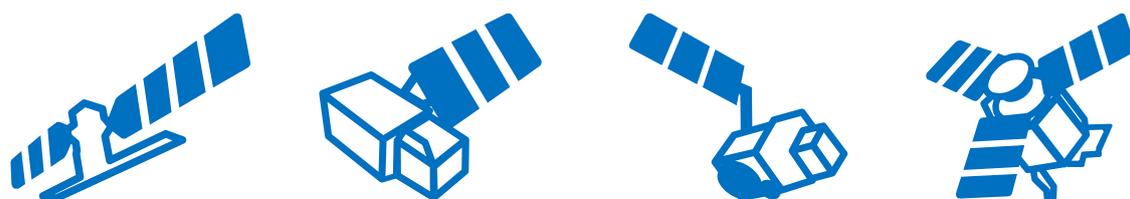




# Copernicus Sentinel Data Access

2018

## Annual Report



# Foreword

Frascati, Italy  
3 May 2019,



It is my pleasure to introduce the Copernicus Sentinel Data Access Annual Report for the 2018 reporting year. This is the fourth such report published since the start of operations, in October 2014. The report is intended to provide an overview of the Sentinels Data Access System currently in operations and its growth over the preceding years. It contains a wealth of detailed information on the Earth Observation data products made available through it, the demographics of users and their uptake of products, the status of agreements with collaborative and international partners, as well as the evolution of the System over the years and the outlook for the future.

The 2018 reporting year has been one of consolidation and growth. With the launch of Sentinel-3B on 24 April 2018, the first generation of the Sentinel-1, -2, -3 and 5p satellites are now all in orbit and operational and, at the end of the year, the final data flows to end users were being prepared for routine operations. The system is therefore approaching a level of maturity and it is perhaps insightful, at this stage, to look at the growth that has taken place over the last few years. By the end of the 2016 reporting year there were just over 50,000 registered users, a figure which has risen nearly four-fold to close to 200,000 by the end of 2018; there were just over one million products published by the end of 2016, whereas now there are 13 million (with the 10 millionth product being published on 2 August 2018); and, while 12 PiB of downloads had been made by the end of 2016, by the end of 2018 there have been 87 PiB. These impressive increases again highlight how successful the Data Access System has been in reaching a global audience, and how users continue to respond enthusiastically to the extensive and increasing data offer of freely available Sentinel data products. By the end of 2018, the Copernicus Sentinel Data Access System operated for ESA was publishing over 26,500 new products per day, a volume of roughly 15 TiB, and delivering on average 166 TiB in daily downloads.

As in previous years, the Annual Report has been prepared by the Serco-led consortium tasked with the development and operations of the Sentinel Data Access System. The consortium partners GAEL, NOA and GRNET have, together with Serco, been instrumental in successfully responding to the continuous pressure for growth on the system, both from the number and range of data products made available and from the ever-increasing user appetite for them. This report therefore presents an insider perspective on the range of the achievements, building on the contributions of all the teams involved in the Copernicus Space Component and its ground segment.



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 consortium for ESA in the Copernicus programme.

Written by:

Richard Knowelden



*The Data Access System Core Centre Operations Bridge, at the Serco premises in Frascati, Italy*

# Documentation

## Reference documents

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

## 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)
Y2018	Refers to the reporting period covered in this report, from 01/12/17 - 30/11/18. Similarly, Y2017 refers to the previous reporting period: 01/12/16 - 30/11/17, Y2016 to reporting period 01/12/15-30/11/17 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=2<sup>10</sup> bytes, 1 MiB= 2<sup>20</sup>bytes, 1GiB= 2<sup>30</sup> bytes, 1 TiB = 2<sup>40</sup> bytes and 1 PiB = 2<sup>50</sup> 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 Copernicus 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. The Copernicus Data Access System retrieves the Copernicus Sentinel-1, -2, -3 (land) and -5P products from the relevant ground segment and makes the products available for users to download from dedicated access points, known as data hubs.

This Annual Report presents the performance of the Copernicus Data Access System operated by ESA during the year **1 December 2017 to 30 November 2018 (Y2018)**, and analyses the trends visible in the public uptake of Copernicus Sentinel data. This is the fourth such report released by the data access service provider, Serco SpA, and covers a year in which a significant milestone was reached: following the successful launches of Sentinel-5P on 13 October 2017 and Sentinel-3B on 25 April 2018, the full set of seven Copernicus Sentinel satellites (Sentinels-1, -2, -3 A&B and -5P) which the Data Access System was designed to serve were in orbit and their data was being made available to the public on a systematic basis.

The magnitude of the task which the Data Access System manages as a result is visible throughout the Report, from the description of the extensions made to the underlying infrastructure, to the statistics about data publication and download. Whereas at the end of Y2015, 355,939 products had been published on the Copernicus Open Access Hub (Open Hub) and 3.38 PiB of data had been downloaded, in Y2018 the **10 millionth data product was published** on the Open Hub and by 30 November 2018 **users had downloaded 87 PiB of data products**. During

the reporting period more than **22,000 products were published per day**. Moreover, the number of **registered users reached 185,000** for the first time, indicating that not only is the existing user base consolidated but also that word is spreading and more and more users are starting to engage with the potential contained in the vast stores of free and open data available through the Copernicus Data Access System.

Y2018 was also the year in which the 5 Copernicus Data and Information Access Services (DIAS) opened their services to the public. The DIAS are operated separately from the Sentinel Data Access System, and statistics about their performance and use are not covered under this report. However, each DIAS downloads Copernicus Sentinel products from the Copernicus Data Access System operated by ESA, and the massive volumes which they have been downloading can be seen in the cumulated download statistics.

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

- **Y2018**: 1 December 2017 – 30 November 2018 (this report)
- **Y2017**: 1 December 2016 – 30 November 2017 (report released on 18 May 2018)
- **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.

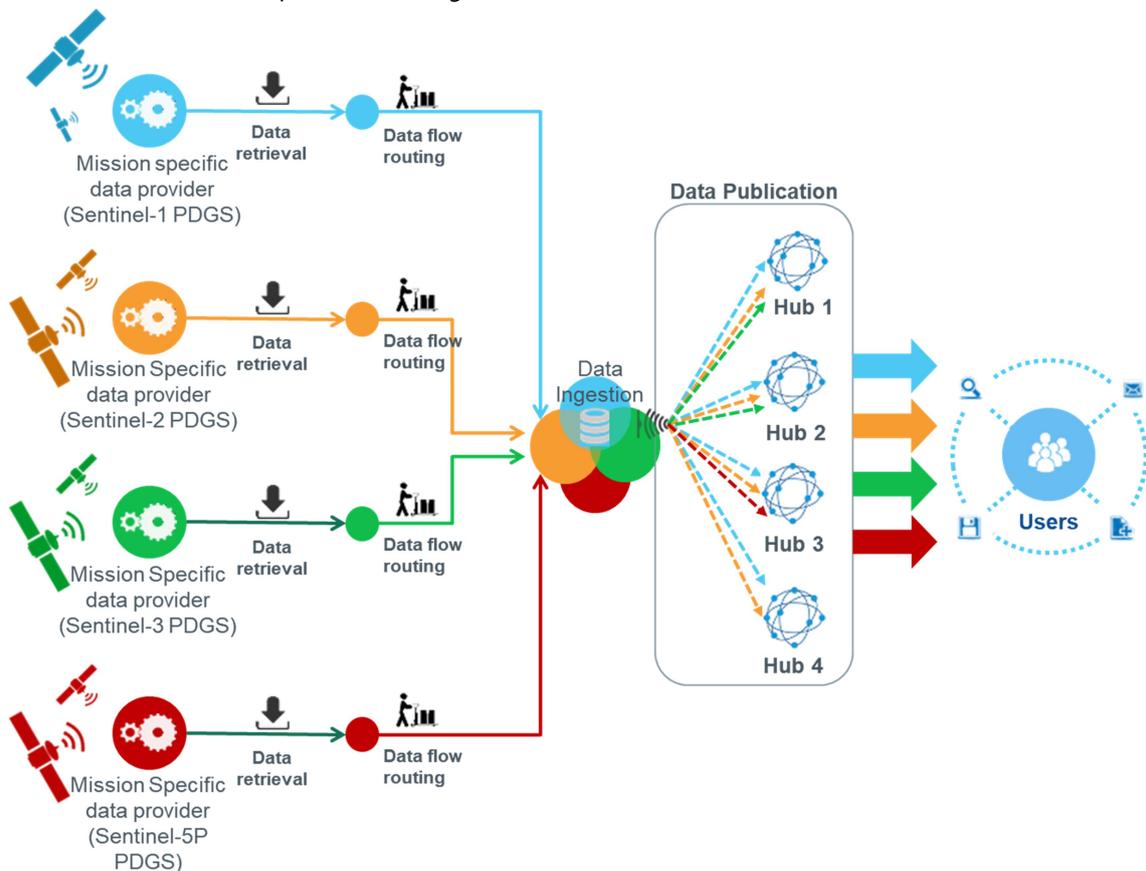


Figure 1: Data Access System Model

Due to the flexible architecture on which the Data Access System is based, the consortium is able to expand the hub configuration to accommodate the 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 and Y2018, the system has operated a total of four main hub services 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, as shown in Figure 2. Each is described in more detail below.

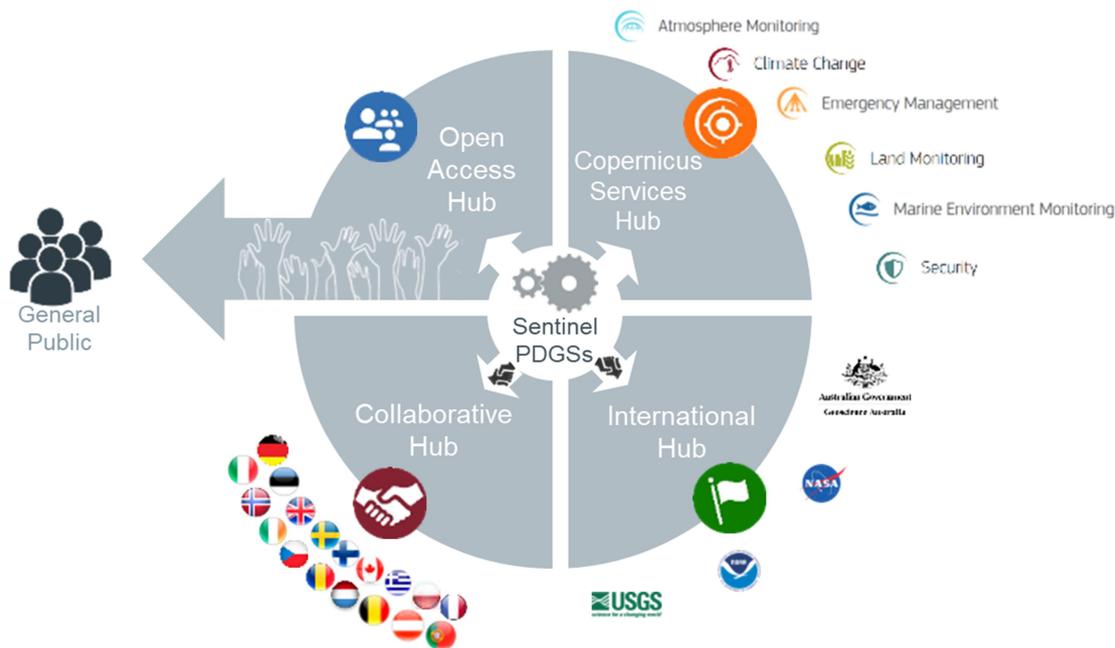


Figure 2: The Sentinel Data Access System Configuration at the end of Y2018

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. The Open Access Hub is composed of two nodes: the SciHub – accessed by graphical user interface – and the APIHub – accessed via user-defined scripts.

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.

The Open Hub provides access to all data products which have been published on the Copernicus Data Access System since the start of operations, via the same catalogue. However, since 10 September 2018, the oldest and least used Sentinel-1 data have started to be removed from the online archive (the Rolling Policy), and are now accessed from an offline archive known as the Long Term Archive (LTA). The plan for the activation of the rollout of the data and the current status are made available on the hub user

information pages (see e.g. <https://scihub.copernicus.eu/userguide>).

The Open Hub is the first hub on which data products from a new mission are published. The initial release of products during the mission ramp-up phase is managed by means of a 'Pre-operations Hub' (PreOps Hub), which is logically linked to the Open Hub but provides a separate access point. This mechanism is used to minimise dependencies with the other hubs in the Sentinel Data Access System before all teething issues have been ironed out and data dissemination operations begin on a routine basis. There are currently two mission-related PreOps Hubs active on the Open Hub: the **Sentinel-3 Pre Operations Hub** (S<sub>3</sub> PreOps Hub) and the **Sentinel-5P Pre Operations Hub** (S<sub>5P</sub> PreOps Hub). These hubs provide access to all products from the respective missions published to date. Following entry into routine operations, the products are released instead through the standard Open Hub interfaces and the relevant PreOps Hub is decommissioned.

In Y2018, a further PreOps Hub was opened on the Open Hub, called the **GNSS Hub**. This Hub makes available a new data product called the GNSS L1b RINEX product, relevant to the Sentinel-1, -2 and -3

missions. Further details about this development are provided in Section 1.2 below.

\*\*\*\*\*

The **Copernicus Services Hub (ServHub)** guarantees free and full access to Copernicus Sentinel data for all Copernicus Services and EU institutions. Users are entitled to make up to 10 concurrent downloads. All data products from all of the missions which are in routine operations are published on the Hub. The ServHub operates the same policy for removing products from the online access as the Open Hub, providing access to the Long Term Archive for data removed by the Rolling Policy.

The DIAS partners also have access to the full set of Copernicus Sentinel data products via ServHub, through a separate access point, known as the DIAS Access Hub, which is logically linked to the main Hub.

\*\*\*\*\*

The **Collaborative Hub (ColHub)** is open to all Copernicus Participating States, following signature of a CollGS agreement with ESA or an internal agreement with the European Commission. The ColHub is configured to support 10 concurrent downloads for each user. The CollGS partners download the Copernicus Sentinel data products as they are published on the hub, and then redistribute the products from their own storage and data access points. Accordingly, a Rolling Policy is applied to ColHub, removing products which have been on the hub for longer than a defined period of time (typically the latest month).

At the end of Y2018, there were 18 CollGS agreements in place and 13 CollGSs in operation (see Section 4).

The dissemination capacity of the ColHub is enhanced by an interconnected data relay system which some of the CollGS partners run in addition to their standard data access point. Through this relay system, each CollGS partner is able to access data from a Data Hub Relay partner as well as directly from the ColHub, and this significantly increases the volumes of data which the CollGS partners are able to download at any given time. By the end of Y2018, a total of 7 Data Hub Relays had been deployed by the CollGS partners. These Data Hub Relays are connected to the CollGS operated in Germany, France, Austria, Norway, UK (two relays) and the Czech Republic.

\*\*\*\*\*

The **International Hub (IntHub)** 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 configured to support 10 concurrent downloads, and a Rolling Policy of 3 weeks is applied. At the end of Y2018, there were 4 technical agreements in place with international partners, all of which were in operations.

Figure 3 below summarises the overall Sentinel Data Access System front-end configuration at the end of Y2018.

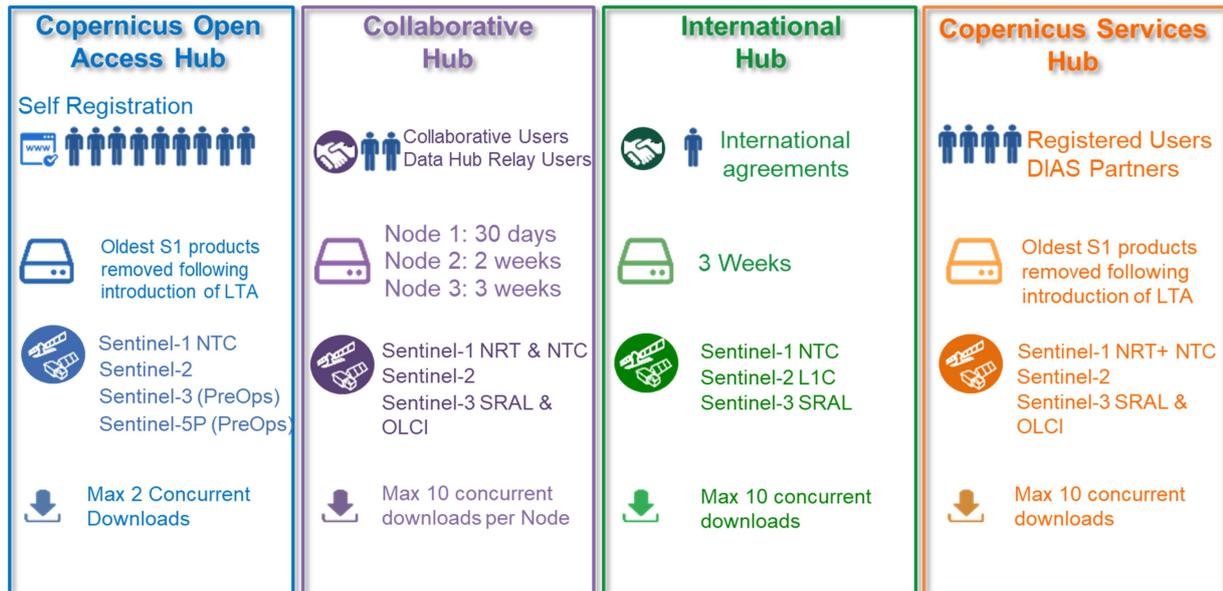


Figure 3: Copernicus Sentinel Data Access System hub characteristics at the end of Y2018

The Data Hubs described in this Chapter are operated under the responsibility of ESA and provide access to all Copernicus Sentinel data products apart from Sentinel-3 Level 1&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)

## 1.1.1 Deployment Physical Architecture

This section provides a brief overview of the physical architecture of the Data Access System as shown in Figure 4.

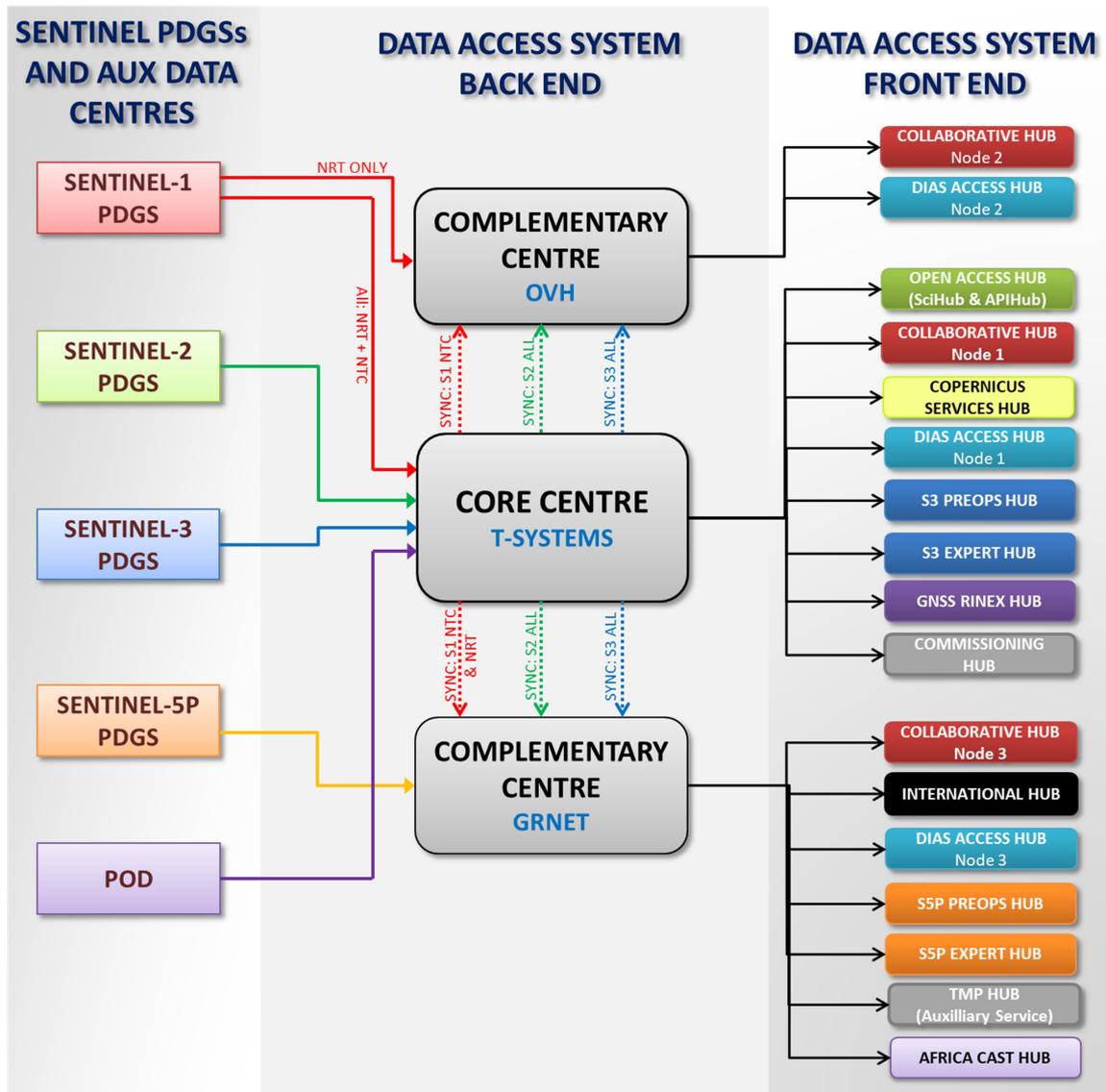


Figure 4: Data Access System Physical Architecture Overview

Figure 4 shows, on the left, the Sentinel PDGSs and Auxiliary Centres which provide data products to the Data Access System, in the middle the 'Back End' Data Access Centres through which the system is run and, on the right, the 'Front End' Data Access Hubs through which the data is exposed to end users.

and two Complementary Centres, which are responsible for ingesting some data products directly from the PDGSs while the majority are retrieved from the Core Centre. The Core Centre is run by T-Systems, while the two Complementary Centres are run by OVH and GRNET.

The three Data Access Centres are each responsible for ingesting a defined sub-set of data products from the Sentinel PDGSs, archiving and cataloguing the data and publishing it to end users on the Data Access Hubs for which they are responsible. The Centres are composed of one Core Centre, which ingests the majority of data products from the PDGSs and has overall responsibility for the system,

The full set of Hubs operated by the Data Access System is shown, along with the Centre which operates them. Some of the Hubs, such as the 'Commissioning Hub', are available to only a small number of internal users and are not further described in this document. The others have been described above. The Open Access Hub and Copernicus Services Hub are operated from the Core

Centres and the International Hub is operated from the Complementary Centre. However, the Collaborative Hub and DIAS Access Hub are operated from three nodes each, in order to enhance access to data for their users. One node for each Hub is operated by each Centre.

The Figure also highlights the data flows through the System. For example, in the case of Sentinel-1 all data products are ingested by the Core Centre, while only NRT products are sent to the OVH Complementary Centre. No products are ingested directly by the GRNET Complementary Centre, but that Centre does retrieve and sync Sentinel-1 products from the Core Centre.

## 1.2 Main Evolutions of the Data Access System in Y2018

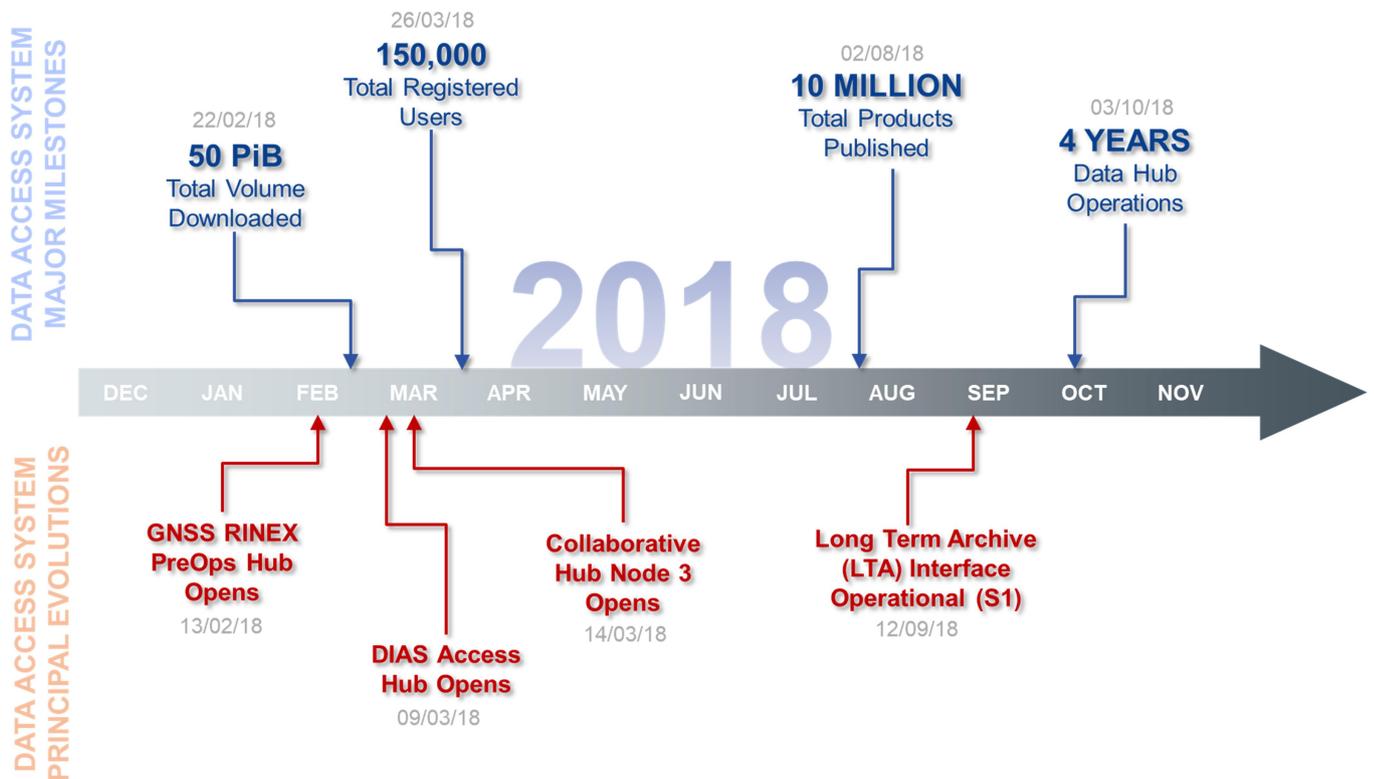


Figure 5: Timeline of the main Y2018 achievements in terms of data dissemination and improvement of the Data Access System

### 1.2.1 Specific Data Hub Evolutions

Y2018 has seen the continuation of Sentinel Data Access System evolutions, implemented to ensure the System can continue to support more users than ever before, providing them with access to vastly

more data products from the growing family of Sentinel missions. The main evolution and improvements undertaken in Y2018 are described in this section.

#### Sentinel-1 Long Term Archive (LTA) Integration

Until September 2018, the Open Hub provided full online access to all available data from the

Copernicus Sentinels. Given the cumulative effect keeping all data available on-line in this way, however, it was expected that by October 2018 the overall volumes would exceed the capacities available in the Sentinel Data Access System. To prevent this risk from materialising, the data access service team developed a means for the System to retrieve products stored off-line in the Sentinel-1 PDGS Long Term Archive (LTA), and make them available to users through the existing interface points (GUI and API), with a slightly reduced timeliness. The first products selected for removing from the on-line access were the oldest and least used Sentinel-1 RAW and WV-SLC data products.

Following an extensive test period which demonstrated that the interface with the LTA was operational, the off-line data access for the Sentinel-1 RAW and WV-SLC data products was activated on 12 September 2018. It is expected that this rolling out of the oldest Sentinel-1 data from the online access will now continue as part of the planned routine operations, enabling the System to maintain the last year of Sentinel-1 data products accessible online). It is highlighted that the Hubs continue to provide unified access to all of the Sentinel-1 Data: the catalogue continues to publish all data, while the discovery and download interfaces (both the GUI and API) provide status information to indicate whether a product is online or offline. Access to the product URL for data that are no longer available online automatically triggers the retrieval of the data from the LTA and the actual download can be initiated once the data are restored (within minutes to hours).

This regime of maintaining the most recent year of data products online, and retrieving all previous products from the off-line LTA, will be applied progressively to Sentinel-2 and Sentinel-3 in the coming year.

### **Sentinel-3 Pre-Operations**

Throughout Y2018, routine dissemination of Sentinel-3A data products continued to be transferred from the S3 PreOps Hub to the standard Open Hub interface. The process had begun on 19 October 2017 when, following the successful Sentinel-3A Routine Operations Review, the Sentinel-3A SRAL data flow was transferred to the

standard Open Hub. Publication of SRAL data on the S3 PreOps Hub ceased on 15 January 2018, the OLCI data flow was transferred on 27 September 2018, and the SLSTR products were transferred on 12 November 2018.

Use of the S3 PreOps Hub continues, however. At the same time as the established Sentinel-3A products were being transferred to the standard Open Hub interface, a new class of Sentinel-3 Synergy products began to be distributed through the S3 PreOps Hub, on 10 October 2018. Moreover, following the launch of Sentinel-3B on 25 April 2018, a dedicated 'Expert Hub' for providing products to expert users was opened two months later on 25 June 2018. After the successful validation of the Sentinel-3B SLSTR products, the products began to be disseminated via the S3 PreOps Hub in November 2018: NRT publication on 12 November and NTC on 19 November 2018. It is expected that all remaining categories of Sentinel-3B data products will be released within the next reporting year.

### **Sentinel-5P Pre-Operations**

After the successful launch of Sentinel-5P on 13 October 2017, the non-validated data was provided to the validation teams via a dedicated Expert Hub. After the data was declared validated for public release, the routine production began to be published via the S5P PreOps Hub on 11 July 2018. Both the S5P PreOps Hub and the Expert Hub, have been set up in the NOAA/GRNET data centre, and with a smooth transition from the originally intended core centre.

### **GNSS RINEX Dissemination**

In addition to the main scientific instrument payloads, the Sentinel-1, -2 and -3 satellites incorporate dual frequency GPS receivers to support precise determination of the satellite orbit, needed for the processing of the scientific data acquired by the main instruments. Up until the beginning of Y2018, the GNSS L1B data generated by these receivers were only circulated inside the ground segment of each Copernicus mission, in particular to the Copernicus Precise Orbit Determination Service. However, scientific users had frequently requested a new type of product– a Sentinel GNSS L1b RINEX

product – to be made fully available to users. Such a product would have many scientific uses, including the study of orbit determination methods and the effect of non-conservative forces (for example, solar radiation, albedo, atmospheric drag, radiation pressure), ionosphere characterisation, gravity field monitoring and geodesy.

In response to this, the GNSS RINEX Pre-Operational Hub was opened on 13 February 2018. From the Hub, users can download all such products relevant to the Copernicus Sentinel-1, -2 and -3 missions. Through the release of these products, the Copernicus Programme aims at supporting the scientific community involved in many geodetic applications worldwide and encouraging new uses for the Copernicus Sentinel GNSS data, maximising the missions' return and becoming a reference for GNSS processing.

**Data Access for DIAS Partners**

The European Commission’s Copernicus Data and Information Access Services (DIAS) initiative is intended to facilitate the process of accessing the vast amounts of data generated by Copernicus missions, and remove complications associated with downloading and storing data. Each DIAS provides a scalable computing and storage environment which is open to the public, and enables businesses, public entities, research organisations and individuals to offer advanced value-adding services, integrating Copernicus data and information with their own data and tools, for the benefit of their user community.

Five DIAS platforms were declared operational during Y2018, at the Copernicus Baveno event on 20-21 June 2018. The DIAS partners have been provided with three dedicated access points on the Copernicus Data Access System, to ensure a sufficient capacity to download the large volumes of products which are required for their respective data offers. Initial access was granted through the standard ServHub interface, before three dedicated access points, known as the DIAS Access Hub, were linked to ServHub during Y2018 and opened to the DIAS partners on 9 March 2018. These nodes are operated on both the secondary sites, granting a considerable capacity to download the fresh data (from the secondary sites operating a rolling archive of latest data) and also

from the main infrastructure that allows to access the full historical archive. Following their opening, these access points have been massively used, avoiding impact on the other data hub services.

The downloads which are made by the DIAS operators are included within the figures reported for the ServHub throughout the data access reporting (i.e. within this Report and in the online Sentinel Data Dashboard). Any statistics concerning the subsequent use of the data products on the DIAS are outside the scope of this Report. Information about the performance of the DIAS and user uptake can instead be accessed from the following websites:



Figure 6: The Copernicus DIAS Initiatives

**Africa Cast Hub**

The dissemination of Sentinel-3 Land products to African users is ensured jointly by ESA and EUMETSAT who each contribute with its respective data dissemination infrastructure: the DHuS and EUMETCast. The Africa Cast Data Hub Service provides an interface for the distribution of Sentinel-3 Level-2 Land products to EUMETSAT. EUMETSAT then transmits the data via EUMETCast to the African users. The service has been setup by the end of July 2018 and has since gone through a test phase followed by a pilot phase. The service is foreseen to be in full operations by January 2019 providing systematic Sentinel-3 OLCI, SLSTR, SRAL and SYN Level-2 Land operational products selected over Africa.

**Network Evolution**

During Y2017, the analysis of network traffic showed a steady and continuing increase. Additionally, a

further jump in usage was foreseen for 2018, when four additional copies of products would need to be brought to ServHub for the DIAS access points. Therefore, at the beginning of Y2018, a review of the overall network was carried out, and a major network redesign was performed during the second quarter of Y2018, in order to reduce the high load on the pick-up point firewall. Under this new design, a new Front End infrastructure at 100 Gbps and a new GÉANT Link at 100 Gbps (up from 10 Gbps) have been operational since the beginning of May 2018.

### Complementary Centres

The OVH infrastructure has been hosting the second node of the ColHub which has performed well during Y2018. The unique node of the IntHub has been successfully operated by NOA/GRNET since 18 October 2017. The NOA/GRNET service was further expanded during Y2018 to host a third node for ColHub. This additional node was introduced on 13 March 2018 in order to reduce the loading on the main infrastructure. Both Complementary Centres, in

addition to the Core Centre, provide a node of the DIAS Access Hub.

Further expansion to the complementary centres took place during Y2018 to support the overall system availability in the face of the increasing pressure experienced by the core infrastructure during the first half of the year.

- The Sentinel-5P PreOps Hub and the Expert Hub were entirely re-located to the GRNET complementary centre, implemented using latest object storage cloud technologies. All Sentinel-5P products are therefore currently disseminated from the GRNET complementary centre,
- A transparent buffer for temporarily relocating any Copernicus Sentinel data was established in the OVH complementary centre. This development was also based on latest object storage, with an adaptation of the Data Hub Software for the seamless management of distributed remote datastores.

## 1.3 Main Mission Developments in Y2018

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.

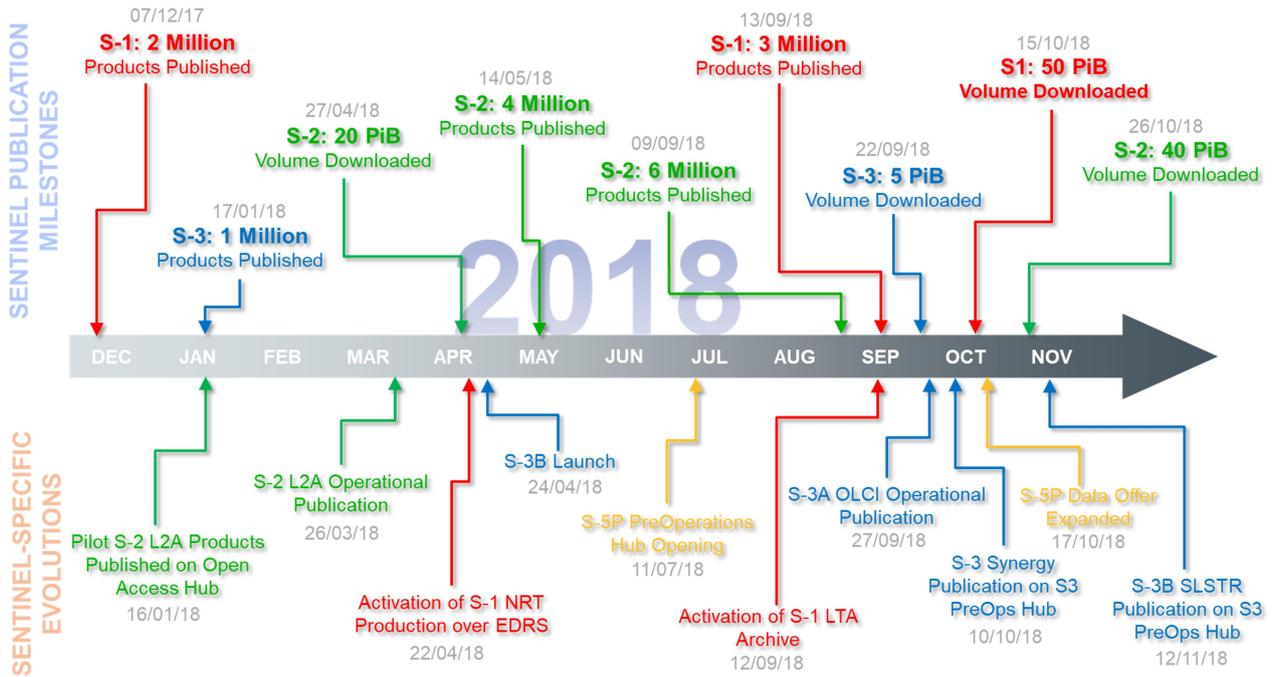


Figure 7: Timeline of the main Y2018 achievements in terms of Sentinel mission-specific published products and evolutions

### Sentinel-1

As a result of user feedback, product format change was introduced on 13 March 2018 for all Sentinel-1 Level-1 and Level-2 products. This was implemented in the Sentinel-1 Instrument Processing Facility (IPF) version 2.90.

EDRS is the world’s first optical satellite communication network in geostationary orbit, allowing data from low-earth orbit (LEO) satellites to be relayed to the ground. The integration of the EDRS service into Sentinel-1 operations began during Y2017 – in May 2017 for Sentinel-1A and October 2017 for Sentinel-1B. Since then, 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. During Y2018, Sentinel-1 NRT production over EDRS was successfully activated on 22 April 2018.

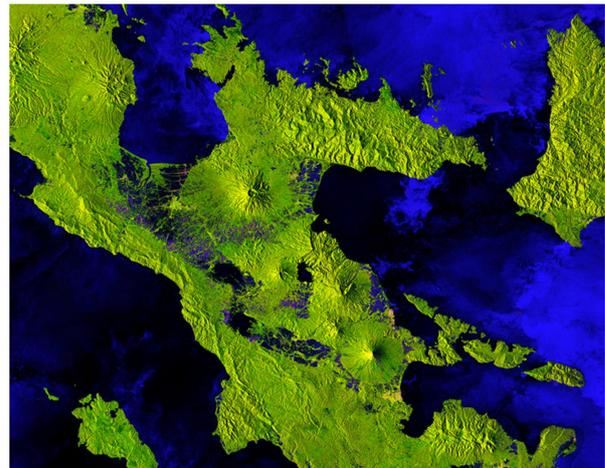


Figure 8: A Sentinel-1B image of Mount Mayon on the island of Luzon in the Philippines, one of the most active volcanoes in the world, taken on 16 January 2018

### Sentinel-2

Pilot Sentinel-2A Level 2A products, which had started to be made available during Y2017 on the Open Hub, were followed by pilot Sentinel-2B L2A products on the ServHub and Open Hub interfaces from 16 January 2018. Then, on 26 March 2018, the pilot service was replaced by an operational service providing routine coverage of the Euro-

Mediterranean region, including an update of the product format and other improvements.

Throughout Y2018, progress was made with repackaging of the Sentinel-2 L1C old product format multi-tile data into the Complete Single Tile format. Following the re-formatting and validation of the first batches of products, the publication of the newly formatted single tiles began on 22 May 2018. The affected dataset covered the sensing period from 4 July 2015 to 6 December 2016 (Sentinel-2A only). Approximately 340,000 existing products have been repackaged, creating over 1.3 million new products. The activity is scheduled to complete in early 2019.

Following requests received at the Copernicus Committee, investigations were made into providing Sentinel-2 L1b products. The first sample datasets were provided to interested stakeholders in early Q3 2018.



*Figure 9: A Sentinel-2 image showing fires within the Arctic Circle in Sweden on 17 July 2018, during the European Summer heat wave*

### Sentinel-3

Publication of a new set of products, L2 Synergy (SYN) products, commenced on the S3 PreOps Hub from 10 October 2018. SYN products rely on the synergistic and co-located combination of OLCI and SLSTR products, with the intention to provide continuity with the SPOT VEGETATION mission. They offer high quality global data of the entire terrestrial surface with complete Earth coverage in 1-2 days, with a primary objective to enable global monitoring of land use.



Figure 10: Launch of Sentinel-3B on 25 April 2018 in Plesetsk, Russia

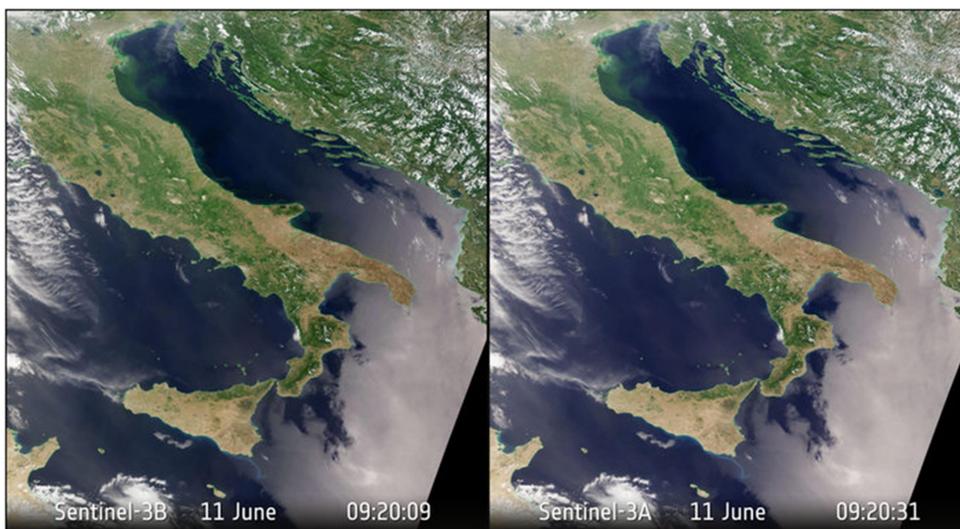


Figure 11: Tandem images from the OLCI instruments on Sentinel-3A and Sentinel-3B, taken 12 second apart on 11 June 2018

following Level 2 data product types qualified for the first open release:

**Sentinel-5P**

Sentinel-5P provides calibrated instrument data as Level-1B products, and measurements of atmospheric components as Level-2 products in Near Real Time (NRT) and Non Time Critical (NTC) processing. The product nomenclature for Non Time Critical production within Sentinel-5P is “Offline (\_OFFL\_)”, however, the NTC abbreviation is used throughout this report to avoid confusion with the discussions of Long Term Archive access. The S5P PreOps hub was opened on 11 July 2018, with the Level-1B calibrated instrument data and the

- Ozone (O<sub>3</sub>) total vertical column (L2\_\_O3\_\_) NRT
- Nitrogen dioxide (NO<sub>2</sub>) vertical column (L2\_\_NO2\_\_) NRT and NTC
- Carbon monoxide (CO) total column (L2\_\_CO\_\_) NTC
- Cloud Parameters (L2\_\_CLOUD\_) NRT and NTC
- Aerosol index product (L2\_\_AER\_AI) NRT and NTC

- Suomi-NPP cloud product (L2\_\_NP\_BDx) NTC

The following Level 2 data product types were then added to the offer on 17 October 2018:

- Ozone (O<sub>3</sub>) total vertical column NTC
- Sulphur dioxide (SO<sub>2</sub>) total vertical column NRT
- Formaldehyde (HCHO) total vertical column NRT

And on 22 November 2018:

- Carbon monoxide (CO) total column NRT

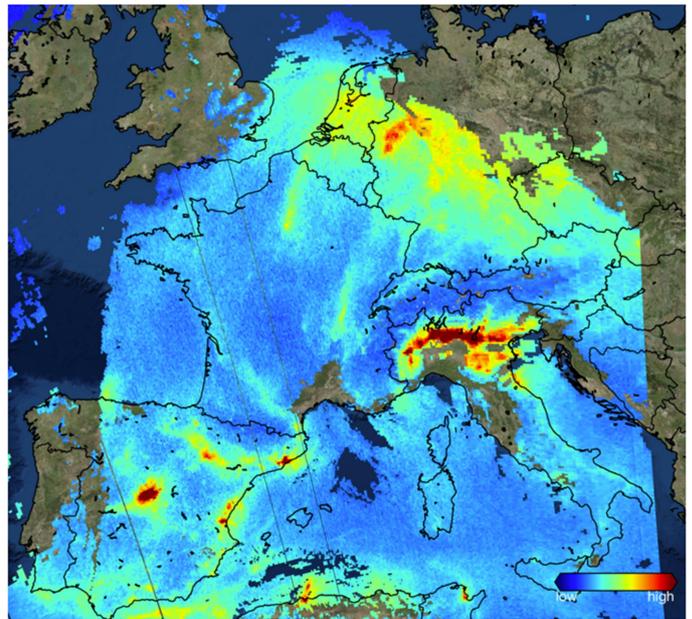


Figure 12: One of the first images from Sentinel-5P, showing nitrogen dioxide over Europe on 22 November 2017

# 2 Data Access Service Growth

During Y2018, the statistics which illustrate the level of public engagement with the Data Access System continued to increase dramatically. User registrations rose 71% to 187,797, the number of Sentinel data products made available for download

on the Open Hub increased by 152% to 13 million products, and the volume of Sentinel data products downloaded by users since the start of operations rose 110% to an enormous 87 PiB. In this chapter, each of these increases is analysed in detail.

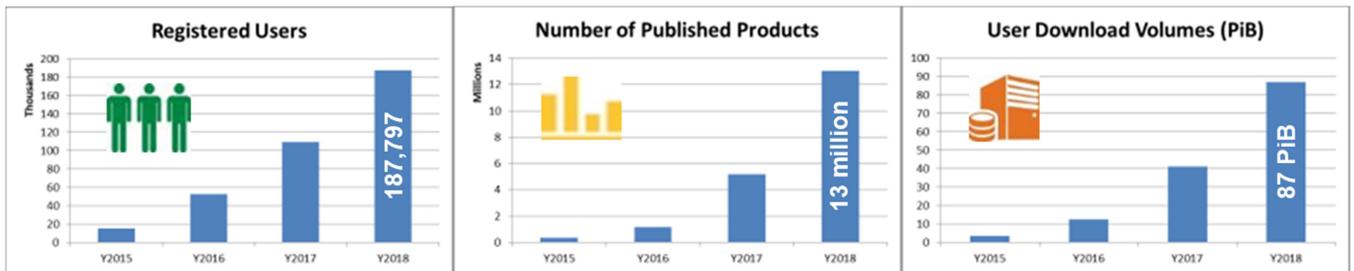


Figure 13: Overall Rise in Data Hub Registered Users, Published Products and User Download Volumes, showing cumulative total for each year since the start of operations

## 2.1 Users take-up

By the end of Y2018, 187,797 users were registered to access the four hub services offered by the Copernicus Data Access System operated by ESA. Figure 14 breaks this overall figure down to show the number of users registered on each hub, and the percentage increase since the end of Y2017. These numbers represent the total number of user accounts 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.



Figure 14: Registered Users per Data Hub

Given that only the Open Hub is open to the public for self-registration, and access to the other hubs is provided on a preregistration basis, this section examines in further detail only the numbers of registrations on the Open Hub.

## 2.1.1 User Registrations

The number of users registered on the Open Hub by the end of Y2018 increased by 71% with respect to

the previous year: at the end of Y2017, there were 109,475 users registered worldwide on the Hub since the beginning of operations (03 October 2014); by the end of Y2018 this number had risen to 187,551.

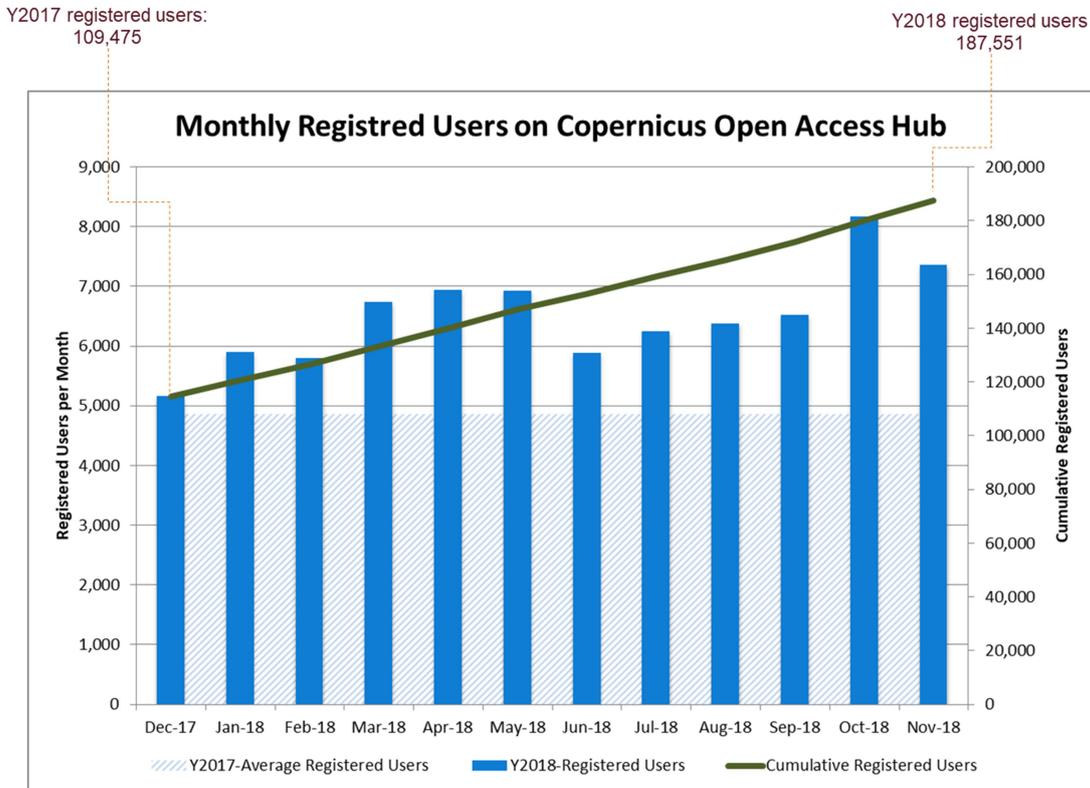


Figure 15: Trend of User Registrations on the Copernicus Open Access Hub

The graph in Figure 15 above shows the number of users who registered each month for access to the Open Hub during Y2018, contrasted against the average number of user registrations made per month during Y2017. The cumulative number of registered users since the start of operations is also shown.

growing awareness about Copernicus during Y2018, and a steadily increasing audience for Copernicus Sentinel data.

It can readily be seen that the number of new user registrations each month was consistently greater than monthly average for Y2017. Indeed, in Y2018 there was an average of 6,506 registrations per month, which is 34% higher than the Y2017 average of 4,846 and 97% higher than the 3,300 Y2016 average. These figures indicate that there was a

## 2.1.2 Open Access Hub Demography

There were some interesting changes during Y2018 in the demographic spread of user registrations.

Europe remains the continent with by far the largest Open Hub user-community, with **72,030 registered users by the end of Y2018**. However, the growing awareness of and interaction with the Open Hub has by no means been limited to Europe. In Figures 16 and 17 below, the increase in user registrations during Y2018 is broken down by continent. These figures show that **the most significant increase in user registrations during Y2018 actually took place in Asia, with an increase of 90%, up to 42,478 users**. Oceania and North America also exhibited

higher percentage increases than Europe (though from significantly lower starting points) with 76% and 73% respectively, and this year a higher percentage increase was also seen in Africa, where a 76% increase was observed, bringing the total number of African registered users to 11,344.

It is highlighted again that these statistics are generated on the basis of the nationality which users insert when they register for access to the hub, and no independent cross-checking based on the user's IP address is performed. It is also worth noting that the statistics here only account for the Open Access Hub and the true demography of users is likely to also be influenced by the availability of alternative national sources of Sentinel data, for example via the Collaborative mirror sites.



Figure 16: Open Access Hub registered users in Europe

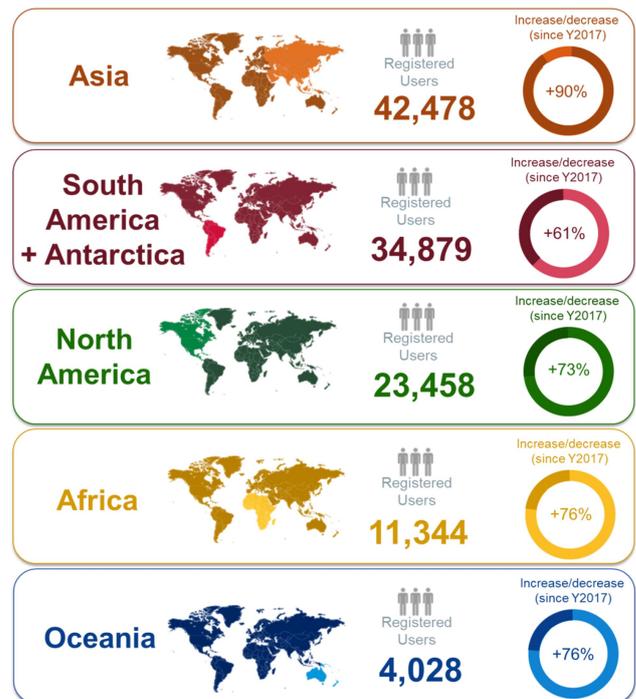


Figure 17: Number of registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent during Y2018

Breaking the per continent figures down by individual country, it emerges that Brazil remains, as in Y2017 and Y2016, the country with the largest number of registered users in the world, with 12,729 self-registered users. Brazil is closely followed by the

United States (12,511 users), Germany (11,806 users) and China (11,318 users).

Focussing specifically on Europe, Figure 18 illustrates the number of registered users in the ESA and European Union Member States by the end of Y2018. The top 5 ESA and European Union Member States in

terms of the number of registered users are shown, as well as the percentage change since Y2017.

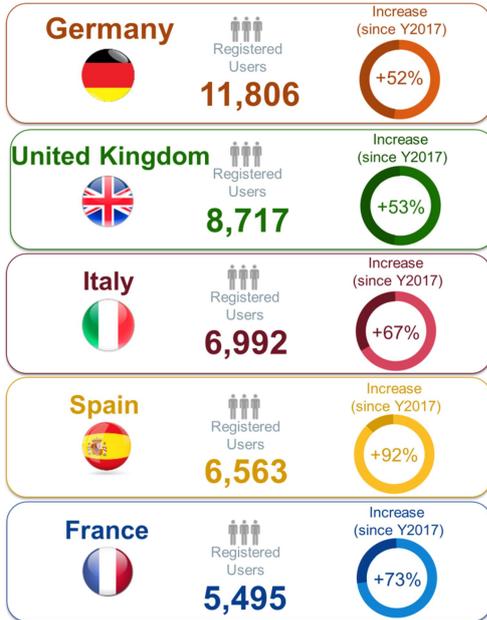


Figure 18: Copernicus Open Access Hub registered user distribution in EU and ESA member states

Interestingly, neither the countries in this list nor the order in which they appear have changed since Y2017, it is simply the numbers which have changed, and again they have shot up. This year it is Spain rather than France which showed the highest percentage increase (92%), but France still experienced another major upsurge, and now has 5,495 registered users. Germany remains the country with the largest number of registered users in Europe and even there registrations increased by 52%, reaching a total number of 11,806 registered users at the end of Y2018.

Another interesting view on the number of user registrations is the trend of countries worldwide reaching more than 500 user registrations. The graph below shows the monthly increase in the number of countries reaching this threshold. The number continues to grow: by the end of Y2018, there were 60 countries across the world with more than 500 registered users (an increase of 28% since Y2017).

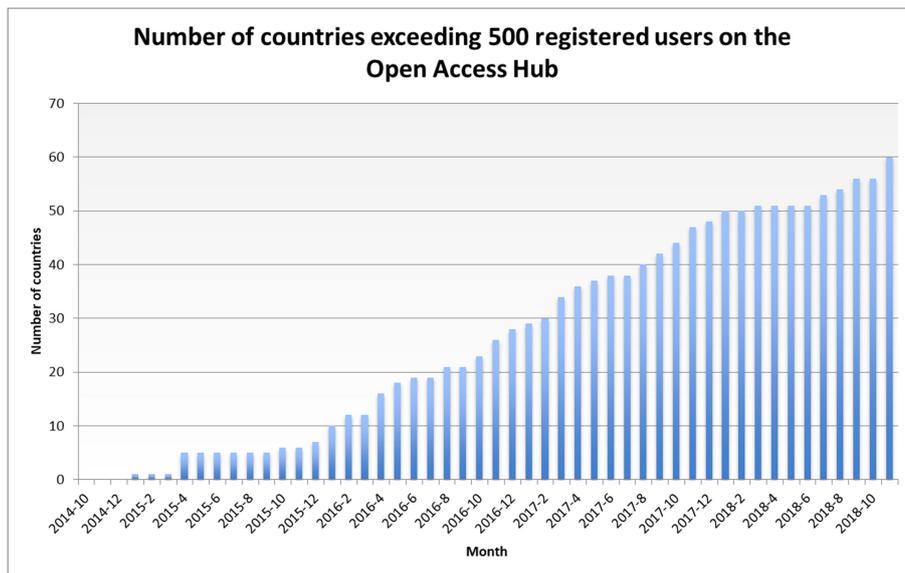


Figure 19: Growth in the number of countries exceeding 500 registered users on the Open Access Hub since the start of operations

User activity on the Hubs is analysed in Chapter 3.

## 2.2 Products Publication

By the end of Y2018 the status of products publication per mission was the following:

- *Sentinel-1A/-1B* and *Sentinel-2A/-2B* products were being routinely published on all the data access hubs
- *Sentinel-3A* SRAL products were being routinely disseminated on all hubs; S-3A OLCI products were being disseminated on the Open Hub, ColHub and ServHub; S-3A SLSTR and SYNERGY products were being disseminated on the Sentinel-3 PreOps Hub. *Sentinel-3B* products were being disseminated on the Sentinel-3 PreOps Hub.
- *Sentinel-5P* products were being disseminated on the Sentinel-5P PreOps Hub.

This section presents the statistics for the publication of those products during Y2018.

### 2.2.1 Publication Growth

By the end of Y2018, a total of 13,049,181 Copernicus Sentinel products had been published on the Open Hub since the start of operations, with a total data volume of 9.69 PiB.

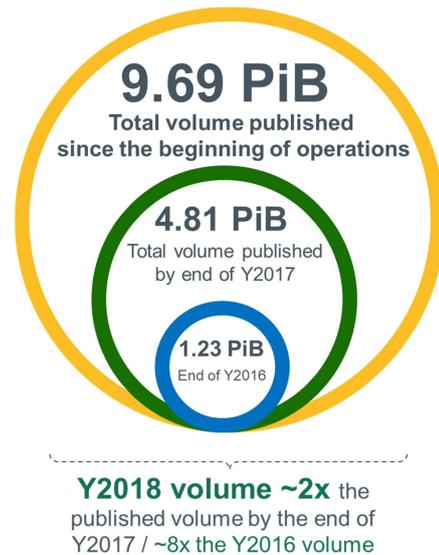


Figure 20: Total volume of published products since the start of operations and comparison with Y2017/Y2016 cumulative volumes

As shown in Figure 20, the cumulative volume of products from all Sentinels published by the end of Y2018 was about double the cumulative volume of products published by the end of Y2017, meaning as much data was published during Y2018 as in the preceding three years put together. The volume of data published therefore continues its year-on-year growth. These figures give a good indication of how quickly the volumes of data are increasing, with data volumes which are unprecedented for Earth Observation missions. For example, the 4.88 PiB published during Y2018 alone is around five times the 1 PiB of data published for ENVISAT over the course of the entire 10 year mission.

Tables 1 and 2 below break these totals down by Sentinel, showing the number and volume of products published in Y2018 as compared to the total since the start of operations. As reported in Table 1, in terms of number of published products Sentinel-2 data continues to exceed Sentinel-1, even though 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: so even though the number of Sentinel-2 products is more than twice that of Sentinel-1 the volume of Sentinel-2 products (3.68 PiB) is significantly less than that for Sentinel-1 (5.13 PiB). There was a notable change in the volume of Sentinel-2 products published during the year, so

although the total volume of Sentinel-1 products available for download remained higher than for Sentinel-2, the volume of Sentinel-2 products published during the year for the first time exceeded the volume of Sentinel-1 products published in the year (2.27 PiB vs 2.08 PiB).

Mission	No. of products published in Y2018	No. of products published from start of Ops to end Y2018	Volume of products published in Y2018 (PiB)	Volume of products published from start of Ops to end Y2018 (PiB)
S1	1,304,078	3,282,679	2.08	5.13
S2	5,058,204	7,390,836	2.27	3.68
S3	1,349,706	2,208,956	0.45	0.81
S5P	166,710	166,710	0.07	0.07
<b>ALL</b>	<b>7,878,698</b>	<b>13,049,181</b>	<b>4.87</b>	<b>9.69</b>

Table 1: Overall number and volume of published products in the Open Access Hub both in Y2018 and since the start of operations, per Sentinel mission

Mission	Daily Average Vol (TiB) published in November 2018	%	Daily Average Vol (TiB) published in November 2017	%
S1	5.79	39	5.82	58
S2	7.76	52	3.22	32
S3	1.18	8	1.01	10
S5P	0.29	2	N/A	0
<b>All</b>	<b>15.02</b>		<b>10.04</b>	

Table 2: Average volume of products published per day in the last month of Y2018 and Y2017, with percentage splits per Sentinel mission

Table 2 shows the Open Hub publication volumes on a daily basis, averaged over one month at the end of the reporting period (November 2018). It can be seen that the average daily volume of data being published by the Data Access System increased by 50% since November Y2017. At the end of Y2018, the majority of NTC products being published were Sentinel-1 and Sentinel-2 products (together accounting for 90% of the daily total), reflecting the fact that both the -A and -B satellites for each mission were in orbit, and that products from each satellite were already being disseminated to the public on a routine operational basis. It is interesting to note that while the total daily volume of Sentinel-1 products (5.79 TiB/day) remained relatively stable as compared to Y2017 (5.82 TiB/day), in terms of

percentage share of the publication volume Sentinel-1 accounted for 38% of the average daily volume whereas by the end of Y2017 it had constituted 58% of the average daily publication volume. The change is again largely explained by the increase in the average volume of Sentinel-2 products published per day, which more than doubled, and by the end of Y2018 accounted for 52% of the average daily volume. This was driven in a large part by the operational distribution of Level-2A products (from 26 March 2018) and the repackaging of Level-1C products into the single tile format (from 22 May 2018). The Sentinel-5P products currently being distributed on the Pre Ops Hub comprised 2% of the daily total by the end of Y2018.

Mission	Daily Average Number of Products Published in during Y2018	%	Daily Average Number of Products Published in during Y2017	%
S1	3,760	17	3,167	28
S2	13,858	62	5,674	51
S3	3,698	16	2,301	21
S5P	1,174	5	0	0
<b>TOTAL</b>	<b>22,490</b>		<b>11,142</b>	

Table 3: Daily average number of products published per mission during Y2018 and Y2017

Table 3 shows the average *number* of products which were published per day in Y2018 on the Open Hub, broken down by mission, with the Y2017 figures included for comparison. It can be seen that the Data Access System was able to publish an average of 22,490 products per day for all missions, almost double the 11,142 products it published per day on the Open Hub during Y2017. This growth was driven largely by the significant increase in the average number of Sentinel-2 products published per day, up to 13,858 per day from 5,672. The System also handled a 61% rise in the average number of Sentinel-3 products published per day and the introduction of the Sentinel-5P products. It is highlighted that the Sentinel-5P daily averages are calculated from 11 July 2018 (when they started to be published on the PreOps Hub) until the end of the

period, but that the daily publication increased steadily during the period as new product types were added.

## 2.2.2 Publication trends

The graphs below show, per Sentinel mission, both the number and volume of products which were published per month on the Open Hub and PreOps Hubs during the Y2018 reporting period. The values represent the sum total of all individual product types published per mission, and for both –A and –B satellites where applicable. The values (except for Sentinel-5P) are also compared to the equivalent ones for Y2017 to highlight the growth that has occurred.

### Sentinel-1

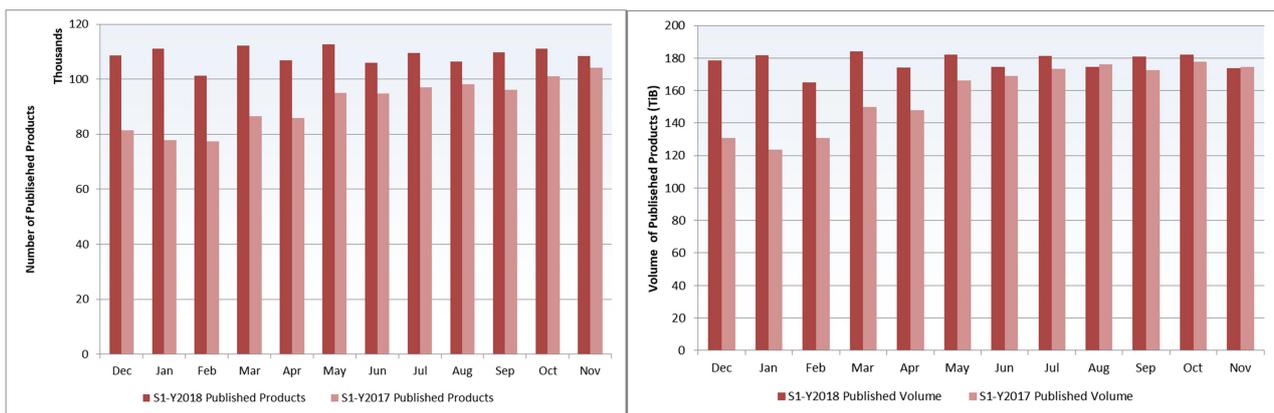


Figure 21: Y2018 and Y2017 monthly number and volume publication trend for Sentinel-1

While a gradual increase in publication took place in Y2017 – principally due to an increase and gradual refinement of the observation scenario following the integration of the EDRS operations in February 2017

for Sentinel-1 and in May 2017 for Sentinel-1B – during Y2018 numbers and volumes of Sentinel-1 data have remained reasonably stable. In fact, the figures for the first and last months of the period

(December 2017 and November 2018) show almost the same number of published products – just over 108,000 in both cases. The Y2018 monthly averages of 108,800 products and 178 TiB are slightly up on the Y2017 averages (91,000 products and 158 TiB). These figures reflect the attainment of the full operations capacity for the Sentinel-1 mission operations and the stability of the operations performance. The smooth trend is related to the continuous effort to optimize the observation scenario and maximize the use of the satellite resources.

This optimization of the observation scenario is also reflected in the evolution of the NRT products available through 2017 and 2018, as it is illustrated in Figure 22. The variation observed in the number of NRT products is a combination of the evolution and optimization of the observation scenario and a seasonal variation mainly related to ice monitoring needs and to the different instrument mode (mostly IW or EW) required in NRT over some cases (the EW product length is twice the IW product length, meaning that observation in EW over a given area results in half the number of products with respect to the observation in IW).

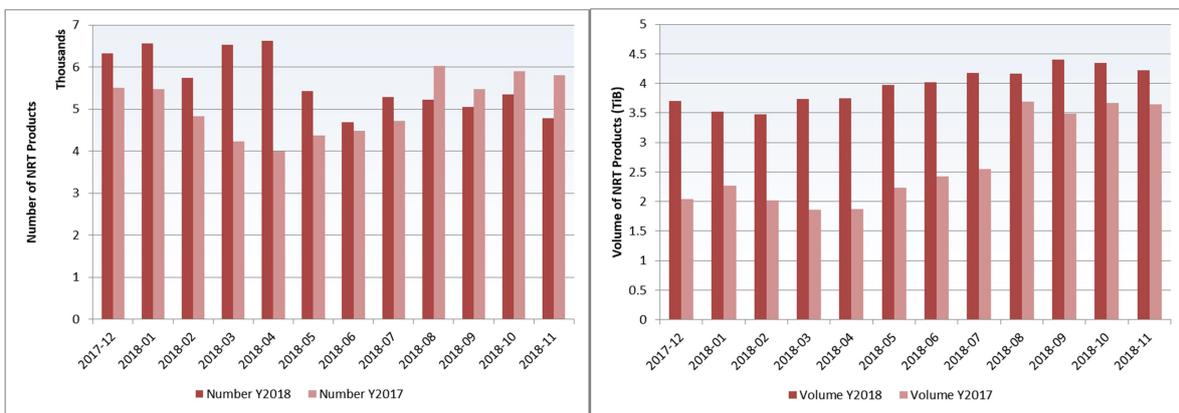


Figure 22: Y2018 and Y2017 monthly number and volume publication trend for Sentinel-1 NRT Production

## Sentinel-2

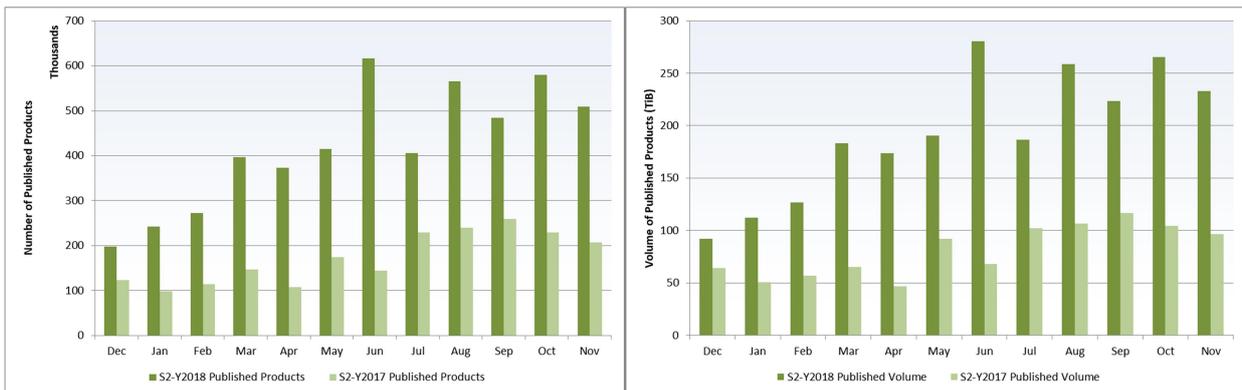


Figure 23: Y2018 and Y2017 number and volume publication trend for Sentinel-2

Sentinel-2 has had dramatic growth in product publication during Y2018, particularly in during the first half of the period. The principal reason for this was that full mission capacity was reached between November 2017 (starting with Sentinel-2B reaching global capacity) and February 2018 (with Sentinel-2A

reaching global capacity). The average monthly number of published products has grown 144% from Y2017 to Y2018, from 173,000 products/month to 422,000; the average monthly volume has grown by a similar amount from 81 TiB/month in Y2017 to 194 TiB/month in Y2018. In addition to the mission

reaching global capacity, publication increased with the start of Level-2A product distribution, from 26<sup>th</sup> March 2018, though during the Y2018 this was solely over the Euro-Mediterranean region.

During Y2018, there was a repackaging of the Level-1C old format products into the latest single tile

format (one old product leads to approximately four in the new format). The publication began on 22<sup>nd</sup> May 2018. About 1.3 million new products have been created by the end of Y2018, representing a volume of 430 TiB (or 18.5% of the total S-2 publication volume during the year). The release scheduled is to complete in early 2019.

### Sentinel-3

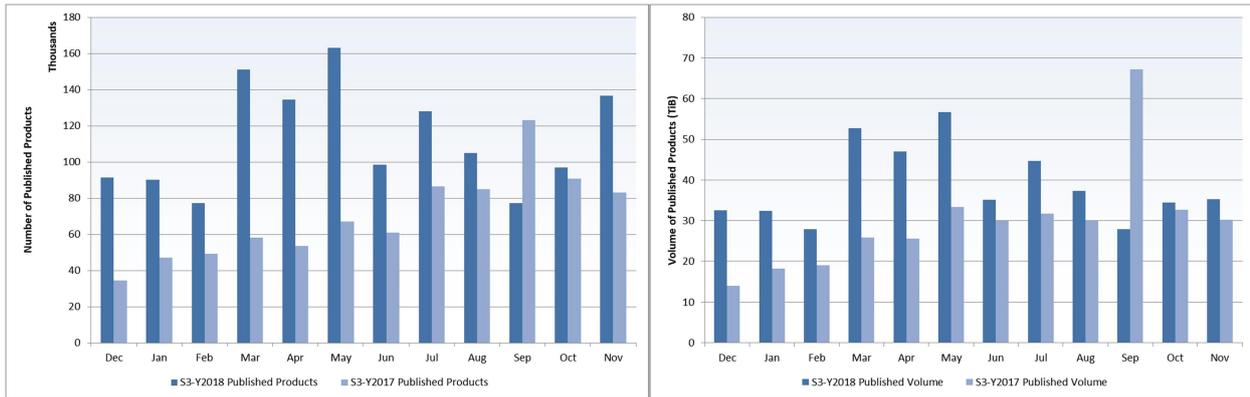


Figure 24: Y2018 and Y2017 monthly number and volume publication trend for Sentinel-3

Figures for Sentinel-3 publication show some monthly variation during the year, with a peak in production during approximately March-May 2018 and a general rise throughout the period. Average figures are significantly up on Y2017: a 62% rise in

monthly product numbers (70,000 per month in Y2017 to 112,000 per month in Y2018), though only a corresponding 30% rise in volume (30 TiB/month in Y2017 to 39 TiB/month in Y2018).

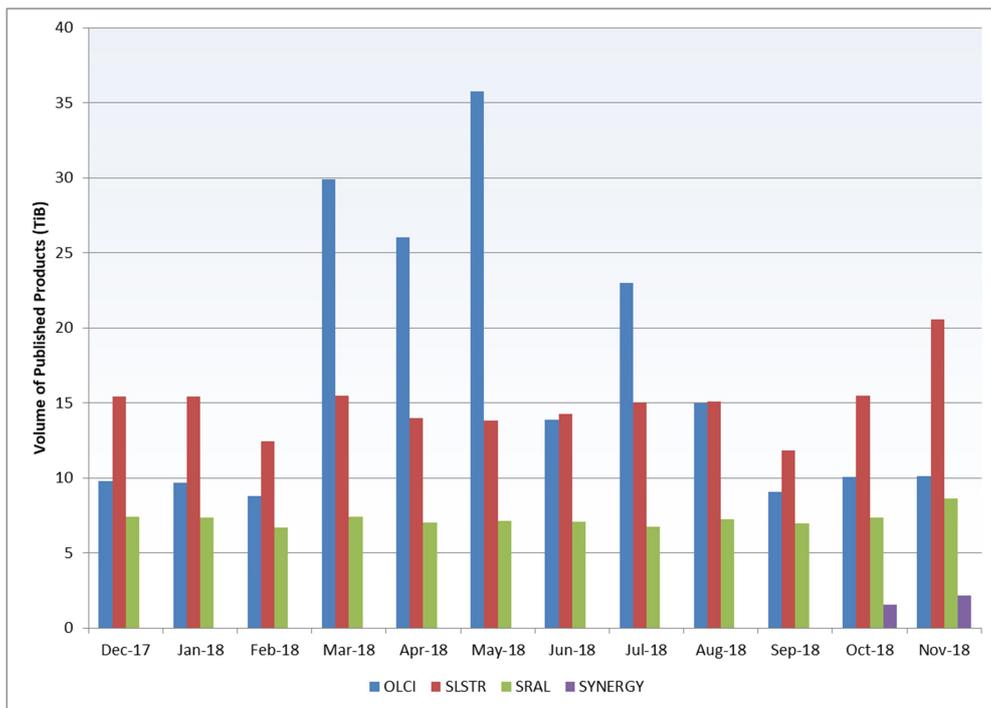


Figure 25: Y2018 monthly volume publication trend per Sentinel-3 product group

Figure 25 shows the Sentinel-3 publication split between four product groups (OLCI, SLSTR, SRAL and Synergy) and provides visibility as to which groups were responsible for the fluctuations in total publication volumes observed. The increase in production publication which can be seen at the end of Y2018 was caused by the introduction of two additional Sentinel-3 products on the S3 PreOps Hub: L2 Synergy products began to be published on 10 October 2018 (although in small numbers compared with the other product types); and Sentinel-3B SLSTR products began to be published in November 2018.

The major peak in product publication which took place from March to May 2018 is clearly caused by a significant increase in the volume of OLCI products

which were published during that time. This peak in OLCI product publication was due to a reprocessing campaign for OLCI Level 1 and Level 2 NTC products, and the reprocessed products began to be published in March 2018. A reprocessing campaign was also carried out for SRAL Level 1 and Level 2 products, and between March and November 2018 88.66 TiB of reprocessed SRAL products were published. Table 4 presents a breakdown of the number of reprocessed products for both SRAL and OLCI Level-1 and Level-2 products, and shows the percentage each set of reprocessed products constituted of the overall OLCI or SRAL publication during Y2018. It can be seen that 43% of all OLCI products published in Y2018 and 19% of all SRAL products were reprocessed products. No reprocessed SLSTR or Synergy products were published during the year.

Instrument	Product Level	Y2018 Total No. of Products Published	Y2018 Total No. of Reprocessed Products Published	% Reprocessed Products
OLCI	Level 1	302,504	130,559	43
	Level 2	302,722	130,397	43
	<b>Total</b>	<b>605,226</b>	<b>260,956</b>	<b>43</b>
SRAL	Level 1	138,125	19,987	14
	Level 2	85,679	21,912	26
	<b>Total</b>	<b>223,804</b>	<b>41,899</b>	<b>19</b>

Table 4: Y2018 total numbers of OLCI and SRAL reprocessed products, and percentage of total published

## Sentinel-5P

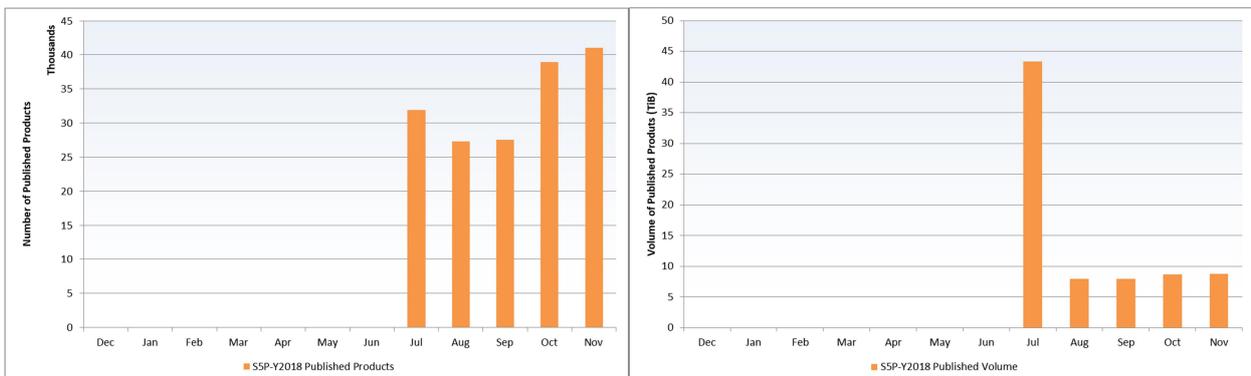


Figure 26: Y2018 monthly volume and number publication trend for Sentinel-5P

The Sentinel-5P PreOps Hub began routine operations on 11 July 2018, so figures are only shown from July 2018 onwards. It can be observed that there is a large spike in the monthly published volume in July 2018: nearly 45 TiB of products were published in this first month, a figure which drops to around 8 TiB/month for the rest of Y2018. The July spike is due to early Phase E2 Level-1B products being published in parallel with the nominal flow during that month. After July 2018 there was a steady rate of L1B publication, together with a large increase in Level-2 products, the latter due to the qualification and publication of NRT and NTC(OFFL) version of products from the previous months. Being

a systematic mission, these fluctuations will normalise once the routine publication of all L2 product types is established.

### 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

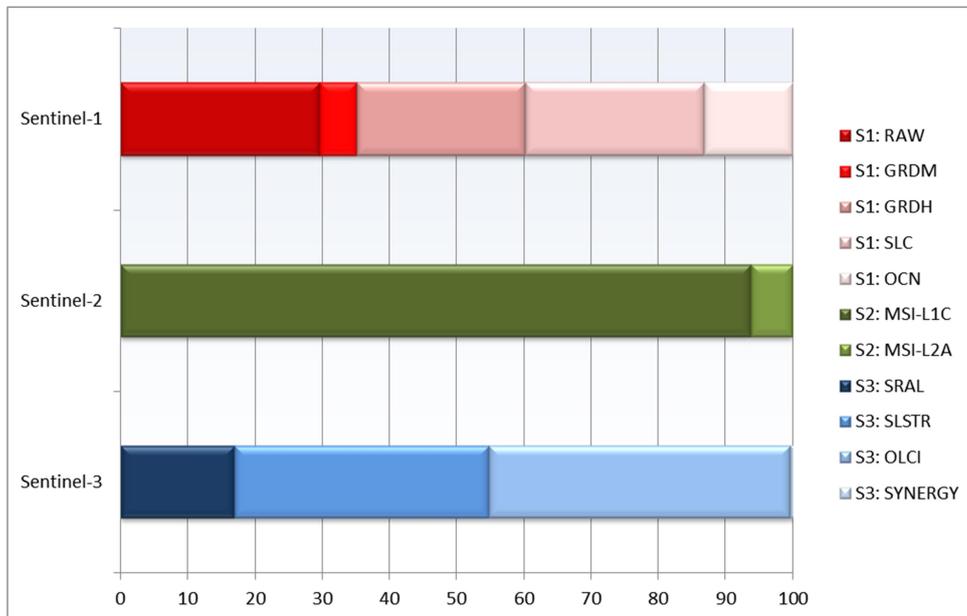


Figure 27: Percentage published number of products per Sentinel mission and product type during Y2018

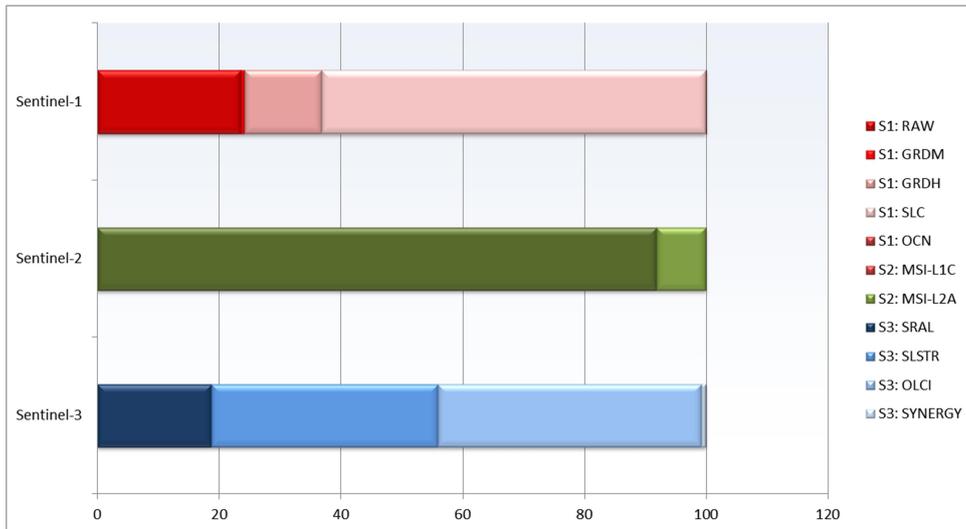


Figure 28: Percentage published volume of products per Sentinel mission and product type during Y2018

Figures 27 and 28 show, for Sentinels 1, 2 and 3, the total percentage published for each product types, both in terms of number and volume of products, during Y2018. For Sentinel-3, for the purposes of readability, the 14 individual product types have been collected into four product groups: SRAL, SLSTR, OLCI and SYNERGY.

For **Sentinel-1** the following product types were available during Y2018:

- Level 0 (Lo-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)

Looking at the numbers published for each level individually, Level 0 accounts for 30% of products, Level 1 for 57% and Level 2 for 13%. In terms of volumes the totals are: 24% for Level 0, 76% for Level 1 and 0.1% for Level 2. These differences are accounted for by the relatively large size of Level 1 SLC products and the relatively small size of Level 2 OCN products.

For **Sentinel-2** the following products types are published:

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

Sentinel-2 published products by number consisted of 94% Level-1C and 6% Level-2A. These figures are almost consistent with the split by volume: 92% Level-1C and 8% Level-2A. The small proportion of Level-2A products is the result of this service only providing products covering the Euro-Mediterranean region during the reporting period. With the service intended to start providing Level-2A products globally early in Y2019, it would be expected that the proportion of Level-2A products will rise in the next year accordingly.

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
- *SYNERGY (synergy of OLCI OL\_1\_EFR and SLSTR SL\_1\_RBT products)*
  - Level 2 SY\_2\_SYN\_\_\_ Surface Reflectance and Aerosol parameters over Land
  - Level 2 SY\_2\_VGP\_\_\_ 1 km VEGETATION-Like product (~VGT-P) - TOA Reflectance
  - Level 2 SY\_2\_VG1\_\_\_ 1 km VEGETATION-Like product (~VGT-S1) 1 day synthesis surface reflectance and NDVI
  - Level 2 SY\_2\_V10\_\_\_ 1 km VEGETATION-Like product (~VGT-S10) 10 day synthesis surface reflectance and NDVI

More details on the products types per mission and per instrument are available in 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:

For Sentinel-1:

<https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario>

For Sentinel-2:

<https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/observation-scenario>

For Sentinel-3:

<https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3/observation-scenario>

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 Copernicus Sentinel Online Document Library at: <https://sentinels.copernicus.eu>

## Sentinel-1

Figure 29 is a heatmap showing the geographical coverage of all Sentinel-1 products published from the start of operations until the end of Y2018. The colour scale illustrates the different numbers of products which were published for each area; red/pink zones are the areas over which the greatest number of Sentinel-1 products have been published, as indicated by the key. All product types except WV mode products, which are available over oceans and coastal zones, are prevented from being applied to the same calculation due to the different footprint used in the those products. The heatmap shows that Sentinel-1 products cover all continents and major island groups, with the highest density of coverage over Europe and in particular the northern maritime regions.

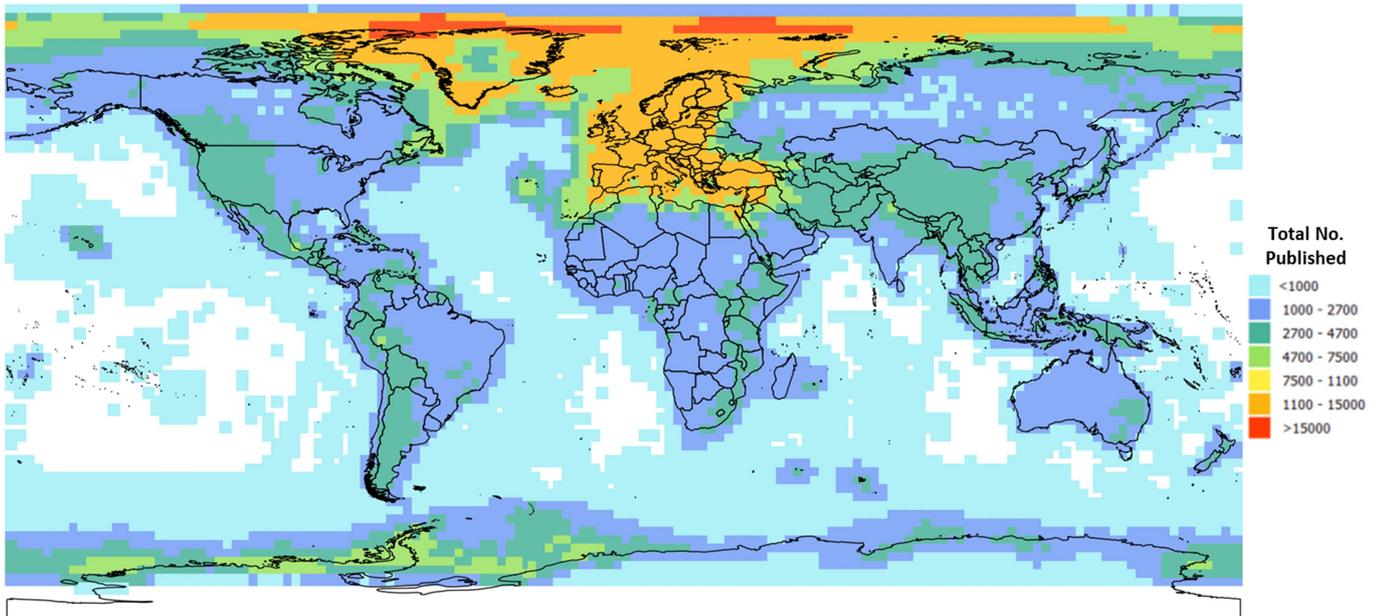


Figure 29: Heatmap of Sentinel-1 products (excluding OCN) published since the start of operations

The geographical coverage analysis can be extended by looking at the coverage of individual Level-1 product types. The heatmaps for GRDM, GRDH and SLC products are shown in Figures 30, 31 and 32 respectively. In all cases they take as input the locations of all products published since the start of operations up to the end of Y2018. As different numbers of products have been published for each product type, care must be taken in reading the keys, which show different ranges for each heatmap. In general, the extent of product coverage may be summarized as follows:

- GRDM – mostly covering sea ice and marine areas, with a strong emphasis on the maritime regions of the far north.
- GRDH & SLC – mostly available over land masses. The highest number of products over Europe and Greenland areas reflects the evolution of the Sentinel-1 observation scenario, initially focused over Europe, and generally the higher observation frequency over Europe.

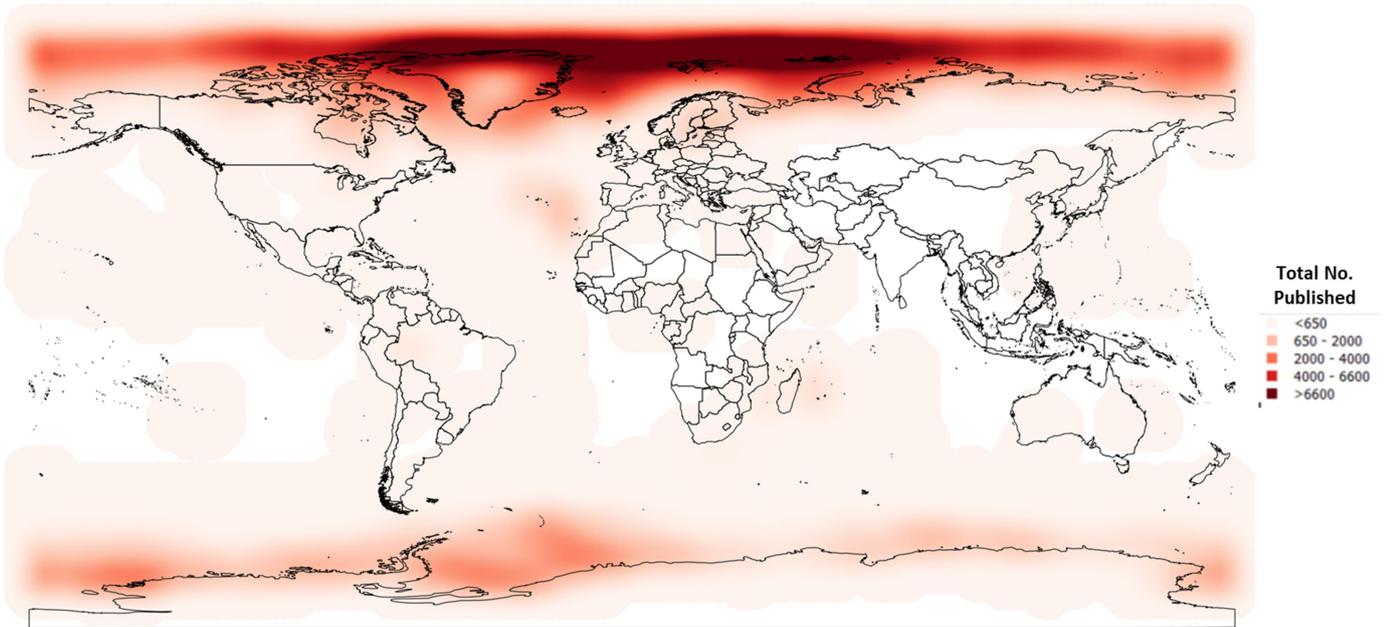


Figure 30: Heatmap of Sentinel-1 GRDM products published since the start of operations

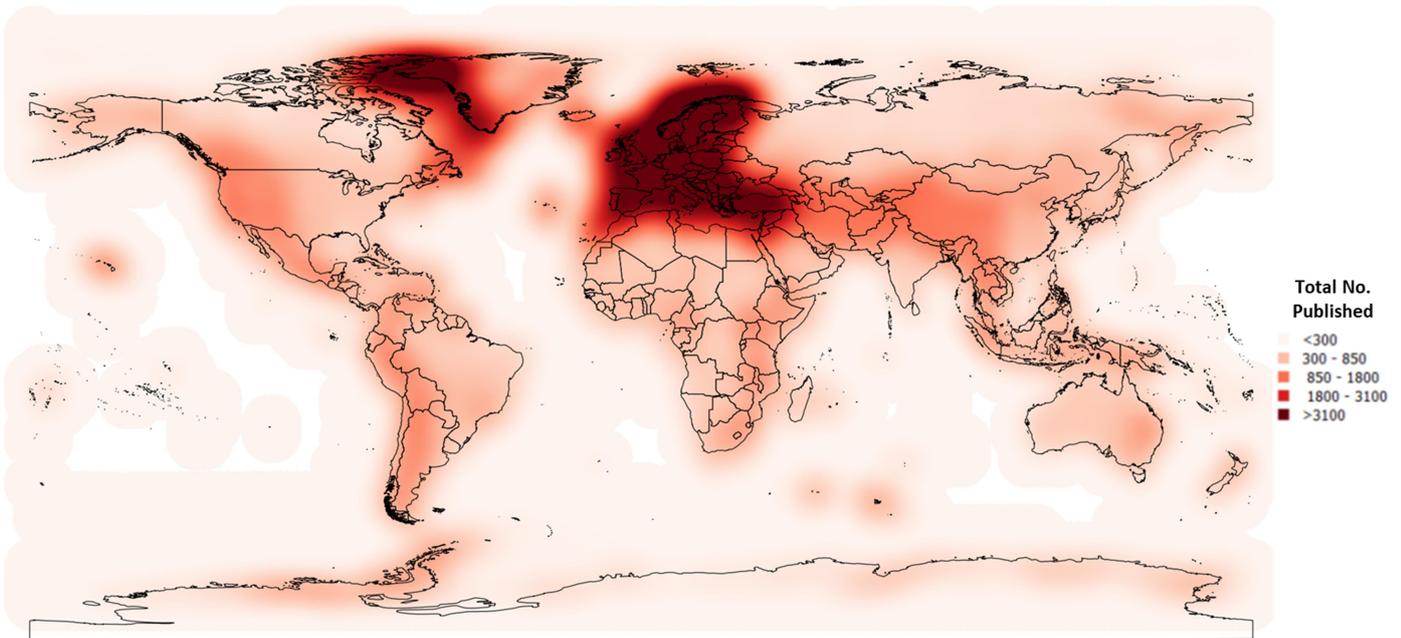


Figure 31: Heatmap of Sentinel-1 GRDH products published since the start of operations

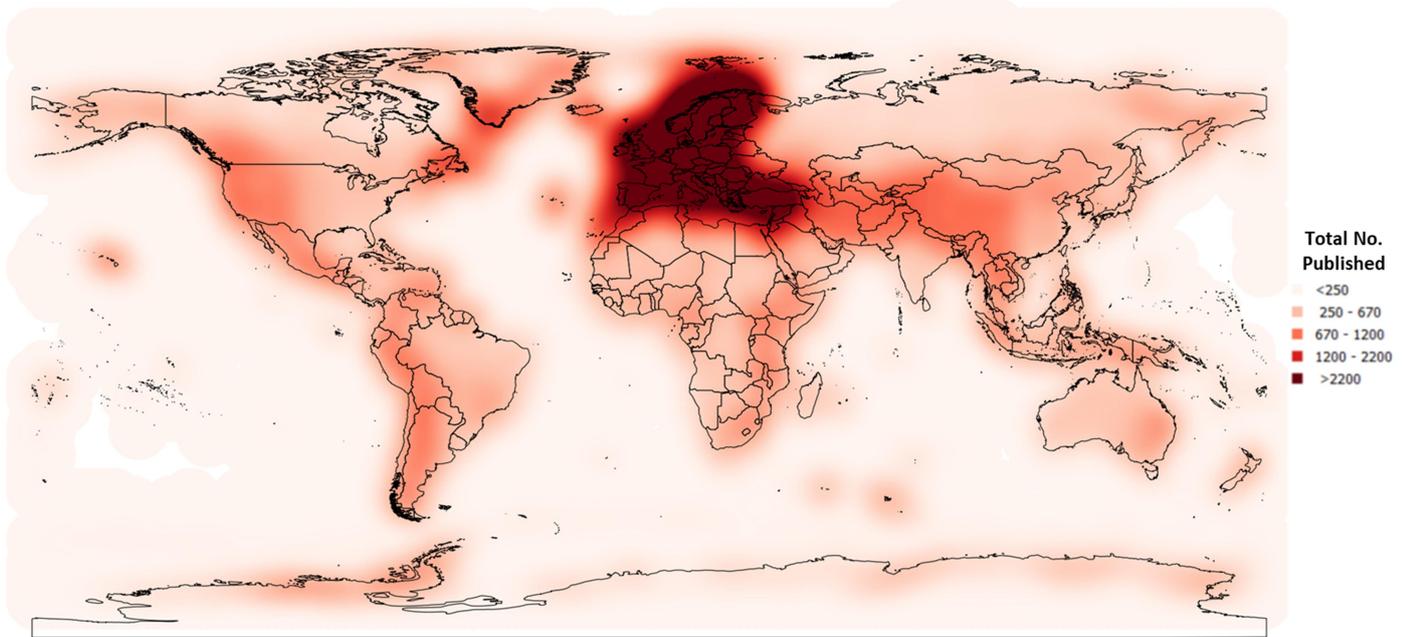


Figure 32: Heatmap of Sentinel-1 SLC products published since the start of operations

### Sentinel-2

The figures below present heatmaps for Sentinel-2 published products: Figure 33 is a heatmap for Level-1C products published since the start of operations and Figure 34 is a heatmap for Level-2A products (published in the Y2018 reporting period). The L1C heatmap shows the coverage is relatively evenly

distributed over the globe’s landmasses (excluding Antarctica) but with an emphasis on Africa and in particular on Europe. As explained above, L2A production has been restricted to the Euro-Mediterranean region during Y2018, though will be extended globally during Y2020; this is clearly shown on the corresponding heatmap.

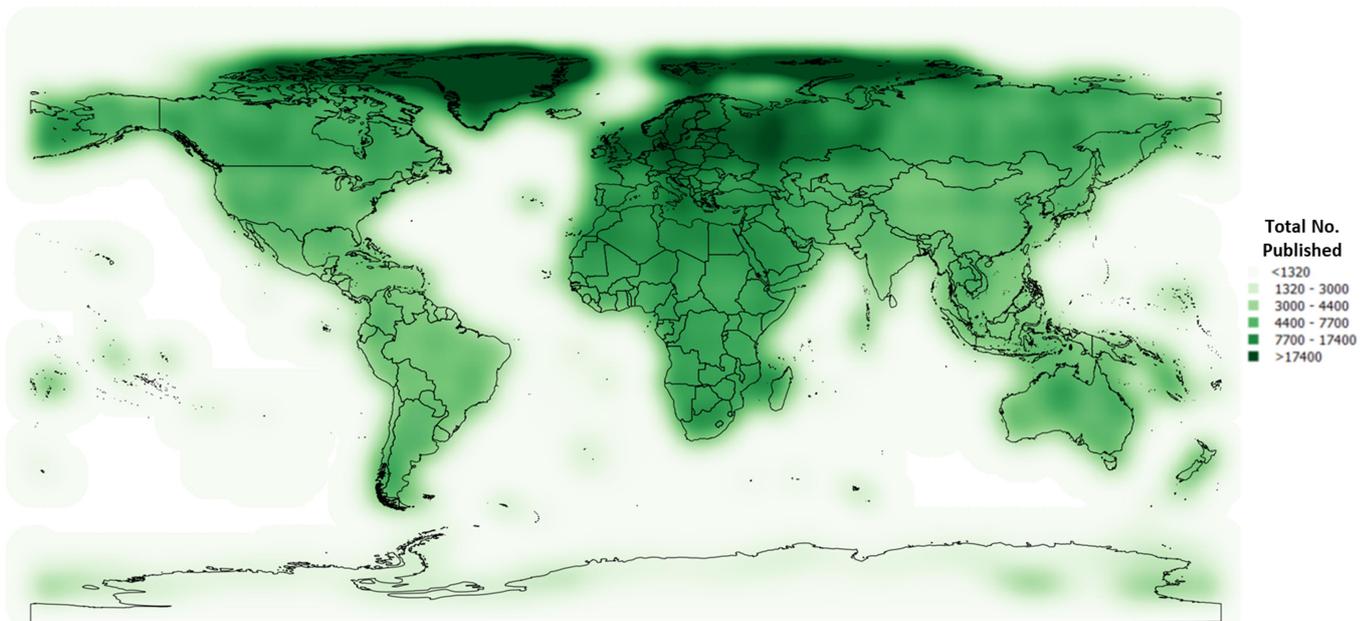


Figure 33: Heatmap of Sentinel-2 Level-1C products published since the start of operations

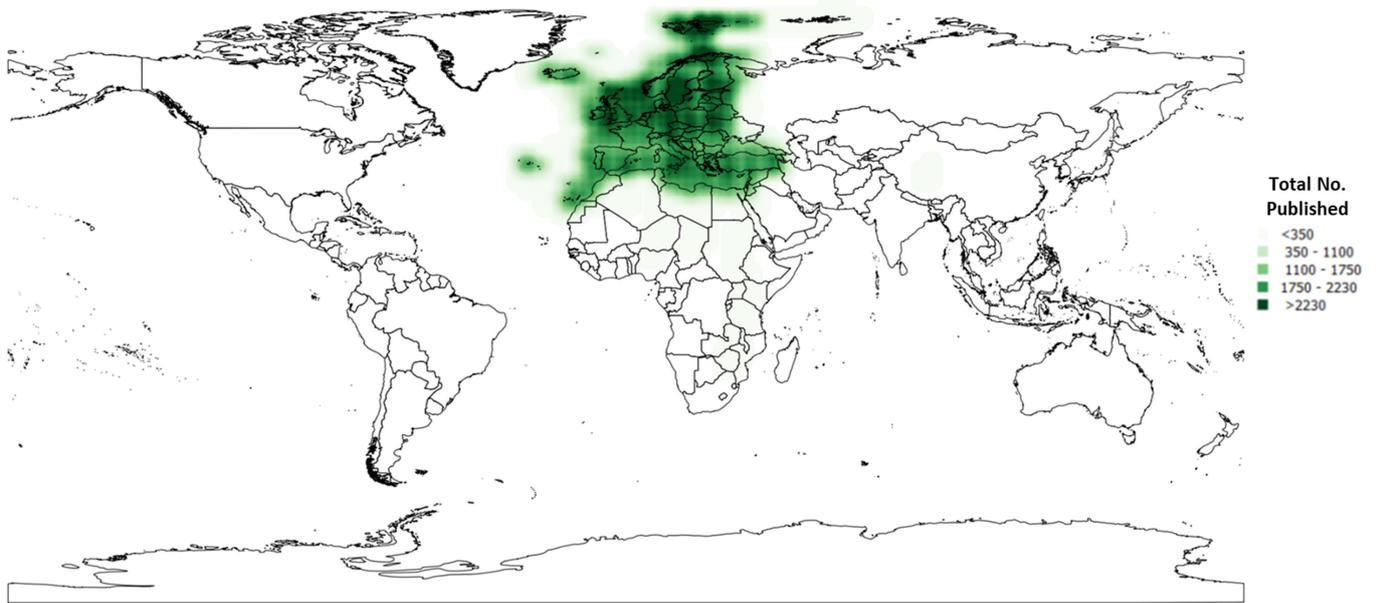


Figure 34: Heatmap of Sentinel-2 Level-2A products published in Y2018

### Sentinel-3

The heatmaps below show the geographical coverage of Sentinel-3 Land products, published and available on the Open Hub since the beginning of operations, and separated out by product group. For SRAL products, a separate 'NRT' heatmap is also provided. SRAL, SRAL-NRT, OLCI and SLSTR are shown in Figures 35, 36, 37, and 38 respectively. Again, care must be taken when reading the keys:

they are different for each plot depending on the number of products published for each instrument.

It is clear that Sentinel-3 products are far more evenly distributed over the globe than for Sentinel-1 and -2. An exception is for SRAL-NRT which are focused on land areas. The apparent emphasis on the poles for all product types is a result of the lower revisit times in these regions.

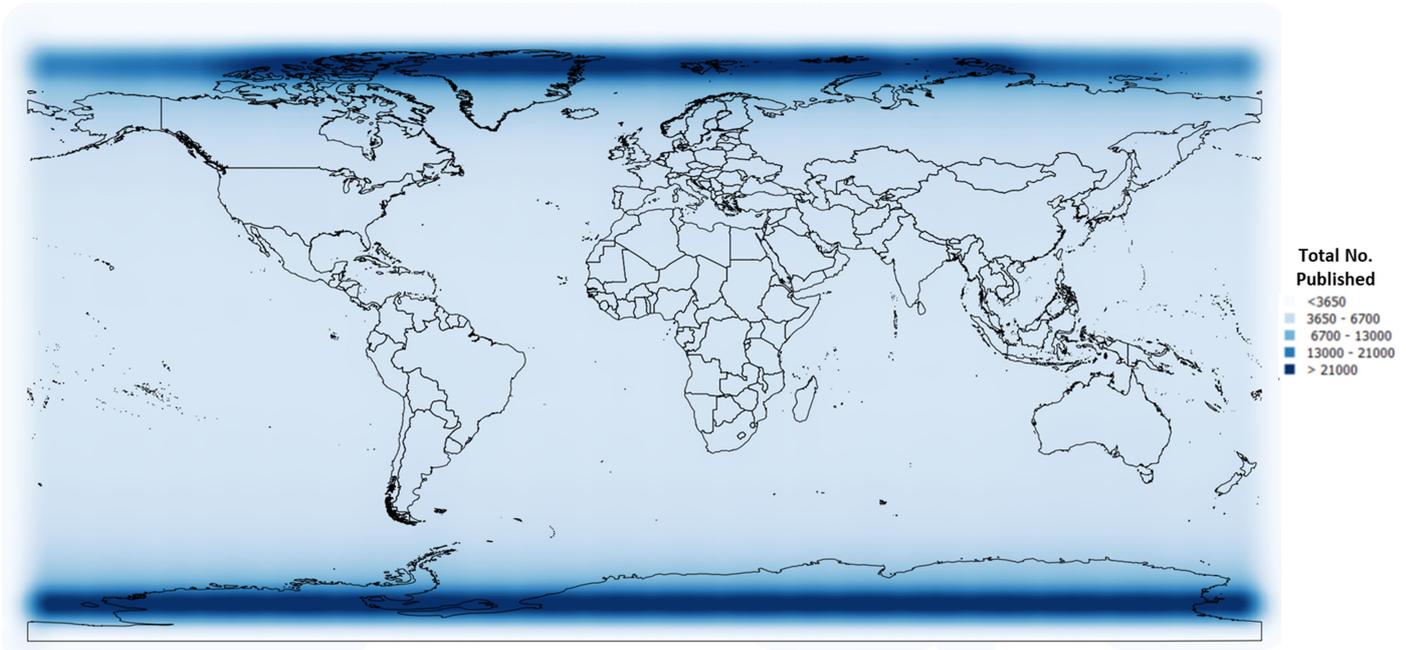


Figure 35: Heatmap of Sentinel-3 SRAL products published since the start of operations

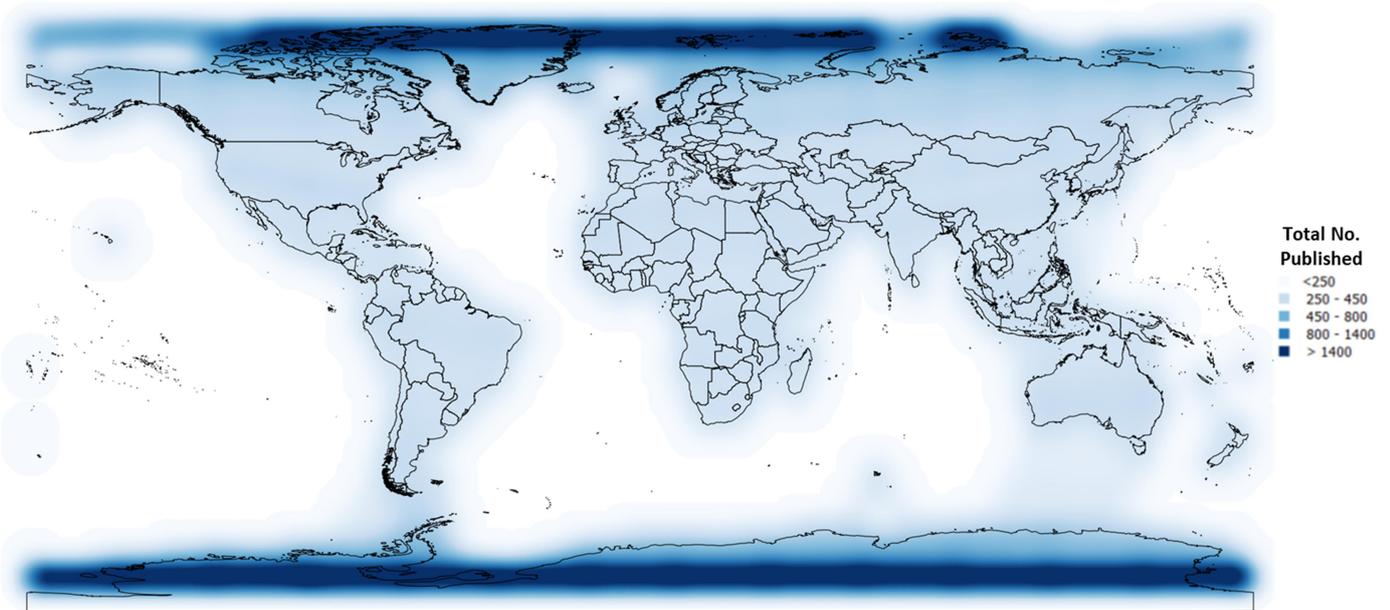


Figure 36: Heatmap of Sentinel-3 SRAL-NRT products published since the start of operations

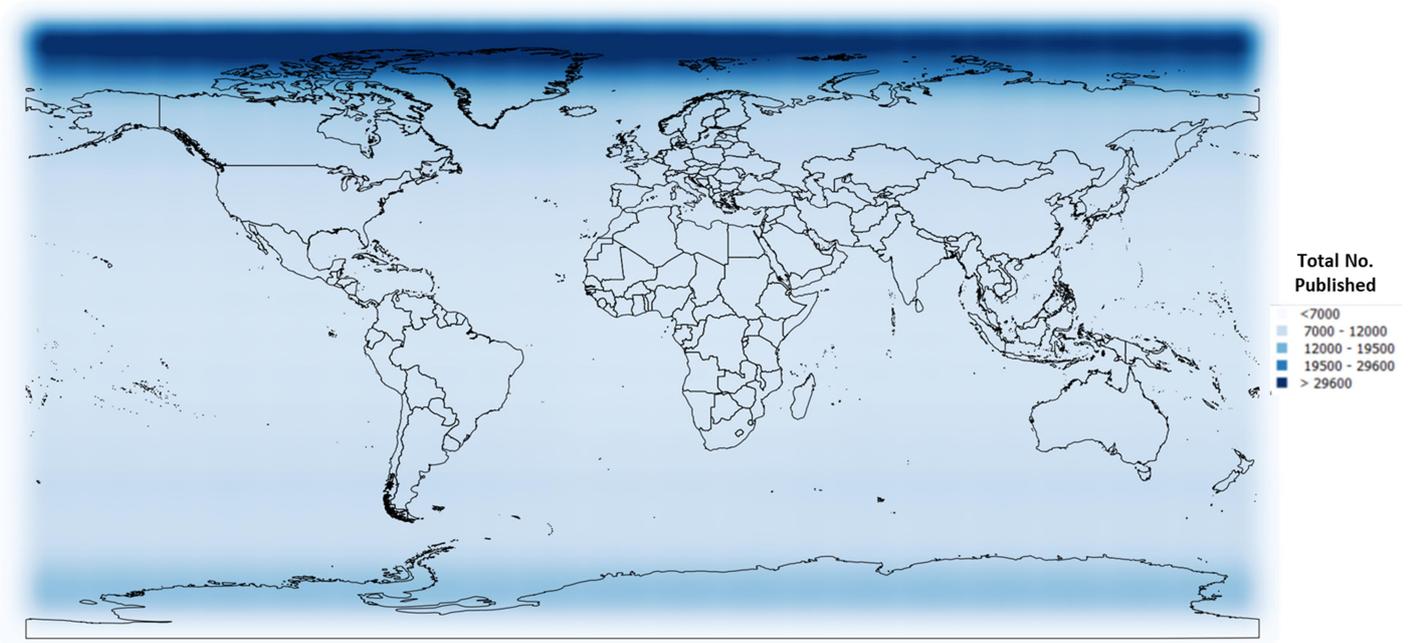


Figure 37: Heatmap of Sentinel-3 OLCI products published since the start of operations

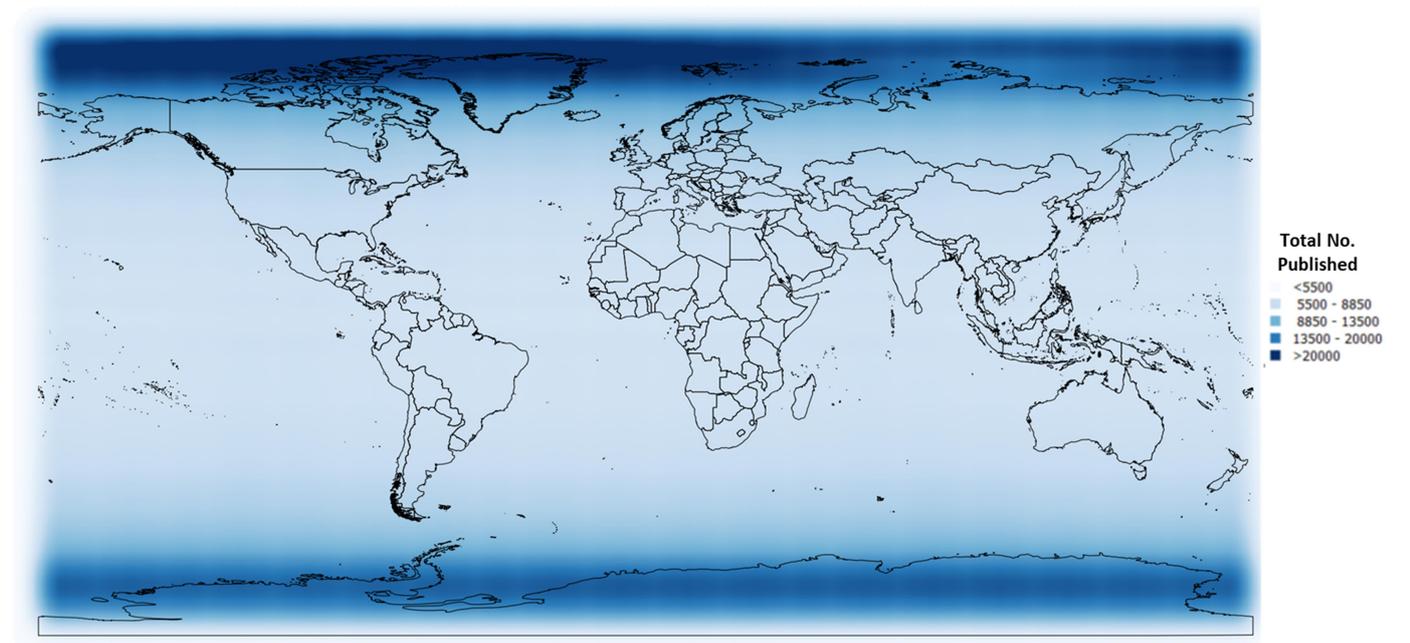


Figure 38: Heatmap of Sentinel-3 SLSTR products published since the start of operations

## Sentinel-5P

Sentinel-5P systematically senses data on the daytime portion of all orbits, the heatmap for

publication is therefore uniform and not included here.

## 2.3 Products Dissemination

This section presents the statistics for user downloads during Y2018.

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, although an analysis of these downloads is reported in Sections 2.3.6 and 2.3.7.

### 2.3.1 Download growth

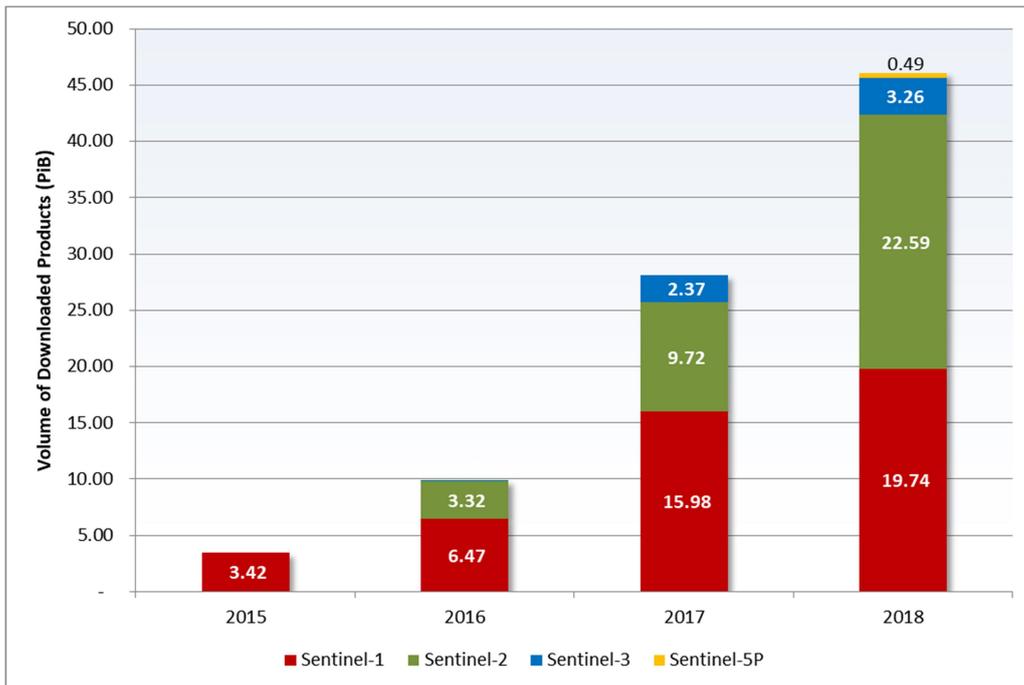


Figure 39: Total volume of products downloaded per year since the start of operations from all of the four hubs, differentiated by mission

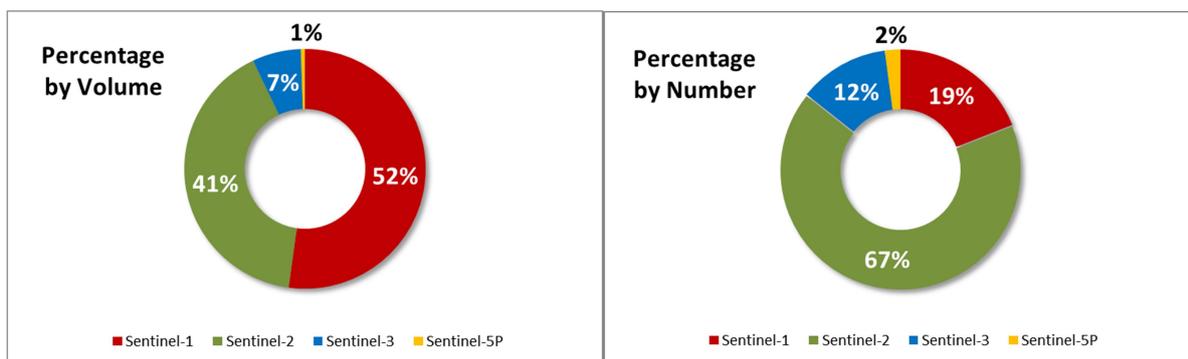


Figure 40: Percentage of total downloads per mission since the start of operations for all of the four hubs, on the left by volume and on the right by number

By the end of Y2018, a massive 86.94 PiB of Sentinel data products had been downloaded from the Data Access System since the start of operations. Just over 50% of this volume (45.6 PiB) was downloaded in Y2018 alone, and this was a 62% increase compared to the volume of data which had been downloaded during Y2017. In terms of *number* of user downloads, **in Y2018 a total of 71.9 million of user downloads were made**, up from 39.8 million during Y2017. This huge rise in the amount of products being downloaded by users not only points to sustained user enthusiasm for Sentinel data, but also demonstrates that, despite the ever increasing volumes, the Data Access System remains capable of managing the huge amount of download requests.

Figure 39 breaks these totals down per mission and per year, and compares the total volume of data downloaded by the end of Y2018 with the total volume which had been downloaded by the end of previous periods. The graph shows that in Y2018, there was a particularly significant increase (132%) in the volume of Sentinel-2 products which were downloaded, rising from 9.72 PiB in Y2017 to 22.59 in Y2018. This increase accounts for most of the

additional 17.5 PiB of data which was downloaded in Y2018, compared to Y2017. In Y2017, the increase was split more evenly between all Sentinels. Sentinel-2 thus became for the first time the most downloaded mission in the year, accounting for 50% of user downloads in Y2018. Sentinel-1 increases were more modest, up 24% to 19.74 PiB. Sentinel-3 increased 38% to 3.26 PiB, though the mission still only accounts for 7% of the total volume of downloads made during the year.

Figure 40 shows that when all downloads since the starts of operations are taken into account, Sentinel-1 remains the mission with the highest volume of products downloaded by users, comprising 52% of the total download volume. In terms of number of products, however, the Sentinel-1 downloads account for only 19%, and the smaller Sentinel-2 products account for as much as 67% of the total number of products downloaded since the start of operations. If the trends noted above continue, it would be expected that Sentinel-2 will become the mission with both the highest number and volume of downloaded products during Y2019, matching also the publication trends.

### 2.3.2 Archive Exploitation Ratio (AER)



Figure 41: Archive Exploitation Ratio per mission at the end of Y2018

Users’ interest in Sentinel products can perhaps most accurately be monitored by looking at the ‘Archive Exploitation Ratio’ (AER). The AER is defined as the total number of users’ downloads made from all the hubs (Open Hub, ColHub, IntHub and ServHub) since

the starts of operations, divided by the total number of products which had been published on the hubs since the start of operations. An AER is expressed as a ratio of published products vs downloaded products: e.g. the ratio 1:X indicates that, for each of

the published products, there was an average number of X downloads.

The AERs reported in Figure 41 were calculated at the end of the Y2018 reporting period. They show that user interest in Sentinel-1 and Sentinel-2 products was equally strong, and has even grown since Y2017, when the ratio for both missions was 1:10. Engagement with Sentinel-3 products appears to have dipped slightly since Y2017, when it was also 1:10, but it is likely that this lower ratio is attributable to the distorting effect which the reprocessing campaigns had on the publication figures. In general, the Sentinel-3 AER is also likely to be lower than the other missions as it does not include the data

downloaded through EUMETSAT. The AER for Sentinel-5P products shows there was an immediate active take up of the products by users.

In the following subsections, further details on the AERs are presented for each mission, grouped by instrument, product level, resolution and timeliness, for the period since the start of operations up to the end of Y2018. The timeliness values are NRT (Near Real Time), NTC (Non Time Critical) or STC (Short Time Critical). The heatmaps then break the exploitation ratio down according to geographical area, and this gives an approximate indication of the geographical zones over which users are particularly interested in downloading data.

## Sentinel-1

Level	Timeliness	Number of Published Products in Y2018	Number of Downloaded Products in Y2018	Archive Exploitation Ratio
Level 0	NTC	386,493	2,935,153	1:7.6
Level 1	NTC	743,229	12,645,527	1:17.0
	NRT	68,351	557,932	1:8.2
Level 2	NTC	174,355	2,567,868	1:14.7

Table 5: Sentinel-1 Products Published, Downloaded and AER for Y2018, per product level and timeliness

Level	Timeliness	Number of Published Products since Start of Operations	Number of Downloaded Products since Start of Operations	Archive Exploitation Ratio
Level 0	NTC	1,046,071	5,271,899	1:5.0
Level 1	NTC	1,966,954	27,821,836	1:14.1
	NRT	159,057	1,325,938	1:8.3
Level 2	NTC	269,649	4,157,983	1:15.4

Table 6: Sentinel-1 Products Published, Downloaded and AER since the start of operations, per product level and timeliness

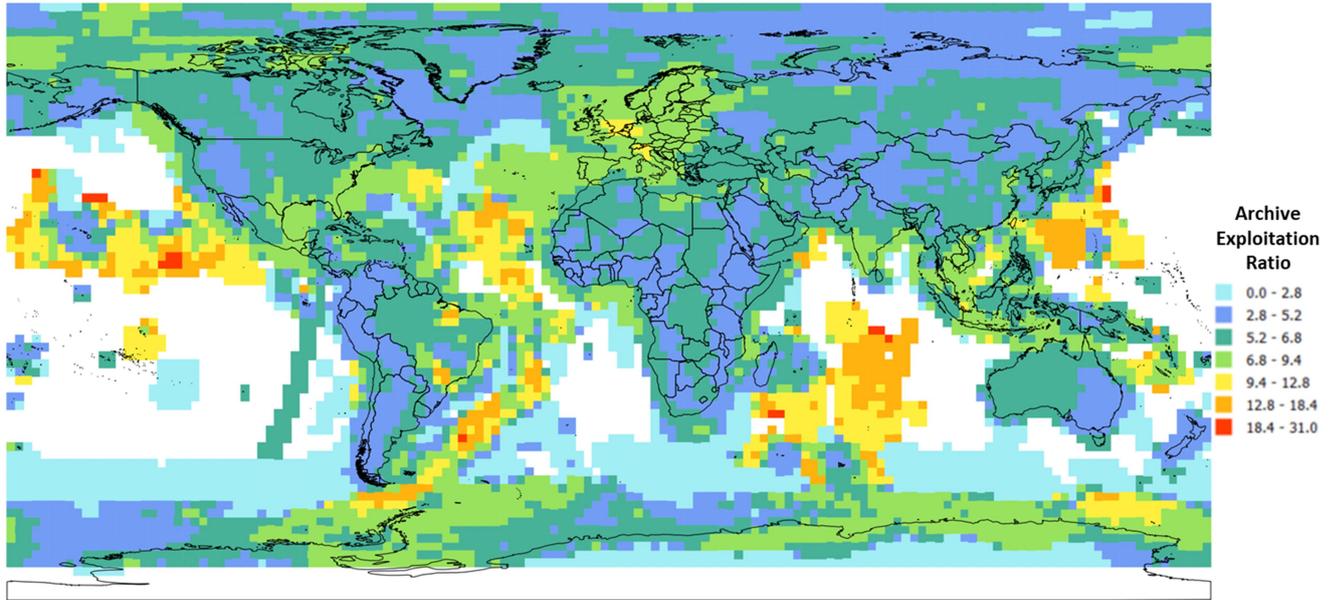


Figure 42: Heatmap showing the archive exploitation ratio for Sentinel-1 Lo and L1 NTC products (excluding WV mode) during Y2018

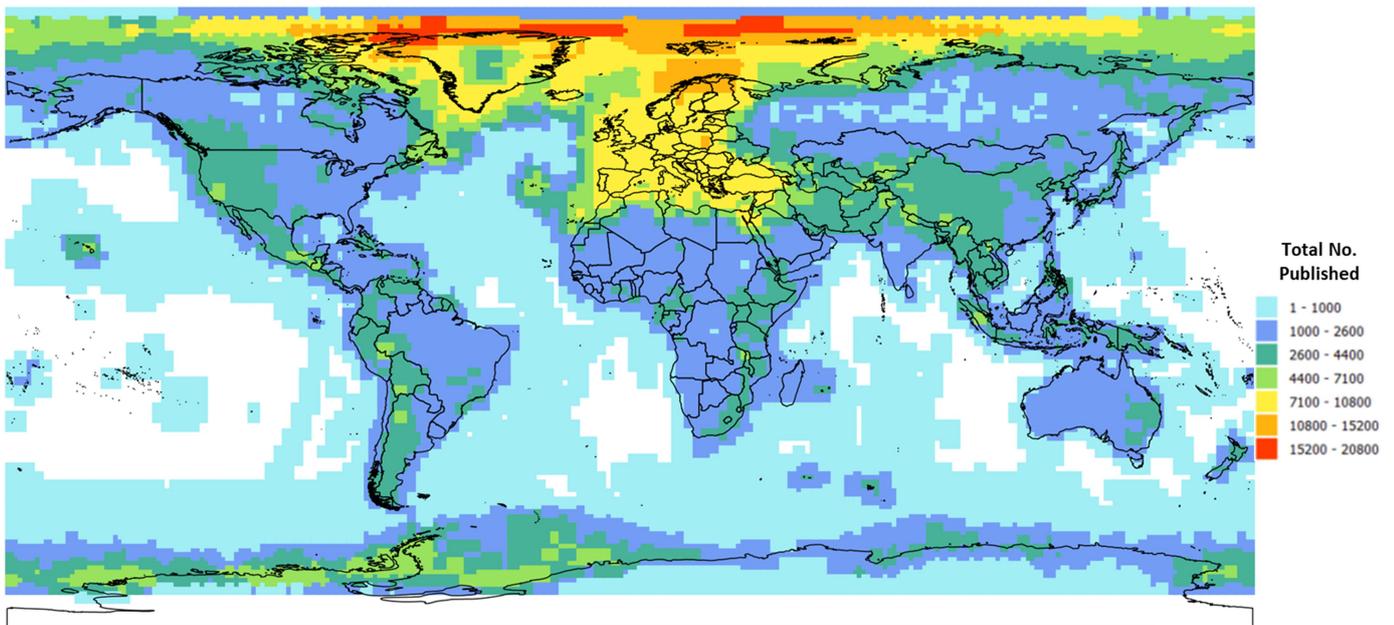


Figure 43: Heatmap showing the Sentinel-1 Lo and L1 NTC published products (excluding WV mode) during Y2018

In terms of the most popular Sentinel-1 product levels/timelinesses, Tables 5 and 6 show that the Level 1 and Level 2 NTC products have more than double the AERs of Level 0 NTC and Level 1 NRT products. Most popular of all during Y2018 were Level 1 NTC products, which had an AER of 1:17, meaning for each product published there were on average 17 downloads during the year. Level 2 NTC

products had an AER of 1:14.7. A similar trend is observed looking at the AERs calculated from the start of operations: 1:14.1 for Level 1 NTC and a 1:15.4 for Level 2 NTC. The tables also show that there has been a growth in interest in Level 0 products over the last year: the AER calculated during Y2018 is 1:7.6, up from that calculated since the start of operations (1:5.0). In fact, 56% of all Lo

product downloads since the start of operations occurred during Y2018. This trend is likely due to DIAS partners downloading all historical and new Lo products to populate their archives.

While overall Sentinel-1 production remains quite stable, there are two significant differences from Y2017 statistics. Firstly, far more Level 2 NTC products were published in Y2018 than in Y2017 – up to 174,355 from 68,600 in Y2017 – meaning that although there have been almost 1 million more downloads of products in this class during Y2018, the AER has dropped slightly, from 1:19 (Y2017) to 1:14.7 (Y2018). Secondly, the popularity of Level 1 NTC products, measured by the AER, has now surpassed Level 2 NTC: an AER of 1:17 has observed during Y2018, up from 1:13 in Y2017.

Figure 42 shows the geographical interest in Sentinel-1 Lo and L1 NTC products, measured by AER (see key in Figure). It shows how many downloads were made during Y2018 per available product over specific geographical points across the globe, taking into account all products published since the start of operations. Because of their particular footprint, which is constituted by more than one polygon, Wave mode products (which include all L2 products) are excluded from the map. The Figure can be compared with the corresponding Sentinel-1 publication heatmap in Figure 43.

Figure 42 suggests that interest in Sentinel-1 products is focused largely on the Earth’s landmasses and, within the landmasses, the interest is highest over the European, Mediterranean and North Atlantic regions, where the AER is between around 1:7 and 1:13, as well as other regions including India, South East Asia, the Gulf of Mexico and the Antarctic coast. However, there are some interesting exceptions; the areas displaying the highest AERs observed are oceanic zones, in particular the South Atlantic, North Pacific and Indian Ocean. In these regions the AERs are often higher than 1:9 and occasionally higher than 1:18 (areas coloured red). Rather than showing them to be the most popular regions, these results actually seem to be a result of very few products being published in these zones: if all of the few products published are downloaded by systematic users then the AER may appear higher than, for example, Europe, over which far more products are published. This is illustrated by Figure 44, below, which shows a heatmap of Sentinel-1 absolute downloads numbers during Y2018, rather than AERs. It is now clear that downloads are focused on Europe, the Mediterranean as well as Arctic regions (for sea ice monitoring). There is also a (lesser) focus of downloads around the Antarctic coast, particularly around the Antarctic Peninsular and the Weddell Sea, presumably related to land ice (glacier and ice shelf) monitoring.

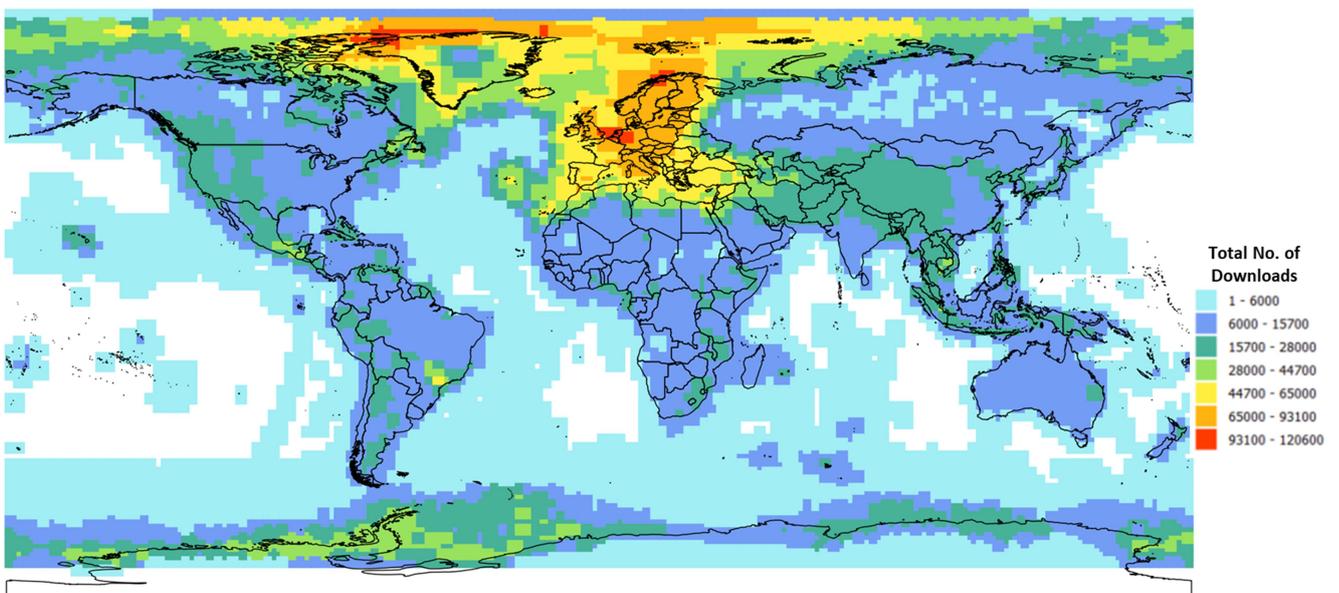


Figure 44: Heatmap showing absolute download numbers for Sentinel-1 Lo and L1 NTC products (excluding WV mode) during Y2018

## Sentinel-2

Level	Number of Published Products in Y2018	Number of Downloaded Products in Y2018	Archive Exploitation Ratio
Level 1C	4,737,253	62,317,329	1:13.2
Level 2A	320,951	3,432,477	1:10.7

Table 7: Sentinel-2 Products Published, Downloaded and AER for Y2018, per product type

Level	Number of Published Products since Start of Operations	Number of Downloaded Products since Start of Operations	Archive Exploitation Ratio
Level 1C	6,467,046	84,775,477	1:13.1
Level 2A	418,621	3,895,176	1:9.3

Table 8: Sentinel-2 Products Published, Downloaded and AER since the start of operations, per product type

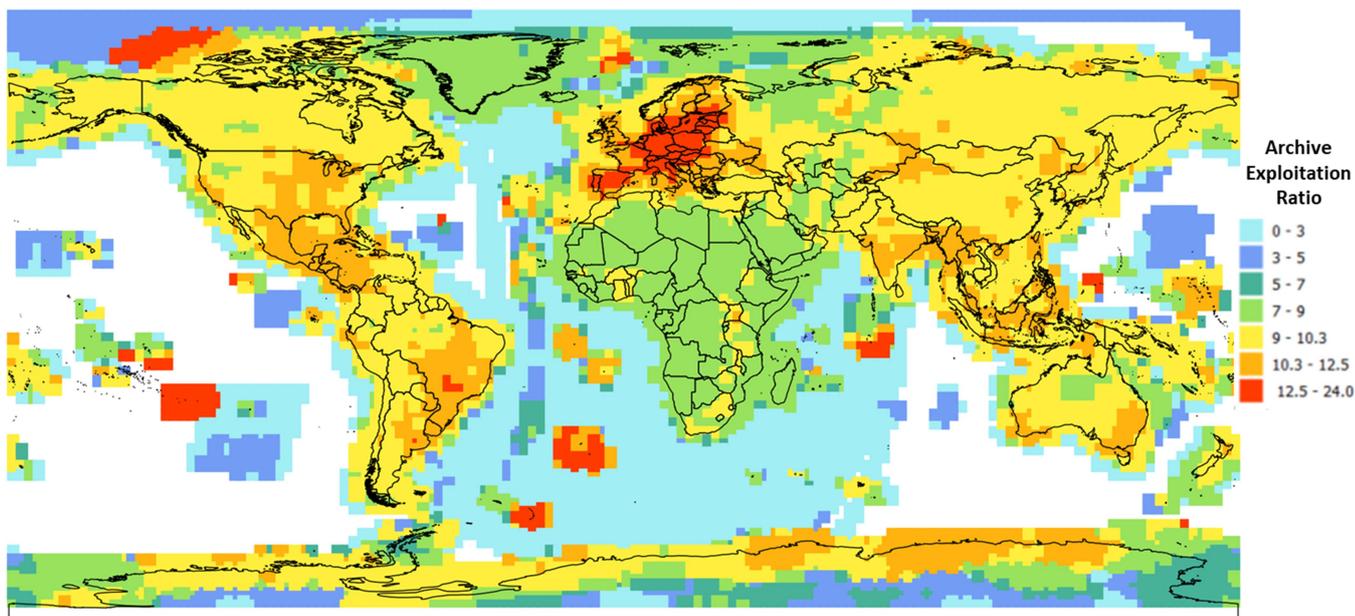


Figure 45: Heatmap showing the archive exploitation ratio for Sentinel-2 L1C products during Y2018

Along with Sentinel-1, the overall AER for Sentinel-2 since the start of operations remains the highest of all Sentinels, at 1:12. For both the L1C and L2A products, Y2018 has seen both very significant increases since Y2017 in all aspects: number of products published, number downloaded and AER (because downloads have risen even faster than

publications). For example, for L1C, publication has increased by 140% to 4,737,253, downloads by 216% to 62,317,329 and the AER up to 1:13.2 from 1:10. Due to the ramp up of L2A production over the year, there has been an even larger increase in the AER: up to 1:10.7 from 1:5 during Y2017.

Figure 45 shows the geographical variation in AER for regions across the globe during Y2018, taking into account downloads of all products published during the year, including those published in previous years. The figure can be compared with the Sentinel-2 publication heatmap (Figure 33). The areas with the highest AERs are, as expected, the landmasses of the Earth, with a focus on Europe, where the AER is mainly greater than 1:12.5. North and South

America, Asia and Oceania show similar levels of interest, with AERs generally in the range 1:9 – 1:12. Africa is the least downloaded continent, with AERs mainly in the 1:7 – 1:9 range. It is noted that there are some regions of 'high interest' (red regions) in the Pacific, South Atlantic and Arctic regions: as noted for Sentinel-1, this is likely caused by the low publications in these regions than by high downloads.

## Sentinel-3

Instrument	Number of Published Products in Y2018	Number of Downloaded Products in Y2018	Archive Exploitation Ratio
SLSTR	507,536	3,840,784	1:7.6
SRAL	223,804	1,423,402	1:6.4
OLCI	605,226	4,023,642	1:6.6
SYNERGY	13,140	28,269	1:2.2

Table 9: Sentinel-3 Products Published, Downloaded and AER for Y2018, per product group

Instrument	Number of Published Products since Start of Operations	Number of Downloaded Products Start of Operations	Archive Exploitation Ratio
SLSTR	912,434	6,912,131	1:7.6
SRAL	421,634	4,858,412	1:11.5
OLCI	861,744	5,795,972	1:6.7
SYNERGY	13,140	28,269	1:2.2

Table 10: Sentinel-3 Products Published, Downloaded and AER since the start of operations, per product group

Tables 9 and 10 show, for Y2018 and since the start of operations respectively, the AER for Sentinel-3, split by product group: SLSTR, SRAL, OLCI and Synergy. Of the groups, the most popular during Y2018, measured by AER, was SLSTR with an AER of 1:7.6. During Y2018, 56% of all SLSTR products made available since the start of operations were published, as well as 56% of all SLSTR downloads made since the start of operations. In contrast, the AER for SRAL products has fallen during the period. For Y2018 it is 1:6.4, while measured from the start of operations it is 1:11.5, and for Y2017 it was 1:17. The reasons for this decrease is that, while the number of published SRAL products almost doubled during Y2018 (53% of all SRAL products were published

during the year), only 29% of total SRAL product downloads were made during the period. An explanation for the drop in downloads is the extensive SRAL reprocessing campaign which took place during Y2018, because the reprocessed products may not have been downloaded again by users. The OLCI AER is stable: 1:6.6 for Y2018, 1:7 for Y2017 and 1:6.7 since the start of operations. The Synergy AER is low at 1:2.2, though this probably reflects the short time during which the products have been available, from October 2018, and the user group had probably not started fully engaging with the products in that short space of time. Y2019 should provide a more accurate AER for the Synergy products.

SLSTR				
Level	Timeliness	Number of Published Products since Start of Operations	Number of Downloaded Products since Start of Operations	Archive Exploitation Ratio
Level 1	NTC	325,869	3,212,425	1:9.9
	NRT	344,831	2,621,297	1:7.6
Level 2	NTC	6,330	46,411	1:7.3
	NRT	235,404	1,031,998	1:4.4

Table 11: Sentinel-3 SLSTR Products Published, Downloaded and AER since the start of operations, per product level and timeliness

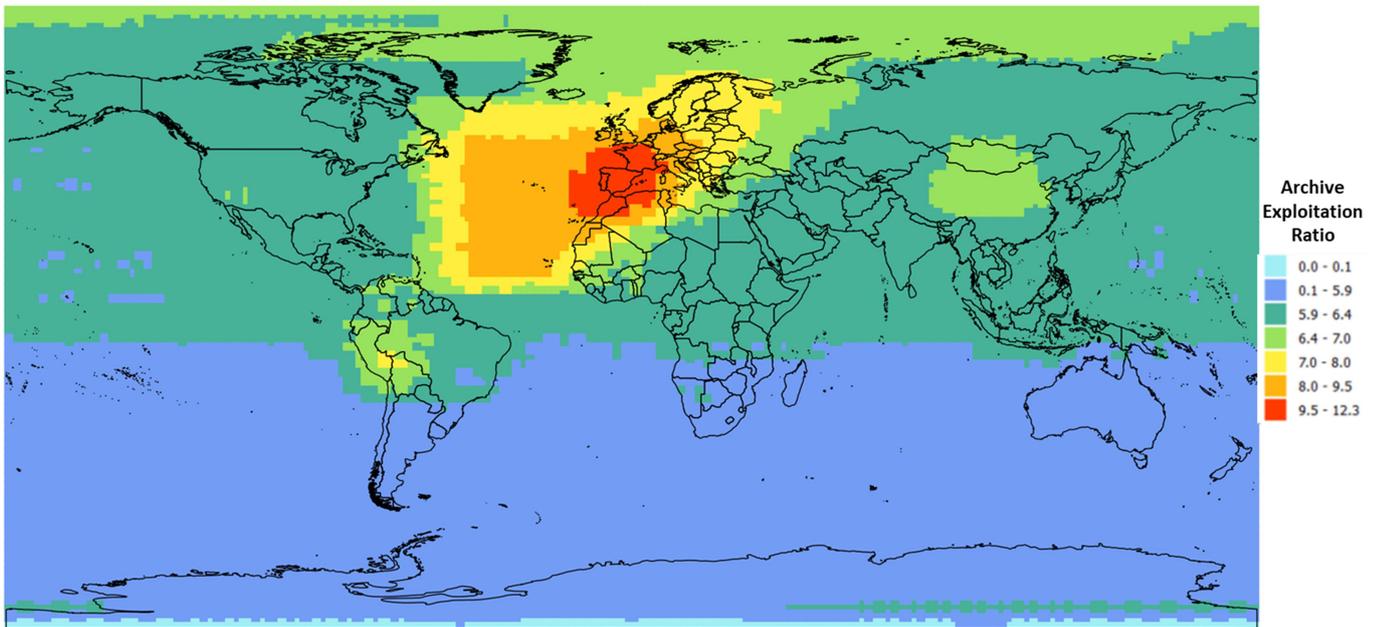


Figure 46: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-1 NTC products during Y2018

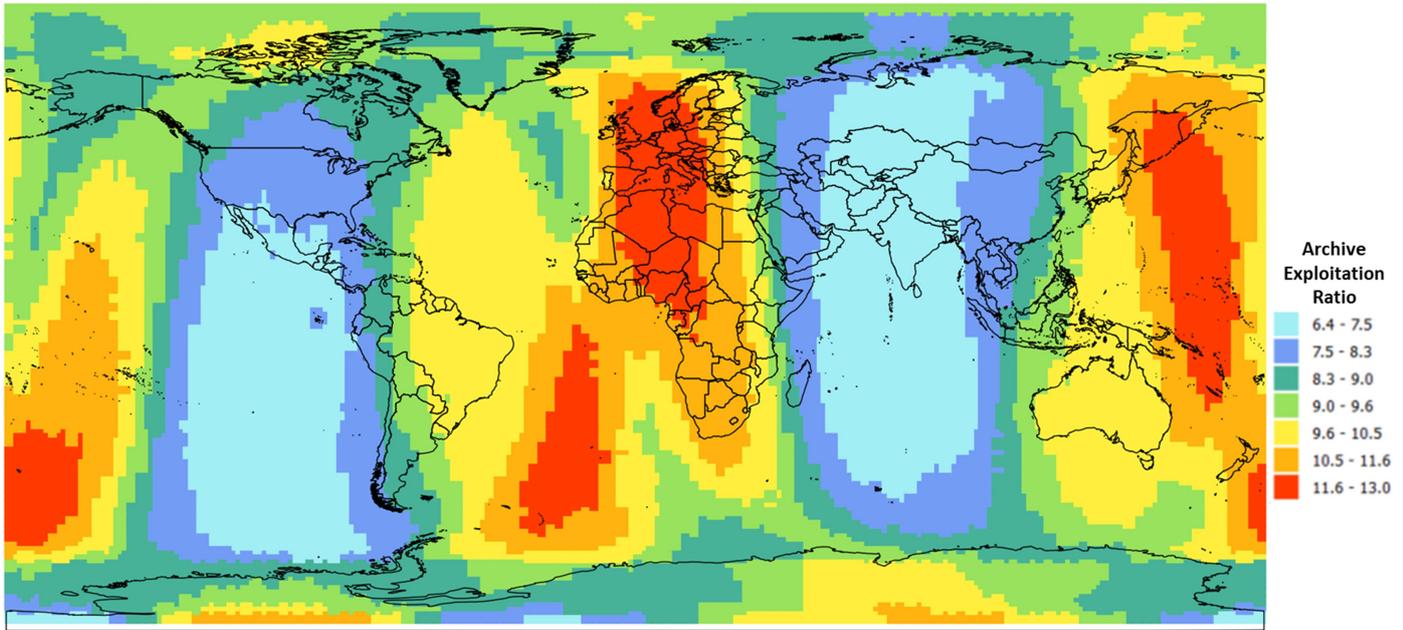


Figure 47: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-2 NTC products during Y2018

Table 11 shows a breakdown of AERs specifically for SLSTR products, by product level and timeliness (NTC or NRT). Ratios are measured from the start of operations. The table shows that the most popular SLSTR products are L1 NTC, with an AER of almost 1:10, increasing from the 1:9 observed during Y2017. The products with the greatest rise in AER are L2 NTC, up to 1:7.3 from 1:4 during Y2017, even if the absolute numbers of publications and downloads for these products are much less than the others. AERs for L1 and L2 NRT products are stable with respect to last year, at 1:7.6 and 1:4.4 respectively.

The heatmaps in Figures 46 and 47 show the geographical variation in AER for regions across the globe during Y2018 for SLSTR Level-1 and Level-2 NTC products respectively. SLSTR (as well as OLCI) products have a near-uniform worldwide coverage,

though with higher intensity of products covering the polar regions due to the higher revisit frequency. Figure 46, for SLSTR Level-1 NTC, shows that downloads were concentrated on the Northern Hemisphere, with downloads being concentrated over the North East Atlantic and especially over Western Europe where the AER rises above 1:10.

Figure 47 shows the equivalent heatmap for Level-2 NTC, products whose footprints cover the entire globe with each pass. All regions of the globe show an AER of at least 1:6. However, interest is concentrated in latitudinal spreads centred on European longitudes and on longitudes 180 degrees away, covering the north and south eastern Pacific. In these regions the AER rises above 1:11 (the red regions on the map).

SRAL				
Level	Timeliness	Number of Published Products since Start of Operations	Number of Downloaded Products since Start of Operations	Archive Exploitation Ratio
Level 1	NTC	101,082	473,282	1:4.7
	STC	39,202	262,543	1:6.7
	NRT	108,319	2,114,888	1:19.5
Level 2	NTC	51,221	537,253	1:10.5
	STC	20,820	155,287	1:7.5
	NRT	83,731	1,315,159	1:15.7

Table 12: Sentinel-3 SRAL Products Published, Downloaded and AER since the start of operations, per product level and timeliness

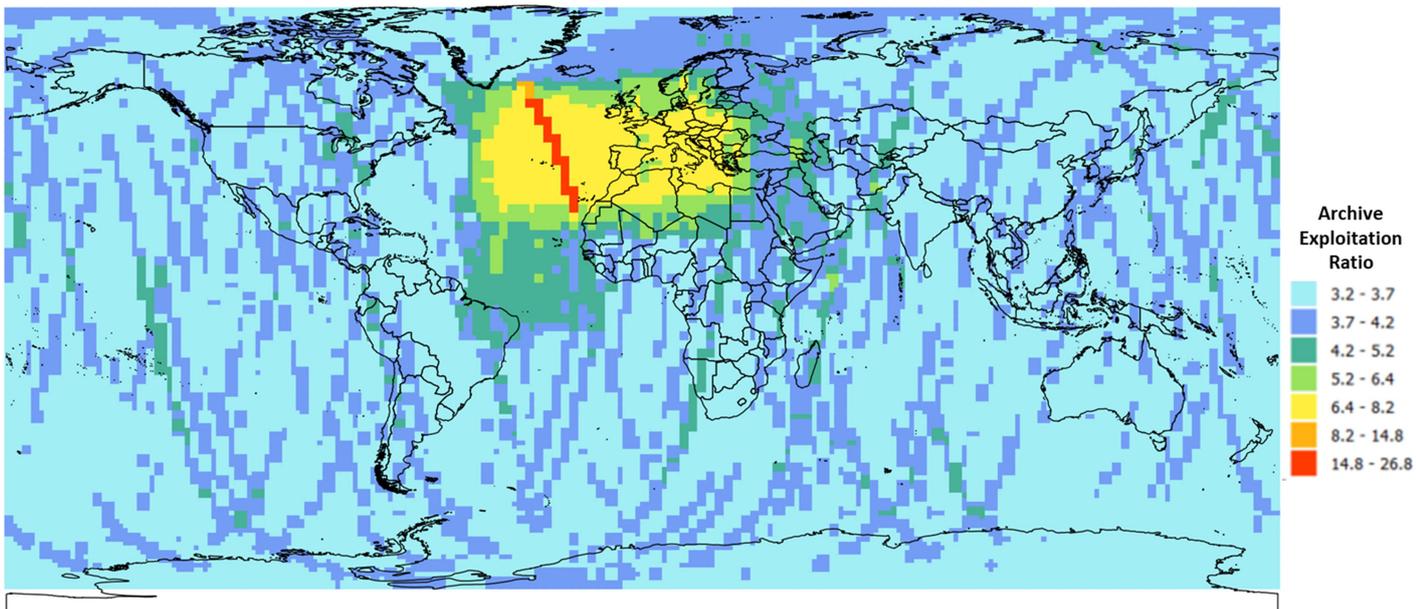


Figure 48: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-1 NRT products during Y2018

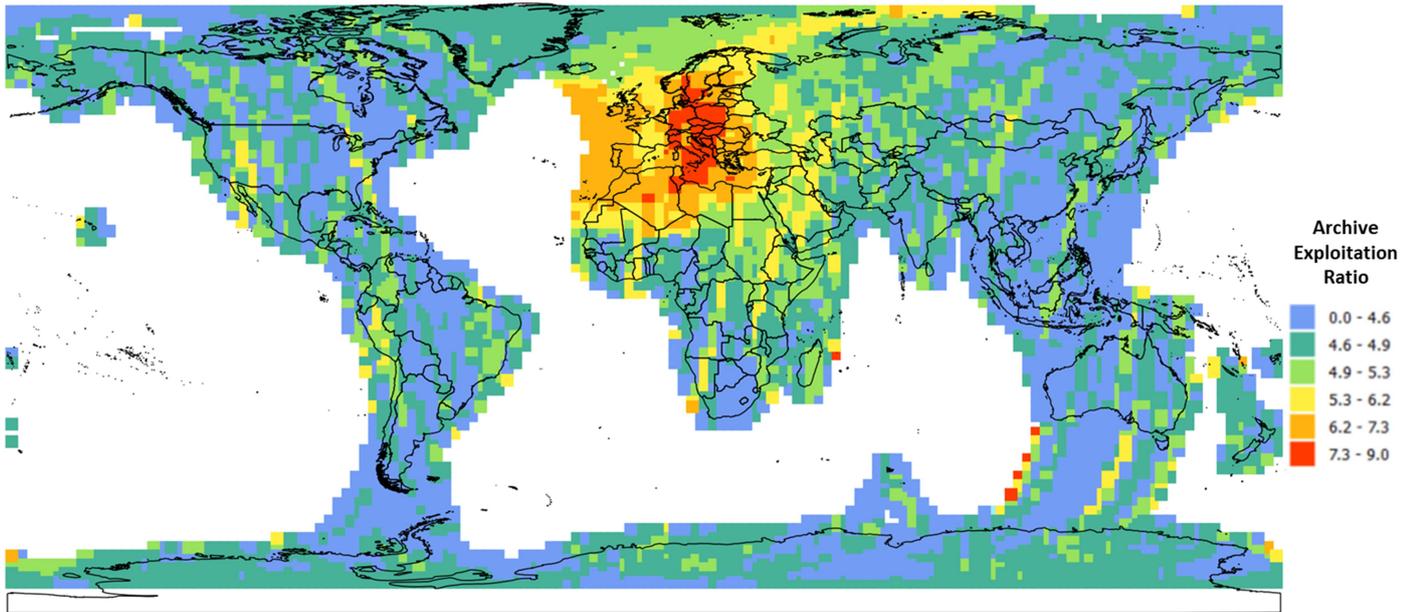


Figure 49: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-2 NRT products during Y2018

Table 12 shows a breakdown of AERs specifically for SRAL products, by product level and timeliness (NTC, STC or NRT; for more information on timeliness refer to <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-altimetry/product-types/nrt-or-ntc>). Ratios are measured from the start of operations.

It should be noted that altimetry products are typically downloaded constantly and over large areas; the sea surface level, for instance, is calculated with an interpolation of various products and its variation is derived by comparing it with the average value of historical data. The table shows that SRAL NRT products have the greatest AERs: 1:19.5 for L1 NRT (down from 1:34 during Y2017) and 1:15.7 for L2 NRT (similar to the 1:17 for Y2017). As in Y2017, it can be seen that Level-2 NTC products are far more popular than Level-1 NTC, with AERs for 1:10.5 and 1:4.7 respectively.

The heatmaps in Figures 48 and 49 show the geographical variation in AER for regions across the globe during Y2018 for SRAL Level-1 NRT and Level-2 NRT products respectively. For Level-1 NRT it is observed that there is interest over the whole globe and the AERs are stable throughout the majority of it, between roughly 1:3 and 1:4. The only significant exception is over Europe and the North Eastern Atlantic, over which AERs rise above 1:6 and, in some small regions, above 1:15. In the case of the Level-2 NRT heatmap, downloads are shown to be largely restricted to landmasses. For most of the globe’s land area, the AER is around 1:4 (blue areas on the map). The main exception is a large area encompassing Europe and Mediterranean and North African regions. In these regions, and in particular over central and southern Europe the AER rises to up to 1:9.

OLCI						
Resolution	Level	Timeliness	Number of Published Products since start of Operations	Number of Downloaded Products since start of Operations	Archive Exploitation Ratio	
Reduced	Level 1	NTC	18,550	134,035	1:7.2	
		NRT	11,067	105,021	1:9.5	
	Level 2	NTC	15,354	107,544	1:7.0	
		NRT	7,189	40,166	1:5.6	
	<b>TOTAL</b>			<b>52,160</b>	<b>386,766</b>	<b>1:7.4</b>
Full	Level 1	NTC	284,771	2,144,940	1:7.5	
		NRT	173,962	1,329,489	1:7.6	
	Level 2	NTC	236,509	1,385,993	1:5.9	
		NRT	114,342	548,784	1:4.8	
	<b>TOTAL</b>			<b>809,584</b>	<b>5,409,206</b>	<b>1:6.7</b>

Table 13: Sentinel-3 OLCI Products Published, Downloaded and AER since the start of operations, per product level and timeliness

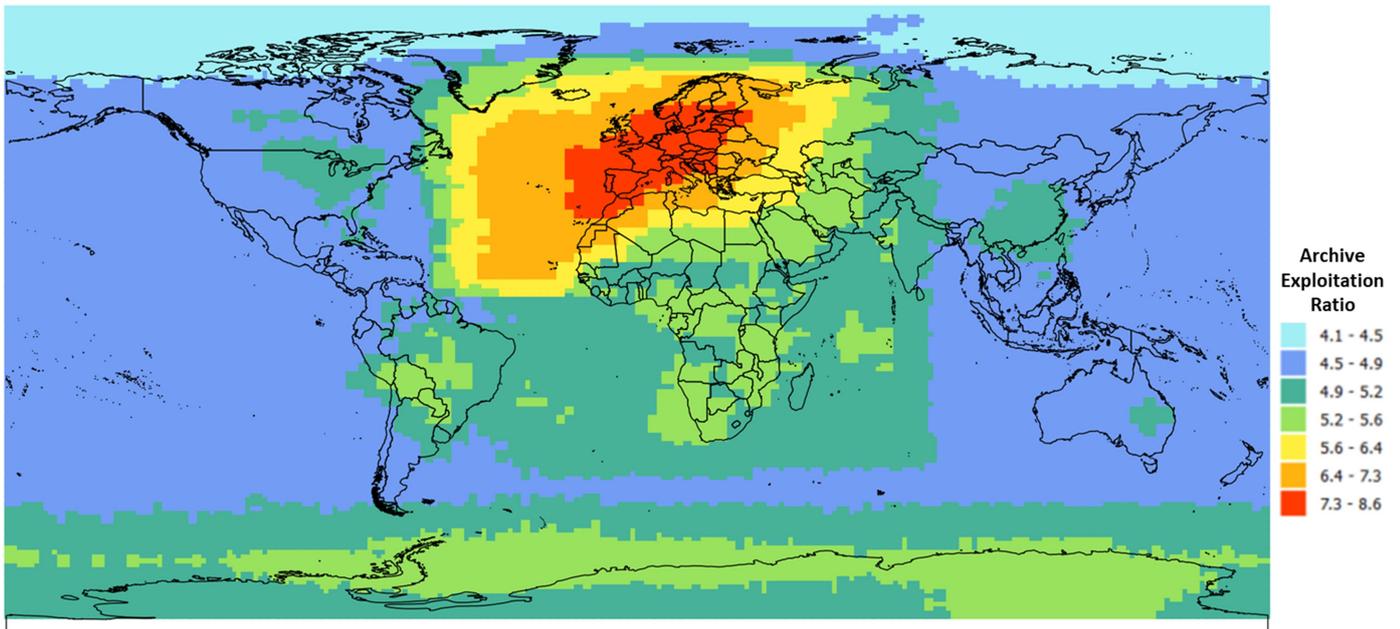


Figure 50: Heatmap showing the archive exploitation ratio for Sentinel-3 OLCI Full Resolution products during Y2018

Table 13 shows a breakdown of AERs specifically for OLCI products, by product level, timeliness (NTC or NRT) and resolution (Reduced or Full). Again, ratios are measured using publication and download figures from the start of operations. AERs range from 1:4.8 for Full Resolution L2 NRT to 1:9.5 for Reduced Resolution L1 NRT. In general, Reduced Resolution products are slightly more popular than Full Resolution, with AERs of 1:7.4 and 1:6.7 respectively. This is reasonably stable with respect to Y2017.

Y2018 for OLCI Full Resolution products. There is interest in OLCI products over the whole globe, with most regions exhibiting AERs of between 1:4 and 1:5. However, there is a concentration of interest over a large region encompassing the Europe, North Africa and the North Eastern Atlantic; over Europe AERs can rise to between 1:8 and 1:9, the highest observed in any region. It is also interesting to note that the majority of the African continent shows an AER of above 1:5, higher than most of Asia, North America and Oceania.

The heatmaps in Figure 50 shows the geographical variation in AER for regions across the globe during

## Sentinel-5P

Level	Timeliness	Product Type	Number of Published Products since Start of Operations	Number of Downloaded Products since Start of Operations	Archive Exploitation Ratio
<b>Level 1B</b>	<b>NTC</b>	<b>[ALL]</b>	<b>24,376</b>	<b>179,029</b>	<b>1:7.3</b>
<b>Level 2</b>	<b>NRT</b>	L2_AER_AI	25,754	184,992	1:7.2
		L2_CLOUD_	25,674	148,467	1:5.8
		L2_CO__	1,589	12,400	1:7.8
		L2_HCHO_	10,658	74,131	1:7.0
		L2_NO2__	25,719	343,506	1:13.4
		L2_O3__	25,653	299,754	1:11.7
		L2_SO2__	10,653	98,687	1:9.3
		<b>[ALL]</b>	<b>125,700</b>	<b>1,161,937</b>	<b>1:9.2</b>
	<b>NTC</b>	L2_AER_AI	2,191	24,219	1:11.1
		L2_CLOUD_	2,190	21,019	1:9.6
		L2_CO__	2,186	47,845	1:21.9
		L2_NO2__	2,017	61,402	1:30.4
		L2_NP_BD3	2,172	9,528	1:4.4
		L2_NP_BD6	2,163	13,155	1:6.1
L2_NP_BD7		2,119	10,898	1:5.1	
L2_O3__		1,596	18,514	1:11.6	
<b>[ALL]</b>	<b>16,634</b>	<b>206,580</b>	<b>1:12.4</b>		
<b>[ALL NRT + NTC]</b>		<b>142,334</b>	<b>1,368,517</b>	<b>1:9.6</b>	

Table 14: Sentinel-5P Products Published, Downloaded and AER since the start of operations, per product level, timeliness and (Level 2) product type

Table 14 shows a first view of the take up of Sentinel-5P products. Archive Exploitation Ratios are presented for Level 1B and Level 2 products, for both NTC and NRT and, for Level 2 products, also per individual product type. As noted previously, products have only been available on the Sentinel-5P PreOps Hub since July 2018, with further products added subsequently. The table shows that Level 2 products are more popular than Level 1B (overall AERs of 1:9.6 for NRT and 1:7.3 for NTC) and that Level 2 NTC is somewhat more popular than Level 2 NRT (overall AERs of 1:12.4 for NTC and 1:9.2 for NRT). The most popular products by ratio are

L2\_No2\_\_ NTC(1:30.4) and L2\_CO\_\_ NTC (1:21.9), although very few Level 2 NTC products had been published by the end of the period. The most popular product in absolute terms is the L2\_O3\_\_ NRT product: 299,754 downloads and an AER of 1:11.7.

It is recalled that Sentinel-5P data dissemination was still in its early days by the end of Y2018, and assuming that knowledge of and interest in the Sentinel-5P mission will still be growing, it is likely that the Y2019 statistics will provide a more representative view of Sentinel-5p user take-up.

### 2.3.3 Download trends

In Table 15 below, the overall numbers and volumes of products downloads since the start of operations

are broken down per hub, showing the different levels of user uptake on each hub.

Hub	Number of Products Downloaded Since Start of Operations	%	Volume of Products Downloaded Since Start of Operations (PiB)	%
Open Access Hub	60,751,728	49	42.79	49
Collaborative Hub	36,824,801	30	28.30	32
International Hub	10,631,735	9	8.17	9
Copernicus Services Hub	14,780,638	12	7.85	9
<b>All Hubs</b>	<b>122,988,902</b>		<b>87.11</b>	

Table 15: Number and Volume of products downloaded since the start of operations, per hub

The largest contributor to the dissemination of Sentinel products since the beginning of operations remains the Open Hub, which by the end of Y2018 had managed 49% of the total volume of downloads since the start of operations. This is a slightly lower proportion of the overall downloads than the Open Hub had managed by the end of Y2017 (59%), and the change can largely be attributed to a significant increase in the proportion of downloads managed by ServHub, which now accounts for 9% of the overall volume, up from 3% by the end of Y2017. The ColHub has also seen a moderate increase, up to 32% from 29%.

2018, as well as the percentage change in this figure since November 2017. All of the hubs except the Open Hub experienced an increase in the volume of user downloads during Y2018, in particular the ServHub (up a massive 1,230%), and the ColHub (up 83%). The increase on the ServHub is largely as a result of downloads from DIAS partners via their dedicated access points from March 2018 (see section 1.2), which are accounted for within ServHub statistics. In contrast, the Open Hub is down by a small amount (7%), possibly explained by the regularisation of dataflows following pre-operations (accounted to the Open Hub) onto the nominal access points (thus allowing to accounting to ColHub, IntHub and ServHub/DIAS Hub).

Table 16 below shows the average daily volume of downloads handled by each hub during November

Hub	Daily average volume (TiB) downloaded in November 2017	Daily average volume (TiB) downloaded in November 2018	% increase Y2017 - Y2018
Open Access Hub	52.3	48.5	-7
Collaborative Hub	29.0	53.1	83
International Hub	9.9	12.4	25
Copernicus Services Hub	2.3	30.6	1,230
<b>All Hubs</b>	<b>93.5</b>	<b>144.6</b>	<b>55</b>

Table 16: Volume disseminated per day during the last month of Y2017 and Y2018

Focusing more specifically on user downloads during Y2018, the graph in Figure 51 shows the volume of

products which users downloaded from each hub and per mission during the current reporting period. This

is the first period during which Sentinel-3 downloads are reported for all hubs, with the data flows having progressively opened operationally during throughout Y2018. For the majority of the period only SRAL products were available directly on the

Hubs; OLCI and SLSTR products were available up until September and November (respectively) only on the Sentinel-3 PreOps hub, whose download figures are accounted for within the Open Hub figures.

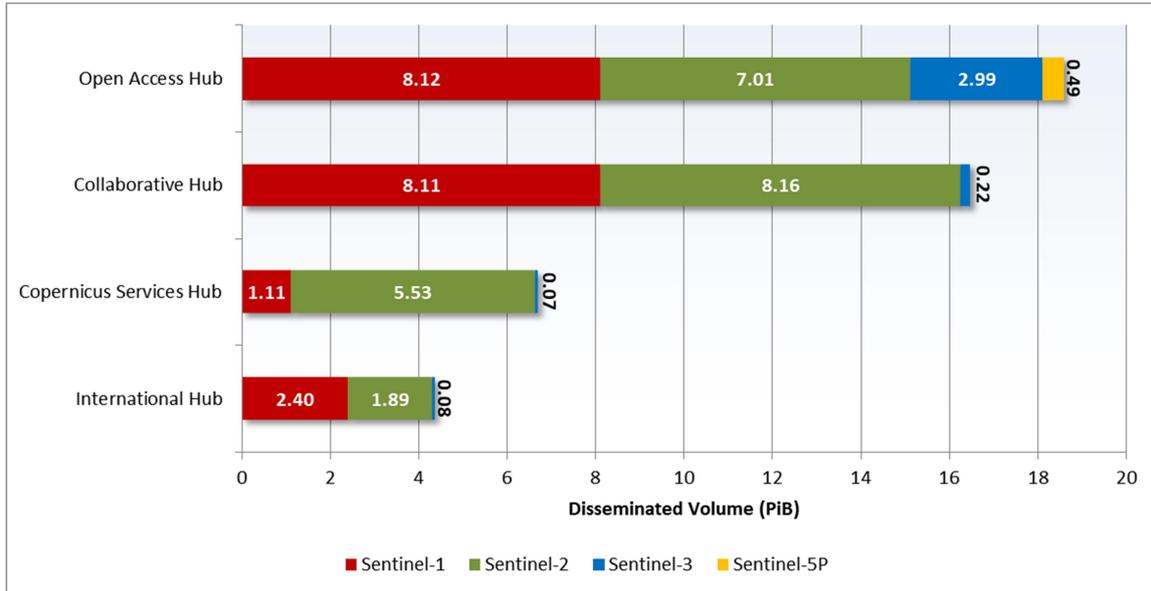


Figure 51: Disseminated volumes (PiB) during Y2018 per Hub and per Mission

The Open Hub and the ColHub were the two hubs with by far the highest download volumes during Y2018 (both 2-4x the ServHub and IntHub totals), with a total of 18.1 PiB and 16.5 PiB respectively. It is interesting to note that on both of these hubs, there was a fairly equal split between Sentinel-1 and Sentinel-2 downloads: on the Open Hub there was an S-1/S-2 percentage split of 45%/39%, while on the ColHub it was 49%/49%. However, Sentinel-3 accounted for a far larger proportion of downloads on the Open Hub at 17% (only 1-2% on all other

hubs). This is due to users only being able to obtain OLCI and SLSTR products from the S-3 PreOps Hub for the majority of the period.

On the ServHub and the IntHub totals of 6.7 PiB and 4.4 PiB respectively were downloaded in the period. On the ServHub, interest was strongly in favour of Sentinel-2, which accounted for 82% of all downloads (only 17% for Sentinel-1). On the IntHub, Sentinel-1 was moderately favoured: 55% versus 43% for Sentinel-2.

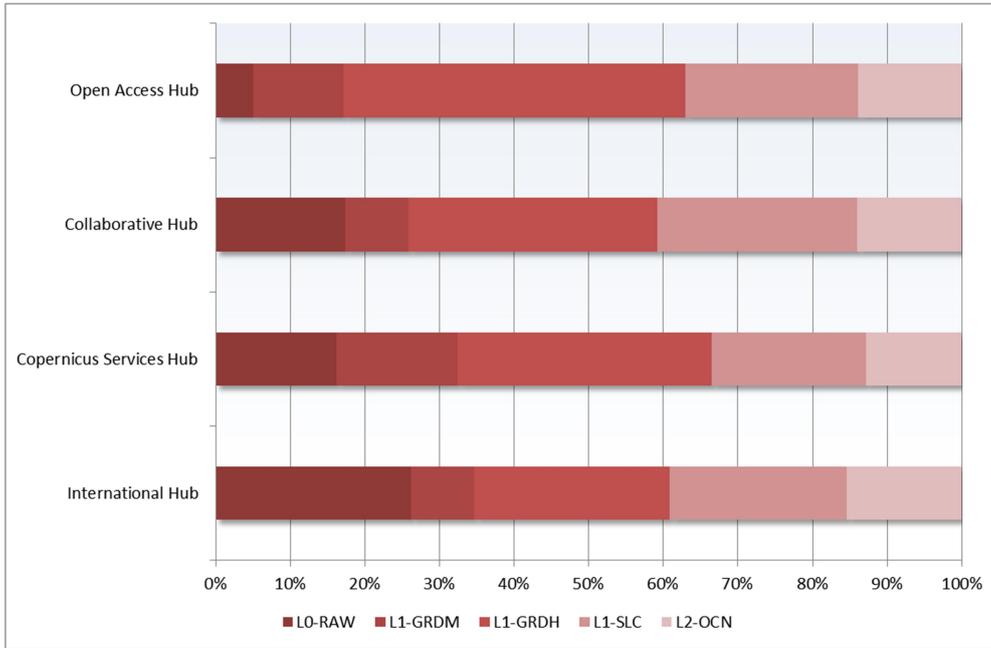


Figure 52: Sentinel-1 dissemination percentages per hub and per product type

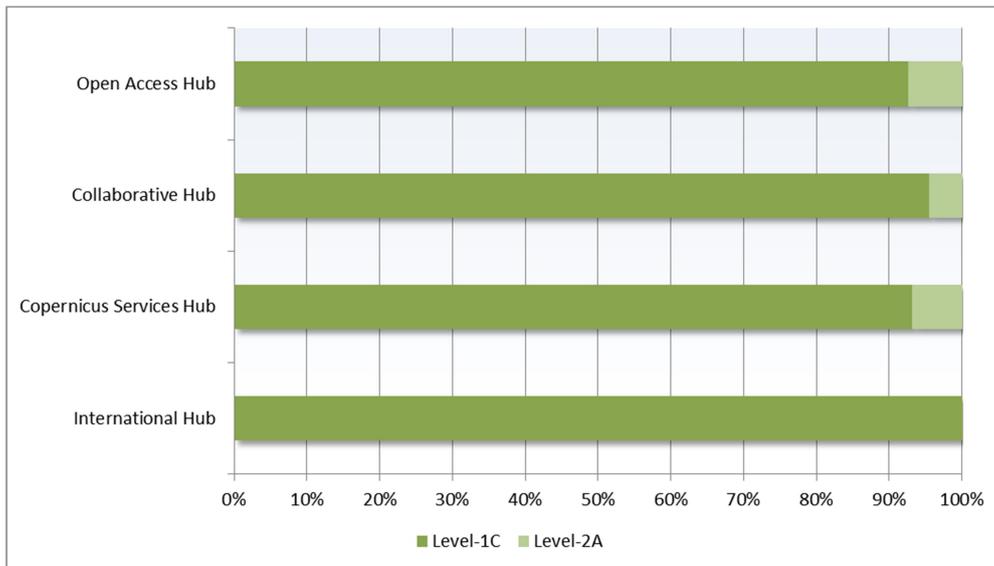


Figure 53: Sentinel-2 dissemination percentages per hub and per product type

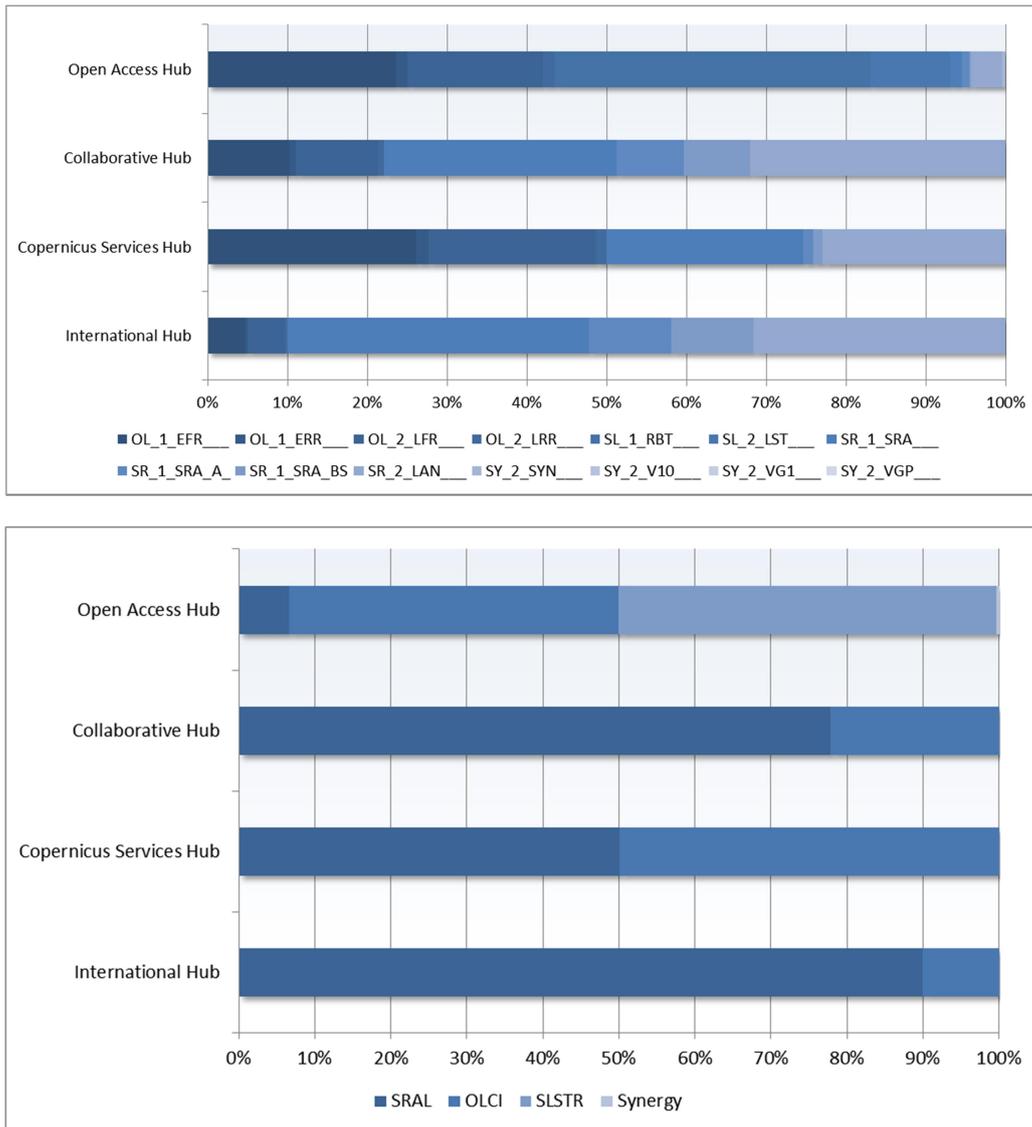


Figure 54: Sentinel-3 dissemination percentages per hub and per product type (graph 1) and product group (graph 2)

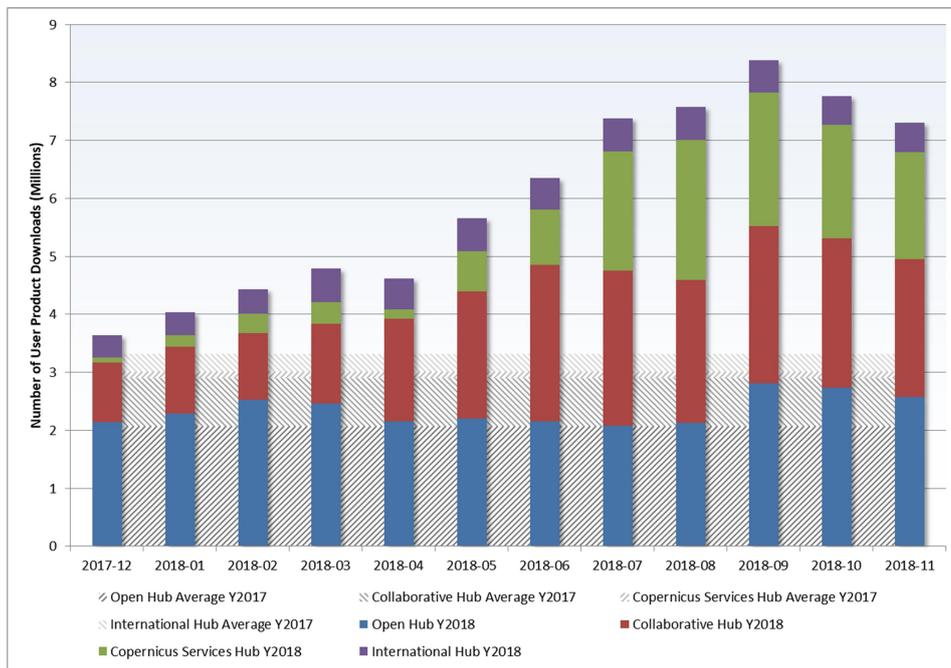
Figures 52, 53 and 54 show the normalized number of disseminated products for each mission, split per product type and pre hub.

In the case of Sentinel-1, L1-GRDH products were the most downloaded on all hubs, making up between 26% and 46% of all downloads. In the case of the IntHub, they were jointly the most downloaded together with Lo\_RAW (both 26%). In the case of the Open Hub, L1-GRDH was significantly the most downloaded (46%) and there was lower interest in Lo\_RAW than other hubs (only 5%). Percentage downloads of L1\_SLC and L1\_OCN were similar on all hubs, ranging from 21-27% for L1\_SLC and 13-15% for L2\_OCN.

For Sentinel-2, all hubs showed a >90% interest in Level-1C products, with correspondingly a <10% interest in Level-2A. This could be attributed to the fact that Level-2A production in Y2018 only covered the Euro-Mediterranean region. Given that operational Level 2A publication did not start until 23 March 2018, it is also possibly fair to assume that the low proportion of the Level 2A products does not reflect the true levels of interest in the data, and that the Y2019 reporting period will give a clearer indication of the take up of Level-2A, when the products will have been available for the whole reporting period and will cover the whole globe.

There are now 14 distinct product types for Sentinel-3 (split between SRAL, OLCI, SLSTR and Synergy). Figure 54 shows the percentage split of the overall volumes downloaded from each of the four hubs per product type. As this can be hard to read (given the number of products and the low percentage of some of the products), Figure 54 also provides the split per each of the four product groups (each instrument plus Synergy products, but it should be noted that neither SLSTR nor Synergy products were available on the ColHub, IntHub or ServHub during the period. The ColHub and IntHub are dominated by SRAL downloads, followed by OLCI. Routine dissemination

of OLCI on all hubs only began on 27 September 2018, so this is unlikely to be a true representation of user interest. The ServHub has an about even split between SRAL and OLCI downloads. Perhaps the most representative distribution for indicating user interest, therefore, is that seen on the Open Hub. Here, SRAL products only accounted for 7% of user downloads: the largest category is SLSTR at 50%, followed by OLCI at 43% and small amount of Synergy (0.4%). As for Sentinel-2, the Y2019 period should give a clearer indication of actual user interest, following routine dissemination of all products on all hubs for a full reporting period.



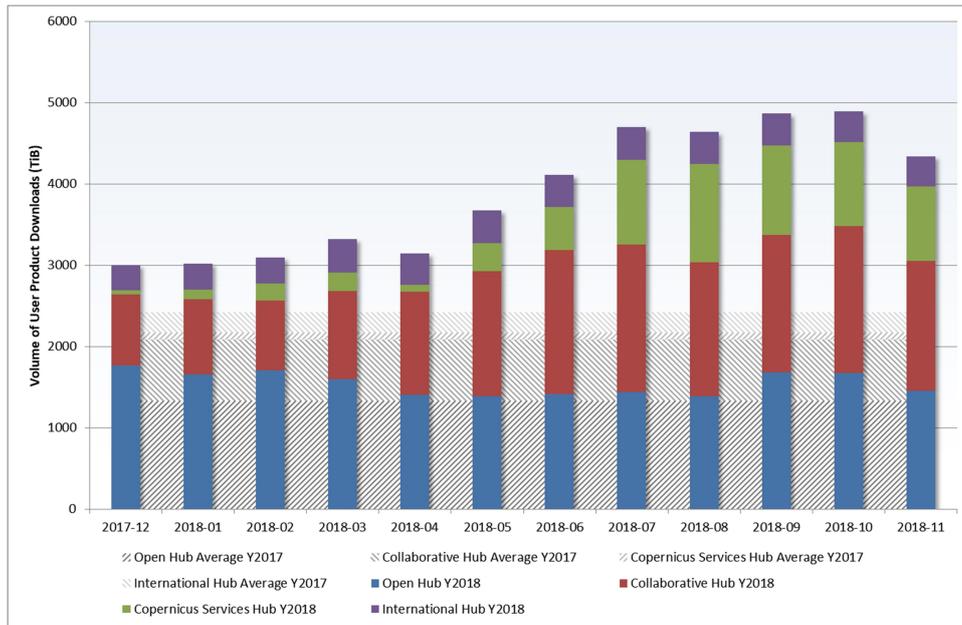


Figure 55: Dissemination number and volume trends per hub during Y2018, with Y2017 averages for comparison

The graphs in Figure 55 above show the monthly number (graph a) and volume (graph b) of downloads made from each hub during Y2018, compared with the average monthly volume and number of downloads made on each hub during Y2017. From these graphs, it can be seen that the both the numbers and volume of downloads increased over the period, particularly in the period between May and September 2018. Product numbers underwent a steeper rise than volumes, presumably driven largely by the Sentinel-2 single-tile format, and the reprocessing of old (higher volume) products into that format.

It can be observed that the disseminations for the Open Hub and the IntHub remained fairly stable during Y2018. In fact, the highest monthly volume on the Open Hub occurred during the first month of the period, 1766 TiB in December 2017 (the monthly average over the whole period was 1546 TiB). The observed increase in total volumes and numbers was driven by principally by both the ColHub and the ServHub. Both experienced significant rises, particularly from May onwards. We can see this by comparing the per month volume average for the first four months of period (December 2017 – March 2018) with the last four months (August 2018 – November 2018). For the ColHub these were 935 TiB and 1685 TiB, an 80% increase. This can be explained

by the growth of existing, and opening of new, National Mirrors during Y2018 (see section 4). For the ServHub the averages were 151 TiB and 1065 TiB, a massive 600% increase. As noted above this is in all probability due to the DIAS partners downloads, which from March 2018 were made via dedicated nodes, though accounted for within ServHub statistics.

## Sentinel-1 Offline Product Retrievals

As mentioned in Section 1, Sentinel-1 Long Term Archive (LTA) interfaces were activated on 12 September 2018, allowing users to retrieve Sentinel-1 products moved offline. By the end of Y2018, 974,279 products were available offline, with a total volume of 1.26 PiB. Even though the interfaces had only been open a short while by the end of Y2018, it is interesting to observe the initial growth in use. Figure 56 shows the number of product retrievals, per month, for both the Open Hub and the ServHub. While very few products were retrieved during September 2018, user take-up has been significant since, with about 9,000 offline products being retrieved from each Hub during November 2018. Y2019 will provide a fuller picture of offline product retrieval.

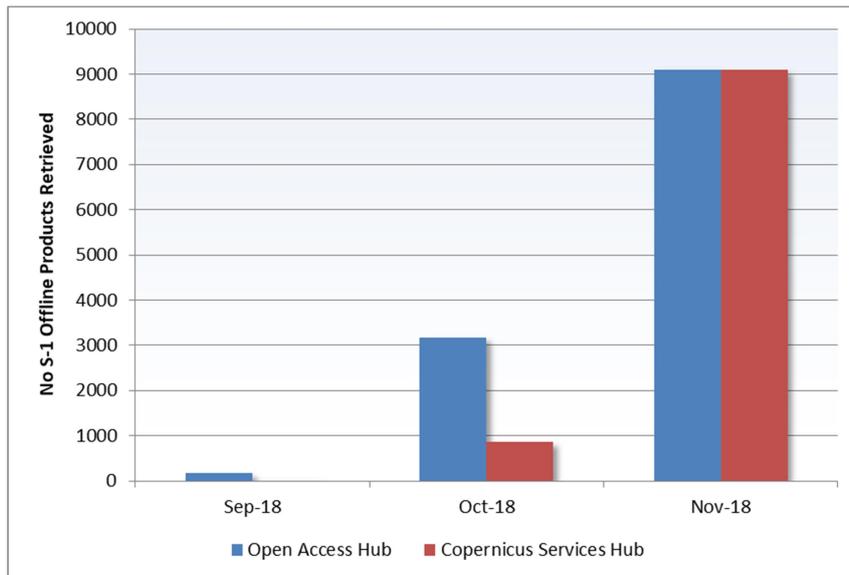


Figure 56: Numbers of Sentinel-1 offline product retrievals per month since opening of the LTA interfaces

## 2.3.4 Downloads per Continent and Country

Another interesting view of product dissemination during Y2018 is that of the continents and individual nations which have performed the most downloads on the Data Access System. Table 17 presents view of the percentage of downloads (by number) which took place on each continent on each of the four Hubs during Y2018. It should be noted that contributions from the Sentinel-3 and Sentinel-5P PreOps Hubs – where the identity and locations of end users are not known – are not included in the statistics.

The overall percentage split is also shown. It is fair to say that Europe dominates on all Hubs except the IntHub (which has only four users, split between the USA and Australia). The ColHub and ServHub essentially entirely dedicated to Europe, the continent accounting for 99.7% and 100% of downloads respectively. The small amount of non-European downloads on the ColHub (0.3%) are

accounted for by the Canadian Collaborative Ground Segment. The Open Hub is the only hub for which all continents have registered users, and it is clear from the table that by far the majority of downloads (62%) in Y2018 were made by European users. Interestingly, despite the lower number of registered users than continents such as Asia or South America had by the end of Y2018, North American users downloaded the second highest number of products from the Open Hub, with a 27% share of the total downloads made in Y2018. By contrast, Asian users, which accounted for as much as 23% of the total number of registered users by the end of Y2018, made only 2.7% of the downloads in Y2018, and South American users, which accounted for 19% of the registered users by the end of Y2018, made as little as 0.82% of the total downloads. These figures indicate that many of the North American users download the data in mass quantities, while the Asian and South American users choose to download a more specific selection of data. The remainder of this section focuses on the Open Hub.

Continent	PERCENTAGE OF DOWNLOADS BY NUMBER				OVERALL
	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	
Europe	62	99.7	100	0	78.0
North America	27	0.3	0	85.2	17.0
Asia	8	0	0	0	2.7
Oceania	1	0	0	14.8	1.9
South America	0.82	0	0	0	0.3
Africa	0.38	0	0	0	0.1

Table 17: Percentage of Y2018 downloads per Continent and per Hub and overall

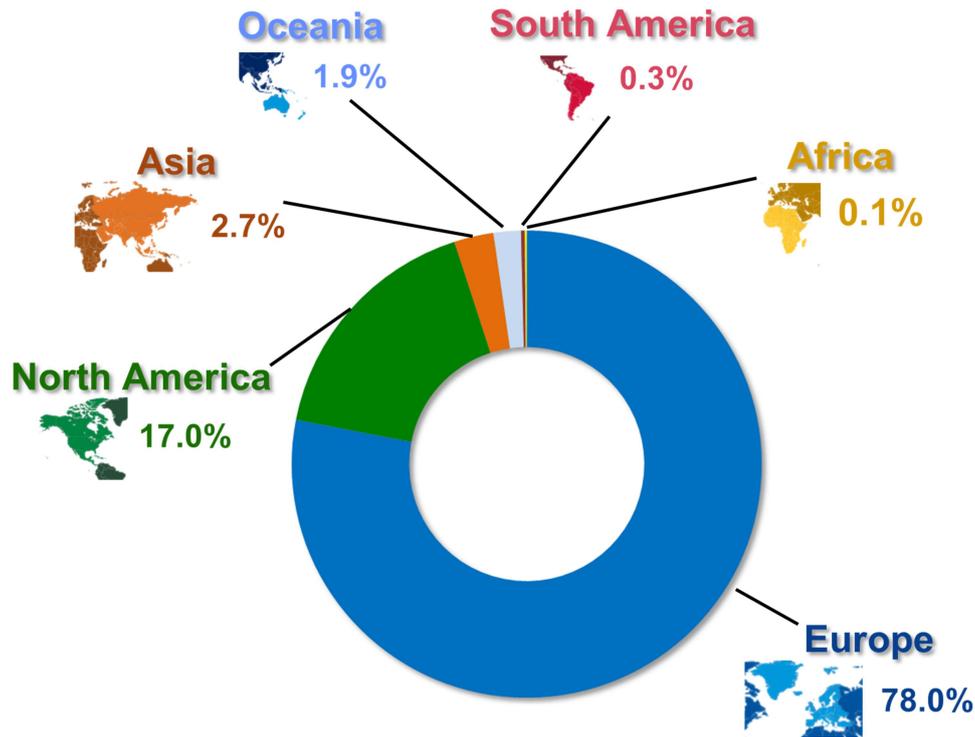


Figure 57: Overall percentage split of Data Access System downloads (all Hubs) by number, per Continent, during Y2018

### Open Access Hub Focus

Table 18 breaks down the overall per continent figures for the Open Hub in Y2018, to show the percentage split between the continents of downloads from each Sentinel mission in Y2018. It is

again recalled that the nationality of users on the Open Hub is based only on the information they themselves provided during registration; no further verification is performed (e.g. via i.p. check).

Sentinel-1		Sentinel-2		Sentinel-3	
Continent	% of Y2018 Downloads	Continent	% of Y2018 Downloads	Continent	% of Y2018 Downloads
Europe	67	Europe	59	Europe	75
North America	19	North America	31	North America	18
Asia	10	Asia	8	Asia	3
Oceania	2	Oceania	1	Oceania	2
South America	0.82	South America	0.81	South America	1
Africa	0.68	Africa	0.27	Africa	0.10

Table 18: Continental percentage split of Y2018 downloads on the Open Access Hub, for each Sentinel mission and overall

From this Table, it can again be seen that European users make by far the greatest numbers of downloads from the Open Hub, accounting for between 59-75% of the downloads per Sentinel. The figures for North America suggest that North American users of the Open Hub are primarily interested in the Sentinel-2 products, although they

still make a significant proportion of the Sentinel-1 and Sentinel-3 downloads. Interest among both Asian and African users appears slightly tipped towards Sentinel-1, while among South American users interest is possibly tipped towards Sentinel-3.

Tables 19 and 20 below present a breakdown of the ten nations with the highest number of downloads for each of the three Sentinels during Y2018. The first

table includes all nations worldwide; the second includes only nations which are ESA and/or EU member states.

Sentinel-1		Sentinel-2		Sentinel-3	
Country	Y2018 Number of Product Downloads	Country	Y2018 Number of Product Downloads	Country	Y2018 Number of Product Downloads
France	1,601,028	United States	4,287,563	Poland	156,513
United States	1,126,086	France	3,881,168	France	118,968
United Kingdom	526,959	Slovenia	1,749,090	United States	92,990
Germany	503,243	Russian Federation	725,287	Italy	53,565
Poland	257,577	Germany	559,184	Germany	24,429
China	194,064	Poland	551,723	United Kingdom	19,854
Italy	193,679	Italy	234,283	Australia	12,944
Russian Federation	189,372	Luxembourg	226,576	China	6,908
Slovenia	179,501	United Kingdom	211,933	Denmark	9,493
Netherlands	141,529	Australia	154,087	Norway	5,155

Table 19: Top 10 Nations (globally) by number of downloads in Y2018 on the Open Access Hub, for each Sentinel mission

Sentinel-1		Sentinel-2		Sentinel-3	
Country	Y2018 Number of Product Downloads	Country	Y2018 Number of Product Downloads	Country	Y2018 Number of Product Downloads
France	1,601,028	France	3,881,168	Poland	156,513
United Kingdom	526,959	Slovenia	1,749,090	France	118,968
Germany	503,243	Germany	559,184	Italy	53,565
Poland	257,577	Poland	551,723	Germany	24,429
Italy	193,679	Italy	234,283	United Kingdom	19,854
Slovenia	179,501	Luxembourg	226,576	Denmark	9,493
Netherlands	141,529	United Kingdom	211,933	Norway	5,155
Denmark	89,487	Spain	143,646	Spain	3,569
Portugal	82,295	Finland	101,019	Slovakia	2,665
Norway	74,509	Austria	84,082	Netherlands	1,484

Table 20: Top 10 Nations (ESA/EU) by number of downloads in Y2018 on the Open Access Hub, for each Sentinel mission

On the national (global) perspective it can be seen that, although the list of individual nations is largely dominated by European nations, some large non-European nations make regular entries. The United States is the most significant of these, being the highest downloader of Sentinel-2 products, the second highest of Sentinel-1 products and the third highest of Sentinel-3 products. China is a large downloader of Sentinel-1 products (sixth) and Sentinel-3 products (eighth), while the Russian Federation makes a high entry for Sentinel-2 (fourth place) and Sentinel-1 (eighth). The following nations appear in the top 10 lists for all Sentinels: France, Germany, United Kingdom, Italy, Poland and the United States.

## 2.3.5 Fresh vs Old Products

Download statistics can be further examined by looking at the age of the products which are downloaded on each Hub. This provides an understanding of the extent to which users are interested in historical data in addition to new publications. The graphs in Figure 58 below show, for each Sentinel mission and per Hub, the percentage of

downloads during Y2018 for products within six given age ranges. These age ranges (measured from the product publication date) are:

- 0 – 2 days
- 2 days – 1 week
- 1 week – 1 month
- 1 month – 3 months
- 3 months – 1 year
- > 1 year

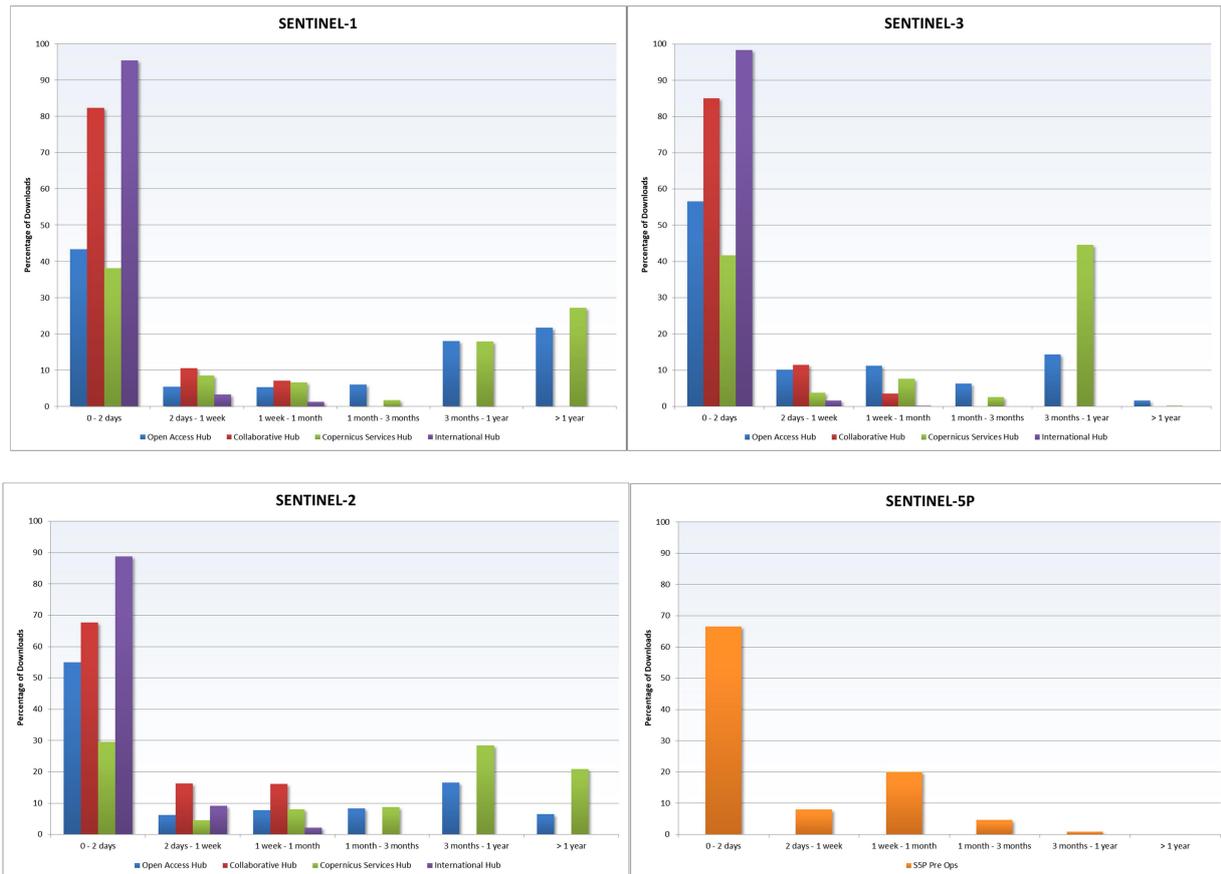


Figure 58: Percentage of Y2018 downloads per product age range, for each Sentinel mission and per Hub

In general it can be observed that newly published products, particularly in the range 0-2 days, are far more popular than older products. This is to be expected for two reasons: firstly many users (and certainly users that systematically download) will already have the older data they are interested in; secondly, many user applications are likely to have a preference for newer data over old. The preference for newer products is particularly true for the ColHub and IntHub: for example, for Sentinel-1 82% of data downloaded from the ColHub was 0-2 days old, with the corresponding figure on the IntHub being a

massive 95%. This is to be expected: the users of these Hubs generally operate by only performing systematic downloads of newly published data. Also, it is noted that the rolling policy on these Hubs means that data older than 1 month is removed.

On the Open Hub, the preference for newer data is still present though is less pronounced. Downloads for products in the 0-2 days category accounted for 43% for Sentinel-1, 55% for Sentinel-2 and 57% for Sentinel-3. There is then a significant drop off in all age ranges between 2 days and 3 months, though

interestingly then small rise in downloads for products older than 3 months. This rise is greatest for Sentinel-1, with 40% of downloads being for products older than 3 months. This trend is perhaps due to the ease of access to data on the Open Hub and the growth of users observed: as new users discover the service, there will likely be some who need all historical data over the areas they are interested in: as most catalogued products are older than 3 months, downloads of historical data will inevitably be weighted towards the older categories. Additionally, the trend could be driven in part by downloads of reprocessed products, at least in the cases of Sentinels-2 and -3.

Of all the Hubs, the ServHub displayed the most even split between the age ranges, with more downloads taking place for products older than 3 months than in the 0-2 days range. For example, for Sentinel-2, 29% of downloads were in the 0-2 days range, while products older than 3 months accounted for 49%. This is likely due to the DIAS Hub’s downloads being accounted for in the ServHub figure: following the opening of the Hub on 9 March 2018, it is likely that the DIAS Partners will have sought to retrieve all available products, new and old.

Data for Sentinel-5P is presented for the S-5P PreOps Hub, currently the only access point for the mission’s products. While 67% of downloads are in the 0-2 days category, the second largest category, accounting for 20%, is for 1 week – 1 month. There is significant drop-off after that, clearly resulting from the lack of older products at the end of Y2018.

### 2.3.6 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, rather than necessitating the download of the full package in order to obtain them.

The statistics on these products component downloads are not taken into account in the (full download) statistics provided above. However, to provide an overview of the user take-up of product component downloads, two months of the reporting period have been analysed: July 2018 and November 2018. Table 21 below reports the number and volume of overall products component recorded in these months.

	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)
<b>July 2018</b>	1,739,795	1,302.81	1,325,766	5.83
<b>November 2018</b>	1,970,140	1,210.57	4,894,463	16.40

Table 21: Number and volume of overall products component downloads from the Open Hub during July and November 2018

It is interesting to note that while the number of full product downloads rose only 13% between July and November 2018, the rate of increase of the products component downloads was much higher: up 270% from 1.3 million July to 4.9 million in November. In November, there were therefore approximately 2.5x more component downloads than full product downloads. The volume of the component downloads is only a small fraction of the full product downloads, since in most cases the component downloads are for very small volume metadata files.

In November 2018, the components most downloaded (in terms of number) are shown in Figure 59. .safe files accounted for the greatest share (30%), followed by .png files (25%), .gml files (20%) and .xml files (18%). The .safe files are the manifest components of the data products, the .gml files are typically the cloud mask information provided with Sentinel-2 products, and the .xml files are typically metadata or annotation files, perhaps used by users to construct their own catalogues of Sentinel data.

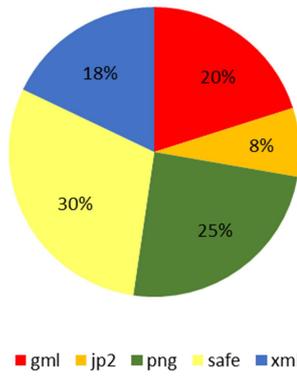


Figure 59: Percentage of component downloads per file type made on the Open Hub during November 2018

### 2.3.7 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 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.

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: these are July and November 2018. 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.

Table 22 shows the volume of partial content downloads on the Open Hub reordered by the system in July and November 2018, compared with the volume of full downloads during the same periods. The analysis takes into account the OpenHub nominal interfaces (graphical and API), excluding any PreOps Hub.

	Volume of full downloads from OpenHub (TiB)	Volume of partial downloads from OpenHub (TiB)
July 2018	1,302.81	523.55
November 2018	1,210.57	99.04

Table 22: Volume of full and partial downloads on the Open Hub nominal interfaces during July and November 2018

Regarding the split between downloads returning the ‘200’ and ‘206’ codes during the two months, only a small proportion returned ‘206’: 3% in July and 2% in November. It is likely that download manager tools are the main contributors to successful downloads returning the ‘206’ code.

## 2.3.8 Dedicated Access Points

### 2.3.8.1 Copernicus Marine Environment Monitoring Service (CMEMS)

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.

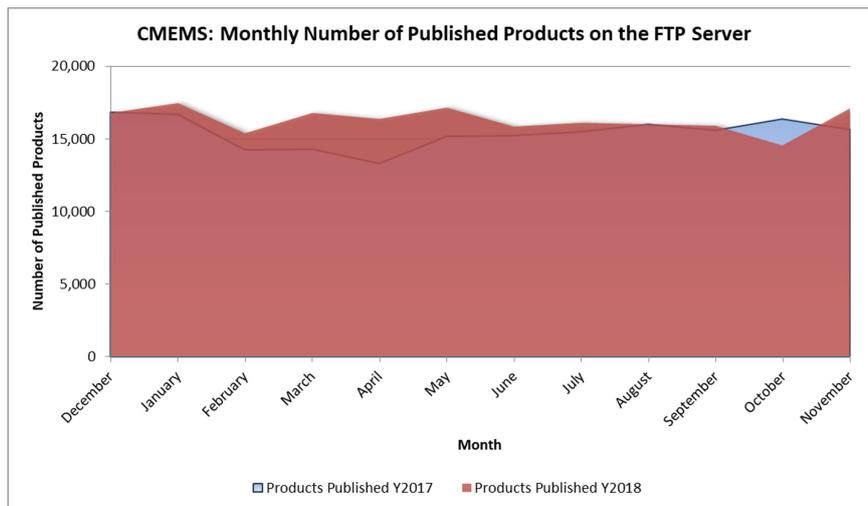


Figure 60: Monthly Product numbers published on CMEMS FTP server for Y2018 and Y2017

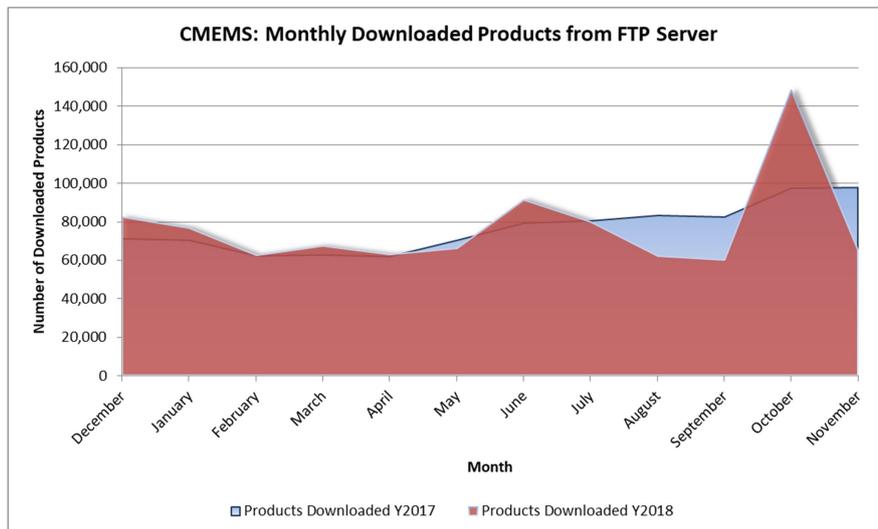


Figure 61: Monthly downloads from CMEMS FTP server for Y2018 and Y2017

During Y2018, a total of 195,385 Sentinel-1 products were published on the ftp server dedicated to the specific needs of CMEMS. This number represents a volume of 183 TiB and a 5.6% increase on the number

of products published during Y2017. This is less than the 24.1% increase observed between Y2017 and 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 923,000 products were downloaded, representing a volume of 586 TiB and a 0.6% increase on Y2017. This small percentage increase (compared with 40.5% from Y2017 to Y2016) is reflective of the lower percentage increase in published products, reflecting the stability of the Sentinel-1 observation scenario and generally of the mission operations.

The archive exploitation ratio (number of products published / number of products downloaded) for Y2018 was 1:4.7, almost identical to the 1:5.0 observed in Y2017.

Table 23 shows monthly trends for the number of products published and downloaded. In terms of published products the numbers have been relatively stable throughout the period, as for Y2017 (the average per month was 16,282 products; for Y2017 it was 15,415). Downloaded products displayed more variation however, with an average of 76,917 products per month, but with peaks in June (91,252 products) and in October (148,205 products) that latter proceeded by a drop off in August and September 2018. This may again be attributed to seasonal time-windows of interest to CMEMS, particularly in sea-ice monitoring.

	Y2017	Y2018	% Difference
<b>Average Number of Products Downloaded per Month</b>	76,428	76,917	0.64
<b>Total Number of Products Downloaded in Period</b>	917,134	923,000	
<b>Average Number of Products Published per Month</b>	15,415	16,282	5.62
<b>Total Number of Products Published in Period</b>	184,981	195,385	

Table 23: CMEMS products publication and download trends during Y2018 and Y2017

### 2.3.8.2 Copernicus Atmosphere Environment Monitoring Service (CAMS)

In order to feed the Copernicus Atmosphere Monitoring Service (CAMS) data assimilation chain with atmospheric component measurements from the Sentinel-5P TROPOMI with the best timelines access has been provided to the Sentinel-5P Payload Ground Segment internal dissemination point (ftp server).

During Y2018 a total of 8.68TiB of data was downloaded by the CAMS, corresponding to the relevant production of Sentinel-5P L2 data for Carbon Monoxide, Methane, Nitrogen Dioxide, Sulphur Dioxide, Ozone and Formaldehyde. The data are downloaded initially to support the

validation purposes as well as integration into the CAMS forecasting models.

### 2.3.9 Data Hub Relays

The Data flow of disseminated products from the ColHub to the Collaborative national Mirror sites is summarized in Figure 63. *Disseminated data* downloaded directly by ESA Nodes are then *exchanged* among Relays and *relayed* to National Mirrors.

The Data Hub Relays (DHR) network was initially set up late in 2016 with a team of 5 Relays, gradually raised to 7 by Y2018. In the first quarter of Y2018, 5 Relays consolidated their activity in the Network (Norway, operated by MET, Germany, operated by DLR, Great Britain, operated by AIRBUS and STFC and Austria, operated by ZAMG) and 1 new Relay, operated by CESNET, began its involvement in the

Network and became fully operational by March 2018. The French Relay suspended its activity at the end of February 2018. The contribution of all 7 Relays (even though in some cases only partially covering the reference period) have been included in the statistics. During the reporting period, the arrival of the Sentinel-3B mission and Sentinel 2A/B L2 products in operations significantly increased the volume of data fluxes, and a more consolidated proactive and participative DHR network for the retrieval and network monitoring activities has been set up, with the aim to reduce the load on ESA core centre

nodes and improve the capabilities of the Relays network.

Improvements to the DHuS software, based on the experiences and feedbacks by Relays, have been implemented accordingly and the DHR Network, constituted by all of 7 Relays, has demonstrated the importance of having alternative product sources in support of ESA source nodes for the dissemination of Sentinel products towards the Collaborative GS partners.

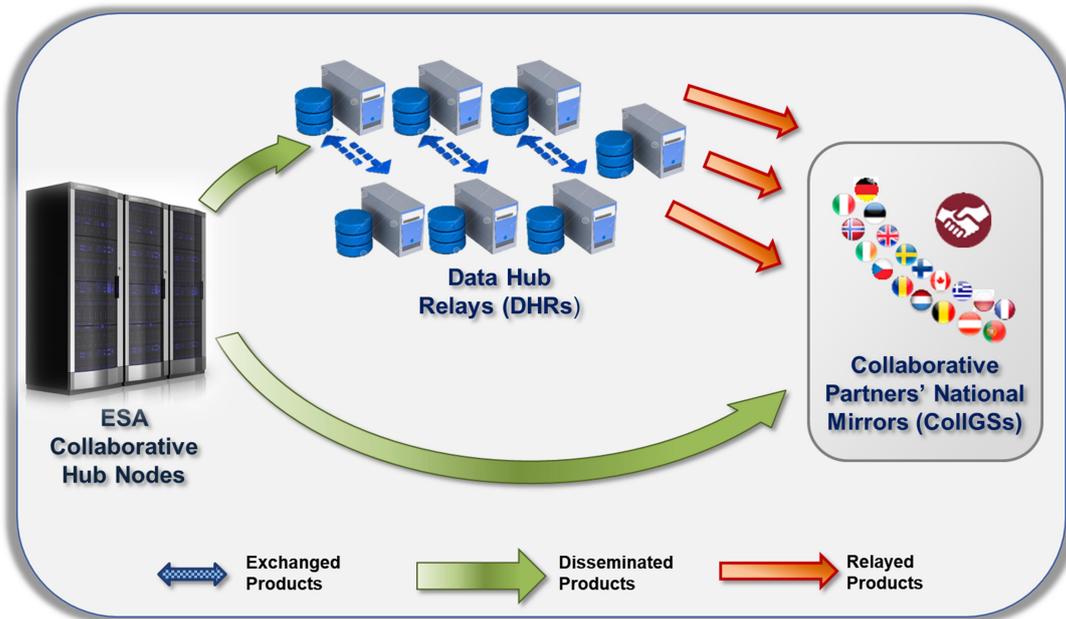


Figure 62: Schematic showing general data flow of products from the Collaborative Data Hub to the Collaborative National Mirrors, highlighting the terminology used

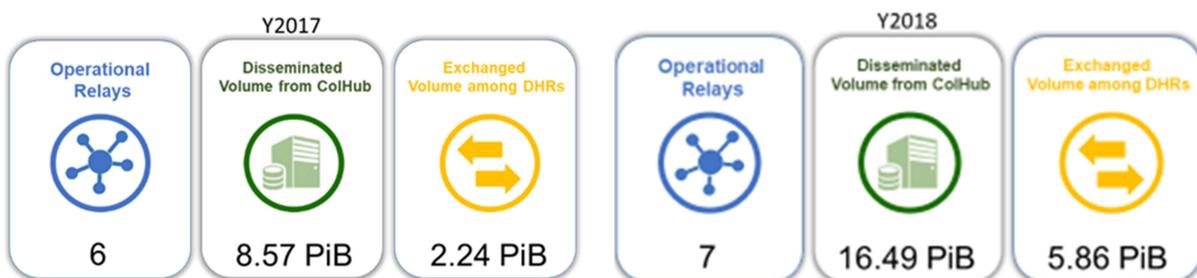


Figure 63: Overall Data Hub Relay statistics for Y2017 vs 2018

During Y2018, the statistics reported in Figure 64 above have been collected and a comparison with the statistics collected in Y2017 is shown. The overall disseminated volume from the ColHub toward the collaborative GS users and Data Hub Relays is 16.49 PiB for a total of 24,171,341 products disseminated.

In more detail in Y2018, the 34.58% (5.70 PiB) of the downloaded volume was disseminated directly to collaborative GS partners and the 65.41% (10.79 PiB) via the Data Hub Relays.

The products disseminated to a Data Hub Relay are in turn relayed to the Collaborative GS initiatives; the 6,706,566 products exchanged among DHRs, having a volume of 5.86 PiB, constitute 27.07% 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 initiatives are the final recipients of products disseminated and exchanged by DHRs, the total volumes depicted in the graph below shows an increase 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 1.43 PiB. In Y2018 (from December 2017 to November 2018) the volume increased by 75.73% from 1.26 PiB to 2.21 PiB.

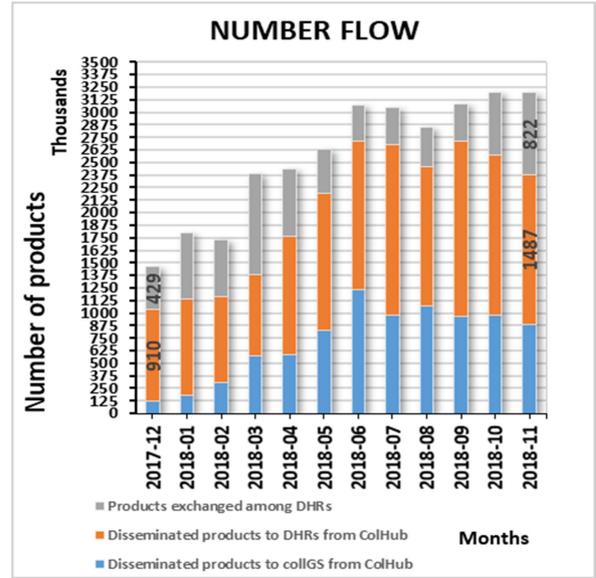
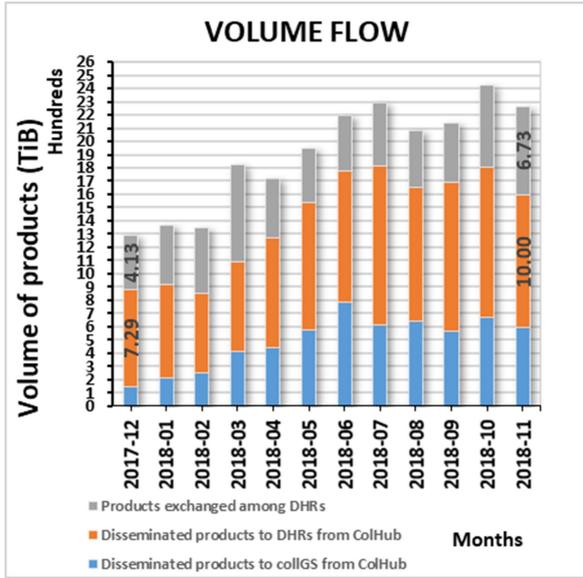
To better understand the improvements made during Y2018 it is worth highlighting that in Y2018 46.79% of the entire volume was disseminated to the DHR Network: 26.14% disseminated to CollGSs and a further 27.07% exchanged among DHRs. In terms of volume and number of products the situation is the following: the total volume flux is of 22.35 PiB with 30,877,907 products; 5.70 PiB with 8,621,680 products were disseminated to Collaborative GSs; disseminated to DHRs were 10.79 PiB with 15,549,661 products, and the exchanged products among DHRs were 5.86 PiB with 6,706,566 products.

This behaviour shows how the number of exchanged products increased month by month and during the years and demonstrates that an active participation of Relays in the dissemination activities can fulfil an important role as alternative product sources in

support to ESA source nodes within the ColHub. Furthermore, the DHR network has been involved in an extra dissemination activity for S2 repackaged products. One of the Relays (CESNET-CZ) was enabled as a specific hub where S2 repackaged products could be downloaded from, and assigned as the main node for the dissemination of those products towards other interested Relays and Collaborative GS and DIAS partners. This demonstrates the flexibility of the usefulness of DHR Network.

In terms of Network configuration, the collaboration between Relays is very good and active. After a first period of assessment of the network, all Relays, including the new ones, were found to guarantee a solid connection, reliability and publication timeliness. A solid example of collaboration in this period may be that between DLR and MET-NO (both of which have been engaged from the beginning of operations) acting as principal alternative product sources nodes: DLR for S2 mission and MET-NO for S1. Additionally, ZAMG acts as the main node for S3 and CESNET as the main node for S2 Repackaged dissemination, as well as being a secondary alternative source for S1.

The Figures below show the evolution of the DHR network data fluxes during Y2018 and from beginning of operations.



(a)

(b)

Figure 64: Data Hub Relay a) Monthly volumes and b) Monthly number of products

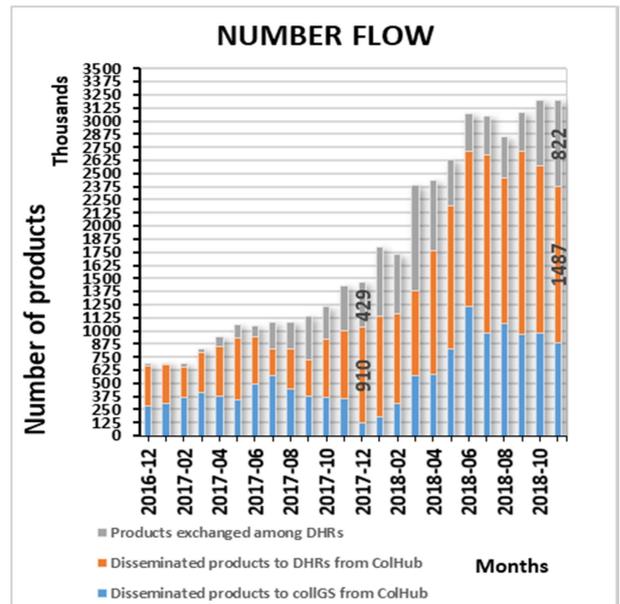
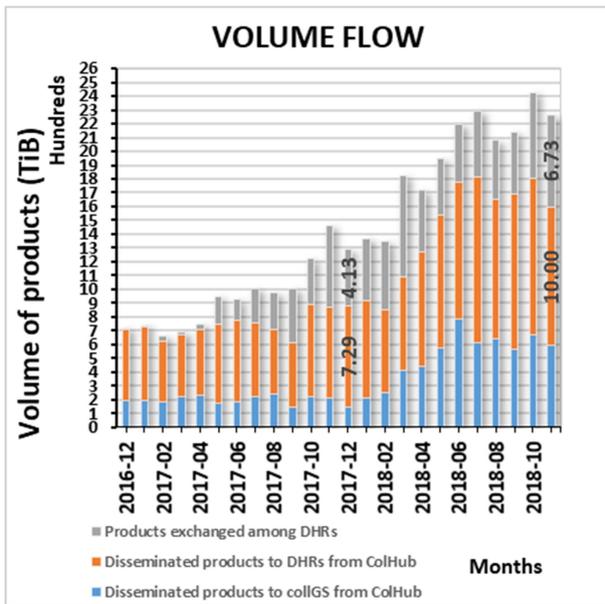


Figure 65: Data Hub Relay a) Monthly volumes from start of operations and b) Monthly number of products from starts of operation

# 3 User Activity

## 3.1 Active Users

For the purposes of this analysis, an 'active user' is defined as a user 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. For more information on 'partial content downloads' refer to section 2.3.7. Moreover, an 'active user' is defined strictly on the basis of downloads and does not include users who log into their accounts or perform searches via the GUI.

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 Figure 67. The variation in these figures reflects the different use constraints of the Hubs. For example, given that the ColHub and IntHub 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 only 96% of Collaborative users are classed as active: this is due to one partner, Estonia, still setting-up at the end of the period. They are due to commence downloads early in the next reporting period.

At the other end of the scale, the Copernicus Open 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 - 26% this period. However, in terms of absolute numbers, there has been an increase of 48% in active users compared to Y2017 (see Figure 68).

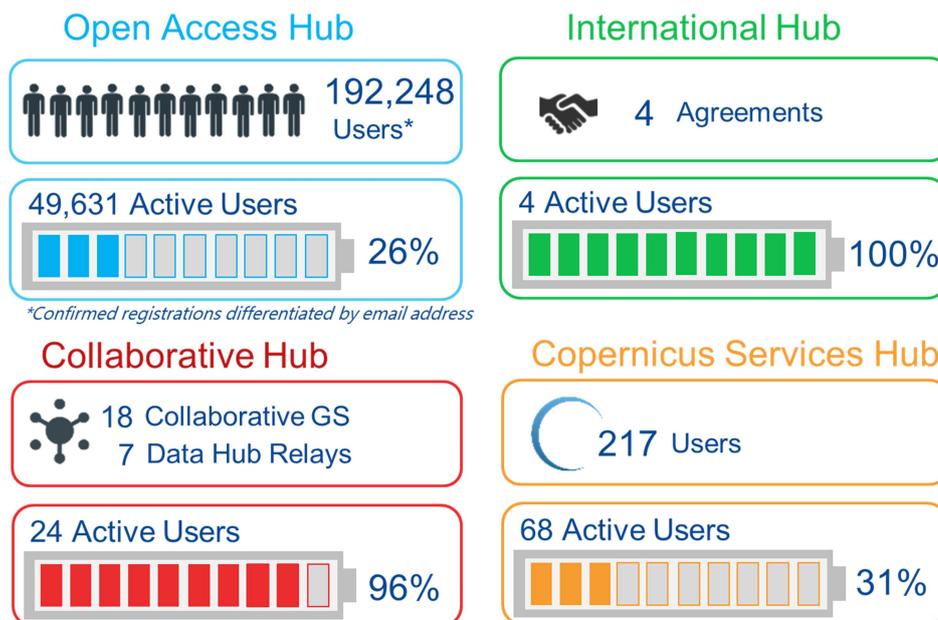


Figure 66: Registered and Active users per hub during Y2018

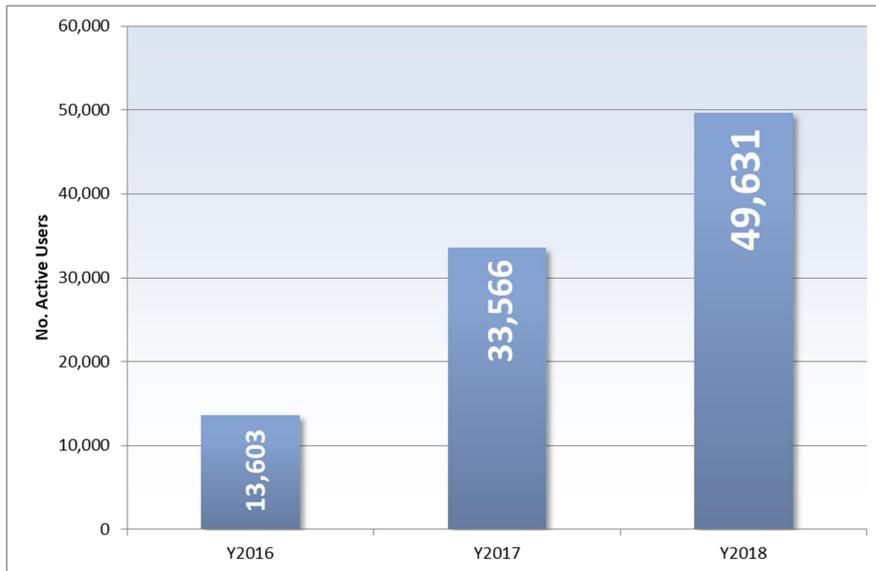


Figure 67: Growth in numbers of active users on the Open Access Hub between Y2016 and Y2018

### 3.2 User downloads profile

This section examines the distribution of user downloads across each of the Hubs and for all active

Sentinels during Y2018. Sentinel-5P is not yet included as it is currently only available on the dedicated Pre-Operations Hub which is open to all by using a common password (without individual user registration).

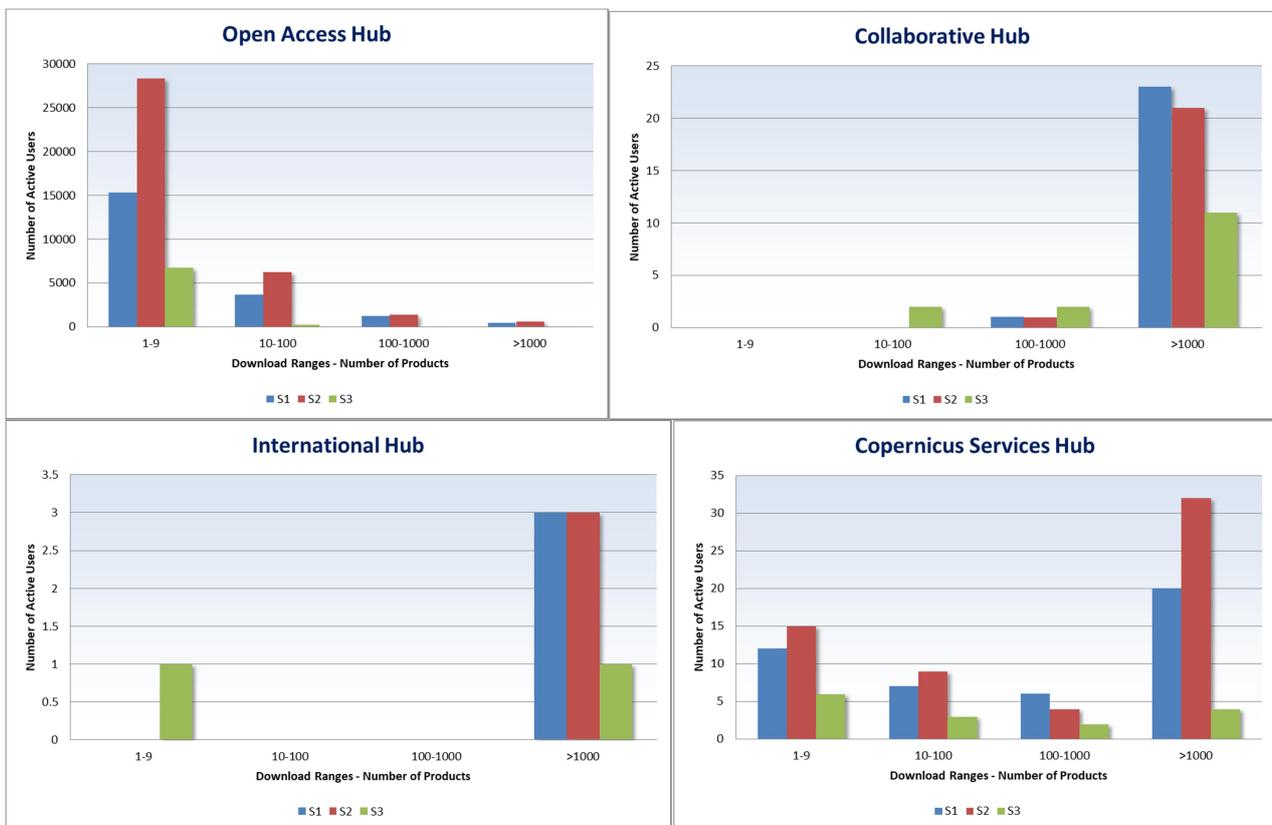


Figure 68: Y2018 Download Ranges for each Data Access System Hub

Figure 69 shows, for each Hub and each Sentinel, the download ranges observed amongst the active users for the Y2018 period. The trend remains similar to those observed in Y2017 and Y2016 and is generally as would be 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 a significant proportion of, the published products in order to make them available on their national sites.

As would also be expected, given the number of active users on the Open Hub, the highest number of users downloading in this mass download range was on the Open Hub, with as many as 454 users for Sentinel-1 and 611 users for Sentinel-2 (figures which were respectively 392 and 341 for Y2017). Nonetheless, by far the majority of users of the Open Hub are still downloading in the 1-9 products range: 15,295 users downloaded 1-9 Sentinel-1 products; 28,387 users downloaded 1-9 Sentinel-2 products; and 6,763 downloaded 1-9 Sentinel-3 products, up from just 917 during Y2017 when the operational service was starting up. Overall, it is also interesting to note that the numbers of active users downloading Sentinel-2 products in all categories has increased at a greater rate than those downloading Sentinel-1 products.

As in Y2017, the ServHub displayed the most variation among the ranges. It is suggested that this can be explained by the differing needs of each Copernicus Service: whereas some of the services, such as the security and emergency services, may only need a few very specific products related to precise locations and time windows, others such as the marine and land services may require the routine and continuous monitoring of large areas of interest. The numbers of ServHub users downloading in the range of 1-9 products and in the range of 100-1,000 products were slightly higher than for Y2017: 33 in the 1-9 range this year compared to 27 in Y2017; and 12 in the 100-1,000 range compared to 5 in Y2017. The two noticeable changes for this period were the number of ServHub users downloading between 10-100 products and over 1,000 products. Even though 10-100 had been the most populated range in Y2017 with 34 users, this year the number was reduced to 19 users. On the other hand, there was a significant rise from 20 ServHub users downloading more than 1,000 products in Y2017 to 56 users in Y2018, and there are now a greater proportion of ServHub users downloading Sentinel-1 and Sentinel-2 products in this mass download range than in any other range, 44% (of ServHub S-1 users) were mass downloading Sentinel-1 products and 53% were mass downloading Sentinel-2 products.

### 3.3 Open Access Hub Active Users focus

throughout Y2018 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). For comparison, the graph also shows the equivalent plots for Y2017.

#### 3.3.1 Monthly Active Users

The graph in Figure 70 shows the number of active users on the Open Hub on a monthly basis

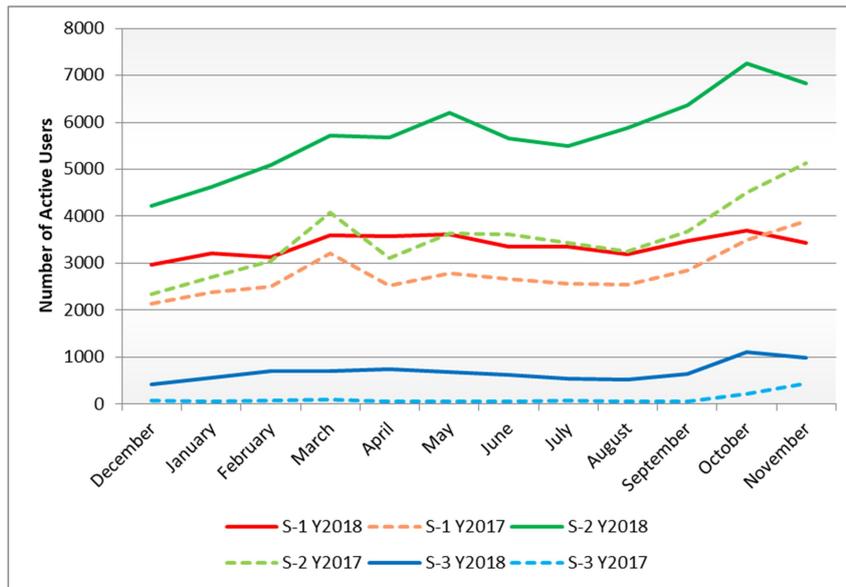


Figure 69: Active user trend per mission in Y2017 and Y2018

It can be observed that the number of active users was higher in Y2018 than in Y2017, for almost all months and for all Sentinels. The exception is November in Y2018 for Sentinel-1, which was slightly below the same month for Y2017 (3,439 vs 3,890 users). This could indicate that the number of active users for Sentinel-1 is stabilizing, and in fact the trend for the whole of Y2018 is relatively flat, remaining roughly between 3,000 and 3,500 active users per month and resulting in **an average of 3,382 Sentinel-1 active users per month during Y2018.**

Sentinel-2 remains the mission with by far the highest number of active users per month and it, by contrast, has seen significant growth during Y2018: during Y2017 the average monthly active users was 3,545, rising to 5,751 in Y2018.

While Sentinel-3 remains the mission with the lowest number of active users, it too has exhibited

noteworthy growth since Y2017 and is in fact the mission with the greatest percentage increase in active users: an average of 688 per month in Y2018 compared with just 111 at the end of Y2017, when the operational distribution of Sentinel-3 via the standard Open Hub sign-in portal was just getting going. The sharp increase seen in the first few months following the opening of the routine dissemination may have been due to increasing awareness and interest in the mission, as well as the staged transfer of products from the S3 PreOps Hub to the Open Hub, which started with the SRAL products being released in October 2017. In general, after the initial increase, the number of active users downloading Sentinel-3 products remained relatively stable from February-September 2018. It then shot up again at the end of September 2018, however, coinciding with the opening of the OLCI data flow on the Open Hub on 27 September 2018.

### 3.3.2 Active users per continent and country

Table 24 shows the number of active users on the Open Hub broken down by continent for Y2017 and

Y2018. It also shows the overall percentage contribution of each continent for both periods and the percentage increase between Y2017 and Y2018. The graph in Figure 71 highlights this growth in active users on all continents, also including Y2015 and Y2016 for overall comparison.

Continent	Y2017	Overall % Y2017	Y2018	Overall % Y2018	% Increase Y2017-Y2018
Europe	14,970	44.6	21,316	42.9	42
Asia	6,710	20.0	11,644	23.4	74
South America + Antarctica	5,776	17.2	7,699	15.5	33
North America	4,074	12.1	5,865	11.8	44
Africa	1,422	4.2	2,204	4.4	55
Oceania	639	1.9	945	1.9	48

Table 24: Open Access Hub active users for Y2018 and Y2017, per continent

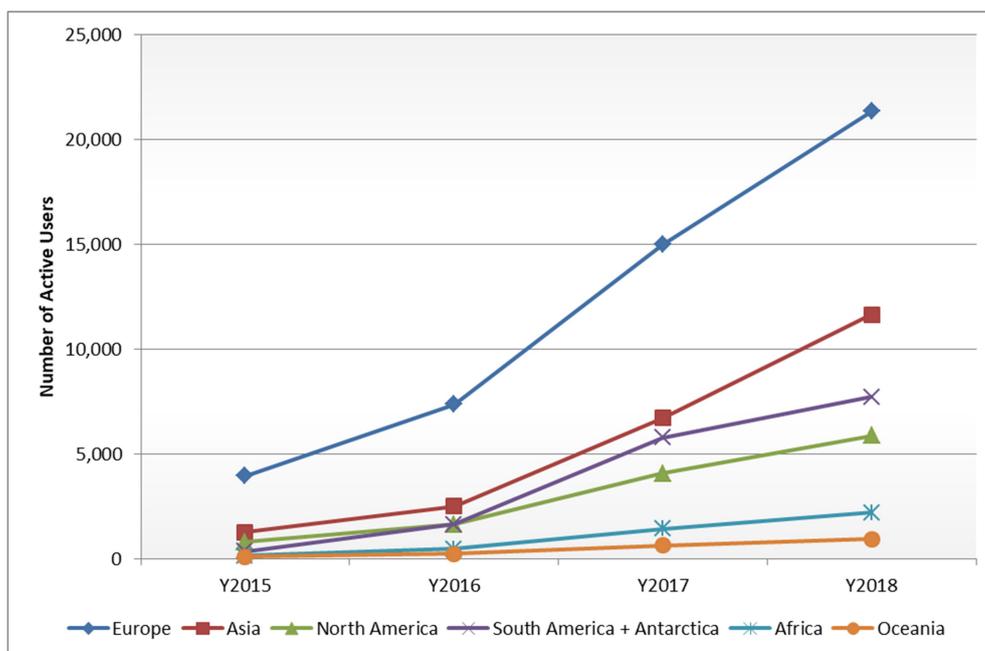


Figure 70: Open Access hub active users trend from Y2015-Y2018, per continent

All continents again experienced strong growth during Y2018. Asia exhibited the highest increase, at 74%, now with significantly more active users (11,644) than any continent except Europe. South America and Antarctica exhibited the lowest growth, but still showed a 33% rise on Y2017. Europe continues to dominate in terms of the overall percentage split, accounting for 42.9% share of the users, though this is slightly down on the 44.6% of Y2017. The greatest rise in share of users was again displayed by Asia, up to 23.4% from 20.0% in Y2017. These figures highlight the continued growth in awareness and use of Copernicus data and services

around the world. It should be noted that Europe has almost double the number of users of any other individual continent (the closest being Asia). Also, it should be stressed that Europe, North America and Oceania (Australia) 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 set of tables below provide a further breakdown of the Open Hub active users, this time on the basis of individual nation. The 'Top 10' active user

countries are provided for all three Sentinels, as well as on a global and European (specifically ESA and/or EU states) basis. The number of active users is provided as well as the percentage increase since Y2017 and the change in ranking of that country.

Sentinel-1 - Global			
Country	Active Users Y2018	% increase from Y2017	Change
China	1959	55	^1
Germany	1453	3	∇1
United States	1145	17	0
Italy	1068	28	^1
India	1054	63	^1
United Kingdom	986	4	∇2
France	847	43	0
Spain	711	30	0
Russian Federation	539	12	^2
Brazil	536	1	∇1

Table 25: Y2018 Top 10 Global Countries: Sentinel-1

Sentinel-1 - ESA/EU			
Country	Active Users Y2018	% increase from Y2017	Change
Germany	1453	3	0
Italy	1068	28	^1
United Kingdom	986	4	∇1
France	847	43	0
Spain	711	30	0
Poland	478	0	0
Netherlands	422	22	0
Greece	324	32	0
Norway	221	16	^2
Portugal	190	0	0

Table 28: Y2018 Top 10 ESA/EU Countries: Sentinel-1

Sentinel-2 - Global			
Country	Active Users Y2018	% increase from Y2017	Change
Germany	2597	38	0
China	2122	133	^5
United States	1892	55	∇1
Spain	1881	71	0
Italy	1682	44	∇2
Brazil	1598	105	^5
India	1344	95	^6
United Kingdom	1319	25	∇3
France	1291	60	^1
Mexico	1259	33	∇4

Table 26: Y2018 Top 10 Global Countries: Sentinel-2

Sentinel-2 - ESA/EU			
Country	Active Users Y2018	% increase from Y2017	Change
Germany	2597	38	0
Spain	1881	71	^1
Italy	1682	44	∇1
United Kingdom	1319	25	0
France	1291	60	0
Poland	770	48	0
Netherlands	655	47	0
Greece	586	65	^1
Portugal	485	33	∇1
Romania	394	35	0

Table 29: Y2018 Top 10 ESA/EU Countries: Sentinel-2

Sentinel-3 - Global			
Country	Active Users Y2018	% increase from Y2017	Change
United States	506	1024	^4
Germany	474	558	0
China	387	579	0
Italy	361	388	∇3
Spain	333	640	^1
United Kingdom	315	600	^1
India	305	771	^2
Brazil	295	794	^2
France	269	408	∇5
Russian Federation	193	383	∇2

Table 27: Y2018 Top 10 Global Countries: Sentinel-3

Sentinel-3 - ESA/EU			
Country	Active Users Y2018	% increase from Y2017	Change
Germany	474	558	^1
Italy	361	388	∇1
Spain	333	640	^1
United Kingdom	315	600	0
France	269	408	∇2
Poland	171	511	0
Netherlands	144	454	0
Greece	86	291	0
Portugal	83	388	0
Romania	69	430	0

Table 30: Y2018 Top 10 ESA/EU Countries: Sentinel-3

On a global scale, the overall dominant continent is clearly Europe. For each Sentinel mission, the countries Germany, Italy, United Kingdom, France and Spain all occur in the top 10 rankings, though in different orders. However, on an individual nation basis, the country with the largest rise in the rankings overall is China: now 1st for Sentinel-1 (up 1), 2nd for Sentinel-2 (up 5) and remaining 3rd for Sentinel-3. Although Germany is still the nation with the highest number of active users for Sentinel-2, China is now first for Sentinel-1 and the United States is first for Sentinel-3, doubling its number of active users from 506 to 1024 and moving up four positions. Germany, China and the United States all appear in the top 3 countries for each mission; other non-European nations which appear in all lists include India and Brazil, both of which showed significant increases, particularly for Sentinel-2 (up 6 and 5 places respectively).

It is interesting to note that total numbers of active users per country is not always reflected in the volume of data downloaded. For example, while China has the most active users for Sentinel-1, it is the 6th ranked nation in terms of downloads, behind France, United States, United Kingdom, Germany and Poland (see section 2.3.4). This indicates that many of the mass data downloaders tend to be European.

Within Europe the rankings are now quite stable, with little significant change from Y2017 and countries generally remaining in the same position or rising/falling one place. The country with the highest number of active users overall is Germany, which was the top European state in terms of active users of all the three missions.

All countries in the lists exhibited percentage increases (or no change) with respect to Y2017. Percentage increases for Sentinel-2 active users were

in all cases slightly larger than for Sentinel-1: a 47% average rise for S-2 vs 18% for S-1.

### 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.*

This section discusses the type of use which registered users of the Open Hub intend to make of the Copernicus data products, in terms of the usage type (Research, Education, Commercial, other) and application domain. It is stressed that this information is requested from users only when they first register for access to the Open Hub. The information may therefore be limited in several ways: there is no independent verification performed of the information provided; users are only able to select one application domain and one usage type from the choices available, meaning that users with multiple domains/usages are not reflected; no further information is obtained from users selecting 'Other' options; and users are not currently given the chance to update their selection, so any developments in the use to which they put the data are also not reflected. Even so, an analysis of the information is still considered helpful in that it provides a broad overview of the uses which users intend to make of the products at the point at which they register.

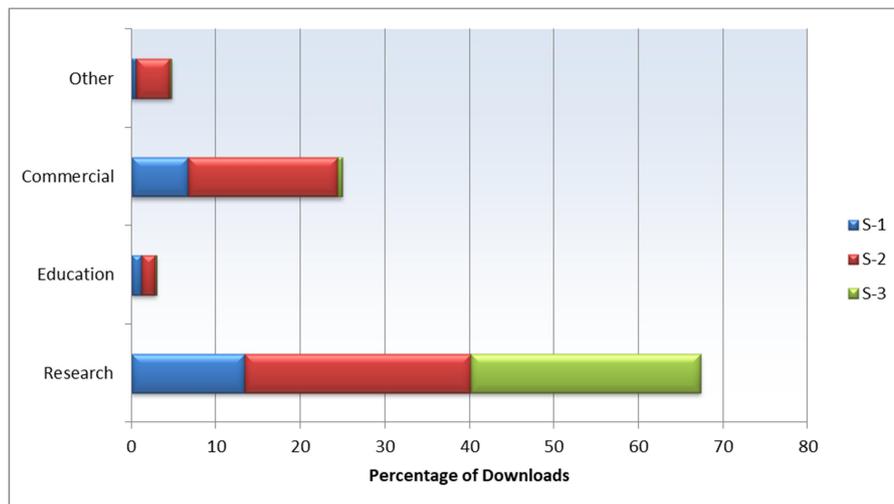
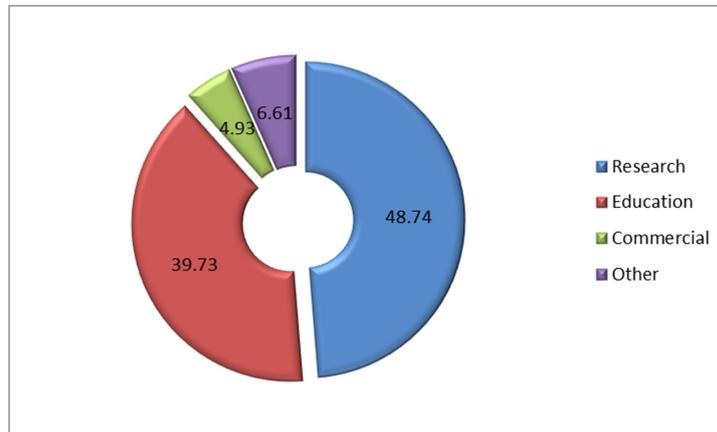


Figure 71: Percentage of Copernicus Open Access Hub registered users per declared usage type at the end of Y2018, and the percentage of downloads performed for Sentinels -1, -2 and -3 for each usage type during Y2018

Figure 72 summarizes the registered users and data downloads in terms of the intended onwards use for the data. The pie chart shows the overall percentage split of registered users between the four available choices for their intended usage type: Research, Education, Commercial and Other. The chart shows that by the end of Y2018, the vast majority of registered users selected 'Research' (49%) and 'Education' (40%) for their usage type, with only 5% selecting 'Commercial'. This is an almost identical split to those recorded in Y2017 and Y2016.

The bar graph analyses the usage type in terms of the downloads made from each mission per declared usage type. In terms of downloads, 'Research' is again the largest category, accounting for 67% of the downloads made, which is a quite significant rise on the 43% of Y2017. The largest shift from Y2017 is the reduction in users downloading in the category 'Other', down to only 6% from 21% in Y2017.

Interestingly, despite the considerably lower percentage of users who registered for access to the data for commercial purposes, 'Commercial' still accounts for a much larger proportion of the data downloads than 'Education', 34% against 4%. This indicates that 'commercial users' download far greater numbers of products per user than the 'education users', and potentially constitute a large proportion of the mass data downloaders, i.e. those downloading more than 1,000 per month. Given the low percentage of the data downloads made by the 'education users', it seems likely that the majority of these users download in the 1-9 products range.

It is also worth remarking that 'research users' downloaded more data products from Sentinel-3 than from any other mission, and that their downloads of Sentinel-3 products constitute 27% of all data downloaded in Y2018. Moreover, almost all Sentinel-3 downloads (97%) are made by 'research

users'. Each of the other three user groups downloaded more data products from Sentinel-2

than from either of the other missions.

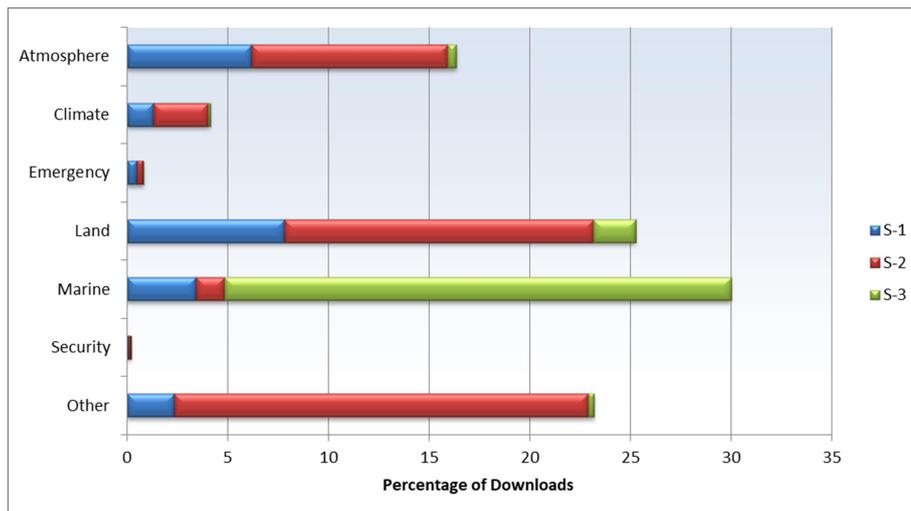
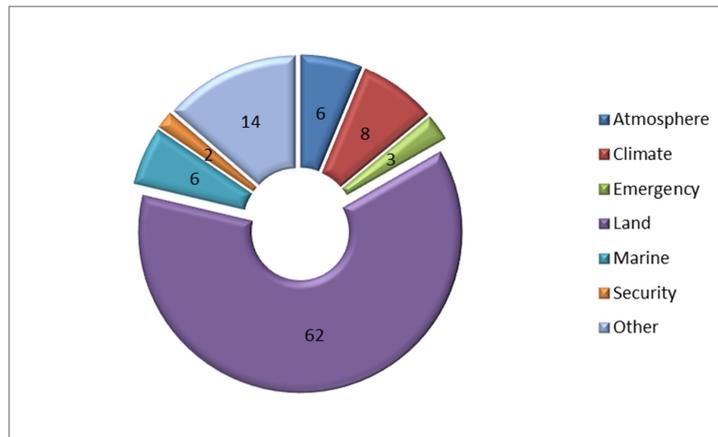


Figure 72: Percentage of Copernicus Open Access Hub users per declared thematic domain at the end of Y2018, and the percentage of downloads performed for Sentinels -1, -2 and -3 for each thematic domain during Y2018

Figure 73 summarizes the Y2018 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 62% of users. Next are 'Other' at 14%, 'Climate' with 8% and 'Atmosphere' and 'Marine', both with 6%. As for usage types, there have been very little change here since Y2017.

In terms thematic domains related to downloads, the big shift observed in the current period is the growth of the 'Marine' domain, now accounting for 30% of all downloads, up from just 5% in Y2017, and now the largest domain. As can be seen from the graph, this is accounted for by the introduction of Sentinel-3 into the download statistics, by far the majority of downloads for this mission being in the 'Marine' domain. Given that 'Marine' only accounts for 6% of

users, a significant number of large, systematic downloads appear to be in this domain.

'Land' accounts for 25% of downloads, making it the second largest category. As expected, S-2 makes up the majority of the 'Land' downloads, which account for 15% of all downloads. After 'Other', which accounts for 23% of downloads, the next largest category is 'Atmosphere' with 16%. It is noted that Sentinel-2 makes up a sizeable proportion of the 'Atmosphere' downloads. Given that 'Land' would be expected to be a more common choice than 'Atmosphere' for Sentinel-2, it is also likely that a proportion of users may have chosen 'Atmosphere' as the default first choice, rather than a value more accurately reflecting usage.

# 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 growing number of re-distributors. These include the National Mirror Sites (provided in the framework of the Collaborative Ground Segment), the sites provided by International Partners (provided in the framework of international agreements) and other Copernicus entrusted entities. Sentinel re-distributors which are known and currently operational are listed in Table 31 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
<b>Collaborative National Mirror Sites</b>	4.1	Austria	<a href="https://data.sentinel.zamg.ac.at">https://data.sentinel.zamg.ac.at</a>	
		Belgium	<a href="http://www.vito-eodata.be">www.vito-eodata.be</a> <a href="http://www.terrascope.be">www.terrascope.be</a>	
		Canada	<a href="ftp://ftp.neodf.nrcan.gc.ca">ftp://ftp.neodf.nrcan.gc.ca</a>	
		Finland	<a href="https://finhub.nsd.c.fmi.fi">https://finhub.nsd.c.fmi.fi</a>	
		France	<a href="https://peps.cnes.fr">https://peps.cnes.fr</a>	
		Germany	<a href="https://code-de.org/">https://code-de.org/</a>	
		Greece	<a href="https://sentinels.space.noa.gr">https://sentinels.space.noa.gr</a>	
		Italy	<a href="http://collaborative.mt.asi.it/">http://collaborative.mt.asi.it/</a>	
		Norway	<a href="https://colhub.met.no">https://colhub.met.no</a> <a href="https://satelitedata.no/">https://satelitedata.no/</a>	
		Portugal	<a href="https://ipsentinel.pt/">https://ipsentinel.pt/</a>	
		Sweden	N/A	Site closed in favour of DIAS on 30/09/18
		UK-1	<a href="http://www.ceda.ac.uk/">http://www.ceda.ac.uk/</a>	
UK-2	<a href="http://sedas.satapps.org/">http://sedas.satapps.org/</a> <a href="https://geobrowser.satapps.org/">https://geobrowser.satapps.org/</a>			
<b>International Partners' Sites</b>	4.2	Geoscience Australia (GA)	<a href="http://www.copernicus.gov.au/">http://www.copernicus.gov.au/</a> <a href="https://copernicus.nci.org.au/sara.client/#/home">https://copernicus.nci.org.au/sara.client/#/home</a> <a href="https://vertex.daac.asf.alaska.edu">https://vertex.daac.asf.alaska.edu</a>	Copernicus Australia Alaska Satellite Facility (Sentinel-1)
		NASA	<a href="https://oceancolor.gsfc.nasa.gov">https://oceancolor.gsfc.nasa.gov</a>	NASA OceanColor Web (Sentinel-3)
			<a href="https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/">https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/</a>	Level-1 and Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center (DAAC) (Sentinel-3)
			<a href="https://disc.gsfc.nasa.gov">https://disc.gsfc.nasa.gov</a>	GES DISC (Sentinel-5P)
		NOAA	<a href="https://coastwatch.noaa.gov">https://coastwatch.noaa.gov</a>	NOAA Coastwatch
		USGS	<a href="https://eros.usgs.gov/sentinel-2">https://eros.usgs.gov/sentinel-2</a>	USGS Earth Resources Observation and Science (EROS) Center
<b>Other Copernicus Entrusted Entities</b>	Not further detailed in this report	EUMETSAT	<a href="https://coda.eumetsat.int/">https://coda.eumetsat.int/</a>	Copernicus Online Data Access (CODA)

Table 31: 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 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 18 Collaborative Ground Segment agreements have been signed with ESA at the end of the Y2018 reporting period. Following signature and formal agreement, ESA provides a dedicated set of credentials to the national contact point for accessing the ColHub.

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 Y2018. The statistics presented in this section are based on the 14 partners who both had active national initiatives during Y2018 and who provided the requested information.

During Y2018, a total of over 4,685 TB of data was reported as distributed to end users via the national

mirrors. This a 140% increase from the volume distributed during Y2017.

Table 32 summarises the status of the 18 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, 14 of the 18 Collaborative Ground Segment partners had opened their national mirror sites. The partners who had not opened their sites by the end of Y2018 are provisionally scheduled to become operational during Y2019. Of the sites already opened in Y2017, an average increase in user growth and publication and download volumes has been reported for Y2018 as follows:

- *Average growth in registered users: 64%*
- *Average growth in publication volume: 132%*
- *Average growth in dissemination volume: 82%*

It is also noted that one of the Collaborative Ground Segment signatories – Sweden – closed their CollGS operations during Y2018, on 30/09/18, in favour of future access to Sentinel data products via the DIAS platforms.

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	Dec-16
9	Canada	Sep-15	yes	22-Sep-15
10	Portugal	Oct-15	yes	24-Feb-17
11	Austria	Feb-16	yes	27-May-16
12	Estonia	Sep-16	no	Foreseen: 01-Jan-19
13	Luxembourg	Apr-17	no	N/A
14	Belgium	Sep-17	yes	01-Sep-17
15	Ireland	Oct-17	yes	19-Feb-18
16	Poland	Nov-17	no	Foreseen: mid-2019
17	Romania	Dec-17	no	N/A
18	Czech Republic	Jan-18	yes	10-Mar-17

Table 32: Collaborative Ground Segment mirror sites summary

CollGS Partner	Overall Number of Registered Users since Start of Operations	% Increase since Y2017	% of Registered Users from the National Country	Number of Active Users in Y2018	% of Registered Users who were Active in Y2018
France	4,172	69%	60%	950	23%
Austria	1,437	24%	83%	96	7%
Germany	1,402	110%	82%	726	52%
UK-2	734	34%	58%	193	26%
Greece	610	23%	69%	68	11%
Norway	440	38%	-	80	18%
Portugal	436	21%	94%	71	16%
Finland	310	59%	77%	56	18%
UK-1	161	48%	73%	73	45%
Sweden	150	15%	-	5-10 per month	-
Czech Republic	126	307%	91%	57	45%
Belgium	114	49%	-	60	53%
Italy	38	31%	-	6	16%
Canada	18	64%	100%	8	44%
Ireland	-	-	-	170	N/A

Table 33: Summary of national mirror site users

Table 33 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 figures and 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 partners recorded rises in the number of registered users since the end of Y2017. Not including Sweden (whose national mirror closed in September 2018), these range from a 21% increase for Portugal to a massive 307% rise for the Czech Republic, though taking into account that the latter has only recently commenced operations. The percentage of

these registered users who were active during Y2018 (meaning they downloaded at least one product) was in general under 50%. In all cases where it was reported, users from the nation hosting the mirror made up the majority of the total registered users. In the case of Ireland, no registration is required to download; the number of active users was determined through unique IP addresses.

In line with the reporting agreement, the Collaborative Ground Segment partners categories their own users according to the same fields used by ESA. Figures 74 and 75 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).

Regarding the *usage category*, 'research' is again the most popular choice for all partners, with the

exception of Canada and UK-1, which in both cases is 'other'. 'Research' accounts for more than 50% of users in Finland, Greece, Italy and Portugal. Discounting 'other', 'education' is the next most popular choice, accounting for more than 30% of users in Austria and the Czech Republic. The least popular category appears to be 'commercial': the partners with the highest proportion of commercial users were Finland and UK-2, but these were only 14% and 21% respectively.

Regarding the *usage field*, 'land' is again the most popular, being the highest field for all partners excepting Canada, Germany and UK-1 and accounting for more than 50% of users for Austria, Belgium, Czech Republic, Finland, France and Portugal. 'Marine' and 'atmosphere' also account for high proportional of users from many partners, particularly the 88% of 'marine' users in Canada and the 23% of 'atmosphere' users in Greece.

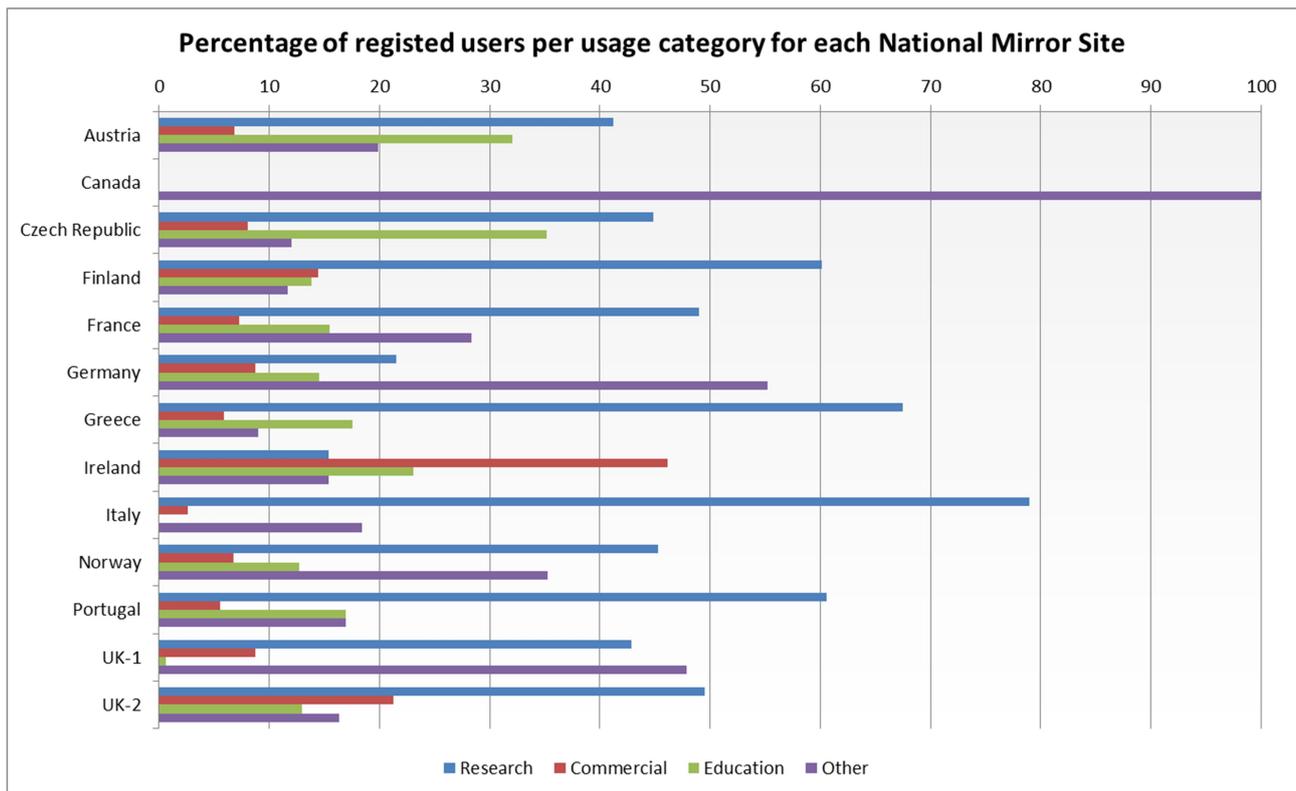


Figure 73: Percentage distribution of mirror site users by usage category

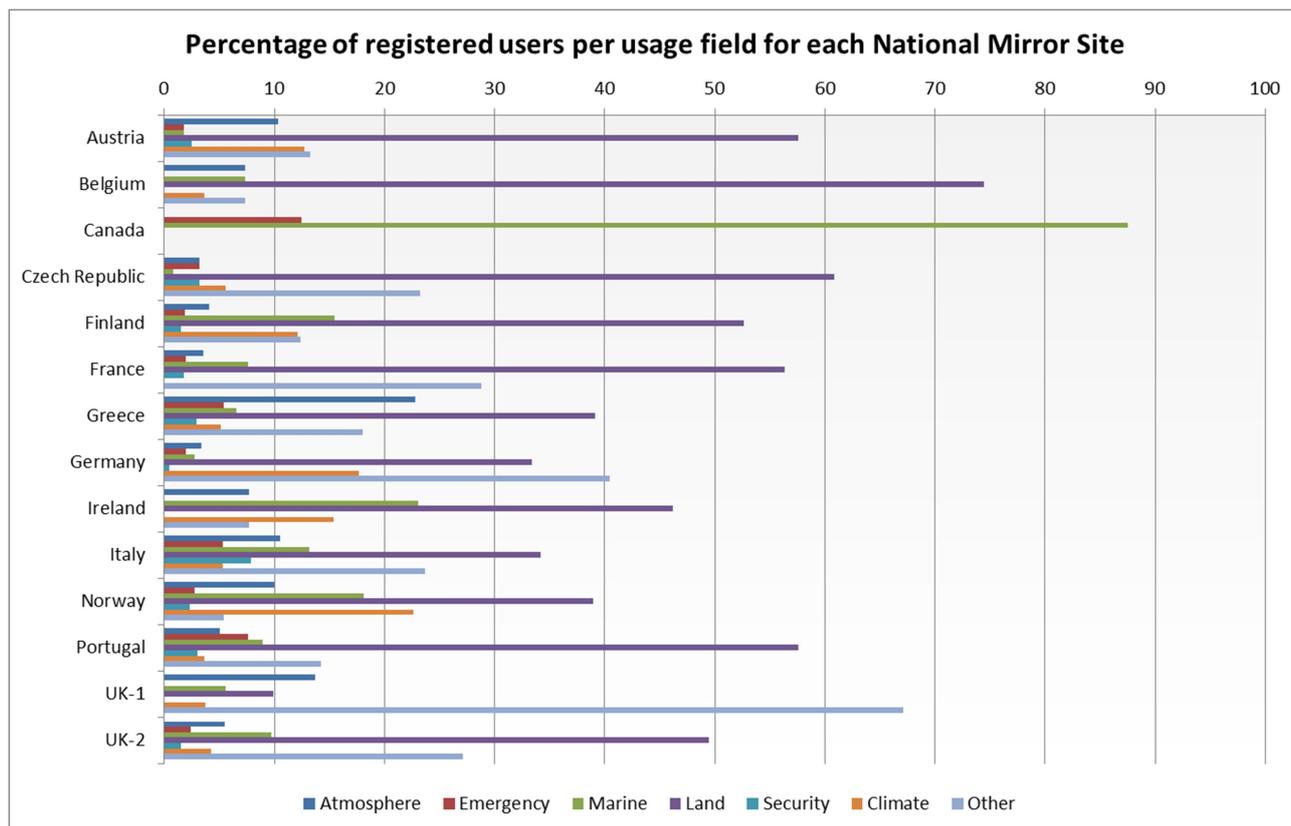


Figure 74: Percentage distribution of mirror site users by usage field

CollGS Partner	Y2018 Published Volume (TB)	% Increase from Y2017	Y2018 Downloaded Volume (TB)	% Increase from Y2017
Austria	3,082	70%	3,400	153%
Belgium	6,610	N/A	6.8	N/A
Canada	40	8%	39.6	28%
Czech Republic	67	N/A	36.3	N/A
Finland	180	33%	12	139%
France	4,559	50%	840	178%
Germany	3,510	81%	11.6	300%
Greece	361	19%	28.2	-3%
Ireland	216	N/A	-	-
Italy	-	-	0.8	N/A
Norway	3,236	76%	270	15%
Portugal	133	45%	1.0	60%
Sweden	95	-27%	14.1	28%
UK-1	2,490	50%	5.1	-15%
UK-2	2,490	1,047%	19.9	24%
<b>TOTAL</b>	<b>27,069</b>	<b>140%</b>	<b>4,685</b>	<b>136%</b>

Table 34: Overall publication and dissemination volumes on mirror sites

Table 34 above reports the total volume of Sentinel data both published on and downloaded from the mirror sites during Y2018, together with an indication of the increase with respect to Y2017. The reported

statistics in general show increases in both published and downloaded volumes for the majority of partners. They tend to be more modest than the huge increases observed in Y2017, which perhaps

indicates that the services are maturing. Exceptions are the -27% decrease in published volume from Sweden, due to the closure of the site in September 2018, and the 15% decrease in downloaded volume on UK-1. There is a large variation in both volumes published and downloaded between the mirror sites, reflecting the specific usages and target users of each. This year, Belgium has the highest overall published volume (6,610 TB), followed by France (4,559 TB), Germany (3,510 TB), Norway (3,236 TB) and Austria (3,082 TB). The highest overall downloaded volume occurred in Austria (3,400 TB), followed by France (840 TB). All mirror sites showed a low volume of downloads with respect to the volume published, with the exceptions of Austria, Canada and Czech Republic. Austria is the only site for which the volume of downloads is higher than that published. Download volumes have increased over the past year: an increase of 136% for the total downloaded volume from mirror sites, in line with the increase of 140% for the total published volume

Table 35 again reports the volumes of data published by and downloaded from the mirror sites during Y2018, now split by Sentinel mission where this information was provided. Of the countries with the

highest overall publication volumes, Austria, Norway, UK-1 and UK-2 publish a majority of Sentinel-1 data, while Belgium, Germany and France publish a majority of Sentinel-2. No partner publishes a majority of Sentinel-3 data, though Finland and Portugal publish more Sentinel-3 data than Sentinel-2. In terms of downloaded volumes, Sentinel-1 was the most popular mission for Austria, Canada, Czech Republic, Finland, France, Norway, Portugal, UK-1 and UK-2, while Sentinel-2 has the majority of downloads from Belgium and Germany.

Figure 75 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, Austria and Greece. Notable exceptions are Belgium, for which almost all data downloaded is for Sentinel-2, and 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	Y2018 Published Volumes (TB)			Y2018 Downloaded Volumes (TB)		
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-1	Sentinel-2	Sentinel-3
Austria	1,772.5	1,082.3	227.3	1,987.0	1,156.0	257.0
Belgium	2,402.0	4,208.0	0.0	0.2	6.6	0.0
Canada	40.0	0.0	0.0	39.6	0.0	0.0
Czech Republic	32.5	24.3	9.7	22.4	12.8	1.1
Finland	96.6	41.6	42.3	10.5	1.4	0.02
France	1,814.0	2,414.0	331.0	537.0	299.0	4.0
Germany	1,474.9	1,792.0	242.7	8.0	3.5	0.1
Greece	242.0	104.4	14.8	22.8	4.7	0.7
Ireland	80.7	80.7	54.3	-	-	-
Italy	-	-	-	0.6	0.1	0
Norway	2,248.0	831.7	156.0	165.0	104.5	0.4
Portugal	107.6	1.3	23.8	0.9	0.03	0.02
UK-1	1,563.3	734.4	178.4	2.5	0.2	2.36
UK-2	1,463.5	1,026.5	0.0	18.2	1.7	0.0
<b>TOTAL</b>	<b>13,337.6</b>	<b>12,341.2</b>	<b>1,280.3</b>	<b>2,814.7</b>	<b>1,590.6</b>	<b>265.7</b>

Table 35: Publication and dissemination volumes per Sentinel on mirror sites

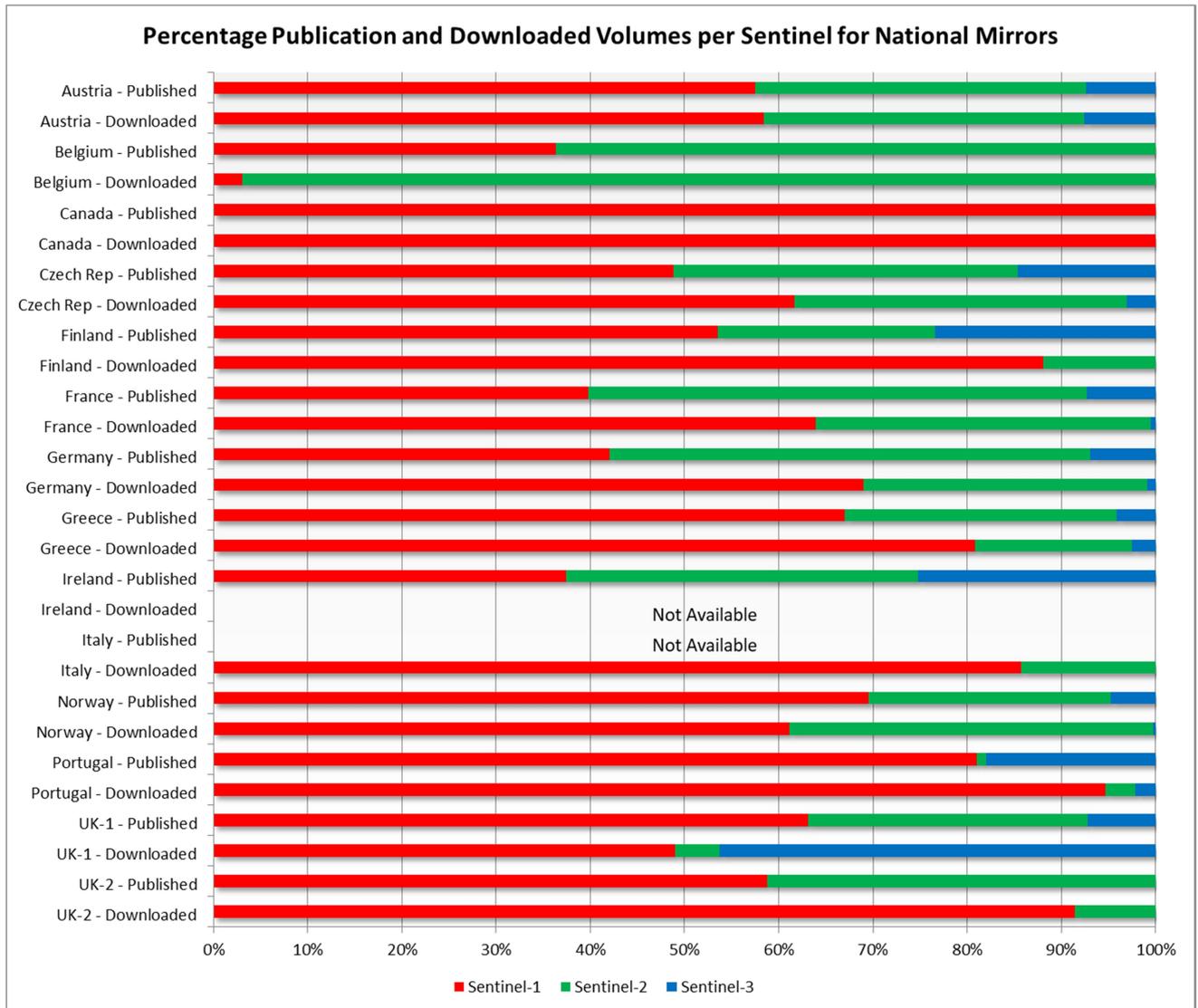


Figure 75: Percentage publication and dissemination volumes per Sentinel on mirror sites

## 4.2 International Technical Agreements

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 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 Y2018, via replies to the annual questionnaire released by ESA.

**Geoscience Australia (GA)** has the primary objective of 'providing free and open access to data from Europe's Sentinel satellite missions for Australasia, South-East Asia and the South Pacific region'. To this end, the regional Copernicus data hub – Copernicus Australia – was opened on 26 June 2015. 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.

During Y2018, the Sentinel Australasia Regional Access (SARA) portal was launched officially in May 2018, making discoverability and access to Sentinel imagery more user-friendly. This was reflected in the increase of data downloads via SARA versus THREDDS server which was the primary distribution mechanism before SARA was introduced. The consortium of Copernicus Australasia Regional Data Hub expanded in 2018 by welcoming the New Zealand Centre for Space Science Technology as a partner, as they saw the value in being involved as a user, contributor and influencer in the Hub's future

direction. Additionally, the Copernicus Australasia Regional Data Hub is currently in the process of developing training material and plans to run Copernicus Australasia workshops in its region in the next half year.

**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 data from the Sentinel-5P mission (retrieved from the PreOps Hub) began to be published on the NASA Sentinel Gateway (NGS).

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. NOAA collection of Sentinel-2 MSI is for a limited region. Sentinel-3 marine data has also been made available from May 2016, though this is received from EUMETSAT's Multicast Terrestrial rather than from ESA's IntHub.

**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 36 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 37 summarizes published and downloaded volumes per partner during Y2018, where available. The percentage change with respect to Y2017 is provided, showing an impressive increase over the year (although some statistics have not been available for Y2018 due to the US govt. shutdown).

Table 38 presents the per Sentinel published and download volumes during Y2018 for each International partner.

NB: for USGS, a total number of 730,879 tile downloads were reported during Y2018, from which a volume of approximately 375 TB has been estimated. Also for USGS, user categories are published on the basis of the proportion of downloads in each category, rather than on registered users.

International Partner	Operation start date	Number of active users in Y2018	% increase in users since Y2017	Principal user categories
GA	26-Jun-15	4,841 (unique IPs)	594%	N/A
NASA	12-Dec-15	8,750	56%	Foreign (89%) US Education (7%) US Gov (2%) US Commercial (1%)
NOAA	May-2016	758	2300%	NOAA National Centres for Coastal Ocean Science US Gov US Navy CoastWatch
USGS	-	178,388	224%	Academic Institutions (33%) Private Business (24%) General Public (19%) US Federal Gov (10%)

Table 36: International Partner general characteristics and statistics for Y2018

International Partner	Total Published Volume in Y2018 (TB)	% Change in Published Volume from Y2017	Total Downloaded Volume in Y2018 (TB)	% Change in Downloaded Volume from Y2017
GA	876	+26%	3,202	+15,520%
NASA	3,033	-4%	4,605	+194%
NOAA	473	+426%	24.4*	-
USGS	-	-	375	+150%

Table 37: International Partner publication and download statistics for Y2018

\* for NOAA, only ftp downloads are included in this figure (they do not include not https usage)

International Partner	Y2018 Published Volumes (TB)				Y2018 Downloaded Volumes (TB)			
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
GA	224	200	452	N/A	-	-	-	N/A
NASA	2,793.8	N/A	68.2	71.7	4,582.7	N/A	8.9	13.3
NOAA	83	40	350	N/A	-	-	-	N/A
USGS	N/A	-	N/A	N/A	N/A	375.0	N/A	N/A

Table 38: International Partner published and download volumes, per Sentinel mission

As reported by the European Commission at [https://ec.europa.eu/growth/content/eu-signs-copernicus-arrangements-four-countries\\_en](https://ec.europa.eu/growth/content/eu-signs-copernicus-arrangements-four-countries_en), new agreements are being set up with further

International Partners, and so it will be highly probable that new partners will be provided access to the IntHub in the next year.

# 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.

## 5.1 Service Availability

Availability, it is defined as the percentage of a given time period during 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 39 below presents the overall availabilities experienced throughout Y2018 for the four Copernicus data access Hubs. For comparison, it also sets out the corresponding values recorded in Y2017, Y2016 and Y2015 where available. For the Open 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 ColHub, the redundancy provided by the second and third nodes (in operation from 27 July 2017 and 13 March 2018 respectively) is taken into account: no downtime is recorded unless all three nodes are simultaneously down (which in fact did not happen during the period). The third node was made available via the NOAA/GRNET service in order to reduce the loading on the main infrastructure, to facilitate access to the DIAS partners.

Table 40 provides an additional breakdown of Y2018 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 (%)			
	Y2018	Y2017	Y2016	Y2015
<b>Open Access Hub</b>	98.48	98.59	95.11	96.62
<b>Collaborative Hub</b>	100	98.04	98.19	96.09
<b>International Hub</b>	99.90	98.89	99.59	N/A
<b>Copernicus Services Hub</b>	98.50	98.60	99.35	N/A

Table 39: Overall availability of each hub during reporting years Y2015 – Y2018

Month	Availability (%)			
	Open Access Hub	Collaborative Hub	International Hub	Copernicus Services Hub
2017-12	99.57	100	99.93	99.75
2018-01	98.68	100	100	99.29
2018-02	100	100	99.97	100
2018-03	96.57	100	100	96.8
2018-04	94.3	100	99.93	92.35
2018-05	100	100	99.96	100
2018-06	96.39	100	100	97.35
2018-07	99.78	100	100	99.79
2018-08	99.83	100	100	99.72
2018-09	99.31	100	100	99.43
2018-10	99.84	100	99.01	99.93
2018-11	97.21	100	100	97.32
<b>Y2018</b>	<b>98.48</b>	<b>100.00</b>	<b>99.90</b>	<b>98.50</b>

Table 40: Monthly availabilities per hub (green shading indicates >95% availability; yellow shading indicates 90-95% availability)

The availability of the Data Access Services during Y2018 was in general very high for all Hubs, with the lowest availability of any Hub being (a still very impressive) 98.48% on the Open Hub. The highest overall availability – and greatest improvement from Y2017 – was the 100% recorded for the ColHub, up from 98.04% during Y2017. This is a result of the ColHub now being operated over three nodes, as mentioned above, and downtime only being recorded in the case when all three are simultaneously down. This never happened during Y2018, and in fact has not occurred since the opening of the second node in July 2017.

Both the Open Hub and the ServHub had Y2018 overall availabilities very similar to those of Y2017: 98.48% for the Open Hub (98.59% in Y2017) and 98.50% for the ServHub (98.60% in Y2017). The slightly lower overall availabilities of these two Hubs was largely the result of abnormally low availability April 2018, as shown clearly in Table 40: 94.30% for the Open Hub and 92.35 for the ServHub. This was principally the result of a severe power outage in the Interxion Frankfurt Data Centre on 10 April 2018, which caused a major Backbone issue affecting many internet services across Germany and neighbouring areas. As a result, most traffic to Copernicus Data

Centres was disturbed and publication of fresh data for most Sentinels was impacted as well as downtime for the ServHub.

The IntHub also exhibited an improvement, up to 99.90% from 98.89% in Y2017: seven months during Y2018 recorded a 100%, while the remaining five were all greater than 99%. The IntHub is hosted on the NOA/GRNET infrastructure, and although the availability was not impacted by the major interruption in April, no new data were published during that outage since they are fed from the Frankfurt Centre.

Despite the improvement in overall availabilities, a number of infrastructure incidents have affected performances of the main online disk archive during the period. On several occasions intensive processing automatically initiated by the disk operating system to balance data on the many disk nodes caused a decrease in overall performance impacting both the ability to publish the new dataflow (causing delays for product publication) and also for the data download. A series of activities were launched by the infrastructure provider to remedy these incidents and balance priorities of the disk maintenance activities. Nevertheless, the stability of performance on the

online archive has been problematic in different periods of the year.

Structured and scheduled maintenance activities were performed routinely, and account for the majority of the service downtimes and temporary performance degradations. Users were notified in advance of the short periods in which each Hub would not be available. Major scheduled activities throughout Y2018 occurred as follows:

- A significant downtime occurred on 5 and 6 March 2018 on the Open Hub, ColHub (node 1) and ServHub; while originally there was a planned maintenance to upgrade storage infrastructure between 07:30-19:00 UTC on 5 March, infrastructure incidents slowed down the upgrade process leading to an extended downtime until 09:00 UCT on 6 March.
- A major planned infrastructure maintenance activity took place from 14:00 UTC on 28 March to 11:00 UTC on 29 March. This planned to complete the infrastructure maintenance remaining from the 5/6 March maintenance activities. The Open Hub (including the API Hub and the Sentinel-3A Pre Ops Hub), the ColHub (node 1) and the ServHub were necessarily unavailable.
- Major infrastructure maintenance activities took place on 10/11 April 2018 and 18/19 June 2018 to integrate new storage elements. Temporary access points were activated in the secondary centres, however, during these periods delays to the publication of new products were necessary.
- Performances were affected on 23 May 2018 due to background storage maintenance activities, on 29 May 2018 due to a network misconfiguration, and on 8 June 2018 as a result of the security patching. Corrective measures and root cause analysis were routinely performed for each issue.
- A series of scheduled maintenances were performed on 30 May 2018, 6 June 2018 and 7 June 2018 for security upgrades, in each case between 07:00 and 16:30 UTC. On 30

May 2018, these resulted in publication delays of Sentinel-1 and Sentinel-3 products on several hubs; on 6 June 2018, it caused an unavailability of the Open Hub and the ColHub node 1, and on 7 June 2018, the unavailability of the ServHub and the Sentinel-3A Pre-operations Data Hub.

- A scheduled maintenance activity on the Open Hub took place for over 24 hours, from 27 August 2017 13:00 UTC until 28 August 15:00 UTC in order to prepare for the activation of the LTA interfaces. During this period upgrades took place on the DHuS software version and databases, affecting the timeliness of data delivery but permitting a download service for the majority of the time. Users were provided with a temporary access hub providing access to the previous two weeks' Sentinel data without registration.
- Routine infrastructure maintenance activities also took place on 5 September from 07:00-16:00 UTC, implying the delay of Sentinels-1, -2 and -3 products, and on until 6 September from 07:00-10:00 UTC, with the delay of Sentinel-3 products.
- Scheduled maintenance again took place on 10 September from 06:00-16:30 UTC, affecting the Open Hub and ColHub, and on 19 September from 06:00-16:30 UTC, affecting the Open Hub and Sentinel-3 Pre-operations Hub.
- A service maintenance took place on the Sentinel-3 Pre-operations Hub from 25 September 14:00 UTC – 26 September 09:30 UTC, during which period the service was unavailable.
- Maintenance activity on the Sentinel-5P Pre-Operations Data Hub and the IntHub took place on 8th October between 07:00 – 10:00 UTC.
- A maintenance activity on the core infrastructure hosting the Data Hub services took place from 5th November 2017 13:00

UTC to 6th November 11:00 UTC. It involved the replacement of switches interconnecting the servers to the rolling archive storage and affected the Open Hub and the ServHub.

- Data Hub software was updated to a new version on 20th November between 08:30-16:00 UTC. The Open Hub experienced short downtimes (up to 1 hour) at the beginning and end of the period.
- Infrastructure security maintenance affecting the Open Hub, IntHub, ServHub and ColHub took place on both 28th and 29th November, between 07:00 and 16:00 UTC

Several unexpected anomalies were experienced during Y2018. Apart from the incident which occurred on 10 April 2018, mentioned above, the most significant such anomalies during Y2018 can be summarised as follows:

- The Open Hub also suffered a series of minor intermittent service downtimes the night of 23 January, and some degraded network performance on 26 January.
- A short unplanned downtime of about 1.5 hours also occurred on the Open Hub on 21 March related to infrastructure issues.
- The ColHub (node 2) experienced a downtime on 25 January due to an infrastructure network failure during the night.
- A blocking infrastructure incident occurred on 24 April 2018, caused by a fault on the server-storage switches failover mechanism on the core infrastructure. This led to a

downtime on all the Hubs hosted on this infrastructure, which lasted from 09:30-14:15 UTC, although access from the complimentary sites for the CollGS, international partners and DIAS partners continued uninterrupted but with delayed publication of fresh data.

- The Open Hub was also affected by a temporary service downtime on 2 June 2018, 00:00-03:18 UTC, during which time the hub was unavailable.
- A major infrastructure upgrade took place between 18 June 2018 12:00 UTC and 19 June 2018 10:00 UTC. During this period the Open Hub, ServHub and node 1 of the ColHub were unavailable.
- On 31 July, a firmware update was performed on some of the network elements the Frankfurt datacentre, causing some unexpected unavailability for Pick-up Point users.
- A power outage at the data centre hosting the Sentinel-5P Pre-Operations Data Hub and IntHub on 16 October from 03:00-12:30 UTC, leading to downtimes.

Despite the downtimes listed above, it is reiterated that overall availability on all Hubs was excellent during Y2018 and the overall volumes of data disseminated in the period have exceeded by far all previous periods.

A graphical representation providing a view of the availability for each Hub is available from the Sentinel Data Dashboard to summarise the ongoing available to the European Commission and Copernicus delegates.

Service Availability

Copernicus Open Access Hub availability from 01-09-2018 to 30-11-2018

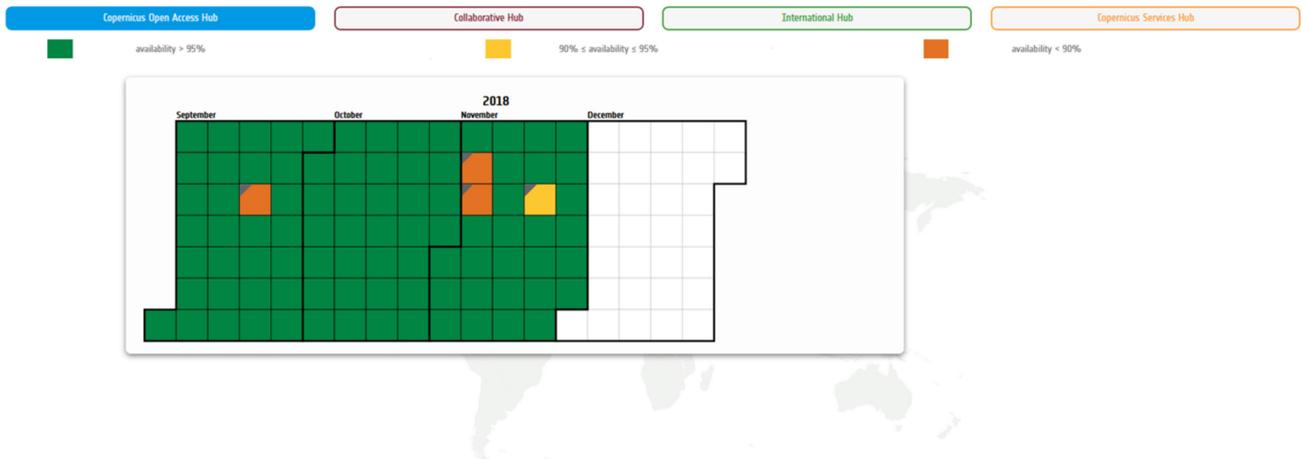


Figure 76: Example of Sentinel Data Dashboard Availability Representation (in this case for the Open Access Hub)

## 5.2 Network Analysis

At the beginning of Y2018, the overall network demand was within the margin for the 20Gb/s overall capacity available from the TSYS centre, with the existing link to the GÉANT network continuing to greatly benefit the data dissemination system. The peaks recorded in the latter part of Y2017 had been successfully reduced by the re-location of the IntHub service from TSYS to a complementary centre hosted by GRNET in Greece, and the opening of an alternative ColHub service. However, loads continued to rise and by March 2018 the peak load on the GÉANT line was approaching saturation point (i.e. 85-95% capacity) of the available 20 Gb/s capacity. The need for a network upgrade was clear, given the ever increasing number of downloads being requested from the system, and with anticipated growth due the arrival of data from Sentinel-5P and Sentinel-3B as well as a further jump in usage foreseen for later when four additional copies of products would need to be brought to the network of DIAS access points

During the second quarter of 2018, therefore, two major network infrastructure upgrades were

completed. Firstly, in April 2018, new firewalls were added to the infrastructure with the integration completed by mid-May 2018, effectively upgrading the outward capacity of the infrastructure to 40Gbps. Secondly, on 2 May 2018 the Frankfurt GÉANT Link was upgraded from 10 Gbps to 100 Gbps to also allow a routing to GÉANT at the full capacity afforded by the firewalls. Since then, the academic and commercial links have run through the same switch interface, meaning that it is no longer possible to show individually the relative proportion GÉANT vs. commercial internet traffic.

Thanks to the added network capacity, the peak values for Y2018 increased from 18 Gbps (before upgrade) to about 30 Gbps (after upgrade). Similar increases have been registered for the average load, which has gone from about 13 Gbps to around 22 Gbps.

The graph in Figure 78 shows the daily average load on the GÉANT link for the period from December 1st 2017 to April 30th 2018 (i.e. during the part of Y2018 before the network upgrade on 2nd May 2018).

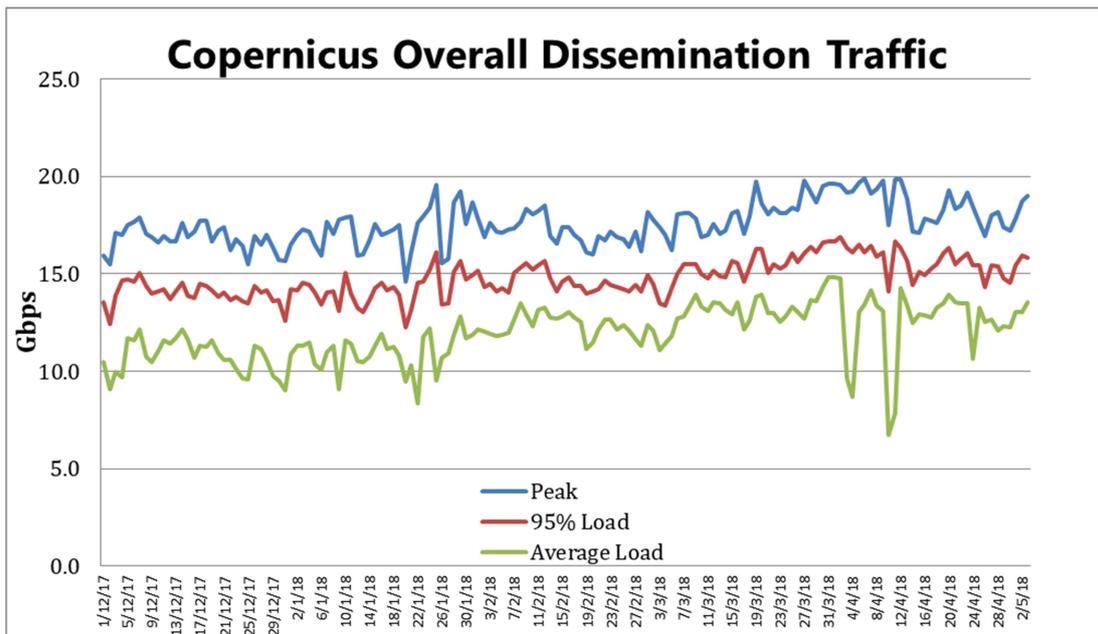


Figure 77: GÉANT link traffic from 01/12/17 – 30/04/18

The graph in Figure 79 shows the daily average combined traffic of both Commercial (DTAG) and Academic (GÉANT) for the period from 2nd May

2018 to 30th November 2018 (i.e. during the part of Y2018 following the network upgrade on 2nd May 2018).

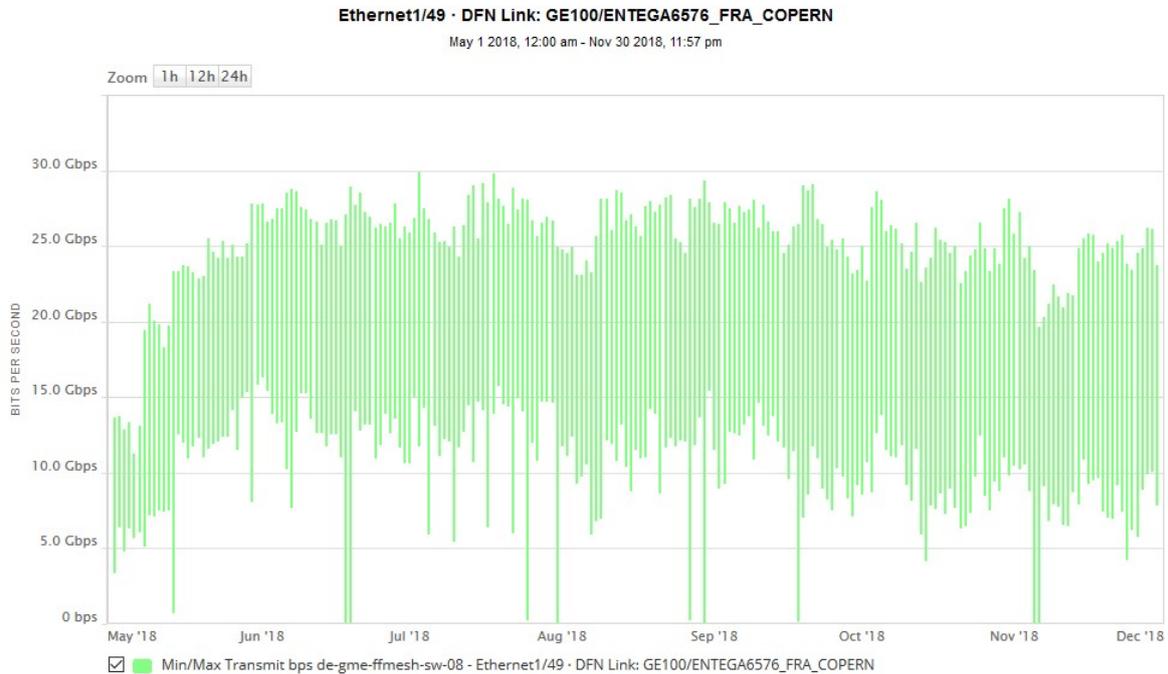


Figure 78: Combined traffic of both Commercial (DTAG) and Academic (GÉANT) from 02/05/18 – 30/11/18 (with the green bars showing the MAX and MIN transmit rate reached on each particular day)

Figure 79 shows quite well the peak of downloads in June and July as the DIAS partners performed much

of the bulk download to establish their initial data collections.

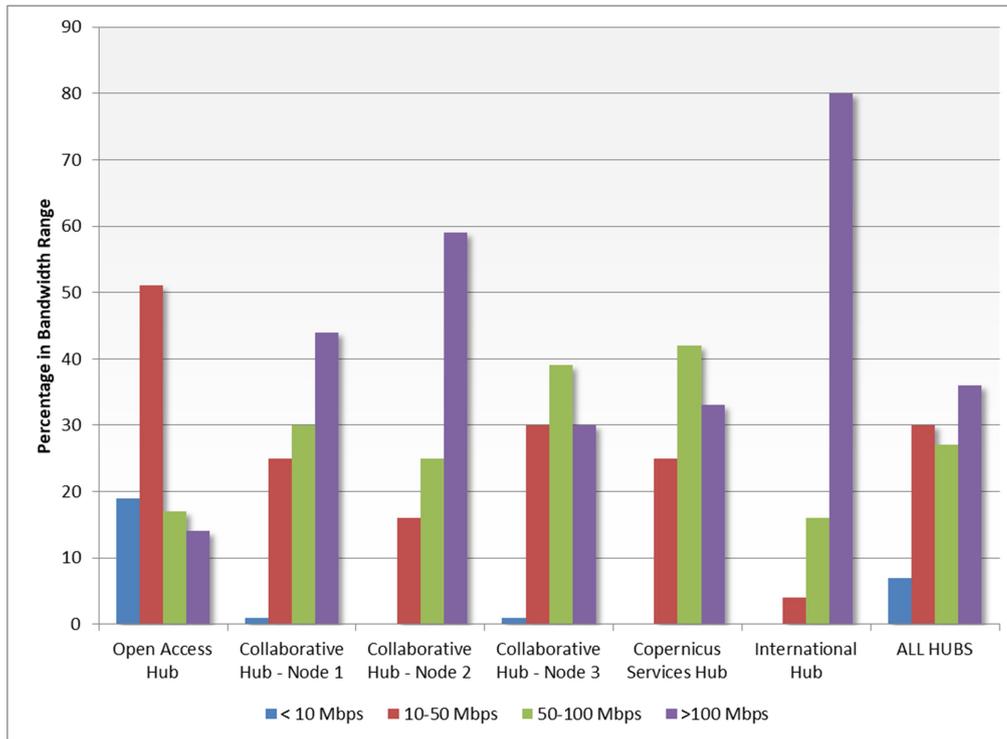


Figure 79: Effective bandwidth range per Hub for all completed downloads during Y2018

Figure 80 shows the effective bandwidth range per Hub, taking into account all completed downloads during Y2018, as well as the overall statistic taking into account all Hubs. For three of the Hub instances – ColHub nodes 1 and 2 and the IntHub – the highest bandwidth range was that for downloads >100 Mbps, indicating that users of these Hubs are generally achieving a very good download bandwidth. The figure is particularly impressive for the ColHub node 2 and the IntHub, for which more than half of all downloads occurred within the >100 Mbps range: 59% and 80% of downloads respectively. For the ColHub node 3 and the ServHub the peak bandwidth range was 50-100 Mbps; another way of looking at this is that the percentage of downloads taking place at >50 Mbps was 69% of the ColHub node 3 and 75% for the ServHub. Concerning the Open Hub, 51% of downloads occurred in the 10-50 Mbps range, a result that is not surprising when the very wide user base and global reach of the Hub is considered, with varying availability of local bandwidth. Overall, the statistic which takes all Hubs into account is encouraging: 36% of all downloads were made at >100 Mbps; the equivalent figure for Y2017 was 23%.

### 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 a data hub. The timeliness depends on the end-to-end design of the mission, from the point in the orbit in which the image was sensed to the geographical position of the receiving antenna, and then to the priority given to each product in the processing and publication chain.

Products are categorized as either Near Real Time (NRT) or Non-Time Critical (NTC). NRT products are intended to be 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. In this section, 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 anomalies. It is recalled that the overall timeliness is affected both by the production in the PDGS as well as any maintenance activity on the Data Hubs that can impact the time to publication.

#### Open Access Hub

Figure 81 shows the average publication timeliness for Sentinel-1 NTC and Sentinel-2 NTC products on the Open Hub during Y2018 and the change with respect to the Y2017 values.

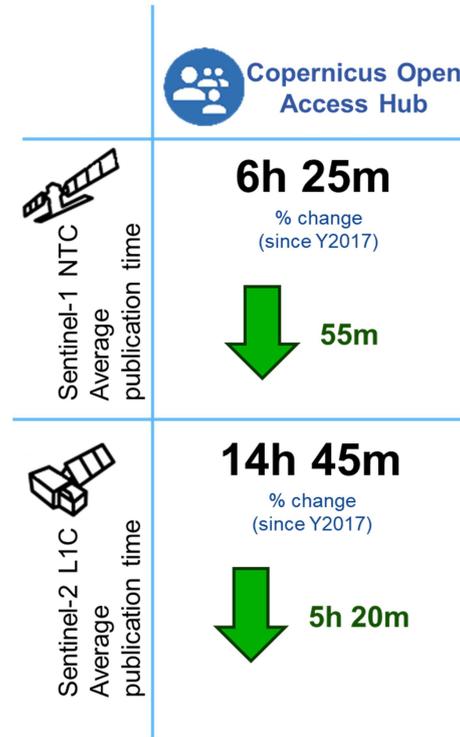


Figure 80: Average publication timeliness on the Open Access Hub during Y2018 for Sentinel-1 NTC and Sentinel-2 NTC products, and comparison with Y2017

Sensing-publication timelinesses for Y2018 have shown a marked improvement from those recorded during Y2017. For the Open Hub, and for both Sentinel-1 and -2 NTC products, the average timelinesses experienced were well below the expected 24 hours: timeliness for Sentinel-1 NTC products was on average 6h 25m; Sentinel-2 NTC products were on average 14h 45m. The greatest improvement was observed for Sentinel-2 products on the ColHub, down 16h 15m from Y2017, though it should be noted that the Y2017 average was brought down by a 103 hour average during the month of December 2016.

Figure 82 shows the monthly average publication timeliness on Open Hub for Sentinel-1 NTC and Sentinel-2 NTC products during Y2018 (S-1 NRT products are not available on the Open Hub and S-2 has no NRT products on any Hub). The dotted lines show the monthly timeliness during Y2017 for comparison. 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

reprocessing or the result of anomalies, and are discussed below.

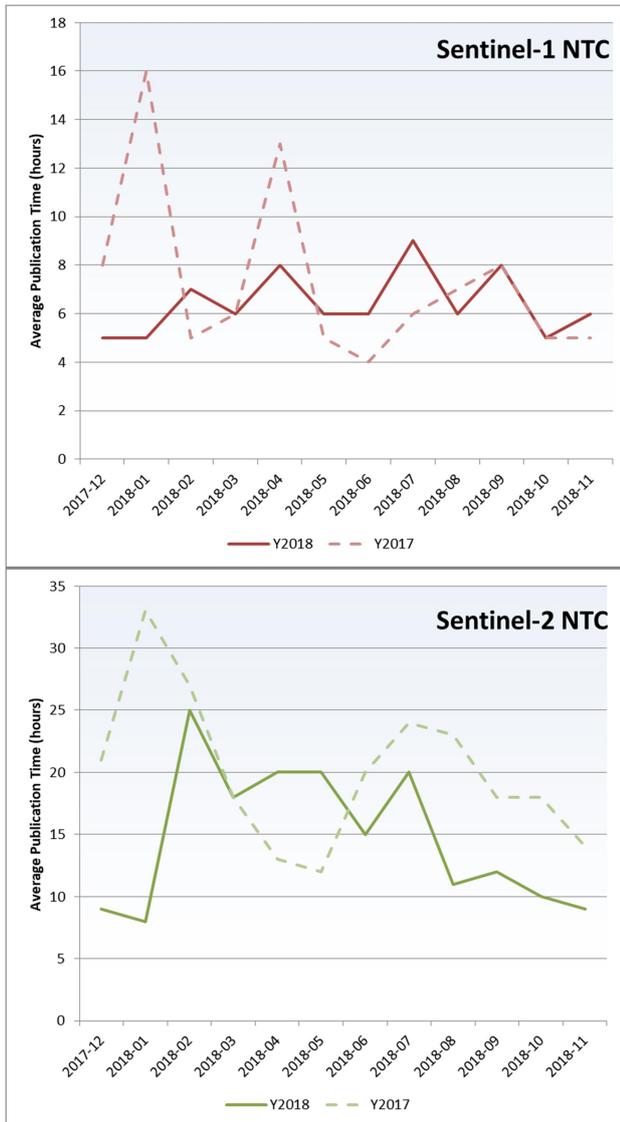


Figure 81: Monthly Average Publication Timeliness on the Open Access Hub for Sentinel-1 and Sentinel-2 NTC products during Y2018, with Y2017 for comparison

For Sentinel-1 it can be seen that the publication timeliness was more stable than during Y2017 and that the 24 hour timeliness constraint was respected, on average, during each month. The worst case was the 9 hour average during July 2018. The best timeliness recorded was a 5 hour average, which occurred during November 2017 and January and October 2018. For Sentinel-2 we can observe a greater fluctuation. While the worst case recorded was an improvement on the 33 hours recorded during Y2017, it was still 25 hours (February 2018). This was caused by a temporary publication delay on Sentinel-

2 products on the Data Hubs linked to ongoing maintenance on the DHuS infrastructures. The delays lasted from 5 February 2018 – 16 February 2018. All other months during the period had averages better than 24 hours, with a best case of 8 hours during January 2018.

Figure 79 shows the publication timeliness of Sentinel-3 products on the Open Hub. As NRT products are published on the Open Hub for Sentinel-3, the graph shows the average timeliness each month for each of SRAL, OLCI and SLSTR products.

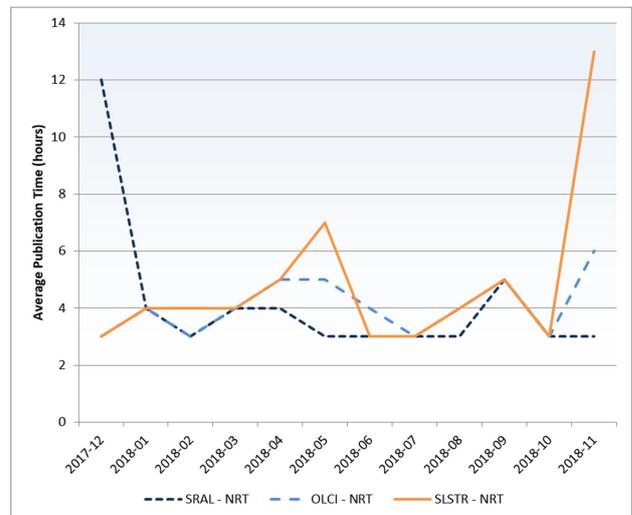


Figure 82: Monthly Average Publication Timeliness on the Open Access Hub for Sentinel-3 SRAL, OLCI and SLSTR NRT products during Y2018

The target 3-hour NRT timeliness was often achieved: for SRAL during February, May, June, July, August, October and November 2018; for OLCI during December 2017 and February, July and October 2018; and for SLSTR during December 2017 and June, July and October 2018). However, a number of months were all slightly higher than the target, driving the overall average during Y2018 to 4.2 hours for SRAL, 4.1 hours for OLCI and 4.8 hours for SLSTR. The largest anomalies and causes were the following:

- SRAL 12 hour average during December 2017: Due to a Sentinel-3A ground segment anomaly, SRAL products were missing or delayed on 13 December 2017.
- SLSTR 7 hour average during May 2018: Due to a network issue at the Svalbard Collaborative Ground Segment site, no

Sentinel-3A NRT products were disseminated to the Hubs for a period on 27 May 2018.

- *SLSTR 13 hour average during November 2018*: Due to a major issue at the Sentinel-3A PDGS on 4 November 2018 leading to missing NRT data, and a temporary publication delay of Sentinel-3A SLSTR NRT products on 26 November 2018.

### Collaborative Hub

Figure 84 shows the average publication timeliness for Sentinel-1 NTC and Sentinel-2 NTC products on the ColHub during Y2018 and the change with respect to the Y2017 values. It should be noted that, as the ColHub is composed of three nodes, the overall yearly average uses the average of the best performing node over any particular month.

As with the Open Hub, sensing-publication timelinesses for Y2018 have shown an improvement from those recorded during Y2017. The greatest improvement was observed for Sentinel-2 products on the ColHub, down 16h 15m from Y2017, though it should be noted that the Y2017 average was brought down by a 103 hour average during the month of December 2016.

Figure 85 shows, respectively, the average monthly timelinesses during Y2018 for Sentinel-1 (NRT and NTC), Sentinel-2, and Sentinel-3 SRAL (NRT and STC) on the ColHub. The statistics use the best performing of the three nodes per month.

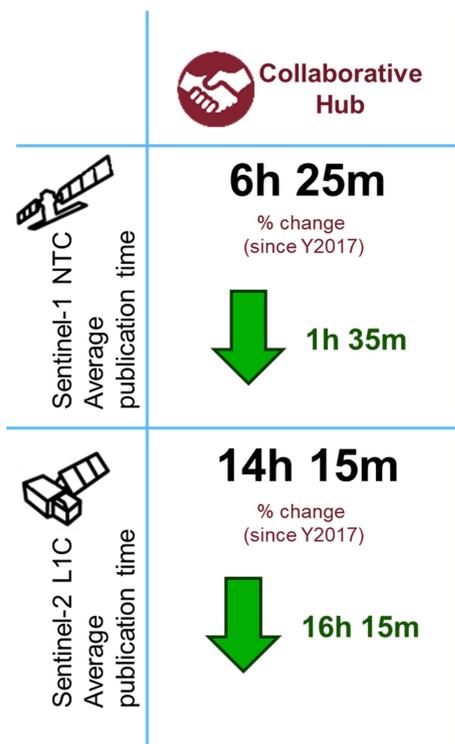


Figure 83: Average publication timeliness on the Collaborative Hub during Y2018 for Sentinel-1 NTC and Sentinel-2 NTC products, and comparison

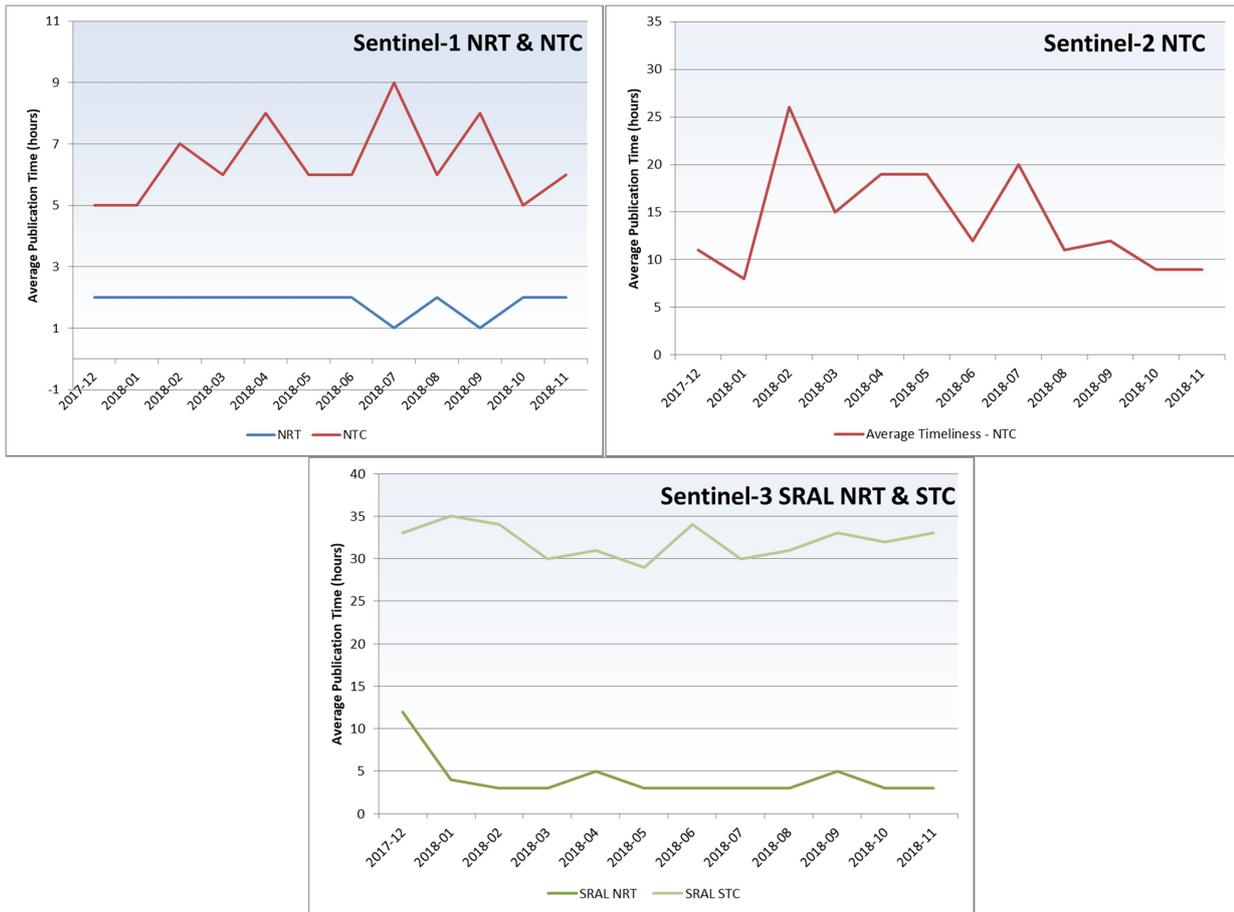


Figure 84: Monthly Average Publication Timeliness on the Collaborative Hub for Sentinel-1 (NRT & NTC), Sentinel-2 (NTC) and Sentinel-3 (NRT & STC) products during Y2018

For Sentinel-1 NRT timeliness on the ColHub, the <3 hour target was achieved, on average, throughout Y2018: the majority of months recorded a 2 hour sensing-publication average, with a 1 hour average being recorded for July and September. <24 hours for NTC products was also achieved for each month, with most months in the 5-8 hours range. The Sentinel-2 timeliness is on average significantly above that for Sentinel-1, probably due to the greater number of products needing to be processed and published, but the average timeliness was in general still less than 24 hours, with most months in the 10-20 hour range. The exception is for February 2018, where a spike of 26 hours is observed. This was caused by a ground segment contingency resulting in the temporary publication delay of Sentinel-2 products on all Data Hubs between 6-16 February.

not quite met during January (4 hours), April (5 hours), September (5 hours) and particularly December 2017 (12 hours). The December timeliness was due to Sentinel-3A ground segment anomalies on 12 and 13 December, leading to the delay of NRT production. For STC production the monthly averages were quite stable, ranging between 29 and 35 hours, with an overall average of 32.1 hours.

Looking at the publication timeliness for Sentinel-3 SRAL, the average times are quite consistent during Y2018. 8 months of the period recorded an average for NRT products of <3 hours; the 3 hour target was

## 5.4 Hub Software Improvement

During 2018, the DHuS software has been subject to a deep architectural review leading to the re-engineering and evolution of a wide number of DHuS functions.

The DHuS maintenance team focused mainly on three high level topics: enhancement of the software performance, support for a new set of EO products and improvements of the data flow.

To provide optimized and stable performances within the DHuS SW, the management of the data-store has been reviewed. More specifically, the DHuS has been enhanced to support a new kind of Relational Database i.e. PostgreSQL, and to allow the possibility of deploying the software in cluster mode to act as one (Scalability 2.0). The DHuS database schema has been analyzed and optimized to improve performances of query response time and to reduce its size on disk.

The product inspection function supported by OData has been enhanced too, in particular for product stored in an OpenStack Swift storage and for netCDF based products (e.g. Sentinel-3, Sentinel-5p). In fact thanks to the introduction of a dedicated cache for netCFD files, the inspection is much faster.

The set of EO products supported by the Hubs has been increased to allow the management of new mission products. The DHuS is now able to manage Sentinel-5p products support (L1B, L2, Auxiliary files), GNSS POD RINEX Auxiliary files support and products from projects as DAME and CMEMS.

New data flow scenarios are supported by the Hub, as the DHuS-Sentinel-1 PDGS LTA interface and the Remote DHuS Datastore function. The LTA interface is currently on-line on the Open Hub, ServHub, DIAS Hub and ColHub node 1, and allows the retrieval of products offline in the DHuS from the Sentinel-1 PDGS. The Remote DHuS Datastore functions allow to configure a remote DHuS instance as a DataStore for downloads and nodes browsing.

The data flow functions supported by Hub have been re-designed and optimized, in particular the Synchronization robustness has been improved, the Eviction has been enhanced to also allow deletion of physical products, leaving the catalogue untouched (designed for the DHuS - LTA interface scenario) and to update product paths (designed for Remote DHuS Datastore scenario).

The DHuS graphical User Interface has been enriched with new features for the Map management. Moreover, the search capability now supports the Shape files and new filters in the advanced search panel and the use session management is more robust.

## 5.5 Open Source DHuS Framework

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.

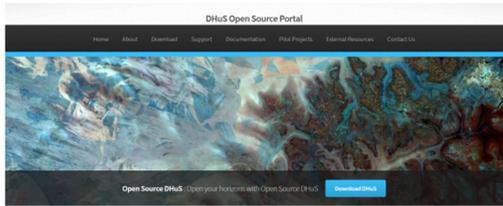
During the period, the activities carried out included DHuS releases publication, Open Source DHuS web

portal redesign, as well as some promotional and educational activities.

### DHuS Releases Publication

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 (<http://sentineldatahub.github.io/DataHubSystem/>). Major new strides were made during the reporting period in the DHuS software consolidation.

No new versions of the software were released during the reporting period, however related, activities carried out included Open Source DHuS promotional and educational activities.



### Open Source DHuS Downloads

Figure 86 shows the number of downloads for each of the published Open Source DHuS versions (the overall amount of users downloads is 4,457). It has to be noted that the number of downloads of the latest version is almost quadrupled compared to the previous version. Analysing the total number of downloads in 2018 is 2891 vs 1566 in 2017. These numbers show a clear growth of the Open Source DHuS Project. This trend is likely to be due to the dissemination activities performed in the reporting period and in general to the growing interest in Copernicus Sentinels' data.

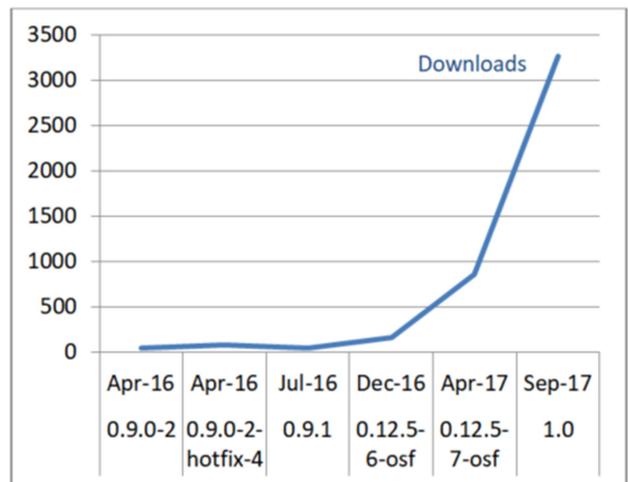


Figure 85: DHuS Software total downloads per Open Source Version

### Support to OS Community

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

### OS DHuS Promotion

In 2018 the Open Source DHuS Framework has been promoted towards the following events and International Conferences:

- **EGU 2018**: European Geosciences Union, 8–13 April 2018, Vienna Austria;
- **COSPAR 2018**: Committee on Space Research of the International Council for Science, 14-22 July 2018, Pasadena, California USA;
- **COWM 2018**: Citizen Observatory Water Management 27-30 November 2018, Venice, Italy;
- **ESA PHI-week 2018**: 12-16 November 2018, Frascati, Rome, Italy.

## Open Source Framework

Y2019 will see new Open Source DHuS releases to support Sentinel-5P products (L1B, L2, AUX), GNSS POD RINEX Auxiliary file, Copernicus Marine environment monitoring service products, and additional products associated to some research projects. New releases cover maintenance items and it is already planned to introduce some new features as Remote DHuS Datastore, a generic LTA interface, as well as eviction and synchronization enhancements.

In the coming year the management of the open source repository will be further improved so that it is expected that additional external software contributions from Open Source DHuS community can also be more easily integrated in the official Open Source DHuS.

# 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 and highlight arising issues. Users are invited to write to the email address: eosupport@copernicus.esa.int. This is first line contact point for all issues concerning Copernicus satellite data. Issues are directly responded to by the front-line eosupport team if possible. Where this is not possible they are either referred to the PDGS Coordination Desk, or, if specifically regarded data access, are forwarded to the Sentinel Data Access System operations team for resolution.

- *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)
- *General*: Miscellaneous requests which do not fit into another category
- *Junk*: Spam, Empty emails, Not an issue

## 6.1 Ticketing Analysis

Feedback and requests received from users of the Open Hub are tracked via a "Ticketing" system with opened tickets are sorted into 8 identified categories:

- *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)

During Y2018 a total of 1,667 tickets were opened, which is down 6% on the Y2017 total of 1,766 tickets. Of these, the largest category was for 'Junk', accounting for 773 tickets. Of the meaningful categories, the largest proportion of tickets were for 'User Accounts' (510 tickets) and 'Service Interface' (254 tickets). Very few tickets were received for the categories 'Features Requests' (2 tickets), 'Web Portals' (5 tickets) and 'Bug' (14 tickets). Figure 87 shows the percentage split between the categories during Y2018.

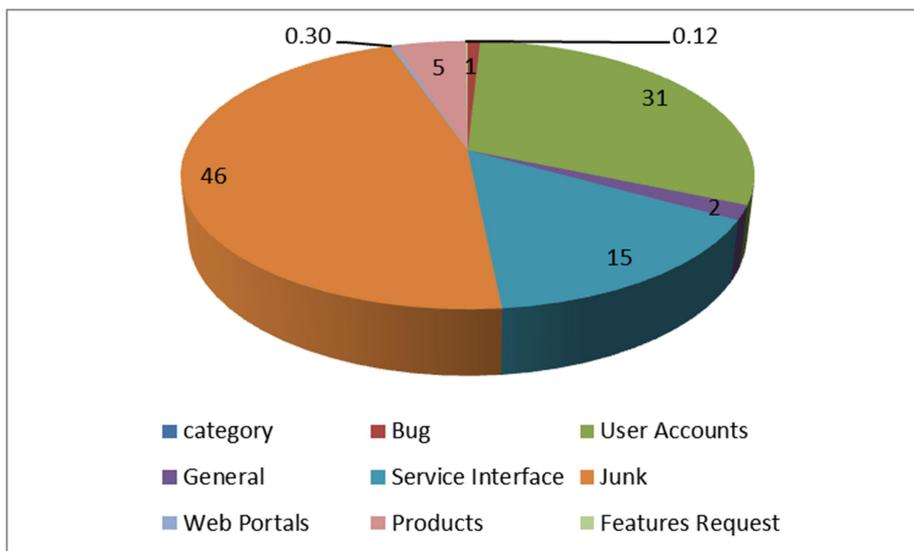


Figure 86: Open Access Hub percentage received tickets per category



During Y2018, 100% of the tickets raised were resolved within the reporting period. The time to respond to all tickets is also logged. During the year,

the average response time was 1 hour 10 seconds and the maximum response time for any ticket was 1 day 12 hours 42 minutes.

# 7 Y2019 Outlook

## 7.1 Sentinel-Specific Developments

The production rate for Sentinel-1 in Y2019 is expected to continue at a similar level to that observed in Y2018. The production rates for Sentinel-2 L1C products will also continue at a similar level, an increase is foreseen for L2A products, as production is increased to cover the whole globe (from the current Europe / Mediterranean area AOI) in December 2018. Regarding Sentinel-3, production from the 3B satellite will progressively enter routine operations on the Hubs during the year. In the case of Sentinel-5P, the qualification of further Level-2 products is expected such that their routine publication via the open access. The Long Term Archive interfaces will be activated for both Sentinel-2 and Sentinel-3 during the second half of the 2019.

Following the deployment of the ESA interface for the ESA/EUMETSAT joint proposal regarding dissemination of Sentinel-3 data over Africa via EUMETCAST a similar joint proposal for further distribution for Sentinel-5P via EUMETCAST has been approved and is expected to become operational in the second half of the year.

## 7.2 Planned Hub Developments

The main focus for Y2019 will be put on the implementation of new data flow scenarios to allow users the on-demand retrieval of specific set of products. Much effort will be also put on

modifications to allow the DHuS to act as master Catalogue, allowing transparent access to distributed data storage (intelligent cache) in remote centres. Until Y2018 the Sentinel Data Access System had provided online access to all the data from the Sentinel missions, starting from the mission's IOCR and operational qualification of the products. By October 2018, the overall volumes exceed the capacities available in the Sentinel Data Access System, with the cost/efficiency of further upgrading the core infrastructure becoming problematic. Activation of the off-line data access interface for Sentinel-1 has been achieved in September 2018, as reported in Section 1. The nominal regime of rolling access to the latest data, at least one year online, with access to all other data through the PDGS/LTA will be applied progressively to Sentinel-2 and Sentinel-3 during Y2019.

For what concerns the new data flow, the Hub will implement a new and more robust DHuS-LTA interface. The data hub software is also being upgraded to support the triggering of on-demand processing from external facilities.

Finally, the EO capabilities will grow since the Hub will be enhanced to support new POD Auxiliary files and potentially support for the dissemination of additional products from other ESA missions.

Particular focus will be put also in implementations designed for the Data Hub Relay and Collaborative Users scenarios as the new monitoring function embedded in the DHuS to provide information about the status of the Hub and a new generation of synchronizers able to manage synchronization from different data sources in an optimized way.

## 8 Bibliography

- European Earth observation programme Copernicus: <http://www.copernicus.eu/>
- Sentinel Online: <https://sentinels.copernicus.eu/web/sentinel/home>
- Copernicus Open Access Hub: <https://scihub.copernicus.eu/>
- Collaborative Hub: <https://colhub.copernicus.eu/>
- International Hub: <https://inithub.copernicus.eu/>
- Copernicus Services Hub: <https://cophub.copernicus.eu/>
- GitHub open source framework: <https://sentineldatahub.github.io/DataHubSystem/>

# 9 Annex 1: List of Acronyms

AER	Archive Exploitation Ratio
API	Application Programming Interface
CLS	Collecte Localisation Satellites
CMEMS	Copernicus Marine Environment Monitoring Service
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
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	Instrument 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
OFFL	Offline
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
SYN	Synergy (Sentinel-3 product type)
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. The sizes given are based on the download volume, i.e. the compressed zip file (average compression rates are provided where applicable, i.e. for Sentinel-1 products).
- short discussion on what new/changed products have appeared in 2018.

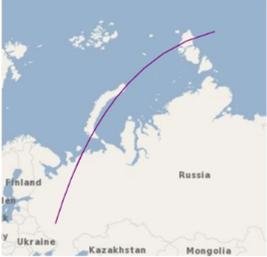
Further information on products can be found on the 'Instrument user guides' following the link:

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

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
Sentinel-1 (SAR)	L0-RAW	Sentinel-1 Level 0 RAW data		1.3 GiB (Average compression rate: 3%)	
	L1-GRDM	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: Medium Resolution		200 MiB (Average compression rate: 40%)	
	L1-GRDH	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: High Resolution		860 MiB (Average compression rate: 44%)	
	L1-SLC	Sentinel-1 Level 1 Single-Look Complex		4 GiB (Average compression rate: 43%)	

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
	L2-OCN	Sentinel-1 Level 2 Ocean		5 MiB	
Sentinel-2 (MSI)	MSIL1C	Sentinel-2 Level 1C		480 MiB	Repackaging into Complete Single Tile format
	MSIL2A	Sentinel-2 Level 2A		600 MiB	
Sentinel-3 (OLCI)	OLCI L1 FR	Sentinel-3 Level 1 OL_1_EFR___ Full Resolution top of atmosphere radiance		600 MiB	
	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	

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
	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 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	
	SRAL L1	Sentinel-3 Level 1 SR_1_SRA__ Echos parameters for LRM, PLRM and SAR mode (resolution 20Hz)		25 MiB	

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
	SRAL L1 A	Sentinel-3 Level 1 SR_1_SRA_A_Echos parameters for PLRM and SAR mode (resolution 80Hz)		2.3 GiB	
	SRAL L1 BS	Sentinel-3 Level 1 SR_1_SRA_BS Echos parameters for LRM, PLRM		1.7 GiB	
	SRAL L2 Land	Sentinel-3 Level 2 SR_2_LAN_1-Hz and 20-Hz Ku and C bands parameters (LRM/SAR/PLRM), waveforms. Over Land	<p>The footprint for this products type depends on timeliness:</p> <p>NTC and STC</p>  <p>NRT (covering only LAND regions)</p> 	36 MiB	

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
Sentinel-3 (SYNERGY)	SY_2_SYN	Surface Reflectance and Aerosol parameters over Land		300 MiB	Available on the S3 PreOps Hub from 10 October 2018
	SY_2_VGP	1 km VEGETATION-Like product (~VGT-P) - TOA Reflectance		35 MiB	Available on the S3 PreOps Hub from 10 October 2018
	SY_2_VG1	1 km VEGETATION-Like product (~VGT-S1) 1 day synthesis surface reflectance and NDVI		70 MiB	Available on the S3 PreOps Hub from 10 October 2018
	SY_2_V10	1 km VEGETATION-Like product (~VGT-S10) 10 day synthesis surface reflectance and NDVI		175 MiB	Available on the S3 PreOps Hub from 10 October 2018

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
Sentinel-5P (TROPOMI)	L1B_RA_B D1 L1B_RA_B D2 L1B_RA_B D3 L1B_RA_B D4 L1B_RA_B D5 L1B_RA_B D6 L1B_RA_B D7 L1B_RA_B D8	Radiance product bands 1-8: 1: 270-300nm 2: 300-320nm 3: 320-405nm 4: 405-500nm 5: 675-725nm 6: 2305-2345nm 7: 2345-2385nm 8: 2345-2385nm		1: 500 MiB 2: 2.8 GiB 3: 2.7 GiB 4: 2.6 GiB 5: 2.6 GiB 6: 2.6 GiB 7: 1.5 GiB 8: 1.6 GiB	Available on the S5P PreOps Hub from 11 July 2018
	L1B_IR_UV N	Irradiance products UVN module 270-775 nm	-	30 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L1B_IR_SIR	Irradiance product SWIR module 2305-2385 nm	-	6 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L2_AER_AI	UV Aerosol Index		13 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L2_CLOUD	Cloud fraction, albedo, top pressure		25 MiB	Available on the S5P PreOps Hub from 11 July 2018

Mission and Instrument	Product types	Description	Footprint on the hub	Average (download) size	New/changed products in Y2018
	L2_CO	Carbon Monoxide (CO) total column		12 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L2_HCHO	Formaldehyde (HCHO) total column		60 MiB	Available on the S5P PreOps Hub from 17 October 2018
	L2_NO2	Nitrogen Dioxide (NO2), total and tropospheric columns		35 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L2_NP_BD'x'	Suomi-NPP VIIRS Clouds X = 3, 6, 7		330 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L2_O3	Ozone (O3) total column		25 MiB	Available on the S5P PreOps Hub from 11 July 2018
	L2_SO2	Sulfur Dioxide (SO2) total column		85 MiB	Available on the S5P PreOps Hub from 17 October 2018