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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Diurnal variability of total column NO_2 measured using direct solar and lunar spectra over Table Mountain, California (34.38° N)" *by* King-Fai Li et al.

Anonymous Referee #2

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King-Fai Li et al 2020 present direct sun and direct moon NO2 measurements over a high altitude mostly unpolluted site, JPL-TMF near Wrightwood, CA, during 6 days (around full moon) in October 2018. They proposed to combine two Langley-like techniques to estimate amount of NO2 atmospheric absorption during the reference spectrum measurement time. The proposed approach takes advantage of 1-D photochemical model to estimate diurnal variation in NO2 and minimum Langley extrapolation technique to reduce the effect of NO2 pollution. Modeling results are compared with the measurements. Chemical reactions for different processes are shown. Accurate measurements of diurnal NO2 variation are important and the topic fits into the scope of the "Atmospheric Measurement Techniques" journal.

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Discussion paper

Major comments:

Not sufficient measurements (only 6 days) were presented in the paper to apply minimum Langley extrapolation technique (MLE). MLE is a statistical method and requires sufficient data to “accouter” conditions with “constant” vertical columns at each solar zenith angle. This threshold was not met during this study. MLE uses as low percentile for fitting as possible (within SNR) to capture background NO2. Increasing percentile used for Langley fitting does not simply improves the statistics, as stated in the paper, but can significantly alter the result. This can be easily remediated by including more measurements, especially at this mostly clean site.

While the idea of improving estimation of slant column density in the reference spectrum using a 1-D photochemical model is appealing, the authors have not demonstrated that it provides a better result than MLE itself. Looking at the data in Fig. 2 and 3, MLE will most likely result in lower amount in the reference spectrum, and the final vertical columns will agree significantly better with the model diurnal change than the retrieved columns (but will have an offset). Authors need to show that the results are better than the MLE by itself, and for that more measurements are required. Note, that to determine amount in the reference spectrum, full moon is not needed, since the analysis is done on the direct sun data. It is not clear from the presented results if the error in the model simulations actually is smaller than the uncertainty in MLE. This needs to be demonstrated.

It is unclear what benefits this approach (1D stratospheric model) will have under the “persistent” pollution levels when the total NO2 abundance is dominated by anthropogenic emissions at all times.

Description of the DOAS fitting settings is not sufficient. What are polynomial orders (e.g. broad band, offset, wavelength shift), what sources of other gases cross sections and at what temperatures were used in the analysis? Were NO2 cross sections at all five temperatures used in the retrieval? If yes, how they were fitted and combined?

Why this fitting window was selected (430 and 468 nm)? How exactly air mass factor was calculated? What is the DOAS fitting quality of NO_2 from direct sun and direct moon (residual OD)?

No error budget is presented for the measured NO_2 columns.

The paper in general reads more like a modeling paper then the measurement paper.

There are routine NO_2 stratospheric measurements conducted by the NDACC stations (zenith sky DOAS) and total column measurements of NO_2 using direct sun and direct moon within Pandonia Global Network. They should be mentioned in the review of NO_2 measurements. In general, citations tend to include mostly early works and not give current status.

It is unclear how the lunar measurement where taken. Lunar irradiance is about 10^6 lower than solar irradiance. In this study, integration time for sun measurements is 16 times shorter then for moon. Difference in lunar vs solar measurements (diffusers, filters, etc), and what effect it has on spectrometer illumination should be presented. Target signal-to-noise ratio stated.

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