Automated Monitoring of Methane Super-emitters using Multiband Satellite Instruments and Machine Learning

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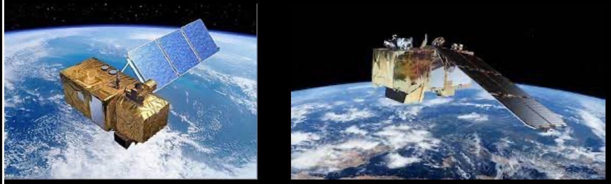
Introduction

- We present a monitoring system that uses Sentinel-2 (S2) observations to systematically detect methane leaks and flaring activity.
- It uses Google Earth Engine (GEE) to efficiently process multiple years of Sentinel-2 data.
- We demonstrate the of use convolutional neural networks (CNN) to automatically detect methane plumes in Sentinel-2 data at the fixed point sources.

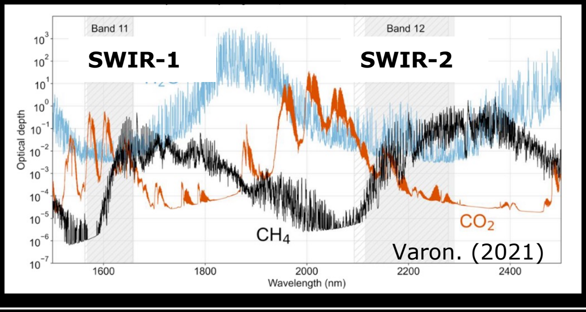
Methane Plume Detection from S2

Revisit time < 5 days

S-2A (2015) S-2B (2016)



- Methane retrievals are performed using the SWIR channels of Sentinel-2 instruments.
- Despite the low spectral resolution, methane retrievals are possible in the close vicinity of a source where methane enhancement can be > 1000 ppb within a 20 m pixel.
- We use a reference observation day to reduce the noise due to surface albedo variation.



Flare Detection

- Flares can be detected in SWIR bands of multiband satellites at a much higher spatial resolution than with VIIRS, MODIS.
- Flaring or lack of flaring can be used as another piece of information for methane monitoring.
- For a location, we identify flares using SWIR2 band radiances relative to a multi point local background.

A cluster of flares observed at an oil/gas facility in Algeria as bright spots in SWIR-1 of Sentinel-2.

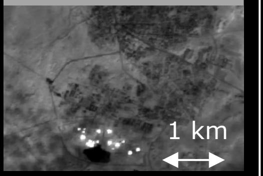
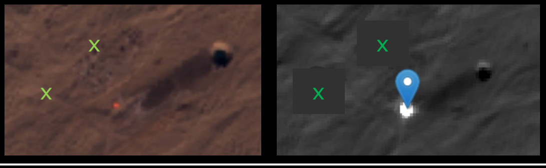


Fig. Flare and reference site in RGB and SWIR-2 band

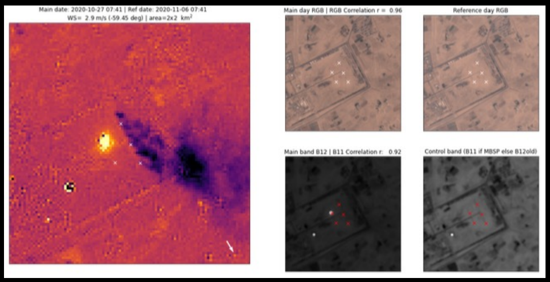


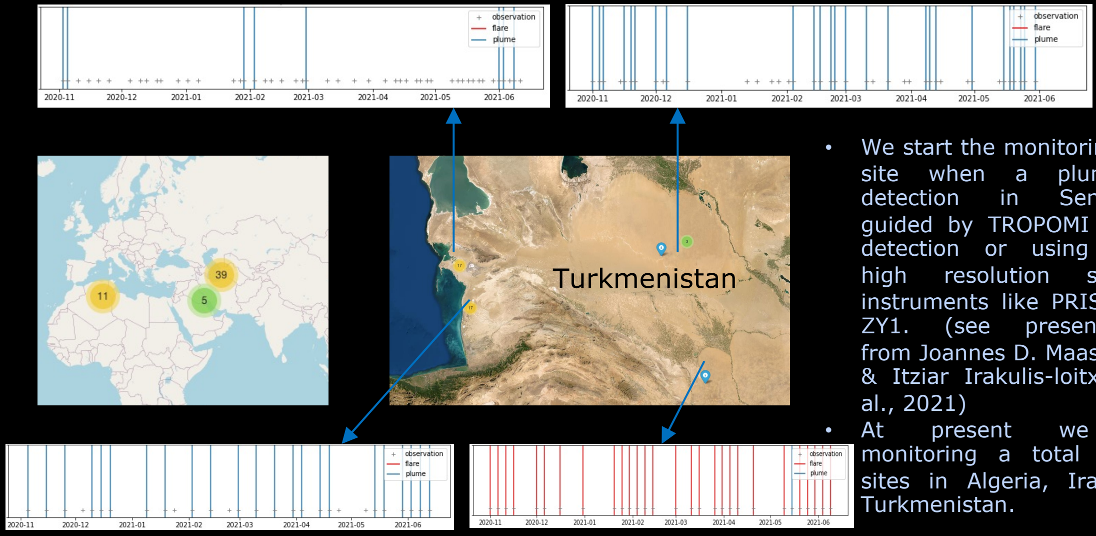
Super-emitter Monitoring System

Method

- For each site, an image series of methane radiance signal (DelR images) is calculated using the GEE python API with the multiband multi pass (MBMP) method of Varon. 2021.
- The reference day used to remove albedo related noise is selected by an iterative search which determine the day the highest spatial correlation in RGB band.
- These DelR image series is then manually flagged for occurrence of methane plumes. RGB bands images are used for assessing possible artifacts such as smoke plumes.

Fig. Example of a DelR image showing a flare and a large methane Plume signal, and RGB images.



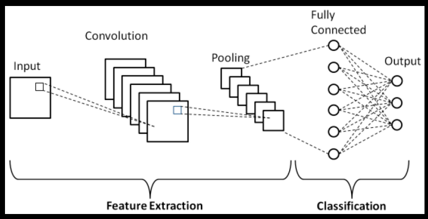


- We start the monitoring of a site when a plume is detection in Sentinel-2 guided by TROPOMI plume detection or using other high resolution satellite instruments like PRISMA or ZY1. (see presentations from Joannes D. Maasakkers & Itziar Irakulis-loitxate et al., 2021)
- At present we are monitoring a total of 55 sites in Algeria, Iraq and Turkmenistan.

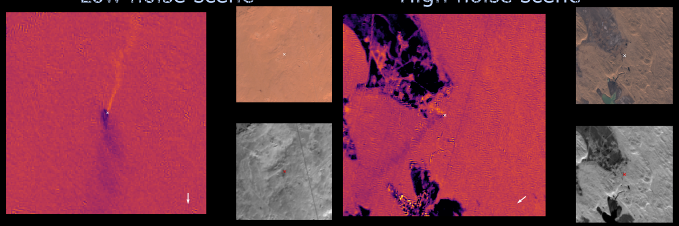
CNN Plume Identification

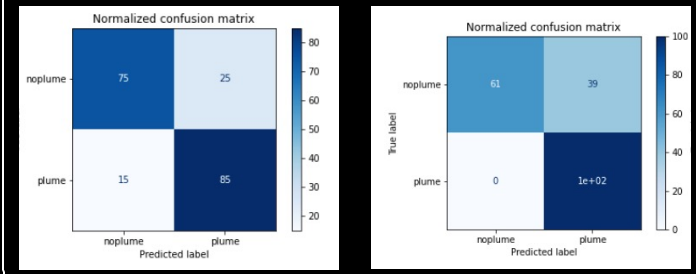
- In future we intend to replace the step of manual image plume detection in the monitoring system with a convolutional neural network. (CNN) model .
- Here we test the applicability of CNN-based plume detection for a low and a high noise monitoring site.

Fig. Example of a CNN image classification architecture.



Low noise scene High noise scene





- For the low noise scene, the CNN successfully identifies all 20 of the plume images in our test set with only one false positive.
- For the high noise scene, after providing a noise proxy image to the CNN, the CNN is able to identify all the plume images but with large number of false positives.
- For the noise proxy, we select a non-methane band S2 image of the main and reference day that has highest correlation with the DelR image.

References

- Varon, D. J., et al. 2021: High-frequency monitoring of anomalous methane point sources with multispectral Sentinel-2 satellite observations, Atmos. Meas. Tech., 14(4), 2771–2785.
- Irakulis-Loitxate, I., et al 2021. Satellites unveil easily-fixable super-emissions in one of the world's largest methane hotspot regions. EarthArXiv.

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