



# A Guide to Using SPECT: The Satellite Point Source Emissions Completeness Tool


Climate Intelligence Program, 2023



# What Is SPECT?

SPECT, the Satellite Point source Emissions Completeness Tool, is an interactive educational tool designed to aid in understanding global methane emissions detection.

Users can compare the capabilities of satellite systems to detect large planet-warming methane emissions from multiple industries like oil and gas, waste, and agriculture.

Created by  RMI

**SPECT** Satellite Point source  
Emissions Completeness Tool

[About](#) [Instructions](#) [FAQs](#)

## Choose 2 Satellites to Compare

Satellite 1

TROPOMI

Satellite 2

GHGSat (10 satellites)

[Edit Custom Satellite](#)

## World Assumptions

Emissions Distribution

Jacob, et al., US, 2022 (def)

AFFECTS: Q

Land Area to Monitor

Global Methane Targets (hi)

AFFECTS: ◆ ↻

Emissions Persistence

20%

AFFECTS: ⌚

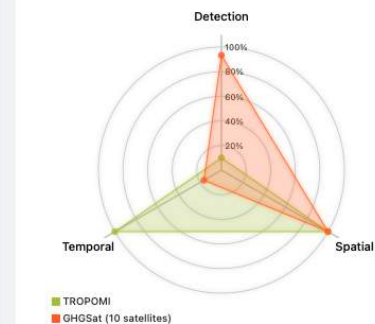
Time Scale of Interest

365 (default)

AFFECTS: ⌚

## Completeness Score Breakdown

	TROPOMI	GHGSat (10 satellites)
Q Detection Score	10%	93.4%
◆ Spatial Score	100%	100%
⌚ Temporal Score	100%	16.4%
Completeness Score	10%	15.4%



## Instrument Parameters

	TROPOMI	GHGSat (10 satellites)
MDL (kg CH <sub>4</sub> /Hour)	15000	100
Daily Coverage (km <sup>2</sup> /day)	74900000	21600
Sample Interval (days)	1	214
Data Available Publically?	All	Limited

**TROPOMI:**  
TROPOMI is an instrument aboard European Space Agency satellite Sentinel-5P, with global methane flux mapping capabilities. It was designed for atmospheric composition monitoring and launched in 2017.

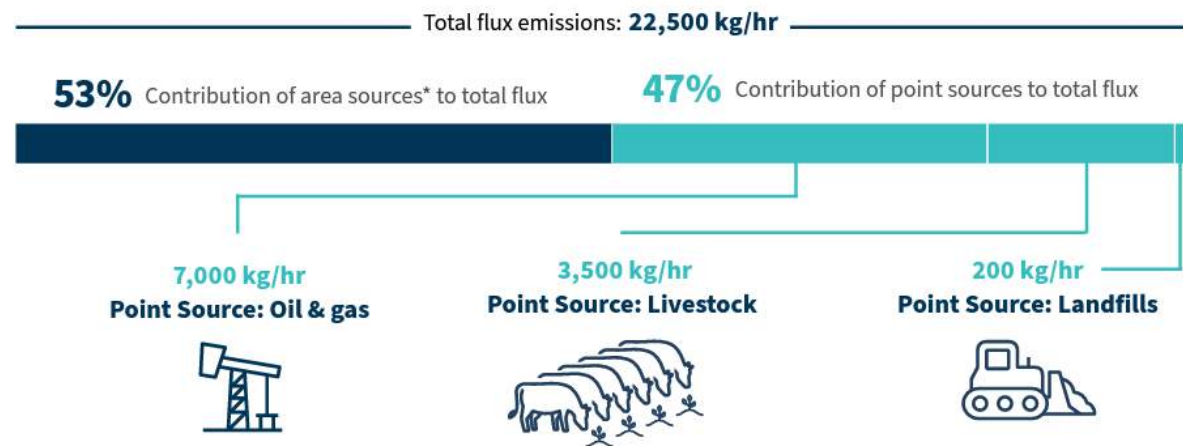
**GHGSat (10 satellites):**  
Simulation of a constellation of GHGSat satellites expected for launch in the mid 2020s.

# What Is Completeness?

SPECT examines different methane-sensing satellites and compares them according to a metric called *completeness*.

Completeness refers to the portion of emissions detectable from a population of methane super-emitters — these are large point sources emitting methane at a rate greater than 25 kg/hr.

## Example point source methane emissions contributions to a regional total



\*Area sources are emissions sources that cannot be attributed to a single location. These include thousands of small sources that individually fall below the point source threshold (10 kg/hr), but collectively accumulate to a large total. They also include diffuse sources such as enteric fermentation, wetlands, wildfires, and other natural sources.

Source: Cusworth, et al., 2022

# Completeness Score Breakdown

In the Completeness Score Breakdown box, you can see that completeness is calculated as the product of three sub scores:

- Detection score
- Spatial score
- Temporal score

Hover over the information icon to see a short definition of each.

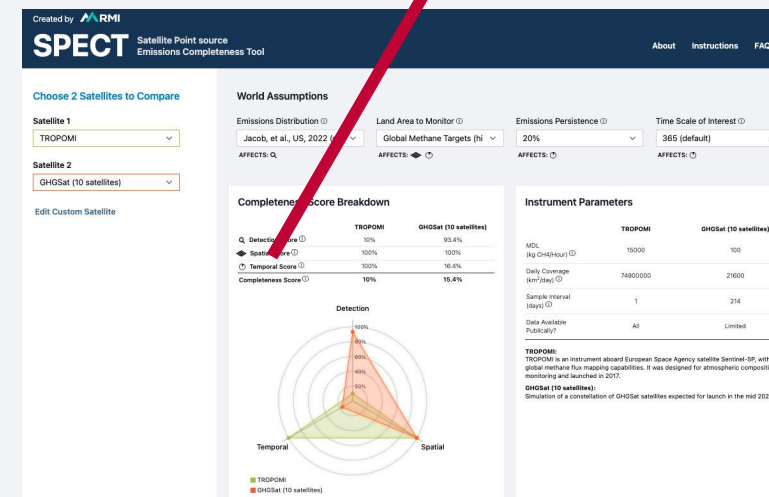
## Completeness Score Breakdown

🔍 Detection Score ⓘ

📍 Spatial Score ⓘ

🕒 Temporal Score ⓘ

📊 Completeness Score ⓘ



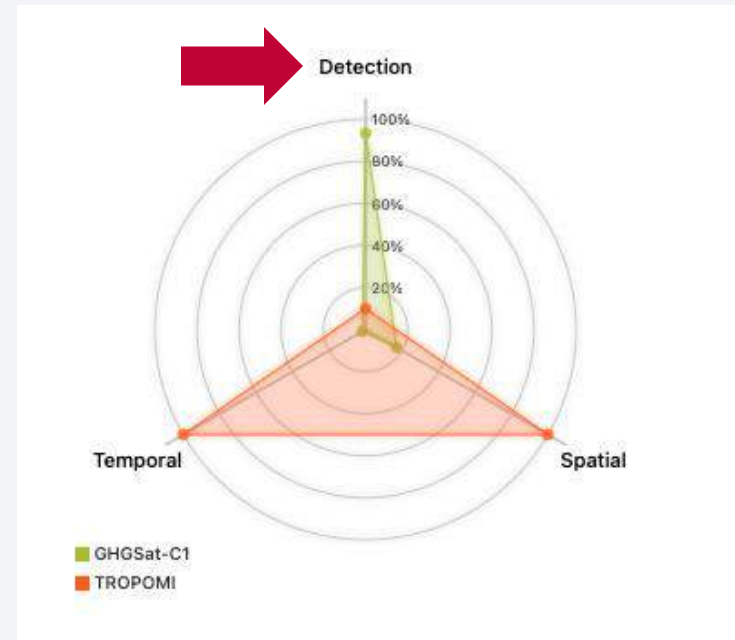
# Detection Score

The Detection score refers to the percentage of point sources detectable by a satellite instrument. This is dependent on the satellite's sensitivity, also called its Minimum Detection Limit (MDL).

A high Detection score indicates that a satellite can detect a higher percentage of point sources – both small and large plumes of methane – within a given emissions distribution. A low detection score indicates that a satellite can only spot larger bursts.

## Completeness Score Breakdown

	GHGSat-C1	TROPOMI
🔍 Detection Score ⓘ	93.4%	10%
📍 Spatial Score ⓘ	17%	100%
🕒 Temporal Score ⓘ	1.8%	100%
<b>Completeness Score ⓘ</b>	<b>0.3%</b>	<b>10%</b>

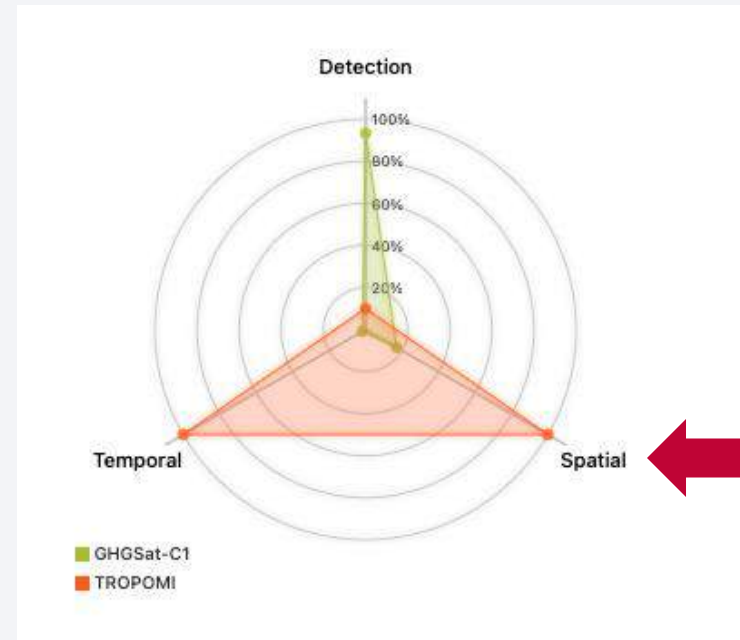


# Spatial Score

The Spatial score illustrates the geographic area observed by the satellite each day, and what percentage of a specified land area the satellite can observe in a defined time period of interest (i.e., a day, month, or year).

## Completeness Score Breakdown

	GHGSat-C1	TROPOMI
🔍 Detection Score ⓘ	93.4%	10%
📍 Spatial Score ⓘ	17%	100%
🕒 Temporal Score ⓘ	1.8%	100%
<b>Completeness Score ⓘ</b>	<b>0.3%</b>	<b>10%</b>



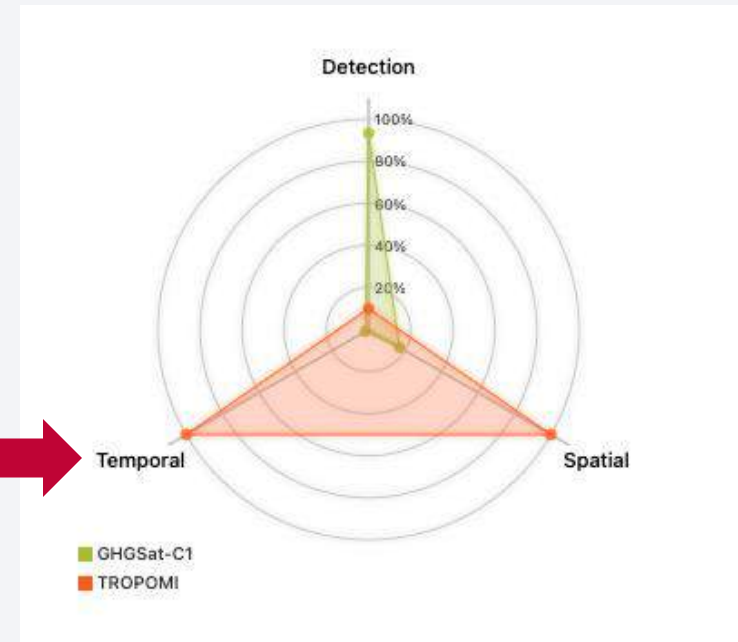
# Temporal Score

The Temporal score refers to the probability that an emissions source is detected. It is primarily affected by two things:

1. The persistence of the emissions source — how often a particular source is emitting methane.
2. The sample frequency — how often a satellite successfully completes an observation of a given area.

## Completeness Score Breakdown




	GHGSat-C1	TROPOMI
🔍 Detection Score ⓘ	93.4%	10%
📍 Spatial Score ⓘ	17%	100%
🕒 Temporal Score ⓘ	1.8%	100%
<b>Completeness Score ⓘ</b>	<b>0.3%</b>	<b>10%</b>



# Calculating “Completeness”

Multiply the Detection score, Spatial score, and Temporal score together and you get your overall Completeness score!


## Completeness Score Breakdown

	Custom Satellite
 Detection Score ⓘ	31%
 Spatial Score ⓘ	100%
 Temporal Score ⓘ	22.1%
<b>Completeness Score ⓘ</b>	<b>6.9%</b>



# Comparison Page

On the Main Comparison page, you'll notice a drop-down menu on the left that allows users to select two satellites to compare.

Created by  **SPECT** Satellite Point source Emissions Completeness Tool

About Instructions FAQs

[Choose 2 Satellites to Compare](#)

Satellite 1  
TROPOMI

Satellite 2  
GHGSat (10 satellites)

[Edit Custom Satellite](#)

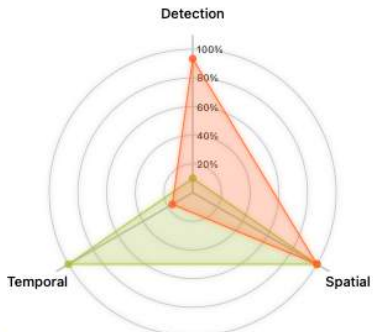
### World Assumptions

Emissions Distribution  Land Area to Monitor  Emissions Persistence  Time Scale of Interest

AFFECTS: Q AFFECTS: AFFECTS: AFFECTS:

### Completeness Score Breakdown

	TROPOMI	GHGSat (10 satellites)
Q Detection Score <input type="text" value="10%"/>	10%	93.4%
Spatial Score <input type="text" value="100%"/>	100%	100%
Temporal Score <input type="text" value="100%"/>	100%	16.4%
Completeness Score <input type="text" value="10%"/>	10%	15.4%



Legend: TROPOMI (green), GHGSat (10 satellites) (orange)

### Instrument Parameters

	TROPOMI	GHGSat (10 satellites)
MDL (kg CH4/Hour) <input type="text" value="15000"/>	15000	100
Daily Coverage (km <sup>2</sup> /day) <input type="text" value="74900000"/>	74900000	21600
Sample Interval (days) <input type="text" value="1"/>	1	214
Data Available Publically?	All	Limited

**TROPOMI:** TROPOMI is an instrument aboard European Space Agency satellite Sentinel-5P, with global methane flux mapping capabilities. It was designed for atmospheric composition monitoring and launched in 2017.

**GHGSat (10 satellites):** Simulation of a constellation of GHGSat satellites expected for launch in the mid 2020s.

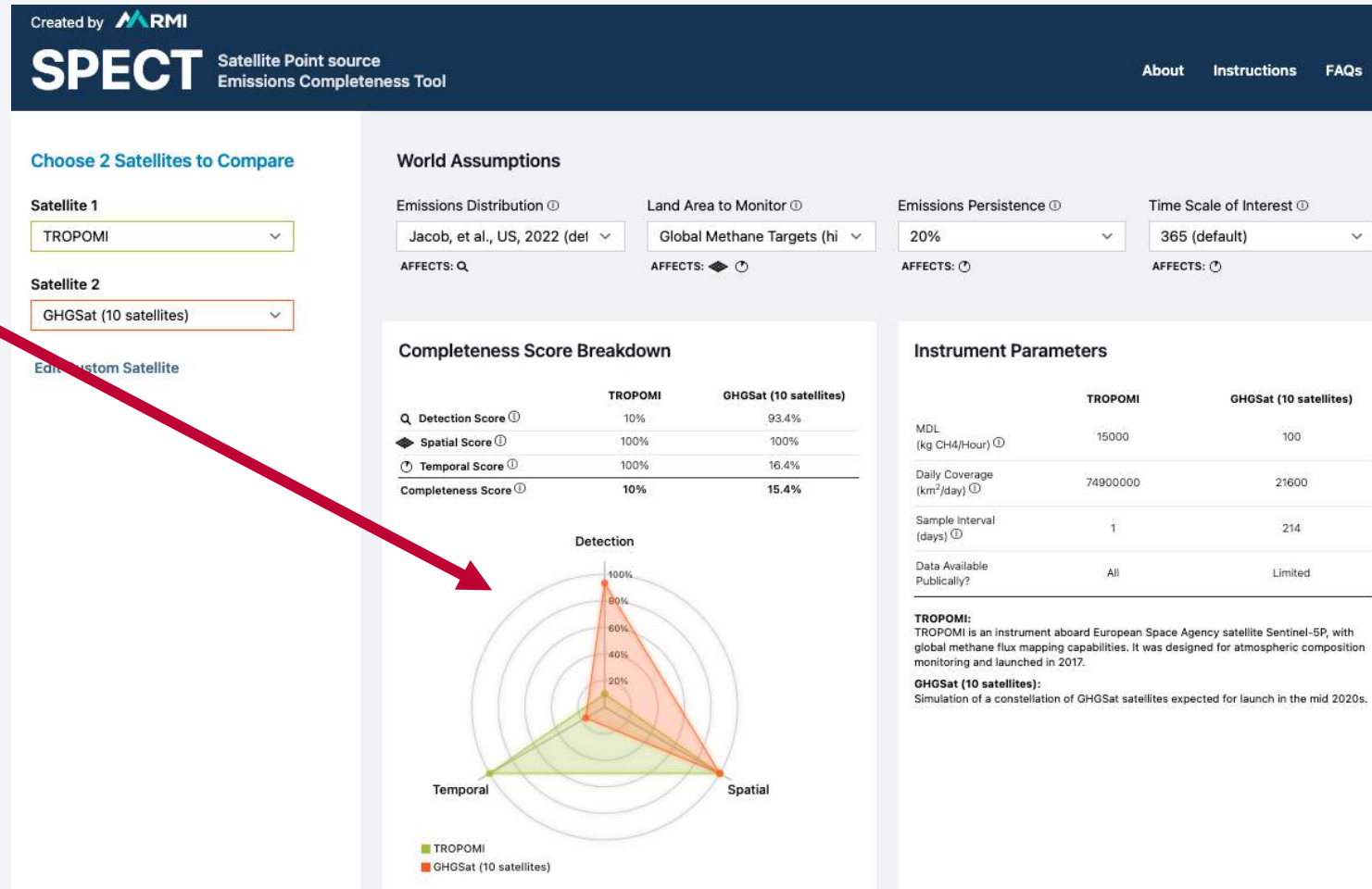
Once a satellite is selected, its pre-set Instrument Parameters populate in a box on the right side.

This includes the satellite's daily coverage, revisit time, and Minimum Detection Limit, or MDL. There's also a short description of each selected satellite technology.


# Comparison Page: Radar Chart

The radar chart in the middle of the page automatically calculates the sub scores and the overall Completeness score for each satellite.

If a satellite scores high in a given sub-score, that vertex of the radar chart will be stretched out near the edge of the circle. Lower scores stay closer to the middle.



# Comparison Page: World Assumptions

Created by  ARMI

## SPECT

Satellite Point source Emissions Completeness Tool

[About](#) [Instructions](#) [FAQs](#)

**Choose 2 Satellites to Compare**



Satellite 1  
TROPOMI


Satellite 2  
GHGSat (10 satellites)


[Edit Custom Satellite](#)

### World Assumptions



Emissions Distribution: Jacob, et al., US, 2022 (del) **AFFECTS: Q**

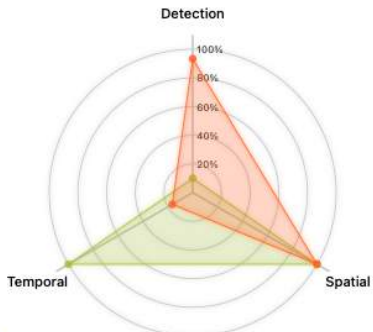
Land Area to Monitor: Global Methane Targets (hi) **AFFECTS:  **

Emissions Persistence: 20% **AFFECTS: **

Time Scale of Interest: 365 (default) **AFFECTS: **

### Completeness Score Breakdown

	TROPOMI	GHGSat (10 satellites)
Q Detection Score	10%	93.4%
 Spatial Score	100%	100%
 Temporal Score	100%	16.4%
Completeness Score	10%	15.4%



**Instrument Parameters**

	TROPOMI	GHGSat (10 satellites)
MDL (kg CH4/Hour)	15000	100
Daily Coverage (km <sup>2</sup> /day)	74900000	21600
Sample Interval (days)	1	214
Data Available Publically?	All	Limited

**TROPOMI:**  
TROPOMI is an instrument aboard European Space Agency satellite Sentinel-5P, with global methane flux mapping capabilities. It was designed for atmospheric composition monitoring and launched in 2017.

**GHGSat (10 satellites):**  
Simulation of a constellation of GHGSat satellites expected for launch in the mid 2020s.

The World Assumptions box allows users to toggle through and view the effects of changing underlying conditions. By changing these assumptions, the Completeness scores for ALL satellites are affected.

Users can adjust the Time Scale of Interest, Land Area, Emissions Distributions, and the assumed Persistence of Emissions.

# Comparison Page: World Assumptions

The icons below each assumption indicate what sub-scores are affected. The timer means that by changing this assumption, temporal scores will be affected. Similarly, the diamond represents an impact on spatial sub-scores, and the magnifying glass represents changes to the detection sub-score

**World Assumptions**  
Curves that describe the point source emissions makeup of a given region

Emissions Distribution ⓘ

Jacob, et al., US, 2022 (default) ▾

AFFECTS: 🔍

The intermittency of emissions sources

Emissions Persistence ⓘ

50% (default) ▾

AFFECTS: ⌚

The area on Earth's surface that is desired for methane monitoring

Land Area to Monitor ⓘ

Global Methane Targets (high pl) ▾

AFFECTS: ⬠ ⌚

Time scale of interest (days)

Time Scale of Interest ⓘ

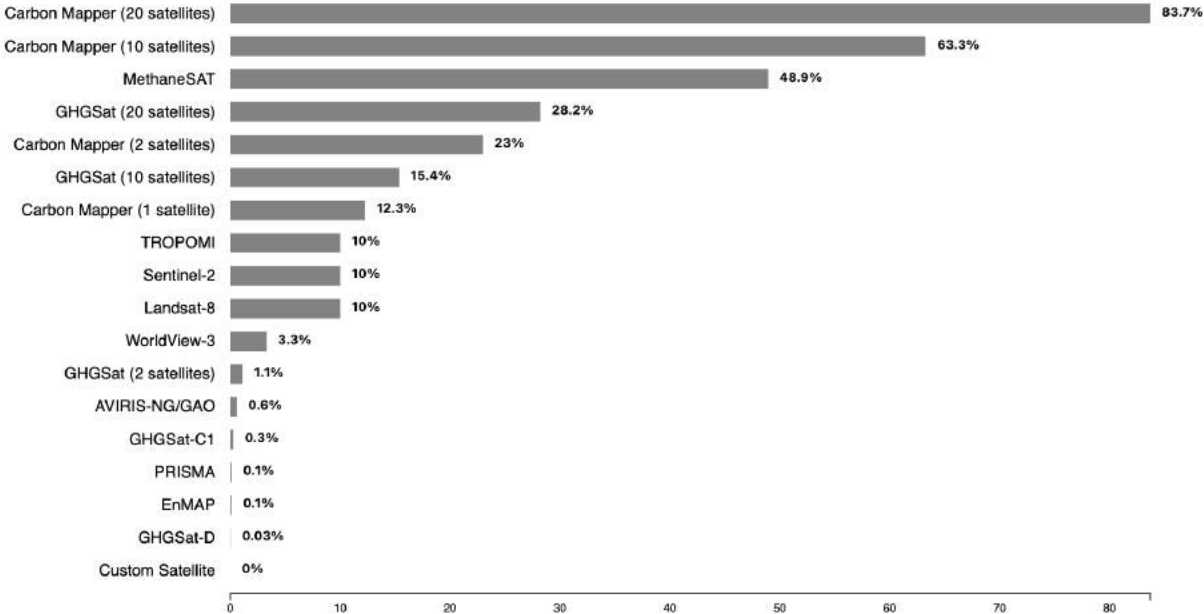
365 (default) ▾

AFFECTS: ⌚ ⬠

# Comparison Page: Bar Chart

By scrolling down on the Main Comparison page, users can view a bar chart that compares completeness across all the pre-entered satellite systems based on the pre-set Instrument Parameters and the specified World Assumptions.

Completeness Score



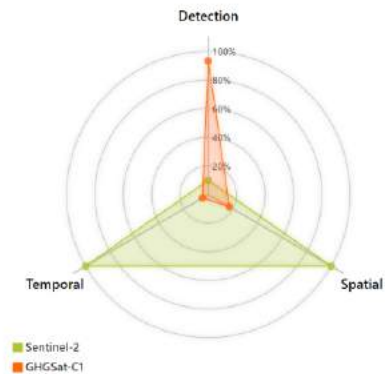
# SPECT Tips and Context

Tradeoffs are an inherent part of satellite system design. For example, some satellites, often referred to as *targeting satellites*, are designed to target small areas with high accuracy and resolution. These satellites are useful for detecting small emissions over a limited geographic area.

Other satellites, sometimes called *global scanners*, have bigger daily coverage, scanning the whole earth in a few days or less. These satellites tend to have relatively lower resolution and are not as effective for detecting small emissions sources.

## Completeness Score Breakdown

	Sentinel-2	GHGSat-C1
🔍 Detection Score ⓘ	10%	93.4%
📍 Spatial Score ⓘ	100%	17%
🕒 Temporal Score ⓘ	100%	4.8%
📊 Completeness Score ⓘ	10%	0.8%



## Instrument Parameters

	Sentinel-2	GHGSat-C1
MDL (kg CH <sub>4</sub> /Hour) ⓘ	3000	100
Daily Coverage (km <sup>2</sup> /day) ⓘ	100000000	2160
Sample Interval (days) ⓘ	1	2345
Data Available Publicly?	All	Limited

### Sentinel-2:

A European Space Agency satellite with methane point-source capabilities launched in 2015.

### GHGSat-C1:

A GHGSat Inc point-source imaging satellite (Iris) launched in 2020.

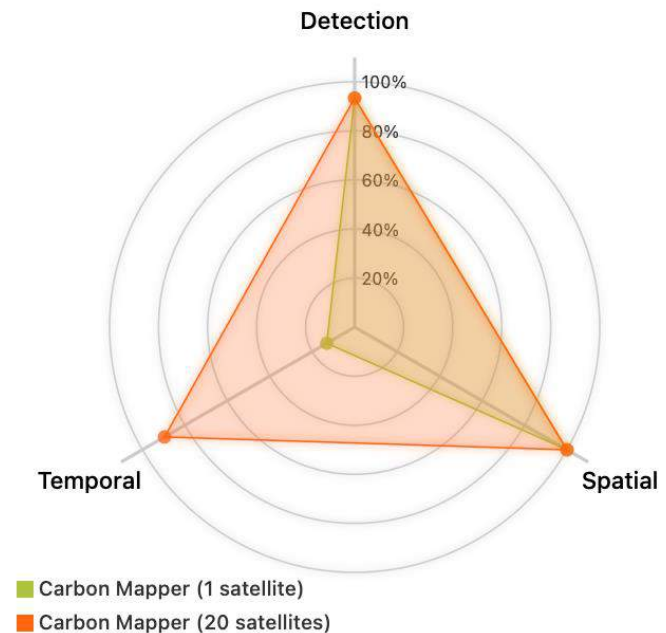
# SPECT Tips and Context

When it comes to global methane point source detection, it is important to balance sufficient sensitivity, spatial coverage, and revisit times.

This is one reason that some organizations are launching constellations of satellites that comprise 10 or more identical satellites. You'll notice that these constellations tend to score high in overall completeness, as they are able to combine low detection thresholds with high spatial coverage and frequent revisits.

## Completeness Score Breakdown

	Carbon Mapper (1 satellite)	Carbon Mapper (20 satellites)
🔍 Detection Score ⓘ	93.4%	93.4%
📍 Spatial Score ⓘ	100%	100%
🕒 Temporal Score ⓘ	13.1%	89.6%
📊 Completeness Score ⓘ	12.3%	83.7%



# Custom Satellite Tab

On this tab, users can enter their own instrument parameters for a real-life or imaginary satellite. This is a great way to explore how adjusting different parameters can affect overall Completeness and Completeness sub-scores.

The screenshot displays the 'Custom Satellite Metrics' section with a red arrow pointing to the 'Enter MDL (kg CH4/hr)' input field. Below it is the 'Enter Daily Coverage (km<sup>2</sup>/day)' input field. A 'Calculate Daily Coverage' checkbox and a 'SAVE SATELLITE' button are also visible.

The 'World Assumptions' section includes dropdown menus for 'Emissions Distribution' (Jacob, et al., US, 2022 (default)), 'Land Area to Monitor' (Global Methane Targets (high prior)), 'Emissions Persistence' (50% (default)), and 'Time Scale of Interest' (365 (default)).

The 'Completeness Score Breakdown' table shows the following scores for the 'CUSTOM SATELLITE':

Metric	Score
Detection Score	100%
Spatial Score	0%
Temporal Score	0%
Completeness Score	0%

Below the table is a radar chart with three axes: 'Detection', 'Spatial', and 'Temporal'. The 'Detection' axis is at 100%, while 'Spatial' and 'Temporal' are at 0%. The chart shows concentric circles representing 20% increments from the center.

The 'Detection Completeness' chart is a line graph with 'kg CH4/hr' on the x-axis (log scale: 1, 10, 100, 1k, 10k) and percentage on the y-axis (10% to 100%). The curve starts at 100% for low emissions and drops to 0% at approximately 2,000 kg CH4/hr.

The 'Temporal Completeness' chart is a line graph with percentage on the y-axis (70% to 100%). The curve starts at 100% and begins to drop at high emission rates.



# Custom Satellite Tab: Detection Completeness

For example, users can enter a satellite Minimum Detection Limit and toggle the Emissions Distribution assumption to see how these inputs combine to form the Detection Completeness sub-score.

The screenshot displays the 'Custom Satellite Metrics' section with the following inputs:

- Enter MDL (kg CH<sub>4</sub>/hr): 100
- Enter Daily Coverage (km<sup>2</sup>/day): 1
- Calculate Daily Coverage:

The 'World Assumptions' section includes:

- Emissions Distribution: Scientific Insights Aerial Survey, I
- Land Area to Monitor: Global Methane Targets (high pri)
- Emissions Persistence: 50% (default)
- Time Scale of Interest: 365 (default)

The 'Completeness Score Breakdown' table is as follows:

	CUSTOM SATELLITE
Detection Score	26.5%
Spatial Score	0.01%
Temporal Score	0.002%
Completeness Score	0%

The 'Q Detection Completeness' graph shows a curve of detection percentage vs. kg CH<sub>4</sub>/hr. A red arrow points to the 26.5% mark on the curve at 100 kg CH<sub>4</sub>/hr.

# Custom Satellite Tab: Spatial Completeness

By entering a Daily Coverage, selecting a Land Area and Time Scale, and scrolling down, users see how these inputs combine to form the Spatial Completeness sub-score.

The screenshot displays the 'Custom Satellite Metrics' and 'World Assumptions' sections of a web interface. The 'Custom Satellite Metrics' section includes input fields for 'Enter MDL (kg CH4/hr)' (100), 'Enter Daily Coverage (km<sup>2</sup>/day)' (10000), and a 'Calculate Daily Coverage' checkbox. The 'World Assumptions' section includes dropdown menus for 'Emissions Distribution' (Scientific Insights Aerial Survey, I), 'Land Area to Monitor' (Global Methane Targets (high pri)), 'Emissions Persistence' (50% (default)), and 'Time Scale of Interest' (365 (default)). A red arrow points to the 'Land Area to Monitor' dropdown, and another red arrow points to the 'Time Scale of Interest' dropdown. Below these sections is a 'Spatial Completeness' visualization showing a blue bar representing 78.8% of the 'Total Land Area to Monitor'.

**Custom Satellite Metrics**

Enter MDL (kg CH<sub>4</sub>/hr)  
100  
AFFECTS: Q

Enter Daily Coverage (km<sup>2</sup>/day)  
10000  
AFFECTS:

Calculate Daily Coverage

**World Assumptions**

Emissions Distribution Scientific Insights Aerial Survey, I

Land Area to Monitor Global Methane Targets (high pri) AFFECTS:

Emissions Persistence 50% (default) AFFECTS:

Time Scale of Interest 365 (default) AFFECTS:

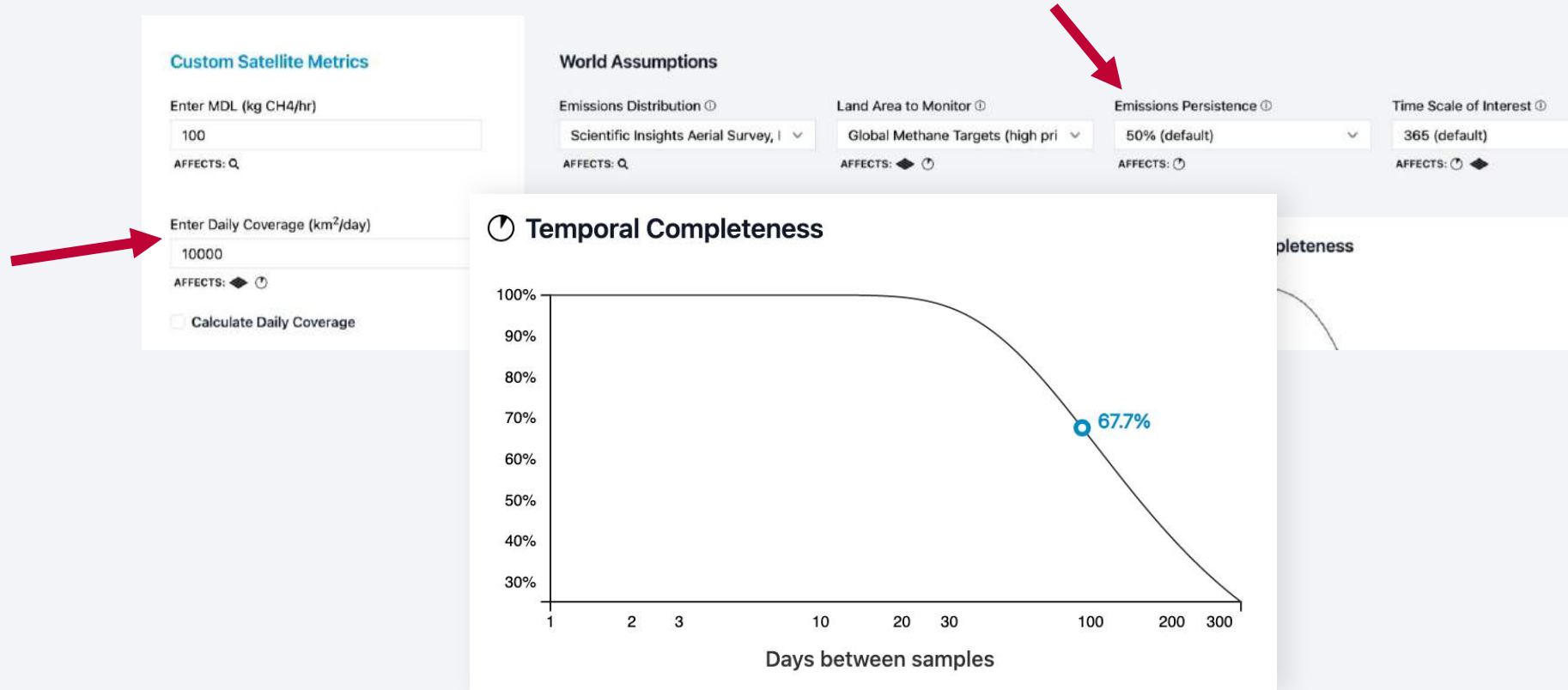
**Spatial Completeness**

78.8%

Total Land Area to Monitor

# Custom Satellite Tab: Temporal Completeness

By entering a Daily Coverage, selecting an Emissions Persistence and scrolling down, users see how these inputs combine to form the Temporal Completeness sub-score.



# Custom Satellite Tab

After saving your entry, the Custom Satellite will appear in the drop downs on the main tab. Note that the custom satellites are evaluated against the same world assumptions as the other satellites.

## Choose 2 Satellites to Compare

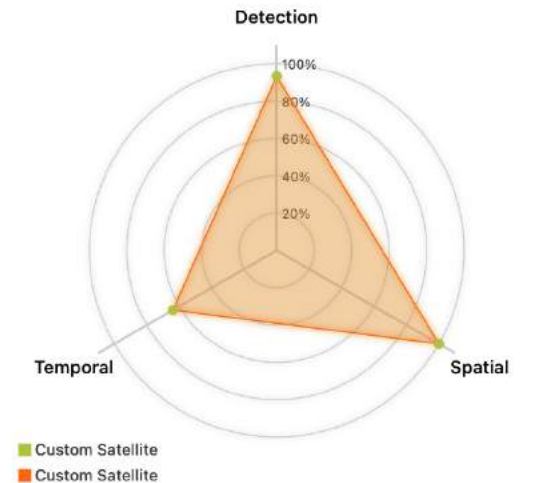
### Satellite 1

#### ✓ Custom Satellite

- AVIRIS-NG/GAO
- Carbon Mapper (1 satellite)
- Carbon Mapper (2 satellites)
- Carbon Mapper (10 satellites)
- Carbon Mapper (20 satellites)
- GHGSat-D
- GHGSat-C1
- GHGSat (2 satellites)
- GHGSat (10 satellites)
- GHGSat (20 satellites)
- PRISMA
- EnMAP
- MethaneSAT
- TROPOMI
- Sentinel-2
- WorldView-3
- Landsat-8

## Completeness Score Breakdown

	Custom Satellite	Custom Satellite
🔍 Detection Score ⓘ	93.4%	93.4%
📍 Spatial Score ⓘ	100%	100%
🕒 Temporal Score ⓘ	63.9%	63.9%
<b>Completeness Score ⓘ</b>	<b>59.7%</b>	<b>59.7%</b>



# Learn More

For more information, check out the FAQ and About tabs. You can also learn more by reading RMI's accompanying report, *Intel from Above: Spotting Methane Super-Emitters with Satellites*.



## Intel from Above

Spotting Methane Super-Emitters with Satellites



Report / January 2023



# Thank You!

We welcome questions, feedback, and comments.

Please reach out to us at [climateintelligence@rmi.org](mailto:climateintelligence@rmi.org).

