Dear Reviewer,

Thank you very much for your comments on our paper. We took your comments into account in the revised version of the manuscript. Please find below our detailed replies (black font) on your comments (blue font).

Reviewer#2 comments:

This paper provides an overview of methods for validating the random-error components of uncertainties in remote-sensing products. While these methods have been described previously in the literature, the authors bring them together here, apply them to various limb-sounding observations, and compare their performance for ozone profiles. The topic is relevant for data providers and data users, and the manuscript is generally well written. Some harmonisation of terminology would be beneficial, however, and the effect of retrieval constraints on the validation of the random error could be better addressed (see specific comments below).

Specific comments

1. ***Consistency of terminology***

- for measurement noise error
  The propagation of instrument noise into the retrieval is referred to by several different names throughout the manuscript—for example, *measurement noise error* (pag. 3, line 29), *ex-ante estimate for instrumental noise* (pag. 9, line 12), and *propagation of instrumental noise* (pag. 1, line 38), while *measurement noise* at pag.4 (lines 9 and 10) is the error in the measurement domain. I recommend reviewing the entire manuscript and adopting a single, consistent term.

We revised using the term “noise”. It is now everywhere either “noise” (at the instrument level) or “propagated measurement noise” (for retrieved ozone profiles).

- in the description of all instrument and in particular in Section 2.5. The presentation of the different cases would benefit from improved harmonisation. Please highlight clearly which aspects are common among the cases and which aspects differ.

In the revised version, we added a short description of type of instruments and also the main principle of ozone profile retrievals and error propagation, for all datasets. The revised Table 1 also contains information about the retrieval method.

2. **Clarity regarding the handling of a priori information**

Statements related to the use of a priori constraints could be better explained.

- Page 6, lines 23–25: “If the retrieval is performed with the Bayesian maximum a posteriori estimates, a data correlation can also arise due to the usage of a priori information. These aspects should be taken into account when validating uncertainties.” It is not evident whether these aspects *have* been taken into account in the analyses presented, apart from the MLS case, for which it is said that “it overestimates the scatter in the geophysical products in cases where the a priori information and other regularisation constraints contribute significantly to

the results," which implies that smoothing error *is* included in the random error. In the OMPS-LP USask case it is specified that smoothing error is not included in the random error; does this mean that smoothing error is included for all other instruments/dataset? A clearer and more systematic description of how a priori information and smoothing error are treated for each instrument, also reporting the equation for the random error, would help.

For all datasets used in the paper, only regularization is applied in the retrievals for majority of datasets. Since the vertical resolution is approximately the same for all considered datasets, "smoothing error" also approximately the same. The smoothing error has both systematic and random components. For limb instruments, the random component smoothing error is usually not estimated: to estimate smoothing error properly, information about high-vertical resolution variability is needed (and this information is not available). Since the vertical resolution of the considered ozone profiles is approximately the same for different datasets, ex-ante random uncertainties are characterized consistently. In the revised version, we presented more details on retrievals (see also above).

- Page 7, lines 27–29: The manuscript states that it is important for this type of analysis that all profiles have similar vertical resolution. Could you better clarify the rationale? Is the requirement related to the relative strengths of the constraints used in each retrieval? While vertical resolution certainly depends on the constraint strength, it also depends on the measurement vertical sensitivity and the chosen retrieval grid.

Since estimates presented in our paper are based on the statistics of differences, the profiles should be compatible, i.e., have similar vertical resolution. This is required in order to be able to neglect vertical smoothing difference errors. In the revised version, we added this note. Natural variability also depends on the vertical resolution. For limb instruments, the vertical resolution depends mainly on constraint strength.

- In general a short description of what the validation of random error has to consider in presence of constraints in the inversion procedure and with the inclusion of the smoothing error in the random error would be valuable, also because it would help readers understand how the presented validation techniques could be extended, for example, to nadir observations

We extended the summary with a short discussion:

"The methods presented in this overview can be also applied to other measurements. In particular, the structure function method has been already successfully applied to total column measurements by TROPOMI in Sofieva et al. (2021). All methods can be applied also to data with coarse vertical resolution, such as profiles retrieved from nadir-looking instruments. For the application of the methods based on the statistics of differences, the profiles should have a compatible vertical resolution. This might require prior application of harmonization (see Keppens et al. (2019) for details). Then the validation of random uncertainties can be performed at the vertical scales corresponding to harmonized profiles"

Minor corrections

- Pag. 6, line 10: an estimate OF THE
- Pag.7, line 25: please remove 'is provided'

- Caption of Fig. 3:
  - 1. vurves -> curves
  - 2. uncertainty estimate AND its standard deviation
- Eq. 15: First c2 -> c1

Corrected