Review:

Rebekah P. Horner et al., **Vertical profiles of global tropospheric nitrogen dioxide (NO_2) obtained by cloud-slicing TROPOMI**

Summary:

In this study, the authors have used 4 years of data from TROPOMI and applied cloud-slicing to obtain a seasonal climatology of NO_2. The study builds on previous cloud-slicing investigations, particularly the work of Marais et al. (2021), but uses an improved algorithm to obtain NO_2 climatological profiles in 5 layers, rather than over a single range of pressures. The authors compare their results to modeled NO_2 from GEOS-Chem, as well as DC-8 aircraft data from several aircraft campaigns. While some earlier studies were based on OMI data, the present work is the first to apply cloud slicing to higher-resolution TROPOMI measurements and obtain altitude-dependent NO_2 mixing ratios. As such, it is an excellent demonstration of how profile information can be obtained from nadir viewing satellites.

The methods described here appear rigorous and the authors clearly explain the algorithmic choices adopted in their approach. I think the paper can be published in nearly its present form. Below are a few minor questions and suggested additions (below).

Comments:

(1) Figures 1, 2, 3, 7 show cloud-sliced NO_2, its IAV and percentage differences relative to GEOS-Chem at various levels. There are geographic gaps at all levels, 320-180 hPa in particular, which make BL retrievals in these areas impossible. It is difficult to find regions where one can assess how much each level contributes, especially the BL, contributes to the total column. A useful addition would be maps of total column NO_2 from cloud slicing, the TROPOMI seasonal cloud-free climatology, and/or GEOS-Chem. Another interesting, but non-essential, addition would be a mean GEOS-Chem profile over an area like the eastern US or a marine region.

(2) The 320-180 hPa cloud-slice data are extremely sparse, if not non-existent, in large geographic areas. Where do the cloud-sliced retrievals in these regions shown in figures 5 and 6 come from? How many such data points are there and why aren't the IQRs larger? Can the number of data points be indicated in the figures as they are for DC-8?

(3) At the end of section 2.2 (page 7), it is stated that no INTEX-A data were used in the upper troposphere, but pages 12 and 13 mention INTEX-A were used in the comparisons. Please add few words to restate that the upper-left panels in figures 5 and 6 do not include these data at 320-180 hPa. Is this also true for 450-320 hPa? A separate question is why no INTEX-B data (e.g. Boersma et al.; 2008) were included. Might their high-altitude measurements be more reliable (in spite of similar instrumentation)?

(4) In figure 4, caption should say "Fig. 5 and 6."

(5) In figure 5, the caption should say “Fig. 4.” and “≤ 5”.

(6) In figure 6, the caption should refer to “Fig 5.”