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Copernicus Sentinel Data Access Annual Report

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Foreword

This is the ninth and final annual report produced by Serco, and it fills me with immense pride to present it. Reflecting on the previous issues brings a touch of nostalgia, reminding me of the dedication and effort poured into this project over the years. This report, like its predecessors, is brimming with fascinating data and achievements.

For nearly a decade, the Copernicus Data Hub Service (DHuS) has been a beacon in the realm of satellite data dissemination, offering invaluable data to users around the globe.

I have been privileged to witness the evolution of this service, transitioning from Operations Manager to Service Manager, and finally to Contract Manager. This journey has provided me with a front-row seat to observe the profound impact of satellite data on research, innovation, and decision-making across diverse fields.

Our service has continuously adapted to meet the increasing demands of the data landscape, publishing over 67 million products and facilitating the download of more than 586 Pebibytes of data.

In 2023 alone, we published 11,663,777 user-level data, amounting to 6.04 PiB of data. To put this into perspective, the total volume of Earth Observation data from the pre-Copernicus era up to 2013 was 5.6 PiB. This remarkable growth in data publication and user engagement underscores the success of the Copernicus program and the critical importance of its data services.

User registration has also seen a significant rise, with nearly 760,000 users registered by the end of October 2023. This growing user base highlights the increasing awareness and reliance on Copernicus data for a myriad of applications. Notably, Europe remains the continent with the largest user base, with substantial growth in Asia and Africa as well.

Significant mission developments this year included: modifying the observation scenario of Sentinel-1A to operate with a single satellite; a reprocessing campaign covering all historical data since the launch of Sentinel-2A in 2015, significantly enhancing data quality; new processing baselines for the OLCI and SYNERGY instruments on Sentinel-3, improving various data types; and expanding the publication of new Surface Topography Mission (STM) Level-2 thematic products to include NRT and STC timeliness. Additionally, user-level data for Carbon Monoxide, Total Ozone, CLOUD, and the Absorbing Aerosol Index from reprocessed Sentinel-5P datasets became available from December 2022 to June 2023. These advancements have ensured that the Copernicus Sentinel missions continue to deliver high-quality data to users worldwide, supporting a wide range of applications and research.

The year 2023 also marks a significant milestone in satellite data management and accessibility with the decommissioning of the Data Hub Service (DHuS) and the launch of the Copernicus Data Space Ecosystem (CDSE). Being closely involved in this transition, I am both honored and excited to share the journey and achievements that have led to this pivotal moment.

The transition from DHuS to CDSE commenced in July 2023 with a series of meticulously planned steps. Initially, online data availability was reduced from six months to one month on platforms like OpenHub, CopHub, and ColHub Node 1, allowing users to adapt and migrate smoothly. The publication of new Sentinel-1 RAW data was also suspended, and historical Sentinel-1 RAW data were removed, streamlining operations in preparation for CDSE.

In November 2023, these efforts culminated in the official shutdown of DHuS services (OpenHub, CopHub, and IntHub). The migration of ColHub Node 1 to the CDSE infrastructure was completed on November 10th, ensuring a seamless transition for users.

The emergence of CDSE signifies a new era in data access service provision. Starting its ramp-up in January 2023, CDSE gradually unveiled its offerings. By July 1st, CDSE operations commenced, setting the stage for a smooth transition from DHuS.

The decommissioning of DHuS is not an end but a new beginning—a new chapter in ESA's data management journey. It builds upon the foundation laid by DHuS to deliver even greater value and impact to users, adapting to the evolving needs and technological advancements in satellite data management.

None of this would have been possible without the dedication of the people from Serco and our industrial partners, Gael Systems, National Observatory of Athens (NOA), GRNET, and Exprivia. I extend my heartfelt gratitude to our dedicated teams for their unwavering commitment throughout the years and during this transition. Your hard work has been instrumental in ensuring a smooth and successful handover.

A special thank you goes to ESA and the European Commission for their trust and support, as we have faced and overcome numerous challenges together over the years, sharing the same objective of achieving operational excellence for the users.

As we look to the future with optimism and determination, let us honor the legacy of DHuS and commit to achieving new heights of excellence in the CDSE era.

Roberto Sciarra
Copernicus Contract Manager, Serco Italia S.p.A.

Thanks to All Contributors:

Thanks to everyone who has contributed to the success of the service, whether for a brief period or many years.

➔ 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.

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Copernicus Data Analyst, Serco Italia S.p.A.

➔ 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

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)
Y2023	Refers to the current reporting period that is 01/01/2023 to 31/10/2023. Similarly, previous reports assume the same convention. Y2022 refers to the reporting period from 01/01/2022 to 31/12/2022. Y2021 refers to the reporting period: 01/12/20 - 30/11/21; Y2020 to the reporting period: 01/12/19 - 30/11/20; Y2019 to the reporting period 01/12/18 - 30/11/19; Y2018 to the reporting period 01/12/17 - 30/11/18; Y2017 to the reporting period 01/12/16 - 30/11/17; Y2016 to reporting period 01/12/15-30/11/16; and Y2015 to the reporting period from 03/10/14 – 30/11/15.

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

Conventions

In this report, the following conventions have been used:

- the SI approved unit symbols KiB, MiB, GiB, TiB and PiB are used to report data volumes: 1KiB=2^{10} bytes, 1 MiB= 2^{20}bytes, 1GiB= 2^{30} bytes, 1 TiB = 2^{40} bytes and 1 PiB = 2^{50} bytes.

- unless otherwise noted, the volume figures refer to the compressed user-level data volumes as published and downloaded via the data hub access points.

➔ Table of Contents

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 Sentinel Data Access System then retrieved the Copernicus Sentinel-1, -2, -3 (land) and -5P user level data from the ground segments, and made them available for users to download from dedicated access points, known as data hubs.

This Annual Report presents the performance of the Copernicus Sentinel Data Access System operated on behalf of ESA, and analyses the trends visible in the public uptake of Copernicus Sentinel data. This is the ninth and final such report released by the data access service provider, Serco Italia Spa, and covers the period 1 January 2023 to 31 October 2023.

As ever, the magnitude of the task which the Data Access System managed is visible throughout the Report, from the description of the extensions made to the underlying infrastructure, to the statistics about data publication and download. Between the start of operations in October 2014, to 31 October 2023, almost **80 million** user-level data were published on the Copernicus Open Access Hub (Open Hub), and users collectively downloaded an impressive **586 PiB**. During the reporting period, almost **40,000** user level data were published per day. Moreover, the number of registered users reached **759,494** by 31 October 2023, indicating that not only is the existing user base consolidated but also that word continues to spread and more and more users are engaging with the potential contained in the vast stores of free and open data available through the Copernicus Data Access System.

The reporting period is shorter than a year for this Report because the Copernicus Sentinel Data Access System was decomissioned in November 2023, concluding 9 years of successful delivery of Copernicus Sentinel user-level data to users. The decomissioning follows the evolution of ESA's Earth Observation services towards an open data space ecosystem, to pave the way for enhanced data access strategies, applications and services, and further increase the ease with which users can exploit Copernicus Sentinel data.

To bring this about, ESA has developed the Copernicus Data Space Ecosystem (CDSE). The CDSE started its ramp-up operations at the end of January 2023 and operated alongside the Data Access System for most of 2023, gradually increasing its functionalities throughout the year. With the decommissioning of the Sentinel Data Access System in November 2023, the CDSE became ESA's sole data access service for Copernicus Sentinel data. The CDSE remains committed to ensuring unrestricted and free access to the data.

Here below are the closure milestones for the Copernicus Sentinel Data Access System:

- The Copernicus Open Access Hub (Open Hub) was closed on 2 November 2023. The Open Hub included the SciHub and APIHub nodes.
- The Copernicus Services Hub (ServHub) was closed on 2 November 2023.
- All three nodes of the Collaborative Hub were closed in favour of the new Collaborative ESA Node Service (see details below).
- The International Hub was closed on 7 November 2023.

As mentioned above, a data hub service has been maintained for the Collaborative Ground Segment, to ensure a smooth continuation of the data retrieval, not only for the Collaborative Ground Segment users, but also for the associated Data Hub Relay user

community, and the French and Greek data centres. Since November 2023, the new Collaborative ESA Node Service has been operating in place of the Collaborative Hub, and it enables the users to continue downloading Copernicus Sentinel Data using the familiar technical interfaces.

Given the decommissioning of the Sentinel Data Access System, this ninth Annual Report covers a shortened period, from **1 January 2023** to **31 October 2023**. It is recalled that in 2022, the reporting period was changed to cover the calendar year, and previously it had always covered the period 1 December – 30 November of each year. Throughout the document, therefore, the following nomenclature is used to distinguish between the various reporting periods:

- **Y2023:** 1 January 2023 – 31 October 2023 (this report)
- **Y2022:** 1 January 2022 – 31 December 2022 (report released on 26/05/2023)
- **Y2021**: 1 December 2020 – 30 November 2021 (reported released on 26/05/2022)
- **Y2020**: 1 December 2019 – 30 November 2020 (report released on 07/09/2021)
- **Y2019**: 1 December 2018 - 30 November 2019 (report released on 25/05/2020)
- **Y2018**: 1 December 2017 – 30 November 2018 (report released on 8/05/2019)
- **Y2017**: 1 December 2016 – 30 November 2017 (report released on 18/05/2018)
- **Y2016**: 1 December 2015 – 30 November 2016 (report released on 5/04/2017)
- **Y2015**: 3 October 2014 – 30 November 2015 (report released on 27/04/2016)

1.1 Data Access System Architecture

The Copernicus Sentinel Data Access System provided different user typologies free and open access to Copernicus Sentinel user-level data. The System was developed and managed by Serco Spa with the consortium partners GAEL Systems, the National Observatory of Athens (NOA) and GRNET S.A. The service included 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.

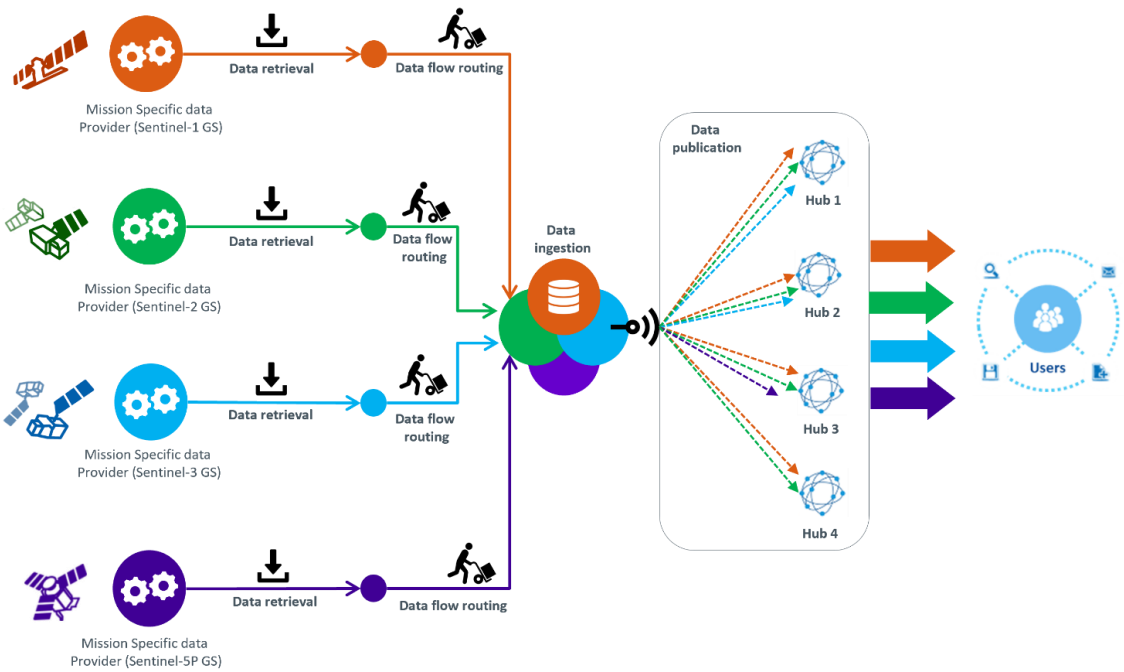

Figure 1: Copernicus Sentinel Data Access System Model during Y2023.

As its general functionality, the Data Access System automatically retrieved user-level data from ESA's Sentinel ground segments and published them online, on a series of dissemination points known as hubs. Accessing these hubs, users were 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 was based, the consortium was 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.

From the end of Y2016 to the closure of the Data Access System on 2 November 2023, the system operated a total of four main hub services through which users could access the user-level data (Figure 1).

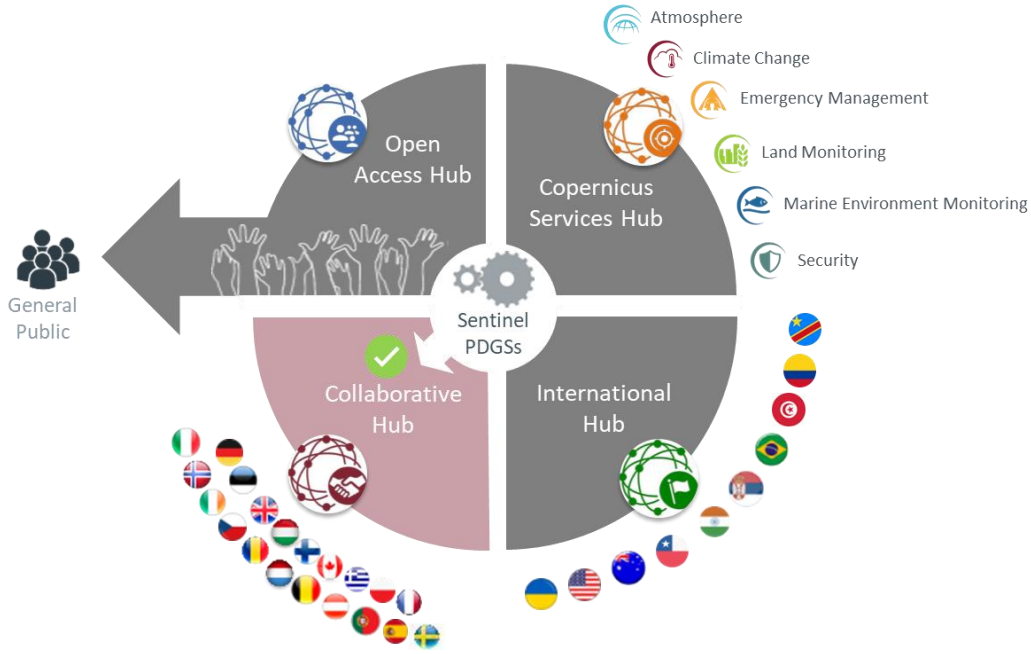

Figure 2: The Sentinel Data Access System Configuration at the end of Y2023. Gray areas underline the data access points that have been dismissed in November 2023.

The **Copernicus Open Access Hub (the Open Hub)**, which was officially shut down on 2 November 2023, offered to all users free, full and open access to Copernicus Sentinel data on the basis of self-registration throughout the reporting period. Accordingly, there have been no restrictions on who could register to download data. The Open Hub was 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 were entitled to make was configured to two.

The Open Hub provided access to all user-level data published on the Copernicus Sentinel Data Access System since the start of operations, via the same catalogue.

Since 30 November 2020, all data on Open Access Hub have been managed within cloud storage systems. The fresh data were made available for immediate access, whereas older (less used) data were available from DIAS cloud archives for asynchronous access. Until June 2023, the nominal configuration has been the following: the latest six months of data available

for immediate access, while the historical data available for deferred access via the Long-Term Archives service interfaces. Orders from the LTAs were generally made available for download within 60 minutes from request (even less, depending on the size of the data). Such configuration changed regarding the immediate access, from six months to one month, by July 2023 up to the Hub closure. Further details of the configuration and performances are outlined in section 2.3.4.

The Open Hub user information pages are kept up to date with the latest information about the rollout of the data and the current status of the data (see e.g. https://scihub.copernicus.eu/userguide) also after the hub shut down.

During the satellite commissioning phase, and in the support of introduction of new user level data types, the access to the first data is conventionally restricted to mission experts, to enable them to carry out the calibration and validation activities required to qualify the user-level data. This need was managed by means of dedicated Expert Hubs: The Sentinel-3 Expert Hub and the Sentinel-5P Expert Hub, and both of these were dismissed on 7 November 2023. Given that they were only available to a small number of users, these hubs are not further described in this report.

In response to a request from scientific users, the **GNSS RINEX Pre-Operations Hub** was opened on 13 February 2018 to provide the GNSS L1B data generated by the dual frequency GPS receivers on board the Copernicus Sentinel-1, -2 and -3 satellites. From the Hub, users can download all GNSS L1b RINEX user-level data relevant to the Copernicus Sentinel-1, -2 and -3 missions. This data has many scientific uses, including the study of orbit determination methods and the effect of non-conservative forces (for example, solar radiation, albedo, atmospheric drag, radiation pressure, ionosphere characterisation, gravity field monitoring and geodesy). This Hub was dismissed on 2 November 2023.

The **TMP Hub** (Temporary Hub) provided the last week of the published user-level data nominally available on Open Hub. This hub was not meant to be accessible by end users during nominal operations, but it was 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 the end users of the various services being then redirected there. It was shut down on 2 November 2023.

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The **Copernicus Services Hub** (ServHub) guaranteed free and full access to Copernicus Sentinel data for all Copernicus Services and EU institutions during the reporting period. Users were entitled to make up to 10 concurrent downloads. All user-level data from all missions in routine operations were published on the Hub. The ServHub was disposed on 2nd of November 2023.

The ServHub followed a Rolling Policy similar to the Open Access Hub. Until June 2023, the most recent 6 months of user-level data were accessible instantly. However, starting from July 2023, only the data from the last month was available until the Hub closure. Historical data for Sentinel-1, -2, and -3 could be accessed through deferred nearline access.

The DIAS partners were provided with three dedicated access points on the ServHub, 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 Hubs, 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. Given that the DIAS have been in routine operations throughout the reporting period, their download figures are a repetition of the publication figures and, when included together in the ServHub statistics, mask the figures from the other activity on the ServHub due to their size. It is recalled that any statistics concerning the subsequent use of the data on the DIAS are outside the scope of this Report.

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The **Collaborative Hub** (ColHub), initially accessible to all Copernicus Participating States, has been designated as the sole hub slated for maintenance

beyond 2023, continuing the CollGS agreements with ESA or internal agreements with the European Commission and persisting in serving the same user community in the future. The ColHub was configured to support 10 concurrent downloads for each user during the reporting period.

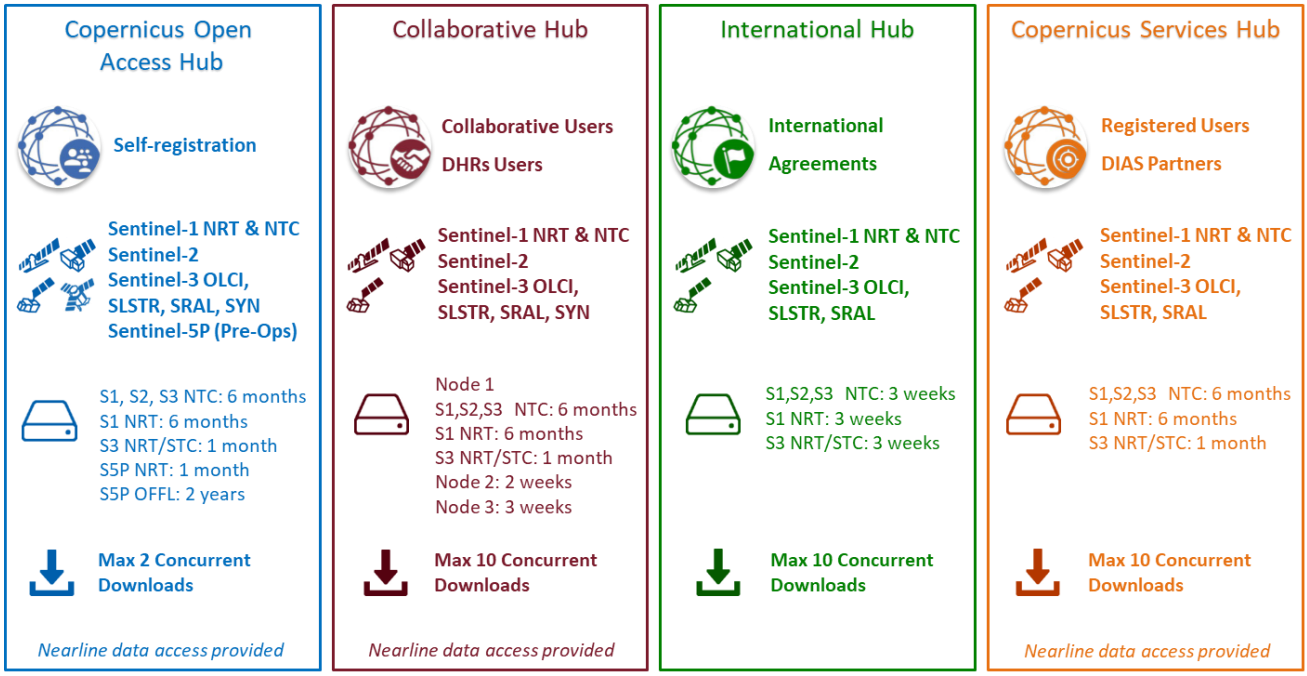

Figure 3: Copernicus Sentinel Data Access System hub characteristics during Y2023. Rolling policies varied during Q3 2023 according to a smooth ramp-down of all services (more details in the text).

Typical user behaviour of CollGS partners is to download the Copernicus Sentinel user-level data as they are published on the hub, and then redistribute the data from their own storage and data access points. Accordingly, a Rolling Policy is applied to ColHub, removing user-level data which have been on the hub for longer than 6 months (this is for node 1 of 3 nodes: see Figure 3 for full details and other nodes). Historical Sentinel-1, -2 and -3 user-level data were available nearline during the reporting period.

By the end of Y2023, there were 20 active CollGS agreements and 16 national sites currently operational (see Chapter 4).

The dissemination capacity of the ColHub is enhanced by an interconnected data relay system which some of the CollGS partners run in addition to their standard data access point. Through this relay system, each CollGS partner is able to access data from a Data Hub Relay partner as well as directly from the ColHub, and this significantly increases the volumes of data which the CollGS partners are able to download at any given time.

By the end of Y2023, a set of 6 Data Hub Relays were deployed by the CollGS partners. These Data Hub Relays are each connected to the CollGSs operated in Austria, Norway, UK(x2), Czech Republic, and Greece..

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The **International Hub** (IntHub), which was closed on 7 November 2023, provided open and free access to data to ESA's Copernicus international partners, following signature of a cooperation agreement with the European Commission and a technical operating arrangement with ESA. During the reporting period, the Hub was configured to support 10 concurrent downloads. The data offer comprised the most recent 3 weeks of Sentinel data, with no access to the historical series.

At the end of the reporting period, there were 12 accounts for international partners on IntHub, for: NASA, NOAA, USGS, Geoscience Australia, Biosense, Indian Space Research Organization, University of Chile, State Space Agency of Ukraine, Brazilian Space Agency, the Institute of Hydrology, Meteorology and

Environmental Studies of Colombia, the Sahel and Sahara Observatory and the Commission Internationale du Bassin du Congo-Oubangui-Sangha. In 2023, there were two more international partners which signed a technical arrangement with ESA: the National Institute for Government Innovation (AIG) in Panama and the Philippine Space Agency (PhilSA)). However, the CDSE was already operational by the time the arrangements were signed, so these initiatives interface directly the CDSE, and no accounts were opened for them on IntHub.

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Figure 3 summarises the overall Sentinel Data Access System front-end configuration during 2023. The Data Hubs described have been operated under the responsibility of ESA from 2014 until the end of operations and provided access to all Copernicus Sentinel user-level data.

1.1.1 Deployment Physical Architecture

During Y2023 the overall architecture of the Data Access System remained the same as in previous years, continuing data dissemination to users and partners until its closure on 2 November 2023. Further details on service closure are given in Section 1.2.2 below.

From Y2021 until its closure, the System has been leveraged on cloud premises with the architecture depicted in Figure 4. The drawing shows on the left the data sources, i.e. the Sentinel ground segments and auxiliary centres which generate the data and provide them to the Data Access System; in the middle, there are the 'Back End' Data Access Centres through which the system is run; and, on the right, the picture shows the detail on 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. Since Y2021, when the System was migrated to the Cloud, the Core Centre and one of the two Complementary Centres are 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 full set of hubs operated by the Data Access System throughout the reporting period is shown in the diagram, along with the Centre which operates them. 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.

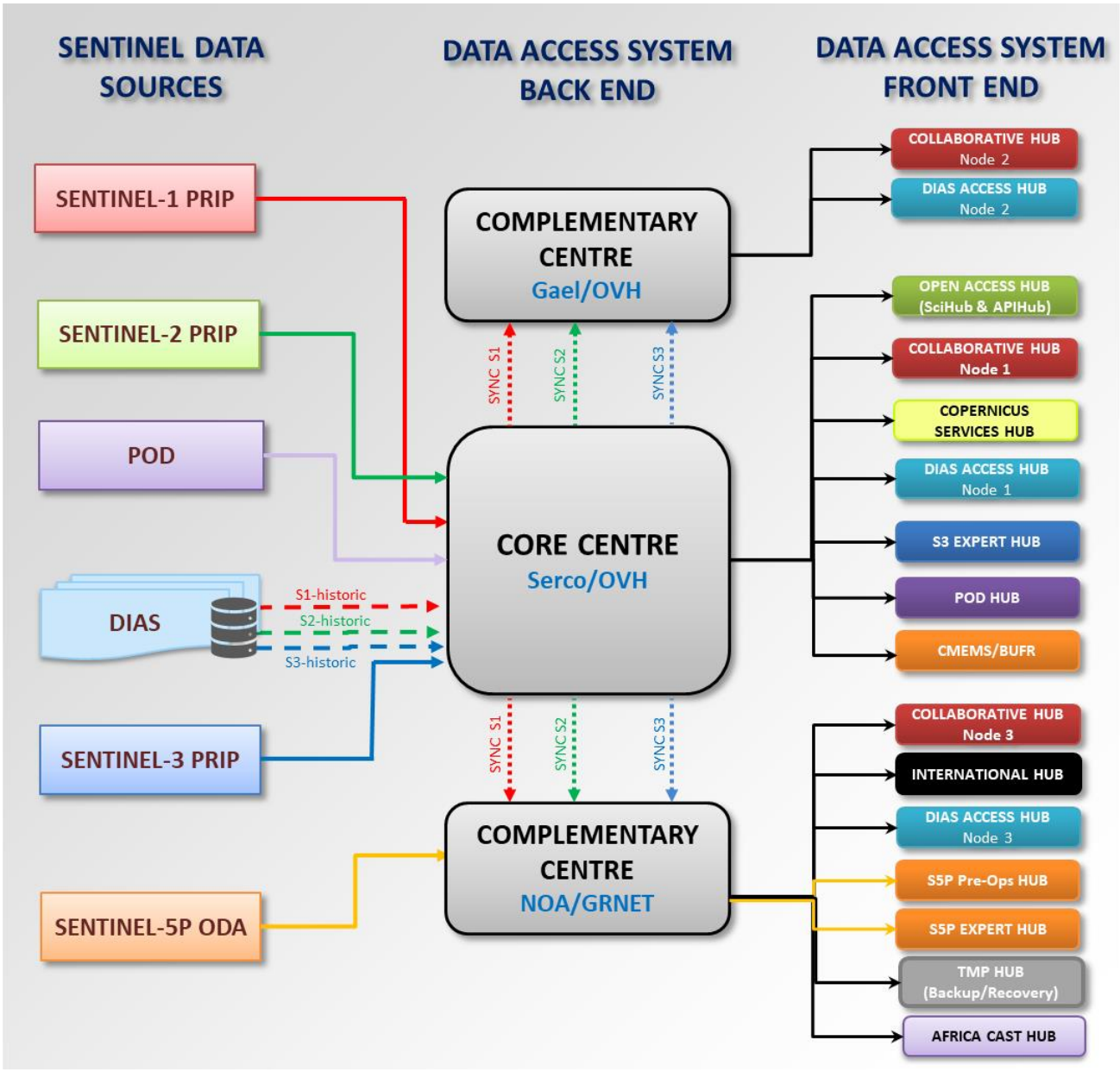


Figure 4: Data Access System Physical Architecture Overview during Y2023.

1.2 Main Evolutions of the Data Access System in 2023

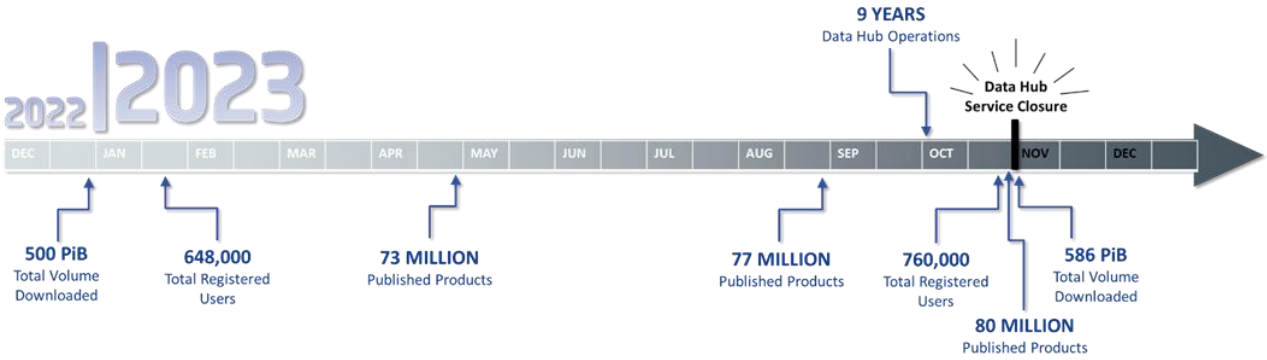


Figure 5: Timeline of the main 2023 achievements related to data dissemination of the Data Access System.

Since Y2021, ESA transferred the ground segment operations to a cloud-based environment, deploying the Sentinel Data Access System on OVH Cloud Infrastructure. This move efficiently handled the rising demand from Sentinel users, while demonstrating readiness for Copernicus Sentinel mission expansion. Utilizing public cloud infrastructures and a service-oriented approach allows ESA to adapt to evolving operational scenarios, ensuring data scalability to user demand. This change in the ground segment data infrastructure set the stage for operating the new Copernicus Data Space Ecosystem, during Y2023.

Since April 2022, the configuration of interface delivery points in the Copernicus Sentinel ground segment has facilitated the systematic production and archiving of Sentinel data, streamlining the overall data lifecycle. The lower-level data (Level-0) is systematically archived for long term preservation. The user level data which is systematically generated is made available "immediately" (in line with the timeliness requirements for each user-level data) for on-line user data access and remains available for immediate on-line download for a configurable time (rolling period). The consolidated version of the rolled-out data remains available for user discovery and download, ensuring access to all mission historical data. Various mechanisms are in place to ensure access to rolled-out data in the Copernicus Sentinel ground segment. Access can be facilitated through storage points, each with different retrieval latencies and data access interfaces (part of the LTA or Data Access Service operations). Additionally, rolled-out data can be regenerated on-the-fly in response to user demand. Bulk reprocessing campaigns for a data period or a specific data type ensure the availability of a harmonised data series.

In Y2023, the Sentinel Data Access System infrastructure underwent no significant changes beyond the closure of the service. Product publication maintained its upward trajectory, reaching nearly 80 million by the end of October 2023. The user registration service operated consistently, concluding with almost 760,000 registered users. A remarkable achievement was recorded on 31 October 2023 with a total download volume since the start of operations of 586PiB, marking a significant milestone after 9 years of service operations.

1.3 Main Developments in the Data Offer in Y2023

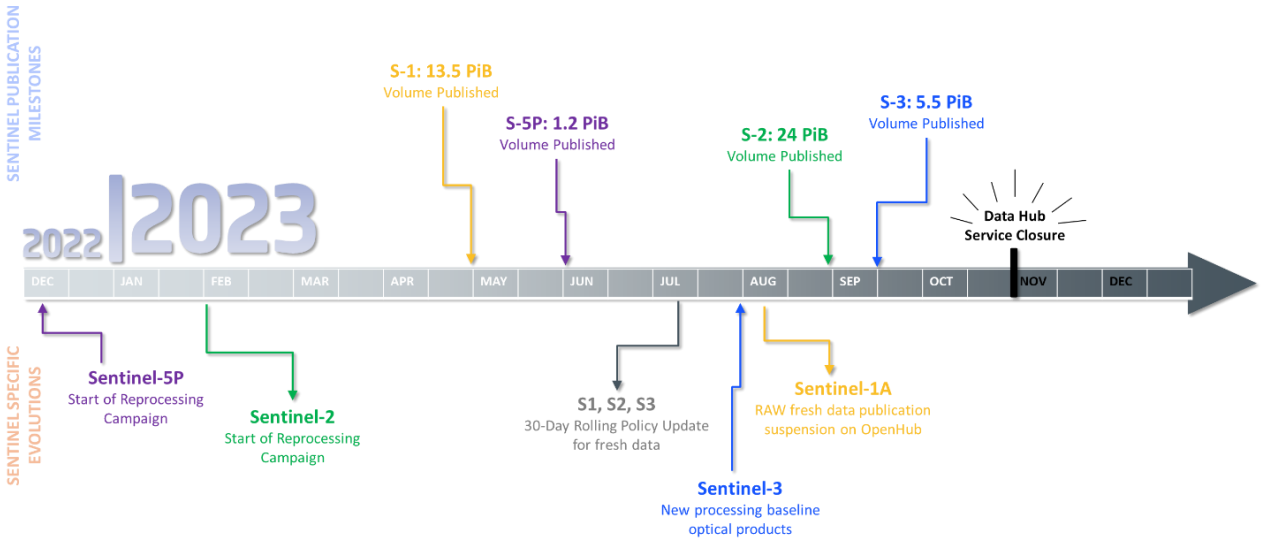


Figure 6: Timeline of the main Y2023 achievements related to mission-specific user-level data publication and evolutions.

The main mission developments that are relevant to the user-level data offer on ESA's Data Access system are outlined below.

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. Unfortunately, despite all concerted efforts, on July 2022, ESA and the European Commission announced that the official end of the Sentinel-1B mission. Copernicus Sentinel-1A remains fully operational and plans are in place to launch Sentinel-1C as soon as possible.

Consequently, the observation scenario of Sentinel-1 mission was modified, counting only on one satellite, and an overhaul of the Sentinel-1A observation plan was carried out in terms of SAR mode, polarisation, observation geometry, revisit and coverage frequency, from September 2022 (see Figure 7 below).

Following the gradual ramp-down of the Data Access System, from July 2023, Sentinel-1 RAW historic data has no longer been available through the Data Hub interfaces. Also, from August 2023, the Sentinel-1 RAW Data Types publication was suspended on the Open Hub. More in general, from July 2023, the rolling policy on data, i.e. the period for which fresh data is kept online and available for immediate access, changed so that instead of the last 6 months of fresh data remaining available for immediate access, only the last 30 days of fresh data was kept available on the Open Hub.

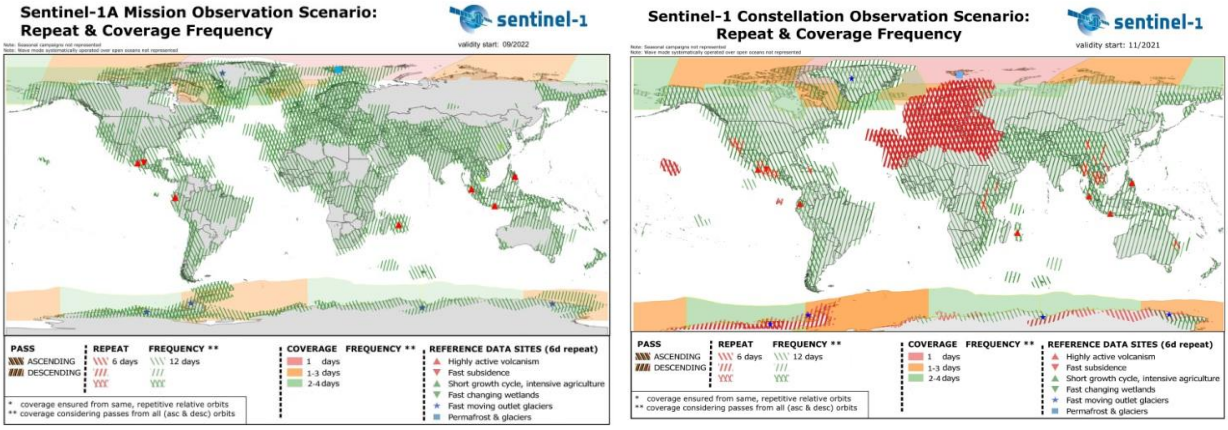


Figure 7: Sentinel-1A observation plan in terms SAR mode, polarisation, observation geometry, revisit, and coverage frequency, starting as of September 2022 (on the left), and the previous configuration for comparison (on the right).

The number of Sentinel-1 user-level data published since the start of operations reached almost **9 million** and the volume of downloads made since the start of operations reached nearly **190 PiB**.

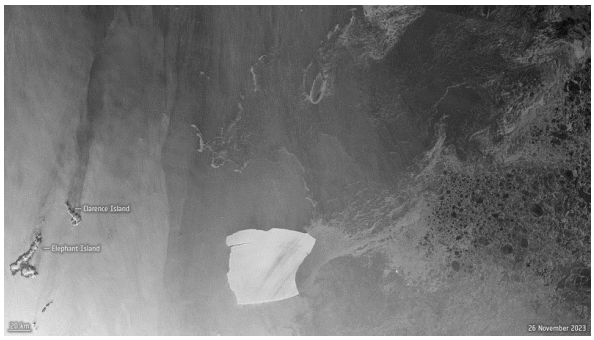


Figure 8: Copernicus Sentinel-1 image captured on 26th November 2023 revealing the iceberg "A23a" being propelled by winds far from Antarctic waters. The image contains modified Copernicus Sentinel data (2023), processed by ESA, CC BY-SA 3.0 IGO.

Sentinel-2

With over **48 million** Sentinel-2 user-level data having been published in Y2023, and **309 PiB** of Sentinel-2 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 during Y2023. No changes concerning the Sentinel-2 data offer during 2023 were made, but as was done for Sentinel-1, from July 2023 the rolling policy on data was reduced from 6 months to 30 days on the Open Hub.

In 2023, a reprocessing campaign was conducted for the Sentinel-2 mission, covering all historical data since 2015 (launch of Sentinel-2A). The activity significantly enhanced data quality, with optimized calibration. User level data from this campaign were not disseminated directly through the Open Access Hub but made available to the DIAS and the Copernicus Data Space Ecosystem operators, and towards the Collaborative Ground Segment partners.

Figure 9: Mount Etna's (Italy) eruption on 15 November 2023 caught from space. The image contains modified Copernicus Sentinel data (2023), processed by ESA, CC BY-SA 3.0 IGO.

Sentinel-3

There were a few changes at the level of individual Sentinel-3 user-level data types during 2023:

- Sentinel-3 OLCI new processing baseline deployed by the end of July 2023 regarding OL_1_EFR and OL_1_ERR data types with NTC timeliness.
- Sentinel-3 SYNERGY new processing baseline deployed by the end of July 2023 regarding: SY_2_SYN and SY_2_VGP data types with NTC and STC timeliness; SY_2_VG1 and SY_2_V10 data types with NTC and STC timeliness; and SY_2_AOD data type NTC.

In August 2022, the new Surface Topography Mission (STM) Level-2 thematic products had been added to the SRAL baseline, enlarging the Data Hub Service data portfolio. These SR_2_LAN_HY, SR_2_LAN_SI, SR_2_LAN_LI data types (respectively for Hydrology, Sea Ice and Land Ice) were initially introduced as a pilot only, however, with NTC timeliness. By the end of September 2023, publication was extended also to NRT and STC timeliness.

In 2023, the number of Sentinel-3 user-level data which was published was more than **19 million** products while the volume of Sentinel-3 data downloaded since the start of operations was nearly **66 PiB**.

As for Sentinel-1 and Sentinel-2, the data rolling policy changed on the Open Hub from 6 months to 30 days.

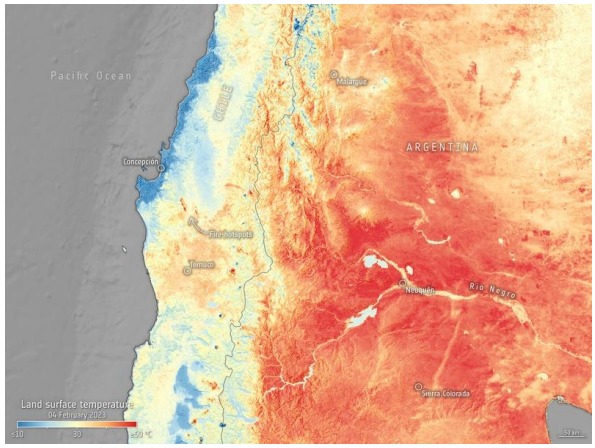


Figure 10: This satellite image, captured on 4th February 2023 shows fires and heatwave in South America. The image contains modified Copernicus Sentinel data (2023), processed by ESA, CC BY-SA 3.0 IGO.

Sentinel-5P

Starting from 5 December 2022, the user-level data for Carbon Monoxide (L2__CO____), Total Ozone (L2__O3____), CLOUD (L2__CLOUD_), and Absorbing Aerosol Index (L2__AER_AI) from the full mission reprocessed datasets of Sentinel-5P began to be released. The campaign concluded in June 2023.

The number of published Sentinel-5p user-level data considerably increased, passing from 2.8 million in to nearly **4 million** in 2023. Moreover, the volume of downloads reached nearly **21 PiB** since the start of operations.

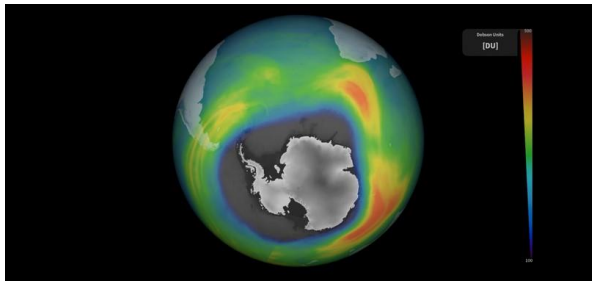


Figure 11: Map of the ozone hole over the South Pole on 16th September 2023. The image contains modified Copernicus Sentinel data (2023)/processed by DLR.

2 Data Access Service Growth

Despite it being the year of service closure, Y2023 witnessed yet another upswing in the statistics which give a general indication of the extent of public interaction with the Data Access System. User registrations rose 19% to nearly **760,000**; the number of Sentinel user-level data made available for download on the Open Hub rose 18% up to **80 million** user-level data; and the volume of Sentinel user-level data downloaded by users since the start of operations rose 45% to an enormous **586 PiB.** In this section, each of these increases is analysed in detail.

2.1 User take-up

By the end of Y2023, **759,494 users** were registered to access the four hub services offered by the Copernicus Sentinel Data Access System. Figure 12 breaks this overall figure down to show the number of users registered on each hub throughout the entire period of operations. 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 Figure 12 provides the most accurate picture available of the number of registered users.

The biggest increase in terms of the number of accounts was seen on the Open Hub, where the number of registered accounts rose from 637,864 users at the end of Y2022 to **759,088 users** at the end of Y2023, an increase of 19%.

The number of accounts also increased on IntHub, from 10 at the end of Y2022 to 12 at the end of Y2023. As mentioned in Section 1, ESA actually signed four new Copernicus technical arrangements with international partners in 2023, but only two new accounts were created on IntHub because the other two partners were directly given accounts on the CDSE.

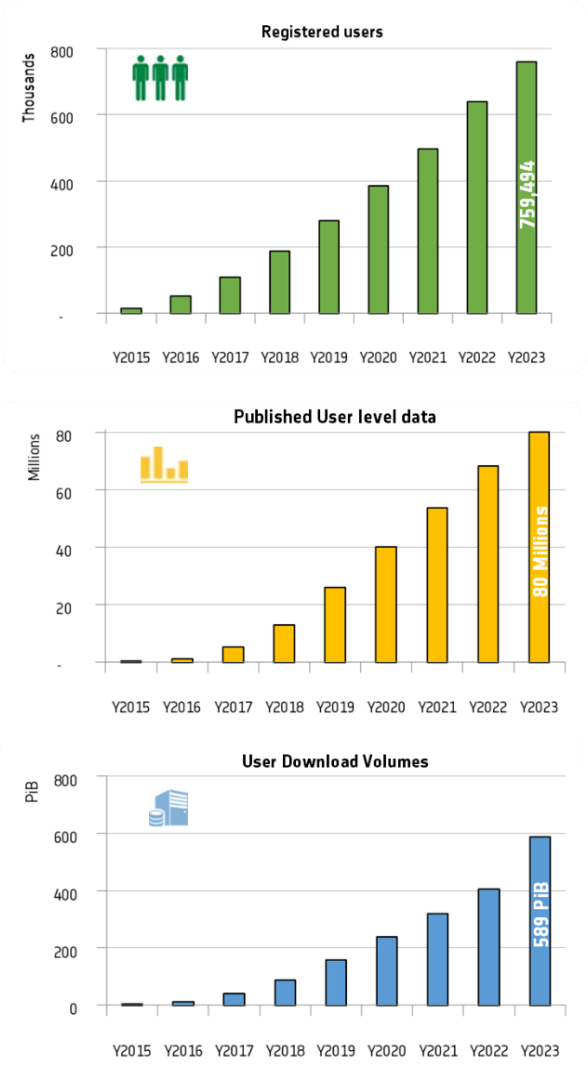


Figure 12: Overall rise in Data Hub Registered Users, Published User-level data, and User Download Volumes, showing cumulative total for each year since the start of operations.

2.1.1 User Registrations

It is interesting to break down the overall figure of 759,088 registrations on the Open Hub into greater detail, to explore patterns and diversity among users who registered for access. It is important to note that such an analysis only makes sense for the Open Hub, because ESA opens the accounts on the other hubs for qualified and known users, and only the accounts on

the Open Hub are created through a self-registration process.

The user registration service on the Open Hub remained open until the closure of services at the end of October 2023.

The graph in Figure 14 shows the number of users who registered each month for access to the Open Hub during Y2023, contrasted against the average number of user registrations made per month during Y2022 (shaded area). The cumulative number of registered users since the start of operations is also shown (orange line).

The graph shows that the number of new user registrations in February, March, April, May, June, and September 2023 was above the monthly average of Y2022, while the remaining 4 months show lower values, below the Y2022 average threshold. The highest number of registrations took place in March 2023, accounting for 16,927 user registrations. A closer examination of this number reveals that the peak can primarily be attributed to new registrations coming from China, with approximately 2,250 registrations from users based in China that month.

The lowest number of registrations took place in July 2023, with 10,443 new users registering. Interestingly, this was also the month in which the CDSE was declared operational and ready for public use, with the intention that new users would open their accounts directly on the CDSE from that point on.

The average number of registrations per month in Y2023 was roughly 13,055, higher than the Y2022 average of 11,826 users per month.

Figure 13: Registered Users per Data Hub on 31 October 2023

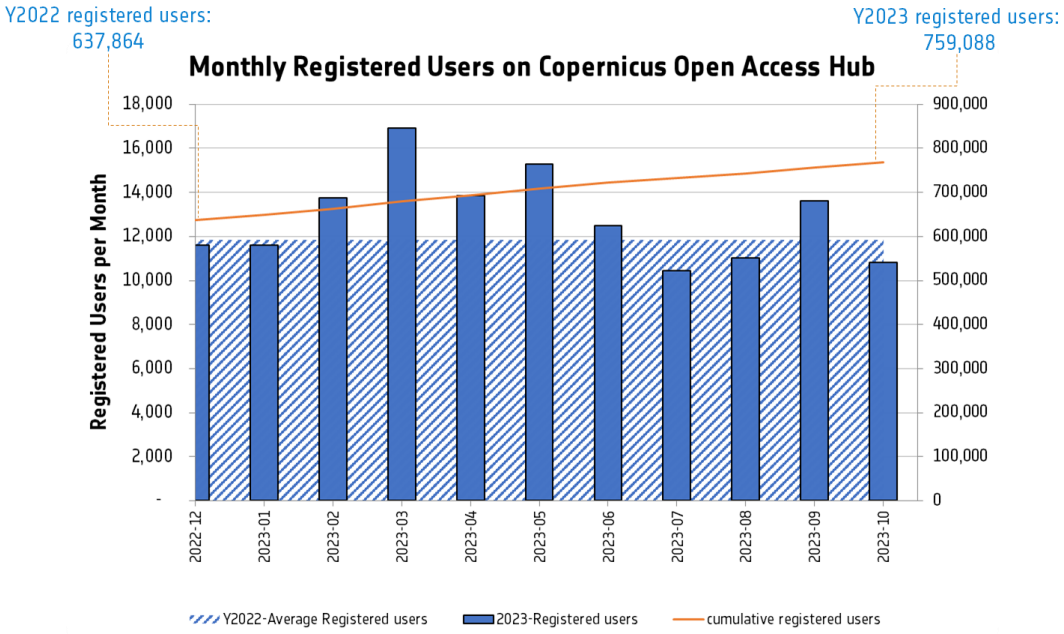


Figure 14: Trend of User Registrations on the Copernicus Open Hub during Y2023.

A potential trigger of peaks in the number of registered users are international conferences at which there is a general EO or a specific Copernicus presence. The Earth Observation department at ESA and the European Commission also host workshops and outreach events throughout the year at which Copernicus is presented, and these are likely to generate interest in registering for access to Copernicus data. Conferences in Y2023 which may have triggered interest in Copernicus Sentinel data were the Copernicus Marine Service's Our Ocean Conference Side Event (Panama, March 2023), the 11th International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry and BIOMASS Workshop (Toulouse, June 2023), the EARSeL Symposium (Bucharest, July 2023), the EUMETSAT's Meteorological Satellite Conference (Malmo, September 2023).

2.1.2 Open Hub Demography

In Figure 15, the number of user registrations on the Open Hub by the end of Y2023 is broken down by continent.

Europe remains the continent with by far the largest Open Hub user-community, with 259,920 registered users by the end of Y2023, up 13% from the end of Y2022. However, the growing awareness of and interaction with the Open Hub has by no means been limited to Europe. Beyond Europe, the largest increase during the year was in the new registrations made in Asia, where the total number of registrations rose by 26% to 222,992 users. A similar percentage increase took place in Africa, where there was a 25% increase in the total number of registrations, with as many as 48,258 new users joining the Hub during Y2023. The number of registered users in South America and North America reached 122,923 and 91,684 respectively, with increases of 20% and 18% since last year. Oceania showed the lowest percentage increase but even there the number of registered users rose by 14% with respect to Y2022, reaching 17,747 users.

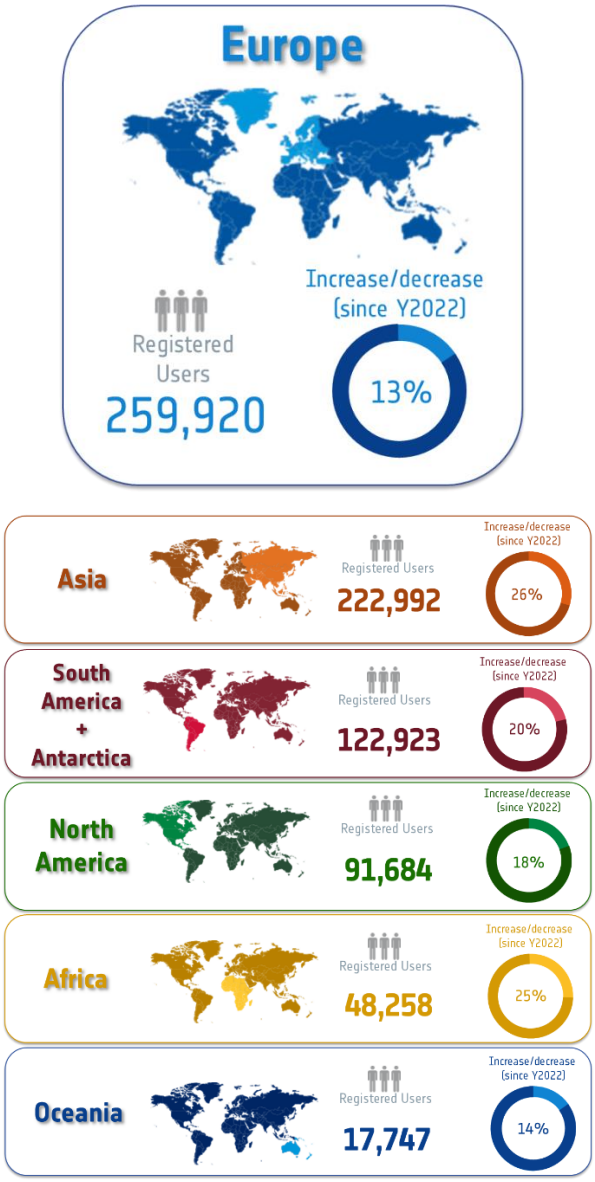


Figure 15: Open Hub registered users per continent since the beginning of operations and the percentage increase in the number of registrations per continent during Y2023.

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 16 shows the monthly increase in the number of countries reaching this threshold. By the end of Y2023, there were 111 countries across the world exceeding 500 registered users, a modest rise from the 108 at the end of Y2022.

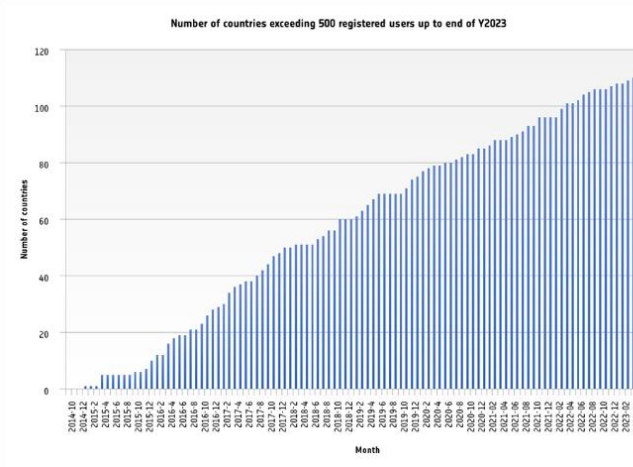


Figure 16: Growth in the number of countries exceeding 500 registered users on the Open Hub since the start of operations.

Zooming in on Europe, an increase in registered user numbers was observed across all ESA and European Union Member States. Figure 17 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 Y2022. The order of these countries is the same as it was in Y2022, with France continuing to show the highest percentage increase (15%) in the number of registered users, and Spain and Italy showing the second highest rises at 14%. In absolute terms, Germany remains the country with the largest number of registered users in Europe, however, with a total of 35,434 registered users at the end of Y2023, an increase of 11% from the end of Y2022.

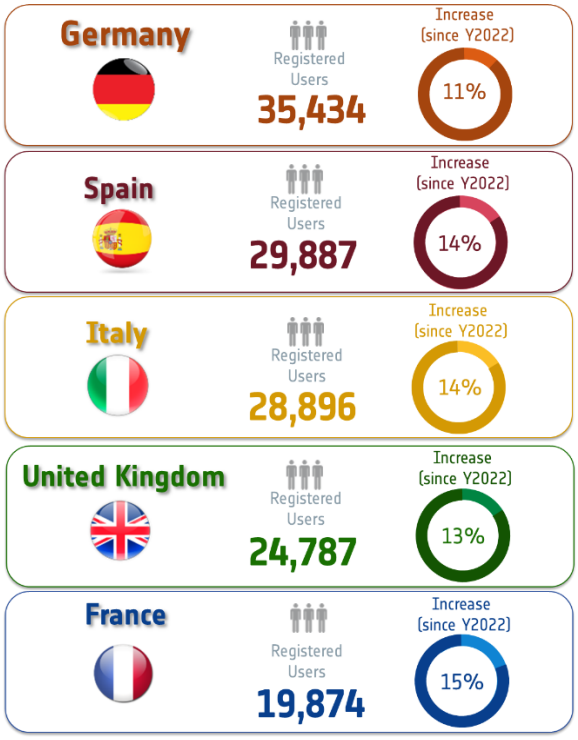


Figure 17: Distribution of Copernicus Open Hub registered users in the 5 EU and ESA member states with the highest number of registered users.

It is highlighted that these statistics are derived from the nationality information provided by users during registration for hub access, so they depend on the accuracy of the information users provide when they register. There is no independent cross-verification conducted based, for instance, on the user's IP address. It is also worth noting that the statistics here only account for the Open Hub and the true number of Copernicus users in each country will depend on the availability of alternative commercial or national sources of Sentinel data, for example via the Collaborative Ground Segment or international Copernicus data access sites.

User activity on the Hubs is analysed in detail in Section 3 below.

2.2 Published Data

Until the closure of the Sentinel Data Access System on 2 November 2023, routine publication of user-level data for Sentinel-1, 2, and 3 continued on each of the data hubs. It is recalled, however, that the user-level data for Sentinel-5P continued to be disseminated exclusively on the dedicated Sentinel-5P Hub. This continued separation was aimed at optimising the retention period for the other Sentinel user-level data, while enhancing download capacity for the data of Sentinel-5P.

The user-level data types available on the Sentinel Data Access System during Y2023 were the following:

- All ***Sentinel-1A*** user-level data were routinely published on all the data access hubs. Access to the historical Sentinel-1B user-level data was maintained.
- ***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 routinely 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 Y2023. 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 Y2023, **a total of 80,023,961 Copernicus Sentinel user-level data had been published on the Open Hub since the start of operations, with a total data volume of 45.41 PiB**. In Y2023 alone, a total of 11,663,777 user user-level data were published, accounting for a total data volume of 6.04 PiB. To put this into context by way of historical comparison, the 6.04 PiB published during Y2023 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 18 below compares the volume of user-level data published in Y2023 with the volumes published in the preceding years. The graph shows that 13% of the total volume of Copernicus Sentinel data ever published on the System was published in Y2023 (15% of the total number of data packages).

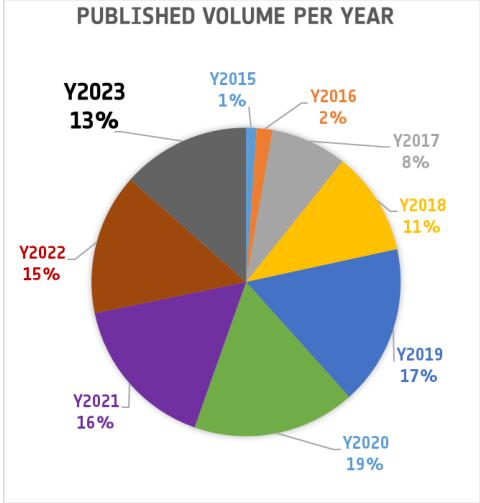


Figure 18: Percentage per reporting year of the total published volume of data since the start of operations (Y2015-Y2023)

The volume of Sentinel user-level data published on the Open Hub during Y2023 makes up 14% of all the user-level data published on the Open Hub since the start of operations. For each of the preceding 4 years the percentage was slightly higher, however, and it is assumed this is because Y2023 consists of only 10 months.

Mission	No. of user-level data published in Y2023	No. of user-level data published since start of Ops	Y2023 No. as % of total published per mission since start of Ops	Volume of user-level data published in Y2023 (PiB)	Volume of user-level data published since start of Ops (PiB)	Y2023 volume as % of total published per mission since start of Ops
S1	592,047	8,969,616	7%	0.96	14.05	7%
S2	7,381,090	48,063,550	15%	3.73	24.47	15%
S3	2,737,488	19,194,197	14%	0.71	5.57	13%
S5P	953,152	3,796,598	25%	0.63	1.32	48%
ALL	**11,663,777**	**80,023,961**	**15%**	**6.04**	**45.41**	**13%**

Table 1: Overall number and volume of published user-level data on the Open Hub both in Y2023 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 Y2023 as a proportion of the total number and volume since the start of operations in 2014.

In terms of the number of published user-level data, Sentinel-2 data continues to dominate: the mission accounts for 63% of the number of user-level data published in Y2023 and 60% of the number of all user-level data published since the start of operations. The percentages reduce slightly when looking at the *volumes* of data published, with Sentinel-2 data constituting 62% of the total volume of data published in Y2023, and 54% of the total volume since the start of operations. It is recalled that these differences in the proportions when looking at the numbers and volumes of data published occur due to the different ways the user-level data for each mission is packaged. For example, the Sentinel-2 user-level data are packaged according to a tiling scheme, with one data package per tile, creating a large number of data packages, and each with a lower data volume than the packages for the Sentinel-1 user-level data. Even though the *number* of Sentinel-2 user-level data published since the start of operations is about 6 times the number of Sentinel-1 data published, therefore, the *volume* of Sentinel-2 data published since the start of operations is less than twice the volume of Sentinel-1 data published (24 PiB of Sentinel-2 data vs. 14 PiB of Sentinel-1 data).

The Sentinel data publication figures for Y2023 show 15% fewer user-level data were published in Y2023 than in Y2022, and 9% less by volume. This decrease is attributed to the fact that there were only 10 months in Y2023 compared to the 12 months from each of the previous reporting periods. Nonetheless, the number and volume of Sentinel-5P user-level data which was published significantly increased compared to Y2022, with a notable 24% increase in the number of Sentinel-5P user-level data published, and almost twice the volume. This notable increase in the Sentinel-5P publication is attributed to the reprocessing campaign, which was completed in June 2023. This campaign involved the provision of auxiliary data on the Sentinel-5P Pre-Ops Hub, specifically AUX_CTMANA, utilized in the reprocessing efforts for NO_2, HCHO, and SO_2. It can be seen from Tables 2 and 3 below that by October 2023, the average daily publication rate of Sentinel-5P data was back in line with the daily publication rate at the end of Y2022. [*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.*]

Overall, the daily average volume of data being published in October 2023 was 10% higher than the daily average volume which was being published in December 2022. This overall increase is due to higher average daily volumes of Sentinel-2 and -3 data being published in October 2023 than were being published in December 2022.

By contrast, the daily average volume of Sentinel-1 data being published was significantly lower than in December 2022, with just over half the daily average volume being published. This decrease for Sentinel-1 is primarily attributed to the planned Data Access System phase out, which involved stopping the Level-

o user-level data publication on the Open Access Hub from July 2023 onwards. There were, however, also instances of data unavailability which occurred in October 2023, which resulted in data loss.

By the end of Y2023, the majority of the average daily published NTC data volume was still primarily made up of Sentinel-1 and -2 data. Together, they comprised 84% of the total average daily volume. There was, therefore, very little change compared to previous years for this combined share: in 2022, Sentinel-1 and -2 data represented an 83% share of the daily volume, and in 2021, the figure was 86%. The percentage share was maintained this year because the decrease in the average Sentinel-1 daily publication volume was compensated for by the increase in the average Sentinel-2 daily publication volume.

Mission	Daily Average Vol (TiB) published in October 2023	Oct 2023 Volume as % of overall daily average	Daily Average Vol (TiB) published in December 2022	Dec 2022 Volume as % of overall daily average
S1	2.68	15%	3.58	22%
S2	12.04	69%	10.14	61%
S3	2.32	13%	2.36	14%
S5P	0.44	2%	0.42*	3%
All	**17.47**		**16.51**	

*Table 2: Average volume of user-level data published per day in the last month of Y2022 (December) and Y2023 (October), with percentage splits per Sentinel mission (*data in November 2022).*

Mission	Daily Average Number of user-level data Published in October 2023	Oct 2023 no. as % of overall daily average	Daily Average Number of user-level data Published in December 2022	Dec 2022 no. as % of overall daily average
S1	1,557	4%	2,216	7%
S2	23,159	65%	19,445	60%
S3	9,091	25%	8,883	27%
S5P	1,907	5%	1,808*	6%
All	**35,714**		**32,353**	

*Table 3: Daily average number of user-level data published per mission during the last month of Y2022 (December) and Y2023 (October), with percentage splits per Sentinel mission (*data in November 2022).*

In terms of the daily average *number* of data published per day, there was also an overall increase of 10% when comparing December 2022 and October 2023. Again, this overall increase is primarily due to the increase in the Sentinel-2 publication, which experienced a notable 19% rise and represents the largest share in the daily average figures. Similarly, to the volume statistics, Sentinel-1 experienced a -30% decrease in the average daily number of published data during October 2023, due to the scheduled phase-out.

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 Y2023. 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 2022, to highlight any changes which have occurred between the years. Please note that the data for Y2023 only encompasses information until October, with figures for November and December 2023 registering as zero.

2.2.2 Publication trends

Sentinel-1

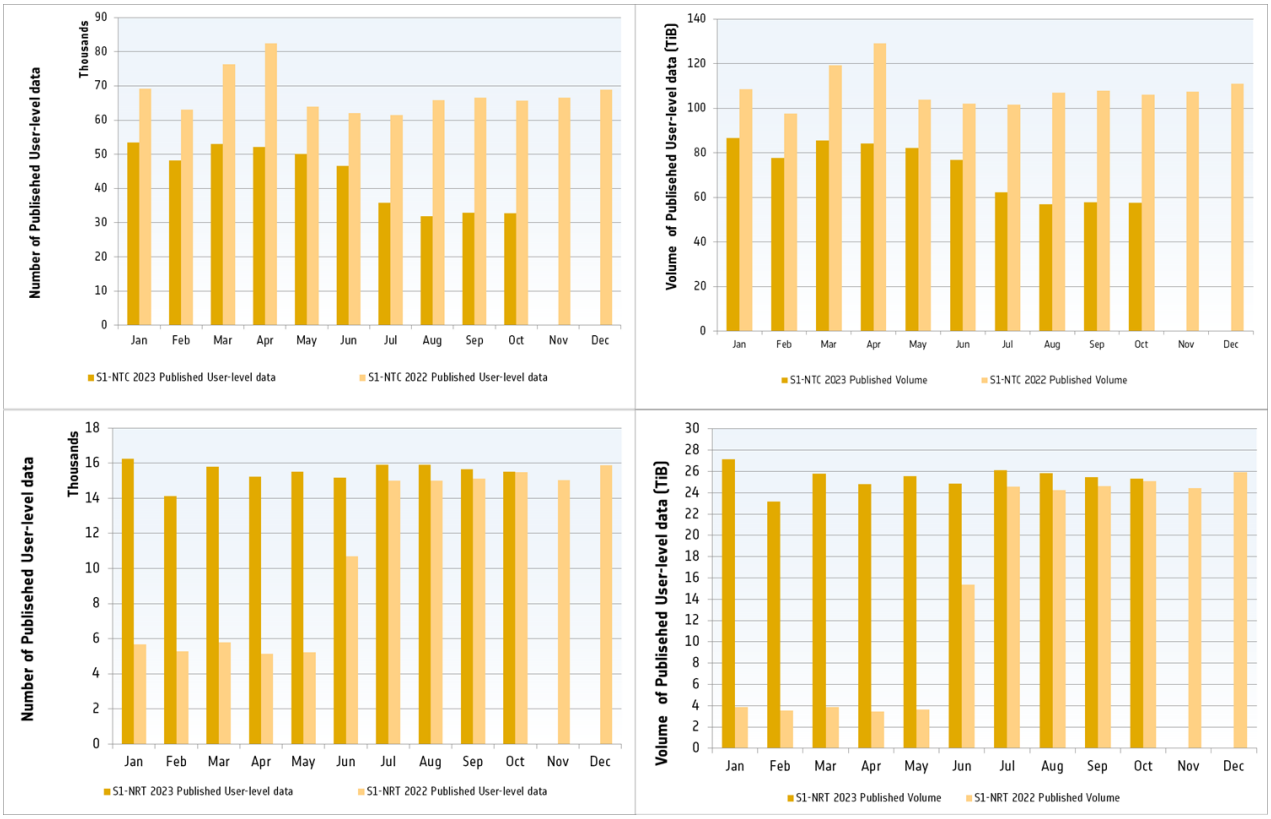


Figure 19: Y2022 and Y2023 monthly number and volume publication trend for Sentinel-1 Non time Critical (above) Near Real Time Production (below).

In Y2023, both the number and volume of Sentinel-1 NTC published data decreased during the year. The main drop visible from July onwards was due to the scheduled Data Hub services phase-out, which included stopping the publication of the Level-0 user level data (S1A RAW) on the Open Hub. The monthly average number of user-level data published in Y2023, 59,205, and the monthly average volume of user-level data published in 2023, 98 TiB, were 12% and 10% down on the Y2022 values.

For the Sentinel-1 NRT data, the picture is much more even throughout the reporting period, with only a slight difference notable for February 2023. It is recalled that the 2022 figures reflect the impact of the Sentinel-1B unavailability, which significantly reduced the Sentinel-1 the publication volume until May 2022, when the recovery plan with Sentinel-1A took effect.

Sentinel-2

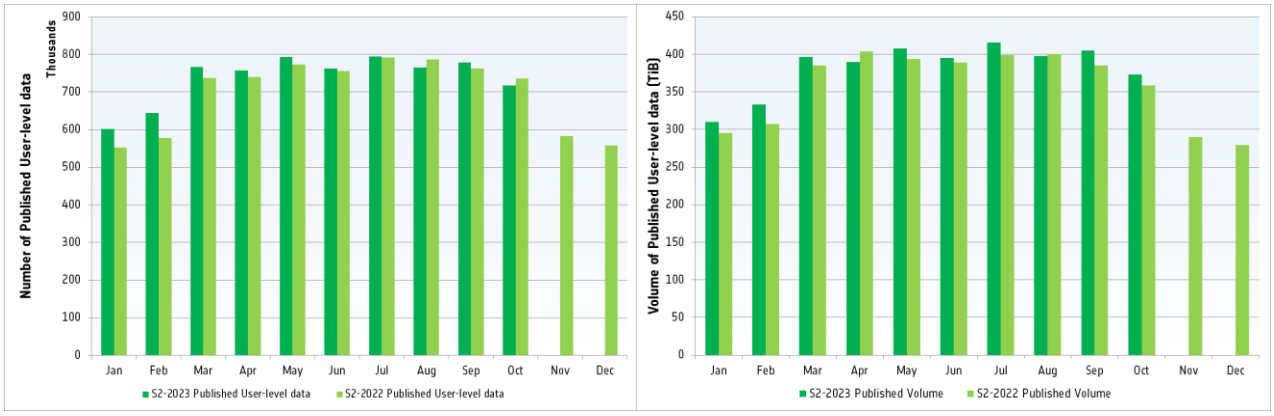


Figure 20: Y2022 and Y2023 number and volume publication trend for Sentinel-2

In the case of Sentinel-2, the monthly numbers and volumes of user-level data published in Y2023 closely mirror the pattern observed in Y2022, .with some smooth increases during Q1 2023. There was an increase of 6% and 7% in the average monthly publication number and volume respectively. An average of 738,109 user-level data was published per month until October 2023, compared with an average of 696,292 per month during Y2022; and an average volume of 382 TiB/month during Y2023 compared with 357 TiB/month in Y2022.

As observed in past years, the average monthly publication figures for Y2023 follow a consistent seasonal pattern. The summer months, characterized by longer daylight hours in the Northern Hemisphere, where the majority of Sentinel-2 imaging occurs due to its larger landmass, generate higher volumes of user-level data. In contrast, the winter months see fewer daylight hours and consequently less data is generated.

Sentinel-3

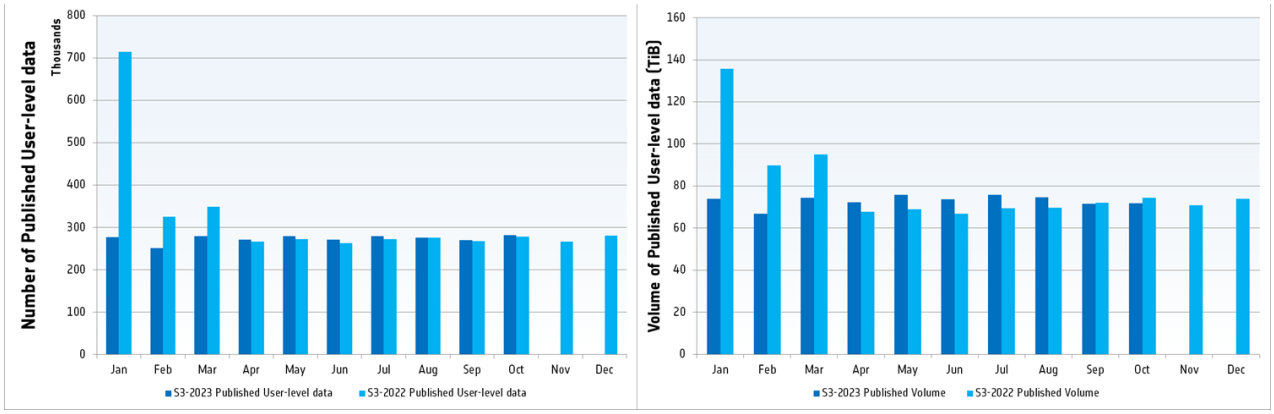


Figure 21: Y2022 and Y2023 monthly number and volume publication trend for Sentinel-3.

The distribution of Sentinel-3 user-level data number and volume remained consistent throughout Y2023. The most significant contrast with the previous year is observed in January, because in January 2022 there was an unexpectedly high publication of 714,198 user-level data, resulting from the SLSTR user-level data reprocessing campaign.

Overall, the average publication rate for Sentinel-3 user-level data in Y2023 was 273,749 data/month and the average volume was 73 TiB/month, respectively 14% and 8% down with respect to Y2022 average figures.

Figure 22 shows that the publication volume throughout Y2023 was largely made up of OLCI and SLSTR user-level data types.

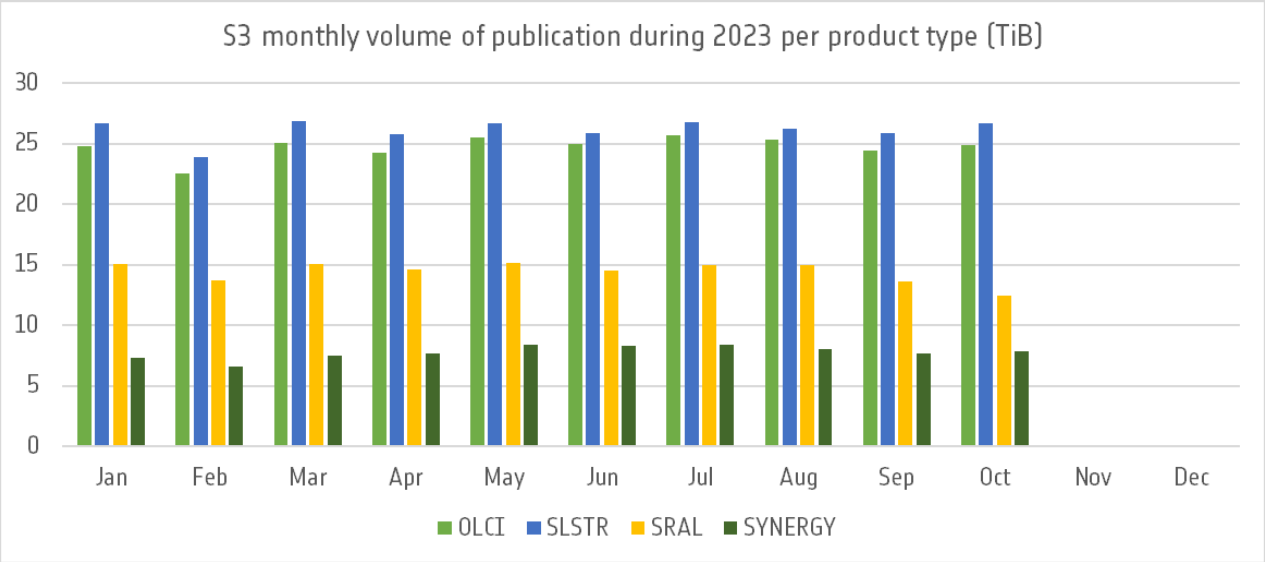


Figure 22: Y2023 monthly volume publication trend per Sentinel-3 user-level data group.

Sentinel-5P

The dedicated Sentinel-5P Hub began routine operations on 11 July 2018, and was still being used to publish Sentinel-5P data at the end of Data Hub operations in October 2023.

Figure 23 illustrates two peaks in the publication of Sentinel-5P user-level data, observed in March and April 2023. These two months collectively contribute to 83% of the total volume published throughout Y2023 and create a substantial 338% increase over the average monthly volume published in Y2022. This massive increase in the amount of Sentinel-5P data published in those months was due to the second release of the reprocessing campaign, which encompassed the entire mission period from 30 April 2018 to 25 July 2022. Starting from 3 March 2023, the Level-1B, Level-2 Methane (L2__CH4___), Level-2 Nitrogen Dioxide (L2__NO2___), and Level-2 Aerosol Layer Height (L2__AER_LH) reprocessed data were made available on the Data Hubs.

Excluding the outlier months, an average of 57,440 data/month were published on the Sentinel-5P Hub during Y2023, corresponding to an average volume of 13.67 TB/month, up only 1% and 6% respectively with respect to Y2022 averages.

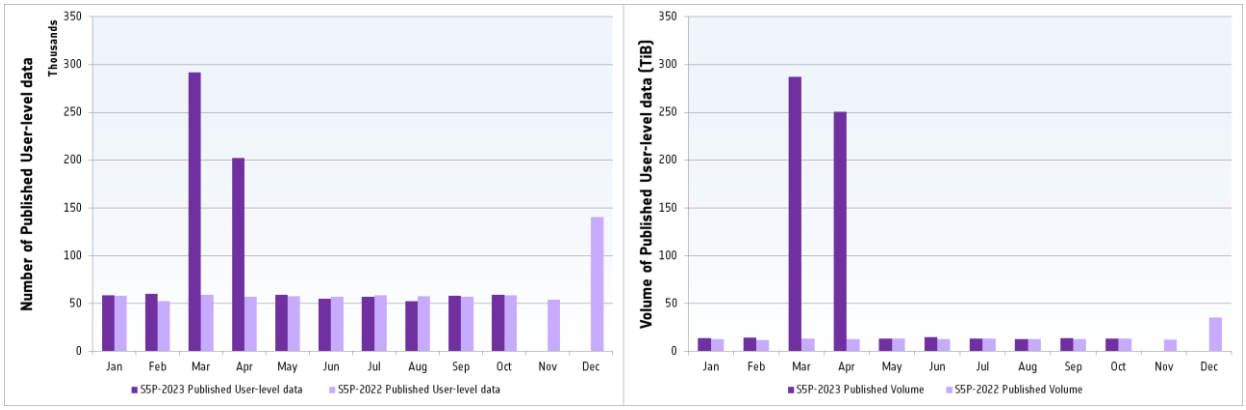


Figure 23: 2022 and 2023 monthly volume and number publication trend for Sentinel-5P.

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 24 and 25 show, for Sentinels -1, -2 and -3, the total percentage published in Y2023 for each data type, both in terms of the number and volume of data published. For Sentinel-3, for the purposes of readability, the individual data types have been collected into four data groups: SRAL, SLSTR, OLCI and SYNERGY; similarly for Sentinel 5P, the individual data types have been grouped in either Level-1B or Level-2.

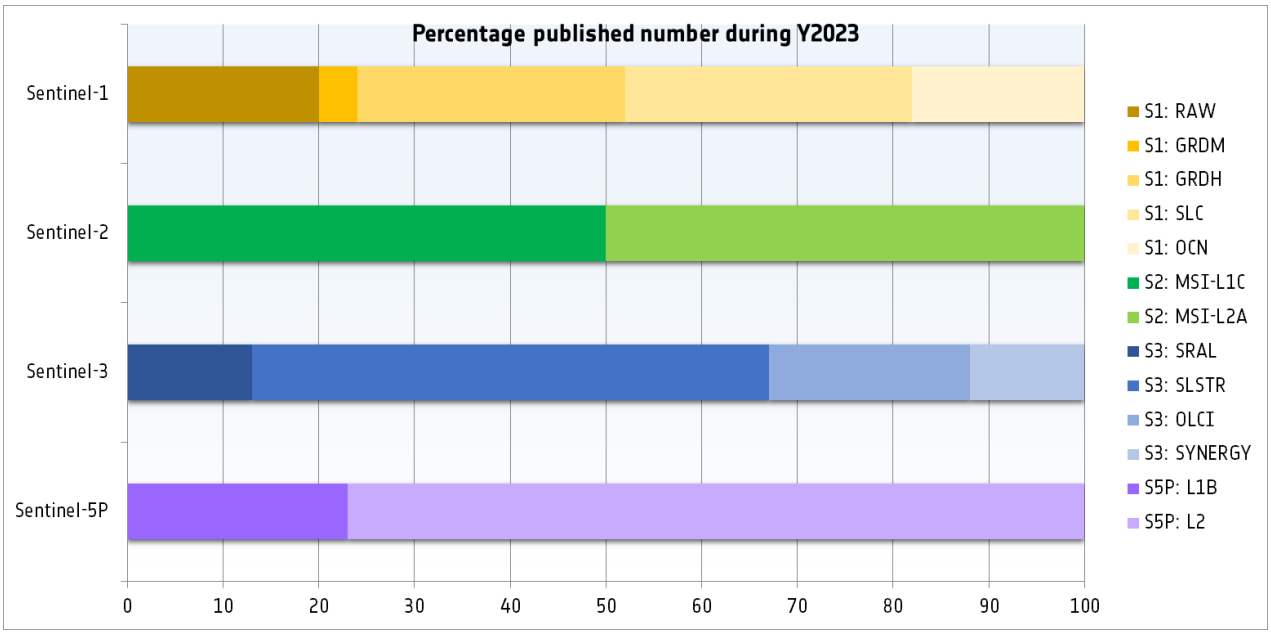


Figure 24: Percentage published number of user-level data per Sentinel mission and user-level data type during Y2023.

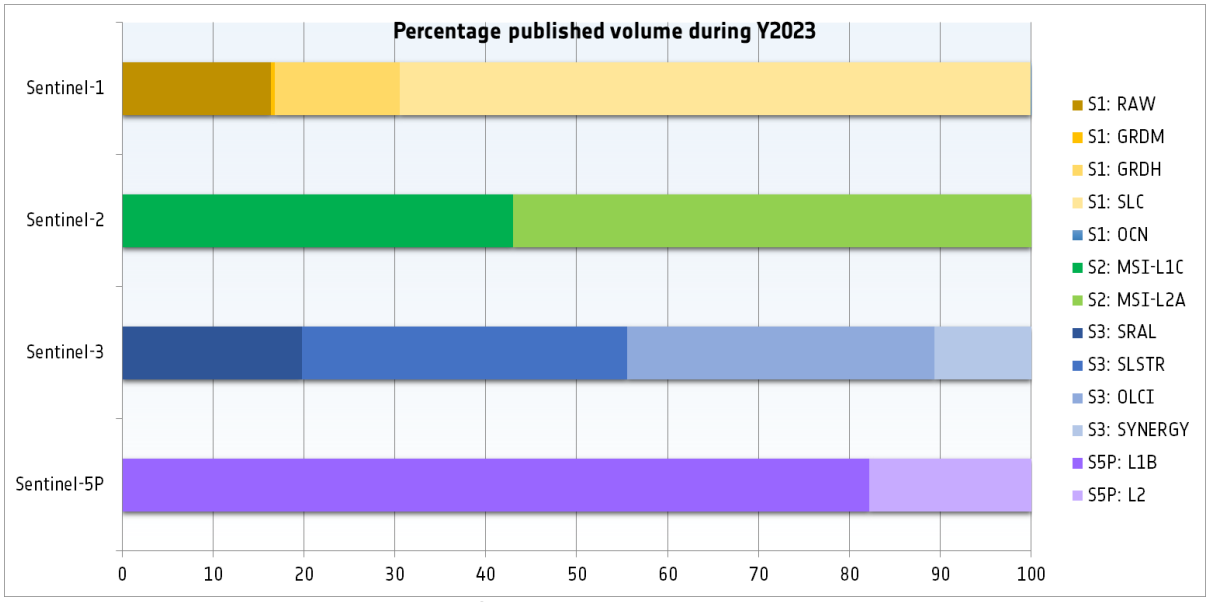


Figure 25: Percentage published volume of user-level data per Sentinel mission and user-level data type during Y2023.

For **Sentinel-1** the following user-level data types were available during Y2023:

- Level 0 (L0-RAW) until July 2023
- 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 user data accounts for 20% of total, Level 1 for 62% and Level 2 for 18%. In terms of volumes, the percentages of split are 16% for Level 0, 83% for Level 1, while Level 2 accounts only for 0.1%. The variation in percentages between number and volume is due to the substantial size difference between Level 1 SLC user-level data and Level 2 OCN user-level data. These percentage figures for both number and volume have remained relatively consistent since Y2018, but unsurprisingly there was a slight shift this year caused by the Level-0 data ceasing to be published on the Open Hub from July 2023 onwards. In terms of number, the percentage share of Level-0 dropped from 28% to 20%, and in terms of volume from 23% to 16%.

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

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

In terms of the number of Sentinel-2 user-level data published the split is 50% vs 50% for Level-1C and Level-2A, while by volume, it is 43% Level-1C and 57% Level-2A. These figures are equal to Y2022. The Level-2A account for a higher percentage of the overall Sentinel-2 publication volume due to the larger size of the individual Level-2A data packages.

For **Sentinel-3** the following user-level data types were published, divided per sub-mission and the 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
- SR_2_LAN_SI STM LAND Thematic user-level data for sea ice
- SR_2_LAN_LI STM LAND Thematic user-level data for land ice

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 most of the overall publication with 54%, although this is less than in Y2022 when 62% of the published Sentinel-3 data had been SLSTR data. Next, but with a much lower percentage is OLCI, with 21%, and then SRAL and SYNERGY accounting respectively for 13% and 11%. By volume, the split is 36% for SLSTR (down from 45%), 34% for OLCI, 20% for SRAL and 11% for SYNERGY. For **Sentinel-5P** the published user-level data types were:

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__PR: 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-1B accounted for 23% of the total number of Sentinel-5P user-level data published, while Level-2 accounted for 77%. In terms of volume, the percentage split is totally reversed, with 82% for Level-1B and 18% for Level-2, which is accounted for by the fact that the Sentinel-5P Level-1B data packages are much larger files than the Level-2 data packages.

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.

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

The heatmap in Figure 26 shows the geographical coverage of all Sentinel-1 data published from the start of operations until 31 October 2023. The colour scale illustrates the differing numbers of 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.

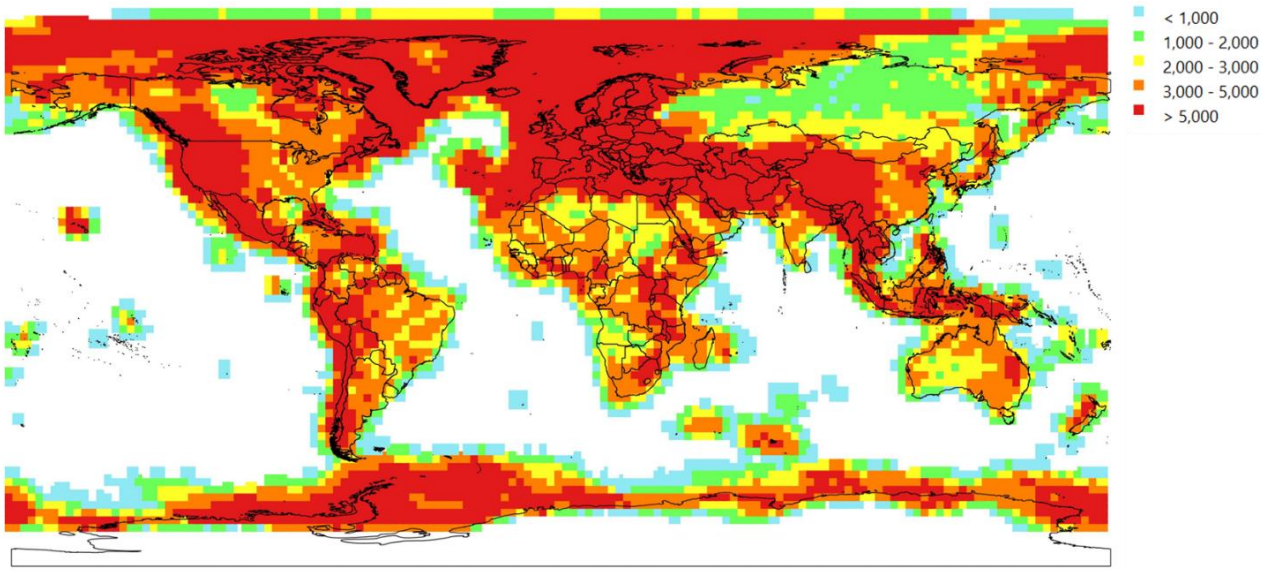


Figure 26: Heatmap of Sentinel-1 user-level data (excluding OCN) published from the start of operations to the end of Y2023.

The heatmap shows that Sentinel-1 user-level data cover all continents and major island groups, with the highest density of coverage over European land and sea areas, the Pacific coastline of the Americas, the far northern and southern sea-ice regions, most of the Middle East and Southeast Asia, and the northern coast and several inland areas of Africa.

It is not visible in the heatmap but, in line with the observation scenario, the greatest density of published Sentinel-1 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) 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 revisit frequency. Sentinel-1 is also used 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 27, 28 and 29 respectively. The Wave mode, which is by default continuously operated over open oceans, is not shown in a map. Each heatmap uses the locations of all data published from the start of operations up to the end of the reporting period. For ease of comparison, the keys and ranges are the same in each case. In general, the extent of data coverage may be summarized as follows:

- *GRDM* – mostly covering sea ice and marine areas, with a strong emphasis on the maritime regions of the far north. Other zones of high publication include the mid-Atlantic and the Indian Ocean around Madagascar. The GRDM user-level data are related to the EW mode (Extra Wide Swath).
- *GRDH & SLC* – mostly available over land masses. The GRDH and SLC user-level data are (mainly) related to the IW mode (Interferometric Wide Swath) and the SM mode (Stripmap). A marginal number of SLC user-level data are generated with the EW mode. The particular density of GRDH and SLC user-level data over Europe and Greenland areas reflects the evolution of the Sentinel-1 observation scenario, which initially focused on Europe, and generally the higher observation frequency over Europe.

Detailed information about the Sentinel-1 observation scenario is set out in the HLOP, and on the dedicated Sentinel-1 section of Sentinel Online, at https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario.

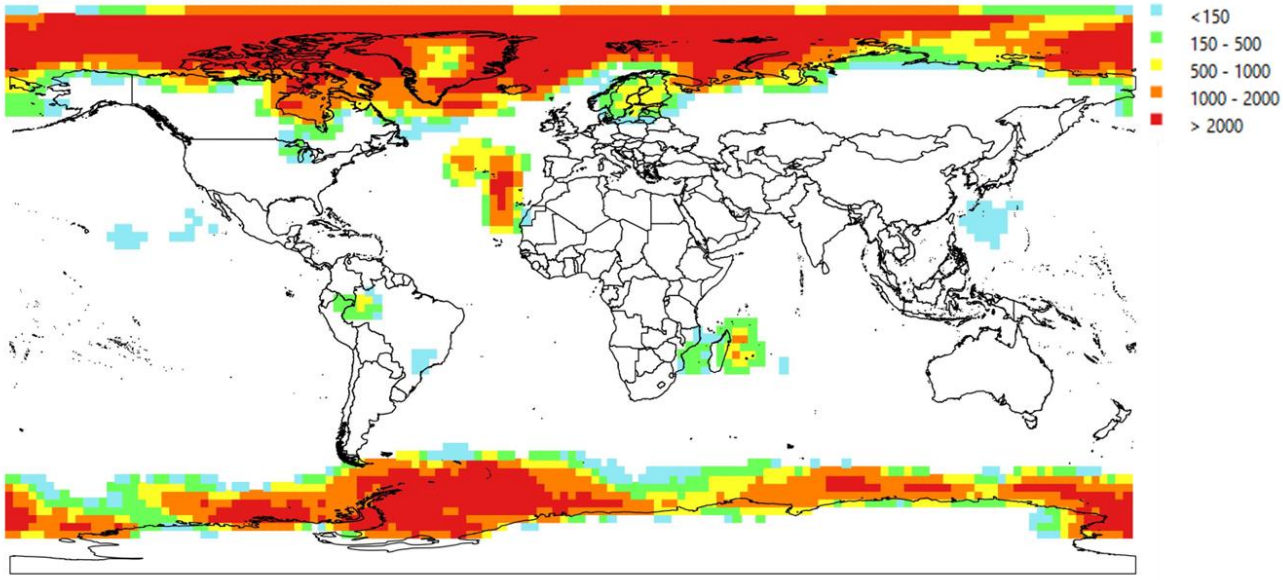


Figure 27: Heatmap of Sentinel-1 GRDM user-level data published from the start of operations to the end of Y2023.

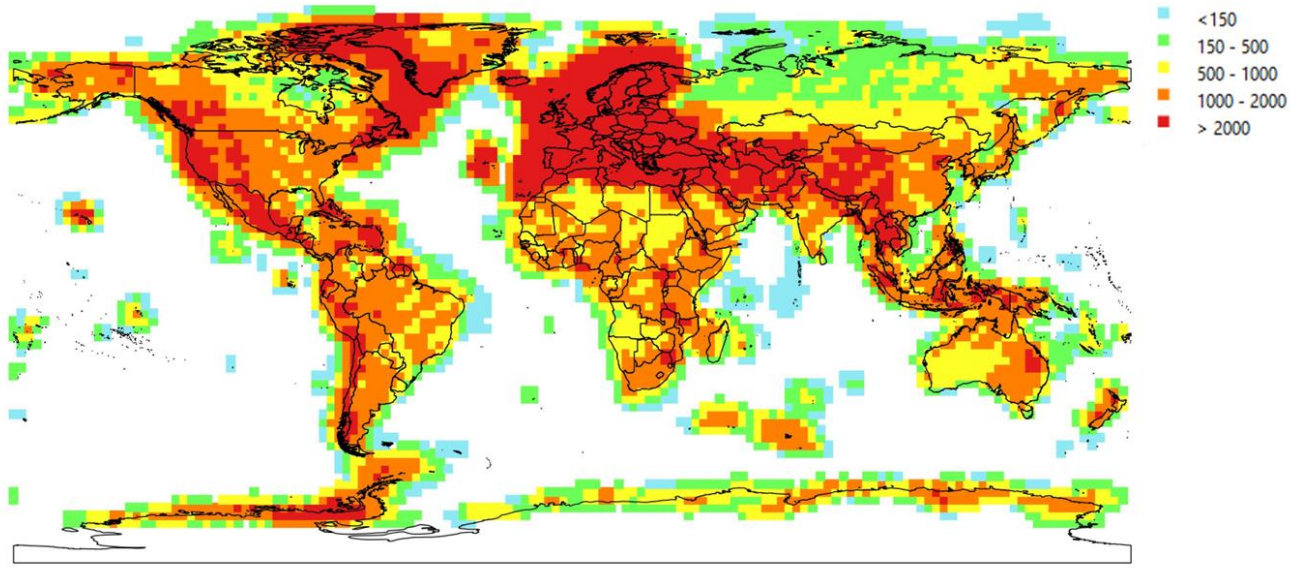


Figure 28: Heatmap of Sentinel-1 GRDH user-level data published from the start of operations to the end of Y2023.

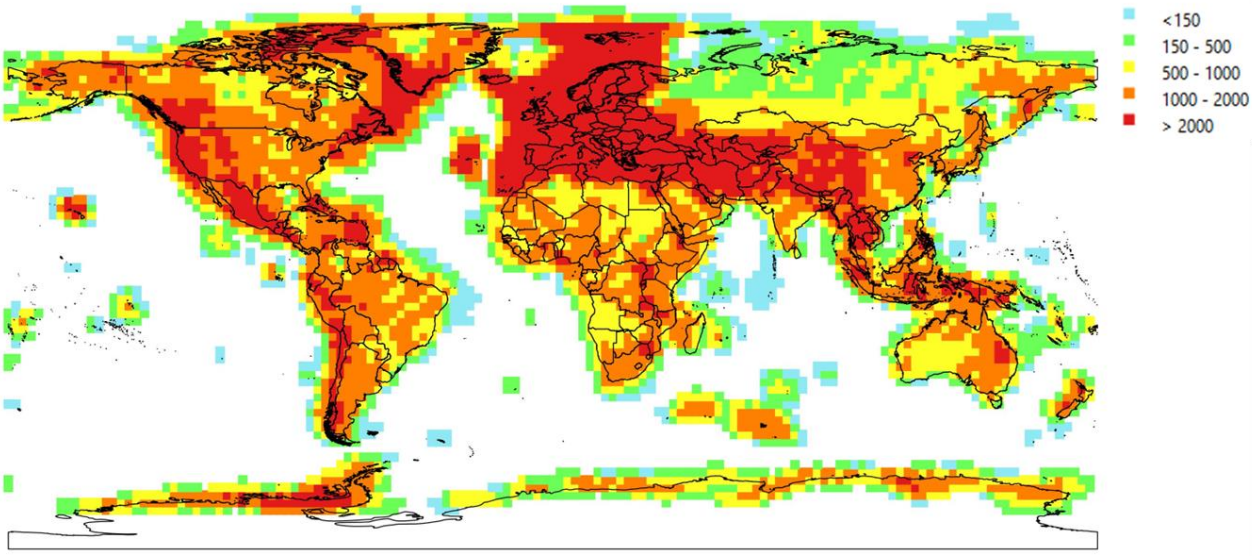


Figure 29: Heatmap of Sentinel-1 SLC user-level data published from the start of operations to the end of Y2023.

Sentinel-2

Figures 30 and 31 below show heatmaps for Sentinel-2 published data, respectively for Level-1C data and Level-2A data, and in both cases from the start of operations until the end of Y2023.

As in previous years, the Level-1C heatmap shows that the coverage is relatively evenly distributed over the globe's landmasses (excluding Antarctica). The 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), few differences between the heatmaps for Level-1C and Level-2A can be observed. The

differences which there are occur mostly in the high northern latitudes, over which it shows fewer Level 2 data have been published historically.

It should be noted that these heatmaps will always be an approximation and cannot represent a precise one-to-one mapping with the published 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.

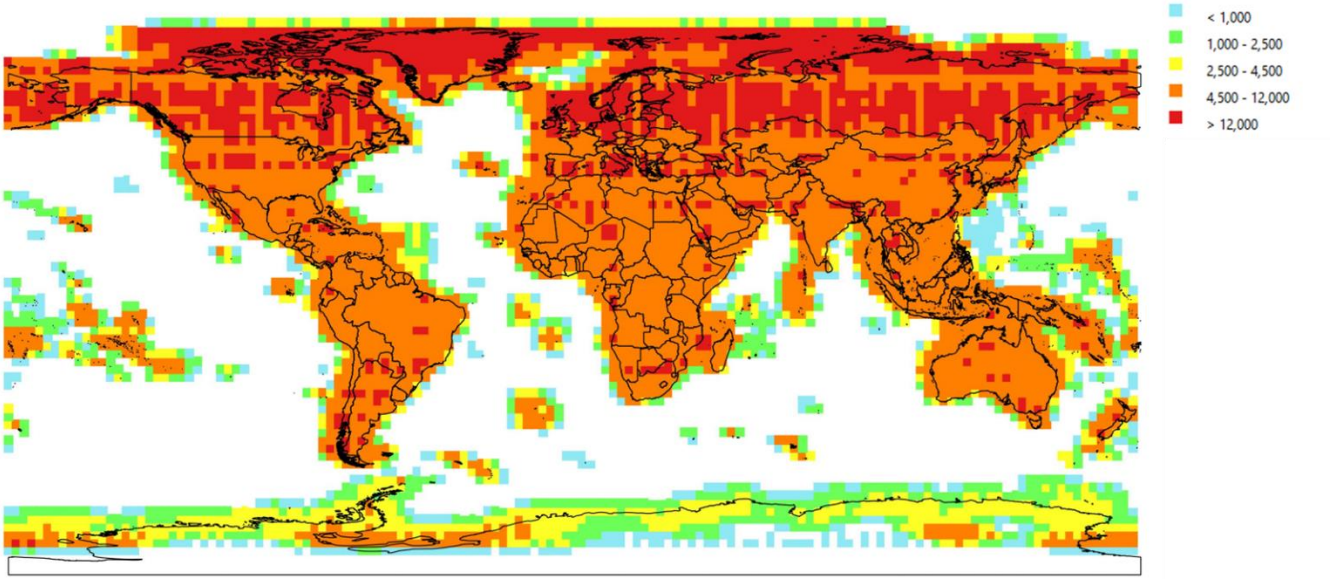


Figure 30: Heatmap of Sentinel-2 Level-1C user-level data published from the start of operations to the end of Y2023.

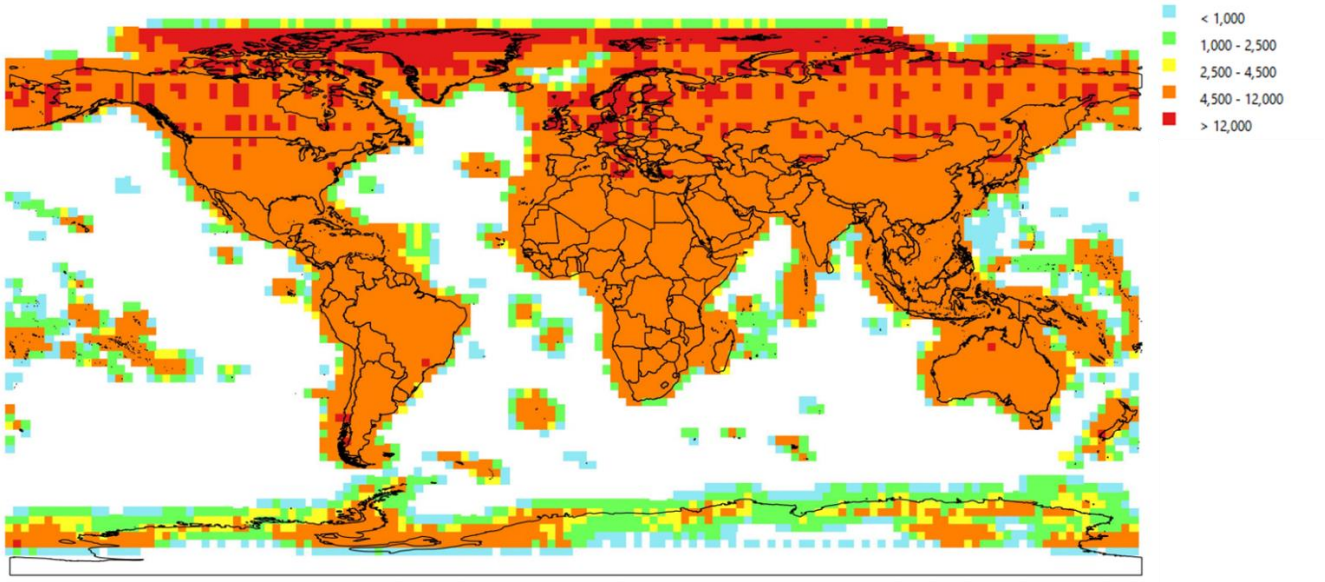


Figure 31: Heatmap of Sentinel-2 Level-2A user-level data published from the start of operations to the end of Y2023.

Sentinel-3

The heatmaps below show the geographical coverage of Sentinel-3 Land data, published and available on the Open Hub since the beginning of operations to the end of Y2023. The heatmaps are separated out by user-level 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 32, 33, 34, 35 and 36 respectively. Care should be taken when reading the keys, which are different for each plot depending on the number of data published for each instrument.

Sentinel-3 data are far more evenly distributed over the globe than Sentinel-1 and -2 data. Only SRAL-NRT Level-2 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.

It is highlighted that the heatmap for the SYNERGY data is composed of many different user-level data types, including the VGT data which are provided in continental tiles, and this creates a heatmap 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.

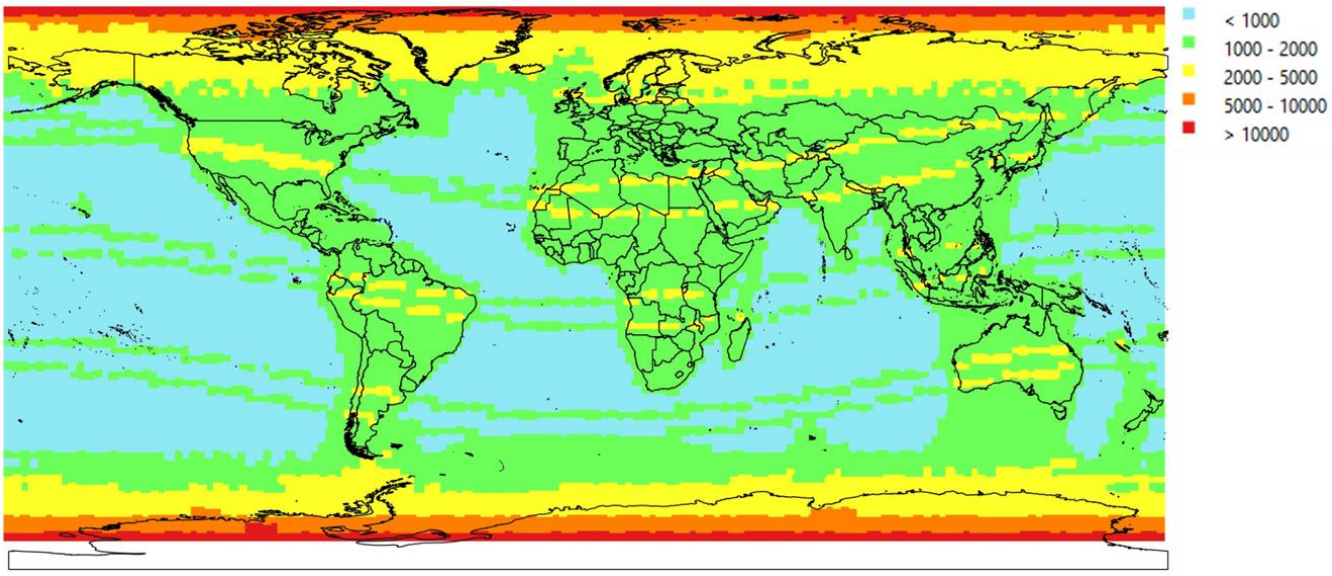


Figure 32: Heatmap of Sentinel-3 SRAL user-level data published since the start of operations to the end of Y2023 (excluding NRT and Level-2).

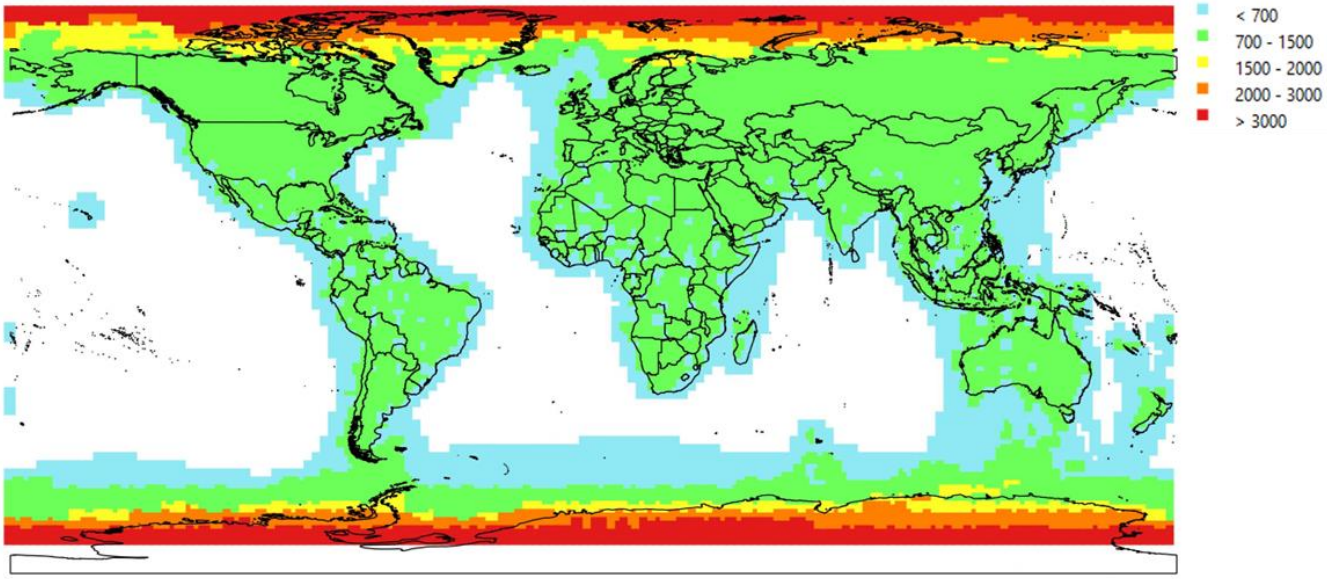


Figure 33: Heatmap of Sentinel-3 SRAL-NRT Level-2 user-level data published from the start of operations to the end of Y2023.

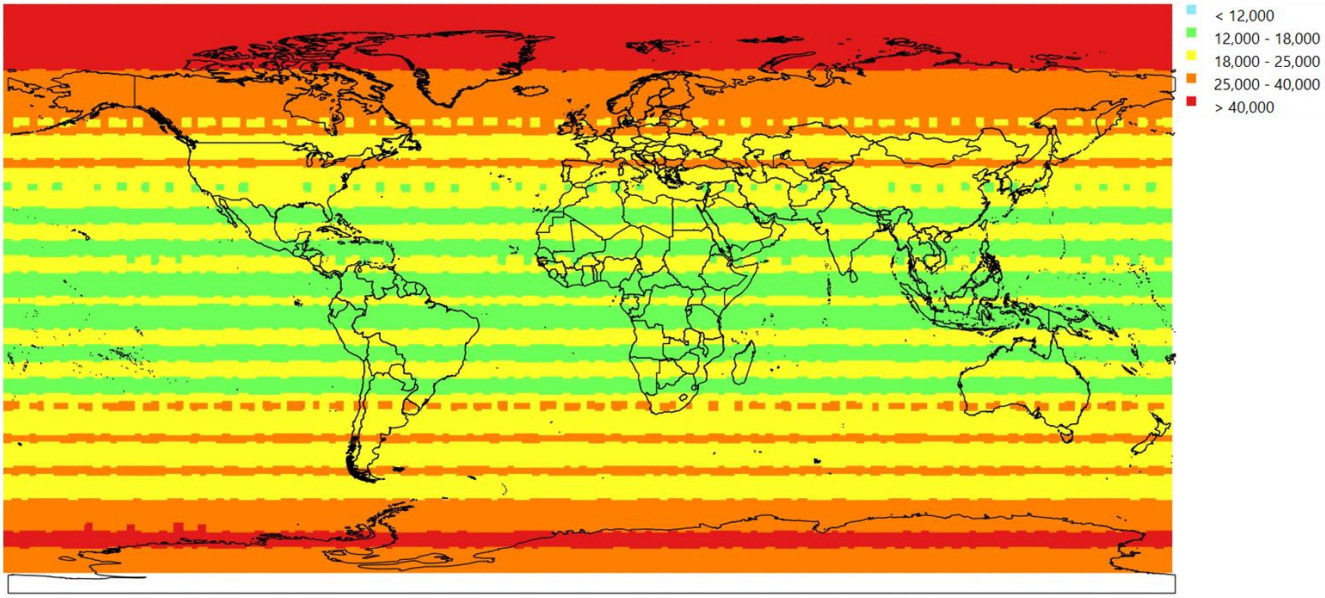


Figure 34: Heatmap of Sentinel-3 OLCI user-level data published from the start of operations to the end of Y2023.

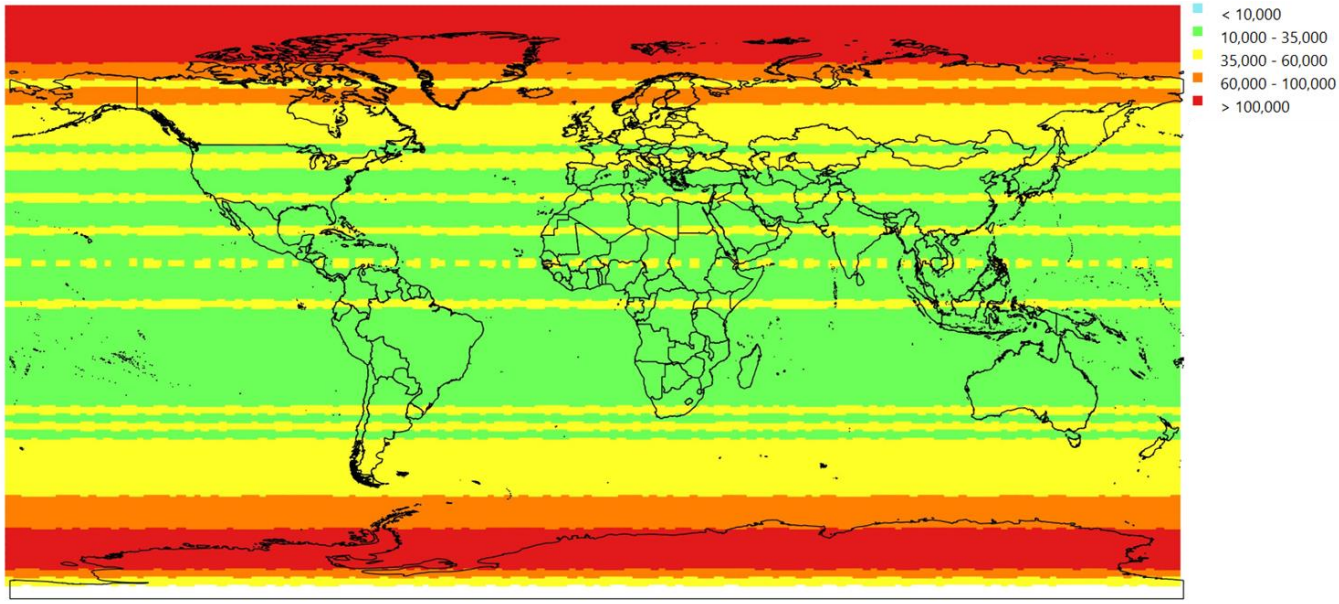


Figure 35: Heatmap of Sentinel-3 SLSTR user-level data published from the start of operations to the end of Y2023.

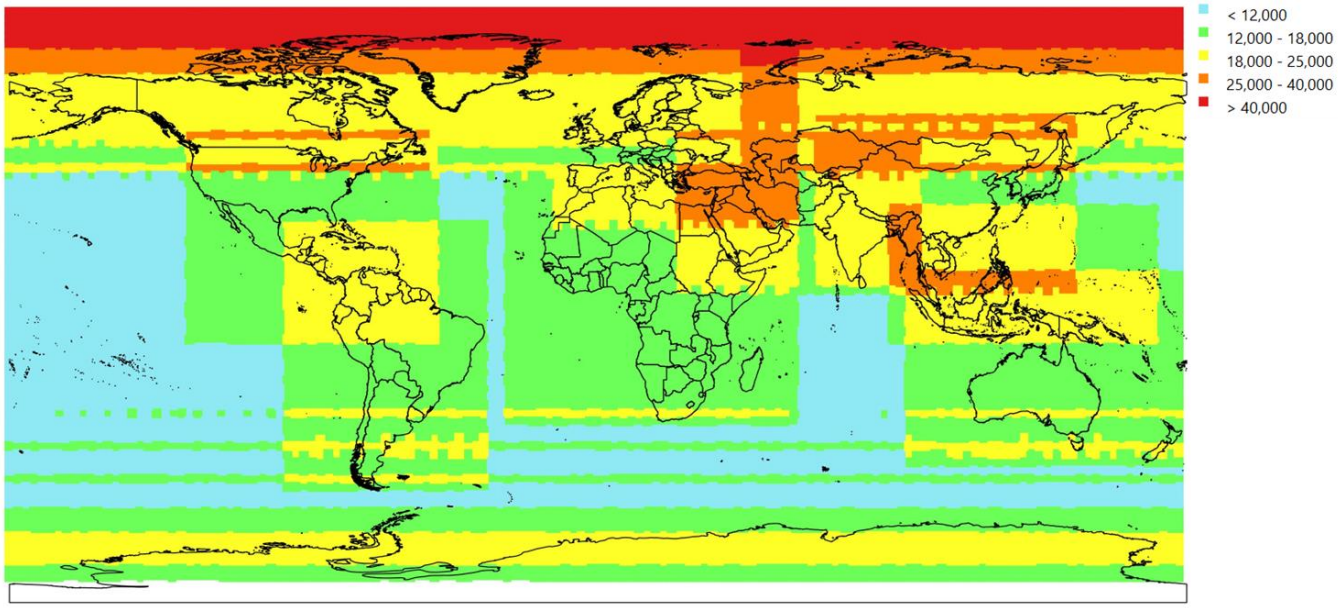


Figure 36: Heatmap of Sentinel-3 SYNERGY user-level data published from the start of operations to the end of Y2023.

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). It is shown below in Figure 37, made up from all Sentinel-5P user-level data published from the start of operations until the end of Y2023.

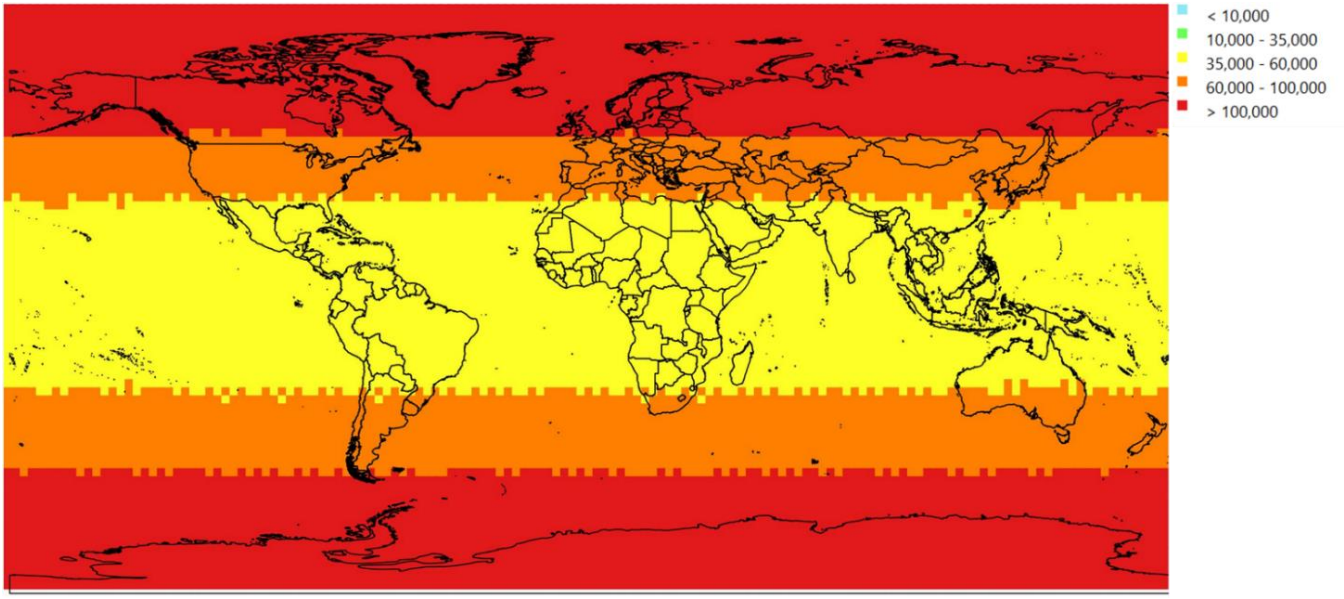


Figure 37: Heatmap of Sentinel-5P user-level data published from the start of operations to the end of Y2023

2.3 Data Downloads

This section looks at user activity in terms of the level of downloads which users made during Y2023 and the types of data which they chose to download.

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

Figures presented in this section 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 2.3.3.1, because the DIAS partners systematically download the full collection of user-level data, so the statistics are more predictable and risk masking the download patterns of the other ServHub users.

2.3.1 Download growth

By the end of Y2023, a huge **586 PiB** of Copernicus Sentinel user-level data had been downloaded from the Data Access System since the start of operations. Excluding DIAS Hub users, this figure amounts to a huge **480 PiB**, and this volume results from **users having downloaded a massive number of 940,670,397 Sentinel data packages since the start of operations**. DIAS Hub users, who conduct systematic downloads involving extensive and organized data retrieval processes, have their Y2023 download figures detailed in Section 2.3.3.3. Figure 38 illustrates the cumulative growth each reporting year in the volume of data downloaded from the Data Access System, excluding the DIAS Hub.

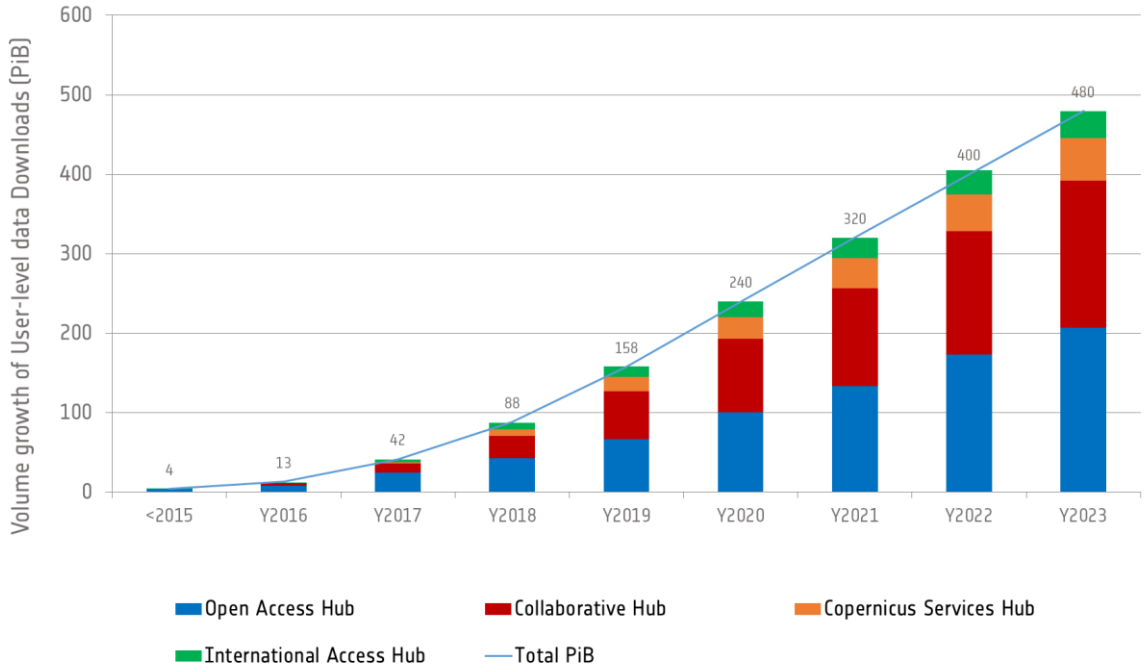


Figure 38: Overall download trend at the end of Y2023, split by Hub (excluding DIAS Hub)

Figure 39 below breaks down the overall cumulative download volume into the volume downloaded each reporting year, separated out by mission, to be able to compare the total volume of data downloaded for each mission by the end of Y2023 with the total volume which had been downloaded by the end of each previous period, i.e. reporting years Y2015-Y2022. *The reader may note that the overall volume since the start of the operations is higher than the sum of all the reported volumes for the reporting periods, and this is caused by the fact that the December 2021 data is included in the overall volumes but not in the*

Y2022 data. It is a consequence of the change of the reporting period, which was aligned to the calendar year in 2022 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 Y2022 reporting period. December 2021 is, however, included in all cumulative statistics, i.e. those calculated from the start of operations to the end of Y2023. This change in the reporting period was introduced to align this annual report with other reports produced internally and for the EC.

As shown in Figure 39, **74.5 PiB of Sentinel data** was downloaded in Y2023, and this was 5% less than the volume downloaded during Y2022. This decrease in the volume downloaded compared to Y2022 is almost certainly due in large part to the closure of the Data Access System on 2 November 2023, and the resulting fact that Y2023 consists of only 10 months, instead of the usual 12. It can also be assumed that multiple users migrated during Y2023 to the CDSE, especially from July 2023 onwards, when the CDSE was declared to be in routine operations. In fact, it is slightly surprising that there was not a bigger percentage decrease compared to previous years. For a couple of years, it has been expected that the demand for downloading data would decrease, due to the move towards developing cloud-based local processing platforms, provided either by ESA or 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. It is still expected that users will increasingly migrate to this way of exploiting the data, particularly given the ever-expanding volumes of data available, but the Y2023 figures again suggest that this migration is not happening on a large scale yet, or that those moving to hosted processing solutions are being replaced by roughly equal numbers of users wishing to download the data. For instance, as mentioned in Section 2.1 and Chapter 3, the numbers of user registrations and active users on the Data Access System continued to increase in Y2023, despite it having been announced as the last year of operations for the Service.

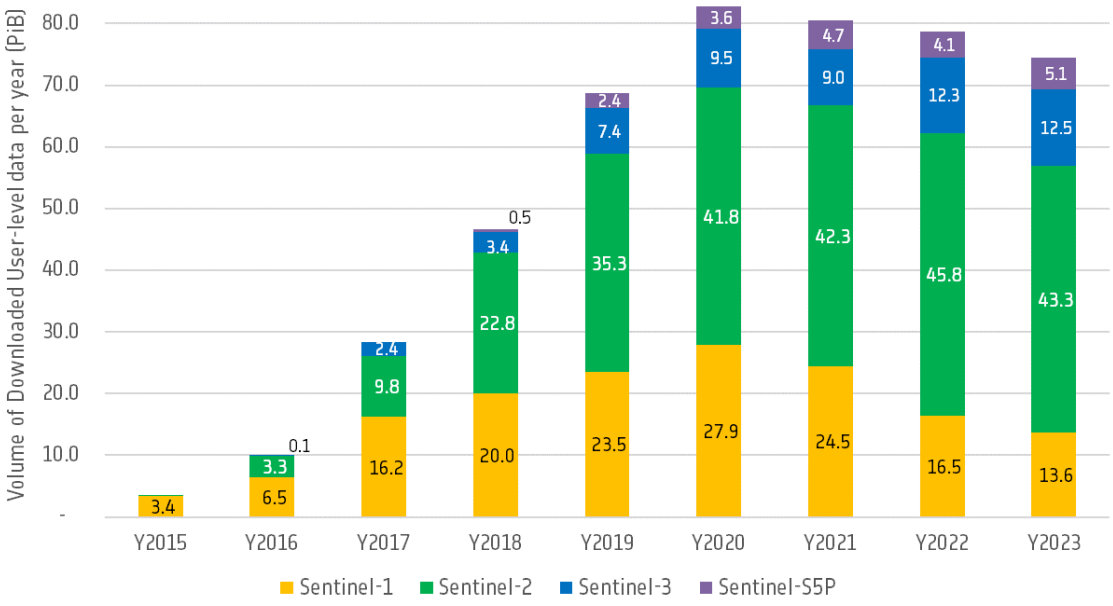


Figure 39: Total volume of user-level data downloaded each year since the start of operations from all the four hubs, differentiated by mission.

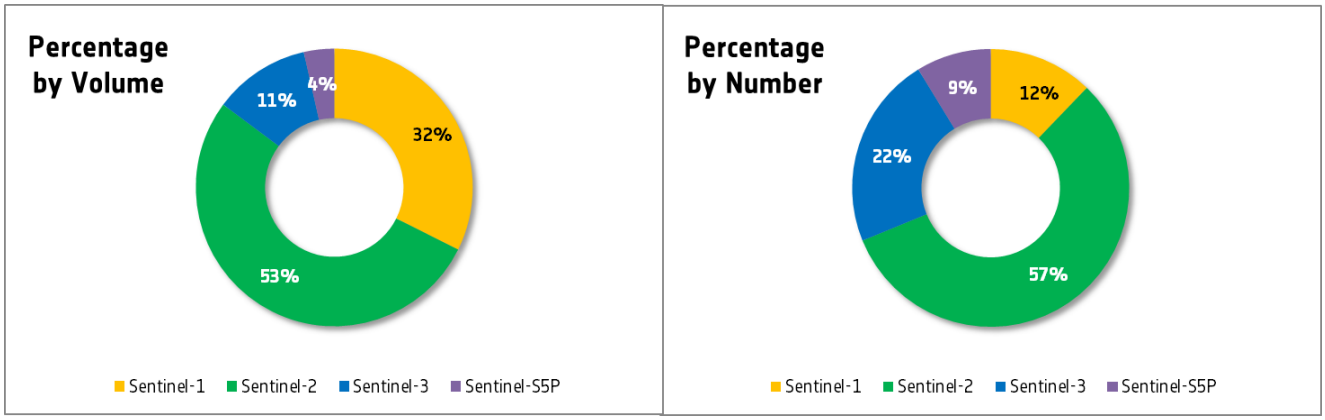


Figure 40: Percentage of total downloads per mission since the start of operations for all hubs, on the left by volume and on the right by number.

Looking at the download volumes separately for each mission compared to Y2022, the volume of data downloaded increased by 8% for Sentinel-3, and by 25% for Sentinel-5P. On the other hand, the volume of Sentinel-2 downloads decreased by 6% and the volume of Sentinel-1 downloads decreased by 9%, reaching the lowest value since Y2016. It is likely that the big decrease in the Sentinel-1 download volume was also the result of the lower Sentinel-1 publication volume, which meant that the users who systematically download the full Sentinel-1 data collection (the group often referred to as the "mass downloaders") had a lower volume of Sentinel-1 data to download this year than they had in previous years.

Figure 40 shows the proportion of the total number and volume of downloads since the start of operations which were accounted for by each Sentinel mission. Notably, Sentinel-2 remains the mission with the highest proportion of downloads, representing 53% of the total download volume and 57% of the total number of downloads. Sentinel-1, on the other hand, accounts for a much larger share of the volume (32%) compared to its share of the overall number of downloads (12%), due to the large average size of its data packages. By contrast, Sentinel-3 and Sentinel-5P, due to their smaller data package size, account for a higher percentage of the number of downloads (22% and 9% respectively) compared to the volume of downloads (11% and 4%, respectively).

2.3.2 Archive Exploitation Ratio (AER)

Interest in Sentinel data can also be monitored by looking at the 'Archive Exploitation Ratio' (AER) for the data. An AER is expressed as a ratio of published data vs downloaded data: e.g., the ratio 1:X indicates that, on average, for each data package published from a mission, there were X number of downloads of that data package. The AERs which are shown in Figure 41 were calculated at the end of Y2023 and represent the total number of user downloads made from all the hubs since the start of operations, divided by the total number of data packages which had been published on the hubs since the start of operations.

The AERs reported in Figure 41 suggest that user interest in Sentinel-3 has slightly increased since Y2022: the AER has increased from 1:12 in Y2022 to 1:13 in Y2023. The AERs for Sentinel-1 and Sentinel-2 remain constant, again at 1:15 and 1:13 respectively. Meanwhile there was a slight dip in the AER for Sentinel-5P, which nonetheless retains the highest exploitation rate of all the missions, at a massive 1:26 (decreased from 1:28 in Y2022).

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 Y2023. 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 Y2023.

Sentinel-1

Level	Timeliness	Number of Published user-level data in 2023	Number of Downloaded user-level data in 2023	Archive Exploitation Ratio
Level 0	NTC	118,111	1,353,470	1 : 11
Level 1	NTC	257,067	4,672,072	1 : 18
	NRT	108,915	2,597,664	1 : 24
Level 2	NTC	107,954	2,158,416	1 : 20

Table 4: Sentinel-1 User-level data Published, Downloaded and AER for Y2023, 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	2,615,004	19,186,431	1 : 7
Level 1	NTC	4,955,219	79,353,107	1 : 16
	NRT	646,809	10,834,618	1: 17
Level 2	NTC	1,107,630	19,760,322	1 : 18

Table 5: Sentinel-1 User-level data Published, Downloaded and AER since the start of operations, per data level and timeliness.

Table 4 suggests that user engagement with each of the Sentinel-1 user-level data types continued to be strong. In particular, the AER for the Level-2 NTC data increased from 1:17 in Y2022 to 1:20 in Y2023. There was also an increase, though modest, in the AER for the Level-0 data, which rose from 1:9 in Y2022 to 1:11 in Y2023, and it can be seen that although the number of Level-0 data published was about half the number which had been published in Y2022 (226,029), the number of Level-0 data packages which were downloaded only fell by 32%. The AER for Sentinel-1 Level 1 NRT data remained at 1:24, as it had been in Y2022, and the AER for the Level-1 NTC data fell slightly from 1:19 in Y2022 to 1:18 in Y2023.

Table 5 provides the AERs using the publication and download figures from the start of operations. When compared with previous years, it can be seen that user interest in the different data types remained fairly stable throughout the years. The overall AER for the Level-1 NRT data since the start of operations shifted in line with the increase in the AER for 2023, rising from 1:15 in Y2022 to 1:17 in Y2023. But the overall AERs for the Level-0 and Level-1 NTC data remained the same as in Y2022, at 1:7 and 1:16 respectively, and there was a negligible shift for the Level-1 NRT.

Figure 42 indicates the geographical areas of interest for users of Sentinel-1 Lo and L1 NTC user-level data, measured by AER. It shows the AERs for the data available over specific geographical points across the globe, considering all data published since the start of operations. The Figure can be compared with the corresponding Sentinel-1 publication heatmap in Figure 26. Because of their 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 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.

Overall, the largest concentrations of interest appear over Asia and Oceania, Central America and the United States, Central Africa and the Southern ice-covered regions, for sea and land ice monitoring. In these areas the AER is generally above 1:3 and can go

higher than 1:5, in particular on the Eastern coast of China.

There are other AER hotspots across the globe, in particular the Maldives Islands and the Western Pacific archipelago Palau (Micronesia), a couple of spots in Antarctica and off the coast of Uruguay.

Some of these hotspots may be linked to the monitoring and forecasting of exceptional floods, climate change adaptation or extreme weather events, such as storms or typhoons. In these cases, interferometry based on radar data is valuable for impact assessment in terms of environment and infrastructure.

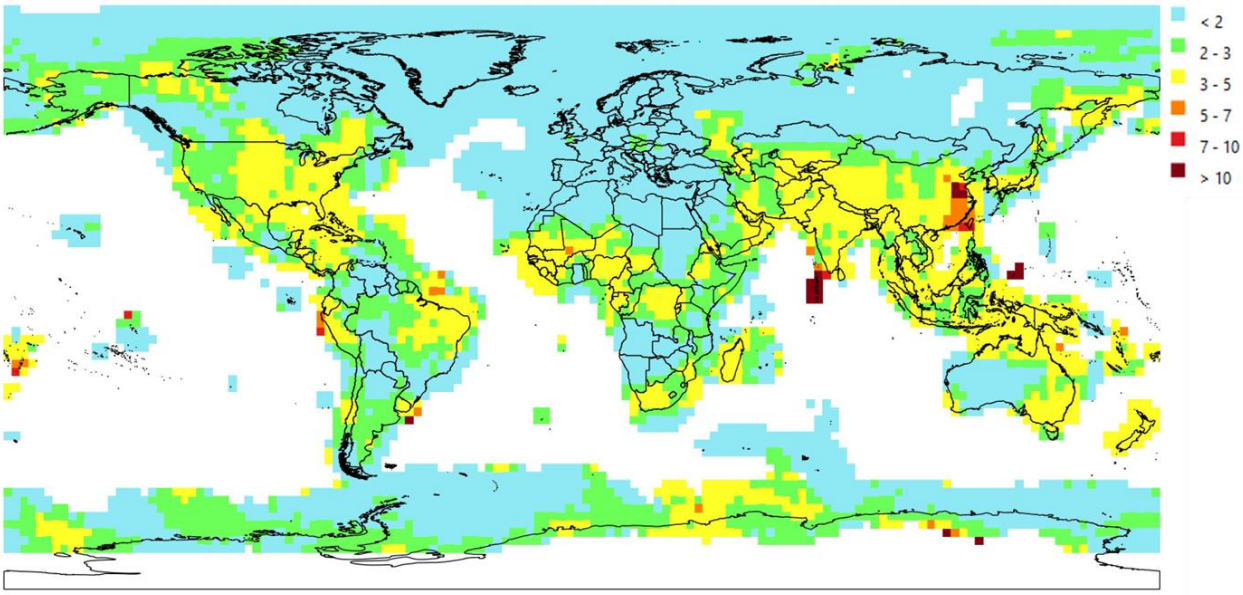


Figure 42: Heatmap showing the archive exploitation ratio for Sentinel-1 Lo and L1 NTC user-level data (excluding WV mode) during Y2023.

Sentinel-2

Level	Number of Published User-level data in 2023	Number of Downloaded User-level data in 2023	Archive Exploitation Ratio
Level 1C	3,691,137	59,486,999	1 : 16
Level 2A	3,689,953	37,910,772	1 : 10

Table 6: Sentinel-2 User-level data Published, Downloaded and AER for Y2023, 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	27,025,804	451,979,568	1 : 17
Level 2A	20,532,715	180,782,112	1 : 9

Table 7: Sentinel-2 User-level data Published, Downloaded and AER since the start of operations, per user-level data type.

Looking at the AERs for Y2023 in Table 6, the AER for Sentinel-2 Level-1C user level data remained the same as it was in Y2022, at 1:16. The AER for Level-2A user-level data remains lower than that for the Level-1C data, but it rose slightly in Y2023, increasing from 1:9 in Y2022 to 1:10 in Y2023. Looking at the overall AERs since the start of operations, again only the AER for the Level-2A data changed compared with Y2022, rising from 1:8 in Y2022 to 1:9 in Y2023.

Figures 43 and 44 indicate the geographical areas of interest for users of Sentinel-2 Level-1C and Level-2A data, respectively, measured by AER. They show how many downloads were made during Y2023 per available data package over specific geographical points across the globe, considering all Sentinel-2 data published since the start of operations. It is noted that all map cells for Level-1C (Figure 43) which had fewer than 300 data packages published within them since the start of operations have been excluded from the AER heatmap, as systematic downloads over them can give a misleading impression of which areas are most popular.

It is interesting to note that this year, the most downloaded Level-1C tiles appear to be those around the Strait of Gibraltar and Morocco, the Seychelles, the Pacific Islands, and Antarctica, with AERs largely in the range 1:5-10 but also reaching 1:>20.

The most downloaded Level-2A tiles appear to be those over the Alps, the Pyrenees, Portugal, Thailand, Antarctica, the Mid-Atlantic Ridge, and the Pacific Islands, with AERs there falling within the ranges of 1:5-10 and 1:10-20.

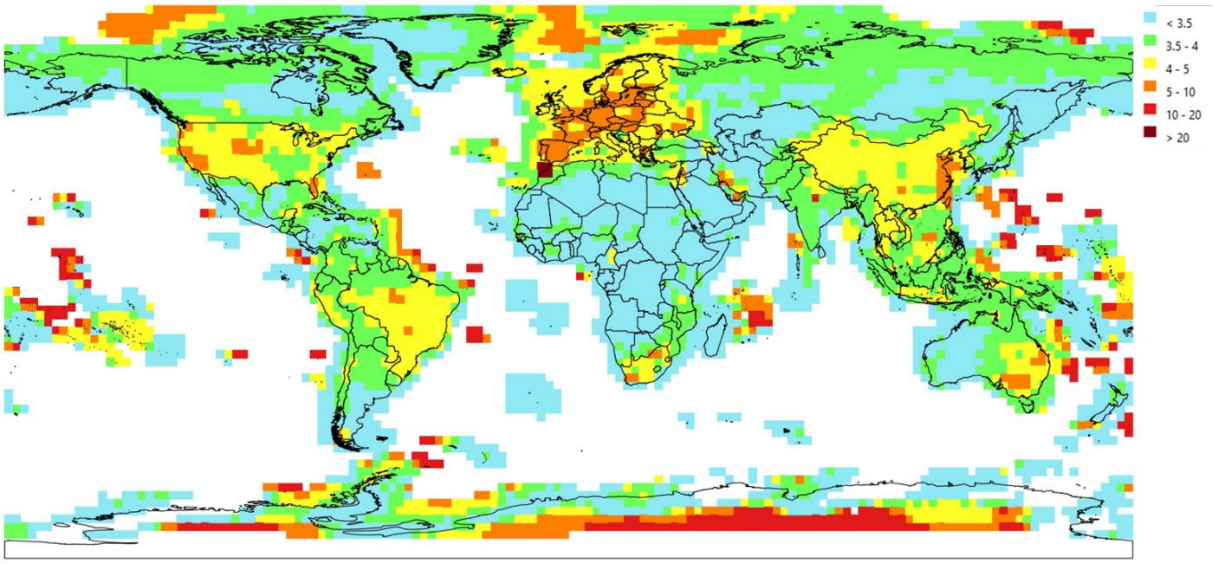


Figure 43: Heatmap showing the archive exploitation ratio for Sentinel-2 L1C user-level data during Y2023.

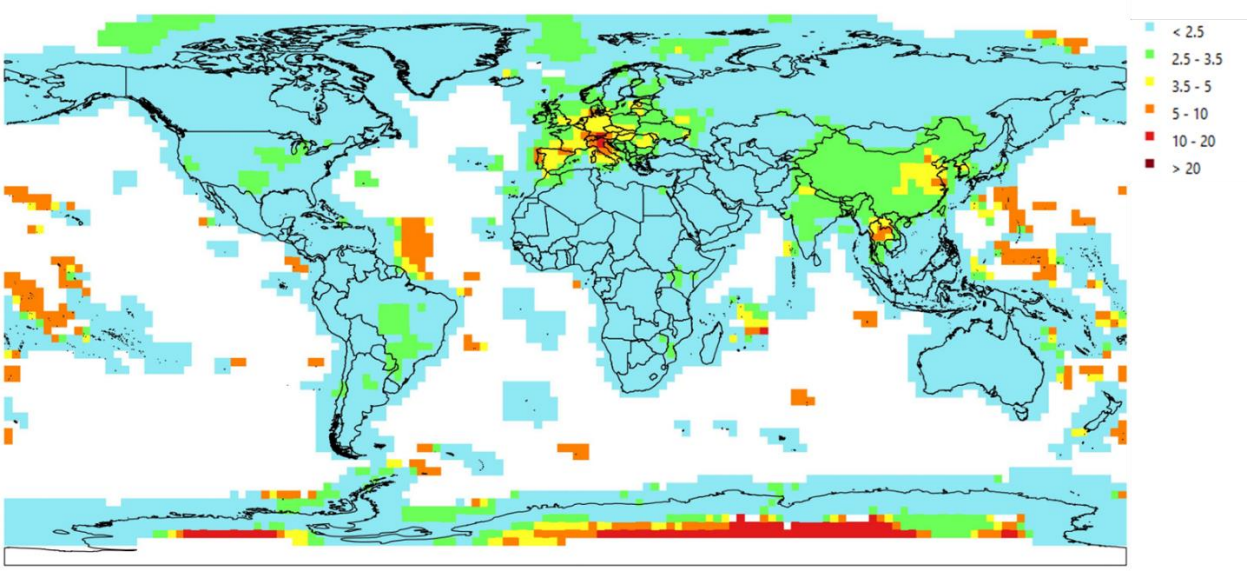


Figure 44: Heatmap showing the archive exploitation ratio for Sentinel-2 L2A user-level data during Y2023.

Sentinel-3

Instrument	Number of Published User-level data in 2023	Number of Downloaded User-level data in 2023	Archive Exploitation Ratio
OLCI	581,237	9,949,231	1 : 17
SLSTR	1,480,448	21,922,345	1 : 15
SRAL	365,123	15,249,956	1 : 42
SYNERGY	310,680	3,129,405	1 : 10

Table 8: Sentinel-3 User-level data Published, Downloaded and AER for Y2023, 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	4,513,676	70,736,045	1 : 16
SLSTR	10,517,306	117,027,415	1 : 11
SRAL	2,356,252	43,983,129	1 : 19
SYNERGY	1,807,005	15,639,500	1 : 9

Table 9: Sentinel-3 User-level data Published, Downloaded and AER since the start of operations, per user-level data group.

As mentioned earlier, the overall AER for Sentinel-3 data since the start of operations reached 1:13, slightly higher than the 1:12 recorded last year. Looking at the individual AERs per data type in Tables 8 and 9, it appears this increase can be attributed to a greater uptake of SLSTR and SRAL data in Y2023 than had been seen in Y2022. In Y2023, SRAL emerged as the most popular Sentinel-3 user level data type, marking a significant shift from the previous year. Its AER ratio surged from 1:30 to 1:42, driven by a remarkable 28%

increase in downloads while publication numbers remained steady. Similarly, the SLSTR AER saw an uptick from 1:11 in Y2022 to 1:15 in 2023. Even though there was actually a decrease in the number of SLSTR products downloaded compared to Y2022, the number of SLTSR products which were published decreased by a greater percentage, leading to an overall rise in the AER. The AER for OLCI remained constant at 1:17, while the SYNERGY AER decreased from 1:11 in Y2022 to 1:10 in Y2023.

Looking at the AER figures for uptake since the beginning of operations, the ratios are very similar to those seen in Y2022, although the big rise in the SRAL Y2023 AER caused the overall SRAL AER to rise from 1:14 in Y2022 to 1:19 in Y2023. The AERs for both OLCI and SYNERGY increased by 1 point, from 1:15 and 1:8 in Y2022 to 1:16 and 1:9 in 2023, respectively; and the AER for SLSTR remained constant at 1:11.

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

SLSTR				
Level	Timeliness	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio
Level 1	NTC	3,276,870	40,522,903	1 : 12
	NRT	2,121,270	24,640,227	1 : 12
Level 2	NTC	2,998,427	38,629,245	1 : 13
	NRT	2,120,738	16,343,368	1 : 8

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

Table 10 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 this, it is possible to see that the increase in the overall SLSTR AER is attributable to an increased interest in the SLSTR Level-2 NTC data, for which the AER rose to 1:13 from 1:10 in Y2022. Downloads for this data type increased by 37% compared to Y2022. Interest in the remaining user-level data types remained steady.

The heatmaps in Figures 45 and 46 show the geographical variation in AER for regions across the globe during Y2023 for SLSTR Level-1 and Level-2 NTC data respectively. Both show that the greatest density of SLSTR NTC data downloads were made over specific geographical points across the globe. For SLSTR Level-1 NTC data, the largest concentration of interest in Y2023 appears over the Colorado River Basin, and the western half of the United States, and an area crossing over northern Australia and eastern Indonesia, where the AERs are in the range 1:7-20.

In comparison to SLSTR Level-1 data, the Level-2 NTC SLSTR data footprints encompass the entire globe with each pass, resulting in a broader coverage and consequently, more regions with an AER of at least 1:4. However, clear areas of interest are still perceptible, and in Y2023 appear to have been the European continent, the southern part of the Mid-Atlantic Ridge and neighbouring countries, and areas in South Brazil, all of which attained AERs in the range 1:12-17.

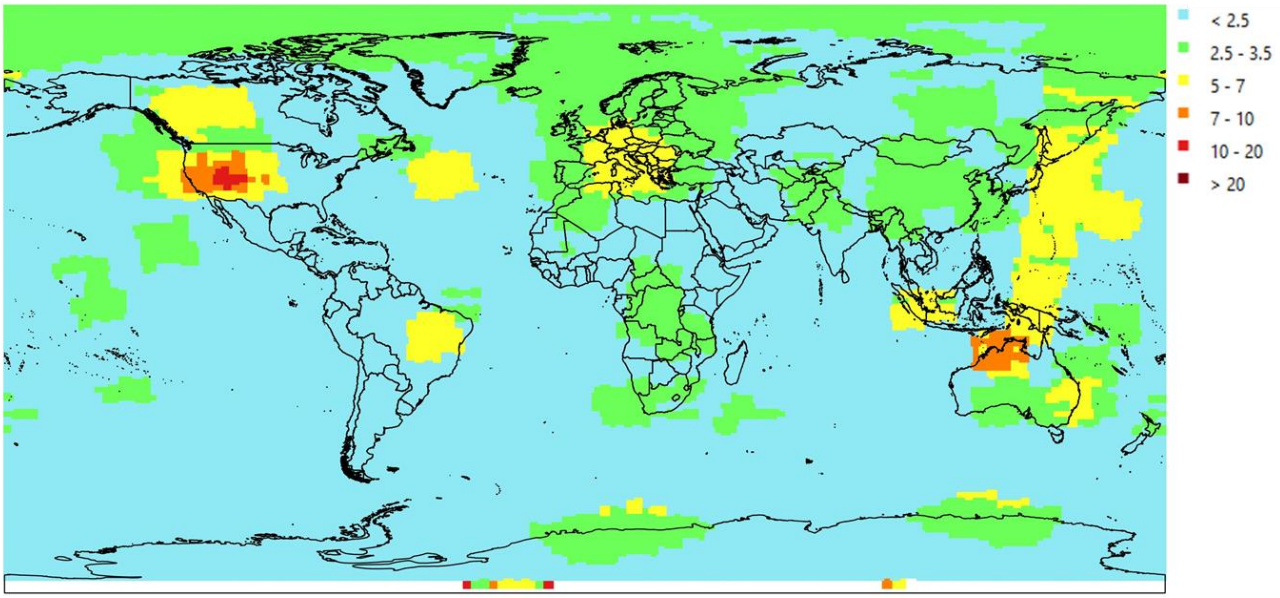


Figure 45: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-1 NTC user-level data during Y2023.

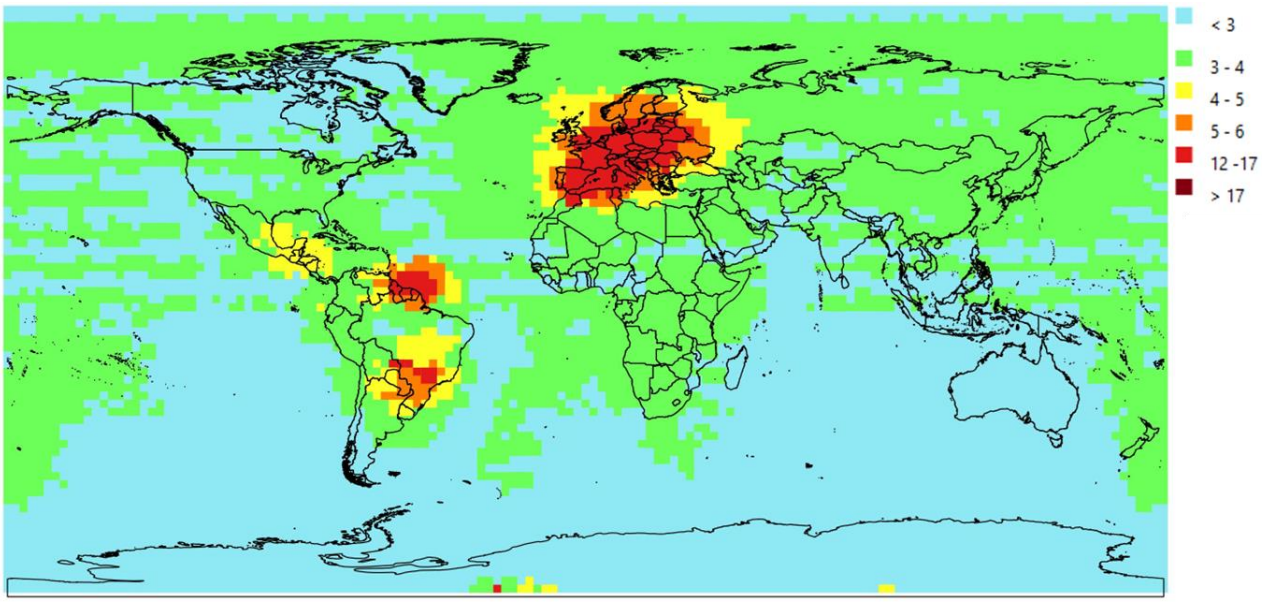


Figure 46: Heatmap showing the archive exploitation ratio for Sentinel-3 SLSTR Level-2 NTC user-level data during Y2023.

Table 11 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.

From this breakdown, the significant increase in the overall SRAL AER is due to a big increase in the AER for the SRAL Level-1 NRT data, which grew from 1:21 in Y2022 to 1:36 in Y2023. This change is attributable to the number of downloads, which rose by 100% in Y2023 (23,060,055 vs 11,528,803). It is interesting to recall that a similar huge increase in uptake for the

SRAL Level-1 NRT data was also noted in Y2022, during which the AER had already risen from 1:11 in Y2021.

SRAL				
Level	Timeliness	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio
Level 1	NTC	430,874	4,429,412	1 : 10
	STC	367,274	2,642,053	1 : 7
	NRT	632,567	23,060,055	1 : 36
Level 2	NTC	254,905	6,024,196	1 : 24
	STC	151,415	1,634,732	1 : 11
	NRT	519,219	6,609,619	1 : 13

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

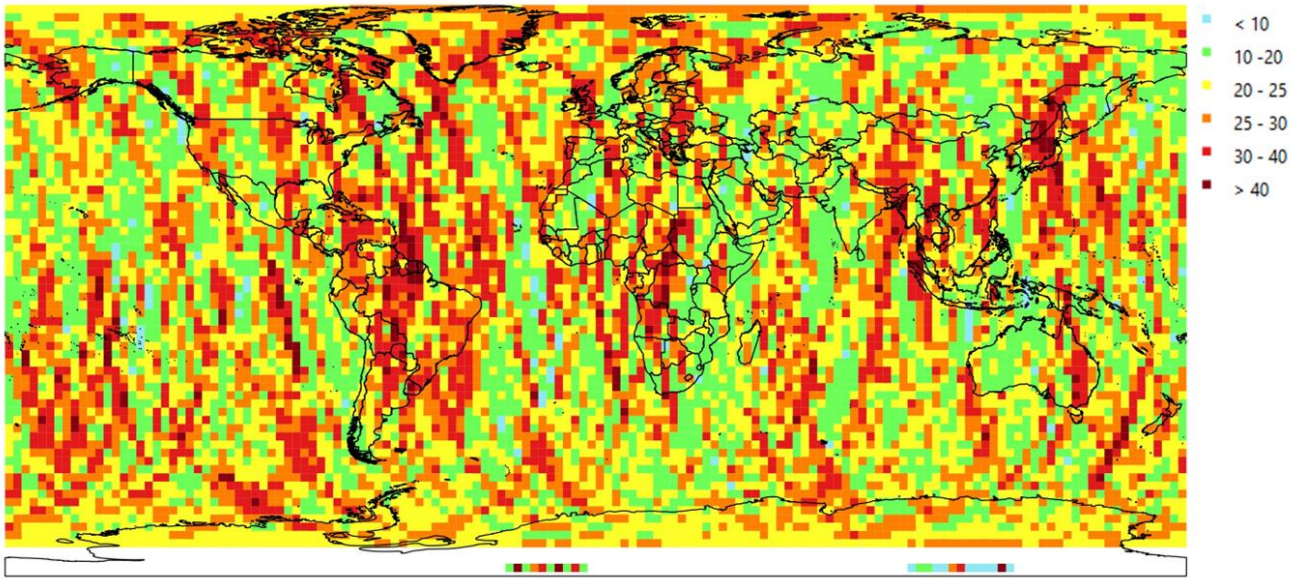


Figure 47: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-1 NRT user-level data during Y2023.

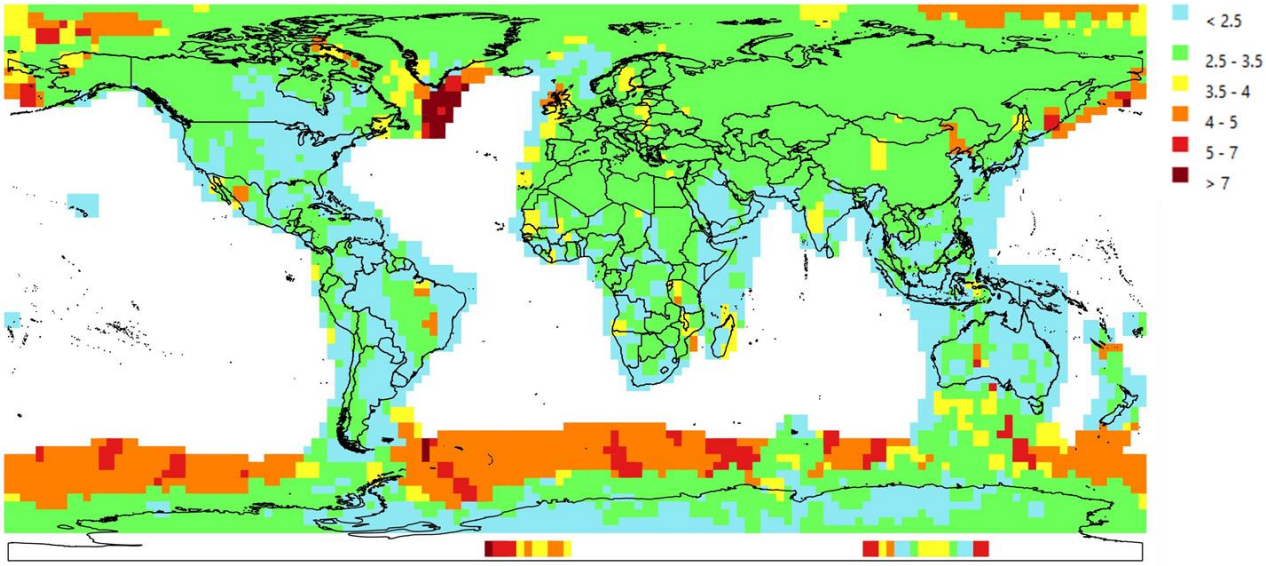


Figure 48: Heatmap showing the archive exploitation ratio for Sentinel-3 SRAL Level-2 NRT user-level data during Y2023.

The heatmaps in Figures 47 and 48 show the geographical variation in AER for regions across the globe during Y2023 for SRAL Level-1 NRT and Level-2 NRT data respectively. For Level-1 NRT, a homogeneous activity can be seen all over the world, over which AERs reach between 1:10 and 1:40, with very few specific hotspots.

The pattern of geographical interest for the SRAL Level-2 NRT user-level data is visible over all landmasses and the Antarctic Sea, all of which reach an AER at the minimum within the range 1:2.5-1:3.5. The regions in red at the borders of the land masses over the Antarctic Sea areas are, perhaps, the result of an artifact generated from the lower number of data published there. However, one definite and notable hotspot lies in the south of Greenland, where the AER reaches 1:>7. It is assumed that this is a result of ice sheet monitoring.

Table 12 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. As noted above, the overall OLCI AER for uptake since the start of operations slightly rose compared to that seen in Y2022, rising from 1:15 in Y2022 to 1:16 in Y2023. Breaking this down into Reduced and Full resolution, the AERs for Y2023 are 1:28 and 1:15, respectively, which aligns with the previous reporting period, with any differences being masked by rounding. The highest AER is attributed to OLCI Reduced Resolution Level-1 NTC data, which increased from 1:14 in Y2022 to 1:38 in Y2023 due to a particularly large increase in the number of downloads (292%). This increase may be the result of the reprocessing baseline released by the end of July 2023.

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	67,567	2,774,422	1 : 41
		NRT	60,667	797,606	1 : 13
	Level 2	NTC	118,045	4,456,975	1 : 38
		NRT	60,228	564,893	1 : 9
	TOTAL		306,508	8,593,896	1 : 28
Full	Level 1	NTC	1,117,027	20,307,459	1 : 18
		NRT	995,748	14,070,756	1 : 14
	Level 2	NTC	1,107,740	19,353,459	1 : 17
		NRT	986,705	8,748,368	1 : 9
	TOTAL		4,207,220	62,480,042	1 : 15

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

The heatmap in Figure 49 shows the geographical variation in AER for regions across the globe during Y2023 for OLCI Full Resolution data. There is interest in OLCI data over the whole globe, with all regions exhibiting AERs of at least 1:>3. Clear hotspots of interest can be seen over eastern China, the east and west regions of the United States and neighbouring coastal areas, South Africa plus neighbouring Botswana and Namibia, and Europe, with a particular peak over the Alps.

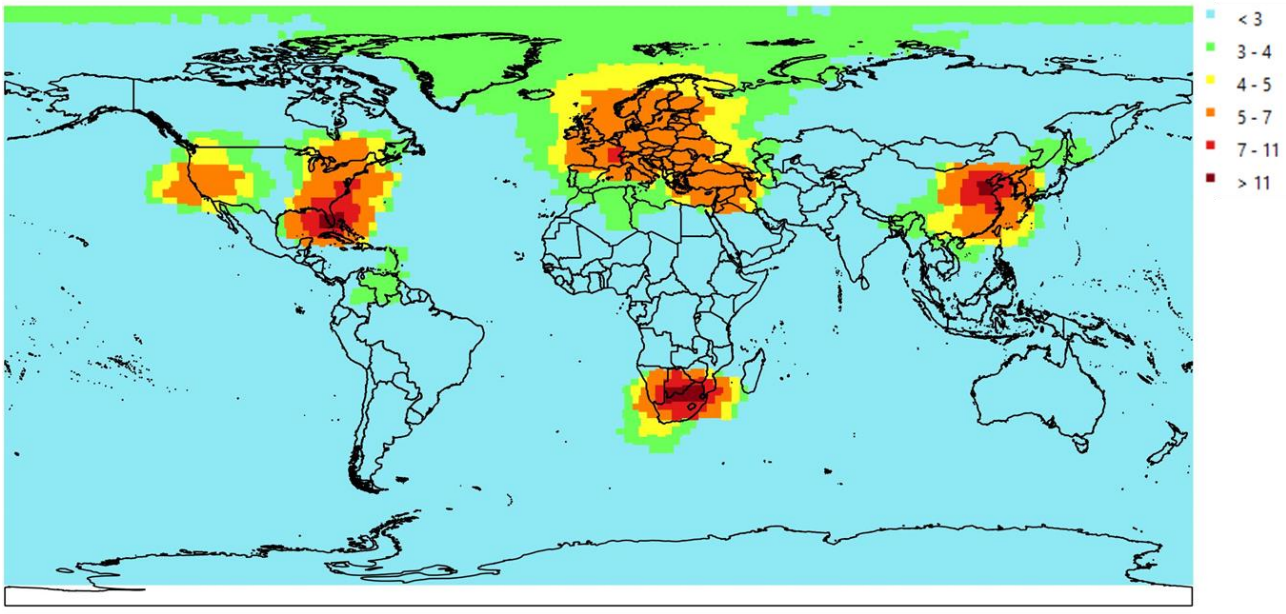


Figure 49: Heatmap showing the archive exploitation ratio for Sentinel-3 OLCI Full Resolution user-level data during Y2023.

Table 13 shows a breakdown of the AER for SYNERGY data, by 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 since start of operations increased by one point to 1:9 in Y2023, and this mild increase can be seen in the AERs for both the NTC and STC OLCI data, with the AER for the NTC data rising to 1:10 (from 1:9 in Y2022) and for the STC data to 1:8 (from 1:7 in Y2022). The increases in the number of data downloaded were 24% and 26% respectively for SYNERGY NTC and STC.

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	912,727	9,308,008	1 : 10
	STC	798,490	6,334,558	1 : 8

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

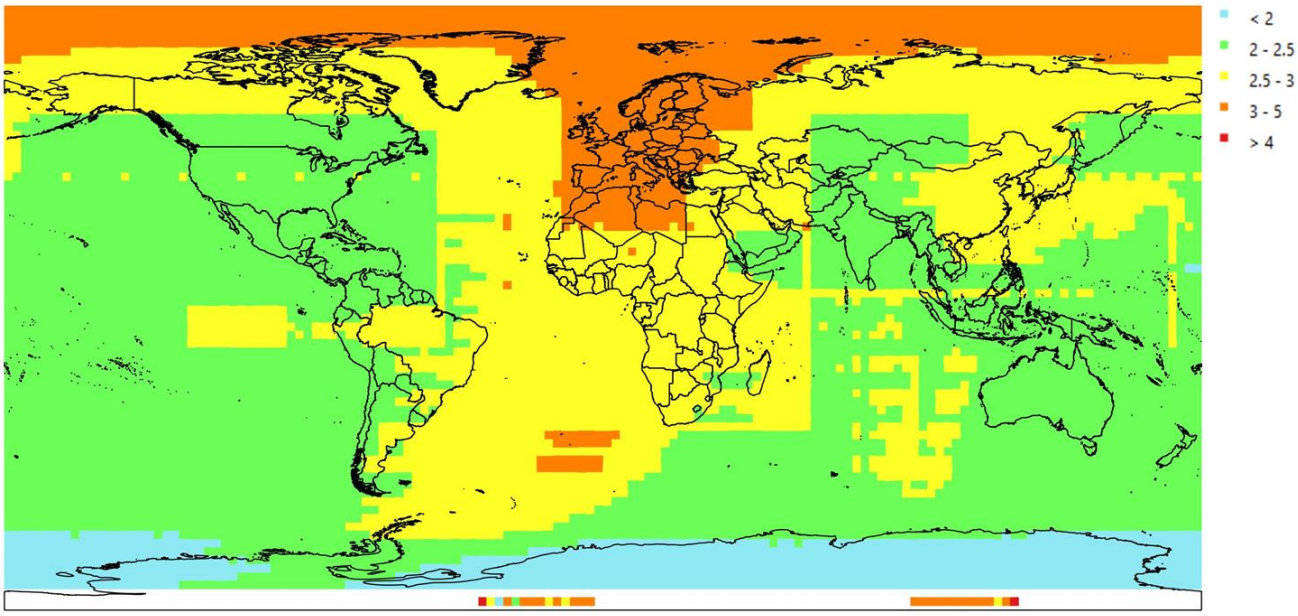


Figure 50: Heatmap showing the archive exploitation ratio for Sentinel-3 SYNERGY user-level data during Y2023.

The heatmap in Figure 50 shows the geographical variation in AER for regions across the globe during Y2023 for SYNERGY data. AERs over most of the landmasses are between 1:2 and 1:3 (green and yellow) with a greater 1:5 across Europe and the Arctic.

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

Sentinel-5P

Level	Timeliness	Product Type	Number of Published User-level data since Start of Operations	Number of Downloaded User-level data since Start of Operations	Archive Exploitation Ratio
Level 1B	NTC	[ALL]	422,937	4,749,131	1 : 11
Level 2	NRT	L2__AER_AI	341,658	9,372,843	1 : 27
		L2__AER_LH	263,313	4,069,237	1 : 15
		L2__CLOUD_	341,253	4,679,087	1 : 14
		L2__CO____	316,743	11,369,260	1 : 36
		L2__HCHO__	326,146	6,848,699	1 : 21
		L2__NO2___	341,097	12,436,096	1 : 36
		L2__O3____	341,056	8,151,943	1 : 24
		L2__O3__PR	123,458	1,942,240	1 : 16
		L2__SO2___	326,140	8,129,640	1 : 25
		[ALL]	2,720,864	66,999,045	1 : 25
	NTC	L2__AER_AI	49,609	1,774,632	1 : 36
		L2__AER_LH	50,482	1,190,008	1 : 24
		L2__CH4___	50,345	5,291,076	1 : 105
		L2__CLOUD_	54,873	1,275,043	1 : 23
		L2__CO____	50,990	3,435,350	1 : 67
		L2__HCHO__	51,300	1,859,386	1 : 36
		L2__NO2___	51,761	4,652,416	1 : 90
		L2__NP_BD3	51,176	771,556	1 : 15
		L2__NP_BD6	50,482	686,353	1 : 14
		L2__NP_BD7	50,401	705,884	1 : 14
		L2__O3____	54,249	1,979,573	1 : 36
		L2__O3__PR	31,938	354,002	1 : 11
		L2__O3_TCL	3,586	142,628	1 : 40
		L2__SO2___	51,605	2,055,585	1 : 40
		[ALL]	652,797	26,173,492	1 : 40
	[ALL NRT + NTC]		3,373,661	93,172,537	1 : 28
Grand Total			3,796,598	97,921,668	1 : 26

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

Table 14 reports a detailed view of the take up of Sentinel-5P user-level data since the start of Sentinel-5P operations. AERs are presented for Level-1B and Level-2 user-level data, for both NTC and NRT and, for Level-2 user-level data, also per individual user-level data type.

The take-up of the Level-1B NTC user-level data appears to have decreased during Y2023, with the AER falling from 1:17 in Y2022 to 1:11 in Y2023.

The overall AER for the Level-2 *NRT* data remained the same as in Y2022, at 1:25, and within each of the individual AERs for the Level-2 NRT data there were only occasional variations, of maximum one point.

By contrast, big variations were seen in the highly exploited Level-2 *NTC* data. The overall AER for the Level-2 NTC data fell sharply from 1:51 in Y2022 to 1:40 in Y2023, and the individual AERs for all except four of the Level-2 NTC data types were lower than they had been in Y2022. Particularly notable were the major drops in the AERs for the L2_CH4 data, which fell to 1:108 from 1:168 in Y2022, and for L2_NO2, which fell from 1:141 in Y2022 to 1:90 in Y2023. These

reductions can be seen in the publication and download figures: for the L2_CH4 methane data, the number of downloads increased by 31% with respect to Y2022, but the number of Level-2 methane data published increased by a massive 109%. Similarly, for the Level-2 Nitrogen Dioxide data, the number of downloads increased by 28% with respect to Y2022, but the amount of data published increased by 102%. The same situation can also be seen for the L2 O3 TCL and SO2 data, with the download numbers increasing by 26% and 28% respectively, but the amount of data published increasing by 108% and 104% respectively. These figures are explained by the reprocessing campaign for these data types which was mentioned in the section on Publication trends (Section 2.2.2), and which led to huge numbers of these Sentinel-5P data being published in March and April 2023.

However, for the reprocessed datasets which had started being released back on 5 December 2022, the AERs increased in Y2023. The AER for the Carbon Monoxide data (L2_CO) increased from 1:60 in Y2022 to 1:67 in Y2023; the AER for the Total Ozone data (L2_O3) went from 1:33 to 1:36, the AER for the CLOUD data (L2_CLOUD) rose from 1:21 to 1:23; and for the Absorbing Aerosol Index (L2__AER_AI) went from 1:33 to 1:36 in Y2023.

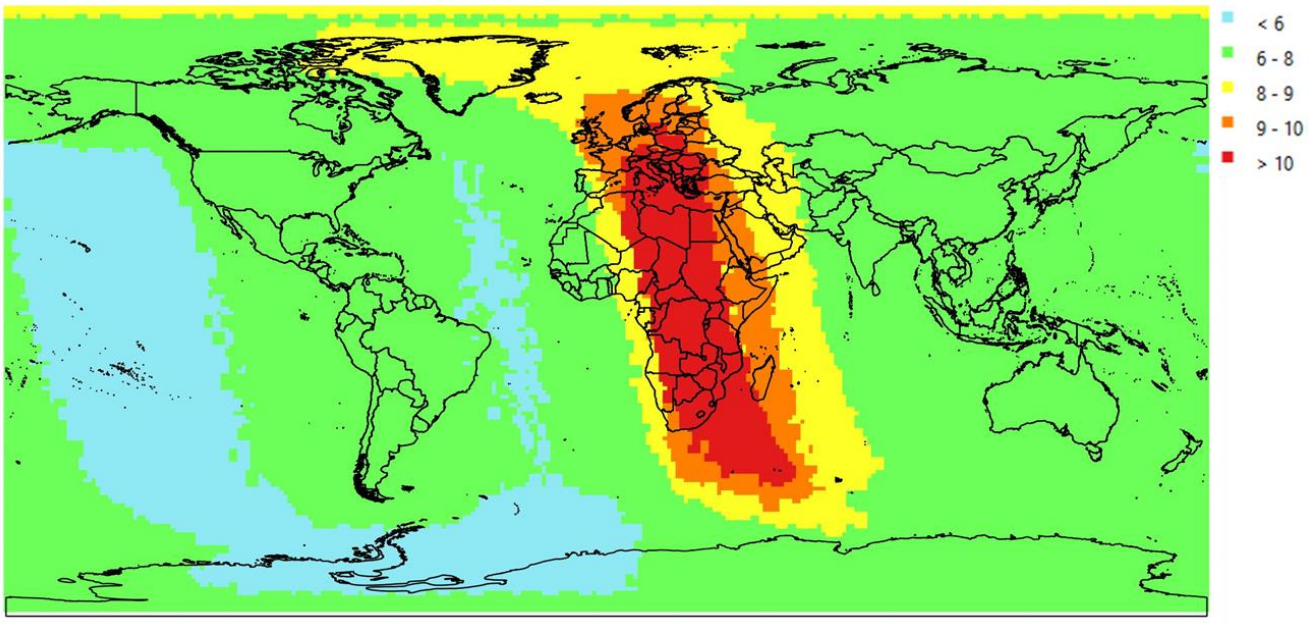


Figure 51: Heatmap showing the archive exploitation ratio for Sentinel-5P NTC (Level-1B & Level-2) user-level data during Y2023.

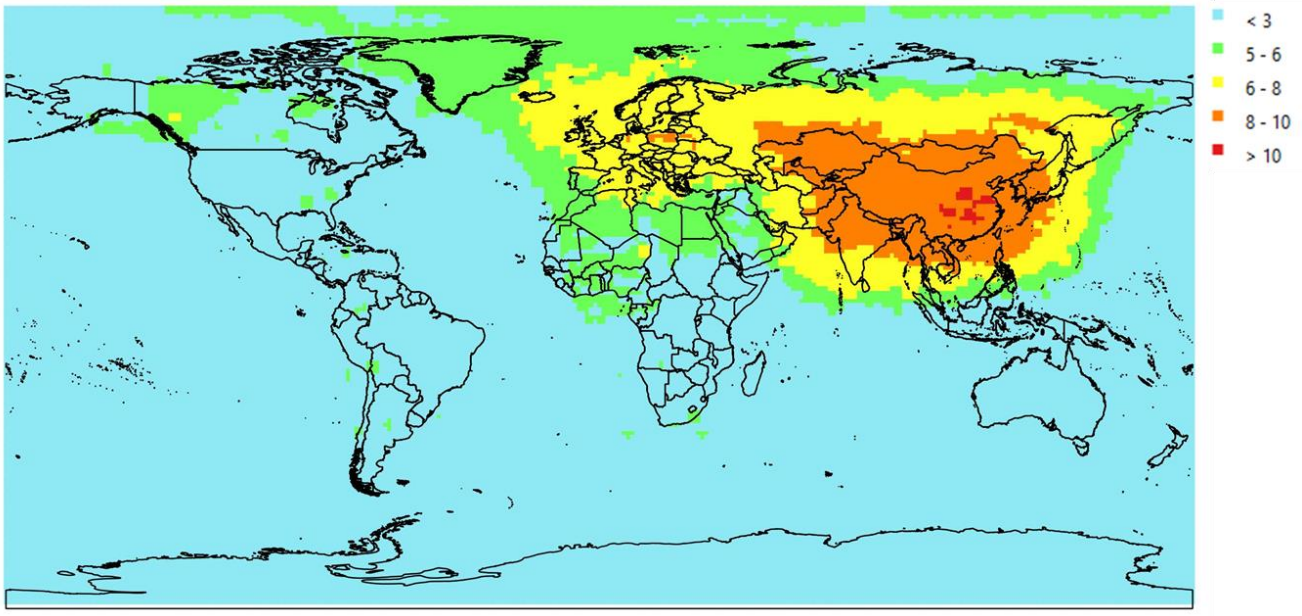


Figure 52: Heatmap showing the archive exploitation ratio for Sentinel-5P NRT (Level-2) user-level data during Y2023.

Figures 51 and 52 show the heatmaps for Sentinel-5P NTC (Level-1B and Level-2) and NRT (Level-2A only) user-level data respectively.

The interest in Sentinel-5P NTC (Level-1B & Level-2) data is very similar to that seen in Y2021 and Y2022, with a very high take-up of the products (1:>10) over Central Europe and stretching all the way down through most of Africa, towards Antarctica.

It is hard to interpret what this actually means, however. Given that the footprint of NTC user-level data encompasses the entire orbit (portion daylight illuminated), it is possible that interest in data over Europe may just extend through Africa to Antarctica, as the result of the footprint of the data, which extends over a large latitudinal range (see Annex 2). Or vice-versa.

It is also worth noting, however, that there is generally high interest in the NTC data over all of the world, with the AER being at least in the range 1:6-8 everywhere other than certain swathes of the Pacific and Atlantic oceans.

For the NRT user-level data, the footprints of which are generally smaller, there is clear heightened interest in the data over Asia, particularly over parts of China, where the AER reaches 1:>10. Interest in the NRT data over Europe is nonetheless also high, with the AERs consistently in the range 1:6-8, and over some small patches of Central Europe, also reaching 1:8-10.

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	475,244,745	51	206.83	43
Collaborative Hub	310,204,192	33	186.21	39
Copernicus Services Hub	99,575,555	11	53.52	11
International Hub	55,645,905	6	33.61	7
All hubs	940,670,397		480.16	

Table 15: Number and Volume of user-level data downloaded since the start of operations, per hub.

In this section, the overall download figures are broken down by hub, to analyse the user activity on each hub. Within the context of the Data Access System, the hubs can be seen as macro-level users, and the following statistics can be used to an extent to examine different user behaviour.

The hub which has experienced the greatest load of download requests since the beginning of operations remains the Open Hub, having supported 51% of all downloads by number and 43% by volume since the beginning of operations, the same proportions as shown in Y2022. These percentages reflect the substantial interest among the general public in Copernicus Sentinel data which has persisted throughout the operations of the Data Access System.

ColHub has supported the second highest number and volume of downloads since the start of operations, with a 33% share by number and a 39% share by volume, marginally higher than its 32% and 38% share in Y2022. The proportion of downloads made from ServHub and IntHub are also very consistent with Y2022, with only the share of the download volume changing slightly for ServHub, reducing from 12% in Y2022 to 11% in Y2023.

Table 15 shows the average daily volume of downloads handled by each hub during October 2023, compared with corresponding value for December 2022, and the percentage change from one year to the next. The average total daily volume of data downloaded by users across all hubs was almost equal in October 2023 and in December 2022, at 233.70 TiB/day in October 2023 compared to 233.52 TiB December 2022, constituting just a 0.1% increase.

At the level of the individual hubs, the most notable figures include a 14% decrease in the daily average volume of downloads made from the Open Hub in December 2023 compared to December 2022, and a 16% decrease in the daily average volume of downloads from IntHub. By contrast, there was a 19% increase in the daily average volume of ColHub downloads in December 2023 compared to December 2022, the same percentage increase which was seen between December 2022 and December 2021. The daily average volume of downloads from ServHub also increased with respect to December 2022, by 11%.

Hub	Daily average volume (TiB) downloaded in October 2023	Daily average volume (TiB) downloaded in December 2022	% increase
Open Access Hub	97.53	113.59	-14%
Collaborative Hub	101.76	85.46	19%
Copernicus Services Hub	22.51	20.31	11%
International Hub	11.90	14.16	-16%
All hubs	233.70	233.52	0%

Table 16: Average volume of data disseminated per day during the last month of Y2023 and Y2022.

Overall, there was a difference of -5% in the download volume disseminated by all hubs during Y2023 (74.5 PiB) compared with Y2022 (78.7 PiB).

The overall yearly download volume from each of the hubs is broken down in Figure 53 by Sentinel mission. 34.1 PiB of data were downloaded from the Open Hub in Y2023, less than the 36.04 PiB which were downloaded from the Hub in Y2022, but more than the 33.5 PiB downloaded from the Hub in Y2021. The Open Hub shows the greatest variation with respect to Y2022 in the volume of Sentinel-1 which was downloaded, with a 24% decrease. The volume of Sentinel-2 downloaded from the Open Hub also decreased by 9%, whereas the volume of Sentinel-3 and Sentinel-5P downloads increased by 3% and 25% respectively. Sentinel-2 remained by far the most downloaded mission from the Open Hub.

There was also a decrease in the volume of Sentinel-1 data downloaded from ColHub, falling by 12% with respect to Y2022, while the download volumes of Sentinel-2 and 3 slightly increased by 5% and 2% respectively. At 30.3 PiB, the overall volume downloaded from ColHub in Y2023 remained very consistent with the volumes downloaded in Y2022 (30.16 PiB) and Y2021 (30.03 PiB).

Only 6.6 PiB was downloaded from ServHub in Y2023, continuing the downward trend which had been seen in Y2022, when the download volume had already fallen from 9.9 PiB in Y2021 to 8.4 PiB. Big decreases can be seen in the download volume for each of the missions compared to Y2022: the volume of Sentinel-1 downloads decreased by 34%, Sentinel-2 by 16%, and Sentinel-3 by 26%.

The same downward trend is visible for IntHub, from which a total of 3.5 PiB was downloaded in Y2023, compared to 4.1 PiB in Y2022 and 6.4 PiB in Y2021. At the level of the individual missions, though, it was only the volume of Sentinel-2 downloads from IntHub which decreased compared to Y2022 (down 24%), whereas there was an increase in the download volumes for Sentinel-1 and Sentinel-3, by 10% and 24% respectively.

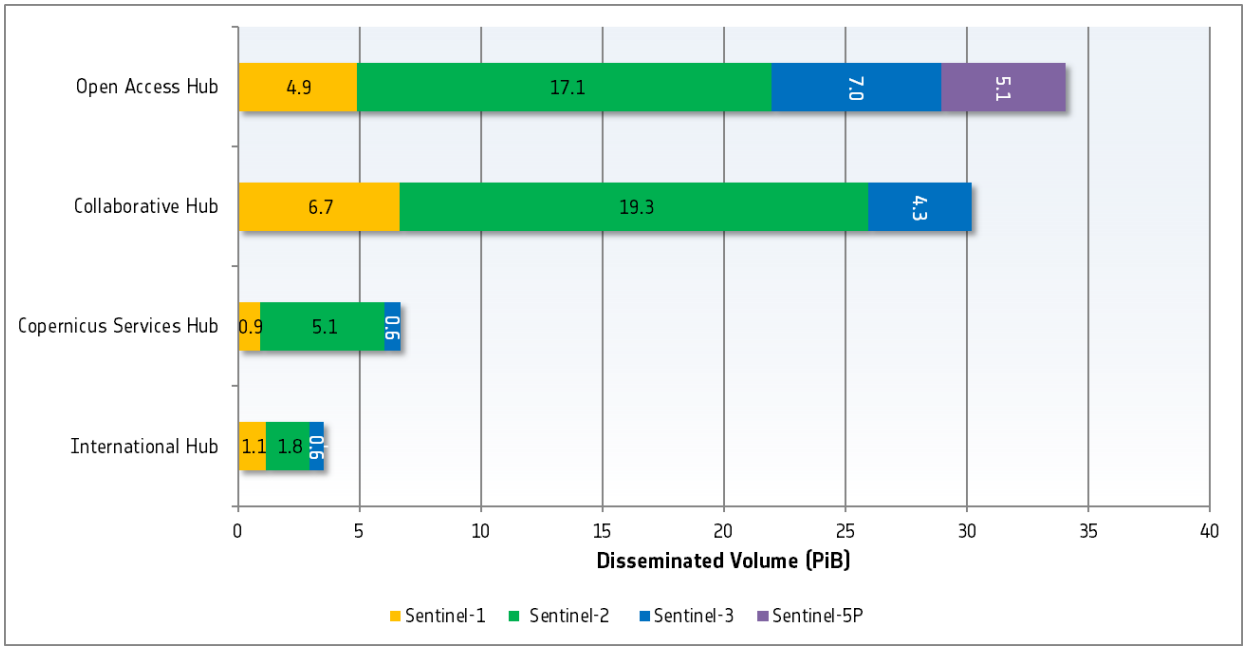


Figure 53: Downloaded volumes (PiB) during Y2023 per Hub and per Mission.

The figures below separate out, for each Sentinel mission, the total numbers of data downloaded from each hub to show the percentage share of the downloads for each 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

As illustrated in Figure 54 below, the most frequently downloaded Sentinel-1 data type overall from all hubs during Y2023 was the Level 1-GRDH, as in previous years. It made up 36% of all Sentinel-1 downloads from all hubs, indicating a great user interest for applications that involve monitoring large-scale surface changes, terrain analysis, agricultural monitoring etc. In particular, on ServHub Level-1 GRDH downloads accounted for 70% of the total Sentinel-1 downloads. This represents also an increase with respect to Y2022, when Level-1 GRDH data constituted 61% of the total number of Senitnel-1 data downloaded from ServHub.

The second most downloaded Sentinel-1 data type (by number) was the Level-2 OCN data, with a 26% share of the downloads from all hubs. Individually, Level-2 OCN data constituted 37% of all downloads from the Open Hub, which is very nearly the share of Level-1 GRDH from the Open Hub (38%).

Level-1 SLC ranks third, with a 22% share of the Sentinel-1 downloads from all hubs. The highest percentage share was seen on ColHub, where Level-1 SLC data downloads constituted 31% of all of the Sentinel-1 downloads from that Hub.

Level-0 RAW and Level-1 GRDM data account for 11% and 5% respectively of the Sentinel-1 downloads from all hubs. For the Level-0 RAW data, it was still on IntHub where the greatest percentage share was seen, with the Level-0 RAW data accounting for 20% of all Sentinel-1 downloads made from IntHub in Y2023.

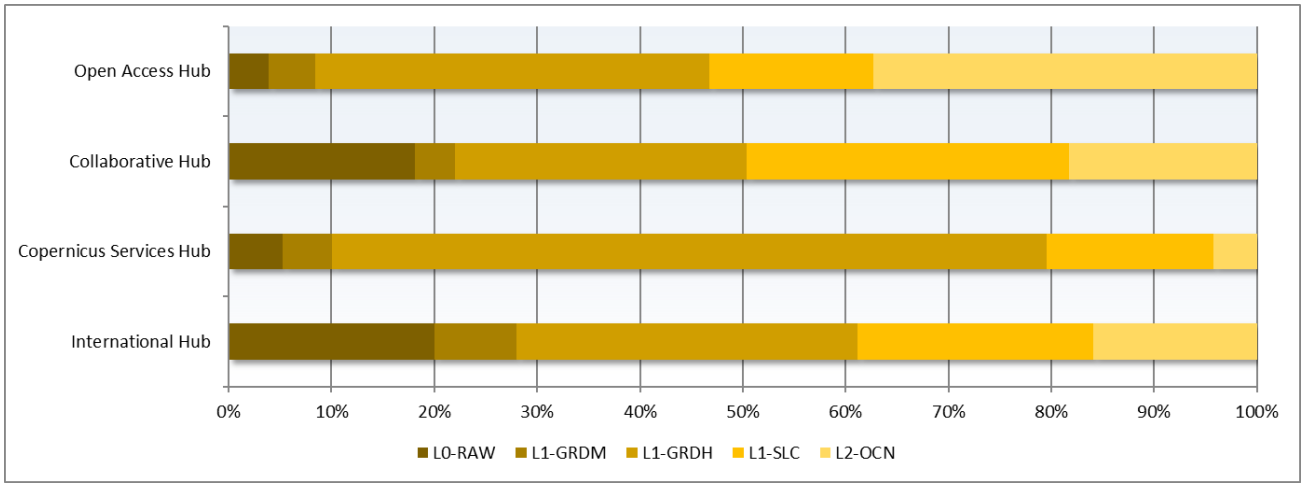


Figure 54: Percentage of total number of Sentinel-1 user-level data downloaded from each hub during Y2023 per user-level data type.

Sentinel-2

For Sentinel-2, the split between Level-1C and Level-2A downloads from all of the hubs is 63% vs 37% respectively, indicating that there is still a great interest in Level-1C data in the user community.

On IntHUb and ServHub, this weighting in the interest is particularly pronounced, with Level-1C downloads accounting for 81% and 68% respectively of the total Sentinel-2 downloads made from those hubs.

On the Open Hub, the relative split between the Sentinel-2 data types was 58% vs 42% in favour of Level-1C, but with the proportion of interest in Level-2A data having increased from 34% in Y2022. The split for ColHub was 63% vs 37%, very similar to Y2022.

These figures indicate that, in general, users prefer flexibility regarding processing, and probably apply their own corrections or algorithms tailored to their specific needs. Without pre-processed atmospheric correction, users have more control over the processing steps and can customize them according to their analysis requirements. It appears there is more limited demand for pre-processed datasets, considering that Y2023 is the fifth year of Sentinel-2 L2A systematic publication and the download proportions still do not match those of the Level-1C data.

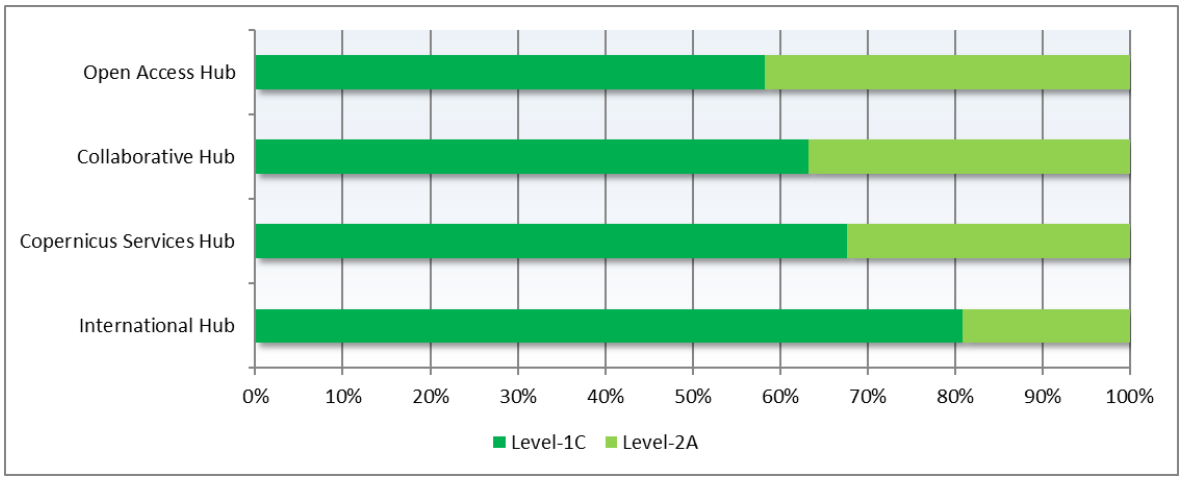


Figure 55: Percentage of total number of Sentinel-2 user-level data downloaded from each hub during Y2023 per user-level data type.

Sentinel-3

There were 19 Sentinel-3 data types published in Y2023, with no introduction of new data types for Sentinel-3 with respect to Y2022. SY_1_MISR__, which was previously only provided on the S3 Expert Hub, has been excluded from the current figures.

The first graph in Figure 56 shows the percentage split of the overall number of Sentinel-3 data downloaded from each of the four hubs per data type. Given that individual user-level data types can be hard to distinguish on this scale, however, the second graph 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 types (SY_2_SYN___ and SY_2_AOD__) are available on IntHub.

Once again, most downloads were accounted for by SLSTR and OLCI user-level data, which together ranged from 94% to 51% of Sentinel-3 downloads from each hub apart from the Open Hub. On the Open Hub, however, it was SRAL data downloads which significantly outweighed the other types, constituting 46% of the total Sentinel-3 downloads from the Open Hub, an even higher proportion than was seen in Y2022, when it had constituted 33% of the total number but had still become the most frequently downloaded Sentinel-3 data from the Open Hub for the first time. SLSTR accounted for 34% (43% in Y2022), OLCI for 17% and SYNERGY for only 3% of the total Sentinel-3 data downloads from the Open Hub. Interestingly, the proportion which constituted SRAL data on the other hubs remained low, ranging from 3% (IntHub) to 13% (ColHub), very similar to Y2022.

Regarding OLCI, it was the most frequently downloaded datatype on ServHub, from which it constituted 52% (49% last year) of the Sentinel-3 downloads. On ColHub and IntHub, SLSTR was the most popular data type, with 55% (54% last year) and 66% (54% last year) respectively for each hub.

SYNERGY data still constitute a small proportion of the Sentinel-3 downloads from each hub, ranging between 1% (ServHub) to 12% (IntHub). Perhaps this again indicates that the user community prefers to process data itself, given that this was the fifth year of systematic production of the SYNERGY data.

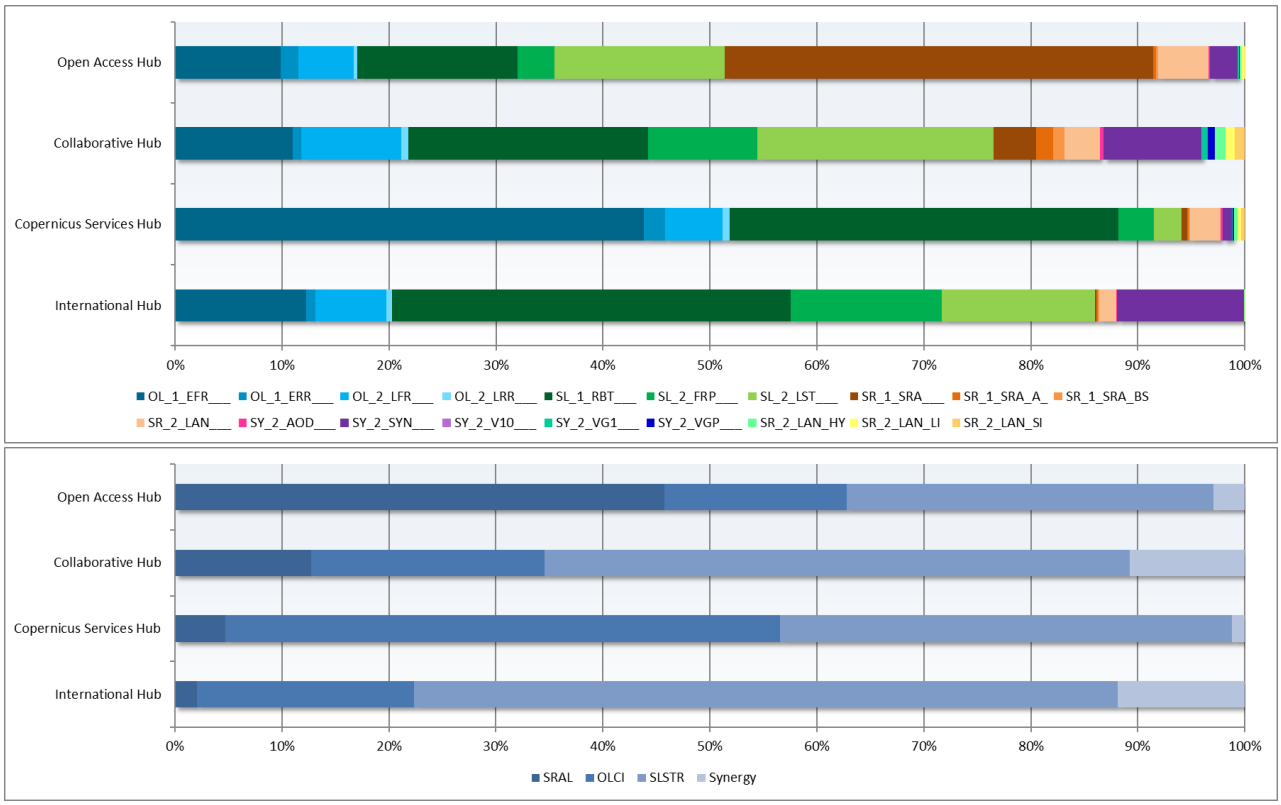


Figure 56: Percentage of total number of Sentinel-3 user-level data downloaded from each hub during Y2023 per user-level data type (graph 1) and user-level data group (graph 2)

Sentinel-5p

Sentinel-5P generates so many different data types that the respective download percentage per data type is hard to show in a meaningful way. Figure 57 shows instead the download split for the two data levels: Level-1B and Level-2. The download split is 6% (3% last year) for Level-1B and a massive 94% Level-2 (97% last year).

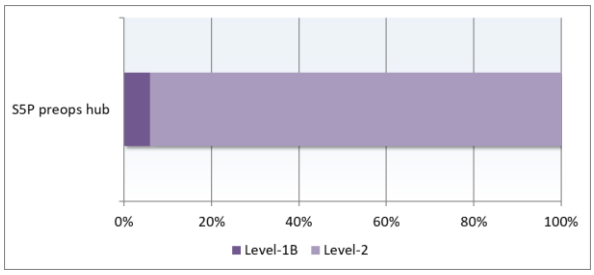


Figure 57: Percentage of total number of Sentinel-5P user-level data downloaded from S5p Hub during Y2023 per data level.

Overall Monthly download figures

The graph in Figure 58 below shows the monthly volume of data downloads made from each hub during Y2023, with the average monthly volume and number of downloads made on each hub during Y2022 included for comparison. In the graph, the x-axis extends to December 2023, despite the reporting period concluding on October 31, 2023. This extension allows for a proper comparison with the average values relative to Y2022.

Throughout all hubs, the number of downloads peaks in March 2023, whereas the volume of downloads peaks in April 2023. There is then a sharp decline in the number of data which was downloaded from the Open Hub in September 2023, and this was followed in October 2023 by similarly sharp drops in the numbers being downloaded from the other hubs, presumably as more and more users started migrating completely to the CDSE. It is curious, however, that the steep drops in the number of products downloaded in September and October were not matched by similar drops in the volume downloaded in those months. It is suggested that the sharp drops in number must have been provoked primarily by users ceasing to download the smaller volume data packages, therefore, such as Sentinel-5P data and Sentinel-2 data.

The average monthly volume of downloads was slightly lower than for the previous year from the Open Hub and ServHub. The figures for the Open Hub show the most significant decrease. The average monthly number decreased by 14%. The average monthly volume, however, remained more or less constant at -1%.

The average monthly download figures for ServHub show a downward trend throughout 2023, resulting in a decrease of -4% in the average monthly download *number* compared to the average in Y2022. In terms of the average monthly *volume* downloaded from ServHub, it was the same as in Y2022.

From IntHub, there was a 1% decrease in the average monthly number of data downloaded, but there was an 8% increase in the average monthly volume, compared to Y2022.

By contrast, ColHub is the only hub with the opposite trend. The average monthly number of downloads increased by as much as 23% compared to the average in Y2022. However, the monthly average volume downloaded remained the same as in Y2022. This pattern could be explained by the ongoing presence of the ColHub, now represented by the Collaborative ESA Node Service following the closure of the overall Data Access System Service.

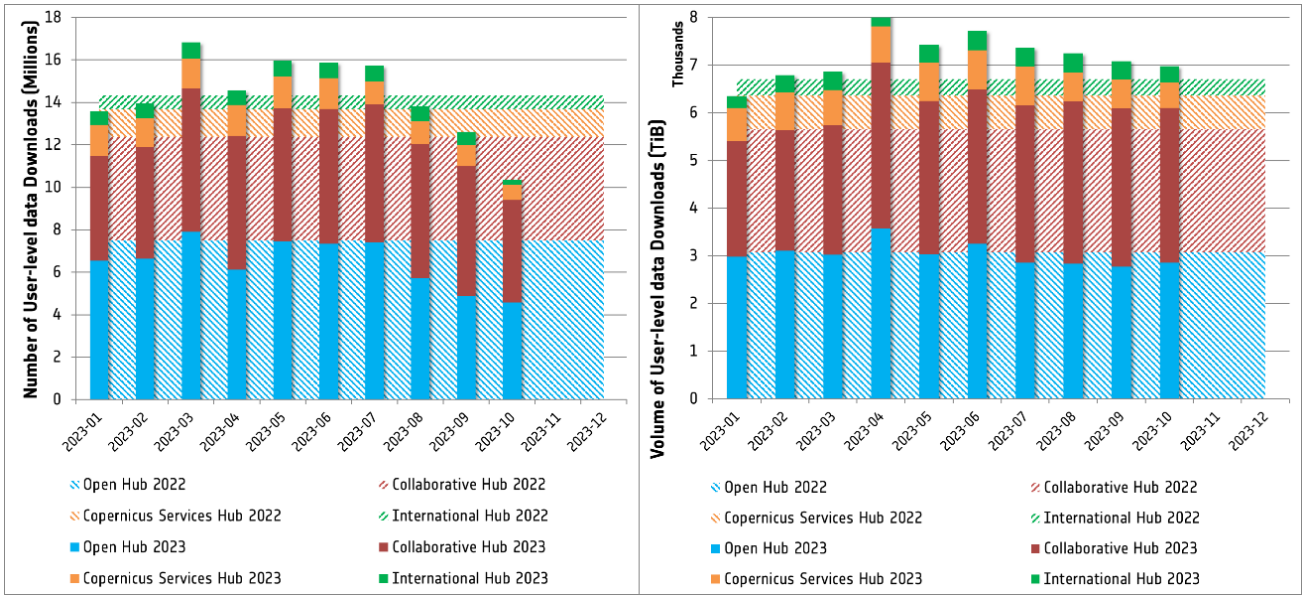


Figure 58: Dissemination volume trend per hub during 2023 (entire 12-months cycle), with Y2022 averages for comparison.

Collaborative Hub focus

Table 17 sets out the amount of data downloaded from each of the three Collaborative nodes in Y2023.

The three nodes handled a remarkably similar share of the total number of data downloaded from ColHub, with the Greek centre (Node 3) just boasting the highest share at 39% of the total number of downloads requested from ColHub.

Of the Sentinel missions, Sentinel-2 was the most frequently downloaded across the three nodes, accounting for 69% of downloads from Node 1, 64% from Node 2, and 83% from Node 3. Meanwhile, Sentinel-3 accounted for 22%, 27% and 39% of the downloads from the three nodes. The least downloaded data was Sentinel-1 data, with shares falling below 10%.

Total Number				
Hub	**Sentinel-1**	**Sentinel-2**	**Sentinel-3**	**Total**
CollHub Node 1	1,600,129	12,627,111	4,053,799	**18,281,039**
CollHub Node 2	1,410,106	11,778,108	4,871,548	**18,059,762**
CollHub Node 3	1,038,463	15,129,775	7,056,241	**23,224,479**
Total	**4,048,698**	**39,534,994**	**15,981,588**	**59,565,280**

Total Volume PiB				
Hub	**Sentinel-1**	**Sentinel-2**	**Sentinel-3**	**Total**
CollHub Node 1	2.7	5.8	1.2	**9.7**
CollHub Node 2	2.5	5.9	1.2	**9.6**
CollHub Node 3	1.4	7.6	1.9	**10.9**
Total	**6.7**	**19.3**	**4.3**	**30.2**

Table 17: Number and Volume of data downloads per ColHub node and Sentinel mission during Y2023.

Similarly, in terms of data *volumes*, the highest proportion was downloaded from the Greek centre (Node 3), which supported a 36% share of the total download volume, while Node 1 and 2 both accounted for 32%. In terms of the individual missions, Sentinel-2 downloads constituted 69% of the download volume on ColHub Node 3, followed by 62% on Node 2 and 60% on Node 1. Sentinel-1 accounted for 28%, 26% and 13% respectively for Node 1, 2 and 3; Sentinel-3 accounted for the lowest share of the

download volume from the nodes, with 18% from Node 3, and a 12% share of the download volume from both Nodes 1 and 2.

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 roughly **179 million** data packages have been downloaded by the DIAS service providers, comprising a total volume of **105.9 PiB**. In terms of the proportion of all downloads on all hubs since the start of operations, DIAS downloads accounted for 16% by number and 18% by volume, the same as in the previous reporting period. During Y2023, 8.2 PiB of data was downloaded from DIAS Hub, with the split between the individual missions shown in Figure 59. The percentage split between Sentinel-1/Sentinel-2/Sentinel-3 is 16%/74%/10%.

In terms of the average daily download volume, an average of 27.7 TiB were downloaded per day during Y2023, an increase from the 24.1 TiB average daily download volume in December 2022. This was also more than the average daily volume downloaded from either ServHub or IntHub, but less than the average daily volume downloaded from Open Hub or ColHub.

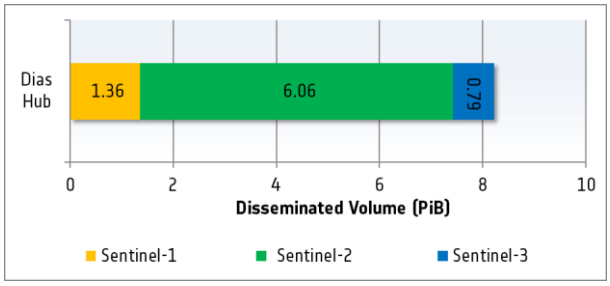


Figure 59: Disseminated volumes (PiB) during Y2023 per Mission on the DIAS Hub.

2.3.4 Fresh vs Old User-level data

An interesting aspect of download trends is the level of user interest in data categorized as "fresh" or "old", based on their publication dates. In the following analysis, this trend is examined individually for each mission and hub. This examination offers insights into the degree to which users are interested in historical data as well as the newly published data, which helps when making decisions about data archiving.

In the following discussion, the term "data age" is used to denote the time difference between the publication date and the download date of an individual data package.

The graphs in Figure 60 below show, for each Sentinel mission and per hub, the percentage of downloads during Y2023 for data within the following six data age ranges:

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

The graphs reveal a pattern similar to that seen in previous years, with a strong inclination towards newer data over older data. This trend is unsurprising for several reasons. Firstly, many user applications are based on having the most recent data because the need is to know what is happening as close to the actual point in time as possible, such as for sea-ice monitoring for shipping routes, ground motion, disaster response etc. Secondly, most large-scale downloaders likely already possess the older data they require, with their downloads primarily focusing on accessing the latest available data. Additionally, as operational processes mature, both the infrastructure supporting downloads and users' expertise in optimizing download procedures improve. Consequently, users become more adept at obtaining data while it is still considered 'fresh'.

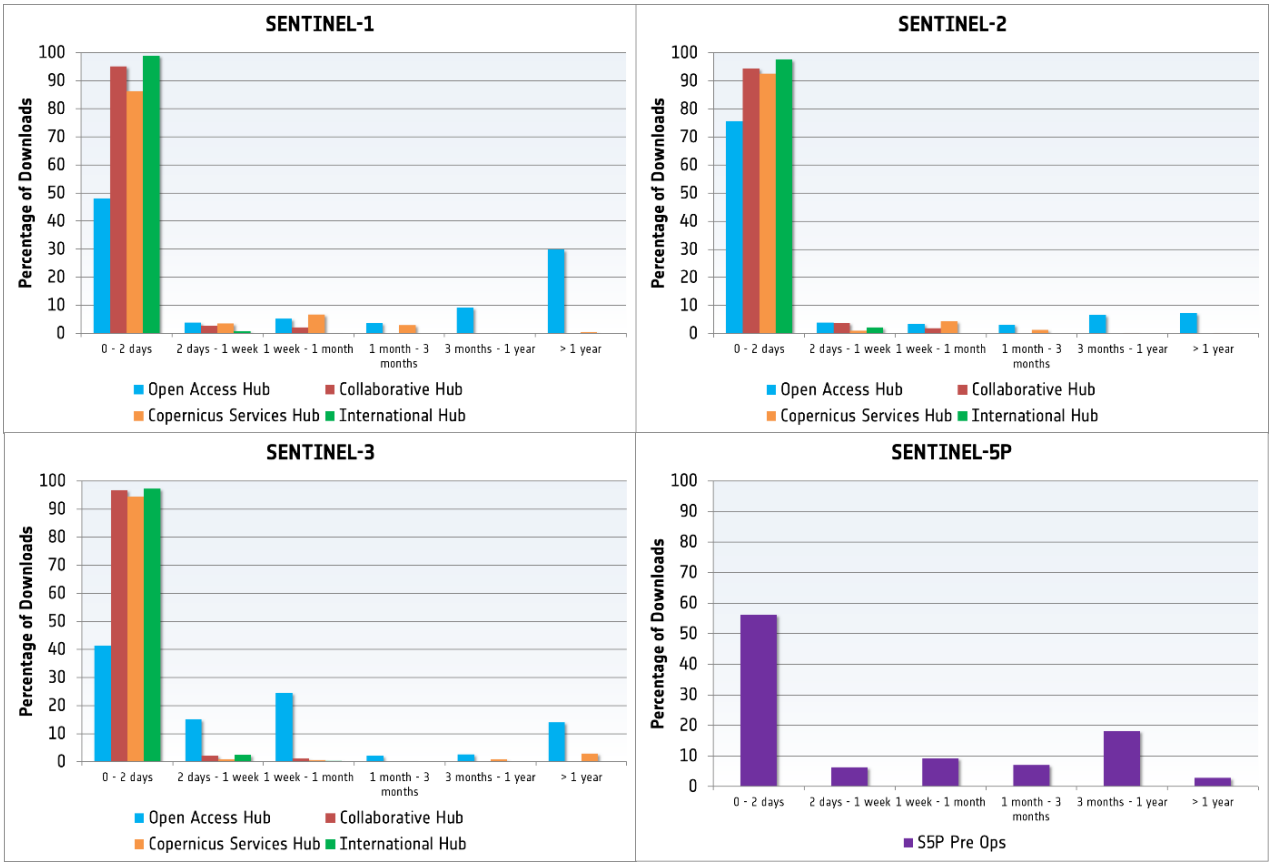


Figure 60: Percentage of Y2023 downloads per user-level data age range each Sentinel mission and per Hub.

However, the picture is slightly less marked than it was in Y2022. While the emphasis on obtaining fresh data is very pronounced on ColHub, ServHub and IntHub, with minimal percentages of data acquired outside the 0-2 day range for each of the Sentinel missions, it is less marked on the Open Hub. On the Open Hub, there was a notable increase in the proportion of data downloaded which was older than 3 months, across all missions. This figure is particularly clear for Sentinel-1, for which almost 30% of Sentinel-1 downloads had a data age of > 1 year from publication, and 9% within the 3 months – 1 year range. Also for Sentinel-3, as much as 25% of the data downloaded had a data age within the 1 week – 1 month range, and 15% within the 2 days – 1 week range. In fact, only 41% of the Sentinel-3 data downloaded from the Open Hub was in the range 0-2 days, the lowest percentage of all the missions. For Sentinel-5P, only approximately 55% of the data downloaded was in the range 0-2 days. The second most popular data age for Sentinel-5P was the 3 months – 1 year range, with 18% of the Sentinel-5P downloads being made in that range. The mission with the highest percentage of data downloaded from the Open Hub within the 0-2 days range was Sentinel-2, for which as much as 76% of the data downloaded was within the 0-2 days range.

There remains a clear need, therefore, for archiving systems to accommodate diverse user preferences and utilization patterns, ensuring that historical data remains accessible and relevant alongside newer datasets.

2.3.5 Nearline Data Retrievals

In Y2023, nearline data retrievals continued to be based on an interface which retrieved the data from a DIAS infrastructure and unsealed 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 meant older data could be removed from the online data store (i.e. moved nearline), and users could request access to these nearline data via the standard interfaces, with all data remaining available to all users. However, with the nearline retrieval there was some amount of

unavoidable time delay following the request, while the data were retrieved from the archive. The threshold for this time delay was 24 hours, although in practice it was usually delivered back online much more quickly. Once retrieved and restored on the hub, the data were then available online to all users to download, for a limited amount of time (at least 3 days), following which the data were put offline again. A user quota on the maximum number of data retrieval requests per hour was 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 were available for all data hubs except the IntHub.

Nearline data retrieval per mission

During Y2023, the rolling policy governing the period in which each of the published data remained online was tuned to satisfy user demand and to optimize the functionality which enabled the data retrieval from the nearline data storages. As illustrated in Figure 61, by the end of Y2023, a total of 68.6 PiB of data were available nearline for retrieval, consisting of 22.3 PiB from Sentinel-1; 41.8 PiB from Sentinel-2; and 4.6 PiB from Sentinel-3.

A sharp increase can be seen in June 2023 in the volume of data which was moved to the nearline storage. This was due to the decision to shorten the online availability of data, from 6 months to 1 month on OpenHub, CopHub, and ColHub Node 1, as part of the phase-out of the Data Access System.

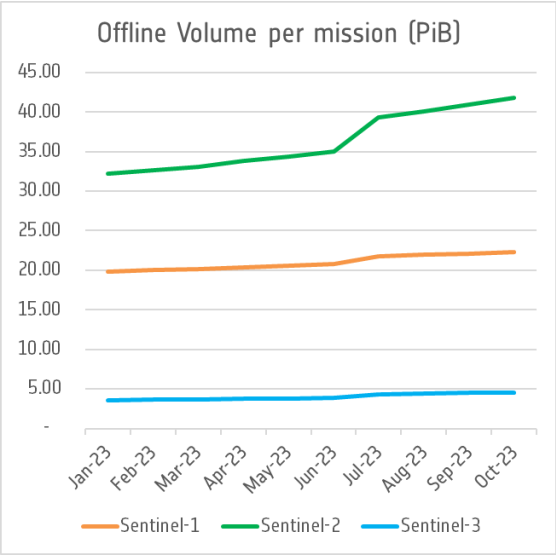


Figure 61: Cumulative growth of Nearline user-level data volume (PiB) per mission during Y2023.

Active Users of the Nearline Data Retrieval

An active user of the nearline data retrieval is defined as a user who submitted at least one request for the retrieval of a nearline data package. 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 Y2023, there were a total of 63,819 active users of the nearline data retrieval, composed of 63,756 from the Open Hub (21% increased since last year) and 63 from the other hubs (-32% with respect to Y2022). Table 18 shows the total number of active users of the nearline data retrieval per mission and per hub. Note that the total of these is greater than the total given above, because a single user could request data from more than one Sentinel.

Hub	Sentinel-1	Sentinel-2	Sentinel-3
Open Access Hub	15,760	53,684	3,590
Collaborative Hub	14	19	6
Copernicus Services Hub	22	26	9
DiasHub	3	4	5

Table 18: Total Active Users of Nearline Retrieval during Y2023, split by mission and hub.

It is interesting to note that of the 94,791 active users of the Open Hub in Y2023 (meaning a user who successfully downloaded at least one complete data package during the year, either from the online or the nearline service), 67% of these submitted at least one request for a nearline data package (in Y2022 there were 53%). This calculation does not distinguish between those active users who made only a successful request for nearline data and those who made a request for both online and nearline data, but it does mean that only 33% of the Open Hub active users did not make a request for nearline data. Once more, this demonstrates a clear interest among the general public in historical data.

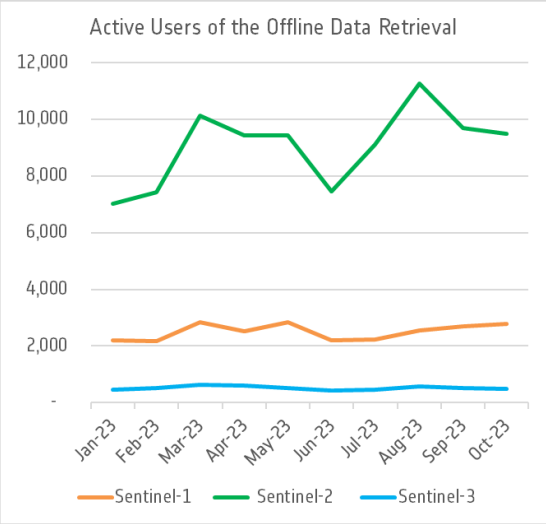


Figure 62: Total Active Users of Nearline Retrieval per mission on the Open Hub per month during Y2023.

Figure 62 shows the total number per month of active users of the nearline data retrieval during Y2023, for each Sentinel. For Sentinel-1, there was an average of 2,502 active users per month for nearline data, indicating a 18% increase since Y2022, with a pretty even spread of the requests throughout the reporting period.

For Sentinel-2, the trend appears to be less stable. There was a notable increase in the number of active Sentinel-2 users of the nearline data retrieval between February and March 2023, reaching a peak of 10,130 active users, followed by a steeper rise between June and August 2023, reaching the maximum in August 2023 with 11,261 active users. It is interesting to note that this fluctuation was also evident throughout Y2022.

The number of active users of Sentinel-3 nearline data retrieval was almost constant over the year, with between 448 and 478 active users, that is -10% with respect to the number of users who were making nearline data retrieval requests in December 2022.

Nearline Data Retrieval Requests

During Y2023, 48 million retrieval requests for nearline data were made, which is 13% more than in Y2022.

Hub	Numbers of retrieval requests in 2023	%
Open Access Hub	47,810,525	99.3%
Collaborative Hub	153,810	0.3%
Copernicus Services Hub	128,702	0.3%
DiasHub	35,188	0.1%
TOTAL	**48,128,225**	

Table 19: Total nearline data retrieval requests during Y2023 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 more than 99% of the overall number of nearline data retrieval requests, up 27% compared with the number which had been made Y2022.

Other hubs show instead a reduction in the total number of retrieval requests when compared to the previous year. For each hub, the percentage share of the overall number of retrieval requests was below 1%. The most impressive decrease is for the DIAS Hub, which passed from supporting roughly 10% of the requests in Y2022 to a number very close to 0% in Y2023.

In Figure 63, the total numbers of nearline retrievals per hub are broken down further to show the total number of requests per month. To be able better to differentiate the figures, the Open Hub is treated separately in the upper panel, while ColHub, ServHub and DIAS are all included in lower panel.

The Open Hub trend exhibits a notable peak in August 2023, with retrieval requests reaching 14.2 million. These requests include nearline requests both via SciHub and via API Hub. This represents a significant increase compared to the previous year, when the maximum of 7.2 million requests was recorded in January 2022. This may well be attributable to the reduction in the online availability of data on the Open Hub, which started to be reduced from 6 months to 1 month from July 2023 onwards, as discussed in the previous section. Even if we exclude the peak in August 2023 from the distribution, the average monthly number of requests remains 19% higher than in Y2022. It is also possible that this heightened activity occurred because Y2023 was the final year of service operations, users feared losing access to the data when the service closed and made a concerted

effort to maximize data restoration before the cessation of operations.

Overall, the trends for the other 3 hubs deviate significantly from the average values of Y2022, with decreases of 63%, 42%, and a substantial 98%, for ColHub, ServHub, and the DIAS Hub respectively. Interestingly, the DIAS Hub demonstrates an upward trend towards the end of the reporting period, however, starting in September 2023 with roughly 13,000 retrieval requests, and reaching 35 thousand nearline requests in October 2023. 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 that period to replenish their store with archived data, before the closure of the Data Access System.

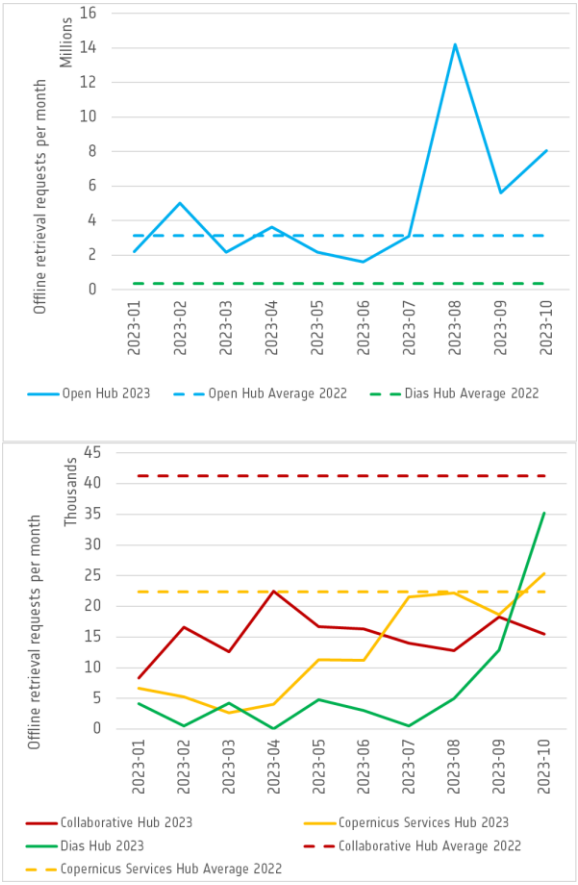


Figure 63: Total nearline retrieval requests during 2023, per month and per hub.

Data Restored and Retrieval Performance

Hub	Sentinel-1	Sentinel-2	Sentinel-3	Total
Open Access Hub	1,953,635	33,595,487	2,815,220	**38,364,342**
ColHub/ServHub/DiasHub	97,980	184,939	34,781	**317,700**
Total	**2,051,615**	**33,780,426**	**2,850,001**	**38,682,042**

Table 20: Total nearline data restored during Y2023 per hub and per mission.

Table 20 shows the number of restored data during 2023, split by mission and hub. Note that, for reasons resulting from the infrastructure architecture, ColHub, ServHub and DIASHub published the same restored data, so they are reported together in the table.

This year, the quantity of data restored from the Open Hub surpassed that from all three other hubs combined by nearly 120-fold, and the volume of data restored on the Open Hub surged by 416% compared to Y2022, in line with the increased number of rerieval requests seen above.

The difference between the number of successful retrievals and the number of requests made can be seen by comparing the figures in Tables 19 and 20 above. It should be noted, however, that this figure indicates both the number of retrievals which were not successful and the number which were requests for nearline data which had already been requested by another user and so had already been delivered back online.

In line with the findings for active users above, the overwhelming majority of data restored on the Open Hub from nearline storage were Sentinel-2 (88%), followed by Sentinel-3 (7%) and Sentinel-1 (5%). On the other hubs, Sentinel-2 was also the first most retrieved data (58%), followed by Sentinel-1 (31%) and Sentinel-3 (11%).

Retrieval Timeliness

Figure 64 shows the average weekly retrieval timeliness across all hubs during Y2023. As can be seen from the graph, during all the months, the average time for the retrieval of nearline user-level data did not overpass the 24 hours. However, there was a significant deterioration in the timeliness in week 42 (October 2023), with the average resolution time hitting about 6 hours. This coincides with the second highest peak in data retrieval requests on the Open Hub, and the highest peak in requests on ColHub/ServHub/the DIAS Hub.

If week 42 is excluded from the calculation of the average resolution time for a retrieval request in Y2023, the time is only 21 minutes. Even with week 42 included, however, the overall average time it took between a retrieval request being made and the data being restored to the hub, across all hubs during the reporting period, was roughly **32 minutes**. This was less than the average time it took during Y2022 (54 minutes).

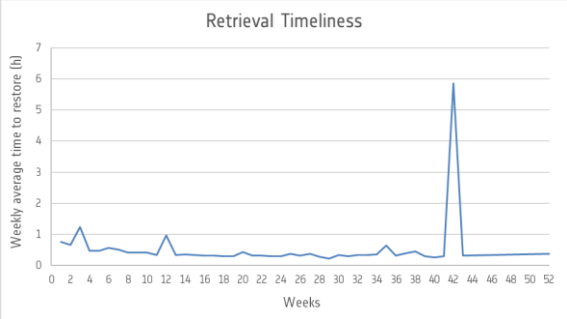


Figure 64: Weekly average time to restore nearline data in Y2023.

2.3.6 Downloads per Continent and Country

Another interesting view on download behaviour during Y2023 is to look at the continents and individual nations which have performed the most downloads 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 Y2023. The overall percentage split by hub is also shown in Tables 21 and 22 below.

The proportion of the overall download volume for each continent is also represented in Figure 65 below.

Continent	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub	Overall
Europe	43.3	99.5	100.00	2.4	68.6
North America	43.7	0.5	N/A	70.0	24.0
Asia	9.5	N/A	N/A	3.5	4.6
Oceania	1.1	N/A	N/A	20.7	1.5
South America	1.2	N/A	N/A	3.3	0.7
Africa	1.2	N/A	N/A	0.1	0.6

Table 21: Percentage of Y2023 downloads (by volume) per Continent and per Hub, and overall.

In Y2023, as in previous years, Europe continued to be the continent which made the most active use of Copernicus Sentinel data, making 68.6% of the total volume of user downloads from all of the hubs.

On the Open Hub, for which all continents have registered users, European users made 43.3% of the total volume of downloads (15.6 PiB), very similar to the North American users who, for the first time, accounted for the highest percentage of the total download volume, with 43.7% (15.8 PiB). Next were the Asian users, with 3.4 PiB, representing 9.5% of the total volume of downloads. Users from Oceania, South America + Antarctica, and Africa each made approximately 1% of the total volume of downloads from the Open Hub, having downloaded 400 TiB, 452 TiB and 435 TiB respectively.

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 (~21%) of the data downloaded from IntHub were downloaded in Oceania because in Y2023, there was still only one partner connected to IntHub from Oceania, Geoscience Australia (see Section 4.2).

ColHub and ServHub were almost entirely used by European users, in line with the programmatic role of the hubs, with 99.5% and 100% respectively of the total number of downloads being made by European users. The small amount of non-European (North American) downloads on the ColHub (0.5%) are accounted for by the Canadian Collaborative Ground Segment.

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

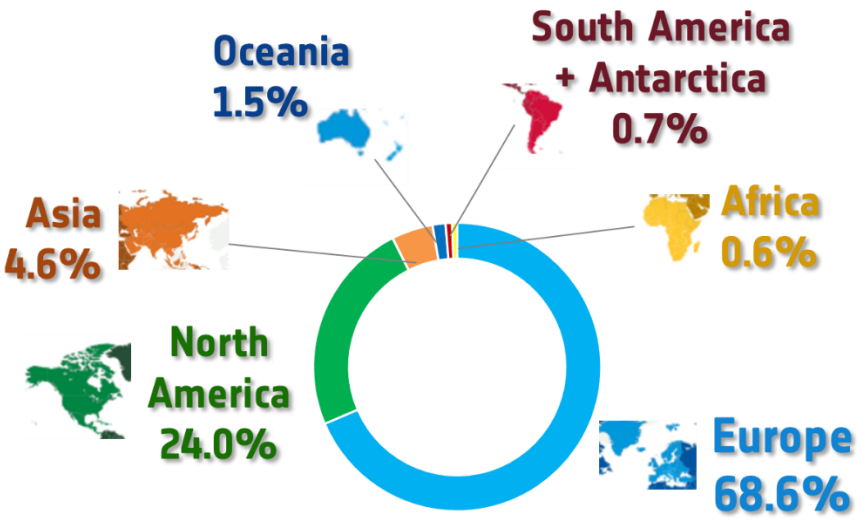


Figure 65: Overall percentage split of Data Access System downloads (all Hubs) by volume, per Continent, during Y2023.

Open Hub Focus

Continent	% of Sentinel-1 Downloads during 2023	% of Sentinel-2 Downloads during 2023	% of Sentinel-3 Downloads during 2023	% of 2023 Downloads
Europe	60.5	38.4	33.9	51.4
North America	25.1	42.6	60.3	38.4
Asia	12.9	13.6	5.0	7.7
Oceania	0.4	0.8	0.6	0.6
South America	0.7	1.9	0.1	0.8
Africa	0.4	2.7	0.1	1.1

Table 22: Continental percentage split of Y2023 downloads (by number) on the Open Hub, for each Sentinel mission and overall.

Table 22 breaks down the overall per continent figures for the Open Hub in Y2023 into the percentage split per continent of the downloads for each Sentinel during the year. It is again recalled that all 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 Sentinel-5P downloads are made on the dedicated Sentinel-5P node of the OpenHub, where is not possible to categorise the users of that dedicated node by country. Sentinel-5P downloads have therefore been included by distributing the figures proportionally across each continent.

This year, Europe continued to be the continent which downloaded the highest volume of Sentinel-1 data in the reporting period by a long margin, making 61% of all Sentinel-1 downloads in Y2023, compared to 25% downloaded by the next most active group, the North American users.

The proportion of Sentinel-2 downloads which were made by European users dropped to 38% during Y2023, however, less than the 41% in Y2022.

For Sentinel-3, the proportion of downloads made by European users also decreased with respect to Y2022, falling to 34% in Y2023 from 45% in Y2022.

It was again the North American users which downloaded the highest proportion of both Sentinel-2 and Sentinel-3 data, having made 43% and 60% of the total downloads in Y2023 for those two missions respectively. Overall, Sentinel-3 downloads by European and North American users together made up a huge 94% of the total number of Sentinel-3 downloads in Y2023, the same proportion as in Y2022.

In Asia, interest remained clearly tipped towards Sentinel-1 and Sentinel-2 data, with Asian users having made 13% and 14% respectively of the total number of downloads for each mission, and only 5% of the total number of Sentinel-3 downloads.

Users from Africa, South America + Antarctica, and Oceania continued to show a preference for Sentinel-2 data, as seen in previous years. Notably, African users made nearly 3% of the total number of Sentinel-2 downloads, which is a higher proportion than in Y2022, when they made just 1.7% of the Sentinel-2 downloads. African users therefore remained the fourth highest downloaders of Sentinel-2 data, above the users from Oceania and South America.

	Sentinel-1		Sentinel-2		Sentinel-3	
	Country	2023 Number of user-level data downloads	Country	2023 Number of user-level data downloads	Country	2023 Number of user-level data downloads
1	Spain	1,357,649	France	3,091,187	Italy	3,398,699
2	France	533,313	Germany	2,001,853	Germany	3,018,357
3	Germany	420,783	Poland	1,826,727	United Kingdom	1,097,396
4	Sweden	131,410	Norway	467,840	Bulgaria	400,643
5	Italy	86,646	United Kingdom	438,508	Norway	357,446
6	Denmark	81,362	Italy	431,890	France	323,208
7	United Kingdom	77,274	Spain	369,135	Spain	237,153
8	Luxembourg	54,778	Netherlands	303,762	Poland	209,390
9	Norway	49,279	Austria	223,455	Netherlands	78,973
10	Poland	45,693	Finland	202,097	Austria	62,855

Table 23: Top 10 ESA/EU states by number of downloads in Y2023 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 Y2023.

Spain, which dropped out of the top 10 for Sentinel-1 downloads during Y2022, claimed the top spot among Sentinel-1 downloaders for Y2023. Finnish users became the 10th highest downloaders of Sentinel-2 data, having not been in the top 10 for any of the missions in Y2022.

France and Italy remained as the highest downloaders of Sentinel-2 and Sentinel-3 data, respectively, despite the number of downloads they made of those missions having decreased by 35% and 13% with respect to Y2022.

The countries that debuted in the lists last year (Sweden, Luxembourg, Netherlands, and Bulgaria) continue to feature in this year's table. Luxembourg and Bulgaria experienced notable increases in their positions, with Luxembourg rising from 10th to 8th most active Sentinel-1 downloader; and Bulgaria moving from 5th to 4th most active Sentinel-3 downloader, having made 25% more Sentinel-3 downloads in Y2023 than in Y2022. The Netherlands, previously 10th in Y2022 for both Sentinel-2 and Sentinel-3, climbed to 8th and 9th positions this year, respectively, showing increases of 11% in Sentinel-2 and 45% in Sentinel-3 downloads. Conversely, Sweden dropped from 2nd to 4th place in the Sentinel-1 list, having made 52% fewer Sentinel-1 downloads in Y2023 than in Y2022.

Slovenia, which in Y2022, had become the 3rd most active Sentinel-2 downloader, this year dropped out of the top 10 for Sentinel-2 downloads, and no longer appears in the table.

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.

While the distribution of user downloads from the Open Hub offers insights, it is important to note that it might not fully reflect national interest in Copernicus Sentinel data. This is due to the availability of data through alternative Copernicus data points, such as national mirror sites and the DIAS platforms. Nonetheless, these figures do offer at least an indication of the level of user interest among the general public within each country for Copernicus Sentinel data.

MyOcean Service

From April 2022 until its closure, the Data Access System included a dedicated access point for delivering Sentinel-1 Level-1 data over surveyed ocean areas to users within the Marine Service via an FTP/S interface.

The MyOcean Service dataset consists of a subsample of Sentinel-1 Level-1 data, filtered over agreed polygons of interest. Products are zipped with a .zip extension responding to the Sentinel-1 user-level data specifications. The rolling policy on the server side is 7 days, calculated from the creation date on the server.

The access point is limited, with read-only access permissions provided to users with personal credentials from the IP address which has been whitelisted by the Data Hub Operations team.

Approximately 60,000 products were published on this access point throughout Y2023, and during Y2023 there were 120TiB user downloads from the FTP/S interface.

2.3.7 Data Hub Relays

The flow of data downloaded from ColHub to the Collaborative national mirror sites is summarized in Figure 66. 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 Y2023, the data exchanged in the DHR Network were from all the missions, including Sentinel-5P which was introduced last year in the exchanges between the 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 were 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.

The DHR network is continuing beyond the closure of the Data Access System and is now supported by ESA's Collaborative Node Service.

During 2023, there were no significant changes in the composition of the DHR network, so at the end of 2023, the team of DHRs consists 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 the UK, operated by AIRBUS and STFC
- Greece, operated by NOA
- Germany, operated by CloudFerro

The project dedicated to support the DHR and CollGS network, known as the Collaborative Data Hub Software Maintenance and Evolution Services, that started in September 2021, was renewed during the reporting period. Frequent contact is maintained with all the partners, to receive feedback and needs, in order to plan evolutions based on those needs.

During 2022, the Data Access team had worked to increase the support activities to enhance the cooperation between the Data Hub Relay network nodes and to improve the data flows, releasing 4 software developments to provide enhanced functions. This software were maintained during 2023.

In support of nurturing the "Collaborative Ecosystem," a dedicated website was launched to serve as a central hub for all stakeholders of the CollGS. This platform consolidates information about CollGS nodes and the Data Hub Software (DHS) suite, serving as a comprehensive resource and a showcase for collaborative activities, thereby strengthening the identity of this user community. The website is: https://collgs.esa.int/

Additionally, the Collaborative Identity Access Management system, established by the end of 2022, continued to be used to seamlessly integrate collaborative users in their roles as service providers. It also centralized the collection of policies governing resource access, serving as a single point of trust for streamlined management and administration.

By the end of 2023, the new ESA Collaborative Node Service was fully supporting the needs of the CollGS community, providing dedicated services for disseminating Copernicus Sentinel data to them. This reflects ESA's commitment ensuring seamless access to Sentinel data for all stakeholders within the Collaborative ecosystem, in order to foster collaboration and facilitate the effective use of Earth observation data for various applications and initiatives. Sustaining the commitment to providing data services to the CollGS community not only maintains the connection with a highly engaged user base but also supports their extensive use of Copernicus data for research and scientific

endeavours, across diverse use cases and applications. This collective effort is helping to lay the groundwork for the upcoming Destination Earth initiative in 2024.

Figure 66 below illustrates the movement of data between ColHub, the DHRs and the CollGS users.

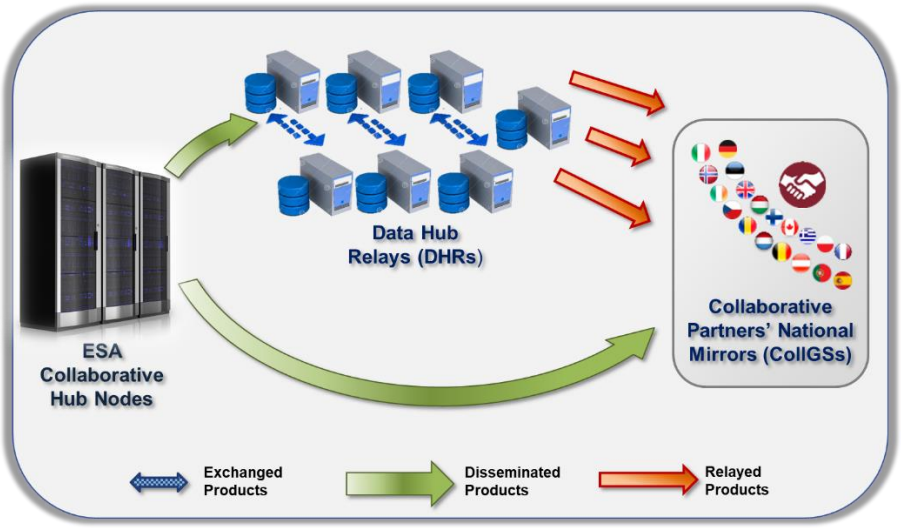


Figure 66: Schematic showing general data flow of user-level data from the Collaborative Data Hub to the Collaborative National Mirrors, highlighting the terminology used.

Figure 67 below sets out the main statistics to show the volume of data circulating round this network. To ensure continuity after the Data Hub Service was dismissed in November 2023, data from November and December 2023 has been included in these figures. This inclusion makes the period two months longer than the 10-month period of Y2023 used throughout the rest of the Report, but the adjustment ensures consistent analytics for the CollGS users, given the continuation of the data dissemination service through the Collaborative ESA Node, and allows for a more direct comparison with Y2022.

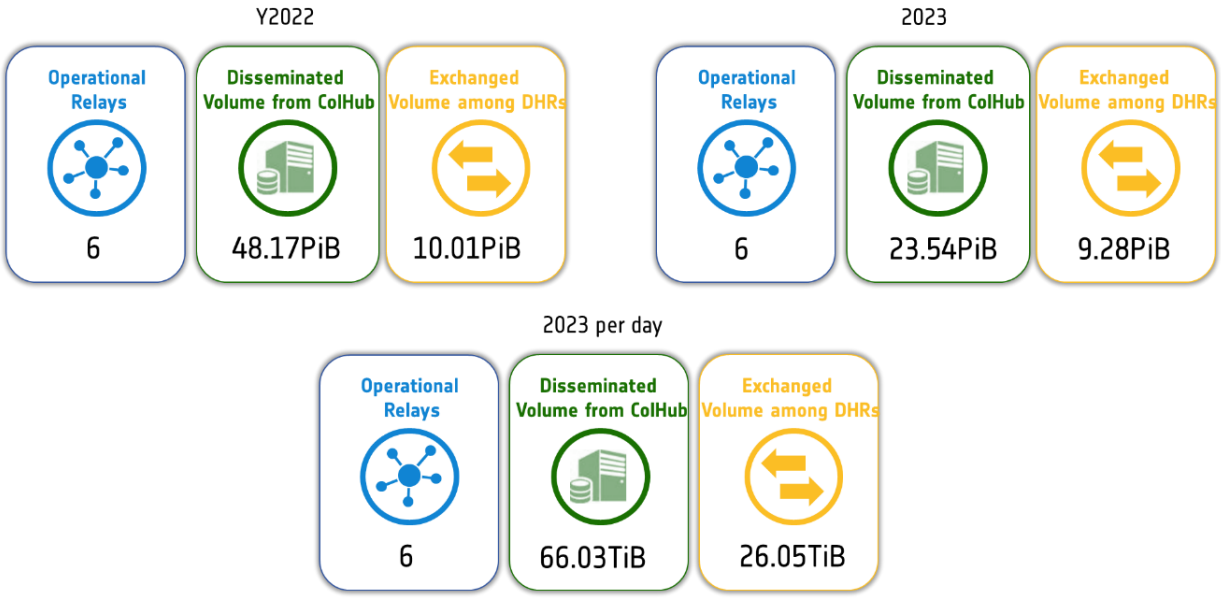


Figure 67: Overall Data Hub Relay statistics for 2023 vs Y2022, with 2023 per day averages.

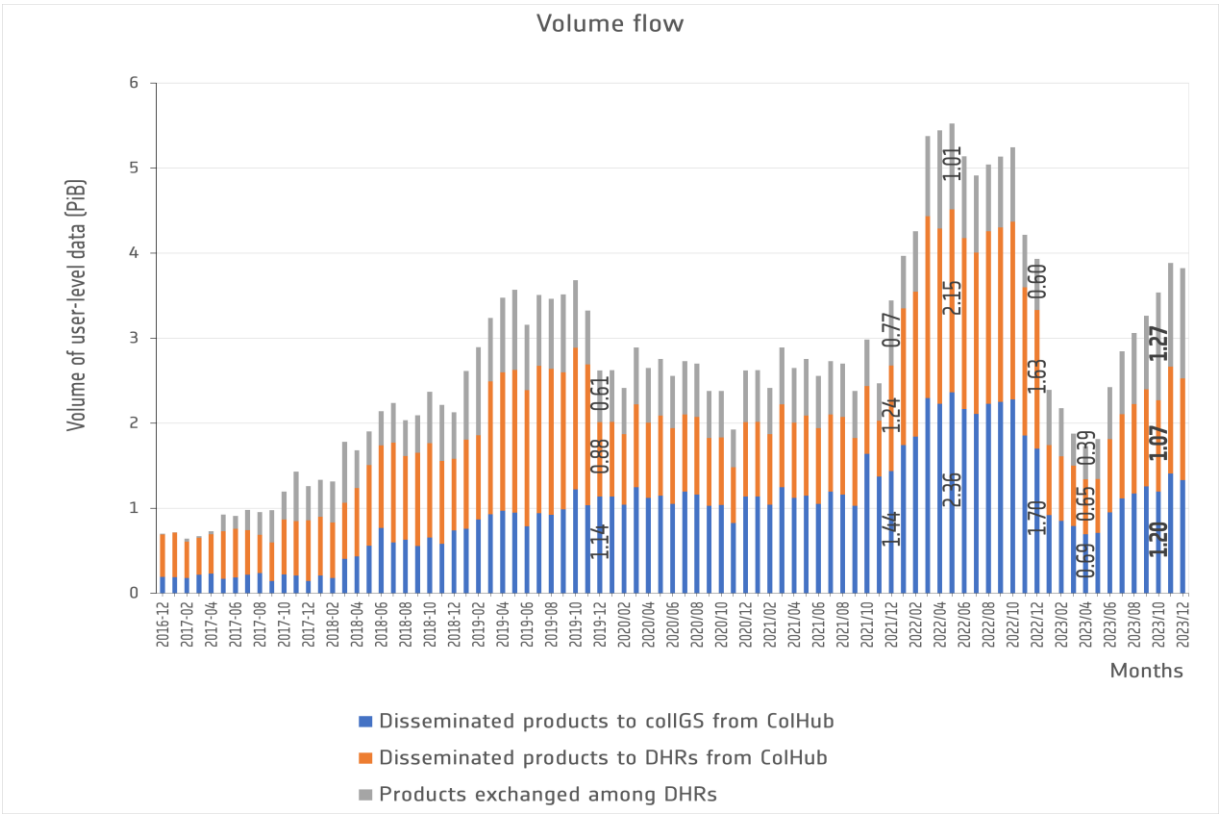
Overall, during 2023, the volume of data disseminated to CollGS partners (including the DHR network) from the ColHub nodes was 23.54PiB, approximately half the volume disseminated in Y2022. The average daily volume disseminated from ColHub during 2023 was 66.03 TiB, also approximately half the daily average of 135 TiB disseminated from ColHub in Y2022. Despite this lower volume downloaded from ColHub, the total volume of data circulated between the DHRs in 2023 was very similar to that circulated in Y2022, falling only slightly from 10.01 PiB in Y2022 to 9.28 PiB in 2023. An average of 26.5 TiB per day was circulated between the DHRs, again slightly lower than the 28.07 TiB calculated for Y2022.

Figure 68 below presents the evolution of the DHR network data volumes since the beginning of DHR operations (i.e. between December 2016 to 31 December 2023). The temporal axis extends beyond the end of the official Y2023 reporting period, again to provide insight into the continuing dissemination through the new ESA Collaborative Node Service.

The figures show the monthly volumes of disseminated 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 following the start of DHR operations. Then, 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. In May 2022, there was a particularly notable peak in the volume of data being passed around the network, with nearly 5.5 PiB flowing around and out. In the period October-December 2022, the volume started decreasing again, although 3.93 PiB of data was still passed around the network in December 2022, which is 14% more than the 3.44 PiB which was recorded in December 2021. The trend shows then a further sharp fall in the volume disseminated from January 2023, reaching as low as 1.73PiB in April 2023, 56% lower than the value from December 2022. From June 2023 onwards, however, the volume started to rebound, finishing with just under 4 PiB being disseminated in December 2023, almost the same as the volume disseminated in December 2022.

The number of data packages and the volumes involved in Copernicus data dissemination continues to grow each year, and these figures demonstrate that the involvement of the DHR Network remains an important part of the overall dissemination architecture for Sentinel data, shouldering as it does a substantial portion of the dissemination load.



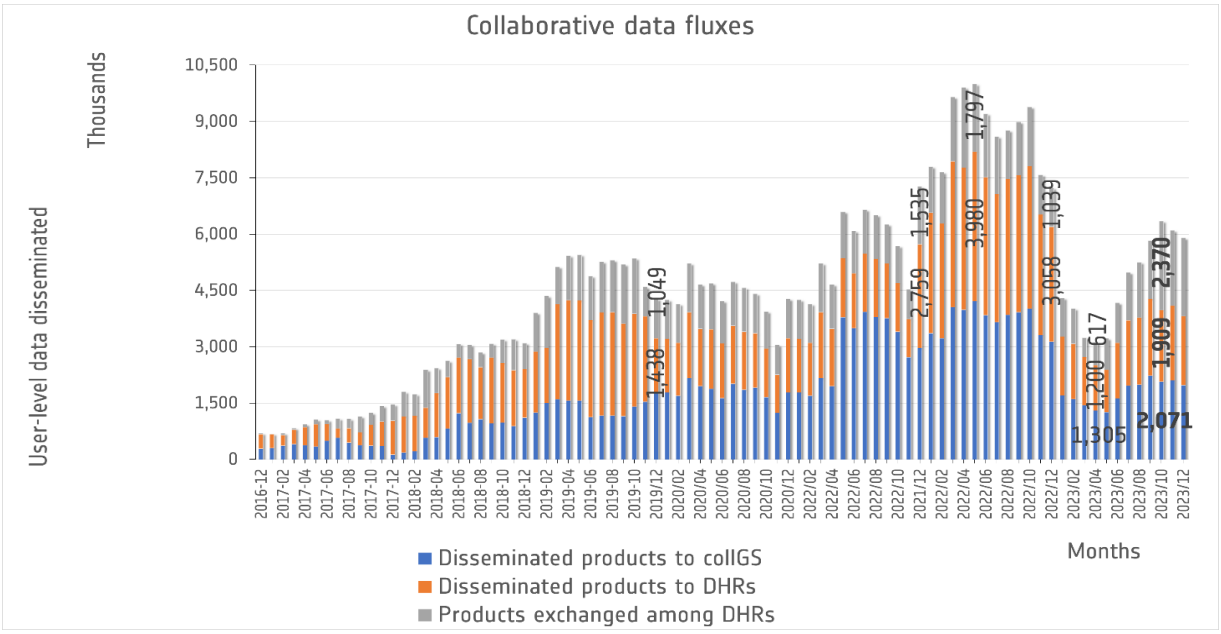


Figure 68: Total data flows in terms of volume (top) and number of user-level data (bottom) during the last 6 years.

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 download within the reporting period. However, users who did not perform a complete download were not necessarily 'inactive': if a user chooses to extract only a specific granule or 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 Figures 69 and 70. The variation in these figures generally reflects the different use constraints of the hubs. For example, given that ColHub and IntHub were established for national institutions to use to stock their own national data centres, 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 – 12% this period. This is again a slightly lower percentage than was calculated for the year before (15% in Y2022), and for the first time in terms of absolute numbers, there were also 4% fewer active users in Y2023 than there were in Y2022. The decrease could, of course, be linked to the closure of the service, which not only made the reporting period 2 months shorter than previous reporting periods, but also meant that users were advised to start migrating to the new CDSE from July 2023 onwards.

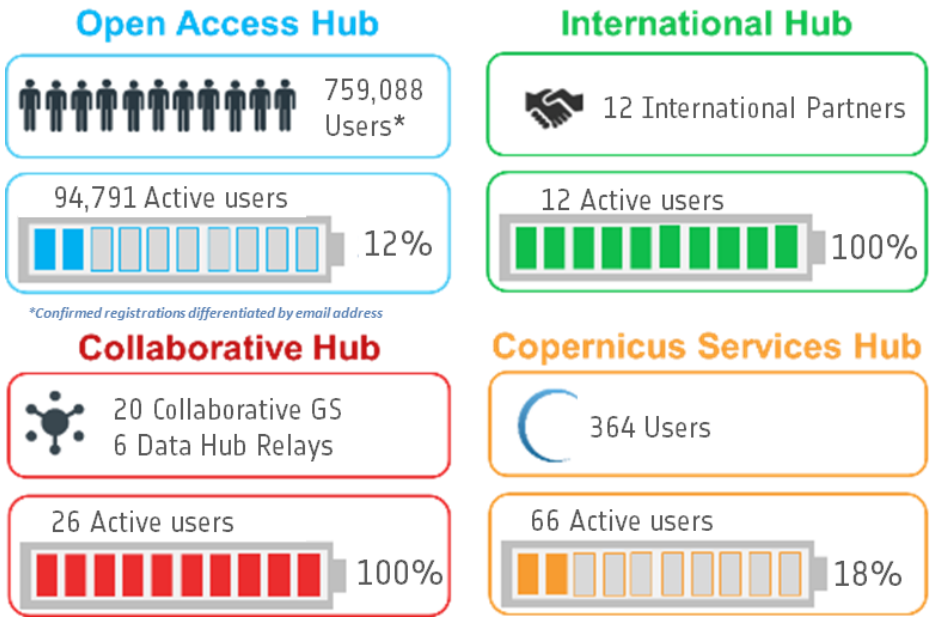


Figure 69: Registered and Active users per hub during Y2023.

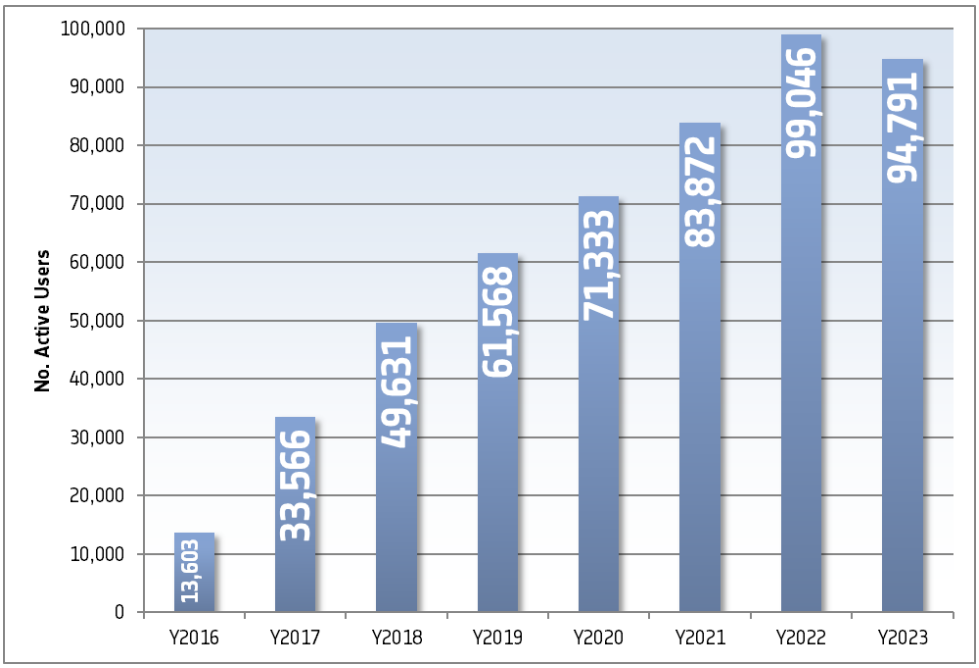


Figure 70: Growth in numbers of active users on the Open Hub between Y2016 and Y2023.

3.2 User downloads profile

This section examines the distribution of user downloads in Y2023 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 account credentials, so no differentiation of user activity is possible.

Figure 71 shows, for each hub and each mission, the download frequency ranges observed among the active users during Y2023. 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.

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 Y2022. 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 users or users who have very specific EO data needs, who would only need to download one or a few user-level data during the year.

Out of 94,791 active users on the Open Access Hub, 69% were Sentinel-2 users (65,530), while only 19% Sentinel-1 (18,044) and 12% Sentinel-3 users (11,397).

As in Y2022, 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. 61,343 Sentinel-2 users downloaded in the '1-9' range, which was 94% of the total number of Sentinel-2 active users, and 8% more than had downloaded in that range in Y2022. For Sentinel-1 and Sentinel-3 users, however, there were fewer who downloaded in the '1-9' range in Y2023 than there had been in Y2022: 16,397 for Sentinel-1, as much as 32% less than in Y2022; and 10,606 for Sentinel-3, 15% less than in Y2022.

More than 50% of ServHub users downloaded more than 1,000 user-level data, slightly less than the 52% in Y2022. Interestingly, the number of ServHub users who downloaded in the `10-100` range increased by 30% with respect to Y2022.

Users of ColHub and IntHub were again heavily grouped in the `>1,000` range, which is not surprising given that the hubs are established for systematic downloaders. However, there were a few users who did not make that level of downloads from the Hubs in Y2023. Unlike in Y2022, when all ColHub users had downloaded in the >1,000 range, in Y2023 there were 2 ColHub users who downloaded between 1-9 data packages (both Sentinel-1 users), and 2 users who downloaded in the 10-100 range. On IntHub, there was again one user who downloaded between 101-1,000 data packages during Y2023, but this year it was between 101-1,000 Sentinel-2 data, whereas in Y2022 it had been Sentinel-1 data.

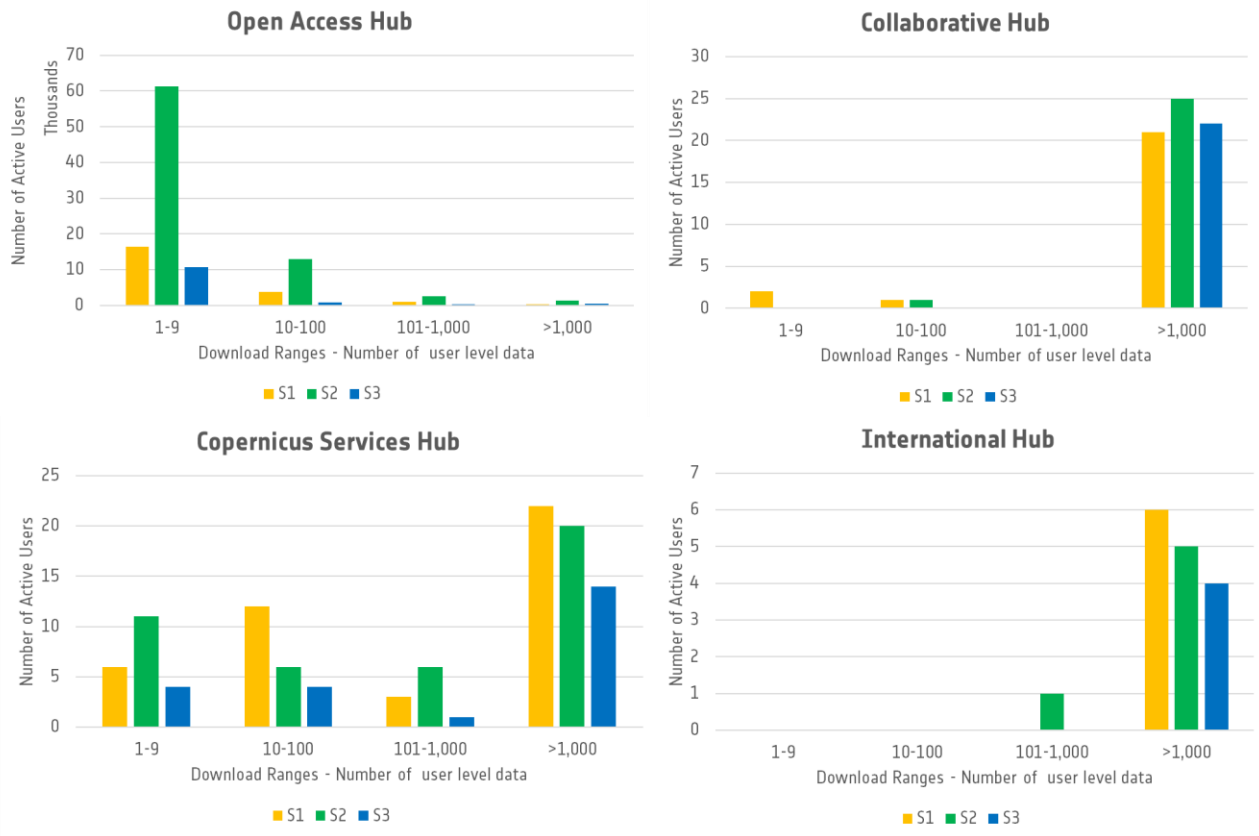


Figure 71: Download Ranges for each Data Access System Hub in Y2023.

3.3 Open Hub Active Users focus

3.3.1 Monthly Active Users

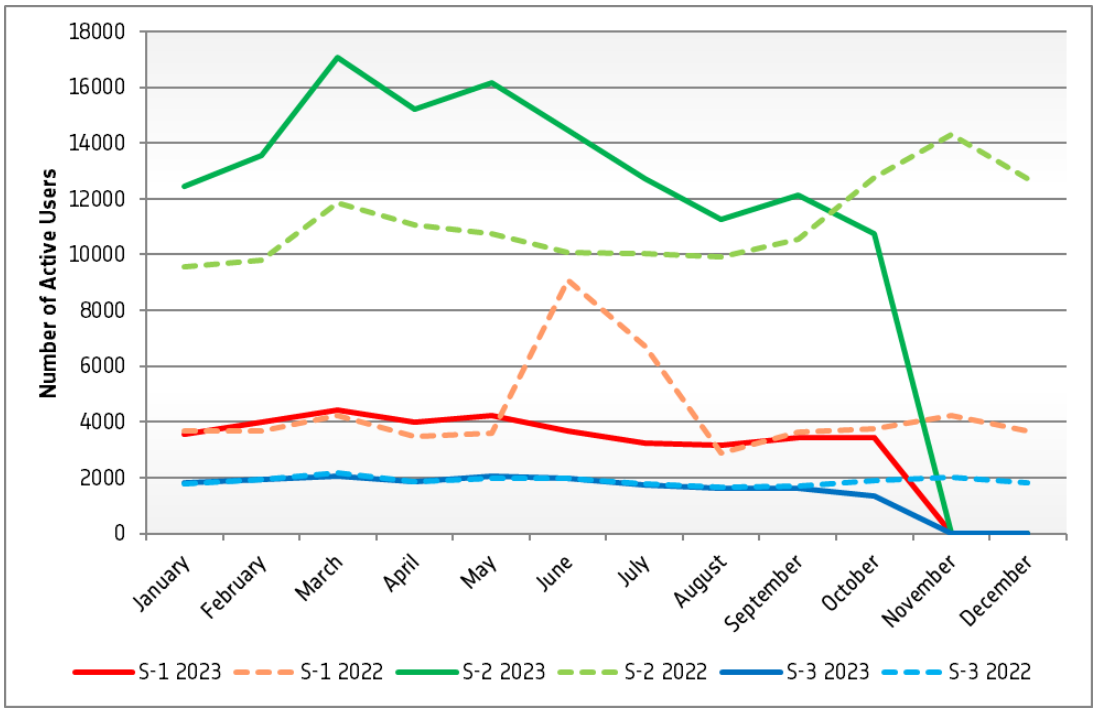


Figure 72: Active user trend per mission in Y2022 and Y2023.

The graph in Figure 72 shows the number of active users on the Open Hub on a monthly basis throughout Y2023 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 Y2022, shown as dotted lines. All values of Y2023 drop to zero in November 2023 due to service closure at the end of October.

It can be clearly seen that there were downward trends for each of the missions over the year, particularly marked from July 2023 onwards, and it is assumed this was caused by users gradually migrating over to the CDSE from that point on. The most gradual decrease can be seen for the Sentinel-1 users, and on average there were 3,713 active Sentinel-1 users per month in Y2023. If the outlier peak in June/July 2022 is excluded from the Y2022 average, the Y2023 average is similar to the Y2022 annual average of 3,685 active users. When the June/July peak is put back in the calculation, however, the Y2023 average monthly number of Sentinel-1 active users becomes 15% lower than the Y2022 average.

By contrast, the average monthly number of active users of Sentinel-2 in Y2023 was actually 22% higher than the Y2022 average, reaching 13,577 active users per month compared to 10,060 in Y2022. The combined values for February and March 2023 are 2.3 times higher than the overall monthly average reported for Y2023, and 2.8 times higher than the average monthly value for Y2022.

The Sentinel-3 trend remains very stable until June 2023, when it starts gradually edging downwards. Overall, there was an average number of 1,796 active Sentinel-3 users per month. This average is very similar to the average for Y2022, which was 1,882 active Sentinel-3 users per month.

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 Y2023 and Y2022. It also shows, for both periods, the proportion for each continent of the overall number of active users, and the percentage increase between Y2023 and Y2022. The graph in Figure 73 then shows the trendlines for the number of active users in each continent, over the years Y2015 to Y2023.

The total number of active users globally decreased by 4% compared to Y2022. Notably this decline is visible in Europe, where the total number of active users dropped by 28% compared with the number in Y2022, significantly contributing to the overall downward trend. There was also a drop, though less significant, in the number of active users in North America, which fell from 9,956 in Y2022 to 9,816 in Y2023.

However, in each of the other regions, there was an increase in the number of active users compared with Y2022, indicating continuing high interest in the Data Hub Services despite the opening of the CDSE. In particular, in Africa there was a 20% increase during the reporting period, the highest percentage increase for any of the continents. The smallest increase was in Oceania, where the number of active users rose by 6% compared to Y2022. In South America and Antarctica there was a 17% increase, and South America and Antarctica remained the region with the third highest number of active users. In Asia there was a 12% increase, and for the first time since the opening of the Sentinel Data Access System, Asia became the region with the highest number of active users, accounting for 34% of the total number of active users in Y2023.

A note of caution is raised, however, when viewing these figures in the absence of any context. For instance, the population numbers for each continent should be taken into account when considering the extent to which Copernicus Sentinel data is penetrating through within each continent.

Continent	2023	Overall % 2023	Y2022	Overall % Y2022	% Increase
Asia	32,348	34.1	28,894	29.1	12%
Europe	28,522	30.0	39,468	39.8	-28%
South America + Antarctica	15,794	16.6	13,491	10.0	17%
North America	9,816	10.3	9,956	13.6	-1%
Africa	5,395	5.7	4,493	4.5	20%
Oceania	3,086	3.2	2,916	2.9	6%

Table 24: Open Hub active users for Y2023 and Y2022, per continent.

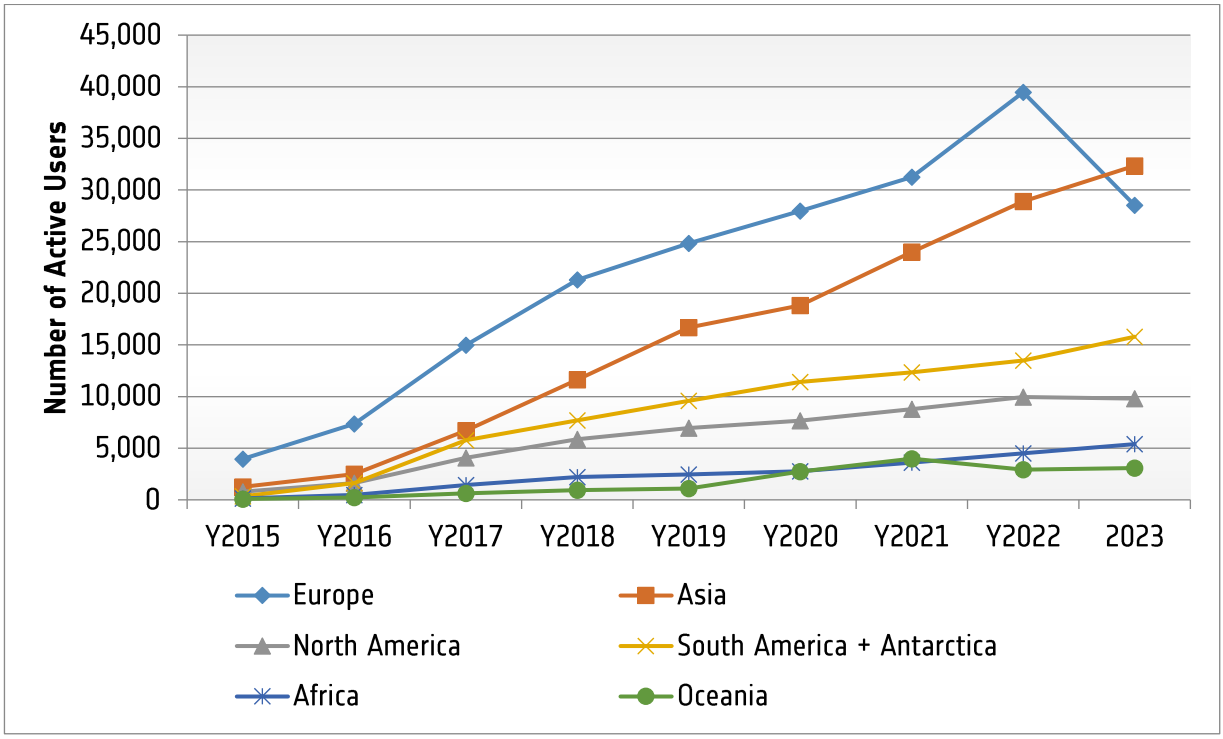


Figure 73: trend in Open Hub active users from Y2015-Y2023, per continent.

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.

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 data package in the year counts as one active user in exactly the same way as a user who downloads more than 1,000 data packages 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 Y2023 is provided for each country, per mission, as well as the percentage increase since Y2022 and any change in the position in the list.

Five ESA/EU member states appear in the global countries figures for each Sentinel mission, namely France, Germany, Italy, Spain and United Kingdom. For the second year running, the UK does not appear in the global Sentinel-2 top 10 but it is present in the Sentinel-1 and Sentinel-3 lists.

However, the three countries dominating the global lists are China, India, and the United States, which appear in the top four positions for each mission. China became the nation with the highest number of active users for each mission, a slight change from Y2022, having risen from 2nd place in the Sentinel-3 list in Y2022 to 1st place in Y2023.

Sentinel-1 - Global					
Ranking	Country	Active Users 2023	% increase from Y2022	Ranking Y2022	Change
1	China	3,184	-1%	1	0
2	India	1,688	4%	2	0
3	United States	1,029	-21%	3	0
4	Italy	996	-10%	5	^1
5	Indonesia	826	7%	6	v1
6	Germany	808	-28%	4	v2
7	Brazil	687	N/A	N/A	N/A
8	United Kingdom	612	-13%	7	v1
9	France	562	-19%	9	0
10	Japan	552	-18%	10	0

Table 25: 2023 Top 10 Global Countries: Sentinel-1

Sentinel-2 - Global					
Ranking	Country	Active Users 2023	% increase from Y2022	Ranking Y2022	Change
1	China	8,439	-1%	1	0
2	India	5,103	59%	6	^4
3	Brazil	4,785	31%	3	0
4	United States	3,193	-3%	5	^1
5	**Spain**	3,108	-18%	2	v3
6	Indonesia	3,037	N/A	N/A	N/A
7	**Germany**	2,823	-23%	4	v3
8	Australia	2,605	9%	8	0
9	Colombia	2,575	29%	9	0
10	**Italy**	2,555	-17%	7	v3

Table 26: 2023 Top 10 Global Countries: Sentinel-2

Sentinel-3 - Global					
Ranking	Country	Active Users 2023	% increase from Y2022	Ranking Y2022	Change
1	China	1,099	-17%	2	^1
2	United States	1,043	-26%	1	v1
3	India	789	13%	5	^2
4	Germany	626	-30%	3	v1
5	Italy	602	-23%	4	v1
6	Spain	549	-20%	6	0
7	Brazil	497	9%	9	^2
8	France	475	-29%	7	v1
9	United Kingdom	413	-20%	8	v1
10	Canada	297	N/A	N/A	N/A

Table 27: 2023 Top 10 Global Countries: Sentinel-3

Sentinel-1 - ESA/EC					
Ranking	Country	Active Users 2023	% increase from Y2022	Ranking Y2022	Change
1	Italy	996	-10%	2	^1
2	Germany	808	-28%	1	v1
3	United Kingdom	612	-13%	3	0
4	France	562	-19%	5	^1
5	Spain	482	-31%	4	v1
6	Poland	353	-33%	6	0
7	Romania	261	6%	9	^2
8	Greece	249	-13%	8	0
9	Netherlands	245	-16%	7	v2
10	Portugal	144	-25%	10	0

Table 28: 2023 Top 10 ESA/EU Countries: Sentinel-1

Sentinel-2 - ESA/EC					
Ranking	Country	Active Users 2023	% increase from Y2022	Ranking Y2022	Change
1	Spain	3,108	-18%	1	0
2	Germany	2,823	-20%	2	0
3	Italy	2,555	-17%	3	0
4	France	1,735	-13%	4	0
5	United Kingdom	1,666	-9%	5	0
6	Poland	1,350	-19%	6	0
7	Greece	1,043	-7%	7	0
8	Netherlands	844	-13%	8	0
9	Portugal	567	-15%	9	0
10	Romania	503	-10%	10	0

Table 29: 2023 Top 10 ESA/EU Countries: Sentinel-2

Sentinel-3 - ESA/EC					
Ranking	Country	Active Users 2023	% increase from Y2022	Ranking Y2022	Change
1	Germany	626	-30%	1	0
2	Italy	602	-23%	2	0
3	Spain	549	-20%	3	0
4	France	475	-29%	4	0
5	United Kingdom	413	-20%	5	0
6	Poland	242	-29%	6	0
7	Greece	221	4%	8	^1
8	Netherlands	138	-44%	7	v1
9	Ukraine	102	N/A	N/A	N/A
10	Portugal	100	-31%	10	0

Table 30: 2023 Top 10 ESA/EU Countries: Sentinel-3

Of the three top countries, it was India which showed the greatest increase in the number of active users, with a 59% increase in the number of Sentinel-2 active users, moving India up from 6th place in the Senitnel-2 list in Y2022 to 2nd place in Y2023; and a 13% increase in the number of Sentinel-3 active users, making India move from 5th to 3rd place in the Sentinel-3 list.

There were also some notable changes in the number of active users in Brazil. Brazil appears in the Sentinel-1 list for the first time, arriving at 7th place, with 687 active Sentinel-1 users in Y2023. The number of active Sentinel-2 users in Brazil also greatly increased, with 4,785 active users in Y2023, a 31% increase compared to Y2022. There was also a 9% increase in the number of active Sentinel-3 users in Brazil compared to Y2022, and Brazil moved up from 9th place to 7th place in Y2023 in the Sentinel-3 list.

Indonesia continued to feature in the Sentinel-1 list but this year also featured in the Sentinel-2 list, with 3,037 active Sentinel-2 users in Y2023, the 6th highest number across the globe. Canada was the other country to make a fresh appearance in the list, entering into the Sentinel-3 list, with the 10th highest number of Sentienl-3 active users in Y2023.

In line with the overall decline in the number of active users in Europe in Y2023, all of the European countries in the global lists had lower numbers of active users in Y2023 than in Y2022, for each mission, and Spain and France dropped out of the tables altogether for Sentinel-1 and Sentinel-2 respectively.

This downwards trend can be even more clearly seen in the Europe-only tables, which show a decrease in the numbers of active users compared to Y2022 for each of the featured countries for each of the missions, with just 3 exceptions. The number of active Sentinel-1 users in Romania increased by 6%, with 16 active users in Y2023, making Romania the country with the 7th highest number of Sentinel-1 active users in Y2023.

Greece had 221 active Sentinel-3 users in Y2023, an increase of 4% compared to Y2022, and Greece replaced the Netherlands with the 7th highest number of active Sentinel-3 users. Finally, Ukraine entered the Sentinel-3 list for the first time, with 102 active Sentinel-3 users, making Ukraine the country with the 9th highest number of active users in Y2023.

Overall, however, there were few changes in the order of the countries in the Europe-only tables. Italy, Germany, and the UK remained the top 3 active Sentinel-1 users, but Italy replaced Germany at the top of the list, with 996 active Sentinel-1 users in Y2023. Overall, the number of active Sentinel-1 users in Europe decreased by an average of 20%.

Notably, the order of countries in the Sentinel-2 list is identical to that seen in Y2022. The highest number of active users for Sentinel-2 was again in Spain, with as many as 3,108 active users, despite being a 18% decrease on last year. Second and third positions are occupied again by Germany and Italy, with 2,823 and 2,555 active users respectively.

The top three European countries for Sentinel-3 active users were also Germany, Italy, and Spain, consistent with the Y2022 list.

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 Copernicus Sentinel 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 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 74 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 October 2023, the vast majority of active users were those who had selected 'Education' (47%) and 'Research' (44%) for their usage type; only 4% were those who had selected 'Commercial', and 5% were those who had selected 'Other' when they registered for an account. These figures closely resemble those of Y2022, suggesting that there have been no significant changes in the user base utilizing Copernicus Sentinel data.

As in previous years, it is then extremely interesting to see from the bar graph the difference in the number of downloads each user group makes.

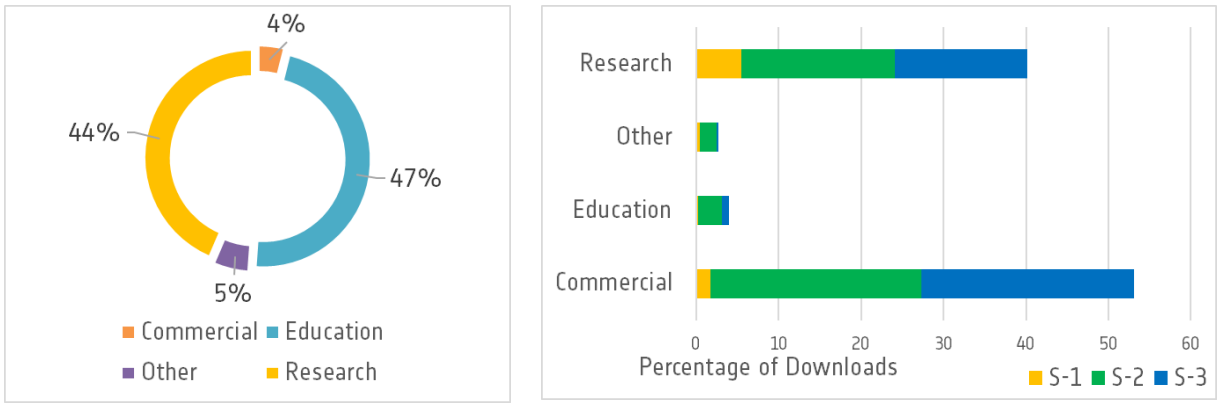


Figure 74: Percentage of Open Hub active users per declared usage type in Y2023, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each usage type during Y2023.

Although only 4% of the active users were those who had selected 'Commercial' on registration, those 4% downloaded 53% of the total number of user-level data downloaded overall in Y2023. This proportion of downloads has also increased slightly compared to Y2022 (it was 51%), though it still does not reach the high of 67% seen in Y2021.

The 'Research' group accounted for 40% of the total number of downloads, that is less than the 42% seen in Y2022.

By contrast, the large 'Education' user group made only very small percentage (4%) 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 2.7% of the total number of downloads, slightly less than the 3.6% seen in Y2022.

Figure 75 breaks down the totals for the number of active users and downloads in Y2023 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 Y2023 (the same as reported in Y2022). Next in order were 'Other' with 13%, 'Atmosphere' and 'Climate' both with 9%, 'Marine' with 6%, 'Emergency' with 3%, and 'Security' with 2%.

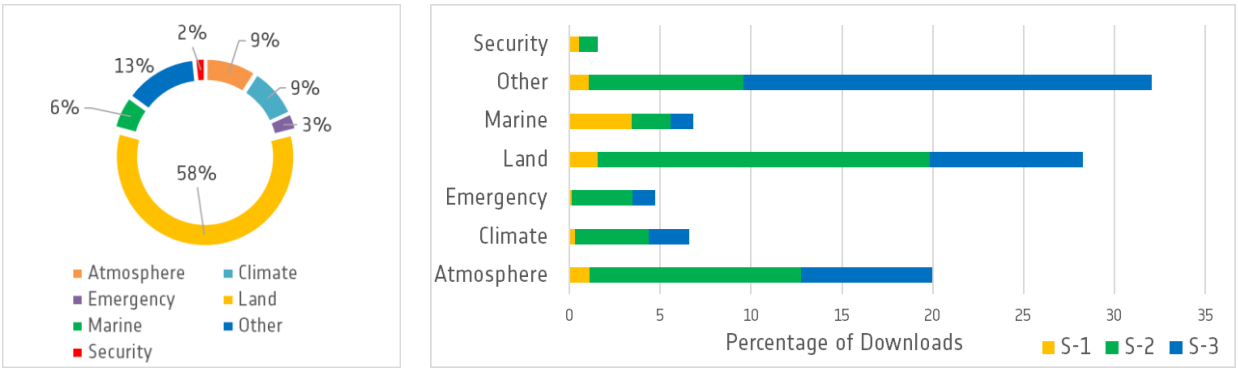


Figure 75: Percentage of Open Hub active users per declared thematic domain in Y2023, and the percentage of downloads (by number) performed for Sentinels -1, -2 and -3 for each thematic domain during Y2023.

Similar to the previous year, the top three application domains by user downloads at the end of Y2023 were 'Other', 'Land', and 'Atmosphere', accounting for 32%, 28%, and 20% of the total downloads, respectively. In Y2022, the proportions were 25%, 24%, and 24%, however, showing a decrease in the proportion of downloads made by the 'Atmosphere' category, but an increase in the proportion downloaded by the 'Other' and the 'Land' users, which was again the most numerous category.

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.

Meanwhile the proportion downloaded by the `Emergency` category also decreased in Y2023, falling from 8% in Y2022 to 5% in Y2023; whereas the proportion downloaded by the `Marine` category increased from just under 5% in Y2022 to 7% in Y2023. `Climate` and `Security` maintained quite stable proportions of 7% and 2% respectively.

4 Data Dissemination Partners

The access to Copernicus Sentinel data which ESA provides 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 31 and 32 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 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 data from one or more of the Sentinel missions, while others offer a very specific subset of user-level data types and/or coverages of particular geographical regions. The objectives of each site are not detailed here but the reader is invited to investigate each in detail via the URLs provided.

Category: Collaborative National Mirror Sites		**Annual Report Section: 4.1**
Category	Partner	Access URL(s)
Collaborative National Mirror Sites	Austria (x2)	https://data.sentinel.zamg.ac.at https://www.sentinel.zamg.ac.at
	Belgium	https://www.terrascope.be
	Canada	ftp://ftp.neodf.nrcan.gc.ca
	Czech Republic (x2)	https://dhr1.cesnet.cz https://dhr2.cesnet.cz
	Estonia	https://ehdatahub.maaamet.ee
	Finland	https://finhub.nsdc.fmi.fi
	France	https://peps.cnes.fr
	Germany	https://code-de.org/
	Greece	https://sentinels.space.noa.gr
	Hungary	https://fir.gov.hu/
	Luxembourg	http://www.lsa-datacenter.lu
	Norway	https://colhub.met.no
	Poland (x2)	https://copernicus.imgw.pl https:/dane.sat4envi.imgw.pl
	Romania	https://sentinels.rosa.ro/
	Sweden	https://digitalearth.se/
	UK-1 (x2)	https://www.ceda.ac.uk/ https://jasmin.ac.uk/

Table 31: Collaborative National Mirror sites active during 2023.

Category: International Partners' Sites		Annual Report Section: 4.2
Category	**Partner**	**Access URL(s)**
International Partners' Sites	**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	http://www.datoscopernicus.cl
	India – Indian Space Research Organisation (ISRO)	https://bhoonidhi.nrsc.gov.inc
	Serbia – Biosense Institute	https://biosens.rs/ (not active in 2023)
	Tunisia Sahara and Sahel Observatory (OSS)	http://misbar.oss-online.org/
	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
	United States – National Aeronautics and Space Administration (NASA) **United States** – National Oceanic and Atmospheric Administration (NOAA)	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/
		https://coastwatch.noaa.gov

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 national actors 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 2023. 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.

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 2023 and who provided the requested information.

Additionally, the figures presented in the following sections are based on data from the entire year of 2023 (up to 31/12/2023), rather than the specific Y2023 period used elsewhere in this report, because each data centre reported continued to operate throughout the full calendar year.

Two sites no longer appear in the statistics tables: the Portuguese site was formally deactivated on 31 March 2023 but had not been operational since 2021, and the UK-2 site had already been discontinued in June 2021. No reports were submitted from Ireland or Italy.

CollGS Partner	Overall Number of Registered Users since Start of Operations	% Increase since Y2022	% of Registered Users from the National Country	Number of Active Users in 2023	% of Registered Users who were Active in 2023	Number of users having accessed the service platform in 2023
Austria	2,072	6	-	39	2	-
Belgium	15,414	58	-	5638	37	657
Canada	21	0	-	1	5	5
Czech Republic	839	28	93	117	14	> 39
Estonia	459	18	88	79	17	-
Finland	730	10	-	171	23	-
France	11,250	15	47	-	N/A	-
Germany	4,332	23	76	240	6	734
Greece	839	1	65	33	4	-
Hungary	12,456	4	4	351	3	-
Luxembourg	400	26	-	125	31	-
Norway	895	3	-	88	10	27
Poland	66	19	98	15	23	-
Romania	111	6	93	16	14	16
Sweden	5	50	-	5	100	25
UK-1	3,528	16	64	106	3	-

Table 33: Summary of active national Copernicus data centres.

Table 33 presents the data on the registered and active users on the national mirror sites, as reported in the annual questionnaires. In this table, and in 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 '-' .Overall, there was an average growth in the number of users registered on CollGS sites of 18% with respect to Y2022. Taking the mean average, 19% of the users registered on the CollGS sites were active during 2023. These overall figures mask huge differences in the way users interact with the national sites, however, and 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.

Usage Category

In line with the agreement on reporting, the CollGS partners categorise their own users according to the same fields used by ESA. Figures 76 and 77 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). Canada, Sweden, and Hungary did not submit figures for this item in their reports this year, so their Y2022 values were used as a reference for the following figures.

It is highlighted that these categories are selected by users when they first register for access to the national site, so the statistics mask any changes which might have occurred in the meantime in the purposes and applications for which users download the data.

`Research` users are no longer the largest group among users of the national CollGS sites, and at the end of 2023 it was the `Other` category which constituted the largest group, making up 38% of all users. The UK-1 site is the primary contributor to the `Other` category, with 96% of its users having selected 'other' as the main purpose for which they download the data, closely followed by the Canadian site, with 90% of its users. In 2023, `Research` was the primary purpose for 34% of the users overall, with Greece and Finland being the major contributors, with 65% and 55% of their users respectively having selected research purposes as their main reason for using for the data.

Overall, 6% of users the national sites were from the 'Commercial' user group, which is the same as in Y2022. The highest proportions of commercial users were registered on the Luxembourg mirror site (16%) and on the Finnish site (9%), again very consistent with Y2022 figures.

22% of users of the national sites were from the category 'Education', slightly down from 24% in Y2022. Education was, however, the largest category of users for the Czech mirror site (72% of users), the Romanian site (59%) and the German site (51%, a big change from Y2022, in which 'other' had constituted the main purpose, with over 60% of users in the 'other' group).

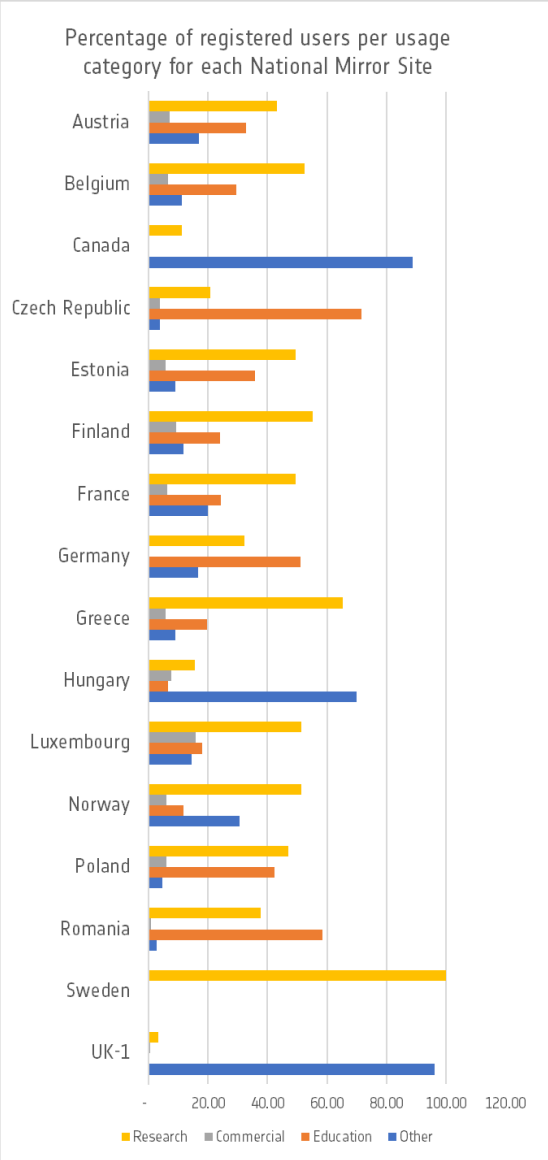


Figure 76: Percentage distribution of mirror site users by usage category.

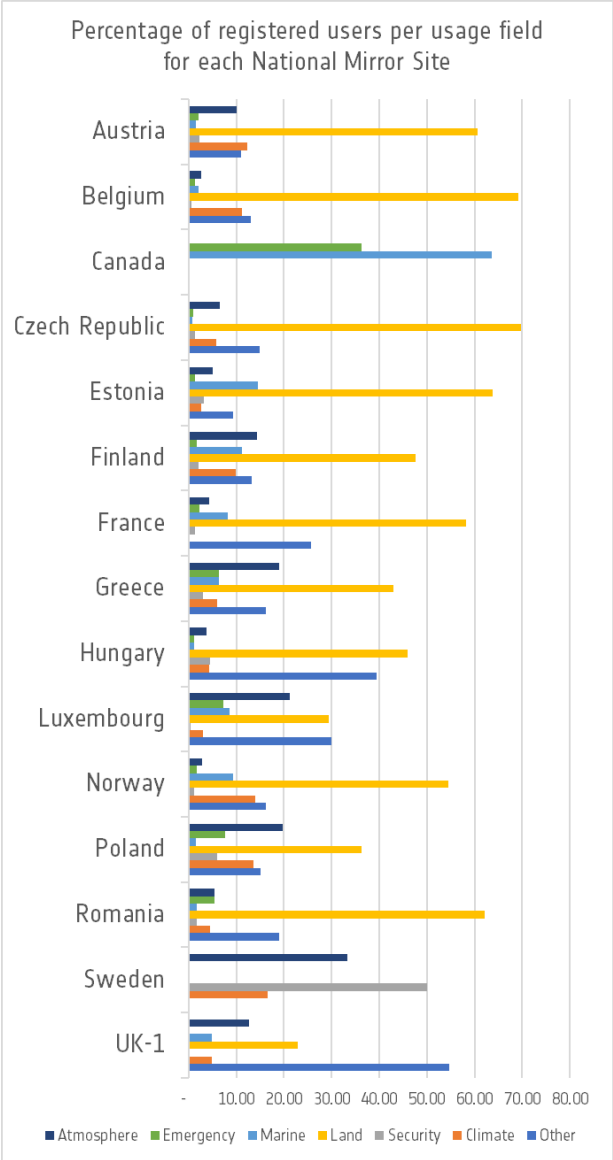


Figure 77: Percentage distribution of mirror site users by usage field.

Usage Field

In 2023, 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, accounting for 58% of the total number of users of the national sites, an increase from 45% in Y2022. The Czech and Belgian sites were the greatest contributors to this figure, with each having roughly 70% of their users selecting 'Land' applications as their principal use of the data, followed by the Romanian site with 62%. Overall, 7 out of the 16 national sites had more than 50% of their users in the `Land' usage field.

The `Other` application category continues to represent a significant share among users of the CollGS sites, with 24% of all users in 2023 (up from 18% in Y2022) having selected 'other' as the main application for which they download data. The German site had the highest proportion of users in this category, with 74%, followed by UK-1 with 55%. On average, approximately 16% of the users on the other sites also selected 'other'.

Users of the Luxembourg site were nearly equally divided between the `Other` and `Land` applications, but a substantial 21% share use the data for

'Atmosphere' applications. Approximately 20% of users of the Greek and Polish sites also use the data 'Atmosphere' applications. By contrast, only low percentages of the national site users selected `Climate`, `Emergency', `Marine' and `Security' as the applications for which they download data. In 2023, the overall percentages for these applications were 3%, 7%, 9% and 0.5% respectively. On the Austrian, Belgian, Norwegian, and Polish sites, the percentage of users who selected 'Climate' did reach above 10% in 2023, however, and on the Estonian and Finnish sites, the percentage of users who selected 'Marine' also went above 10%. It is recalled that the figures presented for the Canadian, Swedish and Hungarian sites are those from Y2022.

CollGS Partner	2023 Published Volume (TB)	% Increase from Y2022	2023 Downloaded Volume (TB)	% Increase from Y2022
Austria	6,742.66	35%	1,142.89	1966%
Belgium	209.20	-21%	1.31	172%
Canada	172.00	641%	-	N/A
Czech Republic	57.08	17%	20.67	-51%
Estonia	12.88	71%	139.45	53%
Finland	275.85	28%	18.01	-92%
France	7,120.63	127%	11,172.60	-16%
Germany	236.13	11%	7.87	67%
Greece	523.13	-94%	5.97	-19%
Hungary				
Luxembourg	5,799.98	-6%	1,300.88	-15%
Norway	8,981.15	55%	1,080.27	56%
Poland	115.67	-53%	24.14	12%
Romania	34.40	-1%	48.10	207%
Sweden*	345.87	2540%	-	N/A
UK-1	1,489.72	-18%	121.71	378%
TOTAL (PB)	**31.36**	**-0.4%**	**14.73**	**-6.1%**
Average 2023 (PB)	**2.09**	**6.2%**	**0.98**	**-6.1%**

Table 34: Overall publication and dissemination volumes on mirror sites in 2023

The average volume of data published on a CollGS site in 2023 remained relatively stable compared to Y2022, with only a 6.2% increase: 2.08 PiB on average per site, up from 1.97 PiB in Y2022. By contrast, the total volume of data downloaded from all sites during the year was 14.73 PiB, which is 6% less than in Y2022.

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 national site. In fact, several CollGS sites now provide on-demand processing of data, and/or online visualisation and processing and the tools needed to support this. While these cutting-edge uses of Copernicus Sentinel data are not explored further in this section, the interested reader can explore the individual Collaborative Ground Segment portals. The executive summaries of the 'Collaborative Ground Segment Workshops' also highlight such initiatives on a per partner basis and are available to download here:

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

Table 34 above shows, where available, the total volume of Copernicus Sentinel data both published on and downloaded from the mirror sites during 2023, together with the percentage change with respect to Y2022. It is again recalled that that these and the following figures include November and December 2023.

In terms of publication volumes, the total number seems very stable compared to Y2022, with a slight decrease of only 0.4% in the overall volume of data published on all sites. However, given that no publication figure was included for Hungary this year, reducing the number of sites from 16 to 15, the

average volume per national site actually increased by 6.2%.

At the level of the individual sites, there were some significant increases compared to the volumes published in Y2022. Sweden this year published nearly 346 TiB of user-level data, which when compared to the 13.1 TiB of data published on the site in Y2022 makes nearly an order of magnitude of difference. The overall figure for Sweden was made up of nearly 340 TiB of Sentinel-2 data published on the site, and 7 TiB of Sentinel-3. Big increases in the published data volumes were also seen on the Canadian and French sites, with 641% and 127% increases respectively with respect to Y2022. The greatest contribution to this increase on the Canadian site was 148 TiB of Sentinel-2 data published in 2023 (negligible volume in Y2022), and on the French site it was again Sentinel-2 data, with nearly 6 PiB published in 2023 (2 PiB in Y2022).

In terms of actual volumes of data published, though, it was the Norwegian site which published the most data, but the French, Austrian and Luxembourg sites also publishes a considerably higher volume of data than that published on the other sites.

When looking at the download volumes in 2023, both the total volume and the average volume decreased by 6% with respect to Y2022. At the level of the individual sites, the figures again show very different types of activity across the mirror sites.

For instance, users of the Austrian site downloaded 55.31 TB in Y2022 and but in 2023 the total increased to a huge 1,143 TB. Of this total volume, the overwhelming majority (94%) was Sentinel-2 data, with the remaining 6% primarily consisting of Sentinel-5P data, which had not been published at all on the site in Y2022. Big increases in the download volume were also seen on the Belgian, Romanian and UK-1 sites, with 172%, 207% and 378% increases respectively.

The largest decreases in the publication volumes with respect to Y2022 were on the Finnish and Czech sites, which saw reductions of 92% and 51% respectively in the download volume. The French site also saw a 16% decrease in the volume downloaded by its users. Nonetheless, it remained the site from which by far the greatest volume of data was downloaded, with its users having downloaded a massive 11,173 TB of data in 2023.

Canada, Hungary and Sweden did not provide figures for the download volumes this year. It is recalled that the Swedish site is not aimed at offering a download service but instead provides users with online hosted processing services.

CollGS Partners	2023 Published Volume (TB)				2023 Downloaded Volume (TB)			
	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P	Sentinel-1	Sentinel-2	Sentinel-3	Sentinel-5P
Austria	1,348.78	4,340.49	866.58	186.80	1.80	1,071.08	0.11	69.90
Belgium	34.10	170.10	4.60	0.40	0.15	1.13	0.00	0.04
Canada	22.00	148.00	2.00	-	-	-	-	-
Czech Republic	5.75	21.68	12.70	16.95	2.95	17.67	0.01	0.05
Estonia	10.26	1.69	0.94	-	63.30	51.97	24.19	-
Finland	112.69	84.31	77.67	1.18	12.55	1.16	2.88	1.42
France	1,099.73	6,020.90	-	-	10,437.30	735.30	-	-
Germany	42.01	44.81	17.49	131.82	3.59	4.17	0.07	0.03
Greece	161.19	230.55	53.27	78.12	2.76	1.93	0.75	0.53
Hungary	-	-	-	-	-	-	-	-
Luxembourg	1,413.98	4,386.00	-	-	15.62	1,285.26	-	-
Norway	2,079.38	5,472.82	1,216.02	212.93	293.07	775.34	8.71	3.15
Poland	28.82	26.58	28.67	31.60	5.59	3.42	14.58	0.54
Romania	11.70	10.40	12.30	-	29.00	12.20	6.90	
Sweden	-	339.93	5.94	-	-	N/A	N/A	-
UK-1	933.81	36.30	406.15	113.46	2.70	118.01	0.01	1.00
TOTAL	**7,304.20**	**21,334.57**	**2,704.33**	**773.26**	**10,870.38**	**4,078.64**	**58.20**	**76.66**
% increase/ decrease	**4%**	**13%**	**26%**	**56%**	**-18%**	**129%**	**-70%**	**140%**

Table 35: 2023 Publication and dissemination volumes in 2023 on mirror sites per Sentinel.

Table 35 breaks down the overall publication and download volumes by Sentinel mission, where this information was available.

3 sites out of the 16 sites published more Sentinel-1 data than any other mission in 2023, and these were Estonia, Finland, and UK-1.

Meanwhile, 9 out of the 16 sites published more Sentinel-2 data than any other mission: Austria, Belgium, Canada, Czech Republic, France, Greece, Luxemburg, Norway, and Sweden.

Only the Romanian site published more Sentinel-3 data than data from the other Sentinels, which was also the case in Y2022 and Y2021.

9 out of the 16 sites published Sentinel-5P data in 2023, with the Austrian site newly added to this list with respect to Y2022. Interestingly, the German site published 3 times as much Sentinel-5P data as data from any other Sentinel. However, users of the German site primarily downloaded Sentinel-2 and Sentinel-1 data.

All publication figures in 2023 saw an overall increase with respect to Y2022, with the percentage increase ranging from 4% (Sentinel-1) and 56% (Sentinel-5P). The large increase in the volume of Sentinel-5P data published can mostly be attributed to the Austrian, German, Norwegian and UK-1 sites, which together published 83% of the total volume of Sentinel-5P data published on the national sites in 2023.

The volume of Sentinel-3 data published on the national sites increased by 26% with respect to Y2022, mostly due to Norway, which alone published almost half (44%) of the total volume of Sentinel-3 data published on the sites.

In terms of download volumes, users of 7 out of the 16 sites downloaded more Sentinel-2 data than data from any other mission (Austria, Belgium, Czech Republic, Germany, Luxemburg, Norway, UK). It was the users of the Luxemburg site who downloaded the greatest volume of Sentinel-2 data across the sites (1,285 TB).

Users of the Estonian, Finnish, French, Greek, and Romanian sites downloaded a higher proportion of Sentinel-1 data than data from any other mission. Of these sets of users, it was the users of the French site who downloaded the highest volume of Sentinel-1 data (10,437 TB).

Users of the Polish site was the only group to download more Sentinel-3 data than data from any other mission, and together they downloaded 60% (14.6 TB) of the total volume of Sentinel-3 data downloaded from the sites.

Figure 78 illustrates the volumes of data published on each national site, next to the volume of data downloaded from each site. This makes it easy to compare user interest in the data with the data offering on the site. For the most part, user interest in the data roughly matches the data offering. There are a few instances, however, in which the data offering appears markedly more varied than user uptake of the data.

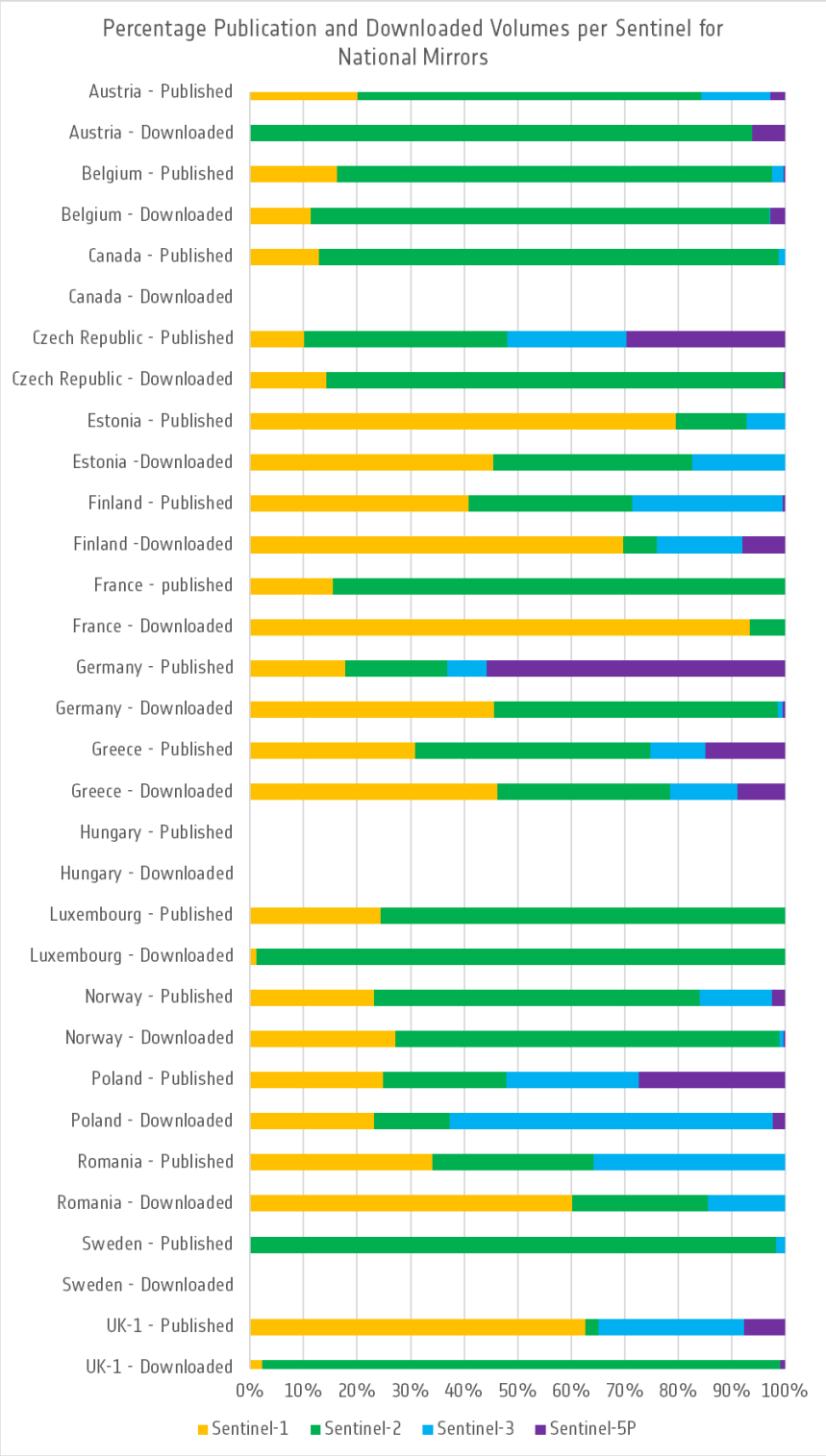


Figure 78: Percentage publication and dissemination volumes per Sentinel on mirror sites in 2023.

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 14 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, initially from IntHub and now from CDSE, and to transfer the data to their national data access sites for use by their own user communities.

During 2023, two accounts were created on IntHub for new international partners: the Sahara and Sahel Observatory (OSS), which signed a TOA on 30 December 2022; and the International Commission of the Congo-Ubangui-Sangha Basin (CICOS), which signed a TOA on 22 March 2023. ESA signed TOAs with two further international institutions in 2023, the Panamanian National Institute for Government Innovation (AIG) and the Philippine Space Agency (PhilSA), but accounts were opened for them directly on the CDSE.

Table 36 below presents an overview of the 13 Copernicus international partner sites which are currently operational, 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
United States National Aeronautics and Space Administration (NASA)	18-Feb-2016	12-Dec-2015	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. 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). The relevant websites are: S1: https://vertex.daac.asf.alaska.edu S2 (HLS which are data derived from Sentinel-2): https://lpdaac.usgs.gov/products/hls30v015/

			S3:https://oceancolor.gsfc.nasa.gov and https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/olci/ S5P: https://disc.gsfc.nasa.gov
United States National Oceanic and Atmospheric Administration (NOAA)	1st signed 7-Mar-2016 – update signed 19-Dec-2017	01-May-2016	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. The site is primarily intended to 98nablee users to download the data and to visualise it online. https://coastwatch.noaa.gov
Australia Geoscience Australia (GA)	24-Mar-2016	26-Jun-2015	GA publishes Copernicus Sentinel data on its data access site 'Sentinel Australasia Regional Access' (SARA). 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. SARA is hosted at the National Computational Infrastructure and operated by the Regional Copernicus Data Hub consortium formed by GA, the New South Wales Office of Environment and Heritage, Queensland Department of Environment and Science, Western Australian Land Information Authority and the Commonwealth Scientific Industrial Research Organisation. https://copernicus.nci.org.au
Serbia The BioSense Institute – Research Development Institute for Information	25-Jan-2019	Mid-Oct 2019	BioSense is revamping its regional data access mirror site/analysis hub, which is aimed at improving access to and the exploitation of Copernicus Sentinel data in the Republic of Serbia and the wider Balkan area. The relevant websites are: https://biosens.rs and https://agrosens.rs.

Technologies in Biosystems			
Brazil Brazilian Space Agency (AEB) and the National Institute for Space Research of Brazil (INPE)	14-Mar-2019	1 December 2021	INPE has incorporated Copernicus Sentinel data into its regional data access/analysis STAC server, to facilitate the access to and exploitation of Copernicus Sentinel data in Brazil. Collections of Sentinel images are available for searching using the STAC protocol and can be browsed at https://data.inpe.br/stac/browser/. For Sentinel 2 data, the bands are being available as in COGeotiff format. The Brazil Data Cube project is developing EO Data Cubes from Sentinel-2 for the extension of Brazil. In 2023, the project started generating the data cubes directly from the local interfaces to the Brazilian Mirror Site. The Sentinel-2 data cubes are being used to develop land use and land cover for the Brazilian biomes. The updated list and descriptions of the Sentinel data cubes can be found using the link http://www.brazildatacube.org/en/data-cube/.
Ukraine State Space Agency of Ukraine (SSAU)	28-Mar-2019	1-Jan-2020	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. 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. http://sentinel.spacecenter.gov.ua/
India Indian Space Research Organisation (ISRO)	11-Apr-2019	26-Jan-2020	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. https://bhoonidhi.nrsc.gov.in
Chile University of Chile	20-Aug-2019	27-Sep-2019	UdeChile, through the Center for Mathematical Modelling (CMM) and its specialised units, in particular the HPC Center and its Image Processing Working Group, operates a regional data access/analysis mirror site to improve access to and the exploitation of Copernicus Sentinel data, initially in Chile and later also in the Latin American region. Currently the site maintains a window of 60 days of all Sentinel-1 and -2 data tiles which intersect the Chilean territory. The site is primarily intended to enable users to download the data. www.datoscopernicus.cl
Colombia	26-Dec-2019	n/a	IDEAM intends to establish a regional data access/analysis site to facilitate access to and the exploitation of Copernicus Sentinel data

Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM)			in the Latin American region. The current area of interest is limited to Colombia. The initial aim of the site is to provide data to create annual reporting of deforestation of the country.
Tunisia Sahara and Sahel Observatory (OSS)	30 Dec 2022	January 2023	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 OSS's partners in GMES and Africa. The website is http://misbar.oss-online.org/
Democratic Republic of Congo Commission Internationale du Bassin du Congo-Oubangui-Sangha (CICOS)	22 March 2023	April 2023	CICOS is incorporating Copernicus Sentinel data into the Earth Observation products and tools which it makes available for users in the field of hydrological forecasting, weather forecast, vegetation cover, land use (Habitat), monitoring of bush fires and the flooded areas forests in the Congo Basin.
Panama National Institute for Government Innovation (AIG)	10 May 2023	Under development	AIG is developing a data centre providing regional access to Copernicus Sentinel data, as part of DG-INTPA's Regional Copernicus Centre in Panama initiative ('CopLAC').
Philippines Philippine Space Agency (PhilSA)	11 December 2023	Under development	PhilSA is developing a local Copernicus data centre for supporting the creation of value-added information and the development of new data products and downstream services in the Philippines. This activity is being developed as part of the European Commission's National Copernicus Capacity Support Action Programme for the Philippines ('CopPhil').

Table 36: International Partners summary.

The international partners send ESA annual feedback on the status of their sites and the uptake of Copernicus Sentinel data from those sites. This year, statistics were received for the NASA, Australian, Brazilian, Ukrainian, Indian, and Chilean sites, and this input is summarised in Tables 37 and 38 below. Where information was not available in their reports this is shown as '-'. No statistics could be provided for the Serbian data centre because it was still being renovated in 2023. Statistics were also not available for Colombia, Congo, Panama and the Philippines, where the data centres are still under construction. NOAA did not submit a report for 2023.

For the Tunisian site, OSS reported that the Copernicus data site is still under development. However, in 2023 its users could access data from its existing MISBAR platform, and to date MISBAR users were mainly using Copernicus Sentinel data for:

- Crop mapping using time-series Sentinel-1 and Sentinel-2 in Tunis
- Crop monitoring using Sentinel-2 data on Libyan regions, with a specific focus on

cereals growing in the southern part of area of interest.

- Quantification of burnt area via Sentinel-2 and Sentinel-3 in forest ecosystem in the North-Africa, mainly during the period July-October

Table 37 presents information about the number and type of users on each of the operational sites. The number of registered users increased on each site in 2023, and there was an average increase across all sites in the number of registered users of 41% per site.

International Partner	Operation start date	Number of active users in 2023	% increase in active users since Y2022	Principal user categories (percentages of registered users unless otherwise stated)
Geoscience Australia (Australia)	26-Jun-15	11,610	43.5%	International public organisation: 4% National/regional/local public authority: 17% Research & education organisation: 32% Business/commercial/professional - SME: 20% Business/commercial/professional - non-SME: 4% Charity or NGO: 2% Private individual - personal interest: 13% Other : 0.3%
NASA (USA)	12-Dec-15	47,861	5%	International public organisation: 92% National/regional/local public authority: 2% Research & education organisation: 5% Business/commercial/professional - SME: 1% Business/commercial/professional - non-SME: 0% Charity or NGO: 0% Private individual - personal interest: 0% Other : 0.3%
University of Chile (Chile)	27-Sep-19	122	47%	-
SSAU (Ukraine)	01-Jan-20	40	33%	Research: 40% Commercial: 3% Education: 47% Other: 10%
ISRO (India)	26-Jan-20	316	101%	International public organisation: 2% National/regional/local public authority: 32% Research & education organisation: 46% Business/commercial/professional - SME: 0% Business/commercial/professional - non-SME: 20% Charity or NGO: 0% Private individual - personal interest: 0% Other : 0.1%
INPE (Brazil)	14-Mar-19	-	N/A	-

Table 37: International Partner general characteristics and statistics for 2023.

*Active users - as user information is not recorded for all downloads, the total number of active users value is based on unique IP addresses. In addition, a review of previous calculations of this value indicates it has been overestimated in the past. A corrected value for this year has been supplied above 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 2023 (TB)	% Change in Published Volume from Y2022	Total Published Volume since start of data distribution (TB)	Total Downloaded Volume in 2023 (TB)	% Change in Downloaded Volume from Y2022	Total Downloaded Volume since start of data distribution (TB)
Geoscience Australia (Australia)	1,319.0	5%	7,751.0	2,891.0	-55%	21,715.0
NASA (USA)	6,498.5	123%	24,005.5	71,152.4	23%	193,436.9
University of Chile	96.4	26%	473.3	0.3	-28%	13.7
SSAU (Ukraine)	91.6	7%	412.2	0.4	-7%	4.8
ISRO (India)	217.0	-3%	715.0	178.0	-26%	611.0
INPE (Brazil)	158.7	9%	343.5	-	N/A	-

Table 38: International Partner publication and download statistics for 2023.

Table 38 above summarises, per partner, the volumes of published and downloaded data by the end of 2023 and, where applicable, also the percentage change with respect to the end of Y2022.

Overall, the average volume of data published per site in 2023 was 1,397 TB, but this figure masks big differences in the approach of each data site with respect to the amount of data they chose to make available to their users.

By far the highest volume of data published on an international partner site in 2023 was on NASA's site, which published an additional 6,499 TB of data in 2023, making a total of 24,006 TB of data published on the site since NASA first started publishing Sentinel data back in December 2015. Users of NASA's site kept pace with the high publication volume and downloaded 71,152 TB of data in 2023, 23% more than the volume they downloaded in Y2022, making a total of 193,437 TB of data downloaded since NASA started publishing Sentinel data.

For the other 4 sites which reported both publication and download values, the volume of data published mostly rose compared to the volume published in Y2022, while the volume of data downloaded by users fell on each site. The Australian site published 5% more data than it had in Y2022, but its users downloaded 55% less data than they had in Y2022. The volume of data published on the Chilean site was 26% more than in Y2022, but the amount of data downloaded from the site was 28% less than in Y2022.

On the Ukrainian site, 7% more data was published than had been published in Y2022 but 7% less was downloaded. The Indian site saw both a 3% decrease in the volume of published data, and a 26% drop in the download volume, with respect to Y2022.

The volume of data published on the Brazilian site increased by 9% compared to Y2022, but no download figures were available.

In Table 39, the overall volumes of user-level data published and downloaded in 2023 are broken down by Sentinel, to show the focus of each site in terms of the Sentinel missions which are made available to their users, and the respective interest of the users. Geoscience Australia reported for the Australian site that although Sentinel-5P data is being published on the site, the volume of Sentinel-5P data downloads is currently not yet being recorded.

The big increase in the volume of data published on NASA's site in 2023 is largely accounted for by increases in the volumes of Sentinel-2 data published (+335% compared to Y2022), Sentinel-5P data (+265% compared to Y2022), and Sentinel-3 data (+114% compared to Y2022), while the volume of Sentinel-1 data published only increased by 19% compared to Y2022.

The Indian site continues to publish only Sentinel-1 and Sentinel-2 data, while the Brazilian site increased the data offer in 2023 to include Sentinel-3 data, publishing nearly 7 TB of Sentinel-3 data in the year.

The Ukrainian site joined the NASA and Australian sites in making Sentinel-5P data available to its users, and published nearly 4 TB of Sentinel-5P data in the year.

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	2023 Published Volume (TB)				2023 Downloaded Volume (TB)			
	S-1	S-2	S-3	S-5P	S-1	S-2	S-3	S-5P
Geoscience Australia (Australia)	182.0	634.0	478.0	25.0	1,498.0	1,036.0	357.0	-
NASA (USA)	1,305.5	1,867.6	2,471.0	854.4	65,276.0	2,835.1	638.5	2,402.9
University of Chile (Chile)	28.8	42.6	25.0	-	0.2	0.1	0.1	-
SSAU (Ukraine)	29.1	36.5	22.2	3.8	0.1	0.3	0.0	-
ISRO (India)	27	190	-	-	33	145	-	-
INPE (Brazil)	8.3	143.7	6.7	-	-	-	-	-

Table 39: Publication and download volumes on each international partner site, per Sentinel mission for 2023.

5 Data Access System perfomance analysis

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

5.1 Service Availability

Service availability is defined as the percentage of a given time period during which it is possible for users to search the catalogue and retrieve data from the system. The service availability of each of the data hubs has been constantly monitored and presented to users in the statistics panel of each data hub. The number of data packages 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 40 below presents the overall availability for each of the four hubs for Y2023, i.e. until the closure of the data hubs in October 2023. For comparison, the table also sets out the corresponding values recorded for Y2015-Y2022, 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 four years: each Hub achieved over 99% overall availability, and 2 of the 4 hubs reached the highest availability yet recorded for that hub.

Hub	2023	Y2022	Y2021	Y2020	Y2019	Y2018	Y2017	Y2016	Y2015
Open Access Hub	**99.89**	99.75	99.39	99.10	99.34	98.48	98.95	95.11	96.62
Collaborative Hub	**100**	100	100	100	100	100	98.04	98.19	96.09
Copernicus Service Hub	**99.93**	99.94	99.90	99.23	99.60	98.50	98.60	99.35	N/A
International Hub	**99.92**	99.91	99.99	99.99	99.95	99.90	98.89	99.59	N/A

Table 40: Overall availability of each hub during reporting years Y2015 – Y2023

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

Month	Open Access Hub	Collaborative Hub	Copernicus Services Hub	International Hub
Jan-23	100	100	100	100
Feb-23	99.72	100	99.85	100
Mar-23	100	100	100	99.96
Apr-23	99.39	100	99.55	100
May-23	99.87	100	100	100
Jun-23	99.97	100	100	100
Jul-23	99.94	100	99.87	99.36
Aug-23	100	100	100	100
Sep-23	100	100	100	99.85
Oct-23	100	100	100	100
Y2023	**99.89**	**100.00**	**99.93**	**99.92**

Table 41: Monthly availabilities during Y2023 per hub (green shading indicates >98% availability; yellow shading indicates <98% availability – not present; red shading indicates <95% - not present)

Table 41 breaks the overall availability figures down by month for each of the hubs. Each year this monthly availability has been improving.- However, this year there was further improvement still and the monthly availability for all of the hubs remained above 99% 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 41, 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 2023, 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 Greek NOA/GRNET infrastructure – achieved 99.92% overall yearly availability, very slightly higher than in Y2022. In fact, for 7 months of 2023, no downtime was recorded on IntHub at all. There was a very slight reduction in the overall availability of ServHub, which had achieved 99.94% in Y2022, and then 99.93% in Y2023.

Mostly, the periods of unavailability were due to scheduled maintenance activities, which were aimed at improving download performance. Below is a list and description of the scheduled upgrades and maintenance activities which took place in Y2023:

- 14/02/2023 from 08:00 to 15:30 UTC.
  A security infrastructure maintenance activity with the purpose of fixing a database exception error was performed. During the maintenance window, access to the service was interrupted.
- 09/05/2023 from 07:00 to 11:00.
  A Maintenance activity was performed to enhance service performance (memory increase of PostgreSQL database) to better cope with increased user activity on Sci/Api Hubs.
- 23/05/2023 from 07:00 to 13:00.
  A Maintenance activity on the NAS disk hosting S3B online data was performed, to migrate data to new disks before scheduled

dismissal, as requested by the cloud provider. Users might have experienced brief interruptions in accessing the following Data Access Services: Sci/Api Hubs, Collaborative Hub Node 1 and Copernicus Services Hub.

- 04/07/2023 from 07:30 to 11:30 UTC.
  A maintenance activity was performed on ServHub and the ColHub Node 1, interrupting these instances for 2 hours. The maintenance was aimed at implementing a RAM increase on the Postgres Cluster, to better cope with increased workload generated by users' activity.
- 10-11/07/2023 and 17-19/07/2023.
  Maintenance activities were performed to update the DHUS software, implementing the needed modification for coping with new Sentinel-3 Processing baseline (3.23). The maintenance window involved all hubs and relative backends, with the following schedule:
    - 10/07/2023 from 6:30 UTC to 16:30 UTC on the Open Access Hub (SciHub and ApiHub), the GNSS POD Hub, the International Access Hub and the Africa Cast Hub.
    - 11/07/2023 from 6:30 UTC to 16:30 UTC on the Collaborative Hub Node 1-2-3, the Copernicus Service Data Hub and the Dias Access Hub Node 1.
    - 17/07/2023 from 6:30 UTC to 16:30 UTC the maintenance interested the DHUS Sentinel-3 backends: Sentinel-3A and Sentinel-3B.
    - 19/07/2023 from 6:30 UTC to 16:30 UTC the maintenance affected the DHUS Sentinel-1A, Sentinel-2A, and Sentinel-2B backends.
    - 19/07/2023 from 6:30 UTC to 13:30 UTC the maintenance activity involved the Sentinel-5P Expert and Pre-Ops hubs, including relative backends.
- 10/10/2023 from 04:30 UTC to 12/10/2023 13:00 UTC
  A maintenance activity was performed on the core infrastructure hosting the data hub services, with no severe impacts on users. The Sentinel-5P Pre-Operations Data Hub was not affected by the maintenance.

Several unexpected anomalies were also experienced during Y2023. The most significant of these anomalies were:

- 07/01/2023 from 03:54 to 04:05 UTC.
  The Collaborative Node 2 was affected by network instability due to a Network issue at the Service Provider hosting the Service. From a user point of view, the service availability didn't have any impact because of the redundancy of the service on the other two nodes of ColHub.
- 24/02/2023 from 00:13 to 00:30 UTC and 20/03/2023 from 23:57 to 00:13 UTC.
  The Open Access hub experienced a short period of unavailability due to a high number of user requests. No major impacts on the service were detected and the fetching and publication of the products continued nominally.
- 07/03/2023 from 05:00 to 08:00 UTC.
  The Collaborative Node 3 was affected by network instability due to a Network outage at the Service Provider hosting the Service. From a user point of view, the service availability didn't have any impact because of the redundancy of the service on the other two nodes of ColHub.
- 07/03/2023 from 05:13 to 05:23 UTC and 06:03 to 06:14 UTC.
  IntHub experienced a short period of unavailability due to a Network issue at the Greek Centre hosting the Service. The Service was promptly restored, and the fetching and publication of the products continued nominally.
- 16/06/2023 from 02:40 to 06:30 UTC.
  An unexpected network incident experienced at the Greek data centre resulted in a stop of publication of fresh S5P products on S5P pre-ops hub. Even though user access to S5P services was possible, data download was not allowed. This event also caused a publication delay of S3A SLSTR on IntHub and ColHub Node 3.

- 14/07/2023 from 13:20 to 16/07/2023 18:30 UTC.
  Following a power failure at the Greek Data Centre, the backup supply systems failed as they were not able to supply the demand due to the extreme heat wave. The interruption affected IntHub, the Sentinel-5P Pre-Ops Hub, and ColHub Node3. Services were successfully restored at 18:30 UTC on 16 July, and the data publication backlog had been recovered by 17 July 2023.
- 27/07/2023 from 14:08 to 15:38 and from 19:30 to 00:30 UTC.
  An unexpected issue on the Object Storage (RADOSGW) the Greek data centre resulted in a delay of publication and some missing Copernicus Sentinel-5P products on Sentinel-5P Pre-Ops Hub and Sentinel-5P Expert Hub. The backlog of missing products has been gradually recovered.
- 27/08/2023 from 15:39 to 28/08/2023 07:57 UTC.
  A network incident on the Greek data centre Object Storage affected the product publication on Sentinel-5P Pre-Ops and Expert Hubs. The issue was caused by an overload of storage nodes, not properly balanced by the network system. After the incident, services were restored, and product publication gradually recovered.
- 10/09/2023 from 09:30 to 10:40 UTC.
  A hardware problem resulted in the failure of the PostgreSQL service to initiate, leading to downtime for the S5P Pre-Ops Hub, ColNode 3, and IntHub. The product publication was not affected during the window.
- 11/09/2023 from 19:40 to 20:05 UTC.
  A hardware issue caused this downtime on the Sentinel-5P Pre-Ops Hub, ColHub Node 3, and IntHub. One of the VMs was migrated back to the problematic host that caused the downtime on 10/09/2023. The faulty node was then removed from the cluster to avoid similar incidents in the future.

5.2 Network Analysis

Data traffic loads

In Y2023, the outgoing traffic from the Sentinel Data Access System exhibited a steady flow of approximately 3 Gbps, with occasional spikes reaching up to 44 Gbps. Notably, the system experienced more loads in activity during the months of March-April-May, as well as July 2023.

Figure 79 shows the daily outgoing traffic from the cloud infrastructure (OVH) during 2023, with the purple line showing the MAX and the green line showing the AVERAGE transmit rate reached on each particular day.

Comparing this figure with the network capacity during Y2022, the overall maximum outgoing traffic did reach similar peaks in July 2022, but the trend in Y2023 was a general decrease in outgoing traffic.

As mentioned, there was a particularly high increase in the outgoing traffic during spring 2023. This may be partially attributed to an improved network configuration that enhanced the speed performance for nearline user level data: in this period the average load was roughly 38 Gbps from 35 Gbps.

A particularly high level of traffic continued to be seen until Services closure, especially in the max trendline.

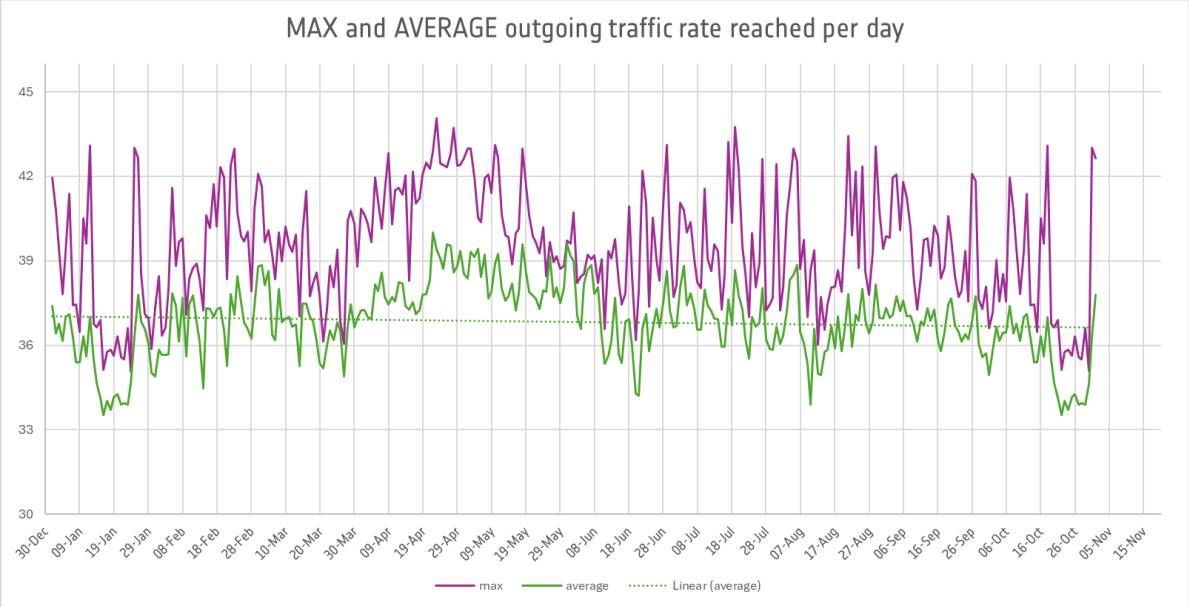


Figure 79: Max and average outgoing traffic in Gbps reached each day during Y2023.

Effective bandwidth

Figure 80 below presents for each hub the percentage of completed downloads performed in October 2023 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 data package and the volume of that downloaded 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 data package on the user's disk, as well as the concurrent activities on the hub at the time the download is made. This provides an approximate overview of the general performance all users of the hubs should have perceived when they downloaded Sentinel user-level data in Y2023.

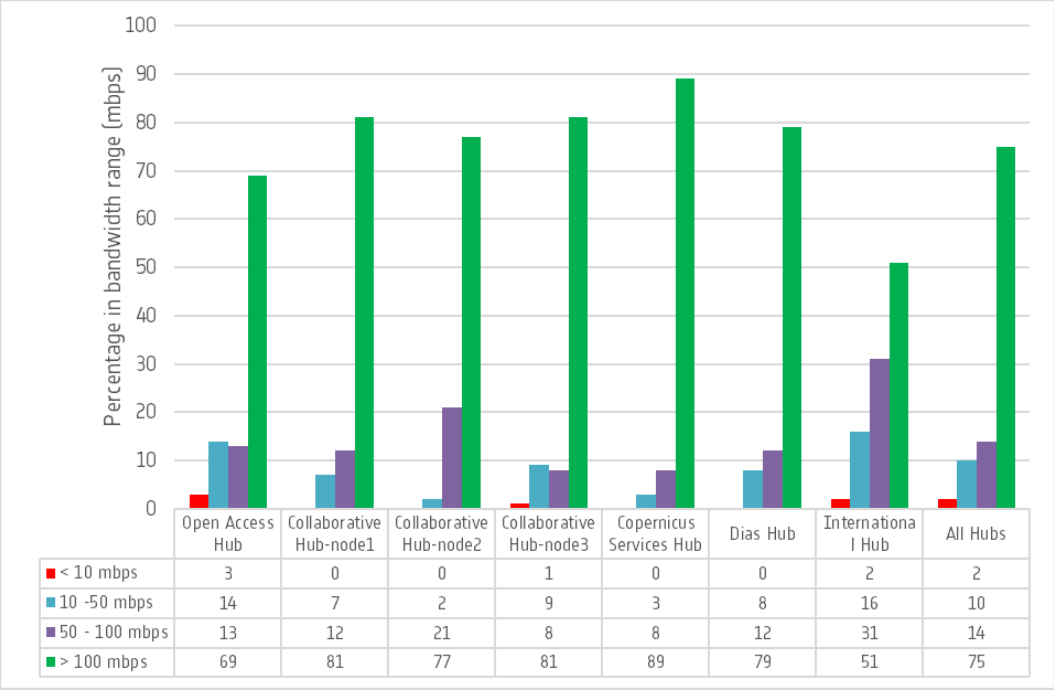
For all hubs, the most frequently experienced (or equal highest) effective bandwidth in October 2023 was >100 Mbps, and this indicates that users were for the most part able to download data at a very fast rate in Y2023. However, there was a slight reduction in the figure with respect to Y2022: considering all hubs together, in October 2023 nearly 75% of all downloads were made at an effective bandwidth of >100 Mbps, whereas the equivalent figure in December 2022 was 80%.

For the Open Hub users, 69% of the downloads they made reached an effective bandwidth higher than 100 Mbps, and this is a decrease with respect to December 2022 when this figure was 78%.

For ServHub and ColHub Nodes, nearly 90% and 80% downloads took place, respectively, at >100 Mbps; in ColHub, the Node 2 shows the lowest figure, at 77%.

On IntHub, the percentage of downloads which were made at a high effective bandwidth remained at the much higher level which had started to be seen in Y2022. There was, however, a decrease compared to Y2022, with 51% of downloads in Y2023 falling in the category `>100 Mbps', whereas in December Y2022 it had been as much as 67%.

Overall, only 2% of downloads made in October 2023 were made at speeds lower than 50 Mbps, and this represents a huge improvement since December 2022, when it was 12%.



	Open Access Hub	Collaborative Hub-node1	Collaborative Hub-node2	Collaborative Hub-node3	Copernicus Services Hub	Dias Hub	International Hub	All Hubs
< 10 mbps	3	0	0	1	0	0	2	2
10 -50 mbps	14	7	2	9	3	8	16	10
50 - 100 mbps	13	12	21	8	8	12	31	14
> 100 mbps	69	81	77	81	89	79	51	75

Figure 80 Effective bandwidth range per Hub for all completed downloads in October 2023.

5.3 Publication Timeliness

Publication timeliness is a measure of the time it takes from the data being sensed by the satellite to the 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 data published after 7 days are either the result of reprocessing or exceptionally serious anomalies.

Table 42 below shows the average sensing to publication timeliness for data on the Open Hub during Y2023, and the change with respect to the Y2022 values. Considering the Open Hub closure, the table below compares the average publication timeliness during the last trimester of 2022 with the figures relative to the last trimester of Y2023 (August-September-October 2023).

mission	Average timeliness for NRT user level data	Increase/ decrease since Y2022	Average timeliness for NTC user level data	Increase/ decrease since Y2022	Average timeliness for STC user level data	Increase/ decrease since Y2022
S1	2h 18m	-2m	3h 37m	+17m	-	
S2	-		5h 31m	-14m	-	
S3-OLCI	2h 6m	-34m	18h 15m	-3h 45m	-	
S3-SLSTR	1h 57m	- 6 min	26h	-1h 3m	-	
S3-SRAL	2h 6m	-14m	26d 5h 16m	-7h 41m	1d 14h 44m	+ 7h 4m
S3-SYNERGY	-		1d 10h 44m	-1h 16m	9h 8m	-1h 12m
S5P	2h 42m	+34m	1d 3h 25m	-1d 6h 35m	-	

Table 42: Average publication timeliness on the Open Hub over Aug-October 2023, and comparison with last trimester of Y2022.

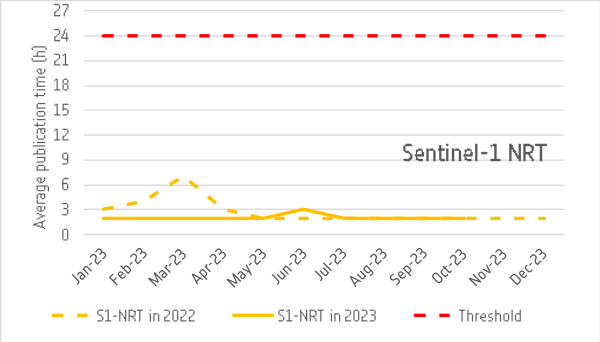
Sentinel-1

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 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.

Figure 81 shows the average monthly timeliness in which Sentinel-1 NRT and NTC data was published on the Open Hub during Y2023. The dotted orange lines show the monthly timeliness during Y2022, 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 Y2023, and in fact an average of 2-3hrs was achieved in all months. The graph shows that the average NRT publication timeliness remained almost constant throughout Y2023, with just a slight drop in June 2023, when the average rose to 3 hours from sensing. Overall, there was a very slight improvement in the average timeliness with respect to Y2022, with it rising to 2hours and 18 minutes during the last trimester of Y2023 (Aug-Oct), compared to 2 hours and 20 minutes in the last 3 months of 2022.

For the Sentinel-1 NTC data, the monthly average publication timeliness showed a more positive and stable trend than was seen in Y2022. With the exception of April 2023, when the average publication timeliness increased from 3 to 5 hours, the monthly average did not exceed 4 hours from sensing in any month.



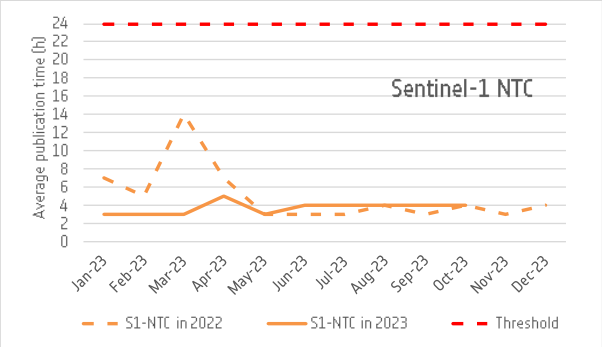


Figure 81: Monthly Average Publication Timeliness on the Open Hub for Sentinel-1 user-level data during Y2023, with 2022 for comparison.

Sentinel-2

The Sentinel-2 publication timeliness in the last trimester of Y2023 (Aug-Oct) was on average 5h 31m, and this is 14 minutes faster with respect to the last trimester of Y2022. Figure 82 illustrates the average publication timeliness for Sentinel-2 data by month. The trend is very even throughout the year, with the average varying only between 5 and 6 hours from sensing. Again, for all months the 24-hour threshold was respected.

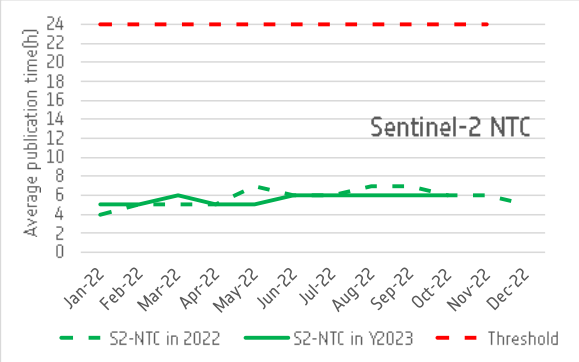


Figure 82: Monthly Average Publication Timeliness on the Open Hub for Sentinel-2 NTC user-level data during Y2023, with 2022 for comparison.

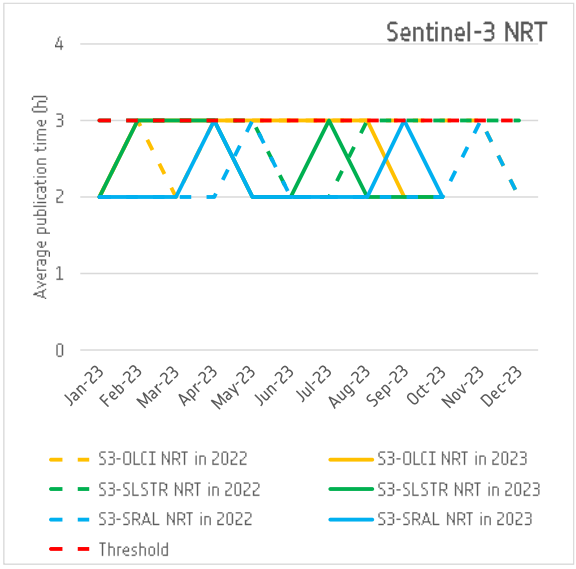
Sentinel-3

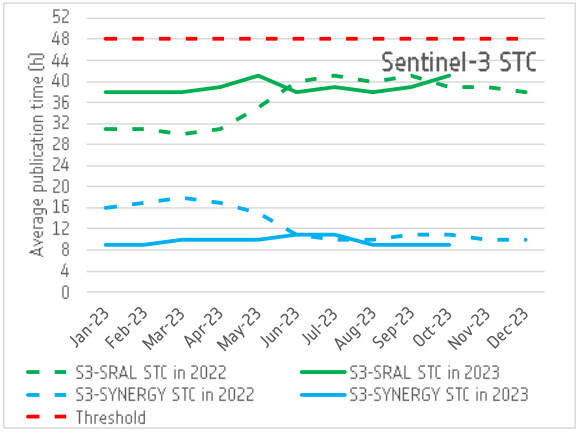
Figure 83 shows the monthly publication timeliness for each set of Sentinel-3 user-level data on the Open Hub, with the values from Y2022 for comparison. The dotted red lines indicate the threshold of expected timeliness (please note, however, that the 30-days threshold for NTC data are not indicated for a better visualisation of results).

For the Sentinel-3 NRT data, the target 3-hour NRT timeliness was achieved for each Sentinel-3

instrument throughout Y2023, as during Y2022. The averages during the last trimester of 2023 were 2h 6m for OLCI, 2h 6m for SRAL and 1h 57m for SLSTR. This represents an improvement of -34 minutes for OLCI, -14 minutes for SRAL and roughly -6 minutes for SLSTR with respect to the last trimester of Y2022.

In more detail, the publication timeliness for Sentinel-3 SRAL NRT remained good throughout Y2023, with an average publication time of 2 hours for most of the months, similar to the previous year, except for the months of April and September in which the average timeliness rose to 3 hours from sensing. The publication timeliness of the OLCI NRT data was also similar to that seen in Y2022, with a monthly average timeliness only slightly higher than that of SRAL.





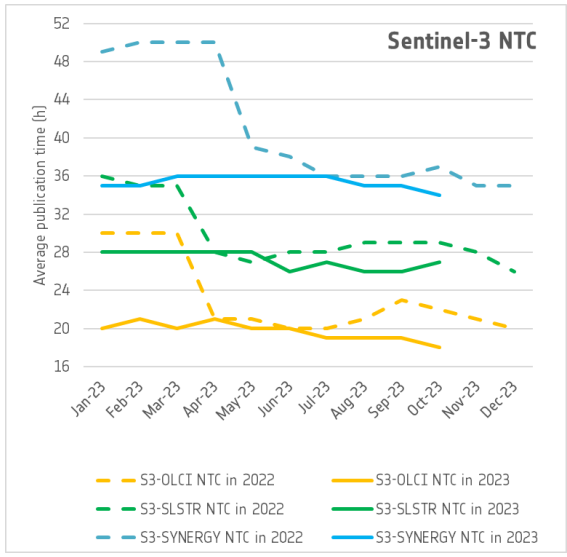


Figure 83: Monthly Average Publication Timeliness on the Open Hub for Sentinel-3 data during Y2023, with 2022 for comparison.

For Sentinel-3 STC SRAL, the average timeliness was considerably above 1 day and degraded by 7 hours with respect to Y2022. For SYN instead the STC timeliness was within 9 hours from sensing, fully implementing the 1-day threshold.

The timeliness for all Sentinel-3 NTC data types was significantly faster and more stable than it had been in Y2022, for all Sentinel-3 NTC data types. . SRAL NTC 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 illustrated in Table 42, during Y2023 the average time for publication of Sentinel-5P NRT data was 2h 42m from sensing, respecting the 3-hour constraint, although this represents an increase of +34 minutes compared to the average figure from Y2022.

For the Sentinel-5P NTC data, the average publication timeliness over Y2023 decreased significantly with respect to Y2022, by roughly 1 day. The offline user-level data also respected the 3-hours timeliness constraints, improving the performance to 1 day and 3 hours (compared to 2 days and 10 hours in Y2022). Sentinel-5P NO_2 data was disseminated in about 10 days and the O_3 TCL data in 15 days.

5.4 Data Hub Maintenance and Software Improvement

During Y2023, the Data Hub Service Maintenance Team focused on adapting the DHuS Service to utilise the Sentinel Data collections hosted within new Copernicus Data Space Ecosystem (CDSE) and the operations of the Complementary Centres ensuring sufficient redundancy and capacities to ensure robust continuity of operations.

The main interface with the CDSE catalogue was the ColHub Primary Node, that acts as proxy for all the Complementary Centres and user download requests. Moreover, no updates were necessary on the Complementary Centres (ColHub Node 2 and 3) side.

To cope with the new Operational Scenario, the DHuS software has been adapted to add the feature for directly connecting to the CDSE OData API and synchronize the products metadata including the browse and quick-look images that are no more generated by the DHuS since the products are not downloaded and ingested on the ColHub Primary Node.

A specific metadata mapping has also been put in place on DHuS software to be compliant with the products information exposed by the CDSE APIs.

To properly interface the CDSE catalogue, the DHuS authentication mechanism has been also improved to be compliant with the OAuth2 protocol for data download.

The interface between the ColHub Primary Node and the Complementary Centres is still regulated by the synchronization with copy mechanism, since both Centres keep a local copy of products.

All DHuS software updates have been also made to ensure a transparent transition for external Users by reducing impacts to the Collaborative community.

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 data:

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

DHuS Releases

In Y2023, four new versions of the Open-Source Framework (OSF) software were released.

- 3.0.8-osf: 5 Ott.22
- 3.0.8.3-osf: 16 June 23

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.

V.3.0.8.3-osf, the latest software update, has successfully resolved the slow ingestion performances of Sentinel-5P user-level data.

Open Source DHuS Downloads

At the end of 2023 the total number of downloads of all versions of the OSF was 9,395, an increase of more than 11% downloads since the end of Y2022. This demonstrates that there was still high interest in the open-source distribution by the user community in Y2023.

Within this total, there were 670 downloads of v. 3.0.8-osf (released in October 2022) and 965 downloads of v. 3.0.8.3-osf (released in June 2023), accounting for the overall downloads throughout the reporting period.

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).

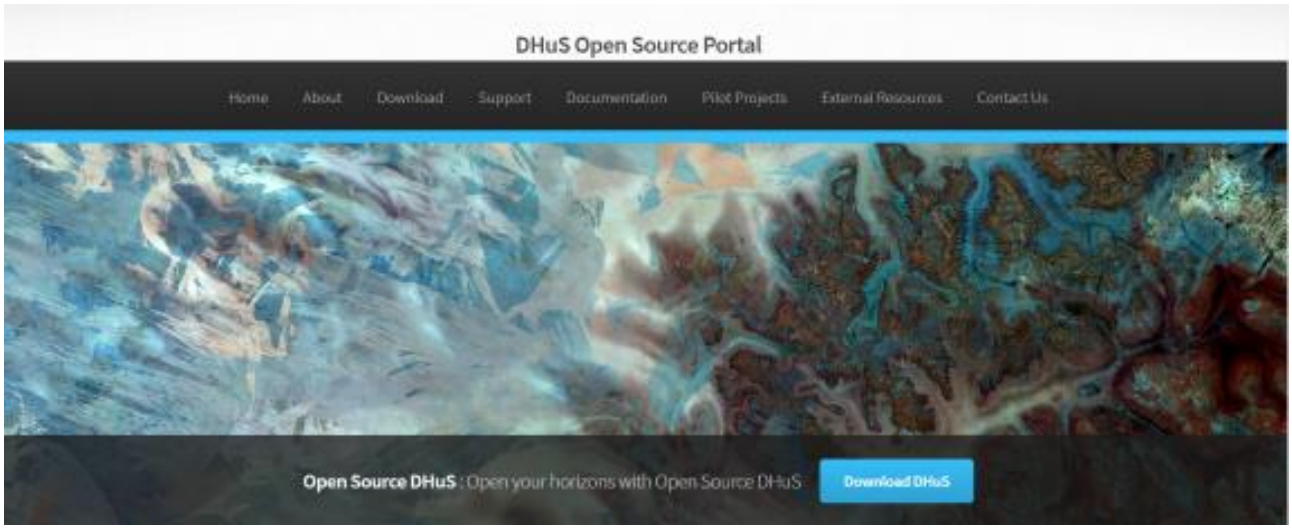


Figure 84: Open Source Dhus portal webpage.

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 Sentinel 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.

Compared to the previous year, the Data Access team saw a notable 33% decrease in total tickets, amounting to 824 tickets over the 10-month reporting period. This decline can also be attributed to the progressive migration of users to the Copernicus Data Space Ecosystem.

Out of the 824 tickets, the 'Junk' category - accounted for 32 tickets (4%).

Among the most significant categories, the majority of tickets (65%) originated from 'User Accounts'. This substantial increase compared to Y2022 (49%) is attributed to an unexpected surge in usage by automated download users, whose accounts were temporarily suspended due to performance degradation issues on the service, resulting in a higher volume of support requests.

The `Service Interface` category accounted for 20% of the total requests (164 tickets). This 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 updated user guides.

There were 49 tickets received in the `Products' category this year, amounting to 6% of the total requests. The tickets which fell in this category were mostly focused on a particular issue encountered when users tried to retrieve certain specific nearline data via the graphical user interface. The difficulty arose as a consequence of the transfer to the cloud infrastructure. The issue was resolved by adjusting the configuration of the eviction policy.

42 tickets were allocated to the `General' category, amounting to 5% of the total.

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

Only 2 tickets were raised for 'Web Portal' adjustments during the reporting period. and no tickets were raised for either 'Features Requests' or 'Bug'.

Figure 85 shows the percentage split between the categories during Y2023.

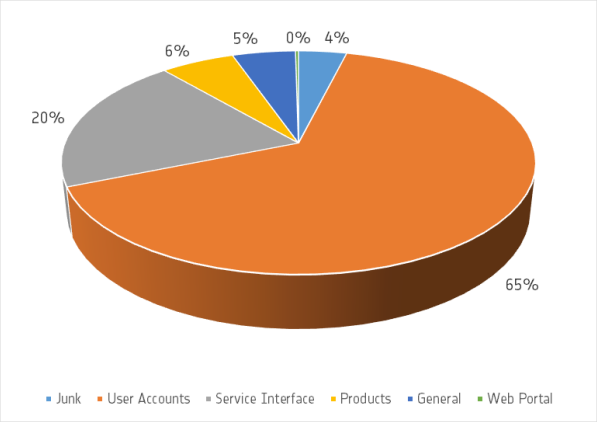


Figure 85: Proportion (percentage) of each category of tickets received from the Open Hub in Y2023.

The time to respond to all tickets is also logged. During the year, the average response time was 20 minutes and 30 seconds. The maximum response time for any ticket was 21 hours 15 minutes.

7 Outlook

In 2023, the Data Access System was decommissioned in favour of the new Copernicus Data Space Ecosystem (CDSE, https://dataspace.copernicus.eu/), which operates within a broader framework. This new ecosystem supports the development of third-party services, including unified User Management, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and integrated applications for user onboarding and local data exploitation.

The CDSE started its ramp-up operations at the end of January 2023 and operated alongside the Data Access System for most of 2023, gradually increasing its functionalities throughout the year. By July 2023, the Copernicus Data Space Ecosystem was fully operational, that coincided with the phasing out of the Sentinel Data Access System. This activity featured an intensive phase-in plan to facilitate the migration of hundreds of thousands of users from the four Data Hubs to the new service.

The support and a dedicated hub for the dissemination of Sentinel user-level data towards and within the Collaborative ground segments partners and DHRs, has been ensured for all of 2023. Moreover, the Collaborative Data Hub Service has been maintained to ensure a smooth continuation of the data retrieval, not only for the Collaborative Ground Segment users, but also for the associated Data Hub Relay user community, and the French and Greek data centres. Since November 2023, the new Collaborative ESA Node Service has been operational, replacing the Collaborative Hub. This Collaborative ESA Node Service allows users to continue downloading Copernicus Sentinel data using the familiar interfaces, ensuring a seamless transition and ongoing accessibility for all users. This guarantees a solid bond within the Collaborative network, supporting not only routine operations during 2024, but also stimulating scientific initiatives within an active user community.

In conclusion, after 9 years of successful service delivery, it is with great pleasure that the Data Hub Operations Team takes this opportunity to express a sincerest gratitude and appreciation for partners and stakeholders, and the customer ESA. Their dedication, expertise, and commitment to excellence have been instrumental in driving the success of the Data Hub System over the past years.

As looking to the future, the Team expertise will continue to be a valuable asset for data dissemination and service delivery, appreciating the memories and achievements shared together.

8 Useful Links

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

Annex 1: List of Acronyms

AER	Archive Exploitation Ratio
AOI	Area Of Interest
API	Application Programming Interface
CDSE	Copernicus Data Space Ecosystem
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)

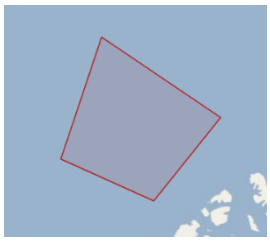
Open Hub	Copernicus Open Access Hub
OSF	Open Source Framework
PAC	Processing and Archiving Centre
PDGS	Payload Data Ground Segment
PLRM	pseudo-LRM
POD	Precise Orbit Determination
PRIP	Production Interface delivery Points
PuP	PARC Universal Packet
R&D	Research and Development
RINEX	Receiver Independent 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

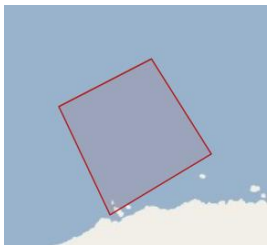
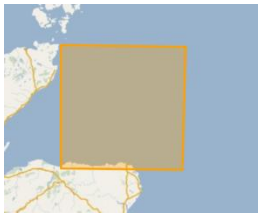
Annex 2: User-level data Type Description

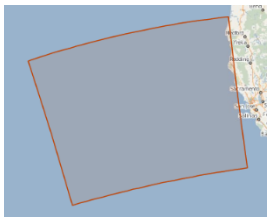
The following table provides:

- 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

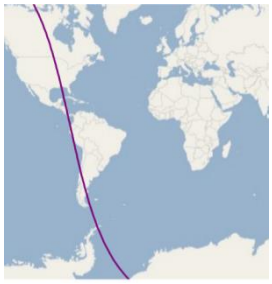
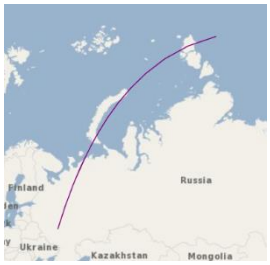
Further information on user-level data can be found on the 'Instrument user guides' following the link: https://sentinel.esa.int/web/sentinel/user-guides/

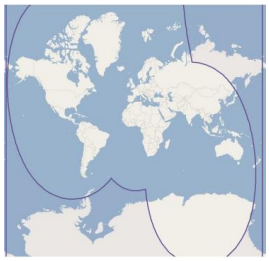
Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
Sentinel-1 (SAR)	L0-RAW	Sentinel-1 Level 0 RAW data		1.3 GiB	
	L1-GRDM	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: Medium Resolution		200 MiB	
	L1-GRDH	Sentinel-1 Level 1 Ground Range, Multi-Look, Detected: High Resolution		860 MiB	

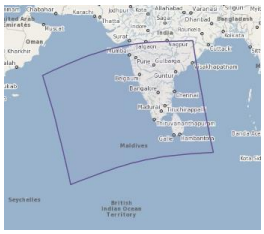
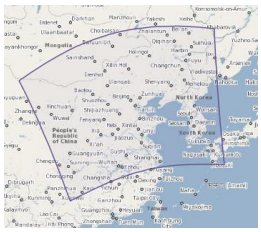
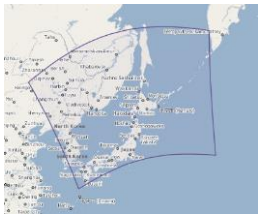
Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
	L1-SLC	Sentinel-1 Level 1 Single-Look Complex		4 GiB	
	L2-OCN	Sentinel-1 Level 2 Ocean		5 MiB	
Sentinel-2 (MSI)	MSIL1C	Sentinel-2 Level 1C		480 MiB	
	MSIL2A	Sentinel-2 Level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

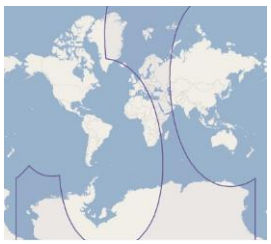
Mission and Instrument	User-level data types	Description	Footprint on the hub	Average size	New/updated user-level data in 2022
Sentinel-3 (SLSTR)	OLCI L2 Land FR	Sentinel-3 Level 2 OL_2_LFR___ Full Resolution Land & Atmosphere geophysical user-level data		100 MiB	Activation of Sentinel-3B data on the 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	
	SLSTRL1 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	The footprint for this user-level data type depends on timeliness: NRT  NTC 	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
Sentinel-3 (SYNERGY)	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.
	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_BD1 L1B_RA_BD2 L1B_RA_BD3 L1B_RA_BD4 L1B_RA_BD5 L1B_RA_BD6 L1B_RA_BD7 L1B_RA_BD8	Radiance user-level data bands 1-8: 1: 270-300nm 2: 300-320nm 3: 320-405nm 4: 405-500nm 5: 675-725nm 6: 2305-2345nm 7: 2345-2385nm 8: 2345-2385nm		1: 500 MiB 2: 2.8 GiB 3: 2.7 GiB 4: 2.6 GiB 5: 2.6 GiB 6: 2,6 GiB 7: 1.5 GiB 8: 1.6 GiB	
	L1B_IR_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 (CH_4) 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