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Interactive comment on "New Observations of Upper Tropospheric NO$_2$ from TROPOMI" *by* Eloise A. Marais et al.

Anonymous Referee #1

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Overview: This is a solid contribution describing a novel upper tropospheric NO2 product derived by cloud-slicing TROPOMI retrievals.

General Comments:

L406: What do you mean by corrected TROPOMI columns. Are you referring to the 13% change in stratospheric variance and 50% decrease in tropospheric columns referred to in line 386. If yes, were these large adjustments based on a comparison with just 3 sites? Justify.

L417: What are the pros and cons of producing two UT NO2 products as opposed to a merged product.

L450: What is the spatial correlation between these distributions and the OTDLIS cli-

matology?

L593 (and in abstract) Can these estimates of UT NO2 be compared directly to aircraft measurements as hinted at in the abstract or do they need to be averaged over weeks or seasons before such a comparison is meaningful. The near zero correlation of with daily free-troposphere values seems to suggest the latter.

How much value would be added if this product was created using multiple years of TROPOMI data as opposed to one year?

Specific Comments L27: Consider deleting the discussion of synthetic columns from the abstract. It may discourage the general reader from reading the manuscript. i.e., consider deleting the section beginning with "This follows refinement" . . . and ending with "overlying stratospheric NO2".

L79: May want to mention SAGE III, which has a few UT measurements of NO2 L130-142. Many details here. My following questions are an attempt to see if I understand what you did.

L132: What is a cluster? Is it the collection of 0.25 x 0.3125 degree boxes assigned to a 4 x 5 box? If yes, are you saying that you throw out an entire cluster if the stratospheric column NO2 relative standard deviation exceeds 0.02?

L136: How are scenes determined? If you break clusters into multiple scenes why don't you start doing this at 80 (2 x 40) as opposed to 100?

L141: How far into a deep convective cloud can TROPOMI see? Does the signal penetrate a few km below the top edge of the highest model layer?

L145: What do you mean by "error on the slope"? Is this the uncertainty of the slope?

L147: I don't understand what you mean by "negative slopes". Wouldn't you expect the partial column to decrease as the cloud top height increases because higher heights mean that TROPOMI is sampling less of the troposphere?

L148: "Converted to mixing ratio". Does this mean that you are dividing by the mass of air between the cloud top pressure and the tropopause?

L179: What is the source of this stratospheric variability? Is it aircraft and/or lightning-NOx?

L202: For TROPOMI, do you use the effective cloud fraction or the effective cloud fraction in the NO2 window?

L216: What do you mean by "free tropospheric" NO2 from TROPOMI. Is this what you called "upper tropospheric" NO2 earlier?

L278: Is AMFtrop.geo a standard TROPOMI data product or did you derive this variable from other terms (VZA, SZA etc.)? Ok, it looks like it is non-standard but easily calculated as you show later.

L349: Could you be more specific here. How was the stratospheric NO2 variance correction applied?

L360: Are estimates of free-tropospheric NO2 from TROPOMI possible on all days or only on days with variations in cloud-cover over a 4 x 5 grid. How many data points are there for each instrument?

L371: Could you explain the meaning of "the sampling footprint shifts by at least 2 degrees in latitude between . . . solstices. i.e., When is it larger

L421: The standalone product version number . . . I would move this sentence later in the paragraph and start with "Cloud fractions from the standalone product . . ."

Technical Corrections. L73: but these are prevalent over heavily — but these are mostly limited to heavily

L74: and are often — that are often

L115: What does "last accessed" mean? Is this the last day that you checked the link

or is it the (last) day that downloaded the model version?

L135: likely — possible

L206: can be $\sim$1 km — are $\sim$ 1 km

L241: downscaling — decreasing

L307: downscaling — downward adjustment

L381: downscale — decrease (Downscaling refers to a change in spatial resolution)

L413: 2018)) — 2018)