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Interactive comment on "Model-based Climatology of Diurnal Variability in Stratospheric Ozone as a Data Analysis Tool" *by* Stacey M. Frith et al.

Anonymous Referee #1

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This manuscript presents a model-based climatology of diurnal ozone variations in the stratosphere (50-0.5 hPa) based on the NASA GEOS-GMI chemistry model. This climatology is of significant utility for observational data inter-comparisons and merging activities as it allows to correct for diurnal sampling biases in ozone records. This is a topic of high relevance for readers of AMT. The paper is well written and covers all the relevant details and citations. I recommend publication after addressing my comments below, most of them being minor.

General comment:

Overall I'm missing a more quantitative discussion on uncertainties and limitations when using the diurnal climatology in different applications. I see three potential sources of uncertainty: (i) model errors, (ii) unresolved inter-annual variability, and

(iii) climatology discretization. While (i) is very difficult to quantify, (ii) and (iii) could be assessed in a straight forward manner.

The influence of inter annual variability is already discussed in a qualitative way (e.g. Fig S10, differences between 2017 and 2018 outputs) but could be extended to include quantitative estimates.

Regarding (iii), a mayor source of uncertainty could be the relative broad temporal resolution of the climatology (monthly) which may introduce systematic deviations close to the terminator, particularly in the polar regions and at upper stratospheric levels (and above) where photochemistry is relatively fast (intra-month terminator variations are not resolved by the monthly climatology). These errors could be evaluated by e.g. applying the climatology-based diurnal correction to the 0.5-hourly resolved model output itself. Further, an upper vertical limit for a "safe use" of the climatology, would be helpful, particularly when considering that the climatology is provided up to ∼80 km (0.01 hPa).

Specific comments:

p1 l21: "polar summer boundary" -> consider to rephrase to "polar day terminator"

p4 l14-15: The reason for the vertical interpolation is not clear. Why switching to a different vertical grid if the climatology is provided on pressure levels and the interpolated levels have a similar vertical resolution as the original pressure levels? Further, Z* and pr are not defined.

p4 l17-20: I guess that local solar time (LST) is meant with "time of day". Can you provide some more details on how the local time binning has been performed? Was the model output at different longitudes (but fixed UT) resampled to local time or was the local time (at fixed longitude) sampled from the output at different UT (and finally zonally averaged)? This question is relevant since the former option (while in principle allowing for better local time resolution) may introduce aliasing effects by e.g. stationary planetary waves while the latter option is much less sensitive to such aliasing effects.

p4 l25-29: Can you quantify the agreement of the climatologies in Figure S10? The difference of the climatologies for different years could provide a good estimate of the uncertainty range caused by intra-annual variability.

p9ff (Day Night Differences): Apart of Aura/MLS there are also other ozone-observing instruments on sun-synchronous platforms, some of them having different equator crossing LSTs compared to MLS. MIPAS on ENVISAT, for example, took sun-synchronous measurements at 10 am - 10 pm equator crossing LST, in principle allowing to extend the validation of the diurnal climatology by means of observed day-night differences to different LSTs.

p11 l1-4: A possible reason for the divergence between GDOC and SAGE-III above 2 hPa could also be related to the limitations of the monthly-resolved diurnal climatology: sunset (SS) and sunrise (SR) times are spread over a certain LST range in the monthly climatology, resulting in an artificial smearing of the diurnal gradient at SS and SR and hence in reduced SR/SS ratios.

p15 l4: the webpage is not accessible.

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