Response to Referee #1:

We are grateful to the referee for her/his careful reading of the manuscript and for her/his corrections and suggestions. Responses to each individual comment that has been quoted […] are given here below.

General comments

1/ *[I have one general comment that relates to the simultaneous use of the linear trend with a VPSCxEESC proxy in the multi linear regression: How well can the linear O3 trend be determined at high latitudes (in winter/spring) when part of this change (through the EESC factor) is already included in the MLR? The combined effect of EESC and linear trends in polar regions is briefly addressed at L.690, but I could not find a discussion on the effect on the trends. This is in particular important in the light of the strong statements made: "To the best of our knowledge, these results represent the first detection of a significant recovery in the stratospheric and the total O3 columns over the Antarctic from one single satellite dataset."]*

As already found in previous studies and stated in the manuscript, "the PSC volume is multiplied by the EESC to account for the changes in the amount of inorganic stratospheric chlorine that activates the polar ozone loss". In other words, the EESC factor is used to decrease the "efficiency" of the VPSC in activating the O_3 loss.

Actually, there is no possible confusion in the MLR between the linear trend and the VPSC x EESC proxy that is non-linear by nature given the strong oscillations in VPSC. The effect of the change in EESC on the amplitudes of the annual oscillations in VPSC which variate from year to year is very weak with, hence, no tendency detectable at all in the VPSC x EESC proxy (see Figure 1 here below). Therefore, it could not compensate the linear trend adjustment at all.

2/ *[I have to say that I am skeptical about the robustness of the speeding up of the trends in recent years, given that these trends are evaluated over really short periods only. Although the authors have done the analysis with statistical rigor, linear trends over periods as short as 2 years (2015-2017) are prone to changes in atmospheric dynamics and circulation (or other factors) that may not be perfectly captured by the MLR proxies. I (strongly) suggest that the authors consider a more careful wording in the conclusions and abstract, stating the evidence for the speeding up of the trends, but also the inherent uncertainties.]*

The speeding up has been investigated by removing the natural variability adjusted over the whole IASI period in order to avoid the effect of short trend-like segments in natural variations on the trend determination.
However, it is true that the uncaptured variability from the MLR performed over the full IASI period might disproportionately affect the estimated trends over varying time periods, but, so might be the calculation of the associated uncertainty, accordingly. This is specifically addressed in Fig.12 of the paper that illustrates the time evolution of both trends and associated uncertainties over varying time periods.
We agree, however, that the comparison of trends calculated over different lengths of time period is not straightforward because the statistical error is not comparable across the fits. This is addressed in Figure 2 here below that represents the minimum amplitude of the estimated trend, by subtracting the associated uncertainty (accounting for the autocorrelation in the noise residuals) from the linear trend; it still shows the significant increase in O_3 change rate across the fits.
Another approach, as suggested by Referee #2, would consist in considering successive time segments of same length. Nevertheless, here again, the uncaptured variability might induce different systematic errors between the successive segments, e.g. in case of "trend-like" noise over a specific segment. The choice of the segment length is also complicated by limitations (long segments would smooth the progressive

acceleration, while short segment would induce larger uncertainty; the jump in September 2010 in the IASI dataset would misrepresent the trend calculated over short segments that encompass the jump period).
Finally, we believe that Fig.12 of the paper is the best alternative to represent the progressive acceleration in the O_3 recovery. Note also that we now consider the autocorrelation in the noise residuals in the uncertainty estimation illustrated in Fig.12.
Nevertheless, we agree that the IASI period is still relatively short to compare trends over successive segments of same length that are long enough to reduce the uncertainty.

Therefore, as suggested, we use, in the revised version, a more careful wording about the speeding up of the O_3 trends through the revised manuscript, especially in the abstract, in Section 4.4 and in the conclusions. For example, one can read now at the end of the abstract: "Additional years of IASI measurements would, however, be required to confirm the O_3 change rates observed in the stratospheric layers over the last years" and at the end of Section 4.4: "Nevertheless, we calculated that additional years of IASI measurements would help in confirming the changes in O_3 recovery and decline over the IASI period (e.g. ~ 4 additional years are required to verify the trends calculated over the 2015-2017 segment in the highest latitudes in LSt). In addition, a longer measurement period would be useful to derive trends over successive segments of same length that are long enough to reduce the uncertainty, in order to make the trend and its associated uncertainty more comparable across the fit."

The title of the manuscript has also been changed accordingly to: "Is the recovery of stratospheric O_3 speeding up in the Southern Hemisphere? An evaluation from the first IASI decadal record".
An alternative to that title would be: "First signs of a speeding up of stratospheric O_3 recovery in the Southern Hemisphere, contrasting with a decline in the Northern Hemisphere, as seen from IASI".

Finally, we have also found a bug in the calculation of the estimated trends through the manuscript. We apologize for this. The overall conclusions remain unchanged but the figures 8 to 12, and the numbers given in the text have been corrected accordingly.

Specific comments

1/ *[L.72: Is this true for both hemispheres, or only NH?]*

Ball et al. (2018) reports a decline in lower stratospheric O_3 between 60°S and 60°N. The polar regions are not included in that study due to limited latitude coverage of instruments merged in the data composites.

2/ *[L.83: "sensitive" does not seem the right word here. Sensitive to what?]*
Changed to "difficult".

3/ *[Section 2.2: It would be good to have an explicit formula for the MLR included here, in addition to the reference to eq. (1) in Wespes et al. (2016).]*

The MLR and the normalization equations are now included in the revised paper at the start of Section 2.2.

4/ *[L.210: A few more words on the GEO and PV proxies would be helpful. Although L.372 states that their contribution is generally small, their use in ozone trend studies is not common practice, so some reference to their purpose and how and why they improve the fit is justified. Are these proxies lat/lon dependent?]*

The use of the GEO and PV proxies is inherited from previous papers (e.g. Knibbe et al., 2014; Wespes et al., 2017) to account for the impact of tropopause height and of the mixing of tropospheric and stratospheric air masses, in particular, on the LSt O_3 variations. Their contributions into the LSt O_3 variations are found minor due to correlations with the annual harmonic term, as expected, but the proxies are kept in the MLR for completeness. They are lat/lon dependent (2.5°x2.5° gridded; this is now mentioned in the revised Table 1), hence, their gridded adjusted coefficients are not comparable on a global basis; only the adjusted signals can be compared.

5/ *[L.357++: SF: energetic particle precipitation (solar protons and also electrons) can also lead to enhanced ozone destruction in the MUSt through NOx catalysed cycles. The main effect of a solar proton event in the MUSt is actually to decrease O3 (and only to second order to decrease O3 destruction).]*

Added as suggested. Note that the role of the solar proton event on the decrease of O_3 destruction, as mentioned in the paper, refers to the LSt where NO_x decrease active chlorine and bromine.

6/ *[L.380++: EPF: I am surprised that the correlation of IASI O3 with EPF is small at low latitudes: Weber et al. (2011) note a rather strong anti-correlation between tropical total ozone and extra-tropical EPF.]*

Weber et al. found a negative correlation between tropical total ozone and extra-tropical EPF at lower latitudes throughout the winter and early spring, while it goes to zero by early summer. On an annual basis, Fig. 5 of the paper shows a weak but negative contribution (up to ~ -5 DU) onto O_3 variations. The negative sign which indicates an opposite response in O_3 to change in EPF is in agreement with the negative correlation, but the absolute value of the “regression” coefficient does not refer to the absolute value of the “correlation” coefficient; it indicates how much the proxy explains/contributes to the O_3 variations, while the absolute value of the correlation coefficient (as shown in Weber et al., 2011) indicates the degree of linearity between 2 variables.

The weak adjusted negative regression coefficients for EPF might result from correlation/compensation effect between the annual cycle and EPF. Despite the year-to-year variations in the EPF proxy, which limit the compensation effect with the 1-yr harmonic term, correlation between the two covariates is expected given the annual oscillations in EPF. This is illustrated in Figure 3 below that compares the global distribution of the fitted coefficient for the 1-yr harmonic term with or without EPF included in the MLR. The global distributions are quite similar with absolute differences (< 5 DU) lower than the EPF regression coefficient, indicating a good overall discrimination, except at the tropics where the EPF contribution is the lowest. Hence, the compensation effect between the 1-yr term (that is the main contributor to O_3 variations) and EPF might underrepresent its contribution at the Tropics. Note however that the correlation between the EPF and 1-yr terms is taken into account in their associated uncertainties.

Some words of caution have been added in the revised Section 3 about a likely compensation between the annual harmonic term and the EPF proxy that also shows an annual oscillation in nature:
“Furthermore, given the annual oscillations in EPF, compensation by the 1-yr harmonic term (eq. 1, Section 2) is found (data not shown), but it remains weaker than the EPF contribution (data not shown), in particular at high latitudes where the EPF contribution is the largest.”

The Weber et al. (2011) reference has been added in the revised version.

7/ *[L.474: suggestion “N.H. mode” -> NAO]*

Changed as suggested.

8/ *[L480: Just as a note: It may also be that large O3 changes impact on the AAO]*

We apologise but we do not understand what the referee means here.

9/ *[L.514: “if the influence of ENSO on stratospheric O3 measurements has been reported”: the word “if” seems a bit out of place here as clearly the influence of ENSO on stratospheric O3 has been reported in the cited studies.]*

Changed to: “Indeed, the influence of ENSO on stratospheric O_3 measurements has already been reported in earlier studies (…), but it is the first time that …”

Technical corrections

[L.233: “EFP” -> *“EPF”]*

Corrected

Figures

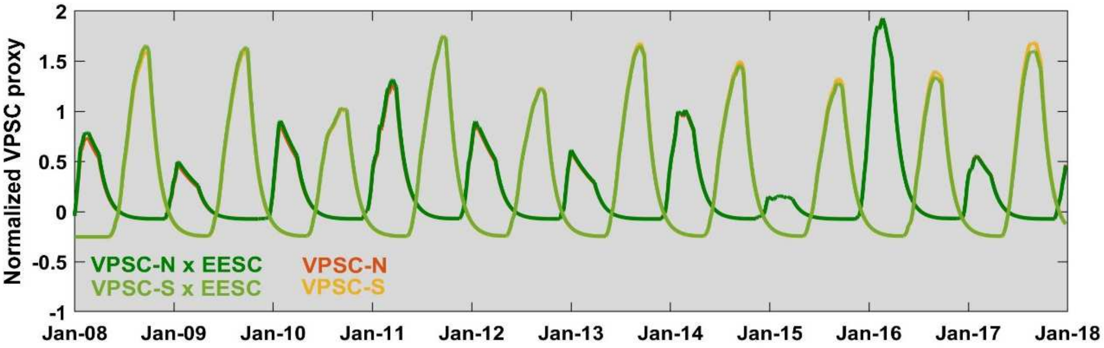

Figure 1: Normalized proxies as a function of time for the period covering January 2008 to December 2017 for the volume of polar stratospheric clouds multiplied or not by EESC and accumulated over time for the north and south hemispheres (VPSC-N and VPSC-S).

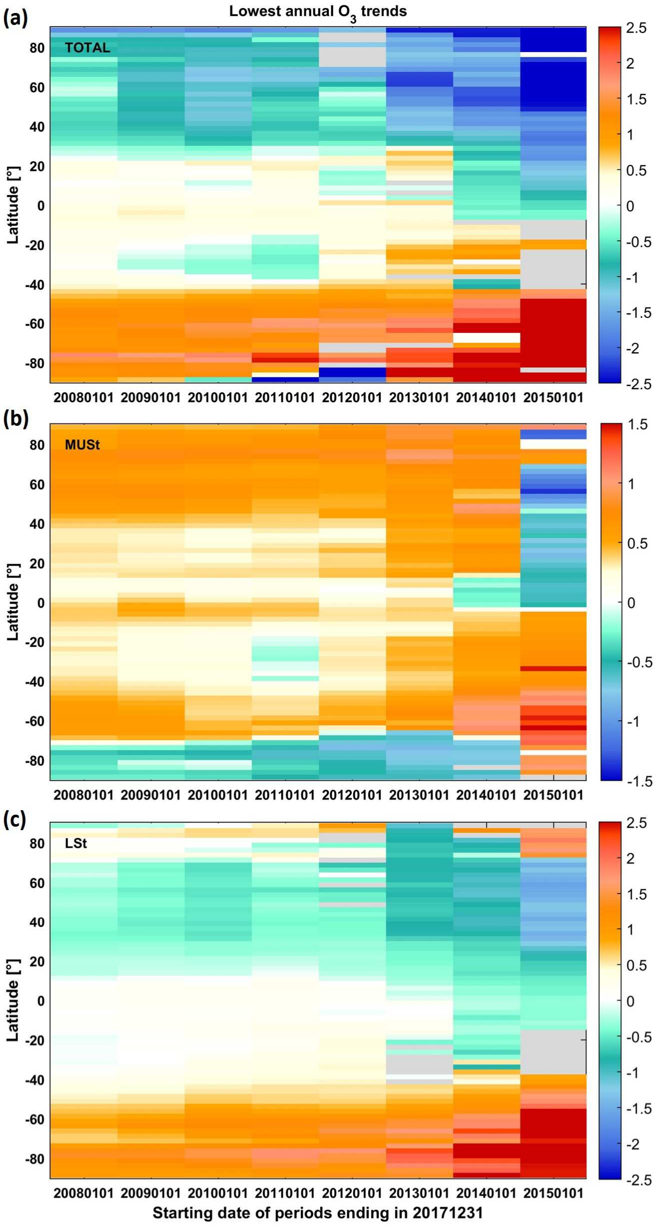

Figure 2: Evolution of estimated linear trend (DU/yr) minus the associated uncertainty accounting for the autocorrelation in the noise residual (DU/yr; in the 95% confidence level) in (a) the total, (b) the MUSt and (c) the LSt O_3 columns (top to bottom panels, respectively), as a function of the covered IASI measurement period ending in December 2017, with all natural contributions estimated from the whole IASI period (2008-2017).

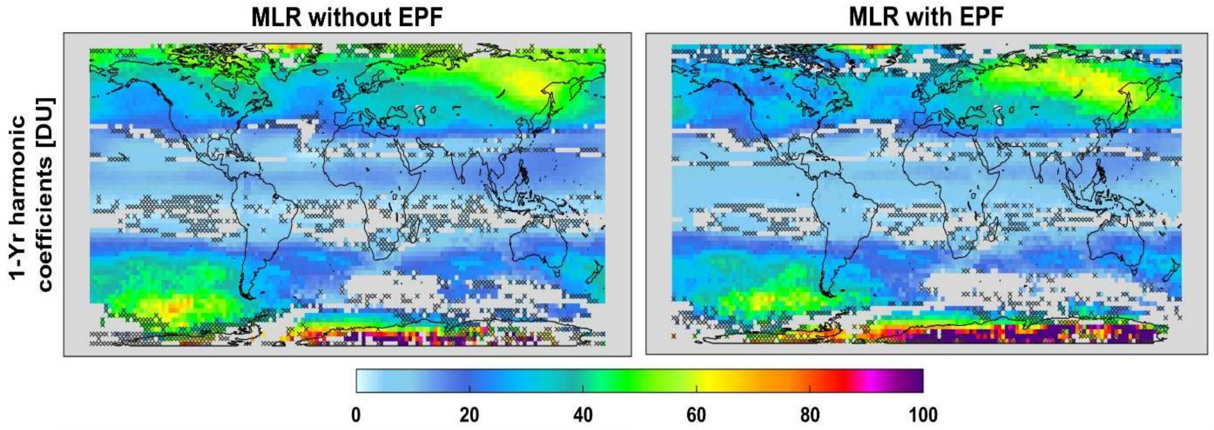

Figure 3: Global distribution of the annual regression coefficient estimates ($\sqrt{a_1^2 + b_1^2}$, in DU) for the 1-yr harmonic term in LSt obtain from the annual MLR without or with EPF (left and right panels, respectively).