

Monitoring Methane Point Sources with Commercial and Civil Satellite Imagery Data

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Global Methane Emissions

- Methane (CH₄) has accounted for ~25% of global warming since industrialization
- CH₄ continues to increase
- Mitigation strategies focus on fossil fuel industries



Ed Dlugokencky, NOAA/GML (gml.noaa.gov/ccgg/trends_ch4/)



Recent and Emerging Methane Sensors

 Landsat-8 (30m res.), Sentinel-2 (20m res.), and WorldView-3 (3-4m res.) provide shortwave infrared (SWIR) CH₄ detection capabilities



Varon et al. 2021



Objectives

- Evaluate multi-band SWIR retrieval techniques to detect and quantify point sources of methane emissions.
 - These retrieval capabilities were evaluated with Landsat-8, Sentinel-2, and WorldView-3 imagery data of well-documented and active oil field sites.
- Provide proof of concept for established methane retrievals on a variety of sceneries, point-source emission rates, and satellite observing systems
- > Identify future developmental needs of methane retrievals for land-imaging sensors

Methane Retrieval

- Implement two-band CH₄ retrieval near and adjacent to its strong absorption near 2300nm
- Simulate at-sensor radiances using MODTRAN6
- Calculate total column CH₄
 concentrations where
- ΔR_{MBSP} is fractional change in TOA reflectance, ΔM_{MBSP} is modeled fractional change in sensor radiance, and ΔX is total column CH₄ enhancement

*See Varon et al. 2021 for details on eq. 1 and 2



$$\Delta M_{MBSP} = \frac{T_S \left(\Delta X\right) - T_S(X_b)}{T_S(X_b)} - \frac{T_W \left(\Delta X\right) - T_W(X_b)}{T_W(X_b)}$$
(2)

$$\Delta R_{MBSP} = \Delta M_{MBSP} \approx \Delta Xm + b$$
 (3)

$$\Delta X = \frac{\Delta R_{MBSP} - b}{m}$$
(4) NGA

Workflow



Sensor Sensitivity to Methane

- MODTRAN simulations for two-band retrievals (ΔM_{MBSP}) show high sensitivity for WorldView-3
- Sentinel-2A and Landsat-8 show lower but comparable levels of spectral sensitivity
- This simulation considered identical sunsensor viewing geometries

Modeled SWIR Radiance from Methane Enhancements



Landsat-8-11/17/2020



Sentinel-2A-11/20/2019



WorldView-3-04/10/2021



Future Work

- Optimization of methane retrievals—reduce false alarms over more heterogeneous surfaces
- Complete emission rate estimates using plume modeling techniques—integrated mass enhancement factors (kg/hr)
- Increase our validation efforts
- Evaluate these retrieval techniques on other emerging sensors with similar spectral and spatial capabilities



Summary

- Landsat-8, Sentinel-2, and WorldView-3 sensors show methane plume detection and quantification capabilities at subkilometer scales
- Leveraging high- and low-resolution satellite sensors can contextualize relationships between facility and regional level emissions
- Emerging methane-focused satellites and retrievals will provide greater international inventory assessments and situational reporting

TROPOMI/WFMD XCH₄ 2018







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