



**CLARIS | LPB**

A Europe-South America Network for Climate Change Assessment

And Impact studies in La Plata Basin

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**Deliverables**



Instrument: **SP1 Cooperation**

Thematic Priority: **Priority Area 1.1.6.3 "Global Change and Ecosystems"**

**FP7 Collaborative Project – Grant Agreement 212492**

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**DELIVERABLES**

**D3.4: Summary of proxy work**

Due date of deliverable: Month 24

Start date of project: **01/10/2008**

Duration: **4 years**

Organisation name of lead contractor for this deliverable: P13-CONICET

Deliverable No	Deliverable title	WP	Lead beneficiary	Estimated indicative person-months (permanent staff)	Nature	Dissemination level	Delivery date
D3.4	Summary of the proxy work	WP3	P13-CONICET	3	O	PU	24

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### **Introduction**

Past hydroclimate variability can be fairly reconstructed using a combination of different types of proxy records. One goal of WP3 is to extend the existing instrumental record backward in time by developing proxy reconstructions. The latter allows the reconstruction of hydroclimatic parameters over longer timescales than the existing instrumental data. Our objective within WP3 is the reconstruction of the paleohydrological variability through the study of lake records across the Argentinean Pampas covering the last ~300 years.

### **General remarks**

Pampean lakes (i.e., Laguna Mar Chiquita, Laguna Melincué and Lagunas Encadenadas del Oeste de Buenos Aires) allowed us the opportunity to identify long-term hydrological changes to better understand the circulation dynamics in South Eastern South America (SESA) during the last three centuries. For instance, Laguna Mar Chiquita (30°54'S-62°51'W), an extensive shallow saline endoreic lake, located in central Argentina, west of the Paraná-Plata basin (Fig. 1), has clearly undergone 20th century hydrologic changes through abrupt lake level fluctuations. The lake is a unique site in South America because continuous lake level measurements have recorded the major 70's change. The lake surface was reduced to less than 2000 km<sup>2</sup> during dry periods, whereas it reached an area of approximately 6000 km<sup>2</sup> during its maximum extension in 2003, making it not only the largest saline lake in South America but also one of the largest saline lakes in the world. Moreover, historical data allowed to reconstruct the lake evolution before the instrumental period.

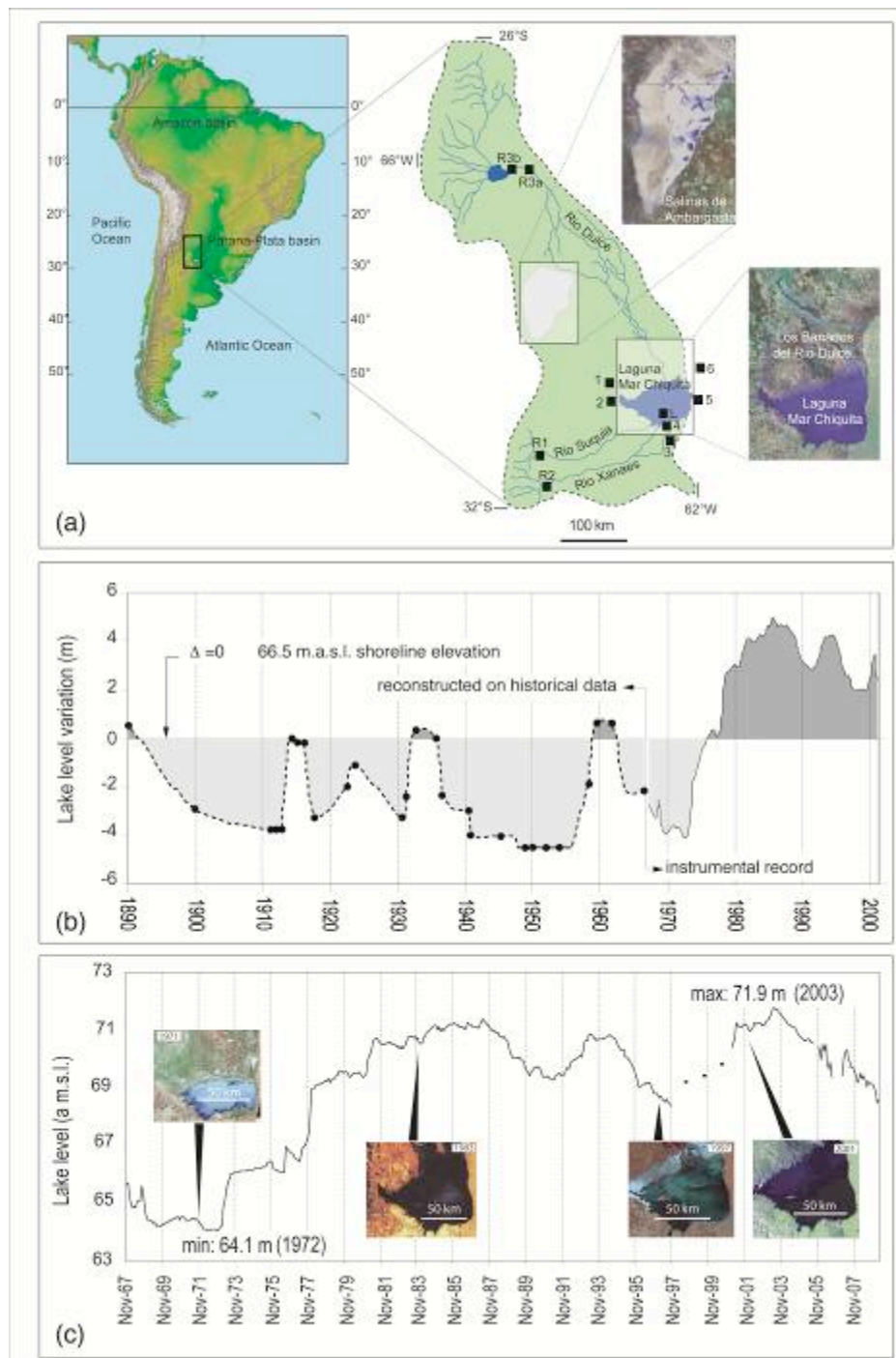
An increasing number of lacustrine records is available for southern South America east of the Andes. New limnogeological results spanning the last centuries across the subtropical Pampean plains of Southern South America can be compared with lacustrine records overall Andean and extra Andean sectors of eastern Patagonia. The development of contrasting hydrological patterns can be observed between the pampean region (Laguna Mar Chiquita, 30°S; Laguna Melincué, 34°S; Lagunas Encadenadas del Oeste de Buenos Aires, 37°S) and eastern Patagonia (Lago Frías, 41°S; Lago Cardiel, 49°S; and Laguna Potrok Aike, 52°S) at both sides of the South American Arid Diagonal during prevailing warm or cold climatic phases, respectively.

Several proxies (lake sediments, historical documents and archaeological data) indicate contrasting hydrological behaviour during the Medieval Climatic Anomaly (MCA) and the Little Ice Age (LIA) (Fig 2). High lake levels in Mar Chiquita after 1,475 cal years BP and by 1,060 cal years BP as well as

archaeological reconstruction indicate wet and warm conditions across the Pampean region for the period prior and synchronous to the MCA. Paleohydrological reconstructions indicate that the MCA wet phase had a magnitude equivalent to the present-day one; however, it was not uniform and included a dry, and therefore cooler, phase between 1,475 cal a BP and 1,060 cal a BP. In contrast, there are multiple evidence of increased aridity during the MCA overall Patagonia as well as all the regions under the influence of latitudinal shifts of the Southern Hemisphere westerlies

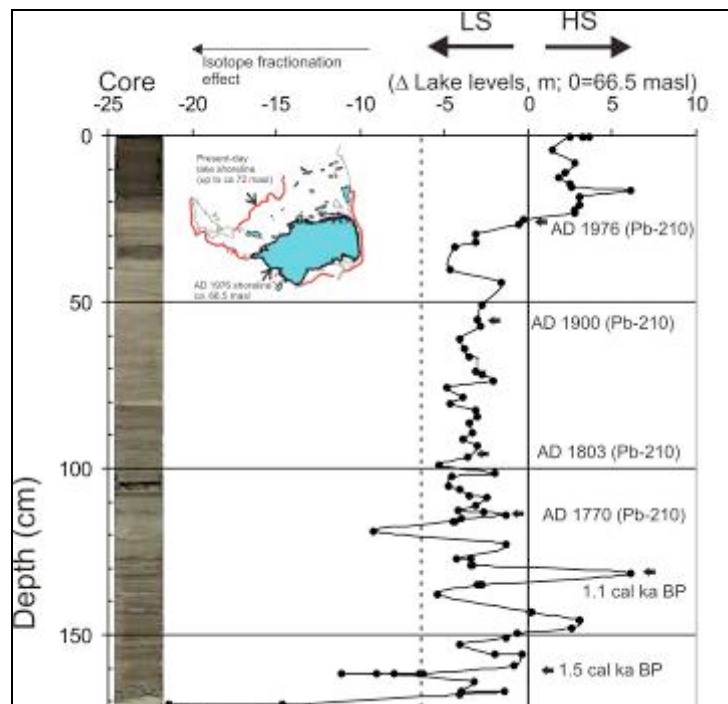
Paleohydrological proxies for the cold period corresponding to the LIA indicate opposite hydroclimatic conditions in the Pampean region and Patagonia, respectively. Several proxies in the Laguna Mar Chiquita record as well a high number of historical sources signify an intense drying northward the Arid Diagonal due to a diminished meridional transport of moisture into the subtropics. Laguna Mar Chiquita, Laguna Melincué and Lagunas Encadenadas del Oeste de Buenos Aires show altogether extremely low water-levels after the wet phase corresponding to the Medieval Climatic Anomaly (last recorded wet pulse around 1,060 cal a BP). Conversely, paleolimnological reconstructions suggest wet conditions in Patagonia or even the Central Andes during the Little Ice Age probably due to a fortified Pacific source of moisture.

Following the scenario of summer precipitation in the subtropics, the lake-levels increase in Lake Mar Chiquita during the MCA and the last part of the 20th century can be interpreted as a response to increased summer moisture convergence. More humid conditions, resulting of increasing low-level jet moisture transport associated with a weaker SACZ seasonal development can further proposed for the MCA. In contrast, colder SST anomalies during the LIA were accompanied by lower precipitations in the pampean region due to a decreased low level jet moisture as identified during present-day cold phases



**Figure 1** (a) Location of Laguna Mar Chiquita and its catchment spanning 26°S to 32°S at the west of the Parana-Plata basin. The first enlarged view shows the location of rainfall (noted 1 to 6), the discharge gauging stations (noted R1, R2, R3a, and R3b) and the measurements of lake level (noted L). The two satellite pictures show the Salinas de Ambargasta and the northern wetlands Bañados del Rio Dulce in the delta of Rio Dulce (source: <http://earth.google.fr>); (b) Lake level variation curve (Piovano et al., 2002): the interval AD 1890-1967 was reconstructed from historical data (circles in dashed line) and instrumental records started in AD 1967. Lake level variation = 0 is an intermediate lake-level stage that matches the AD 1977 shoreline elevation. Positive values represent highstands (dark grey area) and negative values indicate lowstands (pale grey area); (c) Lake level record of Lake Mar Chiquita during the 1967-2009 with satellite images of lake surface variations encountered since the 1970s in association with lake level variations

These paleohydrological data from Patagonia and the Pampean plains further indicate that the development of anti-phase hydrological pattern was active only after the middle Holocene. The anti-phasing cold/wet vs. cold/dry hydrological conditions at different latitudes reveal that increased rainfall triggered by intensified Westerlies in Patagonia are synchronous with a diminished advection of humidity from the tropics to the subtropics.



**Figure 2.** Quantitative paleo-lake level reconstruction based on the isotopic composition of organic matter ( $\delta^{13}\text{C}$ ) on core TMC-02-2 following Piovano et al. (2004a). Photograph of the analyzed core on the left side of the figure.  $\Delta$  lake level is expressed as a deviation of the 66.5 masl shoreline.  $\Delta$  lake level = 0 is an intermediate lake-level stage that matches the AD 1976-1977 shoreline elevation. Positive values represent highstands (lake surface beyond the AD 1976 shoreline position in the scheme) and negative values indicate lowstands (lake surfaces below the AD 1976 shoreline position in the scheme). Cal BP are calibrated radiocarbon ages (Table 1) whereas years AD are derived from the  $^{210}\text{Pb}$  chronology (Piovano et al. 2002). Arrows indicate dated level. Lake levels below -6 m are not realistic and are interpreted as a statistical artefact of the equation for reconstruction paleo-lake levels (see Piovano et al. 2004a) due to super heavy organic carbon isotope compositions during high evaporative phases.

## Publications

### a) Peer reviewed publications

Ariztegui, D., Gilli, A., Anselmetti, F.S., Goñi, R., Belardi, J.B. and Espinosa, S. 2010. Lake level changes in central Patagonia (Argentina): Crossing environmental thresholds for Late Glacial and Holocene human occupation. *Journal of Quaternary Science* 25/7, 1092-1099 (doi:10.1002/jqs.1352).

García Rodríguez, F., Piovano E. L., del Puerto, H, Stutz, S., Bracco, R., Panario R., Córdoba, F., Sylvestre F., Ariztegui, D., 2009. South American lake paleo-records across the Pampean Region. *Science Highlights Paleolimnology, PAGES news* • Vol 17 • No 3, 115-117.

Moy, C., Dunbar, R., Guilderson, T. H., Waldmann, N., Mucciarone, D., Recasens, C., Ariztegui, D., Austin Jr., J. A. and Anselmetti, F. S. In press, A Geochemical sedimentary record of high southern latitude Holocene climate evolution from lago Fagnano, Tierra del Fuego. *Earth and Planetary Science Letters*.

Piovano E.L., Ariztegui D., Córdoba F., Cioccale M., Sylvestre F. 2009. Hydrological variability in South America below the Tropic of Capricorn (Pampas and eastern Patagonia, Argentina) during the last 13.0 ka. In: Vimeux F, Sylvestre F, Khodri M (Eds) *Past climate variability from the Last Glacial Maximum to the Holocene in South America and Surrounding regions: From the Last Glacial Maximum to the Holocene*. Springer- *Developments in Paleoenvironmental Research Series (DPER)* 14. pp 323-351.

Troin, M., C. Vallet-Coulomb, F. Sylvestre and E. Piovano, 2010. Hydrological modelling of a closed lake (Laguna Mar Chiquita, Argentina) in the context of 20th century climatic changes. *Journal of Hydrology*. 393: 233–244.

Waldmann, N., Ariztegui, D., Anselmetti, F. S., Austin Jr., J. A., Moy, C. M., Stern, C., Recasens, C and Dunbar, R. 2010. Holocene Climatic Fluctuations and Positioning of the Southern Hemisphere Westerlies in Tierra del Fuego (54°S), Patagonia. *Journal of Quaternary Science* 25/7, 1063-1075 (doi: 10.1002/jqs.1263).

#### *Submitted*

Córdoba, F., Piovano, E.L., Mulsow, S. (in review). New insights into the Pb-210 dating technique of recent lacustrine environments under situations of hydroclimate change. *Geochimica et Cosmochimica Acta*.

Chiessi, C. M., Mulitza, S., Heslop, D., Piovano, E. L., Vuille, M., Cruz, F. W. and Razik, S. Holocene changes in South American summer monsoon precipitation recorded in marine sediments. *Quaternary Research*.

Troin, M., Vallet-Coulomb, C., Sylvestre, F. and Piovano, E. Hydrologic impact of climate change: assessment of the SWAT model applicability through contrasted climatic conditions (Laguna Mar Chiquita basin, NW Argentina). *Water Resources Research*.

Troin, M., Vrac, M., Khodri, M., Vallet-Coulomb, C., Piovano, E.L. and Sylvestre, F. Coupling statistically downscaled GCM outputs with a basin-lake hydrological model in subtropical South America: Evaluation of the influence of large-scale precipitation changes on regional hydroclimate variability. *Climatic Change*.

#### *Abstracts*

Ariztegui, D., Guedron, S., Coianiz, L. and Piovano, E.L. 2010. Tracking recurring drought/wet intervals and human impact over subtropical South America since the end of the Little Ice Age using Hg content in sediments. *Eos Trans. AGU*, 91(26), Meet. Am. Suppl., Abstract PP24A-04.

Córdoba, F., Piovano, E., Sylvestre, F., 2010. Exploring the linkage between lacustrine proxy data and instrumental record for reconstructing past hydroclimatic variability in the southern Pampas. 18th International Sedimentological Congress. "Sedimentology at the foot of the Andes". Mendoza 2010. Abstract ID: 960.

Guerra, L., Piovano, E., 2010. Contrasting hydroclimate conditions in the Argentinean pampean plains: the paleolimnological record of the little ice age and the 20th century. II International Symposium "Reconstructing Climate Variations in South America and the Antarctic Peninsula over the last 2000 years" 27-30 de octubre de 2010, Valdivia, Chile.

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Schwab, A., Cusminsky, G., Pineda, D., Viehberg, F., Markgraf, V., Ariztegui, D. and Gilli, A. 2010. Recent Ostracods From Patagonia, Argentina, as Paleoenvironmental Indicators. Eos Trans. AGU, 91(26), Meet. Am. Suppl., Abstract PP41A-06.

Vallet-Coulomb, C., Troin, M., Piovano, E., Sylvestre, F. Isotopic modelling of Laguna Mar Chiquita, a large closed saline lake of central Argentina. International Symposium on Isotopes in Hydrology, Marine Ecosystems, and Climate Change Studies. France. March 2011.

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