Detecting and quantifying methane point sources from space-based system

Cristina Ruiz Villena, Alex J. Webb, Rocío Barrio Guilló, Robert J. Parker, Hartmut Boesch.

- Localised methane emitters are important contributors to regional methane budgets.
- New hyperspectral sensors offer a great opportunity to detect and maps emission plumes.
- Here, we demonstrate the use of WorldView-3 to observe emission plumes from an oil and gas facility with very high spatial resolution (4 metres).
Why measure methane...

- Methane has 84 times the GWP of CO₂ over a 20-year period but a shorter lifetime of 12 years.
- 60-70% of methane is anthropogenic.
- There is great potential for climate change mitigation at short timescales.

...from space?

- Satellite observations allow detection and quantification of methane even in areas where monitoring would be difficult or costly.
- There are many current and upcoming satellite instruments with a wide range of capabilities that can be used in synergy.

Particularly point sources from the oil and gas industry

**GLOBAL ANTHROPOGENIC METHANE EMISSIONS IN 2030**

- **OIL & GAS**: 26%
- **AG WASTE BURNING**: 8%
- **RICE**: 6%
- **COAL MINING**: 6%
- **BIOMASS COMBUSTION**: 2%
- **FOSSIL FUEL COMBUSTION**: 1%
- **LANDFILLS**: 1%
- **LIVESTOCK**: 31%
- **WASTEWATER**: 6%

**LEGEND**

- Economically feasible mitigation (24%)
- Company commitments (6%)
- Technically feasible mitigation (57%)
- Residual (43%)

**Sector share of baseline in 2030 (380 MMtCH₄ yr⁻¹)**

Ocko et al. (2021)
**METHODS**

**Spectral PCA-based retrieval**
- Small number of singular vectors from the spectral PCA describe background.
- Spectral CH$_4$ Jacobian describes radiance changes corresponding to methane enhancements.

\[
F(W,J) = \sum_{k=1}^{c} (J_k \cdot W_k) + J_{c+1} \cdot W_{c+1}
\]

1. Forward model

\[
\|y - F(J,W)\|^2 = 0
\]
2. Least-squares fit

**IME flux inversion**
- Source rate estimated from total plume mass, wind speed, and plume length.

**Multispectral:** WorldView-3 (WV-3) 4 x 4 m$^2$
8 broad SWIR bands (30-70 nm)

*Focus of this work*

**Similar satellites:**
- Hyperspectral: PRISMA
- Multispectral: Sentinel-2

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**CH4 Benchmark**

Our WV-3-like retrieval

Synthetic WV-3 retrievals from AVIRIS-NG (ang20170616t212046)
CASE STUDY: ALISO CANYON

- Successful detection of large plume from Aliso Canyon blowout on 20th January 2016.
- Estimated emission rate is 3,130.98 kg/h.
CASE STUDY: MIDDLE EAST OIL AND GAS FACILITY

Emission rate $\sim 3,500$ kg/h

Detector saturation during hot flaring

Enhanced methane [parts per million]
• We have demonstrated the use of WorldView-3 (WV-3) to detect and quantify methane plumes from oil/gas facilities.

• A limitation of WV-3 is presence of hot flaring (due to detector saturation), or complex surfaces.

• In coming years, more missions to detect and quantify methane point sources will become available that will provide an important resource to support methane mitigation measures.

Wide variety of instruments available and many more coming up soon

*Trade-offs*: spatial/temporal/spectral resolution, SNR, etc.