Response to anonymous referee 2's comments

First of all, the authors acknowledge the editor and referees for the valuable comments and suggestions to improve the quality of the paper. The revised manuscript has been read by a native English speaker, in order to correct grammatical errors and awkward sentences.

Response to the general comments:

1) ***Referee 2****: It is not clear why results from this one station are important enough to merit this much attention.*

Authors: Reunion is located in the southwestern Indian Ocean and the Reunion observatory is made up of numerous ground-based instruments and provides long datasets (temperature, ozone, water vapour, aerosols, surface parameters, etc.) for the past 15 years. Most of the datasets have not been heavily analyzed, and show an interesting correlation with Indian Ocean SSTs. Moreover, this paper provides information on a region where very few studies are conducted on temperature variability and trends in the UT-LS, especially in the southern sub-tropics.

2) ***Referee 2****: The record covers only ~16 years, which is not really enough to analyze ENSO or QBO effects or trends.*

Authors: We agree with the referee, the length of the data record is important for the precision of trend determination (Tiao et al., 1990[1]; Kerzenmacher et al., 2006[2]). Nevertheless, it is common that some authors which have analyzed ENSO and QBO effects or trends on temperatures or ozone variability based on less dataset than the present one, e.g., 1998-2005 from ozonesondes flights part of the SHADOZ network by Lee et al. (2010)[3],

[1] Tiao, G. C., Daming, X., Pedrick, J. H., Xiaodong, Z. and Reinsel, G. C: Effect of autocorrelation and temporal schemes on estimates of trend and spatial correlation, J. Geophys. *Res*., 95, 20 507–20 517, 1990.

[2] Kerzenmacher, T.E., Keckhut, P., Hauchecorne, A. and Chanin, M-L: Methodological uncertainties in multi-regression analyses of middle-atmospheric data series, J. Environ. Monit, N 8, 682 - 690, 2006.

[3] Lee, D., M., Shelow, A.M., Thompson and S.K., Miller : QBO and ENSO variability temperature and Ozone from SHADOZ (1998-2005), J. Geosphys. Res, in press, 2010.

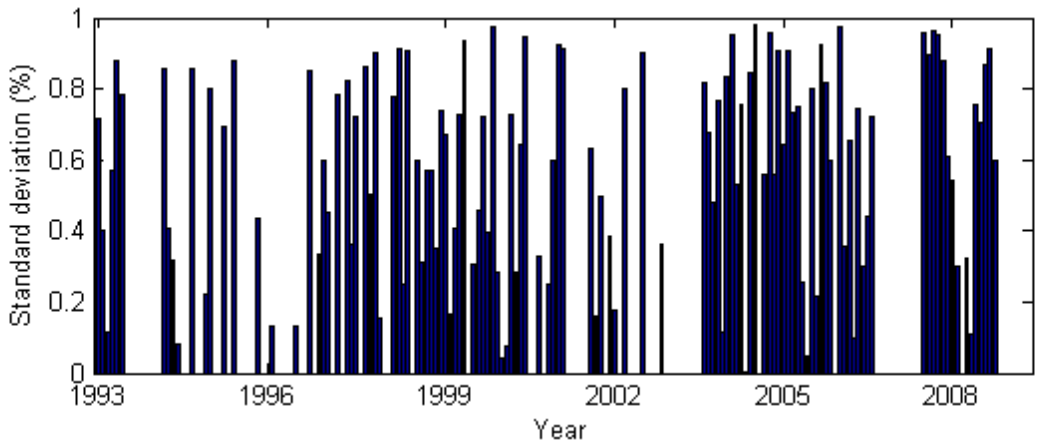
1998-2006 from SHADOZ or 1993-2005 from HALOE satellite data by Witte et al. (2008)[4], 1998-2003 from SHADOZ or 1994-2003 from SAGE II satellite data by Logan et al. (2003)[5], 1986-1996 from ozonesondes flights in Bodeker et al. (1998)[6].

Furthermore, our study covers over 16 years of datasets, thereby, we believe that one can examine roughly 6 cycles of QBO and 3 cycles of ENSO.

3) ***Referee 2****: Sampling of only 2-4 days a month may not be enough for reliable tropospheric temperature monitoring.*

Authors:

This comment is relevant. It focuses on an important point for the detection of temporal trends in tropospheric and lower-stratosphere (LS) temperature. We have examined the monthly standard deviation in terms of percentage defined as the ratio between the standard deviation and the monthly mean temperature, and found to be less than 1% over the 16-year study period (see the figure below, for the case of LS). Hence, the mean profile obtained from 2 to 5 observations over month, still could be representative.



Time evolution of the measured monthly temperature standard deviation in term of percentage at LS over Reunion from radiosonde data collected at Reunion from January 1993 to December 2008.

[4] Witte, J.C, M.R, Schoeberl, A.R, Douglass and A.M Thompson : The Quasi-biennal Oscillation and annual variations in tropical ozone from SHADOZ and HALOE, ACP, 8, 3929-3936, 2008

[5] Logan, J.A : Quasibiennal oscillation in tropical ozone as revealed by ozonesonde and satellite data, J. Geosphys. Res, 108, 4244, doi: 10.1029/2002JD002170, 2003

[6] Bodeker, G.E, I.S, Boyd and W.A, Matthews : Trends and variability in vertical ozone and temperature profiles measured by ozonesondes at Lauder, New Zealand : 1986-1996, J.Geosphys. Res, 103, D22, 28,661-28,681, 1998

4) ***Referee 2:*** *There is no analysis of temporal homogeneity problem arising from the changes in sonde model described in the paper.*

Authors: We thank for the reviewer's valuable comment. In order to check the quality of the data, a comparison between RS80 Vaisala sonde and M2K2-DC Modem has been made at Reunion (SHADOZ newsletter n°11, 2010[7]). This comparison has shown a good agreement between the two sonde models, particularly below 19 km altitude. Above this altitude, the largest difference observed is less than ~3 K. As our study focuses on the UT-LS region, we can consider that the change in sonde model have not any consequence on our regression analysis. This was added in the revised manuscript. (See page 5 line 27 in the revised manuscript)

5) ***Referee 2****: The authors do not claim significant correlation for the Indian Ocean relation, and the information about the climatological cycle is not new.*

Authors:

The reviewer is right. We have not obtained any drastic changes in the climatological cycle.

Correlations that are barely significant for the Indian Ocean relation is in the range of 0.08-0.15. If we consider the case of CPT, the IOD is found to explain about 12 % of the variance of the CPT temperature, we are not surprised to find a low correlation of about 0.15 between IOD and the temperature anomalies at CPT. Indeed, these correlations are consistence with the contribution of IOD on the variation of temperature in the UT-LS observed in our study.

Moreover, the purpose of this study is not to introduce IOD as the key parameter that controls the UT-LS temperature, but also to bring the material to reflect on the possible connection between SST and the UT-LS temperature over Indian Ocean, also motivated by Rosenlof et al. (2008)[8] over the tropical western Pacific Ocean.

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[7] Posny, F., Metzger, J.M and Baray, J.L: A successful change at Reunion Island station (21°S, 55.5°E), SHADOZ Newsletter, No.11, 2010

[8] Rosenlof, K. H., and Reid, G.C.: Trends in the temperature and water vapor content of the tropical lower stratosphere: Sea surface connection, J. Geophys. Res., 113, D06107, doi: 10.1029/ 2007JD009109, 2008.

Response to the specific comments:

Comment 1

Referee 2:

How is the IOD influence "as a result" of what is said before?

Authors:

Now, we have rewritten the sentence. (See page 1 in the revised manuscript)

Comment 2

Referee 2:

These correlations are not likely to be significant.

Authors:

We agree with the reviewer comment, the measured correlations are barely significant. However, these correlations are consistent with the contribution of IOD on the variation of the UT-LS temperature observed in this study, as mentioned in the 5th paragraph of the general comment. Furthermore, Rosenlof et al. (2008) have found a similar correlation between the SST and the temperature anomalies at LS over tropical western Pacific Ocean.

Comment 3

Referee 2:

The sentence beginning "In addition" is unclear.

Authors:

Now, we have rewritten this sentence. (See page 1 in the revised manuscript)

Comment 4

Referee 2:

Last sentence in abstract: It is not clear that the effect of the IOD is statistically significant; the conclusion is very weak.

Authors:

In the revised manuscript, we have added the statistical significance of the influence of IOD on the temperature in the UT-LS, and we have also improved the conclusion. (See pages 1 and 2 in the revised manuscript)

Comment 5

Referee 2:

There are more recent publications on trends in the UT/LS, such as the SPARC temperature trends report, Randel et al. (2009).

Authors:

We agree with the importance to include recent publications on the topic of the paper. As a consequence, we have included few more references to improve the explanation of the IOD reported by Izumo et al. (2010)[9] and Morioka et al. (2010)[10]. Furthermore, we have included the publication of Randel et al. (2009)[11], as suggested by the reviewer.

Comment 6

Referee 2:

The measurements are not really homogeneous given the change from RS-80 to M2K2-DC.

Authors: **See Reply to the general comment-4.**

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[9] Izumo, T., Valariad, J., Lengaigne, M., Boyer Montegut, C., Behera, K., Luo, J-J., Cravatte, S., Masson, S. and Yamagata, T: Influence of the state of the Indian Ocean Dipole on the following year's El Niño, nature geosciences, doi:10.1038/NGEO 760, 2010.

[10] Morioka, K., Tomoki, T. and Yamagata, T: Climate variability in the southern Indian Ocean as revealed by self-organizing maps, Climate Dynamics, doi: 10.1007/s00382-010-0843-x, 2010.

[11] Randel, W.J : An update of observed stratospheric temperature trends, J. Geosphys. Res., 114, doi: 10.1029/2008JD010421, 2009

Comment 7

Referee 2:

12% does not seem all that important, and there is no indication that this influence is statistically significant.

Authors:

Now, we added the statistical significance of the different forcing in the revised manuscript. These results show that the influence of the IOD is statistically significant at CPT and in the LS, with 12.3 ± 7.6 % and 13.1 ± 5.9 % respectively. It is right to say that the influence of IOD is not very significant if we compare the influence of IOD to the Annual Cycle. However, Langematz et al. (2003)[12] have suggested that other effects than ozone and CO_2 changes must be considered to fully explain the observed temperature changes in the LS. We remind that the purpose of the paper is not to present IOD as a parameter contributing mostly on the evolution of the temperature at LS, but we want to highlight the fact that this parameter must be considered to fully explain the observed temperature changes in the LS over Indian Ocean. (See Table 2 of the page 23 in the revised manuscript)

Comment 8

Referee 2:

Again, statistical significance of the difference in trend?

Authors:

Same as for the previous comment, we added the statistical significant of the difference in trend. (See page 14 line 16 in the revised manuscript)

Comment 9

Referee 2:

Should read "Southern Oscillation index"?

Authors:

We have corrected this sentence. (See page 7 line 7)

[12] Langematz, U., Kunze, K., Krüger, K., M., Labitze, K. and Roff, G.L: Thermal and dynamical changes of stratosphere since 1979 and their link to ozone and CO2 changes, J. Geophys. Res, 108, D1, 4027, doi:10.1029/2002JD002069, 2003.