Response to REFEREE # 2 report

We thank Referee #2 for additional comments and several helpful suggestions. We include minor revisions to the text accordingly to **RCs.** We really appreciate huge work of Referee #2 that helps to improve the text of manuscript significantly.

Line numbers in **AC** are indicated for manuscript Version 4.

General:

RC: Compared to the first version of the manuscript the authors clarified the study and included an extensive part comparing their results to the model Australian Community Climate and Earth System Simulator (ACCESS-CCM). Still I am a bit at loss of what to make of the study. More exact, I see a list of features which all need further investigation, because many feature bring up the question how the ozone recovery will take place and how the effects on mid latitude, i.e. Australia and New Zealand will be.
AC: We additionally discuss regional tendencies in the two new paragraphs.
Lines 519–533:
'Note that in the years of maximum ozone hole area (easternmost QSW_{min}), the midlatitude wave 3 anomalies of the positive correlation partly cover New Zealand and southern tip of South America (Fig. 11c–11e, and Fig. S6c–S6e). Positive anomaly here corresponds to climate warming in the years of the easternmost QSW_{min} migrations. In future, predicted ozone recovery may be accompanied by further westward shift of the wave 3 pattern and by weakening of the positive anomaly influence in region of New Zealand and South America (similarly to Fig. 11a and Fig. S6a).
As seen from Fig. 11a and Fig. S6a, both reanalyses show negative correlation anomalies over Australia and East Antarctica in the first time interval 1979–1992 (pre-ozone hole and first ozone hole years, westernmost QSW_{min},). Later, these negative anomalies weaken (Fig. 11b–11d) and appear again in the latest time interval 2011–2014 (Fig. 11e). Note that regression in Fig. 6b and correlation in Fig. S2b also show negative anomaly over south-east part of Australia. These tendencies indicate that Antarctic ozone recovery to pre-ozone hole level may be accompanied by strengthening of negative coupling 'tropospheric temperature – QSW_{min} longitude' in this region. All of these climate effects need further analysis.'

Additionaly, inserted in Section 5 'Conclusions':
Lines 685–686, 'Related shifts in the tropospheric QSW3 pattern play a role in climate variability in regions of Australia, New Zealand and southern tip of South America.'

RC: Sometimes it looks like the authors used a shotgun, fired in the bush and collected what has been hit. As I wrote in the first review, I think it is of importance and validity to hunt for features which need explaining and study. However, it should not stop here, but go on. The publication looks like a list of problems I would present to a PhD student to choose from and start investigating.
AC: We also agree that the analysis in our manuscript has revealed areas that require further examination, and have outlined these in the final paragraph of the conclusions.

RC: The authors removed several strong statements which I criticized in the first version as not being backup up by the analysis. However, I sometimes have the impression, that the authors are scarred by their own statements and back down immediately.
An example (but not the only instance): page 6 line 195ff sounds a bit trivial to me:
(less Ozone -> less heating -> weaker polar jet -> change in wave propagation) also papers are cited which find exactly this.

But the authors say "it MAY impact wave propagation" and in the next sentence: "POSSIBLE couplings ... ."
AC: We rephrase line 198, 'they impact planetary wave propagation' and
Line 200–201: 'Couplings between changes in the QSW structure in Antarctic total column ozone and in atmospheric variables are analyzed below.'

RC: In the end, in the conclusion it is finally cast in certainty. I have to admit, I find this style difficult to follow, but accept that this is a matter of taste.
In summary, I would recommend the publication of the study and hope that the authors follow their own in work in more depth and study if the connections suggested by the correlations really exist and what they mean in detail.
AC: In the final paragraph of the conclusions in the revised manuscript we have outlined specific areas that we regard as requiring further investigation. We hope that this information will guide further studies.

In detail:
RC: The authors still did not define what they mean be a 'composite'. On page 8 line 264 they write composite (average). Do they mean a composite is just an average over the three month S, O, N? Also, I still dont undestand the concept of an anomaly composit. Is it an average over several anomalies? If so, also over S, O, N?
The paragraph page 8, line 264 ff is rather confusing. It took me a while to understand this. I think one of the sentences is superfluous, because both seem to state the same thing with different words.
AC: Anomaly calculation procedure is described in lines 210–214: 'We first produce **monthly** climatological anomalies for each gridded **monthly average** variable at the native horizontal resolution by subtracting the associated long-term **monthly mean** (over 1979–2014 for ERA-Interim and 1981–2014 for NCEP–NCAR). We then produce **averages** of the anomalies in grid boxes of 10°×10° (latitude×longitude) **over the SON months** of each year. Finally, we evaluated…'.

Anomaly composite calculation includes anomaly averaging by criterion of extreme longitudes.

Line 267–272: 'In Fig. 7 we present anomaly composites (averages) for years of extreme western (lower 20th percentiles) and eastern (upper 20th percentiles) QSW_{min} longitudes to further investigate the patterns shown in Fig 6. Monthly mean anomalies for September, October and November were calculated by subtraction of the climatological means of 1979–2014 from monthly mean variable value in each grid box as described above concerning Fig. 6. Then monthly mean anomalies were averaged over the SON months.'
'

RC: page 6 line 177 Do the authors mean, that r=0.39 would already be significant?
AC: Lines 178–179, corrected: '…and the value $r = 0.43$ is significant at the 99% confidence limit based on a two-tailed Student's *t*-test.'

RC: page 7 line 212/13 Wording: Two sentences start with 'We then ... '
AC: Line 214: 'We then evaluated the regression…' changed to
'Finally we evaluated the regression…'

RC: A sentence like line 252 ...variability ... with high probability ... could ... does not sound as if the authors are convinced by there own study. It is another example of what I wrote before, that the authors sometimes seem afraid of their own findings.
AC: Lines 254–256: 'Hence, variability in zonal asymmetry in the Antarctic ozone during the spring months, with high probability, is indicative of the SH regional climate variability.'

RC: line 256 - 259 Is this in contradiction to (Mo and Higgins, 1998)?
AC: The Pacific wave train is present in many relationships (Fig. 9f, Fig. 11, Fig. S2c, Fig. S3d and Fig. S4d), in consistency with (Mo and Higgins, 1998). Our important result is that combined wave activity over the three ocean basins can contribute to the QSW_{min} longitude variability as noted in lines 325–328.

We somewhat modify lines 258–262:
'Zonal asymmetry in the SH troposphere circulation is closely coupled with the Pacific–South American (PSA) mode (Mo and Higgins, 1998). The PSA pattern in the RC distribution in Fig. 6 is of insignificant intensity, whereas pronounced meridional wave trains are seen in Indian–Australian sector and Atlantic–South American sector (U200 in Fig. 6c). As follows from the relationships below, combined wave activity over the three ocean basins can contribute to the QSW_{min} longitude variability.'

RC: page 9 line 313 Do the authors mean, the the surface pressure anomalies cause the variance of the OSWmin longitudinal variance?
AC: Since the QSW3 and SAM activities in the SH tropospheric circulation influence wave penetration into the stratosphere, the surface pressure anomalies cotribute to the OSW_{min} variations. However, we note also that feedback processes are possible (lines 424–427, 446–450, 457–458).

Lines 315–317, corrected: 'Therefore, approximately 57% and 35% of the QSWmin longitude variance (both significant at the 95% confidence limit) can be explained by the surface pressure anomaly variance described by regional (grid box 1, QSW3 pattern) and hemispheric-scale (SAM) indices, respectively.'

RC: page 10 line 322 ... show likely ... in connection with line 325
... could mean ... makes a very weak statement: An assumption which may be true leads probably to a cause.
AC: Line 325, The U200 anomaly composites in Fig. 9b and 9f show meridional …
Line 327–328, Relation of the QSWmin longitude to these wave patterns means combined contribution...

AC: We add also keywords.
Lines 35–36:
Keywords: stratosphere, ozone hole, planetary wave, longitudinal shift, ERA-Interim climatology, ACCESS-CCM chemistry-climate model