This manuscript presents a detailed and comprehensive analysis on the use of the HCHO/NO2 as measured by satellites to characterise the photochemical regimes for ozone production. The manuscript focusses on four different aspects usefulness of HCHO/NO2 as a proxy, the impact of the vertical distribution, spatial heterogeneity, and retrieval uncertainties itself. The analysis draws from a range of model and measured data and makes uses of different statistical approaches. The manuscript provides a wealth of information, but it will be most valuable for the specialist community. I recommend publication in Atmos. Chem. Phys. (although it would also fit well into AMT) after consideration of my comments below.

For the different aspects, different methods and different statistical metrics are used. I would like to get some justification why a specific metric is used and more detail on applied the methods:

- Altitude dependency (section 3.5)
  - Can you please provide some more details on the equation used to compute the first moment of the area (equation 9). The moment of an area is the integral of distance over area. Also, dz is missing.
  - Note that a satellite observes a column which is either given by the integral of the concentration over altitude or mixing ratio over pressure, while here mixing ratios seem to be integrated over height which is not correct.
  - Why is the standard-deviation of the ratio of the first moment of the interquartile range a good metric for the uncertainty
  - What is the impact of altitude sensitivity of the satellite column measurement as described by the averaging kernel on the estimate uncertainty.

- Spatial heterogeneity (Section 3.6)
  - Please justify the use of the metrics given in equation 14 to quantify the representation error.
  - Important to point out that this is not an absolute but a relative metric (with 3x3 km2) as reference

- Satellite errors (section 3.7):
15 assumes uncorrelated random errors between the HCHO and NO2 retrieval. This is the case of measurement noise-driven errors but the scatter (standard deviation) in both will also be the result of variable geophysical parameters (e.g. aerosols) which will have some level of correlation.

- What is the role the different averaging kernels between the satellite and ground-based DOAS instruments

- Total error (Section 3.8)
  - The different error terms are combined into a total error. However, only assumed random components of uncertainties are included (and not systematic ones) so it should be called the total random error. For me, eq. 16 is too some extent trying to combine apples and oranges as the underlying metric in the 3 components is very different and have different meanings.

Minor points:

- Please make sure that all acronyms and abbreviations are spelled out when used for the first time (e.g. NOx, P(O3), DISCOVER-AQ, PAN, VOC, SENEX, SZA, ...)
- 4, l149: ...FNR from a chemistry perspective...
- 5, l.188: heterogenous chemistry is not considered -> can you add a statement on the importance of that assumption on the study.
- 5, l.206: hv -> h. and define h and (nu)
- 6, eq. 1-3: define k and M, state what the sum is summing up
- 6, l. 239: unconstrained observations -> independent observations
- 6 l. 255: contrary to an overestimation in clean ones
- 7, l.262: of NO in the chemical mechanism
- 7, l.262: some of the oxygenated VOCs
- 7 l264: with larger PAN because -> with larger PAN mixing ratios because
- 7, l.277: to reproduce HO2 with -> to reproduce HO2 mixing ratios with
- 7, l. 286: 0.62 10^6 cm-3 -> 0.62 x 10^6 cm-3
- 7 l. 288: at least virtually representative -> what do you mean by `virtually’?
- 7, l. 291: an analytical solution suggesting... -> solution to what?
- 8, l. 328: PO3 -> this has been written as P(O3) before.
- 10, l.399-402: I don’t clearly see this larger decrease in NO2 than of HCHO. The media value of the ratio in Fig.5 is more or less 5 with some variability.
- 31: figure :3 the 3 green lines are very hard to distinguish.
- 37, Figure 9: I assume the y-axis is not given in %