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ARCHIVAL CLIMATE HISTORY SURVEY IN THE CENTRAL ANDES (POTOSI, 16TH-17TH CENTURIES)

Abstract: Proxy climatic data of the Spanish colonization have been collected in Bolivia (mainly in the "Archivo Nacional" located in Sucre, previously Charcas or La Plata), and Spain ("Archivo General de Indias" in Seville). The aim was to reconstruct all the rainy seasons in Potosi from 1585. The archival chronology was based on the large quantity of documents about Potosi, one of the biggest and the richest city of the world during the 16th and the 17th centuries. Potosi's location (4000 m a.s.l.) in an arid and extreme environment is an advantage to study climatic variations. Further, water-power was used to move the silver metallurgy engines from 1574-77, years of the beginning of work on the lake system.

Key words: proxy data, archives, climatic reconstruction, Andes, Bolivia, Peru.

1. Introduction

The aim of the research is to reconstruct, from archival documents, as complete as possible a chronology for the history of climate in the city of Potosi. The main sources are the unpublished "Actas de los Acuerdos del Cabildo" (municipal proceedings) of Potosi, which are preserved from 1585 to 1815. Data from historical chronicles and archives complete this framework. In this paper, we present the reconstruction of the rainy seasons between 1585 and 1700, because the climate of this period is particularly little-known, in spite of the publication of Arzáns' chronicles ([1711] 1970; [1705-1737] 1965), an important early contribution to New World literature, but erratic as a scientific source. Arzans' data can be very useful, but must be compared with the information from the municipal proceedings.

2. The Field Study

Potosi (4000 m; latitude: 19°34'18''S; longitude: 65°34'25''W) is located now in Bolivia whose territory, for most of the period of the Spanish rule (1545-1825), formed

the southern part of the Peruvian viceroyalty (between 1776 and 1815 it depended briefly on the viceroyalty located in Buenos Aires). The city was situated in the "Audiencia de Charcas" (whose capital was La Plata, today Sucre), and during the 16th and 17th centuries was the economical hub of a large part of South America. From the first mining settlement built in 1545, the city grew exponentially during the "silver boom" to reach 150-160,000 inhabitants in 1610. Until the middle of the 17th century, the city remained very important, but the centre of mining production move slowly to Mexico, producing a progressive decadence. Potosi was a ghost city at the end of the colonial period (8,000 inhabitants in 1825) but today has 130,000 inhabitants. The average annual rainfall is some 400 mm, and the average temperature 9°C, although there are 140 days of frost annually (Gioda, Serrano 1998).

2. The Method for Reconstructing the Rainy Seasons

Table 1 presents our reconstruction. The rainy season is very short (from December to April) in this part of the dry Andes. In spite of the Potosi's location at 4000 m a.s.l., precipitations are mainly hail or rain and not snow, because this season corresponds to the tropical austral summer.

Therefore, "Early" corresponds to rain or hail beginning to fall in September, October or November. "Late" means the drought was perceptible, but precipitation occurred at the end of December, in January or in February.

"Normal" corresponds to a well-known rainy season period, but without specific data on climatology or hydrology. Using the municipal archives, we have nearly continuous information because usually the Cabildo, as in all important cities of the Spanish Empire, organised each month frequent meetings where minutes were carefully taken. The records are not complete in Potosi because various volumes have disappeared. The following volumes during the period study are lost: No. 13 (January 1611–June 1614); No. 17 (January 1622-February 1626); No. 21-23 (June 1636-December 1648); No. 25 (January 1652-December 1657); No. 27-29 (October 1661-March 1674); No. 32-36 (November 1681-December 1720). So, our reconstruction presents interruptions when no other alternative sources, for instance from the "Archivo General de Indias", could be used. Arzáns' chronicles are particularly useful at the end of the 17th century, especially from 1676, year of the chronicler's birth, because his historical reconstruction became a lot more trustworthy (Gunnar Mendoza, 1965 in the edition notes of Arzáns' Historia, and Josep Barnadas, pers. com.).

"Quantity of data" is the number of annotations concerning an abnormal climatic phenomenon. "Confidence ratings" are estimated based on the quality of information afforded, ranging from complete (3) to minimal (1). Potosi's municipal proceedings and other archival documents have a very high ranking = 3, Arzáns' chronicles a low one = 1 except during the 1676-1700 period = 2. "References" are abbreviated as follows:

– AACP: Actas de los Acuerdos del Cabildo de Potosí in ANB;
– AGI: Archivo General de Indias, Sevilla, Spain;
– ANB: Archivo Nacional de Bolivia, Sucre, Bolivia;

– Anales: Arzáns B., [1711] 1970, *Anales de la Villa Imperial de Potosí*, Crespo A., editor, Fondo Nacional de Cultura, La Paz, Bolivia;
– Historia: Arzáns B., [1705-1737] 1965, *Historia de la Villa Imperial de Potosí*. Mendoza G. and Hanke L., editors, Brown University, Providence, USA.

3. Discussion

First of all, the many proxy data recorded in the 1625-26 rainy season are linked exclusively with the Lake San Ildefonso dam catastrophe on March 15, 1626. There were more than 2,000 victims, which makes it one of the most deadliest hydraulic tragedies in the world from the 17th century (Serrano, Gioda 1999). An intricate system of aqueducts was built to convey water from one lake group to another and, eventually, to the Ribera, a channel built in 1574-77, to power the silver mills (Gioda, Serrano 1998).

Apparent contradictions between Arzáns' information and archival data may occur for the same year. In the present state of research, we present all the references, but archival data from the Cabildo of Potosi and the Archivo General de Indias seem a lot more trustworthy.

Accurate studies were carried out recently to study on climatic change using dendrochronology in Northern Patagonia and subtropical Argentina (Villalba 1994; Villalba et al. 1998) and glaciology in Bolivia (Thompson et al. 1998). Nonetheless, these data are not nearly as precise as historical reconstruction from archives, where contemporary information has been collected almost at the same time as the occurrence of the abnormal climatic phenomenon (Le Roy Ladurie 1983; Pfister 1999). Such archival-based studies in South America, after early attempts in Chile until the 1930´s, began in the 1980´s in Mendoza (Argentina) first of all making use of archival and press data from Argentina (Prieto 1983; Prieto et al. 1999, 2000). Since the 1990's, they have been extended to the highlands of Bolivia: Altiplano and Andes valleys (Gioda, Prieto 1997, 1998, 1999). Closely related to these efforts is the calibration of the documentary historical record for El Niño events in Latin America (Ortlieb 1999, 2000). However, these latter studies look for the development of particular oceanographic events, and not to a complete chronological reconstruction from archives.

These studies on proxy data and historical reconstruction are federated from 1988 by the ARCHISS (Archival Climate History Survey) project in the framework of WMO, Unesco, and ICA – the International Council on Archives (Baker 1998). The first results of a fuzzy logic analysis are about Mexican proxy data (Duckstein 1998) and we will intend to do the same with Potosi´s data.

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Tab. 1. The reconstruction of rainy seasons in Potosi (Central Andes, Bolivia) 1585-1700.

Years	RAINY SEASON	Quantity of data	Confidence rating	References and notes
1585-86	NORMAL	0	3	ANB, AACP, 5
1586-87	NORMAL	0	3	ANB, AACP, 5
1587-88	NORMAL	0	3	ANB, AACP, 5 ≠ Anales, 44; Historia, 1, 203 (early-very wet)
1588-89	NORMAL	0	3	ANB, AACP, 5
1589-90	NORMAL	0	3	ANB, AACP, 5
1590-91	NORMAL	0	3	ANB, AACP, 5 -6 ≠Anales, 46 (very dry)
1591-92	VERY DRY	> 10	3	Anales, 46; Historia, 1, 217; ANB, AACP, 6, 64-112; ANB, Minas, 56, 320
1592-93	EARLY-NORMAL	1	3	ANB, AACP, 6, 115v ≠Historia, 1, 217-218 (late-wet)
1593-94	EARLY-WET	2	3	AGI, Charcas, 32; AGI, Vázquez, 15, 35-743 ≠ANB, AACP, 7 (normal)
1594-95	WET	3	3	ANB, AACP, 7, 367v-385 (drought, Feb. 1595)
1595-96	NORMAL	0	3	ANB, AACP, 7
1596-97	NORMAL	0	1	ANB, AACP, 7 -8 ≠Anales, 47; Historia, 1, 233 (wet)
1597-98	NORMAL	1	3	ANB, AACP, 8 ≠Antuńez, pers. com. (very dry, Altiplano)
1598-99	NORMAL	0	3	ANB, AACP, 8 -9
1599-1600	LATE-NORMAL	4	3	AGI, Levillier, 408-10 (drought, Dec. 1599 & Jan. 1600)≠Historia, 1, 244 (very wet, end Jan. & Feb. 1600) ≠ANB, AACP, 9 (normal)
1600-01	NORMAL	0	3	ANB, AACP, 9
1601-02	NORMAL	0	3	ANB, AACP, 9 ≠Historia, 1, 250 (dry) ≠Antunéz, pers. com. (very dry, Altiplano)
1602-03	NORMAL	0	3	ANB, AACP, 9 -10
1603-04	NORMAL	0	3	ANB, AACP, 10
1604-05	NORMAL	0	3	ANB, AACP, 10 -11
1605-06	NORMAL	0	3	ANB, AACP, 11 ≠Historia, 1, 263-264; Antunéz (very dry but confusion with the 1609 drought)
1606-07	NORMAL	0	3	ANB, AACP, 12 ≠Historia, 1, 264-265 (wet)
1607-08	VERY DRY	4	3	ANB, AACP, 12, 94v-102
1608-09	VERY DRY	2	3	ANB, AACP, 12, 208; ANB, Minas, 281-282, 1
1609-10	NORMAL	0	3	ANB, AACP, 12
1610-11	VERY DRY	3	3	ANB, AACP, 12, 340v-342v
1614-15	DRY	1	3	ANB, AACP, 14, 70
1615-16	NORMAL	0	3	ANB, AACP, 14
1616-17	NORMAL	0	3	ANB, AACP, 15
1617-18	DRY	1	3	ANB, AACP, 16, 18v
1618-19	NORMAL	0	3	ANB, AACP, 16
1619-20	DRY	1	3	ANB, AACP, 16, 200v
1620-21	NORMAL	0	3	ANB, AACP, 16
1621-22	NORMAL	0	3	ANB, AACP, 16 (data until Jan. 1622)
1623-24	WET	2	1	Anales, 82; Historia, 1, 384-385
1624-25	VERY DRY	1	3	AGI, Vázquez, 33-34
1625-26	VERY WET	> 10	3	ANB, AACP, 18, 3v-20; Anales, 89; Historia, 2, 1
1626-27	VERY DRY	3	3	ANB, AACP, 18, 136-179v
1627-28	WET	2	3	ANB, AACP, 18, 259v-262v
1628-29	EARLY-WET?	1	3	ANB, AACP, 18, 340v-341v (data until Jan. 1629)
1629-30	VERY DRY	1	1	Historia, 2, 32-33
1633-34	NORMAL	0	3	ANB, AACP, 20 (data from Jan. 1634)
1634-35	VERY DRY	> 10	3	ANB, AACP, 20, 160-335
1635-36	NORMAL	1	3	ANB, 20, AACP, 388-389 (drought, Oct. 1635)
1642-43	WET	1	1	Historia, 2, 91
1647-48	VERY DRY	1	1	Antunéz, pers. com. (Altiplano)
1648-49	NORMAL	0	3	ANB, AACP, 24 (data from Jan. 1649)
1649-50	NORMAL	0	3	ANB, AACP, 24
1650-51	VERY DRY	8	3	ANB, AACP, 24, 423v-461v; AGI, Vázquez, 41, 21-397
1651-52	LATE-DRY	1	3	ANB, AACP, 24, 480-482 (data until Dec. 1651)
1654-55	WET	1	1	Historia, 2, 162
1657-58	DRY	1	3	ANB, AACP, 26, 40 (data from Jan. 1658)
1658-59	DRY	1	3	ANB, AACP, 26, 115v-116
1659-60	NORMAL	0	3	ANB, AACP, 26
1660-61	LATE-DRY	2	3	ANB, AACP, 26, 345 (drought until Dec.) ≠ Historia, 2, 488-489 (wet after Dec. 1660?)

Tab. 1. continued.

Years	RAINY SEASON	Quantity of data	Confidence rating	References and notes
1661-62	DRY?	1	1	Historia, 2, 218
1671-72	LATE-WET	2	1	Anales, 143; Historia, 2, 259
1676-77	VERY WET	1	2	Historia, 2, 285
1677-78	WET	1	3	ANB, AACP, 31, 121
1678-79	LATE-WET	3	2	Anales, 148; Historia, 2, 293-294 ≠ ANB, AACP, 31 (normal) ≠ Antunéz, pers. com. (very dry)
1679-80	NORMAL	0	3	ANB, AACP, 31
1680-81	NORMAL	0	3	ANB, AACP, 31
1681-82	NORMAL	0	2	Historia, 2
1682-83	NORMAL	0	2	Historia, 2
1683-84	EARLY-DRY	1	2	Historia, 2, 316
1684-85	DRY	1	2	Historia, 2, 329
1685-86	NORMAL	0	2	Historia, 2
1686-87	NORMAL	0	2	Historia, 2
1687-88	NORMAL	0	2	Historia, 2
1688-89	NORMAL	0	2	Historia, 2
1689-90	NORMAL	0	2	Historia, 2
1690-91	WET	1	2	Historia, 2, 358
1691-92	DRY	2	2	Anales, 167; (drought, Jan. & March 1692); Antúnez, pers. com.(Altiplano)
1692-93	WET	1	2	Historia, 2, 308
1693-94	EARLY-NORMAL	2	3	AGI, Charcas, 32 ≠ Historia, 2, 370-380 & 394-395; Anales, 168 (dry, drought in all Peru 1693-1695)
1694-95	DRY	2	2	Historia, 2, 370-380 & 393-394; Anales, 168
1695-96	LATE-WET	2	2	Historia, 2, 393-394 (dry, 1695) & 381 (wet, Jan. 96)
1696-97	NORMAL	0	2	Historia, 2
1697-98	VERY DRY	1	2	Historia, 2, 393-394
1698-99	NORMAL	0	2	Historia, 2
1699-1700	NORMAL	0	2	Historia, 2

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