

Interactive comment on “Southwestern Tropical Atlantic coral growth response to atmospheric circulation changes induced by ozone depletion in Antarctica” by H. Evangelista et al.

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1. Anonymous Referee #3: “. . . I felt the processes linking ozone depletion to changes in SSTs at the coral site could have been analysed in far more detail and there isn't a great deal of original research in the paper outside of the coral data. This is a shame because, like reviewer #2 I think there is an interesting hypothesis to be tested here.”

Authors : In fact the literature has a great number of publications dealing with the relation coral growth versus SST. Progresses have been made concerning the mechanism explaining the coral response both physiologically and at the molecular level. We have provided references that are dedicated to this issue. So we do not see the necessity

C8280

of exploring this explanation. As “Ideas and Perspectives”, we are addressing to the community a new parameterization to be taken into account while dealing with coral living in the tropics. A description of the whole mechanism linking the ozone depletion in Antarctica and marine biological response at the tropical Atlantic also needs more databases, therefore we avoided using more and more model outputs.

2. Anonymous Referee #3: “. . . Conclusions: most of the conclusions section is actually discussion and needs to be labelled as such. I found it very difficult to read as it lacks a coherent logic and flow. Figures 2 and 3 have several sections but not all of them are mentioned explicitly in the text and therefore it's difficult to know what point the authors are trying to make with them. Each panel should be referenced in the text together with why what they are showing is important.”

Authors : The referee is correct. We reorganized the discussion and conclusion topics so to try a better text flow. In Figure 2, we have specified each section of it in the text, labeling Figure 2a, Figure 2b, etc In Figure 3, sections 3c and 3e were already mentioned in the text. Sections 3a, 3b and 3d were properly introduced.

3. Anonymous Referee #3: “. . . Figures 3a/3b: There are many papers (including Marshall 2003 that the authors cite in this manuscript plus Hines et al. 2000; Bromwich et al. 2007 etc) that clearly demonstrate that NCEP reanalysis data at SH high latitudes are essentially rubbish before 1979. Thus, the results for high latitudes shown in Figure 3a/3b are also rubbish. Unfortunately, all reanalyses are poor in this region before 1979, which is when satellite sounder data over the Southern Ocean first became available to be assimilated into numerical weather prediction models. Before that there are no data to constrain them. It also doesn't state how far back the NCEP data go that you use (1948?). Having said that it's not at all clear what information I'm supposed to be taking from Fig. 3a/3b that's directly relevant to the corals anyway; it may well be that at the much lower latitudes of the coral site then the NCEP data is fine?”

Authors : Although data before 1979 should be seen with caution, and we agree com-

C8281

pletely, a compilation the authors performed in a previous paper, using only surface wind data from several stations around Antarctica, have shown a similar trend. I recommend see the paper below. It means that although NCEP data outputs may already fail in some regions, mainly where databases are scarcer, maybe in the large scale scenario it would work better. Additionally if we consider the mineral dust time series retrieved from ice cores around Antarctica (a proxy of wind speed around Antarctica) we also see a transition (increase of mineral dust) by the end of the 70's decade. It is an indication of increasing resuspension from semi-deserts around Antarctica.

Ref. : Cataldo et.al. Mineral dust variability in central West Antarctica associated with ozone depletion. *Atmospheric Chemistry and Physics (Online)*. , v.13, p.2165 - 2175, 2013.

4. Anonymous Referee #3: "...One aspect the authors do not address is the seasonality of the ozone hole, which only occurs in austral spring, with its effects on the surface circulation likely being limited to the summer. Although the SAM has also become more positive in fall this is generally not thought to be driven primarily by ozone loss and is more likely to reflect intrinsic climate variability. It would be interesting to see how long the effect of the ozone depletion took to impact the SSTs at the coral site by looking at seasonal or monthly data SST/wind stress data. This may also help explain the exact mechanisms involved, which are currently just described with no analysis done other than basic correlations. If the current 'Conclusions' becomes 'Discussion' then it would still be useful to have some conclusions taken from the original work in this paper too."

Authors : Although the ozone depletion data is of monthly resolution, coral growth data is of annual resolution. Growth patterns of tropical corals are basically during the summer season (with higher growth rates) and the winter season (lower growth rates). Therefore we believe that corals at the tropical Atlantic may capture changes in the Southern Ocean wind structure, mainly if they occur in the summer. With respect the "Conclusions" we reviewed the issue and we agreed with the referee.

C8282

5. Anonymous Referee #3: "... Page 13195, Line 2: could be changed to something like 'Recent Southern Hemisphere (SH) atmospheric circulation, predominantly driven by stratospheric ozone depletion over Antarctica, has caused changes in climate across much of the extra-tropics.'"

Authors : We agree with the referee and the suggestion was accepted.

6. Anonymous Referee #3: "...Page 13195, Line 14: the Marshall (2003) reference is not appropriate in the context of corals."

Authors : We agree completely. The reference was removed in that context.

7. Anonymous Referee #3: "...Page 13196, Line 15: impact of GHGs more to do with circulation changes rather than, specifically, any increase in temperatures; e.g. much of Antarctica has cooled in response to the more positive Southern Annular Mode (SAM) that partly results from increasing GHGs"

Authors : We agree partially. Firstly GHGs has to do with increase in temperatures. In case of the Antarctic continent, it seems to be more complicated since West Antarctica and East Antarctica have different temperature trends in average. We have changed the sentence "...One of the most pronounced changes is the poleward displacement of the Southern Hemisphere westerly jet, which has been accompanied by a poleward shift and intensification of oceanic circulation (Thompson et al., 2000; Hartmann et al., 2000). These changes have been attributed to external factors such as increased air temperature due to greenhouse gases (GHG) and the Antarctic ozone depletion." to :

"...One of the most pronounced changes is the poleward displacement of the Southern Hemisphere westerly jet, which has been accompanied by a poleward shift and intensification of oceanic circulation (Thompson et al., 2000; Hartmann et al., 2000). These changes have been attributed in part to external factors such as increased air temperature due to greenhouse gases (GHG), but also to the Southern Annular Mode (SAM) variability enhanced by the Antarctic ozone depletion."

C8283

8. Anonymous Referee #3: "...Page 13196, Line 21: the Zazulie et al. (2010) reference is not the right one to cite here: use one or more of Polvani et al. (2011), Thompson and Solomon (2002) and Thompson et al. (2011)."

Authors : We agree with the referee and have changed the reference Zazulie et al. (2010) to Thompson et al. (2011).

9. Anonymous Referee #3: "...Page 13196, Line 25: change 'by' to 'using' "

Authors : We agree with the referee and have changed.

10. Anonymous Referee #3: "...Page 13196, Line 26: Change 'They' to 'Kang et al. (2011)' and remove reference from later on in the sentence"

Authors : We agree with the referee and have changed.

11. Anonymous Referee #3: "...Page 13197, Line 11: Change 'combined here' to 'here combine'"

Authors : We agree with the referee and have changed.

12. Anonymous Referee #3: "...Page 13197, Line 13: Give a lat/long for the Abrolhos National Park"

Authors : We agree with the referee and have provided the coordinates.

13. Anonymous Referee #3: "...Page 13198, Line 24: Here you introduce the PDO without explaining anything about what it is and why you are interested in seeing how it might affect coral growth and indeed which PDO dataset you use"

Authors : We agree with the referee and have inserted a brief text. We changed the sentence "PDO data is available at <http://www.jisao.washington.edu/aao/>." to :

"PDO data is available at <http://www.jisao.washington.edu/aao/>. PDO is a robust, recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude Pacific basin, which influences a significant part of the globe, especially South America.

C8284

It is a long-lived (at decadal scale) El Niño-like pattern of the Pacific climate. This parameter was considered here, since previous works have detected El Niño-like signals on growth rate of tropical Atlantic at Abrolhos, Evangelista et al. (2007)."

New Reference :

Evangelista, H., Godiva, D., Sifeddine, A., Leão, Z.M.A.N., Rigozo, N.R., Segal, B., Ambrizzi, T., Kampel, M., Kikuchi, R., and Le Cornec, F.: Evidences linking ENSO and coral growth in the Southwestern-South Atlantic. *Climate Dynamics*, 29: 869–880, 2007.

14. Anonymous Referee #3: "...Page 13199, Line 4: The ozone hole has not been gradually recovering since the implementation of the Montreal Protocol in 1989. It got significantly worse during the 1990s (as indeed is shown in Fig 3d) and has only just begun (arguably) to recover; e.g. I think 2015 was the fourth largest ozone hole on record according to NASA Figure 2: Surely the figures should go from a to e top to bottom? Also only Fig 2d is mentioned in the text. All need to be described or removed if not necessary"

Authors : We agree with the referee. From the figure bellow (Figure A) it is possible to see that the gradual ozone depletion recover occurred just from the begging of the XXI century (almost 10 years after the implementation of the Montreal Protocol in 1989). We have changed the sentence. In Figure 2, we cited all "annual growth anomaly" missing in the text.

FIGURE A

15. Anonymous Referee #3: "...Page 13200, Line 5: Again, the AMO is introduced without any reason given as to why it might affect Brazilian corals. All it says is that it reflects a warming of North Atlantic SSTs"

Authors : We agree with the referee and have removed the sentence and the associated reference..

C8285

16. Anonymous Referee #3: "...Page 13200, Line 9: I couldn't find anything about a 'significant increase in the westerly winds by the end of the 1970s' following a quick glance through the Polvani et al. (2011) paper although I may have missed it. But, significant compared to what? If you assume the SAM approximates to the strength of the westerly winds then the Marshall SAM data suggest that the winds around about 1960 were on average stronger than the end of the 1970s. Basically, I don't think there is a change in the SAM that matches the decline in wind anomalies in Fig 3e."

Authors : Maybe the terminology "significant increase" would be too much since no work has made a detailed statistical analysis to demonstrate the "significance" of the change. We removed the term "significant". Nevertheless, there is a number of papers that support an existing increase of the westerlies (the same for cyclonic energy) by the end of the 1970s over the Southern Ocean. A change in SAM is also demonstrated by Thompson and Wallace (2000) as depicted in the figure below (FIGURE B). What is pointed in Figure 3e is not the wind decline but its change in direction.

FIGURE B

Ref. : Thompson, D. W. J., and J. M. Wallace, 2000: Annular modes in the extratropical circulation. Part I: Month-to-month variability. *J. Climate*, 13, 1000-1016.

17. Anonymous Referee #3: "...Page 13200, Line 10: Most researchers now use the SAM rather than AAO. As this paper demonstrates clearly, the SAM impacts a much greater region than simply Antarctica."

Authors : We agree, but our analysis are set on ozone variability.

18. Anonymous Referee #3: "...Page 13200, Line 13: The Marshall SAM index is updated monthly. I suspect the authors are looking at an old website as it does seem to change from time to time. The current website for this dataset is: <https://legacy.bas.ac.uk/met/gjma/sam.html> It's not clear to me whether this dataset is used as the 'ozone depletion area', which is mentioned later on in the paper, or is

C8286

that something different?."

Authors : In the text, we make some comments on SAM index variability but we not use it at ell. So, we decided to simplify the sentence : "The AAO index data is an observation-based Southern Hemisphere Annular Mode index (<http://www.antarctica.ac.uk/met/gjma/sam.html> - last revised in October, 2011) derived from 12 stations around Antarctica to derive the zonal means from 40°S to 65°S (Marshall, 2003)." to :

"The AAO index is the dominant pattern of non-seasonal tropospheric circulation variations south of 20°S and is an observation-based Southern Hemisphere Annular Mode index used to derive the zonal wind means from 40°S to 65°S (Marshall, 2003)."

19. Anonymous Referee #3: "...Page 13200, Line 17: There is too much written about the increase in the westerlies at high latitudes here. Surely the authors should be focussing on the more important factor for this research, which is the increase in the easterly component of the winds at mid-latitudes (30-40S) that is also associated with the ozone depletion (more positive SAM)?."

Authors : From the ozone depletion in Antarctica to coral growth response in the tropics several steps and a sequence of facts are involved and much is needed to better explain this complex teleconnection process. Therefore we concentrated attention only in the postulated cause and the effect.

20. Anonymous Referee #3: "...Page 13200, Line 26: Change 'seaside' to 'coastal'

Authors : We have made the change.

21. Anonymous Referee #3: "...Figure 3: the Cataldo et al. (2012) reference doesn't appear in the main list of references."

Authors : We have provided the reference. The correct is Cataldo et al. (2013):

Cataldo, M., Evangelista, H., Simões, J.C., Godoi, R.H.M., Simmonds, I., Hollanda,

C8287

M.H., Wainer, I., Aquino, E.A., Van Grieken, R.: 2013. Mineral dust variability in central West Antarctica associated with ozone depletion. *Atmospheric Chemistry and Physics*, 13, 2165 – 2175.

22. Anonymous Referee #3: "...Page 13201, Line 18: although the Hadley Centre HadISST is certainly widely used, there are other SST databases available. If you are going to claim that HadISST is the best then you at least need a reference to justify this statement.'

Authors : We agree with the referee and have provided the reference :

New Reference :

Rayner, N.A., Parker, D.E., Horton, E.B., Folland, C.K., Alexander, L.V., Rowell, D.P., Kent, E.C. and Kaplan, A.: 2003. Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *J. Geophys. Res.*, 108(D14), 4407.

23. Anonymous Referee #3: "...Page 13202, Line 7: I think the reference to Fig. 5 here should actually be Fig. 4.'

Authors : We have corrected that.

24. Anonymous Referee #3: "...Page 13202, Line 10: Similarly, I think Fig. 4 should be Fig. 5"

Authors : We have corrected that.

25. Anonymous Referee #3: "...Page 13203, Line 16: Ozone recovery is only likely to push the SAM more negative in austral summer: models suggest that whether it does or not will depend on the amount of GHGs emitted, as the authors allude to."

Authors : We accepted the referee comment and have omitted the sentence : "However, GHG concentrations will continue to rise and that could override the trend reversal in coral growth due to the ozone recovery."

C8288

25. Anonymous Referee #3: "...Comment on Reviewer #2's comments I disagree with the assertion that the westerly wind changes would have occurred with or without the ozone loss. The fact that there are no significant trends in the SAM in austral winter or spring, when there is no ozone effect, suggests that this may not be the case. Modelling and empirical statistical studies have compared the relative impact of the two forcings and ozone is always found to have had a far greater effect (e.g. Polvani et al. (2011) suggest it is 2-3 times larger). Thus, in my opinion, I think the title is fine as it stands.. "

Authors : We agreed with referee 3 and we maintained the title as it is.

Interactive comment on *Biogeosciences Discuss.*, 12, 13193, 2015.

C8289

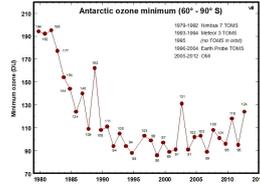


Fig. 1. Lowest value of ozone measured by TOMS (Total Ozone Mapping Spectrometer) each year in the ozone hole.

C8290

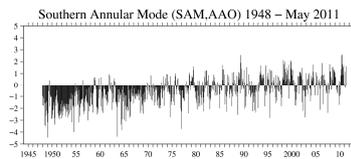


Fig. 2. Leading PC of NCEP-NCAR reanalysis sea-level pressure anomalies, 20-90S, for 1979-2010. The spatial pattern was then projected onto the entire record, and the time series standardized with respect to

C8291