Clim. Past Discuss., 11, C531–C537, 2015
www.clim-past-discuss.net/11/C531/2015/

Climate of the Past Discussions

Interactive comment on "Multi-century lake area changes in the Andean high-elevation ecosystems of the Southern Altiplano" *by* M. S. Morales et al.

B. Luckman (Referee)

luckman@uwo.ca

Received and published: 4 June 2015

At first glance this appears an excellent paper – It is a novel idea and a useful contribution to the regional picture with a well-developed tree-ring chronology and sophisticated analysis of the reconstruction that establishes strong links between the reconstruction, ENSO and possibly the PDO. The relationships are soundly grounded by the statistics but the difficult question is what has actually been reconstructed. The calibration statistics are strong but the data on which that calibration is based leave much to be desired, particularly as I assume there is likely considerable seasonal variation in lake area. I realize that the lake area data are scanty and those used are the best available but it is far from convincing that the average annual data for lake area used in the calibration are a good statistical approximation of the true value. It may be possible

to use the relationship between precipitation and lake area to justify these lake area figures as there is obviously a strong linkage and by calibrating precipitation –lake area relationship one could make inferences about changing lake area from a precipitation reconstruction. This would not change the properties, trends and patterns within the reconstruction and the relationships between the reconstruction and SSTs and might be a stronger, more statistically sound reconstruction.

The technique certainly shows promise but I would prefer to have seen a stronger calibration data set (or a better justification for using these data) before being convinced that a valid measure of annual lake area was being reconstructed. Lake area is clearly an important hydroclimatic variable in this environment and has significant ecological impacts in the Altiplano. Providing an estimate of these changes is a useful tool for examining climate impacts on these systems. However, one wonders whether approaching this problem using a precipitation or PDSI reconstruction would be equally useful or better that the lake area data used here.

Presenting the available data in the supplementary material indicates that the authors are aware of these limitations but I feel that they need to acknowledge this in the text and present a stronger rationale for using these data. The present section 2.3, though an accurate statement, glosses over these limitations and leads to several queries and assumptions about the data (and possibilities) that are clearly not the case based on the supplementary material (see my detailed comments below).

Most of my other comments on the paper are largely corrections/ improvements of the English and a detailed list follows.

The manuscript could be accepted with minor or major revisions depending on the author's response to my comments

Brian Luckman June, 2015

Page Line comment 1822 4 have been shown 5 hydrological 8 in NWA 10 of not from 11

a regional? composite from how many sites? 12 correlation 12 but you are dealing with a composite chronology? 13 order here. Did you screen predictors before making the composite and then reconstruct 17 what is the magnitude of seasonal fluctuations? 22 delete comma 1823 4 in the lowest point of 6 which consequently play 8 do vertebrates nest? 7-12 simplify into two sentences. This is an extreme environment with. . .. These conditions. . . 14 are not is 19 twenty-first 22 dynamics 25 levels recorded at gauging stations but this region lacks such instrumental data. 1824 2 delete assessed 3 P.t are small trees that grow . . . on . . . 4 near the lacustrine areas studied. 10 reorder. The main goal of our study was to use . . .. to develop 13 describe temporal fluctuations of lake area and 15 from the 18 factors, not forcing, variations in lake area? 19 with indices of 20 delete indexes 25 delete a 1825 2 the not a 4 delete the 6 reorder- P.t is a small tree, ca 2-3m tall, and is the largest. . . 7 delete The 8 Extreme 15 a table showing lake area sizes (and possible range of sizes) would be useful here. 21 image not images 21 How did you standardize for seasonal variation in lake area in compiling these annual averages. Also what is the relationship between lake area and pixel size- which determines the precision of your individual estimates. . These procedures need to be defined in more detail as the representativeness of the calibration data is key to the reconstruction. This needs more data. The supplement shows several years in which the data are very sparse so perhaps some data on seasonal variability is needed. Possibly you could have done this on August variability which is the most complete record. Also you never give data on the area of the individual lakes reconstructed. 24 as Z scores 25 to develop a regional mean 26 except for 1983 when no image was available (but Supplementary shows no data for 1985 also). 27 delete comma 1826 1-2 How good is the relationship between precipitation and lake area? Could it also be used to estimate lake area for years prior to 1975 where there is a precipitation record-i.e. an independent verification of part of the reconstruction? 3 the supplement 5 delete comma 6 wetter north and east slopes? 7 on not in 10 contain at least 300 years of record 15 I assume this is perhaps October or November. This raises an interesting question as to whether you estimate lake area for a calendar year (Jan-

Dec) or whether you used an equivalent of the Hydrological year (possibly July-June) - Having seen the data in the supplementary material I guess this doesn't matter. 19 correlation over what period 20 into not in 23 standardize not fit? 25 the signal free 1827 1 footnote bracket? 5-9 and what were the results? What is the EPS cutoff and Rbar values? Should refer to Table 1 here? 9 used 11 of not on 12-15 you carried out several trials e.g. different seasonalizations of lake area, individual months perhaps or just one month (August?)? 14 found 15 et seq. this section needs clarification. Were the two lags used in the final reconstruction? Are they T+1 and T-1? How does leave out one work with lagged predictors? 21-24 invert sentence - The leave out . . .. . . was used to. . .. 26 as not us 1828 4-8 where do you provide the results of these statistical tests? Reference to Figure 2 needed? 12 delete / 13 Fig 3 perhaps? Possibly delete this ref to keep figure refs in order 15 reference to Table 2? 16 within rather than along? 25 dates of extreme events 1829 3-4 reorder. The influence of Pacific sea surface temperatures (?) on lake area fluctuations in the V-C area was estimated by examining the . . . 5 averaged annual what? SSTs? 11 delete The 14 spectral? 15 spectrum or spectra? 1830 3 the or their 5 indices 7 the SSA 13 the regional chronology 14 tree-ring width or just ringwidth? 14 As previously demonstrated (. . .. 24 to capture 1831 3 Fig 2. Figures should be cited consecutively so this should be Fig 3 if you have cited a Figure 2 previously 12 Fig 3b or 2b 15 figure number 19 16th.? The 15th 21 spans most of the 16th century (1504-. . .. 24 high lake area 1832 1 were 3 encompasses 6 begins in the 1930s 8-9 During this 30 year period 1987 was the only year to exceed the long-term historical mean area. 11 A different . . .. changes in lake area 13 periods of lowest lake area 15 The period 1983-2007 is has the smallest 25 year mean and is substantially lower than . . .... 20 delete the sentence similar patterns 21 1857 are similarly the lowest and highest 50 year periods in this 600 year record (Table 2). 23 these results 24-26 the fluctuations have been the lowest or the actual lake areas? 27 delete this sentence? 28 Changes in the occurrence rate. . .. (Fig 4) 1833 1-6 The recurrence interval of extreme events (<20% of the mean area) was between 4-7 years in the 15th -18th century and between 7-15 years in the nineteenth century. It

has steadily increased from ca 6 in the 1930s to 2 in recent years. 10 significantly negatively correlated 17 at an inter-. . .. 1834 1 at a time 3 shows 5 of the nineteenth 6 year 8 over or throughout not along 8 delete around? 10 the 16th, the 15th etc. 17 by not at 19 showing that both records have large. . .. 1835 2 why is the citation to Carilla here? 7 it may be higher but is the lake area reconstruction founded on a stronger calibration data set than the precipitation records? What is the correlation between these two records? Do they share the same chronology predictors? 9-10 is there literature justification for this statement? Would PDSI be comparable to the Lake area parameter or are the data for PDSI lacking? 12 how are these specific intervals defined? 17 how independent are the precipitation PDSI and lake area reconstructions. Are the same chronologies involved? 19 are assumed to be associated? 21 isotope records 29 separated by 1836 1 own=? Individualistic or individual characteristics? Is the proxy record from the silver mines at Potosi any use for comparison? 4 what vegetation index? 8-10 combine these two sentences .. reconstruction indicates that. . . is exceptional over the 1407-2007 period. 11 and the driest 25 and 50 year intervals occur in. . .. . . 14-18 delete first sentence and run on from the paragraph above? 16 that changes from a recurrence interval of . . .. 20 what is oxygen isotopic rate δ18O? 23 seem 26 increasing temperatures or increasing trend of temperatures? 1837 13 analysis reveals or analyses reveal? 15 delete all 16 indices 17 throughout not along 20 period analysed 21 The . . ..strong during the 25 present evidence for 26 from 1700? 28 et seq. simplify- The main oscillatory modes between . . . and . . ...-are similar though negatively related, over the xxx-yyy period 29 indices 1838 1-10 and what are the relationships with precipitation which is also strongly correlated with SSTs? 18 appear 20 period analysed 24 Does it also show the earlier shift ca 1947? 25 evidence 26 from not since? 28 has not have 1839 3 have been documented 7 that the PDO 10 has persisted since 1999. 13 I find it surprising that there is little comparative analysis with precipitation or ENSO reconstructions for the adjacent region based on the same species and possibly some of the same chronologies. How different is the lake area reconstruction from the precipitation reconstruction. This is not to take away

from the lake area reconstruction but are the conclusions about ENSO and PDO any different from those previously identified through precipitation-related reconstructions? 16 provided 26 where the water 29 project 1840 1 presently or present-day not actually 3 don't your results indicate that the last 20-30 years have actually exceeded prior natural variability? Isn't this the value of the present reconstruction? 6-8 possibly but the key will remain the availability of good present day lake data for calibration studies. 18 his help 19 his 20 routine 1841 4 April , 1993, 330-. . . 10 Proc. Not P.? 1842 9 glaciers or a glacier? 20-4 shorten the citation? 1844 11 16°S 1847 is the lowest 25 yr. minimum area correct? 1848 Fig 1 green stars difficult to see Is Vn. Uturunco the name of the lake, mountain and the chronology site? 1849 I find it easier to have the identification of the parts of the diagram BEFORE the description i.e. Figure 2. (a) Observed, etc. 1850 The horizontal orange lines are the means of the periods, not the regime shifts. The regime shifts are difficult to see and could maybe be identified by vertical Arrows above the figure and dates. 1851 Figure 4 caption Changing probability of extreme low values (<20th percentile) from . . .. Caption should indicate how this is smoothed 1853 See comment on labelling components as in Fig 2. Panel last line of caption 1854 (SSA) of reconstructed lake areas (dates) 1855 (SSA) over the 1870-2010 interval.

Supplement Line 1 LANDSAT These data are very sparse only 5/35 years have 8-10 months of data, 27 have 1-3 months of data (15 with 2) and two (1983 and 1985) have none. The record from 1982-1985 has only two months of data. On a monthly basis 20 years have August, 14 have May and 10 have December. This would make it very difficult to see (or correct for) any seasonal pattern. The authors indicate they averaged monthly values to get a yearly average area (and estimated 1983- no mention of 1985). It is difficult to see how, apart possibly for 2005-2009, one could get a reasonable estimate of the annual average. One would imagine that there would be quite a large seasonal variation in lake area in this environment. If this is the case how can one get a reasonable estimate of annual average area from one or two months of data, especially when the months for which data are available vary from year to year- unless, of course,

there is little seasonal variation in lake area? Can some information be provided to assuage these concerns?

How well do these “annual averages “correspond with appropriate precipitation records. Surprisingly scanning the Figure 2 indicates that the residual values have little correlation with the number of months on which the annual average is based. What would happen if you calibrated on the 20 years of August data and estimated (or calibrated estimated annual vs. August total?

Having said this, regardless of the calibration, the analysis of the changes over time, trends, periodicities, etc., in the reconstruction are real and clearly reflect changes in the ringwidth series on which the reconstruction is based. One wonders whether it would be better to reconstruct precipitation from this tree- ring record which could be more strongly calibrated because there is clearly a good relationship with the SST data. Using the satellite data to monitor lake changes and calibrate these against tree rings is a great idea but I would really have to know what the lake data used in the calibration actually represent.

It also would be useful either in the text or supplement to have an indication of the area of the lakes studied i.e. the average size and perhaps extreme annual values.

Interactive comment on Clim. Past Discuss., 11, 1821, 2015.