

Copernicus



2020

Copernicus Sentinel Data Access Annual report



→ Foreword



On Wednesday 11 August 2021, I received the invitation from ESA to introduce the Copernicus Sentinel Data Access Annual Report for the year 2020. At this time, we are going through one of the hottest summers that Europe has experienced since records began. And at this same time, the scientists of the Center BEYOND/NOA for Earth Observation Research and Satellite Remote Sensing and myself find ourselves inside a fully operational framework of actions for monitoring the fires caused by the extreme drought and unprecedented high temperatures. We have had about 10 days of unrelenting action to analyse the data of Sentinel-1/-2/-3/5P downloaded from the Hellenic Mirror Site (CollGS) and the Copernicus Open Access Hub, to provide warnings and deliver assessments to fire controllers, authorities, and citizens. We are struggling to

deal in a timely manner with the impact on ecosystems and to inform people about the atmospheric burden due to the transfer of black carbon over the whole Mediterranean. In Greece alone, about one hundred thousand hectares of land were on fire and more than 90 communities and local economies have been seriously hit in the last ten days. And the damages in Greece are just a small portion of the enormous disasters recorded across the whole world in the Copernicus Sentinel data, with many other disasters having taken place on the western coast of the US, in Siberia, South America, Central and South Africa, the Middle East and the Arab Gulf.

The global need for quick reliable information to support efforts to address climate change and implement an emergency response is reflected in the enthusiastic uptake of the Sentinel-1/-2/-3/5P data across the world. I was interested to read in this Report, for instance, that there was a significant rise in the number of active users in all continents, with the highest percentage increase of 14,6% taking place in Oceania, and as many as 11,427 active users in South America + Antarctica during the year, and 18,836 in Asia. Also notable was the rise in new user registrations across the continents, and it struck me that there are now 83 countries with over 500 registered users, really suggesting the international need for the data.

When the Hellenic Mirror Site was installed back in 2014, it was the first Collaborative Ground Segment ever put in routine operation for addressing national priorities. Since then, our operations have grown in line with the growth in demand for Copernicus Sentinel data, and a number of additional Copernicus Data Hubs are now based at BEYOND/NOA, offering petabytes of satellite data in support to European and international critical services. For example we host the Sentinel-5P Data Hub, which went into operation on 11 July 2018, and which in Y2020 published on average around 54,000 images per month. As evidenced in this Report, this year the Hub dealt with enormous pressure for distributing significantly greater volumes of data than in the previous two years: in Y2020 users downloaded 4,8% more Sentinel-5P data by volume than they had in Y2019, and a total number of 18,509,233 user-level data was downloaded in the year. This was due in large part to the global interest in both the circulation of NO₂ and CO resulting from the large bushfires in New South Wales of Australia, and in the drop in atmospheric pollutants during the Covid-19 lockdown periods.

This Annual Report, prepared by the Serco SpA-led consortium with the contribution of partners GAEL, NOA and GRNET, provides detailed information and knowledge on the operations of the Copernicus Sentinel Data Access System. It presents an insider perspective on the range of the achievements, building on the contributions of all the teams involved in ESA's Copernicus operations.

In my capacities as Research Director and Scientific Leader for the partner BEYOND/NOA, I am excited to be part of the team that achieved, during 2020 alone, the uninterrupted massive publication of 14,129,781 Copernicus Sentinel data, serving 384,427 users over the globe.

Athens,
18 August 2021

Dr Haris KONTOTES
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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.

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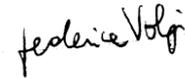
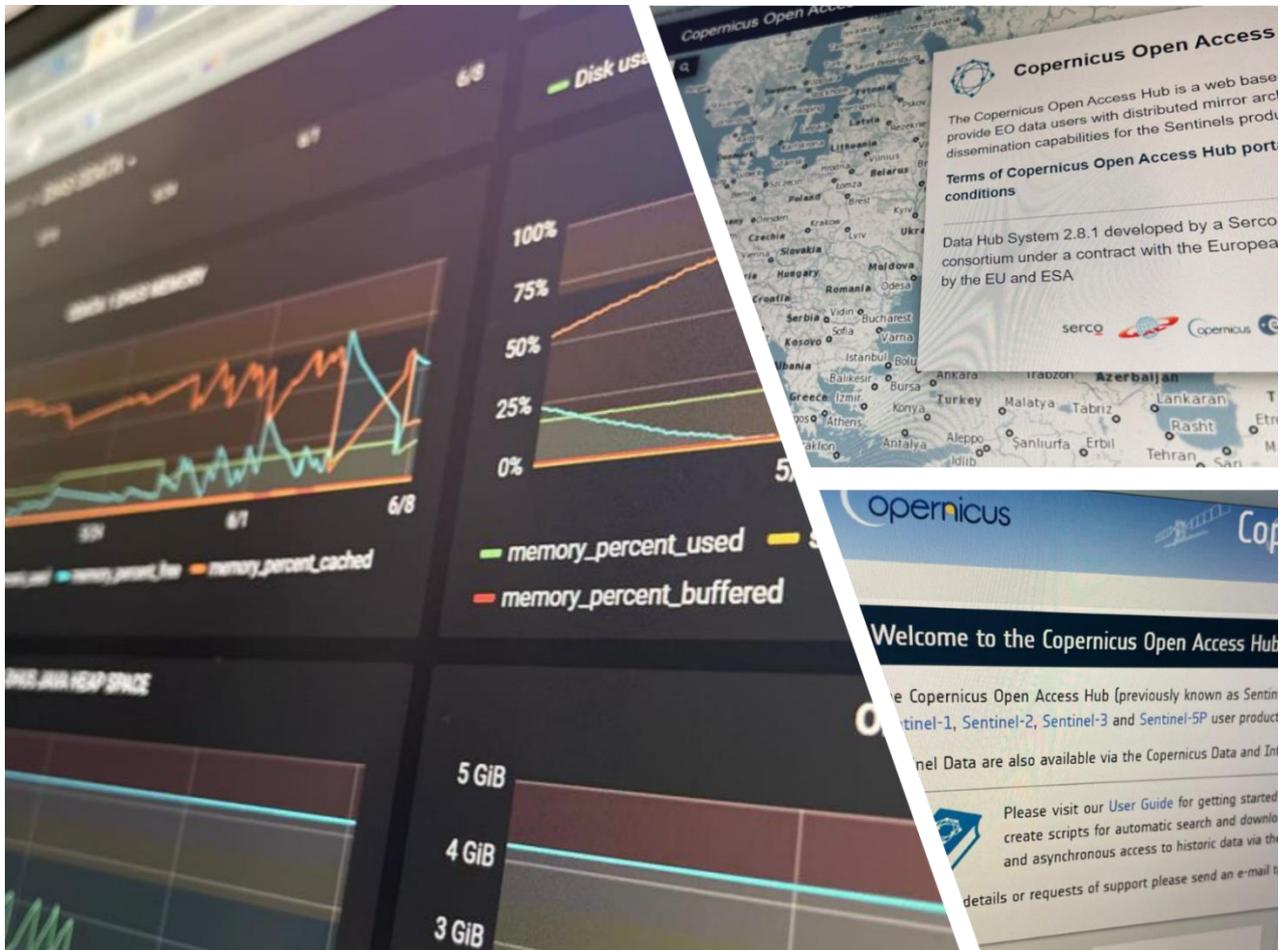



Figure 1: Some pictures of the monitoring system of Sentinel data access service and of the Open Access Hub portal

→ Documentation

Reference documents

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

Definitions

Data Dissemination	Refers to the access and retrieval of Copernicus data by users (could be national Collaborative Ground Segments, Data Hub Relays (DHR) or user of the Open Hub etc) directly from ESA core nodes
Data Exchange	Refers to the transfer of Copernicus data from one Data Hub Relay (DHR) to another DHR
Data Ingestion	Refers to the indexing, storage and publication on the data dissemination infrastructure of the Copernicus data
Data Publication	Refers to the provision of user-level data 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 user-level data)
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=2¹⁰ bytes, 1 MiB= 2²⁰bytes, 1GiB= 2³⁰ bytes, 1 TiB = 2⁴⁰ bytes and 1 PiB = 2⁵⁰ bytes.
- unless otherwise noted, the volume figures refer to the compressed user-level data volumes as published and downloaded via the data hub access points.

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1 INTRODUCTION

Copernicus is a European Union programme which provides operational information on the world's land surfaces, oceans and atmosphere, to support environmental and security policymaking and meet the needs of citizens and service providers. Under the Space Component of the Copernicus programme, ESA 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-level data by the Sentinel ground segments (GS). The Copernicus Sentinel Data Access System retrieves the Copernicus Sentinel-1, -2, -3 (land) and -5P user-level data from the relevant GS and makes them available for users to download from dedicated access points, known as data hubs.

This Annual Report presents the performance of the Copernicus Sentinel Data Access System operated by ESA during the year 1 December 2019 to 30 November 2020 (referred to throughout this report as 'Y2020'), and analyses the trends visible in the public uptake of Copernicus Sentinel data. This is the sixth such report released by the data access service provider, Serco Italia SpA.

The magnitude of the task which the Data Access System manages 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 user-level data had been published on the Copernicus Open Access Hub (Open Hub) and 3.38 PiB of data had been downloaded, in Y2020 the **40 millionth user-level data was published** on the Open Hub and by 30 November 2020 **users had downloaded a massive 240 PiB of user-level data**. During the reporting period more than **38,000 user-level data were published per day**. Moreover, the number of **registered users reached over 380,000 by the end of Y2020**, 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 Sentinel Data Access System.

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

- **Y2020**: 1 December 2019 – 30 November 2020 (this report)
- **Y2019**: 1 December 2018 - 30 November 2019 (report released on 25 May 2020)
- **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)

1.1 Data Access System Architecture

The Copernicus Sentinel Data Access System provides different user typologies free and open access to Copernicus Sentinel user-level data. The System is developed and managed by Serco SpA with the consortium partners GAEL Systems, the National Observatory of Athens (NOA) and GRNET S.A. The service includes the management of the infrastructure, supporting applications and procedures, and expert staff who tailor publication of user-level data to the operational scenarios and respond to user enquiries.

As its general functionality, the Data Access System automatically retrieves user-level data 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 user-level data, either through an interactive graphical web interface (GUI) or automatically, using a scripting interface (API). The figure below illustrates the flow of data through the system. It should be noted that not all user-level data are yet available on all of the hubs: data flows from .

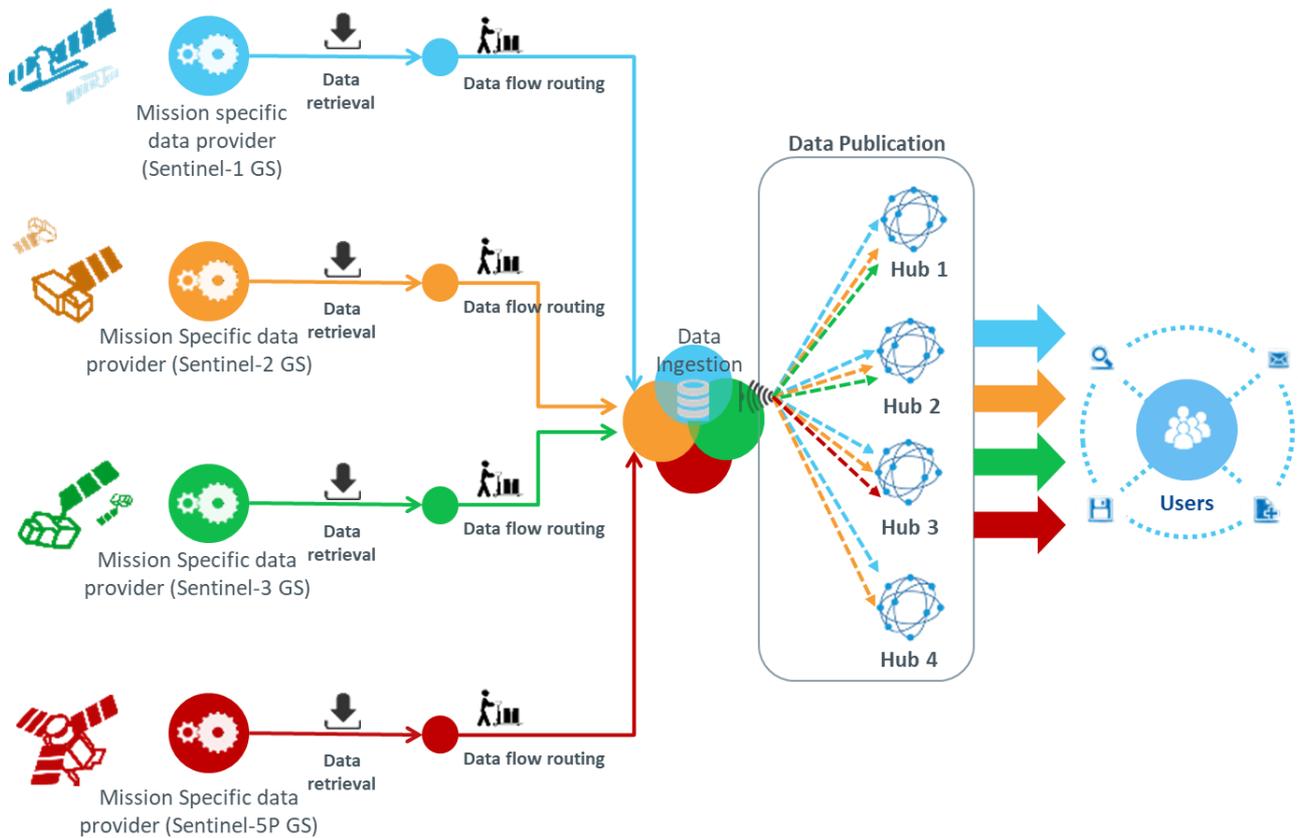


Figure 2: Copernicus Sentinel Data Access System Model

new missions, such as Sentinel-5P, are introduced gradually in a staged manner. This is further described below.

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 user-level data. 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.

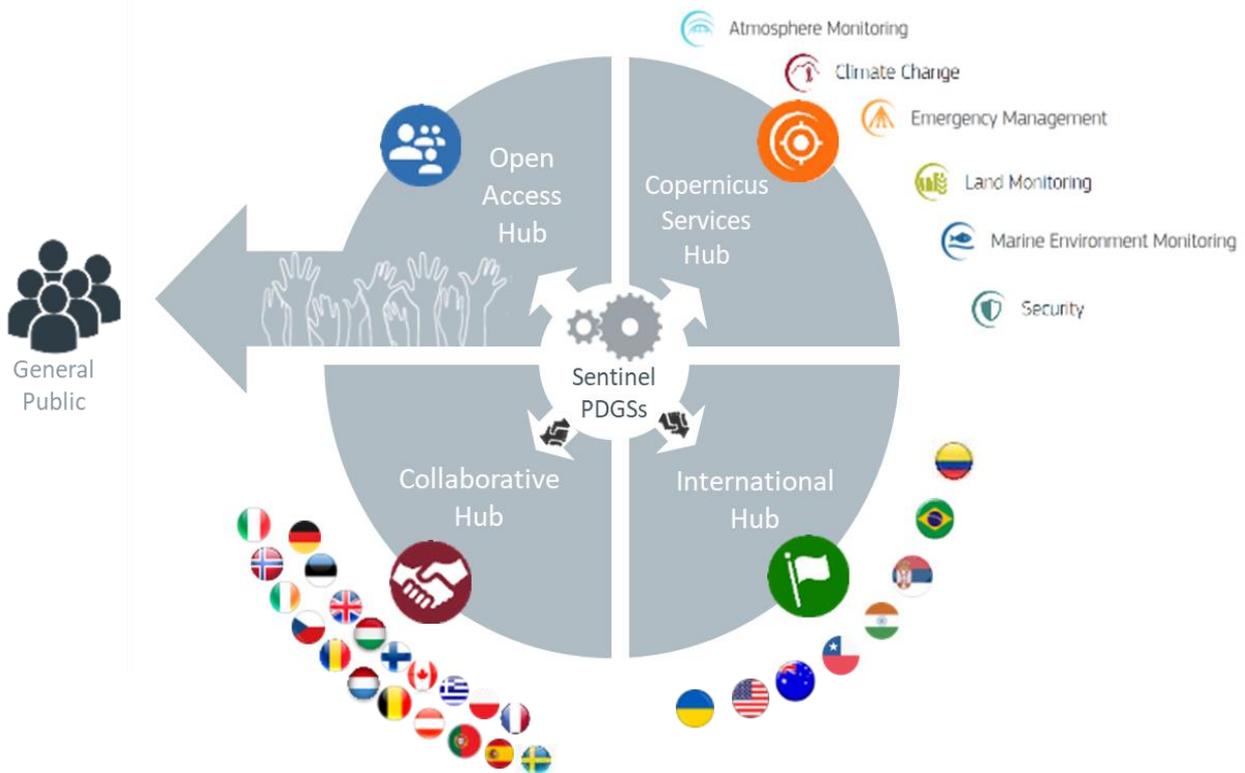


Figure 3: The Sentinel Data Access System Configuration at the end of Y2020

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 data. 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 Open 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 user-level data which have been published on the Copernicus Sentinel Data Access System since the start of operations, via the same catalogue. The freshest data 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 data can be automatically removed from the online storage according to a Rolling Policy, to preserve space for fresh data. When a user requests one of these offline data, the Open

Hub recalls the data from the offline LTA store and makes it available for download via the standard interfaces. The LTA was first introduced for Sentinel-1 data in September 2018 and the functionality was extended to Sentinel-2 data on 24 September 2019 and Sentinel-3 data on 1 August 2019. This configuration was further refined in Y2020 as outlined in Section 2.3.4. 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 the data (see e.g. <https://scihub.copernicus.eu/userguide>).

The Open Hub is generally the first hub on which user-level data 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 user-level data. 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.

The initial release of user-level data 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 user-level data are released instead through the standard Open Hub interfaces and the relevant PreOps Hub is decommissioned.

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 user-level data from Sentinel-5P published in the previous 2 years (i.e. currently all to date), and Near Real Time (NRT) user-level data 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 user-level data relevant to the Copernicus Sentinel-1, -2 and -3 missions. This data 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 user-level data 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 user-level data in order to offer a recovery hub in case of major maintenance activities, providing the continuity of the service, with all the end users of the various services being then redirected there.

The **Copernicus Services Hub** (ServHub) guarantees free and full access to Copernicus Sentinel data for all Copernicus Services and EU institutions. Users are entitled to make up to 10 concurrent downloads. All user-level data from all missions in routine operations are published on the Hub.

The ServHub operates a similar Rolling Policy for removing data from the online access as the Open Hub and ColHub: 1 year of NTC user-level data is kept online and 1 month of NRT user-level data (see Figure 4). 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 user-level data 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 Report, the downloads which are made by the DIAS operators from the Data Access System are 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 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.

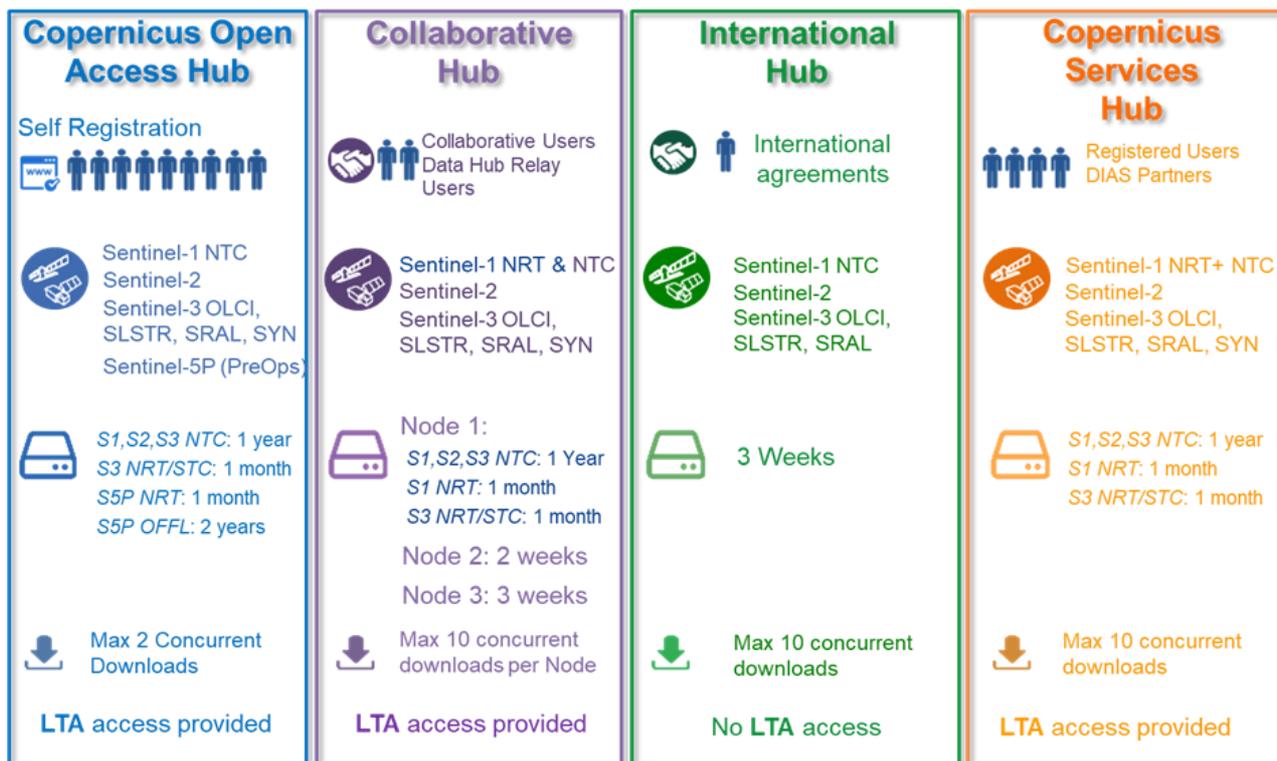


Figure 4: Copernicus Sentinel Data Access System hub characteristics at the end of Y2020

The CollGS partners download the Copernicus Sentinel user-level data as they are published on the hub, and then redistribute the data from their own storage and data access points. Accordingly, a Rolling Policy is applied to ColHub, removing user-level data which have been on the hub for longer than 1 year for standard data and 1 month for NRT data (this is for node 1 of 3 nodes: see Figure 4 for full details and other nodes). As for the Open Hub, and ServHub, the ColHub now has LTA access available for historical Sentinel-1, -2 and -3 user-level data.

At the end of Y2020, there were 20 active CollGS agreements in place and 16 CollGSs in operation (see Chapter 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 Y2020, 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 arrangement 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 Y2020, there were 10 technical agreements in place with international partners, one more than in Y2019 with the technical arrangement signed between the Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM) and ESA on 26 December 2019.

Figure 3 summarises the overall Sentinel Data Access System front-end configuration at the end of Y2020. The Data Hubs described are operated under the responsibility of ESA and provide access to all Copernicus Sentinel user-level data apart from Sentinel-3 Level 1 and 2 marine data. These latter data are made available through the Copernicus Online Data Access (CODA) service which is operated by EUMETSAT and not covered by this report. Further information can be found at:

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

1.1.1 Deployment Physical Architecture

This section provides a brief overview of the physical architecture of the Data Access System. Figure 5 shows, on the left, the Sentinel ground segments and auxiliary centres which generate the data 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 from the Sentinel ground segments, archiving and cataloguing the data and publishing it to end users 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 from the ground segments and has overall responsibility for the system, and two Complementary Centres, which are responsible for ingesting some data 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 Figure also highlights the data flows through the System. For example, in the case of Sentinel-1 all data are ingested by the Core Centre, while only NRT data are sent to the OVH Complementary Centre. Only Sentinel-5P data are ingested directly by the GRNET Complementary Centre, while data from other missions are retrieved and synched from the Core Centre.

The dashed lines illustrate the Long Term Archive (LTA) data retrieval flows which were in operation for the majority of Y2020 for recalling archived user-level data from Sentinels-1, -2 and -3. However, as will be described in greater detail at Section 2 below, a major evolution was implemented during the year to enable the retrieval of historic data from the ONDA DIAS infrastructure, as part of the ongoing transformation of the Data Access System to a cloud-based infrastructure. The transfer in operations of this evolution took place on 30 September 2020 for Sentinel-2, and on 30 November 2020 for Sentinel-1 and Sentinel-3.

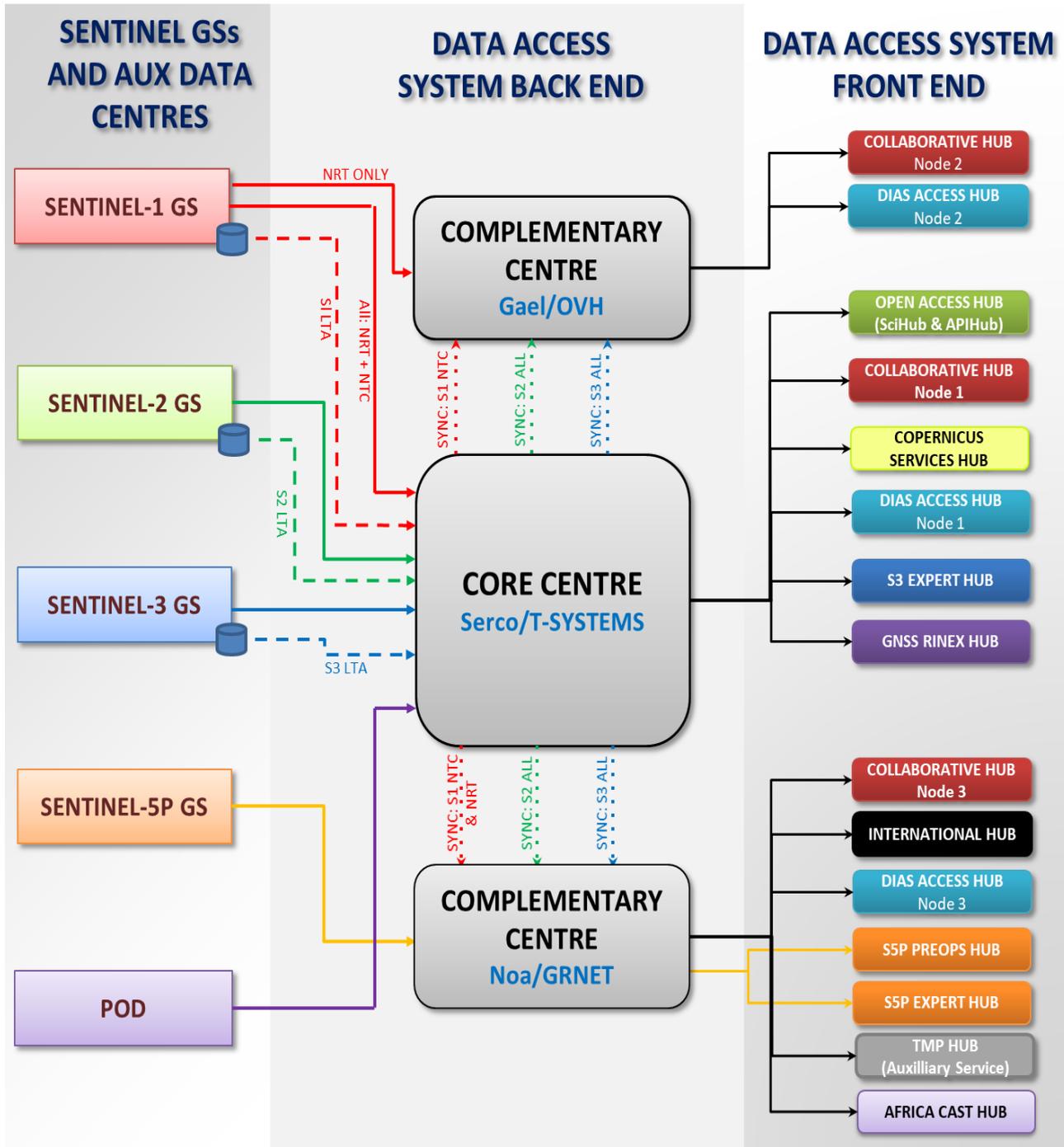


Figure 5: Data Access System Physical Architecture Overview

1.2 Main Evolutions of the Data Access System in Y2020

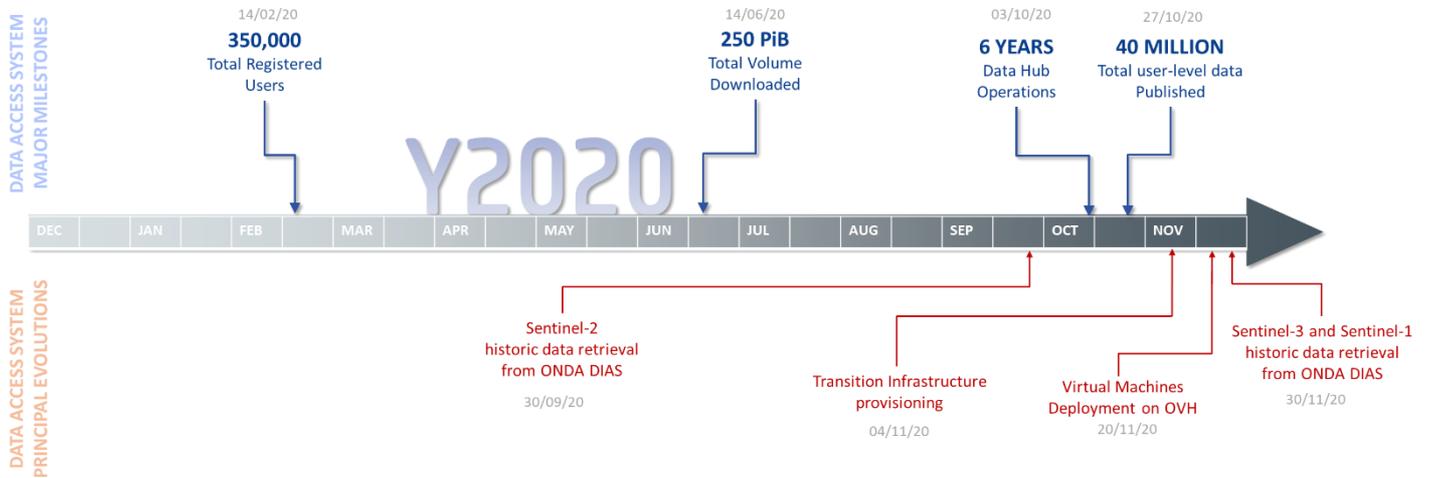


Figure 6: Timeline of the main Y2020 achievements related to data dissemination and improvement of the Data Access System

Y2020 was the start of a major transformation of the Sentinel Data Access System. This transformation is taking place as part of ESA’s strategy to transfer the entire ground segment operations to a cloud environment, in anticipation of the enlargement of the Copernicus Sentinel missions and in response to the ever-increasing demand for Sentinel data. Deployment on public cloud infrastructures, together with a service oriented approach will enable ESA to adapt the Copernicus Ground Segment to evolutions in the operational scenarios, in particular in terms of keeping the data offer appropriately scaled to user demand and the availability of resources.

1.2.1 Background to the ESA Ground Segment Transformation

One of the basic concepts being introduced within the transformation to the cloud-based architecture is that the data flow interfaces, for systematic data transfer

between services, will be based on small data cache areas, referred to as data “interface delivery points”. Each function or service which generates a systematic or routine data flow that will go on to be managed by one or more further services will make the output data available in an interface delivery point located on a cloud-based environment, which is logically considered as part of, and under the responsibility of, the data source service.

Figure 7 below sets out the high level design of the future Copernicus Sentinel ground segment (planned for 2022), based on this concept [taken from CSC Operations – ESA Framework – Ground Segment Architecture ESA-EOPG-EOPGC-TN-7].

The transformation allows the introduction of new operations concepts in which the CSC data lifecycle will play a central role, with major implications for the user experience. It involves a number of trade-offs to be regularly re-evaluated in view of the evolving user demand, the opportunities provided by the evolution of IT technology, and the potential for increased synergy with industrial offers.

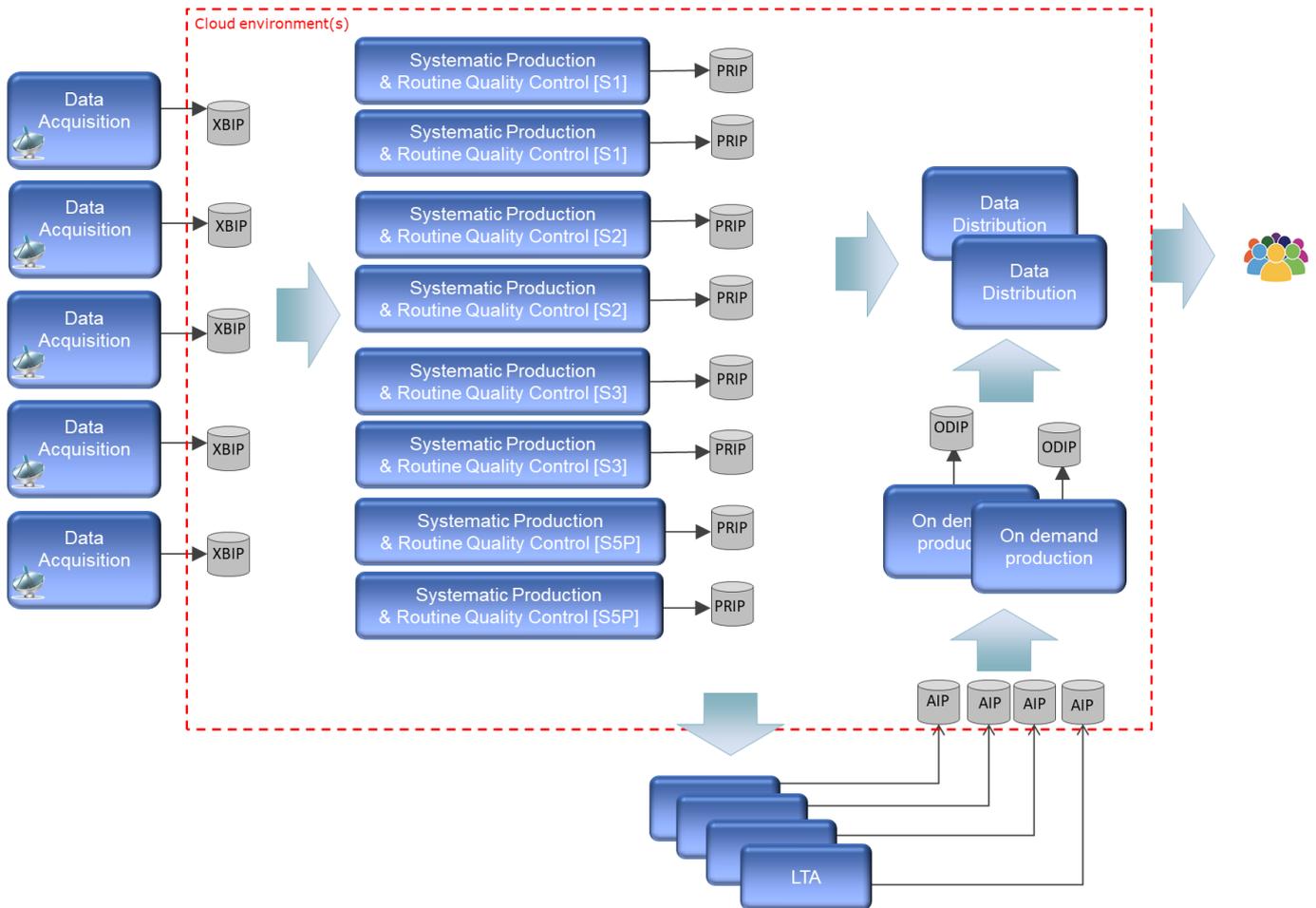


Figure 7: high level design of the future Copernicus Sentinel ground segment (planned for 2022)

The main elements in the data lifecycle, the baseline operations scenario and the key configuration options are:

- All data acquired by the Sentinels and received at the acquisition stations is converted into a raw data stream (in the form of CADU data) and systematically processed by the production services to a set of pre-defined data types, including engineering data required for e.g. calibration activities and user level data to be made available to users.
- The lower level data (Level-o) is systematically archived for long term preservation.
- The user level data which is systematically generated is made available “immediately” (in line with the timeliness requirements for each

user-level data) for on-line user data access and remains available for immediate on-line download for a configurable time period (rolling period). The rolling period may be dynamically adjusted according to the observed user activity, to the geographical area or type of data.

- In some cases, the user level data may be processed with more than one timeliness requirement, as improved auxiliary data (e.g. meteorology actuals vs. forecasts) are available. In such a case, the consolidated data generally will replace the prior versions, again according to a rolling policy.

- The consolidated version of the rolled-out data remains available for user discovery and download, ensuring access to all mission data. Different mechanisms are foreseen to ensure access to rolled-out data, and the operations configuration may be based on any combination of these mechanisms:
 - Rolled-out data may be made available from a storage point, with a different retrieval latency and same or different data access interfaces (typically as part of the LTA service operations or as part of the Data Access service operations);
 - Rolled-out data may be re-generated on-the-fly on user demand;

In addition, bulk reprocessing campaigns for a data period or a specific data type are envisaged, in order to ensure the availability of harmonised data series.

1.2.2 Specific Data Hub Evolution

In Y2020, two major steps achieved in the framework of the transition were taken towards transferring the Data Access System to the new architecture.

- In anticipation of the new operations scenario under which only the lower levels of user data will be preserved, and responding to the user feedback which pointed to limitations in the capacity for retrieval of historic data from the GS/LTA, in particular for Sentinel-2 (quota exhaustion), a new interface was transferred to operations to enable historic data to be retrieved from the ONDA DIAS. This new interface was

initially operated for only part of the historic data set but it was subsequently configured to manage the retrieval of all Sentinel-2 historic data. It was then further extended also to manage the rolled-out Sentinel-1 and Sentinel-3 data. This interface uses the existing capacities for data dissemination available from DIAS and proved an effective means of resolving the quota limitations. The suitability of interfacing with the other DIAS, to increase further the capacities, will be further analysed and transferred to operations as appropriate.

- First steps were taken in the direction of adapting the Data Access Service operations so that they could be transferred from the ESA-furnished network infrastructure at T-Systems to a public cloud environment. In particular, after the provisioning of resources in terms of hosts and datastores in the private cloud, deployment of the virtual machines in the cloud environment was carried out. The full transfer is timed to coincide with the termination of the network contract and the phase-out of the infrastructure hosting the main online archive, and the final steps completing the process will take place at the beginning of Y2021. More details on this can be found in Section 7 “Y2021 Outlook”.

The specific objective for the Data Access team during this transition is to maintain untouched the interfaces operated by the Data Access System (APIs and GUI), and to guarantee the same data offer and timeliness currently available online.

1.3 Main Developments in the Data Offer in Y2020

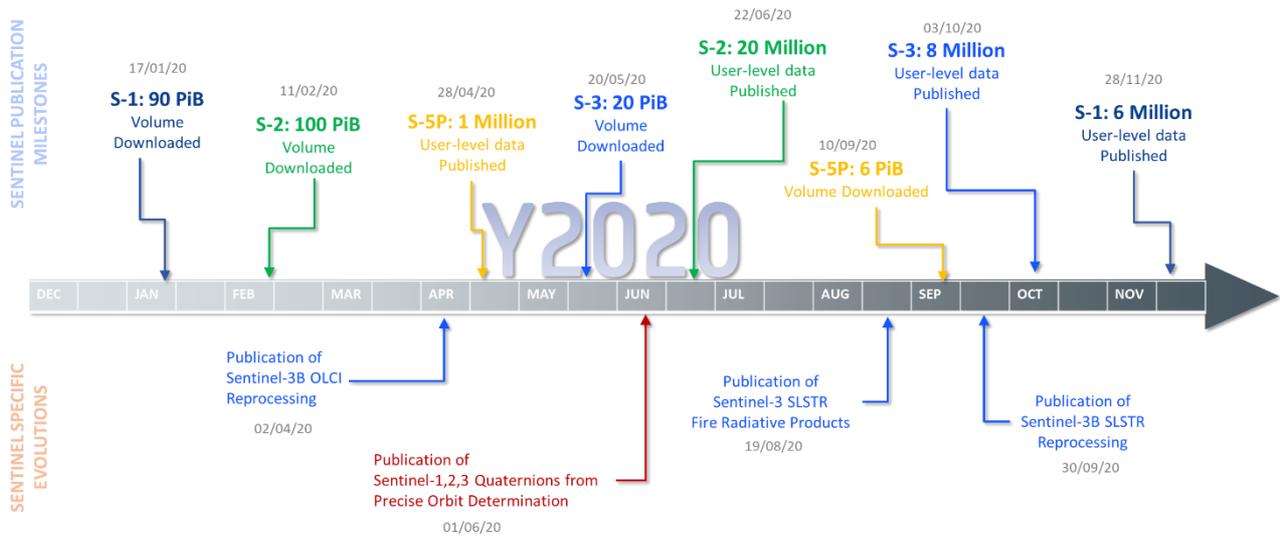


Figure 8: Timeline of the main Y2020 achievements related to Sentinel mission-specific user-level data publication and evolutions

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

Sentinel-1

No adjustments were made to the Sentinel-1 user-level data offer during Y2020.

The number of Sentinel-1 user level data published since the start of operations reached ~6,000,000, and the volume of downloads made since the start of operations reached ~90 PiB.

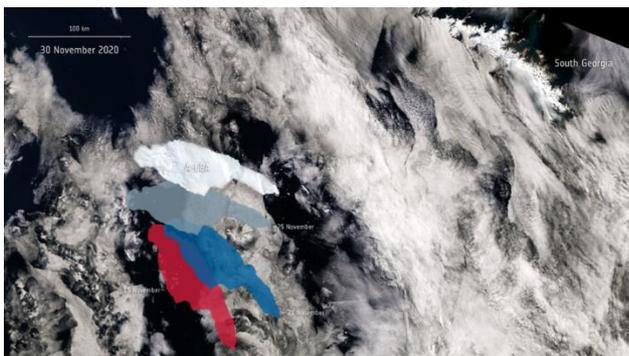


Figure 9: This image shows A-68A giant iceberg’s movements across the Southern Ocean over the 15 days in November 2020 using data from the Copernicus Sentinel-1 and Sentinel-3 missions. [contains modified Copernicus Sentinel data (2020), processed by ESA]

Sentinel-2

With over 20,000,000 user level data having been published in Y2020, and 100PiB of data downloaded, Sentinel-2 remained the mission with the highest volume of both published and downloaded user-level data of all the Sentinel missions in Y2020. No changes concerning its data offer during Y2020 were made.

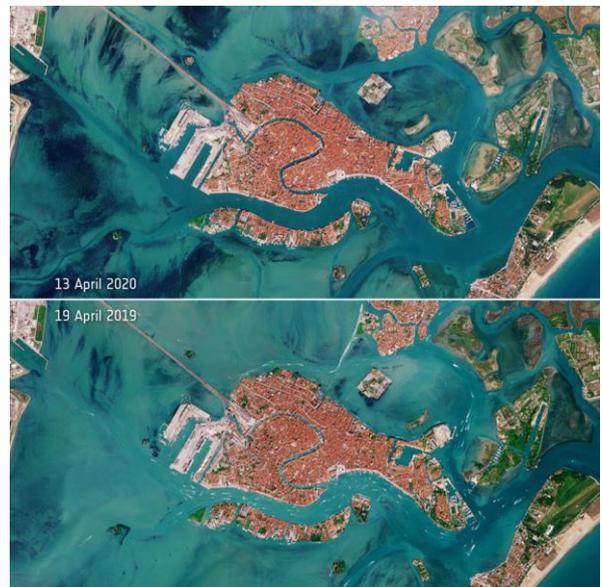


Figure 10: These Sentinel-2 images show one of the effects of the locked-down city of Venice, in northern Italy. The top image, captured 13 April 2020, shows a distinct lack of boat traffic compared to the image from 19 April 2019. [contains modified Copernicus Sentinel data (2019), processed by ESA]

Sentinel-3

There were a few changes at the level of individual Sentinel-3 user-level data types during Y2020:

- SLSTR user-level data (Level-1 SL_1_RBT and Level-2 SL_2_LST) was greatly boosted with respect to Y2019, due to a reprocessing campaign which started in September 2020.
- The new user-level data SLSTR Level-2 Fire Radiative Power (FRP) was introduced in August 2020.
- Copernicus Sentinel-3B OLCI L1 (OL_1_EFR, OL_1_ERR) and L2 (OL_2_LFR, OL_2_LRR) reprocessed data became available in April 2020.

In Y2020, the number of Sentinel-3 user-level data which was published was about 8,000,000, while the volume of Sentinel-3 data downloaded was about 20 PiB.



Figure 11: This image, captured on 31 March 2020 from Sentinel-3, shows the Ganges Delta – the world's largest river delta [contains modified Copernicus Sentinel data (2019), processed by ESA]

Sentinel-5P

No new user-level data types were introduced for Sentinel-5P during Y2020. However, the number of published user-level data considerably increased, passing from 200,000 in Y2019 to 1 million in Y2020.

Moreover, the number of downloads doubled with respect to Y2019: the download peaks visible in January 2020 may be linked to the bushfires occurring in Australia in January, while the peak in the third quarter of Y2020 may be due to the interest in NO₂ and CO user-level data, and a result of the many articles highlighting the drop in atmospheric pollutants during the lockdown periods due to the Covid-19 pandemic.

Auxiliary Files

The main enhancement in the POD user-level data offer in Y2020 was the release of the Copernicus Sentinel-1, -2 and -3 Quaternions files. The Quaternions files for S-1, S-2 and S-3 computed by the Copernicus POD Service became officially available from the Copernicus Sentinels POD Data Hub (<https://scihub.copernicus.eu/gnss/#/home>) on 1 June 2020.

The Quaternions files contain the decoded attitude from the satellites' AOCS data on a time tagged file. In case of data gaps, these Quaternions files are filled with the simulated attitude derived from precise orbital data (please refer to POD File Format Specification (PFS) document for more details).

Thanks to this achievement, users are able to access the Quaternions files for the entire Sentinel-1, -2 and -3 missions - regularly uploaded daily with a latency depending on the mission.

Moreover, in response to scientific user recommendations, precise orbital data and platform data files computed by the Copernicus POD Service have been officially released for the Sentinel-3 mission.

The user-level data include:

- 1 Near Real Time (NRT) Restituted Orbit File (file type: SR__ROE_AX)
- 2 Medium Orbit Ephemerides (MOE) Orbit File (file type: AUX_MOEORB)
- 3 Precise Orbit Ephemerides (POE) Orbit File (file type: AUX_POEORB)
- 4 Precise Platform Data files (file type: AUX_PRCPTF)

Users have been able to access these user-level data from the Open Hub since 14 January 2020. The full

mission data set of Precise Orbit Ephemerides (POE) Orbit Files is available and completed on a daily basis.

The availability of the Sentinel-3 orbital user-level data complements the previous publication of ancillary data and user-level data, including:

- 1 GPS Rinex observation files (also found on the same Data Hub)
- 2 Satellite parameters for POD (mass history file, manoeuvre file, and GPS Antenna ANTEX)
- 3 Sentinel-3 Properties for GPS POD.

By releasing the Quaternions files and the Sentinel-3 precise orbit and platform data files, together with the

GPS Rinex Observation and the other ancillary files, the Copernicus Programme aims at supporting the scientific community involved in many geodetic applications worldwide and encourage new uses for the Sentinels GNSS data, maximising the missions' return and becoming a reference for GNSS processing.

More information about the Copernicus POD Service can be found at:

<https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3/ground-segment/pod>

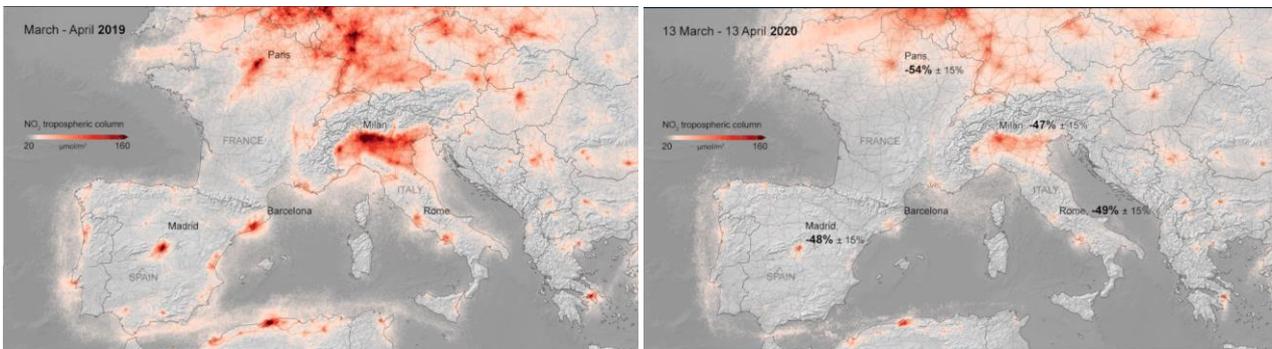


Figure 12: These images, using data from the Copernicus Sentinel-5P satellite, show the average nitrogen dioxide concentrations from 13 March to 13 April 2020, compared to the March-April averaged concentrations from 2019. The percentage decrease is derived over selected cities in Europe and has an uncertainty of around 15% owing to weather differences between 2019 and 2020 [contains modified Copernicus Sentinel data (2020), processed by ESA].

2 Data Access Service Growth

During Y2020, the statistics which illustrate the level of public engagement with the Data Access System continued to increase dramatically. User registrations rose 37% to nearly 385,000; the number of Sentinel user-level data made available for download on the Open Hub rose 54% to 40 million user-level data; and the volume of Sentinel user-level data downloaded by users since the start of operations rose 52% to an enormous 240 PiB (not including the downloads made by the DIAS partners, which was a further 60.15 PiB). In this section, each of these increases is analysed in detail.

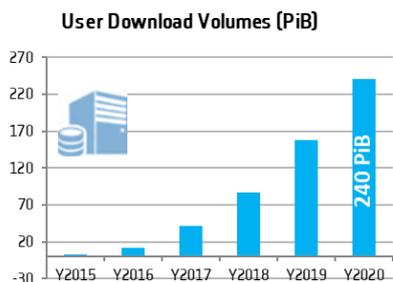
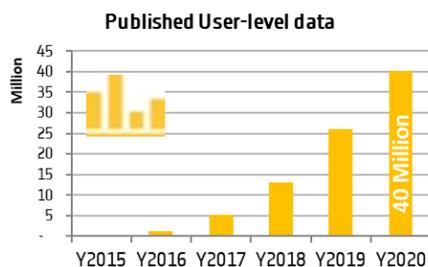
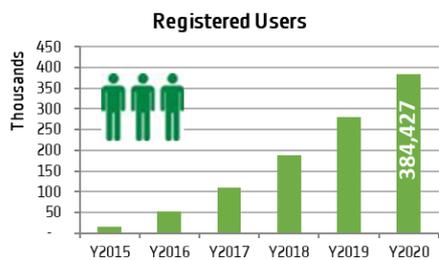


Figure 13: Overall Rise in Data Hub Registered Users, Published User-level data and User Download Volumes, showing cumulative total for each year since the start of operations

2.1 User take-up

By the end of Y2020, **384,427 users** were registered to access the four hub services offered by the Copernicus Sentinel Data Access System operated by ESA. Figure 13 breaks this overall figure down to show the number of users registered on each hub, and the percentage increase since the end of Y2019. 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 Y2019, the greatest change took place on the IntHub: 3 new international partners opened accounts on the hub during the year (Ukraine, Brazil and Colombia), raising the total number of user accounts from 7 to 10, a 43% increase.



Figure 14: Registered Users per Data Hub

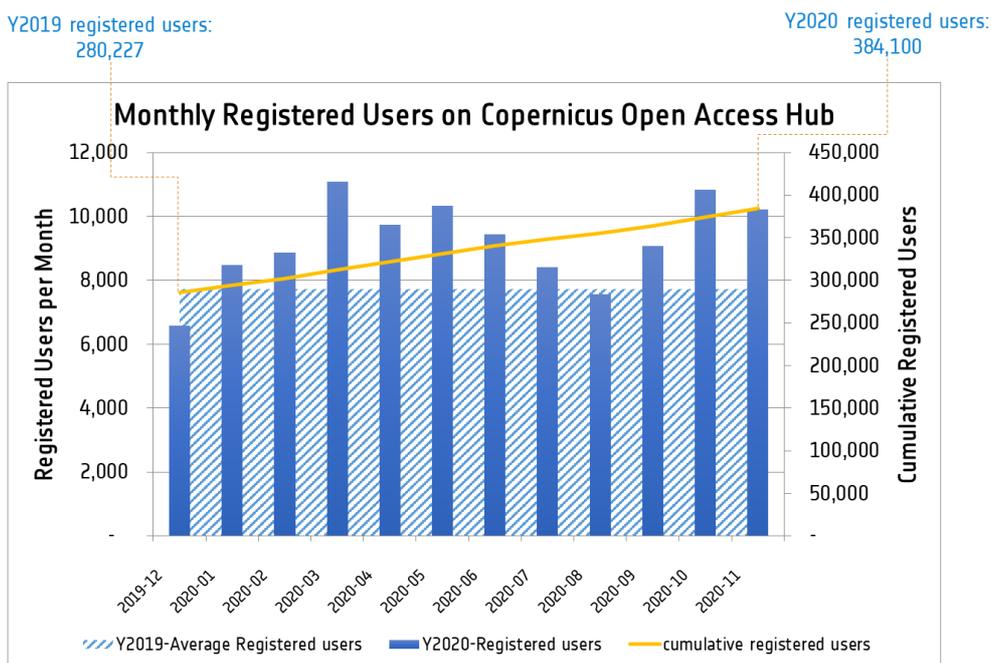


Figure 15: Trend of User Registrations on the Copernicus Open Hub

It is clearly still the Open Hub which supports access for by far the largest number of people, though. By the end of Y2020, 384,100 user accounts had been opened on the Open Hub since the start of operations (3 October 2014). In absolute terms there were 103,873 **new user accounts** opened in Y2020, and again this was the **highest yearly rise in user registrations yet seen since the start of operations**.

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

The graph in Figure 15 above shows the number of users who registered each month for access to the Open Hub during Y2020, contrasted against the average number of user registrations made per month during Y2019. 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 the monthly average for Y2019. Indeed, in Y2020 there was an average of 9,220 registrations per month, which is 19% higher than the Y2019 average of 7,721 and 42% higher than the 6,506 Y2018 average.

Figure 15 shows a very similar pattern to that seen in Y2019, with two peaks in registrations again evident during Y2020: the first in March and the second in October. Whilst it remains conjecture to suggest precisely why a similar pattern is seen in the registrations in 2019, it seems that registrations do take a dip in the months associated with typical vacation periods in Europe.

One potential trigger for new registrations is the launch of a satellite or the release of new user-level data. Another potential trigger for new registrations are outreach events that take place at different points throughout the year. In Y2020, however, due to the global development and concerns over the coronavirus (Covid-19) situation, several Copernicus-related conferences which were scheduled to take place were postponed. Others were held online.

The most significant that took place were:

- **European Space Week 2019 (3-5 Dec 2019)** focused on: 1. How space solutions can help to strengthen the EU’s position as a global leader in climate action; 2. New space economy for sustainable growth; 3. Sustainable space economy: Saving space for future generations; 4. Space solutions for a sustainable Arctic.
- **FOSS4G 2020 (18 - 22 February 2020)**, held at Polytechnic University of Turin (Italy).
- **EGU2020: Sharing Geoscience Online (3–8 May 2020)**: EGU cancelled the physical General Assembly in Vienna and hosted the European Geosciences Union (EGU) 2020 as a week-long series of online activities.
- **2020 ESA Space App Camp (11-21 September 2020)**, online.
- **ESA EO Φ-WEEK 2020 Virtual Event (28 September - 02 October 2020)**, the annual

Earth Observation event organised by ESA-EOP. It focuses on innovation in Earth Observation, and showcases the latest achievements in Earth Observation science, technology and applications.

- **4th Workshop - Scaling up the Sentinels in Europe (26 - 27 October 2020)**: Objective of this webinar was to give a most actual and wide update about developments in relation to Sentinel satellites from Copernicus and ESA. Additionally, knowledge and experience from different national Collaborative Ground Segments (CGS) were presented. Presentations of active projects and innovations raised awareness of the possibilities and motivated ideas to make use of earth observation data making sure the scaling up phase in the programme has already started.
- **Virtual ESA Open Day at ESTEC 2020 (4 October 2020)**.

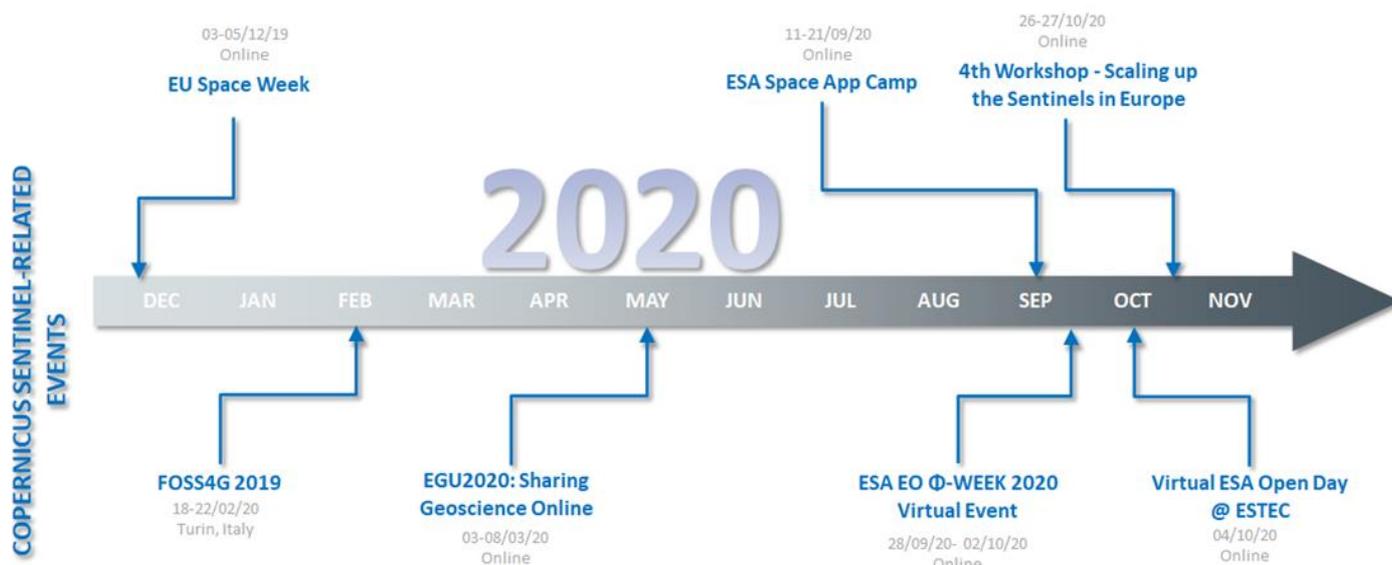


Figure 16: Highlighted Copernicus Sentinel-Related Events in Y2020

2.1.2 Open Hub Demography

In Figure 17 below, the increase in user registrations during Y2020 is broken down by continent.

Europe remains the continent with by far the largest Open Hub user-community, with 139,657 registered users by the end of Y2020, up 35% from Y2019. 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 Y2020 took place in Oceania, with a remarkable increase of 84%, up to 10,361 users. It is speculation but potentially this could be related to the “2019-2020 Australian bushfire season”, which will have created widespread need for satellite images of the affected areas.

The number of registered users also increased significantly in Asia, up by 40% compared with Y2019, to 96,959 users. In absolute terms, the highest number of new registrations in the year was again in Europe, however, and at 36,389 it was the highest number of new accounts opened in Europe for any year so far.

Another interesting view on the number of user registrations is the trend of countries worldwide reaching more than 500 user registrations. The graph in Figure 18 shows the monthly increase in the number of countries reaching this threshold. The number continues to grow: by the end of Y2020 there were 83 countries across the world with more than 500 registered users, a rise from the 71 at the end of Y2019.

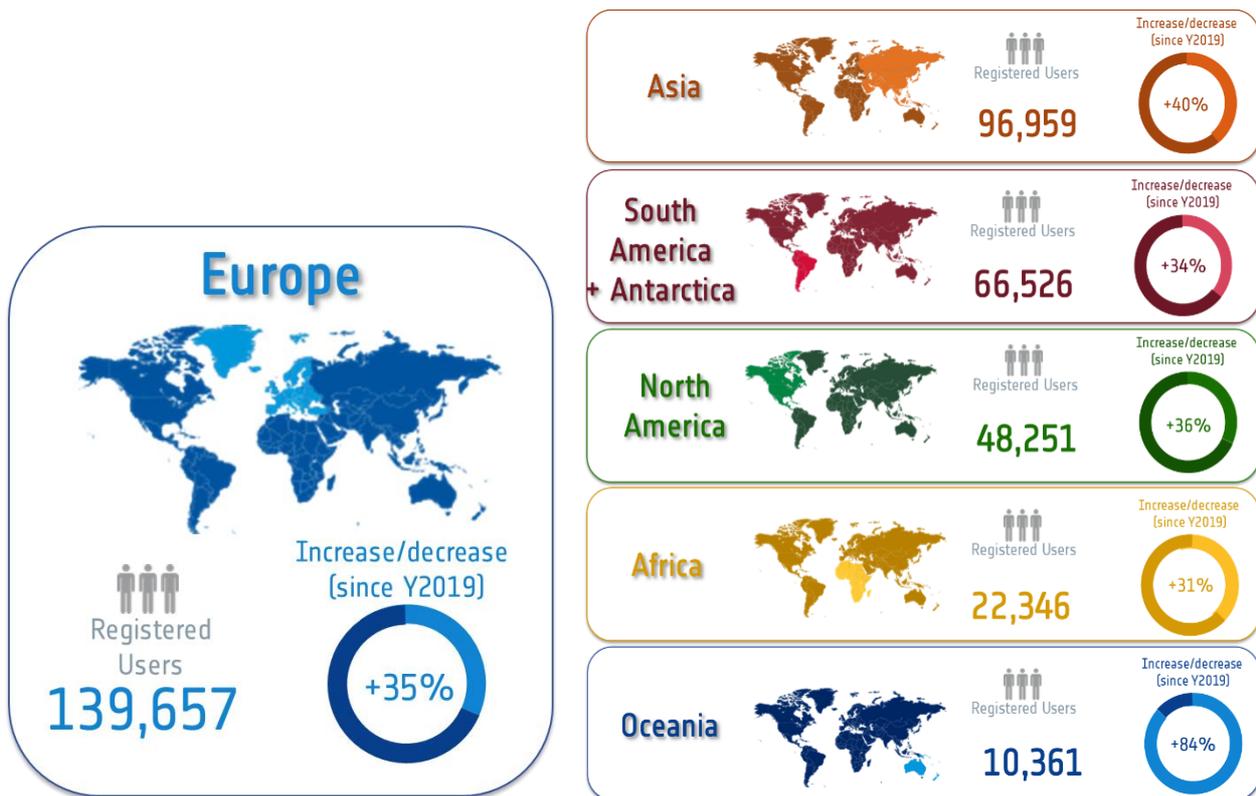


Figure 17: Open Hub registered users in Europe - on left -and number of registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent during Y2020 - on right

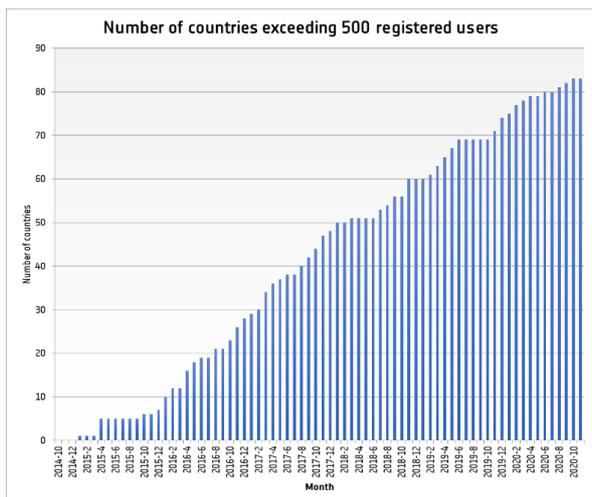


Figure 18: Growth in the number of countries exceeding 500 registered users on the Open Hub since the start of operations

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 Italy which showed the highest percentage increase (49%) in the number of registered users, with Spain showing the second highest rise at 47%. In absolute terms, Germany remains the country with the largest number of registered users in Europe, and even there registrations increased by 30%, reaching a total of 21,445 registered users at the end of Y2020. To put that figure in perspective, it is the same number of registered users as there were across all of Europe at the end of Y2017.

Figure 19 illustrates for the top 5 ESA and European Union Member States the number of registered users, and the percentage change since Y2019.

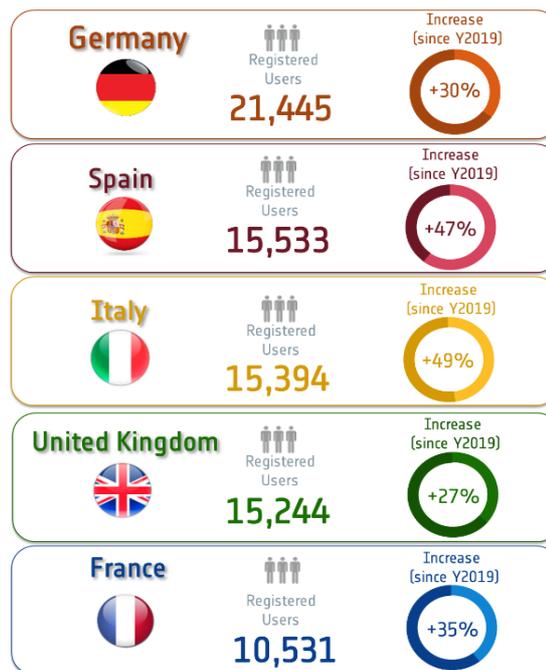


Figure 19: Distribution of Copernicus Open Hub registered user distribution in the 5 EU and ESA member states with the highest number of registered users

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 also to be influenced by the availability of alternative national sources of Sentinel data, for example via the Collaborative GS or international mirror sites.

User activity on the Hubs is analysed in Section 3.

2.2 Published Data

By the end of Y2020, almost all user-level data were being published routinely on each of the data hubs. The exceptions were the Sentinel-5P user-level data which were still being disseminated on the Sentinel-5P PreOps Hub, maximizing the retention period for the other Sentinel user-level data whilst providing an increased download capacity for the new Sentinel-5P atmospheric user-level data. The user-level data types available on each of the hubs during Y2020 were the following:

- **Sentinel-1A/-1B** user-level data were being routinely published on all the data access hubs, although the NRT user-level data are only available on the ColHub and ServHub.
- **Sentinel-2A/-2B** Level-1C and Level-2A user-level data were being routinely published on all the data access hubs
- **Sentinel-3A/-3B** OLCI, SLSTR, SRAL and SYNERGY user-level data were being routinely disseminated on all hubs. NOTE: The SYNERGY SY_2_SYN and SY_2_AOD user-level data started to be available on the IntHub from 14 January 2020.
- **Sentinel-5P** user-level data were being disseminated on the Sentinel-5P PreOps Hub.

This section presents the statistics for the publication of those user-level data on the Open Hub during Y2020. 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 Y2020, a total of **40,102,005 Copernicus Sentinel user-level data had been published on the Open Hub since the start of operations, with a total data volume of 24.87 PiB**. In Y2020 itself, a total of 14,129,781 user-level data were published, accounting for a total data volume of 7.65 PiB. To put this into context, by way of historical comparison the 7.65 PiB published during Y2020 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.

The chart in Figure 20 below compares the volume of user-level data published in Y2020 with the volumes published in the preceding years.

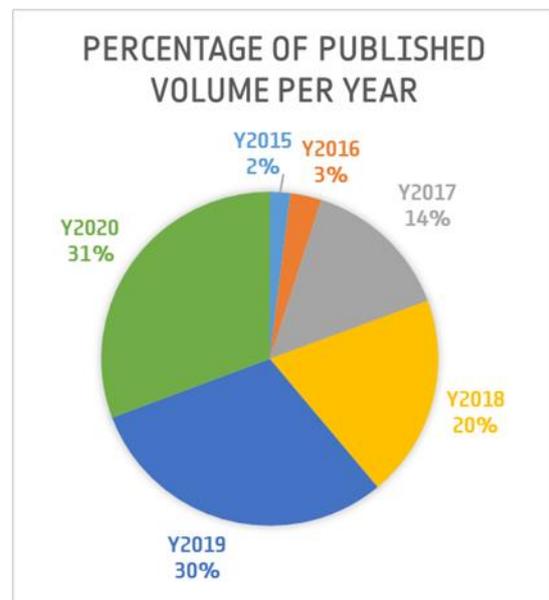


Figure 20: Percentage of the published volume of data per year since the start of operations (Y2015-Y2020)

The volume of Sentinel user-level data published on the Open Hub during Y2020 makes up 31% of all the user-level data published on the Open Hub since the start of operations, matching the level of user-level data published in Y2019. It is interesting to note that the trend is finally levelling off, as all missions reach full operational capacity.

Mission	No. of user-level data published in Y2020	No. of user-level data published since start of Ops	Y2020 No. as % of total published per mission since start of Ops	Volume of user-level data published in Y2020 (PiB)	Volume of user-level data published since start of Ops (PiB)	Y2020 volume as % of total published per mission since start of Ops
S1	1,387,629	6,011,786	23	2.22	9.47	23
S2	8,072,039	23,650,679	34	4.15	12.02	34
S3	4,024,025	9,047,411	44	1.13	3.04	37
S5P	646,088	1,392,129	46	0.15	0.35	44
ALL	14,129,781	40,102,005	35	7.65	24.87	31

Table 1: Overall number and volume of published user-level data on the Open Hub both in Y2020 and since the start of operations, per Sentinel mission

Table 1 above breaks these totals down by Sentinel, showing the number and volume of user-level data published in Y2020 as compared to the total since the start of operations in 2014. As reported in Table 1, in terms of the number of published user-level data, Sentinel-2 data continues to dominate: the mission accounts for 57% of user-level data published in Y2020 and 59% of all user-level data published since the start of operations. However, it should be noted that the relative differences between the number of user-level data and the volumes of user-level data published for each Sentinel depends on the definition of the user-level data types and their standard packaging. For example, the Sentinel-2 user-level data are packaged according to a standardised tiling scheme, with one user-level data per tile: so even though the number of Sentinel-2 user-level data published is over 6 times that of Sentinel-1, in terms of total volume of user-level data published in the year, the figure for Sentinel-2 (4.15 PiB) is only about 2 times that for Sentinel-1 (2.22 PiB). The number of Sentinel-3 user-level data published in Y2020 is three times the number of Sentinel-1 data and, for the second consecutive year, the total number of Sentinel-3 user-level data published since the start of operations surpassed that of Sentinel-1. On the other hand, the volume of Sentinel-3 user-level data published in Y2020 was half the volume of Sentinel-1 data published in Y2020, and the total published volume of Sentinel-3 user-level data since the start of operations amounted to a third of the total volume of Sentinel-1 data published since the start of operations.

As noted above, the overall publication flow was very similar to that of Y2019: only 9% more user-level data by number were published during Y2020 than in Y2019, and only 1.5% more by volume.

Tables 2 and 3 show the Open Hub publication volumes and numbers on a daily basis, averaged over one month at the end of the reporting period (November 2020), with the corresponding figures from the same month in Y2019.

Consistent with the figures already examined, the average daily volume of data being published by the Data Access System in November 2020 was only 0.1% greater than the average daily volume being published in November 2019 (the equivalent change between Y2019/Y2018 was 23%).

At the end of Y2020, the majority of NTC user-level data volume being published was still accounted for by Sentinel-1 and -2, although together they constituted a slightly lower proportion of the total average daily volume in Y2020, down to 78% from 85% of the daily total in Y2019. This change appears largely accounted for by the fact that Sentinel-3 user-level data constituted a significantly greater share of the total daily average publication volume by the end of Y2020, increasing from 12% in November 2019 to 20% in November 2020. This was largely caused by a batch of re-processed SLSTR data from Sentinel-3B which was published during that period and which has inflated the publication figures. There was no change for Sentinel-5P user-level data, which still accounted for just 2% of the total average daily volume.

Mission	Daily Average Vol (TiB) published in November 2020	Nov 2020 Volume as % of overall daily average	Daily Average Vol (TiB) published in November 2019	Nov 2019 Volume as % of overall daily average
S1	6.23	31	6.13	33
S2	9.56	47	9.54	52
S3	4.03	20	2.35	12
S5P	0.40	2	0.46	2
All	20.22		18.48	

Table 2: Average volume of user-level data published per day in the last month of Y2019 and Y2020, with percentage splits per Sentinel mission

Mission	Daily Average Number of user-level data Published in Y2020	Y2020 no. as % of overall daily average	Daily Average Number of user-level data Published in Y2019	Y2019 no. as % of overall daily average
S1	3,802	10	3,799	12
S2	22,115	57	17,896	58
S3	11,025	28	6,826	22
S5P	1,770	5	1,950	6
All	38,712		30,471	

Table 3: Daily average number of user-level data published per mission during Y2020 and Y2019

Table 3 shows the average number of user-level data which were published per day in Y2020 on the Open Hub, broken down by mission, with the Y2019 figures included for comparison. Despite the small changes seen overall in the average daily volumes being published, the Data Access System was actually publishing on average 27% more user-level data per day for all missions in November 2020 than in November 2019 (38,712 user-level data compared with 30,471 user-level data in November Y2019). As noted above, this growth was driven largely by a substantial increase in the average daily number of Sentinel-3 user-level data being published at the end of the year, which rose 62% compared with the number being published in November 2019, and this was largely caused by a batch of re-processed SLSTR data from Sentinel-3B which was published during that period. As a consequence, Sentinel-3 user-level data constituted 28% of the total average daily number of user-level data being published in November 2020, 6% more than their share in November 2019. There was also an increase in the average daily number of Sentinel-2 user-level data being published in November 2020, which was up 24%

as compared to the number in November 2019. It is interesting to note again that this had an almost negligible impact on the average daily volume of Sentinel-2 user-level data being published, which only rose from 9.54 TiB/day in November 2019 to 9.56 TiB/day in November 2020. The average number of Sentinel-1 user-level data being published per day in November 2020 was almost identical to the number being published in November 2019.

2.2.2 Publication trends

The graphs below show, per Sentinel mission, both the number and volume of user-level data which were published per month on the Open Hub and the PreOps Hubs during the Y2020 reporting period. The values represent the sum total of all individual user-level data types published per mission, and for both –A and –B satellites where applicable. The values are also compared with the same months from Y2019, to highlight any changes which have occurred between the years.

Sentinel-1

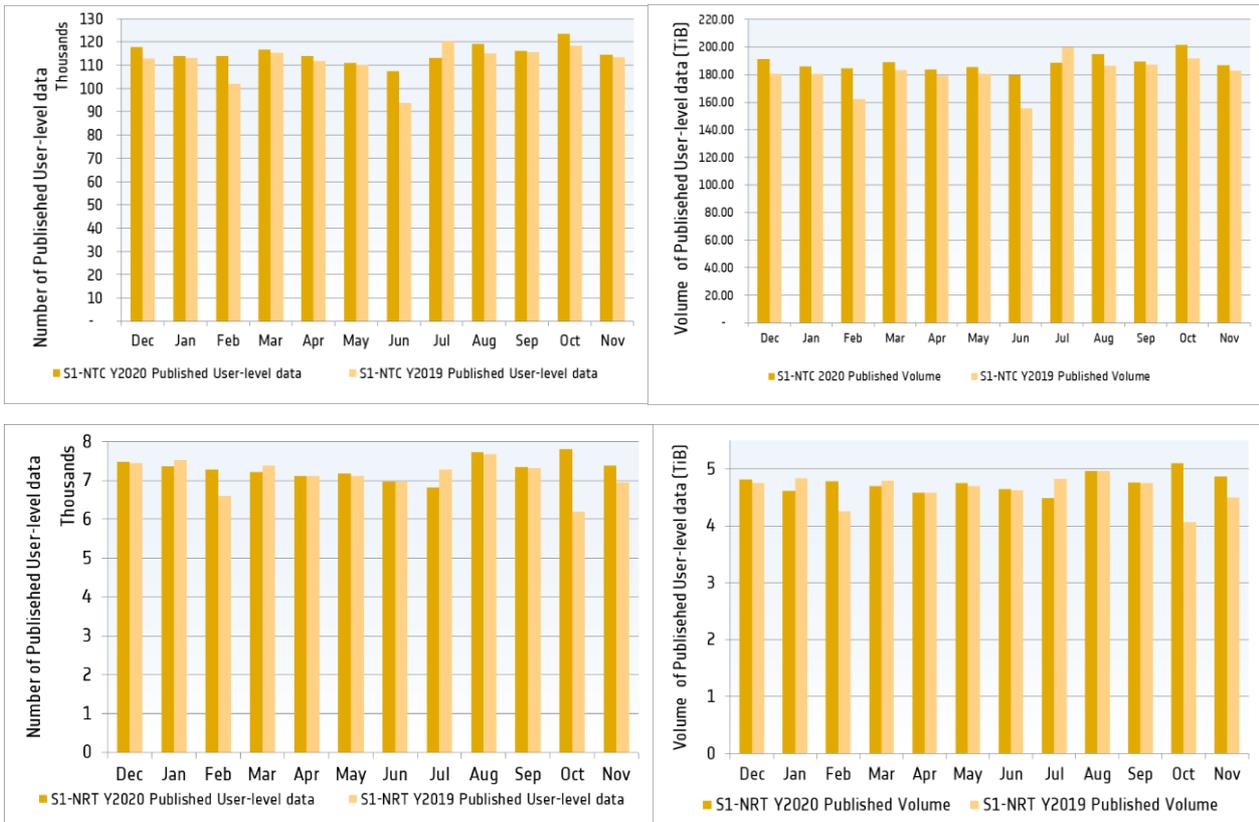


Figure 21: Y2020 and Y2019 monthly number and volume publication trend for Sentinel-1 Non time Critical (up) Near Real Time Production (down)

During Y2020, numbers and volumes of Sentinel-1 NTC published user-level data remained relatively stable, in line with a mission which remains at full operational capacity. The monthly average number of user-level data published in Y2020, 115,068, was only 2.9% up on the Y2019 value, while the monthly average volume of user-level data published in Y2020, 188 TiB, was only 4.2% greater than that of Y2019.

Overall, however, the monthly averages varied less in Y2020 than in Y2019, and the notable dips in publication which were seen in February and June 2019 did not occur in 2020.

The Y2020 monthly averages for the Sentinel-1 NRT user-level data also closely resemble those recorded in Y2019, although again the overall trend is even more steady than that seen in Y2019 (Figure 21).

Sentinel-2

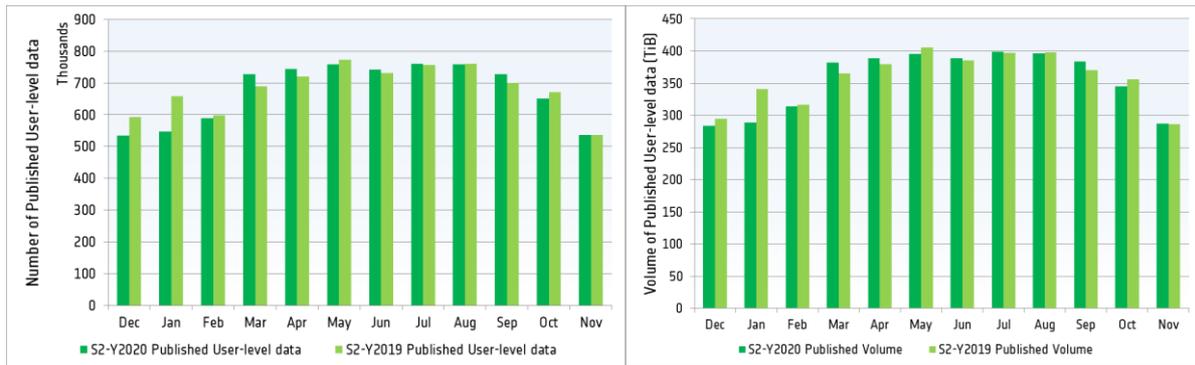


Figure 22: Y2020 and Y2019 number and volume publication trend for Sentinel-2

For Sentinel-2, the average number and volume of user-level data published per month during Y2020 were almost identical to the equivalent figures for Y2019: an average of 672,670 user-level data was published per month in Y2020 compared with an average of 682,317/month in Y2019; and an average volume of 354.25 TiB was published per month in Y2020 compared with an average of 358 TiB/month in Y2019.

As seen in Y2019, the Y2020 average monthly publication figures create a predictable seasonal curve. More Sentinel-2 user-level data 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.

The only noteworthy deviation in the monthly averages between Y2020 and Y2019 occurs in December 2019 and January 2020, with approximately 60 TiB less data published in these two months with respect to the related ones of Y2019: this is due to the publication of Sentinel-2 Level 2A which extended its coverage to the entire globe on 13 December 2018 so a massive population of the processed user-level data outside the European region took place during those days of Y2019.

Sentinel-3

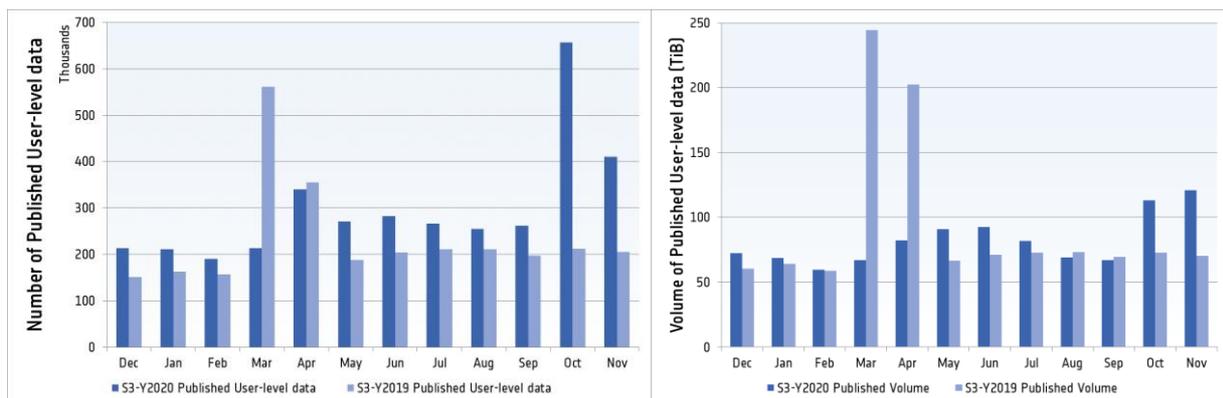


Figure 23: Y2020 and Y2019 monthly number and volume publication trend for Sentinel-3

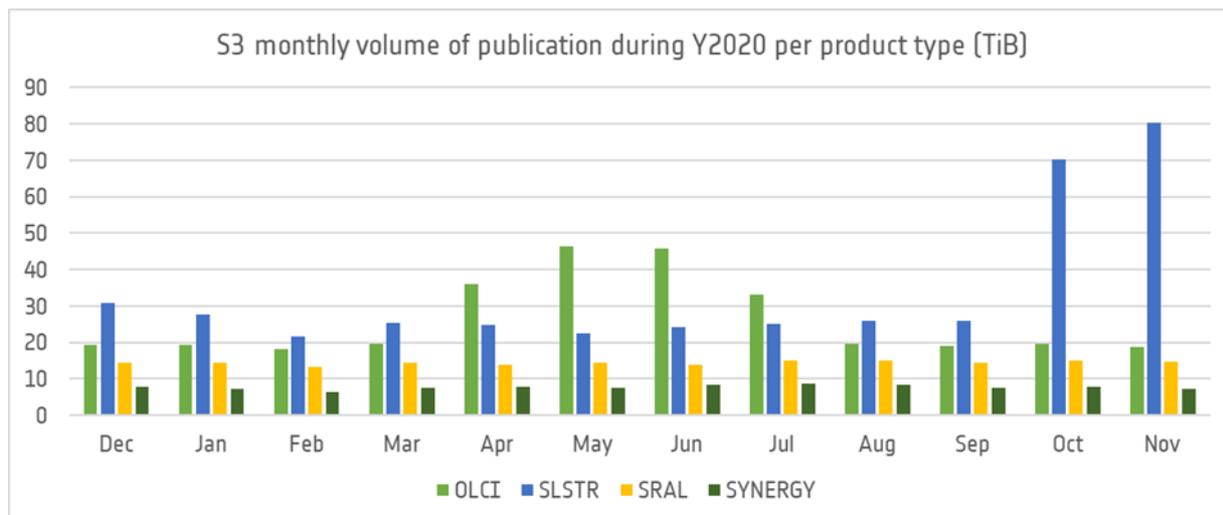


Figure 24: Y2020 monthly volume publication trend per Sentinel-3 user-level data group

For Sentinel-3, two clear peaks in the number of user-level data published stand out from the otherwise relatively even publication figures. In October 2020, the month with the highest publication rate, a total of 656,754 user-level data were published, up a massive 245% from the 190,216 user-level data published during February 2020 (the month with the lowest value). The month in which the second highest number of user-level data was published was November, with 410,348 published data.

The cause of the sharp increase in publication rates in April-July and October-November 2020 is illustrated in Figure 24, which shows the Sentinel-3 monthly publication volumes for each of the four user-level data groups (OLCI, SLSTR, SRAL and SYNERGY).

In the period between April and July 2020, there was a slight rise in OLCI publication (46 TiB in May) followed by higher spikes in SLSTR publication in October and

November (~70TiB and 80TiB respectively). These rises were the result of Sentinel-3B OLCI and SLSTR user-level data being re-processed: the dataset covered both Level-1 and Land Level-2 user-level data, and they covered respectively the reference periods 14 May 2018 – 30 October 2019 for OLCI and 09 May 2018 – 16 February 2020 for SLSTR.

Table 4 presents a breakdown of the number of reprocessed user-level data for both OLCI and SLSTR Level-1 and Level-2 user-level data, and shows the percentage each set of reprocessed user-level data constituted of the overall OLCI and SLSTR publication during Y2020. 41% of all OLCI user-level data published in Y2020 and 25% of all SLSTR user-level data were reprocessed user-level data. No reprocessed SRAL or SYNERGY user-level data were published during the year.

Instrument	Product level	Y2020 Total No. of Published User-level data	Y2020 Total No. of Reprocessed Published User-level data	% Reprocessed User-level data
OLCI	Level 1	301,067	126,381	41
	Level 2	300,975	126,265	41
	Total	602,042	252,646	41
SLSTR	Level 1	585,781	230,481	39
	Level 2	637,118	306,602	48
	Total	1,222,899	537,083	25

Table 4: Y2020 total numbers of SLSTR and SRAL reprocessed user-level data, and percentage of total published

Starting from 19 August 2020, a new user-level data type has been released: SLSTR Level-2 FRP with Fire Radiative Power.

In summary, if all months in Y2020 are included in the calculation, the average publication rate for Sentinel-3 user-level data was 297,514 data/month and the average volume was 82 TiB/month. If the outlier months are excluded, the average publication rates become 240,332 data/month and 74 TiB/month, up 27% and 9% respectively from the Y2020 averages.

Sentinel-5P

The Sentinel-5P Pre-Ops Hub began routine operations on 11 July 2018, and was still being used to

publish user-level data from the mission at the end of Y2020. During Y2020 an average of 53,841 data/month were published on the S5P Pre-ops Hub, corresponding to an average volume of 12.6 TiB/month.

Figure 25 shows very consistent publication rates for each month except May 2020. The peak in the average number and volume of user-level data which were published in May 2020 was the result of temporary publication of a set of L2 NRT data with improved algorithms in parallel with the nominal flow.

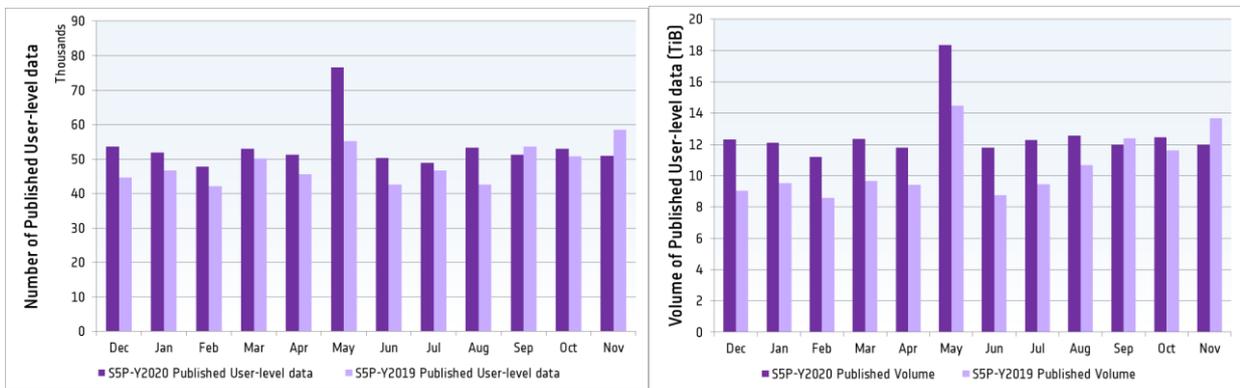


Figure 25: Y2020 monthly volume and number publication trend for Sentinel-5P

2.2.3 Publication Details

In this section, the overall publication figures are broken down by user-level data type and geographical coverage.

Publication per User-level data Type

Figures 26 and 27 show, for Sentinels 1, 2 and 3, the total percentage published for each user-level data

type, both in terms of the number and volume of user-level data, during Y2020. For Sentinel-3, for the purposes of readability, the 15 individual user-level data types have again been collected into four user-level data groups: SRAL, SLSTR, OLCI and SYNERGY; similarly for Sentinel 5P, the 23 individual user-level data types have been grouped in either Level-1B or Level-2.

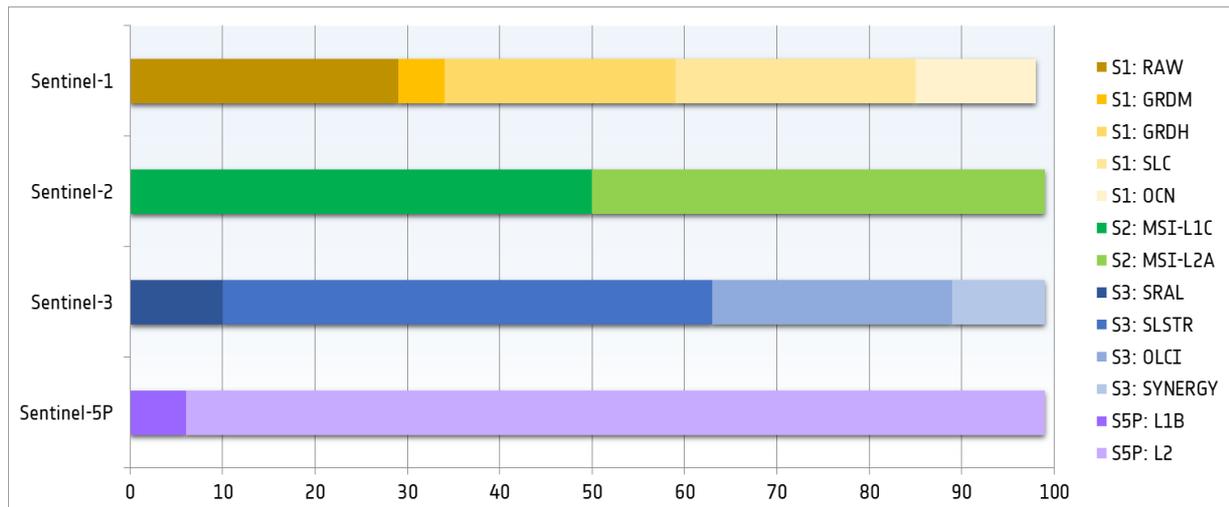


Figure 26: Percentage published number of user-level data per Sentinel mission and user-level data type during Y2020

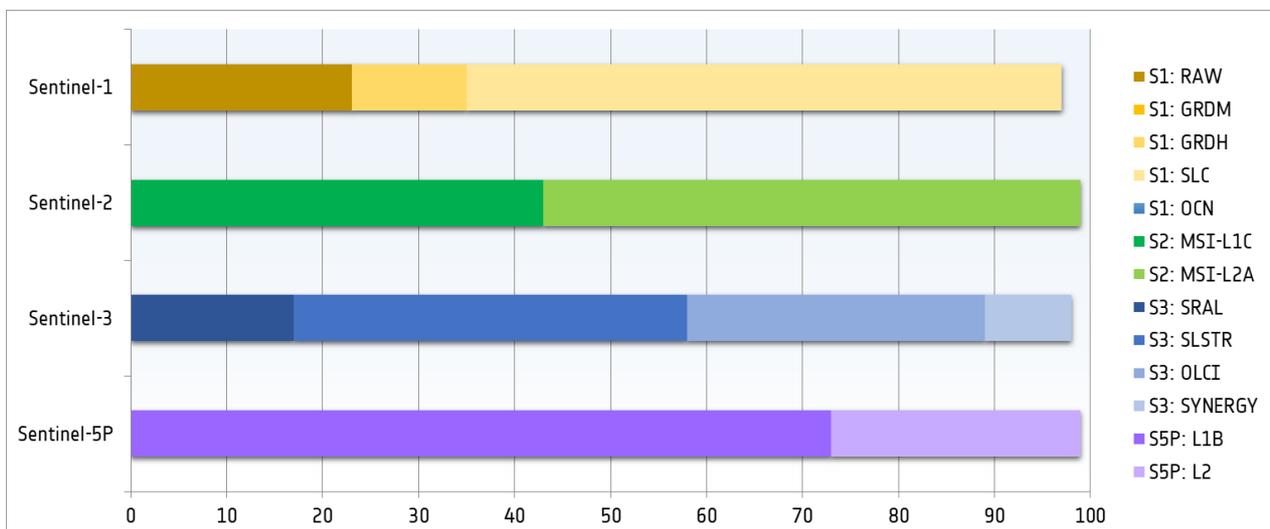


Figure 27: Percentage published volume of user-level data per Sentinel mission and user-level data type during Y2020

For **Sentinel-1** the following user-level data types were available during Y2019:

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

Looking at the numbers published for each level individually, Level 0 accounts for 29% of user-level data, 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 user-level data and the relatively small size of Level 2 OCN user-level data. These percentages for number and volume are stable since Y2018.

For **Sentinel-2** the published user-level data types are:

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

Sentinel-2 published user-level data by number consisted of 50% Level-1C and 50% Level-2A. By volume, the split was: 43% Level-1C and 57% Level-2A. These are very similar figures to the proportions recorded in Y2019. The split in the number of user-level data published is now absolutely equal, but the Level-2A user-level data now account for a higher percentage of the overall Sentinel-2 publication volume due to the larger size of individual user-level data.

For **Sentinel-3** the following user-level data 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 80Hz)
- Level 1 SR_1_SRA_BS Echos parameters for LRM, PLRM Level 1
- Level 2 SR_2_LAN___ 1-Hz and 20-Hz Ku and C bands parameters (LRM/SAR/PLRM), waveforms. Over Land Level 2

Ocean and Land Colour Instrument (OLCI):

- Level 1 OL_1_EFR___ Full Resolution top of atmosphere radiance
- Level 1 OL_1_ERR___ Reduced Resolution top of atmosphere radiance
- Level 2 OL_2_LFR___ Full Resolution Land & Atmosphere geophysical user-level data
- Level 2 OL_2_LRR___ Reduced Resolution Land & Atmosphere geophysical user-level data

Sea and Land Surface Temperature Radiometer (SLSTR):

- Level 1 SL_1_RBT___ Brightness temperatures and radiances
- Level 2 SL_2_LST___ Land Surface Temperature geophysical parameters
- Level-2 FRP with Fire Radiative Power (**new** since August 2020).

SYNERGY (synergy of OLCI OL_1_EFR and SLSTR SL_1_RBT user-level data):

- Level 2 SY_2_SYN___ Surface Reflectance and Aerosol parameters over Land
- Level 2 SY_2_VGP___ 1 km VEGETATION-Like user-level data (~VGT-P) - TOA Reflectance
- Level 2 SY_2_VG1___ 1 km VEGETATION-Like user-level data (~VGT-S1) 1 day synthesis surface reflectance and NDVI
- Level 2 SY_2_V10___ 1 km VEGETATION-Like user-level data (~VGT-S10) 10 day synthesis surface reflectance and NDVI

By number, SLSTR user-level data 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 user-level data types are:

TROPOMI Level-1B radiance/irradiance user-level data:

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

- IR_SIR: Irradiance user-level data SWIR module

TROPOMI Level-2 geophysical user-level data:

- 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__: Sulphur 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 (mid-level) pressure
- L2__NP_BDx (x=3,6,7): Suomi-NPP VIIRS clouds

Split by data level and by number, Level-2 accounted for 93% while Level-1B accounted for 7%; by volume the split was 73% Level-1B and 26% Level-2. This is accounted for by the fact that Sentinel-5P Level-1B user-level data are much larger than Level-2 (see Annex 2).

More details on the user-level data types per mission and per instrument are available in Annex 2.

Publication per Geographical coverage

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

For Sentinel-1:

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

For Sentinel-2:

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

For Sentinel-3:

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

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

https://sentinels.copernicus.eu/documents/247904/685154/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 user-level data published from the start of operations until the end of Y20120. The colour scale illustrates the differing numbers of user-level data published for each area around the globe; red zones are the areas over which the greatest numbers of Sentinel-1 user-level data have been published, as indicated by the key. All user-level data types except WV mode user-level data are included in the count; WV mode user-level data, which are available over oceans and coastal zones, are not included in the calculation due to the different footprint used in those user-level data.

The heatmap shows that Sentinel-1 user-level data cover all continents and major island groups, with the highest density of coverage over Europe, and far northern and southern sea ice regions.

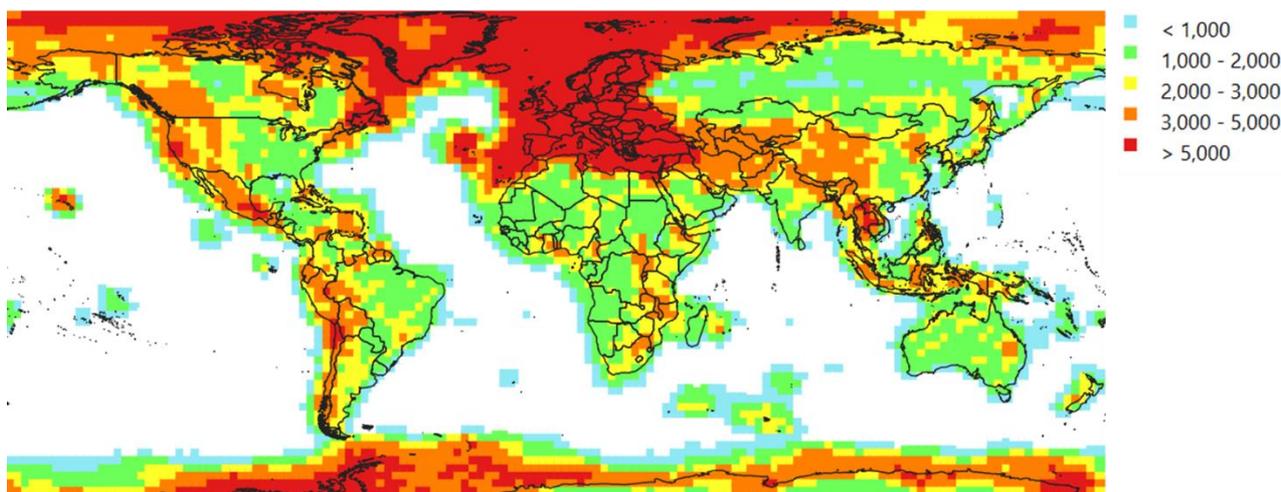


Figure 28: Heatmap of Sentinel-1 user-level data (excluding OCN) published from the start of operations to the end of Y2020

In line with the observation scenario, the greatest density of user-level data 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 user-level data types. The heatmaps for GRDM, GRDH and SLC user-level data 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 user-

level data published from the start of operations up to the end of Y2020. For ease of comparison, the keys and ranges are the same in each case. In general, the extent of data 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 user-level data are related to the EW mode (Extra Wide Swath).
- **GRDH & SLC** – mostly available over land masses. The GRDH and SLC user-level data are (mainly) related to the IW mode (Interferometric Wide Swath) and the SM mode (Stripmap). A marginal number of SLC user-level data are generated with the EW mode. The particular density of GRDH and SLC user-level data 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>.

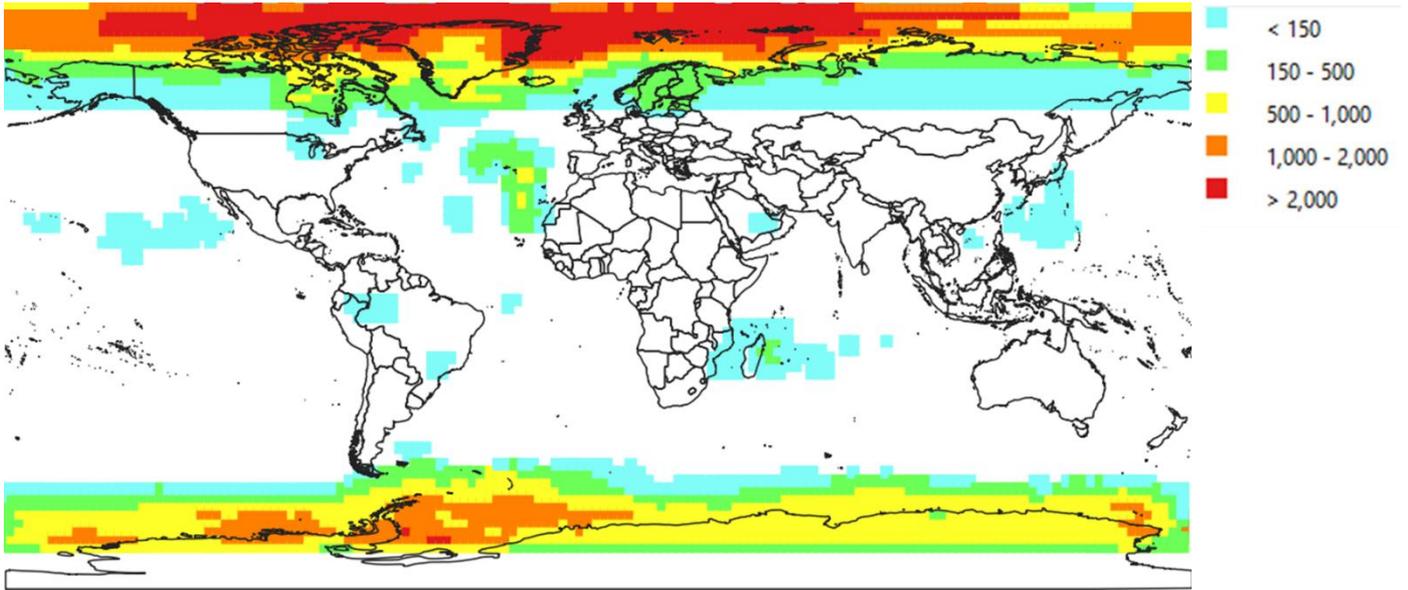


Figure 29: Heatmap of Sentinel-1 GRDM user-level data published from the start of operations to the end of Y2020

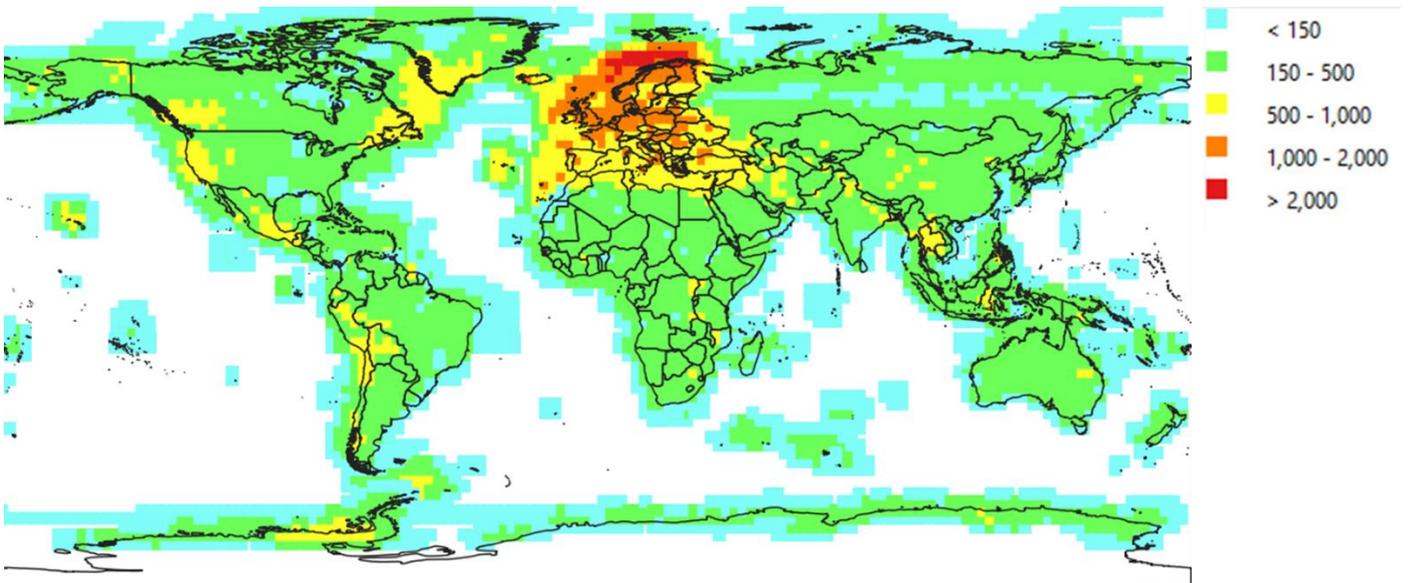


Figure 30: Heatmap of Sentinel-1 GRDH user-level data published from the start of operations to the end of Y2019

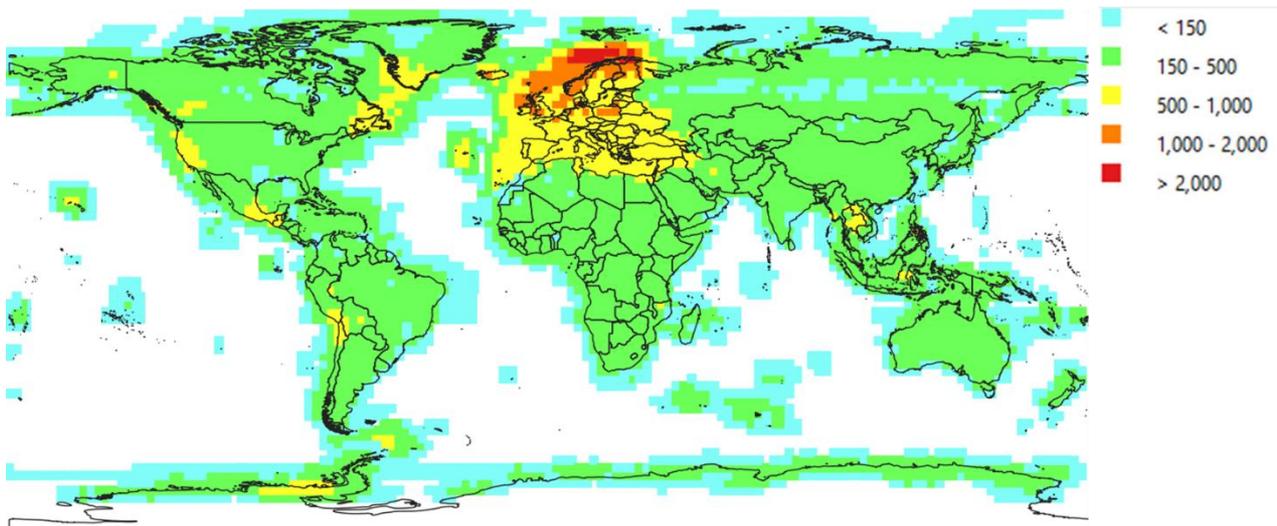


Figure 31: Heatmap of Sentinel-1 SLC user-level data published from the start of operations to the end of Y2020

Sentinel-2

Figures 32 and 33 below show heatmaps for Sentinel-2 published user-level data, respectively for Level-1C user-level data and Level-2A user-level data, 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.

Despite that Level-2A production has been available on a global-coverage basis since December 2018, few differences between L1C and L2A can be observed

and this confirms the Level 2 production is in line with the Level 1 and the publication capacity has reached the same capacity of Level 1 (in terms of geographical coverage) – in fact, differences are mostly focused on the oceans, coastal areas and also near to the south pole, for which the Level 2 seems to have fewer number of published user-level data.

It should be noted that these heatmaps will always be an approximation and cannot represent a precise one-to-one mapping with the published user-level data due to the need to merge the Sentinel-2 data grid onto the heatmap global projection. Some small anomalies are visible; in particular, the red 'dots' across parts of Siberia and Canada in both heatmaps are most likely an artefact caused by plotting the Sentinel-2 data grid onto the map projection. Similarly, the apparent lower publication levels in the heatmap over some small areas of southern Africa, Asia and South America are also likely to be the result of the map projection rather than truly reflecting lower publication levels over these areas.

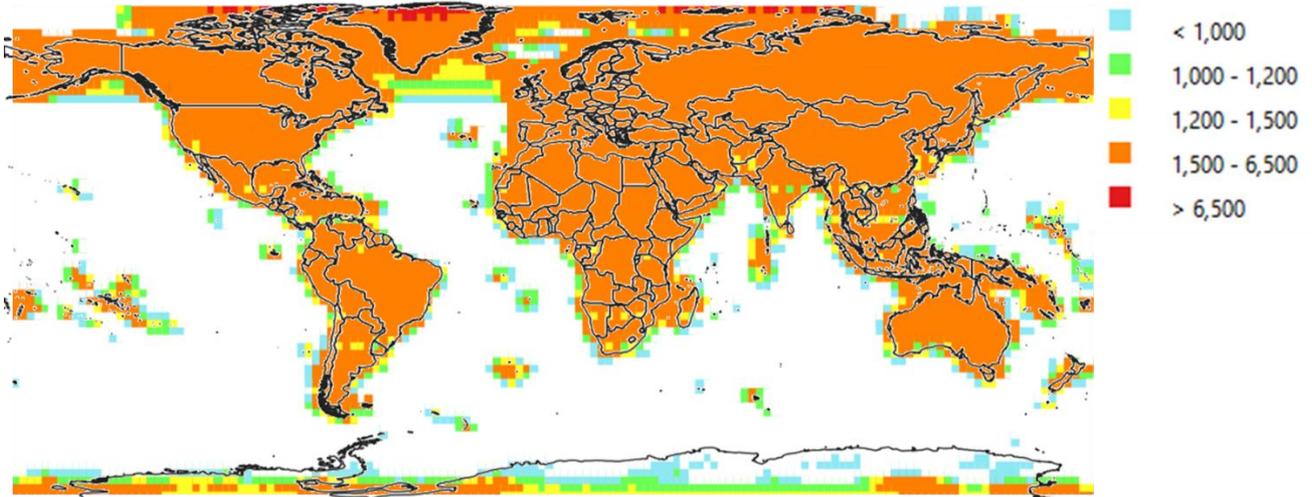


Figure 32: Heatmap of Sentinel-2 Level-1C user-level data published from the start of operations to the end of Y2020

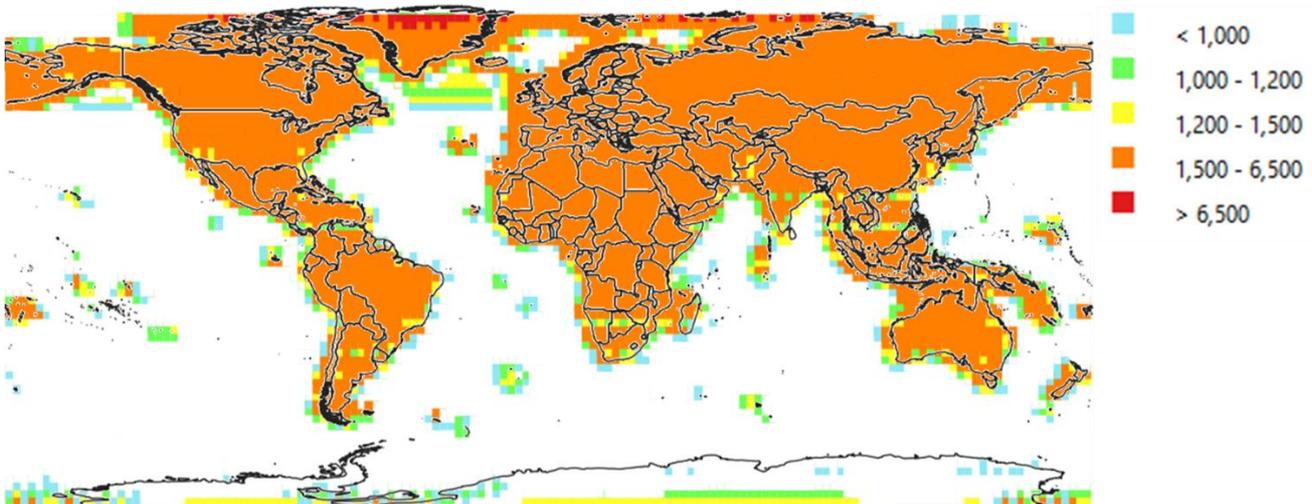


Figure 33: Heatmap of Sentinel-2 Level-2A user-level data published from the start of operations to the end of Y2020

Sentinel-3

The heatmaps below show the geographical coverage of Sentinel-3 Land user-level data, published and available on the Open Hub since the beginning of operations to the end of Y2020. They are separated out by user-level data group. For SRAL user-level data, a separate 'NRT Level-2' heatmap is also provided. SRAL, SRAL-NRT, OLCI, and SLSTR are shown in Figures 34, 35, 36, 37 and 38 respectively.

Care should be taken when reading the keys, which are different for each plot depending on the number of user-level data published for each instrument.

Sentinel-3 user-level data are far more evenly distributed over the globe than for Sentinel-1 and -2. Only SRAL-NRT Level-2 user-level data are focused on land areas. The apparent emphasis on the poles for all user-level data types is a result of the higher revisit frequency over these regions.

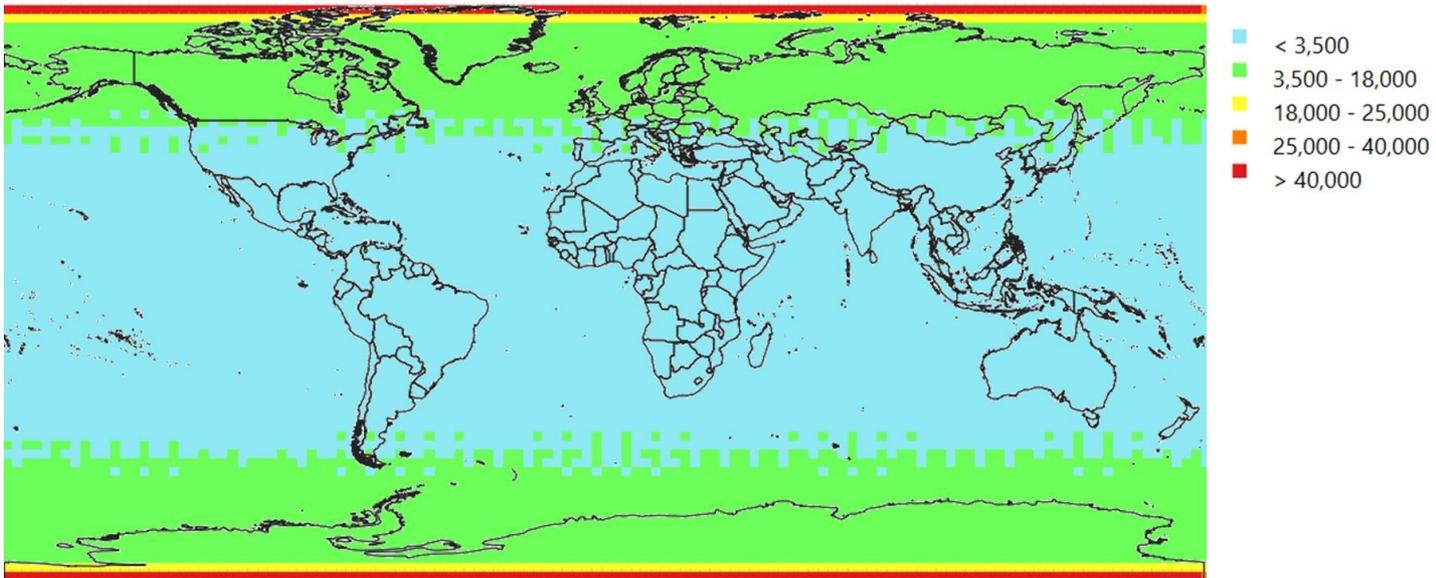


Figure 34: Heatmap of Sentinel-3 SRAL user-level data published since the start of operations to the end of Y2020 (excluding NRT and Level-2)

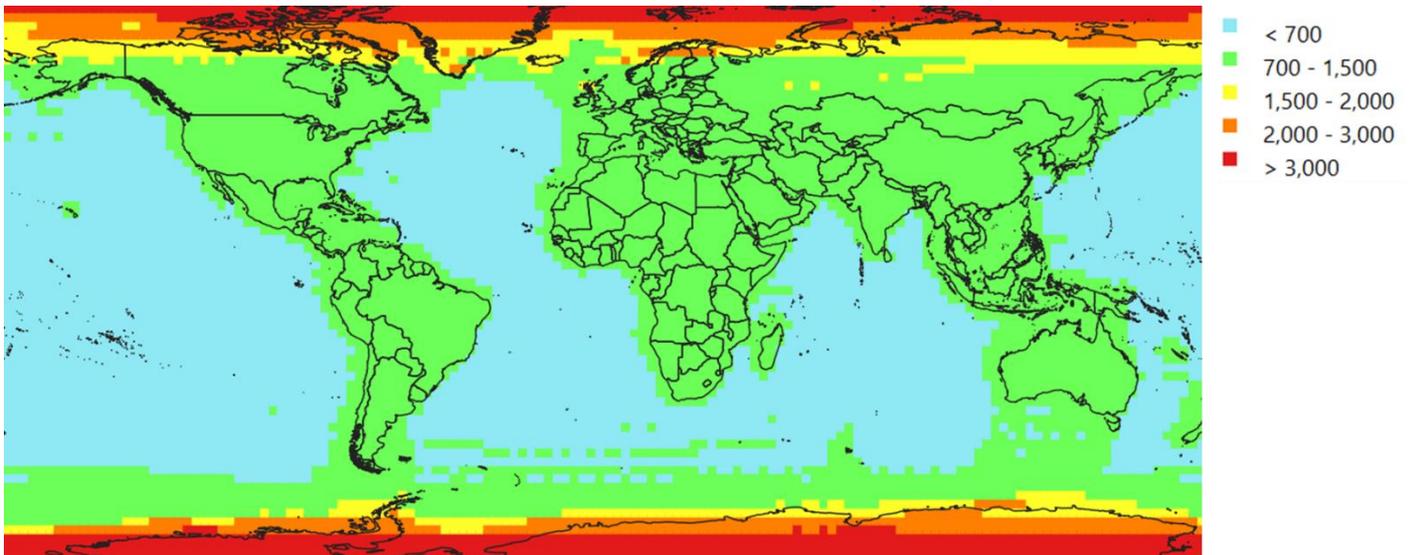


Figure 35: Heatmap of Sentinel-3 SRAL-NRT user-level data published from the start of operations to the end of Y2020

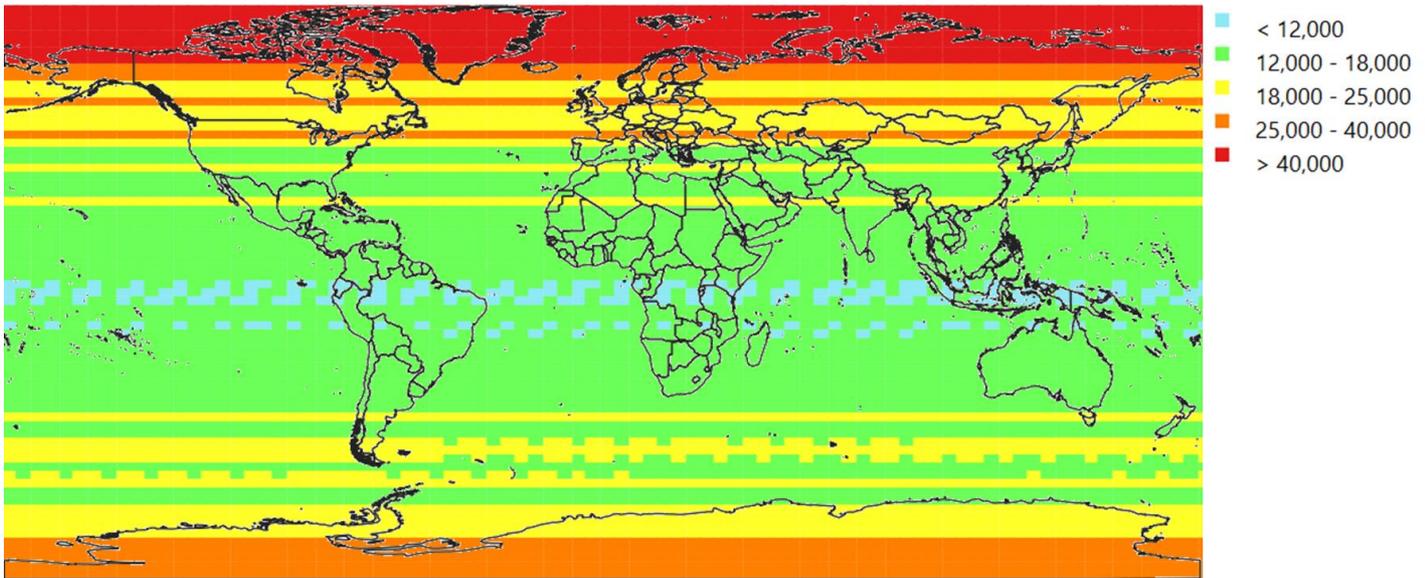


Figure 36: Heatmap of Sentinel-3 OLCI user-level data published from the start of operations to the end of Y2020

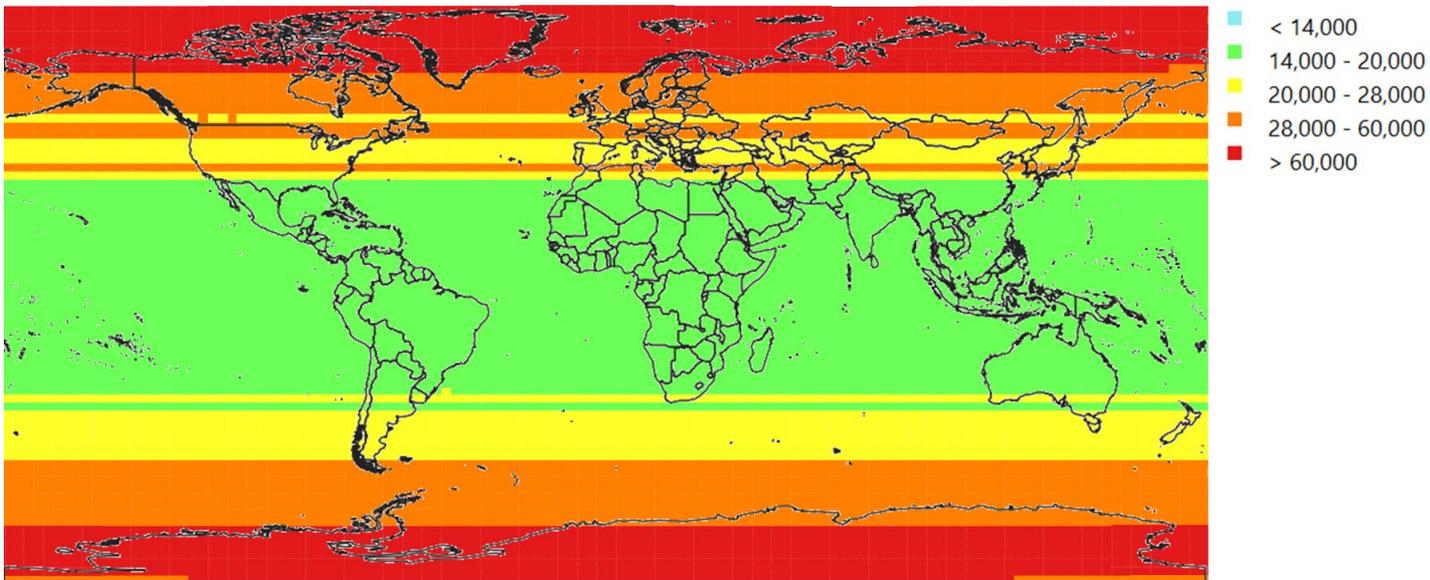


Figure 37: Heatmap of Sentinel-3 SLSTR user-level data published from the start of operations to the end of Y2020

No publication heatmap is provided for the SYNERGY data because the SYNERGY user-level data is composed of many products, including the VGT products which are provided in continental tiles, and this creates a heat map which gives little real idea of the publication density. The heat maps for OLCI and

SLSTR are already provided and depict the actual "acquisition heat". For further details refer to Annex 2 and <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy>

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 user-level data published from the start of operations until the end of Y2020.

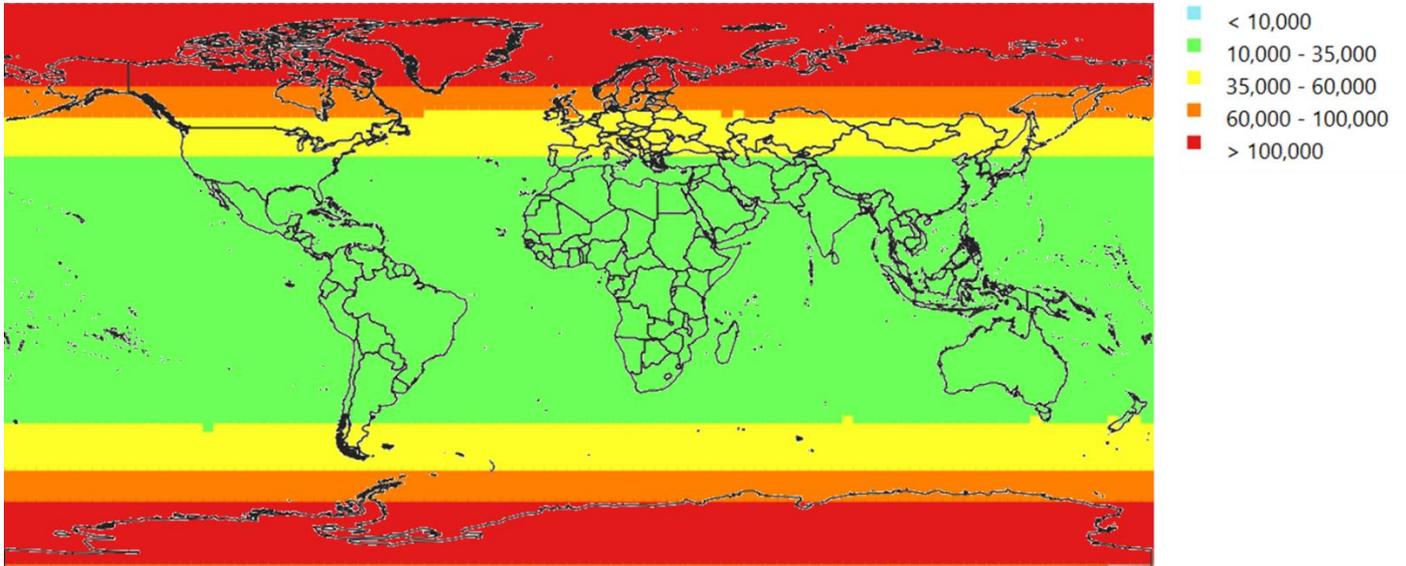


Figure 38: Heatmap of Sentinel-5P user-level data published from the start of operations to the end of Y2019

2.3 Data Downloads

This section looks at user activity in terms of the level of downloads which users made during Y2020 and the types of user-level data which they chose to download.

It is highlighted that 'one download' refers to an uninterrupted download of a complete user-level data. Partial downloads and data component downloads are not included in the overall statistics.

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 user-level data, so the statistics are more predictable and risk masking the download patterns of the other ServHub users

2.3.1 Download growth

By the end of Y2020, a huge 240 PiB of Sentinel data user-level data had been downloaded from the Data Access System since the start of operations. Figure 40 breaks this total down per mission, and compares the total volume of data downloaded by the end of Y2020 with the total volume which had been downloaded by the end of all previous periods, i.e. reporting years 2015-2019. As shown, 82.8 PiB of the total volume of downloads since the start of operations was downloaded during Y2020 alone. This represents about 34% of the total downloaded volume and is an 18% increase on the total volume downloaded during Y2019. The exponential growth in the volume of data downloaded by users during the first 6 years of Sentinel operations is clear: in Y2020, users downloaded 24 times the volume of data which they downloaded in Y2015.

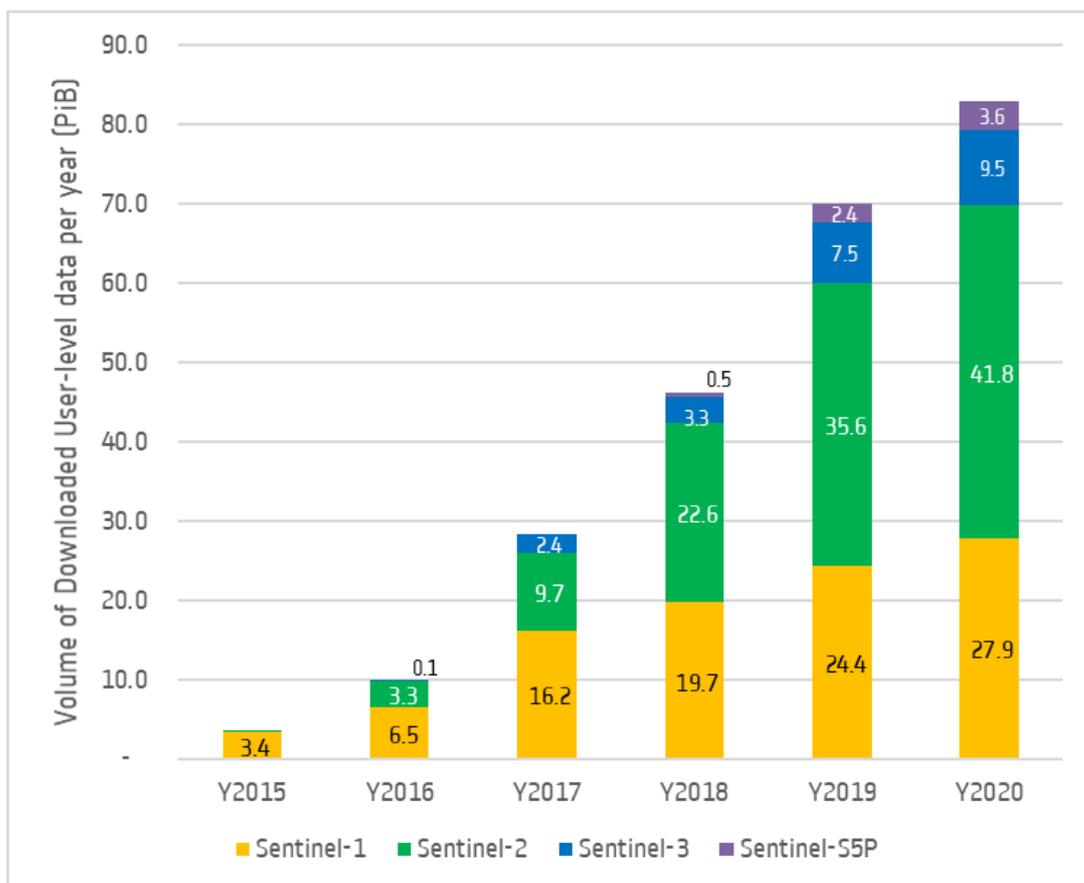


Figure 40: Total volume of user-level data downloaded per year since the start of operations from all of the four hubs, differentiated by mission

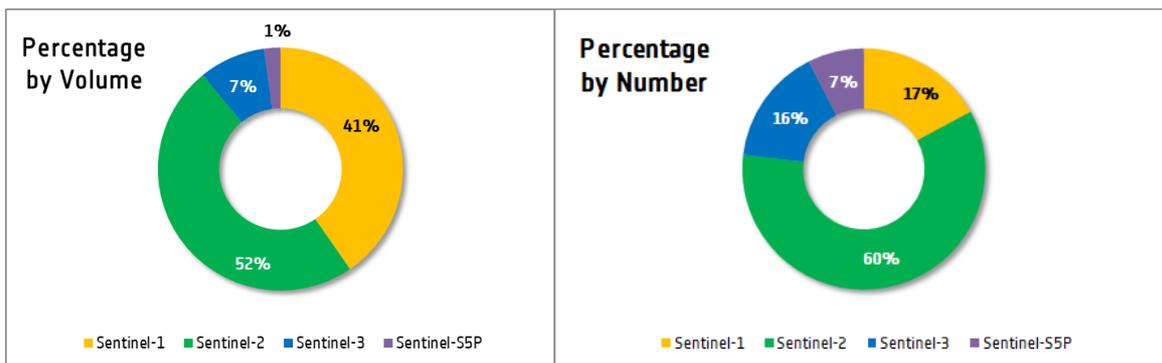


Figure 41: Percentage of total downloads per mission since the start of operations for all of the four hubs, on the left by volume and on the right by number

In terms of the number of user downloads, during Y2020 a total of 151.5 million user downloads were made, an 18% rise on the 128.2 million user-level data downloaded during Y2019. These huge number and volume of successful user downloads demonstrates not only sustained and increasing user enthusiasm for Copernicus Sentinel data but also that the Data Access System has remained capable of serving the ever-increasing number of requests throughout the first phase of Copernicus (2014-2020), despite the complexity of managing the requests and the massive volumes of data involved.

In Y2020, the most notable increases in download volumes were again observed for Sentinel-3 and Sentinel-5P. Sentinel-3 downloads increased by 26%, rising from 7.5 PiB during Y2019 to 9.5 PiB during Y2020, and accounted for 11% of the total volume of user downloads for the year (the same was registered in Y2019). There was an even sharper increase in the volume of Sentinel-5P user-level data downloaded by users, with a total 48% higher than the volume downloaded in Y2019, though still accounting for 4% of the total user downloads made in Y2020.

Increases in download volumes were also seen for both Sentinel-1 and Sentinel-2, and the total share for

the two missions of the overall download volume for the year was 84% (in Y2019 it was 86%). As a proportion of the yearly volume of downloads, Sentinel-2 data continued to be the most downloaded for the year, but in Y2020 accounted for 50% of the volume of all user downloads, down slightly from 51% in Y2019. The proportion of the total volume of downloads which were downloads of Sentinel-1 user-level data also continued to fall, from 35% of the volume of user downloads during Y2019 to 34% during Y2020.

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: 41% and 52% respectively. In terms of the number of user-level data downloaded, however, Sentinel-1 downloads account for much less: only 17%, compared to a massive 60% for Sentinel-2. Due to their smaller average user-level data size, both Sentinel-3 and Sentinel-5P also have a greater impact in terms of number than in volume. While Sentinel-3 only made up 7% of the total downloads since the start of operations by volume, it accounted for 16% by number; Sentinel-5P accounted for only 1% of volume but 7% by number.

2.3.2 Archive Exploitation Ratio (AER)



Figure 42: Archive Exploitation Ratio per mission at the end of Y2020

Interest in Sentinel user-level data can also 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 Y2020 and represents the total number of user downloads made from all the hubs since the start of operations, divided by the total number of user-level data which had been published on the hubs since the start of operations. An AER is expressed as a ratio of published user-level data vs downloaded user-level data: e.g. the ratio 1:X indicates that, for each of the user-level data published from a mission, there was an average number of X downloads.

The AERs reported in Figure 42 show that user interest in Sentinel-1 and Sentinel-2 user-level data was about equal (1:14 and 1:13), a slight increase with respect to Y2018 and Y2019, when it was 1:12 for both missions.

Engagement with Sentinel-3 user-level data also showed a modest growth, rising to 1:9 from 1:8 in Y2019, while the exploitation rate of Sentinel-5P user-level data remains the highest of all of the missions, at a staggering 1:27.

In the following subsections, further details on the AERs are presented for each mission, grouped by instrument, user-level data level, resolution and timeliness, for the period since the start of operations up to the end of Y2020. The timeliness values are NRT (Near Real Time), NTC (Non Time Critical) or STC (Short Time Critical). The heatmaps then break the exploitation ratio down according to geographical area, and this gives an approximate indication of the geographical zones over which users are particularly interested in downloading data.

Sentinel-1

Level	Timeliness	Number of Published user-level data in Y2020	Number of Downloaded user-level data in Y2020	Archive Exploitation Ratio
Level 0	NTC	411,421	3,545,907	1 : 8.6
Level 1	NTC	781,544	16,148,772	1 : 20.7
	NRT	72,090	873,721	1 : 12.1
Level 2	NTC	184,451	3,595,610	1 : 19.5

Table 5: Sentinel-1 User-level data Published, Downloaded and AER for Y2020, per user-level data level and timeliness

Level	Timeliness	Number of Published user-level data since Start of Operations	Number of Downloaded user-level data since Start of Operations	Archive Exploitation Ratio
Level 0	NTC	1,858,065	12,688,731	1 : 6.8
Level 1	NTC	3,667,747	59,949,152	1 : 16.3
	NRT	316,734	2,892,914	1: 9.1
Level 2	NTC	637,275	11,028,407	1 : 17.3

Table 6: Sentinel-1 User-level data Published, Downloaded and AER since the start of operations, per user-level data level and timeliness

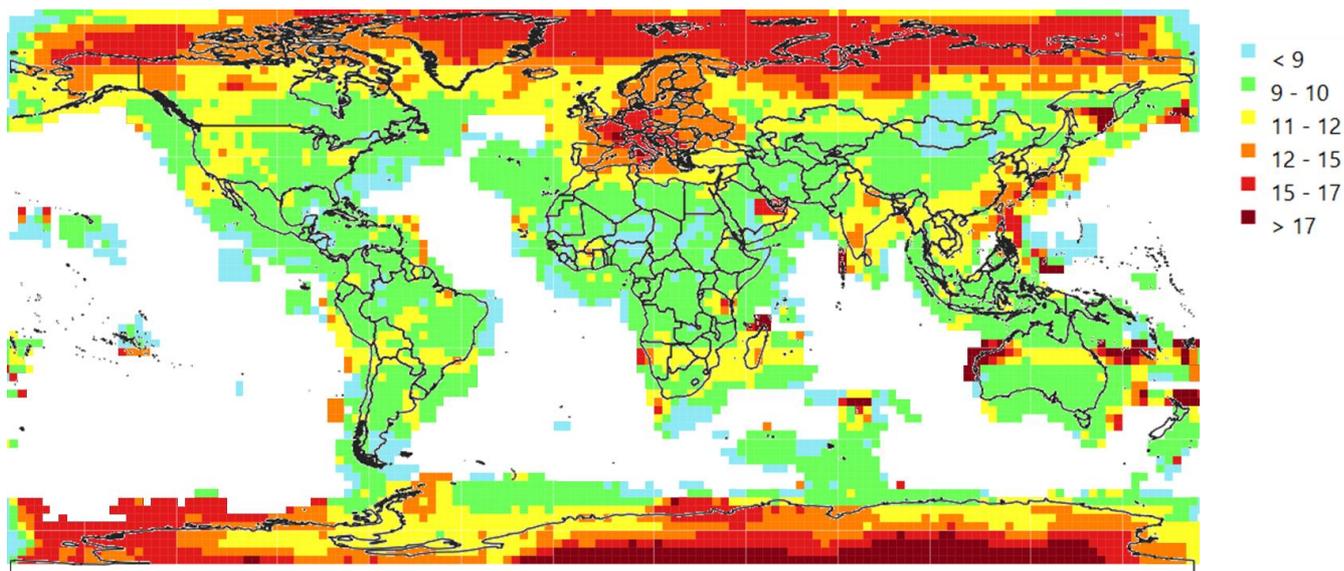


Figure 43: Heatmap showing the archive exploitation ratio for Sentinel-1 Lo and L1 NTC user-level data (excluding WV mode) during Y2020

Overall, the figures in Tables 5 and 6 suggest that user engagement with each of the Sentinel-1 user-level data types has increased since Y2019. The Level 1 and Level 2 NTC user-level data remain the most popular Sentinel-1 data levels/timeliness, with AERs of 1:21 and 1:20 respectively, very similar to the ratios 1:21 and 1:18 calculated for the Level 1 and Level 2 NTC in Y2019.

The AER of Level 1 NRT user-level data increased for the first time since Y2017, rising from 1:8 in Y2017-2019 to 1:12 in Y2020. The Level 0 NTC still have the lowest AER at 1:9, but this has also increased significantly since Y2019, up from 1:6 and similar to the ratio seen in Y2018.

Table 6 reports an overall upward trend observed for the AERs calculated from the start of operations. The AER for Level-0 NTC user-level data has risen the least, from 1:6.3 in Y2019 to 1:6.8 in Y2020. However,

the AERs for each of the other user-level data types rose by one point: for Level-1 NTC the AER rose from 1:15 in Y2019 to 1:16 in Y2020; for Level-2 NTC user-level data from 1:16 to 1:17; and for the Level-1 NRT user-level data from 1:8 to 1:9.

Looking at the figures underlying the AERs, the numbers of user-level data published during Y2020 grew compared with that published in Y2019, for all user-level data types, by a range of 2-5%, with the exception of Level-1 NRT, which dropped by 15%. However, the number of downloads grew for all the user-level data types, by a range of 5-26%, and this led to the higher AERs with the exception of the Level 0 NTC user-level data.

Figure 43 indicates the geographical areas of interest for users of Sentinel-1 Lo and L1 NTC user-level data, measured by AER. It shows how many downloads were made during Y2020 per available data over specific geographical points across the globe, taking

into account all user-level data published since the start of operations. Because of their particular footprint, which is constituted by more than one polygon, Wave mode user-level data (which include all Sentinel-1 Level-2 user-level data) 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 user-level data 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 user-level data 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 1:12 and can go higher than 1:17. There are other AER hotspots across the globe including: the Australian coasts, South East and Far East Asia and South East Africa. 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

Instrument	Number of Published User-level data in Y2020	Number of Downloaded User-level data in Y2020	Archive Exploitation Ratio
Level 1C	4,038,290	77,681,970	1 : 19.2
Level 2A	4,033,749	33,839,452	1 : 8.4

Table 7: Sentinel-2 User-level data Published, Downloaded and AER for Y2020, per user-level data type

Instrument	Number of Published User-level data since the start of Operations	Number of Downloaded User-level data since the start of Operations	Archive Exploitation Ratio
Level 1C	14,808,387	232,863,923	1 : 15.7
Level 2A	8,337,123	66,674,586	1 : 8.0

Table 8: Sentinel-2 User-level data Published, Downloaded and AER since the start of operations, per user-level data type

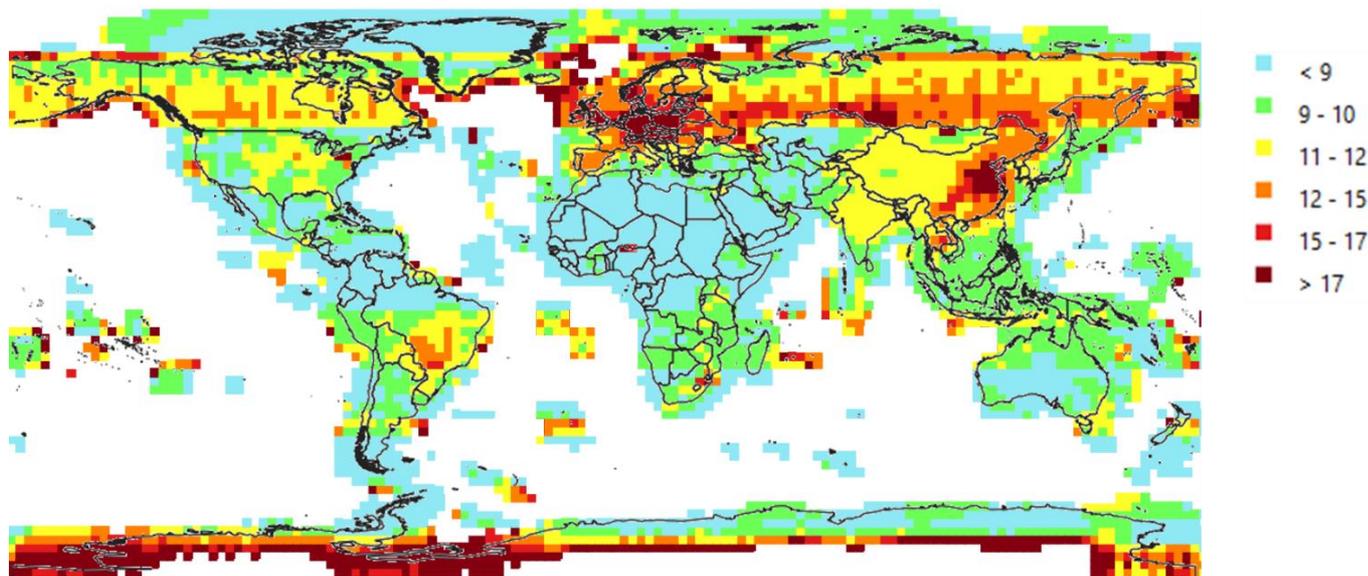


Figure 44: Heatmap showing the archive exploitation ratio for Sentinel-2 L1C user-level data during Y2020

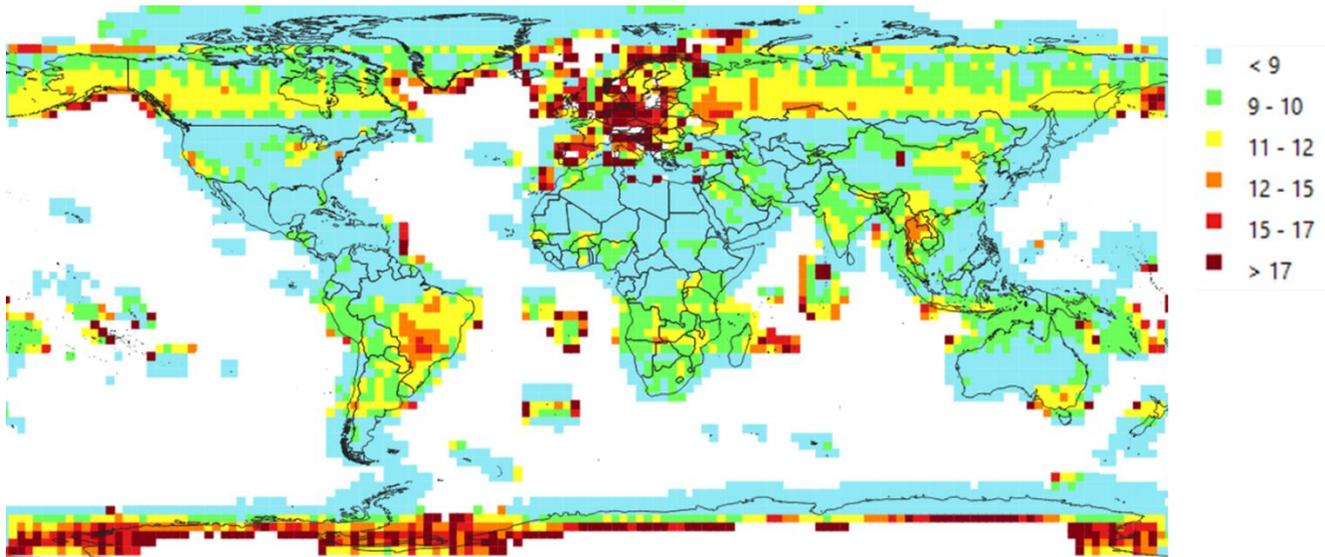


Figure 45: Heatmap showing the archive exploitation ratio for Sentinel-2 L2A user-level data during Y2020

There were also increases in the AERs for Sentinel-2 user-level data with respect to Y2019. The AER for Level-1C user-level data rose from 1:16 in Y2019 to 1:19 in Y2020, while that for Level-2A user-level data rose more modestly from 1:7 to 1:8. In terms of uptake of the two user-level data types since the start of operations, the increases were less visible with the Level-1C overall AER rising from 1:14.4 in Y2019 to 1:15.7 in Y2020; and the Level-2A overall AER rose from 1:7.6 to 1:8.0.

Figures 44 and 45 indicate the geographical areas of interest for users of Sentinel-2 Level-1C and Level-2A user-level data, respectively, measured by AER. They show how many downloads were made during Y2020 per available user-level data over specific geographical points across the globe, taking into account all user-level data published since the start of operations. It is noted that all map cells for Level-1C (Figure 44) which had fewer than 300 user-level data

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 user-level data 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 1:15 for both Level-1C and Level-2A. High levels of interest are also shown over the landmasses of North America, China and Russia with AERs generally in the range of 1:11 – 1:15 for Level-1C and 1:11 – 1:12 for Level-2A. There are some other noticeable non-European ‘hotspots’ where user downloads have been concentrated, such as India and Southeast Asia, central/southern Brazil, southern Africa and Antarctica. 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.

Sentinel-3

Instrument	Number of Published User-level data in Y2020	Number of Downloaded User-level data in Y2020	Archive Exploitation Ratio
OLCI	951,943	11,361,931	1 : 11.9
SLSTR	1,894,974	18,150,776	1 : 9.6
SRAL	365,543	4,237,199	1 : 11.6
SYNERGY	357,708	3,185,081	1 : 8.9

Table 9: Sentinel-3 User-level data Published, Downloaded and AER for Y2020, per user-level data group

Instrument	Number of Published User-level data since the start of Operations	Number of Downloaded User-level data since the start of Operations	Archive Exploitation Ratio
OLCI	2,477,700	24,817,660	1 : 10.0
SLSTR	4,665,894	36,370,015	1 : 7.8
SRAL	1,196,424	12,651,216	1 : 10.6
SYNERGY	707,389	4,692,729	1 : 6.6

Table 10: Sentinel-3 User-level data Published, Downloaded and AER since the start of operations, per user-level data group

Tables 9 and 10 show, for Y2020 and since the start of operations respectively, the AER for Sentinel-3 user-level data, split by user-level data group: SLSTR, SRAL, OLCI and SYNERGY. Of the user-level data groups, the most popular during Y2020, was OLCI with an AER of 1:12 (1:11.9), followed by SRAL with a close value (1:11.6). The increase in the AER for OLCI, from 1:11.5 in Y2019 to 1:11.9 in Y2020, was driven by a rise in downloads: downloads were up 48% in the year, while published numbers were up 43%.

Both OLCI and SRAL user-level data had higher exploitation rates in Y2020 and Y2019 than SLSTR, which had had the highest AER during Y2018. The AER for SLSTR user-level data increased significantly in Y2020, however, from 1:6 in Y2019 to 1:10 in Y2020, with the number of SLSTR user-level data which users downloaded increasing by 62% compared with Y2019.

For SYNERGY user-level data there was also a significant increase in the number of user-level data which were downloaded in Y2020 as compared with Y2019, and the AER increased to 1:9 in Y2020 from 1:4 in Y2019. SYNERGY user-level data only started to be made available from October 2018, meaning that only 13,140 user-level data were published by the end of Y2018. During Y2019, the number of SYNERGY user-level data published rose to 336,541, remaining quite stable in Y2020 with 357,708; but download numbers rose even more steeply, from 1,479,379 to 3,185,081,

leading to the doubling in the AER. This rapid take-up rate suggests the SYNERGY user-level data 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. The AERs of each user-level data-type increased but this time it is the SRAL user-level data which have the highest overall AER, despite only a modest increase from 1:10.1 in Y2019 to 1:10.6 in Y2020. This small apparent increase in the overall AER does of course mask the big increase already noted in the number of SRAL user-level data downloaded since the start of operations, which rose in Y2020 from 830,881 to 12,651,216.

The overall AERs for OLCI and SLSTR user-level data rose by one point each. The AER for OLCI user-level data increased from 1:9 at the end of Y2019 to 1:10 at the end of Y2020, and there was an 84% increase in the total number of OLCI user-level data downloaded since the start of operations by the end of Y2020 compared to the total by the end of Y2019. The overall AER of the SLSTR user-level data rose from 1:7 to 1:8, and the number of downloaded user-level data almost doubled.

The overall AER of the SYNERGY user-level data increased the most significantly of all of the user-level

data types compared with Y2019, rising from 1:4 in Y2019 to 1:7 in Y2020, and the number of downloads rose of 211% from 1,507,648 to 4,692,729.

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

SLSTR					
Level	Timeliness	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio	
Level 1	NTC	1,748,628	16,510,316	1 : 9.4	
	NRT	957,656	10,138,737	1 : 10.6	
Level 2	NTC	1,001,910	4,283,985	1 : 4.3	
	NRT	957,700	5,436,977	1 : 5.7	

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

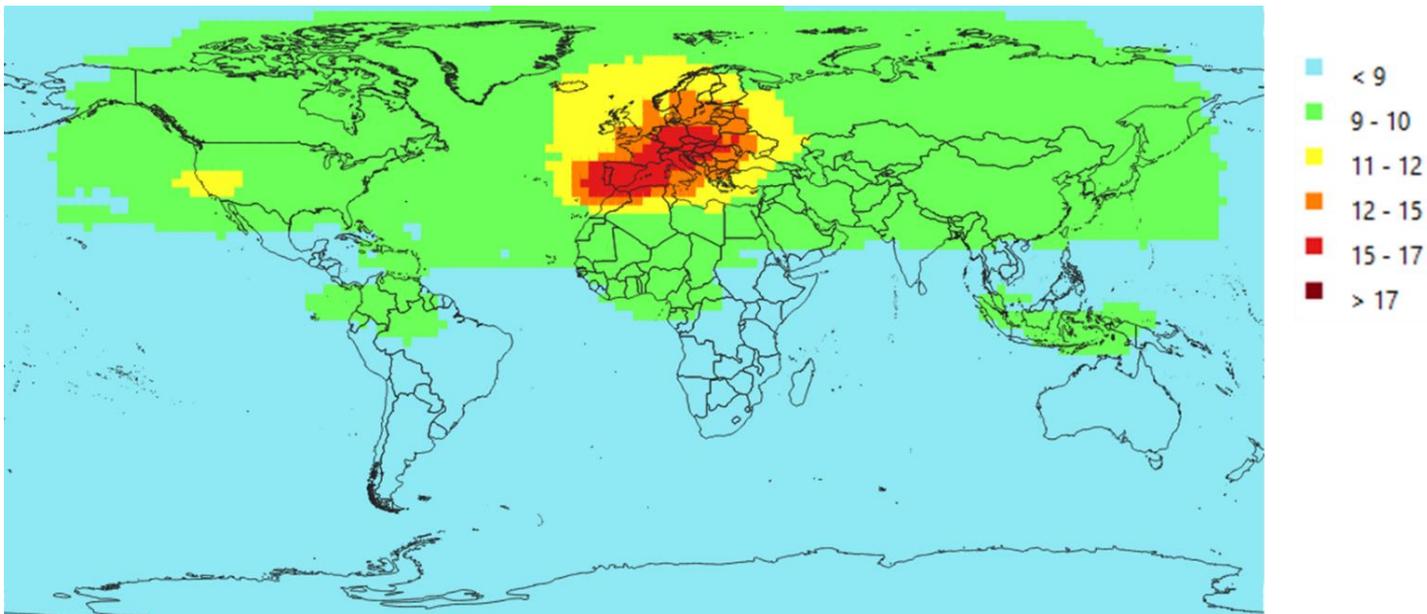


Figure 46: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-1 NTC user-level data during Y2020

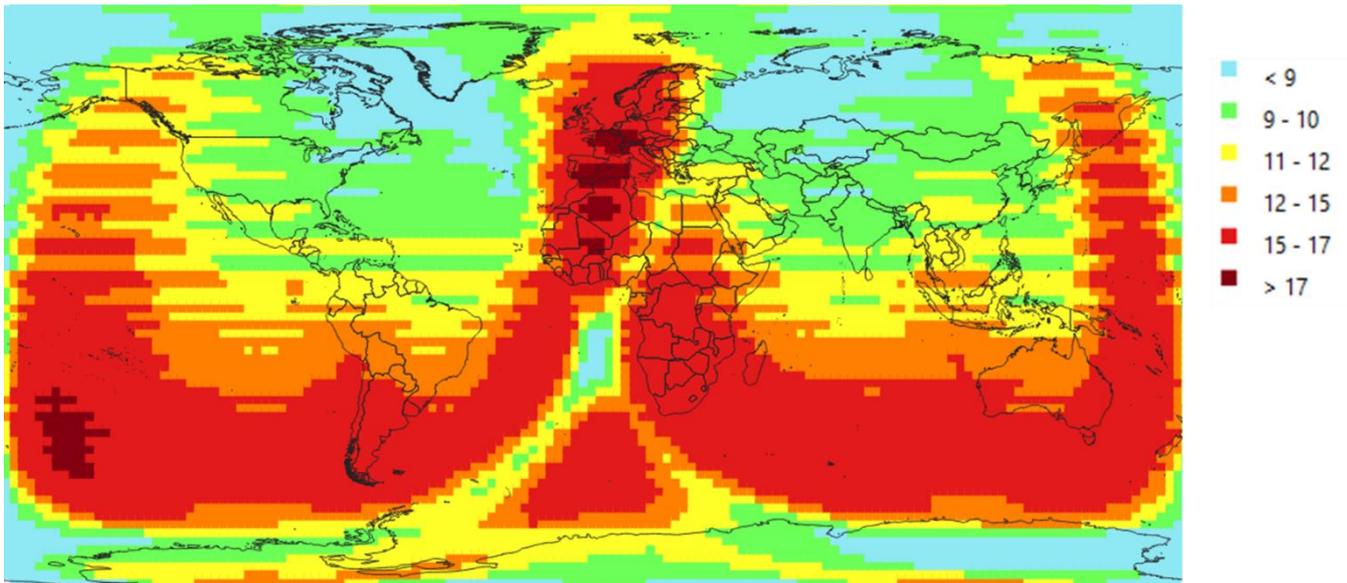


Figure 47: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-2 NTC user-level data during Y2020

Table 11 breaks down the AER for SLSTR user-level data by data level and timeliness (NTC or NRT). The AERs are calculated from the start of operations. From these figures, it seems likely that the overall increased AER of 1:10 for SLSTR user-level data was primarily the result of the increased AER for the SLSTR Level-1 NRT user-level data, which jumped from 1:7 in Y2019 to 1:11 in Y2020. However, there were also big increases in the AERs for the SLSTR Level-1 NTC, which increased from 1:7 in Y2019 to 1:9 in Y2020, and for Level-2 NRT user-level data, which increased from 1:5 in Y2019 to 1:6 in Y2020.

The heatmaps in Figures 46 and 47 show the geographical variation in AER for regions across the globe during Y2020 for SLSTR Level-1 and Level-2 NTC user-level data respectively. SLSTR user-level data have a near-uniform worldwide coverage, though with higher intensity of user-level data 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, where the AER is mostly between 1:9 and 1:10, and particularly over Europe where the AER rises above 1:11. A couple of interesting outlier hotspots also appear in the western regions of the United States, where the AER reached 1:11, the northern part of South-America and Indonesia regions.

Figure 47 shows the equivalent heatmap for Level-2 NTC user-level data, the footprints of which cover the entire globe with each pass. All regions of the globe show an AER of at least 1:9 (with exception of northern Asia and part of Canada and Greenland). However, interest is concentrated in latitudinal spreads centred on European and African longitudes and on longitudes 180 degrees away, covering the north and south eastern Pacific. In these regions the AER at some points rises above 1:15 (the dark red regions on the map).

SRAL					
Level	Timeliness	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio	
Level 1	NTC	252,920	2,015,537	1 : 8.0	
	STC	189,051	1,201,525	1 : 6.4	
	NRT	308,190	3,581,312	1 : 11.6	
Level 2	NTC	112,926	2,578,259	1 : 22.8	
	STC	85,702	663,230	1 : 7.7	
	NRT	247,635	2,611,353	1 : 10.5	

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

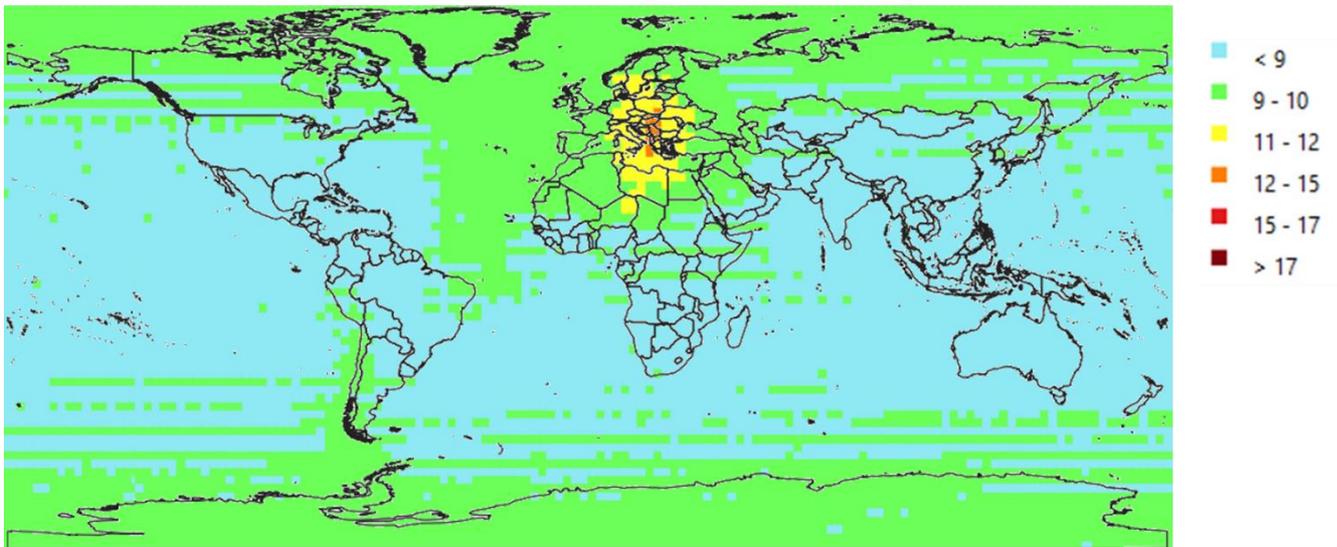


Figure 48: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-1 NRT user-level data during Y2020

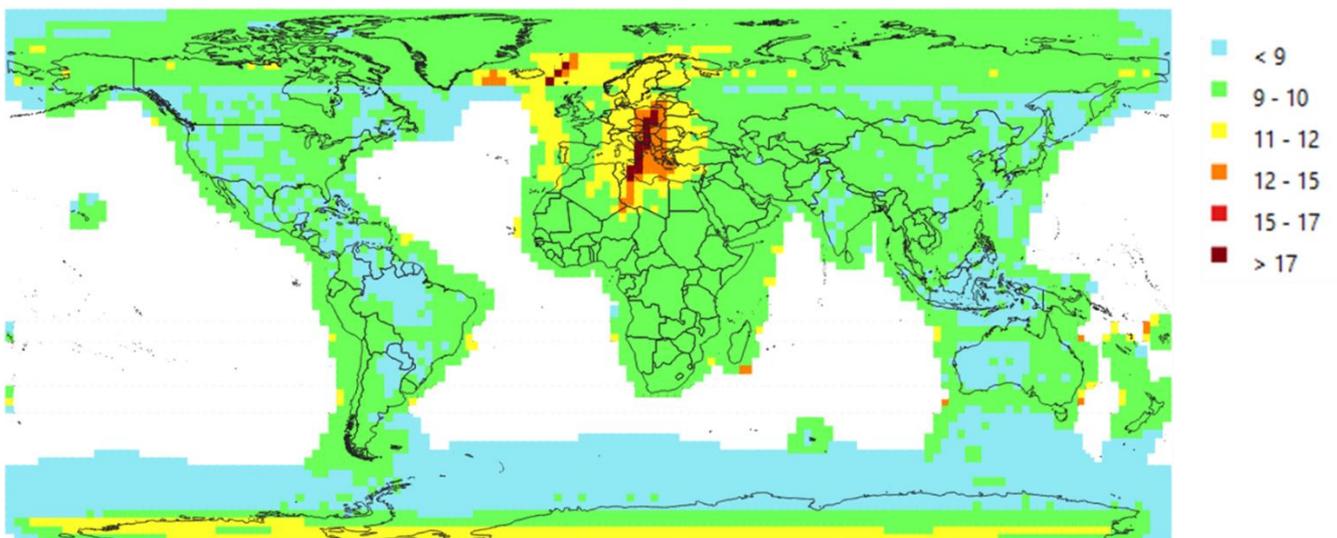


Figure 49: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-2 NRT user-level data during Y2020

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

The table shows that the most popular SRAL user-level data to date are the Level-2 NTC user-level data, which have an elevated AER of 1:23. This AER has increased from 1:18 in Y2019, and it seems fair to surmise that this increase probably drove the rise in the overall SRAL AER from 1:10 to 1:11 by the end of Y2020. In terms of the absolute number of downloads, it was still the Level-1 NRT user-level data which users had downloaded the most by the end of Y2020, and for these user-level data the AER has decreased from 1:13 in Y2019 to 1:12 in Y2020.

The heatmaps in Figures 48 and 49 show the geographical variation in AER for regions across the globe during Y2020 for SRAL Level-1 NRT and Level-2 NRT user-level data respectively. For Level-1 NRT, a high level of activity can be seen over Europe, poles and northern/central regions of the Atlantic, over

which AERs rise above 1:9 and, in some scattered regions, above 1:11. For the rest of the globe, there is interest across the globe, but with AERs at <1:9.

The pattern of geographical interest for the Level-2 NRT user-level data is similar to that for the Level-1 NRT user-level data, although for the Level-2, data downloads are largely restricted to landmasses. As for the Level-1 user-level data, the AER is <1:10 (green areas on the map) for most of the Earth’s land area). Again, however, there is a focussed area of high activity, covering less of the Atlantic and more the European, Mediterranean and North African regions in which the AER rises to up to 1:11, and the real peaks of activity take place around Central Europe, where the AER rises over 1:17.

Table 13 shows a breakdown of the AER for OLCI user-level data, by data 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 Reduced Resolution Level-2 NRT to 1:13 for Reduced Resolution Level-1 NTC. In general, Full Resolution user-level data have been more popular than Reduced Resolution, with overall AERs of 1:10 and 1:9 respectively.

OLCI						
Resolution	Level	Timeliness	Number of Published User-level data since start of Operations	Number of Downloaded User-level data since start of Operations	Archive Exploitation Ratio	
Reduced	Level 1	NTC	37,199	490,059	1 : 13.2	
		NRT	29,956	346,983	1 : 11.6	
	Level 2	NTC	87,556	554,724	1 : 6.3	
		NRT	29,350	228,197	1 : 7.8	
	TOTAL			184,062	1,619,964	1 : 8.8
Full	Level 1	NTC	638,580	7,845,692	1 : 12.3	
		NRT	517,681	5,330,320	1 : 10.3	
	Level 2	NTC	628,905	6,767,926	1 : 10.8	
		NRT	508,472	3,253,757	1 : 6.4	
	TOTAL			2,293,638	23,197,696	1 : 10.11

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

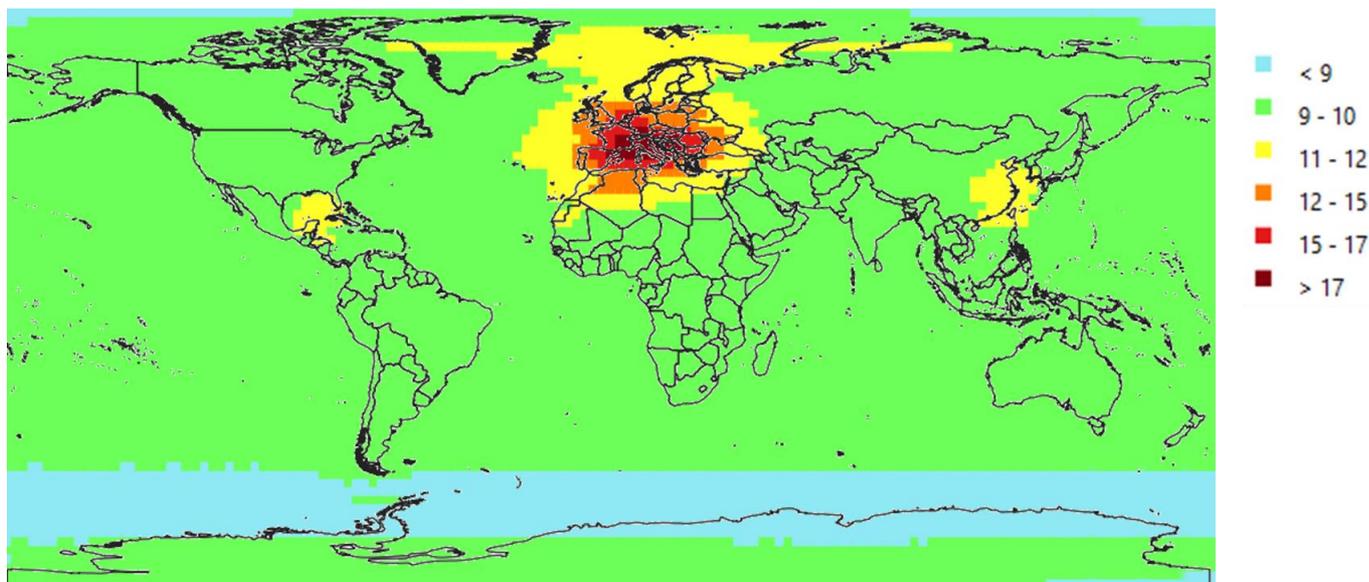


Figure 50: Heatmap showing the archive exploitation ratio for Sentinel-3 OLCI Full Resolution user-level data during Y2020

The Full Resolution ratio has risen since Y2019, by the end of which the figure was 1:9. The most exploited user-level data by the end of Y2020 were the Level 1 NTC user-level data, which had an overall AER of 1:13, 3 points more than the ratio of 1:10 recorded for them at the end of Y2019, and with the number of downloads up by 28%.

The heatmap in Figure 50 shows the geographical variation in AER for regions across the globe during Y2020 for OLCI Full Resolution user-level data. There is interest in OLCI user-level data over the whole globe, with most regions exhibiting AERs of between 1:9 and 1:10 (a rise from the 1:7-1:9 last year). 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 1:12, the highest observed in any region for OLCI Full Resolution user-level data. Other

isolated hotspots, with AERs over 1:11 occur over the United States and South Eastern China.

Table 14 shows a breakdown of the AER for SYNERGY user-level data, by data 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.

As already noted, the overall AER for SYNERGY user-level data rose significantly in Y2020, and this is accounted for mainly by the doubled AER of the Level 2 NTC user-level data, which increased from 1:4 in Y2019 to 1:8 in Y2020, but also by an increase of the Level 2 STC AER from 1:5 by the end of Y2019 to 1:6 by the end of Y2020. To look at this another way, the number of STC user-level data which had been published by the end of Y2020 since the start of Operations increased by 220% with respect to the end of Y2019, and the number of user-level data downloaded increased by 262%.

SYNERGY				
Level	Timeliness	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio
Level 2	NTC	390,848	2,919,133	1 : 7.5
	STC	316,541	1,773,596	1 : 5.6

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

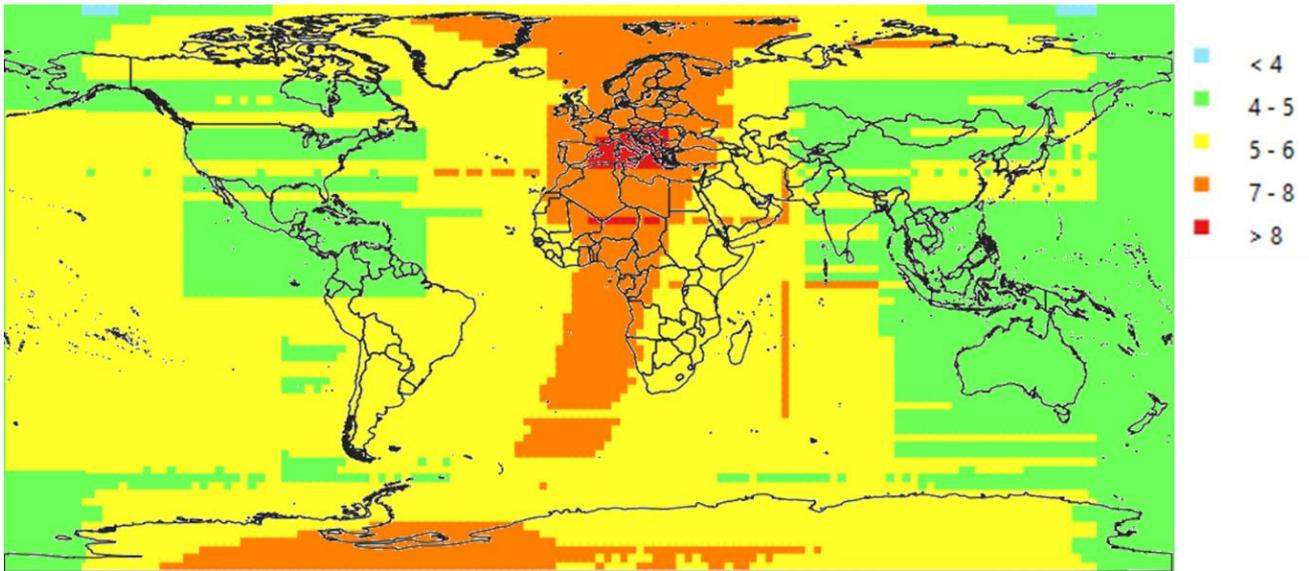


Figure 51: Heatmap showing the archive exploitation ratio for Sentinel-3 SYNERGY user-level data during Y2020

The heatmap in Figure 51 shows the geographical variation in AER for regions across the globe during Y2020 for SYNERGY user-level data. Interest over most of the globe seems to be between 1:4 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 >1:8.

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

Sentinel-5P

Level	Timeliness	Product Type	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio
Level 1B	NTC	[ALL]	109,196	1,585,588	1 : 14.5
Level 2	NRT	L2__AER_AI	155,269	4,077,450	1 : 26.3
		L2__AER_LH	76,903	882,814	1 : 11.5
		L2__CLOUD_	155,145	1,834,151	1 : 11.8
		L2__CO____	130,353	5,638,194	1 : 43.3
		L2__HCHO__	140,018	2,772,225	1 : 19.8
		L2__NO2__	154,768	6,035,231	1 : 39.0
		L2__O3____	155,014	3,542,981	1 : 22.9
		L2__SO2__	140,014	3,498,245	1 : 25.0
		[ALL]	1,107,484	28,281,291	1 : 25.5
		NTC	L2__AER_AI	12,676	464,570
	L2__AER_LH		13,448	231,255	1 : 17.2
	L2__CH4__		13,362	1,372,298	1 : 102.7
	L2__CLOUD_		17,681	372,387	1 : 21.1
	L2__CO____		14,053	1,056,251	1 : 75.2
	L2__HCHO__		14,282	534,644	1 : 37.4
	L2__NO2__		14,826	1,591,708	1 : 107.4
	L2__NP_BD3		14,682	219,830	1 : 15.0
	L2__NP_BD6		13,986	231,399	1 : 16.5
	L2__NP_BD7		13,904	248,184	1 : 17.8
	L2__O3____		17,079	597,662	1 : 35.0
	L2__O3_TCL		960	74,050	1 : 77.1
	L2__SO2__		14,510	580,943	1 : 40.0
	[ALL]		175,449	7,575,181	1 : 43.2
	[ALL NRT + NTC]		1,282,933	35,856,472	1 : 27.9

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

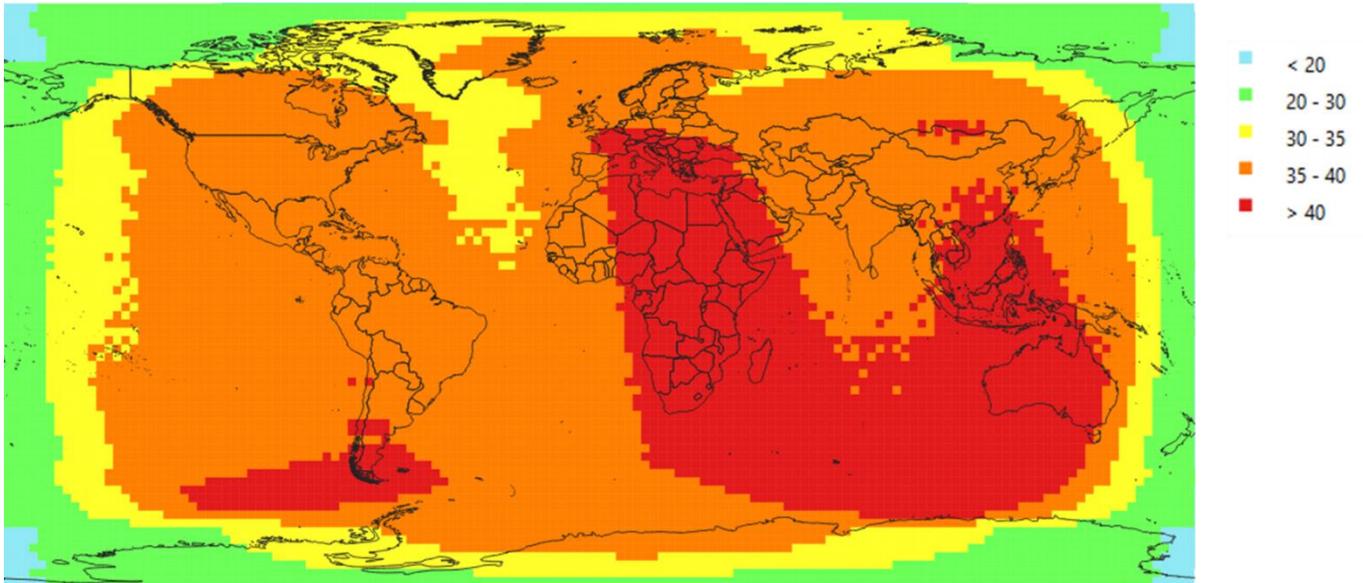


Figure 52: Heatmap showing the archive exploitation ratio for Sentinel-5P NTC (Level-1B & Level-2) user-level data during Y2020

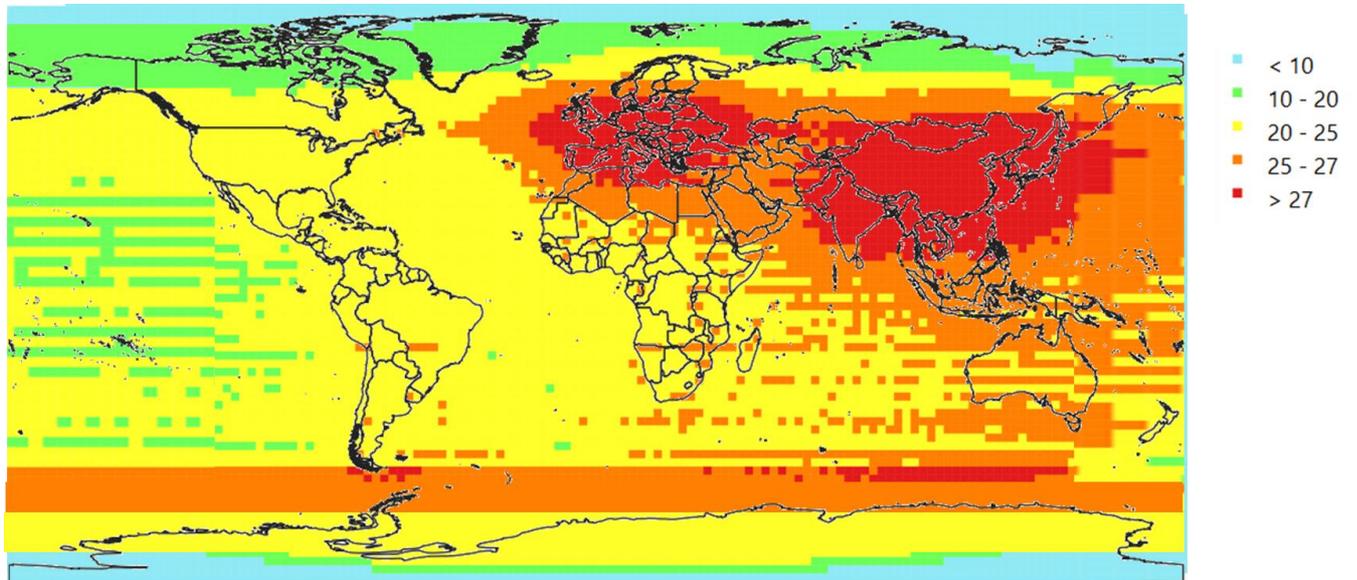


Figure 53: Heatmap showing the archive exploitation ratio for Sentinel-5P NRT (Level-2) user-level data during Y2020

Table 15 reports a detailed view of the take up of Sentinel-5P user-level data since the start of Sentinel-5P operations. AERs are presented for Level-1B and Level-2 user-level data, for both NTC and NRT and, for Level-2 user-level data, also per individual user-level data type.

There was actually a slight decrease in the AER overall and this is because the Level 2 NRT AER decreased from 1:26.5 to 1:25.5. Even though the AER for the Level-1B increased from 1:12 to 1:14 and for the Level-2 NTC there was a massive jump from 1:27 to 1:43, since the number of NRT published is ~11 times that of the NTC, the NRT statistic dominates in the overall

statistic.

The most actively downloaded user-level data for Sentinel-5P to date have been the Level-2 NTC user-level data, with an AER of 1:43, massively up from 1:27 in Y2019. Within this category, by far the most popular user-level data were the Level-2 nitrogen dioxide (L2_NO2) and the methane (L2_CH4) user-level data, which had AERs as high as 1:107 and 1:103 respectively. The carbon monoxide user-level data (L2_CO) was almost as popular with another enormous AER of 1:73. Uptake of the NTC Ozone tropospheric column user-level data L2_O3_TCL, which in Y2019 had had the highest AER of all the

Sentinel-5P user-level data at 1:119, remained high in Y2020, although it fell to 1:77.

As noted above, for the NRT user-level data there was a slight reduction in the overall AER in Y2020, down to 1:25.5 from 1:26.5 in Y2019. From within this group, it was again the carbon monoxide and nitrogen dioxide user-level data which were most actively downloaded, with AERs of 1:43 and 1:39 respectively. Due to the slight drop in AER of the Sentinel-5P NRT, and considering that the number of NRT user-level data (which are slices of the orbit) is generally ~11 times the NTC (which contains the full orbit) this bias in the counting means that overall AER of Sentinel-5P slightly decreased from 1:27.2 in Y2019 to 1:26.9 in Y2020.

However, it is interesting to note that the only AERs for Level-2 NRT user-level data that increased in Y2020 were those of the L2__AER_AI (from 1:17 to 1:26) and L2__NO2__ (from 1:35 to 1:39) user-level

data.

The Level-1B NTC user-level data were overall the least exploited user-level data, with an AER of 1:14, although this has increased from the Y2019 AER of 1:12.

Figures 52 and 53 show the heatmaps for Sentinel-5P NTC (Level-1B and Level-2) and NRT (Level-2A only) user-level data respectively. The footprint of NTC user-level data encompasses 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 user-level data covering Europe, Indonesia/Australia and South America which extend over a large latitudinal range (see Annex 2).

For NRT user-level data, the footprints of which are generally smaller, there is clearly strong interest over Europe, most of Asia and the fringes of Antarctica.

2.3.3 Download trends

Hub	Number of User-level data Downloaded since Start of Operations	%	Volume of User-level data Downloaded since Start of Operations (PiB)	%
Open Access Hub	189,502,191	47	100.37	42
Collaborative Hub	135,513,952	33	92.21	38
Copernicus Services Hub	52,130,227	13	28.03	12
International Hub	28,334,412	7	19.26	8
All hubs	405,480,782		239.86	

Table 16: Number and Volume of user-level data 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, despite the large year on year increases in the volume of data being downloaded from ColHub. At the end of Y2020, 47% of the total number of downloads since the start of operations had been made on the Open Hub, similar to the 46% at the end of Y2019, and 33% from ColHub. The proportion of the total number of downloads which were downloaded from ServHub and IntHub remains unchanged, at 13%, and 7% of the total respectively.

Looking at the proportions by volume a similar split between the missions is seen. However, in this view, ColHub (38%) is now much closer to the Open Hub (42%), and this is likely to be accounted for by a larger number of high volume Sentinel-1 user-level data being downloaded from the ColHub.

Table 17 below shows the average daily volume of downloads handled by each hub during November 2020, as well as the corresponding value for November 2019, and the percentage change between the two years. The average total daily volume of data downloaded by users across all hubs was up to 405.15

TiB in Y2020, up an enormous 89% compared with November Y2019.

Each individual hub experienced an increase in the volume of user downloads during Y2020. There was a 114% increase in the average daily volume of data downloaded both from the Open Hub and from IntHub in November 2020 compared with November Y2019. For ColHub, the average daily volume of data downloaded was up by 70% to 174.79 TiB, which is actually higher than the average daily volume downloaded from the Open Hub and close to half the total daily average volume of user-level data disseminated from all of the hubs. The small decrease (3%) in the average daily download volume from ServHub observed last year between November Y2018 and November Y2019, was this year replaced by an increase of 87% between November Y2020 and November Y2019. This is a particularly interesting statistic, given that the number of active users on ServHub decreased in Y2020 (see Chapter 3 below), so the users which were active this year made significantly more downloads on average than the active users in Y2019.

Hub	Daily average volume (TiB) downloaded in November 2020	Daily average volume (TiB) downloaded in November 2019	% increase
Open Access Hub	142.93	66.93	114%
Collaborative Hub	174.79	102.81	70%
Copernicus Services Hub	55.72	29.73	87%
International Hub	31.71	14.81	114%
All hubs	405.15	214.28	89%

Table 17: Average volume of data disseminated per day during the last month of Y2020 and Y2019

Focusing on total downloads per mission during Y2020, Figure 54 shows the volume of user-level data which users downloaded from each hub and per mission during the year. Although all hubs dealt with increased download volumes during Y2020, the most notable change since Y2019 is the rise in the volume of user-level data downloaded from the OpenHub in Y2020, which increased by 45%. A massive 33.77 PiB was downloaded from the Open Hub, just marginally more than the 33.30 PiB downloaded from ColHub, and the Open Hub resumed its place as the hub which disseminated the greatest volume of data during the year.

This growth was caused by an increase in the volume of data downloaded from each of the Sentinels, but there was a particularly significant increase in the volume of Sentinel-2 data downloaded from the Open Hub in Y2020: 17.73 PiB was downloaded, which represents an increase of 71% with respect to Y2019. Sentinel-2 now constitutes by far the most downloaded mission from the Open Hub, with the volume of Sentinel-1 data downloaded during the year having only risen 23%, from 6.68 PiB in Y2019 to 8.19 PiB in Y2020. Also of note was a large rise in the

volume of Sentinel-5P data downloaded as compared with Y2019, up from 2.42 PiB in Y2019 to 3.58 PiB in Y2020, an increase of 48%. 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.

In comparison to Y2019, 13% more Sentinel-1 data and 45% more Sentinel-3 data was downloaded from ColHub in Y2020. In contrast to the situation on the Open Hub, there was a small decrease in the volume of Sentinel-2 user-level data downloaded from ColHub during the year, from 15.49 PiB in Y2019 to 14.85 PiB in Y2020. For ServHub and IntHub, none of the volumes of Sentinel-1, -2 or -3 data downloaded in Y2020 changed significantly compared to Y2019.

Figures 55, 56, 57 and 58 separate out by Sentinel the total number of user-level data downloaded from each hub, to show the percentage share of the downloads per user-level data type.

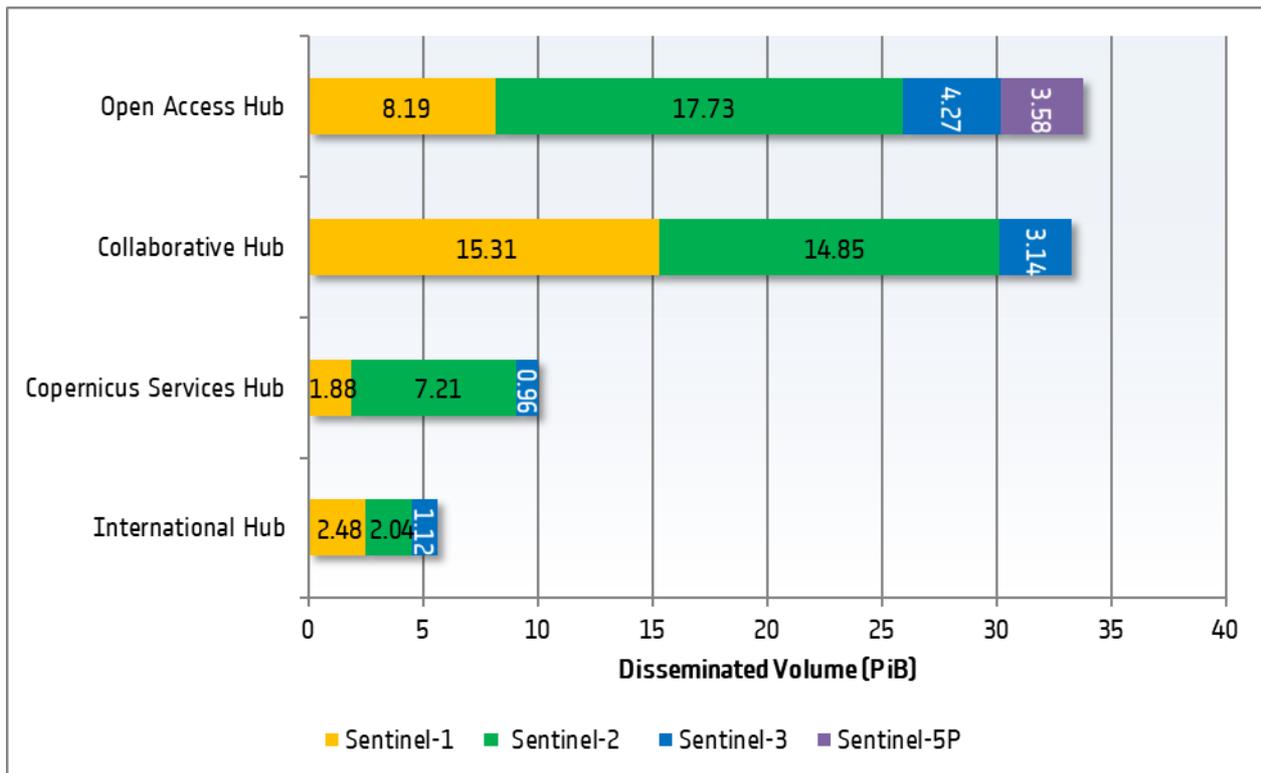


Figure 54: Downloaded volumes (PiB) during Y2020 per Hub and per Mission

Sentinel-1

The most frequently downloaded Sentinel-1 user-level data from all hubs during Y2020 were the Level 1-GRDH user-level data; like in Y2019. At the level of each individual hub, Level 1-GRDH user-level data were also the most frequently downloaded user-level data, making up between 28% (IntHub) and 62% (ServHub) of the number of user-level data downloaded from each hub. This year the Level 1-GRDM user-level data did not exceed 13% of the Sentinel-1 downloads from any of the hubs. By contrast, higher proportions of Level 1-SLC user-level data were downloaded from each hub in Y2020 than had been downloaded in Y2019, with values from 16% to 23% of the total number of Sentinel-1 downloads.

For Lo-RAW user-level data, interest on the Open Hub and ServHub, at 3% and 5% of the total respectively, was much lower than seen on IntHub and ColHub (26% and 17% respectively), suggesting that users of the latter two hubs are more likely to prefer to perform their own processing on raw data than users of the other hubs.

For the Level 2-OCN user-level data, there was negligible change with respect to Y2019. The number

of downloads followed the same pattern as seen in Y2019, with the Level 2-OCN user-level data constituting 15-20% of the Sentinel-1 downloads from each hub except ServHub, on which they constituted only 3%.

Sentinel-2

Y2020 was the second consecutive year of Sentinel-2 Level-2A systematic publication. Interest in the Level-2A user-level data continued on each hub apart from on IntHub, where there was actually a 63% decrease in the number of Level-2A user-level data downloaded from the Hub so that Level-2A user-level data constituted only 9% of the Sentinel-2 user-level data downloaded from IntHub in Y2020. On the Open Hub, Level-2A user-level data were a larger proportion of the Sentinel-2 user-level data downloaded in Y2020 than they had been in Y2019, increasing from 22% of the total in Y2019 to 31% in Y2020. There was a similar increase on ServHub: Level-2A user-level data constituted 39% of the total number of Sentinel-2 downloads in Y2020, whereas in Y2019 they had constituted 33%. The split in downloads from ColHub between Level-1C and Level-2A was equivalent to that in Y2019.

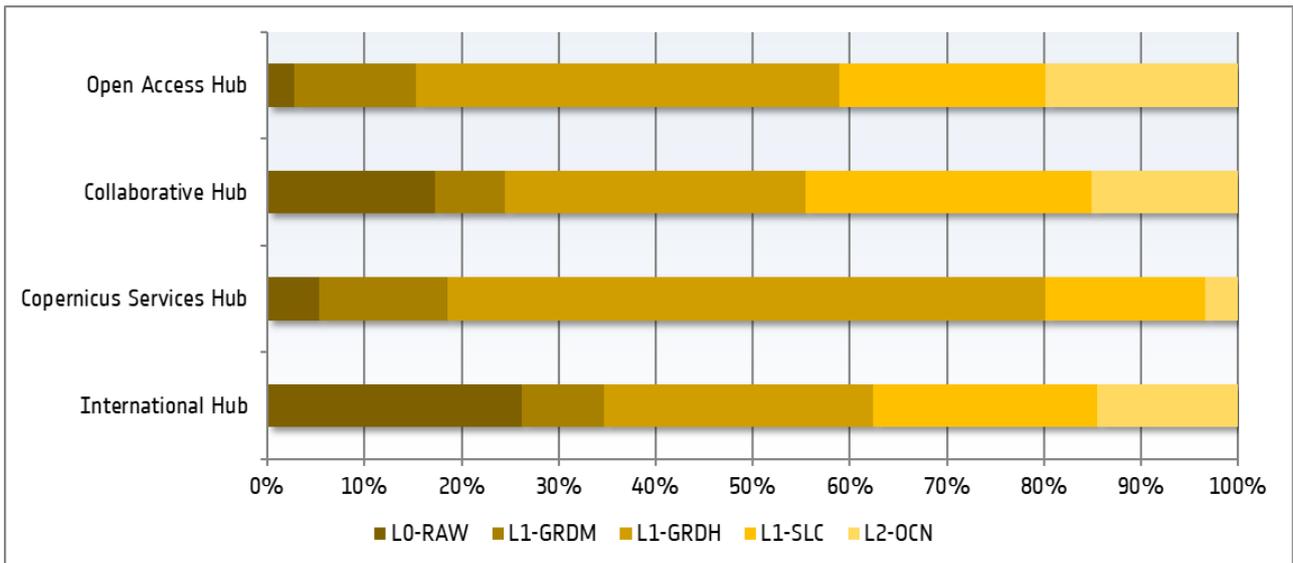


Figure 55: Percentage of total number of Sentinel-1 user-level data downloaded from each hub during Y2020 per user-level data type

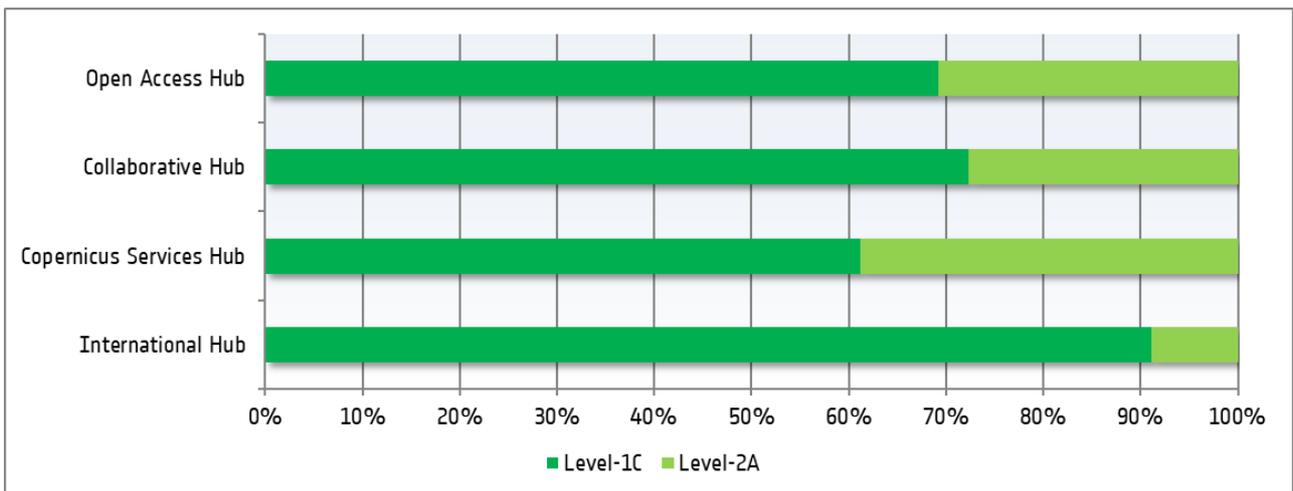


Figure 56: Percentage of total number of Sentinel-2 user-level data downloaded from each hub during Y2020 per user-level data type

Sentinel-3

There are 15 distinct user-level data types for Sentinel-3 (split between SRAL (4x), OLCI (4x), SLSTR (3x) and Synergy (4x)). Figure 57 (the first one) shows the percentage split of the overall volumes downloaded from each of the four hubs per user-level data type. Given that individual user-level data types can be hard to distinguish on this scale, Figure 57 (the second one) shows the same proportions but with the user-level data combined into user-level data groups (each instrument plus SYNERGY user-level data). While during Y2019, neither SLSTR nor SYNERGY

user-level data were available on ColHub or ServHub, in Y2020 the Hubs offered the complete set of user-level data-types. Moreover, if during Y2019 SYNERGY user-level data were not available on IntHub at any point during that period, during Y2020 dissemination of one of its user-level data-types (SY_2_SYN___) was registered on IntHub.

The majority of downloads was accounted for by SLSTR and OLCI user-level data, which together ranged from 89% to 80% of Sentinel-3 downloads from each hub. SLSTR constituted 57% of Sentinel-3 user-level data downloaded from ColHub, and 50% and 46% of Sentinel-3 user-level data downloaded

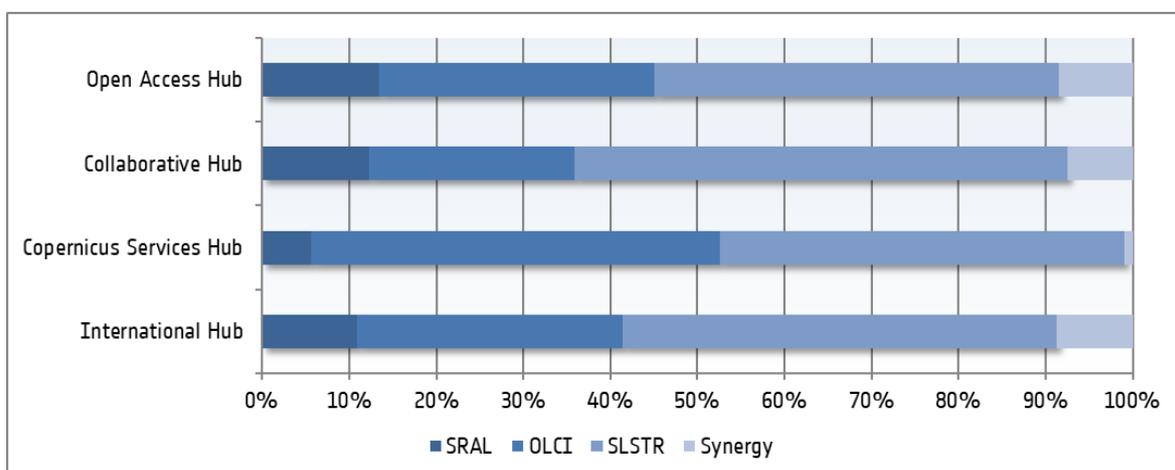
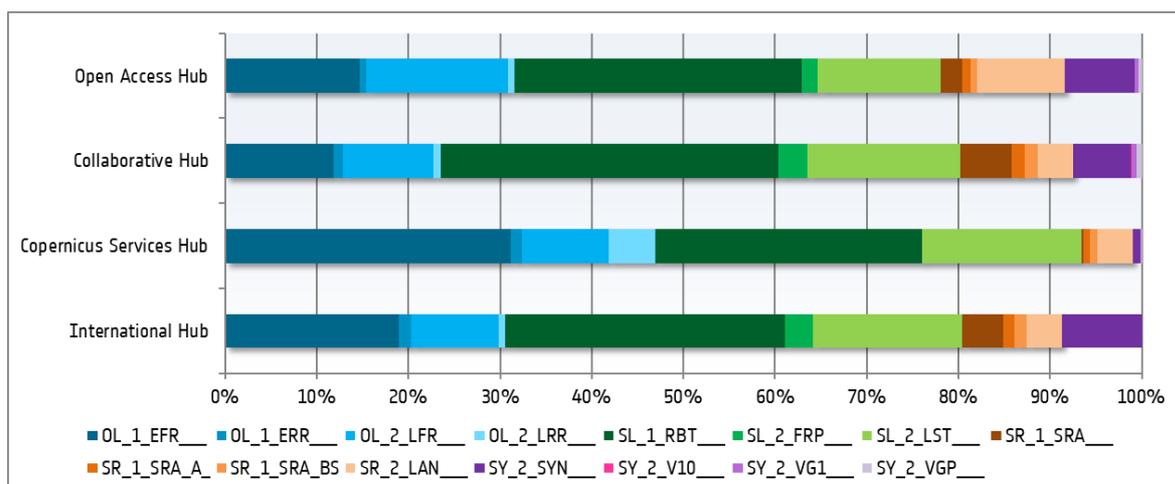


Figure 57: Percentage of total number of Sentinel-3 user-level data downloaded from each hub during Y2020 per user-level data type (graph 1) and user-level data group (graph 2)

from the IntHub and Open Hub respectively. From ServHub, however, it was OLCI user-level data which were the most frequently downloaded, at 47% of the total. SRAL user-level data constituted only a small proportion of the Sentinel-3 downloads from each hub, between 6-13%, and SYNERGY user-level data accounted for 9% or less.

Sentinel-5p

Due to the number of different Sentinel-5p user-level data which are published, the per user-level data download percentage is not shown. However, Figure 58 does show the download split on the S5p PreOps Hub for the two data levels: Level-1B and Level-2. The download split per level was 4% Level-1B (775,622

user-level data) and a massive 96% Level-2 (17,733,611 user-level data)

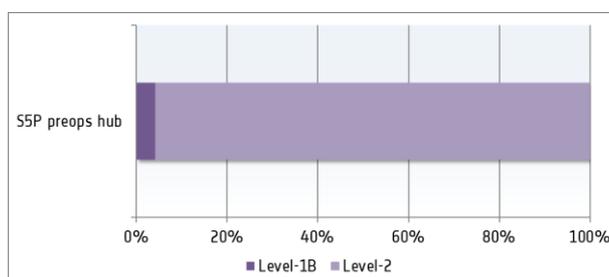


Figure 58: Percentage of total number of Sentinel-5P user-level data downloaded from S5p PreOps Hub during Y2020 per data level

Overall Monthly downloads

The graphs in Figure 59 below show the monthly number (top graph) and volume (bottom graph) of downloads made from each hub during Y2020, with the average monthly volume and number of downloads made on each hub during Y2019 included for comparison. The monthly total for all hubs was above the Y2019 average, for both numbers and volumes of user-level data downloaded, but by a much smaller margin than seen in Y2019 compared to the Y2018 average. The greatest increase with respect to Y2019 was in the number of user-level data downloaded per month: the monthly average number of user-level data downloaded in Y2020 was 12,746,264, while the monthly average in Y2019 was 10,682,153.

In terms of trends, the line was much more flat this year than for any other year since reporting began. The start of the year certainly saw fewer downloads, from both ColHub and the Open Hub, and in December 2019, the average number of downloads for the month from all hubs was lower than the monthly average for Y2019. However, there was a surge in download activity in March 2020, and from then on, the monthly average varied little, so that the

total number of user-level data downloaded in the last three months of Y2020 from the Open Hub was 19% higher than the total downloaded in the first three months. Interestingly, this year there was not even the usual dip in download activity in July and August which has been observed in other years, corresponding to the northern hemisphere holiday period, and download activity was actually around the highest for the year in those months. Overall, apart from the December 2019 dip, the average value on the OpenHub was always 35% above the average value of Y2019.

Although not very visible in the graphs, there were peaks of download activity on ServHub in August and October 2020 (1,819,964 and 1,891,345 respectively). This may have been due to the publication of Sentinel-3 SLSTR Fire Radiative Products on ServHub (19 August 2020) and the start of Sentinel-2 historic data retrieval for ServHub from ONDA DIAS (30 September 2020).

It may be interesting to note that the March peak in download activity took place at the time the COVID-19 pandemic was taking hold across the globe and that several countries were entering lockdown at that time.

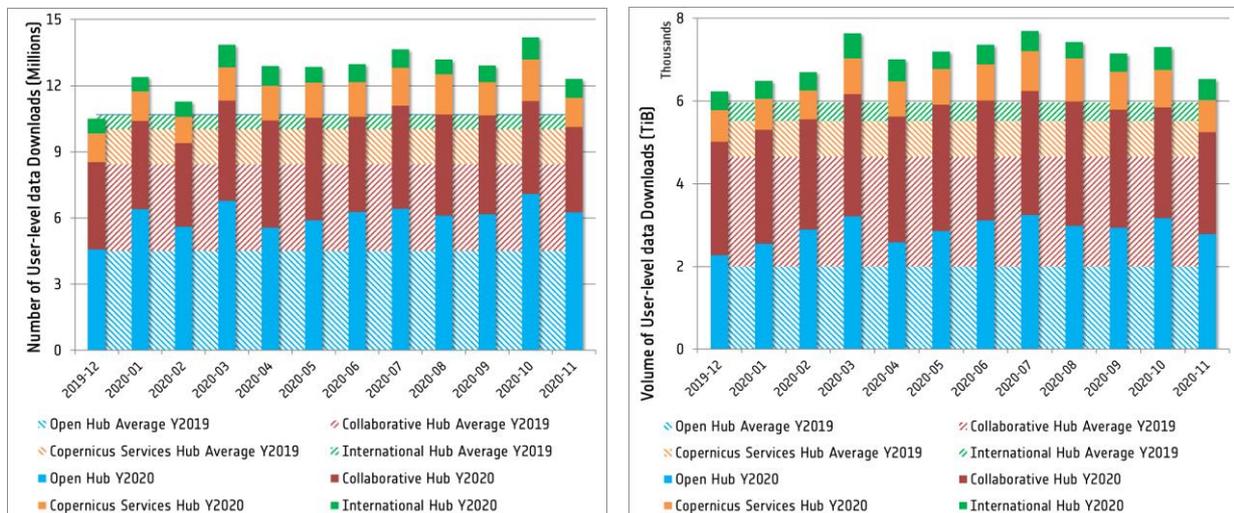


Figure 59: Dissemination number and volume trends per hub during Y2020, with Y2019 averages for comparison

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. The DIAS service providers are necessarily systematic downloaders, who retrieve all or most of the published user-level data, 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 95 million user-level data have been downloaded by the DIAS service providers, comprising a total volume of 60.15 PiB. In terms of the proportion of all downloads on all hubs since the start of operations, DIAS downloads now account for 20% by number and 21% by volume. During Y2020 alone, nearly 35 million user-level data were downloaded, making up a yearly volume of 22.73 PiB.

In terms of average daily download volume, 130.72 TiB were downloaded per day during November 2020. 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 from ColHub.

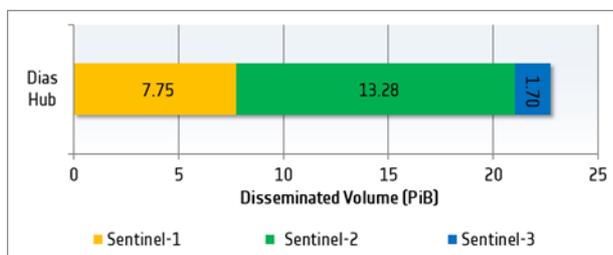


Figure 60: Disseminated volumes (PiB) during Y2020 per Mission on the DIAS Hub

Figure 60 shows the total volume of user-level data downloaded in Y2020 from the DIAS Hub, split by mission. The percentage split between Sentinel-1/Sentinel-2/Sentinel-3 is 35%/58%/7%.

2.3.4 Offline Data Retrievals

Starting with Sentinel-1 at the end of Y2018, and subsequently for Sentinel-2 and Sentinel-3, Long Term Archive (LTA) interfaces were activated to allow the efficient management of the overall data volumes accumulated since the respective mission launches. The LTA interfaces were activated for Sentinel-1 on 12 September 2018, Sentinel-3 on 1 August 2019, Sentinel-2 L1C on 24 September 2019 and Sentinel-2 L2A in March 2020. These interfaces allowed older user-level data to be removed from the online data store (i.e. moved offline), freeing up space for newer online user-level data. Users can request access to these offline user-level data and all data remains available to all users. However, with the offline retrieval there is some amount of unavoidable time delay following the request, while the user-level data 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, user-level data are then available online to download for a limited amount of time (at least 3 days), following which the user-level data are put offline again. A user quota on the maximum number of user-level data retrieval requests per hour is applied.

In this reporting period, responding to the user feedback pointing to limitations in the capacity for retrieval of historic data from the LTA (quota exhaustion), a new interface was transferred to operations for the retrieval of historic data from the DIAS infrastructure. This interface uses the existing capacities for data dissemination available from DIAS and has proven significant at resolving the quota limitations. This new retrieval scenario was transferred to operations for Sentinel-2 in September 2020 and then for Sentinel-1 and Sentinel-3 in November 2020.

Offline interfaces are available for all data hubs except the IntHub.

Offline User-level data per mission

During Y2020, the rolling policy governing the period in which each of the published user-level data remain online has been reduced in favour of the functionality enabling the data retrieval from offline data storages. As shown in Figure 61, by the end of Y2020, a total of 29.91 PiB of user-level data are available offline for retrieval, consisting of 11.94 PiB from Sentinel-1, 15.93 PiB from Sentinel-2 and 2.04 PiB from Sentinel-3. The volume of Sentinel-3 offline user-level data is instead still low compared with the other two missions (due to the nature of this mission which replaces the old user-level data with newer reprocessed user-level data instead of putting them offline).

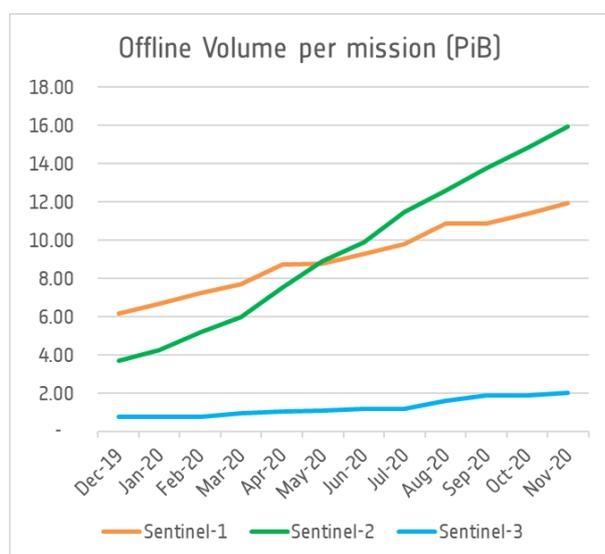


Figure 61: Cumulative growth of Offline user-level data volume (PiB) per mission

Active Users of the Offline Data Retrieval

An active user of the offline data retrieval is defined as a user who submitted at least one request for the retrieval of an offline user-level data. During Y2020, there were a total of 26,528 unique users of the offline data retrieval, composed of 26,451 from the Open Hub and 77 from the other hubs. The table below shows the total number of active users of the offline data retrieval per mission and per hub. Note that the total of these is greater than the total given above, because a single user can request user-level data from more than one Sentinel.

Hub	Sentinel-1	Sentinel-2	Sentinel-3
Open Access Hub	12,402	16,502	1,265
Collaborative Hub	12	12	8
Copernicus Services Hub	40	32	11
DiasHub	6	6	6

Table 18: Total Active Users of Offline Retrieval during Y2020, per mission and per hub

It is interesting to note that as the Open Hub had 71,333 active users in Y2020 (meaning, in this case, a user who downloaded at least one user-level data during the year), 37% of these submitted a request for an offline user-level data.

Figure 62 shows the total number of active users of offline data retrieval per month during Y2020 (from December 2020), for each Sentinel. For Sentinel-1, there was an average of 1,748 active users per month for offline data. This number dropped off in May to September, with particularly low levels seen in July and August, coinciding with the usual summer leave period. Sentinel-2 registered a sharp rise in active users of offline data retrieval in May 2020, when the number of active users went up from 1,000 to 3,000, perhaps caused by the introduction of offline user-level data for Level 2A, and with the rest of the line roughly following the increase in the volume of data moved offline. By contrast, the active users of Sentinel-3 offline data retrieval increased gradually over the year, starting from 54 active users in December 2019 and rising to 240 active users in November 2020.

User-level data Retrieval Requests

During Y2020, the number of requests for offline data retrievals which were submitted and accepted was greater than 52 Million. This total does not include retrieval requests which were made for a user-level data 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. The total number of requests reported in Table 19 is 131 times the total number of retrieval requests made in Y2019.

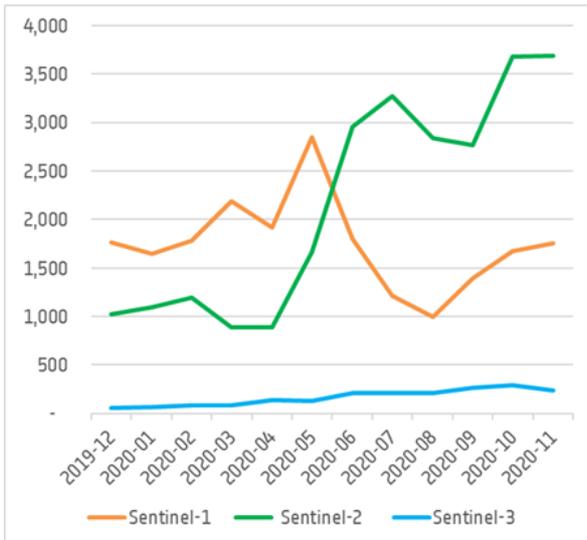


Figure 62: Total Active Users of Offline Retrieval per mission on the Open Hub per month during Y2020

Open Hub and ServHub users made respectively 48% and 38% of the requests, while users of the other hubs account for the remaining 13%. It is interesting to recall that there were only 11-40 active users of the offline user-level data retrieval on ServHub (depending on the mission), so those users must on average have made considerably more requests than the active users of the offline user-level data retrieval on the Open Hub.

In Figure 63, these totals are broken down to show the total number of requests per month and per hub.

From this Figure, it can be seen that the significant offline retrieval activity by the ServHub users took place primarily in just two months: July and, to a lesser extent, March 2020. This could be due to users having difficulty retrieving in those months, i.e. and submitting multiple requests for the same data. The activity of the Open Hub users of the offline retrieval services was more evenly spread throughout the year, starting from 0.5 Million in December 2019 to 5.2 million in October 2020, with the trend line following more closely the volume of user-level data being moved offline. During the period corresponding to the last peak, around 10,000 user-level data were being restored per week, and an analysis has indicated that performances were a bit negatively impacted by the spike, with most user-level data being restored in around 30 hours, degrading the service performance with respect to the declared service performance.

Hub	Numbers of retrieval requests in Y2020	%
Open Access Hub	25,173,829	48
Collaborative Hub	1,084,339	2
Copernicus Services Hub	20,117,231	38
DiasHub	6,025,724	11
TOTAL	52,401,123	

Table 19: Total offline user-level data retrieval requests during Y2020 per hub

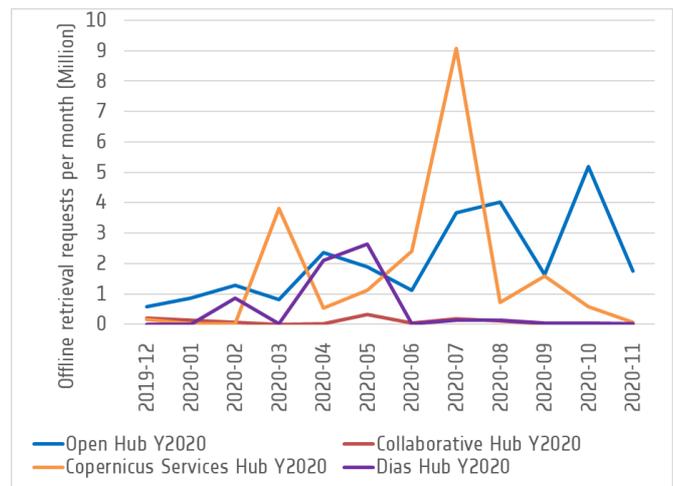


Figure 63: Total offline retrieval requests during Y2020, per month and per hub

As might be expected, small interest in offline user-level data retrieval is visible from ColHub users. It is assumed that these users will have been downloading all of the user-level data they need at the moment they appear online on ColHub, and storing them on their own national data access sites, with no need to access the archived user-level data.

Restored User-level data and Retrieval Performance

Table 20 below shows the number of restored user-level data during Y2020 per mission and per hub. Note that, for reasons resulting from the infrastructure architecture, the ColHub, ServHub and DIASHub publish the same restored user-level data, so they are reported together in the table.

This year, the number of restored user-level data from the three hubs combined was almost equal to the number of restored user-level data from the Open Hub. The majority of restored user-level data were .

Hub	Sentinel-1	Sentinel-2	Sentinel-3	total per hub
Open Access Hub	239,699	437,972	209,464	887,135
ColHub/ServHub/DiasHub	193,203	272,417	351,164	816,784
Total	432,902	710,389	560,628	1,703,919

Table 20: Total offline user-level data restored during Y2020 per hub and per mission

Sentinel-2 user-level data (42%), followed by Sentinel-3 (33%) and Sentinel-1 (25%). Offline retrieval of Sentinel-2 user-level data was particularly high from the Open Hub, whereas for the other hubs, the majority of restored user-level data were Sentinel-3 user-level data. In Y2019, 90% of the user-level data retrieved had been Sentinel-1 user-level data, in line with the opening dates for the LTA user-level data retrieval interfaces.

Overall, it is noted that the total number of requests reported in Table 19 is 31 times the total number of user-level data which were restored in Y2020. This number reduces to 28 times for the Open Hub and 33 times for the other hubs. The difference gives an indication of the number of retrieval which were either not successful or which were requests for user-level data which had already been requested by another user

Retrieval timeliness

During Y2020, the overall average time it took between a retrieval request being made and the user-level data being restored to the hub, across all hubs, was 18 hours and 27 minutes. This is under the 24 hour threshold communicated to users but a significant increase with respect to the average time recorded in Y2019. There were also considerable variations behind this figure. This worsening in the average timeliness was largely due to the massive increase in the number of requests made during the year, which put enormous strain on the LTA retrieval process.

In order to improve retrieval performances, a number of improvements were implemented during Y2020: firstly, the download process was improved to allow

the download of multiple user-level data in parallel from each mission’s LTA. Secondly, a new quota management was introduced on the Data Hub Software (DHuS) for interfacing the LTAs: a User quota allowing a user to submit a maximum number of ‘in progress’ retrieval requests, and a Service quota allows the DHuS to accept a defined maximum number of orders to submit towards the LTAs. These quotas assists in avoiding unintentional loads on the LTAs.

Figure 60 shows the average weekly retrieval timeliness across all hubs during months June-November 2020. As it can be seen from the graph, the July month was characterized by the average time for the retrieval of offline user-level data which overpassed the 24 hours goal. The improvement in overall timeliness in the last two months illustrates the impact of the change outlined in section 1.2.2 in which ONDA DIAS was set as a source of the historical user-level data restore.

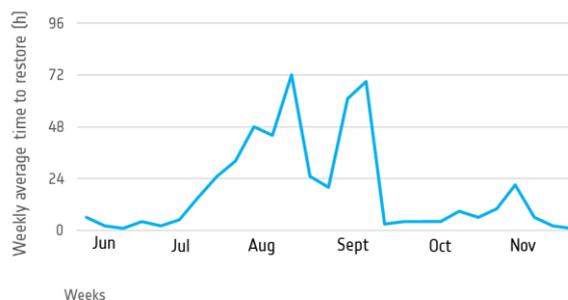


Figure 64: Weekly average time to restore of offline user-level data during Jun-Nov 2020

2.3.5 Downloads per Continent and Country

Another way of examining user-level data dissemination during Y202019 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 Y202019. The overall percentage split is also shown. For the case of Sentinel-5P, all 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 and Y2019, 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 total number 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, having made 43% of the total number of downloads. This is a slightly lower proportion than was recorded in Y2019, when European users made 57% of the total number downloads from the Open Hub. In contrast, the proportions for North America (up to 40% from 31%), Asia (up to 14% from 9%) and Oceania (up to 2.4% from 2.01%) have all risen slightly. When the continents are listed in order of the *volume* 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 in the previous year are still in evidence. While users from Asia make up 26% of the total number of active users on the Hub by the end of Y2020, they only accounted for 14% of the total number of downloads. Similarly, users from South America make up 16% of active users but only 11% of downloads. By contrast, users from North America comprise only 11% of active users but account for 40% 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.

It is also interesting to note the differing intensity of activity on the International Hub between the continents. It is particularly striking that such a high proportion of the user-level data downloaded from IntHub were downloaded in Oceania because there is only one partner connected to IntHub from Oceania, Geoscience Australia (see Section 4.2). It is also exciting to see the new activity from the more recent international partners, in Europe (Serbia and Ukraine), Asia (India) and South America (Chile, Brazil and Colombia). It is not yet possible to characterise the use being made by the partners in each continent from the differing levels of activity, because it is still such early days for the new sites. For instance, although there are now three international accounts in both North America and South America, the data access sites in North America were already operational even before the start of Copernicus, whereas the three South American sites are being specifically built, following the signature of the Copernicus cooperation arrangement with the EU, to house and distribute the Copernicus Sentinel 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 Y202019 would rise to 73% (by number) and 77% (by volume).

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

Continent	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	Overall
Europe	42.9	99.8	100	2.6	66.6
North America	39.7	0.2	N/A	64.3	23.1
Asia	13.6	N/A	N/A	0.8	6.6
Oceania	2.4	N/A	N/A	31.0	3.1
South America	1.0	N/A	N/A	1.2	0.5
Africa	0.4	N/A	N/A	0	0.2

Table 21: Percentage of Y2020 downloads (by number) per Continent and per Hub and overall

Continent	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	Overall
Europe	43.3	99.9	100	2.9	70.2
North America	38.1	0.1	N/A	76.3	20.8
Asia	14.4	N/A	N/A	0.9	5.9
Oceania	2.4	N/A	N/A	18.7	2.2
South America	1.3	N/A	N/A	1.3	0.6
Africa	0.5	N/A	N/A	0	0.2

Table 22: Percentage of Y2020 downloads (by volume) per Continent and per Hub and overall

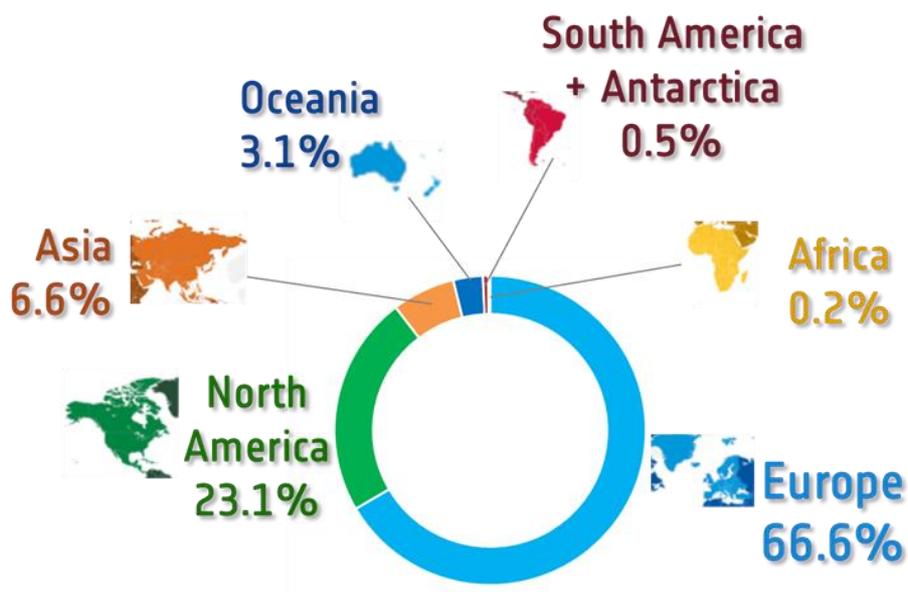


Figure 65: Overall percentage split of Data Access System downloads (all Hubs) by number, per Continent, during Y2020

Continent	% of Sentinel-1 Downloads during Y2020	% of Sentinel-2 Downloads during Y2020	% of Sentinel-3 Downloads during Y2020	% of Y2020 Downloads
Europe	52.9	37.7	35.7	42.9
North America	23.5	42.0	52.1	39.7
Asia	18.8	16.2	8.7	13.6
Oceania	3.4	2.2	2.8	2.4
South America	1.0	1.4	0.2	1.0
Africa	0.6	0.4	0.4	0.4

Table 23: Continental percentage split of Y2020 downloads (by number) on the Open Hub, for each Sentinel mission and overall

Open Hub Focus

Table 23 breaks down the overall per continent figures for the Open Hub in Y2020, 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 IP check). Sentinel-5P is not included as all downloads are still on the PreOps Hub, as mentioned above.

Table 23 shows that this year the sequence of continents is no longer the same for all Sentinels, and there is evidently a growing popularity of Sentinel data, and this year particularly of Sentinel-3 data, around the globe. While European users still downloaded the highest number of Sentinel-1 user-level data in Y2020 by a long margin (53% of total Sentinel-1 downloads), it was the North American users which downloaded the highest number of both Sentinel-2 and Sentinel-3 user-level data. The sharp increase in interest from North American users was particularly striking for Sentinel-3 user-level data. In Y2019, North American users downloaded 25% of the Sentinel-3 user-level data, and European users a massive 70%; in Y2020, the proportion of Sentinel-3 user-level data downloaded by North American users rose to 52%, and the proportion downloaded by European users halved to 36%. Overall, Sentinel-3 downloads by European and North American users together made up a huge 89% of the total number of Sentinel-3 downloads.

It is recalled that there was 26% increase in the volume of Sentinel-3 data downloaded during Y2020,

so in absolute terms, Europe actually downloaded 29% less Sentinel-3 data than in Y2019: more than 5 million Sentinel-3 user-level data were downloaded in Europe during Y2020, whereas in Y2019 the downloads were more than 7 million. So the reason for the increase in Sentinel-3 downloads can be attributed to the increased activity in Asia and Africa, where in absolute terms the number of downloads increased by, respectively, 4 and 10 times the number of downloads made in Y2019 for this mission.

It is also highlighted that the North American proportion includes the mass downloads of Sentinel user-level data which are made by the US corporate cloud service providers, which source their Copernicus Sentinel data directly from the Open Hub.

In Asia, interest in previous years has been clearly tipped towards Sentinel-1 data, but in Y2020 this interest appeared to be levelling out across the missions, with Asian users having made 16% of the total number of Sentinel-2 downloads, up from 11% in Y2019, and the proportion of Sentinel-3 downloads rising from 2% in Y2019 to 9% in Y2020.

Interest from users in Oceania, South America and Africa also appears to have been fairly level across the missions in Y2020, after notable increases in the interest in Sentinel-1 user-level data in Oceania and South America (up from 1.8% to 3.4%, and from 0.4% to 1.0% of Sentinel-1 downloads in Y2019 respectively), and in Sentinel-3 user-level data in Africa (up from 0% to 0.4% of the total Sentinel-3 downloads in Y2019).

Sentinel-1			Sentinel-2		Sentinel-3	
	Country	Y2020 Number of User-level data downloads	Country	Y2020 Number of User-level data downloads	Country	Y2020 Number of User-level data downloads
1	France	1,327,654	Germany	4,712,212	Germany	1,652,180
2	Germany	511,537	France	3,896,197	Poland	534,946
3	UnitedKingdom	477,006	UnitedKingdom	574,075	Norway	529,372
4	Norway	234,976	Norway	539,102	Italy	491,264
5	Italy	162,240	Italy	397,530	UnitedKingdom	407,967
6	Sweden	106,109	Poland	366,322	France	374,779
7	Denmark	104,310	Spain	362,081	Denmark	321,717
8	Poland	63,258	Ukraine	228,781	Portugal	258,302
9	Portugal	60,504	Belgium	199,176	Spain	222,585
10	Switzerland	54,826	Slovenia	156,932	Belgium	132,044

Table 24: Top 10 ESA/EU states by number of downloads in Y2020 on the Open Hub, for each Sentinel mission

Focussing specifically on user activity in Europe, Table 24 above presents a breakdown of the ten ESA/EU member states with the highest number of downloads for each of the three Sentinels during Y2020. The lists are dominated by the following five nations, which appear in the top 10 downloaders for all missions: France, Germany, Italy, Norway and the United Kingdom. The top downloaders overall are German users, who downloaded the highest number of both Sentinel-2 and Sentinel-3 user-level data and the second highest number of Sentinel-1 user-level data. Next are the French users, who downloaded the highest number of Sentinel-1 and the second highest number of Sentinel-2 user-level data. The United Kingdom downloaded the third highest number of both Sentinel-1 and Sentinel-2 user-level data and the fifth highest number of Sentinel-3 user-level data.

The increase in activity by the Norwegian users was the most notable during the year, however. In Y2019, Norwegian users had been eighth in the list for Sentinel-1, having downloaded 78,615 user-level data (299% less than in Y2020); sixth in the list of Sentinel-

3 downloaders, with 77,186 Sentinel-3 downloads (686% less than in Y2020); and had not featured at all in the list for Sentinel-2 downloads. In Y2020, by contrast, Norwegian users were the third or fourth highest downloaders for each of the missions. It is also interesting to note that Italian users downloaded far fewer Sentinel-3 user-level data in Y2020 than they had in Y2019, having downloaded 4,983,730 Sentinel-3 user-level data in Y2019 and only 491,264 during Y2020, a decrease of 90%. Nonetheless, Sentinel-3 was still the most downloaded mission by Italian users, as it had been in Y2019. This year, Danish, Polish and Portuguese users also downloaded more Sentinel-3 user-level data than user-level data from any other mission.

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

2.3.6 Fresh vs Old User-level data

Download statistics can be further examined by looking at the age of the user-level data 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. Even though a rolling policy is now applied to each of the hubs, after a user-level data is removed from online access, it can still be retrieved on all hubs except the IntHub. However, a time lag can be expected as the user-level data is retrieved from an external source.

The graphs in Figure 66 below show, for each Sentinel mission and per Hub, the percentage of downloads during Y2020 for user-level data within six age ranges (measured from the user-level data publication date). These are:

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

The first observation to be made is that – as in previous years – there is a clear preference for newer user-level data over old and overall this preference was more pronounced this year than in Y2019. This is to be expected for several reasons: many user applications are likely to have a preference for the most recent data; most large scale downloaders are already likely to have the older data they are interested in, with downloads focusing on the latest available data; and, as the operations mature, not only is the infrastructure supporting the downloads increasingly fine-tuned but users are also getting more experienced at optimising the download processes on their side.

- 0 – 2 days

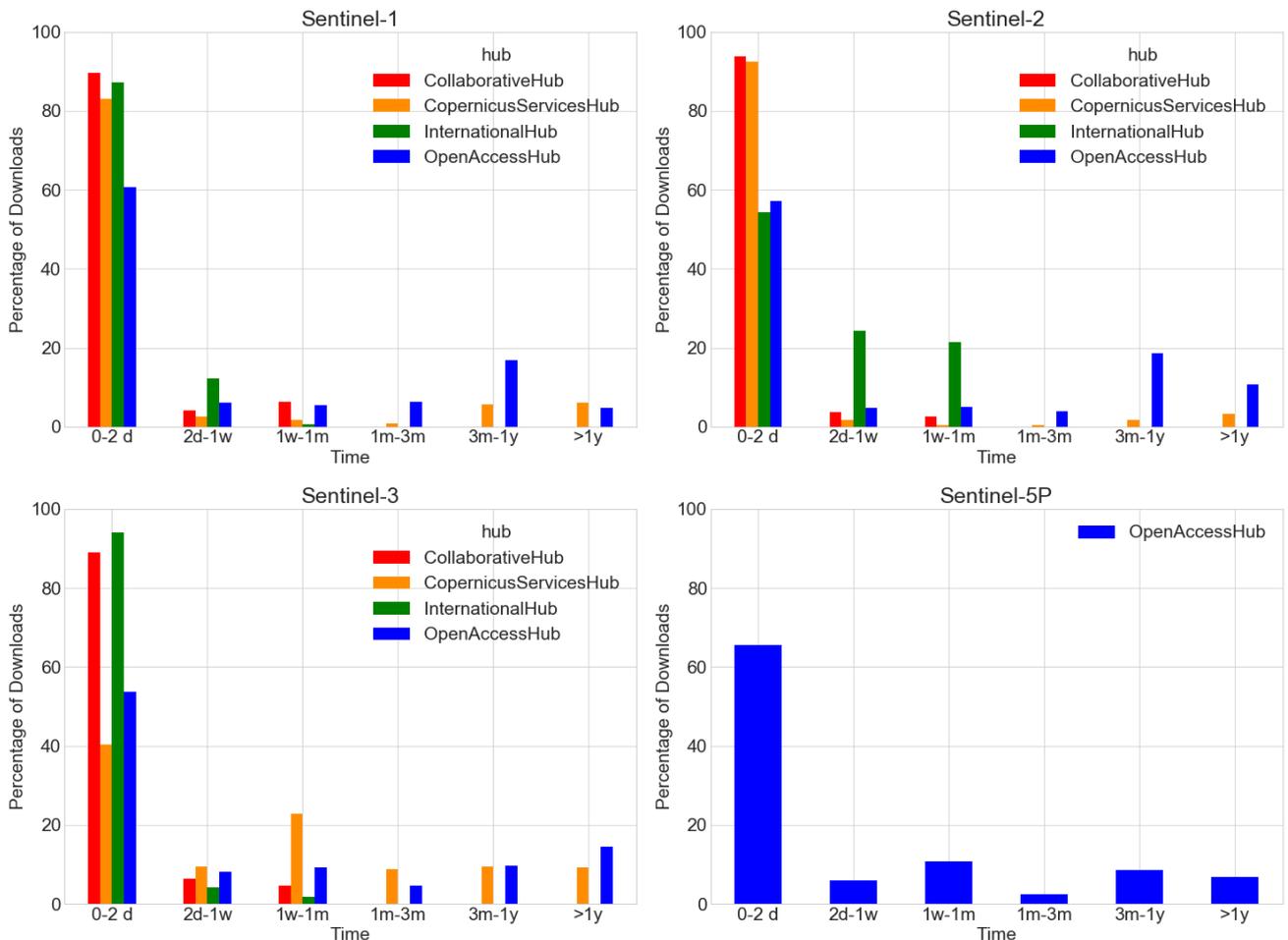


Figure 66: Percentage of Y2020 downloads per user-level data age range each Sentinel mission and per Hub

However, it is interesting to note that this preference is distinctly more marked on ColHub, from which around 90% of the data downloaded in Y2020 was from the time range 0-2 days, irrespective of the mission. Users of ServHub mostly showed the same marked preference, but there was a notable difference for Sentinel-3 data, for which only 40% of the data ServHub users downloaded was from the 0-2 day range. As much as 24% of the Sentinel-3 data downloaded from ServHub was from the time range 1week - 1month. This may be accounted for by the fact that many of the scientific applications for Sentinel-3 user-level data (e.g. atmospheric and climate-related) are likely to require data from the largest historical range available. This is a similar pattern to that seen for Sentinel-3 data downloads from ServHub in Y2019, although in Y2019 the spike for older user-level data was in the 3month - 1year range, from which 29% of the user-level data were downloaded.

A slightly different bias is seen from the IntHub users, for whom the freshness of the Sentinel-2 data appears to have been less critical. Approximately 90% of the Sentinel-1 and Sentinel-3 data which IntHub users downloaded was from the 0-2 day range (slightly down from 98% in Y2019), but for Sentinel-2 this dropped to 54% of downloads, with the remainder of the data downloaded falling in either the 2day-1week or 1week – 1month time ranges. This is also a very similar pattern to that which was seen for Sentinel-2 downloads from IntHub in Y2019, in which only 56% of Sentinel-2 data downloaded was from the 0-2 day range and the rest was evenly split between the 2days – 1week and the 1week – 1month ranges.

On both the ColHub and the IntHub, no downloads were made of data older than 1 month. For the IntHub, this was inevitable given that the rolling policy removes all user-level data from the Hub after 3 weeks, and the operational LTA interfaces had not been established for the IntHub during Y2020. On ColHub, the rolling policies vary according to the type of user-level data but no data remains online for longer than one month.

On the Open Hub, the preference for newer data is still clear though less pronounced. Downloads for user-level data in the 0-2 days category accounted for 61% for Sentinel-1, 57% for Sentinel-2, 54% for Sentinel-3,

and as much as 66% for Sentinel-5P. For Sentinels -1 and -2, the next most downloaded range was user-level data between 3months - 1year, constituting around 18% of downloads from each mission. For Open Hub users of Sentinel-3 user-level data, the second highest portion of downloads (16%) was actually of data older than 1 year. For Sentinel-5P users, the remaining 34% of the data they downloaded was fairly evenly split between all time ranges older than 2 days, with a small weighting in favour of data between 1week – 1month old.

The greater uptake of older user-level data on the Open Hub compared with the other hubs is possibly due to the open registration policy and the continuing 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. It should also be noted that Sentinel-1/-2/-3 user-level data are available for 1 year online under the rolling policy.

For Sentinel-5P, 66% of downloads from the PreOps Hub were in the 0-2 days range; 5.84% fell within 2 days – 1 month; and 11% fell in the 1 week – 1 month range. There is then a small rise (9%) in downloads for user-level data older than 3 months.

2.3.7 Dedicated Access Points

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 Y2020 a total of 23.9 TiB of data was downloaded by CAMS corresponding to the relevant production of Sentinel-5P L2 data for Carbon Monoxide, Methane, Nitrogen Dioxide, Sulphur Dioxide, Ozone and Formaldehyde.

All Near Real Time Level-2 user-level data are also routinely provided to EUMETSAT for redistribution via EUMETCast, since 29 August 2019.

2.3.8 Data Hub Relays

The flow of user-level data downloaded from ColHub to the Collaborative national mirror sites is summarised in Figure 67. 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. During the reporting period, the user-level data exchanged in the DHR Network were from Sentinel 1 A/B, Sentinel 2A/B L1C, Sentinel 2A/B L2A and Sentinel 3A/B.

The DHR Network was initially set up in late 2016, with a team of 5 DHRs. The number of relays had grown to 7 by the end of Y2018, but in Y2019 two relays were decommissioned and during Y2020 two Relays were operated on a best effort basis: the German Relay, operated by DLR, and the UK Relay, operated by AIRBUS while new programmatic elements were being put in place. By the end of Y2020, therefore, there were DHR partners in the following member states:

- Norway, operated by MET Norway;
- Austria, operated by ZAMG;
- The Czech Republic, operated by CESNET;
- Germany, operated by DLR, and
- UK operated by AIRBUS

The decrease in the volume of data exchanged between the DHRs in Y2020 as compared with Y2019, shown in Figure 68 below, is a consequence of the fact that two of the five relays were operating on best efforts, and therefore the exchange of the data on these nodes was reduced. There was also a quite significant decrease in the total volume downloaded from ColHub overall (i.e. by both the Collaborative mirror sites and the DHRs), which more than halved, falling from 28.84 PiB in Y2019 to 13.12PiB in Y2020. This decrease is partly attributable to some Collaborative Ground segment activities migrating to the DIAS, as well as an overall tuning of the data offers being managed by the individual Collaborative Ground segments according to the local user needs.

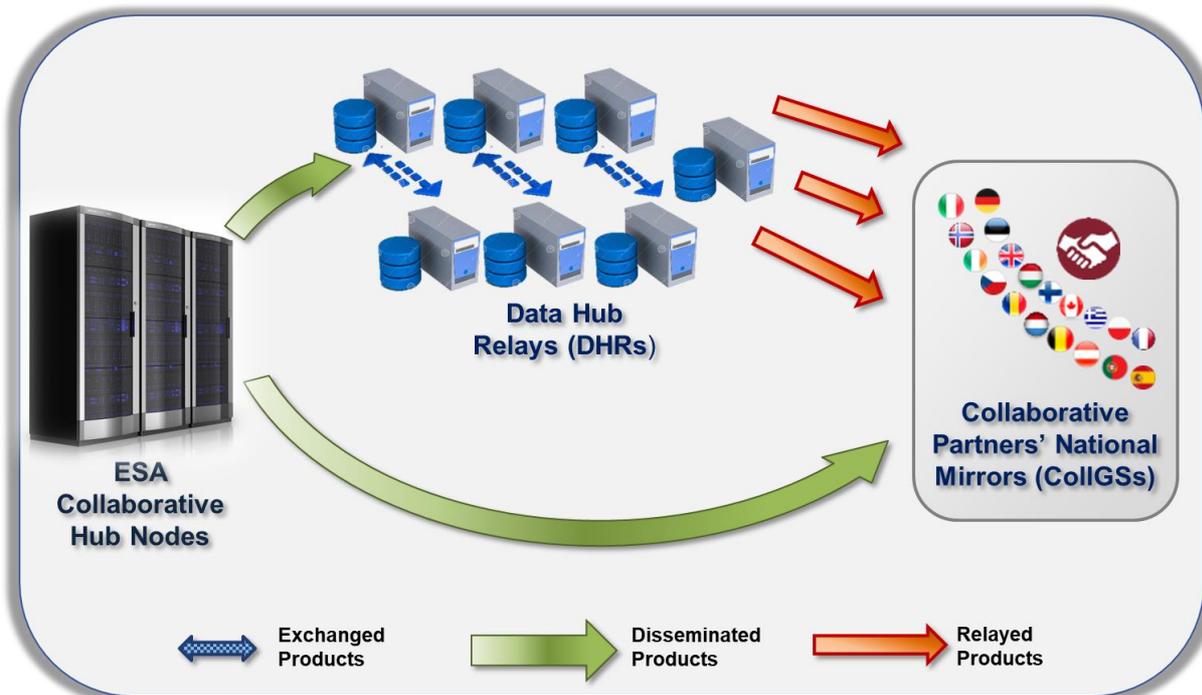


Figure 67: Schematic showing general data flow of user-level data from the Collaborative Data Hub to the Collaborative National Mirrors, highlighting the terminology used

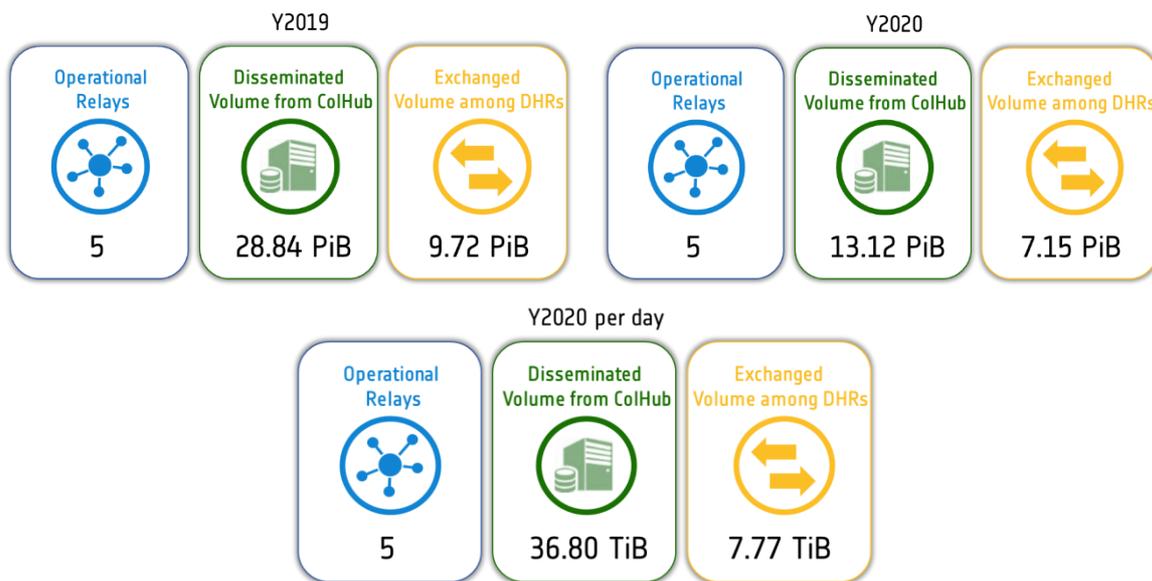


Figure 68: Overall Data Hub Relay statistics for Y2020 vs 2019, with Y2020 per day averages

Overall, the Network continued to demonstrate the importance of having alternative data sources to support ColHub in the dissemination of Sentinel user-level data towards the Collaborative Ground Segment partners. Only 21% (2.77 PiB) of the volume downloaded from ColHub was delivered directly to Collaborative mirror sites, whereas 79% (10.35 PiB)

was delivered via the DHR Network. This percentage split shows the extent to which the DHRs reduce the load on ColHub.

Figure 69 below presents the evolution of the DHR network data volumes since the beginning of DHR operations (i.e. between December 2016 to 30 November 2020). It shows the monthly volumes of

disseminated user-level data from ColHub to the Collaborative mirror sites (blue columns), from ColHub to DHRs (in orange) and the exchanged volumes among DHRs (in grey). The graphs give 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 data moved around the network of Collaborative Ground Segment access points in the first 3 years since the start of DHR operations but, during Y2020 a considerable decrease in activity, due to the reduced number of DHRs participating on a full operational basis in the DHR network. During the period from October 2019 to November 2020, there was a notable reduction in the volume of data being passed around the network, and

from Y2019 to Y2020 it decreased by 40% from 39 PiB to 20 PiB.

However, the number of user-level data and the volumes involved in Copernicus data dissemination is growing each year, and the involvement of the DHR Network still remains an important part of the overall dissemination architecture for Sentinel data. The data volumes, as reported in Figure 6g above, give an idea of the 'effort' made each day by the Network: an average of 36.80 TiB of data is disseminated to the Relays each day, composed of an average of about 59,000 user-level data.

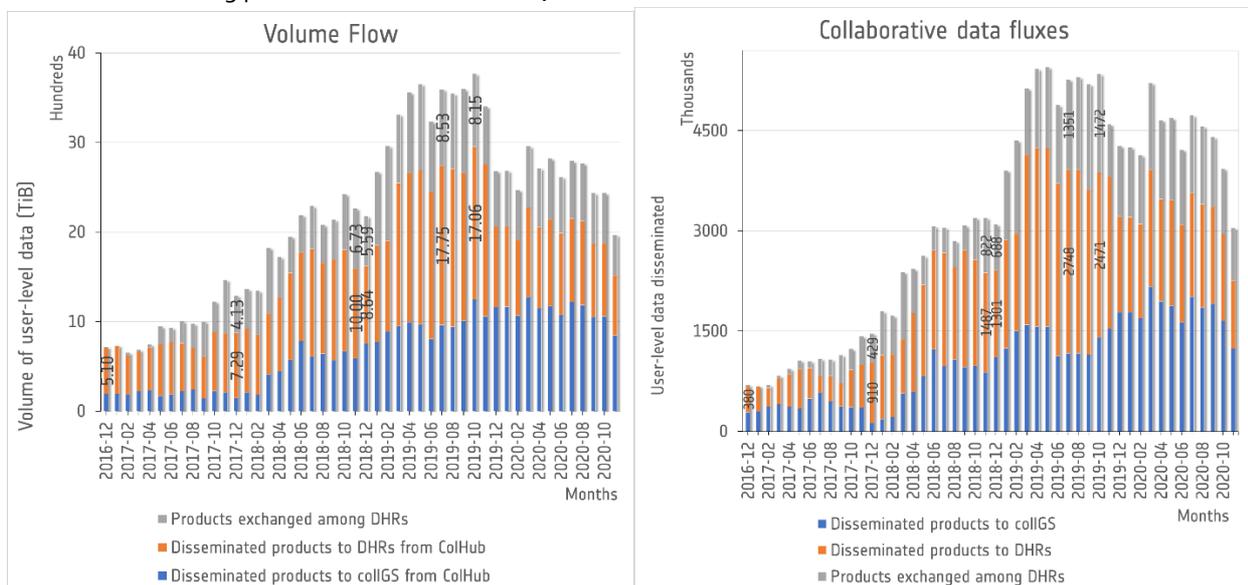


Figure 6g: Total data flows in terms of Volume (left) and number of user-level data (right) during the last 4 years

3 User Activity

3.1 Active Users

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 (Y2020). 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 user-level data, 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 user-level data metadata from the Sentinel archive, for instance to create an independent catalogue for future use. 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 – 19% this period. This is a slightly lower percentage than the 22% calculated for Y2019, but in terms of absolute numbers, there were 15% more active users in Y2020 than in Y2019 (see Figure 70).

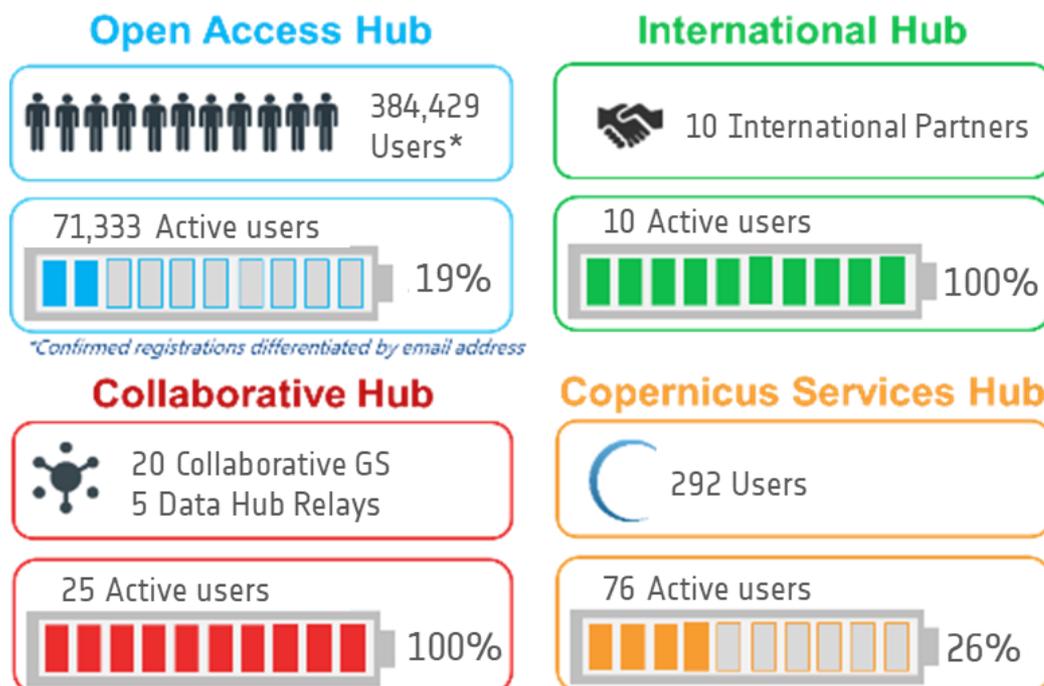


Figure 70: Registered and Active users per hub during Y2020

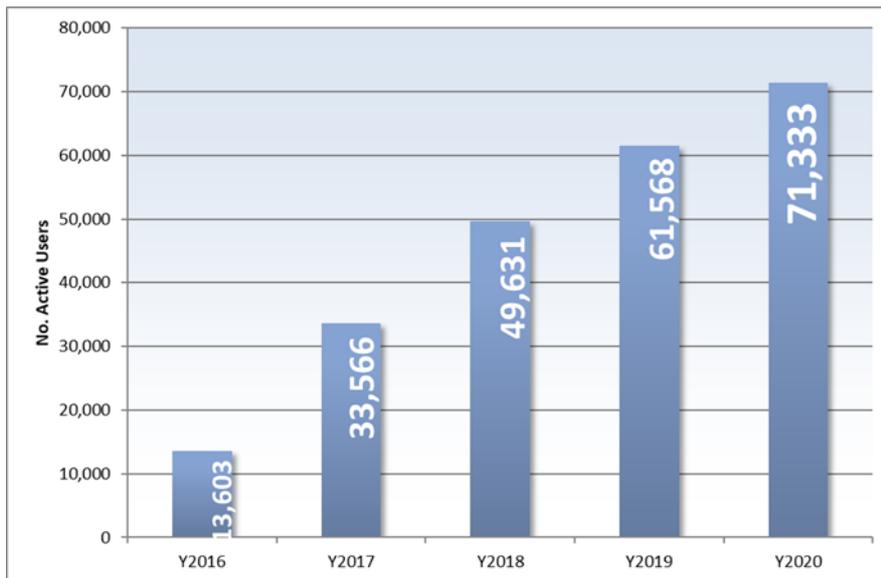


Figure 71: Growth in numbers of active users on the Open Hub between Y2016 and Y2020

3.2 User downloads profile

This section examines the distribution of user downloads across each of the hubs and for all active Sentinels during Y2020. 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 72 shows, for each hub and each mission, the download ranges observed among the active users during Y2020. The overall trends remain similar to those of Y2018 and Y2019 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 user-level data 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 user-level data near the end of Y2020 and whose services are not yet fully operational (see section 4).

The opposite trend is observed on the Open Hub: for example, a large majority (74%) of Sentinel-2 active users downloaded between 1-9 user-level data 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 user-level data during the year.

As in Y2019, 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: 40,608 users for Sentinel-2 compared with 16,165 for Sentinel-1 and 10,734 for Sentinel-3. Overall, there were more active users who downloaded 1-9 Sentinel-1 or Sentinel-2 user-level data than there had been in Y2018. For Sentinel-3, however, the number of users who downloaded between 1-9 user-level data actually fell by 4% with respect to Y2019.

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 user-level data, in absolute terms there were still many more users who downloaded in that range than on all the other hubs put together: 1,160 for Sentinel-2, 393 for Sentinel-1 and 319 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.

Concerning ServHub, 49% of users downloaded more than >1,000 user-level data, lower than the 62% of active users who downloaded in this range in Y2019.

In Y2020, the proportion in the other categories was as follows: 22% in the '1-9' category, 14% in the '10-100' category' and 15% in the '100-1000' category. It is suggested that this more even distribution across the download ranges 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 user-level

data 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.



Figure 72: Y2020 Download Ranges for each Data Access System Hub

3.3 Open Hub Active Users focus

3.3.1 Monthly Active Users

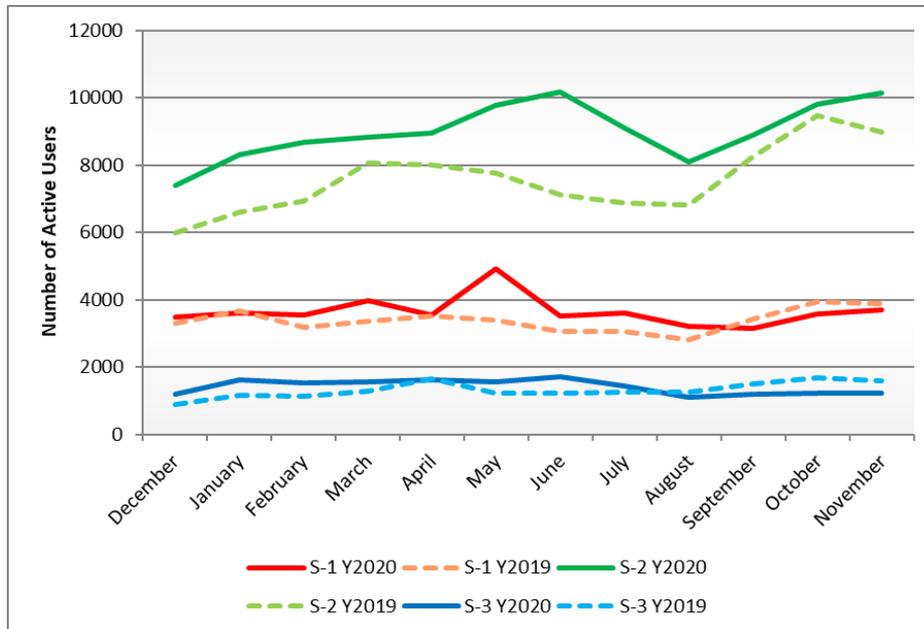


Figure 73: Active user trend per mission in Y2020 and Y2019

The graph in Figure 73 shows the number of active users on the Open Hub on a monthly basis throughout Y2020 for each Sentinel mission (i.e. the number of users that downloaded at least one user-level data from a particular Sentinel mission in the month). For comparison, the graph also shows the equivalent plots for Y2019, shown as dotted lines

For Sentinel-1, there were some months during Y2020 in which the number of active users was slightly higher than it had been in the equivalent month in Y2019, 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 5,000 active users per month. In fact, **the average number of active users/month during Y2020 was 3,650, which is close to the 3,386 average during Y2018**. These trends suggest that the number of active users for Sentinel-1 remains stabilized, as seen in Y2019.

For Sentinel-2, the number of active users was higher in Y2020 than in Y2019, for all months of the year. Sentinel-2 continued to be the mission with the

highest number of active users per month: the number of active users in December 2019 was 7,406, while in November 2020 it had risen to 10,140. **The average number per month was 9,012, which is 18% higher than the average of 7,574 during Y2019**. Sentinel-2 was the mission with the highest percentage rise throughout Y2020.

Concerning Sentinel-3, Figure 73 shows a decrease in the number of active users from July onwards, so that, as for Sentinel-1, by the end of Y2020 there was roughly the same average number of Sentinel-3 active users as there had been at the start of Y2020: in December 2019, there were 1,187 active users of Sentinel-3 user-level data, while by November 2020 there were 1,234. However, in the overall comparison with Y2019, **the average number per month also rose 6% during Y2020, up to 1,410 from 1,322 in Y2019**.

3.3.2 Active users per continent and country

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 25 below shows the number of active users on the Open Hub broken down by continent, for Y2019 and Y2020. It also shows, for both periods, the proportion for each continent of the overall number of active users, and the percentage increase between Y2019 and Y2020. The graph in Figure 74 highlights this growth in active users on all continents, also including Y2015, Y2016, Y2017 and Y2018 to gauge the overall trends

Once again, there was a rise in the number of active users in all continents during the year. The highest increase was in the number of active users from Oceania, up 146% to 2,727 users, and for the first time there were approximately the same number of active users from Oceania as from Africa. The number of active users from South America+Antarctica also rose significantly, up 19% compared to Y2019, to 11,427. Europe, Asia and Africa all experienced similar level growth, at 13%, 13% and 12% respectively.

The highest number of active users still comes from Europe, where there were almost 28,000 active users in the year, representing 39.2% of the total number of active users in Y2020. Asia was the second most active continent, with 18,836 active users, 26.4% of the total number of active users for Y2020 (slightly down from 27.1% last year).

Continent	Y2019	Overall % Y2019	Y2020	Overall % Y2020	% Increase Y2019-Y2020
Europe	24,836	40.3	27,972	39.2	13
Asia	16,686	27.1	18,836	26.4	13
South America + Antarctica	9,584	15.5	11,427	16.0	19
North America	6,954	11.3	7,680	10.8	10
Africa	2,469	4.0	2,771	3.9	12
Oceania	1,109	1.8	2,727	3.8	146

Table 25: Open Hub active users for Y2020 and Y2019, per continent

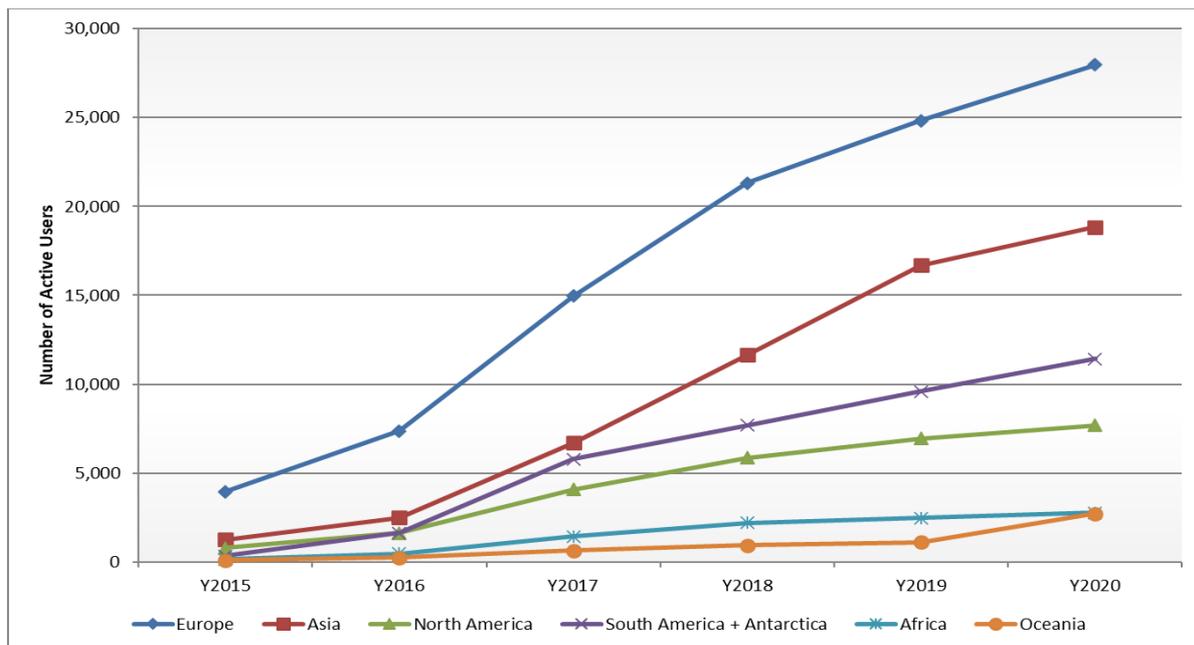


Figure 74: trend in Open Hub active users from Y2015-Y2020, per continent

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 user-level data, 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 user-level data in the year counts as one active user in exactly the same way as a user who downloads more than 1,000 user-level data 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 nations. The 'Top 10' active user countries are provided for all three Sentinels, as well as on a global and European basis (specifically ESA and/or EU member states). The number of users who downloaded a user-level data from each mission during Y2020 is provided for each country, as well as the percentage increase since Y2019 and any change in the position in the list.

Four ESA/EU member states, Germany, Italy, United Kingdom, 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, three other nations also appear in all the top 10 for each

mission: China, India, and the United States, and China remains the country with the most active users for both Sentinel-1 and Sentinel-2, with 2,137 and 4,188 active users respectively. Indonesia and Colombia appear in the lists for the first time: Indonesia with 640 active users of Sentinel-1 data; and Colombia with 1,721 active users of Sentinel-2 data. Russia, which in Y2019 was in the top 10 for Sentinel-1 and Sentinel-3 active users, has disappeared from the lists.

The highest rises in the numbers of active users were in the non-ESA/EU nations: for example, the number of users in Australia who downloaded Sentinel-1 data rose by 164% to 1,610, and India became the country with the second highest number of active users of Sentinel-1 data in Y2020. For Sentinel-2, the largest percentage increases were seen in the numbers of active users in Colombia, the United States and Spain (up 150%, 64% and 30% respectively). For Sentinel-3, the number of active users in China increased by 24% and it became the country with the second highest number of active users of Sentinel-3 user-level data. It is interesting to note that for Sentinel-2, all nations in the top 10 saw rises in active users during Y2020; however, for Sentinel-1, three nations in the top 10 saw decreases of between 3% and 9% during the year, and the same applies to Sentinel-3 where six nations saw decreases of between 2% and 31%.

In terms of growth in the number of active users in the ESA/EU member states with respect to Y2019: for Sentinel-1, the highest growth recorded was by Poland (30%); while for Sentinel-2 and Sentinel-3 it was recorded for Greece (with 43% and 21% respectively).

Sentinel-1 - Global				
Country	Active Users Y2020	% increase from Y2019	Ranking Y2019	Change
China	2,137	1	1	0
Australia	1,610	164	11	^9
India	1,384	2	2	√1
Germany	1,219	-3	3	√1
Italy	1,172	6	4	√1
UnitedStates	982	1	5	√1
UnitedKingdom	793	-9	6	√1
France	734	0	7	√1
Spain	700	-3	9	0
Indonesia	640	7	15	^5

Table 26: Y2020 Top 10 Global Countries: Sentinel-1

Sentinel-1 - ESA/EC				
Country	Active Users Y2020	% increase from Y2019	Ranking Y2019	Change
Germany	1,219	-3	1	0
Italy	1,172	6	2	0
UnitedKingdom	793	-9	3	0
France	734	0	4	0
Spain	700	13	5	0
Poland	533	30	6	0
Greece	321	22	8	^1
Netherlands	320	-3	7	√1
Portugal	294	N/A	N/A	N/A
Romania	192	N/A	N/A	N/A

Table 29: Y2020 Top 10 ESA/EU Countries: Sentinel-1

Sentinel-2 - Global				
Country	Active Users Y2020	% increase from Y2019	Ranking Y2019	Change
China	4,188	27	1	0
Brazil	3,316	15	3	^2
Spain	3,260	30	4	^1
Germany	3,226	7	2	√2
Italy	2,577	28	6	^1
UnitedStates	2,396	64	5	√1
India	2,233	18	7	0
Colombia	1,721	150	19	^11
Mexico	1,689	7	8	√1
UnitedKingdom	1,638	12	9	√1

Table 27: Y2020 Top 10 Global Countries: Sentinel-2

Sentinel-2 - ESA/EC				
Country	Active Users Y2020	% increase from Y2019	Ranking Y2019	Change
Spain	3,260	30	2	^1
Germany	3,226	7	1	√1
Italy	2,577	28	3	0
UnitedKingdom	1,638	12	4	0
France	1,565	8	5	0
Poland	1,271	39	6	0
Greece	915	43	8	^1
Netherlands	911	7	7	√1
Romania	672	44	9	0
Norway	400	N/A	N/A	N/A

Table 30: Y2020 Top 10 ESA/EU Countries: Sentinel-2

Sentinel-3 - Global				
Country	Active Users Y2020	% increase from Y2019	Ranking Y2019	Change
UnitedStates	814	-11	1	0
China	774	24	5	^2
Italy	759	9	3	0
Germany	754	-2	2	√2
Spain	677	10	6	^1
India	589	18	8	^2
UnitedKingdom	453	-11	7	0
France	421	-11	9	^1
Brazil	403	-11	10	^1
Mexico	303	-31	12	^2

Table 28: Y2020 Top 10 Global Countries: Sentinel-3

Sentinel-3 - ESA/EC				
Country	Active Users Y2020	% increase from Y2019	Ranking Y2019	Change
Italy	759	9	2	^1
Germany	754	-2	1	√1
Spain	677	10	3	0
UnitedKingdom	453	-11	4	0
France	421	-11	5	0
Poland	239	-3	6	0
Netherlands	216	12	7	0
Greece	174	21	8	0
Portugal	157	14	9	0
Romania	121	N/A	N/A	N/A

Table 31: Y2020 Top 10 ESA/EU Countries: Sentinel-3

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, 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 of the information provided; users are only able to select one application domain and one usage type from the choices available, meaning that users with multiple domains/usages are not reflected; no further information is obtained from users selecting 'Other' options; and users are not currently given the chance to update their selection, so any developments in the use to which they put the data are also not reflected. Even so, 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 data at the point at which they register.

Figure 75 summarizes the active users and data downloads in terms of the intended onwards use for the data. The circle chart shows the overall percentage split of active users between the four available choices for their intended usage type: Research, Education, Commercial and Other. The chart shows that by the end of Y2020, the vast majority of active users were those who had selected 'Research' (49%) and 'Education' (42%) for their usage type, and only 5% were those who had selected 'Commercial' when they registered for an account. This is an almost identical split to that recorded in previous reporting years.

It is, then, extremely interesting to see from the bar graph that although only 5% of the active users were those who had selected 'Commercial' on registration, those 5% downloaded as much as 41% of the total number of user-level data downloaded overall in Y2020.

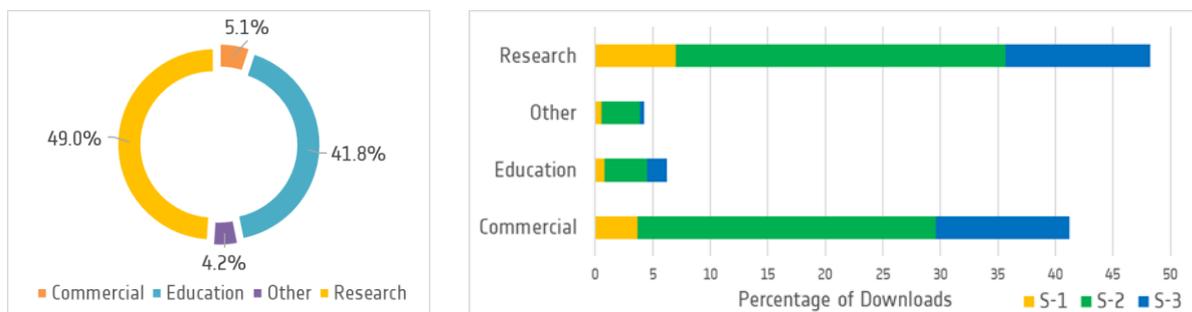


Figure 75: Percentage of Open Hub active users per declared usage type in Y2020, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each usage type during Y2020

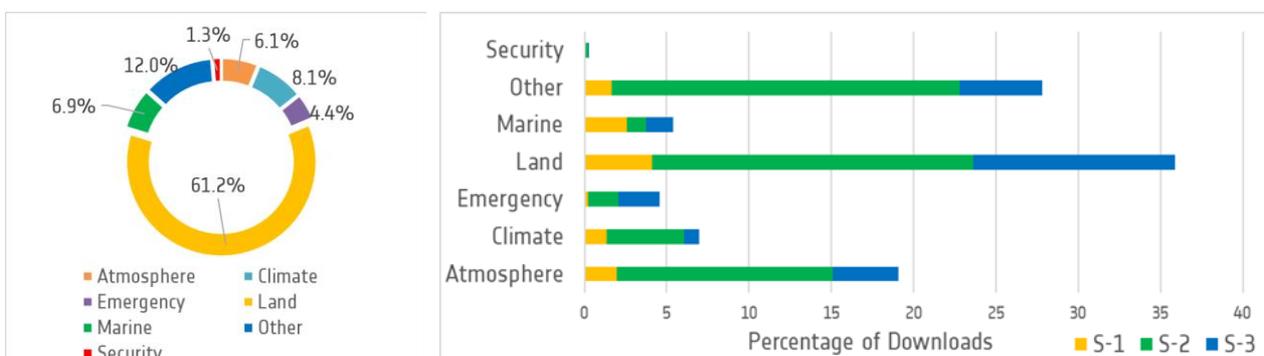


Figure 76: Percentage of Open Hub active users per declared thematic domain in Y2020, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each thematic domain during Y2020

This is almost as high a proportion as was downloaded by the large 'Research' user group, which made 48% of the total number of downloads. It seems very likely, therefore, that the 'Commercial' user group is largely composed of mass downloaders, possibly wishing to replicate the data collection on their own infrastructure.

It is also interesting to note that there was a big increase in activity from the Commercial user group during the year with respect to Y2019: in Y2019, the number of downloads made by the Commercial user group constituted 30%, and this was only half the proportion made by the large Research user group (61%). The Commercial users also made a significantly higher proportion of the Sentinel-3 downloads in Y2020 than they had in Y2019, up to 11.66% from 3.76% during Y2019.

By contrast, although the 'Education' user group accounted for 4.2% of the number of active users in Y2020, those active users only made 6% of the total number of downloads. This suggests that those who download the data for the purpose of education, tend to be the users who download only the specific user-level data they need, probably via the GUI.

The 'Other' user group again accounted for only 4% of the total number of downloads, the same proportion as in Y2019.

Figure 76 breaks down the totals for the number of active users and downloads in Y2020 according to the seven thematic domains which users can choose from when they register for an account on the Open Hub. The circle chart shows that users who selected 'Land' as their application domain continued to be by far the

largest group of active users, accounting for 61.2% of the total number of active users in Y2020. Next in order were 'Other' with 12%, 'Climate' with 8%, 'Marine' with 7%, and 'Atmosphere' with 6%.

As in Y2019, 'Land' is also the application domain for which the majority of downloads were made, with 36% of the total number of downloads in Y2020 made for Land applications, up from 33% 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 an increase in the number of Sentinel-3 user-level data downloaded for 'Land' applications as well, up to 12% of the total number of downloads, from 7% in Y2019.

The proportion of data downloaded for 'Marine' applications fell sharply again, this time from 18% of all downloads in Y2019 to just 5% in Y2020. This is again largely due to a considerable reduction in the proportion of Sentinel-3 user-level data downloaded for 'Marine' applications. Downloads for Sentinel-3 'Marine' applications had still constituted 13% of the total downloads in Y2019, but in Y2020 this figure was down to 1%.

Yet again, although the 'Atmosphere' user group constituted only 7% of the total number of active users in Y2020, they made a high proportion (19%) of the total number downloads in Y2020. This disparity between the number of active users in the group and the number of downloads they make is also seen again for the 'Other' user group, which constituted 12% of the active users but made 27% of the downloads.

4 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. Tables 32 and 33 below set 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 the Serco-led consortium.

It is also highlighted that each data dissemination partner follows its own strategy for the Copernicus Sentinel user-level data it chooses to make 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 user-level data from one or more of the Sentinel missions, while others offer a very specific subset of user-level data 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: Collaborative National Mirror Sites		Annual Report Section: 4.1
Category	Partner	Access URL(s)
Collaborative National Mirror Sites	Austria	https://data.sentinel.zamg.ac.at https://www.sentinel.zamg.ac.at
	Belgium	www.terrascope.be
	Canada	ftp://ftp.neodf.nrcan.gc.ca
	Czech Republic	https://dhr1.cesnet.cz
	Estonia	https://ehdatahub.maaamet.ee
	Finland	https://finhub.nsd.c.fmi.fi
	France	https://peps.cnes.fr
	Germany	https://code-de.org/
	Greece	https://sentinels.space.noa.gr
	Hungary	Not yet public
	Ireland	https://eobrowser.speir.ichec.ie
	Italy	https://collaborative.mt.asi.it/
	Luxembourg	www.lsa-datacenter.lu
	Norway	https://colhub.met.no https://satelitedata.no/
	Poland	https://copernicus.imgw.pl
	Portugal	https://ipsentinel.pt/
	Romania	https://dhus.rosa.ro/
	Spain	Not yet public
	Sweden	https://www.ai.se/en/swedish-space-data-lab
	UK-1	UK1 site: https://www.ceda.ac.uk/
UK-2	JASMIN site: https://jasmin.ac.uk/ https://geobrowser.satapps.org	

Table 32: Collaborative National Mirror sites

Category: International Partners' Sites		Annual Report Section: 4.2	
Category	Partner	Access URL(s)	
International Partners' Sites	Serbia - Biosense Institute	https://biosens.rs/	
	Brazil - Brazilian Space Agency (AEB) and the National Institute for Space Research of Brazil (INPE)	Not available	
	Colombia	Not available	
	Australia - Geoscience Australia (GA)	https://copernicus.nci.org.au/	
	India - Indian Space Research Organisation (ISRO)	https://bhoonidhi.nrsc.gov.in	
	United States - National Aeronautics and Space Administration (NASA)	Alaska Satellite Facility (Sentinel-1)	https://vertex.daac.asf.alaska.edu
		NASA OceanColor Web (Sentinel-3)	https://oceancolor.gsfc.nasa.gov
		Level-1 and Atmosphere Archive & Distribution System (LAADS)	https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurement/olci/
		Distributed Active Archive Center (DAAC) (Sentinel-3)	
		GES DISC (Sentinel-5P)	https://disc.gsfc.nasa.gov
		HLS (derived products from Sentinel-2)	https://lpdaac.usgs.gov/products/hlss30v015/
	United States - National Oceanic and Atmospheric Administration (NOAA)	https://coastwatch.noaa.gov	
	Ukraine - State Space Agency of Ukraine (SSAU)	http://sentinel.spacecenter.gov.ua	
Chile - University of Chile	www.datoscopernicus.cl		
United States - US Geological Survey (USGS)	https://eros.usgs.gov/sentinel-2		

Table 33: Sentinel Data Dissemination Partners

4.1 Collaborative Ground Segment Agreements

ESA Member States and other Copernicus Participating States are complementing the 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 user-level data. 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 (CollGS).

A total of 20 CollGS agreements had been signed with ESA by the end of Y2020. Following the signature of an 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.

Table 34 summarises the status of the 20 current CollGS agreements, listed in order of the date on which the agreement was signed with ESA. It is highlighted 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.

The CollGS partners provide information about the activity on their national mirror sites via an annual questionnaire which ESA sends out. The statistics presented in this section are based on the 16 partners who both had active national initiatives during Y2020 and who provided the requested information.

By the end of the reporting period, most of the CollGS partners had transferred their sites into operations. This now includes the Polish site, which became operational in January 2020. The Hungarian site is still under final testing and has not yet been opened to the public. The implementation of the Spanish site has been delayed, primarily due to the COVID situation. The Spanish team is aiming to implement their solution within 2021.

For the sites which had already been opened prior to Y2020, there was an average growth in the number of users registered on their sites of 87%.

There was an 18% drop in the average volume of data published on a CollGS site during the year compared with Y2019: in Y2019, the average volume published on a site had been 2.42 PB and in Y2020 it was 1.99 PB.

Interestingly, however, the total volume of data downloaded from all of the sites during the year was actually 21% higher in Y2020 than in Y2019, with a total of 2.37 PB downloaded, and an average of 0.39 PB which is 1,080% higher than the same value in Y2019 (see Table 36). This may indicate fine tuning of the data offer on the various CollGS sites according to the user needs.

Overall, however, it is highlighted that the data download volumes discussed in this section are only one way of measuring the 'output' of a particular Collaborative Ground Segment. In fact, several CollGS sites now provide on-demand processing of data, and/or online visualisation and processing 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. The 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/collaborative/workshop>

Progressive Number	CollGS Partner	CollGS Agreement Signature Date	Opened Mirror Site? (yes/no)	Operation start date
1	Greece	May 2014	Yes	6 Feb 2015
2	Norway	Sep 2014	Yes	18 Oct 2016
3	Italy	Oct 2014	Yes	28 May 2016
4	Germany	Nov 2014	Yes	07 Mar 2017
5	Finland	Jan 2015	Yes	24 May 2016
6	UK-1	Mar 2015	Yes	1 May 2015
	UK-2	Mar 2015	Yes	1 Sep 2016
7	France	Mar 2015	Yes	1 May 2015
8	Sweden	June 2015	Yes	1 Oct 2019
9	Canada	Sep 2015	Yes	22 Sep 2015
10	Portugal	Oct 2015	Yes	24 Feb 2017
11	Austria	Feb 2016	Yes	27 May 2016
12	Estonia	Sep 2016	Yes	1 Jan 2019
13	Luxembourg	Apr 2017	Yes	1 May 2019
14	Belgium	Sep 2017	Yes	27 Sep 2017
15	Ireland	Oct 2017	Yes	19 Feb 2018
16	Romania	Dec 2017	Yes	30 Nov 2018
17	Czech Republic	Jan 2018	Yes	15 Mar 2017
18	Poland	Mar 2018	Yes	1 Jan 2020
19	Hungary	October 2019	No	Not yet public
20	Spain	November 2019	No	Not yet public

Table 34: Collaborative Ground Segment mirror sites summary

CollGS Partner	Overall Number of Registered Users since Start of Operations	% Increase since Y2019	% of Registered Users from the National Country	Number of Active Users in Y2020	% of Registered Users who were Active in Y2020
France	6,983	18%	57%	-	-
Germany	6,196	176%	80%	2448	40%
UK-1	1,877	46%	80%	699	37%
Austria	1,794	9%	78%	78	4%
UK-2	1,302	28%	-	-	-
Belgium	913	667%	34%	630	69%
Greece	770	9%	66%	33	4%
Norway	716	25%	-	150	21%
Portugal	594	13%	92%	24	4%
Finland	505	16%	-	147	29%
Czech Republic	318	61%	97%	71	22%
Sweden	200	50%	-	-	-
Luxembourg	151	119%	-	39	26%
Romania	39	61%	-	-	-
Poland	34	N/A	97%	33	97%
Canada	20	0%	-	2	10%
Hungary	11	N/A	-	-	-

Table 35: Summary of national mirror site users

Table 35 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 which provided their reports, and if the statistics were not provided, this is shown as '-'.

It should be noted that, while it is interesting to look at the statistics as a whole, the figures from each CollGS will necessarily be different, partly due to the different start dates for each site but also because partners can impose their own restrictions on registering and accessing the data: some of the CollGS are completely open to all types of users, while others are only open to a few selected users.

In line with the agreement on reporting, the CollGS partners categorise their own users according to the same fields used by ESA. Figures 77 and 78 below show the percentage of registered users from each national mirror site assigned to each 'usage category' (research, commercial, education, other) and to each

'usage field' (specific field for which the data is used e.g. land, marine, atmosphere etc).

Usage Category

12 out of the 16 partners who provided data had 'Research' as their top category of user and 'Research' users accounted for 45% of all CollGS users. In fact, the category represents over 50% of users of the national sites in Belgium, Finland, France, Greece, Portugal, UK-2, Poland, Norway, Luxembourg and Hungary. In Hungary, the number of users which fall into the 'Research' category reaches 73%.

Overall, 8% of the CollGS users were from the 'Commercial' user group, which is consistent with Y2019. Most notably, commercial users constituted 20% of the users of the Belgian mirror site.

19% of the CollGS users were from the category 'Education', and this was the largest category of users for the Czech mirror site (51% of users) and the Romanian site (65%).

Usage Field

By the end of Y2020, the group of registered users which ascribed themselves to the 'Land' category was still the largest group of users on most of the CollGS sites, and accounted for 50% or more of users of the sites in Austria, Belgium, Czech Republic, France, Portugal, Romania and UK-2. 'Marine' and 'Atmosphere' also accounted for a high proportion of users from many partners, in particular in Canada where 70% of the registered users ascribed

themselves to the 'Marine' category, and in Finland where 50% of the registered users did.

24 % of the registered users of the Luxembourg site and 27% of the Hungarian site considered themselves 'Atmosphere' users.

'Other' was the highest group of registered users of the German, Hungarian, Luxembourg and UK-1 sites.

Taking into account all users for all partners, the top fields were 'Land', accounting for 45% of users, 'Other' (22%), 'Marine' (14%) and 'Atmosphere' (11%)..

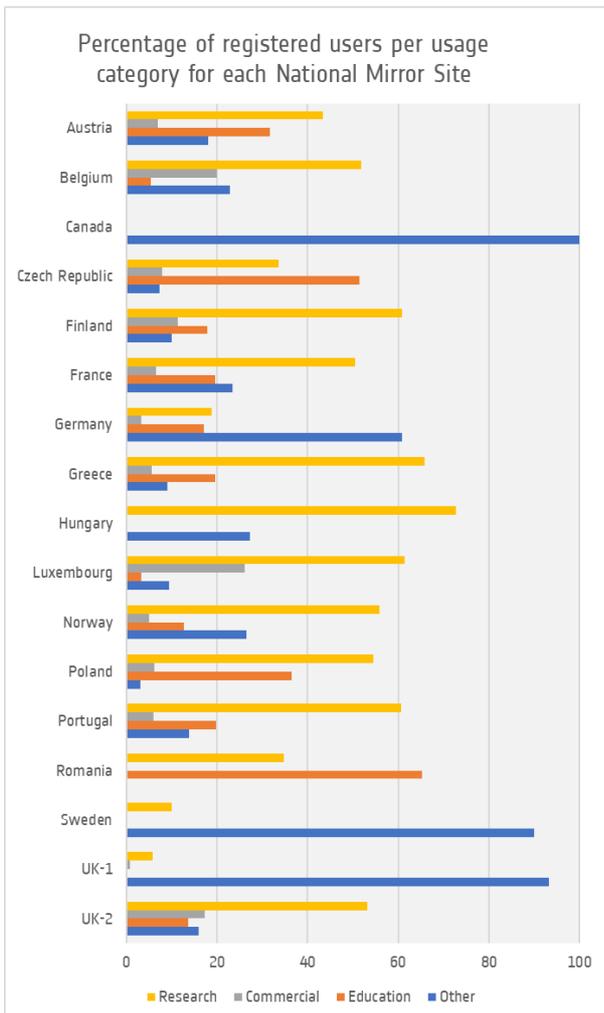


Figure 77: Percentage distribution of mirror site users by usage category

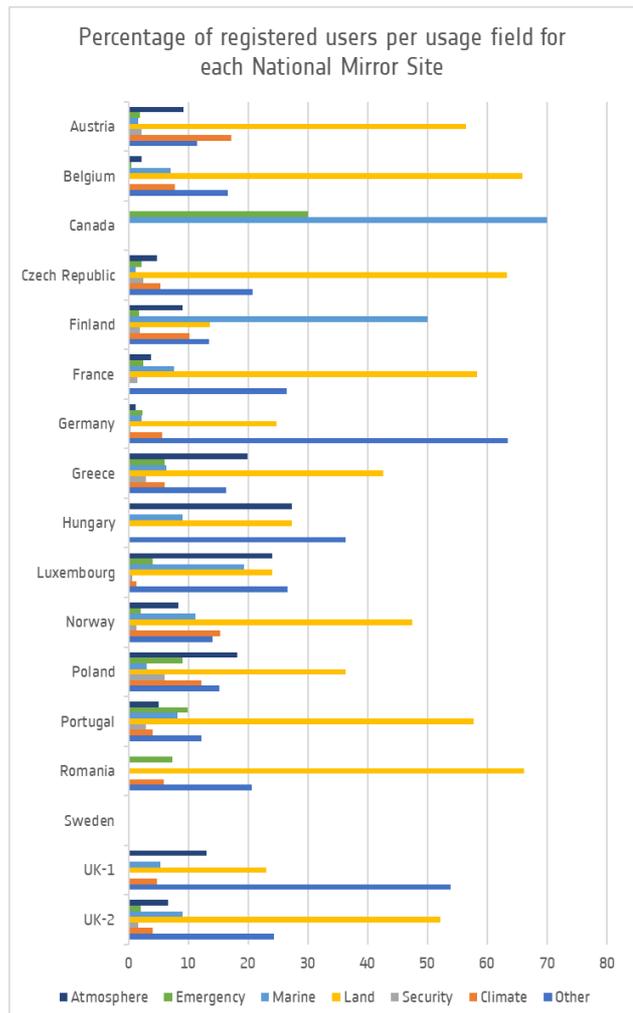


Figure 78: Percentage distribution of mirror site users by usage field

CollGS Partner	Y2020 Published Volume (TiB)	% Increase from Y2019	Y2020 Downloaded Volume (TiB)	% Increase from Y2019
Austria	6,739	1%	186	-46%
Belgium	179	220%	0.8	-98%
Canada	45	46%	63	58%
Czech Republic	46	-8%	49.3	-24%
Finland	121	116%	108.9	299%
France	3,439	-37%	1237	15%
Germany	3,162	-52%	737.2	2,049%
Greece	532	14%	11.9	-35%
Hungary	100	N/A	N/A	N/A
Luxembourg	10,213	6%	414	-4%
Norway	5,360	11%	518	37.00%
Poland	182	N/A	6	N/A
Portugal	153	18%	0.08	-84%
Romania	23	64%	0.6	2,900%
Sweden	59	N/A	N/A	N/A
UK-1	2,073	-1%	2.9	-74%
UK-2	2,239	-33%	2.6	-82%
TOTAL	34,665	-13%	2.37 PiB	-12%
average Y2020	2,039	-18%	0.39 PiB	+1,080%

Table 36: Overall publication and dissemination volumes on mirror sites

Table 36 above reports, where available, the total volume of Copernicus Sentinel data both published on and downloaded from the mirror sites during Y2020, together with the percentage change with respect to Y2019. Overall, this year is more varied than the last, with a number of decreases as well as increases reported. In particular, as already mentioned, the total data volume published in the year (34,665 TiB) was 13% lower than in Y2019.

The greatest individual increases in publication volumes were seen in Belgium (220% increase), Finland (116%) and Romania (64%). The greatest individual decreases were seen on the French (-37%), German (-52%) and UK-2 (-33%) sites.

In terms of volumes of downloads made by users, the overall sum of 3,338 TiB was 21% higher than the Y2019 total. This increase is largely due to a 2049% rise in the reported volume of downloads from the German site: in Y2019, users of the German CollGS downloaded 34.3 TiB of data, but in Y2020 this volume jumped to 737.2 TiB. It is interesting to note that the

data downloaded was predominantly from Sentinel-2 (97%), even though the publication volumes were more evenly spread. It is also flagged that the German CollGS team transferred their CODE-DE system from version 1 to version 2 during the year, and this included a change in the service provider. Version 2 was opened to users on 1 April 2020.

The other partners which showed enormous growth in download volume between Y2019 and Y2020 were Romania (up 2,900%), and Finland (up 299%).

In terms of absolute volumes of data downloaded, the French site dealt with the highest volume of downloads of the year, with 1,237 TiB downloaded by its users. This was followed by Germany (737.2 TiB) Norway (518 TiB) and Luxembourg (414 TiB).

The majority of mirror sites showed lower download volumes than the volumes published. The exceptions to this were the Czech and Canadian sites, which supported a higher download volume (49.3 and 63 TiB respectively) than published volume (46 and 45 TiB respectively).

CollGS Partners	Y2020 Published Volume (TiB)				Y2020 Downloaded Volume (TiB)			
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
Austria	2,225	3,868	645	0	53	42	91	0
Belgium	60	118	0	0	0.3	0.5	0	0
Canada	45	0	0	0	63	0	0	0
Czech Republic	12	21	13	0	42	7	0.3	0
Finland	72	23	24	2	5	4	100	0.3
France	1,918	2,016	0	0	897	340	0	0
Germany	926	1,427	286	524	22	689	26	0.3
Greece	296	167	68	-	8	3	1	-
Hungary	43	18	25	14	N/A	N/A	N/A	N/A
Luxembourg	5,540	4,673	0	0	3	411	0	0
Norway	1,874	3,099	387	-	446	62	10	-
Poland	57	43	42	40	0.6	0.9	0.4	4
Portugal	119	14	20	0	0.04	0.02	0.01	0
Romania	12	5	6	0	504	87	12	0
Sweden	0	59	0	0	N/A	N/A	N/A	N/A
UK-1	1,521	43	328	181	2	0.5	0.03	0
UK-2	1,064	1,175	0	0	2	0.3	0	0
TOTAL	15,784	16,769	1,844	761	2,047	1,645	240	4

Table 37: Y2020 Publication and dissemination volumes per Sentinel on mirror sites

Table 37 breaks the publication and download volumes down by Sentinel mission, where this information was available. 9 sites published more Sentinel-1 data than any other mission in Y2020, and these were Canada, Finland, Greece, Hungary, Luxembourg, Poland, Portugal, Romania, and UK-1, a similar list to that seen in Y2019. Of these sites, the Canadian site was the only one which only published Sentinel-1 data. 7 sites published more Sentinel-2 data than any other mission: Austria, Belgium, Czech Republic, France, Germany, Norway, and UK-2.

Poland and Hungary joined the countries that publish Sentinel-3, while France and Norway showed a decrease in the volume of Sentinel-3 user-level data published on its site.

Concerning Sentinel-5P data, this year there were several partners which started to publish the data: Poland, Hungary and Finland; while UK-1 increased its publication of Sentinel-5P data sevenfold. Overall, the average volume of Sentinel-5P user-level data published in Y2020 per national mirror increased 425% from the previous year (the average volume

published during Y2019 was 29TiB while in Y2020 it rose to 152.2TiB).

In terms of download volumes, Figure 79 shows that there was some very interesting user activity. For instance, although Luxembourg published similar volumes of Sentinel-1 and Sentinel-2 data, with a slightly higher volume of Sentinel-1 data, 99% of the volume of data downloaded by users was Sentinel-2 data. As already mentioned, a similar disparity between the published and downloaded volumes was seen on the German site, from which the overwhelming majority of the data downloaded by users was again Sentinel-2 data. By contrast, an almost equal volume of Sentinel-1 and Sentinel-2 data was published on the UK-2 site, but users almost exclusively downloaded the Sentinel-1 data. Similarly, for Norway, where a higher volume of Sentinel-2 user-level data was published than Sentinel-1, the volume of Sentinel-1 data downloaded was over seven times higher than the volume of Sentinel-2 data.

While users of the Austrian site showed a significant preference for Sentinel-3 data, this preference was

the most marked on the Finnish site: 91% of the volume of data downloaded from the Finnish site was Sentinel-3 data, despite the fact that 60% of the volume of data published was Sentinel-1 data, and 19% Sentinel-2 data.

No downloads are reported for Sweden, and this is in line with the scope of the Swedish site, which is not aimed at users who wish to download the data but instead offers online hosted processing services.

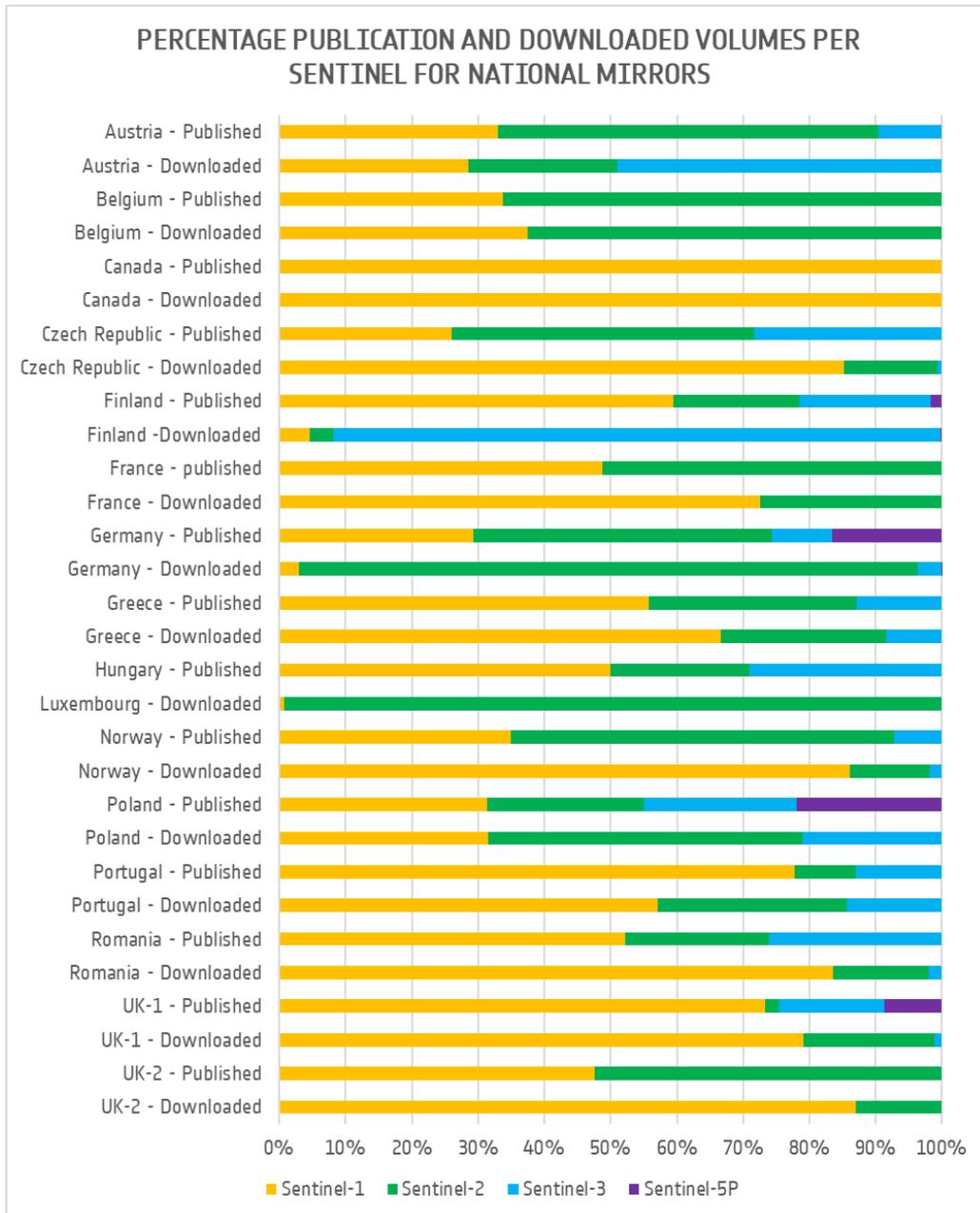


Figure 79: Percentage publication and dissemination volumes per Sentinel on mirror sites

4.2 International Technical Agreements

The Copernicus programme has a strong international dimension. In support of 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 10 Cooperation Arrangements with international partners to advance the mutually beneficial exchange of satellite data, in-situ data and support for calibration/validation activities.

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 from IntHub and transfer the data to

their national data access sites, for use by their own user communities.

The major developments during Y2020 were:

- Two of the international partners, ISRO (India) and SSAU (Ukraine), opened their sites on an operational basis, each already attracting significant numbers of active users during the year (see Table 39 below).
- A TOA was signed with the Colombian partner the Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM) on 26 December 2019. IDEAM is now in the process of setting up its regional data access/analysis site, to facilitate access to and the exploitation of Copernicus Sentinel data in the Latin American region. The site will initially be aimed at providing data to create annual reporting of deforestation in the country.

Table 38 below 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 TOA with ESA.

International Partner	TOA signature date	Date started distributing Sentinel data from the site	Purpose of the national data access site
<p>United States</p> <p>National Aeronautics and Space Administration (NASA)</p>	<p>18-Feb-2016</p>	<p>12-Dec-2015</p>	<p>The aim of NASA's mirror site is to re-use and re-disseminate Copernicus Sentinel data, to increase distribution capacity, and maximise the benefits to Earth Science research and applications. The site is primarily intended to enable users to download the data.</p> <p>NASA started distributing Sentinel-1 user-level data 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 user-level data from 16/02/2016 to the present being available for re-dissemination. As well as the Sentinel-1 and -3 user-level data, during 2018 data from the Sentinel-5P mission began to be published on the NASA Sentinel Gateway (NGS).</p> <p>The relevant websites are:</p> <p>S1: https://vertex.daac.asf.alaska.edu</p>

			<p>S2 (HLS which are data derived from Sentinel-2): https://lpdaac.usgs.gov/products/hlss30v015/</p> <p>S3: https://oceancolor.gsfc.nasa.gov and https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/</p> <p>S5P: https://disc.gsfc.nasa.gov</p>
<p>United States US Geological Survey (USGS)</p>	<p>19-Feb-2016</p>	<p>16-Feb-2017</p>	<p>USGS provides storage and redistribution of Sentinel-2 data on its Earth Resources Observation and Science (EROS) Center. The current USGS Sentinel-2 archive is only a partial representation of all available acquisitions from ESA however.</p> <p>USGS also makes available Full Resolution Browse (FRB) images in Georeferenced Tagged Image File Format (GeoTIFF) for Sentinel-2 tiles. This user-level data is a simulated natural colour composite image created from three selected bands (11, 8A, 4) with a ground resolution of 20 meters.</p> <p>USGS develops algorithms and processing methodologies in order to enhance the interoperability and synergistic use of Landsat and Sentinel-2 data streams.</p> <p>https://eros.usgs.gov/sentinel-2</p>
<p>United States National Oceanic and Atmospheric Administration (NOAA)</p>	<p>1st signed 7-Mar-2016 - update signed 19-Dec-2017</p>	<p>01-May-2016</p>	<p>NOAA provides access to satellite data for understanding and managing oceans and coasts. It makes available the oceanographic user-level data from the Copernicus Sentinel missions. Data is made available on the CoastWatch – OceanWatch site. For Sentinel-1, published user-level data 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, received from EUMETSAT’s Multicast Terrestrial.</p> <p>The site is primarily intended to enable users to download the data and to visualise it online.</p> <p>https://coastwatch.noaa.gov</p>
<p>Australia Geoscience Australia (GA)</p>	<p>24-Mar-2016</p>	<p>26-Jun-2015</p>	<p>GA publishes Copernicus Sentinel data on its data access site ‘Sentinel Australasia Regional Access’ (SARA).</p> <p>SARA provides free and open access to data from Copernicus Sentinels 1-3, primarily for users in Australasia, South-East Asia, the South Pacific, the Indian Ocean and the Australian Antarctic Territory. For the Sentinel-3 Land user-level data, the site provides a 60 day rolling archive of Global S3 user-level data, offering a subset cut to the Australasia region of interest.</p> <p>The site is primarily intended to enable users to download the data.</p>

			<p>SARA is hosted at the National Computational Infrastructure and operated by the Regional Copernicus Data Hub consortium formed by GA, the New South Wales Office of Environment and Heritage, Queensland Department of Environment and Science, Western Australian Land Information Authority and the Commonwealth Scientific Industrial Research Organisation. New Zealand's Centre for Space Science Technology joined as a consortium partner in 2018.</p> <p>https://copernicus.nci.org.au</p>
<p>Serbia</p> <p>The BioSense Institute – Research Development Institute for Information Technologies in Biosystems</p>	<p>25-Jan-2019</p>	<p>Mid-Oct 2019</p>	<p>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.</p> <p>The relevant websites are: https://biosens.rs and https://agrosens.rs.</p>
<p>Brazil</p> <p>Brazilian Space Agency (AEB) and the National Institute for Space Research of Brazil (INPE)</p>	<p>14-Mar-2019</p>	<p>Site not in operations by end Y2020</p>	<p>INPE is setting up a regional data access/analysis hub, to facilitate the access to and exploitation of Copernicus Sentinel data in Brazil.</p>
<p>Ukraine</p> <p>State Space Agency of Ukraine (SSAU)</p>	<p>28-Mar-2019</p>	<p>1-Jan-2020</p>	<p>SSAU has established a regional data access mirror site, the 'Data Hub System – Ukraine', to facilitate access to and the exploitation of Copernicus Sentinel data in Ukraine.</p> <p>SSAU publishes on the Data Hub System – Ukraine all available Copernicus Sentinel data over Ukraine and the immediately surrounding regions. The site is primarily intended to enable users to download the data.</p> <p>http://sentinel.spacecenter.gov.ua/</p>
<p>India</p> <p>Indian Space Research Organisation (ISRO)</p>	<p>11-Apr-2019</p>	<p>26-Jan-2020</p>	<p>ISRO has established a regional data access site called Bhoonidhi, which provides access to all data from Sentinels -1 and -2 over India and the immediately surrounding regions, together with data from other EO missions, such as Landsat-8. The site is primarily intended to enable users to download the data.</p> <p>https://bhoonidhi.nrsc.gov.in</p>
<p>Chile</p>	<p>20-Aug-2019</p>	<p>27-Sep-2019</p>	<p>UdeChile, through the Center for Mathematical Modelling (CMM) and its specialised units, in particular the HPC Center and its Image</p>

University of Chile			<p>Processing Working Group, operates 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. Currently the site maintains a window of 45 days of all Sentinel-1 and -2 data tiles which intersect the Chilean territory. UdeChile is planning to expand the window to 6 months during 2021.</p> <p>The site is primarily intended to enable users to download the data.</p> <p>www.datoscopernicus.cl</p>
<p>Colombia</p> <p>Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM)</p>	26-Dec-2019	2018	<p>IDEAM is in the process of establishing a regional data access/analysis site to facilitate access to and the exploitation of Copernicus Sentinel data in the Latin American region. The current area of interest is limited to Colombia.</p> <p>The initial aim of the site is to provide data to create annual reporting of deforestation of the country.</p>

Table 38: International Partners summary

The international partners which have opened their national data access sites provide annual feedback on the use of their sites and the uptake of Copernicus Sentinel data. The input received for Y2020 is summarised below. Where information was not available this is shown as 'N/A'.

Table 39 presents information about the number and type of users on each of the operational sites. Unfortunately no statistics are available this year for the Serbian national data site because it suffered a major set-back at the beginning of February 2020 when, due to an overfilling of the system drive with unusually large log files, the hard disk failed and all of

the data was lost, including the setup. BioSense plans to spend 2021 restocking the archive with Copernicus Sentinel data over the Balkan regions, and making the latest year and a half (from 1 January 2020) available for download to its users.

It should also be noted that for USGS and NASA, 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 Y2020	% increase in active users since Y2019	Principal user categories (percentages of registered users unless otherwise stated)
Geoscience Australia (Australia)	26-Jun-15	9,291	3%	N/A
NASA (USA)	12-Dec-15	106,338	548%	<i>[percentages are of download proportions]</i> Research (inc. government): 5.8% Commercial: 10% Education: 7.9% Other (US Organization and foreign users): 76.3%
NOAA (USA)	01-May-2016	5,006	-37%	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	56,257	-76%	<i>[percentages are of download proportions]</i> Academic Institution: 50% Private Business: 17% General Public: 12% Other: 8% Non-profit Organization: 6% Non-US Federal/National Government: 4% US Federal Government: 3%
University of Chile (Chile)	27-Sep-19	355	92%	Research: 40% Commercial: 6% Education: 33% Other: 21%
SSAU (Ukraine)	01-Jan-20	39	N/A	Research: 59% Education: 28% Other: 13%
ISRO (India)	26-Jan-20	166	N/A	N/A
IDEAM (Colombia)	N/A	N/A	N/A	N/A
AEB (Brazil)	N/A	N/A	N/A	N/A
BioSense (Serbia)	N/A	N/A	N/A	N/A

Table 39: International Partner general characteristics and statistics for Y2020

International Partner	Total Published Volume in Y2020 (TB)	% Change in Published Volume from Y2019	Total Published Volume since start of data distribution (TB)	Total Downloaded Volume in Y2020 (TB)	% Change in Downloaded Volume from Y2019	Total Downloaded Volume since start of data distribution (TB)
Geoscience Australia (Australia)	1999	0.63	3226	3,786	-0.0025	12,324
NASA (USA)	2623	3%	11,325	17,880	1.16	33,021
NOAA (USA)	236	146%	918	73	280%	73
USGS (USA)	-	-	-	284.34	-	-
University of Chile (Chile)	1.4	-96%	1.8	1.5	400%	1.8
SSAU (Ukraine)	114	N/A	114	0.5	N/A	0.5
ISRO (India)	61	N/A	68	60	N/A	59
IDEAM (Colombia)	1	N/A	2	1.0	N/A	2.0
AEB (Brazil)	N/A	N/A	N/A	N/A	N/A	N/A
BioSense (Serbia)	N/A	N/A	N/A	N/A	N/A	N/A

Table 40: International Partner publication and download statistics for Y2020

Table 40 above summarises, per partner, the volumes of published and downloaded data by the end of Y2020 and, where applicable, also the percentage change with respect to the end of Y2019. The changes which took place on the Chilean site are particularly striking: despite a nearly 100% decrease in the volume of data published on the site during the year, users of the site downloaded 400% more data in Y2020 than in Y2019. This corresponds well with the 92% increase in active users which engaged with the site in Y2020.

Similarly notable changes with respect to Y2019 can be seen for NOAA’s site: the volume of data which NOAA published more than doubled in Y2020 with respect to Y2019, and the amount of data downloaded increased by 280%, even though there

was actually a 37% drop in the number of active users on the site as compared with Y2019.

In Table 41, the overall volumes of user-level data published and downloaded in Y2020 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.

More information about the Commission’s international cooperation on EO data exchange under Copernicus can be found at:

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

International Partner	Y2020 Published Volume (TB)				Y2020 Downloaded Volume (TB)			
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
Geoscience Australia	351	680	968	N/A	1,927	1,232	627	N/A
NASA (USA)	2,242.7	N/A	251.6	128.9	16,627.1	N/A	125	1,128
NOAA (USA)	72	62	102	N/A	72	0.002	2.3	N/A
USGS (USA)	N/A	-	N/A	N/A	N/A	284	N/A	N/A
University of Chile	0.6	0.5	0.2	N/A	0.9	0.4	0.2	N/A
SSAU (Ukraine)	54	36.6	23.6	N/A	0.3	0.1	0.01	N/A
ISRO (India)	13	48	N/A	N/A	10.7	49.8	N/A	N/A
IDEAM (Colombia)	N/A	1	N/A	N/A	N/A	1	N/A	N/A
AEB (Brazil)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BioSense (Serbia)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 41: International Partner published and download volumes, per Sentinel mission for Y2020

5 Data Access System performance 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 user-level data 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 user-level data 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 42 below presents the overall availability for each of the four hubs for Y2020. For comparison, the table also sets out the corresponding values recorded for Y2019, 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 confirm the impressive results of Y2019: each Hub achieved over 99% overall availability, and IntHub showed an improvement on the availability recorded during Y2019.

Hub	Y2020	Y2019	Y2018	Y2017	Y2016	Y2015
Open Access Hub	99.10	99.34	98.48	98.95	95.11	96.62
Collaborative Hub	100	100	100	98.04	98.19	96.09
Copernicus Service Hub	99.23	99.60	98.50	98.60	99.35	N/A
International Hub	99.99	99.95	99.90	98.89	99.59	N/A

Table 42: Overall availability of each hub during reporting years Y2015 – Y2020

Month	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub
2019-12	99.01	100	99.12	100
2020-01	99.78	100	99.85	100
2020-02	99.95	100	100	100
2020-03	99.45	100	99.79	100
2020-04	99.79	100	100	100
2020-05	96.23	100	95.79	100
2020-06	99.21	100	99.52	100
2020-07	99.87	100	99.94	100
2020-08	99.92	100	99.96	99.94
2020-09	99.58	100	99.76	100
2020-10	99.24	100	99.82	100
2020-11	97.00	100	97.08	100
Y2020	99.10	100	99.23	99.99

Table 43: Monthly availabilities during Y2020 per hub (green shading indicates >98% availability; yellow shading indicates 95-98% availability; red shading indicates <95% - not present)

Table 43 breaks the overall availability figures down by month for each of the hubs.

The highest overall availability was 100% recorded for ColHub. 100% service availability was also recorded for ColHub in Y2019 and Y2018. This result 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 data if a problem arose on one of the other nodes. A period of simultaneous downtime never happened during Y2020, 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 99.99% from an already impressive 99.95% in Y2019. In fact, for eleven months of Y2020, no downtime was recorded on the Hub at all; small periods of unavailability were recorded only in August 2020.

As can be seen from Table 43, there were only two Hubs in which monthly availability went below 99%. The hubs affected were the OpenHub and ServHub, both of which run on the same infrastructure, which means that both tend to be affected simultaneously when periods of unavailability occur. The months

with the lowest availability were May 2020 (96.23% on OpenHub and 95.79% on ServHub) and November 2020 (97.00% on OpenHub and 97.08% on ServHub). This was the result of a series of extended scheduled maintenance activities, which impacted the Open Hub, ServHub, Sentinel-5P Pre-Operations Hub and Node 1 of ColHub, as described further below.

The previous years of infrastructure upgrades and lessons learnt have created a system which is operationally robust, notwithstanding the ever-increasing pressures which are placed on the system through user activity and data publication. Below is a list and description of the scheduled upgrade and maintenance activities which took place in Y2020:

- **03/12/19** 08:00-17:30 – A scheduled maintenance took place on the Open Hub (including the API Hub and GNSS Rinex Pre-Ops Hub) during which occasional service interruptions may have been experienced. Request and download of Sentinel-2 user-level data from the Long Term Archive was temporarily suspended.
- **04/12/19** 08:00-17:30 – A scheduled maintenance took place on the ServHub and ColHub (node 1 only) during which occasional service interruptions may have been experienced.
- **28/01/20** 09:00-16:00 – A scheduled maintenance took place on the core infrastructure, involving the update of the virtualization infrastructure. The affected hubs were the Open Hub (including the API Hub), the ColHub Node 1 and the

ServHub. The hubs were available but the publication of new user-level data was delayed, along with some degradation in download performances.

- **04/02/20** – Due to a planned maintenance activity at ground segment level, the restoration service of the Sentinel-2 Long Term Archive was temporarily suspended, with services resuming by the end of the same day.
- **25 - 26/02/20** 08:00-17:30 – An infrastructure security maintenance activity took place on the Open Hub, ColHub, IntHub and ServHub. Publication delay in Sentinel-1, -2 and -3 user-level data resulted, along with some service interruptions.
- **03/03/20** 08:00-17:30 - An infrastructure security maintenance activity took place on the Open Hub (including the APIHub). The request and download for Sentinel-2 LTA user-level data was suspended during this window.
- **04/03/20** 08:00-17:30 - An infrastructure security maintenance activity took place on the ColHub (Node 1) and ServHub. Some service interruptions resulted.
- **04/05/20 - 07/05/20** - Due to a planned maintenance activity at ground segment level, the restoration of Sentinel-2 long term archived user-level data was suspended on this day, commencing from 06:00. During the period, Sentinel-2 offline user-level data were unavailable from all data hubs. The resumption was intended to last for only one day (04/05/20), but the occurrence of a contingency on a component upgrade resulted in it being extended until 07/05/20.
- **14/05/20** 06:00-15:00 – Planned infrastructure maintenance activity was performed on the Sentinel-5P Pre-Operations Hub, with service interruptions occurring during the period.
- **18/05/20 - 19/05/20** 14:00-14:00+1 – A scheduled maintenance took place on the main storage facilities. The affected hubs were Open Hub (including the API Hub), the ColHub Node 1 and the ServHub, which were unavailable during the period.
- **09/06/20 - 10/06/20** 07:00-17:30 – Planned infrastructure security maintenance activities took place on the Open Hub, IntHub, ColHub and

ServHub. Some service interruptions resulted during the maintenance window.

- **16/06/20** 07:00-17:30 – Planned maintenance activities took place on the Open Hub (including API Hub). The request and download of offline Sentinel-2 user-level data (stored on the LTA) was suspended.
- **17/06/20** 07:00-17:30 – Planned maintenance activities took place on the ServHub and ColHub (Node 1). Some service interruptions resulted during the maintenance window.
- **22/06/20** 02:30-05:00 – Planned maintenance activities, involving the update of the network infrastructure, took place on the Open Hub (including APIHub), ServHub and ColHub (Node 1). Some periods of downtime were experienced during the window.
- **15/07/20** 07:00-16:00 - During this planned maintenance the Data Hub services continued to run, however, data publication was delayed and users may have experienced a degradation in download and node inspection performances. The following access point experienced periods of downtime: the Open Hub (also including API Hub, Copernicus Sentinels POD Data Hub); ColHub - Node 1; Copernicus ServHub. The ColHub Node-2 and Node-3 and the S5P Pre-Ops Hub were not be affected by the maintenance.
- **04/08/20** 08:00-10:00 – An infrastructure maintenance was performed on the IntHub which caused the publication delay of all Sentinel-1, Sentinel-2 and Sentinel-3 data. The request and download were temporarily suspended.
- **25/08/20 - 26/08/20** 06:00 - 17:30 – Security maintenance activities were performed on the following data hub instances, causing the publication delay of all Sentinel-1, Sentinel-2 and Sentinel-3 user-level data: the Open Hub, IntHub, ColHub, ServHub. During this maintenance activity, minor service interruptions might have occasionally been experienced by the users.
- **01/09/20** 06:00-17:30 – A scheduled maintenance took place on the main facilities affecting temporarily the following data hub instances: the Open Hub (also including API Hub and the POD Data Hub). The request and download of Sentinel-2 user-level data stored on the Long Term Archive (LTA) was temporarily suspended.

- **02/09/20** 07:00-17:30 A scheduled maintenance took place on the main facilities affecting temporarily during the maintenance window the following data hub instances: ServHub and ColHub - Node 1.
- **11/11/20** 08:30-16:30 – During this maintenance, access to the Open Hub (only API Hub access point) and the data publication on the catalogue were temporarily suspended for the duration of the maintenance.
- **17/11/20** 08:30-16:30, **18/11/20** 08:30-16:30 - During this maintenance, the data hub software was updated and two downtimes of approximately 1 hour each could have been experienced, preventing the end-users from querying and downloading data. Moreover the data publication on the catalogue was temporarily suspended for the entire duration of the maintenance. The following access points experienced periods of downtime: the Open Hub - SciHub access point only (only on 17/11/20); ColHub Node1 (only on 18/11/20); ServHub (only on 18/11/20). ColHub Node-2, Node-3 and the S5P Pre-Ops Hub were not affected by the maintenance.

Several unexpected anomalies were also experienced during Y2020. The most significant of these anomalies were:

- **30/12/19** 09:00-13:45 – A service downtime occurred on the Open Hub (including the API Hub and the GNSS Rinex Pre-Ops Hub), ServHub and ColHub (node 1). The downtime was due to an infrastructure incident temporarily affecting the NFS connections between the storage and the virtual machines.
- **24 - 29/01/20** – The restoration service of the Sentinel-2 Long Term Archive was suspended due to a contingency occurring at ground segment level, preventing the retrieval of offline user-level data from all data hubs.
- **31/01/20 - 11/02/20** – The restoration service of the Sentinel-1 Long Term Archive was suspended due to an infrastructure anomaly, preventing the retrieval of offline user-level data from all data hubs. Services were restored for the APIHub on 03/02/20 and the SciHub on 11/02/20.
- **27/05/20** 00:00-15:00 – A service downtime was experienced on the Open Hub (including

APIHub), ServHub and ColHub (Node 1) due to a problem on the power supply line of the data centre. During this period, a temporary access hub was activated for providing access to the previous two weeks of Sentinel data without registration.

- **06/06/20 - 16/06/20** – As a result of a critical anomaly at ground segment level, the restoration of Sentinel-2 offline user-level data was degraded from the night of 06/06/20, before being temporarily suspended on 09/06/20. The service was resumed on 13/06/20 at a reduced restoration rate, before being increased to the nominal operational level on 16/06/20.
- **07/07/20** – The Sentinel-3 offline user-level data restoration from LTA was temporarily suspended for 2 hours from 13:00 UTC to 15:00 UTC for maintenance activity on the databases for improving data restoration performances.
- **17/07/20** – As a consequence of a ground segment contingency, the restoration service of the Sentinel-2 long term archived user-level data was suspended for an extended period. The service resumed on 24/07/20.
- **12/08/20** – Due to an anomaly at the Svalbard ground station, the processing of a number of Sentinel-2B acquisitions downlinked over the station was not performed in real-time. The affected L1C and L2A were user-level data with sensing time between 2020-08-11T08:54:49.979 and 2020-08-12T08:02:27.668 UTC (sensing orbits 17924 to 17936). The data were recovered in the subsequent days.
- **25/09/20** – As a consequence of a contingency at network level, the nominal availability of several Sentinel-2 Level-2A user-level data was affected between 25 and 28 September 2020. The data were recovered in the subsequent days.
- **08/10/20** 07:19-08:33 - The SSL certificate renewal activity caused the unresponsiveness of the following access points for about 1 hour and 30 minutes: the Open Hub, ColHub Node 1 and ServHub. The GUI was temporarily unreachable and some users might have experienced download problems using the APIs.
- **28/10/20** 17:19-18:36 – Unscheduled downtime experienced by the Open Hub (only SciHub access point) for 1h:15m, caused by an internal

issue in the database of the data catalogue, due to an out-of-memory that was fixed in short time.

- **3/11/20 - 4/11/20** 20:00 -12:00+1 - A link outage between the two T-Systems data centres provoked an unscheduled downtime on all T-Systems services for about 15 hours. The incident affected the following access points: the Open Hub (also including API Hub, and the POD Data Hub); ColHub - Node1; ServHub.

5.2 Network Analysis

Infrastructure upgrades

The network capacity during Y2020 continued to benefit from the two major infrastructure upgrades which were undertaken during 2018, when new firewalls were added to the infrastructure, upgrading the outward capacity of the infrastructure to 40Gbps, and the Frankfurt GÉANT Link was 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 Y2020, specifically on the Open Hub and ServHub infrastructures.

Data traffic loads

Since no new Copernicus missions were launched in Y2020 there were no particular increases of traffic load predicted for Y2020 other than the usual rise due to the ever-increasing number of active users and consequently more downloads being requested from the system.

Figure 80 shows the percentage of utilization of the network link during Y2020, with the blue lines showing the MAX and the green line showing the AVERAGE transmit rate reached on each particular day. This demonstrates that the user requests have been managed and the maximum peaks did not overpass the 40% of usage (with the exception of one day in October 2020).

During the first half of Y2020, average throughput of data disseminated to the data hub users increased from around 20 Gbps to around 25 Gbps, with peaks of near 28 Gbps observed. A stabilization of traffic was seen over the summer months, with average load at around 25 Gbps. Since September 2020, activity picked up again and the bandwidth throughput rose up to more than 32/33 Gbps for the rest of the year.

A short but significant drop in traffic to about 13 Gbps can be seen in May 2020. This was the result of several Pick up point VMs becoming unavailable, due to a problem on the power supply line of the data centre, as reported in the previous section.

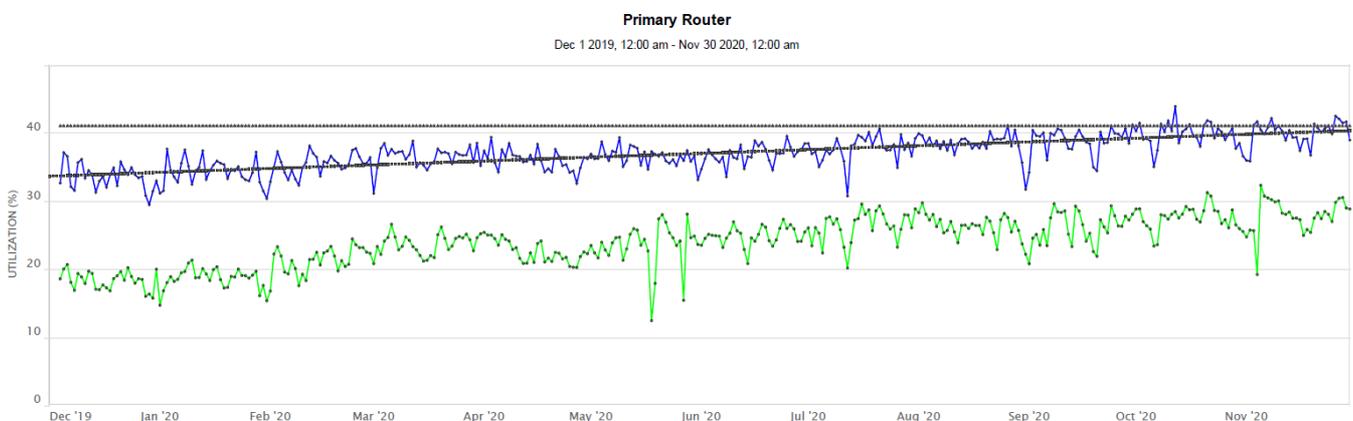


Figure 80: Percentage of utilization of the network link during Y2020 with the blue lines showing the MAX and the green line showing the AVERAGE transmit rate reached on each particular day

Effective bandwidth

Figure 81 below presents for each hub the percentage of completed downloads performed in Y2020 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 user-level data and the volume of that downloaded user-level data. The effective bandwidth depends on many factors, such as the actual network bandwidth available to the user, the performance required to save the user-level data on the user's disk, as well as the concurrent activities on the hub at the time the download is made. Figure 81 shows the effective bandwidth on each hub, taking into account all of the completed downloads during Y2020, as well as providing the combined statistics for all of the hubs together. This provides an approximate overview of the rates at which users of the hub were able to download the Sentinel user-level data.

Quite impressively this year, 56% of the effective bandwidth associated to the users of Open Hub was higher than 100 mbps.

For all hubs except the DIAS and IntHub, the most frequently experienced (or equal highest) effective bandwidth was >100 Mbps. This indicates that users of the Open Hub, ServHub and ColHub were for the most part able to download user-level data at a very fast rate.

For ServHub and ColHub Nodes 1 and 2, more than 65% of downloads took place at >100 Mbps; and for both the OpenHub and ColHub Node 3 over 40% of

downloads occurred at >100Mbps: 56% and 48% respectively.

For the Open Hub, the most frequently experienced effective bandwidth was >100Mbps range, with 56% of downloads from the Open Hub taking place in this range. This is considerably higher than the 23% and 18% registered respectively for Y2019 and for Y2018. The percentage of downloads taking place at 50-100 Mbps rose in Y2020: 26%, compared to 14% in Y2019. 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: 60% of all downloads were made at an effective bandwidth of >100 Mbps; the equivalent figure in Y2019 was 45% and for Y2018 was 36%. Moreover, 81% of downloads during Y2020 were made at speeds of over 50Mbps, up from 68% during Y2019. Enhancement of the network at the T-Systems operated hubs during Y2019 and Y2020 will certainly have contributed to these improvements.

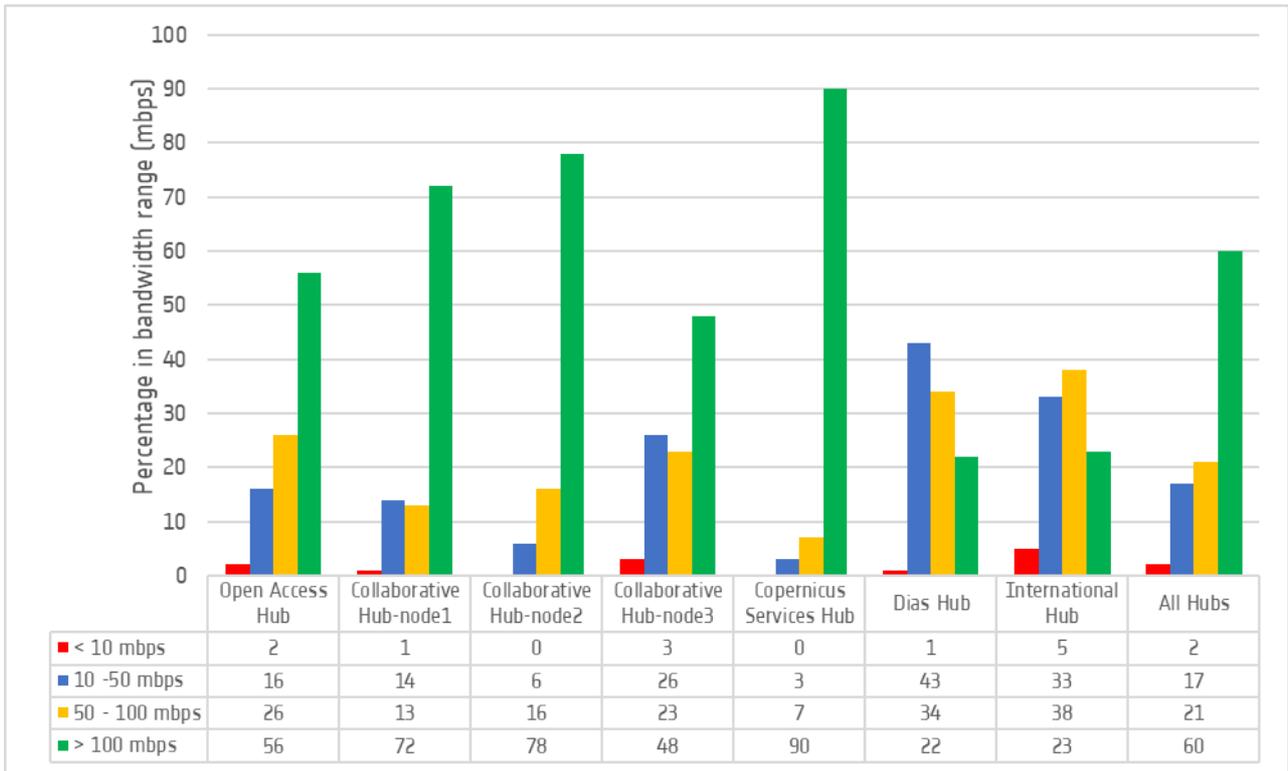


Figure 81: Effective bandwidth range per Hub for all completed downloads during Y2020

5.3 Publication Timeliness

Publication timeliness is a measure of the time it takes from the data being sensed by the satellite to the user-level data 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 user-level data in the processing and publication chain. The publication timeliness can be affected by a disturbance at any point in this production and publication chain.

User-level data are categorized as either Near Real Time (NRT) or Non-Time Critical (NTC). NRT user-level data 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 user-level data is that they will be published within 24 hours from sensing; for Sentinel-3 NTC user-level data the latency is 30 days from sensing, allowing consolidation of some auxiliary or ancillary data.

In this section, only user-level data 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 user-level data published after 7 days are either the result of reprocessing or exceptionally serious anomalies.

Open Hub

Figure 82 shows the average sensing-publication timeliness for Sentinel-1 NTC and Sentinel-2 NTC user-level data on the Open Hub during Y2020, and

the change with respect to the Y2019 values. As for last year, it is highlighted that the Y2020 average publication timeliness figures have been calculated over the last three months of the reporting period.

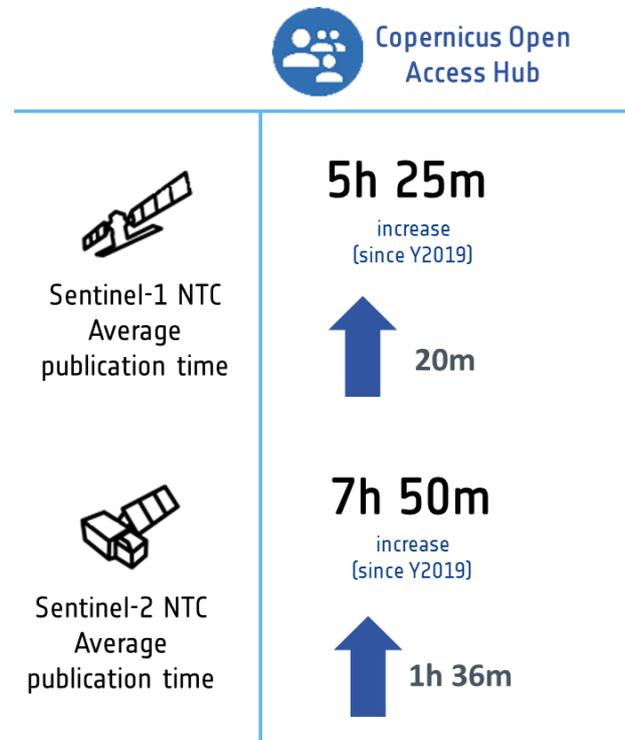


Figure 82: Average publication timeliness on the Open Hub over Y2020 for Sentinel-1 NTC and Sentinel-2 NTC user-level data, and comparison with Y2019

Sentinel-1 NTC user-level data were on average available for download within 5h 25m from sensing; and Sentinel-2 NTC user-level data on average within 7h 50m. For both sets of NTC data, this represents a small deterioration in the timeliness with respect to the average timeliness for Y2019. It is highlighted, however, that in comparison with the threshold, the publication timeliness of both Sentinel-1 and -2 NTC user-level data on the Open Hub calculated for Y2020 were well below the expected 24 hours.



Sentinel-3 Average publication time per instrument and timeliness

Instrument	Timeliness					
	NRT (<3h)	Increase/decrease since Y2019	STC (<48h)	Increase/decrease since Y2019	NTC (<1month)	Increase/decrease since Y2019
OLCI	2h 25m	+ 9m			1d 5h 12m	+ 34m
SLSTR	2h 13m	+ 4m			1d 6h 33m	+ 26m
SRAL	2h 6m	+ 5m	1d 4h 35m	+ 30m	25d 12h 12m	+ 1h 11m
SYNERGY			12h	+ 4h	1d 17h 21m	+ 1h 53m

Table 44: Average publication timeliness on the Open Hub during Y2020 for Sentinel-3 NRT, STC and NTC user-level data for each instrument

For Sentinel-3, the average Y2020 publication timeliness per instrument is shown in Table 44. Given the timeliness thresholds of <3h 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 user-level data take far longer than NTC user-level data from the other instruments – 25d 25h 12m – due to the need for specific consolidation of auxiliary data in this case. Comparing with the previous year, the publication timeliness related to the NTC user-level data of all the Sentinel-3 instruments was almost stable with a small increase/deterioration (<5%) with respect to the previous year.

The average publication timeliness of NRT user-level data from the OLCI, SLSTR and SRAL instruments remained well within the required 3 hour threshold.

There was, however, a noteworthy deviation with respect to the Y2019 publication timeliness for the SYNERGY STC user-level data, for which the timeliness increased by about 50% with an average period of 12h from sensing to publication.

Figure 83 shows the monthly average publication timeliness on the Open Hub for Sentinel-1 NTC and Sentinel-2 NTC user-level data during Y2020 (S-1 NRT user-level data are not available on the Open Hub and Sentinel 2 has no NRT user-level data on any Hub). The dotted lines show the monthly timeliness during Y2019 for comparison.

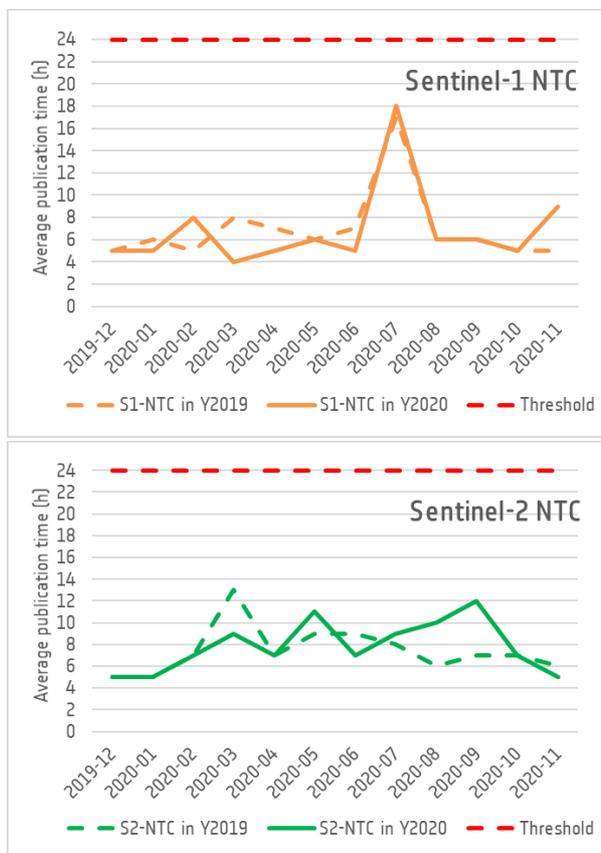


Figure 83: Monthly Average Publication Timeliness on the Open Hub for Sentinel-1 and Sentinel-2 NTC user-level data during Y2020, with Y2019 for comparison

For Sentinel-1, it can be seen that the monthly publication timeliness trend was similar to the that shown in Y2019, even repeating the peak in July, during which this year the average publication timeliness reached 18 hours, 3 times higher than the average timeliness during the other months of Y2020.

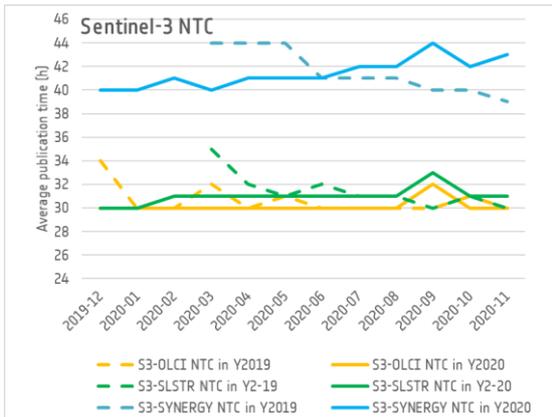


Figure 84: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 OLCI, SLSTR and SYNERGY NTC user-level data during Y2020, with Y2019 for comparison

The cause of the July peak this year was an anomaly on the Sentinel-1 ground segment on 11 July 2020, resulting in a delayed S1 NTC production during two days. However the 24 hour timeliness constraint was respected, on average, during each month. The best timeliness achieved was the 4 hour average recorded for March 2020.

For Sentinel-2, the trend again fluctuates though with less extreme peaks. Again, for all months the 24 hour threshold was respected. The best average timeliness achieved was the 5 hours recorded for three months, December 2019, January and November 2020. The worst case was the average timeliness of 12 hours recorded for September 2020.

Figure 84 shows the monthly publication timeliness of Sentinel-3 OLCI, SLSTR and SYNERGY NTC user-level data on the Open Hub. The graphs shows a stable publication timeliness trend during Y2020 and it is also worth mentioning that the introduction of the new user-level data type for S3B SL_2_FRP in August 2020 did not impact the timeliness in publication.

With respect to the previous year, the average monthly timeliness for the OLCI and SLSTR NTC user-level data improved, with the notable exception of the September average, in which the averages peaked at 33 and 32 hours. This was due to some issues at ground segment level which occurred on 15 September and 16 September 2020. The SYNERGY publication timeliness was also affected, and pushed the average for the month up to 44h. Overall, the

average monthly publication timeliness or the SYNERGY user-level data was worse during the second half of Y2020, and slower than the timeliness achieved in the same months in Y2019.

SRAL NTC user-level data are not shown on the graph due to the far longer timescale in which they are published which would distort the graph, but, as per last year, it is confirmed that an average monthly timeliness of 25 days was achieved throughout Y2020, below the 30 days threshold.

Figure 85 shows the monthly publication timeliness for each set of Sentinel-3 NRT user-level data on the Open Hub, with Y2019 for comparison. Note that some of the values which were higher than 6h during Y2019 were cut from the graph to improve the visibility of the Y2020 values.

The target 3-hour NRT timeliness was achieved for each instrument for all of Y2020, with the exception of August 2020 in which the publication timeliness registered was 5h for each NRT data type, driving the overall Y2020 average up to 2h 33m for SRAL, 2h 35m for OLCI and 2h 42m for SLSTR (the respective averages for Y2019 were 2h 1m/2h 16m/2h 9m, so an overall decay). This was due to an issue occurring at Ground Segment level on 31 August, which caused a temporary pause in production of OLCI, SLSTR and SRAL Near Real Time user-level data, and so delayed publication of the sensed data.

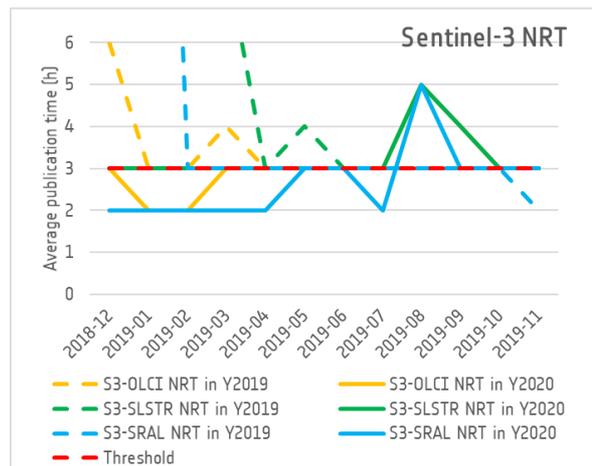


Figure 85: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 OLCI, SLSTR and SRAL NRT user-level data during Y2020, with Y2019 for comparison

Conclusions for S1, S2, S3 timeliness

Revisiting the publication timeliness of NTC user-level data, and excluding the month of July for Sentinel-1, August-October for Sentinel-2, and September for Sentinel-3, for which the anomalies have been described in the section above, the publication timeliness was 5h 7m for Sentinel-1, 6h 16m for Sentinel-2, 1d 4h 32m for S3 OLCI, 1d 6h for SLSTR, 25d 10h 56m for SRAL and 1d 16h 53m for SYNERGY. This is very comparable to the timeliness reported in Y2019 and indicates that outside these noted incidents, the performances in terms of timeliness were stable.

Sentinel-5P timeliness



Sentinel-5P
Average publication time per level and timeliness

Level	Timeliness	
	NRT	Offline
Level-1B		6h 3m
Level-2	2h 15m	2d 23h 17m

Figure 86 Average publication timeliness on the Open Hub during Y2020 for Sentinel-5P NRT and Offline user-level data, for each level

Sentinel-5P NRT user-level data shall be available for users to download within 3 hours from sensing and, as shown in Figure 86, during Y2020 the average time for publication of Sentinel-5P NRT user-level data was 2h 15 m, respecting the constraint.

The Sentinel-5P timeliness threshold for the Offline user-level data depends on the level: Level-1B shall be available to users to download within 12 hours of sensing, and Level-2 within 14 days. It can be observed that the average timeliness for Offline data during Y2020 respected the constraints and, moreover, most of the Level-2 OFFL user-level data are currently generated in 3 days, with the exception of the NO₂ that is disseminated in about 10 days and the O₃_TCL that is generated in 15 days.

Collaborative Hub



Collaborative Hub



Sentinel-1 NTC
Average publication time

5h 23m

increase
(since Y2019)



30m



Sentinel-2 NTC
Average publication time

7h 9m

increase
(since Y2019)



58m

Figure 87: Average publication timeliness on the Collaborative Hub over Y2020 for Sentinel-1 NTC and Sentinel-2 NTC user-level data

Figure 87 shows the average publication timeliness for Sentinel-1 NTC and Sentinel-2 NTC user-level data on the ColHub during Y2020, and the change with respect to the Y2019 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 Y2020 average publication timelinesses have been calculated over the last three months of the reporting period.

Almost identical behaviour can be seen for the ColHub as for the Open Hub. Again, there was a small deterioration in the timeliness for both Sentinel-1 and -2 NTC user-level data on the ColHub, with the Sentinel-1 publication timeliness rising from 4h 53m from sensing in Y2019 to an average of 5h 23m in Y2020. The average publication timeliness of Sentinel-2 user-level data rose by 58 minutes, to an average of 7h 9m from sensing.

The average monthly timeliness during Y2020 for Sentinel-1 NTC, Sentinel-2 and Sentinel-3 NTC on the ColHub are omitted because, as demonstrated by the

comparison of Figure 82 and Figure 87, the numbers are very similar to those reported for the Open Hub.

However it is interesting to see the behaviour of the Sentinel-1 and Sentinel-3 NRT timeliness on the ColHub. Figure 88 shows that the <3 hour target was achieved, on average, throughout Y2020. For the Sentinel-1 NRT user-level data, a 2 hour sensing-publication average was achieved for all months, apart from January 2020, in which the average rose to 3 hours.

For Sentinel-3 NRT production, a similar trend is again observed to that of the Open Hub: some timeliness transgressions occurred during Y2020, with the 3 hour threshold then being respected for all user-level data types with exception of August and September 2020 for NRT data from the OLCI and SLSTR instruments, and for August 2020 for SRAL. The reason may be attributed to the issue on the ground segment which, as described in the Open Hub section, temporarily delayed the production of NRT user-level data on 31 August. However, it can be seen that, with respect to the Open Hub timeliness, the impact on OLCI and SLSTR NRT publication timeliness on ColHub was more significant and the average monthly publication timeliness for the NRT data rose to 6 hours from sensing, as opposed to 5 hours on the Open Hub.

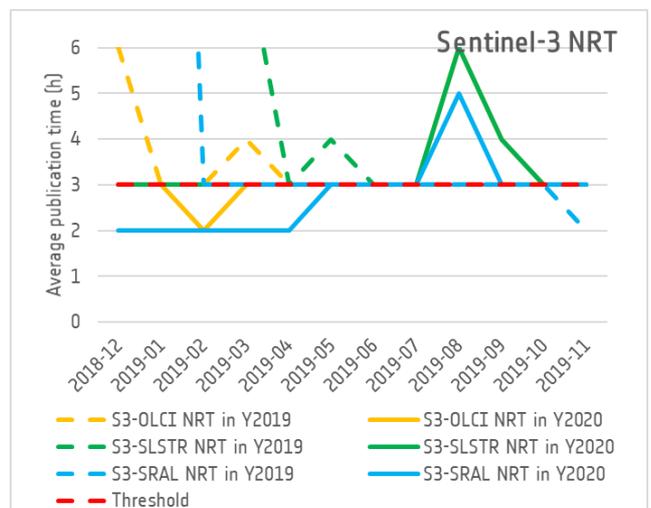
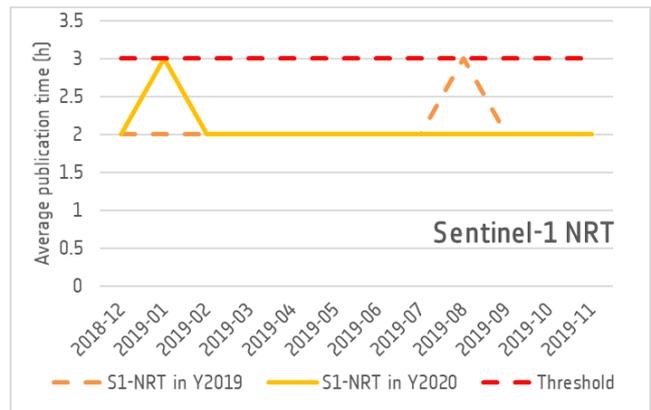


Figure 88: Monthly Average NRT Publication Timeliness on the Collaborative Hub for Sentinel-1 and Sentinel-3 user-level data during Y2020, with Y2019 for comparison

5.4 Data Hub Maintenance and Software Improvement

During Y2020, the Maintenance Team of the Data Hub Service focused on:

- an evolution of the data-flow scenario, to improve the retrieval of fresh user-level data from upgraded GS interfaces and to extend the offline user-level data retrieval from the DIAS Service;
- the implementation of Sentinel-2 On-Demand interface support, to enable the processing of Sentinel-2 L2A user-level data from the GS. However, this feature was not transferred into operations on any of the data hubs, in favour of the next feature listed;
- the enhancements of the LTA Broker interface for Orders monitoring and quota management;
- the support for the publication of a new set of Copernicus Sentinel user-level data (further details are provided below);
- the introduction of a tool to migrate externalized DHuS databases.

The introduction of the new Copernicus Sentinel GS Pick-Up Points (PRIP) being performed in the frame of the ESA 'Copernicus Ground Segment Transformation' project gave the team the chance to introduce a new Download Manager for retrieving the systematic production of fresh user-level data, replacing the current set of diverse download managers (i.e. GMP, GMP₃, DAG-C) in the DHuS scenario. The purpose of the new Download Manager is to provide a configurable and flexible download manager solution for all instances interacting with PRIP interfaces. Dedicated integration phases have been achieved with success involving the Sentinel-1 and Sentinel-3 PRIP Interfaces.

Furthermore, the data-flow scenario has been extended with the design and implementation of a solution which enables the DHuS to use the DIAS Service as a data source for historical user-level data. This development is in anticipation of the implementation of the Ground Segment

Transformation, as described further in Section 1.2.1. The use of ONDA DIAS has opened the way to replacing the legacy LTA component for the provision of Sentinel-1, Sentinel-2 (including Level-2A) and Sentinel-3 historical user-level data. The implementation of the new solution also provided the opportunity for improving the download process, the Orders monitoring and quota management, for both user quota and Service quota. This has been providing a better user experience during the retrieval of offline user-level data and related order monitoring.

The set of Copernicus Sentinel user-level data supported by the DHuS has been increased, to allow the management of new mission user-level data. The DHuS is now able to manage:

- Sentinel-3 SLSTR Level 2 Fire Radiative Power (SL_2_FRP___) user-level data with relevant computed quicklook;
- Sentinel-3 SYNERGY Level 2 Aerosol Optical Depth AOD (SY_2_AOD___) user-level data;
- Sentinel Auxiliary POD Quaternions (AUX_PROQUA) user-level data.

5.5 Open Source DHuS Framework

The Data Hub Software (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 archive of Copernicus Sentinel user-level data:

(<http://sentineldatahub.github.io/DataHubSystem/>).

DHuS Releases

No new versions of the OSF software were released during the reporting period.

A further release of the DHuS is planned for Y2021. It will support Sentinel Auxiliary POD and RINEX files, Sentinel-3SL_2_FRP___ and SY_2_AOD___ user-level data types and SMOS data; together with the extraction of further Sentinel-2 metadata.



Open Source DHuS Downloads

At the close of Y2020, the total number of downloads of all versions of the OSF was 5,855, up from 5,008 in Y2019. Specifically concerning v2.0 (released in March 2019), the total downloads numbered 1,109 at the close of Y2020, up from 478 by the end of Y2019.

Support to OS Community

Technical support has been provided to the different users (typically institutional agencies and research centres), through a dedicated Role Account (DataHubSystem@serco.com).

6 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 the first line contact point for all issues concerning Copernicus Sentinel 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 they specifically relate to data access, they are forwarded to the Sentinel Data Access System operations team for resolution.

Ticketing Analysis

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 reset, credentials loss, deletion, edit profile issue)
- **Features Request:** Improvements suggested by users about all the topics of ticket categories
- **Products:** Issues relating to the user-level data itself (production coverage, data quality, external tool usage, data 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 (any related issue is then managed in the maintenance cycle)
- **General:** Miscellaneous requests which do not fit into another category
- **Junk:** Spam, Empty emails, Not an issue

During Y2020, a total of 1,252 tickets were received, which is a 27% decrease with respect to Y2019. The 'Junk' category - which was the largest category in Y2019 and Y2018 – still accounted for as many as 263 tickets (21%). Of the meaningful categories, the largest proportion of tickets were for 'User Accounts' (568 tickets/45%) and 'Service Interface' (304 tickets/24%), followed by 'Products' (72 tickets/6%) and 'General' (44 tickets/3%). As in previous years, very few tickets were received for the remaining categories: in particular, during Y2020 only 1 ticket was raised for 'Web Portals' and zero tickets for 'Features Requests' and 'Bug'. Figure 8g shows the percentage split between the categories during Y2020.

During Y2020, 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 18 minutes and 40 seconds (halved with respect to Y2019). The maximum response time for any ticket was 20 hours 48 minutes which was quicker than the slowest response registered during Y2019 (1d 10h 26m).

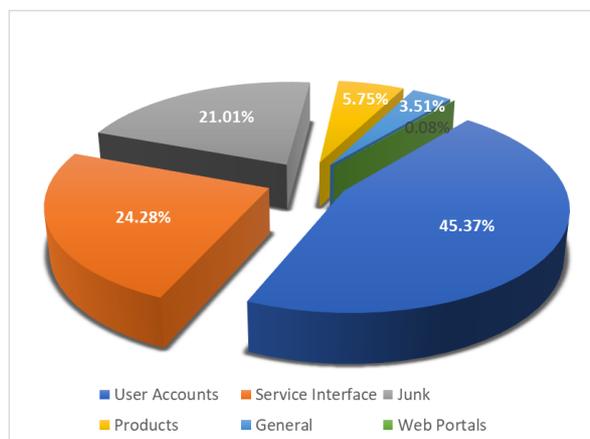


Figure 8g: Proportion (percentage) of each category of tickets received from the Open Hub in Y2020

7 Y2021 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 user-level data types. However, the major change and challenge will be continuing the migration of the Data Access Service to a public cloud environment, as part of ESA's 'Ground Segment Transformation' project, as described in Section 1.2.1 above.

The main objective during Y2021 will be to make the Data Access System completely independent from the current dedicated infrastructure, which is reaching its end-of-life. The transition will be performed by implementing the software features which are necessary to perform a lift-and-shift process towards a commercial cloud environment. The transition is scheduled to be completed at the end of Q2 2021.

The DHuS 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 during Y2021 will be to extend the service improvements which are possible when operating in a cloud environment to the entire Data Access System.

The main challenge of the Data Access transition in Y2021 will be the parallel execution of application and

data migration tasks while upgrading the current DHuS system solution to cope with the new CSC data production interfaces. The Data Access system will fetch data from new infrastructure agnostic solutions designed for exposing data generated by the mission production components, instead of fetching data from the current GS data production solutions deeply connected to the infrastructure provided by ESA. This system upgrade represents an additional step for the complete CSC GS transition to the cloud.

The Data Access team will continue to focus on maintaining untouched the interfaces operated by the Data Access System (APIs and GUI), and guaranteeing the same data offer currently available online, ensuring that fresh data will be available for immediate download and the access to the historical data will be guaranteed by the DHuS-DIAS interface..

The Data Hub users will be notified in advance about the transition schedule, keeping in mind that the objective is to avoid any interruption of the service.

In addition to this evolution of the Data Access infrastructure, Y2021 is the year in which reactivation of a number of elements in the Data Hub Relay network is foreseen.

8 Useful Links

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

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 user-level data 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

PAC	Processing and Archiving Centre
GS	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 user-level data 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

Annex 2: User-level data Type Description

The following table provides:

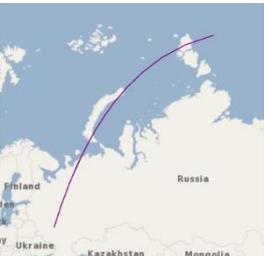
- the description of user-level data types per each mission,
- the image of how their footprints are visualized on the hub,
- the average size of the user-level data based on the calculation of the annual published user-level data. The sizes given are based on the download volume, i.e. the compressed zip file (average compression rates are provided where applicable, i.e. for Sentinel-1 user-level data).
- a short discussion on what new/changed user-level data have appeared in 2018.

Further information on user-level data can be found on the 'Instrument user guides' following the link: <https://sentinel.esa.int/web/sentinel/user-guides/>

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
Sentinel-1 (SAR)	Lo-RAW	Sentinel-1 Level 0 RAW data		1.3 GiB	
	L1-GRDM	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: Medium Resolution		200 MiB	
	L1-GRDH	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: High Resolution		860 MiB	
	L1-SLC	Sentinel-1 Level 1 Single-Look Complex		4 GiB	

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
	L2-OCN	Sentinel-1 Level 2 Ocean		5 MiB	
Sentinel-2 (MSI)	MSIL1C	Sentinel-2 Level 1C		480 MiB	
	MSIL2A	Sentinel-2 Level 2A		600 MiB	Global coverage from 13/12/18 (previously Euro-Mediterranean region only)
Sentinel-3 (OLCI)	OLCI L1 FR	Sentinel-3 Level 1 OL_1_EFR___ Full Resolution top of atmosphere radiance		600 MiB	Activation of Sentinel-3B data on 17/12/18
	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 user-level data		100 MiB	Activation of Sentinel-3B data on the Open Hub on 24/01/19

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
	OLCI L2 Land RR	Sentinel-3 Level 2 OL_2_LRR___ Reduced Resolution Land & Atmosphere geophysical user-level data		170 MiB	
Sentinel-3 (SLSTR)	SLSTR L1 RBT	Sentinel-3 Level 1 SL_1_RBT___ Brightness temperatures and radiances		480 MiB	
	SLSTR L2 Land	Sentinel-3 Level 2 SL_2_LST___ Land Surface Temperature geophysical parameters	<p>The footprint for this user-level data type depends on timeliness:</p> <p>NRT</p> <p>NTC</p>	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

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data 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/PLRM), waveforms. Over Land	<p>The footprint for this user-level data type depends on timeliness:</p> <p>NTC and STC</p>  <p>NRT (covering only LAND regions)</p> 	36 MiB	Activation of Sentinel-3B data on 11/12/18

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
Sentinel-3 (SYNERGY)	SY_2_SYN	Surface Reflectance and Aerosol parameters over Land		300 MiB	Activation on the Open Hub from 25/03/19
	SY_2_VGP	1 km VEGETATION-Like user-level data (~VGT-P) - TOA Reflectance		35 MiB	
	SY_2_VG1	1 km VEGETATION-Like user-level data (~VGT-S1) 1 day synthesis surface reflectance and NDVI		70 MiB	
	SY_2_V10	1 km VEGETATION-Like user-level data (~VGT-S10) 10 day synthesis surface reflectance and NDVI		175 MiB	

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
Sentinel-5P (TROPOMI)	L1B_RA_B D1	Radiance user-level data 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	
	L1B_RA_B D2			2: 2.8 GiB	
	L1B_RA_B D3			3: 2.7 GiB	
	L1B_RA_B D4			4: 2.6 GiB	
	L1B_RA_B D5			5: 2.6 GiB	
	L1B_RA_B D6			6: 2,6 GiB	
L1B_RA_B D7	7: 1.5 GiB				
L1B_RA_B D8	8: 1.6 GiB				
	L1B_IR_UV N	Irradiance user-level data UVN module 270-775 nm	-	30 MiB	
	L1B_IR_SIR	Irradiance user-level data SWIR module 2305-2385 nm	-	6 MiB	
	L2_AER_AI	UV Aerosol Index		13 MiB	
	L2_AER_L H	Aerosol Layer Height		120 MiB	NRT and OFFL user-level data available on the S5P PreOps Hub from 30/09/19
	L2_CLOUD	Cloud fraction, albedo, top pressure		25 MiB	

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
	L2_CO	Carbon Monoxide (CO) total column		12 MiB	
	L2_CH4	Methane (CH4) total column		40 MiB	OFFL user-level data available on the S5P PreOps Hub from 01/03/19
	L2_HCHO	Formaldehyde (HCHO) total column		60 MiB	OFFL user-level data available on the S5P PreOps Hub from 05/12/18
	L2_NO2	Nitrogen Dioxide (NO2), total and tropospheric columns		35 MiB	
	L2_NP_BD' x'	Suomi-NPP VIIRS Clouds X = 3, 6, 7		330 MiB	
	L2_O3	Ozone (O3) total column		25 MiB	

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in Y2019
	L2_O3_TCL	Ozone (O ₃) tropospheric column	-	1 MiB	OFFL user-level data available on the S5P PreOps Hub from 01/03/19
	L2_SO2	Sulphur Dioxide (SO ₂) total column		85 MiB	OFFL user-level data available on the S5P PreOps Hub from 05/12/18