Anonymous Referee #2

Responses in Red

This paper presents analyses aimed at highlighting and explaining some unusual ozone anomalies in the middle stratosphere from a 22-year set of observations from Lauder, NZ. The unusual anomalies consist of (1) one month of high ozone in June 2001, and (2) relatively high ozone at the end of the record during 2009-2013. The objectives of the paper are to point out these ozone anomalies and demonstrate that they are related to large-scale dynamical variations. While the authors do infer some circulation changes for these periods, the results are hand-wavy and (in my opinion) do not provide fundamentally important new results of a standard appropriate for ACP. Some specific comments are below.

In the revision, we provide some additional analysis and discussion to document the source of the two anomalies over Lauder (details below). We certainly admit that additional benefit could be gained from more detailed three-dimensional dynamical and chemical modeling of the events. We hope that documenting the observations within the context of a 22-year dataset and providing preliminary interpretation will motivate future work on the detailed cause of these anomalies.

The analysis of the June 2001 event is quite superficial. The authors show some anomalous circulation behavior in Fig. 4 (postage-stamp figures which are difficult to see; why are 15 panels needed?), but this result begs for more substantial analysis. Why is there an anomalous anticyclone near 10 hPa in this month? What are its horizontal and vertical characteristics, and dynamical origin? Is this tied to some anomalous circulation in the troposphere? Why is this important?

We have removed 7 of the 15 panels from Figure 4 and changed the color scale somewhat to help emphasize the anti-cyclone. We also and added a Figure 5 in order to show the vertical characteristics of this field at the latitude of Lauder. As is shown in the new Figure 5, there is no clear signature in the troposphere. We do not have any clear answer as to "why" this dynamical feature has occurred, but it seems important for interpreting O_3 measurements to be aware that such a large change can occur as a result of unusual dynamics.

The additional text which goes with the new Figure 5 reads: "Figure 5 shows the vertical structure of this feature at 45ºS, identified by zonal anomalies of geopotential height over a range of pressure surfaces from 1000 to 0.1 hPa. Elevated values extend from the tropopause (~200 hPa) into the lower mesosphere, tilting westward and narrowing with height. The anomaly peaks at ~10 hPa, with a longitudinal extent of ~120°. "

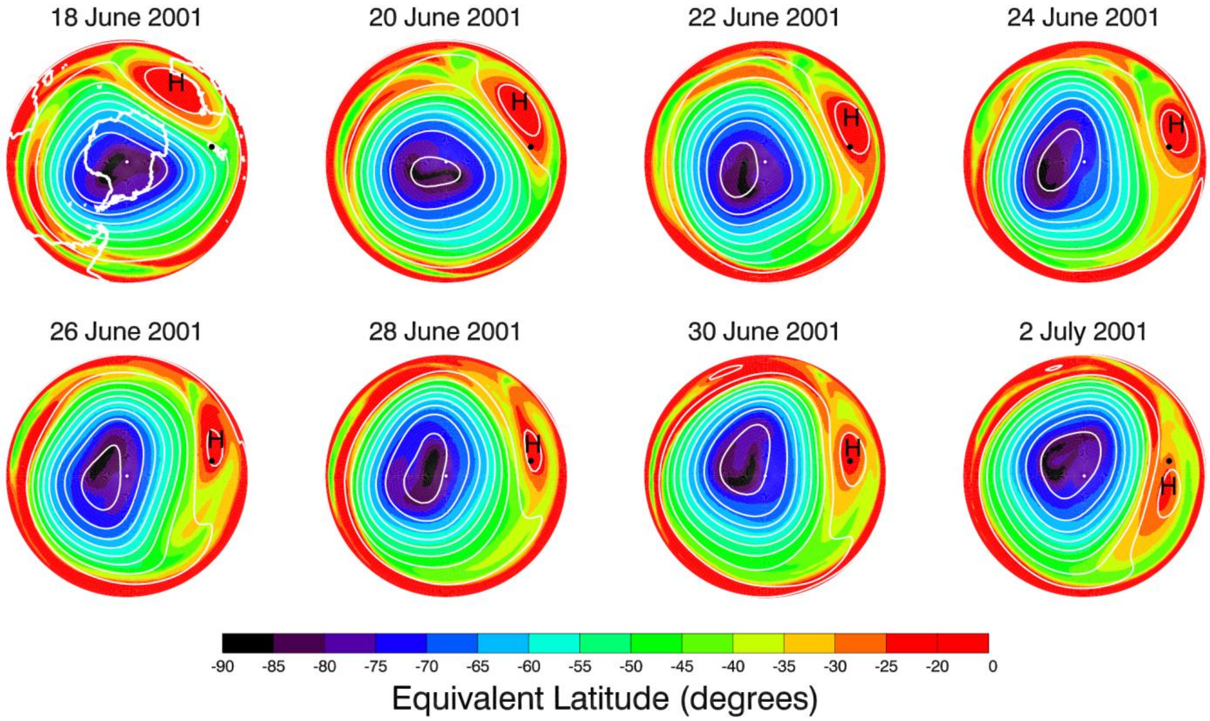

Figure 4– The tracer equivalent latitude (see text) for the Southern Hemisphere at 650 K. The location of Lauder (45°S, 169.7°E) is indicated by a black dot. White contours are 650 K streamlines at constant intervals. The black "H" indicates the location of strong anticyclonic circulation.

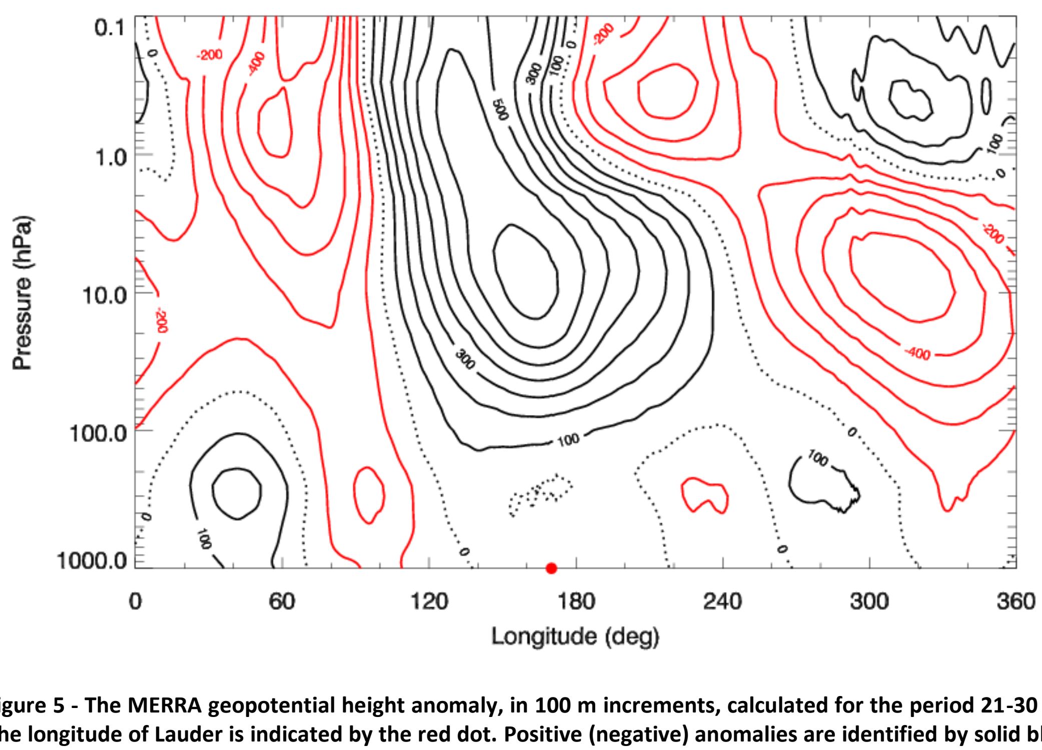

Figure 5 - The MERRA geopotential height anomaly, in 100 m increments, calculated for the period 21-30 June 2001, at 45°S. The longitude of Lauder is indicated by the red dot. Positive (negative) anomalies are identified by solid black (red) contours, while the black dotted line indicates zero anomaly.

Regarding the 2009-2013 event: the agreement with MLS ozone data in Fig. 5 is impressive, but the construction of Fig. 6 is misleading (norming the individual satellites to separate segments of the MOPI data). Note that as a result of this construction there is a significant mismatch between the SAGE, HALOE and MLS results for the overlap during 2004-2005. I think the overall agreement of MOPI with satellite data would look less impressive if the satellite data were merged consistently using the overlap period. Alternatively, it might be useful to use one of the merged ozone datasets that are available in the community for this comparison (e.g. GOZCARDS or the SPARC Data Initiative data sets).

Yes, it certainly cannot be denied that a different construction of the Figure 6 (now Figure 7) might degrade the visual agreement between the satellite and MOPI data. However, given that only the MOPI dataset spans the entire period shown in Figure 6 (now Figure 7) this seems to us to be the best choice. The text has been rewritten to read: "Since only the MOPI1 measurements are available throughout the entire time period, all of the satellite measurements have been offset so that the average ozone matches that of MOPI1 during the period of coincidence. We note that there is an increase of ~4% in the MOPI measurements relative to both the locally coincident and the zonally averaged and convolved Aura MLS (shown in Fig. 6), which occurs primarily near the beginning of the Aura MLS timeseries."

I like Fig. 7 as arguing for a link with global-scale circulations, but the following discussions in Section 4 regarding links to tropical ozone, N2O and the QBO seem unfocused, and arrive at a conclusion that the anomalies are 'caused by the rate at which N2O moves from the tropics to southern midlatitudes'. This is quite hand-wavy, as these patterns in Figs. 7 and 9 could easily be associated with changes in overturning circulation (given the decreasing vertical gradient of N2O across the globe).

Yes, this is a very good point. We now point out in the text that it is the competition between descending air and poleward moving air that determines N_2O and O_3 in this region, so the text reads: "The lower stratospheric anomalies in O_3 and N_2O at 40°S to 50°S are likely to be caused by the variations in the rate at which tropical air with high N_2O and low O_3 air moves into the Southern mid-latitudes, relative to the rate at which low N_2O and high O_3 air descends into this region."

We have also made some changes to the text and have added a reference to Mahieu et al. (2014) at the end of Section 4 together with the text: "While the beginning and endding dates are slightly different, Fig. 10 is qualitatively consistent with the conclusion in Mahieu et al. (2014) that the air in the SH mid-latitude lower stratosphere is younger in 2010/2011 than in 2005/2006, while the opposite is true in the NH." We also divided Section 4 into subsections to make it easier to follow.

But more importantly, these results strongly overlap the findings recently published in Nedoluha et al, ACPD, 2015; hereafter N15), including the large-scale coherence between ozone and N2O over much of the globe (shown in their Fig. 4) and out-of-phase changes (or trends) between the tropics and SH midlatitudes (Fig. 9a is copied from N15). What is the additional novel information here? Overall I do not appreciate that there are important new results in this paper that enhance our fundamental understanding of ozone or large-scale circulation beyond the results of N15.

Yes, to the extent that the high mid-stratospheric O_3 from 2009-2013 over Lauder is related to changes in the tropics there is admittedly indeed significant overlap between some of the results of this paper and N15. However, N15 does not include the ground-based dataset, and is very much focused on the tropics. What we found particularly interesting was how the tropical results of N15 helped to explain at least one temporal variation in our long Lauder measurement dataset.