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Dear Editor,

Please find enclosed the revised manuscript entitled “Mapping methane plumes at very high spatial resolution with the WorldView-3 satellite” that we submitted for publication in Atmospheric Measurement Techniques, Manuscript ID: amt-2021-238.

In this new version we have taken into account the remarks and suggestions that the reviewers made, which were constructive and useful, and improved the quality and the understanding of the paper. The detailed explanation of the changes and corrections introduced in the new version is attached below. Other minor changes have been done to update the manuscript considering it was sent four months ago.

We kindly thank you for your interest and attention, and we hope that the revised version is satisfactory. If there are any further changes that you desire, then we are most willing to consider them.

Sincerely yours,

Elena Sánchez García
Researcher Scientist, Corresponding author

DETAILED EXPLANATION OF CHANGES INTRODUCED

Answer to Reviewer 1 (Vladimir Savastiouk)

Suggestions for minor edits

We thank the referee for his beneficial suggestions. All of the minor changes made following the referee's suggestions are as follows:

Comment 1:

Referee: 1. I am not an expert on methane retrievals, but while the paper has a good discussion about the uncertainties it does not give clear guidance on the absolute level of methane concentrations that can be detected with this technique. It will be useful to know, for example, whether this method can be used for detecting permafrost thaw methane leakage in the Arctic.

Answer:

The main discussion about the potential levels of methane detection can be found in subsection 3.1 and the main findings are illustrated in Figure 9. This graph presents the IME fraction that can be detected for different sites and the minimum flux (detection threshold) achievable for those simulated sites. In addition, with the real cases presented in the manuscript, it offers a first assessment of the potential of WV-3 for point-source methane emissions.

In the reviewed version we have upgraded Figure 9 with a refined sampling of flux rates for a better understanding of the detection threshold at the three sites. We have also clarified in the text the flux rate levels that can be detected and their relationship with the real cases shown.

Further research is needed to understand its application to other sites/emission types. The example of the permafrost suggested by the reviewer would be very interesting but challenging due to the high latitude (large SZA and heterogeneity) and the diffuse nature of the emissions. Because of its high SNR, methane mapping in water bodies (e.g. off-shore wells) could be an interesting area of study with WV-3.

Comment 2:

Referee: AMF calculations require some knowledge of the vertical distribution of the absorber. There is no indication in the paper as to what distribution is used for methane plumes.

Answer:

The AMF is calculated as: AMF = $(\cos^{-1}(SZA) + \cos^{-1}(VZA))$. This calculation assumes a plane parallel purely absorbing atmosphere.

We have updated the term in the manuscript as "geometric air mass factor" to specify this point.

Comment 3:

Referee: The claim that the usage of Time-Delayed-Integration (TDI) of 16 lines contributes to a superior SNR is not supported by a reference or by an explanation of why this is the case. It may be trivial to the authors, but maybe of interest to some non-expert readers.

Answer: TDI refers to the exposure of the same area multiple times by different pixels in the detector as the satellite is moving. These measurements can be added and consequently improve the noise of the image. In an ideal scenario under a perfect registration, the noise would improve by the square root of the TDI stages. WV-3 design with narrow spectral bands and large spatial resolution means that the energy collected at a pixel-level is a-priori small. However, the products delivered by WV-3 contain 16 TDI stages which contribute to largely reducing the noise (ideally noise improves by 4 from a single acquisition).

The revised manuscript includes an improved explanation of the TDI and its effect on the SNR. Regarding the SNR study, we thought not to focus so much so as not to distort the main objective of the paper. We explain here in more detail:

The study of the WV-3 instrument noise is based on the SNR estimation over one of the selected sites for simulation (see Algeria site in Fig. 5). The dataset for WV-3 is a tasked acquisition at approximately 24.8° VZA and 57.2° SZA over the Algeria O&G production facilities on the 2020/12/29 centered. The considered dataset for S2 is *S2A_MSIL1C_20201224T101431_N0209_R022_T31SGR_20201224T121510*. This is just a few days apart since the acquisition on the same day included cirrus over the selected area. The selected area for both missions is approx. 1.7× 1.7 km^2 for both missions at latitude 31.7791° N and longitude 5.9884° E.

The method to estimate the SNR calculates the variance of the higher-order coefficient of the Discrete Cosine Transform (DCT) similarly to (Alonso et al., 2019). The obtained S2 B12 SNR is approximately 290 while the SNR for WV-3 is approximately 400 and 430 for B7 and B8 respectively. Although the optical design of WV-3 is based on narrow bands and larger spatial resolution pixels, the instrument noise is excellent due to the processing of the images in Time-Delayed-Integration (TDI) of 16 lines as compared to 2 lines for the S2 mission.