Author response to referee comment #1

May 18, 2021

We thank referee #1 for this comprehensive review. We appreciate the level of detail and your effort very much. All the comments are useful and help improving this work. We answered all points addressed in the review and implemented your suggestions. We have addressed the referee's comments on a point to point basis as below for consideration. All page and line numbers refer to the first version of the manuscript. We introduced a numbering of the editorial comments and hope that it reflects the referees view.

1 General comments

R2: **The authors state at the end of section 4 that the "discrepancy in the [ISRF] values is quite significant" and that "we believe that depending on the mission parameters, this effect should be taken into account for the assessment of the ISRF stability and consequently the performance of the SH". But then in the next sentence they state: "We also conclude, that for the Sentinel-5/UVNS instrument the impact of this effect is of second-order and does not degrade the performance of the SH significantly". This important conclusion is however stated without any further motivation or evidence. It also seems contradictory to the previous sentence. In contrast, the error budget from tables 1 to 3 should be discussed in view of the S5 ISRF requirements error budget, which is intimately linked to the Sentinel-5 product requirements and quality. In this respect, the nature of the S5-ESA scene should be discussed. Is this scene referring to the type 2 non-uniform scene as defined by the S5 system requirements document (Appendix A)? While this is meant to represent a realistic scene with inhomogeneities representing a more averaged land situation, the still moderate and more randomly distributed signal variations result in quite uniform smeared out signal conditions in along-track direction (averaged over the 7km across-track footprint of S5). So the 75% scene presented her seems to be a more realistic case for typical non-uniform scenes, with sharp surface type transitions (city or desert to vegetation, or land to water). The latter seems never to meet the 2% ISRF shape error budget of the S5 SRD not even for a normally distributed PSF.).**

Response: We confirm that the S5-ESA scene is referring to the type 2 non-uniform scene as defined by the S5 SRD. We will describe the derivation of this scene in more detail.
In our manuscript, the calibration scenes refer to conditions with a sudden transition from bright to dark illumination without accounting for motion smear of the satellite platform. These scenes will be used for static on-ground laboratory measurements of the slit homogenizer performance and to validate the prediction models. We agree, that we should make the use case of these scenes more clear and that the ISRF distortions associated with the calibration scenes are not representing real flight measurements but will only be measured in the laboratory. The resulting ISRF errors are exaggerated with respect to real in-flight scenarios. In the revised version of the manuscript we will describe the realistic scenes from the SRD and make our performance assessment based on these realistic scenes. We will only keep an exemplary 50% stationary calibration scene result and emphasize their use case and the resulting exaggerated ISRF distortions.

The aberrations present in the Sentinel-5/UVNS spectrograph are dependent on the position on the FPA in spectral and spatial direction. Further, the specific aberration type of the final instrument will not be determined but only the RMS spot sizes. In a revised manuscript we will consider several other types of aberration and also their mixing behaviour to make a more thorough and realistic case of the Sentinel-5/UVNS spectrograph.

2 Specific comments

R2: **1. I think it would be interesting to also add the expected ISRF error for an optics without SH to the results (tables) presented in Section 4, if that would be possible. Since this would provide the reference with respect to the currently flying push-broom missions.**

Response: We will include simulation results of the case with no slit homogenizer present in order to compare with push-broom missions using a classical slit.

R2: **2. The reasoning for making the case for slit-homogenizations, as presented in the context of future missions with even higher spatial resolution like CO2M (Section 3, line 195ff), is a bit confusing. Although I understand, what the authors intend here. The relevance for CO2M is not in terms of CO2 emission inhomogeneities, but again, as for the other missions, in terms of radiances variation. The latter is in the extreme cases governed by clouds and surface and not dominated by atmospheric constituents. Especially the variation of CO2 emission is at times at the sub percent level to the background, therefore not contributing to radiance scene homogeneities. However, underlying variations in surface reflection (e.g. transitions of cities to rural land and lakes) may cause significant ISRF distortions without proper slit-homogenizations, which then, in turn would affect the very high accuracies needed to quantify the elevated CO2 emission plume concentrations. So in this respect NO2 emissions may provide a better example of a single point variations, although even there I would assume that the largest effect on NO2 retrieval accuracies due to ISRF distortions is still originating from surface variations or cloud edges.**

Response: We agree and will revise this section.

3 Editorial comments

R2: **1. Section 1, line 34ff: I would add here the linear detector array spectrometer with scanning mirrors like GOME-1/2 and SCIA have a large IFOV in along-track direction and a box-cart like PSF. You could also mention GOME-2 [Munro et al., 2016] in this respect.**

Response: We will add this information.

R2: **2. Section 2.1, line 106. Shouldn't this reference be to Fig. 3b and not a?**

Response: Indeed, this will be changed.

R2: **3. Section 2.2, line 128: missing space.**

Response: Done.