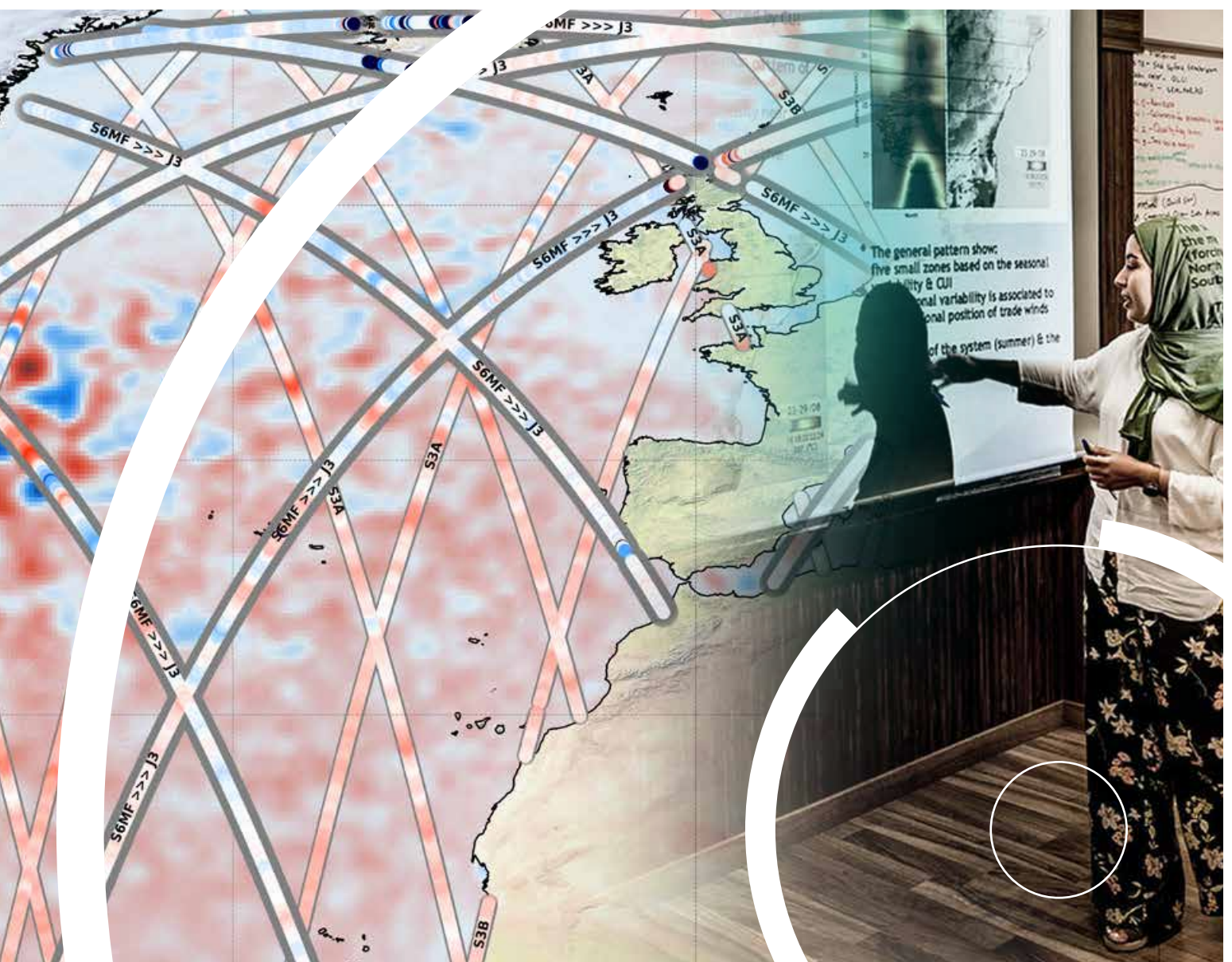# EUMETSAT

Copernicus data user uptake

2021 report

Monitoring weather and climate from space

COPERNICUS AND EUMETSAT IN 2021

EUMETSAT operates satellite missions, delivers data, and provides support services to the European Union's Copernicus Earth observation programme. EUMETSAT currently operates the ocean-monitoring Sentinel-3 mission, together with ESA, and the Sentinel-6 and Jason-3 missions. In the future, EUMETSAT will operate the Sentinel-4, Sentinel-5 and CO2M atmosphere-monitoring missions.

A vast volume of data from these satellites is delivered to a wide variety of data users all over the world, within operational timeframes. As well as measurements from the satellites, the data provided include derived marine and atmosphere geophysical products. These data also contribute to the Copernicus 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. Through communication activities, user support and training services, EUMETSAT works with new and experienced users of Earth observation data to maximise the impact and utility of the data. The data are made freely available through the Copernicus programme. The infographics and stories in this report aim to share how much data was used over the past year, by whom, where, and for what purpose. In 2021, the first products from Copernicus Sentinel-6 Michael Freilich were released. New versions of the Sentinel-3 atmospheric composition products were released in 2021 (e.g. optical depth) with substantial improvements to the data quality.

98.95% Average timeliness for data delivery

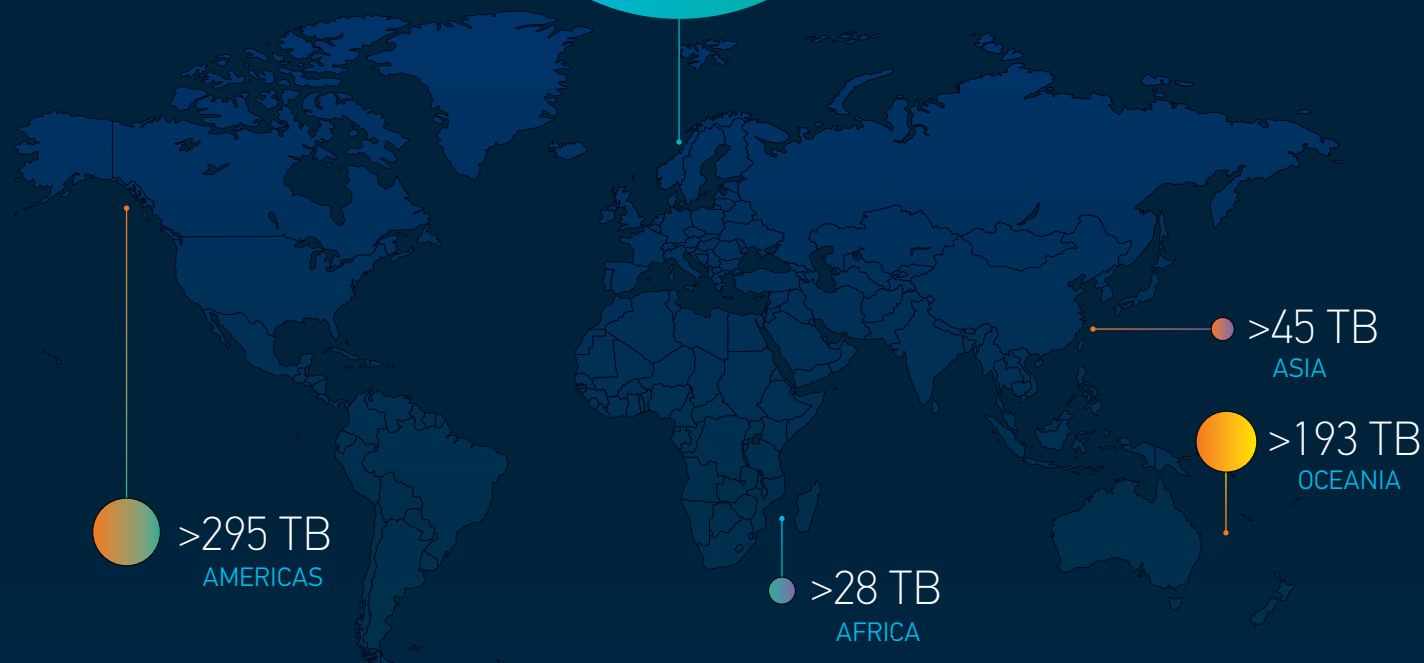**98,692 TB** Data delivered by EUMETCast push service

2,542 TB Total data downloaded from online pull services

EUMETSAT

>2,070 TB
Data downloaded worldwide from
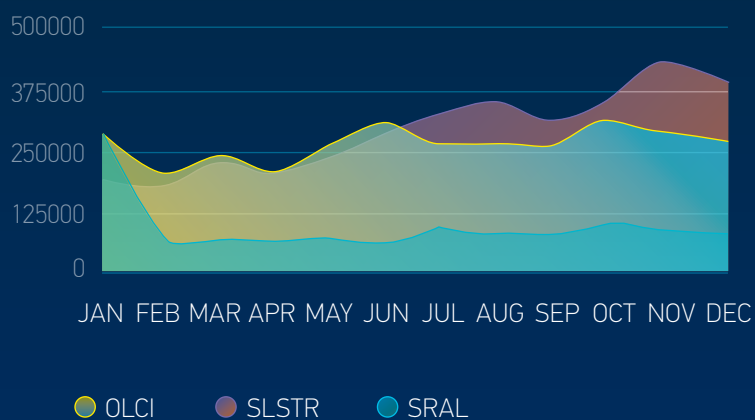Copernicus Online Data Access (CODA)

>1,509 TB
EUROPE

>45 TB
ASIA

>193 TB
OCEANIA

>295 TB
AMERICAS

>28 TB
AFRICA

NUMBER OF FILES DOWNLOADED FOR EACH SENSOR

TOTAL FILES DOWNLOADED

OLCI   3,921,826

SLSTR 4,644,079

SRAL   1,190,547

Sentinel-3 has three instrument packages to observe ocean and land colour (OLCI), ocean and land temperature (SLSTR), and ocean surface topography (SRAL). Peaks in downloads typically correspond with enhanced use around events and during reprocessing campaigns by downstream providers such as the Copernicus Services.

500000

375000

250000

125000

0

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
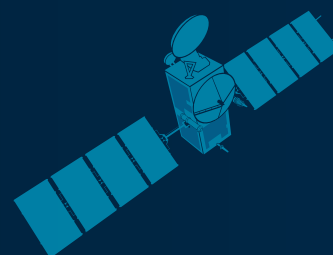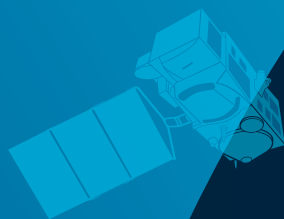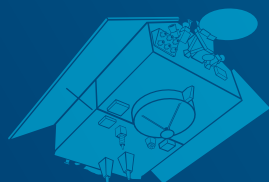
● OLCI   ● SLSTR   ● SRAL

THE MARINE VALUE CHAIN:

COPERNICUS SATELLITE DATA FROM EUMETSAT USED BY THE COPERNICUS MARINE SERVICE

The Copernicus Marine Service, coordinated by Mercator Ocean International, is the prime downstream user of the Sentinel-3 and -6 marine data EUMETSAT provides. The data are accessed by various thematic application and monitoring and forecasting centres, which are groups of organisations from across Europe with expertise in ocean remote sensing and modelling. The centres produce a wide variety of value-added products for use in a range of different marine applications.

Within this portfolio are more than 300 upstream requirements related to products produced and disseminated by EUMETSAT. The examples here show how data from EUMETSAT satellites feature in the value chains where Copernicus Marine Service products meet downstream user needs.

EUMETSAT

INPUT DATA

Sentinel-3 and -6, as well as the Jason missions, produce information about the ocean surface (sea surface, significant wave height and wind speed) from altimetry measurements.

ADDED VALUE

Data from these EUMETSAT-operated missions are combined with those from other altimeters, undergo quality control and are merged, then interpolated to produce Level 3 and Level 4 products with improved coverage.

ADDED VALUE

Level 3 and Level 4 data can be assimilated into models.

OUTPUT DATA

Ocean models can extend our understanding of ocean processes or forecast the ocean state.

OCEAN VALUE CHAIN:

Sentinel-3, Sentinel-6 and Jason wave data contribute to renewable energy operations

USE EXAMPLE   The best sites for renewable energy devices that exploit wind and wave energy can be selected.

INPUT DATA

Sentinel-3 measures the ocean colour and EUMETSAT provides derived products including parameters such as chlorophyll-a, total suspended matter, and light attenuation.

ADDED VALUE

Data from Sentinel-3 are combined with data from other ocean colour sensors.

ADDED VALUE

Downstream services use the combined products to derive further products such as identifying harmful algal bloom species.

OUTPUT DATA

Data can provide water quality indicators such as eutrophication indexes or the presence or risk of a harmful algal bloom.

OCEAN VALUE CHAIN:

Sentinel-3 ocean colour data contribute to water quality monitoring and protection of human health

USE EXAMPLE   Warnings can be issued about poor water quality to support aquacultural operations and health initiatives related to tourism activities.

THE ATMOSPHERIC COMPOSITION VALUE CHAIN:

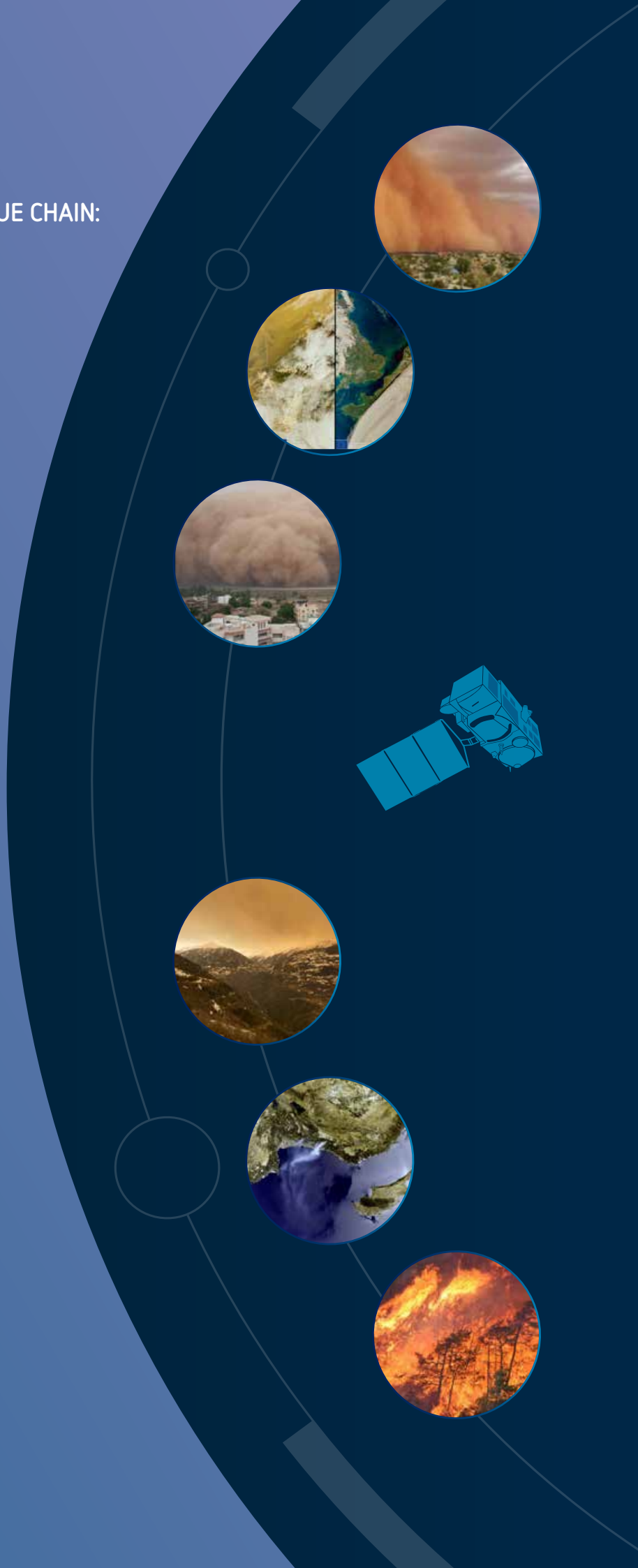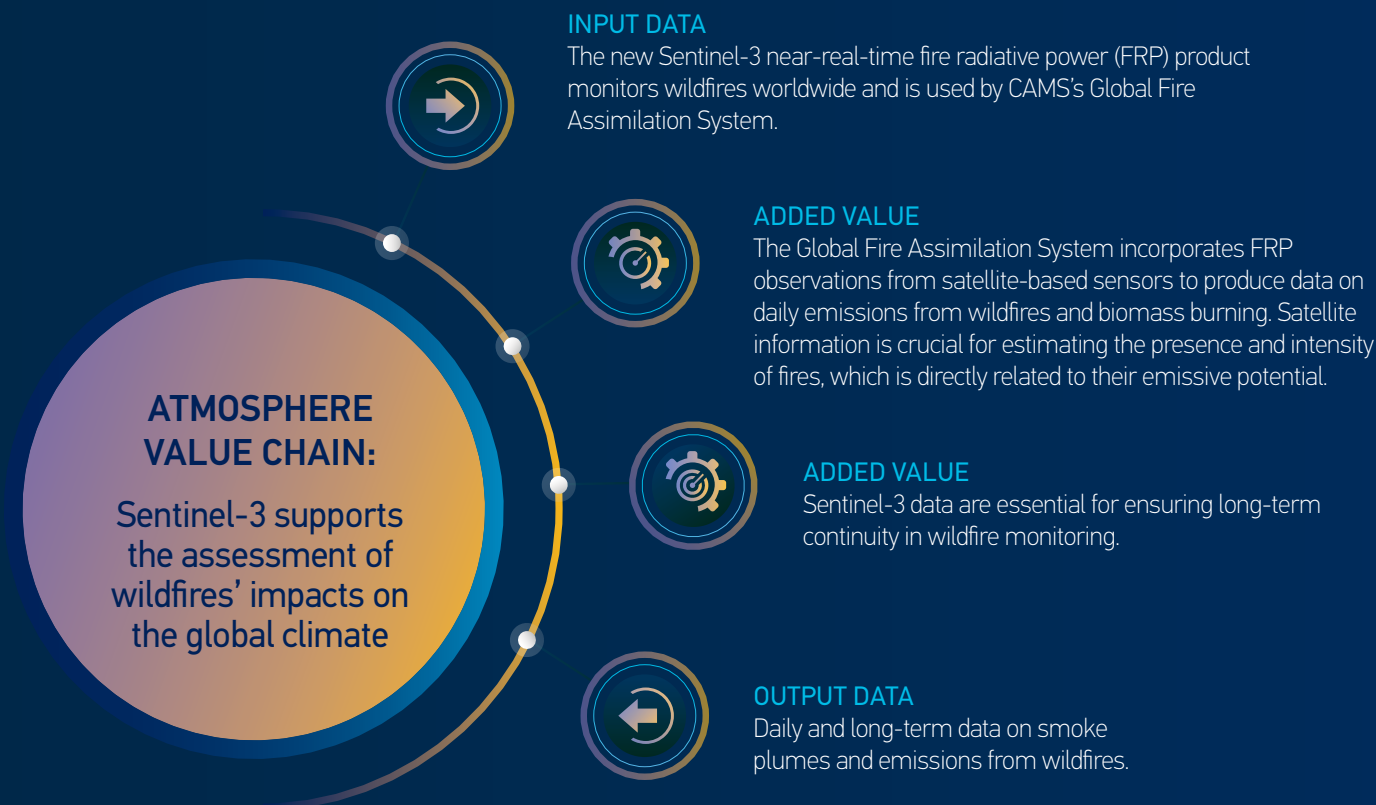# COPERNICUS SATELLITE DATA FROM EUMETSAT USED BY THE COPERNICUS ATMOSPHERE MONITORING SERVICE
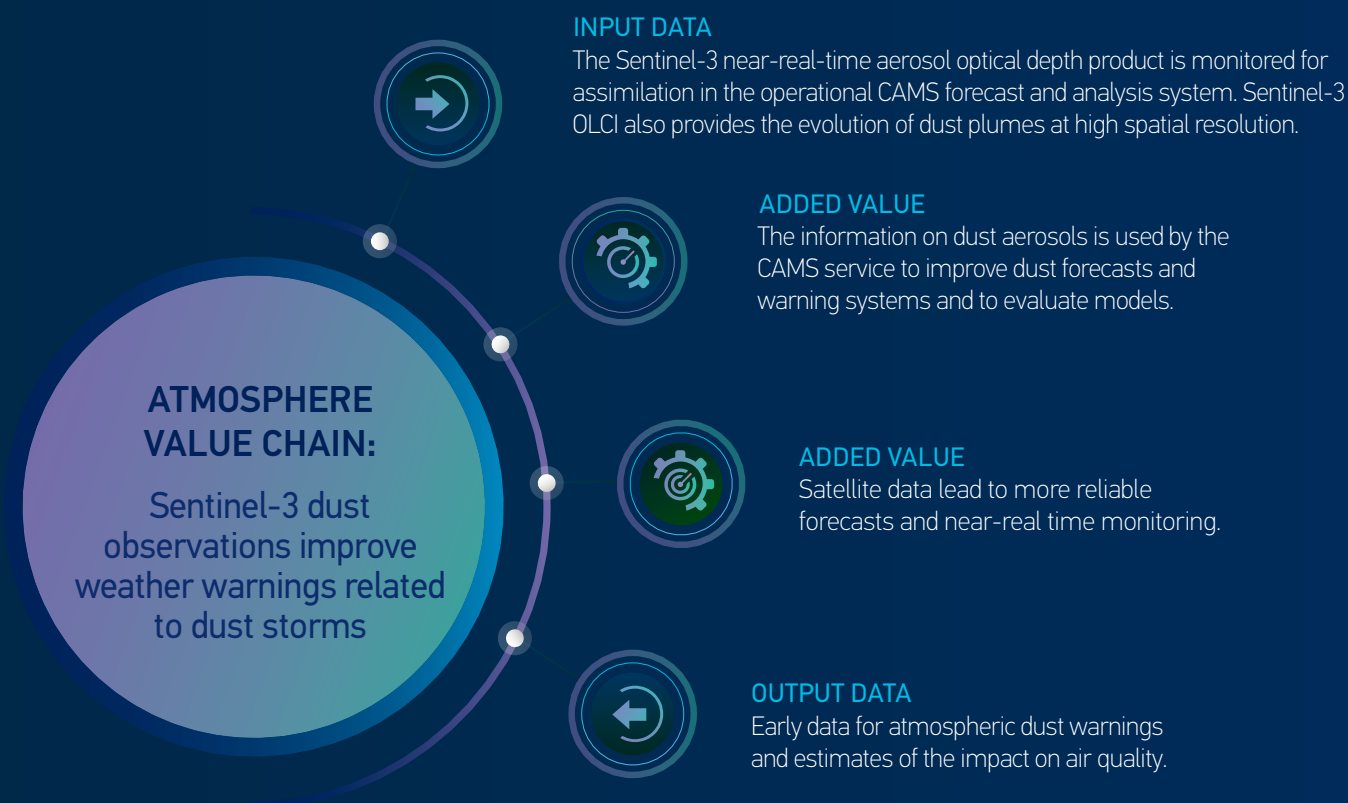
Sentinel-3 datasets are provided to the Copernicus Atmosphere Monitoring Service (CAMS), coordinated by the European Centre for Medium-Range Weather Forecasts, the prime downstream user of the products. CAMS produces and distributes a unique ensemble of added-value information based on model forecasts and analyses integrating satellite information. These encompass air quality and global composition forecasts and analyses, monitoring of greenhouse gases, and a radiation and fire assimilation system. CAMS implements downstream applications and tools for their global and regional products to address emissions monitoring, air quality and climate policies, and key science applications. CAMS serves more than 24,000 registered users.

The new Sentinel-3 near-real-time datasets are currently monitored by CAMS to be included in the assimilation system. Forecasts need near-real-time, high-quality products, which are provided by a limited number of sensors. The datasets are also essential to ensure continuity, in line with the principles of the Copernicus programme.

EUMETSAT

INPUT DATA

The new Sentinel-3 near-real-time fire radiative power (FRP) product monitors wildfires worldwide and is used by CAMS's Global Fire Assimilation System.

ADDED VALUE

The Global Fire Assimilation System incorporates FRP observations from satellite-based sensors to produce data on daily emissions from wildfires and biomass burning. Satellite information is crucial for estimating the presence and intensity of fires, which is directly related to their emissive potential.

ADDED VALUE

Sentinel-3 data are essential for ensuring long-term continuity in wildfire monitoring.

ATMOSPHERE VALUE CHAIN:

Sentinel-3 supports the assessment of wildfires' impacts on the global climate

OUTPUT DATA

Daily and long-term data on smoke plumes and emissions from wildfires.

USE EXAMPLE   Quantify the emissions from wildfires at the global scale and their impact on climate.

INPUT DATA

The Sentinel-3 near-real-time aerosol optical depth product is monitored for assimilation in the operational CAMS forecast and analysis system. Sentinel-3 OLCI also provides the evolution of dust plumes at high spatial resolution.

ADDED VALUE

The information on dust aerosols is used by the CAMS service to improve dust forecasts and warning systems and to evaluate models.

ATMOSPHERE VALUE CHAIN:

Sentinel-3 dust observations improve weather warnings related to dust storms

ADDED VALUE

Satellite data lead to more reliable forecasts and near-real time monitoring.

OUTPUT DATA

Early data for atmospheric dust warnings and estimates of the impact on air quality.

USE EXAMPLE   Improve the forecast of intense dust events.

PROGRAMME OF
THE EUROPEAN UNION

Copernicus
Europe's eyes on Earth

SYNCHRONISING DATA FROM MULTIPLE SATELLITES FOR WATER QUALITY INFORMATION FOR POLICY MAKERS

Data from the Copernicus programme can provide valuable information for European Union member states to manage marine environments, define policy objectives, and monitor how well those objectives are being met. The Belgian Science Policy Office (BELSPO) funds projects seeking to exploit Earth observation data for such applications under its Support to Exploitation and Research in Earth Observation (STEREO) programme. Coastal water quality impacts important sectors of the European economy including food, human health, and tourism. The European Water Framework Directive aims to protect freshwater resources and ensure the good ecological status of EU waters, including marine waters up to one nautical mile from shore.

Multi-Sync (a BELSPO STEREO project) aimed to bring together data from the Copernicus Sentinel-2 and -3 satellites, with geostationary optical data from SEVIRI (an instrument aboard EUMETSAT's Meteosat Second Generation satellites), and an array of other optical data (e.g. from the MODIS and VIIRS instruments) to support water quality-related applications in the North Sea.

> " Monitoring the status of highly dynamic and complex marine coastal ecosystems requires Earth observation products with high spatial and temporal resolution. Currently, there is no single sensor that provides such products. In Multi-Sync, we combined data products from different sensors, for example, Sentinel-2 and Sentinel-3, into an optimised multi-scale Earth observation product that fits those requirements.
>
> *BELSPO/RBINS/GHER/* "

EUMETSAT

USER STORY

The Multi-Sync project brought together experience in ocean colour remote sensing from high-resolution and medium-resolution low Earth orbiting and geostationary platforms to optimise the Earth observation data quality and availability for activities such as eutrophication monitoring and sediment transport monitoring near harbours.

THE CHALLENGE

Optimal water quality information requires monitoring at a combination of temporal and spatial scales.

DATA ACCESS

Online data access portals for each of the missions operated by EUMETSAT and ESA respectively.

PROCESS

Data was combined and gaps were filled using a new version of the data interpolating empirical orthogonal functions (DINEOF, https://github.com/aida-alvera/DINEOF).
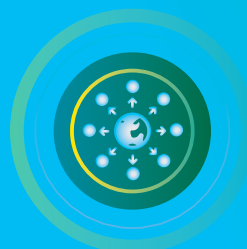
DISTRIBUTION

Output products from the processors developed during the Multi-Sync project are now distributed by the Copernicus Marine Service.

VALUE

Optimised multi-scale ocean colour products provide valuable water quality information in the coastal zone where many economically important activities take place, with a temporal and spatial resolution that cannot be obtained with single traditional sensors.

Belgian Science Policy Office

belspo

GHER GeoHydrodynamics & Environment Research

museum

PROGRAMME OF THE EUROPEAN UNION

Copernicus
Europe's eyes on Earth

FACILITATING THE MONITORING OF DUST EVENTS

Monitoring and forecasting of dust events is vital for the activities of weather services, regional air quality management, and for scientific research. Dust concentrations affect weather and climate, and can have impacts on human health. agriculture and solar energy generation. They also play an important role in wider Earth System processes (such as providing essential nutrients to ocean ecosystems).

Monitoring dust concentrations requires in situ and satellite data as well as models. To fully utilise these data, and translate them in to decision-making processes, requires skilled personnel. For this, international agencies can work together to provide appropriate training.

To build capacity, a series of activities took place in 2021 with key stakeholders in the sector including the World Meteorological Organisation (WMO), Spain's national meteorological service (AEMET), the Barcelona Super Computer Centre (BSC) and the European Network for Aerosol, Clouds and Trace Gas Infrastructure (ACTRIS).

Aerosol index from 388 and 354 nm 2021-02-06T00:00:00.000000000
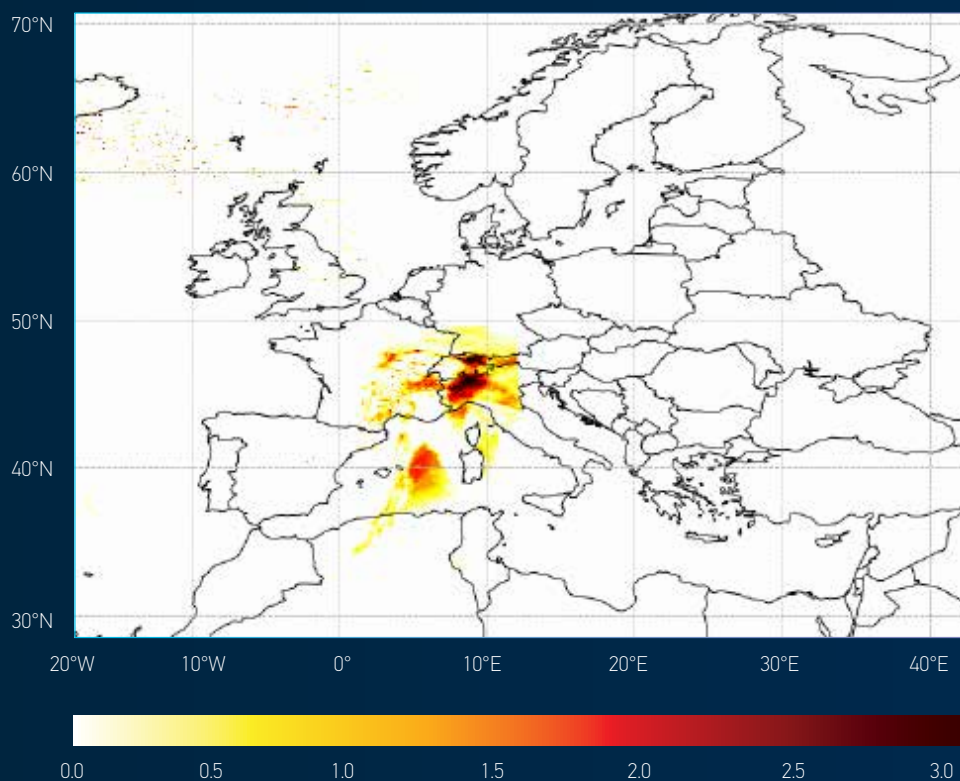
> The forecasting and monitoring of atmospheric dust is important for weather services, the management of air quality, and research.
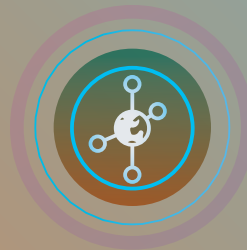
EUMETSAT

USER STORY

A series of workshops brought together key experts to develop and deliver training material on dust and aerosol data sets.
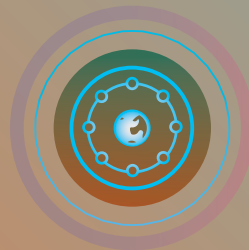
THE CHALLENGE
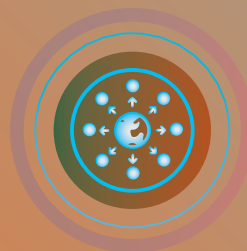Introduce and facilitate the use of dust observations and forecasts.

DATA ACCESS
Data come from forecast models, satellite observations and ground-based networks and are available from multiple access points - WMO, Copernicus Data Access, Copernicus Services.

PROCESS
Data are explored and processed with a series of Jupyter notebooks.

DISTRIBUTION
All datasets and forecasts are made publicly available - the training is collected in an interactive web course *https://dust.trainhub.eumetsat.int/docs/index.html*

VALUE
Courses were attended by more than 500 users from 35 countries across Europe and Africa. Training material is free and open for reuse.
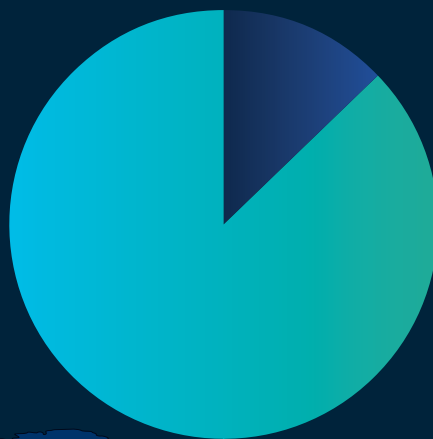
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Copernicus
Europe's eyes on Earth

EUMETSAT

AEMet
Agencia Estatal de Meteorología

WORLD METEOROLOGICAL ORGANIZATION

ACTRIS
Exploring the Atmosphere

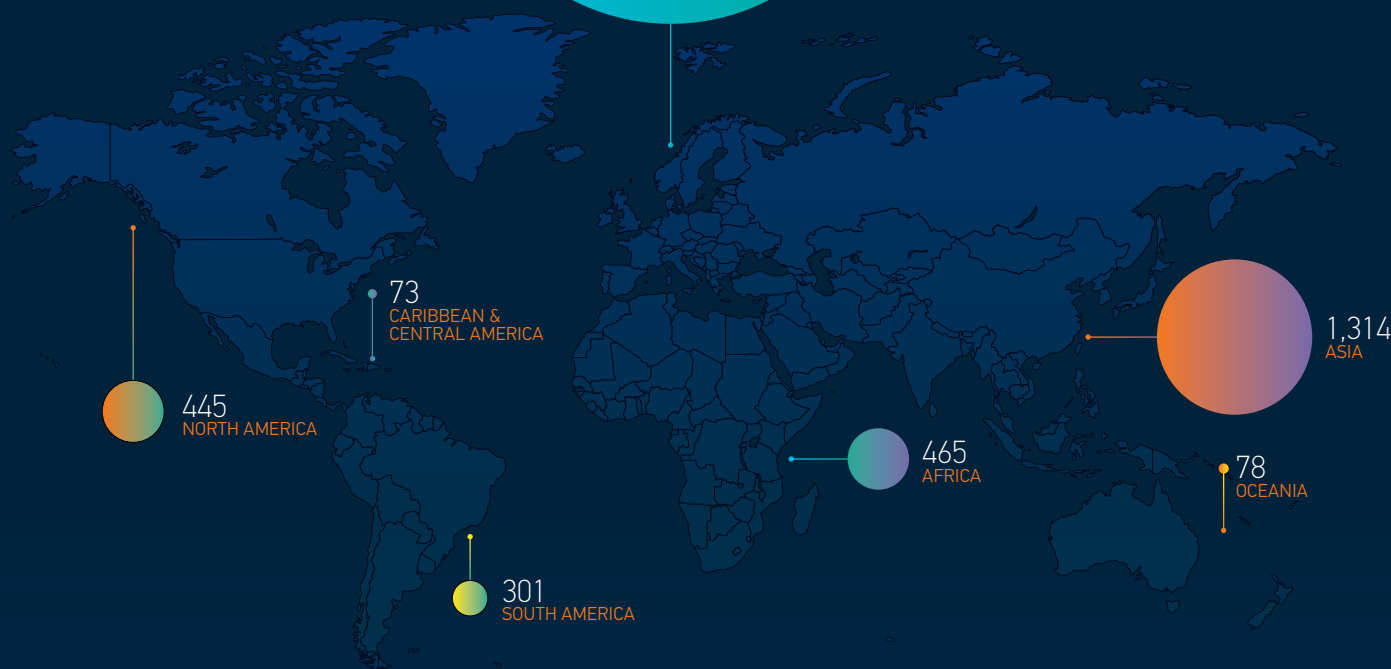**6,480**
Worldwide users
(institutions and individuals)

3,804
EUROPE

3,241
EUROPEAN UNION

563
REST OF EUROPE

EU AND COPERNICUS
PARTICIPATING STATES

GERMANY	554
ITALY	521
FRANCE	425
SPAIN	329
GREECE	197
POLAND	185
BELGIUM	148
PORTUGAL	148
NETHERLANDS	131
NORWAY	69

73
CARIBBEAN &
CENTRAL AMERICA

445
NORTH AMERICA

1,314
ASIA

465
AFRICA

78
OCEANIA

301
SOUTH AMERICA

USER SECTORS

PRIVATE INDIVIDUAL	40.12%
NATIONAL INSTITUTION	21.31%
RESEARCHER	12.23%
EDUCATION	11.77%
COMMERCIAL SME	8.43%
COMMERCIAL NON-SME	3.52%
INTERNATIONAL ORGANISATION	2.59%

EUMETSAT

1,513 Active users each quarter

702 Sentinel-3 users from EUMETCast

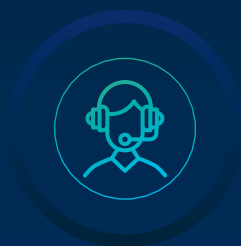**10,089** WEkEO users

44,538 YouTube views

2,824,201 Twitter impressions

22,832 Website views

2,651 Users trained to date

324 Help desk queries answered

**31** New scientific publications using Sentinel-3 data

PROGRAMME OF
THE EUROPEAN UNION

Copernicus
Europe's eyes on Earth

COPERNICUS TRAINING IN PHASE ONE

During phase one of the Copernicus programme, EUMETSAT delivered an extensive portfolio of training to users of Sentinel-3, -5p and -6 data and on products from the Copernicus services. The training was designed to help a diverse range of data users spanning academia and research, governance, and commercial sectors to access data and work with them in ways that suit their own applications. Attendees predominantly came from across Europe, although additional collaborative training events were held across Africa, Asia, and the Americas.

Training activities were based on the use of open source tools and took place online and in person to support a variety of formats and learning needs. After the training, EUMETSAT continued to support participants. This included short-term mobility support to help participants develop applications or present results of their work at conferences or to validation teams. It also included the writing of case studies showcasing their work, expert support through the EUMETSAT User Helpdesk and mentoring by trainers, and collaboration on related events and further training courses.

COPERNICUS TRAINING IN PHASE ONE

Aims of the training

Training impacts
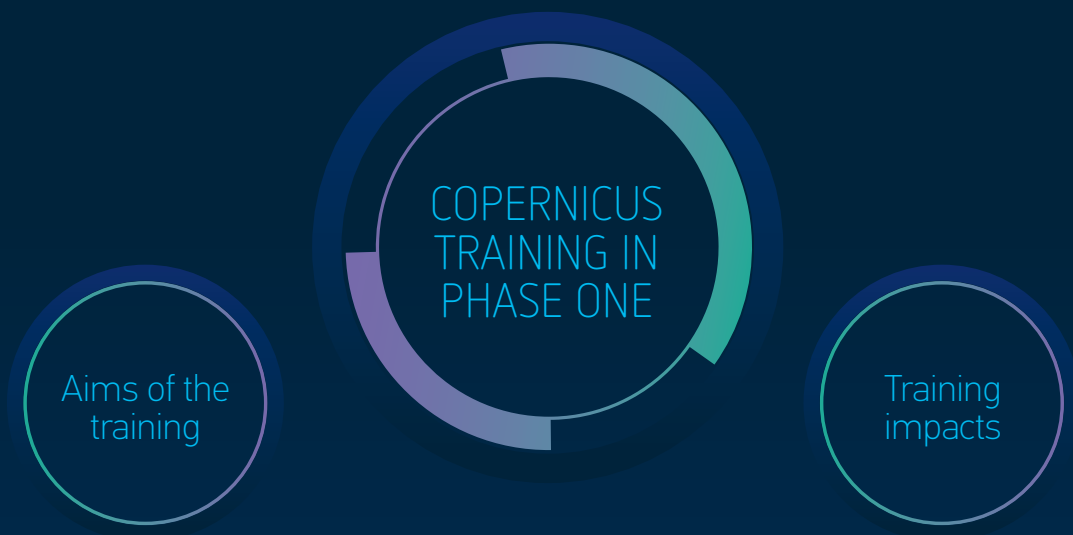
- Promote use of Copernicus data by sharing examples of marine and atmospheric composition applications.
- Support data users in deciding which data are the most appropriate for their applications.
- Provide information about data access and formats.
- Share examples of common workflows in open source software and programming languages.
- Create long-term users of the Copernicus data through participant-led training events.
- Advise data users about additional training and support opportunities.
- Showcase work done by training participants during the courses and afterwards.
- Obtain feedback on Copernicus data and related services.

Training participants have reported making the following achievements after their courses:

- Writing a master's thesis using Sentinel-3 data for coastal water quality in the Baltic Sea.
- Integrating Sentinel-3 data into cruise support for regular monitoring at a European hydrographic institute.
- Contributing to assessment of Ocean and Land Colour Instrument (OLCI) reprocessing.
- Integrating data into routine model validation for safety at sea advisories.
- Setting up routine data access to integrate Sentinel-3 into products for aquaculture operations.
- Producing a publication on routine validation of OLCI in complex waters.
- Holding presentations of validation activities at Sentinel-3 Validation Team and Group for High Resolution Sea Surface Temperature meetings.
- Running two independent courses, training about 100 new users in North Africa.
- Writing a master's thesis on detection of island wakes with Sentinel-3.
- Delivering independent training courses for the Global Monitoring for Environment and Security and Africa programme.

EUMETSAT

Training feedback

The level of participants' satisfaction is monitored constantly to gather suggestions and feedback on how to improve training and data uptake. The level of appreciation is very high, with 95% recommending or highly recommending attendance of training events.

> "I discovered new commands and the environment of Jupyter that will absolutely enhance my capabilities for data processing. Amazing work!"
>
> "It was great to be given 'recipes' for dealing with the various datasets. This was my expectation of the course and it was met."
>
> "This course has been great, also because it has shown the possibility to have lectures, practical sessions and interactions online, something that was hard to believe just a few months ago!"

AI FOR EARTH MONITORING MOOC

EUMETSAT launched a massive open online course (MOOC) on the use of machine learning techniques with Copernicus data on 18 October 2021.

The six-week course introduced participants to the range of Copernicus data and services and the WEkEO online data access platform.

As well as having access to more than 40 short videos, participants learnt how to use artificial intelligence and machine learning techniques with Copernicus environmental data using a series of new Python-based Jupyter notebooks, which are hosted on WEkEO and Github.

The course was extensively promoted using targeted marketing and this helped attract more than 7,000 people to register for the course by the launch day. The number of participants registered has since increased to more than 10,000, from 167 countries. The MOOC also led to an increase in the number of WEkEO users, with more than 5,000 new account registrations.

The whole project was led by EUMETSAT together with the European Centre for Medium-Range Weather Forecasts, the European Environment Agency, and Mercator Ocean International, in support of the Copernicus programme.

EUMETSAT

Eumetsat-Allee 1
64295 Darmstadt
Germany
Tel: +49 6151 807 3660/3770
Email: ops@eumetsat.int
www.eumetsat.int