Detection of Methane with Hyperspectral Satellite Sensors

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Greenhouse gases in the atmosphere are the main driving force of climate change. Besides carbon dioxide, methane is the other important greenhouse gas. The global warming potential (GWP) of methane is 83 times that of CO2 over a 20 year period. Thus, it is important to monitor the spatial and temporal distributions of methane, both from natural and anthropogenic sources for purposes of climate modeling and prediction, and for validation of compliance with carbon reduction targets. Currently, the TROPOMI instrument onboard the Sentinel-5P satellite is capable of detecting methane with the 2305 to 2385 nm short-wave infrared (SWIR) channels. The TROPOMI instrument is designed for global observations with a spatial resolution of 7 km x 3.5 km. There are also reports of methane plume detection with high resolution satellites, also using the SWIR bands. In this paper, we examine the resolution and signal-to-noise ratio (SNR) requirements of using high resolution hyperspectral sensors for detecting localized methane sources. The top-of-atmosphere signals are simulated using the MODTRAN radiative transfer code, for specific methane emission scenarios. The detection limits are calculated as functions of the absorption cross-section of the methane molecules, as well as the sensor's spatial resolution, spectral bandwidth and signal-to-noise ratio. There are four main absorption regions regions for methane molecules: 1.62 - 1.79 microns, 2.15 - 2.45 microns, 3.15 - 3.50 microns and 7.2 - 8.2 microns. However only the first three are usable as the last one is outside the atmospheric transmission windows. Detection algorithms based on the differential optical absorption spectroscopy (DOAS) technique and the associated detection limits will be discussed.

Keywords: Methane, greenhouse gases, hyperspectral sensors, detection algorithms, radiative transfer modeling