Response to Reviewer #1 Comments

We thank the reviewer for their helpful comments. We have incorporated as many of the reviewers' suggestions as possible into the revised manuscript. All reviewer comments are in italics and the author's responses are in standard font.

The article delivers on its goal of evaluating potential sources of a priori ozone profile information for use in retrievals from TEMPO measurements over North America. The accomplishment is well-summarized by the first sentence of the last paragraph: "This study is a first step in determining what source of a priori vertical O3 profiles should be applied to best enhance the ability of TEMPO to retrieve tropospheric and LMT column O3 in North America."

The retrievals envisioned in the article fall into the best-estimate-for-today category of retrieval approaches. That is, they seek to bring in as much information from climatologies or models or other sources as they can into the final near-real-time product. Such approaches may not be well-suited for climate change studies as it can become difficult to unravel the sources of any trends from the influences of the measurements versus the influence of the varying a priori profiles. Even with the averaging kernels and a priori profiles provided for each retrieval, assimilation applications of the data will be more complicated too. Do the developers envision that the models will use these retrievals as input to influence the forecasts?

The reviewer brings up an important point. The tropospheric ozone (O_3) retrieval algorithm for TEMPO is still under development and testing, and therefore the purpose of this study is to determine the general impact of different sources (climatology products and near-real-time (NRT) data assimilation, reanalysis, and chemical transport model (CTM) data) of a priori profiles on TEMPO tropospheric and lowermost tropospheric (LMT) O_3 retrievals. As the reviewer identifies, implementing NRT daily/hourly predictions from CTM or air quality models as the a prior in tropospheric O_3 retrievals from TEMPO is best suited when using this output to study topics such as air quality or event-based processes (e.g., air quality exceedances, wildfires, stratospheric intrusions, pollution transport, etc.). Using an a priori from model-predicted NRT daily/hourly information will in fact impact the error/uncertainties and trends of retrieved tropospheric O_3 from TEMPO and the final algorithm will likely use an hourly-resolved monthly mean climatology based on model outputs. Follow-on studies to this manuscript are currently being conducted to develop different CTM-simulated O_3 climatology products and test them in the tropospheric O_3 retrieval algorithm. To better emphasize these important points, additional text has been added to the updated manuscript, primarily in the conclusions section: "The results of this study demonstrate that using simulated O_3 profile data will improve near-surface TEMPO O_3 retrievals, however, implementing NRT daily/hourly predictions from CTM or air quality models as the a prior is best suited for using TEMPO data to study topics such as air quality or event-based processes (e.g., air quality exceedances, wildfires, stratospheric intrusions, pollution transport, etc.). Applying NRT daily/hourly predictions from CTM or air quality models as the a priori will impact errors/uncertainties and long-term trends in tropospheric O_3 retrievals from TEMPO and these impacts would be difficult to separate from actually retrieved information. Therefore, the

standard TEMPO O_3 profile algorithm will likely use an hourly-resolved monthly mean climatology and follow-on studies to this manuscript are currently being conducted to develop different CTM-simulated O_3 climatology products and test them in the retrieval algorithm. It is important to note that TEMPO data users can easily use the output from the standard retrieval and recalculate the tropospheric O_3 vertical profiles using a different source of a priori following the methods of this study.".

A major application of TEMPO products is envisioned to be the assimilation of the O_3 data (and other chemical constituents) into CTM and air quality models to improve retrospective analysis and forecasts of air quality and tropospheric chemical composition. The standard product of TEMPO O_3 retrievals, or recalculated profiles using a different a priori following the methods of this study, can be assimilated into CTM or air quality models.

A key performance index for the study is the ability of the retrieved profiles to identify high ozone levels in the lowermost troposphere (LMT 0-2km). With this in mind, Tables 4 and 5 should give correlations so that the readers can better compare the performance of the a priori profiles alone, provided in the earlier tables, to the performance of the retrieved profiles.

We agree with the reviewer and these correlation values have been added for tropospheric and LMT column O_3. Additional text has also been added to the updated manuscript to explain these results.

I was surprised that the article does not include a discussion of the effects of surface reflectivity (and knowledge of the surface reflectivity and surface pressure) on the lower layer information content. What ground reflectivity was assumed in the clear sky retrievals? How will seasonal variability, especially snow cover, be addressed in the algorithm? A future study could also consider the use of clear versus cloudy or partially cloudy (with cloud height and cloud fraction information from the measurements) results for adjacent pixels to try to identify the below cloud columns better (or even to apply some version of cloud slicing).

We agree with the reviewer that near-surface O_3 retrievals from ultraviolet + visible (UV+VIS) wavelengths are sensitive to surface reflectance/albedo (primarily in the VIS). TEMPO retrieval sensitivity studies which produced the averaging kernels (AK) used during this study (see Zoogman et al. (2017)) applied surface albedo values from the Global Ozone Monitoring Experiment (GOME) albedo database and surface pressure was taken from the GEOS-5 meteorological model. The GOME database provides a monthly mean surface albedo climatology at a spatial resolution of 1° × 1° for multiple wavelengths (from 335 to 772 nm) which were interpolated/extrapolated to match TEMPO retrieved wavelengths. The spatio-temporal variability of snow-cover is taken into account when producing TEMPO AKs, but for this study, which is focused on summer-months, will not have any impact on the results. Some text has been added to updated manuscript to reflect this information: "Surface albedo is taken into account using the GOME albedo database interpolated to match TEMPO wavelengths." and "For detailed

information about the TEMPO retrieval sensitivity studies, and the input variables, used to derive AKs applied during this study see Zoogman et al. (2017).". In the actual TEMPO retrieval, surface albedo will be retrieved as a first-order polynomial in the UV following Liu et al. (2005, 2010) and a new climatology of visible surface albedo spectra has been developed for fitting surface albedo spectra in the visible using multiple parameters (Zoogman et al., 2016). Surface albedo is typically well retrieved from this algorithm and its effect on the retrieval sensitivity/information content is taken into account.

We also agree with the reviewer that a future study focused on the impact of clouds (e.g., fraction height, etc.) would be interesting.

Editorial erratum

Table 3 does not contain a listed section for JPL TMF results.

Table 3 does not have a listed section for JPL TMF results as this table presents the statistics of the comparison of the diurnal time-series of hourly-averaged tropospheric and LMT O_3 from the climatology and models to observations. No hourly-averaged lidar observations were available from the JPL TMF system for diurnal time-series evaluation as stated in Sect. 2.1 of the manuscript: "During the summer of 2014, the JPL TMF lidar only conducted measurements during the nighttime hours and therefore will only be used for daily-averaged comparisons to TB-Clim and model predictions". To better explain this, the updated manuscript in Sect. 2.4 now reads: "Due to the hours of operation, the evaluation at the JPL TMF lidar location was not conducted for hourly-averages and is only applied for summer- and daily-averages.".

References

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