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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Response of the Antarctic stratosphere to warm pool El Niño Events in the GEOS CCM" *by* M. M. Hurwitz et al.

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Re: ACP–2011–170 ("Response of the Antarctic stratosphere to warm pool El Niño events in the GEOS CCM")

We kindly thank this reviewer for his/her helpful comments. Our responses directly follow each comment.

M. M. Hurwitz and co-authors

A Title:- There is not a single plot/analysis of any chemical species, so is it really CCM study or GCM study?

We agree with the reviewer that this is a purely dynamical study. We analysed GEOS chemistry-climate model simulations, however, as reflected in the title. The model output is currently being used to examine the impact of WPEN events on Antarctic ozone.

B Authors argue enhanced planetary wave driving during WPEN events leads to warmer temperatures in Antarctic stratosphere and is well captured in model simulations. However, on page 18 (Table 2) MERRA data shows 40-50% increase in eddy heat fluxes during WPEN events, whereas model doesn't show significant difference in eddy heat fluxes for WPEN and ENSON events. And although authors try to provide some additional proofs in Figure 4, 5 and 6, it is difficult to believe that simulated response is real. Wave forcing depends on three different mechanism, wave generation, wave propagation and wave breaking. Authors need to show some additional analysis to argue that simulated response is indeed due to enhanced wave breaking (for e.g eddy heat flux- temperature relationship shown in Newman et. al. 2001). Including some analysis from transient run (e.g. CCMVal REF1 run), would be also a good idea to show what happens to eddy momentum flux (u'v') (and/or EP Fluxes).

We have added revised Figure 3, a scatter plot showing the strong correlation between eddy heat flux and temperature. The steeper slope of the (red) line of best fit suggests that the model is more sensitive to changes in eddy heat flux than is the real atmosphere (black line). In MERRA, both the mean heat flux magnitude and mean temperature are larger in WPEN/QBO-E than in the ENSON composite. Similarly, in the GEOS CCM, both the mean heat flux magnitude and mean temperature in the WPEN simulation are larger than in the ENSON simulation. These findings are consistent with our argument that the relative increase in eddy heat flux during WPEN events leads to an enhancement of temperatures in the polar lower stratosphere in November/December.

Figure A (FOR REVIEW PURPOSES ONLY) shows a reduction in eddy momentum flux (i.e., more planetary wave breaking) at SH high latitudes in October/November, in

ACPD

11, C7684–C7695, 2011

the WPEN simulation as compared with ENSON.

The CCMVal REF-B1 simulation was run with an earlier version of the GEOS CCM that had (1) no internal QBO and (2) a poor representation of the SPCZ, so the SH response to WPEN events was poorly simulated. Thus, we do not think it is useful to show any results from this simulation.

C Author select year 1991 and 1994 to create boundary conditions for the simulations. But these years are close to Pinatubo eruption (specially year 1994), which caused significant changes in tropospheric and stratospheric circulation (Robock, 2000). So authors need to caution the readers about selection of these years.

The Mt. Pinatubo eruption may have affected atmospheric conditions in late 1991 and early 1992 (Robock, 2000; Yang and Schlesinger, 2002). To our knowledge, there is no strong evidence of volcanic effects on the SH atmosphere in 1994-1995. Since the atmospheric response to the 1991-1992 WPEN event was similar to the response to the 1994-1995 WPEN event, we conclude that the impact of the Mt. Pinatubo eruption on the response of the Antarctic stratosphere to the 1991-1992 WPEN event was likely negligible.

We have added a comment on the possible volcanic effects on the response to the 1991-1992 WPEN event in Section 3.2 of the revised manuscript.

Yang, F., and Schlesinger, M. E.: On the Surface and Atmospheric Temperature Changes Following the 1991 Pinatubo Volcanic Eruption - A GCM Study, J. Geophys. Res., 107(D8), 4073, doi:10.1029/2001JD00037, 2002.

D Page 8:- line 17 and page 9, line 8, Does it mean “Holton-Tan mechanism” is not valid for MERRA and model simulations? Again using transient run, authors can show that Holton-Tan mechanism is well represented.

The Holton-Tan mechanism relates the phase of the QBO to changes in planetary wave forcing, and in turn, to changes in the strength of the Arctic vortex in mid-winter. At the

ACPD

11, C7684–C7695, 2011

16th Conference on Middle Atmosphere ("QBO Influence on Polar Stratospheric Variability in the GEOS CCM", Hurwitz et al., 2011), we reported that this same formulation of the GEOS CCM simulates the Holton-Tan relation. That is, the phase of the zonal wind QBO and polar lower stratospheric winds are strongly correlated in the Arctic (and weakly correlated in the Antarctic) in mid-winter.

In the present paper, we found that the Antarctic stratosphere is insensitive to the phase of the QBO in a specific case: in October/November and during ENSO neutral years. The MERRA reanalysis and the ENSON simulation yielded the same conclusion.

1 Page 2, Line 1- Abstract:- First sentence is very long(more than 60 words).

We have divided this sentence in two.

2 Page 2, Line 23 – "OLR?" and again very long sentence.

We have shortened this sentence and removed the reference to OLR.

3 Page 3, Line 20-30, again very long sentences.

We have revised the structure of this paragraph.

4 Page 6, line 27, reference?

We have added a reference to Molod et al. (2011).

5 Page 9, line 10, "warming" or "final warming?"

"Warming" i.e., enhanced temperature. Enhanced planetary wave driving in October/November increases the temperature of the Antarctic stratosphere in November/December (and also hastens the breakup of the vortex i.e., the final warming).

6 Page 11, line 24, 5 days! Where?

We have removed our comment about the impact of WPEN events on the breakup of the Antarctic vortex. We will discuss the relationship between ENSO and the breakup date in more detail in a future paper.

ACPD

11, C7684–C7695, 2011

7 Figure 1. Again is it possible to add plot showing temp, wind, eddy heat flux differences between two simulations?

Yes. Please see the revised Figure 1.

8 Figure 2, 3, 4, 5, 6 – Non-linear colour scheme is very confusing. I think it would be good idea to have labelled contour, and shaded regions showing 90% and 95% significance.

We have changed the contouring scales for revised Figures 2, 4, 6 and 7. We have kept the non-linear scale in revised Figure 5 to emphasize the planetary wave structures.

9 Figure 4(a and b)- Is it from MERRA or from NCEP as in caption.

In revised Figure 5, we compare the modelled results with the MERRA reanalysis. We have fixed the caption accordingly.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 9743, 2011.

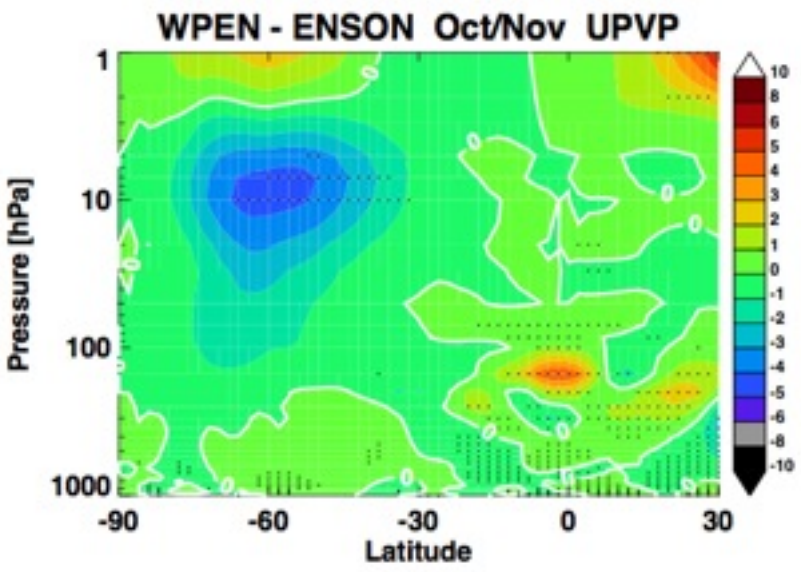

Fig. 1. Figure A

ACPD
11, C7684–C7695, 2011

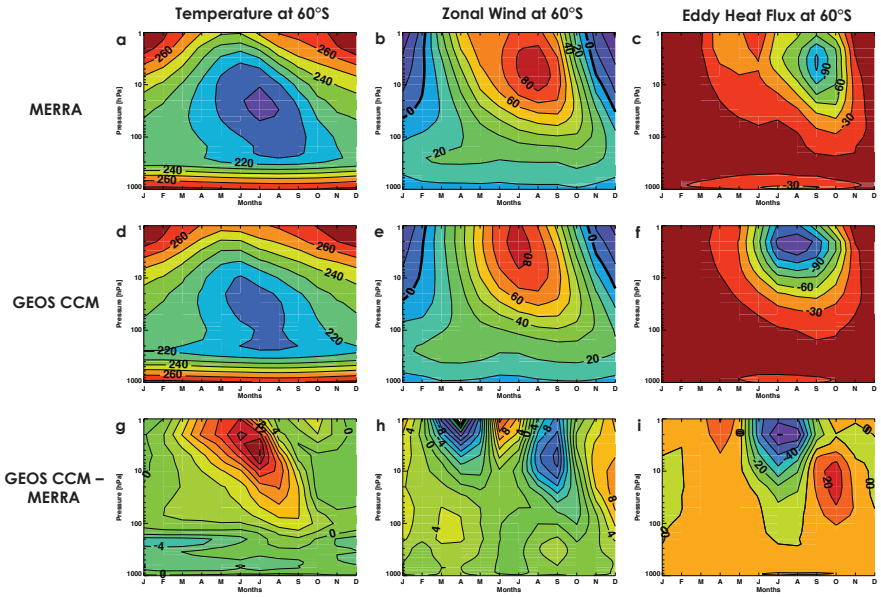

Fig. 2. Revised Figure 1

ACPD
11, C7684–C7695, 2011

Interactive Comment

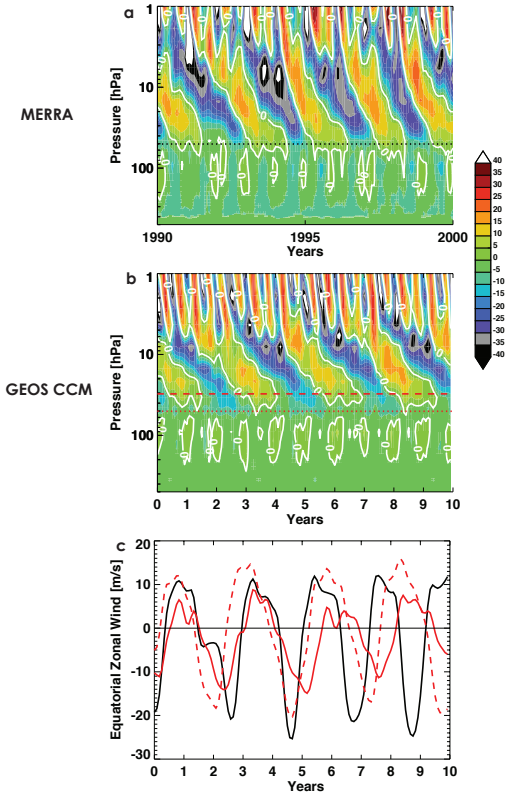

Fig. 3. Revised Figure 2

ACPD
11, C7684–C7695, 2011

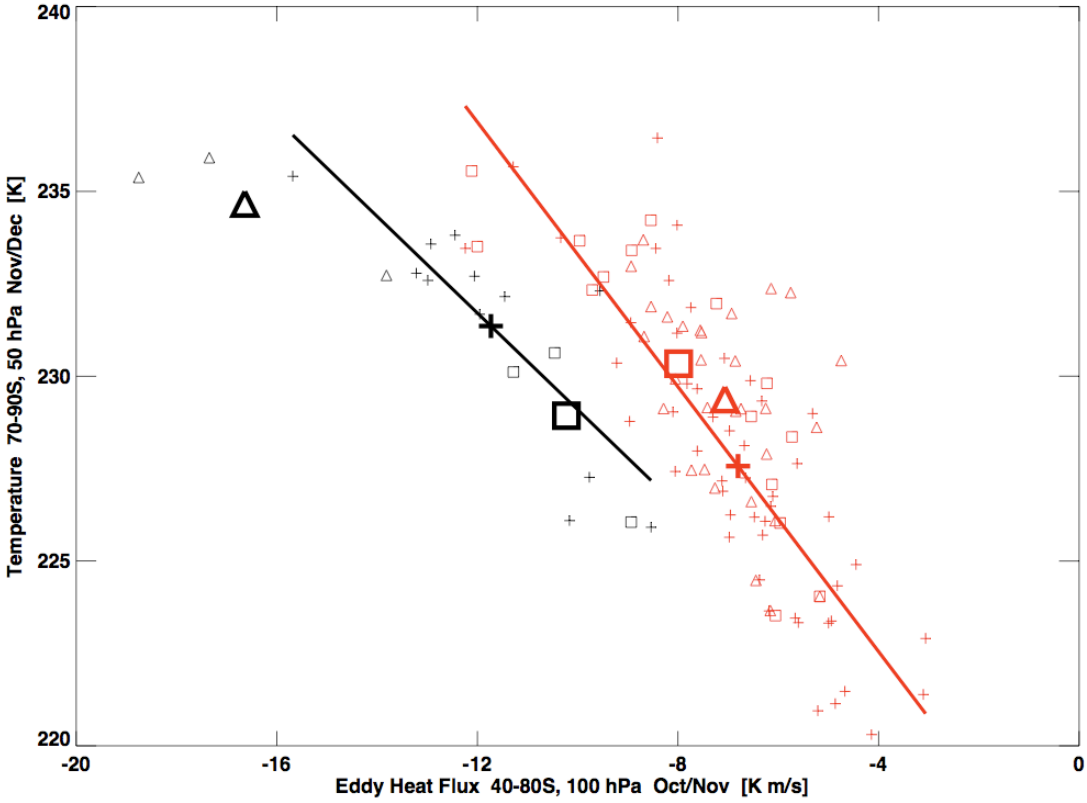

Fig. 4. Revised Figure 3

ACPD
11, C7684–C7695, 2011

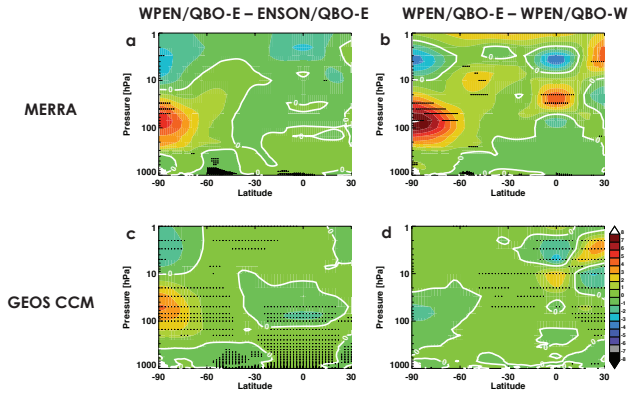

Fig. 5. Revised Figure 4

ACPD
11, C7684–C7695, 2011

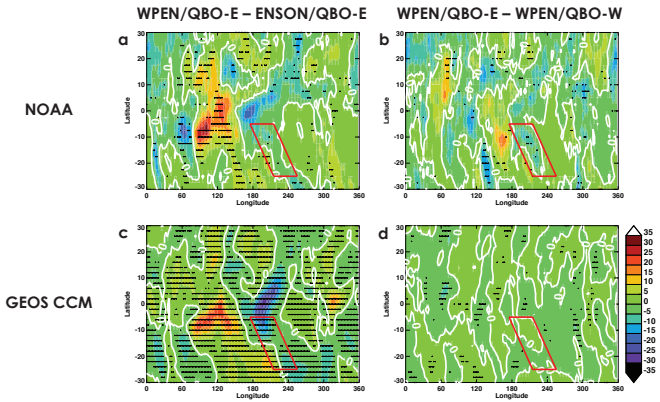

Fig. 6. Revised Figure 6

ACPD
11, C7684–C7695, 2011

Interactive Comment

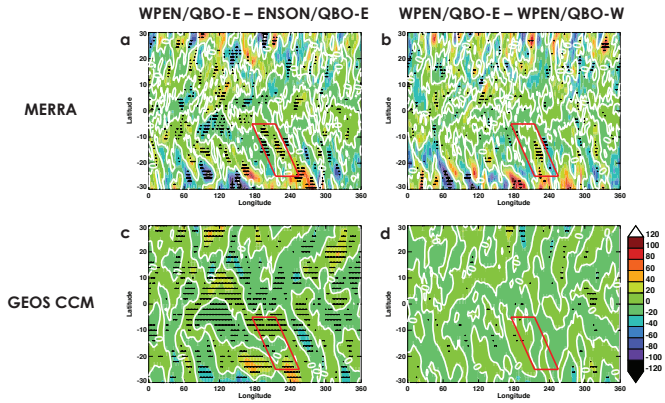

Fig. 7. Revised Figure 7

ACPD
11, C7684–C7695, 2011

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