7TH INTERNATIONAL GEOLOGICA BELGICA MEETING 2021,
15-17 September 2021
AfricaMuseum Tervuren (Belgium)

Lac Bertrand (2018) by Moises Gamboa

Lacustrine record of last millennia precipitation from Lake Esponja and Lake Bertrand of Northern Chilean Patagonia

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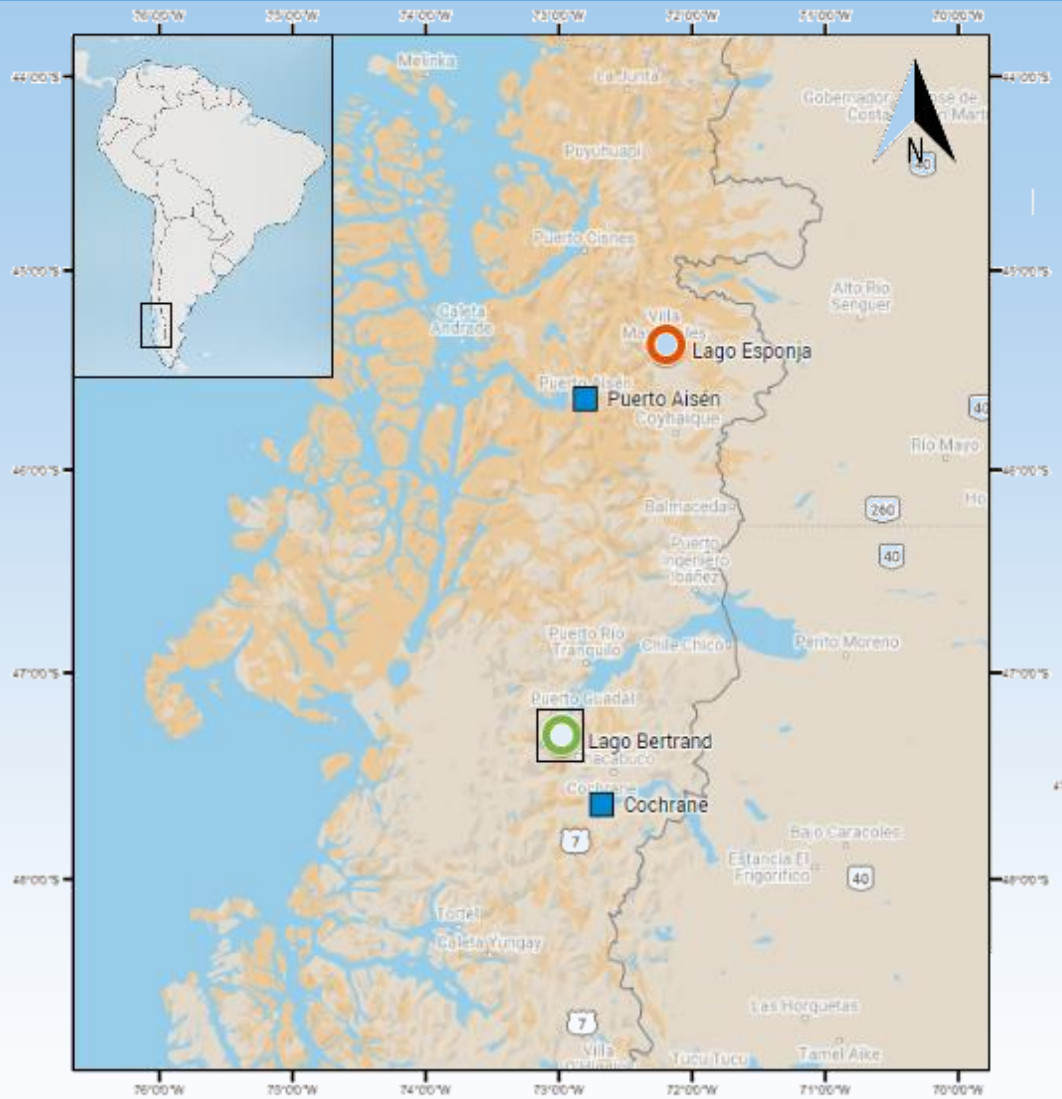
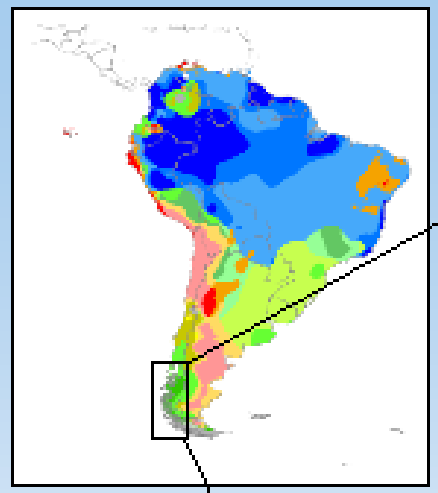
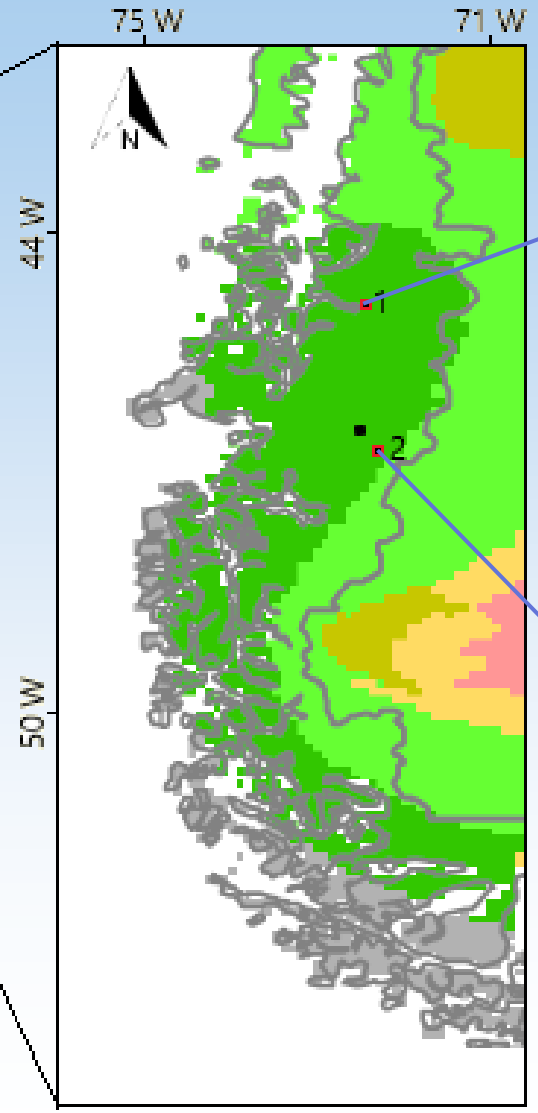


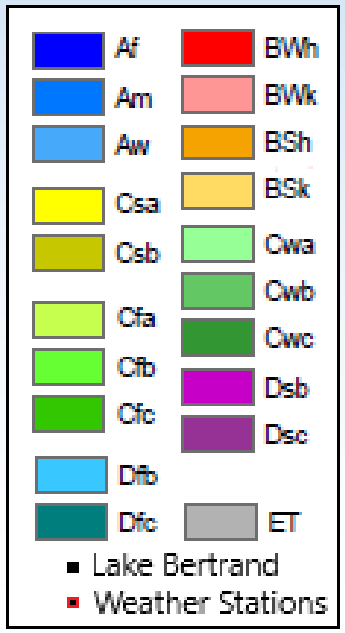
Legend :

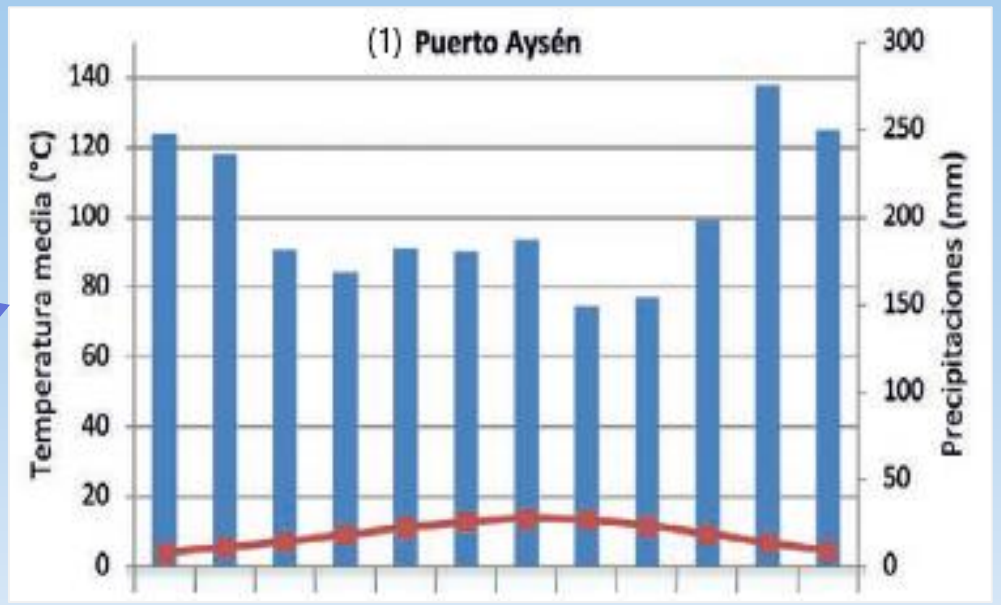
- Core : LBb11-A
- Weather stations
- Road 7
- CRU TS 3.0 Grid (-72.9180; -72.7660E ; -46.8481;-47.0120N)

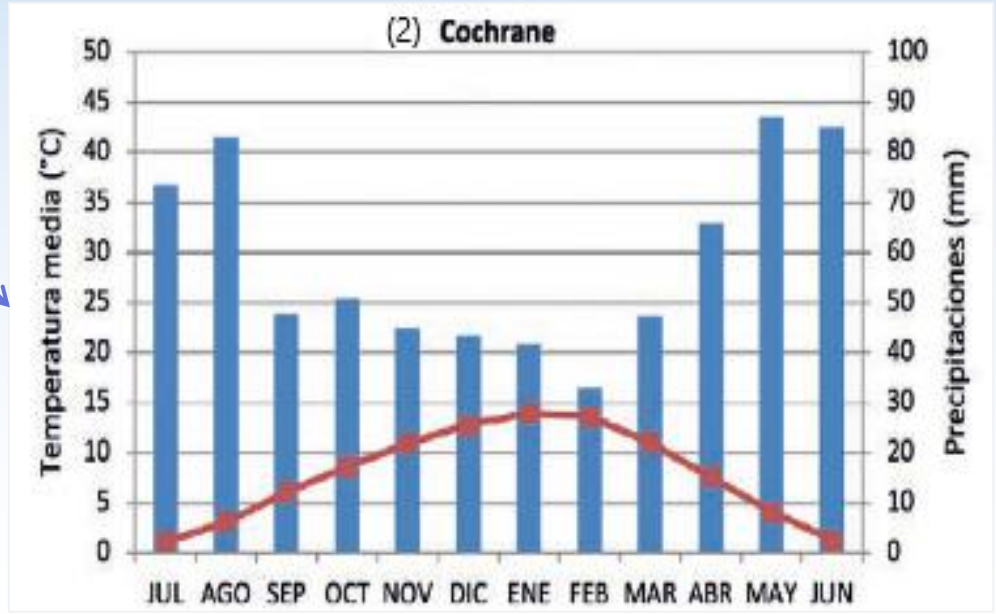
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere



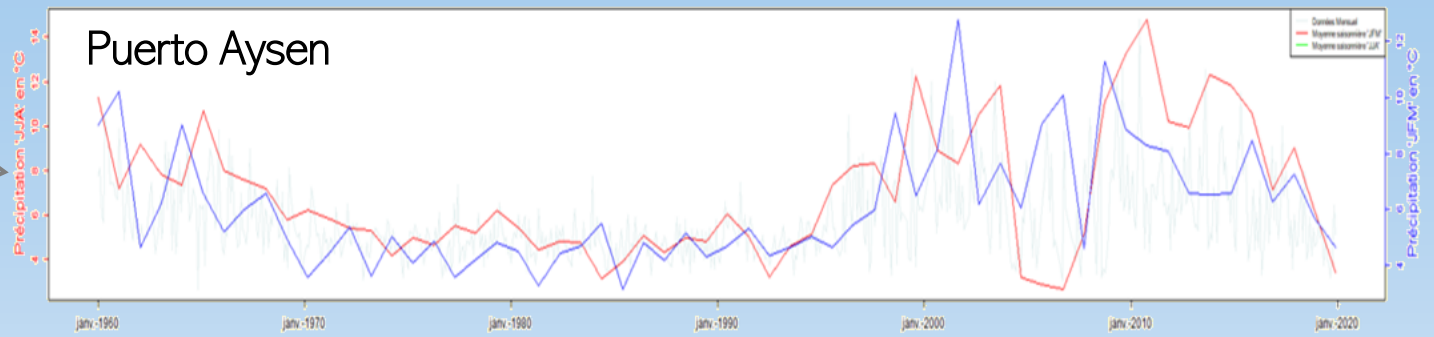

75 W
71 W
44 W
50 W
N
1
2

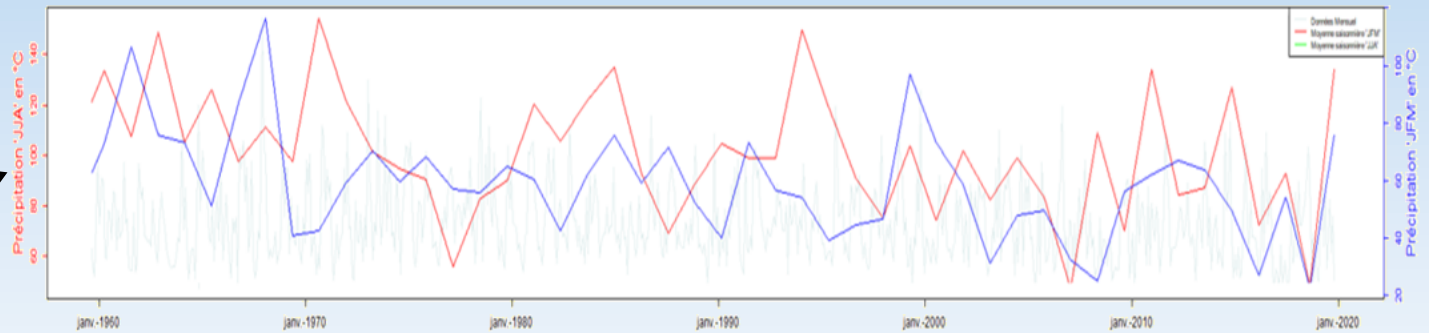

Af
Am
Aw
Csa
Csb
Cfa
Cfb
Cfc
Dfb
Dfc
BWh
BWk
BSh
BSk
Cwa
Cwb
Cwc
Dsb
Dsc
ET
Lake Bertrand
Weather Stations

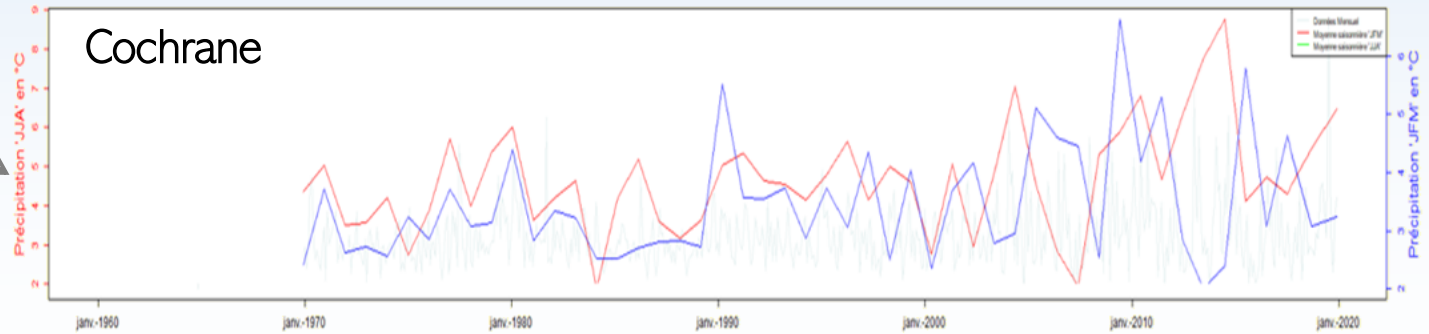

(1) Puerto Aysén
Temperatura media (°C)
Precipitaciones (mm)
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300


(2) Cochrane
Temperatura media (°C)
Precipitaciones (mm)
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70
80
90
100
JUL AGO SEP OCT NOV DIC ENE FEB MAR ABR MAY JUN

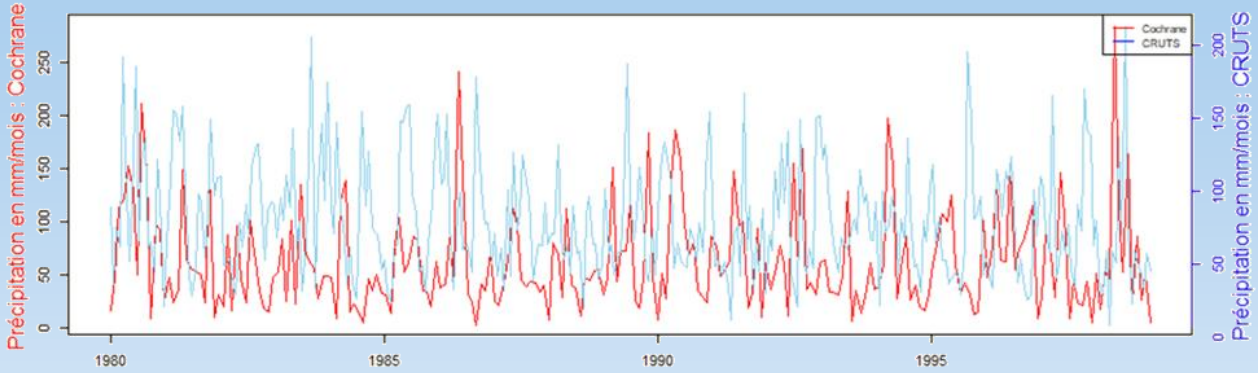

76°00'W
75°00'W
74°00'W
73°00'W
72°00'W
71°00'W
44°00'S
45°00'S
46°00'S
47°00'S
Puerto Aguirre
LEs14
N
Puerto Aisén
Puerto Chacabuco
Coyhaique
Quitralco
Balmaceda
Puerto Ingeniero Ibáñez
Puerto Río Tranquilo
Chile Chico
Parque Nacional Laguna San Rafael
Puerto Guadal
LBb11
Cochrane
7
Calluqueo
Legend :
Core
Weather stations
Road 7
CRU TS 3.0 Grid
(-72.9180; -72.7660E ; -46.8481;-47.0120N)

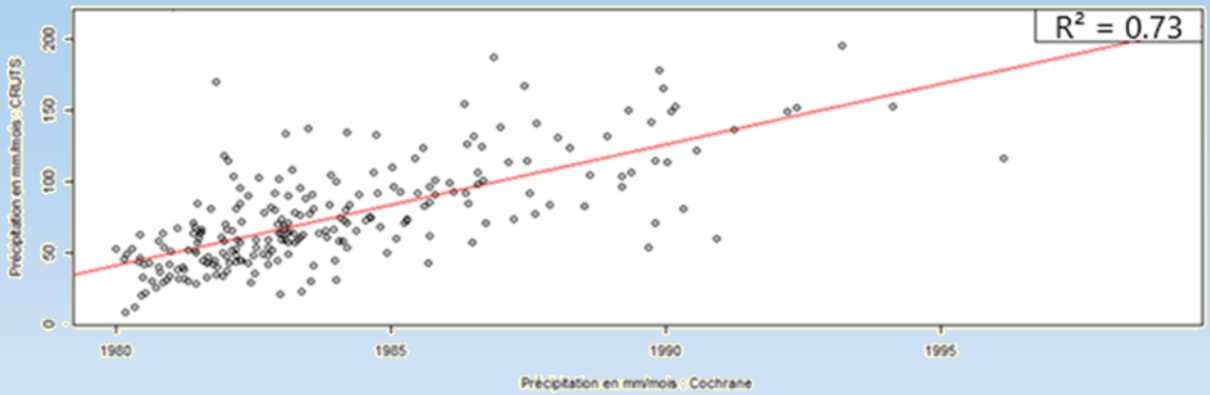

Puerto Aysen
Précipitation 'JJA' en °C
Précipitation 'JFM' en °C
janv.-1960
janv.-1970
janv.-1980
janv.-1990
janv.-2000
janv.-2010
janv.-2020


Précipitation 'JJA' en °C
Précipitation 'JFM' en °C
janv.-1960
janv.-1970
janv.-1980
janv.-1990
janv.-2000
janv.-2010
janv.-2020

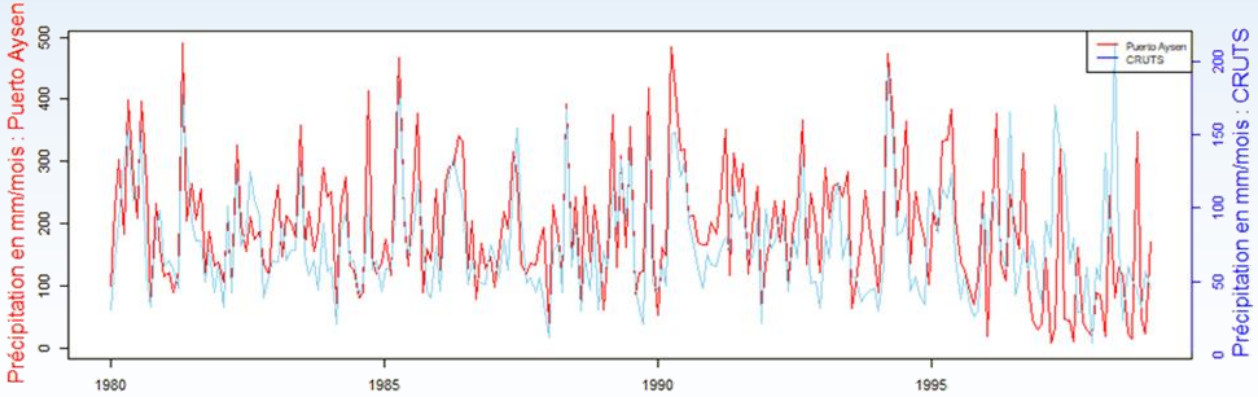

Cochrane
Précipitation 'JJA' en °C
Précipitation 'JFM' en °C
janv.-1960
janv.-1970
janv.-1980
janv.-1990
janv.-2000
janv.-2010
janv.-2020

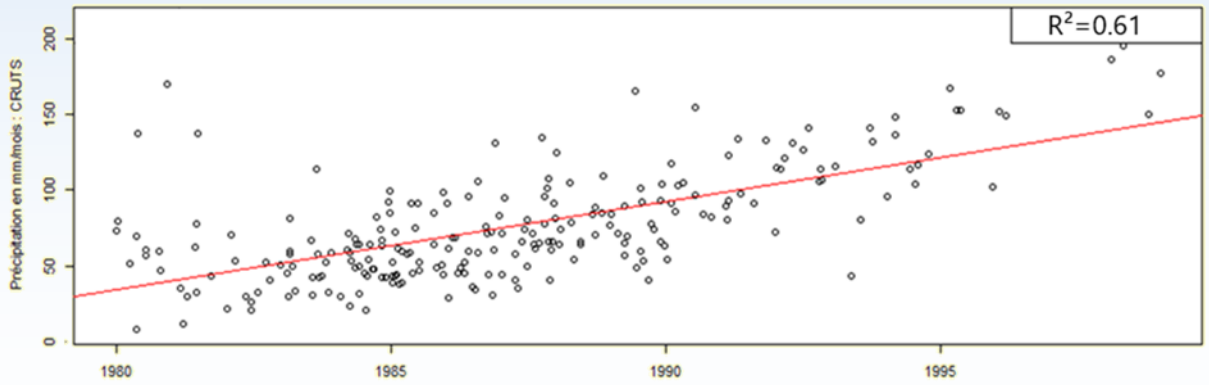
Correlation of monthly average precipitation from Cochrane station and CRU TS data



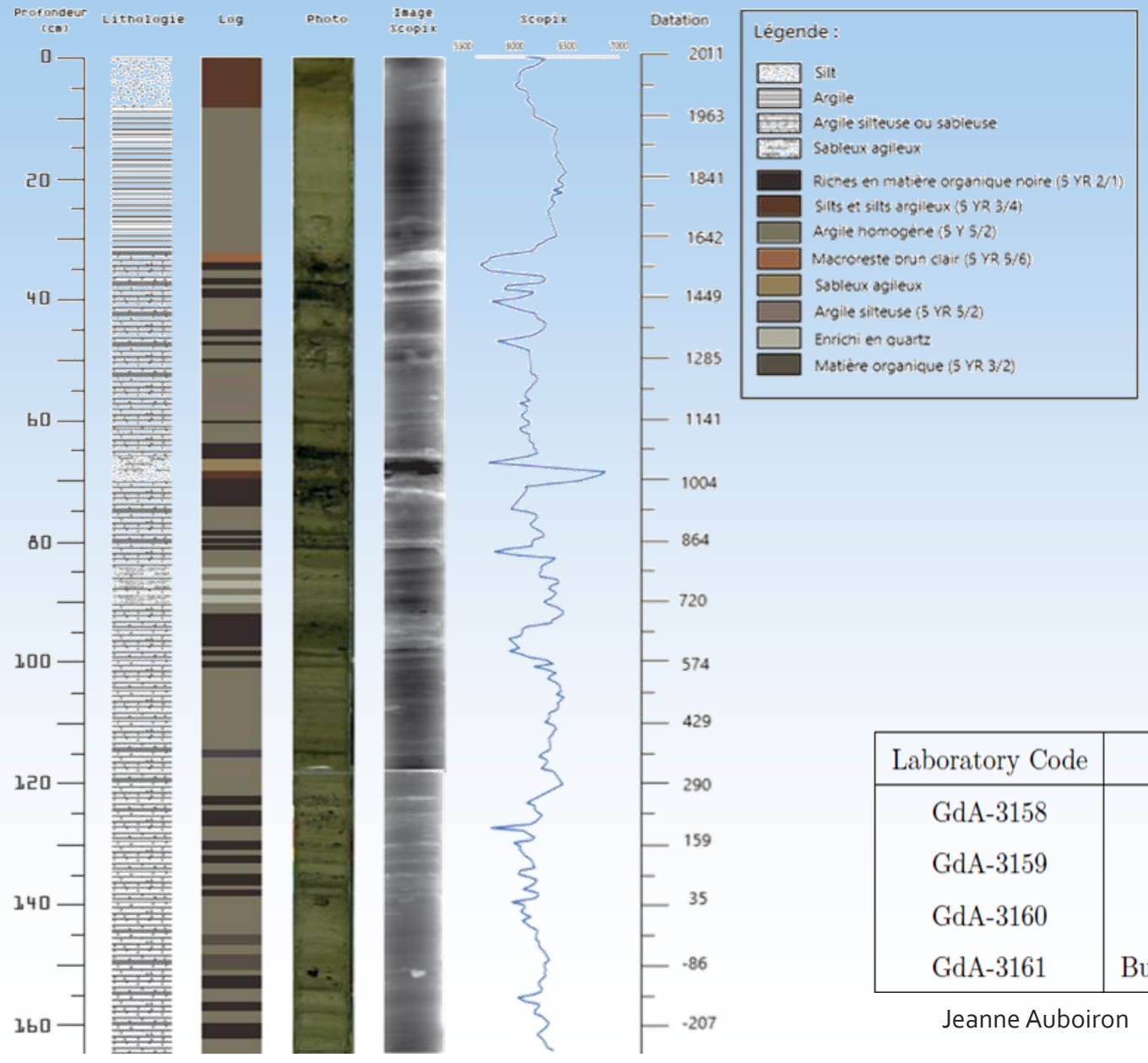


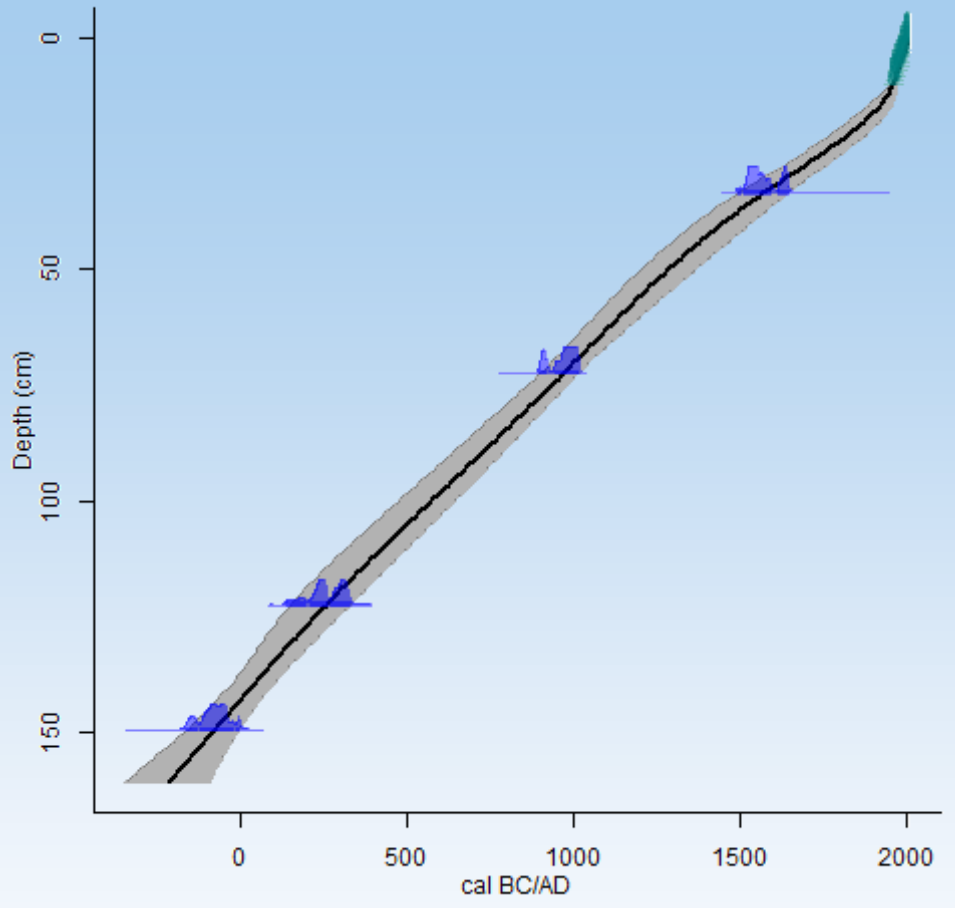
Correlation of monthly average precipitation from Puerto Aysen station and CRU TS data





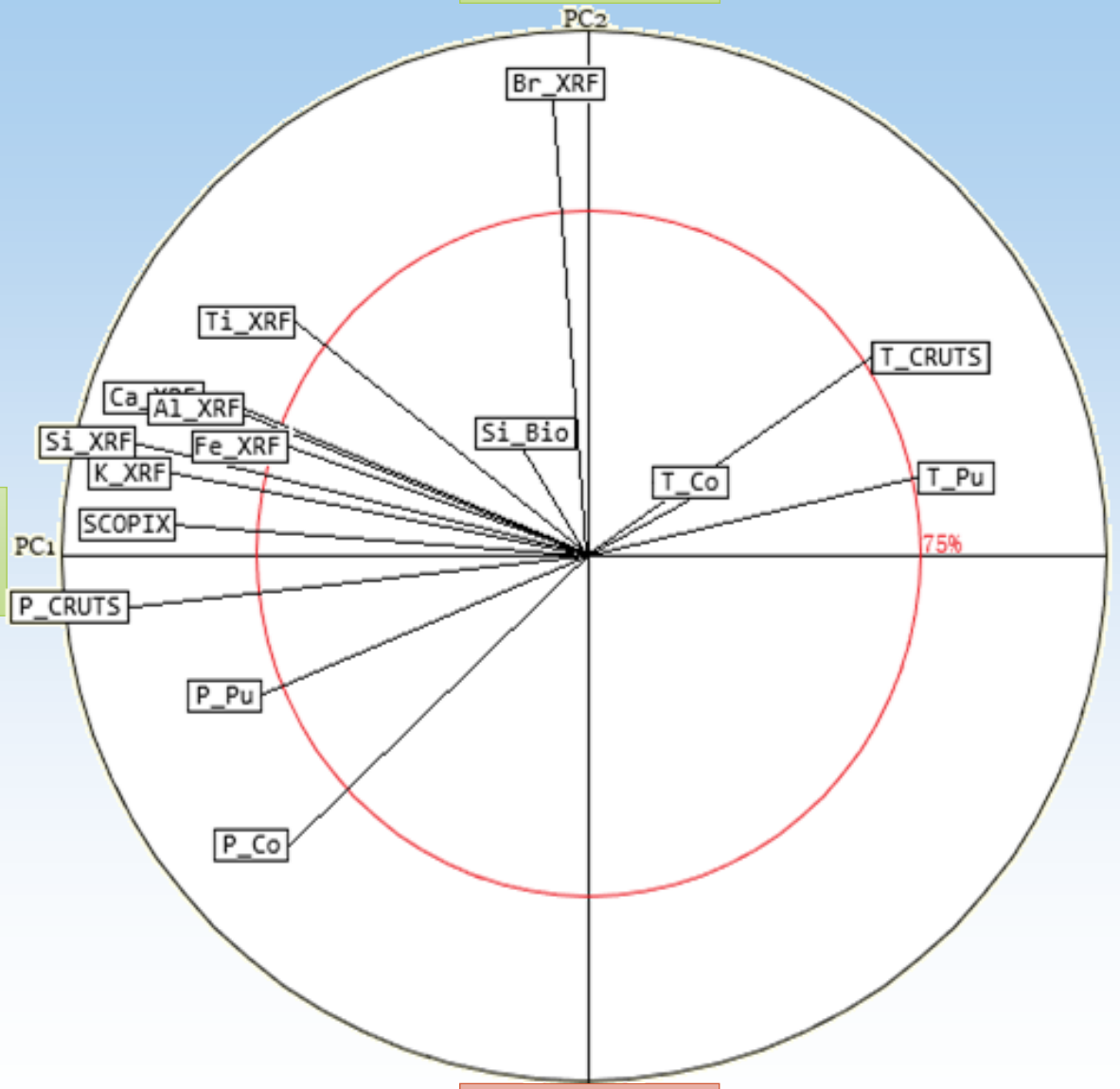
LBb11 Core





Laboratory Code	Material	Core depth (cm)	^{14}C yr BP $\pm 1\sigma$	Calibrated age cal. yr BP
GdA-3158	Wood	32.5-34.5	300 ± 25	1507 (1649) 1792
GdA-3159	Wood	72-73	1070 ± 25	981 (1055) 1129
GdA-3160	Wood	122-123	1780 ± 25	240 (303) 366
GdA-3161	Bulk sediment	149-150	2595 ± 25	-804 (-676) -548

(+) Organic



(+) Detrital, (+) SCOPIX, (+) Instrumental Precipitation

(-) Detrital, (-) SCOPIX, (-) Instrumental Precipitation

(-) Organic

Multiple linear regression

by the ordinary least squares method :

$$y_i = a_0 + a_1 x_{i,1} + \cdots + a_p x_{i,p} + \epsilon_i$$

CRU TS precipitation (1901-2018)

SCOPIX data, and detrital elements (0-12cm)

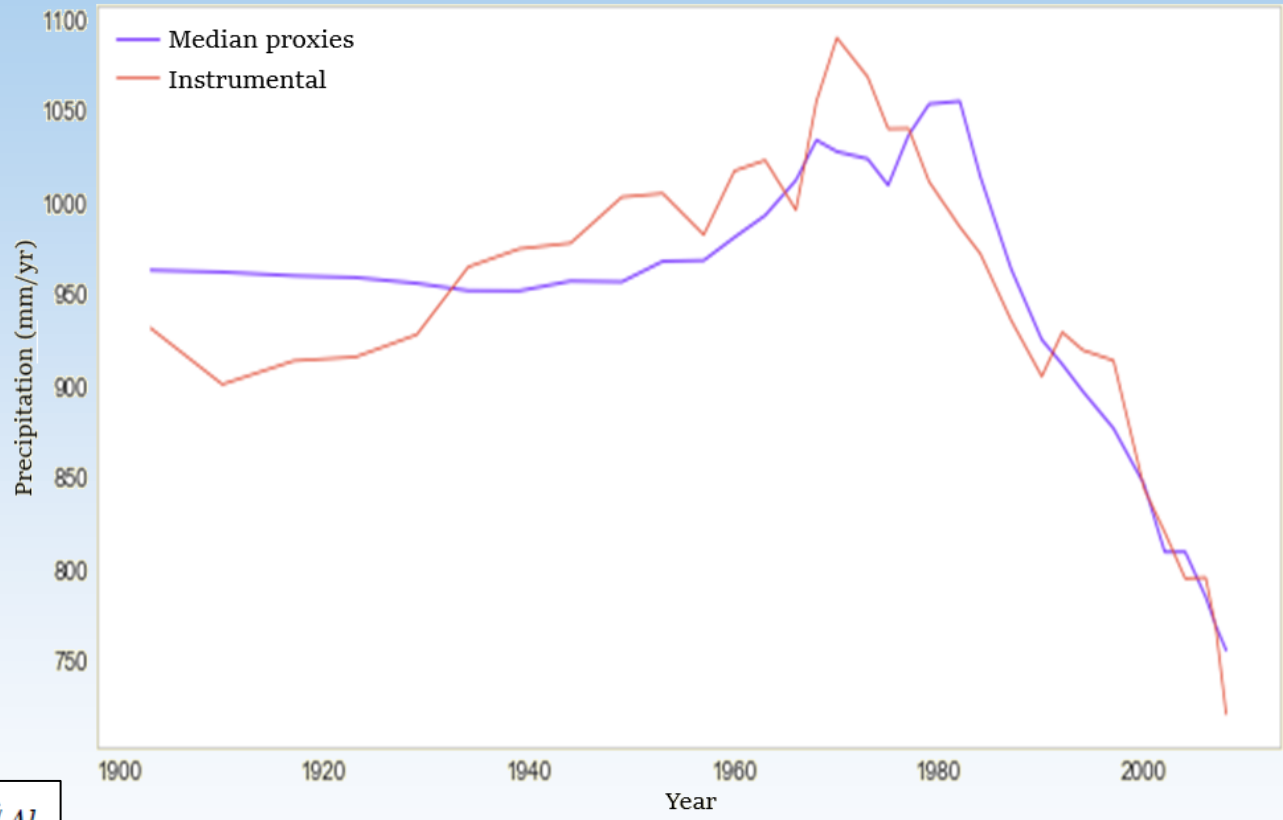
Pattern error

X1 = SCOPIX values
X2 = Si/Al ratio
X3 = Ti/Al ratio

We will estimate the parameters and obtain :

$$\hat{y}_i = \hat{a}_0 + \hat{a}_1 x_{i,1} + \cdots + \hat{a}_p x_{i,p}$$

$$Précipitations_{reconstruite} = 8260.51 + -0.97\hat{SCOPIX} + -90.22\hat{Si/Al} + -490.34\hat{Ti/Al}$$



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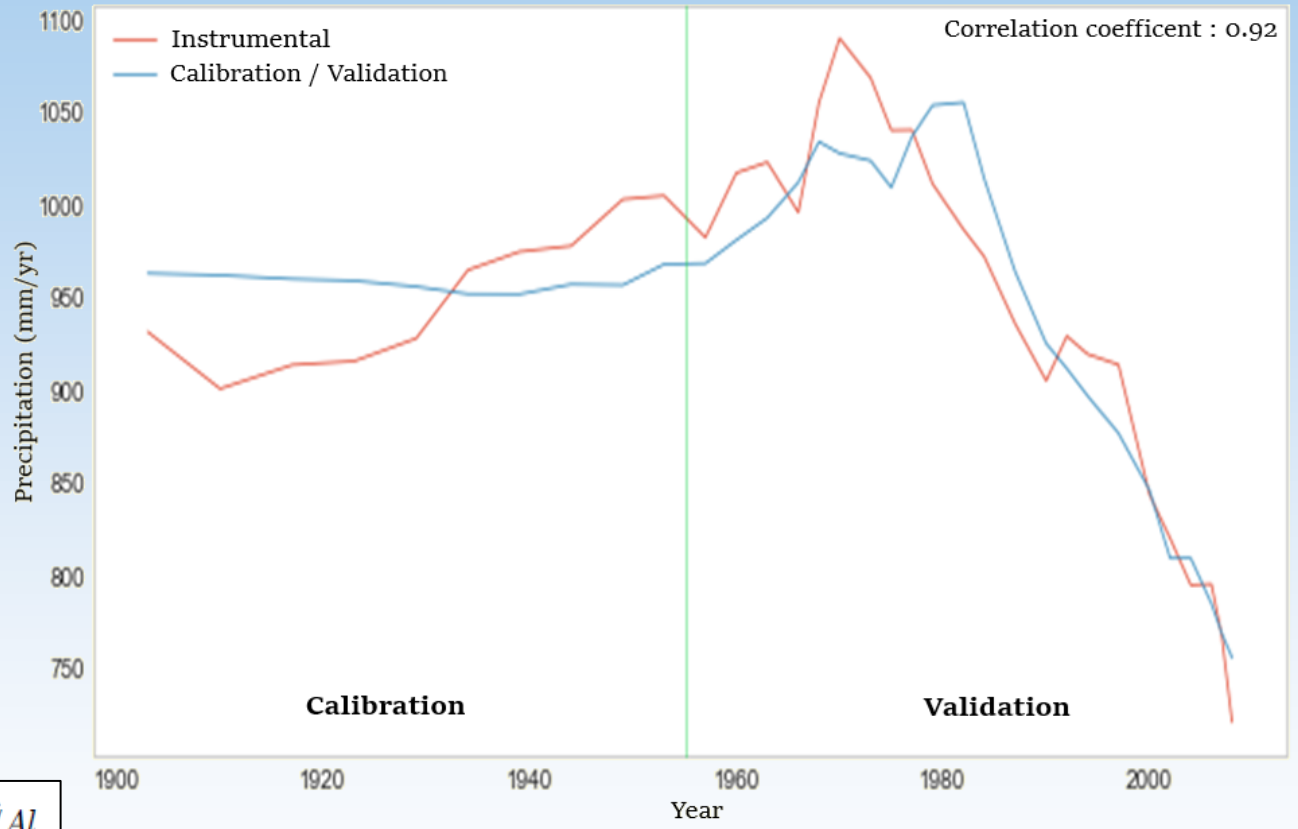
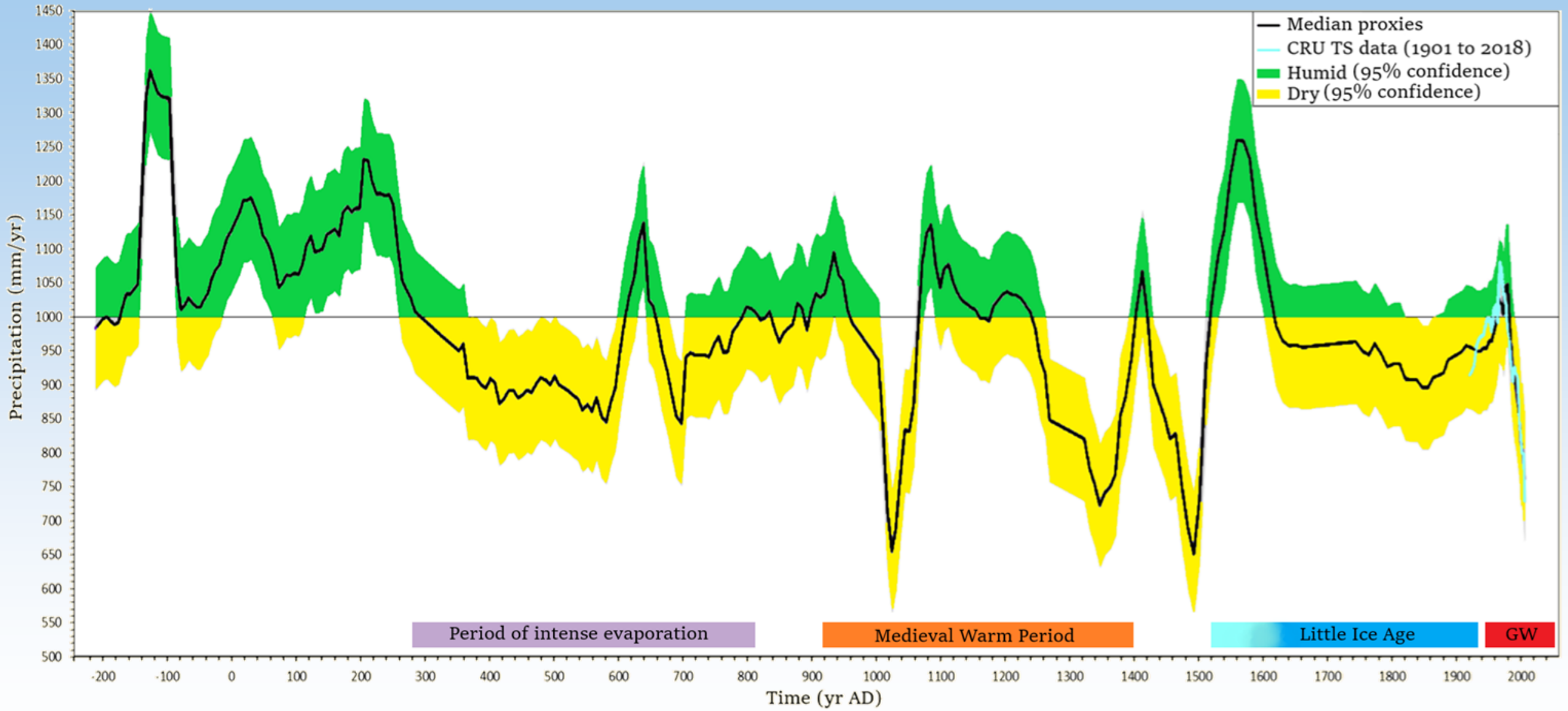
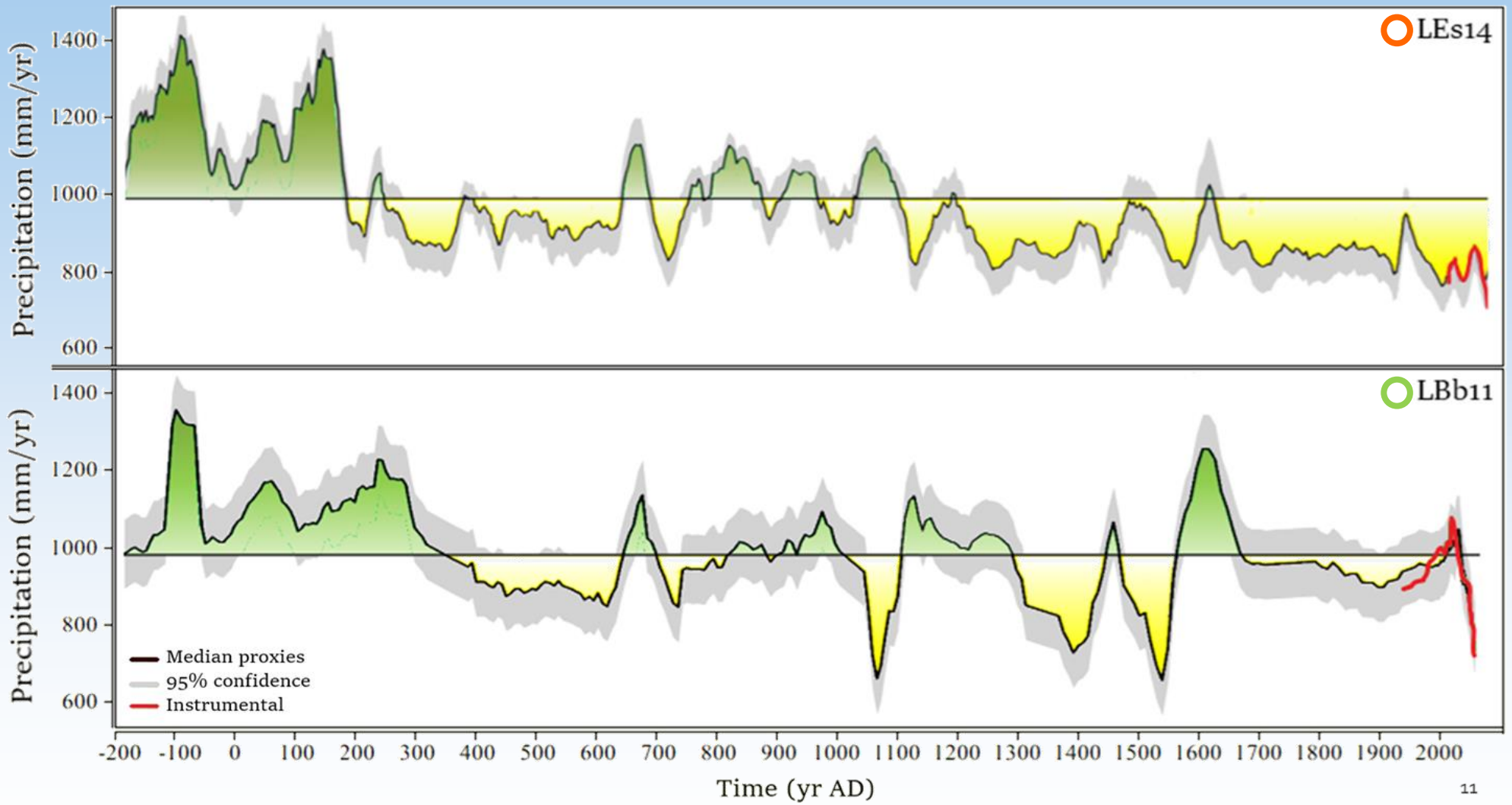
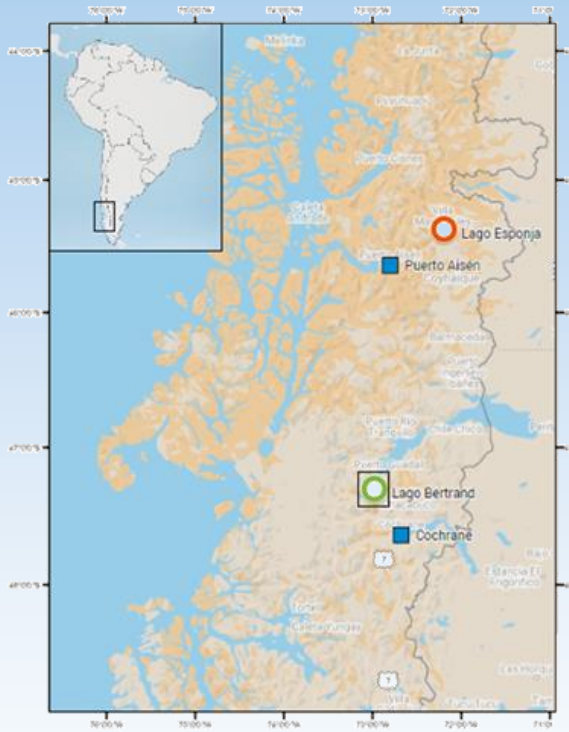
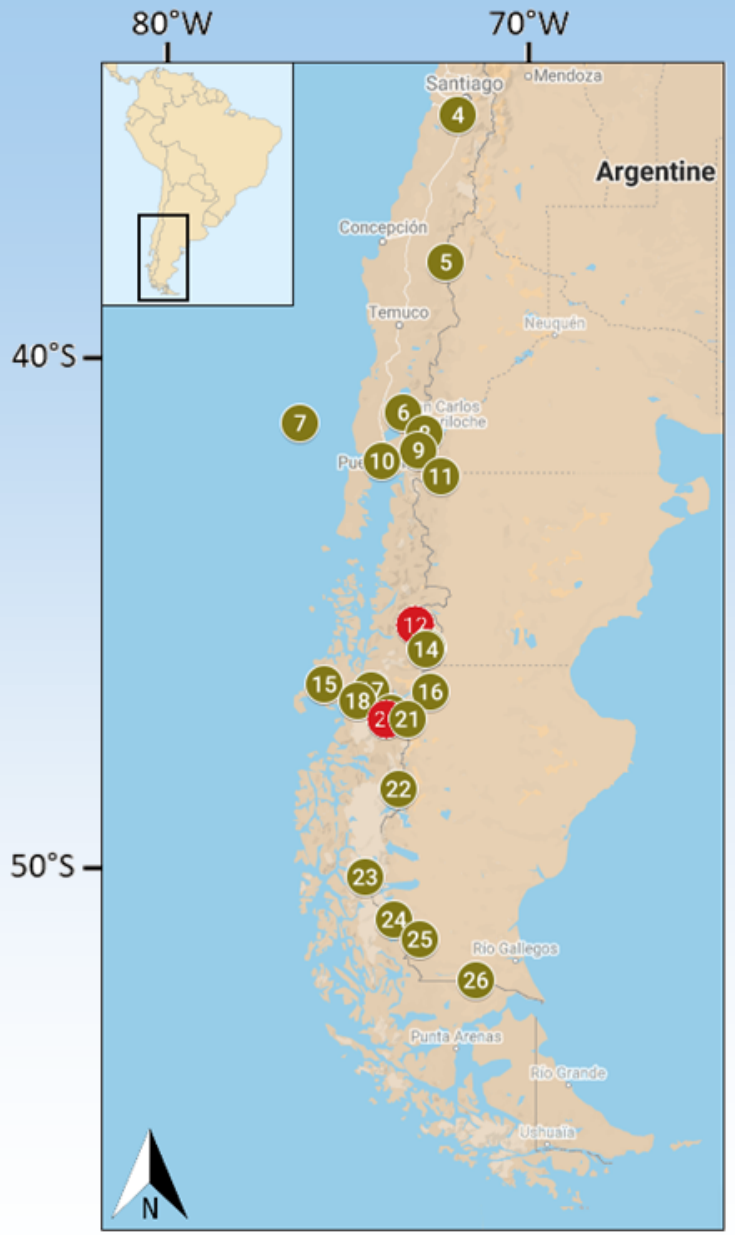


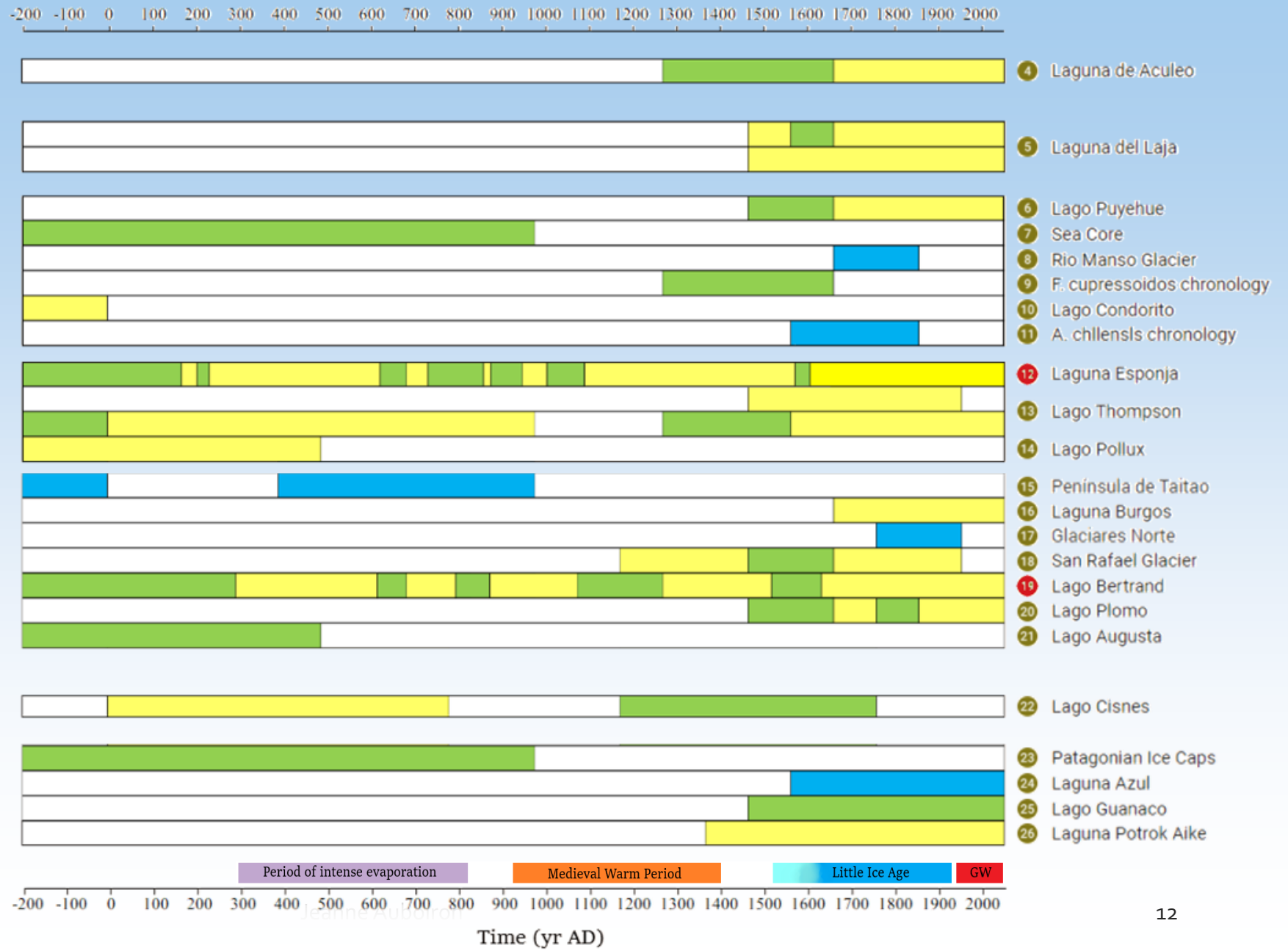

Median proxies
CRU TS data (1901 to 2018)
Humid (95% confidence)
Dry (95% confidence)
Precipitation (mm/yr)
Time (yr AD)
Period of intense evaporation
Medieval Warm Period
Little Ice Age
GW


LEs14
LBb11
Precipitation (mm/yr)
1400
1200
1000
800
600
Median proxies
95% confidence
Instrumental
-200 -100 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Time (yr AD)


Lago Esponja
Puerto Aisén
Lago Bertrand
Cochrane


Humid
Dry


80°W
70°W
40°S
50°S
Santiago
Mendoza
Argentine
Concepción
Temuco
Neuquén
Rio Gallegos
Punta Arenas
Rio Grande
Ushuaia
N


-200 -100 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
4 Laguna de Aculeo
5 Laguna del Laja
6 Lago Puyehue
7 Sea Core
8 Rio Manso Glacier
9 F. cupressoidos chronology
10 Lago Condorito
11 A. chilensis chronology
12 Laguna Esponja
13 Lago Thompson
14 Lago Pollux
15 Península de Taitao
16 Laguna Burgos
17 Glaciares Norte
18 San Rafael Glacier
19 Lago Bertrand
20 Lago Plomo
21 Lago Augusta
22 Lago Cisnes
23 Patagonian Ice Caps
24 Laguna Azul
25 Lago Guanaco
26 Laguna Potrok Aike
Period of intense evaporation
Medieval Warm Period
Little Ice Age
GW
Time (yr AD)

Conclusion

- Reconstruction using geochemical and sedimentary data
- Consistent with published data
- Similar approach on other lakes

References:

Araneda, A., Jana, P. *et al.* Changes in sub-fossil chironomid assemblages in two Northern Patagonian lake systems associated with the occurrence of historical fires. *Journal of Paleolimnology* **50,** 41-56. issn : 0921-2728, 1573-0417.

Elbert, J. *et al.* Quantitative high-resolution winter (JJA) precipitation reconstruction from varved sediments of Lago Plomo 47° S, Patagonian Andes,1530–2002. *The Holocene* **22,** 465-474. issn : 0959-6836, 1477-0911. http://journals.sagepub.com/ doi/10.1177/0959683611425547 (2020) (avr. 2012).

Hepp, C., Reyes, C. & Muñoz, S. R. Analyse des données historiques de cinq stations météorologiques de la région d'Aysén (Patagonie) (2014).

Lagabrielle, Y. *et al.* Neogene to Quaternary tectonic evolution of the Patagonian Andes at the latitude of the Chile Triple Junction. *Tectonophysics* **385,** 211-241 (2004).

Lopez, P., Sirguey, P., Arnaud, Y., Pouyaud, B. & Chevallier, P. Snow cover monitoring in the Northern Patagonia Icefield using MODIS satellite images (2000–2006). *Global and Planetary Change* **61,** 103-116 (2008).

Peel, M. C., Finlayson, B. L. & Mcmahon, T. A. Updated world map of the Köppen-Geiger climate classification, 36 (2007).

Lamy, F., Hebbeln, D., Röhl, U. & Wefer, G. Holocene rainfall variability in southern Chile : a marine record of latitudinal shifts of the Southern Westerlies. *Earth and Planetary Science Letters* **185,** 369-382 (2001).

Jenny, B. *et al.* Moisture changes and fluctuations of theWesterlies in Mediterranean Central Chile during the last 2000 years : the Laguna Aculeo record (33 500 S). *Quaternary International* **87,** 3-18 (2002).

Thank you for your attention