Response to anonymous referee #2
Our response in blue

General comments. The authors present an explicit means to explore uncertainties which are known but not well-accounted for in the paleoproxy literature, in particular for proxy measurements made in corals and molluscs. To improve the impact of the paper I suggest (1) inclusion of chronological error in the algorithm; (2) additional sensitivity experiments involving more of the proxy calibration parameters; (3) discussion of the results in the context of existing proxy reconstruction uncertainty estimates and interpretations; (4) overall revision for clarity and focus; (5) correction and revision of the code for use in an open source computing environment.

Short responses to suggestions, further discussed in the specific comments:

(1) the influence of the chronological error would be interesting for calendar reconstructions, which is not the aim of this study.
(2) The error related to the proxy calibration is not estimated by Monte Carlo simulation but directly calculated from the calibration dataset. We clarified this in the revised manuscript.
(3) We could not find any mollusk or coral study providing an error bar for paleoclimate statistics (mean or variance) that we could use for comparison. The reconstruction error bar (or precision) mentioned in the articles always refers to single data points.
(4) The manuscript was largely revised for clarity.
(5) The code was translated into R language.

Specific comments.
1. Revise the abstract to focus solely on the results and conclusions of the study; give specific results and conclusions from the exercises performed in support of the manuscript.

We revised the abstract in that way.

2. Revise the introduction (section 1) to clearly identify the novelty and scope of the study. I think this is the development of an code to estimate standard error, systematic error and potential systematic error, via Monte Carlo algorithm, for the high resolution aragonitic paleoproxy archives: corals and molluscs. Alternatively the authors might want to consider making both the algorithm and illustrations more generalized to a broader range of proxy data taken from marine sediments, tree rings, ice cores, and lake sediments.

We revised the introduction focusing more directly on corals and mollusks and being more specific in our aims. It would be very useful to extend the method to a broader range of proxy data. However every type of proxy would require a specific code, specific experiments and discussions that would go far beyond the scope of this article.

3. Structure section 2.1 to better categorize all the potential sources of uncertainty in the interpretation of paleoclimatic data. Given (1) and (2) it may be clearer to revise this section and the introduction to focus more narrowly on the targeted proxy archive (corals and molluscs), rather than the more general question for all categories of proxy data. The authors can then discuss the extension of their approach to other proxies with similar and additional sources of uncertainty.

Section 2.1. was revised to precisely describe the principles of the MoCo analyses and to define precisely all the variables and the types of error. The sources of uncertainty were categorized and described in section 3.

4. Revise the code (section 2.3) to operate in an open-source environment such as Octave (www.octave.org), rather than Matlab, a commercial product. This is easy to do and improves the accessibility of the software to those without Matlab access. On my system MoCo runs a lot slower in Octave than in Matlab, but not impractically so.

The code was translated to be used with the widely used open-source environment R. 2 versions are now available online, one for Matlab and one for R.

5. Revise the MoCo implementation to permit random and systematic chronological uncertainty, for instance in radiometric ("absolute") dating by Th/U or radiocarbon; relative dating from density banding, x-ray fluorescence, cyclical isotopic or minor element chemistry; age model interpolation between tie-points, etc. For the latter, see Chapter 3 of: Ault, Toby R. 2011. The continuum of drought in western North America. Ph.D. Dissertation (191 p), University of Arizona, Dept. of Geosciences. I think including age uncertainty would be a great and novel addition to this tool. Or can such chronological uncertainties be simulated vis-a-vis the existing parameters in MoCo?

We agree that age uncertainty is a very important issue that needs to be addressed. However, this type of uncertainty relates to calendar paleoclimatic reconstructions which are generally performed for the last millennium (Cobb et al., 2003). Age uncertainty would thus affect inter-proxy correlations, but not the estimate of the statistics (mean and variance). Here, as we added in the introduction, our analysis does not apply to this type of calendar reconstructions. We acknowledge in the last paragraph of the discussion the need for additional work to estimate these uncertainties. However, this would require a different and specific version of the MoCo program, several additional experiments and specific discussion, and would thus need a new article focused on that question.
Cobb, K. M., Charles, C. D., Cheng, H., and Edwards, R. L.: El Niño/Southern Oscillation and tropical Pacific climate during the last millenium, Nature, 424, 271-276, 2003.

6. In section 3.1, the algorithm requires a long realistic target time series, and suggests that this be derived from climate models. Discuss the extent to which the results might be biased if the relevant properties of the real climate are different from that of the climate model time series.

This pertinent comment meets the comments of referee#1 on the climate non-stationarity. We stated in section 5.5 that "*The standard and systematic error estimated with the IPSL_CM4v2 GCM Niño1+2 time series are therefore not reliable because the seasonal cycle and the ENSO variability are not correctly represented (Table 2).*"
We further explored this question with a new experiment (exp. 6) that shows that, in a same location, the standard error of the reconstructed statistics increases linearly with the climate variability. The linear relationship strongly depends on the sample size.
The influence of the difference between the true climate and the target time series can be estimated for each statistics from the relationships in figure 7. It appears that the standard error of variances would be much more affected.

This limitation is further discussed in section 6.3 Quantifying errors: contribution and limitations. We propose a method using the value of the reconstructed variance and the relationships estimated by experiment 6 to narrow the effect of this bias o the standard error.

7. Section 4: It would be good to have results and discussion of additional sensitivity experiments that explored the proxy calibration parameters, particularly in Alpha and Beta via R, sigma_T, and sigma_P.

Potential systematic errors from proxy calibration are not estimated by Monte Carlo simulations but are simply calculated on the side using the equations of error propagation given in section 2.1. We clarified this confusion in the text.

8. Some comparison and discussion of the resulting uncertainty simulations, relative to those commonly cited in the literature and mentioned in section 1, would be useful. For example, how much different are the MoCo error bars relative to those, say, from the Cole et al (Science, 1993) Tarawa coral oxygen isotope record? How do those revised uncertainties affect interpretation of that record?

It would be actually very interesting to know how error bars proposed in previous studies would be affected by using our method. However, this was not possible for several reasons:

1. Uncertainties in temperature reconstructions from coral Sr/Ca have been estimated and discussed (De Villiers et al., 1995), but only the error bar of the individual data point are studied. Unfortunately, we could not find any example of a mollusk/coral study where an error bar was given for the paleoclimate proxy record statistics. Tudhope et al. (2001) compared the standard deviation of fossil coral records with the standard deviation of modern corals. They identified the problem of statistical representativeness but only addressed it qualitatively. Cole et al. (1993) does not apply to this case because it is a calendar reconstruction.
2. One of our results is that the standard and systematic errors of the paleoclimate statistics is not only dictated by the proxy but strongly depends on the species and on local environmental features (climate characteristics, local spatial and temporal variability). To parameterize MoCo, many biological and field data are needed that we do not have for other locations.

We added in section 6.1: "*The standard error, as defined here, has never been quantitatively assessed in coral-based studies as far as we know although it may be very large. It means that errors have been so far largely underestimated*."

Cole, J. E., Fairbanks, R. G., and Shen, G. T.: Recent Variability in the Southern Oscillation: Isotopic results from a Tarawa Atoll coral, Science, 260, 1790-1793, 1993.
De Villiers, S., Nelson B.K., Chivas A.R.: Biological controls on coral Sr/Ca and d18O reconstructions of sea surface temperatures, Science, 269, 1247-1249, 1995.
Tudhope, A. W., Chilcott, C. P., McCulloch, M. T., Cook, E. R., Chappell, J., Ellam, R. M., Lea, D. W., Lough, J. M., and Shimmield, G. B.: Variability in the El-Niño Southern Oscillation Through a Glacial-interglacial Cycle, Science, 291, 1511-1517, 2001.

Technical corrections.
1. Abstract: The first four sentences are introductory and can be deleted.
We deleted some of these sentences and focused the others on corals and mollusks.

2. Give results of preliminary experiments and tests in the abstract.
The abstract was revised to be more focused on the results, but specific results related to every uncertainty sources are too numerous be all stated.

3. p. 2480, l 25-6: for an example at the paleoreconstruction stage, see Gergis et al, 2011, Clim. Dyn. in press, available here: http://climatehistory.com.au/publications/
I could not find Gergis et al.(2011), Clim. Dyn. On this web page. There is Gergis et al.(2011), Climatic change, in press, but it did not seem to involve Monte Carlo simulations . Thanks for the interesting reference though.

4. Section 6.4: Some examples of forward modeling of coral oxygen isotopic composition as a function of temperature and salinity are: Brown et al (JGR, 2006), Thompson et al (GRL, 2011).
References were included.

5. The code has some errors (line 8, after line 98) and does not run out-of-thebox in Matlab 7. It can be corrected/revised for use in Matlab 7 or Octave 3.2 (www.octave.org), as follows: (1) line 7: a=load('MoCo_timeseries.txt'); (2) line 8: a=a(:,1); (3) after line 98 and before line 99, add the loop: if length(find(_isnan(ts)))<1, error('The timeseries values are beyond biological limits'); end
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