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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.

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We are grateful to Dr. Thompson for the considered review of this MS and in particular for raising the interesting question as the extent to which the regional Sea Surface Salinity (SSS) and $\delta^{18}O_{sw}$ relationships seen within the unforced isotope-enabled HadCM3 simulation are stable through time. The stability analysis approach presented for the metrics used by the main part of the study in figure 6 can be replicated for the slope of the $\delta^{18}O_{sw}$ - SSS regression relationships and this provides one way to address these questions. We concur with Dr. Thompson that these considerations

are coherent with the material presented in the study and also that such analysis has potentially useful implications for the field of model pseudo-proxy work. What follows is a proposed new figure (Fig 8, attached) showing the temporal regression slopes on the regional and tropical Pacific scales and also the spatial slopes over the tropical Pacific, using the same 50year chunking approach seen in Fig 6, with additional textual material for Section 3.4 of the MS. We will be guided by the editor as to whether the inclusion of the proposed figure is a desirable addition or whether the description of the results is sufficient alone.

Caption for Figure 8:

Fig. 8. Values of the $\delta^{18}O_{sw}$ - SSS temporal regression slopes calculated using the spatial averages over the Warm Pool, Western Cold Tongue (WCT) and NINO3 boxes, as well as the entirety of the tropical Pacific domain (30°S to 30°N and 120°E to 70°W), using both the entire 750 yr of model simulation data (black dots) and also this same data split into fifteen non-overlapping 50yr intervals (grey dots). Also shown is the spatial regression slope calculated using the means (over either the entire simulation or the 50year chunks) of the two variables over all the model grid squares within the tropical Pacific domain. The locations of the box regions are shown on Figures 2/4. The green reference line shows the 0.27 permil/psu value for the spatial Tropical Pacific slope of LeGrande and Schmidt, 2006.

Text for Section 3.4 (beginning at Page 761, line 15):

To evaluate the stability of the temporal and spatial $\delta^{18}O_{sw}$ - SSS relationships, the same analysis undertaken on the F_{sw},F_{cov},$RMSE_{10}$ and $RMSE_{90}$ metrics in Figure 6 was also replicated for the $\delta^{18}O_{sw}$ - SSS regression slopes. In the case of the WP, WCT and NINO3 regional temporal slopes, the range of the values calculated within the non-overlapping 50year chunks is sufficient to overlap with those calculated for the temporal slopes of the data averaged across the entirety of the tropical Pacific (Fig 8). However, all of these ranges remain distinct from that of the associated spatial slope calculated across the tropical Pacific domain model grid-squares, with the latter term being very stable across the 50year intervals. Consequently, whilst the regional differences in temporal slope seen across the entire model simulation might have been interpreted somewhat differently within any given 50year interval, the observation that many of these values differ from the associated tropical Pacific spatial slope is likely to remain robust to such sampling. Furthermore, the inter-chunk ranges of all the model temporal and spatial slope values remain considerably lower than that derived from the spatial regression of the available instrumental data (LeGrande and Schmidt, 2006). The observed variability in the temporal regression slopes between the different 50year intervals may have arisen through sampling uncertainty within the noise associated with these relationships within a stationary climate and/or non-stationary changes in the $\delta^{18}O_{sw}$ - SSS relationships through time. The range of the temporal regression slopes amongst the non-overlapping 50year chunks does not significantly exceed what would be expected through sampling uncertainty around the whole record values within a stationary climate, provided that the assumed decorrelation time of the tropical climate system exceeds 9months (not shown). This result does not mean that the temporal relationships are necessarily stationary on this (or indeed any other) time-scale, simply that the range of slopes seen for that one time-scale is not inconsistent with the sampling uncertainty associated with regression noise within a stationary system. Such an outcome suggests that unforced multi-decadal changes in processes that affect $\delta^{18}O_{sw}$, but not SSS, such as changes in precipitation moisture source regions, are likely to be relatively unimportant compared to those processes which affect both variables (such as the regional precipitation/evaporation balance). This provides further support, in the context of the model climate, for the underlying principle of the salinity pseudo-coral approach. However, the relatively noisy nature of many of the regional scale temporal $\delta^{18}O_{sw}$ - SSS regressions means that records of multi-centennial duration are likely to be necessary to robustly establish their slopes. Conversely, the discrepancy between the instrumental and HadCM3 spatial slopes cannot be attributed to such temporal sampling uncertainty and must arise from spatial sampling uncertainty

in the former and/or model bias issues.

Dr. Thompson also raises quite a few minor/structural comments, which are very constructive and which we are happy to implement as suggested in the final revision stage. We are greatly indebted to Dr. Thompson for taking such care and time to produce such a detailed and thorough review in this regard. The only points upon which we would like to reply to directly are as follows:

Page 752, line 16-18) We suspect the tongue of relatively negative F_{cov} values extending eastwards from PNG relates to a dipole effect caused by N/S movement of the model SPCZ during ENSO events. Whilst interesting in principle, the absolute F_{cov} values remain sufficiently small as to be relatively unimportant compared to F_{sw} (as is indeed the case for the entirety of the western Pacific). Given that we seek to focus on first order features, to minimise the limitations of the spatial biases in the model (which this would also be subject to), we don't think additional discussion of this feature would add useful content to the MS.

Page 755, line 5-10) In principle, yes, the d18Osw-SST relationships may contribute to the spatial variations seen in $\delta^{18}O_{coral}$-SST, as per Evans et al 2000, although local and/or biological factors (which the model cannot resolve) may also be important. We would propose simply to add an additional sentence at this point stating that: " This effect could potentially account for some of the observed spatial variability in $\delta^{18}O_{coral}$-SST calibration relationships (Evans, 2000)".

Page 761, lines 15-29) We entirely agree with this comment, it is certainly not our intention to suggest that the HadCM3 climate yields the 'true' value of any term, including the spatial SSS-$\delta^{18}O_{sw}$ slope. We had thought however, that the use of the phrasing: "... than the true (in the sense of the isotope-enabled model) value in the case ... " made it sufficiently clear that the term 'true' would then be used in that sense throughout. Nonetheless, for clarity we propose to replace 'true' with 'true value observed in the HadCM3 model' throughout this paragraph. As the reviewer says, given that models may disagree substantially on this term and the instrumental estimates are subject to large uncertainties, the really interesting issue is that we arguably have no way of establishing what the 'true' value actually is.

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

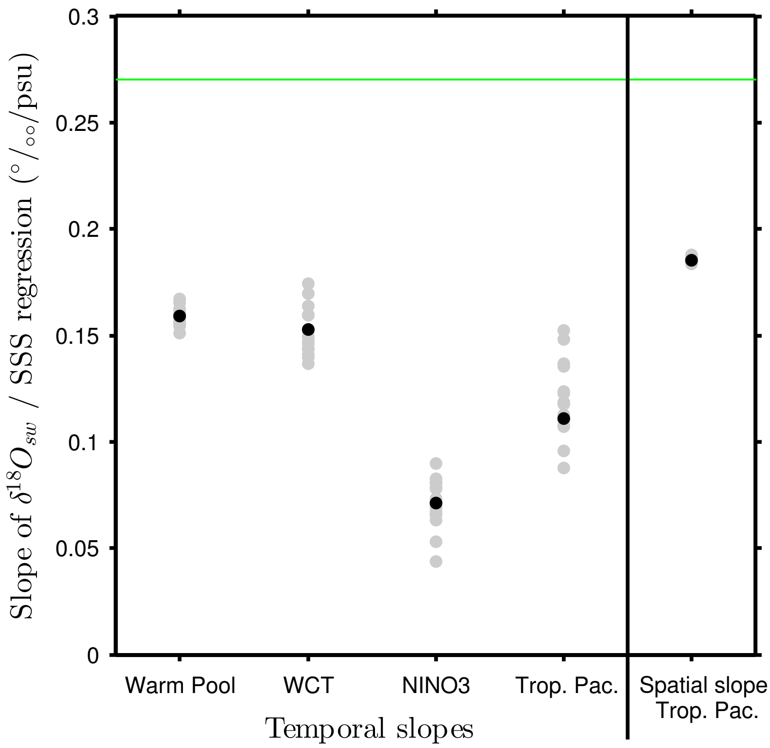

Fig. 1. Proposed form of Figure 8