# PRELIMINARY VERIFICATION OF ATMOSPHERIC METHANE DETECTION USING A SHORT-WAVE INFRARED HYPERSPECTRAL CAMERA

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**ABSTRACT**

Methane is a potent greenhouse gas with a substantially higher climate warming potential than carbon dioxide on a per-molecule basis, making the detection and quantification of methane emissions an important climate-monitoring objective. Hyperspectral methane detection is typically performed in the 2000-2500 nm wavelength range, where methane exhibits strong absorption bands. However, the principal methane absorption features overlap with absorption bands of atmospheric water vapor and carbon dioxide, whose concentrations are several orders of magnitude higher than that of methane. Rather than relying on the careful removal of water vapor and carbon dioxide contributions from the measurements, an alternative approach is to utilize weaker methane absorption bands that are spectrally isolated from other atmospheric constituents.

A suitable methane absorption feature exists near 1650 nm, where interference from water vapor and carbon dioxide is negligible. Instrumentation operating in the short-wave infrared (SWIR) region is generally less expensive, lighter, and more compact than comparable mid-infrared imaging systems. These characteristics make SWIR sensors particularly attractive for drone-based remote sensing applications. However, the relatively weak methane absorption at 1650 nm, combined with the limited quantum efficiency of detector technologies in this spectral region, makes methane detection challenging. To the best of our knowledge, this wavelength has not previously been used for aerial methane remote sensing because significantly stronger methane signatures are available at longer wavelengths.

In this work, we investigate the methane detection limit achievable at the 1650 nm absorption band. The analysis combines high-resolution atmospheric absorption modeling based on the HITRAN database with illumination and viewing geometries representative of drone-based imaging. Instrument performance is incorporated into the analysis using differential optical absorption spectroscopy (DOAS). Because the selected methane absorption feature is spectrally isolated from major atmospheric interferents, the detection limits can be experimentally evaluated under controlled laboratory conditions.

Experimental measurements were conducted using a Specim ImSpector N17E spectrograph coupled with an Allied Vision Goldeye G-008 SWIR camera. In the laboratory setup, methane was confined within a 10 cm optical path positioned in front of a diffusely reflecting white target illuminated by a halogen light source in a reflection geometry. The illumination was adjusted to approximate direct solar irradiance in the SWIR region, providing laboratory conditions representative of outdoor drone-based observations. Preliminary experimental results are presented and compared with the theoretical detection limit estimates.

***Index Terms—*** methane, DOAS, hyperspectral, vibrational spectroscopy, SWIR, infrared, gas sensor