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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "The diurnal and semidiurnal tides over Ascension Island (8 S, 14 W) and their interaction with the stratospheric QBO: studies with meteor radar, eCMAM and WACCM" *by* R. N. Davis et al.

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We would like to thank the referees for their constructive comments and we were very pleased to see that they find the paper suitable for publication in ACP. We have made many changes to the paper based on their recommendations. The revised draft is attached. We believe further discussion on some of the points raised would be helpful. We will address our responses to the comments in the same order that they were made by the referees:

1 Response to Referee 1

1.1 Major points

1) We fundamentally disagree with the referee about the relevance of the model/observation comparisons. The models are in a constant state of development and comparisons with single-site observations such as those presented in the paper are a very useful tool for evaluating progress. The location of Ascension Island makes the comparisons presented in the paper particularly useful as there are relatively few ground-based instruments at equatorial latitudes, and previous model validation has mostly been at mid and high latitudes. The authors are fully aware of the presence of the various tidal modes over Ascension Island, and we have specifically not attempted to extrapolate the observations to other longitudes. Further, the observation/modelling community has carried out extensive validation using ground-based instruments to improve model performance, for example consider as examples the following papers published within the last ten years: Andrioli et al. (2009); Buriti et al. (2008); Chang et al. (2010); Deepa et al. (2006); Guo and Lehmacher (2009); Manson et al. (2011); Tomikawa and Tsutsumi (2009); Xiong et al. (2004); Zhang et al. (2004); Zhao et al. (2004, 2011).

The Ward et al. (2010) paper mentioned in the comment presents useful comparisons between satellite and radar observations, finding good agreement between the two, and the observations are also compared with the predictions of eCMAM. However, these comparisons in the Ward et al. (2010) paper focus on two intervals of the CAWSES campaign, September-October 2005 and March-April 2007. In contrast, the results presented in the Ascension Island paper are a climatology. In fact, the Ward paper concludes: "Past differences between satellite and ground-based observations led to doubts in the observation techniques involved. Work can now proceed more coherently, with satellite and ground-based observations providing complementary data sets with which models can be validated and on which mesospheric assimilation efforts can be based."

2) We are very grateful for this comment as we had indeed not given the ENSO enough consideration and it looks to be a very interesting factor in long-term tidal variability. We have added to the paper the data of the ENSO multivariate index for the relevant years to investigate any relationship with tidal amplitudes, the results are presented in the updated figures 13 and 17. The discussion section has been updated accordingly. Further, in response to the comment that the correlation analysis does not address the question of at what height the QBO affects the tidal amplitudes, we agree and have expanded the discussion to emphasise that the correlations do not imply causality. We do however still consider the correlations between tidal amplitude perturbations and the QBO at different heights to be of interest to the general community and would like to keep them in the final draft.

3) In response to the question about the error bars we have now included in the paper the standard errors on the means of the composite-monthly mean amplitudes and phases. These were calculated by dividing the standard deviation of all the 4-day least-square fit values within a month by the square root of the number of days included. These errors thus include both the systematic error and also the natural inter-monthly variation in tidal parameters that had previously been left more-or-less undiscussed in the paper. The standard errors on the means are generally small, for example they were 1.1 ms^{-1} (amplitude) and 0.3 hours (phase) in December 2002, and when averaged over all included months and years the standard-errors on the monthly means were found to be 1.3 ms^{-1} and 0.4 hours. We are thus confident in the quality of the data we have presented. We have now added these values to the paper but would like to retain the standard deviations shown on the plots as a measure of the interannual

variability.

1.2 Minor points

1) The Ward paper has been cited, thank you.

2) The white circular gaps on Figure 1c are due to the radar receivers being briefly short-circuited to prevent saturation by the direct wave during the transmission of successive pulses. Meteors thus can't be detected at these narrow ranges. This has now been explained in the paper.

3) Reference now given in the paper.

4) The composite-year monthly-mean winds presented in Figure 4 were produced by averaging the mean wind values obtained from the 4-day least square fits, this has now been explained in the paper.

5) The missing a,b labels have been added to all relevant figures, thank you.

6) We have replotted the data presented in Figure 7 and all the other lineplots to show zonal and meridional components seperately. This has greatly improved the clarity of the figures, with the observations always plotted in black, CMAM always in red and WACCM always in blue.

7) Agreed, we have fixed the text accordingly.

8) Agreed, this sentence has been removed.

9) A reference has been included, thank you.

2 Response to Referee 2

2.1 Major points

1) We prefer to show the figures for each individual month rather than four seasonally-representative months as the move to individual months has been a major advancement in model progress in recent years. We have however prepared figures that display the zonal and meridional components seperately, this has greatly improved the clarity of the data presented and the colour key has been simplified.

2) The vertical wavelengths reported in the tables are not calculated from the difference between the top and bottom height gates but rather from a line of best fit through all the points. However, we understand the concern and while we would like to leave the vertical wavelengths in (they represent a more useful test of the models' ability to reproduce the different modes over one location than the absolute differences in phase) we have expanded the text to include more detailed discussion of the method and its drawbacks.

2.2 Minor points

1) Figure 12 was indeed produced using the QBO phase as defined at a height of 10 hPa. However later figures (i.e. Figures 13 and 14) investigated the correlation with the QBO as defined at other heights. This has now been clarified in the text, thank you.

2) Any missing months within each seven-month window were set to the mean of the remaining months in that window, up to a maximum of three missing months. Any more than that and no mean was taken and a gap in the running mean recorded. This has now been explained in the paper, thank you.

3) We did not intend to imply that causality followed correlation and have thus altered the text to avoid any confusion in our conclusions, thank you.

4) The effect/affect mistake on page 24 has likewise been fixed.

5) Vincent et al. (1998) observed the increased amplitudes during the Eastwards phase of the QBO to extend from March through to May/June. Burrage et al. (1995) presented data from an interval of only a little over three years, but they did comment on interannual variability of the September equinox amplitudes. Figure 12 in the Ascension Island paper does indeed show variability of the September equinox amplitudes, however it is smaller than the variability of the March amplitudes. For example, at a height of 87.5 km the diurnal amplitudes increase by approximately 50% from Westward to Eastward QBO phase, while in September at the same height the increase is only around 10%. The discussion has been expanded to cover these points.

6) The geographic coordinates reported in the paper have now been reported in a consistent manner, thank you.

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