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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Vertical structure of MJO-related subtropical ozone variations from MLS, TES, and SHADOZ data" *by* K.-F. Li et al.

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Interactive Discussion

Discussion Paper

21st December, 2011

Prof. Geraint Vaughan
Editor
Atmos. Chem. Phys.

Dear Prof. Geraint Vaughan,

Thank you very much for handling the review process of our paper. We have revised the paper according to the referees' comments. We have added Fig. 3 which shows the raw time series of MLS O_3 over Fiji, demonstrating the intraseasonal variability before the MJO-phase composite averaging.

We also appreciate very much the comments from the referees. We carefully considered their comments and below are our detailed responses. Please note that the referees' comments are red italic and our responses are black. The revised manuscript has also been submitted as Supplement with this reply. Shall you have other inquiries, please don't hesitate and contact with me. We look forward to hearing from you.

Yours sincerely,
K.-F. Li and co-authors.

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I Editor's Comment

E.1 *Both reviewers are very positive so I encourage you to address their (minor) comments and submit a revised version to ACP. Thank you for making the Editor's job easy!*

We thank the Editor for handling our manuscript and his favour in our manuscript.

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II Comments from Referee #1

R1.1 *Review report on Vertical structure of MJO-related subtropical ozone variations from MLS, TES, and SHADOZ data, by Li et al., submitted to ACPD.*

This paper analyzes ozone profile measurements from satellite sensors and ozonesondes at Fiji (18S, 178E) and confirms that the significant MJO-time scale ozone variability in the subtropics is located around 100-50 hPa, i.e., in the stratosphere. This is a follow-on paper by the same group (Tian et al., 2007) who analyzed satellite total ozone data and found significant MJO-time scale ozone variability in the subtropics. The analysis method is sound, and the logic is clear. The paper is well written and concise, and the figures are well organized and easy to understand. I recommend its publication basically in its present form.

The authors may or may not consider the following comments of mine during the preparation of the final revised manuscript.

I am interested in what is happening beyond 40N and 40S. Is there a teleconnection-like pattern, i.e., a wave train of quasi-stationary Rossby waves along the great circle? There are some hints in Fig. 3 and also in figures by Weare (JGR, 2010). If there is such a wave train, lower stratospheric ozone should respond to it.

We thank the referee for his/her favour in our manuscript. We also thank the referee for bringing out a possible teleconnection between the tropical and extra-tropical ozone. Indeed, we did noticed this connection and we are working on the project. The dynamical aspects of MJO-teleconnection in extra-tropics is well-known and has been studied extensively; see, e.g., *Matthews AJ, Hoskins BJ, Masutani M (2004) The global response to tropical heating in the Madden-Julian oscillation during northern winter, Q. J. R. Meteor. Soc., 130, 1991–2012.* We do see that lower stratospheric ozone responds to these dynamical changes in the northern mid-latitudes. We are currently drafting a manuscript to report this

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observation.

R1.2 *The authors emphasize that the signal is mainly located within the stratosphere. But, at the same time, based on the TES results, the authors note that there are some contributions (24%-27%) from the troposphere. If this is related to the stratosphere-totroposphere (ST) ozone irreversible transport, there could be a significant impact on the tropospheric photochemistry. It might be quite interesting to investigate what is the actual agent for this (potential) ST transport. Is it a diffusion-type, average transport at MJO time scales? Or, is it related to the enhancement/reduction of frequency of shorter time-scale phenomena such as synoptic tropopause folding?*

We definitely agree that studying ST transport through atmospheric tracers like O_3 on MJO time scales would be an interesting topics. However, such observations would be very limited by the vertical resolution of the measurements. In our case, TES weighting function has a very broad peak near the tropopause which covers significant portions in both upper troposphere and lower stratosphere. It is very hard to partition and quantify the MJO modulations in these two regions. What we could conclude with certainty was that the tropospheric contributions cannot be more than 30% and the majority of the MJO modulation should come from the lower stratosphere. This was a statement we put into the abstract. To investigate the role of ST transport in O_3, we would prefer using future global measurements of higher vertical resolutions, or reanalysis/modeling data that are currently available. This will be another interesting paper!

R1.3 *Fig. 9* [or Fig. 10 in the revised manuscript] *may show double peaks around 100 hPa and around 60-50 hPa for TES and SHADOZ (Fiji), but only single peak around 100 hPa for MLS. Figs. 6 and 7 also show the similar tendency. (This might be a puzzle because MLS has much higher vertical resolution in the stratosphere and is known to give reliable measurements in the stratosphere.) But, if the double-peak feature is true, then this might mean that there are two different*

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mechanisms for MJO-time scale ozone variability, one operating around 100 hPa and the other operating around 60-50 hPa.

We thank the referee for pointing out the hint of a double-peak structure. We did notice it. However, as the referee pointed out, MLS has better vertical resolutions in the lower stratosphere. It also provides more daily observations in enclosed region over Fiji. But yet MLS observations do not reveal such double-peak structure. Therefore, we would re-evaluate such structures when there are more independent data available. At this point, we would trust MLS more and take the double peaks from TES and SHADOZ with a grain of salt.

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III Comments from Referee #2

R2.1 *Review of "Vertical structure of MJO-related subtropical ozone variations from MLS, TES, and SHADOZ data", by Li., K.-F., B. Tian, D. E. Waliser, et al.*

Review of the paper:

This is a very interesting study of MJO signals in ozone detected in measurements from Aura MLS, TES, and OMI satellite retrievals and also SHADOZ ozonesondes from Fiji. The study includes ECMWF geopotential height and TRMM rainfall measurements to help validate and to make geophysical sense of the ozone anomalies. The technique used is to break down the ozone intra-seasonal anomalies into several time-averaged phases of the MJO. This method is similar to the second method of MJO analysis described by Tian et al. [2010].

We thank the referee for his/her favour in our manuscript.

R2.2 *This paper is well written and does not require substantial changes. However, the paper along with the several related and cited MJO papers [including Weare, 2010] never seem to plot original time series of measurements. If a time series is plotted in these papers it is usually a constructed time series derived from the EOF/EEOF component analysis of intra-seasonal pre-filtered measurements. If the MJO variability is really is a substantial signal in the data it should be readily identifiable in the original non-filtered time series measurements. It would really strengthen this paper for the average reader not accustomed to EOF analysis if the authors could include at least one additional figure showing original (i.e., no filtering) time series in regions of the subtropics where there is significant MJO signal detected from their analyses. Perhaps one could plot original time series in these regions that have not been filtered other than removing seasonal cycles to better identify intra-seasonal variability.*

We agree with this referee that adding a figure of original time series in sub-

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tropics would strengthen the paper for the average reader not accustomed to EOF analysis. In response to this, we have added a new figure [Fig. 3 in the revised manuscript], showing the deseasonalized raw time series of MLS O_3 measurement over Fiji. To aid the reader, we overplotted the bandpassed time series to illustrate the intra-seasonal variability. A description has also been added accordingly to the second paragraph of Sect. 4:

> "The intraseasonal variability in stratospheric column O_3 can be seen from the seasonal anomalies. As an example, Fig. 3 shows the deseasonalized (cyan) time series over Fiji observed by MLS. The MLS O_3 anomalies are obtained by averaging the swath footprints that fall into the 10°-longitude $\times$ 8°-latitude box centered at Fiji. MLS has almost daily coverage over the enclosed region. The orange line is the bandpassed time series, which resembles the intraseasonal variability in the raw time series. During the boreal winters (unshaded regions), there are suppressed O_3 anomalies that roughly correspond to strong MJO events due to the downward movements of the tropopause (Tian et al., 2007). The intraseasonal variability seems to be larger during boreal summers (grey shades), but those may also be related to Asian Monsoons and it is difficult to isolate the effects from the MJO (Zhang and Dong, 2004)."

R2.3 *Figure 9 is missing in the "printer friendly" version it may have been a PDF conversion error or related problem. (However, the non-printer friendly version does have Figure 9 included.) All of the nine figures seem to be legible in the online PDF file (i.e., text, etc. within figures are all readable) and shouldn't require changes unless ACP has other guidelines for figures.*

We appreciate the referee for pointing this error out. We will make sure that Fig. 9 will appear correctly in the final version.

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Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C13476/2011/acpd-11-C13476-2011-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 24503, 2011.

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