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## Context

- Methane is a critical short-lived climate pollutant with a global warming potential over 80 times that of CO<sub>2</sub> on a 20 year timescale.
- It is responsible for ~25% of the warming that we experience today, and reducing methane emissions is a critical part of achieving 1.5 and 2 degree pathways with minimal or no overshoot.
- The oil and gas (O&G) sector :
  - Ranks second among anthropogenic methane;
  - Possibility of a 40% reduction of its emissions at no net cost.
- For effective mitigation adapted and precise regulations have to be deployed based on the methane emitting behavior of each site of the O&G supply chain parts (Fig.1) and operators.

## Motivations

Methane emitting behavior of each site of O&G supply chain parts can be monitored in time by the use data from satellites dedicated to methane measurements. However, satellites measurements generally concerned methane emissions from all sectors (agriculture, landfilled, etc.) and are not directly related to any type of ground informations like type of site and operator in our case. In order to associate detected methane plumes to the emitting site and its informations (site type and operator), satellite detection has to be spatially matched with ground informations.

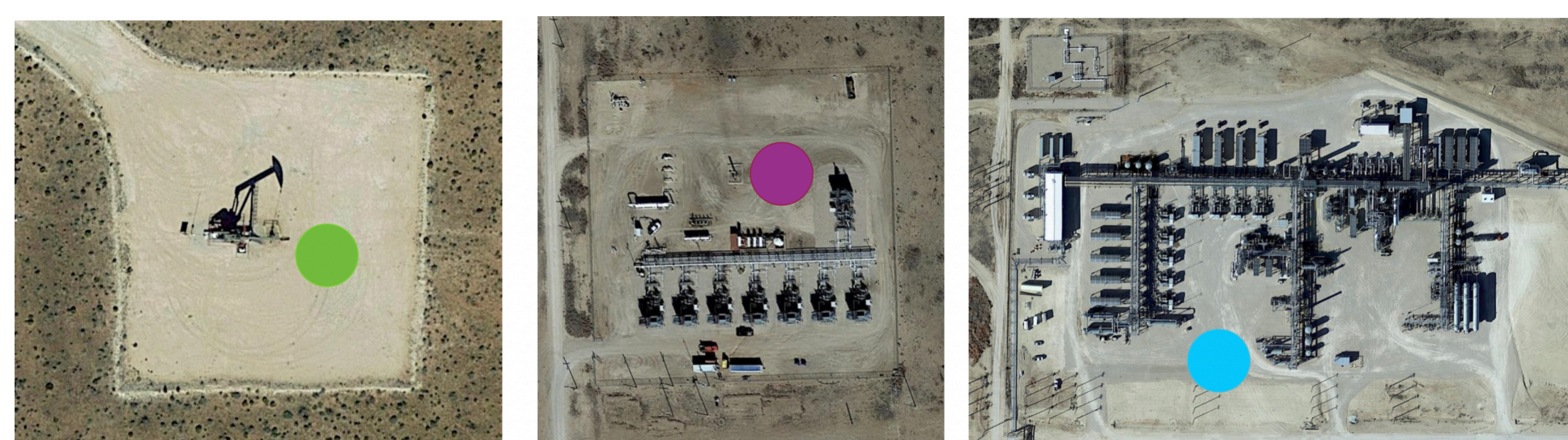
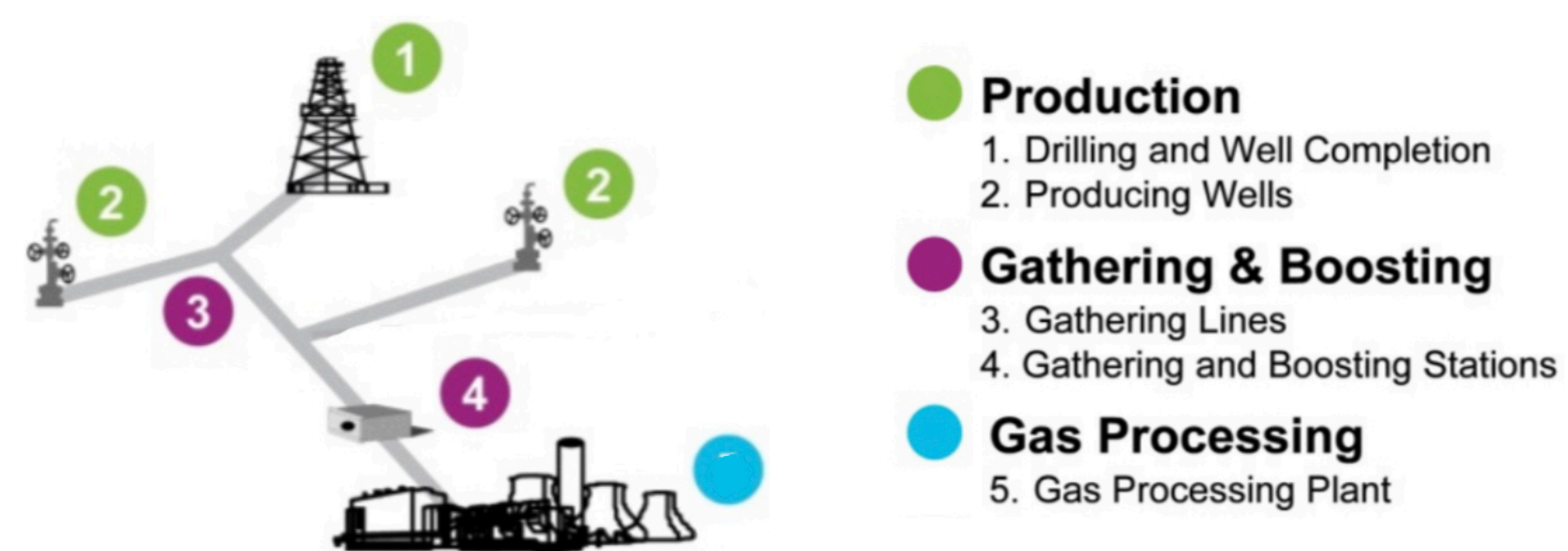
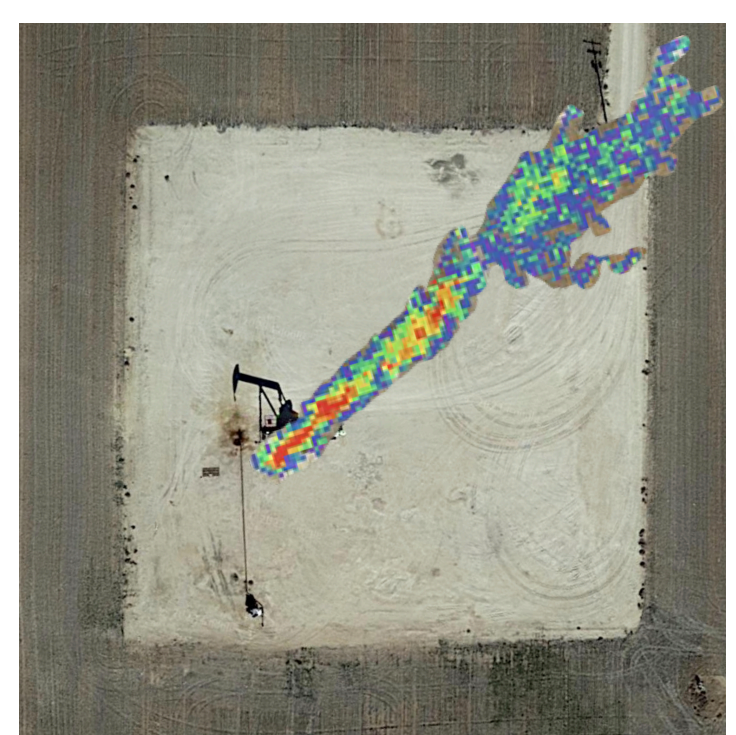


Fig.1: O&G supply chain parts and their corresponding type of site

## GHGSat data

### Characteristics :

- Methane plume detected worldwide (in every sector)
- Detected plume: Latitude, Longitude, CH<sub>4</sub> rate
- Not linked to O&G sector, site type and operator



GHGSat
Latitude
Longitude
CH <sub>4</sub> rate
Site type ? ●●●
Operator ?

Fig.2: data obtained from one GHGSat detection

## PermianMAP data

Methane plume detections from AVIRIS-NG GAO aircraft and CarbonMapper in Delaware and Midland basins (Permian) USA collected during 2 campaigns in 2021.

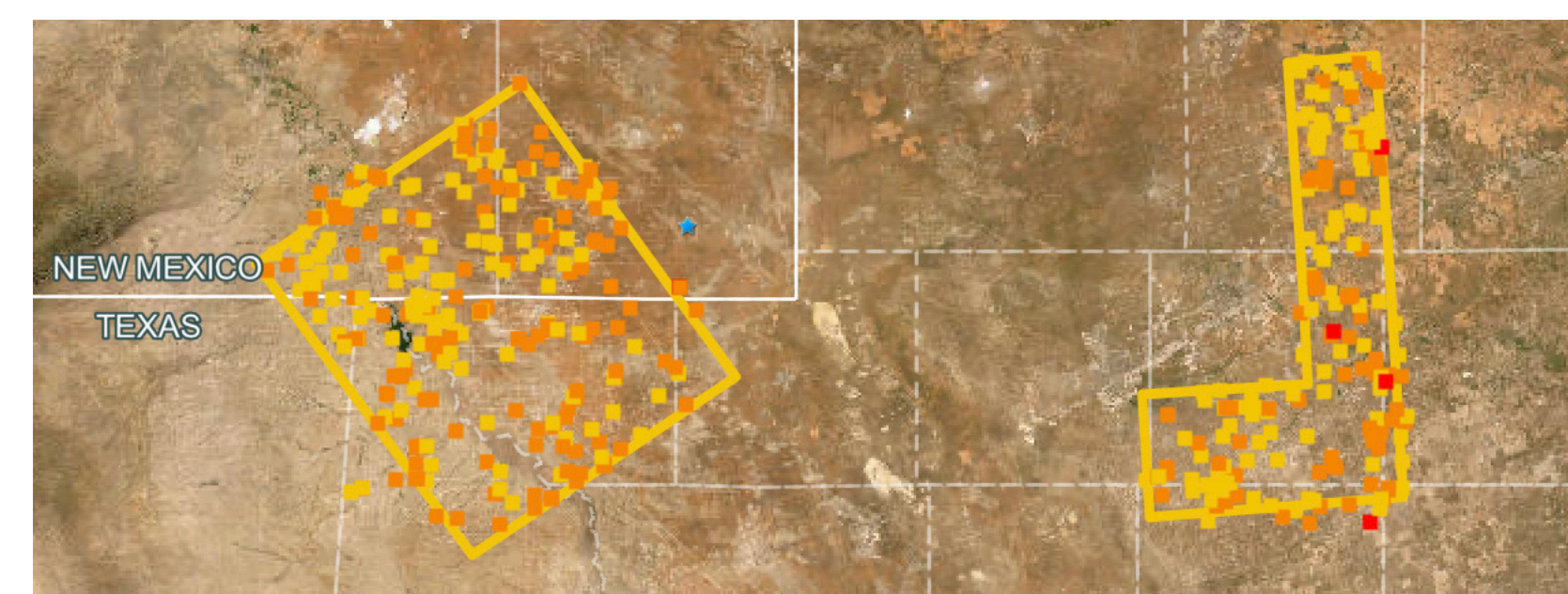
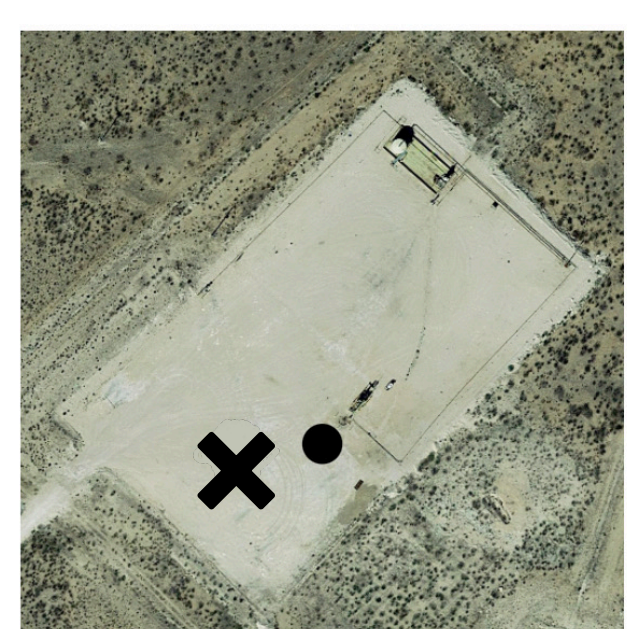


Fig.3: PermianMAP study zones in the Permian basin

Each detection was manually labeled by O&G sites type and operators (Fig.4)



One PermianMap detection

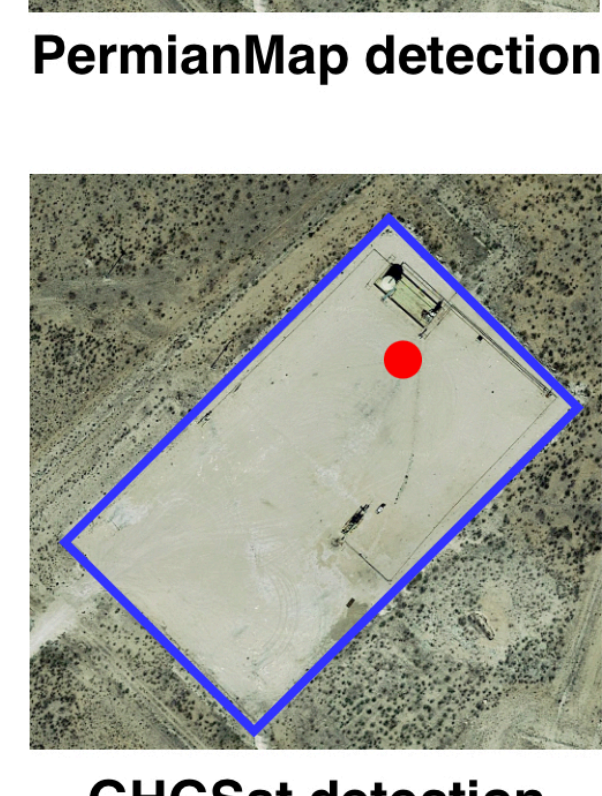
PermianMAP
Latitude
Longitude
CH <sub>4</sub> rate
ID Site
Site type ●
Operator 1

Fig.4: Example of data obtained from one PermianMAP detection

## Objectives

In order to obtain methane emissions profiles by sites type and operators, GHGSat detections need to be automatically labeled and grouped by site type and operator. The PermianMAP data being labelled by site type and operator is used to transfer information to GHGSat detections. To transfer informations from PermianMAP to GHGSat, GHGSat detection has to be detected in a site where one or many PermianMAP detection are present as illustrated in Fig.5.

For a same site :



PermianMAP
Latitude
Longitude
CH <sub>4</sub> rate
ID Site
Site type ●
Operator 1

GHGSat
Latitude
Longitude
CH <sub>4</sub> rate
Site type ? ●
Operator ?

Fig.5: Information transfer from PermianMAP to GHGSat

## Methodology

1

Spatially filter and conserve GHGSat detections which belong to PermianMAP 2 study zones (convex shape)

2

Use of the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) to automatically and spatially group PermianMAP and GHGSat methane detections by sites. Generally O&G site size is 200 x 200m, so 200 m is imposed as maximum cluster size (haversine distance). As output, a cluster is expected to correspond to one site.

3

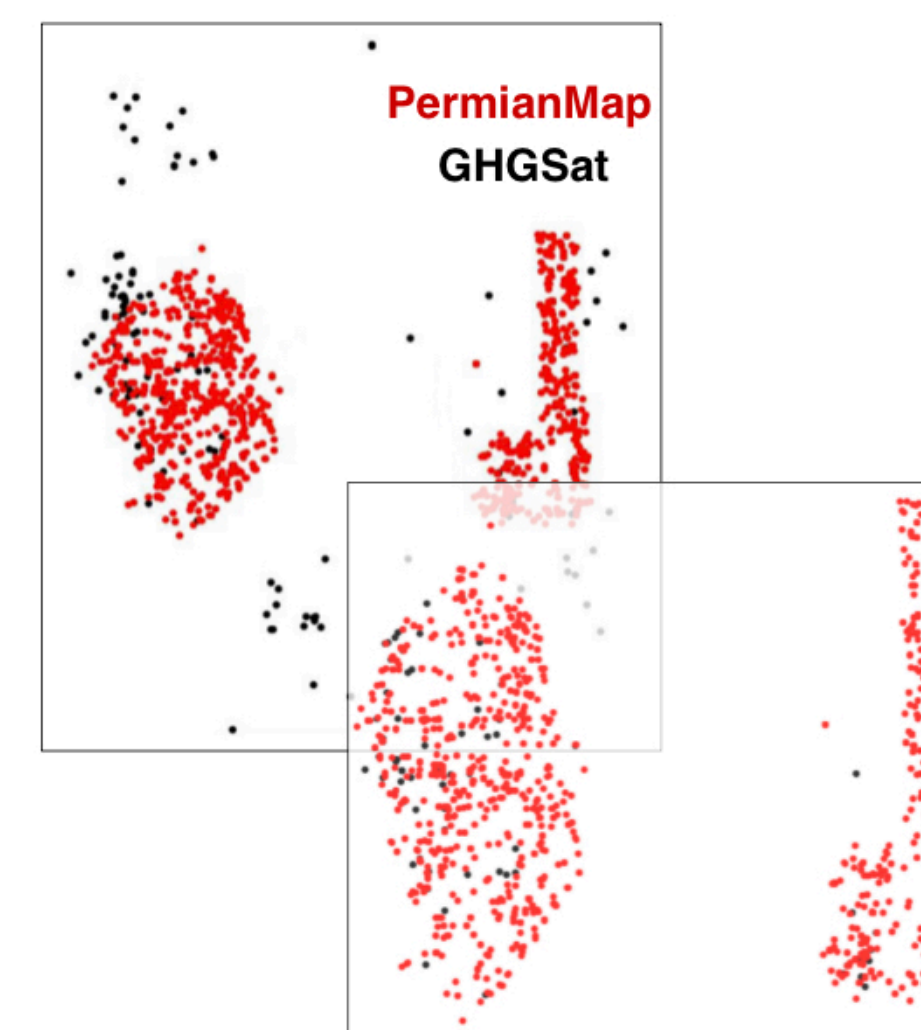
Every cluster regrouping both GHGSat and PermianMAP detections have to contain a single ID indicating that one cluster correspond to one site. If a cluster contains more than one site (ID), every site center coordinated of this abnormal cluster is manually extracted and detections are redistributed around the center coordinates of each site with KDTree algorithm.

4

PermianMAP dataset could contains some errors/uncertainty concerning the attribution of a site type and operator to one detection. Then, clusters with unclear informations (e.g. many site types or operators affected to a single site) were remove. For each obtained final cluster, PermianMAP detections information is transferred to GHGSat detections.

PermianMap	GHGSat
Latitude	Latitude
Longitude	Longitude
CH <sub>4</sub> rate	CH <sub>4</sub> rate
Site ID	-
Site type	?
Operator	?

Restrict Satellite detections to PermianMAP survey zone



DBSCAN clustering (200m): Group GHGSat & PermianMAP detection by site

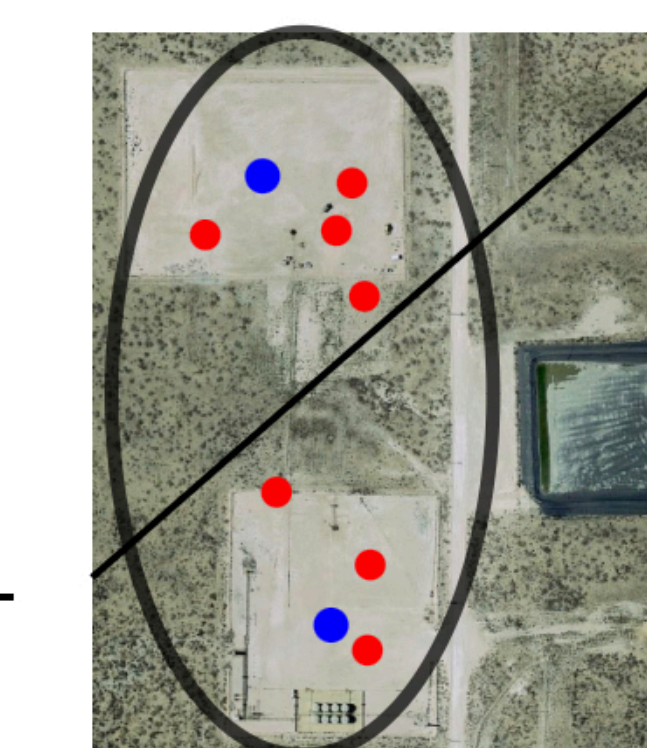


Verification : 1 cluster ≙ 1 site ID

Emissions profiles by site & operator

GHGSat	PermianMap
Latitude	Latitude
Longitude	Longitude
CH <sub>4</sub> rate	CH <sub>4</sub> rate
-	Site ID
Site type	Site type
Operator	Operator

Removal of clusters with unclear informations 1 cluster ≙ X site type & X operator



Tagged GHGSat dataset

Voronoi diagram + KDTree : Detection dissociation in X new clusters (sites center coordinates)

Correction : For the cluster where 1 cluster ≙ > 1 site ID

Fig.6: O&GProfile entire method description from input to output

## Results

- 32 sites gathered both PermianMap and GHGSat detections which allow to automatically labelled 103 GHGSat detections spread over the 2 basins.
  - DBSCAN clustering permits to obtain 98,8% of correct association (1 cluster ≙ 1 site ID) and the semi-automated correction step 100%.
- ⇒ Obtention of methane emissions profiles by O&G sites and operators.

	Number of Plumes	Avg CH <sub>4</sub> (kg/h)
Production	454	1084
Gathering & Boosting	507	2484
Processing	86	1799

Table 1: Number of methane plumes and average methane rate by site type observed by PermianMAP and GHGSat on the period 2021-2022

## Conclusion

- O&GProfile allows to automatically associate satellite methane plume detections to concerned O&G site type and operator.
- Automatic association based on DBSCAN algorithm performed correct association in 98,8% of the case and 100% with the use of semi-automated correction process
- Limitation and future directions:** the O&GProfile required to have access to prior study with labeled O&G site type (rare). Automatic detection and recognition of site type could permit to applied O&GProfile without the use of prior study.