



Sentinel Data Access

2017

Annual Report



Foreword

Frascati 20 April 2018,



It is my sincere pleasure to introduce the third Sentinels Data Access Annual report. This report charts the continued growth of data provision from the Sentinel satellites and highlights the continuously growing demand for data that has been recorded during the last year. I am truly impressed to see that the number of users registered to access the Sentinel data has rapidly exceeded the 100,000 mark. There are now also more than 5 million products available for download. The Copernicus Space Component and its associated ground segment undoubtedly constitute a unique Earth Observation System in terms of capacity and quality. The overall take-up of Copernicus data as

illustrated in this report is strongly reflecting the value of Earth Observation measurements made with the Sentinels. This success is rooted in the excellent cooperation between the European Commission and ESA. In addition, close interaction with all stakeholders and numerous users has been essential.

The Annual Report has been prepared again by the Serco SpA/GAEL consortium, which is responsible for the development and operations of the Sentinel Data Access System. This year their consortium is joined by NOAA and GRNET to enhance the distribution of the Sentinel Data. The report amply demonstrates their dedication to ensure that the data are available to all users. However, the overall Copernicus Space Component and its successful Ground Segment are based on a far larger European industrial endeavor. It is only proper to acknowledge and thank all those that have helped to contribute to the overall success of the Copernicus Programme – an outstanding example of European cooperation in Space!



Nicolaus Hanowski
*Head, Mission Management &
Ground Segment Department ESA/ESRIN*

Document Scope

A deliverable of the Sentinels Rolling Archive, Operations Maintenance and Evolution contract, this document provides an annual look at the Sentinel Data Access Service operated by Serco, Gael, NOA and GRNET consortium for ESA in the Copernicus programme.

Written by:

Adriana Grazia Castriotta



Richard Knowelden




Figure 1: Sentinel Data Access team

Documentation

Reference documents

Key	Title	link
[RD-1]	Sentinel High Level Operations Plan (HLOP)	https://sentinels.copernicus.eu/documents/247904/685154/Sentinel_High_Level_Operations_Plan

Definitions

Data Dissemination	Refers to the access and retrieval of Copernicus data by users (could be national Collaborative Ground Segments, Data Hub Relays (DHR) or user of the Open Hub etc) directly from ESA core nodes
Data Exchange	Refers to the transfer of Copernicus data from one Data Hub Relay (DHR) to another DHR
Data Ingestion	Refers to the indexing, storage and publication on the data dissemination infrastructure of the Copernicus data
Data Publication	Refers to the provision of products available online for download by users
Data Relay	Refers to the transfer of Copernicus Data from a Data Hub Relay (DHR) to a national Collaborative Ground Segment
Rolling Archive	Online accessible repository of Copernicus data representing a subset of the total mission archive and regularly updated to maintain a fixed archive volume (e.g. the last months of products)
Y2017	Refers to the reporting period covered in this report, from 01/12/16 - 30/11/17. Similarly, Y2016 refers to the previous reporting period: 01/12/15 - 30/11/16 and Y2015 to the reporting period from 03/10/14 – 30/11/15.

NB the acronyms used in the document can be found in Annex 1: List of Acronyms.

Conventions

In this report, the following conventions have been used:

- the SI approved unit symbols KiB, MiB, GiB, TiB and PiB are used to report data volumes: 1KiB=2¹⁰ bytes, 1 MiB= 2²⁰bytes, 1GiB= 2³⁰ bytes, 1 TiB = 2⁴⁰ bytes and 1 PiB = 2⁵⁰ bytes.
- unless otherwise noted, the volume figures refer to the compressed product volumes as published and downloaded via the data hub access points.

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1 INTRODUCTION

Copernicus is a European Union programme which provides operational information on the world's land surfaces, oceans and atmosphere, to support environmental and security policymaking and meet the needs of citizens and service providers. Under the Space Component of the Copernicus programme, ESA is developing a family of dedicated satellites, called the Sentinels, to serve the programme's Earth Observation requirements. The data acquired from these missions is systematically downlinked and processed to operational user products by the Sentinel ground segments. ESA's Sentinel Data Access System is designed to retrieve the Sentinel-1, -2, -3 (land) and -5P products from the relevant ground segment and make the products available for users to download from dedicated access points.

On 3 October 2014, the Sentinel Data Access System began the operational supply of data products from the Copernicus Sentinel-1A satellite mission. Since 2014, the Data Access System has been continually evolving, to keep pace with the rapid growth both in the amount of Copernicus Sentinel data available for distribution and user demand for that data.

The current annual report is the third such report released by the data access service provider, Serco SpA, analysing the performance of the Data Access System and the public uptake of Copernicus Sentinel data. This 2017 annual report takes up from where the 2016 report left off, and tracks the system's performance and user activity during the period 1 December 2016 to 30 November 2017.

Throughout the document the following nomenclature will be used to signify a particular reporting period:

- Y2017 (this report): 1 December 2016 – 30 November 2017
- Y2016: 1 December 2015 – 30 November 2016 (report released on 5 April 2017)
- Y2015: 3 October 2014 – 30 November 2015 (report released on 27 April 2016)

1.1 Data Access System architecture

The Sentinel Data Access System provides to different user typologies free and open access to Copernicus Sentinel data products. The System is developed and managed by Serco SpA. The service includes the management of the infrastructure, supporting applications and procedures, and expert staff who tailor publication of products to the operational scenarios and respond to user enquiries.

As its general functionality, the Data Access System automatically retrieves products from ESA's Sentinel ground segments (PDGSs) and publishes them online, on a series of dissemination points known as hubs. Accessing these hubs, users are able to explore the data collections and download products, either through an interactive graphical web interface or automatically, using a scripting interface. The figure below illustrates the flow of products through the system. It should be noted that not all products are yet available on all of the hubs: data flows from new missions are introduced gradually in a staged manner. This is further described below.

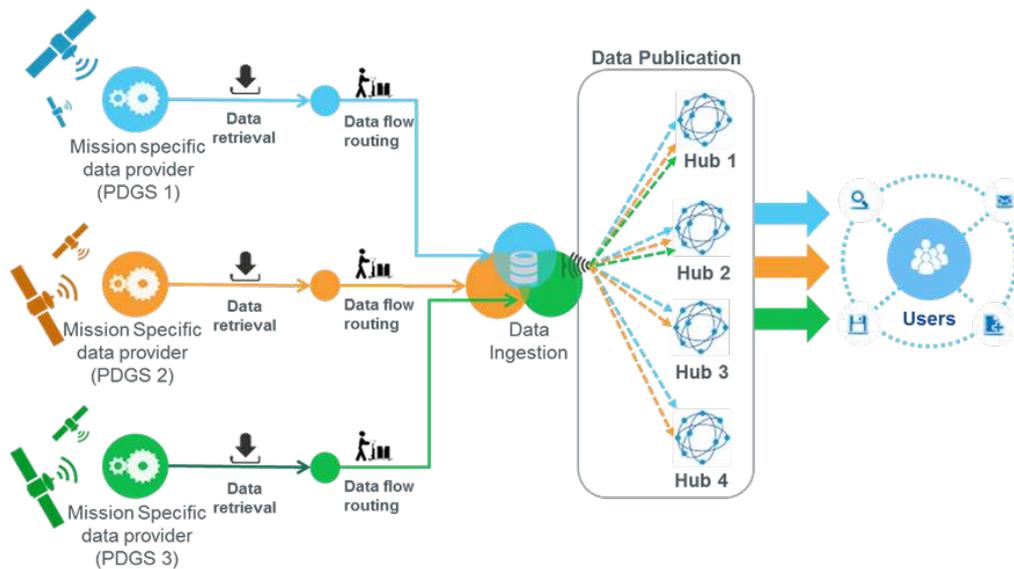


Figure 2: Data Access System Model

Due to the flexible architecture on which the Data Access System is based, the consortium is able to expand the hub configuration to accommodate an ever-widening user base and the different operational data access requirements of the various stakeholders involved in Copernicus.

Since the end of Y2016, and throughout Y2017, the system has operated a total of four hubs through which users can access the data products. Each of these hubs has been configured to meet the needs of its target community of users.

- The **Copernicus Open Access Hub (the Open Hub)** is the hub which offers to all users free, full and open access to Copernicus Sentinel data on the basis of self-registration. Accordingly, there are no restrictions on who can register to download products. Due to the high number of users active on the hub at any one time, and the need to ensure bandwidth remains available for all users, the number of concurrent downloads which users are entitled to make is configured to two. Currently, no policy is in place for removing products from the online access according to criteria such as the age of the product (known as a Rolling Policy).

Logically linked to the Open Hub, there are currently two Pre-Operations Hubs, the **Sentinel-2B Pre-Operations Hub (S2B PreOps Hub)** and the **Sentinel-3 Pre Operations Hubs**

(S3 PreOps Hub). These are dedicated data access points which provide access to all products from the respective missions published to date. The pre-ops hub mechanism is used during a mission’s ramp-up phase to minimise dependencies with the other hubs in the Sentinel Data Access System before data dissemination operations begin on a routine basis. Following entry into routine operations, the products are provided through standard Open Hub interfaces and the relevant pre-ops hub is decommissioned.

- The **Copernicus Services Hub (ServHub)**, which guarantees free and full access to Sentinel data for all Copernicus Services and EU institutions. Users are entitled to make up to 10 concurrent downloads. No Rolling Policy is currently in operation.
- The **Collaborative Hub (ColHub)**, which is open to Copernicus Participating States, following signature of a CollGS agreement with ESA or an internal agreement with the European Commission. The hub is configured to support 10 concurrent downloads for each user.
- The **International Hub (IntHub)**, which is open to international partners, following signature of a cooperation agreement with the European Commission and technical operating agreements with ESA. The hub is also

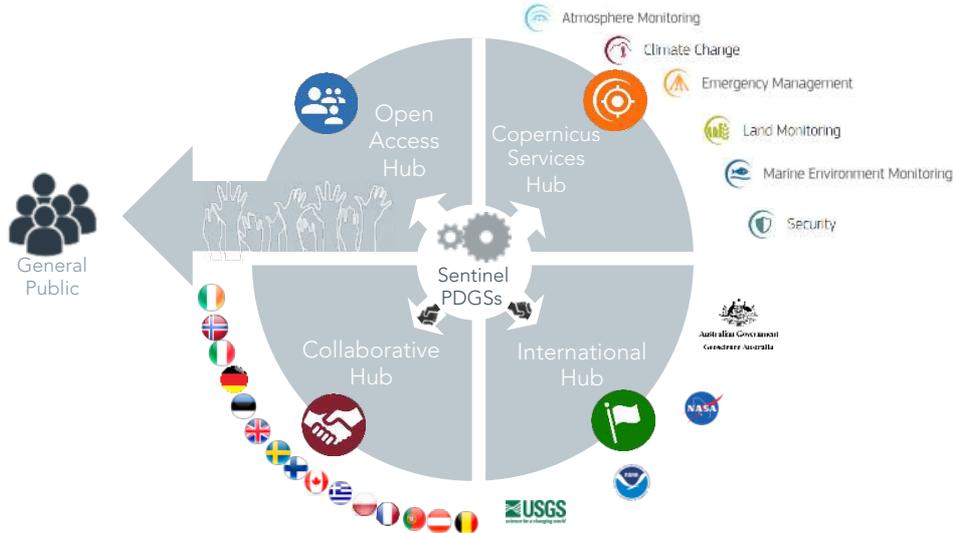


Figure 3: The Sentinel Data Access System configuration by end Y2017

configured to support 10 concurrent downloads. Currently, the international partners are: Geoscience Australia (GA), the National Oceanic and Atmospheric Administration (NOAA – US), the National Aeronautics and Space Administration (NASA – US), and the US Geological Survey (USGS – US).

The figure above illustrates the overall Sentinel Data Access System configuration by end of Y2017

The figure below summarizes the main differences between the hubs in terms Rolling Policy, which Sentinel products are currently supported and concurrent downloads.

It is assumed that the partners accessing the Collaborative Hub and the International Hub will download the Sentinel data products as they are published on the hub, and then redistribute the products from their own storage and data access points. Accordingly, each hub operates a Rolling Policy, removing products which have been on the hub for 30 days (or 14 days in the case of the Collaborative Hub Node 2 – see Chapter 1.2.1 for further information on the node).

The Data Hubs listed in this Chapter are operated by ESA and provide access to all Copernicus Sentinel data products apart from Sentinel-3 Level 1 and Level 2 marine products. These latter products are made available through the Copernicus Online Data Access (CODA) service which is operated by EUMETSAT and not covered by this report. Further information can be found at:

[https://www.eumetsat.int/website/home/Data/Data Delivery/CopernicusOnlineDataAccess/index.html](https://www.eumetsat.int/website/home/Data/Data%20Delivery/CopernicusOnlineDataAccess/index.html)

Copernicus Open Access Hub	Collaborative Hub	International Hub	Copernicus Services Hub
Self Registration	Collaborative Users Data Hub Relay Users	International agreements	Registered Users
No Rolling Policy Applied	Node 1: 30 days Node 2: 14 days	30 Days	No Rolling Policy Applied
Sentinel-1 NTC Sentinel-2 Sentinel-3 (preops)	Sentinel-1 NRT & NTC Sentinel-2 L1C Sentinel-3 SRAL	Sentinel-1 NTC Sentinel-2 L1C	Sentinel-1 NTC Sentinel-2 Sentinel-3 SRAL
Max 2 Concurrent Downloads	Max 10 concurrent downloads per Node	Max 10 concurrent downloads	Max 10 concurrent downloads

Figure 4: Sentinel Data Access System hub characteristics

1.2 Evolutions of the Data Access System in Y2017

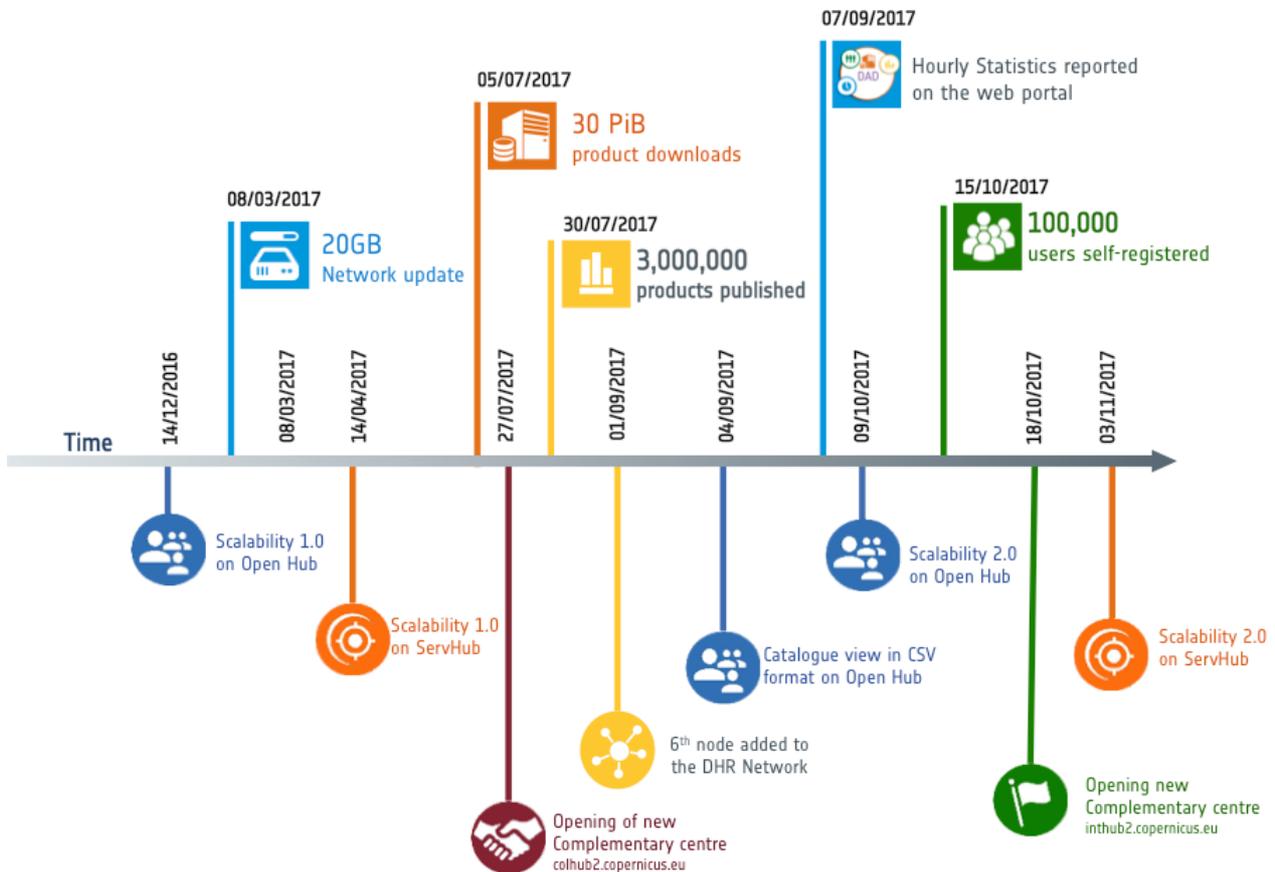


Figure 5: Timeline of the main Y2017 achievements in terms of data dissemination and improvement of the Data Access System

1.2.1 Specific Data Hub Evolutions

Copernicus Open Access Hub

The Copernicus Open Access Hub is composed of two nodes: the SciHub – accessed by the graphical user interface – and the APIHub – accessed via user-defined scripts. At the beginning of the reporting period, the main goal was to improve the availability and reliability of the both nodes in order to meet the demands being imposed by both the increased number of products arriving from new missions and from a significant rise in user activity experienced towards the end of 2016. During the first quarter of 2017, the availability of the Hub was significantly enhanced, reaching an overall availability of 99.19% for the quarter. Since then, availability has

continued to be maintained at a high level, with no month below 97% and an overall availability for Y2017 of 98.59%.

As per standard practice from previous years, a staged deployment of new data flows was made on the Open Hub. For Sentinel-3A this initial deployment was made via the Sentinel-3A PreOps Hub and continued up to March 2017. The opening of the Sentinel-2B PreOps Hub, following the Sentinel-2B commissioning, took place in July.

In September 2017, a new catalogue view was introduced for products published on the Open Hub in the form of comma-separated values (CSV) files. These allow users easy access to the full catalogue in a compact format, which can be considered as a reference for the complete list of qualified data on the Hub.

Sentinel-2B PreOperations Hub

The S-2B PreOps Hub was opened on 6 July 2017 for initial dissemination of Level-1C products. Uptake for the new data from S-2B was strong, as expected, with the overall archive exploitation ratio of Sentinel-2 remaining the highest for all Sentinels during Q3. Although the service suffered some initial disruptions due to some Sentinel-2 ground segment anomalies, all products were subsequently recovered and published. Routine dissemination of the complete Sentinel-2B production via the standard Open Hub interfaces was announced on 9 October 2017, with the S-2B PreOps Hub decommissioned shortly afterwards.

Sentinel-3A PreOperations Hub

The opening of the S-3A PreOps Hub took place on 20 October 2016 as part of the mission ramp-up phase. Initially, OLCI Level 1 Near Real Time (NRT) products were made available, with further progressive openings of data flows taking place during the following months: 18 November 2016 (SLSTR Level 1), 14 December 2016 (SRAL Level-1B and Level 2, plus OLCI Level 1 Non Time Critical (NTC)), 19 January 2017 (SLSTR Level 1 Non Time Critical (NTC)), 10 March 2017 (SRAL Level-1A NTC/STC). All these openings were closely coordinated with EUMETSAT. The transfer to routine dissemination of S3A products and subsequent decommissioning of the S-3A PreOps Hub began on 19 October 2017, following the successful S-3A Routine Operations Review, with the transfer of the S-3A SRAL data flow towards the nominal Open Hub.

Scalability

Towards the end of the Y2016 reporting period, several factors combined to stretch the system to an extent no longer sustainable with existing scalability capabilities: new Sentinel launches, new product types for existing Sentinels, more searches and an increased number of downloads. While temporary measures were adopted with some success, new measures implemented at the start of this period sought to identify and solve the

root architectural causes. At the start of Y2017, a software upgrade was deployed on the Copernicus Open Access Hub to increase the scalability of the data distribution system and introduce redundancy, greatly improving overall system reliability and availability and ensuring fewer service interruptions during maintenance activities. The principal feature of the upgrade is that the system can now separate the user queries and downloads across a larger pool of servers, via the provision of multiple servers for a single logical access point. Routine maintenance activities may also now be performed by removing a server individually from the pool and managing the user sessions on the remaining servers, frequently eliminating the need for a complete suspension of the service. Additional hardware server capacities were also deployed towards the end Q1 2017, providing a further margin of reliability. The scalability improvements were also subsequently applied to the Copernicus Services Hub in April 2017.

Complementary Centres

The Sentinel Data Hubs are primarily hosted within a large data centre from T-Systems in Frankfurt, part of the overall Copernicus Wide Area Network connecting all major centres involved in the acquisition, processing and archival of the Sentinels data. The growth of the Sentinel missions' family, increasing user uptake and the continuing need to maintain performance, availability, reliability and timeliness mean that a future strategy to face this evolving operational scenario is of paramount importance. One implementation which took place this period was the procurement of two additional Data Hub nodes, aiming to take the load off the primary Data Hub via a distributed hosting infrastructure providing transparent and well-balanced user access and improved availability through on-line redundancy. Two such secondary infrastructures, or Complementary Hubs, have been commissioned:

- One Complementary Hub hosted by OVH France, corresponding to the initial collaborative site put in place through the ESA

collaborative initiative. The site provides ColHub Node 2, which began operations on 27 July 2017. ColHub node 2 has been implemented using OpenStack Storage, a dedicated cloud operating system which controls large pools of computing, storage and networking resources throughout a data centre and managed via an administration dashboard. This is intended to provide easier scale-out than a traditional NAS (Network-Attached Storage), handling up to several PB of stored data.

- One Complementary Hub hosted by GRNET in Greece, providing redundancy for connectivity to the GÉANT network and hot redundancy in case of major maintenance of the primary site. From 18 October 2017 the International Hub was relocated to this site and it became the primary, and only, IntHub, releasing resources and network bandwidth from the primary centre through removal of direct IntHub access.

Both Complementary Hubs are generally sourced from the primary centre. This implies an additional latency in product publication while they are being copied, though this has been measured and is well within the nominal publication timeliness. Both Complementary Hubs operate a rolling policy and in line with the quota management set out for the Collaborative and International access allow a maximum of 10 concurrent downloads.

The Complementary Hubs have been used during the reporting period to improve the availability in case of maintenance activities necessary on the primary centre. On 1 August 2017 a major maintenance activity took place on all Sentinel Data Hub services, lasting from 06:30-16:00 UTC. During the window, access was provided successfully via the ColHub Node 2 Complementary Hub.

Data Hub Relays

Qualification of several of the Data Hub Relays (DHRs), providing an additional dedicated service to the Collaborative Ground Segments (CollGS), were successfully completed during Q1 2017 and followed by an ongoing period of initial operations. The DHRs are intended to enhance the download possibilities for CollGS partners by providing an additional distributed set of data dissemination points, allowing any CollGS connected to the network to download any Sentinel products hosted at a hub relay. This increases the number of data access points for each CollGS, serving in turn to increase the overall re-dissemination capacity, providing redundancy for unavailabilities, while reducing the load on ESA's ColHub.

The hosting of a DHR was introduced as an explicit task in some of the existing CollGS agreements between ESA and the CollGS partner. In general, the DHRs are located in a network location well connected with a "local" national collaborative ground segment, and are used to serve that CollGS as well as any other CollGS instance which wishes to connect to the hub relay. Each DHR hosts a particular range of products, selected to ensure optimal re-dissemination potential and levelling of workloads, and originally retrieved from the primary data access nodes. The decision on which DHR is to host which products is centrally made by ESA based on preferences expressed by CollGSs, with the DHR network also allowing further exchange of products between DHRs in order to ensure continued performance optimization. Each DHR re-uses the software system of the main data hub nodes and receives operational support from ESA. Currently, six data hub relays have been deployed by the partners, physically located in Germany, France, Austria, Norway and the UK (two relays). Initial feedback received from CollGS partners has indicated that they are proving very beneficial in organising the optimised bulk transfer of Sentinels data.

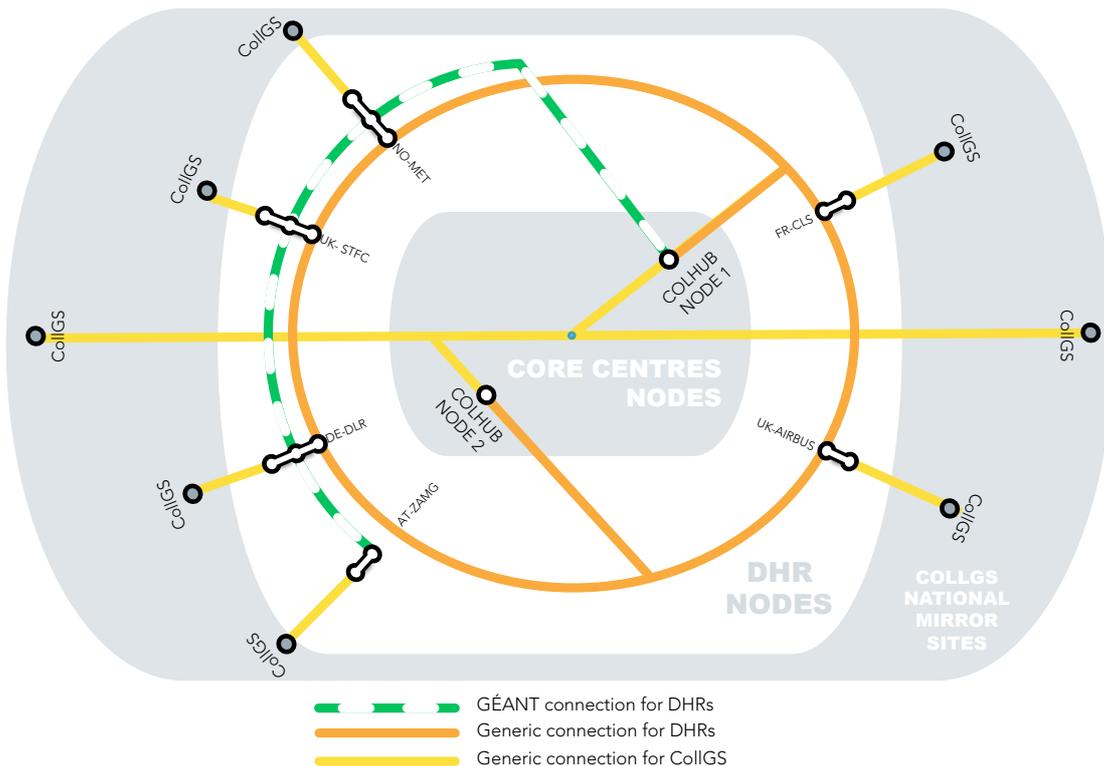


Figure 6: DHR Network for Collaborative Nodes

The figure above shows how the network works.

- Core Centre Nodes (node 1 and node 2 of the Collaborative Hub) are the product source nodes for Collaborative GS partners, but also for DHRs. They are connected toward Relays and Collaborative GSs through a generic commercial connection (yellow and orange lines).
- DHR Nodes act as alternative product sources and they are connected with ESA nodes and collaborative through different kind of connections:
 - o Orange: generic commercial connection used among relays.
 - o Green and White lines are the GÉANT connections. Some Relays are connected through both commercial and GÉANT, whereas the Austrian Relay only in GÉANT. In this case Austria can connect only to Node 1.

Since the product source nodes should distribute S1, S2 and S3 data among Collaborative partners, the load on these nodes is critical, and the risk of overloading them is a key point. The overload could cause a system failure and the following

interruption of data dissemination. Based on this risk, the scope of the DHR Network is to support ESA nodes in disseminating data among Collaborative Countries, by reducing the overload on product source nodes. Furthermore, in case of crash of a single product source node, the DHR network can still guarantee connection among them thanks to their interoperability, and dissemination and distribution towards Collaborative GS partners and end users thanks to the DHR Network which can guarantee data fluxes continuously.

Initial feedback received from CollGS partners has indicated that they are proving very beneficial in organising the optimised bulk transfer of Sentinels data. Further analysis on the DHR network operations during the reporting period will be provided in the Chapter 2.3.8.

Network Evolutions

During the last quarter of 2016, the total average of network traffic from the main data hubs centre had risen to 7.6 Gbps of the 10 Gbps available bandwidth. Therefore, although not yet saturated, an increase in dissemination capacity was considered necessary in order to anticipate any

future network congestion due to the growth foreseen throughout the year. In March 2017, the infrastructure was upgraded to activate a second 10 Gbps network and firewall, doubling the total available bandwidth capacity from 10 Gbps to 20 Gbps. This upgrade allowed the separation of the Open Hub traffic from that of ServHub, ColHub and IntHub, isolating the performances of the latter from the heaviest volume of traffic of the Open Hub. The upgrade was timely: since then there has been a steady increase in traffic, occasional peaks of network activity up to 18 Gbps have been recorded in Q3 2017, consistent with the expected increase in overall user uptake, and both the network and firewall have coped well.

The link to the GÉANT network has continued to greatly benefit the data dissemination system throughout the period. In Q3 2017 the 10 Gb/s

link with GÉANT was almost fully utilised. This was alleviated by the re-location of the International Hub to the complementary centre in Greece.

Options for further upgrades in network capacity continue to be analysed in order to pre-empt any blockages due to insufficient bandwidth caused by the predicted future growth of the system.

1.3 Main Mission Developments in Y2017

In relation to the data distribution activities, the main mission developments that are relevant to the data products offerings from the hub system are outlined below.

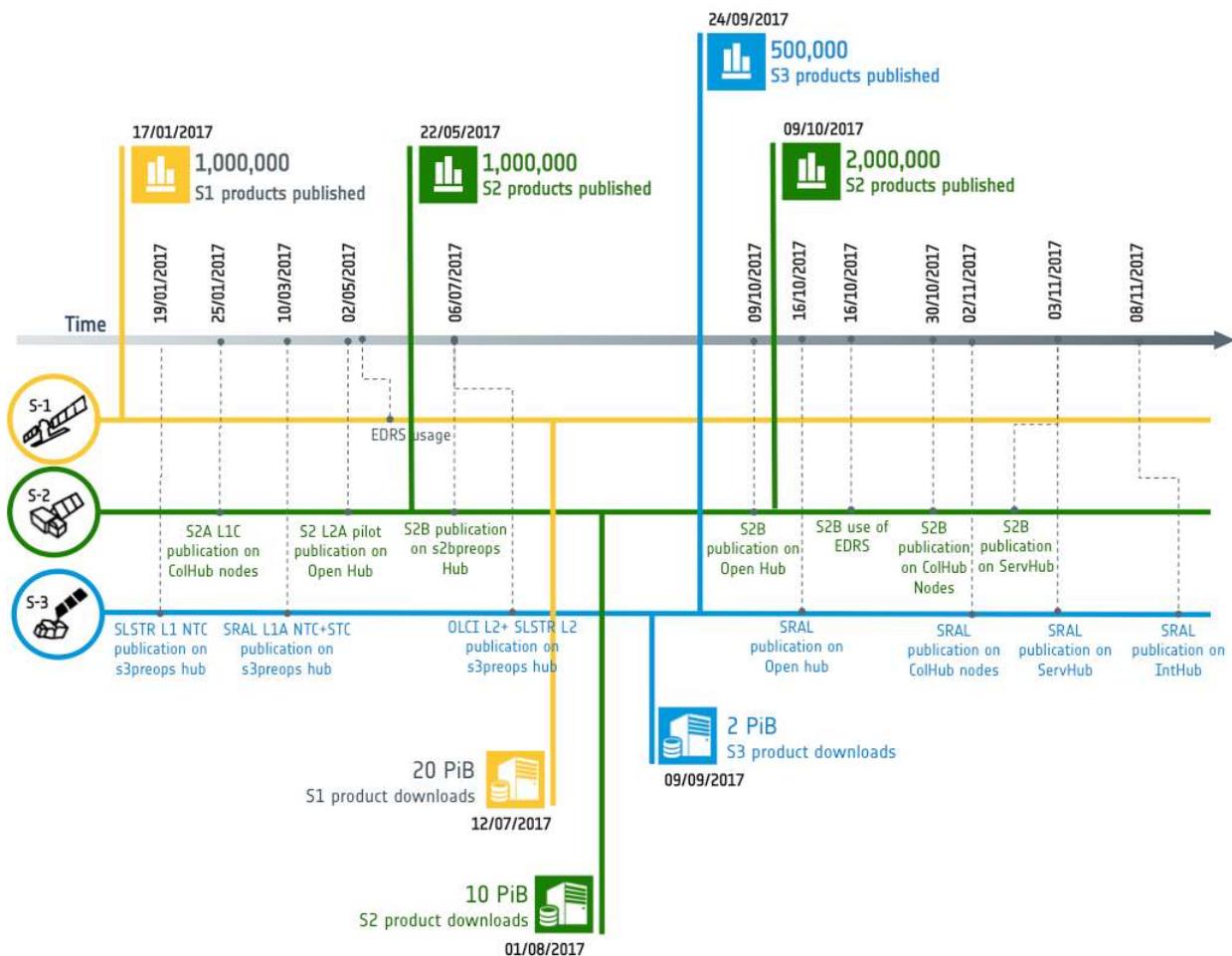


Figure 7: Timeline of the main Y2017 achievements in terms of published products and volume of Downloads for Sentinel missions

1.3.1 Sentinel-1

The Sentinel-1 data distribution has seen an increase of the available data flow following the integration of the EDRS service in the Sentinel-1 operations (starting in May 2017 for Sentinel-1A and October 2017 for Sentinel-1B). The complementary download capabilities provided by the EDRS service have resulted in an increase of the mission observation scenario and consequently an increase of the available data volume to users. As the world's first optical satellite communication network in geostationary orbit, EDRS allows data from low-earth orbits (LEO) to be relayed to the ground.

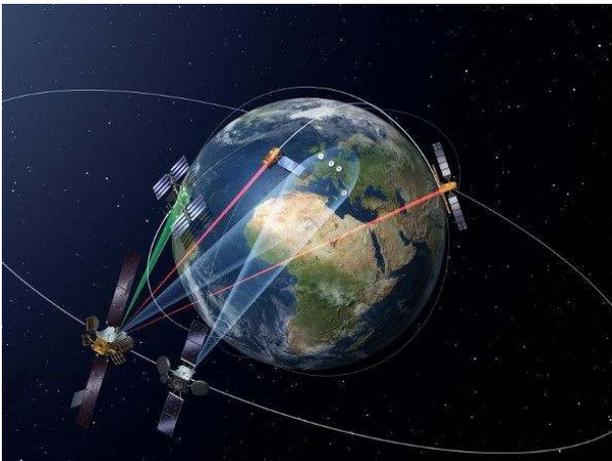


Figure 8: The EDRS Constellation

1.3.2 Sentinel-2A

A pilot dissemination for the pre-operational production of Sentinel-2 Level-2A atmospherically corrected data over Europe (EEA-39) commenced from the Open Hub on 2 May 2017 and subsequently on the ServHub, with over 97,670 L-2A products published in Y2017. The generated products are published 48-60 hours following the availability of the corresponding Level 1C products.

A further pilot for dissemination of Sentinel-2 L1C products with specific high latitude DEM was initiated for the ColHub partners in August 2017.

A new naming convention was introduced for Sentinel-2 Level-1C products generated after December 16 2016. The format was introduced to overcome the 256 character limitation on pathnames imposed by Windows platforms. It was achieved through compaction of the filenames, including the naming of internal folders and files. In addition, a TCI (True Colour Image) in JPEG2000 format has been included within the Tile folder of Level-1C products with the new naming convention. For further information see:

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/naming-convention>

To harmonise the Sentinel-2 L1C products available from the Data Hubs there is a campaign planned to convert old product format multi-tile data to the latest single tile format for early 2018.

1.3.3 Sentinel-2B

Sentinel-2B was launched on 7 March 2017 and placed in an orbit phased 180° from its constellation partner Sentinel-1A. The focus during this period has been on commissioning, starting operations and stabilising the Sentinel-2B data flow, with initial dissemination of Level-1C products from the Sentinel-2B PreOps hub taking place on 6 July 2017. Largely due to the introduction of Sentinel-2B products, the number of Sentinel-2 products published during Q3 2017 nearly doubled with respect to the number published during the previous quarter.



Figure 9: Examples of the first images received from Sentinel-2B

1.3.4 Sentinel-3A

Since the opening of the Sentinel-3A PreOps Hub on 20 October 2016, new product types have progressively been added to the data flow throughout the period, as follows:

- OLCI Level 1 Near Real Time (NRT) – 20/10/16
- SLSTR Level 1 – 18/11/16
- SRAL Level-1B and Level 2, OLCI Level 1 Non Time Critical (NTC) – 14/12/16
- SLSTR Level 1 Non Time Critical (NTC) – 19/01/17
- SRAL Level-1 and Level-1A NTC/STC – 10/03/17
- OLCI Level 2 (full and reduced resolution for the land colour and atmosphere parameters), SLSTR Level 2 (Land Surface Temperatures) – 06/07/17

The Sentinel-3A Routine Operations Review was held on 16 October 2017 and marked the transition point for the decommissioning of the PreOps Hub and the routine publication through the nominal access points.

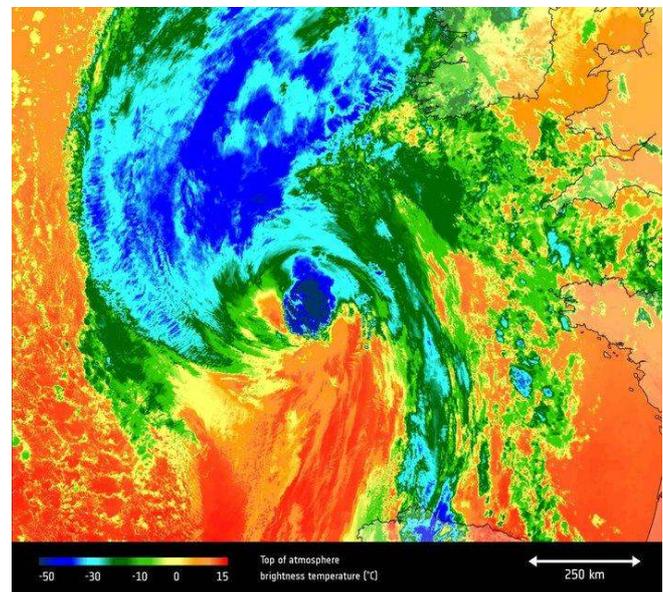


Figure 10: Sentinel-3 images Hurricane Ophelia's temperature as it approaches Europe

2 Data Access Service Growth

During Y2017, the number of user registrations and the volume of Sentinel products which were published and disseminated towards end users greatly increased with respect to Y2016. In this chapter, each of these increases is examined in detail.

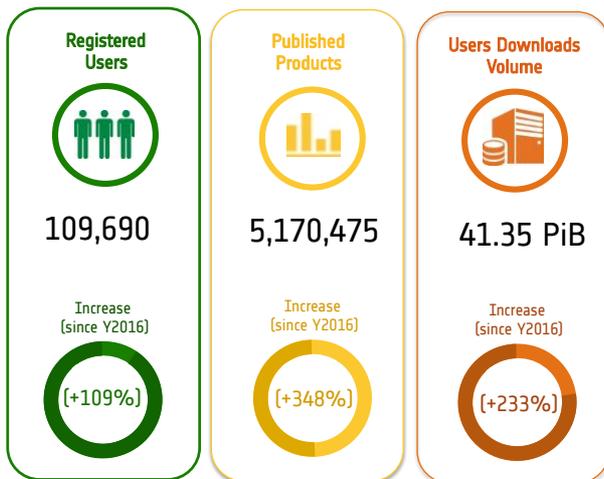


Figure 11: Overall Data Hub Registered Users, Published Products and User Download Volumes for Y2017, measured from the start of operations

2.1 Users take-up

By the end of Y2017, 109,690 users were accessing the various services offered by the ESA's Sentinel Data Access System. To give an indication of the level of engagement with the Data Access System across the different services, the following table shows the number of Data Access users per different hub instance. These numbers are the total number of user accounts which have been opened on each hub since the start of their operations. It is highlighted that duplicated accounts are removed from this calculation, so the figure provides the most

accurate picture available of the number of registered users.

Given that only the Copernicus Open Access Hub is open to the public for self-registration, and access to the other hubs is provided on a pre-registration basis, this section looks only at the numbers of registrations on the Open Access Hub.

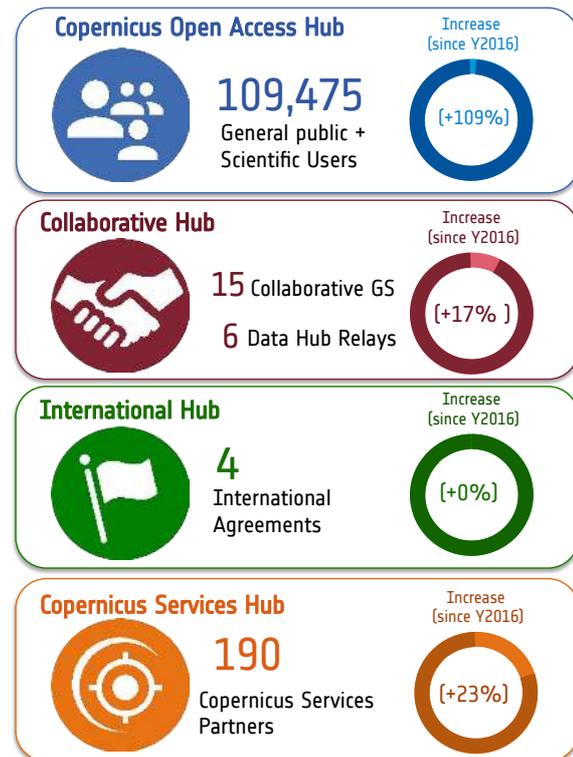


Figure 12: Registered Users per Data Hub

2.1.1 Users Registrations

The number of users registered on the Copernicus Open Access Hub in Y2017 has increased by 109% with respect to the previous reporting period: at the end of Y2016, there were 52,318 users registered worldwide on the Hub since the beginning of operations (03 October 2014); by the end of Y2017 this number had risen to 109,475.

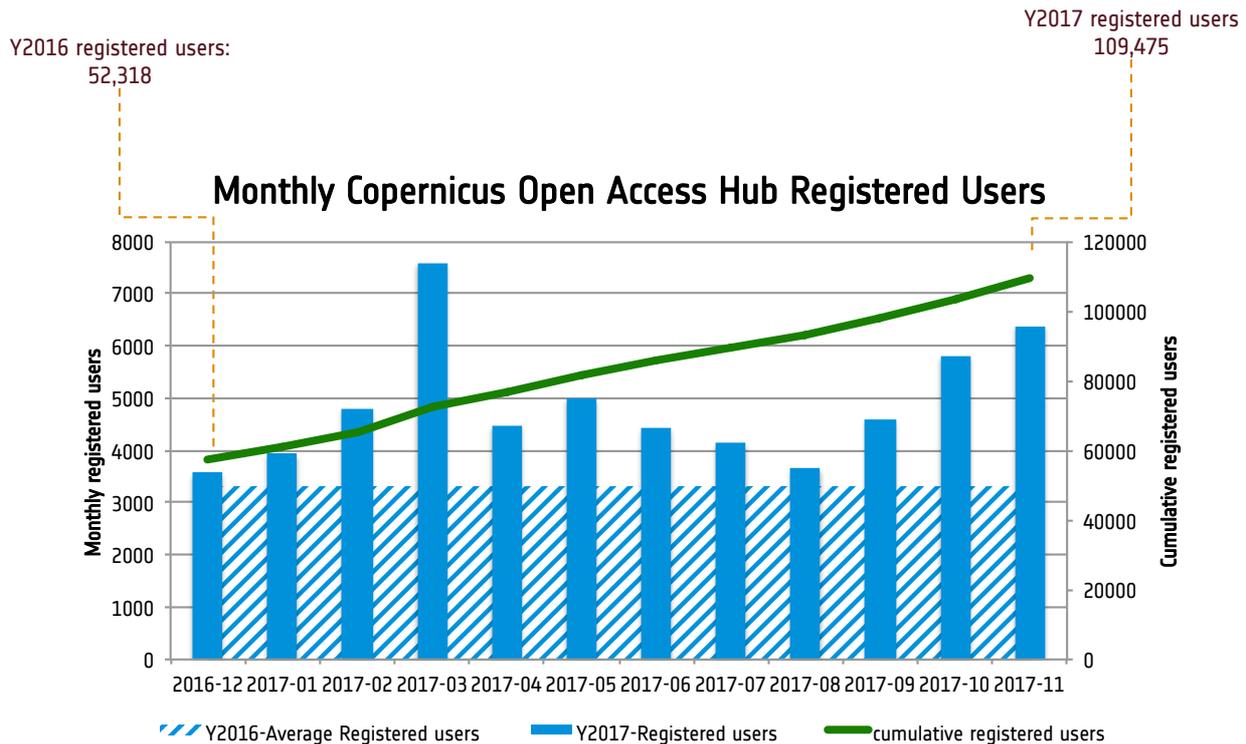


Figure 13: Trend of User Registrations on the Copernicus Open Access Hub

The graph in Figure 13 above shows the monthly number of users who registered for access to the Copernicus Open Access Hub during Y2017 and the cumulative number of registered users since start of operations; those values are compared with the average monthly user registrations performed during Y2016.

It is interesting to note that the monthly trend of new user registrations continued to be consistently greater than the average for Y2016 during the reporting period. This indicates that interest in Sentinel data has been increasing in a steady and consistent way throughout the three years in which the data has been available.

It can be also seen that the number of new registrations per month was oscillating during Y2017, presenting a great peak of registered users in March 2017 and largely increasing since September 2017. With an average number of 4,617 per month observed during the period (excluding the March peak) the monthly number of registered users is the 23% percentage higher than the monthly average number of registered users during Y2016.

The peak observed on 7 March 2017 saw 1,024 new registrations in one day and, as consequence, the number of new registrations exceeded 7,000 for that month. On this date the Sentinel-2B satellite was launched and this event increased the interest in Open Hub. After that day, the number of registered users followed the nominal linear and constant trend of registrations.

2.1.2 Open Access Hub Demography

To give an indication of the level of engagement with ESA’s Sentinel Data Access System across the world, this section shows the number of users who have registered for access to the Open Hub in each continent. It is recalled that these statistics are generated on the basis of the nationality which users insert when they self-register for access to the hub. No independent cross-checking with the user’s IP address is carried out.

Europe has by far the largest user-community, with 43,580 registered users by the end of Y2017. However, the growing awareness of and interaction with the Copernicus Open Access Hub has by no means been limited to Europe. In

Figures 14 and 15 below, the increase in user registrations since Y2016 is broken down by continent. These figures show that the most significant increase in user registrations in Y2017 actually took place in North America and Oceania, with an increase of 130% and 132% respectively. All continents achieved over 100% growth during the period.

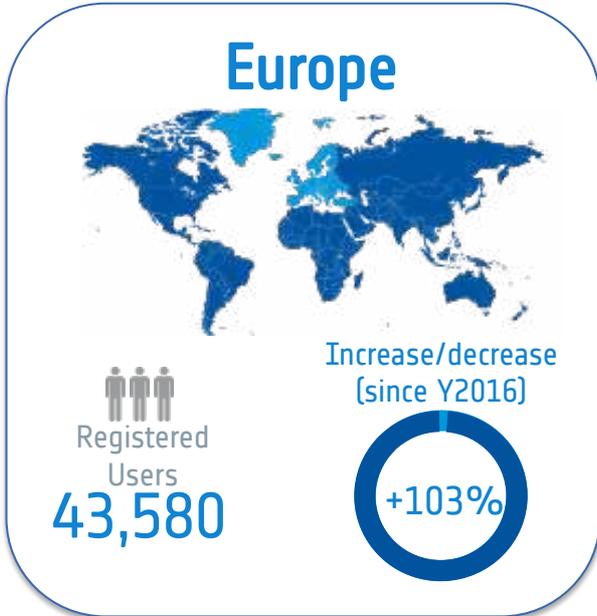


Figure 14: Open Access Hub registered users in Europe

Breaking the figures down even further by country, it emerges that Brazil, as per last year, is still the single country with the largest number of users in the world by the end of Y2017, with 8,165 self-registered users.

Focussing more specifically on Europe, Figure 16 illustrates the density of registered users in the ESA and European Union Member States by the end of Y2017¹. On the left side of the figure, the

top 5 ESA and European Union Member States in terms of the number of registered users are shown, and how this has changed with respect to Y2016.

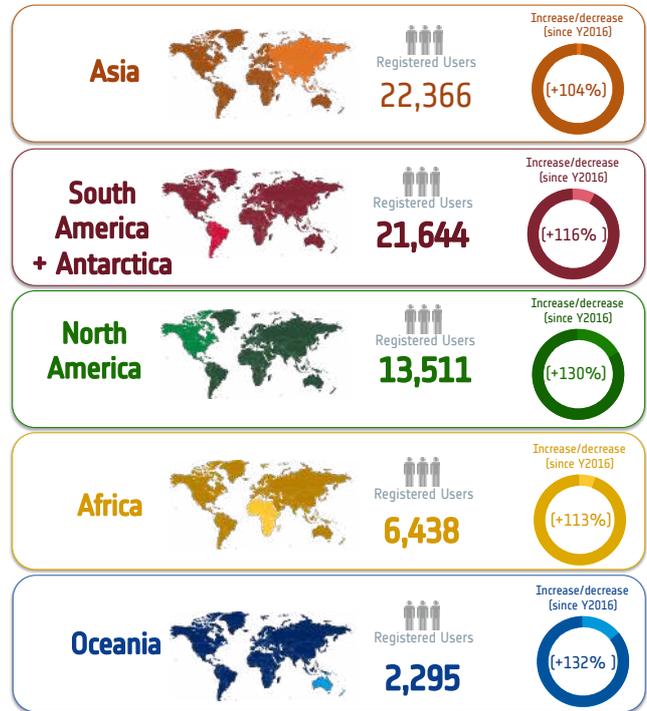


Figure 15: Number of registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent since Y2016

¹ It is noted that this total number of registered users does not precisely correspond to the total of all of the per continent registered users values. The reason for this is that some users have opened different accounts using the same email address but different continents for their location. These duplicated accounts are filtered out in the calculation of the total number of registered users, but it is not possible to apply the same filter to the per continent statistics because a choice

would have to be made as to which is the real continent in which that user operates.

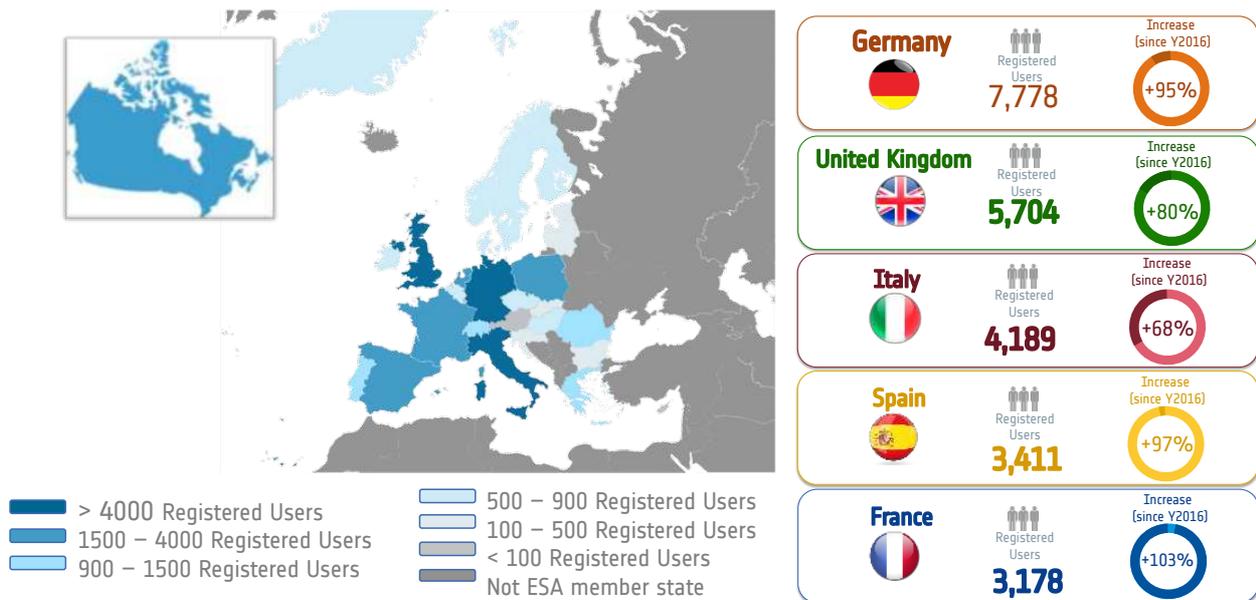


Figure 16: Copernicus Open Access Hub registered user distribution in EU and ESA member states

Within Europe, it is **Germany** which has the largest number of users registered on the Copernicus Open Access Hub. German user registrations increased by 95% since Y2016, reaching a total number of 7,778 self-registered users at the end of Y2017.

Another interesting view on the number of user registrations is the trend of countries reaching more than 500 user registrations. The graph below shows the monthly increase in the number of countries reaching this threshold. By the end of Y2017, there were 47 countries across the world with more than 500 registered users (an increase of 81% since Y2016).

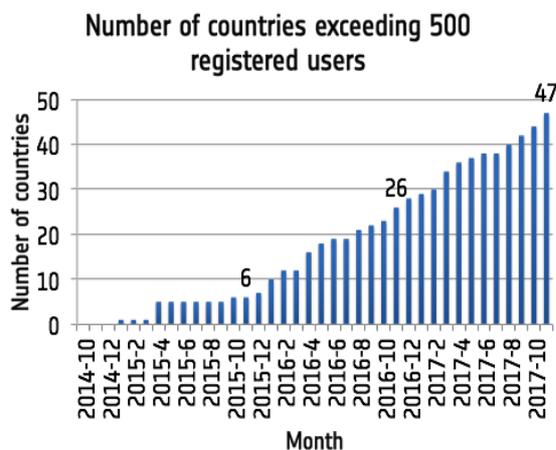


Figure 17: Growth in the number of countries exceeding 500 registered users on the Open Access Hub since the start of operations

User activity on the hubs is analysed in Chapter 3 below.

2.2 Products Publication

By the end of Y2017, Sentinel-1A and -1B, Sentinel-2A and -2B were being routinely published on all the data access hubs. Sentinel-3A products were being published on the dedicated PreOps hub, with the dataflows progressively transferred to the nominal access points following the Sentinel-3A routine operations review. This section presents the statistics for the publication of those products during Y2017.

2.2.1 Publication Growth

By the end of Y2017, a total of 5,170,475 Copernicus Sentinel products had been published on the Copernicus Open Access Hub since the start of operations, with a total data volume of 4.81 PiB. The table below breaks these totals down by Sentinel, and the figure compares the total volume published by the end of Y2017 with the total volume published by the end of Y2016.

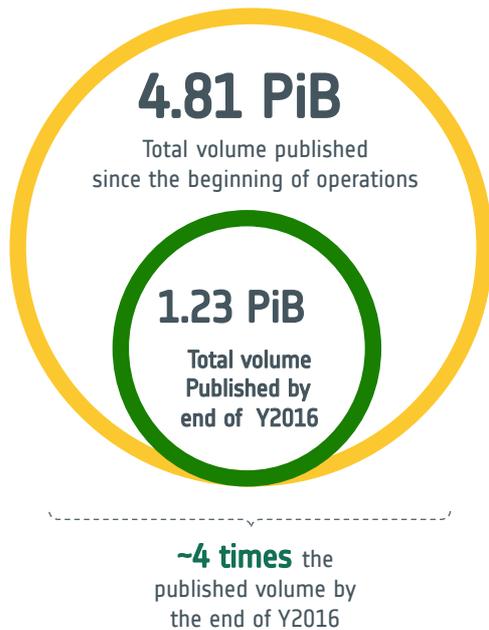


Figure 18: Total volume published since the start of operations and comparison with Y2016 published volume

As reported in the table below, in terms of number of published products, Sentinel-2 data exceeded Sentinel-1 despite the fact that Sentinel-1 started its operations one year before Sentinel-2. The relative differences between the number of products and the volumes of products published for each Sentinel depends on the definition of the product types and their standard packaging. For example, the Sentinel-2 products are packaged according to a standardised tiling scheme, with one product per tile.

As underlined in Figure 18, the cumulative volume of Sentinel products published by the end of Y2017 was about 4 times the cumulative volume of products published by the end of Y2016. 74% of the total volume published since the start of operations was published in Y2017, and **in the last 4 months of Y2017 alone, the Data Access System published more than the overall volume of products ever published from the beginning of operations by the end of Y2016 (1.25 PiB).**

These figures give a good indication of how quickly the volumes of data are increasing, and that the system is coping with data volumes which are unprecedented for Earth Observation missions. For example, the 4.81 PiB published in Y2017 alone can be compared to the around 1 PiB

of data published for ENVISAT over the course of the entire 10 year mission.

mission	Y2017-number of published products since start of operations	Y2017-volume of published products since start of operations (PiB)
S1 ²	1,978,597	3.05
S2	2,332,632	1.40
S3	859,246	0.36
ALL	5,170,475	4.81

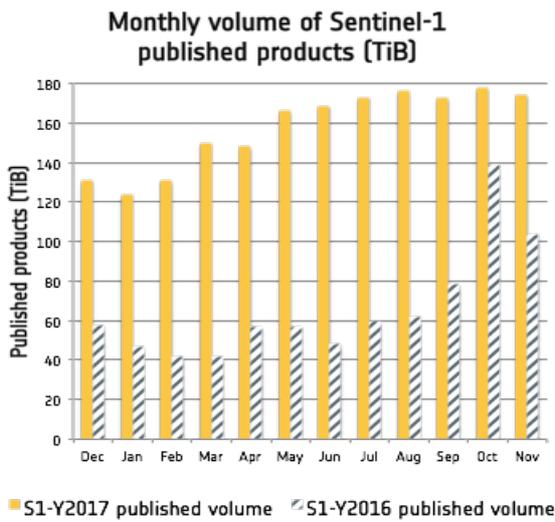
Table 1: Overall number and volume of published products on the Open Access Hubs since the start of operations, per Sentinel

MISSION	Daily average volume (TiB) published in November 2017	Daily average volume (TiB) published in November 2016
S1 ³	5.82	3.45
S2	3.22	1.13
S3	1.01	n/a
ALL	10.04	4.58

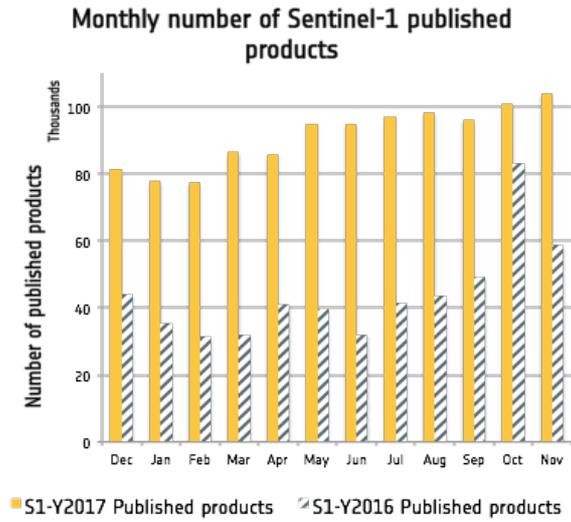
Table 2: Average volume of products published per day in the last month of Y2016 and Y2017

² S1 NTC only

³ S1 NTC only



(a)



(b)

Figure 19: Y2017 and Y2016 volume (graph a) and number (graph b) publication trend for Sentinel-1

Looking at what the Open Hub publication volumes mean on a daily basis, it can be seen that by November 2017, the average daily volume of data being published by the Data Access System increased by 119% since November Y2016 (see Table 2).

average daily publication volume of 5.82 TiB per day in November 2017, Sentinel-1 products constituted 58% of the total average daily publication volume (see Figure 20), and by the end of Y2017 Sentinel-1 products constituted two-thirds of the total volume of products which had been published since the start of operations.

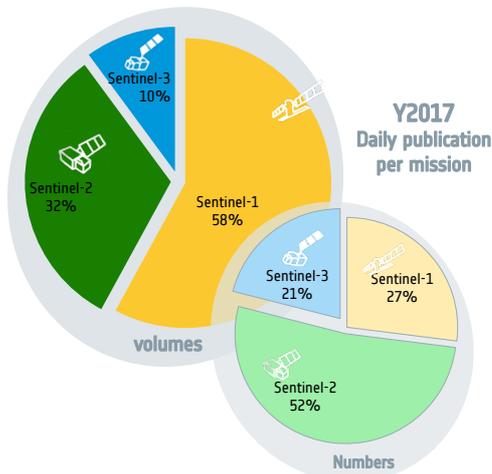


Figure 20: Y2017 average daily publication numbers and volumes per Sentinel

At the end of Y2017, the majority of NTC products being published were Sentinel-1 and Sentinel-2 products, reflecting the fact that both the –A and –B satellites were in orbit, and products from each satellite were already being disseminated to the public on a routine operational basis. With an

2.2.2 Publication trends

The following graphs show, per Sentinel, the monthly volume (graph a) and number (graph b) of products which were published on the data access hubs during Y2017, compared with the values recorded for Y2016.

Sentinel-1

Sentinel-1 NTC production gradually increased from an average of ~130 TiB per month to ~170 TiB due to the gradual introduction of the EDRS since May 2017.

The two following maps describe the overall Sentinel-1 constellation observation scenario, in terms of SAR mode, polarisation, observation geometry, revisit and coverage frequency, starting as of October 2016 (Figure a) and May 2017 (Figure b).

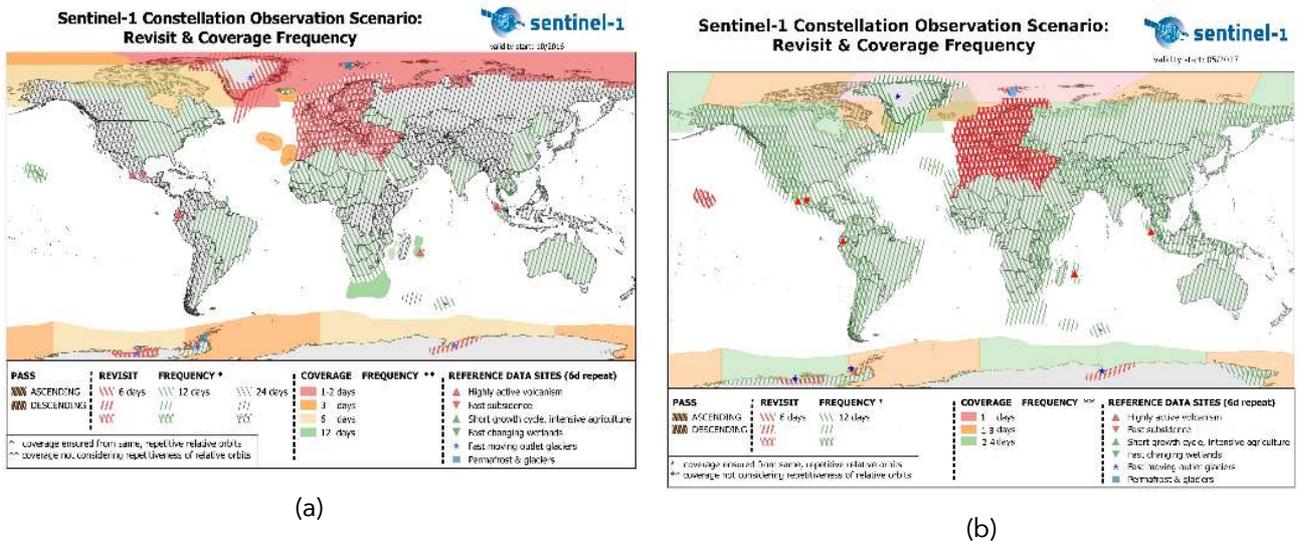


Figure 21: Overall Sentinel-1 constellation observation scenario

These maps are regularly updated on <https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario> to reflect the further increase of the overall system capacity, in particular with the gradual use of the European Data Relay System (EDRS). In fact, an increase in number of the GRDH and SLC monthly products was planned from May 2017. Comparing the number of published products reported in December 2016 with May 2017, an increase of +25% and +76% is registered respectively for the GRDH and SLC publication trends and, since GRDH and SLC products have an average volume

of 1GB and 7GB respectively, this also is evident in the volume graph (a) which highlights the higher volumes published from May 2017.

The Wave mode, continuously operated by default over open oceans, is not shown on the maps below but an increase of +76% is also noted for the OCN products starting from May 2017.

Moreover, in March 2017, the Sentinel-1A RAW products increased the production rate by about 13%, with this value was stabilizing during the following months.

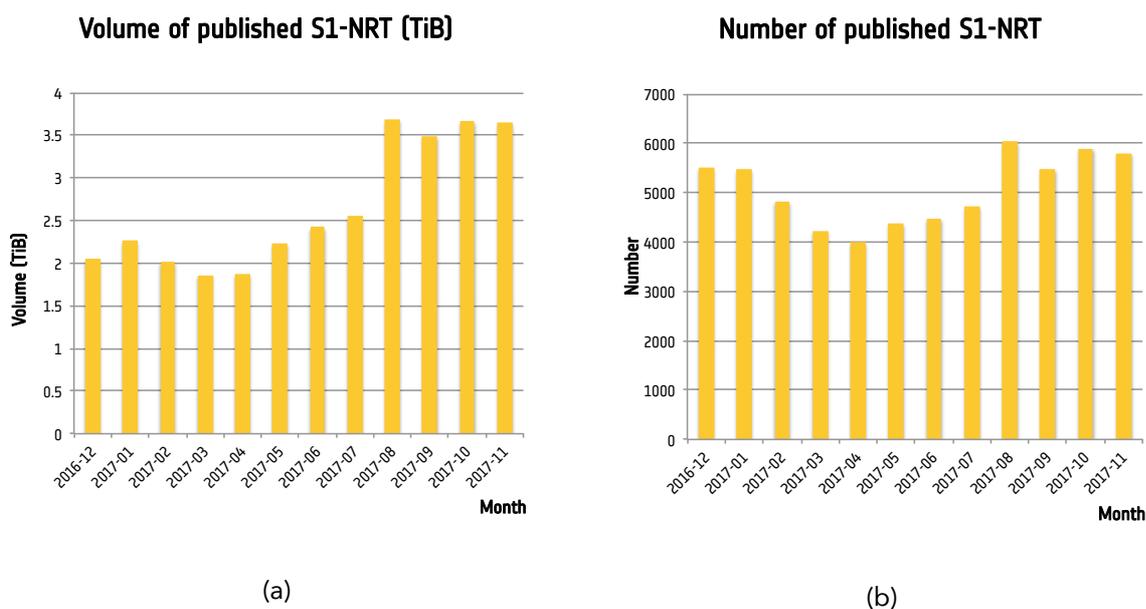
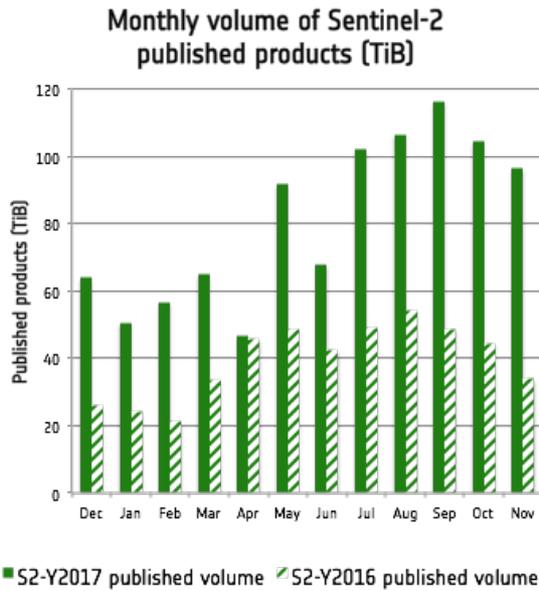
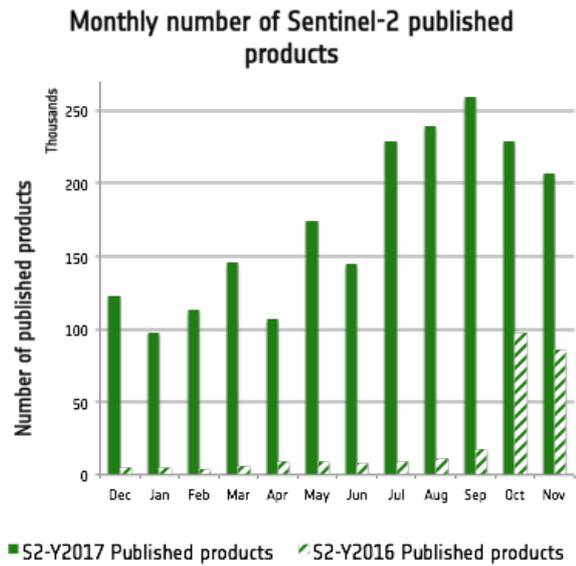


Figure 22: Y2017 average monthly volume (graph a) and number (graph b) publication trend for Sentinel-1



(a)



(b)

Figure 23: Y2017 and Y2016 volume (graph a) and number (graph b) publication trend for Sentinel-2

Since the start of operations a total of 90,551 Sentinel-1 Near Real Time (NRT) products have been published on the Collaborative Data Hub (60,812 of which were published during Y2017). The average monthly volume of Sentinel-1 Near Real Time (NRT) published during Y2016 was 2 TiB and it followed an increase during the year reaching about the 78% the monthly average volume currently published: in November 2017, the monthly volume of Sentinel-1 NRT published on ColHub instances is 3.65 TiB.

Sentinel-2

The Sentinel-2 operation capacity gradually increased during the reference period.

In particular, there were some remarkable dates in which the publication received a massive increase. These are:

- 2 May 2017: the Level 2A started to be published on Open Access Hub with an average number of published products of about 12,500 per month. By the end of the reporting period, the access to the routine pre-operational Level-2A products is available from all the Data Hubs;
- 6 July 2017: Sentinel-2B Level 1C publication started on the S2b PreOps

hub, almost doubling the whole publication flow of Sentinel-2 products and gradually increasing the number of published products.

The Sentinel-2 Ground Segment suffered a sporadic anomaly between March and May 2017 inclusive, leading to an incomplete dissemination of production with about 11% of products missing throughout the period. The recovery of the product dissemination was completed within Q2 2017. Additionally In August, as a consequence of a contingency occurring at one of the Ground stations, the publication of Sentinel-2 products in the data hubs was temporarily interrupted and recovered within first week of September.

As seen in Figure 23, in the last three months of the reporting period the publication has gradually decreased due to the lower amount of sunlight at northern latitudes, with the acquisition plan changed accordingly, reducing the acquisition at high northern latitudes. The figures below report an example of the Sentinel-2A acquisition plan at such high northern latitudes in June 2017 and in November 2017.

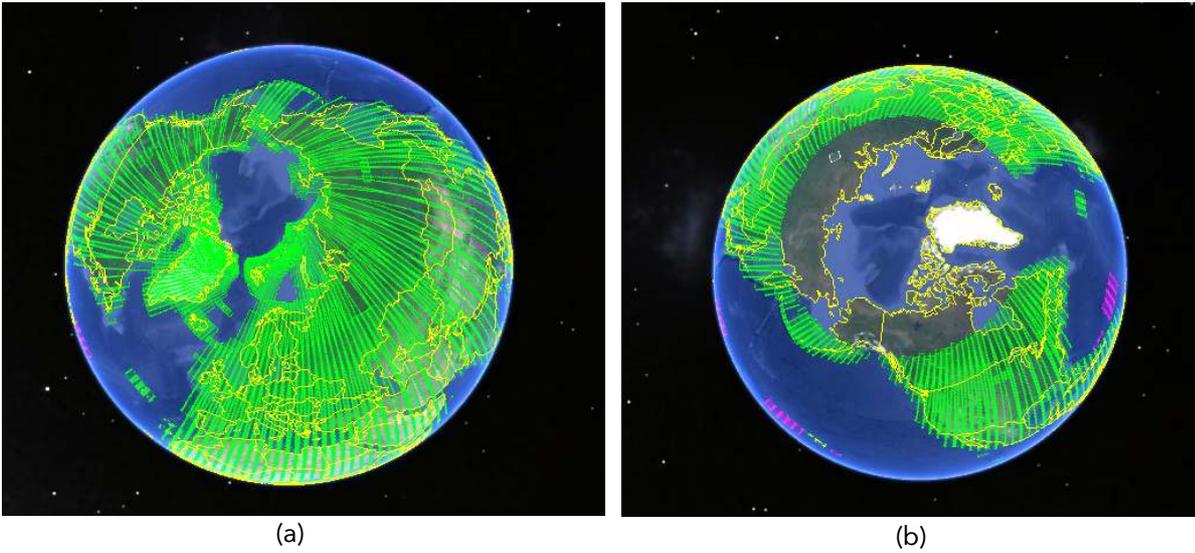
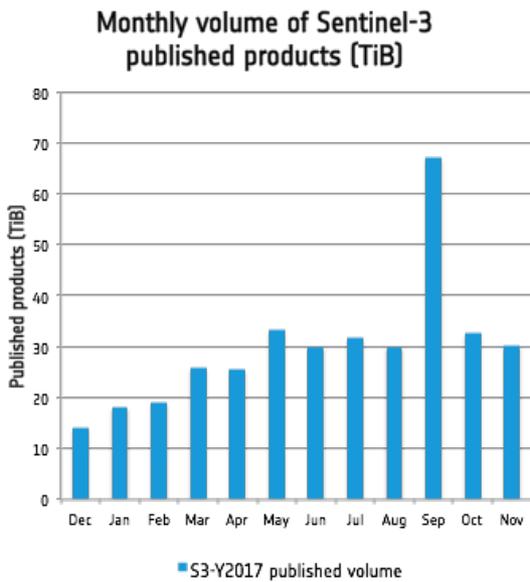
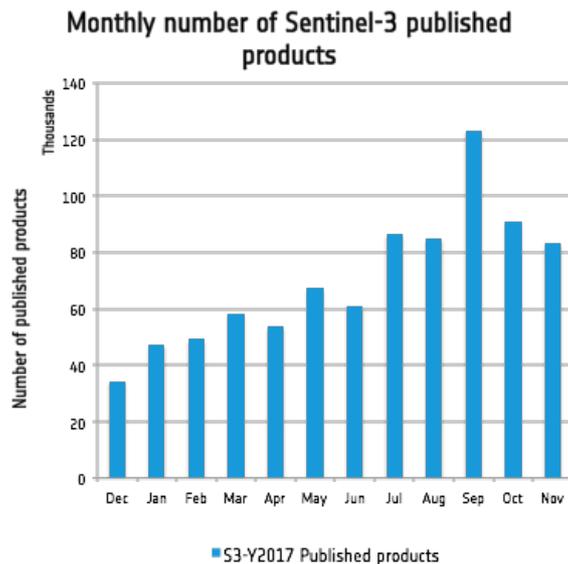


Figure 24: Sentinel-2 acquisition plan at high northern latitudes in June 2017 (a) and November 2017 (b)

Sentinel-3



(a)



(b)

Figure 25: Y2017 volume (graph a) and number (graph b) publication trend for Sentinel-3

The publication of Sentinel-3 products on S3 PreOps hub started with the OLCI products from 20 October 2016. SLSTR products started to be published on 17 November 2016 and, on 14 December 2016, the SRAL products were added to the nominal production flow published on the S3 PreOps hub. Many different product types per each of the Sentinel-3 instruments were gradually

added during the reference period and the complete set of product types related to the instruments on board of the satellite are now being routinely published on S3 PreOps hub since 6 July 2017.

In more detail, the breakdown graph related to the numbers of Sentinel-3 products published by the S3 PreOps hub reported below shows the

ramp-up phase for each of the Sentinel-3 instruments.

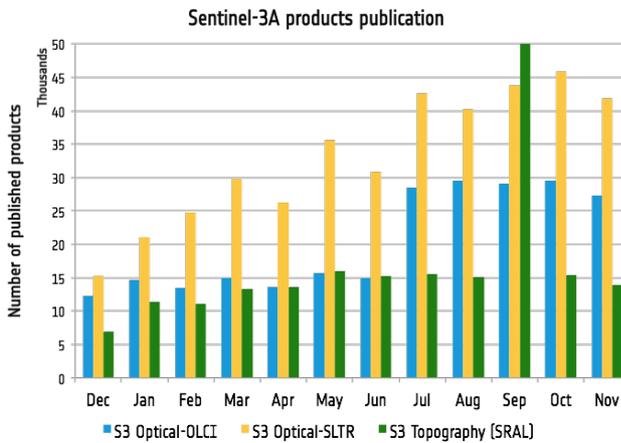


Figure 26: Number of monthly Sentinel-3 published products during Y2017, per instrument

The number of Sentinel-3 SLSTR products published (yellow bars on the graph) gradually increased from December 2016 to March 2017 and, in April 2017, an update to the IPF processor caused a gap in publication of the Level-1 NTC products. This gap and any backlog produced was restored in May and, since then, the publication was stabilized until July 2017, in which an increase of +37% was registered due to the start of Level-2 products publication.

Sentinel-3 OLCI products publication (blue bars on the graph) is almost stable over the whole period though there was an increase of +90% in its production in July 2017 again due to the start of Level-2 products publication.

The publication of Sentinel-3 SRAL products (green bars) started on 14 December 2016, remained stable in until March 2017, in which it increased about +21% due to the start of publication of SRAL Level-1A And Level-1. The publication of the SRAL Level-2 products started in September and, in the same month, the massive increase (+233%) of the number of SRAL products published was due to a reprocessing campaign planned in the Sentinel-3 processing baseline. Publication of Sentinel-3 SRAL historical data commenced on the Open Hub on 18 October 2017.

2.2.3 Publication Details

In this section, the overall publication figures are broken down by product type and geographical coverage.

Publication per product type

The diagrams in Figure 27 below report the total percentage of volume (graph a) and number (graph b) of products published per mission during Y2017, split by the published percentage of product types. It can be seen that the most frequently published products are the Sentinel-2 products, accounting for 51% of the total number of products published in the Data Access Hubs.

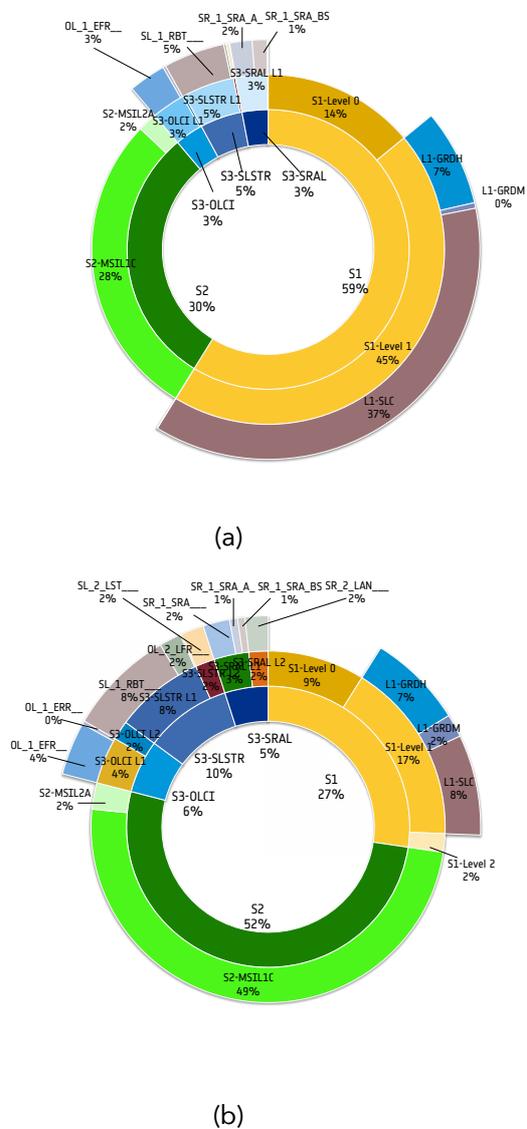


Figure 27: Total percentage of volume (a) and number (b) of products published per mission in Y2017, split by product type

For Sentinel-1 the following products types are published:

- Level 0 (L0-RAW)
- Level 1 Ground Range, Multi-Look, Detected: Medium Resolution (L1-GRDM)
- Level 1 Ground Range, Multi-Look, Detected: High Resolution (L1-GRDH)
- Level 1 Single-Look Complex (L1-SLC)
- Level 2 Ocean (L2-OCN)

From the graph above it can be seen that 33%, 61% and 6% of Sentinel-1 published products in Y2017 is constituted by Level 0, Level 1 and Level 2 respectively. At least one L1-GRD product type is available for each of the L0 products.

For Sentinel-2 the following products types are published:

- Level 1C (MSIL1C)
- Level 2A (MSIL2A)

From the graph above it can be seen that 95% of Sentinel-2 published products is constituted by Level 1C products and only 5% by Level 2A, it is recalled that the Level 2A production is in a pre-operational phase (as described in Chapter 1.2.1).

For Sentinel-3 the following products types, divided per sub-mission, and related instrument on board of the satellite, are published:

- Synthetic Aperture Radar Altimeter (SRAL)
 - Level 1 SR_1_SRA___ Echos parameters for LRM, PLRM and SAR mode (resolution 20Hz)
 - Level 1 SR_1_SRA_A_ Echos parameters for PLRM and SAR mode (resolution 80Hz)
 - Level 1 SR_1_SRA_BS Echos parameters for LRM, PLRM Level 1
 - Level 2 SR_2_LAN___ 1-Hz and 20-Hz Ku and C bands parameters (LRM/SAR/PLRM), waveforms. Over Land Level 2
- Ocean and Land Colour Instrument (OLCI):
 - Level 1 OL_1_EFR___ Full Resolution top of atmosphere radiance
 - Level 1 OL_1_ERR___ Reduced Resolution top of atmosphere radiance
 - Level 2 OL_2_LFR___ Full Resolution Land & Atmosphere geophysical products

- Level 2 OL_2_LRR___ Reduced Resolution Land & Atmosphere geophysical products
- Sea and Land Surface Temperature Radiometer (SLSTR):
 - Level 1 SL_1_RBT___ Brightness temperatures and radiances
 - Level 2 SL_2_LST___ Land Surface Temperature geophysical parameters Level 2

More details on the products types per mission and instrument are available in the Annex 2.

Publication per Geographical coverage

The geographical areas over which the Sentinels gather data are determined by the observation scenarios for each mission, which are available online via the following links:

- <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario> for S1,
- <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/observation-scenario> for S2 and
- <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3/observation-scenario> for S3.

These scenarios are in turn governed by the overarching Sentinel High Level Operations Plan (HLOP), which is a document agreed between ESA and the European Commission and also available online from the Document Library at:

<https://sentinels.copernicus.eu>.

Figure 28 below is a heatmap which shows the geographical coverage of the Sentinel-1 products published during Y2017. The colour scale illustrates the different numbers of products which were published for each area; red zones are the areas for which the greatest number of Sentinel-1 products were published. It should be highlighted, however, that the WV mode products, which are available over oceans and coastal zones, are not shown in this heatmap, due to the different footprint used in the those products which prevents the same calculation from being applied to the product count.

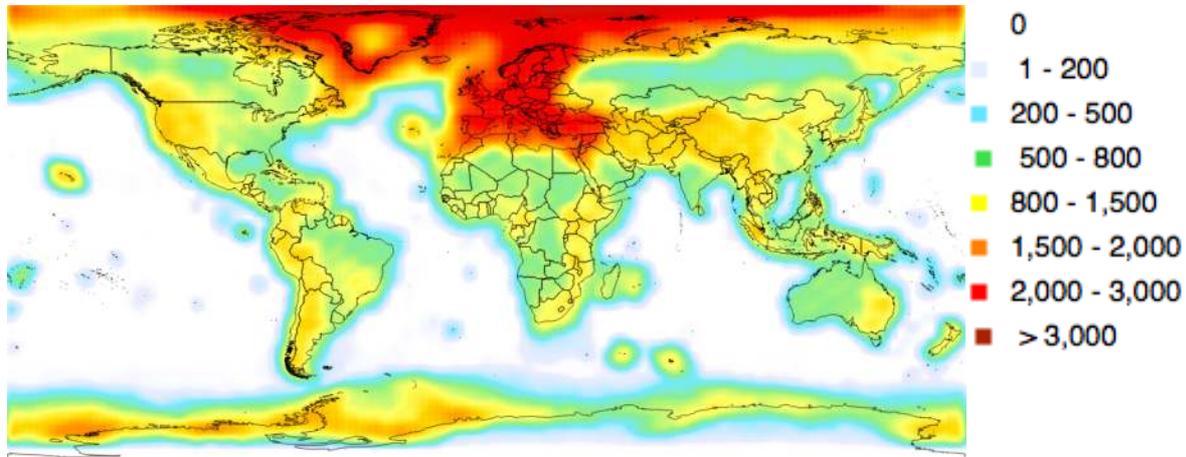


Figure 28: Heatmap of Sentinel-1 published products (excluding OCN) published since start of operations

The heatmap shows the global coverage of the Sentinel-1 data published since the beginning of operations, with the highest number of products available over Europe and maritime monitoring areas.

It is interesting to break the overall Level 1 geographical coverage down further to show the coverage per product type, because different Sentinel-1 product types are suitable for different geographical areas.

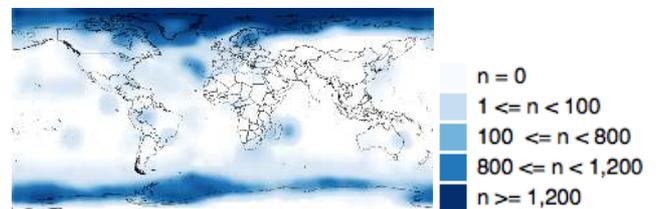
The HLOP determines which Sentinel-1 products will be available for which area of the world, and the maps in Figure 30 illustrate that:

- GRDM products are mostly available for sea ice and marine areas;
- GRDH products are mostly available over land masses;
- SLC products are also mostly available over land masses.

S1 GRDH



S1 GRDM



S1 SLC



Figure 30: Heatmaps of Sentinel-1 products published since start of operations per product type: GRDH (Ground Range, Multi-Look, Detected: High Resolution), GRDM (Ground Range, Multi-Look Detected: Medium Resolution), SLC (Single-Look Complex)



Figure 29: Sentinel-1 satellite

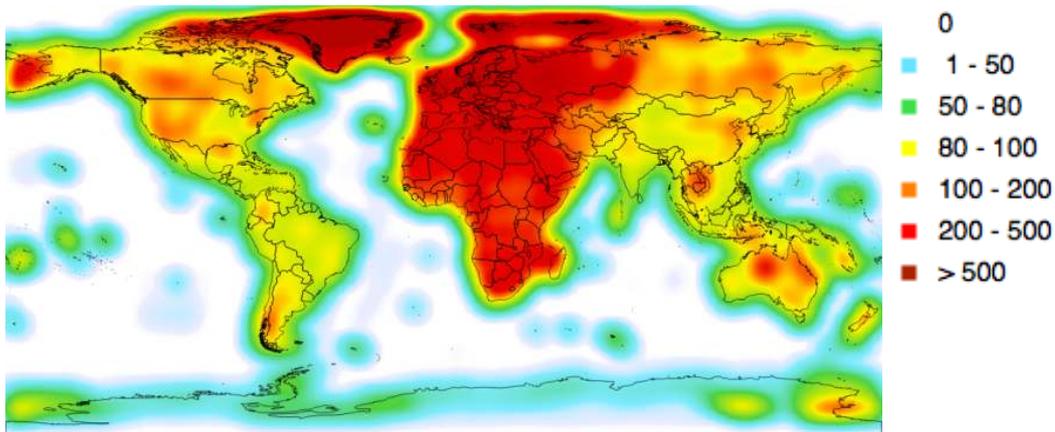


Figure 31: Heatmap of Sentinel-2A Level 1C products published since start of operations

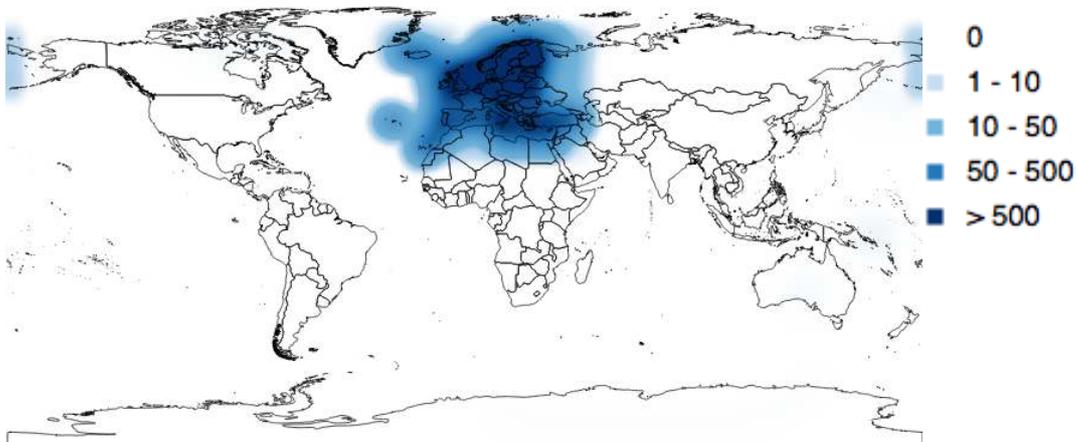


Figure 32: Heatmap of Sentinel-2A Level 2A products published during Y2017

While the Sentinel-1 heatmap shows a variable density acquisition rate over different geographical areas, the heatmap in Figure 31 shows that Sentinel-2A Level 1C is aimed at achieving more evenly spread global coverage, although focused on European and African land masses.

techniques. The heatmaps below show the geographical coverage of the products, distinct by instrument, belonging to this mission published and available on the Open Hub since the beginning of the operations.

As anticipated, during Y2017, the pilot publication of Sentinel-2 level 2A was focused on the European geographical area, as shown in Figure 32.

Sentinel-3, which is intended to provide sustained Ocean and Land observation data, serve primarily the marine operational users but will also allow the monitoring of sea ice and land ice, as well as inland water surfaces, using novel observation



Figure 33: The Sentinel-2 satellite

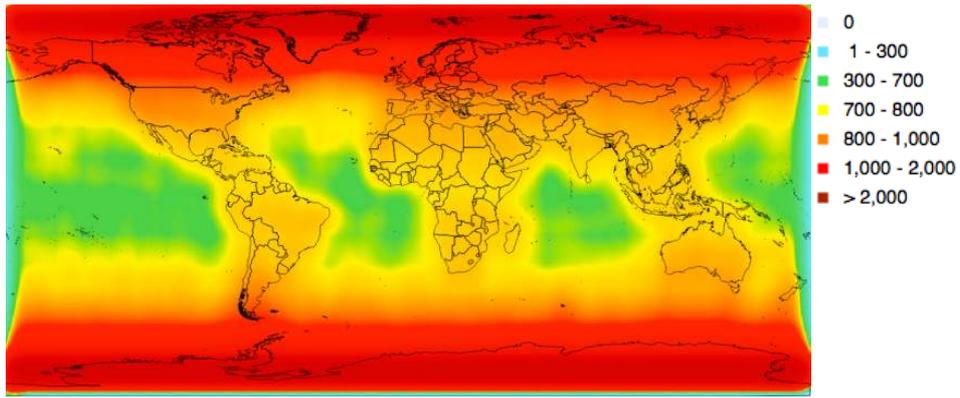


Figure 34: Heatmap of Sentinel-3 SRAL published products since start of operations

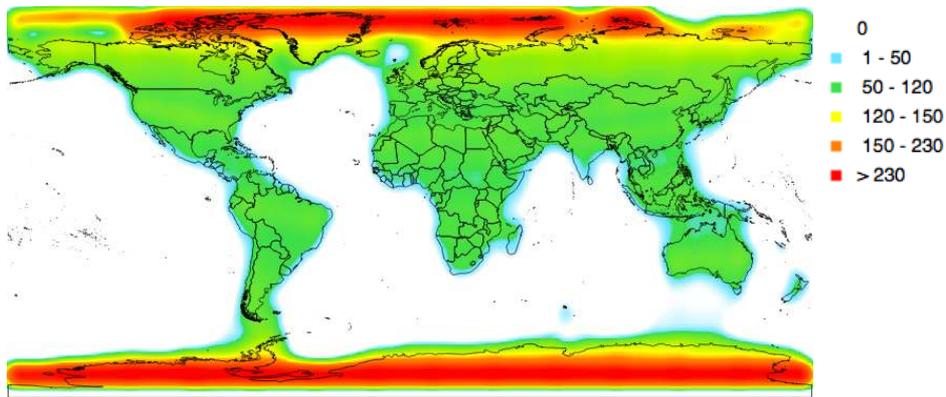


Figure 35: Heatmap of Sentinel-3 SRAL NRT Level-2 published products since start of operations

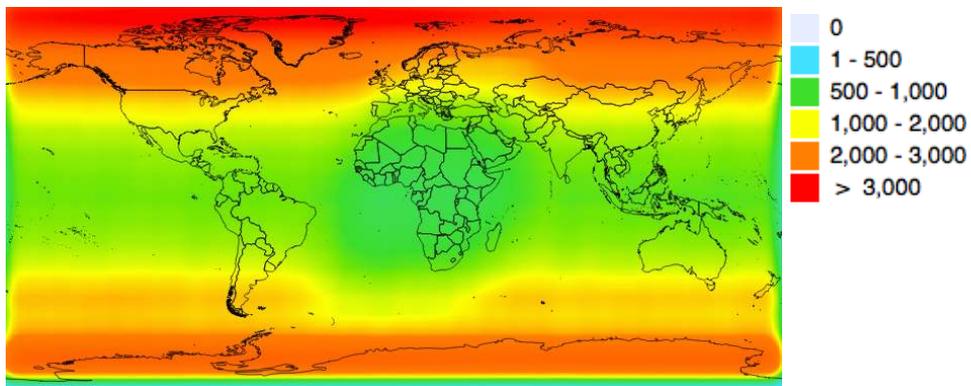


Figure 36: Heatmap of Sentinel-3 OLCI published products since start of operations

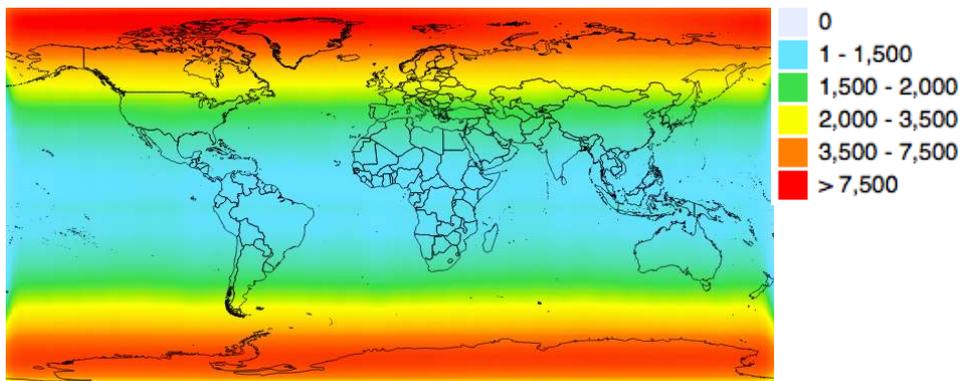


Figure 37: Heatmap of Sentinel-3 SLSTR published products since start of operations

Sentinel-3 has a uniform distribution of publication. An exception is done on the Sentinel-3 SRAL NRT level-2 products which covers the land regions on the map, as shown on the dedicated heatmap reported on Figure 35.

It is worth to mention that, during the reporting period, the publication of the OLCI products with reduced resolution, which have a pole-to-pole footprint (as shown in Appendix 2) have been affected by a software issue preventing the publication of their footprints, especially those having footprint intersecting a specific region of the north pole in summer. This is the reason why in the centre of the OLCI map a lower number of products are shown.

2.3 Products Dissemination

This section presents the statistics for user downloads during Y2017.

It is important to mention that 'one download' refers to an uninterrupted download of a complete data product. Partial downloads and product component downloads are not included in the overall statistics, but an analysis of these downloads is reported in sections 2.3.5 and 2.3.6.

2.3.1 Download growth

During Y2017, a massive increase of user downloads (+133%) from the Data Access System was registered compared with the volume of downloads during Y2016. In Y2017, a total of 39.8 million of user downloads, corresponding to a total volume of 28.08 PiB, were made from the Data Access System.

To give an example of what this jump in data volume means, the volume of downloads performed during last 4 months of Y2017 (10.75 PiB) is greater than the total volume performed during the whole Y2016.

Figure 38 breaks these totals down per mission and per year, and compares the total volume of

data downloaded by the end of Y2017 with the total volume which had been downloaded by end of previous periods.

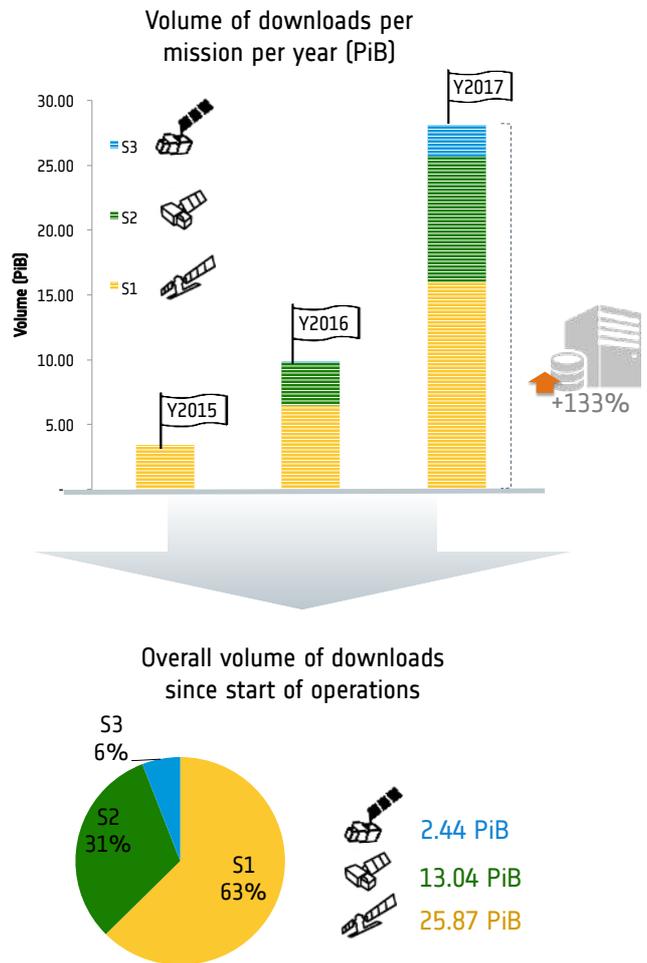


Figure 38: Total volume of products downloaded per year and since the start of operations, differentiated by mission

These figures demonstrate the high level interest of Sentinel-1 data during the third year of its operations: 9.76 PiB of Sentinel-1 products had been downloaded by users by the end of Y2016, in two years of operations, and by the end of Y2017 this had risen by 164% to a total of 25.87 PiB of products since the start of operations.

The level of interest in Sentinel-2 products has been high throughout the year: 2.66 PiB of Sentinel-2 products had been downloaded by users by the end of Y2016; by the end of Y2017 this had risen by 365% to a total of 13.04 PiB of products since start of operations.

Sentinel-3 data, for which downloads commenced from 20 October 2016 (0.06 PiB in 40 days), reached, by the end of Y2017, a total volume of 2.44 PiB since start of operations.

2.3.2 Archive Exploitation Ratio

Users' interest in Sentinel products can be monitored more directly by looking at the 'Archive exploitation ratio'. The Archive Exploitation Ratio shown in the figure below was computed at the end of Y2017, as the total number of users' downloads made from all the hubs (Open Hub, Collaborative Hub, International Hub and Copernicus Service Hub) since the starts of operations, divided by the total number of products which had been published on the hubs since the start of operations.

It is expressed as a ratio of published products vs downloaded: e.g. the ratio 1:X indicates that, for each of the published products, there is an average number of X downloads.

The ratio reported in figure 39 shows that, by the end of Y2017, the user interest is now equally distributed: there was an increase of interest in Sentinel-2 products within the Sentinel Data Access community during Y2017, from the 1:9 statistic reported for Y2016, to 1:10 now.

Archive exploitation ratio



Figure 39: Archive exploitation ratio per mission at end Y2017

This uptake could be related to the change in product format distribution (from multi-tiles to single-tile format) done on 27 September 2016 that allowed easier access for users with more limited bandwidths.

Sentinel-1 interest remained stable during this year with the ratio value of 1:10, indicating that despite the increasing volumes the Data Access System is capable of managing the huge amount of download requests.

By the end of Y2017, the Sentinel-3 ratio was 1:10 indicating a high level of interest in this mission.

In the following table, further details on archive exploitation ratio are reported per each mission grouped by instrument, level, resolution and timeliness for the period since start of operations up to the end of Y2017.

Level	Timeliness	NUMBER OF PUBLISHED PRODUCTS SINCE START OF OPERATIONS	NUMBER OF DOWNLOADED PRODUCTS SINCE START OF OPERATIONS	Archive exploitation ratio
Level 0	NTC	659,578	2,336,723	1:4
Level 1	NTC	1,223,725	15,148,535	1:12
	NRT	90,551	767,806	1:8
Level 2	NTC	95,294	1,589,028	1:17

Table 3: Sentinel-1 number of published and downloaded products since the beginning of operations per level and timeliness and related archive exploitation calculation

Level	Timeliness	Y2017 PUBLISHED PRODUCTS	Y2017 DOWNLOADED PRODUCTS	Archive exploitation ratio
Level 0	NTC	356,242	982,394	1:3
Level 1	NTC	670,298	8,415,074	1:13
	NRT	60,812	449,958	1:7
Level 2	NTC	68,600	1,297,167	1:19

Table 4: Sentinel-1 number of published and downloaded products during Y2017 per level and timeliness and related archive exploitation calculation

Sentinel-1

As reported above, the Sentinel-1 archive exploitation ratio remained stable during Y2017 with respect to the previous year and, since the start of operations, the archive exploitation ratio detailed per Level and timeliness reported in table 3 above reveals that there are 8 downloads each Sentinel-1 Near Real Time (NRT) product published on ColHub nodes. The user community is also mostly interested in the Level 1 and Level 2 Sentinel-1 Non Time Critical products (NTC), which have an archive ratio of 1:12 and 1:17 respectively

The table above reports the number of Sentinel-1 published products during Y2017 and user downloads made during Y2017 per level and timeliness. The archive exploitation ratio, reported in the table, is calculated by dividing the number of downloads made during Y2017 by the number of published products during the same period (Y2017).

As noted on the section 2.3.4, the downloads of products older than 1 year make up only a small percentage of the total, so this archive ratio, calculated based on Y2017, provides a rough indication of how the interest in Sentinel-1 products has changed in Y2017 compared to the ratio calculated since the start of operations.

The interest in Level 1 NRT products is less in this reference period and, in more details, both GRDM and GRDH with NRT timeliness had a decrease in number of downloads per each of the available products.

Level 0 NTC are stable in terms of archive exploitation ratio with an average of 3 downloads

per published product, while Level 1 NTC products received an significant increase in interest, especially for the SLC products which were published during Y2017.

Level 2 NTC, instead, had 19 downloads for each product published during Y2017 with respect to 17 downloads of each available product since the beginning of operations.

Regarding the geographical interest of Sentinel-1 NTC products, the heatmaps in Figure 40 presents a geographical representation of the average normalized download values (“Archive exploitation ratio⁴”) of Sentinel-1 NTC products made during Y2017. They provide a rough idea of how many downloads were made during Y2017 per available product since the start of operations over a specific geographical area.

Because of their particular footprint, which is constituted by more than one polygon, the Sentinel-1 WV mode, which include all the Level 2 products, were excluded from the heatmap.

⁴ It is calculated as the number of downloads made on all the Hubs (Open Hub, ColHub, ServHub and IntHub) during Y2017 on each cell of the map divided by the number of products published in the corresponding geographical area since the starts of operations

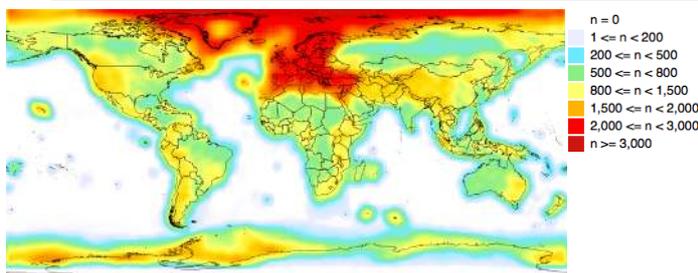
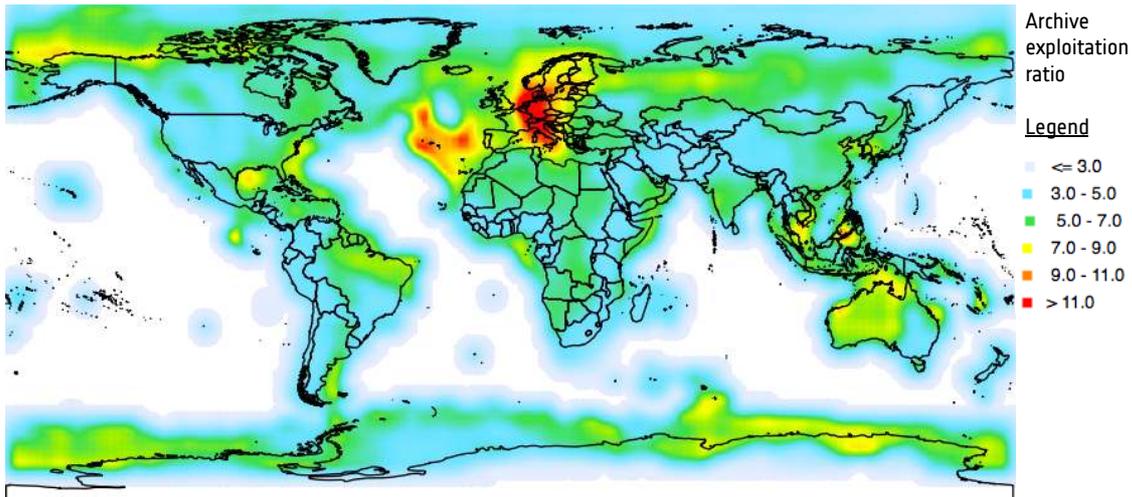


Figure 40: Heatmap of the area of interest of Sentinel-1 NTC Level 0 and Level 1, excluding WV mode products and, on the side graph, the corresponding publication density heatmap

For ease of reference, the publication density heatmap (see section 2.2.3) is shown again below the download heatmap (note that the scale differs between each type of heatmap).

The red spots on the map correspond to the regions of the globe in which many (>11) users downloads per available products were made during Y2017.

During Y2017, as per last year, the user interest in Sentinel-1 was focused on the Atlantic Ocean and the European area, in which the average number of downloads is at least 7 for each of the available products. The side figure shows the detailed Archive exploitation heatmap of Sentinel-1 NTC over the European region. It reveals that the most intense zone in terms of the user interest is the central European zone (Italy, Germany, Austria, Switzerland, Belgium, Netherland and Denmark), in which there are at least 10 downloads for each published product. It has to be noted that the zone coloured in red in the figure 41 is covered by ~100K of products published since the start of operations, so an archive exploitation ratio of 1:10 would mean that the number of downloads on this area in Y2017 is on average around 1M.

Sentinel-2

By the end of Y2017, the total number of Sentinel-2 published products was more than 2.3 million, with 96% of them made up of Level-1C. The overall Sentinel-2 archive exploitation ratio registered since the beginning of operations is 1:10, which is mostly given by the high number of Level-1C published and downloaded products, whose archive exploitation ratio is 1:10. Tables 5a and 5b below show that there was not much variation of interest in Y2017 with respect to the overall period since start of operations.

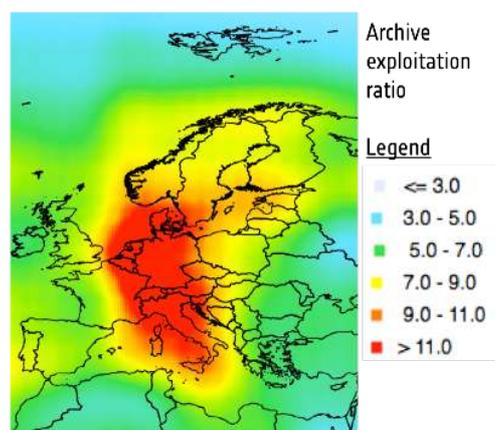


Figure 41: Heatmap of the European region area of interest of Sentinel-1 NTC Level 0 and Level 1, excluding WV mode products.

Instrument	Level	NUMBER OF PUBLISHED PRODUCTS SINCE START OF OPERATIONS	NUMBER OF DOWNLOADED PRODUCTS SINCE START OF OPERATIONS	ARCHIVE EXPLOITATION RATIO
MSI	Level 1C	2,234,962	22,318,192	1:10
	Level 2A	97,670	462,699	1:5

Table 5a: Sentinel-2 number of published and downloaded products since the beginning of operations per level and related archive exploitation calculation

Instrument	Level	Y2017 PUBLISHED PRODUCTS	Y2017 DOWNLOADED PRODUCTS	ARCHIVE EXPLOITATION RATIO
MSI	Level 1C	1,973,439	19,694,593	1:10
	Level 2A	97,670	462,699	1:5

Table 5b: Sentinel-2 number of published and downloaded products in Y2017 per level and related archive exploitation calculation

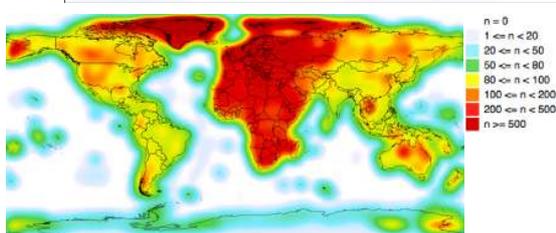
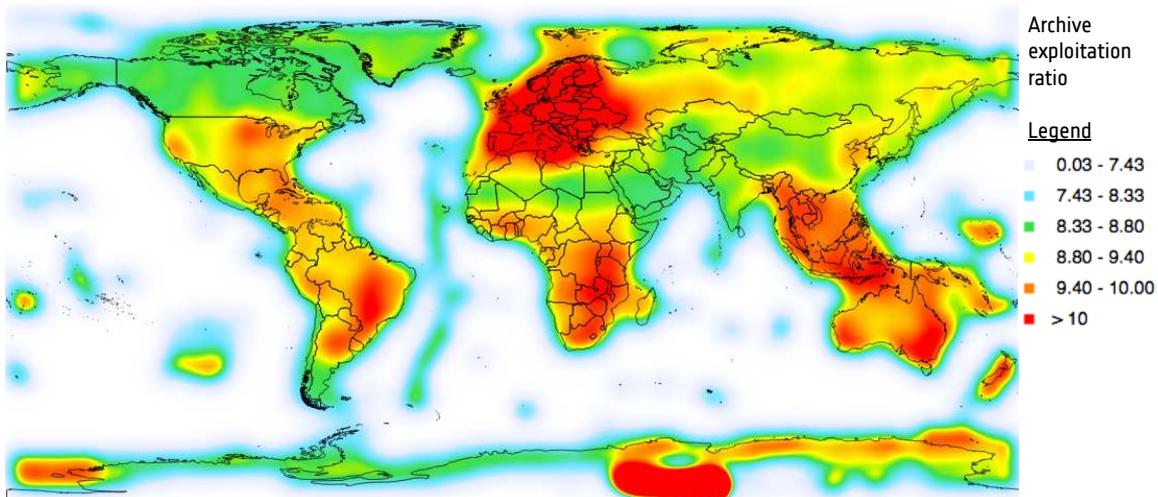


Figure 42: Heatmap showing areas of interest for Sentinel-2 MSIL1C users in Y2017 and, on the side graph, the corresponding publication density heatmap

In terms of geographical interest, the figures above show the geographical representation of the average normalized downloads values of Sentinel-2 Level-1C products made during Y2017, as well as and the publication (since the start of operations) density heatmaps for reference.

As shown by the archive exploitation heatmap above, the most intense areas of interest in the Sentinel-2 Level-1C products (more than 10 downloads per available product) are European and South-East Africa, regions in which there are a high number of available products. In addition, South-East Asia, Oceania North-Eastern USA and

Brazil are zones in which there was a great interest in Sentinel-2 products: during Y2017 users downloaded an average of at least 10 products for each available within regions. The red spot placed on the Antarctic region is due to the low quantity of available products on this area

Sentinel-3

The Table 6 below shows the archive exploitation ratio of Sentinel-3, split per instrument (SLSTR, SRAL and OLCI) and reveals that SRAL products have the highest number of downloads together with the lowest number of published products, meaning its archive exploitation ratio is an impressive 1:17, much higher than the ratios for OLCI and SLSTR.

Instru ment	NUMBER OF PUBLISHED PRODUCTS SINCE START OF OPERATIO NS	NUMBER OF DOWNLOADED PRODUCTS SINCE START OF OPERATIONS	ARCHIVE EXPLOIT ATION RATIO
SLSTR	404,898	3,017,347	1:8
SRAL	197,830	3,435,010	1:17
OLCI	256,518	1,772,330	1:7

Table 6: Sentinel-3 number of published and downloaded products since the beginning of operations per instrument and related archive exploitation calculation

A couple of considerations on the SRAL instrument may be highlighted by analysing these results:

- 1) Publication on Open Hub: as reported above, the SRAL products are the first of the Sentinel-3 mission that have been published on the operational instance of the Open Access hub;
- 2) Altimetry products are typically downloaded constantly and over large areas: for instance, the sea surface level is calculated with an interpolation of various products and its variation is derived by comparing it with the average value of historical data.

SRAL products are distributed by the Data Access Systems in three timelinesses: Non time critical (NTC), Short Time Critical (STC) and Near Real Time (NRT) – see

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-altimetry/product-types/nrt-or-ntc> for reference - and SRAL products with the latter two timelinesses are accessible to users on the Data Access Hubs for 30 days, after which they are removed definitively.

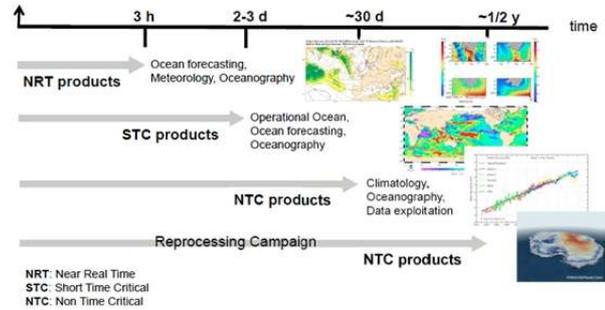


Figure 43: Sentinel-3 SRAL Level-2 Product Timeliness (Credit: ESA)

The Table 7 below reports the archive exploitation ratio of SRAL products grouped by Level and timeliness.

SRAL NRT products have the greatest archive exploitation ratio: 1:34 for the Level-1 and 1:24 for the Level-2.

The Level-1 NTC products have an average of 4 downloads per available products and, in further detail, between the products types SR_1_SRA___, SR_1_SRA_A_, SR_1_SRA_BS, the first received a slightly greater interest from Sentinel-3 SRAL users because the average number of downloads per available product was 5 while, for the other products types (Level-1 NTC) it is 3.

The geographical interest in SRAL NRT products is reported in the heatmaps below: due to their different usage and different footprint coverage, Level-1 and Level-2 heatmaps are reported separately.



Figure 44: The Sentinel-3 satellite

Level	Timeliness	NUMBER OF PUBLISHED PRODUCTS SINCE START OF OPERATIONS	NUMBER OF DOWNLOADED PRODUCTS SINCE START OF OPERATIONS	ARCHIVE EXPLOITATION RATIO
Level 1	NTC	49,695	181,173	1:4
	STC	25,300	103,732	1:4
	NRT	52,742	1,809,490	1:34
Level 2	NTC	18,871	274,276	1:15
	STC	10,401	72,090	1:7
	NRT	40,821	994,249	1:17

Table 7: Sentinel-3 SRAL number of published and downloaded products since the beginning of operations per instrument and related archive exploitation calculation

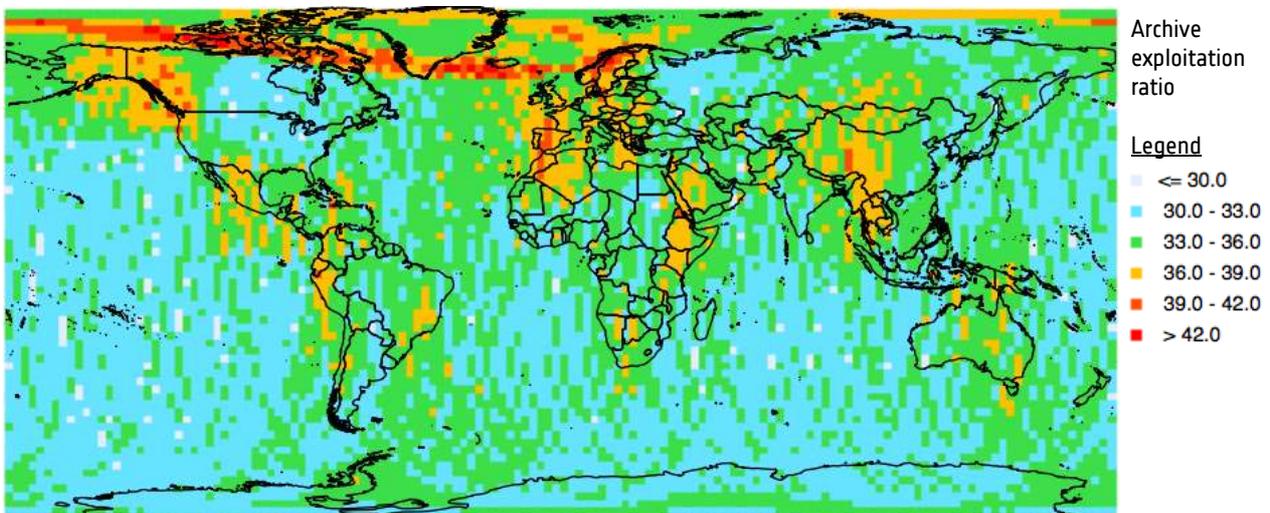


Figure 45: Heatmap showing areas of interest for Sentinel-3 SRAL Level-1 NRT users in Y2017

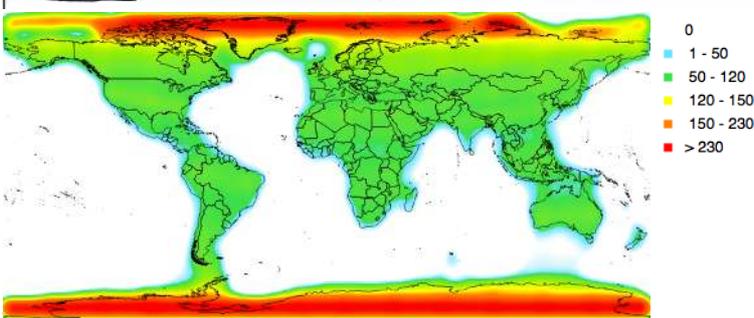
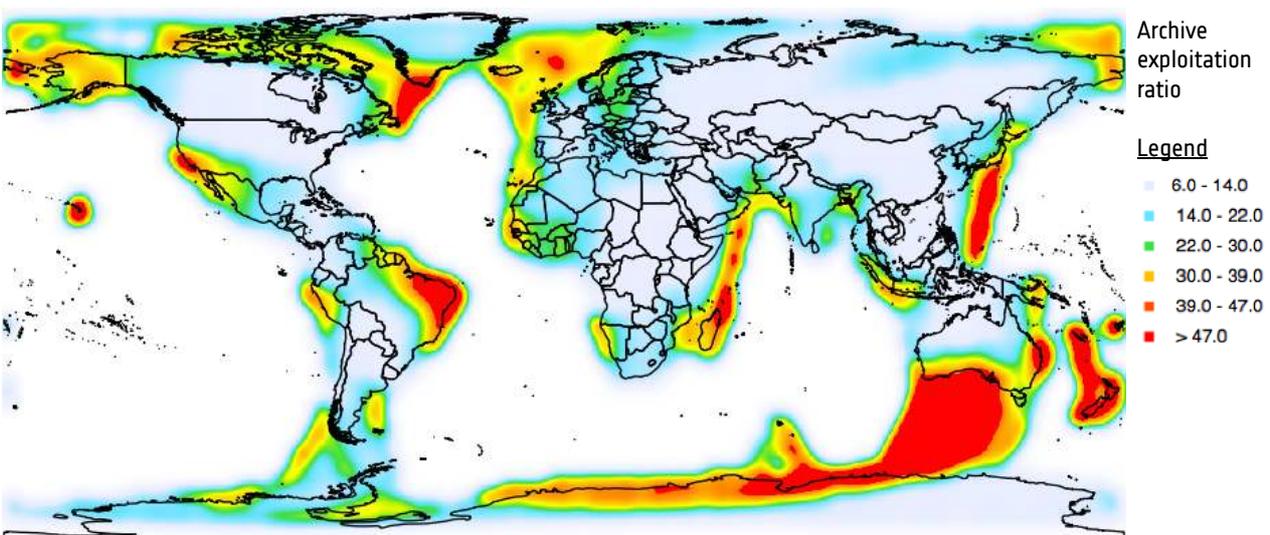


Figure 46: Heatmap showing areas of interest for Sentinel-3 SRAL Level-2 NRT users in Y2017 and, on the side graph, the corresponding publication density heatmap

From the heatmap in Figure 45 it is possible to say that the interest in Sentinel-3 SRAL Level-1 NRT products, in terms of geographical coverage, is high all over the world because there are very few zones on the map which have less than 30 downloads each available product. The oranges/red zones shows the regions in which

there is the greatest interest and they often cover land regions, with exception of Norwegian sea: Northern and Western Europe, Morocco, Algeria and East Africa, China and parts of Mongolia, Quebec, Canada, Mexico, Peru, part of Brazil and some regions in Australia.

Instrument	Level	Timeliness	NUMBER OF PUBLISHED PRODUCTS SINCE START OF OPERATIONS	NUMBER OF DOWNLOADED PRODUCTS SINCE START OF OPERATIONS	ARCHIVE EXPLOITATION RATIO
SLSTR	Level 1	NTC	155,926	1,410,472	1:9
		NRT	178,580	1,380,320	1:8
	Level 2	NTC	1,312	4,982	1:4
		NRT	69,080	275,573	1:4

Table 8: Sentinel-3 SLSTR number of published and downloaded products since the beginning of operations per instrument, level and timeliness and related archive exploitation calculation

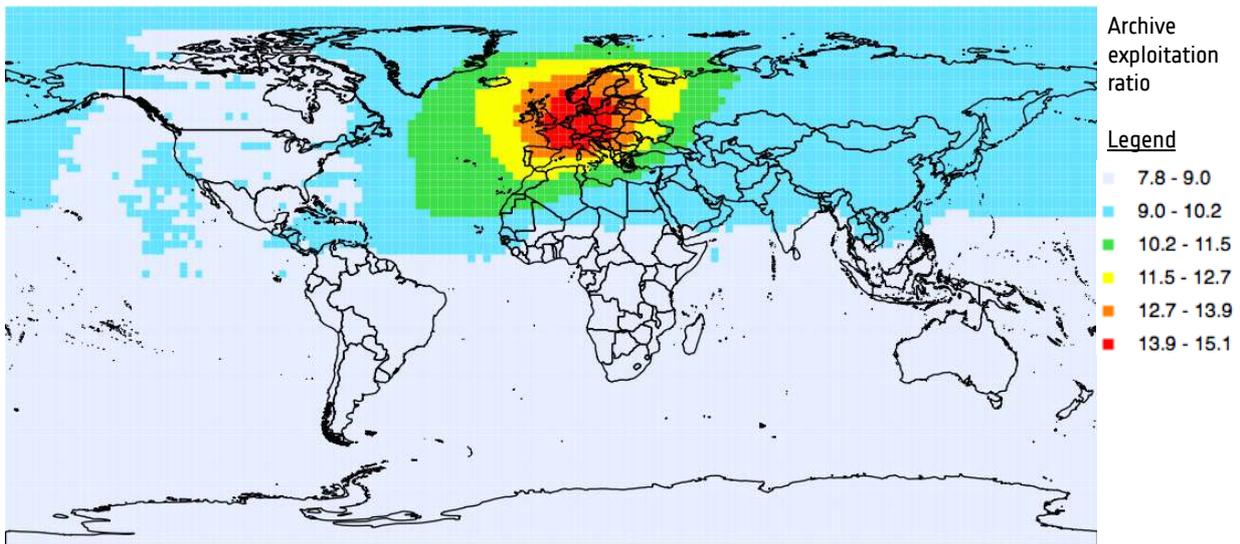


Figure 47: Heatmap showing areas of interest for Sentinel-3 SLSTR Level-1 users in Y2017

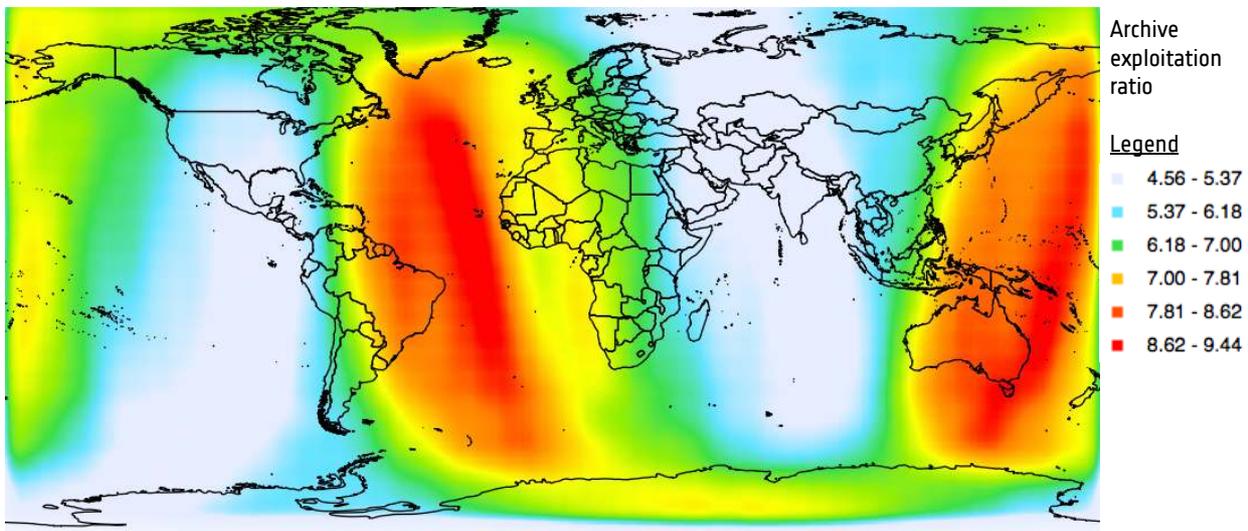


Figure 48: Heatmap showing areas of interest for Sentinel-3 SLSTR Level-2 NTC users in Y2017

As shown in the publication heatmap, Sentinel-3 SRAL Level-2 NRT products cover the land region of the Earth with higher intensity on the poles and lower intensity on coastal region. The map in Figure 48 shows that every internal land regions are coloured so, for every product covering the internal land regions, there are at least 6 downloads each available product. Coastal regions, particularly of Europe, East Africa, East Asia and Oceania, are the principal ones showing red, indicating a high level of interest.

As reported in section 2.2.3, published Sentinel-3 SLSTR and OLCI products have a near-uniform worldwide coverage, though with a higher intensity of products covering the Polar regions due to the higher revisit frequency. SLSTR Level-1 products were the most downloaded during Y2017, especially the NTC ones. In terms of geographical coverage, downloads of Level-1 NTC and Level-1 NRT products are similar, so they are reported in a single heatmap below:

On the map, every part of the Earth received at least 7.8 downloads per available product, with Europe being the most downloaded region.

Another interesting view of the geographical interest for the SLSTR products is related to the Level-2 NTC products, whose footprints cover the entire globe each pass (for further information, see Annex 2).

The geographical interest in Sentinel-3 SLSTR Level-2 NTC products is global, with each region of the Earth having at least 4 downloads per available product. However, of particular interest are the zones covering the Atlantic Ocean, the South Pole and Oceania.

Table 9 reports the archive exploitation ratio of OLCI products grouped by resolution, level and timeliness. The product having the greatest (1:10) average number of downloads per published product is the Reduced resolution Level-1 NRT, followed by other Level-1 product types (1:9 for the Reduced resolution Level-1 NTC products and 1:8 for Full resolution Level-1 products).

Additionally, it is noted that the NRT products have an archive exploitation ratio lower than the corresponding NTC products for all products levels and resolutions with exception of Level-1 NTC products with reduced resolution, for which the downloads made from the beginning of operations are 10 times the number of available products.

Instrument	Resolution	Level	Timeliness	NUMBER OF PUBLISHED PRODUCTS SINCE START OF OPERATIONS	NUMBER OF DOWNLOADED PRODUCTS SINCE START OF OPERATIONS	ARCHIVE EXPLOITATION RATIO
OLCI	Reduced	Level 1	NTC	5,251	40,665	1:8
			NRT	5,994	60,529	1:10
		Level 2	NTC	2,115	9,460	1:4
			NRT	2,111	9,240	1:4
	TOTAL			15,471	133,080	1:8
	Full	Level 1	NTC	81,614	616,490	1:8
			NRT	92,987	738,392	1:8
		Level 2	NTC	33,065	145,372	1:4
			NRT	33,381	152,182	1:5
		TOTAL			241,047	1,858,406

Table 9: Sentinel-3 OLCI number of published and downloaded products since the beginning of operations per instrument, resolution, level and timeliness and related archive exploitation calculation

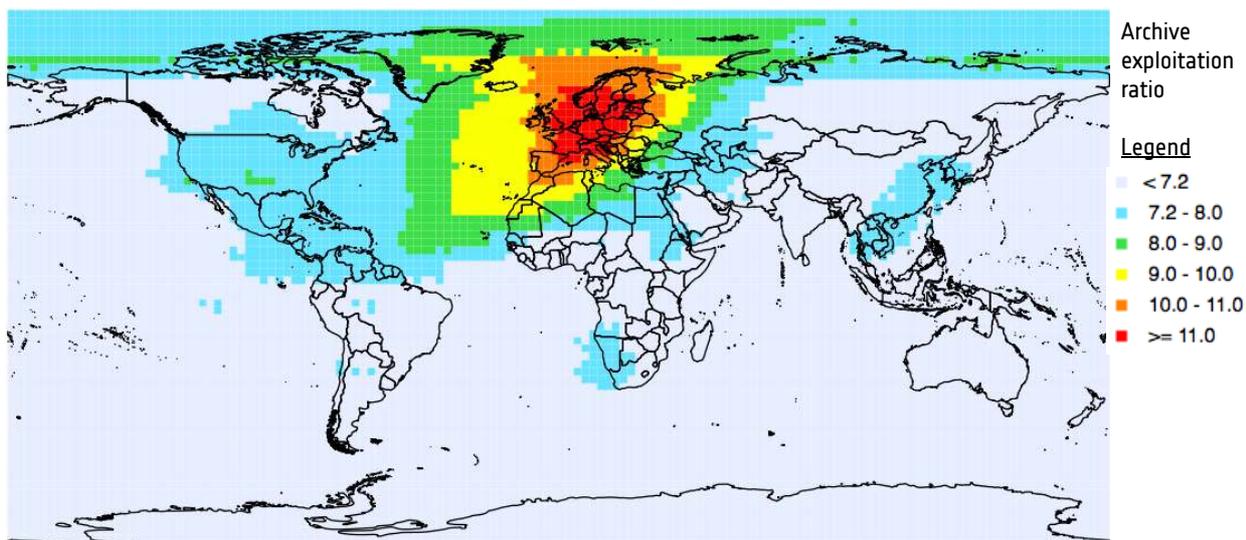


Figure 49: Heatmap showing areas of interest for Sentinel-3 OLCI Full resolution users in Y2017

2.3.3 Download trends

In the heatmap above the normalized users downloads of OLCI Full resolution products are shown.

The distribution of the geographical area of interest for the Sentinel-3 OLCI full resolution shows a particular interest in European region. Several more regions, including the North Pole, North America excluding Canada and Quebec, Central America, South-East China, North Africa and Namibia received a higher number of downloads per available product compared to the other parts of the Earth.

This section reports on the volume and number of products disseminated toward the users since the start of operations.

In Table 10 below, the overall numbers of products downloads are broken down per hub, to show the different levels of user uptake on each.

The biggest contributor to the dissemination of Sentinel products since the beginning of operations remains, as per last year, the Copernicus Open Access Hub, which has managed 59% of the overall volume of downloads.

Hub	Number of products downloaded since start of operations	Volume of products downloaded since start of operations (PiB)
Open Access Hub	32,408,782	24.60
Collaborative Hub	12,653,460	11.81
International Hub	4,480,636	3.80
Copernicus Services Hub	1,421,792	1.14
All hubs	50,964,670	41.35

Table 10: Number and volume of products downloaded since the start of operations, per hub

Table 11 below shows the increase in the volume of downloads since the previous reporting period. All of the Hubs received an increase of the volume of user downloads during Y2017, especially the Copernicus Open Access Hub which, by the end of Y2017, is handling more than three times the daily volume of downloads it had been handling at the end of Y2016. The relatively smaller increase in downloads from the Collaborative Hub is due to the introduction of the Data Hub Relays as outlined in section 1.2.1.

Focusing more specifically on user downloads during Y2017, the graph in Figure 50 below show

the volume of products which users downloaded from each hub and per mission during Y2017.

It is important to note that Sentinel-3 products began to be published by the end of reporting period on all the Data Access Instances with exception of the International Hub, in which the publication of Sentinel-3 products will follow in the next reporting period. The overall volume of Sentinel-3 downloads done from the Collaborative and Copernicus Services Hubs during Y2017 was less than 0.01 PiB so the graph does not report the values of Sentinel-3 downloads for those Hubs.

Hub	Daily average volume (TiB) downloaded in November 2016	Daily average volume (TiB) downloaded in November 2017	% increase since Y2016 in average daily volume downloaded
Open Access Hub	16.8	52.3	212%
Collaborative Hub	21	29.0	38%
International Hub	5.3	9.9	88%
Copernicus Services Hub	1.7	2.3	35%
All hubs	44.8	93.5	109%

Table 11: Volume disseminated per day during the last month of Y2016 and Y2017

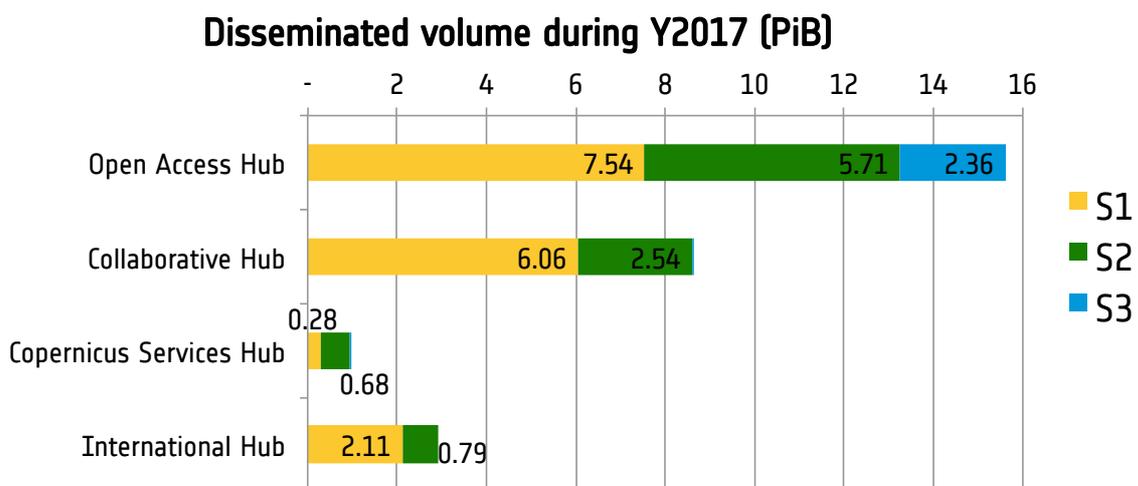


Figure 50: Disseminated volumes during Y2017 per hub and per mission

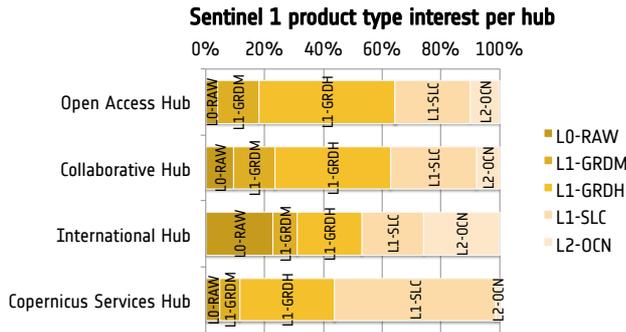


Figure 51: Dissemination percentages per hub and per product type for Sentinel-1

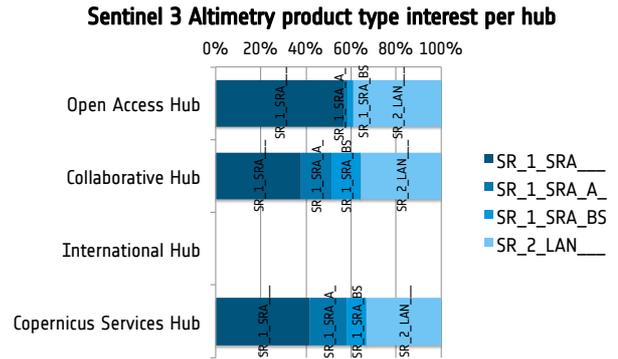


Figure 52: Dissemination percentages per hub and per altimetry product type for Sentinel-3

On the Copernicus Open Access Hub, Sentinel-1 and Sentinel-2 are the missions mostly downloaded (48% and 37% of downloads are respectively done on the Sentinel-1 and Sentinel-2 missions) while Sentinel-3 downloads, accounting for 15% of the overall products downloads during Y2017 on the Open Hub, are at a good starting point considering that it was in a preoperational phase for the majority of the period (the altimetry mission started the operational phase in October 2017).

On the other hand, an evident interest in one mission in particular can be deduced in other hubs: more than 70% of downloaded volume on the International and collaborative hubs was for Sentinel-1 and more than 70% of downloaded volume on the Copernicus Services Hub was for Sentinel-2 products.

Figure 50 above also highlights that the overall volume of downloads made on the International Hub and the Copernicus Services Hub is low compared to the volume of downloads made from the Copernicus Open Access Hub and the Collaborative Hub.

Looking at the breakdown of the disseminated number of Sentinel-1 products per products type on each hub in Figure 51, it can be seen that GRDH products were the most popular Sentinel-1 products for users of the Copernicus Open Access Hub (46%) and in Collaborative Hub (39%). Users of the International Hub showed more evenly distributed interest in the RAW, GRDH, SLC and OCN, with the highest interest in OCN (26%). SLC products are highly downloaded by the Copernicus Services Hub users (55%).

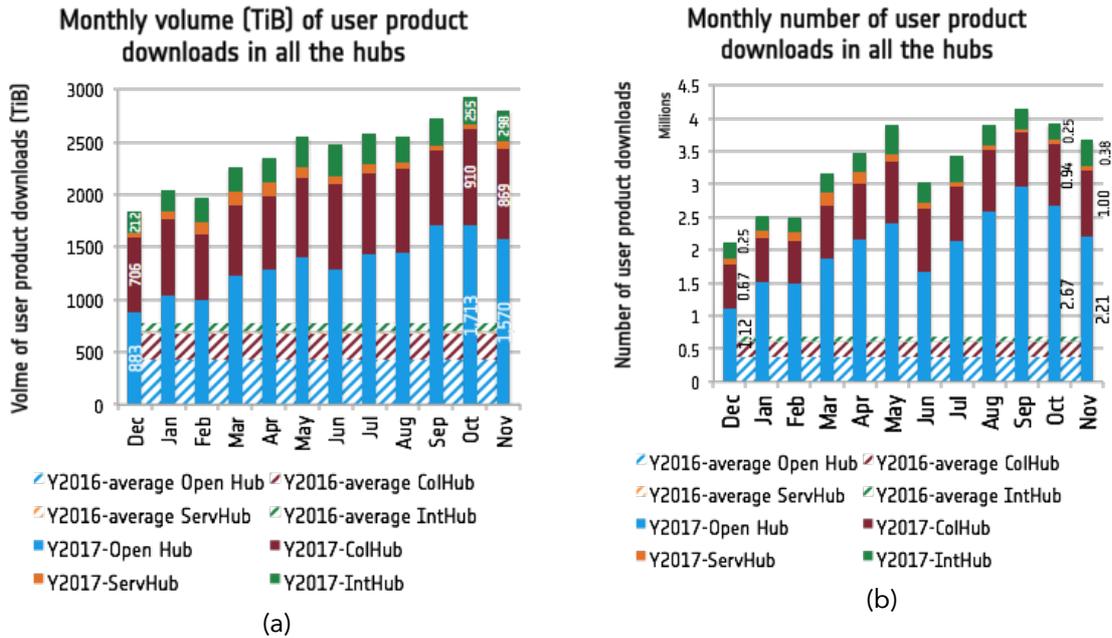


Figure 53: Dissemination volume and number trends per hub during Y2017 compared with the trends for Y2016

The breakdown of the disseminated number of Sentinel-3 Altimetry products per products type on each hub is shown in the Figure 52. It can be seen that "SR_1_SRA___" and "SR_2_LAN___" are the products type receiving mostly interest from the user community: more than 60% of Sentinel-3 downloads are for those two product types.

The graphs in Figure 53 above show the monthly volume (graph a) and number (graph b) of downloads made from each hub during Y2017, compared with the average monthly volume and number of downloads made on each hubs during Y2016. From those graphs, it can be seen that for the volume of downloads the general trend was an increase over the period on all the hubs. An exception was the Copernicus Services Hub, for which downloads rose and fell in number during the period with the most downloads between February and May.

From those graphs, it can be seen that the increase in the daily average volume of downloads announced in Table 11 was linear in months. Less visible but also impressive is how rapidly the volume of downloads on the Open Access Hub increased from November 2016 (505 TiB) to December 2016 (883 TiB). By the end of the reporting period the volume of downloads on the Open Hub had almost doubled, reaching an

average monthly volume of downloads of 1.53 PiB.

The increase of downloaded volume of products is less visible on the Collaborative and International Hubs: as shown on the graph above, the Collaborative downloaded volume went from 706 TiB in December 2016 to 869 TiB in November 2017; for the International Hub the monthly downloaded volume went from 212 TiB to 298 TiB at the end of the reporting period.

Despite the fact that the Data Access System reserved 2 nodes, one of them based on OpenStack storage, for the privileged access to the Collaborative Hub, the downloaded volume on this hub was more or less stable (the download volume increase between November 2017 and November 2016 was only 20%). This could be referred to the fact that, during the reporting period, there was no variation in product publication baseline until November (Sentinel-2B and Sentinel-3A SRAL products joined the Collaborative Data Hub on 30 October and 2 November respectively) and because, as described in section 1.2.1, the introduction of the Data Hub Relays in the Collaborative GS context played a support role for the dissemination of sentinel products toward National Mirrors, without impacting too much on the collaborative nodes.

2.3.4 Fresh vs Old Products

The overall download figures can be further broken down to analyse the average age of products in which users of each hub are most interested.

The scatter graphs below show per sentinel, the percentage of users downloads made in Y2017 per hub, differently coloured according a series of temporal ranges. The temporal ranges are the amount of time between the date on which the product was published on the hub and the date on which it was downloaded by users.

It should be noted that due to the rolling policy in force on the Collaborative and International Hubs there are no downloads for data older than 1 month.

The graphs in Figure 54 show that the majority of activity on the hubs during Y2017 was, with exception of Copernicus Open Access Hub, aimed at downloading freshly published products. In particular, 69% and 66% of Sentinel-1 product downloads, made on the Collaborative and International hubs respectively, were done up to only 2 days after they were published on the hub. However, there was still notable interest in the older Sentinel-1 data available: 12% of downloads on the Copernicus Open Access Hub and 13% of downloads done on the Copernicus Services Hub were more than 1 year old (in this latter hub, only the 16% of Sentinel-1 downloads were done within 2 days from publication).

An additional interesting aspect shown on the Sentinel-1 graph for the Copernicus Services Hub is the high percentage (57%) of products downloaded for data published between 1 month and 1 year before. Matching of this information with the high level of interest in SLC data demonstrated in the statistic of dissemination percentages per product type for Sentinel-1 (Figure 51), this may indicate the high interest in interferometry studies from Sentinel-1 that compare data from different epochs.

For Sentinel-2, a similar degree of interest in older products is visible: 20% of Sentinel-2 products

downloads made on the Copernicus Open Access Hub were done on products older than 1 month, on the Copernicus Services Hub in Y2017, such type of downloads constitutes the 37%, whereas the 79% of downloads made on the Open Hub and the 63% of downloads made on the Copernicus Services hub were of products up to 1 month. Less than 1% of users downloads are done after 1 year from the Sentinel-2 publication time on both Open Hub and Copernicus Services Hub, although it should be noted that there is also a relatively smaller set of Sentinel-2 mission data in this period, which were first made available on 02/12/2015.

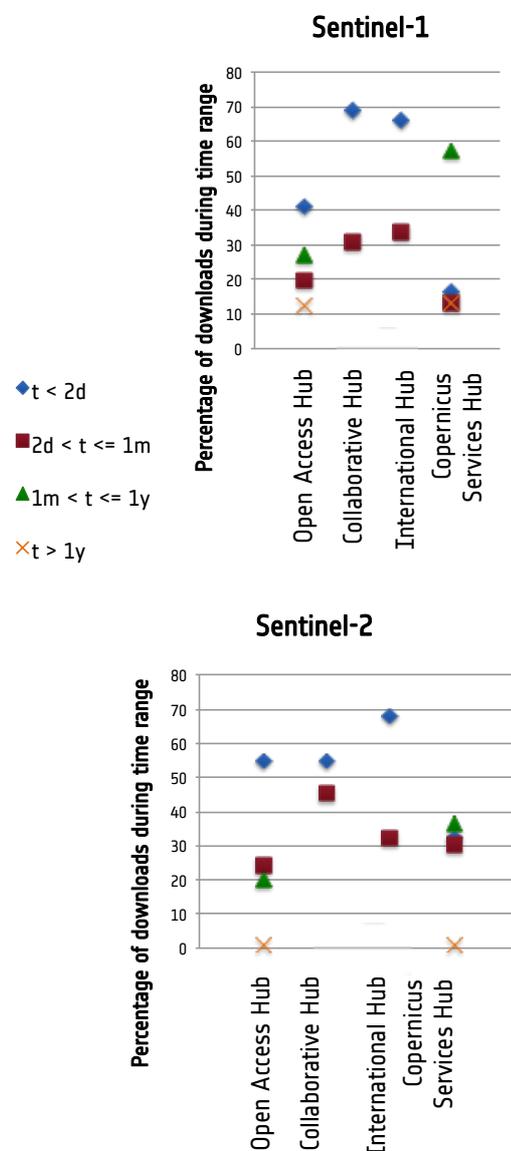


Figure 54: Percentage of user downloads made in different publication-download temporal ranges, per hub and for Sentinel-1 and Sentinel-2

2.3.5 Product component downloads

The data hubs support download of the components of a product via the OData API, allowing the extraction of one or more files of interest within the product package, avoiding the download of the full package in order to obtain them.

The statistics on these products component downloads are quite difficult to process because of the quantity of information, and they are not taken into account in the statistics provided above. However, two months of the reporting period were analysed in detail to provide an overview of the interest from users in component downloads. The months chosen for the analysis were July 2017 and November 2017.

The table below reports the number and volume of overall products component registered in July and November 2017.

Comparing this to the full product downloads for Sentinel-1 and Sentinel-2 done on the Open Hub during July and November 2017, there are roughly 4 times the number of component downloads made. The volume is clearly much less (since in most cases the component downloads are very small volume metadata files).

In November 2017, the components most downloaded (in terms of number) are reported in

the side graph and they correspond to the .gml (51%), .xml (26%) and .safe files (14%). The .gml files are typically the cloud mask information provided with the Sentinel-2 products. The .safe files are the manifest components of the data products, also containing metadata values. The .xml files are typically metadata files or annotation files. The latter two components downloads (.xml and .safe) are probably used by users to construct their own catalogues of Sentinel data and, indeed, as it is reported in the right side of the figure above, the most downloaded types of .xml file are MTD_MSIL1C.xml (38% of the overall xml downloaded files), MTD_TL.xml (28% of the overall xml downloaded files), [S1A_product_name].xml or [S1B_product_name].xml (14% for Sentinel-1A and 12% of Sentinel-1B products reaching the 26% of the overall xml downloaded files).

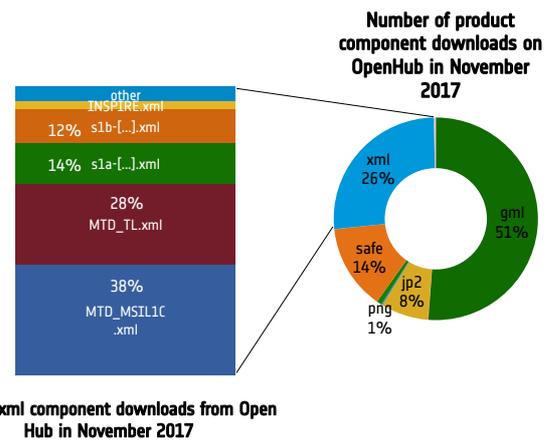


Figure 55: Number and type of component downloads made on the Open Hub in November 2017

Month	Number of full product downloads from OpenHub	Volume of full product downloads from OpenHub (TiB)	Number of products component downloads from OpenHub	Volume of products component downloads from OpenHub (TiB)
July 2017	965,184	1,004.44	4,357,562	3.89
November 2017	1,581,324	1,340.56	6,094,003	7.41

Table 12: Number and volume of overall products component downloads during July and November 2017

2.3.6 Partial content downloads

As part of the http standard, the data hubs also support download of “byte ranges” of a product via the OData API. This feature is used by internet browsers to pause and resume downloads and also by download manager tools to fetch products by chunks, downloading them in different temporary files and then joining them in the original order.

The volume of full completed downloads performed by chunks or pausing and resuming downloads are recorded by the monitoring system and added to the overall volume of successful full products downloads (as reported in section 2.3 above) but, in case the user interrupts the download at a certain point of the on-going download process (including cases in which the user decides to not resume the download after he switched off his computer, or in case there is a timeout setting on the client side), the monitoring systems does not record this event in the full product downloads statistic, even if this download is part of the outgoing volume successfully provided to users community.

In this section, two months have been analysed for the extraction of statistics on the volume of the users partial content downloads that have not been completed because the user voluntary stopped the download.

The ‘200’ code message is returned for each of the http download requests, including those done pausing and resuming the download, while the ‘206 partial content’ code is returned in case of chunked downloads (fulfilling a byte range download request). The volume of partial content downloads reported in this section contains both the collection of volume reported with the 206 and 200 codes.

The table below shows the volume of partial content downloads on the Open Hub registered by the system in July and November 2017; the difference between those two data represents the volume of downloads that started and than stopped by the client (the user voluntary stopped

the download process). The hubs taken into account for this analysis are the OpenHub nominal interfaces (graphical and API), excluding any preoperational hub.

Month	Volume of full products downloads [TiB]	Volume of partial content downloads [TiB]	Volume of user downloads refused by users [TiB]
Jul-17	1,004.44	1,120.93	116.49
Nov-17	1,340.56	1,435.47	94.91

Table 13: Volume of full, partial content and refused by users downloads on OpenHub nominal interfaces (graphical and API), excluding any preoperational hub

The following graphs report the detailed proportion of downloads returning the ‘200’ and ‘206’ codes during the months taken into account.

Assuming that the download manager tools (such as ‘Downthemall’ on Firefox) are the main contributors to the successful downloads returning the ‘206’ code, it can be derived that less 10% of downloads made on OpenHub in the analysed months were made using a download managers.

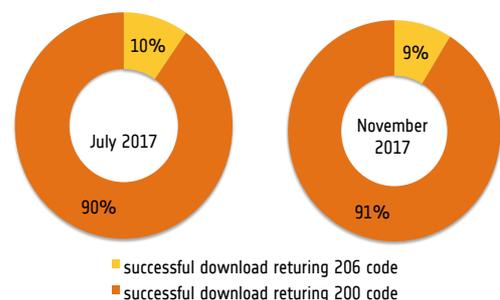


Figure 56: Pie charts showing a comparison of successful download returning 206 and 200 code, during July and November 2017

2.3.7 Copernicus Marine Environment Monitoring Service (CMEMS) dedicated access point

CMEMS: Monthly Published Products on the FTP Server

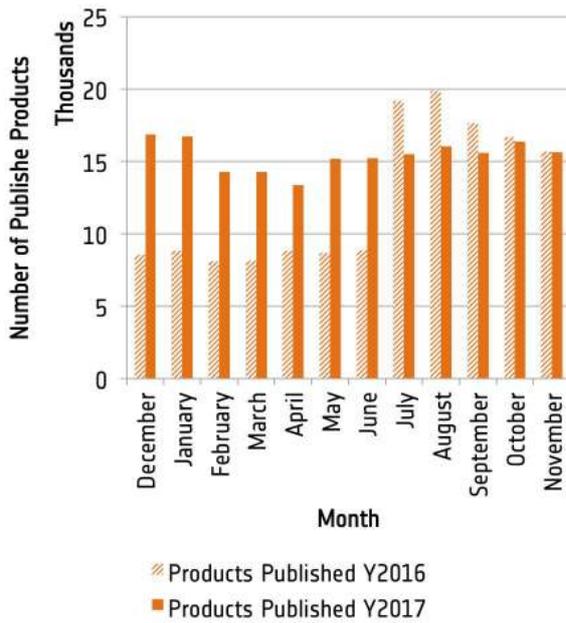


Figure 57: Monthly product numbers published on CMEMS FTP server for Y2017 and Y2016

CMEMS: Monthly Downloaded Products from FTP Server

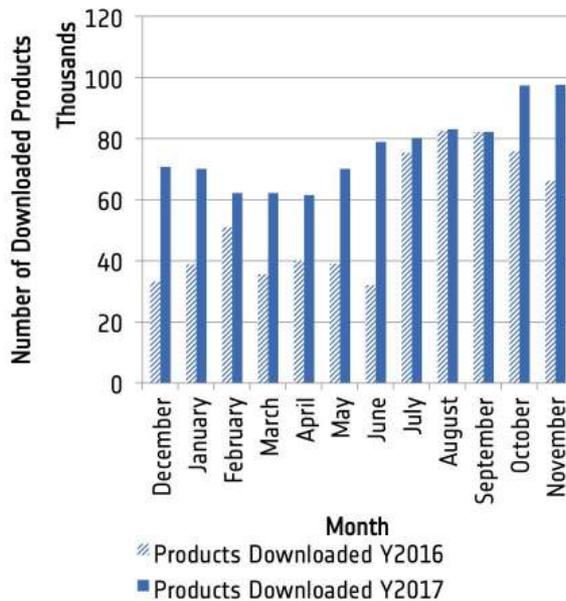


Figure 58: Monthly downloads from CMEMS FTP server for Y2017 and Y2016

Since the Commissioning Phase for Sentinel-1A, a dedicated dissemination point has been made available for the Copernicus Marine Environment Monitoring Service (CMEMS) to ensure delivery of the products to CMEMS with best timeliness right from the start of data dissemination activities. CMEMS established its operational interfaces around this dedicated access point (ftp server) and so the service has been maintained throughout the full Sentinel-1 operations. The ftp service has been available since 29 September 2014 and has been maintained throughout the data access operations. The products retrieved are NRT-3h and Fast-24h for both Sentinel-1A and Sentinel-1B.

During Y2017, a total of 184,981 Sentinel-1 products were published on the ftp server dedicated to the specific needs of CMEMS. This number represents a volume of 172 TiB and a 24.1% increase on the number of products published during Y2016. As multiple teams within CMEMS may access and download the same products, the statistics for products downloaded are higher than those for published products. In total 917,134 products were downloaded, representing a volume of 656 TiB and a 40.5% increase on Y2016.

The archive exploitation ratio for Y2017 was 1:5.0, a small increase on Y2016 (archive exploitation ratio 1:4.4)

The side graph below show monthly trends for the number of products published and downloaded. The monthly totals have been more stable during this period than for Y2016, and higher on average. In Y2016, the introduction of the nominal flow of Sentinel-1B products had a significant impact in the second half of the period, although the observed increase was also due to the seasonal time-windows of interest to CMEMS. A lesser such increase in downloads was also observed in the second half of Y2017. This may again be attributed to seasonal interest windows, particularly in sea-ice monitoring.

	Y2016	Y2017	%Difference
Average Number of Products Downloaded per Month	54,392	76,428	40.51
Total Number of Products Downloaded in Period	652,698	917,134	
Average Number of Products Published per Month	12,420	15,415	24.11
Total Number of Products Published in Period	149,042	184,981	

Table 14: CMEMS products publication and download trends between Y2016 and Y2017

2.3.8 Data Hub Relays

The Data flow of disseminated products from the Collaborative Data Hub to the Collaborative national Mirror sites is summarized in Figure 59. Disseminated data downloaded directly by ESA Nodes are then exchanged among Relays and relayed to National Mirrors.

The Data Hub Relays (DHR) network, previously introduced in section 1.2.1, was initially set up late in 2016 with a set of 5 Relays, gradually becoming operational during Y2017. These DHRs are operated by MET-NO, DLR, AIRBUS, STFC, CLS. A further DHR, operated by ZAMG, joined the Network in 2017, becoming fully operational by September.

During the reporting period, the arrival of the Sentinel-2B and Sentinel-3A missions in operations increased the need to establish new dissemination rules between the DHR nodes and a new DHR network test campaign was announced, with the aim to reduce the load on ESA core centre nodes.

Improvements to the DHuS software, based on the tests outcomes, have been implemented and the DHR Network, constituted by all of 6 Relays, has demonstrated the importance of having alternative product sources in support to ESA source nodes for the dissemination of Sentinel products towards the collaborative GS.

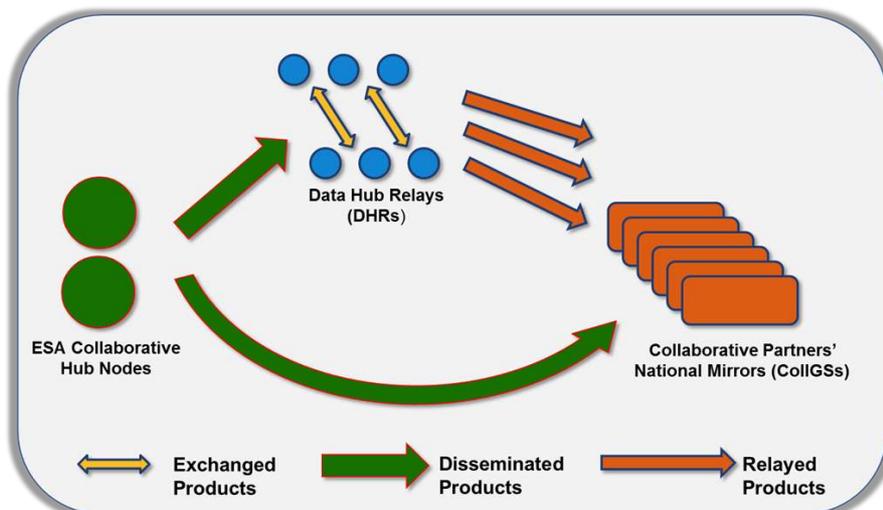


Figure 59: Schematic showing general data flow of products from the Collaborative Data Hub to the Collaborative National Mirrors, highlighting the terminology used

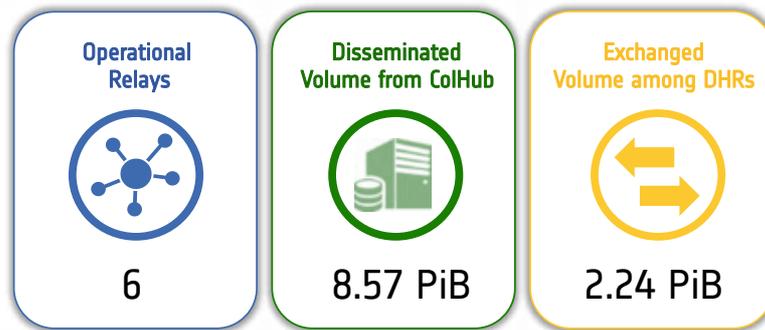


Figure 60: Overall Data Hub Relay statistics for Y2017

During Y2017, the statistics reported in Figure 60 above have been collected. The overall disseminated volume from the Collaborative Data Hub toward the collaborative GS users and Data Hub Relays is 8.57 PiB for a total of 9,789,269 products disseminated. In further detail, 47% of the downloaded volume was disseminated directly to collaborative GS partners and the residual 53% (4.56 PiB) from Data Hub Relays.

The products disseminated to a Data Hub Relay are in turn relayed to the collaborative GS users so, the 2,100,055 products exchanged among DHRs, having a volume of 2.24 PiB, constitutes the 21% of the overall volume the collaborative GS users retrieved from the overall Data Hub Relay Network including ColHub nodes. This percentage is an indication on how the load on the ColHub Node was reduced with the introduction of Data Hub Relays.

The figure below shows the monthly volumes of disseminated products from ColHub nodes to the collaborative GSs (blue columns), from ColHub nodes to DHRs (in orange) and the exchanged volumes among DHRs (in grey columns). Considering that the collaborative GS users are the final recipients of products disseminated and exchanged by DHR, the total volumes depicted in the graph below shows an increase of in the demand of products by CollGSs: from December 2016 to November 2017, the monthly amount of products disseminated and exchanged among DHRs increased by 103%, from 0.70 PiB to 1.42 PiB.

In December 2016, 47% and 51% of the entire volume was disseminated respectively to CollGSs and DHRs from ColHub Nodes, whereas only 2%

was exchanged among DHRs. Following full setup and configuration of the DHR Network, the percentage of exchanged volumes increased significantly: in November 2017, the products disseminated from ColHub nodes directly to CollGSs was 19%, 40% was the percentage of disseminated products to DHRs and 41% was the percentage of products exchanged among Relays (596 TiB).

The amount of data exchanged among DHRs has been increasing throughout the reference period: during the first quarter of the year the number of products exchanged among DHRs was about 116K; by the end of reference period (the last 3 months) the exchange data reached 1 million products. In terms of volumes, the amount of exchanged data was 66 TiB during the first quarter of the year, reaching 1.3 PiBs when all 6 relays become operative (last 3 months of reference period).

This behaviour shows how the number of exchanged products increased month by month and demonstrates that Relays can fulfil an important role as alternative product sources in support to ESA source nodes within the Collaborative hub.

In terms of Network configuration, the best example of collaboration between nodes is identified by the two DLR-MET-NO nodes. They guaranteed a solid connection, reliability and publication timeliness and act as alternative product sources nodes: DLR for S2 mission and MET-NO for S1. They began to exchange data to and from other Relays reaching the following results: in the last 3 months of Y2017, DLR

exchanged 26% of total exchanged volumes and

MET-NO 62%.

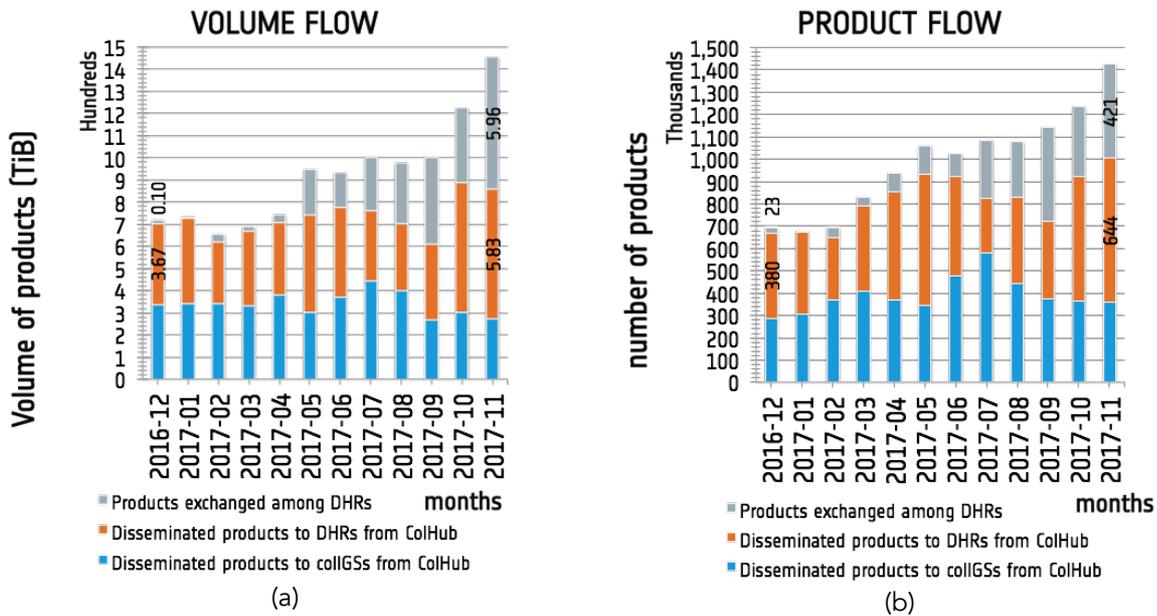


Figure 61: Data Hub Relay a) Monthly volumes and b) Monthly number of products

3 User Activity

3.1 Active Users

For the purposes of this analysis, an ‘active user’ is defined as one who is both registered and who has performed at least one complete download within the current reporting period. However, users who did not perform a complete download were not necessarily ‘inactive’: if a user chooses to extract only a specific granule or tile from a product, this is not counted by the system as a complete download and hence users who only made partial downloads would not be classed as active users. In addition, users may have downloaded only product metadata from the Sentinel archive, for instance to create an independent catalogue for future use. Section 2.3.6 can be referred to for more information on ‘partial content downloads’.

For each of the four Hubs, the total number of active users, together with this figure as a percentage of each Hub’s total number of registered users, is presented in the figure below. There is clearly a great variation in these figures and this reflects the different use constraints of the

Hubs. For example, given that the Collaborative and International Hubs were established for the use of national institutions, with each partner institution using only one user account, it was expected each of these partners would use their accounts during the period, and this is shown to be the case. It is noted that the only 90% of Collaborative users are classed as active, which is due to two new CollIGSs arriving late in the reporting period: Ireland and Belgium. They have been provided with accounts but are setting-up and have yet to commence downloads.

At the other end of the scale, the Copernicus Open Access Hub is open worldwide to anyone who wishes to register an account. It therefore has far more registered users and - as expected - a lower percentage of active users - 31% this period. Possible reasons for this can easily be conjectured: ‘historical’ users who were only active in previous periods, users only performing partial products downloads, users who have used their accounts only to explore product availability and extract information from metadata. In any case, the percentage of active users this period has increased to 31% from 26% in Y2016, even as the number of registered users has more than doubled (109,475 at the end of Y2017, up from 52,318 at the end of Y2016).

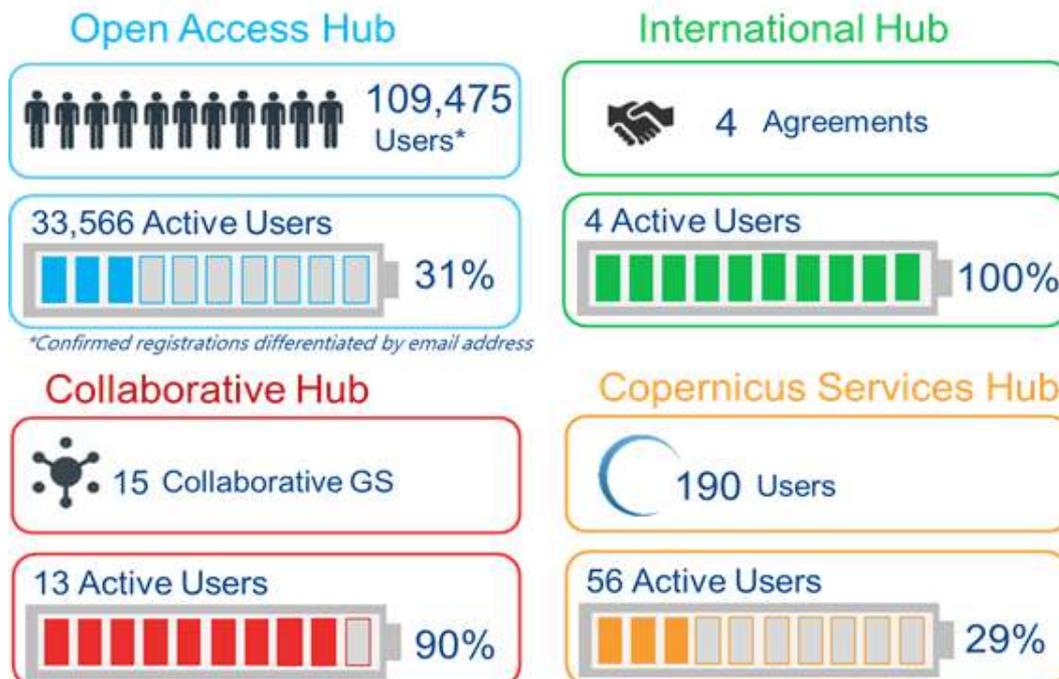


Figure 62: Active users in Y2017, per hub

3.2 User downloads profile

This section examines the distribution of user downloads across each of the Hubs and for all active Sentinels during Y2017.

Figure 63 shows, for each Hub and each Sentinel, the download ranges observed amongst the active users for the Y2017 period. The trend is similar to that observed in Y2016 and is generally as expected. For the ColHub and IntHub, almost all active users are downloading >1,000 products; it is assumed that such users would routinely retrieve all, or the majority of, the published products. The trend is reversed for the Open Access Hub: the vast majority of users downloaded 1-9 products during the period, with progressively fewer in the higher ranges. However, as APIHub statistics are

included within the Open Access Hub, this category also includes some users who autonomously retrieve much larger numbers of products. In fact, although a negligible proportion with respect to the numbers of users in the lowest range, the Open Access Hub had far more users retrieving >1,000 products than any other hub: 392 users for Sentinel-1 and 341 users for Sentinel-2.

As in Y2016, the ServHub displayed the most variety amongst the ranges with, for example, as many users downloading 1-9 Sentinel-1 products as there were downloading >1,000. This is explained by the differing needs amongst the Services: whereas some, such as security and emergency services, may only need a few very specific products related to precise locations and time windows, others may require the routine and continuous monitoring of large areas of interest.

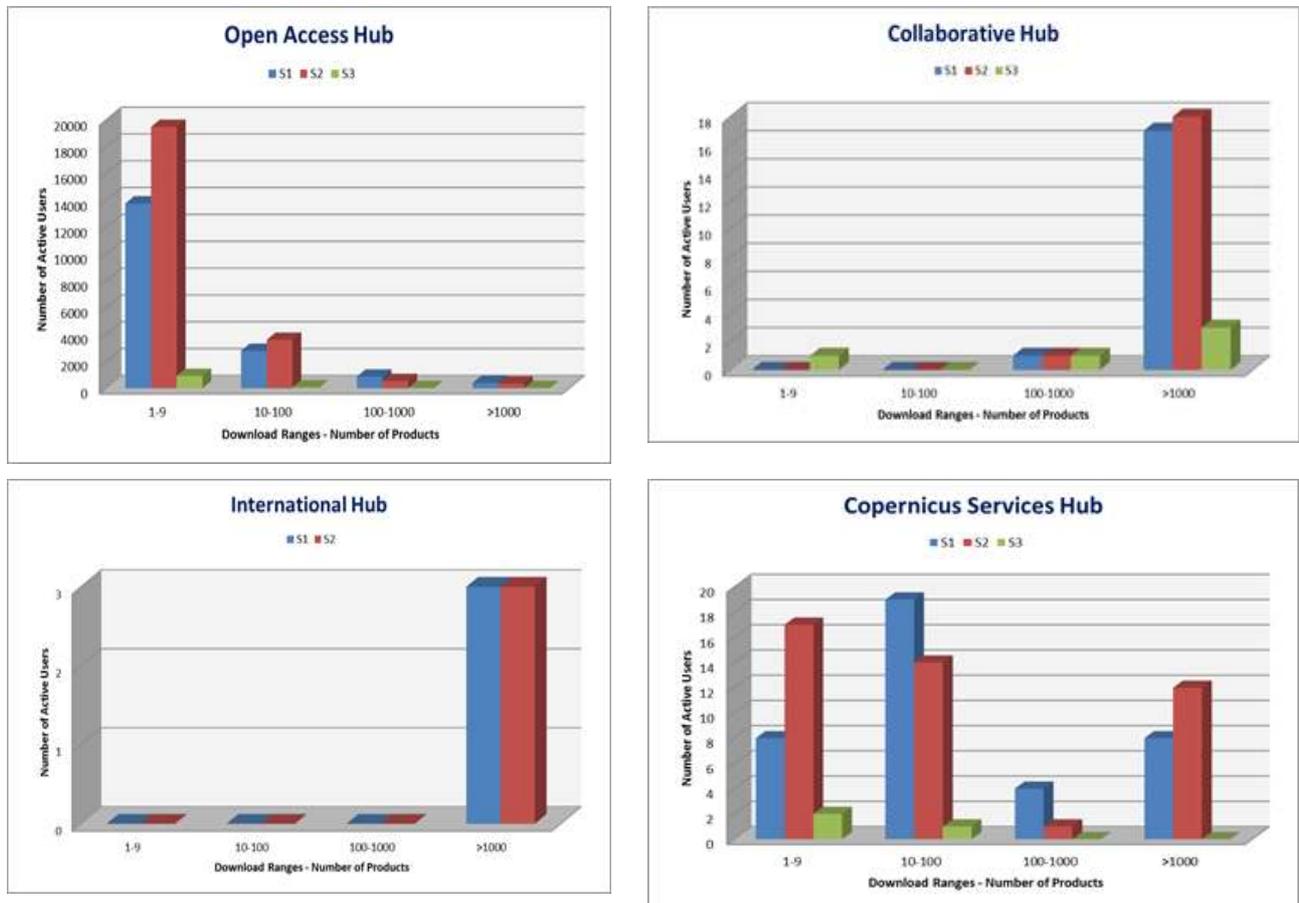


Figure 63: User download profiles, per hub

Hub	Sentinel-1			Sentinel-2			Sentinel-3
	Y2016	Y2017	% diff	Y2016	Y2017	% diff	Y2017
Open Access Hub	111	306	275	58	467	806	7,929
Collaborative Hub	104,069	216,607	208	37,372	310,203	830	3,803
International Hub	258,447	560,964	217	272,528	640,935	235	N/A
Copernicus Services Hub	806	2,955	367	3,398	25,755	758	4

Table 15: Average downloads per user in Y2016 and Y2016, per hub and per mission

Table 15 presents a summary of the average number of downloads per user, for all available missions on each Hub. It also provides, for Sentinels-1 and -2, the corresponding figures for Y2016, as well as the percentage increase between the two periods. Such a comparison is not given for Sentinel-3 due to the fact that products only became available late in Y2016 on Open Hub and in October 2017 (only SRAL instrument) on other hubs and do not represent a full year of downloads.

Not only has the number of registered users increased significantly in Y2017 but the table clearly shows that the number of downloads per user has seen a huge rise too. In all cases – for all Hubs and both Sentinels 1 and 2 – this rise is greater than 200%, with increases over 800% observed for S-2 products on the Open Access and Collaborative Hubs. Such increases are

expected as S-2A products became progressively more available throughout the year, but are surely also due to interest spreading about S-2 imagery around the globe. As for Y2016, it is seen that both ColHub and IntHub active users are using their accounts to download a high proportion of published products. It is interesting to note that the number of S-3 products downloaded per user via the Open Access Hub far exceeds that for S-1 and S-2, at almost 8,000. This may be attributed to the fact that S-3 products were only available from the Sentinel-3 Pre-Ops Hub (included in the Open Hub stats) until October 2017, meaning both institutional and active users accessed their products from this point - and many of these accessed via shared guest accounts - as well the fact that Sentinel-3 products tend to be of more specialist interest. From October 2017, Sentinel-3 SRAL (topographic) products have been available directly from the Open Hub.

Monthly number of active users on Copernicus Open Access Hub during Y2017

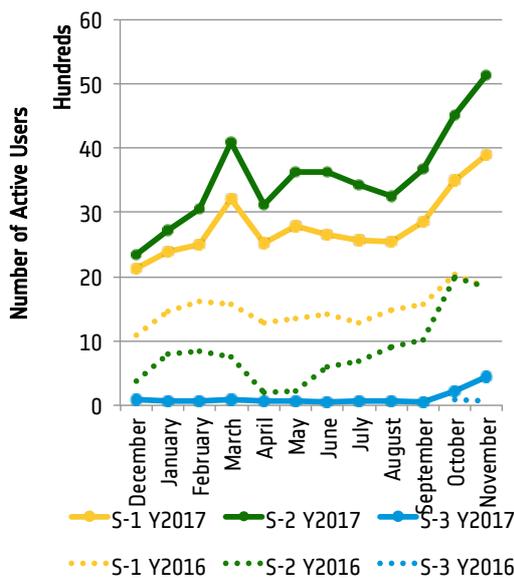


Figure 64: Active user trend per mission in Y2016 and Y2017

3.3 Open Access Hub Active users focus

3.3.1 Monthly Active Users

The graph in Figure 64 shows the number of active users on the Copernicus Open Access Hub on a monthly basis throughout Y2017 and for each Sentinel mission (i.e. the number of users that downloaded at least one product for one of the Sentinels in the particular month). An 'active user' is defined strictly on the basis of downloads and

Continent	Y2016	Overall % Y2016	Y2017	Overall % Y2017	% Increase Y2016-Y2017
Europe	7,366	53.3	14,970	44.6	103
Asia	2,497	18.1	6,710	20.0	169
North America	1,624	11.7	4,074	12.1	151
South America + Antarctica	1,625	11.8	5,776	17.2	255
Africa	473	3.4	1,422	4.2	201
Oceania	238	1.7	639	1.9	168

Table 16: Open Access Hub active users for Y2016 and Y2016, per continent



does not include those users who only logged into their accounts or performed searches via the GUI: any user who made at least one complete download during the month is defined as 'active'. For comparison, the graph also shows the equivalent plots for Y2016. It should be noted that records for Sentinel-3 active users only began in October 2017 with SRAL instrument.

It can be observed that the number of active users is far higher in Y2017 than in Y2016, for all months and for all Sentinels. The growth is in the region of 1,000 additional active users each month for Sentinel-1, though this is surpassed by Sentinel-2, which had an additional 2,000-3,000 users per month. The growth can be attributed to the evolutions made during Y2017 – the growth of the data offer and the scalability evolutions made at the end of Y2016 – but also to a growing global awareness of the Copernicus missions and their products (see next section). Rapid growth in users for Sentinel-2, in particular, took place following the start of dissemination of single-tile products in September 2016, which made products easier to both select and download. Since that point, the number of active users for Sentinel-2 has surpassed those for Sentinel-1, with the difference remaining reasonably constant throughout the period at around 750 additional users. It is also observed that the number of active users for Sentinel-1 and Sentinel-2 followed a very similar trend throughout Y2017, both exhibiting a spike in usage in March - presumably due to the launch of S-2B - and strong growth towards the end of the period.

Sentinel-3 has followed a different path. Products were only available on the Pre-Ops Hub for the majority of the period, with most users using a common guest account leading to fewer active users being recorded than was actually the case. This also explains why these active 'users' were responsible for downloading large numbers of products. Since the move of SRAL products to routine operations in October 2017, the number of Sentinel-3 active users has, as expected, exhibited a strong upward trend given that active users are now required to use personal accounts.

3.3.2 Active users per continent and country

Table 16 shows the number of active users on the Open Access Hub broken down by continent for Y2016 and Y2017. It also shows the overall percentage contribution of each continent for both period and the percentage increase between Y2016 and Y2017. The graph in Figure 65 highlights this growth in active users on all continents and also includes Y2015 for comparison.

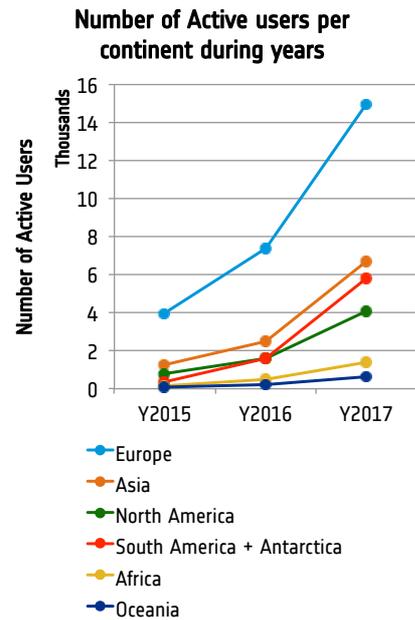


Figure 65: Open Access Hub active users trend from Y2015-Y2017, per continent

All continents experienced strong growth during Y2017. South America exhibited the strongest growth, at 255%, and now has significantly more active users than North America. In terms of overall percentages, Europe still dominates with a 44.6% share of the users. These figures highlight the growing awareness and use of Copernicus services around the world. It should be noted, however, that Europe still has more than double the number of users than any other continent (the closest being Asia). Also, it should be stressed that Europe and North America have national mirrors available as an alternative source of products; the continents which displayed the strongest percentage growth on the Open Hub may indicate that there are fewer alternatives available.

The tables below provide a further breakdown of the Open Hub active users, this time on the basis of country. The 'Top 10' active user countries are provided for all three Sentinels, as well as on a global and European (specifically ESA/EU states) basis. The number of active users is provided as well as the percentage increase since Y2016 and the change in ranking of that country.

The tables reflect the findings on a continental level: although European countries dominate, non-European countries made the largest increases and are moving up the rankings. The dominant country overall is Germany, which came top on a Global basis for Sentinel-1 and Sentinel-2 and second for Sentinel-3. Outside Europe, the country with the largest rise in the rankings overall

is China: now 2nd for Sentinel-1 (up 3), 7th for Sentinel-2 (up 8) and 3rd for Sentinel-3 (up 14). Within Europe there has been less change from Y2016, with countries generally remaining in the same position or rising/falling one place. For Sentinel-2 the changes were larger, although this was from a very low user base in Y2016. The largest change is Greece for Sentinel-1 data, up 5 places to 8th position.

All countries in the lists exhibited percentage increases from Y2016. As expected, these were smallest for Sentinel-1 (increases in the range 30-200%), higher for Sentinel-2 (in the range 150-750%) and greatest for Sentinel-3 (increases often above 1,000%, although again, this was from a low starting point).

Sentinel-1 - Global			
Country	Active Users Y2017	% increase from Y2016	Change
Germany	1404	68	0
China	1262	137	^3
United States	977	57	^1
United Kingdom	949	53	∇1
Italy	834	30	∇3
India	646	155	^5
France	592	51	0
Spain	546	81	0
Brazil	533	25	∇3
Colombia	520	189	^5

Table 17: Y2017 Top 10 global countries: Sentinel-1

Sentinel-2 - Global			
Country	Active Users Y2017	% increase from Y2016	Change
Germany	1883	145	0
United States	1218	196	^1
Italy	1170	157	∇1
Spain	1098	222	^1
United Kingdom	1054	172	∇1
Mexico	947	511	^4
China	912	566	^8
Peru	896	745	^11
Colombia	885	475	^2
France	808	203	∇4

Table 18: Y2017 Top 10 global countries: Sentinel-2

Sentinel-3 - Global			
Country	Active Users Y2017	% increase from Y2016	Change
Italy	74	393	^2
Germany	72	279	0
China	57	2750	^14
France	53	1225	√3
United States	45	1400	^11
Spain	45	463	√2
United Kingdom	45	80	√6
Russian Federation	40	1233	^7
India	35	N/A	N/A
Brazil	33	N/A	N/A

Table 19: Y2017 Top 10 global countries: Sentinel-3

Sentinel-1 - ESA/EC			
Country	Active Users Y2017	% increase from Y2016	Change
Germany	1404	68	0
United Kingdom	949	53	^1
Italy	834	30	√1
France	592	51	0
Spain	546	81	0
Poland	480	95	0
Netherlands	347	52	0
Greece	246	132	^5
Romania	210	69	^1
Portugal	191	54	√1

Table 20: Y2017 Top 10 ESA/EC countries: Sentinel-1

Sentinel-2 - ESA/EC			
Country	Active Users Y2017	% increase from Y2016	Change
Germany	1883	145	0
Italy	1170	157	0
Spain	1098	222	^1
United Kingdom	1054	172	√1
France	808	203	0
Poland	519	179	^1
Netherlands	446	117	√1
Portugal	364	219	0
Greece	356	296	^1
Romania	291	273	^3

Table 21: Y2017 Top 10 ESA/EC countries: Sentinel-2

Sentinel-3 - ESA/EC			
Country	Active Users Y2017	% Increase from Y2016	Change
Italy	74	393	^2
Germany	72	279	0
France	53	1225	^4
Spain	45	463	0
United Kingdom	45	80	∇4
Poland	28	600	^1
Netherlands	26	767	^4
Greece	22	450	∇1
Portugal	17	467	^2
Romania	13	225	∇3

Table 22: Y2017 Top 10 ESA/EC countries: Sentinel-3

3.3.3 Users per declared uses and thematic domains

The registration phase includes the collection of user information (e.g. user country, thematic domain and usage type) selected by the user from a set of predefined lists. There is no active verification of the information entered, so the statistics presented here rely on the self-registered data. The information provided by users registered on the Open Access Hub since the beginning of the operations until the end of the reporting period has been analysed and reported.

This section discusses the uses for which products downloaded via the Open Hub are intended and the overall domains into which users fall. It is stressed that this information is requested from users upon registration and may therefore be limited in several ways: there is no independent verification performed and only one domain and one usage may be selected by users from the choices available, meaning that information is lost regarding users with multiple domains/usages. Additionally no further information is obtained from users selecting 'Other' options. Even so, the information collected does serve to provide a broad overview of how products are used.

Figure 66 below summarizes the data for usage type. On the left, it shows the split of users between the four available choices: Research, Education, Commercial and Other. On the right, the figure shows the percentage split amongst downloads, per usage type and between Sentinel-1 and Sentinel-2. Nearly 90% of users fall into the categories of Research (51%) and Education (38%), with only 5% using the data for purely Commercial purposes. This is an almost identical split to that recorded in Y2016. In terms of downloads, Research is again the largest category, accounting for 43%. However, Commercial accounts for a much larger proportion than Education, 31% against 6%. This is similar to Y2017, although in the current period Sentinel-2 accounts for most downloads in all categories except Education; in Y2016 Sentinel-1 downloads were dominant in all cases. Sentinel-2 'Other' downloads, on which no further information is available, account for 19% of all downloads.

Figures 67 summarizes the Y2017 data for the seven thematic domains in the same way as for usage types, above. By far the largest domain continues to be Land, accounting for 63% of users. Next are 'Other' at 13% and Climate with 8%. As for usage types, there have been very little change since Y2016. As for Y2016, the three largest categories for downloads continue to be Land, Atmosphere and Other, however the other category now dominates, at nearly 37% of downloads (4.5 from Sentinel-1 and 32.3% from Sentinel-2).

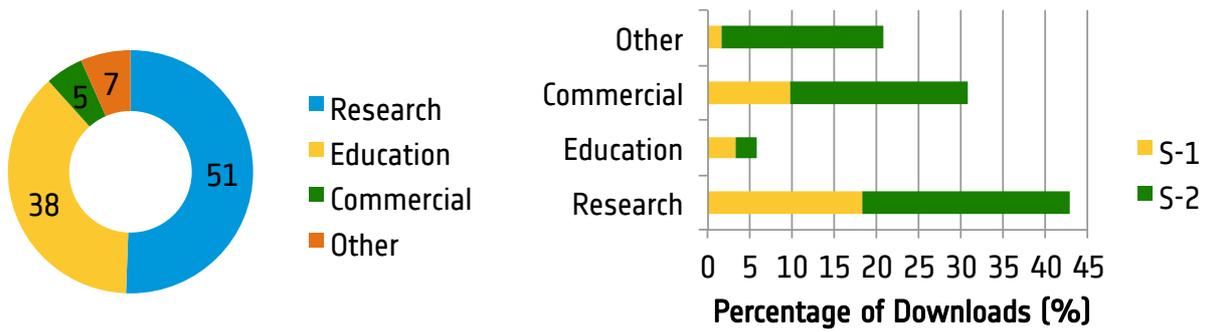


Figure 66: Percentage of Copernicus Open Access Hub users per declared usage type at the end of Y2017, and the percentage of downloads performed for Sentinel-1 and Sentinel-2 for each usage type during Y2017

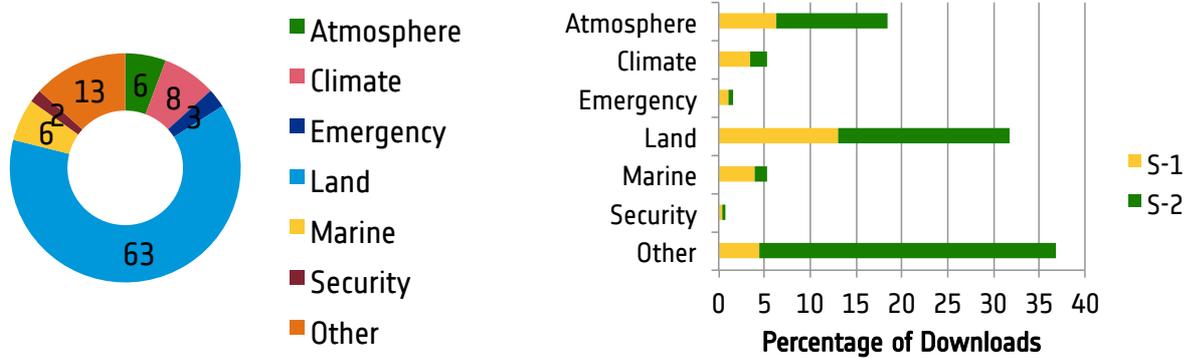


Figure 67: Percentage of Copernicus Open Access Hub users per declared thematic domain at the end of Y2017, and the percentage of downloads performed for Sentinel-1 and Sentinel-2 for each thematic domain during Y2017

4 Data Dissemination Partners

In addition to the ESA-provided Copernicus Hubs detailed in this report, online access to Sentinel data products is also available through a number of re-distributors. These include the National Mirror Sites (provided in the framework of the collaborative ground segment), the sites provided Internal Partners (provided in the framework of international agreements) and various other providers of commercial and non-commercial

services. Sentinel re-distributors which are known and currently operational are listed in Table 23 below. Note that the list may not be comprehensive and the content of each site is outside the responsibility of ESA and Serco consortium.

It should be noted all third party providers follow their own particular strategy on which Sentinel products to provide and for how long they are made available, from a complete mirroring of all available Sentinel products to very specific subset of product types and/or coverages of particular geographical regions. The objectives of each site are not detailed here but the reader may investigate each via the URLs provided.

Category	Annual Report Section	Partner	Access URL(s)	Additional Description
Collaborative National Mirror Sites	4.1	Austria	https://data.sentinel.zamg.ac.at	
		Canada	ftp://ftp.neodf.nrcan.gc.ca	
		Finland	https://finhub.nsdsc.fmi.fi	
		France	https://peps.cnes.fr	
		Germany	https://code-de.org/	
		Greece	https://sentinels.space.noa.gr	
		Italy	http://collaborative.mt.asi.it/	
		Norway	https://colhub.met.no	
		Portugal	https://ipsentinel.ipma.pt/	
		Sweden	https://swea.rymdstyrelsen.se/portal/	
		UK-1	http://www.ceda.ac.uk/	
UK-2	http://sedas.satapps.org/ https://geobrowser.satapps.org/			
International Partners' Sites	4.2	Geoscience Australia (GA)	http://www.copernicus.gov.au/ https://vertex.daac.asf.alaska.edu	Copernicus Australia
		NASA	https://oceancolor.gsfc.nasa.gov	Alaska Satellite Facility NASA OceanColor Web
			https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/	Level-1 and Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center
		NOAA	https://coastwatch.noaa.gov	NOAA Coastwatch
		USGS	https://eros.usgs.gov/sentinel-2	USGS Earth Resources Observation and Science (EROS) Center
Other Third Party Sites	Not further detailed in this report	EUMETSAT	https://coda.eumetsat.int/	Copernicus Online Data Access (CODA)
		Google	https://cloud.google.com/storage/docs/public-datasets/sentinel-2	Google Cloud - Sentinel-2 Data
		Amazon	http://sentinel-pds.s3-website.eu-central-1.amazonaws.com/image-browser/	Sentinel on AWS
			http://sentinel-pds.s3-website.eu-central-1.amazonaws.com/	
		Planet	https://www.planet.com/pulse/sentinel-2-and-landsat-8-data-now-available-on-the-planet-platform/	
		CloudFerro sp	http://www.cloudferro.com/en/eocloud/	EO Cloud Portal

Table 23: Sentinel Data Dissemination Partners

4.1 Collaborative Ground Segment Agreements

Copernicus Participating States are complementing the exploitation of the Sentinel missions and supporting the redistribution of Sentinel data products by establishing additional data access points (mirror sites) and, in some cases, developing new products. These are the users of the Collaborative Hub (ColHub) described in this report and their national mirror sites are part of the expanding network known as the Collaborative Ground Segment.

A total of 14 Collaborative Ground Segment agreements have been signed with ESA up to the end of the Y2017 reporting period. Following signature and formal agreement, ESA provides a dedicated set of credentials to the national contact point for accessing the Collaborative Hub.

The Collaborative Ground Segment partners replied to an annual questionnaire requested by ESA on the retrieval and use of Sentinel data on their national mirror sites. Not all of the national services planned under the Collaborative agreements were operational by the end of Y2017. The statistics presented in this section are based on the 9 partners who both had active national initiatives during Y2017 and who provided the requested information.

During Y2017, a total of almost 2,000 TB of data was reported as distributed to end users via the national mirrors. This a 255% increase from the volume distributed during Y2016.

Table 24 summarises the status of the 14 current Collaborative Ground Segment agreements, listed in order of the date on which the agreement was signed with ESA. It is noted that the UK's Collaborative Ground Segment consists of two mirror site initiatives: UK-1 indicates the site operated for the academic community; UK-2 indicates the site operated independently and aimed at commercial users.

By the end of the reporting period, 80% of the Collaborative Ground Segment partners had opened their national mirror sites. Of these, two (Germany and Portugal) opened their sites during the reporting period; the others had previously opened their sites during Y2016 and Y2015. The partners who had not opened their sites by the end of Y2017 are provisionally scheduled to become operational during Y2018. Of the sites already opened in Y2016, an impressive average increase in user growth and publication and download volumes has been reported for Y2017:

- Average growth in registered users: 80%
- Average growth in publication volume: 189%
- Average growth in dissemination volume: 463%

Progressive Number	CollGS Partner	CollGS Agreement Signature Date	Opened Mirror Site (yes/no)	Operation start date
1	Greece	May-14	yes	06-Feb-15
2	Norway	Sep-14	yes	18-Oct-16
3	Italy	Oct-14	yes	28-May-16
4	Germany	Nov-14	yes	07-Mar-17
5	Finland	Jan-15	yes	24-May-16
6	UK-1	Mar-15	yes	01-May-15
	UK-2	Mar-15	yes	09-Sep-16
7	France	Mar-15	yes	12-Sep-15
8	Sweden	Jun-15	yes	Apr-16
9	Canada	Sep-15	yes	22-Sep-15
10	Portugal	Oct-15	yes	24-Feb-17
11	Austria	Feb-16	yes	31-May-16
12	Estonia	Sep-16	no	N/A
13	Belgium	Sep-17	no (Scheduled Mar-18)	N/A
14	Ireland	Oct-17	no	N/A

Table 24: Collaborative Ground Segment mirror sites summary

CollGS Partner	Overall Number of Registered Users since Start of Operations	% Increase since Y2016	% of Registered Users from the National Country	Number of Active Users in Y2017	% of Registered Users who were Active in Y2017
France	2476	93%	55%	1411	57%
Austria	1159	34%	82%	127	11%
Germany	659	N/A	81%	659	100%
UK-2	542	221%	56%	228	42%
Greece	494	30%	72%	85	17%
Portugal	360	N/A	-	326	91%
Norway	319	195%	-	40	13%
Finland	195	34%	75%	31	16%
UK-1	109	63%	79%	55	50%
Italy	29	38%	-	12	41%
Canada	11	10%	100%	7	64%
Sweden	-	-	-	160	-

Table 25: Summary of national mirror site users

Table 25 presents the data on the registered and active users on the national mirror sites, as reported in the provided annual questionnaires. On this and subsequent tables in the section, statistics are only shown for the CollGS partners who provided it, and where partial information was provided the statistics not available are shown as ‘-’.

All countries recorded an increase in the number of registered users compared with Y2016, ranging from 10% for Canada to 221% for UK-2, and between 30-40% in the majority of cases. The level of activity of users with respect to those registered

varies greatly, ranging from 100% in the case of Germany to 11% and 13% for Austria and Norway respectively. In most reported cases, the number of registered users from the country hosting the national mirror made up the majority: over 70% in all cases except France (55%) and UK-2 (56%) and, in the case of Canada, 100%.

In line with the reporting agreement, the Collaborative Ground Segment partners categories their own users according to the same fields used by ESA. The tables below show the percentage of registered users from each national mirror assigned to both ‘usage category’

(research, commercial, education, other) and 'usage field' (specific field for which the data is used e.g. land).

For the usage category, 'research' is generally the most popular choice, accounting for an average of 48% of all users; it is also the top category for 6 national mirrors, and accounts for over 50% of the users from Canada, Finland, France, Greece and UK-2. 'Education' accounts for an average of 19% of users, including about 30% of users from Norway and Austria. 'Commercial' accounts for an average of 9% of users, with the highest proportion from Norway (18%), followed by UK-2 (22%) and Finland (12%).

In terms of usage field, 'land' is the top choice: it accounts for an average of 50% of users, and over 50% in Austria, France and Finland. 'Marine' and 'atmosphere' account for 7% and 6% respectively, with 'marine' also making up 100% of the 11 Canadian users. 'Emergency' and 'security' have the fewest users: only 2% of users on average are registered to each of these fields. Other points of interest include the 25% of Greek users registered with 'atmosphere' and the 63% of German users who are uncategorized and classed under 'other'.

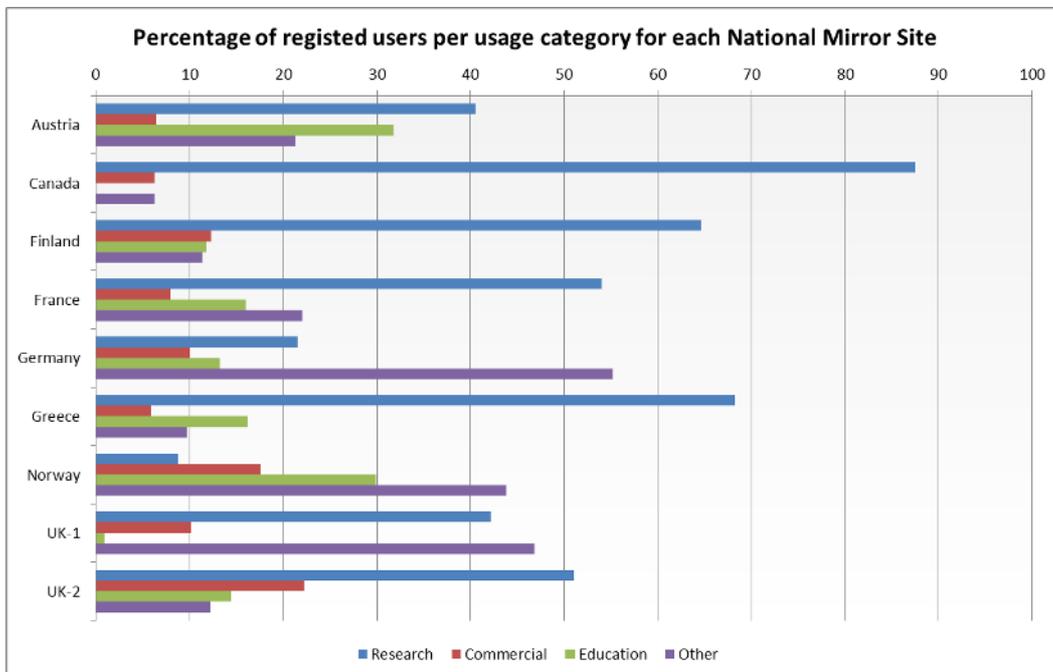


Figure 68: Percentage distribution of mirror site users by usage category

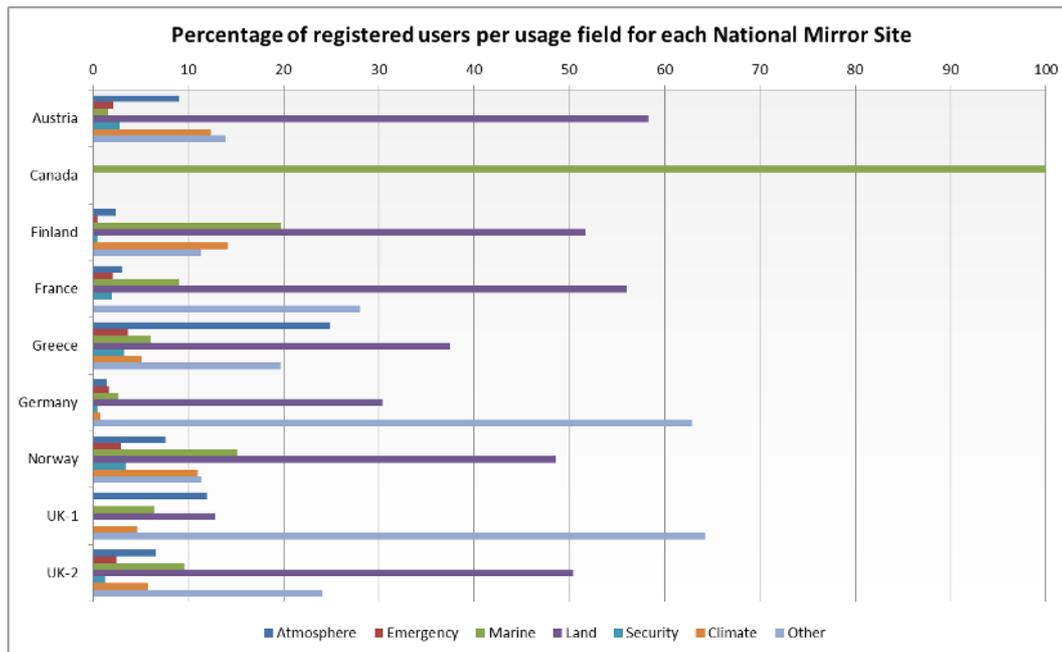


Figure 69: Percentage distribution of mirror site users by usage field

CollGS Partner	Y2017 Published Volume (TB)	% Increase from Y2016	Y2017 Downloaded Volume (TB)	% Increase from Y2016
Austria	1816	85%	1345	821%
Canada	37	117%	31	288%
Finland	135	445%	5	646%
France	3041	233%	302	-
Germany	1941	N/A	2.9	N/A
Greece	302	145%	29	481%
Norway	1840	N/A	234	N/A
Portugal	92	N/A	0.6	N/A
Sweden	131	-	11	82%
UK-1	1659	110%	6	-
UK-2	217	N/A	16	N/A
TOTAL	11211	294%	1983	255%

Table 26: Overall publication and dissemination volumes on mirror sites

Table 26 above reports the total volume of Sentinel data both published on and downloaded from the mirror sites during Y2017, together with an indication of the increase with respect to Y2016. The reported statistics show very significant increases in both published and downloaded volumes for all mirror sites. France has the highest published volume (3,041 TB), followed by Germany (1,941 TB), Norway (1,840 TB) and Austria (1,816 TB). Austria exhibited by far the highest download volume (1,345 TB), with France the second highest (302 TB). Apart from Austria and Canada, all mirror sites showed a low volume of downloads with respect to the volume

published. However, download volumes have increased dramatically over the past year: an increase of 255% for the total downloaded volume from mirror sites, compared to an increase of 294% for the total published volume.

Table 27 again reports the volumes of data published by and downloaded from the mirror sites during Y2017, this time split by Sentinel mission when this information is provided. Of the countries with the highest overall publication volumes, both France and Norway publish a majority of Sentinel-1 data and Germany publishes a majority from Sentinel-2. In terms of

downloaded volumes, Sentinel-1 was the most popular mission for Austria, Canada, Greece, Finland, Norway and UK-1 & -2, while Sentinel-2 had the majority of downloads for Germany and Sweden.

Figure 70 shows a comparison, in percentage terms, between publication and download volumes per Sentinel for all reported national mirror cases. In the majority of cases the download percentages roughly match those of publication: examples being Canada, Germany, Greece and Norway. Notable exceptions are Finland, where far more Sentinel-3 data than Sentinel-2 data is published, but far more Sentinel-2 downloaded, and Sweden, for which over 80% of the publication volume is for Sentinel-1 but where Sentinel-2 accounts for over 80% of the download volume.

CollGS Partner	Y2017 Published Volumes (TB)			Y2017 Downloaded Volumes (TB)		
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-1	Sentinel-2	Sentinel-3
Austria	-	-	-	1209.0	412.0	195.0
Canada	36.0	1.0	0.0	30.0	1.0	0.0
Finland	104.7	4.9	25.7	4.5	0.8	0.0
France	1687.0	1073.2	280.4	-	-	-
Germany	596.3	1204.0	0.0	1.2	1.7	0.0
Greece	259.3	41.8	1.4	27.7	1.3	0.1
Norway	1055.0	358.4	76.2	127.3	92.8	1.6
Portugal	61.7	4.5	26.0	0.3	0.3	0.02
Sweden	108.7	16.7	5.8	1.7	9.0	0.1
UK-1	1129.9	364.0	164.9	4.7	1.6	0.006
UK-2	126.9	90.5	0.0	13.6	2.2	0.0
TOTAL	5165.6	3158.9	580.4	1419.9	522.8	196.8

Table 27: Publication and dissemination volumes per Sentinel on mirror sites

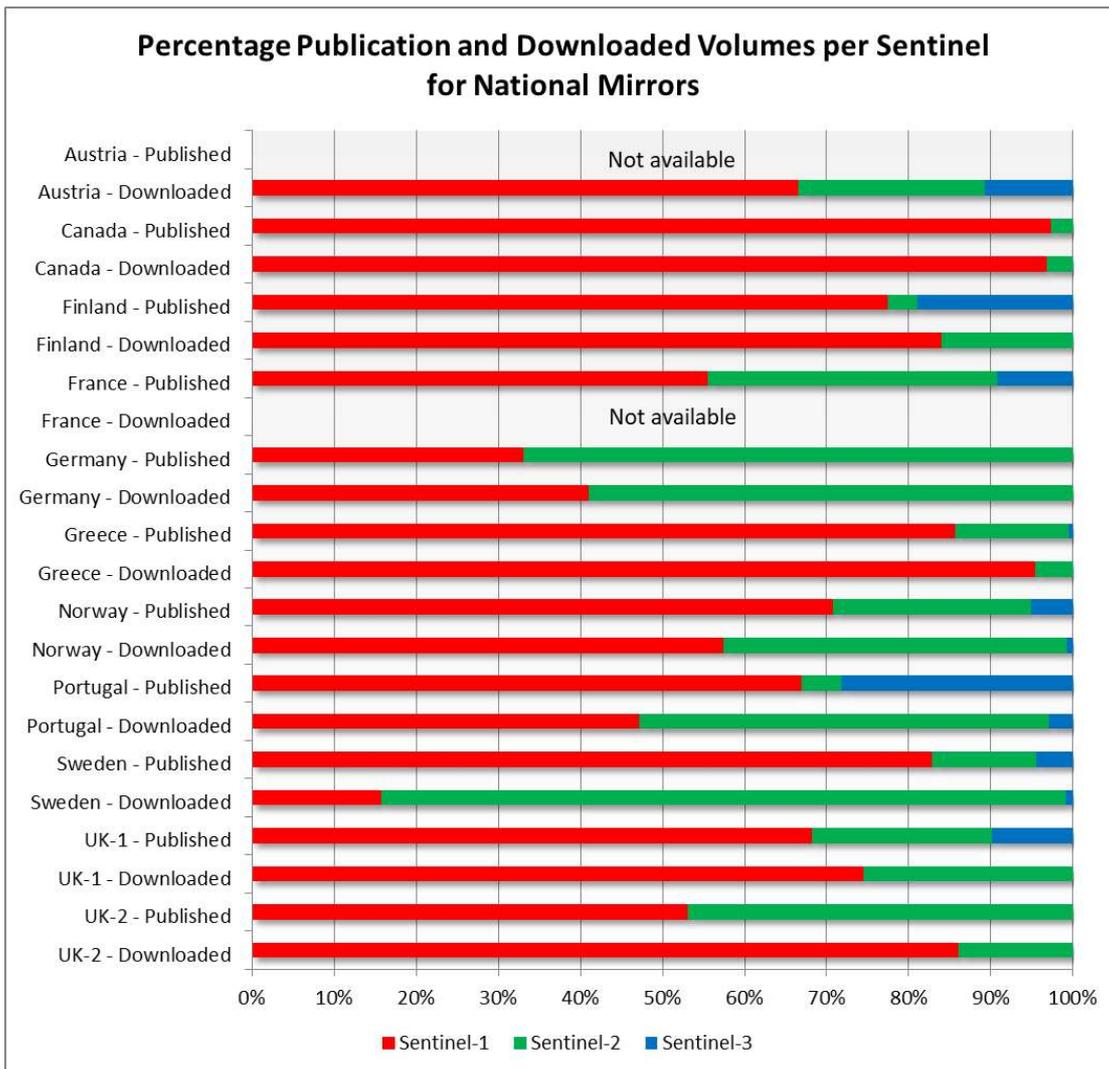


Figure 70: Percentage publication and dissemination volumes per Sentinel on mirror sites

4.2 International Technical Arrangements

The European Commission and ESA have agreed with NASA, the National Oceanic and Atmospheric Administration (NOAA), the US Geological Survey (USGS) and Geoscience Australia (GA) to make Copernicus Sentinel data available to them via a dedicated access point, the International Hub (IntHub).

These agencies transfer the data to their own dissemination points, for use by their own user communities.

Feedback was received from the international partners on the use of their sites during Y2017, via replies to the annual questionnaire released by ESA.

Geoscience Australia (GA) opened its regional Copernicus data hub – Copernicus Australia – on 26 June 2015, with the aim of providing free and open access to data from the Copernicus Sentinel satellites for the South-East Asia and South Pacific region. The project is operated collaboratively by GA, the New South Wales Office of Environment and Heritage, Queensland Department of Science Information Technology and Innovation and the Commonwealth Scientific Industrial Research Organisation (CSIRO). The National Computational Infrastructure (NCI) in Canberra is contracted to implement and operate the hub. A new interactive interface with user registration has

been developed, significantly improving users' ability to query data. It is in its final testing phase and due for release in early 2018.

During Y2017, GA disseminated Sentinel-1, -2 and -3 data, with the products published on the hub the original products as supplied by ESA. GA has multiple ongoing and developing projects that use Sentinel-1 and Sentinel-2 data on a national scale; CSIRO is currently the main user of Sentinel-3 data. Australian users accounted for 96.6% of all downloads (by volume) during Y2017, with New Caledonian users a distant second with 3.4%.

NASA started distributing Sentinel-1 products from its Alaska Satellite Facility data portal, Vertex, on 12 December 2015. The aim of its mirror site is to re-use and re-disseminate Sentinel products, to increase distribution capacity, and maximise the benefits to Earth Science research and applications. In addition, Sentinel-3 OLCI data is made available as part of the OceanColor Web; all products from 16/02/2016 to the present being available for re-dissemination. As well as the Sentinel-1 and -3 products, during 2018 the NASA Sentinel Gateway (NGS) plans start publishing data from the Sentinel-5P mission. NASA has a total of 7405 registered users of Sentinel data during Y2017, of which 13% were from the US.

The stated objective of **NOAA** is to provide access to oceanographic products from the

Copernicus Sentinel missions. Data is made available on the CoastWatch – OceanWatch site. For Sentinel-1, published products include those over the US, Arctic and Antarctic. The data is then processed into wind speed and the original data is not generally mirrored. Sentinel-2 MSI data has limited regional availability.

USGS provide storage and redistribution of Sentinel-2 data products. The agreement between ESA and USGS allows for free and open public access and redistribution of MSI imagery from USGS access systems, such as EarthExplorer. The current USGS Sentinel-2 archive is only a partial representation of all available acquisitions from ESA.

Table 28 presents summary information on each international partner, including operation start date, number of active users and user categories.. On this and subsequent tables in the section, where no information was provided this is shown as '-'

Table 29 summarizes published and downloaded volumes per partner during Y2017, where available. The percentage change with respect to Y2016 is provided, showing an impressive increase over the year for both GA and NASA (for NOAA and USGS Y2016 statistics are not available).

International Partner	Operation start date	Number of active users in Y2017	% increase in users since Y2016	Principal user categories
GA	26-Jun-15	698 (unique IPs)	477%	N/A
NASA	12-Dec-15	5,596	119%	Foreign (87%) US Education (8%) US Gov (3%) US Commercial (1%)
NOAA	May-2016	30	428%	US Gov (23%) CoastWatch (77%)
USGS	-	55,141 (unique IPs)	-	Academic Institutions (47%) Private Business (20%) General Public (16%) Non-Profit Orgs (7%)

Table 28: International Partner general characteristics and statistics for Y2017

International Partner	Total Published Volume in Y2017 (TB)	% Change in Published Volume from Y2016	Total Downloaded Volume in Y2017 (TB)	% Change in Downloaded Volume from Y2016
GA	694	+264%	20.5	+31%
NASA	3,153	+138%	1,564	+127%
NOAA	90	N/A	120	N/A
USGS	-	-	150	N/A

Table 29: International Partner publication and download statistics for Y2017

International Partner	Y2017 Published Volumes (TB)			Y2017 Downloaded Volumes (TB)		
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-1	Sentinel-2	Sentinel-3
GA	206.0	119.0	369.0	1.2	19.3	0.02
NASA	3,084.3	N/A	68.2	1,559.9	N/A	3.7
NOAA	N/A	18.0	72.1	67.7	N/A	52.5
USGS	N/A	-	N/A	N/A	150.0	N/A

Table 30: International Partner published and download volumes, per Sentinel

NB: For USGS, a total number of 291,970 Sentinel-2 tile downloads were reported during the reporting period: from this a volume of approximately 150 TB has been estimated. Also for USGS, user categories are also published on the basis of the proportion of downloads in each category, rather than on registered users.

Table 30 above presents the per Sentinel published and download volumes during Y2017 for each International partner.

Figure 71 shows a comparison, in percentage terms, between publication and download volumes per Sentinel for each international partner.

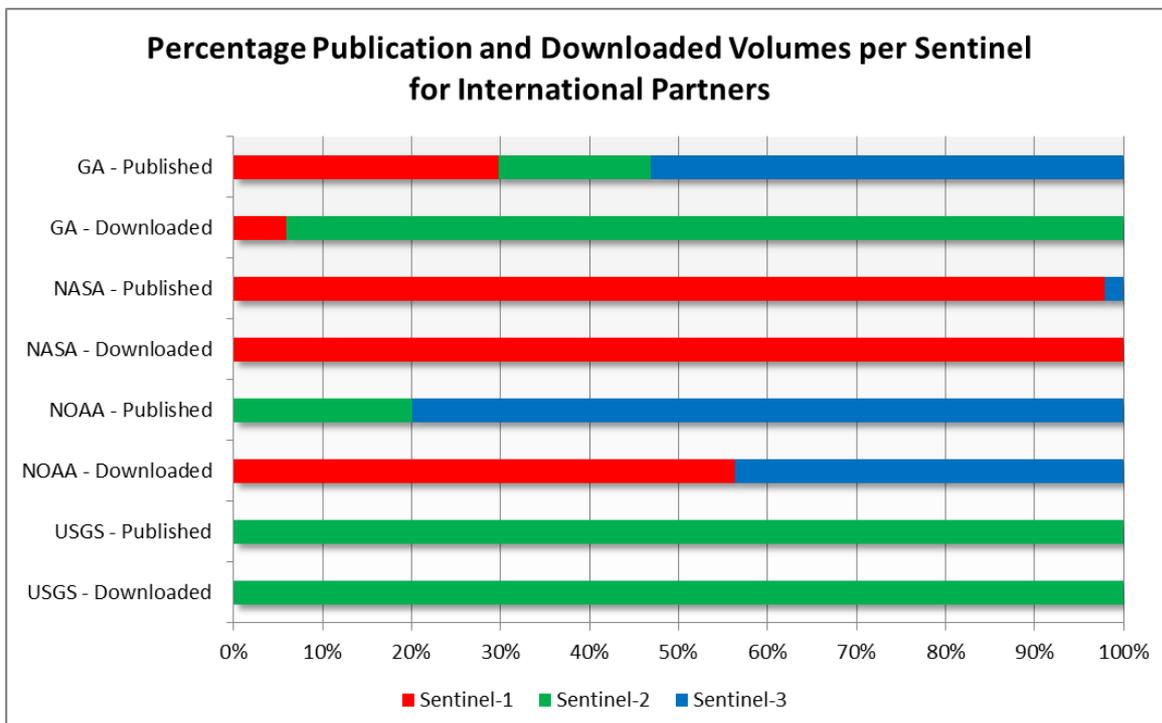


Figure 71: Percentage publication and dissemination volumes per Sentinel for International Partners

5 Data Access System performance analysis

Performances analysis has a key role in the continuous improvement process of the Sentinels data access services. The approach and the results from this continuous analysis process are described in this section.



Figure 72: Open Access Hub website statistics panel for products published and downloaded in last 24h

5.1 Service Availability

Availability, it is defined as the percentage of times it is possible for users to search the catalogue and retrieve products from the system. Operations of the data access system are constantly monitored, the results are collected and regularly analysed to verify system performances.

It is highlighted that a first view of the availability of the data hubs is presented to the users via the statistics panel on the website front page, providing the number of products published and downloads to give the users a feel for the current performance.

Table 31 below presents the overall availabilities experienced throughout Y2017 for the four

Copernicus data access Hubs. For comparison, it also sets out the corresponding values recorded in Y2016 and Y2015 where available. For the Open Access Hub, it is noted that the availability values are calculated using the combined availability of each access instance, the Graphical User Interface and the API Hub. For the Collaborative Hub, the redundancy provided by the second node, in operation from 27 July 2017, is taken into account: no downtime is recorded until both nodes are simultaneously down (which in fact did not happen during the rest of the period).

Table 32 provides an additional breakdown of Y2017 availabilities for each Hub on a monthly basis. The shading is on the basis of availability ranges: green indicates availability over 95%, yellow indicates availability in the range 90%-95%, and red indicates availability worse than 90%.

Hub	Availability (%)		
	Y2017	Y2016	Y2015
Open Access Hub	98.59	95.11	96.62
Collaborative Hub	98.04	98.19	96.09
International Hub	98.89	99.59	N/A
Copernicus Services Hub	98.60	99.35	N/A

Table 31: Overall availability of each hub during Y2017, Y2016 and Y2015

Month	Availability (%)			
	Open Access Hub	Collaborative Hub	International Hub	Copernicus Services Hub
2016-12	94.76	97.51	98.76	99.54
2017-01	97.97	96.6	99.42	95.72
2017-02	99.91	99.49	100	100
2017-03	99.69	94.63	99.02	99.29
2017-04	97.89	99.34	99.19	94.99
2017-05	96.66	96.11	97.31	97.66
2017-06	99.66	93.88	99.6	99.55
2017-07	99.96	98.64	99.03	100
2017-08	99.03	100	98.15	98.8
2017-09	97.8	100	97.31	98.01
2017-10	99.45	100	99.53	99.63
2017-11	100	100	99.23	99.76
Y2017	98.59	98.04	98.89	98.60

Table 32: Monthly availabilities per hub (green shading indicates >95% availability; yellow shading indicates 90-95% availability)

Following the scalability improvements introduced at the start of the reporting period, the availability of the Data Access Services was in general very high for all Hubs throughout Y2017. The Hubs all experienced very similar availabilities, the total during the year falling between 98% and 99% in each case. The lowest overall availability was measured on the ColHub, but even this was measured at a high 98.04%. Only four calendar months - across all of the Hubs - recorded availabilities under 95%, and there was no month in which the availability was below 93%. The Open Access Hub experienced a significant improvement, up to 98.59% from 95.11% in Y2016; the figure would have been even higher were it not for the lower availability recorded in December 2016, at the start of the period, during which the scalability improvements were being implemented. In fact, if only the last six months of the period are taken into account the Open Hub availability reaches 99.31%. Concerning the ColHub, following the introduction of the second node on OpenStack storage, availabilities were recorded at 100% for the remaining months, meaning neither of the nodes was simultaneously down. This evolution has therefore contributed an immediate and significant improvement.

Structured and scheduled maintenance activities were performed routinely, and account for the majority of the service downtimes. Users were notified in advance of the short periods in which each Hub would not be available. Nevertheless, several anomalies were experienced during Q2 with the underlying infrastructure supporting the Data Hubs, and these unexpected service interruptions had some impact on the overall user experience. Root cause analysis was routinely performed each time an anomaly occurred. Of particular concern was a major infrastructure anomaly on 22 May 2017, which resulted in a 15 hour downtime for all the hubs, although a slightly shorter interruption to the ColHub. The infrastructure reported multiple hardware failures that impacted the overall performance and system availability. The ColHub service was the first to be recovered after this major anomaly because ColHub manages a smaller rolling archive and not the complete historic production of the Sentinel data.

During Q3 2017, two major scheduled maintenance events resulted in reduced availability of the data hubs hosted in the main infrastructure data centre (T-Systems), both corresponding to infrastructure upgrades

identified to improve the performances following the analysis of previous anomalies. The first, on 1 August 2017, was an upgrade of the operating environment which resulted in a ~7 hour downtime. The second, on 13 September 2017, corresponded to an upgrade to the firmware of the disk infrastructure hosting the online data archive and resulted in downtime of ~10 hours. During both these maintenance periods, data access for ColHub users was maintained via the second node of the collaborative hub hosted in the secondary centre at OVH. Additionally, an open access for all users providing access to the latest 14 days of data was managed through a temporary hub hosted in the secondary centre operated by NOA/GRNET.

Several minor unscheduled maintenances also took place during the third quarter, most of which were attributed to disk infrastructure issues. The first two such events occurred prior to the major maintenance activities described above, caused by the operating system background tasks re-distributing the data archive amongst the available disks in an unoptimized manner. A further event, traced to an uneven balancing of the I/O nodes amongst the virtual servers, caused downtime on several services on 26 September 2017 and a backlog in the publication of Sentinel-1 data of over 24 hours, subsequently recovered on the 27 September. This latter event also resulted in poor availability on the IntHub.

Outside of the availability figures reported above there was one additional extended downtime for the S2B PreOps Hub occurred in late July, due to incorrect configuration of the automated alarming at application level and resulting in a weekend of unavailability of the service. Following the unavailability the misconfiguration was promptly corrected.

5.1.1 Copernicus Hubs Availability

Open Hub

At the start of this reporting period significant availability improvements were observed as a direct result of the software upgrade made at the end of the previous period. Installed in stages in mid-December and introducing enhanced scalability and load balancing capability, this vastly improved version of the DHuS allows the system to parallelize the user queries and downloads across a larger pool of servers and introduced redundancy to ensure fewer service interruptions during maintenance activities. From then on, the Open Hub has been far more resilient in coping with increased load due to rising user activity levels and the improvement in availability has been significant. From an overall availability of 90.49% in Q4 2016, a jump to 99.19% was recorded in Q1 2017, accompanied by a high level of stability and a significant reduction in the number of interruptions (only on one occasion did the downtime last for more than 3 hours). Each of the downtimes that did occur was planned and linked to a scheduled maintenance activity.

In April 2017, a series of maintenance activities were performed on the Open Hub, to add additional servers and continue to increase the scalability of the Hub. These activities accounted for two of the service interruptions lasting for longer than 3 hours, including a short period during which it was not possible to register new Open Hub users.

Colhub

The ColHub experienced some slight reductions of performance during the Q1 2017. Five interruptions occurred which lasted for more than 3 hours, the longest of which lasted over 10 hours. The main cause of these events was a version of the software which was provided to the data hub relays on 22 February 2017. The aim of the software upgrade was to increase the synchronisation performances and reduce the latency in the retrieval of products by users. As the first version of this upgrade put additional stress on Node 2, reducing its stability, the relative

parameters were tuned in coordination with the data hub relay partners to reduce overall loading on the node. In addition, software enhancements were installed on 8 March 2017, resolving the problem and fully restoring the stability of the hub.

The main node of ColHub (Node 1) experienced excellent availability during Q2 2017 (99%). A scheduled service upgrade to reinforce the service with a new set of servers had some impact on availability in the second half of June: due to observed reduced disk performances, the upgrade has to be rolled back and rescheduled. ColHub Node 2 experienced more frequent downtimes than Node 1, resulting in delays in the synchronisation of data from the back-end servers.

IntHub

The overall performance of IntHub remained stable during Q1 2017, with very few interruptions over the 3 month period and no interruptions which lasted for longer than 3 hours.

In Q3 2017, performance tuning issues occurred which delayed the timeliness of data publication on the IntHub, all of which were subsequently resolved.

ServHub

The ServHub experienced a slightly reduced performance during Q1 2017, with four downtimes lasting longer than 3 hours, the longest of which lasted for nearly 10 hours. The most significant interruption occurred in January 2017, and was caused by the system failing to cope with a series of complex queries from users involving the extraction of sub-components of the product. Performance was improved and stable for the rest of the period.

5.2 Network Analysis

Early in the reporting period, several significant improvements were made to the network, and in particular to the GÉANT connectivity in order to improve download volumes and performances and help to eliminate network performance issues experienced especially by very remotely placed users.

- Firstly, on 27th February 2017, the configuration on the public interface of the IntHub server was changed, increasing the size of the data packets transmitted through the network. The MTU (Maximum Transmission Unit) was enlarged from 2,500 MTU to 9,000 MTU. The change allowed the speed of data transfers to GÉANT users to be increased.
- On 28th February 2017, a network re-design activity was performed, commissioning a second 10 Gbps link and splitting of the individual Data Hub traffic between the two 10Gbps firewalls.
- In March and April, additional firewall fine-tuning activities were undertaken to maximize network performance on the Copernicus network.

The graphs below present the network traffic from the main T-Systems infrastructure. The GÉANT link is sized at 10 Gb/s, a steady increase of uptake on this link during the year can be seen (from academic / research partners with own GÉANT connectivity). The overall dissemination from the 2*10 Gb/s firewalls also shows clearly the steady increase in download trends.

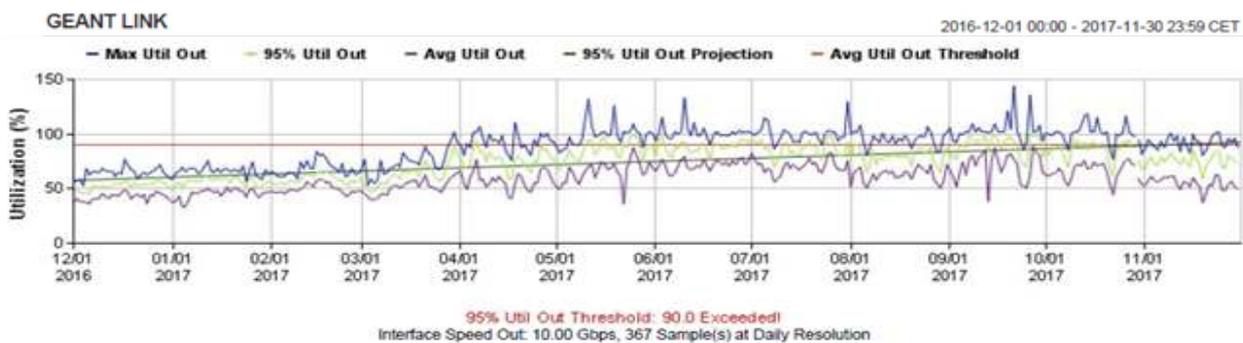


Figure 73: GÉANT link outbound network utilization

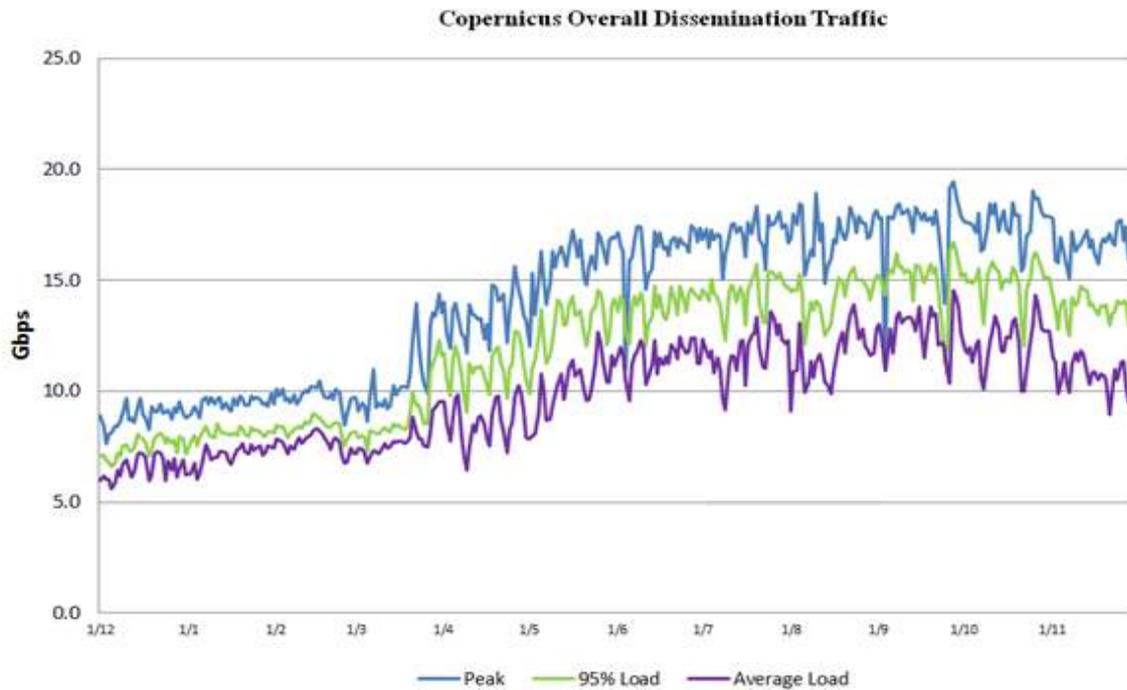


Figure 74: Copernicus overall dissemination traffic during Y2017

A comparison of some users downloads performances was conducted comparing two periods before and after the MTU change (date: 27/02/2017) and it is reported that the number of downloads after the MTU change has increased by 31% and the download failures were reduced for the USGS partner (61% less). On the other hand, a comparison of the effective bandwidth during the periods before and after the MTU change revealed a huge increase of effective bandwidth for NOAA and USGS users (+109% and +473% respectively).

The effect of the re-location of the IntHub service can be seen in both of the figures above, with a timely reduction of the loading on the 10Gb/s link available for GÉANT leading to a reduction of the load towards the end of the period.

Figure 75 shows the effective bandwidth range per hub, taking into account all completed downloads in Y2017, as well as the overall statistic taking into account all the hubs. It can be seen that for all the hubs apart from the Open Hub, the highest bandwidth range was that for downloads >100 Mbps, which indicates that the majority of Collaborative, International Partners and users of the Copernicus Service Hub are achieving a good download bandwidth. Given the very wide user base on the Open Hub (worldwide and with varying availability of local bandwidth), the fact that 50% of Open Access Hub downloads fell in the 10-50 Mbps range is not a surprise. The statistics for all hubs reflects the result for the Open Hub due to the large proportion of overall downloads made through this hub.

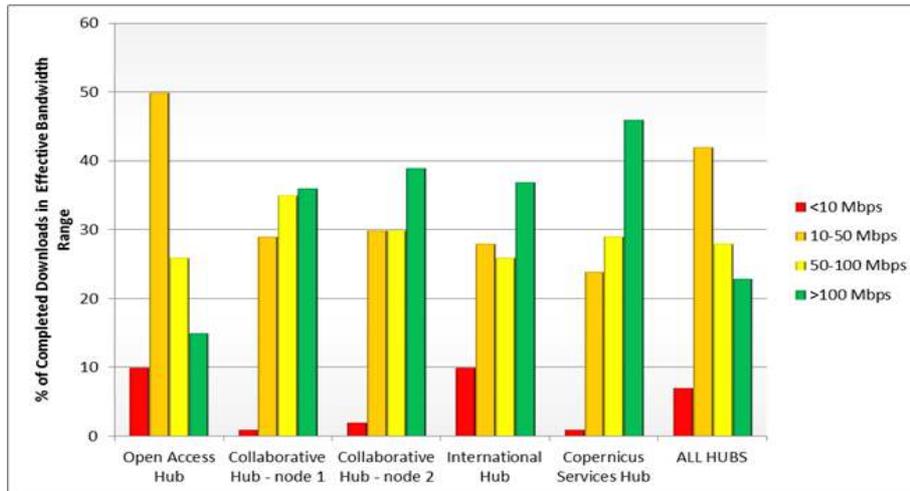


Figure 75: Completed downloads performed in Y2017 per effective bandwidth range and per hub

5.3 Publication Timeliness

Publication timeliness is a measure of the time it takes from the data being sensed by the satellite to the product being published on the hub. The timeliness depends on the end-to-end design of the mission, from the geographical position of the receiving antenna to the priority given to each product in the publication chain.

Products are categorized as either Near Real Time (NRT) or Non-Time Critical (NTC). NRT products are made available to the users less than 3 hours after acquisition of the data by the sensor. The expectation for NTC products is that they will be published within 24 hours from sensing.

The figure on the right reports the monthly average publication timeliness on Copernicus Open Access Hub for Sentinel-1 NTC and Sentinel-2 Level 1C products during Y2017. Only products which were published within 7 days of sensing were included in the calculation, to remove as far as possible retrospectively processed data and report the performance measured on the routine dataflow. Products published after 7 days are either the result of reprocessing, or the result of anomalies and are discussed below.

As expected, given the different designs of the two missions, Sentinel-1 products are published

within a shorter time from sensing than Sentinel-2 products: by the end of Y2017, the Sentinel-1 NTC products were published on average within 5 hours from sensing while Sentinel-2 Level 1C products were published on average within 14h from sensing. In particular, during Y2017, with exception of 2 peaks in January and April, Copernicus Open Access Hub ensured the publication of Sentinel-1 NTC products with a monthly average of within 8 hours from sensing.

As reported in section 2.2.2., the Sentinel-2 Ground Segment suffered a sporadic anomaly between March and May 2017 included, leading to an incomplete dissemination of production with about 11% of products missing throughout the period. Those products were excluded from the calculation of the average publication timeliness values of the nominal data flow, reported in graph 1 of Figure 76, but they are reported in graph 2, showing the percentage of Sentinel-2 products published between 7 and 30 days from sensing date: clearly, the recovery of the products was completed in May 2017.

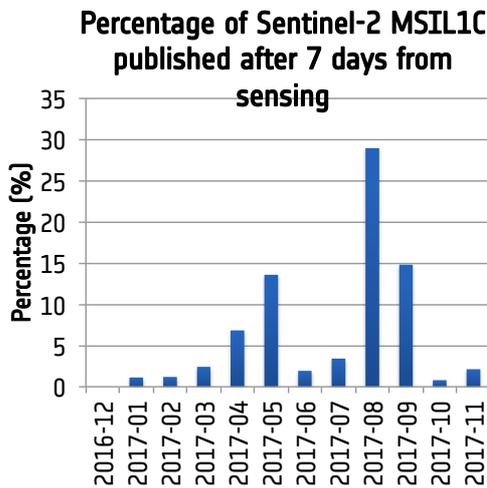
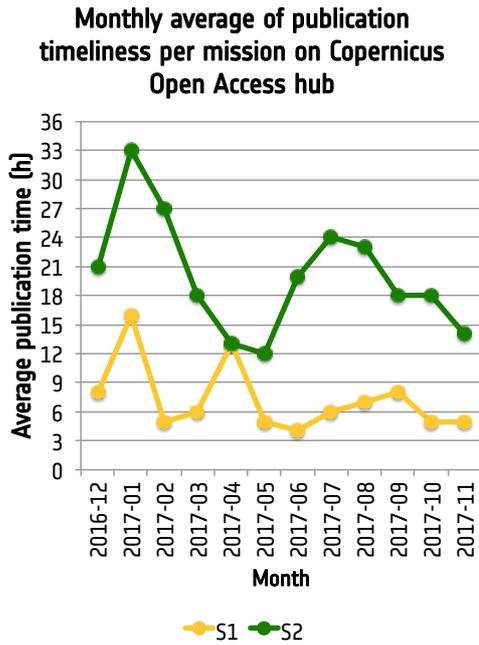


Figure 76: Y2017 monthly average publication timeliness on the Open Access Hub for Sentinel-1 and Sentinel-2 (graph 1) and percentage of sentinel-2 published products between 7 and 30 days from sensing (graph 2)

Moreover, the PDGS anomalies continued to be present with the upcoming Sentinel-2B, which influenced the production of the Sentinel-2A products during June and July months. Additionally in August, as a consequence of a contingency occurring at one of the ground station, the publication of Sentinel-2 products in the data hubs was temporarily interrupted and recovered within first week of September.

The histograms hereafter show the percentage of products published in the Open Hub instance during Y2017, grouped by hours taken from sensing to publication. The cumulative percentage of published products with time passed from sensing is shown in the line included on the graph. The threshold of 7 days is used for the Sentinel-1 mission, while, in accordance with the second graph in Figure 76, the threshold was moved to 30 days for Sentinel-2 (in order to consider also the reported percentage of products published between 7 and 30 days from sensing). Sentinel-2B products are included in this distribution beginning from the time they started to be published on Open Access Hub GUI interface (the preoperational phase is not considered).

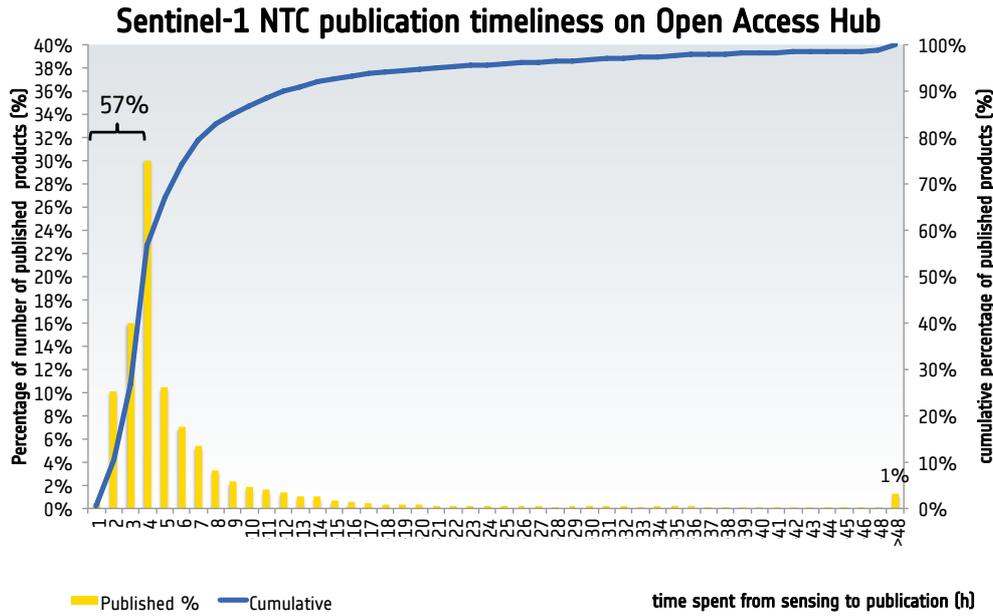


Figure 77: Sentinel-1 NTC publication timeliness histogram during Y2017

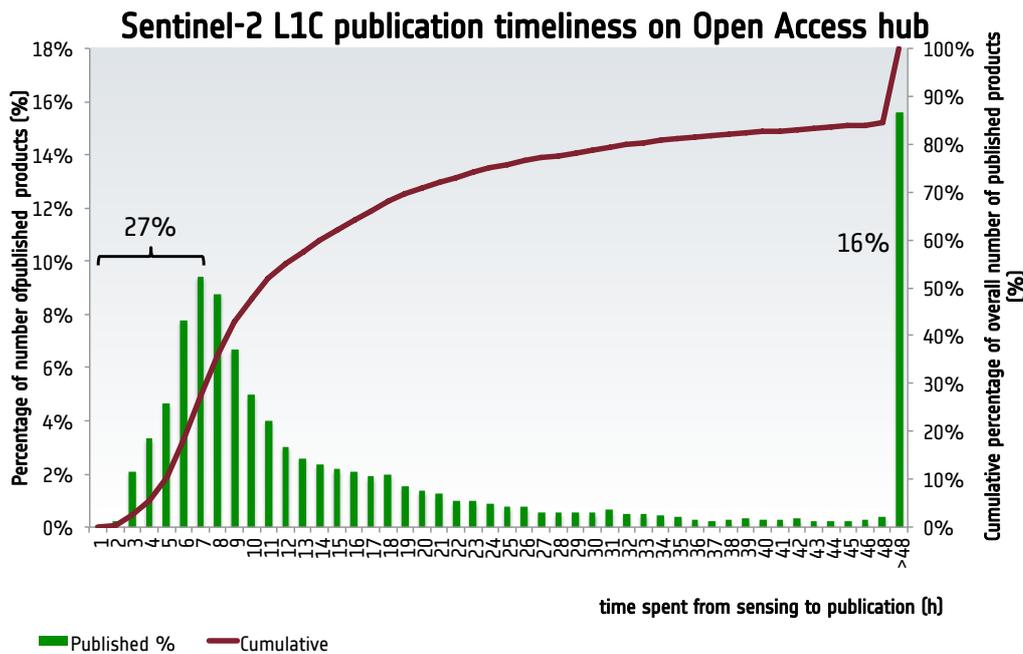


Figure 78: Sentinel-2 MSIL1C publication timeliness histogram during Y2017

- As reported in Figure 77, the Sentinel-1 modal value of publication is 4h from sensing and, within this time, 57% of products were available for user download. Only 1% of products were published after more than 48 hours from sensing during Y2017.
- Figure 78 shows the Sentinel-2 modal value of publication is 7h from sensing and, within this time, 27% of products were available for user download. During Y2017, 80% of products

were published within 24 hours from sensing, 16% after more than 48 hours.

The publication timeliness reported above concerned the end-to-end performance from downlink to data availability in the hubs, which is what the user is interested in, but performance of the data hub service may also be measured in terms of time from product availability for pick-up on PDGS side (data retrieval from PDGS) to its

publication on the Open Access Hub (availability for users download on Open hub).

As reported in the introduction, the publication flow for NTC products is centralized on the T-Systems infrastructure hosting, the back ends of the Open Hub and Copernicus Services Hub instances, and a node of Collaborative Hub. The complementary hubs (on the OVH and GRNET infrastructures and hosting the International Hub and the second node of Collaborative Hub) synchronize the products from the same back ends of the instances hosted on the T-Systems infrastructure, naturally the transfer from one infrastructure to another will generate a small delay in publication. It has been demonstrated from average publication timeliness values per hub and per mission reported below, that this delay is 1.5 hours, on average, following the publication time on the T-Systems infrastructure-hosted instances.

Furthermore, it has to be noted that the data flows of different mission are slightly different and use dedicated approaches (e.g. the Sentinel-1 dataflow uses compression of the file, which facilitates user downloads, something that is not necessary for Sentinel-2 data).

The graph on the right reports the percentage of products that were published within the time (in hours) from following retrieval from the PDGS, and the cumulative percentage per mission published on the reference period. In order to report the nominal dataflow, such measurements took place over a 1 month period during which no maintenance activity was performed on the Copernicus Open Access Hub.

Time spent from data retrieval from PDGSs to availability for users downloads on Copernicus Open Access Hub

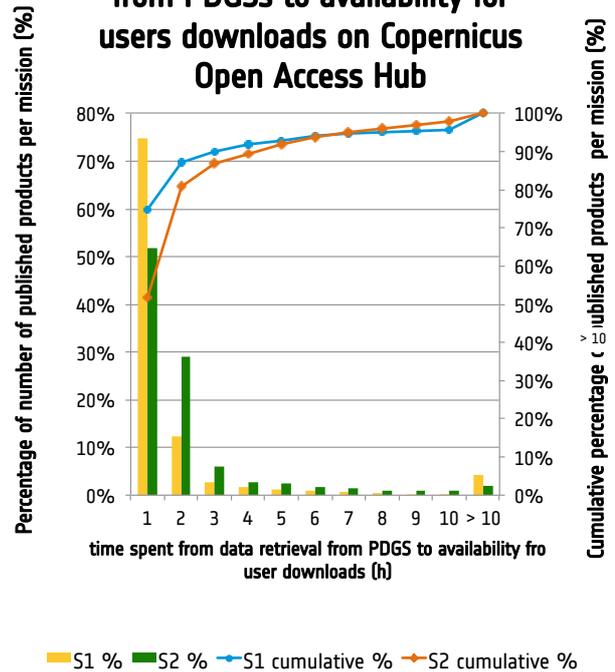


Figure 79: percentage of products that were published within the time (in hours) following retrieval from the PDGS, and the cumulative percentage per mission published on the reference period.

The graph shows that, within an hour following the retrieval from PDGS, the Open Hub published the majority of Sentinel-1 NTC products and within 2 hours, the majority of Sentinel-2 L1C: in particular, within 3 hours 90% of Sentinel-1 NTC and 87% of Sentinel-2 L1C products were respectively published. Any contingency on the dataflow were handled within nominal working hours or during on-call activities, so publication delays of more than 10 hours from the retrieval date are, for S1 NTC and S2L1C respectively, only 4% and 2%.

Concerning the recent infrastructure update of the International and Collaborative Hubs, the performance in publication remained stable and the target timeliness was ensured.

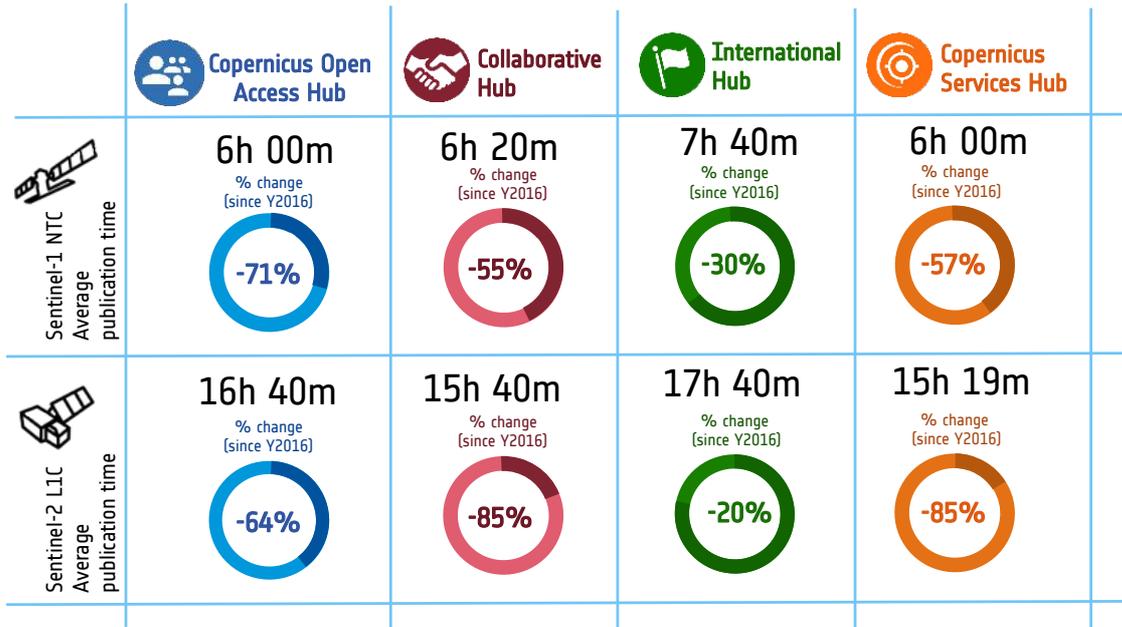


Figure 80: Average publication timeliness per hub during the last three months of Y2017 for Sentinel-1 NTC and Sentinel-2 L1c Products

Figure 80, above, shows the average publication timeliness for Sentinel-1 NTC and Sentinel-2 Level 1C products on each hub during the last three months of Y2017 and the percentage change with respect to the same values measured during Y2016 (with a percentage decrease signifying an improvement in average publication timeliness). It can be observed that significant improvements have been observed on all hubs and for both S-1 and S-2 product since Y2016.

As outlined in Section 2.3.7 above, Sentinel-1 NRT products are provided to the Copernicus Services via their dedicated access points, and this provides the timeliest access to the NRT data.

During Y2017, the Sentinel-1 NRT products were also provided to the Collaborative Ground Segment partners via both nodes of the Collaborative Hub. The figure below illustrates the average publication timeliness for Sentinel-1 NRT products on the two Collaborative Hub nodes.

Percentage of Sentinel-1 NRT products published per time spent from sensing in the ColHub Nodes

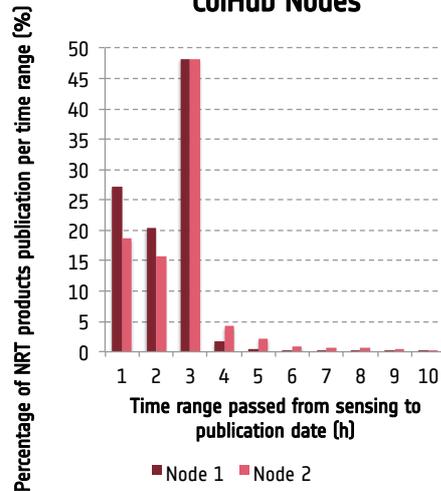


Figure 81: Y2017 Percentage of Sentinel-1 NRT products published on ColHub nodes in hours from sensing

From this graph, it can be seen that the overwhelming majority of NRT products were delivered via both nodes to the Collaborative Ground Segment partners within 3 hours from sensing.

5.4 Reporting improvement

Starting 4 September 2017 the following statistics related to the Sentinel Data Access systems have been reported on the Copernicus Open Access Hub portal:

- a) Registered users
- b) User downloads volume
- c) Published products
- d) Open Access Hub Availability over the past Month

The statistics have a reporting period starting at the beginning of operations (03/10/2014) and are updated on an hourly basis. They can be found at <https://scihub.copernicus.eu/reportsandstats/>



Figure 82: Data Hub Services overall statistics since the start of operations

The values shown are a subset of the information reported on the Sentinel Data Dashboard, a web-based tool and accessible on <http://dashboard.copernicus.eu>, which has been developed to give relevant ESA/EU stakeholders direct access to real-time status and statistics concerning the Copernicus Space Component operations. The reported information on this interface provide an overview of the 4 core centre Hubs (Open Hub, ColHub, IntHub and ServHub), statistics and an events description covering a reporting period both over the past 3 months (91 days) and over the past month (30 days).

The statistics are updated on a daily basis and provide up-to-date information about the performance of ESA’s Data Access system and user uptake of Sentinel products. During the reporting period a series of improvements to the Data Dashboard were released and put in operation.

In the images on the right some examples of Sentinel Data Dashboard are provided.



Figure 83: Sentinel Data Dashboard examples

The first version of the Dashboard was released to the European Commission on 17 February 2017. Analysis is now underway to foresee the possibility to provide a wider visibility to some areas of the Dashboard; possibilities include additional statistical information on the National Mirror operations provided by the collaborative GS partners are also being studied, as well as increasing the temporal range of information provided.

5.5 Operation procedure improvements

During the year 2017 there has been a significant increase of the Sentinels data offer. Sentinel-2B and Sentinel-3A joined the constellation of the Sentinels family. Sentinel-1A, Sentinel-1B and Sentinel-2A have increased their nominal production and data coverage. As a consequence, there have been an increasing number of products and data volumes to be handled and to be served to a user community in constant growth.

The Data Hub Service Operations had to cope with this operational boost and had to improve the operations activities for minimizing maintenance downtimes, increasing monitoring and control activities on expanding infrastructure and archives, ensuring a higher availability and reliability, granting each user with a fair download experience.

In 2017, two additional operation centres have been opened. The first Data hub Operations Centre was opened back in October 2014 in occasion of the publication of the very first Sentinel-1A product.

On the 27th of July 2017, first complementary data hub operations centre was opened, followed by the second centre on the 18th of October 2017.

5.6 Hub Software Improvement

During the past year, the Data Hub Software evolved to cope with the growing amount of products sensed by the Sentinels and to improve the reliability and stability of the service. Moreover, new features have been added to the DHuS to support new operational scenarios and to integrate new technologies.

5.6.1 Scalabilities

From an architectural point of view, the Data Hub has been enhanced to introduce a new scalable deployment mode in order to guarantee a higher service availability and avoid overload of single instance due to increased user requests. The Data Hub scalable deployment (scalability) has been incrementally implemented in two major software versions introducing new technologies.

The objective of the “scalability” solution was to have several DHuS instances (a cluster of DHuS) acting as one logical instance to share the user load for both downloads and queries: the deployments in scalable mode were completely transparent to the user.

The first version of the “scalability” deployment mode was based on the SymmetricDS technology and transferred into operations first on the Open Hub during December 2016. This first solution was based on a “replication” mechanism in charge of synchronizing the Databases of each node of the cluster. All the nodes of the cluster had an embedded database (HSQL instance) and Solr. One of the nodes, the “master”, was in charge of the product retrieval and the other nodes, the “replicas” were in charge of answering the user requests.

The second version of the *scalability mode* builds on the first implementation and was transferred into operation in October 2017. The approach used in the development of this second solution

was to enable the possibility to address externalized instances of the Database and Solr so that all the DHuS nodes of a cluster could access the same database and Solr Instances (a technology swap to prefer the use of Postgres was also implemented, opening the option for further future evolutions using multiple database instances and additional replication/sharding technologies). This solution resulted in an improved coherency on data on all the nodes of the cluster and an optimization in the use of the infrastructure resources.

days before and after the scalability transfer to operations decreased by 91% and their number in the period after 15 December was the 88% less than 75 days before. This demonstrates a significant improvement in the service.

5.6.2 New Store interface

The Data Hub Software has been enhanced to be able to store products in an OpenStack Object Storage system found in many cloud environments. In order to implement the possibility to use an ObjectStorage, the Data Hub has been redesigned from an architectural point of view, introducing an abstract layer in charge of the management of the storage. A new interface called "Datastore service" has been introduced in the Data Hub System that allows the Hub to interface both traditional file systems and OpenStack object storage "Swift", and to better support other storage systems in the future. The DHuS is therefore able to use such kinds of storages for the data archiving function. On 27 July 2017 the ColHub service was reinforced by Node 2 using the new Swift storage, demonstrating the DHuS capability to be compatible with cloud environments.

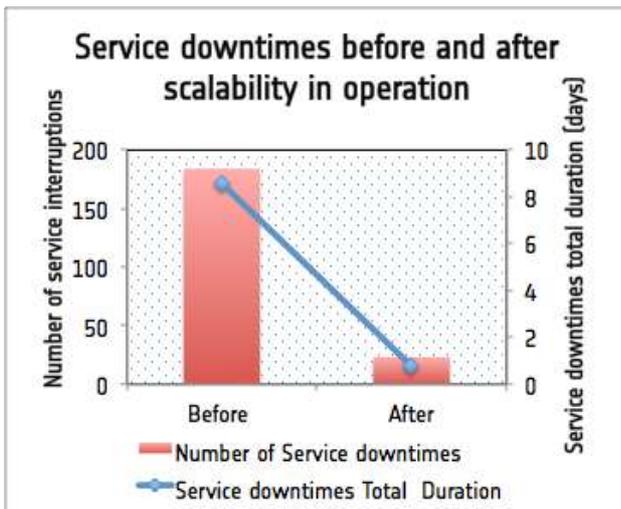


Figure 84: Effect of scalability improvements on service downtimes

The date on which the service scalability officially went in operation was 15 December 2016.

As proof of how successful these changes have been, the overall availability of Copernicus Open Access Hub service downtimes (user side) has been studied and compared in two periods (75 days long) before and after the scalability transfer to operation. The reference periods used were the following:

- P1: 01/10/2016 ---- 14/12/2016 (before scalability change)
- P2: 15/12/2016 ---- 28/02/2016 (after scalability change)

The results in terms of number of service interruption and their total duration during the reporting period are shown in Figure 84.

It reports a decrease of service downtimes both in terms of numbers and in duration: the overall duration of service downtime measured over 75

5.6.3 API evolutions

The interfaces exposed by the Data Hub evolved during the year. In particular, the OpenSearch API has been upgraded with new indexes and filters, the OData API has been enhanced with new functions and has started its evolution process from version 2 of the OData standard to version 4. It is foreseen within the next year to fully support the OData entities currently implemented with the v2 standard also with the v4 standard.

A first batch of new functions dedicated to DHuS administrators have been developed already in OData v4; the migration of the existing entities will be done gradually, with a period of backward compatibility before any function is deprecated and a full roadmap highlighting the steps of this process will be communicated to the users to assist them in updating their scripts.

5.6.4 Catalogue view and Deleted products

As a result of user feedback, and supported by an analysis of the various ways in which users are using the current APIs, it has become apparent that many users/organisations are interested in obtaining a complete listing of the all products published on the Open Hub. This can be achieved through the existing API functions of the data hub software, and during the current reporting period two new features have been developed to facilitate this listing.

The first feature allows for a compact format (comma separated values .csv) format to be obtained directly from the OData API to reduce the need for lengthy XML parsing. The Open Hub "catalogue view" is published at <https://scihub.copernicus.eu/catalogueview/>.

The second feature is a new OData API that has been designed to provide visibility of any products that may have been deleted from the operational Hubs. Such deletions may be due to requests from the Sentinel operations teams, for example because of subsequently discovered quality issues. This API is made available at <https://scihub.copernicus.eu/dhus/odata/v1/DeletedProducts>.

This information together with the full catalogue view of the Open Hub service, allows users to have a clear overview of the definitive list of the best quality products available on the Hubs from the start of operations.

5.6.5 Synchronization function evolution

The synchronization functionality is one of the main features of the Data Hub. During the past year, these functions have been consolidated, optimized and enhanced.

The metadata synchronization function allows the synchronisation of the products from "back-end" instances of the Data Hub Software responsible for the ingestion, indexing and quicklook creation,

towards the "front-end" instances responsible for management of the user queries and downloads. This function has been crucial for independent management of the multiple streams of from the Sentinel production.

The remote synchronization is the functionality which allows efficient copying of the Sentinel production from instances of the Data Hub Software running in different centres, without requiring re-ingestion and maintaining unique identification of the products to ensure consistency and avoid duplication. This feature is essential for the operations of the Data Hub Relays Network and the complementary Data Hub centres.

Both the metadata and remote synchronizers are now able to retrieve products relative to a specific geographic area, in fact it is possible to add a geographic filter in the synchronizer configuration.

5.7 Open Source DHuS Framework

5.7.1 Introduction-Overview

The Data Hub Software is made available as open source software to any interested parties and can be easily installed and configured by users to manage a local archive of Sentinel products. Major new strides were made in the consolidation of the Open Source DHuS Framework that organises and controls the publication of the software towards the interested users.

During the period, the activities carried out included DHuS releases publication, Open Source DHuS web portal redesign, as well as some promotional and educational activities.

5.7.2 DHuS Releases Publication

To provide the latest version of the software to users, the DHuS releases publication plan foresees a periodic publication (at least every six months) to align the code base with the software version that

is in operations on the Open Hub at the publication time.

On 15 December 2016 the 4th open source DHuS release was published (v.0.12.5-6-osf). This version included all the enhancements made for efficient management Sentinel-1, Sentinel-2 and introduced the Sentinel-3A missions. On 10 April a new DHuS (v.0.12.5-7-osf) was published. This version included a smart installer to encourage an easy DHuS installation.

On 28 September the latest DHuS (v1.0) was published. This version includes capability for Sentinel-2A Level2A in compact format, new features as supporting deployment with cloud-based storage infrastructures (OpenStack object infrastructures), an alternative graphical user interface realized with the Open Web Components (outlined further below), and the Catalogue extraction API.

One of the most important changes in version 1.0 was a complete new code organization. In fact, a code migration has been performed, porting it from a single GitHub⁵ repository to several new GitHub repositories. The new modular structure will facilitate the creation of new contributions from external developers and in general the growth of the Open Source DHuS Community.

Number of DHuS Software distribution downloads per Open Source Version published in Y2017

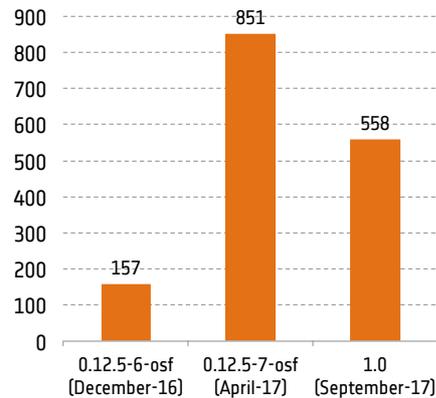


Figure 85: DHuS Software total downloads per Open Source version

Figure 85 shows the number of downloads for each of the published Open source DHuS versions (the overall amount of users downloads is 1,566). It has to be noted that the number of downloads for the v1.0 is related to the period covering October and November 2017 and it is expected that this number would increase in the next year.

Support to OS Community

Technical support has been provided to the different users (typically institutional agencies and research centres):

New DHuS add-ons

Linked to the code organization, the process to manage new missions via modular “add-ons” is now very easily performed. Within the open source repository, and developed through R&D projects, different add-ons related to non-Sentinels have been put in place in DHuS version 1.0. These new add-ons allow the management of CosmoSkyMED, Landsat-8 and Pleiades products.

Support to OS Community

Technical support has been provided to the different users (typically institutional agencies and research centres):

- New Open Source DHuS Web Portal: During Y2017 the new Open Source DHuS portal was also made available at <http://sentineldatahub.github.io/DataHubSystem/>. It provides visibility of all activities and

⁵ GitHub is a Web-based Git version control repository hosting service

projects related to the Open Source Framework. In particular an ad-hoc section has been included for experimental initiatives: it is represented by such pilot projects as DHuS-docker integration, multi-mission access, WMS integration and DHuS transformations.

- DHuS in Cartoons: a series of episodes realized in cartoons format illustrate the DHuS

from different points of view: as user, as developer and as administrator.

- The DHuS open source has also been promoted towards the Free and Open Source Software for Geospatial Conference (FOSS4G-e) conference, held in Paris from July 18th to 22nd, via the ESA booth at this conference.



Figure 86: Examples of support provided to the Open Source community

6 User Feedback

Feedback from users is constantly taken into account in order to determine if the data access service is in line with user expectations. Users are invited to write to the email address eosupport@copernicus.esa.int, which is the first line contact point for all issues concerning Copernicus satellite data. Any issues that cannot be directly replied to by the eosupport team are sorted by the PDGS Coordination Desk, all emails regarding data access are forwarded to the Sentinel Data Access System operations team for resolution.

6.1 Ticketing Analysis

Feedback and requests received from users of the Copernicus Open Access Hub are tracked via a "ticketing" system. During Y2017, users raised 1,766 tickets and 100% of these were resolved within the period (32% more than the total number of tickets opened and managed during Y2016). The average response time per ticket was 27 hours 8 minutes and 5 seconds.

Since 1 November 2017, 7 tickets categories were identified:

- *Service Interface*: Technical Issue on Interfacing to the Service (network, API, scripting, GUI, over quota reached, over quota warning received)
- *User Accounts*: User accounts Management (registration, validation, password reset, credentials loss, deletion, edit profile issue)
- *Features Request*: Improvements suggested by users about all the topics of ticket categories
- *Products*: Issue on Products (production coverage, product quality, external tool usage, products deletion request, download failure, unzipping issue, Naming convention information)
- *Web Portals*: News to be published, User guide update

- *Bug*: Service malfunctions reported by users and recognized as bugs (related issue are then managed in the maintenance cycle)
- *Junk*: Spam, Empty emails, Not an issue

During November, 93 tickets were opened and managed by the Sentinel Data Access System operations team. Among them, 72 tickets originated directly from Copernicus Open Access Hub users and 21 from PDGS Coordination Desk. 57% out of those 93 were classified under the User Account category as shown in the graph below.

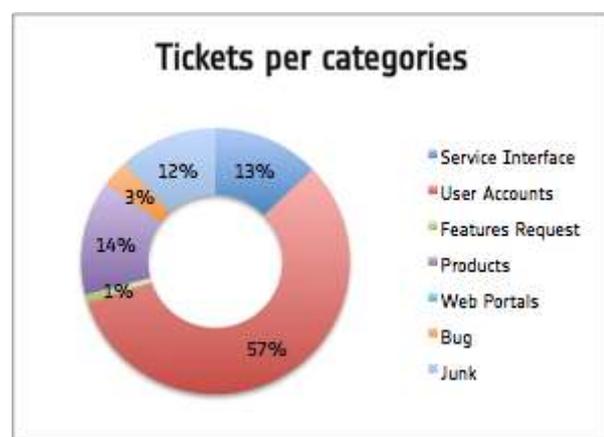


Figure 87: Open Access Hub received tickets per category

For what concerns the features requested during Y2017, requests have ranged between improvements in the colour scheme used in the Graphical User Interface, availability of the catalogue view, and additional services such as a web mapping service. These improvements are discussed with ESA and prioritised according to the maintenance schedule of the software. The evolution to include a web mapping service is not currently planned since this is considered to overlap with developments made within the commercial sector, and will likely be a future feature of the DIAS platforms.

7 Outlook

7.1 Sentinel-1

Sentinel-1 is scheduled to continue its routine operations throughout the next period. It is highlighted that, due to the ever-expanding size of the mission's archive, S-1 will be the first mission for which a Rolling Archive Policy will be implemented on the Open Hub, with older products being routinely accessed from a Long Term Archive (LTA) (see 7.5.4). The Sentinel-1 data production rate in Y2018 is expected to reach around 10 TiB of data a day (uncompressed volume).

7.2 Sentinel-2



Figure 88: Inuvik antenna

Following the successful pilot dissemination for the pre-operational production of Sentinel-2 Level-2A atmospherically corrected data over Europe since 2 May 2017, Sentinel-2 Level 2A will start its operational phase in early 2018. This will begin with the systematic production of products covering the European region with improved timeliness and will subsequently be expanded worldwide. The Level 2A service will eventually be supplemented with an on-demand service for the generation of L2A data for the historical downloads.

The Sentinel-2B ramp-up phase will end in Q1 of 2018 and, with the introduction of EDRS will reach full acquisition capability. Sentinel-2A, encountering an issue on the Optical Communications Payload (OCP) during Y2017, will begin the full observation scenario on 2018.

With the aim to optimize the timeliness in Sentinel-2 product publication, during the next reporting period a new ground station will start to be used: Inuvik, sited above the Arctic Circle in Canada.

The Sentinel-2 L1C production volume is expected to reach 4 TiB per day in 2018; with the full L2A production this is likely to reach around 9 TiB per day.

7.3 Sentinel-3

During 2018, the Sentinel family will continue to grow with the launch of Sentinel-3B in April. As the twin of Sentinel-3A, the new entry into the constellation will double the observational capacity and significantly improve global revisit times. Sentinel-3B's orbit will be identical to -3A's, flying a 27 day orbital cycle at 814.5 km, but will be placed +/- 140° out of phase. Such a configuration will allow short revisit times of less than two days for OLCI and less than one day for SLSTR at the equator. As for Sentinel-3A, mission management and operations will be jointly handled by EUMETSAT and ESA. Preparations for launch are currently on-going.

In terms of product dissemination, transfer to routine dissemination of all Sentinel-3A products on the Open Hub took place in October 2017. On the ColHub and ServHub, only SRAL products are currently available. During 2018, further staged openings of data flows will progressively make all Sentinel-3A products available on the ColHub, ServHub and IntHub. These will be joined by Sentinel-3B products following a successful Routine Operations Review.

The combined production from Sentinel-3A and Sentinel-3B is expected to reach around 2 TiB per day.

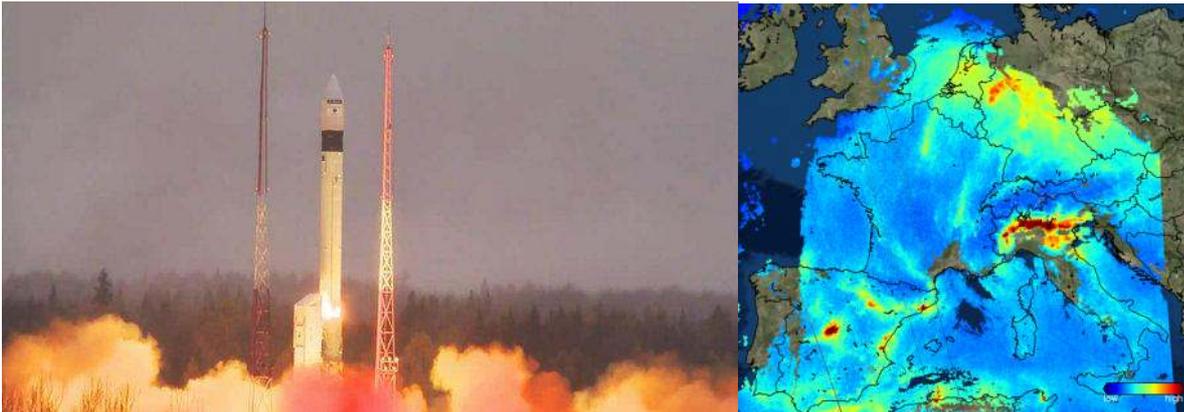


Figure 89: Sentinel-5P launch on 13/10/17 and the first image of air pollution (nitrogen oxide) over Europe

7.4 Sentinel-5P beginnings

Launched on 13 October 2017, the Sentinel-5P satellite is still being prepared for service. This new mission will take the task of monitoring air quality into a new era, promising to image air pollutants in more detail than ever before and bringing the issue of air pollution sharply into focus. TROPOMI is the single payload of the Sentinel-5P spacecraft, the purpose of which is to measure atmospheric properties and constituents. The instrument uses passive remote sensing techniques to attain its objective by measuring at the Top of Atmosphere (TOA) the solar radiation reflected by and radiated from the Earth.

The Sentinel-5P data will be progressively published to all users following the recommendations of the In Orbit Commissioning Review, currently planned in Q2 2018. The Sentinel-5P data production is expected to account for an additional 1 TiB of data per day, split between Near Real Time (NRT) and Non Time Critical (NTC) processing of the TROPOMI data.

7.5 Planned developments

7.5.1 OData V4

An upgrade of the DHuS OData API is foreseen, to version 4. Such an enhancement will make available new features to the end users (e.g. geographic query, XQuery usage). The Data Hub already exposes some entities in OData v4 for DHuS administrators, and in Q3 2018 it is foreseen to port all the entities available in OData v2 to OData v4.

The transfer to operation of OData v4 will be managed gradually:

1. In the first phase of the API update, the existing entities will be available in both OData v2 to OData v4 in separate access points ([DHuS_address/odata/v1 and [DHuS_address/odata/v2) for a certain amount of time;
2. The entities available in OData v2 will be removed from the Hub and only the one in OData v4 will remain available.

An ICD providing details about the changes introduced in the API will be disseminated to the users before the transfer to operation of the new OData entities. This document will provide the necessary information about how to interrogate the new version of OData and how to use the new

supported features. A dedicated focus will be put on the API syntax and responses for OData v4.

7.5.2 Additional Performance Improvements

During 2017 Q4 an activity of Data Hub database optimization has been planned and started. Such activity has the objective of reducing the size of the DHuS Database and improving its performances.

The activity is planned progressively:

- The first step of the database optimization activity consists in updating the structure of the database schema to improve its performances and reduce its size with any necessary the adaptation of software;
- The second step will be a benchmarking activity to allow the evaluation of performances with a different database technologies.

This activity together with the implementation of a Service High Availability will ensure an optimization of the response times and the removal of single points of failure by adding systems redundancy to every layer of the architecture.

7.5.3 Additional Data Dissemination Services

Copernicus Sentinel-1, -2 and -3 GNSS L1B RINEX data will start to be routinely made available to users. These data are generated by the ESA Precise Orbit Determination (POD) service. The GNSS L1B RINEX data has several scientific uses, the most obvious being the study of orbit determination methods and, in particular, the effect of the non-conservative forces (solar radiation, albedo, atmospheric drag, radiation pressure etc.). Other uses include:

1. Ionospheric characterization, as the dual-frequency GPS measurements contain

information about the TEC (Total Electron Content) in the ionosphere.

2. Gravity field monitoring, as it is possible to determine the time-variable part of the gravity field.
3. Geodesy, as the inclusion of LEO measurements into the global GNSS processing is supposed to be advantageous for the determination of global parameters.

7.5.4 Long term archive integration

The Sentinel Data Hubs have thus far been operated to provide online access to the full set of core user products from the Sentinel satellites since their respective In Orbit Commissioning Reviews (IOCR) and following the staged qualification of different product types. The Open Hub and the ServHub have had, as yet, no rolling policy implemented, with the full set of products made available online from the start of each mission up to the present. Due to the growth in the number of product types provided by existing missions and the upcoming data flows from Sentinel-5P and the yet-to-be-launched Sentinel-3B, a more sustainable strategy has been sought, balancing availability of the full product library with rapid, online access to the most recent and requested products. On the online side, the current 8 petabytes of storage will be expanded to 10 petabytes, providing capacity for 1 year of data from all Sentinels missions operated by ESA and including all foreseen provided product types. Products older than, for example, 18 months will be evicted from the online Data Hubs and made available indefinitely from geographically redundant Long Term Archive (LTA) services, already present as part of the Sentinels' Processing and Archiving Centres (PACs).

From a user perspective, retrieval of products from LTAs will continue to be initiated as it is at present: the Data Hubs will provide the full catalogue of available Sentinel products (both online and offline) and access will be via the GUI or API. The main impact will be a small delay in the retrieval of data compared to online products, typically from a few minutes to a few hours, with a worst-case estimate of 24 hours. Offline data will be flagged

as such, so that users will know when to anticipate a delay. Products ordered via the GUI will be initially recorded in the user shop-cart as 'under retrieval', later undergoing a status update when they are available to download. For orders made via API, standard http protocol codes will be used to report the status, with user scripts expected to implement retry for download once the products are available.

Rollout of the LTA service will be announced to users well in advance and be implemented in a controlled, staged manner. Initially, the oldest and least requested Sentinel-1 products (1A RAW products) will undergo eviction, followed by an initial qualification and performance characterisation phase, then the gradual extension of eviction to all Sentinel-1 Level 0 products older than 18 months and finally to all Sentinel-1 data products with the same aging.

Retrieval performance from the LTA will be monitored and fine-tuned during the initial operations phase following the first evictions. LTA system overload will be prevented both by a restriction on the maximum number of orders from any access service and by a per-user quota on the number of LTA products retrievable within a set period.

7.5.5 Open Source Framework

Y2018 will see new Open Source DHuS release to support Sentinel-5P products, fix issues present in the previous release and it will introduce some new features and performance improvements.

In the coming year it is expected that new external software contributions will also be integrated in the official Open Source DHuS repository.

7.6 Data Hub Relays

The conducted tests aimed at optimizing the connections between Data Hub Relays highlighted the importance of the OData synchronizer in the frame of the DHR Network and offered

suggestions of improvement of this feature and practical working proposals.

A new version of the OData Synchronizer, called 'SMART' synchronizer, will minimize the synchronization failures and will allow the parallelization of synchronization from more than one DHR node, reducing the work load on the Collaborative Data Hub nodes.

New upcoming monitoring features of the DHuS SW will allow the direct monitoring of the DHR operations on a dedicated GUI available and shared between the operators, giving the possibility to have a full and quick overview of the whole network and positively increasing coordination between DHRs.

Furthermore, during the next reporting period, the DHR network will be enlarged: a new node, operated by CESNET and placed in Czech Republic, will be added to the Network.

7.7 DIAS

Thanks to the European Union's Copernicus programme, vast quantities of satellite data are freely available to manage the environment and benefit European citizens. This offers a wealth of opportunities. However, it has been recognised that downloading and storing these data involves some complex logistical challenges for many users.

With such a quantity of data available, the European Commission is making efforts to ensure that the process of accessing this data and information is easier, so that issues associated with downloading and storing can be avoided.

To this end, the European Commission launched the Copernicus Data and Information Access Services (DIAS).

Following a tender and evaluation process, ESA, acting on behalf of the European Commission, has now signed DIAS contracts with four industrial consortia. DIAS will give unlimited, free and

complete access to Copernicus data and information.

DIAS provides a scalable computing and storage environment for third parties. Third parties will be empowered to offer advanced value-adding services integrating Copernicus with their own data and tools to the benefit of their own users.

By the second quarter of 2018, five DIAS platforms will be available to users (four under contract from ESA and one through EUMETSAT). DIAS will not

only provide a cloud-based one-stop shop for all Copernicus satellite data and imagery as well as information from the six Copernicus services, but will also give access to sophisticated processing tools and resources.

The DIAS platforms will initially source the Sentinels' data from the Data Access System and are expected to change the paradigm for provision of Sentinel Data for many users in 2018 and beyond.

8 Bibliography

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- International Hub: <https://inthub.copernicus.eu/>
- Copernicus Services Hub: <https://cophub.copernicus.eu/>
- GitHub open source framework: <http://sentineldatahub.github.io/DataHubSystem/>



9 Annex 1: List of Acronyms

API	Application Programming Interface
CLS	Collecte Localisation Satellites
CMEMS	Copernicus Marine Environment Monitoring Service
CODA	Copernicus Online Data Access (EUMETSAT operated)
ColHub	Collaborative Hub
CollGS	Collaborative Ground Segment
CSV	Comma Separated Values
DHR	Data Hub Relay
DHuS	Data Hub Software
DIAS	Data and Information Access Service
DLR	German Aerospace Centre (Deutsches Zentrum für Luft und Raumfahrt)
EC	European Commission
EDRS	European Data Relay System
ESA	European Space Agency
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GA	Geoscience Australia
GML	Geography Markup Language
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRD(H/M)	Ground Range Detected (High/Medium Resolution)
GRNET	Greek Research and Technology Network
GS	Ground Segment
GUI	Graphical User Interface
HLOP	High Level Operations Plan
HSQL	HyperSQL (Database)
HTTP	Hypertext Transfer Protocol
IntHub	International Hub
IOCR	In Orbit Commissioning Review
IPF	Image Processing Facility
LEO	Low Earth Orbit
LRM	Low Resolution Mode
LTA	Long Term Archive
MET-NO	Norwegian Meteorological Institute
MTU	Maximum Transmission Unit
NASA	National Aeronautics and Space Administration
NOA	National Observatory of Athens
NOAA	National Oceanic and Atmospheric Administration
NRT	Near Real Time
NTC	Non-Time Critical
OCN	Ocean (S-1 product category)
OCP	Optical Communications Payload (for EDRS)
OData	Open Data Protocol
OLCI	Ocean and Land Colour Instrument (Sentinel-3 instrument)

Open Hub	Copernicus Open Access Hub
PAC	Processing and Archiving Centre
PDGS	Payload Data Ground Segment
PLRM	pseudo-LRM
POD	Precise Orbit Determination
PuP	PARC Universal Packet
R&D	Research and Development
RINEX	Receiver Independent Exchange Format
S-1	Sentinel-1
S-2	Sentinel-2
S-3	Sentinel-3
S-5P	Sentinel-5 Precursor
SAFE	Standard Archive Format for Europe
SAR	Synthetic Aperture Radar
ServHub	Copernicus Services Hub
SLC	Single Look Complex
SLSTR	Sea and Land Surface Temperature Radiometer (Sentinel-3 instrument)
SRAL	SAR Altimeter (Sentinel-3 instrument)
STC	Short Time Critical
STFC	Science and Technology Facilities Council
TCI	True Colour Image
TEC	Total Electron Content
TOA	Top Of Atmosphere
TROPOMI	TROPOspheric Monitoring Instrument (Sentinel-5P)
USGS	United States Geological Survey
UTC	Coordinated Universal Time
VM	Virtual Machine
WAN	Wide Area Network
WMS	Web Map Service
XML	eXtensible Markup Language
ZAMG	Zentralanstalt für Meteorologie und Geodynamik

10 Annex 2: Product Type Description

The following table provides:

- the description of products types per each mission,
- the image of how their footprints are visualized on the hub,
- the average size of the products based on the calculation of the annual published products,
- short discussion on what new/changed products have appeared in 2017.

Further information on products can be found on the 'Instrument user guides' following the link:

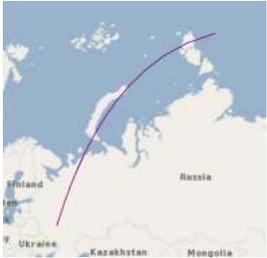
<https://sentinel.esa.int/web/sentinel/user-guides/>

Mission and Instrument	Product types	Description	Footprint on the hub	Average size	New/changed products in Y2017
Sentinel-1 (SAR)	L0-RAW	Sentinel-1 Level 0 RAW data		1.3 GiB	
	L1-GRDM	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: Medium Resolution		200 MiB	
	L1-GRDH	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: High Resolution		860 MiB	
	L1-SLC	Sentinel-1 Level 1 Single-Look Complex		4 GiB	

	L2-OCN	Sentinel-1 Level 2 Ocean		5 MiB	
Sentinel-2 (MSI)	MSIL1C	Sentinel-2 Level 1C		480 MiB	<ol style="list-style-type: none"> 1. Sentine-2 Level-1C new naming conversion since 16 December 2016 (see section 1.3.2) 2. Sentinel-2B Level-1C products started to be published on 6 July 2017 (see section 1.3.3)
	MSIL2A	Sentinel-2 Level 2A		600 MiB	Sentinel-2 Level-2A over Europe started to be published on 2 May 2017 (see section 1.3.2)
Sentinel-3 (OLCI)	OLCI L1 FR	Sentinel-3 Level 1 OL_1_EFR__ _ Full Resolution top of atmosphere radiance		600 MiB	OLCI level-1 NTC started to be published on 14 December 2016 (see section 1.3.4)
	OLCI L1 RR	Sentinel-3 Level 1 OL_1_ERR__ _ Reduced Resolution top of atmosphere radiance		690 MiB	

	OLCI L2 Land FR	Sentinel-3 Level 2 OL_2_LFR__ Full Resolution Land & Atmosphere geophysical products		100 MiB	OLCI Level 2 started to be published on 6 July 2017 (see section 1.3.4)
	OLCI L2 Land RR	Sentinel-3 Level 2 OL_2_LRR__ Reduced Resolution Land & Atmosphere geophysical products		170 MiB	
Sentinel-3 (SLSTR)	SLSTR L1 RBT	Sentinel-3 Level 1 SL_1_RBT__ Brightness temperatures and radiances		480 MiB	SLSTR Level 1 Non Time Critical (NTC) started to be published on 19 January 2017 (see section 1.3.4)
	SLSTR L2 Land	Sentinel-3 Level 2 SL_2_LST__ Land Surface Temperature geophysical parameters	<p>The footprint for this products type depends on timeliness:</p> <p>NRT</p>  <p>NTC</p> 	90 MiB	SLSTR Level 2 started to be published on 06 July 2017 (see section 1.3.4)

Sentinel-3 (SRAL)	SRAL L1	Sentinel-3 Level 1 SR_1_SRA_ _Echos parameters for LRM, PLRM and SAR mode (resolution 20Hz)		25 MiB	SRAL Level 1 started to be published on 10 March 2017 (see section 1.3.4)
	SRAL L1 A	Sentinel-3 Level 1 SR_1_SRA_A _Echos parameters for PLRM and SAR mode (resolution 80Hz)		2.3 GiB	SRAL Level 1A NTC ad STC started to be published on 10 March 2017 (see section 1.3.4)
	SRAL L1 BS	Sentinel-3 Level 1 SR_1_SRA_B S Echos parameters for LRM, PLRM		1.7 GiB	SRAL Level 1B started to be published on 14 December 2016 (see section 1.3.4)

	<p>SRAL L2 Land</p>	<p>Sentinel-3 Level 2 SR_2_LAN_ _ 1-Hz and 20-Hz Ku and C bands parameters (LRM/SAR/PL RM), waveforms. Over Land</p>	<p>The footprint for this products type depends on timeliness:</p> <p>NTC and STC</p>  <p>NRT (covering only LAND regions)</p> 	<p>36 MiB</p>	<p>SRAL Level 2 started to be published on 14 December 2016 (see section 1.3.4)</p>
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