



Determination of droughts and high floods of the Bermejo River (Argentina) based on documentary evidence (17th to 20th century)



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SUMMARY

This study reconstructs a series of droughts and high flow volumes of the Bermejo River from the 17th to 20th century based on a content analysis of historic documentary evidence, which is calibrated with instrumental climate data. The historic data series shows an increase in the frequency of extraordinarily high waters beginning in the 19th century and a significant decrease in extreme droughts beginning in 1890. The data are compared to variations in the Mendoza River for the same period, which show that there was a long-standing lack of correlation between the rivers.

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“Upon news of the Bermejo River in January 1568, I sent Captain Juan Gregorio Bazán, who hurried toward the rising sun for more than fifty leagues... approaching the mountains from which the river flowed, there was such flooding that they all were nearly lost.”
[(Diego Pacheco, 1566, the earliest report of the flood.)]

1. Introduction

Documentary sources can be used to create detailed chronologies and reconstruct river flow volumes and climate (Metalcalfe et al., 2002; Pfister et al., 2009; Ogilvie, 2010). Most research on the reconstruction of river flow volumes from historic records is concentrated in Europe (Brázdil et al., 2005a, 2006; Thorndycraft et al., 2003; Barriendos and Martín-Vide, 1998; Benito et al., 2003; Brázdil et al., 2005b; Pfister et al., 2002; Williams and Archer, 2002). This topic has also been worked on in North America, but to a lesser extent (Endfield and O'Hara, 1997; Florescano and Swan, 1995; O'Hara and Metcalfe, 1995; Mendoza et al., 2006; Jones, 2003; Saint-Laurent et al., 2009). In South America, archival evidence, although it has not been fully exploited, has been used since 1991 to extend instrumental records of river flows in central and northern Argentina, such as the those of the Salí-Dulce and Salado River Basins (Prieto et al., 1996; Prieto, 2009; Dussel and Herrera, 1999; Herrera et al., 2003; Herrera et al., 2011), the Del Plata River Basin (Prieto and Richard Jorba, 1991), the Paraná River (Prieto, 2007, 2009), and

the Mendoza River (Prieto et al., 1999, 2001; Prieto and Rojas, 2012).

This paper presents a detailed reconstruction of the flow of the Bermejo River from the year 1600 to the present, based on published and unpublished data from historic documents. The Bermejo River flows through Bolivia and Argentina. Its headwaters are in the subtropical Andes (northwestern Argentina and southern Bolivia). Its principal tributaries are the Grande River of Tarija, in Bolivia, as well as the Iruya and San Francisco Rivers in Argentina. As the Bermejo River leaves the mountains and heads east into the Gran Chaco region, it flows into a large sedimentary plain with vast flooded areas, typical of a lowland river. The high waters created by rains and snowmelt in the upper basin are concentrated from November to April, with a maximum in February. The low period is from May to November.

2. Materials and methods

2.1. Data source

2.1.1. Archives and collections

The Spanish colony in the Americas was extremely bureaucratic. The crown ordered that all official documents be done in triplicate. One copy was archived in the city where it was produced, the second sent to the governing body or viceroyalty, and the third sent to the crown in Spain. This led to an enormous accumulation of documents, especially in the imperial capital (Prieto and García-Herrera, 2009).

The principal repository is the *Archivo General de las Indias* (General Archive of the Indies or AGI) in Seville, which includes documents from the earliest part of the Spanish colonization of

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the Americas. For the current study, the most relevant sections of the archive were the *Audiencia de Charcas*, *Audiencia de Buenos Aires*, and *Indiferente General*. Until 1776 the Bermejo River region depended on the Viceroyalty of Peru. For this period, the most notable documents are the earliest conquistadors' 16th-century accounts and reports by the governors and military officials on the fight against the natives. They informed the king about the advances made into indigenous territory in the 17th and 18th centuries. Around the end of the 19th century, Argentine and Chilean historians transcribed AGI reports from these countries, in particular reports and letters from royal officials. From Argentina, [Levillier \(1922\)](#) is notable for this. There are also relevant documents archived in Madrid such as the *Archivo de la Real Academia de la Historia* (Archives of the Royal Academy of History) which includes significant Jesuit documents and the *Colección Mata Linares*. In the *Archivo de la Biblioteca Nacional* (Archive of the National Library) in Buenos Aires, there are a number of manuscripts written by priests as well as their travel journals that predominantly cover the Chaco region, which includes modern Argentina, Paraguay, and Bolivia. Another relevant collection is the *Cartas Anuas* (Annual Letters) of the Jesuits, which spans the early 1600s to 1767, when they were expelled from Spanish America. The letters were originally in Latin and are located in the Vatican Library. Those from Argentina and Paraguay were translated and published in [Documentos para la Historia Argentina \(1927\)](#). Other letters from the Jesuit Order have been found in the *Biblioteca Nacional de Chile* (National Library of Chile). There is valuable information in the archives of the orders of San Ignacio, San Francisco, and Seráfica and their local and regional administrative offices.

The most important political and administrative unit in Hispanic America was the viceroyalty. At the beginning of 1544, the Viceroyalty of Peru was created in Lima, which included the study region for two centuries. In 1776 the Viceroyalty of Río de la Plata was created and its capital was in Buenos Aires. Its jurisdiction included Bolivia, Paraguay, Uruguay, Argentina, and northern Chile.

Most of the information since 1776, including records from Bolivia, is preserved at the *Archivo General de la Nación* (General National Archive) in Buenos Aires (in the *Alto Perú* section). In Argentina, provincial archives are located in the provincial capitals. We were especially interested in those from the provinces of Tucumán, Salta, Santiago del Estero, Jujuy, and some records from Santa Fe. In all of these, information goes back to the earliest part of the conquest and continues until the 20th century, including significant hydrological data. The most relevant documentation for Bolivia is located in the *Archivo Nacional de Bolivia* (National Archive of Bolivia) in Sucre as well as some provincial archives such as the *Centro de Documentación Eclesiástica* (Ecclesiastical Documentation Center) at the Franciscan Convent, in Tarija.

In addition, there is information on the Gran Chaco region and the Bermejo River from accounts and diaries of soldiers, travelers (locals and foreigners), and traders, most of which were published beginning in the middle of the 19th century. These old books can be found in specialized libraries and museums in Buenos Aires: *Museo Mitre*, *Biblioteca Nacional* (National Library). The *Archivo General del Ejército* (General Archive of the Army) has information on the war of the Triple Alliance (1864–1869), whose battlefields were in the Chaco region.

2.1.2. Sources

2.1.2.1. Documentary sources for the colonial period. The principal sources for the colonial period were recorded at the same time or immediately after a climatic event (primary or first-hand sources). The colonial part of most archives has a section with government reports, letters, and articles sent to the Spanish Crown by viceroys, governors, and military and colonial officials, which have

information on regional issues. There are reports of hydrological and meteorological extremes that affected the regional economy such as droughts, floods, and excessive rains. The first continuous reports of swells and floods for the Bermejo River and the region begin around 1600. There are reports of priests who traveled to the area to evangelize indigenous groups, letters from functionaries of the Spanish Crown, and reports of royal officials and soldiers that went into the forest to fight the natives.

To a lesser degree, we also considered secondary sources, but these may include distortions or exaggerations. The best-known of these are the *crónicas*, a literary genre written by conquistadores, soldiers, or priests who wanted to extol their own real or supposed deeds by lauding their poverty or bravery. They were often written long after the events they describe, making their chronologies questionable (see [Fig. 1](#)).

Old maps also provide important information on a region's past climate. For example, there is a collection of maps in the AGI and AGN which show the successive courses of rivers to over three hundred years. One of the most illustrative is Father Caamaño's map, which shows the change in course of the Salado River, located near the Bermejo River, as a result of to extremely high waters in 1787 ([Fig. 2](#)). Most of these maps were compiled by Father Furlong in his *Cartografía Jesuítica del Río de la Plata* (1936).

Beginning in the 18th century there were a number of "naturalist missionaries," notably [José Jolís \(1767\)](#), who was involved in the *reducciones* in the Gran Chaco from 1762 to 1767 and traveled around the Bermejo and Grande Rivers. Others include [Fray Antonio Lapa \(1779\)](#), [Fernández Cornejo \(1790\)](#), [Felix de Azara from 1781–1801 \(1941\)](#) and Francisco [Murillo \(1780\)](#), who carried out the first expedition to navigate the Bermejo by ship.

2.1.2.2. Documents from the republican period. Documents used for this period were principally accounts about the navigation and exploration of the Bermejo River by explorers, adventurers, and later, traders. They focused on determining the river's navigability and forming navigation societies.

The Franciscan Order resumed its evangelization of the region after the Jesuits were expelled in 1767. This period includes numerous reports and documents by priests going to the missions. These include [Cuadernos Franciscanos \(1858\)](#), which refer to the extraordinary floods of the Bermejo in 1858 and 1863 ([Pellichi, 1868](#)) and writings of the other Franciscans ([Pellichi et al., 1995](#)). Starting in 1860, there was an increase in the number of books published by naturalists and adventurers on their explorations along the river.

Government and military reports began with the Indian Wars carried out by the Argentine government beginning in 1884, which produced an extensive bibliography on the features of the region, written by soldiers and functionaries such as [Fontana \(1977\)](#) and [Aráoz \(1886\)](#) who report the extraordinary floods of 1872, [Gobelli \(1912\)](#), and [Carranza \(1884\)](#). [Victorica \(1885\)](#) deserves special mention.

Information from newspapers is available beginning in 1870. Data from the national newspapers *La Nación* and *Clarín* were used to complete and calibrate the historical series with the instrumental period that began in 1940.

2.2. Treatment of the information

It was necessary to make a selection of documents to extract and categorize data. To verify the validity of the information, we used the linguistic technique of content analysis, which that makes it possible to derive climatic data from historical documents. This transforms information with different purposes into hydroclimatic data that can be treated statistically. It technique allows

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