



Copernicus Sentinel-2 Mission Status and Outlook

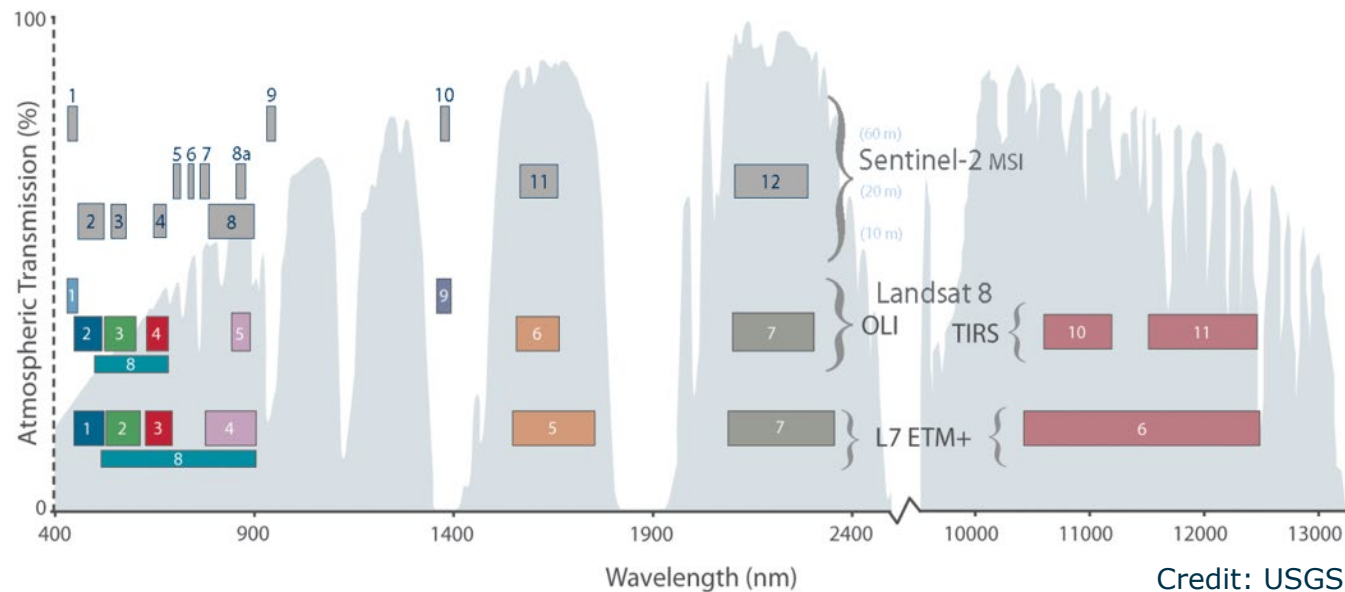
Ferran Gascon, Olivier Colin, Jean-Baptiste Gratadour, Andrea Ferrari, Valentina Boccia, Davide Moretti, Franco Marchese, Kate Symonds, Constantin Mavrocordatos, et al.

25 May 2022

Living Planet Symposium 2022, Bonn

Sentinel-2 Mission

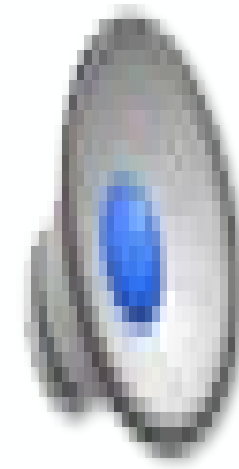
- ✓ Optical multi-spectral mission for the monitoring of land and coastal regions.
- ✓ Constellation of two satellites (currently Sentinel-2A and Sentinel-2B).
- ✓ Polar sun-synchronous orbit at an altitude of 786km, with LTDN (Local Time of Descending Node) 10h30.
- ✓ Swath of 294km.



- ✓ Free & open products for feeding a large range of applications.

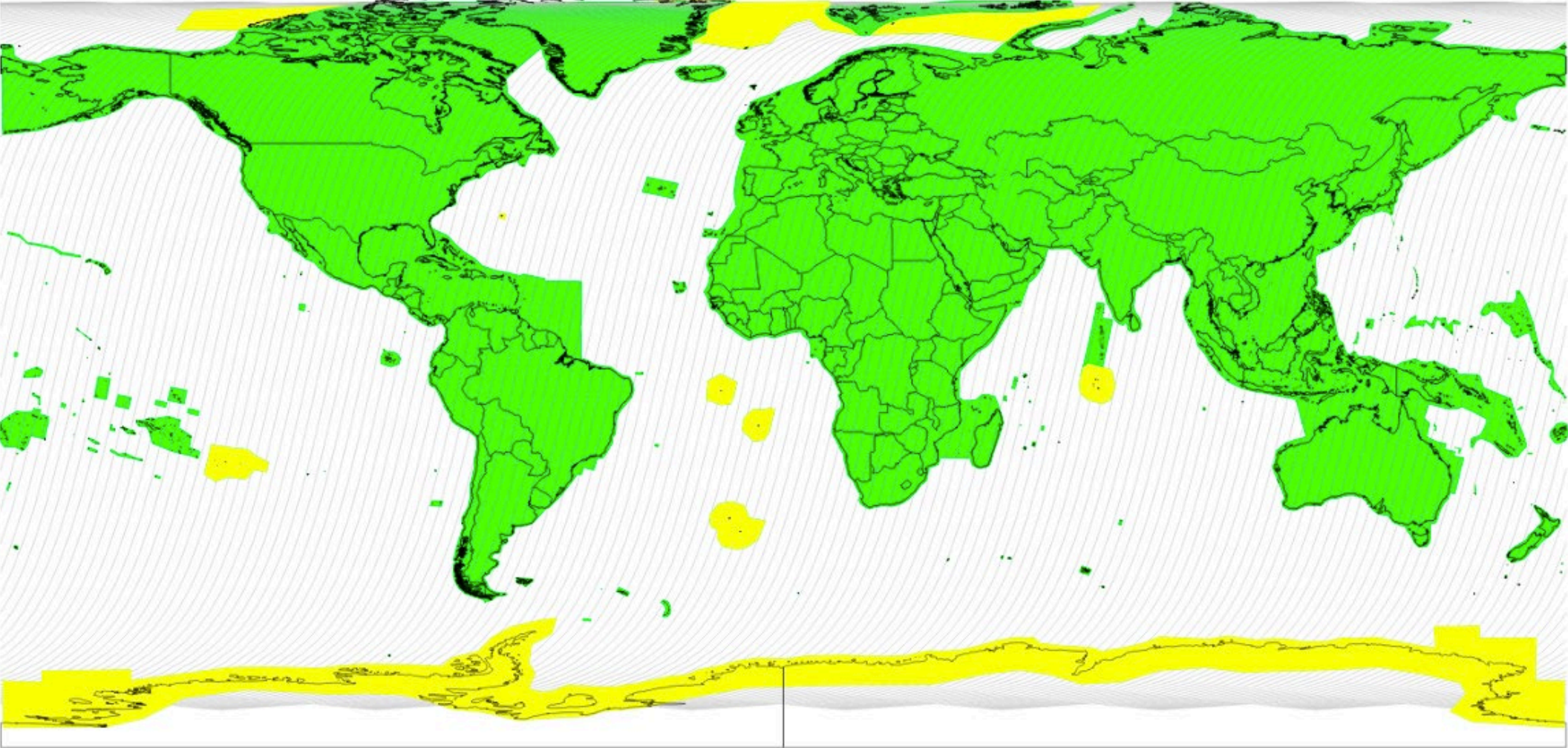


- ✓ Good health of both Sentinel-2A and Sentinel-2B satellites.
- ✓ Observation scenario further extended.
- ✓ New Processing Baseline generating CEOS-ARD (Analysis Ready Data) compliant products.
- ✓ New pilot production for Level-2H and Level-2F products over Belgium under evaluation.
- ✓ Towards Sentinel-2 Collection-1.
- ✓ Top European mission in terms of scientific peer-reviewed publications and distributed data volume.



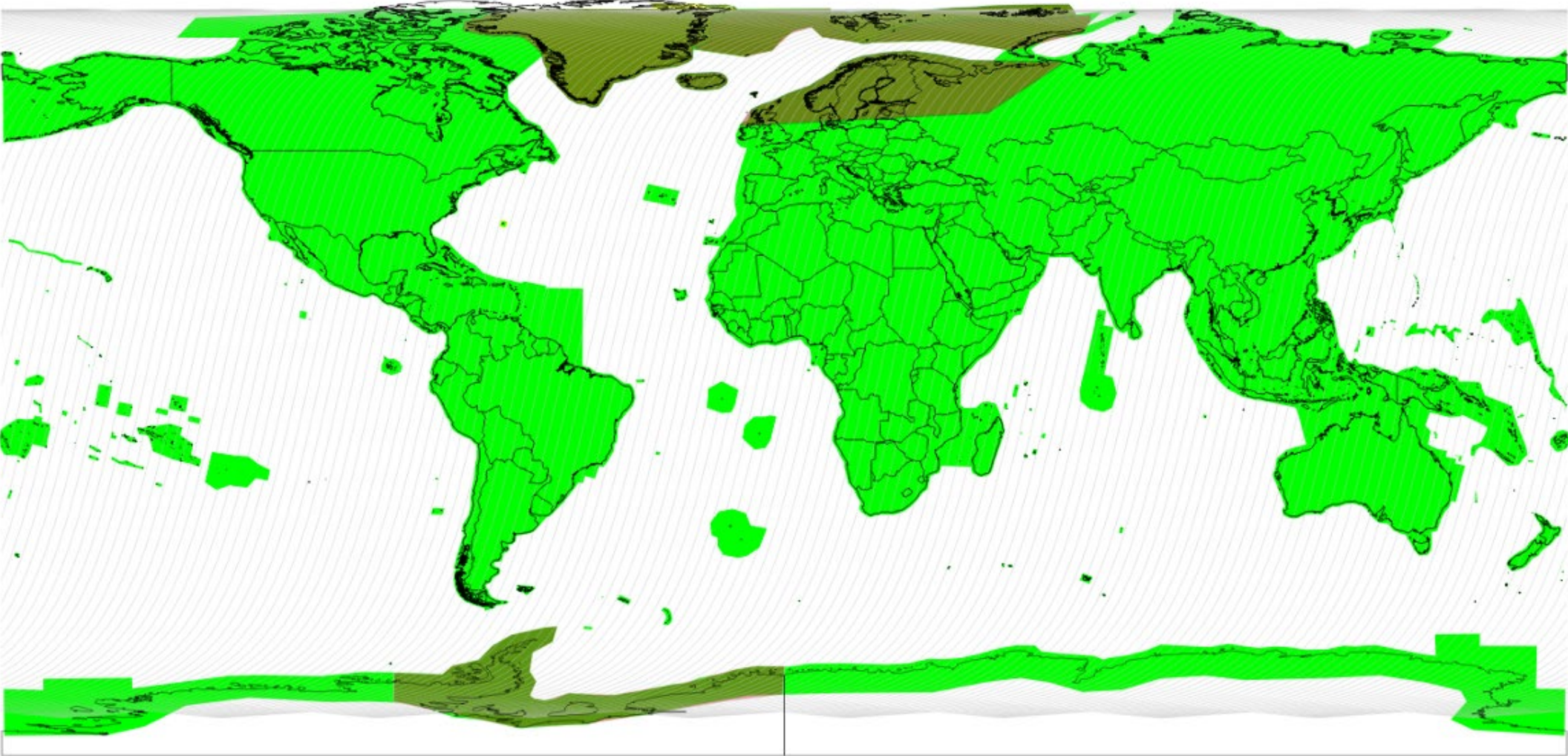
*Normalised Difference Vegetation Index (NDVI) dynamic map by
https://apps.sentinel-hub.com/digital_twin_sandbox/
Copyright: Contains modified Copernicus Sentinel data
(2021) processed by Sinergise*

Observation Scenario



5-day
10-day

Observation Scenario



- SZA < 82deg
- SZA < 85deg

SZA
=
Sun
Zenith
Angle



Sentinel-2 Products

Type	Code	Description	Users	Coverage
Core Products	Level-1B	Top-of-atmosphere radiances in sensor geometry	Expert users	Global (distributed over Alps and Norway)
	Level-1C	Top-of-atmosphere reflectances in cartographic geometry	All users	Global
	Level-2A	Surface reflectances in cartographic geometry		
Pilot Products	Level-2H	Harmonised Sentinel-2 + Landsat-8/9 surface reflectances in cartographic geometry	On-demand	Pilot productions
	Level-2F	Fused Sentinel-2 + Landsat-8/9 surface reflectances in cartographic geometry		

Sentinel-2 Data Quality



COPERNICUS SPACE COMPONENT SENTINEL OPTICAL IMAGING
MISSION PERFORMANCE CLUSTER SERVICE

Data Quality Report
Sentinel-2 L1C MSI
April 2022

Ref.: OMPC.CS.DQR.01.03-2022
Issue: 74.0
Date: 11/04/2022
Contract: 4000136252/21/I-BG

COPERNICUS SPACE COMPONENT SENTINEL OPTICAL IMAGING
MISSION PERFORMANCE CLUSTER SERVICE

Data Quality Report
Sentinel-2 MSI L2A
April 2022

Ref.: OMPC.CS.DQR.002.03-2022
Issue: 48.0
Date: 11/04/2022
Contract: 4000136252/21/I-BG

THE EUROPEAN SPACE AGENCY

Sentinel

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Data Product Quality Reports

The MPC-CC provides a monthly status of the quality of Sentinel-2 L1C and L2A products via respective Data Quality Reports (DQR). The DQRs provides information on the monitoring and measurement of L1C and L2A product performances against the proposed specification, viz:

Geometric Performance

- Geometric Calibration Status
- Absolute Geolocation
- Multi-Spectral Registration
- Multi-Temporal Registration

Radiometric Performance

- Radiometric Calibration Status
- Radiometric Uncertainty
- Noise
- Modulation Transfer Function

It also documents observed anomalies and known issues, the list of defective pixels, and any processing chain improvements resulting in an increment of the Processing Baseline.

TECHNICAL GUIDES

- Sentinel-1 SAR
- Sentinel-2 MSI
 - MSI Instrument
 - Products and Algorithms
 - Processing Baseline
 - Calibration and Validation
 - **Data Product Quality Reports**
 - Anomaly Database
 - POD Instruments and Products
 - Appendices
- Sentinel-3 OLCI
- Sentinel-3 SLSTR
- Sentinel-3 Synergy
- Sentinel-3 Altimetry
- Sentinel-5P TROPOMI

<https://sentinels.copernicus.eu/ca/web/sentinel/data-product-quality-reports>

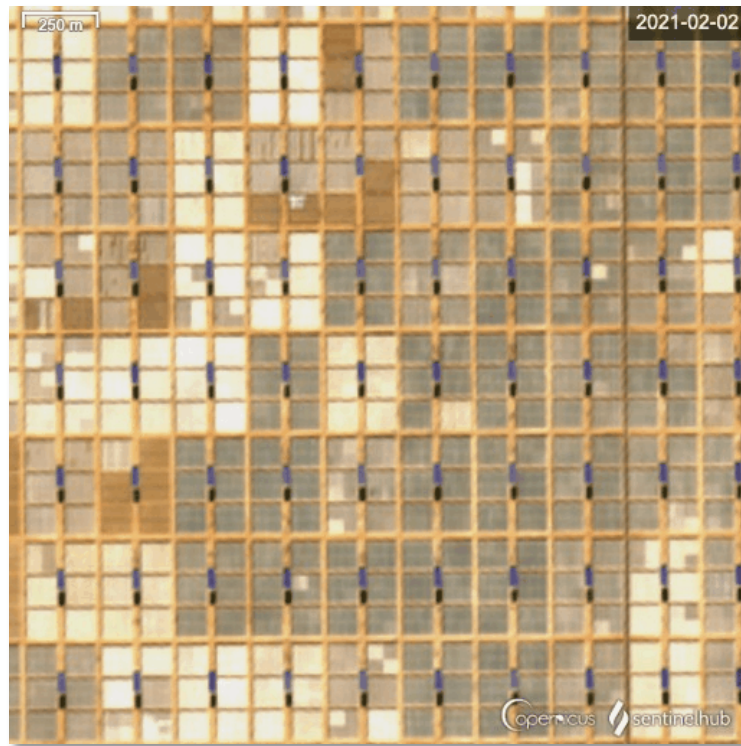


- 2021 August: Worldwide deployment of the geometry-refined production.
- 2021 December: Publication of Sentinel High-Level Operations Plan (HLOP) issue 3.1
- 2021 December: Generation Level-2H and Level-2F pilot production over Belgium for evaluation.
- 2022 January: Upgrade of Level-1C and Level-2A products (baseline for coming Collection 1).
- 2022 January: Level-2A product compliant to CEOS-ARD (Analysis Ready Data) specifications.
- 2022 January: Release of new Sen2Cor Level-2A stand-alone processor (version 2.10).

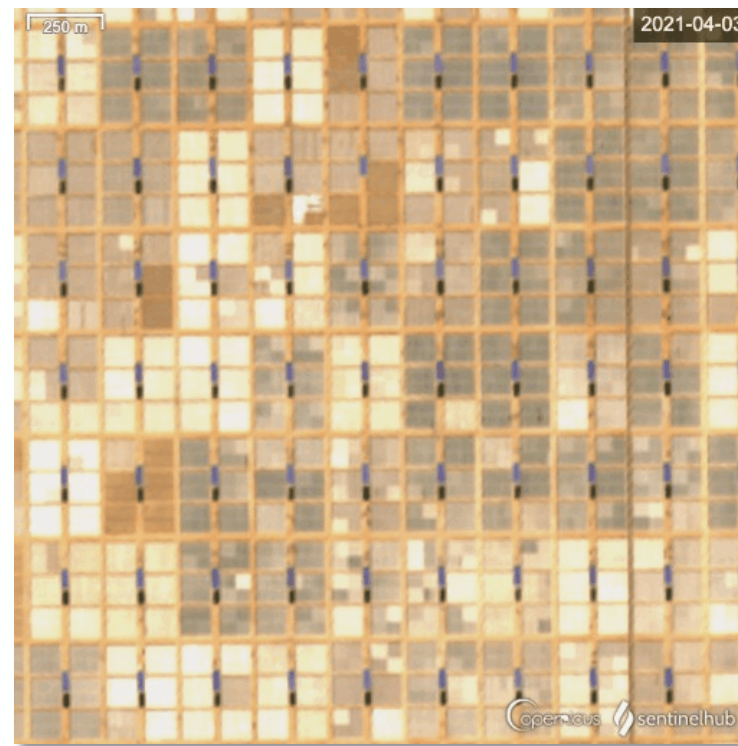
New Sentinel-2 Products Geometric Refinement

Improvement of previous in-flight performances :

- ✓ Absolute geolocation accuracy from 11m improved to **8 m** (CE95).
- ✓ Multi-temporal co-registration accuracy from 12m improved to **5 m** (CE95).



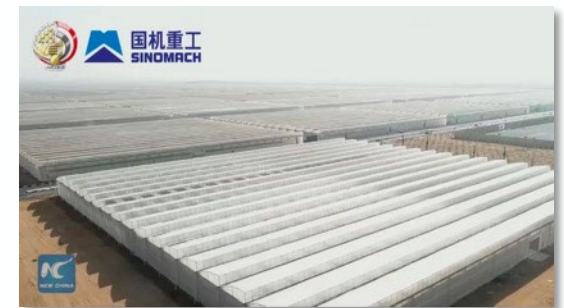
Not Refined Geometry



Refined Geometry



Egypt's former desert



Copyright: New China TV

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<https://ceos.org/ard>



CEOS Analysis-Ready Datasets

The following table summarises all of the satellite EO datasets that have been assessed as CEOS Analysis Ready Data (CEOS ARD). DOI links are provided for access, along with links to further information, sample products, and the completed CEOS ARD self-assessment and peer review outcome documents.

Product	CEOS ARD Type	PFS Version	Agency	Mission(s)	Threshold Specification	Target Specification	Access (DOI)	Info	Self Assessment	Peer Review
Landsat Collection 2	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	81%	Landsat 4-5, 7, 8	Link	PDF	
Landsat Collection 2	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	100%	83%	Landsat 4-5, 7, 8	Link	PDF	
Sentinel-2 Level-2A	Surface Reflectance	v5.0	ESA	Sentinel-2A, 2B	100%	Not assessed	Link	Link	PDF	
EnMAP	Surface Reflectance	v5.0	DLR	EnMAP	100%	Not assessed	TBA	Link	PDF	

Under Peer Review

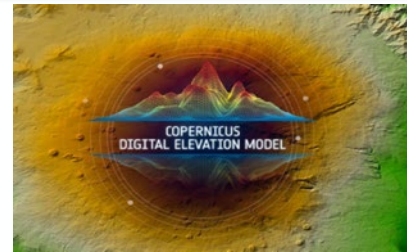
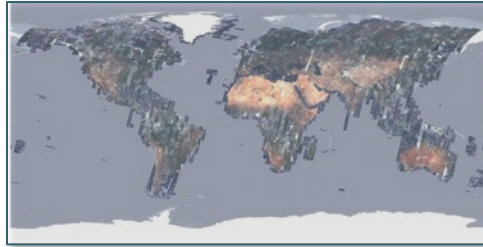
Product	CEOS ARD Type	PFS Version	Agency	Mission(s)	Access (DOI)	Info	Self Assessment	Peer Review	Sample Products
Sentinel-2 Level-2A (E84)	Surface Reflectance	v5.0	Element 84	Sentinel-2A, 2B	TBA	TBA	TBA	TBA	TBA
Sentinel-1 RTC	Normalised Radar Backscatter	v5.5	Sinergise & Digital Earth Africa	Sentinel-1 (A, B)	Link	Link	TBA	TBA	TBA
Landsat Collection 2 U.S. ARD	Surface Reflectance	v5.0	USGS	Landsat 4, 5, 7, 8, 9	Landsat 4-5, 7, 8	Link	PDF	TBA	Link
Landsat Collection 2 U.S. ARD	Surface Temperature	v5.0	USGS	Landsat 4, 5, 7, 8, 9	Landsat 4-5, 7, 8	Link	PDF	TBA	Link

Interoperability with Landsat



✓ Geometry :

- ✓ S2 GRI (Global Reference Image)
- ✓ Copernicus DEM (Digital Elevation Model)
- ✓ CEOS DEMIX (DEMs Intercomparison eXercise)
- ✓ DGGS (Discrete Global Grid System)



✓ Level-1 Radiometry :

- ✓ Pre-flight sensor comparison using an integrating sphere
- ✓ S2 spectral responses close to Landsat-8/9
- ✓ Absolute radiometry inter-comparison



✓ Level-2A Radiometry and Cloud Mask:

- ✓ CEOS ACIX (Atmospheric Correction Intercomparison eXercise)
- ✓ CEOS CMIX (Cloud Mask Intercomparison eXercise)
- ✓ CARD4L [<http://ceos.org/ard>]

Remote Sensing of Environment 208 (2021) 112366

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ACIX-Aqua: A global assessment of atmospheric correction methods for Landsat-8 and Sentinel-2 over lakes, rivers, and coastal waters

Nima Pahlevan^{a,b,c}, Antoine Mangin^a, Sundarabalan V. Balasubramanian^a, Brandon Smith^{a,b}, Krista Alikas^a, Kohel Arai^a, Claudio Barbosa^a, Simon Bélanger^a, Caren Binding^a, Mariano Bresciani^a, Claudia Giardino^a, Daniela Gurlin^a, Yongzhen Fan^a, Tristan Harmel^a, Peter Hunter^a, Joji Ishikawa^a, Susanne Kratzer^a, Moritz K. Lehmann^a, Martin Ligi^a, Ronghua Ma^a, François-Régis Martin-Lauzer^a, Leif Olmanson^a, Natascha Oppelt^a, Yanqun Pan^{a,b}, Steef Peters^a, Nathalie Reynaud^a, Lino A. Sander de Carvalho^a, Stefan Simis^a, Evangelos Spyros^a, François Steinmetz^a, Kerstin Stelzer^a, Sindy Sterckx^a, Thierry Tormos^a, Andrew Tyler^a, Quinten Vanhellemont^a, Mark Warren^a

✓ Level-2H and Level-2F

- ✓ Sen2Like

remote sensing

MDPI

Article

Atmospheric Correction Inter-Comparison Exercise

Georgia Doxani^{1,*}, Eric Vermote^{2,*}, Jean-Claude Roger^{2,3}, Ferran Gascon⁴, Stefan Adriaensens⁵, David Frantz^{6,7}, Olivier Hagolle⁷, André Hollstein⁸, Grit Kirches⁹, Fuqin Li¹⁰, Jérôme Louis¹¹, Antoine Mangin¹², Nima Pahlevan^{2,13}, Bringfried Pflug¹⁴ and Quinten Vanhellemont¹⁵

Open Access Article

Harmonizing the Landsat Ground Reference with the Sentinel-2 Global Reference Image Using Space-Based Bundle Adjustment

by Rajagopalan Rengarajan^{1*}, James C. Storey¹ and Michael J. Choate²

¹ KBR, Sioux Falls, SD 57030, USA
² U.S. Geological Survey, Earth Resources Observation and Science Center, Sioux Falls, SD 57030, USA
 * Author to whom correspondence should be addressed.

Remote Sens. 2020, 12(19), 3132; <https://doi.org/10.3390/rs12193132>

Received: 3 August 2020 / Revised: 18 September 2020 / Accepted: 20 September 2020 / Published: 24 September 2020

CEOS
Committee on Earth Observations Satellite

Working Group Calibration & Validation

Terrain Mapping SubGroup and DEMIX Update

Peter Strobl, EC-JRC, WGCV
 CEOS WGCV #48, Virtual Meeting/Session
 Hosted by Webex
 28 October 2020

Remote Sensing of Environment 233 (2019) 111369

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

An inter-comparison exercise of Sentinel-2 radiometric validations assessed by independent expert groups

Nicolas Lamquin^a, Emma Woolliams^a, Véronique Bruniquel^a, Ferran Gascon^a, Javier Gorroño^a, Yves Govaerts^a, Vincent Leroy^a, Vincent Lonjou^a, Bahjat Alhammoud^a, Julia A. Barsi^a, Jeffrey S. Czupla-Myers^a, Joel McCorkel^a, Dennis Helder^a, Bruno Lafrance^a, Sébastien Clerc^a, Brent N. Holben^a

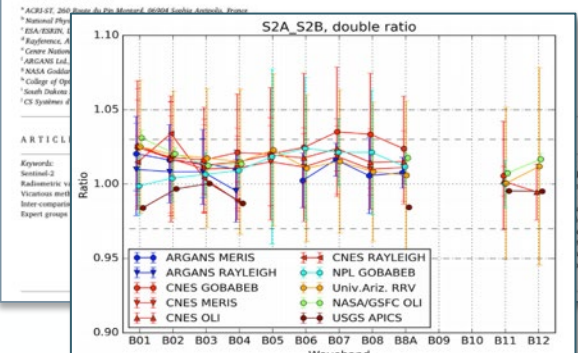
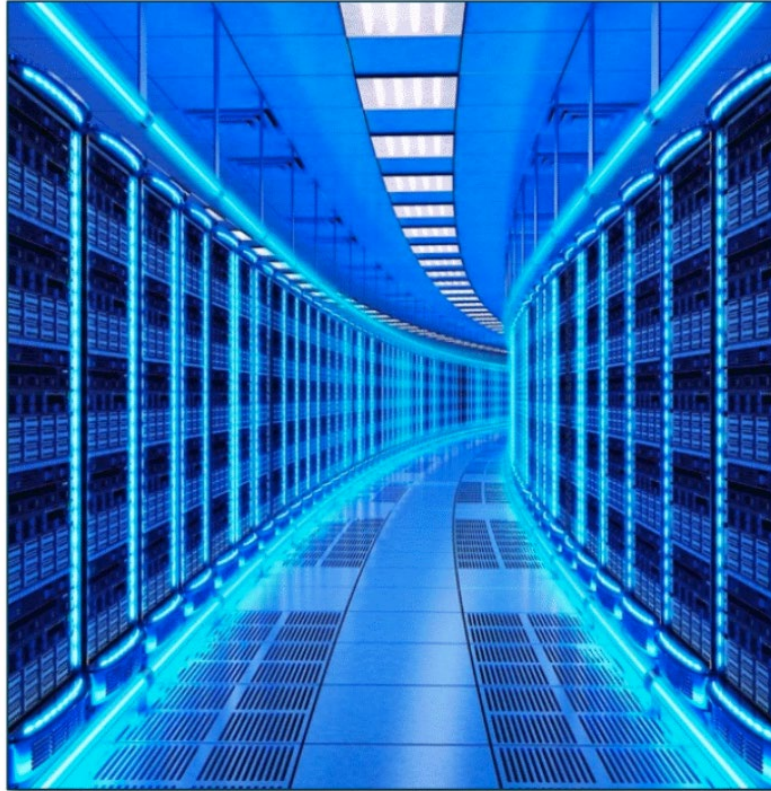


Fig. 10. Double ratios g(S2A)/g(S2B) for each calibration validation method.

- Sentinel-2 archive reprocessing to generate Collection-1.
- Distribution of Sentinel-2 GRI (Global Reference Image) as a free & open product.
- Completion of the Ground Segment Transformation (with new Data Distribution service).
- Evaluation of S2-Landsat harmonised and fused products for pilot production over Belgium.
- Development of new Aquatic Reflectance layer within Level-2A product.
- Explore usage of DGGS (Digital Global Grid System).
- Definition of new product evolutions.
- Replacement of current flying units.



- Collection 1 generated by reprocessing full S2 archive for both Level-1C and Level-2A products.
- Reprocessing campaign foreseen to start in June 2022, published progressively on DIAS platforms and completed by Q1 2023.
- Using latest processing baselines for Level-1C and Level-2A products.
- Collection 1 will be CEOS-ARD compliant [<http://ceos.org/ard>].

Schedule Overview

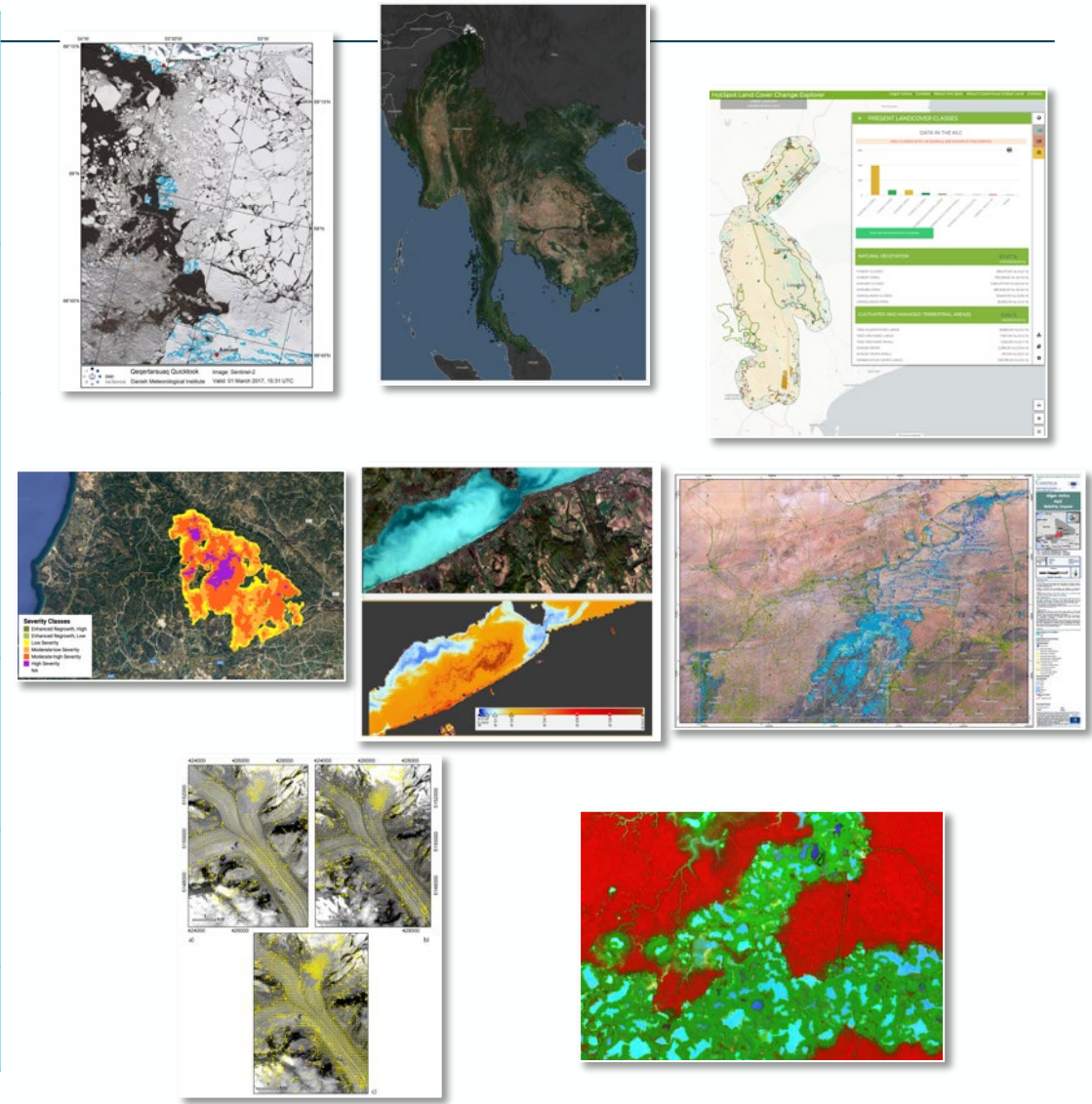


- The 2-satellite constellation operations remains the baseline.
- Third unit (S2A as baseline) will be parked in orbit and kept in hot stand-by.



Broad Range of Applications

<p>CEMS Copernicus Emergency Management Service</p>	<ul style="list-style-type: none"> - Emergency response to rapid mapping (burnt area, flood, landslides, volcanoes) - Risk recovery (e.g. crop change, floods) - Validation (e.g. fires, floods, landslides) - EFFIS/GWIS (Burned area mapping, fire severity and vegetation recovery)
<p>CMEMS Copernicus Marine Environment Monitoring Service</p>	<ul style="list-style-type: none"> - Sea-ice charting - Coastal waters Turbidity - Coastal waters Total Suspended Matter
<p>CLMS Copernicus Land Monitoring Service - Global and Pan-European Components</p>	<ul style="list-style-type: none"> - Hot Spot Monitoring for EU field projects and international policies - Global Mosaics - Inland waters Turbidity - Inland waters Total Suspended Matter - Biophysical products - Land cover products
<p>CSS Copernicus Security Service Copernicus Maritime Surveillance Service European Maritime Safety Agency / CleanSeaNet</p>	<ul style="list-style-type: none"> - Oil spill detection and polluter identification (CleanSeaNet) - Maritime surveillance (e.g. ship detection, search and rescue, anti-piracy)
<p>CSS – SEA Copernicus Security Service Support to External Action</p>	<ul style="list-style-type: none"> - Up-to-date background information - Integration with very high resolution imagery - Feature of interest extraction
<p>C3S Copernicus Climate Change Service</p>	<ul style="list-style-type: none"> - Glaciers mapping - Glaciers flow velocities



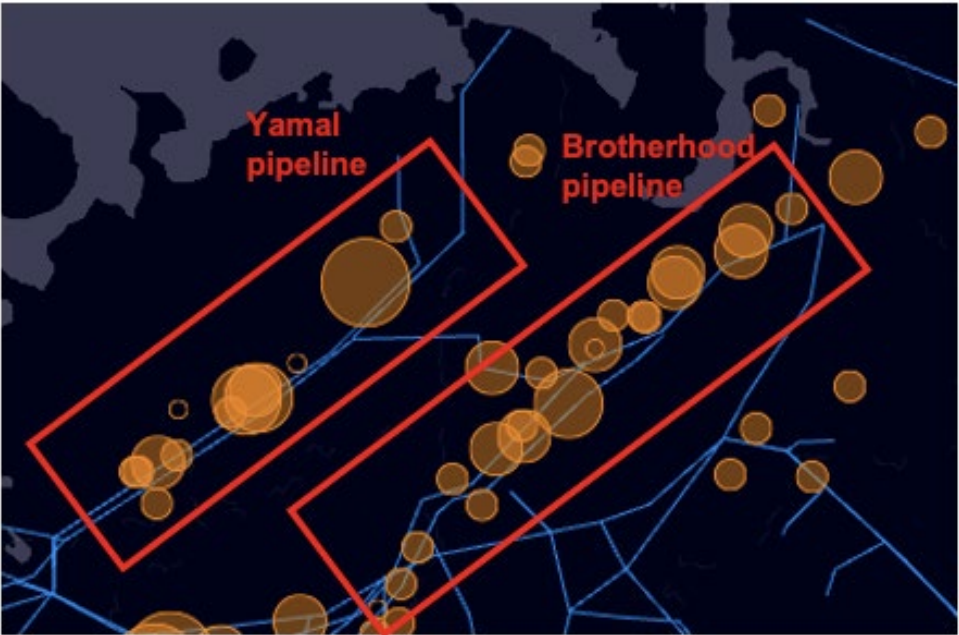
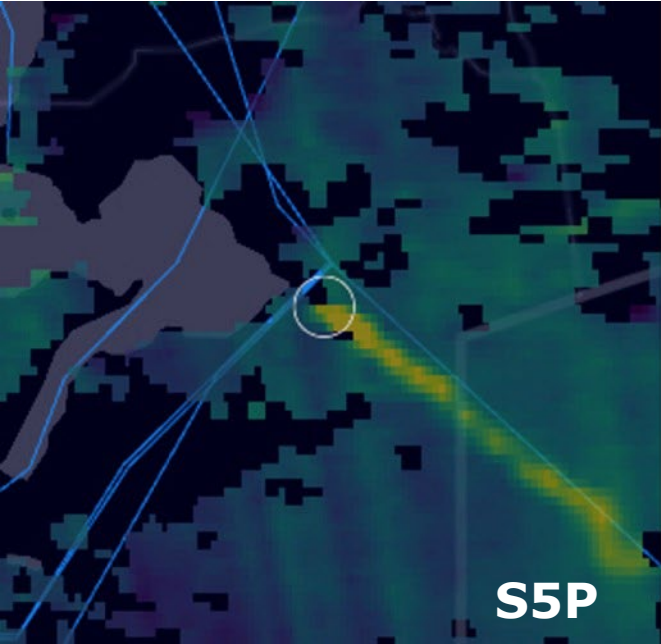
... as well as in national services, and the scientific and commercial domains



Sentinel-2 Mapping High-resolution Methane Emissions



- Sentinel-2 used to detect individual methane leakages from natural gas facilities worldwide.

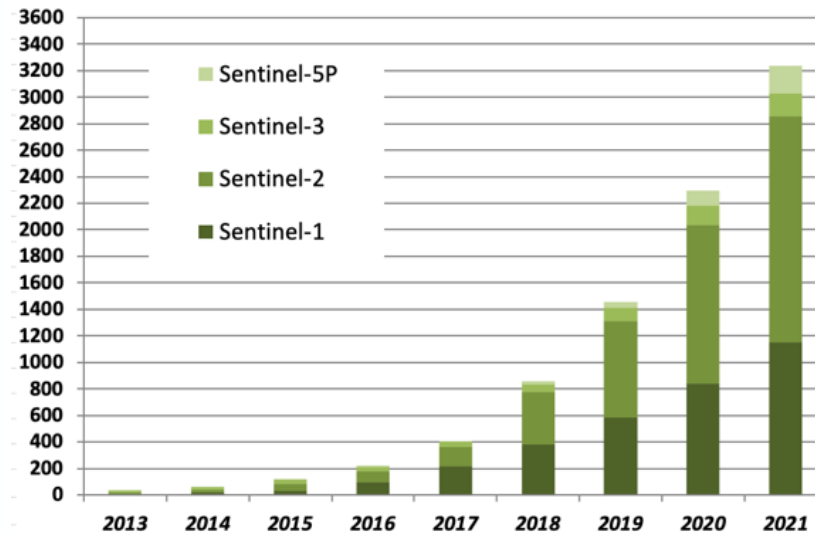
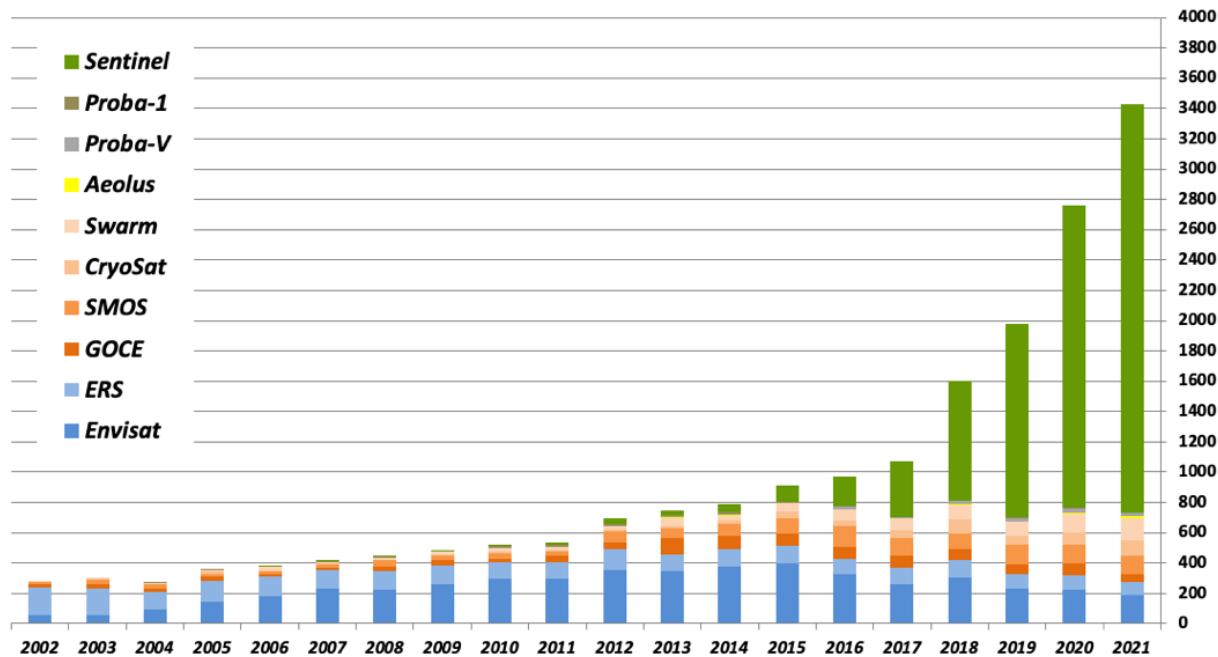


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https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-5P/Monitoring_methane_emissions_from_gas_pipelines

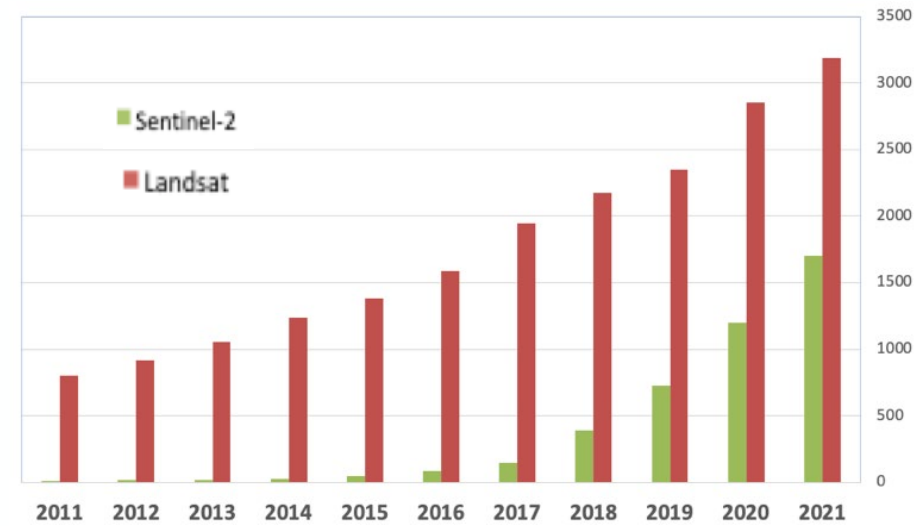


Peer-Reviewed Publications



1704 publications in 2021

Method: Based on Elsevier SCOPUS database, exact number of peer reviewed publications searching for mission/instrument name within papers title, abstract and keywords, and excluding conference papers.





<https://sentinels.copernicus.eu/ca/web/sentinel/missions/sentinel-2/mission-status>

