ANNUAL REPORT 2015

EUMETSAT

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The word of the Director-General

"2015 will remain a landmark in EUMETSAT's history due to the entry into force of two new programmes, EPS-Second Generation (EPS-SG) and Jason-Continuity of Service (Jason-CS)."

Alain Ratier
Director-General

As a result of safe operations of seven spacecraft in orbit, one great satisfaction of 2015 was the very high availability of all data services to users, which is the *raison d'être* of EUMETSAT.

In the case of the Meteosat Rapid Scan Service, this owed much to mitigation measures prepared to cope with possible further degradation of the thermal control of the ageing Meteosat-8 and Meteosat-9 satellites, and successfully activated when degradations occurred on Meteosat-9. Great satisfaction was also had with the unblocking of the de-spin mirror of Meteosat-10's GERB-3 instrument as a result of 22 months of thorough investigation and in-orbit testing.

The portfolio of EUMETSAT data services was again enriched by new products and by an exceptional range of new third-party data services introduced in cooperation with our partners from China, India, Japan and the US. Another important innovation was the opening of a first Web Map Service named "EUMETView" that facilitates visualisation and overlay of EUMETSAT imagery with other sources of geospatial information.

The extension of cooperation with China to include reciprocal access to direct broadcast data from Metop and FY-3 polar-orbiting satellites and exchange of processing software gave EUMETSAT access to regional FY-3C sounding products within 30 minutes from sensing, based on data processed at five X/L Band stations of the EARS network.

2015 was decisive for the continuity of services in the next five to ten years.

Of course, the launch of MSG-4, the last Meteosat Second Generation satellite, on 15 July, and its successful commissioning just five months after launch, was of major significance in this regard. Indeed, with MSG-4 stored in orbit as Meteosat-11 - nominally for 2.5 years - and ready to enter operational service at any time with one week's notice, EUMETSAT now has all in-orbit assets in hand to secure a safe and cost-effective transition to Meteosat Third Generation.

This success put a finishing touch to the MSG development programme, which is viewed as an outstanding success of the cooperation with ESA and industry and the achievement of a generation of European engineers and scientists.

The continuity of high-precision altimeter observations of ocean currents, sea state, wind speed and sea level was also secured at least until 2021 with the launch of Jason-3, which finally took place on 17 January 2016, after a *sine die* postponement linked to the failure of Falcon-9 in June. This was a relief for all programme partners, in particular in Europe, where programme funding was insufficient to support a further postponement of the launch.

Metop-C has remained on track for launch in October 2018, following the successful repair of the MHS and IASI instruments, achieving key milestones towards the continuity of the polar-orbit data service.

For the challenging MTG development programme, 2015 was a year of contrasts with, on the one hand, the first satellite hardware delivered, EUMETSAT's contracts for launch and LEOP services signed and key ground segment development milestones passed and, on the other hand, the space segment development slipping by one year in October, requiring major replanning in 2016 for EUMETSAT's system and ground segment development activities.




The word of the Director-General

2015 will remain a landmark in EUMETSAT's history due to the entry into force of two new programmes, EPS-Second Generation (EPS-SG) and Jason-Continuity of Service (Jason-CS).

With two series of Metop-SG spacecraft (A and B) equipped with complementary instruments and flying simultaneously on the same mid-morning orbit, the EPS-SG system will improve all the observing capabilities of the current Metop satellites, bring completely new ones, and will be Europe's contribution to the Joint Polar System shared with the US in the 2020-2040 timeframe. The programme, involving cooperation with ESA, CNES and DLR for the development of satellites and instruments, and with NOAA for shared ground segment infrastructure services and joint operations, had a fast start, completing its preliminary design phase in the autumn.

The entry into force of the Jason-CS programme, three months ahead of the 21st Conference of the Parties (COP21) to the UN Framework Convention on Climate Change, confirmed EUMETSAT's continued commitment to monitoring of ocean circulation and mean sea level, a key parameter for adaptation to climate change in coastal areas. The Jason-CS programme is EUMETSAT's contribution to the Sentinel-6/Jason-CS cooperative mission also involving ESA, NASA, NOAA, CNES and the EU through Copernicus, based on the heritage of Jason-2 and Jason-3.

The approval of both new programmes left EUMETSAT no choice but to deliver its new office building in time for accommodating the EPS-SG and Jason-CS teams and for terminating a contract for rented offices. This was achieved within budget and with more than 300 persons moved across all buildings in a few months.

2015 was also the first year of EUMETSAT in Copernicus, marked by the establishment of its Copernicus Programme Office, the build-up of all teams required to support Sentinel-3 operations and the completion of a complex cooperative test campaign with ESA, which confirmed the readiness of EUMETSAT for the launch and commissioning of Sentinel-3A. These efforts were rewarded by the successful launch of Sentinel-3A by ESA on 16 February 2016.

The international agenda was dominated by the 17th WMO Congress, where China confirmed its intention to launch its future FY-3E polar-orbiting satellite on the unpopulated early morning orbit, and by the preparation for COP21 and the GEO Ministerial Summit, both within the Committee of Earth Observation Satellites (CEOS).

Finally, EUMETSAT started to define its strategy for the next decade - named "Challenge 2025" - addressing *inter alia* the optimum realisation of the portfolio of programmes acquired in recent years, its future role in Copernicus and the "big data" challenge.

All these achievements required the highest commitment from all EUMETSAT personnel and I wish to express my sincere gratitude to all of them, along with my personal thanks to the EUMETSAT Council and its advisory bodies for their trust and guidance.

Alain Ratier
Director-General

Member and Cooperating States

MEMBER STATES

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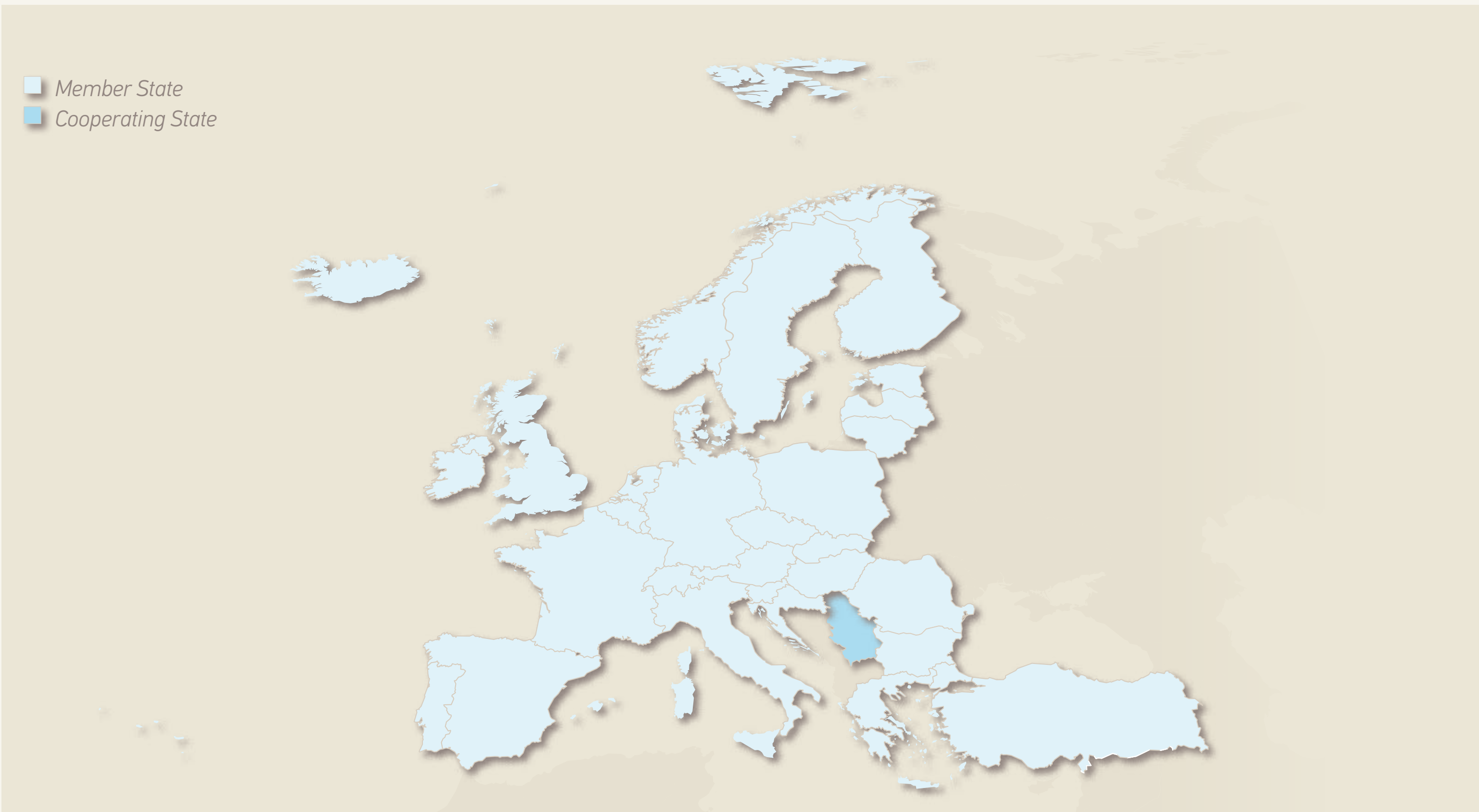
COOPERATING STATE

2009



Discussions started with Serbia, the only remaining EUMETSAT Cooperating State, to plan and prepare its accession as a full Member State in 2017, when its Cooperating State Agreement expires.

In line with its Membership Accession Policy, EUMETSAT has continued to monitor the EU accession process of the western Balkan countries and provided preliminary information to those considering joining EUMETSAT as Cooperating States.

2015 highlights

2015 was marked by the launch of MSG-4, the approval of the EPS-Second Generation and Jason-CS programmes and the inauguration of a new office building required for delivering a larger portfolio of programmes. It was also the first year of EUMETSAT in Copernicus, focused on the preparation for the launches of Jason-3 and Sentinel-3A.

January

Conclusion of the System Requirements Review of the METimage instrument to be flown on the Metop-SG A satellites

The EUMETSAT Sentinel-3 Flight Operations Segment (FOS) passes its Acceptance Review

February

After 22 months of investigations and in-orbit testing, the de-spin mirror of Meteosat-10's GERB-3 instrument is unblocked

The first part of the Jason-3 Operational Readiness Review is declared successful by CNES, NASA, NOAA and EUMETSAT

March

The MSG-4 Satellite is declared ready for shipment to the launch site

Readiness of the MSG system and teams for the operations of a constellation of four MSG satellites in orbit

July

Successful launch of MSG-4 by Ariane-5, from Kourou

EUMETSAT takes over control of the MSG-4 satellite from ESOC

Completion of the preliminary design of the MTG mission data acquisition ground stations

Conclusion of the preliminary design of the METimage instrument and authorisation to proceed with phase C activities

Conclusion of the four-partner (NASA, ESA, NOAA and EUMETSAT) Jason-CS System Requirements Review

August

Inauguration of the new office building

MSG-4 reaches its commissioning longitude of 3.5°W and acquires its first SEVIRI and GERB-4 images

Kick-off of the contract for the launch services for the first three MTG satellites

September

EUMETSAT User Conference co-organised with Météo-France in Toulouse

Start of the real-time dissemination of MSG-4 image data and products

Conclusion of the preliminary design of the MTG telemetry tracking and control (TT&C) stations

Signature of the contract for the MTG level 2 processing facility (L2PF)

The EUMETSAT Jason-CS programme enters into force

April

EUMETSAT and Roshydromet (Russia) sign a new Cooperation Agreement

Completion of the preliminary design of the IASI-New Generation instrument to be flown on the Metop-SG A satellites

The MSG-4 satellite is shipped to Kourou, for launch from the European Space Port

May

Start of EPS-SG programme activities

Signature of the Jason-CS space segment contract by ESA and industry

June

The Jason-3 Operations Readiness Review is closed and the satellite is shipped to Vandenberg for launch

The EPS-SG System Preliminary Design Review concludes EUMETSAT's phase B activities

The EUMETSAT Council approves the scope of the Jason-CS programme

The EUMETSAT Council approves the EPS-SG programme

October

Signature of Metop-SG Cooperation Agreement with ESA

Completion of the preliminary design of the EPS-SG overall ground segment

November

The ESA Preliminary Design Review of the Metop-SG satellites is declared successful

Signature of the contract for the launch and early operations phase (LEOP) services for the first three MTG satellites

December

Signature of EPS-SG agreements with NOAA (Joint Polar System Agreement), CNES (IASI-NG Agreement) and ESA (Sentinel-5 Arrangement)

Signature of Sentinel-6/Jason-CS Arrangement with ESA

MSG-4 enters in-orbit storage and is handed over to Operations as Meteosat-11

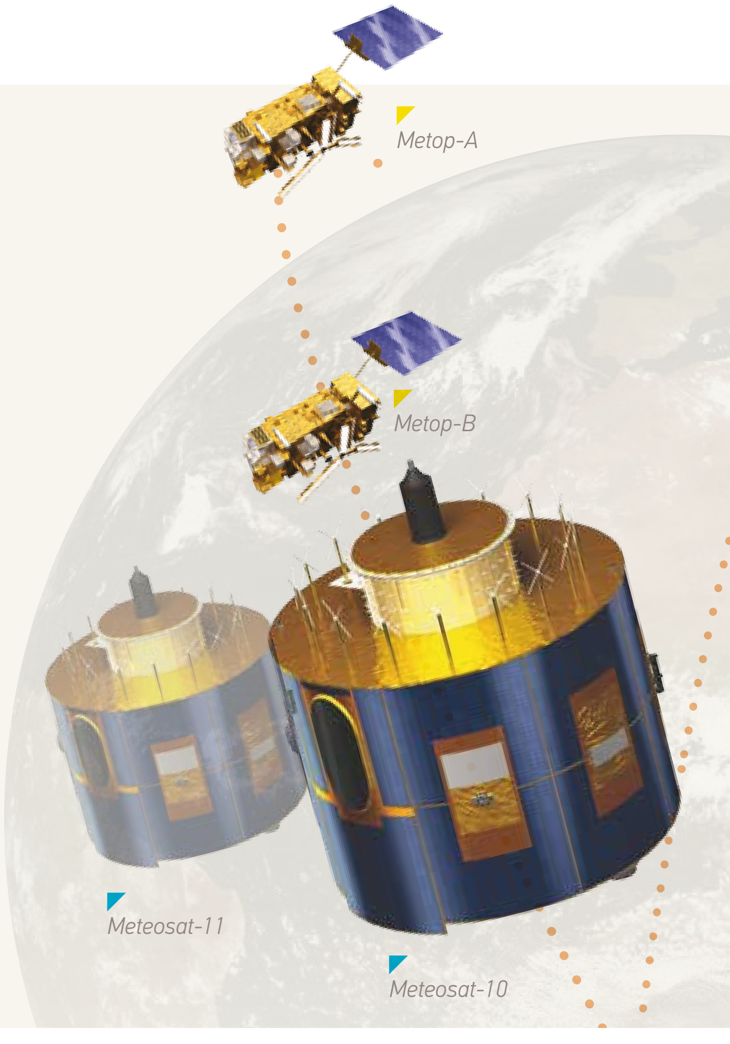
The critical design of the MTG mission data acquisition ground stations is completed

Operating complex satellite systems around the clock

In 2015, EUMETSAT exploited seven satellites and delivered observations of weather, atmospheric composition, ocean, land and climate from three orbits

Meteosat satellites

Meteosat-11		*In-orbit storage*
Successfully launched on 15 July and stored in orbit in December following successful commissioning		
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	*3.5°E*	*Meteosat Back-up Services*
Provides a hot back-up for both the full disc and rapid scan services		
Meteosat-7	*57.5°E*	*Indian Ocean Data Coverage (IODC)*
Supports the IODC mission, bridging an observational gap in this region		



Safe operations of a fleet of four Meteosat satellites

Meteosat-7, the last first-generation Meteosat satellite, was exploited from 57.5°E, bridging an important observation gap over the Indian Ocean, and will stay there until its move to a graveyard orbit in May 2017.

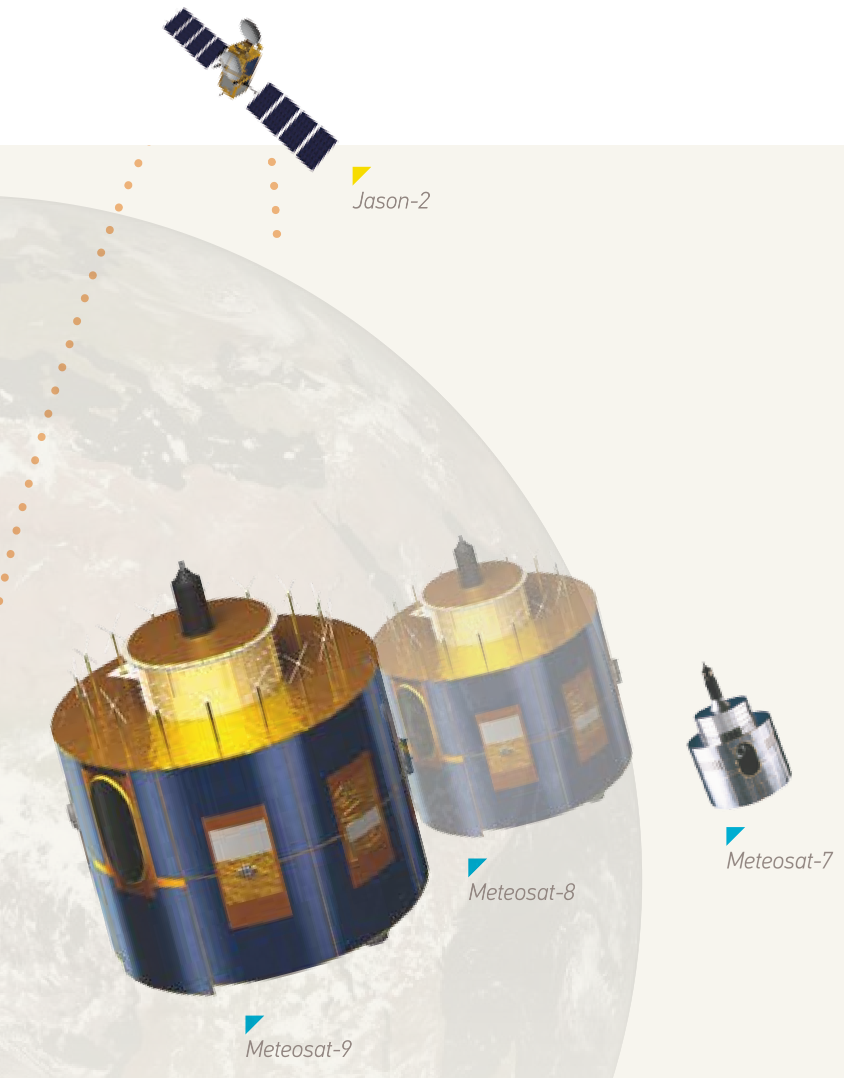
The first three Meteosat Second Generation (MSG) satellites, two of which have exceeded their design lifetime, remained in their nominal orbital positions.

Meteosat-10 delivered the primary full Earth scan service covering Europe and Africa from 0° longitude, while Meteosat-9 was exploited for the Rapid Scan Service (RSS) over Europe and adjacent seas from 9.5°E.

Meteosat-8 served as a hot back-up for both missions from 3.5°E and was also used to perform special scanning sessions at the same 10-minute frequency as the future MTG-I satellite to support the generation of relevant test data.

The Geostationary Earth Radiation Budget (GERB) mission was performed by Meteosat-9 until 30 April and then taken over by Meteosat-10 when its GERB-3 instrument came back to nominal imaging after the de-spin mirror was unblocked.

The first North-South orbit inclination manoeuvre of Meteosat-10 was executed on 23 February and its planned East-West station keeping manoeuvre was advanced from 16 to 10 June to mitigate collision risk with an old Intelsat-804 satellite, which was expected to come as close as 1.4km, according to warnings from the US Joint Space Operation Center (JSpOC).



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-2	*NSO 66° incl.*	*Ocean Surface Topography Mission*
Delivers measurements of sea surface heights from a non-synchronous orbit at 1,336km altitude (mission shared with NOAA, CNES, NASA)		

Two Metop satellites flown in formation

As part of the Initial Joint Polar System (IJPS) shared with the United States, the EUMETSAT Polar System (EPS) continued to be exploited as a dual satellite system collecting global, highly accurate observations of atmospheric, ocean and land parameters that are only accessible from low Earth orbits. These are critical for forecasts up to 12 days ahead.

Metop-A and Metop-B were flying on the same sun-synchronous mid-morning orbit, about half an orbit apart (48 minutes), with their GOME-2 ozone-monitoring instruments operating in different modes, i.e. with the full 1,920km swath and coarse spatial resolution on Metop-B and with a half swath and higher spatial resolution on Metop-A.

Metop-B served as the primary satellite, dumping its data twice per orbit, at Svalbard and at McMurdo - the latter through the Antarctic Data Service (ADA) provided through NOAA - to deliver global data to users with the shortest possible latency. As the secondary satellite, the ageing Metop-A dumped data only once per orbit at Svalbard and supported the ARGOS localisation and data collection mission.

On both satellites, the IASI instruments were reconfigured to put the Corner Cube Compensating Devices of their interferometers in “stop” mode to improve performance.

The last full out-of-plane manoeuvre of Metop-A was successfully performed in two burns on 14 October and 4 November.

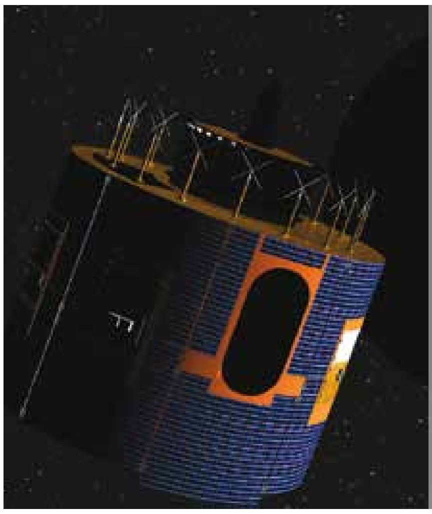
Jason-2 performs its first anti-collision manoeuvre

Flying on a different, non-synchronous orbit inclined at 66°, the Jason-2 satellite continued to deliver high-precision observations of wave height, mean sea level and ocean currents, after more than seven years in orbit. The mean sea level data series, which started in 1992 with Topex/Poseidon, now covers 23 years, constituting an invaluable Climate Data Record.

A collision avoidance manoeuvre was executed on 18 November, followed on 19 November by the manoeuvre required to bring the spacecraft back to its nominal repeat ground track.

Operating complex satellite systems around the clock

Availability of satellite systems remained very high throughout 2015



Meteosat services available from three orbital slots

The availability of the Indian Ocean Data Coverage (IODC) mission remained high throughout the year as Meteosat-7 performed well. Thanks to optimisation of the battery reconditioning sequence and charge cycle, its battery voltage remained above the minimum level required to exploit all on-board systems, even during the critical eclipse seasons.

Owing to the excellent performance of Meteosat-10 and to the use of Meteosat-8 as a backup during decontamination of its SEVIRI instrument, the availability of the primary 0° service remained very high, though slightly below target in January, when temporary network problems affected the timeliness of data delivery.

Metop ground station, Svalbard, Spitzbergen, Norway

The only other noticeable outages occurred in April, when an undesired switch-off of the Meteosat-10 SEVIRI calibration module caused the loss of 75 minutes of data, and in November, when Meteosat-10 went to safe mode due to a space weather event. In the latter case, the service could be rapidly taken over by the Meteosat-8 back-up satellite, limiting the outage to 2.5 hours.

A serious anomaly affected Meteosat-10 when the gain of its telecommand receiver (RX1) dropped suddenly before settling at a low but operations-compatible level, but this had no impact on the service, as spacecraft commanding was swapped to the redundant unit (RX2). Investigations attributed the anomaly to a loose connection of a band-pass filter component, and concluded that no redundancy had been lost on board. This was corroborated by the observed temperature-dependency of the gain level.

The thermal control of the ageing Meteosat-9 satellite degraded further in April and September with fuel migration events causing spin axis wobble and degradation of geometric quality of Rapid Scan Service imagery. Imaging performance could, however, be recovered by commanding heaters from the ground to increase the temperature of the fuel tanks by up to 7 degrees.

This had no significant impact on the availability of the Rapid Scan Service, which remained high also because Meteosat-8 continued to be used to bridge the 48-hour monthly interruptions required to preserve the lifetime of the Meteosat-9 scanning system. However, the one-month winter interruption from 13 January to 10 February was not backed-up, following the decision to preferably use the limited number of rapid scan cycles that remain possible with Meteosat-8 to bridge the Meteosat-9 monthly 48-hour gaps until mid-2016.

The conclusion of the annual Meteosat Lifetime Review was postponed to 2016, pending completion of studies aimed at reconciling discrepancies between fuel consumption rates estimated by different methods on board MSG-2,-3 and -4.

The EUMETSAT Polar System keeps its dual satellite capacity

The availability of the dual Metop EPS system continued to be very high, though with an increasing contrast between the healthy primary Metop-B satellite and the ageing Metop-A.

The only significant unplanned outages on the primary Metop-B satellite were due to space weather events encountered over the South Pole and the South Atlantic Anomaly, causing the loss of 86 hours of data from the MHS microwave moisture sounding instrument in September and 93 hours of data from the IASI instrument in July and November.

The noise of the long-wave infrared channels of the HIRS legacy sounder continued to evolve erratically due to a known anomaly, but remained within specifications, with no impact on the products delivered.

On the ageing, secondary Metop-A satellite, space weather caused the loss of only 16 hours of IASI data and some temporary reduction of the number of ARGOS and Search and Rescue messages transmitted to ground but the irreversible degradation of sounding instruments started to impact the quality of products.

The noise affecting channels 3 and 8 of the AMSU-A1 microwave temperature sounder continued to increase exponentially, reaching a level that degrades the quality of multi-sensor temperature and humidity sounding products to a point where their production had to be terminated on 7 December. By contrast, the noise of channels 3 and 4 of the MHS microwave moisture sounder have continued to slowly decrease and the increasing number of quality warning flags generated by the IASI instrument went back to normal in April, after the instrument electronics were swapped to the redundant unit, causing a five-day outage.

EUMETSAT LEO Mission Control Centre, Darmstadt, Germany

On the ground, occasional problems with antenna control units caused the loss of a few data dumps from both spacecraft in Svalbard from June to September, partially mitigated by recovery of Metop-B data through acquisition at McMurdo. These known anomalies will be eliminated by the ongoing refurbishment of both antennas.

The annual EPS Lifetime Review confirmed that Metop-A can be exploited beyond the end of the commissioning of Metop-C, in spring 2019, if it does not use fuel to recover from a safe mode in the meantime.

Jason-2 is healthy, ready to cross-calibrate its Jason-3 successor

EUMETSAT, CNES, NOAA and NASA extended the Jason-2 mission until the end of 2017 and agreed the solution proposed by CNES for fixing the CPU overload of one of the satellite processors, which introduced a single point of failure in 2013.

Optimising and modernising ground infrastructure

Reliability and efficiency are the common goals for all evolutions of ground infrastructure

In the area of multi-mission infrastructure, major events were the Technical Infrastructure Building achieving the "gold level" of the Certified Energy Efficient Datacentre Award (CEEDA) and the readiness of the multi-mission dissemination system (MMDS) for operations after extensive load tests. A separate, generic environment was also developed for processing third-party data more efficiently and with increased IT security.

The migration of the central facility (CF), the last element of the Meteosat Second Generation ground segment to be virtualised, started its final validation test campaign in December. The swap of Meteosat operations from the legacy to the virtualised facility is foreseen in spring 2016.

The ongoing cycle of EPS ground system upgrades aimed at removing obsolescence and increasing efficiency prior to the launch of Metop-C progressed towards its completion, which is foreseen in early 2017. The refurbishment of both core data acquisition (CDA) stations passed major milestones in Svalbard with the completion of the upgrades of all data acquisition and telemetry tracking and command chains and the kick-off of those of the antenna control systems. In Darmstadt, the virtualisation of the control centre and processing systems entered its Architectural Design Review in December.

Using new technology, a contract for a 50mbps fibre-link communication service with Svalbard achieved a 50 percent reduction in running costs.

Studies started on the replacement of the obsolescent ASCAT (Advanced Scatterometer) calibration transponders installed in Turkey, considering the increasing rate of failure observed during calibration campaigns.

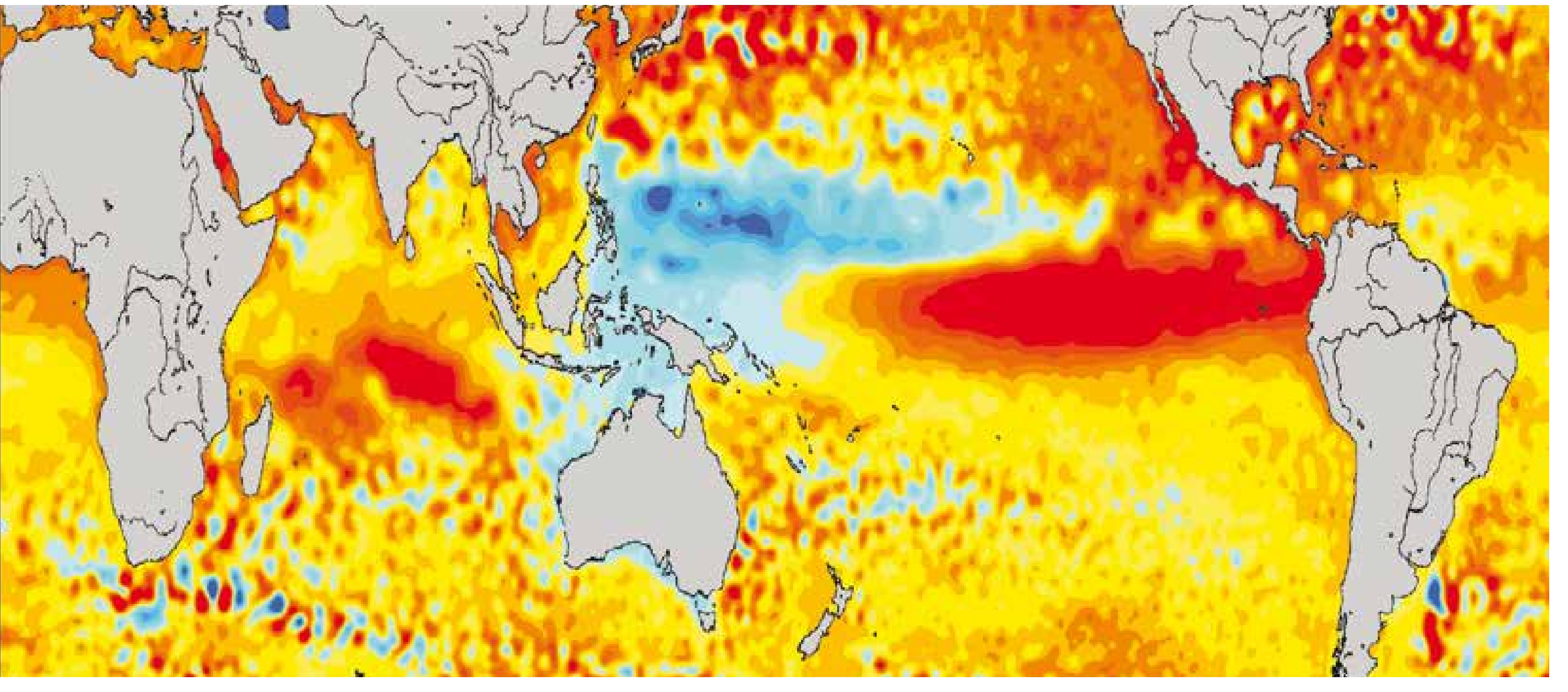
As part of the restructuring of the EPS mission control software around multi-mission kernels, the design of a re-engineered flight dynamics facility was completed. However, the design of the re-engineered mission planning facility had to be put on hold due to conflict of resources with the preparation of the MSG-4 launch.

Looking to the five-year horizon, a roadmap of pathfinder projects for future data services was prepared with prospective studies assessing the relevance of cloud and other "big data" technologies to emerging user needs. The roadmap will be proposed to the Council in spring 2016, after discussion at a dedicated technical workshop.

Delivering services and benefits to real-time users

In an exceptionally warm 2015, the real-time delivery of Metop and Jason observations helped predict El Niño and heat waves in Europe

Eastward migration of warm ocean waters (in red) from the western to the central Pacific observed by Jason-2 (source: LEGOS/CLS)

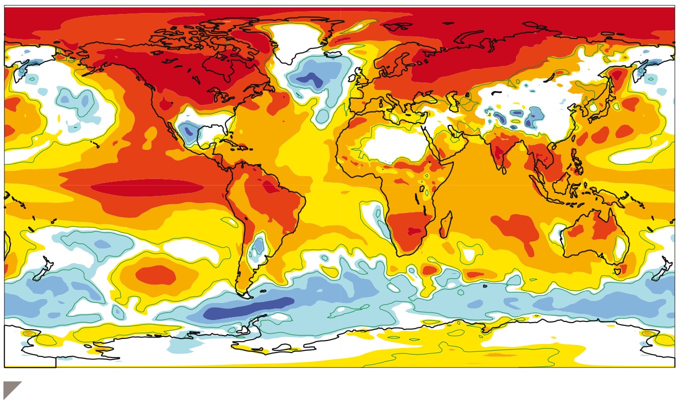


Jason observations help predict El Niño and a warm winter in Northern Europe

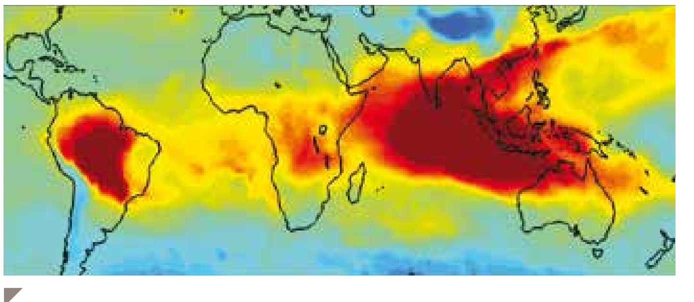
Seasonal forecasts were particularly important in 2015 to predict the evolution of a very intense El Niño episode, which brought major climate perturbations to the tropics and well beyond. Jason-2 ocean observations were a critical input to the numerical models coupling the atmosphere and the ocean used for this type of probabilistic forecasts.

Maps of ocean surface topography anomalies (departure from climatology) derived from Jason-2 observations have continuously monitored the signature and evolution of the El Niño phenomenon in the Pacific Ocean, showing the eastward migration of warm waters from the western to the central Pacific. As a result of colder than normal surface ocean waters in the western part of the basin, subsidence and severe drought substituted convective precipitation over Indonesia, causing large wild fires and associated CO plumes observed by the IASI sounders of EUMETSAT's Metop satellites. Larger wild fires than usual were also observed in the Amazon forest, which scientists consider as a remote effect of the El Niño episode.

In northern Europe and Russia, which are less influenced by El Niño, exceptionally warm temperatures were observed in the 2015-2016 winter and forecast by ECMWF.



ECMWF's seasonal forecast released in November 2015 for the winter 2015-2016, predicting anomalies of 2m temperature exceeding 2 degrees over Russia and the extreme northern latitudes



CO plumes associated with large-scale wild fires in Indonesia and the Amazon forest, observed by IASI imagery in November 2015 (source: LATMOS/ULB)

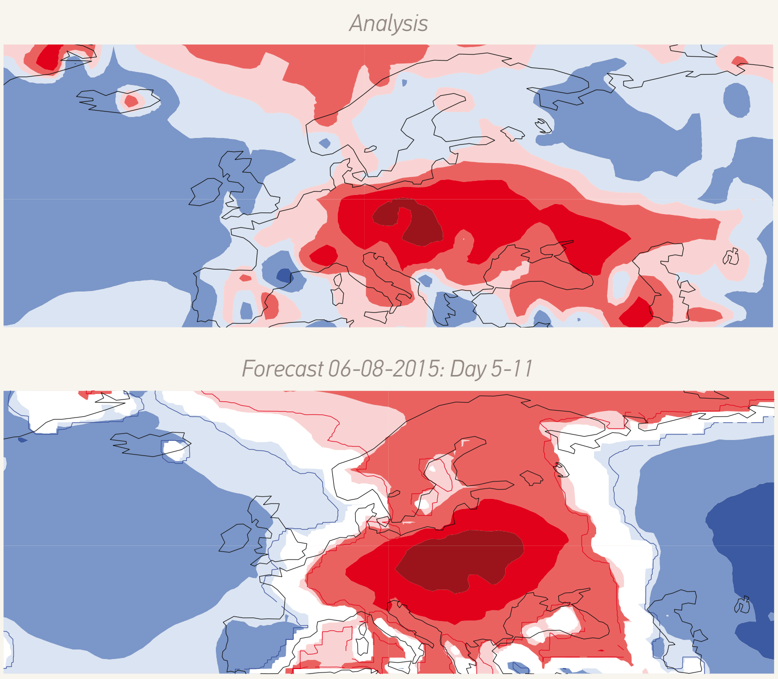
Delivering services and benefits to real-time users

People cool off from the heat at the Miroir d'Eau, a public art piece on the quay of the Garonne river, in Bordeaux, south-western France, June 30, 2015, during an unusual heat wave (source: REUTERS/Regis Duvignau)

Metop and Jason observations support forecasts and early warnings of heat waves in Europe

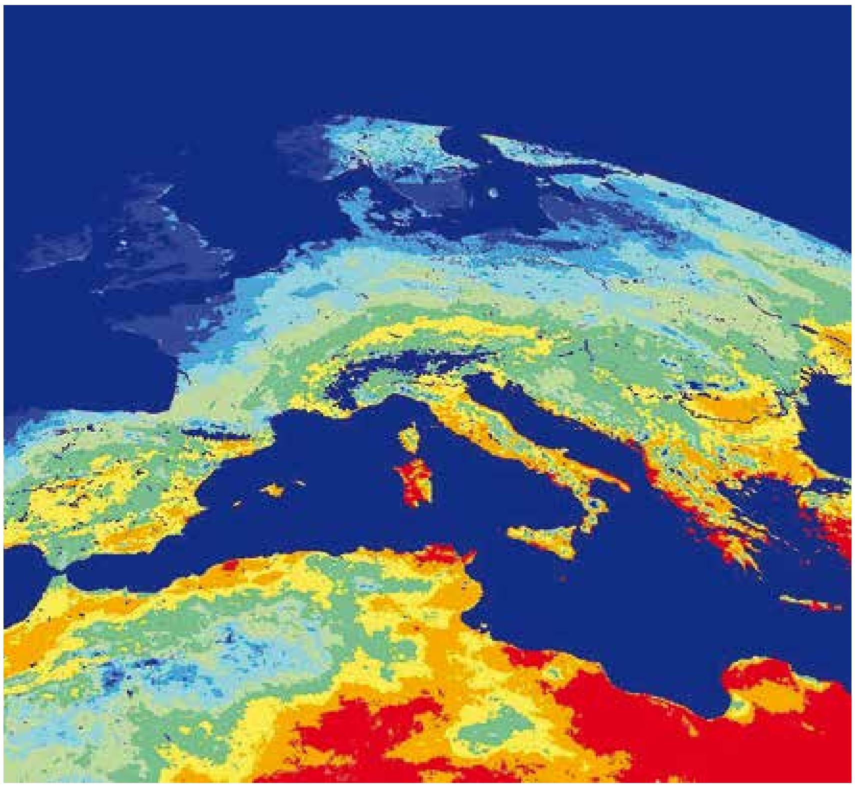
In a record-breaking year for average global temperatures (2015 was 0.76° C warmer than the 1961-1990 average) and in some places in Europe (39.6° C was recorded in Frankfurt), recurring heat waves and drought hit central and eastern Europe over the summer and caused widespread wildfires in the Iberian Peninsula.

Early warnings released by the Member States' National Meteorological Services were essential to reduce impacts on health and the economy. These warnings are based on medium- and extended-range numerical forecasts ingesting data from both Metop and Jason-2.



ECMWF probabilistic forecast (bottom) of temperature anomalies of up to 10 degrees one week before a heat wave hit Central Europe in August, compared to the conditions actually observed (top). These forecasts involve models coupling the ocean and the atmosphere and ingesting data from both Metop and Jason-2 (source: ECMWF).

10-day Normalised Difference Vegetation Index at the end of August from Meteosat imagery, showing dry vegetation over central and southern Europe (green to yellow). Healthy vegetation appears in blue (source: LSA SAF)



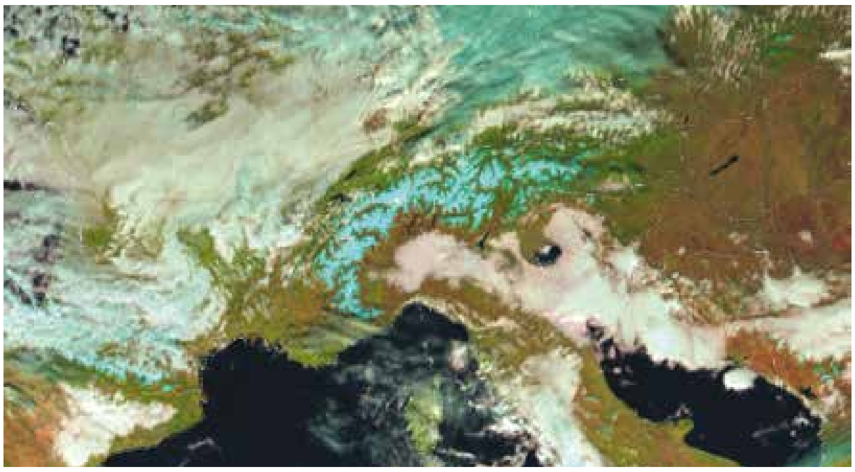
Meteosat imagery of land surfaces observes impacts of an exceptionally warm 2015

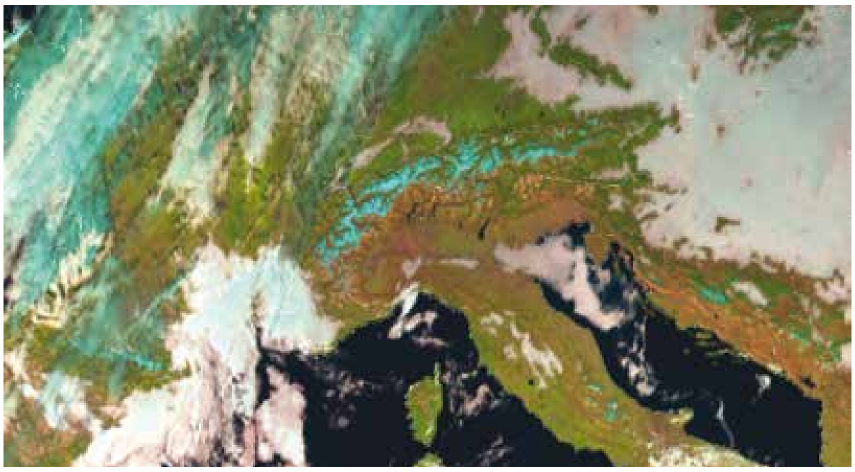
Though the horizontal resolution of Meteosat multi-spectral imagery is too coarse (a few kilometres over Europe) to depict all details of land surfaces that are better observed by high resolution imagery from dedicated polar-orbiting satellites like Sentinel-2, the very high revisit frequency of 5 to 15 minutes achievable from the geostationary orbit has the unique advantage of enabling much more frequent observations of cloud-free pixels, as cloud patterns move across the field of view. As a result, composite maps of vegetation or snow cover can be produced in a few hours or days and compared between any periods.

Thus the severe cumulative effects of the series of heat waves on vegetation could be observed and monitored by Meteosat imagery, showing highly stressed vegetation over southern and central Europe.

Likewise, Meteosat imagery brought evidence of the exceptional lack of snow pack over the Alps at the end of the year, when drier and warmer-than-average conditions had a severe impact on winter tourism.

These land surface monitoring capabilities will be significantly improved with the third generation of Meteosat satellites currently under development and expected to provide imagery at horizontal resolution better than 1 kilometre.





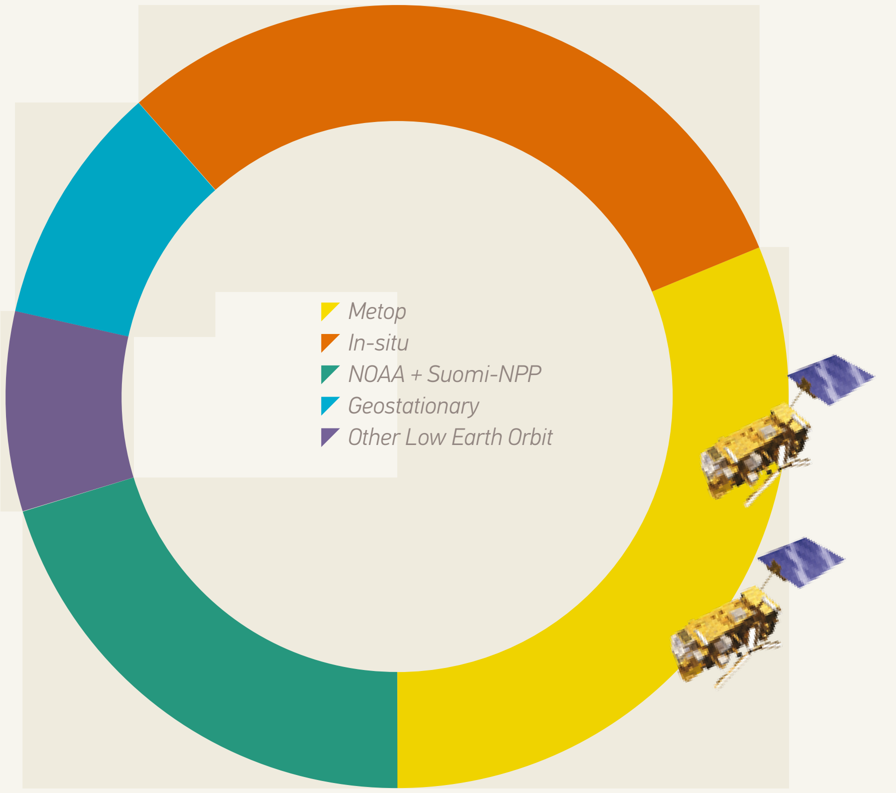
5km resolution Meteosat-10 images on 20 December in 2014 (top) and 2015 (bottom) showing the lack of snow in the Dolomites and the southern French Alps

Delivering services and benefits to real-time users

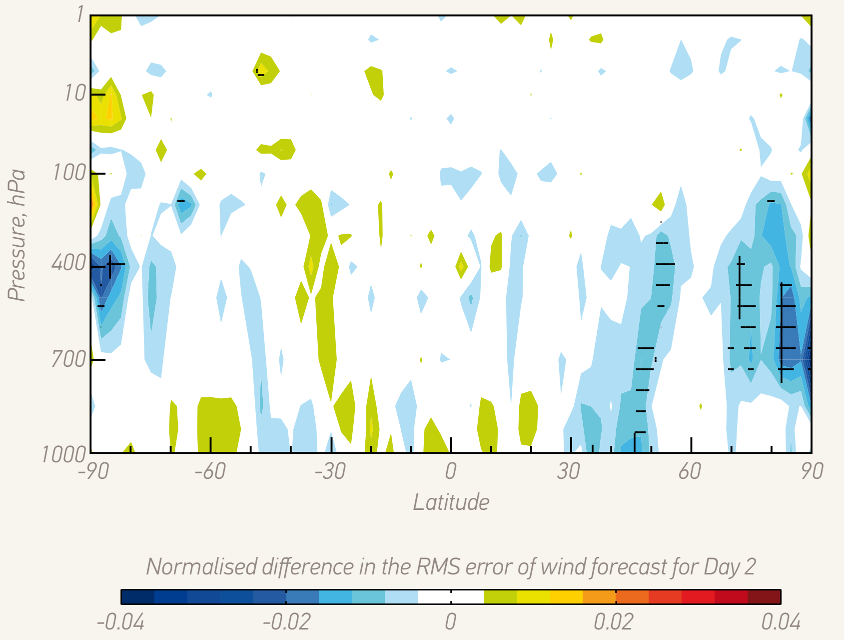
Metop data remain the most important source of satellite data for numerical weather prediction in Europe

From a statistical perspective, observations from both Metop satellites continued to be the most important observational inputs ingested by models, as demonstrated by new studies from the Met Office and ECMWF.

A study from the Met Office confirmed that the dual Metop system is the most significant source of error reduction in Day-1 forecasts across all types of observations, and ECMWF demonstrated the positive impact of EUMETSAT's new dual and single Metop wind products on their Day-2 forecasts for the Northern Hemisphere.



Relative contributions to the reduction of day-1 forecast errors from all observations ingested in the Met Office global model. The satellite data accounted for 69.74%, out of which dual Metop data represented 44.45% and IJPS (Metop, NOAA, S-NPP) 73.81% (source: Met Office).



EUMETSAT's new dual and single Metop wind products have a positive (blue shaded) impact on the ECMWF Day-2 forecasts of wind over the Northern Hemisphere, in the full depth of the atmosphere, from the surface to 100 hPa (source: ECMWF)

Meteosat imagery was decisive to follow storm tracks and nowcast fast developing thunderstorms

"Living off the western edge of the European landmass, Met Éireann forecasters rely heavily on Metop data to initialise their numerical models and on Meteosat imagery to track the actual movement and development of approaching Atlantic storms, like the six storms which hit Ireland in December 2015."

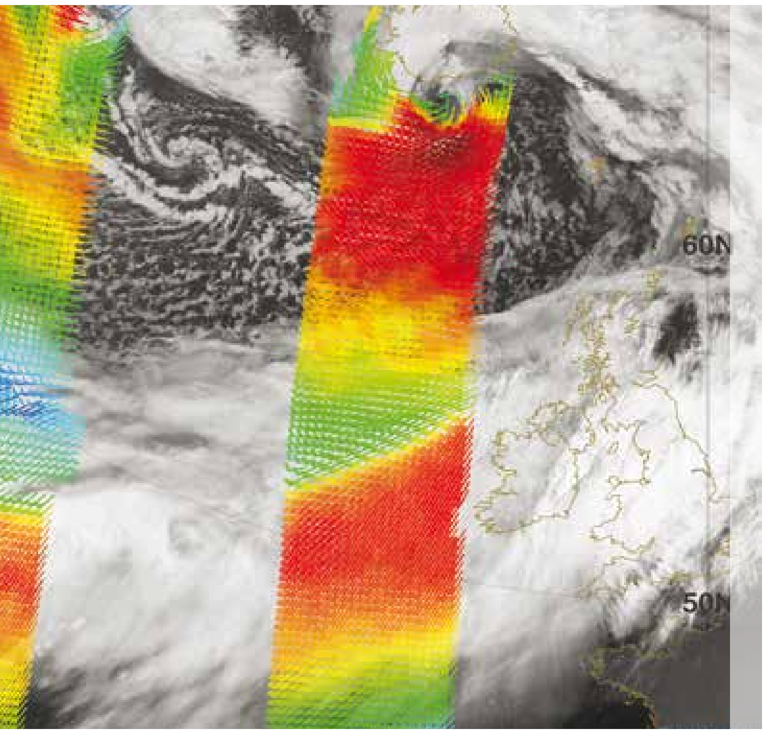
source: RTÉ

Gerald Flemming
Head of General Forecasting
Met Éireann

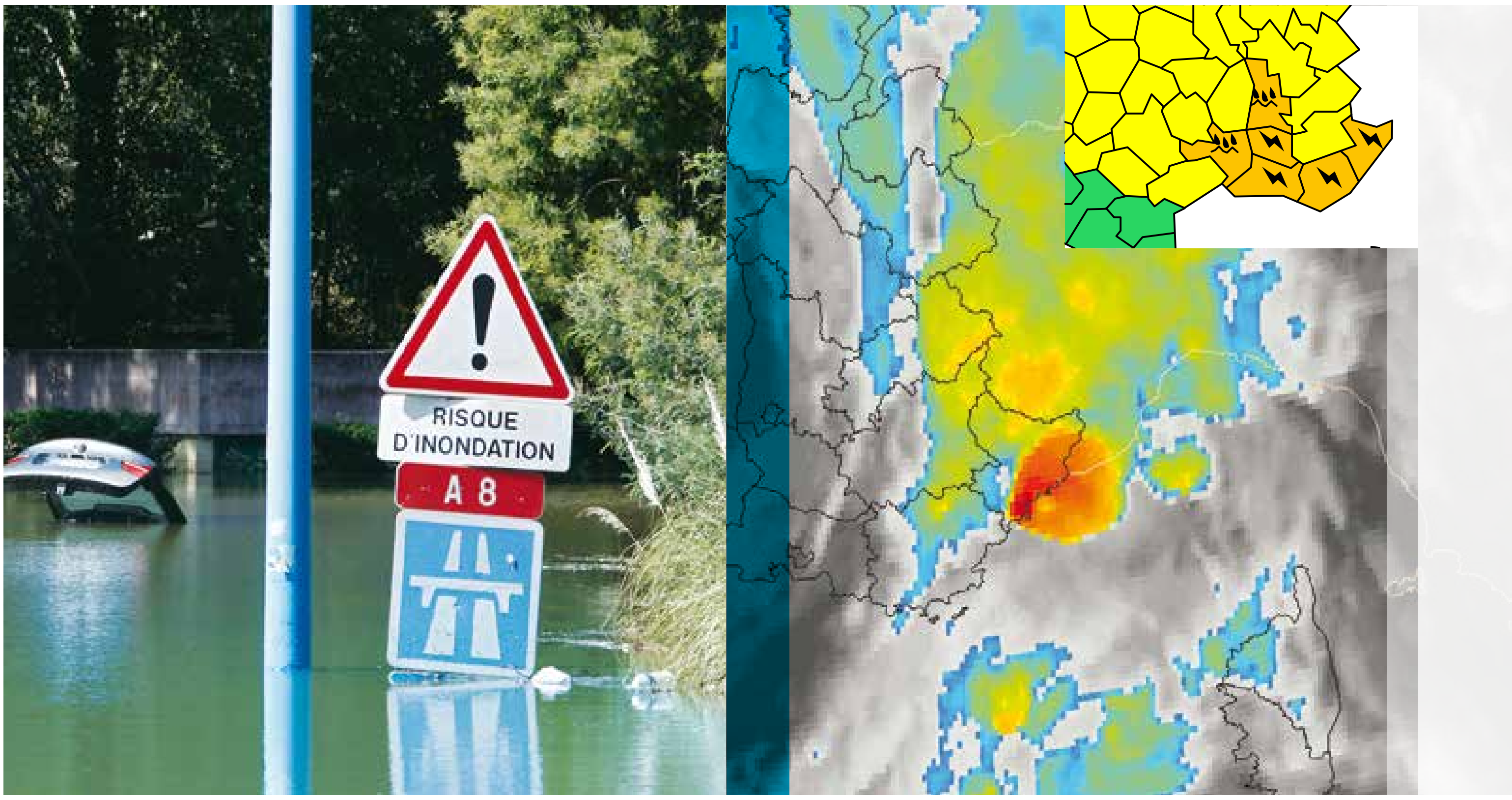
Meteosat confirms the numerical prediction scenario for a succession of six large winter storms

Numerical weather prediction, combined with real-time Meteosat imagery, helped the Met Office and Met Éireann to forecast and verify the track and intensity of a succession of six Atlantic winter storms which hit the UK and Ireland. In December, these storms brought such tremendous accumulations of rainfall that consequent flooding lasted for many weeks, bringing a miserable Christmas period for those affected. Storm Desmond set a new UK record when 341mm of rain fell in 24 hours at Honister Pass on 5 December and caused severe flooding to many towns and cities, as did storms Eva and Frank in Ireland and the northern UK around Christmas and New Year. In all cases, both weather services released timely warnings based on accurate forecasts enabling the deployment of flood defences by the authorities that saved many towns and villages from even greater damage.

Storm Desmond, as observed by Meteosat and Metop on 5 December (right). Rescue workers evacuate local residents by boat from a flooded residential street in Carlisle, UK on 6 December 2015 (left, source: REUTERS/Phil Noble). British police declared a major incident in northern England after prolonged heavy rain caused wide-spread flooding and forced emergency services to evacuate residents from their homes.



Development of a short-lived but exceptionally intense convective cell near Antibes, French Riviera, as observed by Meteosat-10 imagery on 3 October (right) and the orange warning released by Météo-France (inset). A traffic warning sign reads, "Danger of Flooding" near an abandoned car that is submerged in deep water after flooding caused by torrential rain in Mandelieu, France, 4 October, 2015 (left, source: REUTERS/Eric Gaillard).



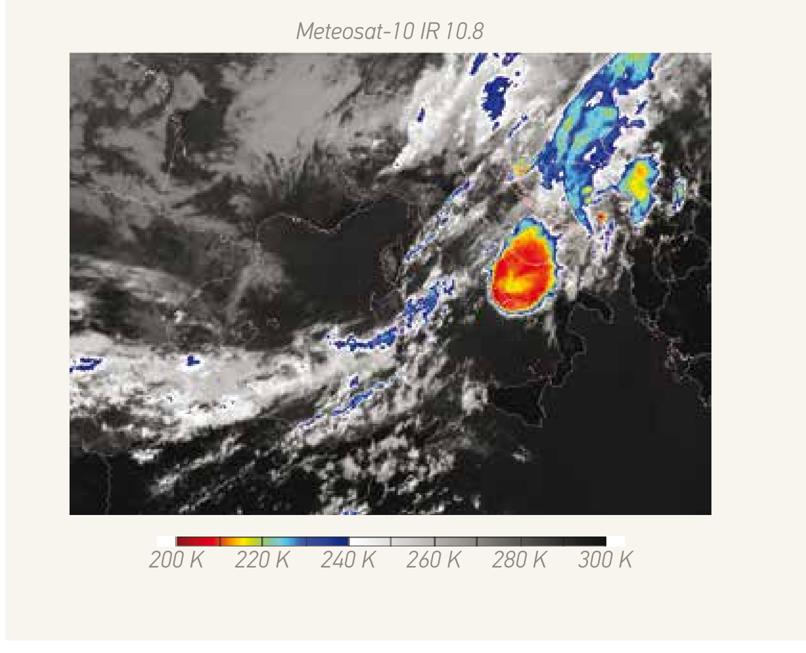
Meteosat imagery, an invaluable resource for nowcasting fast-developing, severe weather

Meteosat imagery again proved critical for "nowcasting" the development of dangerous convective systems that can only be predicted a few hours ahead.

This was particularly the case in early September, when an exceptional convective system hit the Balearics and Italy, bringing to Menorca its worst storm in 33 years and tennis ball-sized hail to Naples.

One of the most severe weather events of the year happened in southern France on 3 October, when a convective system, announced with an orange warning released by Météo-France, produced several extremely intense, short-lived cells. It took only two hours for this system to generate a deluge over a very narrow path right over the most populated area of the French Riviera. The flooding was responsible for the deaths of 20 people in several cities.

Meteosat-10 infrared imagery (5 September at 09:00 UTC) showing the cold, ring-shaped storm that developed over the Mediterranean Sea close to Naples



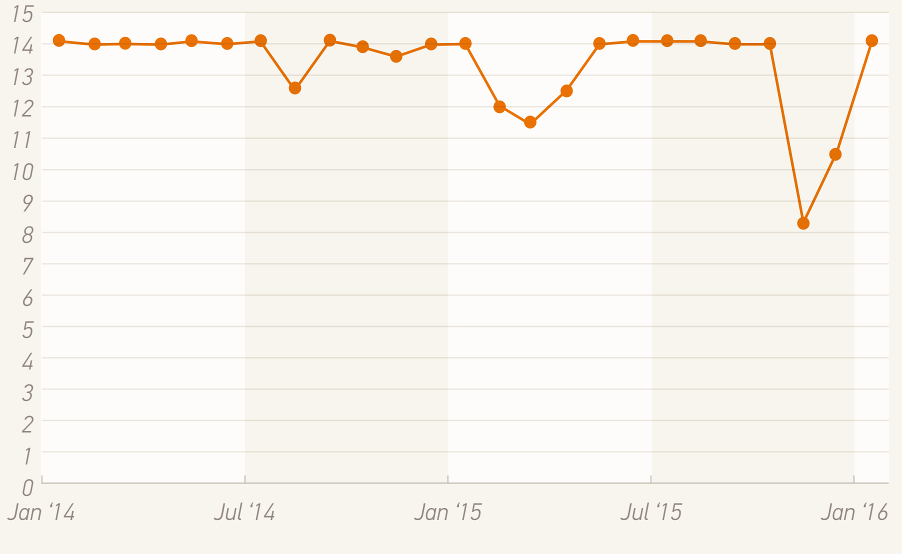
Data access and real-time delivery

The EUMETCast service continued to broadcast time-critical data to users with 99.9 percent availability and the EARS service, providing access to regional data from polar-orbiting satellites within 15 to 30 minutes from sensing, was expanded to include data from the Chinese FY-3 satellites

One challenge for EUMETSAT is to deliver observational products as quickly as possible after sensing - because the value of observations for forecasting diminishes with increasing latency - and to offer the easiest possible access to users worldwide.

To achieve this, EUMETSAT broadcasts its data and products in real time to users in Europe, Africa and the Americas, using the highly reliable, flexible and cost-effective satellite-based technology used for digital TV broadcasting.

Monthly average of supported passes per day



Availability of EUMETCast services remains at 99.9 percent

The availability of the EUMETCast-Europe, -Africa and -Americas services has remained at a high level throughout 2015, above 99.9 percent for EUMETCast-Europe. The availability of EUMETCast-Americas dropped to 95.1 percent in July due to an interference problem at the uplink station.

While geostationary imagery needs to be disseminated within minutes from sensing, global data from polar-orbiting satellites have less stringent latency requirements and are acquired only when satellites dump on-board recorded data to ground stations. If located at very high latitude, one station can acquire data at each orbit cycle, every 100 minutes, around 14 times a day, but more time is then needed to extract products to be broadcast via EUMETCast.

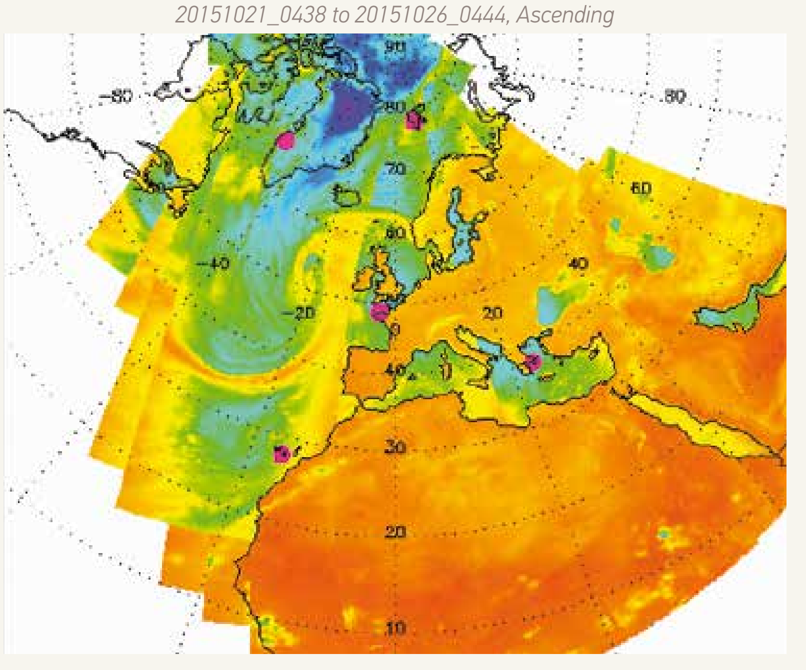
Within the Initial Joint Polar System shared with NOAA, Metop-B data are acquired twice per orbit to halve latency to 50 minutes, once by EUMETSAT at Svalbard, Spitzbergen, and once at McMurdo by the Antarctic Data Acquisition (ADA) service available through NOAA.

On average, 12.8 Metop-B passes per day were acquired at McMurdo out of the 14.2 possible, due to the priority assigned from January to April to the support of the launch and early operations of NASA's Soil Moisture Active Passive (SMAP) mission and to radome maintenance in November and December, during which no pass could be acquired.

The US-provided ADA service acquired an average of 12.8 Metop-B passes per day (bottom) at the McMurdo ground station in Antarctica (top)

Data access and real-time delivery

Geographical coverage of the first EARS-FY3 regional sounding product service based on acquisition and local processing of FY-3C direct broadcast data at five stations of the EARS network



EARS regional data services expand with Chinese data

The EUMETSAT Advanced Retransmission Service (EARS) regional data services deliver products from polar-orbiting satellites with an even shorter latency of 15 to 30 minutes from sensing, through the local processing, collection and dissemination of sounding and imagery data directly broadcast by the satellites to a few well distributed ground stations. This short latency, combined with more frequent observations available from multiple satellites, makes products usable for nowcasting over Europe.

Content wise, imagery and sounding products extracted from Metop-B and NOAA-19 data at the EARS station in Moscow were incorporated in the EARS-IASI and EARS-NWC (EARS-Nowcasting) data services and the EARS-VIIRS (Visible Infrared Imaging Radiometer Suite) imagery services evolved with the addition of the Day/Night Band channel.

The major achievement was undoubtedly the expansion of EARS regional data services with data from the Chinese FY-3C polar-orbiting satellite broadcast to the EARS stations in Athens, Kangerlussuaq, Lannion, Maspalomas and Svalbard. EARS-VASS (Vertical Atmospheric Sounding Service) for sounding products from MWHS-II and IRAS sounder data was opened in October, as the first EARS-FY3 regional data service.

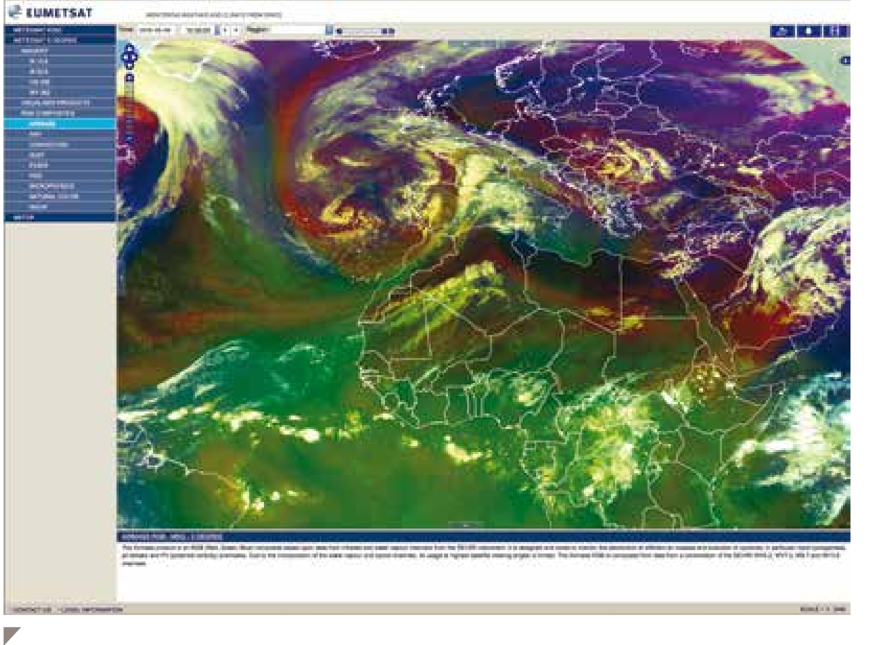
New user notification and ordering services offered on the web

A new user notification service (UNS), with a more user-friendly web interface and the option of subscribing to an email news service, was launched in May.

A new light-weight, web-based, more intuitive online ordering client was also released to users on 1 December and will operate in parallel to the existing ordering mechanism for six months. By the end of 2015, it was already used for about 50 percent of all submitted orders.

EUMETView: a first web map service

A pilot web map service (WMS) named "EUMETView" was opened to test the new WMS technology and gauge users' interest in web imagery delivered in a way which facilitates visualisation and overlay with other geospatial data. Though based on a limited set of products, including low-resolution Meteosat imagery, EUMETView attracted an average of 195 unique visitors per day, 60 percent from Europe, and dedicated online surveys confirmed users' interest in the further development of WMS services involving full-resolution imagery.



Display of Airmass RGB imagery, one of the most popular products of the EUMETView Web Map Service

Delivering support to climate services

Within the Global Framework for Climate Services, EUMETSAT's efforts to recalibrate and reprocess historical data were rewarded by the release of several 30-year long climate data records. Research on how to quantify uncertainties attached to climate data records continued in cooperative projects to fulfil one key requirement of Climate Services.

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 e.g. to address the Grand Science Challenges of the World Climate Research Programme, as illustrated by a reference article published in "Nature Geoscience[1]" in 2015 on clouds, circulation and climate sensitivity, 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.

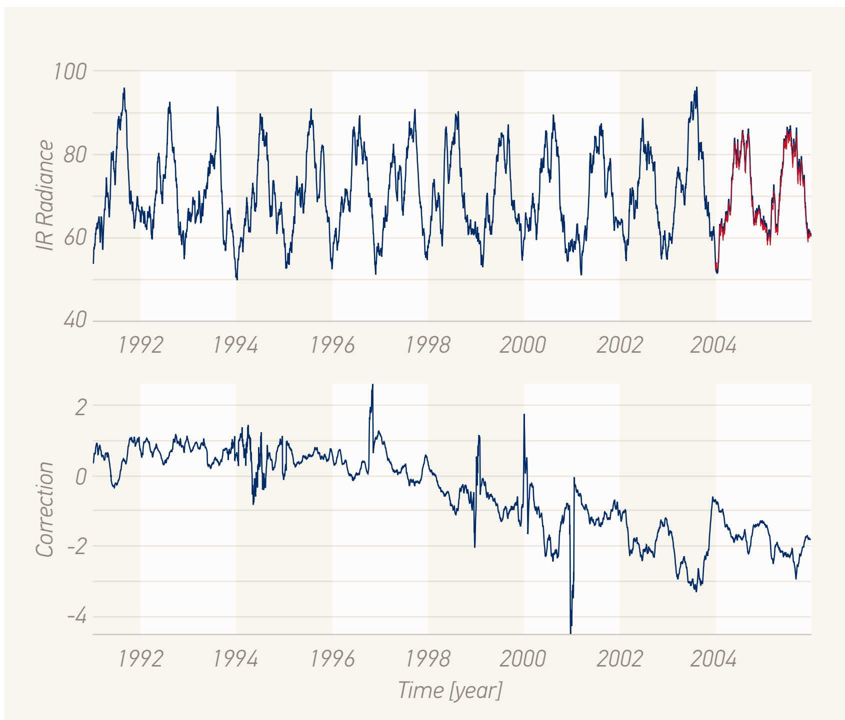
Recalibration of historical data and innovative algorithms enhance fundamental data records

The strategy for cross-calibrating Meteosat infrared imagery from 1982 to the present against IASI reference data available only since 2006 was implemented, using long infrared data records (from NASA's AIRS sounder and NOAA's series of HIRS-2 instruments) overlapping with IASI data for propagating backwards in time the excellent cross-calibration achievable with IASI.

The evaluation of daily recalibration coefficients calculated over 27 years, back to Meteosat-4, showed that recalibration eliminates most artefacts present in the operational calibration of first generation (Meteosat-4 to -7) satellites. Further, it reduces bias with respect to Meteosat Second Generation in the periods of overlap and against reference observations collected by the observatory of Payerne, Switzerland.

A 27-year-long fundamental climate data record of infrared brightness temperature covering both generations of Meteosat satellites back to Meteosat-4 was then created and delivered to the CM SAF and the ERA-CLIM2 and SCOPE-CM international climate research projects.

Recalibrated Meteosat first generation infrared imagery at the WMO reference station of Payerne, Switzerland (top, in blue) compares well with Meteosat Second Generation (in red) in the period of overlap (2004-2006). The time series of recalibration corrections (bottom) shows that artificial trends and other artefacts have been eliminated in the period 1996-2006.



Likewise, the CM SAF reprocessed microwave imagery from a series of six SSM/I and three SSMIS radiometers flown on American DMSP satellites to correct calibration artefacts due to moonlight and sunlight intrusions and emissive reflectors and released a 30-year-long (1983–2013) fundamental climate data record.

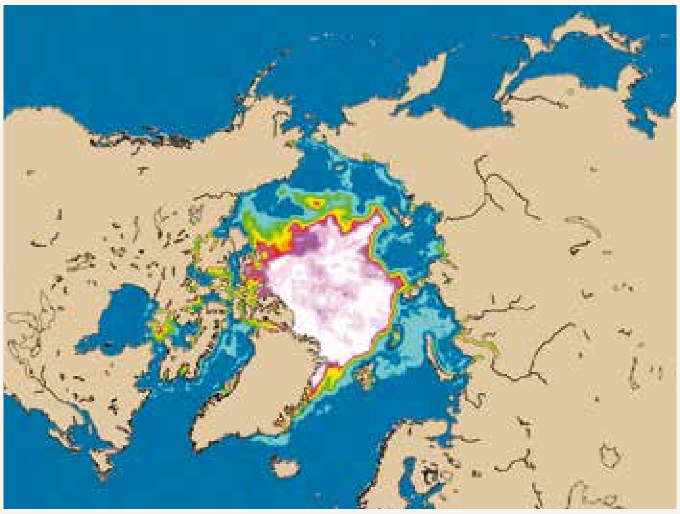
A new, innovative algorithm implementing the wave optics theory was used to reprocess self-calibrated GPS radio-occultation observations from the GRAS instruments of both Metop satellites and to deliver a more accurate record of the vertical profile of bending angle over the period 2006–2014 to the ERA-CLIM2 project.

[1] *Bony,S. et al., 2015. Clouds, circulation and climate sensitivity.* Nature Geoscience, *8(4), pp.261-268.*

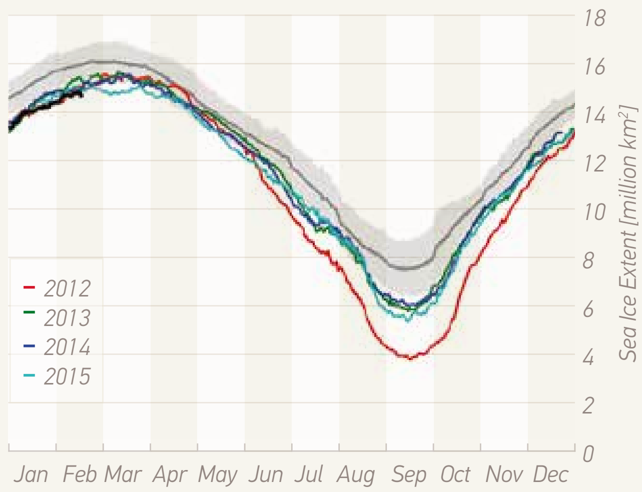
Delivering support to climate services

Sea ice concentration map in the arctic (left) and evolution of sea ice extent over recent years (right) (source: OSI SAF)

Sea Ice Concentration - Reproc NH / 2015-09-11 12:00:00



Arctic Sea Ice Extent



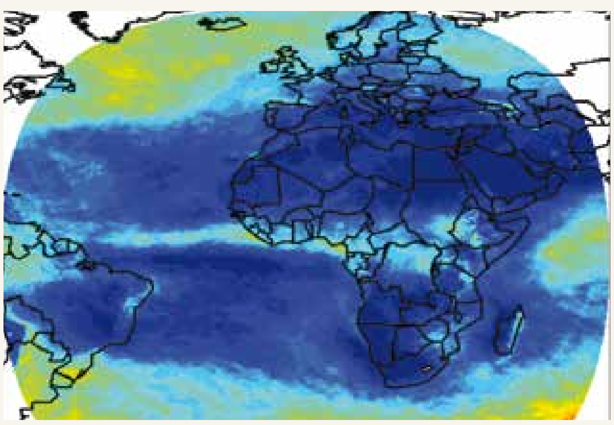
30-year-long records released for essential sea ice and radiation climate variables

The SAF on Ocean and Sea Ice (OSI SAF) reprocessed more than 35 years of microwave imagery (October 1978 - April 2015) from US satellites to release a TCDR of sea ice parameters documenting *inter alia* the evolution of the extension of sea ice in the Arctic Ocean. This record expands into an interim climate data record (ICDR) through day-to-day processing of microwave imagery available in real time from the SSMIS instrument, using the same algorithm.

Another 30-year-long TCDR called SARAH (Surface Solar Radiation Data Set - Heliosat) was released by the CM SAF. Derived from visible imagery from two generations of Meteosat, it documents solar surface irradiance, direct normalised irradiance and the effective cloud albedo in the 1983-2014 period.

Two walruses rest on a piece of floating ice in the ocean near Svalbard, Spitzbergen. According to scientists, large congregations of walruses observed in some parts of the Arctic coastal areas reflect their need to find alternative resting places.

Three new climate data records of wind vector in the troposphere and at the ocean surface were also released. They use wind vectors estimated from the displacement of clouds (atmospheric motion vectors) observed by Metop-A imagery in the polar regions (2007-2014) and by the Meteosat Second Generation satellites over Africa, Europe and adjacent seas (2004-2012) and ocean sea surface wind vectors extracted from 10 years of scatterometer observations from NASA's Quikscat mission (1999-2009).



Monthly means of effective albedo of clouds for June 2015 (source: CM SAF)

FIDUCEO project team holding a science workshop at NPL Teddington, UK, in October 2015

Assessing uncertainties in cooperative research projects

The optimum use of climate data records in climate services requires knowledge and traceability of uncertainties attached to each record. This is a scientific challenge in itself to which EUMETSAT contributes through cooperative research projects aimed at developing relevant methods and tools.

Concluding its contribution to the FP7 CORE-CLIMAX project, EUMETSAT delivered an assessment of the European capacity to generate climate data records, addressing more than 40 CDRs of essential climate variables. The assessment uses methods and metrics proposed and tested by EUMETSAT to qualify the maturity of the end-to-end process for the production of a CDR, from scientific development to quality evaluation.

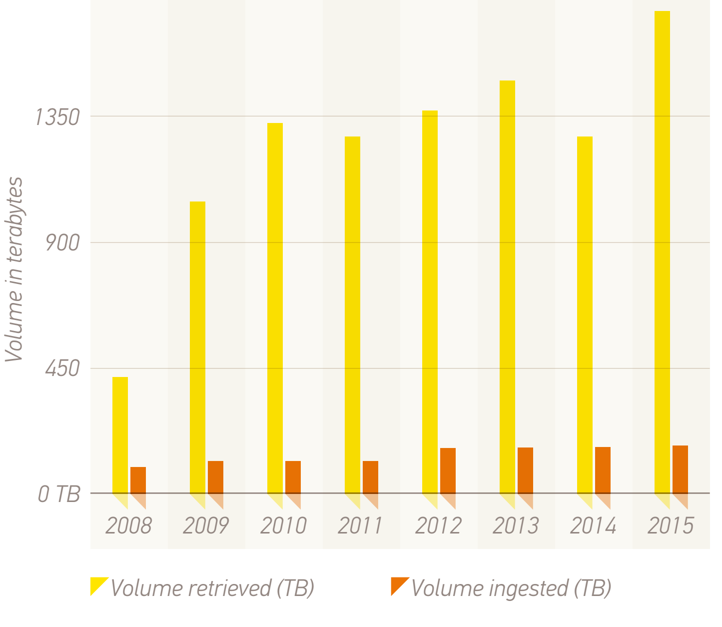
The FIDUCEO and GAIA-CLIM projects, both of which kicked off in 2015 and are funded by the EU's Horizon 2020 programme, will develop methods for assessing and tracing uncertainties attached to CDRs, using metrology as a reference (FIDUCEO) and comparison of input satellite data against ground-based observations (GAIA-CLIM). EUMETSAT will deliver documented data records from Meteosat first generation and heritage infrared sounders to FIDUCEO and construct a GAIA-CLIM virtual observatory (VO) that enables comparison of satellite-data, ground-based measurements and reanalyses, taking into account estimated uncertainties for all sources.

EUMETSAT started to trace historical Meteosat visible imagery to metrological references and to design the GAIA-CLIM VO after a survey of user requirements for uncertainty information. Aerosol optical depth and vertical profiles of temperature and humidity were selected as the first entries to the VO, including relevant data records from EUMETSAT sounding and imaging instruments (SEVIRI, IASI, HIRS, MHS). For comparison purposes, *in-situ* observations and model outputs will be collocated with satellite data and converted into simulated satellite observations using radiative transfer modelling.

Delivering support to climate services

The IT infrastructure needs continuous adaptation for data preservation, fast reprocessing of increasingly large data volumes and services to users

EUMETSAT Data Centre: a living archive



A responsive IT infrastructure

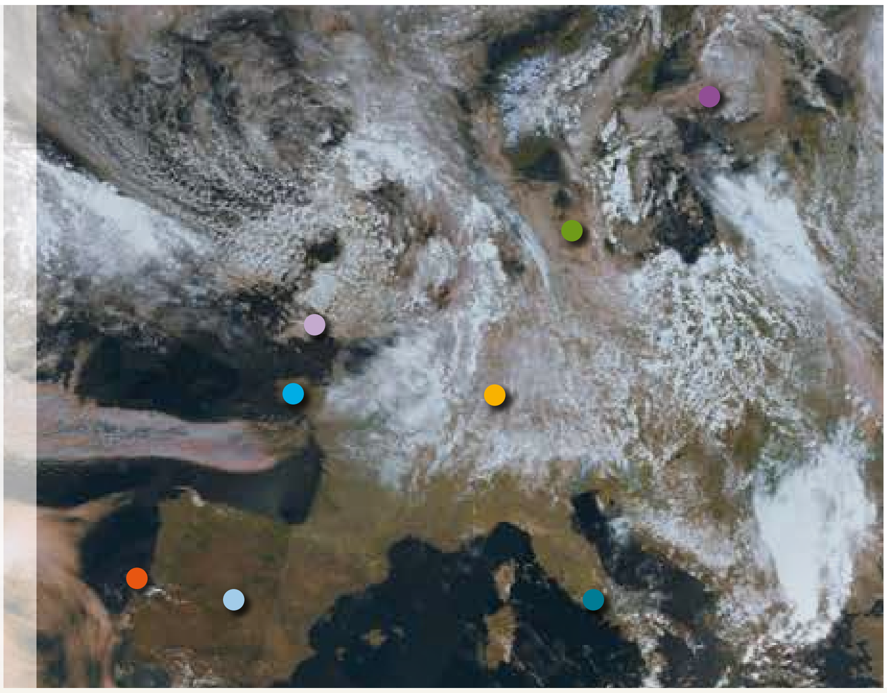
The volume of data delivered to users by the EUMETSAT Data Centre reached a new record of 430 Terabytes – 15 percent above the previous record – and digital object identifiers (DOI) were introduced to enable the digital identification of climate data records for their easy referencing in scientific publications.

Algorithms used to extract climate data records from archived data are becoming increasingly complex, involving more sophisticated representation of measurement physics for a given instrument, or combining information from different sensors and satellites.

Therefore EUMETSAT embarked on an upgrade of its IT infrastructure targeting more flexible access to large datasets and increased computer power for mass reprocessing and quality analysis. The detailed design of this infrastructure was completed in December, and the procurement of a first batch of hardware started after completion of prototyping and sizing analyses.

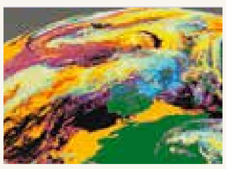
Developing enhanced and new products in partnership with Member States and other satellite operators

Cooperative development involving the Satellite Application Facilities again brought new and enhanced products to operational status for the benefit of a broad range of applications



In order to exploit the full potential of its satellites in a broad range of meteorological and environmental applications, EUMETSAT has adopted a distributed architecture for its application ground segment. This involves central facilities in Darmstadt and a network of Satellite Application Facilities (SAFs), each specialising in one application area. Each SAF constitutes a consortium of institutes from Member States, led by a National Meteorological Service (NMS).

This network allows the best use of distributed resources for the development and delivery of innovative products, capitalising on scientific expertise, close interactions with application experts and cross-network cooperation.

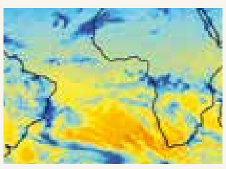


NWC SAF

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

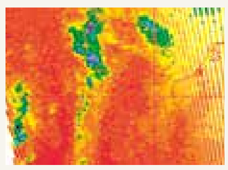
OSI SAF

Ocean and Sea Ice
Led by Météo-France



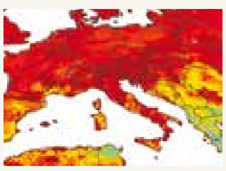
CM SAF

Climate Monitoring
Led by Deutscher Wetterdienst, Germany



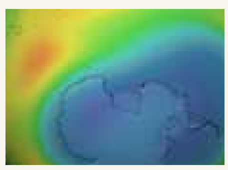
NWP SAF

Numerical Weather Prediction
Led by Met Office, UK



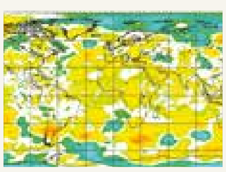
LSA SAF

Land Surface Analysis
Led by Portuguese Meteorological Institute



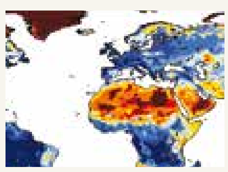
O3M SAF

Ozone and Atmospheric Chemistry Monitoring
Led by Finnish Meteorological Institute



ROM SAF

Radio Occultation Meteorology
Led by Danish Meteorological Institute



H SAF

Support to Operational Hydrology and Water Management
Led by Italian Meteorological Service

Developing enhanced and new products in partnership with Member States and other satellite operators

Investing in improvements of instrument characterisation and calibration

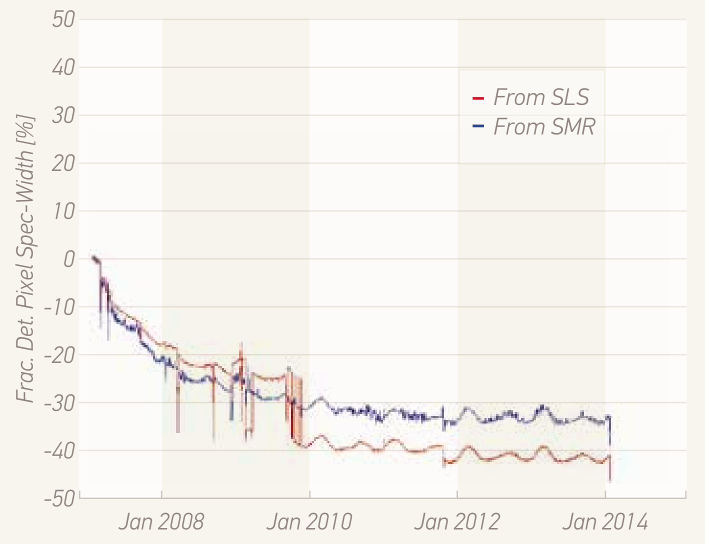
High priority has continued to be assigned to improvements of instrument characterisation and calibration, considering their potential to enhance the quality of all downstream products.

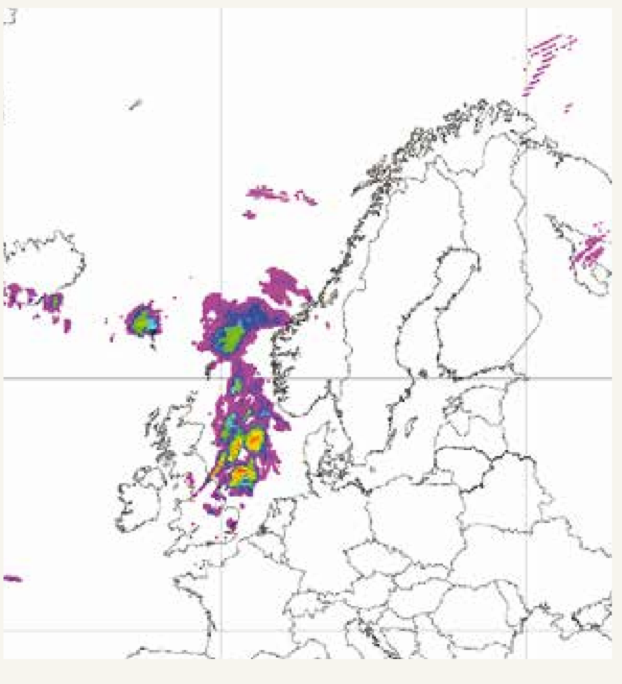
The focus was on the reduction of biases in Meteosat-7 infrared imagery through cross-calibration with IASI and the development and validation of software for the calibration of MSG visible channels, using MODIS data and observations of the moon and deep convective clouds.

The calibration of ASCAT radar backscatter data was improved by an intensive external calibration campaign using transponders deployed in Turkey.

Spectral and angular artefacts were removed from the GOME-2 instrument level 1b product and a back-up spectral calibration algorithm was validated and implemented for use in case of a failure of the nominal on-board calibration source.

Performing a fit of the measured GOME-2 spectrum to Fraunhofer lines of known position in the solar spectrum provides a slightly noisier but more stable spectral calibration (SMR in blue) than the nominal calibration using the on-board Spectral Line Source Lamp (SLS in red)





Map of instantaneous precipitation rate extracted from Meteosat infra-red imagery and cross-calibrated in real time by the closest microwave precipitation measurements available from polar-orbiting satellites (source: H SAF)

New and improved products and user software

Meteorology

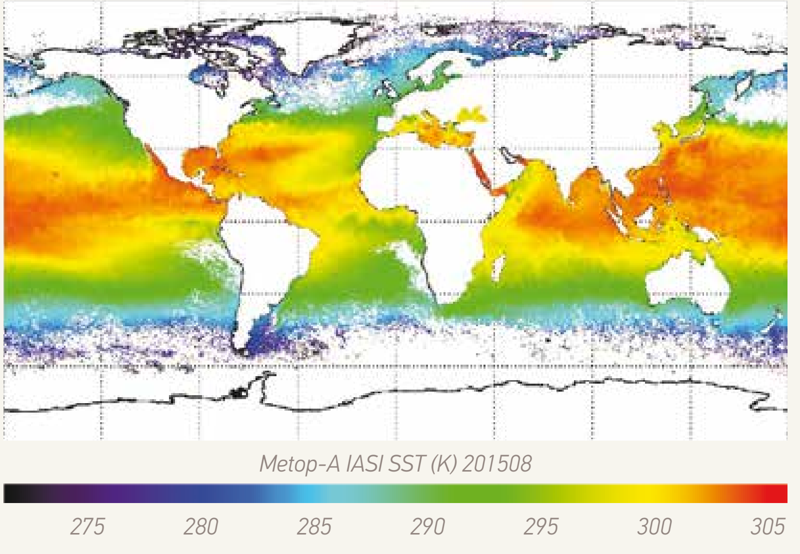
The accuracy of AVHRR wind (Atmospheric Motion Vector) products extracted over the poles was improved using dual Metop image triplets (i.e. Metop-A/Metop-B/Metop-A or Metop-B/Metop-A/Metop-B images) instead of pairs for estimating the displacement of clouds.

Vertical profiles of temperature and moisture extracted from Metop IASI instrument data were enhanced to include cloud fraction as a percentage and to correct bias affecting daytime estimates of land surface temperature over desert soils. IASI Level 1 products were also enhanced to improve the detection of clouds in the presence of sea ice and in sunglint conditions.

Hydrology

The multi-satellite product overlaying convection areas and instantaneous precipitation maps extracted from Meteosat infrared imagery was enhanced to enable quasi real-time ("rapid update") cross-calibration of precipitation retrievals by microwave measurements from polar orbits.

Skin sea surface temperature products of high quality index (above 3) extracted from IASI/ Metop-B night and day data, in August 2015 (source: OSI SAF)



Ocean

A global map of the skin temperature of the ocean extracted from IASI observations was introduced as a new high-quality product, taking advantage of the excellent calibration of the instrument.

New algorithms were introduced by the SAF on Ocean and Sea Ice (OSI SAF) for the production of all global sea ice maps (sea ice edge, type, concentration and drift) to improve the robustness of sea ice edge and type products against sensor degradation and across the transition between seasons. This also adds quality indices to sea ice concentration products and enables the ingestion of additional AMSR-2 (Advanced Microwave Scanning Radiometer) data for retrieving the sea ice drift products.

Chemistry

The main new product was the daily maximum NO_2 photolysis rate extracted from GOME-2 data describing how fast NO_2 is decomposed to NO and O radical. As the latter is an import agent for the formation of tropospheric ozone, the product informs on the speed of chemical reactions increasing ozone concentration in case of NO_2 pollution episodes, like smog.

The most significant enhancements to existing products were the addition of tropospheric ozone content to all GOME-2 ozone vertical profile products, the inclusion of an infrared index discriminating dust from other aerosol types in the Metop multi-sensor product on aerosol properties, and the introduction of a more powerful algorithm that improves the retrieval of CO (column and vertical profile) from IASI spectra.

Land

The soil moisture product extracted from ASCAT radar backscatter observations was improved by the introduction of new parameters in the retrieval model.

User software

New and enhanced user software packages were released by the SAFs on their web pages.

A new generic wind processor software, which can extract ocean surface wind vectors from radar backscatter observations of any of the pencil-beam Ku-band scatterometers flown by NASA (Seawinds, Rapidscat), ISRO (Oceansat-2, Scatsat-1), and CNSA (HY-2A), has replaced former mission-specific software.

New versions were also introduced for the AAPP processing software used to extract sounding products from Initial Joint Polar System (IJPS) satellite data, which now map VIIRS imagery on to Cross-track Infrared Sounder (CrIS) larger sounding pixels, for the RTTOV (radiative transfer model) software, now equipped with Python and C++ interfaces and improved treatment of surfaces (both SAF on Numerical Weather Prediction) and for the ROPP software used by NWP models for ingesting radio occultation observations (SAF on Radio Occultation Meteorology).

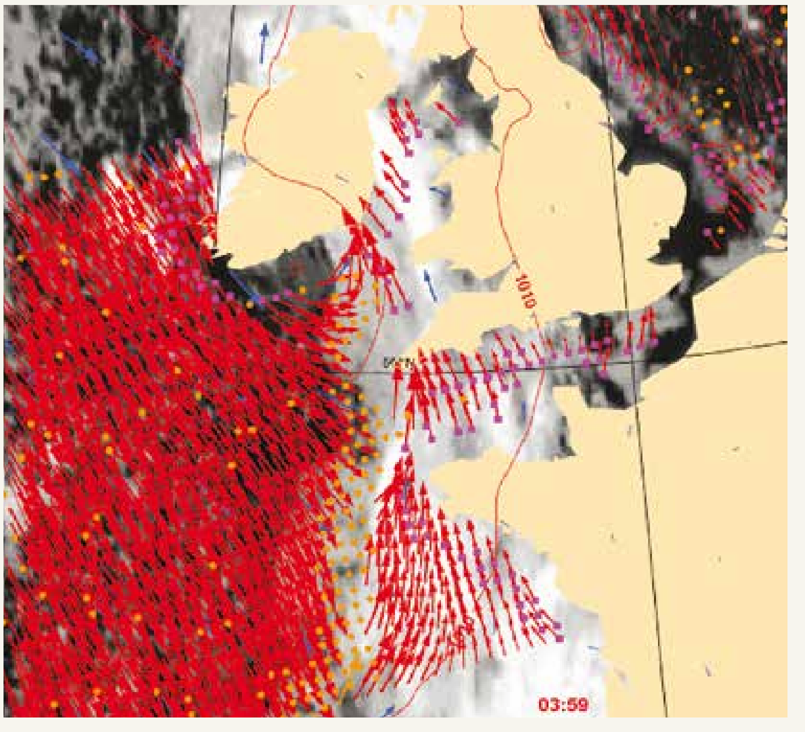
Developing enhanced and new products in partnership with Member States and other satellite operators

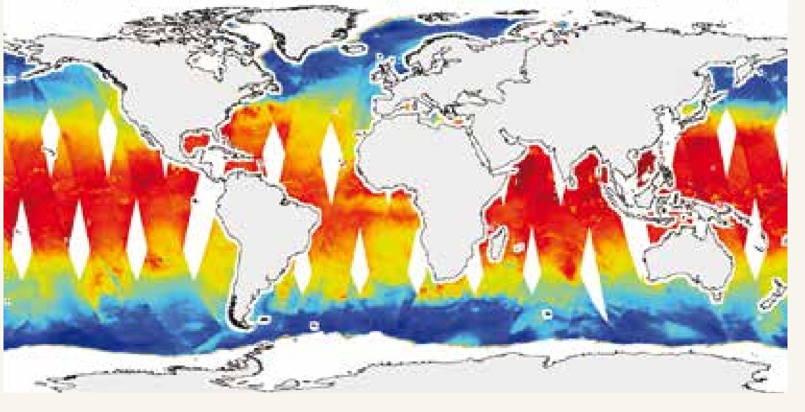
2015 was exceptional for the number of third-party data services introduced in cooperation with international partners

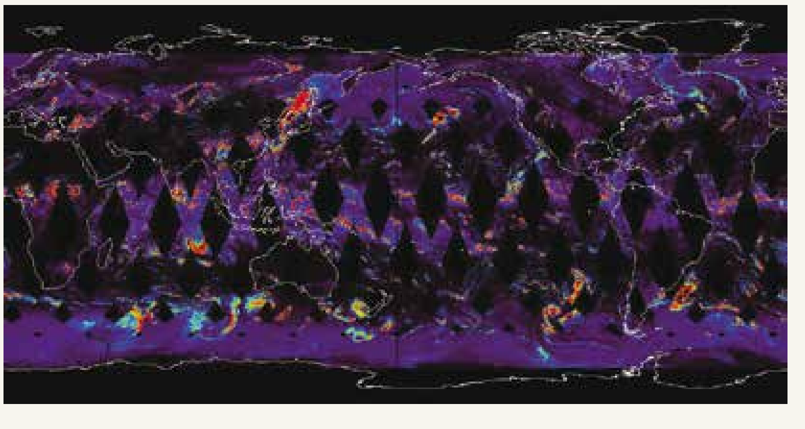
Cooperation augments the portfolio of ocean and precipitation products

In spring, a range of new microwave imagery data services, introduced in cooperation with CSOA (China), JAXA (Japan) and NASA, enriched the portfolio of precipitation and marine products available to Member States' National Meteorological Services (NMSs) and the ECMWF.

Thus, sea surface temperature (SST) products became available - even in cloudy areas - from microwave imaging radiometers aboard the Japanese (JAXA) GCOM-W1 and the Chinese (CSOA) HY-2A satellites, together with sea ice, ocean surface wind speed products and imagery of precipitation, the latter also available from the NASA global precipitation mission core observatory. Cooperation with CSOA and NASA also brought back to four the number of scatterometer missions (Metop-A/-B, HY-2 and Rapidscat) accessible to Member States' NMSs and the ECMWF for the delivery of ocean surface wind vector products.

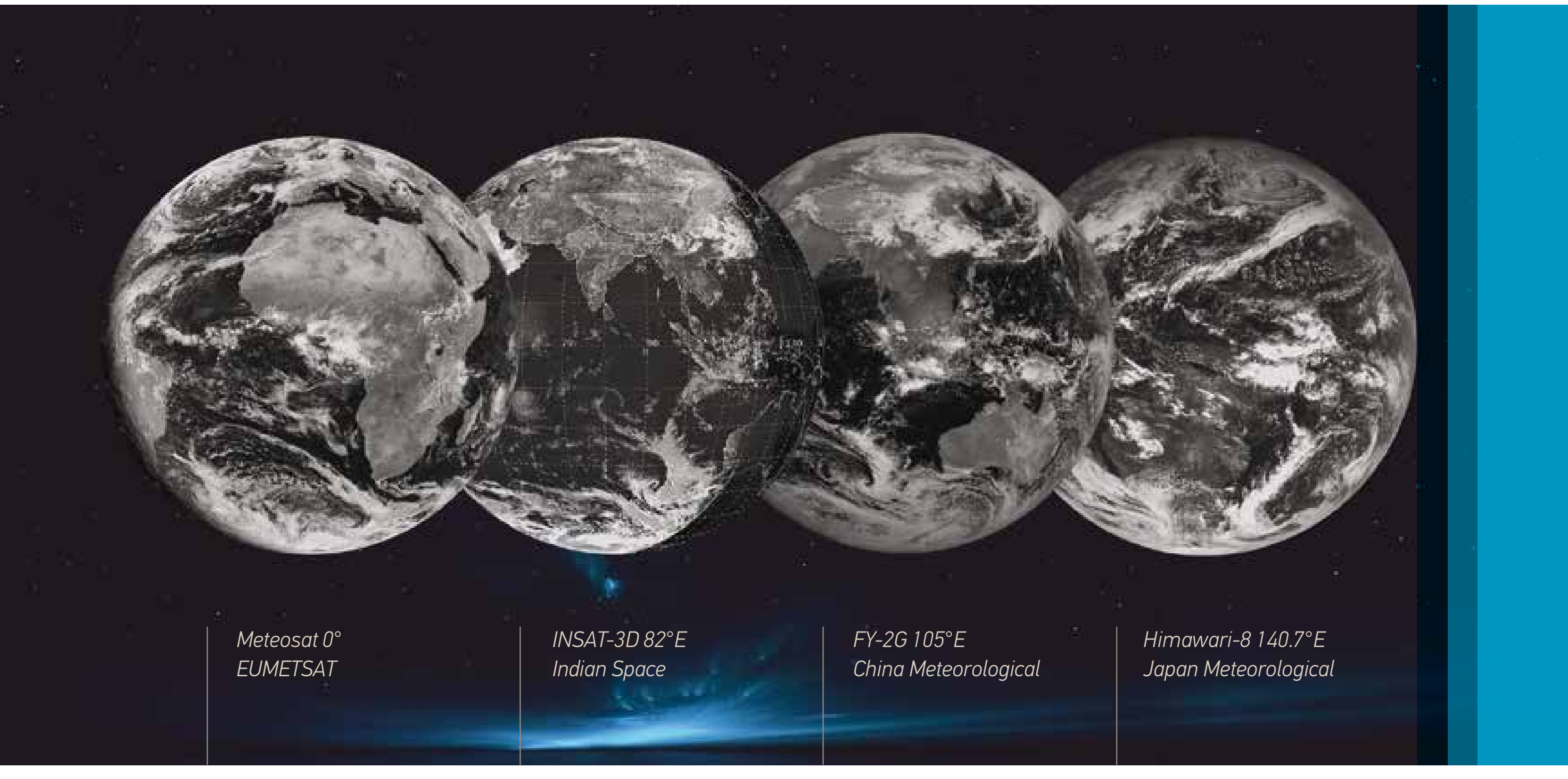






New products available from partner missions: ocean surface wind vectors from NASA's Rapidscat (top), all weather sea surface temperature from CSOA's HY2A (middle) and precipitation imagery from JAXA's GCOM-W1 (bottom)

Geostationary imagery of the Indian Ocean from EUMETSAT (Meteosat 10) and international partners' satellites i.e. INSAT-3D (ISRO, India), FY-2G (CMA, China) and Himawari-8 (JMA, Japan)



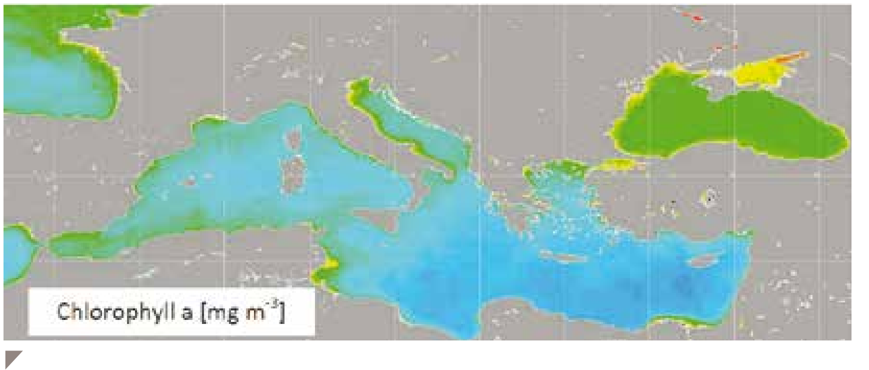
EUMETSAT users benefit from a new generation of partners' geostationary satellites

In summer, third-party geostationary data services were greatly improved by more capable satellites deployed by international partners, i.e. when the China Meteorological Administration's (CMA) new FY-2G satellite replaced FY-2E at 105°E, when the Japanese Meteorological Agency (JMA) declared Himawari-8 operational at 140.7°E and when half-hourly imagery data and sea surface temperature products became available from the new Indian Space Research Organisation (ISRO) INSAT-3D satellite.

Third party data services for Copernicus

For Copernicus, EUMETSAT continued to deliver marine (sea surface temperature, ocean colour) and atmospheric composition (aerosols optical depth and ozone profile) products from the US Suomi-NPP satellite to the Copernicus Atmospheric and Marine Environment Monitoring Services, including a new NOAA Coast Watch ocean colour product covering the Mediterranean and Black Seas and a gridded (0.02 degree) sea surface temperature product.

EUMETSAT disseminated new Copernicus Global Land Service products to three continents, via EUMETCast-Europe, -Africa and –Americas, including a 10-day composite mapping of inland water bodies (an essential climate variable) and their evolution throughout the year and the maximum and the minimum extent of the water surface.



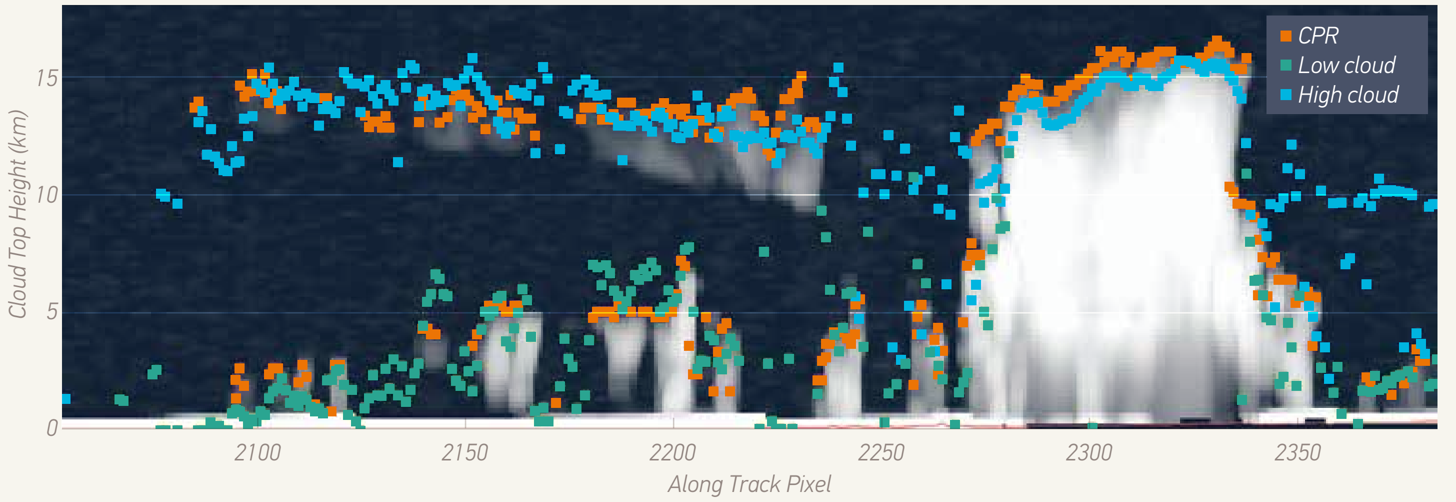
New chlorophyl product extracted from ocean colour observations taken by the VIIRS instrument of the US Suomi-NPP satellite, available to Copernicus users via EUMETCast (source: NOAA)

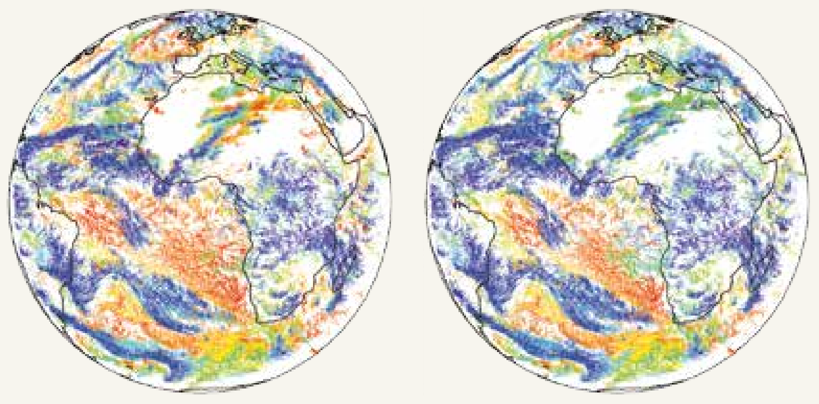
Developing enhanced and new products in partnership with Member States and other satellite operators

Scientific developments target future products

The use of the new optimal cloud analysis (OCA) product for the height assignment of atmospheric motion vectors was introduced in the operational environment, bringing significant improvements in the presence of multi-layer clouds or thin cirrus clouds in jet-stream areas.

Validation of the Meteosat optimum cloud analysis (OCA) product against cloud profiling radar (CPR) measurements from the Calipso research mission demonstrates its capability to distinguish low (green plots) from high (blue plots) clouds



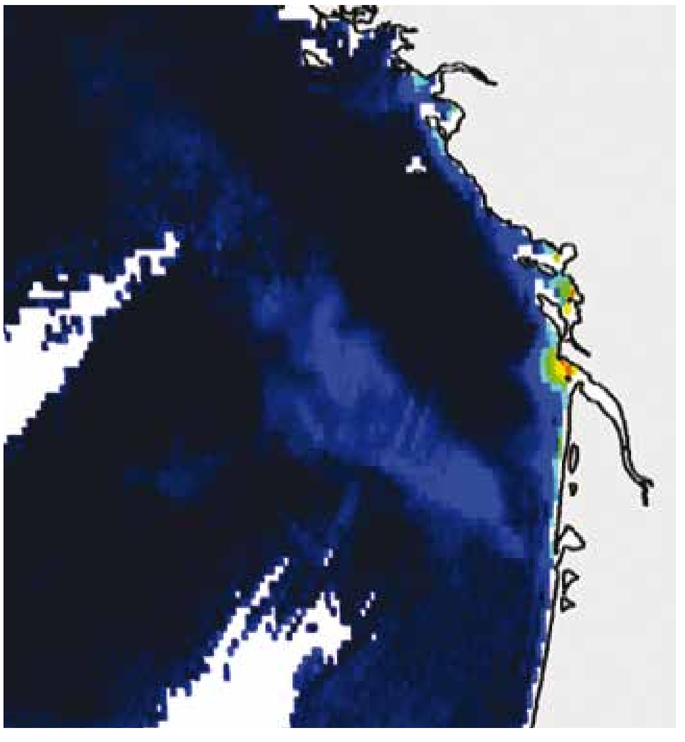


The OCA enables the assigning of the right altitude to cloud tops and hence to the wind vectors estimated from their displacement. It reveals low level winds (in green) off the West coast of Africa (right) which were previously confused with high level winds (in red) (left).

Improved algorithms for retrieving vertical profiles of bending angles from GRAS radio-occultation data, based both on geometric and wave optics theory, were implemented and found to out-perform the current operational algorithm in terms of accuracy in the lower troposphere. The impact of these improvements on the downstream extraction of temperature profiles started to be evaluated by the ROM SAF.

The extension of the Metop multi-sensor aerosol optical depth product (PMAp) to cover land areas in addition to the ocean was validated, targeting the release of an operational product in 2016. In addition, the (O3M SAF) software library for SO_2 retrieval was integrated in the operational IASI Level-2 processor for verification prior to trial dissemination of products, planned in 2016

Algae (coccolithophore) bloom extracted from a series of frequent (15 minute) Meteosat images showing the value of accessing more cloud-free images, as clouds move across the Meteosat field of view. Over the same period, less frequent MODIS/Aqua imagery was almost 100% obscured by clouds.



An ongoing study has already demonstrated that several ocean colour parameters can, under certain conditions, be derived from MSG imagery, including detection of phytoplankton blooms. Although the SEVIRI instrument is not designed to observe ocean colour, the imagery available every 15 minutes from the geostationary orbit has the unique advantage of enabling much more frequent observations of cloud-free pixels, as cloud patterns move across Europe, and monitoring of fast variations. Meteosat Third Generation is expected to improve further this potential.

The H SAF is preparing the release of homogeneous time series of ASCAT soil moisture since the beginning of the ASCAT mission and a Meteosat Evapotranspiration product is also under development by the SAF on Land Surface Analysis.

The SAF CDOP-3 evaluation board working in cluster mode at EUMETSAT headquarters, 24 November 2015

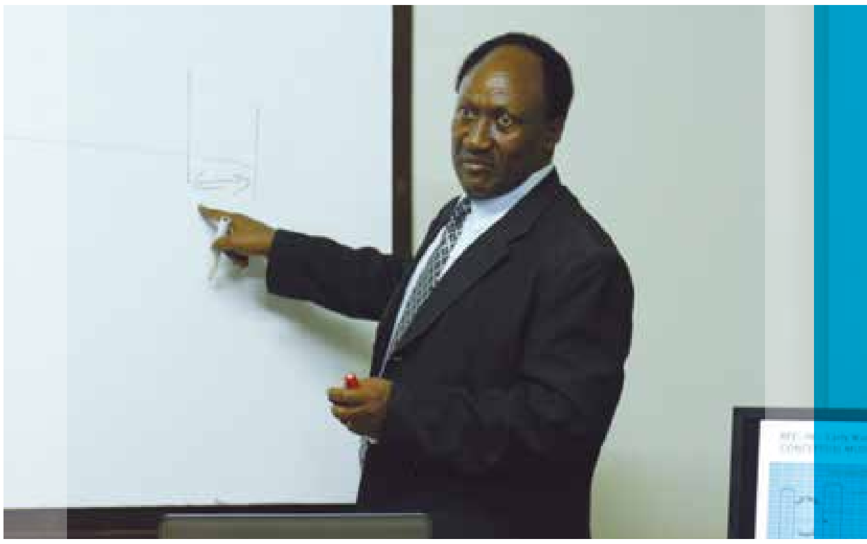
The eight SAFs submit their proposals for development and operations in 2017-2021

In 2015, the eight SAFs submitted their proposals for the third Continuous Development and Operations Phase (CDOP-3) covering the delivery of operational and new products based on current satellite systems and their contributions to the development of MTG and EPS-SG systems in the period 2017-2021. In support of the preparation of proposals, meetings were organised with Copernicus service providers to avoid duplication of product development efforts and to define interfaces for exchanging products.

All CDOP-3 proposals were evaluated in the autumn by an independent board and will now be amended in response to recommendations for submission to the EUMETSAT Council in spring 2016.

Supporting and expanding the user base

To realise the full benefit of strategic investments in advanced satellite systems, EUMETSAT continuously invests in fellowships, training, capacity building, sustained interactions with users and outreach



Joseph Kagenyi, Principle Meteorologist, training forecasters on satellite applications in Africa at the WMO-CGMS Centre of Excellence, Nairobi, Kenya, August 2015

User training

Training is crucial for expanding EUMETSAT's user base and for developing the use of its data in a growing range of meteorological, climate and environmental applications and in research.

As part of a cooperative effort, the EUMETSAT training programme involves an international network of experts on satellite products, applications and techniques for using satellite data across the European Meteorological Infrastructure[2], the network of SAFs and the WMO Virtual Laboratory (VLab) and regional Centres of Excellence.

Most of the courses now include separate classroom and online phases. This makes the courses accessible to more participants and allows them to bring cases from their work into the sessions, as an integral part of their on-the-job training.

In 2015, EUMETSAT organised a first training course on the use of SAF on Climate Monitoring products applications in Pretoria, Africa, and dedicated one session of the Nordic Meteorological Post-Graduate Education (NOMEK) training course to the posting by forecasters of imagery in social media.

EUMETSAT also agreed to support a new, multi-annual training programme called SEEMET (South-Eastern Europe METeorological course), at the request of the Informal Conference of Eastern European Directors of National Meteorological and Hydrological Services (NMHSs) (ICEED), starting in 2016. The SEEMET grouping, like those already established by Nordic and Baltic countries, will increase efficiency and focus on regional requirements.

[2] The EMI is composed of the European National Meterological Services, their EUMETNET grouping, ECMWF and EUMETSAT

Training and training coordination events

February

Course on satellite applications for the Middle East region, classroom phase, Muscat, Oman, following a prior online phase in December 2014-January 2015

March

Course on the use of satellite imagery in the forecasting process, for Southern African Development Community (SADC), classroom phase, WMO-CGMS Centre of Excellence, Pretoria, South Africa

Course on the use of EUMETSAT data by forecasters of Baltic countries for nowcasting cyclogenesis and frontal structures, Tallin, Estonia

WMO/EUMETSAT course on applications of SAF on Land Surface Analysis satellite products in agrometeorology, Addis Ababa, Ethiopia

April

17th Brazilian Symposium on Remote Sensing organised by the National Institute for Space Research (INPE), João Pessoa, Brazil

May

Nordic Meteorological Post-Graduate Education (NOMEK) course on the use of satellite and radar data for forecasting of high-impact weather, Norrköping, Sweden

Course on imagery, products of meteorological satellites and their applications over South America and South Atlantic Ocean, WMO-CGMS Centre of Excellence, Cachoeira Paulista, Brazil

International summer school on applications with the newest multi-spectral environmental satellites, Bracciano, Italy

Participants attending the Nordic Meteorological Post-Graduate Education (NOMEK) training course on the use of satellite and radar data for forecasting of high-impact weather, Norrköping, Sweden, May 2015 (far right)

June

Training of forecasters on satellite applications in Africa (SAC-XIII-E), online phase in English language

Training on the use of SAF on Climate Monitoring gridded satellite products for climate services and research in Africa, WMO-CGMS Centre of Excellence, Pretoria, South Africa

Joint EUMETSAT/Roshydromet training event on applications of satellite data for hydrometeorology and environmental monitoring, Moscow, Russia

August

Training of forecasters on satellite applications in Africa (SAC-XIII-E), classroom phase in English language, WMO-CGMS Centre of Excellence, Nairobi, Kenya

September

4th SLAGEE training on "MSG Land Surface Applications: Drought and Environmental Response", Matera, Italy

Online training (webinar) on the use of real-time RapidScat data

Training of forecasters on satellite applications in Africa (SAC-XIII-F), online phase in French language

Ibero-American workshop on satellite meteorology, Montevideo, Uruguay

8th European Conference on Severe Storms, Wiener Neustadt, Austria

Autumn School on nowcasting using satellite data, Thessaloniki, Greece

November

Course on the use of Meteosat rapid scan data for nowcasting of high-impact weather, Prague, Czech Republic

Training development workshop for regional training institutions in WMO RA VI, Warsaw, Poland

1st Africa/Middle-East Expert meeting and workshop on the health impact of airborne dust, Amman, Jordan

Training of forecasters on satellite applications in Africa (SAC-XIII-F) classroom phase in French language, WMO-CGMS Centre of Excellence, Niamey, Niger

Online training week on precipitation

December

Meeting of SEEMET trainers, preparation of the 2016 training course, Ljubljana, Slovenia

Supporting and expanding the user base

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 ECMWF and six in EUMETSAT Member States.

Two new fellows were recruited in 2015 to work on already selected research topics:

- “Use of satellite soil moisture information for nowcasting and short range NWP forecasting”, hosted by CNMCA (Italian National Meteorological Centre), Italy;
- “Developing a dynamical infrared emissivity atlas based on IASI retrievals”, hosted by the Met Office, UK.

In addition, two new research topics were selected:

- “GNSS-R Observation Operator Development and Impact Evaluation (GOODIE)”, (Netherlands);
- “European High-Resolution Soil Moisture Analysis (EHRSOMA)”, (Austria).

A third research topic, “Demonstrating the Operational Benefits of MTG Lightning Imager (DELIGHT)”, proposed by Finland, was selected as a back-up in case the recruitment fails for one of the selected topics.

In 2015, EUMETSAT hosted 25 visiting scientists from Europe, America and Asia.

"As a EUMETSAT fellow at ECMWF, I develop new methods for ingesting water vapour imagery from geostationary satellites into numerical weather prediction models."

Julie Letertre-Danczak
EUMETSAT Fellow
ECMWF

EUMETSAT User Conference

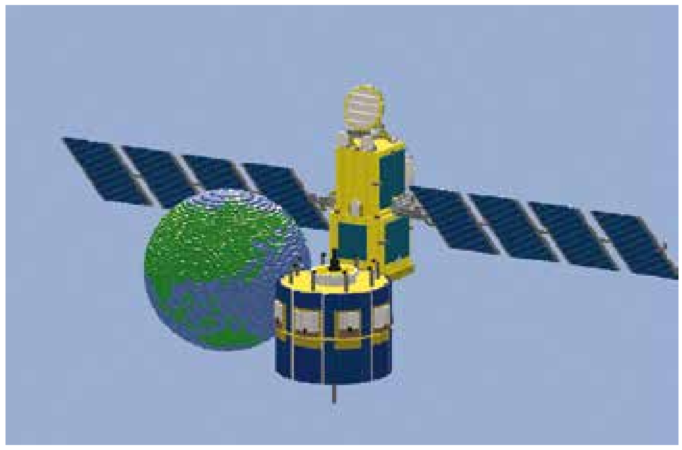
The 2015 EUMETSAT Satellite User Conference was co-organised with Météo-France in Toulouse and attracted more than 400 participants from 38 countries.

Two special sessions addressed user preparedness for future geostationary satellites and satellite data requirements of very high resolution numerical weather prediction models. The conclusions of the latter were discussed by a panel of leaders of short-range numerical weather prediction (NWP) from Europe, the United States and Japan. The discussion was moderated by Dr Florence Rabier, the ECMWF’s Director-General-elect and was captured in a position paper published in the European Meteorological Society’s newsletter.

The 2016 Conference will be organised by EUMETSAT in Darmstadt, on 26-30 September and the 2017 conference will be co-organised with the Italian Meteorological Service, in Rome.

Panel discussion on “Advances in utilisation of satellite data for nowcasting and limited area modelling” during the 2015 EUMETSAT Satellite User Conference, with (left to right) Jean-François Mahfouf (Météo-France), Masahiro Kazumori (JMA), panel moderator Florence Rabier (ECMWF), Jeanette Onvlee (KNMI), Stan Benjamin (NOAA), and Roger Saunders (Met Office)
(source: © Christophe Ciais - Météo-France)

The winning entries in the Learning Zone Minecraft competition, in the category "EUMETSAT Satellite Designs" were the entries from Janis Lizio, 6-12 yrs (left), and Hao Yang He, 13-16 yrs (right)



Outreach

The regular provision of images and animations on YouTube (>1.4 million views) and Flickr and their promotion on Twitter, Facebook and Google+ continued to drive significant traffic towards the EUMETSAT website. Imagery of the MSG-4 launch was viewed 30,876 times on Flickr on 14-15 July, 10 times the average number of views of EUMETSAT imagery, and Twitter tweets reached 334,200 people. The eight-minute narrated video "A Year of Weather 2015", based on animated imagery from EUMETSAT, NOAA and JMA geostationary satellites, was viewed 295,871 times on YouTube (http://bit.ly/1WRi1g2) in January-February 2016.

EUMETSAT and the Met Office jointly organised an outreach session during the Edinburgh Science Festival, attracting 50 participants and reaching a much larger audience through coordinated social media activities.

EUMETSAT was also involved as a data provider in a German coding competition linked to the international Technology, Entertainment and Design (TED) organisation.

Targeting the young, an online satellite-building competition using the Minecraft game was widely advertised with the support of national weather services, WMO, educational magazines, websites and social media and drove a lot of additional visitors to the Learning Zone youth education website. Four winners were selected by a panel of university design students. A cartoon animation was also developed to explain the role of satellites in weather and climate monitoring and is now used with school groups as a learning tool.

An internal project team was established to prepare for the celebration of EUMETSAT's 30th Anniversary in 2016.

Local life

The 2015 Christmas party raised €3,470, which was donated to the local Red Cross (Deutsches Rotes Kreuz) for its refugee support activities. These activities include translation support, information and advice on asylum procedures, dealing with the local authorities, integration support, conflict prevention and language courses.

On behalf of EUMETSAT employees, Silvia Castaner (left), Director of Administration, and Anne-Marie Andrieux (second from right) and Klaus Noetzel (right), representing the Staff Association Committee, present a cheque to Riza Yilmaz (second from left), head of the social work section of the DRK Kreisverband Darmstadt

Supporting and expanding the user base

Cars drive through a flooded main road in Mifol near the city of Vlore, Albania, 3 February 2015. Soldiers were deployed in Albania to help rescue villagers and strengthen flood barriers after rivers burst their banks under heavy rain (source: REUTERS/Arben Celi).

"EUMETSAT is essential for providing scientific knowledge and data for national and regional forecast of extreme weather and our understanding of climate change."

Prof Dr Petrit ZORBA
Head of the Department of Climate and Environment, Institute of GeoSciences, Energy, Water and Environment, Albania

Support to capacity-building initiatives

In support of the WMO strategy, EUMETSAT strives to further the use of satellite data in the periphery of Europe and in Africa, which is best observed by Meteosat. This includes facilitation of real-time access to data through EUMETCast, training of trainers and users and contributions to capacity-building initiatives supported by the WMO, Member States' National Meteorological and Hydrological Services (NMHS), the European Union and the African Union.

Weather services of western Balkans, eastern European and Caucasian countries use data operationally

At EUMETSAT Information Days held in Tirana, Albania, and Tbilisi, Georgia, all NMHSs of western Balkans, eastern European and Caucasian countries demonstrated operational use of EUMETSAT data available through EUMETCast.

WMO and EU representatives considered this an asset for setting up regional and national multi-hazard early warning systems in support of disaster risk reduction and the implementation of the EU directive on the assessment and management of flood risks, with the possible financial support of the EU Instrument for Pre-Accession Assistance (IPA-2) or the European Neighbourhood Instrument (ENI).

Participants at the 6th RAIDEG meeting which was held at EUMETSAT headquarters, Darmstadt, 24-28 August 2015

In Africa, EUMETSAT supports EU-funded capacity building and user preparedness for MTG

Through the Monitoring Environment and Security in Africa (MESA) project, EUMETSAT supported the African Union Commission (AUC) on user training and data access via EUMETCast, hosting a training session organised by the European Commission Joint Research Centre and assisting factory acceptance testing of EUMETCast stations. EUMETSAT also supported the project governance, collecting feedback on data access and training at the first MESA Forum, held in Nairobi, and attending the fourth meeting of the MESA Steering Committee organised by the AUC and the Indian Ocean Commission (IOC) in Mauritius. This meeting identified EUMETCast as the preferred solution for providing access to Sentinel-3 marine products to Africa in response to the AUC's request to the Commission.

The possible EUMETCast dissemination of Sentinel-3 marine products to Africa is also relevant to a "GMES & Africa" project on marine, natural resources and water management applications agreed by the EU-Africa Space Troika involving the Commission's Directorates General for Internal Market, industry, Entrepreneurship and SMEs (DG GROW) and International Cooperation and Development (DG DEVCO) and the AUC and supported through the new EU Pan-African Fund. EUMETSAT will support the project formulation study in the areas of data access and capacity building.

Within the 10th European Development Fund (EDF) programme on resilience to natural hazards in sub-Saharan Africa, EUMETSAT supported the African Development Bank (AfDB) in the formulation of a continental project proposed by the African Centre of Meteorological Applications for Development (ACMAD) to develop a regional numerical weather prediction capacity. This includes a RARS-Africa (Regional Advanced Retransmission Services) system providing real-time access to data broadcast by polar-orbiting satellites to a network of four African L/X band stations, for ingestion in numerical models. EUMETSAT agreed to support the procurement and deployment of the RARS-Africa system and hosted a dedicated workshop in April, where the design of the network of stations was established with host institutions in South Africa, Kenya, Gabon and Niger, along with the sharing of tasks for its implementation and operations. The host institutions then worked on the identification and characterisation of the potential sites, including radio frequency surveys and assessment of telecommunication capacities.

An MTG Africa Preparation Study (MAPS), addressing the requirements and priorities of African users of MTG data and products in relation to applications, was kicked-off in June. Requirements started to be discussed in August within the WMO Regional Association I (RA-I) Dissemination Expert Group (RAIDEG), designated as the reference user group. The RAIDEG feedback will be decisive for establishing an "MTG Africa concept" for migrating African users and applications from MSG to MTG under the implementation plan of the integrated African strategy on meteorology (weather and climate services) agreed in February by the African Conference of Ministers in Charge of Meteorology (AMCOMET) and for mobilising funds accordingly.

All of these initiatives attracted support from the XVIth session of the WMO RA-I and the 3rd session of AMCOMET held in Cape Verde. At that meeting, RA-I stressed the importance of EUMETCast-Africa for data access and appreciation for the 300kbps increase in bandwidth agreed by EUMETSAT to disseminate additional products requested by the RAIDEG. The continuation of Indian Ocean Data Coverage (IODC) services after the de-orbiting of Meteosat-7 and EUMETSAT's support for training delivered by the four regional Centres of Excellence for Education and Training in Satellite Meteorology were also appreciated.

All of these matters will be discussed in depth at the 12th EUMETSAT User Forum in Africa, to be held in September 2016 in Kigali, Rwanda, in cooperation with the local government.

Optimum deployment of the recurrent satellites

The successful launch and commissioning of MSG-4 put a finishing touch to the MSG development programme, viewed as an outstanding success of the cooperation with ESA and for a generation of European engineers and scientists. The launch of Metop-C will follow in 2018.

With the MSG-4 satellite safely stored in orbit, EUMETSAT is ready for a smooth transition to MTG

MSG-4 was launched on 15 July and became operational as Meteosat-11 on 14 December, just five months after launch, upon successful commissioning of an end-to-end system supporting operations of a constellation of up to four Meteosat satellites. Meteosat-11 is now stored in orbit - nominally for 2.5 years - and ready to enter operational service at any time with one week's notice. Thus, EUMETSAT has all in-orbit assets in hand to secure a safe and cost-effective transition to Meteosat Third Generation.

The sequence of activities started on 4 March with confirmation of the satellite's readiness for the launch campaign and fulfilment of MSG-4 launch and early operations phase (LEOP) requirements by the launch window offered for an Ariane-5 dual launch service (flight VA224) on 2 July, the contractual launch date agreed with Arianespace.

On 17 March, the EUMETSAT System Readiness Review confirmed that the full system, including the ground segment supporting operations of four satellites in orbit and the operations team, was ready for the launch, however, the possible impact on MSG-4 of an anomaly encountered on 11 March on one telecommand receiver of Meteosat-10 had to be considered. EUMETSAT's authorisation to ship the satellite to Kourou was therefore postponed to 13 April, after investigations by ESA and industry had confirmed there were no implications from that Meteosat-10 anomaly.

MSG-4 arriving at Felix Eboue airport, Cayenne, French Guiana, 29 April 2015 (source: Arianespace)

The satellite arrived in Kourou on 29 April and went through all planned configuration and testing activities. Its fuelling was authorised on 4 June after checking the status of the co-passenger satellite and the launcher. However, at this point Arianespace had to postpone the launch to 8 July, due to a conflict of resources with the launch of Sentinel-2A. MSG-4 was finally fuelled and declared ready for launch by ESA on 22 June.

The mating of MSG-4 on the launcher and its encapsulation under the fairing with the co-passenger were completed on 30 June but Arianespace had to de-encapsulate and de-mate both satellites to perform some verification, which delayed the launch until 15 July. The remaining launch campaign activities were then executed nominally, leading to a flawless Ariane-5 dual launch on 15 July, at the opening of the launch window, at 21:42:07 (UTC).

Upon completion of a very smooth LEOP phase, EUMETSAT took over the control of the satellite from ESOC on 26 July and started commissioning testing immediately, while the spacecraft was still drifting at a speed of 1.9° per day towards its commissioning longitude of 3.4°W, which it reached on 2 August.

The first SEVIRI image was acquired on 4 August. Real-time dissemination of image data to National Meteorological Services and the ECMWF for evaluation purposes started on 22 September, followed by environmental products on 24 September and dissemination to all users from 12 October to 26 November in support of preparedness for the use of MSG-4.

All commissioning tests performed in orbit and on ground, including calibration validation of imagery and products, demonstrated nominal performance of the end-to-end system, including SEVIRI and all MSG-4 on-board subsystems, with the exception of the GERB-4 instrument. This instrument had acquired its first image on 7 August but could not retain synchronisation with the satellite spin due to a malfunction of the electronics generating its timing signals. Fortunately, extensive in-orbit testing showed that the instrument keeps synchronised when the satellite spin rate is slightly reduced, by 0.08 rpm, with no impact on the mission. GERB-4 imaging and commissioning could resume and be completed by the end of November.

From 2 to 11 December, a sequence of formal reviews assessed the full test results and confirmed the readiness of the MSG system to support in-orbit storage and routine operations of MSG-4 in a constellation of up to four satellites, as well as the capability of MSG-4 to deliver image data and core products fulfilling operational quality requirements.

As a result, the satellite was commanded to in-orbit storage on 7 December, handed over to the Operations Department on 14 December and renamed Meteosat-11.

Successful launch of the MSG-4 satellite from the European Space Port in Kourou, French Guiana, 15 July 2015 at 21:42 UTC (source: Arianespace)

The first image captured by the SEVIRI instrument on MSG-4, 4 August 2015 at 10:00 UTC

Metop-C, the third and last Metop Satellite, is on track for launch in October 2018

After the 2014 decision to postpone the launch of Metop-C from February to October 2018, the launch preparation activities were re-planned and renegotiated with ESA, CNES, NOAA and Metop industry.

The main challenge was then to complete the repair of the MHS and IASI instruments, both affected by anomalies, and to start the recalibration of the GOME-2 instrument, in time for the delivery of all three instruments for reintegration on to the satellite payload module (PLM) in March 2016. This is required to meet the target launch readiness date of 1 October 2018.

The MHS instrument had to be reconfigured with a spare Q-band source to eliminate unexpected glitches on two of its channels but passed its reacceptance testing and was delivered back to the PLM contractor on 30 July for storage until March 2016.

The IASI repair was also completed with new mechanisms and motors equipped with a new type of magnet mounted on both the scan unit and the corner cube of the interferometer. The scan unit was rebuilt and successfully retested. The instrument passed vibration tests and is now ready for its reacceptance test campaign, planned for the first quarter of 2016.

The recalibration campaign of the GOME-2 instrument started in December and should be completed in March 2016.

The Microwave Humidity Sounder (MHS) instrument of Metop-C is fitted with sensors and measurement cables and put into the chamber for thermal vacum testing (source: Airbus Defence and Space)

Thus, at the end of the year, all three instruments were on track for timely delivery to the satellite PLM, which in the meantime went through its yearly reactivation and a functional test in the summer, before re-entering storage until March 2016.

The suitability of the current EPS ground segment architecture to support operations of three Metop satellites in orbit (Metop-A, -B and -C) during Metop-C commissioning was demonstrated, subject to the upgrade of server capacities to sustain the load of three Metop data streams. This upgrade is foreseen as part of the virtualisation and migration of the EPS-SG ground segment to new hardware, which passed its Architectural Design Review.

Development of future geostationary and polar-orbit satellite systems

2015 was a year of contrasts for the challenging MTG development programme

Meteosat Third Generation

In the 2020-2040 timeframe, the Meteosat Third Generation (MTG) system will continue and augment the services delivered by the Meteosat Second Generation (MSG) series in support of nowcasting and very short-range forecasting of high-impact weather over Europe, Africa and adjacent seas.

MTG will be the most complex and innovative geostationary system ever built, comprising two separate lines of satellites exploited simultaneously. The MTG-I (imaging) line will improve the current Meteosat imagery mission and augment it with a lightning imaging capability. The MTG-S (sounding) line will establish a world-first hyperspectral infrared sounding capability from the geostationary orbit that delivers 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 trace gases in support of air quality, pollution and climate monitoring.

Despite tangible progress in important areas, the development of the MTG satellites encountered persistent difficulties which postponed launches by one year, to the second half of 2020 for MTG-I1 and to the first half of 2022 for MTG-S1.

The main factors were delays in the integration of the structure and thermal model (STM) of the platform common to both spacecraft and in the development of critical subsystems shared by the Flexible Combined Imager (FCI) of MTG-I and the Infrared Sounder (IRS) of MTG-S.

Alain Ratier, EUMETSAT Director-General, and Stéphane Israël, Arianespace Chairman and CEO signed a contract entrusting Arianespace with the first launch services for MTG

"MTG is a very innovative system expected to bring massive improvement to very short range forecasts, but this is also a formidable development challenge for EUMETSAT, ESA and European industry."

Alexander Schmid
Replacing Sergio Rota, on 26 October 2015, as the Associate Director for Geostationary Programmes

On the positive side, the delivery of the first satellite hardware enabled the integration of the platform STM to start in November. Significant progress was achieved in the development of the scan assembly shared by the FCI and IRS instruments, the design of the Lightning Imager (LI) was validated and frozen, and, most importantly, all design reviews passed so far confirmed the high level of compliance of subsystems, which allows confidence in the overall satellite performance.

In relation to the space segment, EUMETSAT delivered to ESA the first flight master keys to be decrypted by the satellite for command authentication. It also signed contracts for the launch services for the first three MTG satellites (MTG-I1,-S1 and -I2) and for the launch and early operations phase (LEOP) services required to place these satellites in their operational orbit after separation from the launcher.

In parallel, EUMETSAT achieved significant progress in system and ground segment development activities.

The consolidated system and ground segment integration verification and validation (IV&V) plans served as a reference for the procurement of an industrial IV&V support service, for which an invitation to tender (ITT) was published in November.

Integration of the structural and thermal model of the platform common to both MTG spacecraft at OHB premises, in Bremen (source: OHB System AG)

The approach for the system validation tests involving firstly the spacecraft simulator (SATSIM) and then various models of the platform and the full spacecraft was agreed with ESA. It started to be implemented in December, when ESA delivered a first version of the satellite simulator (SATSIM-I-v0) to EUMETSAT to support the testing of the first delivery of the MTG mission control centre (Mission Operations Facility, MOF).

With the kick-off of the product extraction facility (L2PF), all five ground segment facilities required to control the MTG-I satellite, acquire and process its data, are now under contract, and the detailed design of four of them is well advanced, with first pre-deliveries expected in 2016 for initial testing.

The detailed design of the data acquisition (MDA) ground stations was completed and, in view of the good progress achieved in the design of the telemetry tracking and control (TT&C) ground stations and the mission control centre (MOF), the detailed design of the full mission control and data acquisition chain is expected to be validated in the first half of 2016.

The data processing and product extraction chain is also taking shape. The detailed design of the infrastructure hosting the image processing software and managing the production of image data – the core element of the MTG-I image data processing facility (IDPF-I) - was completed. Work on the preliminary design of the downstream product extraction facility (L2PF) started in September.

The procurement of the additional capacities required to process data and extract products from the MTG-S sounding mission was prepared in parallel.

Substantial scientific work was dedicated to the definition and prototyping of algorithms for data processing and extraction of MTG-I and MTG-S products and the delivery of proxy and test data representing FCI and LI measurements for user preparedness and testing purposes.

Dedicated reviews also confirmed that upgrades of existing multi-mission ground segment elements (infrastructure, monitoring, data access and data dissemination) and extensions of the multi-mission network will fulfil MTG requirements. As a result, a first batch of network equipment was procured and rooms were prepared in the EUMETSAT buildings to host the first MTG pre-deliveries (mission control centre, satellite simulator and IDPF-I processing infrastructure) and support their early testing in the first quarter of 2016.

Unfortunately, the one-year slippage of the space segment development announced mid-October will require replanning of EUMETSAT activities in the first half of 2016. It has already been decided to postpone the MTG-I System Implementation Review (SIR) and the ITT for the procurement of the IDPF-S to the third quarter of 2016, and the deployment strategy for the MTG ground stations is being reconsidered, taking into account obsolescence issues.

Development of future geostationary and polar-orbit satellite systems

After its approval in June, the EPS-SG programme made a fast start and completed its preliminary design phase

EUMETSAT Polar System Second Generation

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

The EPS-SG system is composed of two series of spacecraft, Metop-SG A and B, equipped with complementary instruments and flying simultaneously on the same mid-morning orbit as the current Metop satellites. 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 UVN sounder and by two advanced imagers, METimage and 3MI. Metop-SG B is a microwave imaging mission, focused on radar observations of ocean-surface wind and soil moisture and all-weather microwave imagery of precipitation (MWI) and ice clouds (ICI). Both satellites are equipped with a GNSS radio-occultation instrument (RO) for limb soundings of temperature and humidity at high vertical resolution.

The programme approval process made decisive progress on 22 May, when committed contributions reached the 95 percent threshold agreed by the Council to authorise the start of development activities, and was concluded on 23 June, when all 30 Member States had cast their positive votes.

Most of the cooperation agreements required for the implementation of the programme were then signed with partners, i.e. the Metop-SG agreement and the Sentinel-5 arrangement with ESA, the IASI-NG agreement with CNES and the Joint Polar System agreement with NOAA, the latter during the 84th Council session.

The signature of the Cooperation Agreement with DLR was postponed to 2016, pending conclusion of a full contract between industry and DLR for the development and procurement of three instruments. In the meantime, DLR was authorised to proceed with advanced phase C activities until June 2016, in parallel to the negotiation of a full phase C/D contract.

Following the successful Preliminary Design Reviews (PDR) for both Metop-SG satellites and all their instruments, the space segment development programme entered its detailed design phase. The target launch dates are June 2021 and December 2022 for the first Metop-SG A and Metop-SG B satellites.

"The development of the EPS-SG system will bring more accurate and completely new observations to numerical weather prediction and climate monitoring."

Gökhan Kayal
EPS-SG Programme Manager
EUMETSAT

Alain Ratier, Director-General and Volker Liebig, ESA's Director of Earth Observation Programmes, signing the Metop-SG Cooperation Agreement on 5 October 2015 at ESA headquarters in Paris, France (source: ESA)

EPS-SG payload complement and targeted applications

EPS-SG Satellite-A missions	Instrument (and provider)	Predecessor on Metop	Applications benefitting
Infrared Atmospheric Sounding (IAS)	IASI-NG (CNES)	IASI (CNES)	Atmospheric Chemistry; Climate Monitoring; Nowcasting (NWC) at high latitudes; Numerical Weather Prediction (NWP); Oceanography
Microwave Sounding (MWS)	MWS (ESA)	AMSU-A (NOAA) MHS (EUMETSAT) AVHRR (NOAA)	Climate Monitoring; Nowcasting (NWC) at high latitudes; Numerical Weather Prediction (NWP)
Visible-Infrared Imaging (VII)	METIMAGE (DLR)		Climate Monitoring; Hydrology; Nowcasting (NWC) at high latitudes; Numerical Weather Prediction (NWP); Oceanography; Land
Radio Occultation (RO)	RO (ESA)	GRAS (ESA)	Climate Monitoring; Numerical Weather Prediction (NWP)
UV/VIS/NIR/SWIR Sounding (UVNS)	SENTINEL-5 (COPERNICUS, ESA)	GOME-2 (ESA)	Atmospheric Chemistry; Climate Monitoring; Numerical Weather Prediction (NWP)
Multi-viewing, -channel, -polarisation Imaging (3MI)	3MI (ESA)		Atmospheric Chemistry; Climate Monitoring; Nowcasting (NWC) at high latitudes; Land
EPS-SG Satellite-B missions	**Instrument (and provider)**	**Predecessor on Metop**	**Applications benefitting**
Scatterometer (SCA)	SCA (ESA)	ASCAT (ESA)	Climate Monitoring; Hydrology; Nowcasting (NWC) at high latitudes; Numerical Weather Prediction (NWP); Oceanography; Land
Radio Occultation (RO)	RO #2 (ESA)	GRAS (ESA)	Climate Monitoring; Numerical Weather Prediction (NWP)
Microwave Imaging for Precipitation (MWI)	MWI (ESA)		Climate Monitoring; Hydrology; Nowcasting (NWC) at high latitudes; Numerical Weather Prediction (NWP); Oceanography
Ice Cloud Imager (ICI)	ICI (ESA)		Climate Monitoring; Hydrology; Nowcasting (NWC) at high latitudes; Numerical Weather Prediction (NWP)
Advanced Data Collection System (ADCS)	ARGOS-4 (CNES)	A-DCS (CNES)	Climate Monitoring; Oceanography

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

After confirmation of the compatibility of both Metop-SG satellites with Ariane-5, Soyuz and Falcon-9, the Council approved the procurement plan for the launch and LEOP services for the first three Metop-SG satellites. Signature of contracts is targeted for 2017, as required to deliver inputs to the Critical Design Review of the satellites in 2018. In view of the expected evolution of the launch service market, including the introduction of Ariane-6, further launch services will be procured at a later stage.

The EUMETSAT development of the EPS-SG system and ground segment progressed at the same fast pace as the space segment, concluding the preliminary design phase in October. The system design was found complete, consistent and fulfilling user requirements, thus creating a sound basis for the development phase.

The successful Preliminary Design Review of the overall ground segment (OGS) paved the way for the preparation for the procurement of its two main building blocks. These are the mission control and operations (MCO) chain and the payload data acquisition and processing (PDAP) chain.

The draft requirements for the MCO chain were published, workshops were held to present the flight dynamics and mission planning software to be re-used to 10 potential bidders and the publication of the invitation to tender (ITT) followed in December.

Likewise, the draft requirements for the PDAP chain were published in November ahead of the release of the ITT, planned for 2016. EUMETSAT scientists delivered the first versions of the algorithm theoretical basis documents (ATBD), product generation specifications (PGS) and product format specifications (PFS) for data processing and product extraction for all Metop-SG instruments which will be part of the ITT data package and prototyped various candidate algorithms. On the engineering side, the processing software to be delivered to potential bidders for possible re-use in the PDAP development was prepared and tested.

A contract was established for the provision of site infrastructure and services required in Svalbard, Spitzbergen, for installing the Metop-SG data acquisition ground stations of the PDAP chain and the telemetry tracking and command (TT&C) ground stations of the MCO chain.

Finally, discussions progressed well with NOAA on the detailed scope of the work required to implement the agreed sharing of Joint Polar System ground infrastructure and data acquisition services in Svalbard and McMurdo.

Operational oceanography in the context of Copernicus

With Jason-3 and Sentinel-3A ready for launch, 2015 was full of promise for operational oceanography

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

EUMETSAT is involved in the development of two ocean missions, Jason-3 and Sentinel-3A, both scheduled for launch in the first quarter of 2016, and is preparing to exploit both systems on behalf of the European Union Copernicus programme.

EUMETSAT Copernicus Sentinel-3 team ready for launch

After some hurdles, Jason-3 is ready to take over the reference ocean surface topography mission from Jason-2

Replacing the ageing Jason-2 satellite, Jason-3 will expand until 2021 the unique mean sea level climate data record initiated in 1992 by Topex-Poseidon. Jason-3 will also continue to provide the reference ocean surface topography measurements used for cross-calibrating all other altimeter missions, including Sentinel-3.

The Jason-3 satellite after arrival in Vandenberg Air Force Base (source: Thales Alenia Space)

After NOAA announced 22 July as the contractual launch date for Jason-3, EUMETSAT authorised CNES to proceed with the preparation of the satellite for the launch campaign.

The first part of the Four Partner Review (ORR-1), which assessed the readiness of the full Jason-3 system for launch, concluded on 17 February that the system would be ready for launch on 22 July and agreed to review the results of the full rehearsals three months before launch, at the ORR part 2 (ORR-2). The ORR-2 was considered successful on 28 April but the Review Board was informed that an anomaly had just been detected on a satellite thruster during a final test performed before the satellite enters its shipment container. The closure of the ORR was therefore subject to the resolution of the thruster anomaly, which was achieved on 9 June. On that basis, the partners authorised the shipment of the spacecraft to the Vandenberg Air Force Base (VAFB) on 17-18 June and the Copernicus-funded operations build-up phase started at EUMETSAT on 1 July.

In the meantime, the delayed shipment of the spacecraft and uncertainties on the certification of the launch vehicle by NASA had forced NOAA to postpone the launch from 22 July to 8 August.

All satellite and payload tests had been concluded at VAFB when satellite fuelling preparation had to be stopped immediately after the explosion of a Falcon-9 rocket at Cape Canaveral, on 28 June. The satellite was put in storage in the clean room of the SpaceX Payload Processing Facility with remote video surveillance by industry from Cannes and periodic checks performed by the NASA resident at VAFB, and the launch campaign team returned to Europe.

SpaceX announced that the most likely cause of the explosion was a rupture of a strut supporting a helium pressurisation tank. SpaceX started to rebuild the first and second stages of the Jason-3 launcher - the last of the V1.1 version of Falcon-9 - using new struts, with mid-December referred to as a possible launch date. NOAA, after consultation with the other programme partners, directed SpaceX to notify VAFB of 15 December as the Jason-3 launch slot, as necessary to trigger all safety reviews required to authorise the launch in this timeframe.

A number of check points followed to reassess readiness for launch on 15 December, based on the latest information available on the launcher investigation and rebuild activities, and the four partners decided to restart the launch campaign on 9 November and to de-store the satellite.

Unfortunately, it became evident that a safe launch on 15-16 December was not feasible and NASA postponed its Launch Vehicle Readiness Review to 8 December, concluding that the earliest possible launch slot was 4 January 2016, subject to agreement of the VAFB. The partners decided to start fuelling the spacecraft on 16 November to preserve the 4 January slot opportunity and to gain maximum flexibility for restarting launch campaign activities if the launch was to slip further in the first quarter of 2016.

The fuelling of the satellite was completed on 20 November and, considering that the earliest possible slot had moved to 17 January, the remaining launch campaign activities were re-planned in two segments. The teams from CNES and industry stayed at Vandenberg until mid-December for mating the spacecraft with the launcher and returned there on 9 January to perform final preparations for launch.

After Falcon-9 had returned to flight on 21 December in its new, more capable version 1.2, the 17 January slot was confirmed by the NASA delta Launch Vehicle Readiness Review, the US Key Decision Point, both held in December, and ultimately by the Launcher Flight Readiness Review held on 8 January,

Jason-3 was finally successfully launched on 17 January 2016 to the relief of all programme partners.

Operational oceanography in the context of Copernicus

EUMETSAT team testing the Sentinel-3 ground segment at EUMETSAT headquarters

EUMETSAT ready for the launch of Sentinel-3A, after a challenging test programme in cooperation with ESA

The Sentinel-3 marine mission will provide complementary altimeter measurements to those of Jason-3 and restart the series of highly accurate measurements of sea surface temperature and ocean colour which was interrupted after the loss of the ESA Envisat mission.

As part of its contribution to the ESA development programme, EUMETSAT supported the final phase of the ground segment development, as well as system validation tests in preparation for launch and commissioning. In parallel, as part of the Copernicus tasks entrusted by the EU, the operations team was built up and the handover of the Sentinel-3A satellite and ground systems was planned and prepared.

The readiness of EUMETSAT's Sentinel-3 mission and satellite control centre (flight operations segment) was confirmed in June after its Acceptance Review and closure of residual issues by further testing in cooperation with ESOC.

The Acceptance Reviews of all launch-critical EUMETSAT ground segment multi-mission elements (data dissemination, archive, user portal) upgraded for Sentinel-3 were also closed in June, after successful load tests simulating the addition of MSG-4 and Sentinel-3A data to existing data streams.

The industrial development of the payload data ground segment (PDGS) was more difficult but the acceptance testing of the minimum configuration needed at EUMETSAT to support launch and commissioning was completed in May. This provided inputs into the testing of the complete PDGS also involving the ESA core ground station in Svalbard, which showed limitations of the system.

In view of these limitations, ESA then started the verification and validation testing of the full Sentinel-3 ground segment with the goal of achieving the best possible PDGS status at the Ground Segment Acceptance Review (GSAR) in July. The review found all safety-critical ground segment elements ready for launch and was closed in September, subject to successful completion of the on-site acceptance test (OSAT) of the launch configuration of the PDGS, which was achieved in December by ESA, EUMETSAT and industry.

In parallel to its contribution to the ground segment development, EUMETSAT became increasingly involved in the ESA system validation tests (SVTs) coupling ground segment elements with the satellite simulator and ultimately the platform and the real Sentinel-3A full satellite. EUMETSAT was first connected to the real Sentinel 3A satellite in August, gaining valuable experience in running satellite databases and procedures, and confirmed the launch readiness of its systems and teams in October, after the final SVT tests.

Finally, EUMETSAT supported ESOC's LEOP rehearsals and rehearsed some routine operations scenarios with the spacecraft simulator during operations validation tests (OVT) of its own, from 27 November to 4 December.

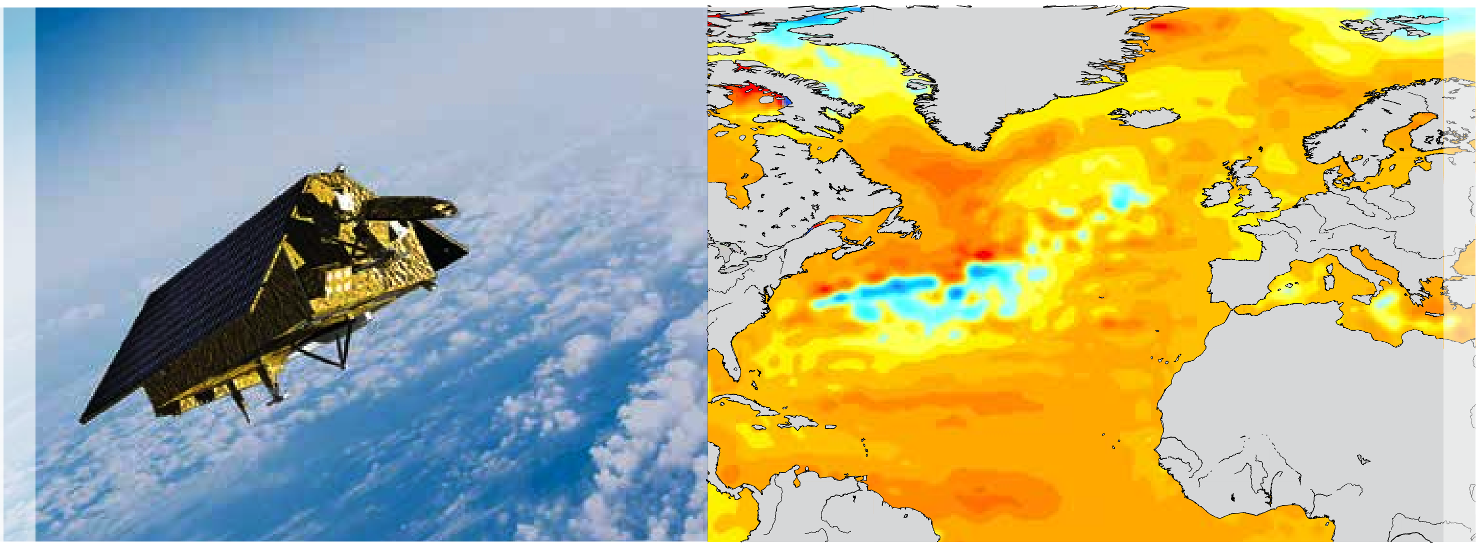
All activities converged at the end of December, in time for the launch of Sentinel-3A, which had slipped in the meantime to the early days of 2016. EUMETSAT was thus ready to support launch and in-orbit commissioning of the satellite.

In parallel, under the EU-funded Copernicus Third Party Programme, EUMETSAT prepared for taking over operations of the spacecraft and the Marine Data Centre from ESA after five months of in-orbit commissioning, and for starting the subsequent operations ramp-up phase.

At the end of 2015, handover plans for the FOS and PDGS and all software licences required for FOS operations had been signed with ESA, all human resources required to support operations were in place and the negotiation of industrial contracts for maintenance and handover support was almost complete.

Monitoring sea level in our changing climate

Three months ahead of the COP21 Conference, EUMETSAT confirmed its commitment to the continuation of mean sea level monitoring until 2030, through its contribution to the Sentinel-6/Jason-CS cooperative mission



The Jason-CS satellite will continue to map mean sea level trends over the North Atlantic and European semi-enclosed seas (source: LEGOS/CLS). Available over the global ocean, this information is essential for adaptation to climate change in coastal areas, particularly in the Small Island Developing States (SIDS).

The EUMETSAT Jason-CS programme enters into force in time for COP21

Building on the heritage of previous Jason missions, the Sentinel-6/Jason-CS (Continuity of Service) cooperative mission involves Europe, through EUMETSAT, ESA, CNES and the European Union, and the United States, through NASA and NOAA.

With two successive satellites, it will continue the high-accuracy ocean surface topography measurements beyond Jason-3, at least until 2030. As a result, a constellation of one Jason and two Sentinel-3 satellites will be maintained in orbit in the period 2016-2030, as the European backbone of an international space-based, ocean-observing system supporting operational oceanography and climate monitoring.

The legal framework for EUMETSAT's contribution is the Jason-CS optional programme, which entered into force on 9 September, when the subscriptions of 12 Participating States (Austria, France, Germany, Iceland, Italy, Luxembourg, Netherlands, Portugal, Sweden, Switzerland, United Kingdom, Turkey) reached 90% of the financial envelope. This level reached 94.82% at the end of 2015, following further subscriptions by Norway and Denmark.

The programme covers system activities, the development of the full ground segment, a fixed financial contribution to the ESA development of the first satellite and co-funding of the recurrent unit with the EU, with the understanding that EUMETSAT will exploit the European part of the system on behalf of the EU Copernicus programme.

After confirmation that US participation was included in the NASA 2016 budget, discussions on the overarching agreement between EUMETSAT, ESA and NASA/NOAA and on the implementing arrangement between ESA and EUMETSAT converged in October. This followed consultation with the European Commission on policy aspects confirming, in particular, that a free, open and unrestricted data policy would prevail for the cooperative Sentinel-6/Jason-CS mission, as for Topex-Poseidon and Jason-1,-2 and -3. The ESA-EUMETSAT arrangement was signed on 18 December.

In the meantime, ESA signed the satellite contract in Berlin, in the presence of Mr Rainer Bomba, the State Secretary of the German Federal Ministry for Transport and Digital Infrastructure.

The System Requirements Review involving all partners confirmed that the design of the full system and the satellite were consistent and validated the end user requirements, system requirements and operation concept documents.

On that basis, the requirements for the overall ground segment (OGS) were then consolidated by EUMETSAT and traced to higher level requirements. EUMETSAT established a ground segment functional model, reusing existing assets for mission control and data processing infrastructure, in preparation for the Overall Ground Segment Requirements Review (OGSRR). The review started in November and should conclude in January 2016.

European Space Policy and Copernicus

In the context of the discussion of a future European Space Strategy and ahead of the COP21 conference, climate and big data were high on the European Space Policy agenda, giving opportunities for targeted EUMETSAT interventions at high level meetings

Top French and UN officials celebrating the Paris Agreement (left, source: REUTERS/Stephane Mahe), established by the World Climate Change Conference 2015 (COP21). Satellite series exploited by EUMETSAT (clockwise from top left: Metop-SG, MTG, Sentinel-3 and Jason-CS) will monitor climate change over the next two decades.

Satellites and science to support the European response to COP21

Participating in a round table discussion on climate services at the 7th Annual Conference on EU Space Policy, the Director-General stressed that climate records accumulated over 35 years by EUMETSAT's satellites and its commitment for two more decades of observations are a unique European asset for the emerging Copernicus Climate Change Monitoring Service. He recommended that the science community be involved, together with service industry, in Horizon 2020 demonstration projects targeting the development of downstream and sectorial climate information services.

The Director-General also participated in a lunch debate organised by the Sky and Space Intergroup of the European Parliament entitled, "To COP21 and beyond: the space contribution to the fight against climate change". His message was that monitoring anthropogenic CO_2 emissions is a scientific challenge in itself that can only be met by a complex information system of which space is only one component and that Europe could become the reference worldwide if it embarks now on the demonstration of such a system. This would require an ambitious study programme involving observation system simulations and numerical modelling and, in parallel, the development of a European CO_2 satellite mission that EUMETSAT could operate in synergy with its own greenhouse gas monitoring assets.

Supporting the European Commission in space dialogues

EUMETSAT participated in the EU-led Space Dialogues with South Africa, China and the US to promote the relevance of bilateral cooperation with partner agencies. During the EU-US dialogue meeting, the NOAA-EUMETSAT cooperation on the Joint Polar System emerged as a possible model for other transatlantic cooperation, where each party requires autonomy and none can afford independence.

Copernicus data access and user uptake

Data access was also high on the European Space Policy agenda, triggering EU studies, workshops and meetings involving ESA, the Commission, the Joint Research Centre and contractors. This was supported by EUMETSAT throughout the year, in the context of the preparation of its own roadmap for pathfinder projects for future data services based on cloud and big data technologies.

As a provider of part of the Copernicus core ground segment, EUMETSAT was involved in the Integrated Ground Segment Task Force and Coordination Group established by the Commission and the Copernicus Programme Committee to provide strategic and technical guidance for the evolution of the overall Copernicus ground segment also including collaborative elements and to deliver a roadmap for their progressive integration.

In this context, EUMETSAT presented the proven capacity of EUMETCast to offer equal data access opportunities across the EU to all users equipped with standard, low-cost VSAT terminals, regardless of limitations of local communication networks.

At the informal Space Council meeting organised by the Luxembourg EU Presidency, the Director-General stressed EUMETSAT's long-term commitment to deliver satellite data inputs for the development of information services.

Discussion on data access and formats during the Copernicus Users' Information Day, EUMETSAT headquarters, Darmstadt, 11 September 2015

A first year of successful cooperation with the European Commission on Copernicus

After a kick-off workshop where interfaces, interactions and reporting on entrusted tasks were agreed with the Commission, the EUMETSAT 2015 Copernicus Work Programme started to be implemented by a fully staffed Copernicus Programme and Service Management Office.

As soon as EU budget appropriations became available, work orders were released to the five contractors selected under framework contracts for Sentinel-3 operations support to build up the operations team. Later in the year, the procurement plan was amended to assure continued support from the ESA contractors for ground segment maintenance services into the critical early operations phase.

The ESA-EUMETSAT Joint Operations Management Plan (JOMP) covering Sentinel-3 operations was reviewed at the Sentinel-3 Ground Segment Acceptance Review and a draft published in August, providing *inter alia* the framework for the joint implementation of changes authorised by the Commission.

The Operations Coordination Working Groups established with ECMWF and Mercator-Océan, the providers of the Copernicus Atmosphere Monitoring Service (CAMS) and Copernicus Marine Environment Monitoring Service (CMEMS), met regularly to discuss user feedback and requirements for EUMETSAT Copernicus data and products services.

This triggered the submission of a joint ESA/EUMETSAT change proposal to the Commission for the introduction of Sentinel-3 aerosol and fire radiative power (FRP) products required by the CAMS service, including near real-time products to be disseminated by EUMETSAT.

The CAMS and CMEMS services also formally requested to the Commission that EUMETSAT continue the dissemination of selected products from the Suomi-NPP satellite under its Copernicus Agreement, after closure of the "Suomi-NPP for Copernicus" demonstration project funded by the EU GMES Initial Operations (GIO) programme in June. This was accepted by the Commission and EUMETSAT started to deliver key performance indicators for this service in July.

EUMETSAT was tasked with preparing a change proposal addressing the dissemination of Sentinel-3 marine products to African users, as a result of high-level discussions between the Commission and the African Union Commission.

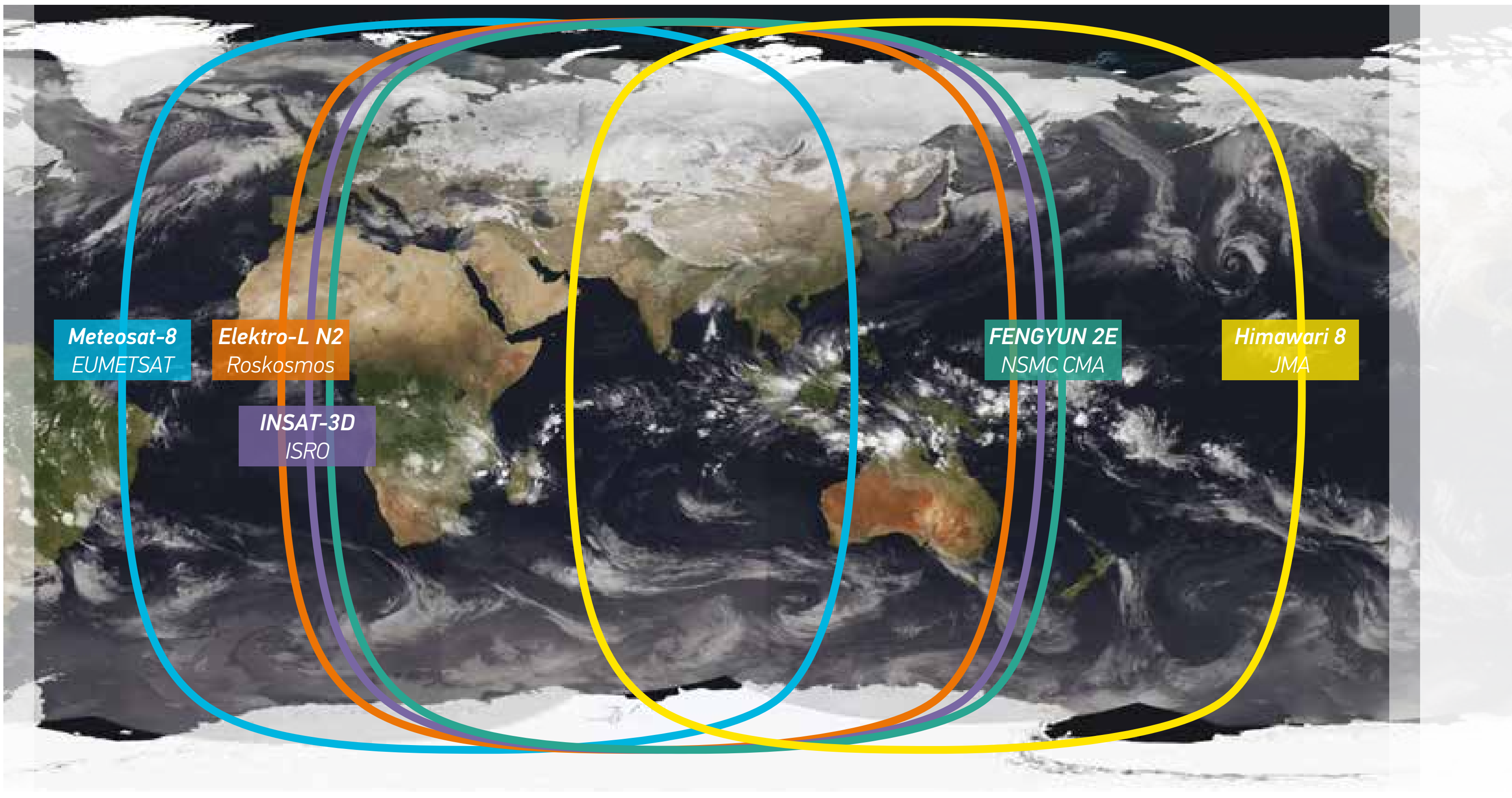
On 11 September, EUMETSAT hosted, at its headquarters, a Copernicus Users' Information Day on access to Sentinel-3 marine products attracting more than 100 participants, and 60 more via WebEx, to witness live demonstrations of EUMETCast and the Earth Observation Portal.

The development of a EUMETSAT Copernicus website linked to the Copernicus.eu web portal started as a contribution to the Commission's Copernicus communication plan.

EUMETSAT concluded the assessment of user requirements for future Copernicus marine and atmosphere monitoring services under the GMES-PURE (Partnership for User Requirements Evaluation) project it co-funded with the Commission and presented the results to the Copernicus User Forum. The method designed by EUMETSAT was reused by the Commission in further studies on requirements.

Cooperation with other satellite operators

Through cooperation with other satellite operators, EUMETSAT delivers its data to a broader user community and gains access to additional data for the benefit of its Member States



Scenario for a more resilient multi-partner coverage of the Indian Ocean (above) agreed by CGMS-43 (below). Optimum coverage with overlap is expected from Meteosat-8 (41.5°E), Elektro L N2 (77.8°E) INSAT-3D (82°E) and FY-2E (86.5°E) and Himawari 8 (140.7°E).

Multilateral cooperation to better observe the Indian Ocean

The 43rd Plenary Session of the Coordination Group for Meteorological satellites (CGMS) hosted by NOAA in Boulder, USA, from 18-22 May, welcomed the accession of the Indian Space Research Organisation (ISRO) to membership.

CGMS also agreed a multi-partner scenario for the continuation and enhancement of Indian Ocean Data Coverage (IODC) services after the de-orbiting of Meteosat-7 and a roadmap for its timely implementation. The scenario involves ISRO's INSAT-3D satellites at 82°E, the CMA FY-2E satellite as a back-up satellite at 86.5°E, Roshydromet's Elektro L satellites around 76°E and Meteosat-8, if relocated to 41.5°E after the successful commissioning of MSG-4.

Other matters discussed were user preparedness for future generation geostationary satellites, the development of the "WMO Integrated Global Observing System Vision 2040" and the implementation of the architecture for climate monitoring from space coordinated by the Joint CEOS-CGMS Climate Working Group.

Bilateral cooperation with partners worldwide

The signature of the Joint Polar System Agreement, during the 84th session of the EUMETSAT Council, established on firm ground the long-term future of the cooperation with NOAA on polar-orbiting satellites, in the context of the respective EPS-SG and Joint Polar Satellite System (JPSS) programmes.

The cooperation on future geostationary lightning imagery missions (GOES-R and MTG-I) developed further with a joint workshop in Rome on algorithms, data processing, calibration and validation, where exchange calibration and validation data was agreed, and with the decision of EUMETSAT to extend its EUMETCast-Americas Service into 2016 to facilitate the transition to future GOES-R data access services.

Operational cooperation was marked by one activation of EUMETSAT's Svalbard station to acquire two NOAA18/19 orbits that could not be acquired in Fairbanks and by the operational readiness of a full back-up chain enabling acquisition of Metop data at Fairbanks, Alaska, and their repatriation to EUMETSAT via back-up links to cope with the possible temporary loss of the Svalbard station.

Alain Ratier, Director-General of EUMETSAT and Stephen Volz, NOAA Assistant Administrator, signed the JPS Agreement during the 84th session of the EUMETSAT Council

Interactions with NOAA and NASA leadership were essential to support risk management in the difficult preparation of the Jason-3 launch and decision-making on the cooperation framework for the implementation of the Jason-CS/Sentinel-6 cooperative mission - a necessary input into the proposed EUMETSAT Jason-CS programme. This culminated in October with the successful negotiation of a "Concept Paper" at a meeting in Washington, which also involved ESA.

EUMETSAT and the China Meteorology Administration (CMA) extended their cooperation to regional data services involving their respective polar-orbiting satellites. In addition to reciprocal access to direct broadcast data from Metop and FY-3 satellites, this covers exchange of processing software, redistribution of products and support to users. As a result, EUMETSAT gained access to regional FY-3C sounding products within 15 to 30 minutes from sensing in support of nowcasting of high-impact weather and short-range forecasting. The positive impact of FY-3 data is expected to increase further when CMA launches its future FY-3E on the unpopulated early morning orbit, as announced at the 17th WMO Congress.

Mr Kiran Kumar, the new Chairman of ISRO, confirmed ISRO's interest in further developing cooperation with EUMETSAT. Bilateral discussions focussed on the continuation of IODC services, in which ISRO plays a central role with its INSAT-3D and INSAT-3DR satellites, and on the preparation for ISRO's Scatsat-1 ocean surface wind scatterometer mission slated for launch in summer 2016. EUMETSAT participated in a scatterometer workshop organised by ISRO in Ahmedabad, followed by technical interactions on real-time access to Scatsat-1 data to be acquired at Svalbard and at ISRO's AFEOS station in Antarctica.

In the margins of the CEOS Plenary meeting, the Director-General and the new Administrator of the Japanese Meteorological Agency (JMA) discussed cooperation on data exchange, science, development of new products and preparation of users for the next generation of geostationary satellites. EUMETSAT agreed to become the redistribution hub for Himawari-8 data for its Member States and partner organisations.

The positive feedback from EUMETSAT users to precipitation products from JAXA's GCOM-W1 mission was presented at the CEOS Plenary, where EUMETSAT voiced the need for a follow-up GCOM-W2 mission to avoid a critical data gap.

EUMETSAT signed a new Cooperation Agreement with Russia's Roshydromet in April. Both agencies organised a joint training workshop in Moscow, planned their contributions to multi-partner IODC services and discussed further exchange of data from Meteor M N2, Elektro-L N2 (launched on 11 December) and Copernicus marine missions, subject to arrangements with the Commission.

With the Korean Meteorological Agency (KMA), EUMETSAT started to prepare a new Cooperation Agreement and supported the first International Satellite Conference organised by KMA in Seoul. The conference focused on applications of its COMS geostationary satellite and planning for a future KMA low Earth orbit satellite.

Global partnerships

EUMETSAT plays an active role in global partnerships, including the GFCS, CEOS and GEO

Global Framework for Climate Services and COP21

As a follow-up to the Benoni Declaration on Climate Services adopted in 2014 during the 11th EUMETSAT User Forum in Africa, the GFCS African, Pacific and Caribbean (ACP) Task Team launched an identification study for a future project funded by the 11th European Development Fund aimed at developing climate services and support to WMO Regional Climate Centres in the ACP regions. This will implement both the intra-ACP strategy and the integrated African strategy on weather and climate services adopted by African Ministerial Conference on Meteorology (AMCOMET) ministers.

On behalf of CGMS, the Director-General informed the 17th WMO Congress of the commitment of CEOS and CGMS agencies to coordinate the implementation of the architecture for climate monitoring from space through a Joint Climate Working Group, as their contribution to the "Observation and Monitoring" pillar of the GFCS. Referring to the recommendations of the Symposium on "Climate Research and Earth Observations from Space: Climate Information for Decision Making" in Darmstadt in 2014, he invited the Congress to encourage space agencies to pursue the dialogue with the World Climate Research Programme to realise the best possible scientific benefit of the combination of operational meteorological satellites and targeted research missions.

The findings of the symposium, published in the Bulletin of the American Meteorological Society[3] and a new brochure "Climate@Eumetsat", were EUMETSAT's key contributions to science and space events preparing for the Conference of the Parties to the UN Framework Convention on Climate Change (COP21). They included a roundtable discussion at Le Bourget air show and the International Science Conference on "Our Common Future under Climate Change" held in Paris in July. EUMETSAT was also represented by its Chief Scientist at a COP21 side event organised by ECMWF to present the Copernicus Climate Change and Atmospheric Monitoring Services and supported a one-hour Twitter "tweetchat" on the usage of satellite data for climate monitoring organised by the Committee for Earth Observation Satellites (CEOS).

Dr Kenneth Holmlund, EUMETSAT Chief Scientist, presenting at a side event of COP21 in Paris, 10 December 2015

Architecture for climate monitoring from space

At the CEOS Plenary in Kyoto, the CEOS-CGMS Joint Climate Working Group (JCWG), tasked to coordinate the implementation of the architecture, presented its four-year work plan to be implemented under ESA chairmanship and EUMETSAT vice-chairmanship.

Under this plan, EUMETSAT, ESA and the Joint Research Centre, with the support of the EU Copernicus programme, started to enhance the inventory database for climate data records of essential climate variables handed over by NASA. This was necessary in order to establish traceability from CDRs of ECVs to the fundamental data records used for their production and ultimately to the satellite missions providing the contributing observations. The inventory, transformed by EUMETSAT into an online integrated SQL database with dynamic web pages, will then be used in support of gap analyses and planning for future missions.

Considering that the Global Climate Observing System (GCOS) programme is the major source of requirements for the architecture, EUMETSAT volunteered to support the GCOS conference "Global Climate Observations, the Road to the Future", organised in 2016 in Amsterdam to launch the future GCOS Implementation Plan.

[3] Climate Symposium 2014: Findings and Recommendations. Bulletin of the American Meteorological Society, Vol. 96, ES145-ES147

CEOS and GEO

EUMETSAT participated in the 31st meeting of the CEOS Strategy Implementation Team (SIT) hosted by CNES, in Paris, where CEOS contributions to COP21 were prepared and the CEOS three-year rolling work plan was adopted. It also hosted the SIT Technical Workshop and a coordination day involving all CEOS virtual constellations and working groups.

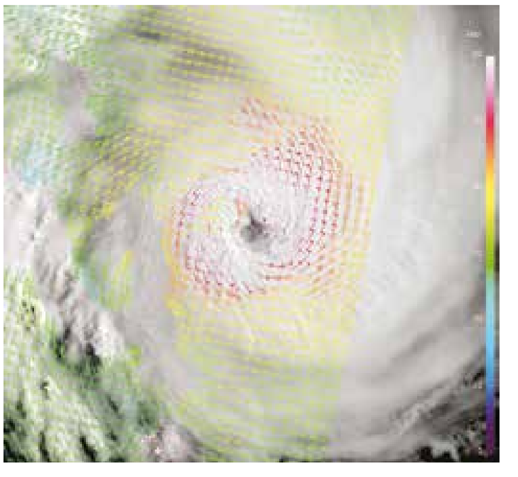
At the CEOS Plenary meeting hosted by JAXA in Kyoto, climate discussions focussed on the CGMS-CEOS report to the 43rd session of the UN's Subsidiary Body for Scientific and Technical Advice (SBSTA-43) and on communication during the paperless UNFCCC COP21 conference in Paris. In addition, CEOS established its positions for the GEO Plenary and Ministerial Summit, seeking membership on the Programme Board and observer status on the Executive Committee.

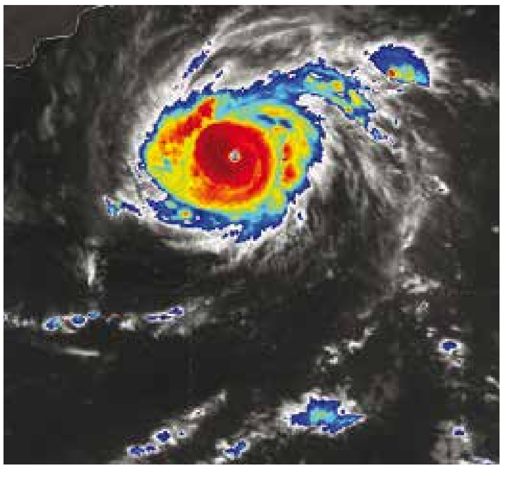
During discussion on the CEOS strategy for water observations from space, EUMETSAT stressed that the lack of planned follow-up to the current precipitation imagery missions championed by Japan and the US would create a critical gap.

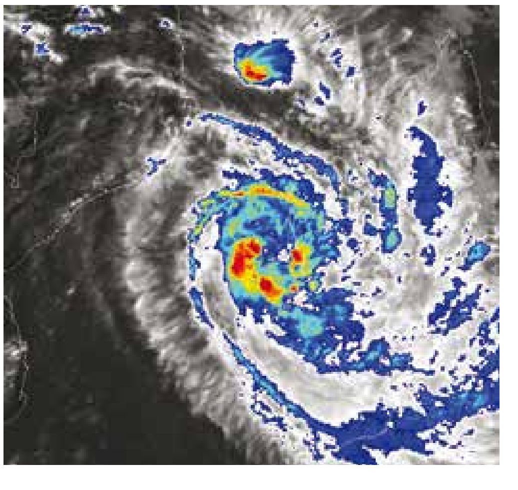
Attending the GEO-XII Plenary and Ministerial Summit in Mexico City, EUMETSAT was present on the booth of the European Commission and stressed in a statement to the plenary, that the continuity of its data services, now secured by the launch of MSG-4 and the approved EPS-SG and Jason-CS programmes, was an asset to the GEO Strategic Plan 2016-2025. Through a joint statement delivered by the NOAA Administrator, EUMETSAT, CMA and NOAA confirmed their support of GEO initiatives through the continuation of the GEONETCast data broadcast system considered as a GEO foundational task.

EUMETSAT responded to three activations of the Charter on Space and Major Disasters, in Africa, the South Pacific and the Middle East. Meteosat and Metop imagery products were delivered to support crisis management related to floods in Madagascar caused by Tropical Storm Chedza (16 January), Cyclone Pam devastating the Vanuatu islands (9–15 March) and Chapala, one of the strongest cyclones to ever hit Yemen (29 October–3 November).

Imagery delivered by EUMETSAT in support of disaster management: cyclone Pam in the Vanuatu Islands (top), cyclone Chapala in Yemen (middle), and tropical storm Chedza in Madagascar (bottom)







Management and administration

As part of its commitment to continuous improvement, EUMETSAT adjusted its organisation to cope with a larger programme portfolio, improved further its matrix operations and updated its procurement procedures

Organisational management

After the approval of the EPS-SG and Jason-CS programmes, the organisation of the Low Earth Orbit (LEO) Division was adjusted to delegate the management of these new programmes within the division, which allowed the Associate Director for LEO Programmes, Marc Cohen, to take the new role of deputy Director for Programme Preparation and Development (PRD). The role includes responsibility for modelling EUMETSAT's process for the development of complex satellite systems and transferring critical knowledge to a new generation of programme and project managers.

In response to an ISO audit and to the Staff Survey 2014, a project was set up to simplify and transform the management system documentation into a user-friendly, web-based "navigable" system, based on the upfront visualisation of the operations and development processes. This will make more immediately understandable to newcomers the missions assigned to EUMETSAT by its Convention – its *raison d'être* – its customers and its business environment.

An Enterprise Resource Planning (ERP) Task Force started to re-assess the compliance and implementation of the ERP tool (currently SAP) with EUMETSAT's business and internal control requirements. Identified "quick-win" simplifications of some SAP workflows were initiated, in parallel to the assessment of opportunities for more complex enhancements and for simplification of the overly complex human resources planning process.

Following benchmarking of information and communication technology (ICT) services, a new ICT strategy was established to increase security and cost efficiency. The target is a 5 percent reduction of overall costs by 2020, despite the significant increase in the number of users, using Cloud or external services whenever safe and appropriate.

In the context of the matrix organisation, all competence areas of the Technical and Scientific Support (TSS) Department and their objectives, activities and technology roadmaps were presented to the customer departments responsible for operations (OPS) and development (PRD). An off-site workshop involving TSS and PRD management and HR business partners was also held to share an in-depth understanding of the planning, tasks and challenges of the development phase of the EPS-SG programme and implications for TSS support and workload.

In the TSS Department, management indicators were introduced to assess the performance of development support tasks, the compliance of support to operations with applicable Service Level Agreements and the satisfaction of internal customers. The resource management framework (RMF) web tool assisting in the allocation and planning of TSS human resources providing support to a portfolio of several projects became ready for operations in December.

In response to the Staff Survey 2014, measures were identified to delegate some decisions and simplify visa loops and other administrative processes, including through the introduction of an electronic workflow system. This replaced paper-based with electronic signatures for simple approval processes.

Work also started on the design of a bottom-up process supported by a web tool for the submission of proposals for improvements to the management system by individual staff, and for their processing at divisional, departmental and organisational levels.

"Internal Communication Business Partners" providing advice and support were assigned to two departments as a pilot experiment. Internal communication was also enhanced through quarterly staff assemblies addressing topics of general interest, including the socio-economic benefits of EUMETSAT, the human resources strategy, revised procurement procedures, the ICT strategy, innovative developments of technical infrastructure and third-party data services.

New office buildings were delivered on schedule and within budget to host the EPS-SG and Jason-CS programme teams

Mr Jochen Partsch, Lord Mayor of Darmstadt, Mr Rainer Bomba, State Secretary of the German Federal Ministry for Transport and Digital Infrastructure, Alain Ratier, EUMETSAT Director-General, and Mr Mathias Samson, State Secretary of the Hessian Ministry for Economy, Energy, Transport and State Development, inaugurate the new office building on 27 August

General infrastructure and internal services

The new office building (East Building), including a new canteen, was constructed on schedule and within budget and inaugurated on 27 August in the presence of Secretaries of State from the German Federal and the Hessian Ministries, the Lord Mayor of Darmstadt and the Head of the German Delegation. This new "East Building" hosted the canteen services delivered under a new contract from 1 October.

The Headquarters Agreement was amended to reflect the additional pieces of land provided for this building and for the car park, following contractual arrangements with the German Authorities on the respective use of the land.

The procurement of temporary office containers needed to accommodate people who cannot be hosted in the Main and East Buildings over the next six years had to be reopened due to the saturation of the German market by child care and refugee housing. Containers were delivered on 19 November, ahead of the 31 November deadline for the cancellation of the contract for rented offices.

The new office accommodation plan was implemented across old and new buildings, involving transitory solutions pending readiness of the temporary office containers and 329 moves.

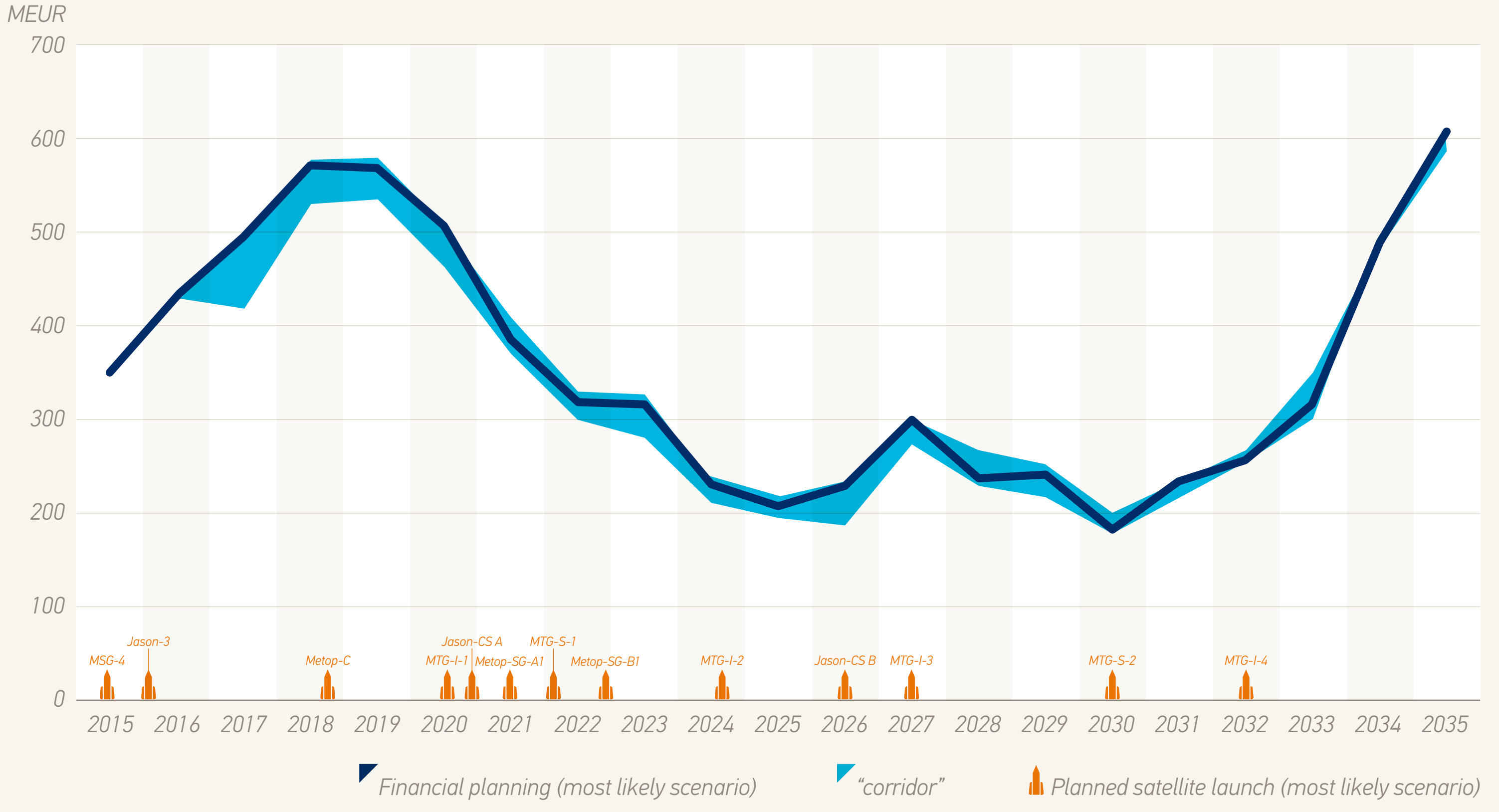
The main events in the corporate IT area were the replacement of the backbone of the network, the migration to an upgraded email exchange system and the roll outs of Internet Explorer 11, an electronic workflow tool and the resource management framework (RMF) tool assisting in the planning of TSS human resources.

Quality management

The surveillance audit performed by DQS maintained the ISO9001:2008 certification for another year and the implications of the changes introduced in the new ISO 9001:2015 standard were assessed to prepare for the recertification of the EUMETSAT management system against this standard, in November 2017.

Management and administration

Preliminary financial planning established at the end of 2015 after the announced one-year slippage of the MTG space segment development schedule



Financial processes

The annual accounts 2014 were audited by Bundesrechnungshof with an unqualified opinion, and a simplified presentation of the annual accounts was adopted for the 2015 accounts.

The late announcement of a one-year slippage of the MTG space segment development schedule required late revisions of draft Budgets for 2016 in November, but it was impossible to revisit the financial planning in full depth, as impacts could only be assessed in broad terms. However, the preliminary assessment shows reduced contributions in 2016 and 2017 and increases in 2019-2021, with a plateau in the years 2018 – 2020, due to the rephasing of the expenditure of the MTG and EPS-SG Programmes which now have comparable schedules.

Management of human resources

Concepts of partial invalidity and "temporary incapacity" were approved by the Council for implementation in 2016 to bridge identified gaps in the social security coverage for staff members.

The implementation of the human resource strategy established to counteract the effects of ageing and the deficit of attractiveness for highly experienced engineers and managers is now measured by indicators such as the number of staff under 40 recruited during the ongoing massive recruitment campaign. The recruitment and induction process was tailored to the needs of the Early Career Employee Programme for which four "mentored" posts were identified for recruitment in 2016 at grade A1 and for initial two-year contracts.

The skill assessment process measuring the availability of business-critical skills against needs is now operational in the OPS and TSS departments, providing key inputs to training plans and human resource planning.

A dedicated newsletter on learning and development opportunities was created and a set of course modules was selected for developing business-critical skills in system and requirements engineering.

"We undertook extensive consultation in our Member States, to explain our procurement procedures and opportunities that will be coming up, particularly in relation to the EPS-Second Generation ground segment procurements."

Eleni Katsampani
Head of Contracts
EUMETSAT

Main contracts and financial agreements approved by the Council

Frame contract for ground segment engineering and maintenance support
Extension of the MSG back-up and ranging ground station (BRGS) service
Extension of the MSG primary ground station maintenance service
Extension of the EUMETCast-Americas data broadcast service
Communication service between headquarters and MSG ground stations in Fucino
Electric power supply
Contract changes for the replanning of the Metop-C launch to October 2018
Launch services for the first three Meteosat Third Generation satellites
Launch and early operations phase services for the first three Meteosat Third Generation satellites
Level-2 processing facility (L2PF) of the Meteosat Third Generation ground segment
Agreement with ESA concerning the cooperation on Metop-SG series of satellites
Agreement with CNES concerning the supply of IASI-NG instruments
Authorisation given to DLR to proceed with METimage advanced phase C activities
Site infrastructure service in Svalbard for EPS and EPS-SG ground stations
Implementing arrangement with ESA concerning cooperation on Sentinel-6/Jason-CS
Meteosat controller team
System administration support service for operations IT systems
SAP hosting services
Rental of Temporary Office Building
Security and reception services
Catering services

Procurement process

The procurement procedures were extensively reviewed, restructured and simplified to improve readability for all staff involved in the procurement process and enhanced to capture EUMETSAT's updated regulatory framework and lessons learnt. The main changes are the publication of weighing factors associated with evaluation criteria with the ITT documentation and improvements to the tender evaluation process through the inclusion of previously undocumented best practices.

The amended procurement procedures were presented to Industrial Focal Points of Member States, along with an overview of the planned EPS-SG ground segment procurements. National industry briefings were held in Slovenia, Lithuania and Estonia to inform about EUMETSAT's procurement policy, process and forthcoming opportunities.

In addition, specific Industry Days were held in July to brief industry on planned EPS-SG ground segment procurements and introduce the first ITT, attracting more than 90 participants from about 70 companies. Further Industry Days followed in September and November to introduce an ITT for the procurement of a MTG integration, verification and validation support service and the second ITT for the EPS-SG ground segment.

The threshold for procurements submitted for the approval of Council was increased from 1.5 M€ to 2M€ to reflect inflation since 2010.

The use of the electronic bidding system, initially introduced for the procurement of consultancy support, was extended to studies. It will be further used to support all firm fixed-price procurements, where technical and financial offers do not need to be submitted separately.

Internal control

A further evolution of the internal control framework, regrouping the financial control and internal audit functions under one roof, was approved for implementation in 2016. It will maintain the combination of *a priori* and *a posteriori* independent internal controls, whilst introducing built-in flexibility to further reduce the scope of *a priori* controls.

The accepted recommendations from an external SAP security audit performed under the supervision of the Financial Controller started to be implemented by the ERP Task Force.

Risk management

Management of operational risks concentrated on critical in-orbit and ground assets and investigations of anomalies.

Being prepared for further thermal control degradations on board the ageing Meteosat-8 and -9 satellites, EUMETSAT could recover image quality when degradations did occur on Meteosat-9, through a 7-degree temperature increase of fuel tanks commanded from the ground. The investigation of an anomaly of a mission-critical command receiver of Meteosat-10 and of possible implications for MSG-4 was also highly demanding, as was the investigation of the anomaly encountered on ground with the GERB-4 instrument, which proved decisive in unblocking the de-spin mirror of GERB-3 in orbit and resynchronising GERB-4 with the spin rate of MSG-4.

A Metop safe mode recovery simulation was performed to assess EUMETSAT's readiness to respond to such an emergency situation and EUMETSAT engineers attended Spot-5 de-orbiting operations at the invitation of CNES, to prepare for the de-orbiting of Metop-A.

The implications of the debris created by the dislocation of a Defense Meteorological Satellite Program (US) satellite flying above the Metop orbit was assessed and agreement was reached with CNES for the provision of an additional conjunction assessment service (CAESAR).

On ground, the reinforced mechanical maintenance established after the collapse of one Meteosat antenna in 2013 detected anomalies on another antenna, calling for the timely replacement of equipment. Additional diesel generators were rented to mitigate risks of failure, when those of the uninterruptable power supply (UPS) system had to be used for five hours to power operations rooms during the disconnection of the three transformers from the 20kV-grid for preventive maintenance. One side of the UPS system was also replaced to improve overall maintainability and configuration control of the diesel generators was improved to avoid recurrence of contamination of fuel in tanks.

IT security audits were conducted for new systems including the multi-mission elements of the Sentinel-3 ground segment and the first "MTG flight master keys". Training and awareness sessions targeting all EUMETSAT staff were held on IT security risks, addressing both operations and office IT systems, including exposure to cyber criminality when using public Wi-Fi.

In the area of development risks, decisions made in previous years in the context of the MSG and EPS development programmes paid off. Firstly, the decision to launch MSG-4 immediately after its refurbishment and store it in orbit saved 15M€ and put EUMETSAT in the best possible position for a safe transition to MTG. Likewise, the benefit of the decision not to invest 12M€ on the refurbishment of the Metop-C GRAS instrument to accommodate a change in one GPS frequency was increased by the US decision to maintain the current set of frequencies until 2026. Finally, the severe degradations observed during the inspection of the scan mechanism of the Metop-C IASI instrument confirmed that rebuilding the scan assembly was the right decision, although it attracted additional costs.

The *sine die* postponement of the Jason-3 launch due to the failure of Falcon-9 required in-depth assessment of technical and financial risks with CNES and Member States and the slippage of the Sentinel-3A launch called for exceptional measures to maintain critical support services beyond the limit of signed contracts. An independent assessment of the readiness of EUMETSAT's Sentinel-3 ground segment was also carried out ahead of the ESA Ground Segment Acceptance Review.

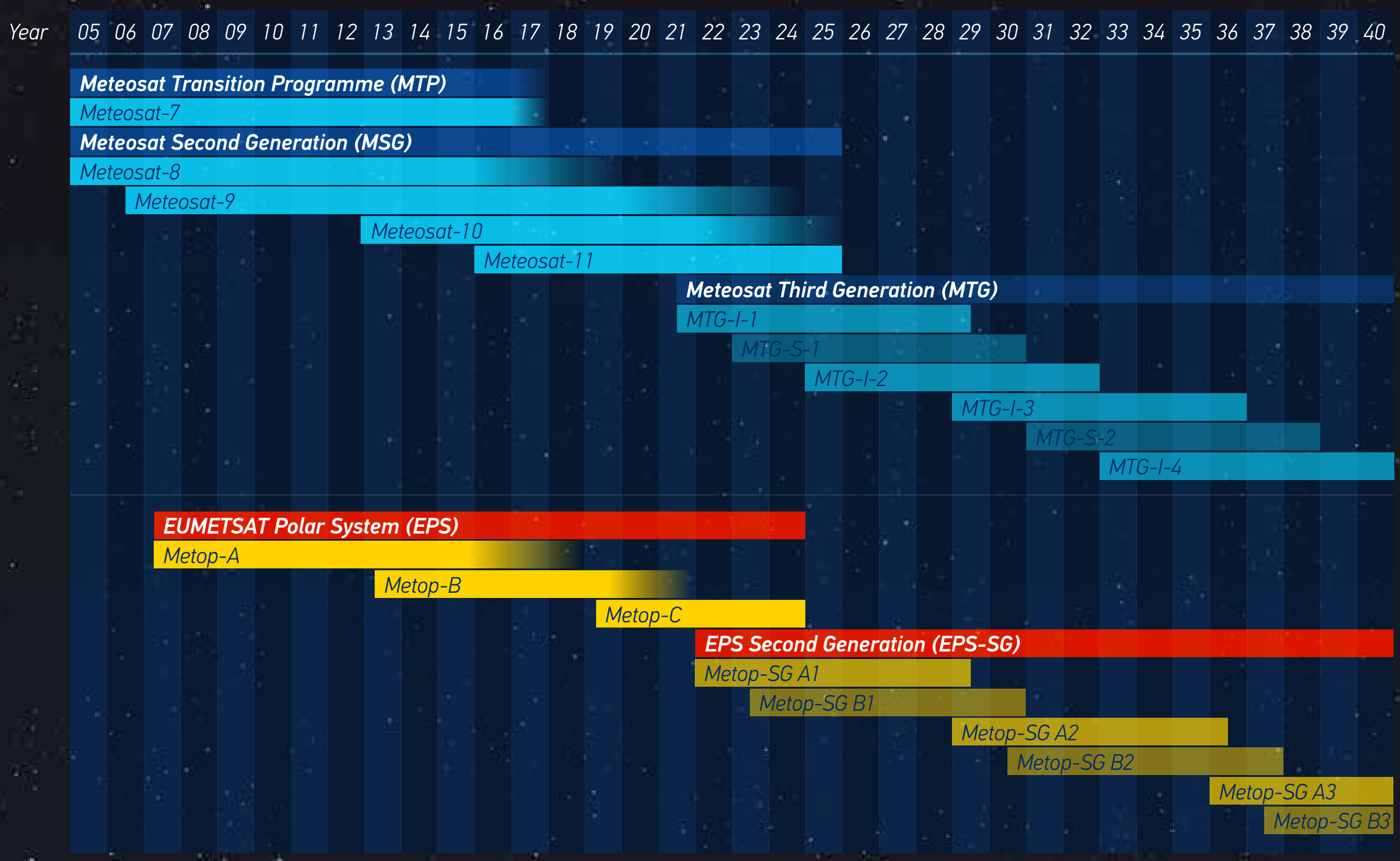
EUMETSAT prepared proactively for the World Radiocommunication Conference 2015 through coordinated actions with partner agencies, WMO, Member States, ESA, EUMETNET and the European Commission. These were aimed at preserving frequencies used for commanding EUMETSAT and Copernicus satellites (S band), acquiring their data (L, X and Ka bands), observing the ocean with the C and Ku band radars of Metop-SG, Jason and Sentinel-3 and delivering the Search and Rescue mission (406-406.1 MHz), from conflicting allocation requests from commercial fixed-satellite services, maritime mobile satellite service, RLAN (Wi-Fi) and mobile broadband (5G).

Following terrorist attacks in Europe, travel security in Europe has become another focus of risk management.

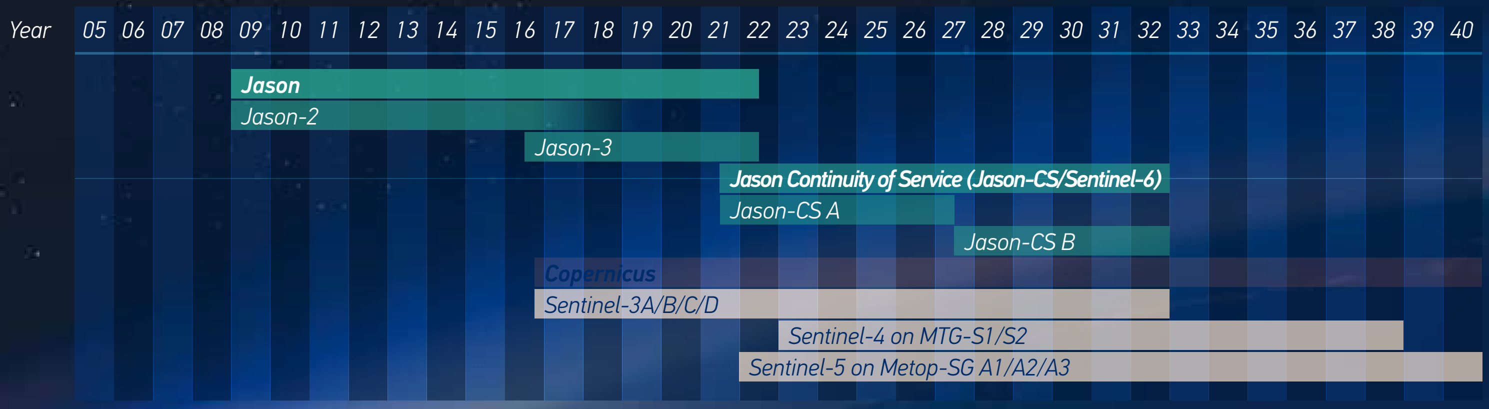
Key figures

EUMETSAT mission planning

Mandatory programmes



Optional and third-party programmes

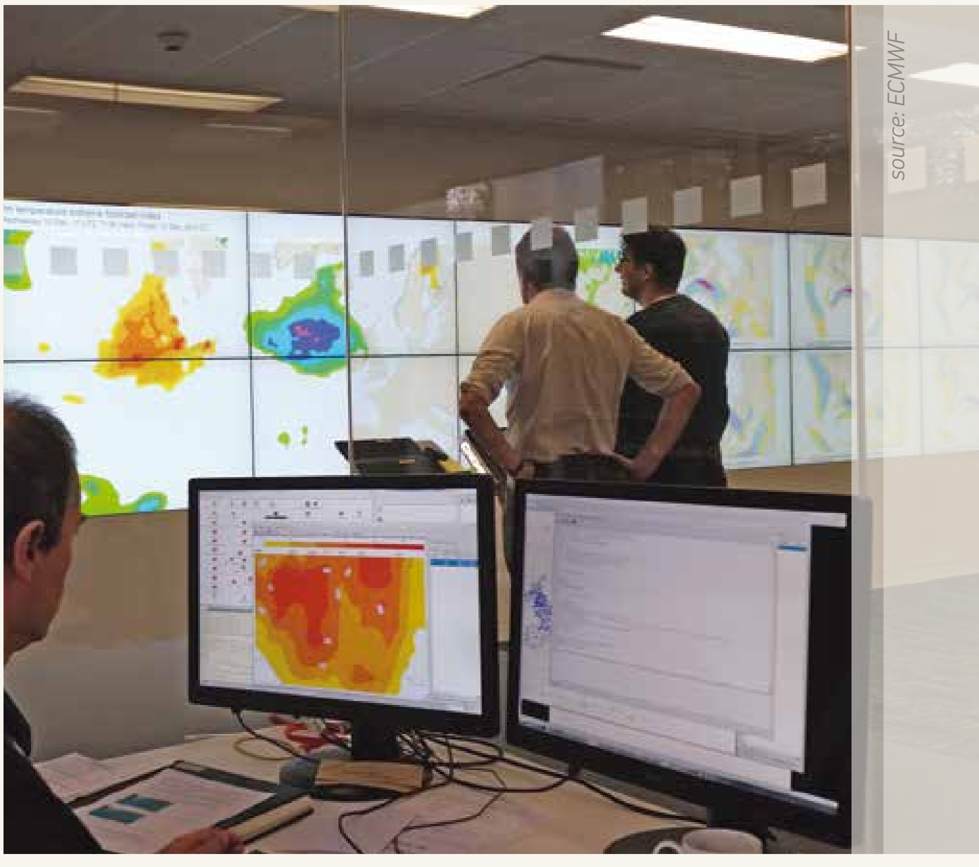


Key figures

The EUMETSAT user base

The EUMETSAT user base comprises National Meteorological Services of its Member States, the ECMWF, international partners and licensed users.

At the end of 2015 the number of licensed users was 2,037.



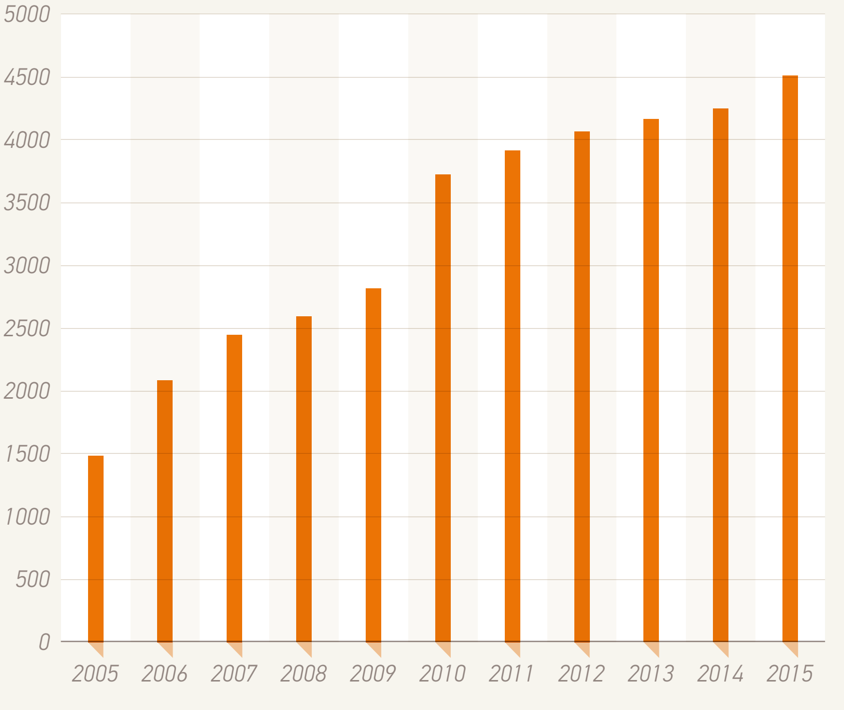
User enquiries

A total of 3,204 user enquiries were processed in 2015.

Member and Cooperating States 72.52%
Other countries 27.48%

EUMETCast users

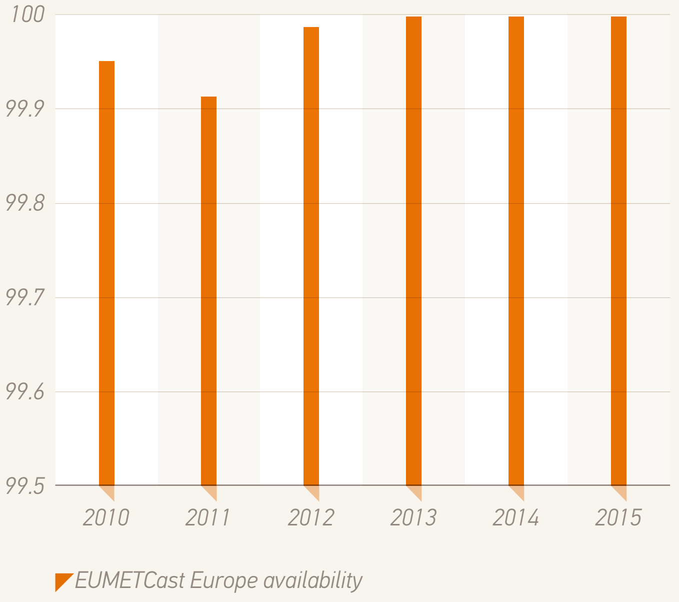
At the end of 2015 there were 3,409 registered users of EUMETCast, using a total of 4,508 reception stations, out of which 74 percent were located in Member States.



Number of registered EUMETCast reception stations at year-end

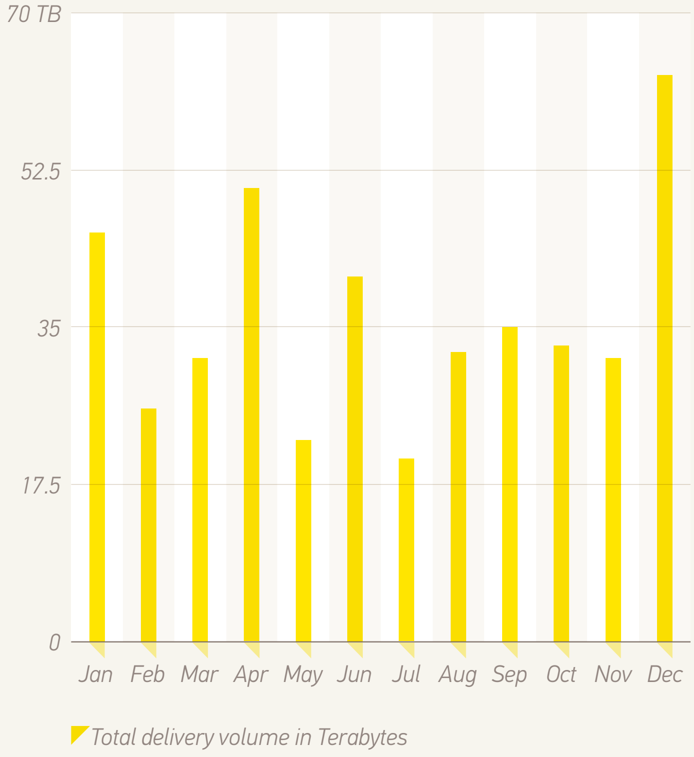
EUMETCast Europe availability 2010–2015

The availability of EUMETCast Europe remained at a record-breaking high level of 99.99 percent throughout 2015.



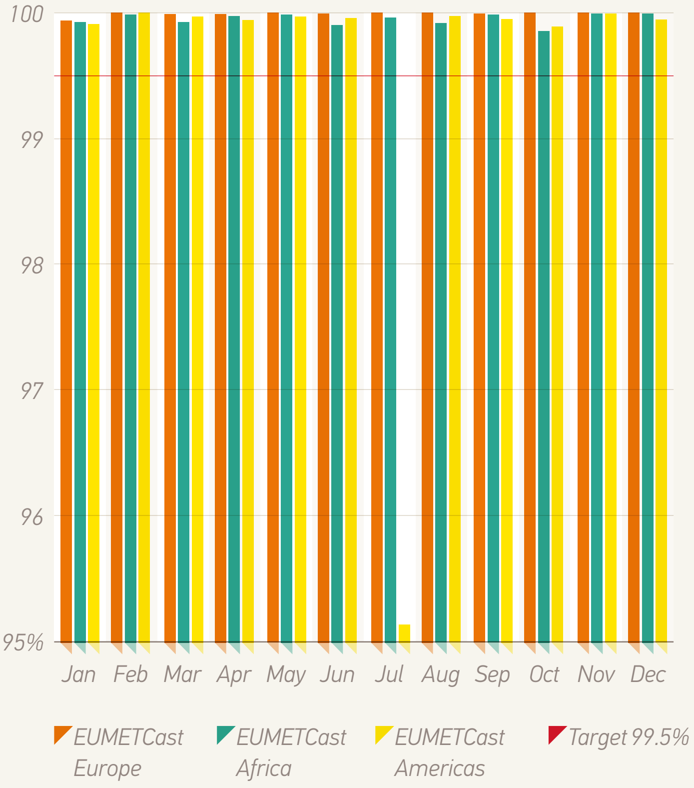
Data Centre users and orders

At the end of 2015, there were 3,594 registered users of archived data, as a result of an average 51 new registrations per month. On average 215 users per month accessed the Data Centre Online Ordering Tool for search and ordering.



EUMETCast availability 2015

The availability of EUMETCast Americas was impacted by interference at the turnaround site in July but remained above 95 percent.

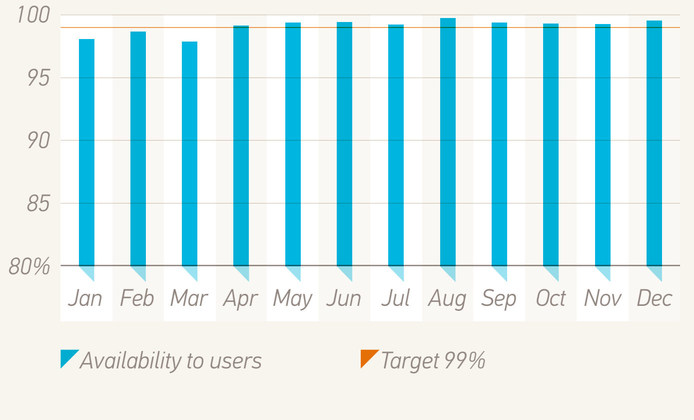


Key figures

Operational performance indicators

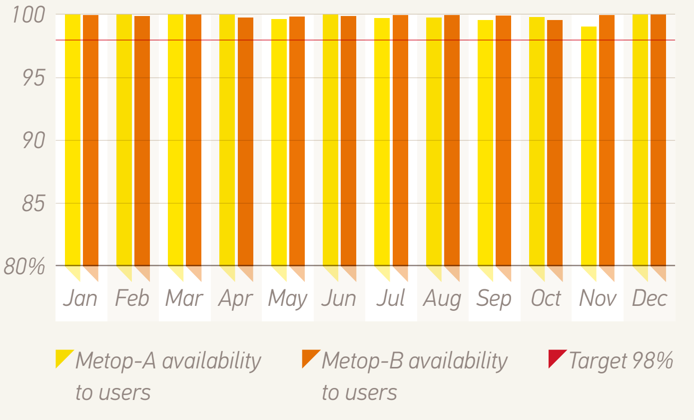
Availability of Meteosat SEVIRI Full Disc image data (0°)

The availability of image data was marginally impacted by ground segment anomalies in January and by eclipse conditions in February-March.



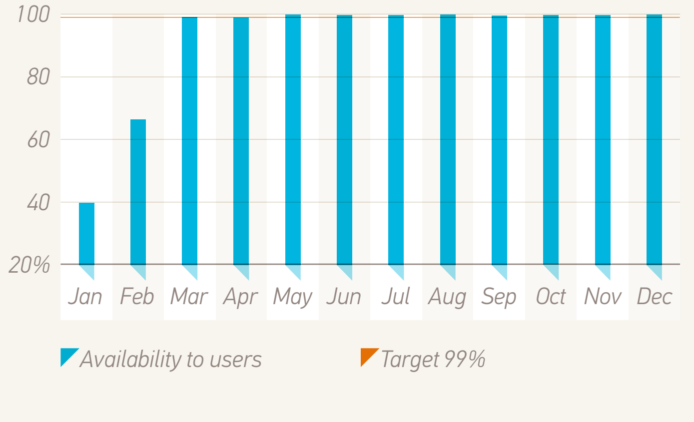
Availability of Metop AMSU Level 1B BUFR data

Availability remained above target with an average of 99.89 percent availability for the prime service (Metop-B).



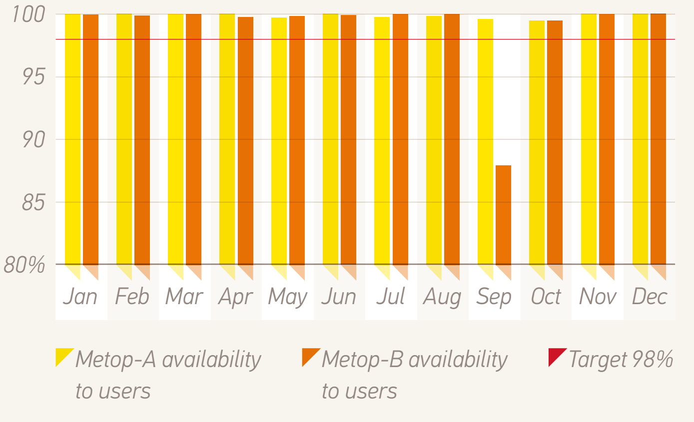
Availability of Meteosat SEVIRI Rapid Scan data (9.5°E)

The rapid scan service was paused from 13 January to 10 February to preserve the lifetime of the scan mechanism of Meteosat-9.



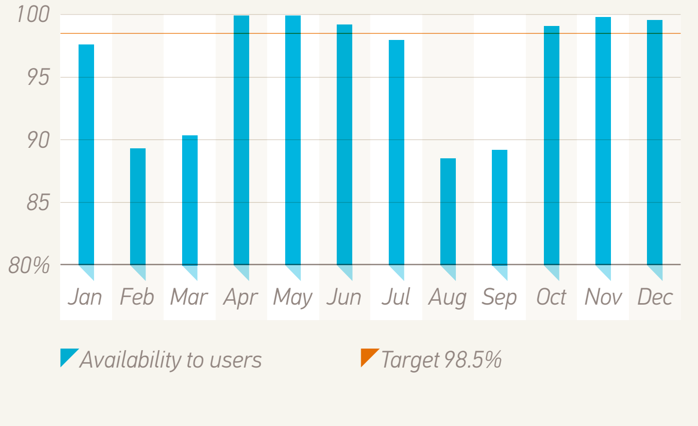
Availability of Metop MHS Level 1B BUFR data

The availability of Metop-B products dropped below target in September as the instrument went to a fault mode due to a space weather event.



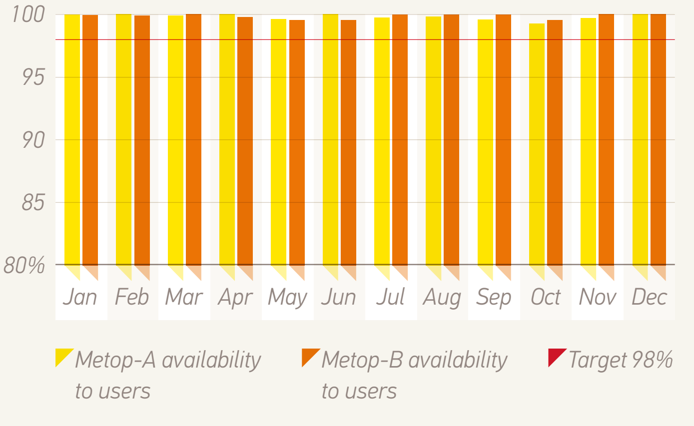
Availability of Meteosat IODC image data (57.5°E)

The availability of image data was impacted during critical eclipse conditions in February-March and August-September.



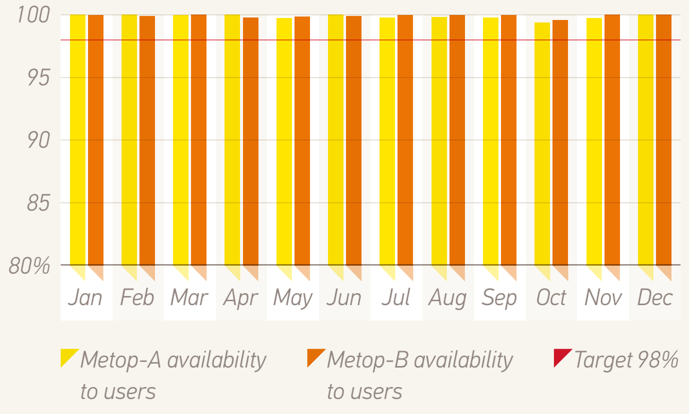
Availability of Metop ASCAT Level 1B data

Availability remained above target with an average availability of 99.79 percent for Metop-A and 99.84 percent for Metop-B.



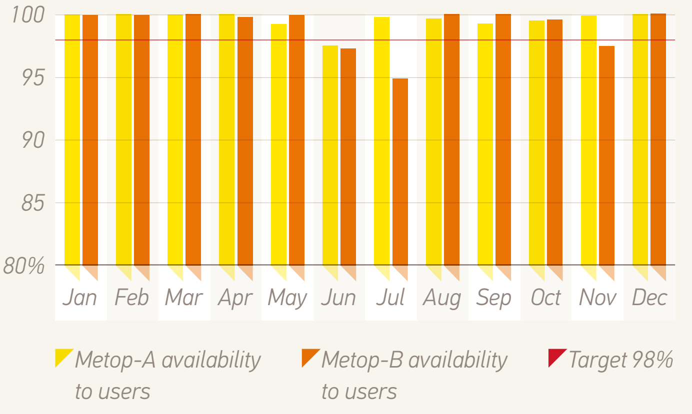
Availability of Metop AVHRR Level 1B data

Availability remained above target with an average of 99.89 percent availability for the prime service (Metop-B).



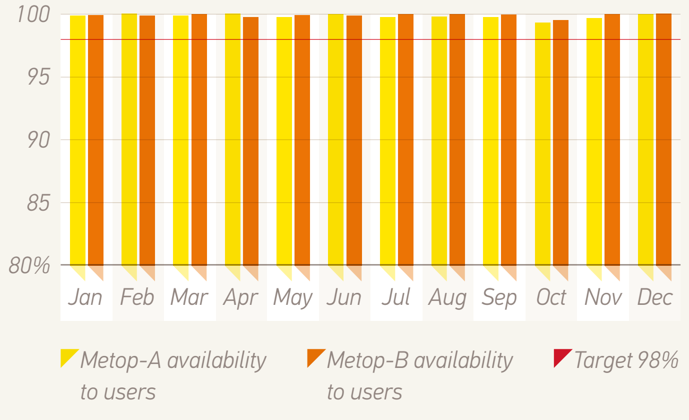
Availability of Metop IASI Level 1C BUFR data

The availability of products dropped slightly below target in June (Metop-A and -B), July and November (Metop-B) due to instrument anomalies caused by space weather events.



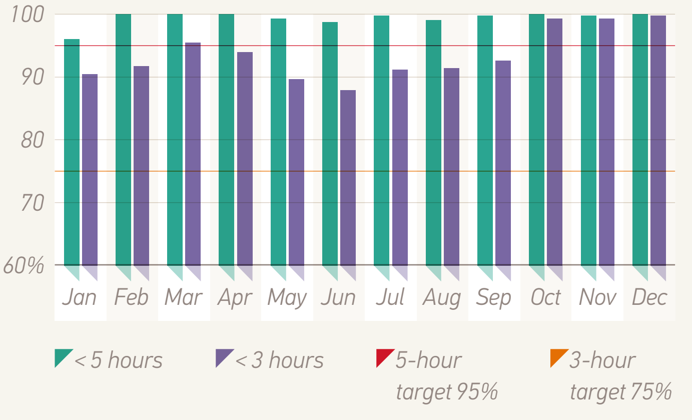
Availability of Metop GOME-2 Level 1B data

Availability remained above target with an average availability of 99.81 percent for Metop-A and 99.89 percent for Metop-B.



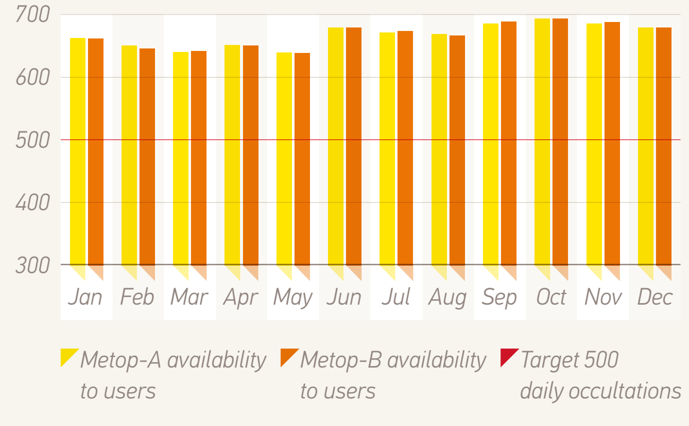
Availability of Jason-2 operational geophysical data records

Availability of Jason-2 data services remained above targets throughout 2015.



Availability of Metop GRAS Level 1B data

Availability remained above target, with an average of 667 daily occultations for both Metop-A and Metop-B satellites.

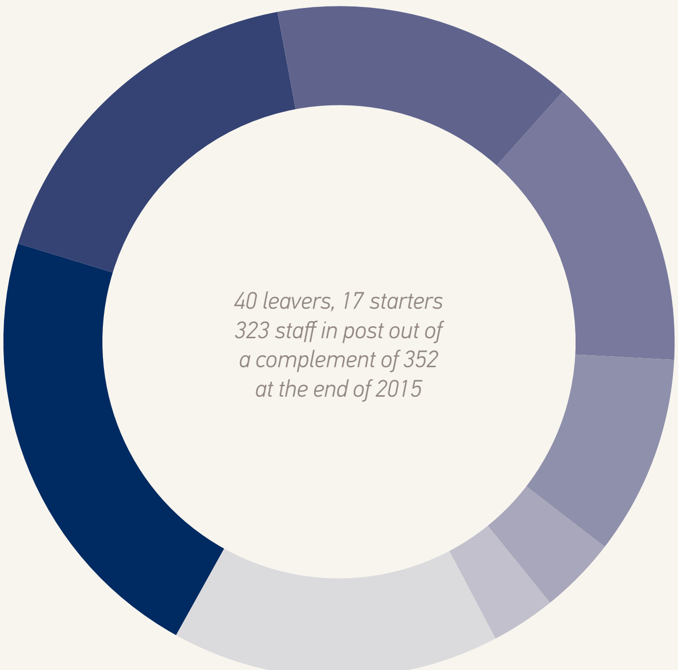


Key figures

Human resources

Staff in post

31 December 2015

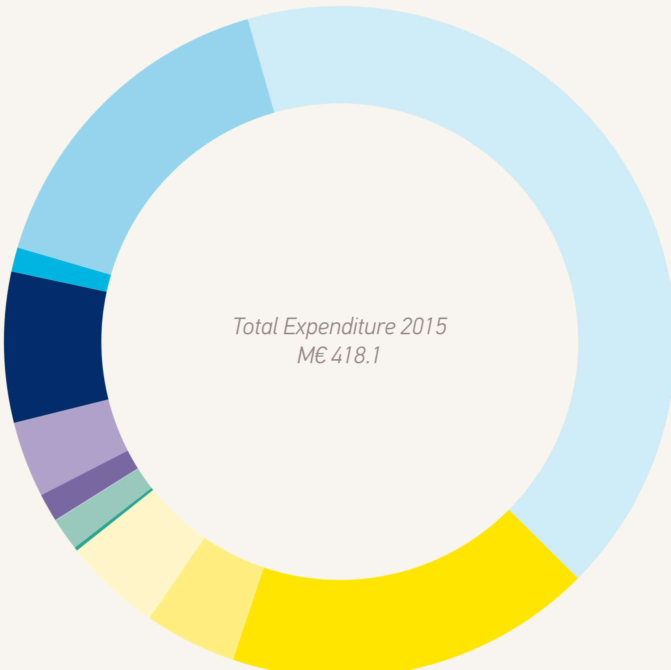


- *Germany* *21.63%*
- *France* *17.87%*
- *United Kingdom* *14.42%*
- *Italy* *14.11%*
- *Spain* *9.72%*
- *Netherlands* *3.45%*
- *Belgium* *3.13%*
- *Other Member States* *15.67%*

Financial information

Expenditure Budgets

Total Expenditure 2015



GB	*M€ 30.3*
MTP	*M€ 4.9*
MSG	*M€ 67.1*
MTG	*M€ 175.1*
EPS	*M€ 74.0*
EPS-SG PP	*M€ 18.6*
EPS-SG	*M€ 19.7*
Jason-2	*M€ 0.7*
Jason-3	*M€ 6.6*
Jason-CS	*M€ 0.1*
Sentinel-3	*M€ 5.8*
Copernicus	*M€ 15.2*

Financial information

EUMETSAT's 2015 Financial Statement has been audited by the Bundesrechnungshof. The following tables, in K€, are a summary of the information for 2015 included in those accounts.

Summary Revenue and Expenses

	KEUR
Revenue	
Member & Cooperating State Contributions	*351,651*
Other Contributions	*-5,244*
Tax on Salary	*6,749*
Sales Revenue	*2,017*
Other Revenue	*50,649*
Asset Impairments	*0*
Total Revenue	*405,822*
Expenses	
Costs for Human Resources	*130,090*
Other Operating Expenses	*9,248*
Satellites related costs	*22,474*
SAF, Prospective Activities, Research Fellows	*10,214*
Depreciation	*69,762*
Asset Impairments	*0*
Total Expenses	*241,788*
Revenue from Financial Operations	*292*
Net surplus for the period	*164,326*
Surplus to be distributed to Member and Cooperating States	*23,816*
Result Allocated to Reserves	*140,510*

Summary Balance Sheet

	KEUR
Assets	
Current Assets	*717,102*
Non-Current Assets	*2,012,967*
Total Assets	*2,730,069*
Liabilities	
Current Liabilities	*586,791*
Non-Current Liabilities	*194,526*
Total Liabilities	*781,317*
Total Net Assets/Equity	*1,948,752*
Total Liabilities & Net Assets/Equity	*2,730,069*

Member and Cooperating State Contributions

	KEUR
Member State Contributions	
Austria	*7,302*
Belgium	*9,260*
Bulgaria	*929*
Croatia	*1,066*
Czech Republic	*3,498*
Denmark	*6,178*
Estonia	*378*
Finland	*4,698*
France	*50,921*
Germany	*66,007*
Greece	*5,080*
Hungary	*2,280*
Iceland	*216*
Ireland	*3,329*
Italy	*38,987*
Latvia	*502*
Lithuania	*696*
Luxembourg	*710*
Netherlands	*14,866*
Norway	*8,936*
Poland	*8,733*
Portugal	*4,105*
Romania	*3,166*
Slovakia	*1,654*
Slovenia	*880*
Spain	*25,618*
Sweden	*9,738*
Switzerland	*11,879*
Turkey	*14,225*
United Kingdom	*45,452*
Total Member State Contributions	*351,289*
Cooperating State Contributions	
Serbia	*362*
Total Cooperating State Contributions	*362*
Total Member and Cooperating States Contributions	*351,651*

Appendix

Organisation

EUMETSAT Council

Prof A. Eliassen (Chairperson)
Norwegian Meteorological Institute

Mr I. Čačić (Vice-Chairperson)
Meteorological and Hydrological Service of Croatia

Policy Advisory Committee (PAC)

Dr M. Gray (Chairperson)
Mr H. Roozekrans (Vice-Chairperson)

Scientific and Technical Group (STG)

Mr S. Nilsson (Chairperson)
Mr M. Manso Rejón (Vice-Chairperson)

STG Operations Working Group (STG-OWG)

Mr P. Labrot (Chairperson)
Mr A. Dybbroe (Vice-Chairperson)

STG Science Working Group (STG-SWG)

Mr H. Roquet (Chairperson)
Ms I. Trigo (Vice-Chairperson)

Administrative and Finance Group (AFG)

Dr G. Seuffert (Chairperson)
Ms E. Lábó (Vice-Chairperson

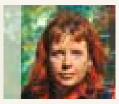
Data Policy Group (DPG)

Mr A. Rubli (Chairperson)
Mr S. Olufsen (Vice-Chairperson)

Financial Control
J. Travesi Garcia

Director-General
Alain Ratier

Chief Scientist
Dr K. Holmlund

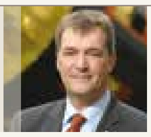


Communication and Information Services
C. Ritsert-Clark

Quality Management and Assessment
G. Bernède

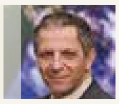
Strategy and International Relations
P. Counet

Director of Programme Preparation and Development
Clemens Kaiser



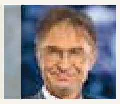
Geostationary Programmes
A. Schmid

Low Earth Programmes
Dr M. Cohen



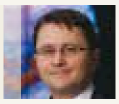
Director of Operations and Services to Users
Livio Mastroddi

Flight Operations
M. Williams



Real Time Services and System Operations
S. Burns

User Support and Climate Services
J. Saalmueller



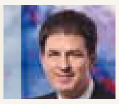
Copernicus Programme and Services Unit
D. Provost

Director of Administration
Silvia Castañer

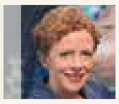
Contracts
E. Katsampani

Finance
P. Collin

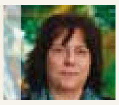
General Services
B. Kaufmann



Personnel
F. Brazil

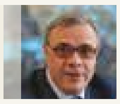


Legal Affairs
M. Lauth



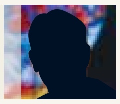
Director of Technical and Scientific Support
Yves Buhler

Process Assurance and Management Support
L. Sarlo



Generic Systems and Infrastructure
G. Mori

Remote Sensing and Products
Vacant



System Engineering and Projects
J. González Picazo

Information and Communication Technology Unit
O. Gümrah

Appendix

EUMETSAT Council Delegates and Advisors, 1 January 2016

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)*
Dr T. Spassova	*NIMH*
Ms M. Milenkova	*NIMH*

Croatia

Mr I. Čačić	*Meteorological and Hydrological Service (DHMZ)*
Mr D. Tomšić	*DHMZ*

Czech Republic

Mr V. Dvořák	*Czech Hydrometeor-ological Institute*

Denmark

Ms M. Thyrring	*Danish Meteorological Institute (DMI)*
Mr K. Hansen	*DMI*
Mr H.S. Andersen	*DMI*

Estonia

Mr T. Ala	*Estonian Environment Agency*
Mr P. Lagemaa	*Estonian Environment Agency*

Finland

Prof J. Damski	*Finish Meteorological Institute (FMI)*

France

Mr J.-M. Lacave	*Météo-France*
Mr O. Gupta	*Météo-France*
Ms I. Bénézeth	*Ministère de L' Ecologie, du Développement durable et de l'Energie*
Ms C. Carretta	*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*
Dr C. Brüns	*Deutsches Zentrum für Luft-und Raumfahrt (DLR)*

Greece

Dr I. Poulopoulos	*Hellenic National Meteorological Service*
Dr I. Matsangouras	*Hellenic National Meteorological Service*

Hungary

Ms K. Radics	*Hungarian Meteorological Service (OMSZ)*

Iceland

Dr A. Snorrason	*Icelandic Meteorological Office (IMO)*
Mr I. Kristinsson	*IMO*

Ireland

Mr L. Campbell	*Met Éireann*

Italy

Col. S. Cau	*Aeronautica Militare*
Dr P. Rosci	*Ufficio Generale per la Meteorologia (SMA-US-AM)*
Lt Col. P. Capizzi	*SM-CSA Department of Meteorology*
Dr F. Battazza	*Agenzia Spaziale Italiana*

Observers

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

Latvia

Ms D. Falkane	*Latvian Environment, Geology and Meteorology Centre*

Lithuania

Mr S. Balys	*Lithuanian Hydrometerological 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	*Norwegian Meteorological Institute (Met.no)*
Mr J. Sunde	*Met.no*
Mr S. Rasmussen	*Met.no*
Mr E. A. Herland	*Norwegian Space Centre*

Poland

Dr P. Lagodzki	*Institute for Meteorology and Water Management (IMGW)*
Dr P. Struzik	*IMGW*
Ms E. Wozniak-Dudzinska	*IMGW*

Portugal

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

Romania

Dr I. Sandu	*National Meteorological Administration (RNMA)*
Dr G. Stancalie	*RNMA*
Ms F. Georgescu	*RNMA*
Ms M. Mateescu	*RNMA*

Slovak Republic

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)*
Dr F. Belda	*AEMET*
Mr M. Palomares	*AEMET*
Mr J. Rodriguez	*AEMET*
Mr E. Vez	*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 A. Rubli	*MeteoSwiss*

Turkey

Mr I. Gunes	*Turkish State Meteorological Service*
Mr E. Erdi	*Turkish State Meteorological Service*

United Kingdom

Mr R. Varley	*Met Office*
Mr B. Truscott	*Met Office*
Mr S. Turner	*MetOffice*

Appendix

Participation in major external events in 2015

95th AMS Annual Meeting	4-8 January
7th Annual Conference on European Space Policy	27-28 January
3rd Copernicus User Forum	29 January
XVIst session of RA I and 3rd session of AMCOMET	10-14 February
Conference on “Copernicus - the road to economic development”	26-27 February
30th meeting of the CEOS Strategy Implementation Team	31 March – 1 April
Community Satellite Processing Package and International MODIS/AIRS Processing Package Users' Group meeting	13-16 April
4th Copernicus User Forum	15 April
EU-Africa Space Troika meeting	20 April
2015 NOAA Satellite Conference	27 April – 1 May
4th MESA Project Steering Committee meeting	27-30 April
36th International Symposium on Remote Sensing of Environment	10-15 May
43rd CGMS Plenary Session	18-22 May
17th WMO Congress	27-29 May
5th Copernicus User Forum	3 June
Roundtable on climate and satellites	17 June
EU-ESA-China Dialogue on Space Technology and Cooperation	19 June
International Science Conference on “Our Common Future under Climate Change”	7-10 July
MESA Forum	31 August -04 September
Meeting of the CEOS Strategy Implementation Team	16-18 September
17th European Interparliamentary Space Conference	21-22 September
6th Copernicus User Forum	25 September
Meteorological Technology World Expo	13-15 October
Scatterometer workshop organised by ISRO	28-29 October
World Radiocommunication Conference 2015 (WRC-15)	2-27 November
PV 2015 Conference “Ensuring Long-Term Data Preservation and Adding Value to Scientific and Technical Data”	3-5 November
29th CEOS Plenary meeting	4-6 November
Meeting of the Global Framework for Climate Services (GFCS) Africa, Caribbean, Pacific (ACP) Task Team	4-6 November
Meeting of European customers of European launch service	9 November
GEO-XII Plenary and Ministerial Summit	9-13 November
Sixth Asia/Oceania Meteorological Satellite Users' Conference	9-13 November
1st KMA International Meteorological Satellite Conference	16-18 November
European Parliament Sky and Space Intergroup debate - “To COP21 and beyond: the space contribution to the fight against climate change”	18 November
7th Copernicus User Forum	20 November
Informal Space Council meeting, organised by the Luxembourg EU Presidency	30 November
21st Conference of the Parties to the UN Framework Convention on Climate Change (COP21)	30 November – 12 December
8th Meeting of the US-EU Dialogue on Civil Space Cooperation	10 December

Scientific and technical publications in 2015

*Ardauy, P.E., Gail, W., Hooke, W., Macauley, M., Marley, S., Puschell, J., **Schmetz, J.**, Velden, C., 2015. Optimizing Requirements for the Next Generation of Satellite Observing Systems. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

*Barbosa, H., **Nietosvaara, V.**, Silva, L., 2015. Satellite observations of Hurricane Bill (2009): links to African easterly waves and precipitation patterns. 95th AMS Annual Meeting, Phoenix, United States, Americ. Met .Soc.*

*Boylan, P., Wang, J., Cohn, S., **Hultberg, T.**, **August, T.**, Fetzer, E., Maddy, E., Wong, S., 2015. Evaluation of surface-based inversions from ERA-Interim and satellite data over Antarctica using dropsonde data from the 2010 Concordiasi Experiment. EGU General Assembly 2015, Vienna, Austria, Eur. Geophys. Union.*

*Bruniquel, J., Féménias, P., Goryl, P., **Bonekamp, H.**, 2015. Sentinel-3 Mission Performance Center: paving the way of high-quality controlled data. EGU General Assembly 2015, Vienna, Austria, Eur. Geophys. Union.*

*Carbajal Henken, C., Doppler, L., **Lindstrot, R.**, Preusker, R., Fischer, J., 2015. Exploiting the sensitivity of two satellite cloud height retrievals to cloud vertical distribution. Atmos. Meas. Tech. 8, 3419–3431.*

*Cotton, P., Andersen, O., Boy, F., Cancet, M., Cipollini, P., Dinardo, S., Gommenginger, C., Egido, A., Fernandes, M.J., Nilo Garcia, P., Lucas, B., Moreau, T., Naeije, M., **Scharroo, R.**, Stenseng, L., Benveniste, J., 2015. Improved Oceanographic Measurements from SAR Altimetry: Results and Scientific Roadmap from the ESA Cryosat Plus for Ocean Project. Sentinel-3 for Science Workshop, Venice, Italy, ESA.*

***Courcoux, N.**, Schröder, N., 2015. The CM SAF ATOVS tropospheric water vapour and temperature data record: overview of methodology and evaluation. Earth Syst. Sci. Data Discuss. 8, 127–171.*

*Culverwell, I., Lewis, H., Offiler, D., **Marquardt, C.**, Burrows, C., 2015. The radio occultation processing package, ROPP. Atmos. Meas. Tech. 8, 1887–1899.*

*De Chiara, G., English, S., Janssen, P., Bidlot, J., **Figa-Saldana, J.**, **Anderson, C.**, Bonavita, M., 2015. Status of Scatterometer Winds in the ECMWF System: Operational and Research Activities. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

*Dutour Sikirić, M., Janeković, I., **Tomažić, I.**, Kuzmić, M., Roland, A., 2015. Comparison of ALADIN and IFS model wind speeds over the adriatic [Usporedba ALADIN i IFS Modela brzine vjetra preko Jadrana]. Acta Adriatica 56, 67–82.*

*Fenoglio-Marc, L., Buchhaupt, C., Dinardo, S., **Scharroo, R.**, Benveniste, J., Becker, M., 2015. The German Bight: Preparing for Sentinel-3 with a cross-validation of SAR and PLRM Cryosat-2 altimeter data. Sentinel-3 for Science Workshop, Venice, Italy, ESA.*

*Fenoglio-Marc, L., Dinardo, S., **Scharroo, R.**, Roland, A., Dutour Sikiric, M., Lucas, B., Becker, M., Benveniste, J., Weiss, R., 2015. The German bight: A validation of CryoSat-2 altimeter data in SAR mode. Adv. Space Res. 55, 2641–2656.*

*Fenoglio-Marc, L., **Scharroo, R.**, Annunziato, A., Mendoza, L., Becker, M., Lillibridge, J., 2015. Cyclone Xaver seen by geodetic observations. Geophys. Res. Lett. 42, 9925–9932.*

*Garcia, O., Schneider, M., **August, T.**, Hase, F., Blumenstock, T., Sepulveda, E., **Hultberg, T.**, Sanroma, M., Gomez-Pelaez, A., Cuevas, E., Romero-Campos, P., 2015. Towards a Near Operational Validation of IASI level 2 trace gas products. ATMOS 2015, Heraklion, Greece, ESA.*

*Garcia, O., Sepulveda, E., Schneider, M., Hase, F., **August, T.**, Blumenstock, T., Kühl, S., Munro, R., Gomez-Pelaez, A., **Hultberg, T.**, Redondas, A., Barthlott, S., Wiegele, A., Gonzalez, Y., Sanroma, E., 2015. Consistency and quality assessment of the Metop-A/IASI and Metop-B/IASI operational trace gas products (O3, CO, N2O, CH4 and CO2) in the Subtropical North Atlantic. Atmos. Meas. Tech. Discuss. 8, 13729–13778.*

***Gigli, S.**, **Lamarre, D.**, **Coppens, D.**, **Stuhlmann, R.**, **Tjemkes, S.**, 2015. The MTG Infrared Sounder Functional Chain. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

*Grossi, M., Valks, P., Loyola, D., Aberle, B., Slijkhuis, S., Wagner, T., **Beirle, S.**, **Lang, R.**, 2015. Total column water vapour measurements from GOME-2 MetOp-A and MetOp-B. Atmos. Meas. Tech. 8, 1111–1133.*

***Grzegorski, M.**, **Munro, R.**, **Lang, R.**, **Poli, G.**, **Holdak, A.**, 2015. Retrieval of aerosol optical properties over land using PMAp. EGU General Assembly 2015, Vienna, Austria, Eur. Geophys. Union.*

***Gutiérrez, R.**, **Watts, P.**, **Steenbergen, T.**, **Risquez, D.**, **Patterson, T.**, **Just, D.**, **Ledez, C.**, **Fowler, G.**, **Stuhlmann, R.**, 2015. MTG-FCI Level 1C Dataset for User Format Familiarisation. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

*Höschen, H., Schröder, M., Lockhoff, M., **August, T.**, **Hultberg, T.**, Fennig, K., 2015. An Evaluation of the Difference in Quality between Water Vapor Profiles from ATOVS and IASI+MW. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

*Iwanski, R., Mäkelä, A., Punkka, A., Poelman, D., Wapler, K., **Grandell, J.**, **Stuhlmann, R.**, 2015. Experimental MTG Lightning Imager proxy data at National Meteorological Services Enhancing the MTG LI User Readiness. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

*Jia, Y., Pei, Y., Savi, P., **Notarpietro, R.**, 2015. Soil moisture retrieval from GNSS-R signals. Int. Conf. Electromagnetics in Adv. Appl., Torino, Italy.*

***Keegan, C.**, **Schlüssel, P.**, **Lean, D.**, 2015. EPS Second Generation. CSPP/IMAPP Users' Group Meeting, Darmstadt, Germany, EUMETSAT.*

***Klinc, M.**, **Pessina, S.**, 2015. Optical Tracking in Support to Routine Operations and Conjunctions Analysis for the EUMETSAT Geosynchronous Fleet. 25th Int. Symp. on Space Flight Dynamics (ISSFD), Munich, Germany.*

*Kocsis, Z., Putsay, M., Bölöni, G., Szücs, M., Szenyan, I., **König, M.**, 2015. Impact of background Model to the MSG Global Instability Indices (GII) Processing. EUMETSAT Meteorol. Satellite Conf., Toulouse, France, EUMETSAT.*

***Kokhanovsky, A.**, 2015. Remote sensing of snow albedo, grain size and pollution from space, in: Remote Sensing of the Cryosphere. John Wiley.*

Appendix

Scientific and technical publications in 2015

***Kokhanovsky, A.**, 2015. The modern aerosol retrieval algorithms based on the simultaneous measurements of the intensity and polarization of reflected solar light: a review. Front. Envir. Sci.*

***Kokhanovsky, A.**, Davis, A., Cairns, B., Dubovik, O., Hasekamp, O., Sano, I., Mukai, S., Rozanov, V., Litvinov, P., Lapyonok, T., Kolomiets, I., Oberemok, Y., Savenkov, S., Martin, W., Wasilewski, A., Di Noia, A., Stap, F., Rietjens, J., Xu, F., Natraj, V., Duan, M., Cheng, T., **Munro, R.**, 2015. Space-based remote sensing of atmospheric aerosols: The multi-angle spectro-polarimetric frontier. Earth-Sci. Rev. 145, 85–116.*

***Kokhanovsky, A.**, **Munro, R.**, 2015. Cloud retrieval algorithm for the imaging spectro-polarimeter on board. EGU General Assembly 2015, Vienna, Austria, Eur. Geophys. Union.*

***Kwiatkowska, E.**, Ruddik, K., Ramon, D., Vanhellemont, Q., Brockmann, C., Lebreton, C., **Bonekamp, H.**, 2015. Ocean colour products from geostationary platforms, opportunities with Meteosat Second and Third Generation. Ocean Sci. Discuss. 12, 3143–3167.*

*Langen, J., Ingmann, P., Meijer, Y., **Munro, R.**, **Retscher, C.**, 2015. Copernicus Sentinel-5: Long-Term Global Monitoring of Atmospheric Composition. ATMOS 2015, Heraklion, Greece, ESA.*

*Larsson, R., Rayer, P., Saunders, R., Bell, W., Booton, A., Buehler, S., Eriksson, P., **John, V.**, 2015. The high altitude SSMIS channels: Validation of fast radiative transfer simulations by comparison with line-by-line simulations. EGU General Assembly 2015, Vienna, Austria, Eur. Geophys. Union.*

***Lattanzio, A.**, Fell, F., Bennartz, R., Trigo, I., **Schulz, J.**, 2015. Quality assessment and improvement of the EUMETSAT Meteosat Surface Albedo Climate Data Record. Atmos. Meas. Tech. 8, 4561–4571.*

*Lelli, L., Mei, L., Rozanov, V., Vountas, M., **Kokhanovsky, A.**, Jaeger, M., Burrows, J., 2015. Algorithm Development and Verification of Aerosol and Cloud Products for Sentinel-5 Precursor. ATMOS 2015, Heraklion, Greece, ESA.*

*Le Traon, P.Y., Antoine, D., Bentamy, A., **Bonekamp, H.**, Breivik, L.A., Chapron, B., Corlett, G., Dibarboure, G., DiGiacomo, P., Donlon, C., 2015. Use of satellite observations for operational oceanography: recent achievements and future prospects. J Oper. Oceanogr. 8, S12–S27.*

*Levinsen, J., Khvorostovsky, K., **Ticconi, F.**, Shepherd, A., Forsberg, R., Sorensen, L., Muir, A., Pie, N., Flament, T., Hurkmans, R., Moholdt, G., Gunter, B., Lindenbergh, R., Kleinherenbrink, M., 2015. ESA ice sheet CCI: derivation of the optimal method for surface elevation change detection of the Greenland ice sheet - round robin results. Int. J. Remote Sens. 36, 551.*

***Marbach, T.**, **Riedi, J.**, **Lacan, A.**, **Schlüssel, P.**, 2015. The 3MI Mission: Multi-Viewing, -Channel – Polarisation Imager of the EUMETSAT Polar System – Second Generation (EPS-SG) dedicated to aerosol and cloud monitoring. SPIE Proceed. 9613.*

*Mariani, S., Casaioli, M., Lanciani, A., Flavoni, S., **Accadia, C.**, 2015. QPF performance of the updated SIMM forecasting system using reforecasts. Meteorol. Appl. 22, 256–272.*

*Mukai, S., Sano, I., Muka, M., **Kokhanovsky, A.**, 2015. Detection of haze and/or cloud. EGU General Assembly 2015, Vienna, Austria, Eur. Geophys. Union.*

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Appendix

Glossary of terms and acronyms

3MI	Multi-viewing, -channel, -polarisation Imaging (Metop-SG A instrument)
AAPP	ATOVS and AVHRR Pre-processing Package software
ACMAD	African Centre of Meteorological Applications for Development
ACP	African, Caribbean and Pacific Group of States
ADA	Anarctic Data Acquisition Service (provided through NOAA)
AEMET	Agencia Estatal de Meteorología
AfDB	African Development Bank
AIRS	Advanced Infrared Sounder
AMCOMET	African Conference of Ministers in Charge of Meteorology
AMS	American Meteorological Society
AMSU	Advance Microwave Sounding Unit (Metop instrument)
AMV	Atmospheric Motion Vectors
ARGOS	A system for data collection and localisation via satellite from the polar orbit (France)
ASCAT	Advanced Scatterometer (Metop instrument)
ATBD	Algorithm theoretical basis documents
AUC	African Union Commission
AVHRR	Advanced Very High Resolution Radiometer (Metop instrument)
BUFR	Binary universal form for the representation of meteorological data
CAESAR	Collision risks mitigation service provided by CNES
CAMS	Copernicus Atmosphere Monitoring Service
CDA	Core Data Acquisition stations (Metop)
CDOP-3	Third Continuous Development and Operations Phase (of SAFs)
CDR	Climate data record
CEEDA	Certified Energy Efficient Datacentre Award
CEOS	Committee on Earth Observation Satellites
CF	Central facility (MSG)
CGMS	Coordination Group for Meteorological Satellites
CLS	Collecte Localisation Satellites
CMA	China Meteorological Administration
CMEMS	Copernicus Marine Environment Monitoring Service
CM SAF	SAF on Climate Monitoring
CNES	Centre National d'Etudes Spatiales (French space agency)
COP21	21st Conference of the Parties to the UN Framework Convention on Climate Change
Copernicus	Earth Observation Programme of the European Union
CORE-CLIMAX	Coordination of Earth Observation Data Validation for Reanalysis (EU/FP7 project)
CrIS	Cross-track Infrared Sounder (Suomi-NPP instrument)
CNMCA	Il Centro Nazionale di Meteorologia e Climatologia Aeronautica (Italian National Meteorological Centre)
CNSA	China National Space Administration
DG DEVCO	European Commission Directorate General for International Cooperation and Development
DG GROW	European Commission Directorate General for Internal Market, Industry, Entrepreneurship and SMEs
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
DMSP	Defense Meteorological Satellite Programme (USA)
DOI	Digital Object Identifier
DQS	Deutsche Gesellschaft zur Zertifizierung von Managementsystemen
EARS	EUMETSAT Advanced Retransmission Service
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential climate variable
EDF	European Development Fund
EISC	European Inter-parliamentary Space Conference
Elektro	Russian Geostationary meteorological satellite
EMI	European Meteorological Infrastructure
Envisat	ESA Earth observation satellite (mission ended 2012)
EPS	EUMETSAT Polar System
EPS-SG	EPS Second Generation
ERA-CLIM	European Reanalysis of Global Climate Observations (EU/FP7 project)
ERP	Enterprise Resource Planning
ESA	European Space Agency
ESOC	European Space Operations Centre (ESA)
EU	European Union
EUMETCast	EUMETSAT's satellite data broadcast service
FCI	Flexible Combined Imager
FIDUCEO	Fidelity and uncertainty in climate data records from Earth Observations (EU Horizon2020 project)
FOS	Flight operations segment (Sentinel-3)
FP7	European Framework Programme 7
FRP	Fire Radiative Power
FY	Fengyun (Chinese meteorological satellites)
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
GERB	Geostationary Earth Radiation Budget (MSG instrument)
GFCS	Global Framework for Climate Services
GIO	GMES Initial Operations programme
GNSS	Global Navigation Satellite System
GOES	Geostationary Operational Environmental Satellite (USA)
GOME-2	Global Ozone Monitoring Experiment-2 (Metop instrument)
GRAS	GNSS Receiver for Atmospheric Sounding (Metop instrument)
H SAF	SAF on Support to Operational Hydrology and Water Management
Himawari	Japanese geostationary meteorological satellite
HIRS	High-resolution Infrared Radiation Sounder (Metop instrument)
HY	Haiyang (Chinese oceanographic satellites)
IASI	Infrared Atmospheric Sounding Interferometer (Metop instrument)
IASI-NG	IASI Next Generation (Metop-SG A instrument)

ICEED	Information Conference of Eastern European Directors of National Meteorological and Hydrological Services
ICI	Ice Cloud Imager (Metop-SG B instrument)
ICDR	Interim climate data record
IDPF	Image data processing facility (MTG)
IJPS	Initial Joint Polar System
INPE	National Institute for Space Research (Brazil)
INSAT	Indian National Satellite System
IODC	Indian Ocean Data Coverage
IOS	In-orbit storage
IRAS	Infrared Atmospheric Sounder (FY-3C instrument)
IRS	Infrared Sounder (MTG-S instrument)
ISRO	Indian Space Research Organisation
ITT	Invitation to tender
IV&V	Integration verification and validation
Jason-2	Ocean altimeter satellite (NASA/CNES/NOAA/EUMETSAT)
Jason-3	Ocean altimeter satellite (NASA/CNES/NOAA/EUMETSAT/EU)
Jason-CS	Jason Continuity of Service, ocean altimeter satellite (NASA/ESA/NOAA/EUMETSAT/EU)
JAXA	Japan Aerospace Exploration Agency
JMA	Japanese Meteorological Agency
JOMP	Joint Operations Management Plan
JPS	Joint Polar System
JSpOC	Joint Space Operation Center (US Air Force)
KMA	Korea Meteorological Agency
LATMOS	Laboratoire Atmosphères, Milieux Observations Spatiales, University of Versailles
LEGOS	Laboratoire d'Études en Géophysique et Océanographie Spatiales, Toulouse
LEOP	Launch and early operations phase
LI	Lightning Imager (MTG-I instrument)
LSA SAF	SAF on Land Surface Analysis
MAPS	MTG African Preparation Study
MCO	Mission control and operations (EPS-SG)
MESA	Monitoring of Environment and Security in Africa
Meteosat	EUMETSAT geostationary meteorological satellite
Metop	EUMETSAT polar-orbiting meteorological satellite (EPS)
MHS	Microwave Humidity Sounder (Metop instrument)
MMDS	EUMETSAT multi-mission real-time data dissemination system
MODIS	Moderate Resolution Imaging Spectroradiometer (NASA instrument)
MOF	Mission operations facility (MTG)
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
MTG-I	MTG imaging satellite
MTG-S	MTG sounding satellite
MWI	Microwave Imaging for precipitation (Metop-SG B instrument)
MWS	Microwave Sounding (Metop-SG A instrument)
NASA	National Aeronautics and Space Administration (US)
NMHS	National Meteorological and Hydrological Service
NMS	National Meteorological Service

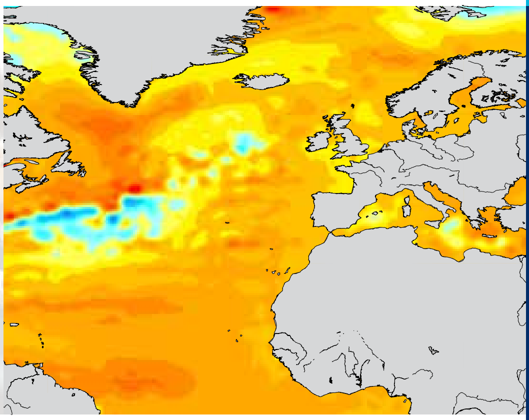
NOAA	National Oceanic and Atmospheric Administration (US)
NOMEK	Nordic Meteorological Post-Graduate Education
NWC	Nowcasting
NWC SAF	SAF on Nowcasting and Very Short Range Forecasting
NWP	Numerical Weather Prediction
NWP SAF	SAF on Numerical Weather Prediction
O3M SAF	SAF on Ozone and Atmospheric Chemistry Monitoring
OCA	Optimal Cloud Analysis
Oceansat	Indian ocean remote sensing satellite (ISRO)
OGSRR	Overall Ground Segment Requirements Review
ORR	Operational Readiness Review
OSAT	On-site acceptance test
OSI SAF	SAF on Ocean and Sea Ice
OVT	Operations validation test
PDAP	Payload data acquisition and processing (EPS-SG)
PDGS	Payload data ground segment (Sentinel-3)
PDR	Preliminary Design Review
PFS	Product format specification
PGS	Product generation specification
PMAp	Metop multi-sensor aerosol optical depth product
PURE	Partnership for User Requirements Evaluation (EU/FP7 project)
RAL	Rutherford Appleton Laboratory
QuikSCAT	NASA satellite (mission ended 2009)
RA-1	WMO Regional Association 1
RAIDEG	RA-1 Dissemination Expert Group
RARS	Regional Advanced Retransmission Service
RMF	Resource Management Framework
RO	Radio Occultation (Metop-SG instrument)
ROM SAF	SAF on Radio Occultation Meteorology
ROPP	Radio Occultation Processing Package
Roshydromet	Russian Federal Service for Hydrometeorology and Environmental Monitoring
RSS	Rapid Scan Service (MSG)
RTTOV	Radiative Transfer for TOVS (TIROS Operational Vertical Sounder)
SADC	Southern African Development Community
SAF	Satellite Application Facility
SARAH	Surface Solar Radiation Data Set - Heliosat
SATSIM	Satellite simulator (MTG)
SCOPE-CM	Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (WMO)
Seawinds	Scatterometer on QuikSCAT (NASA)
SEEMET	South-Eastern Europe METeorological course
Sentinel-3	Copernicus satellite
SEVIRI	Spinning Enhanced Visible and Infrared Imager (MSG)
SIDS	Small Island Developing States
SLAGEE	Satellite Applications in Land Surface Analysis, Group for Eastern Europe
SMAP	Soil Moisture Active Passive mission (NASA)
SSMIS	Special Sensor Microwave Imager Sounder (US instrument)
SST	Sea surface temperature
STM	Structure and Thermal Model

Glossary of terms and acronyms

SBSTA-43	*43rd Session of the UN's Subsidiary Body for Scientific and Technical Advice*
Suomi-NPP	*Suomi National Polar-orbiting Partnership (NASA/NOAA)*
SVT	*System validation test*
TCDR	*Thematic climate data record*
TED	*Technology, Entertainment and Design*
TIB	*Technical Infrastructure Building*
TIROS	*Television Infrared Observation Satellite*
TT&C	*Telemetry tracking and control*
UNS	*User Notification Service*
UPS	*Uninterruptable Power Supply*
UTC	*Coordinated universal time*
VAFB	*Vandenberg Air Force Base (USA)*
VASS	*Vertical Atmospheric Sounding Service*
VII	*Visible-Infrared Imaging*
VIIRS	*Visible Infrared Imaging Radiometer Suite (US instrument)*
Vlab	*Virtual Laboratory for Training and Education in Satellite Meteorology (WMO)*
VO	*Virtual Observatory*
WMO	*World Meteorological Organization*
WMS	*Web Map Service*

"Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making"

Article 7.7c of the Paris Agreement



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