



Sentinel-2 Mission Status and DIAS Overview

Ferran Gascon (Sentinel-2 Mission Manager)

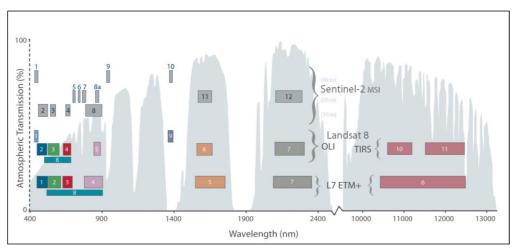
09 October 2018, Oslo

ESA UNCLASSIFIED - For Official Use

Sentinel-2 Mission



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





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





















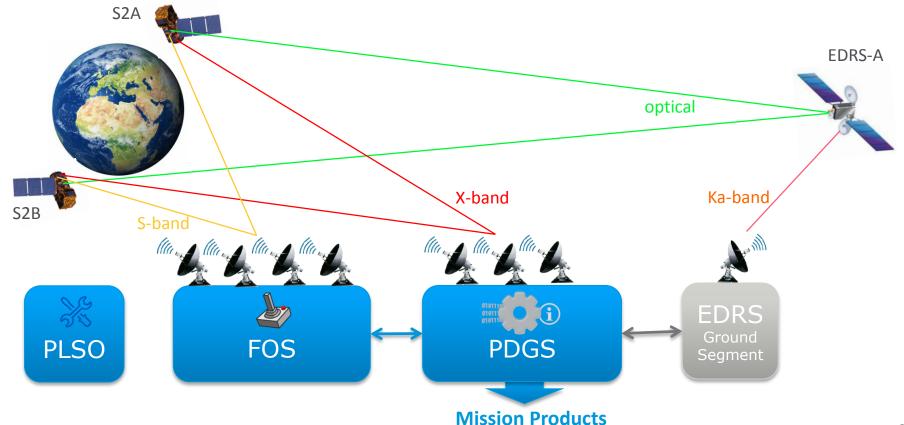






Sentinel-2 Mission System Overview





Sentinel-2 Mission Status



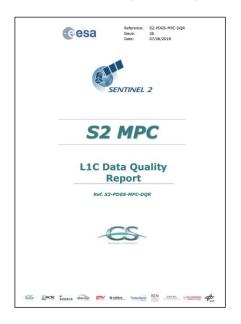
- ✓ Nominal Sentinel-2 constellation operations with Sentinel-2A and Sentinel-2B.
- ✓ Performing global and systematic acquisitions (5day revisit) since 17 February 2018.
- ✓ The European Data Relay System (EDRS) service is being used operationally by both Sentinel-2A and Sentinel-2B.
- ✓ New core product (Level-2A surface reflectance) generated and distributed since 26 March 2018 for Europe.

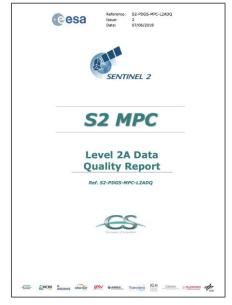


Mission Status and Data Quality Reports









✓ Links:

- ♦ https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/mission-status
- ♦ https://sentinels.copernicus.eu/documents/247904/685211/Sentinel-2_L1C_Data_Quality_Report
- ♦ https://sentinels.copernicus.eu/documents/247904/685211/Sentinel-2-L2A-Data-Quality-Report

Mission Products Catalogue



Product Name	Measurement Provided	Distribu tion	Productio n	Preser vation
Level-1B	Top-of- atmosphere radiances in sensor geometry	Expert users	Systematic	Long- term
Level-1C	Top-of- atmosphere reflectances in cartographic geometry	Public	Systematic	Long- term
Level-2A	Surface reflectances and pixel classification in cartographic geometry	Public	Systematic + SNAP	1,5 year rolling archive



Observation Scenario (Mission Requirements)

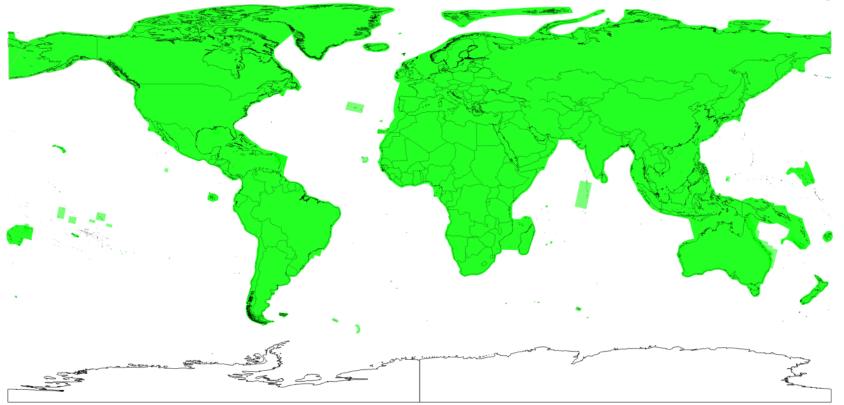






Observation Scenario (HLOP 2.1)

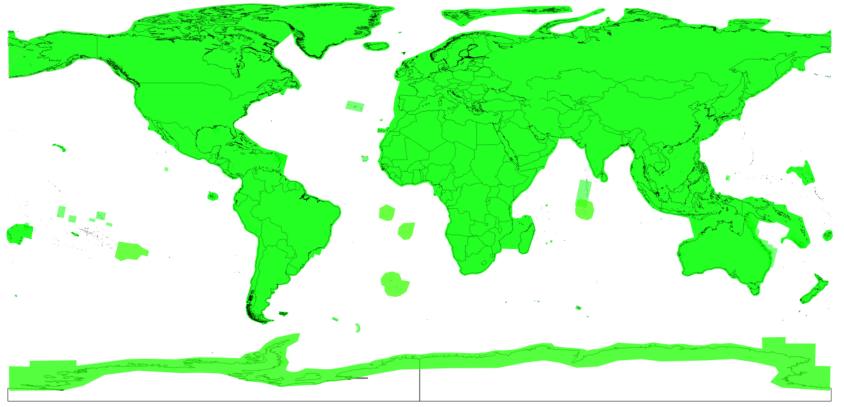






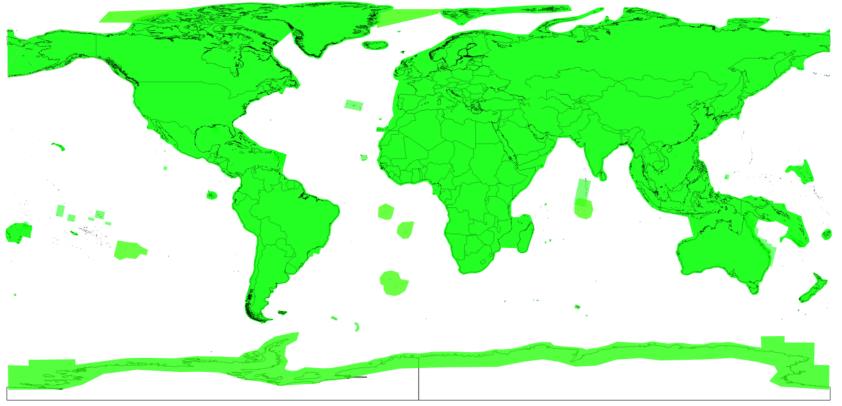
Observation Scenario (HLOP 2.2)





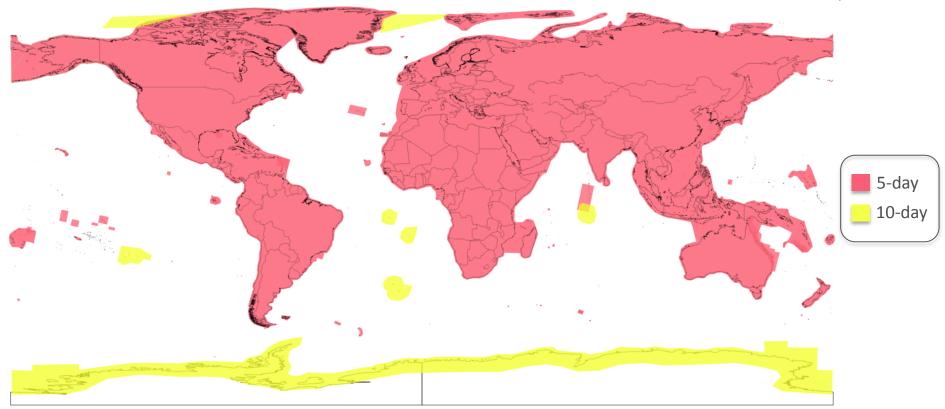
Observation Scenario (Current)





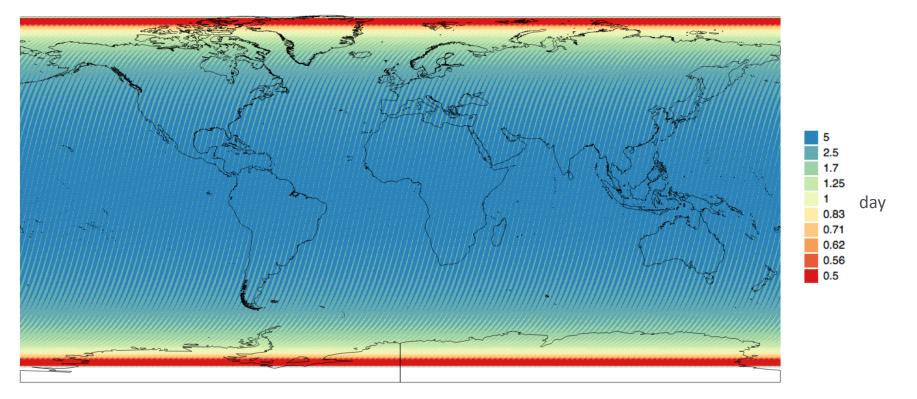
Revisit Time





Coverage

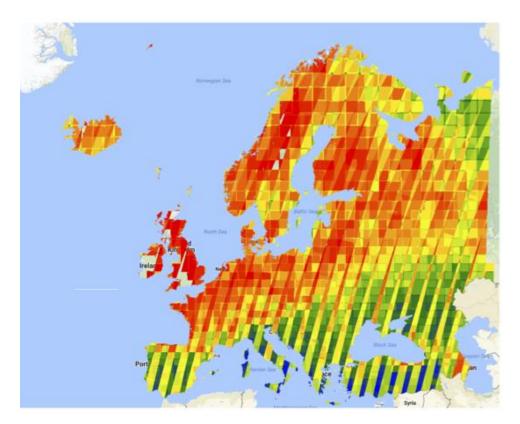




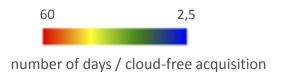


Effective Coverage (cloud-free)



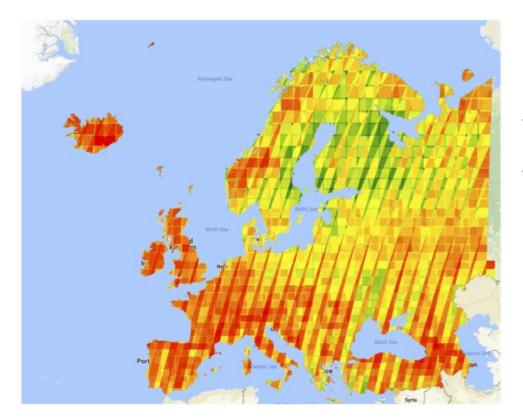


- Period July-August 2017 (2 months)
- Average number of days between cloudfree acquisitions (defined as tiles with <20% cloud covered).



Effective Coverage (cloud-free)



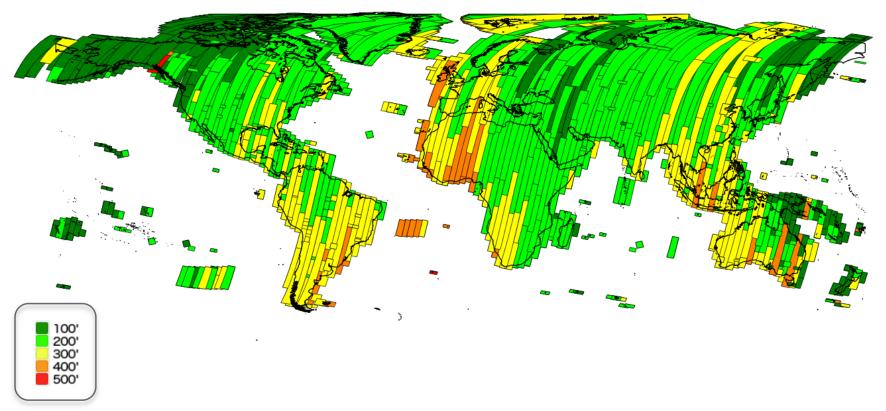


- Period March-April-May 2018 (3 months)
- Average number of days between cloudfree acquisitions (i.e. with tiles <20% cloudy).



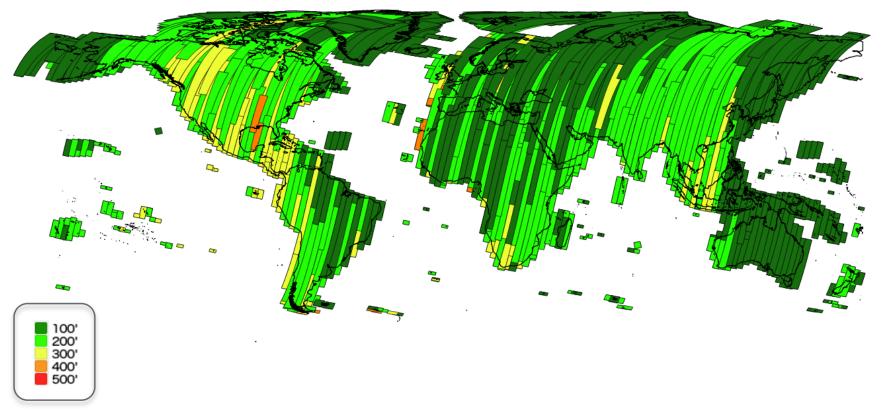
On-board Latency for S2A in 2016





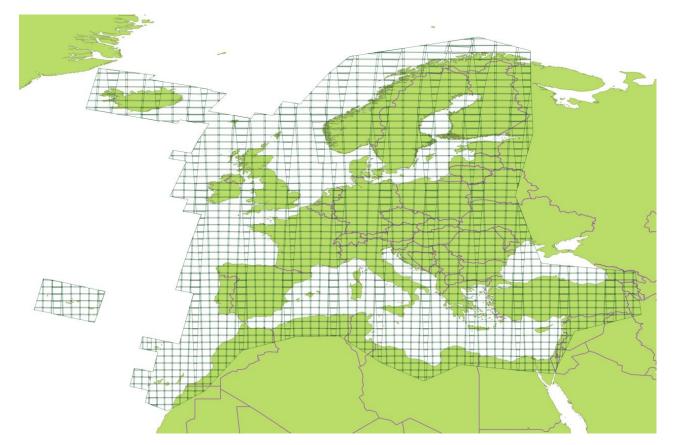
On-board Latency for S2A in 2018





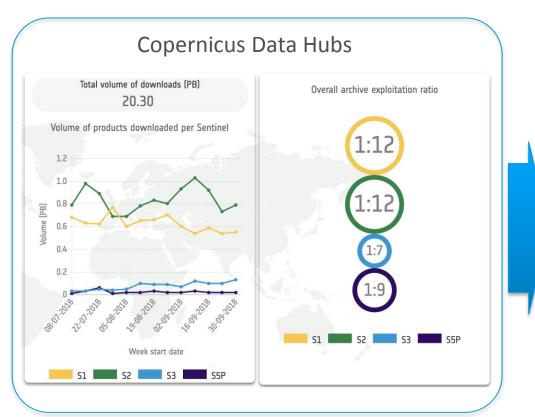
Level-2A Product Geographical Coverage





Data Distribution





Private companies re-distributing Sentinel products through free and pay-per-use schemes

Google Earth Engine O mundi CREODIAS

WEB SERVICES POWERED BY COMMON SOURCE

ONDA S

International partners mirror sites disseminating towards own national communities









Collaborative mirror sites











Data Distribution





Copernicus Open Access Hub



LATEST NEWS



173,494 Self registered Users



56,783,968 Products Downloaded 40.33 PB Volume Downloaded



No Rolling Policy



Sentinel-1 NTC

Sentinel-2

Sentinel-3 (preops) Sentinel-5P (preops)



Max 2 concurrent Downloads



Collaborative Hub



LATEST NEWS



18 Collaborative GS 7 Data Hub Relays



32,445,285 Products Downloaded 25.34 PB Volume Downloaded



Node1: 30 days

Node2: 2 weeks

Node3: 3 weeks



Sentinel-1 NRT & NTC



Sentinel-2

Sentinel-3 SRAL



Max 10 concurrent downloads per Node



International Hub



LATEST NEWS



International Agreements



9,733,994 Products Downloaded 7.53 PB Volume Downloaded



3 weeks



Sentinel-1 NTC Sentinel-2 L1C

Sentinel-3 SRAL



Max 10 concurrent downloads



Copernicus Services Hub



LATEST NEWS



217 Registered Users



29,994,291 Products Downloaded 19.07 PB Volume Downloaded



No Rolling Policy



Sentinel-1 NRT & NTC Sentinel-2





Max 10 concurrent downloads













































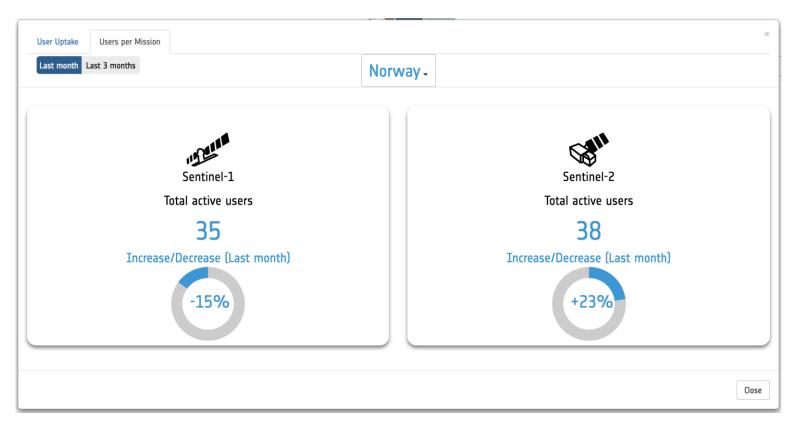




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Data Distribution





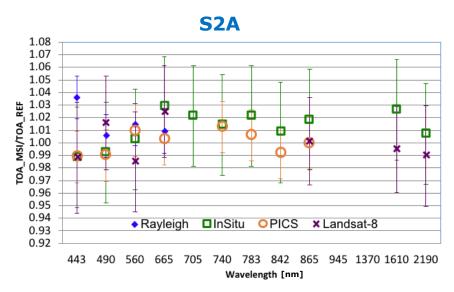


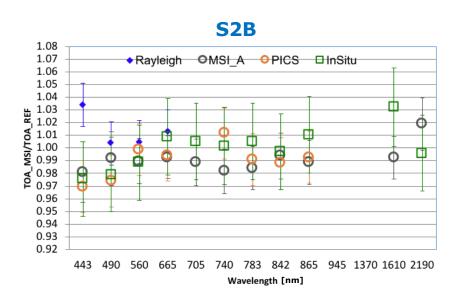
L1C - Absolute Radiometric Accuracy



The Absolute Radiometric Accuracy is within the threshold level (5%).

Good consistency over all methods.





Plots show the ratio of MSI measurements over reference values. Error bars indicate the validation method uncertainty.

























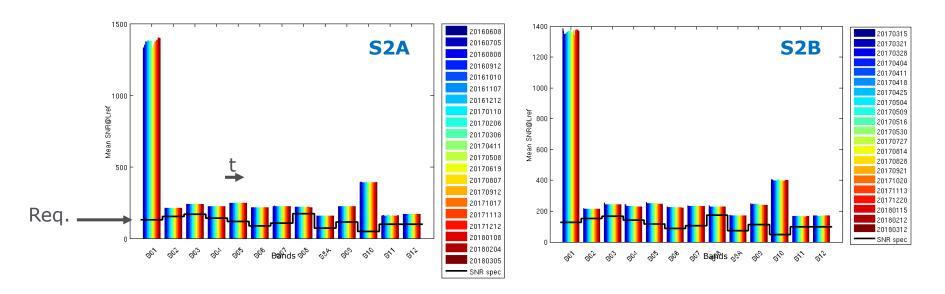




L1C - Signal-to-Noise Ratio (SNR)



The SNR for both S2A and S2B is compliant with the MRD requirement.

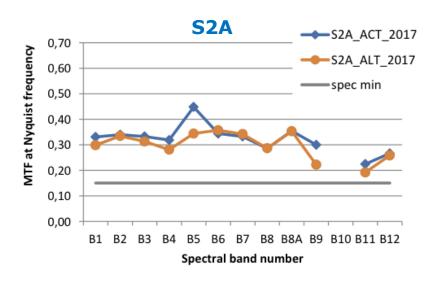


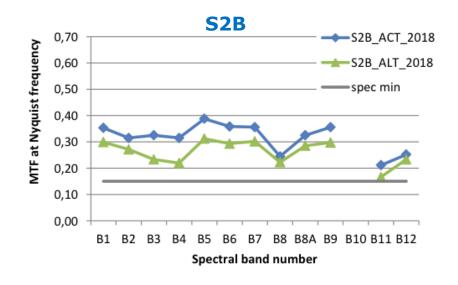
The noise characteristics are very stable over time.



L1C - Modulation Transfer Function (MTF)

























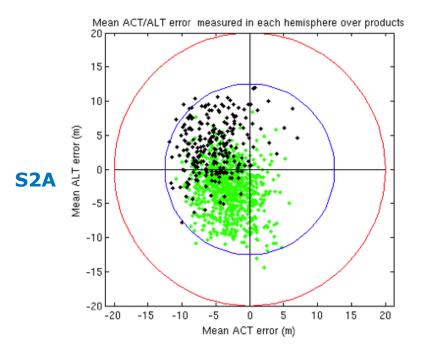




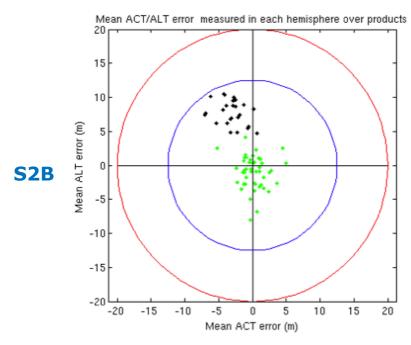


L1C - Geolocation accuracy





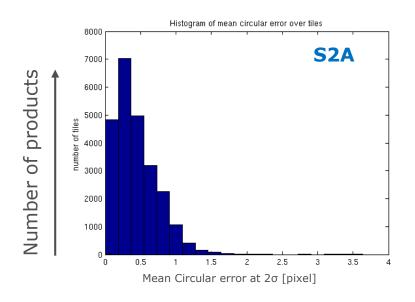
1079 L1C products Circular error @95.5% conf. level: 11.16 m



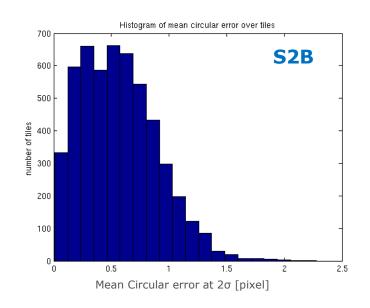
75 L1C products Circular error @95.5% conf. level: 11.29 m

L1C - Multi-temporal co-registration





Mean Circular Error at 2σ: 1 pixel 1103 products (06/2016 - 06/2018)

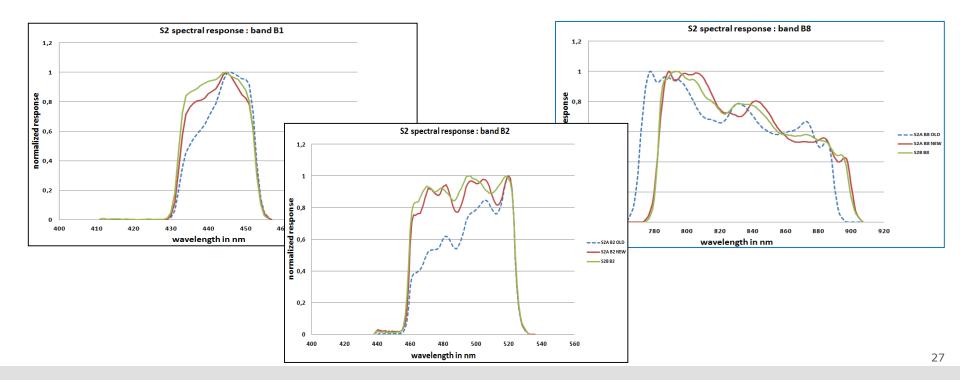


Mean Circular Error at 2σ : 1.18 pixel 527 products (05/2017 – 06/2018)

L1C - Spectral band characteristics



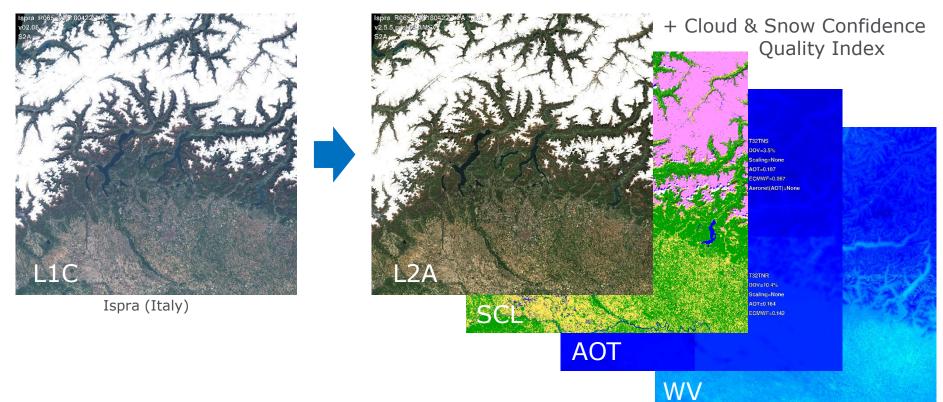
An anomaly was <u>identified and corrected</u> for the spectral response function of S2A (15/01/2018), affecting bands B01, B02, and B08 (https://cophub.Copernicus.eu/news/News00138).





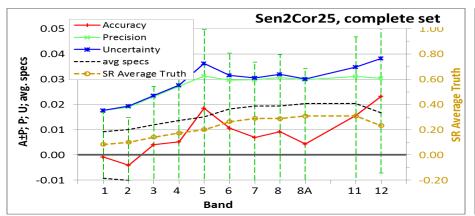
L2A Processor outputs

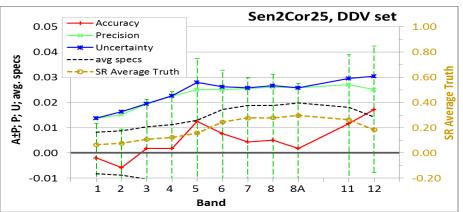




L2A - Surface Reflectance Radiometric Accuracy







- → DDV subset performs better than the complete data set
- → Best accuracy for bands 3, 4, 8A, however better uncertainty for bands 1 and 2
- → Average accuracy is within requirements except band 5_{complete_set} and band 12





















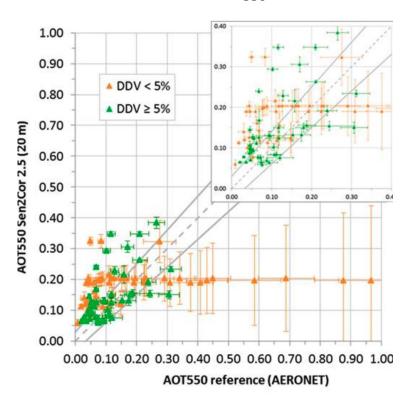




L2A – Aerosol Optical Thickness (AOT) Accuracy



Correlation plot of L2A AOT_{550} at 20 m resolution over AOT_{550} reference from AERONET



Accuracy requirement (solid lines): $|\Delta AOT550| \le 0.1*AOT550_{ref} + 0.03$

Dashed line: Sen2Cor-output = Reference

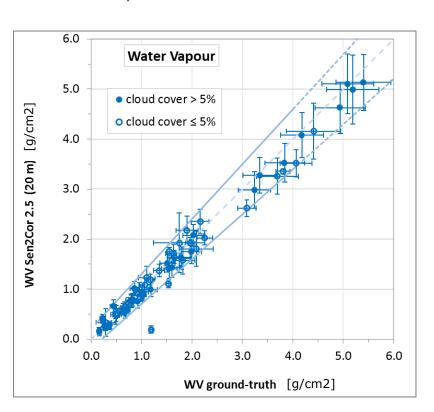
Green triangles: Results for DDV-algorithm

Orange triangles: Results for fall-back processing with configured start VIS=40 km

L2A – Water Vapour (WV) Accuracy



Correlation plot of WV values retrieved over WV reference from AERONET:



WV accuracy requirement (solid lines): $|\Delta WV| \le 0.1 * WV_{ref} + 0.2$

No. of products: 71 WV retrievals with the requirement: 97%



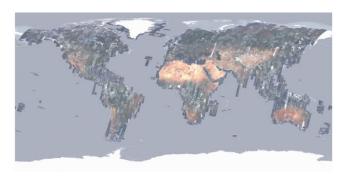
Evolutions - Geometric refinement with GRI



- L1 processor is being upgraded to improve geolocation and multi-temporal coregistration.
- Processing based on the usage of a GRI (Global Reference Image) as a source of GCPs.

A full repeat cycle dataset of well-localized and as cloud-free as possible mono-spectral (band 4) Level-1B products

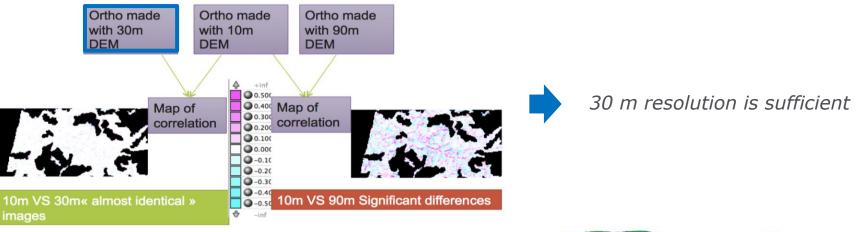
Elaboration and validation of the GRI is on going (completion expected in January 2019).



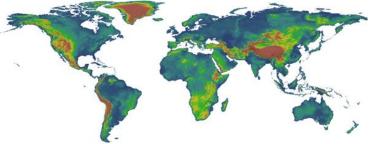
Evolutions – Digital Elevation Model (DEM)



DEM will be upgraded to improve geolocation over mountainous regions



30m DEM currently in procurement process



Mission Outlook



- 2018 October: New batch of L1C product evolutions (e.g. tile sensing time, detectors masks).
- 2018 Q4: Start of worldwide L2A operational production.
- 2018 Q4: Completion of the conversion of the archive into single-tile format.
- 2019 Q2: Start of the geometry-refined production using Global Reference Image (GRI).
- 2019 Q2: Usage of improved DEM (30m resolution) for L1C and L2A productions.
- 2019: Online on-demand L2A processing/reprocessing from L1C archive products.





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Large range of applications...





Agriculture, Forests & Carbon, Vegetation monitoring



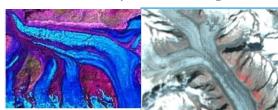
Emergency management



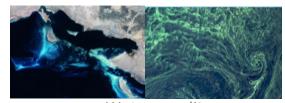
Geology



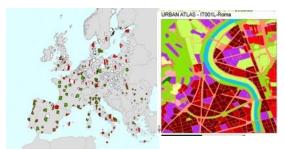
Land cover classification, high resolution layers & change.



Glaciers & Ice



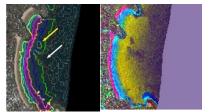
Water quality



Regional to Urban Applications



Global Land use & change



Coastal zones/bathymetry







































Denmark scorched, impact of summer 2018 heatwave Agricultural fields around the town of Slagelse in Zealand (DK)



Copyright: Contains modified Copernicus Sentinel data (2017/2018) / processed by ESA

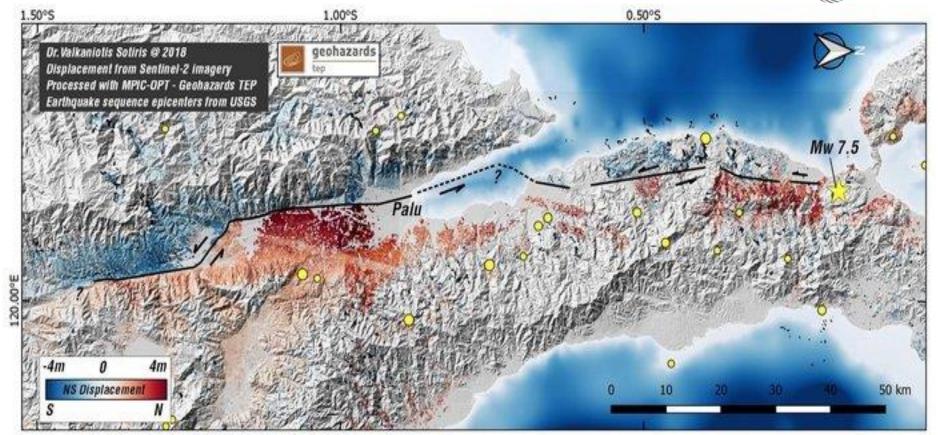
Sentinel-2 maps Indonesia earthquake





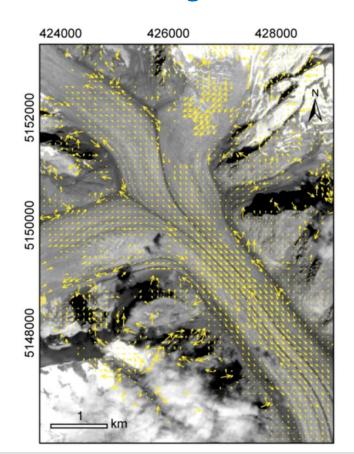
Sentinel-2 maps Indonesia earthquake





Glacier Monitoring





[Kääb et al., 2016]

For Aletsch Glacier, Swiss Alps, tracked displacements using Sentinel-2A band 8 data from 30 July and 8 September 2015, i.e. over 40 days.

Example of Antarctica Acquisitions





✓ Icebreakers

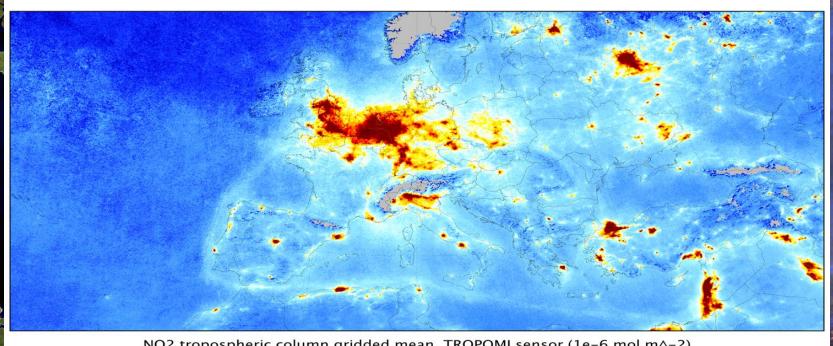
opened a way through

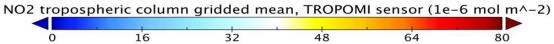
the ice for providing

supplies to the

research bases.









living planet MILAN 13-17 May 2019

UNDERSTANDING THE EARTH SYSTEM

SPACE 4.0 AND EARTH OBSERVATION

BENEFITS FOR A RESILIENT SOCIETY

PUBLIC AND PRIVATE SECTOR INTERACTIONS

Deadlines

Session Proposals 17 June 2018 Abstracts
11 November 2018

Registration April 2019 lps19.esa.int



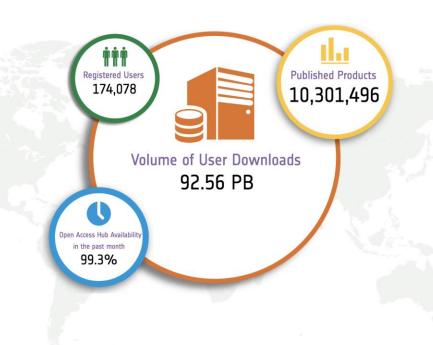


DIAS (Data and Information Access Services)



DIAS Context







Overall archive exploitation ratio

Statistics on 2018.10.09







































DIAS Objectives





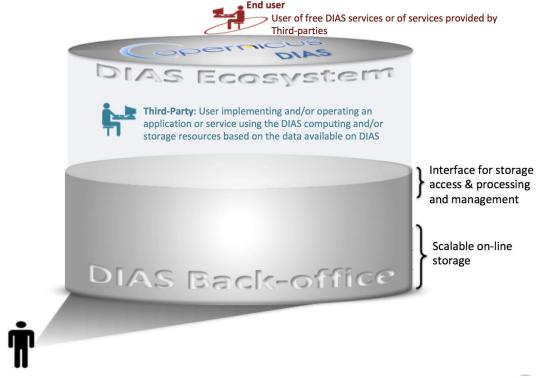
Creating and enabling a European EO Data ecosystem for research and business

DIAS is one of the cornerstones of Copernicus.

Copernicus DIAS builds a common European approach to EO data exploitation with Copernicus data at its core

Overview and Key Actors





DIAS Provider: In charge of DIAS back-office services, interfaces operations, and providing to Third-Parties access to the DIAS computing and storage resources.

DIAS Data Offer





All DIAS offer access to Copernicus Data and **Information** for local processing, with some particularities for each DIAS

Each DIAS may provide access to additional EO & non-EO data according to the respective DIAS business models.

Data offers will evolve according to demand and each DIAS strategy



The DIAS **Data Offers** are public and available through the various DIASs' web sites

Data Sources for Copernicus Data & Information























Copernicus Services Information

Other Data Sources



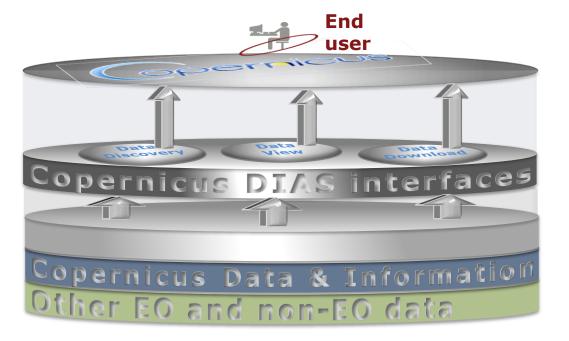
Free DIAS Services



All DIAS allow users (end users and third-parties) to freely:

- Discover available data & information
- Download available data & information

In addition, a **View** service is offered to browse images.



Data discovery, view and download are interfaces available on each DIAS.

Additional services may be provided by any DIAS at any point in time according to the users demand and respective DIAS business models.





DIAS Services Offer



ALL DIAS offer cloud computing & storage resources to be procured by Third-parties for further data processing.



Part of the DIAS Service Offer

Additional interfaces and services available to store and integrate "user data" into the DIAS "data offer".

All DIAS offer resources and additional services to Third-parties under a publically available service offer.

Each DIAS publishes its own commercial offer for Third-parties.

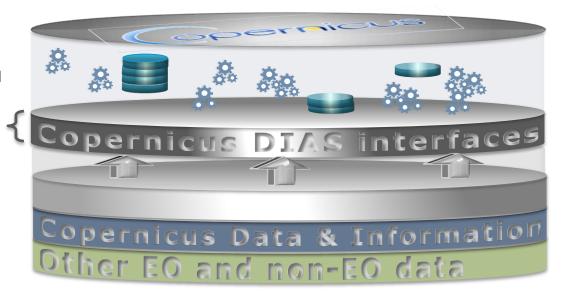
Each DIAS may offer additional services at any point in time depending on the respective business model and user needs.

-5

DIAS Interfaces for Local Processing



Each DIAS offers standard OGC interfaces, popular cloud APIs (e.g. swift), and/or new innovative solutions (e.g. ENS, data cube, etc.) to access the Data Offer.



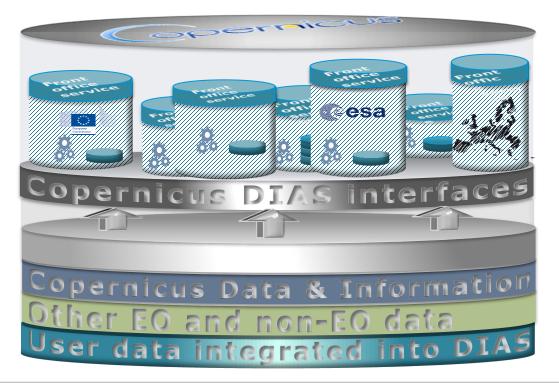
Each DIAS publishes a documented interface service offer for Third-parties.

Each DIAS may offer additional interfaces at any point in time depending on the respective DIAS business models and user needs.

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DIAS Ecosystem





Third-party services can build up on the DIAS relying on the Data Offer, the Service Offer and the underlying DIAS.





























http://e.copernicus.eu/DIAS









Highlights since last workshop



- ♦ 2017 Mar 07: Launch of Sentinel-2B.
- ♦ 2017 May 23: Start of S2A Level-2A pilot products distribution (European coverage).
- ♦ 2017 Jun 15: Sentinel-2B In-Orbit Commissioning Review (IOCR).
- ♦ 2017 Jul 06: Start of Sentinel-2B Level-1C product distribution
- ♦ 2017 Nov: Operational usage of EDRS by Sentinel-2B
- ♦ 2017 Dec: Start of Sentinel-2B Level-2A pilot product distribution (European coverage).
- ♦ 2018 Feb: Operational usage of EDRS by Sentinel-2A.
- ♦ 2018 Feb 17: Start of worldwide and systematic acquisitions (5-day revisit).
- ♦ 2018 Mar 26: Start of Level-2A core product distribution (European coverage).
- ♦ 2018 Jun 21: Public opening of 4 DIAS (Data and Information Access Services).

Large range of applications...









SENTINELS MODERNISE EUROPE'S AGRICULTURAL POLICY



25 May 2018 In a move that could benefit around 22 million farmers, the EU's Common Agricultural Policy has entered the space age. Offering detailed and timely information on crops and farmland, the Copernicus Sentinels are now being used to simplify and modernise this longest-serving EU

The Common Agricultural Policy (CAP) came into force in 1962 to ensure affordable food for European citizens and a fair standard of living for

farmers. While this philosophy remains at policy's heart, the focus is also now firmly on sustainability, environmental protection, biodiversity and the climate



Copernicus Sentinel-2 leads precision farming into new era

The European Union's Copernicus Sentinel-2 satellites are supplying unprecedented views of Earth, mainly providing information for agricultural and forestry practices and helping to manage food security. But how are they making a difference to farmers in particular?

Jointly operated by Airbus Defence and Space and their agronomic partners, Arvalis and Terres Inovia (the French crop technical institutes, respectively in charge of cereals and oilseed crops), FARMSTAR is a precision agriculture

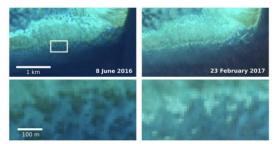
service that provides farmers in France with recommendation maps for various crop inputs (fertilizers, growth



In May 2018, it concluded its winter crops campaign, serving 16,000 farmers for a total of 93,000 field plots, amounting to 0.8 Mha. For the second year, it has made an extensive usage of Copernicus Sentinel-2 images, in particular since the mission reached its nominal 5-days revisit performance, with the second satellite also in operation

Launched on 23 June 2015 and 07 March 2017 respectively. Sentinel-2A and -2B carry an innovative wide swath high-resolution multispectral imager





Runking	T User T	Tepic "	Geographical Covera; T	us Y	Website
2	365FarmNet	Agriculture	Worldwide	Yes	https://www.365farmnet.com
2	Airbus (FARMSTAR)	Agriculture	Worldwide	Yes	http://www.intelligence-airbusds.com/en/7850-farmstar
1	Amazon	Data Relay	Worldwide	Yes	https://aws.amazon.com/t/public-datasets/sentinel-2/
1	Argana	Coral Reef	Worldwide	Yes	https://sen/lconsl.org/
3	BigData Earth	Fires, Agriculture	Worldwide	No	http://www.bigdelaeerth.com/
1	CNES (PEPS ,THEIA)	L2A	Worldwide	Yes	https://peps.ones.fr/rocketWhome https://theis.ones.fr/
3	Descaries Labs	NDWI, Water management	USA	No	https://www.descarteslabs.com/
1	DG-AGRI	Agriculture	Europe	Yes	https://ec.europa.eu/agricu/ture/index.en
2	EOX	Global mosaic	Worldwide	Yes	https://eox.at/
1	ESRI	Image Visualisation, Image Processing	USA	No	http://sentinelZesri.s3.amazonaws.com/spp/index.html
3	FAROS - FARM OBSERVATION SYSTEM	Agriculture	Europe	Yes	http://www.iptsat.com/index.php/It/archivio-news-ita/142-copernicus-sentinel-agricoltura-no
3	GAF	Geology	Africa	Yes	https://www.gaf.de/content/gaf-demonstrates-improved-geological-mapping-sentinel-data
1	GEOSCIENCE Australia	Data Relay	Pacific	No	http://www.copernicus.gov.au/regionaldataaccess
2	Geosys	Agriculture	Worldwide	No	http://www.georgys.com/
1	Google	Data Relay	Worldwide	Yes	https://cloud.google.com/storage/docs/public-datesets/sentinel-2
1	NASA	L2A, Synergistic products	Worldwide	No	https://his.gafo.nasa.gov/
1	Norwegian Meteo Intistute	loe manitaring	Arctic Areas	Yes	https://www.met.no/
1	Planet Observer	Cloud free mosaics	Worldwide	No	https://www.planelobserver.com/
1	REDD+ (JRC)	Data Dissemination for Forestry	Tropical belts	Yes	https://cidportal.jrc.ec.europa.eu/forobs/sentinel.py
1	Sen4CAP	Agriculture	Worldwide	Yes	http://ess-sen4csp.org/
1	Sinergise	Image Visualisation, Data Access, Agriculture	Worldwide	Yes	https://www.sinengise.com/
2	Starling	Forestry	Worldwide	Yes	http://www.starling-verification.com/
2	toarta	Bathimetry	Worldwide	No	https://www.tcarta.com/satelite-derived-bathymetry
1	The GreenLand	Agriculture, Precise farming	Europe	Yes	https://thegreenland.eu/
1	The GreenLand	Forestry	Europe	Yes	https://thegreenland.eu/
2	VISTA Remote Sensing in Geosciences G	Agriculture, Hydrology, Environment	Worldwide	Yes	http://www.vista-geo.de/en/
1	VITO	Agriculture, L2A	Worldwide	Yes	https://remotesensing.vito.be/hubspot-lopics/sentinel-2
2	WRMS	Water Management, Agriculture	India, Worldwide	No	https://www.weether-risk.com/
3	Wuudis Data (MHG Systems)	Forestry	Europe	Yes	https://www.wuudis.com/en/forest-operators/

Maintaining a list of top S2 users.



Special issue on Remote Sensing of Environment (RSE) on "Science and **Applications** with Sentinel-2".









































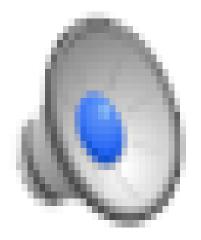






Water bodies monitoring in Africa





Theewaterskloof Dam in South Africa's Western Cape Province

























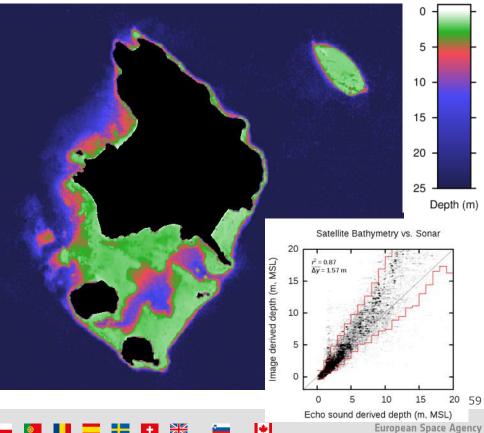




Coral Reef: Bathymetry Lizard Island, Great Barrier Reef



















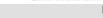






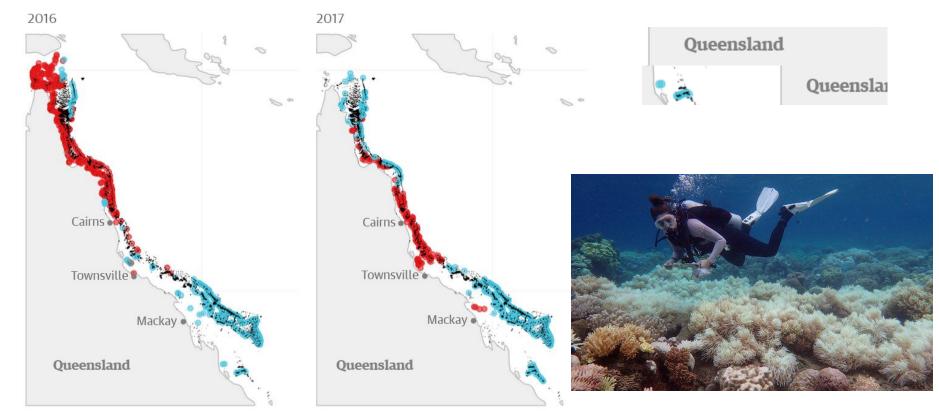






Massive Bleaching on the Great Barrier Reef in 2016/2017





Guardian graphic | Source: ARC Centre of Excellence for Coral Reef Studies

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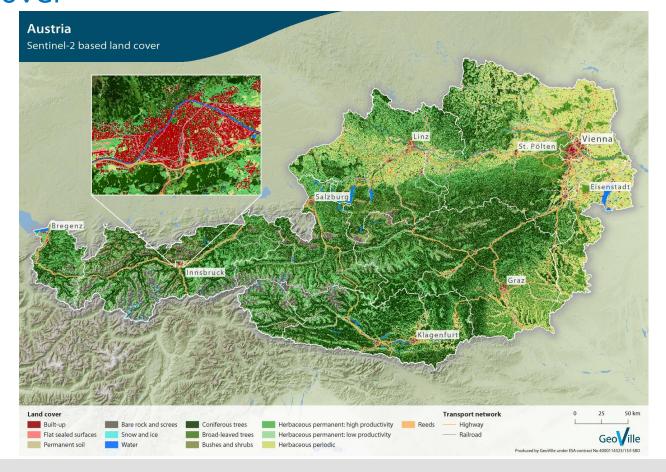
Coral reef bleaching event





Land Cover





General DIAS Service Principle



- □ The usage of DIAS services is directly engaged between a Third-Party user and a DIAS Provider on the basis of:
 - The services offered by the DIAS (Service Offer)
 - The data available through DIAS (Data Offer)
 - The Service Level Agreement offered by the DIAS provider



□ DIAS offering is public information accessible through each DIAS service portal.

European Space Agency

Concluding remarks



- ✓ Mission fully deployed and in a very good status.
- ✓ All elements of the mission system are operating nominally.
- ✓ Mission reached observation capacity beyond mission requirements accounting for requests from Copernicus Services and Member States.
- ✓ New core product released (Level-2A surface reflectance).
- ✓ Sentinel-2 operationally serving the Land, Marine Monitoring, Emergency Management and Security Copernicus Services, as well as a large range of private/public applications and R&D projects.

L1C - Geolocation accuracy



