Clim. Past Discuss., 9, C553–C557, 2013
www.clim-past-discuss.net/9/C553/2013/

Climate of the Past Discussions

Interactive comment on "Inter-annual tropical Pacific climate variability in an isotope-enabled CGCM: implications for interpreting coral stable oxygen isotope records of ENSO" *by* T. Russon et al.

T. Russon et al.

tom.russon@ed.ac.uk

Received and published: 29 April 2013

We are grateful to Dr. Berkelhammer for the constructive review of this MS. The reviewer requests some extra discussion on how to handle the spatial bias within this (or indeed any other) climate model, particularly in the sense of moving forwards towards the use of such analyses in the interpretation of actual coral stable isotope records from single, or multiple locations. We certainly concur with the reviewer that these are very interesting problems and not ones that are readily addressed from the analysis presented in this MS alone. We feel, and it appears that the three reviewers of the MS

largely agree, that the study has sufficient value and novelty (given the paucity of operational isotope-enabled coupled ocean/atmosphere GCMs) as an exploratory 'what-if' study alone. Nonetheless, we agree that the proposal of the reviewer to include an additional short subsection at the end of the discussion section of the MS, which will suggest possible further avenues for a) addressing model bias and b) directly comparing model data to coral records, would be a useful addition. Proposed text for this sub-section is as follows:

Section 3.5 Directions for future work

The structural uncertainty present in the assumption that the HadCM3 realisation of the ENSO phenomenon usefully represents that of the real climate system constitutes an inherent limitation in applying the results of the present study to the interpretation of real $\delta^{18}O_{coral}$ records. Given the likely extent of spatial bias present within the HadCM3 realisation of predicted $\delta^{18}O_{coral}$ ENSO-related variability, it would not be recommended to use the associated $\delta^{18}O_{coral}$-SST relationships (e.g. Fig 3D-F) as surrogates for real coral calibrations. However, the model analysis may still usefully suggest in which regions the absence of such calibrations may lead to relatively small, as opposed to first-order, errors in subsequent SST inferences. On a qualitative level, the present analysis also suggests that combining, at least within any simple linear framework, $\delta^{18}O_{coral}$ records from different regions of the tropical Pacific, in order to reconstruct a particular SST anomaly index (such as NINO3.4) may be challenging. Future work could seek to apply more sophisticated field reconstruction techniques (for example, Emile-Geay et al., 2013a) to the isotope-enabled model output. Comparison of such analyses with those undertaken on SST-only and salinity-derived coral pseudo-proxies would then allow for investigation of whether the inclusion of the isotope processes alters the extent to which the available spatial distribution of real $\delta^{18}O_{coral}$ records affects the capacity of such techniques to reconstruct remote SST indices. From a modelling perspective, in order to better quantify the impact of the spatial biases on the results of the analysis presented here, future experiments could be undertaken with

flux-corrected versions of the CGCM. However, whilst such an approach would act to correct climatological biases in SST, it would not necessarily account for other limitations within the model realisation of an ENSO-like phenomenon. A preferable strategy would be the inter-comparison of a range of isotope-enabled CGCMs, including those with widely differing spatio-temporal manifestations of an ENSO-like phenomenon, an exercise that will only be possible as more such models become available.

Additional reference introduced in the above: Emile-Geay, Julien, Kimberly M. Cobb, Michael E. Mann, Andrew T. Wittenberg, 2013: Estimating Central Equatorial Pacific SST Variability over the Past Millennium. Part I: Methodology and Validation. J. Climate, 26, 2302–2328. doi: http://dx.doi.org/10.1175/JCLI-D-11-00510.1

Dr. Berkelhammer also raises the possibility of including an additional figure to schematically show the intended interpretation of the metrics used in the paper. This is a nice idea and may well help with the readability of the MS. We would propose to include an additional panel in Figure 2 (i.e. a panel C) which shows an x-y plot of the F_{sw} and F_{cov} metrics, with the regions deemed indicative of certain interpretative regions highlighted. This form is favoured over a flow-diagram approach, as suggested initially by the reviewer, as such a figure could become quite complex and involve a large amount of text. A revised form of Figure 2 (with extra panel) is attached and the following text would consitute the additional material in the caption.

Panel C) Schematic guide to the interpretation used in the text of the F_{sw} and F_{cov} metrics, as defined in Equations 2 and 3. The green markers show where the metric values associated with the averages over the three domains highlighted on panels A) and B) plot within such a framework.

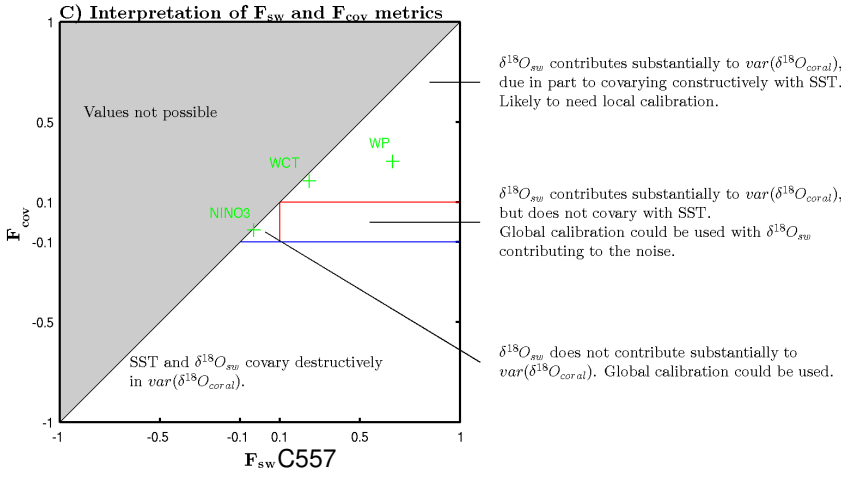
Finally, Dr. Berkelhammer raises a range of minor comments, many of which are purely linguistic and are also covered in the other reviewers. We will address these during the preparation of the revised MS. Regarding the more substantial of these minor comments:

Comment 3) it is, of course, possible to intensify the colorbars on the map plots. However, in the case of Fig 2B and 4A, we consider it desirable for these to be on the same axis as the corresponding other panels, i.e. 2A and 4B, such that one of the points of the figures becomes to illustrate the relatively low amplitude values seen in the former panels relative to the latter.

Comment 4) the empirical isotopic paleotemperature equation is sometimes given with a quadratic term included, but the exponent of this is relatively small. Were such a term to be included the forms of the metric equations (2/3) would become greatly more complex and this is not considered desirable. We would propose to change the phrasing to: "This relationship provides the basis of the standard isotope paleo-temperature equation, shown here in linear form as Equation 1."

Comment 11) the choice of 0-10m is imposed by the depth resolution of the HadCM3 ocean GCM, i.e. this is the uppermost level of the ocean in the model. The use of the average over the top 20m, or indeed greater depths (provided these do not start to intersect the model thermocline) has little bearing on the results as temperature, salinity and $\delta^{18}O_{sw}$ are relatively homogeneous within the mixed layer. The choice of 0-10m is largely motivated by the fact that most coral species of interest for such proxy studies are constrained to live in such a depth range.

Interactive comment on Clim. Past Discuss., 9, 741, 2013.


C) Interpretation of F_{sw} and F_{cov} metrics
Values not possible
WCT
WP
NINO3
SST and $\delta^{18}O_{sw}$ covary destructively in $var(\delta^{18}O_{coral})$.
$\delta^{18}O_{sw}$ contributes substantially to $var(\delta^{18}O_{coral})$, due in part to covarying constructively with SST. Likely to need local calibration.
$\delta^{18}O_{sw}$ contributes substantially to $var(\delta^{18}O_{coral})$, but does not covary with SST. Global calibration could be used with $\delta^{18}O_{sw}$ contributing to the noise.
$\delta^{18}O_{sw}$ does not contribute substantially to $var(\delta^{18}O_{coral})$. Global calibration could be used.
F_{cov}
F_{sw}C557
1
0.5
0.1
-0.1
-0.5
-1
-1
-0.5
-0.1
0.1
0.5
1