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Atmospheric Measurement Techniques
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# *Interactive comment on* "High spatial resolution imaging of methane and other trace gases with the airborne Hyperspectral Thermal Emission Spectrometer (HyTES)" *by* G. C. Hulley et al.

**Anonymous Referee #1**

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General Comments

Overall this manuscript presents some intriguing measurements of fugitive gas emissions using airborne TIR imaging spectrometry and makes a sufficient contribution to the growing body of literature on this topic to merit consideration by AMT.

There are a number of typographical items such as surplus prepositions that are easily rectified with the help of a grammar checking tool; these are not listed in this review and are left to the authors to fix. Beyond this minor issue, the manuscript contains a number of material deficiencies that should be addressed before acceptance by AMT.

Specific Comments

P2, L3-4: Seawater and vegetation do have low albedo in the SWIR, but both also tend to exhibit low thermal contrast with respect to the overlying airmass. So the advantage claimed for TIR over SWIR is not as "distinct" as it could be.

P2, L6-7: Methane hydrates decompose at the ocean surface. The authors presumably mean "ocean floor."

P2, L9-10: "Another key advantage of TIR hyperspectral data is the ability to distinguish between different trace gas signatures within a single plume."

This cannot be claimed as a particular advantage of TIR, since spectral unmixing is a technique that has been applied across several spectral bands for decades.

P2, L17-18: The authors class MAGI-L as an airborne sensor, yet the reference cited makes clear that it is a space concept, one moreover that has not flown. The authors clearly have the airborne MAGI in mind, for which a more appropriate reference would be doi:10.1139/TGRS.2015.2422817.

P2, L19-20: ". . .HyTES has the highest number of spectral bands (256) which improves the detection sensitivity of trace atmospheric gas constituents. . ."

This statement is too simplistic. Detection sensitivity could be enhanced by higher spectral resolution for substances that have narrow spectral diagnostic features (compared with the instrumental spectral resolution). This will be true for some gases, but by no means all.

In addition, when determining detection sensitivity the spectral resolution must be traded against the received radiance per channel. Thus the 256 channels of HyTES result in correspondingly reduced radiometric flux in each spectral channel. This is an important consideration for HyTES in particular, since its QWIP focal plane has a comparatively low quantum efficiency. The statement regarding detection sensitivity should therefore be discussed in greater depth.

P2, L36: ". . .provide in situ measurements to validate those results." Explain how this was accomplished.

P3, L8-10: "…relatively low power requirements" with two cryocoolers? Relative to what?

P3, L13: "A single sensor calibration is used for an entire field campaign…"

TIR sensors are prone to calibration drift and a single calibration is never regarded as valid for even a single flight, let alone an entire campaign. The temperature of the Dewar window alone will change with altitude in the unpressurized airplane cabin. The authors' procedure calls into question the accuracy of their data.

P4, L19: TIR gas detection does not necessarily require a "strong" thermal contrast, but the contrast does have to be finite.

P5, L28-29: Can 100 m really be regarded as "high spatial resolution" in the context of this report?

P7, L5-6: Clarify what is meant by "column" in this context.

P7, L13-14: SCR is a dimensionless quantity, which does not comport with the RHS of Eq. (13). Eq. (6) of the Funk et al. (2001) reference provides the correct form of the SCR. This has significant ramifications if Eq. (13) really was used to assess signal strength as the authors state.

P11, L3-4: "The ability to distinguish between different trace gas signatures within a single plume is a key advantage of TIR hyperspectral data."

As already stated above, this is NOT unique to TIR and therefore cannot be claimed as a specific advantage.

P15: There are several problems with Table 1:

1. In the header, IFOV should be accompanied by 3 asterisks to link it to the legend at bottom.

2. For AisaOWL use HgCdTe in place of MCT, as has been done in the remainder of the table.

3. Both MAKO and SEBASS use Si:As blocked impurity band detectors (and incidentally, "cooled helium prism" refers, albeit in mangled fashion, to a dispersion element, rather than a detector).

4. The scan angles given for HyTES and SEBASS are approximately twice the actual values.

An overarching question about this table concerns what the criteria for inclusion were. The SIELETERS group provide a much more comprehensive tabulation of TIR sensors in a paper not cited here (see doi:10.1364/OE.23.016164). The authors' table would benefit from significant revision.

P17, L18-20: Caption and accompanying figure (P23): At least some of the transmittances shown in Figure 5 do not correspond to the standard atmosphere that the authors claim to have used (in particular, total extinction of the 8.4-micron H2S feature as shown is not credible – see also remarks for Figure 14 on P32, below). It would be instructive to provide the MODTRAN derived column densities for these spectra.

P17, L30-33: Caption and accompanying figure (P26): The description of the inset needs rewording. It's said to be a CMF image overlain onto surface temperature, yet the underlying image is actually from Google Earth. The last sentence of this caption only adds to the confusion, but maybe it's moot since the figure is neither cited nor explained in the text and can thus be simply deleted.

P32: Figure 14: The peak absorption coefficient for H2S is almost 3 orders of magnitude smaller than ammonia in the TIR band and is unlikely to be detected by this sensor unless its abundance is at potentially lethal levels (a reportable episode at the very least). Has a concentration estimate been computed for this observation?

Technical Corrections

P2, L22: The HyTES spectral range is everywhere else given as 7.5-12 microns, except here.

P5, L15: ISAC is invoked before being defined (P5, L19).

P5, L24-25: The "downwelling" radiances should actually be upwelling.

P10, L3-4: It's OK to use SCFH because it's an industry standard, but these values should also be accompanied by their equivalents in SI units.

P10, L13: I spent some time searching for quantitative results in Fig. 12 before realizing that the authors must have meant Fig. 13. Confusing.

P11, L4: SO2 is listed twice.

P11, L19: Insert "Figure" before "14."

P12, L22: "Square Cubic Feet/Hr." should of course be "Standard Cubic Feet/Hr." It's already defined above, so why not just use SCFH? In any case, as mentioned above, these values should be accompanied by their equivalents in SI units.

P13, L6-16, L26-27, L33-38, L48-50, L54-56; P14, L10-12, L15-16, L53-54: Citations incomplete.

P16: Table 2: Provide fluxes in SI units as well as SCFH.

P24: Figure 6: Y-axis should actually be "Normalized Absorption."

P31: Figure 13: Provide flow rates in SI units as well as SCFH.

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