

2022

Copernicus Sentinel Data Access Annual Report



→ Foreword



This Annual Report is packed with statistics showing, once again, that ESA's Copernicus Sentinel Ground Segment processed and delivered an immense volume of data to users, with good stability and availability. This has been the final year of full operations for the Sentinel Data Access System, and I am pleased to see how well it continued to perform its crucial role in the Sentinel Ground Segment chain, getting the data out to users.

I asked to write the Foreword to the Report this year to record my appreciation for the remarkable achievements of the partners in the Serco-led consortium over the past eight years in operating the Sentinel Data Access System. The consortium, consisting of Serco SpA, Gael Systems, the National Observatory of Athens, and GRNET SA, has been with ESA since the start of Copernicus operations back in 2014, and throughout all that time it has managed the evolution in the uptake of Copernicus Sentinel data with notable agility. Between 3 October 2014 and 30 November 2015, the System had to cope with nearly 3 million downloads by users. In 2016, it was recognised that Copernicus had already become the 3rd largest data provider in the world¹. By 31 December 2022, users had made as many as 775,769,051 downloads of Copernicus Sentinel data from the data hubs, meaning the System had distributed a total of 405 PiB of data to users all across the world. The Data Access System, which was initially designed to serve mainly the download requests of the six Copernicus Services, was able to cope with this massive and rapid expansion.

The overall service performance of the consortium has been excellent. The team has responded immediately whenever serious interventions were needed, such as when a step change in the system infrastructure was enabled to cope with increased demand. When a dramatic re-routing of the entire data flow was required after a fire broke out at the data centre hosting critical elements of the access system in March 2021, the team managed to reconfigure the interfaces and restore the data flow in just two days. The fire took place right at the time the consortium was transferring the Data Access System to a cloud-based architecture, and thanks to the increased flexibility and redundancy they secured with this new infrastructure, no Copernicus data was lost.

In addition to the technical management of the operations, the consortium has served as the interface for over 700,000 registered users. The team has dealt with over ten thousand tickets raised by users. It has also provided continuous support to ESA with its reporting requirements and in ensuring information about the performance of the System is transparent and freely available. Each year the team has compiled this annual report packed with valuable statistics. The Sentinel Data Dashboard gives hourly updates on the uptake of Sentinel data from the System and on the System's performance. The active preparation for and participation at all of the related conferences and workshops has also been hugely appreciated.

ESA is of course looking forward to the next phase of Copernicus Sentinel data access, with the new consortium led by T-Systems and the exciting Copernicus Data Space Ecosystem. However, this is the right place and time to thank the Serco-led team for the huge successes of the Copernicus Data Access System.

Nicolaus Hanowski
Head of the Mission Management & Ground Segment Department
Directorate of Earth Observation Programmes, ESA

¹ 'Copernicus Market Report', Issue 1, dated November 2016, prepared by PwC for the European Commission

→ 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 the Serco Gael consortium for ESA as part of the Copernicus programme.

Written by:

Adriana Grazia Castriotta
Serco SpA

→ Documentation

Reference documents

Key	Title	link
[RD-1]	Sentinel High Level Operations Plan (HLOP)	https://sentinels.copernicus.eu/documents/247904/685154/Sentinel+HLOP+-+Issue+3.1+-+16+Dec+2021.pdf/272ed3c8-999f-5178-e9fo-9a4d1b85a697?t=1641968029861

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)
Y2021	Refers to the reporting period covered in the previous reports, from 1/12/20 - 30/11/21. Similarly, Y2020 refers to the previous reporting period: 1/12/19 - 30/11/20; Y2019 to the reporting period 1/12/18 - 30/11/29; Y2018 to the reporting period 1/12/17 - 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. The Copernicus Data Access System retrieves the Copernicus Sentinel-1, -2, -3 (land) and -5P user-level data from the relevant ground segment 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 Data Access System operated by ESA during 2022 and analyses the trends visible in the public uptake of Copernicus Sentinel data. This is the eighth such report released by the data access service provider, Serco Italia SpA. This year ESA has decided to align the reporting year with the calendar year, in order to coincide better with the reporting needs of the European Commission. Whereas in previous years the annual report covered the period 1 December to 30 November, therefore, this year the reporting year runs from 1 January 2022 to 31 December 2022. As a result, statistics for the month of December 2021 are not included in the figures for the year 2022. They are, however, included in all cumulative statistics, unless explicitly stated otherwise.

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. In 2022, the **68 millionth** data package was published on the Open Hub and on average almost **40,000** data packages were published per day. Moreover, the number of registered users on the Open Hub increased again, from 496,382 users at the end of Y2021 to **638,259** by the end of 2022, and there were 108 countries across the world with more

than 500 registered users, a rise from 96 at the end of Y2021.

Despite the growing shift towards local processing on cloud-based data collections, such as those on the five DIAS, as many as **161,656,822** data packages were downloaded in 2022 alone, and **99,046** individual users from across the globe made at least one complete download during the year.

These figures suggest that there is still considerable demand for download services as well as hosted processing services, and not only that the existing user base consolidated but also that word is continuing to spread, and more and more users around the world are starting to engage with the potential contained in the vast stores of free and open data available through the Copernicus Data Access System.

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

- **2022:** 1 January 2022 – 31 December 2022 (this report)
- **Y2021:** 1 December 2020 – 30 November 2021 (report released on 26 May 2022)
- **Y2020:** 1 December 2019 – 30 November 2020 (report released on 07 September 2021)
- **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 free and open access to Copernicus Sentinel user-level data to defined groups of users. 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.

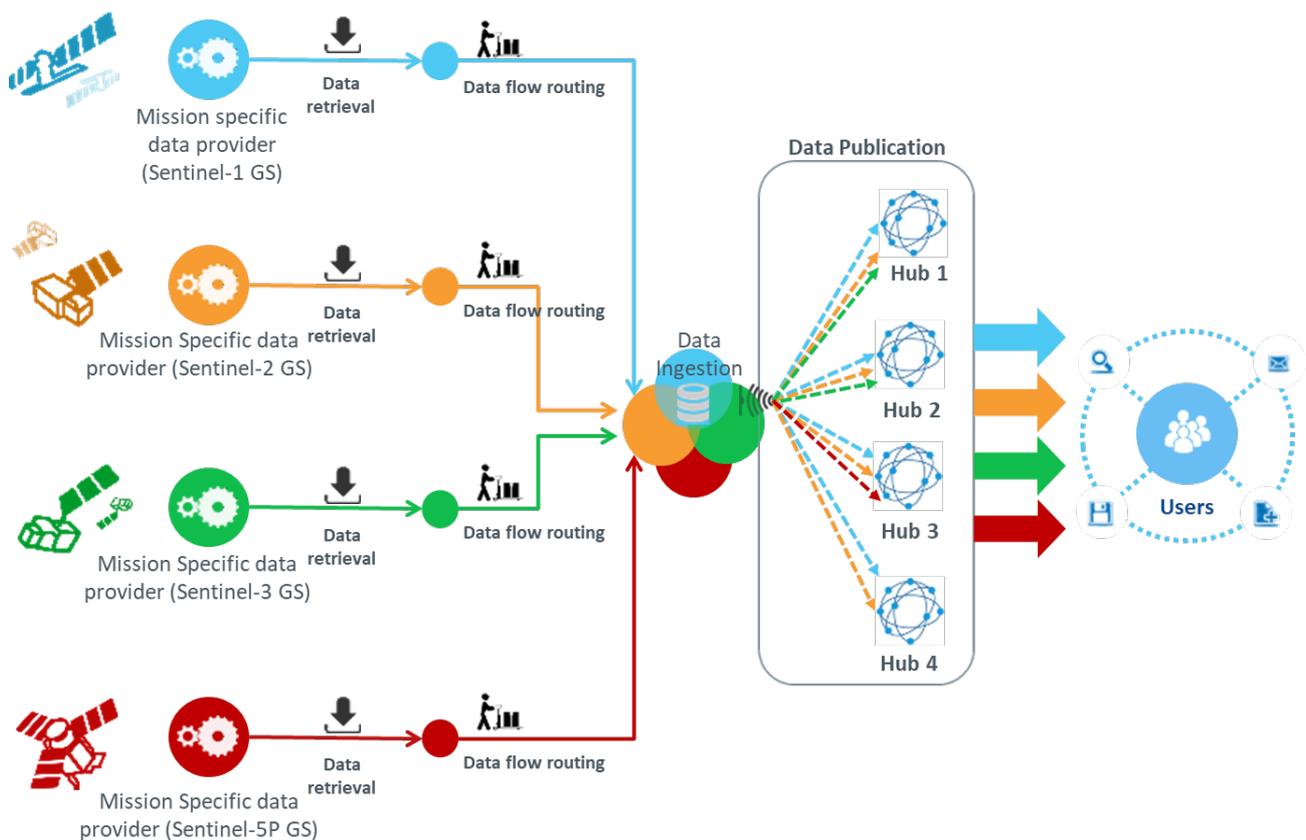


Figure 1: Copernicus Sentinel Data Access System Model

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 above illustrates the flow of data through the system.

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 1. Each is described in more detail below.



Figure 2: The Sentinel Data Access System Configuration at the end of 2022

1.1.1 Data Access Hubs

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 on the Open Hub 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.

Since 30 November 2020, all data are managed within cloud storage systems. The fresh data are made available for immediate access, whereas older (less used) data are available from DIAS cloud archives for asynchronous access. The current configuration is that the latest six months of data are available for immediate access, and all other data are available

from the cloud archive. These archived data are generally made available for download within 60 minutes of the user making the request (it can be less, depending on the size of the data). Further details of the configuration and performances are outlined in section 0.

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, access to the first data is restricted to 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, and there are still two in operation: the Sentinel-3 Expert Hub, which distributes only the Sentinel-3 MISR data, 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.

As soon as the Sentinel-5P user-level data were qualified, they have been available to the public on a dedicated hub called the Sentinel-5P Hub. Having this separate data flow for the Sentinel-5P data has enabled the team to keep all the Level-2 and L1B_RA

and L1B_IR user-level data available for immediate access. This configuration continued in 2022. The Sentinel-5P Hub provides access to all standard user-level data from Sentinel-5P published to date, and Near Real Time (NRT) user-level data from the current 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 Level-1B RINEX user-level data relevant to the 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) hosts a back-up of the last week of the published user-level data 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 continuity of the service, with all 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 the same Rolling Policy for removing data from the online access as the Open Hub and the Collaborative Hub: 6 months of user-level data is kept online (see Figure 3). Access to the nearline data 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. Those 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. 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 also 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 Collaborative Ground Segment (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 3 summarises the overall Sentinel Data Access System front-end configuration at the end of 2022. 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 statistics on this service are not covered by this report. Further information can be found at:

<https://www.eumetsat.int/website/home/Data/DataDelivery/CopernicusOnlineDataAccess/index.html>

1.1.2 Data Access System Physical Architecture

During 2021, a major evolution of the architecture of the overall Data Access System was implemented, as part of its transformation to a cloud-based infrastructure. This section provides a brief overview of the updated physical architecture of the Data Access System. Further detail about the transition to the cloud is provided in Section 1.2 below.

Figure 4 shows the full set of hubs operated by the Data Access System is shown in the diagram, along with the Centre which operates them. On the left of the diagram, 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 and two Complementary Centres. Core and Complementary Centres share the ingestion of the user-level data as depicted by the lines in Figure 4. During 2021, the Core Centre was transferred to the OVH Cloud infrastructure, so the Core Centre and one of the two Complementary Centres are now run on the OVH Cloud infrastructure and operated by Serco Italia SPA and Gael respectively. The other Complementary Centre is run on the GRNET infrastructure and operated by NOA.

The Open Hub and ServHub are operated from the Core Centre 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 synchronized by the Complementary Centre.

The dashed lines illustrate the asynchronous data retrieval flows for recalling archived user-level data from Sentinels-1, -2 and -3. This revised configuration for the retrieval of archived data has been in place since 30 September 2020 for Sentinel-2, and 30 November 2020 for Sentinel-1 and Sentinel-3.

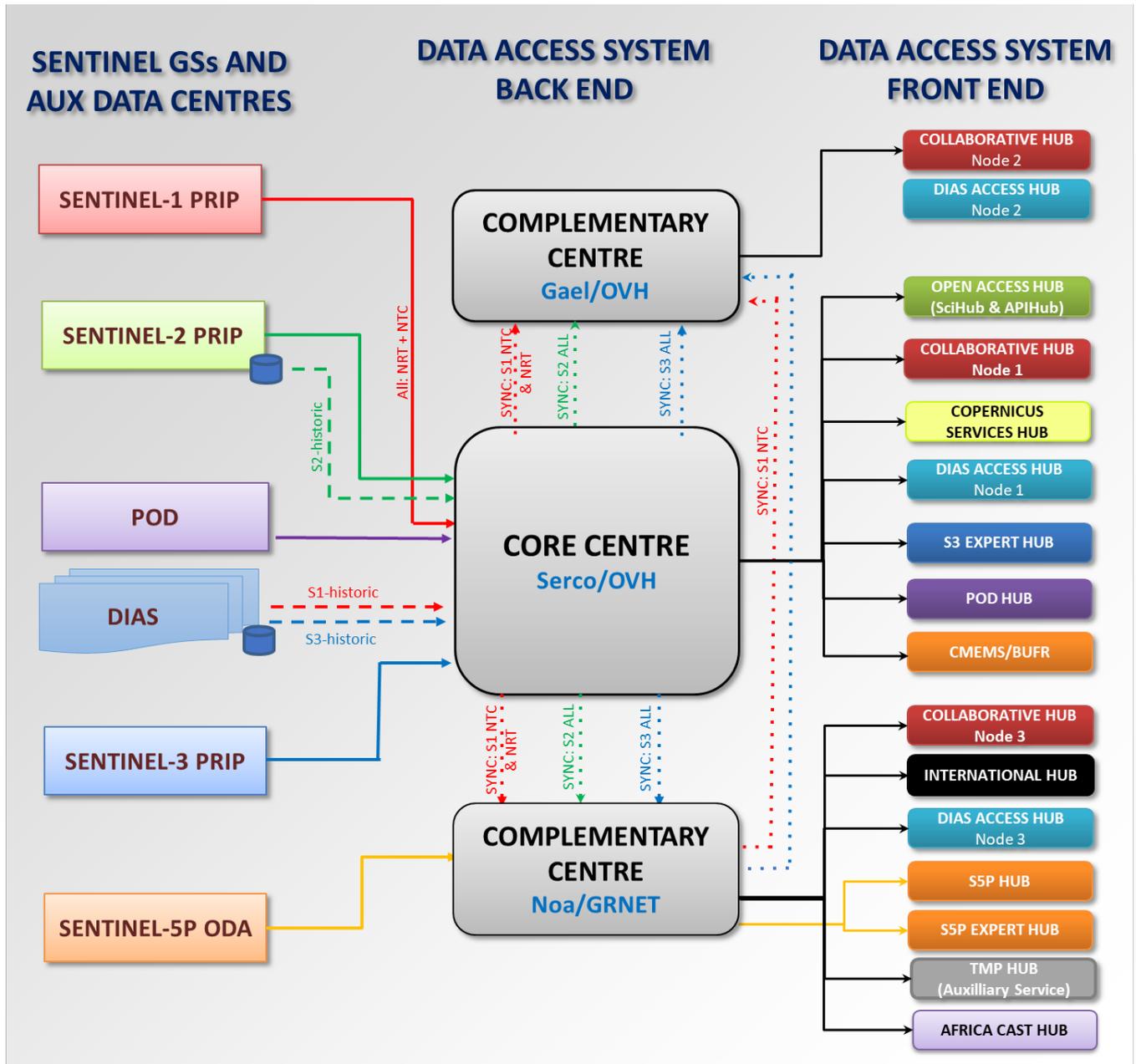


Figure 4: Data Access System Physical Architecture Overview

1.2 Main Evolutions of the Data Access System in 2022

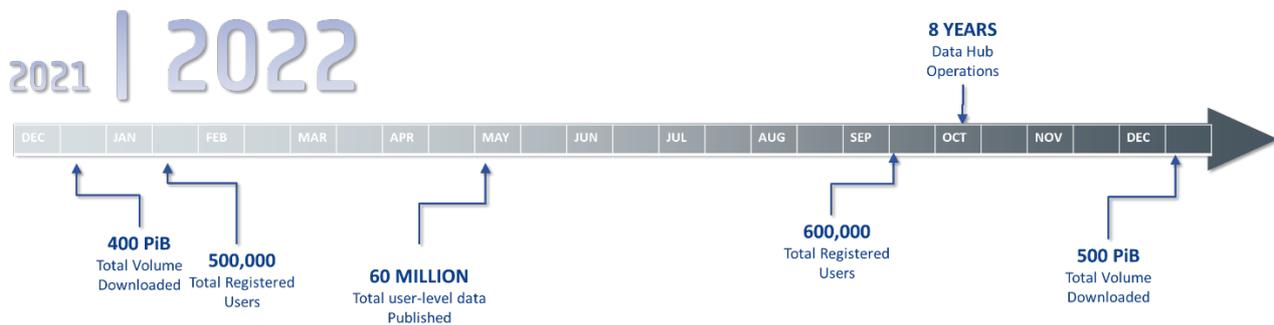


Figure 5: Timeline of the main 2022 achievements related to data dissemination of the Data Access System

In 2022, the major transformation of the Sentinel Data Access System was completed. This transformation took 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 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.

In April 2022, the latest configuration of PRIPs for Sentinel-1A, Sentinel-2A and -2B, Sentinel-3A and -3B were transferred to operations, completing the new configuration of the Copernicus Sentinel ground segment.

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, are now 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 service now makes the output data available in an interface delivery point located on a cloud-based environment, which is logically considered part of, and under the responsibility of, the data source service.

Figure 6 below sets out the high-level design of the Copernicus Sentinel ground segment, based on this concept [taken from CSC Operations – ESA Framework – Ground Segment Architecture ESA-EOPG-EOPGC-TN-7].

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

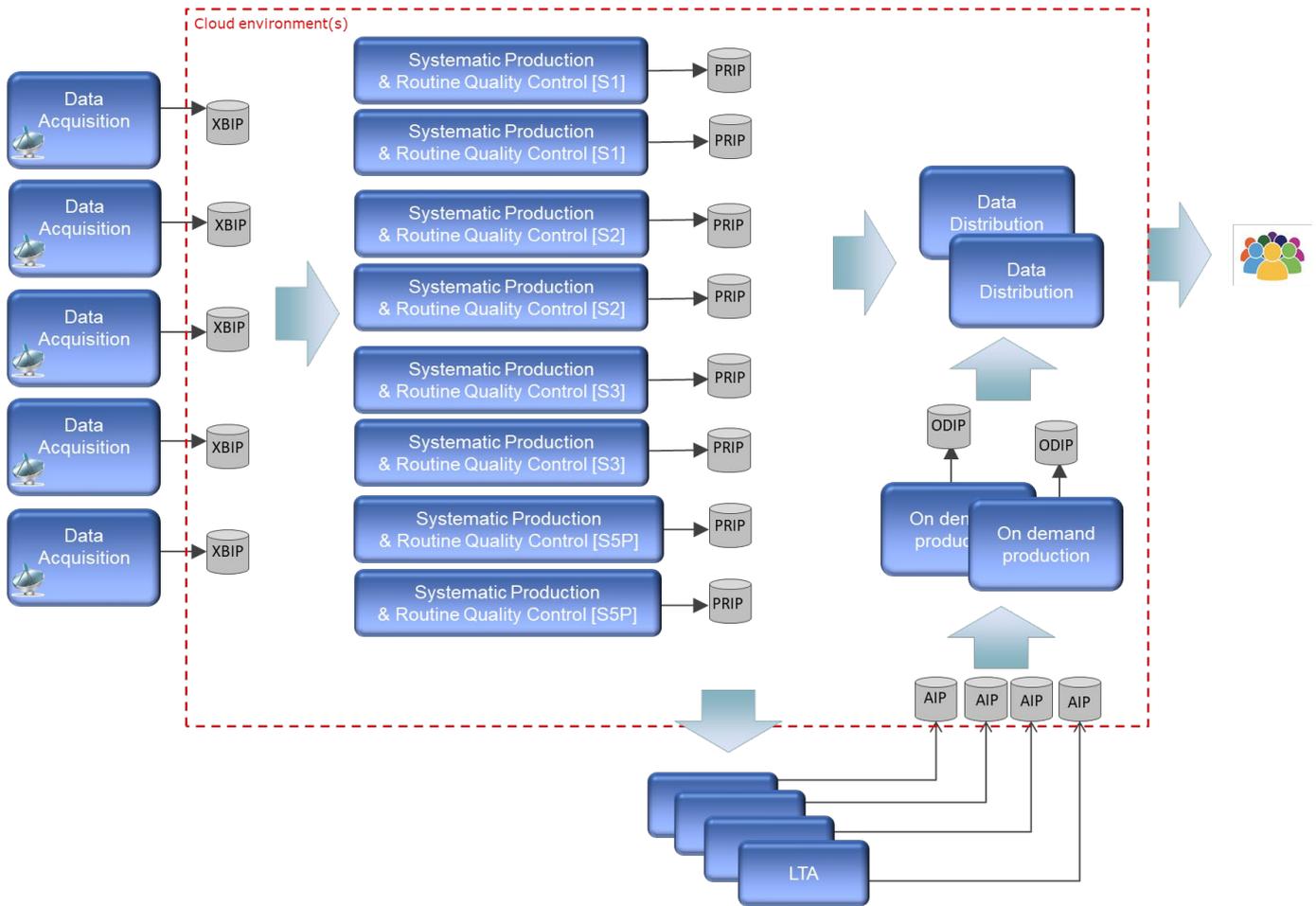


Figure 6: high level design of the 'transformed' Copernicus Sentinel ground segment

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 will remain 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 for ensuring 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);

- o Rolled-out data may be re-generated on-the-fly, following 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 2022, no major changes to the public cloud environment, provided by OVH cloud hosting service, were performed.

1.3 Main Developments in the Data Offer in 2022

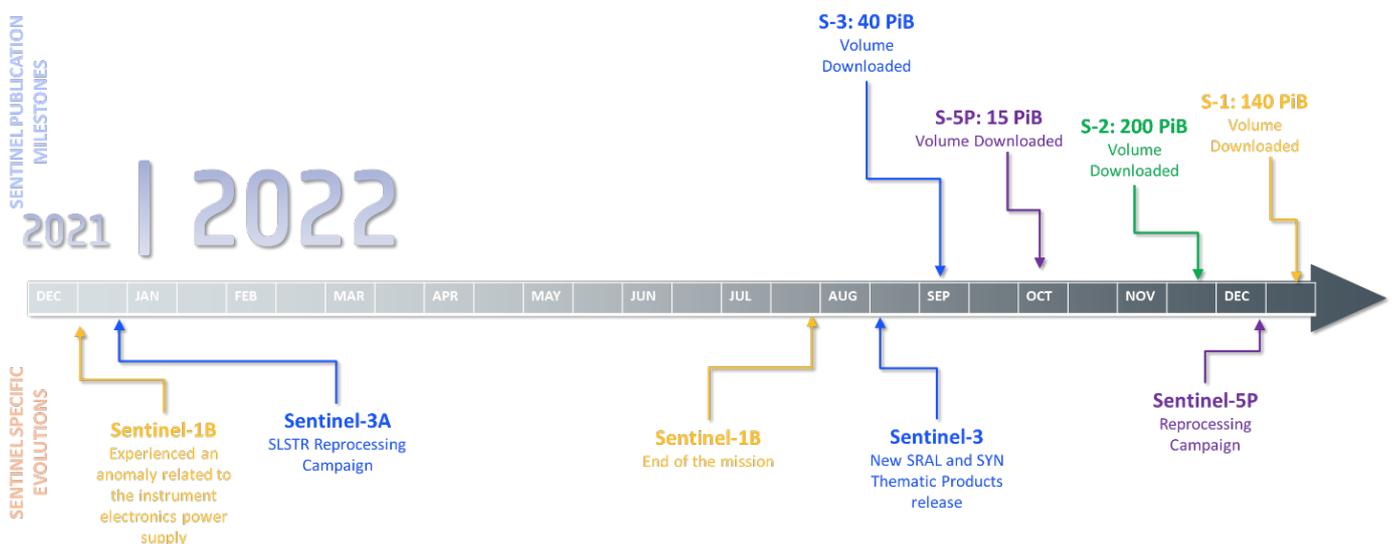


Figure 7: Timeline of the main 2022 achievements related to Sentinel mission-specific user-level data publication and evolutions

Sentinel-1

On 23 December 2021, Copernicus Sentinel-1B experienced an anomaly related to the instrument electronics power supply provided by the satellite platform, leaving it unable to deliver radar data. Spacecraft operators and engineers spent the following months working tirelessly to rectify the issue. Unfortunately, despite all concerted efforts, on July 2022, ESA and the European Commission announced the end of the mission for Sentinel-1B. Copernicus Sentinel-1A remains fully operational and plans are in force to launch Sentinel-1C as soon as possible.

As a consequence, the observation scenario of Sentinel-1 has been modified, to maximise as far as possible the acquisitions available with just one satellite. The updated Sentinel-1A observation plan, which was put into operation in September 2022. An overview of the revised Sentinel-1A observation plan and the previous configuration, for comparison, are shown on the two maps in Figure 8 below.

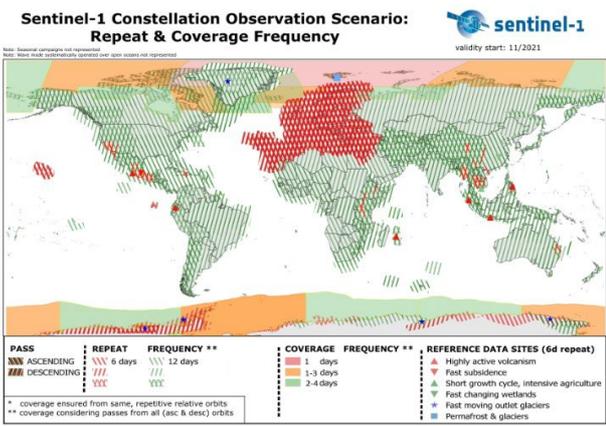
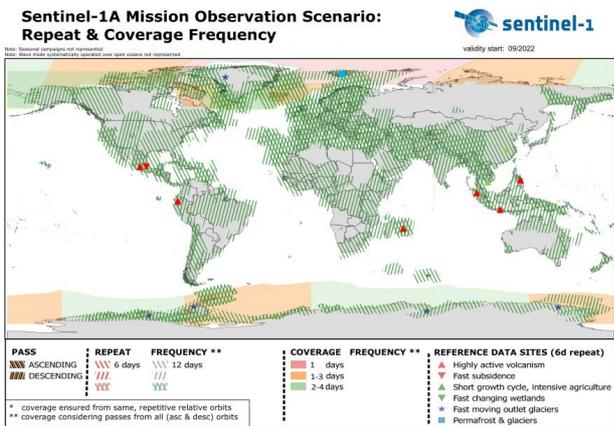


Figure 8: Sentinel-1A observation plan in terms SAR mode, polarisation, observation geometry, revisit and coverage frequency, starting as of September 2022 (on the left), and the previous configuration for comparison (on the right)

The number of Sentinel-1 user-level data published since the start of operations reached ~8,000,000, and the volume of Sentinel-1 downloads made since the start of operations reached ~140 PiB.

Sentinel-2

With over 40,000,000 Sentinel-2 user-level data having been published in 2022, and 204PiB of data downloaded since the start of operations, Sentinel-2 remained the mission with the highest volume of both published and downloaded user-level data of all the Sentinel missions in 2022. No changes concerning its data offer during 2022 were made.

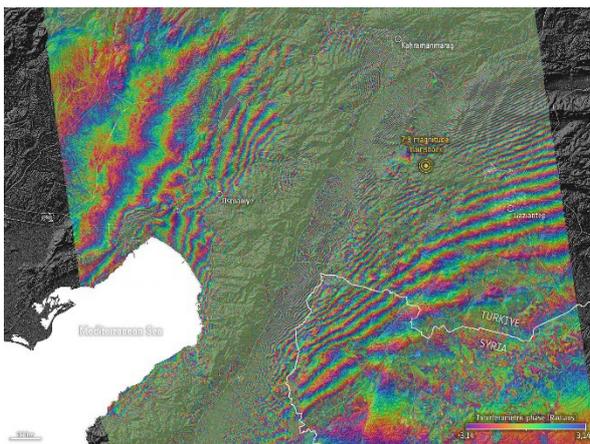


Figure 9: Interferogram showing the seismic surface displacement in the area near Gaziantep, generated from multiple Copernicus Sentinel-1 scans – before and after the earthquakes on 8 Feb 2023. (contains modified Copernicus Sentinel data (2023), processed by ESA, CC BY-SA 3.0 IGO)



Figure 10: Part of Puglia, or Apulia, a region in southern Italy, is featured in this image captured by the Copernicus Sentinel-2 mission in June 2022 (contains modified Copernicus Sentinel data (2022), processed by ESA)

Sentinel-3

There were a few changes at the level of individual Sentinel-3 user-level data types during 2022:

- Sentinel-3A SLSTR Reprocessing Campaign: this activity, which began in December 2021, involved SL_1_RBT and SL_2_LST product types with sensing time interval of 01/05/2018 - 16/01/2020 and 01/05/2018 - 16/01/2020 respectively.
- Sentinel-3 SRAL Land SYNERGY new product types were introduced in August 2022: SR_2_LAN_HY, SR_2_LAN_LI, SR_2_LAN_SI and SY_1_MISR_ (but this latter is not made available to the users)

In 2022, the number of Sentinel-3 user-level data which was published was more than 16,000,000, while the volume of Sentinel-3 data downloaded since the start of operations reached nearly 45 PiB.



Figure 11: This Sentinel-3 image, captured on 19 April 2022, shows a nearly cloud free picture of the Baltic sea (contains modified Copernicus Sentinel data (2022), processed by ESA)

Sentinel-5P

On 29 November 2021, the Sentinel-5P Ozone Profile user-level data started to be published on the Sentinel-5P Hub (Near Real Time and Offline timeliness), adding to the long list of Sentinel-5P user-level data available on the Hub.

On 5 December 2022, the Sentinel-5P full mission reprocessed datasets for Carbon Monoxide (L2_CO___), Total Ozone (L2_O3___), CLOUD (L2_CLOUD_) and Absorbing Aerosol Index (L2_AER_AI) user-level data started to be published.

The number of published Sentinel-5p user-level data considerably increased, passing from 2.0 million in Y2021 to 2.8 million in 2022. Moreover, the volume of downloads reached 15PiB since the start of operations.

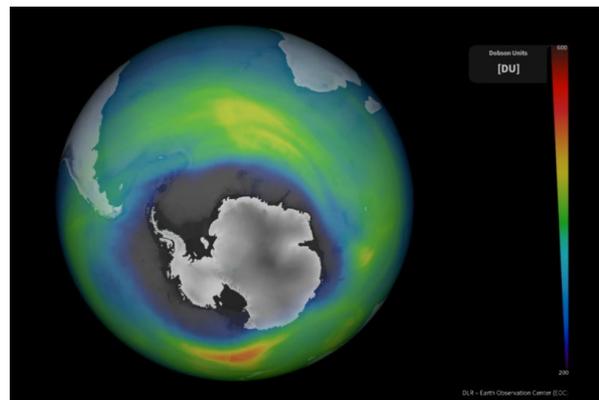


Figure 12: Map of the ozone hole over the South Pole on 16 September 2022. (contains modified Copernicus Sentinel data (2022)/processed by DLR)

2 Data Access Service Growth

During 2022, the statistics which illustrate the level of public engagement with the Data Access System continued to increase dramatically. User registrations rose 27% to nearly **640,000**; the number of Sentinel user-level data made available for download on the Open Hub rose 26% to **68 million** user-level data; and the volume of Sentinel user-level data downloaded by users since the start of operations rose 25% to an enormous **405 PiB** (not including the downloads made by the DIAS partners, which was a further **97.69** PiB). In this section, each of these increases is analysed in detail.

2.1 User take-up

By the end of 2022, **638,259 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 Y2021. 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 highlighted in the introduction, the current reporting period lasts 13 months instead of the usual 12 months. Given that this affects the total number of users who registered in 2022, the increase has been calculated using only the last 12 months for 2022 and comparing the figure with the total number of registered users at 31 December 2021, rather than at 30 November 2021.

In terms of percentage increase in the number of registered users since Y2021, the greatest change took place on the Open Hub which gained 26% more registered users during 2022, raising the total number of user accounts from 505,464 at the end of 2021 to 637,864 at the end of 2022. This increase of 132,400 registered users during the year is higher than the number of new registrations in Y2021 (111,907) and so again this was the **highest yearly rise in user registrations yet seen since the start of operations**. It also gives some perspective to note that the number

of new registrations in 2022 alone is higher than the total number of new users who registered on the Open Hub in the years between the opening of the Hub in October 2014 and the end of Y2017.

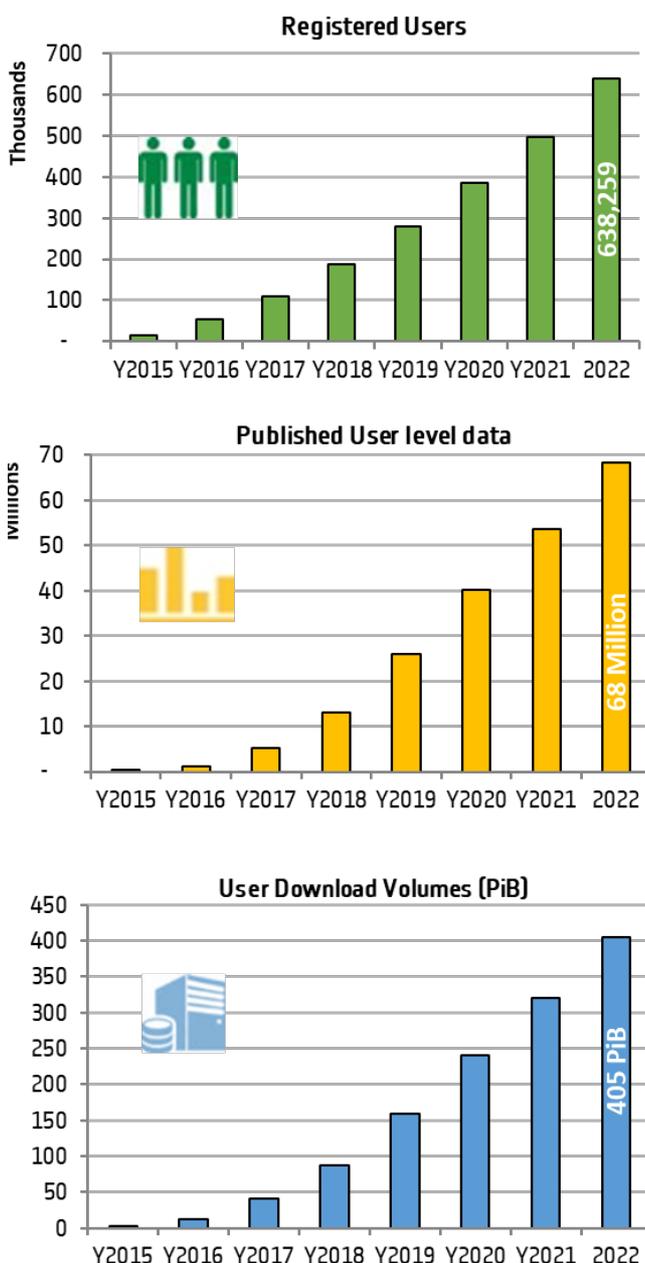


Figure 13: Overall rise in Data Hub Registered Users, Published User-level data and User Download Volumes, showing cumulative total for each year since the start of operations

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 shows the number of users who registered each month for access to the Open Hub during 2022, contrasted against the average number of user registrations made per month during Y2021. The cumulative number of registered users since the start of operations is also shown.

The graph shows that the number of new user registrations each month was often close to the monthly average for Y2021 but there were at least 6 months in which the number of registrations significantly exceeded the Y2021 monthly average: in March, April, May, September, October and November. Indeed, in 2022 there was an average of 11,672 registrations per month, which is 18% higher

than the Y2021 average of 9,885, and 27% higher than the 9,220 Y2020 average.



Figure 14: Registered Users per Data Hub

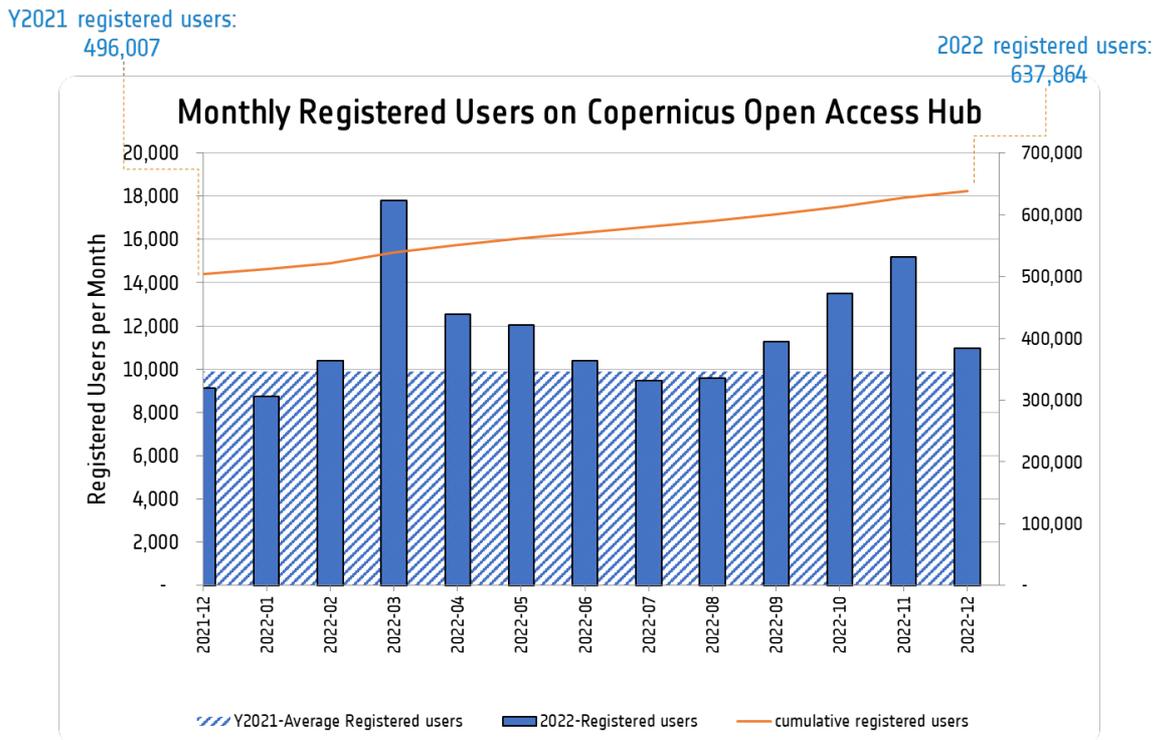


Figure 15: Trend of User Registrations on the Copernicus Open Hub

A potential trigger of peaks in the number of registered users are international conferences at which there is a EO and Copernicus presence. The Earth Observation department at ESA and the European Commission, among others, host workshops and outreach events throughout the year at which Copernicus is presented, and these are also likely to generate interest in registering for access to Copernicus data. For instance, in 2022 there was the Sentinel-2 Validation Team Meeting (11-13 April 2022), the European Geosciences Union (EGU) General Assembly 2022 (23 – 27 May 2022), the ESA Living Planet Symposium in Bonn (23-27 May 2022) or ECMWF’s Summer of Weather Code 2022 (1 March – 28 September 2022).

It is also interesting to see that again this year there was the usual dip in the number of registrations in the months typically associated with vacation periods in Europe which has also been observed in all previous years.

2.1.2 Open Hub Demography

In Figure 16, the increase in user registrations on the Open Hub during 2022 is broken down by continent.

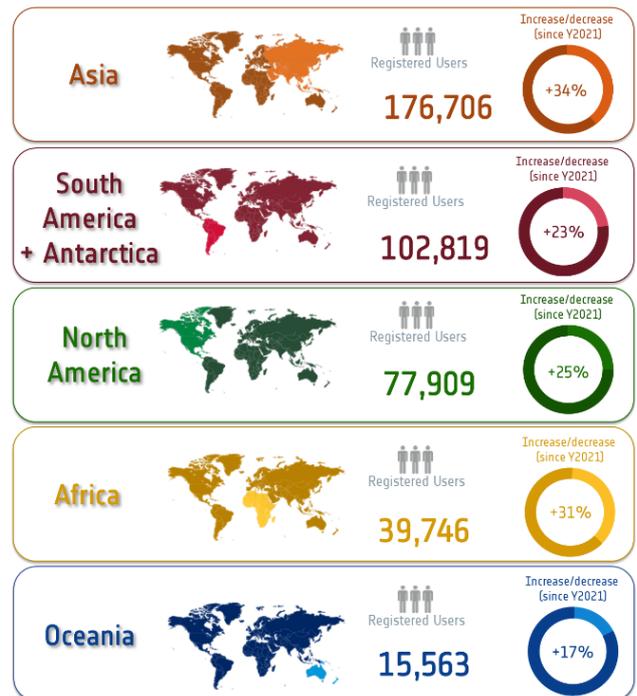


Figure 16: Open Hub registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent during 2022

Europe remains the continent with by far the largest Open Hub user-community, with 229,454 registered users by the end of 2022, up 29% from Y2021. However, the growing awareness of and interaction with the Open Hub has by no means been limited to Europe. Beyond Europe, the largest increase this year was in the new registrations made in Asia, where the total number of registrations rose by 34% to 176,706. A similar percentage increase took place in Africa, where there was 31% increase in the total number of registrations, with as many as 9,265 new users joining the Hub. This year, South America and North America reached more than 100,000 and 70,000 registered users respectively, with an increase of 23% and 25% since last year. In Oceania, there was a less dramatic increase in the total number of user registrations but it nonetheless rose by 17% in 2022, reaching 15,563 users. In absolute terms, the highest number of new registrations in the year was again in Europe, and at 51,390 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 17 shows the monthly increase in the number of countries reaching this threshold. The number continues to grow: by the end of 2022 there were 108

countries across the world with more than 500 registered users, a rise from the 96 at the end of Y2021.

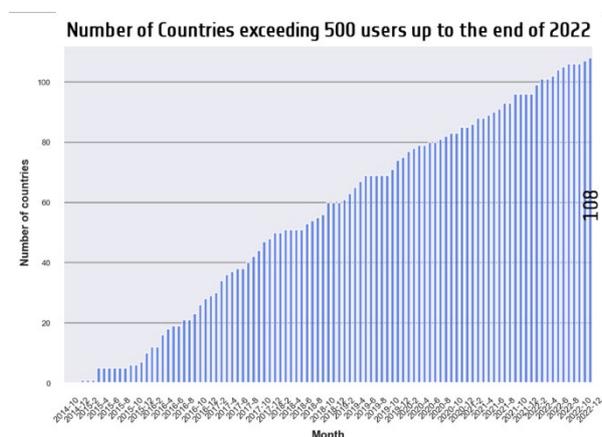


Figure 17: Growth in the number of countries exceeding 500 registered users on the Open Hub since the start of operations

Focusing specifically on Europe, there was a significant increase in registered user numbers in all of the ESA and European Union Member States. Figure 18 illustrates the figures for the 5 ESA and European Union Member States with the highest numbers of registered users, including the percentage change for each country since Y2021. The order of these countries is the same as it was in Y2021 but this year it was France which showed the highest percentage increase (27%) in the number of registered users, with Spain showing the second highest rise at 26%. In absolute terms, Germany remains the country with the largest number of registered users in Europe, and even there registrations increased by 21%, reaching a total of 31,874 registered users at the end of 2022.

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 Ground Segment or international Copernicus data access sites.

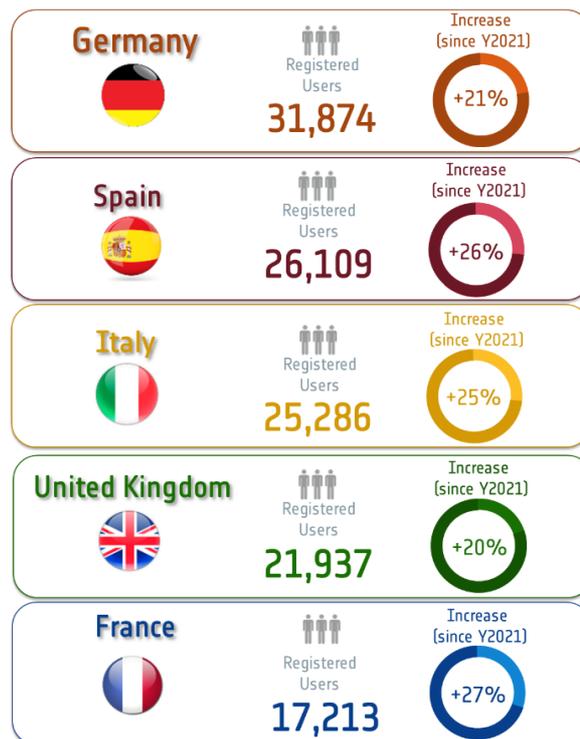


Figure 18: Distribution of Copernicus Open Hub registered users in the 5 EU and ESA member states with the highest number of registered users

2.2 Published Data

By the end of 2022, 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 dedicated Sentinel-5P Hub, in order to be able to maximise the retention period for the other Sentinel user-level data whilst providing an increased download capacity for the Sentinel-5P atmospheric user-level data. The user-level data types available from the hubs during 2022 were the following:

- All **Sentinel-1A/-1B** user-level data were routinely published on all of the data access hubs.
- **Sentinel-2A/-2B** Level-1C and Level-2A user-level data were routinely published on all the data access hubs.
- **Sentinel-3A/-3B** OLCI, SLSTR, SRAL and SYNERGY user-level data were routinely disseminated on all hubs.
- **Sentinel-5P** user-level data were disseminated on the dedicated Sentinel-5P Hub.

This section presents the statistics for the publication of the user-level data on the Open Hub during 2022. For the purpose of these publication statistics, the dedicated Sentinel-5P Hub is deemed to constitute part of the Open Hub.

2.2.1 Publication Growth

By the end of 2022, a total of **68,360,184 Copernicus Sentinel user-level data** had been published on the Open Hub since the start of operations, with a total data volume of **39.37 PiB**. In 2022 alone, a total of 13,766,370 user-level data were published, accounting for a total data volume of 6.64 PiB. To put this into context, by way of historical comparison the 6.64 PiB published during 2022 alone is more 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 compares the volume of user-level data published in 2022 with the volumes published in the preceding years. *The percentages are calculated dividing the overall volume of data published from the start of operations by the published volumes from in each reporting year* The sum of all the percentages does not quite reach 100% because the December 2021 value, 0.52 PiB published user level data, is not considered in the calculation.

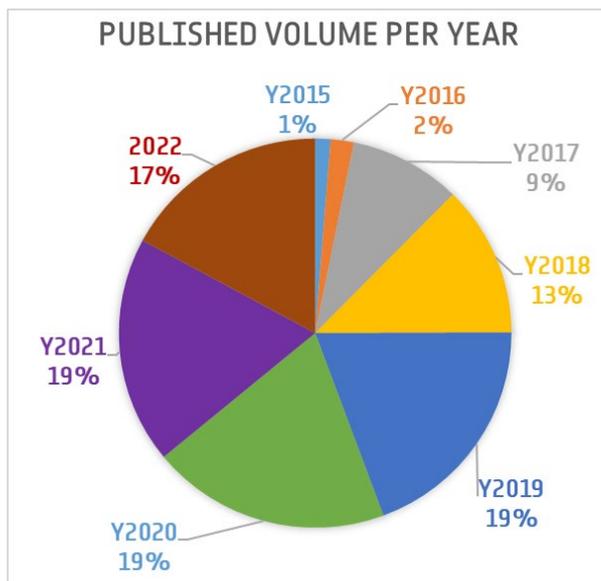


Figure 19: Percentage per reporting year of the total published volume of data since the start of operations (Y2015-2022)

The volume of Sentinel user-level data published on the Open Hub during 2022, makes up 17% of all the user-level data published on the Open Hub since the start of operations. For each of the preceding 3 years the percentage was actually slightly higher, and the data volumes published during those years constituted 19% of the overall published user level data. This slight decrease in the published data volume in 2022 is attributed mostly to the unavailability of Sentinel-1B data since December 2021.

Mission	No. of user-level data published in 2022	No. of user-level data published since start of Ops	2022 No. as % of total published per mission since start of Ops	Volume of user-level data published in 2022 (PiB)	Volume of user-level data published since start of Ops (PiB)	2022 volume as % of total published per mission since start of Ops
S1	811,889	8,377,569	10%	1.27	13.09	10%
S2	8,355,363	40,682,460	21%	4.26	20.74	21%
S3	3,831,245	16,456,709	23%	0.93	4.85	19%
S5P	767,873	2,843,446	27%	0.17	0.69	25%
ALL	13,766,370	68,360,184	20%	6.64	39.37	17%

Table 1: Overall number and volume of published user-level data on the Open Hub both in 2022 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 2022 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 61% of the number of user-level data published in 2022 and 60% of all user-level data published since the start of operations. It should be noted, however, 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 5 times that of Sentinel-1, in terms of total volume of user-level data published in the year, the figure for Sentinel-2 (4.26 PiB) is only about 3 times that for Sentinel-1 (1.27 PiB). Moreover, the *number* of Sentinel-5P user-level data published in 2022 was close to the number of Sentinel-1 data, but the *volume* of Sentinel-5P user-level data published in 2022 was about an eighth of the volume of Sentinel-1 data published in 2022.

As noted above, the publication figures for Sentinel-1 are affected by the unavailability of the Sentinel-1B unit since the end of December 2021. The number of Sentinel-1 user-level data published in 2022 was 44% lower than the number published in Y2021, and 42% lower in terms of volume.

The overall publication volumes for the other missions, however, were slightly higher than those

published in Y2021 (2% for Sentinel-2, 14% for Sentinel-3 and 12% for Sentinel-5P). This can be seen more clearly in Tables 2 and 3 below, which show the average daily publication figures for December 2022 compared with the figures from December 2021. The average daily volume of Sentinel-2 and -3 data being published in December 2022 was slightly higher than the average daily volume being published in December 2021. The same average daily volume was published for Sentinel-5P, and a significantly lower volume, just over half, was published for Sentinel-1. *It is highlighted that the Sentinel-5P data for 2022 were taken in November 2022 instead of December, in order to avoid mixing the reprocessing campaign number with the nominal data flow.*

Nevertheless, at the end of 2022, the majority of NTC user-level data volume being published daily was still accounted for by Sentinel-1 and -2, and together they constituted 83% of the total average daily volume. This is lower than the 86% share of the daily total which they constituted in Y2021 of daily total, but higher than the 78% seen in Y2020.

Mission	Daily Average Vol (TiB) published in December 2022	Dec 2022 Volume as % of overall daily average	Daily Average Vol (TiB) published in December 2021	Dec 2021 Volume as % of overall daily average
S1	3.58	22%	6.51	35%
S2	10.14	61%	9.67	51%
S3	2.36	14%	2.19	12%
S5P	0.42*	3%	0.42	2%
All	16.51		18.79	

Table 2: Average volume of user-level data published per day in the last month of 2021 and 2022, with percentage splits per Sentinel mission (*data in November 2022)

Mission	Daily Average Number of user-level data Published in December 2022	Dec 2022 no. as % of overall daily average	Daily Average Number of user-level data Published in December 2021	Dec 2021 no. as % of overall daily average
S1	2,216	7%	4,280	13%
S2	19,445	60%	18,168	55%
S3	8,883	27%	8,787	27%
S5P	1,808*	6%	1,763	5%
All	32,353		32,998	

Table 3: Daily average number of user-level data published per mission during the last month of 2021 and 2022, with percentage splits per Sentinel mission (*data in November 2022)

In terms of the average *number* of data being published per day, there was an overall decrease of 2%. However, it can be seen that there was an increase in the average number of Sentinel-2 (+7%), Sentinel-3 (+1%) and Sentinel-5P (+3%) user-level data published per day, and it is suggested that the overall decrease is attributable to the -48% decrease in the number of Sentinel-1 data published per day.

2.2.2 Publication trends

The graphs below show, per Sentinel, both the number and volume of user-level data which were published per month on the Open Hub and the S5P Hub during 2022. The values represent the 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 2021, to highlight any changes which have occurred between the years.

Sentinel-1

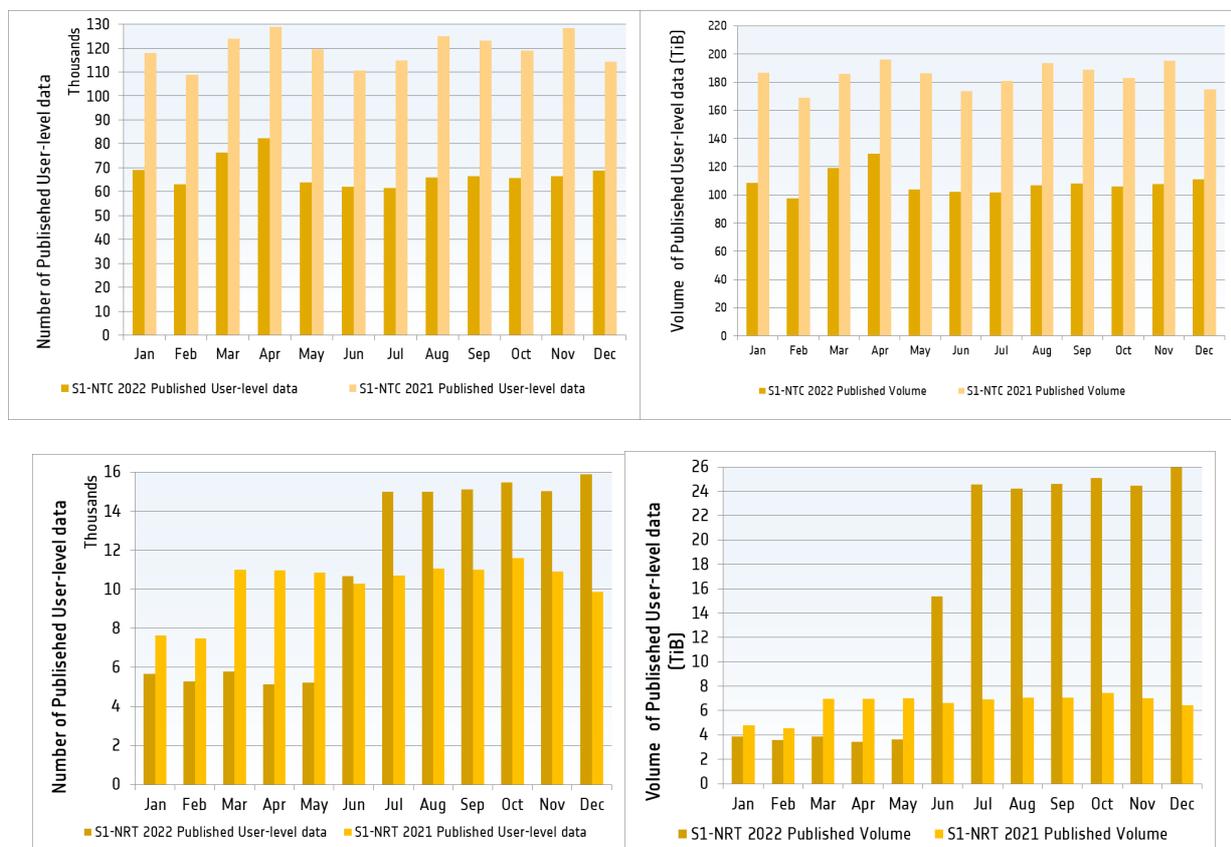


Figure 20: 2021 and 2022 monthly number and volume publication trend for Sentinel-1 Non time Critical (above) Near Real Time Production (below)

During 2022, numbers and volumes of Sentinel-1 NTC published user-level data were halved due to the unavailability of Sentinel-1B data from 23 December 2021 onwards. The monthly average number of user-level data published in 2022, 67,658, and the monthly average volume of user-level data published in 2022, 109 TiB, were 40% down on the 2021 values.

The 2022 monthly publication rates for the Sentinel-1 NRT user-level data in Figure 21, however, clearly

show the change in processing strategy carried out during the year for Sentinel-1 user-level data: as mentioned in Section 1.3 above, in June 2022

action was taken to adjust the Sentinel-1A observation scenario in order to fill some gaps created by the unavailability of Sentinel-1B. This brought a 187% increase in the monthly number of NRT user-level data published, rising from 5,224 user-level data published in May 2022, to 15,005 in July, with similar figures onwards. It should be noted that the

annotated timeliness depends on the geographical area covered by the user-level data and it is not any more an indication of a different user-level data

quality. Data tagged NRT-3h and Fast-24h is now processed only once and is made available to all users of the Open Hub.

Sentinel-2



Figure 21: 2021 and 2022 number and volume publication trend for Sentinel-2

For Sentinel-2, the average number and volume of user-level data published per month during 2022 increased with respect to 2021, and this was due to the new Processing Baseline which was introduced in February 2022. There was an increase of 6% and 5% in the average monthly publication number and volume respectively: an average of 722,480 user-level data was published per month after February 2022 compared with an average of 679,983/month in 2021; and an average volume of 376.92 TiB was published

per month after February 2022 compared with an average of 357.39 TiB/month in 2021.

As seen in previous years, the 2022 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.

Sentinel-3

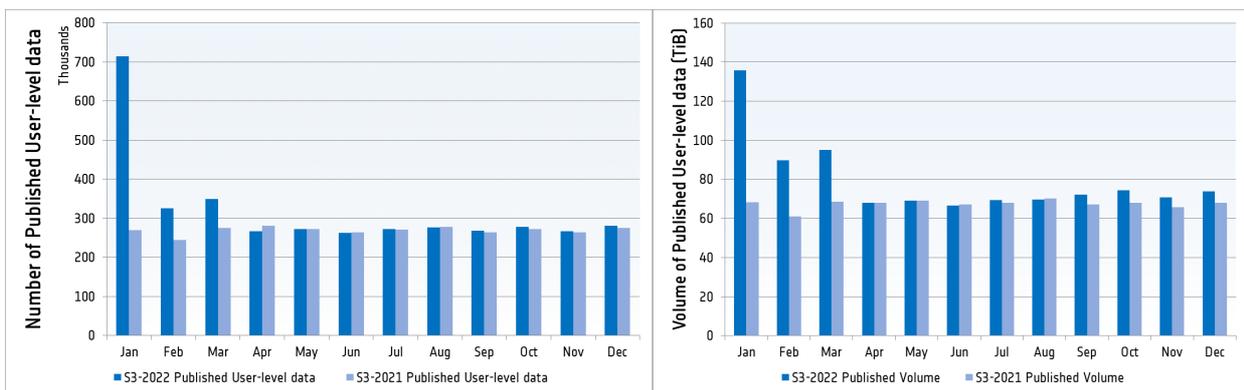


Figure 22: 2021 and 2022 monthly number and volume publication trend for Sentinel-3

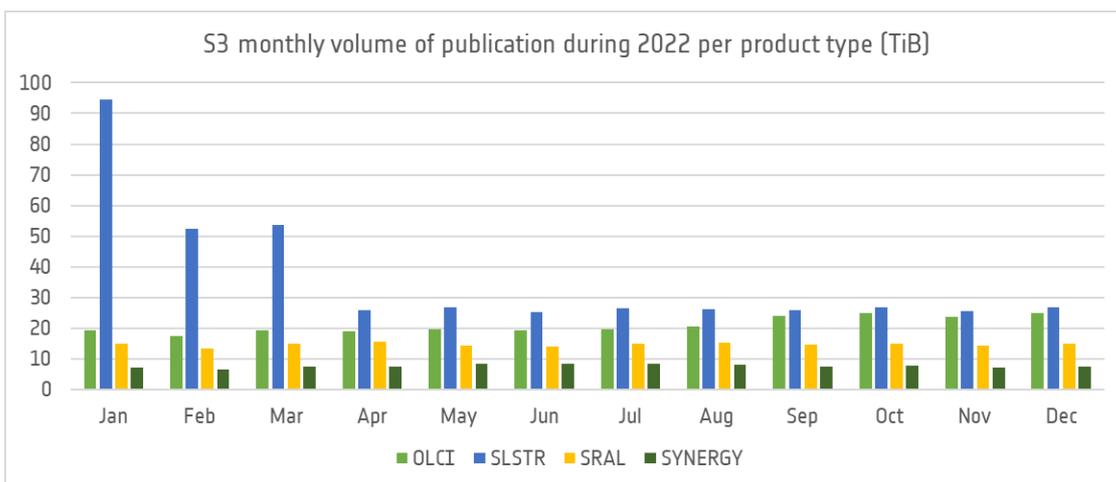


Figure 23: 2022 monthly volume publication trend per Sentinel-3 user-level data group

The publication of Sentinel-3 user-level data was also relatively even during 2022, although January 2022 is a notable exception and was the month with by far the highest publication rate. A total of 714,198 user-level data were published in the month, which is a massive 163% higher than the 271,500 average number of user-level data which published per month in 2022.

The cause of the sharp increase in publication in January 2022 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). It can be seen that in January 2022, there was a huge increase in the volume of SLSTR data published that month (+67 TiB), and this was the result of the continuing reprocessing campaign for the Sentinel-3A SLSTR Level-1 SL_1_RBT and Level-2 SL_2_LST user-level data.

Table 4 presents the number of reprocessed data for SLSTR Level-1 SL_1_RBT and Level-2 SL_2_LST in 2022 and, supported by Figure 24, we see that the spike in the publication of SLSTR in January 2022 is due to the 595,941 reprocessed user-level data that were published in addition to the nominal data flow

and that constitute 45% and 35% of all SLSTR Level 1 and Level-2 data (respectively) published in 2022. This dataset matches the analogous Sentinel-3B dataset published last year. No reprocessed OLCI, SRAL or SYNERGY user-level data were published during the year.

Since 4 August 2022, three new thematic user-level data have been introduced in the publication chain of Sentinel-3: SR_2_LAN_HY, SR_2_LAN_SI, SR_2_LAN_LI. These products are NTC and the oldest sensing date for these user-level data is 24 June 2022. The introduction of these new user-level data led to an average increase of 5% in the average monthly volume of SRAL user level data published.

In summary, if all months in 2022 are included in the calculation, the average publication rate for Sentinel-3 user-level data was 319,274 data/month and the average volume was 79.54 TiB/month. If the outlier months are excluded, the average publication rates become 271,500 data/month and 70 TiB/month, up 1% and 4% respectively from the 2021 averages.

Instrument	Product level	2022 Total No. of Published User-level data	2022 Total No. of Reprocessed Published User-level data	% Reprocessed User-level data
SLSTR	Level 1	654,380	297,953	45
	Level 2	829,651	297,988	35

Table 4: 2022 total numbers of SLSTR reprocessed user-level data, and percentage of total number of Level-1 SLSTR data published during 2022

Sentinel-5P

The dedicated Sentinel-5P 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 2022.

On 29 November 2021, the Sentinel-5P Ozone Profile user-level data started to be published on the Sentinel-5P Hub (Near Real Time and Offline timeliness), adding to the long list of Sentinel-5P user-level data available on the Hub.

Figure 25 shows very consistent publication rates of Sentinel-5P data for each month except December

2022, in which the number of published user-level data exceeded the average monthly publication rate by 146%, and the volume by 176%. This peak is attributed to the fact that on 5 December 2022 the Sentinel-5P full mission reprocessed datasets for Carbon Monoxide (L2_CO___), Total Ozone (L2_O3___), CLOUD (L2_CLOUD_) and Absorbing Aerosol Index (L2_AER_AI) user-level data started to be published. Excluding the outlier month, an average of 57,040 data/month were published on the Sentinel-5P dedicated Hub during 2022, corresponding to an average volume of 12.9 TiB/month, up 23% and 2% respectively from the 2021 averages.

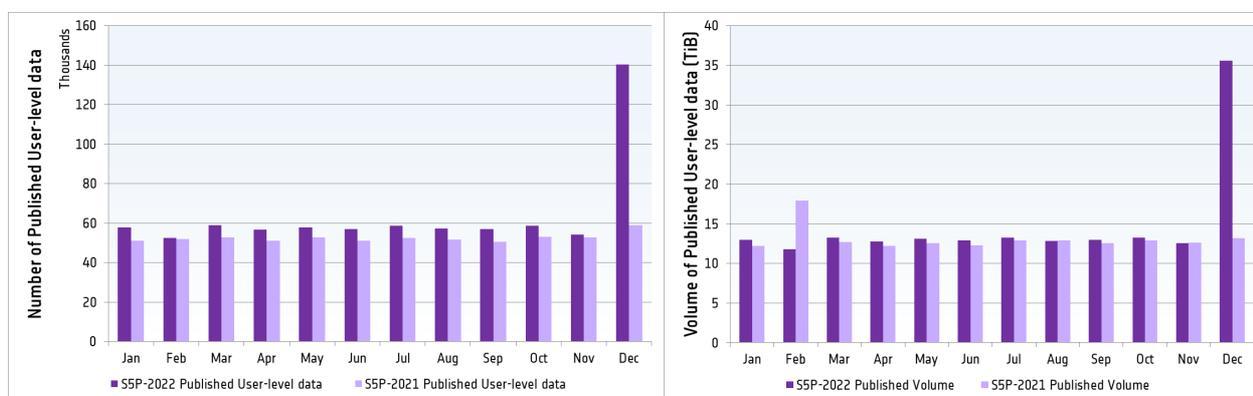


Figure 24: 2021 and 2022 monthly volume and number publication trend for Sentinel-5P

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 2022. For Sentinel-3, for the purposes of readability, the 20 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 27 individual user-level data types have been grouped in either Level-1B or Level-2.

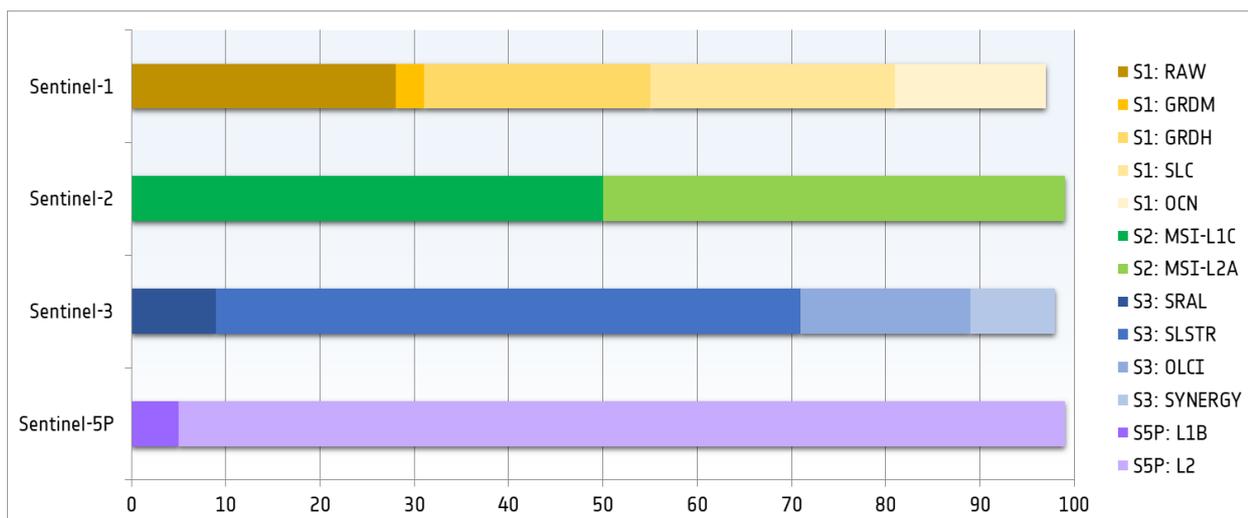


Figure 25: Percentage published number of user-level data per Sentinel mission and user-level data type during 2022

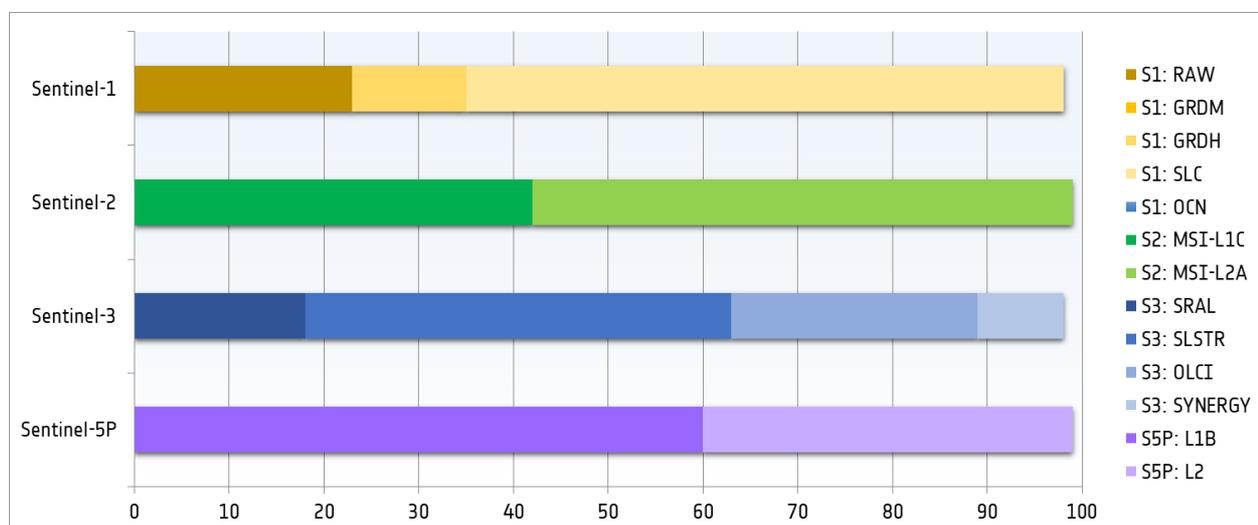


Figure 26: Percentage published volume of user-level data per Sentinel mission and user-level data type during 2022

For **Sentinel-1** the following user-level data types were available during 2022:

- 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 28% of user-level data, Level 1 for 53% and Level 2 for 16%. In terms of volumes, the totals are: 23% for Level 0, 75% for Level 1 and 0.1% for Level 2. The difference in the percentages for number and volume 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 have been almost stable since Y2018.

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

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

In terms of the number of Sentinel-2 user-level data published, 50% was Level-1C and 50% Level-2A. By volume, the split was: 43% Level-1C and 57% Level-2A. 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 SR_2_LAN_HY STM LAND Thematic user-level data for hydrology (**new since 2022**)
- SR_2_LAN_SI STM LAND Thematic user-level data for sea ice (**new since 2022**)
- SR_2_LAN_LI STM LAND Thematic user-level data for land ice (**new since 2022**)

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
- Level-2 FRP with Fire Radiative Power.

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

- Level 1 SY_1_MISR___ Correspondence and collocation grids between OLCI/SLSTR acquisition and image grid and SYN Level 2 internal grid (i.e. OLCI instrument grid) (**not available to users**)
- Level 2 SY_2_AOD___ Global Aerosol parameter over land and sea on super pixel resolution (4.5 km x 4.5 km)

- 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: 62%. Next are OLCI with 18%, followed by SRAL and SYNERGY, each with 9%. The split by volume is: 45% for SLSTR, 26% for OLCI, 18% for SRAL and 9% for SYNERGY.

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))
- L1B_IR_UVN: Irradiance user-level data UVN module
- L1B_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 (**new since 29 November 2021**)
- 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

- *AUX_CTMANA and AUX_CTMFCT: A-priori profile shapes for the NO₂, HCHO and SO₂ vertical column retrievals*

Split by data level and by number, Level-2 accounted for 94% of the total number of Sentinel-5P user-level data published, while Level-1B accounted for only 5%. However, in terms of volume, the split was reversed with 60% Level-1B and 39% 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/web/sentinel/user-guides/sentinel-1-sar/document-library/-/asset_publisher/1dO7RF5fJMbd/content/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 2022. 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.

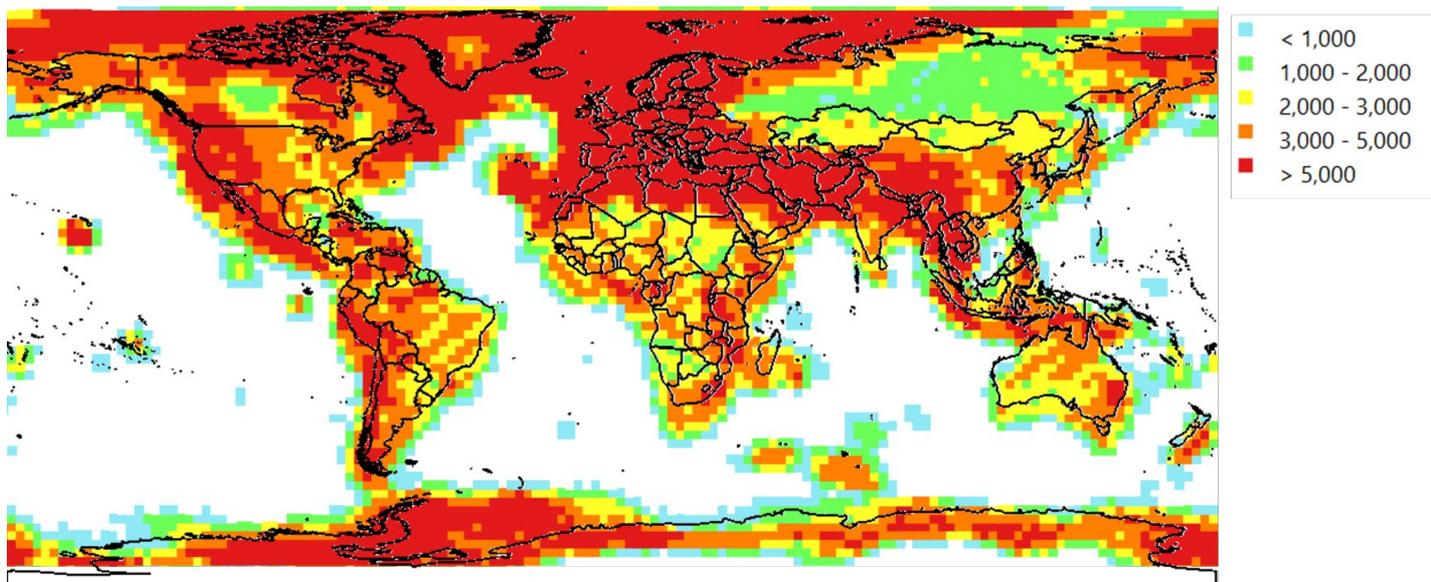


Figure 27: Heatmap of Sentinel-1 user-level data (excluding OCN) published from the start of operations to the end of 2022

The heatmap shows that Sentinel-1 user-level data cover all continents and major island groups, with the highest density of coverage over Europe, the northern coast and inland areas of Africa, most of the Middle-East, the Pacific coastline of the Americas and the far northern and southern sea-ice regions. The lowest publication density is found over most of Russia, the Sahel, Central Canada and Southwestern Australia.

It is not visible in the heatmap but, in line with the observation scenario, the greatest density of published user-level data is 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 with two satellites in orbit) 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 in particular to support 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, which is by default continuously operated 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 2022. For ease of comparison, the keys and ranges are the same in each case. In general, the extent of data coverage may be summarised as follows:

- *GRDM* – mostly covering sea ice and polar 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>.

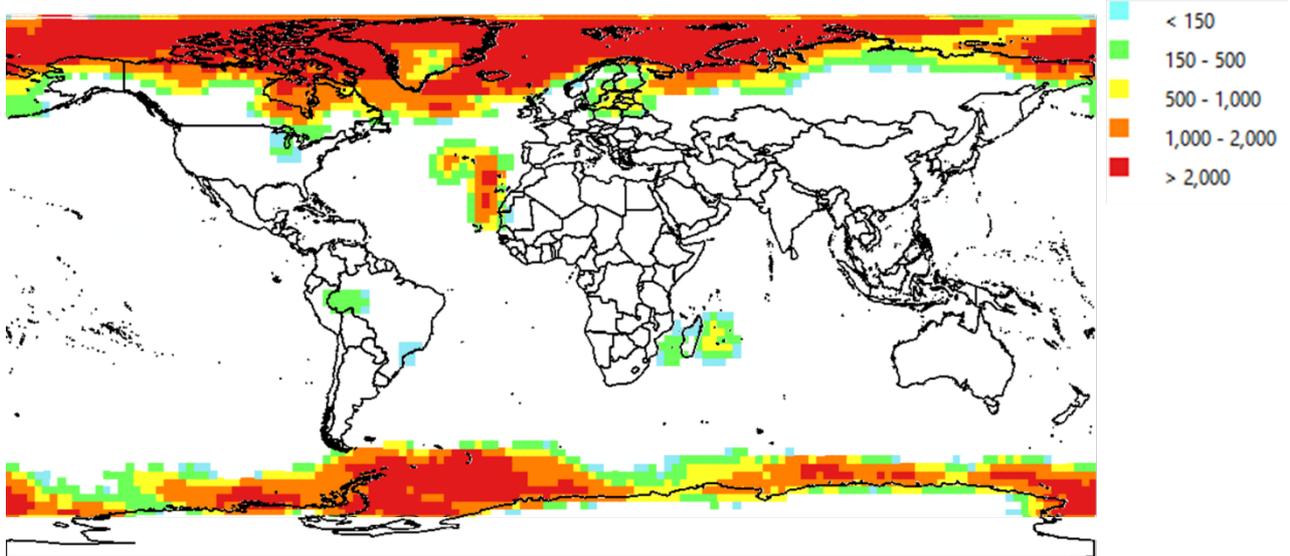


Figure 28: Heatmap of Sentinel-1 GRDM user-level data published from the start of operations to the end of 2022

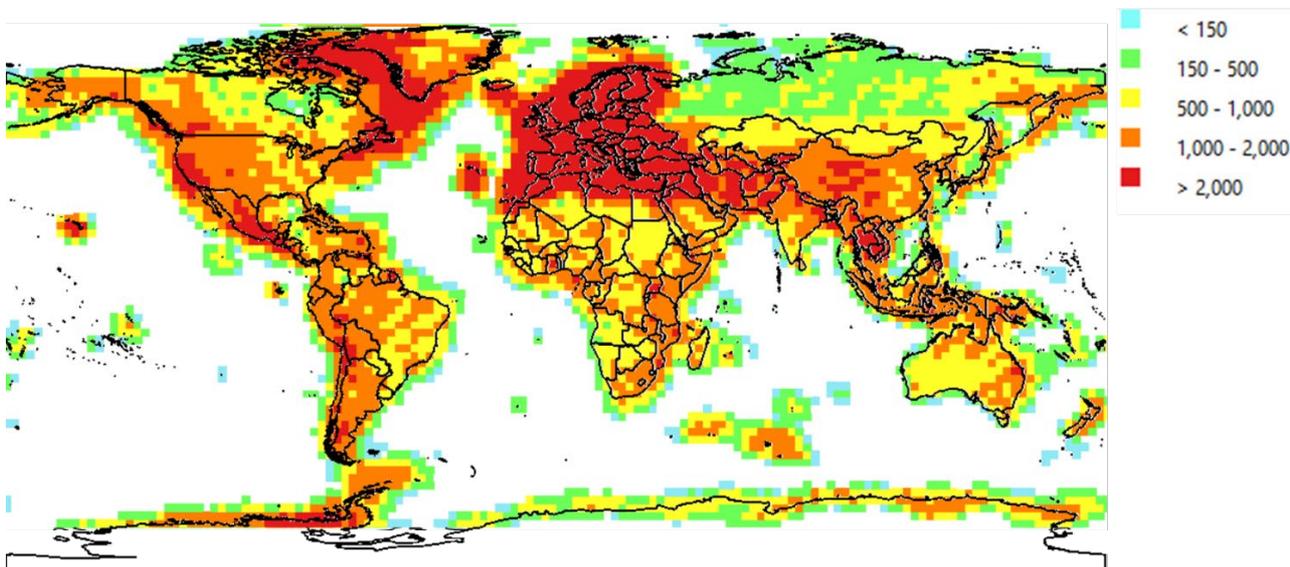


Figure 29: Heatmap of Sentinel-1 GRDH user-level data published from the start of operations to the end of 2022

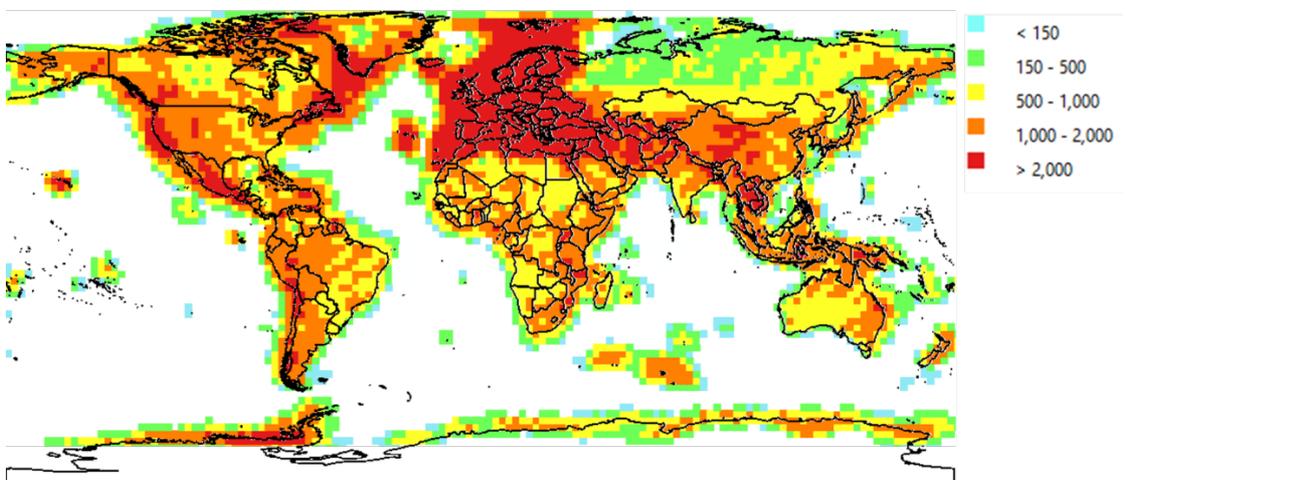


Figure 30: Heatmap of Sentinel-1 SLC user-level data published from the start of operations to the end of 2022

Sentinel-2

Figures 32 and 33 below show heatmaps for Sentinel-2 published user-level data, respectively for Level-1C data and Level-2A data, and in both cases from the start of operations until the end of 2022.

As in previous years, the Level-1C 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.

Although the global coverage of Level-2A user-level data started later than that of Level-1C (December

2018), only a few differences between the heatmaps for Level-1C and Level-2A can be observed. However, a higher publication density of Level-1C can be seen from around 40°N, and especially over Arctic regions.

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 Europe and Russia 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.

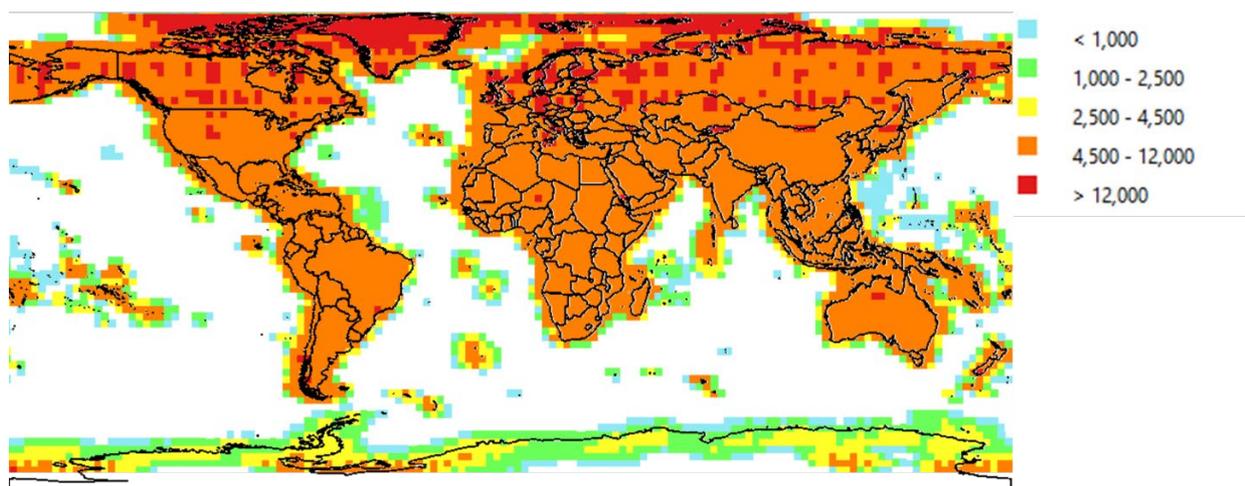


Figure 31: Heatmap of Sentinel-2 Level-1C user-level data published from the start of operations to the end of 2022

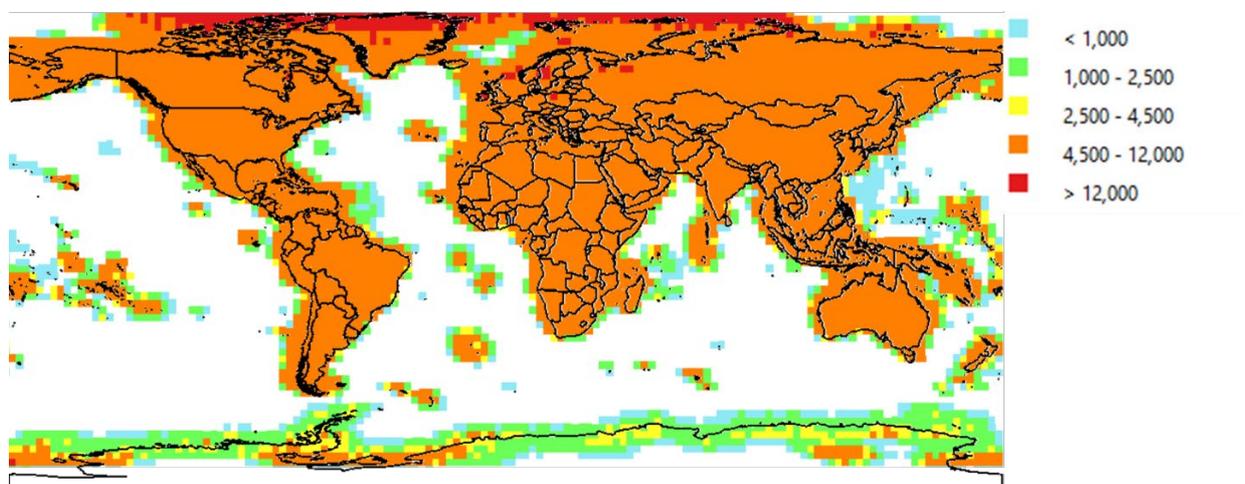


Figure 32: Heatmap of Sentinel-2 Level-2A user-level data published from the start of operations to the end of 2022

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 2022. The maps are separated out by data group. For SRAL data, a separate 'NRT Level-2' heatmap is also provided. SRAL, SRAL-NRT Level-2, OLCI, SLSTR and SYNERGY 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.

The immediately visible difference is that Sentinel-3 data cover also the oceans and seas. Only the smaller subset of 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.

The heatmap for the SYNERGY data is composed of many user level data, including the VGT data which are provided in continental tiles, and this creates a heat map which gives little real idea of the publication density. For further details, refer to Annex 2 and <https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy>.

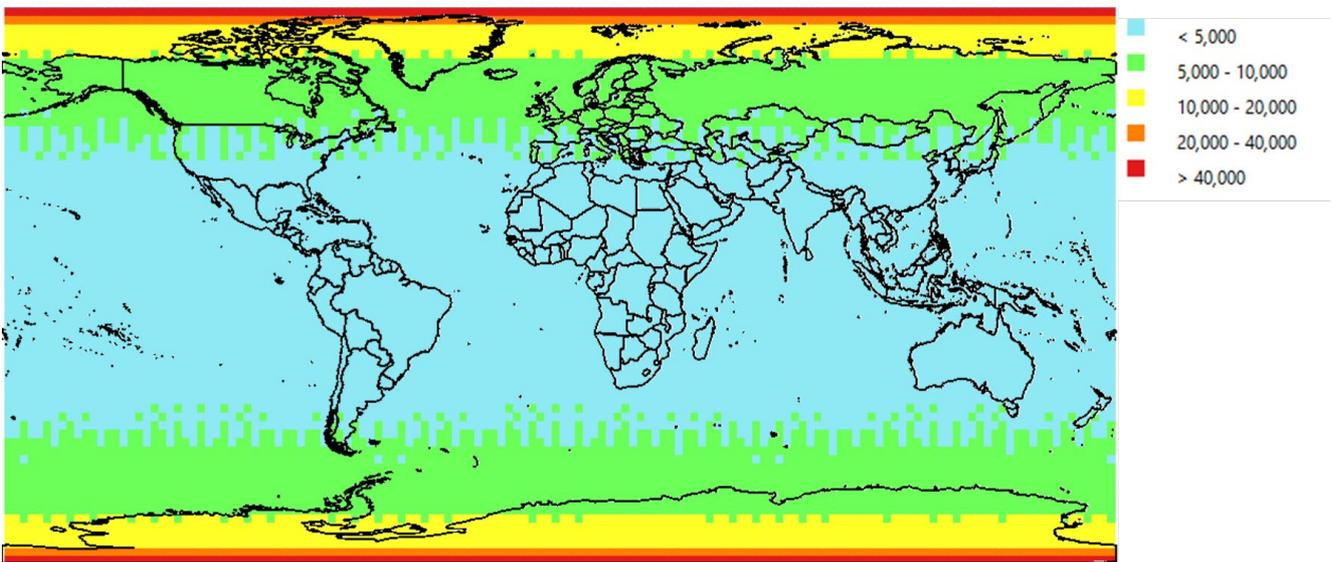


Figure 33: Heatmap of Sentinel-3 SRAL user-level data published since the start of operations to the end of 2022 (excluding NRT and Level-2)

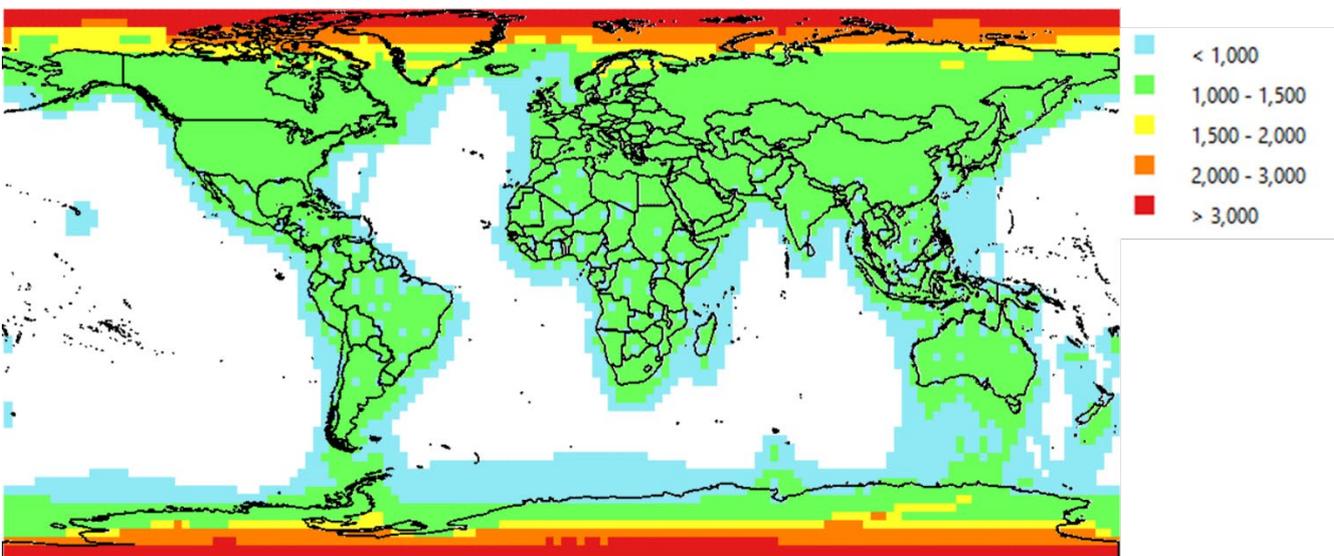


Figure 34: Heatmap of Sentinel-3 SRAL-NRT Level-2 user-level data published from the start of operations to the end of 2022

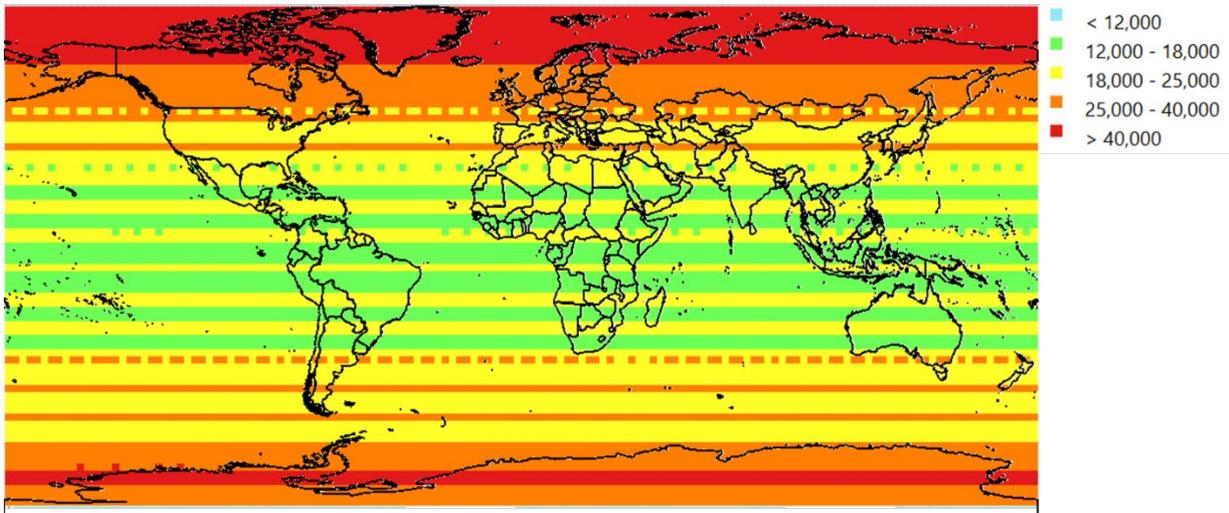


Figure 35: Heatmap of Sentinel-3 OLCI user-level data published from the start of operations to the end of 2022

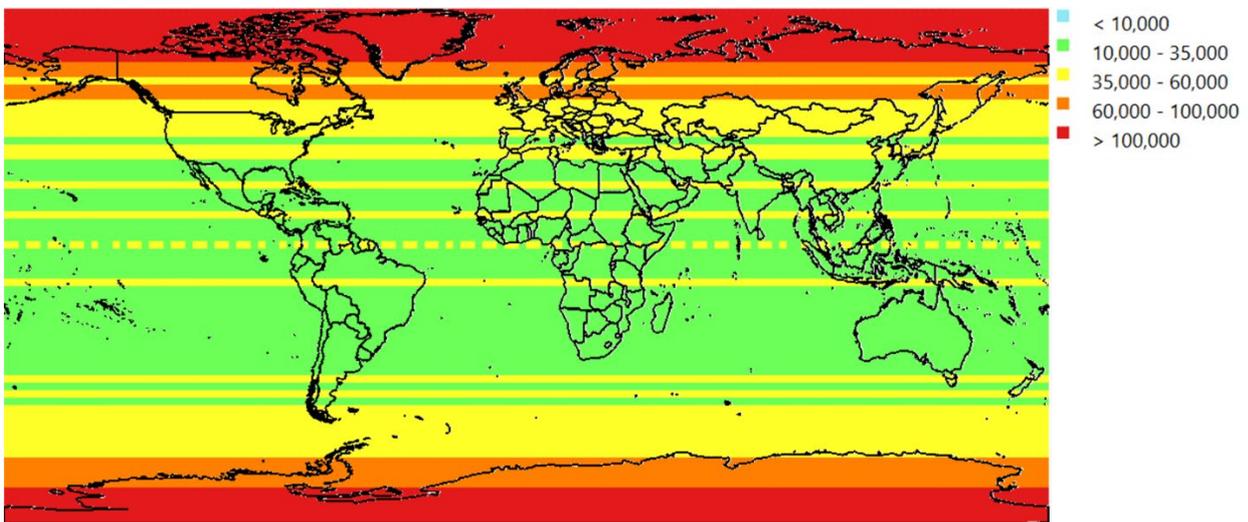


Figure 36: Heatmap of Sentinel-3 SLSTR user-level data published from the start of operations to the end of 2022

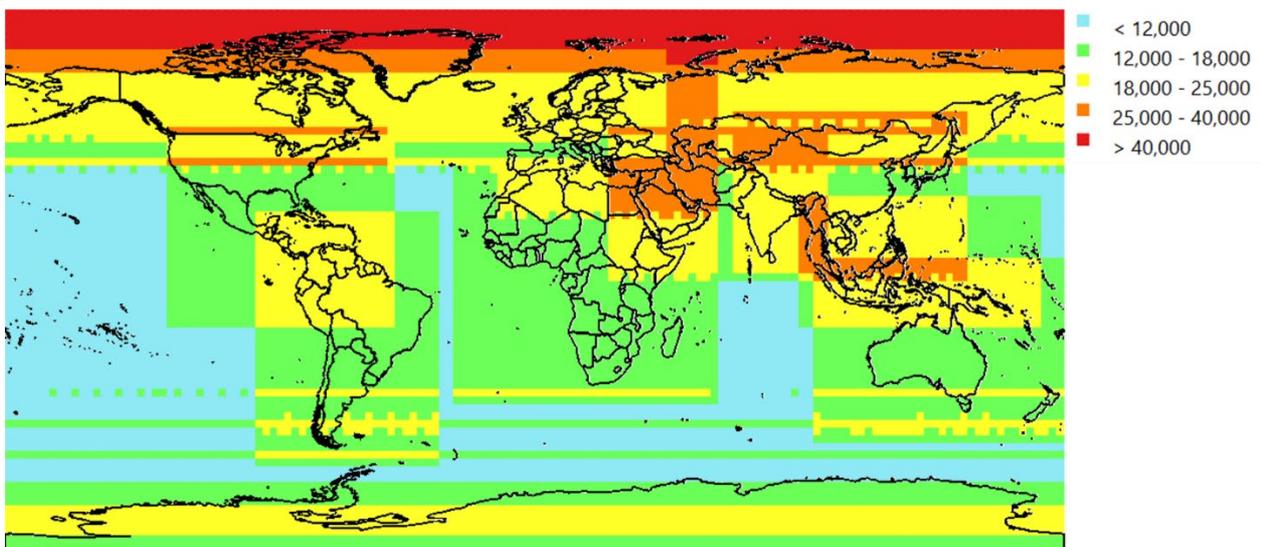


Figure 37: Heatmap of Sentinel-3 SYNERGY user-level data published from the start of operations to the end of 2022

Sentinel-5P

Sentinel-5P systematically senses data on the daytime portion of all orbits, meaning the heatmap for publication is uniform (highlighting only the

increased overlap of orbits towards the poles). The heatmap is shown above, made up from all Sentinel-5P user-level data published from the start of operations until the end of 2022.

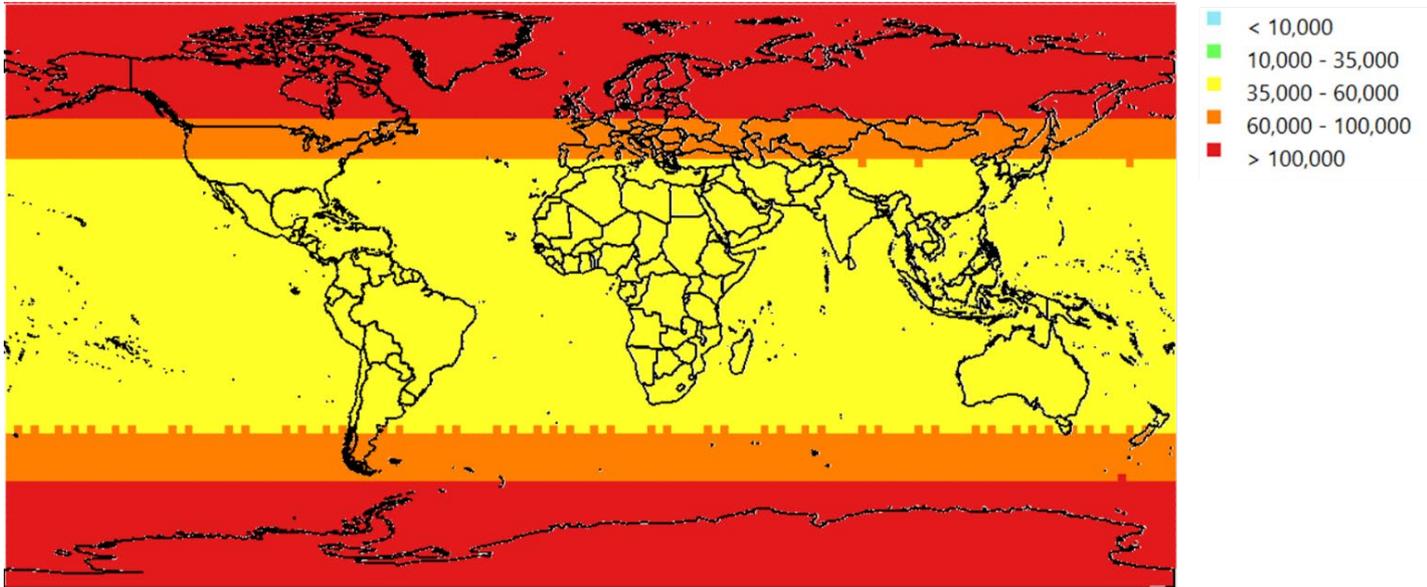


Figure 38: Heatmap of Sentinel-5P user-level data published from the start of operations to the end of 2022

2.3 Data Downloads

This section looks at user activity in terms of the level of downloads which users made during 2022 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: the Open Hub, Collaborative Hub, International Hub and Copernicus Services Hub. Downloads from the DIAS Hub are presented separately, in Section 2.3.3.2, 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 2022, a huge **405 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 2022 with the total volume which had been downloaded by the end of each previous period, i.e. reporting years Y2015-Y2021. *The reader may note that the overall volume since the start of the operations is higher than the sum of all the reported volumes in all the periods and it is caused by the fact that the December 2021 data is included in the overall volumes but not in the 2022 data. It is a consequence of the change of the reporting period, which is now aligned to the calendar year instead of running from 1 December – 30 November. As a result, December 2021 is skipped in the annual statistics because it does not fall in the reporting year Y2021 nor in the current 2022 reporting period. December 2021 is, however, included in all cumulative statistics, i.e. those calculated from the start of operations to the end of 2022. This change has been introduced in order to align this report with other reports produced internally and for the EC.*

As shown in the Figure, 78.6 PiB of the total volume of downloads since the start of operations was downloaded during 2022 alone. This represents about 19% of the total downloaded volume and, as observed also last year, it is actually 2% less than the volume downloaded during the previous year (Y2021). The continual growth in the volume of data downloaded by users, which was observed during the first 7 years of Sentinel operations, could appear to have levelled off, therefore, leaving Y2020 as the peak year for data downloads. Such a levelling off in the demand for downloading the data has been anticipated for a few years, due to the move towards developing cloud-based local processing platforms, provided either on a commercial basis or as a national/institutional solution. These platforms host an impressive array of both operational and experimental services to enable users to engage with Copernicus Sentinel data without having to download any data to their own hardware, and it is expected that users will increasingly migrate to this way of exploiting the data, particularly given the ever-expanding volumes of data available.

However, it does not actually appear as if that migration is happening on a large scale yet. As mentioned in Section 2.1 and Chapter 3, the numbers of user registrations and active users continued to increase significantly in 2022. One explanation for this discrepancy, i.e. the decrease in the overall volume of downloads despite the growing number of users, could be that the new active users in 2022 were predominantly those who do not need the full collection of Sentinel data as it is published and who instead choose specific images according to their needs. It seems perhaps more likely, however, that the lower overall volume of downloads in 2022 was affected by the lower published volume of Sentinel-1 data. As mentioned above, 1.3 PiB of Sentinel-1 data was published in 2022 compared with 2.2 PiB in Y2021, due to the unavailability of Sentinel-1B since 23 December 2021. That this was the most likely cause of the lower overall volume of data downloads in 2022 is supported by the fact that the volume of Sentinel-2 and -3 data downloads actually increased significantly compared with the volumes downloaded

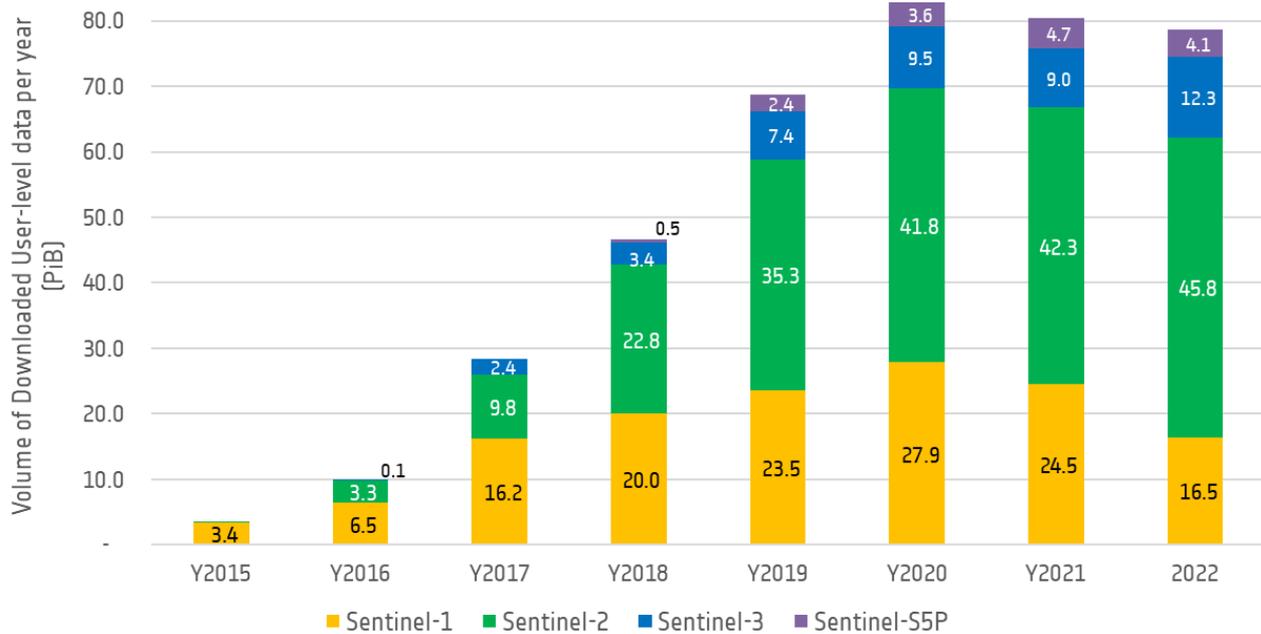


Figure 39: Total volume of user-level data downloaded per year since the start of operations from all of the four hubs, differentiated by mission

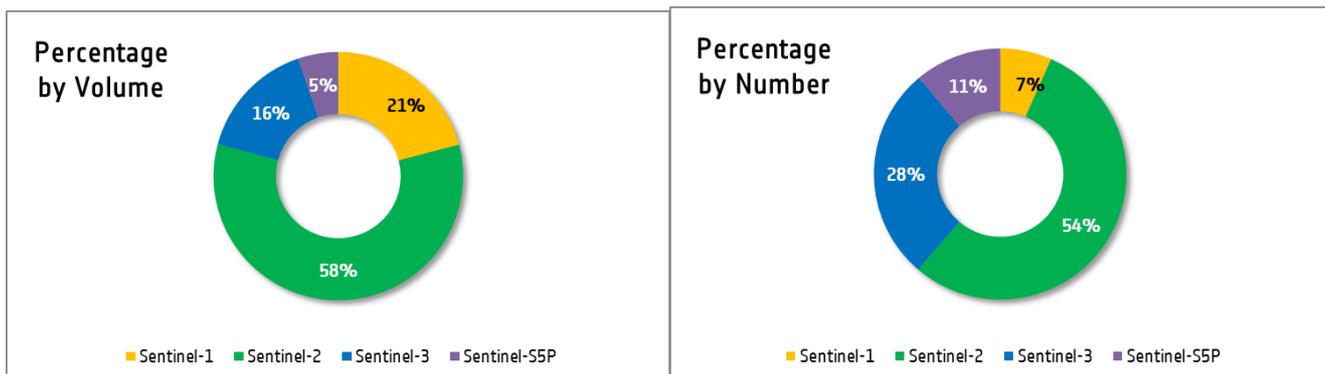


Figure 40: Percentage of total downloads per mission since the start of operations for all of the four hubs, on the left by volume and on the right by number

in both Y2021 and Y2020. It was only in the volume of Sentinel-1 data downloads that there was a significant decrease: 8 PiB (-33%) less Sentinel-1 data was downloaded in 2022 than in Y2021 and 11.4 PiB (-41%) lower than in Y2020, and it is this drop in Sentinel-1 downloads which brought the overall volume of data downloaded in 2022 below the Y2021 and Y2020 levels.

Nonetheless, despite the sharp decrease in the volume of Sentinel-1 downloads, Sentinel-1 downloads still accounted for 21% of the total volume of user downloads for the year, as shown in Figure 41

As a proportion of the yearly volume of downloads, Sentinel-2 data continued to be the most downloaded

for the year, and in 2022 accounted for 58% of the volume of all user downloads during the year, slightly higher than the 57% in Y2021. The volume downloaded in 2022 was 8% greater than in Y2021, rising from 42.3 PiB in Y2021 to 45.8 PiB in 2022.

However, the greatest proportional increase in the volume of data downloads was for Sentinel-3: the volume of user-level data downloaded by users increased by 37% with respect to Y2021, rising from 9.0 PiB in Y2021 to 12.3 PiB in 2022. To give some perspective, just that increase of 3.3 PiB is equivalent to the volume of all Sentinel-3 data downloaded in Y2018.

Figure 41 shows that when all downloads since the start of operations are taken into account, Sentinel-2

downloads still constituted the majority of both the total *volume* (58%) and the *number* (54%) of user-level data downloaded. Sentinel-1 downloads accounted for a smaller proportion: 21% in terms of volume and only 7% in terms of the number of downloads. Due to their smaller average user-level data size, both Sentinel-3 and Sentinel-5P have a greater impact in terms of number than in volume. While Sentinel-3 only made-up 16% of the total downloads since the start of operations by volume, it accounted for 28% by number; Sentinel-5P accounted for only 5% of volume but 11% by number.

In terms of the *number* of user downloads during 2022, a total of 161.6 million user downloads were made, and this represents a 13% drop on the 185.7 million user-level data downloaded during Y2021.

2.3.2 Archive Exploitation Ratio (AER)

Interest in Sentinel user-level data can also be monitored by looking at the 'Archive Exploitation Ratio' (AER). The AERs which are shown in Figure 42 were calculated at the end of 2022 and represent 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 of that user-level data.

The AERs reported in Figure 41 suggest that user interest in Sentinel-3 has slightly increased since 2021: the AER has increased from 1:11 in Y2021 to 1:12 in 2022. The other AERs remain constant, again at 1:15 for Sentinel-1, 1:13 for Sentinel-2 and the exploitation rate of Sentinel-5P user-level data remains the highest of all the missions, at a staggering 1:28.

In the following subsections, further details on the AERs are presented for each mission, grouped by instrument, data level, resolution, and timeliness, for

the period since the start of operations up to the end of 2022. 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.



Figure 41: Archive Exploitation Ratio per mission at the end of 2022

Sentinel-1

Level	Timeliness	Number of Published user-level data in 2022	Number of Downloaded user-level data in 2022	Archive Exploitation Ratio
Level 0	NTC	226,029	1,991,488	1 : 9
Level 1	NTC	339,386	6,500,487	1 : 19
	NRT	99,816	2,407,438	1 : 24
Level 2	NTC	130,542	2,153,950	1 : 17

Table 5: Sentinel-1 User-level data Published, Downloaded and AER for 2022, per 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	2,496,893	17,832,961	1 : 7
Level 1	NTC	4,698,152	74,681,035	1 : 16
	NRT	537,894	8,236,954	1 : 15
Level 2	NTC	999,676	17,601,906	1 : 18

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

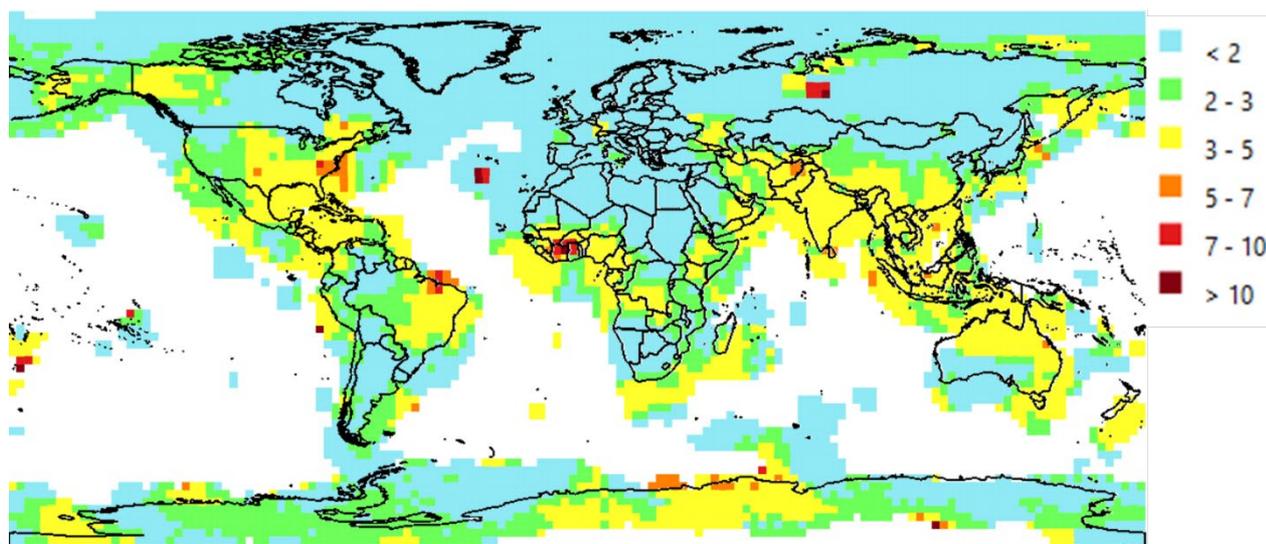


Figure 42: Heatmap showing the archive exploitation ratio for Sentinel-1 Lo and L1 NTC user-level data (excluding WV mode) during 2022

Overall, the figures in Tables 5 and 6 suggest that user engagement with each of the Sentinel-1 user-level data types has remained similar to that seen in Y2021, with a strong uptake of all data types, and the lowest interest shown for the Level-0 data. This year the AER for the Sentinel-1 Level 1 NRT data remains at 1:24, and the data type continues to be the most popular Sentinel-1 data level/timeliness during the year.

The 2022 AER of the Level-1 and Level-2 NTC user-level data saw a slight decrease in terms of user

interest, with 1:19 and 1:16 respectively, slightly lower than the ratios calculated for the Level-1 and Level-2 NTC in Y2021, respectively 1:20 and 1:19. The Level-0 NTC still has the lowest AER at 1:9, although this has increased slightly since Y2021, when it was 1:8.

The overall AER calculated from the start of operations for Level-0 NTC data remained stable at 1:7, and for Level-2 NTC it remained at 1:18, as it had been in Y2021. There was a slight decrease in the overall AER for Sentinel-1 Level-1 NTC, which

changed from 1:17 in Y2021 to 1:16 in 2022. By contrast, there was an increase in the overall AER for Level-1 NRT, which rose from 1:13 in Y2021 to 1:15 in 2022, following the growth of interest shown during the reporting year..

Looking at the figures underlying the AERs, the numbers of all user-level data published during 2022 with exception of Level 1 NRT was a half compared with that published in Y2021 and this drop is due to the Sentinel-1B unavailability during the year.

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 2022 per available data over specific geographical points across the globe, taking into account all user-level data published since the start of operations. The Figure can be compared with the corresponding Sentinel-1 publication heatmap in Figure 28. 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. It is also 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.

Due to the reduced number of Sentinel-1 NTC downloads in 2022, compared with the previous years, the heatmap is very different to previous years and the areas of particular interest for Sentinel-1 users appear more starkly. Particular spots of interest emerge near the Azores, in central Russia, the East Coast of the United States, north-east Brazil, the Pacific Islands, and in West Africa over Cote d'Ivoire, Ghana and Burkina Faso. In these areas the AER ranges between 1:5 to 1:10 but in certain spots it even reaches the top range of 1:>10. There are also large concentrations of interest in Sri Lanka, Antarctica, and Afghanistan.

Sentinel-2

Level	Number of Published User-level data in 2022	Number of Downloaded User-level data in 2022	Archive Exploitation Ratio
Level 1C	4,189,214	68,662,953	1 : 16
Level 2A	4,166,287	39,015,999	1 : 9

Table 7: Sentinel-2 User-level data Published, Downloaded and AER for 2022, per user-level data type

Level	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	23,334,667	392,492,569	1 : 17
Level 2A	16,842,762	142,871,340	1 : 8

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

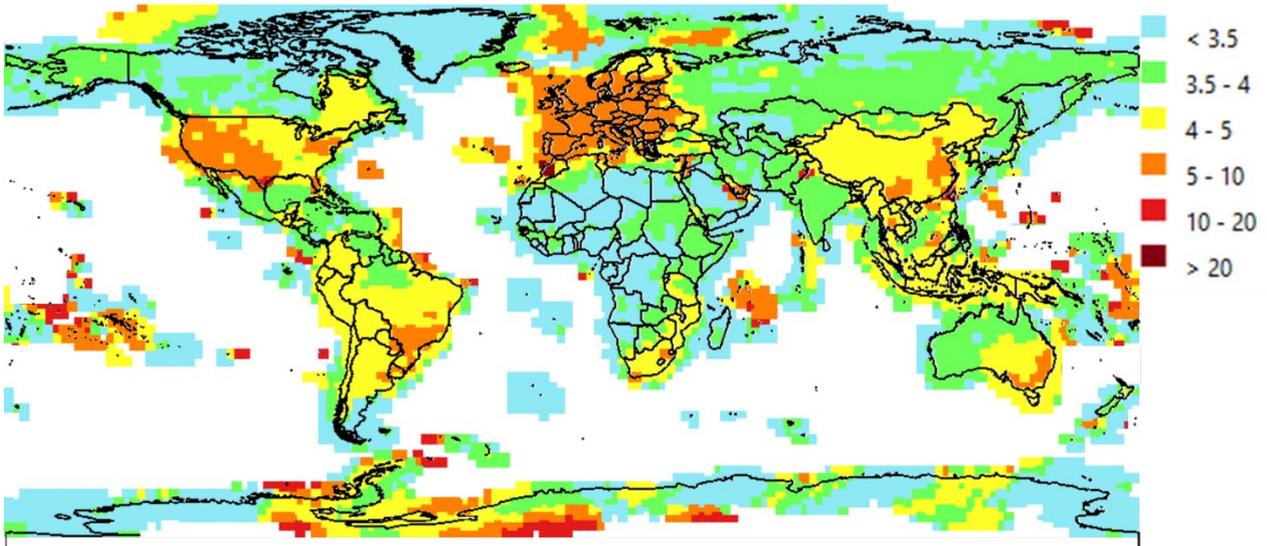


Figure 43: Heatmap showing the archive exploitation ratio for Sentinel-2 L1C user-level data during 2022

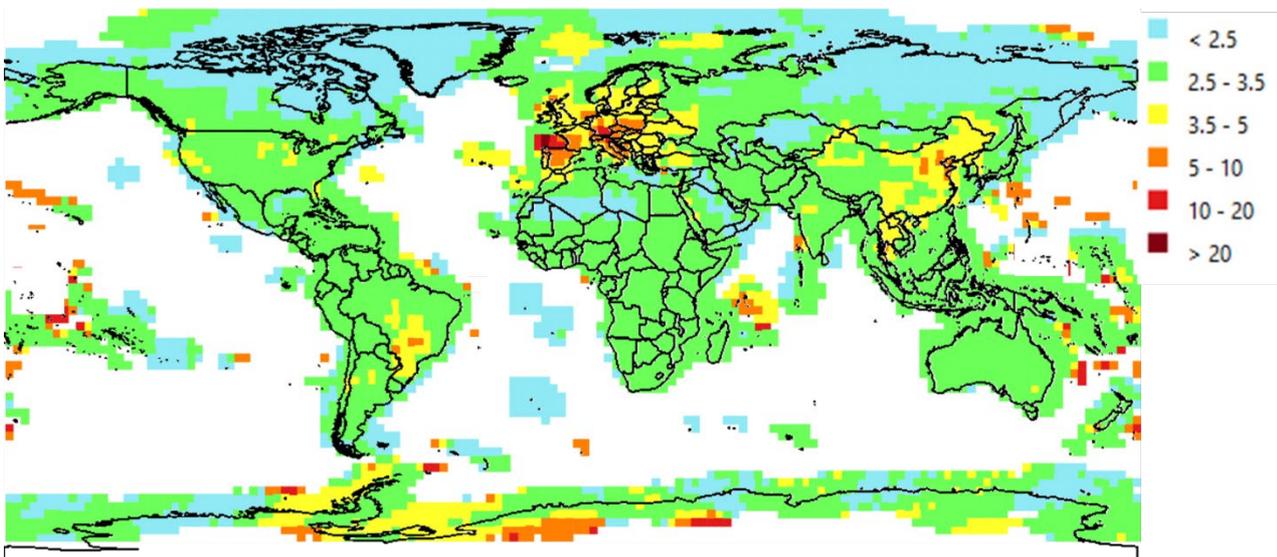


Figure 44: Heatmap showing the archive exploitation ratio for Sentinel-2 L2A user-level data during 2022

Looking at the figures in Table 7, the AER for Sentinel-2 Level-1C user level data significantly decreased with respect to Y2021, changing from 1:21 in Y2021 to 1:16 in 2022. The AER for Level-2A user-level data was instead the same as in Y2021, at 1:9. In terms of the AERs for the two user-level data types since the start of operations, the decreases were so small as to be not perceptible.

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 Y2021 per available data package 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. This year, a new scale has been used in the heatmaps, giving a better gradation and a more nuanced view of the different levels of user uptake than has previously been presented.

Both heatmaps highlight more or less the same areas of particular interest for users. In the Pacific Islands and sections of Antarctica, the AER reaches as high as 1:10-20 in both the Level-1C and the Level-2A heatmaps. Areas of the Atlantic Ocean, near Morocco in the Level-1C map and near the north coast of Spain

in the Level-2A map, appear as particular ‘hotspots’ where the AER reaches as high as 1:>20. Over European landmasses and sections of the Arctic, the Level-1C AER is mainly greater than 1:5, as it also is over large sections of the Indian Ocean, the United

States, southern Brazil, the Atlantic Ocean near the north-east Latin American coastline, south-east Australia, and east and south China.

Sentinel-3

Instrument	Number of Published User-level data in 2022	Number of Downloaded User-level data in 2022	Archive Exploitation Ratio
OLCI	696,100	12,155,951	1 : 17
SLSTR	2,367,830	26,531,989	1 : 11
SRAL	394,015	11,882,717	1 : 30
SYNERGY	373,346	3,939,060	1 : 11

Table 9: Sentinel-3 User-level data Published, Downloaded and AER for 2022, per user-level data group

Instrument	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio
OLCI	3,932,439	60,786,814	1 : 15
SLSTR	9,036,858	95,105,070	1 : 11
SRAL	1,991,129	28,733,173	1 : 14
SYNERGY	1,496,325	12,510,095	1 : 8

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 2022 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. There were big changes in the 2022 AERs compared with those calculated for Y2021. In Y2021, the most popular data groups had been OLCI with an AER of 1:32, followed by SLSTR with 1:16. This year, however, it was SRAL which was the most popular data group, with an AER of 1:30, showing a steep increase with respect to Y2021 (1:30 vs 1:11 in Y2021). This change was caused by a tripling in the number of downloads of SRAL data compared with Y2021 (it was 3,928,035 in Y2021). For SYNERGY there was a more modest increase in the number of data which were downloaded in 2022, with the AER rising only from 1:9 in Y2021 to 1:11 in 2022.

The biggest reduction in the AER was for the OLCI data group, with the AER falling from 1:32 in Y2021 to 1:17 in 2022, due to half number of downloads having been carried out compared to the number downloaded in Y2021. The number of OLCI downloads in 2022 is, however, very similar to the

numbers of OLCI downloads which were made in both Y2020 (11,361,931), and Y2019 (11,203,402), making Y2021 the outlier year.

The drop in the SLSTR AER was less significant but still noticeable, falling from 1:16 in Y2021 to 1:11 in 2022. This lower ratio was caused by a modest increase in the number of SLSTR products which were published, rising from 1,851,432 in Y2021 to 2,367,830 in 2022, combined with a relatively small drop in the number of downloads, falling from 30,332,055 in Y2021 to 26,531,989 in 2022.

When the AERs are calculated using the total download and publication numbers since the start of operations, a different picture emerges. The overall AERs of OLCI and SYNERGY remained at 1:15 and 1:8 respectively, as they had been in Y2021, and OLCI continued to have the highest AER of all the data types. The biggest increase in the overall AERs was for the SRAL data group, for which the AER rose from 1:11 in Y2021 to 1:14 in 2022. The overall AER for SLSTR also increased but only slightly, rising from 1:10 in Y2021 to 1:11 in 2022.

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.

Level	Timeliness	SLSTR		
		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	2,860,258	34,417,184	1 : 12
	NRT	1,701,422	19,995,555	1 : 12
Level 2	NTC	2,774,838	28,242,456	1 : 10
	NRT	1,700,339	12,648,567	1 : 7

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

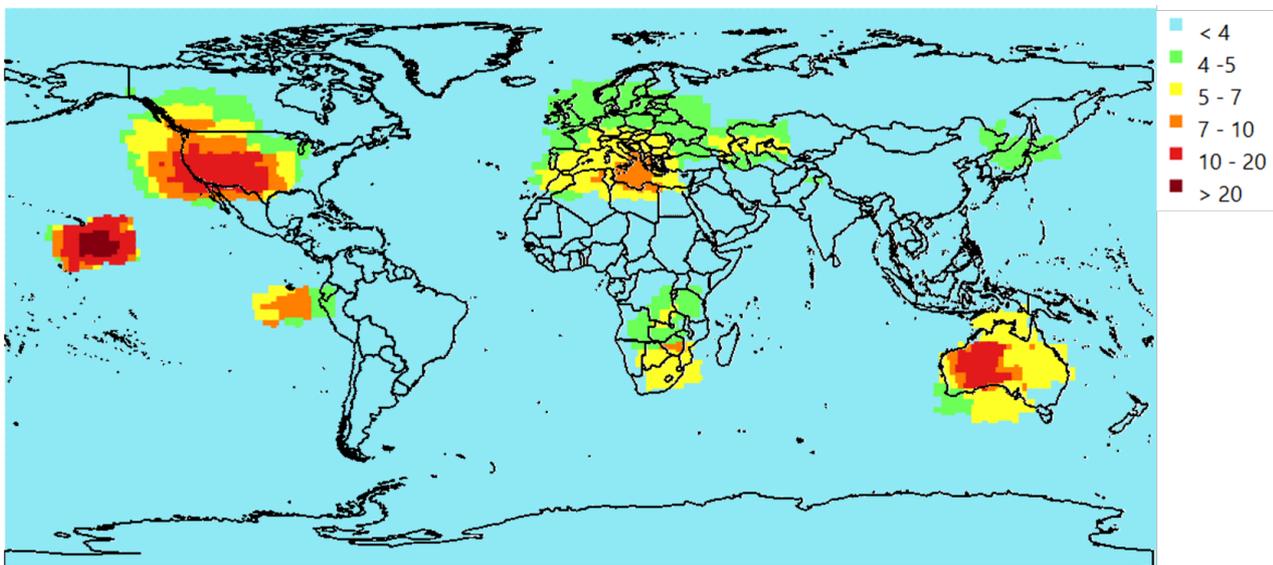


Figure 45: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-1 NTC user-level data during Y2021

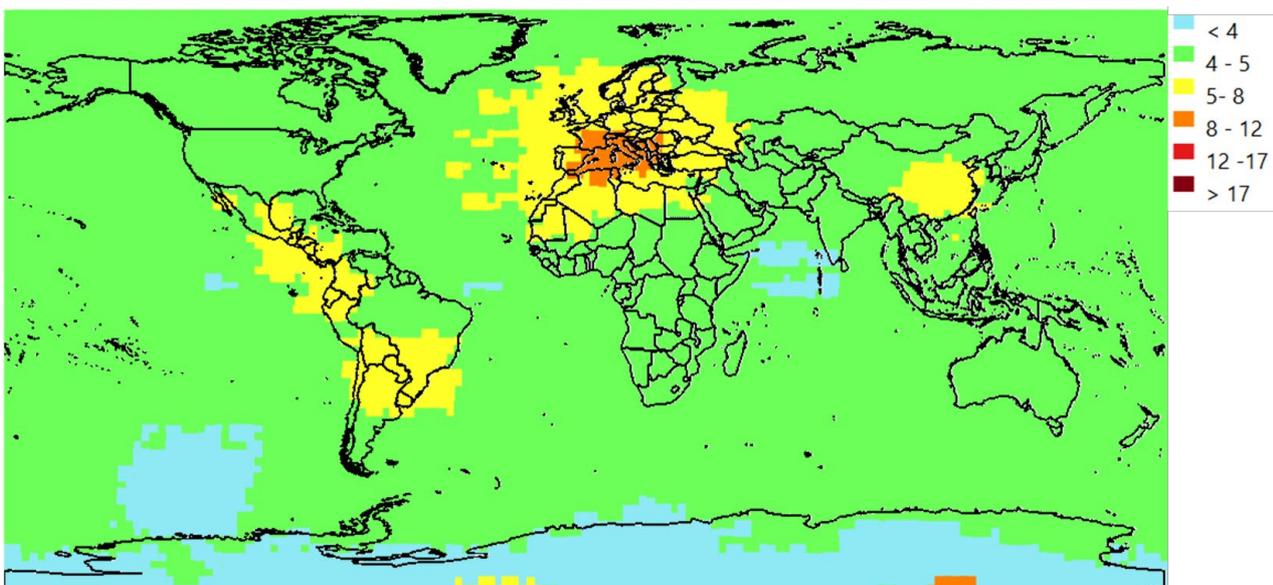


Figure 46: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-2 NTC user-level data during 2022

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 1:11 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 1:11 to 1:12 in 2022. The interest in the other user-level data type is stable.

The heatmaps in Figures 46 and 47 show the geographical variation in AER for regions across the globe during 2022 for SLSTR Level-1 and Level-2 NTC user-level data respectively. Again, a different scale has been used to that used in previous years, giving a better gradation and a clearer picture of the areas of particular user interest. Figure 46, for SLSTR Level-1

NTC, shows very clearly that the area of maximum user interest, i.e. where the AER reached 1:>20, was in the North Pacific Ocean, approximately around Hawaii. Other clear hotspots are the United States, the South Pacific Ocean around the Galapagos, Western Australia, and the Mediterranean Sea between Italy and Libya.

Figure 47 shows the equivalent heatmap for SLSTR Level-2 NTC data, the footprints of which cover the entire globe with each pass. However, interest is again clearly concentrated in specific geographical areas, centred on European regions, South America and eastern part of China. In these regions the AER rises to between 1:5 - 8, and even to 1:8-12 over Mediterranean areas.

Level	Timeliness	SRAL		Archive Exploitation Ratio
		Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	
Level 1	NTC	383,460	3,632,174	1 : 9
	STC	319,856	2,253,427	1 : 7
	NRT	540,118	11,528,803	1 : 21
Level 2	NTC	183,841	4,598,314	1 : 25
	STC	129,300	1,357,458	1 : 10
	NRT	434,545	5,461,140	1 : 13

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

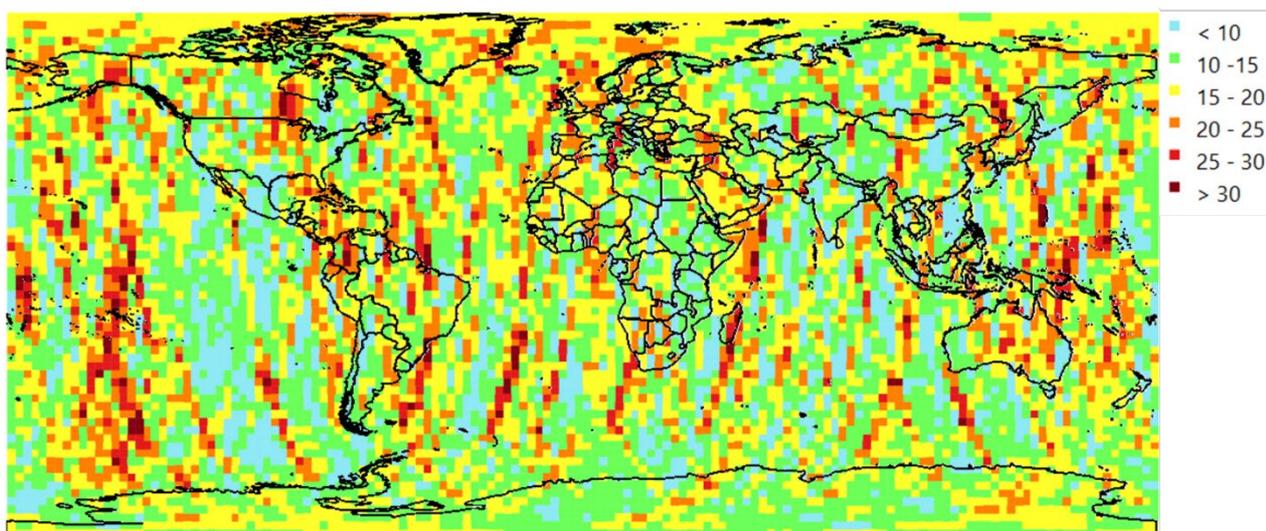


Figure 47: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-1 NRT user-level data during 2022

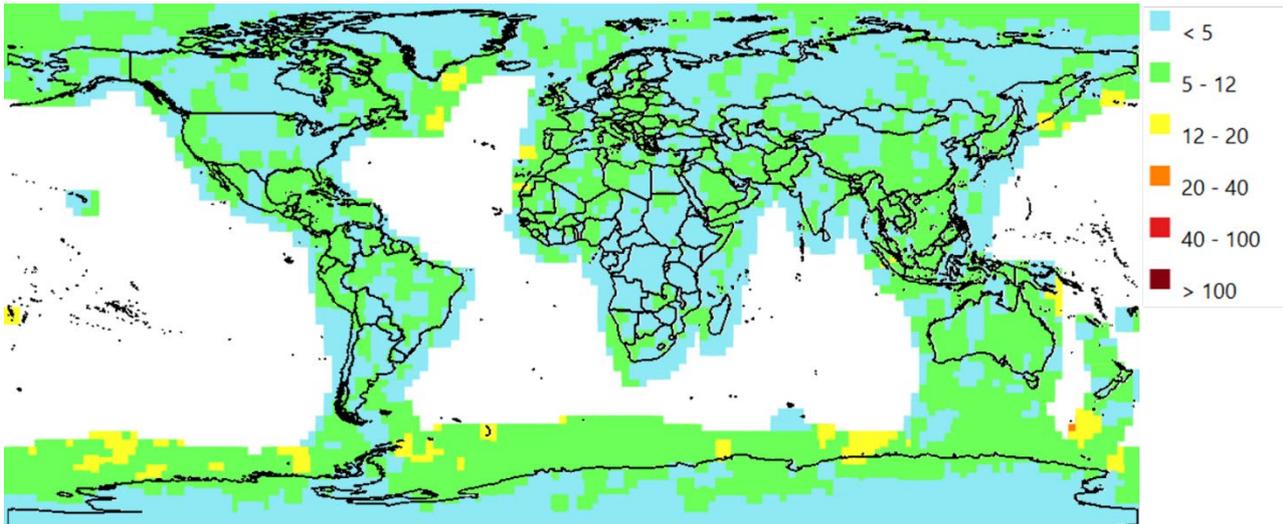


Figure 48: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-2 NRT user-level data during 2022

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, as in previous years, the Level-2 NTC user-level data, which have an elevated AER of 1:25. This AER has also increased from 1:24 recorded in Y2021.

However, there was a very significant change in the AER for Level-1 NRT user-level data, which rose from 1:11 in Y2021 to 1:21 in 2022. The dramatic increase in the overall AER for the SRAL data group in 2022 can almost certainly be attributed to this change in the uptake of the Level-1 NRT, especially given that in terms of the absolute number of downloads, the Level-1 NRT remained by far the most downloaded SRAL data type, with a massive 11,528,803 downloads since the start of operations, over twice the number of downloads for the next most downloaded SRAL data type, Level-2 NRT.

The heatmaps in Figures 48 and 49 show the geographical variation in AER for regions across the globe during 2022 for SRAL Level-1 NRT and Level-2 NRT user-level data respectively. For Level-1 NRT, the activity is mixed across the world, with the AERs ranging between 1:10 and 1:30.

The heatmap for the Level-2 NRT 2 user-level data is restricted to landmasses. The AER is <1:5 (white-blue

areas on the map) for most of the Earth’s land area. The regions in yellow at the borders of the land masses are, perhaps, the result of an artifact generated by the less user-level data published on those specific areas.

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. Overall, the AERs are very similar to those seen in Y2021.

For the Reduced Resolution data types, the individual AERs range from 1:9 to 1:38. The biggest variation with respect to Y2021 across the whole table is in the AER for the Reduced Resolution Level-2 NTC, which rose from 1:7 in Y2021 to 1:14 in 2022. When taken as a group, the overall AER for the Reduced Resolution data group is much higher than that for the Full Resolution group, with overall AERs of 1:28 and 1:14 respectively. However, within the Full Resolution data group, the individual AERs all remain high (1:13 – 1:18), with only the uptake of the Level-2 NRT data still lagging a bit behind, now at 1:9. Moreover, in absolute terms, the numbers of downloads of the Full Resolution data are also all much higher than for the Reduced Resolution data group, in line with the much higher numbers of Full Resolution data which has been published.

The heatmap in Figure 50 shows the geographical variation in AER for OLCI Full Resolution data. There is interest in OLCI user-level data over the whole globe, with most regions exhibiting AERs in the range 1:3-4 and 1:7.

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	58,883	2,253,195	1 : 38	
		NRT	51,837	655,004	1 : 13	
	Level 2	NTC	109,360	1,526,912	1 : 14	
		NRT	51,290	466,228	1 : 9	
	TOTAL			271,296	7,671,076	1 : 28
Full	Level 1	NTC	980,537	17,191,894	1 : 18	
		NRT	859,241	11,457,571	1 : 13	
	Level 2	NTC	971,219	17,297,839	1 : 18	
		NRT	850,145	7,270,362	1 : 9	
	TOTAL			3,661,142	53,217,667	1 : 15

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

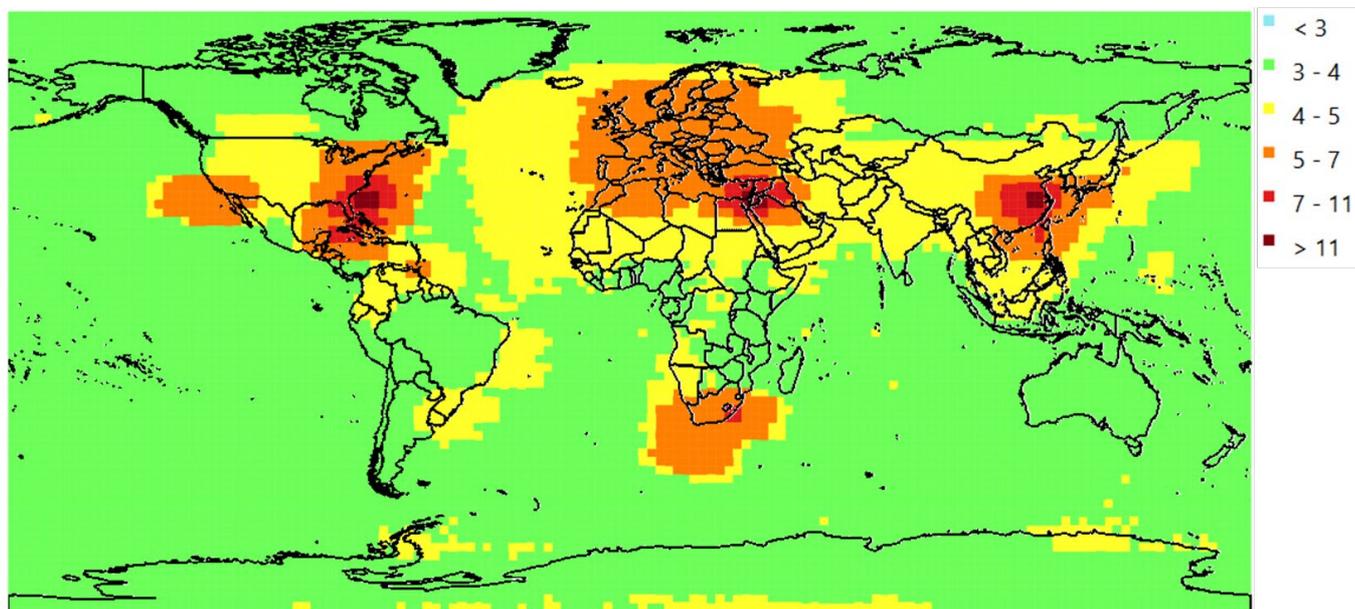


Figure 49: Heatmap showing the archive exploitation ratio for Sentinel-3 OLCI Full Resolution user-level data during 2022

This year, the map shows concentrations of interest with AERs in the range 1:5-7 in Europe and the Middle-East, the Gulf of Mexico, Caribbean and the east of the United States, eastern Asia. There are three spots (in eastern China, just off the East coast of the United States, and around North Sinai), where the AERs rise above 1:11, the highest observed in any region for OLCI Full Resolution user-level data.

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 remained stable at 1:8 since the start of operations. There were only modest increases in both the overall individual AERs since the end of Y2021: the

AER for the Level-2 STC data increased from 1:6.5 in Y2021 to 1:7.3 in 2022, and the AER for Level-2 NTC rose from 1:8.6 to 1:9.3. These modest increases in the overall AERs mask the bigger changes in the actual numbers behind the ratios, however. The number of user-level data which had been *published* by the end of 2022 since the start of operations increased by 35% for Level-2 STC data and by 39% for Level-2 NTC data with respect to the end of Y2021; in terms of the number of *downloads*, Level-2 STC data increased by 48% while Level-2 NTC downloads increased by 57% compared to Y2021.

The heatmap in Figure 51 shows the geographical variation in AER for regions across the globe during 2022 for SYNERGY data. Interest over most of the globe was between 1:2 and 1:4, but there is a clear

concentration of interest over most of Europe. Here, the AER rises to 1:5-6.

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>

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	800,376	7,482,959	1 : 9
	STC	695,702	5,026,132	1 : 7

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

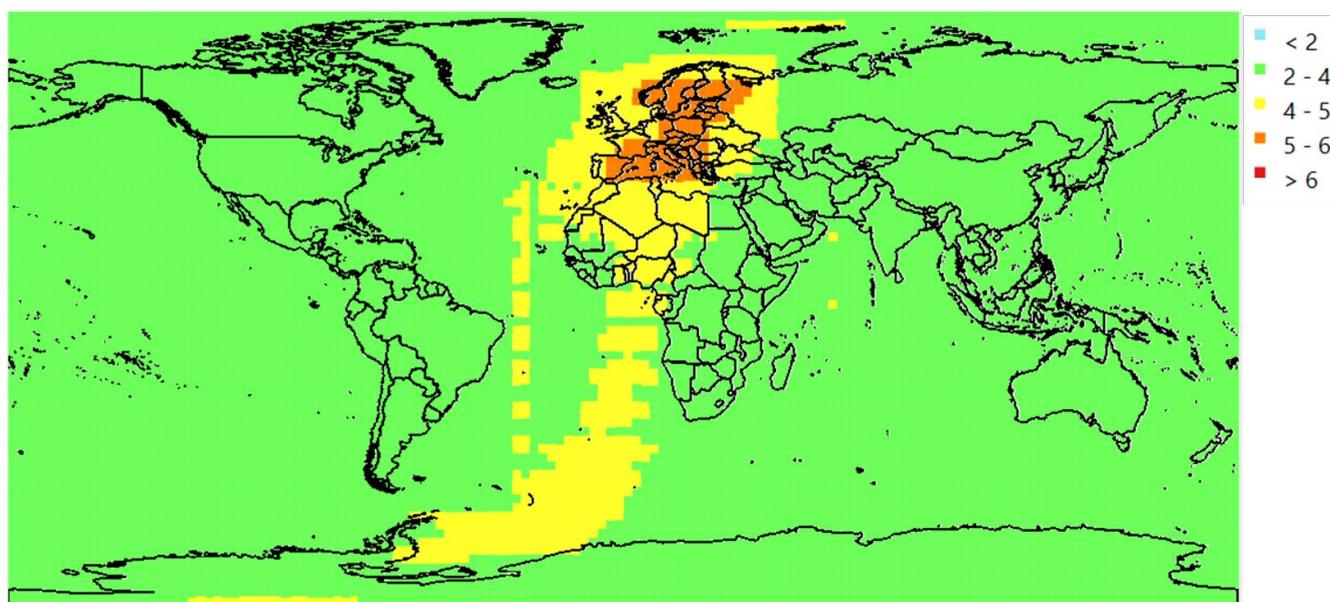


Figure 50: Heatmap showing the archive exploitation ratio for Sentinel-3 SYNERGY user-level data during 2022

Sentinel-5P

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 data and, for Level-2 user-level data, also per individual user-level data type.

The overall AER for Sentinel-5P user-level data remained very similar to that seen in Y2021, at 1:28 compared with 1:29 in Y2021. The overall AER for the Level 2 NRT data group remained the same as in Y2021, at 1:25; while the overall AER for the Level-1B NTC fell slightly, from 1:55 in Y2021 to 1:51 in 2022. It is interesting to note this much higher exploitation rate for the Sentinel-5P NTC data, and even though

far fewer NTC data than NRT were published, users still downloaded as many as 20,050,514 NTC data packages.

Within this Sentinel-5P NTC data group, there were some staggeringly high individual AERs. Judged according to AER, by far the most popular user-level data were the Level-2 methane (L2_CH4) and nitrogen dioxide (L2_NO2) user-level data, which had AERs as high as 1:168 and 1:141 respectively (even higher than in Y2021, in which the AERs were 1:125 and 1:132 respectively). The biggest decrease in uptake in 2022 was for the carbon monoxide user-level data (L2_CO), the AER for which fell from 1:91 in Y2021 to 1:60 in 2022.

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]	196,883	3,304,928	1 : 17	
Level 2	NRT	L2__AER_AI	289,136	7,945,693	1 : 27	
		L2__AER_LH	210,710	3,212,091	1 : 15	
		L2__CLOUD_	288,730	3,974,664	1 : 14	
		L2__CO__	264,160	9,927,943	1 : 38	
		L2__HCHO__	273,545	5,848,121	1 : 21	
		L2__NO2__	288,571	10,942,814	1 : 38	
		L2__O3__	288,533	6,966,106	1 : 24	
		L2__O3__PR	70,852	1,127,368	1 : 16	
		L2__SO2__	273,539	6,965,381	1 : 25	
		[ALL]	2,247,776	56,910,181	1 : 25	
		NTC	L2__AER_AI	43,653	1,453,626	1 : 33
	L2__AER_LH		24,199	831,181	1 : 34	
	L2__CH4__		24,099	4,039,770	1 : 168	
	L2__CLOUD_		48,689	1,038,594	1 : 21	
	L2__CO__		45,039	2,684,396	1 : 60	
	L2__HCHO__		24,990	1,405,970	1 : 56	
	L2__NO2__		25,623	3,612,009	1 : 141	
	L2__NP_BD3		24,944	553,560	1 : 22	
	L2__NP_BD6		24,247	482,259	1 : 20	
	L2__NP_BD7		24,166	504,573	1 : 21	
	L2__O3__		48,067	1,606,284	1 : 33	
	L2__O3__PR		5,765	120,784	1 : 21	
	L2__O3_TCL		1,727	113,187	1 : 66	
	L2__SO2__		25,299	1,604,187	1 : 63	
	[ALL]		390,507	20,050,380	1 : 51	
	[ALL NRT + NTC]			2,638,283	76,960,561	1 : 29
	Grand Total			2,835,166	80,265,489	1 : 28

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

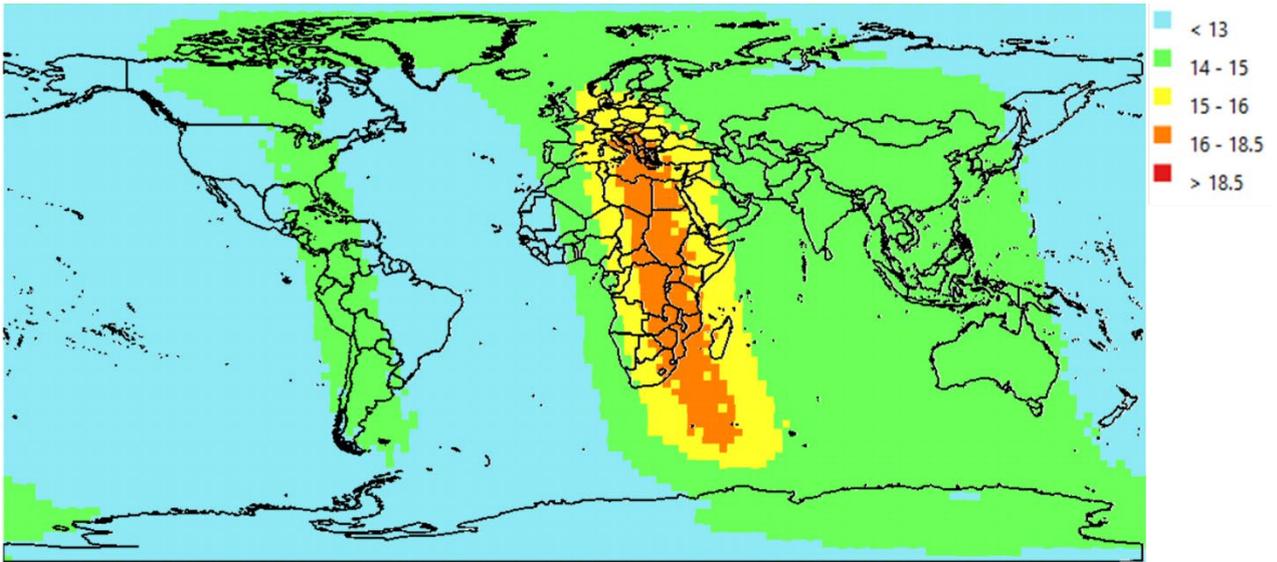


Figure 51: Heatmap showing the archive exploitation ratio for Sentinel-5P NTC (Level-1B & Level-2) user-level data during 2022

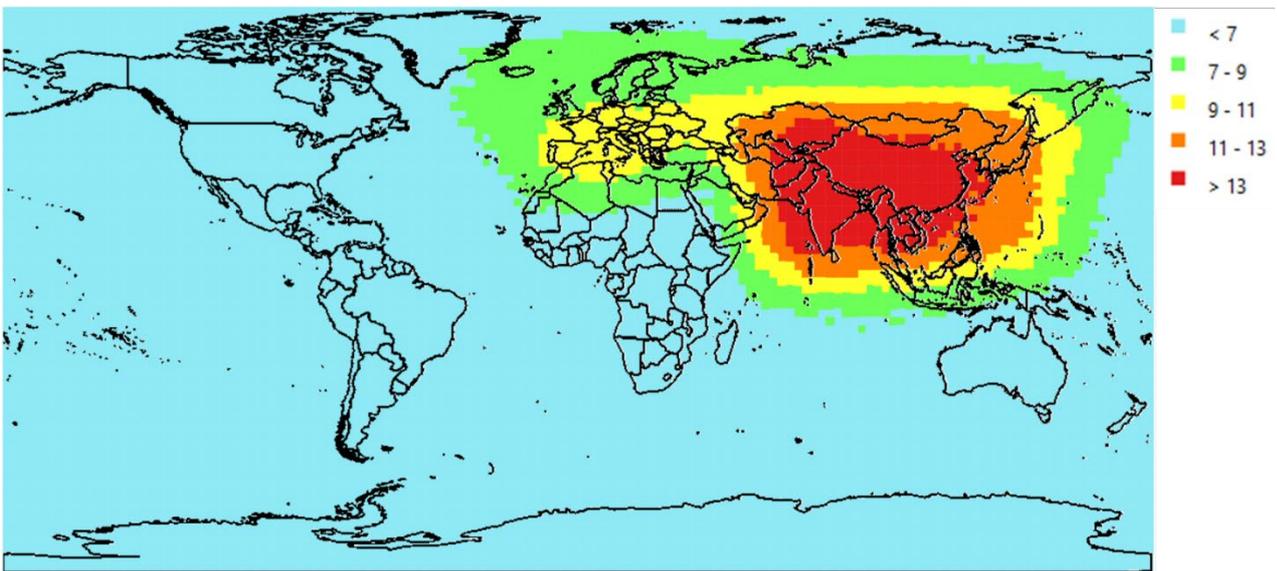


Figure 52: Heatmap showing the archive exploitation ratio for Sentinel-5P NRT (Level-2) user-level data during 2022

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 footprints of NTC user level data encompass the entire orbit (portion daylight illuminated). It is suggested, therefore, that for the interest over Europe which then apparently extends through Africa and down into Antarctica,

could be the result just of interest in user-level data covering Europe but which extend over a large latitudinal range (see Annex 2).

For NRT user level data, whose footprints are generally smaller, there is now a very marked particular interest in Sentinel-5P NRT data over Asia.

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	393,004,431	51	172.75	43
Collaborative Hub	246,663,268	32	155.26	38
Copernicus Services Hub	87,100,059	11	46.84	12
International Hub	49,001,293	6	30.06	7
All hubs	775,769,051		404.90	

Table 16: Number and Volume of user-level data downloaded since the start of operations, per hub

The hub which has experienced the greatest load of download requests since the beginning of operations remains the Open Hub, despite the large year on year increases in the amount of data being downloaded from ColHub. By the end of 2022, 51% of the total number of downloads made from all of the hubs since the start of operations had been made from the Open Hub, a slightly higher proportion than at the end of Y2021 (50%), while 32% was made from ColHub (31% during Y2021). Correspondingly, the proportions made from ServHub and IntHub had fallen slightly by the end of 2022, decreasing to 11% and 6% from 12% and 7% in Y2021.

Looking at the proportions by volume, a similar split between the hubs is seen. However, in this view, the proportion downloaded from ColHub (38%) is closer to that from the Open Hub (43%), 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 December 2022, as well as the corresponding value for December 2021, and the percentage change between the two years. The average total daily volume of data downloaded by users across all hubs was higher in December 2022 than in December 2021, at 233.52 TiB compared to 196.41 TiB, constituting a 19% increase.

At an individual level, all the hubs experienced an increase in the average daily volume of user downloads in the compared months, despite the Sentinel-1B satellite unavailability. The most notable increases compared to 2021 were on the Open Hub and the Collaborative Hub, on which there were increases of 21% and 19% in the daily average volume downloaded respectively, reaching average daily volumes of 114 TiB and 85 TiB, and together constituting 85% of the daily download volume from all of the Sentinel Data Hubs.

Hub	Daily average volume (TiB) downloaded in December 2022	Daily average volume (TiB) downloaded in December 2021	% increase
Open Access Hub	113.59	94.03	21%
Collaborative Hub	85.46	71.93	19%
Copernicus Services Hub	20.31	18.03	13%
International Hub	14.16	12.43	14%
All hubs	233.52	196.41	19%

Table 17: Average volume of data disseminated per day during the last month of 2022 and 2021

However, as already noted, when looking at the year as a whole, the overall download volume was lower in 2022 than it had been in Y2021: 78.65 PiB of data was downloaded in 2022 and 80.45PiB in Y2021. It is

recalled that the December 2021 data, with a download volume of 5.95PiB, has been excluded, i.e. it is not in the total for either Y2021 or 2022.

This decrease in the overall yearly download volume was caused by a large decrease in the volume of user-level data downloaded from IntHub and ServHub. From IntHub, the volume downloaded was 36% less than it had been in Y2021 (4.1 PiB in 2022 vs 6.4 PiB in Y2021), and from ServHub it was 16% less (8.4 PiB in 2022 vs 9.9 PiB in Y2021). Interestingly, looking at the breakdown of the volumes by mission in Figure 54, these decreases do not appear to have been caused only by the Sentinel-1B unavailability. The volume of Sentinel-1 data downloaded from both hubs was certainly lower than it was in Y2021 (from ServHub the volume fell only slightly, from 1.8 PiB to 1.4 PiB, while from IntHub it halved, falling from 2.1 PiB to 1.0 PiB in 2022), but the volume of Sentinel-2 data downloaded from both hubs also decreased significantly compared with the Y2021 volumes, and on IntHub the volume of Sentinel-3 data downloaded also halved. In fact, the only increase seen on ServHub and IntHub was a modest rise in the volume of Sentinel-3 data which was downloaded from ServHub: in Y2021 0.75 PiB of Sentinel-3 data was downloaded, and in 2022 the volume increased by 17% to 0.88 PiB.

By contrast, there were increases in the overall download volumes from both the Open Hub and ColHub. A total of 36.04.0 PiB was downloaded from the Open Hub in 2022, 8% more than the 33.5 PiB downloaded from it in Y2021, and the Open Hub

remained the hub which disseminated the greatest volume of data during the year, followed by ColHub. This latter disseminated a total of 30.16 PiB in 2022, just a few decimals of PiB more than had been downloaded from ColHub in Y2021 (30.03PiB).

These increases were caused by rises in the volumes of Sentinel-2 and Sentinel-3 data downloaded from both hubs. On the Open Hub, the volumes of Sentinel-2 and Sentinel-3 data downloaded rose by 12% and 60% respectively. On ColHub, there were increases of 24% and 36% respectively. Moreover, although there was a 39% decrease in the volume of Sentinel-1 data downloaded from ColHub, there was only an 18% decrease in the volume downloaded from the Open Hub, presumably as a result of users engaging with the increased acquisition scenario for Sentinel-1A.

Perhaps more surprisingly, there was also a drop in the volume of Sentinel-5P data downloaded (necessarily from the Open Hub); the volume fell by 13% from 4.7 PiB in Y2021 to 4.1 PiB in 2022.

Overall, Sentinel-2 continued to constitute by far the most downloaded mission from all of the hubs, with 45.8 PiB downloaded in 2022 (up from 42.3 in Y2021), compared with .14.5 PiB of Sentinel-1 data, 12.3 PiB of Sentinel-3, and 4.1 PiB of Sentinel-5P.

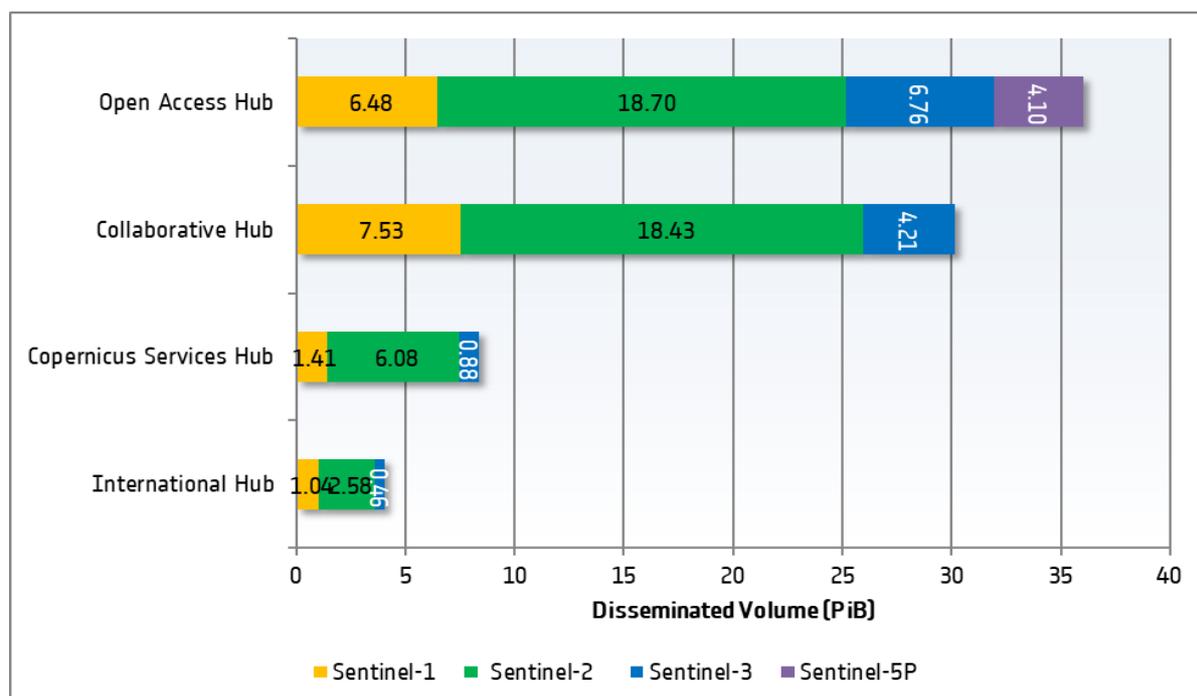


Figure 53: Downloaded volumes (PiB) during 2022 per Hub and per Mission

Figures 55, 56, 57 and 58 below separate out the total volumes of data downloaded from each Sentinel mission into the percentage share of the downloads per user-level data type. This breakdown is shown per hub, to give an idea of the differing levels of interest in the various data types among the users of each hub.

Sentinel-1

The most frequently downloaded Sentinel-1 user-level data overall from all hubs during 2022 were the Level 1-GRDH user-level data, as seen in the previous years. 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 29% (ColHub) and 61% (ServHub) of the number of user-level data downloaded from each hub. The exception was on ColHub, from which the most downloaded data type for Sentinel-1 was Level-1 SLC (30%), though by a small margin and the overall proportion of Level 1-SLC user-level data downloaded from all of the hubs in 2022 did not change compared with the proportion in Y2021, at 25% of the total number of Sentinel-1 downloads.

For Lo-RAW user-level data, interest on the Open Hub and ServHub, both at 9% of the total respectively, was much lower than seen on IntHub and ColHub (21% and 18% 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 were small changes with respect to Y2021. The number of Level-2 OCN data downloaded from the Open Hub and IntHub decreased, constituting 17% of the Sentinel-1 downloads from each hub, instead of the 25% and 18% from Y2021. On ColHub, however, the proportion increased to 19% from 17%, and on ServHub Level-2 OCN data again constituted only 6% of the total number of Sentinel-1 downloads from the hub, as in Y2021.

This year, the Level 1-GRDM user-level data did not exceed 8% of the Sentinel-1 downloads from any of the hubs.

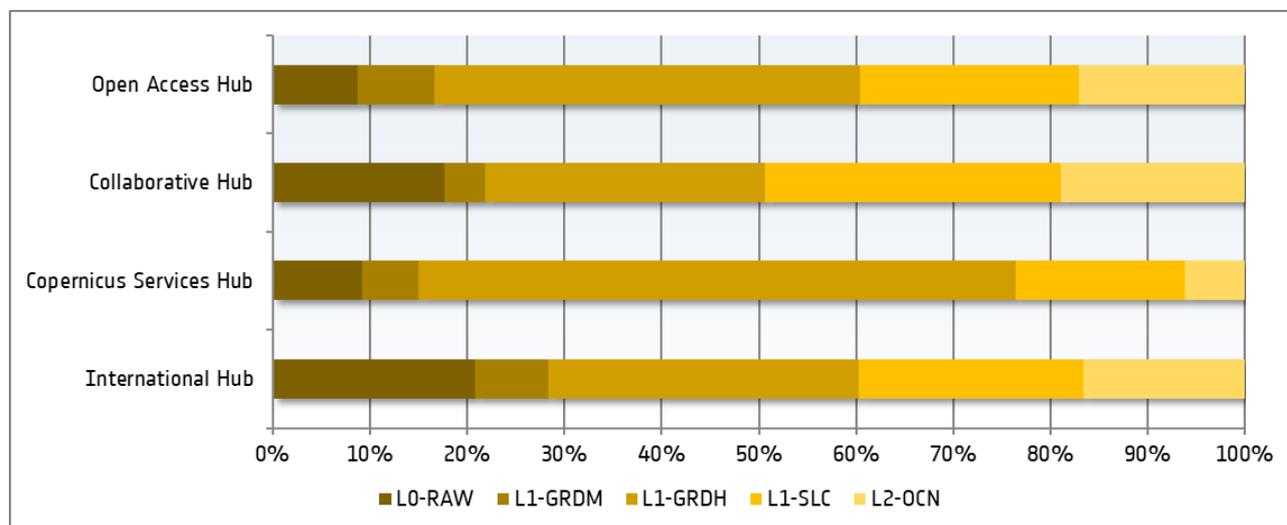


Figure 54: Percentage of total number of Sentinel-1 user-level data downloaded from each hub during 2022 per user-level data type

Sentinel-2

2022 was the fourth year of Sentinel-2 Level-2A systematic publication. Interest in the Level-2A user-level data increased on each hub compared with Y2021, apart from on ServHub, on which the Level-2A user-level data again constituted 35% of the total number of Sentinel-2 downloads in 2022, confirming the same interest in Level-2A data shown in Y2021 by the ServHub users.

On the Open Hub, there was a particularly significant rise in the proportion of Sentinel-2 user-level data

downloaded in 2022 which was Level-2A, increasing from 24% in Y2021 to 34% in 2022. The increase in the proportion of Level-2A data downloaded from IntHub also rose significantly, although it started from a much lower point, reaching 11% in 2022 from 5% in Y2021. The increase on ColHub was more modest, but with the proportion rising to 37% from 35% in Y2021, ColHub became the hub with, proportionally, the highest interest from its users in the Level-2A data compared to the Level-1C.

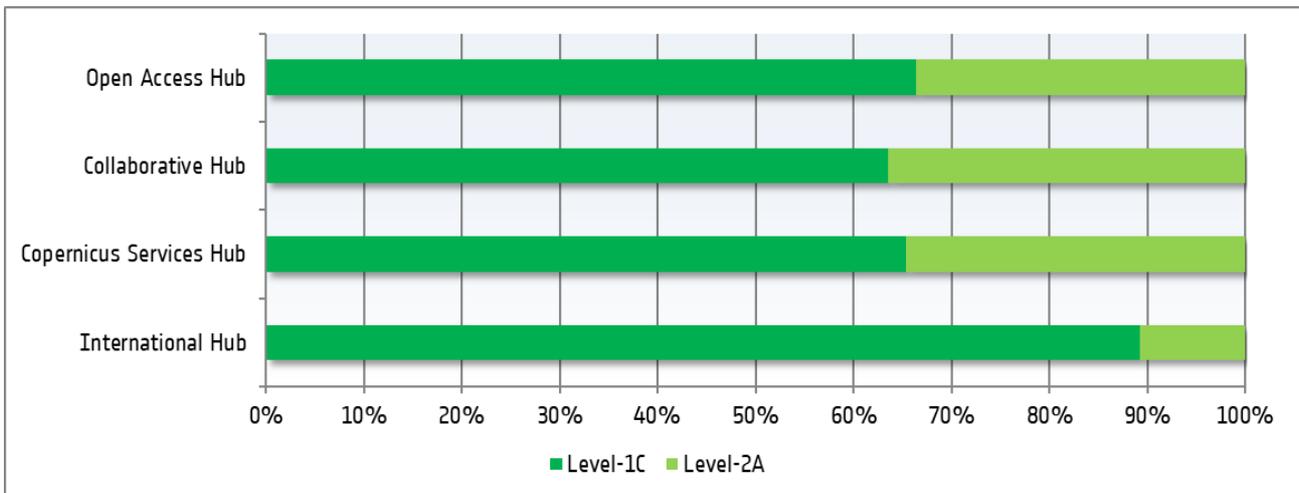


Figure 55: Percentage of total number of Sentinel-2 user-level data downloaded from each hub during 2022 per user-level data type

Sentinel-3

With the new user-level data types SR_2_LAN_HY, SR_2_LAN_LI, SR_2_LAN_SI and SY_1_MISR__, there were 20 distinct user-level data types in 2022 for Sentinel-3 (split between SRAL (7x), OLCI (4x), SLSTR (3x) and Synergy (6x)). The first graph in Figure 57 shows the percentage split of the overall number of Sentinel-3 user-level data 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, however, the second graph in Figure 57 shows the same proportions but with the user-level data combined into user-level data groups (each instrument plus SYNERGY user-level data). It is recalled that only two SYNERGY user-level data type (SY_2_SYN__ and SY_2_AOD__) are available on IntHub.

Once again, the majority of downloads was accounted for by SLSTR and OLCI user-level data, which

together ranged from 93% to 63% of Sentinel-3 downloads from each hub, as in the previous years. However, for the first time the proportion of data downloaded from the Open Hub which was SRAL data significantly surpassed that of OLCI data, with as much as 33% of the Sentinel-3 data downloaded from the Open Hub being SRAL data, compared with 21% for OLCI. Interestingly, the proportion which constituted SRAL data on the other hubs remained low, ranging from 4% (IntHub) to 12% (ColHub).

OLCI was the most commonly downloaded data-type on only ServHub, from which it constituted 49% of the Sentinel-3 downloads. On the other three hubs, it was SLSTR data which was the most popular, constituting 58% of Sentinel-3 data downloaded from IntHub, 54% from ColHub, and 43% from the Open Hub.

SYNERGY user-level data constituted only a small proportion of the Sentinel-3 downloads from each hub, ranging between 2% (ServHub) to 17% (IntHub).

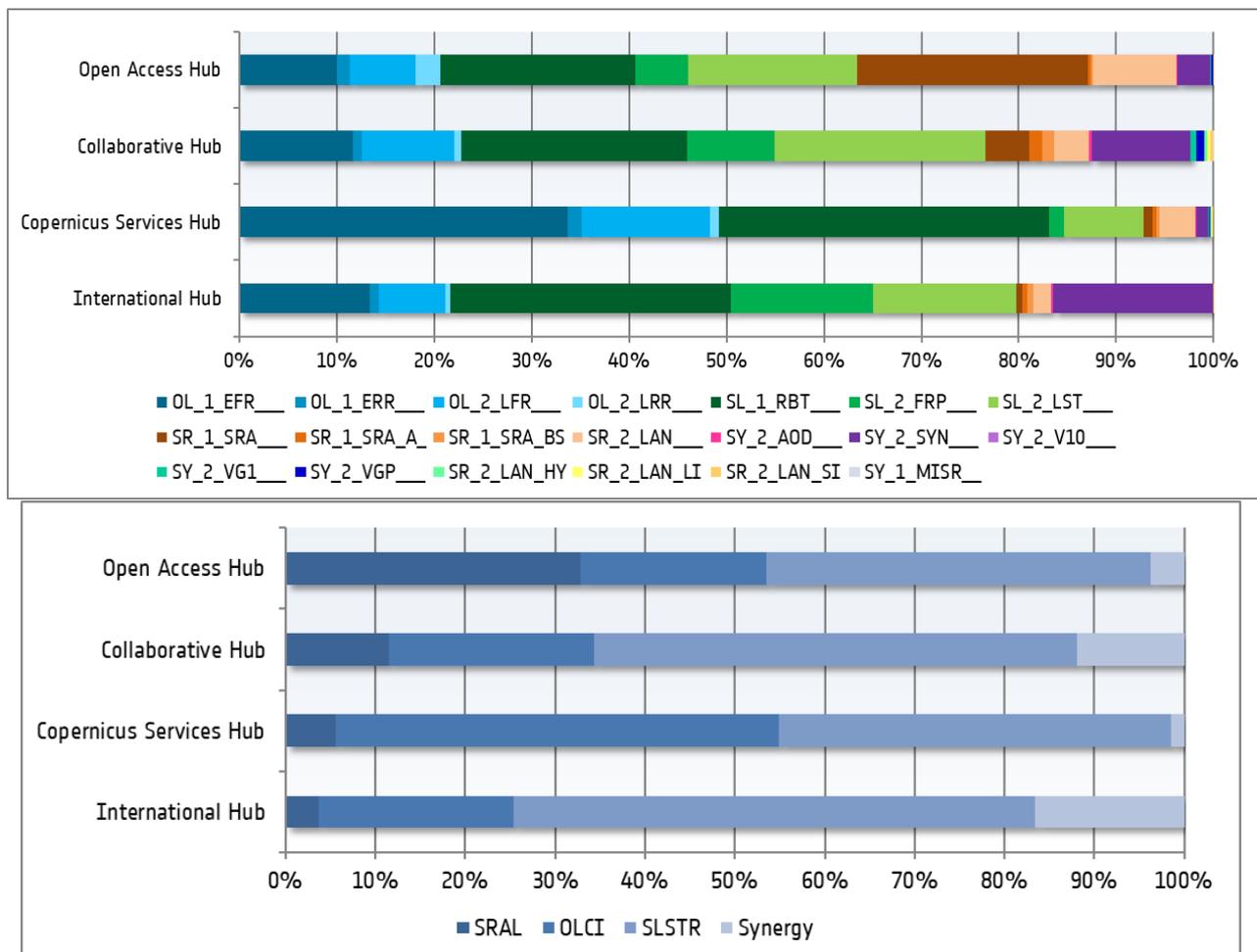


Figure 56: Percentage of total number of Sentinel-3 user-level data downloaded from each hub during 2022 per user-level data type (graph 1) and user-level data group (graph 2)

Sentinel-5p

Due to the number of different Sentinel-5P user-level data which are published, the download percentage per data type is not shown. However, Figure 58 shows the download split on the Sentinel-5P Hub for the two data levels: Level-1B and Level-2. The download split per level was 3% Level-1B (699,036 user-level data) and a massive 97% Level-2 (21,201,363 user-level data).

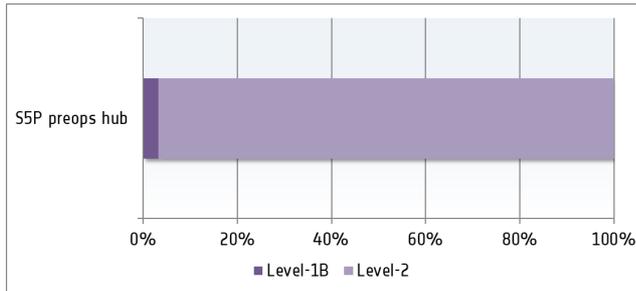


Figure 57: Percentage of total number of Sentinel-5P user-level data downloaded from S5p Hub during 2022 per data level

Overall Monthly download figures

The graph in Figure 59 below shows the monthly volume of user-level data downloads made from each hub during 2022, with the average monthly volume and number of downloads made on each hub during 2021 included for comparison.

The average monthly volume of downloads was slightly lower than for the previous year from three of the hubs. The most significant variation is seen in the figures for IntHub, from which the monthly average

volume downloaded was 36% lower in 2022 than it was in 2021, with a monthly average of 348 TiB/pcm of user-level data downloads in 2022, compared to 542 TiB/pcm in 2021. There was also a 16% drop in the monthly average compared to last year for ServHub, while for ColHub it was almost similar to the previous year (only 2% lower). The exception was the Open Hub, on which the average monthly volume of user-level data downloads increased by 8% with respect to Y2021, rising from 2,858 TiB/pcm in 2021 to 3,076 TiB/pcm in 2022.

When looking at the Open Hub figures, it is worth noting that during the last trimester of 2021 some download dysfunctions were observed on the Open Hub which were caused by a high number of sessions generated by some users operating outside the download quotas. Following that discovery, several attempts to adopt specific load balancing rules were made in the period January-May 2022, with the aim of improving the download experience for all on the Open Hub. On 26 May 2022, the network configuration was changed in order to improve the download speed performance for nearline user level data. The impact of this change in the network configuration appears to be visible in the monthly download figures shown in Figure 59. In June 2022, the number and volume of downloads made that month were 23% and 12% higher (respectively), compared to the average number and volume for the previous period Jan-May 2022.

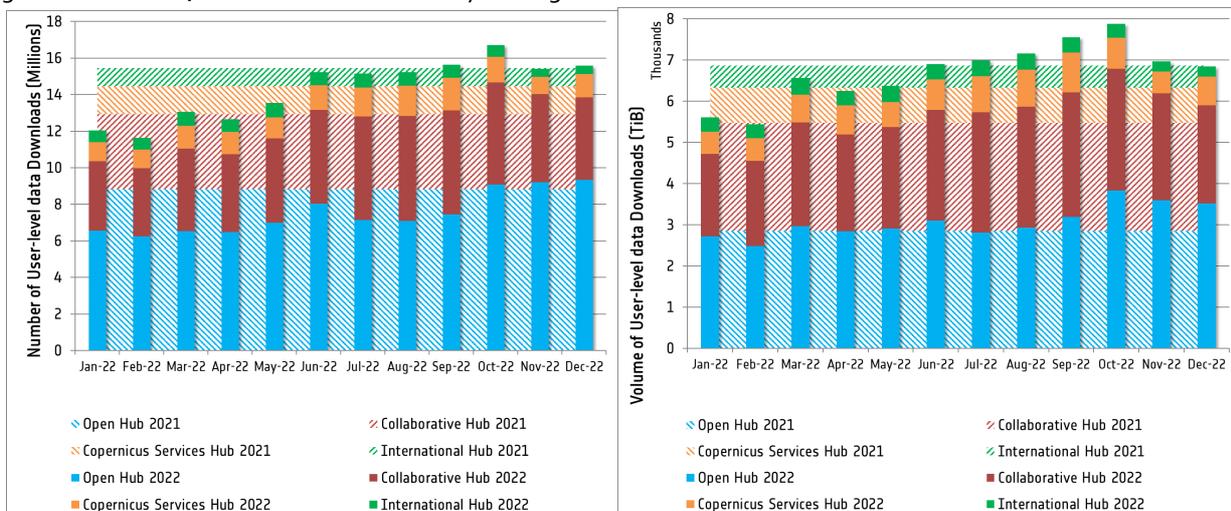


Figure 58: Dissemination volume trend per hub during 2022, with 2021 averages for comparison

The numbers fall off again in July and August, but this dip in download activity during the northern hemisphere summer months has been observed every year. Indeed, in September-December 2022, the monthly average number and volume of downloads from the Open Hub increased again, this time by 28% and 23% with respect to the average monthly figures during the summer quarter. This period of intense user download requests caused some overload on the network. The Data Hub team accordingly made the necessary infrastructure changes (specifically on NAS disks) in order to improve the download performance and enable the system to cope better with the huge quantity of requests. By October 2022, the Open Hub was enabling more than 6 successful downloads per second, and a corresponding peak in downloads for October can be seen in Figure 59. The monthly number and volume of downloads from the Open Hub remained high and above the Y2021 averages during November and December 2022.

Different download trends can be seen for ColHub and ServHub. On both hubs, the monthly number and volume of downloads also increased in June 2022 but surprisingly the downloads remained high during the whole summer period. Between June and September 2022, the average monthly volume of downloads from ColHub increased by 27% with respect to the previous period, and from ServHub by 41% (from averages of 2.2 PiB and 619TiB per month, respectively, to 2.8 PiB and 875TiB). In September 2022, the downloads from ColHub and ServHub reached the maximum of 128 and 40 downloads/min. As for the Open Hub, the volumes of downloads from both hubs decreased again in November and December 2022. In fact, although the average number of downloads from ColHub in the last trimester was 21% higher than the overall monthly average number of downloads for all of 2021, the monthly average number of downloads from ColHub in the last trimester was actually 21% lower than the average monthly number of downloads in 2021.

On IntHub, the trends were all downwards. The monthly average number of downloads in 2022 was almost stable throughout the majority of the year and, in the period from January to October 2022, it was 29% lower than the overall average monthly number in 2021 (711K/pcm in 2022 vs 1 million/pcm in

2021). During the last two months of 2022, the average monthly number of downloads decreased again by 39% compared to the average calculated for the previous months of 2022, down to 436K/pcm. A significant part of this decrease is attributable to the closure of the Copernicus data centre run by the international partner the United States Geological Survey (USGS) (see more in Chapter 4). In Y2021, the North American partners downloaded 5,239 TiB of data from IntHub, and in 2022 that volume fell to 3,218 TiB. However, the international partners in Europe also downloaded much less data in 2022 than in Y2021, with the volume halving from 150 TiB in Y2021 to 77 TiB in 2022.

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 **163 million** user-level data have been downloaded by the DIAS service providers, comprising a total volume of **97.69 PiB**. In terms of the proportion of all downloads on all hubs since the start of operations, DIAS downloads now account for 17% by number and 19% by volume. During 2022 alone, more than 27 million user-level data were downloaded, making up a yearly volume of 14.09 PiB.

In terms of average daily download volume, 24.1 TiB were downloaded per day during December 2022. 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 shows the total volume of user-level data downloaded in 2022 from the DIAS Hub, split by mission. The percentage split between Sentinel-1/Sentinel-2/Sentinel-3 is 20%/68%/13%, showing a decrease in Sentinel-1 downloads with respect to the values registered last year (35%), caused by the unavailability of Sentinel-1B user-level data in 2022.

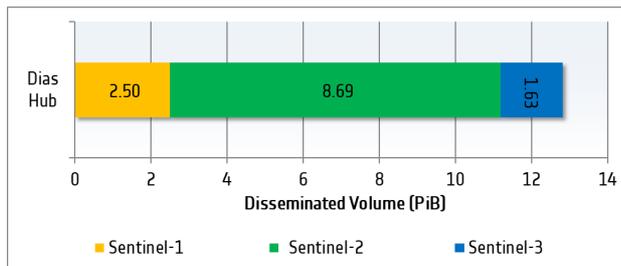


Figure 59: Disseminated volumes (PiB) during 2022 per Mission on the DIAS Hub

2.3.4 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, determining when a user-level data is removed from online access, that data can still be retrieved from 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 67 below show, for each Sentinel mission and per Hub, the percentage of downloads during 2022 for user-level data within six age ranges (measured from the date of publication). These are:

- 0 – 2 days
- 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. 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 so are better able to download the data while it is still ‘fresh’.

However, it is interesting to note that this preference for fresh data is particularly marked on ColHub and IntHub, and less so on the Open Hub. More than 90% of the data downloaded from ColHub and IntHub in 2022 was from the time range 0-2 days, irrespective of the mission. For IntHub, this is a change with respect to Y2021, during which only 45% of Sentinel-2 downloads from IntHub were in the 0-2 day range, which was particularly notable given that IntHub does not provide access to any data older than 21 days. On ColHub, the rolling policy varies according to the node being used: Node 2 and Node 3 of ColHub have respectively 2 and 3 weeks, while Node 1 has a 1 year rolling policy. Notwithstanding the longer rolling policy on ColHub Node 1, no downloads were made of data older than one month.

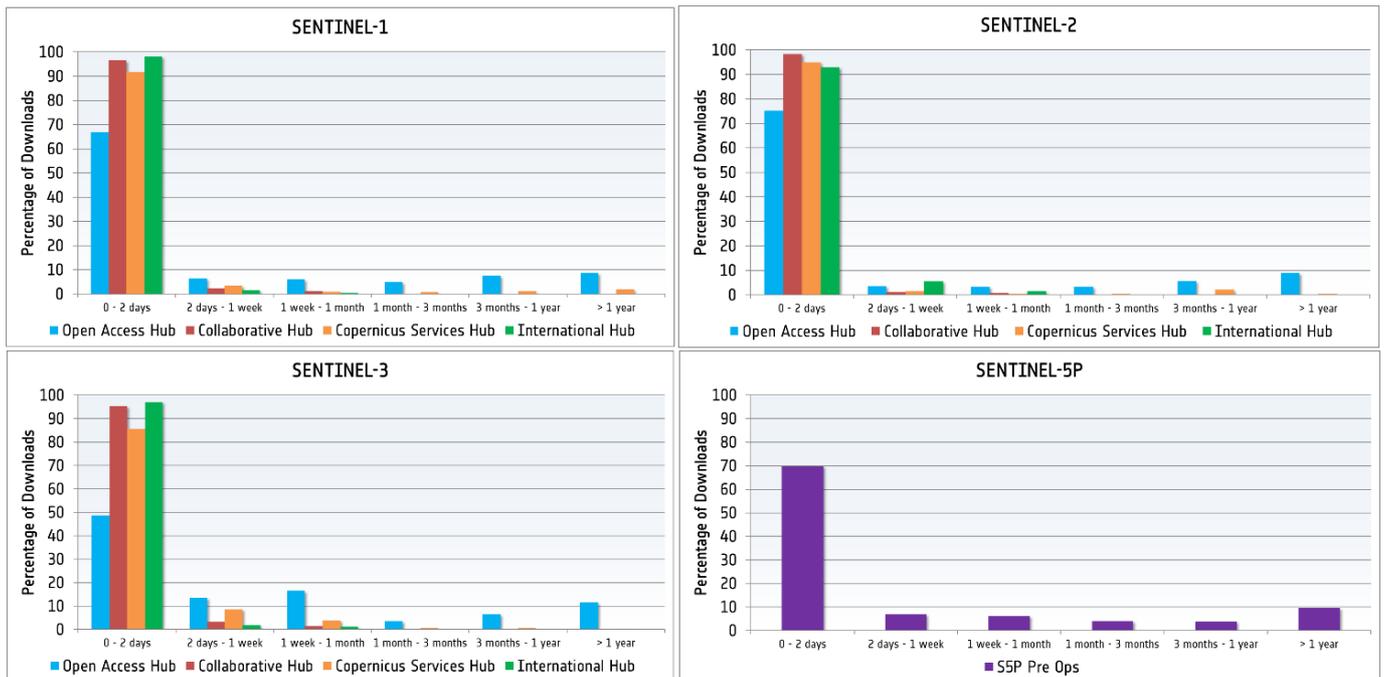


Figure 60: Percentage of 2022 downloads per user-level data age range each Sentinel mission and per Hub

Users of ServHub also mostly showed the same marked preference for fresh data: more than 85% of the downloads were focused on the 0-2 day range for all the missions.

On the Open Hub, the preference for newer data is still clear but it is less pronounced, particularly in relation to Sentinel-3 data. Downloads of user-level data in the 0-2 days category accounted for 67% for Sentinel-1, 75% for Sentinel-2, 48% for Sentinel-3, and 70% for Sentinel-5P. Almost 30% of Sentinel-3 downloads from the Open Hub were of data between 2 days and 1 month old. Moreover, for each of the missions, as many as 8% of the downloads from the Open Hub were of the data which is older than 1 year.

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 almost certainly be some who need historical data over the areas they are interested in.

2.3.5 Offline Data Retrievals

In 2022, offline data retrievals have been based on an interface which retrieves the data from a DIAS infrastructure and unseals it in less than 60 minutes

after the user’s request, very much faster than the older solution based on the Long Term Archives (LTAs). This interface allows older user-level data to be removed from the online data store (i.e. moved nearline). 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 all users for 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.

This retrieval scenario was transferred to operations for Sentinel-2 in September 2020, and then for Sentinel-1 and Sentinel-3 in November 2020.

Nearline data are available for all data hubs except the IntHub.

Offline User-level data per mission

During 2022, the rolling policy governing the period in which each of the published user-level data remain online has been tuned to satisfy the user request and optimize the functionality which enables the data

retrieval from offline data storages. As shown in Figure 62, by the end of 2022, a total of 54.77 PiB of user-level data were available offline for retrieval, consisting of 19.68 PiB from Sentinel-1, 31.60 PiB from Sentinel-2 and 3.49 PiB from Sentinel-3.

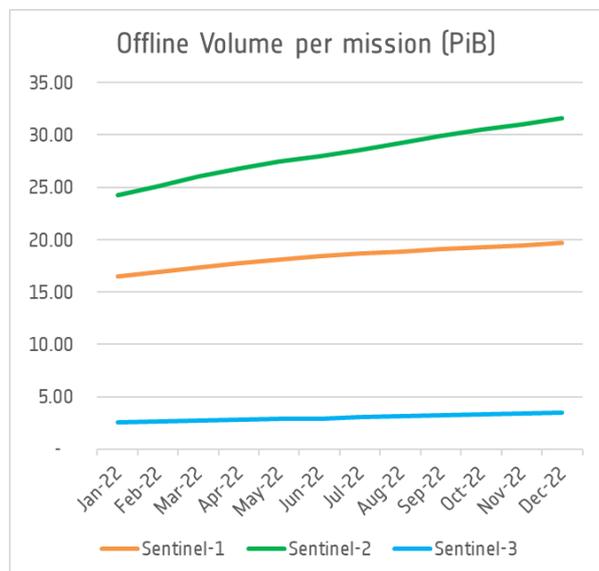


Figure 61: Cumulative growth of Offline user-level data volume (PiB) per mission during 2022

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. It is worth highlighting that the figures do not distinguish between requests which resulted in a successful data download and those which did not.

During 2022, there were a total of 52,784 active users of the offline data retrieval, composed of 52,700 from the Open Hub (9% increased since last year) and 92 from the other hubs (stable). 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	16,008	41,221	3,792
Collaborative Hub	13	13	13
Copernicus Services Hub	37	42	14
DiasHub	5	5	5

Table 18: Total Active Users of Offline Retrieval during 2022, per mission and per hub

It is interesting to note that of the 99,046 active users of the Open Hub in 2022 (meaning a user who

successfully downloaded at least one user-level data during the year either from the online or offline service), 53% of these submitted a request for an offline user-level data (in Y2021 there were 57%). This calculation does not distinguish between those active users who made only a successful request for offline data and those who made a request for both online and offline data, but it does mean that 47% of the Open Hub active users did not make a request for offline user-level data.

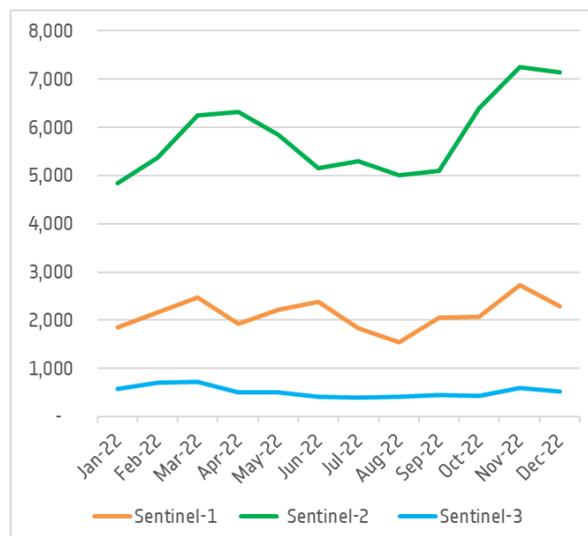


Figure 62: Total Active Users of Offline Retrieval per mission on the Open Hub per month during 2022

Figure 63 shows the total number of active users of offline data retrieval per month during 2022, for each Sentinel. For Sentinel-1, there was an average of 2,129 active users per month for offline data, registering a 4% decrease since last year. This number was relatively constant throughout the reporting year.

For Sentinel-2, there were consistently more than 5,000 active users per month of the offline data retrieval. There was a sharp rise in the number of active users between January-April 2022, and then again between September-November 2022 till the end of the year, when the number of active users went up from 5,000 to 7,000 users. This trend was already observed in the same period in Y2021. but this time it cannot have been caused by the introduction of offline user-level data for Level 2A, as appeared to be the case last year. It may, therefore, be due to some case-studies on vegetation growth that need to access the previous year's data for comparison with the current up-to-date data.

The number of active users of Sentinel-3 offline data retrieval was almost constant over the year, between 400 to 750 active users, 8% higher than the number of active users at the end of last year.

User-Level Data Retrieval Requests

During 2022, 42.7 million retrieval requests for offline data retrievals were made, and this was 63% fewer than last year.

Hub	Numbers of retrieval requests in 2022	%
Open Access Hub	37,671,970	88
Collaborative Hub	495,154	1.2
Copernicus Services Hub	268,586	0.6
DiasHub	4,244,285	9.9
TOTAL	42,679,995	

Table 19: Total offline user-level data retrieval requests during 2022 per hub

Table 19 shows the number of requests per hub during the year. As usual, the majority of the retrieval requests were made on the Open Hub, which processed 88% of the overall number of requests. However, there was a 66% decrease in the number of retrieval requests from the Open Hub compared with the number which had been made Y2021.

It is interesting to note that this year there was an enormous increase in the number of offline retrieval requests made on the DIAS Hub, with the number of requests rising from 998,727 in Y2021 to 4,244,285 in 2022. Having constituted only 0.9% of the total number of retrieval requests in Y2021, the DIAS Hub retrieval requests constituted 9.9% in 2022.

In Figure 64 and 65, the total numbers of offline retrievals per hub are broken down further to show the total number of requests per month (note that, in order to appreciate also the differences between hubs, the OpenHub and ServHub user activity are represented separately).

From the graph in Figure 64, it can be seen that there continued to be a massive number of retrieval requests from the Open Hub in January and February 2022, although at just over 7 million this was fewer than the approximately 10 million which were still being made in November 2021. The number of requests then dropped off dramatically in March 2022. This may be explained by the fact that, following the transfer to the cloud, which was completed in April 2021, it was initially decided to keep the user-level data online for just one month and this policy was maintained until July 2021. Between August 2021 and February 2022, however, the rolling policy of online user-level data was progressively changed and this change was completed in February 2022 when, from a user perspective, the user-level data started to be kept online for up to 6 months. There was also significant offline retrieval activity by the Open Hub users in the period between August and September 2022, with the number of requests rising from just over 2 million in July 2022 to 4.5 million by September. The numbers of requests then fell off again dramatically in the last trimester, decreasing to the lowest level for the year at just over 1 million requests in December 2022.

The big change in the overall figures for the DIAS Hub seem to have been caused by a sudden and one-off peak of offline retrieval activity in June 2022. In each of the other months the activity was low, with approximately 100,000 requests being per month but in June the total rose to around 2.2 million requests. The cause of this sudden rise cannot be deduced by looking at the statistics, and it can only be surmised that one of the DIAS service providers chose June to replenish their store with archived data.

The offline retrieval activity of the ServHub users was moderate throughout the year, ranging from 14,000 requests in December to a high of 34,000 in April 2022.

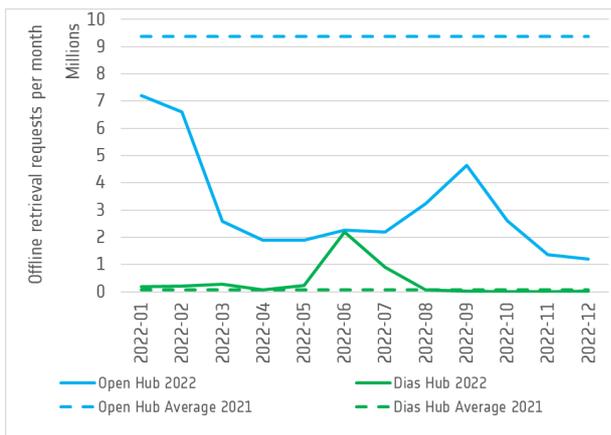


Figure 63: Total offline retrieval requests during 2022, per month

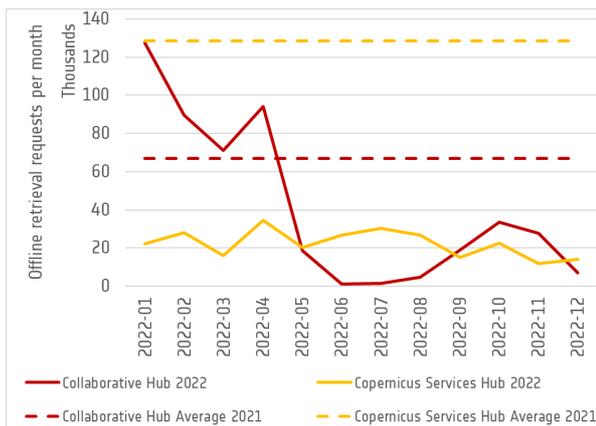


Figure 64: Total offline retrieval requests during 2022, per hub

As might be expected, and as was already observed in the previous two years, only a small interest in offline user-level data retrieval is visible from ColHub users. In more details, a decrease throughout the year is visible and the number of requests went from 130,000 in January to 0 in June 2022. 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 shows the number of restored user-level data during 2022, per mission and per hub. Note that, for reasons resulting from the infrastructure architecture, 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 Open Hub was almost 6 times the number of

restored user-level data from the three other hubs combined, and the number of the overall restored user-level data from all the hubs was 2 times the Y2021 number (7,191,546 compared with 4,009,557). The difference between the number of successful retrievals and the number of requests made gives an indication of the number of retrievals which were either not successful or which were requests for user-level data which had already been requested by another user.

Most of the restored user-level data were Sentinel-2 user-level data (62%), followed by Sentinel-3 (26%) and Sentinel-1 (13%). Interestingly, there is a slight difference in the behaviour on the different hubs: on the Open Hub, Sentinel-3 data were the second most retrieved data after Sentinel-2, while from the ColHub/ServHub/DIASHub interfaces it was Sentinel-1, with the 25% of requests from those hubs.

Hub	Sentinel-1	Sentinel-2	Sentinel-3	total per hub
Open Access Hub	784,692	4,077,390	1,801,150	6,663,232
ColHub/ServHub/DiasHub	130,224	353,703	44,387	528,314
Total	914,916	4,431,093	1,845,537	7,191,546

Table 20: Total offline user-level data restored during 2022 per hub and per mission

Retrieval Timeliness

Figure 66 shows the average weekly retrieval timeliness across all hubs during 2022. As can be seen from the graph, during all the months, the average time for the retrieval of offline user-level data stayed well within 24 hours.

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 during the reporting period, was **54 minutes and 13 seconds**. This was an impressive reduction of the average time it took during Y2021 (20 hours).

In fact, after the inclusion of an additional check on the retrieval requests submitted by users and their effective execution, the monthly average for restoring user level data returned to be well within the optimal delivery range and stabilized under 1 hour from March 2022 onwards (Figure 65 shows the detailed weekly average time to restore in 2022).

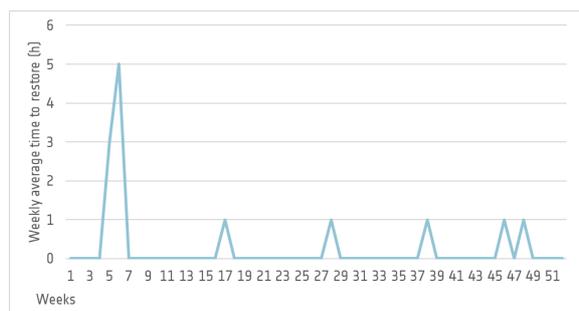


Figure 65: Weekly average time to restore of offline user-level data in 2022

2.3.6 Downloads per Continent and Country

Another interesting view on download behaviour during 2022 is to look at the continents and individual nations which have performed the most downloads

	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	Overall
Europe	44.7	99.7	100	1.8	69.4
North America	42.7	0.3	N/A	77.1	19.8
Asia	9.3	N/A	N/A	2.5	8.2
Oceania	1.1	N/A	N/A	16.1	1.3
South America	1.2	N/A	N/A	2.5	0.7
Africa	1.2	N/A	N/A	0	0.5

Table 21: Percentage of 2022 downloads (by volume) per Continent and per Hub and overall

from the Data Access System. Table 21 presents the percentage of downloads (by volume) which were completed in each continent from each of the four main hubs during 2022. The overall percentage split by hub is also shown. For the case of Sentinel-5P, all downloads are made on the Sentinel-5P dedicated node of OpenHub, 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.

In 2022, as in previous years, Europe continued to be the continent which made the most active use of Copernicus Sentinel data, making 69% of the total volume of user downloads from all of the hubs. 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 proportion of the overall volume of downloads which were made by European users in 2022 would rise to 76%.

On the Open Hub, for which all continents have registered users, the volume of downloads which European users made increased by 25% with respect to the previous year, up to 16.10 PiB from 12.84 PiB in Y2021, and the European downloads accounted for 45% of the total volume of downloads making Europe continent the most active user group on the Open Hub.

North American users made 43% of the user-level downloads from the Open Hub this year, having downloaded almost 15.38 PiB, an increase of 4% on the volume of downloads they made in the Y2021 (14.83 PiB). North America was again the continent which downloaded the second highest volume of data.

There was a big increase in the proportion of Open Hub downloads which were made from Africa. Whereas the African users had made 0.5% of the Open Hub downloads in Y2021, in 2022 the proportion rose to 1.2%, with 0.41 PiB of data downloaded. For the first year, therefore, the African users made the same proportion of Open Hub downloads as the South American users, and a higher proportion than the users from Oceania.

Indeed, the volume of downloads from the Open Hub made by users from Oceania decreased to 0.43 PiB, which was 1.1% of the total Open Hub volume, significantly less than the 2.8% share the users from Oceania had made in Y2021. Likewise, Asian users made a lower proportion of the overall volume of downloads in 2022: in Y2021, they had made 12.6% of the total volume of downloads, but having downloaded 3.34 PiB in 2022, this proportion fell to 9.3%.

It is also interesting to note the differing intensity of activity on IntHub between the continents. It is particularly striking, for instance, that such a high

proportion (16.1%) 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 (GA) (see Section 4.2). Looking at the figures from IntHub and the Open Hub together, it seems possible that the decrease in activity on the Open Hub by users in Oceania is linked to the increased activity of GA on IntHub, i.e. the success of GA's data centre in Australia may be providing users in Oceania with the most convenient access point for the data, and they increasingly do not need to request downloads from a centre based on the other side of the world.

ColHub and ServHub are almost entirely dedicated to European users, in line with the programmatic role of the hubs, with the continent accounting for 99.7% and 100% of total number of downloads respectively. The small amount of non-European (North American) downloads on the ColHub (0.3%) are accounted for by the Canadian Collaborative Ground Segment.

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

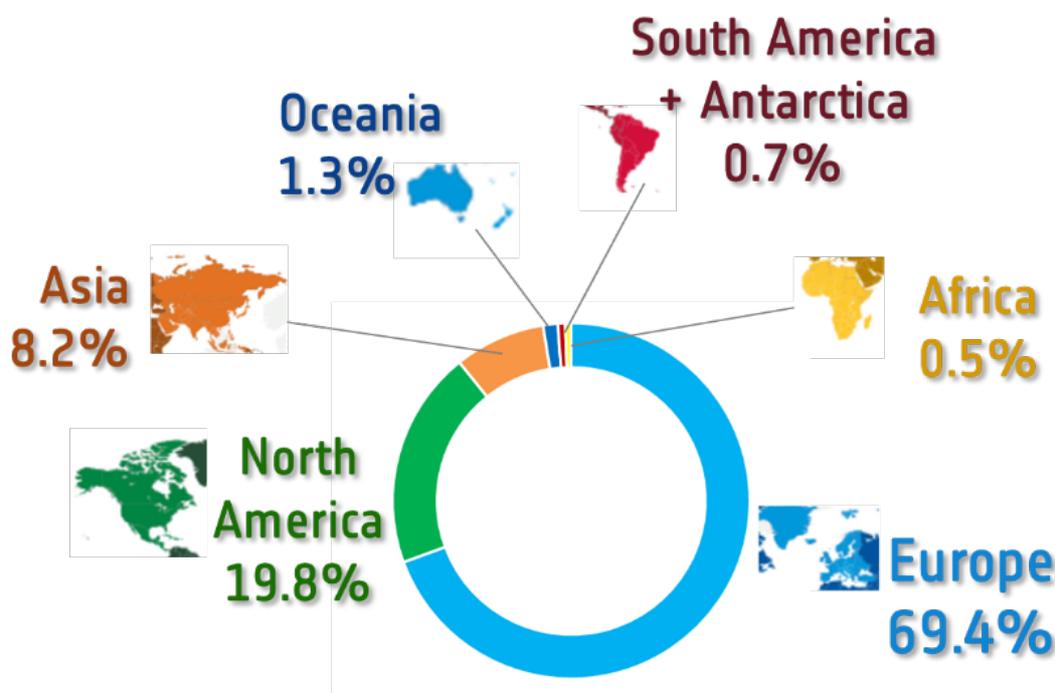


Figure 66: Overall percentage split of Data Access System downloads (all Hubs) by volume, per Continent, during 2022

Continent	% of Sentinel-1 Downloads during 2022	% of Sentinel-2 Downloads during 2022	% of Sentinel-3 Downloads during 2022	% of 2022 Downloads
Europe	50.3	41.4	39.7	44.8
North America	34.2	45.1	54.3	45.2
Asia	13.2	9.1	5.3	7.4
Oceania	1.1	1.3	0.6	0.9
South America	0.7	1.4	0.1	0.7
Africa	0.5	1.7	0.1	0.9

Table 22: Continental percentage split of 2022 downloads (by number) on the Open Hub, for each Sentinel mission and overall

Open Hub Focus

Table 22 breaks down the overall per continent figures for the Open Hub in 2022, showing the percentage split between the continents of downloads from each Sentinel mission during the year. It is again recalled that all of the statistics regarding the nationality of users on the Open Hub are based on the information users themselves provide when they register for an account on the Open Hub; no further verification of that information is performed (e.g. via IP check), for the sake of privacy. It is also recalled that statistics for Sentinel-5P downloads are not included, because all downloads are still made on the dedicated S5P node of the OpenHub, as mentioned above, and it is not possible to categorise the users of that dedicated node by country.

This year, Europe continued to be the continent which downloaded the highest volume of Sentinel-1 user-level data in 2022 by a long margin, making 50% of all Sentinel-1 downloads, compared to 34% downloaded by the next most active group, the North American users. The proportion of Sentinel-2 downloads which were made by European users also rose significantly, increasing from 32% in Y2021 to 41% in 2022, and to lesser extent also for Sentinel-3 downloads, of which the proportion rose from 40% in Y2021 to 45% in 2022. Nonetheless, it was still the North American users which downloaded the highest number of both Sentinel-2 and Sentinel-3 user-level data, having made 45% and 54% of the total downloads for those two missions respectively. The interest from North American users was particularly high for Sentinel-3

user-level data. Overall, Sentinel-3 downloads by European and North American users together made up a huge 93.9% of the total number of Sentinel-3 downloads.

In Asia, interest remained clearly tipped towards Sentinel-1 and Sentinel-2 data, with Asian users having made respectively 13% and 9.1% of the total number of downloads. However, the proportion of Sentinel-3 downloads made by Asian users did increase to 5.3% in 2022 from 4.6% in Y2021.

The big increase already noted above in the overall proportion of downloads from the Open Hub made by African users, appears to have been created principally by them having made an increased volume of Sentinel-2 downloads in 2022 compared to the previous year. In Y2021, African users had downloaded the lowest volume of Sentinel-2 data, making 0.7% of the total volume of downloads. In 2022, however, they downloaded 1.7%, making them the fourth highest downloaders of Sentinel-2 data, above the users from Oceania and South America. There was little change in their activity for Sentinel-1 and Sentinel-3 data, however, and Africa continued to be the continent which downloaded the least data from those missions.

Although it was less marked in 2022 than in Y2021, the users from South American and Oceania continued to show a preference for Sentinel-1 and Sentinel-2 data, over Sentinel-3.

It is interesting to look at these proportions of downloads per continent together with the numbers of active users from each continent (discussed in greater detail in Section 3.3.1). The same discrepancies which were observed in previous years between the number of active users in a continent and the proportion of the downloads they make continue to be seen. While users from Asia made up 29% of the total number of active users on the Open Hub in 2022, they only accounted for 9% of the total number of downloads, and it can be seen from Table 22 that they downloaded significantly lower volumes of the data from each of the Sentinels than either the North American or European users. Similarly, users from South America made up 14% of active users but only 1.2% of downloads. By contrast, users from North

America constituted only 10% of active users but accounted for 43% of all downloads from the Open Hub and were the highest downloaders of Sentinel-2 and Sentinel-3 data. 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. This observation fits with the understanding 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.

African users constituted 4.5% of active users but still made 1.2% of downloads.

	Sentinel-1		Sentinel-2		Sentinel-3	
	Country	2022 Number of user-level data downloads	Country	2022 Number of user-level data downloads	Country	2022 Number of user-level data downloads
1	France	810,017	France	4,769,779	Italy	3,901,083
2	Sweden	274,574	Germany	3,489,356	Germany	3,839,168
3	Germany	255,874	Slovenia	1,330,769	United Kingdom	1,229,518
4	Norway	176,279	Poland	977,435	Poland	496,810
5	Italy	150,586	United Kingdom	440,834	Bulgaria	319,344
6	Denmark	119,820	Norway	435,469	Norway	314,142
7	Poland	84,799	Italy	379,591	Spain	279,155
8	United Kingdom	76,459	Spain	374,147	France	270,373
9	Austria	63,778	Austria	277,594	Austria	133,103
10	Luxembourg	54,113	Netherlands	273,557	Netherlands	54,463

Table 23: Top 10 ESA/EU states by number of downloads in 2022 on the Open Hub, for each Sentinel mission

Focussing specifically on user activity in Europe, Table 23 above presents a breakdown of the ten ESA/EU member states with the highest number of downloads for each of the three Sentinels during 2022. It is exciting to see that this year there are four new countries in the lists compared with last year, Sweden, Luxembourg, Netherlands and Bulgaria, and this is the first time which Bulgaria has appeared among the top Sentinel downloaders. Bulgaria entered the Sentinel-3 list directly as one of the top 5 downloaders of Sentinel-3 data, and Sweden even went straight in

to second place in the list of top Sentinel-1 downloaders.

It is interesting to note that the countries which were new entries in the top 10 last year (Finland, Latvia, Austria and Czech Republic), this year did not appear again in the lists, with exception of Austria which, with double the number of data downloaded this year compared with last year, appears again in the top ten countries for Sentinel-2 downloads and also became a new entry in the Sentinel-1 and Sentinel-3 lists. Similarly, Poland and Norway were missing in the Sentinel-1 and Sentinel-2 lists last year but this year

are present in all three lists. Polish users made 166% more Sentinel-2 downloads in 2022 than they had in Y2021, making them the fourth most active Sentinel-2 downloaders in 2022, and there was also a huge 427% increase in the number of Sentinel-3 downloads they made, so that they became the fourth highest downloaders of Sentinel-3 data, having been the tenth highest last year.

The usual five nations which regularly appear as top 10 downloaders for all the missions (France, Germany, Italy, Norway and the United Kingdom) do all appear again in the top 10s for each of the Sentinel missions.

One change compared with Y2021 is that the top downloaders overall this year were the German users, who downloaded 7,584,398 user-level data (53% more than the 4,950,456 they downloaded last year), and they overtook the French users who this year downloaded 5,850,169 (20% less) user-level data. As in Y2021, the French users downloaded the highest number of both Sentinel-1 and Sentinel-2 data, but this year it was the Italian users who downloaded the highest number of Sentinel-3 user-level data, instead of the German users.

Spain and Switzerland dropped out of the top 10 for Sentinel-1 and Sentinel-2 downloads; Belgium and Denmark dropped out of the Sentinel-3 list. There was a notable increase in Sentinel-3 activity by the UK users this year: they were the third highest downloaders for Sentinel-3, up from fourth place, having made 154% more Sentinel-3 downloads than they had in Y2021.

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

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

CAMS downloads the full production of Sentinel-5P Level-2 near real time data for Carbon Monoxide, Sulphur Dioxide, Ozone and Formaldehyde monitoring, as well as the non-time critical Methane data, all amounting to a total of around 11TiB downloaded by CAMS in 2022.

Since 29 August 2019, all Near Real Time Level-2 user-level data have also been routinely provided to EUMETSAT for redistribution via EUMETCast.

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 68. 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 all the missions, including Sentinel-5P which was introduced last year in the exchanges between relays.

The DHR Network was initially set up in late 2016. The number of relays had grown to 7 by the end of Y2018, but two relays were decommissioned in Y2019, and in Y2020 two of the relays started to be operated on a best-efforts basis. During Y2021, a new node in Greece was added, and the two nodes in the UK which had previously either been deactivated or were working on a best-efforts basis, were both re-activated.

During 2022, no significant changes occurred in the

DHR network composition, so at the end of 2022, the team of DHRs consisted of 6 nodes and there were DHR partners in the following member states:

- Norway, operated by MET;
- Austria, operated by ZAMG;
- The Czech Republic, operated by CESNET;
- 2 nodes in UK operated by AIRBUS and STFC
- Greece, Operated by NOA

The project dedicated to supporting the DHR and Collaborative network, the *Collaborative Data Hub Software Maintenance and Evolution Services*, that started in September 2021, was renewed during the reporting period and a strong contact has been kept with all the partners in order to receive feedback and be able to plan the evolutions based on their needs. In particular during 2022, the Data Access team increased the support for enhancing the cooperation between the Data Hub Relay network nodes and improving the data flows. The Data Hub Relays have been involved more in the definition of requirements for the development of the DHS suite, a set of dedicated software designed to improve the capabilities of the Data Hub Network in order to be ready for the Digital Twin Earth project planned in the next years (from 2024 onwards). During 2022, 4 software developments have been delivered providing different functions:

- Data Flow Network Environment component (DAFNE) providing users with a strong dataflow visualization and control solution in terms of configured synchronizers, evictions, products published within the DHR and CollGS network and in terms of service performance, as service availability and publication latency.
- Transformation Framework component (TF) that provides the capability to trigger parallel processing of Sentinel-2 Level-2A products using Sen2Cor, the CFI provided by ESA, implementing classification and atmospheric correction with the Digital Elevation Model of the Shuttle Radar Topography Mission (SRTM DEM).
- Semantic Framework component (SF) that aims to establish an open knowledge base for associating real-world phenomena with

relevant Sentinel data and possible processing transformations, accessible to DHR users via natural language search. This is ensured defining a unique vocabulary (indexes, keywords) drawn up based on use cases of interest for DHR users. The first Use Case that will be implemented is a semantic search for earthquake identification.

- A new version of the DHuS software has been distributed to a set of DHRs acting as beta users to receive feedback about the concept. The version includes a new mechanism of synchronization which identifies the best data source in terms of bandwidth and performance.

Moreover, the concept of “Collaborative Ecosystem” has been put in place. A dedicated web site was implemented which acts as an entry point for all stakeholders of the CollGS, and provides all the information concerning CollGS nodes and the DHS suite in a single access point. The website will also act as a showcase for the CollGS activities, furthering in this way the identity of this user community.

In addition, a Collaborative Identity Access Management (IAM) system has been set up, which removes the need for deploying a local IAM on each DHR centre. DHR participants can therefore benefit from an authentication and authorisation infrastructure which is provided as an IAM service, facilitating the sharing not only of data but also services, working together to strengthen the Copernicus data distribution and exploitation.

In order to ensure a successful uptake of the new developments, the Data Access team has planned a series of activities to engage the users to test and use the different software delivered within the DHS suite, and involving the Collaborative IAM and the sharing of the relevant services, for the second phase of the Collaborative project and in particular for the first months of 2023.

As displayed in Figure 69 below, the volume of data disseminated to CollGS partners (including the DHR network) from the ColHub nodes increased from 42 PiB in Y2021 to 48 PiB in 2022 and reached an average daily volume of 135 TiB to all ColHub users. Figure 69 also shows that there was an increase in the volume of

data exchanged between the DHRs in 2022 as compared with Y2021. It is assumed that this was due to the introduction of the 6th node of the DHR network, which became fully operational in 2022. To give an idea of the 'effort' made each day by the DHR

Network, an average of 66 TiB of data is disseminated to the Relays each day from the ColHub nodes, composed of an average of about 117,000 data packages.

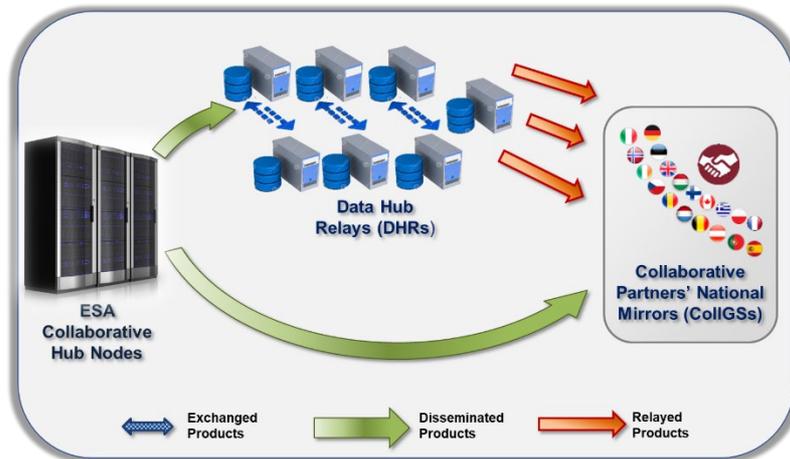


Figure 67: Schematic showing general data flow of user-level data from the Collaborative Data Hub to the Collaborative National Mirrors, highlighting the terminology used

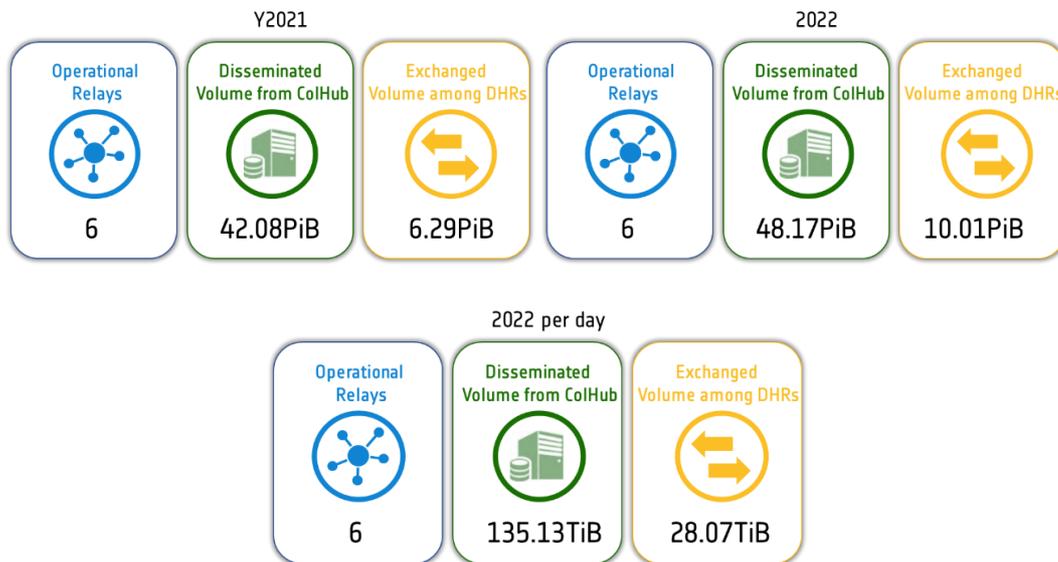


Figure 68: Overall Data Hub Relay statistics for 2022 vs Y2021, with 2022 per day averages

Overall, the DHR Network continued to demonstrate the importance of having alternative data sources to support ColHub in the dissemination of Sentinel user-level data towards the CollIGS partners. 52% (24.78 PiB) of the volume downloaded from ColHub was delivered directly to Collaborative mirror sites, whereas 48% (22.73 PiB) was delivered to mirror sites via the DHR Network. This percentage split shows the extent to which the DHRs reduce the load on ColHub.

Figures 70 and 71 below present the evolution of the DHR network data volumes since the beginning of DHR operations (i.e. between December 2016 to 31 December 2022). 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 volumes exchanged between DHRs (in grey). The graphs give an overview of the trend in the data flow from ColHub and through the DHR Network.

Overall, there was a marked rise in the number and volume of data moved around the network of CollGS access points in the first 3 years after the start of DHR operations. However, during Y2020 there was a considerable decrease in activity, due to the reduced number of DHRs participating on a full operational basis in the DHR network. In Y2021, as would be expected with two nodes reactivated and an additional node joining the network, the overall activities increased again and the volumes surpassed even the levels seen in Y2019. Following the

introduction of the new DHR node in Greece in May 2021, there was a distinctly upward trend in the volume of data being passed around the overall CollGS network, and in May 2022 the overall volumes reached 5.53 PiB. By November and December 2022, this trend appeared to be slowing, but still 3.93 PiB of data was being passed around the full CollGS network in December 2022, 14% more than the 3.44 PiB which was recorded in December 2021 and 48% more than the 2.65 PiB of April 2021, before the introduction of the 6th node in Greece.

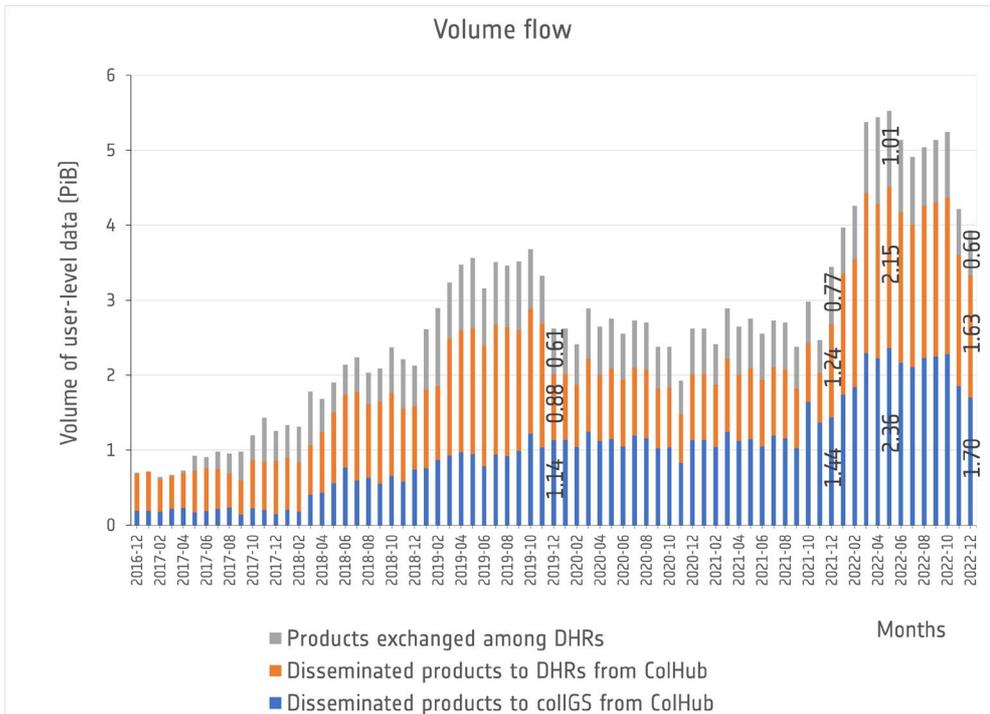


Figure 69: Total data flows in terms of Volume during the last 6 years

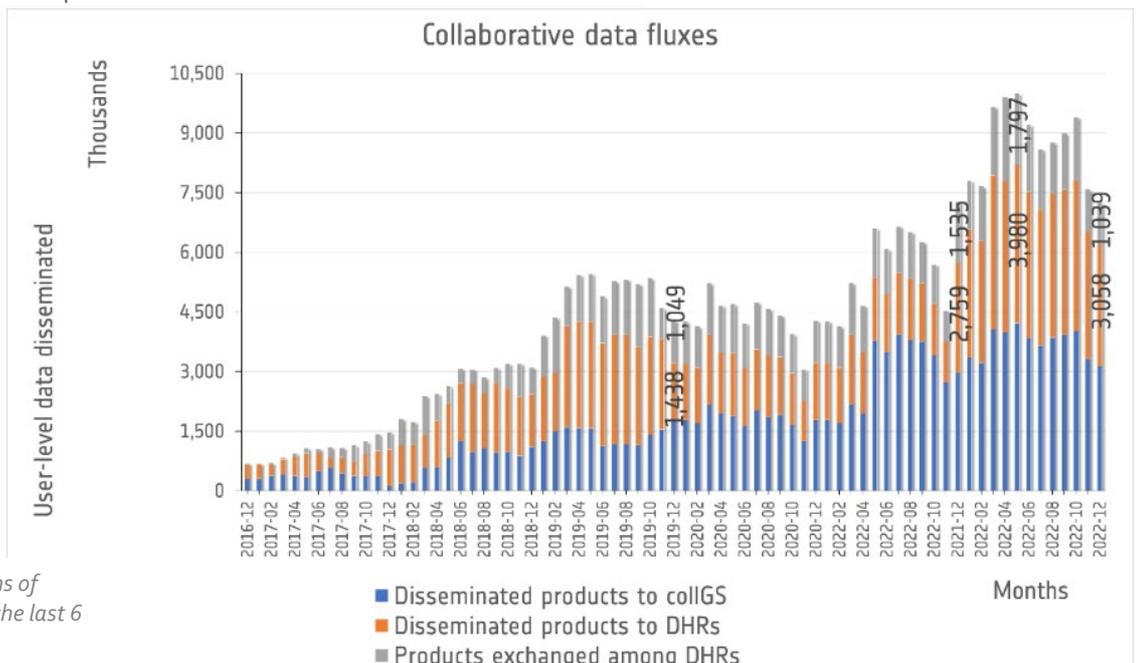


Figure 70: Total data flows in terms of number of user-level data during the last 6 years

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 data package download within the reporting period (01/01/2022 - 31/12/2022). However, users who did not perform a complete download were not necessarily 'inactive': if a user chooses to extract only a specific granule or a 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. Users may also have downloaded only 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 ColHub and IntHub were established for the use of national institutions, with each partner institution having only one user account, it was expected that each of these partners would use their accounts during the period. This is shown to be the case: 100% of registered users on both hubs 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 – 15% this period. This is again a slightly lower percentage than was calculated for the year before (17% were active users in Y2021), but in terms of absolute numbers, there were 18% more active users in 2022 than there were in Y2021 and the highest number yet seen (see Figure 73).

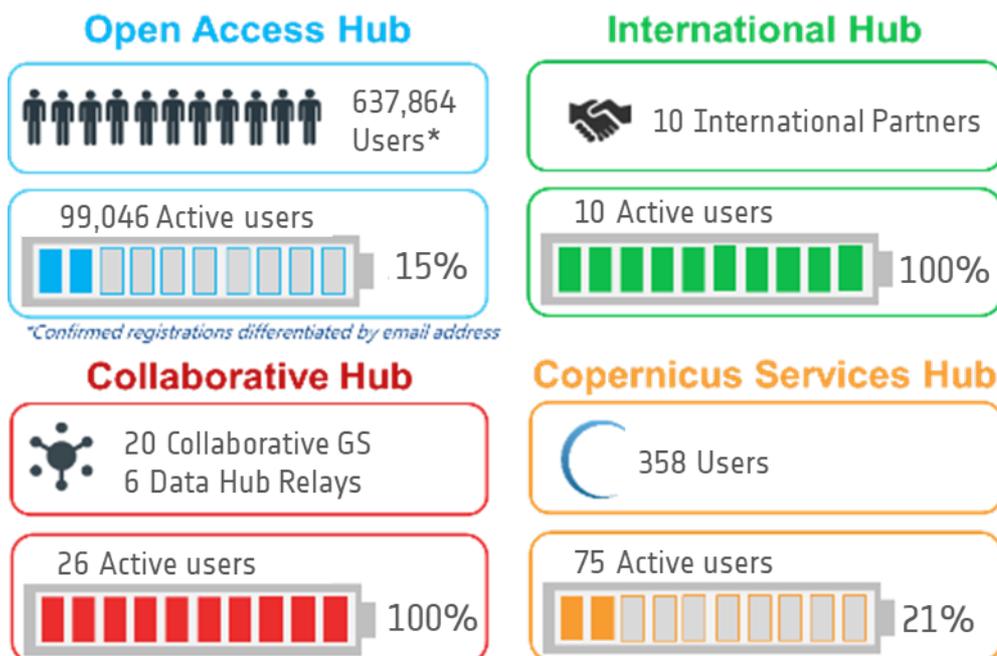


Figure 71: Registered and Active users per hub during 2022

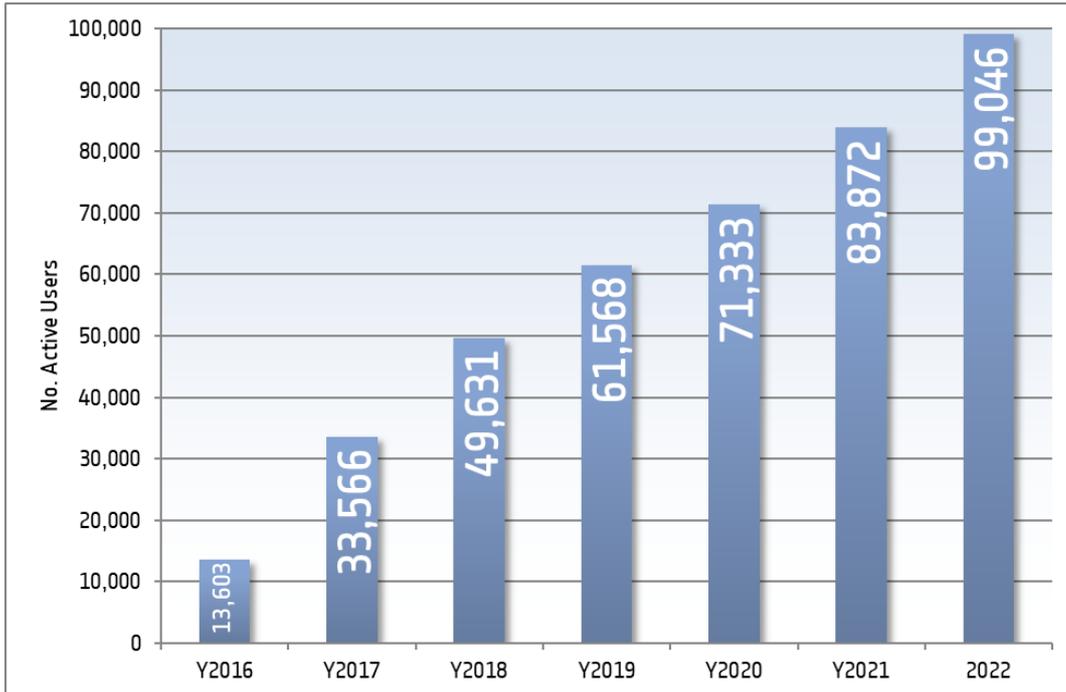


Figure 72: Growth in numbers of active users on the Open Hub between Y2016 and 2022

3.2 User downloads profile

This section examines the distribution of user downloads in 2022 across each of the hubs and for all Sentinels. Sentinel-5P is not included as it is still only available on the dedicated Hub, which all users access with the same password so no differentiation of accounts is possible.

Figure 75 shows, for each hub and each mission, the download ranges observed among the active users during 2022. The overall trends remain similar to those of the past years and are generally as would be expected. For ColHub and IntHub, almost all active users were downloading in the range '>1,000 user level data', 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. Unlike in previous years, there were no exceptions to this download behaviour on ColHub, while on IntHub, there was just one user which downloaded data at a lower frequency, and this was still in the high frequency 101-1000 download range. This user is likely to be a newly arrived user, still experimenting

with the services it wishes to provide to its users (see section 4).

The opposite trend is observed on the Open Hub, and it is almost identical to the trend seen in Y2021. The overwhelming majority of active users for each mission 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 either casual or specialist users, who would only need to download one or a few user-level data during the year.

As in Y2021, 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 56,970 users for Sentinel-2 compared with 24,138 for Sentinel-1 and 12,531 for Sentinel-3. Each of these figures is significantly higher than the numbers of active users who were downloading in that range last year, with respective increases of 15%, 39% and 19% on the Y2021 numbers.

It is also worth highlighting that the scale used in the bar chart for the Open Hub is different to the scale used for the other hubs. The number of active users on the Open Hub is measured in thousands, while for the other hubs it is just measured in single units. So

although only a small proportion of the total number of active users on the Open Hub downloaded more than 1,000 user-level data, there were actually many more users who downloaded in that range than on all the other hubs put together: 389 for Sentinel-1, 1,287 for Sentinel-2, and 597 for Sentinel-3. This suggests that many large, systematic users, who may not have access to the other ESA hubs, are regular users of the Open Hub. Interestingly, although the number of users who downloaded between 1-9 Sentinel-1 data from the Open Hub in the year significantly increased in 2022 (up 39%), the number of users who downloaded more than 1,000 Sentinel-1 data from the Open Hub decreased by 23%. For the first time, more Sentinel-3 Open Hub users downloaded in the '>1,000' range than Sentinel-1 Open Hub users.

Concerning ServHub, the distribution has evened out even more, with a shift in the profiles towards the higher download ranges: 52% of ServHub users downloaded more than 1,000 user-level data, a higher proportion than the 44% of active users who downloaded in this range in Y2021. Although to a

lesser extent, the proportion of users who downloaded in the '101-1,000' range also increased, rising from 11% in Y2021 to 14% in 2022. There was a corresponding decrease in the proportion of ServHub users who downloaded in the '1-9' range, which fell from 32% in Y2021 to 21% in 2022. 13% downloaded in the '10-100' category', which is the same proportion as it was in Y2021. This shift towards the higher download frequencies appears mostly to have been caused by the Sentinel-2 active users moving into the higher download ranges. Overall, it is suggested that this relatively more even distribution across the download ranges for ServHub 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.

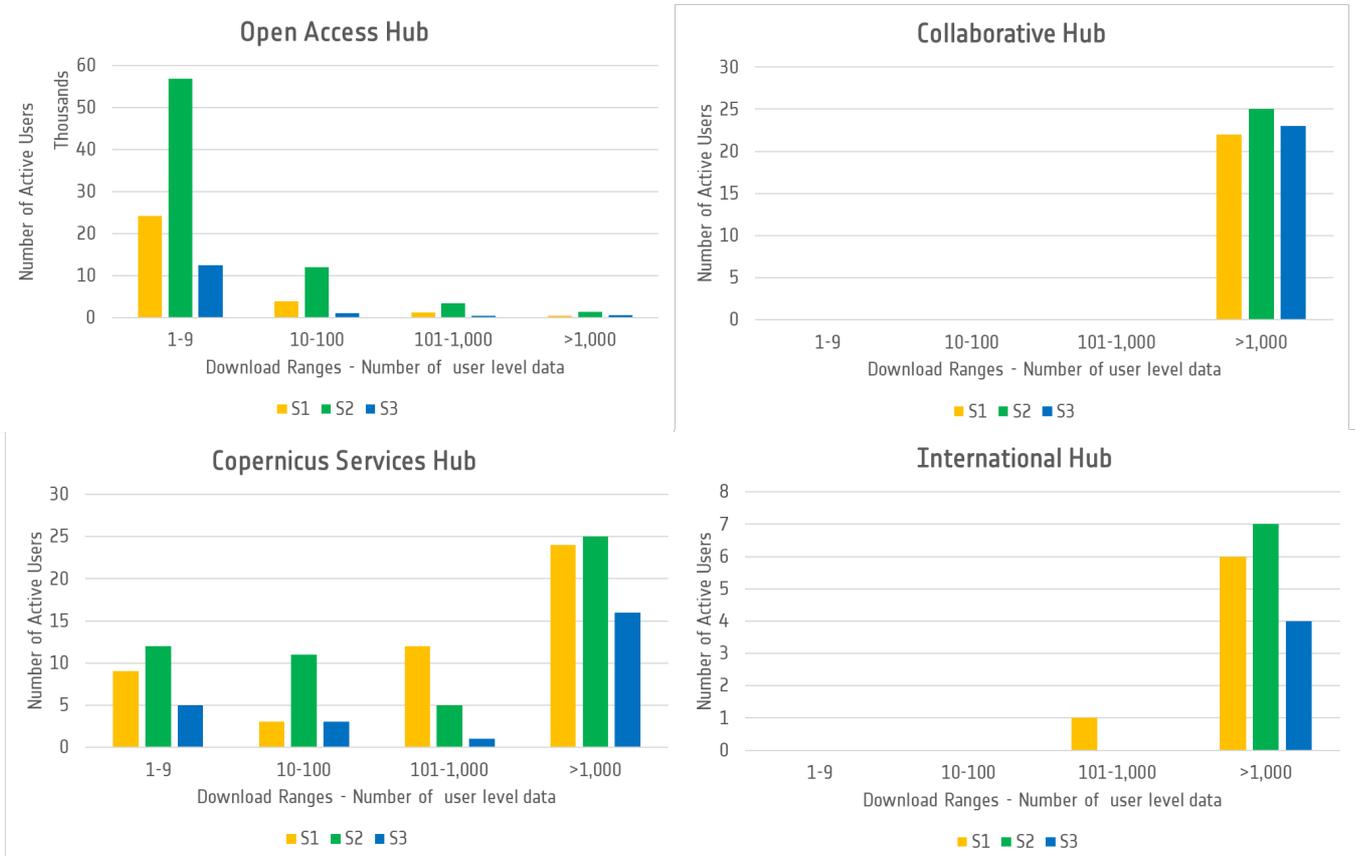


Figure 73: Download Ranges for each Data Access System Hub in 2022

3.3 Open Hub Active Users focus

3.3.1 Monthly Active Users

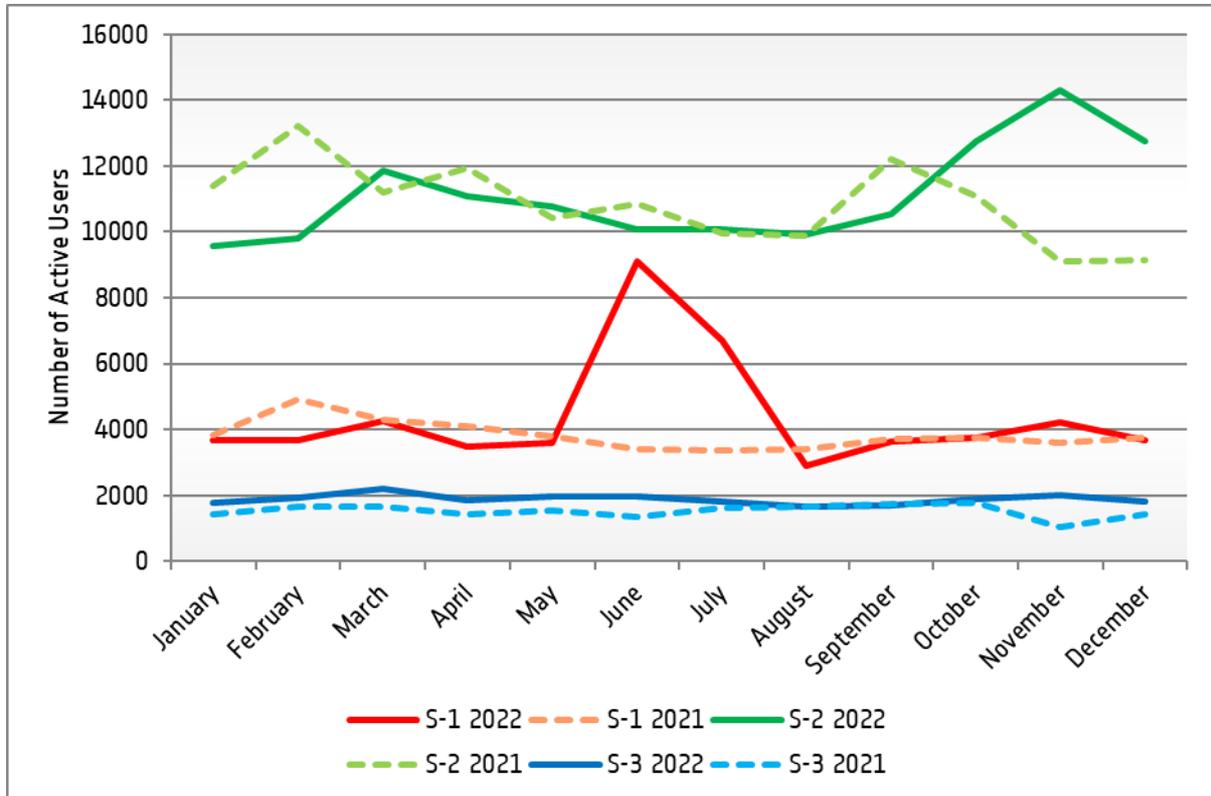


Figure 74: Active user trend per mission in 2021 and 2022

The graph in Figure 76 shows the number of active users on the Open Hub on a monthly basis throughout 2022 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 2021, shown as dotted lines.

For Sentinel-1, the trend was for the most part very similar to that seen in Y2021. However, there were anomalous peaks in June and July, and these were not present in Y2021. The June peak was the most extreme, with more than 9,000 active users of Sentinel-1, almost three times as many as there were in the preceding month. In July, there were still as many as 6,713 active Sentinel-1 users, but after that the number evened out again, to average at just under 4,000 active users for the rest of the year. Overall, **the average number of active Sentinel-1 users/month during 2022 was 4,083, which is 6% higher than the**

3,837 average last year, and this results from the June and July peaks.

The cause of these dramatic peaks cannot be determined from the data hub side. It is speculation but it is perhaps relevant that there were multiple unrelated and devastating natural disasters in June and July 2022, such as the major earthquakes which hit Afghanistan, Iran and the Philippines, the floods which overran Bangladesh, southern China, Greater Sydney and Kentucky, and the extensive heatwaves and related forest fires. Sentinel-1 data would have been useful for monitoring the impact of all of these disasters.

By contrast, the average number of active users of Sentinel-2 user-level data was 8% lower in 2022 than in Y2021, with 10,060 active users per month in 2022 instead of 10,994 per month in Y2021. This drop in the overall average was largely caused by much lower numbers of active Sentinel-2 users in January and

February 2022 than there had been in the same months in Y2021. Between March and September 2022, the trend was similar to that seen in the same period last year, with the number of users per month ranging between 10,000-12,000 users. The pattern changed again in the last trimester, however, when the number active Sentinel-2 users suddenly increased over 12,000, reaching a peak of 14,000 in November 2022. It is interesting to note that these months in which there were the highest numbers of Sentinel-2 active users for the year, were the same months in which there were the highest number and volume of Open Hub downloads in the year, as seen earlier in Figure 58.

Concerning Sentinel-3, Figure 76 shows a stable, almost constant number of active users throughout the whole year, with a **monthly average number of active users of 1,656, up 14% from the 1,529 monthly average registered last year**. As for Sentinels -1 and -2, there was a noticeable increase in the number of active users in November 2022. The number of active users for each mission increased by 12% for Sentinels -1 and -2, and by 6% for Sentinel-3, with respect to the number of active users in October 2022.

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 being accurate.

Table 24 below shows the number of active users on the Open Hub broken down by continent, for 2022 and Y2021. It also shows, for both periods, the

proportion for each continent of the overall number of active users, and the percentage increase between 2022 and Y2021. The graph in Figure 77 highlights this growth in active users on all continents, also including the years Y2015 to Y2020 to gauge the overall trends.

There was a rise in the number of active users in all continents during the year, with the exception of Oceania, which had 27% fewer active users than it had in Y2021, dropping from 3,988 in Y2021 to 2,916 in 2022, which is only slightly more than the 2,727 active users there had been in Y2020. Looking at the trend lines in Figure 77, it can be seen that this is actually the first time that the number of active users in a continent has been lower than it was in the previous year. Meanwhile, the number of active users in Africa continued to rise, this year by 24%, making the number of active users in Africa once again higher than the number in Oceania, as it had been in all years except Y2021. It is recalled, though, that in Y2021 the number of active users in Oceania had risen by a massive 46% compared with Y2020, potentially related to the vast forest fires experienced in Australia that year, and it is possible therefore that Y2021 will remain the outlier year.

The highest number of active users was still in Europe, where there was again a big increase in the number of active users compared with Y2021, rising by 26% to 39,468 active users in the year. This represents 40% of the total number of active users in 2022.

The number of active users also increased significantly in Asia, with 20% more active users than there had been in Y2021. The active users from Asia constituted 29% of the total number of active users in 2022, with the number reaching nearly 30,000.

South America + Antarctica and North America both experienced a similar level of growth, with numbers of active users 13% and 9% higher than they had been in Y2021.

Continent	2022	Overall % 2022	Y2021	Overall % Y2021	% Increase Y2021-2022
Europe	39,468	39.8	31,262	37.2	26%
Asia	28,894	29.1	23,987	28.6	20%
North America	13,491	13.6	12,341	14.7	9%
South America + Antarctica	9,956	10.0	8,780	10.5	13%
Africa	4,493	4.5	3,609	4.3	24%
Oceania	2,916	2.9	3,988	4.7	-27%

Table 24: Open Hub active users for 2022 and Y2021, per continent

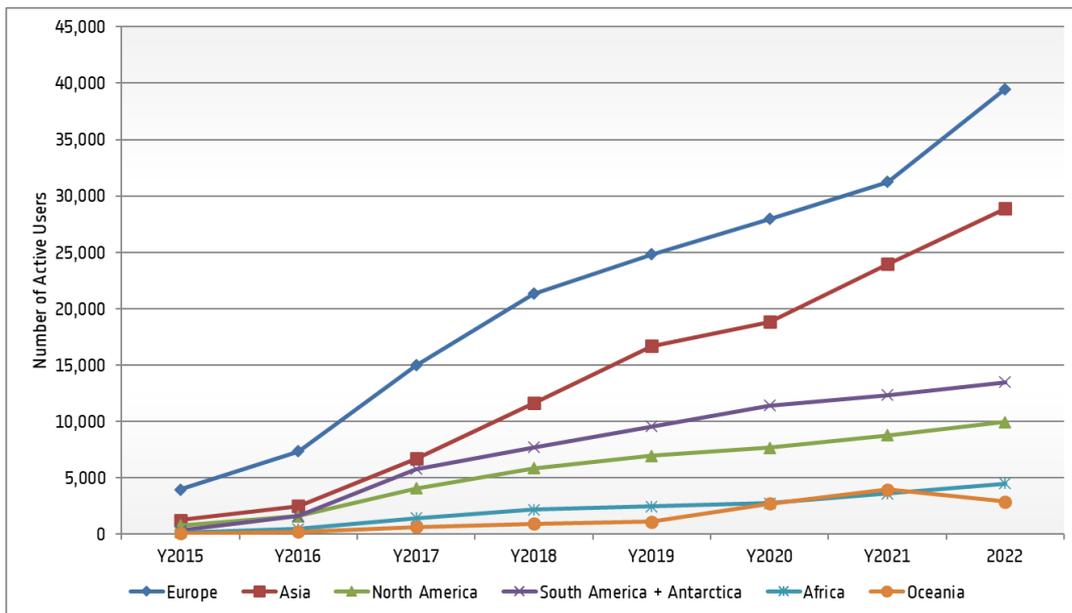


Figure 75: trend in Open Hub active users from Y2015-2022, per continent

It is highlighted that in Europe, North America, South America, Asia 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 was no local Copernicus Sentinel data access site in Africa in 2022.

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, both on a global and European level (specifically ESA and/or EU member states). The number of users who downloaded at least one user-level data during 2022 is provided for each country, per mission, as well as the percentage increase since Y2021 and any change in the position in the list.

Four ESA/EU member states, Germany, Italy, France and Spain, appear in the top 10 lists for each Sentinel mission, both in the global tables and in the Europe-only tables. For the second year running, the UK does not appear in the global Sentinel-2 top 10 but it is present in all of the other lists. In the Europe-only tables, the lists are very similar to those seen in Y2021, with only slight rearrangements in the order of the

countries. One notable change is in the Sentinel-3 top 10, where Austria has re-entered the list, with 146 active users of Sentinel-3 data in 2022, and Romania has dropped out.

Looking only at the lists for the ESA/EU member states, the countries which appear in the Sentinel-1 list are the same as those which appeared in Y2021, but there was only one country in which the number of active Sentinel-1 users increased, and that was Romania, where the number of active Sentinel-1 users rose 5%, from 235 users in Y2021 to 247 in 2022. For each of the other countries, there was a reduction in the number of active users, with the biggest drop seen for Greece, where the number fell by 12%, from 327 users in Y2021 to 287 in 2022. There was a slightly smaller reduction in the number of active Sentinel-1 users in Germany compared with in Italy (-4% compared with -8%) so Germany became again the European country with the highest number of active Sentinel-1 users.

The highest number of active users for Sentinel-2 was again in Spain, with as many as 3,800 users, a 5% increase on last year. However, it was France which saw the biggest increase in the number of active users, with 14% more users than there had been in Y2021, and very nearly reaching 2,000 active Sentinel-2 users. Overall, the number of Sentinel-2 active users increased in each European country, apart from in Greece where there were 9% fewer active users than there had been in Y2021, with the number falling from 1,221 users to 1,116.

For Sentinel-3, it was in Poland which saw the biggest increase in the number of active users, going up by a huge 37%, from 247 users to 339. Two European countries saw their number of active Sentinel-3 users fall with respect to Y2021: one of these was again Greece, but with just a 1% decrease; and the other was Spain, where the number fell by 4% with respect to Y2021, leaving Spain with 668 active Sentinel-3 users for 2022 instead of the 714 from Y2021.

In the global tables, three non-European nations also appear in the top 10 for each mission: China, India, and

the United States. Brazil also appears again in the top 10 for Sentinels -2 and -3. China is the country which had the most active users for Sentinels -1 and -2, worldwide, with 3,220 active users for Sentinel-1 (up 5% since Y2021), and 8,482 for Sentinel-2 (up 26%). In Y2021 China had also had the highest number of Sentinel-3 users, but after a 47% increase in the number of active Sentinel-3 users in the United States, the United States replaced it at the top of the list in 2022, with 1,419 active users. Russia, which in Y2021 had appeared in the top 10 for Sentinel-3 active users, this year did not feature in any of the lists.

Also interesting to note is that Japan features in the lists for the first time, having become the country with the 10th highest number of active users of Sentinel-1 data in 2022. In Indonesia, which first appeared in the top 10 for Sentinel-1 active users in Y2020, the number of active users increased by 19%, and Indonesia became the country with the sixth highest number of Sentinel-1 active users in 2022.

For Sentinel-2, Colombia replaced Mexico in the list and had the ninth highest number of Sentinel-2 active users, with 1,990, just 1 active user more than there were in France. Only one country saw a reduction in the number of its active Sentinel-2 users in the year, and this was Australia, where the number of active Sentinel-2 users fell by 33%, from 3,551 active users in Y2021 to 2,388 in 2022.

For Sentinel-3, there was also only one country in the global list in which the number of active users dropped, Spain, and the general pattern was instead for there to be significant increases in the number of Sentinel-3 active users in each country. The largest increase was that already highlighted for the United States, where the number of active Sentinel-3 users went up by 47%. Also of note were the 38% increase in the number of active Sentinel-3 users in India, where the number rose from 507 in Y2021 to 699 in 2022; and the 22% increase in Brazil, where the number rose from 375 in Y2021 to 456 in 2022.

Sentinel-1 - Global				
Country	Active Users 2022	% increase from Y2021	Ranking Y2021	Change
China	3,220	5	1	0
India	1,622	14	2	0
United States	1,303	18	5	^2
Germany	1,129	-4	4	0
Italy	1,103	-8	3	∇2
Indonesia	769	19	10	^4
United Kingdom	700	-6	7	0
Spain	694	-3	9	^1
France	693	-5	7	∇1
Japan	675	N/A	N/A	N/A

Table 25: 2022 Top 10 Global Countries: Sentinel-1

Sentinel-1 - ESA/EC				
Country	Active Users 2022	% increase from Y2021	Ranking Y2021	Change
Germany	1,129	-4	2	^1
Italy	1,103	-8	1	∇1
United Kingdom	700	-6	3	0
Spain	694	-3	5	^1
France	693	-5	4	∇1
Poland	527	-10	6	0
Netherlands	291	-7	8	^1
Greece	287	-12	7	∇1
Romania	247	5	9	0
Portugal	191	-1	10	0

Table 28: 2022 Top 10 ESA/EU Countries: Sentinel-1

Sentinel-2 - Global				
Country	Active Users 2022	% increase from Y2021	Ranking Y2021	Change
China	8,482	26	1	0
Spain	3,800	5	2	0
Brazil	3,649	2	3	0
Germany	3,534	3	5	^1
United States	3,280	19	7	^2
India	3,218	33	8	^2
Italy	3,096	10	6	∇1
Australia	2,388	-33	4	∇4
Colombia	1,990	N/A	N/A	N/A
France	1,989	14	10	0

Table 26: 2022 Top 10 Global Countries: Sentinel-2

Sentinel-2 - ESA/EC				
Country	Active Users 2022	% increase from Y2021	Ranking Y2021	Change
Spain	3,800	5	1	0
Germany	3,534	3	2	0
Italy	3,096	10	3	0
France	1,989	14	5	^1
United Kingdom	1,821	11	4	∇1
Poland	1,666	3	6	0
Greece	1,116	-9	7	0
Netherlands	975	4	8	0
Portugal	664	2	9	0
Romania	561	4	10	0

Table 29: 2022 Top 10 ESA/EU Countries: Sentinel-2

Sentinel-3 - Global				
Country	Active Users 2022	% increase from Y2021	Ranking Y2021	Change
United States	1,419	47	2	^1
China	1,322	6	1	∇1
Germany	898	20	4	^1
Italy	779	3	3	∇1
India	699	38	7	^2
Spain	688	-4	5	∇1
France	667	28	6	∇1
United Kingdom	518	17	8	0
Brazil	456	22	9	0
Poland	339	35	11	^1

Table 27: 2022 Top 10 Global Countries: Sentinel-3

Sentinel-3 - ESA/EC				
Country	Active Users 2022	% increase from Y2021	Ranking Y2021	Change
Germany	898	20	2	^1
Italy	779	3	1	∇1
Spain	688	-4	3	0
France	667	28	4	0
United Kingdom	518	17	5	0
Poland	339	37	6	0
Netherlands	245	32	8	^1
Greece	212	-1	7	∇1
Austria	146	N/A	N/A	N/A
Portugal	145	12	9	∇1

Table 30: 2022 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 category of use (Research, Education, Commercial, other) and the application domain. It is again stressed that users are only asked to categorise their intended use of the data 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 78 summarizes the active users and data downloads in terms of the intended onwards use for the data (category of use). 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 2022, the vast majority of active users were those who had selected 'Education' (45.8%) and 'Research' (44.7%) for their usage type; only 4.1% were those who had selected 'Commercial', and 5.5% were those who had selected 'Other' when they registered for an account. This is an almost identical split to that recorded in previous reporting years, with the biggest difference being a slight rise in the proportion of active users who had selected 'Other' for their intended usage type, going up from 3.8% in Y2021 to 5.5% in 2022.

It is, then, extremely interesting to see from the bar graph that although only 4.1% of the active users were those who had selected 'Commercial' on registration, those 4.1% downloaded 46% of the total number of user-level data downloaded overall in 2022. While still disproportionately high, this is actually a lower proportion of the downloads than the 'Commercial' group had made in Y2021, when it had been 67%. The corresponding increase in 2022 was in the proportion downloaded by the 'Research' group. Until Y2021, this group had always made the highest proportion of the overall number of downloads, and although the 'Research' group still did not make more of the total downloads than the 'Commercial' group made in 2022, its share increased from a low of 29% in Y2021 to 39% in 2022.

By contrast, the large 'Education' user group made only very small percentage (less than 5%) of the total number of downloads in the year. It seems very likely, therefore, 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 3% of the total number of downloads.

Figure 79 breaks down the totals for the number of active users and downloads in 2022 according to the seven application domains from which users can choose 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 58% of the total number of active users in 2022. Next in order were 'Other' with 13%, 'Atmosphere' and 'Climate' with 9%, 'Marine' with 6%, 'Emergency' with 3% (which decreased of 48% since last year) and 'Security' with 2%. This was a very similar split to that seen in Y2021, with the biggest increase in the number of active users seen for the 'Atmosphere' group, which had had 7% of the active users in Y2021, and the biggest decrease seen for the 'Emergency' group, which in Y2021 had constituted 6% of the active users.

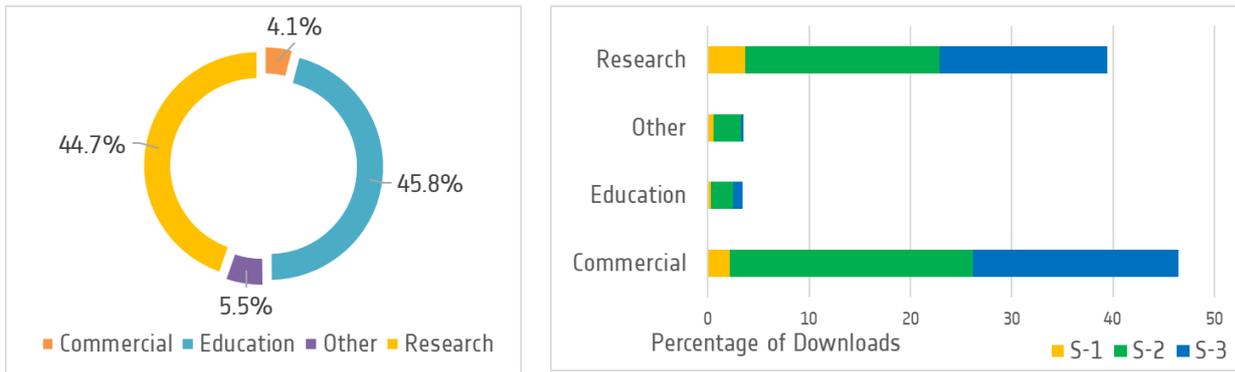


Figure 76: Percentage of Open Hub active users per declared usage type in 2022, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each usage type during 2022

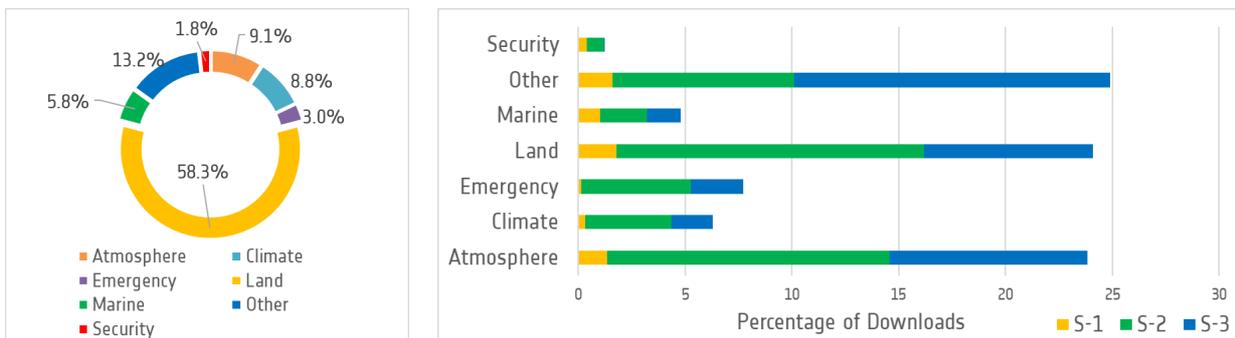


Figure 77: Percentage of Open Hub active users per declared thematic domain in 2022, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each thematic domain during 2022

This year the podium for the number of user downloads per application domain is shared by the 'Other', 'Land' and 'Atmosphere' groups, with 25%, 24% and 24% of the total number of downloads in 2022 respectively. This was a similar proportion as had been downloaded by the 'Land' group in Y2021 (21%), but it is a big reduction for the 'Other' group, which in Y2021 had made as much as 47% of the total number of downloads. Meanwhile, the percentage of downloads made by the small groups of 'Atmosphere' and 'Emergency' users were those which increased the most significantly compared to Y2021. Although the 'Emergency' group accounted for only 3% of the active users in 2022, they made nearly 8% of the total number of downloads, up from 4% in Y2021. As mentioned, the 'Atmosphere' group, which accounted for 9% of the active users, made as much as 24% of the total number of downloads in 2022, whereas previously their share had always been

between 16-19%. This rise is accounted for by the group having in 2022 increased the number of downloads they made by 240% compared with the number they downloaded in Y2021.

The majority of the 'Other' downloads were made from Sentinel-3 data and this is the only domain for which Sentinel-3 was the most downloaded mission, while for the other domains the majority of downloads were made from Sentinel-2 data.

The proportion of data downloaded for 'Marine' applications remained low in 2022, at just under 5%. The proportion of downloads made for 'Security' applications did increase slightly compared to previous years, with the group having this year also made a small share of the Sentinel-1 downloads for the first time, but the overall proportion remained marginal, at 2%.

4 Data Dissemination Partners

The access to Copernicus Sentinel data which ESA provides through the Copernicus Sentinel Data Access System is complemented by an ever-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		Agreement signed	Annual Report Section: 4.1	Start of operations
Category	Partner		Access URL(s)	
Collaborative National Mirror Sites	Austria	Feb 2016	https://data.sentinel.zamg.ac.at https://www.sentinel.zamg.ac.at	27 May 2016
	Belgium	Sept 2017	https://www.terrascope.be	27 Sept 2017
	Canada	Sept 2015	ftp://ftp.neodf.nrcan.gc.ca	22 Sept 2015
	Czech Republic	Jan 2018	https://dhr1.cesnet.cz https://dhr2.cesnet.cz	15 March 2017
	Estonia	Sept 2016	https://ehdatahub.maaamet.ee	1 January 2019
	Finland	Jan 2015	https://finhub.nsdcm.fmi.fi	24 May 2016
	France	March 2015	https://peps.cnes.fr	1 May 2015
	Germany	Nov 2014	https://code-de.org/	7 March 2017
	Greece	May 2014	https://sentinels.space.noa.gr	6 Feb 2015
	Hungary	Oct 2019	https://fir.gov.hu/	1 May 2022
	Ireland	Oct 2017	https://eobrowswer.speir.ichec.ie	19 Feb 2018
	Luxembourg	April 2017	http://www.lsa-datacenter.lu	1 May 2019
	Norway	Sept 2014	https://colhub.met.no https://satellitedata.no/	18 Oct 2016
	Poland	March 2018	https://copernicus.imgw.pl https://dane.sat4envi.imgw.pl	1 January 2020
	Romania	Dec 2017	https://dhus.rosa.ro/	30 Nov 2018
	Spain	Nov 2019	Not yet available	n/a
Sweden	June 2015	https://digitalearth.se	1 Oct 2019	
UK-1	March 2015	UK1: site: https://www.ceda.ac.uk/ JASMIN site: https://jasmin.ac.uk/	1 May 2015	

Table 31: Collaborative National Mirror sites

International Partner	Access URL(s)
Australia – Geoscience Australia (GA)	https://copernicus.nci.org.au/
Brazil – Brazilian Space Agency (AEB) and the National Institute for Space Research of Brazil (INPE)	https://sentinel-hub.inpe.br/#/home https://brazildatacube.org
Chile – University of Chile	https://www.cmm.uchile.cl/?page_id=39137
Colombia – Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM)	not yet available
India – Indian Space Research Organisation (ISRO)	https://bhoonidhi.nrsc.gov.in
Serbia – Biosense Institute	https://biosens.rs/
Tunis Sahara and Sahel Observatory (OSS)	http://www.oss-online.org/en/
Ukraine – State Space Agency of Ukraine (SSAU)	http://sentinel.spacecenter.gov.ua
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) Distributed Active Archive Center (DAAC) (Sentinel-3) https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurement/olci/
	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
United States – US Geological Survey (USGS)	https://eros.usgs.gov/sentinel-2

Table 32: Copernicus International 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 2022. 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.

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 2022 and who provided the requested information.

For the sites which had already been opened prior to 2022, there was an average growth in the number of users registered on their sites of 27%. However, on the Hungarian site, there was a huge increase in the number of registered users in 2022, with the number rising from 61 in Y2021 to 11,930 in 2022. The team explained that this huge increase took place following a public announcement and presentation of the site at the closure event of the previous FIR project, in May 2022.

There was a 26% increase in the average volume of data published on a CollGS site during the year

compared with Y2021: in 2022, the average volume published on a site was 1.97 PB, whereas in Y2021 it had been 1.47 PB. However, the total volume of data *downloaded* from all of the sites during the year was actually 152% higher in 2022 than in Y2021, with a total of 15.69 PB downloaded and an average of 1.05 PB per CollGS, which is 138% higher than the same value in Y2021 (see Table 36).

By the end of the reporting period, most of the CollGS partners had transferred their sites into operations. The implementation of the Spanish site has been delayed, however. Moreover, the second UK site, which was aimed primarily at commercial users, was suspended in June 2021, and the Portuguese site was suspended in 2022.

It should be explained that the Polish Copernicus data access service is divided into two parts: the national operator provides users with the newest data (last 30 days), whereas the rest of the data, the whole archive of Sentinel data for Poland, is accessible through the Sat4Eniv project, on the webpage <https://dane.sat4envi.imgw.pl>. The statistics presented here cover only the site run by the national operator, and so do not represent the full uptake of data from the Polish CollGS.

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, with 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 presentations given by the CollGS partners at each 'Collaborative Ground Segment Workshop' are also publicly available and can be downloaded from the following site:

<https://sentinel.esa.int/web/sentinel/missions/collaborative/workshop>

CollGS Partner	Overall Number of Registered Users since Start of Operations	% Increase since Y2021	% of Registered Users from the National Country	Number of Active Users in 2022	% of Registered Users who were Active in 2022	Number of users having accessed the service platform in 2022
Austria	1,952	5	-	26	1	-
Belgium	9,776	134	10	5932	61	543
Canada	21	0	-	1	5	5
Czech Republic	653	25	94	139	21	> 34
Estonia	377	15	87	53	14	-
Finland	663	11	-	120	18	-
France	9,579	12	56	-	N/A	-
Germany	3,482	35	78	894	26	82
Greece	822	2	65	20	2	-
Hungary	11,930	18,254	99	351	3	-
Luxembourg	311	39	-	108	35	-
Norway	868	7	-	68	8	-
Poland	56	30	98	10	18	-
Romania	104	19	92	15	14	26
Sweden	5	50	-	5	100	25
UK-1	3,029	23	74	79	3	-

Table 34: Summary of Collaborative Ground Segment national mirror site users

Table 34 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.

6 out of the 16 CollGS partners provide the take-up of local platform services, which means that they had the possibility to expose their catalogue also over APIs and the data are available to be downloaded with an external authentication from the cloud and Jupyter Notebooks platforms and provided the statistics of users accessing the platform in 2022. It is interesting to note that, in some cases such as Canada, Romania and Sweden, the number of users accessing the platform is greater than the number of active users and this indicate the interest of users to access to the data without the need to actually download it.

In line with the agreement on reporting, the CollGS partners are asked to categorise their own users according to the same fields used by ESA. Figures 80 and 81 below show the percentage of registered users from each national mirror site assigned to 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

10 out of the 16 partners which provided data had 'Research' as their top category of user and 'Research' users accounted for 43% of the CollGS users. In fact, the category represents over 50% of users of the national sites in Belgium, Estonia, Finland, Greece, Luxembourg, Norway, Poland and Sweden. In Sweden, the number of users which fall into the 'Research' category reaches 100% and it was also high in Greece (66%) and Belgium (62%).

Overall, 6% of the CollGS users were from the 'Commercial' user group, which is consistent with Y2021. Most notably, however, commercial users constituted 18% of the users of the Luxembourg mirror site and 10% of the users of the Finnish site.

24% of the CollGS users overall were from the category 'Education', but this was the largest category of users for the Czech mirror site (69% of users) and the Romanian site (62%). The 'other' category is the

most common in Canada, Uk-1, Hungary and Germany.

Usage Field

In this section, the split of users from the German site are omitted because they are grouped under different categories. For the other 15 CollGS partners, by the end of 2022, 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, Estonia, France, Norway and Romania.

In Canada, 64% of the registered users ascribed themselves to the 'Marine' category, whereas for the other countries this field is selected by less than 13% of the registered users. The remaining 36% of the users on the Canadian site describe their usage as 'Emergency', which again constitutes not even 10% of the users on any of the other sites. This clear

difference in the types of users engaging with the national sites, highlights well the principle underlying the CollGS, that states be able to develop their own national sites which are tailored to the specific needs and interests of their national users.

Sweden site was the only site on which the majority of registered users (50%) ascribed themselves to the category of 'Security'.

33% of the registered users of the Swedish site, 20% of the Polish site, 19% of the Greek site and 18% of the Luxembourg site considered themselves 'Atmosphere' users.

'Other' was the most common usage field among users of the Luxembourg and UK-1 sites, in particular accounting for about 55% of the users of the UK-1 site.

Taking into account all users for all partners, the top usage fields were 'Land', accounting for 45% of users, 'Other' (18%), 'Atmosphere' (10%), 'Marine' (9%) and 'Climate' (7%)

Percentage of registered users per usage category for each National Mirror Site

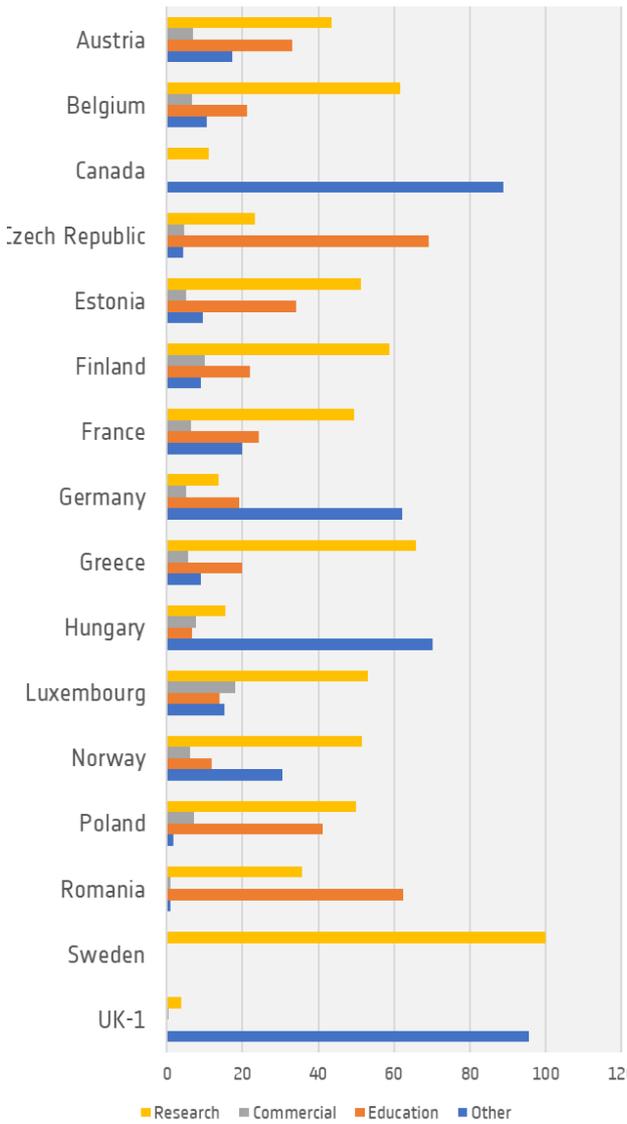


Figure 78: Percentage distribution of mirror site users by usage category

Percentage of registered users per usage field for each National Mirror Site

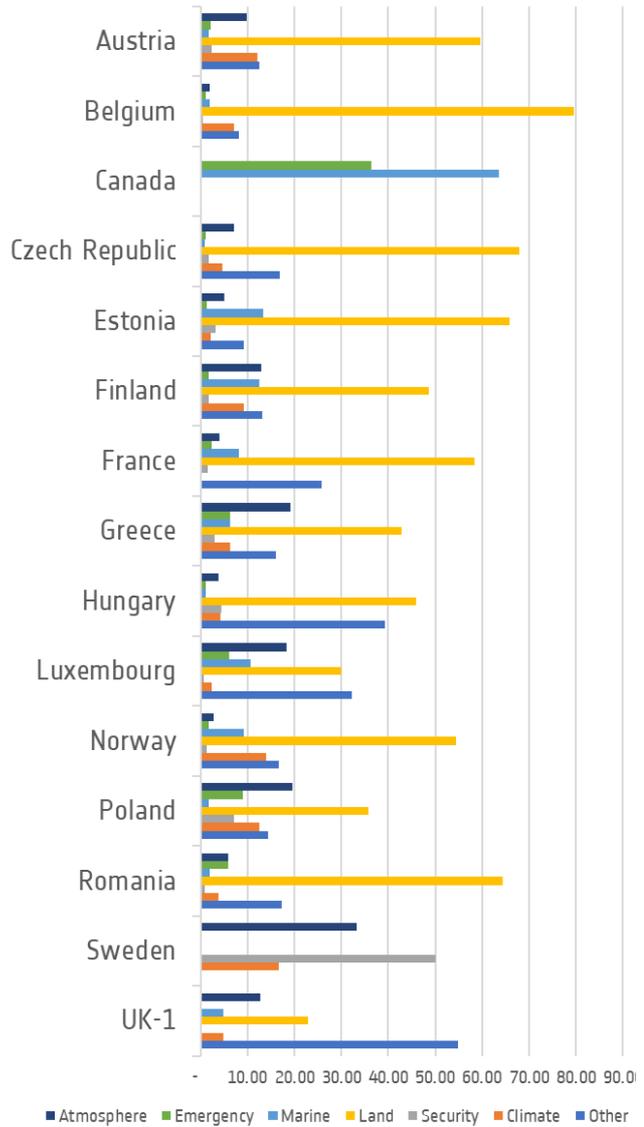


Figure 79: Percentage distribution of mirror site users by usage field

CollGS Partner	2022 Published Volume (TB)	% Increase from Y2021	2022 Downloaded Volume (TB)	% Increase from Y2021
Austria	4,981.20	-22	55.31	-70
Belgium	263.60	21	0.48	-23
Canada	23.20	-47	19.30	-51
Czech Republic	48.61	-82	41.88	-78
Estonia	7.53	-79	91.36	373
Finland	215.42	30	229.56	460
France	3,138.00	-19	13,319.40	192
Germany	213.46	N/A	4.70	N/A
Greece	9,241.16	1,683	7.39	-59
Hungary	11.00	-74	13.22	N/A
Luxembourg	6,201.80	-16	1,529.82	559
Norway	5,795.80	122	690.65	-36
Poland	246.24	-2	21.52	59
Romania	34.61	-24	15.67	3,165
Sweden*	13.10	31	-	N/A
UK-1	1,824.70	5	25.48	155
TOTAL (PB)	31.50	26	15.69	152
Average 2022 (PB)	1.97	34	1.05	138

Table35: Overall publication and dissemination volumes on mirror sites

Table 35 above reports, where available, the total volume of Copernicus Sentinel data both published on and downloaded from the mirror sites during 2022, together with the percentage change with respect to Y2021.

Overall, there are a number of decreases as well as increases reported. In particular, the total data volume published in the year (31.50 PiB) was 26% higher than in Y2021, mostly due to the huge increase (1,683% larger) published on the Greek site, which this year made the largest collection of data available for its national users.

Following Greece, the greatest individual increases in publication volumes were seen in Norway (122% increase) in Sweden (31% increase), Finland (30%) and Belgium (21%). The greatest individual decreases were seen on the Czech (-82%) and Estonian (-79%) sites.

In terms of volumes of downloads made by users, the overall sum of 15.69PiB was 152% higher than the Y2021 total. This increase in absolute values is largely

due to a rise in the reported volume of downloads from the French and Luxembourg sites: in 2022, users of the French CollGS downloaded 13PiB of data, and in Y2021 this volume had been lower than 5 PiB. It is interesting to note that the data downloaded in 2022 was predominantly from Sentinel-1 (94%), even though the volume of Sentinel-2 data published on the French site was double the volume of Sentinel-1 data published in 2022. The volume of downloads from the Luxembourg site was almost 6 times the volume downloaded in Y2021. Here the downloads were mostly of Sentinel-2 data (95%).

The other partners which showed enormous growth in the download volume in 2022 with respect to Y2021 were the sites in Romania (up 3,165%), Finland (up 460%) and Estonia (up 373%).

The majority of mirror sites showed lower download volumes than the volumes published in the year. The exceptions were the Estonian site, which supported a much higher download volume (91TB) than published volume (8TB), and the French, Finnish, and Hungarian sites.

CollGS Partners	2022 Published Volume (TB)				2022 Downloaded Volume (TB)			
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
Austria	1,058.14	3,587.67	335.39	0	0.18	54.96	0.17	0
Belgium	63.44	200.16	0	0.01	0.09	0.39	0	0.01
Canada	21.00	0.30	1.90	0	18.00	0	1.30	0
Czech Republic	5.32	21.95	13.18	8.16	10.59	10.32	0.01	20.96
Estonia	5.54	1.38	0.61	0	54.63	29.73	7.00	0
Finland	69.29	85.38	58.00	2.75	48.33	10.71	160.98	9.53
France	1,067.00	2,071.00	0	0	12,500.00	819.4	0	0
Germany	80.69	72.88	25.70	34.19	0.92	3.65	0.12	0.01
Greece	152.59	242.22	55.46	54.48	6.09	4.89	1.77	0.73
Hungary	1.00	1.00	3.00	6.00	0.17	13.04	0.01	0.002
Luxembourg	1,405.61	4,796.19	0	0	80.01	1,449.81	0	0
Norway	1,012.19	3,934.82	817.44	31.35	504.89	184.19	1.38	0.19
Poland	29.74	157.80	28.75	29.95	4.15	0.92	15.96	0.49
Romania	11.34	10.79	12.48	0	10.95	2.64	2.09	0
Sweden*	0	12.6	0.5	0	-	-	-	-
UK-1	980.00	56.70	459.00	329.00	9.26	15.68	0.50	0.04
TOTAL	7,021.03	18,827.91	2,146.31	495.88	13,248.25	1,780.93	191.29	31.96
% increase/decrease	-32%	48%	56%	122%	227%	-13%	74%	-17%

Table36: 2022 Publication and dissemination volumes per Sentinel on mirror sites

Table 36 breaks the publication and download volumes down by Sentinel mission, where this information was available. 4 sites out of the 16 published more Sentinel-1 data than any other mission data in 2022, and these were Canada, Estonia, Germany and UK-1. This list includes fewer countries than last year, and this is maybe due to the lower availability of Sentinel-1 data in 2022 caused by the loss of Sentinel-1B.

Meanwhile, 10 sites out of the 16 published more Sentinel-2 data than any other mission data: Austria, Belgium, Czech Republic, Finland, France, Greece, Luxembourg, Norway, Poland and Sweden. The Swedish site which previously published only Sentinel-2 data, this year started also publishing Sentinel-3 data.

As in Y2021, only the Romanian site published more Sentinel-3 data than data from the other Sentinels.

In addition to the 8 sites which were already publishing Sentinel-5P data in Y2021 (Belgium, Czech Republic, Finland, Germany, Greece, Hungary, Poland and UK-1), this year, the Norwegian also started publishing Sentinel-5P data. As in Y2021, the Hungarian site was the only site which published more Sentinel-5P data in 2022 than data from any other Sentinel.

The higher figure for the overall data volume published this year can be attributed to big increases in the average publication volumes per national site for all missions except Sentinel-1. There was a 48% increase for Sentinel-2; 56% for Sentinel-3; and an impressive 122% for Sentinel-5P. Meanwhile, the average volume of Sentinel-1 data published in 2022 per national site decreased by 32%. However, it is again recalled that comparisons with last year's statistics should be read with caution, given the missing input from the German mirror site for last year.

Figure 82 compares the proportions for the volumes of data published from each mission, with the proportions for the volumes download from each mission. This gives a view on whether the user activity is in line with the data being made available. On the Canadian site, for instance, there is an almost direct match between the proportions of Sentinel-1 and Sentinel-2 data which was published and the proportions of data from each mission which were downloaded by users. A similar congruence can be seen on the Austrian, Belgian, Estonian, French, Greek and Luxembourg sites.

There is more of a disparity between the volumes published and downloaded on the other sites. Hungary, for instance, published mostly Sentinel-5P

data, but 99% of the volume of data downloaded by users was Sentinel-2 data. Similarly, users of the German and Finnish sites showed an overwhelming preference for Sentinel-2 and Sentinel-3 data, respectively, despite more evenly spread proportions of published data from Sentinels -1, -2 and -3.

The Norwegian and Polish sites published more Sentinel-2 data than Sentinel-1 data, but the Norwegian site registered a majority of Sentinel-1 data downloads (73%), and the Polish users downloaded a majority of Sentinel-3 data (74%). By contrast, the UK-1 site published a far higher volume of Sentinel-1 data than Sentinel-2 data but the

majority of the data downloaded was from Sentinel-2 (62%).

On the Czech site, which published a majority of Sentinel-2 data, the majority of data downloaded by users was Sentinel-5P data (50%). For the Romanian site, on which the proportion of publication volumes is almost even, the majority of the data downloaded was Sentinel-1 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.

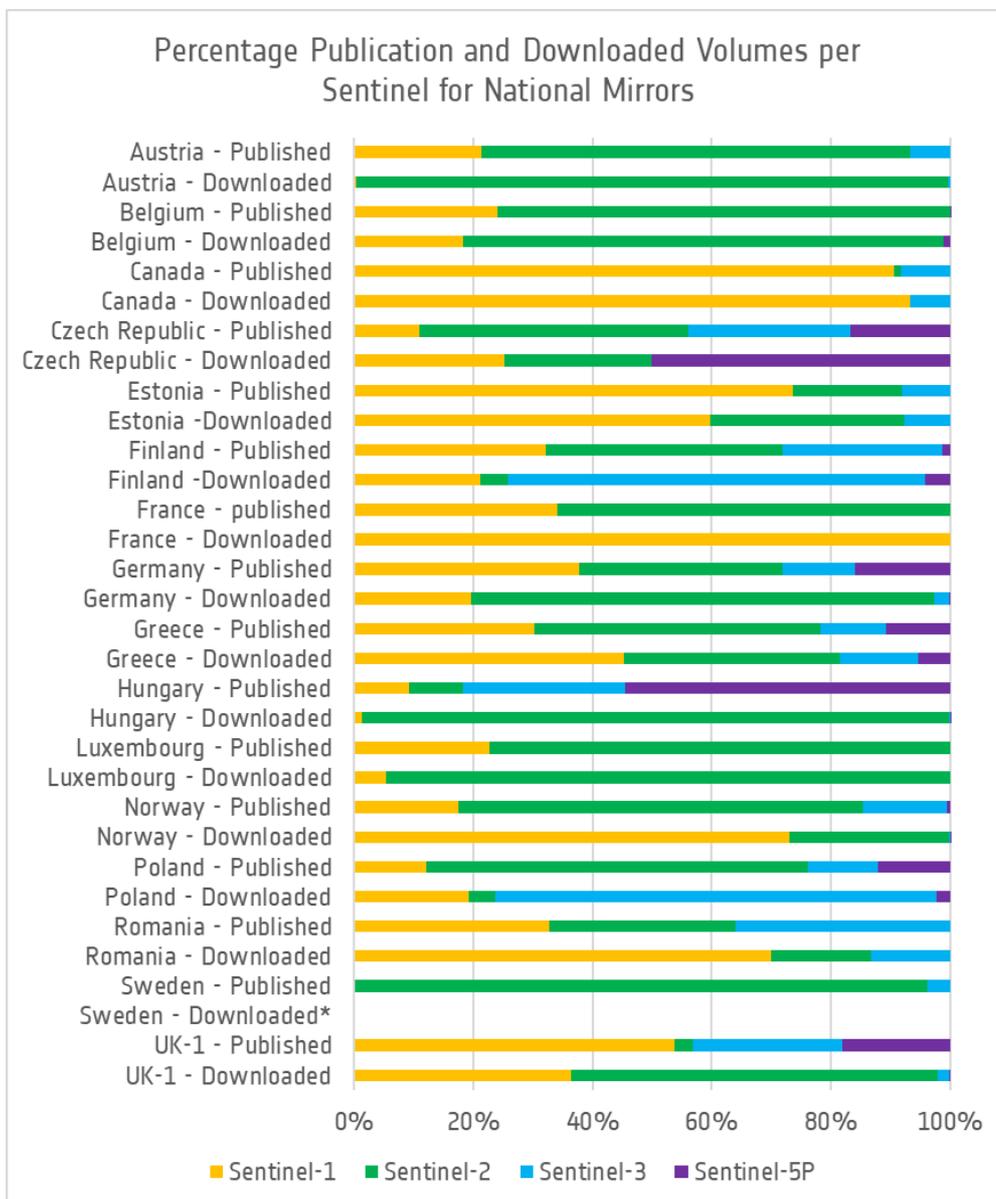


Figure 8o: Percentage publication and dissemination volumes per Sentinel on mirror sites

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 11 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 to transfer the data to their national data access sites for use by their own user communities.

In 2022, one new international partner joined the group: the Sahara and Sahel Observatory (OSS) and ESA signed a Copernicus technical operating arrangement on 30 December 2022, making OSS ESA's first Copernicus international partner in Africa.

Also within 2022, USGS announced on its site that it would stop collecting new Sentinel-2 data on 19 October 2022, and that it would remove all Sentinel-2 data was removed from the USGS archive on 18 November 2022. By the end of the year, therefore, there was no active mirror site under the ESA TOA with USGS.

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/hlss30vo15/</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>Up until 18 November 2022, USGS provided storage and redistribution of Sentinel-2 data on its Earth Resources Observation and Science (EROS) Center. The USGS Sentinel-2 archive was only a partial representation of all available acquisitions from ESA however.</p> <p>USGS also made 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>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 is primarily intended to provide free and open download 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, which is reduced to a subset cut to the Australasia region of interest (ROI) after that period. Limited provision of Sentinel 5P data from the Australasia ROI is now also being trialled.</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,</p>

			<p>Queensland Department of Environment and Science, Western Australian Land Information Authority and the Commonwealth Scientific Industrial Research Organisation.</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>In “ramp-up” phase during 2022</p>	<p>INPE has set up a regional data access/analysis hub, to facilitate the access to and exploitation of Copernicus Sentinel data in Brazil.</p> <p>The website is https://sentinel-hub.inpe.br/</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>University of 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 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</p>

			<p>region. Currently the site maintains a window of 60 days of all Sentinel-1 and -2 data tiles which intersect the Chilean territory.</p> <p>The site is primarily intended to enable users to download the data.</p> <p>https://www.cmm.uchile.cl/?page_id=39137</p> <p>www.datoscopernicus.cl</p>
<p>Colombia</p> <p>Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM)</p>	<p>26-Dec-2019</p>	<p>N/A</p>	<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>
<p>Tunis</p> <p>Sahara and Sahel Observatory (OSS)</p>	<p>30 Dec 2022</p>	<p>N/A</p>	<p>OSS operates a regional Earth Observation centre which it intends to use as a platform for improving access to, and the exploitation of Copernicus Sentinel data in the North Africa region, and by its partners in GMES and Africa.</p> <p>http://www.oss-online.org/en/</p>

Table 33: International Partners summary

The international partners which have started 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 2022 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. BioSense spent 2021 restocking the archive with Copernicus Sentinel data over the Balkan regions, after the hard disk failure during the previous year which had resulted in a total data loss for the site. BioSense was able to restock the latest year and a half (from 1 January 2020), but they faced errors with the GUI and were not able to get their instance of the DHuS working properly during

2022. They are waiting until they move into their new building in 2023 before they restart the national site.

The Brazilian data centre was still in the “ramp-up phase” during 2022, so only a few statistics are included in this Report.

There is currently no active Copernicus data access site in Colombia.

It should also be noted that for USGS, the figures presented under ‘Principal user categories’ are calculated on the basis of the proportion of downloads which were made by each category of user, while for the other partners the percentages show the proportion of their registered users which fall into each category.

International Partner	Operation start date	Number of active users in 2022	% increase in active users since Y2021	Principal user categories (percentages of registered users unless otherwise stated)
Geoscience Australia (Australia)	26-Jun-15	* 8,093	16.3%	International public organisation: 5% National/regional/local public authority: 19% Research & education organisation: 28% Business/commercial/professional - SME: 23% Business/commercial/professional - non-SME: 3% Charity or NGO: 2% Private individual - personal interest: 23% Other : 0.3%
NASA (USA)	12-Dec-15	45,485	27%	National or regional institutions and bodies : 2% Other international national or regional institutions or public authorities: 93% Research and education organisations: 5% Commercial and private bodies – SMEs and non SMEs: 1%
NOAA (USA)	01-May-2016	N/A	N/A	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	311,367	443.4%	<i>[percentages are of download proportions]</i> Academic Institution: 52% General Public: 14% Private Business: 10% Non-U.S. Federal/National Government: 9% U.S. Federal Government: 7% Other: 5% Non-profit Organization: 3% U.S. State/Provincial/Departmental Government: 1% U.S. Local Government: 0% Tribe/Nation/Indigenous Group: 0%
University of Chile (Chile)	27-Sep-19	83	-78.3%	Research: 40% Commercial: 6% Education: 33% Other: 21%
SSAU (Ukraine)	01-Jan-20	30	-49.2%	Research: 43% Education: 47% Other: 10%
ISRO (India)	26-Jan-20	157	40.2%	National or regional institutions and bodies: 40% Research and education organisations: 41% Commercial and private bodies – non SMEs: 18% Other: 1%
IDEAM (Colombia)	01-Dec-18	N/A	N/A	N/A
AEB (Brazil)	14-Mar-19	N/A	N/A	N/A
BioSense (Serbia)	N/A	N/A	N/A	N/A

Table 34: International Partner general characteristics and statistics for 2022

* Active users - as user information is not recorded for all downloads on the Australian site, they have used the total number of unique IP addresses for the number of active users. In addition, when they reviewed the previous calculations of this value, it appeared to have been overestimated in the past. They supplied a corrected value for this year and when compared to the (corrected) value for last year (6731) indicates an increase of 3.4% in "active users" this year.

International Partner	Total Published Volume in 2022 (TB)	% Change in Published Volume from Y2021	Total Published Volume since start of data distribution (TB)	Total Downloaded Volume in 2022 (TB)	% Change in Downloaded Volume from Y2021	Total Downloaded Volume since start of data distribution (TB)
Geoscience Australia (Australia)	1,251	-36	6,432	6,393	44	21,715
NASA (USA)	2,910.30	N/A	17,668.40	58,034.85	249	122,138.87
NOAA (USA)	896	114	2,235	36	-31	160
USGS (USA)	N/A	N/A	N/A	710.71	43	N/A
University of Chile (Chile)	77	-44	388	0.39	-74	3
SSAU (Ukraine)	85.69	-23	320.67	0.4	-88	4.40
ISRO (India)	224	36	476	239	273	351
IDEAM (Colombia)	N/A	N/A	N/A	N/A	N/A	N/A
AEB (Brazil)	145.04	79	187.09	-	N/A	-
BioSense (Serbia)	N/A	N/A	N/A	N/A	N/A	N/A

Table 35: International Partner publication and download statistics for 2022

Table 40 above summarises, per partner, the volumes of published and downloaded data by the end of 2022 and, where applicable, also the percentage change with respect to the end of Y2021.

In terms of the total published volumes since the start of operations, NASA has the highest value, in line with it having been one of the first sites to open, back in 2015, together with Geoscience Australia (GA). There was an enormous 249% increase in the volume of downloads from the site in 2022 compared with the volume downloaded in Y2021, and overall the highest volume of data has been downloaded from NASA’s site by a long stretch.

Also notable this year was the activity on the Indian and Brazilian sites. They increased their yearly published volumes by 36% and 79% respectively, compared with the volumes published in Y2021, and the volume of downloads from the Indian site was almost three times higher than it had been in Y2021, reaching as much as 239 TB.

There were also changes on the NOAA site this year compared with the previous year: there was a 114% increase in the volume of data published on the site during the year, higher even than the 77% increase

already seen in Y2021. The volume of data downloaded from the site was 31% lower than it had been in Y2021 (especially for Sentinel-1 and -3 data), but it should be recalled that in Y2021 there had been a massive 474% increase in the volume downloaded compared with Y2020.

The volume of data which Chile and Ukraine published was 44% and 23% lower than in Y2021, and the amount of data downloaded by the users also decreased by 74% and 88% respectively.

In Table 41, the overall volumes of user-level data published and downloaded in 2022 are broken down by Sentinel (where this information was available), 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	2022 Published Volume (TB)				2022 Downloaded Volume (TB)			
	S-1	S-2	S-3	S-5P	S-1	S-2	S-3	S-5P
Geoscience Australia (Australia)	166	607	470	8	3,497	2,501	395	N/A *
NASA (USA)	1,090.1	429.3	1,157.1	233.8	53,905.1	1,145.31	1,244.55	1,739.89
NOAA (USA)	71.2	113.2	711.8	-	11.11	2.37	22.16	-
USGS (USA)	N/A	-	N/A	N/A	N/A	710.71	N/A	N/A
University of Chile (Chile)	20.23	35.66	20.63	-	0.29	0.06	0.04	-
SSAU (Ukraine)	26.59	36.52	22.58	-	0.18	0.24	0.002	-
ISRO (India)	17	207	-	-	93	146	-	-
IDEAM (Colombia)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AEB (Brazil)	7.02	138.02	-	-	N/A	N/A	-	-
BioSense (Serbia)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 36: International Partner published and download volumes, per Sentinel mission for 2022

* While Sentinel 5P data is now being published on GA's site, download statistics are not yet being recorded.

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 2022. For comparison, the table also sets out the corresponding values recorded for Y2015-Y2021, 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 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 the previous three years: each Hub achieved over 99% overall availability, and 2 of the 4 hubs reached the highest availability yet recorded for that hub.

Hub	2022	Y2021	Y2020	Y2019	Y2018	Y2017	Y2016	Y2015
Open Access Hub	99.75	99.39	99.10	99.34	98.48	98.95	95.11	96.62
Collaborative Hub	100	100	100	100	100	98.04	98.19	96.09
Copernicus Service Hub	99.94	99.90	99.23	99.60	98.50	98.60	99.35	N/A
International Hub	99.91	99.99	99.99	99.95	99.90	98.89	99.59	N/A

Table 37: Overall availability of each hub during reporting years Y2015 – 2022

Month	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub
Jan-22	99.88	100	100	100
Feb-22	99.95	100	100	100
Mar-22	99.57	100	99.9	99.78
Apr-22	99.78	100	99.98	99.64
May-22	100	100	100	100
Jun-22	100	100	100	100
Jul-22	98.7	100	100	100
Aug-22	99.78	100	100	100
Sep-22	99.82	100	99.82	99.82
Oct-22	99.64	100	100	100
Nov-22	99.94	100	99.61	99.61
Dec-22	99.94	100	100	100
Y2021	99.39	100.00	99.94	99.90

Table 38: Monthly availabilities during Y2021 per hub (green shading indicates >98% availability; yellow shading indicates <98% availability – not present; red shading indicates <95% - not present)

Table 43 breaks the overall availability figures down by month for each of the hubs. Each year this monthly availability has been improving, and in Y2021 there was only one month in which the monthly availability fell below 98% and this was only for one hub, the Open Hub. However, this year there was further improvement still and the monthly availability for all of the hubs remained above 98% for every month in the year. It is clear that 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.

The highest overall availability was 100% which was recorded for ColHub. As can be seen in Table 43, 100% service availability was also recorded for ColHub in all years since Y2018. It has been possible to achieve and sustain this optimum availability due to the 3 nodes which operate in parallel on ColHub. These nodes 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 2022, 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 99.91% overall yearly availability, which is actually slightly worse than the 99.99% availability reached last year but it will still have delivered a very good experience from the user point of view. In fact, for 8 months of 2022, no downtime was recorded on the Hub at all. The slight reduction is due to small periods of unavailability which were unavoidable during scheduled maintenance activities aimed at improving the download performance.

Below is a list and description of the scheduled upgrades and maintenance activities which took place in 2022:

- 04/01/2022 08:00-18:00: Maintenance activity to adopt specific load balancing rules in order to improve download experience on APIHub/SciHub.

- 25/01/2022 08:00-16:00: Infrastructure maintenance to permit the necessary configuration on DHuS side of the new ONDA Object Storage (Offline Catalogue).

- 07-08-14-15/02/2022 07:30-16:30: maintenance to upgrade the 20 ESXi hosts on OVH belonging to DHuS Dedicated External Cloud to fix the latest VMware vulnerability: VMSA-2022-0001 (vmware.com). Services will be moved between the VMware Cluster so no downtime has been experienced.

- 23-02-2022 07:30-16:30: Maintenance request for TTO of DHuS version 3.0.2 on all the backends instances of Sentinel-1, Sentinel-2, Sentinel-3. No Service Downtime during the maintenance window, short delay in new product publication.

- 05/04/2022 07:30-16:30: Maintenance activity to permit the operational switch of S3A and S3B PDGS to new PRIP interface. During the maintenance window publication delays have been experienced for Sentinel-3A and B user level data on all hubs.

- 06/04/2022 07:30-16:30: Maintenance activity with the aim to perform the operational switch of S1A PDGS to New PRIP interface. During the maintenance window publication delays have been experienced for Sentinel-1A user level data on all hubs.

- 26/05/2022 07:30-15:30: Maintenance activity on the Open Access Hub to allow the network configuration in order to improve the download speed performance for nearline user level data. During the maintenance window users have experienced short download interruptions.

- 06/06/2022 06:00-16:00 - 07/06/2022 06:00-16:00: A maintenance activity, to upgrade the security level of the DHUS infrastructure has been done. During the maintenance period, not service interruptions nor publication delay for Copernicus Open Access Hub, Collaborative Data Hub Node1, Copernicus Services Data Hub and International Access Hub.

- 12-13-14/09/2022 and 19-20-21/09/2022 06:30-16:30: A series of maintenance activities aiming at updating the data hub software have been performed. During the maintenance window performance degradation and short interruption of the service have been experienced on Collaborative

Data Hub Nodes 1 ,2 and 3, Copernicus Services Access Hub, International Access Hub, SciHub, APIHub and Copernicus Sentinels POD Data Hub)

- 27/09/2022 6:30-13:00: Infrastructure maintenance activity with the purpose to update the object storage. The publication of all Copernicus Sentinel-1, Sentinel-2 and Sentinel-3 user level data has been delayed. No major issues were reported by end users.
- 11/10/2022 from 06:30 to 13:30 UTC: An infrastructure maintenance activity with the purpose of improving downloads performance on Sentinel-3A/S3B NAS Disks has been performed. No major issues were reported by end users
- 22/11/2022 from 07:30 to 16:30 UTC: A scheduled maintenance has been performed on Collaborative and Copernicus Services Hubs aiming at improving the network capabilities: in more details, the data flow was split in order to use two different gateways with a consequence of more capacity for each hub.

Several unexpected anomalies were also experienced during 2022. The most significant of these anomalies were:

- 14/01/22 07:34-08:27: Unexpected Out of Memory issue on PostreSQL Pool that precluded the correct switch between the nodes. During the period no products have been published because write operations on the DB were prevented.
- 02/03/2022 15:50-16:00: Unexpected delay of responsiveness of SciHub due to many concurrent requests that affected the Service Availability.
- 15/03/2022 17:01-17:15: The Greek Complementary Centre hosted by GRNET experienced a network problem. A 3rd partied provider had an outage between their premises and the GRNET up-link that affected the most of GRNET infrastructure by cutting internet for about 13minutes. Service affected: ColHub3 DiasHub3 S5P Access Hub.
- 22/03/2022 07:05 – 07:20: An unexpected behaviour which caused some periods of Service Unavailability on SciHub during the following time windows: from 00:51 to 01:57 from 05:59 to 06:11 from 07:41 to 07:52. Problem was due to an unexpected sudden downtime on 3 of 4 Solr Nodes. Publication has not been affected, while service access has.

- 05/04/22 03:01-04:26: An unexpected number of user requests caused a short period of unavailability of Open Hub. During this period both the access to the service and the user level data publication have been affected.
- 11/04/2022 03:09-05:45: Unpredicted issue on the infrastructure caused the temporary data publication unavailability in the ColHub, IntHub and Sentinel 5P Hub. There was a problem with the database configuration and it has been fixed thanks to the estimation that could prevent any further occurrence on the same issue. During this temporary issue service access has not been affected.
- 16/05/2022 18:16- 17/05/2022 09:03: Due to an internal network problem of connectivity between the database and the Sentinel-5P Hub, the publication of fresh data has been suspended and fully recovered soon after the unavailability.
- 22/06/2022 13:07 - 22/06/2022 13:51: Due to an unexpected issue on Proxy service, the Collaborative Hub Node 02 has experienced periods of unavailability. During this temporary issue service access has been affected. The publication of fresh products has been nominal. The problem has been solved and the service availability restored.
- 10/07/2022 15:55 - 22:33, 19/07/2022 06:26 – 07:16, 30/07/2022 01:49 - 03:19 and 12/08/2022 19:03 - 20:44: The Open Access hub has experienced periods of unavailability due to a software issue. The cause has been investigated and fixed by adopting some mitigation measures in order to limit the impact on the user's experience. No further occurrences due to the same cause were encountered.
- 01/10/2022 from 13:14 to 13:43 and from 14:17 to 16:30 UTC: The Open Access hub has experienced periods of unavailability due to a database issue. The cause has been investigated and fixed by adopting some mitigation measures in order to limit the impact on the user's experience. No further occurrences due to the same cause were encountered.
- 23/11/22 from 12:07 to 12:31 UTC: The Open Access hub has experienced a short period of unavailability due to a research index issue caused by an intensification of a user activity. Service has been restored and has been fully operative since then.

5.2 Network Analysis

Data traffic loads

During 2022, the outgoing traffic from the Sentinel Data Access System was loaded with a particularly great number of download requests, above all in May, September and October.

Figure 83 shows the daily outgoing traffic from the cloud infrastructure (OVH) during 2022, 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 reached more than 50 Gbps of usage.

Comparing this figure with the network capacity during Y2021, the overall maximum outgoing traffic

did reach similar peaks in July 2021, but the trend in 2021 was a general decrease in outgoing traffic, whereas the trend in 2022 was a general increase.

As mentioned, there was a particularly high increase in the outgoing traffic in May 2022. This may be partially attributed to a new network configuration which was designed to improve the download speed performance for nearline user level data: in this period the average load went from an average of 35 Gbps to around 45 Gbps. Then in September the highest peak in the outgoing traffic was seen, reaching as much as 53Gbps in the week beginning 13 September 2022. Although the traffic decreased again after that peak, a particularly high level of traffic continued to be seen until mid-November 2022. In December, the outgoing traffic average daily rate was much lower, varying between 20 and 35 Gbps.

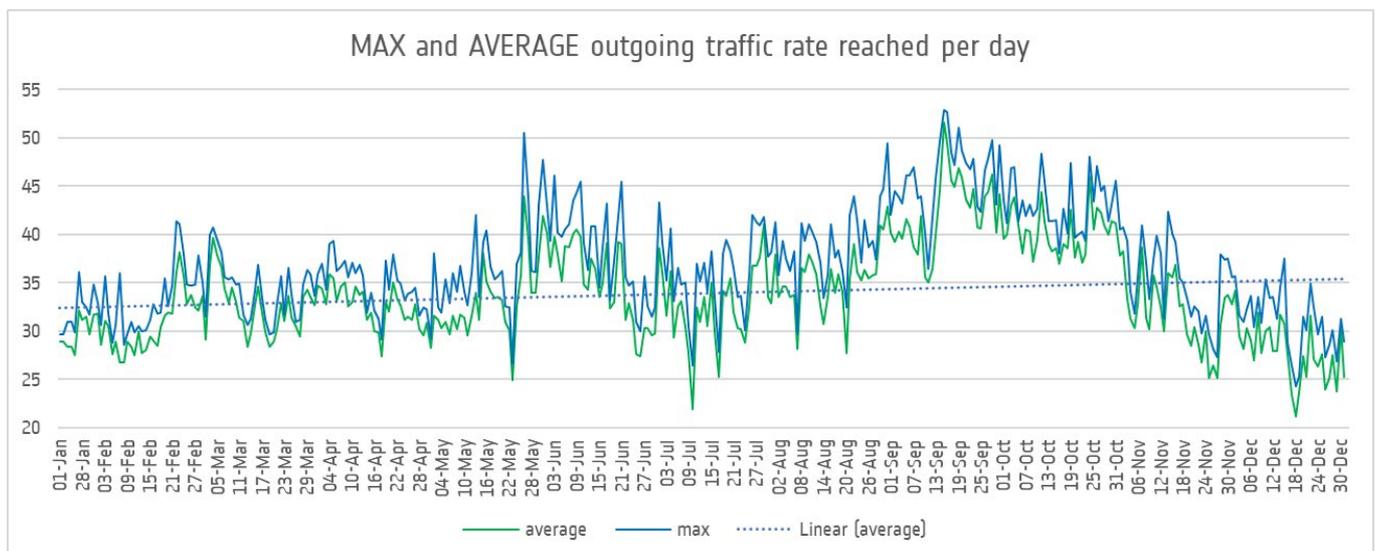


Figure 81: Max (in blue) and average (in green) outgoing traffic in Gbps reached each day during 2022

Effective bandwidth

Figure 84 and 85 below present for each hub the percentage of completed downloads performed in December 2021 and December 2022 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 package and the volume of that downloaded user-level data package. 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 package on the user’s disk, as well as the concurrent activities on the hub at the time the download is made. The Figures show the effective bandwidth on each hub, taking into account all of the completed downloads during December 2021 and December 2022, as well as providing the combined statistics for all of the hubs together. This provides an approximate overview of the general improvement all users of the hubs should have perceived when they downloaded Sentinel user-level data in 2022.

For all hubs, the most frequently experienced (or equal highest) effective bandwidth in December 2022 was >100 Mbps, and this indicates that users are now for the most part able to download user-level data at a very fast rate. Calculating the effective bandwidth for all hubs together, it is clear that there was a marked improvement in the effective bandwidth

experienced by users since 2021: in December 2022, 80% of all downloads were made at an effective bandwidth of >100 Mbps, whereas the equivalent figure in December 2021 was 51%.

For the Open Hub users, 78% of the downloads they made reached an effective bandwidth higher than 100 mbps, and this is a massive increase from the 38% which was calculated in December 2021.

For ServHub and ColHub Nodes, more than 75% of downloads took place at >100 Mbps; and in particular for Node 1 it reached 90% of downloads.

The most dramatic change was seen for IntHub users, however. In December 2021, they had experienced an effective bandwidth over 100 mbps for just 11% of their downloads. In December 2022, by contrast, as many as 67% of the IntHub downloads were made with an effective bandwidth of >100 mbps. Moreover, only 9% of downloads during December 2022 were made at speeds lower than 50Mbps, and this is a big decrease from the 31% in December 2021. It is assumed that this marked improvement will have resulted from improvements in the network infrastructure connecting Europe to USA, Africa, Asia and South America, and perhaps in particular the new EU-funded EllaLink submarine cable, which opened on 1 June 2021, and connects the EU to Latin America with 100Tbps of capacity over 4 fibre pairs.

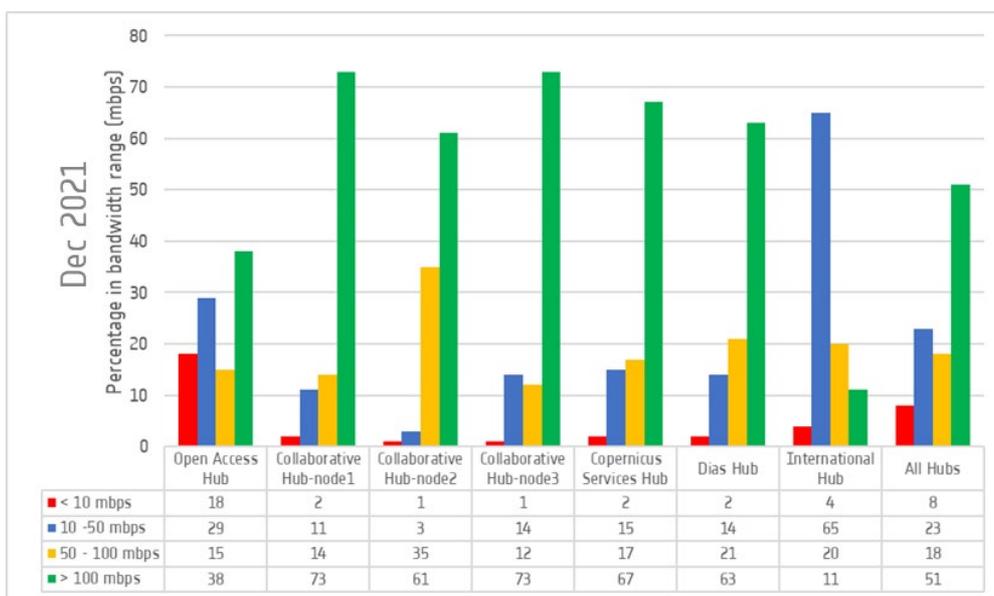


Figure 82 Effective bandwidth range per Hub for all completed downloads in Dec 2021

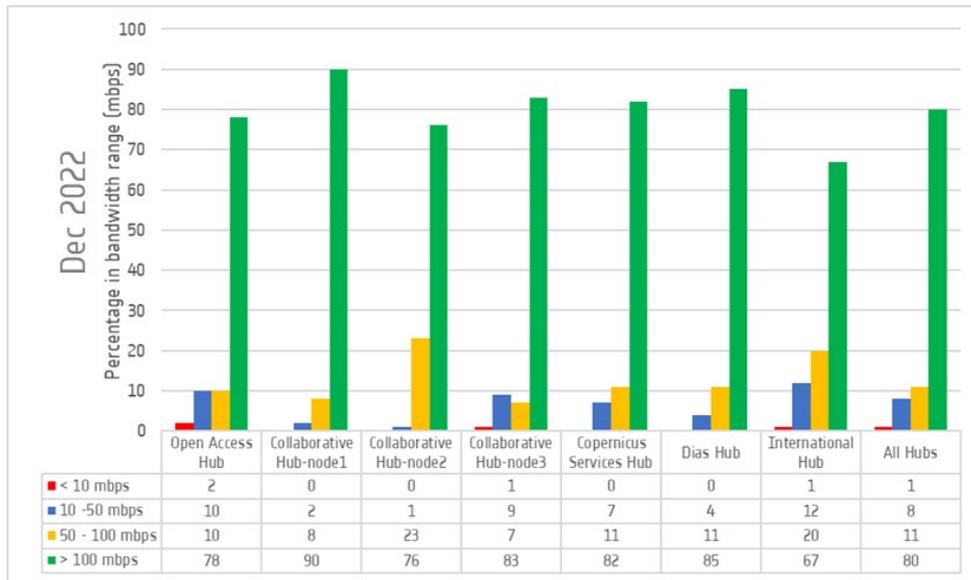


Figure 83: Effective bandwidth range per Hub for all completed downloads in Dec 2022 (after multiple network improvements done during the year)

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 Short Time Critical (STC) or Non-Time Critical (NTC).

The expectation for **Sentinel-1** and **Sentinel-2** user-level data is that they will be published within 24 hours from sensing.

For **Sentinel-3**, the annotated timeliness provides an indication on the expected availability date and it is:

- **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;
- **STC** user level data are expected in less than 48 hours and
- for **NTC** user-level data the latency is 30 days from sensing, allowing consolidation of some auxiliary or ancillary data.

Sentinel-5P NRT user-level data are intended to be available for users to download within 3 hours from sensing while for the **Sentinel-5P Offline** user-level data, the timeliness threshold depends on the level:

- **Level-1B** to be available to users to download within 12 hours of sensing, and
- **Level-2** within 14 days.

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 and Sentinel-5P Level 2, which has a 1 month and 14 days timeliness respectively). 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.

mission	Average timeliness for NRT user level data	Increase/ decrease since Y2021	Average timeliness for NTC user level data	Increase/ decrease since Y2021	Average timeliness for STC user level data	Increase/ decrease since Y2021
S1	2h 20m	-2h	3h 20m	-7h	-	
S2	-		5h 45m	-1h 30m	-	
S3-OLCI	2h 40m	+20m	22h 0m	-8h 0m	-	
S3-SLSTR	3h 00m	=	1d 4h 40m	-7h 40m	-	
S3-SRAL	2h 20m	+20m	26d 12h 57m	+1d 1h 57m	1d 7h 40m	+ 8h 20m
S3-SYNERGY	-		1d 12h 0m	-12h 20m	10h 20m	-17h 20m
S5P-L1B	-		5h 0m	-1h	-	
S5P-L2	2h 8m	+8m	2d 10h 0m	+16h 0m	-	

Table 84: Average publication timeliness on the Open Hub over last trimester of 2022 for user-level data, and comparison with last trimester of Y2021

As for last year, it is highlighted that the 2022 average publication timeliness figures have been calculated considering the availability of data on the Open Hub over the last three months of the reporting period.

Table 86 above shows the average sensing-publication timeliness for the user-level data on the Open Hub during 2022, and the change with respect to the 2021 values.

Sentinel-1

It is recalled that since 23 February 2021, for Sentinel-1, the same processing has been performed for L1/2 user-level data tagged NRT as NTC. The annotated timeliness depends on the geographical area covered by the user-level data (giving priority on the European covered areas) and it is not anymore an indication of a different data quality. Data is processed only once and made available to all users of all the Hubs.

Figures 87 and 88 show the average monthly timeliness in which Sentinel-1 NRT and NTC user-level data was published on the Open Hub during 2022. The dotted orange lines show the monthly timeliness during 2021, for comparison, and the dotted red lines show the threshold of the expected time for user-level data availability.

As in previous years, the NRT user-level data easily achieved the <24 hour target throughout 2022, and in fact an average of 3hrs or less was achieved in all months except February and March 2022. March saw the worst reduction in the average monthly

publication timeliness, when the average timeliness achieved was close to 7 hours from sensing. This was a consequence of 9 hours of maintenance done for an upgrade of the software on the back ends of all the system. Such maintenance window was not impacting the service from a user point of view but the publication of Sentinel-1 data were stopped generating a backlog of data to be published in the following days and the consequent delay in the publication.

Overall, however, as the dotted line shows, the average publication timeliness was more stable than it had been in Y2021 and it remained constant between May to December 2022, below 3 hours from sensing. The overall average publication timeliness during last three months was 2hours and 20 minutes.

As for the Sentinel-1 NRT data, February, March and April 2022 were the worst months for the average publication timeliness of the NTC data, with it reaching as high as 14h from sensing in March. However, after this fairly rocky start at the beginning of the year, the average monthly publication timelessness for the NTC data more or less stabilised from May onwards, fluctuating only between 3 and 4 hours from sensing. During the last trimester of 2022, the Sentinel-1 NTC data were on average available for download within 3h 20m from sensing. This represents a big improvement (-7h) in the timeliness with respect to the average timeliness measured in the last trimester of 2021. It is also highlighted that

the average monthly publication timeliness of the NTC data was well below the expected 24 hours throughout the whole of the year.

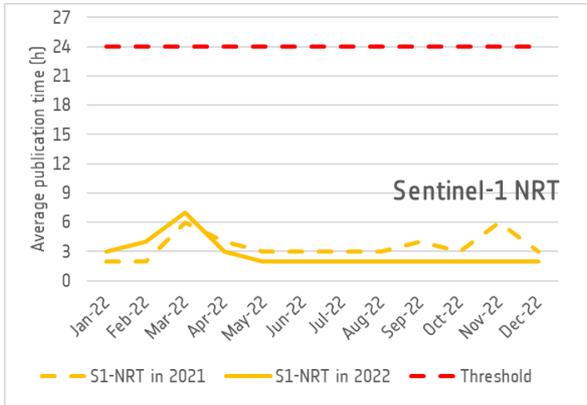


Figure 85: Monthly Average Publication Timeliness on the Open Hub for Sentinel-1 NRT user-level data during 2022, with 2021 for comparison

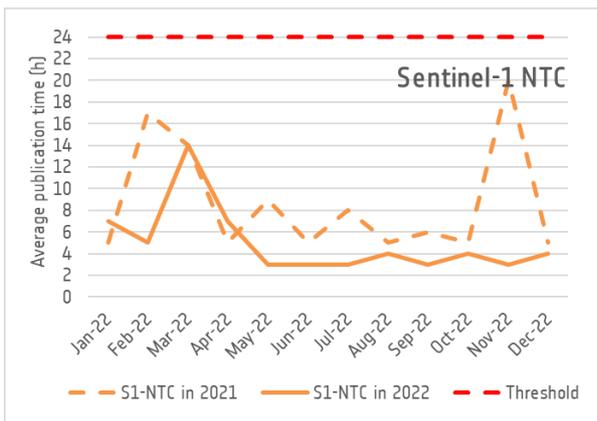


Figure 86: Monthly Average Publication Timeliness on the Open Hub for Sentinel-1 NTC user-level data during 2022, with 2021 for comparison

Sentinel-2

The Sentinel-2 publication timeliness in the last trimester of 2022 was on average 5h 45m, and this is 1 hour and 30 minutes faster with respect to Y2021. Figure 89 shows the average publication timeliness for Sentinel-2 per month, and it can be seen that the trend was more constant than it had been in Y2021 throughout the year, with the average fluctuating only between 4 and 7 hours from sensing. The best monthly average timeliness achieved in January 2022, at 4 hours, and the worst case was in May 2022, at 7 hours from sensing. Again, for all months the 24 hour threshold was respected.,.

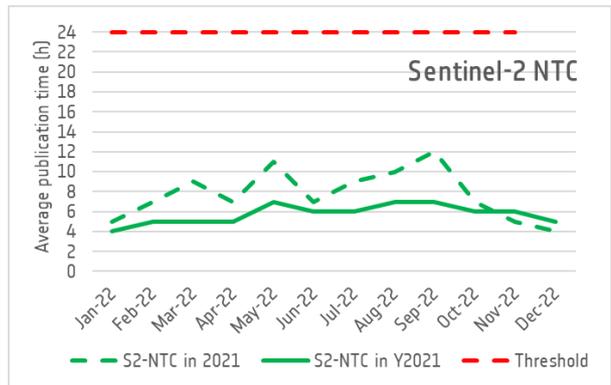


Figure 87: Monthly Average Publication Timeliness on the Open Hub for Sentinel-2 NTC user-level data during 2022, with 2021 for comparison

Sentinel-3

Figures 90, 91, 92 show the monthly publication timeliness for each set of Sentinel-3 user-level data on the Open Hub, with the values from Y2021 for comparison. The dotted red lines indicate the threshold of expected timeliness (please note, however, that the 30-days threshold for NTC data are not indicated for a better visualisation of results).

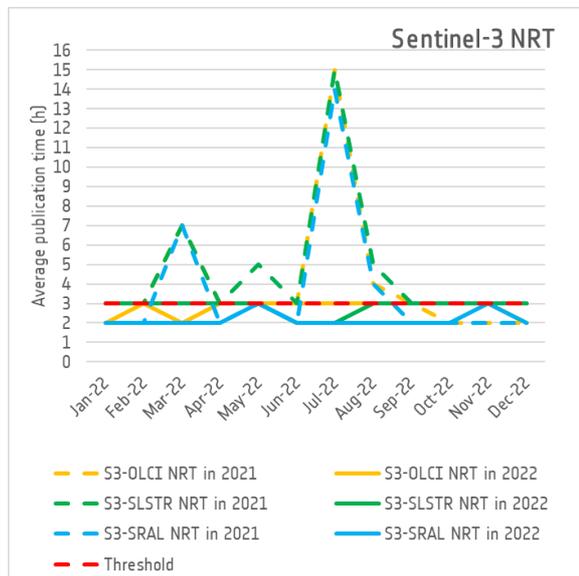


Figure 88: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 NRT user-level data during 2022, with 2021 for comparison

For the Sentinel-3 NRT data, the overall averages during the last trimester of 2022 were 2h 40m for OLCI, 2h 20m for SRAL and 3h for SLSTR. This

actually represents a slight decline in the timeliness of 20 minutes for OLCI and SRAL with respect to the last trimester of Y2021.

However, it is important to note that the target 3-hour NRT timeliness was achieved for each instrument for all the months during 2022, and this is a big improvement with respect to the previous year, in which there were some issues with timeliness due to an issue within the Ground Segment, especially in July 2021.

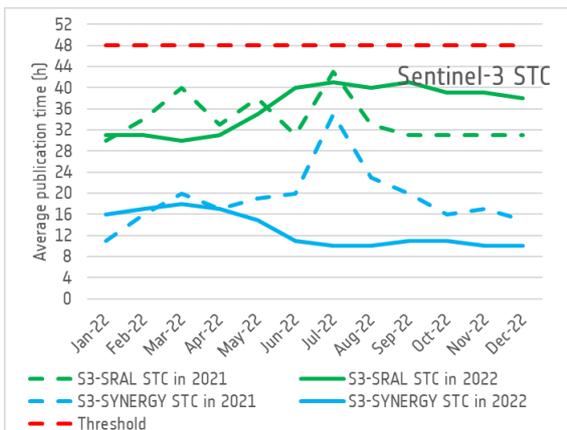


Figure 89: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 STC user-level data during 2022, with 2021 for comparison

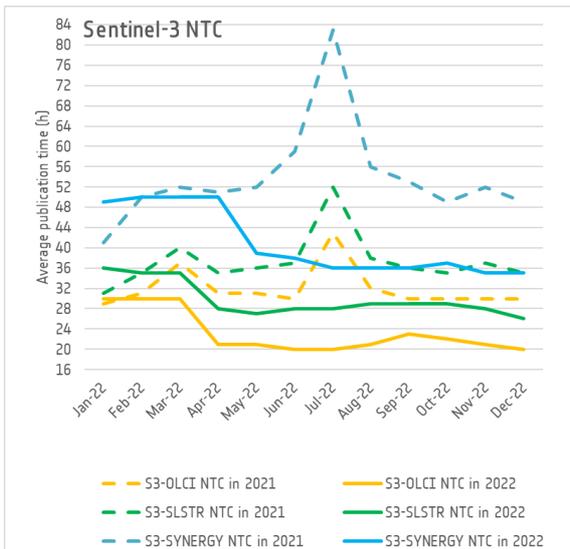


Figure 90: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 NTC user-level data during 2022, with 2021 for comparison

For Sentinel-3 STC and NTC user level data, it can be seen that on average the thresholds were respected in

all cases. The timeliness for all NTC data types greatly improved from April and May onwards, date in which there was the switch to the Sentinel-3 PRIP, and when compared with the previous year, it can be seen that there was a much stronger performance for each data type. On the other hand, the timeliness for the SRAL STC data was more unstable during the year and it actually ended at a worse level than it had been at the start of the year. Such decrease of publication performance may be related to the change of the data source of the datatype (which has been switched to the Sentinel-3 PRIP on April 2022) and not to the data hub system because all the data types follow the same data flow.

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 a timeliness of 26d 12h 57m was achieved throughout the last trimester of 2022, below the 30 days threshold.

Sentinel-5P

As shown in Table 86, during 2022 the average time for publication of Sentinel-5P NRT user-level data was 2h 8m, respecting the 3 hour 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 2022 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.

5.4 Data Hub Maintenance and Software Improvement

During 2022, the Data Hub Service Maintenance Team focused on:

- Improving management of the requirements stemming from the EU General Data Protection Regulation (GDPR).
- Supporting the dissemination of new Sentinel product types.
- Introducing the possibility of setting up an ancillary CEMS Service by disseminating Sentinel-2 PDI products.
- Enhancing the security software and fixing newly identified vulnerabilities.
- Implementing a series of bug fixes aimed at enhancing the Administrator experience.

The support for new Sentinel product types was enhanced, allowing the dissemination of the following Product Types:

- Sentinel-3 SLSTR L2 FRP (new IPF)
- Sentinel-3 SRAL Level-2 Thematic products (SR_2_LAN_SI; SR_2_LAN_HY; SR_2_LAN_LI)
- Sentinel-3 Auxiliary Files (SR___MDO_AX; SR___POE_AX)
- Sentinel-5P Auxiliary Files (AUX_BGCLD, AUX_BGO₃, AUX_BGHCHO, AUX_BGSO₂)
- Sentinel-6 Auxiliary Files (AX___ROE_AX; AUX_GNSSRD; AUX_PROQUA; AX___MOED_AX; AX___POE_AX)

The European Union General Data Protection Regulation (GDPR) is a data protection ruling that took effect in 2018. Since DHuS software manages data of its own registered Users coming from all over the world, it has been updated to cope with the GDPR requirements. The DHuS GDPR compliancy is ensured by the externalization of User Management from the software itself and the deletion of Users info stored on DHuS databases. Indeed, the entire User Management has been delegated to an external

Identity Access Management (IAM): Keycloak. The DHuS software configuration has also been updated to be able to interface Keycloak and to allow registered users to properly access DHuS instances and perform all currently allowed functionalities.

A dedicated implementation was carried out to support the new Sentinel-2 emergency service activities carried out by CEMS. Sentinel-2 PDI (Product Data Items) "MSI_L1C_TL" and "MSI_L2A_TL" are now indexed in the DHuS Catalogue and put directly in offline status. The related Sentinel-2 data can be retrieved by connecting with the Sentinel-2 LTA interface. This service for CEMS is not yet operational, and is instead in monitoring mode to evaluate the potential performance gains.

Finally, different contributions have been inserted into the DHuS software to address security vulnerabilities affecting the software, such as Log4Shell and Tomcat.

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

In Y2022, four new versions of the Open Source Framework (OSF) software were released.

- 2.7.9-osf: 16 Dic.21
- 2.7.10-osf: 26 Gen.22
- 3.0.6-osf: 2 Mag.22
- 3.0.8-osf: 5 Ott.22

V. 2.7.9-osf introduces the fix for the Log4Shell vulnerability, including the last log4j 2.16.0 library.

V.2.7.10-osf brought in the fix for the Log4Shell vulnerability, including the last log4j 2.17.1 library.

The main objective of **V. 3.0.6-osf** was to ensure better management of GDPR requirements by redirecting all User Management to an external Identity Access Management, Keycloak.

V.3.0.8-osf introduced a fix for Tomcat vulnerabilities that were affecting version 3.0.6-osf. To solve this, an upgrade of all Tomcat libraries to 8.5.82 version was done.

Open Source DHuS Downloads

At the end of 2022, the total number of downloads of all versions of the OSF was 8,430, an increase of 1,037 downloads since the end of Y2021.

Within this total, there were 224 downloads of v2.7.9-osf (released in December 2021), 441 downloads of v.2.7.10-osf (released in January 2022), 855 downloads of v. 3.0.6-osf (released in May 2022) and

670 downloads of v. 3.0.8-osf (released in October 2022). Overall, therefore, there were **2,190** downloads of the Open Source DHuS versions published in Y2022.

Support to OS Community

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

As in previous years, during Y2022 the OSF was highlighted at the event 'Collaborative Ground Segment Workshop', which took place on 10-11 October 2022 in Prague, and provided the opportunity to the Collaborative Ground Segment partners to express their feedback and future needs towards the OSF.

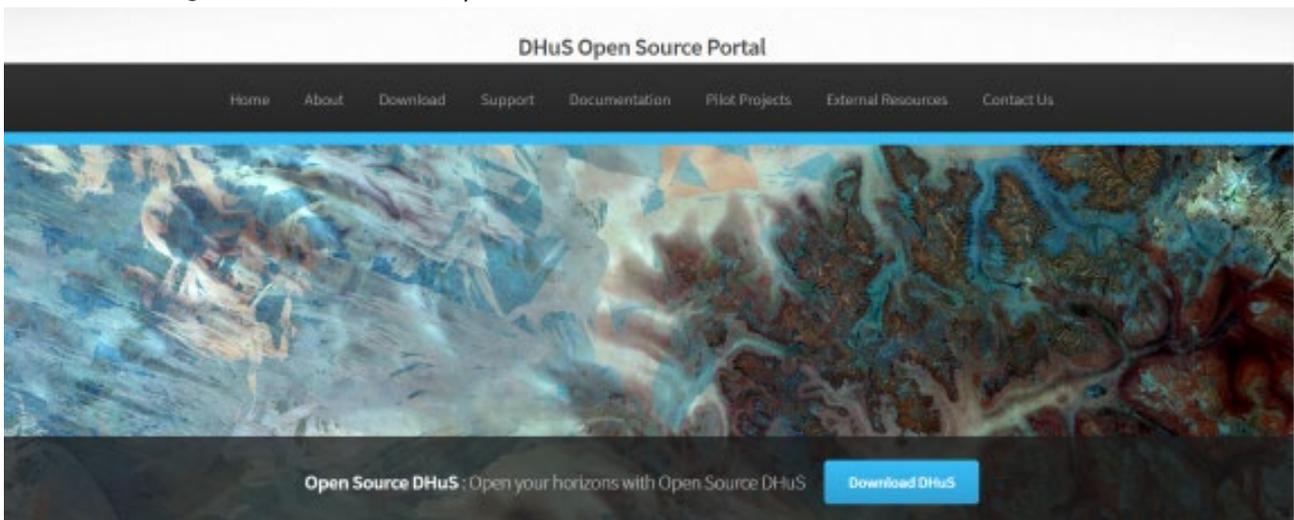


Figure 91: Open Source DHuS portal webpage

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 satellite data. Where possible, the eosupport team will directly resolve the issue. Where this is not possible, the issue is either referred to the Ground Segment Coordination Desk, or, if it relates specifically to data access, it is forwarded to the Sentinel Data Access System operations team for resolution.

6.1 Ticketing Analysis

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

- **Service Interface:** Technical issue on interfacing to the Service (network, API, scripting, GUI, over quota, over quota warning received);
- **User Accounts:** issues relating to the management of user accounts (registration, validation, password reset, credentials loss, deletion, edit profile);
- **Features Request:** Improvements suggested by users about any of the topics of the ticket categories;
- **Products:** Issue on user-level data (production coverage, user-level data quality, external tool usage, user-level 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 (the 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 2022, a total of 1,234 tickets were received by the Data Access operations team, with a -6% decrease with respect to Y2021. The 'Junk' category - accounted for 86 tickets (7%).

Of the meaningful categories, the largest proportion of tickets were for 'User Accounts' (604 tickets/49%) and 'Service Interface' (407 tickets/33%), 'Products' (62 tickets/5%) and 'General' (74 tickets/6%).

In more detail, the 'Service interface' category included support requests for using the nearline data interface which had been introduced in Y2021. These tickets were resolved by giving further support to the relevant users, as well as providing the already updated user guides. The tickets which fell in the 'Products' category were mostly focused on a particular issue encountered when users tried to retrieve certain specific data via the graphical user interface. The difficulty arose as a consequence of the transfer to the new cloud infrastructure, during which there was a need to preserve the data already ingested in the previous infrastructure. The issue was resolved by the Data Access team, with some adjustment in the configuration of the eviction policy.

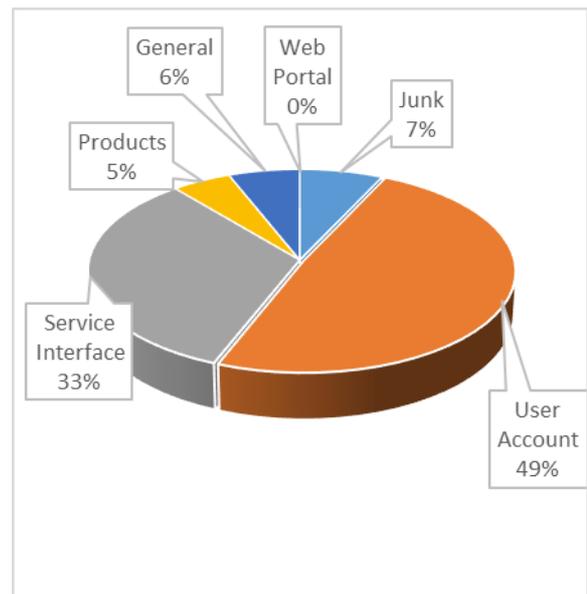


Figure 92: Proportion (percentage) of each category of tickets received from the Open Hub in 2022

As in previous years, very few tickets were received for the remaining categories: in particular, during 2022 only 1 ticket was raised for 'Web Portals' and zero tickets were raised for either 'Features Requests' or 'Bug'. Figure 94 shows the percentage split between the categories during 2022.

During 2022, 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 19 minutes and 45 seconds. The maximum response time for any ticket was 20 hours 16 minutes.

7 2023 Outlook

2023 will be the year of decommissioning the current Data Access System in favour of the new data access service which will be operated within a broader ecosystem, the Copernicus Data Space Ecosystem (<https://dataspace.copernicus.eu/>). The Copernicus Data Space Ecosystem will enable the development of third-party services, including but not limited to unified User Management, IaaS and PaaS services, as well as access to integrated applications facilitating user onboarding for local data exploitation. The Copernicus Data Space Ecosystem will ensure primarily the free and open access to Sentinel user-level data but it will also include the following key services:

- Data Distribution Service for both Sentinel data and data from the Copernicus Contributing Missions;
- On-demand Production Service for Sentinel data;
- Streamlined Access Service allowing immediate local direct access to specific Sentinel data collections;
- Traceability Service allowing the registration and verification of data sources.

On 16 December 2022, the new Copernicus Data Space Ecosystem kicked-off and the new service will be fully operational in July 2023, after a progressive phase-in period which will correspond with the phasing out of the current Sentinel Data Access System. The initiative has quite an intense phase-in plan, in order to allow hundreds of thousands of existing users of all four Data Hubs to migrate their workflows to the new service. A limited but stable roll-out is planned for the end of January 2023, with continuous upgrades over the following months, until full service will be made available by the end of June 2023.

The support and a dedicated hub for the dissemination of Sentinel user-level data towards and within the Collaborative ground segments partners, and DHRs, will be ensured for all of 2023.

The eventual aim is for Copernicus to achieve full interoperability with the Destination Earth future data infrastructures, as well as with Member States' earth observation data infrastructures.

8 Useful Links

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

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
PDGS	Payload Data Ground Segment
PLRM	pseudo-LRM
POD	Precise Orbit Determination
PRIP	Production Interface delivery Points
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 2022

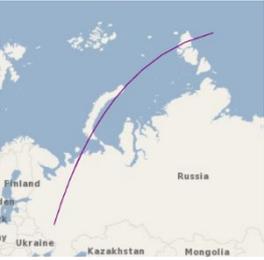
Further information on user-level data can be found on the 'Instrument user guides' following the link: <https://sentinel.esa.int/web/sentinel/user-guides/>

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
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	

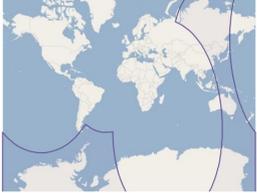
Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
	L1-SLC	Sentinel-1 Level 1 Single-Look Complex		4 GiB	
	L2-OCN	Sentinel-1 Level 2 Ocean		5 MiB	
Sentinel-2 (MSI)	MSIL1C	Sentinel-2 Level 1C		480 MiB	
	MSIL2A	Sentinel-2 Level 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	

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
Sentinel-3 (SLSTR)	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
	OLCI L2 Land RR	Sentinel-3 Level 2 OL_2_LRR___ Reduced Resolution Land & Atmosphere geophysical user-level data		170 MiB	
	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

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
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
	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

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
	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	The footprint for this user-level data type depends on timeliness: NTC and STC  NRT (covering only LAND regions) 	36 MiB	Activation of Sentinel-3B data on 11/12/18. In 2022, the SR_2_LAN_HY, SR_2_LAN_LI, SR_2_LAN_SI have been introduced.
Sentinel-3 (SYNERGY)	SY_1_MISR	Correspondence and collocation grids between OLCI/SLSTR acquisition and image grid and SYN Level 2 internal grid (i.e. OLCI instrument grid)	N/A	N/A	Not available to the users.
	SY_2_SYN	Surface Reflectance and Aerosol parameters over Land		300 MiB	Activation on the Open Hub from 25/03/19

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
	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	
Sentinel-5P (TROPOMI)	L1B_RA_B D1	Radiance user-level data bands 1-8:		1: 500 MiB	
	L1B_RA_B D2	1: 270-300nm		2: 2.8 GiB	
	L1B_RA_B D3	2: 300-320nm		3: 2.7 GiB	
	L1B_RA_B D4	3: 320-405nm		4: 2.6 GiB	
	L1B_RA_B D5	4: 405-500nm		5: 2.6 GiB	
	L1B_RA_B D6	5: 675-725nm		6: 2,6 GiB	
	L1B_RA_B D7	6: 2305-2345nm		7: 1.5 GiB	
	L1B_RA_B D8	7: 2345-2385nm		8: 1.6 GiB	
	L1B_RA_B D8	8: 2345-2385nm			
	L1B_IR_UVN	Irradiance user-level data UVN module 270-775 nm	-	30 MiB	

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
	L1B_IR_SIR	Irradiance user-level data SWIR module 2305-2385 nm	-	6 MiB	
	L2_AER_AI	UV Aerosol Index		13 MiB	
	L2_AER_LH	Aerosol Layer Height		120 MiB	NRT and OFFL user-level data available on the S5P Hub from 30/09/19
	L2_CLOUD	Cloud fraction, albedo, top pressure		25 MiB	
	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 Hub from 01/03/19

Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
	L2_HCHO	Formaldehyde (HCHO) total column		60 MiB	OFFL user-level data available on the S5P Hub from 05/12/18
	L2_NO2	Nitrogen Dioxide (NO ₂), total and tropospheric columns		35 MiB	
	L2_NP_BD'x'	Suomi-NPP VIIRS Clouds X = 3, 6, 7		330 MiB	
	L2_O3	Ozone (O ₃) total column		25 MiB	
	L2_O3_TCL	Ozone (O ₃) tropospheric column	-	1 MiB	OFFL user-level data available on the S5P Hub from 01/03/19
	L2_SO2	Sulphur Dioxide (SO ₂) total column		85 MiB	OFFL user-level data available on the S5P Hub from 05/12/18