Review of paper: "Simultaneous assimilation of satellite NO_2, O_3, CO and HNO_3 data for the analysis of tropospheric chemical composition and emissions", by Miyazaki et al.

General Comments:

This is a very comprehensive piece of work and a valuable contribution to the data assimilation literature. It is suitable for publication in ACP once the authors address the following: (i) more references need to be introduced to defend statements made (examples given in the specific comments below); (ii) consider splitting the conclusions section (which is a bit too long) into a discussion and a conclusion proper, the latter providing the main message of the paper (e.g. the last 2 paragraphs of the current conclusions could form the basis for this revised conclusions section); and (iii) introduce acronyms when first used, both in the abstract and in the main manuscript.

The authors should also address the specific comments below.

Specific Comments:

P. 16132, L. 24: Provide references for why ozone is important for air quality and climate.

P. 16133, L. 18: Provide references discussing the large uncertainties in bottom-up inventories.

P. 16134, L. 27: Provide references on the value of MLS (and other limb sounders) for the UTLS.

P. 16135, L. 2: Provide references for data assimilation (e.g. Kalnay, 2003).

P. 16136, end of section 1: I suggest you indicate in which section the conclusions are provided.

P. 16137, Eq. (2): I suggest you motivate the introduction of the x_{true} term (the text does not appear to discuss it).

P. 16137, L. 11: Is the measurement error the random error? Is it assumed the measurements have no bias?

P. 16138, L. 4: Provide references for the poorer resolution for GOME-2 and SCIAMACHY.

P. 16138, L. 12: Provide a reference for the product specification document.

P. 16139, L. 13: Provide references for the statement about TES DOFs in the tropospheric tropics.

P. 16141, L. 10: What is the impact of not applying the bias correction?

P. 16147, L. 13: Mention the non-linearity of H when H is first introduced (p. 16136).

P. 16151, L. 24: Quantify the statement that the DOF is "large".

P. 16153, L. 23: What is the "above-mentioned"?

P. 16157, L. 20: Is the statement about the OmF and bias reflected in the OmA statistics?

P. 16159, L. 27: Be more specific than "non-CO".

P. 16161, L. 22: Provide references for the separation of the troposphere and stratosphere.

P. 16163, L. 2: Provide references for the statement about ozone precursors.

P. 16173, L. 8: I suggest you remove "dramatic".

P. 16174, L. 16: I suggest you identify the bottom-up inventories.

P. 16175, L. 2: Provide references for these previous inverse modelling studies.

P. 16176, L. 24: Provide references describing twin experiments.

P. 16177, L. 2: What do you mean by a perfect model scenario? In standard nomenclature, no $\mathbf{Q}$ error covariance matrix included, but a $\mathbf{B}$ error covariance matrix is included?

P. 16197, Table 4: What is "num" in the caption? What number of ensemble members did the "loc" experiments have? I suggest you identify in bold the smallest number in each column.

P. 16208, Fig. 6: Indicate in the caption what the vertical bars show.

P. 16210, Fig. 8: Indicate in the caption what red/blue colours show. Also, as I understand it, the "control run" is marked as "free" in the figure. Either change the figure or indicate this in the caption. Same for Figures 9 and 10.

P. 16213, Fig. 11: Indicate in the caption that the upper and lower panels discussed comprise of 9 members each, e.g., use the form "upper 9 panels".

P. 16214, Fig. 12: Fig. 12 is not quite like Fig. 11 (different number of panels), so please rephrase.

P. 16215, Fig. 13: Indicate in the caption that the control run is the model run (as shown in the figure). What is the size of the bin?

P. 16216, Fig. 14: Use the form "upper 6 panels" and "lower 6 panels".

P. 16217, Fig. 15: Indicate in the caption what red/blue colours show. Indicate that O_3, CO and NO_2 are shown in the left, centre and right panels, respectively.

Technical points:

P. 16139, L. 27: should be "upper troposphere".

P. 16141, L. 24: Should be "...recommendations in Livesey...".

P. 16149, L. 16 and 17: "...forecast atmospheric concentrations of...".

P. 16150, L. 15: conduced-> conducted.

P. 16155, L. 14: Use the subscript "3" for ozone.

P. 16156, L. 22: matricies-> matrices

P. 16159, L. 24: are larger->have higher values

P. 16162, L. 5: should be "...O_3 are found...".

P. 16162, L. 28: Omit "the" after "Since".

P. 16163, L. 7-8: should be "...data assimilation experiment with a bias...".

P. 16172, L. 12: remove repeated "the"; L. 16: should be "...knowledge of...structure is...".

P. 16174, L. 14: great-> large

P. 16195, Table 2: many-> several

P. 1698, Table 5: Could this be made bigger? Same for Tables 7 and 8.

P. 16203, Fig. 1 caption: Should be "$\mathbf{Y^o}$".