanda de investigación

- Llevar a cabo muestreos estacionales con alta resolución temporal (cada hora) en puntos relevantes
- Medir caudal y conductividad en (+ antes y después) los afluentes relevantes con más frecuencia y en algunos puntos observar la evolución del caudal durante el día
- Observar nivel de agua subterránea en puntos clave y medir conductividad + muestras de isótopos
- Analizar isotopos radioactivos como de tritio x carbono

Follow up:

- Tracer (salts) induction on the Argentinian side of the Cordillera and continuous conductivity measurements in the main stream on the Chilean side would
- The assessment of groundwater age and residence time needs to be further assessed by taking and analyzing 13C samples (short-term due to the seasonal variation and long-term due to the distinction between Holocene and Pleistocene groundwater)
- Additional continuous temperature measurements could be carried out at high altitudes with simple temperature sensors storing the data in data loggers at several elevation points of the Rio Grande catchments.

Isotope	Symbol	Protons	Neutrons	Atomic weight	Abundance %
Hydrogen	H	1	0	1	99.984
Deuterium	^2H, D	1	1	2	0.016
Tritium	^3H, T	1	2	3	0.00005
Oxygen 16	^{16}O	8	8	16	99.76
Oxygen 17	^{17}O	8	9	17	0.04
Oxygen 18	^{18}O	8	10	18	0.20

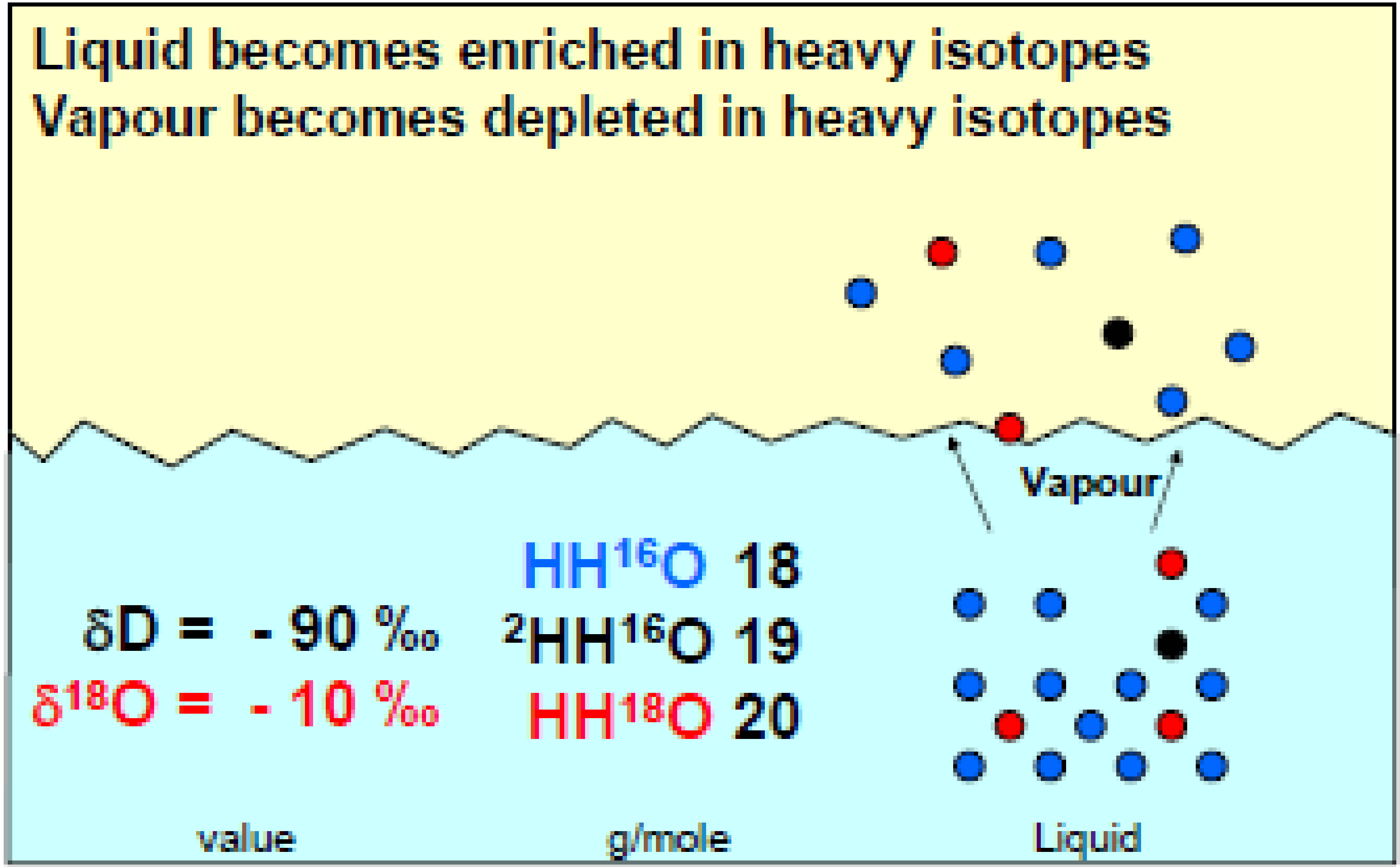
^{2}H and ^{18}O are the ‘rare’ fractions.

They are expressed as a ratio of the ‘abundant’ fraction, e.g. $R = [^{18}O] / [^{16}O]$

They are measured and also expressed relative to a standard (e.g. SMOW, Stand Mean Ocean Water)

They are also expressed in per mil, ‰

$$\delta^{18}O \text{ ‰} = \frac{(^{18}O/^{16}O)_{sample} - (^{18}O/^{16}O)_{SMOW}}{(^{18}O/^{16}O)_{SMOW}} \times 1000$$


Liquid becomes enriched in heavy isotopes
Vapour becomes depleted in heavy isotopes
Vapour
$HH^{16}O$ 18
δD = - 90 ‰
$^{2}HH^{16}O$ 19
$\delta^{18}O$ = - 10 ‰
$HH^{18}O$ 20
value
g/mole
Liquid

s to

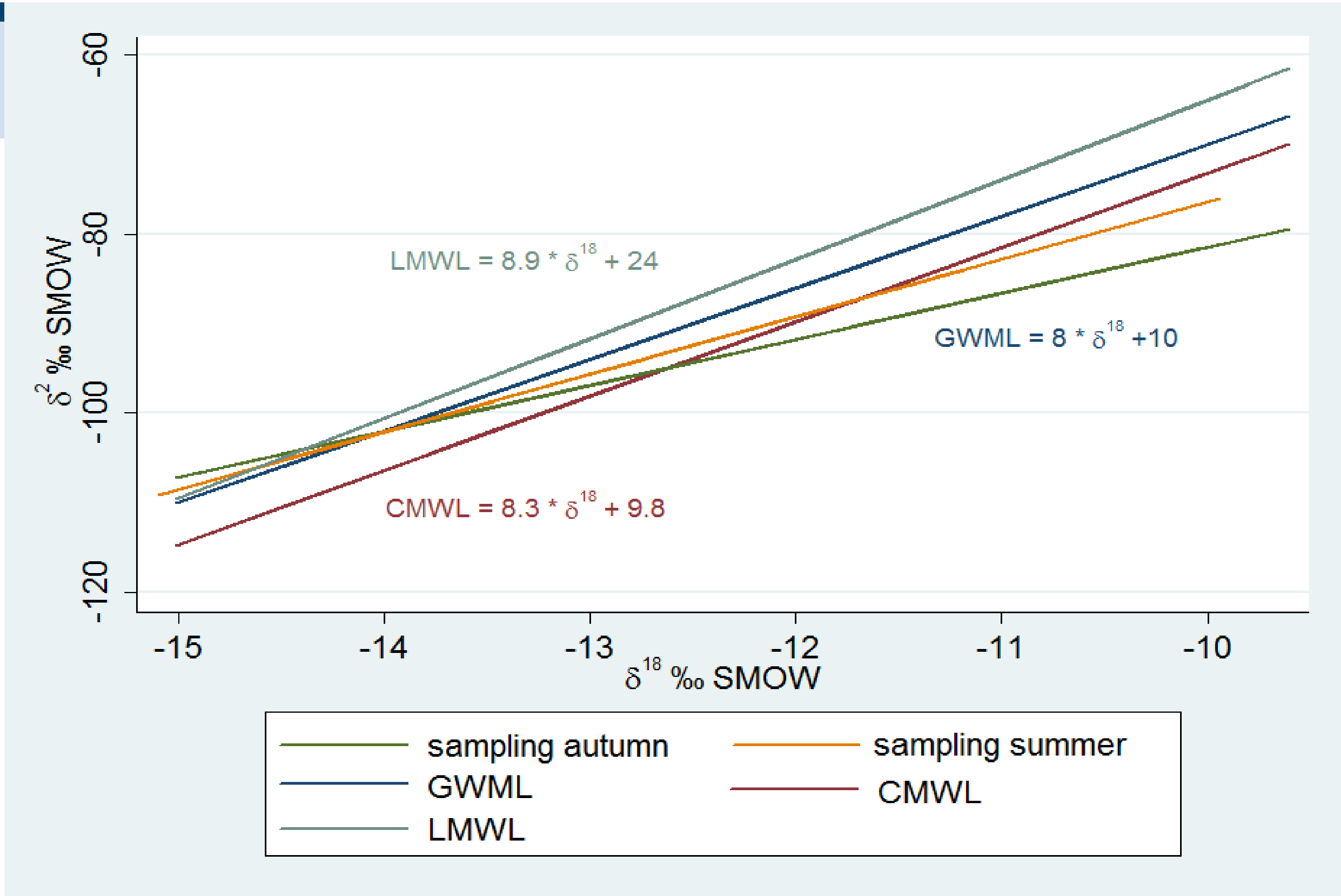


Figure 11: comparison of two sampling regression lines in rio Grande in summer and autumn with relevant meteoric water lines: the Global Meteoric Water Line $\delta^2H=8*\delta^{18}O+10$, the Chilean Meteoric Water Line: $\delta^2H=8.3*\delta^{18}O+9.8$ (Spangenberg et.al., 2007) and a Local meteoric Water Line $\delta^2H=8.9*\delta^{18}O+24$ for the lower part of the Limarí basin (calculated by Barrerra 2012 in the scope of a MSc thesis)