ANNUAL REPORT 2017

EUMETSAT

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THE WORD OF THE DIRECTOR-GENERAL

2017 was described by the World Meteorological Organization as "the warmest year on record not influenced by an El Niño event" and was marked by a rapid succession of three exceptionally destructive cyclones in the Caribbean region. One of these, Irma, was the strongest cyclone on record outside of the Caribbean Sea and Gulf of Mexico.

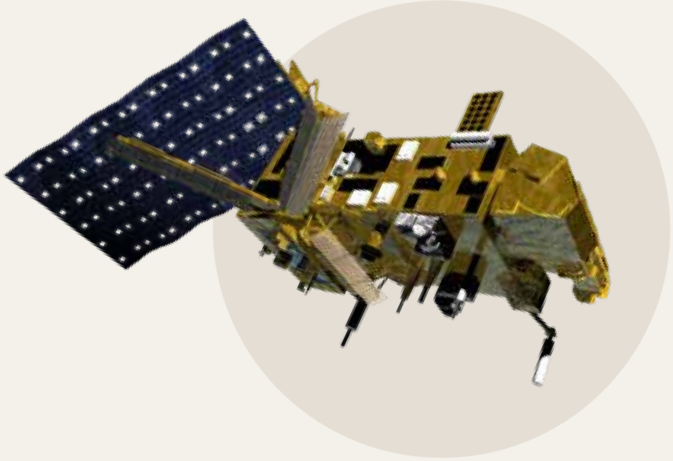
As in 2016, a tropical cyclone developed in the Azores region. It became the easternmost cyclone on record to reach category 3 intensity, impacting the United Kingdom and Ireland when it evolved into a large mid-latitude storm.

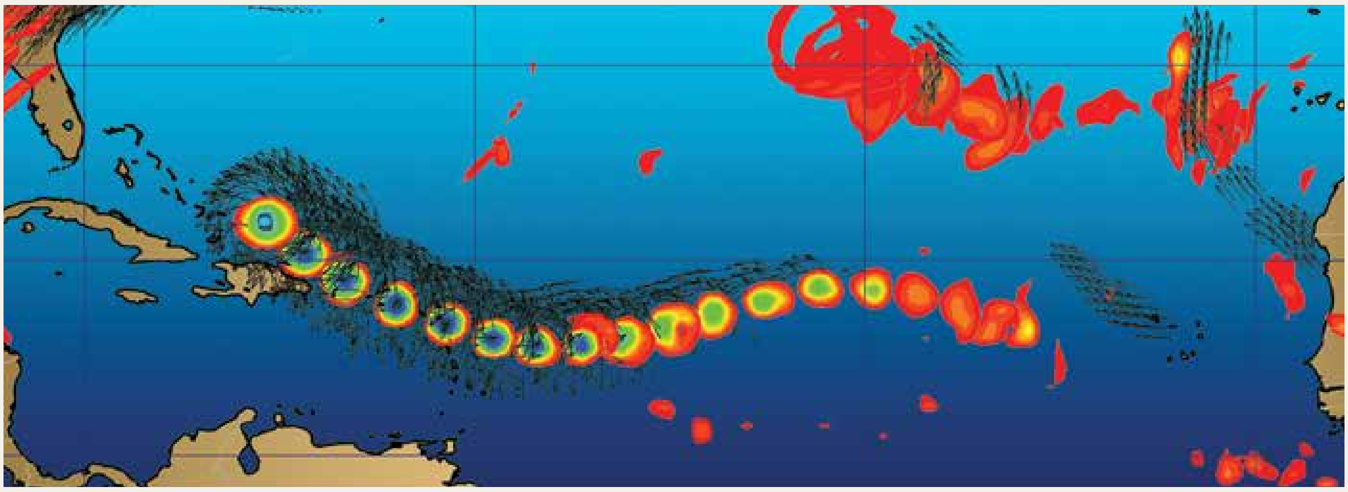
Summer heat waves and widespread dry conditions persisting into the autumn caused devastating wildfires in Portugal and other southern European countries.

Bearing in mind the urgent need to implement the Paris Agreement, these large-scale extreme weather events carrying the footprint of climate change remind us that accurate weather forecasts and early warnings are a corner-stone of adaptation in all countries, regardless of their level of development.

Not surprisingly, media coverage focused on disaster management and losses illustrated by high-resolution imagery. The reduction in lives lost and damage to property that can be attributed to early warnings based on accurate medium-range weather forecasts received very little reportage. The contribution of observations from meteorological satellites received even less. Indeed, the government of the United States thanked the European Union for providing high-resolution imagery from its Copernicus Sentinels to support disaster management after the landfall of hurricanes, but the European Centre for Medium-Range Weather Forecasts' (ECMWF) simulation showing that numerical weather prediction models would have simply missed the initial development of Irma off the Cape Verde islands if it had not been fed with satellite observations went unnoticed.

This is not a reason for frustration, as one can be proud that accurate weather forecasts and early warnings are taken for granted. On the contrary, this is a unique opportunity to stress the excellence and complementarity of operational EUMETSAT and Copernicus satellites, the former providing observations that are vital for preparedness, and the latter, imagery for disaster management.





THE WORD OF THE DIRECTOR-GENERAL

The start of routine operations of Sentinel-3A, the first Copernicus satellite operated by EUMETSAT on behalf of the EU, and the de-orbiting of Meteosat-7, the last Meteosat first generation satellite, made 2017 a landmark in the history of EUMETSAT satellite operations.

The entry into routine operations of Sentinel-3A signalled the start of a new era for EUMETSAT, as it now exploits a first operational Copernicus ocean-monitoring Sentinel on behalf of the EU, in addition to Jason-3.

The end of the exceptionally long lifetime of Meteosat-7 - more than 19 years - concluded 40 years of operations of Meteosat first generation satellites.

In retrospect, this foundational programme appears as the first demonstration of the capacity of ESA, EUMETSAT and European industry to deliver and exploit cost-effective and long-lived operational systems of European meteorological satellites that maximise return on investments.

The continued high availability of the four Meteosat Second Generation and the first two Metop satellites, all having exceeded their design lifetimes, has now confirmed this capacity. This enabled EUMETSAT Member States in 2017 to initiate the decision-making process for extending their operations well beyond 2020 at a total annual cost of about €40 million, which can be seen as a benchmark for two multi-satellite systems of this class.

In addition to ensuring a safe transition to the next-generation, more capable, Meteosat Third Generation (MTG) and EUMETSAT Polar System-Second Generation (EPS-SG) systems, extended operations offer additional benefits to Member States, the World Meteorological Organization and the worldwide user community.

Indeed, Meteosat-8, the first Meteosat Second Generation satellite which was launched in 2002, has already brought geostationary observations over the Indian Ocean to a standard never achieved before in this cyclone-prone region, and has a greater positive impact on global numerical weather prediction than the first-generation Meteosat-7 satellite.

Likewise, EUMETSAT plans to exploit the ageing Metop-A satellite on a drifting orbit up until 2022, thus forming with Metop-B and Metop-C a three-satellite constellation providing unprecedented observational inputs into global weather forecasts for up to three years.

The development of "big data" services took off in 2017. EUMETSAT launched a set of dedicated pathfinder projects for its own purposes, and, building on the infrastructure and innovative technology established in this framework, adopted an original distributed architecture for the Copernicus Data and Information Access platform it will deploy in cooperation with the ECMWF and Mercator-Ocean, the providers of the Copernicus Marine Environment, Atmosphere Monitoring and Climate information services.

Another major business objective was to advance preparations for the launch and commissioning of Sentinel-3B and Metop-C - both planned for 2018 - and for the operation of constellations of three Metop and two Sentinel-3 spacecraft.

On both fronts, the status at year's end was green. EUMETSAT and ESA achieved readiness for the launch of Sentinel-3B in December, and the launch of Metop-C remained on target for autumn 2018 after the successful repair and recalibration of the MHS and GOME-2 instruments and excellent progress achieved in the system validation test and operations preparation programmes.

In parallel, the cooperation with ESA passed important milestones in the development of the next-generation EUMETSAT satellite systems.

As a result of the schedule recovery measures undertaken by industry under the supervision of ESA, the MTG satellites' development schedule remained stable, enabling the performance of the first system validation test involving the satellite platform and the ground segment's mission control chain. In parallel, EUMETSAT accepted the two ground stations deployed in Italy and Switzerland for the acquisition of mission data and the first versions of the IT infrastructures hosting data processing chains, and commenced acceptance testing for the two satellite tracking, command and control stations in Italy and Romania.

THE WORD OF THE DIRECTOR-GENERAL

Likewise, cooperation with ESA, also involving the French Space Agency (CNES), the German Aerospace Centre (DLR) and United States' National Oceanic and Atmospheric Administration (NOAA) advanced the design of the EPS-SG system, comprising the Metop-SG A and -SG B satellites and a EUMETSAT-developed, end-to-end ground segment. EUMETSAT completed the preliminary design of the two main functional chains of the EPS-SG ground segment and kicked-off the contract for the launch services for the first pair of satellites.

However, replanning became necessary at the end of the year to realign the integration and test programme of the Metop-SG A satellite with the postponed delivery of some instruments. This reminded us that EPS-SG, like MTG, is one of the most innovative satellite systems under development in Europe. It involves significant technological challenges and development risks associated with instruments that will either be world premieres or achieve unprecedented levels of performance to fulfil user requirements approved by the EUMETSAT Member States.

Finally, the preliminary design of the Jason-CS/Sentinel-6 system and ground segment was concluded in 2017. The progress achieved in ground segment procurements and prototyping gives confidence that EUMETSAT will be ready in November 2018 to support the first system validation test involving the satellite platform and the mission control centre.

The progress achieved in the challenging development of these next-generation, multi-satellite systems, together with the confirmation that their design will achieve targeted performances, makes ESA and EUMETSAT confident that they will start in 2021 to "deploy world class, innovative, operational space systems for monitoring the weather, atmospheric composition, oceans and climate for the benefit of European citizens and our economy, building on synergies between EUMETSAT and relevant Copernicus assets". This will realise the main goal of the shared vision for joint contributions to the Space Strategy for Europe formalised in a statement I co-signed in November with my ESA counterpart, Prof Jan Wörner.

This will open a new era for operational meteorology, the main stakes being to revolutionise short-range forecasting of severe weather using MTG observations and to make medium-range forecasts up to 12 days ahead even more accurate using EPS-SG as the source of global observations of highest positive impact on global numerical weather prediction. This is expected to substantially improve the safety of people and property in Europe and increase the annual socio-economic benefit EUMETSAT satellites generate in Europe, currently estimated at more than €5.5 billion based on the most conservative assumptions.

With the deployment of the Copernicus Sentinel-4 and Sentinel-5 missions as part of the MTG and EPS-SG systems, and the full deployment of the Copernicus Sentinel-3 and Sentinel-6 missions, another common goal is to enable the EU's Copernicus programme to bring air quality forecasting to a new standard to better protect the health of European citizens and to boost the development of operational oceanography at the service of our blue economy.

From EUMETSAT's perspective, this will realise the Challenge 2025 strategy adopted by the Council in June 2016.

Preparing for the realisation of further objectives of the Space Strategy of Europe, EUMETSAT joined forces with ESA to support the European Commission in the planning and scoping of Copernicus in the next EU Multi-annual Financial Framework for 2021-2027. The focus was on a possible additional Sentinel mission for monitoring atmospheric CO_2 that could be exploited from 2025 onwards by EUMETSAT in synergy with its own missions, in support of the implementation of the Paris Agreement.

All of 2017's achievements have paved the way for a challenging 2018, during which EUMETSAT will demonstrate its first "big data" services, and, after the launch and commissioning of Sentinel-3B and Metop-C, for the first time exploit 11 satellites on behalf of its 30 Member States and the EU for monitoring weather, atmospheric composition, the oceans and our changing climate.

As none of these achievements would have been possible without the commitment of all EUMETSAT technical, scientific and administrative personnel, I wish to express my sincere gratitude to all of them. I also extend a warm welcome to our new staff, in particular, the young engineers and scientists who joined EUMETSAT in 2017.

My gratitude also goes to the EUMETSAT Council and its advisory bodies for their trust and guidance.

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

Cooperating State

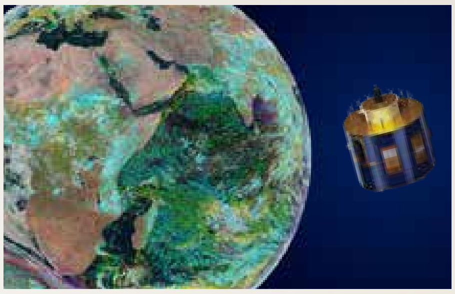
2009

Interactions restarted in the second half of the year with the new Serbian government on the possible accession of the Republic of Serbia as a full Member State after the expiration of its Cooperating State Agreement, and a special payment plan for the entry fee was proposed to facilitate accession.

In December, the Council approved a draft accession agreement and transition measures ensuring continuity of data services to Serbia into 2018 until the entry into force of its assumed accession.

Detailed information on accession was provided to Malta and Montenegro, which are both eligible for EUMETSAT membership as a Member of the European Union or a country having entered a pre-accession process.

2017 HIGHLIGHTS



JANUARY

Entry into force of the Jason-CS Memorandum of Understanding with ESA, NASA and NOAA

Reintegration of the repaired GOME-2 instrument on the payload module of the Metop-C satellite

Swapping of dual-Metop EPS operations to a new, virtualised ground segment

Start of development of the EPS-SG payload data acquisition and processing chain

FEBRUARY

Operational Meteosat Second Generation services start over the Indian Ocean with Meteosat-8

MARCH

Signature of a framework agreement with the China National Space Administration

Start of the third five-year Continuous Development and Operations Phase (CDOP 3) for the eight EUMETSAT Satellite Application Facilities

JULY

The Commission accepts the EUMETSAT, ECMWF and Mercator-Ocean joint proposal for a distributed Copernicus DIAS platform

The Jason-2 satellite is moved to a lower altitude with a long repeat cycle orbit

The agreement with China's State Oceanic Administration is extended by five years

AUGUST

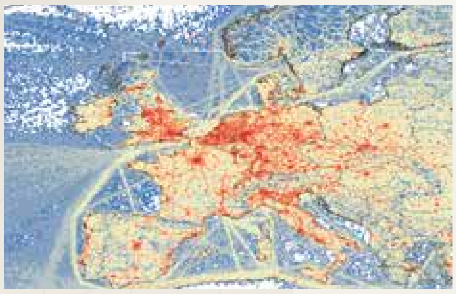
The ageing Metop-A is left drifting from its nominal orbit to extend service up until 2022

The EUMETSAT Copernicus Online data access service becomes operational

SEPTEMBER

Signature of a contract with Arianespace for launch services for the first Metop-SG satellites

First system validation test involving the MTG satellite platform and the mission control chain of the ground segment



APRIL

Start of EPS/Metop-C system integration verification and validation

De-orbiting of Meteosat-7, after more than 19 years in orbit

MAY

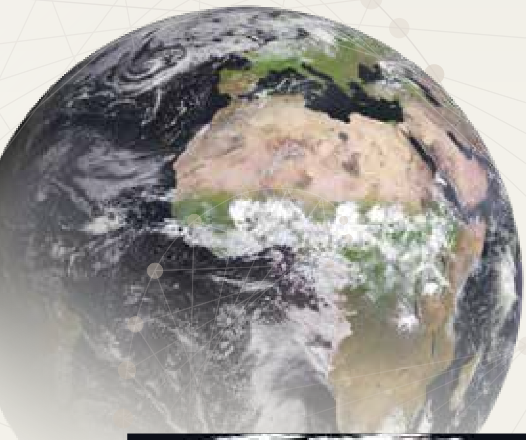
EUMETSAT starts to support the European Commission in the scoping and planning of Copernicus 2.0

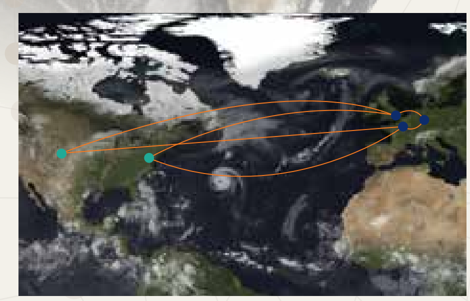
Conclusion of the preliminary design of the mission control and operations chain of the EPS-SG ground segment

JUNE

Decision to repair the MHS instrument of Metop-C

Start of recalibration of Metop-C's GOME-2 instrument





OCTOBER

Entry into operations of new transatlantic links used for data exchange with NOAA

Completion of the preliminary design of the Jason-CS/Sentinel-6 system

Validation of the design of the information-centric service infrastructure for pathfinder "big data" services

NOVEMBER

First meeting of the MTGUP! user preparedness group involving Member States' national meteorological services

Signature of a contract for hosting the EPS-SG reference X-band ground station in the Azores

Completion of the recalibration of Metop-C's GOME-2 instrument

DECEMBER

Acceptance of MTG mission data acquisition stations in Italy and Switzerland

Acceptance of repaired MHS instrument of Metop-C

Conclusion of preliminary design of the Jason-CS/Sentinel-6 ground segment

Readiness for de-storage of Meteosat-11 and relocation of Meteosat-9, -10 and -11 satellites

Start of deployment of the information-centric service infrastructure supporting pathfinder "big data" services

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK

Meteosat satellites

Meteosat-11
In-orbit storage

Meteosat-10
0°E — *Full Disc Imagery*
Provides the prime Meteosat full disc imagery service over the European continent, Africa and parts of the Atlantic and Indian oceans

Meteosat-9
9.5°E — *Rapid Scan Service (RSS)*
Delivers the RSS over Europe and adjacent seas

Meteosat-8
41.5°E — *Indian Ocean Data Coverage (IODC)*
Delivers the EUMETSAT contribution to the multi-partner IODC service from 41.5°E

Meteosat-7
57.5°E — *Indian Ocean Data Coverage (IODC)*
Supported the IODC mission, until 31 January 2017

The de-orbiting of Meteosat-7 puts a successful end to the foundational Meteosat first generation programme

Meteosat-7, the last Meteosat first generation spacecraft located over the Indian Ocean, was switched off on 11 April, after being manoeuvred to a graveyard orbit 500-600km above the geostationary orbit, well in excess of ISO 24113 debris mitigation requirements.

This put an end to the exceptionally long lifetime of Meteosat-7 - more than 19 years - and at the same time to 40 years of Meteosat first generation operations and to the Meteosat Transition Programme which bridged the gap with Meteosat Second Generation.

A more capable Meteosat-8 satellite replaces Meteosat-7 over the Indian Ocean

In the meantime, the Meteosat-8 second generation satellite entered routine operations from 41.5°E on 1 February as EUMETSAT's best effort contribution to more resilient Indian Ocean Data Coverage (IODC) services, fulfilling World Meteorological Organization (WMO) requirements and involving geostationary satellites from India, Russia and China.

Meteosat-8 was manoeuvred twice, on 26 September to realign its spin axis with the perpendicular to the orbit plane, and on 13 December to reduce the risk of collision with a decommissioned Nigerian satellite.

EUMETSAT ready for in-orbit destorage of Meteosat-11 and relocation of satellites

The Meteosat-9 and -10 satellites remained in their nominal orbital positions and Meteosat-11 in its in-orbit storage configuration.

A Meteosat-10 inclination manoeuvre was executed on 22 May, followed by an increase of the spin rate of the satellite by 0.4rpm.

In December, readiness was achieved for the in-orbit destorage of Meteosat-11 and the next cycle of relocation manoeuvres required in the first quarter of 2018, when Meteosat-9 ceases to be usable in rapid scan mode and needs to be replaced by Meteosat-10.

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK

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 & Rescue missions

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

Jason-2
NSO 66° incl. — *Additional Ocean Surface Topography Mission*
Delivers measurements of ocean surface topography and sea state measurements from a long repeat cycle orbit (mission shared with CNES, NOAA, NASA)

Copernicus Sentinel-3A
SSO 98.7° incl. — *Copernicus Sentinel-3 mission*
Delivers Copernicus Marine data services from 814km altitude

The ageing Metop-A is left drifting from its nominal orbit to extend service up until 2022

The EUMETSAT Polar System continued to be exploited as a dual-Metop satellite system.

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

A Metop-B out-of-plane manoeuvre was executed on 13 September in a new one-burn strategy that reduces the length of mission outage during such manoeuvres.

The ageing Metop-A continued to serve as the secondary satellite, dumping global data only once per orbit at Svalbard whilst providing primary support to the ARGOS localisation and data collection mission.

Metop-A could be maintained on its nominal orbit for two more months than foreseen, until 23 August. The Local Time at Ascending Node of its orbit was then left drifting at a rate of 5 seconds per week, which slowly brings the satellite closer to Metop-B, in order to extend its operational lifetime up until 2022. It will then be re-orbited to comply with debris mitigation regulations, as agreed by the EUMETSAT Council.

Within a three-satellite ocean-monitoring constellation, the ageing Jason-2 satellite is manoeuvred to a lower, long repeat cycle orbit

The high precision ocean altimetry mission from the reference non-synchronous orbit continued to be performed by the Jason-3 satellite.

After being exploited until June on a "reference interleaved" orbit that doubles the space and time sampling of the measurements of both Jason satellites, the ageing Jason-2 satellite was manoeuvred to a lower (-27km), long repeat cycle orbit to free the reference orbit for future missions.

Sentinel-3A flight operations included nominal out of plane manoeuvres and activations of the Sea and Land Surface Temperature Radiometer (SLSTR) instrument in non-nominal modes requested by the Sentinel-3 Validation Team for assessing stray light and the capability of visible channels to detect gas flares during night-time.

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK

Meteosat-8 brings geostationary imagery to a new standard over the Indian Ocean

The availability of the Indian Ocean Data Coverage (IODC) services delivered by Meteosat-7 from 57.5°E until 31 January and then by Meteosat-8 from 41.5°E, remained very high, though 1% below target in the third quarter for imagery products. This was due to slightly degraded attitude stability of Meteosat-8 at the start of the critical autumn eclipse season.

With Meteosat-8 operational at 41.5°E, the standard of geostationary imagery over the Indian Ocean increased to a level never achieved before, with images taken every 15 minutes in 12 spectral channels, including the 1km high-resolution visible channel. Studies performed by the European Centre for Medium-Range Weather Forecasts (ECMWF) showed that wind vector products extracted from Meteosat-8 imagery have a greater positive impact on numerical weather prediction than Meteosat-7 products due to their higher number and better quality.

In addition, EUMETSAT's Central Europe Member States and user communities in Africa, the Western Balkans, Eastern Europe and Black Sea countries confirmed that the 41.5°E position is more attractive for them than the former 57.5°E position of Meteosat-7.

The Council takes steps to extend operations of healthy Meteosat Second Generation satellites

The availability of the 0° Full Earth Scan service remained very high, as a result of the excellent performance of Meteosat-10, though the timeliness of some imagery products was impacted by known problems with the multi-mission data dissemination system until their elimination in July.

The availability of the Rapid Scan Service performed from 9.5°E remained close to the maximum achievable with no backup satellite, as there was almost no outage in addition to the planned one-month pause (from 10 January to 9 February) and 48-hour monthly interruptions which are both required to preserve the lifetime of Meteosat-9's scan mechanism. It was, however, 1% below target in the third quarter, due to the entry of the platform into safe mode on 28 September, which caused a 27-hour interruption of the imagery service and a five-day outage for meteorological products.

The availability of Earth radiation products was only impacted by periodic blockings of the GERB instrument's de-spin mirror, attributed to solid lubricant particles.

In view of the good health of all Meteosat Second Generation (MSG) satellites and their predicted fuel lifetime, the Council opened the voting process for extended operations until 2030.

Likewise, the Council opens the vote for extending operations of a robust EUMETSAT Polar System

The primary Metop-B satellite continued to perform well with only a couple of anomalies affecting the HIRS and AMSU-A1 legacy sounders.

The noise of AMSU-A1's channel 7 became out of specification from 31 January to 16 February before returning to nominal level. This triggered an investigation also addressing anomalous noise previously observed on the same channel of the Metop-A instrument.

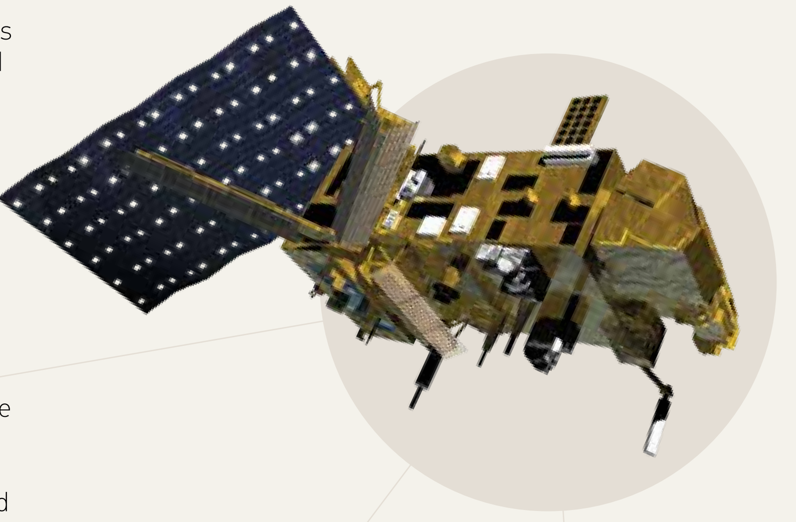
The erratic variations of the high noise level of all long wave channels of the HIRS infrared sounder experienced in 2016 reappeared in December for a couple of weeks and disappeared again. This suggests that the loose filter wheel identified as the likely cause of noise variations may have different stable positions.

The ageing, secondary, Metop-A satellite continued to perform well despite further degradations of its legacy HIRS and AMSU-A1 infrared and microwave sounders.

Despite the loss of two channels in 2009 and 2016 and the high, exponentially increasing noise of its channel 3, the AMSU-A1 microwave temperature sounder continued to deliver usable data, except at the end of May, when high noise spikes were observed on channel 5.

OPERATING COMPLEX SATELLITE SYSTEMS AROUND THE CLOCK

The HIRS instrument continued to be operated in high power mode in an attempt to migrate lubricant back into the bearings of its filter wheel motor. However, the filter wheel is suspected to have stopped for five hours on 28 August, corrupting all products. Erratic high noise has continued to affect long wave channels, and the prognosis is that this non mission-critical instrument will soon reach the end of its lifetime.



By contrast, the IASI instrument continued to perform very well, and the noise of all channels of the MHS microwave humidity sounder remained within specifications, with the exception of occasional noise spikes on one channel.

Space weather events and a ground segment hardware failure caused minor losses and outages of data for both satellites.

In view of the good health of the Metop-A and -B satellites and their predicted lifetime, the Council opened the voting process for extended operations of the EPS system until 2027.

Jason-2 changes orbit to extract maximum benefits from its end of life

The availability of all Jason-3 product services remained above targets throughout the year.

The ageing Jason-2 satellite also performed very well until mid-March, but then entered safe hold mode three times due to anomalies of two of its three gyroscopes observed at ambient temperature above 25°C.

EUMETSAT, CNES, NOAA and NASA decided on 20 June to move the satellite from its "reference interleaved" orbit to a lower (-27km), longer repeat cycle orbit and to continue investigations on this orbit in parallel to mission operations. The satellite will use the 8km ground track spacing of this orbit to produce a high resolution map of the mean sea surface height at 1cm accuracy. This will provide a reference for extracting sea surface height anomalies from early measurements of future altimeter missions that do not repeat ground tracks of previous missions, like Sentinel-3B.

Mission operations started on the new orbit on 24 July and have since then been nominal with only one interruption due to a gyroscope anomaly, from 14 September to 13 October.

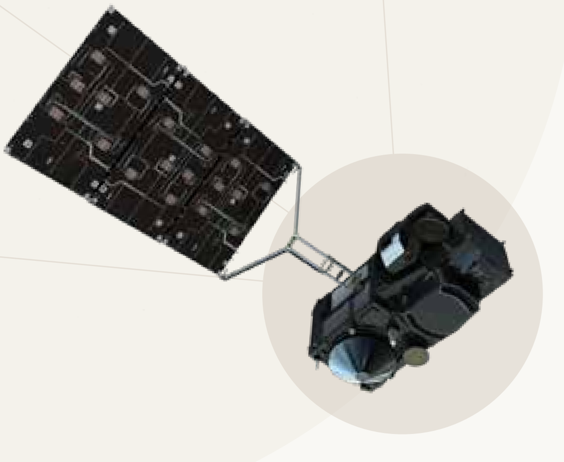
In December, the four Jason-2 programme partners confirmed their decision to extend Jason-2 operations until the end of 2019.

A promising start to Sentinel-3A routine operations

The availability of the Sentinel-3A satellite and instruments remained high, with minor outages of optical instruments, probably due to space weather, causing the loss of a couple of days of SLSTR visible and infrared imagery and the corruption of part of Ocean and Land Colour Instrument (OLCI) data over a total of 21 hours.

The Sentinel-3A mission entered into routine operations on 16 October, after the release of all products in July.

In the first quarter of routine operations, the availability of data and marine product services was close to 100% for altimeter and sea surface temperature products, and 1% below the 98.5% target for ocean colour products, as a result of instrument and ground segment anomalies.



EVOLUTION OF GROUND INFRASTRUCTURE

Virtualisation and increased cooling efficiency further reduce energy consumption and carbon footprint

Dual-Metop operations were swapped in January to the new, virtualised configuration of the EPS ground segment developed for three-Metop operations, with no discontinuation of services. The virtualised mission control system was then deployed at the Backup Control Centre in Madrid, putting the finishing touch to the virtualisation project, which, as anticipated, reduced power consumption by 84%, saving €44,000 on electricity costs and 167t of CO_2 emissions per year.

The power usage effectiveness measuring the ratio of the power used in the Technical Infrastructure Building (TIB) to the "useful" power delivered to IT equipment was further improved from 1.45 to 1.35, and row housing was installed to separate hot and cold corridors to further improve cooling efficiency.

Refurbished control rooms will host operations of more satellite systems in the same space

After the dismantling of the Meteosat-7 control systems, the Meteosat control room started to be refurbished to accommodate both MSG and MTG operations in the same limited space, using the latest technology for the flexible allocation of screens to different missions. Meteosat operations were migrated to the first refurbished half in December, enabling the execution of an anti-collision manoeuver from there and the start of the refurbishment of the second half.

A similar project started in June to transform the current EPS and Sentinel-3 control rooms into a single, more efficient Low Earth Orbit (LEO) control room also capable of hosting EPS-SG and Jason-CS operations.

A multi-mission Radio Occultation Support Network (RSN) service fulfilling the requirements of the EPS and EPS-SG GNSS radio-occultation missions was procured to reduce overall costs.

The downsizing of Meteosat Second Generation ground station services is on track

All activities required to replace Meteosat Second Generation ground station services available from Usingen until April 2018 progressed according to the very tight schedule. The objective is to reduce the number of ground station sites and related operations cost in anticipation of the planned reduction of the number of satellites in orbit, while securing the continuity of safe operations of the current fleet of four.

One antenna in Fucino previously used for Meteosat-7 operations was made MSG-capable in February, enabling operations of the fleet of four satellites without one of the three antennas hosted in Usingen. The unused antenna could then be dismounted, relocated and rebuilt in Fucino and was declared ready for operations on 20 November.

The first refurbished half of the Meteosat Mission Control Centre became available for operations in December

EVOLUTION OF GROUND INFRASTRUCTURE

Three MSG-capable antenna are available in Fucino, Italy

Replacements for backup tracking and command and mission data acquisition capacities from the two antennas remaining in Usingen until April 2018 had to be established in parallel. This was to provide temporary services until both antennas become available again in 2019 after their relocation to the existing backup site at Cheia, Romania.

For this purpose, one telemetry tracking and control station already deployed in Fucino to support MTG development was made ready for temporary use for MSG operations, after testing with Meteosat-11, and an antenna available in Lario was refurbished to provide a temporary MSG mission data acquisition service.

As a result, the first configuration of the Meteosat ground segment capable of operating four satellites without services from Usingen is still planned to be ready for operations by March 2018.

The next step, for which a contract was signed in December, will be the relocation of the two remaining antennas from Usingen to Cheia.

MTG TT&C antenna in Fucino, Italy is used as a temporary backup for MSG operations

In Kangerlussuaq, DMI Director Marianne Thyrring presents the new EARS antenna to Denmark's Minister for Energy, Utilities and Climate Lars Christian Lilleholt (right) (source: K. Vilic, DMI)

Ground systems for polar orbit missions upgraded in far north and Turkish desert

EUMETSAT entered the final stages of the EPS ground segment refurbishment required to support operations in the next decade.

After completion of the design of the three new C-band transponders to be used for calibrating the Metop ASCAT instruments, the upgrade of the hosting infrastructure started in a desert area of Turkey, taking into account the requirements for hosting the Metop-SG calibration transponders at a later stage. The challenging objective is to deploy the new transponders in summer 2018 to support the commissioning of Metop-C.

In Svalbard, Spitzbergen, the refurbishment of both Metop command and data acquisition stations was completed with the upgrade of the obsolete S-band converters.

Also in the far north, but in Greenland, an additional X/L-band antenna was deployed at the Kangerlussuaq EARS station in cooperation with the Danish Meteorological Institute to provide additional capacity for the planned acquisition of data broadcast by US, Chinese and EUMETSAT's Metop-SG satellites. For the same purpose, all of the network of EARS stations' physical communication lines were upgraded to a scalable fibre-based solution and bandwidth was increased from 6 to 10Mbps.

TOWARDS EUMETSAT BIG DATA SERVICES

Cloud infrastructure starts to be deployed for pathfinder big data services

The six pathfinder projects for big data services addressing online data access, web map services, multi-casting of large data volumes via terrestrial networks, format conversion and processing as a service entered their development phase.

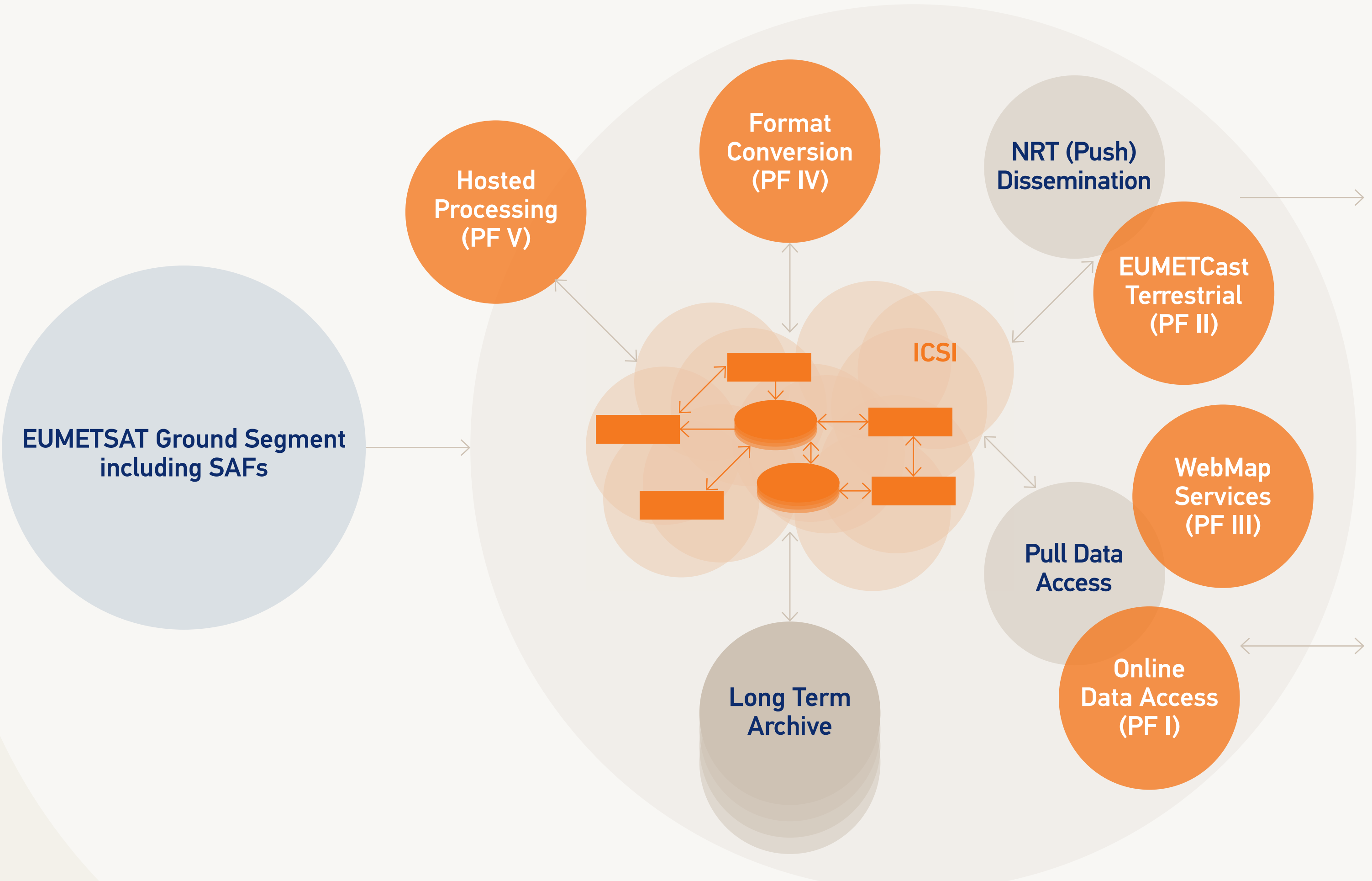
After the procurement of industrial support for the cloud infrastructure, web applications software and hosted processing services, architectural concepts for the cloud infrastructure supporting all pathfinder services were assessed against use cases, leading to the selection of a preferred architecture in October.

The design of the software as a service and data as a service layers of the infrastructure was then finalised, followed by the start of the design and prototyping of online data access, web map services and the format conversion toolbox.

The deployment of the cloud infrastructure and supporting web applications software started in December and should be complete in February 2018 for end-to-end testing prior to the user validation phase planned for April.

User validation concepts and use cases were selected for each pathfinder service. In particular, software for retrieving surface albedo products from Meteosat imagery and for tracking tropical mesoscale convective systems were selected for testing hosted processing.

Overview of pathfinder big data services and the supporting information-centric cloud infrastructure (in orange) added to existing systems (in grey)

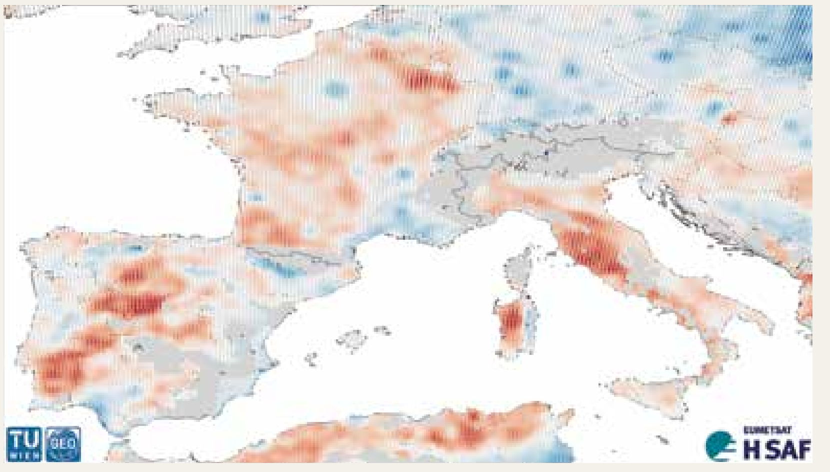


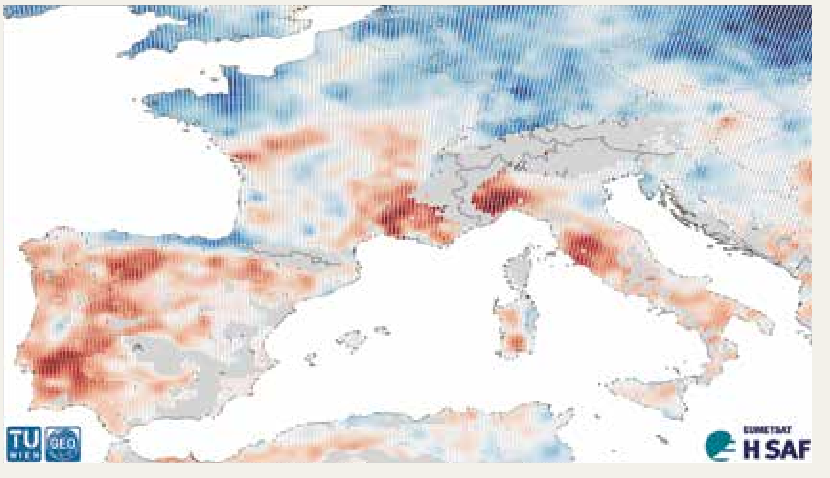
EUMETSAT SATELLITES TRACK CLIMATE FEATURES

Metop radars observe persistent widespread dry conditions in southern Europe

In a year 2017 described by the World Meteorological Organization as globally "one of the three warmest years on record and the warmest not influenced by an El Niño event", southern Europe experienced high temperatures associated with summer heat waves and widespread dry conditions.

Deficits of precipitation were prominent in spring and summer, making 2017 the driest year on record in Italy and the third driest year in Portugal. Dry conditions even persisted into the autumn in Portugal and Spain, which had its driest autumn on record.





Right: Maps of soil moisture anomalies illustrate extremely dry conditions over southern Europe persisting from spring (top) into autumn (bottom) (source: H SAF)

Below: A woman with children cool off in water fountains in a park as hot summer temperatures hit Paris, France, 22 June 2017 (source: Reuters)

EUMETSAT SATELLITES TRACK CLIMATE FEATURES

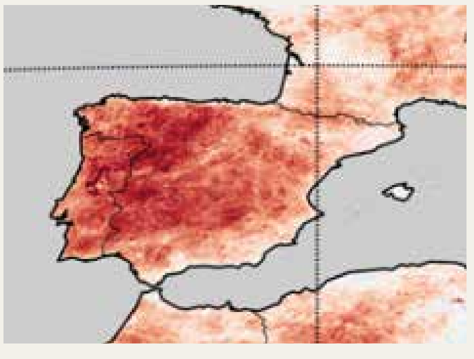
During persistent dry and warm conditions, Portugal is hit by devastating wildfires in June and October

Wildfires were very active in the Mediterranean region, particularly in Croatia, southern France, Italy, Spain and Portugal.

The most devastating fire outbreak occurred on 17-18 June in central Portugal, killing 64 people near Pedrogao Grande, followed in mid-October by further unusually late fire outbreaks killing another 45 in Portugal and north-western Spain.

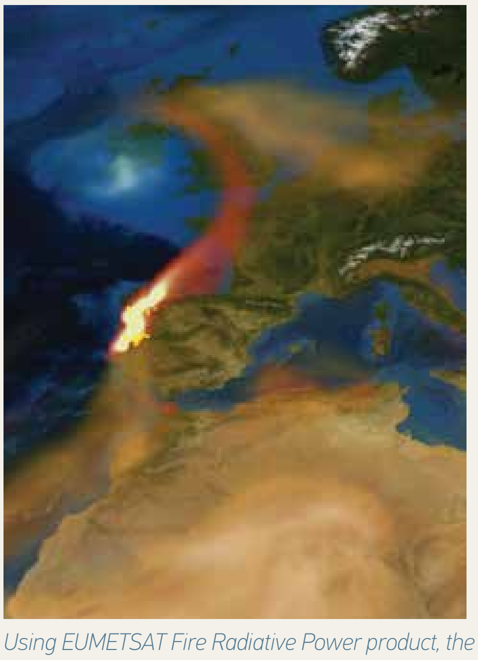
Firefighters work to put out a forest fire near Bouca, in central Portugal (source: Reuters)

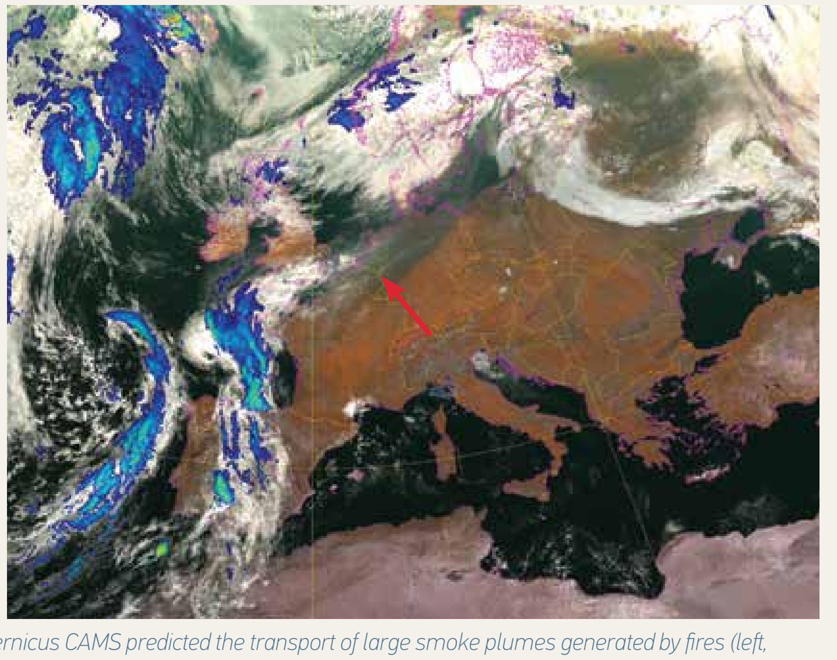
In October, composite Meteosat imagery shows a persisting pattern of high land surface temperature anomaly over the Iberian Peninsula, with "hot spots" exceeding 7 °C above normal in central Portugal



Over the weekend of 14-15 October, exceptionally warm and dry conditions and strong winds triggered by Hurricane Ophelia circulating off the Azores caused more than 140 wildfire breakouts in central and northern Portugal and Galicia, in Spain.

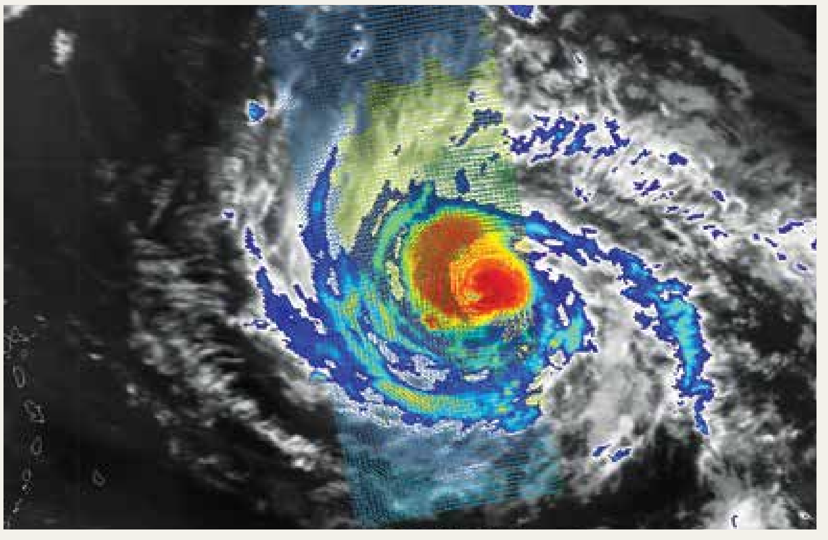
The intensity of fires was measured by the Fire Radiative Power products extracted from Metop imagery used by the Copernicus Atmosphere Monitoring Service to predict the transport of smoke across Europe, which was also observed in real time by Meteosat imagery.





Using EUMETSAT Fire Radiative Power product, the Copernicus CAMS predicted the transport of large smoke plumes generated by fires (left, source: Copernicus CAMS) as far east as the Netherlands, which was confirmed by Meteosat imagery (red arrow) on 17 October (right)

EUMETSAT SATELLITES TRACK CLIMATE FEATURES

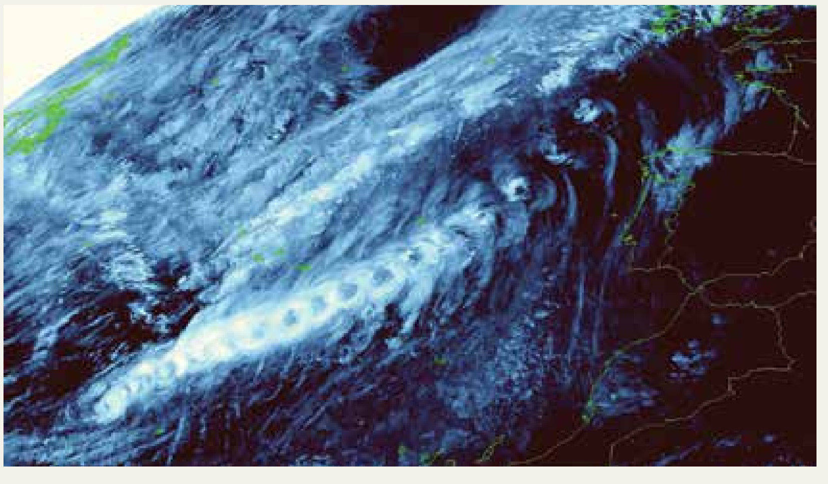


On 4 September, Meteosat imagery and the Metop-A ASCAT radar map the cloud structure and the ocean surface wind field around Irma, on its way to the Caribbean

EUMETSAT satellites observe a very active hurricane season in the North Atlantic...

The North Atlantic hurricane season was very active, with 17 named storms, a rapid succession of three exceptionally destructive hurricanes in late August and September (Harvey, Irma and Maria) and the highest accumulated cyclone energy ever recorded in September.

Irma was the strongest hurricane on record outside of the Caribbean Sea and Gulf of Mexico, reaching Category 5 intensity on 5 September with winds of 280km/h, and killed more than 20 people in the Caribbean.



Ophelia's progress towards the North Atlantic from 13 October to 16 October as observed by Meteosat-10 at three-hourly intervals (top). Large waves crash along sea defences and the harbour as storm Ophelia approaches Porthleven in Cornwall, UK, 16 October 2017 (bottom, source: Reuters).

...including Ophelia, the easternmost cyclone on record to reach category 3 intensity

Closer to continental Europe, cyclone Ophelia formed on 11 October due to warm sea surface temperature, below-average temperature aloft and low wind shear. On 14 October, while south of the Azores, it became the easternmost hurricane on record to reach Category 3 intensity, generating high winds which contributed to destructive wildfires in Portugal.

Shortly after achieving peak intensity, Ophelia quickly weakened whilst accelerating its course towards the north and became extratropical on 16 October. It brought strong winds, high waves and heavy rains and caused widespread damage in the United Kingdom and Ireland, where at least three people died.

EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

EUMETSAT satellites play a key role in preparedness for tropical cyclones

Through their positive impact on the quality of seasonal forecasts and medium-range numerical prediction, Jason and Metop observations play a key role in the preparedness for tropical cyclones. Once again, in 2017, this proved vital for French, Dutch, Portuguese, Spanish and UK citizens who live on islands in the tropics.

Firstly, Jason ocean surface topography measurements have contributed to probabilistic seasonal forecasts from the ECMWF, the Met Office, Météo-France and other centres predicting months in advance that the June-November 2017 cyclone season would likely be more active than average in the North Atlantic.

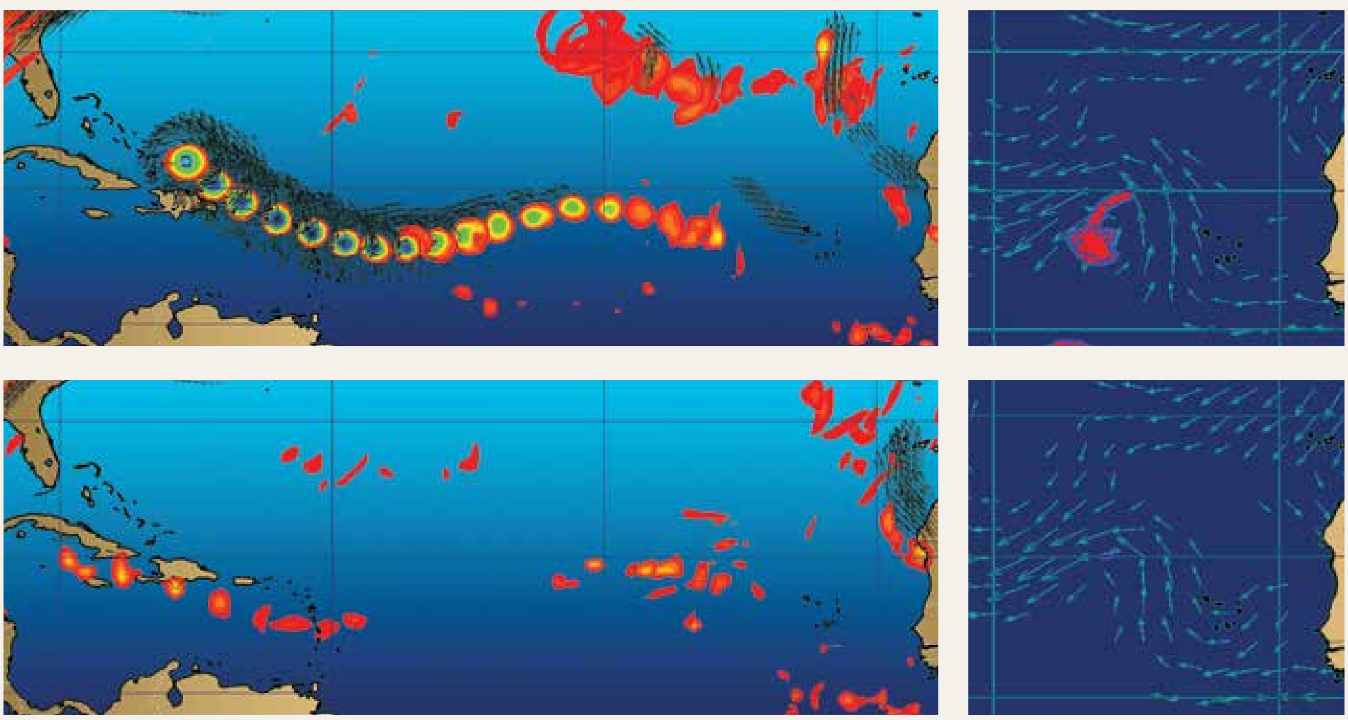
Then, Metop observations were crucial for preparedness, being critical inputs for medium-range forecasts of the initial development of cyclones, the evolution of their intensity and trajectory which altogether determine the territories exposed to risks. A three-to-four-day lead time is indeed necessary for civil protection and for local authorities to take appropriate measures on remote islands, including the mobilisation of additional resources from non-exposed territories.

In the case of Irma, simulations performed by the ECMWF of a complete loss of observations from meteorological satellites starting four days before Irma hit the European Caribbean islands revealed that, without satellite observations, their global model would have simply missed the initial development of Irma off the Cape Verde islands.

In the Caribbean Islands of Saint Martin and Saint-Barthélémy, hit for the first time by a cyclone of Category 5 intensity, good trajectory forecasts enabled exceptional measures to be taken three days in advance. This certainly contributed to limiting human losses on a devastated Saint Martin Island.

The forecast-based yellow warning of 3 September (inset) informing the population of Saint Martin of the arrival of Irma three days in advance contributed to limiting the number of lives lost on Saint Martin island (main photo, source: Reuters)

The initial conditions largely determined by satellite observations (below, top right) were essential to the very good ECMWF forecasts of the development and trajectory of Irma, shown at intervals of 12 hours (top left). Without satellite observations (bottom) the model misses the initial development of Irma due to poor initial conditions.



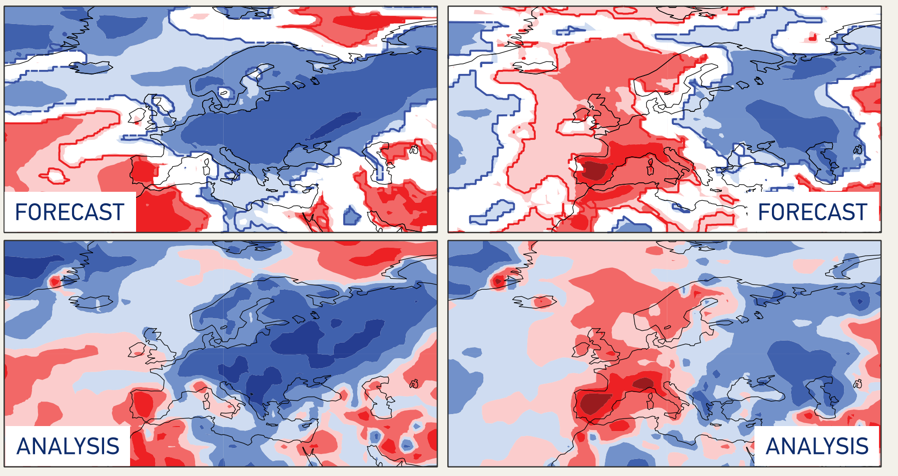
EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

Jason and Metop data help predict late cold spells and early heat waves more than one week in advance

Numerous heatwaves hit southern Europe from mid-June to early August 2017, setting temperature records in Granada and Cordoba, Spain, both above 45°C, in Pescara, Italy, and Antalya, Turkey.

By contrast, in the third week of April, a late cold spell had severe impacts on agriculture in several European countries.

Both events were announced more than one week in advance by the ECMWF probabilistic forecasts using coupled atmosphere-ocean models initialised by Jason and Metop observations.



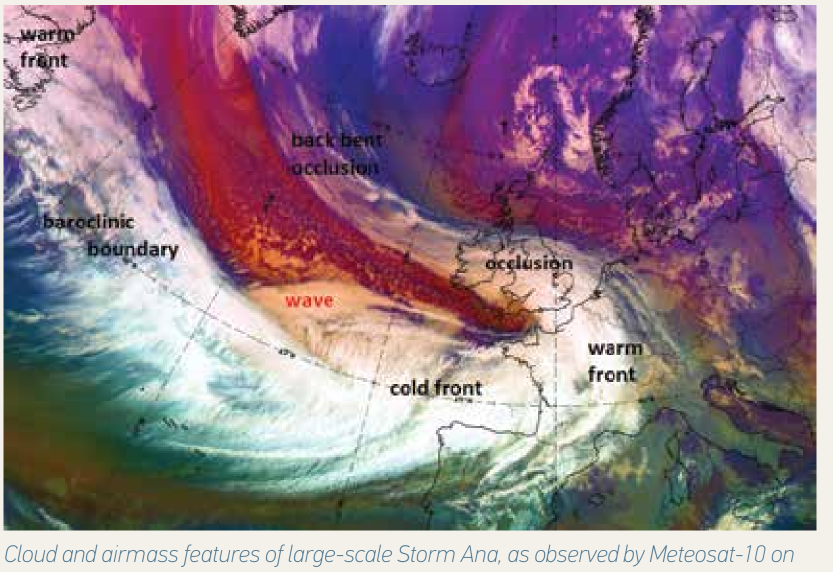
Using data from Metop and Jason, the ECMWF probabilistic forecasts predict more than one week in advance temperatures over Europe 3 to 6 degrees below normal in April (top left) and 3 to 10 degrees above normal in June (top right). Observed conditions (analysis) are shown in the lower panels (source: ECMWF)

Storm Ana batters many parts of Central and Northern Europe

Metop observations currently account for 27% of the total reduction of errors in Day 1 forecasts due to all observations ingested in real time. They were again essential for the numerical prediction of large-scale winter storms, like the one hitting Brittany, France, on 6-7 March, with wind gusts above 190km/h, and one which struck Austria and the Czech Republic in October, killing 11 people.

The most remarkable large-scale storm in 2017 was perhaps Ana, which brought both high winds and heavy precipitation across Europe from 10-12 December.

Over the Alps, Ana advected moist and warm air from the Mediterranean Sea to the mountains, producing heavy rain and snowfall south of the Alps and a very strong Föhn storm to the north, with wind-speeds of 200km/h recorded in Salzburg. On 11 December, western France, Spain and Italy were also slammed by strong winds, heavy rain and snow, before the centre of the storm moved northeast on 12 December, bringing severe weather from Poland to Finland.



Cloud and airmass features of large-scale Storm Ana, as observed by Meteosat-10 on 10 December at 06:00 UTC

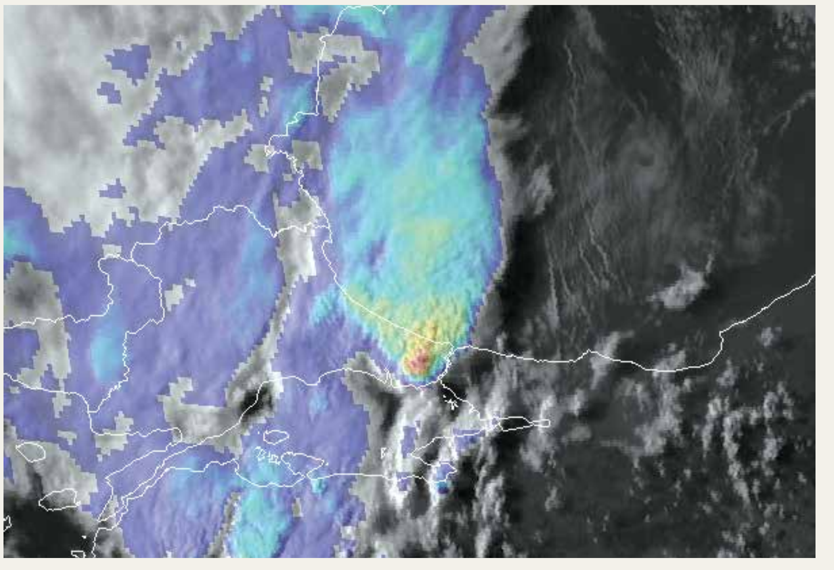
Waves crash against a lighthouse on the Vlavelez seafront in the northern Spanish region of Asturias, 11 December 2017 (source: Reuters)

EUMETSAT SATELLITES HELP FORECAST HIGH-IMPACT WEATHER

Meteosat imagery helps Turkish forecasters to nowcast severe thunderstorms…

Meteosat imagery was used by forecasters for nowcasting the development of a number of severe thunderstorms and releasing warnings aimed at mitigating their destructive impact.

On 27 July, Turkish State Meteorological Service forecasters used Meteosat imagery to detect and monitor the development of a convective "supercell" that produced high winds and hailstones up to 9cm in diameter over Istanbul, killing two people and injuring dozens and damaging rooves, trees, vehicles and even an aeroplane.



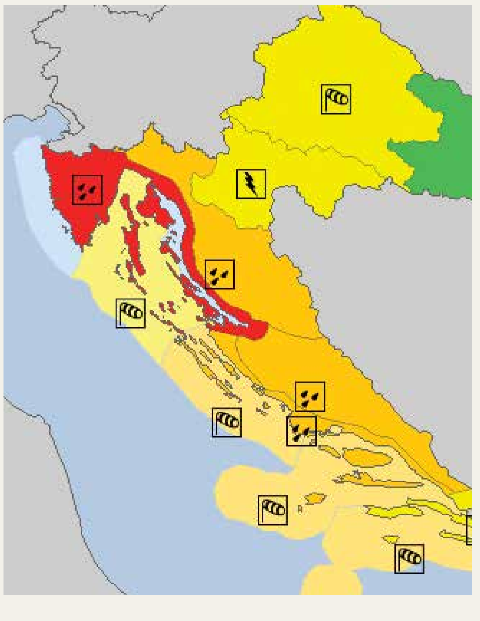
Meteosat-8 visible imagery overlaid with infrared imagery showing the turbulent texture of clouds around a developing supercell characterized by very cold cloud top temperatures (in red).

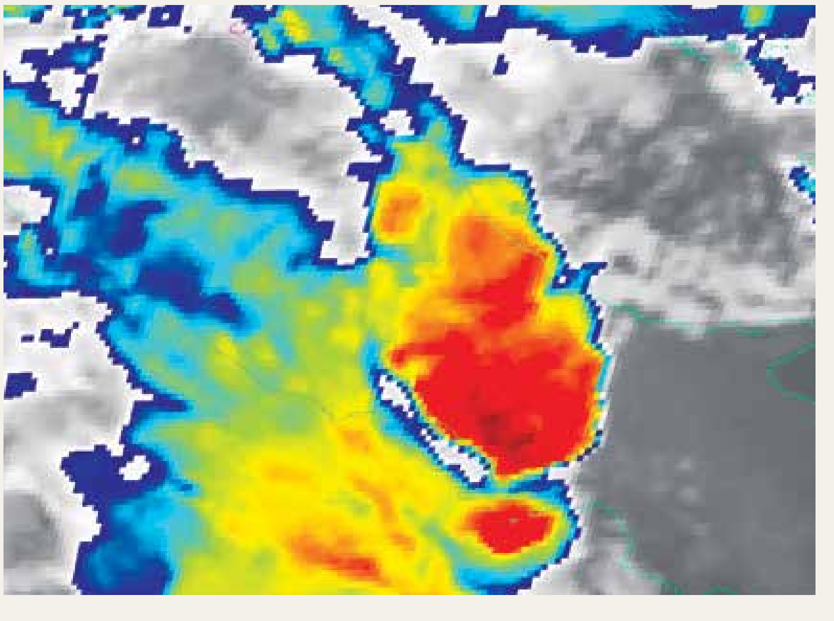
…and confirm red warning issued by the Croatian Meteorological and Hydrological Service

In Croatia, a red warning issued by the national meteorological service informed citizens one day in advance that a severe thunderstorm coming from Tuscany, where it had flooded Livorno and killed six persons, would reach the country in the evening of 10 September.

Indeed, the announced thunderstorm further developed in a flow of moist air, becoming increasingly unstable over a warm Adriatic sea to form a mesoscale convective system of more than 400km in diameter. It remained quasi-stationary over northern Dalmatia on 11 September, producing 283mm of rain in 12 hours in Zadar and also causing devastating flash floods in Nin.

On 10 September, the Croatian weather service released a red warning about a severe thunderstorm (below left, source: DHMZ/Meteoalarm). Meteosat-10 infrared imagery from 11 September (below right) shows very cold cloud tops (in red) associated with severe convection and a distinct warm spot (blue) enclosed in a cold U-shape indicating penetration into the warmer stratosphere and strong wind shear.





DATA ACCESS AND REAL-TIME DELIVERY

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

EUMETSAT must deliver observational products safely to a widely distributed population of operational users as quickly as possible after sensing because the value of observations for forecasting diminishes with increasing latency. In particular, geostationary imagery must be disseminated within minutes from sensing for nowcasting applications.

Time-critical products are therefore broadcast to operational users by EUMETCast services using commercial telecommunication satellites and the same reliable, flexible and cost-effective technology as used for digital TV broadcasting. These "push mode" services are supplemented by online services, including an increasing range of web map services.

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

The availability of all EUMETCast services remained above 99.9%, except in July and August when it dropped slightly, whilst remaining above the 99.5% target, due to a hardware failure within the power supply system of the data uplink station.

The capacity of the EUMETCast-Europe service was increased to two transponders, and the second transponder started to be used operationally for the redistribution of GOES-16 imagery from NOAA.

The EUMETCast-Africa service was reprocured to become independent from the EUMETCast-Europe service in 2018 and increase bandwidth capacity to offer full flexibility to address the specific requirements of the African user community.

More content and new developments for online data access and user support services

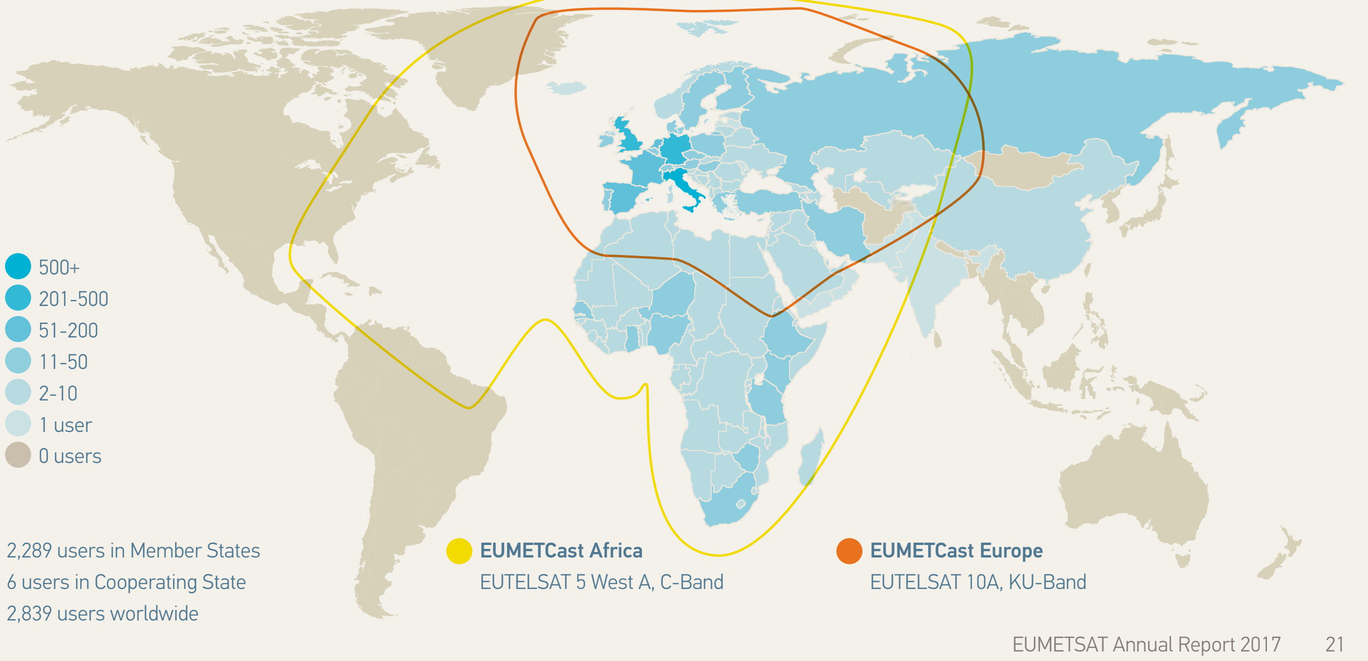
With the addition of Sentinel-3A marine products and Meteosat-8 volcanic ash, fog, convection, cloud microphysics and snow cover products, the EUMETView pilot Web Map Service now offers online visualisations of the full set of Meteosat and Sentinel-3 products. It will become operational in 2018, on a dedicated platform enabling online visualisation of 30 days of imagery products.

The Copernicus Online Data Access (CODA) service became directly accessible via the EUMETSAT EO Portal in August in a single sign-on version. It then was augmented by a new "CODARep" service making the reprocessed Sentinel-3A data acquired during the commissioning and operations ramp-up phases available online.

The CODA and EUMETView services are precursors of more advanced online data access and web services to be demonstrated in 2018 by the pathfinder projects for big data services.

To improve support to users, new versions of the web-based data centre ordering application were released and, in view of the positive user feedback, the old Java-based ordering application was phased out in July.

User handbooks for the Copernicus Sentinel-3 products were made available on the web and a new version of the netCDF format was introduced that reduces the size of products by 30-70% whilst maintaining compatibility with existing open-source netCDF-4 tools.



DATA ACCESS AND REAL-TIME DELIVERY

The EARS network gives fast access to regional products from polar-orbiting satellites

Because of less stringent latency requirements from users, global Metop data are recorded on board, dumped to high-latitude ground stations at each 100-minute orbit cycle, 14 times a day, and repatriated to EUMETSAT 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 dumped twice per orbit at Svalbard and McMurdo, to halve latency to 50 minutes.

To fulfil the more stringent timeliness requirements of nowcasting at high altitudes and very short-range forecasting across Europe, the EUMETSAT Advanced Retransmission Service (EARS) 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 dissemination of output products via EUMETCast-Europe.

New products for the EARS regional data services

The cloud top height product delivered as part of the EARS-NWC imagery service was improved by updated processing software.

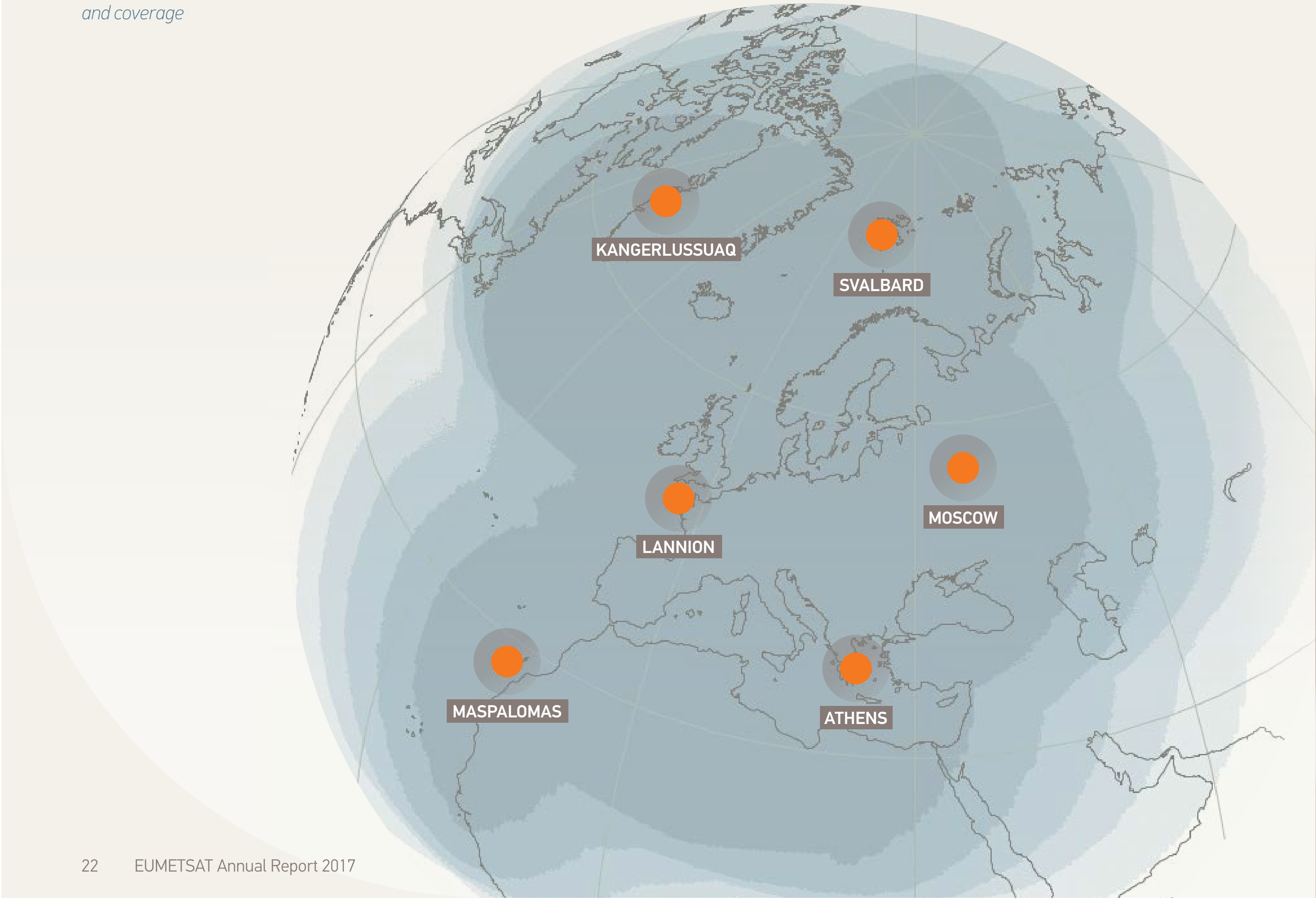
Noise information available from HIRS and AMSU instruments was added to regional ATOVS sounding products to inform users of the quality of input observations.

The EARS-IASI level 1 service delivering infrared spectra was extended in coverage, with the addition of Metop-B products extracted at the Russian Khabarovsk station.

The pilot EARS-IASI level 2 regional service delivering profiles of temperature and humidity became operational after the deployment of a more capable retrieval algorithm.

After the launches of the NOAA-20 and the Chinese FY-3D satellites in November, preparations for new EARS FY-3D and EARS-NOAA20 regional services for sounding and imagery products was accelerated.

EARS European ground station network and coverage



SUPPORT TO CLIMATE SERVICES

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

Mobilising expertise and infrastructure in Darmstadt and across its network of Satellite Application Facilities (SAFs), in particular at the SAF on Climate Monitoring (CM SAF), EUMETSAT's climate monitoring activities encompass recalibration of historical satellite data, production of homogeneous series of physical parameters (e.g. radiance, reflectance) called fundamental climate data records, downstream extraction of series of geophysical parameters (e.g. temperature, wind) forming thematic climate data records (TCDR) and validation throughout the process.

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

Out of the almost 100 climate data records accepted by the World Climate Research Programme for use in the next round of Climate Model Intercomparison Projects, almost one-third originates from EUMETSAT.

A new, simplified policy framework aligned with the Challenge 2025 strategy

Based on the positive final assessment of the activities performed under the five-year Climate Monitoring Implementation Plan (CMIP), the Council adopted a new, simplified policy framework for EUMETSAT's support to climate services aligned with the Challenge 2025 strategy. This replaces the CMIP and complements dedicated plans and mechanisms in place for integrating activities of the SAFs and headquarters.

The multi-annual Climate Service Development Plan was updated to include the planned support to the Copernicus Climate Change Service (C3S) agreed with the ECMWF.

Data, metadata and software rescued to preserve the heritage of Meteosat first generation

Preservation of data, metadata, software and documentation was an important component of the end-of-life of Meteosat-7 and the closure of the Meteosat first generation programme after 40 years of operations.

In particular, a last decontamination of Meteosat-7's MVIRI instrument was performed prior to de-orbiting to recalibrate infrared imagery for future data reprocessing, and the real-time image processing chain was reconditioned into a standalone Meteosat first generation reprocessing chain duly tested with Meteosat-2 data.

The development of software for the automated detection of anomalies present in the oldest Meteosat images was launched to complement this processing chain.

SUPPORT TO CLIMATE SERVICES

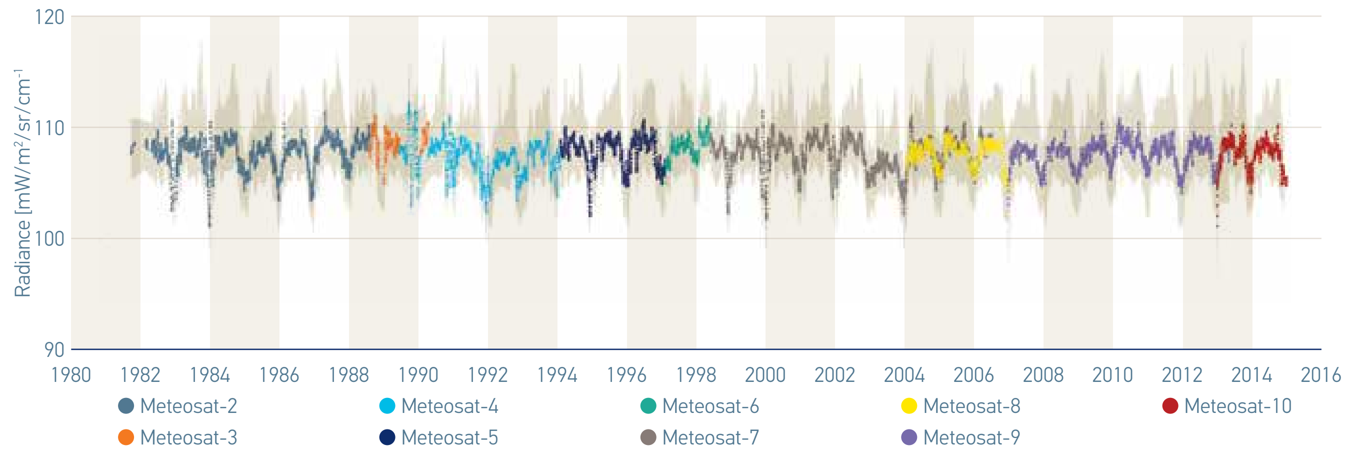
Recalibration efforts rewarded by a set of long multisensor fundamental climate records

Building on past recalibration efforts, a number of fundamental climate data records were produced and released.

A 33-year (1982-2015) record of cross-calibrated infrared imagery from Meteosat-2 to Meteosat-9 is now available as the highest quality input for the downward production of records of cloud parameters.

Using cross-calibration methods developed with the Climate SAF, two records of recalibrated microwave soundings and microwave imagery from legacy US and EUMETSAT instruments (SSM/T2, AMSU-B, MHS, SMMR, SSM/I and SSMIS) were published covering respectively 21 (1994-2015) and 37 years (1978-2015).

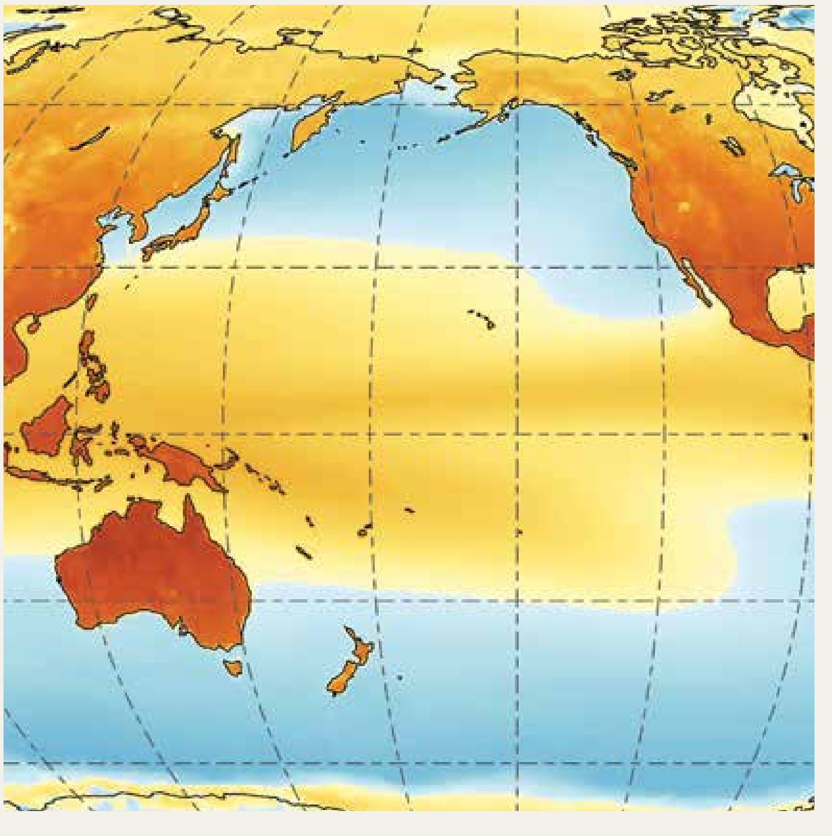
The Radio Occultation observations from the GRAS/EPS, COSMIC and CHAMP missions were reprocessed using wave optics algorithms to produce several records of bending angle profiles for use in reanalysis projects.



Recalibration of Meteosat 10.8 µ images has eliminated jumps between series of observations from successive satellites

A first record of Metop-B HIRS infrared soundings, including uncertainty estimates, was delivered to the Copernicus Climate Change Service for assessment, and a first quality assessment of HIRS soundings from the NIMBUS-6, TIROS-N, NOAA-6 and NOAA-8 pioneer satellites was performed.

The reprocessing of historical IASI data to level 1C started in November using a new processor delivered by CNES that enables the recovery of missing products, the production of quality flags and the addition of information on the percentage of cloud and land present in each sounding pixel.



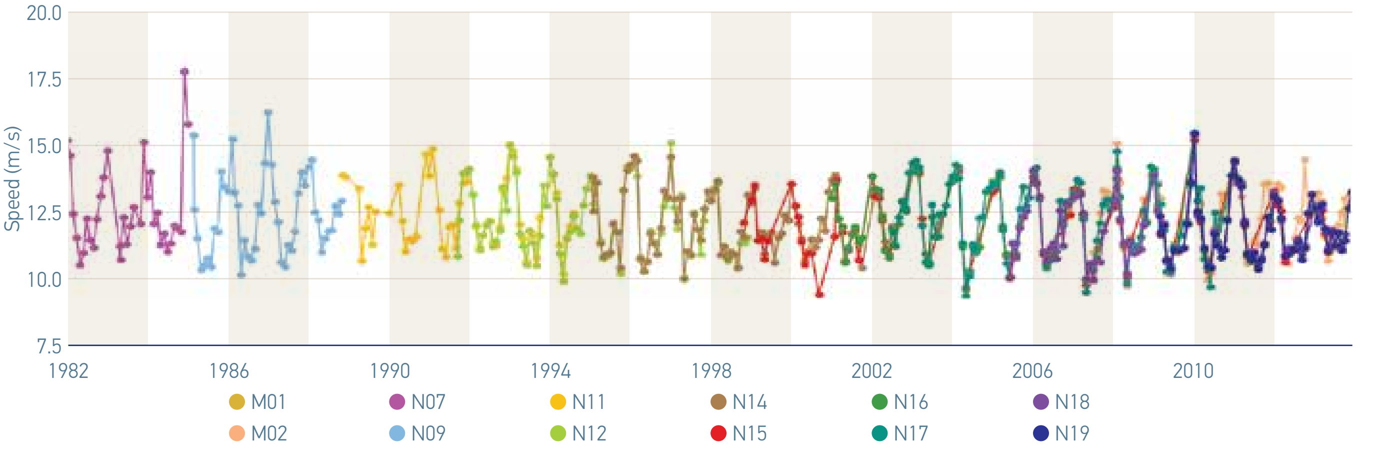
Average brightness temperature from microwave imagery calculated from a climate record of 37 years (1978-2015) (source: CM SAF)

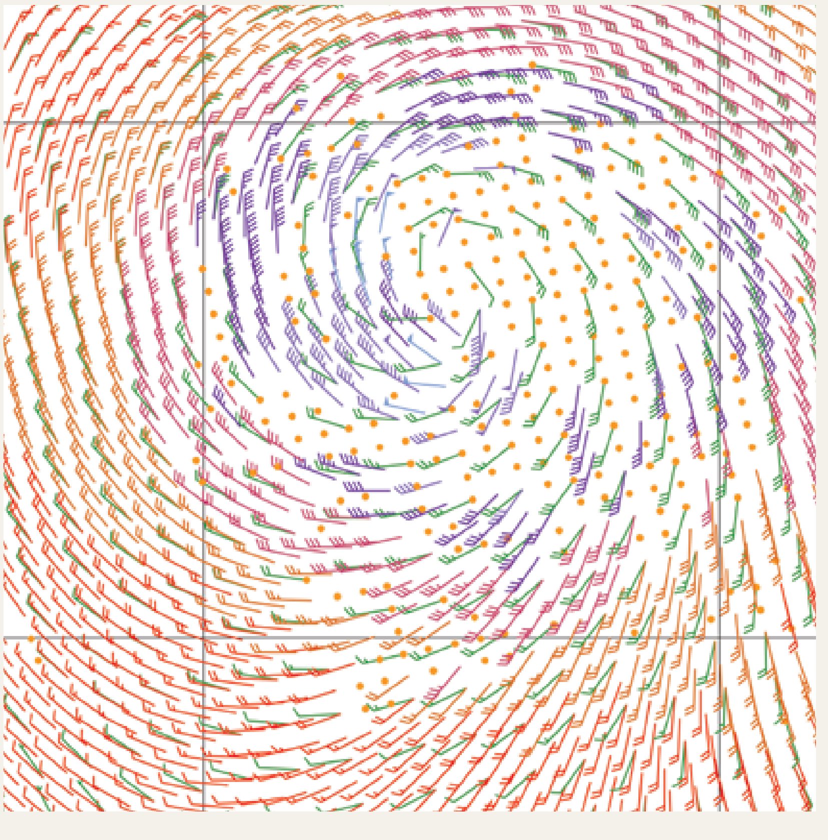
SUPPORT TO CLIMATE SERVICES

New, long climate records of essential climate variables of the dynamics of the atmosphere, land and oceans

Atmospheric wind vectors could be extracted from the displacement of clouds observed by successive overlapping infrared images available only at coarse resolution from NOAA pioneer satellites (NOAA 7 to 9) and combined with reprocessed data from more recent NOAA-10 to -19 and Metop-A and -B satellites to form a 33-year record (1982-2014) of wind vectors over polar regions.

Time series (1982–2014) of monthly mean speed of wind vectors estimated from the displacement of clouds observed over the Northern Hemisphere by successive AVHRR instruments identified by different colours





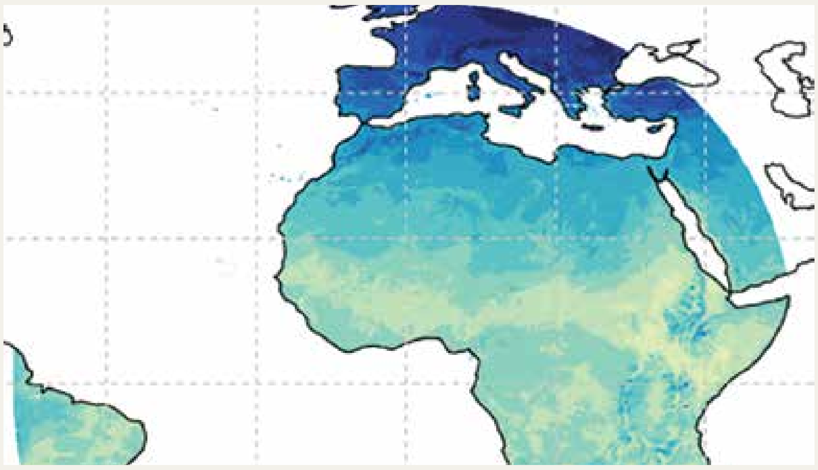
The Satellite Application Facility on Ocean and Sea Ice (OSI SAF) also published two records of wind vectors, but at the surface of the ocean, as measured by space-borne radar scatterometers. This included records at 25km resolution covering the lifetimes of the ESA ERS-1 and ERS-2 satellites (1992-2001) and at 25km and 50km resolution covering the lifetime of the Indian Oceansat-2 satellite (2009-2014).

Sample of ocean surface wind field extracted from the Oceansat-2 climate record (2009-2014) (source: OSI SAF)

SUPPORT TO CLIMATE SERVICES

The OSI SAF improved and extended its record of sea ice concentration based on the reprocessing of historical passive microwave imagery data to cover 36 years (1979-2015).

Taking advantage of the availability of new, longer fundamental records of microwave imagery and Meteosat infrared imagery, the SAF on Climate Monitoring (CM SAF) extended and improved its climate record of ocean-atmosphere fluxes and precipitation over the ocean (HOAPS) and created a first Meteosat record of hourly land surface temperature at 5x5km resolution covering the period 1991-2015.

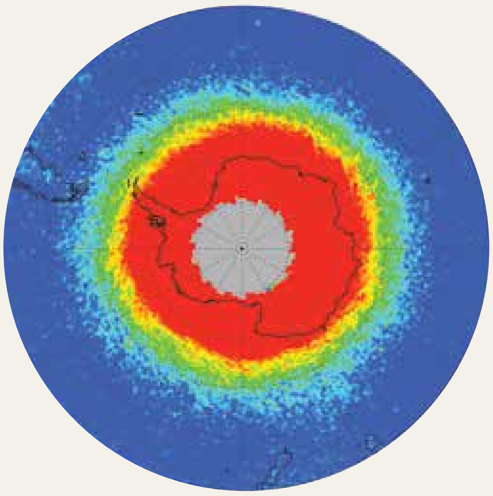


Average land surface temperature for January 2010 at 5x5km resolution extracted from a Meteosat climate record (source: CM SAF)

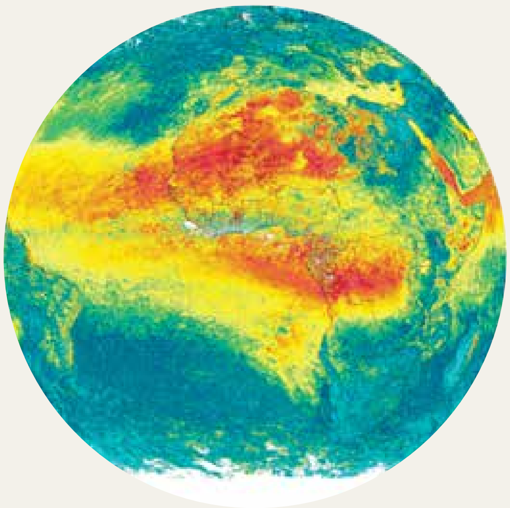
Climate records of aerosol properties and trace gases from the geostationary and polar orbits

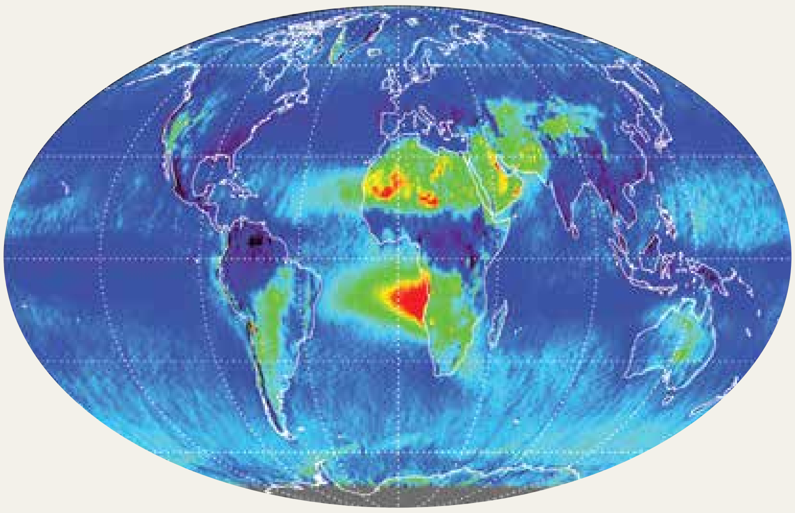
The CM SAF extended further its records of cloud properties, cloud and surface albedo and surface radiation parameters extracted from AVHRR (CLARA) and Meteosat imagery (SARAH) to cover more than 33 years, and released a first Meteosat Second Generation record of daily and monthly average aerosols optical depth, that can be used in combination with the GOME-2 record of absorbing aerosol index produced by the SAF on Atmospheric Composition Monitoring (AC SAF).

The AC SAF also released 10-year (2007-2016) records of column concentration of O_3, NO_2, OCLO, BrO, SO_2, HCHO and water vapour derived from Metop data.



Chlorine dioxide (OClO) column concentration over Antarctica in August 2015, from a GOME-2 climate record (source: AC SAF)





Different views on aerosols in our changing climate: average optical depth extracted from a Meteosat climate record (left) and average index characterising absorbing aerosols extracted from a GOME-2 climate record (right) (source: CM SAF)

SUPPORT TO CLIMATE SERVICES

Tracing uncertainties of climate records in collaborative research projects

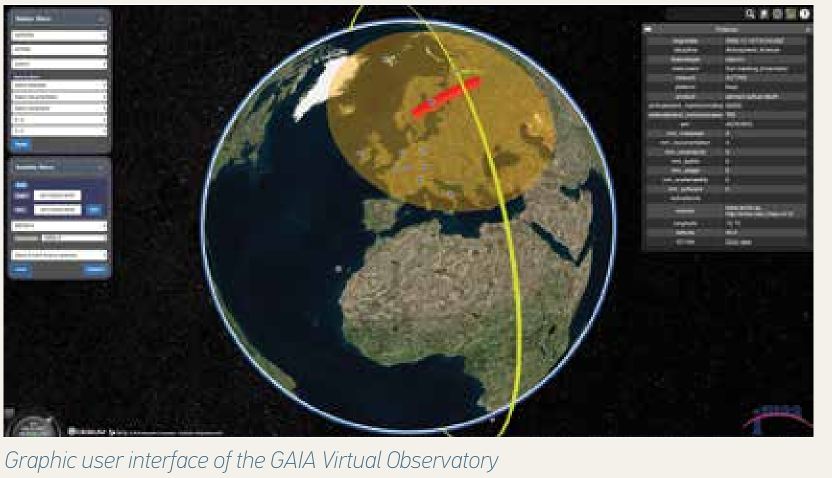
Further milestones were achieved in EUMETSAT's contributions to EU-funded cooperative research projects aimed at assessing the quality and uncertainties attached to climate data records.

As part of the QA4ECV project, EUMETSAT delivered bi-directional reflectance function data for GOES (2000-2003), GMS-5 (1998-2003) and Meteosat (1982-2014) to its partners for use in the production of a climate record of surface albedo combining geostationary and AVHRR imagery. The first attempted combination confirmed that the better sampling of geostationary products reduces the total uncertainty of the combined products.

Within the FIDUCEO project, EUMETSAT continued to assess the three most important sources of uncertainty attached to visible imagery of the first generation of Meteosat - those relating to the spectral response function, the instrument electronics and the geolocation and time of the measurements - and study their propagation into fundamental climate data records. For the assessment of spectral response function uncertainties, a reference set of Meteosat-7 calibration coefficients using spectral response measured pre-launch, updated using a linear, spectrally neutral ageing model of the visible detectors was compared with coefficients recalculated using reconstructed time variations of the spectral response due to the actual ageing of the detectors using an inverse modelling technique. The recalculated calibration coefficients confirmed that ageing of the detectors is spectrally dependent, causing a faster signal decrease over time at the shortest wavelengths of the broad band visible channel of the MVIRI instrument.

The new calibration coefficients were computed and used to deliver a first climate record of Meteosat visible imagery for Meteosat-5, -6 and -7 containing uncertainty estimates associated with the three main sources.

For the GAIA-CLIM project, EUMETSAT completed the development of the Virtual Observatory (VO) enabling the comparison of satellite and in-situ data, using forward radiative transfer modelling to simulate satellite data from in-situ measurements and numerical weather prediction model outputs to bridge residual time-space differences.

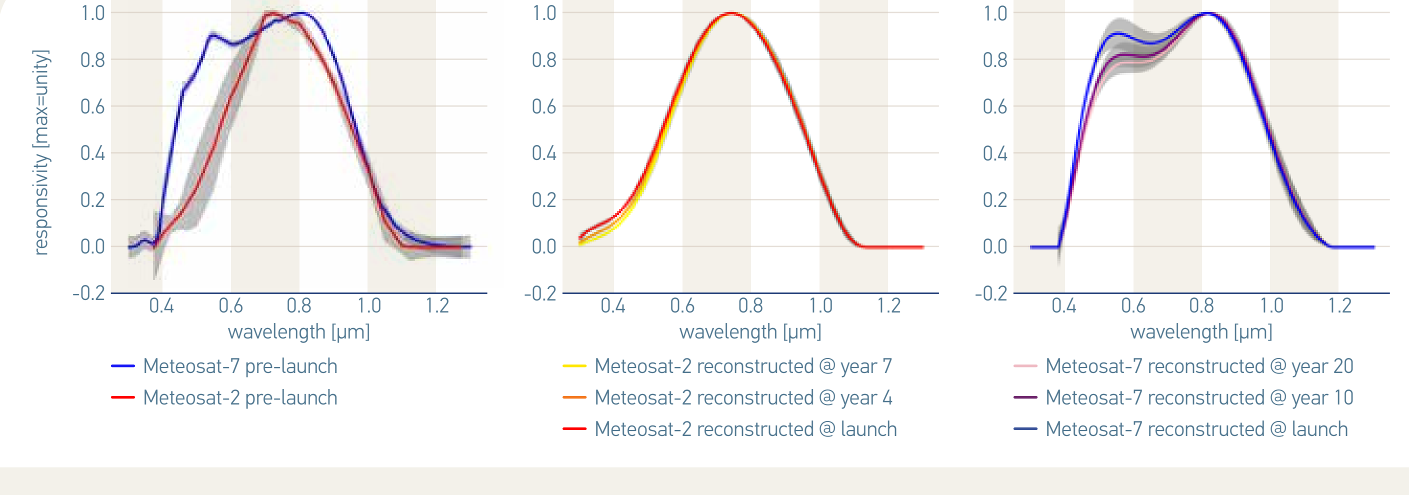


Graphic user interface of the GAIA Virtual Observatory

The built-in database for collocating and comparing reference measurements of temperature, moisture and ozone profiles and aerosols parameters available from the GRUAN, AERONET and TCCON networks with satellite data was deployed and populated.

A road show was organised to promote the use of the VO by climate institutions in Europe and concluded in December, after 12 presentations across the continent.

Spectral response function measured pre-launch for Meteosat-2 and Meteosat-7 (left) and reconstructed for Meteosat-2 (middle) and Meteosat-7 (right), after 1, 10 and 20 years, showing faster degradations at shorter wavelengths



DEVELOPING ENHANCED AND NEW PRODUCTS IN PARTNERSHIP WITH MEMBER STATES

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 Satellite Application Facility (SAF) consortia distributed across its Member States. Each SAF is specialised in one application area and led by a National Meteorological Service (NMS).

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.

A new five-year product development cycle starts across the headquarters and the Satellite Application Facilities

After consolidation of their product development plans, all Satellite Application Facilities kicked off their third Continuous Development and Operations Phase (CDOP 3) covering the period 2017-2022. The Ozone SAF was renamed Atmospheric Composition Monitoring SAF (AC SAF) to reflect its actual scope, and the Romanian National Meteorological Service (MeteoRomania) joined the Nowcasting SAF consortium.

In parallel, at headquarters, science roadmaps were published for "aerosols" and "atmospheric motion vector" products and prepared for "radio occultation" and "hyperspectral infrared sounding" products.

These and other roadmaps to be released in 2018-2019 provide the science framework for multi-annual development plans for families of products using a multi-mission approach to algorithms and processors.

Improved calibration and quality control as a fundamental investment

The calibration and quality of Meteosat and EPS physical (level 1) products were further improved to provide better inputs for the downstream extraction of geophysical (level 2) products and more information on the actual quality of products.

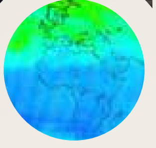
Calibration coefficients for the Meteosat visible channels were revised to compensate for effects of the ageing of the SEVIRI instruments of the Meteosat-8, -9 and -10 satellites.

Upgrades to the Meteosat processing software eliminated a known geo-referencing offset (bias) of 1.5km in Meteosat imagery that had so far been corrected on the user side, and corrected the Meteosat-8 cloud mask from artefacts due to the increasing high inclination of this satellite.

A software patch was uploaded to the Metop-B satellite to improve the nonlinear, signal-dependent corrections applied by the on-board processing of IASI spectra in the CO_2 absorption band.

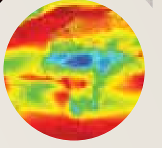
On the ground, the IASI level 1 processing software was upgraded to recover cloud information previously missing in high latitude products, and noise information available from all Metop sounding instruments was appended to multi-instrument sounding products to provide users with additional information on their quality.

DEVELOPING ENHANCED AND NEW PRODUCTS IN PARTNERSHIP WITH MEMBER STATES



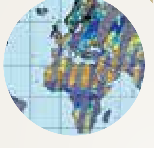
EUMETSAT AC SAF

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



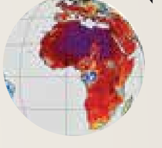
EUMETSAT CM SAF

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

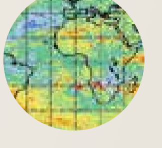


EUMETSAT LSA SAF

Land Surface Analysis
Led by Instituto Portugues 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

DEVELOPING ENHANCED AND NEW PRODUCTS IN PARTNERSHIP WITH MEMBER STATES

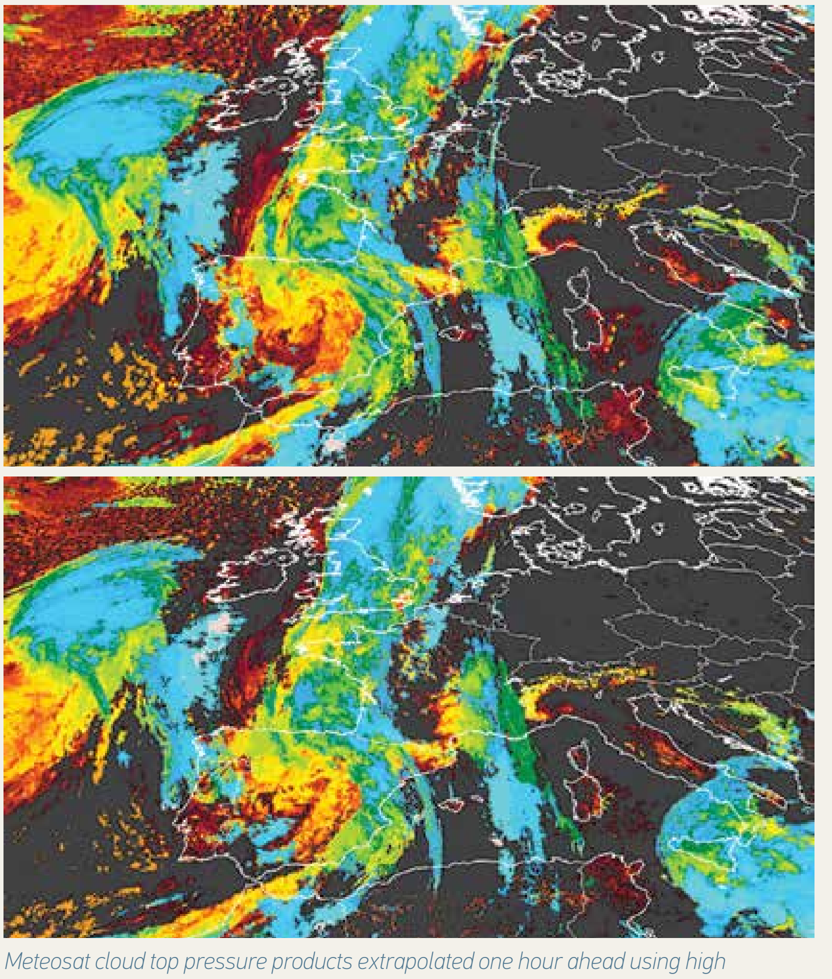
New and improved operational products and user software

Nowcasting

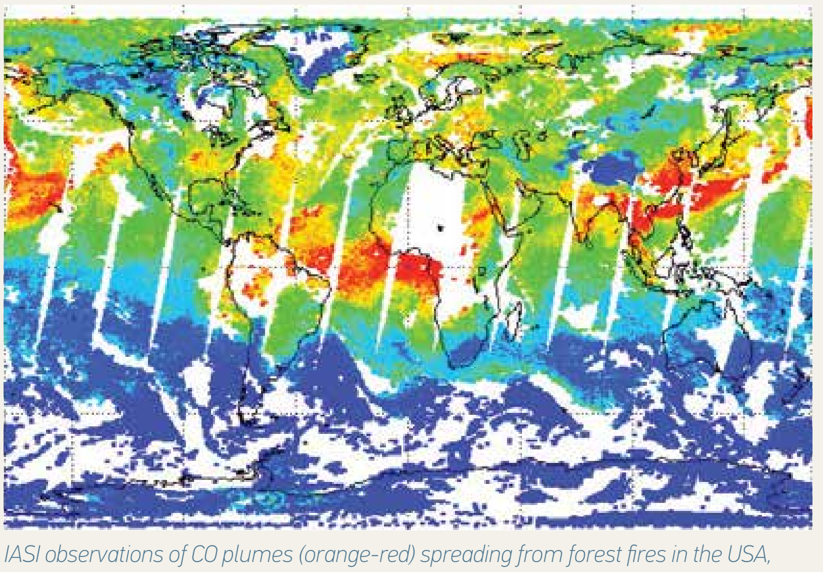
The Meteosat Optimal Cloud Analysis product was made available in real time at its full production frequency of 15 minutes. Demonstrational user software was released by the NWC SAF that extrapolates geostationary imagery products up to one hour ahead, using the high-resolution atmospheric wind vectors extracted from the same imagery.

Numerical weather prediction

A 1% negative bias was removed from the Meteosat Tropospheric Humidity (THU) product, and new versions of the RTTOV radiative transfer modelling software and of the ASCAT Wind Data Processor software were released, the latter introducing flow-dependent error estimates.



Meteosat cloud top pressure products extrapolated one hour ahead using high resolution wind vectors extracted from Meteosat imagery (top) compared with actual observations (bottom) (source: NWC SAF)



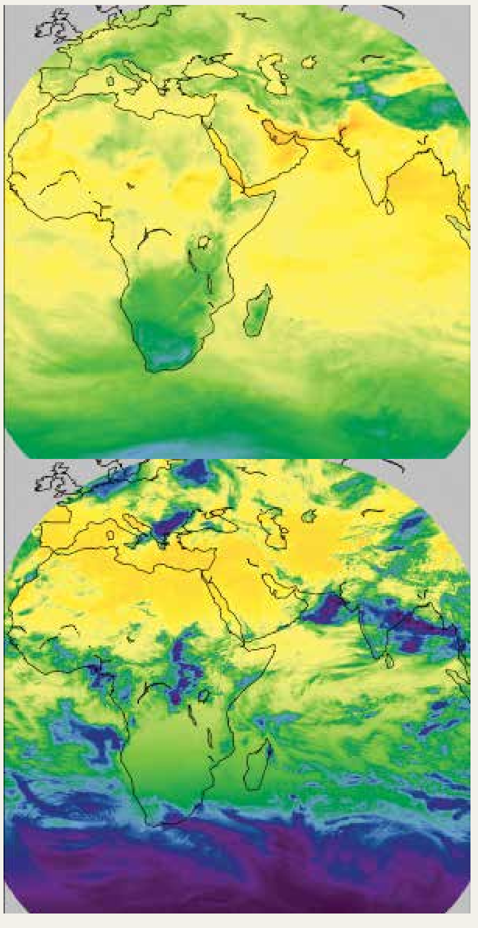
IASI observations of CO plumes (orange-red) spreading from forest fires in the USA, Canada and Russia, and other CO sources in Africa and Asia, 15 August 2017 (source: AC SAF)

Atmospheric composition

Near-real-time sulfur dioxide (SO_2) and carbon monoxide (CO) column concentration products were introduced as the first in a series of trace and greenhouse gas products extracted from IASI observations using algorithms developed by the AC SAF.

A new version of the multisensor Metop Aerosol Optical Depth product available over sea and land surfaces (except over snow/ice) improved the separation of clouds from thick dust and volcanic ash.

DEVELOPING ENHANCED AND NEW PRODUCTS IN PARTNERSHIP WITH MEMBER STATES



Ocean and sea ice

New pre-operational Sea Ice Surface Temperature and non-validated Land Ice Surface Temperature products were released as part of an integrated set of high latitude (North of 50°) products also including Sea Surface Temperature.

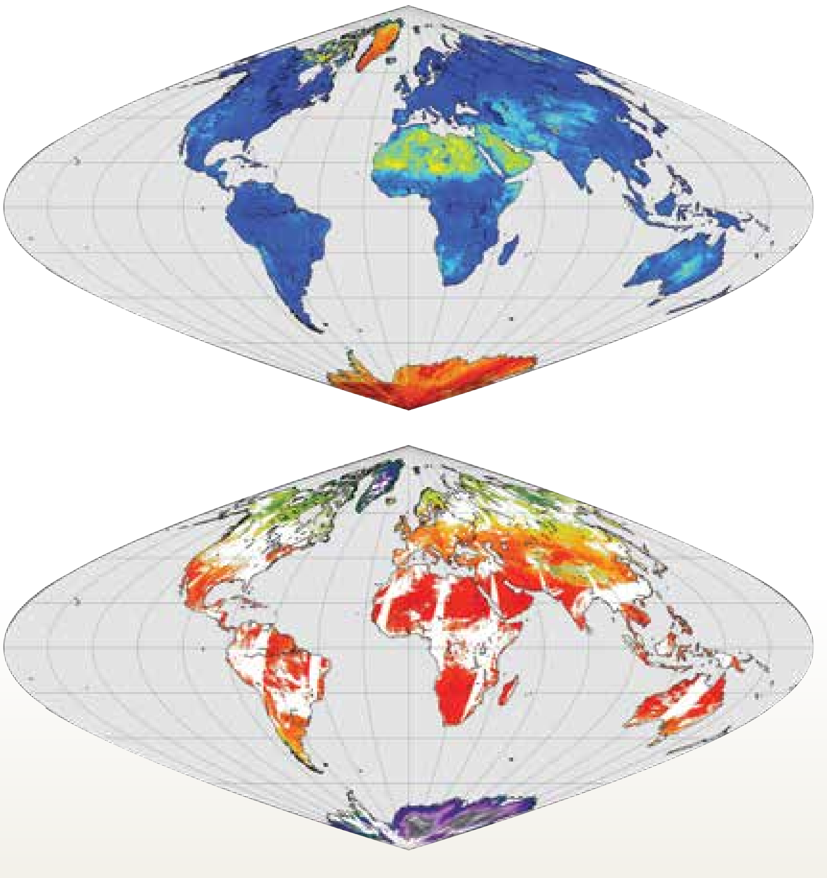
The 12-channel imagery available from Meteosat-8 enabled the release of Meteosat sea surface temperature and ocean surface radiative flux products over the Indian Ocean.

The quality of IASI sea surface temperature products improved at mid and high latitudes, and a new indicator informs on the presence of dust aerosols and the quality of individual products.

Microwave imagery from the Japanese GCOM-W1 mission was introduced as an additional input for the production of multisensor global sea ice edge and sea ice type products and was used to produce a new global gridded Sea Ice Concentration product.

Most of the ocean products from the OSI SAF were converted to netCDF4, the preferred format of the marine user community.

Ocean surface radiative fluxes (long wave top, short wave bottom) over the Indian Ocean derived from Meteosat-8 imagery (source: OSI SAF)



Hydrology and land surfaces

A daily global snow cover product identifying snow-covered, snow-free, cloud-covered/non-classified surfaces on a 0.01° x 0.01° grid was extracted from AVHRR imagery.

Ten-daily land surface albedo and land surface temperature products on 1km grids were extracted from Metop AVHRR and from Meteosat imagery.

A Meteosat reference evapotranspiration product was released, estimating the evaporative demand of the atmosphere for a hypothetical reference surface, i.e. independently of crop type, crop development or management practices.

The Meteosat Active Fire Monitoring (FIR) product was improved to reduce the number of false detections of fires in mountainous areas.

Ten-daily Land Surface Albedo (top) and Land Surface Temperature (bottom) products extracted from Metop AVHRR imagery (source: LSA SAF)

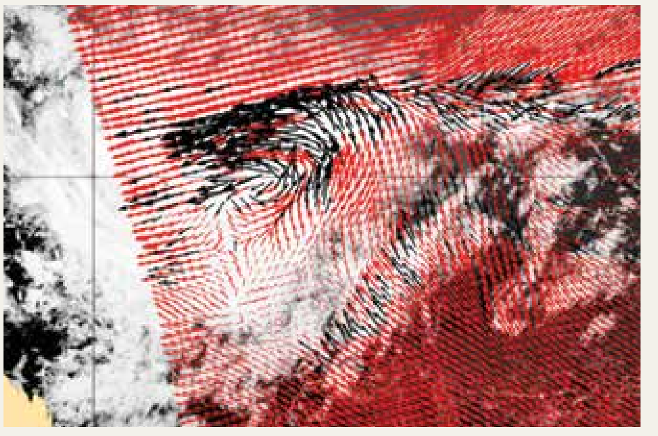
DEVELOPING ENHANCED AND NEW PRODUCTS IN PARTNERSHIP WITH MEMBER STATES

New products available from international partners

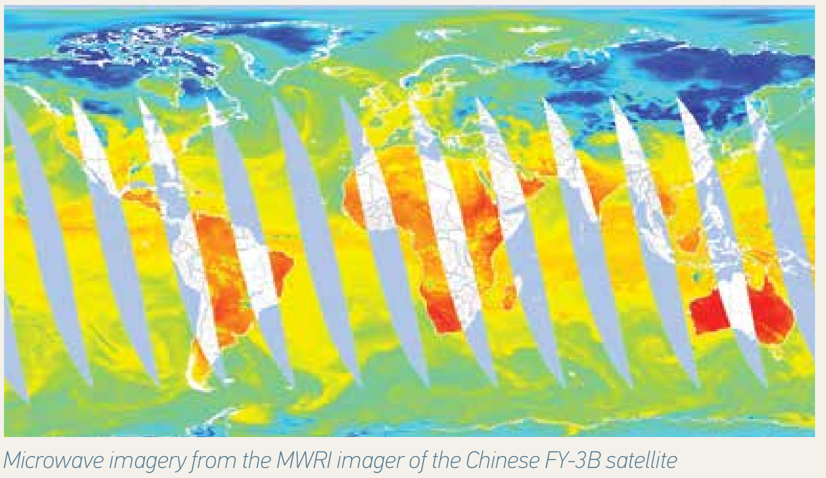
A new geostationary data service was introduced to redistribute six imagery channels (0.9, 3.8, 8.0, 9.7, 10.7 and 11.9 µ) from the Russian Electro-L N2 satellite.

Dissemination of GOES-16 imagery at 2km resolution in 15 spectral channels available from NOAA started at half-hourly frequency and continued at 15-minute frequency, when GOES-16 was moved over the Atlantic by NOAA.

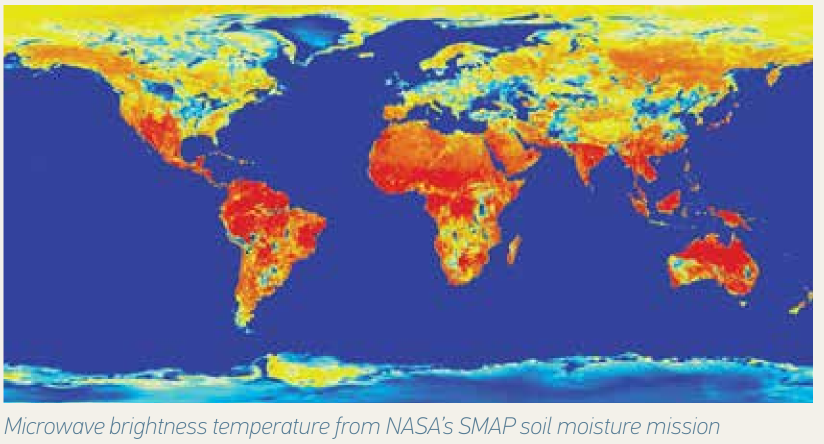
With ISRO, a near-real-time data service started to deliver radar backscatter measurements and ocean surface wind vector products at 25km resolution from Scatsat-1.



Ocean surface wind field product from ISRO's Scatsat-1 mission



Microwave imagery from the MWRI imager of the Chinese FY-3B satellite



Microwave brightness temperature from NASA's SMAP soil moisture mission

Microwave imagery from the MWRI imagers of the Chinese FY-3B and FY-3C polar orbit satellites started to be disseminated to NMHS of Member States and the ECMWF on 5 October.

A new service was opened to redistribute resampled calibrated microwave brightness temperature available from NASA's SMAP soil moisture mission.

The quality control of the all-weather sea surface temperature product extracted from AMSR-2/GCOM-W1 microwave imagery available from JAXA was enhanced by improved detection of C-band radio frequency interference and land-ocean flags.

On behalf of the Copernicus Global Land Service, new versions of the Leaf Area Index, Fraction of Vegetation Cover and Fraction of Absorbed Photosynthetically Active Radiation products extracted from PROBA V imagery were introduced in the EUMETCast-Europe and -Africa dissemination programmes.

An ADM-Aeolus service was prepared to ensure the redistribution of near-real-time vertical profiles of wind vector products after the commissioning of the ESA Doppler lidar mission planned for launch in 2018.

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 EUMETSAT cooperative training programme aims at expanding EUMETSAT's user base and the use of satellite products in a growing range of applications and research areas.

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

Preparing forecasters for new roles, using next generation satellites and big data services

EUMETSAT aligned its user training strategy with its Challenge 2025 strategy.

Whilst maintaining the current thematic and geographic priorities, the new training strategy will prepare forecasters to evolve towards new roles of weather advisors and to use big data services and combinations of different types of products, e.g. lightning, radar and satellite imagery and model outputs.

Another top priority is user preparedness for next generation satellites, starting with a MTG User Preparedness Project that launched at the end of the year.

Online and classroom training accessed by thousands of trainees

In 2017, 567 trainees attended EUMETSAT courses and an additional 454 attended EUMETCal 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 1,268, and a total of 52,000 library pages were viewed.

A Copernicus ocean training support service was established and the Copernicus marine Massive Open Online Course (MOOC) was rerun and followed by 1,500 participants. Building on this success, a Copernicus Atmospheric MOOC project started with the ECMWF, the provider of the Copernicus Atmosphere Monitoring Service.

"My goal, as a EUMETSAT Fellow, is to improve high-resolution soil moisture analysis by removing estimation error and improving data assimilation."

Jasmin Vural
EUMETSAT Fellow
Zentralanstalt fur Meteorologie und Geodynamik (ZAMG)

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 in EUMETSAT Member States.

A survey conducted in 2017 showed that 58 out of the 59 fellows having completed their EUMETSAT fellowship since 1990 found their way on the job market, including 48 in meteorology or atmospheric sciences.

A new call for research topics attracted 24 proposals from 13 Member States, out of which four will be selected in 2018 for fellowship positions to be opened for recruitment in 2018 and 2019.

EUMETSAT hosted 30 visiting scientists from around the world to work on scientific topics including use of fiducial reference measurements, visible calibration, validation of Sentinel-3 and Lightning Imager (LI) products, processing of MTG Infrared Sounder (IRS) data, retrieval of atmospheric motion vectors from IASI data and cloud physical properties from Meteosat imagery.

SUPPORTING AND EXPANDING THE USER BASE

Training and training coordination events

FEBRUARY/MARCH

Copernicus training on operational marine surface analysis using Copernicus and EUMETSAT marine data - *online phase*

Satellite Application Course (SAC XIV) on severe weather forecast applications in French, *Niamey, Niger*

Workshop on the Use of Gridded Satellite Data for Climate Services in Europe - *Online Phase*

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

APRIL

Course on the use of satellite data in marine analysis and forecasting in French, *Casablanca Morocco*

WMO / EUMETSAT course on the use of satellite products for drought monitoring and agro-meteorological applications, *Budapest, Hungary*

Copernicus training on operational marine surface analysis using Copernicus and EUMETSAT marine data, *Riga, Latvia*

18th Brazilian symposium on remote sensing, *Santos, Brazil*

Nordic Meteorological Competency Training Course (NOMEK), *Oslo, Norway*

MAY

Satellite Application Course for African Forecasters in English - *online*

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

Copernicus training workshop on the applications of Sentinel-3 ocean colour products, *Lisbon, Portugal*

Training course on access to satellite products and their applications in central Asia (SADCA), *Istanbul, Turkey*

JUNE

Roshydromet/EUMETSAT training workshop on satellite data and product applications for Russian speaking weather forecasters, *Moscow, Russia*

EUMeTrain training on weather briefings and other forecast applications for European weather forecasters - *online*

JULY/AUGUST

Southern African Satellite Application Course for forecasters (SAC-VI) classroom phase in English, *Pretoria, South Africa*

Copernicus training on the use of Copernicus marine data for ocean applications in Europe - *online*

Conference on Computer Assisted Learning for meteorology (CALMET), *Melbourne, Australia*

SEPTEMBER

EUMeTrain training on weather briefings and forecast applications for European forecasters - *online*

Copernicus training on the use of Copernicus marine data for ocean applications in Europe, *Oostende, Belgium*

Copernicus training on operational marine surface analysis using Copernicus and EUMETSAT marine data - *online*

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

5th SALGEE training workshop for Eastern Europe on "Meateosat Land Surface Applications: heat waves, drought hazard and fire Monitoring", *Yerevan, Armenia*

OCTOBER

14th Ibero-American workshop on tropical satellite meteorology, *Santa Cruz de la Sierra, Bolivia*

International Summer School on applications of multi-spectral environmental satellites, *Bracciano, Italy*

GODAE Oceanview International School on new frontiers in operational oceanography, *Mallorca, Spain*

6th WMO Sand and Dust Storms-Warning Advisory and Assessment System (SDS-WAS) Course, *Istanbul, Turkey*

Copernicus training on the use of Copernicus marine data for ocean applications in Africa - *online*

NOVEMBER/DECEMBER

Copernicus training on operational marine surface analysis using Copernicus and EUMETSAT marine data, *Accra, Ghana*

WMO workshop of experts and developers of colour-coded imagery products, *Tokyo, Japan*

Training course on "Climate change and conservation in the Caatinga", *Maceió, Brazil*

Satellite Application Course for African Forecasters (SAC-XV) in English, *Nairobi, Kenya*

Workshop on the use of gridded satellite data for climate services in Africa, *Pretoria, South Africa*

Workshop on marine forecasting using altimeter and scatterometer data in French, *Casablanca, Morocco*

SUPPORTING AND EXPANDING THE USER BASE

User conferences

The 2017 EUMETSAT Meteorological Satellite Conference in Rome was co-organised with the Italian Meteorological Service and attracted 550 participants. The conference included specific sessions on hydrology, short-range numerical weather prediction applications and future satellite missions. It was the occasion for all SAFs to present their achievements across applications.

A workshop on the use of satellite data for nowcasting storms and numerical weather prediction (NWP) was organised during the ECMWF user meeting, addressing inter alia preparation for the use of MTG LI and IRS observations

Preparations began for the 2018 conference in Tallinn, Estonia, organised with the Estonian Environment Agency, and a Memorandum of Understanding was signed with the American Meteorological Society for the next joint user conference to be held in Boston in October 2019.

Gen Silvio Cau, Director of the Italian Meteorological Service, opening the 2017 EUMETSAT Meteorological Satellite Conference in Rome, Italy

In the context of Copernicus, EUMETSAT co-organised the International Ocean Colour Science conference in Lisbon, taking this opportunity deploy a Copernicus booth and deliver a Copernicus training event in partnership with the Portuguese IPMA.

Scientists explore Sentinel-3 OLCI data at a training session that was part of the IOCS conference in Lisbon, Portugal (source: Hayley Evers-King, PML Applications Ltd.)

SUPPORTING AND EXPANDING THE USER BASE

Outreach

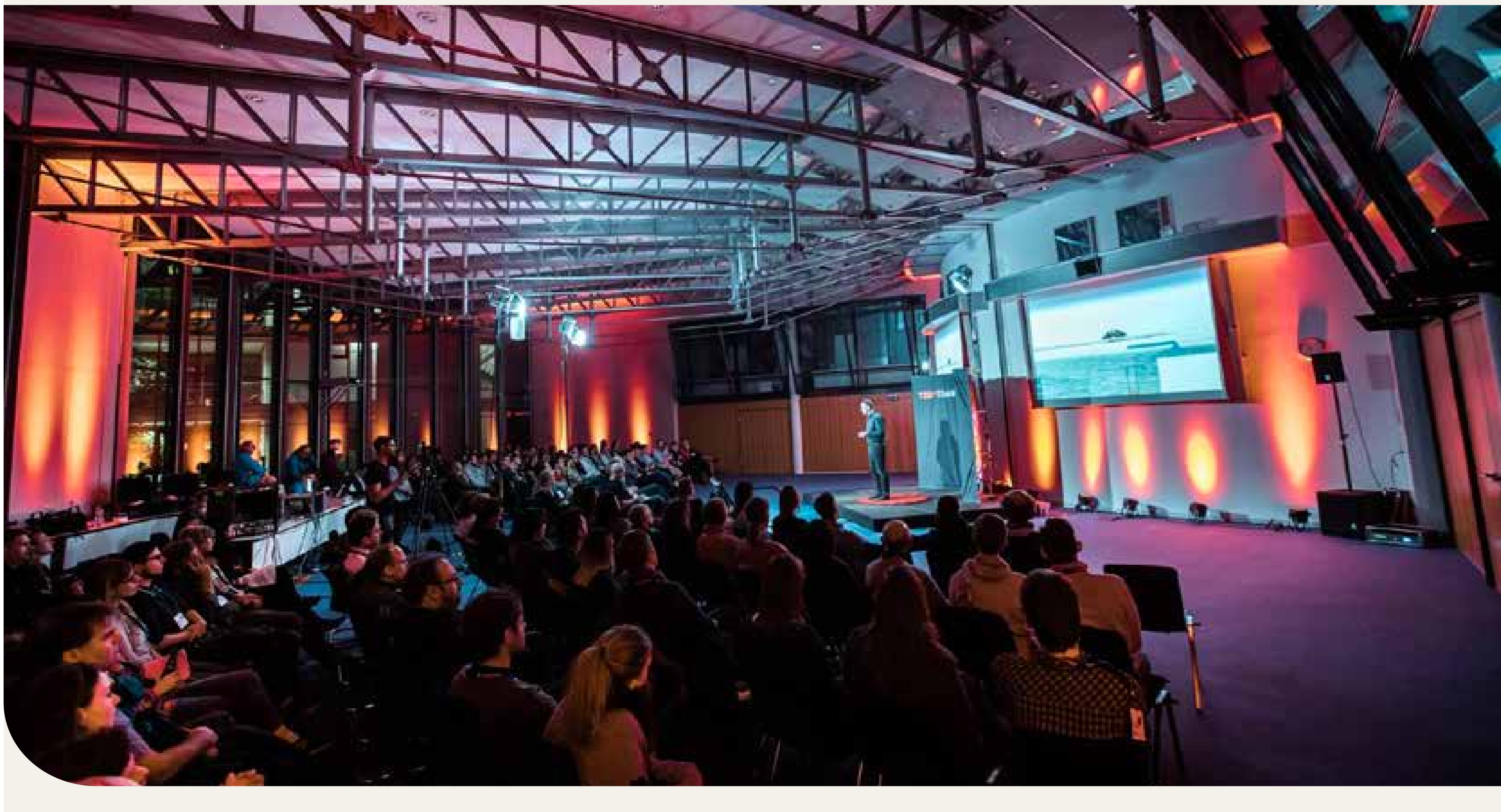
The EUMETSAT Flickr and YouTube channels each received over 2 million views, including up to 12,000 views alone for three video animations showing one year of sea surface temperature, ozone and sea ice observed from space. These videos were also posted on the EUMETSAT Science Blog and triggered articles online including on the BBC News website.

EUMETSAT and the Intergovernmental Oceanographic Commission launched a new Minecraft competition inviting six to 16-year-olds to build Minecraft models of the Sentinel-3 or Jason-3 satellites or design an ocean-monitoring system with satellites, buoys, robots etc.

EUMETSAT shared a booth with the Met Office at the New Scientist Live festival in London to communicate on EUMETSAT satellites and the use of their data for weather forecasting.

EUMETSAT and Mercator-Ocean co-organised a Copernicus marine TEDx communication event and a first Copernicus marine hackathon. Attractive video talks from leading oceanographers made the TEDx #TheBlueDot the fourth most popular hashtag on Twitter across Germany, and the datanauts involved in the fully booked hackathon competed in the “live” development of apps using Copernicus marine data, the winner being a smart ship-routing app.

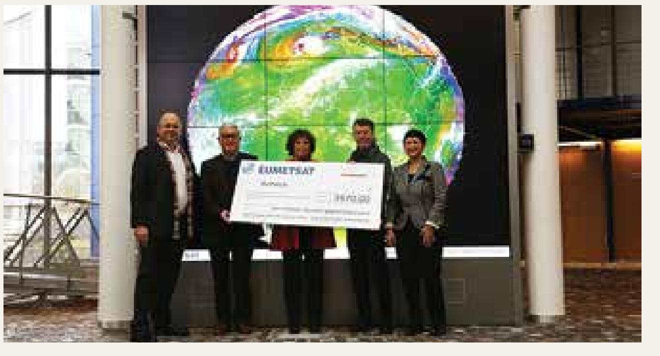
Remko Scharroo, EUMETSAT Remote Sensing Scientist, presenting at the TEDx “Decoding the blue dot” event, 16 November 2017



Local life

Tours of EUMETSAT headquarters advertised in cooperation with Darmstadt Marketing attracted 3,298 visitors - 12% more than in 2016 - including large numbers of young visitors and children on summer and autumn weekends.

The €3,670 raised by the 2017 Christmas Party was donated to Darmstädter Bündnis gegen Depression, a local organisation supporting people suffering from depression.



On behalf of EUMETSAT employees, Alain Ratier, Director-General, and Karim Haggouchi, chairman of the Staff Association Committee, present a cheque to Mrs Gill-Schultz representing Darmstädter Bündnis gegen Depression

SUPPORT TO CAPACITY BUILDING INITIATIVES

The operational use of Meteosat data develops further in the neighbourhood of Europe

National Meteorological and Hydrological Services (NMHS) of Western Balkan and Eastern European and Black Sea countries reported significant development in their operational use of EUMETSAT data available via EUMETCast at EUMETSAT Information Days organised in Podgorica, Montenegro, and Minsk, Belarus, with the WMO and the support of the European Union.

In view of the growing interest in the improved resolution of Meteosat-8 imagery products, the EUMETCast software was upgraded in Western Balkan countries to enable the visualisation of these products.

The second training course of the multi-annual South-Eastern Europe Meteorological (SEEMET) programme hosted in Bar, Montenegro, focused on the use of satellite products in weather forecasting.

Exploratory discussions started with the St Petersburg WMO VLab Centre of Excellence on a similar training programme for NMHS of Eurasian countries.

"Cooperation with EUMETSAT is part of our strategy to get up-to-date, high quality data and information to provide information that contributes to our actions towards achieving the Sustainable Development Goals and better inform our citizens."

Ms Ivana Vojinović
Director General for Environment
Ministry of Sustainable Development and Tourism, Montenegro

Participants in the multi-annual training course on satellite meteorology for South Eastern European countries, Bar, Montenegro, May 2017

SUPPORT TO CAPACITY BUILDING INITIATIVES

In Africa, EUMETSAT supports EU-funded projects and preparations for MTG

At the first ministerial AMCOMET/HYDROMET Africa Forum, EUMETSAT co-organised two sessions on capacity building projects and applications of Earth observation with the African Union Commission and the World Bank. The forum stressed the need for mobilising resources to prepare the transition of African users to Meteosat Third Generation. This priority was confirmed at technical level by the WMO RA-I Dissemination Expert Group, together with the continued need for access to outputs of forecast models via EUMETCast-Africa.

As part of the "Monitoring of Environment and Security in Africa" (MESA) capacity-building project, EUMETSAT supported the deployment or upgrade of 195 EUMETCast data access stations in Africa and the training of 2,250 persons, starting with the staff responsible for system administration and applications software at each beneficiary institution. Upgrades of the EUMETCast software were also delivered for the extraction from the disseminated data flow of Sentinel-3 marine products, Meteosat-8 imagery and products available from third parties, including maps of vegetation index and burnt areas, composite rainfall estimates and selected outputs of forecast models.

EUMETSAT supported the MESA Steering Committee in the assessment of the sustainability of the deployed capacity and its reuse for marine, water and natural resources services to be developed by a new GMES and Africa project funded by the EU Pan-African Programme. The contribution of EUMETSAT to this new project will be formalised in 2018 with the African Union Commission.

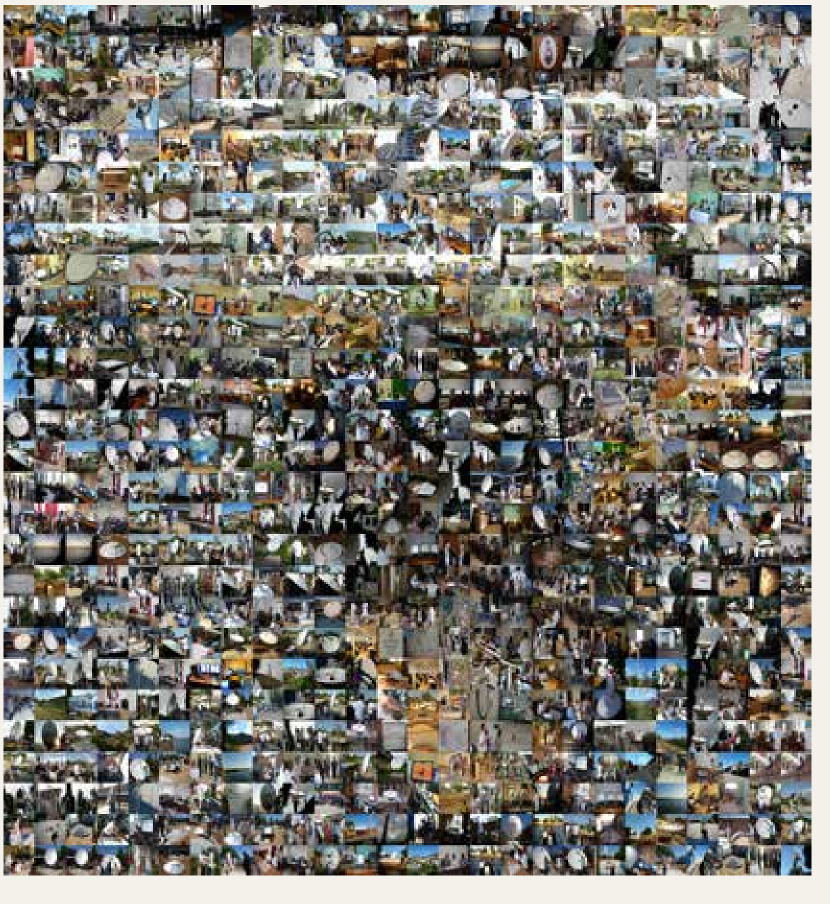
As part of the "Satellite and Weather Information for Disaster Resilience in Africa" (SAWIDRA) project managed by the African Development Bank and funded by the EU intra-ACP Disaster Resilience programme, EUMETSAT started to contribute to the development of an African numerical weather prediction capacity led by ACMAD.

Its support concentrates on the procurement and deployment of a network of four X/L band stations enabling the acquisition and processing of data from polar-orbiting satellites and the delivery of a "Regional Advanced Retransmission Service (RARS) - Africa" providing satellite products to the African forecast model. The envisaged sites for hosting the stations were confirmed with the responsible entities, subject to a positive outcome of radio frequency surveys.

Cooperation with Africa will be reviewed by the 13th EUMETSAT User Forum in Africa to be hosted in Abidjan, Côte d'Ivoire on 24-28 September 2018.

Simplifications of the Meteosat data policy agreed for future big data services

The EUMETSAT data and service policy was reviewed to offer users the best opportunities arising from the cloud-based big data services to be demonstrated by pathfinder projects and to enable affordable administration of such services. As a result, the complex policy for Meteosat imagery data will be simplified in 2019 and will become driven by data latency instead of imagery resolution and time sampling.



A map of Africa made from a collage of photos of all EUMETCast stations

OPTIMUM DEPLOYMENT OF RECURRENT SATELLITES

Metop-C launch readiness remains planned for autumn 2018 despite the need to reintegrate two repaired instruments

Metop-C satellite testing completed

The thermal vacuum tests of the service module (SVM) and payload module (PLM) of the Metop-C satellite were concluded early April, after the reintegration of the repaired GOME-2 instrument on the PLM.

The tests raised only one significant anomaly, on the X-band transponder, leading to its replacement by a spare. Unfortunately, they also confirmed the critical performance degradations of two channels of the MHS instrument observed during previous functional tests.

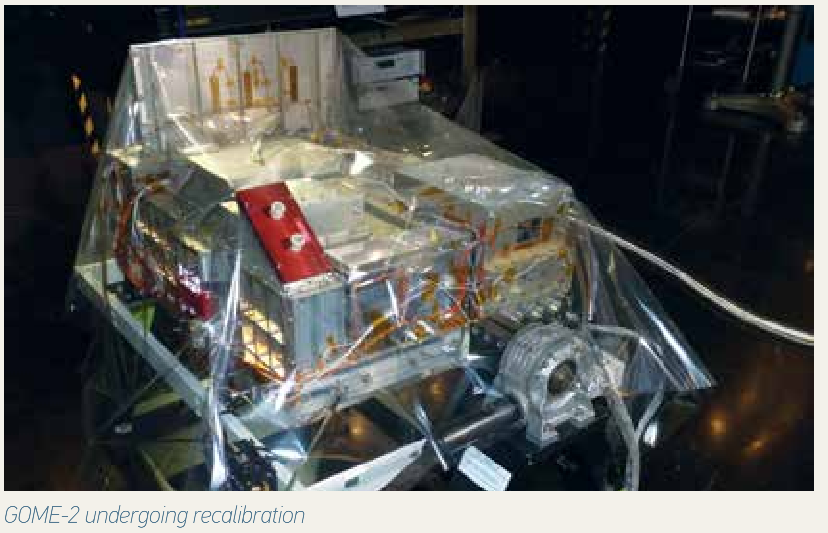
It was decided to dismount the instrument for investigation and repair and to use its refurbished engineering model for the spacecraft mechanical tests. The GOME-2 instrument was also dismounted and shipped to Delft, the Netherlands, for recalibration and was replaced by its structural model.

The PLM was shipped from ESTEC to Toulouse and integrated with the SVM and the solar array for testing of the full spacecraft in a configuration including intermediate models of both instruments. Spacecraft testing, including radio frequency compatibility, mechanical and health tests were completed before the Christmas break.

The repaired MHS and the recalibrated GOME-2 instruments are ready for reintegration

The investigation of the MHS instrument pointed to likely independent failures within the front ends of both channels, probably at the level of downconverters for which flight qualified spares were available. EUMETSAT and ESA therefore decided to proceed with the repair. The downconverters were confirmed to be the faulty components, and their replacement restored the radiometric performance of the instrument. The repaired instrument was subjected to vibration, thermal vacuum and electromagnetic compatibility tests and was ready to be shipped back to Toulouse at the end of the year for reintegration and testing on the satellite.

In the meantime, the GOME-2 instrument had undergone its recalibration campaign and was shipped back to the satellite for reintegration in January 2018.



GOME-2 undergoing recalibration

Metop-C's service module undergoes thermal vacuum tests in March 2017 (source: ESA, G. Porter)

EUMETSAT advances system validation tests and preparation of launch service

At EUMETSAT, system integration, verification and validation (SIVV) tests started in April, using the virtualised configuration of the EPS ground segment baselined for three-Metop operations. Eight of the ten test slots could be completed at the end of the year.

The launch service Preliminary Mission Analysis Review confirmed that the revised launcher trajectory restores ample performance margins on the launcher side, but led to consideration of an alternative trajectory for the Final Mission Analysis that provides better conditions for the acquisition of first satellite signals by ESOC. As for previous Metop launches, an assessment of frequency interferences between Metop-C, Metop-A and Metop-B was performed to determine interference-free periods of four consecutive days. The one-month launch slot will be notified to Arianespace in January 2018, after a final schedule assessment.

In line with previous launch preparation activities, the EUMETSAT Council agreed flexible arrangements to support responsive management of risks inherent to the last sequence of the satellite assembly integration and test activities and the launch campaign.

DEVELOPMENT OF THE METEOSAT THIRD GENERATION SYSTEM

The MTG satellites and ground segment pass key development milestones and a first successful system validation test

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

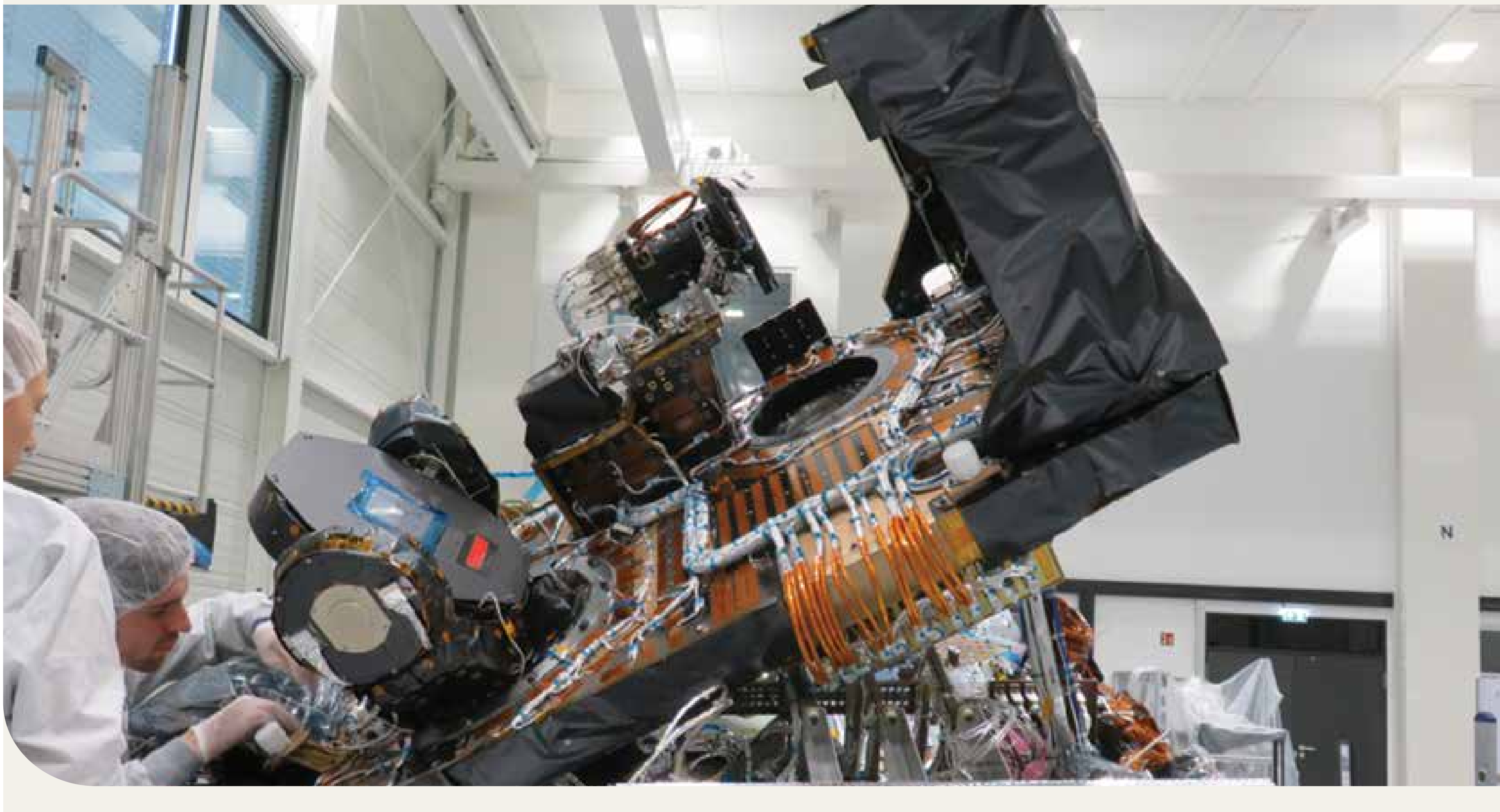
MTG, the most complex and innovative meteorological geostationary system ever built, comprises two separate lines of satellites exploited simultaneously. The MTG-I (imaging) line will improve the current Meteosat multispectral imagery mission and add a new lightning imaging capability. The MTG-S (sounding) 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.

In a stable schedule, the detailed design of the MTG satellite platform is completed

The overall development schedule of the MTG satellites remained stable in 2017, as a result of exceptional risk control and schedule recovery measures undertaken by industry since the end of 2015 under the supervision of ESA. The Flight Acceptance Reviews remain planned for December 2020 for MTG-I1 and August 2022 for MTG-S1, consistent with launches mid-2021 and early 2023.

This created the conditions for ESA and EUMETSAT to conclude a fair package deal with industry for partial financial coverage of these exceptional measures that ensures the financial viability of the continuation of the challenging development programme whilst acknowledging some responsibility of industry. The revised technical baseline associated with the settlement restored a few more months of schedule margins through further optimisation of the assembly, integration and test sequence of the first satellites and commits industry to a list of space segment deliverables required to support EUMETSAT's system and ground segment development activities.

The ESA space segment development programme achieved a major milestone with the completion of the detailed design of the platform common to both satellites and of the integration of its engineering model.



Structural/thermal model of the MTG Flexible Combined Imager's telescope assembly in the OHB cleanroom in Bremen (source: OHB)

DEVELOPMENT OF THE METEOSAT THIRD GENERATION SYSTEM

The design of both MTG satellites remains compliant with EUMETSAT requirements

The development of the MTG-I satellite and its two instruments, the Flexible Combined Imager (FCI) and the Lightning Imager (LI) progressed towards Critical Design Reviews, all planned for 2018, with performance budgets remaining compliant with EUMETSAT's requirements.

After the successful mechanical testing of the challenging scan mechanism and the secured production of detectors, the telescope and cooled optics drive the critical path of the FCI development. The development of the LI is less schedule-critical, despite the need to adjust its mechanical design and the pending selection of detectors achieving the required 70% quantum efficiency.

The MTG-S satellite Intermediate Design Checkpoint (IDCP-S) confirmed the robustness of the satellite design. However, it identified higher than expected micro-vibrations originating from the cryogenic cooler of the cold optics at the level of the sensitive corner cube mechanism of the interferometer of the Infrared Sounder (IRS).

The mounting of the instrument radiator to the main structure was therefore modified with the introduction of elastomer elements to better isolate the mechanism from micro-vibrations.

The development of the specific Ariane-5 interface adapter continued under the EUMETSAT launch service contract, with margins against the planned first fit check with the MTG-I1 satellite.

Arianespace confirmed that a standard nitrogen purging line under the Ariane-5 fairing will fulfil the cleanliness requirements of the Copernicus Sentinel-4/UVN instrument.

First MTG SVT celebrated by the mission control team at EUMETSAT (top) and the satellite team at OHB in Bremen (bottom)

The mission control chain and the satellite platform have a first, promising conversation

The first delivery of the mission operations facility (MOF) of the MTG ground segment, basically a mission control chain, was integrated and tested with the satellite simulator and database available from space segment industry and other ground segment elements required to prepare for the first system validation test (SVT-I1-v0).

Upon completion of the integration of the platform electrical model, this test could be performed on 26-28 September, thus achieving the first major system milestone of the programme.

The test involved the platform located at OHB premises in Bremen and the MTG-I mission control chain, ground station front ends and interface simulators installed at EUMETSAT premises. It enabled the first successful exchange of telemetry and commands between the MTG ground segment and the platform via an interface unit procured as part of the telemetry tracking and command stations. The Test Review Board confirmed on 27 October that the full sequence of tests had been executed with no blocking anomaly and declared the test successful.

DEVELOPMENT OF THE METEOSAT THIRD GENERATION SYSTEM

As part of a robust ground segment design, MTG ground stations get ready

The mission data acquisition (MDA) ground stations were assembled in Lario, Italy, and Leuk, Switzerland, and then fully tested using the communication links established with EUMETSAT.

In parallel, the first telemetry tracking and command station was deployed in Fucino, Italy. It passed on-site acceptance tests and was cleared for temporary use in support of MSG operations after formal testing involving tracking of Meteosat-11. The second station started to be assembled in Cheia, Romania.

In October, the MTG-I Ground Segment Critical Design Review Part 1 confirmed the robustness of the detailed design of the overall MTG-I ground segment and authorised proceeding with the preliminary acceptance testing of all ground stations.

After completion of acceptance testing of both MDA stations, the full MDA facility passed formal preliminary acceptance in December and entered its warranty phase. Acceptance testing of the two-station telemetry tracking and command facility is planned for the first quarter of 2018.

The first MTG telemetry, tracking and command station was deployed in Fucino, Italy

As the MTG-I data processing chains take shape, EUMETSAT prepares for independent verification

The less-advanced development of the MTG-I data processing chain passed important intermediate milestones towards completion of its critical design, with the delivery of the processing infrastructures hosting the processing software.

The processing infrastructure of the instrument data processing facility for the MTG-I mission (IDPF-I), including a first version of the level 0 processing software, was integrated with the simulator of MTG payload data and tested, achieving good performances even at the maximum data rate. The processing infrastructure was formally accepted in October.

Likewise, the critical design of the processing infrastructure of the level 2 processing facility (L2PF) for the MTG-I mission was validated in October. Its first version was made available to EUMETSAT on the cloud for familiarisation ahead of the first physical delivery expected in 2018.

In addition, the MTG Preliminary Design and Component Reviews (PDCR) were closed out for all four EUMETSAT Satellite Application Facilities developing MTG-I level 2 products and user software, i.e. the H SAF, NWC SAF, LSA SAF and OSI SAF.

Building on level 1 processing algorithms delivered by space segment industry, EUMETSAT's scientists and engineers continued to develop end-to-end reference processors for the FCI and LI instruments. This is required to assess MTG-I mission performances and to generate simulated observations and representative test data to be used for the independent verification of the operational processing chains developed by the IDPF-I and L2PF contractors.

The algorithm workshops confirmed the increasing maturity of the FCI level 1 processing algorithms developed by the IDPF-I contractor which could be ingested into the EUMETSAT FCI reference processor for assessing expected instrument performances. Likewise, the EUMETSAT LI reference processor could produce level 1 products comparing well with results of processing performed by the instrument contractor and was therefore considered fit to support the verification of the operational processing chain.

DEVELOPMENT OF THE METEOSAT THIRD GENERATION SYSTEM

The MTG mission data acquisition ground station at Leuk, Switzerland, was assembeled and fully tested

Consolidation of processing algorithms enables the procurement of the MTG-S level 1 processing chain

Substantial efforts involving experts and user groups brought the algorithms for processing IRS and UVN/Sentinel-4 data to level 1 (spectra) to the maturity required for the release of the invitation to tender for the IDPF-S image data processing facility for the MTG sounding mission. The ITT could finally be published at the end of May, enabling the selection of a contractor in December, for a kick-off planned for April 2018.

The day-1 baseline for IRS level 2 processing was realigned to the proven approach already used for the IASI infrared spectrometers aboard the Metop satellites.

Preparing for the System Implementation Review

In the last quarter, the EUMETSAT system team started to prepare the second part of the System Implementation Review. This is designed as an intermediate review prior to the System Critical Design Review for the MTG-I mission foreseen for 2019. Taking into account the latest performance budgets for the FCI and IRS instruments and the detailed design of the ground segment, the review will assess system performances and technical budgets for both MTG-I and MTG-S missions and the suitability of planned system upgrades for the fulfilment of the MTG-S mission.

Preparatory activities included the reassessment of the volume of MTG-I data to be disseminated, considering national meteorological services' need to access in real time more than the four channels initially foreseen for the MTG-I 2.5-minute rapid scan mission. It is now assumed that all 16 FCI channels will be disseminated at normal resolution, in addition to the four initially foreseen channels, at high resolution.

DEVELOPMENT OF THE EUMETSAT POLAR SYSTEM - SECOND GENERATION

Apace with the space segment development, EUMETSAT signs contract for launch services and completes the preliminary design of the two main components of the EPS-SG ground segment

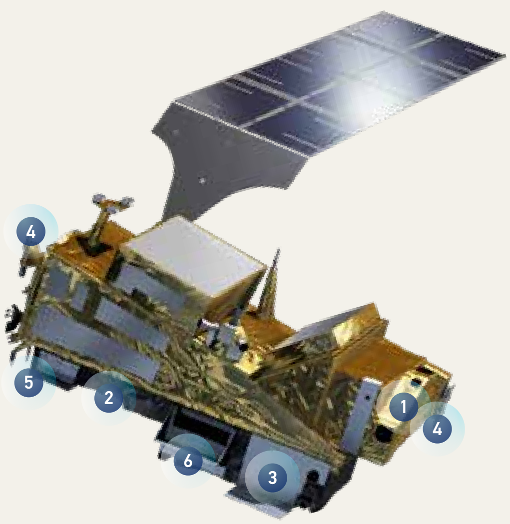
The EUMETSAT Polar System-Second Generation (EPS-SG) is Europe's contribution to the Joint Polar System to be shared with the US National Oceanic and Atmospheric Administration (NOAA) in the 2021-2042 timeframe.

The EPS-SG system is composed of a pair of spacecraft, Metop-SG A 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-SG A is an atmospheric sounding and imaging mission. It has 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-SG B 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 Global Navigation Satellite System (GNSS) radio-occultation instrument (RO) 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*	Atmospheric Chemistry, Climate Monitoring, Nowcasting (NWC) at high latitudes, Numerical Weather Prediction, Oceanography
2 MWS *Microwave Sounding (MWS)*	*AMSU-A, MHS, AVHRR*	Climate Monitoring, Nowcasting (NWC) at high latitudes, Numerical Weather Prediction
3 METIMAGE *Visible-Infrared Imaging (VII)*		Climate Monitoring, Hydrology, Land, Nowcasting (NWC) at high latitudes, Numerical Weather Prediction, Oceanography
4 RO *Radio Occultation (RO)*	*GRAS*	Climate Monitoring, Numerical Weather Prediction
5 SENTINEL-5 *(Copernicus)* *UV/VIS/NIR/SWIR Sounding (UVNS)*	*GOME-2*	Atmospheric Chemistry, Climate Monitoring, Numerical Weather Prediction
6 3MI *Multi-viewing, -channel, -polarisation Imaging (3MI)*		Atmospheric Chemistry, Climate Monitoring, Land, Nowcasting (NWC) at high latitudes

Metop-SG B satellite

Instrument/Mission	Predecessor on Metop	Applications Benefitting
1 SCA *Scatterometer*	*ASCAT*	Climate Monitoring, Hydrology, Land, Nowcasting (NWC) at high latitudes, Numerical Weather Prediction, Oceanography
2 RO#2 *Radio Occultation (RO)*	*GRAS*	Climate Monitoring, Numerical Weather Prediction
3 MWI *Microwave Imaging for Precipitation (MWI)*		Climate Monitoring, Hydrology, Nowcasting (NWC) at high latitudes, Numerical Weather Prediction, Oceanography
4 ICI *Ice Cloud Imager (ICI)*		Climate Monitoring, Hydrology, Nowcasting (NWC) at high latitudes, Numerical Weather Prediction
5 ARGOS-4 *Advanced Data Collection System (ADCS)*	*A-DCS*	Climate Monitoring, Oceanography

● Atmospheric Chemistry ● Climate Monitoring ● Hydrology ● Land
● Nowcasting (NWC) at high latitudes ● Numerical Weather Prediction ● Oceanography

DEVELOPMENT OF THE EUMETSAT POLAR SYSTEM - SECOND GENERATION

Despite fast progress in the detailed design of both Metop-SG satellites, the integration and test programme of Metop-SG A needs replanning

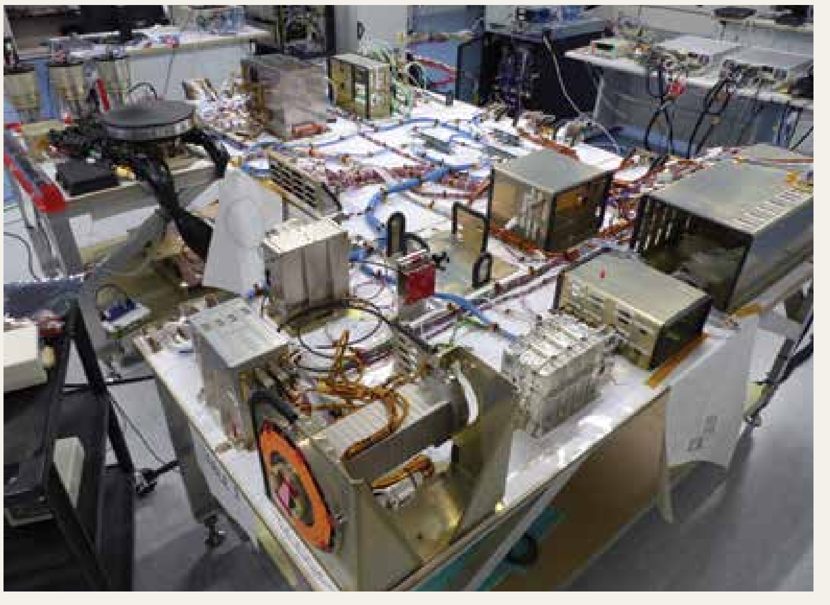
The ESA-led development of both Metop-SG satellites progressed rapidly into the critical design of satellite subsystems, completing the design of the satellite structure, solar array, propulsion module, on-board computer and some units of the attitude and orbit control system.

This enabled the manufacturing of the satellite structure to start in March and the satellite electrical functional model (EFM) programme to proceed with the incremental integration of engineering models of platform units and first functional tests.

The critical design of the subsystems of the ESA-procured MWS, 3MI and RO instruments of Metop-SG A and the preliminary design of those of the MWI, ICI and SCA instruments of Metop-SG B progressed in parallel. This occurred at a somewhat slower pace than anticipated due to technological challenges, relating in particular to the receivers of the MWS, MWI and ICI microwave radiometers.

A new “directional antenna” design was adopted for the ARGOS-4 DCS receiver to fulfil ARGOS mission requirements whilst preserving the compatibility of the volume of the Metop-SG B satellite with the launcher fairing.

The critical design of the subsystems of the CNES-procured IASI-NG instrument progressed, though facing challenges in the design of the focal plane, the cryogenic assembly and the interferometer. Additional challenges were the qualification of the potassium bromide (KBr) optical material of the interferometer and the development of detectors. In December, after extensive testing, a configuration of the KBr material with no antireflective coating was selected as the baseline. It was considered that this would increase instrument performance well above specifications in the mission-critical CO_2 absorption band and that stray light could be addressed by other features of the instrument design.



Testing using the electrical functional model of the Metop-SG satellite (source: ESA)

In September, a Design Check Point confirmed that the development of the DLR-procured METimage instrument was on the right path. However, risks to the schedule were high. These were associated with an infrared detector supply issue also impacting the development of the 3MI and Sentinel-5 instruments, and to the delayed start of the development contracts for the derotator optics, the telescope mirrors and the beam splitter.

At the end of the year, DLR and METimage industry, with the support of ESA and EUMETSAT, started to assess how to limit the inevitable delays in the delivery of the instrument models for the Metop-SG A satellite for its integration and test campaign. ESA and Metop-SG industry started to assess how to mitigate impacts on the satellite side, taking into account the delivery schedule of other instruments impacted by technology issues, in particular MWS, 3MI, IASI-NG and Sentinel-5.

The replanning may postpone the launch of Metop-SG A1 from September 2021 into 2022.

DEVELOPMENT OF THE EUMETSAT POLAR SYSTEM – SECOND GENERATION

EUMETSAT consolidates the EPS-SG system design and signs launch service contract

A System Engineering Check Point in March confirmed end-to-end performance budgets, processing specifications and estimates of the volume of data products for all instrument functional chains.

End-to-end performances were then continuously reassessed taking into account the progress achieved in the design of the satellites, instruments and ground segment, showing compliance with system requirements.

The contract for launch services for the first pair of Metop-SG satellites was signed in September with Arianespace, enabling the timely start of preliminary mission analysis activities. The signing of the contract for the corresponding launch and early operations phase services followed in October.

The two main ground segment functional chains complete their preliminary design

The mission control and operations (MCO) and the payload data acquisition and processing (PDAP) chains of the EPS-SG ground segment had their preliminary design validated in July and November. Both contractors were authorised to proceed with the critical design phase, and the production of the first pre-deliveries to EUMETSAT.

A pre-delivery of the MCO mission control subsystem was tested at EUMETSAT in August. Since then, it has been used for familiarisation purposes and preparations for the first system validation test with the Metop-SG A satellite.

The Preliminary Design Review of the PDAP chain was the occasion for EUMETSAT to provide the contractor with new versions of processing algorithms and specifications for all instrument chains and of the legacy processing software to be reused in the development.

A first pre-delivery of the PDAP processing infrastructure hosting all data processing chains passed on-site acceptance tests at EUMETSAT in November.

The procurement of the two processing chains to be provided to the PDAP contractor for integration into this processing infrastructure progressed in parallel. CNES awarded a contract for the operational processor for IASI-NG level 1C products and EUMETSAT released the ITT for the operational processor for Sentinel-5 level 2 products.

In addition, the Requirements Review process for the contributions of SAFs to the development of EPS-SG level 2 products was launched in the margins of the EUMETSAT user conference.

"The validation of the preliminary design of the two EPS-SG ground segment chains was a major achievement for EUMETSAT and industry. It also showed the challenging complexity of the system."

Jean-Christophe Gros
EPS-SG Ground Segment Manager
EUMETSAT

Sites get ready to host ground stations in Spitzbergen and the Azores

The site infrastructures required to host the ground stations developed under the MCO and PDAP contracts were prepared in Svalbard and the Azores.

The Svalbard site was made available to the MCO and PDAP contractors after infrastructure tests and inspection, enabling the start of the foundation work necessary for hosting the S-Band telemetry tracking and control and Ka-band mission data acquisition stations.

The Azores site infrastructure service contract was signed, and the architectural drawings and civil works calculation were validated. The site will host the PDAP reference X-band station used for the acquisition of data directly broadcast by the Metop-SG satellites.

Finally, the preliminary design of the EPS-SG upgrades of the multi-mission archive, offline monitoring services and data dissemination system was completed.

OPERATIONAL OCEANOGRAPHY IN THE CONTEXT OF COPERNICUS

With Sentinel-3A joining Jason-3 in routine operations and readiness achieved for the launch of Sentinel-3B, the European backbone of the global ocean monitoring system will be fully deployed in 2018

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.

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

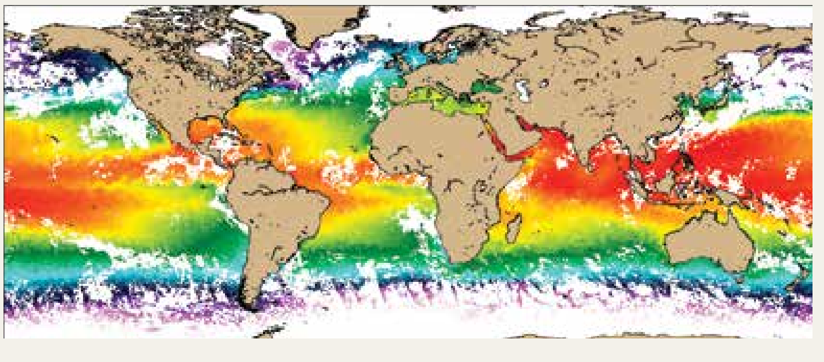
Flying on a non-synchronous orbit to avoid aliasing of sea level measurements by tidal signals, Jason-3 provides the most accurate altimeter measurements of sea level. They are therefore used for cross-calibrating other altimeter missions.

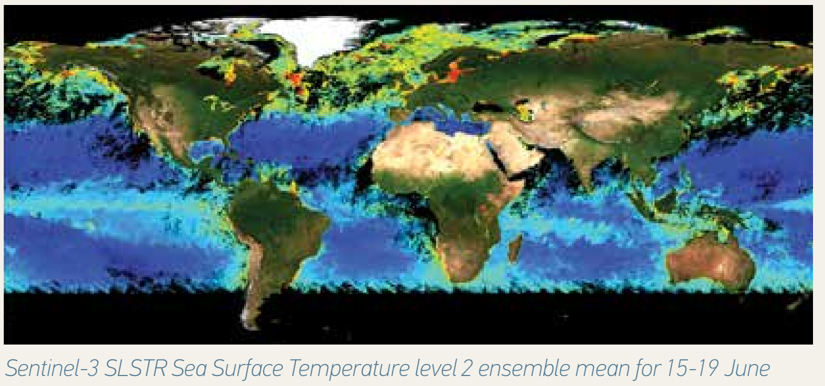
The Sentinel-3 marine mission provides additional altimeter measurements to those of Jason-3 and has restarted the series of highly accurate measurements of sea surface temperature and ocean colour interrupted after the loss of Envisat.

After the release of all marine products, Sentinel-3A enters routine operations

The shortcomings of the Sentinel-3 marine payload data ground segment (PDGS) were tackled following the plan agreed with ESA for the progressive release of all Sentinel-3 products to users.

In April, an important milestone towards resilient operations was achieved when the PDGS DEV platform, that is capable of compiling and (re) building the full PDGS software, including all instrument processors, at any time, was accepted and all offline level 1 products were released.





Sentinel-3 SLSTR Sea Surface Temperature level 2 ensemble mean for 15-19 June 2017 (top) and Sentinel-3 OLCI level 2 Algal Pigment Concentration (bottom)

Unfortunately, the Sentinel-3 Validation Team (S3VT) workshop held with ESA on 15-17 February concluded that, while altimeter products were already excellent, the quality of level 1 products extracted from the optical observations of the SLSTR and OLCI instruments was insufficient for the operational production of level 2 products.

This postponed the Sentinel-3A Routine Operations Readiness Review (RORR) to give enough time to resolve identified SLSTR channel coregistration, OLCI solar calibration and cloud masking issues.

The optical level 2 products could be released on 5 July, and, as a result, the full set of Sentinel-3A level 1 and core marine level 2 products became available to all users, including the altimeter level 2P and level 3 products directly usable by ocean prediction models.

Since then, all near-real-time products have been delivered in "push" mode via EUMETCast-Europe and online via the Copernicus Online Data Access (CODA) service directly accessible via the EUMETSAT EO Portal.

Copernicus Sentinel-3A entered routine operations on 16 October after the successful Routine Operations Readiness Review.

OPERATIONAL OCEANOGRAPHY IN THE CONTEXT OF COPERNICUS

"The start of Sentinel-3A operational data services to users rewarded substantial efforts, and we are now ready for Sentinel-3B."

Hilary Wilson
EUMETSAT Copernicus Sentinel-3 Mission and System Upgrade Manager

EUMETSAT gets ready for the launch of Sentinel-3B

The launch of Copernicus Sentinel-3B was prepared with ESA. Two changes to the dual Sentinel-3 flight operations configuration were implemented, i.e. tandem operations of Sentinel-3A and Sentinel-3B with a 30-second separation during Sentinel-3B commissioning and orbital phase separation reduced from 180° to 140° in the subsequent nominal operations phase.

The Sentinel-3A marine PDGS was first re-engineered and improved in robustness and capacity with the replacement of obsolescent network equipment, removal of single points of failure and the addition of a second production chain to handle two data streams.

The EUMETSAT Sentinel-3 ground systems were declared ready on 8 June for verification and validation testing in their dual-satellite configuration.

The PDGS was tested until October, using as inputs the incoming real-time Sentinel-3A data stream plus a simulated Sentinel-3B data stream, and the tests of the dual-satellite flight operations segment were completed in the same timeframe.

Load tests then confirmed the capacity of the EUMETSAT multi-mission system to cope simultaneously with data from two Sentinel-3, three Metop and six Meteosat Second and Third Generation satellites.

An end-to-end test campaign followed, leading to a EUMETSAT Ground Segment Acceptance Review. This provided EUMETSAT's readiness inputs for the formal acceptance of the full Sentinel-3 ground segment and the ESA satellite Flight Acceptance Review which was declared successful on 12 December.

EUMETSAT supported the final system validation tests involving the ground segment and the Sentinel-3B satellite, which were concluded on 18 December.

OPERATIONAL OCEANOGRAPHY IN THE CONTEXT OF COPERNICUS

The Jason-CS/Sentinel-6 system and ground segment development is catching up with the space segment

With two successive satellites, the Sentinel-6/Jason-Continuity of Service (CS) cooperative programme will continue the high-precision ocean altimetry mission after Jason-3, until at least 2030.

It involves Europe, through EUMETSAT, ESA, CNES and the EU Copernicus programme, and the United States, through NASA and NOAA.

Through its Jason-CS optional programme, EUMETSAT develops the ground segment, coordinates system activities, contributes a fixed financial contribution to the ESA development of the first satellite and co-funds the second with the EU. EUMETSAT will then exploit the Sentinel-6 mission on behalf of Copernicus.

Ireland became the 16th Participating State in the EUMETAT Jason-CS programme in June, bringing the level of subscription to 97.24 %. The subscription period was extended until July 2018.

After the entry into force of the Memorandum of Understanding formalising the cooperation between NOAA, NASA, ESA and EUMETSAT, the four-partner Joint Steering Group (JSG) met for the first time in June to review programme plans, with the European Commission attending as an observer. The Sentinel-6 Mission Advisory Group also met for the first time.

The ESA-led space segment development completed the detailed design of the satellite and all of its European and US instruments, and NASA placed a contract for the launch service for the first satellite.

In view of the late entry into force of the EUMETSAT Jason-CS optional programme, the major challenge for EUMETSAT-led system and ground segment development activities was to catch up with the space segment development.

The management framework for system activities was consolidated with the signature of a Cooperation Agreement with CNES and the drafting of a Jason-CS Programme Implementation Plan with ESA.

The System Preliminary Design Review was then prepared. This included consolidation of the system requirements, technical budgets and product specifications and the release of high-level plans for system integration, verification and validation tests, as well as for satellite system validation tests (SSVT) involving the satellite and the ground segment.

The System Preliminary Design Review was closed in October and the authorisation was given for system activities to enter the full development phase, focusing on the preparation of the first SSVT-1 test scheduled for November 2018.

The preliminary design of the Jason-CS overall ground segment was validated in December by a Preliminary Design Review (PDR).

In view of the very tight ground segment development schedule, a "Procurement Readiness Key Point" had been organised in April to authorise the release of the ITT for the payload data acquisition and processing (PDAP) chain prior to the ground segment PDR. The ITT was released in May and the contract awarded in December.

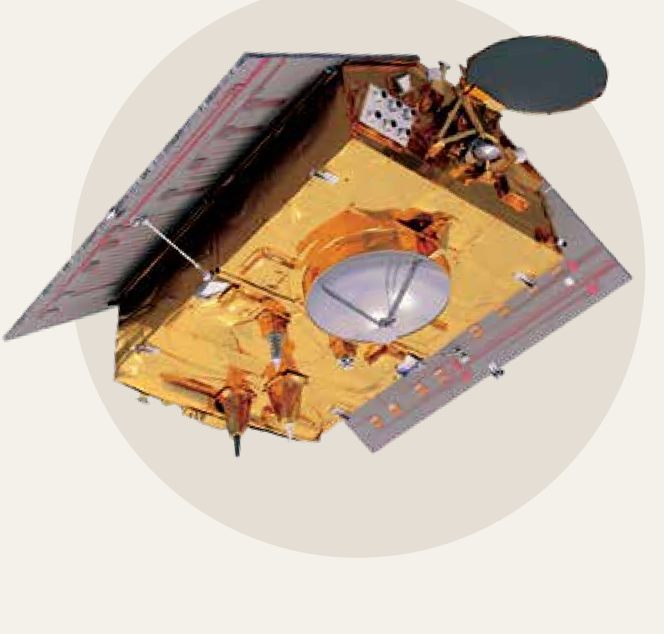
The two other main components of the ground segment, the mission and operations control chain (MOC) and the multi-mission support services, reuse existing assets for schedule and efficiency reasons.

The hardware and software infrastructure needed to support the SSVT-1 test with the satellite was deployed, enabling the deployment of a version V0 of the mission control software in December and the ingestion of a first version of the satellite database.

The ESA-led procurement of the satellite simulator needed to prepare this test was concluded in October and the first delivery is expected in the first quarter of 2018.

At this point, the space segment, system and ground segment schedules remain compatible with a launch of Jason-CS/Sentinel-6A in November 2020, though with low margin.

Artist's impression of Jason-CS/Senteinl-6 satellite (source: ESA/ATG medialab)



COPERNICUS OPERATIONAL COOPERATION WITH THE EUROPEAN COMMISSION

The cooperation with the Commission further develops in the area of access to Copernicus data and information

Partnering with the ECMWF and Mercator-Ocean for a distributed Copernicus Data and Information Access Service platform

Building on the technical concepts and infrastructure design established for its pathfinder big data services, EUMETSAT proposed a distributed concept for a Copernicus Data and Information Access Services (DIAS) platform in partnership with the ECMWF and Mercator-Ocean, providers of the Copernicus Atmosphere, Climate Change and Marine Environment services.

After endorsement of the concept by Copernicus governance, the Commission formally accepted a joint proposal for the design, development and staggered deployment of a DIAS platform fulfilling its published functional requirements.

The three partners defined the detailed scope of version V0 of the multisite platform to be deployed in 2018 and the components each partner needs to provide for its deployment. A joint V0 Deployment Readiness Review was then planned for January 2018 to confirm that the combination of all contributions is fit for purpose.

An information day held at EUMETSAT with the Commission, the ECMWF and Mercator-Ocean to present the platform to user entities, in particular service-orientated small and medium enterprises and others, attracted about 200 participants. A dedicated webpage was also created (www.wekeo.eu).

At the end of the year, discussions started on the planning, sharing of tasks and procurements for the deployment of the next, fully operational V1 version.

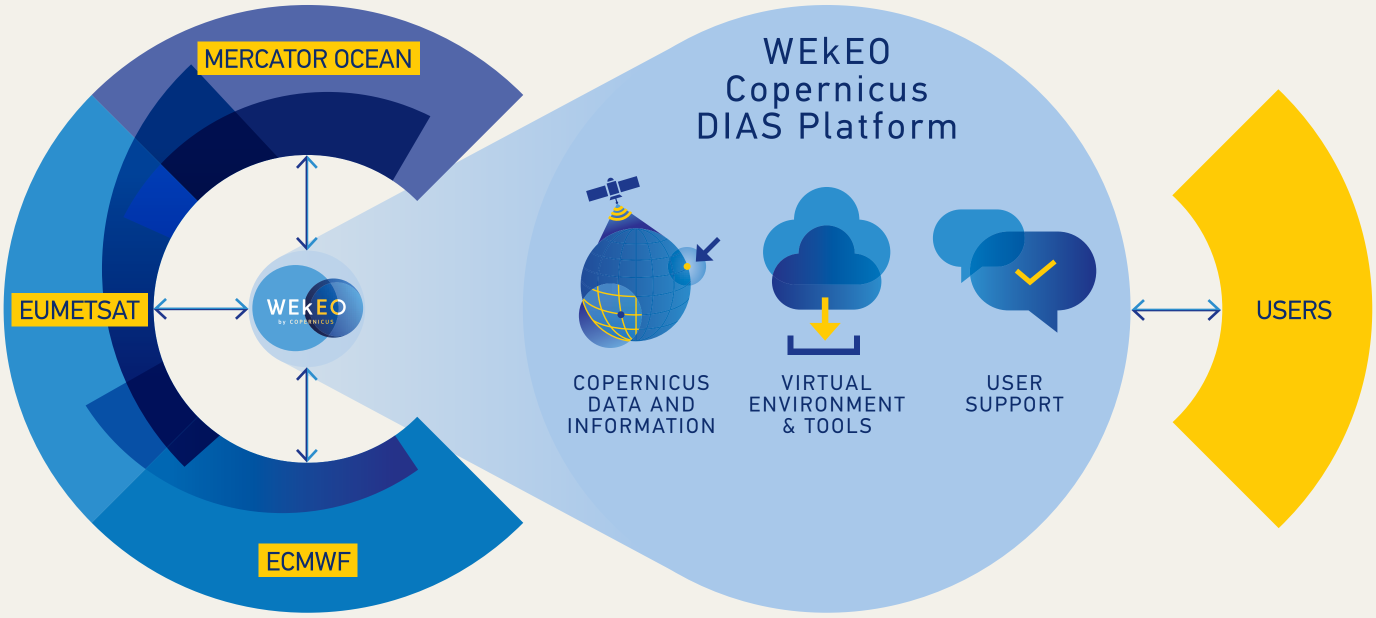
Expanding access to Copernicus data to Africa and worldwide

ESA and EUMETSAT proposed to the Commission to “push” Sentinel-3 land products to African users via EUMETCast-Africa, using the more than 500 EUMETCast stations deployed throughout the continent. Both agencies also worked on another joint proposal for the dissemination of near-real-time Sentinel-5P atmospheric composition products via EUMETCast-Europe.

Geoscience Australia and NOAA confirmed at Copernicus data access coordination meetings their high satisfaction with the level of service provided by EUMETSAT for the transfer of Copernicus marine data to their countries using its EUMETCast-Terrestrial multicasting system.

In response to multiple requests from operational meteorological user entities, the Commission designated EUMETSAT as the point of contact for routing selected near-real-time marine products from Sentinel-3 and Sentinel-1 to the World Meteorological Organization’s Global Telecommunication System.

Distributed concept of the Copernicus DIAS platform proposed to the European Commission in partnership with ECMWF and Mercator-Ocean



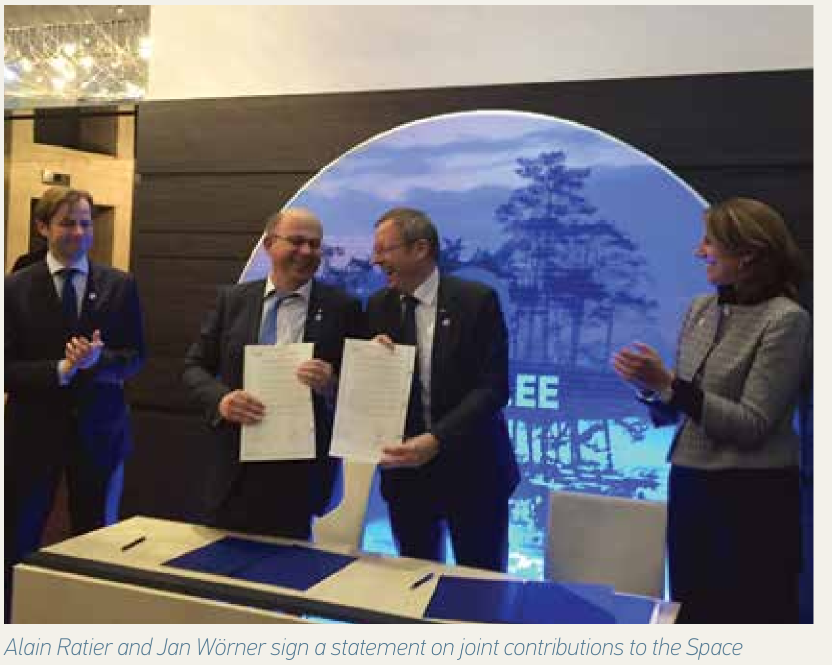
CONTRIBUTION TO THE SPACE STRATEGY FOR EUROPE

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

At a hearing in front of the Security and Defence Subcommittee of the European Parliament, the Director-General presented the EUMETSAT perspective on the protection of space infrastructure for European security and defense. He stressed that EUMETSAT satellite systems are vital space infrastructure for the safety of EU citizens and therefore need protection against space debris, cyber risks, and also continued access to vital frequencies, some of which may face competition from the development of 5G services.

The Director-General attended the EU-ESA informal space ministerial meeting co-organised in Tallinn by the Estonian EU Presidency and the Spanish Chairmanship of the ESA Council to discuss the future of Copernicus and how “new space” industry could be involved in a European geospatial ecosystem. In his intervention, he advised that sustained research and scientific development will be essential to develop information services in areas other than high resolution imagery, in particular for estimating anthropogenic CO_2 emissions and developing sectorial climate services, and advocated for synergies between the EU Copernicus and research and innovation programmes to create the widest spectrum of opportunities.

In the margins of this ministerial meeting, the Director-General signed with his ESA counterpart a statement on the joint ESA-EUMETSAT contributions to the Space Strategy for Europe. The statement communicates on the value of weather information services, the cooperation between ESA and EUMETSAT in the development of meteorological satellite systems and their joint contributions to Copernicus. It re-affirms the common goal to keep Europe a world leader in satellite meteorology with EUMETSAT Polar System-Second Generation and Meteosat Third Generation systems, and the commitment to partner with the European Commission for the deployment and exploitation of Copernicus Sentinel missions monitoring the ocean, atmospheric composition and climate in synergy with EUMETSAT’s own missions.



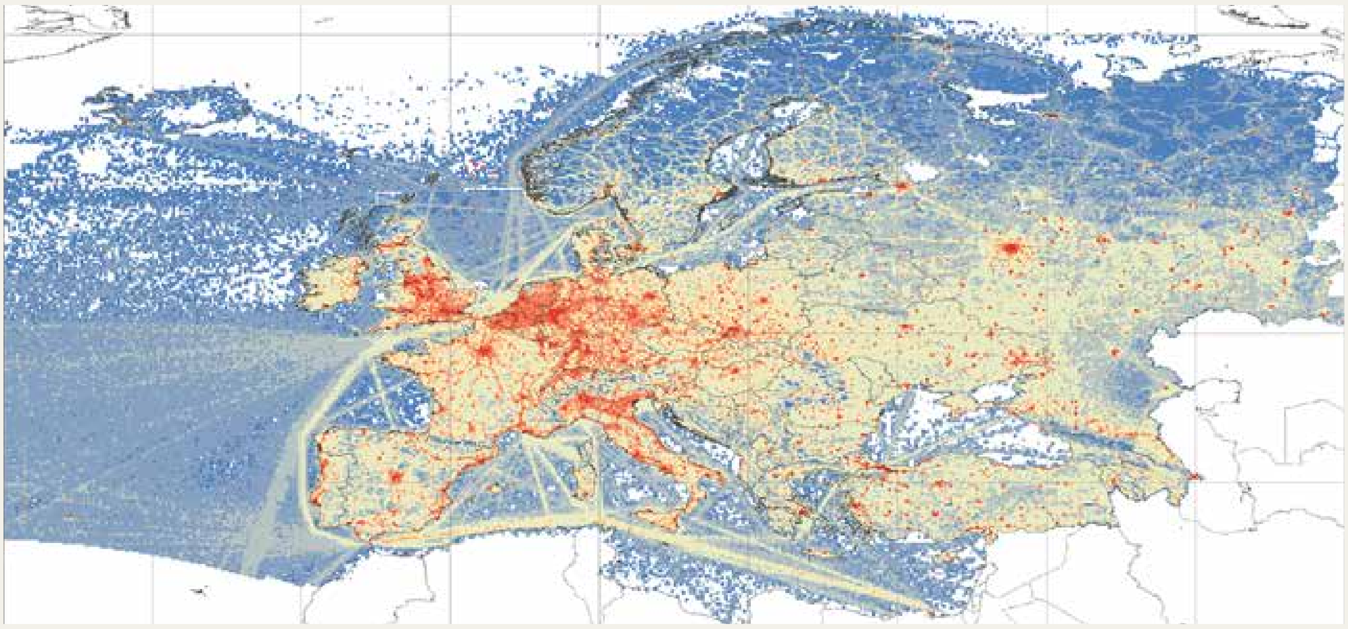
Alain Ratier and Jan Wörner sign a statement on joint contributions to the Space Strategy for Europe, in Tallinn, Estonia

At the Le Bourget air show, the Director-General participated in a high-level round table moderated by his ESA counterpart on how to formalise the commitment of institutional customers of launch services to using Ariane-6. Recalling the contracts already signed with Arianespace, he stressed that EUMETSAT can only consider launch service contracts using Ariane-6 when the launcher is flight proven.

EUMETSAT supported the Space Dialogues between Europe and space-faring nations, preparing joint contributions with JAXA and JMA to the EU-Japan dialogue held in Tokyo.

CONTRIBUTION TO THE SPACE STRATEGY FOR EUROPE

EUMETSAT joined forces with ESA to support the European Commission in preparation for the future of Copernicus



European total CO_2 emissions of the TNO-CAMS inventory of anthropogenic sources excluding the land use, land-use change and forestry sectors for 2014, gridded at a resolution of 0.125° x 0.0625° (source: Copernicus Operational Anthropogenic CO_2 Emissions Report 2017)

EUMETSAT supported the user requirements definition process arranged by the Commission for potential additional Copernicus Sentinel missions, including the preparation of a final user workshop held on 14 September.

This included participation in two taskforces established by ESA and the Commission to assess requirements for an information system for monitoring anthropogenic CO_2 emissions and for a new Sentinel mission providing measurements of CO_2 and CH_4 column concentrations as critical inputs.

Support was also provided to the polar expert groups tasked with assessing user requirements for monitoring the Arctic environment, which identified a passive microwave radiometer mission as one priority. The EUMETSAT Council confirmed the relevance of this mission to EUMETSAT due to high synergies with the EPS-SG missions.

EUMETSAT also supported the Commission in the evaluation of scenarios for the evolution of the Copernicus space component in the next EU Multi-annual Financial Framework (MFF), within a trilateral working group established with ESA.

The Director-General and the ESA Director of Earth Observation Programmes formed a joint technical taskforce to support this trilateral working group and propose cooperation scenarios for joint contributions to the deployment and exploitation of potential Sentinels of relevance to EUMETSAT.

Building on the first outputs of this task force, the trilateral working group produced a reference presentation describing EU and ESA planning assumptions, EU priorities, candidate new Sentinel missions and preliminary cost estimates for all Copernicus space component activities envisaged in the next MFF. This was welcomed by the Copernicus Programme Committee, the ESA PB-EO and the EUMETSAT Council.

In parallel, an internal assessment confirmed that EUMETSAT had the capacity to support the development and deployment of up to two more full-scale Sentinel missions in the 2020-2025 timeframe and their exploitation from 2025 onwards.

After confirmation of user requirements and priorities by the Commission, EUMETSAT and ESA consolidated their proposed sharing of tasks for the development, deployment and operations of the foreseen Sentinel missions of relevance to EUMETSAT, focussing on the CO_2 monitoring mission.

Interactions between ESA and the Commission will continue in 2018 to support the Commission in preparing its Copernicus proposal for the next EU MFF.

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 engages in space weather monitoring from space

Meeting for its 45th plenary session in Jeju, South Korea, at the invitation of the Korea Meteorological Administration (KMA), the Coordination Group for Meteorological Satellites discussed its contributions to the monitoring of the climate and greenhouse gases from space.

It also endorsed a work plan for the coordination of members' contributions to space weather monitoring from space, within a global framework for space weather monitoring and information services involving the UN COPUOS, WMO, ICAO and ISES.

The monitoring of aerosols, fires, and flash floods was agreed as the first priority for further development of non-meteorological applications of geostationary satellites.

Bilateral cooperation brings mutual benefits and serves worldwide user communities

The preparation of US instruments for the launch of Metop-C, the design of the shared ground systems of the future Joint Polar System and the development of the Jason-CS/Sentinel-6 system were the priorities of the intense cooperation with NOAA and NASA.

In the area of operations, NOAA and EUMETSAT completed the testing of their new JEUNO transatlantic communication system, including backup links, in preparation for the exchange of larger volumes of data.

Scientific cooperation with NOAA focused on the calibration and validation campaign of the GOES-16 Advanced Baseline Imager and Lightning Mapper, enabling EUMETSAT to gain experience and access to unique datasets for preparations for its MTG-I Lightning Imager mission.

The Cooperation with China developed further, with the entry into force of new agreements.

A Framework Agreement was signed with the China National Space Administration (CNSA) providing a policy framework and longer term perspective for the development of existing cooperation with the China Meteorological Administration (CMA) and the China State Oceanic Administration (SOA).

Alain Ratier and China National Space Adminstration Vice Administrator Wu Yanhua sign a cooperation framework agreement in Beijing, China

This enabled the entry into force of a new Memorandum of Understanding extending the cooperation with SOA on satellite marine data applications and exchange to the full series of HY-2 ocean-monitoring satellites exploited by the SOA satellite centre (NSOAS).

COOPERATION WITH OTHER SATELLITE OPERATORS

A new data exchange protocol was signed during the visit to EUMETSAT of Ms Liu Yaming the new CMA Administrator.

The 3rd joint technical workshop with CMA concentrated on coordinated planning for the next generation polar-orbiting satellites, the evolution of communication links for the exchange of larger volumes of data and scientific cooperation for monitoring greenhouse gases from space.

In February, the Director-General and the ISRO Chairman explored further cooperation opportunities, and agreed to use fast broadband communication networks to exchange increasing volumes of real-time data.

As a result, EUMETSAT set up EUMETCast Terrestrial receiving stations at ISRO and IMD for multicasting large volumes of EUMETSAT data to India, including Copernicus Sentinel-3 marine products. On ISRO's side, internet-based routing of data via the government/research broadband network was implemented for the transfer of Scatsat-1 data from the Shadnagar processing centre to EUMETSAT.

ISRO and EUMETSAT also discussed a joint visiting scientist programme focussing on validation of ocean colour products and retrieval of aerosol parameters and processing of data from radio occultation and microwave sounders under development by ISRO.

Finally, letters were exchanged with CNES and ISRO to extend EUMETSAT's participation in the CNES-ISRO SARAL ocean altimeter mission until the end of 2019.

Under a five-year extension of the cooperation with the Japan Meteorological Agency signed in July, EUMETSAT hosted a Japanese visiting scientist tasked with recalibrating infrared imagery from the GMS-1 to MTSAT- 2 geostationary satellites using methods developed by EUMETSAT.

Ms Liu Yaming, new CMA Administrator, and Alain Ratier, sign a new data exchange protocol on 8 May, in Darmstadt.

Discussion with JAXA focused on access to CO_2 and CH_4 products from GOSAT and cross-calibration of a future GOSAT-2 instrument using IASI data. Within CEOS and the CGMS, EUMETSAT continued to stress the user criticality of a follow-on to the GCOM-W1 microwave imagery mission, currently under study by JAXA.

EUMETSAT signed a new data exchange protocol with the Korea Meteorological Administration and informed its Korean partner that European radio occultation and microwave sounders under development for its EPS-SG programme may be of interest to Korea for its first 500kg-class polar-orbiting meteorological satellite.

A second joint training event organised with Roshydromet in Moscow attracted about 100 Russian-speaking meteorologists from WMO member countries having access to EUMETSAT data. This success was acknowledged at a high-level bilateral meeting organised in Sochi, Russian Federation, where further cooperation objectives were agreed, including acquisition of Metop-C data at Russian stations and scientific cooperation on infrared hyperspectral sounding using the IASI and IKFS-2 instruments.

The extended Cooperation Agreement with the Department of Environment of Canada entered into force on 3 January.

Delegates at the EUMETSAT-Roshydromet bilateral meeting in Sochi, Russia, 9 November 2017

GLOBAL PARTNERSHIPS

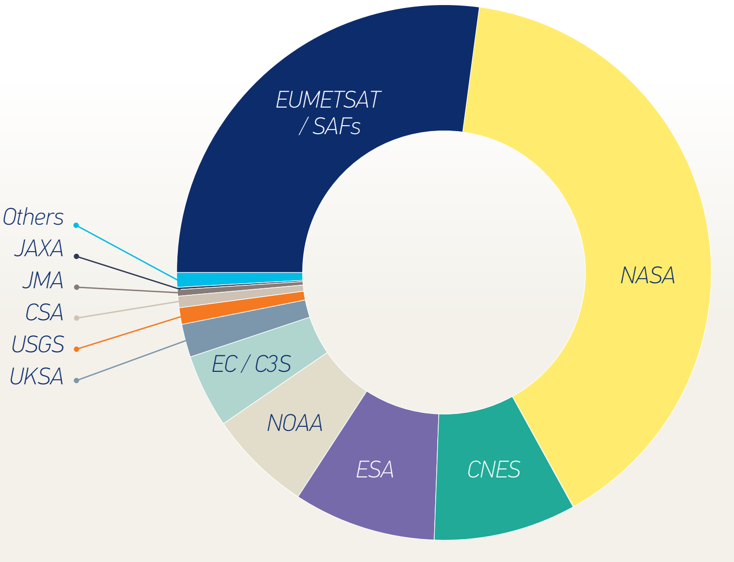
EUMETSAT plays an active role in global partnerships with a focus on climate monitoring from space

EUMETSAT supports the Global Framework for Climate Services in Africa

As part of a task team involving Regional Climate Centres and Regional Economic Communities from the African, Caribbean and Pacific (ACP) regions, the African Union Commission, the ACP Secretariat and the EU Joint Research Centre, EUMETSAT supported the identification and formulation study for a first Global Framework for Climate Services ACP project aimed at developing climate services in those regions.

The study outcome was used to scope a capacity development project on intra-ACP climate services and related applications which the 11th European Development Fund committee in December agreed to fund.

EUMETSAT's contribution will focus on data access and training and will be formalised with the other project stakeholders in 2018. In anticipation, a training course on climate monitoring from space was organised for African users, including trainees nominated by NMHS and Regional Climate Centres.



EUMETSAT provides 26% of the 913 existing and planned climate data records of essential climate variables observable from space produced by CEOS and CGMS member agencies

The Global Architecture for Monitoring Climate from Space reports to COP23

Within the Joint Working Group on Climate tasked by the CGMS and the Committee for Earth Observations Satellites (CEOS) to coordinate the implementation of the global architecture for monitoring climate from space, EUMETSAT consolidated and published the web-based inventory of existing and future climate data records of essential climate variables observable from space (http://climatemonitoring.info/ecvinventory).

The 913 entries collected from 11 CGMS and CEOS member agencies - including 496 existing and 417 planned records and a total of 237 entries (26%) from EUMETSAT and its SAF network - was much higher than expected. They covered 30 of the 37 ECVs identified in the 2016 Global Climate Observing System Implementation Plan as observable from space.

EUMETSAT then coordinated the gap analysis to be completed in 2018 under its two-year chairmanship of the Joint Working Group on Climate.

The inventory and the first results of the gap analysis were used to prepare the response of CEOS and CGMS to the requirements of the GCOS Implementation Plan and a formal statement to the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UN Framework Convention on Climate Change (UNFCCC). Both were delivered at the 23rd Conference of the Parties to the UNFCCC (COP23) organised by Fiji in Bonn, Germany, with the support of the German government.

EUMETSAT participated in COP23 side events and in associated interactions with media on contributions of space and Copernicus to monitoring and prediction of climate change and CO_2 emissions and related data access services.

EUMETSAT also contributed to the drafting of a CEOS white paper defining a target constellation for observing CO_2 from space to be deployed by CEOS and CGMS agencies in support of implementation of the Paris Agreement.

At a meeting of heads of space agencies on climate monitoring organised by CNES as a side event of the One Planet Summit, the Director-General stressed that understanding the carbon cycle and estimating anthropogenic CO_2 emissions are two objectives that go hand in hand.

GLOBAL PARTNERSHIPS

CEOS and GEO

Within CEOS, EUMETSAT participated in the virtual constellations for ocean monitoring and supported the concept of a new "COVERAGE" portal proposed by NASA to provide online access to ocean observations, based on interoperability with other ocean data platforms.

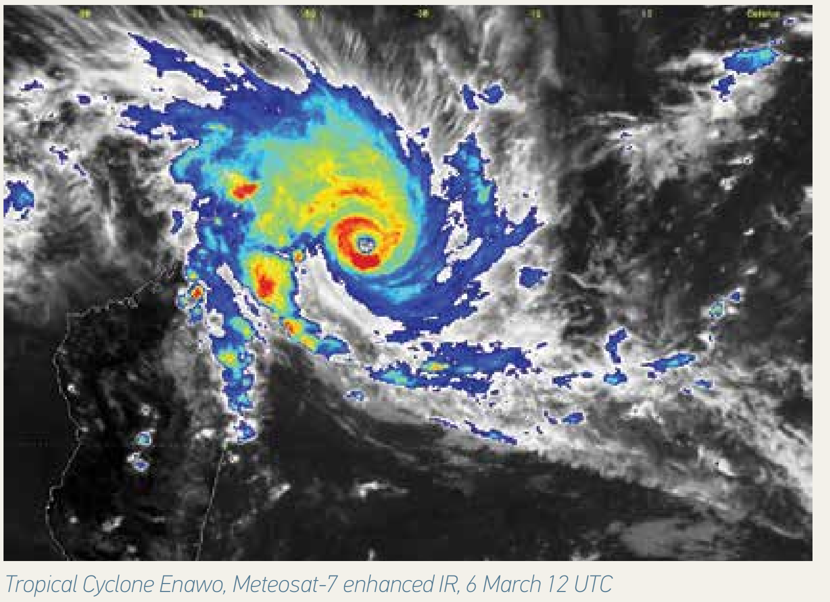
At the plenary meeting hosted in Rapid City by the United States Geological Survey, EUMETSAT expressed support for the priorities presented by the European Commission for its incoming 2018 CEOS chairmanship and by NOAA for its two-year chairmanship of the Strategy Implementation Team. Thus, EUMETSAT is committed to supporting the Commission and NOAA in the definition of a target constellation for monitoring CO_2 from space and future data access architectures, the fulfilment of Sustainable Development Goals, the combined use of observations from geostationary and low-Earth orbits and the enhancement of the CEOS relationship with the CGMS, GEO and the WMO.

Within the Group for Earth Observation (GEO), EUMETSAT supported the definition of the EuroGEO regional initiative launched by the European Commission and contributed to the "Europe for GEO" booth at the organisation's plenary meeting in Washington. Applications and user benefits of the global GEONETCast data broadcast system deployed with NOAA and the CMA as a foundational task of the GEO System of Systems were also showcased.

EUMETSAT responded to two activations of the Charter on Space and Major Disasters, in March and April, delivering Meteosat-7 infrared imagery to Madagascar when the country was hit by Cyclone Enawo and, for the very first time, true colour imagery at 300m resolution from Sentinel-3A to assess the extent of coastal floods in northern Peru.

EUMETSAT prepared for co-chairing the Charter with DLR from April to October 2018.

Coastal floods in Northern Peru, observed in true colour by OLCI/Sentinel-3A on 4 April



Tropical Cyclone Enawo, Meteosat-7 enhanced IR, 6 March 12 UTC

MANAGEMENT AND ADMINISTRATION

Organisational management

The response to the new German labour legislation mobilised management across the organisation and imposed exceptional measures for achieving compliance whilst securing vital continuity of the workforce.

This included grouping ongoing consultancy contracts requiring similar skills into service frame contracts, conversion of some 70 consultancy positions into staff posts and differentiating identification badges, email addresses and canteen prices for staff and on-site contractors.

The policy for the protection of personal data was aligned with the EU General Data Protection Regulation entering into force in May 2018.

The management system documentation was simplified, restructured around the seven key business processes and prepared for its transformation into a user-friendly, navigable information system available on the intranet.

A competence planning exercise started to assess the competences and human resources to be maintained after the deployment of the full in-orbit capacity of the MTG, EPS-SG and Jason-CS systems, and to plan the necessary transfers from development to technical support and operations.

Financial processes

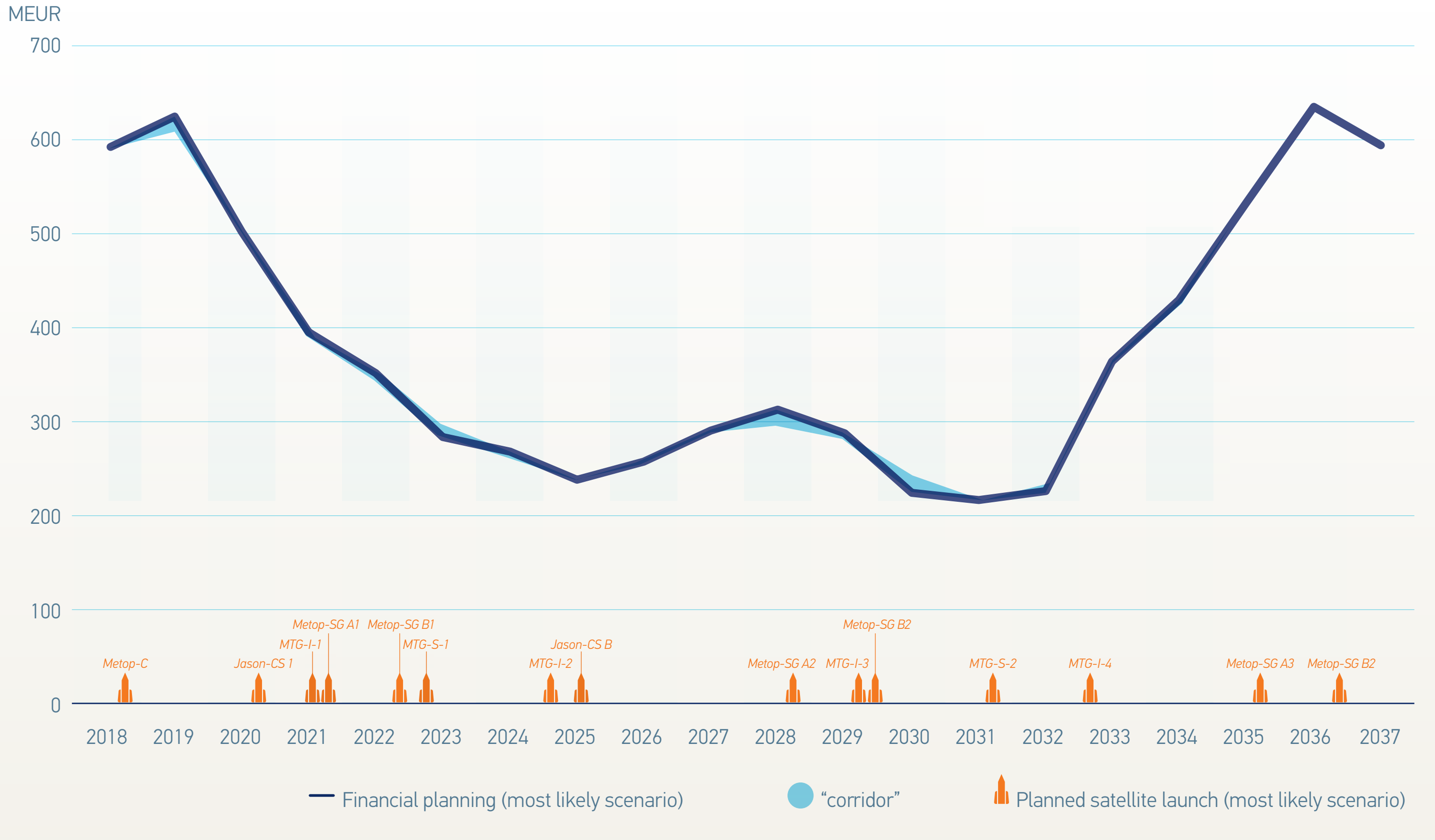
The audit of the EUMETSAT 2016 annual accounts was concluded by the German Bundes Rechnungshof with an unqualified opinion, and Tribunal de Contas of Portugal became the external auditor for 2018-2020.

Charges for negative interest on EUMETSAT-managed funds could be avoided using all available market options compatible with its financial rules.

“Sustainability” was adopted as the most suitable objective for the management of the pension funds and the long-term strategic asset allocation was revised to achieve the associated 5.5% target return on investment.

Considering that overall contributions of Member States were likely to exceed €600 million in 2018 and 2019 and €500 million in 2020 as a consequence of the unforeseeable realignment of the MTG and EPS-SG schedules and payment profiles, an external financing facility was proposed to enable Member States to smooth out their contributions peak at their own cost, if needed. The facility was abandoned as none of the Member States decided to use it. The Council approved contributions of €593 million for 2018, noting that the financial planning was peaking at €622 million in 2019, but with significant evolutions expected in 2018, as a result of the ongoing replanning of the EPS-SG development programme.

Financial planning (contributions) 2018-2037



MANAGEMENT AND ADMINISTRATION

MAIN CONTRACTS AND FINANCIAL AGREEMENTS APPROVED BY COUNCIL

Staff healthcare services

Transitional service frame contracts grouping existing consultancy contracts for compliance with the new German labour legislation

New satellite-based data broadcast service for Africa (EUMETCast-Africa)

Extension of cloud infrastructure and software services for pathfinder big data services

Extension of secondary backup TT&C ground station service for Meteosat

Temporary Meteosat mission data acquisition service from Lario

Relocation of two Meteosat ground stations from Usingen to Cheia

Extensions of maintenance services for EPS ground segment facilities

Extension of EPS and EPS-SG analyst and controller service

Service for precise GNSS ephemeris and auxiliary data for processing EPS and EPS-SG radio occultation data

Increase of financial liability to ESA to cover the impact of exceptional measures for MTG schedule recovery on recurrent satellites

Instrument data processing chain for the Meteosat Third Generation sounding mission

Increase of financial commitment to ESA to cover the impact of the introduction of a new model of the METimage instrument on the development of Metop-SG satellites

Launch services for the first pair of Metop-SG satellites

Launch and early operations services for the first pair of Metop-SG satellites

Payload data acquisition and processing chain of the Jason-CS ground segment

Procurement process

The threshold for approval of procurements by the Director-General was increased from €500,000 to €700,000 to take into account the cumulative effects of past inflation.

The transitional procurement approach adopted to achieve compliance with the new German labour legislation was presented to consultancy industry prior to the release of 60 requests for quotations for groupings of ongoing consultancy contracts with management overheads. All 30 contracts requiring Council approval were agreed in December.

Industry briefings were held to present procurements for the image data processing facility for the MTG sounding mission (IDPF-S), the payload data acquisition and processing (PDAP) chain of the Jason-CS ground segment and the EPS-SG Sentinel 5 level 2 operational processor.

A Copernicus industry briefing was also held to present the overall development and procurement approach for the Copernicus Data and Information Access Service (DIAS) platform jointly deployed with the ECMWF and Mercator-Ocean.

In June, EUMETSAT presented its procurement process and forthcoming business opportunities to Polish industry in Warsaw.

General infrastructure and services

A long-term rental contract was signed with the German government and the Land of Hessen for an initial extension of 5,500m^2 enabling required site security improvements and the deployment of additional temporary building modules in 2018. These modules will fulfil increased accommodation needs arising from the unforeseen alignment of the MTG, EPS-SG and Jason-CS workload peaks and transition measures adopted to comply with the new German labour legislation.

In addition, the temporary rental contract with the Land of Hessen was amended to offer additional parking space in the short term, and to open the possibility of allocating to EUMETSAT the full remaining land surrounding its current premises, if and when required.

These arrangements enabled EUMETSAT to install a second, security-controlled site entrance for the delivery of goods and to conclude contracts for the installation of rented building modules and the construction of a warehousing facility, both needed in 2018.

Cabling from the main server rooms and two office buildings was renewed to increase the data transfer capacity from 100MB/s to 1GB/s, and up to 10GB/s in the future.

Internal IT services evolved with the roll-out of a new intranet platform offering blog and other innovative internal communication functionalities and facilitating the generation of content.

For the sake of efficiency, the generic Internet service was integrated into the same contract as the Internet service supporting operations.

MANAGEMENT AND ADMINISTRATION

Human resources management

A health and safety policy was formalised using German regulations as a benchmark, and, in view of the high workload, burnout prevention was the selected theme for the annual health campaign.

A concept for a EUMETSAT "crèche" aimed at reinforcing the quality of life at work for young or future parents was defined as an input to a feasibility study planned for 2018.

The internship programme was retargeted to host for up to six months students and persons having just finished their studies. Three more young engineers and scientists were recruited for initial contracts of two years under the Early Career Programme.

Twenty-four staff recruitments were initiated to replace consultants in 2018 and achieve compliance with the new German labour legislation.

Training budgets were delegated to all departments to improve the execution of non-strategic training. In addition, specialised training sessions and a "management toolkit" were delivered to assist managers in day-to-day performance management.

Quality management

EUMETSAT achieved certification against the new, more demanding 2015 version of the ISO 9001 standard, as a result of further improvements of its management system, including the generalisation of risk-based thinking.

A cloud-based ideas management tool was rolled out to support the processing of changes to the management system proposed by staff.

Twenty percent of the quality cartography of the existing operational software was realised using processes and tools introduced in 2016.

Internal control

The internal audit function published a code of ethics and a business plan capturing its planned evolution towards the targeted level 3 of the Internal Audit Capability Model.

Priorities for internal audits were derived from matching a generic audit universe with the corporate risk universe, and the targeted frequency of audits was defined.

"The Early Career Programme really opens your possibilities to a career within EUMETSAT."

Chiara Cocchiara
Junior Systems Operations Engineer
EUMETSAT

RISK MANAGEMENT

An integrated policy for risk and information security management

An integrated risk and information security management policy built on three components started to be implemented.

The first component tailors the ISO 31000 standard for risk management at corporate level and across operations, development and administrative activities.

The second is an information security management system (ISMS) following the ISO IEC 27001 standard and covering satellite systems, generic IT systems and all "connected" objects.

A four-year investment plan was established for this ISMS and the operational security team was reinforced. In addition, internal communication campaigns raised staff awareness of the criticality of information security.

The third component is a business continuity management system (BCMS) providing a proportionate capacity to restore prime services to users after disasters that are outside EUMETSAT's control, through recovery measures addressing both operations functional chains and critical administrative support functions.

A full BCMS mission control evacuation exercise, including remote activation of satellite backup control centres located in Italy, Spain and Sweden, tested the continuity of safe operations of satellites in case of disaster. In addition, access to business-critical components of the document management and email systems and to some SAP applications was replicated for use outside EUMETSAT premises in case of disaster.

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

Studies confirmed that the proposed frequency allocation to 5G mobile services could create interference with the acquisition of data from meteorological satellites at dedicated Ka-band stations and with unique passive microwave measurements that are sensitive to surface emissions. Should frequency allocations to 5G differ regionally, the global consistency of these measurements may also be threatened.

As the permanent Secretary of the Coordination Group for Meteorological Satellites, EUMETSAT alerted the ITU on the severe impact such interference could have on weather and climate monitoring from space.

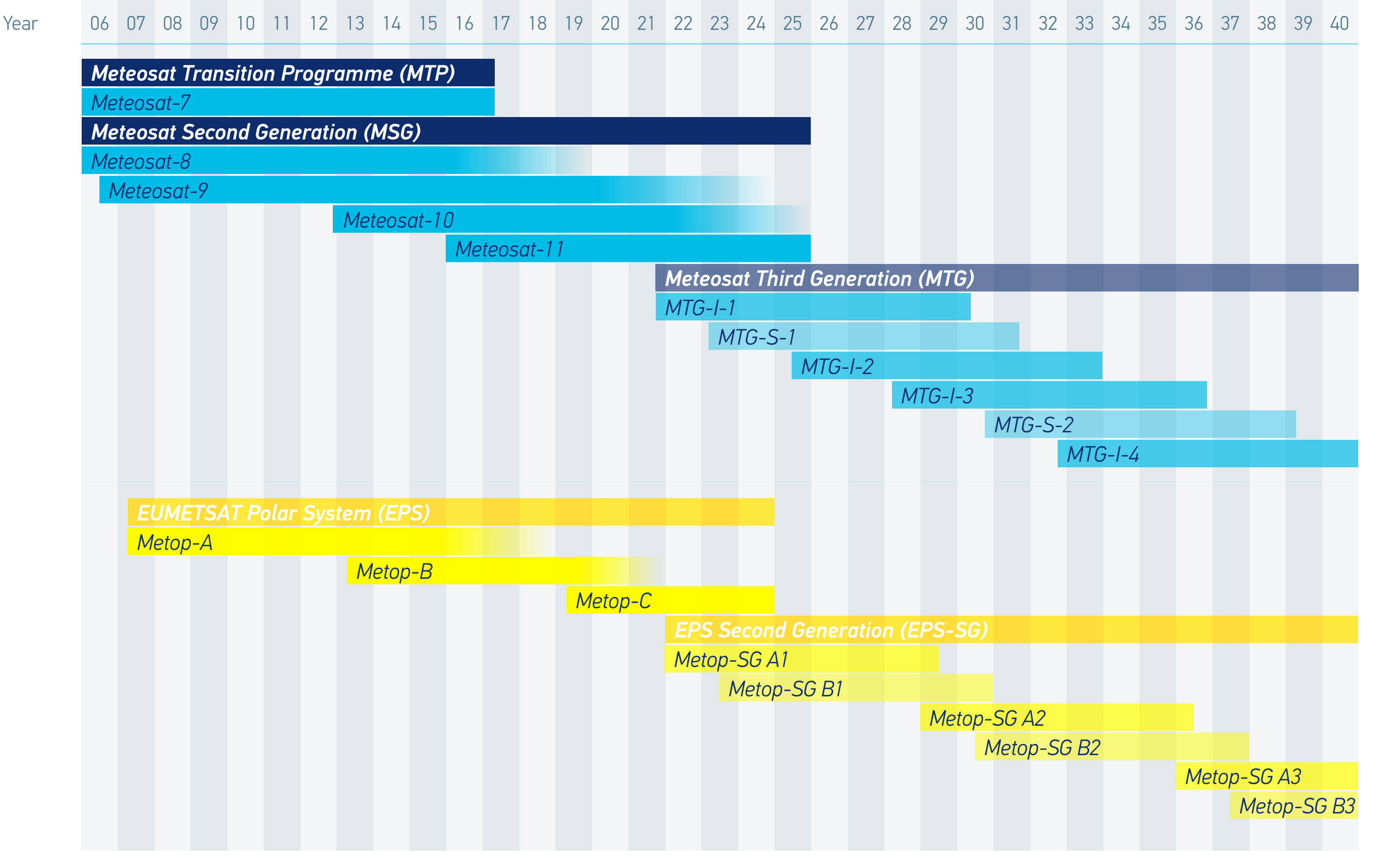
In Europe, EUMETSAT contributed to studies demonstrating that interference could be mitigated by enforcing 5G exclusion zones of a few kilometres around each Ka-band station and imposing on 5G stations emitting in the 26GHz band the requirement to filter unwanted emissions into the neighbouring 24GHz band used for passive microwave measurements.

Another concern emerged when a commercial operator of cubesats started to transmit data to the Svalbard station in an unregistered Ka-band carrier frequency that may interfere with the 26.7GHz channel registered by EUMETSAT and NOAA for the downlink of data from their Joint Polar System satellites.

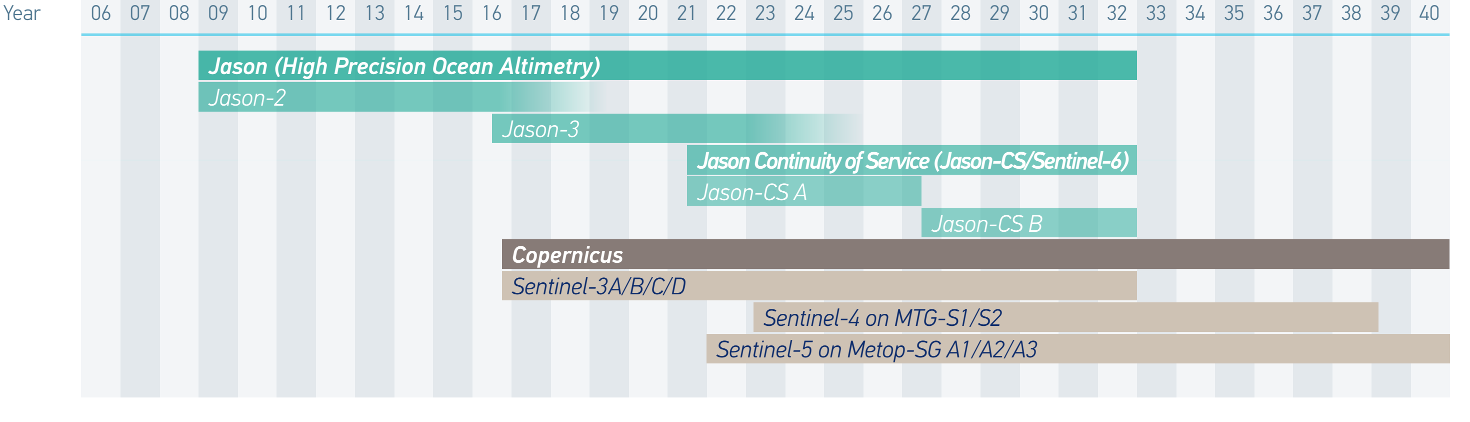
KEY FIGURES

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 National Meteorological Services of its Member States, the ECMWF, international partners, researchers and a number of individual licensed users.

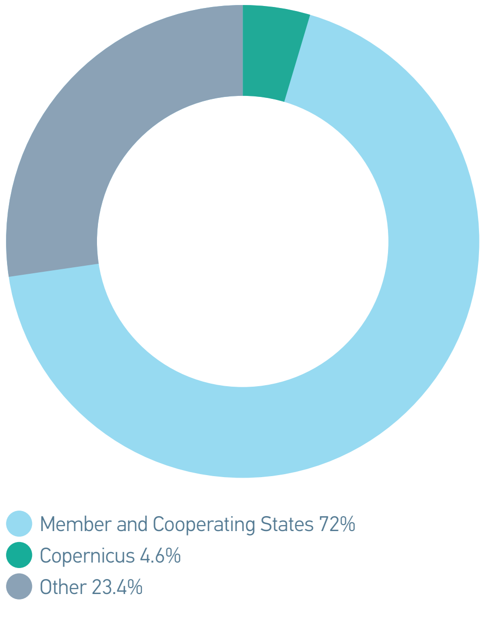
At the end of 2017, the number of licensed users was 1,991.

The EUMETSAT Copernicus user base is comprised of the Copernicus Marine Environment Monitoring (CMEMS), Atmosphere Monitoring (CAMS) and Climate Change Monitoring (C3S) services and individual licensed users of Copernicus products.

At the end of 2017, the number of active licensed users of Copernicus Sentinel-3 products was 1,290.

User enquiries

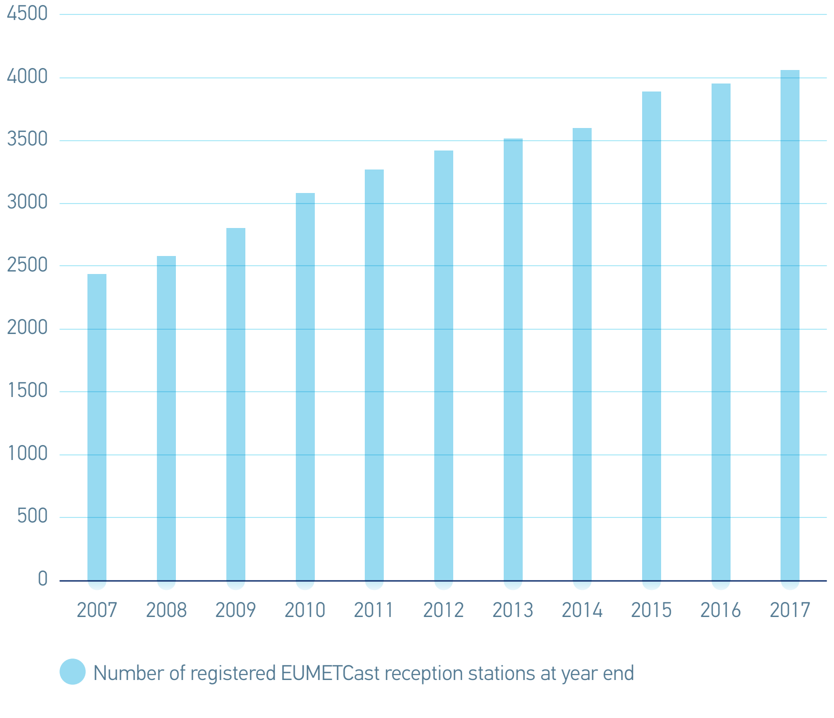
A total of 3,337 user enquiries were processed, including 72% from Member States and 4.6% related to Copernicus.



EUMETCast and CODA users

At the end of 2017, there were 4,042 registered EUMETCast reception stations deployed in Europe and Africa, of which 82% were located in Member States. These stations are exploited by 2,839 registered user entities, out of which 411 receive both EUMETSAT and Copernicus data.

In addition, a total of 879 active users were downloading Sentinel-3 marine products via the EUMETSAT Copernicus Online Data Access system, with on average 98 new users per month.

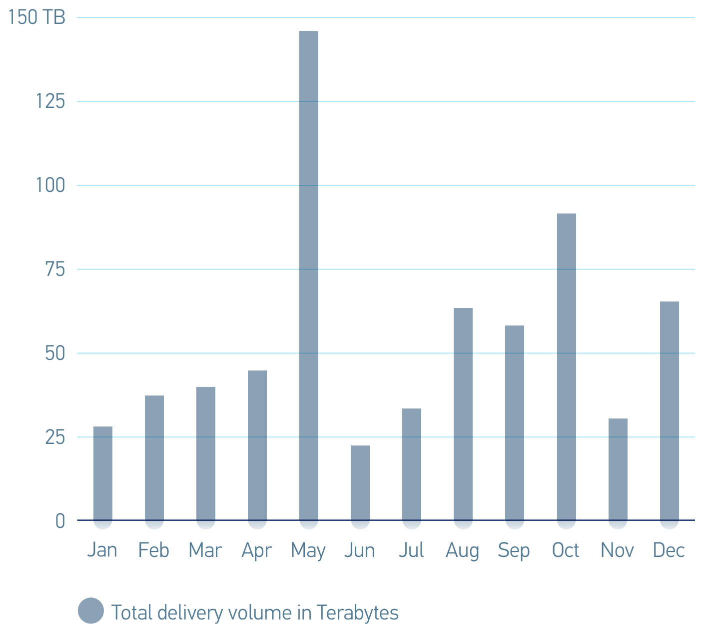


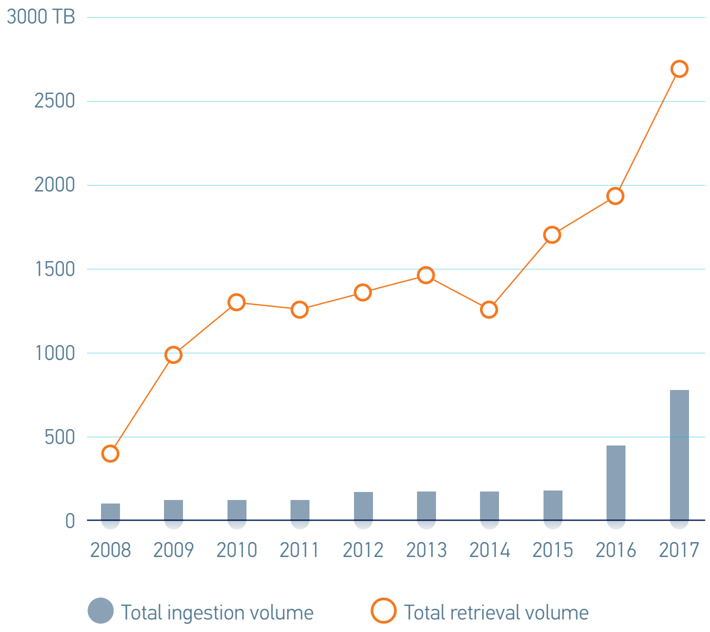
KEY FIGURES

Data Centre users and orders

The number of new users registering and ordering archived data increased by 32% in 2017, to 1,324, out of which 171 users ordered Copernicus data. This brought the total number of registered active users to 5,861 at the end of the year.

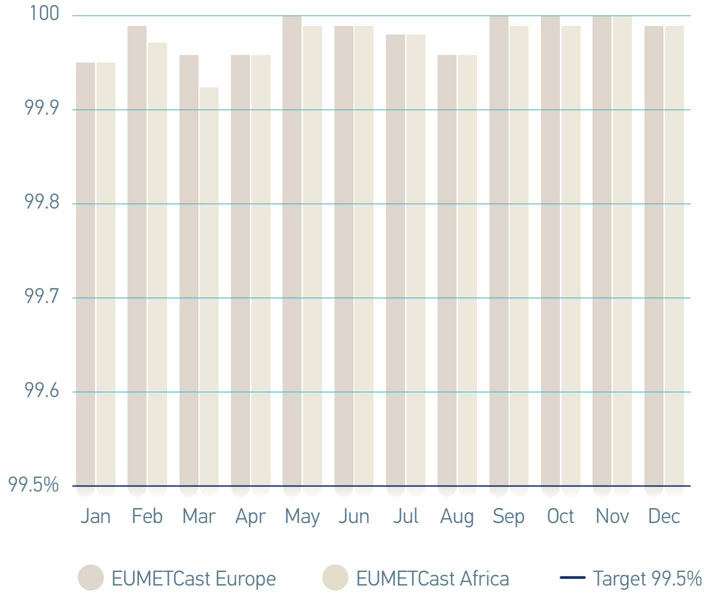
The total volume of products delivered increased by 25%, to 650 TBytes, a new record value. This volume was delivered in over 14 million files, which represents on average one file of 40 Mbytes every 2 seconds.





EUMETCast availability 2017

The availability of EUMETCast Europe remained at a high level of 99.96 percent throughout 2017.

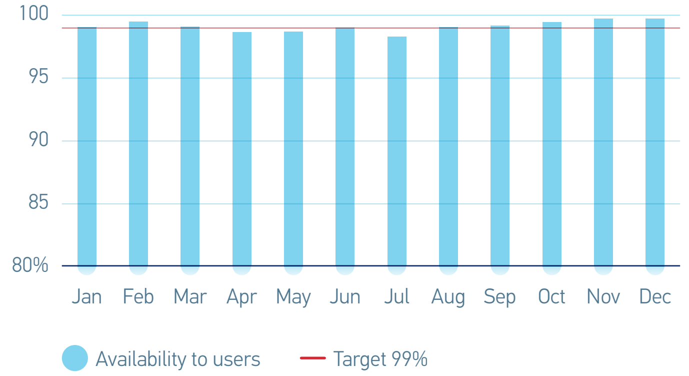


KEY FIGURES

Operational performance indicators

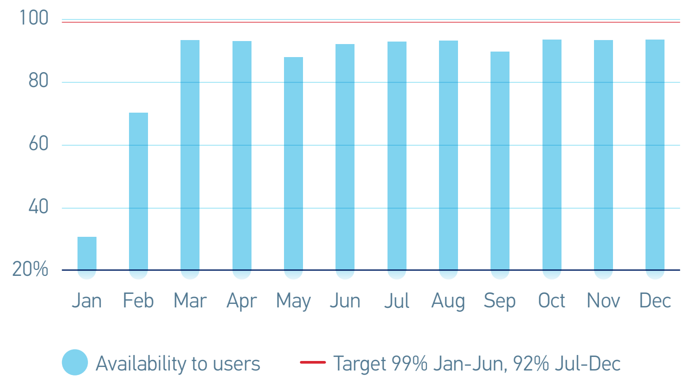
Availability of Meteosat SEVIRI Full Earth Scan products (0°)

The timely availability of products to users was slightly below the 99% target in April, May and July due to the combination of tank-heater switching on board the spacecraft and dissemination problems.



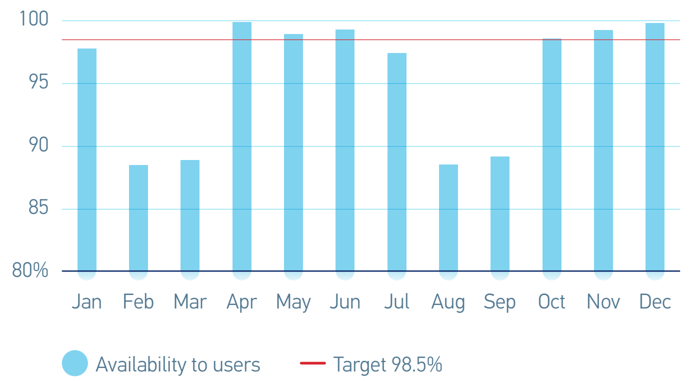
Availability of Meteosat SEVIRI Rapid Scan products (9.5°E)

The service was interrupted one month in January-February to preserve the lifetime of the Meteosat-9 scan mechanism, and the timely availability of products to users was below target in September due to a satellite safe mode event. The below target availability in May is an artefact due to two planned 48-hour service interruptions including the first and last days of the month.

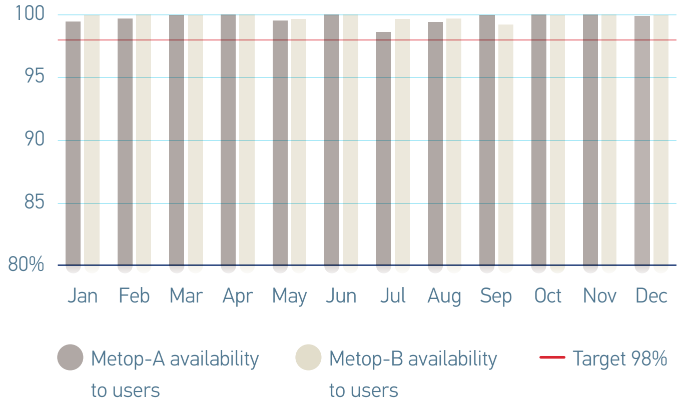


Availability of Meteosat IODC image products (57.5°E)

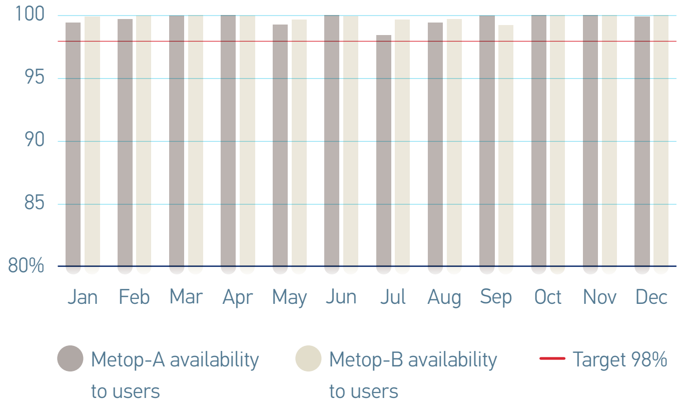
The availability of products to users was slightly below target in January due to higher straylight effects in eclipse season (Meteosat-7) and in May-June due to anomalies affecting the Meteosat-8 SEVIRI instrument and data dissemination systems.



Availability of Metop AMSU level 1B products

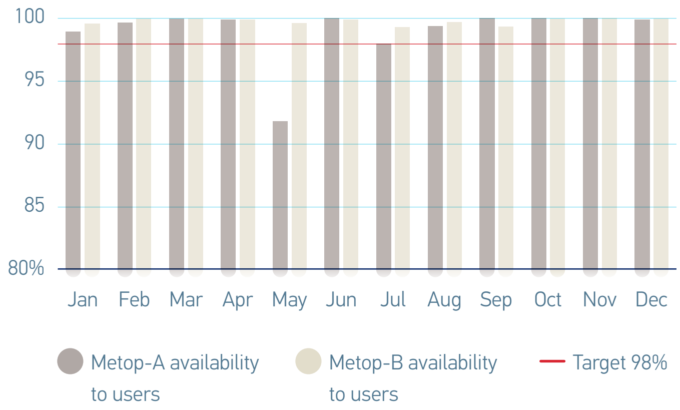


Availability of Metop MHS level 1B products



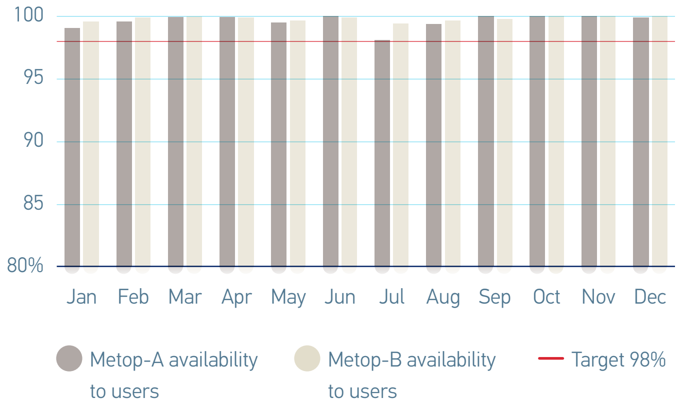
Availability of Metop ASCAT level 1B products

The availability of Metop-A products to users was below target in May due to a heating anomaly of the instrument and in July due to data dissemination anomalies affecting all services to varying degrees.



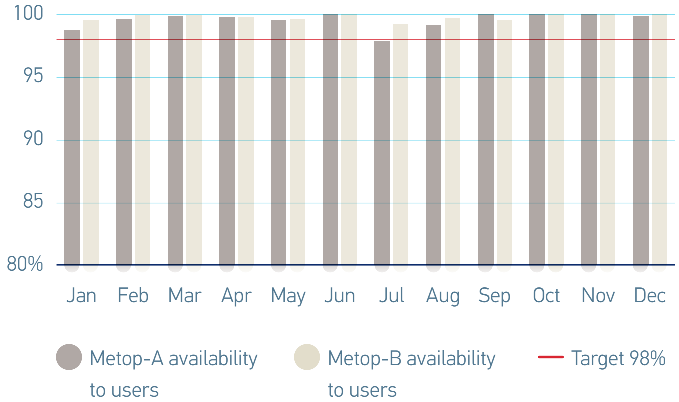
KEY FIGURES

Availability of Metop AVHRR level 1B products



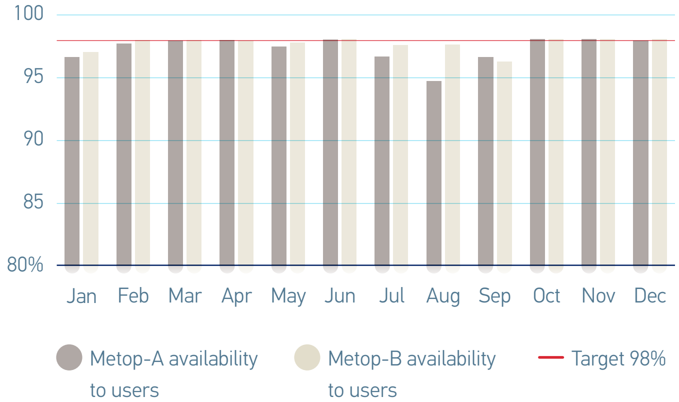
Availability of Metop GOME-2 level 1B products

The availability of Metop-A products to users was slightly below target in July due to data dissemination problems affecting all services to varying degrees.

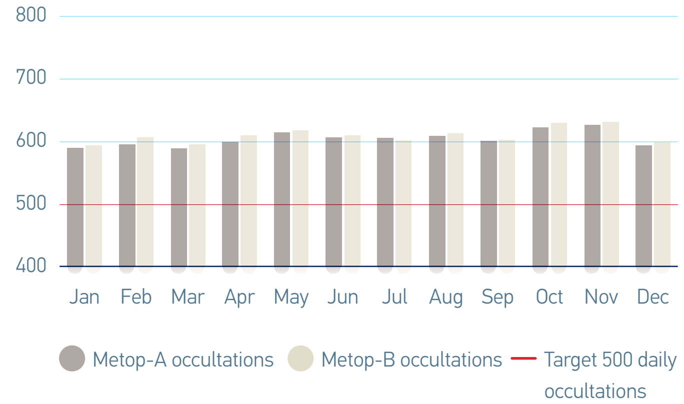


Availability of Metop IASI level 1C BUFR products

The availability of products to users was slightly below target for Metop-A in January, August and September due to moon calibration experiments, instrument and data dissemination anomalies. It was slightly below target for Metop-B in September due to a satellite manoeuvre and a moon calibration experiment.

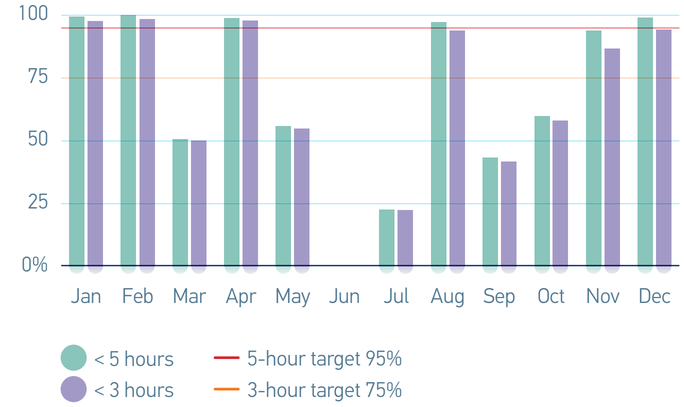


Number of real-time Metop GRAS level 1B products

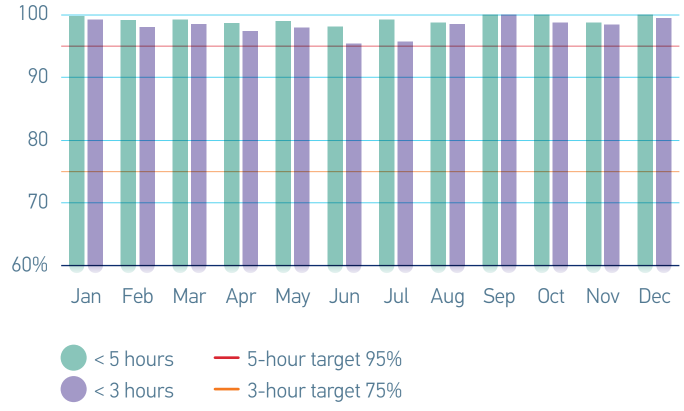


Availability of Jason-2 near-real-time products

The service was interrupted I June and the availability of products to users was significantly degraded from March onwards due to an anomaly affecting two gyroscopes of the satellite, and in orbit tests performed in support of related investigations.



Availability of Jason-3 near-real-time products

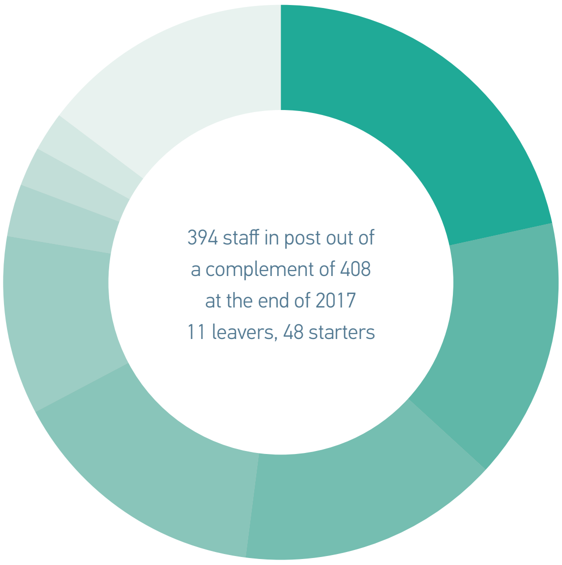


KEY FIGURES

Human resources

Staff in post

31 December 2017

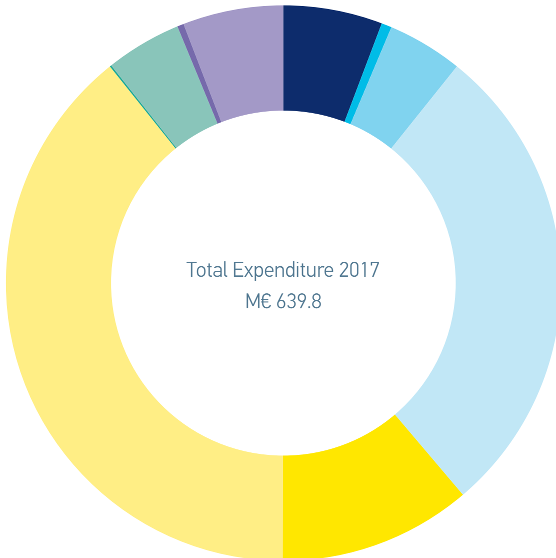


Germany	21.57%
France	15.23%
United Kingdom	15.23%
Italy	15.23%
Spain	10.41%
Netherlands	3.05%
Belgium	2.28%
Portugal	2.28%
Other	14.72%

Financial information

Expenditure Budgets

Total Expenditure 2017



GB	M€ 36.9
MTP	M€ 3.8
MSG	M€ 28.1
MTG	M€ 179.4
EPS	M€ 71.8
EPS-SG	M€ 251.0
Jason-2	M€ 0.6
Jason-CS	M€ 28.3
Sentinel-3	M€ 2.4
Copernicus	M€ 37.5

KEY FIGURES

Financial information

EUMETSAT's 2017 Financial Statement has been audited by the Tribunal De Contas. The following tables, in K€, are a summary of the information for 2017 included in those accounts.

Summary Revenue and Expenses

	KEUR
Revenue	
Member & Cooperating State Contributions	539,071
Other Contributions	20,101
Tax on Salary	8,043
Sales Revenue	2,046
Other Revenue	85,238
Total Revenue	**654,499**
Expenses	
Costs for Human Resources	148,400
Other Operating Expenses	10,709
Satellite-related costs	49,143
SAF, Prospective Activities, Research Fellows	13,450
Depreciation	123,004
Total Expenses	**344,706**
Revenue from Financial Operations	122
Net surplus for the period	**309,915**
Surplus to be distributed to Member and Cooperating States	54,520
Result Allocated to Reserves	255,395

Summary Balance Sheet

	KEUR
Assets	
Current Assets	1,024,065
Non-Current Assets	2,465,901
Total Assets	**3,489,966**
Liabilities	
Current Liabilities	801,771
Non-Current Liabilities	523,538
Total Liabilities	**1,325,309**
Total Net Assets/Equity	**2,164,657**
Total Liabilities & Net Assets/Equity	**3,489,966**

Member and Cooperating State Contributions

	KEUR
Member State Contributions	
Austria	11,358
Belgium	13,519
Bulgaria	1,359
Croatia	1,559
Czechia	5,166
Denmark	9,468
Estonia	553
Finland	7,235
France	78,682
Germany	102,759
Greece	7,454
Hungary	3,367
Iceland	342
Ireland	5,233
Italy	59,373
Latvia	741
Lithuania	1,080
Luxembourg	1,109
Netherlands	23,055
Norway	13,862
Poland	12,897
Portugal	6,324
Romania	4,641
Slovakia	2,442
Slovenia	1,285
Spain	37,387
Sweden	15,122
Switzerland	18,593
Turkey	22,107
United Kingdom	70,465
Total Member State Contributions	**538,537**
Cooperating State Contributions	
Serbia	534
Total Cooperating State Contributions	**534**
Total Member and Cooperating State Contributions	**539,071**

Organigramme, 1 January 2018

EUMETSAT Council
Prof A. Eliassen (Chair)
Prof G. Van der Steenhoven (Vice-Chair)

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

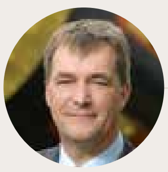
STG — **Scientific and Technical Group**
Mr S. Nilsson (Chair)
Mr M. Manso Rejon (Vice-Chair)

STG-OWG — **STG Operations Working Group**
Mr A. Dybbroe (Chair)
Mr J. Asmus (Vice-Chair)

STG-SWG — **STG Science Working Group**
Mr P. Stammes (Chair)
Mr D. Biron (Vice-Chair)

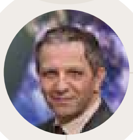
AFG — **Administration and Finance Group**
Dr G. Seuffert (Chair)
Ms E. Labo (Vice-Chair)

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



Director of Programme Preparation and Development
Clemens Kaiser

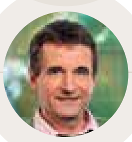
Geostationary Programmes
A. Schmid



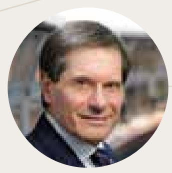
Low Earth Orbit Programmes
Dr M. Cohen

EPS Programme Manager
M. Lugert

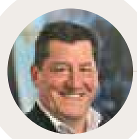
EPS-SG Programme Manager
G. Kayal



Jason-CS Programme Manager
F. Parisot



Director of Operations and Services to Users
Livio Mastroddi

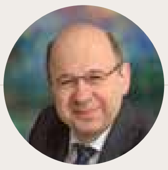


Copernicus Programme Office
D. Provost

Flight Operations
M. Williams

Real Time Services and System Operations
S. Burns

User Support and Climate Services
J. Saalmueller



Director-General
Alain Ratier

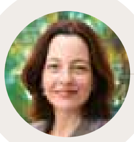
Financial Control and Internal Audit
J. Travesi Garcia

Chief Scientist
Dr K. Holmlund

Quality Management
A. Duflaut

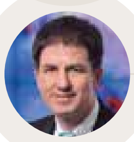
Strategy, Communication and International Relations
P. Counet

Director of Administration
Silvia Castañer



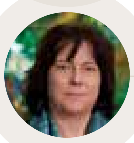
Contracts
E. Katsampani

Finance
P. Collin



General Services
B. Kaufmann

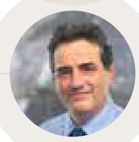
Personnel
R. Clerici



Legal Affairs
M. Lauth

Director of Technical and Scientific Support
Yves Buhler

Process Assurance and Management Support
L. Sarlo



Generic Systems and Infrastructure
G. Mori

Remote Sensing and Products
B. Bojkov

System Engineering and Projects
J. González Picazo

Information and Communication Technology
O. Gümrah

APPENDIX

EUMETSAT Council Delegates and Advisors, 1 January 2017

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 V. Dvořák	Czech Hydrometeor-ological Institute (CHMI)
Mr M. Rieder	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	Finish Meteorological Institute (FMI)
Prof J. Pulliainen	FMI

France

Mr J.-M. Lacave	Météo-France
Ms A. Debar	Météo-France
Ms L. Desmaizieres	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
Lt. M. Papachristou	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
Lt. Col. P. Capizzi	Ministero dell'Economia e delle Finanze
Dr F. Battazza	Agenzia Spaziale Italiana

Observers: EACCS Chairperson (Serbia), ECMWF, ESA, EUMETNET, European Commission, NOAA, WMO

Latvia

Mr A. Viksna	Latvian Environment, Geology and Meteorology Centre

Lithuania

Mr S. Balys	Lithuanian Hydrometeorological Service

Luxembourg

Ms M. Reckwerth	MeteoLux, Administration de la navigation aérienne

Netherlands

Mr G. Van der Steenhoven	Koninklijk Nederlands Meteorologisch Instituut (KNMI)

Norway

Prof A. Eliassen	Council Chairperson
Mr R. Skalin	Norwegian Meteorological Institute (Met.no)
Mr J. Sunde	Met.no
Mr S. Rasmussen	Met.no
Ms S. Giaever Ruth	Met.no
Mr E. A. Herland	Norwegian Space Centre

Poland

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

Portugal

Prof M. Miranda	Istituto Portugues do Mar e da Atmosfera (IPMA)
Dr P. Viterbo	IPMA

Romania

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

Slovakia

Dr M. Benko	Slovak Hydrometeorol-ogical 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 I. Gunes	Turkish State Meteorological Service
Mr E. Erdi	Turkish State Meteorological Service

United Kingdom

Mr R. Varley	Met Office
Mr S. Turner	Met Office
Mr M. Gray	Met Office

APPENDIX

Participation in major external events

97th annual meeting of the American Meteorological Society	*22-26 January*
9th European Space Policy Conference	*24-25 January*
6th meeting of the GFCS Partner Advisory Committee	*5-7 March*
C3S General Assembly	*7 March*
CEOS Strategy Implementation Team	*25-28 April*
WMO Executive Council meeting	*10-15 May*
3rd International Ocean Colour Science Meeting	*13-18 May*
Joint meeting of the Copernicus Programme Committee and the ESA PB-EO	*9 June*
45th Plenary Session of the Coordination Group for Meteorological Satellites	*11-16 June*
1st meeting of the GMES & Africa Policy Coordination and Advisory Committee	*4-6 September*
CEOS Strategy Implementation Team	*12-15 September*
5th Session of the GCOS Steering Committee	*22 September*
Copernicus Marine Week	*25 - 29 September*
8th Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-8)	*16-21 October*
31st CEOS Plenary meeting	*17-20 October*
WMO-ITU frequency workshop	*23 - 24 October*
EU – Japan space dialogue meeting	*25 October*
GEO-XIV Plenary meeting	*25-26 October*
WMO symposium for leaders of education and training	*30 October - 3 November*
19th European Inter-parliamentary Space Conference (EISC)	*6-7 November*
EU-ESA informal space ministerial meeting	*7 November*
World Bank seminar on Global Weather Enterprise	*28 November*
21st International TOVS Study Conference (ITSC-21)	*28 November – 6 December*
Meeting of heads of space agencies, One Planet Summit	*11 December*

Scientific and technical publications

Aguilar Taboada, D., Righetti, P., Houdroge, R., 2017. Lessons Learned from Initial Sentinel-3A Maneuver Operations. *31st Int. Symposium on Space Technol. & Science, Matsuyama, Japan.*

Anderson, C., Figa Saldana, J., Wilson, J., Ticconi, F., 2017. Validation and Cross-Validation Methods for ASCAT. *IEEE J. Sel. Topics Appl. Earth Observ. in Remote Sens., 10(5), 2232–2239.*

Antonelli, P., Revercomb, H., Giuliani, G., Cherubini, T., Businger, S., Lyman, R., **Tjemkes, S., Stuhlmann, R.,** Moncet, J., 2017. Regional Retrieval Processor for Direct Broadcast High-Resolution Infrared Data. *J. Appl. Meteor. Climatol. 56(6), 1681–1705.*

Avbelj, J., Just, D., 2017. Generation of the New Sensor Image Data from Lower-Resolution Images: A MTG Case Study. *EUMETSAT Meteorol. Satellite Conf., Rome, Italy.*

Belmonte-Rivas, M., Stoffelen, A., Verspeek, J., Verhoef, A., Neyt, X., **Anderson, C.,** 2017. Cone Metrics: A New Tool for the Intercomparison of Scatterometer Records. *IEEE J. Sel. Topics Appl. Earth Observ. in Remote Sens., 10(5), 2195–2204.*

Bennartz, R., Höschen, H., Picard, B., Schröder, M., Stengel, M., Sus, O., **Bojkov, B.,** Casadio, S., Diedrich, H., Eliason, S., Fell, F., Hollmann, R., Preusker, R., Willén, U., 2017. An Intercalibrated Dataset of Total Column Water Vapour and Wet Tropospheric Correction Based on MWR on board ERS-1, ERS-2, and Envisat. *Atmos. Meas. Tech., 10, 1387–1402.*

Berry, D., Schick, M., 2017. EUMETSAT Submission Information Package (SIP). *Big Data in Space (BiDS'17).*

Bonsignori, R., 2017. In-Orbit Verification of MHS Spectral Channels Co-Registration Using the Moon. *Proc. SPIE, 10402.*

Brockley, D., Baker, S., Femenias, P., Martinez, B., Massmann, F., Otten, M., Paul, F., Picard, B., Prandi, P., Roca, M., Rudenko, S., **Scharroo, R.,** Visser, P., 2017. REAPER: Reprocessing 12 Years of ERS-1 and ERS-2 Altimeters and Microwave Radiometer Data. *IEEE Trans. Geosci. Remote Sens., 55(10), 5506-5514.*

Cardellach, E., Lauritsen, K. B., **Notarpietro, R., Von Engeln, A.,** 2017. Survey on User Requirements for Potential Ionospheric Products from EPS-SG Radio Occultation Measurements - *ROM SAF Report 25 (No. SAF/ROM/METO/REP/RSR/025).*

Coppens, D., Theodore, B., Klaes, D., 2017. MTG-IRS: From Raw Measurements to Calibrated Radiances. *Proc. SPIE, 10402.*

Damiano, A., Righetti, P., Lang, R., Sancho, F., 2017. Flight Dynamics Support to Extend Instruments Useful Lifetime. *31st Int. Symposium on Space Technol. & Science, Matsuyama, Japan.*

Efremenko, D., Molina Garcia, V., **Gimeno Garcia, S.,** Doicu, A., 2017. A Review of the Matrix-Exponential Formalism in Radiative Transfer. *J. Quant. Spectrosc. Radiat. Transfer, 196, 17–45.*

Hautecoeur, O., Borde, R., 2017. Derivation of Wind Vectors from AVHRR/Metop at EUMETSAT. *J. Atmos. Ocean. Tech., 34(8), 1645–1659.*

Hernandez-Pajares, M., Garcia-Fernandez, M., Rius, A., **Notarpietro, R., Von Engeln, A.,** Olivares-Pulido, G., Aragon-Angel, A., Garcia-Rigo, A., 2017. Electron Density Extrapolation above F2 Peak by the Linear Vary-Chap Model Supporting New GNSS-LEO Occultation Missions. *J. Geophys. Res.: Space Physics, 122(8), 9003-9014.*

Holmlund, K., Bojkov, B., Klaes, D., Schlüssel, P., 2017. The Joint Polar System: Towards the Second Generation EUMETSAT Polar System. 2017. *IEEE Int. Geoscience Remote Sens. Symposium (IGARSS), Fort Worth, United States.*

Holmlund, K., Bojkov, B., Schlüssel, P., Stuhlmann, R., Schüller, L., Cohen, M., Schmid, A., Provost, D., Burns, S., 2017. Status of EUMETSAT Satellite Programs: Toward the Next Generation Meteorological Satellites. *97th AMS Annual Meeting, Seattle, United States. Americ. Met. Soc.*

Horvath, A., **Hautecoeur, O., Borde, R.,** Deneke, H., Buehler, S., 2017. Evaluation of the EUMETSAT Global AVHRR Wind Product. *J. Appl. Meteor. Climatol. 56(8), 2353–2376.*

Hultberg, T., August, T., 2017. Removal of Instrument Artefacts by Harmonisation of Hyperspectral Sensor Data from Multiple Detectors. *Proc. SPIE, 10423.*

Hultberg, T., August, T., Lenti, F., 2017. Local or Global? How to Choose the Training Set for Principal Component Compression of Hyperspectral Satellite Measurements: A Hybrid Approach. *Proc. SPIE, 10423.*

Kanak, J., Okon, L., Setvak, M., Dioszeghy, M., **Nietosvaara, V.,** 2017. Scientific and Application Potential of Stereoscopic Imager Based on Meteosat Satellites. *2017 EUMETSAT Meteorol. Satellite Conf., Rome, Italy.*

Khlystova, I., Sunda, M., 2017. Test Tools and Test Data for the Future EUMETSAT EPS-SG Platform. *19th EGU General Assembly, Vienna, Austria, Eur. Geophys. Union.*

Klaes, D., 2017. A Status Update on EUMETSAT Programmes and Plans. *Proc. SPIE, 10402.*

Klinc, M., Pessina, S., 2017. Optical Tracking Extended Network in Support to Operational Flight Dynamics and Conjunction Analysis for Meteosat. *31st Int. Symposium on Space Technol. & Science, Matsuyama, Japan.*

APPENDIX

Scientific and technical publications

Kobayashi, S., Poli, P., **John, V.,** 2017. Characterisation of Special Sensor Microwave Water Vapor Profiler (SSM/T-2) Radiances Using Radiative Transfer Simulations from Global Atmospheric Reanalyses. *Adv. Space Res., 59(4), 917–935.*

Kokhanovsky, A., Munro, R., Lang, R., Lindstrot, R., Huckle, R., Marbach, T., Poli, G., 2017. The Multi-Viewing, Multi-Channel, Multi-Polarisation Imager on Board the Future EUMETSAT Polar System - Second Generation and Its Application for the Aerosol Retrieval. *19th EGU General Assembly, Vienna, Austria, Eur. Geophys. Union.*

Korkin, S., Lyapustin, A., Sinyuk, A., Holben, B., **Kokhanovsky, A.,** 2017. Vector Radiative Transfer Code SORD: Performance Analysis and Quick Start Guide. *J. Quant. Spectrosc. Radiat. Transfer, 200, 295–310.*

Kwiatkowska, E., 2017. Colouring Our View of the Oceans. *ROOM, (13), 64–69.*

Lamquin, N., Bourg, L., Lerebourg, C., Martin-Lauzer, F., **Kwiatkowska, E.,** Dransfeld, S., 2017. System Vicarious Calibration of Sentinel-3 OLCI. *CALCON Technical Meeting, Logan, United States.*

Lattanzio, A., Matthews, J., Takahashi, M., Stöckli, R., 2017. A SCOPE-CM Project for the Retrieval of Land Surface Albedo Using Imagery Acquired by Geostationary Satellites. *2017 EUMETSAT Meteorol. Satellite Conf., Rome, Italy.*

Luojus, K., Ripper, E., Pulliainen, J., Cohen, J., Ikonen, J., Takala, M., Lemmetyinen, J., Nagler, T., Schwaizer, G., Derksen, C., **Bojkov, B.,** Kern, M., 2017. Long Term Changes in Northern Hemisphere Snow Cover from SWE Timeseries Constrained with SE data. *2017 IEEE Int. Geoscience Remote Sens. Symposium (IGARSS), Fort Worth, United States.*

Metsämäki, S., Ripper, E., Mattila, O., Fernandes, R., Schwaizer, G., Luojus, K., Nagler, T., **Bojkov, B.,** Kern, M., 2017. Evaluation of Northern Hemisphere and regional Snow Extent Products within ESA SnowPEx-project. *2017 IEEE Int. Geoscience Remote Sens. Symposium (IGARSS), Fort Worth, United States.*

Miyaoka, K., Gruber, A., **Ticconi, F.,** Hahn, S., Wagner, W., **Figa-Saldana, J., Anderson, C.** 2017. Triple Collocation Analysis of Soil Moisture from Metop-A ASCAT and SMOS against JRA-55 and ERA-Interim. *IEEE J. Sel. Topics Appl. Earth Observ. in Remote Sens., 10(5), 2274–2284.*

Montes Rubio, R., **Hao, N.,** Liu, S., Valks, P., Trautmann, T., 2017. Improvement of GOME-2 Retrieval on the Study of Tropospheric Air Pollutants over China. *AOGS 2017, Singapore.*

Muller, J., Kharbouche, S., Lewis, P., Danne, O., Blessing, S., Giering, R., Gobron, N., Lanconelli, C., Govaerts, Y., **Schulz, J., Doutriaux-Boucher, M., Lattanzio, A., Aoun, Y.,** 2017. Land ECVs from QA4ECV Using an Optimal Estimation Framework. *19th EGU General Assembly, Vienna, Austria, Eur. Geophys. Union.*

Murolo, F., Dammann, K., De Smet, A., Grandell, J., 2017. Half year of operational service from EUMETSAT's Indian Ocean Data Coverage with a MSG Satellite. *2017 EUMETSAT Meteorol. Satellite Conf., Rome, Italy.*

Pessina, S., Righetti, P., Branco, J., Moreno Villa, V., Peters, T., 2017. Metop Long Term Free-Dynamics Attitude Analysis, for Improved Re-Entry Prediction. *31st Int. Symposium on Space Technol. & Science, Matsuyama, Japan.*

Quartly, G., Nencioli, F., Labroue, S., Femenias, P., **Scharroo, R.,** Abdalla, S., Bonnefond, P., Cancet, M., Frery, M., Baker, S., Muir, A., Brockley, D., Shepherd, A., Garcia, P., Roca, M., Calmant, S., Cretaux, J., 2017. Ensuring that the Sentinel-3A Altimeter Provides Climate-Quality Data. *Proc. SPIE, 10422.*

Reid, I., Papalexi, M., **Slater, N.,** 2017. The Influence of Socially Orientated Growth of Virtual Teams: A Conceptual Model. *In: Phantom ex Machina: Digital Disruption's Role in Business Model Transformation (pp. 237–249).*

Righetti, P., Dyer, R., 2017. Feasibility of Metop-A Mission Extension on Drifting Local Time. *31st Int. Symposium on Space Technol. & Science, Matsuyama, Japan.*

Sancho, F., Fischer, J., **Tarquini, S.,** 2017. Non-nominal Attitude Manoeuvres during Metop-A Extended Lifetime. *31st Int. Symposium on Space Technol. & Science, Matsuyama, Japan.*

Schick, M., Dillmann, M., Wolf, L., Miguens, J., Stoicescu, M., 2017. EUMETSAT, ECMWF & Mercator Océan Partners DIAS. *Big Data from Space (BiDS'17), Toulouse, France.*

Schlüssel, P., Kayal, G., 2017. Introduction to the Next Generation EUMETSAT Polar System (EPS-SG) Observation Missions. *Proc. SPIE, 10423.*

Sihler, H., Lübcke, P., Lang, R., Beirle, S., de Graaf, M., Hörmann, C., Lampel, J., Penning de Vries, M., Remmers, J., **Trollope, E.,** Wang, Y., Wagner, T., 2017. In-Operation Field-of-View Retrieval (IFR) for Satellite and Ground-Based DOAS-type Instruments Applying Coincident High-Resolution Imager Data. *Atmos. Meas. Tech., 10, 881–803.*

Spezzi, L., Watts, P., Jackson, J., 2017. EUMETSAT Total Precipitable Water Algorithm for the Polar System - Second Generation (EPS-SG) Visible/Infrared Imager (METimage). *2017 EUMETSAT Meteorol. Satellite Conf., Rome, Italy.*

Stoicescu, M., Fabre, J., Roy, M., 2017. Architecting Resilient Computing Systems: A Component-Based Approach for Adaptive Fault Tolerance. *J. Syst. Architecture, 73, 6–16.*

Stuhlmann, R., Holmlund, K., Schmetz, J., Roquet, H., **Tjemkes, S., Grandell, J., Pohjola, H., Lekouara, M., Munro, R., Fowler, G., Schmid, A., Aminou, D.,** 2017. Observations depuis l'orbite géostationnaire avec Meteosat troisième génération (MTG). *La Meteorologie, (96–97), 53–61.*

Theodore, B., Vasquez, M., Coppens, D., Klaes, D., 2017. Intercomparisons of IASI on METOP and Infrared Multi-Spectral Instruments. *Proc. SPIE, 10402.*

Thorne, P., Madonna, F., **Schulz, J.,** Oakley, T., Ingleby, B., Rosoldi, M., Tramutola, E., Arola, A., Buschmann, M., Mikalsen, A., Davy, R., Voces, C., Kreher, K., De Maziére, M., Pappalardo, G., 2017. Making Better Sense of the Mosaic tf Environmental Measurement Networks: A System-of-Systems Approach and Quantitative Assessment. *Geosci. Instrum. Method. Data Syst., 6, 453–472.*

Ticconi, F., Anderson, C., Figa Saldana, J., Wilson, J., Bauch, H., 2017. Analysis of Radio Frequency Interference in Metop ASCAT Backscatter Measurements. *IEEE J. Sel. Topics Appl. Earth Observ. & Remote Sens., 10(5), 2360–2371.*

Tomasi, C., Fuzzi, S., **Kokhanovsky, A.,** 2017. Atmospheric Aerosols: Life Cycles and Effects on Air Quality and Climate. *Wiley-VCH.*

Tomazic, I., Montagner, F., O'Carroll, A., Kwiatkowska, E., Scharroo, R., Nogueira Loddo, C., Martin-Puig, C., Bonekamp, H., Lucas, B., Dinardo, S., Dash, P., Taberner, M., Coto Cabaleiro, E., Santecesaria, V., Wilson, H., 2017. Operational Marine Products from Copernicus Sentinel-3 Mission. *19th EGU General Assembly, Vienna, Austria, Eur. Geophys. Union.*

Wolf, L., 2017. Reflections of the Big Data Thematic. *97th AMS Annual Meeting, Seattle, United States. Americ. Met. Soc.*

Wu, D., Baum, B., Choi, Y., Foster, M., Karlsson, K., Heidinger, A., Poulsen, C., Pavolonis, M., Reidi, J., **Roebeling, R.,** Sherwood, S., Thoss, A., **Watts, P.,** 2017. Toward Global Harmonization of Derived Cloud Products. *Bull. Amer. Meteor. Soc., 98(2), ES49-ES52.*

Zinke, S., 2017. A Simplified High and Near-Constant Contrast Approach for the Display of VIIRS Day/Night Band Imagery. *Int. J. Remote Sens., 38(19), 5374–5387.*

Zinke, S., 2017. Applying N-Bit Floating Point Numbers and Integers, and the N-Bit Filter of HDF5 to Reduce File Sizes of Remote Sensing Products in Memory-Sensitive Environments. *Comput. Geosci., 99, 155–158.*

APPENDIX

Glossary

ACMAD	African Centre of Meteorological Applications for Development
ACP	African, Caribbean and Pacific Group of States
AfDB	African Development Bank
AGRHYMET	Agriculture, Hydrology and Meteorology Centre
ARGOS	System for data collection and localisation via satellite from the polar orbit (France)
AUC	African Union Commission
CDOP-3	Third Continuous Development and Operations Phase (of SAFs)
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CMA	China Meteorological Administration
CNES	Centre National d'Etudes Spatiales (French space agency)
CNSA	China National Space Administration
Copernicus	Earth Observation Programme of the European Union
DIAS	(Copernicus) Data and Information Access Service (platform)
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
EMI	European Meteorological Infrastructure
EPS	EUMETSAT Polar System
EPS-SG	EPS Second Generation
ESA	European Space Agency
ESOC	European Space Operations Centre (ESA)
EU	European Union
EUMETCast	EUMETSAT's satellite data broadcast system
FIDUCEO	Fidelity and Uncertainty in Climate Data Records from Earth Observations (EU Horizon2020 project)
GAIA-CLIM	Gap Analysis for Integrated Atmospheric ECV CLImate Monitoring (EU Horizon2020 project)
GCOM	Global Change Observing Mission satellite (Japan)
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)
IMD	India Meteorological Department
ISRO	Indian Space Research Organisation
Jason-2	Ocean altimeter satellite (NASA/CNES/NOAA/EUMETSAT)
Jason-3	Ocean altimeter satellite (NASA/CNES/NOAA/EUMETSAT/EU)
Jason-CS/ Sentinel-6	Jason Continuity of Service, ocean altimeter satellite (NASA/ESA/NOAA/EUMETSAT/EU)
JAXA	Japan Aerospace Exploration Agency
JMA	Japan Meteorological Agency
JPS	Joint Polar System (shared with NOAA)
KMA	Korea Meteorological Agency
LEOP	Launch and early operations phase
MESA	Monitoring of Environment and Security in Africa
Meteosat	EUMETSAT geostationary meteorological satellite
Metop	EUMETSAT polar-orbiting meteorological satellite (EPS)
MOOC	Massive open online course
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
MTG-I	MTG imaging satellite
MTG-S	MTG sounding satellite
NASA	National Aeronautics and Space Administration (US)
NMHS	National Meteorological and Hydrological Service
NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration (US)
NSOAS	National Satellite Ocean Application Services (China)
NWP	Numerical weather prediction
RA-I	WMO Regional Association 1
Roshydromet	Russian Federal Service for Hydrometeorology and Environmental Monitoring
SAF	Satellite Application Facility
SAWIDRA	Satellite and Weather Information for Disaster Resilience in Africa
SBSTA	Subsidiary Body for Scientific and Technical Advice (UN)
Sentinel-3	Copernicus satellite
SOA	State Oceanic Administration (China)
Suomi-NPP	Suomi National Polar-orbiting Partnership (NASA/NOAA)
SVT	System validation test
Vlab	Virtual Laboratory for Training and Education in Satellite Meteorology (WMO)
WMO	World Meteorological Organization
WMS	Web Map Service

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