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Climate of the Past Discussions

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Interactive Comment

Interactive comment on "Madagascar corals reveal Pacific multidecadal modulation of rainfall since 1708" *by* C. A. Grove et al.

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Reply to reviewer comments

Overall quality: The reviewer has two major concerns regarding our data.

1) The reviewer indicates we need to demonstrate that coral records share a common signal on inter-annual timescales.

We can provide a table demonstrating the significant relationships between corals on interannual timescales. An example is shown below (Table A). All coral records are significantly correlated on interannual timescales with the exception of MAS3 and MASB.

2) The reviewer indicates that the shared signals need to be shown to have a climatic

or environmental interpretation.

We provide substantial evidence suggesting a link between the PDO and our coral proxies. Various robust statistical approaches, such as spectral analysis, wavelet analysis and trend break analysis, are applied to our data, all indicating a climatic link.

Although the correlation of G/B data with the best available rainfall record, which comes from a station 200 km south of Antongil Bay, is rather low with R= 0.3, it is shown to be statistically significant over a 100 year period as published in Grove et al. (2010). In the same paper, the sparseness of rainfall data in Madagascar is documented, and provides reasoning for using a station record 200 km away from our study site. Nevertheless, we now demonstrate that the cores share a significant amount of variance on interannual time scales (Table A).

The reviewer suggests that there are sufficent high-quality rainfall data for the western Indian Ocean available, yet does not provide the source of such data. We are not aware of any bias-free rainfall dataset for Madagascar. We have compared various rainfall reconstructions and gridded data products such as NCDC and CRU rainfall data with TRMM data and found clear differences between datasets. We therefore decided the longest observational record documented for Madagascar, from the capital Antananarivo, was most suited for this study, to provide an assessment of long-term rainfall change between 1900-1985 and to show that the mid-20th century peaks in coral G/B (deforestation) are not realted to rainfall.

Not only are the rainfall data products inconsistent for our region, it is difficult to calibrate G/B with CRU rainfall when G/B is also influenced by deforestation. For this reason annual average MASB G/B shows a low significant correlation with CRU rainfall ($R = 0.232$; $P = 0.017$; $N = 105$), as well as annual average MAS1 Ba/Ca ($R = 0.231$; $P = 0.019$; $N = 102$). All other cores (MAS3 G/B, ANDRA G/B, MAS1 G/B and MAS3 Ba/Ca) are not significantly correlated with CRU rainfall.

Specific comments:

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Lines 9-10 This is the first paper linking specifically the PDO to rainfall in the western Indian Ocean. Deser et al. (2004) and Reason & Rouault (2002) point to ENSO-like decadal variability and/or PDO influences on SST.

Lines 67-69: The method of dating coral cores can be found in Grove et al. (2010). We can refer to that more clearly in the revised version.

Line 75: Growth rate was determined by measuring the distance between density minima for any given year, using the program CoralXDS (Helmle et al., 2011).

Line 81-82: We will provide a better reference for humic acid relations to luminescence lines, i.e. Susic and Boto, 1989; Susic et al., 1991; Matthews et al., 1996; Isdale et al., 1998; Wild et al., 2000.

Line 90-91: We will adjust the starting dates accordingly.

Line 91: Our paper does not discuss correlations with SST. This is beyond the scope of the current paper. We aim to illustrate that multi-decadal Sr/Ca signals also track the PDO using the same filter as for river runoff proxies and the PDO. We use this as additional information to support our case.

Line 92: We will re-formulated the sentence to "indicator for suspended sediment runoff"

Lines 95-96: We agree with the reviewer on clarifying the link between Mn and ash fallout from slash-and-burn deforestation.

"Mn is an indicator for biological activity in seawater (Abram et al., 2003; Wyndham et al., 2004). Fallon et al. (2002) and Alibert et al. (2003) proposed two possible mechanisms for the seasonal cycle in Mn/Ca. An increase in the photoreductive dissolution of suspended particulate Mn oxides, which increases in spring with increasing solar radiation (Fallon, 2000; Alibert et al., 2003); or alternatively, a diagenetic release of Mn at the seawater sediment interface as a result of reducing conditions induced by decaying organic matter produced in spring and summer (Alibert et al., 2003). The latter

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process is what we infer for our Mn spikes, related to the intense deforestation periods (Abram et al., 2003; Wyndham et al., 2004). High Mn levels are associated with decaying organic matter following ash fallout from wildfires, which promote phytoplankton blooms (red tides). As the organic matter decays with time it produces reducing conditions, subsequently increasing seawater Mn concentrations. In the MAS1 and MAS3 records, temporally aligned G/B increases at the same time as Mn/Ca (without a marked increase in Ba/Ca), which is consistent with the massive addition of organic matter after documented periods of high slash-and burn deforestation."

Line 99: We will provide further references to instrumental data used in the present study. The statistical methods have already been described in the paper and the Appendix.

Line 115: We will refer to Table A to demonstrate the significant shared interannual variance between coral records. We used the MASB record only for the correlation with the tree ring based PDO reconstructions because we were interested in the coherence beyond the 20th century. The 20th century signals in G/B and Ba/Ca has been overprinted by deforestation in any of the 4 single coral records and cannot provide a clean picture on the relationship with the PDO. Since only MASB extends beyond the 20th century, we can only use that record to establish the teleconnection with the PDO.

Lines 116-128: Please see the above response and Table A on the climatic link of our coral records with the PDO.

The D'Arrigo PDO reconstruction is a high-quality record that combines many single long-term records for a large-scale representation for the PDO.

Line 151: We believe that we guide the reader through the analysis and provide sufficient explanation for the presentation of our results.

Lines 493-505: We will repeat the analysis with the 5% significance level.

Lines 518-533: The 10-year running means are applied in order to make the figure

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readable and to omit high-frequency noise. The 10-year running mean is simply chosen for illustrative purposes and not to highlight a particular decadal frequency.

Line 550: Redundant since we describe it in the Appendix.

Lines 565-570: The global rainfall dataset is used to verify whether the PDO relationship we infer do indeed appear as spatial correlation patterns.

Other specific comments which are not addressed here will be changed along the lines the reviewer suggested in the revised version of the manuscript.

References

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Interactive comment on Clim. Past Discuss., 8, 787, 2012.

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	G/B	Ba/Ca
MAS1 vs. MAS3	R = 0.430; P <0.001; N = 71	R = 0.656; P <0.001; N = 71
MAS1 vs. ANDRA	R = 0.627; P <0.001; N = 92	
MAS1 vs. MASB	R = 0.546; P <0.001; N = 102	
MAS3 vs. ANDRA	R = 0.568; P <0.001; N = 71	
MAS3 vs. MASB	R = 0.129; P = 0.284; N = 71	
ANDRA vs. MASB	R = 0.467; P <0.001; N = 92	

Table A. Correlations of annual average G/B and Ba/Ca between coral records. Correlations are calculated using the maximum number (N) of years shared between corals.