Comment on amt-2021-238
Folkert Boersma (Referee)

Referee comment on "Mapping methane plumes at very high spatial resolution with the WorldView-3 satellite" by Elena Sánchez-García et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-238-RC2, 2021

Review ‘Mapping methane plumes with WorldView-3 satellite’ by Sanchez-Garcia et al.

This manuscript reports on the very high resolution (4 m) capability of the WorldView3 satellite to detect methane enhancements. This capability makes it (potentially) possible to detect smaller leaks in gas and oil infrastructure, although one needs to know where to look first, as the Worldview3 satellite appears to be a pointing sensor. Strong is the finding that an earlier reported CH4 leak in Turkmenistan has still not been closed. Also the message that multiple CH4 plumes would be detected as one large CH4 enhancement by coarser sensors is powerful.

The retrieval technique appears straightforward and uses relatively broad spectral bands in which CH4 has a differential absorption strength. The technique is aimed at detecting enhancements rather than absolute values, and therefore compares the depth of an ‘on’ (strong absorption) CH4 band to a spectrally nearby ‘off’ (weak absorption) band, and explains the difference by the integrated amount of CH4 along the photon path.

The implicit assumption is that there are no other processes that result in spectrally varying signals at the sensor (surface emissivity, other absorbers, instrument issues) for the two bands. This is evident from Eq. (2) that presupposes the existence of a direct relation between the methane enhancement and the ‘on/off’ ratio of radiance signals. It furthermore remains unclear how the air mass factor (AMF) has been calculated, and whether the AMF may be assumed to be spectrally constant. Also it remains unclear how surface heterogeneity would influence the CH4 retrieval, or how surface effects could be accounted for. I think the retrieval approach should be discussed in much more detail, providing more justification for why certain steps are taken or why simplifications have been made.

Then the paper lacks a discussion on the WV3 satellite specifics, such as orbit, overpass time, spectral coverage and spatial coverage. This makes it very difficult to judge what is now the true potential of WV3 to detect plumes around the globe, and with what revisit time, taking into account cloudiness. The paper also would benefit strongly from or perhaps even need an evaluation of the CH4 enhancements against independent CH4 data, such as for example from Sentinel-2 or TROPOMI. Without such an evaluation, it remains difficult to properly judge the potential of the interesting CH4 enhancements to
serve as quantitative source of information rather than just images of possible CH4 plumes.

Minor comments

P1, L8-9: detection of methane alone is in itself not a mitigation strategy, although it can be the start of one.

P3-4: please clarify what “WV-3 images are processed with a Time-Delayed Integration of 16 lines means”. I guess this has to do with co-adding spectra, but it is not entirely clear. What is the ultimate signal-to-noise level after co-addition?

P4, Eq. (1): please define the air mass factor in this case. How is it calculated?

L101: band 5 still has CH4 absorption ...

L104: why does band 8 show less spectral correlation with bands 1 to 6? Can there be saturation of the CH4 signal in band 8?

P4: please specify what the integrated mass enhancement is. I guess it is all the CH4 higher than background levels within the contours of the plume, but this may not be immediately clear to everyone.

L129: awkward to state that retrievals “are confused”.

L131: here and later please specify at which altitude you take the wind speed to drive the plume, and why.

L144-146: sentence starting “Techniques such as ... in the retrieval” is difficult to follow. Please rephrase or clarify.

L153-154: how can you assume that all the CH4 is in a 8 km column?

L157: please explain what the effective wind speed is. Is this the wind speed profile weighted with some sort of CH4 number density profile?

Figure 3: why is it that the effective wind is so much lower than the 10 meter altitude wind?

Figure 4: we are seeing a WRF LES-simulated plume but for which altitude are the mixing ratios depicted?

L211: is the spectral optical depth defined as the vertical (rather than slant) optical depth? It seems to me that the viewing geometry (AMF) needs to be accounted for.

L217: what is the source of information for the “TOA radiance scene”? It seems to be the observed radiance, but for which scenes, viewing geometries, surface properties then?

In Fig. 15 there are some straight lines appearing as CH4 enhancements along the north-south direction. What explains those lines?