In the manuscript "High-frequency monitoring of anomalous methane point sources with multispectral Sentinal-2 satellite observations" Daniel J. Varon and colleagues investigate the potential of observations from the Sentinel-2 MultiSpectral satellite Instrument (MSI) to identify and quantify emissions from strong CH_4 point sources over favourable surfaces. They present three different approaches to analyse integrated radiances from two different measurement bands (around 1650 nm and 2200 nm) in terms of atmospheric CH_4 concentrations, which are then converted to emissions. The algorithms are eventually applied to observations near a well pad in an oil field in Algeria and near a compressor station in an oil/gas field in Turkmenistan. In addition, the results are compared to observations and emissions from a second satellite, the GHGSat-D demonstration satellite instrument.

The introduced approach has the potential to fill a gap in the current observing system for CH_4 emissions. Although it is only applicable to large emissions (> 3 t h^{-1}) occurring over quasi-homogeneous surfaces, it utilizes observations from satellites, so far not used for greenhouse gas retrievals, having fine spatial resolution and a good re-visiting time. The manuscript fits well in the scope of AMT and I recommend publication after some modifications along the line of the comments below.

The manuscript is well-written and conclusive. The methods are described in a comprehensive way, although the authors should elaborate a bit more detailed on their basic assumptions regarding surface reflectance and scattering effects in both bands. In addition, further sensitivity tests for the inferring gas CO_2 (as already done for water vapor) would be appropriate. See specific comments below.

Specific comments:

P4, L92f: How would the mean optical depth of CO_2 in both bands compare to that of CH_4?

P4, L103: Concerning your assumption about the surface and aerosol reflectance properties in bands 11 and 12 – could you provide any references for your assumption that they are similar in both bands? According to a publication from Chen et al. (2006) using VIRS and MODIS observations (their Table 1), it seems that depending on surface type, the e.g., surface reflectance properties can differ at 1620 nm and 2130 nm.

Would you have any possibility using model simulations to investigate the effect of variable surface and aerosol reflectance properties on your retrieval (I assume the statement "The model accounts… not for … scattering" in L106f refers only to aerosol scattering)? I could also imagine that these effects are partly captured by your factor *c* in Eq. 1.

P5, L115f: I agree with your statement that "Aerosol effects… (1) uniform across the scene, (2) … not co-emitted with methane…", however, what happens if the 'general' atmospheric aerosol load across the scene is relatively heavy on the day of the control observation but relatively clean on measurement days, or vice versa? Would this have an influence on the retrieved CH_4 columns or also be correctly captured by *c*?

P5, L137: Any ideas why the fractional signals from the satellites are different? Is it related to the different windows and/or to slightly different instrument characteristics / calibration?

P5, L141f: Similar tests as done for water vapour could potentially also be done for CO_2 to quantify any induced bias on the CH_4 column as indicated in L402.
Additionally, would a relatively high atmospheric CO_2 background concentration in the observed scene during e.g., the control observation, have a large influence on the retrieved CH_4 column if the

observation itself only exhibit low atmospheric CO_2 background concentrations (in the case of the multi-band approaches)?

P5, L142: "… this affects m_{SBMP} by only 6%...": I do not quite understand what exactly the 6% refers to. Does it mean, a potential change in water vapour would cause a change of m_{SBMP} by 6%, which would then be larger than the ~3% caused by a doubling of CH_4 (L137), OR is the ~3% change caused by CH_4 only modified by the stated 6% from water vapour so that, in this special case, the overall effect of water vapour on m_{SBMP} would be only around 0.18% (0.06*0.03)?

P8, L199f: Would it be possible to also add figures of top-of-atmosphere reflectances for bands 11 and 12 for the scenes Korpezhe, Savannah, Urban and Farmland? That would be a good opportunity to visualize the variability in surface reflectivity for the scenes as mentioned in paragraph L223-228 (although I understand that the manuscript is already quite figure-heavy).

P12, L309: I would suggest also adding the median value for MBMP as done for SBMP and MBSP in L313.

P13, L314: I think "less" would fit better here: "…because it is not subject to…" → …because it is less subject to…

P13, L318f: As indicated at the beginning of Sect. 4.2, depending on the scene, one or the other method may work better. How would Fig. 6 and the mean emission look like if SBMP and MBSP were used instead of MBMP? Would one get a bias, enlarge the error bars or would the single emissions get 'more' variable? Additionally, how does a change of the control scene influence the retrieval precision (Fig. 5)?

P13, L323f: Have you, in addition to the plume free scenes before and after the mission, also tested the 8 plume free scenes within the mission for the Hassi Messaoud oil field or are there any reasons why they cannot be used as control observations? Would their RMS value also be around 20%?

Fig. 1: I would suggest adding column to "slant optical depths" → slant column optical depths

Fig. 2: Just a comment: The SBMP retrieval appears to have some issues with surface elevation (or shadows caused by hills due to different illumination conditions on 2019-Oct-06 and 2019-Nov-20) if I interpret the red areas in the upper left and lower right corner in (d) correctly. Otherwise, the remaining part of that plot looks 'cleaner' than for the MBSP retrieval in (e).

<u>Technical corrections:</u>

P4, L87: I would suggest capitalizing "high-resolution transmission molecular absorption (HITRAN)" → HIgh-resolution TRANSmission molecular absorption (HITRAN) database

P18, L444: "DJJ" → D.J.J.

Fig. 4: Please add labels (a) and (b) to the two subfigures.

<u>References</u>

Chen, Y., Sun-Mack, S., Arduini, R. F., and Minnis, P.: Clear-sky and surface narrow band albedo variations derived from VIRS and MODIS Data, in: conference on cloud physics, CD ROM edition, 5.6 Atmospheric radiation 12th, Conference, Atmospheric radiation, vol. 12, Atmospheric radiation, Boston, Mass., USA, 2006.