

Responses to referee#3

We would like to thank referee#3 for his constructive review. Our responses are organized as follows. We first summarized the major modifications in the manuscript according to the comments of the referees then we provide detailed responses to each referee's point. Our responses are written in italic green.

Major modifications in the manuscript

- 1. The title has been revised in order to be less general, according to comments from referees 2 and 3 and is now: "On the capability of the future ALTIUS UV-VIS-NIR limb sounder to constrain modelled stratospheric ozone"*
- 2. We also realized that the ALTIUS simulated profiles have inherited some noise from NR since the EnKF procedure adds small perturbations to each model state at each model time step. This would explain some of the larger variability and lower correlation in the comparison between (AR,NR) and (CR,NR) which was pointed out by referee 1 & 2. This is now discussed in the paper with the help of the error scaling profiles calculated by the Desroziers method for NR and AR which are shown. This is something which has not been anticipated before the first submission of the manuscript.*
- 3. Two additional experiments have been added in order to evaluate the impact of the low sampling of ALTIUS during the night, a questions raised by referee 1. They consider the assimilation of MLS all data and MLS daytime data with a system configured as for the assimilation run.*

Responses

The topic of the paper is to show how assimilation of measurements from the upcoming ALTIUS instrument will improve our understanding of the atmospheric state. The paper is lucidly written and well referenced. The title is in my mind too general.

The title has been revised, see the introduction above.

I have only one comment about the content of the paper:

A fundamental question (in my mind): What is the real purpose of this paper and study? I think that you already have a confirmation that your instrument will fly and that must be congratulated! If results from this study were bad (ALTIUS measurements do not offer any additional constrain), I think you would like to hide your results in your drawer. But I guess that you can be happy with the results.

It is correct to say that ALTIUS is currently under development, and that this study comes after the mission has been accepted for development by ESA. In particular, the space segment is in phase C (detailed design), while the ground segment will terminate its phase B by the end of 2021. However, there remains a number of challenges faced by the industrial consortium. Not the least of them is the relative complexity of the measurement plan: the baseline scenario is a repetition of the primary sequence "bright limb → solar occultation → stellar occultations → solar occultation → bright limb". In particular, the stellar occultations are the most complex to implement, and their implementation is yet to be fully confirmed. One of the key conclusions of this study is that, even small in number, the occultations performed by ALTIUS do make sense from the point of view of data assimilation. This conclusion reinforce the importance of the stellar occultations in the mission planning.

In the introduction, we changed "Second, we also want to measure the added value of the different ALTIUS modes of observation (solar, stellar, planetary and lunar occultations, and bright limb measurements) in particular during the polar night where bright limb observations will not be available" by "Second, we also want to measure the added value of the different ALTIUS modes of observation (solar, stellar, planetary and lunar occultations, and bright limb measurements) in particular for the stellar occultations which are the most complex to implement in the mission scenario".

But this conclusion does not lead to any further developments because a real ALTIUS data simulator (if such an entity exists) has not been used in getting the results.

A study like this would be interesting if data from a realistic data simulator were used or when real data from flying instrument will start flowing in. Results could affect the ALTIUS mission planning and provide help in determining possible biases between various ALTIUS measurement modes and biases with respect to results from other instruments.

One of the novelty of ALTIUS is that it pushes the geographical coverage limits of UV-VIS-NIR limb sounders to their maximum by combining bright limb, solar, and stellar occultations. The results contained in this study stem for the combination of all possible observation modes. This study could be used by other teams willing to propose new UV-VIS-NIR limb sounders: our results can help balancing the importance of different observation geometries, and help justifying the appropriateness of a new limb sounder. The assumptions made on the

instrument performance, i.e. applying a strict compliance to the ALTIUS signal-to-noise ratio requirements, do not make our conclusions only ALTIUS-relevant. As our requirements are not very different than those considered for other missions (see Bovensmann et al., 1999; Rault and Xu, 2011; Bourassa et al., 2012; these references are now cited in Sect. 4.3.2), one cannot expect dramatically different results with another sensor. Hence we believe that our conclusions are realistic, and reach beyond the scope of ALTIUS.

Bovensmann, H., Burrows, J. P., Buchwitz, M., Frerick, J., Noël, S., Rozanov, V. V., ... Goede, A. P. H. (1999). SCIAMACHY: Mission Objectives and Measurement Modes. Journal of the Atmospheric Sciences, 56(2), 127–150.

Didier F. Rault, Philippe Q. Xu, "Expected data quality from the upcoming OMPS/LP mission," Proc. SPIE 8177, Remote Sensing of Clouds and the Atmosphere XVI, 817709 (26 October 2011); <https://doi.org/10.1117/12.897848>

Bourassa, A. E., McLinden, C. A., Bathgate, A. F., Elash, B. J., and Degenstein, D. A. (2012), Precision estimate for Odin-OSIRIS limb scatter retrievals, J. Geophys. Res., 117, D04303, doi:[10.1029/2011JD016976](https://doi.org/10.1029/2011JD016976).