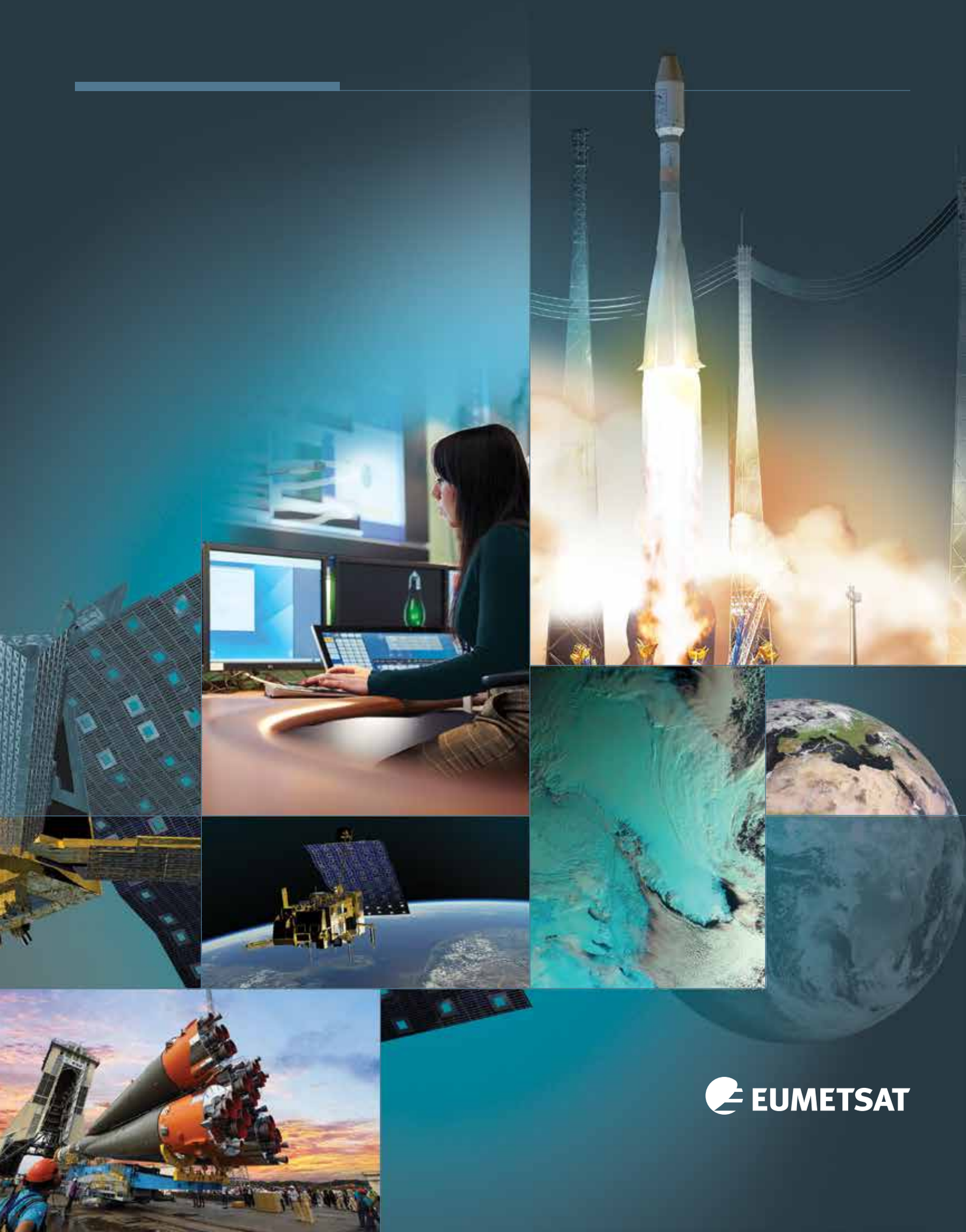
ANNUAL REPORT
2018



EUMETSAT


EPS
METOP
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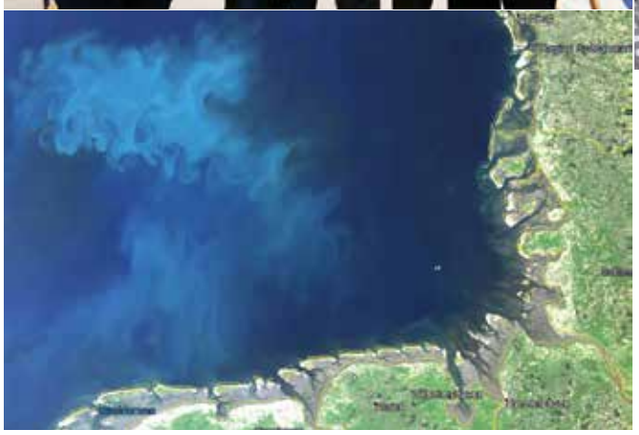
TABLE OF CONTENTS

THE WORD OF THE DIRECTOR-GENERAL



With complex manoeuvres of the Meteosat Second Generation (MSG) fleet and the start of flight operations for two newly launched satellites, 2018 was a landmark for EUMETSAT flight operations.

Meteosat-11 entered operational service at the beginning of the year, after reconfiguration from in-orbit storage to imaging mode, and a series of manoeuvres relocated the three MSG satellites that observe Europe and Africa from around 0° longitude.

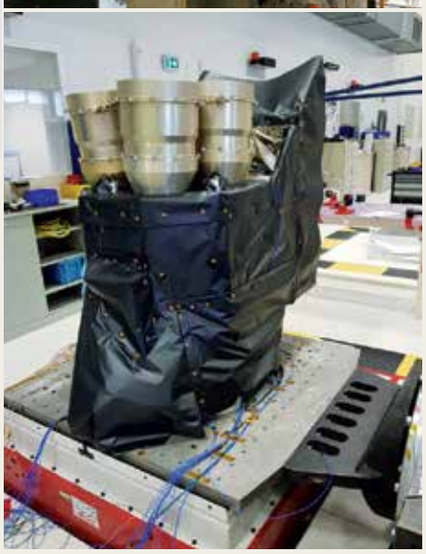
The launch of Metop-C - the last Metop satellite - on 7 November, after a long and complex launch campaign, was a fitting reward for the excellent cooperation with ESA, CNES, NOAA and industry and put an end to the development phase of the EUMETSAT Polar System.

Finally, EUMETSAT took over flight operations of the Copernicus Sentinel-3B satellite on 28 November, seven months after its launch, and has since then been operating a pair of Sentinel-3 satellites.

Beyond the legitimate satisfaction of our engineers and scientists from the exploitation of a fleet of 11 satellites, multi-satellite constellations bring substantial benefits and assurance to user communities in Europe and worldwide.

The Copernicus Sentinel-3 marine mission, designed from the outset as a dual-satellite mission, now offers accurate marine observations with the targeted global coverage frequency. With Jason-3, it forms the European backbone of an international space-based, ocean-monitoring system.

THE WORD OF THE DIRECTOR-GENERAL



With three Meteosat satellites in operation around 0° longitude, the average availability of the five-minute Rapid Scan Service jumped again from 92% to 98.5%, providing additional assurance that fast imagery will always be available to "nowcast" the rapid development of thunderstorms over Europe.

Likewise, the exploitation of a third Metop satellite will undoubtedly increase beyond its current level of 27% the contribution of our polar system to the reduction in errors in forecasts one day ahead attributable to all near-real-time observations.

Last, but not least, the in-orbit deployment and good health of all seven current-generation Meteosat and Metop satellites gives Europe full assurance of a safe transition to the innovative next-generation systems that are still in their challenging development phase.

The larger volumes of data available from the fleet feed the pre-operational big data services EUMETSAT deployed in 2018 for its own purposes and for Copernicus. Thus, the Copernicus WEkEO Data and Information Access Service platform, a partnership with the European Centre for Medium-Range Weather Forecasts (ECMWF) and Mercator Ocean International, demonstrated the original, distributed and federative architecture EUMETSAT champions for cloud services.

At the same time, the challenging development of the Meteosat Third Generation (MTG), EPS-Second Generation (EPS-SG) and Jason-Continuity of Service (Jason-CS/ Sentinel-6) next-generation satellite systems progressed towards completion of their detailed design phases, in partnership with ESA.

One year before completion of the detailed design of the MTG-I system, the development schedules of the satellite and ground segment proved stable enough for EUMETSAT to select 1 October 2021-31 March 2022 as the contractual six-month term for the launch of the MTG-I1 satellite.

This launch schedule drove planning for the transition of African users from MSG to MTG, which was discussed at the 13th EUMETSAT User Forum in Africa in response to the signing by high-level African officials of the "Abidjan Declaration on the next generation of satellite products for weather and climate services in Africa".

The first Metop-SGA satellite's integration and test programme needed replanning to absorb delays in the delivery of three complex optical instruments, which postponed the launch to the end of 2022. Complex knock-on effects on the ground segment and system development and integration plan need detailed assessment in 2019.

The successful first system validation test between the EUMETSAT ground segment and a development model of the Jason-CS satellite confirmed that EUMETSAT, ESA, NASA and NOAA work apace towards the launch of the Jason-CSA satellite and the start of the Copernicus Sentinel-6 mission at the end of 2020.

THE WORD OF THE DIRECTOR-GENERAL

The year 2018 was also one of multilateral achievements shaping the future of the global observing system monitoring the pulse of our planet, to which EUMETSAT contributed as Permanent Secretary of the Coordination Group for Meteorological Satellites (CGMS) and a member of the Committee for Earth Observation Satellites (CEOS).

The first achievement was the setting up of a multilateral mechanism enabling the CGMS satellite operators to continuously review an integrated plan for the deployment of next-generation satellites. The mechanism will allow operators to assess gaps in the realisation of the target architecture designed by the United Nations' World Meteorological Organization for the global integrated observation system in 2040.

During the European Commission's chairmanship of CEOS in 2018, CEOS and the CGMS sponsored the definition of a "Constellation Architecture for Monitoring Carbon Dioxide and Methane from Space" and invited their members to populate the multiple orbits with relevant satellites and instruments. The common objective is to deliver observational inputs to greenhouse gas emissions monitoring services, helping the parties to the Paris Agreement to take stock of their Nationally Determined Contributions to the reduction of emissions.

In partnership with ESA, EUMETSAT also supported European preparations for the 2019 ITU World Radiocommunication Conference, advising that unwanted emissions of 5G ground equipment outside its allocated 26GHz band needs to be regulated to preserve the integrity of unique global humidity measurements by passive microwave instruments operating in the neighbouring 24GHz band.

The EUMETSAT contribution to the next phase of the EU Copernicus programme took shape during discussions with ESA and the European Commission, resulting in the adoption of a bilateral cooperation scenario with ESA addressing joint contributions. Both agencies are now working together on the definition of system and ground segment requirements for a Sentinel mission to monitor carbon dioxide and methane that EUMETSAT will operate in synergy with the Sentinel-4 and Sentinel-5 missions and its own atmospheric chemistry instruments.

In addition, the European Commission, the ECMWF, ESA and EUMETSAT established a European high-level research roadmap for the progressive development of a Copernicus greenhouse gas emissions monitoring service combining Earth system modelling and observations from precursors to this future Sentinel mission.

Having curbed and even reversed the ageing trend of its population of technical staff through the implementation of the human resources strategy adopted in 2014, EUMETSAT is fit for future challenges… … starting in 2019 with the first operational "big data" services and parallel integration of three next-generation satellite systems, for the first time in its history.

Indeed, even if Member States' financial contributions to the MTG and EPS-SG development programmes passed their peak in 2018, the workload peak will spread over the next five years.

This gives me one more reason to express my sincere gratitude to all EUMETSAT technical, scientific and administrative personnel for their commitment and outstanding contributions to the sustained success of the organisation.

I also wish to express my gratitude to the Council and its advisory bodies for their trust and guidance, and add my personal thanks to Prof A. Eliassen, the outgoing Council Chairman, and a hearty welcome to his successor, Prof G. Van der Steenhoven.

Alain Ratier
Director-General

MEMBER AND COOPERATING STATES

Member States

1993	1986	2014	2006	2010	1986	2013	1986	1986	1986	1986	2008	2014	1986	1986
2009	2014	2002	1986	1986	2009	1986	2010	2006	2008	1986	1986	1986	1986	1986

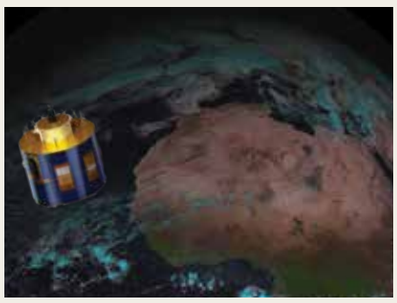
The Republic of Serbia ceased to be a Cooperating State after expiration of its Cooperating State Agreement on 31 December 2017 and not confirming its intention to become a Member State by the deadline set by the EUMETSAT Council.

As the European Council confirmed the "credible enlargement perspective for and enhanced EU engagement with the Western Balkans" on 28 June, EUMETSAT continued to explore the interest of Western Balkans countries eligible for EU accession in becoming Cooperating or Member States, in line with its own Membership Accession Policy.

2018 HIGHLIGHTS

January

- Meteosat-11 is reconfigured from in-orbit storage to imaging mode

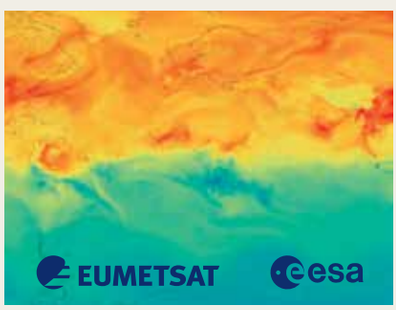


February

- Start of deployment of version V0 of the Copernicus WEkEO Data and Information Access Service platform
- Meteosat-11 enters operational service

March

- Readiness of EUMETSAT systems and teams for the launch of Sentinel-3B
- The Meteosat-9, -10 and -11 constellation operates in a new in-orbit configuration
- ESA and EUMETSAT agree on a cooperation scenario for joint contributions to Copernicus 2.0



April

- Launch of the Copernicus Sentinel-3B satellite
- Conclusion of the system validation tests involving the Metop-C satellite and the EPS ground segment

May

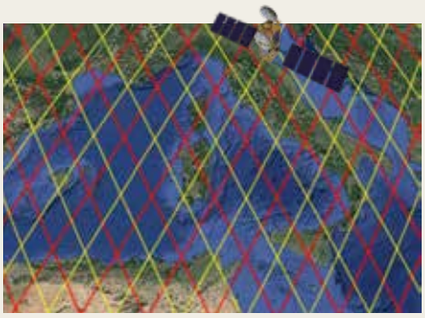
- Metop-C satellite Flight Acceptance and Launch and Operations Readiness reviews
- Start of user validation phase of pathfinder big data services
- European-Chinese workshop on monitoring of greenhouse gases

June

- Demonstration of version V0 of the Copernicus WEkEO DIAS platform
- Start of Metop-C launch campaign

July

- Manoeuvre of the Jason-2 satellite to an "interleaved" one-year repeat cycle orbit
- Signature of a cooperation arrangement with ESA for the deployment of the Sentinel-3C and -3D satellites
- Signature of a new cooperation agreement with the China Meteorological Administration
- Signature of a new memorandum of understanding with the African Union Commission



2018 HIGHLIGHTS

August

- Interruption of the Metop-C launch campaign, satellite "babysitting" in Kourou

September

- The Metop-C launch campaign restarts
- African leaders sign the "Abidjan Declaration" on the next generation of satellite products for weather and climate services in Africa
- Signature of a cooperation arrangement with the African Union Commission on GMES and Africa project
- The European Commission, EUMETSAT, NOAA, NASA and CNES extend Jason-3 operations until January 2021

October

- Start of combined Metop-C satellite and launcher operations in Kourou

November

- Launch of Metop-C and start of flight operations
- Start of dual Sentinel-3 flight operations

December

- ESA concludes the detailed design of the MTG-I satellite
- Opening of version V0.1 of the Copernicus WEkEO DIAS platform
- Release of operational level 1 products from Sentinel-3B
- Acquisition of the first data from all Metop-C instruments
- EUMETSAT and the Indian Space Research Organisation extend cooperation for another five years

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK

Meteosat satellites

Meteosat-11
0°E — Full Earth Scan imagery
Provides the Meteosat primary full disc imagery service over the European continent, Africa, and parts of the Atlantic and Indian oceans

Meteosat-10
9.5°E — Rapid Scan Service (RSS)
Delivers the Meteosat secondary RSS service over Europe and adjacent seas

Meteosat-9
3.5°E — Backup spacecraft
Hot backup satellite for the Full Earth and Rapid Scan services

Meteosat-8
41.5°E — Indian Ocean data coverage (IODC)
Delivers the EUMETSAT best-effort contribution to multi-partner IODC services

Meteosat-11 enters operational service after a cycle of relocation manoeuvres also involving Meteosat-9 and -10

Meteosat-8 continued observations at 41.5°E as EUMETSAT's best-effort contribution to Indian Ocean data coverage (IODC) services shared with China, India and Russia.

After reconfiguration from in-orbit storage to imaging mode, the Meteosat-11 satellite entered operational service on 20 February, in the middle of a one-month cycle of complex satellite relocation manoeuvres which also involved Meteosat-9 and -10.

Meteosat-11 was relocated from its storage location at 3.4°W to 0°, Meteosat-10 from 0° to 9.5°E and Meteosat-9 from 9.5°E to 3.5°E, with no interruption of the primary image data service and only a five-day interruption of the secondary Rapid Scan Service (RSS).

In the new configuration of the Meteosat constellation established on 27 March, Meteosat-11 took over the primary Full Earth Scan service from Meteosat-10 at 0°, Meteosat-10 took over the secondary RSS from Meteosat-9 at 9.5°E, and Meteosat-9 became a hot backup for both services.

Additional manoeuvres in June kept the inclination of the Meteosat-10 and -11 satellites within the specified range.

The ageing Metop-A is left drifting from its nominal orbit to extend service

The exploitation of the EPS continued in a dual-satellite configuration.

Metop-B served as the primary satellite, dumping data twice per orbit at Svalbard and McMurdo to deliver global data to users with the shortest possible latency.

The ageing Metop-A secondary satellite dumped data only once per orbit at Svalbard, whilst providing primary support to the ARGOS localisation and data collection mission. The local time at ascending node of its orbit was left drifting to extend its operational lifetime until the end of 2021.

Low Earth Orbit satellites

Metop-B
SSO 98.7° incl. EPS Primary Mission
Delivers the primary operational EPS services from 817km altitude

Metop-A
SSO 98.7° incl. EPS Secondary Mission
Delivers additional EPS services from 817km altitude and primary support to the ARGOS and Search and Rescue missions

Metop-C
SSO 98.7° incl. Under commissioning

Jason-3
NSO 66° incl. Primary Ocean Surface Topography Mission
Delivers measurements of ocean surface topography and sea state from a non-synchronous, 10-day repeat orbit at 1,336km altitude (mission shared with CNES, NOAA, NASA and Copernicus)

Copernicus Sentinel-3A and -3B
SSO 98.7° incl. Copernicus dual satellite Sentinel-3 mission
Delivers Copernicus marine data services from 814km altitude

Jason-2
NSO 66° incl. Additional Ocean Surface Topography Mission
Delivers measurements of ocean surface topography and sea state measurements from a one-year repeat cycle orbit at 1,311km altitude (mission shared with CNES, NOAA, NASA)

An out-of-plane manoeuvre maintained the nominal orbit of Metop-B, and each Metop satellite was manoeuvred once to reduce the risk of collision with space debris.

The Jason-2 satellite moves to an "interleaved" orbit to map the mean sea surface height at higher resolution

The Jason-3 satellite delivered the high-precision ocean altimetry mission from the reference non-synchronous orbit with a repeat cycle of 10 days.

The ageing Jason-2 satellite continued to deliver the same observations, but from a one-year repeat cycle orbit with 8km ground track spacing to produce a 1cm accuracy map of the mean sea surface height at an equivalent resolution. This map will improve the error budget of all ocean altimeter missions and provide the reference surface for extracting sea surface height anomalies from early measurements of altimeter missions that do not repeat ground tracks of previous missions, like Sentinel-3B. Upon completion of the one-year cycle, the satellite moved to an "interleaved" orbit to bring the targeted map to a resolution equivalent to a ground track spacing of 4km.

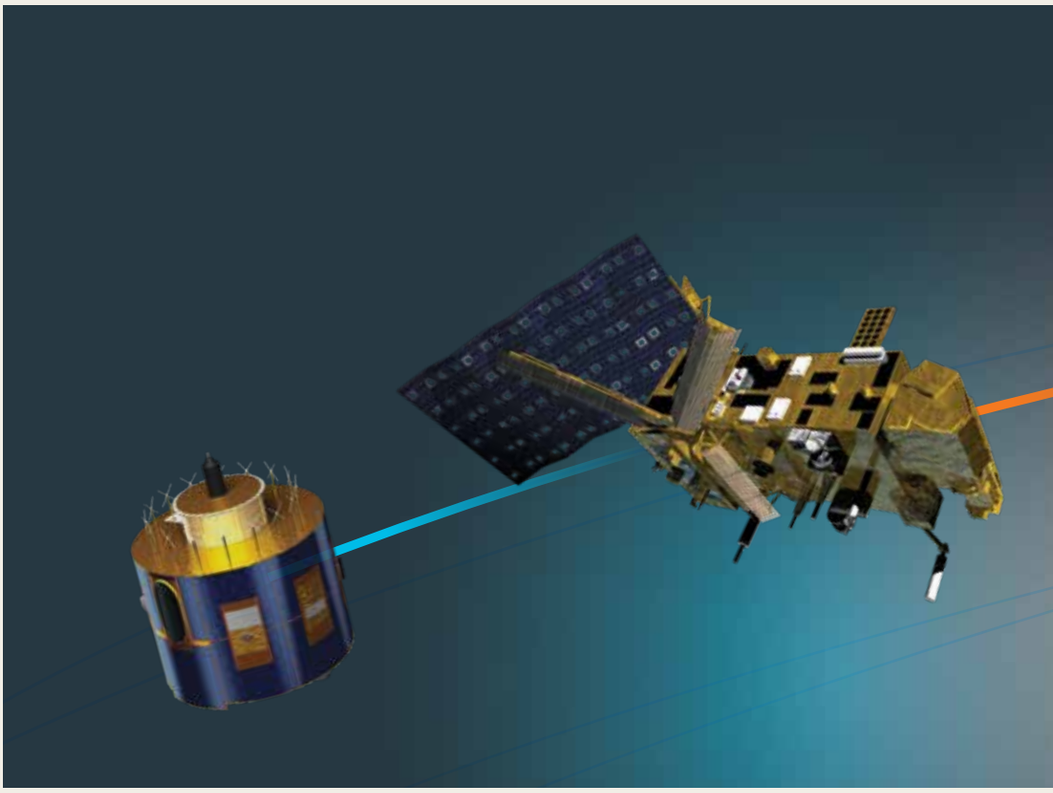
Two series of excess-fuel depletion manoeuvres reduced the amount of fuel remaining on board to 4kg, which is enough for four more years of operations.

A second Copernicus Sentinel-3 satellite joins the ocean-monitoring constellation exploited by EUMETSAT

Flight operations of the Copernicus Sentinel-3A satellite were closely coordinated with flight operations of Sentinel-3B performed by ESOC during in-orbit commissioning of the new satellite. This ensured safe tandem operations, with a separation of 30 seconds for cross-calibration purposes.

EUMETSAT took over flight operations of Sentinel-3B on 28 November and conducted a series of flip manoeuvres for the angular characterisation of the Ocean and Land Colour Instrument (OLCI) diffuser, plus additional manoeuvres for cross calibrating the radar altimeters of both Sentinel-3 satellites.

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK



The Meteosat Rapid Scan Service returns to record-high availability, as Meteosat-9 becomes a hot backup satellite

The average availability of the secondary rapid scan imagery service increased by 6.5% to 99% from April, when Meteosat-9 became available as a hot backup satellite and could fill the 48-hour monthly service gaps needed to preserve the lifetime of the scan mechanism of Meteosat-10.

Meteosat-9 also backed up the primary full disc imagery service in May, when Meteosat-11 entered safe mode. This contributed to maintaining the availability of the service above the challenging 99% target.

Lifetime review predicts Meteosat-8 will remain operational over the Indian Ocean until June 2022

The availability target for the IODC service was reset from 99% to 97%, to account for thermal control degradations on board Meteosat-8 and high inclination operations affecting the geometric quality of some images in eclipse conditions.

The annual Meteosat Lifetime Review concluded that Meteosat-8 had the capacity to support the IODC service for two more years, until June 2022, due to increased confidence in the fuel reserve and recalculation of the probability of being able to re-orbit the satellite to a graveyard orbit.

Despite further degradation, Metop-A should remain operational until the end of 2021, as part of a three-Metop constellation

The primary Metop-B satellite continued to perform well, with only a few hours' outage time of three instruments, due to space weather events and to the planned decontamination of the IASI hyperspectral infrared sounder.

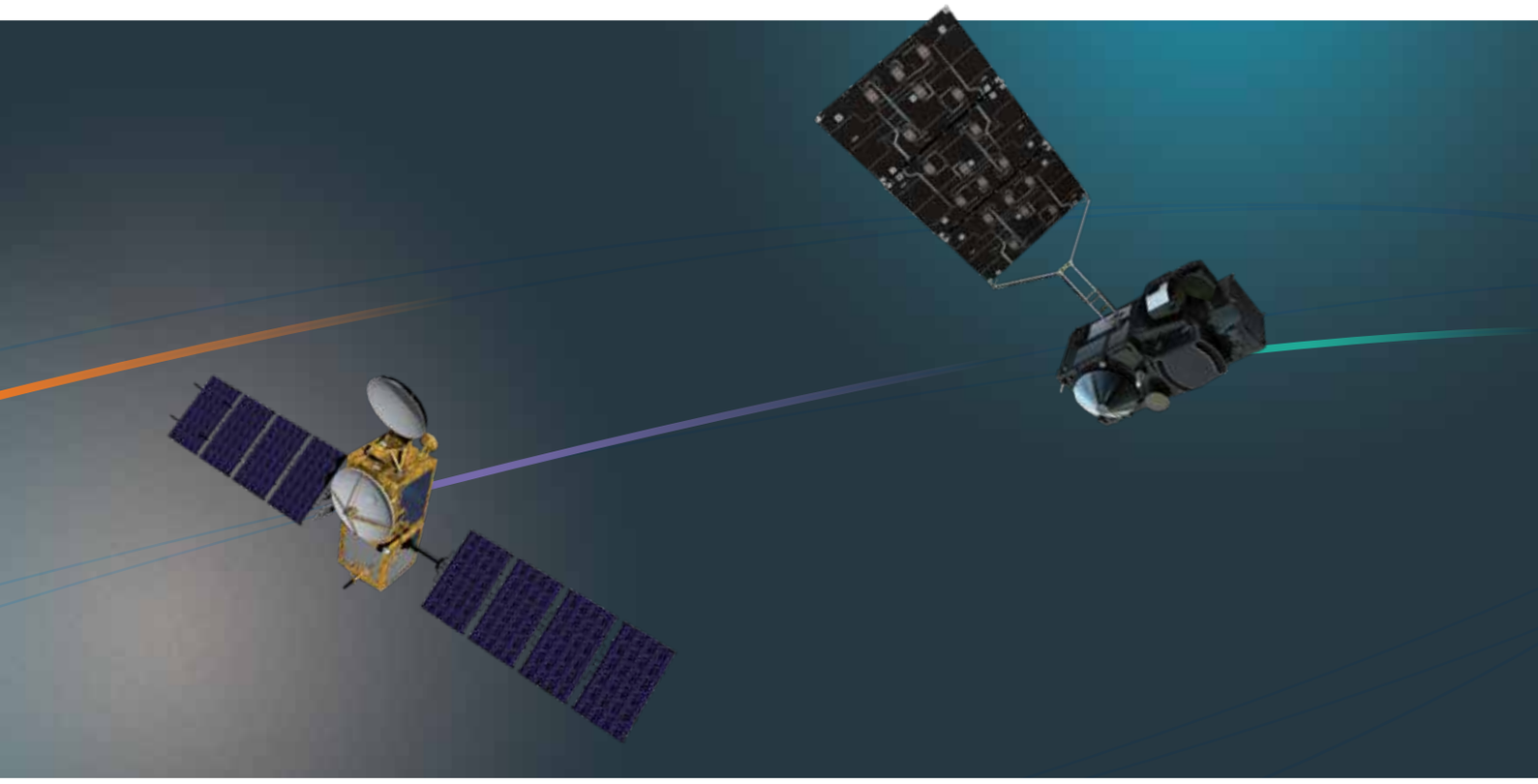
The ageing Metop-A satellite also performed well, with only around 10 hours' outage time of two instruments due to space weather events.

However, the NOAA-provided legacy HIRS and AMSU-A1 infrared and microwave sounders degraded further, and the noise of one MHS moisture sounder channel started to rise at the end of the year.

The HIRS instrument's filter wheel motor stalled a second time before restarting, despite instrument operations working in high-power mode in an attempt to migrate lubricant back into the motor bearings. The prognosis remains that the instrument is bound to fail soon.

The annual lifetime review confirmed that EUMETSAT can exploit a three-Metop constellation until Metop-A needs re-orbiting at the end of 2021 to comply with space debris mitigation guidelines.

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK



Jason programme partners prepare strategy for extracting the maximum benefit from ageing Jason-2 satellite

As the Jason-3 satellite continued to perform flawlessly with an availability close to 100%, NOAA, NASA, CNES, EUMETSAT and the European Commission decided to extend operations by two years, until January 2021.

Availability of the ageing Jason-2 satellite remained above 95%, despite four safe hold mode events triggered by a known, temperature-dependent anomaly of two of the three gyroscopes.

As ageing gyroscopes seem to become more resilient after a period of rest, the programme partners started to assess a preventive gyroscope swap strategy to maximise mission availability.

Extended operations close to approval for MSG and EPS, considered for Jason-2

Twenty-six of the 30 Member States voted in favour of extensions to MSG operations until 2030 and to EPS operations until 2027, giving confidence that unanimity will close the vote in 2019.

Discussion of a possible extension of Jason-2 operations until 2022 started at the end of the year, with the understanding that a formal proposal will be subject to a positive assessment of the satellite's expected lifetime.

EUMETSAT and ESA explore further optimisation of operations and data processing for Sentinel-3 optical instruments

The availability of Sentinel-3A real-time products remained above the 98.5% target for altimeter products, but fluctuated around this target for products from the SLSTR and OLCI optical instruments. This was mainly due to frequent decontaminations of the SLSTR instrument, and re-occurrence of an anomaly affecting only one of the OLCI instrument's five cameras, but which blocked processing of the full instrument data.

The temperature of the SLSTR detectors was increased by 1°K in an attempt to reduce the frequency of decontaminations, and ESA and EUMETSAT started to assess how the OLCI processing chain could be modified to enable continued processing in case of partial unavailability of the instrument.

EVOLUTION OF GROUND INFRASTRUCTURE

Energy efficiency further increases and mission control centres are modernised to contain operations costs

The ratio of consumed power to power actually delivered to IT equipment in the Technical Infrastructure Building improved from 1.35 to 1.30 after additional cooling optimisation using row housing to separate hot and cold corridors.

The installation of new uninterruptible power systems saved energy, CO_2 emissions and maintenance costs, and two new emergency diesel generators added part of the backup capacity needed for uninterrupted operations of the MTG and EPS-SG systems.

For a modest investment of €1.4 million, the redesign and modernisation of the Geostationary Mission Control Centre will accommodate MSG and MTG operations in the space previously used only for MSG, whilst using advanced video distribution technology for the flexible allocation of screens across different functions.

A more complex project began for transforming the separate EPS and Sentinel-3 control rooms into a single, more efficient Low Earth Orbit Mission Control Centre also capable of hosting operations of EPS-SG, Jason-CS/ Sentinel-6 and up to two more missions.

Inauguration of the new Geostationary Mission Control Centre, in the presence of high-level officials, from left to right: Prof H. Moser, responsible for meteorology and Earth observation at the Federal Ministry for Transport and Digital Infrastructure (BMVI), Mr S. Nilsson, Chairman of the EUMETSAT Science and Technical Group, Prof G. Adrian, Head of the German Delegation and President of DWD, Dr T. Miethaner, BMVI Director for Digital Society, Alain Ratier, EUMETSAT Director-General, and Prof G. Van der Steenhoven, EUMETSAT Council Chairman

EVOLUTION OF GROUND INFRASTRUCTURE

The capacity of data dissemination and regional data acquisition systems increases to fulfil new requirements

The multichannel data dissemination system increased in capacity to ingest additional data flows from Sentinel-3B and Sentinel-5P, and to match the higher bandwidth of the EUMETCast real-time data broadcast systems.

A second X/L-band antenna was deployed in Athens to enable acquisition of direct broadcast data from Metop-SG and more third-party polar-orbiting satellites.

Rationalisation of Meteosat primary ground station services

At the end of March, all Meteosat Second Generation primary ground station services started to be provided from Fucino, Italy, after the relocation of one antenna from Usingen, Germany. This allowed for closing the MSG ground station services from Usingen in April. The consolidation involved the relocation of the Backup Satellite Control Centre from Usingen to Fucino and the setting up of temporary backup station services in Fucino and Lario, Italy, for the safe continuity of operations.

After relocation from Usingen to Cheia, Romania, the two remaining antennas will replace the temporary backup station services in 2019.

The three-antenna capacity for MSG mission data acquisition will be downscaled in the next decade, to keep pace with the reduction in the number of MSG satellites in orbit.

The Athens EUMETSAT Advanced Retransmission Service (EARS) station is now equipped with two X/L-band antennas

Dismounting of one Meteosat backup antenna in Usingen for shipment to Cheia

EUMETSAT SATELLITES TRACK CLIMATE FEATURES

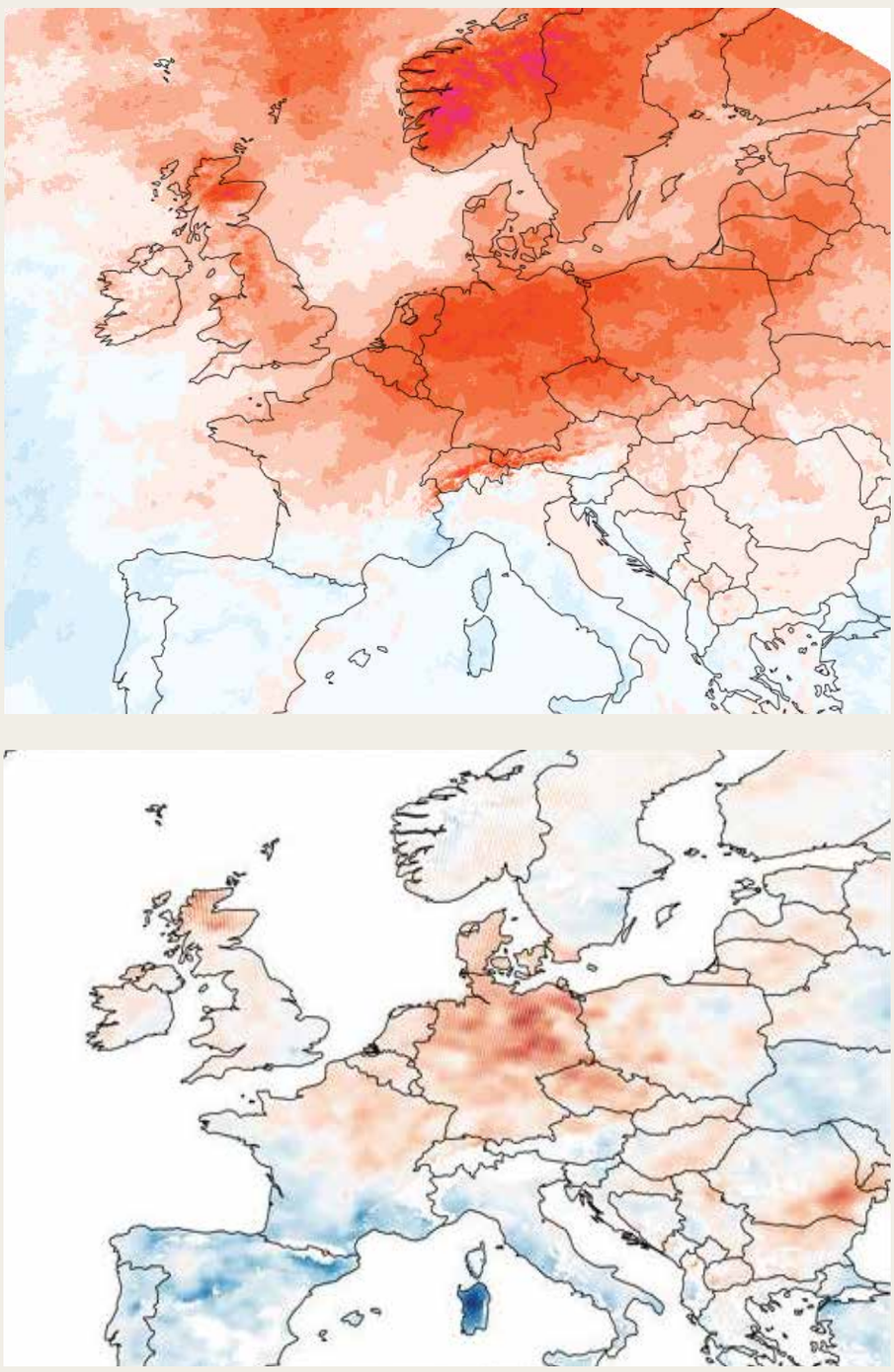
Exceptionally dry and hot conditions in Northern Europe and an active cyclone season in the Northern Atlantic were on the climate agenda for 2018

Metop radars and Meteosat imagers observe exceptionally hot and dry conditions in Northern Europe...

The World Meteorological Organization (WMO) describes 2018 as globally "the fourth warmest year on record", behind the years 2015 to 2017. The weak La Niña conditions prevailing at the beginning of the year may explain why 2018 was slightly cooler.

In Europe, summer temperatures were the warmest on record and 1.3°C above the 1981-2010 average, according to the Copernicus Climate Change Service (C3S) global reanalysis that assimilates observations from all EUMETSAT satellites.

The late spring and summer was exceptionally hot and dry in large parts of Europe, leading to droughts and wildfires. Unlike 2017, the areas affected most were Northern and Central Europe. Sunshine duration up to 40% longer than average and very low precipitation made 2018 the driest and warmest year on record north of 45°N.



Maps of sunshine duration (top, source: CM SAF) and soil moisture (bottom, source: H SAF) anomalies averaged over 2018, derived respectively from Meteosat imagery and Metop-C ASCAT measurements

EUMETSAT SATELLITES TRACK CLIMATE FEATURES

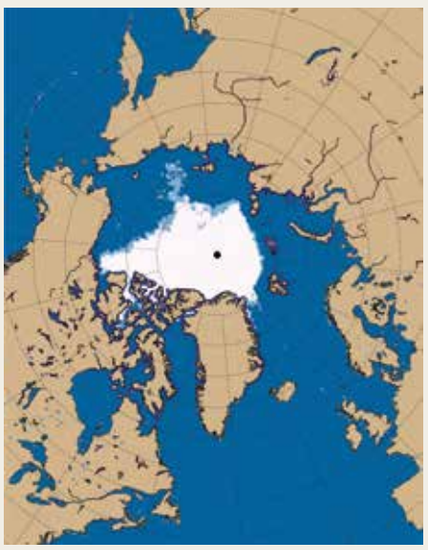
Smoke billowing from several fires stretching from the west coast of Norway to central Sweden, captured by Sentinel-3 on 17 July 2018 (top). A photo capturing one of the wildfires in Karbole outside Ljusdal, Sweden on 15 July 2018 (bottom, source: Reuters).

...and Sentinel-3 monitors the resulting wildfires

Sweden experienced record-breaking temperatures in May and July and had only 13mm of rain in the same period. This triggered an exceptional number of wildfires, resulting in a burnt area of 250km² in July. Abnormal wildfire activity also occurred in Latvia, Norway, Germany, the United Kingdom and Ireland.

In Southern Europe, wildfires spread rapidly near Athens on 23 July due to unusually high winds for that time of year, with gusts of up to 124km/h north of Athens.

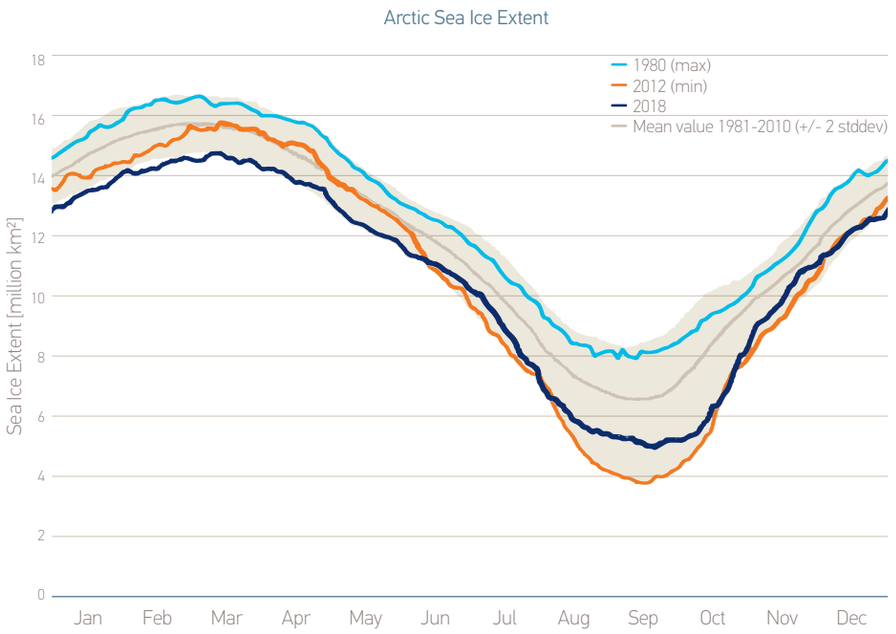
EUMETSAT SATELLITES TRACK CLIMATE FEATURES



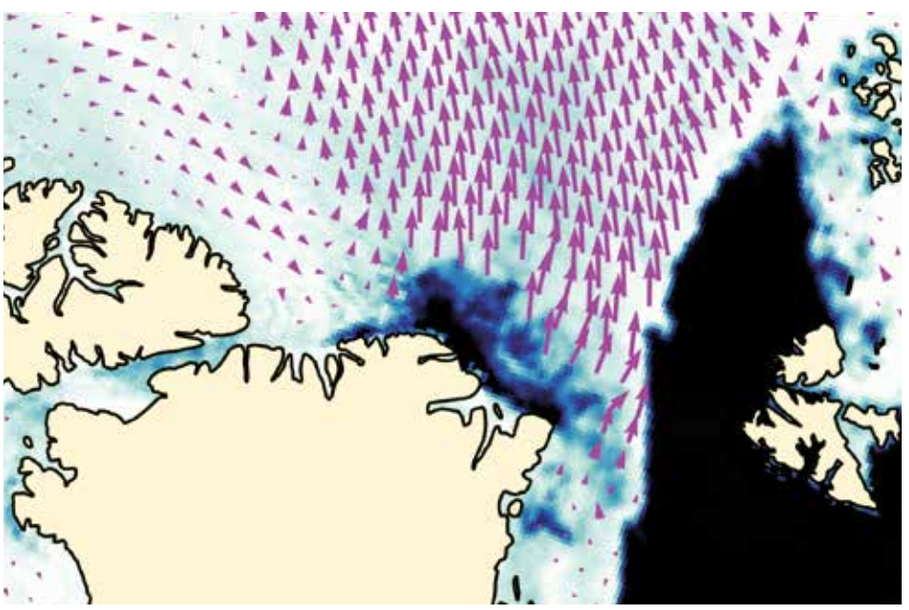
For the first time ever, satellites observe a large polynya in northern Greenland during wintertime

The Arctic sea ice extent was well below the 1981-2010 average throughout 2018 and at a record-low level from January to June. However, the September minimum ice extent was clearly above the record low of 2012. The largest area of "open ice" since 1979 kept the North-East Passage open all summer, with ice concentrations from 30% to 70%.

For the first time since the start of satellite measurements in 1979, a large polynya (a region of open water surrounded by ice) was observed during winter. The polynya opened in northern Greenland, which is usually covered by stable multi-year ice, and reached its maximum extent of 60,000km² on 25 February. The phenomenon coincided with an unusual period of sustained strong winds, carrying warm air with above-freezing temperatures from the south.

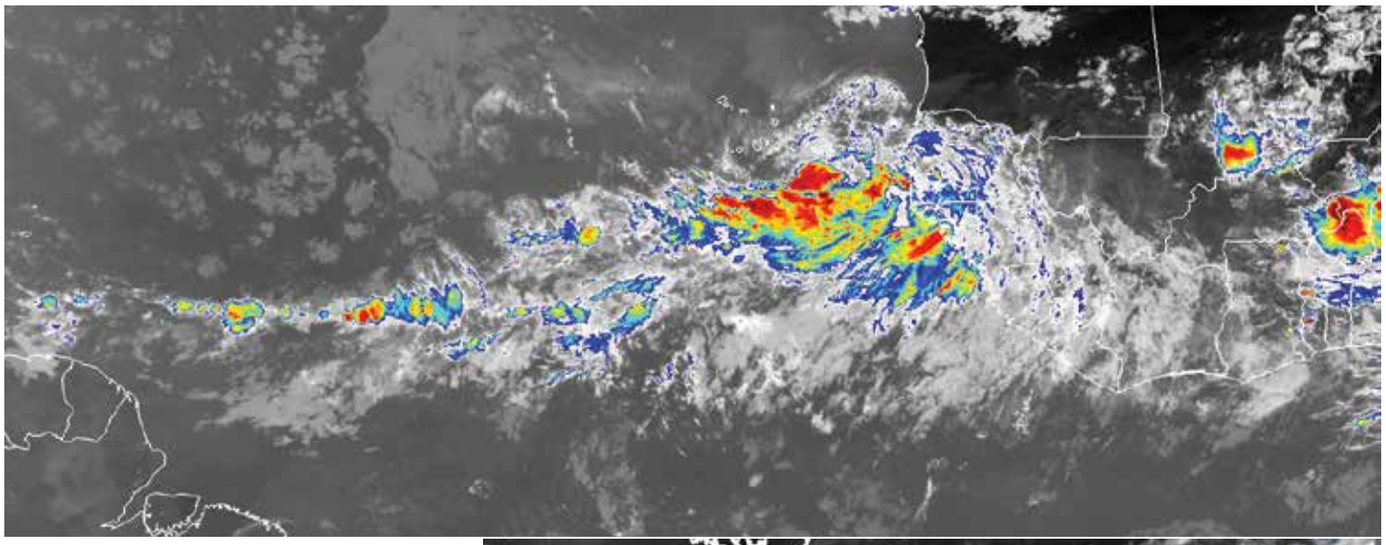


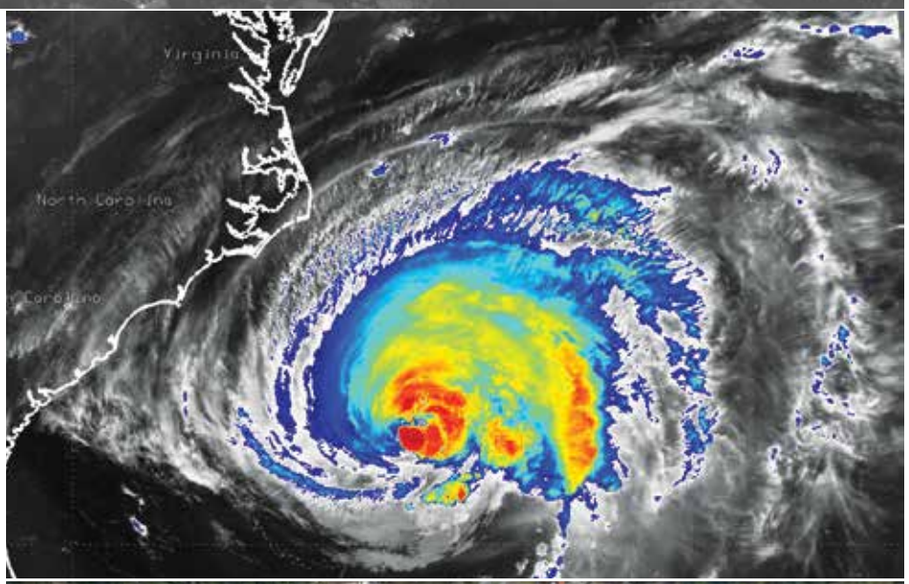
Arctic sea ice extent reached its minimum on 20 September (map) in an annual cycle (black curve) exhibiting a record low from January to June and an absolute minimum above the record observed in September 2012 (orange curve) (source: OSI SAF)



Map of sea ice concentration overlaid with sea ice drift vectors for 25 February 2018, showing a polynya (dark blue) north east of Greenland and sea ice drifting to the north, pushed by strong winds and swell from the south (source: OSI SAF)

EUMETSAT SATELLITES TRACK CLIMATE FEATURES





An active tropical cyclone season in the Northern Atlantic

The tropical cyclone season was very active in the Northern Hemisphere, with 76 cyclones in total, well above the average number of 63.

A tropical wave observed on 30 August off the west coast of Africa gave birth to Florence, the first cyclone of the season in the Northern Atlantic. Florence intensified to Category 4 before weakening to Category 1 when making landfall and was the wettest cyclone on record in the Carolinas, causing floods and taking 53 lives.

Meteosat imagery observes the tropical wave giving birth to Hurricane Florence off the west coast of Africa on 30 August (top). On 13 September, Metop imagery (middle) detects cloud tops colder than -40°C (in red) announcing heavy rain close to landfall. Houses sit in floodwater caused by Hurricane Florence in this aerial picture (bottom), on the outskirts of Lumberton, North Carolina (US) on 17 September (source: Reuters).

EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

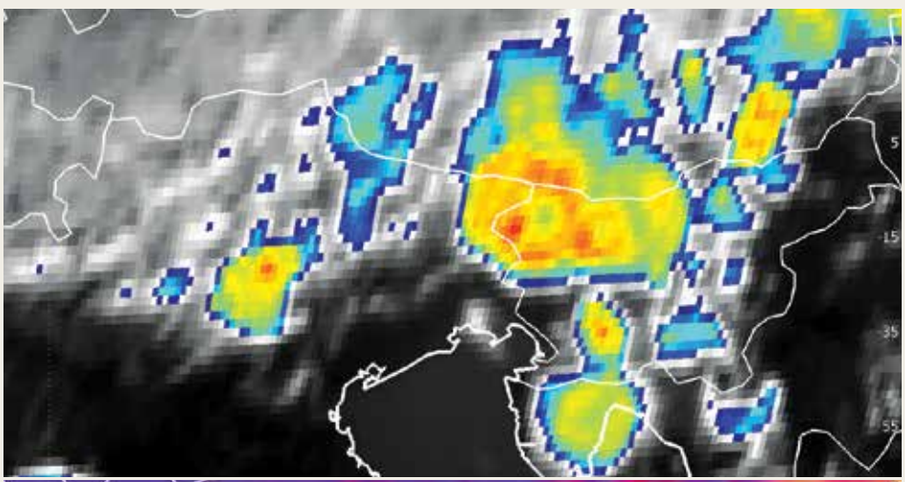
Meteosat imagery helps forecasters nowcast severe thunderstorms

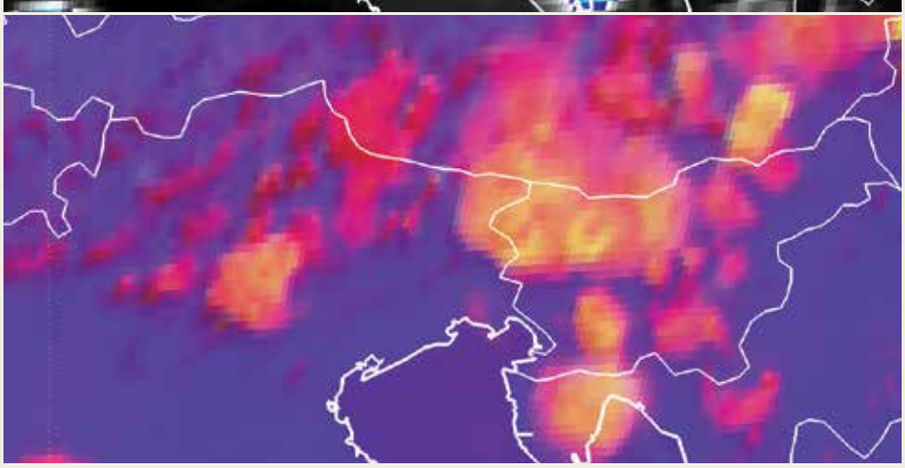
Forecasters use Meteosat imagery for nowcasting the fast development of severe thunderstorms and releasing timely warnings to mitigate their destructive impact.

This was the case on 24 August, when thunderstorms developed in north-eastern Italy and Slovenia within an area of strong instability, producing intense lightning and up to 80mm of rain in six hours.

"Using satellite products in combination with other real-time data, we could detect convection in its early development stage and issue timely warnings to protect life and property."

Blaž Šter
Meteorologist
Slovenian Environment Agency



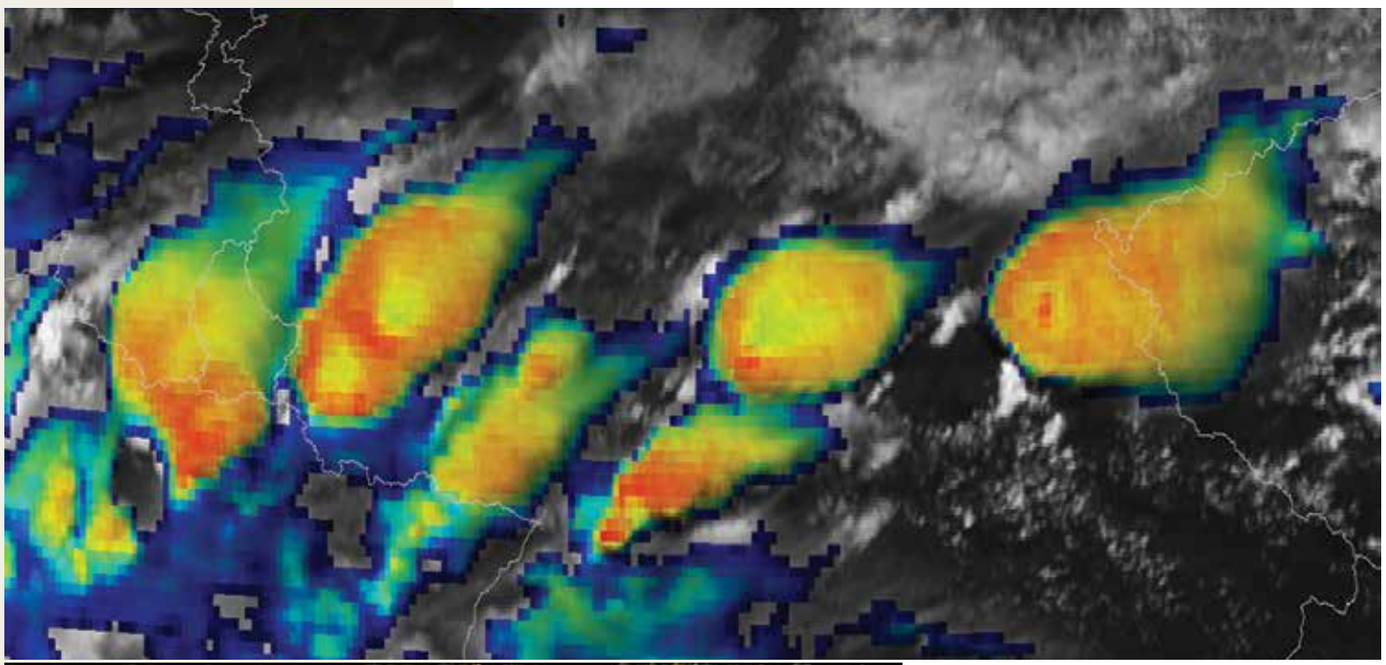


Meteosat colour-coded imagery diagnoses severe convection developing over parts of Italy and Slovenia (bottom, in yellow), while infrared imagery shows cloud tops colder than -70°C in some places (top, in orange)

Work begins to repair a collapsed road, after mudslides and flash flooding caused damage in Saalbach, Austria on 24 August 2018, (source: Getty Images)

EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

In mid-June, Meteosat imagery also helped nowcast the evolution of a series of thunderstorms bringing heavy rain, hail and severe lightning over Central Europe, causing floods and damage to infrastructure across eastern France, Luxembourg, Germany and Czechia.



Combined Meteosat visible and infrared imagery (top) depicts the real-time evolution of severe thunderstorms across Central Europe on 18 June 2018. Cars are stopped on the Quai d'Ouchy after heavy rain caused flash flooding in Lausanne, Switzerland on 11 June 2018 (left, source: Reuters).

EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

Metop observations help forecast large-scale winter storms and tropical cyclones five days in advance

"We used vertical profiles of temperature and moisture, available within 15 to 30 minutes from sensing from Metop satellites, to analyse whether wind gusts in the mid-troposphere dry-air intrusion associated with Friederike would reach the ground."

Christian Herold
Forecaster
Deutscher Wetterdienst (DWD)

Dual-Metop observations currently account for 27% of the total average reduction in one day weather forecast errors attributed to all observations ingested in real time by numerical weather prediction models. This figure of merit should increase in 2019 when products become available from a third Metop satellite.

These observations were again essential for forecasting large-scale winter storms several days ahead, the most remarkable being Cyclone Friederike (also called Storm David), in January. Friederike brought cyclone-like winds across the British Isles, France, the Netherlands, Belgium, Germany, Central Europe and northern Italy, with gusts above 200km/h in Germany. It killed 13 people and caused economic losses in the € billion range, a toll which would have been much higher without accurate forecasts and early warnings across Europe.

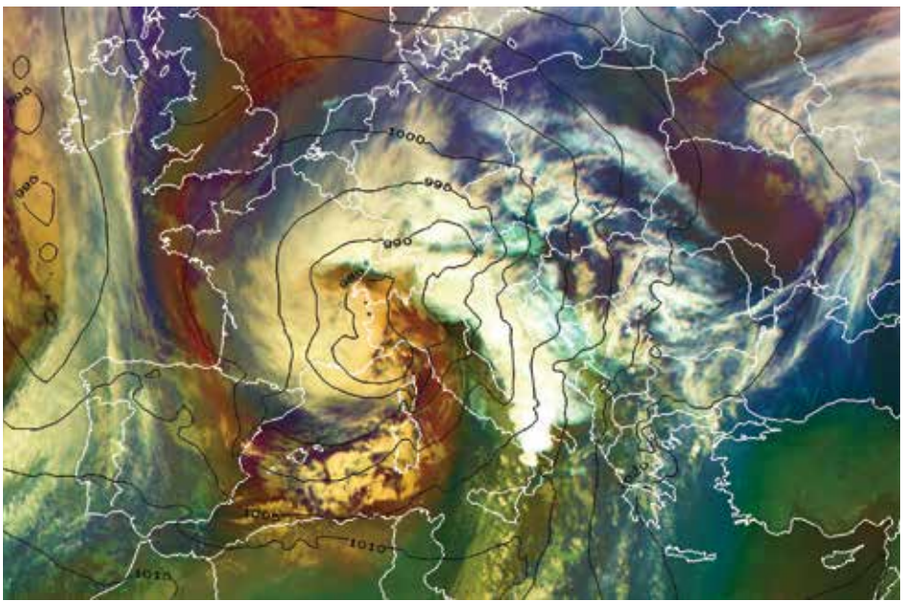
Forecasters used Meteosat imagery and regional Metop infrared soundings available within 15 to 30 minutes from sensing to confirm and detail the numerical forecast and release early warnings.

Real time Meteosat colour-coded mapping of air masses (right) showing a band of dry-air intrusion (see yellow arrow) within the centre of the low-pressure system associated with storm Friederike on 18 January. The exceptional storm was announced five days in advance by the Deutsche Wetterdienst (DWD) model forecast (left), triggering red warnings from forecasters over central Germany (below) and preventive interruptions of railway traffic (bottom right, source: Reuters).

EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

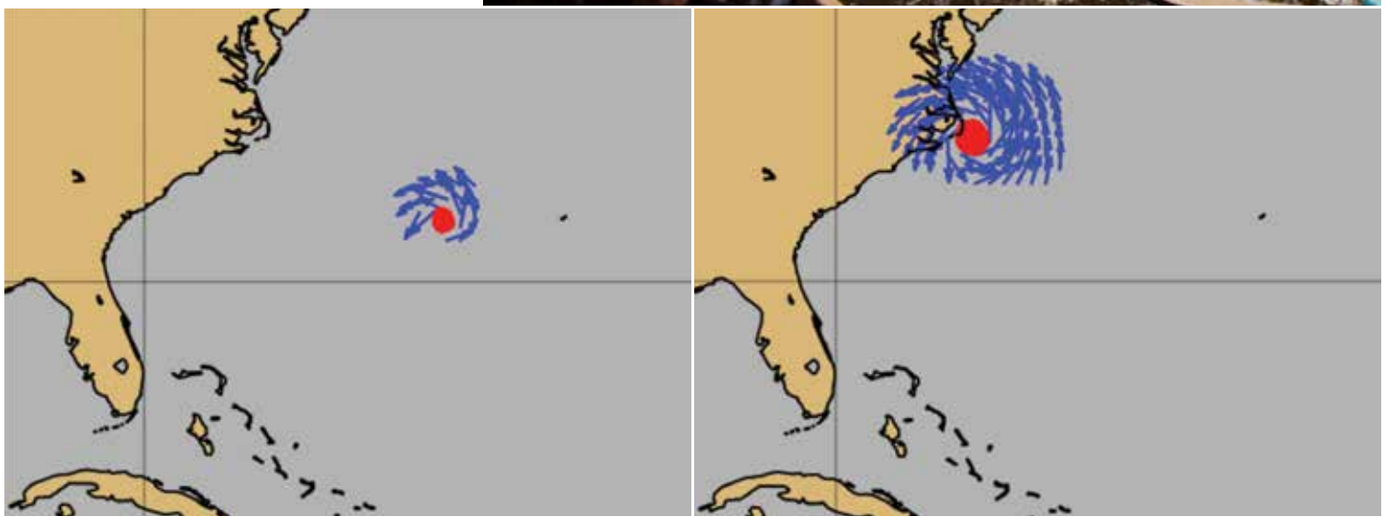
At the end of October, another remarkable low-pressure system developed over the warm Mediterranean Sea, bringing high winds and heavy precipitation to Southern Europe, and causing flash floods and landslides in Italy. The storm took 30 lives and was the costliest on record, with losses of more than €40 billion.

In the tropical Atlantic, home to a number of European citizens, satellite data proved once again essential for an accurate, early forecast of cyclone landfall in support of preparedness. Indeed, the European Centre for Medium-Range Weather Forecasts (ECMWF) showed that without satellite data, its five-day numerical forecasts would have underestimated the intensity of Hurricane Florence and totally missed its landfall on the coast of North Carolina.



Meteosat colour-coded mapping of air masses, overlaid with numerical forecast of surface pressure field showing the air mass and cloud structure around the 977hPa low

Without satellite data (bottom left), the ECMWF five-day forecast would have underestimated the intensity and missed the landfall of Hurricane Florence in North Carolina, contrary to the operational forecast using satellite data (bottom right). A US Army soldier in Lumberton, North Carolina, during relief efforts for flooding caused by Hurricane Florence, 18 September 2018 (bottom, source: Reuters)



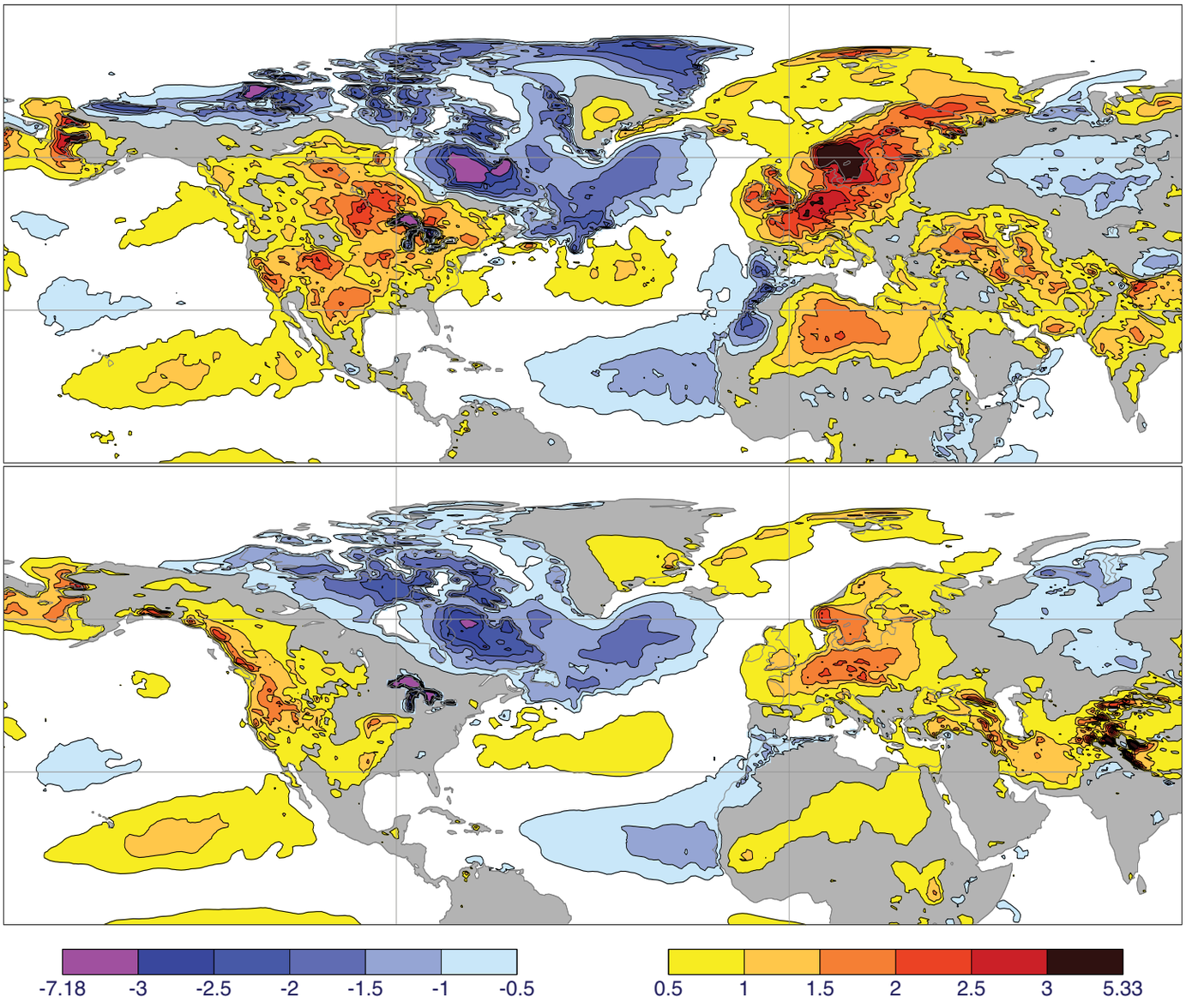
EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

Jason, Metop and Sentinel-3 ocean observations help predict sustained dry and hot conditions in Northern Europe from May to August

Jason and Sentinel-3 observations of sea surface height and Sentinel-3 and Metop observations of sea surface temperature, combined with Metop observations of the atmosphere and soil moisture, contribute to the skill of numerical forecasting for weather phenomena influenced by ocean and land surface conditions, in particular forecasts on sub-seasonal and seasonal scales.

Assessment studies performed by the ECMWF confirmed that having knowledge of ocean conditions and soil moisture contributed to the accuracy of sub-seasonal forecasts of surface temperature anomalies during the exceptionally long, warm period over Northern Europe. However, initial atmospheric conditions were the most important in that case.

The comparison between actual composite anomalies of 2m temperature over the period 9 May - 6 August (ERA-5 reanalysis, top) and those forecast operationally three weeks in advance by the ECMWF (bottom), demonstrates the skills of extended range forecasts (source: ECMWF)



EUMETSAT delivers time-critical data safely to a widely distributed population of operational users in push mode and online

As the value of observations for forecasting diminishes with increasing latency, EUMETSAT must deliver observational products to a widely distributed population of operational users as safely and quickly as possible after sensing.

Using commercial telecommunication satellites and the same reliable, flexible and cost-effective technology as used for digital TV broadcasting, the EUMETCast services broadcast fast-repeat Meteosat imagery and other time-critical products within minutes to European and African forecasters who nowcast high-impact weather. Online data access services are also available for less demanding applications.

The availability of EUMETCast data broadcast services remains well above the 99.5% target

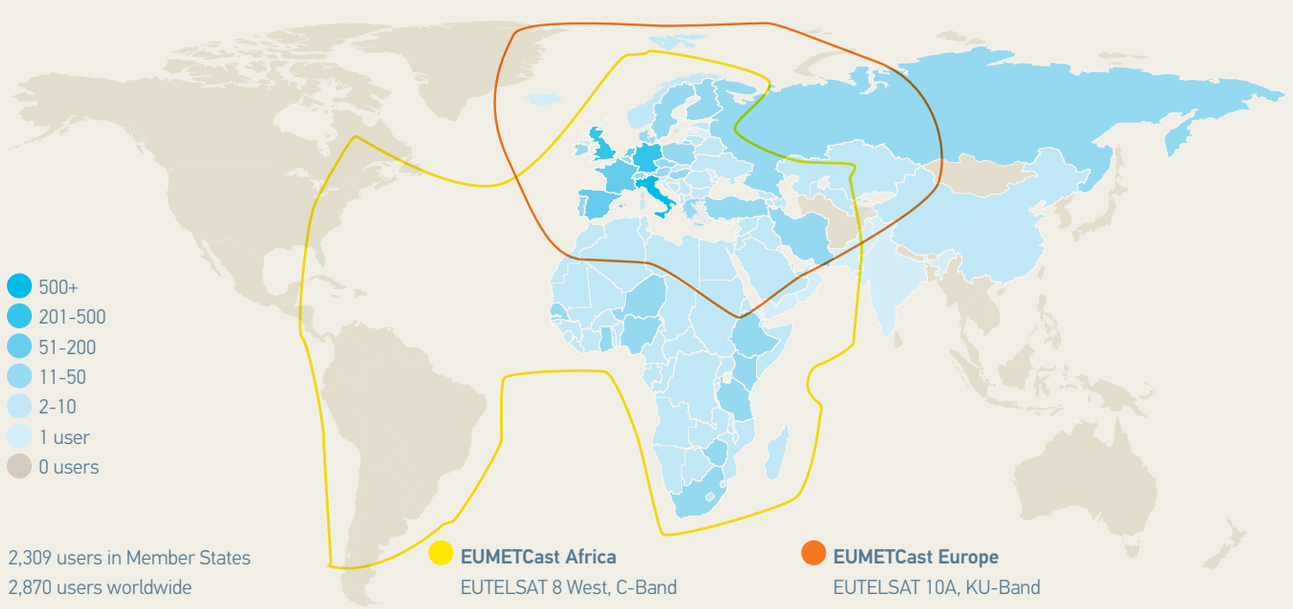
The monthly average availability of EUMETCast services remained above 99.9%, except in April when it dropped to 99.7%, when it was impossible to uplink data for two hours to one of the two transponders used by EUMETSAT on a EUTELSAT satellite. This was caused by an interfering uplink from another EUTELSAT customer.

Modernisation boosts capacity, flexibility and availability of EUMETCast services in Africa

The modernised EUMETCast-Africa service, implementing the higher capacity DVB-S2 standard, became operational in August after a three-month overlap with the legacy service for the migration of users.

Becoming independent from EUMETCast-Europe, the new service provides full flexibility to deliver specific data flows to users in Africa. Another new feature is the automatic switching to a backup uplink station, which increased the average availability of the service to 99.98%.

Setup of a new antenna in Abidjan as part of the migration to the new EUMETCast-Africa service, implementing the DVB-S2 standard



The EARS network gives fast access to regional products from the polar-orbiting satellites of EUMETSAT and partners

Because of less stringent latency requirements from users, global Metop data are recorded on board and dumped each 100-minute orbit cycle, 14 times a day, to an Arctic ground station at Svalbard, and transmitted to EUMETSAT headquarters for fast "pipeline" processing and broadcasting of output products via EUMETCast. Within the Initial Joint Polar System (IJPS) shared with NOAA, Metop-B data are also dumped at McMurdo, Antarctica, thus halving the latency to 50 minutes.

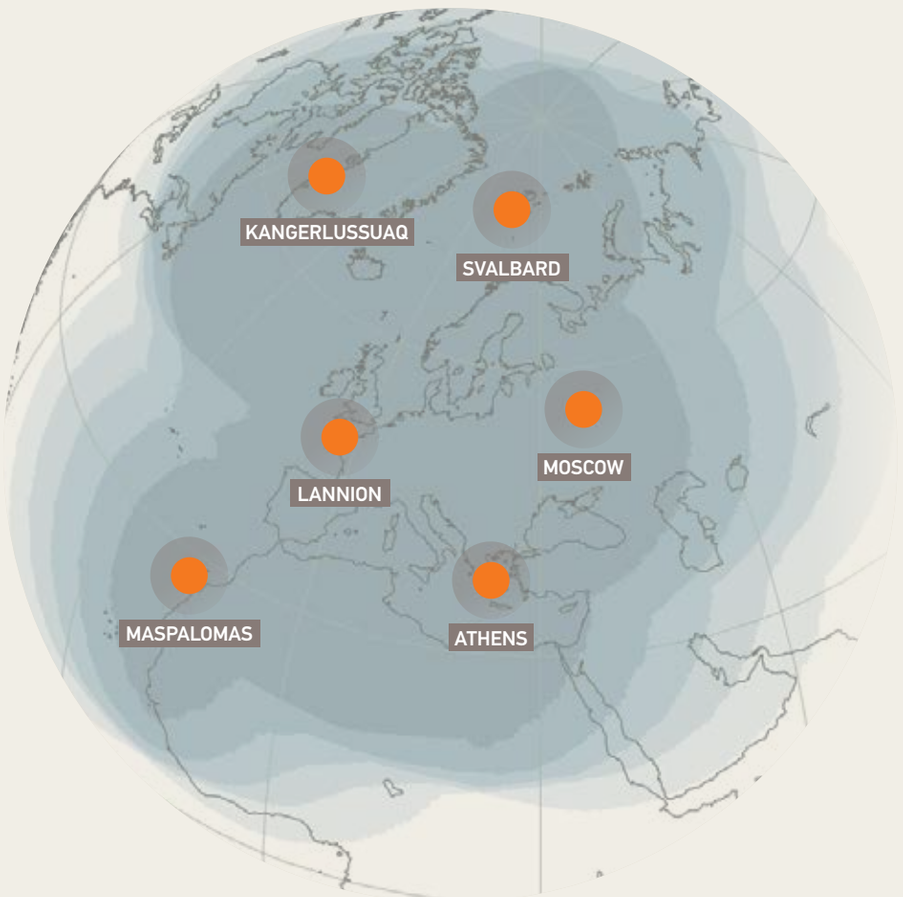
To fulfil more stringent timeliness requirements of nowcasting at high latitudes and very short-range forecasting across Europe, the EARS network delivers regional products from EUMETSAT, US and Chinese polar-orbiting satellites within 15 to 30 minutes of sensing. This is achieved through local processing of sounding and imagery data directly broadcast by the satellites to a European network of ground stations and broadcasting of output products via EUMETCast-Europe.

EARS regional data services deliver NOAA-20 products and prepare to add FY-3D products

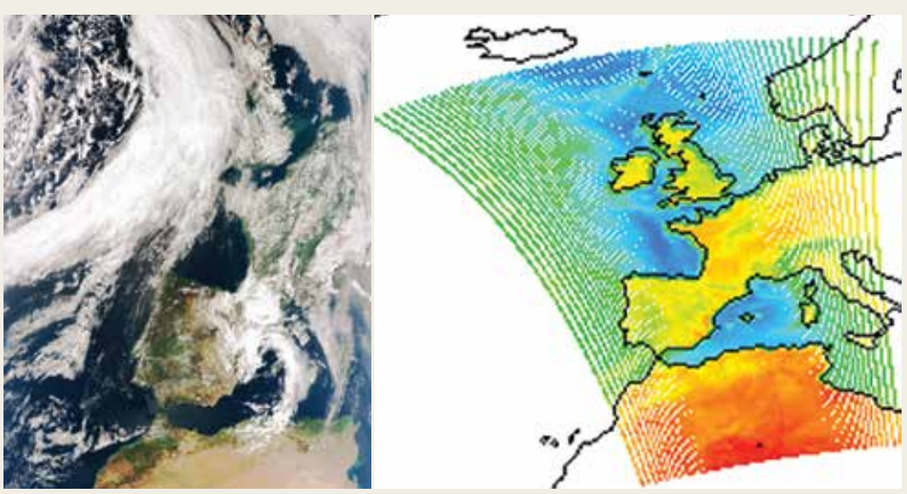
An upgrade of the software deployed across the network of EARS stations enabled local preprocessing of data broadcast by NOAA-20, the new NOAA primary satellite for the afternoon orbit.

Thus, multispectral imagery and sounding products from NOAA-20 instrument data extracted in Athens, Kangerlussuaq, Lannion, Maspalomas and Svalbard augmented the EARS regional data services.

The Maspalomas and Svalbard stations started to acquire data broadcast by the new Chinese FY-3D polar-orbiting satellite, in preparation for new regional services planned for 2019.



EARS European ground station network and coverage



NOAA-20 VIIRS imagery (left) and FY-3D microwave sounder data (right) acquired at the EARS station located in Lannion, France

EUMETSAT deploys a cloud service infrastructure and champions distributed big data services

Following strategic decisions made in 2017, EUMETSAT validated technical concepts that enable a distributed and federative approach to big data services, and completed the design of the cloud service infrastructure and application software needed for the implementation of these services for EUMETSAT and Copernicus purposes.

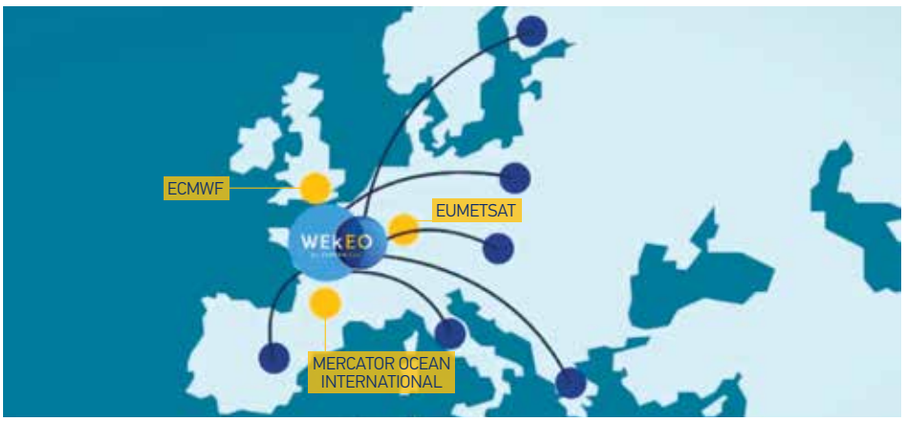
The target is a service platform integrating a couple of geographically distributed cloud infrastructures and data holdings seen as one by all users, whilst offering connectivity with other platforms for reciprocal data access, plus a front-end functionality for hosting user projects using commercial cloud resources at their own cost.

After tuning of the "brokerage" software layer enabling users to see distributed clouds as one, the first instance of the cloud service infrastructure deployed at EUMETSAT supported the parallel deployment of EUMETSAT pathfinder big data services and the demonstrational version (V0) of the Copernicus WEkEO DIAS platform.

EUMETSAT pathfinder big data services enter user validation phase

National meteorological and hydrological services (NMHS) began user validation of the six pathfinder services for multicasting of large data volumes via terrestrial networks, web map services, online data access and product customisation and hosted processing in May.

After initial positive feedback, the elimination of known infrastructure limitations, the maturation of user documentation and the mobilisation of additional resources for communication with users, including a dedicated portal linked to a help desk, boosted the user validation phase, which is expected to conclude in February 2019.



Distributed and federative approach for big data services, illustrated by the Copernicus WEkEO DIAS platform deployed in partnership with the ECMWF and Mercator Ocean International

EUMETSAT, the ECMWF and Mercator Ocean International demonstrate distributed and federated Copernicus Data and Information Access Services

The Copernicus WEkEO DIAS platform deployed in partnership with the ECMWF and Mercator Ocean International was the full test bed for the brokerage software layer enabling users to see distributed cloud infrastructures and data holdings as one.

Its deployment combined instances of the same cloud service and brokerage software infrastructure at the three partners' premises, with the ECMWF Climate Data Store and other existing assets supporting the Copernicus Climate Change (C3S), Marine Environment Monitoring (CMEMS) and Atmosphere Monitoring (CAMS) services.

An initial V0 configuration demonstrated the original platform design features and their use by hosted projects at a Copernicus event held in June by the European Commission in Baveno, Italy. This configuration used brokerage infrastructure deployed at EUMETSAT and Mercator Ocean International, federated data access with the Austrian Earth Observation Data Centre (EODC) for accessing Sentinel-1 and Sentinel-2 data, and commercial cloud elasticity.

Version V0.1 followed in December, increasing capacity and improving federated data access with the introduction of "data adaptors" enabling access to data at the source location without copying them. This improved access to Copernicus data and information hosted outside the data holdings of the three WEkEO partners.

The ECMWF and EUMETSAT launch a joint European Weather Cloud (EWC) initiative for cloud-based meteorological data and information access services

Building on the same technical heritage, the ECMWF and EUMETSAT launched a two-year pilot phase of an EWC initiative for cloud-based meteorological data and information access services. This initiative realises the cloud strategy of both organisations and the EUMETNET grouping of European NMHS.

Using cloud capacities set up by EUMETSAT and the ECMWF, commercial elasticity and harmonised data access with NMHS, the EWC will offer access to a wealth of data and information services across the European meteorological ecosystem.

SUPPORT TO CLIMATE SERVICES

EUMETSAT rescues, recalibrates and reprocesses historical satellite data in support of Copernicus and other climate services, and contributes to research on the assessment of uncertainties attached to climate records

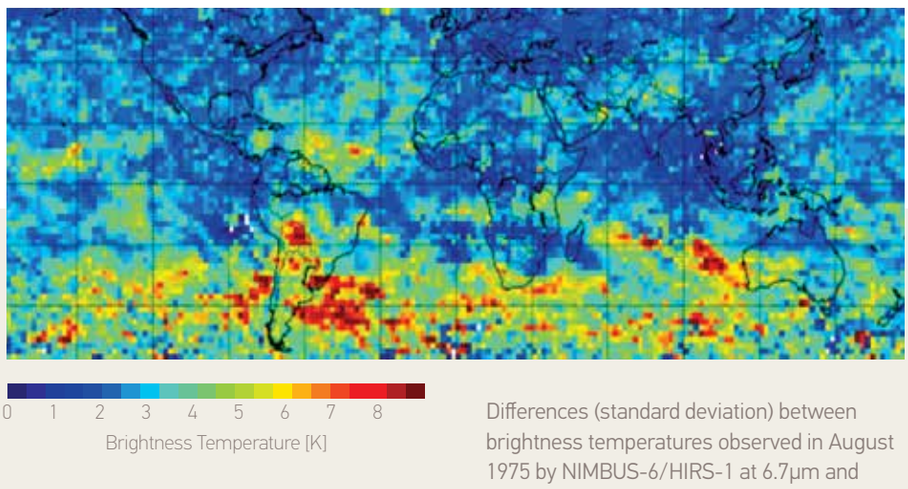
Mobilising expertise and infrastructure at its headquarters and across its network of Satellite Application Facilities (SAFs), EUMETSAT rescues and recalibrates historical satellite data, produces and validates homogeneous series of physical parameters (e.g. radiance, reflectance), called fundamental climate data records, and of derived geophysical parameters (e.g. temperature, wind), called thematic climate data records.

EUMETSAT climate records can then be used directly or ingested into the best numerical Earth system prediction models used in "reanalysis" (hindcast) mode to produce consistent records of a broader range of climate variables.

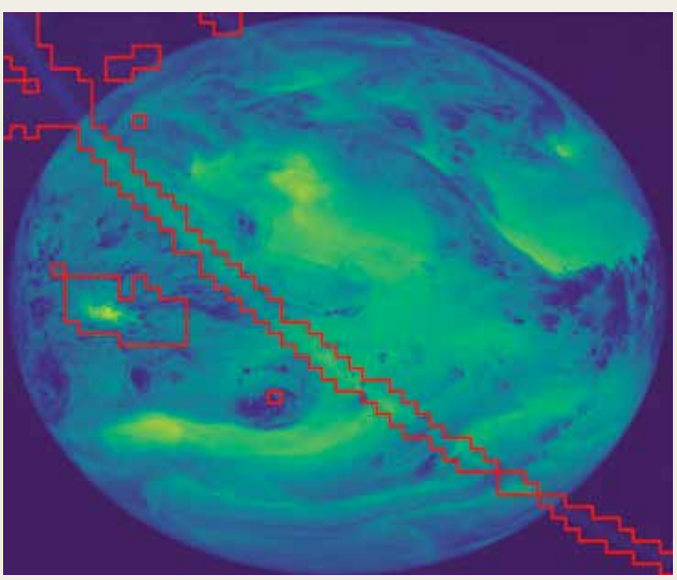
A promising assessment of water vapour soundings from the NIMBUS-6 pioneer satellite

In the absence of contemporary reference observations, HIRS-1 measurements from the US NIMBUS-6 pioneer satellite were assessed against ECMWF model outputs after conversion of the latter into satellite observables using a radiative transfer model.

For the 6.7µm water vapour channel, the significant differences found over the poorly observed Southern Ocean demonstrate that the NIMBUS-6 HIRS-1 data contain unique historical information on water vapour in this region.



Differences (standard deviation) between brightness temperatures observed in August 1975 by NIMBUS-6/HIRS-1 at 6.7µm and calculated from the ECMWF ERA-5 reanalysis



The automated detection of image anomalies paves the way for the rescue and reprocessing of data from the oldest Meteosat satellites

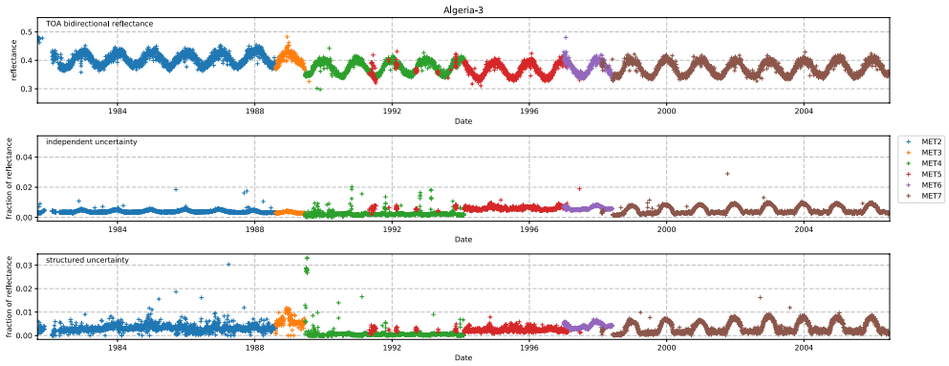
The automation of detection of 30 types of anomaly present in historical Meteosat imagery allowed for the processing of the entire archive in less than 24 hours and attachment of metadata to each image. This achieved a prerequisite for the backwards extension of existing Meteosat climate records.

The automated detection of anomalies in a Meteosat-5 image points to direct stray light affecting some pixels marked in red

SUPPORT TO CLIMATE SERVICES

The first climate record of Meteosat first generation visible imagery with full uncertainty characterisation

Within the Horizon 2020 FIDUCEO research project, EUMETSAT completed the assessment of the three most important sources of uncertainty attached to visible imagery of the first generation of Meteosat; those relating to evolutions of the spectral response function, ageing of instrument electronics and geolocation errors. This resulted in the production of the first climate record of recalibrated visible imagery against natural reference targets, such as desert surfaces, that includes pixel-level uncertainty estimates traced to the three sources.

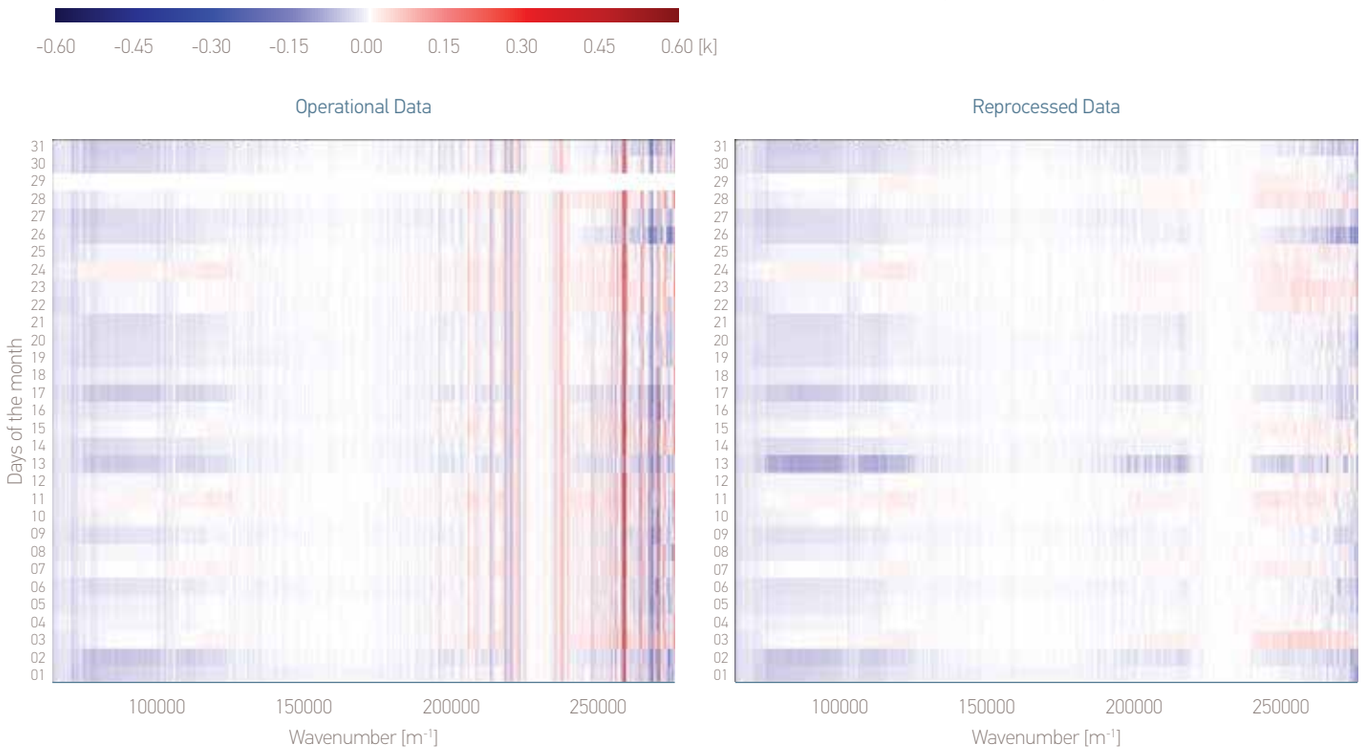


Climate record of Meteosat recalibrated visible reflectance (top panel) and associated estimates of random (middle panel) and structured (bottom panel) uncertainties. Each colour identifies one of six Meteosat first generation satellites.

Reprocessing of IASI infrared spectra restores missing products and eliminates cross-pixel artefacts

The reprocessing of IASI/Metop-A infrared spectra using a new CNES processor filled gaps in early mission products, decreased unexplained differences between adjacent sounding pixels and added new information on product quality and cloud/land fractions present in each pixel.

Noise anomalies in IASI/Metop-A infrared spectra for May 2010 as a function of days (y-axis) and wave number (x-axis) for operational (left) and reprocessed (right) data. Reprocessing restored missing products on 29 May and eliminated inter-pixel artefacts showing as vertical strips in operational data.



SUPPORT TO CLIMATE SERVICES

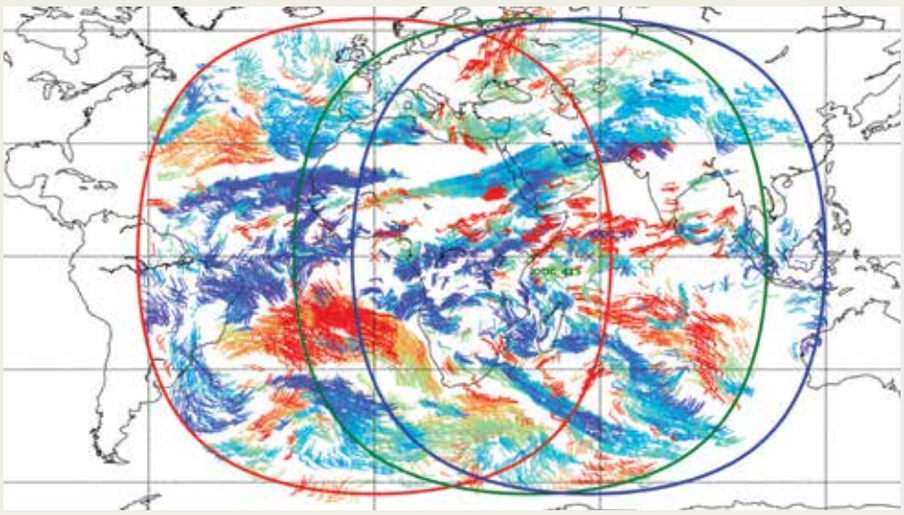
New records of essential climate variables of the dynamics and chemistry of the atmosphere

EUMETSAT delivered 32-year long (1982-2014) records of cloud mask, cloud top height, water vapour and wind vectors derived from Meteosat imagery to the C3S. The comparison of overlapping wind fields from three satellites of two different generations demonstrated the internal consistency of the multi-satellite record and confirmed that international cooperation can produce consistent climate records across the full ring of geostationary satellites.

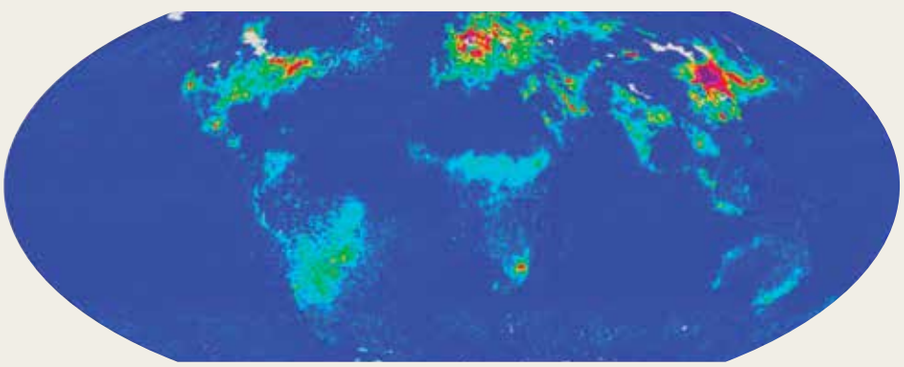
The SAF on Atmospheric Composition Monitoring (AC SAF) released 10-year GOME-2 records (2007-2017) of NO2 concentration in the troposphere and water vapour column concentration.

New records of surface climate variables observed from geostationary and polar orbits

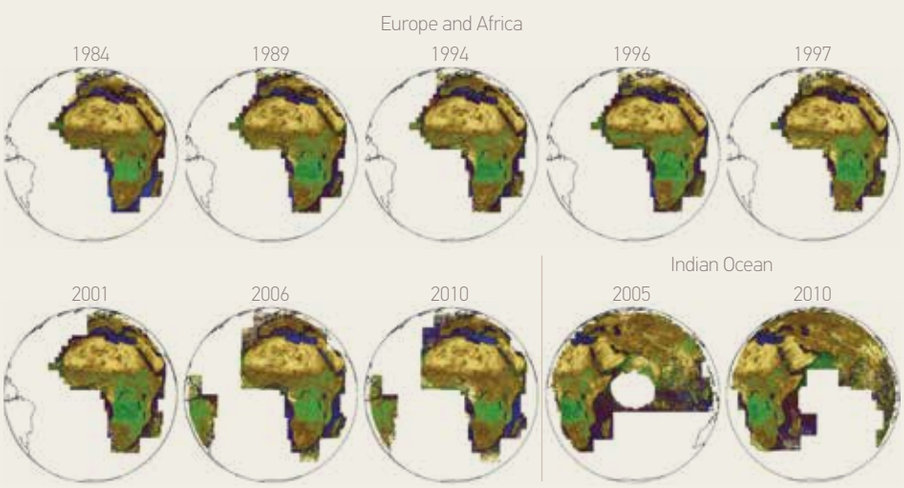
As part of the Horizon 2020 Q4ECV project, EUMETSAT co-processed Meteosat and AVHRR imagery and used a new cloud mask available from the SAF on Climate Monitoring (CM SAF) to produce records of surface albedo with reduced uncertainty over Europe and Africa (32 years) and over the Indian Ocean (12 years).



Seamless wind field reprocessed from overlapping infrared imagery acquired on 14 February 2017 by one first generation (Meteosat-7 at 57.5°E) and two second generation Meteosat satellites (Meteosat-8 at 41.5°E and Meteosat-10 at 0°)

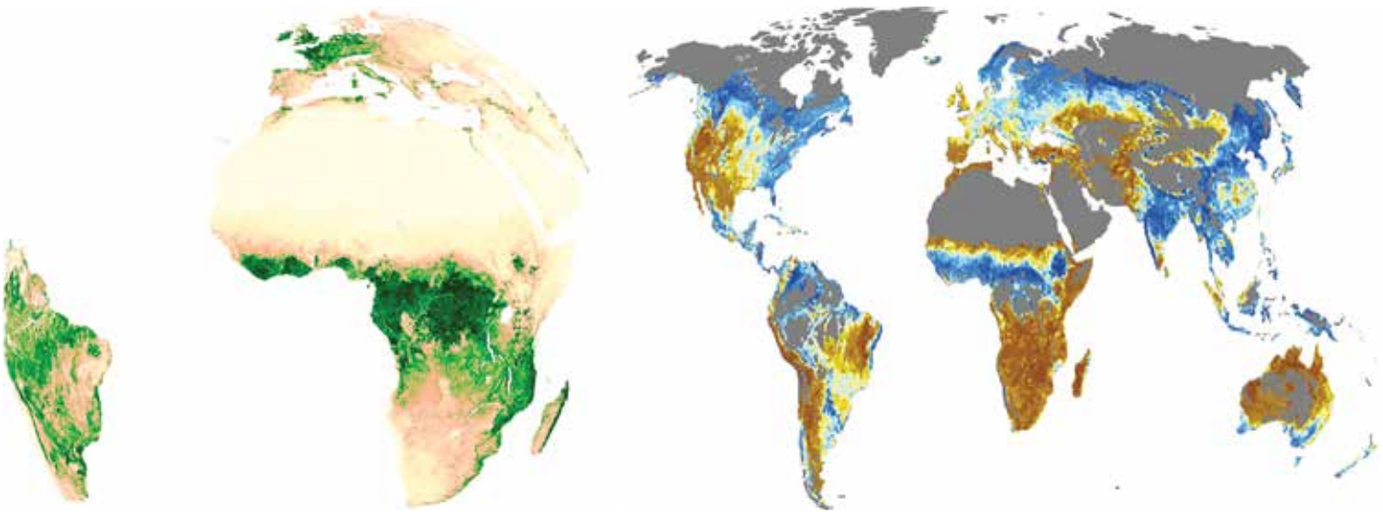


Average concentration of NO_2 in the troposphere in February 2013 from the GOME-2 climate record



Sample maps of annual surface albedo average over Europe and Africa (top left to lower centre) and over the Indian Ocean (lower right) based on imagery from nine Meteosat satellites

SUPPORT TO CLIMATE SERVICES



Sample daily map of Leaf Area Index (LAI) from a Meteosat climate record, measuring the amount of live foliage per unit surface (top left, source: LSA SAF). Sample map of the degree of soil saturation from a Metop climate record (top right, source: H SAF).

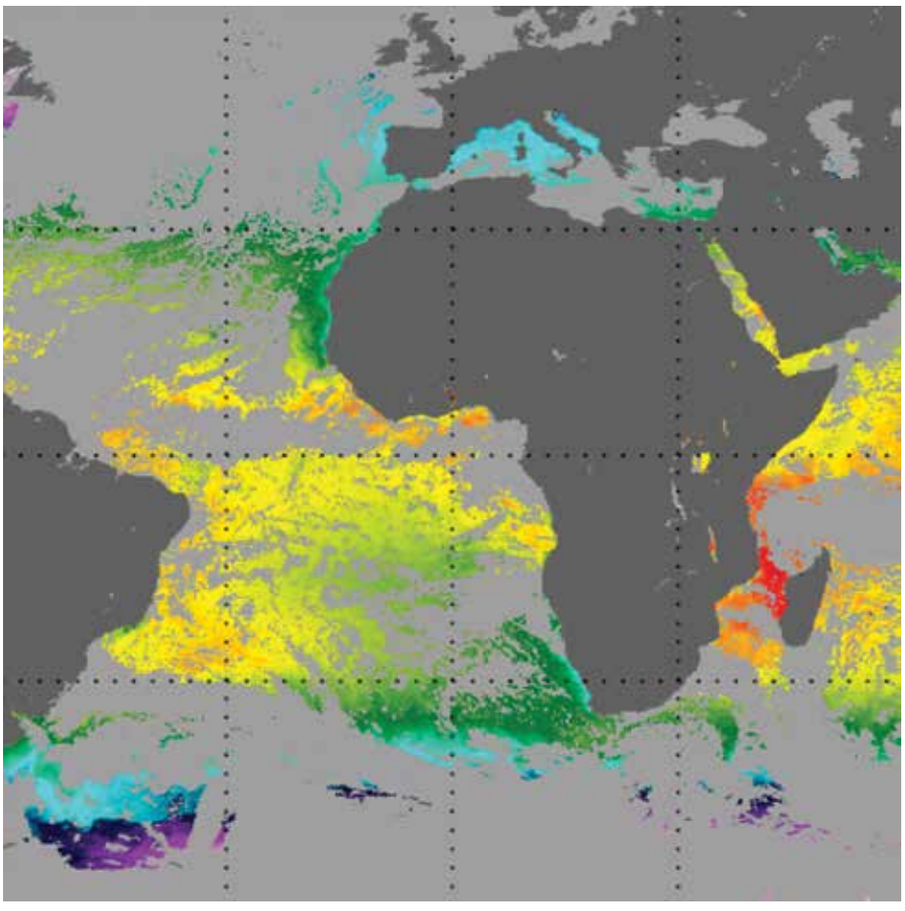
The SAF for Land Surface Analysis released Meteosat records (2004 - 2012) of vegetation cover, leaf area index and fraction of absorbed photosynthetically active radiation.

The Hydrology SAF released a Metop record (2007 - 2017) of soil moisture at a 12.5km resolution, based on the reprocessing of ASCAT C-band radar backscatter measurements.

The SAF on Ocean and Sea Ice published a Meteosat record (2004 - 2012) of hourly sea surface temperature.

Three more interim climate records for "live" climate monitoring

The introduction of three more interim climate records extending existing records of soil moisture, cloud cover and surface incoming shortwave radiation on a day-to-day basis enhanced the EUMETSAT capacity for "live" climate monitoring.



Sample of hourly sea surface temperature from a Meteosat climate record

A EUMETSAT competence network for developing enhanced and new products

In order to exploit the full potential of its satellites in a broadening range of meteorological and environmental applications, EUMETSAT relies on its central facilities in Darmstadt and a network of eight SAF consortia distributed across its Member States. Each SAF is specialised in one application area and led by an NMHS.

This cooperative network makes the best use of distributed resources and scientific expertise for the development and delivery of innovative products, building on close interactions with application experts.

EUMETSAT AC SAF

Atmospheric Composition Monitoring
Led by Ilmatieteen Laitos (FMI), Finland

EUMETSAT CM SAF

Climate Monitoring
Led by Deutscher Wetterdienst (DWD), Germany

EUMETSAT H SAF

Support to Operational Hydrology and Water Management
Led by Centro Operativo per la Meteorologia (COMet), Italy

EUMETSAT LSA SAF

Land Surface Analysis
Led by Instituto Português do Mar e da Atmosfera (IPMA), Portugal

EUMETSAT NWC SAF

Support to Nowcasting and Very Short Range Forecasting
Led by Agencia Estatal de Meteorología (AEMET), Spain

EUMETSAT NWP SAF

Numerical Weather Prediction
Led by Met Office, United Kingdom

EUMETSAT OSI SAF

Ocean and Sea Ice
Led by Météo-France (MF), France

EUMETSAT ROM SAF

Radio Occultation Meteorology
Led by Danmarks Meteorologiske Institut (DMI), Danemark

EUMETSAT published new science roadmaps guiding the development of Global Navigation Satellite System (GNSS) radio occultation and hyperspectral infrared products from different instruments and prepared others for marine and atmospheric chemistry products.

Improving instrument configuration, calibration and first-level processing as a fundamental investment

At EUMETSAT headquarters, the priority remained the further optimisation of instrument configurations, calibration and processing for the extraction of physical products used as inputs for the downstream extraction of geophysical environmental products.

An optimum configuration of the GRAS GNSS radio occultation instruments that improves performances in rising occultation and reduces vertical error correlation in the lower stratosphere was adopted for all Metop instruments after testing with Metop-A.

An upgrade of GOME-2 data processing mitigated the impact on solar calibration from the partial loss of solar visibility due to the drifting orbit of Metop-A and corrected a 5km geolocation error caused by an offset in the mounting of the instrument on the satellite.

Improved processing of imagery from the Sentinel-3A SLSTR dual-view instrument restored some missing scan lines, corrected geometric calibration for the oblique view and introduced a probabilistic algorithm for cloud screening.

More frequent, shorter calibration sequences of the microwave radiometer on board Sentinel-3A improved the accuracy of "wet" tropospheric corrections to sea surface height measurements from the altimeter.

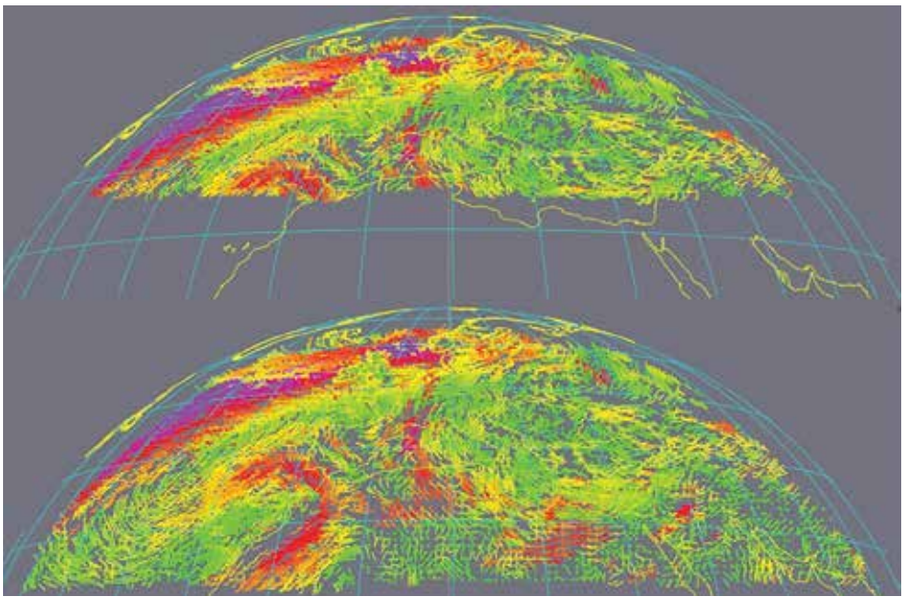
Further improvements will follow in the coming years, through the implementation of new science roadmaps for the development of image navigation registration and calibration tools, and the use of fiducial reference measurements for calibration.

DEVELOPING AND ACQUIRING NEW PRODUCTS IN COOPERATION WITH MEMBER STATES AND INTERNATIONAL PARTNERS

New and improved operational products and user software for meteorology

Meteorology

The extraction of meteorological products from Meteosat 5-minute rapid scan imagery was extended further south to observe fast evolutions of weather patterns impacting the Canary Islands and Maghreb countries, and propagating towards continental Europe.



Wind fields extracted from Meteosat 5-minute rapid scan imagery now cover latitudes down to 22°N

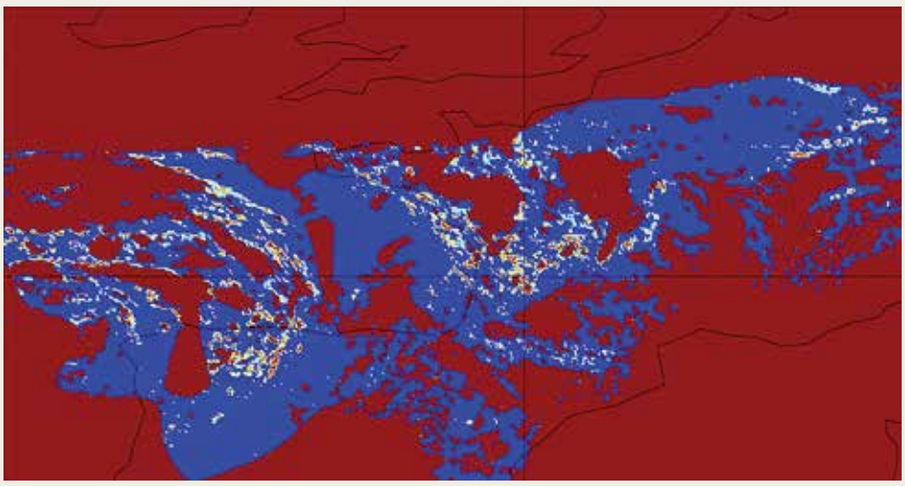
DEVELOPING AND ACQUIRING NEW PRODUCTS IN COOPERATION WITH MEMBER STATES AND INTERNATIONAL PARTNERS

Demonstrational nowcasting software estimating the probability of a thunderstorm developing within 30 minutes through the detection and tracking of convective cells in Meteosat imagery gained maturity.

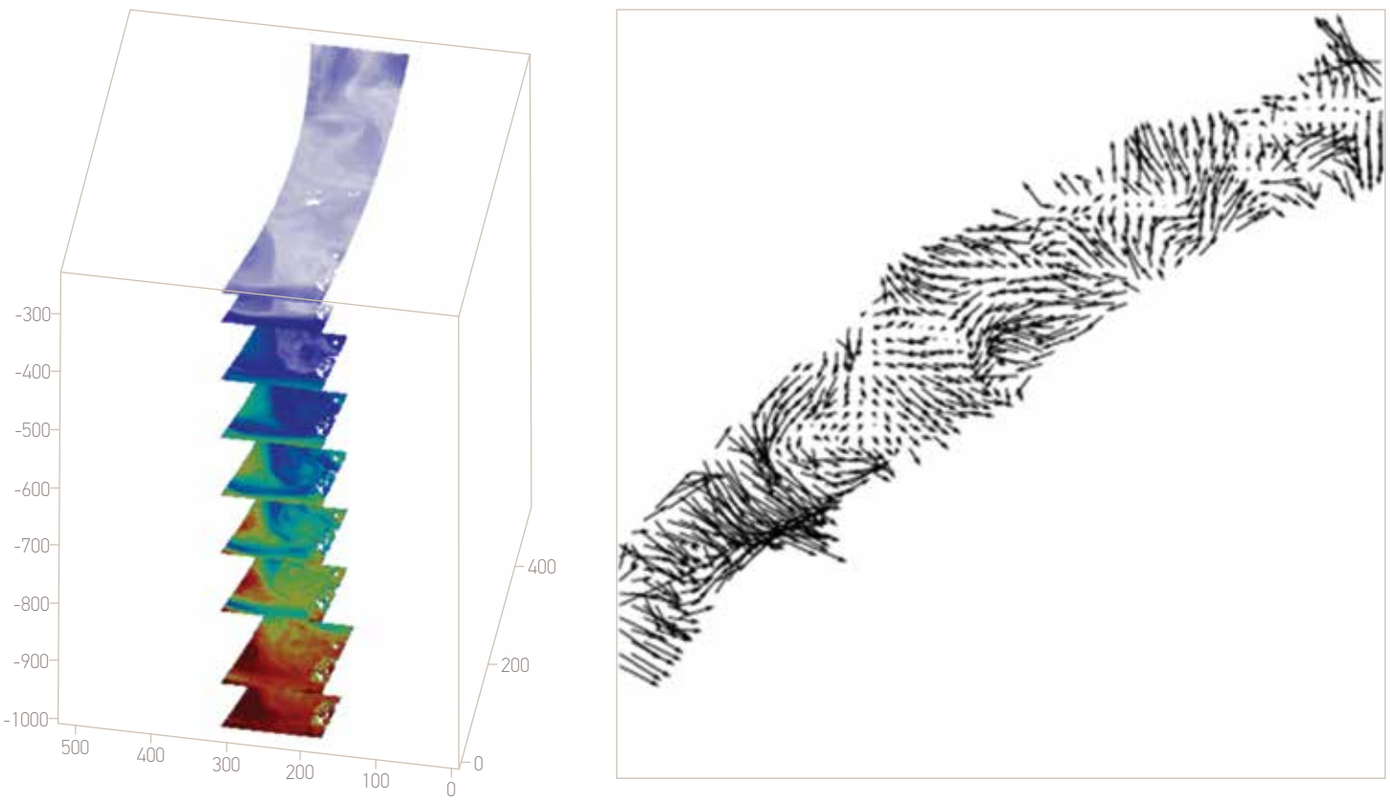
A new algorithm improved the retrieval of temperature and moisture vertical profiles from IASI infrared spectra, in particular when co-registered all-weather microwave soundings from AMSU/MHS instruments were missing for initialisation.

A first set of prototype three-dimensional wind fields was extracted by time correlation of three-dimensional fields of moisture and ozone retrieved from IASI infrared spectra over successive, overlapping swaths.

Both innovations pave the way for the processing of hyperspectral infrared spectra expected every 30 minutes over Europe from the IRS sounder on board the MTG-S satellites.



Probability index for the development of thunderstorms within 30 minutes derived from Meteosat imagery, ranging from 0 (blue) to 3 (red) and corresponding to 75% (source: NWC SAF)



Wind fields at different pressure levels (right) extracted by time-correlating successive three-dimensional ozone and moisture fields from IASI instruments (left)

DEVELOPING AND ACQUIRING NEW PRODUCTS IN COOPERATION WITH MEMBER STATES AND INTERNATIONAL PARTNERS

Atmospheric composition

Retrievals of column concentration of BrO from GOME-2 spectra and HNO_3 from IASI spectra were prototyped.

The validation of the near-real-time processor developed by ESA for extracting aerosol optical depth from Sentinel-3 SLSTR data started at the end of the year.

Ocean and sea ice

The use of a new transfer function relating C-band radar backscatter to wind vector that takes out incidence-angle dependent artefacts improved the spatial consistency of global and coastal ocean surface wind fields derived from ASCAT data.

The accuracy of Sentinel-3A altimeter significant wave height products improved for wave height lower than 1m.

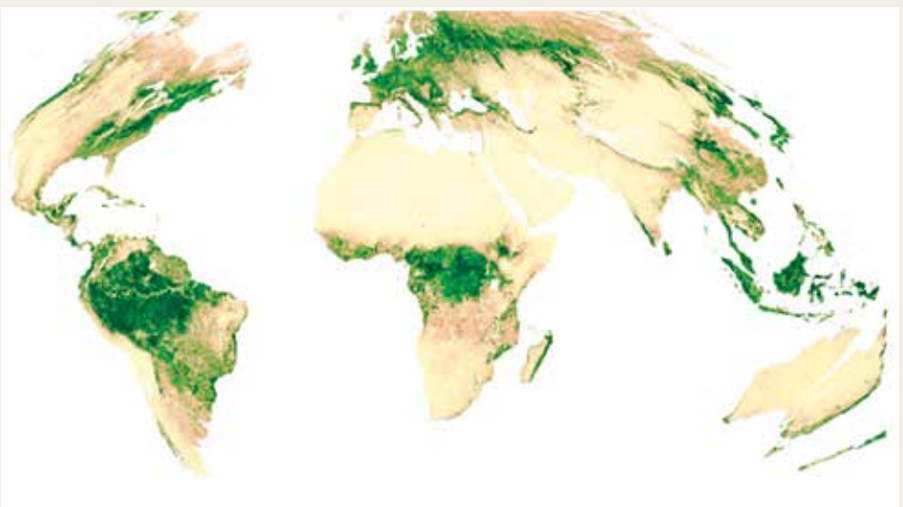
The frequency of medium resolution sea ice drift maps doubled from 12 to six hours.

Hydrology and land surfaces

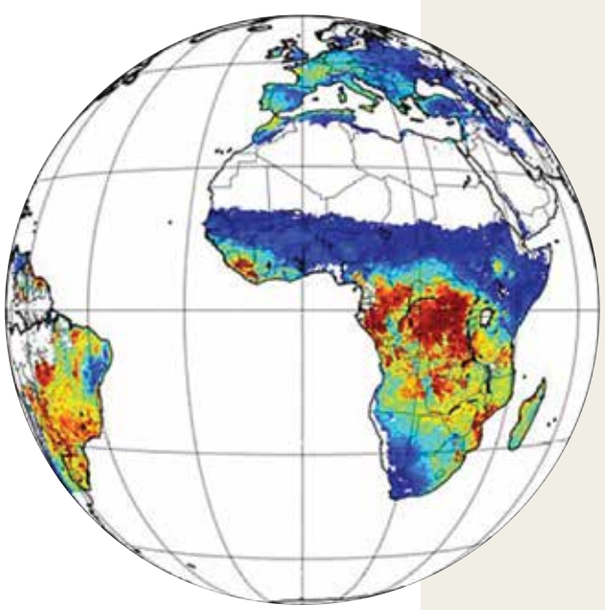
The processing of Metop AVHRR imagery produced a set of global, 10-day vegetation products (Fraction of Vegetation Cover, Leaf Area Index and Fraction of Absorbed Photosynthetically Active Radiation) on a 0.01° x 0.01° grid.

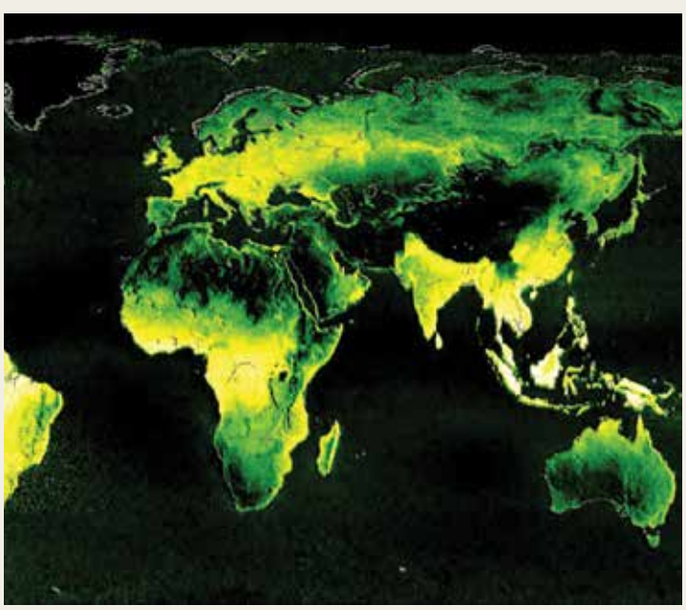
A Meteosat Gross Primary Production product, providing a quantitative measure of the carbon uptake of vegetation by photosynthesis and a GOME-2 sun-induced chlorophyll fluorescence product, estimating the light emitted from vegetation as a by-product of photosynthesis became available for use by Earth system models capable of simulating the carbon cycle.

10-day synthesis map of Leaf Area Index extracted from AVHRR imagery



Meteosat Gross Primary Production (left, for March 2017) and GOME-2 sun-induced fluorescence products (right, averaged over 2007-2016) address the carbon and energy cycles





New and improved products become available from international partners

The dissemination frequency of multispectral imagery from the Japanese Himawari-8 geostationary satellite increased from 30 to 10 minutes, and the similar but quarter-hourly GOES-East image data service improved with the addition of the 0.47µ channel.

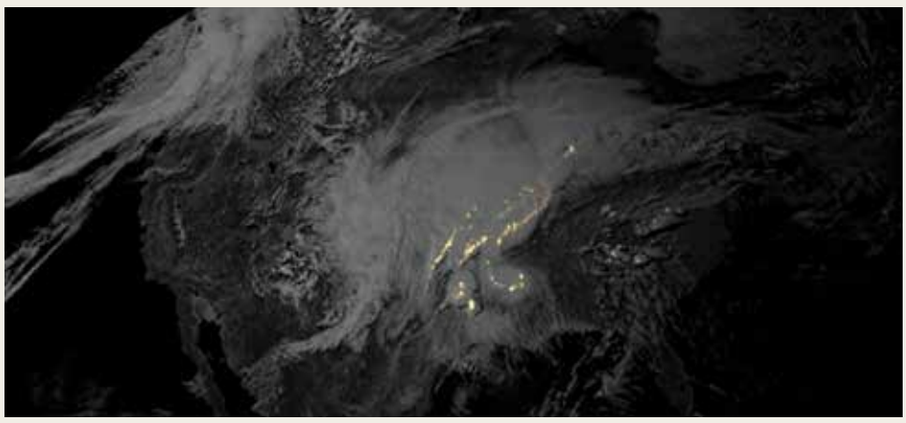
Redistribution of NOAA lightning products from the GOES-East Lightning Mapper started to prepare users for applications of similar products from the MTG-I Lightning Imager (LI).

The redistribution of NOAA particle products from GOES-16 became the first third-party space weather data service.

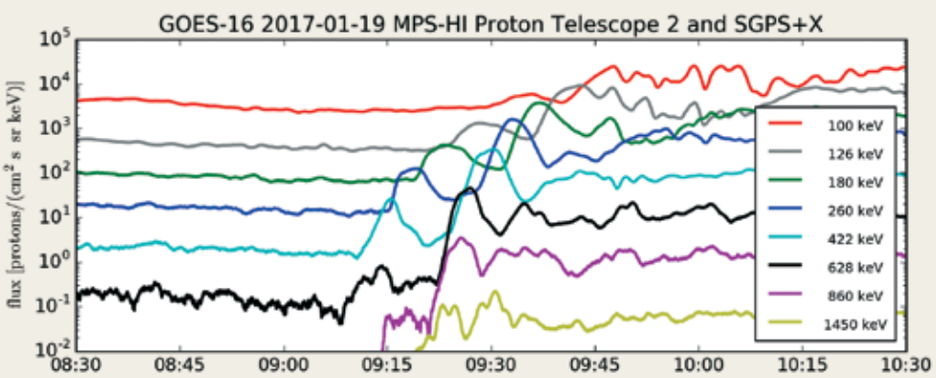
EUMETSAT started redistribution of real-time NOAA-20 microwave and infrared sounding products, as well as short wave infrared spectra from the Chinese TanSat CO_2 monitoring mission.

Cooperation with the Finnish Meteorological Institute (FMI) and the China State Oceanic Administration (CSOA) allowed for testing additional acquisition of global data from the Chinese HY2A ocean-monitoring satellite at the Sodankylä station, in order to improve the timeliness of the existing HY2A data service.

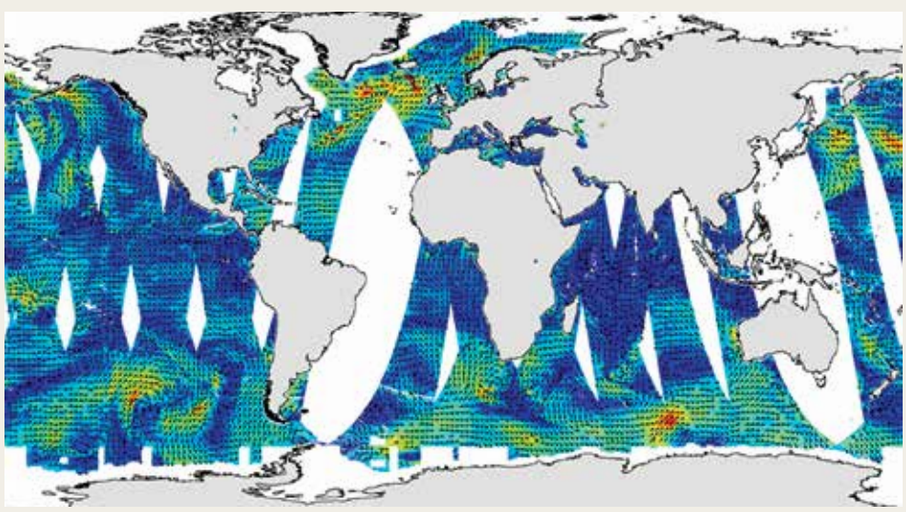
After the launch of ESA's Aeolus Earth Explorer satellite on 22 August, EUMETSAT accelerated preparations for a real-time redistribution service of vertical wind profiles expected to start after satellite commissioning.



Lightning products from the GLM instrument of GOES-16



High-energy particle flux products from GOES-16



Sea surface wind vector products from the scatterometer of HY-2

SUPPORTING AND EXPANDING THE USER BASE

EUMETSAT continuously invests in research fellowships, training, capacity building and sustained interactions with users to realise the full benefit of advanced satellite systems

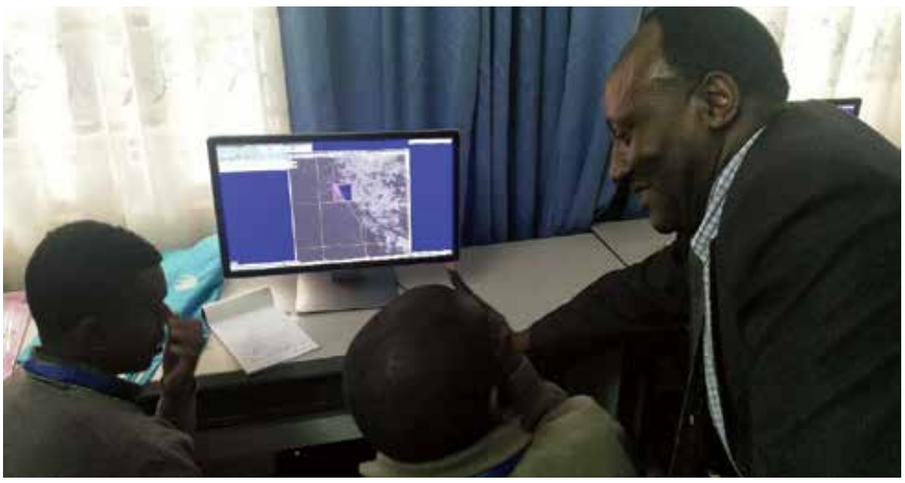
The aim of EUMETSAT's cooperative training programme is to expand the user base and the use of satellite products in a growing range of applications and research areas.

The programme involves experts in satellite products, applications and techniques for using satellite data networked across the European Meteorological Infrastructure, EUMETSAT's SAFs, the WMO Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) and its regional Centres of Excellence.

A new user training plan for the period 2019-2023

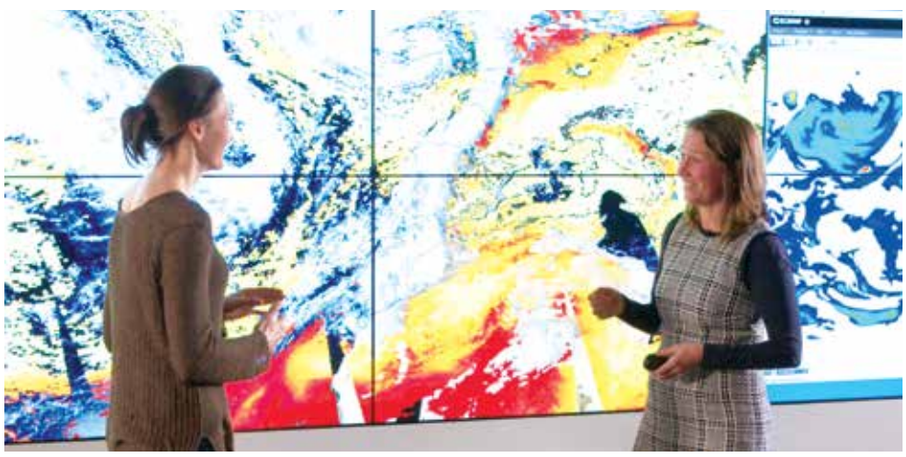
The 2019-2023 User Training Plan approved in 2018 implements the training strategy adopted in 2017.

The plan will prepare forecasters for new weather advisory roles and for the use of big data services and observations from next-generation satellites. It builds on synergies with the EUMETNET computer-assisted learning programme and the EUMeTrain programme, for training trainers and developers of MTG products.



Joseph Kagenyi, from the Kenya Meteorological Department, guides trainees on how to use satellite data in weather forecasting during an ASMET training course in Nairobi, Kenya

EUMETSAT supported the African Satellite Meteorology Training (ASMET) programme in the production of online training material for the combined use of satellite and NWP products for forecasting convection and fog.



Dr Melanie Ades (right), CAMS development scientist at ECMWF, presenting part of the Copernicus MOOC on atmospheric composition monitoring

Online and classroom training accessed by thousands of trainees

The annual training programme addressed the full spectrum of applications of satellite data, targeting the EUMETSAT and Copernicus user communities in Europe and worldwide.

More than 400 trainees from 65 countries attended EUMETSAT courses, and an additional 500 attended EUMeTrain courses supported by EUMETSAT.

Online and classroom courses were again combined to attract more participants, some as part of their on-the-job training based on real work cases. The number of case studies available in the online training library increased to 1,345 and 81,000 library pages were viewed.

Advertised by the scientific journal "Nature" and at a hackathon hosted by the FMI, the first Copernicus massive open online course (MOOC) on atmospheric composition monitoring, co-organised with the ECMWF, attracted more than 2,700 participants.

SUPPORTING AND EXPANDING THE USER BASE

Training and training coordination events

January/February

Copernicus training on marine data in ocean models and for operational applications using Copernicus and EUMETSAT marine data – *online phase*

Copernicus training on marine data in ocean models and for operational applications using Copernicus and EUMETSAT marine data, *Hamburg, Germany*

Training Workshop on Sand and Dust Storms in the Arab Region, *Cairo, Egypt*

"Baltic+" course on severe weather forecast applications for forecasters of the Baltic region – *online phase*

Integrated modelling workshop on EUMETSAT CMDS products, plus data from CMEMS and OSI-SAF, *Hamburg, Germany*

March

Using the Copernicus Marine Data Stream for Ocean Applications (Europe) – *online phase*

"Baltic+" course on severe weather forecast applications for forecasters of the Baltic region, *Riga, Latvia*

13th EUMETSAT Satellite Application Course (SAC-ME), *Muscat, Oman*

African Satellite Meteorology Education & Training (ASMET 11) meeting, *Casablanca, Morocco*

April

Using the Copernicus Marine Data Stream for Ocean Applications (Europe), *Riga, Latvia*

Operational Marine Surface Analysis using EUMETSAT's Copernicus Marine Data Stream (CMDS) – *online phase*

Nordic Meteorological Competency Training Course (NOMEK), *Helsinki, Finland*

The 6th Convection Working Group (CWG) meeting, *Ljubljana, Slovenia*

May/June

Workshop on the Use of Gridded Satellite Data for Climate Services, focusing on CM SAF data and tools, *Riga, Latvia*

South-Eastern European Meteorological Training Course (SEEMET) on basic satellite meteorology and severe weather forecast applications, *Primošten, Croatia*

Operational Marine Surface Analysis using EUMETSAT's Copernicus Marine Data Stream, *Lisbon, Portugal*

International Summer School on applications with the newest multi-spectral environmental satellites, *Bracciano, Italy*

July/August

Workshop on the Use of Gridded Satellite Data for Climate Services in Africa, focusing on CM SAF data and tools – *online phase*

Workshop on the Use of Gridded Satellite Data for Climate Services in Africa, focusing on CM SAF data and tools, *Pretoria, South Africa*

Identifying African Weather Systems and Features in Satellite Imagery Course (XVI E-SAC 2018) – *online facilitated course*

12th EUMETCal Workshop for trainers and training managers in NMHSs, *Riga, Latvia*

15th Ibero-American workshop on tropical satellite meteorology, *Cartagena, Colombia*

September/October

Copernicus marine forecasting workshop, using EUMETSAT's Copernicus marine data stream for surface analysis – *online phase*

6th Autumn School on the use of satellite data on nowcasting high impact weather, *Thessaloniki, Greece*

WMO/EUMETSAT Training Course on the Use of Satellite Data and Products for Drought Monitoring and Agro-meteorological Applications in RA II/RA VI, *Darmstadt, Germany*

November

Participation in the EUMeTrain Marine Event Week 2018 – *online*

Satellite Application Course for African Forecasters in English, *Nairobi, Kenya*

Workshop on climate change and conservation in the Caatinga area, *Maceió, Brazil*

International Remote Sensing School for Hydrological Applications, focusing on the use of H SAF soil moisture products for hydrological risk management, *Rome, Italy*

Copernicus and the Global Monitoring of Environment and Security (GMES) and Africa expert exchange workshop, *Darmstadt, Germany*

Satellite Application Course for African Forecasters in English, *Pretoria, South Africa*

Monitoring Atmospheric Composition, Copernicus massive open online course - *online*

December

Meteorological Simulator Build Workshop for WMO RA VI NMHS trainers, *Helsinki, Finland*

Satellite Application Course for African Forecasters in English, *Casablanca, Morocco*

Copernicus Marine Forecasting Workshop, using EUMETSAT's Copernicus Marine Data Stream for surface analysis, *Pretoria, South Africa*

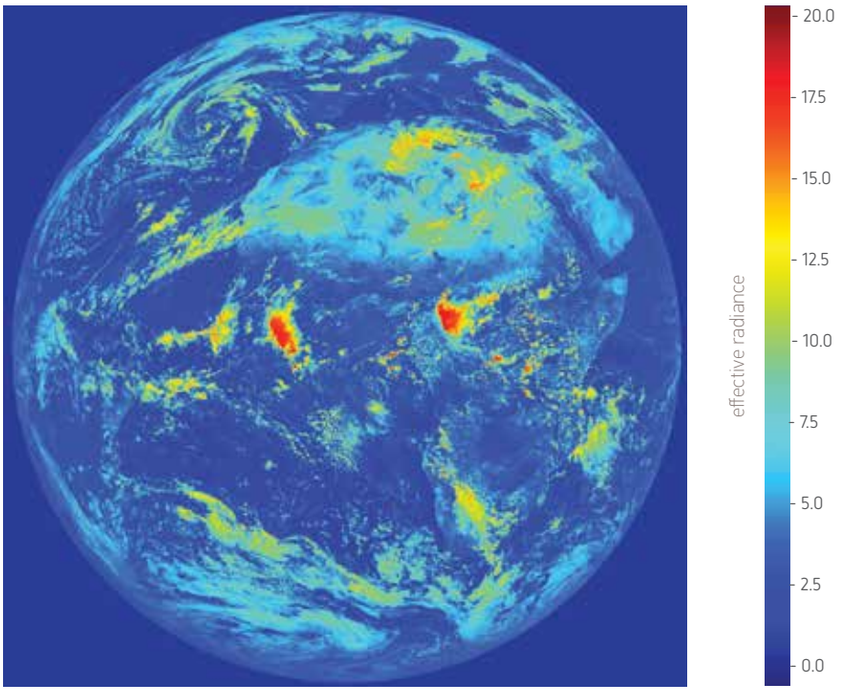
SUPPORTING AND EXPANDING THE USER BASE

Preparing Member States' NMHS for using MTG

The MTG User Preparation project (MTGUP) established an online forum for moderated discussions across the users designated by Member States' NMHS on the use and applications of MTG products and on their user preparation projects.

A first set of simulated MTG imagery products was delivered for familiarisation with formats and product sizes, and users were encouraged to use precursor GOES-16, Himawari-8 and FY-4A products.

At the request of the MTGUP Advisory Group, EUMETSAT prepared an information package addressing the areas where MTG products will have the highest impact, illustrated by use cases to help weather services build their business case for investment in the necessary infrastructure upgrades.



Simulated imagery product (radiance) from the 0.4 µ channel of the Flexible Combined Imager (FCI)

Research fellowships and visiting scientists

The EUMETSAT fellowship programme draws young, talented scientists into research on the use of satellite data, with the aim of consolidating the science base on the user side. It supports four fellowships at the ECMWF and six within EUMETSAT Member States.

Four research topics were selected for fellowship positions becoming vacant:

- Characterisation and reduction of uncertainties in all-sky microwave radiative transfer
- Four-dimensional consistency of satellite wind products for assimilation in regional NWP models
- Impact of MTG infrared sounding observations in a convection permitting model
- Assimilation of scaled projected states from radiances of advanced infrared sounders

A new call for research proposals was released in December, with a prescribed research area on "Preparation of innovative nowcasting applications using novel MTG capabilities".

In 2018, EUMETSAT hosted 24 visiting scientists from Australia, Belgium, Canada, China, Denmark, France, Italy, Slovenia, Sweden, the United Kingdom and the United States for presentations on Arctic prediction and climate analysis and cooperative scientific work.

Science work focused on the calibration and validation of instrument data using fiducial reference measurements and airborne campaigns, processing and validation of optical and microwave imagery and infrared soundings, retrieval of cloud properties and fire products, and the improvements of Sentinel-3 marine products.

"As a research fellow, I contribute to improving the quality of ECMWF forecasts and acquire essential knowledge and experience for my future career."

Peter Weston
EUMETSAT Fellow
ECMWF

SUPPORTING AND EXPANDING THE USER BASE

"2018 was quite challenging for our event management team, but the presence of VIPs in the middle of the night at the Metop-C launch event was rewarding."

Lorna Putze
Manager Communication and Events
EUMETSAT

Evolution of data and service policy

Following the "Oslo Declaration", the Council adopted a simplified, latency-driven Meteosat data and service policy offering full-resolution Meteosat imagery at 15-minute intervals free of charge three hours after sensing, hourly imagery without license and fast track user registration. For services available at cost, the policy will reduce the number of license types and data usage categories, based on two lower flat fees, one for service providers/broadcasters and one for end users.

User conferences

The 2018 EUMETSAT Meteorological Satellite Conference in Tallinn on 17-21 September, co-organised with the Estonian Environment Agency, attracted 399 participants from 39 countries.

Specific sessions addressed the multiple observational challenges of complex air-sea-ice and land-sea interactions within the Baltic and Arctic basins. Plans for cloud services were also discussed and illustrated by a demonstration of the EUMETSAT pathfinder big data services.

Taimar Ala, Director-General of the Estonian Environment Agency, during the opening of the 2018 EUMETSAT User Conference in Tallinn, Estonia

EUMETSAT, the American Meteorological Society and NOAA released the first announcement for their 2019 Joint Satellite Conference to be held in Boston.

The 2020 EUMETSAT User Conference will be co-organised with the DWD and held in Würzburg, Germany.

EUMETSAT hosted meetings of the Copernicus Sentinel-3 Science and Validation Team and the Group for High Resolution Sea Surface Temperature, each attracting more than 100 participants. EUMETSAT also supported the international Ocean Surface Topography Science Team conference in the Azores, organised by CNES.

Communication and outreach

The year 2018 was exceptionally demanding for external communication and outreach, with two launch events and a contemporary art exhibition held at EUMETSAT, in addition to regular events.

External communication continued to make extensive use of social media, with the number of followers of the EUMETSAT Twitter account increasing by 25% to reach 20,000 at the end of the year.

The live streaming of the Metop-C launch attracted over 4,000 views on Facebook, with Metop-C ranking first among the top five trending hashtags on Twitter in Germany, and the video on global weather in 2017 attracting more than 16,400 views on YouTube.

SUPPORTING AND EXPANDING THE USER BASE

EUMETSAT promotes contemporary art and satellites for African development

From 22 March to 6 May, EUMETSAT hosted the African contemporary art exhibition "Lumières d'Afrique" on the theme climate change, access to energy and African development, commissioned by the African Artists for Development endowment fund for the 21st Conference of the Parties to the UN Framework Convention on Climate Change. The inauguration took place in the presence of the WMO Secretary General as a World Meteorological Day event, and gave the opportunity to 11 out of the 54 artists to discuss their works of art. The exhibition attracted more than 1,000 visitors from the local and international community of the Darmstadt and Frankfurt areas, and motivated a number of EUMETSAT staff who gave multilingual presentations of the artworks and guided tours of the headquarters.

Following on from this occasion, EUMETSAT, African Artists for Development and Arianespace announced their plan to select a new African artwork for the launch of MTG-I1, considered an asset for the development of Africa in the decades to come. The winning work of art will feature on the fairing of the Ariane-5 launcher.

Burundian artist, Teddy Mazina, presenting his artwork entitled "Résistance Romantique" at the opening of the Lumières d'Afrique art exhibition in EUMETSAT headquarters, Darmstadt, 22 March 2018

The Metop-C launch event attracts VIPs to Darmstadt in the middle of the night

At EUMETSAT headquarters, 250 guests witnessed the Metop-C launch in the middle of the night, including the ESA Director-General and Director of Earth Observation, the ECMWF Director-General, the Arianespace Chief Executive Officer, the Airbus Vice President for Space, the NASA Director for Earth Sciences, the CNES Associate Director for Earth Observation and the Japan Aerospace Exploration Agency (JAXA) representative in Europe. NOAA's Assistant Administrator for NESDIS, Steve Volz, also gave a much-appreciated speech via video.

Dr Florence Rabier, ECMWF Director-General speaking at the Metop-C launch in EUMETSAT headquarters, Darmstadt, Germany, 7 November 2018

EUMETSAT also co-organised the Sentinel-3B launch event with ESA and the European Commission. Taking place in Berlin, the event coincided with the opening day of the Innovation and Leadership in Aerospace (ILA) air show.

Finally, EUMETSAT co-organised the first Copernicus hackathon on atmospheric monitoring in Helsinki with CAMS, the FMI and the University of Helsinki. The winning project combined air pollution data with information on the health of urban vegetation to support informed decisions about where to live in a city.

EUMETSAT had booths at the European Space Policy Conference in Brussels and at the Meteorological Technology Expo in Amsterdam to promote its data services.

SUPPORTING AND EXPANDING THE USER BASE

Local Life

Tours of EUMETSAT headquarters, organised in partnership with Darmstadt Marketing, attracted 2,489 visitors which compares well with 2017, considering three months of interruption to visits during the refurbishment of dedicated facilities.

The €3,690 raised at the 2018 Christmas Party was donated to Freiwilligenzentrum Darmstadt, a local association helping refugees and voluntary workers to find jobs.

A local media event on space and research and the inauguration of the new Geostationary Mission Control Centre, in the presence of the Council Chairman, the Head of the German Delegation and German officials, gave EUMETSAT the opportunity to communicate via national and regional media on its business and value to society.

Karim Haggouchi, Chairman of the Staff Association Committee and Alain Ratier, Director-General, present a cheque to the association "Freiwilligenzentrum Darmstadt"

SUPPORT TO CAPACITY BUILDING INITIATIVES

EUMETSAT supports capacity building initiatives in the neighbourhood of Europe and in Africa, the best observed continent by Meteosat

EUMETSAT provides data access and user training in the neighbourhood of Europe

Support to the NMHS of countries in the neighbourhood of Europe focused on the removal of obsolescence from the EUMETCast data acquisition stations deployed in Western Balkans, Eastern European, Caucasian and Central Asian countries, in partnership with the NMHS of Croatia and Turkey.

EUMETSAT supported the third annual South-Eastern European Meteorological Training Course (SEEMET) held in Primošten, Croatia.

The EUMETSAT Information Days planned for Skopje, Republic of North Macedonia, and Nur-Sultan, Kazakhstan, in 2019, will review data access, user training and the development of operational applications of EUMETSAT data.

The Abidjan Declaration and the 13th EUMETSAT User Forum in Africa boost the transition to MTG

The 13th EUMETSAT User Forum in Africa, hosted by the NMHS of Côte d'Ivoire in Abidjan, attracted more than 170 participants from 50 African countries on 24-28 September.

The forum opened just after the signing of the Abidjan Declaration on the next generation of satellite products for weather and climate services in Africa by African ministers, the African Union Commissioner for Rural Economy and Agriculture and representatives from five African Regional Economic Communities.

The 13th EUMETSAT User Forum took place in Abidjan, Africa, in a workshop atmosphere

The declaration encourages the strengthening of African capacities to access and exploit MTG data and to design an "African Meteorological Satellite Application Facility" with the WMO and EUMETSAT, for tailored local productions that will fulfil Africa-specific user needs.

It serves as a reference for mobilising funds from the European Commission and other sponsors to support the transition of Africa to MTG.

Following the priorities of the declaration, the forum focused on climate change resilience and disaster risk reduction and the transition of African users to MTG, based on a roadmap proposed by EUMETSAT to address user priorities established by the RAI Dissemination Expert Group (RAIDEG), and reviewed the status of EU-funded capacity-building initiatives.

The Minister of Environment for Cape Verde, representing the African Ministerial Conference on Meteorology, the African Union Commissioner for Rural Economy and Agriculture, the Minister of Transport for Côte d'Ivoire and representatives from five African Regional Economic Communities sign the Abidjan Declaration, in the presence of the WMO, the EU and EUMETSAT officials

EU-funded capacity building projects bring the benefits of EUMETSAT and Copernicus data to Africa

Developing an African numerical weather prediction capacity using direct broadcast data from polar-orbiting satellites

EUMETSAT continued to support the ACMAD-led continental sub-project of the Satellite and Weather Information for Disaster Resilience in Africa (SAWIDRA) project funded by the intra-ACP Disaster Resilience Programme and managed by the African Development Bank. The sub-project develops an African NWP capacity, supported by a network of four X/L band stations enabling the acquisition and real-time processing of data broadcast by polar-orbiting satellites and the delivery of products to African models.

EUMETSAT produced technical specifications for the procurement of ground stations to be deployed in Gabon, Kenya, Niger and South Africa and for the communication links needed to collect real-time products from all stations and to deliver the full set to users through the Pretoria hub of the WMO global telecommunication system.

Dr Mahama Ouedraogo, African Union Commission Director of Human Resources, Science and Technology, and Philippe Brunet, European Commission Director for Space Policy, Copernicus and Defence, signing the cooperation arrangement in the area of Copernicus data access and the use of Sentinel data

Bringing the benefits of Copernicus to Africa

EUMETSAT and the African Union Commission (AUC) signed a memorandum of understanding on cooperation on Earth observation, and an implementation arrangement covering EUMETSAT's support on the EU-funded GMES and Africa project.

Building on the 180 EUMETCast-Africa data access stations deployed and the 2,250 persons trained during the previous MESA (Monitoring of Environment and Security in Africa) project, the GMES and Africa project targets the development of marine and coastal resources and water and natural resources services using Copernicus data.

EUMETSAT presented its portfolio of Copernicus products and data access services at a first GMES and Africa workshop held by the European and African Union commissions in Accra, Ghana, to assess the needs of the 13 African consortia responsible for the sub-regional implementation of the targeted services.

EUMETSAT then supported the GMES and Africa project teams in the planning of data access, procurement of new EUMETCast stations and maintenance for existing ones, and user training.

Finally, in application of the "Copernicus Data Access Agreement" signed by the European and African commissions, EUMETCast-Africa started to broadcast Sentinel-3 land products available from ESA, in addition to marine products already disseminated, and hosted a workshop on user training with the four GMES and Africa marine consortia.

EUMETSAT added new products to its EUMETCast-Africa broadcast programme, including maps of the extension of surface waters in Western Africa produced by the EU Joint Research Centre.

The cooperation agreement with ASECNA, the African agency for air navigation safety, was renewed for a five-year period.

DEPLOYMENT OF RECURRENT SATELLITES

The successful launch of Metop-C and the promising start of its in-orbit validation concluded a complex launch campaign impacted by external risks

After full testing, the Metop-C satellite becomes flight-ready

Testing of the Metop-C satellite started with intermediate models of the MHS and GOME-2 instruments, and concluded after reintegration of the repaired and recalibrated flight models.

The dismounting of the two S-band transponders used for commanding the satellite proved necessary to correct an anomaly traced to an unsoldered wire.

Another anomaly affected one of the four focal plane assemblies of the GOME-2 instrument, producing regular spikes in part of the measured spectrum. In view of the low impact - a 4% loss of accuracy on measurements of NO2 concentration - and the disproportionate risk of an attempt to repair, ESA and EUMETSAT decided to fly the instrument "as is", and the EUMETSAT on-ground processing software was updated to support the in-orbit assessment and mitigation of the anomaly.

After reintegration of both S-band transponders, ESA accepted the satellite for flight on 18 May, and a last system validation test confirmed its full compatibility with the ground segment.

EUMETSAT systems and teams get ready for the launch campaign

In the meantime, the EUMETSAT system integration, verification and validation test campaign had progressed apace with the satellite testing and concluded on 9 April.

EUMETSAT confirmed its readiness for launch on 25 May and gave ESA consent to ship the satellite to Kourou for launch on the then manifested date of 21 September.

Unfavourable weather conditions postpone the launch

The very low probability of launch-compatible weather in September forced Arianespace and EUMETSAT to negotiate the postponement of the launch to a more favourable period.

Despite uncertainties about the launch date, ESA and EUMETSAT started the launch campaign on 14 June and shipped all flight hardware and ground support equipment to Kourou.

The postponement of the launch date to 6 November imposed a pause in the launch campaign from 17 August to 12 September with "babysitting" of the satellite.

The Director-General visits teams from ESA, EUMETSAT and industry in Kourou during satellite babysitting

DEPLOYMENT OF RECURRENT SATELLITES

A complex launch campaign ends with a flawless launch

Preparations for launch and operations continued at EUMETSAT in parallel to the launch campaign, achieving launch readiness of the EPS ground segment in August and concluding rehearsals of all commissioning and operations scenarios on 18 October.

The fuelling of the satellite was authorised on 5 October, after the Soyuz-ST launcher passed the Flight Readiness Review, but, unfortunately, the failure of a Soyuz-FG rocket on 11 October raised doubts about the flight worthiness of the launcher assigned to Metop-C.

The start of combined operations involving the satellite and the launcher upper stage could only be authorised on 19 October, based on preliminary enquiry results and with the assurance that Metop-C could move back to storage, if necessary. The decision to proceed beyond the point of no return came on 26 October, after formal confirmation of the root cause of the Soyuz-FG failure and the return to flight of Soyuz on 25 October.

The Metop-C satellite was flawlessly launched on 7 November, at 01:47 CET.

ESOC took control of the satellite after its separation from the launcher, acquired its first signal and performed all early flight operations, including deployment of the solar array and all antennas and activation, configuration and verification of all on-board systems required for satellite commissioning.

A fast, promising start to satellite in-orbit validation

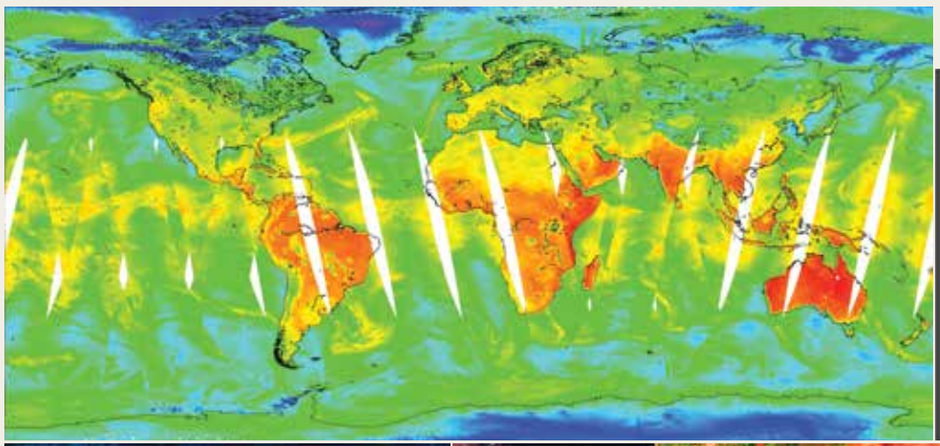
After EUMETSAT took over flight operations on 10 November, satellite in-orbit validation tests involving ESA's European Space Research and Technology Centre (ESTEC), CNES, NOAA and industry started. All instruments were switched on while the satellite was drifting towards its commissioning position, which it reached on 19 November after drift stop and altitude-raising manoeuvres.

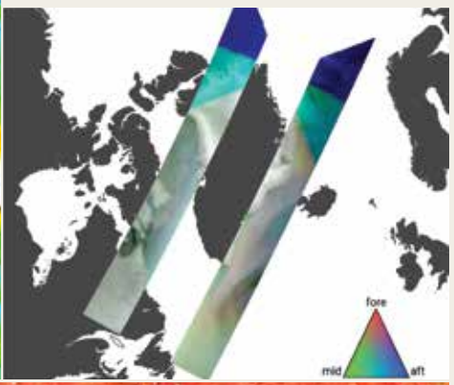
The first observations from all instruments were acquired from mid-November to mid-December. On 19 December, the acquisition of the first solar spectrum measured by GOME-2 was a relief, as the spectral spike anomaly observed on ground was not present.

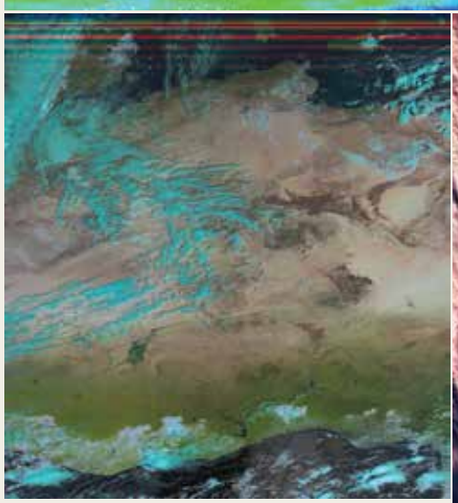
The flow of GRAS, AVHRR, MHS and AMSU level 1 products was opened to calibration validation experts before Christmas, and the only area of concern at the end of the year was the higher than expected noise from two MHS channels.

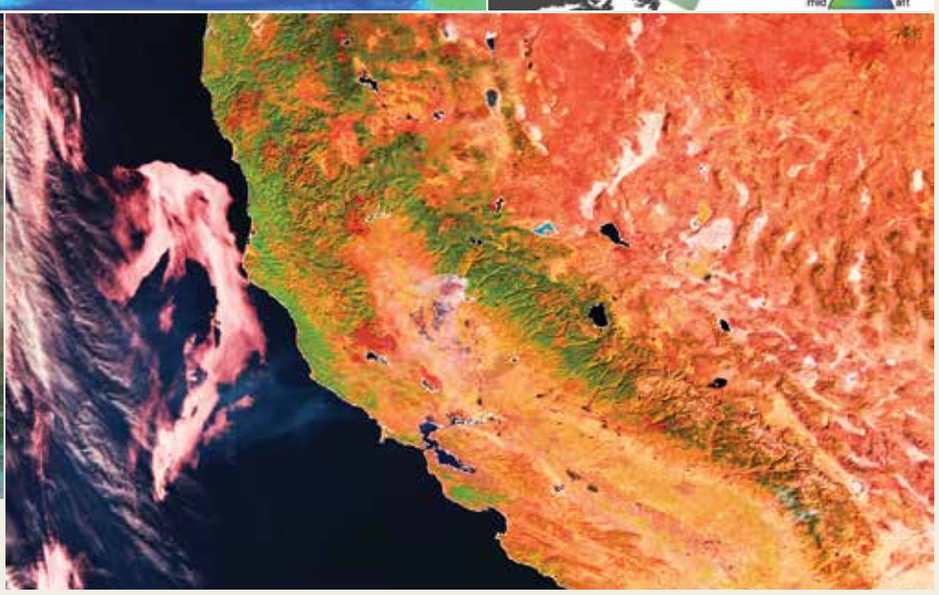
Manfred Lugert (right), EPS Programme Manager and Lorenzo Lattanzi (left), EPS Quality Assurance Manager after the successful launch of Metop-C in Kourou, French Guiana

DEPLOYMENT OF RECURRENT SATELLITES

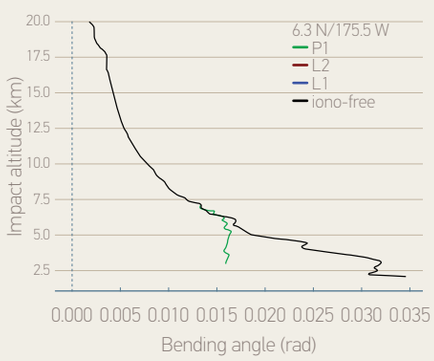




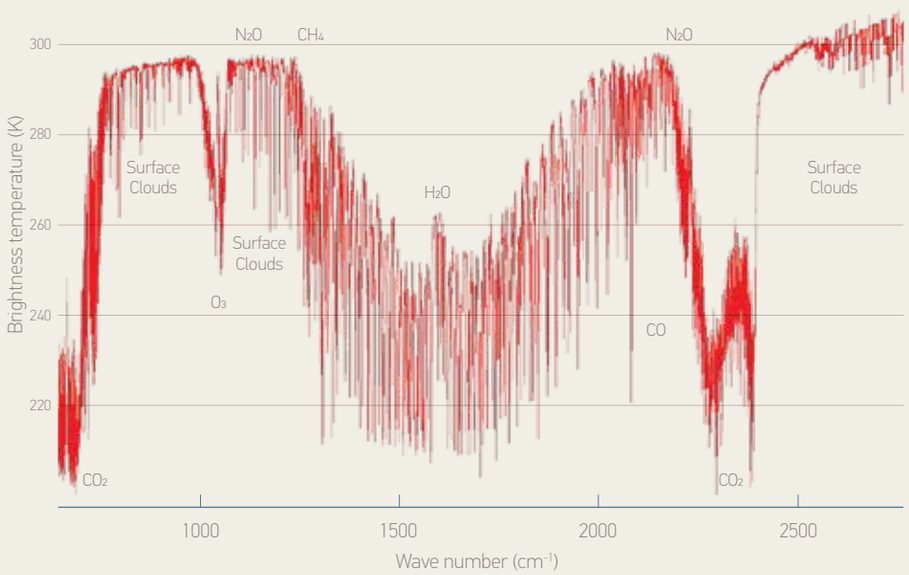




First Tropical GRAS/Metop-C Occultation



First IASI/Metop-C spectrum (12 December 2018)



A selection of some of the first Metop-C data

EUMETSAT selects the six-month launch period for the MTG-I1 satellite and starts system and ground segment integration

The massively improved and new observations expected from the MTG system will revolutionise nowcasting and very short-range forecasting of high-impact weather over Europe and Africa in the next decade.

MTG, the most complex and innovative meteorological geostationary system ever built, comprises two separate lines of satellites exploited simultaneously. The MTG-I (imaging) line will improve the current Meteosat multispectral imagery mission and add a new lightning imaging capability. The MTG-S (sounding) line will establish a hyperspectral infrared sounding capability providing vertical profiles of temperature and moisture every 30 minutes over Europe. On board MTG-S, the synergy between the EUMETSAT Infrared Sounder and the Copernicus Sentinel-4 Ultraviolet, Visible and Near-Infrared Sounder will provide a unique, integrated capability to monitor the fast evolution of ozone, carbon monoxide, sulphur dioxide and other gases in support of air quality forecasting and climate monitoring.

The critical design phase of the MTG-I satellite nears completion

The detailed design phase of the MTG-I satellite passed a major milestone in December, with the validation of the Flexible Combined Imager (FCI) design by an ESA formal review showing high compliance with performance requirements. ESA initiated the same formal review for the Lightning Imager (LI) in November.

The results of both reviews, together with confirmation of compatibility of the satellite with Ariane-5, will feed into the decisive Critical Design Review of the full satellite planned for spring 2019.

The detailed design phase of the MTG-S satellite also progressed towards the Critical Design Review planned for 2020, with the validation of the Copernicus Sentinel-4 UVN instrument design and the maturation of the critical subsystems of the IRS infrared sounder.

As the integration of flight hardware advances, EUMETSAT selects the six-month launch period for MTG-I1

The production and testing of the first flight model of the FCI progressed substantially, despite the need to replace the accidentally damaged primary structure of the telescope optical bench and to adjust its mechanical design in order to make the excellent wave-front error performances more resilient to vibrations.

Likewise, tests qualified the thermal design of the LI and the redesign of its optical bench structure, while parallel qualification of two detector design options increased confidence in the fulfilment of quantum efficiency requirements.

The structural and thermal models of both instruments and the platform are ready for integration into a satellite structural and thermal model for mechanical testing in early 2019.

Structural and thermal models of the LI (left) and FCI (right) of MTG-I (source: Thales Alenia Space, OHB, ESA)

DEVELOPMENT OF THE METEOSAT THIRD GENERATION SYSTEM

Functional tests started on the first flight model of the platform shared by both types of MTG satellites prior to its integration with the engineering models of the FCI and LI instruments to form a hybrid model of the full MTG-I1 satellite.

After reassessment of schedule risks with ESA and industry, EUMETSAT notified Arianespace of its decision to select the period 1 October 2021 - 31 March 2022 as the six-month window for the launch of the MTG-I1 satellite.

ESA and EUMETSAT prepare for the second system validation test

ESA and EUMETSAT agreed the scope of the second system validation test (SVT-I1-V1) coupling the satellite hybrid proto-flight model with the mission control chains deployed by EUMETSAT and the provider of the launch and early operations phase (LEOP) service.

EUMETSAT integrated the new versions of the satellite simulator and the mission control software needed to prepare this test into its multi-mission infrastructure, and declared the LEOP mission control chain ready for the test.

EUMETSAT prepares for testing processing chains

After the infrastructure hosting all instrument data processing chains passed endurance tests, the formal review of the detailed design of the MTG-I image data processing facility (IDPF-I) authorised the production of a second version of the facility, containing the FCI geometric processing chain.

EUMETSAT completed the development of simulated instrument data and reference processors capable of generating test datasets for the validation of the IDPF-I operational processors.

The formal review of the detailed design of the level 2 processing facility for the MTG-I mission (L2PF-I) authorised the production of the first version of the facility, which passed factory acceptance tests on 21 December.

The preliminary design of the image data processing facility for the MTG-S mission (IDPF-S) started in the summer with a first IRS algorithm workshop and planning of design work for the Sentinel-4/UVN level 1 processor.

The price conversion process foreseen by the L2PF contract for the addition of MTG-S level 2 processing chains started in November with the release of a change request to the contractor, based on new EUMETSAT algorithm specifications tailoring the heritage from IASI processing to IRS.

EUMETSAT consolidates the ground segment detailed design and starts system integration and testing

Paving the way for the System Critical Design Review planned for the end of 2019, an intermediate review validated the MTG-I technical budgets, the high-level plan for the MTG-I system and ground segment integration, verification and validation (IV&V) and the approach for the completion of the MTG system development to include MTG-S.

The review confirmed that predicted system performances meet the observed evolution of user requirements, triggering the formal update of the End-User Requirements document.

After acceptance on 28 June, the two telemetry, tracking and control (TT&C) ground stations deployed in Fucino, Italy, and Cheia, Romania, became ready for integration into the system.

Thus, version V0.4 of the MTG-I-dedicated system composed of all four ground stations, a first version of the mission control centre, the instrument data processing infrastructure and data dissemination and archiving systems could be integrated and used for testing data circulation across the system.

A workshop kicked off the cycle of MTG System Integration Readiness reviews for the SAFs developing MTG products.

An MTG telemetry tracking and control ground station and its shelter in Cheia, Romania

DEVELOPMENT OF THE EUMETSAT POLAR SYSTEM - SECOND GENERATION

The detailed design of the Metop-SGA satellite is validated, after a complex replanning exercise

EPS-SG is Europe's contribution to the future Joint Polar System shared with NOAA.

The EPS-SG system is composed of a pair of satellites, Metop-SGA and B, equipped with complementary instruments and flying simultaneously on the same mid-morning polar orbit as the current Metop satellites, and a comprehensive ground segment.

Metop-SGA is an atmospheric sounding and imaging satellite, equipped with a suite of infrared and microwave instruments for sounding temperature, moisture and trace gases in the atmosphere (IASI-NG, MWS), complemented by the Copernicus Sentinel-5 sounder and two advanced imagers, METimage and the 3MI polarimeter.

Metop-SGB is an all-weather microwave-imaging mission focusing on radar observations (SCA) of ocean-surface wind and soil moisture, and microwave imagery of precipitation (MWI) and ice clouds (ICI).

Both satellites are equipped with a GNSS radio occultation instrument for limb sounding of temperature and humidity at high vertical resolution.

Metop-SG A satellite

	Instrument/Mission	Predecessor on Metop	Applications Benefitting
1	IASI-NG *Infrared Atmospheric Sounding (IAS)*	*IASI*	
2	MWS *Microwave Sounding (MWS)*	*AMSU-A, MHS, AVHRR*	
3	METIMAGE *Visible-Infrared Imaging (VII)*		
4	RO *Radio Occultation (RO)*	*GRAS*	
5	SENTINEL-5 *(Copernicus)* *UV/VIS/NIR/SWIR Sounding (UVNS)*	*GOME-2*	
6	3MI *Multi-viewing, -channel, -polarisation Imaging (3MI)*		

Metop-SG B satellite

	Instrument/Mission	Predecessor on Metop	Applications Benefitting
1	SCA *Scatterometer*	*ASCAT*	
2	RO#2 *Radio Occultation (RO)*	*GRAS*	
3	MWI *Microwave Imaging for Precipitation (MWI)*		
4	ICI *Ice Cloud Imager (ICI)*		
5	ARGOS-4 *Advanced Data Collection System (ADCS)*	*A-DCS*	

Atmospheric Chemistry · Climate Monitoring · Hydrology · Land

Nowcasting (NWC) at high latitudes · Numerical Weather Prediction · Oceanography

DEVELOPMENT OF THE EUMETSAT POLAR SYSTEM - SECOND GENERATION

The development of the Metop-SGA satellite needs replanning, with knock-on effects for the development of the EPS-SG system

ESA, EUMETSAT and industry had to replan the development of the Metop-SGA satellite to postpone the integration of the late METimage, IASI-NG and Sentinel-5 instruments.

Despite the introduction of intermediate instrument models usable for early satellite integration, the launch slipped from September 2021 to November 2022.

This forced EUMETSAT to start resynchronising the development of the EPS-SG ground segment that largely depends on mature information from the detailed design of the late instruments.

Thus, EUMETSAT had to postpone the delivery of instrument data processing specifications to the contractor developing the payload data acquisition and processing (PDAP) chain by one year, and to revise the development logic of that chain to introduce an additional preliminary version for ground segment pre-integration purposes.

The EUMETSAT teams will validate the detailed design of the full EPS-SG system in two steps, starting in 2019 with the mission control and operations chain and concluding one year later with the data processing chain and the rest of the system.

ESA validates the detailed design of the Metop-SGA satellite

ESA validated the detailed design of the Metop-SGA satellite and the instruments procured under the same contract, taking into account an assessment of the satellite interfaces with the METimage, IASI-NG and Sentinel-5 instruments, plus the demonstrated compatibility with the Soyuz launcher.

The detailed design of the METimage and IASI-NG instruments developed by the German Aerospace Centre (DLR) and CNES progressed for all subsystems, retiring two major development risks.

A six-meter high structure for the satellite model of Metop Second Generation ahead of extensive testing at Airbus in Toulouse (source: RUAG Space)

DLR adopted a dual-cooler configuration for the METimage focal plane to obtain the required radiometric performances from infrared detectors operating at lower temperature, while CNES completed the challenging qualification of the potassium bromide (KBr) optical material of the IASI-NG interferometer, which secures radiometric performances above specifications in the mission-critical CO_2 absorption band (8.7 - 15.5µ).

The progressive integration of the electrical and functional models of the instruments and platform enabled the start of electrical and functional tests for the Metop-SGA satellite in parallel to the manufacturing of structural and thermal models.

The detailed design of the EPS-SG ground segment is nearing completion

The development of the EPS-SG ground segment passed major milestones, with the validation of the detailed design of the mission control chain, and the acceptance of the second version of its satellite monitoring and control software for use in the first system validation test campaign with the Metop-SG A satellite.

DEVELOPMENT OF THE EUMETSAT POLAR SYSTEM - SECOND GENERATION

Building on the first ground segment deliveries, EUMETSAT prepares for system integration and testing with the Metop-SGA satellite

Conclusive performance tests validated the detailed design of the processing infrastructure of the payload data acquisition and processing (PDAP) chain in December.

The IASI-NG instrument processor entered its detailed design phase, and the development of the Sentinel-5 level 2 processor started, both for integration into the PDAP processing infrastructure.

EUMETSAT validated the detailed design of all required upgrades to multi-mission infrastructure and concluded the requirements reviews for the six SAFs developing EPS-SG products.

The detailed design of the ground segment elements shared with the NOAA JPSS system progressed towards a decisive key point scheduled for 2019.

The Svalbard and Azores sites are ready for the deployment of ground stations

The S-band telemetry, tracking and command ground station and the Ka-band and X-band data acquisition stations started factory acceptance tests at the end of the year, while the Svalbard and Azores sites were achieving readiness for hosting them, after completion of civil construction work.

Ka-band mission data acquisition antenna (left) and S-band telemetry tracking and control antenna (right) under factory acceptance testing before shipment to Svalbard

EUMETSAT prepares for system integration and first system validation test with the Metop-SGA satellite

The assessment of the latest design information, including the predicted performances of the instruments, confirmed that the performances of end-to-end instrument chains comply with EPS-SG system requirements.

Two system checkpoints validated the approach for system and ground segment integration, verification and validation, and for the preparations of the first system validation test with the Metop-SGA satellite.

Hosting infrastructure for Ka-band antenna (top right) and S-band antenna (bottom right) and command and control shelter (left) at Svalbard

OPERATIONAL OCEANOGRAPHY IN THE CONTEXT OF COPERNICUS

With Jason-3 and two Sentinel-3 satellites in orbit after the launch of Sentinel-3B, the European backbone of the global ocean monitoring system is in place

Only satellites can provide global observations of the physical and biological state of the ocean and the atmospheric parameters that drive its variability. The ingestion of their measurements of sea state, sea surface height, temperature and wind, ocean colour, sea ice, incoming solar radiation and precipitation by predictive numerical models of the ocean, along with equally indispensable in-situ observations from ships, buoys and profiling floats (ARGO) has opened the era of operational oceanography.

EUMETSAT provides ocean observations from its own Meteosat and Metop satellites and shares dedicated missions with CNES, ESA, the European Union, NASA and NOAA.

Whilst exploiting the Jason-3 and Sentinel-3 Copernicus marine missions on behalf of the European Union, EUMETSAT is preparing for Jason-CS/ Sentinel-6 as the follow-up to Jason-3.

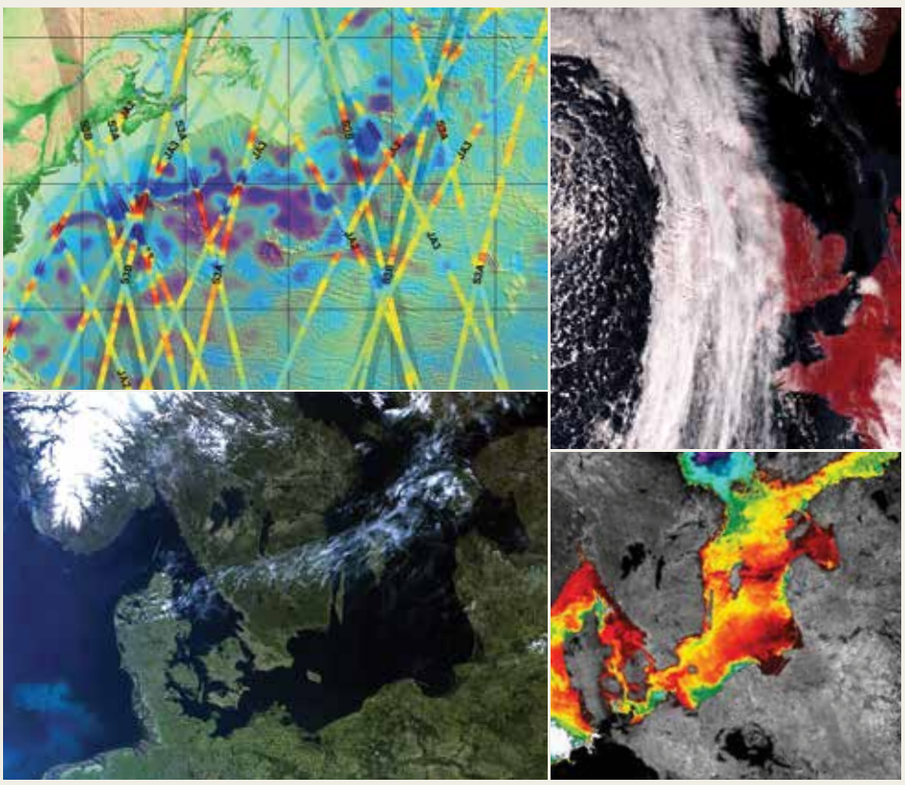
Flying on a non-synchronous orbit to avoid aliasing of sea level measurements by tidal signals, Jason-3 and Jason-CS/ Sentinel-6 provide the most accurate altimeter measurements of sea level that are used for cross-calibrating other altimeter missions.

The dual-satellite Sentinel-3 marine mission provides additional altimeter measurements and highly accurate observations of sea surface temperature and ocean colour.

EUMETSAT takes over Sentinel-3B flight operations and releases level 1 products

After successful operations validation tests, ESA and EUMETSAT confirmed on 23 March their readiness for the launch of the Sentinel-3B satellite.

After the launch on 25 April and the conclusion of the early operations phase by ESOC the next day, satellite in-orbit commissioning started, with flight operations performed by ESOC, while EUMETSAT was preparing to take over.



First products generated from Sentinel-3B data include SRAL/MWR (top left), SLSTR visible (top right) and infrared (bottom right), and OLCI (bottom left)

EUMETSAT received the first X-band data on 1 May and contributed to the production of first images from the OLCI and SLSTR instruments and first data from the altimeter, all published between 7 May and 6 June.

ESOC then reduced the time separation with Sentinel-3A to 30 seconds (210km), reaching the tandem flight configuration agreed for cross calibration on 6 June, with EUMETSAT operating Sentinel-3A and ESOC operating Sentinel-3B.

The activation of all operational Sentinel-3B level 1 and 2 processors enabled the staggered release of products, which the Sentinel-3 Validation Team (S3VT) found to be of the same quality as Sentinel-3A products.

In the meantime, EUMETSAT had sent its first command to the satellite on 31 July, taking an increasing role in commanding in preparation for taking over flight operations.

A review co-chaired with ESA concluded the in-orbit commissioning phase on 17 October, triggering the start of the Sentinel-3B operations ramp-up phase during which the system will reach its full capacity.

OPERATIONAL OCEANOGRAPHY IN THE CONTEXT OF COPERNICUS

The ESA and EUMETSAT teams celebrate the handover of Sentinel-3B flight operations in Darmstadt

Sentinel-3B then started to drift away from Sentinel-3A towards its final orbital position for dual Sentinel-3 routine operations, 140 degrees ahead of Sentinel-3A.

EUMETSAT took over flight operations of Sentinel-3B on 28 November, after a drift stop manoeuvre performed by ESOC.

By mid-December, Sentinel-3B level 1 products and altimeter level 2 marine products had been released to users.

EUMETSAT and ESA plan for the deployment of Sentinel-3C

EUMETSAT signed a cooperation arrangement with ESA for the deployment of the Sentinel-3C and -3D satellites, and followed up the ESA procurement of both satellites to prepare for the first system validation test with the Sentinel-3C satellite.

The upgrades to the EUMETSAT ground segment that are necessary to remove obsolescence, increase operational robustness and capacity to support the launch of Sentinel-3C and operations of a three-satellite Sentinel-3 constellation started in December with a system requirements review.

EUMETSAT bridges the schedule and funding gaps of its Jason-CS development programme

ESA and industry optimised the Jason-CS satellite assembly, integration and test sequence to accommodate the late delivery of the altimeter and integrate the NASA-provided microwave radiometer and GNSS radio-occultation receiver.

Catching up with the satellite development, EUMETSAT validated the detailed design of the end-to-end system in December at a formal checkpoint involving the four programme partners in the review of processing specifications, mission performance budgets, plans for system integration and testing and operations preparation.

This achievement built on the fast progress in the detailed design of the ground segment, and on the production and testing of the first versions of its payload data acquisition and processing (PDAP) as well as mission operations and control (MOC) chains.

Using a EUMETSAT-provided processing infrastructure, industry completed factory acceptance tests of a first version of the PDAP chain, pre-integrated the NASA-provided microwave radiometer processor and started the development of the altimeter processors.

After integration with the satellite simulator, a first version of the in-house developed MOC chain was used with the satellite database to produce flight control procedures and prepare the first satellite system validation test (SSVT-1) with the satellite.

The success of this test, performed with ESA on 14-15 November, demonstrated that the EUMETSAT-led ground segment development had bridged its schedule gap with the satellite development.

System integration, verification and validation then started with NOAA, after confirmation of the suitability of its Fairbanks station and communication links with the EUMETSAT mission control centre.

Thus, the efforts across all programme partners maintained the target launch date of November 2020.

On 17 December, Spain became the 17th Participating State in the EUMETSAT Jason-CS optional programme, subscribing at the level needed to eliminate the financial shortfall of the programme.

EUMETSAT teams perform system validation tests involving the Jason-CS mission control software and the satellite test bench

EUMETSAT contributes to policy discussions on the implementation of the Space Strategy for Europe

EUMETSAT satellite systems are a vital space infrastructure for the safety of citizens

At the annual EU-US space dialogue hosted by the US State Department in Washington, NOAA and EUMETSAT highlighted the vital contribution of their shared Joint Polar System to the forecasts showing the development of the devastating Hurricane Irma and the release of timely warnings three days before landfall. On this occasion, the Director-General stressed the complementarity of meteorological and Copernicus satellites, the former being essential for preparedness and the latter for disaster management.

During a round table discussion on "security of space operations" at the annual European Space Policy Conference, the Director-General reiterated that the safety of citizens depended on the availability of EUMETSAT satellites and that space situational awareness services were increasingly important to protect this vital space infrastructure, as large constellations are being deployed. He advocated for more European investment in a space surveillance and tracking capacity.

From Baveno to Copernicus 2.0, EUMETSAT's commitment to Copernicus goes from strength to strength

EUMETSAT participated in the 20th anniversary celebrations of the foundational Baveno Manifesto as one of the signatories. The Director-General used this occasion to recall how, in 1998, Europe was developing the second generation of Meteosat and the EUMETSAT Polar System to become the world leader in meteorology, and was only dreaming of being the operational leader in other areas of Earth observation. In 2009, the ratified Lisbon Treaty created the framework for the dream to come true 10 years later with Copernicus. Although Europe can be legitimately proud of this achievement, it should invest more in innovative Earth observation instrument technology, as do China and the United States, to remain in the lead and realise new ambitions.

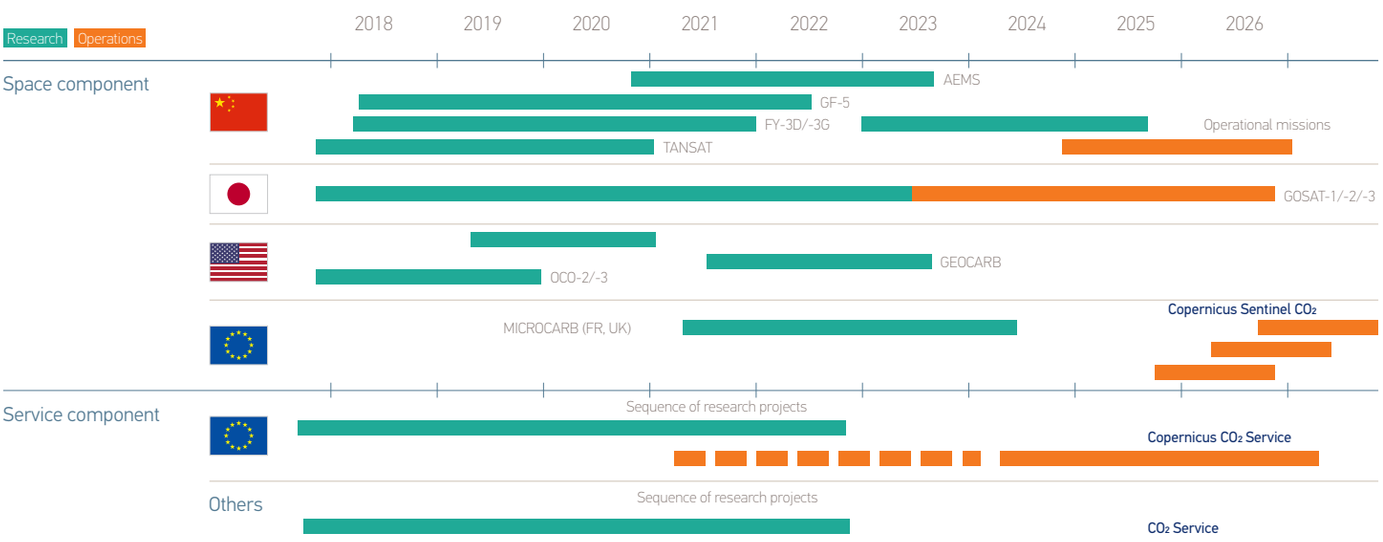
ESA and EUMETSAT continued to support the Commission in the planning of the Copernicus 2.0 programme, formalising a bilateral cooperation scenario for joint contributions to the further deployment of the Copernicus Sentinel-3, -4, -5, and -6 missions and a possible additional CO_2 monitoring Sentinel mission. The ESA and EUMETSAT Councils and the Copernicus Programme Committee welcomed the scenario in the context of discussions on the draft regulation on an EU Space Programme published in June by the Commission.

EUMETSAT communicated to all Copernicus stakeholders its expectation that the regulation confirm its current role in the Copernicus governance, in view of its commitment to deploy the Sentinel-4, -5 and -6 missions in the period 2020-2025, and its readiness to further commit to the deployment and operations of a CO_2 monitoring Sentinel mission.

En route to monitoring CO_2 emissions in support of the Paris Agreement

The European Commission, ESA, the ECMWF and EUMETSAT established a high-level research roadmap for the phased development of a Copernicus information system combining observations and Earth system modelling for monitoring CO_2 emissions, building first on space-based observations of greenhouse gas concentrations from precursor missions.

Conceptual roadmap for the development of an operational CO_2 emission monitoring service



CONTRIBUTION TO THE SPACE STRATEGY FOR EUROPE

Chinese and European experts discuss the monitoring of greenhouse gases in Beijing

EUMETSAT and its Chinese partners organised a joint workshop in Beijing on the monitoring of greenhouse gases, involving the Commission, ESA, the ECMWF, the WMO/UNEP Integrated Global Greenhouse Gas Information System (IG3IS) programme and the Integrated Carbon Observation System.

Assuming China and Europe will each deploy a greenhouse gas emissions monitoring system under the IG3S umbrella, the workshop encouraged coordinated research roadmaps and cooperation on planning of satellite missions, exchange of data and calibration/validation. The EU-ESA-China space dialogue endorsed this conclusion.

In addition, EUMETSAT joined forces with CNES to propose a Horizon 2020 project for enhancing the sole European precursor mission, MicroCarb, and with ESA on the definition of system and ground segment requirements for an operational Copernicus Sentinel mission for CO_2 monitoring.

COPERNICUS COOPERATION WITH THE EUROPEAN COMMISSION

The Commission and EUMETSAT amend their Copernicus Agreement for the safe continuation of Copernicus operations into 2021 and preparations for Copernicus 2.0

The European Commission and the EUMETSAT Council approved an amendment to the bilateral Copernicus Agreement to cover operations until September 2021 and contributions to the definition of technical requirements for a possible CO_2 monitoring Sentinel mission.

When signed in 2019, this amendment will mitigate a severe risk of discontinuity in view of the uncertain schedule for the approval of the legal instruments for entrusting Copernicus 2.0 tasks to EUMETSAT under the next EU Multi-annual Financial Framework.

Competition opens for the industrial exploitation of the WEkEO DIAS platform

After presentation to Copernicus stakeholders of the original design features of the Copernicus WEkEO DIAS platform developed in partnership with the ECMWF and Mercator Ocean International, the European Commission approved the procurement approach for the exploitation of the operational versions of the platform, starting in 2019.

EUMETSAT released the Copernicus invitation to tender for the industrial exploitation of the platform and DIAS services after presentation at an industry briefing.

Demonstration of WEkEO V0 during the Copernicus 20th anniversary in Baveno, Italy

Access to Copernicus data expands worldwide

In response to change requests from the Commission, EUMETSAT started broadcasting Sentinel-3A land products to Africa in August, and prepared infrastructure upgrades with ESA for broadcasting Sentinel-5P near-real-time atmospheric composition products to the European Earth system modelling community.

Technical operating agreements were prepared with ISRO and the Brazilian Institute for Space Research (INPE) to implement the exchange of Copernicus-relevant data foreseen by cooperation arrangements signed by the European Commission and the governments of India and Brazil, and data exchange network infrastructures were tested.

EUMETSAT, ECMWF and Mercator Ocean International WEkEO teams meet at EUMETSAT, 25 January 2018

COOPERATION WITH OTHER SATELLITE OPERATORS

Through cooperation with other satellite operators, EUMETSAT supports the optimisation of the global observing system, delivers its data to a broader user community and gains access to additional data for the benefit of its own users

The Coordination Group for Meteorological Satellites prepares for the realisation of the Vision 2040 for the WMO observing system

Meeting for its 46th plenary session in Bangalore, India, at the invitation of ISRO, the CGMS established the conceptual articulation between the Vision 2040 for the WMO Integrated Observing System (WIGOS) and their current and planned satellite programmes.

While the Vision 2040 defines the targeted architecture of the observing system proposed to CGMS agencies for their respective contributions, the "CGMS Baseline" - updated every five years - captures the contributions already committed through approved programmes. Thus, periodic gap analyses between the Vision 2040 and the CGMS Baseline will guide CGMS agencies in their prioritisation and planning for additional contributions.

As a test case, the CGMS analysed gaps in passive microwave observations. Spotting a short-term gap in low frequency (from 6.6 to 10GHz) imagery missions providing all-weather measurements of sea surface temperature and polar ice parameters, the CGMS invited all of its members to add a 6.6GHz channel to future microwave imagers and increase horizontal resolution, in order to realise the multi-orbit constellation targeted by Vision 2040.

The CGMS appreciated that the launch of the Chinese FY-3E satellite will start populating the early-morning orbit with passive microwave moisture and temperature sounders. The CGMS also invited its Korean and Indian members to complement the three main orbits with the microwave sounders they plan to launch post-2020.

The CGMS will conduct an annual risk assessment of whether the CGMS Baseline is implemented as planned, considering launch or in-orbit failures and programme cancellations or delays, to trigger contingency measures building on available redundancies.

Bilateral cooperation brings mutual benefits and serves worldwide user communities

The Director-General met the Executive Secretary of the US National Space Council and retired Navy Rear Admiral Tim Gallaudet, Deputy Administrator of NOAA, to present the scope and mutual benefits of the cooperation with NOAA and NASA.

NOAA and EUMETSAT finalised a scientific cooperation agreement and completed the migration of exchanged data flows from legacy transatlantic links to a new JEUNO network, which improved latency of key products by 15 minutes on both sides.

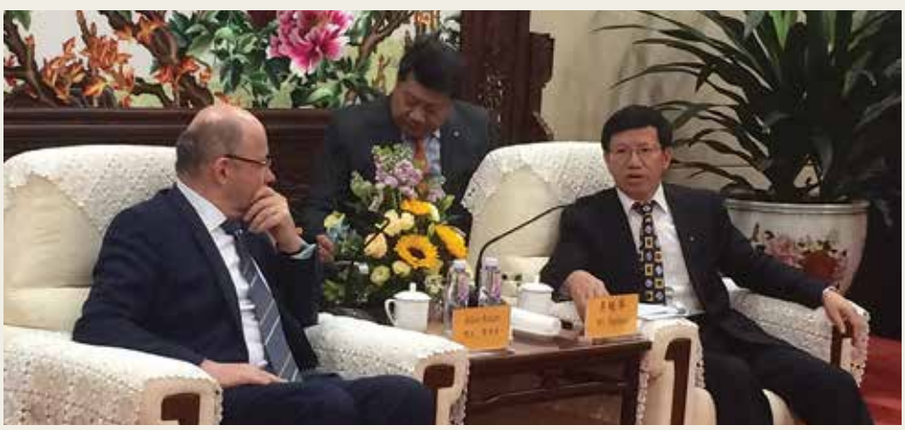
The NASA Director for Earth Sciences and the Director-General discussed cooperation opportunities arising from the US Decadal Survey for Earth Sciences and Applications from Space (ESAS), including a possible cooperative Doppler wind lidar mission also involving ESA and NOAA, similar to Jason-CS.

During discussions held in Beijing in May, China's National Space Administration (CNSA), Meteorological Administration (CMA) and State Ocean Administration (CSOA) and EUMETSAT adopted a common approach for upgrading communication infrastructures to exchange high volumes of near-real-time data.

The CNSA and EUMETSAT identified polarimetry as a promising topic for science cooperation, building on instruments under development on both sides, and agreed to establish a tripartite agreement with CNES to involve EUMETSAT in the use of data from the Chinese-French Oceanography Satellite (CFOSAT) marine mission operated by the CSOA.

Science cooperation with the CSOA concentrated on processing of scatterometer data from the HY2 satellite and calibration/validation of ocean colour observations, for which the CSOA presented a comprehensive plan at a workshop hosted at EUMETSAT.

Wu Yanhua, Deputy Administrator of CNSA and Alain Ratier during a bilateral meeting in Beijing



COOPERATION WITH OTHER SATELLITE OPERATORS

Tripartite arrangements with the Finnish Meteorological Institute enabled the start of additional acquisition of HY2 data at the Sodankylä station, to reduce the latency of marine products.

A new cooperation agreement with the CMA entered into force on 17 July for a period of five years.

A bilateral technical and scientific workshop addressed upgrades to communication infrastructures, exchange of data from newly launched satellites, future missions and science cooperation focusing on hyperspectral infrared sounding, lightning imagery and radio occultation.

During the 46th CGMS plenary session in Bangalore, the Director-General and the new ISRO Chairman, Dr K. Sivan, agreed to extend the bilateral cooperation agreement for five years through an exchange of letters, which was signed on 13 December.

Cooperation continued to focus on data exchange and processing of scatterometer, radio occultation and microwave radiometer data, building on the successful joint near-real-time Scatsat-1 ocean-surface wind product service and planned new instruments on both sides.

4th CMA-EUMETSAT bilateral workshop in Beijing, on 8 May

EUMETSAT discussed the benefits expected from lightning imagery and infrared hyperspectral soundings from geostationary orbits for weather nowcasting with the Japan Meteorological Agency (JMA), in support of the planning of their Himawari-next programme.

EUMETSAT hosted for one year a visiting scientist from the JMA, who recalibrated imagery from Japanese GMS and MTSAT geostationary satellites for the period 1978-2016.

Together with Roshydromet, EUMETSAT prepared a 2019 joint training event for Russian-speaking forecasters of Eurasian countries in cooperation with the WMO Training Centre located in St. Petersburg. Discussions included the possible acquisition of high-quality hyperspectral infrared soundings from the Meteor-M N2 satellite at more Russian ground stations.

Dr K. Sivan, Chairman of the Indian Space Research Organisation and Secretary of the Department of Space and Alain Ratier during the 46th CGMS in Bangalore

GLOBAL PARTNERSHIPS

EUMETSAT explores opportunities for additional contributions to the WMO Integrated Global Observing System

On 20 March at the Arctic Meteorological Summit, the Secretary-General of the WMO and the Director-General spoke with one voice to stress that real-time environmental and situational awareness in the Arctic requires high elliptical orbit (HEO) observation missions.

Only this orbit can provide imagery at the same high frequency as geostationary satellites at lower latitudes. This was acknowledged by the Vision 2040 for the WMO Integrated Global Observing System (WIGOS) discussed at the 70th meeting of the WMO Executive Council.

The EUMETSAT Council identified other opportunities for new missions that could complement MTG and EPS-SG as EUMETSAT's contribution to the realisation of the vision 2040 for the WIGOS.

The first opportunity is to add a Doppler lidar wind sounding capability to the EPS-SG programme, assuming the ESA Aeolus Earth Explorer mission demonstrates a positive impact on weather forecasts from world premiere measurements of vertical wind profiles.

To assess this opportunity, ESA and EUMETSAT planned a series of joint Aeolus evaluation workshops and agreed to prepare a joint study roadmap for a possible operational mission.

Another opportunity is the deployment of a small constellation of miniaturised, low-cost microwave sounders to complement the reference MWS instrument of the EPS-SG programme.

EUMETSAT supports the Global Framework for Climate Services in the African, Caribbean and Pacific regions

As a member of the Global Framework for Climate Services (GFCS) Partner Advisory Committee, EUMETSAT participated in discussions on governance and its links with WMO programmes in the proposed new WMO governance structure.

Supporting the setup of a first capacity development project on "Intra-ACP Climate Services and related applications" funded by the European Union to develop climate services in the African, Caribbean and Pacific regions, EUMETSAT hosted a workshop to assist the ACP Regional Climate Centres and African Regional Economic Communities in the preparation of their grant proposals to the Commission.

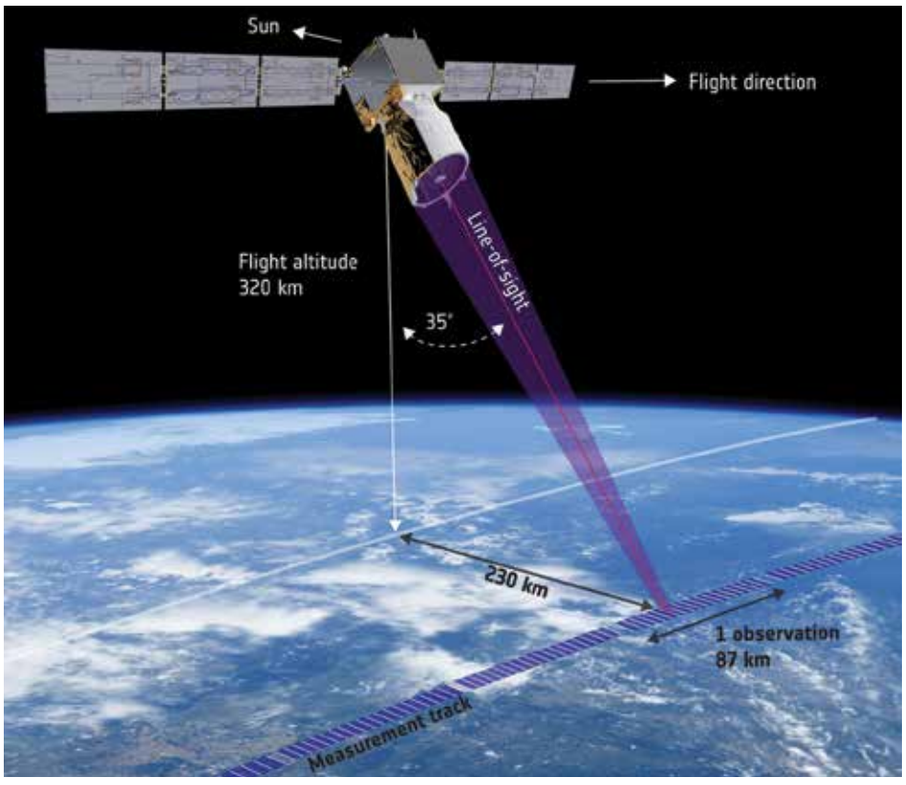
Discussions followed with the C3S, the EU Joint Research Centre (JRC), the WMO and the ACP Secretariat to coordinate support to data access, technical assistance, deployment of the JRC "climate station" and the EUMETSAT SAF Climate Monitoring Toolbox and user training.

Broadcasting of interim climate records of soil moisture, fractional cloud cover and surface incoming shortwave radiation then started via EUMETCast-Africa to support "live" climate monitoring in the ACP regions.

The Architecture for climate monitoring from space takes steps to include monitoring of greenhouse gases

The Joint Working Group on Climate coordinating the implementation of the architecture on behalf of the CGMS and CEOS performed a first gap analysis concentrated on eight GCOS-critical essential climate variables (ECVs). They did this using the 2017 version of the web-based inventory (http://climatemonitoring.info) of existing and planned climate records of ECVs observable from space.

The gap analysis report assessing how to use available satellite measurements to bridge identified gaps in climate records for eight ECVs (CO_2, CH_4, precipitation, sea surface temperature, salinity, land surface temperature, leaf area index and land biomass) and identifying needs for new missions



ESA Aeolus Earth Explorer mission: artist's impression (source: ESA)

for the start or continuation of records was endorsed by CEOS and the CGMS.

The Joint Working Group started the first incremental update of the inventory in November, with the collection of new entries from CGMS and CEOS agencies.

One outcome achieved by the European Commission's 2018 chairmanship of CEOS was the endorsement of a white paper on the "Constellation Architecture for Monitoring Carbon Dioxide and Methane from Space" to be deployed by CEOS and CGMS agencies, promoting a multi-orbit architecture consistent with the one adopted for the space component of the Vision 2040 for WIGOS.

The CGMS and CEOS tasked the Joint Working Group on Climate with coordinating the deployment of the constellation, and with reporting on progress as part of statements to the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UN Framework Convention on Climate Change (UNFCCC), and amended its terms of reference accordingly.

On behalf of the Joint Working Group, EUMETSAT presented the "Statement on Climate Monitoring from Space" to the 49th meeting of the SBSTA, delivered during the 24th Conference of the Parties to the UNFCCC (COP-24) hosted in Katowice, Poland.

Committee on Earth Observation Satellites (CEOS)

EUMETSAT hosted the meetings of the CEOS Sea Surface Temperature Virtual Constellation and the CEOS Working Group on Calibration and Validation, as well as a Strategy Implementation Team (SIT) workshop, in preparation for the CEOS plenary.

EUMETSAT presented its approach for a Copernicus Data and Information Access Service platform at a CEOS "big data" workshop organised by the European Commission.

At the CEOS plenary session held in Brussels on 16-18 October, EUMETSAT contributed to discussions on applications of geostationary satellites to land, flood and fire monitoring and new data architectures, including Copernicus DIAS platforms.

Group on Earth Observations (GEO)

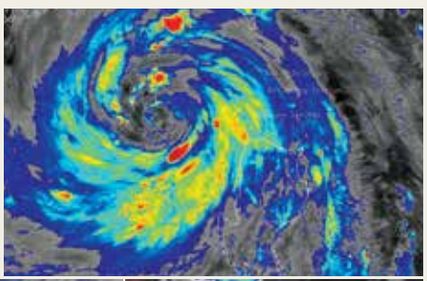
EUMETSAT operated the GEONETCast global data broadcast system in partnership with NOAA and the CMA as a GEO foundational task, and supported the EuroGEOSS regional initiative for an integrated European approach to GEO. EUMETSAT also participated in initial discussions on the 2020-2022 work programme at the GEO-XV Plenary hosted in Kyoto, Japan.

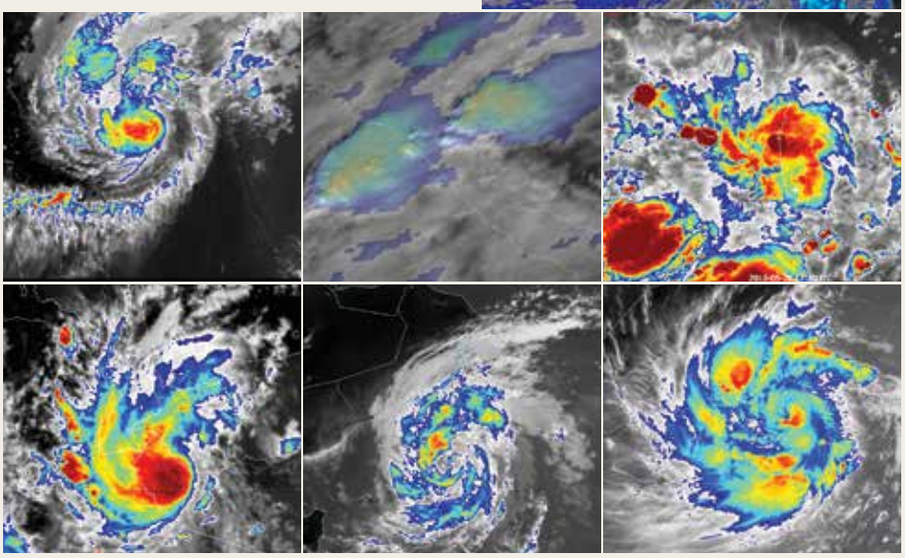
EUMETSAT co-chaired the International Charter on Space and Major Disasters with DLR from April to October.

In 2018, EUMETSAT provided Meteosat and Metop imagery in response to seven Charter activations, including; three times in May when cyclones Sagar and Mekunu flooded Djibouti, Yemen and Oman and monsoon rains flooded Sri Lanka, and three times in the September-December period, when Typhoon Mangkhut flooded the Philippines, flash floods hit southern Russia, and tropical storm Phethai made landfall in India.

"After the completion of the first analysis of gaps in climate records, a new challenge for the Joint Working Group on Climate is now to coordinate the greenhouse gas monitoring constellation."

Joerg Schulz
Chairman
CEOS-CGMS Joint Working Group on Climate





Organisational management

Cross-departmental work continued on the design of a competence planning process for periodically re-assessing the competences and human resources needed after completion of the development of the MTG, EPS-SG and Jason-CS satellite systems and the planning of timely transfers of skills from development to operations. The objective is to maintain skills, knowledge and resources at an appropriate level across the organisation for exploiting the new satellite systems, deploying their recurrent satellites and preparing future development programmes, taking account of demography.

The implementation of measures adopted to ensure compliance with the new German labour legislation, whilst securing the vital continuity of the workforce, mobilised management across the organisation.

A large number of transitional service frame contracts was necessary to group ongoing consultancy contracts into service consortia, along with a massive recruitment campaign for converting existing consultancy positions into staff posts, when no other compliant solution could be found.

The development of a system for automating the cumbersome production of operations performance indicators continued and should bring efficiency gains in 2019.

Financial processes

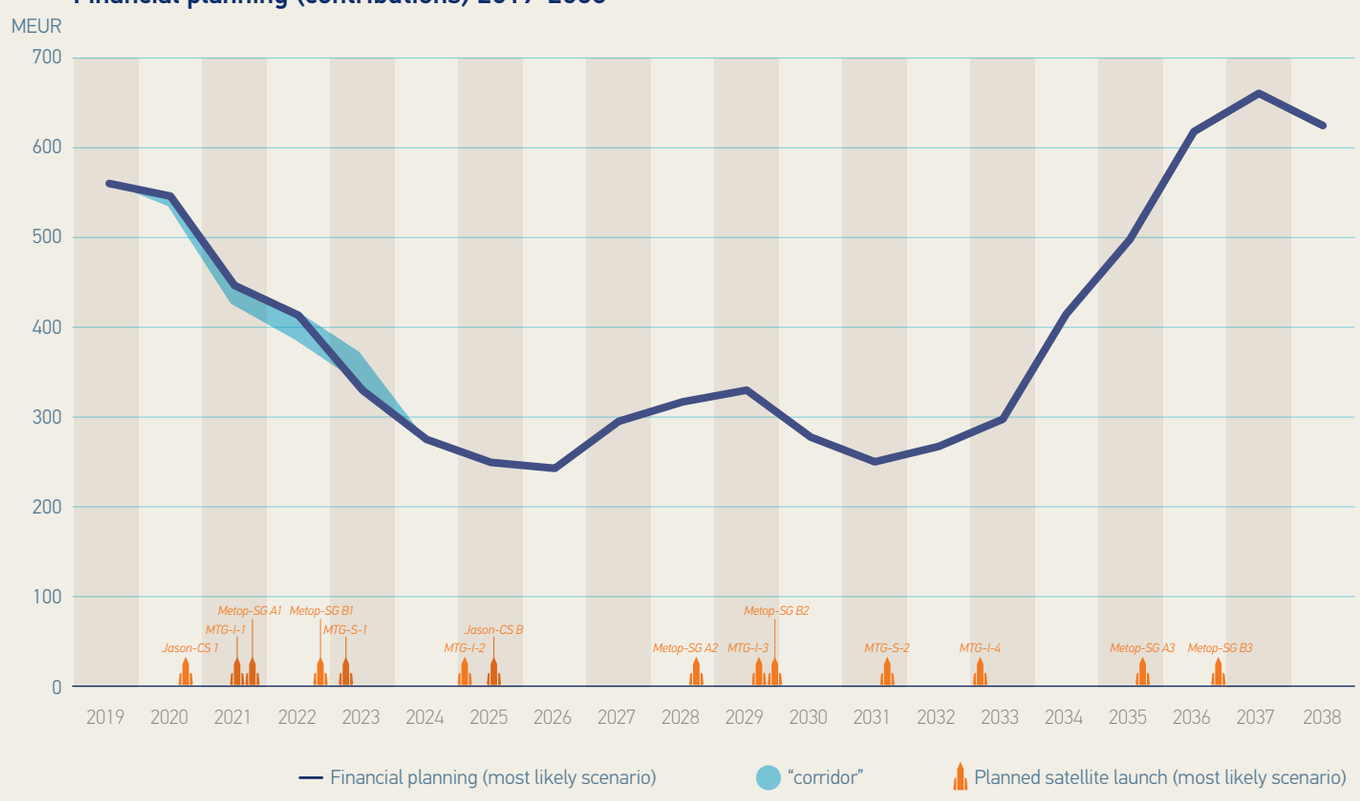
Despite using all available market options, EUMETSAT could not avoid charges for negative interest, and decided to mitigate impacts by increasing the share of annual contributions due by Member States on 1 September from 20% to 30%.

The long-term strategic asset allocation for the Pension Special Account was revised to decrease the minimum level of fixed income assets from 70% to 35% and increase the maximum level of growth assets from 30% to 65%. This was necessary to achieve the long-term 3.5% real target rate of return required to fulfil the "sustainability" objective assigned to the fund.

Human resources management

An assessment showed that the long-term human resources strategy adopted in 2014 has curbed and even reversed the rising average age of engineers, kept the average wage cost flat and secured the critical skills needed for the safe completion of the current development cycle. In particular, the Early Career Employment Programme attracted 13 engineers and scientists below the age of 30, with the majority of posts filled by women.

Financial planning (contributions) 2019-2038



A business case study started for an onsite childcare facility, further enhancing the attractiveness of the organisation for families.

The recruitment process was modernised to cope with a massive recruitment campaign, which included 99 advertised posts in 2018. The introduction of a cloud-based tool helped facilitate the identification of vacancies by job seekers and automated the processing of applications, and a recruitment brokering service linked EUMETSAT to selected online recruitment platforms. EUMETSAT also participated in multiple job fairs to increase its visibility among young professionals.

In December, 86% of staff members participated in the first simplified staff survey, which is to be repeated every second year.

Procurement process

EUMETSAT concluded 60 transitional service frame contracts, grouping 253 ongoing consultancy contracts into service consortia to maintain the on-site workforce and skills whilst complying with the new German labour legislation. Competitive tender actions for service contracts to cover additional needs were released.

The use of frame contracts further developed to increase efficiency in the procurement of services and standard equipment, and to offer the flexibility required for pathfinder-type projects and increase multi-mission capacity.

EUMETSAT presented its procurement process and forthcoming business opportunities to Polish industry at the "Warsaw Industry Days".

The industry briefing on the Copernicus invitation to tender for the industrial exploitation of the operational Copernicus WEkEO DIAS platform and services attracted 127 participants from 60 companies.

Main contracts and financial agreements approved by Council
User help desk and data centre operations service
Frame contract for operational IT equipment
Framework contract for operational wide-area network services
Security operations centre service
Industrial support to operations of the Metop satellite
One-year extension of the EPS analyst and controller service
Change to the MTG Agreement with ESA to cover post-storage activities for recurrent satellites
Increased financial liability to ESA to cover the replanning of Metop-SGA development
Operational processor for Sentinel-5 atmospheric composition products
Upgrade of EPS backup control site infrastructure to also host EPS-SG and Jason-CS backup control centres

General infrastructure and internal services

Although a new warehouse facility freed up part of the previous goods receipt area for use as office space, the rental of new porta-cabins proved necessary to provide an additional 80 work spaces for a five-year period.

A second entrance to the premises dedicated to the delivery of goods and the access road enabling trucks to transport goods to the warehouse facility were constructed.

Experts from Member States started their assessment of requirements for a proposed extension of the East Building with a review of the measures carried out in 2017- 2018 for optimising the use of existing office space, the need to replace temporary buildings and the accommodation needs arising from future developments. Based on their findings, the Council authorised the start of the architectural and planning phase for the extension.

The use of cloud-based services further developed with the replacement of the library management software by software as a service, the introduction of cloud-based tools supporting risk management, tracking and processing of applications to vacancies and a digital signature system.

The migration of more than 1,000 individual computers to Windows 10 started in September with a pilot phase and should be complete in summer 2019.

MANAGEMENT AND ADMINISTRATION

Quality management

After restructuring around the seven key business processes, the high-level documentation of the management system evolved into an online, navigable information system available on the intranet.

This formed the reference for the first ISO 9001:2015 surveillance audit, which maintained the EUMETSAT certification for one more year.

Internal control

The Council increased the threshold for transactions subject to independent a priori financial control from K€5 to K€15 with effect from 1 April 2019, based on statistics showing that this will substantially reduce the number of transactions to be processed by the financial control function, whilst keeping financial risks at a very low level.

Risk management

The introduction of a risk management plan in the administration department completed the harmonisation of risk management across the organisation, now supported by a cloud-based tool facilitating the transfer end escalation of risks.

At corporate level, the most critical risks addressed were frequency interferences associated with the worldwide deployment of 5G services and volatility of skills associated with the measures adopted to comply with the new German labour legislation.

Within the development area, the Metop-C launch campaign was the main focus, due to the late discovery of a GOME-2 instrument anomaly and the failure of a Soyuz-FG launcher after the fuelling of Metop-C.

Management of information security and business continuity expands across the organisation

The cross-organisational information security management system became operational and improved further with the setting up of a computer emergency response team and connections between the internal service desk and the security team enabling faster processing of requests for information security services.

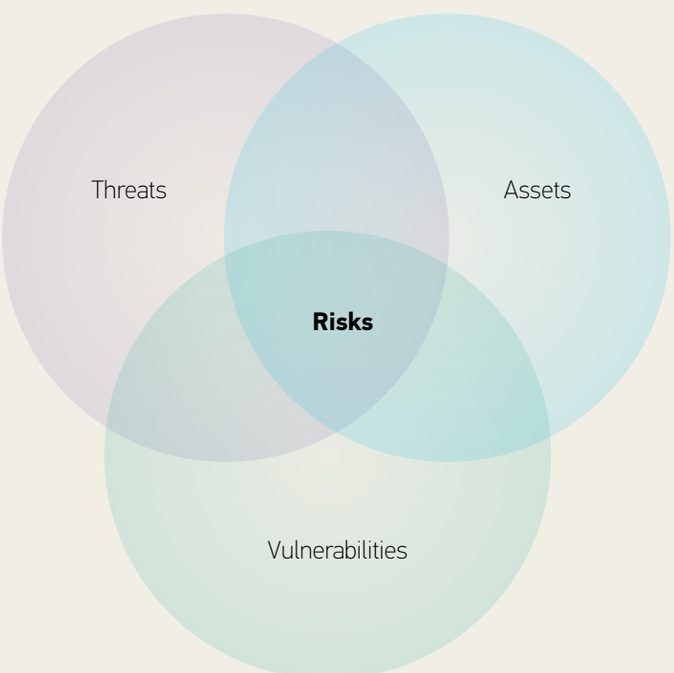
The extension of the business continuity management system to the administrative area progressed with the initiation of procurements for remote access to emails, the document management system and SAP functionalities - enabling post-disaster recovery of operations-critical administrative functions. In addition, the emergency activation of the Meteosat Backup Mission Control Centre was tested from the Operations Evacuation Coordination Room hosted by the DWD in Offenbach, after its redeployment from Usingen to Fucino.

EUMETSAT advocates for allocation of interference-free frequencies to 5G services

EUMETSAT and ESA studies demonstrated that the worldwide introduction of 5G mobile services in the 26GHz frequency band would threaten unique global humidity measurements by passive microwave instruments operating in the neighbouring 24GHz band if unwanted emissions of ground equipment were not capped.

In July, the European Conference of Postal and Telecommunications Administrations decided to limit unwanted emissions at levels considered acceptable for protecting the integrity of passive microwave measurements from six EUMETSAT and Copernicus instruments operating in the 24GHz band over Europe, subject to further assessment and confirmation by experience in orbit.

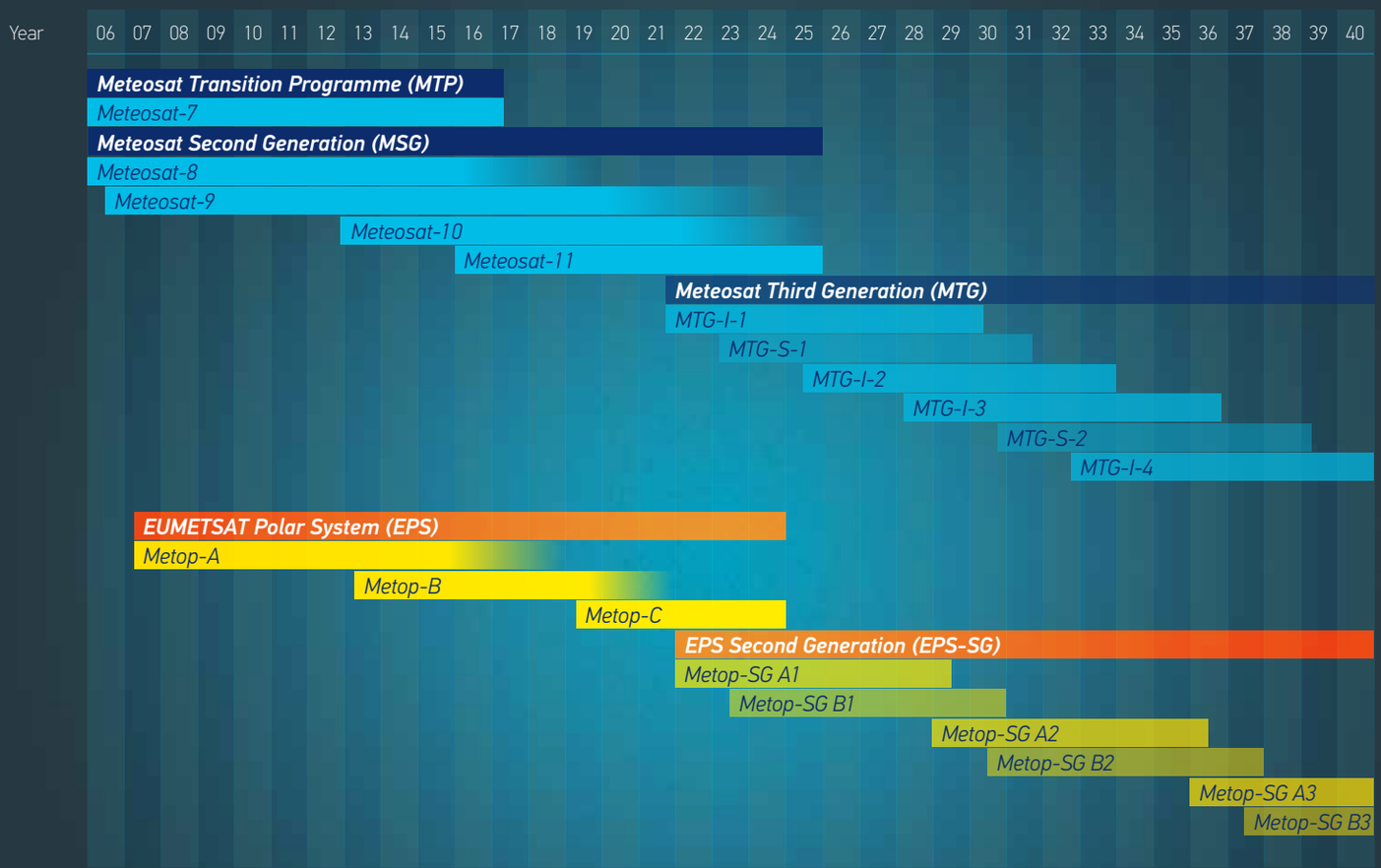
The next challenge will be to arrive at a compromise during the ITU World Radiocommunication Conference 2019 that preserves the integrity of measurements at global scale.



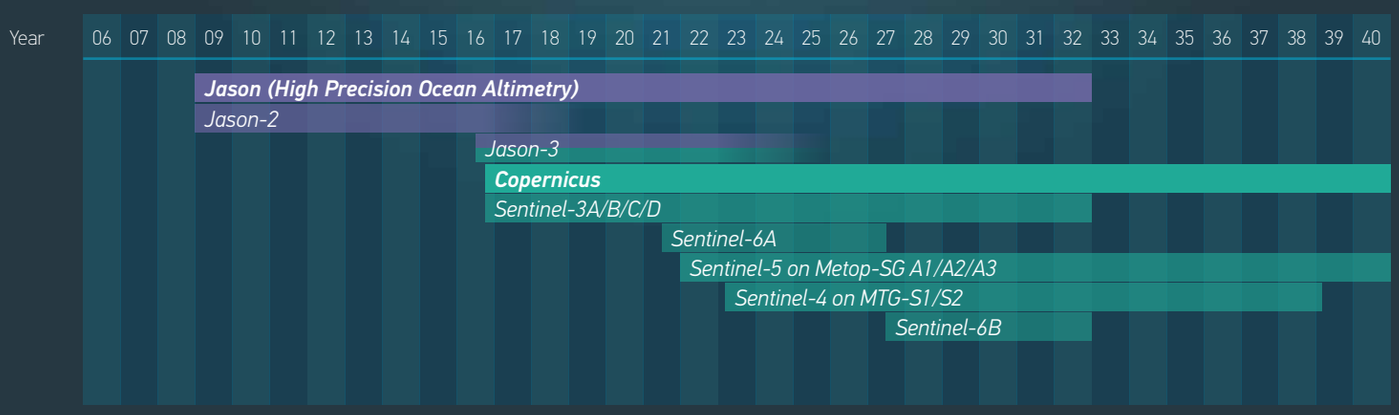
KEY FIGURES

EUMETSAT mission planning

Mandatory programmes



Optional and third-party programmes



KEY FIGURES

The EUMETSAT user base

The EUMETSAT user base is comprised of users in the NMHs of its Member States, the ECMWF, international partners, researchers and a number of individual licensed users.

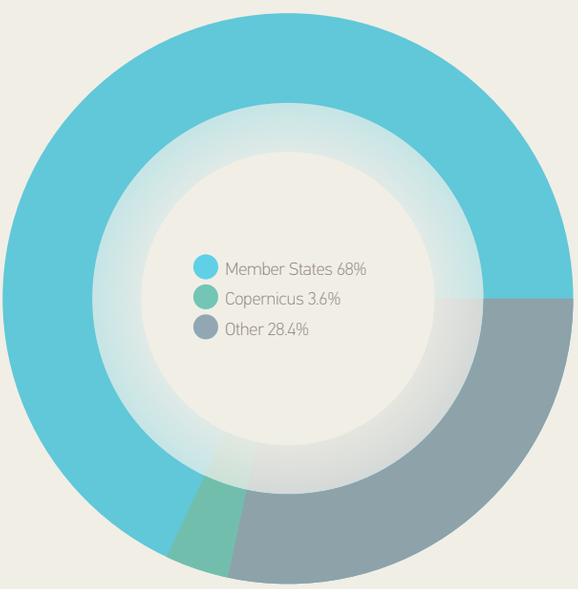
At the end of 2018, the number of licensed users was 1943.

The EUMETSAT Copernicus user base is comprised of the Copernicus CMEMS, CAMS and C3S services and individual licensed users of Copernicus products.

At the end of 2018, the number of active licensed users of Copernicus Sentinel-3 products was 1,290.

User enquiries

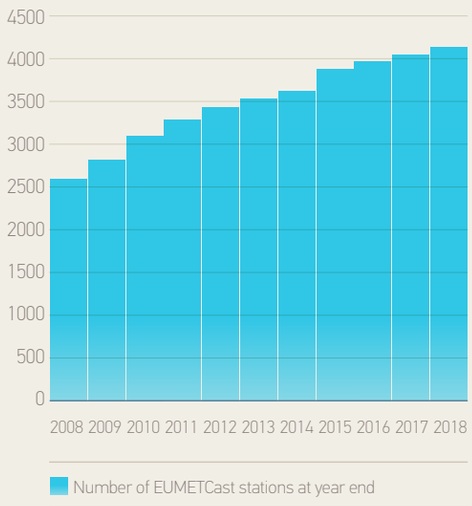
A total of 3,202 user enquiries were processed, of which 68% were from Member States and 3.6% related to Copernicus.



KEY FIGURES

EUMETCast and Copernicus Online Date Access (CODA) Users

At the end of 2018, there were 4,132 registered EUMETCast reception stations, of which 82% were located in Member States. These stations are exploited by 2,870 registered user entities, out of which 444 receive both EUMETSAT and Copernicus data.

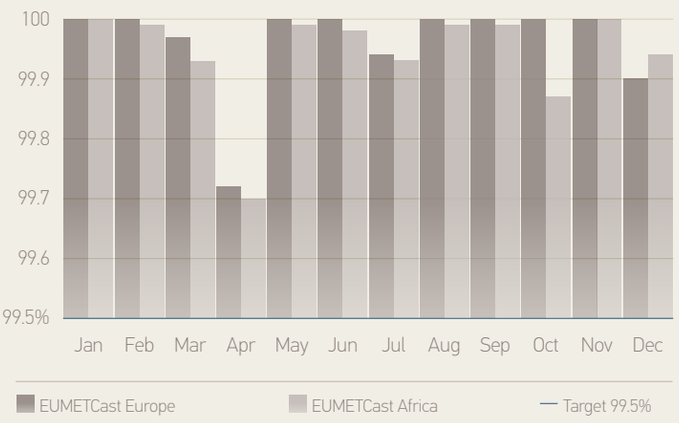


EUMETCast availability 2018

The EUMETCast service broadcasts time-critical data to users with 99.95% availability.

In addition, 3,177 active users downloaded Sentinel-3 marine products via the EUMETSAT CODA system, with on average 117 new users per month.

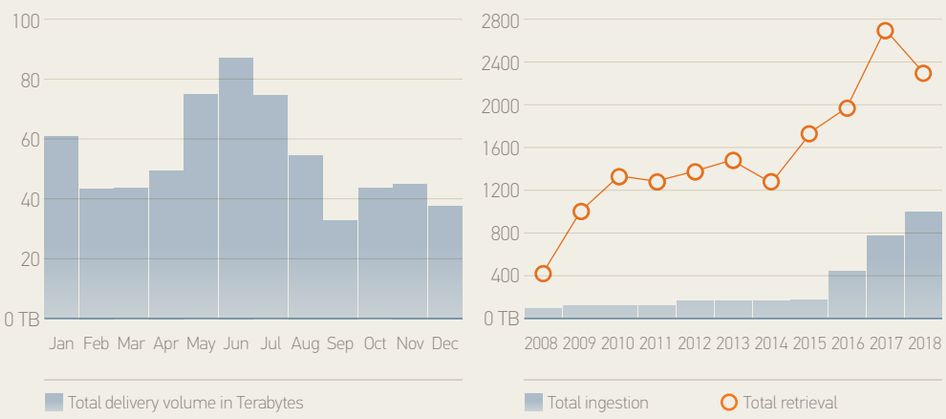
The CODA service provided download services to users with 98.46% availability.



Data Centre users and orders

At the end of 2018, the cumulative number of Data Centre users reached 7,137. This figure includes an average of 107 new users per month, of which 13 ordered Copernicus data. On average, 335 unique users ordered from the EUMETSAT Data Centre per month.

The volume and amount of products delivered in 2018 stayed below the all-time high of 2017. In total, over 11 million files were delivered in 2018, with a delivery volume of 648 TBytes.

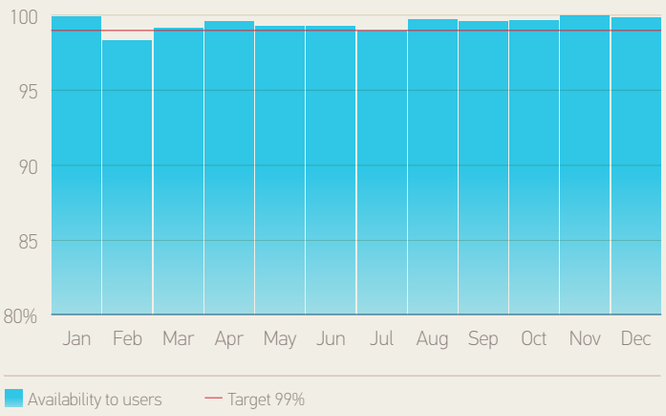


KEY FIGURES

Operational performance indicators

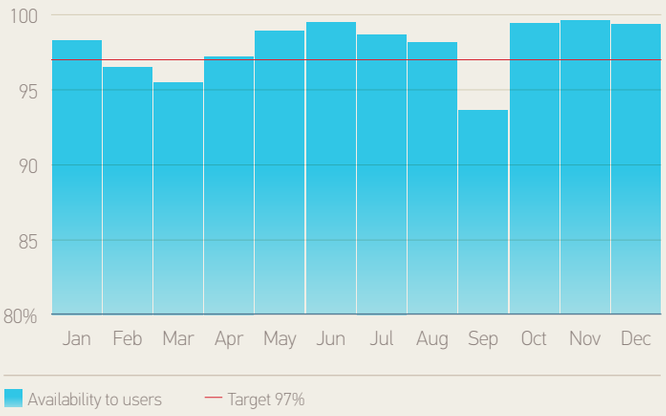
Availability of Meteosat SEVIRI Full Earth Scan products (0°)

The availability was slightly below target in February due to a network firmware switch anomaly on ground.



Availability of Meteosat IODC image products (41.5°E)

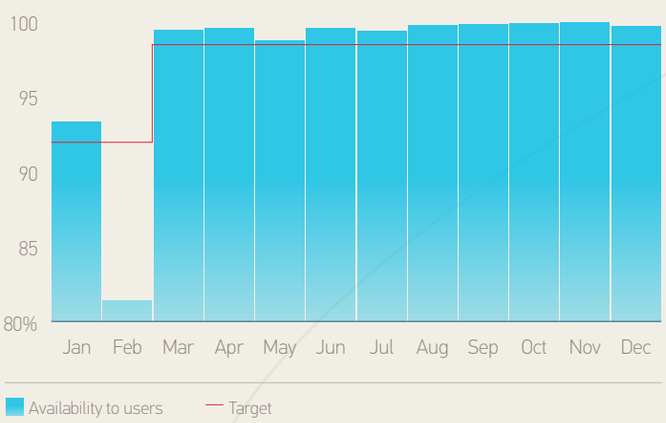
Availability was below target in February due to an anomaly of the multi-mission data dissemination system, in March due to degraded satellite thermal control in eclipse conditions, and in September due to a platform safe mode event.

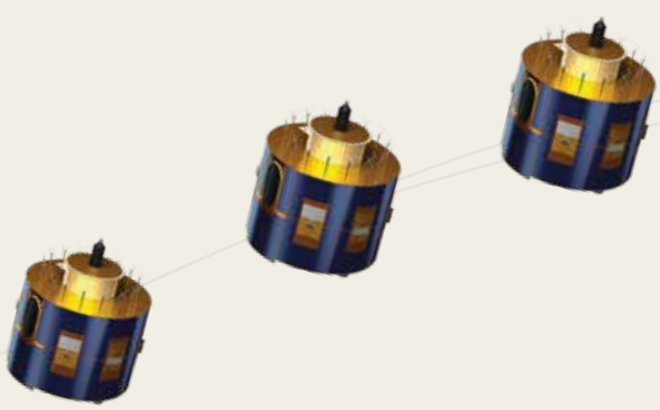


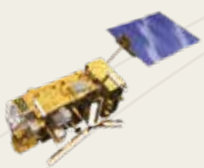
Availability of Meteosat SEVIRI Rapid Scan products (9.5°E)

The target increased from 92% to 98.5 % in March, when a backup satellite (Meteosat-9) became available again.

Below-target availability in January-February was due to the planned 28-day interruption of service required to preserve the lifetime of the scan mechanism of Meteosat-9 and to a five-day outage during relocation manoeuvres.



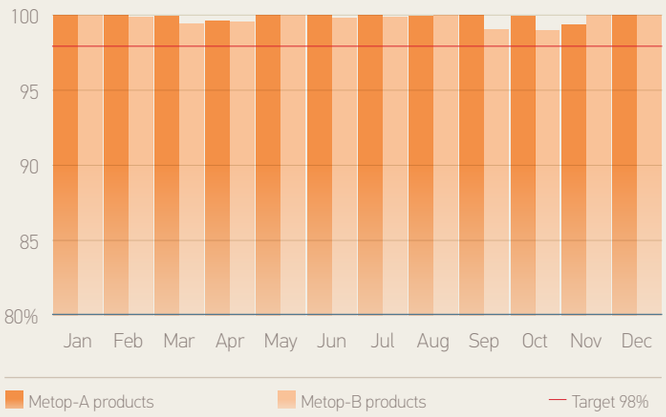




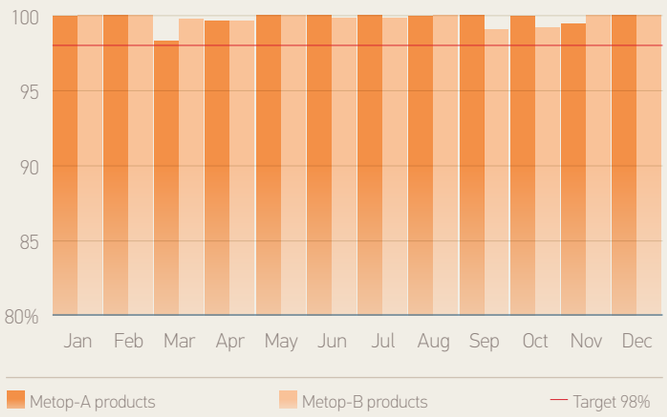
KEY FIGURES

Operational performance indicators

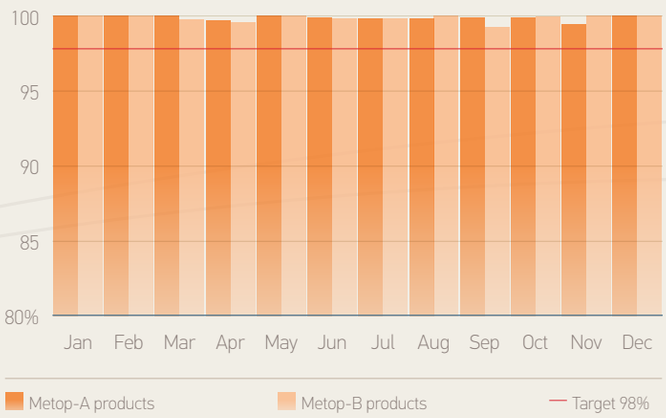
Availability of Metop AMSU level 1B products to users



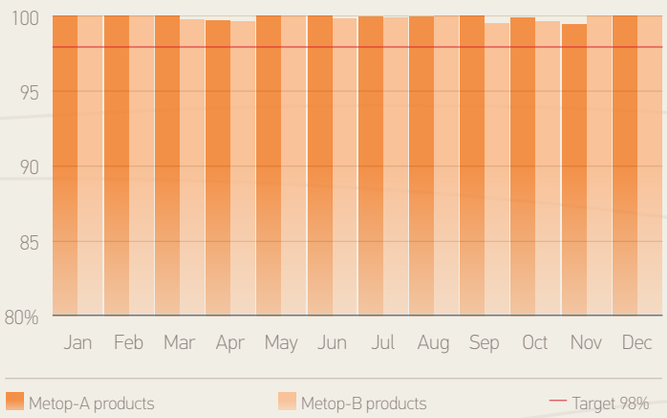
Availability of Metop MHS level 1B products to users

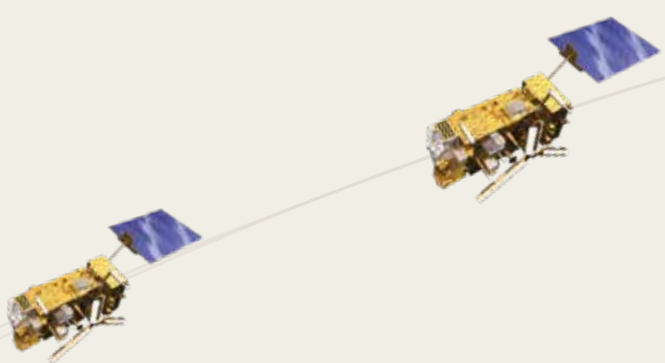


Availability of Metop ASCAT level 1B products to users

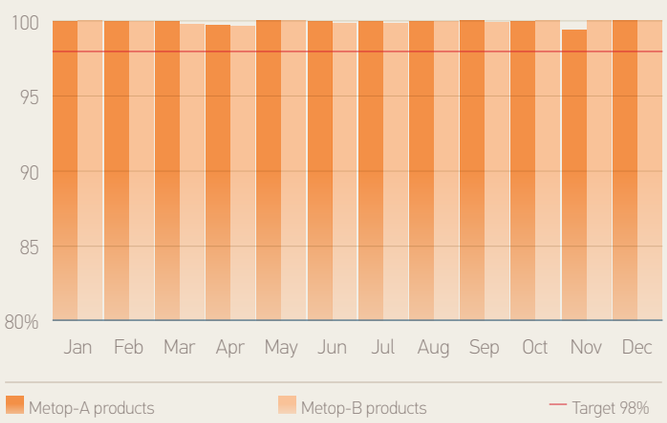


Availability of Metop AVHRR level 1B products to users





Availability of Metop GOME-2 level 1B products to users

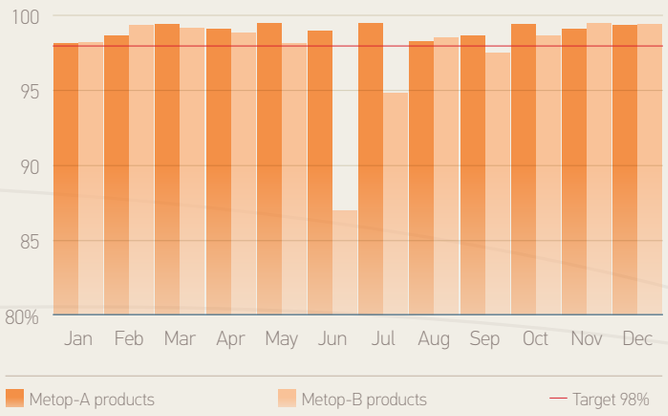


KEY FIGURES

Operational performance indicators

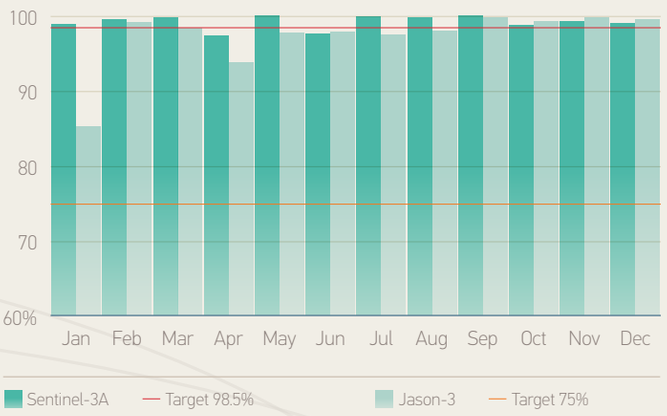
Availability of Metop IASI level 1C BUFR products to users

Availability of Metop-B data was below-target in June-July due to the planned decontamination of the IASI instrument, and in September during the out of plane manoeuvre of the satellite.



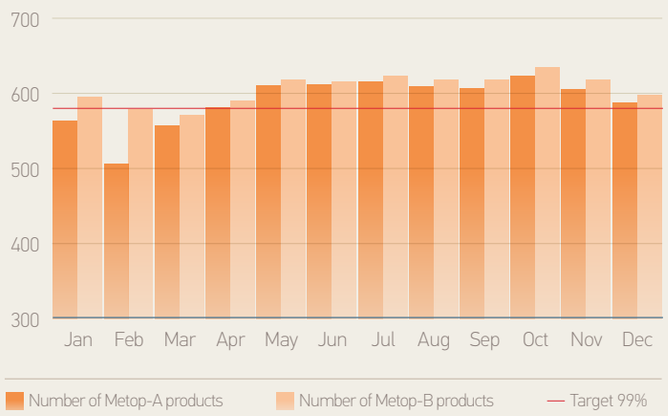
Availability of Jason-3 and Sentinel-3 near-real-time altimeter products to users

Availability of Jason-3 products decreased in January due to an anomaly of the software shared by the US and European ground stations.



Number of real-time Metop GRAS level 1B products to users

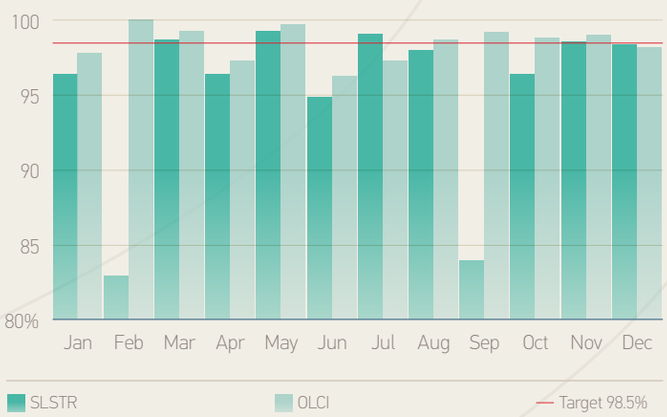
The number of radio-occultation measurements from Metop-A was below target in January-March, due to a GRAS instrument configuration test campaign.

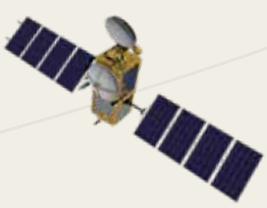


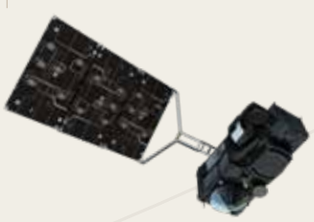
Availability of Sentinel-3A OLCI and SLSTR level 1 products to users

Availability of OLCI products was below target in April due to a ground segment anomaly and in June/July due to re-occurrence of a known anomaly of the instrument.

Availability of SLSTR products was below target in February and September due to planned instrument decontaminations, and in April and June due to ground segment anomalies.







KEY FIGURES

Financial information

EUMETSAT's 2018 Financial Statement has been audited by the Tribunal De Contas. The following tables, in K€, are a summary of the information for 2018 included in those accounts.

Summary Revenue and Expenses

	KEUR
Revenue	
Member State Contributions	594,759
Other Contributions	42,885
Sales Revenue	2,157
Other Revenue	62,897
Asset Impairments	
Total Revenue	**702,698**
Expenses	
Costs for Human Resources	110,315
Services and Works Contracts	56,982
Other Operating Expenses	11,259
Satellite-related costs	59,151
SAF, Prospective Activities, Research Fellows	10,785
Depreciation	202,107
Asset Impairments	0
Total Expenses	**450,599**
Expenses from Financial Operations	208
Net surplus for the period	**251,891**
Surplus to be distributed to Member and Cooperating States	70,246
Result Allocated to Reserves	181,645

Summary Balance Sheet

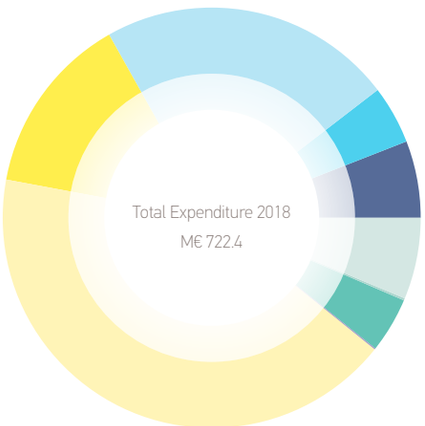
	KEUR
Assets	
Current Assets	1,009,705
Non-Current Assets	2,708,573
Total Assets	**3,718,278**
Liabilities	
Current Liabilities	807,648
Non-Current Liabilities	584,293
Total Liabilities	**1,391,940**
Total Net Assets/Equity	**2,326,338**
Total Liabilities & Net Assets/Equity	**3,718,278**

Member State Contributions

	KEUR
Member State Contributions	
Austria	12,494
Belgium	14,502
Bulgaria	1,530
Croatia	1,596
Czechia	5,384
Denmark	10,339
Estonia	688
Finland	7,863
France	83,489
Germany	114,158
Greece	6,401
Hungary	3,633
Iceland	499
Ireland	6,505
Italy	60,934
Latvia	845
Lithuania	1,269
Luxembourg	1,247
Netherlands	25,459
Norway	14,655
Poland	14,240
Portugal	6,500
Romania	5,351
Slovakia	2,695
Slovania	1,325
Spain	39,343
Sweden	17,035
Switzerland	21,447
Turkey	27,287
United Kingdom	86,046
Total Member State Contributions	**594,759**

Expenditure Budgets

Total Expenditure 2018

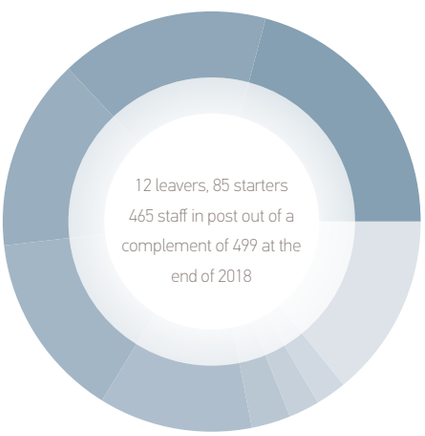


GB	M€ 43.0		Jason-2	M€ 0.6	
MSG	M€ 32.5		Jason-CS	M€ 30.8	
MTG	M€ 163.9		Sentinel-3	M€ 1.2	
EPS	M€ 100.7		Copernicus	M€ 45.4	
EPS-SG	M€ 304.3				

Human Resources

Staff in post

31 December 2018



Germany	20.86%	Portugal	3.01%
Italy	16.13%	Belgium	2.37%
United Kingdom	14.84%	The Netherlands	2.37%
France	14.41%	Other	14.18%
Spain	11.83%		

APPENDIX

Organigramme, 31 December 2018

EUMETSAT Council
Prof G. Van der Steenhoven (Chair)
Mr E. Moran (Vice-Chair)

PAC — **Policy Advisory Committee**
Dr M. Gray (Chair)
Mr H. Roozekrans (Vice-Chair)

STG — **Scientific and Technical Group**
Mr S. Nilsson (Chair)
Mr M. Manso Rejon (Vice-Chair)

- **STG-OWG** — **STG Operations Working Group**
  Mr A. Dybbroe (Chair)
  Mr J. Asmus (Vice-Chair)
- **STG-OWG** — **STG Science Working Group**
  Mr P. Stammes (Chair)
  Mr D. Biron (Vice-Chair)

AFG — **Administration and Finance Group**
Mr S. Rasmussen (Chair)
Mr S. Green (Vice-Chair)

DPG — **Data Policy Group**
Mr S. Olufsen (Chair)
Mr A. Longden (Vice-Chair)

Financial Control and Internal Audit
Jose Travesi Garcia

Programme Preparation and Development
Cristian Bank

MTG Programme
Alexander Schmid

EPS Programme
Manfred Lugert

EPS-SG Programme
Gökhan Kayal

Jason-CS Programme
Francois Parisot

APPENDIX

Director-General
Alain Ratier

Chief Scientist
Dr Kenneth Holmlund

Quality Management
Carmelo Aveni Cirino

Strategy, Communication and International Relations
Paul Counet

Operations and Services to Users
Livio Mastroddi

Copernicus Programme and Service Management Office
Dany Provost

Flight Operations
Mike Williams

Real Time Services and System Operations
Sean Burns

User Support and Climate Services
Joachim Saalmueller

Administration
Silvia Castañer

Contracts
Eleni Katsampani

Finance
Per Collin

General Services
Bernd Kaufmann

Human Resources
Raffael Clerici

Legal Affairs
Mechtild Lauth

Technical and Scientific Support
Yves Buhler

Process Assurance and Management Support
Andrea Duflaut

Generic Systems and Infrastructure
Graziano Mori

Remote Sensing and Products
Bojan Bojkov

System Engineering and Projects
Joaquin González Picazo

Information and Communication Technology
Okan Gümrah

APPENDIX

EUMETSAT Council Delegates and Advisors, 1 January 2018

Austria

Dr M. Staudinger	Zentralanstalt für Meteorologie und Geodynamik (ZAMG)
Mr L.A. Berset	Österreichische Forschungsförderungs-gesellschaft

Belgium

Dr D. Gellens	Insitut Royal Météorologique (IRM)
Mr P. Rottiers	Belgian Science Policy Office

Bulgaria

Prof H. Branzov	National Institute of Meteorology and Hydrology (NIMH)
Prof C. Georgiev	NIMH

Croatia

Ms B. Ivancan-Picek	Meteorological and Hydrological Service (DHMZ)
Dr N. Strelec Mahovic	DHMZ

Czechia

Mr M. Rieder	Czech Hydrometeor-ological Institute (CHMI)
Mr L. Černikovský	CHMI
Mr M. Setvák	CHMI

Denmark

Ms M. Thyrring	Danish Meteorological Institute (DMI)
Mr S. Olufsen	DMI

Estonia

Mr T. Ala	Estonian Environment Agency

Finland

Prof J. Damski	Finnish Meteorological Institute (FMI)
Prof J. Pulliainen	FMI

France

Mr J.-M. Lacave	Météo-France
Ms A. Debar	Météo-France
Ms I. Bénézeth	Ministère de L' Ecologie, du Développement durable et de l'Energie
Ms C. Ivanov-Trotignon	Centre National d'Etudes Spatiales (CNES)

Germany

Prof Dr G. Adrian	Deutscher Wetterdienst (DWD)
Dr M. Rohn	DWD
Dr G. Seuffert	Bundesministerium für Verkehr und digitale Infrastruktur
Mr T. Ruwwe	Deutsches Zentrum für Luft-und Raumfahrt (DLR)

Greece

Brig. Gen. N. Vogiatzis	Hellenic National Meteorological Service (HNMS)
Mr C. Karvelis	HNMS

Hungary

Ms K. Radics	Hungarian Meteorological Service (OMSZ)

Iceland

Dr A. Snorrason	Icelandic Meteorological Office (IMO)

Ireland

Mr E. Moran	Met Éireann

Italy

Gen. S. Cau	Aeronautica Militare
Dr A. Bartolini	Ministero dell'Economia e delle Finanze
Dr F. Battazza	Agenzia Spaziale Italiana

APPENDIX

Observers: ECMWF, ESA, EUMETNET, European Commission, NOAA, WMO

Latvia

Mr K. Treimanis	Latvian Environment, Geology and Meteorology Centre
Mr A. Viksna	Latvian Environment, Geology and Meteorology Centre

Lithuania

Mr S. Balys	Lithuanian Hydrometerological Service
Ms V. Raliene	Lithuanian Hydrometerological Service

Luxembourg

Ms M. Reckwerth	MeteoLux, Administration de la navigation aérienne

Netherlands

Mr H. Roozekrans	Koninklijk Nederlands Meteorologisch Instituut (KNMI)

Norway

Mr R. Skalin	Norwegian Meteorological Institute (Met.no)
Mr S. Rasmussen	Met.no
Mr L.-A. Breivik	Met.no
Mr T. Wahl	Norwegian Space Centre

Poland

Dr P. Lagodzki	Institute for Meteorology and Water Management (IMGW)
Dr P. Szczepanska	IMGW
Dr P. Struzik	IMGW
Mr J. Trzosowski	IMGW

Portugal

Prof M. Miranda	Istituto Portugues do Mar e da Atmosfera (IPMA)
Ms I. Trigo	IPMA
Ms C. Gonçalves	IPMA

Romania

Ms E. Mateescu	National Meteorological Administration (RNMA)
Dr G. Stancalie	RNMA

Slovakia

Dr M. Benko	Slovak Hydrometeorological Institute

Slovenia

Dr K. Bergant	Slovenia Environmental Agency

Spain

Mr M.A. López González	Agencia Estatal de Meteorologia (AEMET)
Mr J. A. Fernández-Monistrol	AEMET
Mr S. Garcia Dominguez	AEMET
Ms M. López	Centro para el Desarrollo Tecnologico Industrial

Sweden

Mr R. Brennerfelt	Swedish Meteorological and Hydrological Institute (SMHI)
Mr S. Nilsson	SMHI
Ms B. Aarhus Andrae	SMHI

Switzerland

Dr P. Binder	MeteoSwiss
Mr M. Keller	MeteoSwiss
Dr F. Fontana	MeteoSwiss

Turkey

Mr V. M. Coskun	Turkish State Meteorological Service (TSMS)
Mr E. Aydin	TSMS
Mr M. Altinyollar	TSMS
Mr E. Erdi	TSMS

United Kingdom

Mr P. Evans	Met Office
Mr S. Turner	Met Office
Mr M. Gray	Met Office
Mr A. Longden	Met Office

APPENDIX

Participation in major external events

98th Annual Meeting of the American Meteorological Society	Austin, USA	*7-11 January*
EU-US space dialogue meeting	Washington DC, USA	*18 January*
10th European Space Policy Conference	Brussels, Belgium	*23-24 January*
GMES and Africa – Copernicus Workshop	Accra, Ghana	*19-21 February*
Arctic Meteorology Summit 2018	Levi, Finland	*20 March*
2nd WMO Development Partners Conference on Strengthening and Sustaining National Meteorological and Hydrological Services	Geneva, Switzerland	*21-22 March*
33rd meeting of CEOS Strategy Implementation Team	Boulder Colorado, USA	*23-25 April*
46th Plenary Session of the Coordination Group for Meteorological Satellites	Bangalore, India	*3-8 June*
15th International Weather and Climate Forum (IWF)	Paris, France	*4-5 June*
First Grant preparation workshop for the intra-ACP Climate Service programme	Darmstadt, Germany	*12-14 June*
Celebration of 20 years of Copernicus	Baveno, Italy	*21-22 June*
70th meeting of the WMO Executive Council (EC-70)	Geneva, Switzerland	*20-29 June*
34th meeting of CEOS Strategy Implementation Team	Darmstadt, Germany	*11-14 September*
ECOWAS Hydromet Forum and DRR platform	Abidjan, Côte d'Ivoire	*19-21 September*
4th Bureau Meeting of AMCOMET	Abidjan, Côte d'Ivoire	*21 September*
Ocean Surface Topography Science Team meeting: 25 years of altimetry	Azores, Portugal	*24-29 September*
69th International Astronautical Congress (IAC)	Bremen, Germany	*1-5 October*
9th Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC-9)	Jakarta, Indonesia	*6-11 October*
Meteorology Technology World Expo	Amsterdam, the Netherlands	*9-11 October*
20th European Interparliamentary Space Conference (EISC)	Brussels, Belgium	*15-16 October*
32nd CEOS Plenary meeting	Brussels, Belgium	*16-18 October*
26th GCOS Steering Committee Meeting	Helsinki, Finland	*16-18 October*
ESA Intermediate Ministerial Meeting	Madrid, Spain	*25 October*
GEO-XV Plenary meeting	Kyoto, Japan	*29 October - 2 November*
GMES and Africa Forum	Libreville, Gabon	*19-23 November*
EU-ESA China Space Dialogue meeting	Brussels, Belgium	*25 November*
2nd Grant preparation workshop for the Intra-ACP Climate Services programme	Brussels, Belgium	*28-30 November*
5th European Space Solutions Conference	Marseille, France	*3-7 December*

APPENDIX

Scientific and technical publications

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APPENDIX

Scientific and technical publications

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Fougnie, B., Marbach, T., Lacan, A., Schluessel, P., Lang, R., Poli, G., Munro, R., 2018. The 3MI mission on-board EPS-SG: a multi-spectral multi-polarization multi-directional imager for operational characterization of aerosol and cloud. *Proc. SPIE 10764.*

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APPENDIX

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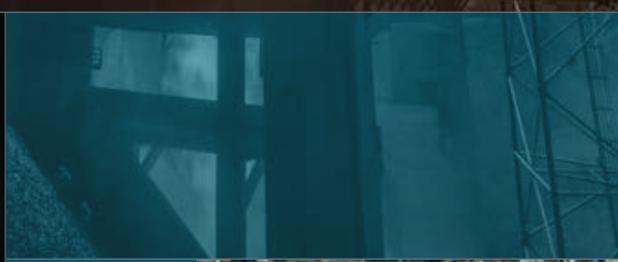
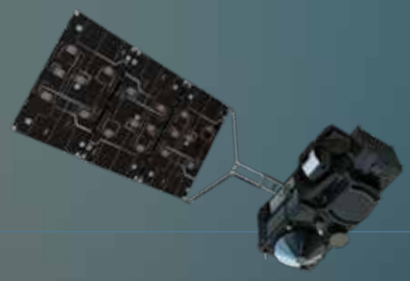
APPENDIX

Glossary

ACMAD	African Centre of Meteorological Applications for Development
ACP	African, Caribbean and Pacific Group of States
AfDB	African Development Bank
ASECNA	Agency for Aerial Navigation Safety in Africa and Madagascar
AUC	African Union Commission
C3S	Copernicus Climate Change Service
CAMS	Copernicus Atmosphere Monitoring Service
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CMA	China Meteorological Administration
CMEMS	Copernicus Marine Environment Monitoring Service
CNES	Centre National d'Etudes Spatiales (French space agency)
CNSA	China National Space Administration
Copernicus	Earth Observation Programme of the European Union
CSOA	China State Oceanic Administration
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
EARS	EUMETSAT Advanced Retransmission Service
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential climate variable
ESA	European Space Agency
ESOC	European Space Operations Centre (ESA)
EUMETCast	EUMETSAT's satellite data broadcast system
FIDUCEO	Fidelity and Uncertainty in Climate Data Records from Earth Observations (EU Horizon2020 project)
GCOS	Global Climate Observing System
GEO	Group on Earth Observations
GEONETCast	Global network of satellite data broadcast systems
GFCS	Global Framework for Climate Services
GNSS	Global Navigation Satellite System
GOES	Geostationary Operational Environmental Satellite (NOAA)
Himawari	Japanese geostationary meteorological satellite
IJPS	Initial Joint Polar System (shared with NOAA)
ISRO	Indian Space Research Organisation
JAXA	Japan Aerospace Exploration Agency
JMA	Japan Meteorological Agency
KMA	Korea Meteorological Agency
NASA	National Aeronautics and Space Administration (US)
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NOAA	National Oceanic and Atmospheric Administration (US)
RA-I	WMO Regional Association 1
Roshydromet	Russian Federal Service for Hydrometeorology and Environmental Monitoring
SAF	Satellite Application Facility
SBSTA	Subsidiary Body for Scientific and Technical Advice (UN)
Vlab	Virtual Laboratory for Training and Education in Satellite Meteorology (WMO)
WEkEO	Copernicus DIAS reference service for environmental data, virtual processing environments and skilled user support deployed by EUMETSAT, the ECMWF and Mercator Ocean International
WMO	World Meteorological Organization





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