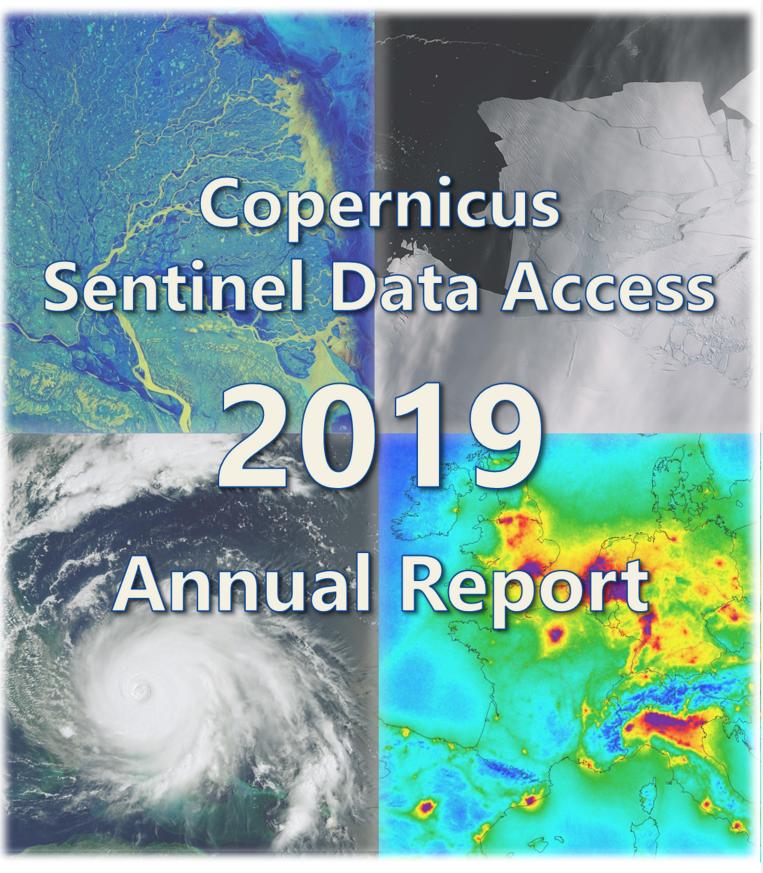




serco





grnet









Foreword



It is my pleasure to introduce the Copernicus Sentinel Data Access Annual Report for the 2019 reporting year. This is the fifth 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.

After five years of Copernicus operations, we have become used to seeing the eye-catching and information-rich images which the Copernicus

Sentinels produce on a daily basis. This Report is an annual reminder of the complexity of the task and the enormity of the effort which lies behind those images, and ensures that they reach the expert users and general public as soon as they are needed. Year on year the numbers keep getting larger and harder to get one's head around. In Y2019 alone, for instance, users made 128 million downloads, accounting for a massive 70 PiB of data. This was 20 times the volume of data which users downloaded in 2015, and over 50% more than users had downloaded even in Y2018. The contrast with the pre-Copernicus era also highlights the scale of the task being managed by the Copernicus operations teams: the volume of products which was published in Y2019 alone on the Copernicus Open Access Hub was greater than the entire collection of Earth Observation data which ESA had accumulated before the launch of Sentinel-1.

It is also exciting to see how enthusiastically Copernicus Sentinel data is being taken up across the world, and the increasing involvement of international actors in the Copernicus ecosystem. Although 76% of all downloads were made by European users in Y2019, there were as many as 36,802 non-European users actively downloading data from the Copernicus Open Access Hub during the year, which represents a significant increase on previous years. Moreover, these users are additional to those who download data from the regional Copernicus Sentinel data access sites offered by international partners, and five new technical agreements were signed with international partners in Y2019 to support the establishment of further such regional sites. Closer to home, the ESA/EU member states' Sentinel Collaborative Ground Segment also expanded during the year, with two new partners joining the network. With most Collaborative mirror sites now operational, approximately 40,000 TB of Copernicus Sentinel data was made available to additional user groups on these European sites during Y2019.

As in previous years, this 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 ESA's Copernicus operations.

Nicolaus Hanowski

Head, Mission Management & Ground Segment Department, ESA/ESRIN

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Document Scope

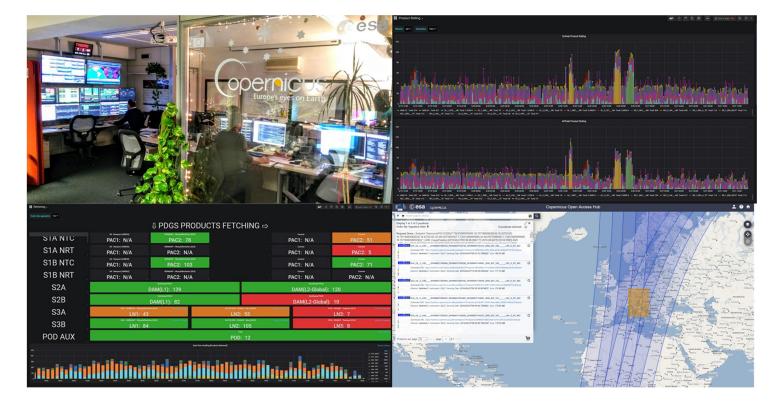
A deliverable of the Sentinels Rolling Archive, Operations Maintenance and Evolution contract, this document provides an annual look at the Sentinel Data Access Service operated by Serco Gael consortium for ESA in the Copernicus programme.

Written by:

Richard Knowelden

Adriana Grazia Castriotta

Liou Goldwidt













Documentation

Reference documents

Key	Title	link
[RD-1]	Sentinel High Level Operations Plan (HLOP)	https://sentinels.copernicus.eu/documents/247904/6 85154/Sentinel_High_Level_Operations_Plan

Definitions

Data Dissemination	Refers to the access and retrieval of Copernicus data by users (could be national Collaborative Ground Segments, Data Hub Relays (DHR) or user of the Open Hub etc) directly from ESA core nodes
Data Exchange	Refers to the transfer of Copernicus data from one Data Hub Relay (DHR) to another DHR
Data Ingestion	Refers to the indexing, storage and publication on the data dissemination infrastructure of the Copernicus data
Data Publication	Refers to the provision of products available online for download by users
Data Relay	Refers to the transfer of Copernicus Data from a Data Hub Relay (DHR) to a national Collaborative Ground Segment
Rolling Archive	Online accessible repository of Copernicus data representing a subset of the total mission archive and regularly updated to maintain a fixed archive volume (e.g. the last months of products)
Y2019	Refers to the reporting period covered in this report, from 01/12/18 - 30/11/19. Similarly, Y2018 refers to the previous reporting period: 01/12/17 - 30/11/18, Y2017 to the 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.

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: $1KiB=2^{10}$ bytes, 1 MiB= 2^{20} bytes, 1GiB= 2^{30} bytes, 1 TiB = 2^{40} bytes and 1 PiB = 2^{50} 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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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 has developed 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 2018 to 30 November 2019 (referred to throughout this report as 'Y2019'), and analyses the trends visible in the public uptake of Copernicus Sentinel data. This is the fifth such report released by the data access service provider, Serco Italia SpA.

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 Y2019 the 20 millionth data product was published on the Open Hub and by 30 November 2019 users had downloaded 158 PiB of data products. During the reporting period more than 30,000 products were published per day. Moreover, the number of registered users reached 280,000, 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.

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

- **Y2019**: 1 December 2018 30 November 2019 (this report)
- Y2018: 1 December 2017 30 November 2018 (report released on 8 May 2019)
- **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)

Data Access System 1.1 **Architecture**

The Copernicus 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, applications and supporting 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 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, such as Sentinel-5P, are introduced gradually in a staged manner. This is further described below.

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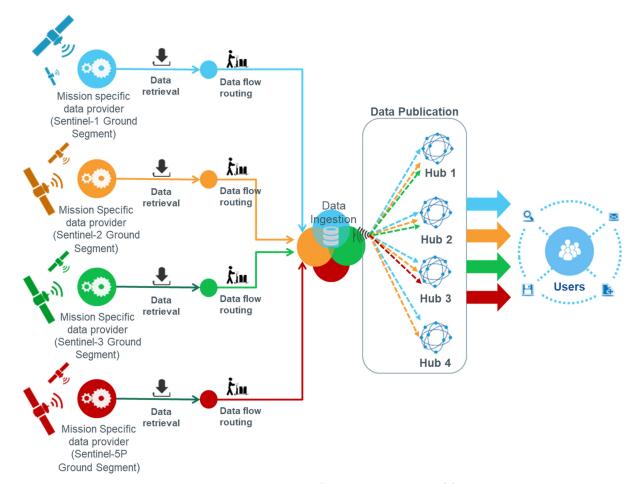


Figure 1: Copernicus Sentinel Data Access System Model

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, 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 Y2019

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 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 Sentinel Data Access System since the start of operations, via the same catalogue. The freshest data products are kept online for about one year and users are able to download them directly from the online collection. The Open Hub also interfaces to Long Term Archives (LTAs), so that the oldest products can be automatically removed from the online storage according to Rolling Policy to preserve space for fresh data. When a user requests one of these offline data products, the Open Hub recalls the product from the offline LTA store and makes it available for download via the standard interfaces. The LTA was first introduced for Sentinel-1 data products in September 2018 and the functionality was extended to Sentinel-2 products on 24 September 2019 and Sentinel-3 products on 1 August 2019. The Open Hub user information pages are kept up-to-date with the latest information about the rollout of the data and the current status of products (see e.g. https://scihub.copernicus.eu/userguide).

The Open Hub is generally the first hub on which data products from a new mission are published. During the satellite commissioning phase, the first data which the satellite acquires is released to the mission experts, to enable them to carry out the calibration and validation activities required to qualify the data products. This initial release is managed by means of an Expert Hub, of which the Open Hub currently supports two: the Sentinel-3 Expert Hub and the Sentinel-5P Expert Hub. The Expert Hubs are only ever available to a small number of users and so are not further described in this report.

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The initial release of products to the public 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, allowing teething issues to be ironed out in parallel with the routine dissemination operations of the other missions. Following entry into routine operations, the products are released instead through the standard Open Hub interfaces and the relevant PreOps Hub is decommissioned.

Given the decommissioning of the Sentinel-3 Pre-Operations Hub on 19 June 2019, there currently remains only one mission-related PreOps Hub active on the Open Hub: the Sentinel-5P Pre Operations Hub (S5P PreOps Hub). This hub provides access to all standard products from Sentinel-5P published in the previous 2 years (i.e. currently all to date), and Near Real Time (NRT) products from the previous month.

In response to a request from scientific users, the GNSS RINEX Pre-Operations Hub was opened on 13 February 2018 to provide the GNSS L1B data generated by the dual frequency GPS receivers on board the Copernicus Sentinel-1, -2 and -3 satellites. From the Hub, users can download all GNSS L1b RINEX products relevant to the Copernicus Sentinel-1, -2 and -3 missions. This product has 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.

Another hub, called the TMP Hub (Temporary Hub) provides the last week of the published products nominally available on Open Hub. This hub is not meant to be accessible by end users during nominal operations, but it is continuously updated with fresh products in order to offer a recovery hub in case of maintenance activities, providing continuity of the service, with all the end users of the various services being then redirected there.









The Copernicus Services Hub (ServHub) quarantees 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 missions in routine operations are published on the Hub. The ServHub operates a similar Rolling Policy for removing products from the online access as the Open Hub and ColHub: 1 year of NTC products is kept online and 1 month of NRT products (see Figure 3). Access to the Long Term Archive is available for Sentinel-1, -2 and -3 data which has been removed through the Rolling Policy.

The DIAS partners have been provided with three dedicated access points on the Copernicus Sentinel 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 Hub, were linked to ServHub during Y2018 and opened to the DIAS partners on 9 March 2018.

In this year's Report, the downloads which are made by the DIAS operators from the Data Access System have for the first time been separated out from the figures reported for the ServHub. Now that the DIAS are in routine operations, the DIAS operators download the entire data collection in real time, so their download figures are a repetition of the publication figures and, when included together in the ServHub statistics, mask the figures from the other activity on the ServHub due to their size. It is recalled that any statistics concerning the subsequent use of the data products on the DIAS are outside the scope of this Report.

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 1 year for standard products and



1 month for NRT products (this is for node 1 of 3 nodes: see Figure 3 for full details and other nodes). As for the Open Hub, the ColHub now has LTA access available for historical Sentinel-1, -2 and -3 products.

At the end of Y2019, there were 19 active CollGS agreements in place and 16 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 Y2019, a set of 5 Data Hub Relays were deployed by the CollGS partners. These Data Hub Relays are



connected to the CollGSs operated in Germany, Austria, Norway, UK and the Czech Republic.

The International Hub (IntHub) is open to international partners, following signature of a cooperation agreement with the European Commission and a technical operating agreement with ESA. The hub is also configured to support 10 concurrent downloads. A rolling policy of 3 weeks is applied for all data and the IntHub does not currently allow LTA access. At the end of Y2019, there were 9 technical agreements in place with international partners, a significant expansion from the 4 at the end of Y2018.

Figure 3 below summarises the overall Sentinel Data Access System front-end configuration at the end of Y2019.

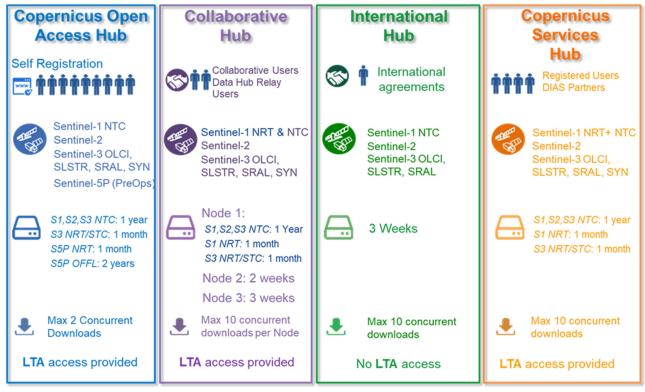


Figure 3: Copernicus Sentinel Data Access System hub characteristics at the end of Y2019

The Data Hubs described in this section 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

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1.1.1 Deployment Physical **Architecture**

This section provides a brief overview of the physical architecture of the Data Access System, which is illustrated in Figure 4.

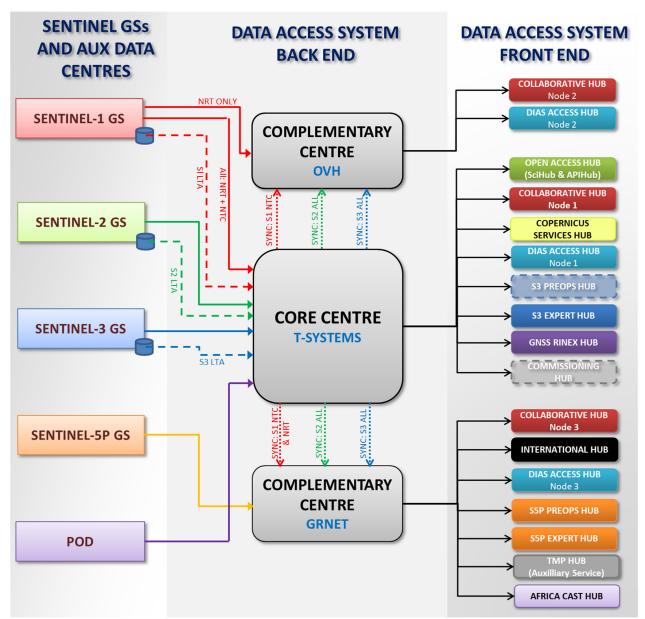


Figure 4: Data Access System Physical Architecture Overview

Figure 4 shows, on the left, the Sentinel ground segments and auxiliary centres which generate the data products and provide them 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.

The three Data Access Centres are each responsible for ingesting a defined sub-set of data products from the Sentinel ground segments, archiving and cataloguing the data and publishing it to end users

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on the Data Access Hubs for which they are responsible. The Data Access Centres are composed of one Core Centre, which ingests the majority of data products from the ground segments and has overall responsibility for the system, and two Complementary Centres, which are responsible for ingesting some data products directly from the ground segments while the majority are retrieved from the Core Centre. The Core Centre is currently run by T-Systems, while the two Complementary Centres are run by OVH and GRNET.

The full set of hubs operated by the Data Access System is shown, along with the Centre which operates them. The Open Hub and ServHub are operated from the Core Centres and the IntHub is operated from the Complementary Centre. However, the ColHub and the DIAS 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 hubs with dashed boundaries are those which have been decommissioned during Y2019: the Sentinel-3 PreOps Hub (the data having now been moved to the major hubs) and the Commissioning Hub.

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. Only Sentinel-5P products are ingested directly by the GRNET Complementary Centre, while products from other missions are retrieved and synced from the Core Centre. The dotted lines illustrate the LTA product retrieval flows in operation for Sentinels-1, -2 and -3.













Main Evolutions of the 1.2 **Data Access System in** Y2019

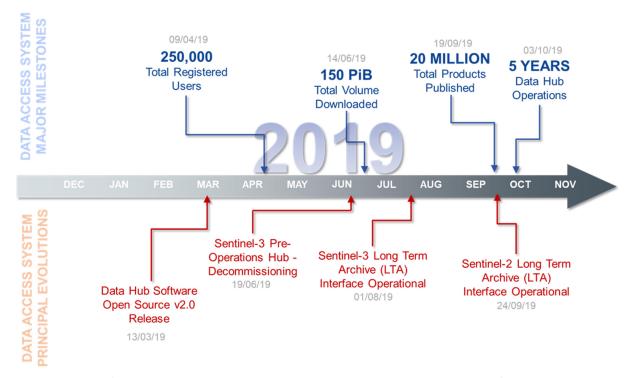


Figure 5: Timeline of the main Y2019 achievements related to data dissemination and improvement of the Data Access System

1.2.1 Specific Data Hub **Evolutions**

Y2019 saw few major evolutions to the Sentinel Data System, as the complete constellation progressed towards its full operational scenario and the scalability upgrades which had been made in previous years continued to enable the Data Access System to expand in step with user demand. Nonetheless, there were still some adjustments made to the System in Y2019, and those evolutions are represented on the timeline in Figure 5 above, and described in this section.

Sentinels 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 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 ground segment Long Term Archive (LTA), and make them available to users through the existing interface points (GUI and API), with a slightly reduced timeliness.

The off-line LTA data access was activated first for the Sentinel-1 RAW and WV-SLC data products, on



12 September 2018. This rolling out of the oldest Sentinel-1 data from the online access continued throughout Y2019, as part of the planned routine operations, enabling the System to maintain the last year of Sentinel-1 data products accessible online. In Y2019, the LTA function was extended to Sentinel-2 and Sentinel-3. The integration and activation was completed for Sentinel-3 on 1 August 2019 and for Sentinel-2 on 24 September 2019. Online access to at least one year of data is maintained for the majority of the products. An evolution of the Data Hub Software to support transparent access to distributed data storage has been put into place to allow a small extension to the volume of Sentinel-2 data kept on line before the activation of the Sentinel-2 LTA interface. A minimum of 18 months online access is therefore currently provided for Sentinel-2 Level-2A products.

It is highlighted that the hubs continue to provide unified access to all of the data products: 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 from the standard interfaces as soon as the data are restored (within minutes to hours).

Sentinel-3 Pre-Operations

The process of decommissioning the S₃ PreOps Hub began for Sentinel-3A products on 19 October 2017, after the successful Sentinel-3A Routine Operations Review, but the S₃ PreOpsHub continued to be used in Y2019 to distribute the new set of Synergy Level 2 products, which had just been released on 10 October 2018, and the Sentinel-3B products. During the first half of Y2019, routine dissemination of these Sentinel-3 data products was also gradually transferred from the S₃ PreOps Hub to the standard Open Hub interface. The complete Sentinel-3 A and B production was available on the standard Open Hub interfaces from March 2019 when the SYNERGY ioined the data offer. production decommissioning of the S3 PreOps Hub was finally completed on 19 June 2019.









Sentinel-5P Re-distribution via EUMETCast

The joint ESA/EUMETSAT proposal for the distribution of Sentinel-5p data products via EUMETCast also progressed during Y2019. The required interfaces with the Sentinel-5p ground segment were developed, integrated and validated in the first half of 2019, and the service was transferred to operations in the third quarter of 2019. EUMETSAT now receives the routine flow of Sentinel-5p NRT data, for re-distribution via EUMETCast.

Africa Cast Hub

The dissemination of Sentinel-3 Land products to African users is ensured jointly by ESA and EUMETSAT which both contribute with their respective data dissemination infrastructure: the DHuS and EUMETCast. The Africa Cast Data Hub Service (AfricaCast) 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.

At the beginning of Y2019, the AfricaCast service was still ramping-up, and the Hub was put into preoperations following the successful review of the Phase 1 completion. The service was subsequently declared operational in the first quarter of 2019, with both Sentinel-3A and -3B Land Level-2 production being made available in accordance with the foreseen timeliness.

Data Hub Open Source Framework (OSF)

Version 2.0 of the Data Hub Open Source Framework was released in March 2019. This version included several improvement including support for Sentinel-5P products (L1B, L2, AUX), GNSS POD RINEX Auxiliary file; a performance enhancement based on database schema optimization and scalability; and improvements to the data flow handling through the introduction of the remote DHuS datastore and synchronizers. More information can be found in section 5.5.

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1.3 Main Developments in the Data Offer in Y2019

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.

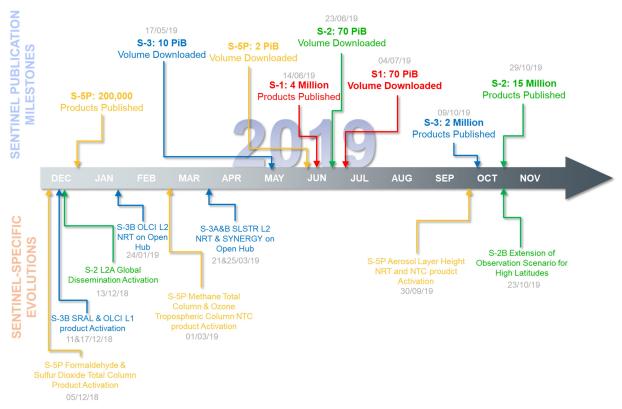


Figure 6: Timeline of the main Y2019 achievements related to Sentinel mission-specific products publication and evolutions

Sentinel-1

No adjustments were made to the Sentinel-1 product offer during Y2019. In terms of satellite observations, new coverage was added or revisit frequency increased as described in the Sentinel High Level Operations Plan [RD-1], mainly including: 12-day regular coverage of the inner part of Greenland; increased coverage of Ukraine to a level similar to the European scheme; increased coverage frequency over specific areas of Africa and Australia; observation of waters around various islands worldwide to support maritime surveillance etc.

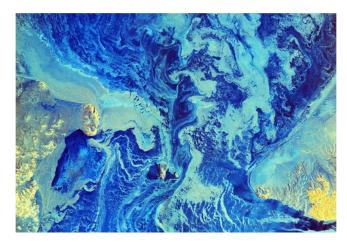


Figure 7: Sentinel-1 image from 7 March 2019, showing Bering Strait to be virtually ice-free [contains modified Copernicus Sentinel data (2019), processed by ESA]





Sentinel-2

The following changes were implemented in the Sentinel-2 observation scenario during Y2019:

- On 13 December 2018, the dissemination of the Sentinel-2 Level-2A worldwide coverage began, starting from Sentinel-2B sensing orbit 9243 and Sentinel-2A sensing orbit 18152.
- An expansion of the observation scenario was made on 20 October 2019 for Copernicus Sentinel-2A and on 23 October 2019 for Copernicus Sentinel-2B, to include the following new areas:
 - Pacific Islands (e.g. Tuamotu, Austral Islands, Kiribati, Juan Fernandez, Archipelago.)
 - > Bermuda Island
 - Sargasso Sea.
- On 23 October 2019, the observation scenario of Copernicus Sentinel-2B was also extended to include the acquisition of Northern Europe and Arctic Areas in low illumination conditions (sun zenith angles up to 85°).



Figure 8: Sentinel-2 image from 8 September 2019, showing multiple bushfires in New South Wales, Australia [contains modified Copernicus Sentinel data (2019), processed by ESA]

Sentinel-3

The Sentinel-3 product offer continued to be updated during Y2019, for the most part with the staged introduction of qualified products from Sentinel-3B,

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following the successful completion of the Copernicus Sentinel-3B Commissioning Phase on 17 October 2018. The following series of updates was made during the year:

- On 11 December 2018, the Sentinel-3B Level-1B and Level-2 Near-Real-Time (NRT) SRAL products, and the Level-1B, Level-1A, Level-1BS and Level-2 Non-Time-Critical (NTC) and Short-Time-Critical (STC) SRAL products started to be published on the Open Hub.
- o From 17 December 2018, the Sentinel-3B Level-1 NRT and NTC OLCI products (OL_1_EFR and OL_1_ERR) were published on the Open Hub. The Sentinel-3B Level-2 NRT and NTC OLCI products (OL_2_LFR and OL_2_LRR) started to be distributed on 24 January 2019.
- On 30 January 2019, the RINEX Observation files from Sentinel-3B began to be made available on the GNSS Rinex Hub. With this, all RINEX observation files from the Copernicus Sentinel-1, -2 and -3 missions were made available to the scientific community.
- On 27 February 2019, the Sentinel-3B Level-2 SLSTR NRT and in NTC (SL_2_LST) products were made available for the first time on the S3 PreOps Hub. The official release of the SLSTR Sentinel-3A and -3B products on the Open Hub took place on 20 March 2019 for the Sentinel-3A products, and on 21 March 2019 for the Sentinel-3B products.
- All Sentinel-3B SYNERGY data product types (SY_2_SYN, SY_2_VGP, SY_2_VG1, SY_2_V10) were also made available on the S3 PreOps Hub on 27 February 2019. The SYNERGY Sentinel-3A and Sentinel-3B products were subsequently officially released on the Open Hub on 25 March 2019.
- On 21 March 2019, a set of Sentinel-3B SRAL products from the Commissioning Phase was published on the Open Hub, to cover a gap following the official release of the SRAL products in December 2018.
- On 19 April 2019, a set of Sentinel-3A SRAL reprocessed data (SRAL L1 SR_1_SRA_A_ and SR_1_SRA_BS) started to be released on the Open Hub. These products belonged to the same reprocessing campaign of SR_1_SRA and SR_2_LAN, which was published in November









2018. The data was re-processed to Processing Baseline 2.45, providing a homogeneous time series from the start of the Sentinel-3A mission aligned to the current Sentinel-3A and Sentinel-3B processing baseline. The release was made with user products published gradually, incrementally (oldest data first) starting from 19 April 2019.

o On 3 June 2019, a new set of Sentinel-3 SYNERGY STC products (SY_2_SYN STC, SY_2_VGP STC, SY_2_VG1 STC, SY_2_V10 STC)

started to be systematically made available on the Open Hub, ServHub and ColHub. SYNERGY STC products are produced during the same day of sensing, using the underlying OLCI SLSTR NRT products; i.e. meteorological forecast data. These products are made available for 30 days, as with other Sentinel-3 NRT products. After that, only the corresponding NTC products are available for download.

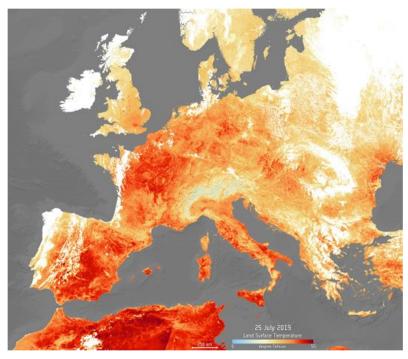


Figure 9: Heatmap generated using data from Sentinel-3's SLSTR instrument, showing the heatwave across Europe during July 2019 [contains modified Copernicus Sentinel data (2019), processed by ESA]

Sentinel-5P

Sentinel-5P provides calibrated instrument data as Level-1B products, and measurements 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.

At the start of Y2019, Sentinel-5p was still in its ramp-up phase, following the successful In-Orbit Commissioning Review of 24 April 2018. The staggered release of products through the S5 PreOps Page 18/134

Hub continued throughout the year, with most of the Sentinel-5p products available online by 5 March 2019, when Sentinel-5p completed its ramp-up phase and entered into routine operations. The following list outlines the additions which were to the product offer during Y2019:

- On 18 December 2018, the Sentinel-5p Sulphur Dioxide (SO₂) and Formaldehyde (HCHO) Offline products were added to the routine product offer. Products starting from 5 December 2018 were made available.
- On 1 March 2019, ESA released the Sentinel-5p Methane (CH4) and Ozone Tropospheric Column (O3_TCL) Offline products on the S5 PreOps











- Reprocessed CH₄ data products were Hub. subsequently made available on 13 March 2019, for selected orbits reprocessed in the frame of the Validation campaign performed prior to the public CH4 data release.
- An increased spatial resolution was successfully introduced in the Sentinel-5p operations scenario, from 6 August 2019. The spatial resolution was increased from 7 km to 5.5 km along track for all measurements. This scenario had successfully been tested during the Sentinel-5P Commissioning Phase and one of the recommendations from the In-Orbit
- Commissioning Review was to implement it within the operational phase. It is expected that this improved spatial resolution will enable better exploitation of the measurements for air quality monitoring. The change increased the data volume by about 20%.
- On 30 September 2019, the Sentinel-5p Aerosol Layer Height product was released on the S5p PreOps Hub. The products are available in Near Real Time, Offline and Reprocessed timeliness. The new product was made available dating back to the first acquisitions.

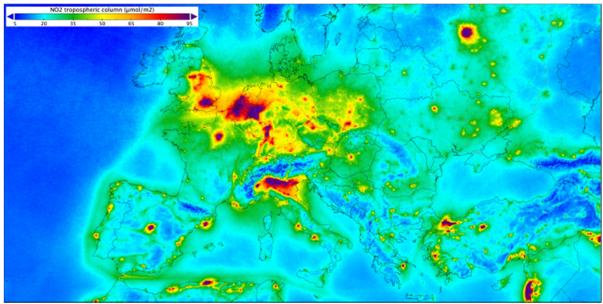


Figure 10: High levels of nitrogen dioxide over Europe, shown on a map generated from Sentinel-5P measurements between April and September 2018 [contains modified Copernicus Sentinel data (2018-2019), processed by KNMI / ESA]











2 Data Access Service Growth

During Y2019, the statistics which illustrate the level of public engagement with the Data Access System continued to increase dramatically. registrations rose 49% to nearly 281,000, the number of Sentinel data products made available for download on the Open Hub doubled to 26 million products, and the volume of Sentinel data products downloaded by users since the start of operations rose 82% to an enormous 158 PiB. In this section, each of these increases is analysed in detail.

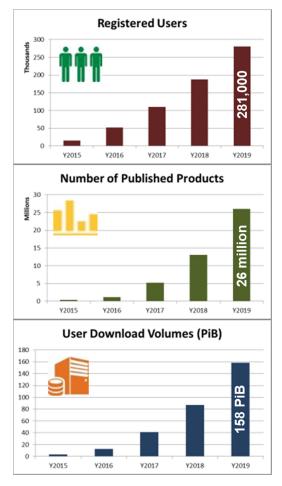


Figure 11: Overall Rise in Data Hub Registered Users, Published Products and User Download Volumes, showing cumulative total for each year since the start of operations











2.1 User take-up

By the end of Y2019, 280,521 users were registered to access the four hub services offered by the Copernicus Sentinel Data Access System operated by ESA. Figure 12 breaks this overall figure down to show the number of users registered on each hub, and the percentage increase since the end of Y2018. 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.

As can be seen, in terms of percentage increase since Y2018, the greatest change took place on the IntHub: 3 out of the 5 new international partners opened accounts on the hub, raising the total number of user accounts from 4 to 7, a 75% increase.

It is clearly still the Open Hub which supports access for by far the largest number of people, though. By the end of Y2019, 280,227 user accounts had been opened on the Open Hub since the start of operations (3 October 2014). Although the percentage change since Y2018 looks modest when compared with the 71% increase which took place between Y2017 and Y2018, in absolute terms there were 92,676 new user accounts opened in Y2019, and this was the highest yearly rise in user registrations yet seen since the start of operations.



Figure 12: Registered Users per Data Hub

It is interesting to break down this overall figure of user registrations on the Open Hub into greater detail, to examine the trends and range of users who are registering for access. This analysis only makes sense for the Open Hub, because accounts on the other hubs are opened by ESA for qualifying users and not through a self-registration process.











2.1.1 User Registrations

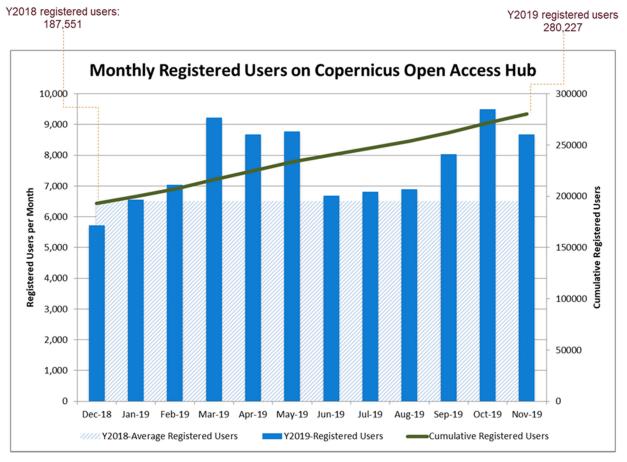


Figure 13: Trend of User Registrations on the Copernicus Open Hub

The graph in Figure 13 above shows the number of users who registered each month for access to the Open Hub during Y2019, contrasted against the average number of user registrations made per month during Y2018. The cumulative number of registered users since the start of operations is also shown.

It is clear from the graph that the number of new user registrations each month was generally greater than monthly average for Y2018. Indeed, in Y2019 there was an average of 7,721 registrations per month, which is 19% higher than the Y2018 average of 6,506 and 59% higher than the 4,846 Y2017 average. These figures continue to highlight the growing awareness concerning Copernicus, and the steadily increasing audience for Copernicus Sentinel data. Two peaks in registrations are evident during Y2019: the first in March and the second in September/October. Whilst it remains conjecture to suggest precisely why this occurred, it is possible that the March rise was the result of new Sentinel-3 products being published on the Open Hub during that month (see section 2.2); the September rise could be the simply the result of a return to normal registration following the usual dip in activity which tends to take place every year during the Northern Hemisphere summer months.

It is also possible that the various Copernicus Sentinel-related events throughout Y2019 could have had some impact on user uptake of Sentinel data, particularly in registrations on the Open Hub and related downloads. Figure 14 provides a timeline of the most significant events throughout the year. While a strong connection to registration numbers is not possible, these events will certainly have improved awareness of the Copernicus missions and their products.

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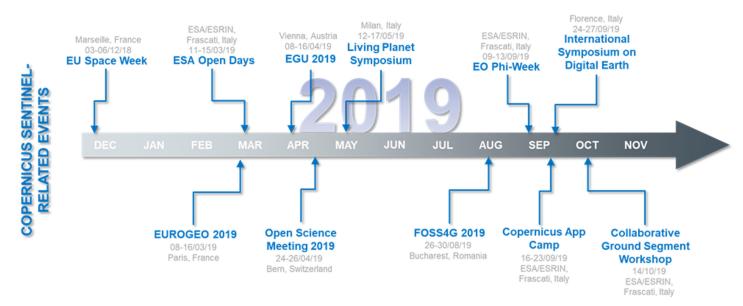


Figure 14: Highlighted Copernicus Sentinel-Related Events in Y2019

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2.1.2 Open Hub Demography

In Figures 15 and 16 below, the increase in user registrations during Y2019 is broken down by continent.

Europe remains the continent with by far the largest Open Hub user-community, with 103,268 registered users by the end of Y2019, up 43% from Y2018. However, the growing awareness of and interaction with the Open Hub has by no means been limited to Europe. Significant increase in user registrations during Y2019 took place in Asia, with an increase of 63%, up to 69,219 users. North America and Africa also exhibited higher percentage increases than Europe (though still also from significantly lower



Figure 15: Open Hub registered users in Europe

Focusing specifically on Europe, there was a significant increase in registered user numbers in all of the ESA and European Union Member States. This year it was again Spain which showed the highest percentage increase (61%) in the number of registered users, with Italy showing the second highest rise with 48%. Germany remains the country with the largest number of registered users in

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starting points) with 51% and 50% respectively. It is highlighted that in absolute terms the actual number of new accounts opened was the highest of any year so far, and the highest number of new users registering from Europe.

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 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.

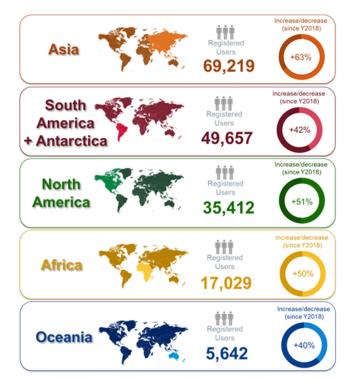
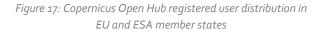


Figure 16: Number of registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent during Y2019

Europe, and even there registrations increased by 39%, reaching a total number of 16,445 registered users at the end of Y2019. Figure 17 below illustrates for the top 5 ESA and European Union Member States the number of registered users, and the percentage change since Y2018.

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7,828



The order of countries in the list is close to that of Y2018 and Y2019, the only change being that Spain and Italy have switched places in the list.

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 Y2019 there were 71 countries across the world with more than 500 registered users, a rise from the 60 at the end of Y2018.

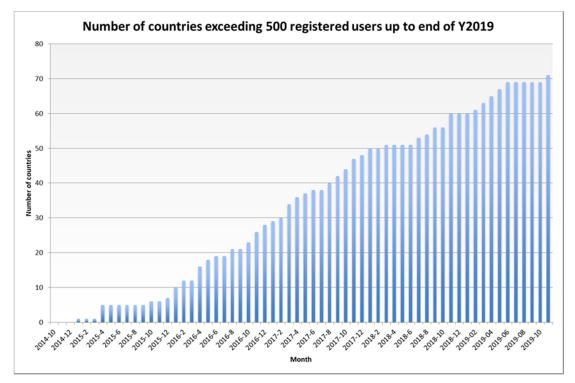


Figure 18: Growth in the number of countries exceeding 500 registered users on the Open Hub since the start of operations

User activity on the Hubs is analysed in Section 3.

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Published Products

By the end of Y2019, almost all products were being published routinely on each of the data hubs. The exceptions were the Sentinel-5P products which were still being disseminated on the Sentinel-5P PreOps hub, maximizing the retention period for the other Sentinel products whilst providing an increased download capacity for the new Sentinel-5P atmospheric products, and the Sentinel-3 SYNERGY products which were not yet requested by international partners and so not yet available on IntHub. The following diagram illustrates the products types available on each of the hubs:

- **Sentinel-1A/-1B** products were being routinely published on all the data access hubs, though in the case of Sentinel-1 NRT products are only on the ColHub and ServHub.
- Sentinel-2A/-2B products were being routinely published on all the data access hubs
- Sentinel-3A/-3B OLCI, SLSTR and SRAL products were being routinely disseminated on all hubs; Sentinel-3 SYNERGY products were being routinely disseminated on all hubs except the IntHub.
- Sentinel-5P products were being disseminated on the Sentinel-5P PreOps Hub.

This section presents the statistics for the publication of those products on the Open Hub during Y2019. For the purpose of these publication statistics, the Sentinel-5P PreOps Hub will be deemed to constitute part of the Open Hub.

2.2.1 Publication Growth

By the end of Y2019, a total of 25,972,224 Copernicus Sentinel products had been published on









the Open Hub since the start of operations, with a total data volume of 17.23 PiB. In Y2019 itself, a total of 12,923,043 products were published, accounting for a total data volume of 7.54 PiB. The chart in Figure 19 below compares the volume of products published in Y2019 with the volumes published in the preceding years.

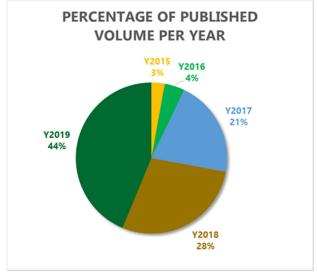


Figure 19: Percentage of the published volume of data per year since the start of operations (Y2015-Y2019)

The volume of Sentinel products published on the Open Hub during Y2019 makes up 44% of all the products published on the Open Hub since the start of operations, continuing the year-on-year growth seen in previous reporting years. In fact, the trend seen in Y2019 is similar to that observed at the end of Y2018, when the total volume published during that year was close to double the total published during the preceding three years put together. These figures show that the overall data volumes are still increasing rapidly on a scale unprecedented for Earth Observation missions. To put this into context, by way of historical comparison the 7.54 PiB published during Y2019 alone is more even than ESA's entire collection of EO data from the pre-Copernicus era, which amounted to 5.6 PB by the end of 2013.











Mission	No. of products published in Y2019	No. of products published from start of Ops to end Y2019	% no. in Y2019	Volume of products published in Y2019 (PiB)	Volume of products published from start of Ops to end Y2019 (PiB)	% volume in Y2019
S1	1,341,478	4,624,157	29	2.12	7.25	29
S2	8,187,804	15,578,640	53	4.19	7.87	53
S3	2,814,430	5,023,386	56	1.10	1.91	58
S5P	579,331	746,041	78	0.12	0.19	64
ALL	12,923,043	25,972,224	50	7.54	17.23	44

Table 1: Overall number and volume of published products on the Open Hub both in Y2019 and since the start of operations, per Sentinel mission

Mission	Daily Average Vol (TiB) published in November 2019	% (of overall publication)	Daily Average Vol (TiB) published in November 2018	% (of overall publication)
S1	6.13	33	5.79	39
S2	9.54	51	7.76	52
S3	2.35	12	1.18	8
S5P	0.46	2	0.29	2
All	18.47		15.02	

Table 2: Average volume of products published per day in the last month of Y2018 and Y2019, with percentage splits per Sentinel

Tables 1 and 2 below break these totals down by Sentinel, showing the number and volume of products published in Y2019 as compared to the total since the start of operations in Y2014. As reported in Table 1, in terms of number of published products, Sentinel-2 data continues to dominate: the mission accounts for 63% of products published in Y2019 and 60% of all products published since the start of operations. However, it should be noted that 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 over 6 times that of Sentinel-1, in terms of total volume of products, the figure for Sentinel-2 (4.19 PiB) is only about 2 times that for Sentinel-1 (2.12 PiB). Twice the number of Sentinel-3 products were published in Y2019 compared with the number of Sentinel-1 products and, for the first time, the total number of Sentinel-3 products published since the start of operations surpassed that of Sentinel-1. On the other hand, the volume of Sentinel-3 products published in Y2019 was half the volume of Sentinel-1 products published in Y2019, and the total published volume of Sentinel-3 products since the start of operations amounted to a quarter of the total volume of Sentinel-1 products published since the start of operations.

Looking at publication growth since Y2018, 64% more products by number were published during Y2019, and 54% more by volume. This is largely accounted for by large increases over the year for Sentinels-3 and 5P (~2x and 3.5x the Y2018 numbers respectively), due to the introduction of new product types throughout Y2019. Sentinel-2 also saw a 62% rise on Y2018 numbers, largely driven by Level-2A production being increased to a global scale and by the continued repackaging of historical Level-1C products into the single tile format. It is interesting to note that, as shown in Table 1, 50% of all products for all missions published since the start of operations were published during Y2019.

Table 2 shows the Open Hub publication volumes on a daily basis, averaged over one month at the end of the reporting period (November 2019), with the corresponding figures from the same month in Y2018. Over the year, the average daily volume of data being published by the Data Access System

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increased by 23% (the equivalent change between Y2018/Y2017 was 50%). At the end of Y2019, the majority of NTC product volume being published was still accounted for by Sentinel-1 and -2 (together making up for 85% of the daily total). In fact, Sentinel-2 alone continues to make up just over half the total volume, just as it did during Y2018. Although still small in comparison, the largest increases in daily publication have come from Sentinels-3 and -5P. Sentinel-3 has more than doubled its daily volume (up to 2.35 TiB in y2019 from 1.18 in Y2018), and it is up to a 12% share of the

total daily publication volume: this is due to Sentinel-3B completing its commissioning phase and new product types starting to be disseminated. While Sentinel-5P still only accounts for 2% of total daily volume, in absolute terms it has grown 60% over the year (up to 0.46 TiB from 0.29 TiB in Y2018): again, this is driven by new product types starting to be disseminated and a ramp-up of production.

Mission	Daily Average Number of Products Published in during Y2019	%	Daily Average Number of Products Published in during Y2018	%
S1	3,799	12	3,760	17
S2	17,896	58	13,858	62
S3	6,826	22	3,698	16
S5P	1,950	6	1,174	5
TOTAL	30,471		22,490	

Table 3: Daily average number of products published per mission during Y2019 and Y2018

Table 3 shows the average *number* of products which were published per day in Y2019 on the Open Hub, broken down by mission, with the Y2018 figures included for comparison. During Y2019, the Data Access System published an average of 30,471 products per day for all missions, a 35% increase on the 22,490 products/day published per day during Y2018. This growth was driven largely by the increase in products from Sentinels-2, -3 and -5P mentioned above: new products types for Sentinels-3 and -5P and an increase in Level-2A production for Sentinel-2. Between Y2018 and Y2019, Sentinel-2 production per day increased by 29%; Sentinel-3 by 85%; and Sentinel-5P by 66%. By contrast, Sentinel-1 was almost stable. In terms of the percentage split of the total, the most significant changes are a 5% drop for

Sentinel-1 (down from 17% to 12%) and a 6% rise for Sentinel-3 (up from 16% to 22%).

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 Y2019 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 are also compared with the same months in Y2018, to highlight the growth that has occurred.

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Sentinel-1

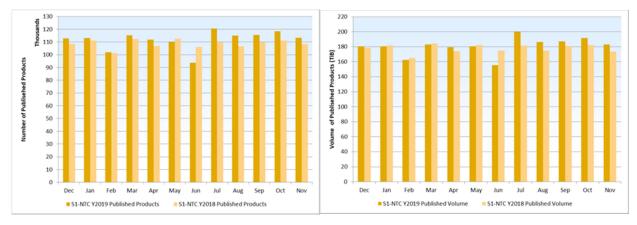


Figure 20: Y2019 and Y2018 monthly number and volume publication trend for Sentinel-1

During Y2019, numbers and volumes of Sentinel-1 published products remained relatively stable. Given that such stability was also experienced during Y2018, this can be taken as a reflection of the maturity of the mission in its full operations capacity and its observation scenario, as well as the continuing stability of operations performance. Figures comparing Y2019 with Y2018 confirm this stability: the monthly average number of products for Y2018, 11,790 products, is only 3% up on the Y2018 value, while the monthly volume average for Y2019, 181 TiB, is just 2% greater than that of Y2018.

The number and volume of Sentinel-1 NRT products throughout Y2019 (with Y2018 for comparison) is shown in Figure 20. Numbers and volumes are up on Y2018 for almost all months, due to continuing optimisation of the observation scenario. Some small degree of seasonal variation is still observed, as in previous years. This is mainly related to ice monitoring needs and to the different instrument modes (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).

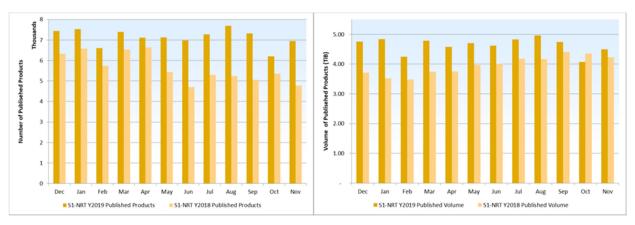


Figure 21: Y2019 and Y2018 monthly number and volume publication trend for Sentinel-1 NRT Production











Sentinel-2

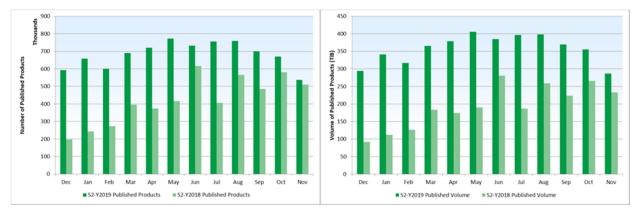


Figure 22: Y2019 and Y2018 number and volume publication trend for Sentinel-2

For Sentinel-2, the average number of products published per month during Y2019 was 682,317 (62% higher than the equivalent figure for Y2018); by volume it was 358 TiB/month (85% higher than for Y2018). In comparison with Y2018, during which Sentinel-2 experienced peaks and dips in product publication outside the expected seasonal variation, the number of products published per month in Y2019 followed a more predictable seasonal curve. More Sentinel-2 products are generated in the summer months when there are more daylight hours in the Northern Hemisphere - which has the larger land mass and is therefore where the majority of Sentinel-2 imaging takes place - and fewer in the winter months. Although this seasonal variation in publication levels will still exist in the future, the

variation is likely to be less pronounced: on 23 October 2019 the Sentinel-2B observation scenario was extended also to include the acquisition of Northern Europe and Arctic areas in low illumination conditions (increasing sun zenith angles up to 85 degrees).

A further cause of growth was the activation of global Level-2A data dissemination on 13 December 2018. Prior to that, Level-2A production had been limited to the Euro-Mediterranean region.

The campaign to repackage the Level-1C old format products into the latest single tile format was finalised in June 2019 replacing an overall of 347,089 old products with 1,317,206 products in the new format, representing a volume of ~635 TB.

Sentinel-3

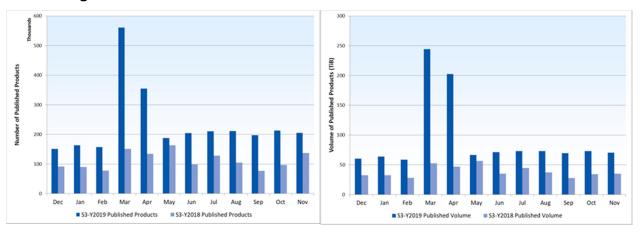


Figure 23: Y2019 and Y2018 monthly number and volume publication trend for Sentinel-3





For Sentinel-3, two clear peaks in product publication stand out from the otherwise relatively even publication figures. In March 2019, the month with the highest publication rate, a total of 560,915 products were published, up a massive 258% from the 156,915 products published during February 2019.

The cause of the sharp increase in publication rates in March and April is illustrated in Figure 24, which shows the Sentinel-3 monthly publication volumes for each of the four product groups (OLCI, SLSTR, SRAL and SYNERGY).

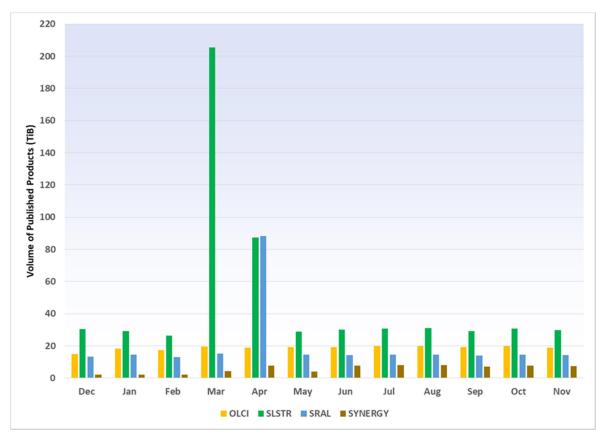


Figure 24: Y2019 monthly volume publication trend per Sentinel-3 product group

In March 2019, there was a huge rise in SLSTR publication (206 TiB), followed by lesser but about equal spikes in both SLSTR and SRAL publication in April (~88 TiB for both). These rises were the result of Sentinel-3 products being transferred from the Sentinel-3 Pre-Ops Hub to the Open Hub, in preparation for full routine dissemination and decommissioning of the pre-ops hub. For Sentinel-3 SLSTR products, the transition began on 20 March 2019 for Sentinel-3A and on 21 March 2019 for Sentinel-3B. The transition included the publication of Sentinel-3A NTC historical data belonging to a specified Processing Baseline and providing a homogenous time series from the start of the

Sentinel-3A mission (19 April 2016 to 5 April 2018). The re-processed dataset covered both Level-1 and Land Level-2 products. Similarly, in the case of the SRAL rise in April, from 19 April 2019 Sentinel-3A SRAL reprocessed data began to be incrementally made available from the Open Hub, covering the reference period 1 March 2016 to 1 February 2018. Final decommissioning of the Sentinel-3 Pre-Ops Hub took place on 19 June 2019.

Table 4 presents a breakdown of the number of reprocessed products for both SLSTR and SRAL Level-1 and Level-2 products, and shows the percentage each set of reprocessed products constituted of the overall SLSTR and SRAL

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publication during Y2019. 35% of all SLSTR products published in Y2019 and 25% of all SRAL products were reprocessed products. No reprocessed OLCI or SYNERGY products were published during the year.

Two further developments contributed to the increase in the monthly publication rate as compared with the Y2018 figures. The data products from Sentinel-3B started to be published in Y2019: Sentinel-3B SRAL started to be published on 11 December 2018; Sentinel-3B OLCI L1 on 17 December 2018; and Sentinel-3B SLSTR on 21 March Secondly, Sentinel-3 NRT products were released for the first time, directly on the Open Hub, in the first half of Y2019: Sentinel-3B OLCI Level-2 NRT on 24 January 2019; and Sentinel-3A and 3B SLSTR Level-2 NRT on 21 March 2019.

The publication of SYNERGY products increased steadily throughout the year. These products, which rely on a combination of OLCI and SLSTR data (see next section for the full composition), were first made available on the Sentinel-3 Pre-Ops Hub on 10 October 2018 and began to be published on the Open Hub on 25 March 2019.

If all months in Y2019 are included in the calculation, the average publication rate for Sentinel-3 products was 234,536 products/month and the average volume was 94 TiB/month. If the outlier months of March and April are excluded, the average publication rates become 189,874 products/month and 68 TiB/month, up 69% and 74% respectively from the Y2018 averages.

Instrument	Product Level	Y2019 Total No. of Products Published	Y2019 Total No. of Reprocessed Products Published	% Reprocessed Products
SLSTR	Level 1	807,142	343,736	42
	Level 2	195,163	10,112	5
	Total	1,002,305	353,848	35
SRAL	Level 1	156,346	38,330	24
	Total	156,346	38,330	24

Table 4: Y2019 total numbers of SLSTR and SRAL reprocessed products, and percentage of total published

Sentinel-5P

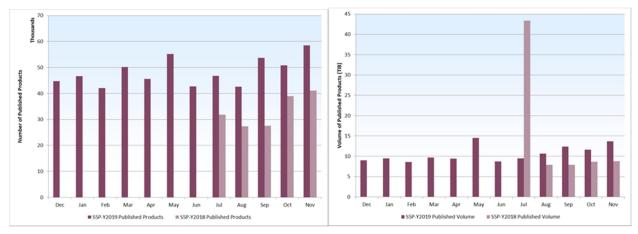


Figure 25: Y2019 monthly volume and number publication trend for Sentinel-5P

The Sentinel-5P Pre-Ops Hub began routine operations on 11 July 2018, and was still being used to publish products from the mission at the end of Y2019. During Y2019 an average of 48,278

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products/month were published on the pre-ops hub, corresponding to an average volume of 11 TiB/month.

Figure 25 shows an overall growth in the number and volume of Sentinel-5P products published per month, as would be expected with the mission ramp up and release of new product types. During Y2019 the following Level-2 product activations were achieved:

- Formaldehyde total column (S5P_L2_HCHO__) from o5 December 2018
- Sulfur Dioxide total column (L2_SO2__) from o5 December 2018









- Methane total column (L2_CH4_) (NTC(OFFL)) from o1 March 2019
- Ozone tropospheric profile (L2_O3_TCL) (NTC(OFFL)) from 01 March 2019
- Aerosol Layer Height (L2_AER_AI) (NRT and NTC(OFFL)) from 19 September 2019

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

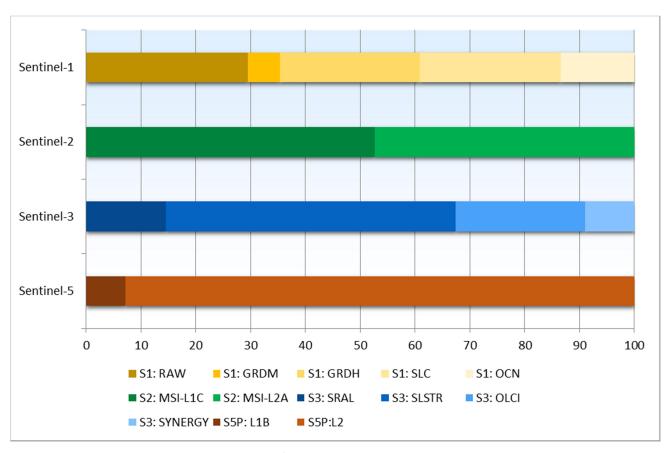


Figure 26: Percentage published number of products per Sentinel mission and product type during Y2019











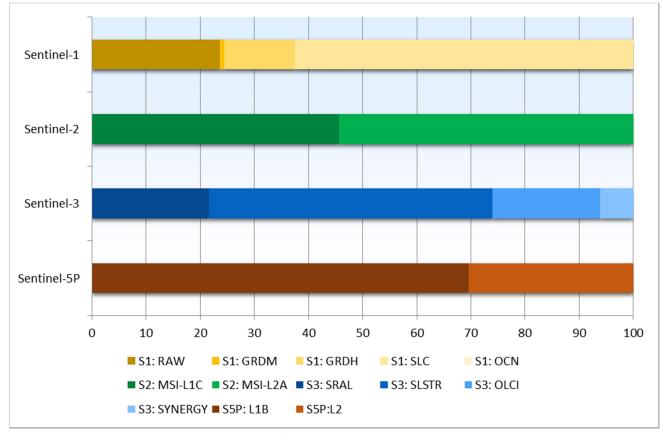


Figure 27: Percentage published volume of products per Sentinel mission and product type during Y2019

Figures 26 and 27 show, for Sentinels 1, 2 and 3, the total percentage published for each product type, both in terms of number and volume of products, during Y2019. For Sentinel-3, for the purposes of readability, the 14 individual product types have again been collected into four product groups: SRAL, SLSTR, OLCI and SYNERGY; similarly for Sentinel 5P, the 23 individual product types have been grouped in either Level-1B or Level-2.

For **Sentinel-1** the following product types were available during Y2019:

- Level o (Lo-RAW)
- Multi-Look, Level 1 Ground Range, 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 o accounts for 29% 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. These percentages for number and volume are very similar to those of Y2018.

For **Sentinel-2** the published product types are:

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

Sentinel-2 published products by number consisted of 53% Level-1C and 47% Level-2A. By volume the split was: 46% Level-1C and 54% Level-2A. This is a dramatic change from previous years, when Level-1C dominated. For example, during Y2018 L1C accounted for 94% by number and 92% by volume. The split is now almost equal, though while Level-1C accounts for a slightly higher percentage by number, Level-2A now accounts for a larger volume percentage due to the larger size of individual products. This change is due to the activation of global Level-2A data dissemination on 13 December

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2018. Previously, only the Euro-Mediterranean region had been covered.

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

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 8oHz)
- 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 SL_1_RBT___ Brightness temperatures and radiances
- Level 2 SL_2_LST___ Land Surface Temperature geophysical parameters Level

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









By number, SLSTR products account for the majority of overall publication: 53%. Next are OLCI with 24%, SRAL with 15% and SYNERGY with 9%. The split by volume is quite similar, although SRAL then accounts for slightly more than OLCI (22% vs 20%).

For **Sentinel-5P** the published product types are:

TROPOMI Level-1B radiance/irradiance products:

- L1B_RA_BDx (x=1-8): Radiance products bands 1-8 (UV (1,2), UVIS (3,4), NIR (5,6), SWIR (7,8))
- IR_UVN: Irradiance product UVN module
- IR_SIR: Irradiance product SWIR module

TROPOMI Level-2 geophysical products:

- L2__O3___: Ozone total column
- L2__O3_TCL: Ozone tropospheric column
- L2__O3_PR: Ozone profile
- L2__O3_TPR: Ozone tropospheric profile
- L2__NO2__: Nitrogen dioxide, total and tropospheric columns
- L2__SO2__: Sulfur dioxide total column
- L2__CO___: Carbon monoxide total column
- L2__CH4___: Methane total column
- L2__HCHO__: Formaldehyde total column
- L2__CLOUD_: Cloud fraction, albedo, top pressure
- L2__AER_AI: UV aerosol index
- L2__AER_LH: Aerosol layer height (midlevel) pressure
- L2__NP_BDx (x=3,6,7): Suomi-NPP VIIRS clouds

Split by product level and by number, Level-1B accounted for 93% while Level-2 accounted for 7%; by volume the split was 70% Level-1B and 30% Level-2. This is accounted for by the fact that Sentinel-5P Level-1B products are much larger than Level-2 (see Annex 2).

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



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scenarios for each mission, which are available online via the following links:

For Sentinel-1:

https://sentinels.copernicus.eu/web/sentinel/mission s/sentinel-1/observation-scenario

For Sentinel-2:

https://sentinels.copernicus.eu/web/sentinel/mission s/sentinel-2/observation-scenario

For Sentinel-3:

https://sentinels.copernicus.eu/web/sentinel/mission s/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/documents/247904/6 85154/Sentinel_High_Level_Operations_Plan

For Sentinel-5p, there is no separate observation scenario as the operations do not in general vary from the baseline scenario set out in the HLOP.

Sentinel-1

Figure 28 displays a heatmap showing the geographical coverage of all Sentinel-1 products published from the start of operations until the end of Y2019. The colour scale illustrates the differing numbers of products published for each area around the globe; red zones are the areas over which the greatest numbers of Sentinel-1 products have been published, as indicated by the key. All product types except WV mode products are included in the count; WV mode products, which are available over oceans and coastal zones, are not included in the calculation due to the different footprint used in 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 far northern and southern sea ice regions.

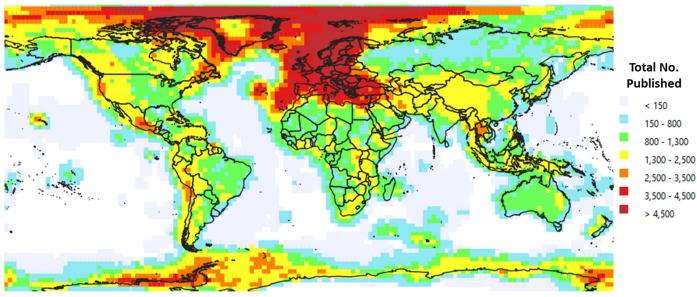


Figure 28: Heatmap of Sentinel-1 products (excluding OCN) published from the start of operations to the end of Y2019

In line with the observation scenario, the greatest density of products is seen over Europe, the arctic regions and, to a lesser extent, Antarctica. A full coverage of European land (EEA-39 countries) and surrounding seas (Exclusive Economic Zones - EEZ) is performed at each constellation repeat cycle (6 days) to support many Copernicus and national activities. A full coverage is ensured every constellation repeat cycle both in ascending and descending passes, thus providing a very good revisiting frequency. Sentinel-1



is also used to complement the observations over Europe and support in particular some activities of the Copernicus services outside Europe, some national services / use on national territories outside Europe (e.g. Canada or French and UK overseas territories / departments) and some national services / use outside national territories (e.g. Antarctica), as well as to support international cooperation. Moreover, additional observations are performed to support key activities which are only possible with SAR data (e.g. InSAR related applications for geo-

hazard and tectonic areas monitoring).

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 29, 30 and 31 respectively. The Wave mode, continuously operated by default over open oceans, is not shown in a map. In all cases they take as input the locations of all products published from the start of operations up to the end of Y2019. For ease of comparison, the keys and ranges are the same in each case. 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. Other zones of high publication include the mid-Atlantic and the Indian Ocean around Madagascar. The GRDM products are related to the EW mode (Extra Wide Swath).
- GRDH & SLC mostly available over land masses. The GRDH and SLC products are (mainly) related to the IW mode (Interferometric Wide Swath) and the SM mode (Stripmap). A marginal number of SLC products are generated with the EW mode. The particular density of GRDH and SLC products over Europe and Greenland areas reflects the evolution of the Sentinel-1 observation scenario, which initially focused on Europe, and generally the higher observation frequency over Europe.

Detailed information about the Sentinel-1 observation scenario is set out in the HLOP, and on the dedicated Sentinel-1 section of Sentinel Online, at

https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario.

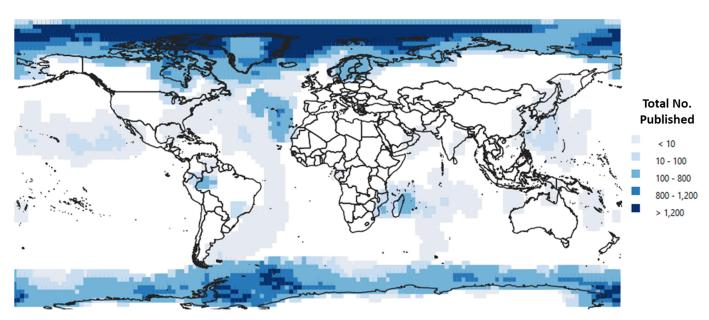


Figure 29: Heatmap of Sentinel-1 GRDM products published from the start of operations to the end of Y2019











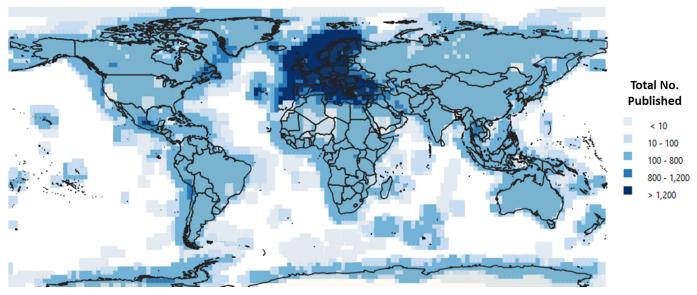


Figure 30: Heatmap of Sentinel-1 GRDH products published from the start of operations to the end of Y2019

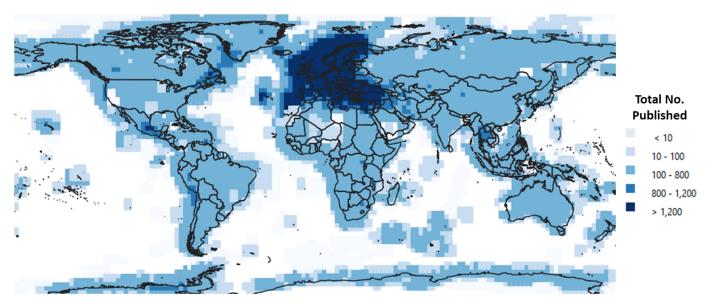


Figure 31: Heatmap of Sentinel-1 SLC products published from the start of operations to the end of Y2019

Sentinel-2

Figures 32 and 33 below show heatmaps for Sentinel-2 published products, respectively for Level-1C products and Level-2A products, and in both cases from the start of operations until the end of Y2019.

As in previous years, the L1C heatmap shows that the coverage is relatively evenly distributed over the globe's landmasses (excluding Antarctica). The particular density over the arctic regions is due to the polar orbits of the satellites, which mean the higher the latitude, the greater the revisit frequency. The same effect is not seen for Antarctica partly because

only the coastline areas of Antarctica are included in the observation scenario, and partly because only one of the two Sentinel-2 satellites is used for observations over Antarctica.

Given that Level-2A production has been available on a global-coverage basis since December 2018, a quite even distribution over the same landmasses can now be observed, albeit at lower numbers than for Level-1C. There is however, still an emphasis on the Euro-Mediterranean area, due to L2A products having previously only been available over that region. It should be noted that these heatmaps will always be an approximation and cannot represent a precise

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one-to-one mapping with the published products due to the need to merge the Sentinel-2 product grid onto the heatmap global projection. Some small anomalies are visible; in particular, the 'dots' across parts of Siberia and Canada in the Level-2A heatmap are most likely an artefact caused by plotting the Sentinel-2 product grid onto the map projection. Similarly, the apparent lower publication levels in the Level-2A heatmap over some small areas of southern Europe are also likely to be the result of the map projection rather than truly reflecting lower publication levels these over areas.

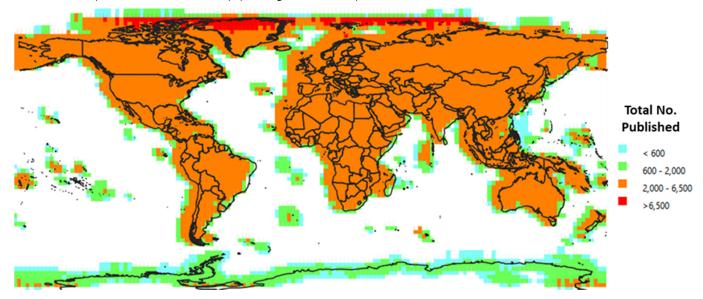


Figure 32: Heatmap of Sentinel-2 Level-1C products published from the start of operations to the end of Y2019

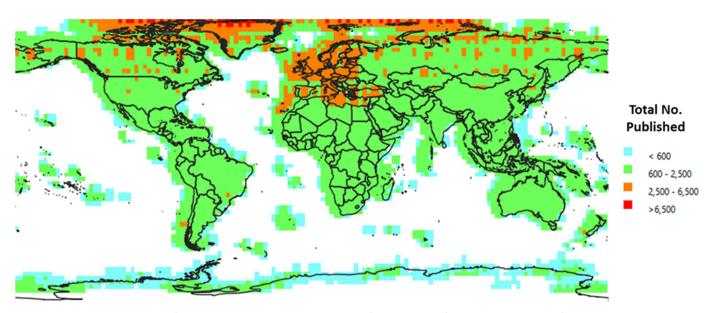


Figure 33: Heatmap of Sentinel-2 Level-2A products published from the start of operations to the end of Y2019

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 to the end of Y2019. They are separated

out by product group. For SRAL products, a separate 'NRT Level-2' heatmap is also provided. SRAL, SRAL-NRT, OLCI and SLSTR are shown in Figures 34, 35, 36 and 37 respectively. Care should be taken when reading the keys, which are different for each plot

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depending on the number of products published for each instrument.

Sentinel-3 products are far more evenly distributed over the globe than for Sentinel-1 and -2. Only SRAL-NRT Level-2 products are focused on land areas. The apparent emphasis on the poles for all product types is a result of the higher revisit frequency over these regions. For SYNERGY products, the unusual features seen in the heatmap are a result of the large size and non-uniform shape of SYNERGY products: for further details refer to Annex 2 and https://sentinel.esa.int/web/sentinel/userguides/sentinel-3-synergy.

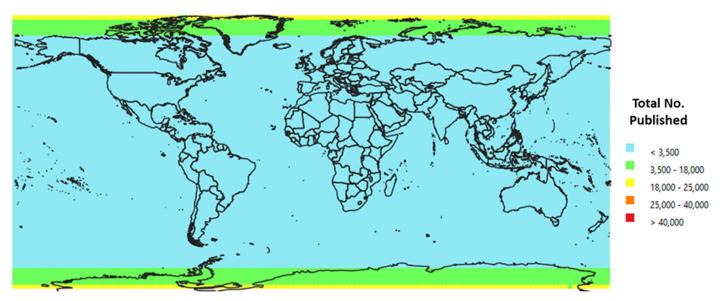


Figure 34: Heatmap of Sentinel-3 SRAL products published since the start of operations to the end of Y2019 (excluding NRT and Level-2)

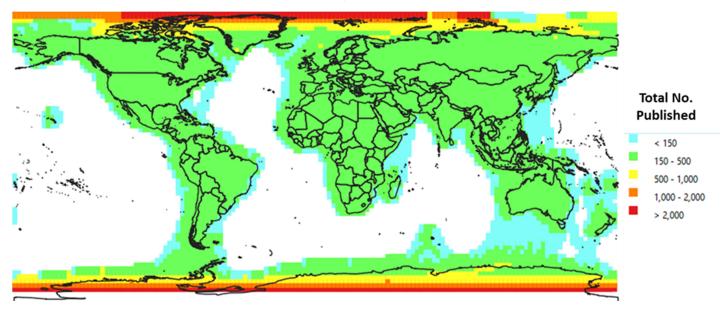


Figure 35: Heatmap of Sentinel-3 SRAL-NRT products published from the start of operations to the end of Y2019



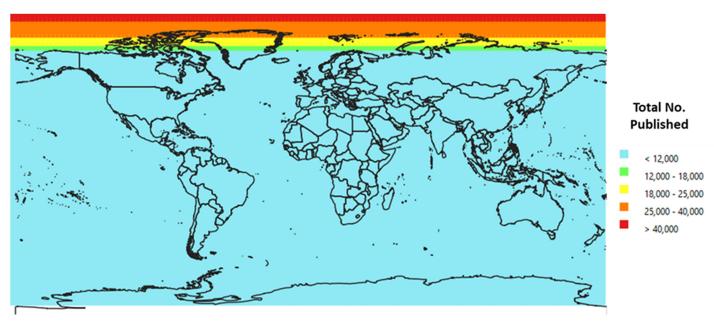


Figure 36: Heatmap of Sentinel-3 OLCI products published from the start of operations to the end of Y2019

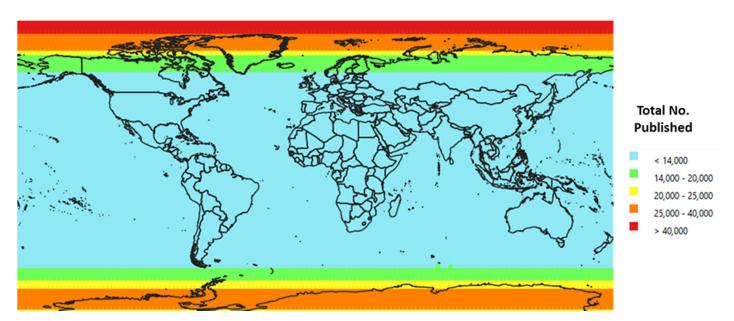


Figure 37: Heatmap of Sentinel-3 SLSTR products published from the start of operations to the end of Y2019



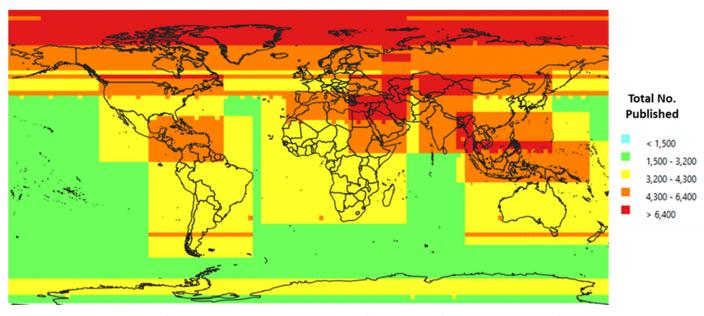


Figure 38: Heatmap of Sentinel-3 SYNERGY products published from the start of operations to the end of Y2019

Sentinel-5P

Sentinel-5P systematically senses data on the daytime portion of all orbits, meaning the heatmap for publication is uniform. It is shown below, made up from all Sentinel-5P products published from the start of operations until the end of Y2019.

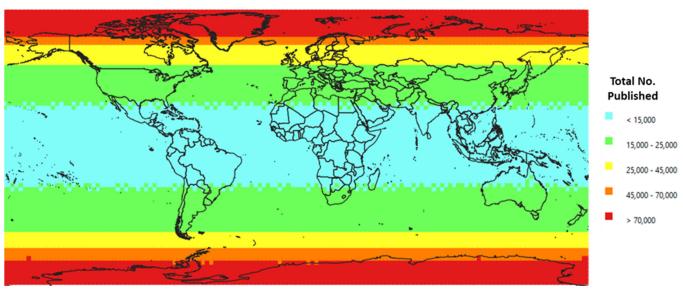


Figure 39: Heatmap of Sentinel-5P products published from the start of operations to the end of Y2019

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Product Downloads

This section looks at user activity in terms of the level of downloads which users made during Y2019 and the types of products which they chose to download.

It is highlighted 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,

2.3.1 Download growth

By the end of Y2019, a huge 158 PiB of Sentinel data products had been downloaded from the Data Access System since the start of operations.

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

It should also be noted that in this section the statistics cover downloads from the following hubs: Open Hub, Collaborative Hub, International Hub and Copernicus Services Hub. Downloads from the DIAS Hub are presented separately, in Section 2.3.3.1, because the DIAS partners systematically download the full collection of data products.

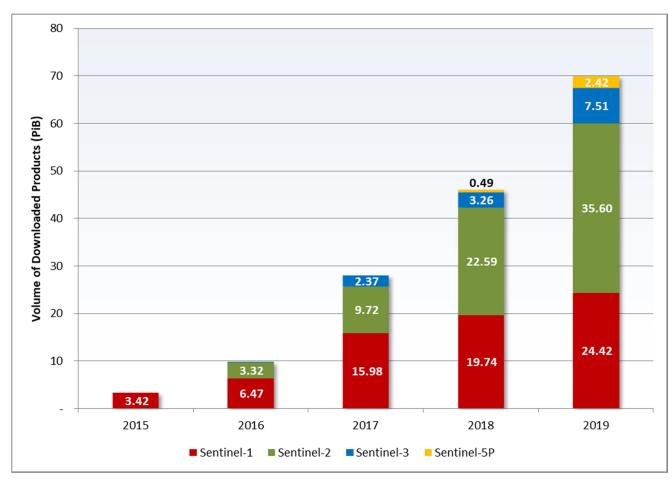


Figure 40: Total volume of products downloaded per year since the start of operations from all of the four hubs, differentiated by

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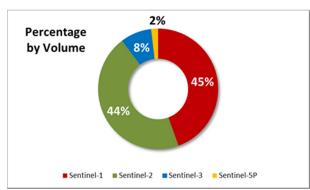












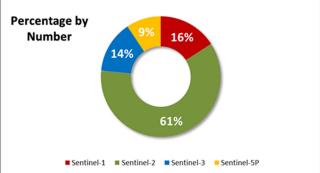


Figure 41: Percentage of total downloads per mission since the start of operations for all of the four hubs, on the left by volume and on the right by number

Figure 41 breaks these totals down per mission and per year, and compares the total volume of data downloaded by the end of Y2019 with the total volume which had been downloaded by the end of all previous periods, i.e. reporting years 2015-2018. As shown, 69.95 PiB of the total volume of downloads since the start of operations was downloaded during Y2019 alone. This represents about 44% of the total downloaded volume and is a 52% increase on the total volume downloaded during Y2018. exponential growth in the volume of data downloaded by users during the first 5 years of Sentinel operations is clear: in Y2019, users downloaded 20 times the volume of data which they downloaded in Y2015.

In terms of *number* of user downloads, during Y2019 a total of 128.2 million user downloads were made, a 78% rise on the 71.9 million downloaded during Y2018. This huge number of user download requests demonstrates not only sustained and increasing user enthusiasm for Copernicus Sentinel data but also that the Data Access System remains capable of serving the ever-increasing number of requests, despite the complexity of managing the requests and the massive volumes of data involved.

Figure 40 also shows that in Y2019 the most notable increases in download volumes were observed for Sentinel-3 and Sentinel-5P. Sentinel-3 downloads increased by 130%, rising from 3.26PiB during Y2018 to 7.51 PiB during Y2019, and accounting for 11% of the total volume of user downloads for the year, up significantly from the 7% recorded for Y2018. There was an even sharper increase in the volume of Sentinel-5p products downloaded by users, with a total almost 400% higher than the volume downloaded in Y2018, and accounting for 3% of the total user downloads made in Y2019. It is recalled, of course, that Y2019 was the first full year of Sentinel-5P operations, and it was a year in which the product offer was increased with several new product types.

Increases in download volumes were also seen for both Sentinel-1 and Sentinel-2, and these two missions still accounted for 86% of the volume of all user downloads during the year. As a proportion of the yearly volume of downloads, Sentinel-2 data continued to be the most downloaded for the year, accounting for 51% of the volume of all user downloads in Y2019. Sentinel-1 fell slightly, from 42% of the volume of user downloads during Y2018 to 35% during Y2019.

Figure 41 shows that when all downloads since the start of operations are taken into account, both Sentinel-1 and Sentinel-2 have almost equal splits of the total volume: 45% and 44% respectively. In terms of number of products, however, Sentinel-1 downloads account for much less: only 16%, compared to a massive 61% for Sentinel-2. Due to their smaller average product size, both Sentinel-3 and Sentinel-5P also have a greater impact in number terms than in volume terms. While Sentinel-3 only made up 8% of the total downloads since the start of operations by volume, it accounted for 14% by number; Sentinel-5P accounted for only 2% of volume but 9% by number.

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2.3.2 Archive Exploitation Ratio (AER)

Archive Exploitation Ratio



Figure 42: Archive Exploitation Ratio per mission at the end of Y2019

Interest in Sentinel products can be monitored by looking at the 'Archive Exploitation Ratio' (AER). The AER which is shown in Figure 42 above was calculated at the end of Y2019 and represents the total number of user downloads made from all the hubs since the start 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 products published from a mission, there was an average number of X downloads.

The AERs reported in Figure 41 show that user interest in Sentinel-1 and Sentinel-2 products was equally strong, and remains as it was for 2018 (both at 1:12). Engagement with Sentinel-3 products is slightly lower, but remains at 1:8, as in Y2018. However, the mission which recorded the largest growth during Y2019 - in fact the largest growth in AER ever recorded for any mission – was Sentinel-5P. As the mission has become operational and new products have been made available, the AER has grown to 1:26, from an already impressive 1:9 in Y2018. Even though there are still far fewer total products available for Sentinel-5P than for the other missions, user interest in the products is already substantial.

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 Y2019. 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.

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Sentinel-1

Level	Timeliness	Number of Published	Number of Downloaded	Archive	
revei Timeliness		Products in Y2019	Products in Y2019	Exploitation Ratio	
Level 0	NTC	400,573	3,823,957	1:9.5	
Level 1	NTC	760,148	15,545,701	1:20.5	
Level 1	NRT	85,587	693,255	1:8.1	
Level 2	NTC	183,175	3,263,149	1:17.8	

Table 5: Sentinel-1 Products Published, Downloaded and AER for Y2019, 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	1,446,644	9,142,824	1:6.3	
Level 1	NTC	2,886,203	43,800,380	1:15.2	
Level 1	NRT	244,644	2,019,193	1:8.3	
Level 2	NTC	452,824	7,432,797	1:16.4	

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

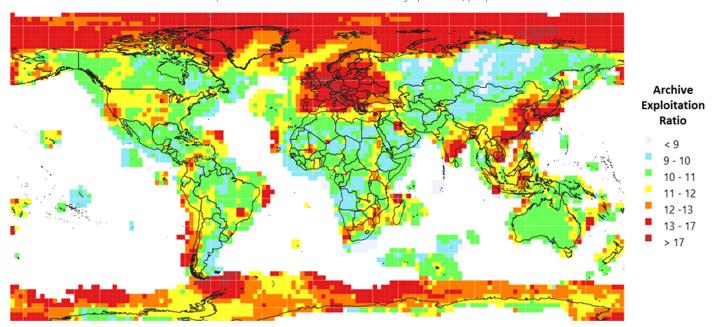


Figure 43: Heatmap showing the archive exploitation ratio for Sentinel-1 Lo and L1 NTC products (excluding WV mode) during Y2019

In terms of the most popular Sentinel-1 product levels/timelinesses, Tables 5 and 6 show that the most popular products are Level 1 and Level 2 NTC products, with AERs of 1:21 and 1:18 respectively. Level 1 NRT products have an AER around half that of NTC, at 1:8, while the Level o NTC have the lowest AER at 1:6. It is interesting to note that uptake of the Level-1 NRT products has not varied, either with respect to Y2018 or with respect to the overall uptake since the start of operations, remaining stable at 1:8. On the other hand, the figures suggest that user engagement with each of the other products has increased since Y2018. In particular, the AER for the Level-1 NTC products has jumped from 1:17 last year to 1:21 in Y2019, and the AER for Level-2 NTC products has risen from 1:15 to 1:18. In line with this, an overall upward trend is also observed for the AERs

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calculated from the start of operations: the AER for Level-o NTC products has risen from 1:5 in Y2018 to 1:6 in Y2019; for Level-1 NTC products it has risen from 1:14 in Y2018 to 1:15 in Y2019; and for Level-2 NTC products the AER has risen from 1:15 to 1:16.

Looking at the figures underlying the AERs, the numbers of products published during the Y2019 grew from that published in Y2018 for all product types in the range 2-5%, with the exception of Level-1 NRT, which grew by 25%. However, the number of downloads grew by a greater amount, in the range 20-30%, and this led to the higher AERs.

Figure 43 indicates the geographical areas of interest for users of Sentinel-1 Lo and L1 NTC products, measured by AER. It shows how many downloads were made during Y2019 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 Sentinel-1 Level-2 products) are excluded from the map. The

Figure can be compared with the corresponding Sentinel-1 publication heatmap in Figure 28. It is noted that all map cells which had fewer than 100 products published within them since the start of operations are excluded from the AER heatmap as systematic downloads over them can give a misleading impression of which areas are most popular.

The heatmap shows that interest in Sentinel-1 products is concentrated largely on the Earth's landmasses, almost all of which show an AER of greater than 1:9. Overall, the largest concentrations of interest appear over Europe and high latitude Northern and Southern ice-covered regions, for sea and land ice monitoring. In these areas the AER is generally above 1:13 and can go higher than 1:17. There are other AER hotspots across the globe including: the United States eastern seaboard, the Chilean coast, South East and Far East Asia and Eastern India. Some of these are clearly linked to tectonic boundaries, for which interferometry based on radar data can be used to monitor activity levels and assist in disaster response operations.

Sentinel-2

Level	Number of Published Products in Y2019	Number of Downloaded Products in Y2019	Archive Exploitation Ratio
Level 1C	4,303,051	69,699,659	1:16.2
Level 2A	3,884,753	28,931,362	1:7.4

Table 7: Sentinel-2 Products Published, Downloaded and AER for Y2019, 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	10,770,097	155,181,953	1:14.4
Level 2A	4,303,374	32,835,134	1:7.6

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



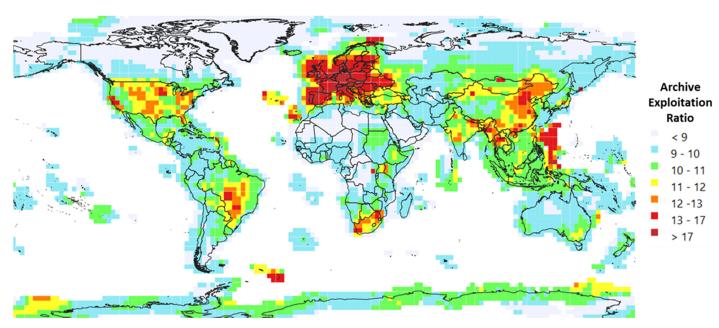


Figure 44: Heatmap showing the archive exploitation ratio for Sentinel-2 L1C products during Y2019

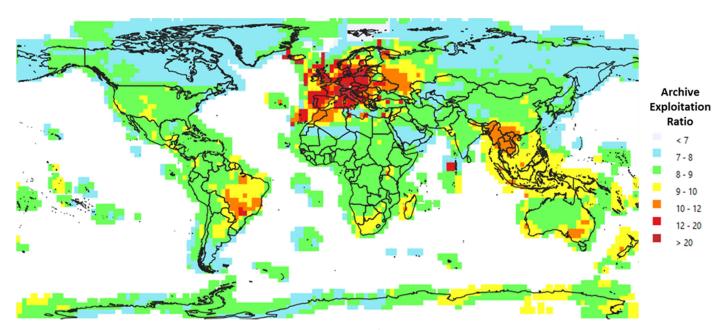


Figure 45: Heatmap showing the archive exploitation ratio for Sentinel-2 L2A products during Y2019

Y2019 saw huge increases in both the numbers of products published and downloaded for both Level-1C and Level-2A. In particular, for Level-2A, the ramp-up to global coverage meant that by the end of Y2019 there were about 10 times as many Level-2A products published in Y2019 as there had been by the end of Y2018. The AER for Level-2A products suggests that users were not quite able to keep pace with this sudden expansion in the number of products published. In Y2018, the AER for Level-2A

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Date 25/05/20 Issue 1 Rev 0 products was 1:9 whereas in Y2019, it fell slightly to 1:8. On the other hand, the AER for Level-1C products rose from 1:13 in Y2018 to 1:14 in Y2019.

Figures 44 and 45 indicate the geographical areas of interest for users of Sentinel-2 Level-1C and Level-2A products, respectively, measured by AER. They show how many downloads were made during Y2019 per available product over specific geographical points across the globe, taking into account all products published since the start of operations. The figures









can be compared with the Sentinel-2 publication heatmap (Figures 32 and 33). It is noted that all map cells for Level-1C (Figure 44) which had fewer than 300 products published within them since the start of operations are excluded from the AER heatmap, as systematic downloads over them can give a misleading impression of which areas are most popular.

For both product types, the global spread is quite similar: the areas with the highest AERs are, as expected, European landmasses, where the AER is mainly greater than 1:12 for both Level-1C and Level-

2A. Similar levels of interest are shown over the landmasses of North and South America, Asia and Oceania, with AERs generally in the range of 1:9 – 1: 17 for Level-1C and 1:18 – 1:12 for Level-2A. There are some noticeable non-European 'hotspots' where user downloads have been concentrated, such as East and Southeast Asia, central/southern Brazil, South Africa and New South Wales. Siberia, northern Canada, the Middle East, central Australia and Saharan Africa are the approximate land areas over which users have shown the least activity, with AERs less than 1:9 for Level-1C and around 1:8-9 for Level-2A.

Sentinel-3

Instrument	Number of Published Products in Y2019	Number of Downloaded Products in Y2019	Archive Exploitation Ratio
SLSTR	1,845,018	11,203,402	1:6.1
SRAL	409,247	3,548,608	1:8.7
OLCI	664,013	7,656,511	1:11.5
SYNERGY	336,541	1,479,379	1:4.4

Table 9: Sentinel-3 Products Published, Downloaded and AER for Y2019, per product group

Instrument	Number of Published Products since Start of Operations	Number of Downloaded Products Start of Operations	Archive Exploitation Ratio
SLSTR	2,770,920	18,219,239	1:6.6
SRAL	830,881	8,414,017	1:10.1
OLCI	1,525,757	13,455,729	1:8.8
SYNERGY	349,681	1,507,648	1:4.3

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

Tables 9 and 10 show, for Y2019 and since the start of operations respectively, the AER for Sentinel-3, split by product group: SLSTR, SRAL, OLCI and SYNERGY. Of the product groups, the most popular during Y2019, measured by AER, was OLCI with an AER of 1:12, followed by SRAL with an AER of 1:9. The significant increase in the AER for OLCI, from 1:7 in Y2018 to 1:12 in Y2019, was driven mostly by a rise in downloads: downloads were up 90% in the year, while published numbers were up only 10%.

Interestingly, both OLCI and SRAL products had higher exploitation rates in Y2019 than SLSTR, which had the highest AER during Y2018. The AER for

SLSTR products decreased from 1:8 in Y2018 to 1:6 in Y2019. The number of SLSTR products which users downloaded actually increased by 192% compared with Y2018, so the fall in the AER for SLSTR is explained by the even larger rise in SLSTR products which were published in Y2019: the number of SLSTR products published in Y2019 was 264% higher than the number published in Y2018.

However, it is notable that for SYNERGY products there was also a huge increase in number of products which were published in Y2019 as compared with Y2018, and yet the AER nonetheless increased from 1:2 in Y2018 to 1:4 in Y2019. SYNERGY products only

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started to be made available from October 2018, meaning that only 13,140 products were published by the end of Y2018. During Y2019, The number of SYNERGY products published rose to 336,541, but download numbers rose even more steeply, to 1,479,379, leading to the doubling in the AER. This fast rapid take-up rate suggests the SYNERGY products have been adopted with enthusiasm by the Sentinel-3 user community.

When the AERs are calculated using the download and publication numbers from the start of operations, the pattern looks slightly different. It is SRAL, rather than OLCI, which has the highest AER, as was also the case in Y2018, , although the AER for SRAL products dropped slightly to 1:10 from 1:12 at the end of Y2018. The AERs for SLSTR also dropped slightly, from 1:8 at the end of Y2018 to 1:7 at the end of Y2019. The AER for OLCI rose , from 1:7 at the end of Y2018 to 1:9 at the end of Y2019, and the SYNERGY AER doubled from 1:2 to 1:4.

The remainder of this section examines in greater detail the AERs for each Sentinel-3 product groups, as well as portraying geographical areas of interest for Sentinel-3 users in heatmaps.

	SLSTR						
Level	Timeliness	Number of Published Products	Number of Downloaded Products	Archive			
Level		since Start of Operations	since Start of Operations	Exploitation Ratio			
Level 1	NTC	1,321,255	9,397,474	1:7.1			
Level 1	NRT	788,029	5,730,159	1:7.3			
Lovel 2	NTC	34,059	225,755	1:6.6			
Level 2	NRT	627,577	2,865,851	1:4.6			

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

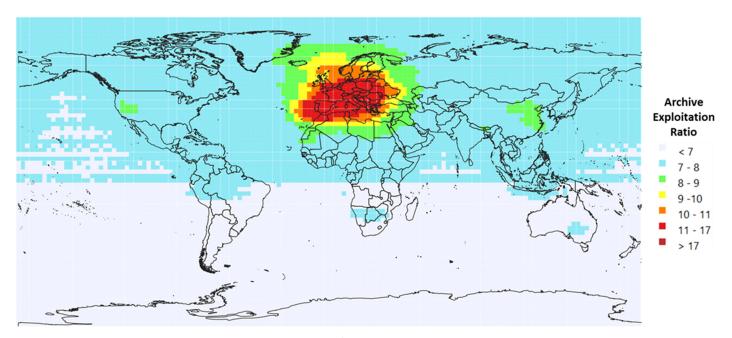


Figure 46: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-1 NTC products during Y2019









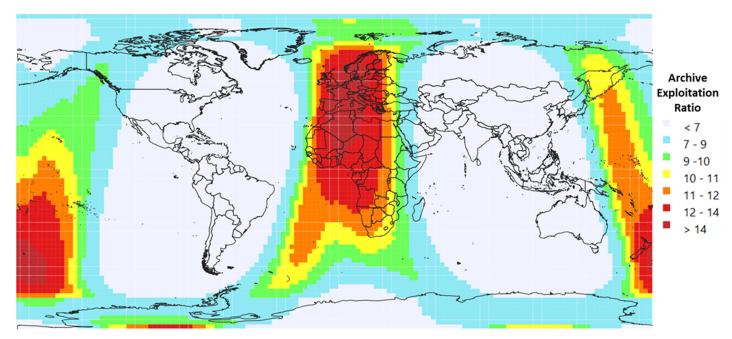


Figure 47: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-2 NTC products during Y2019

Table 11 breaks down the AER for SLSTR products by product level and timeliness (NTC or NRT). The AERs are calculated from the start of operations. The table shows that in fact the overall AER of 1:6 for SLSTR products is the result of the lower AER for the SLSTR Level-2 products, which had an AER of 1:5 by the end of Y2019. Each of the other product groups had an AER of 1:7, equivalent to an average of seven user downloads per product published. The notable change since Y2018 is the fall in the AER to 1:7 for the Level-1 products: the NTC products had had an AER of 1:10 at the end of Y2018, and the NRT products had had an AER of 1:8. On the other hand, the AER for the Level-2 NRT products had slightly risen, having been 1:4 at the end of Y2018. The AER for the Level-2 NTC products had already been 1:7 at the end of Y2018.

The heatmaps in Figures 46 and 47 show the geographical variation in AER for regions across the globe during Y2019 for SLSTR Level-1 and Level-2

NTC products respectively. SLSTR 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, as in previous years, downloads were concentrated on the Northern Hemisphere, and particularly over Europe where the AER rises above 1:11. A couple of interesting outlier hotspots also appear in the eastern regions of China and the western regions of the United States, where the AER reached 1:8-9.

Figure 47 shows the equivalent heatmap for Level-2 NTC products, the footprints of which cover the entire globe with each pass. All regions of the globe show an AER of at least 1:7. 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 at some points rises above 1:14 (the dark red regions on the map).

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	SRAL						
Level	Timeliness	Number of Published Products	Number of Downloaded Products	Archive			
	rimeliness	since Start of Operations	since Start of Operations	Exploitation Ratio			
	NTC	206,809	1,298,901	1:6.3			
Level 1	STC	118,579	683,322	1:5.8			
	NRT	218,063	2,781,481	1:12.8			
	NTC	77,180	1,423,655	1:18.4			
Level 2	STC	41,509	347,759	1:8.4			
	NRT	168,741	1,878,899	1:11.1			

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

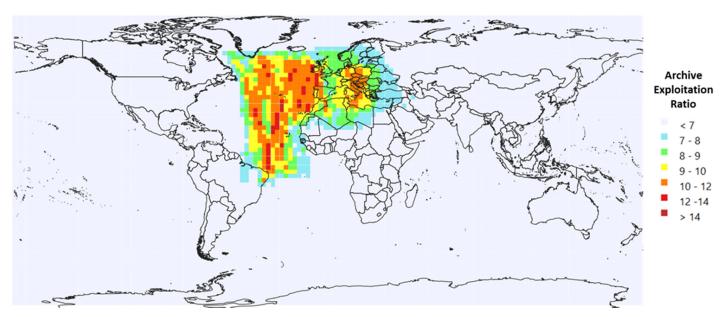


Figure 48: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-1 NRT products during Y2019

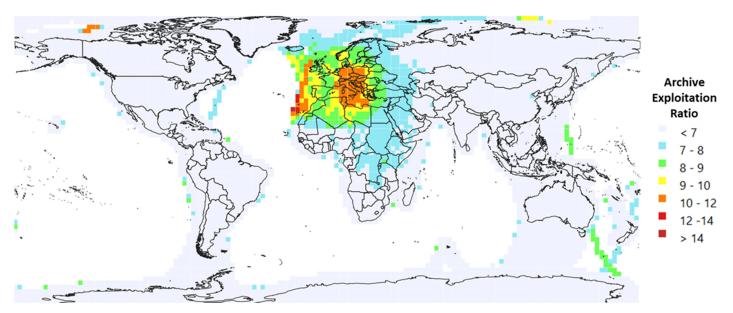


Figure 49: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-2 NRT products during Y2019

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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/userguides/sentinel-3-altimetry/product-types/nrt-orntc). The AERs have been calculated 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 the SRAL products which have the greatest AERs are Level-2 NTC, with an elevated AER of 1:18 (up from 1:11 in Y2018), and Level-1 NRT with an AER of 1:13 (down from 1:20 during Y2018). In Y2018, it was both of the NRT product groups which had had the highest AERs, but by the end of Y2019, the Level-2 NRT AER had fallen from 1:16 to 1:11. As in Y2018, it can be seen that Level-2 NTC products are far more popular than Level-1 NTC, with AERs of 1:18 and 1:6 respectively.

The heatmaps in Figures 48 and 49 show the geographical variation in AER for regions across the globe during Y2019 for SRAL Level-1 NRT and Level-2 NRT products respectively. For Level-1 NRT, a high level of activity can be seen over Europe and northern/central regions of the Atlantic, over which AERs rise above 1:10 and, in some scattered regions, above 1:12. For the rest of the globe, there is interest across the globe, but with AERs at <1:7.

The pattern of geographical interest for the Level-2 NRT products is similar to that for the Level-1 NRT products, although for the Level-2 products downloads are largely restricted to landmasses. As for the Level-1 products, the AER is <1:7 (light blue areas on the map) for most of the Earth's land area). Again, however, there is a focussed area of high activity, this time slightly shifted over to the East, covering less of the Atlantic and more the European, Mediterranean and North African regions. Over central Europe the AER rises to up to 1:10, and the real peaks of activity take place around Madeira and the Canary Islands, where the AER rises over 1:12.

OLCI						
Resolution	Level	Timeliness	Number of Published Products since start of Operations	Number of Downloaded Products since start of Operations	Archive Exploitation Ratio	
	Level 1	NTC	29,057	290,695	1:10.0	
	Level 1	NRT	21,348	214,669	1:10.1	
Reduced	Level 2	NTC	25,243	248,701	1:9.9	
		NRT	16,880	119,932	1:7.1	
		TOTAL	92,528	873,997	1:9.4	
	Level 1	NTC	445,951	4,584,271	1:10.3	
	Level 1	NRT	334,020	2,950,490	1:8.8	
Full	Level 2	NTC	388,079	3,478,955	1:9.0	
	Level Z	NRT	265,179	1,568,016	1:5.9	
		TOTAL	1,433,229	12,581,732	1:8.8	

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











Archive **Exploitation** Ratio < 7 7 - 8.5

9 - 10

12 - 14

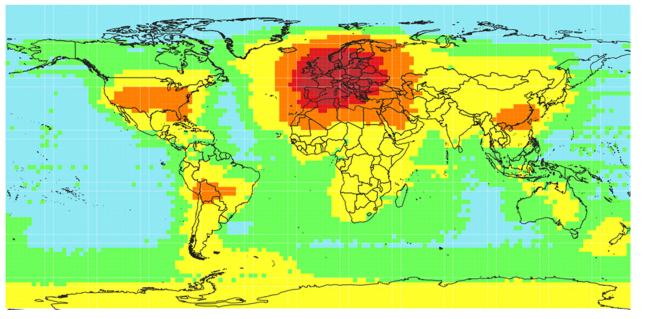


Figure 50: Heatmap showing the archive exploitation ratio for Sentinel-3 OLCI Full Resolution products during Y2019

Table 13 shows a breakdown of the AER for OLCI products, by product level, timeliness (NTC or NRT) and resolution (Reduced or Full). Again, the AERs have been calculated using publication and download figures from the start of operations. AERs range from 1:6 for Full Resolution Level-2 NRT to 1:10 for Reduced Resolution Level-1 NRT. In general, Reduced Resolution products are marginally more popular than Full Resolution, with overall AERs of 1:9.4 and 1:8.8 respectively. This shows a small rise from Y2018, during which these figures were 1:7.4 and 1:6.7.

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

Y2019 for OLCI Full Resolution products. There is interest in OLCI products over the whole globe, with most regions exhibiting AERs of between 1:7 and 1:9 (a rise from the 1:4-1:5 last year). Almost all land masses show AERs of above 1:9. There is a concentration of interest over a large region encompassing the Europe, the Mediterranean, North Africa and the North Eastern Atlantic; over Europe AERs rise above 1:14, the highest observed in any region for OLCI Full Resolution products. Other isolated hotspots, with AERs over 1:10 occur over the United States, South Eastern China, Bolivia and parts of the Amazonian rainforest region in Brazil.

SYNERGY					
Lavel Timedia es		Number of Published Products	Number of Downloaded Products	Archive	
Level	Timeliness	since Start of Operations	since Start of Operations	Exploitation Ratio	
Level 2	NTC	250,771	1,018,620	1:4.1	
Level 2	STC	98.910	489,028	1:4.9	

Table 14: Sentinel-3 SYNERGY Products Published, Downloaded and AER since the start of operations, per product level and timeliness













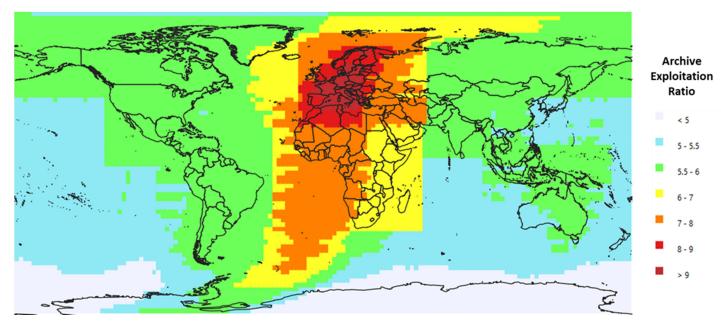


Figure 51: Heatmap showing the archive exploitation ratio for Sentinel-3 SYNERGY products during Y2019

Table 14 shows a breakdown of the AER for SYNERGY products, by product level (only Level 2 is applicable), and timeliness (NTC or STC). Again, the AERs have been calculated using publication and download figures from the start of operations but these figures encompass the first full year of SYNERGY product publication. AERs for both NTC and STC are similar, though slightly higher for the STC products: 1:5 for STC products and 1:4 for NTC.

The heatmap in Figure 51 shows the geographical variation in AER for regions across the globe during Y2019 for SYNERGY products. Interest over most of

the globe seems to be between 1:5 and 1:6, though a concentration of interest over Europe and European longitudes is visible which echoes the SLSTR Level-2 NTC heatmap. Over central and western Europe, the AERs even rise to >1:9.

The overall shape of the features in the heatmap are the result of the large size and irregular shape of some SYNERGY products. For more information, refer to Annex 2 and https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy.

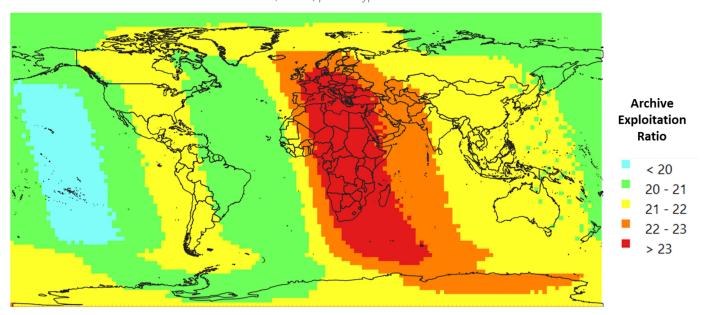




Sentinel-5P

		Product	Number of Published	Number of Downloaded	Archive	
Level	Timeliness		Products since Start of	Products since Start of	Exploitation Ratio	
		Type	Operations	Operations	Exploitation Natio	
Level 1B	NTC	TOTAL	65,365	809,966	1:12.4	
		L2AER_AI	88,327	1,518,486	1:17.2	
		L2AER_LH	10,357	122,078	1:11.8	
		L2CLOUD_	88,230	1,099,378	1:12.5	
		L2CO	63,841	3,133,583	1:49.1	
	NRT	L2HCHO	73,169	1,710,774	1:23.4	
		L2NO2	88,253	3,107,443	1:35.2	
		L2O3	88,170	, ,	1:27.1	
		L2SO2	73,175	2,126,525	1:29.1	
		TOTAL	573,522	15,205,225	1:26.5	
	NTC	L2AER_AI	7,232	182,254	1:25.2	
		L2AER_LH	8,014	58,115	1:7.3	
Level 2		L2CH4	7,927	431,260	1:54.4	
Level 2		L2CLOUD_	12,236	176,407	1:14.4	
		L2CO	8,619	422,833	1:49.1	
		L2HCHO	8,846	195,845	1:22.1	
		L2NO2	9,402	530,831	1:56.5	
	NIC	L2_NP_BD3	7,908	105,180	1:13.3	
		L2NP_BD6	7,916	117,209	1:14.8	
		L2_NP_BD7	7,834	124,371	1:15.9	
		L2O3	11,638	278,787	1:24.0	
		L2O3_TCL	515	61,262	1:119.0	
		L2SO2	9,067	233,282	1:25.7	
		TOTAL	107,154	2,917,636	1:27.2	
	TOTAL [I	NRT + NTC]	680,676	18,932,827	1:27.8	

Table 15: Sentinel-5P Products Published, Downloaded and AER since the start of operations, per product level, timeliness and (Level-2) product type



Figure~52: Heatmap~showing~the~archive~exploitation~ratio~for~Sentinel-5P~NTC~(Level-1B~&~Level-2)~products~during~Y2019~inches for~Sentinel-5P~NTC~(Level-1B~&~Level-2)~products~during~Y2019~inches for~Sentinel-5P~NTC~(Level

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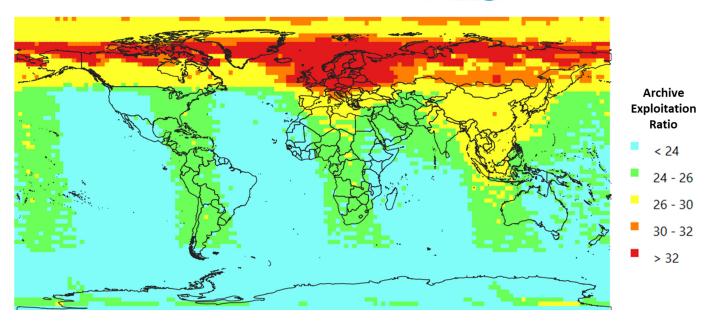


Figure 53: Heatmap showing the archive exploitation ratio for Sentinel-5P NRT (Level-2) products during Y2019

As noted above, Sentinel-5P has seen an extraordinary rise in overall AER during Y2019, up to 1:26 from 1:9 at the end of Y2018. This was brought about by a ramp-up of production for existing products, six additional products added during Y2019 (bringing the total number of products (NRT+NTC) to 31), and a rise in user awareness of the mission. Table 15 reports a detailed view of the take up of Sentinel-5P products. AERs are presented for Level-1B and Level-2 products, for both NTC and NRT and, for Level-2 products, also per individual product type. The table shows that Level-2 products are far more frequently downloaded than Level-1B (overall AERs of 1:12 for Level-1B and 1:28 for Level-2) and that the AER for Level-2 NTC products is very similar to that of Level-2 NRT products (overall AERs of 1:27.2 for NTC and 1:26.5 for NRT). While AERs for all product types have grown significantly, NRT products overall have seen a particularly large increase in interest: at the end of Y2018 their AER was lagging somewhat behind that for NTC. The most popular products by ratio are L2_CO___NTC (1:49), L2_NO2___NTC (1:35), L2_CH4___NRT (1:54), L2_CO___NRT (1:49), and L2_NO2___NRT (1:57). The largest recorded AER was actually for L2_O3_TCL NRT products (1:119), although it is highlighted that since this is a once per day product very few of these products have so far been published (only 515).

Figures 52 and 53 show the heatmaps for Sentinel-5P NTC (Level-1B and Level-2) and NRT (Level-2A only) products respectively. The footprint of NTC products encompass the entire orbit (portion daylight illuminated) and therefore the apparent interest over Europe, through Africa and down into Antarctica is likely the result of interest in products covering Europe which extend over a large latitudinal range (see Annex 2). For NRT products, whose footprints are generally smaller, there is clearly an increased interest over the European continent and high northerly latitudes. There is also a (lesser) increase in interest over China and much of east Asia.

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2.3.3 Download trends

In Table 16 below, the total number and volume of product downloads since the start of operations are broken down per hub, showing the different levels of user uptake on each hub. It is recalled again that only downloads from the Open Hub, Collaborative Hub,

International Hub and Copernicus Services Hub are examined. Downloads from the Sentinel-5P PreOps Hub are included in the Open Hub Total. Downloads from the DIAS Hub are presented separately, in Section 2.3.3.1, because the DIAS partners systematically download the full collection of data products, in a routine and predictable way.

Hub	Number of Products Downloaded Since Start of Operations	%	Volume of Products Downloaded Since Start of Operations (PiB)	%
Open Access Hub	116,375,677	46	66.59	42
Collaborative Hub	85,077,416	33	60.20	38
International Hub	18,752,822	7	13.61	9
Copernicus Services Hub	33,798,799	13	17.98	11
All Hubs	254,004,714		158.38	

Table 16: Number and Volume of products downloaded since the start of operations, per hub

The hub which has borne the greatest load of download requests since the beginning of operations remains the Open Hub. At the end of Y2019, 46% of the total number of downloads since the start of operations had been made on the Open Hub, similar to the 49% at the end of Y2018. Looking at the proportion of downloads managed through the other hubs, the changes have also been modest. The greatest rise was seen for ColHub, which had dealt with 30% of all download requests by the end of Y2018, and this was up to 33% by the end of Y2019. ServHub has also seen a small rise, up to 13% of the total from 12% at the end of Y2019. IntHub, however, has dropped slightly to 7% of the total, from 9%. Looking at the proportions by volume a similar split is seen. However, in this view, ColHub (38%) is now much closer to the Open Hub (42%), likely accounted for by a larger number of high volume Sentinel-1 products being downloaded from the ColHub.

Table 17 below shows the average daily volume of downloads handled by each hub during November 2019, as well as the corresponding value for

November 2018 and the percentage change between the two years. The average total daily volume of data downloaded by users across all hubs was up to 214 TiB in Y2019, up 48% on the previous year. All of the hubs except ServHub experienced an increase in the volume of user downloads during Y2019. The average daily volume of data downloaded from the Open Hub was up by 38% compared with November Y2018, and up by 19% for IntHub. For ColHub, the average daily volume of data downloaded was up by as much as 94% to 103 TiB, and constituted approximately half of the aggregated daily average volume of products disseminated. If this daily download rate continues through to the next year, it is expected that the ColHub will soon become the hub to have managed the greatest load of downloads since the start of operations. The small decrease (3%) in the average daily download volume from ServHub is in all likelihood accounted for by the fact that the DIAS service providers used the dedicated DIAS nodes for all of Y2019 (see Section 2.3.3.1), rather the using the ServHub.

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Hub	Daily average volume (TiB) downloaded in November 2018	Daily average volume (TiB) downloaded in November 2019	% increase Y2018 - Y2019
Open Access Hub	48.5	66.9	38
Collaborative Hub	53.1	102.8	94
International Hub	12.4	14.8	19
Copernicus Services Hub	30.6	29.7	-3
All Hubs	144.6	214.3	48

Table 17: Average volume of data disseminated per day during the last month of Y2019 and Y2018

Focusing on total downloads per mission during Y2019, Figure 54 shows the volume of products which users downloaded from each hub and per mission during the year. Although all hubs dealt with increased download volumes during Y2019, the most notable change since Y2018 is the rise in the volume of products downloaded from ColHub in Y2019. A massive 31.17 PiB was downloaded, and ColHub overtook the Open Hub for the first time as the hub which disseminated the greatest volume of data during the year.

In comparison to Y2018, 67% more Sentinel-1 data, 90% more Sentinel-2 data and 880% more Sentinel-3 data was downloaded from ColHub in Y2019. For ServHub and IntHub, the volume of Sentinel-1 and Sentinel-2 data downloaded during the year did not change significantly (slightly up from 6.64 PiB and 4.29 PiB in Y2018) but, as for ColHub, there was a big increase in the volume of Sentinel-3 products downloaded. It is recalled, of course, that the Sentinel-3 values for Y2018 on ColHub, ServHub and IntHub were unavoidably low, because most products were only available on the S3 PreOps Hub during Y2018.

On the Open Hub, the total volume of data downloaded rose from 18.61 PiB in Y2018 to 23.32 PiB in Y2019. This growth was caused by an increase in the volume of data downloaded from Sentinels -2, -3 and -5. In fact, the volume of Sentinel-1 data downloaded from the Open Hub actually fell quite significantly, from 8.12 PiB at the end of Y2018 to 6.68 PiB at the end of Y2019. For the first time, the volume of Sentinel-2 data downloaded from the Open Hub (10.34 PiB) overtook the volume of Sentinel-1 data downloaded. Also of note was a large rise in the volume of Sentinel-5P data downloaded as compared with Y2018, up from 0.49 PiB in Y2018 to 2.42 PiB in Y2019, an increase of nearly 400%. This uptake was of course limited to the Open Hub because throughout Y2019 it was still only possible to download Sentinel-5P data from the S5p PreOps Hub, and the figures for the S5P PreOps Hubs are only included in the Open Hub download statistics.

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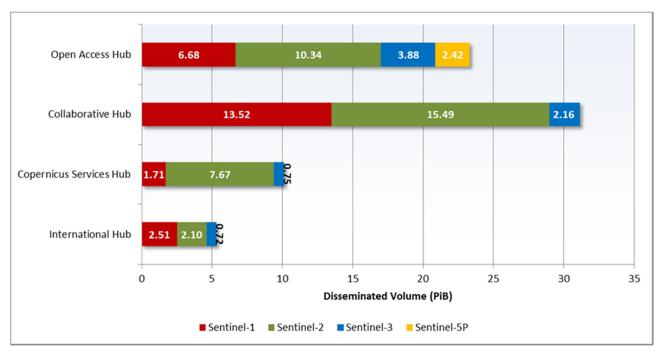


Figure 54: Disseminated volumes (PiB) during Y2019 per Hub and per Mission

Figures 55, 56, 57 and 58 separate out by Sentinel the total number of products downloaded from each

hub, to show the percentage share of the downloads per product type.

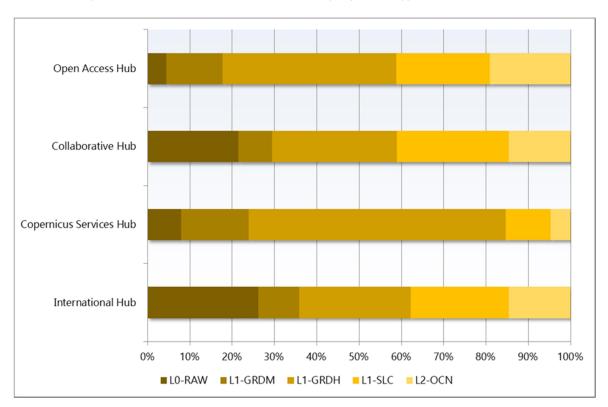


Figure 55: Percentage of total number of Sentinel-1 products downloaded from each hub during Y2019 per product type











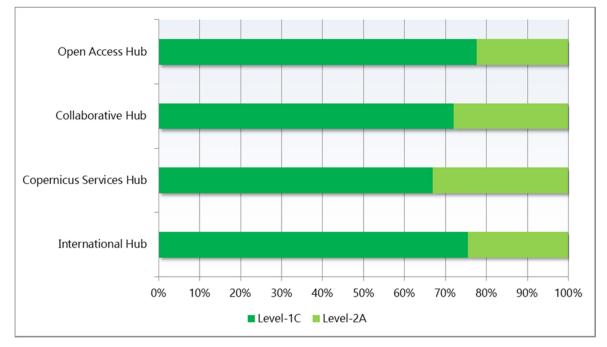
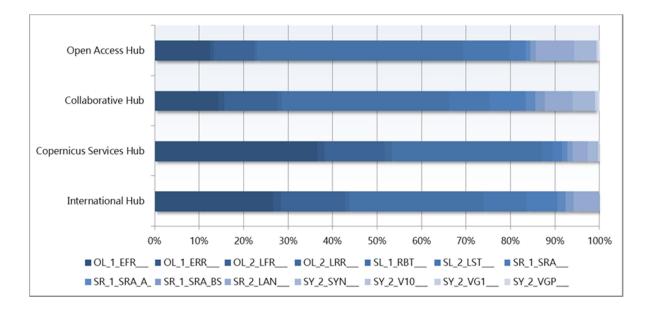


Figure 56: Percentage of total number of Sentinel-2 products downloaded from each hub during Y2019 per product type













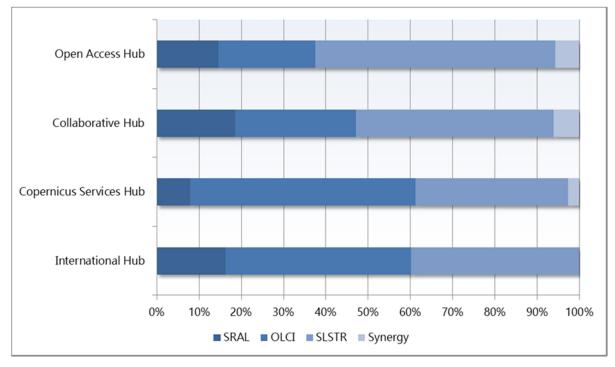


Figure 57: Percentage of total number of Sentinel-3 products downloaded from each hub during Y2019 per product type (graph 1) and product group (graph 2)

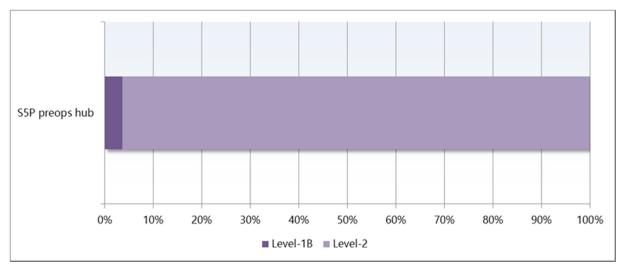


Figure 58: Percentage of total number of Sentinel-5P products downloaded from S5p PreOps Hub during Y2019 per product level

Sentinel-1

L1-GRDH products were again the most frequently downloaded Sentinel-1 product from all hubs, making up between 26% and 61% of all Sentinel-1 downloads. In the case of IntHub, they were jointly the most downloaded products, together with Lo_RAW (both 26%). The greatest increase in the uptake of L1-GRDH products was on ServHub: L1-GRDH products constituted 61% of downloads from ServHub in Y2019, up from only 46% in Y2018.

For Lo-RAW products, interest on the Open Hub and ServHub, at 5% and 8% of the total respectively, was much lower than seen on IntHub and ColHub (26% and 21% respectively), suggesting that users of the latter two hubs are more likely to prefer raw data on which they can perform their own processing.

L1_SLC and L2_OCN products constituted a lower proportion of the Sentinel-1 downloads from

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ServHub than they did of the Sentinel-1 downloads from the other hubs, at 11% and 5% respectively. On the other hubs download proportions for the two product groups were quite similar: L1_SLC ranged between 22-26% of Sentinel-1 downloads; L2_OCN ranged between 15-19%.

Sentinel-2

For Sentinel-2 downloads, all hubs showed a similar split between Level-1C and Level-2A products. In contrast to Y2018, when Level-1C constituted >90% of Sentinel-2 downloads from each hub, downloads of Level-2A products made up between a quarter and a third of Sentinel-2 downloads from each hub in Y2019. The proportion of Level-1C products ranged between 78% (Open Hub) and 67% (ServHub) of the overall Sentinel-2 downloads. This increase in the uptake of Level-2A products may be linked to the start of Level-2A global coverage, the greater number of Level-2A products available or simply increased awareness of the products.

Sentinel-3

There 14 distinct product types for Sentinel-3 (split between SRAL (4x), OLCI (4x), SLSTR (2x) and Synergy (4x)). Figure 57 shows the percentage split of the overall volumes downloaded from each of the four hubs per product type. Given that individual product types can be hard to distinguish on this scale, Figure 54 shows the same proportions but with the products combined into product groups (each instrument plus SYNERGY products). It should be









noted that neither SLSTR nor SYNERGY products were available on ColHub or ServHub during all of Y2019, and SYNERGY products were not available on IntHub at any point during the period. However, given that the majority of product types were available on all hubs during Y2019, this is the first year in which user interest in the products can start to be assessed per hub.

The majority of downloads was accounted for by SLSTR and OLCI products, which together ranged from 75% to 89% of Sentinel-3 downloads from each hub. SLSTR consitituted57% of Sentinel-3 products downloaded from the Open Hub, and 47% of Sentinel-3 products downloaded from ColHub. While for ServHub and IntHub, it was OLCI products which were the most frequently downloaded, at 53% and 44% of the total respectively. SRAL products constituted only a small proportion of the Sentinel-3 downloads, between 8-19%, and SYNERGY products accounted for 6% or less.

Sentinel-5p

Due to the number of different Sentinel-5p products which are published, the per product download percentage is not shown. However, Figure 58 does show the download split on the S5p PreOps Hub for the two product levels: Level-1B and Level-2. The download split per level was 4% Level-1B (640,937 products) and a massive 96% Level-2 (17,385,281 products).











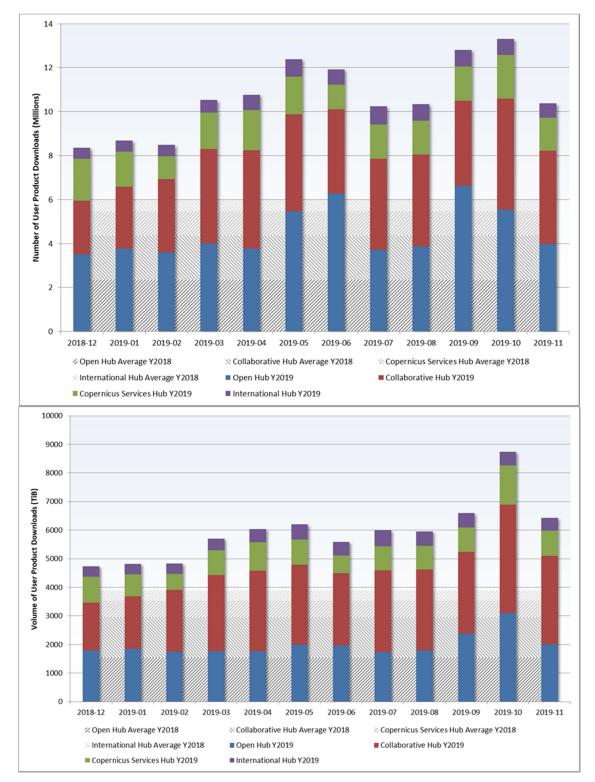


Figure 59: Dissemination number and volume trends per hub during Y2019, with Y2018 averages for comparison

The graphs in Figure 59 above show the monthly number (top graph) and volume (bottom graph) of downloads made from each hub during Y2019, with the average monthly volume and number of downloads made on each hub during Y2018 included

for comparison. It is clear that the monthly total for all hubs is significantly above the Y2018 average, for both numbers and volumes of products downloaded. The greatest increase with respect to Y2018 was in the number of products downloaded per month: the

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Y2019 monthly average number of products downloaded was 10,682,13 products, which was a 56% rise on the 5,993,201 average in Y2018. Given that the monthly volume values do not outstrip the Y2018 values to the same extent as the number values (apart from in October 2019), it is likely that it was mainly the rapid uptake of Sentinel-5P products which caused the wide divergence between the numbers of products downloaded per month in Y2019 and Y2018.

In terms of trends, it is interesting to note that the total number of products downloaded in the last three months of Y2019 from ColHub was 53% higher than the total downloaded in the first three months, indicating a substantial increase in activity on the Hub through the course of the year. For IntHub and ServHub, the same statistic is 40% and 11% respectively. The rise in the number of downloads made from these hubs appears to have taken place steadily and progressively throughout the year, as Figure 59 shows only small fluctuations throughout the year on all three hubs and no very significant peaks and troughs. It is suggested that this constant growth in activity on the hubs was likely caused by both the rise in the number of products published on the hubs and the increasing numbers of registered users on each hub. As each of these three hubs have a large proportion of systematic downloaders, a fairly strong link would be expected between the rise in registrations/published products and the number of downloads made from the hubs.

On the Open Hub, rises were more modest, and the monthly trend has more obvious peaks and troughs. In particular, in terms of download numbers, peaks were observed in both June and September 2019 (6,277,864 and 6,615263 downloads respectively in those months). A significant trough is visible between these peaks, in July and August 2019 (<4 million downloads per month), which may be related to the northern hemisphere holiday period. It is expected that on the Open Hub there will be a less strict link between user numbers/publication figures and downloads: as discussed in the section on user registrations above, on the OpenHub there exist many more users, who download specific, isolated products, rather than whole collections of products, , than on the other hubs.









In addition to the reasons suggested above, download trends, particularly on the Open Hub, may have been influenced by outreach events for the Copernicus programme, which took throughout Y2019. Figure 14 in Section 2.1.1 provides a timeline of the major events which took place throughout the year.

2.3.3.1 DIAS Hub Downloads

Downloads by the DIAS service providers from the dedicated DIAS Hub have not been included in any of the download figures presented in the sections above. They are by definition systematic downloaders, who retrieve all or most of the published products, meaning they are not likely to display any particular trends and are thus considered separately in this section.

Since the start of DIAS Hub operations, in Y2018, a total of almost 57 million products have been downloaded by the DIAS service providers, comprising a total volume of 37.42 PiB. In terms of the proportion of all downloads on all hubs since the start of operations, DIAS downloads now account for 19% by number and 20% by volume. During Y2019 alone, nearly 35 million products were downloaded, making up a yearly volume of 21.99 PiB.

In terms of average daily download volume, 54.20 TiB were downloaded per day during November 2019. This was more than the average daily volume downloaded from either ServHub or IntHub, but less than the average daily volume downloaded from Open Hub and roughly half the average daily volume downloaded from ColHub.

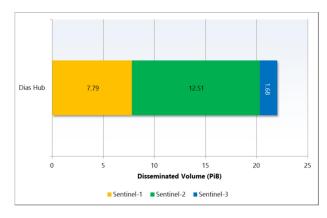


Figure 6o: Disseminated volumes (PiB) during Y2019 per Mission on the DIAS Hub



Figure 60 shows the total volume of products downloaded in Y2019 from the DIAS Hub, split by mission. The percentage split between Sentinel-1/Sentinel-2/Sentinel-3 is 35%/57%/8%.

2.3.3.2 Long Term Archive (LTA) Retrievals

From the end of Y2018, and throughout Y2019, Long Term Archive (LTA) interfaces were activated for Sentinels-1, -2 and -3: Sentinel-1 on 12 September 2018, Sentinel-3 on 1 August 2019 and Sentinel-2 on 24 September 2019. These interfaces allow older products to be moved into the LTA, freeing up space for newer online products. Users can request access to these offline products, though with some amount of unavoidable time delay following the request, while the products are retrieved from the archive. The threshold for this time delay is 24 hours, although in practice it is usually much less. Once retrieved and restored on the hub, products are then available online to download for a limited amount of time (at least 3 days), following which the products are put offline again. A user quota on the maximum number of product retrieval requests per hour is applied.

Figure 4 provides details of how long new products are available online, per mission, before being moved to the LTA.

LTA interfaces are now available for all data hubs except the IntHub.

Offline Product Growth

By the end of Y2019, a total of 9.06 PiB of data had been moved to the LTA, consisting of 5.62 PiB from Sentinel-1, 2.70 PiB from Sentinel-2 and 0.74 PiB from Sentinel-3. Figure 61 shows the cumulative growth of data on the LTA since the opening of the interfaces, per mission.









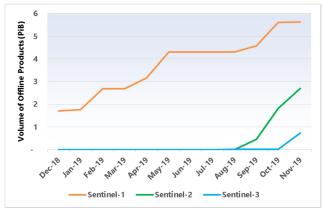


Figure 61: Cumulative growth of Offline product volume (PiB) per mission

During Y2019, movement of products offline and into the LTA was handled manually, and this explains why the growth lines are not regular. Due to operational priorities, there were some months (e.g. March, June, July and August 2019 for Sentinel-1) in which no products could be moved offline. It is planned that the transfer process will be automated during Y2020, and from that point on movement offline is expected to be regular and systematic.

In the rest of this section on the LTA, statistics are presented from March 2019 onwards, unless otherwise stated. This was the first month in which the version of the data hub which supports the generation of LTA statistics was in operation.

LTA Active Users

An active user of the LTA is defined as one who submitted a request for the retrieval of an offline product. During Y2019, there were a total of 11,623 unique users of the LTA, composed of 11,564 from the Open Hub and 59 from the other hubs. The table below shows the total number of LTA active users per mission and per hub. Note that the total of these is greater than the total given above, because a single user can request products from more than one Sentinel.

Hub	Sentinel-1	Sentinel-2	Sentinel-3
Open Access Hub	10,024	1,954	79
Collaborative Hub	15	7	4
Copernicus Services Hub	34	15	4
Dias Hub	5	3	2

Table 18: Total LTA Active Users during Y2019, per mission and per hub



Users of Sentinel-1 accounted for by far the greatest proportion of the active users of the LTA (83%), although it can be assumed that this is largely because the other missions' LTA access was only available for a short period at the end of Y2019. It is interesting to note that as the Open Hub had 61,568 active users in Y2019 (meaning, in this case, a user who downloaded at least one product during the year), 19% of these submitted a request for an offline product.

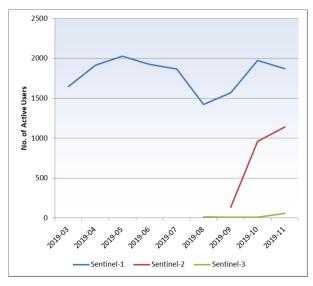


Figure 62: Total LTA Active Users per mission on the Open Hub per month during Y2019

Figure 62 shows the total number of LTA active users per month during Y2019 (from March 2019), for each Sentinel. For Sentinel-1, there was an average of 1,352 LTA active users per month. There was a drop in the August-September 2019 period, perhaps caused by both the holiday period and very few additional Sentinel-1 products being moved offline in the period immediately preceding this (see Figure 61). When access to the LTA was opened for Sentinel-2 products on 24 September 2019, there was already a considerable volume of products available for download and the take-up by Sentinel-2 users was immediate. By the end of the first month and a half of offline access, already just under 2,000 Sentinel-2 users had downloaded products from the LTA, with the active user growth line closely resembling the increase in the volume of products made available through the offline LTA. Sentinel-3, the take-up line also resembles the growth in the volume of the products made available on the LTA, and once Sentinel-3 products started to









be moved offline in October and November 2019, there were 79 Sentinel-3 users who started to access those offline products.

Product Retrieval Requests

During Y2019, almost 400,000 requests for product retrievals from the LTA were submitted and accepted. This total does not include retrieval requests which were made for a product which was already being processed as a result of another request; these requests are redundant and therefore discarded. Table 19 shows the number of requests per hub during the year (recorded from March 2019). Open Hub users made 73% of the requests, with users of the other hubs accounting for the remaining 27%.

Hub	Number	% of Total
Open Access Hub	291,398	73
Collaborative Hub	20,672	5
Copernicus Services Hub	40,498	10
DiasHub	46,794	12
TOTAL	399,362	

Table 19: Total LTA product retrieval requests during Y2019 per hub

Figure 63 presents a monthly view of this total, showing the total number of requests per month and per hub.

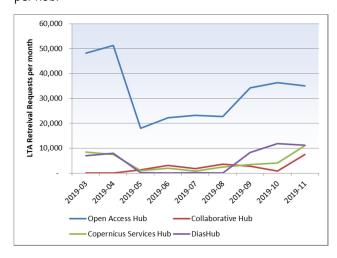


Figure 63: Total LTA retrieval requests during Y2019, per month and per hub

Given that the numbers of LTA active users remained quite constant from March to July 2019, the large spike in requests which can be seen in this graph in March and April is almost certainly due to a few users running extensive campaigns to download large





amounts of historical data from the archives. During this period around 10,000 products were being restored per week; an analysis has indicated that performances were not greatly negatively impacted by the spike, with most products being restored in under 6 hours.

Between May and August, the number of requests dropped to around 20,000 per month, before rising again in the latter part of Y2019, corresponding to the opening of LTA access for Sentinel-2 and -3 products.

Restored Products and Retrieval Performance

The table below shows the number of restored products during Y2019 per mission and per hub. Note that, for reasons resulting from the infrastructure architecture, the ColHub, ServHub and DIASHub publish the same restored product, so they are reported together in the table.

Hub	Sentinel-1	Sentinel-2	Sentinel-3	TOTAL per hub
Open Access Hub	266,002	24,775	3,496	294,273
ColHub/ServHub/DiasHub	102,867	3,300	7,539	113,706
TOTAL per mission	368,869	28,075	11,035	407,979

Table 20: Total products restored from LTA during Y2019 per hub and per mission

As expected, given the LTA opening dates per mission, the majority of restored products are for Sentinel-1 (90%), followed by 7% for Sentinel-2 and 3% for Sentinel-3. It is noted that the total number of restored products is slightly higher than the total









number of requests reported in Table 19. This is likely due to the fact that the statistics are from March 2019, and some Sentinel-1 retrieval requests submitted prior to this may have resulted in a restored product in March.

Retrieval timeliness

From March 2019 to November 2019, the overall average time it took between a retrieval request being made and the product being restored to the hub, across all hubs, was 2.9 hours. This is significantly under the 24 hour threshold communicated to users. There were, however, considerable variations behind this figure.

In order to improve retrieval performances still further a number of improvements have been worked on during Y2019, although they will not be transferred to operations until the next reporting period. Firstly, the download process is being improved to allow the possibility of downloading multiple products in parallel from each mission's LTA. Secondly, a new quota management will be introduced on the Data Hub Software (DHuS) for interfacing the LTAs: a User quota will allow a user to submit a maximum number of 'in progress' retrieval requests, and a Service quota will allow the DHuS to accept a defined maximum number of orders to submit towards the LTAs. These quotas will assist in avoiding unintentional loads on the LTAs.

2.3.4 Downloads per Continent and Country

Another way of examining product dissemination during Y2019 is by looking at the continents and individual nations which have performed the most downloads from the Data Access System. Tables 21 and 22 present views of the percentage of downloads (by number and by volume respectively) which were completed in each continent from each of the four main hubs during Y2019. The overall percentage split is also shown. For the case of Sentinel-5P, all Page 68/134

Date 25/05/20 Issue 1 Rev 0 downloads are still made on the S5 PreOps Hubs, where the identity and locations of end users are not known. The assumption has therefore been made to take the total of Sentinel-5P downloads and split them per continent in the same proportion as the total [Sentinel-1+Sentinel-2+Sentinel-3] downloads split.

As in Y2018, Europeans continue to be the users making the most downloads from all hubs except the IntHub (as expected, as its purpose is to serve institutional users outside ESA/EU member states). ColHub and ServHub are almost entirely dedicated to Europe, which again is in line with the programmatic









role of the hubs, with the continent accounting for 99.8% and 100% of downloads respectively. The small amount of non-European (North American) downloads on the ColHub (0.2%) are accounted for by the Canadian Collaborative Ground Segment. On the Open Hub, for which all continents have registered users, European users were still the group making the majority of downloads from the Hub (56.8%). This is a slightly lower proportion than was recorded in Y2018, when European users made 62% of the downloads from the Open Hub. In contrast, the proportions for North America (up to 30.8% from 27%), Asia (up to 9.3% from 8%) and Oceania (up to 2% from 1%) have all risen slightly. When the continents are listed in order of the number of downloads made from each, the position of each continent remains unchanged.

On the Open Hub, the same discrepancies between proportions of registered users and downloads which were observed during Y2018 are still in evidence.

While users from Asia make up 25% of the total number of registrations on the Hub, they only account for 9.3% of downloads; similarly users from South America make up 18% of user registrations but only a tiny 0.8% of downloads. By contrast, users from North America comprise only 13% of registered users but account for 30.8% of downloads. These figures seem to indicate that many North American users download data in large quantities, while the Asian and South American users choose to download a more specific selection of data.

For the sake of completeness, it is noted that if the downloads made by the DIAS service providers were taken into account in this breakdown by continent, the overall proportion of downloads which were made by European users in Y2019 would rise to 80.7% (by number) and 84.1% (by volume).

The remainder of this section focuses on download statistics from the Open Hub alone.

	PERCENTAGE OF DOWNLOADS BY NUMBER						
Continent	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	OVERALL		
Europe	56.8	99.8	100	1	75. 5		
North America	30.8	0.2	0	68.0	17.3		
Asia	9.3	0	0	0	3.9		
Oceania	2.0	0	0	30.8	2.8		
South America	0.8	0	0	0	0.4		
Africa	0.3	0	0	0	0.1		

Table 21: Percentage of Y2019 downloads (by number) per Continent and per Hub and overall

	PERCENTAGE OF DOWNLOADS BY VOLUME						
Continent	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	OVERALL		
Europe	60.2	99.9	100	1	79.1		
North America	28.1	0.1	0	76.3	15.2		
Asia	8.7	0	0	0	2.9		
Oceania	1.6	0	0	22.5	2.3		
South America	1.0	0	0	0	0.3		
Africa	0.4	0	0	0	0.1		

Table 22: Percentage of Y2019 downloads (by volume) per Continent and per Hub and overall







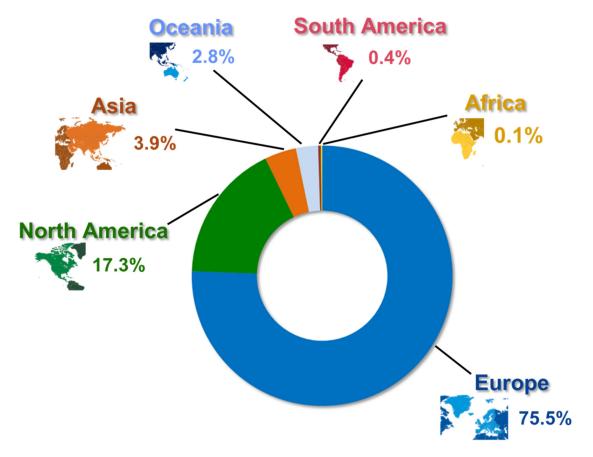


Figure 64: Overall percentage split of Data Access System downloads (all Hubs) by number, per Continent, during Y2019

Open Hub Focus

Table 23 breaks down the overall per continent figures for the Open Hub in Y2019, showing the percentage split between the continents of downloads from each Sentinel mission during the year. 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-5P is not included as all downloads are still on the PreOps Hub, as mentioned above.

Sentin	ntinel-1 Sentinel-2 Sentinel-		el-3	OVERALL			
Continent	% of Y2019 Downloads	Continent	% of Y2019 Downloads	Continent	% of Y2019 Downloads	Continent	% of Y2019 Downloads
Europe	61.0	Europe	48.8	Europe	70.4	Europe	56.8
North America	19.0	North America	36.8	North America	25.4	North America	30.8
Asia	17.2	Asia	10.5	Asia	2.4	Asia	9.3
Oceania	1.8	Oceania	2.2	Oceania	1.7	Oceania	2.0
South America	0.4	South America	1.2	South America	0.1	South America	0.8
Africa	0.7	Africa	0.4	Africa	0.0	Africa	0.3

Table 23: Continental percentage split of Y2019 downloads (by number) on the Open Hub, for each Sentinel mission and overall

Table 23 shows that this year the sequence of continents is now the same for all Sentinels: in order

of highest to lowest downloader it is Europe, North America, Asia, Oceania, South America and Africa.

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European users downloaded the highest number of Sentinel-1 and Sentinel-3 products in Y2019 by a long margin (61% and 70.4% respectively), albeit with a slightly lower percentage share then during Y2018. The picture for Sentinel-2 looks slightly different. European users made 48.8% of the downloads from the Open Hub, which is the first time they accounted for less than half of all Sentinel-2 downloads, down from 59% overall during Y2018. This is indicative of a growing popularity of particularly Sentinel-2 data around the globe. For instance, users from North America accounted for 36.8% of Sentinel-2 downloads, a proportion which will include the mass downloads of Sentinel-2 products made by the US

corporate cloud service providers, which source their Copernicus Sentinel data directly from the Open Hub. In Asia, interest seems somewhat tipped towards Sentinel-1 data, where the continent accounts for 17.2% of downloads, compared with 10.5% for Sentinel-2 and only 2.5% for Sentinel-3. For Sentinel-3, downloads from Europe and North America together made up a huge 95.8% of downloads, with interest in the products from the rest of the world appearing slow to take off.

Table 24 below presents a breakdown of the ten ESA/EU member states with the highest number of downloads for each of the three Sentinels during Y2019.

Sen	Sentinel-1		tinel-2	Sentinel-3	
Country	Y2019 Number of Product Downloads	Country	Y2019 Number of Product Downloads	Country	Y2019 Number of Product Downloads
France	1,050,841	France	4,354,911	Italy	4,983,730
Germany	766,014	Germany	1,282,472	France	636,637
Luxembourg	384,309	Poland	1,256,028	Germany	428,384
United Kingdom	301,739	United Kingdom	604,135	Poland	355,086
Poland	277,023	Slovenia	461,001	United Kingdom	322,574
Italy	190,010	Italy	453,624	Norway	177,186
Denmark	120,758	Spain	276,021	Denmark	90,686
Norway	78,615	Luxembourg	237,142	Netherlands	61,215
Austria	57,636	Austria	167,498	Belgium	56,035
Switzerland	53,571	Finland	77,745	Spain	50,781

Table 24: Top 10 ESA/EU states by number of downloads in Y2019 on the Open Hub, for each Sentinel mission

The lists are dominated by the following five nations, which appear in the top 10 downloaders for all missions: France, Germany, Italy, Poland and the United Kingdom. The top downloaders overall are French users, who downloaded the highest number both Sentinel-1 and Sentinel-2 products and the second highest number of Sentinel-3 products. Next are the German users, who downloaded the second highest number of both Sentinel-1 and Sentinel-2 products and the third highest number of Sentinel-3 products. It is also interesting to note the marked interest of Italian users in Sentinel-3 data. In Y2019, Italian users downloaded approximately 26 times more Sentinel-3 data than Sentinel-1 data and around 11 times more than Sentinel-2 data. Norwegian users also downloaded more Sentinel-3 products than products from any other mission. Users from Switzerland, Luxembourg and Denmark

downloaded more Sentinel-1 products than any other type, while users from each of the other countries in the table downloaded more Sentinel-2 products than products from any other mission.

It should be noted that the distribution of user downloads from the Open Hub is not necessarily a good indication of national interests in the Copernicus Sentinels, since the data may now be accessed through many national mirrors and also via the DIAS initiatives.

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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 65 below show, for each Sentinel mission and per Hub, the

percentage of downloads during Y2019 for products within six age ranges (measured from the product publication date). These are:

- o − 2 days
- 2 days 1 week
- 1 week 1 month
- 1 month 3 months
- 3 months 1 year
- > 1 year

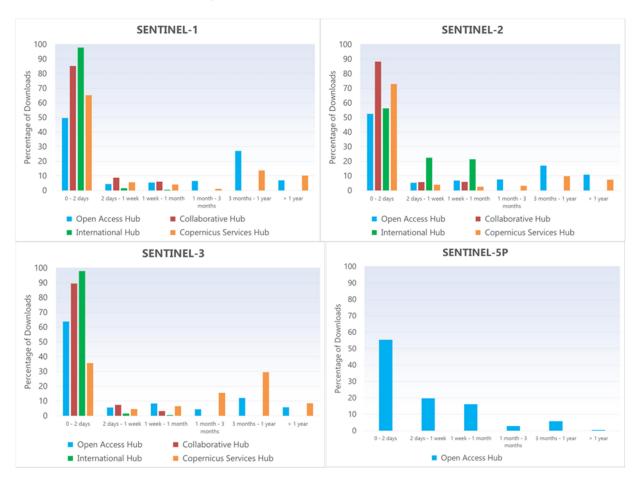


Figure 65: Percentage of Y2019 downloads per product age range, for each Sentinel mission and per Hub

While analysing these statistics, it is important to bear in mind the rolling policy applied to the hubs, which changed during Y2019 (see Figure 4). After a product is removed from online access, it can still be retrieved via LTA interfaces on all hubs except the IntHub, but early retrieval while it is online remains the fastest and easiest way to access data.

The first observation to be made is that – as in previous years – there is a clear preference for newer products over old. Overall, products in the o-2 days range made up more than 50% of downloads for all Page 72/134

missions. On a per hub basis, this range accounts for 50% or more of all missions on all hubs, the only exception being Sentinel-3 on the ServHub, where it made up 36%. This is to be expected for two reasons: firstly, many user applications are likely to have a preference for the most recent data; secondly, most large scale downloaders are already likely to have the older data they are interested in, with downloads focusing on the latest available.

Looking in more detail at each hub, the situation is quite similar to Y2018. The preference for newer



serco







products is again particularly true for the ColHub and IntHub. On the ColHub, almost 90% of downloads for each of Sentinel-1/-2/-3 are in the *o-2 days* range; on the IntHub, an even greater percentage of downloads for Sentinels-1 and -3 fell in the *o-2 days* range – 98%. An exception is seen for Sentinel-2 downloads on the IntHub: only 56% of downloads fell into the o-2 days category, with the rest evenly split between the *2 days – 1 week* and the *1 week – 1 month* categories. On both the ColHub and the IntHub o% of downloads fell into ranges of greater than one month. For the IntHub, this was inevitable given that the rolling policy removes all products from it after 3 weeks, and that operational LTA interfaces had not been established for the IntHub by the end of Y2019.

On the Open Hub, the preference for newer data is still clear though is less pronounced. Downloads for products in the o-2 days category accounted for 50% for Sentinel-1, 53% for Sentinel-2 and 64% for Sentinel-3. While there is a drop-off in all of the time ranges between 2 days and 3 months, there is then a small rise in downloads for products older than 3 months. This rise is greatest for Sentinel-1, with 27% of downloads being for products older than 3 months. This trend is perhaps due to the open registration policy on the Open Hub and the growth in the number of new users registering which has already been discussed. As new users discover the service, there will likely be some who need 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 >3 month time ranges. Additionally, the trend could be driven in part by downloads of reprocessed products, at least in the cases of Sentinels-2 and -3. It should also be noted that Sentinel-1/-2/-3 products are available for 1 year online under the rolling policy.

As already mentioned, an exception to the rule that the freshest products are the most popular occurs for Sentinel-3 downloads on the ServHub. Only 36% of downloads fell in the *o-2 days* range, with 29% falling in *3 months - 1 year*, and 8% > 1 year. This can probably be accounted for by several factors: firstly, the continued move of Sentinel-3 products away from the PreOps hub during the year, leading to new users discovering Sentinel-3 data; secondly, the amount of reprocessed data released for Sentinel-3 leading to renewed interest in historical data (see section 2.2); thirdly, the fact that many of the scientific applications for Sentinel-3 products (e.g. atmospheric and climate-related) are likely to require data from the largest historical range available.

For Sentinel-5P, 55% of downloads from the PreOps Hub were in the o-2 days range; 20% fell within 2 days – 1 month; and 16% fell in the 1 week – 1 month range.

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 2019 and November 2019. Table 25 below reports the number and volume of overall products component downloads 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)
July 2019	2,693,814	1,554.13	2,358,218	8.04
November 2019	2,793,707	1,796.70	1,587,143	11.26

Table 25: Number and volume of overall products component downloads from the Open Hub during July and November 2019









In July 2019, the number of product component downloads was quite similar to the number of full product downloads: 2,358,218 vs 2,693,814. However, by November 2019, the number of component downloads had dropped by 33% to 1,587,143. It is not certain why this fall occurred. One potential explanation is that growing awareness of the DIAS platforms has created less need for users to explore product components directly on the Data Hubs.

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. However, between July and November 2019 the monthly volume of product component downloads rose from 8.04 TiB to 11.26 TiB. This was due to a rise in the numbers of high volume components (notably .jp2 and .png) downloaded between the two months.

Figure 66 shows the overall split, by number, of downloaded components for November 2019. The greatest shares are accounted for by .xml (35%), .gml (27%) and .safe (19%). The .xml files are typically metadata or annotation files, perhaps used by users to construct their own catalogues of Sentinel data; the .gml files are typically the cloud mask information provided with Sentinel-2 products; and the .safe files are the manifest components of the data products.

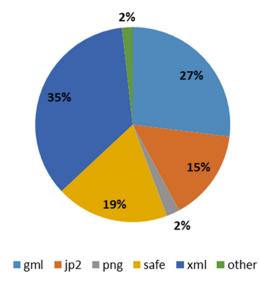


Figure 66: Percentage of component downloads per file type made on the Open Hub during November 2019

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2.3.7 Partial content downloads

As part of the http standard, the Data Hubs also support the 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, if 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 switching off their computer, or in case there is a timeout setting on the client side), the monitoring system does not record this event in the full product downloads statistic, even if this download is part of the outgoing volume successfully provided to the user 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 2019. 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 26 shows the volume of partial content downloads on the Open Hub reordered by the system in July and November 2019, 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 2019	1,554.13	95.45
November 2019	1,796.70	111.34

Table 26: Volume of full and partial downloads on the Open Hub nominal interfaces during July and November 2019

Regarding the split between downloads returning the '200' and '206' codes during the two months, only a small proportion returned '206', and this was consistent between the two months: 2% in July and 1% November. It is probable that download manager tools are the main contributors to successful downloads returning the '206' code. The figures are comparable to Y2018.











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 products retrieved are NRT-3h and Fast-24h for both Sentinel-1A and Sentinel-1B.

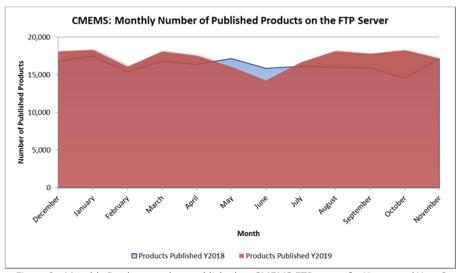


Figure 67: Monthly Product numbers published on CMEMS FTP server for Y2019 and Y2018

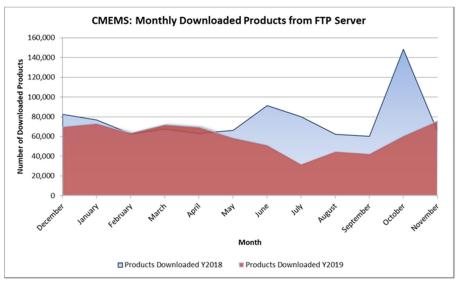


Figure 68: Monthly downloads from CMEMS FTP server for Y2019 and Y2018

During Y2019, a total of 206,357 Sentinel-1 products were published on the ftp server dedicated to the specific needs of CMEMS. This represents a 5.6%

increase on the number published during Y2018 and accounts for a volume of 191 TiB. This rate of increase is almost identical to that between Y2017 and Y2018. 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, 710,782 products were downloaded during the year, representing a 23% decrease on that during Y2018 and accounting for a volume of 526 TiB. This is the first year in which a decrease in product downloads has been observed. As the service has been fully accessible during Y2019 it cannot be accounted for by unavailability. A possible explanation is that some CMEMS users were identified as downloading products multiple times, probably due to issues with the script configuration. In Y2019 they were advised to fix this issue and as a result have subsequently been downloading fewer products overall.

The archive exploitation ratio (number of products published / number of products downloaded) for









Y2019 was 1:3.4, slightly down on the 1:4.7 observed in Y2018.

Figures 67 and 68 show the Y2019 monthly trends for the number of products published and downloaded. In terms of published products, it can be seen that numbers have been quite stable throughout the period, as they were for Y2018 (the average per month was 17,196 products; for Y2018 it was 16,282). Downloaded products displayed more variation however, though this was less than the variation during Y2018 (which had largely been the result of a significant peak in October 2018). During Y2019 there were on average 59,232 products downloaded per month, though with a trough between July and September. This may again be attributed to seasonal time-windows of interest to CMEMS, particularly in sea-ice monitoring, meaning a drop-off is expected during the Northern Hemisphere summer.

	Y2018	Y2019	% Difference
Average Number of Products Downloaded per Month	76,917	59,232	-22.99
Total Number of Products Downloaded in Period	923,000	710,782	
Average Number of Products Published per Month	16,282	17,196	5.62
Total Number of Products Published in Period	195,385	206,357	

Table 27: CMEMS products publication and download trends during Y2019 and Y2018

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 timeliness available, access has been provided to the Sentinel-5P Payload Ground Segment internal dissemination point (ftp server).

During Y2019 a total of 32.85 TiB of data was downloaded by CAMS (up from 8.68 TiB in Y2018), 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 of the products, as well as being integrated into the CAMS forecasting models.

It is noted that redistribution of Sentinel-5P data from EUMETSAT via EUMETCast also began during Y2019, commencing on 29 August 2019.

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2.3.9 Data Hub Relays

The flow of products downloaded from ColHub to the Collaborative national mirror sites is summarized in Figure 69. Data is either downloaded directly from the ESA nodes by the national mirror site or it is downloaded by one of the partners participating in the Data Hub Relay (DHR) network and from there either exchanged between the other network partners or relayed directly to a national mirror site.

The DHR Network was initially set up late in 2016 with a team of 5 Relays. This number was raised to 7 by Y2018 but in Y2019 was again down to 5, because two Relays (France and one in the UK) were decommissioned. The current members of the DHR Network are: Norway, operated by MET, Germany, operated by DLR, Great Britain, operated by AIRBUS,

Austria, operated by ZAMG, and the Czech Republic, operated by CESNET.

The remaining Relays have consolidated their activity in the DHR Network and improved the configuration to guarantee higher performances in terms of bandwidth for retrieving and exchanging data, completeness of the product collections and timeliness of data published. Moreover, continuous improvements to the DHuS software were made based on the experience of and feedback provided by the Relays, and the experience acquired in operating the Sentinel Data Access System.

During the reporting period, the products exchanged in the DHR Network were from Sentinel 1 A/B, Sentinel 2A/B L1C, Sentinel 2A/B L2A and Sentinel 3A/B.

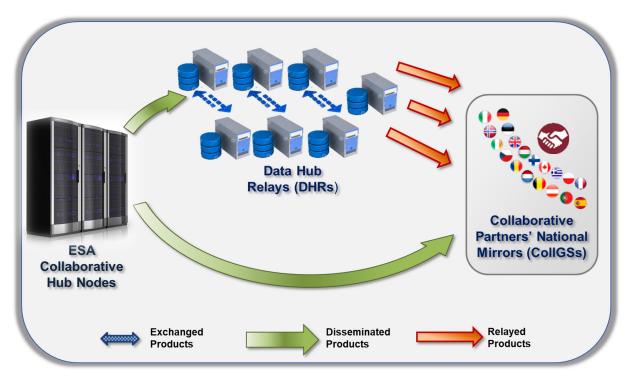


Figure 69: Schematic showing general data flow of products from the Collaborative Data Hub to the Collaborative National Mirrors, highlighting the terminology used













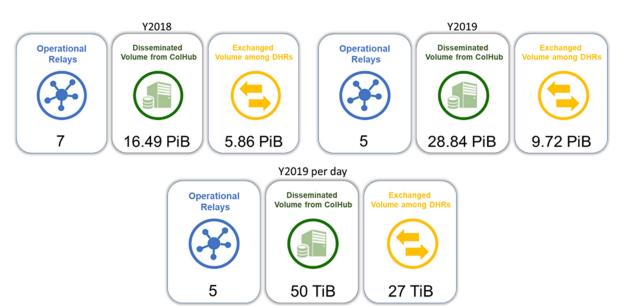


Figure 70: Overall Data Hub Relay statistics for Y2019 vs 2018, with Y2019 per day averages

Overall, the Network has demonstrated the importance of having alternative product sources to support ColHub in the dissemination of Sentinel products towards the Collaborative Ground Segment partners. Figure 70 above shows that there was a large increase in the total volume downloaded from ColHub by the Collaborative mirror sites and the DHRs, from 16.49 PiB in Y2018 to 28.84 PiB in Y2019, from a total of 43,701,785 products. This increase reflects a pro-active and participative collaboration of the Relays within the DHR Network.

38.49% (11.10PiB) of the volume downloaded from ColHub was delivered directly to Collaborative mirror sites and 61.51% (17.74 PiB) was delivered via the DHR Network. The products disseminated to the DHRs are in turn relayed to the Collaborative GS users. A volume of 9.72 PiB was exchanged amongst DHRs, thus constituting 25.21% of the 38.56 PiB total volume the Collaborative mirror sites retrieved from the DHR Network and directly from ColHub (the total volume being the sum of volumes Disseminated to GS + disseminated to DHRs + Exchanged among DHRs) This percentage split shows the extent to which the DHRs reduce the load on ColHub.

The figures below present the evolution of the DHR network data volumes for Y2019 and since beginning of DHR operations (i.e. December 2016 to November 2019). Figure 72 below shows the monthly volumes of disseminated products from ColHub to the Collaborative mirror sites (blue columns), from ColHub to DHRs (in orange) and the exchanged volumes among DHRs (in grey). Considering that the Collaborative mirror sites are the final recipients of products disseminated and exchanged by DHRs, the total volumes depicted in the graph below show an increase in the demand of products by Collaborative mirror sites from the DHR Network: from December 2016 to November 2019, the monthly amount of products disseminated and exchanged among DHRs demonstrated a continuous growth in volumes of data being passed around the network and from Y2018 to Y2019 it increased by 72.51% from 22.35 PiB to 38.55 PiB.

The number of products and the volumes involved in the dissemination is growing each year, and the involvement of the DHR Network has become a crucial part of the overall dissemination architecture for Sentinel data. The data volumes, as reported in Figure 70, give an idea of the 'effort' made each day by the Network: each day, an average of 50TiB/ of data is disseminated to the Relays, composed of an average of about 76,500 products. As shown in Figure 70, the number of Relays was reduced, but the solidity and reliability of the Relays demonstrated a successful management of the network by quaranteeing timeliness and completeness in data publication. It is recalled that these loads are generated by products from only Sentinels-1, -2 and -

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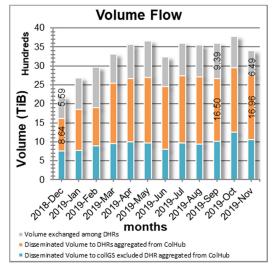


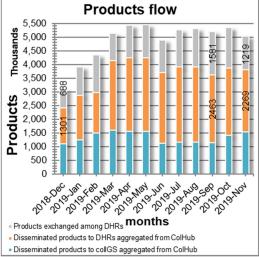


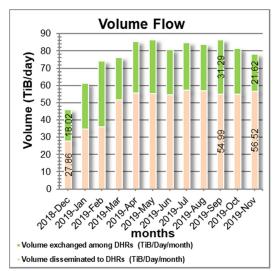


3, and all further missions, including Sentinel-5p, will emphasise yet further the need for these additional sources for obtaining the data products.

Figure 71 shows the trend in volume disseminated to the Relays and exchanged between the Relays, by making an average of the volume per day for each month. It demonstrates a constant trend once the whole 3 Sentinel missions had started their operational data flow from ColHub.







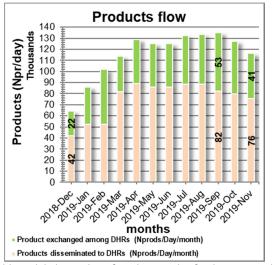


Figure 71: Data Hub Relay Monthly and daily volumes (left)) and Monthly and daily number of products (right) for disseminated and exchanged data flows (the top graphs give monthly totals; the bottom graphs give the daily averages over each month)

Figure 72 gives an overview of the trend in the data flow from ColHub and through the DHR Network, showing an overall marked rise in the number and volume of products moved around the network of Collaborative Ground Segment access points in the almost 3 years since the start of DHR operations.

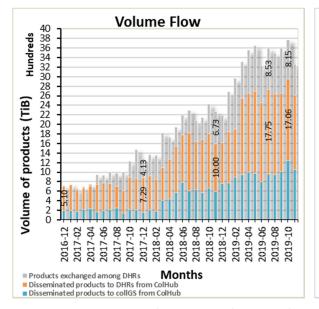












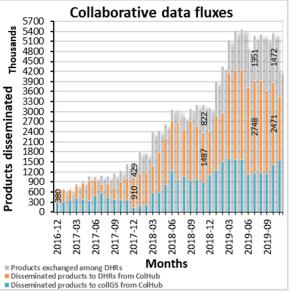


Figure 72: Total data flows in terms of Volume (left) and number of products (right) during the last 3 years









3 User Activity

Active Users 3.1

For the purpose of this report, an 'active user' is defined as a user who is both registered and who has performed at least one complete download within the reporting period (Y2019). 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 73. The variation in these figures generally 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. This is shown to be the case: 100% of registered users were active users.

At the other end of the scale, the 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 - 22% this period. This is a slightly lower percentage than the 26% calculated for Y2018, but in terms of absolute numbers, there were 49% more active users in Y2019 than in Y2018 (see Figure 74).

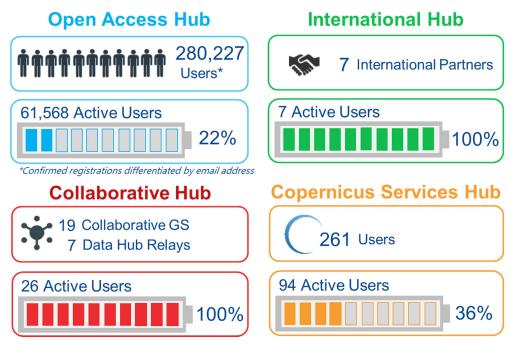


Figure 73: Registered and Active users per hub during Y2019











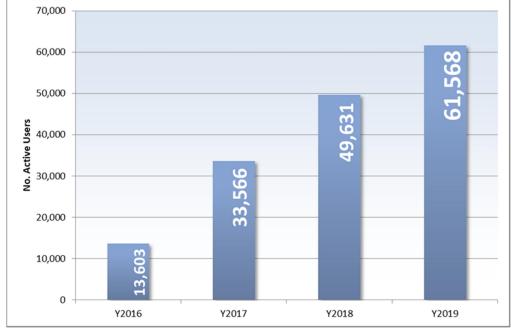


Figure 74: Growth in numbers of active users on the Open Hub between Y2016 and Y2019

User downloads profile

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

Sentinels during Y2019. Sentinel-5P is not yet included as it is still only available on the dedicated PreOps Hub, which all can access using the same password so no differentiation of accounts is possible.

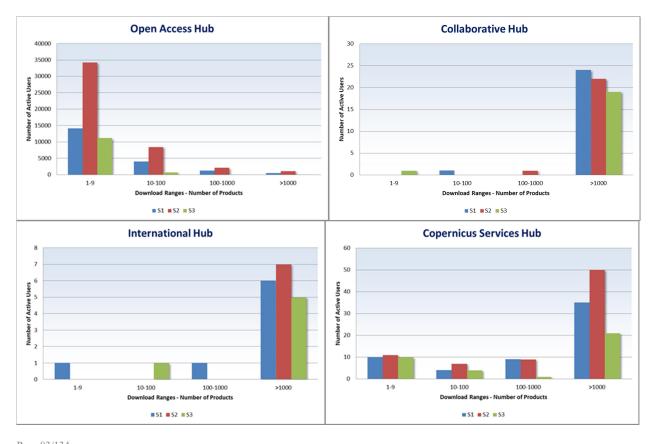














Figure 75: Y2019 Download Ranges for each Data Access System Hub

Figure 75 shows, for each hub and each mission, the download ranges observed among the active users during Y2019. The overall trends remain similar to those of Y2018 and Y2017 and are generally as would be expected. For the ColHub and IntHub, almost all active users were downloading in the range '>1,000 products', and this corroborates with the assumption that the Collaborative mirror sites and international partners would routinely retrieve all, or a significant proportion of, the published products in order to make them available on their national sites. In both cases, the few users in the lower categories are likely to be due to the arrival of new users, who only started retrieving products near the end of Y2019 and whose services are not yet fully operational (see section 4).

The opposite trend is observed on the Open Hub, from which a large majority (76%) of active users downloaded between 1-9 products during the year. Given the global and open nature of the Open Hub, this behaviour is also expected: a large proportion of users who register are casual or specialist users, who would only need to download one or a few products during the year.

As in Y2018, the number of Sentinel-2 users on the Open Hub who downloaded in the '1-9' range exceeded the number of Sentinel-1 and Sentinel-3 users who downloaded in that range: 34,198 users for Sentinel-2 compared with 14,155 for Sentinel-1 and 11,174 for Sentinel-3. Overall, there were more active users who downloaded 1-9 Sentinel-2 or Sentinel-3 products than there had been in Y2018. For Sentinel1, however, the number of users who downloaded between 1-9 products actually fell by 7% with respect to Y2018. This fall reflects an overall trend of the total number of Sentinel-1 active users (all categories) falling 4% since Y2018 although it is noted that absolute numbers in the '10-100' and '100-1000' categories rose by 9% and 7% respectively.

It is also worth noting that while only a small proportion of the total number of active users on the Open Hub downloaded more than 1,000 products, in absolute terms there were still many more users who downloaded in that range than on all the other hubs put together: 1,125 for Sentinel-2, 437 for Sentinel-1 and 243 for Sentinel-3. This highlights that many large, systematic users, who may not have access to the other hubs, are regular users of the Open Hub.

The greatest variation among the ranges can be observed on the ServHub, although a clear majority (62%) of users downloaded more than >1,000 products. This was a significantly higher proportion than the 47% of active users who downloaded in this range in Y2018. In Y2019, the proportion in the other categories was as follows: 18% in the '1-9' category, 9% in the '10-100' category' and 11% in the '100-1000' category. It is suggested that the observed variation may 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.

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3.3 Open Hub Active Users focus

3.3.1 Monthly Active Users

The graph in Figure 76 shows the number of active users on the Open Hub on a monthly basis throughout Y2019 and for each Sentinel mission (i.e. the number of users that downloaded at least one product from a particular Sentinel mission in the month). For comparison, the graph also shows the equivalent plots for Y2018, shown as dotted lines.

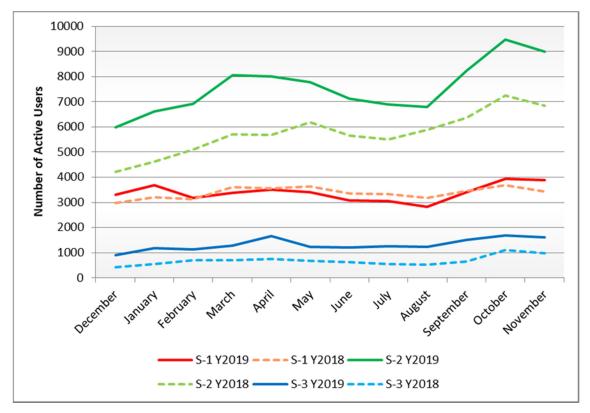


Figure 76: Active user trend per mission in Y2019 and Y2018

For Sentinel-1, there were some months during Y2019 in which the number of active users was slightly higher than it had been in the equivalent month in Y2018, and some months in which it was slightly lower. In general, however, the number of active users per month was very similar in both years and relatively steady, ranging between 3,000 to 4,000 active users per month. In fact, the average number of active users/month during Y2019 was 3,386, which is almost identical to the 3,383 average during Y2018. These trends suggest that the number of active users for Sentinel-1 has currently stabilized.

For Sentinel-2 and Sentinel-3, the number of active users was higher in Y2019 than in Y2018, for all months of the year. Sentinel-2 continued to be the

mission with the highest number of active users per month and again the number of users downloading Sentinel-2 images had increased significantly by the end of Y2019: the number of active users in December 2018 was 5,992, while in November 2019 it had risen to 8,990. The average number per month was, 7,574, which is 32% higher than the average of 5,751 during Y2018. Figure 76 shows a drop in the number of active users in June, July and August 2019, and it is assumed that this was the result of the summer month and holiday period in the Northern Hemisphere.

While the number of active users for Sentinel-3 remained modest in comparison to the numbers for Sentinel-1 and Sentinel-2, the mission experienced the highest percentage rise throughout Y2019. In

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December 2018, there were 899 active users of Sentinel-3 products, while by November 2019 there were 1,602; the average number per month also rose 92% during Y2019, up to 1,322 from 688 in Y2018. The sustained increase over the year is likely to be linked to increasing awareness and interest in the mission, helped by the activation of the final Sentinel-3B data flows (SRAL and OLCI in December 2018), as well as the staged transfer of products from the S3 PreOps Hub to the Open Hub. The small spike in active users which occurred in April (up to 1,663) was probably caused by the publication of massive amounts of Sentinel-3A SRAL reprocessed data during that month.

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.

Table 28 shows the number of active users on the Open Hub broken down by continent, for Y2018 and Y2019. It also shows, for both periods, the proportion for each continent of the overall number of active users, and the percentage increase between Y2018 and Y2019. The graph in Figure 77 highlights this growth in active users on all continents, also including Y2015, Y2016 and Y2017 to gauge the overall trends.

3.3.2 Active users per continent and country

Continent	Y2018	Overall % Y2018	Y2019	Overall % Y2019	% Increase Y2018-Y2019
Europe	21,316	42.9	24,836	40.3	17
Asia	11,644	23.4	16,686	27.1	43
South America +					
Antarctica	7,699	15.5	9,584	15.5	24
North America	5,865	11.8	6,954	11.3	19
Africa	2,204	4.4	2,469	4.0	12
Oceania	945	1.9	1,109	1.8	17

Table 28: Open Hub active users for Y2019 and Y2018, per continent

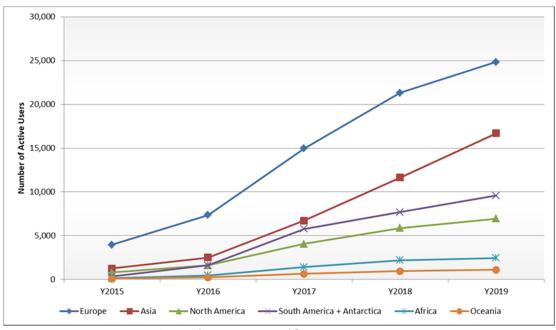


Figure 77: Open Hub active users trend from Y2015-Y2019, per continent











percentage increase since Y2018 and any change in the position in the list.

Once again, there was a rise in the number of active users in all continents during the year. Also the same as Y2018, the highest increase was in the number of active users from Asia, up 43% to 16,686 users. Numbers from South America rose 24% to 9,584, while North America, Europe and Oceania all experienced similar level growth, at 19%, 17% and 17% respectively. The ranking of continents according to percentage share remains the same as for Y2018. Notwithstanding these large increases in the number of Asian users, the highest number of active users still come from Europe, which had 40.3% of the total number of active users in Y2019 and almost double the number of active users of any other individual continent. Asia was next, with 27.1%, up from 23.4% last year. These figures highlight the continued growth in awareness and use of Copernicus data and services around the world.

It is highlighted that in Europe, North America, South America and Oceania (Australia), national mirror sites are available as an alternative and more local source for the products, and that the numbers presented here may be far from the total number of active users of Copernicus Sentinel data in those continents. As far as it is known, there are not currently any local Copernicus Sentinel data access sites in Asia or Africa.

It is also recalled that the total numbers of active users per continent do not necessarily match the volume of data downloaded by users in each continent. For instance, a user who downloads just one product in the year counts as one active user in exactly the same way as a user who downloads more than 1,000 products in the year. The active user statistics always need to be read in conjunction with the data download statistics, therefore, in order to generate a picture of the level of user activity within a continent.

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 users who downloaded a product from each mission during Y2019 is provided for each country, as well as the

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Sentinel-1 - Global					
Country	Active Users Y2019	% increase from Y2018	Change		
China	2,110	8	0		
India	1,358	29	^3		
Germany	1,256	-14	v 1		
Italy	1,102	3	0		
United States	968	-15	v 2		
United Kingdom	873	-11	0		
France	734	-13	0		
Russian Federation	722	34	^1		
Spain	619	-13	v 1		
Brazil	610	14	0		

Table 29: Y2019 Top 10 Global Countries: Sentinel-1

Sentinel-2 - Global					
Country	Active Users Y2019	% increase from Y2018	Change		
China	3,302	56	^1		
Germany	3,022	16	v 1		
Brazil	2,892	81	^3		
Spain	2,505	33	0		
United States	2,128	12	v 2		
Italy	2,013	20	v 1		
India	1,896	41	0		
Mexico	1,577	25	^2		
United Kingdom	1,461	11	v 1		
France	1,455	13	v 1		

Table 30: Y2019 Top 10 Global Countries: Sentinel-2

Sentinel-3 - Global					
Country	Active Users Y2019	% increase from Y2018	Change		
United States	914	81	0		
Germany	768	62	0		
Italy	694	92	^1		
Russian Federation	625	224	^6		
China	624	61	v 2		
Spain	618	86	v 1		
United Kingdom	511	62	v 1		
India	498	63	v 1		
France	471	75	0		
Brazil	452	53	v 2		

Table 31: Y2019 Top 10 Global Countries: Sentinel-3

Sentinel-1 - ESA/EU					
Country	Active Users Y2019	% increase from Y2018	Change		
Germany	1,256	-14	0		
Italy	1,102	3	0		
United Kingdom	873	-11	0		
France	734	-13	0		
Spain	619	-13	0		
Poland	410	-14	0		
Netherlands	329	-22	0		
Greece	263	-19	0		
Norway	187	-15	0		
Austria	177	2	^2		

Table 32: Y2019 Top 10 ESA/EU Countries: Sentinel-1

Sentinel-2 - ESA/EU						
Country	Active Users Y2019	% increase from Y2018	Change			
Germany	3,022	16	0			
Spain	2,505	33	0			
Italy	2,013	20	0			
United Kingdom	1,461	11	0			
France	1,455	13	0			
Poland	912	18	0			
Netherlands	850	30	0			
Greece	639	9	0			
Romania	466	18	^1			
Portugal	448	-8	v 1			

Table 33: Y2019 Top 10 ESA/EU Countries: Sentinel-2

Sentinel-3 - ESA/EU					
Country	Active Users Y2019	% increase from Y2018	Change		
Germany	768	62	0		
Italy	694	92	0		
Spain	618	86	0		
United Kingdom	511	62	0		
France	471	75	0		
Poland	247	44	0		
Netherlands	193	34	0		
Greece	144	67	0		
Portugal	138	66	0		
Norway	112	70	^1		

Table 34: Y2019 Top 10 ESA/EU Countries: Sentinel-3



respectively.

Five ESA/EU member states, Germany, Italy, United Kingdom, France and Spain, appear in the top 10 rankings for each Sentinel mission, both in the global tables and in the Europe-only tables. In the global tables, four other nations also appear in the top 10 for each mission: China, India, the United States and Brazil. China has now emerged as the country with the highest number of active users for both Sentinel-1 and Sentinel-2, with 2,110 and 3,302 active users

The highest rises in the numbers of active users were in the non-ESA/EU nations: for example, the number of users in India who downloaded Sentinel-1 products rose by 29% to 1,358, and India became the country with the second highest number of active users of Sentinel-1 data in Y2019. For Sentinel-2, the largest percentage increases were seen in the numbers of active users in Brazil, China and India (up 81%, 56% and 41% respectively). For Sentinel-3, the number of active users in the Russian Federation increased by a massive 224% and it became the country with the fourth highest number of active users of Sentinel-3 products. It is interesting to note that, for Sentinels-2 and -3, all nations in the top 10 saw rises in active users during Y2019; however, for Sentinel-1, five nations in the top 10 saw decreases of between 11% and 15% during the year.

Considering only ESA/EU member states (Tables 32-34), the position of each country within the tables has changed little since either Y2017 or Y2018. For Sentinels-1 and -3, the top 9 countries in the list were the same as those listed in Y2018, and for Sentinel-2 it was the top 8 countries which remained the same. Germany again had the highest number of active users for all three missions. In terms of growth, the global trends are reflected here: for Sentinels-2 and -









3 (with the exception of Portugal for Sentinel-2) all nations experienced growth, while for Sentinel-1 8 nations in the top 10 experienced reductions of between 11% and 22%. For Sentinel-2, the highest growth recorded was by Spain (33%) while for Sentinel-3 it was for Italy (92%).

3.3.3 Users per declared uses and thematic domains

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; users are asked to state their user country, thematic domain and usage type from a set of predefined lists during the registration process. The information may therefore be limited in several ways: there is no independent verification performed 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, and as in previous years, 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.

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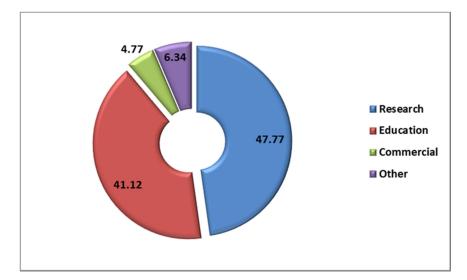












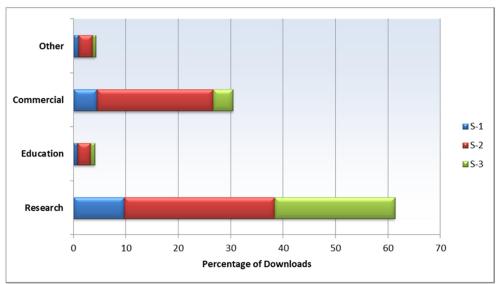


Figure 78: Percentage of Open Hub active users per declared usage type at the end of Y2019, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each usage type during Y2019

Figure 78 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 Y2019, the vast majority of registered users selected 'Research' (48%) and 'Education' (41%) for their usage type, with only 5% selecting 'Commercial'. This is an almost identical split to those recorded in previous reporting years.

The bar graph analyses the usage type in terms of downloads made from each mission per declared usage type. 'Research' is again the largest category, accounting for 61% of the downloads made, which is slightly down on the 67% of Y2018. On the other hand, a small rise can be seen in the number of downloads made by the 'Commercial' category of users, who downloaded 30% of the total number of products in Y2019, compared with 25% in Y2018. 'Education' and 'Other' both accounted for only 4% of downloads, similar to the values for Y2018.

The largest rise at the level of individual mission was the increase in the number of downloads of Sentinel-3 products made by the 'Commercial' user group: during Y2018 hardly any of the Sentinel-3 downloads were made by 'Commercial' users, with only 0.15% of the total number, but during Y2019, 'Commercial' users made3.76% of the Sentinel-3 downloads. In general, Sentinel-3 downloads were more evenly

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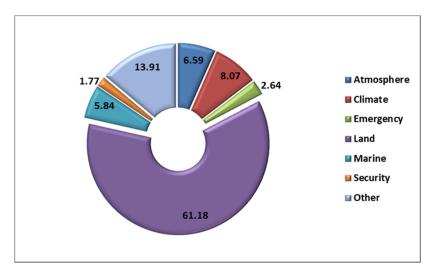




distributed between the categories this year than they had been in Y2018, when 97% of the downloads fell into 'Research' (the figure is 81% for Y2019). The 'Commercial' users also made a significantly higher proportion of the Sentinel-2 downloads in Y2019, up to 22.17% from 17.71% during Y2018.

It is interesting to note that even though the 'Education' user group consists of considerably more registered users than the 'Commercial' user group,

'Commercial' users accounts for a far greater proportion of downloads. 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.



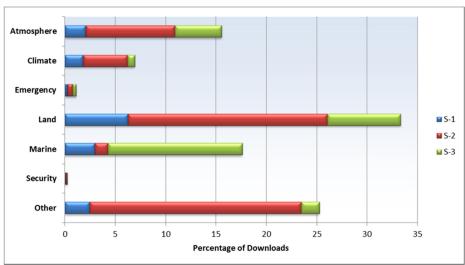


Figure 79: Percentage of Open Hub active users per declared thematic domain at the end of Y2019, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each thematic domain during Y2019

Figure 79 summarizes the Y2019 data for the seven thematic domains in the same way as done for the usage types. Users who registered 'Land' as their intended application continued to be by far the largest group, accounting for 61% of registered

users. Next in order were 'Other' with 14%, 'Climate' with 8%, 'Atmosphere' with 7%, and 'Marine' with 6%. As was the case for usage types, this was a very similar distribution to that seen in Y2018.

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In Figure 79 above, the total number of downloads has been separated out into the intended application domain and split down by Sentinel. 'Land' has now also emerged as the application for which the majority of downloads were made, with 33% of the downloads up from 25% in Y2019. As in previous years and as would be expected, Sentinel-2 downloads comprise the majority of the 'Land' downloads, and 20% of all downloads were made for Sentinel-2 'Land' applications. There was a significant increase in the number of Sentinel-3 products downloaded for 'Land' applications as well, up to 7% of the total number of downloads, from 2% Disregarding 'Other', 'Land' was the largest application domain for all three missions in Y2019.

In Y2018, it had been 'Marine' applications for which the greatest proportion of downloads had been









made, but in Y2019 the proportion fell from 30% of all downloads to just 18% in Y2019. This is largely due to a considerable reduction in the proportion of Sentinel-3 products downloaded for 'Marine' applications. Downloads for Sentinel-3 'Marine' applications had constituted as much as 25% of the total downloads in Y2018, but in Y2019 this figure was down to 13%.

It is again noted that Sentinel-2 downloads for 'Atmosphere' applications made up a sizeable proportion of the total number downloads in Y2019 (9%), which is unexpected. It is of course possible that these results have been distorted by a proportion of users choosing 'Atmosphere' when they registered, simply because it appears as the default first choice in the drop down options.











Data Dissemination Partners

The access to Copernicus Sentinel data which ESA provides through the Copernicus Sentinel Data Access System is complemented by a growing number of national and commercial re-distributors which also provide online access to the data. These redistribution points include the national mirror sites which are provided in the framework of the Collaborative Ground Segment, and the sites which are provided by international partners in the framework of international agreements. Table 35 below sets out the links to these national and international data access sites. Please note that the list may not be comprehensive and the content of each site is outside the responsibility of ESA and Serco consortium.

It is also highlighted that each data dissemination partner follows its own strategy on the Copernicus Sentinel products it makes available through its site, and the length of time for which it makes the data available. Some sites offer a complete mirror of all available products from one or more of the Sentinel missions, while others offer a 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 is invited to investigate each in detail via the URLs provided.

Category	Annual Report Section	Partner	Access URL(s)	Additional Description
		Austria	https://data.sentinel.zamg.ac.at	
		Belgium	www.vito-eodata.be www.terrascope.be	
		Canada	ftp://ftp.neodf.nrcan.gc.ca	
		Czech Republic	https://dhr1.cesnet.cz	
		Estonia	https://ehdatahub.maaamet.ee	
		Finland	https://finhub.nsdc.fmi.fi	
		France	https://peps.cnes.fr	
		Germany	https://code-de.org/	
Collaborative		Greece	https://sentinels.space.noa.gr	
National Mirror	4.1	Ireland	https://eo browswer.speir.ichec.ie	
Sites		Italy	http://collaborative.mt.asi.it/	
Sites		Luxembourg	www.lsa-datacenter.lu	
			https://colhub.met.no	
		Norway	https://satellitedata.no/	
		Poland	https://copernicus.imgw.pl	
		Portugal	https://ipsentinel.pt/	
		Romania	https://dhus.rosa.ro/	
		UK-1	http://archive.ceda.ac.uk/	
		2	http://sedas.satapps.org/	
		UK-2	https://geobrowser.satapps.org/	
		Biosense (Serbia)	https://biosens.rs/	
		Geoscience Australia	http://www.copernicus.gov.au/	
		(GA)	https://copernicus.nci.org.au/sara.client/#/home	Copernicus Australia
			https://vertex.daac.asf.alaska.edu	Alaska Satellite Facility (Sentinel-1)
			https://oceancolor.gsfc.nasa.gov	NASA OceanColor Web (Sentinel-3)
International Partners' Sites	4.2 NASA	NASA	https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/	Level-1 and Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center (DAAC) (Sentinel-3)
			https://disc.gsfc.nasa.gov	GES DISC (Sentinel-5P)
		NOAA	https://coastwatch.noaa.gov	NOAA Coastwatch
		University of Chile	www.datoscopernicus.cl	Copernicus Chile
		USGS	https://eros.usgs.gov/sentinel-2	USGS Earth Resources Observation and Science (EROS) Center

Table 35: Sentinel Data Dissemination Partners













Collaborative Ground 4.1 **Segment Agreements**

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

A total of 20 Collaborative Ground Segment agreements had been signed with ESA by the end of Y2019. One of the agreements came to an end¹ in Y2018 and 19 remain active. Following signature of the agreement, ESA passes a dedicated set of credentials to the national contact point to enable it to access the ColHub. ESA also provides technical support to the national contact point to help it optimise its access to the data.

The Collaborative Ground Segment partners provide information about the activity on their national mirror sites via an annual questionnaire which ESA sends out. Not all of the national services planned under the Collaborative agreements operational by the end of Y2019. The statistics presented in this section are based on the 16 partners who both had active national initiatives during Y2019 and who provided the requested information.

Table 36 summarises the status of the 19 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, 16 of the 19 Collaborative Ground Segment partners had opened their national mirror sites. The partners who had not opened their sites by the end of Y2019 are scheduled to become operational during the following year.

For the sites which had already been opened prior to Y2019, the following impressive average increases in user growth and publication volumes are calculated:

- Average growth in registered users: 29%
- Average growth in publication volume: 47%

For dissemination volumes, the total reported actually dropped 41% during Y2019, to a total of 2,766 TB. This is largely due to a 90% drop in the dissemination from the Collaborative Ground Segment who reported by far the largest volume during Y2018: 3,400 TB, down to 342 TB in Y2019. This was most likely due to a single user downloading large amounts of historical data to populate their archive during Y2018.

It is noted that the product download volumes discussed in this section are only one way of measuring the 'output' of a particular Collaborative Ground Segment. In fact, several are now providing on-demand processing of data, together with online visualisation and the tools needed to support this. While these cutting-edge uses of Copernicus Sentinel data are not explored further in this section, the interested reader can explore the individual Collaborative Ground Segment portals. executive summaries of the 'Collaborative Ground Segment Workshops' also highlight such initiatives on a per partner basis and are available to download here:

https://sentinel.esa.int/web/sentinel/missions/collabo rative/workshop

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¹ The Swedish National Space Agency is now (2019) developing a National Space Data Lab together with Lindholmen Science Park, Research Institutes of Sweden AB and Luleå University of Technology. The aim is to offer easy methods for analysis of Copernicus data and other space data based on Artificial Intelligence (AI), and the lab will also offer a data cube based on the Open Data Cube project.









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	01-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	yes	01-Jan-19
13	Luxembourg	Apr-17	yes	01-May-19
14	Belgium	Sep-17	yes	01-Sep-17
15	Ireland	Oct-17	yes	19-Feb-18
16	Poland	Nov-17	no	Foreseen: early 2020
17	Romania	Dec-17	yes	30-Nov-18
18	Czech Republic	Jan-18	yes	14-Mar-17
19	Hungary	Oct-19	no	Foreseen: second half of 2020
20	Spain	Nov-19	no	Not known

Table 36: Collaborative Ground Segment mirror sites summary

CollGS Partner	Overall Number of Registered Users since Start of Operations	% Increase since Y2018	% of Registered Users from the National Country	Number of Active Users in Y2019	% of Registered Users who were Active in Y2019
France	5,716	37%	56%	1,140	20%
Germany	2,245	60%	80%	761	34%
Austria	1,647	15%	-	95	6%
UK-2	1,021	39%	62%	216	12%
Greece	704	15%	68%	60	9%
Norway	587	33%	-	150	26%
Portugal	514	28%	93%	40	8%
Finland	434	40%	64%	85	20%
UK-1	204	27%	79%	58	28%
Czech Republic	197	56%	95%	89	45%
Ireland	188	11%	-	-	-
Estonia	161	N/A	87%	100	62%
Belgium	119	4%	60%	85	71%
Italy	49	29%	-	-	-
Luxembourg	36	N/A	33%	13	36%
Canada	20	10%	100%	10	50%
Romania	12	N/A	-	5	42%

Table 37: Summary of national mirror site users

Table 37 presents the data on the registered and active users on the national mirror sites, as reported in the annual questionnaires. On this and subsequent

figures and tables in the section, statistics are only shown for the CollGS partners who provided it, and

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where partial information was provided the statistics not available are shown as '-'.

As expected, all partners with operational sites recorded rises in the number of registered users during Y2019. It should be noted that it is not easy or useful to compare the figures from each CollGS, partly due to the different start dates for each site but also because each partner may impose different restrictions on registering and accessing the data: some of the ColIGS are completely open to all types of users, while others are only open to a few selected users.

The percentage of registered users who were active during Y2019 (meaning they downloaded at least one product) was in general under 50%, with the exception of three partners - Belgium, Estonia and Canada. In almost all cases where it was reported, users from the nation hosting the mirror made up the majority of the total registered users (the exception being Luxembourg at 33%).

In line with the reporting agreement, the Collaborative Ground Segment partners categorise their own users according to the same fields used by ESA. Figures 80 and 81 below show the percentage of registered users from each national mirror site assigned to both 'usage category' (research, commercial, education, other) and 'usage field' (specific field for which the data is used e.g. land, marine, atmosphere etc).









Usage Category

11 out of the 17 partners who provided data had 'Research' as their top category and 'Research' accounted for 45% of all CollGS users. In fact, the category accounted for more than 50% of users for Belgium, Estonia, Finland, France, Greece, Italy, Portugal and UK-2.

Overall, 8% of the CollGS users were from the 'Commercial' user group, which consistent with Y2018. Most notably, commercial users constituted 58% of the users of the Irish mirror site and 31% of the users of the Luxembourg site.

27% of the CollGS users were from the category 'Education', and this was the largest category of users for the Czech mirror site (42% of users) and the Romanian site (64%) mirror sites.

Usage Field

'Land' is again the most popular usage field, being the highest field for all partners except Canada, Germany, Luxembourg and UK-1, and accounting for 50% or more of users for Austria, Belgium, Czech Republic, Estonia, Finland, France, Ireland, Portugal, Romania and UK-2. 'Marine' and 'Atmosphere' also account for a high proportion of users from many partners, including the 70% of 'Marine' users in Canada and the 21% of 'Atmosphere' users in Greece. Taking into account all users for all partners, the top fields were 'Land', accounting for 50% of users, 'Other' (28%), 'Marine' (7%) and 'Atmosphere' (6%).





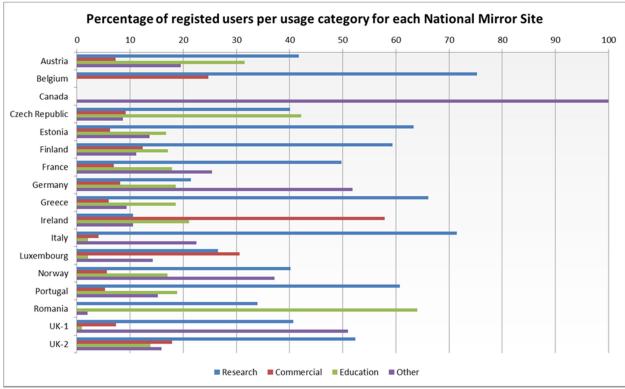


Figure 80: Percentage distribution of mirror site users by usage category

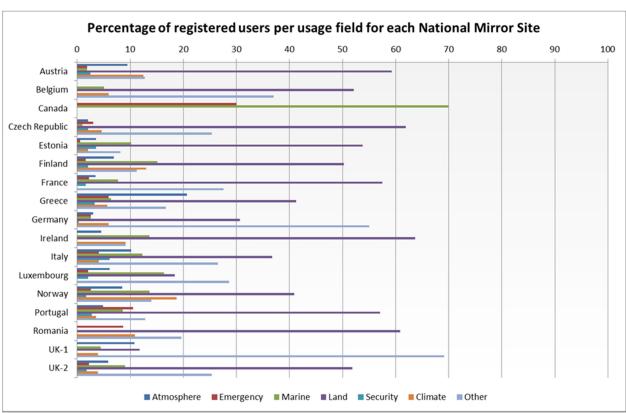


Figure 81: Percentage distribution of mirror site users by usage field











CollGS Partner	Y2019 Published Volume (TB)	% Increase from Y2018	Y2019 Downloaded Volume (TB)	% Increase from Y2018
Austria	6,639	115%	342	-90%
Belgium	56	-99%	42.1	518%
Canada	43	8%	40	1%
Czech Republic	50	-25%	65.3	80%
Estonia	128	N/A	15.6	N/A
Finland	56	-79%	27.3	128%
France	5,437	19%	1,079	28%
Germany	6,655	90%	34.3	196%
Greece	467	29%	18.2	-35%
Ireland	-	-	46.2	-
Italy	83	-	-	-
Luxembourg	9,655	N/A	651	N/A
Norway	4,809	49%	378.5	40%
Portugal	131	-1%	0.5	-49%
Romania	14	N/A	0.02	N/A
UK-1	2,099	-16%	11.0	115%
UK-2	3,345	34%	14.5	-17%
TOTAL	39,667	47%	2,766	-41%

Table 38: Overall publication and dissemination volumes on mirror sites

Table 38 above reports, where available, the total volume of Copernicus Sentinel data both published on and downloaded from the mirror sites during Y2019, together with the percentage change with respect to Y2018. Overall, this year is more varied than the last, with a number of decreases as well as increases reported. There are again large variations in both volumes published and downloaded between the mirror sites, reflecting the specific usages and target users of each. 7 out of the 12 partners who provided statistics for both years reported increases, and those increases were large enough to make the total data volume published (39,667 TB) 47% higher than in Y2018.

The greatest individual increases in publication volumes were seen by Austria (115% increase), Germany (90%) and Norway (49%). In terms of absolute volumes, the Luxembourg site dealt with the highest volume of downloads of the year with 9,655 TB, followed by Germany (6,655 TB), Austria (6,639 TB) and France (5,437 TB).

In terms of volumes of downloads made by users, the overall sum of 2,766 TB was 41% down on the Y2018 total, largely the result of a 90% drop in downloads from Austria (which had by far the highest download volume in Y2018). In absolute terms, the highest download volumes came from France (1,079 TB), Luxembourg (651 TB) and Norway (378.5 TB). The partners which showed the largest growth in download volume between Y2018 and Y2019 were Belgium (up 518%), Germany (up 196%) and Finland (up 128%). The majority of mirror sites showed lower download volumes than the volumes published. An interesting exception to this was the Czech Republic, which was the only partner to have a higher download volume (65.3 TB) than published volume (50 TB).

Table 39 breaks the publication and download volumes down by Sentinel mission, where this information was available. Countries who published more Sentinel-1 data than any other mission were: Belgium, Canada, Estonia, Finland, Greece, Italy, Luxembourg, Portugal, Romania and UK-1. Countries which published more Sentinel-2 data than any other mission were Austria, Czech Republic, France, Germany, Norway and UK-2. No country published more Sentinel-3 or Sentinel-5P data than any other mission. In fact, at this stage, only two partners are publishing any Sentinel-5P data: Germany and UK-1.

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In terms of download volumes, a similar trend may be observed, with some interesting exceptions. For example, although France publishes almost twice as much Sentinel-2 data as Sentinel-1, Sentinel-1 downloads are about four times higher than for Sentinel-2. Although Luxembourg published about equal volumes of Sentinel-1 and Sentinel2 products, the Sentinel-2 download volume is over 200 times higher than for Sentinel-1. Similarly, for Norway, although about equal volumes of Sentinel-1 and Sentinel-2 products are published, Sentinel-1 download volumes are over six times higher.

Austria was the only country which reported a majority of Sentinel-3 downloads. Users of the



Austrian mirror site downloaded about twice the volume of Sentinel-3 data volume as they downloaded of both Sentinel-1 and Sentinel-2 combined.

In terms of Sentinel-5P downloads, only Ireland and UK-1 reported any downloads.

These differences between publication and download volumes can be seen graphically in Figure 82 which shows a comparison, in percentage terms, between publication and download volumes per Sentinel for all reported national mirror cases.

	Y20	019 Publishe	d Volumes (ТВ)	Y2019 Downloaded Volumes (TB)			
CollGS Partner	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
Austria	2140	3997	502	0	88	58	196	0
Belgium	24	22	0	0	14	28	0	0
Canada	43	0	0	0	40	0	0	0
Czech Republic	15	23	13	0	39	23	4	0
Estonia	59	41	29	0	9	7	0.1	0
Finland	27	15	14	0	19	8	0.8	0
France	1852	3398	187	0	864	214	1	0
Germany	1751	4093	778	33	11	17	7	0
Greece	241	168	59	0	12	6	1	0
Ireland	-	-	-	-	-	-	-	-
Italy	41	27	15	0	-	-	-	-
Luxembourg	4934	4722	0	0	3	648	0	0
Norway	2044	2139	627	0	321	52	6	0
Portugal	103	14	14	0	0.4	0.1	0.01	0
Romania	7	3	4	0	0.0	0.017	0	0
UK-1	1471	163	439	26	1	0.03	10	0.001
UK-2	1,632	1,713	0	0	13	1	0	0
TOTAL	16,381	20,536	2,681	58	1434	1060	225	0

Table 39: Y2019 Publication and dissemination volumes per Sentinel on mirror sites







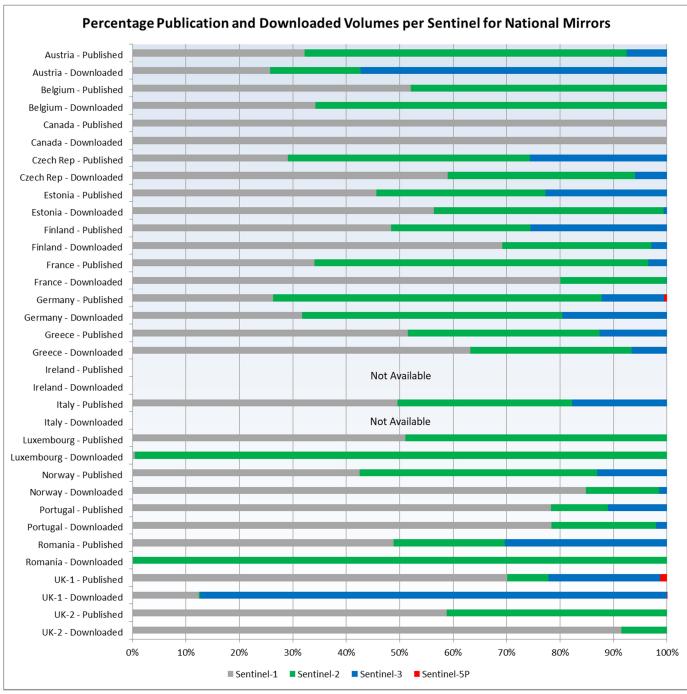


Figure 82: Percentage publication and dissemination volumes per Sentinel on mirror sites

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4.2 International Technical Agreements

The Copernicus programme has strong international dimension. In support the international data sharing principles of the Group for Earth Observation (GEO), and in line with the Copernicus programme's policy of full, open and free-of-charge access to Copernicus data and information, the European Commission has entered into 9 Cooperation Arrangements with international partners to advance the mutually beneficial exchange of satellite data, in-situ data and support for calibration/validation activities (https://www.copernicus.eu/en/international-cooperation-area-data-exchange).

ESA is entrusted with ensuring the exchange of satellite data under these cooperation arrangements, and for that purpose enters into technical operating arrangements (TOAs) with the agencies nominated by the partner countries. Under the TOAs, the nominated agencies are able to download Copernicus Sentinel data products from IntHub and transfer the data to their national data access sites, for use by their own user communities.

Table 40 presents an overview of the international partner sites which have already been established, or which are in the process of being established. The partners are listed in order of the date on which they signed the arrangement with ESA.

International Partner	TOA signature date	Data centre open by end Y2019? (Y/N)	Date started distributing Sentinel data from the site	Purpose of the national data access site
United States National Aeronautics and Space Administration (NASA)	18-Feb- 2016	Y	12-Dec-2015	The aim of NASA's mirror site is to re-use and redisseminate Copernicus Sentinel data, to increase distribution capacity, and maximise the benefits to Earth Science research and applications. NASA started distributing Sentinel-1 products from its Alaska Satellite Facility data portal, Vertex, on 12 December 2015. 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 began to be published on the NASA Sentinel Gateway (NGS). The relevant websites are: S1: https://vertex.daac.asf.alaska.edu S3: https://oceancolor.gsfc.nasa.gov and https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/ S5P: https://disc.gsfc.nasa.gov
United States	19-Feb-	Y	-	USGS provides storage and redistribution of Sentinel-2 data products on its Earth Resources Observation and

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US Geological	2016			Science (EROS) Center.
Survey (USGS)	2010			
				https://www.usgs.gov/centers/eros The agreement between ESA and USGS allows for free and open public access and redistribution of MSI imagery, such as EarthExplorer, from existing USGS access systems. The current USGS Sentinel-2 archive is only a partial representation of all available acquisitions from ESA.
				USGS develops algorithms and processing methodologies in order to enhance the interoperability and synergistic use of Landsat and Sentinel-2 data streams.
Australia Geoscience Australia (GA)	24-Mar- 2016	Y	26-Jun-2015	GA publishes Copernicus Sentinel data on its data access site 'Sentinel Australasia Regional Access' (SARA).
				The primary aim for SARA is to provide free and open access to Copernicus Sentinel data to users in Australasia, South-East Asia and the South Pacific region.
				The relevant websites are: http://www.copernicus.gov.au/
				https://copernicus.nci.org.au/sara.client/#/home
				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. In 2018, the New Zealand Centre for Space Science Technology joined the consortium as a partner.
United States National Oceanic and Atmospheric Administration (NOAA)	1st signed 16-Feb- 2016 - update signed 19- Dec-2017	Y	01-May-2016	NOAA provides access to satellite data products for understanding and managing oceans and coasts. It makes available the oceanographic products from 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 publishes a collection of Sentinel-2 MSI over 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

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				ESA's IntHub.
				The relevant website is: https://coastwatch.noaa.gov
Serbia The BioSense Institute – Research Development Institute for Information Technologies in Biosystems	25-Jan- 2019	Y	Mid-Oct 2019	BioSense has established a regional data access mirror site/analysis hub to improve access to and the exploitation of Copernicus Sentinel data in the Republic of Serbia and the wider Balkan area. The relevant websites are: https://biosens.rs and https://biosens.rs and https://agrosens.rs .
Brazil Brazilian Space Agency and the National Institute for Space Research of Brazil	14-Mar- 2019	N	n/a	INPE intends to establish a regional data access/analysis hub, to improve the access to and exploitation of Copernicus Sentinel data in Brazil.
Ukraine State Space Agency of Ukraine (SSAU)	28-Mar- 2019	N	n/a	SSAU intends to establish a regional data access/analysis site to improve access to and the exploitation of Copernicus Sentinel data in Ukraine. SSAU intends to make available to users all available Copernicus Sentinel data products over Ukraine.
India Indian Space Research Organisation (ISRO)	11-Apr- 2019	N	n/a	ISRO intends to establish a regional data access/analysis mirror site to improve access to and the exploitation of Sentinel data in India. ISRO intends to make available to users all Copernicus Sentinel data products over India and surrounds.
Chile University of Chile	20-Aug- 2019	Y	27-Sep-2019	UdeChile, through the Center for Mathematical Modelling (CMM) and its specialised units, in particular the HPC Center and its Image Processing Working Group, has established a regional data access/analysis mirror site to improve access to and the exploitation of Copernicus Sentinel data, initially in Chile and later also in the Latin American region. In the initial stage, the site will make available to users all Copernicus Sentinel data products over the land and marine territories of Chile. The relevant website is: www.datoscopernicus.cl

Table 40: International Partners summary

The international partners which have opened their national data access sites provide annual feedback on

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Date 25/05/20 Issue 1 Rev 0 the use of their sites and the uptake of Copernicus Sentinel data. The input received for Y2019 is











summarised below. Where information was not available this is shown as '-'

Table 41 presents information about the number and type of users on each of the operational sites. It should be noted that for USGS, the figures presented

under 'Principal user categories' are calculated on the basis of the proportion of downloads which were made by each category of user, while for the other partners the percentages show the proportion of their registered users which fall into each category.

International Partner	Operation start date	Number of active users in Y2019	% increase in active users since Y2018	Principal user categories (percentages of registred users unless otherwise stated)
Geoscience Australia (GA)	26-Jun-15	9,029	141%	N/A
NASA (USA)	12-Dec-15	16,414	88%	Research (inc government): 2% Commercial: 1% Education: 6% Other (US Organisation and foreign users): 92%
NOAA (USA)	May-2016	8,012	957%	NOAA National Centres for Coastal Ocean Science NOAA National Weather Service Ocean Prediction Centre NOAA Satellite Analysis Brance US Navy CoastWatch/OceanWatch
USGS (USA)	16-Feb-17	235,594	32%	[percentages are of download proportions] Academic Institutions: 52% Private Business: 17% General Public: 14% Non-US Federal/National Gov: 5% Non-profit Organizations: 4% US Federal Government: 3%
University of Chile	27-Sep-19	185	N/A	Research: 41% Commercial: 7% Education: 31% Other: 20%

Table 41: International Partner general characteristics and statistics for Y2019

Table 42 summarizes published and downloaded volumes per partner during Y2019, where available, together with the percentage change with respect to

Y2019, if applicable. The total volumes of published and downloaded data since the start of data distribution are also provided where available.

International Partner	Total Published Volume in Y2019 (TB)	% Change in Published Volume from Y2018	Total Published Volume since start of data distribution (TB)	Total Downloaded Volume in Y2019 (TB)	% Change in Downloaded Volume from Y2018	Total Downloaded Volume since start of data distribution (TB)
GA (Australia)	1,229	+40%	3,016	5,070	+58%	8,272
NASA (USA)	2,540	-16%	8,681	8,280	+80%	15,141
NOAA (USA)	96	-1	682	19.2	0	41
USGS (USA)	1,128	N/A	-	353	-6%	-
University of Chile	36	N/A	36	0.3	N/A	0.3
Biosense (Serbia)	0.0249	N/A	0.0249	N/A	N/A	N/A
ISRO (India)	3.4	N/A	3.4	N/A	N/A	N/A

Table 42: International Partner publication and download statistics for Y2019

NB1: In the cases of Biosense and ISRO, products have been retrieved from the ColHub but are not yet available for download by users of the national data access site. These partners are therefore not included in Table 41, and in Tables 42 and 43, the figures in the

'published' columns should be taken as the total downloaded from the ColHub by the end of Y2019.

NB2: for USGS, a total number of 603,261 tile downloads were reported during Y2018, from which a volume of approximately 353 TB has been estimated.

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In Table 43, the overall volumes of products published and downloaded in Y2019 are broken down by Sentinel, to show the focus of each site in

terms of the Sentinel missions which are made available to their users, and the respective interest of the users.

International	Y2	Y2019 Published Volumes (TB)			Y2019 Downloaded Volumes (TB)			
Partner	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
GA (Australia)	271	506	452	0	-	-	-	-
NASA (USA)	2,209.6	N/A	212.7	117.7	7,936.6	N/A	54.4	288.7
NOAA (USA)	0.9	43.1	51.9	0	16.1	0.02	3.0	0
USGS (USA)	N/A	1,128	N/A	N/A	N/A	353	N/A	N/A
University of Chile	16.4	12.8	6.6	0	0.19	0.08	0.04	0
Biosense (Serbia)	0.0153	0.0049	0.0047	N/A	N/A	N/A	N/A	N/A
ISRO (India)	1.9	1.5	N/A	N/A	N/A	N/A	N/A	N/A

Table 43: International Partner published and download volumes, per Sentinel mission for Y2019

More information about the Commission's international cooperation on data exchange can be found at:

https://www.copernicus.eu/en/international-cooperation-area-data-exchange







5 Data Access System perfomance analysis

Performance analysis plays a key role in the continuous improvement of the Sentinel Data Access System. The approach and the results from this continuous analysis process are described in this section.

5.1 Service Availability

Service availability is defined as the percentage of a given time period during which it is possible for users to search the catalogue and retrieve products from the system. The service availability of each of the data hubs is constantly monitored and presented to users in the statistics panel of each data hub. The number of products published and downloads made in the previous 24hrs is also provided for each hub, to broaden the view of the current performance of the hub.

Table 44 below presents the overall availability for each of the four hubs for Y2019. For comparison, the table also sets out the corresponding values recorded for Y2018, Y2017, Y2016 and Y2015 where available. For the Open Hub, it is highlighted that the

availability values are calculated using the combined availability of each access instance, i.e. the Graphical User Interface (GUI) 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).

In general, the achievements regarding availability were impressive during Y2019. Each Hub achieved over 99% overall availability; each Hub showed an improvement on the availability recorded during Y2018; and the availability recorded for each Hub during Y2019 was the highest of any year since the start of operations.

Table 45 breaks the overall availability figures down by month for each of the hubs. Attention is drawn to the fact that for the first year since the start of reporting, the average availability per month never fell below 97% for any of the hubs. Moreover, the monthly availability for ColHub, taking into account the three nodes, never fell below 100%.

Hub	Availability (%)						
пии	Y2019	Y2018	Y2017	Y2016	Y2015		
Open Access Hub	99.34	98.48	98.59	95.11	96.62		
Copernicus Services Hub	99.60	98.50	98.60	99.35	N/A		
Collaborative Hub	100	100	98.04	98.19	96.09		
International Hub	99.95	99.90	98.89	99.59	N/A		

Table 44: Overall availability of each hub during reporting years Y2015 – Y2019











	Availability (%)							
Month	Open Access Hub	Copernicus Services Hub	Collaborative Hub	International Hub				
2018-12	99.59	99.35	100	100				
2019-01	99.85	100	100	99.47				
2019-02	99.8	99.75	100	100				
2019-03	99.53	99.7	100	100				
2019-04	99.88	99.84	100	100				
2019-05	99.6	100	100	100				
2019-06	97.16	97.42	100	99.97				
2019-07	98	99.5	100	100				
2019-08	99.74	99.86	100	100				
2019-09	99.47	99.97	100	100				
2019-10	99.76	99.79	100	100				
2019-11	99.6	99.98	100	100				
Y2019	99.34	99.60	100.00	99.95				

Table 45: Monthly availabilities during Y2019 per hub (green shading indicates >95% availability; yellow shading indicates 90-95% availability)

The highest overall availability was the 100% recorded for the ColHub. 100% service availability was also recorded for ColHub in Y2018. In both years, it was achieved due to the 3 nodes operating in parallel, which provide sufficient redundancy to safeguard service continuity: as long as one of the nodes remained operational, users could switch to that node to retrieve the products if a problem arose on one of the other nodes. A period of simultaneous downtime never happened during Y2019, and in fact it has not occurred since the opening of the second node for the ColHub in July 2017. The 3-node structure also enables the service team to carry out maintenance on the nodes without disrupting the service availability.

The IntHub - hosted on the NOA/GRNET infrastructure – achieved its highest overall yearly availability, up to 99.95% from an already impressive 99.90% in Y2018. In fact, for 10 months of Y2019, no downtime was recorded on the Hub at all; small periods of unavailability were recorded only in January and June 2019.

As can be seen from Table 45, there were only three instances in which monthly availability went below 99%. The hubs affected were the Open Hub and ServHub, both of which run on the same infrastructure, which means that both tend to be simultaneously when affected periods unavailability occur. The month with the lowest availability was June 2019 for both cases: 97.16% on the Open Hub and 97.42% on ServHub. This was the result of a series of relatively lengthy scheduled maintenance activities, including an update of the firmware for the Isilon storage (where the products are stored), which took place on the infrastructure during the period 24-27 June 2019. The maintenance activities impacted the Open Hub, ServHub, and even Node 1 of ColHub. During this time, the search and download functions were affected on each of the hubs, and there was an extended period of downtime which lasted from 12:00 on 26 June to 12:00 in 27 June 19 (as described in the incident log below).

Overall, fewer critical infrastructure maintenance and security patching activities were required in Y2019 than in Y2018, however, and this is the major reason for the all-round strong performance of the hubs in Y2019. The previous years of infrastructure upgrades and lessons learnt have created a system which is operationally robust, notwithstanding the everincreasing pressures which are placed on the system through user activity and product publication.

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Moreover, there were no unexpected infrastructure adversities in Y2019, unlike in Y2018 when severe power outage in the Interxion Frankfurt Data Centre affected the overall availability across the hubs. During 2018 there were 111 hours of maintenance downtime on the Open Hub, but in 2019 this figure was reduced to only 27 hours: on ServHub, there were 106 hours of maintenance-related downtime during 2018, and in 2019 this also fell to 27 hours.

The majority of the 27 hours is accounted for by the 24hr downtime described above which took place in June. The remaining disruptions were caused, as in previous years, by structured and scheduled upgrade and maintenance activities which were necessary both to renovate the system and to enable it to evolve with demand. Users were notified in advance of the short periods in which each hub would suffer a degraded performance, publication delay or a downtime. Below is a list and description of the scheduled upgrade and maintenance activities which took place in Y2019:

- 10/12/18 13:00-16:30 Software upgrade activity on the Sentinel-3 Pre-Operations Hub, involving two short service interruptions of approximately 30 minutes.
- 11/12/18 07:00-16:00 Infrastructure security maintenance effecting the Open Hub and the ColHub (Node 1).
- 12/12/18 07:00-16:30 Infrastructure security maintenance effecting the ServHub and the Sentinel-3 Pre-Operations Data Hub.
- 20/12/18 08:00-11:00 Service maintenance on the Sentinel-5P Pre-Operations Data Hub.
- 11/01/19 08:00-16:00 Maintenance activity on the core Data Hub infrastructure, involving the replacement of switches interconnecting the servers to the rolling archive storage. The following services were affected: Open Hub, ColHub (node 1) and S Hub.
- 22/01/19 09:00-16:00 Maintenance activity on the core Data Hub infrastructure, involving the replacement of switches interconnecting the servers to the rolling archive storage. The following services were affected: Open Hub, ColHub (node 1) and ServHub. During the period,

product publication was delayed and some degradation in download was experienced.

- 12/03/19 07:00-16:30 Scheduled infrastructure security maintenance causing the publication delay of products on the Open Hub, IntHub, ServHub and ColHub. In particular, the publication of Sentinel-2 L2A products was suspended between 12/03/19 13:00 - 13/03/19 18:00.
- 13/03/19 07:00-16:30 Scheduled infrastructure security maintenance causing the publication delay of products on the Open Hub, IntHub, ServHub and ColHub.
- 18/03/19 07:00 21/03/19 -Scheduled infrastructure security maintenance causing the publication delay of products on the Open Hub. Although this scheduled maintenance was intended to complete at 16:30 on 19/03/19, it was later extended to 21/03/19.
- 19/03/19 07:00 21/03/19 Scheduled infrastructure security maintenance causing the publication delay of products on ServiHub, Sentinel-3 PreOps Hub and ColHub (node 1). Although this scheduled maintenance was intended to complete at 16:30 on 19/03/19, it was later extended to 21/03/19.
- 24/06/19 06:30-11:30 A maintenance activity took place on the Open Hub, ServHub and ColHub node 1. During the window, no service downtime occurred but there was performance degradation on search and download functions.
- 25/06/19 07:00-15:30 A maintenance activity took place on the Open Hub, ServHub and ColHub node 1. During the window, no service downtime occurred but there was performance degradation on search and download functions.
- 26/06/19 12:00 27/06/19 12:00 A maintenance activity took place on the Open Hub, ServHub and ColHub node 1. During the window, the services were not available.
- 10/07/19 07:30-16:00 A scheduled maintenance took place on the Open Hub (including the API Hub), the ServHub and the ColHub (node 1). During the period there was a service



interruption of around 1 hour and a temporary delay of products publication.

- 22/07/19 and 23/07/19 07:00-16:30 Security maintenance activities took place on the Open Hub, IntHub, ColHub and ServHub, resulting in delays of Sentinel-1, -2 and -3 products.
- 29/07/19 07:00-16:30 Security maintenance activities took place on the Open Hub (including the API Hub and RINEX Hub), resulting in service interruptions.
- 30/07/19 07:00-16:30 Security maintenance activities took place on the ServHub and ColHub (node 1) resulting in service interruptions.
- o7/08/19 08:00-12:00 An anomaly resulted in this planned maintenance activity involving the proxies for the Open Hub (including the API and RINEX Hubs). During the window, the access points along with the Web Portals were unavailable for about 2 hours.
- 12/08/19 09:00-15:00 A series of infrastructure maintenance activities were scheduled on the Open Hub (including API Hub), ServHub and ColHub node 1. During the window, downtimes of about 2 hours were experienced.
- 12/09/19 07:30-08:30 a network maintenance activity took place on the Open Hub (including API and RINEX Hubs). The service was not available during the window.
- 28/10/19 09:00-17:00 A scheduled maintenance took place on the Open Hub (not including the API Hub). The Hub was available but the publication of new products was delayed.
- 30/10/19 09:00-17:00 A scheduled maintenance took place on the API Hub (not including the Open Hub). The Hub was available but the publication of new products was delayed.
- o6/11/19 og:oo-11:oo An infrastructure maintenance activity took place on the Open Hub (including the API Hub and GNSS RINEX Pre-Ops Hub), during which a downtime of about 30 minutes duration occurred.
- 26/11/19 & 27/11/19 08:00-17:30 (each day) Planned maintenance activities took place on the Open Hub, IntHub, ColHub and ServHub.









The publication of Sentinel-1, -2 and -3 products was delayed.

Several unexpected anomalies were also experienced during Y2019. The most significant such anomalies can be summarised as follows:

- o1/03/19 13:20 03/03/19 01:45 A blocking infrastructure incident took place at one of the Data Hub centres, caused by a disk failure in the front-end nodes accessing the storage to which the virtual machines are connected. This resulted in downtime for the following services: Open Hub, ServHub, ColHub (node 1), Sentinel-3 PreOps Hub, GNSS RINEX PreOps Hub.
- 01/03/19 03/03/19 Due to an issue at network Level, Sentinel-3B SLSTR, SRAL and OCLI products were delayed in various timeslots during these three days.
- 27/03/19 10:10-11:00 An unscheduled network incident resulted in the following services being unreachable: Open Hub, ServHub, ColHub (node 1).
- 11/04/19 09:59-11:35 A service interruption was caused by an unscheduled maintenance activity due to an infrastructure problem affecting principally the Open Hub.
- 27/05/19 21:00 29/05/19 02:00 A network incident at the core centre caused new products publication to be temporarily suspended for all missions and impacted performances on the following hubs: Open Hub, ServHub, ColHub Node 1, Sentinel-3 Pre-Operations Hub.
- 30/05/19 02:13-03:55 and 07:26-07:47 —
 Unscheduled downtime occurred on the Open Hub, but the root cause was rapidly identified and fixed.
- 10/06/19 11/06/19 14:30 various short unscheduled interruptions and performance degradations occurred on the Open Hub, ServHub and ColHub node 1. The root cause was identified as a network anomaly and service performance was restored to nominal on 11/06/19 at 14:30.
- 24/06/19 01:50-02:40 Open Hub suffered from degraded service response times and service interruptions during this period. This was found



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- to be the result of excessive user request on the service.
- 28/06/19 09:25-13:15 A ground segment network incident occurred during this period, delaying new products publication for all missions and on all services. It also resulted in poor performances for response times and downloads on the Open Hub, ServHub and ColHub node 1.
- 04/07/19 21:00 to 06/07/19 00:00 The Sentinel-5P PreOps Hub experienced a degradation in service response times and occasional downtimes. This was identified as being the result of massive user requests on the service, and resolved by the number of sessions being limited.
- 05/07/19 19:15-21:15 Unscheduled downtimes were experienced on the Open Hub, due to an infrastructure incident.

- 10/07/19 18:00 to 11/07/19 08:50 Connection issues were experienced on the Open Hub (including the API Hub) and the ColHub node 1.
 The performance of the ServHub was also degraded, although it remained accessible.
- 18/07/19 10:30-11:20 An unscheduled downtime took place on the Open Hub (though not including the API Hub).
- 24/07/19 11:50-12:20 A network switch failure resulted in a short downtime on the Open Hub (including API and RINEX Hubs), ServHub and ColHub node 1. The service was restored by routing the traffic to the secondary network switch.
- 26/11/19 05:00-07:00 The Open Hub experienced an unscheduled downtime during this period.

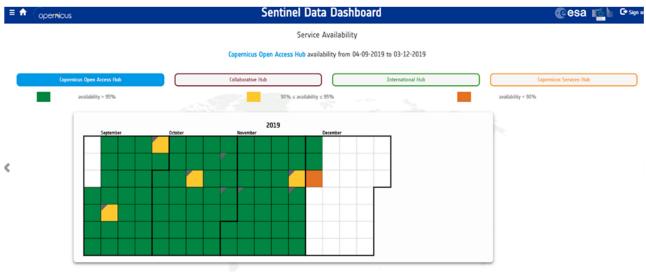


Figure 83: Example of Sentinel Data Dashboard Availability Representation (in this case for the Open Hub)

5.2 Network Analysis

Infrastructure upgrades

The network capacity during Y2019 has continued to benefit from the two major infrastructure upgrades were undertaken during 2018: new firewalls added to the infrastructure, upgrading the outward capacity of the infrastructure to 40Gbps, and the Frankfurt GÉANT Link upgraded from 10 Gbps to 100 Gbps to allow a routing to GÉANT at the full capacity

afforded by the firewalls. Following these upgrades, the academic and commercial links have run through the same switch interface, meaning that it is no longer possible to show individually the proportion of internet traffic which is routed through GÉANT vs. the commercial link. Further network adaptations were also made during Y2019, specifically on the Open Hub and ServHub infrastructures. On 12 September 2019, the Open Hub server network link

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was migrated from a 10 Gb to a 25 Gb link, which allowed for an increase in user download traffic. A similar upgrade was made on the ServHub on 8

Data traffic loads

October 2019.

These upgrades were made in time to cope with the increase in traffic loads which was predicted to take place after the arrival of new products from Sentinel-3 and Sentinel-5P, and the increase in Sentinel-2 Level-2A production. Traffic loads also continued to rise due to the ever-increasing number of active users and consequently downloads being requested from the system. Moreover, with the DIAS in full operations, four additional copies of each of the products published on the system had to be brought to the network of DIAS access points.

The graph in Figure 84 shows the daily average combined traffic of both the commercial link (DTAG) and the academic link (GÉANT) for Y2019. During the first half of Y2019, average throughput of data disseminated to the data hub users increased from around 15 Gbps to around 20 Gbps, with peaks of near 30 Gbps observed. A reduction in traffic was seen over the summer months, with average load at around 18 Gbps. From 12 September 2019, activity









picked up again and the bandwidth throughput stabilised at an average of around 21 Gbps for the rest of the year.

A short but significant drop in traffic to about 6 Gbps can be seen in early March 2019. This was the result of a severe drop in the performance of several virtual machines, due to a hard disk failure on a Front End physical node which triggered a 'FlexProtect' job. This job performs a resource intensive security check, taking significant resources from all virtual machines on which it runs for the extent of the check (in the range 6 to 36 hours). The incident lasted from 1-3 March 2019. The drop in traffic observed on the 26/27 June was caused by maintenance on the Pick-Up Point operating system, resulting in a downtime on the Pick Up Point of around 20 hours. In mid-October, there was instead a sudden increase in activity, with aggregate traffic statistics showing a peak of close to 28 Gbps for data disseminated to all users. This peak was probably the result of a temporary increase of traffic bandwidth for the VSAM (Virtual Storage Access Method) migrated proxy service performance. After the initial increase, the flow of traffic returned to more normal values and for the remainder of Y2019 stabilised, with the average bandwidth throughput at around 22 Gbps.

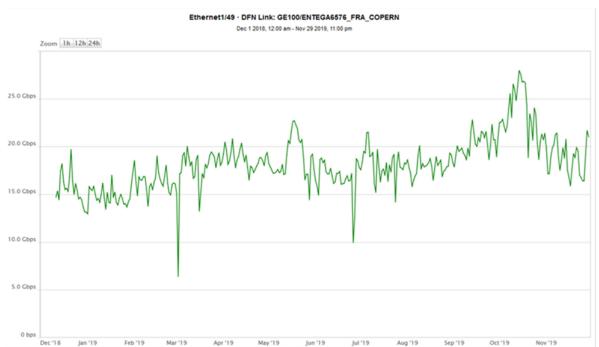


Figure 84: Combined traffic of both Commercial (DTAG) and Academic (GÉANT) from 02/05/18 – 30/11/18 (with the green bars showing the MAX and MIN transmit rate reached on each particular day)

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Effective bandwidth

Figure 85 below presents for each hub the percentage of completed downloads performed in Y2019 in the following four effective bandwidth ranges: <10Mbps, 10-50Mbps, 50-100Mbps and >100Mbps. The effective bandwidth is calculated using the time it takes to download a product and the volume of that downloaded product. The effective bandwidth depends on many factors, such as the actual network bandwidth available to the user, the performance required to save the product on the user disk, as well as the concurrent activities on the hub at the time the download is made. Figure 85 shows effective bandwidth on each hub, taking into account all of the completed downloads during Y2019, as well as providing the combined statistics for all hub. This provides an approximate overview of the rates at which users of the hub were able to download the Sentinel products.

For all hubs except the Open Hub, the most frequently experienced (or equal highest) effective bandwidth was >100 Mbps. This indicates that users of ServHub, ColHub, IntHub and the DIAS Hub were for the most part able to download products at a very fast rate. For the ColHub nodes 2 and 3, an impressive 65% of downloads took place at >100 Mbps; and for both the IntHub and the DIAS Hub over 50% of downloads occurred at >100Mbps: 54% and 53% respectively. Given that the partners using the ColHub and ServHub have not significantly changed since Y2018, the improvement in the effective bandwidth for those hubs is likely to be the result of the network infrastructure upgrades which were carried out in Y2019, as described at Section 5.2 above.

For the Open Hub, the most frequently experienced effective bandwidth was instead the 10-50Mbps range, with 47% of downloads from the Open Hub taking place in this range. This is slightly lower than the 51% calculated for Y2018. The percentage of downloads taking place at >100 Mbps rose in Y2019: 23%, compared to 14% in Y2018. It is expected that downloads from the Open Hub will be more evenly spread across the full range of speeds, given the very wide user base and global reach of the Open Hub, with varying availability of local bandwidth. Again due to the diversity of users, it is not possible to identify a single reason for the rise in downloads taking place at >100Mbps on the Open Hub, and it is likely to be the result of a combination of factors. Some potential contributing factors could be: the increase in availability of fibre optic broadband across Europe, which provide users with much higher bandwidths; users of the Open Hub becoming more expert at adapting their scripts to the characteristics of the service; and the infrastructure upgrades which were made to enhance the Open Hub service, as discussed in Section 5.2 above.

Overall, the statistic which takes all hubs into account shows an encouraging and sustained improvement: 45% of all downloads were made at an effective bandwidth of >100 Mbps; the equivalent figure in Y2018 was 36% and for Y2017 was 23%. Moreover, 68% of downloads during Y2019 were made at speeds of over 50Mbps, up from 63% during Y2018. One factor which could have resulted in the observed improvements is the enhancement of the network done on the T-Systems operated hubs during Y2019.

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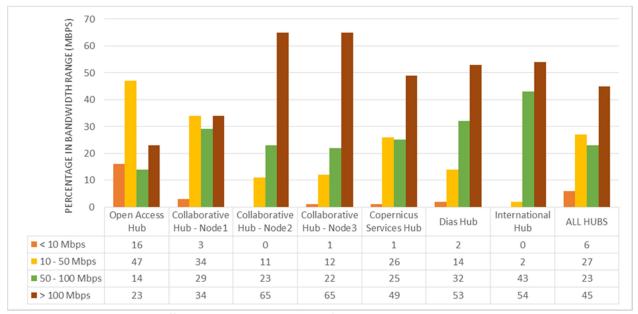


Figure 85: Effective bandwidth range per Hub for all completed downloads during Y2019











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 at 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. The publication timeliness can be affected by a disturbance at any point in this production 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 Sentinel-1 and Sentinel-2 NTC products is that they will be published within 24 hours from sensing; for Sentinel-3 NTC products the latency is 30 days from sensing, allowing consolidation of some auxiliary or ancillary data.

In this section, only products which were published within 7 days of sensing are included in the calculations (with the exception of Sentinel-3 NTC, which has a 1 month timeliness). This is to remove as far as possible the risk of distorting the figures with retrospectively processed data, and to be able to report the performance measured on the routine dataflow, given that products published after 7 days are either the result of reprocessing or exceptionally serious anomalies.

Open Hub

Figure 86 shows the average sensing-publication timeliness for Sentinel-1 NTC and Sentinel-2 NTC products on the Open Hub during Y2019 and the change with respect to the Y2018 values. As for last year, it is highlighted that the Y2019 average publication timelinesses have been calculated over the last three months of the reporting period.

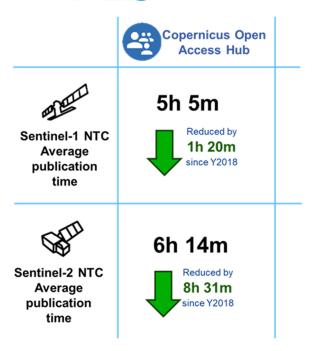


Figure 86: Average publication timeliness on the Open Hub over the last three months of Y2019 for Sentinel-1 NTC and Sentinel-2 NTC products, and comparison with Y2018

As can be seen from the diagram, for both Sentinel-1 and Sentinel-2 the average timeliness for Y2019 again showed a marked improvement compared with the previous reporting year. Firstly, in comparison with the threshold, the publication timeliness of both Sentinel-1 and -2 NTC products on the Open Hub were well below the expected 24 hours. Sentinel-1 NTC products were on average available for download within 5h 5m from sensing; and Sentinel-2 NTC products on average within 6h 14m. The Sentinel-2 timeliness contained the greatest improvement, down a huge 8h 31m from Y2018, which was an even greater reduction than the 20m drop between Y2018/Y2017. improvement for Sentinel-1 was 1 h 20m, again an even greater improvement on the reduction of 55m observed between Y2018/Y2017. It is highlighted that these improvements in publication timeliness took place notwithstanding the greater volumes of products being published during Y2019.

Sentinel-3	Average Publication Timeliness					
Instrument	NRT (<2h) STC (<48h) NTC (<1 mon					
OLCI	2h 16m	-	1d 4h 38m			
SLSTR	2h 9m	-	1d 6h 7m			
SRAL	2h 1m	1d 4h 5m	25d 11h 1m			
SYNERGY	-	8h	1d 15h 28m			

Table 46: Average publication timeliness on the Open Hub during Y2019 for Sentinel-3 NRT, STC and NRC products for each instrument



For Sentinel-3, the average Y2019 publication timeliness per instrument is shown in Table 46. As Y2019 was the first reporting period during which products from all instruments were available on the Open Hub for the full period, a comparison with Y2018 is not included. Where a certain instrument timeliness is not applicable on the Open Hub this is shown as a '-'. Given the timeliness thresholds of <2h for NTC, <48h for STC and <1 month, it can be seen that on average the thresholds were respected in all cases. It is noted that SRAL NTC products take far longer than NTC products from the other instruments - 25d 11h 1m - due to the need for specific consolidation of auxiliary data in this case.

Figure 87 shows the monthly average publication timeliness on Open Hub for Sentinel-1 NTC and Sentinel-2 NTC products during Y2019 (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 Y2018 for comparison. Products published after 7 days are discussed below.









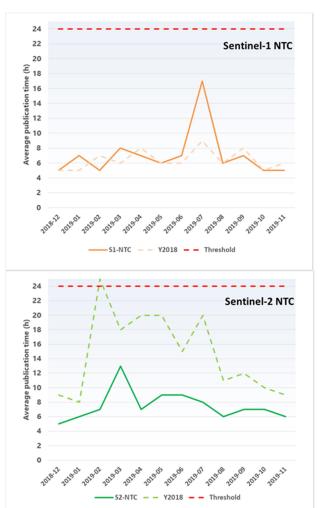


Figure 87: Monthly Average Publication Timeliness on the Open Hub for Sentinel-1 and Sentinel-2 NTC products during Y2019, with Y2018 for comparison

For Sentinel-1, it can be seen that the publication timeliness was somewhat less stable in Y2019 than during Y2018, and for some months - in particular July – the timeliness was worse than in the previous year. However the 24 hour timeliness constraint was respected, on average, during each month. The worst case was the 17 hour average during July 2019. The best timeliness recorded were the 5 hour averages recorded for December 2018 and February, October and November 2019. For Sentinel-2 a similar degree of fluctuation is observed, though in this case the average timeliness improved for every month over the Y2018 values. Again, for all months the 24 hour threshold was respected. The best average for the month was 5 hours during December 2018 and the worst case was 11 hours during March 2019.

Figure 88 shows the monthly publication timeliness of Sentinel-3 NTC products on the Open Hub: OLCI,



SLSTR and SYNERGY. An encouraging trend is observed whereby the publication timeliness of these products improves as Y2019 progresses, particularly for SLSTR (down from 45 hours in December 2018 to 30 hours in November 2019) and SYNERGY (47 hours in December 2018 to 39 hours in November 2019). SRAL NTC products are not shown on the graph due to the far longer timescale in which they are published which would distort the graph, but an average of 25 days was achieved throughout Y2019, below the 30 day threshold.

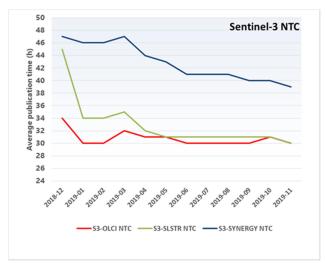


Figure 88: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 OLCI, SLSTR and SYNERGY NTC products during Y2019

Figure 89 shows the monthly publication timeliness for each set of Sentinel-3 NRT products on the Open Hub.

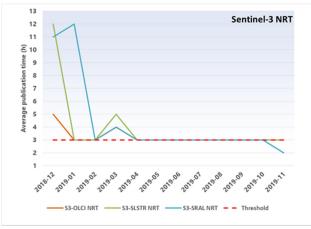


Figure 89: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 OLCI, SLSTR and SRAL NRT products during Y2019









The target 3-hour NRT timeliness was achieved from April 2019 onwards, for each product type. However, a number of months at the beginning of the year were significantly higher than the target, driving the overall Y2019 average down to 4.4 hours for SRAL, 3.25 hours for OLCI and 3.9 hours for SLSTR (the respective averages for Y2018 were 4.2/4.1/4.8 hours, so an improvement for all except SRAL). The disruption in the publication flow at the beginning of the year can for the most part be attributed to the following anomalies and causes:

December 2018:

Delays for OLCI (5 hour average), SLSTR (12 hour average) and SRAL (11 hour average) NRT products: an anomaly at the Svalbard ground segment on 1 December 2018 resulted in delays of several hours in the processing and publication chain for all Sentinel-3A and 3B products; a further delay occurred on 6 December 2018, due to service interruptions at the ground segment; on 10 December 2018, a delay in Sentinel-3 NRT products was caused by a network issue in the ground segment.

January 2019:

Delay on SRAL (12 hour average) NRT products: An anomaly occurred on the Sentinel-3B SRAL instrument on 28 January 2019, resulting in products being unavailable for an outage duration of 20 hours, 12 minutes and 40 seconds.

- March 2019:

Small delays on SLSTR (5 hour average) and SRAL (4 hour average) NRT products: following a Ground Segment anomaly on 5 March 2019 some SRAL NRT products were missed; a further anomaly on 9 March 2019 resulted in some Sentinel-3B NRT products being missed.

Collaborative Hub

Figure 90 shows the average publication timeliness for Sentinel-1 NTC and Sentinel-2 NTC products on the ColHub during Y2019, and the change with respect to the Y2018 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 noted above, it is highlighted that the Y2019 average













publication timelinesses have been calculated over the last three months of the reporting period.

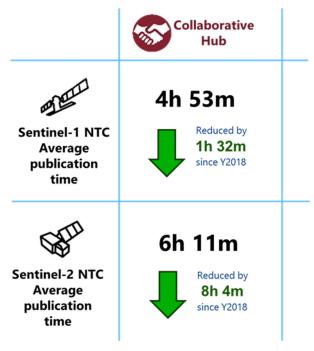


Figure 90: Average publication timeliness on the Collaborative Hub over the last 3 months Y2019 for Sentinel-1 NTC and Sentinel-2 NTC products

Almost identical reductions can be seen for the ColHub as for the Open Hub. Again, the greatest improvement was observed for Sentinel-2 products on the ColHub, with the publication timeliness reduced by down 8h 4m from Y2018 to an average of 6h 11m from sensing. Sentinel-1 products were down 1h 32 minutes, to an average of 4h 53m from sensing.

Figure 91 shows the average monthly timeliness during Y2019 for Sentinel-1, Sentinel-2, and Sentinel-3 NTC products on the ColHub. The statistics use the best performing of the three nodes per month. For Sentinel-1 and Sentinel-2, the 24 hour threshold was respected for all months, with the worst cases again occurring in July for Sentinel-1 (17 hour average) and March 2019 for Sentinel-2 (13 hour average). For Sentinel-3 the trend of improving timelinesses throughout the year - in particular for SLSTR and SYNERGY is again observed.

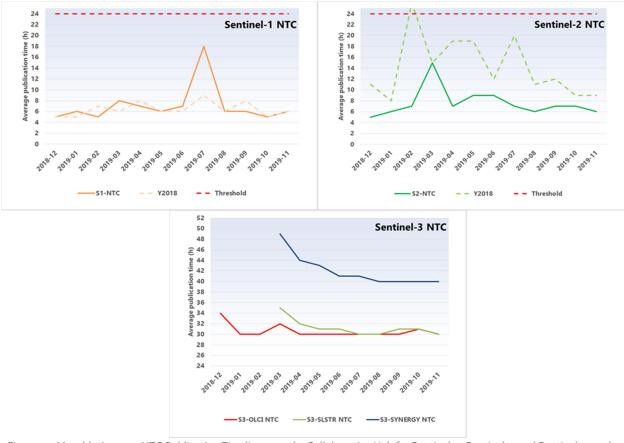


Figure 91: Monthly Average NTC Publication Timeliness on the Collaborative Hub for Sentinel-1, Sentinel-2 and Sentinel-3 products during Y2019

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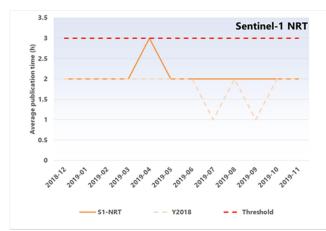












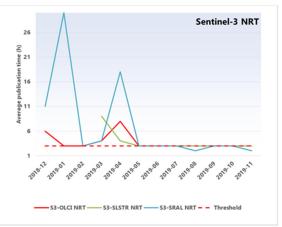


Figure 92: Monthly Average NRT Publication Timeliness on the Collaborative Hub for Sentinel-1 and Sentinel-3 products during
Y2019

For Sentinel-1 NRT timeliness (Figure 92) on the ColHub the <3 hour target was achieved, on average, throughout Y2019. The majority of months recorded a 2 hour sensing-publication average, with the only divergence being a 3 hour average in April 2019.

For Sentinel-3 NRT production, a similar trend is again observed to that of the Open Hub: some timeliness transgressions occurred early during Y2019, with the 3 hour threshold then being respected for all product types from May 2019 onwards. The worst case was the 30 hour average for SRAL products observed during January 2019, probably again the result of the Sentinel-3B instrument anomaly described above. One difference from the Open Hub is timeliness regressions observed during April 2019: 18 hours for SRAL and 8 hours for OLCI. This may have been the result of a Ground Segment issue experienced on 5 April 2019, which resulted in some missed Sentinel-3A data, and a further such anomaly on 27 April 2019, resulting in missed NRT data from Sentinel-3A.





During Y2019, work on the Data Hub Software (DHuS) has mainly focussed on an evolution of the data flow scenario, to extend the use of the offline product retrieval from the LTA and to support the publication of a new set of EO products.

To cope with overall volumes threatening to exceed the capacities available in the Sentinel Data Access System, and with the cost/efficiency of further upgrading the core infrastructure becoming problematic, much effort was put on activating the offline data access interface for Sentinels-2 and -3, in addition to that already activated for Sentinel-1 in September 2018. The rolling access regime has been implemented accordingly for Sentinels-2 and -3, according to which at least one year of the freshest data is kept online, with access to all other data being provided through the ground segment/LTA. In addition, a more robust DHuS-LTA interface was put in place, relying on the LTA Broker ground segment component. The LTA Broker interface is currently

Open Source DHuS 5.5 Framework

The DHuS is made available as open source software to any interested party and can be easily installed and configured by users wishing to manage a local Copernicus archive Sentinel products. (http://sentineldatahub.github.io/DataHubSystem/).

In Y2019, further strides were made in the consolidation of the Open Source DHuS Framework (OSF) that organises and controls the publication of the software towards the interested users. The activities carried out included the publication of a new DHuS version, and various promotional and educational activities.









activated on the Open Hub, ServHub, DIAS Hub Node 1 and ColHub Node 1.

Furthermore, the data flow scenario is evolving to allow users to retrieve specific sets of products ondemand from ground segments. The Maintenance Team is currently working to achieve this goal.

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 GNSS POD Auxiliary files support and SMOS products from Earth Explorers mission.

DHuS add-ons have been improved to extract additional metadata from the Sentinel products, enhancing the user experience on the hubs. In particular, the Mean Sun Angle, Granule Identifier and Datastrip Identifier metadata are now available for Sentinel-2 products.

Finally, the DHuS Graphical User Interface (GUI) has been enriched with the LTA orders monitoring feature, which enables users to monitor the status of offline product requests submitted to the LTA Broker chain. In addition, the GUI now allows the display of coordinates on the map, with support for two different formats: decimal degrees (DD) and DMS (degrees minutes and seconds).

DHuS Releases

Y2019 saw the release of v2.0 of the OSF, on 13 March 2019. This version introduced: support for Sentinel-5P products (L1B, L2, AUX); GNSS POD RINEX Auxiliary files; a performance enhancement based on database schema optimization and scalability; and improvements to the data flow handling through the introduction of the remote DHuS datastore and synchronizers.

A further release of the OSF is planned for 2020 and will include: performance enhancements, new datastores, support for OData v4 entities and support for new EO products, including COSMO-Skymed, SMOS, Landsat-8, Pleiades and Precise Determination Orbit (POD) files.



















Open Source DHuS Downloads

At the close of Y2019, the total number of downloads of all versions of the OSF numbered 5,008, up from 4,457 in Y2018. Specifically concerning v1.0 (released in September 2017), the total downloads numbered 3,522, up from 2,891 by the end of Y2018. Downloads of v.2.0 (released in March 2019) numbered 478 by the end of Y2019. The total number of downloads during Y2019 therefore numbered 551, of which 73 were for v1.0 and 478 were for v2.0

Support to OS Community

Technical support has been provided to the different users (typically institutional agencies and research centres). In particular, a series of four webinar sessions on v2.0 of the OSF were held for Collaborative Ground Segment operators and

EUMETSAT during June and July 2019. The main topics covered included OSF installation and configuration, eviction configuration, database access and performances and network connection fine-tuning with ColHub nodes.

OS DHuS Promotion

During Y2019 the OSF was promoted at the following events:

- Living Planet Symposium 2019: 13–17 May 2019, Milan, Italy
- Frascati Scienza: og September 2019, Frascati, Italy;
- Collaborative Ground Segment Workshop: 14-15 October 2019, Frascati, Italy;

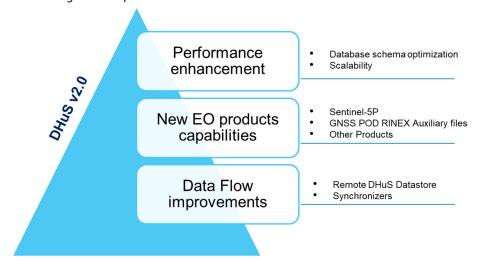


Figure 93: Data Hub Open Source Framework v2.0 improvements









User Feedback

Feedback from users is constantly monitored in order to determine if the data access service is in line with user expectations and to identify issues as they arise. 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 Ground Segment Coordination Desk, or, if specifically regarded data access, are forwarded to the Sentinel Data Access System operations team for resolution.

Ticketing Analysis 6.1

Feedback and requests received from users of the Open Hub are tracked via a "Ticketing" system with opened tickets 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 credentials loss, deletion, edit profile issue)
- Features Request: Improvements suggested by users about all the topics of ticket categories

- Products: Issue on **Products** (production coverage, product quality, external tool usage, products deletion request, download failure, unzipping issue, Naming convention information)
- Web Portals: News to be published, User guide update
- Bug: Service malfunctions reported by users and recognized as bugs (related issue are then managed in the maintenance cycle)
- General: Miscellaneous requests which do not fit into another category
- Junk: Spam, Empty emails, Not an issue

During Y2019 a total of 1,717 tickets was received, a very similar number to the Y2018 1,667 total. Of these, the largest category was for 'Junk', accounting for 602 tickets (35%), which can therefore be discarded. Of the meaningful categories, the largest proportion of tickets were for 'User Accounts' (534 tickets/31%) and 'Service Interface' (333 tickets/19%), followed by 'General' (150 tickets/9%) As in previous years, very few tickets were received for the categories 'Features Requests' (2 tickets), 'Web Portals' (8 tickets) and 'Bug' (7 tickets). Overall, the distribution of tickets is very similar to that of Y2018. Figure 94 shows the percentage split between the categories during Y2019.

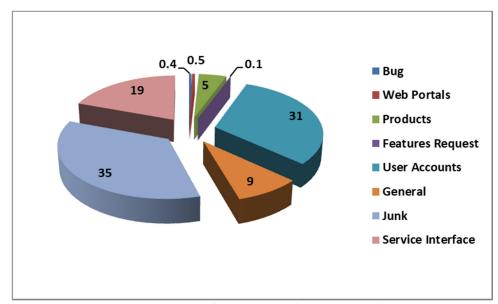


Figure 94: Proportion (percentage) of each category of tickets received from the Open Hub



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During Y2019, 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 36 minutes and 4

seconds (an improvement on the 1 hour 10 seconds average for Y2018). The maximum response time for any ticket was 1 day 10 hours 26 minutes.











7 Y2020 Outlook

During the next year, the Data Access team will manage the standard service evolutions, such as decommissioning the S5P PreOps Hub and handling the introduction of the remaining product types. However, the major change and challenge will be the migration of the Data Access Service to a cloud infrastructure.

The transition will begin at the end of 2020, but it is already being prepared by the Data Access team. The main objective is to make the Data Access System completely independent from the current infrastructure provided through ESA, implementing the software features which are necessary to perform a lift-and-shift process towards a commercial cloud environment.

Cloud environments offer a wider set of possibilities to implement an elastic service and to reduce the cost of the infrastructure, especially from a storage point of view. The Data Hub software is already equipped with capabilities to run in a cloud environment, and part of the Data Hub services already run in these conditions, namely ColHub and the DIAS Hub. The aim of the transition will be to extend the service improvements which are possible

when operating in a cloud environment to the entire Data Access System.

The specific objective for the Data Access team during the transition will be to maintain untouched the interfaces operated by the Data Access System (APIs and GUI), and to guarantee the same data offer currently available online. The main challenge will be managing the data offer to ensure that fresh data will be available for immediate download and the access to the historical data will be guaranteed by the DHuS-Ground Segment LTA interface.

The Data Hub users will be notified in advance about the transition schedule, but the intention is to avoid any interruption of the service.

The backdrop to this transition is part of a strategy being managed ESA and supported by the EU to transform many elements of the Copernicus Space Component Ground Segment towards cloud computing in anticipation of the enlargement of the Copernicus Sentinel Missions and adaptation for an ever increasing demand for the Sentinel data.







8 Bibliography

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- Copernicus Open Access Hub: https://scihub.copernicus.eu/
- Collaborative Hub: https://colhub.copernicus.eu/
- International Hub: https://inthub.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
AOI	Area Of Interest
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
ISRO	Indian Space Research Organisation
LEO	Low Earth Orbit
LRM	Low Resolution Mode
LTA	Long Term Archive
MET-NO	Norwegian Meteorological Institute
MSI	Multispectral Instrument (Sentinel-2 instrument)
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
OSF	Open Source Framework











DAC	Dra saccing and Austriains Contro
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
SARA	Sentinel Australasia Regional Access
ServHub	Copernicus Services Hub
SLC	Single Look Complex
SLSTR	Sea and Land Surface Temperature Radiometer (Sentinel-3
	instrument)
SMOS	Soil Moisture and Ocean Salinity satellite
SRAL	SAR Altimeter (Sentinel-3 instrument)
SSAU	State Space Agency of Ukraine
STC	Short Time Critical
STFC	Science and Technology Facilities Council
SYN	Synergy (Sentinel-3 product type group)
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
2,1110	Zentralanstale for Meteorologic ond deodynamik





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).
- a 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 Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
Sentinel-1 (SAR)	L0-RAW	Sentinel-1 Level 0 RAW data	Opole Crakow Washin Lviv Ostrava Ivano-Frankiv Slovakia Kosice Ch	1.3 GiB	
	L1-GRDM	Sentinel-1 Level 1 Ground Range, Multi- Look, Detected: Medium Resolution		200 MiB	
	L1-GRDH	Sentinel-1 Level 1 Ground Range, Multi- Look, Detected: High Resolution	Hyderabad Thatta Gandhidham Rajk	860 MiB	
	L1-SLC	Sentinel-1 Level 1 Single-Look Complex	Hrodna Lida Minsk Bialystok Belai Baranav Warlaw Brest Pinsk Lutsk Zhutor	4 GiB	













Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
	L2-OCN	Sentinel-1 Level 2 Ocean		5 MiB	
Sentinel-2	MSIL1C	Sentinel-2 Level 1C	Guntur	480 MiB	
(MSI)	MSIL2A	Sentinel-2 Level 2A		600 MiB	Global coverage from 13/12/18 (previously Euro- Mediterranea n region only)
	OLCI L1 FR	Sentinel-3 Level 1 OL_1_EFR Full Resolution top of atmosphere radiance	The property of the property o	600 MiB	Activation of Sentinel-3B data on 17/12/18
Sentinel-3 (OLCI)	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	MeanTons MeanTo	100 MiB	Activation of Sentinel-3B data on the Open Hub on 24/01/19

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Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
	OLCI L2 Land RR	Sentinel-3 Level 2 OL_2_LRR Reduced Resolution Land & Atmosphere geophysical products		170 MiB	
	SLSTR L1 RBT	Sentinel-3 Level 1 SL_1_RBT Brightness temperatures and radiances		480 MiB	
Sentinel-3 (SLSTR)	SLSTR L2 Land	Sentinel-3 Level 2 SL_2_LST Land Surface Temperature geophysical parameters	The footprint for this products type depends on timeliness: NRT NTC	90 MiB	NRT activation on the Open Hub on 21/03/19
Sentinel-3 (SRAL)	SRAL L1	Sentinel-3 Level 1 SR_1_SRA Echos parameters for LRM, PLRM and SAR mode (resolution 20Hz)		25 MiB	Activation of Sentinel-3B data on 11/12/18

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Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
	SRAL L1 A	Sentinel-3 Level 1 SR_1_SRA_A_ Echos parameters for PLRM and SAR mode (resolution 80Hz)		2.3 GiB	Activation of Sentinel-3B data on 11/12/18
	SRAL L1 BS	Sentinel-3 Level 1 SR_1_SRA_BS Echos parameters for LRM, PLRM		1.7 GiB	Activation of Sentinel-3B data on 11/12/18
	SRAL L2 Land	Sentinel-3 Level 2 SR_2_LAN 1-Hz and 20- Hz Ku and C bands parameters (LRM/SAR/PL RM), waveforms. Over Land	The footprint for this products type depends on timeliness: NTC and STC NRT (covering only LAND regions)	36 MiB	Activation of Sentinel-3B data on 11/12/18
			Finland Russia		

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Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
Sentinel-3 (SYNERGY)	SY_2_SYN	Surface Reflectance and Aerosol parameters over Land	Corporate Planet Corporate Pl	300 MiB	
	SY_2_VGP	1 km VEGETATION- Like product (~VGT-P) - TOA Reflectance		35 MiB	Activation on
	SY_2_VG1	1 km VEGETATION- Like product (~VGT-\$1) 1 day synthesis surface reflectance and NDVI	The state of the s	70 MiB	the Open Hub from 25/03/19
	SY_2_V10	1 km VEGETATION- Like product (~VGT-\$10) 10 day synthesis surface reflectance and NDVI	Service of the control of the contro	175 MiB	











Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
	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	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	
	L1B_IR_UV N	Irradiance products UVN module 270-775 nm	-	30 MiB	
Sentinel- 5P (TROPOMI)	L1B_IR_SIR	Irradiance product SWIR module 2305- 2385 nm	-	6 MiB	
	L2_AER_AI	UV Aerosol Index	Septimies Septimies Septimies Septimies Septimies Septimies Septimies Septimies Septimies	13 MiB	
	L2_AER_LH	Aerosol Layer Height		120 MiB	NRT and OFFL products available on the S5P PreOps Hub from 30/09/19
	L2_CLOUD	Cloud fraction, albedo, top pressure	The second secon	25 MiB	

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Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
	L2_CO	Carbon Monoxide (CO) total column		12 MiB	
	L2_CH4	Methane (CH4) total column		40 MiB	OFFL products available on the S5P PreOps Hub from 01/03/19
	L2_HCHO	Formaldehyd e (HCHO) total column	The base of the ba	60 MiB	OFFL products available on the S5P PreOps Hub from 05/12/18
	L2_NO2	Nitrogen Dioxide (NO2), total and tropospheric columns	The base of the control of the contr	35 MiB	
	L2_NP_BD' x'	Suomi-NPP VIIRS Clouds X = 3, 6, 7		330 MiB	
	L2_03	Ozone (O3) total column	The second secon	25 MiB	

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Mission and Instrum -ent	Product types	Description	Footprint on the hub	Average size	New/updated products in Y2019
	L2_03_TCL	Ozone (O3) tropospheric column	-	1 MiB	OFFL products available on the S5P PreOps Hub from 01/03/19
	L2_SO2	Sulfur Dioxide (SO2) total column	The second secon	85 MiB	OFFL products available on the S5P PreOps Hub from 05/12/18



