Responses to Referee #2

Our responses in italics. In the revised manuscript, all changes (except minor technical corrections) are highlighted in red.

The paper by Manney et al., introduces jet based coordinates to map comprehensive satellite observations of particularly UTLS data and segregating tropospheric and stratospheric data. The jets are identified by basically the wind speed and spatial separation (in the case of multiple jets) at a given longitude refining and modifying previous algorithms from other authors. Meteorological and observational data are then displayed in their relative distances to the locations, where jet streams are identified. The jet based coordinates are directly compared with equivalent latitude data and both coordinates are used to map satellite observations of ozone.

The authors demonstrate that jet based coordinates provide a powerful tool to map instantaneous as well as climatological observations and map collocated regions of strong gradients of PV and tracer (ozone, CO, CH4) across the jet. They conclude, that jet based coordinates provide a more detailed view on the relation of gradients of e.g. PV and ozone and that equivalent latitude (EqL) coordinates tend to wash out this signature.

The paper is of high value and importance for the scientific community. It is very well written, methods are sound and the results are presented in a clear and concise way. The paper is very convincing, but the only point I found a bit misleading is the interpretation of the equivalent latitude to jet based coordinate comparison. Therefore I clearly recommend the paper for publication after the following considerations have been addressed.

We thank the referee for his/her helpful comments.

Main point: I would appreciate a consideration of the pros and cons of both methods on p.1868, l.11, since it is implied that jet based coordinates are superior over EqL representations. This clearly holds for jet-based processes, but not necessarily for a complete tracer climatology including non-jet longitudes. The jet-based aspect should be stronger emphasized in the conclusions along with the constraints and limitations. The comparison of the PV and ozone contours of Figure 11 (center) and Figure 10 (top) illustrates, that the EqL-Theta view does not obscure tracer structures. It expands the sharp PV- and ozone gradients at the STJ. This is comparable to e.g. vertical ozone profiles, which are displayed as a function of Theta instead of altitude, which stretches the stratospheric part of the profile depending on the vertical Theta-gradient. The same holds here for horizontal gradients of PV (or EqL, ozone, CO) in the horizontal direction at the jet using EqL-coordinates. Therefore the gradients in Figure 7 are much less pronounced in EqL coordinates.

Both referees remarked on the lack of balance between the treatment of the new jet-coordinate view that we are presenting here and existing frameworks used to view the extra-tropical UTLS. It was never our intention to dismiss the value of those methods, but we appear to have been too enthusiastic in highlighting the added value of our new methods. We have revised the text throughout (and modified several of the figures, as discussed below and in the response to referee#1's comments) to not only give a more balanced view of different coordinate systems, especially EqL versus the jet coordinate, but also to highlight ways in which both frameworks can be used together to provide further insight into dynamics and transport around the UTLS jets. The largest changes are in the discussion of Figures 5 through 7, Figures 10 and 11 (now Figures 10 through 12), and in the Introduction and the Discussion and Conclusions sections. In the introduction, for example, we have modified the statement regarding the complications of using the EqL coordinate in the UTLS to read:

"In these regions, the O_3 field suggests mixing in a broad area between edge of the subvortex and the

tropopause. At both levels, the jet is often discontinuous or may have multiple cores at some longitudes, with corresponding complexity in the PV contours; its strength also varies greatly with longitude. Equivalent latitude (EqL) calculated from PV is a very useful coordinate in the polar winter stratosphere where, since the circulation is organized by a single, simply-connected jet of relatively uniform strength around each EqL contour, it not only accurately segregates different air masses but also provides a complete description of the relationships of those air masses to the jet structure. In contrast, while an EqL coordinate still shows the boundary between different air masses in an average sense (around an EqL contour) in the UTLS, it can obscure the details of the relationships of those air masses to the complex, discontinuous system of jets, and associated variations in trace gas distributions and gradients around EqL contours."

In the conclusions section, the summary statement about trace gas distributions in different coordinate systems has been reworked as follows:

"The view of UTLS MLS O_3 data is compared using EqL and distance from the subtropical jet as horizontal coordinates in combination with several vertical coordinates. While both views show evidence of STE in the existence of O_3 values characteristic of the stratosphere well below the tropopause, the EqL/q view blurs the representation of the jet and the strong gradients (in PV, tropopause altitude, and O_3) crossing the jet core, and thus the relationship of that STE to the jets, wherein stratospheric O_3 values in the troposphere are concentrated poleward of and below the jets. The view using the subtropical jet core as both horizontal and vertical coordinates highlights the correlation between strong PV and tropopause height gradients and very strong O_3 gradients. The jet coordinates also highlight evidence of poleward transport across the top of the jet. Vertical coordinates relative to the tropopause are also valuable, especially in defining the strong trace gas gradients across the tropopause. For studies such as quantifying the geographic and temporal variability of large-scale trace-gas gradients across the tropopause, it may prove valuable to examine both tropopause- and jet-relative vertical coordinates in combination with the horizontal jet coordinate, as well as using the EqL/tropopause framework to obtain a global picture."

Numerous other changes have been made throughout the text, which will be described in the responses to the referees' specific comments.

Second - as stated by the authors - the jet coordinates are only defined where a jet is identified. EqL contains all longitudes, which put constraints on the direct comparison and interpretation of the relation between both quantities.
The weaker appearance of gradients is therefore the result of two things: Expanding a sharp PV (EqL) gradient at the jets and remapping of data filtered by different conditions.

*As stated in the response to referee#1, we have reworked what was Figure 10 into two figures (Figures 10 and 11): The new figure 10 shows the data in EqL/theta coordinates mapped separately for the data points at longitudes that did and did not have a subtropical jet core identified. In fact, the mapping using only the strong jet regions is **very** similar to that in the top panels of the original Figure 10, indicating that the inclusion of weak jet regions was, in this case, a minor factor. This figure also allows us to discuss the differences between strong and weak jet regions and hence demonstrate one way in which we can use our jet characterization within the EqL framework to get additional information on the differences between strong and weak jet regions.*

*Mapping PV into EqL coordinates (e.g., in numerous studies of the polar winter stratosphere) generally **highlights** regions of strong PV gradients, since, although the morphology of PV and EqL is the same by definition, the gradients are very different – where PV gradients are strong, EqL (that is, the area enclosed by the contour) does not change much between one PV contour and the next and thus they will appear closely spaced when mapped in EqL coordinates; we therefore do not think that the "expansion" of the PV gradients is in itself a significant factor.*

The fact that Figure 10(top) and Figure 11(middle) both show ozone-following PV contours, illustrates correspondence in both coordinate systems. Fig. 10(top) and 11(middle), however, also illustrates the complementary information of both coordinates: The jet based coordinates show the relation to jet, the EqL coordinates demonstrate that a strong diabatic component leads to the high ozone tongues up to 300 ppbv below the tropopause and in vicinity of the jet. Note that this feature is much more prominent in the EqL representation, however the link to jet itself is better to see in jet-based coordinates. As such I don't see any coordinate superior over the other, both together provide a very powerful combination. Both remove to some extent undulations of the tropopause, but address different questions: Which role play the jets (and only the jets)? Where is PV conservation violated?

In conjunction with reworking Figure 10 (now Figures 10 and 11) to show both weak and strong jet regions, we have modified the text to discuss the differences in the two coordinate representations without making any statement about one being superior to the other; in addition, we now discuss ways in which the two views can be used together (and the jet information used with the EqL coordinate) to provide even more information.

Minor:

p.1838, l.23: The subvortex jet as part of the polar night jet: Maybe it would be good to emphasize here that the 'subvortex jet' is meant to be different from the upper tropospheric polar jet.

Upon reviewing this sentence, we found it unnecessarily complex and very difficult to follow, so it has been reworded as follows:

"Although O_3 depletion occurs throughout the lower stratosphere, a substantial portion of that depletion takes place in the subvortex, the lowest part of the polar vortex that extends into the lowermost stratosphere (the region of the stratosphere between the tropical tropopause level, typically 380K potential temperature, and the extratropical tropopause, e.g., Holton et al., 1995). At these altitudes, ozone-depleted air can be more efficiently transported to midlatitudes (e.g., Lee et al., 2002; Santee et al., 2011) because the permeability of the transport barriers defined by the UTLS jets is greater than that in the vortex proper."

p.1854, l.14 ff (Fig.5): The Figure shows two local maxima of Equivalent latitude on a given Theta level (e.g. Fig.5, upper right, 420-440K). This is strange, since EqL on an isentrope should be continuously increasing from low to high Eql. Clearly this must be the result of the jet based remapping, but does a bimodal isentropic equivalent latitude distribution make sense? What is the physical background, when airmasses are normalized to jet altitudes in the vertical direction, when they are several thousands of kilometers away from the jet? Note that transport within the stratosphere is quasi isentropic, thus sloped downward towards the poles.

There is no inherent physical reason why the EqL a certain distance poleward of a jet may not be higher than that slightly closer to it. However, the cases noted here are quite far from the jet in both directions, where the influence of the jet is weak, and hence are probably not particularly meaningful. We have made a note to this effect in the text.

p.1855, l.22: The fact that the polar (subtropical) jet is washed out relative to the subtropical (polar) jet is explained by temporal non-coincidence. However, the latitudinal distance relative to each other at any given longitude is completely ignored, but seems to be the driving agent (see Fig. 1/2)

We have added sentences about the jet influence diminishing with increasing distance in latitude, both here and in the discussion of Figures 10–12.

p.1856, l.25-29: Is it possible to plot ozone in the same coordinates? This would nicely illustrate the relationship between EqL and negative PV-gradients above the winter STJ.

This is exactly the type of study that we are working on for our detailed study of the climatology and variability seen in the MLS and ACE trace gas data and its relationships to the jets. As such, we feel it is *beyond the scope of this paper.*