

# IDENTIFICATION AND INTERPRETATION OF ENSO IMPACTS IN THE PERUVIAN HISTORICAL DOCUMENTARY RECORD: INSIGHT INTO CLIMATE CHANGES IN PERU

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## El Niño chronologies from documentary historical records from Peru

Since the first mentions of the “El Niño” climatic and oceanographic alterations observed along the coast of northernmost Peru (Carranza, 1891; Carrillo, 1893), a quite abundant literature has been devoted to this phenomenon in Peru, and in other areas that are impacted by oceanographic and meteorological consequences of ENSO (El Niño–Southern Oscillation). Major contributions dealing with past climate anomalies related to El Niño, mainly strong rainfalls occurring in the austral summer in Piura and the Sechura Desert coupled to a warming of the coastal waters (and associated effects), were provided by Eguiguren, (1894), Murphy (1923, 1925), Petersen (1935) and Schweigger (1964). The first attempts to reconstruct El Niño occurrences from documentary data were made by Quinn and collaborators (Quinn et al. 1987; Quinn and Neal, 1992, Quinn, 1993). Quinn largely based his reconstructions of El Niño occurrences on evidence from Peru, namely reports of anomalous rainfalls (or snowfalls), climatically induced diseases, length of ship travels, mass mortality of fishes, etc. In his later works (Quinn and Neal, 1992, Quinn, 1993), he included more evidence from other nearby countries (Bolivia, Chile, and the northeastern Brazil). For many years, it has been considered that Quinn’s chronologies of El Niño (and ENSO) events were the reference on which could be calibrated other works.

However, in several previous works (e.g. Hocquenghem & Ortlieb, 1992; Ortlieb, 2000, 2002; Ortlieb et al., 2002), we discussed the reliability of number of the proposed reconstructed El Niño events, particularly those related to evidence from Peru. A cautious reappraisal of the documentary information used by Quinn and collaborators, including a critical evaluation of each of the historical sources led us to eliminate a number of so-called El Niño events (in Quinn’s series). Beside, it was shown that in many cases, the only written evidence used by Quinn dealt with climate and hydrological anomalies which cannot be (anymore) considered as clearly diagnostic for El Niño conditions: the best examples being the floods (“huaycos”) of the Rimac and other rivers in Central Peru, or strong snowfalls in the Andes of southern Peru (Ortlieb, 2000). Recent climatic researches (e.g. Rome-Gaspaldy & Ronchail, 1998), as well as the information obtained during the last two strong El Niño events of 1982-83 and 1997-98, indicate clearly that only the rainfall excess in summer occurring along the coastal area of northwestern Peru can be considered as diagnostic for former El Niño conditions. Thus, other rainfall and meteorological anomalies reported from the central and southern coast of Peru, or in the Peruvian Andes, should not reliably be linked to El Niño (or La Niña) conditions, if there are no evidence for coincident rainfall anomalies from northern Peru and southern Ecuador.

Following an alternative approach consisting in an analysis of archival material from the Trujillo area, Garcia Herrera et al. (2008) recently proposed another chronological sequence of “Peruvian” El Niño events for the period 1525-1900 (Table 1). The authors heavily relied upon historical information which concerns almost exclusively the La Libertad Department. The Garcia et al. El Niño chronology includes only a few former events of large magnitude, that were not documented in the Trujillo area but had been reconstructed on the basis of evidence from more northern areas (Piura, and southern Ecuador).

Several recent works aimed to compile high-resolution paleoclimatic data to produce multiproxy records of ENSO events in the last ~five centuries. These works commonly include data from ice-cores, corals, tree-rings and documentary researches (Gergis & Fowler, 2008; McGregor et al., 2009; Wilson et al., 2010). One of these multiproxy El Niño sequence, reconstructed by Gergis and Fowler (2008), partially integrates, among other documentary data, the information from Quinn & Neal



(1992) and Ortlieb (2000) (Table 1). All these attempts to produce a chronology of El Niño events actually show that no consensus is obtained. Actually, it becomes clear, now, that for different reasons (changes in teleconnection patterns, variation of modality of ENSO manifestations, distinction between the recently defined “Eastern Pacific El Niño” and “Modoki El Niño”, interaction between ENSO and Pacific Decadal Oscillation, etc.), it will probably be impossible to build-up a consolidated sequence of El Niño events of the last centuries in any particular area, including Peru.

### **On-going yearly reconstruction of possible former El Niño manifestations in Peru**

Even though it becomes illusory to establish “the” chronological sequence of El Niño events through an analysis of meteorological and oceanographic anomalies occurred in Peru, it remains useful and pertinent to gather documentary information of the last ~5 centuries at a yearly time-scale. Such work is in progress and should be published in 2011 (Ortlieb & Hocquenghem, in prep). The 4th column of Table 1 indicates the years for which we interpret that El Niño conditions were met (with indication of intensity of the probable events and, in many cases, the restricted reliability of the documentary data at hand to reconstruct El Niño manifestations).

This study compiles all the citations of mentions of climatic and coastal anomalies in Peru, year by year, between 1525 and 1925, found either in published form or in unpublished written archives. These citations include all the documentary material that has been used by previous authors (Quinn et al., 1987; Quinn and Neal, 1992; Ortlieb, 2000; Garcia-Herrera et al., 2008), and also contains additional data not referred to previously. Emphasis is given to original data and, at odds with the methodology followed by Quinn et al. (1987), no importance is given to the repetition by several authors of the same information.

Short comments regarding the possible relationship of the reported climate anomalies with El Niño event occurrences are given. In a number of cases, the citations of sources referred to by previous authors are discussed, and it is eventually explained whether we agree, or disagree, with the previous interpretation proposed for the reconstruction of El Niño conditions.

The interpretation of past climatic conditions, and of the “anomalous” character of some meteorological features is naturally based on comparisons with present-day situations. However this procedure is not straightforward. How anomalous (and indicator of El Niño conditions) is a rainfall event in a specific area? To which extent a drought in the Peruvian Andes may be related to El Niño? Does a bloom of vegetation along the coast of southern Peru during the eighteenth century indicate El Niño or La Niña conditions? How reliable is an information on the abundance (or lack) of some fishes to depict coastal oceanographic conditions?

If comparisons with modern manifestations of El Niño are necessary to support the interpretation of former El Niño occurrences, it must be taken into account several considerations and caveat. One of them deals with the differences between El Niño manifestations between one event and another one (even in modern times): the very strong events of 1982-83 and 1997-98 had quite different meteorological impacts in the southern Andes of Peru. Another important consideration is that the regional atmospheric circulation pattern was most probably different from nowadays during the Little Ica Age (Ortlieb, 2000; Ortlieb 2002; Ortlieb et al., 2002). In this sense, one must also deal with the fact that reports of “anomalous” conditions, by informants of the past centuries, may not refer to what would be seen as “anomalous” today (and vice-versa!).

This work does not only discuss the possible occurrence of El Niño occurrences in the past centuries, and also aims to use the available documentary data to characterize interannual climate variability, involving as much information of the different regions of Peru as possible.

### **Implication for the interpretation of climate change in Peru during the last centuries**

The analysis of documentary information on former climatic anomalies that could be produced by El Niño manifestations in Peru lead us to compile much valuable data on interannual climate variability, in numerous areas. The analysis of this high resolution, and well-dated, data extracted from written reports yields information which can also be used to define mean climate variations at longer time scales (decades to centuries), as well as climatic changes within a recent past. Of particular interest is the characterization of the mean climate during the sixteenth, seventeenth and eighteenth centuries with respect to the more recent and much more documented nineteenth and twentieth centuries. While it has been established from both documentary (e.g. Ortlieb, 2002 and Ortlieb et al.,

2002) and paleoceanographic studies (e.g. Gutierrez et al., 2009) that a major climate shift occurred around 1817-1820, it is important and timely to attempt to characterize the variability of the climate of Peru in its distinct regions and to identify the major differences with the climate variability recorded in the last 190 years. This kind of information is deeply needed for any characterization of climate changes which covers past periods for which no instrumental data are available.

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