

# ***Interactive comment on “Centennial-scale precipitation anomalies in the southern Altiplano (18° S) suggest an extra-tropical driver for the South American Summer Monsoon during the late Holocene” by Ignacio A. Jara et al.***

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Referee #2 also discussed key issues and provided constructive comments on the original manuscript. The Referee raised three major issues. Here are the individual responses to them:

## 2.1. Lack of information about the chronology

Response: This issue was also raised by Referee #1. We agree with both reviewers that more supporting information about the chronology of the record is desirable.

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We have now added all the details of the radiocarbon dates, the estimated reservoir correction, and the age-depth curve in the form of a new table and figure in the Supplementary Material (see attached document). On the other hand, we tend to disagree with Referee #2 that an additional figure with the previous investigations of Lago Chungará should be added because those investigation were, in their majority, focused on different research problems and covered time periods not relevant for our manuscript.

## 2.2 More extended discussion of past ENSO variability

Response: We agree with Referee #2 that more records of past ENSO variations contribute to a more comprehensive discussion. Following the Referee's suggestion, we have added two of the four articles suggested by her/him. Added mentions to the ENSO reconstruction from Barr et al. (2019) (lines 394-396), and the *Botriococcus* spp. curves from El Junco Lake (Zhang et al., 2014) (lines 392-394), the latter record complements well with the evidence from the same lake presented in our original manuscript (Conroy et al., 2008). Despite of considering the two other suggested articles as relevant ENSO reconstructions, we decided not to include the Ortega et al., (2019) article suggested by Referee #2 because it provides evidence for ENSO variability at timescales ranging from multi-millennial to millennial. As such, its potential contribution to our discussion is not critical. Similarly, we decided not to include Vargas et al. (2006) because this article presents a chronology for individual ENSO-driven events that does not represent a continuous record able to capture mean-state values and/or centennial-scale anomalies of past ENSO activity. Nonetheless, we would like to stress that we consider these two articles as scientific relevant reconstructions.

## 2.3 ITCZ influence over SASM

Response: Referee #2 contents that we are too easily disregarding shifts in the ITCZ as potential drivers of SASM changes. We acknowledge that Referee # 2 has raised a relevant topic that demands a careful discussion. In our original manuscript we used the flagship Holocene record of the ITCZ position from the Cariaco Basin (% of Tita-

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mium; Haug et al., 2001). This record does not exhibit any noticeably centennial-scale excursion for the period between 2300-1000 cal yr BP (Fig. 06). Hence, we posit that our Chungará record was largely unaffected by centennial-scale north-south shifts of the ITCZ. Referee #2 suggested to analyse the Cariaco curve in the same way than Salvatecci et al. (2014), which examined this record by normalizing it with the mean value of the last 1650 years (Fig. 3 in that article). We note that this interval does not cover the main climate anomalies detected at Chungará (2600-1000 cal yr BP), which prevents a comprehensive comparison. Nonetheless, the Salvatecci et al. (2014) normalized curve shows overall positive values between 1650-1230 cal yr BP (300-720 AC in Fig. 3 from that article). These positive values could be understood as an overall northward position of the ITCZ relative to the mean state of the 1650 years, a change that could explain the dry anomaly observed at Chungará during that time. Nonetheless, we note the positive values of the Salvatecci et al. (2014) curve are only anomalous in the context of the last 1650 cal yr BP, being indistinguishable in a longer-term context. These anomalies result from the %Ti experiencing the lowest values of the entire Holocene during the Little Ice Age between 430-180 cal yr BP (Fig 3 in Haug et al., 2001). In other words, the anomalous positive values result largely from the mean normalization rather than a genuine northward shift in the ITCZ position during that time. To clarify our point, we have plotted the % of Titanium from Cariaco normalized by the mean of the last 1650 years (upper plot in attached figure) along with with the same proxy normalized by the mean 4500 years (lower plot). When normalizing by the mean values of the last 4500 years, any positive anomaly between 1650-1230 cal yr BP disappears. For all this reasons, we decide not to comment the Salvatecci et al. (2014) article and keep with our interpretation based on the raw Cariaco data presented in Haug et al 2001. However, we are open to consider commenting on the Salvatecci et al (2014) article in the manuscript if the Editor consider relevant to do so.

Minor comment: Line 76-77. It is necessary to add updated references on the geological setting. Other authors (Barnes and Ehlers, 2009; Jordan et al., 2010) point out that slow steady-state uplift since 40 Ma is more consistent than enhanced short periods

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of uplift. Response: We have added that a slow and more steady uplift has also been proposed, citing Barnes and Ehlers (2009).

Line 216. “: : is supported by multiple lines of evidence”. This sentence is too imprecise. References are needed. Response: The different types of evidence supporting the reservoir effect of the article are discussed at Giralt et al. (2008), as mentioned in the main text.

Line 355. What kind of geochemical data?. As it is mentioned above, a figure with the available data (such as Bao et al., 2015) is necessary. Response: By “geochemical data” we refer to the work of Giralt et al. (2008), which uses mineralogical and chemical parameters such as Total Organic Carbon, Total Biogenic Silica, XRF scanning and gray values among others. These analyses are now mentioned in section 2.3. and a reference to the study has been added following the lines mentioned by Referee #2.

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Please also note the supplement to this comment:

<https://www.clim-past-discuss.net/cp-2019-13/cp-2019-13-AC2-supplement.pdf>

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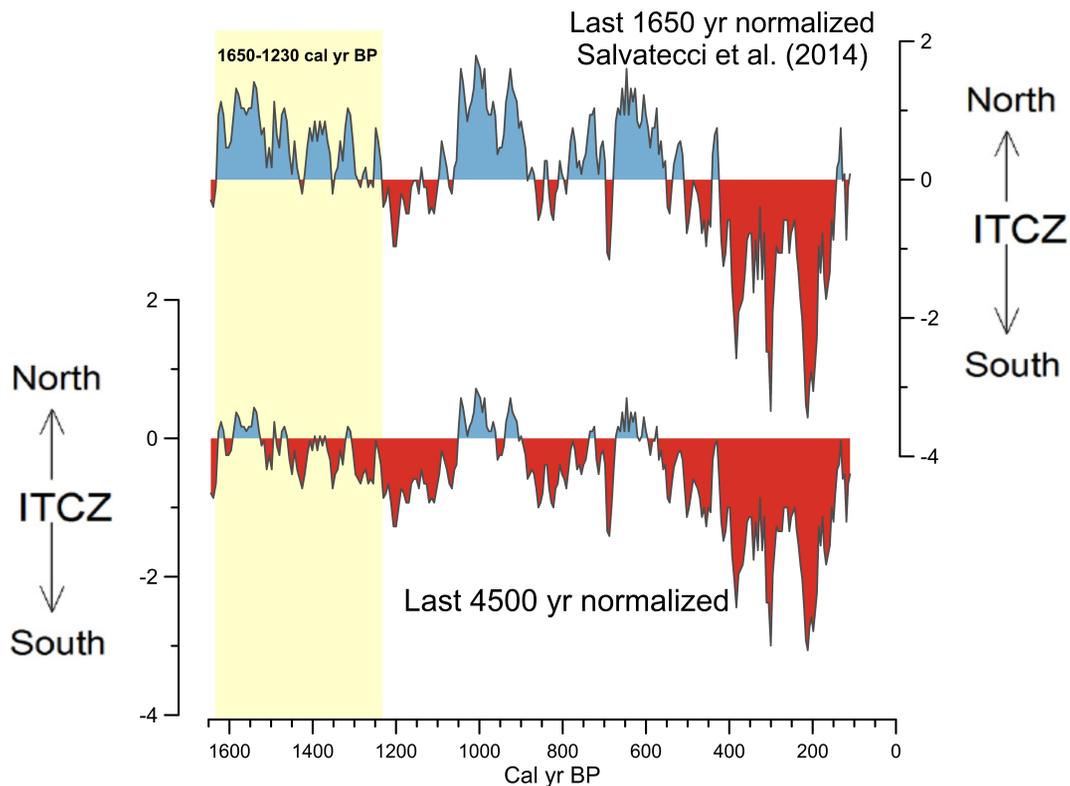


Fig. 1. Figure to comment section 2.3 ITCZ influence over SASM

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