EUMETSAT

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Copernicus data user uptake

2023 report











Monitoring weather and climate from space

EUMETSAT IN 2023

EUMETSAT is a key service provider in the Copernicus programme, the Earth observation component of the European Union's space programme. EUMETSAT operates satellite missions, delivers data, and provides support services to Copernicus. EUMETSAT operates the Copernicus Sentinel-3 mission, together with ESA, and the Sentinel-6 mission, together with CNES, NOAA, NASA and ESA. EUMETSAT provides the marine data streams from the Sentinel-3, Sentinel-6 and Jason-3 missions, as well as atmosphere products relating to aerosols and fires from Sentinel-3.

These satellite missions produce a vast volume of data which EUMETSAT delivers to a wide variety of data users all over the world within stringent operational timeframes. As well as measurements from the satellites' instruments, the data provided include derived marine and atmospheric geophysical products. These data also contribute to the Copernicus marine, atmosphere and climate services and supply governments, businesses, scientists, and the public with vital information about our planet as part of a value-adding chain that rapidly multiplies the benefits of the data.

To maximise the impact and utility of Copernicus data, EUMETSAT works with new and experienced users of Earth observation data through communication activities, user support and training services. The data are made freely available through the Copernicus programme.

In the future, EUMETSAT will operate the Sentinel-4 and Sentinel-5 atmosphere-monitoring missions, the Copernicus carbon dioxide and methane emissions monitoring mission, CO2M, and will deliver global ocean and atmosphere products from the Copernicus Imaging Microwave Radiometer (CIMR) and Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL) missions.

The infographics and stories below aim to show how much data was used over the past year, by whom, where, and for what purpose.

A highlight of 2023 was a data visualisation workshop, organised by EUMETSAT, which brought together data experts and communication experts to share examples of using satellite data for compelling story telling.

And at the request of the Copernicus Atmosphere Monitoring Service (CAMS), EUMETSAT performed a full reprocessing of the aerosol optical depth product from Sentinel-3's Sea and Land Surface Temperature Radiometer. The data spans Sentinel-3's lifetime. 2015-2023. and will be included CAMS' next reanalysis product, EAC-5.



DAIA ACCESS





Number of files downloaded for each instrument data stream

TR:	13,946,075
l:	4,687,744
L:	3,223,188
eidon-4:	230,518





DATA



resources/case-studies/record breaking-tropicalcyclone-freddysses-indian-ocean (1

Storm Freddy

Freddy was a record-breaking tropical storm that traversed the entire southern Indian Ocean in 2023. Satellite data offers vital information for monitoring, forecasting, and managing the impacts of tropical storms. Copernicus Sentinel-3 provides sea surface temperature and altimetry data, important inputs for forecast models, and for monitoring impacts, such as storm surges and waves associated with such events. The images below show the sea surface temperature from the Copernicus Sentinel-3 Sea and Land Surface Temperature Radiometer, above the storm development threshold of 26-27 degrees centigrade, and a snapshot of the resulting wave height field around the storm track, produced from data from Sentinel-3 and -6 altimeters.



40 60 80 100 120 140





es/monitoring-internal-waves-in-thetrait-of-gibraltar

(2)>

Internal waves

Internal waves play a crucial role in how energy is transferred in the ocean and can affect the movement of nutrients and other essential chemical species, including those related to the ocean carbon cycle. Internal waves can reach scales of more than 100m vertically and, as a result, are a concern for underwater operations, eg, by submarines. They can have very little surface expression, especially compared to their scale at depth, however, they have also been associated with interesting features by sailors, including "dead water". The image shown here, from the Copernicus Sentinel-3 Ocean and Land Colour Instrument (OLCI) shows an example of how internal waves can be detected in surface glint.





(a) Internal Froude number (G2) estimation based on the (b) tidal current prediction (m s-1) over the Camarinal Sill at 45m depth (Vázquez et al., 2008). The horizontal black line delimits the positive/negative current directed toward the Mediterranean/Atlantic side. The vertical gray rectangle indicates the time during which the internal waves would have been released (13 May 2023, 18:45 UTC). Credit: Marina Bolado-Penagos, GHER



studies/loch-neagh-algal-bloom



Loch Neagh algal bloom

Lough Neagh, a significant source of freshwater in Northern Ireland, was plagued by algal blooms in summer 2023. Multiple factors led to a particularly intense year of algal bloom. Nutrient influx from agriculture, invasive species and calm weather conditions played a role in the proliferation of cyanobacteria, commonly known as blue-green algae. These blooms have developed not just over most of Lough Neagh, but also the broader Northern Ireland coast. Algal blooms affect water guality and can create health risks. The Copernicus Sentinel-3 OLCI image of Lough Neagh and the northern Irish Sea on 4 September 2023, clearly shows the presence of these algal blooms.





COPERNICUS DATA IN THE CLOUD

The growing volume of available satellite data, combined with the complex data needs of many environmental applications, is changing the paradigm of how users access and work with data. Cloud computing offers the opportunity to bring users close to the data to work on computational resources. This can reduce the need for transfer of data, localised storage, and extensive, permanently available and user-maintained computing resources.



EUMETSAT trainer delivering a Jupyter Notebook based tutorial at the ESA Big Data from Space conference

More cloud computing systems are being developed, each with their own data offers and user communities. The need for users to be able to work seamlessly across cloud systems is increasing. Similarly, changes in how data are served are helping to make access to customised portions of data sets more efficient. EUMETSAT has investigated the development of workflows to exploit new data formats and technologies to facilitate user access to large volumes of data across multiple cloud systems. The European Space Agency's "Big Data from Space" conference in November, 2023, brought together the Earth observation and cloud infrastructure communities to discuss and advance new approaches to big data analysis for satellite applications.

During the event, EUMETSAT provided training on new approaches to data-proximate computing, facilitating marine and atmospheric composition workflows using Copernicus and EUMETSAT's own mission data streams, in a multi-cloud context, spanning both the WEkEO Data and Information Access Service and the European Weather Cloud. Building heavily on previous development work by EUMETSAT, the European Centre for Medium-Range Weather Forecasts (ECMWF) and the Met Office (UK), EUMETSAT provided interactive demonstrations of how adopting cloud-optimised approaches to data formatting (cloud optimised GeoTiFF/ ZARR) and object storage can support targeted and efficient data access and analysis.

The tutorial also showed how these analyses can be effectively scaled using parallel processing (dask) to either exploit local or, preferentially, data-proximate computing resources. Although the prototype data sets, developed solely for this tutorial, are no longer available, all demonstration Jupyter notebooks from the event were made available on the WEkEO GitHub, and are open for continued development and discussion.



USER ENGAGEMENT



EUMETSAT





in

using Sentinel-3 data







Follow the data stream

> SUPPORTING COMMUNITY BASED VALIDATION OF OCEAN COLOUR SATELLITE DATA USING OPEN SOURCE TOOLKITS

Validation of satellite data is essential for the accuracy of environmental applications. However, the validation process requires use of extensive collections of in situdata from around the world, which would be impossible for a single organisation to collect and process. Therefore, community efforts to collect data and compare it to satellite measurements are vital. EUMETSAT has developed a toolkit, ThoMaS, to support this for the validation of Copernicus Sentinel-3 OLCI ocean colour data and supports training on the use of the toolkit.

Enterne / die Dates | # Takes D SEALINE out ThoMaS - a Tool to generate Matchups of OC products with Sentinel-3/OLCI Police (Apple 105) (apple A.O. (S24OuC) from the FUMETIAT Data Store. The enviro MAL Committe Access BUMETSAT SSIGLD products from the BUMETSAT Data Stor P 4 burches of this last C 473, 3 Mill Franci David License D READAR P MT License This code is loanned under as MIT loanse. See the UCENDE.tur for details on the + AM CHINESIDE package, Copuright ELMETSAT 2023. + AN CONTREUTIN



USER STORY

Users wants to compare their in-situ ocean colour data to that available from satellites to ensure the data are of high quality and can be used for various marine applications. EUMETSAT benefits from these comparisons to understand current instrument performance and inform future processor development.

THE CHALLENGE

Comparing satellite and in-situ measurements in a consistent way can be a challenge. Users can struggle to access correct versions of satellite data, to extract the relevant representative and high-quality pixels, or to use appropriate statistical analysis.



PROCESS

Jupyter notebooks have been developed, helping users to understand how the ThoMaS toolkit works. The notebooks contain examples of extracting matchups and comparing to specific data sources including those available through community repositories and from common instrument types. The toolkit finds and extracts the relevant satellite data and conducts statistical analysis when input data is available for comparison.

DISTRIBUTION

The toolkit and supporting notebooks are available via the EUMETSAT gitlab. EUMETSAT has integrated training on ThoMaS into regular marine applications training courses, presentations to the Sentinel-3 Validation Team, specific webinar short courses. and at communityorganised conferences. In collaboration with NASA, further training sessions are run alongside those on an open source community in-situ data processor.

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DATA ACCESS

The ThoMaS toolkit used the EUMETSAT Data Access Client (EUMDAC) to help users extract relevant satellite images containing relevant pixels for their validation activities.



VALUE

The ThoMaS toolkit allows users to easily extract matchups between their data and that from the Copernicus Sentinel-3 OLCI mission. This supports their work using satellite data for marine applications, while simultaneously supporting development of OLCI products by EUMETSAT. Other members of the community contribute to the toolkit, building a solid base of expertise for continued validation of ocean colour missions.





Follow the data stream

COPERNICUS DATA TO SUPPORT EUROPEAN REGIONS





data sets produced by EUMETSAT that are relevant to NEREUS interests



USER STORY

NEREUS is a network of European regions using space technologies. NEREUS represents the interests of those regions while simultaneously highlighting the regional dimension of European space policy and programmes. NEREUS' key mission, as a unique thematic network for matters of regional space uses, is to explore the benefits of space technologies for European regions and their citizens and to promote the use of space and its applications. There is a demonstrated need for and interest in synergistic use of data from Copernicus Sentinels to support monitoring and policies at regional level in key sectors such as tourism, energy, water resources, agriculture.



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THE CHALLENGE

Translating data into useful information to be used by citizens, companies and administrations at regional level is still a great challenge. Much needs to be done to facilitate data access, management and processing to overcome policy barriers, governance difficulties, technical issues and lack of skills, awareness and know-how on data usability. In addition, adding value to data through post-processing, aggregation, usage of models and/or artificial intelligence techniques is often necessary.



PROCESS

information at NEREUS events attended by more than 200 policymakers, stakeholders, regional representatives and value-adders Europe-wide. Needs for workshops, training, data discovery and data access were identified.

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DATA ACCESS

During the workshop, Jupyter notebooks were showcased to access all relevant data from Earth observation services.



EUMETSAT participated in and provided

VALUE

The community dialogue and presentation of European activities from the data provider and user sides identified key actions needed to improve data uptake. Copernicus and European data and services are deemed essential, with a recommendation to improve access and guidance and to maintain constant interaction with value adders and local users.





COMMUNICATION AND OUTREACH

EUMETSAT coordinated a series of six webinars on visualising Copernicus Earth observation data and storytelling over a sixweek period in the early summer of 2023.

At the webinars, representatives from news outlets such as the BBC, The New York Times, Le Monde, Agence France-Presse (AFP) and the Financial Times talked about how they use Earth observation data online, while experts from various institutions such as the European Commission's Directorate-General Joint Research Centre (JRC), EUMETSAT and the USA's National Oceanic and Atmospheric Administration (NOAA) shared their insights on visualising Earth observation data.

The webinars also included sessions on how to use Copernicus Earth observation and service data to communicate with the public, with a particular focus on accessing and using data from the Copernicus Atmosphere Monitoring (CAMS), Marine (CMEMS), Climate (C3S) and Emergency Management (CEMS) Services.

More than 1,500 people attended the webinars and more than 29,000 users from all over the world have since viewed the recordings. Some of the key outcomes have also been recorded in a good practice guide which is available at - https://eodata4storytelling.eu/

The recordings of all the webinars can be accessed at: https://bit. ly/3RN5RcJ





The Missolonghi-Aitoliko Lagoons, part of a Natura 2000 site located on the western coast of Greece Credit: European Union, Copernicus Sentinel-2 imagery