Review:

Eunjo Ha et al., First evaluation of the GEMS glyoxal products against TROPOMI and ground-based measurements

Summary:

The authors present retrieved glyoxal columns from the GEMS instrument. Given its short lifetime, measurements from GEO are particularly well-suited to monitoring this trace gas, and the present study is the first of its kind to do this. Glyoxal retrievals from space are challenging due to the gas' low concentrations and to spectral interference from other trace species. The authors have done an excellent job in extracting the glyoxal signal from the data, although the main components of the retrieval algorithm do not differ significantly from approaches in previous studies. I would like to see some additional elaboration on the methods used here, as well as error analyses and studies of sensitivities of the retrieval to assumptions in the algorithm.

The writing in this paper is clear and the manuscript is well organized. Citations are appropriate. With the additions and minor corrections suggested below, I believe it should be published in AMT.

General comments:

(1) On page 8 (lines 189-193), the empirical NO_2 correction is discussed. When applied, summer differences with TROPOMI become larger, and the winter smaller. In figure 6, or in a separate similar figure, it would be useful to show the GEMS glyoxal with and without the NO_2 correction. How does this affect the correlation coefficients? Could differences in correlation lend support the inclusion of the correction?

(2) The VCDs derived relative to spectra from clean reference regions are corrected using GEOS-Chem modeled glyoxal. These model amounts are likely low. Silva et al. suggest the error may be a factor of 3. Have the authors tried increasing the model offsets to counter the effects of these erroneous background values? Perhaps comparisons could be shown.

(3) This paper would benefit from a more comprehensive error analysis, particularly with consideration of the contribution of the major systematic errors, including AMF and background. Glyoxal is a difficult measurement and these errors are likely to be large. Lerot et al. estimated up to 70% error in polluted regions, which I suspect might even be low, given the uncertainties the authors have identified related to background and reference-sector choice.

(4) Were glyoxal amounts in the reference sector estimated at local times comparable to the measurements? If not, perhaps any difference would be negligible. The authors could mention/justify a reason for ignoring this.

Minor comments and suggested corrections:

(1) Page 1, Line 20: Without the NO2 correction, GEMS and TROPOMI VCDs are approximately equal in summer. I suggest modifying the wording in the abstract, maybe: "Specifically, with an empirical NO_2 correction applied, GEMS VCDs are significantly lower in summer and higher in winter…".

(2) Page 3, Lines 64-67: Please add couple more sentences describing the GEMS instrument, including the native spatial resolution. This will help put the 4 x 4 co-adding in context.

(3) Page 3, Line 75: "…converted to the VCD by dividing by the air mass factor …"

(4) Page 4, Line 100: The fitting window 433.0 – 461.5 nm is approximately the same as used by Lerot et al. and references therein. Did the authors in the present study arrive at this independently? Please clarify and include relevant citations.

(5) Page 6, Line 131: Please explicitly define AMF and AMF_0.

(6) Page 9, Line 233: "MAX-DOAS". Also, would it be reasonable to show GEMS vs MAX-DOAS diurnal correlation coefficients for each station?

(7) Page 20, caption figure 4: Please make it clear that Domain 2 is excluded from the surrounding Domain 1 (I assume that is what is meant).

(8) Pages 21-22, captions of figures 5 and 6, (and the body text), please state that the GEMS glyoxal amounts are shown before NO_2 correction. As suggested above, I recommend to showing the comparisons with and without the correction