Reply to Anonymous Referee #2

We would like to thank anonymous referee #2 for his constructive comments and suggestions helping to improve the quality of the manuscript. The answer to these comments is given below with indications of how the manuscript is revised in bold.

Major comments

Referee's comment

1.The time series of GOMOS observations only spans about 3 QBO cycles, and it is far from obvious that there is a actually a QBO signal over the whole altitude range in O3 or NO2. For example, in Fig. 2, there is a clear QBO signal in O3 below 30km, but above that, it is far from convincing, and some time series could help the interpretation. It is not obvious that there is a QBO signal in the temperature plot either above 30km (Fig. 4).

Answer

We agree that it is not obvious to see the QBO signal in time-height sections. In order to better visualize the relation between minor constituents measured by GOMOS and the QBO signal, we added a time-height section of the evolution of the Equatorial wind between 100 to 10 hPa wind evolution at 10 and 30 hPa (Additional material Figures 1 and 2). We added also a plot of the evolution of O_3, NO_2, NO_3 and T at 26 km, 35 km and 40 km and Equatorial wind at 10 and 30 hPa (Additional material Figures 3 to 5) and the correlation coefficient between the temperature between 20 and 55 km and the equatorial zonal wind at 10 hPa and 30 hPa (Additional material Figure 6). For upper levels (45-50 km) we agree that the evidence of a relation between the QBO signal and constituent variations is not so clear. However we consider interesting to look at the sign of the correlation with temperature, good indicator of vertical motions induced by adiabatic cooling and warming depending on the sign of the vertical wind, even if the causes of these temperature changes are not fully understood.

Referee's comment

2.How the authors extract the O_3 field from the multi-parameter regression is not clear either, and the authors could present more clearly the intermediate steps, starting with the ozone seasonal deviations, and showing the fitted components. It is not clear how these regressed ozone fields are used in the rest of the paper. For example, in Fig. 3, there is a clear positive correlation between O_3 and NO_2 above 40 km, but does it imply that this a QBO-related signal ?

Answer

We apologize for a bad formulation in the manuscript of the methodology applied to the data. We tested a multi-parameter fit to the data but finally we decided not use it in the manuscript. The results presented are simply the deviations from the mean for the whole period without applying any correction. We don't use the multi-parameter fit because it does not change significantly the results concerning the O_3 and NO_2 response to QBO due to the small amplitude of annual and semi-annual variations of these constituents in the equatorial region. **The section concerning the multi-parameter fit is removed in the revised version.** For the positive correlation between O_3 and NO_2 above 40 km, see answer to the previous comment.

Answer

Referee's comment

3.The authors propose a new hypothesis to explain the anti-correlation between NO2 and T above 40 km. As I read Baldwin 's review article (p217; right column), it is mentioned that ascent modifies NOy gradient, hence presumably N2O, a well-know source of NOx. The authors should clarify what is new in their hypothesis.

Answer
We agree with the fact that vertical ascent modifies N_2O and NO_y gradients is not new and is described in the Baldwin (2001) review paper. However the reason for a QBO signal in NOx (NO_2 for GOMOS because it provides only night-time measurements) above 5hPa (around 37 km) is not fully understood. We cite a sentence from Baldin (2001) page 217: "*The reason for a large QBO signal in NO as not yet been determined. However it is likely due to the dominant contribution of NO to NO_y at these altitudes*". What is new in our work is the identification from satellite observations of a region between 40 and 50 km and where NO_2 and O_3 are correlated between themselves (and anti-correlated with temperature but this is less clear for NO_2 around 45 km where the NO_2-T correlation coefficient is around 0). **The text is modified in the revised version to better explained what is the contribution of GOMOS results in this discussion.**

Minor comments.

Referee's comment
Anomalies in the chemical constituents or tracers are driven by the mean meridional circulation cells induced by the QBO wind vertical shears, at least in the in the dynamically-controlled region. These cells have a latitudinal extend with, in the easterly shear phase, rising motions at equator and descent near 20 degrees, as seen in the aerosol observations on Figure 26 (also CH4 on Fig 28) of Baldwin 's review article. I wonder if the authors have averaged over a too broad latitude range (20S-20N), thereby weakening the signatures. The authors could check on that, if the GOMOS sampling allows.

Answer
GOMOS data are averaged in the latitude range 15°S to 15°N as explained in section 3 Data selection and processing, step 3 of the selection and averaging procedure. Consequently, the 20 degrees region does not affect our results.

Referee's comment
In beginning of section 5 (line 13), the NO_3 concentration is said to sensitive to T, but later in that section it is mentioned that this only occurs in a limited range 25-46 km. The information should be put together in same paragraph.

Answer
The information is put together in the same paragraph in the revised version. The limitation to the 25-46 km range is not due to physical or chemical processes but to the increase of NO_3 concentration uncertainty outside this range preventing to detect any correlation. **This point is clarified in the revised version.**

Referee's comment
An additional suggestion is that the whole vertical structure of the QBO winds could be used in a lag-correlation plot (altitude vs time in years) with respect to O_3 at a chosen level, for example.

Answer
The status of the QBO is only known from radiosondes from 100 to 10 hPa. As wind data are not available in the full altitude range of GOMOS data, it is not possible to compare directly the QBO wind with GOMOS data at the same altitude. The addition of the time-height section of the Equatorial wind between 100 to 10 hPa (see answer to major comment #1) allows to better understand the vertical structure of the QBO winds.

Referee's comment
Caption of Fig 1. Indicate in caption the meaning of black line

Answer

Done. The black line is the latitude where the occultation takes place(right scale) for the given year fraction.