SRON	TECHNICAL NOTE	**Doc. no.:** SRON-ESG-TN-2021-003
TANGO		**Issue :** 1.2
		Date : 25 March 2022
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Satellite instruments for CH_4 and CO_2 hotspot detection

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Document Change Record

Issue	Date	Changed Section	Description of Change
1.0	4 June 2021	All	Initial version
1.1	3 November 2021	All	Added iSIM-SWIR
1.2	25 March 2022	All	Added WorldView-3

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Abbreviations and Acronyms

Item	Meaning
FMC	forward motion compensation
SRON	Netherlands Institute for Space Research

Reference Documents

[RD1] Sudhanshu Pandey et al. “Satellite observations reveal extreme methane leakage from a natural gas well blowout”. In: *Proceedings of the National Academy of Sciences* 116 (2019), pp. 26376–26381. DOI: 10.1073/pnas.1908712116.

[RD2] Ivar R. van der Velde et al. “Vast CO_2 release from Australian fires in 2019–2020 constrained by satellite”. In: *Nature* 597 (2021), pp. 366–369. DOI: 10.1038/s41586-021-03712-y.

1 Introduction

Recent advances in satellite remote sensing of long-lived greenhouse gases (GHG) have attracted broad scientific and societal interest [RD1, RD2]. Satellites have become an important tool to quantify natural and anthropogenic GHG emissions, helping nations in their effort to meet the objectives of the Paris Climate Agreement.

Spurred by the recent results, multiple new initiatives are under development for the detection of CH_4 and CO_2 hotspots and urban sources, among them the TANGO mission that was developed for the ESA Scout call. In the context of the TANGO study at SRON Netherlands Institute for Space Research, we have listed key instrument specifications of several instruments (both operational and under development) for the detection of CH_4 and CO_2. The list may help developers and future users of such instruments or their data. Please let us know if you have suggestions to update the list.

2 List of satellite instruments and key specifications

Table 1: Key specifications of several instruments for the detection of CH_4 and CO_2.

instrument	spatial sampling [m]	swath width [km]	spectral resolution [nm]	spectral range [nm]	SNR	FMC	ref.
GOSAT	10500	910	0.03–0.12	758–775 1563–1724 1923–2083	300	✓	1
GOSAT-2	10500	910	0.01–0.11	755–772 1563–1695 1923–2381	300	✓	2
GaoFen-5	10500	750	0.03 0.07 0.07 0.11	759–769 1568–1583 1642–1658 2043–2058	300 300 250 250		3
Sentinel-5	7500	2670	0.4 0.4 0.25 0.25	685–710 745–773 1590–1675 2305–2385	520 200 240 110		4
MicroCarb	6400 2000	14 40	0.03 0.05 0.06 0.08	758–768 1261–1278 1596–1618 2024–2051	285 378 344 177		5
TROPOMI	4400 6200	2700	0.35 0.227	661–786 2300–2389			6
CO2M	2000	250	0.12 0.30 0.35	747–773 1590–1675 1990–2095	75 240 150		7
TanSat	2000	18	0.044 0.12 0.16	758–778 1594–1624 2042–2082		✓	8
OCO-2	1700	10	0.04 0.08 0.10	758–773 1591–1622 2043–2083	400	✓	9
NanoCarb	1000	128	0.23 0.65	1606–1612 1635–1653			10
TANGO	300	30	0.45	1590–1675	270	✓	11
MethaneSAT	200	200	0.22 0.3	1236–1319 1592–1680			12
CO2Image	50	50	1.29	1982–2092	100	✓	13
GHGSat	50	12	0.1	1630–1675	200	✓	14
PRISMA	31	31	11	400–1010 920–2500	300 (1500–1750 nm) 150 (1950–2350 nm)		15
Carbon Mapper	30	18	5	400–2500	300–600 (CH_4)	✓	16
Sentinel-2	20	290	90 180	1565–1655 2100–2280	100		17
iSIM-SWIR	5	7.5		450–900 900–1700		✓	18
WorldView-3	1.24 3.7 3.7 3.7	13.1	40–180 30 40 40–70	400–1040 1195–1225 1550–1750 2145–2365			19

FMC stands for forward motion compensation. References (with hyperlinks):

1. *Appl. Opt.* 48 (2009) 6716–6733, https://doi.org/10.1364/AO.48.006716; *Atmos. Meas. Tech.* 9 (2016) 2445–2461, https://doi.org/10.5194/amt-9-2445-2016; *GOSAT Data Users Handbook*, https://www.eorc.jaxa.jp/GOSAT/document.html. Swath is only sampled 3 times. There is also 1 TIR spectral range.
2. *GOSAT-2 Data Users Handbook*, https://www.eorc.jaxa.jp/GOSAT/document.html. Swath is only sampled 5 times. There are also 2 TIR spectral ranges.
3. *IEEE Trans. Geosci. Remote Sens.* 59 (2021) 899–914, https://doi.org/10.1109/TGRS.2020.2998729. Swath is usually sampled 5 times. Parameters for spatial heterodyne spectroscopy interferometer GMI.
4. ESA Special Publication SP-1336 (2020), http://esamultimedia.esa.int/docs/EarthObservation/SP_1336_Sentinel-5_web.pdf. Spectral oversampling ratio 2.5–3. There are bluer spectral ranges.
5. Buisson, F., *An updated status of MicroCarb Project*, IWGGMS-14 (2018), https://iwggms14.physics.utoronto.ca/presentation-archive.
6. *Atmos. Meas. Tech.* 13 (2020) 3561–3580, https://doi.org/10.5194/amt-13-3561-2020. There are bluer spectral ranges.
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12. https://www.methanesat.org/fit-with-other-missions; *Atmos. Meas. Tech.* 14 (2021) 3737–3753, https://doi.org/10.5194/amt-14-3737-2021. Spectral oversampling ratio 3. First band used for O_2, second for CO_2 and CH_4.
13. *Atmos. Meas. Tech.* 13 (2020) 2887–2904, https://doi.org/10.5194/amt-13-2887-2020; *Atmos. Meas. Tech.* 13 (2020) 731–745, https://doi.org/10.5194/amt-13-731-2020. Spectral oversampling ratio 2.5.
14. *Atmos. Meas. Tech.* 14 (2021) 2127–2140, https://doi.org/10.5194/amt-14-2127-2021.
15. *Remote Sens. Environ.* 262 (2021) 112499, https://doi.org/10.1016/j.rse.2021.112499; *Appl. Opt.* 59 (2020) 6888–6901, https://doi.org/10.1364/AO.389485; *Geophys. Res. Lett.* 48 (2021) e2020GL090864, https://doi.org/10.1029/2020GL090864 uses 1920–2099 nm for CO_2 and 2215–2450 nm for CH_4.
16. https://carbonmapper.org/our-mission/technology.
17. *Remote Sens. Environ.* 120 (2012) 25–36, https://doi.org/10.1016/j.rse.2011.11.026; *Atmos. Meas. Tech.* 14 (2021) 2771–2785, https://doi.org/10.5194/amt-14-2771-2021. Given spectral ranges are used for CH_4: there are other spectral ranges.
18. Camera with 4 spectral bands in each of the two spectral ranges (https://satlantis.com/isim-swir), used in GEI-SAT microsatellites (e.g. https://innovate.research.ufl.edu/2021/05/17).
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