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STATUS OF THE CURRENT AND FUTURE ESA EARTH OBSERVATION MISSIONS AND PROGRAMMES

CGMS is informed of the status of the current European Space Agency Earth Observation missions. Two of them, MSG and MetOp are in co-operation with EUMETSAT. The Gravity field and steady-state Ocean Circulation Explorer, GOCE, the first Explorer satellite launched on 17 March 2009, ended its mission in November 2013, exceeding its predicted lifetime. The SMOS satellite was launched on 2 November 2009. All reprocessed Level 1 and 2 data are available from the ESA Cal/Val portal since mid-March 2012. The CryoSat-2 satellite was launched on 8 April 2010. Release of systematic CryoSat products (Level 1b and 2) to scientific community is going on. The Proba-V small satellite was launched on 7 May 2013. Its coarse resolution imager continues the data acquisition of the Vegetation payload on-board SPOT-4 and 5. The Swarm satellites were launched on 22 November 2013. About 4,000 data user projects worldwide use data from the ESA EO missions and this number is increasing further. The total volume of ESA EO mission data exceeds 100 Terabytes per year.

CGMS is further informed of the status of the future European Space Agency Earth Observation missions. Two of them, MTG and Post EPS (now EPS SG) are in co-operation with EUMETSAT. The Living Planet Programme has three lines of implementation: Earth Explorer satellites, Earth Watch satellites plus services and applications demonstration. Progress in the preparation of the forthcoming Explorer missions ADM-AeolusS, EarthCARE and BIOMASS is described. Copernicus represents the major new initiative of European efforts in Earth Observation. The start of the Copernicus pre-operational services took place in 2008, with the provision of the relevant data. The first Copernicus dedicated satellite (“Sentinel-1A”) was launched on 3 April 2014, other Sentinels will follow in 2015 onwards. Related activities are under way at all stages within the Agency, the EC and at Member States level.

CGMS is also informed of the status of the Earth Watch Programme Element, Global Monitoring of Essential Climate Variables (also known as the ‘ESA Climate Change Initiative’ or CCI). The CCI Programme has continued to progress well. The thirteen existing project teams have made significant progress on algorithm development and on specifying a future operational system. The Programme achieved its phase 1 objectives end-2013 and continues in Phase 2 starting since early 2014.

Status of the Current and Future ESA Earth Observation Missions and Programmes

1 INTRODUCTION

This paper provides information on the status of the current and future European Space Agency Earth Observation missions. ESA's Living Planet Programme comprises a science and research element, which includes the Earth Explorer missions, and an Earth Watch element, which is designed to facilitate the delivery of Earth observation data for use in operational services. Earth Watch includes the well-established meteorological missions with the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat). These missions (MSG, MTG, MetOp and EPS-SG) are not dealt with in this report.

Current in-flight missions include three R&D satellites from the Earth Explorer series, and two small satellites of the Proba series. The status of future Earth Explorer and Earth Watch missions is presented, as well as the progress in the development of the ESA Climate Change Initiative (CCI).

Although the past ESA ERS-1, ERS-2, Envisat and GOCE missions are no longer operating, users can easily access the large ESA archives to get products generated from their respective instrument complements.

2 CURRENT ESA SATELLITE SYSTEMS

Satellites	Equator Crossing Time Altitude	Launch date	Access to data or products	Instruments	Status, applications and other information
PROBA-1	8:30 (D) 615 km	22/10/2001	Earthnet on line	CHRIS, SREM	The orbit is drifting from the original 10:30 desc. ECT.
SMOS	06:00 (A) 755 km	2/11/2009	SMOS data centres	MIRAS (Microwave Imaging Radiometer using Aperture Synthesis), GPS, STA	L-band radiometer for salinity & soil moisture observation
PROBA-2	06:00 (A) 730 km	2/11/2009	Earthnet on line	SWAP, LYRA, TPMU, DSLP	2nd flight unit of the PROBA programme. Main mission: space weather
CryoSat-2	717 km (92° incl.)	8/04/2010	Earthnet on line	SIRAL (SAR Interferometric Radar Altimeter), DORIS, LRR	Polar ice monitoring
PROBA-V	10:30 (D)	5/07/2013	Commissioning	VEGETATION-P	2nd flight unit of the PROBA programme. Main mission: vegetation monitoring
Swarm A & C	87.4°	22/11/2013	Commissioning	ACC, SM, EFI (SWARM), GPS (ESA), LRR (DLR), STR (SWARM), VFM	Planned commissioning until mid-April 2014
Swarm B	88°	22/11/2013	Commissioning		

2.1 Status of current Earth Explorer satellites

Three ESA Earth Explorer missions are currently in operation, namely SMOS (launched in 2009), CryoSat-2 (launched in 2010) and Swarm (launched in 2013). All three missions, as well as GOCE, have provided outstanding results of interest to the meteorological and climate research communities at large.

2.1.1 GOCE

In orbit from March 2009 to November 2013, the Gravity field and steady-state Ocean Explorer (GOCE) measured the Earth's gravity field with unprecedented detail to advance our understanding of ocean circulation, sea-level change and Earth-interior processes.

2.1.1.1 Status of spacecraft

GOCE successfully completed its last measurement cycle at an altitude of 223.88 km on 19 October 2013. The satellite re-entered into the Earth atmosphere on 11 November 2013. No damage or casualties due to debris have been reported. The GOCE spacecraft was indeed working very well until just minutes before re-entry.

2.1.1.2 Performance and results

Data products at all levels are routinely generated and are of excellent quality. A detailed review of the Level 2 products (gravity field models and related functions, i.e. gravity gradient grids, precise orbits, etc.) has demonstrated the compliance of GOCE with its mission requirements. All Level 1 data up to 1st October 2013, which marks the last instrument calibration activity, were processed and released both to the user community and the Level 2 processing facility. Production of Level 2 is ongoing and expected to finish by Q2 2014. During the remainder of the nominal mission and also after the start of the orbit decay on 21 October data generation continued nominally up to the satellite re-entry on 11 November. Fully-fledged gravity field (Level 2) products based on re-processed gradiometer Level 1b data, the so-called Release 4 models based on data acquired until summer 2012, i.e. until the start of the initial orbit lowering, were released in 2013 Q1. This fourth generation set of gravity field models from the mission marked a cornerstone delivery of the mission. Release 5 models, which will be all-encompassing models including all data acquired by GOCE during its active life, including the very low orbit data, are expected around mid-2014. A GOCE User Workshop will be held in autumn 2014.

2.1.2 SMOS

Launched on 2 November 2009, SMOS is the second Earth Explorer Opportunity mission to be developed as part of ESA's Living Planet Programme. SMOS carries a novel microwave sensor to capture images of brightness temperature, from which information on soil moisture and ocean salinity is derived. The data acquired from the SMOS mission will lead to better weather and extreme-event forecasting, and contribute to seasonal-climate forecasting.

2.1.2.1 Status of spacecraft

The platform is operated under CNES responsibility. No major anomalies or failures have been identified since launch, and the same applies for the interfaces to the payload. The 4th ESA-CNES Annual Review in October 2013 confirmed that after 4 years in orbit the spacecraft platform is operating nominally, with all sub-systems showing very good performance and no signs of degradation. The remaining amount of propellant is sufficient to maintain spacecraft operations for another 120 years! Due to the implemented mitigation strategies, the performance of the instrument continues to be excellent, accounting for 99.92% of availability for generating observation data. The cumulative data lost since 1 May 2010 hence amounts to 0.107% and the degraded data amounts to 1.26%, with an overall mission performance of 98.63%.

2.1.2.2 Performance and results

In general, the RFI situation in particular over Europe continues to improve. ESA's EO frequency management group works in close cooperation with the national spectrum management authorities in order to improve the SMOS RFI situation.

The NRT light data product is regularly distributed by ESA to the WMO's Global Telecommunication System (GTS) network, with the UK Met Office injecting the data into the system, as well as to EUMETSAT's EUMETCast system. This direct link into the data collection points for operational agencies will increase the uptake of SMOS data in this community.

The reprocessed level 2 ocean salinity data has been made available to the user community in April 2013. The 2nd mission data reprocessing campaign is foreseen to commence at the beginning of 2014.

Amongst the many outstanding results already achieved by SMOS, of particular interest are:

- The observation of hurricane Sandy and measurements of surface wind speed in stormy conditions;
- The monitoring of warm, salty eddies being carried north by the Gulf Stream and colder, less-salty water transported southward along North America's east coast by the Labrador Current, mixing the water masses off Cape Hatteras;
- The monitoring of wetlands and their relation with methane emissions;
- The thinning of ice in marginal, seasonal ice zones;
- The comparison between SMOS and Aquarius data, the differences in the data yielding even more detail about variations in the salinity of the oceans;
- The contribution to improving flood forecasts as demonstrated with the extreme floods in Central Europe in June 2013;
- The tracking of tropical cyclone Phailin and typhoons Nari and Wipha in October 2013 in Asia, measurement of ocean surface winds under stormy conditions and readings of soil moisture when the storms hit land; and,

- Revealing remarkable similarities between spatial patterns observed by the GOCE gravity instrument and the SMOS radiometer beneath the Antarctic ice surface.

This variety of results shows off how versatile is the ESA SMOS mission.

2.1.3 CryoSat-2

ESA's Earth Explorer CryoSat-2 mission, launched on 8 April 2010, is dedicated to the precise monitoring of the changes in the thickness of marine ice floating in the polar oceans and variations in the thickness of the vast ice sheets that overlie Greenland and Antarctica.

2.1.3.1 Status of spacecraft

The overall performance of the CryoSat-2 mission during the past year was satisfactory. On October 2, 2013, the space segment experienced a major issue on the power subsystem, most likely caused by a radiation-induced damage and recovered with no major impact on science operations which resumed on 11 October. The ground segment performed well with no major anomalies.

During the reporting period, the end-to-end mission performance, namely the overall mission data return, taking into consideration the planned (0.4%) and the unplanned unavailability (10.0%) of the space and ground segment, was 89.6%. The end-to-end space and ground system's availability was 90.0%. The reduced performance was related due to the above-mentioned problem on the power subsystem. Since the start of the operational phase, the overall mission data return has been 97.7%.

2.1.3.2 Performance and results

The activities related to the release of the next ice product baseline (i.e. Baseline C) are progressing according to plan. The acceptance review of the intermediate baseline took place in mid-December 2013. The final release of Baseline C is planned for the second quarter of 2014.

The reprocessing campaign of all CryoSat data, acquired from July 2010 to January 2012, has been completed. The planning of the 2014 CryoSat-2 Validation Experiment (CryoVEx 2014) in the Arctic is well underway. The campaign implementation plan is being consolidated and options for an extra SMOS component (i.e. thin sea ice thickness) are being pursued. In collaboration with ESA, NASA is currently carrying out large-scale airborne field campaigns in the Arctic in March and April 2014 as part of the Operation IceBridge.

The first map of Arctic ice thickness was released in June 2011. Since then, important new results have been obtained with CryoSat-2:

- Three years of observations by ESA's CryoSat-2 satellite show that the West Antarctic Ice Sheet is losing over 150 cubic kilometres of ice each year – considerably more than what has so far been estimated. The imbalance in West Antarctica continues to be dominated by ice losses from glaciers flowing into the Amundsen

Sea. The increase of ice loss could be due to faster thinning, but that part of it may also be down to CryoSat-2's capacity to observe previously unseen terrain. Thanks to its novel instrument design and to its near-polar orbit, CryoSat-2 allows to survey coastal and high-latitude regions of Antarctica that were beyond the capability of previous altimeter missions, and these regions are crucial for determining the overall imbalance. The findings from a team of UK researchers at the Natural Environment Research Council's Centre for Polar Observation and Modeling were presented at the American Geophysical Union's Fall meeting.

- Until recently, altimeter measurements of sea-level height could only be made over open oceans because of land interference closer to the coast. In the last few years, however, progress has been made in reducing these effects, also thanks to the new generation of radar altimeters being heralded by CryoSat-2. This has allowed scientists not only to map water levels closer to the coast, but also profile land surfaces and inland water targets such as small lakes, rivers and their intricate tributaries.
- On 5 and 6 December 2013, a major storm passed through northern Europe causing flooding, blackouts, grounding flights and bringing road, rail and sea travel to a halt. CryoSat-2 measured the storm surge as high waters passed through the Kattegat Sea between Denmark and Sweden. Since the storm coincided with a period of high tides in the North Sea, there were extremely high sea levels – a 'storm surge'. In the UK, sea levels were at their highest since the 1953 North Sea Floods, while in Germany, parts of Hamburg were flooded. The observations matched predictions, helping to confirm model forecasts.

2.1.4 SWARM

Swarm is the third Earth Explorer Opportunity Mission of ESA's Earth Observation Envelope Programme. This constellation of three satellites is designed to measure the magnetic signals that stem from Earth's core, mantle, crust, oceans, ionosphere and magnetosphere.

2.1.4.1 Status of spacecraft

The three Swarm satellites were successfully launched on 22 November 2013 into their circular polar target orbit at 490 Km altitude. Soon after launch, the five meter long booms were all deployed flawlessly, the satellites were operating in fine pointing mode and synchronised with the UTC time through the use of the GPS signals. All instruments have been switched on. The commissioning phase is on-going with satellite manoeuvring, instrument "calibration", level 1b and PDGS verification.

Since the intensity of solar activity is currently lower than anticipated, the original plan of where to place the satellites at the beginning of science operations has been reviewed recently by the scientific community and experts in ESA. Two satellites are now being lowered to an altitude of about 462 km and an inclination of 87.35°. They will orbit almost side by side, about 150 km apart as they pass over the equator. Over the life of the mission they will both descend to about 300 km. The third satellite is being placed in a higher orbit of 510 km and at a different inclination of 87.75°, slightly closer to the pole.

2.1.4.2 Performance and results

After completion of the commissioning phase and Phase E1, the operational phase (Phase E2) will start. The overall status of the Swarm mission was presented at the AGU Fall meeting in San Francisco on 13 December 2013.

2.2 Status of current Earth Watch satellites

2.2.1 Proba-V

Launched on 7 May 2013, Proba-V is tasked with a full-scale mission: to map land cover and vegetation growth across the entire planet every two days. Proba-V is flying a lighter but fully functional redesign of the 'Vegetation' imaging instruments previously flown aboard France's full-sized Spot-4 and Spot-5 satellites, which have been observing Earth since 1998. The Spot Vegetation dataset had close to 10 000 registered users around the globe and has contributed to hundreds of scientific papers over 15 years. But with further Spot satellites lacking the capacity to carry Vegetation instruments, Proba-V has been designed to meet the future needs of this group. Proba-V's Vegetation instrument boasts improved spatial resolution from its Spot predecessors: 350 m resolution compared to 1 km for Spot Vegetation, with 100 m resolution available within its central field of view.

Proba-V will provide data to the instrument's worldwide user community of scientists and service providers. Uses of Proba-V Vegetation data include day-by-day tracking of extreme weather, alerting authorities to crop failures, monitoring inland water resources and tracing the steady spread of deserts and deforestation.

2.2.1.1 Status of spacecraft

The Proba-V In-Orbit Commissioning Review successfully took place on 27 November 2013. The Proba-V system and all its elements were thereafter declared ready for operation/exploitation from technical viewpoint as an ESA Earth Watch mission.

2.2.1.2 Performance and results

ESA is coordinating with the Participating States on the implementation of the programme element. Proba-V is the first of its kind within the Earth Watch Programme, and grants Programme Participants the specific right to derive and use high-level products and exploiting them in a national programme.

Access to Proba-V data has been opened on 3 December 2013. The kilometric Earth Watch products are distributed in accordance with the approved data policy. Any user can register under the standard ESA fast registration procedure for free and open access at https://earth.esa.int/web/guest/pi-community/apply-for-data/fast-registration. Proba-V data have been cross-calibrated with its predecessor, the Vegetation sensor on France's Spot-5 satellite. As of 18 February 2014, the Proba-V mini-satellite had yielded in its first two months of work, a valuable harvest for around a hundred scientific teams around the globe, including more than 5000 images, 65 daily global maps and six 10-day global syntheses.

2.2.2 Sentinel-1

The Sentinel-1 mission is a polar-orbiting satellite system for the continuation of Synthetic Aperture Radar (SAR) operational applications. Sentinel-1 is a C-band imaging radar mission to provide an all-weather day-and-night supply of imagery for GMES user services. The SAR will operate in two main modes: Interferometric Wide Swath and Wave. The first has a swath width of 250 km and a ground resolution of 5×20 m.

The first Sentinel-1A satellite was successfully launched on 3 April 2014. It will be followed by the second satellite within two years. The satellite has now entered a three-months commissioning phase during which it will be put into its operational orbit and calibrated for supplying true data. However a first set of acquisitions took place on April 12, just one day after the satellite was put into its operational attitude. These included an image of Brussels in Belgium, the seat of the European Commission, an area in Namibia currently flooded by the Zambezi river, an image of the Pine Island Glacier in Antarctica, currently in a state of 'irreversible retreat', and a transect over the northern part of the Antarctica Peninsula.

3 FUTURE ESA SATELLITE SYSTEMS

3.1 Future Earth Explorer missions

The Earth Explorers are research missions designed to address key scientific challenges identified by the science community while demonstrating breakthrough technology in observing techniques. Involving the science community right from the beginning in the definition of new missions and a peer-reviewed selection process ensures that a resulting mission is developed efficiently and provides the exact data required by the user.

3.1.1 EarthCARE

EarthCARE – the largest and most complex Earth Explorer mission to date – is being developed as a joint venture between ESA and the Japan Aerospace Exploration Agency, JAXA. EarthCARE will advance our understanding of the role that clouds and aerosols play in reflecting incident solar radiation back into space and trapping infrared radiation emitted from Earth's surface. By acquiring vertical profiles of clouds and aerosols, as well as the radiances at the top of the atmosphere, EarthCARE aims to address these issues. The mission will employ high-performance lidar and radar technology that has never been flown in space before.

The main EarthCARE risk remains associated with the development of the ATLID and its challenging transmitter, due to the technologies involved and the complexity of this instrument. The next EarthCARE science workshop is planned in fall-2014.

Current plans call for a launch readiness of EarthCARE in 2017. The mission has a design lifetime of three years, including a six-months commissioning phase.

3.1.2 ADM-AEOLUS

The ADM (Atmospheric Dynamics Mission)-Aeolus satellite will carry a single, but complex, instrument that will probe the atmosphere to profile the world's winds. Reliable and timely wind profiles are urgently needed by meteorologists to improve weather forecasts. In the long term, they will also contribute to climate research. Aeolus will carry a pioneering instrument called ALADIN that uses laser light scattering and the Doppler Effect to gather data on wind.

Developing the laser transmitter has been a very long and difficult undertaking – forging new technologies in many areas such as optics, opto-electronics, precision mechanics and thermo-mechanical design. The first flight laser transmitter qualification campaign was successfully completed and the consent to ship to Astrium Toulouse given just before Christmas 2013 for integration into the ALADIN instrument. The 2nd laser transmitter build was completed and the acceptance test campaign for functional, performance and mechanical vibration tests started in January. The integration of the third laser transmitter has started; this laser will be used for life test and as flight spare. The objective is to complete the power laser head integration in May 2014 and start the life test mid-2014. The ADM-Aeolus Flight Acceptance Review is planned in October 2015.

3.1.3 BIOMASS

The Biomass mission has been selected in May 2013 as the 7th Earth Explorer mission of its Living Planet programme. The satellite will be designed to provide, for the first time from space, P-band radar measurements that are optimised to determine the amount of biomass and carbon stored in the world's forests with greater accuracy than ever before. This information, which is poorly known in the tropics, is essential to our understanding of the role of forests in Earth's carbon cycle and in climate change. These objectives will be achieved by measuring biomass and forest height at a resolution of 200 m and forest disturbances at a resolution of 50 m.

Reliable knowledge of tropical forest biomass also underpins the implementation of the UN Reducing Emissions from Deforestation and forest Degradation (REDD+) initiative – an international effort to reduce carbon emissions from deforestation and land degradation in developing countries.

In addition, the measurements made by Biomass offer the opportunity to map the elevation of Earth's terrain under dense vegetation, yielding information on subsurface geology and allowing the estimation of glacier and ice-sheet velocities, critical to our understanding of ice-sheet mass loss in a warming Earth. Biomass also has the potential to evolve into an operational system, providing long-term monitoring of forests – one of Earth's most important natural resources. The launch of the mission is foreseen for 2020.

Two industrial consortia led by Astrium-Ltd. and OHB respectively have started their work on the Phase B1. The two parallel studies will run for 10 months and will end with Intermediate System Requirement Reviews in September 2014. The initial activities focus on the definition of the system baseline concept.

3.2 Future Earth Watch missions

In addition to meteorological satellites, the GMES (Global Monitoring for Environment and Security) Sentinel missions, which form part of the GMES Space Component, will collect robust, long-term climate-relevant datasets. Also ESA has initiated studies on a Jason-CS mission aimed at continuing high-precision altimetry observations of the ocean beyond the current Jason-1, -2 and 3 series.

3.2.1 Sentinel-2

The pair of Sentinel-2 satellites will routinely deliver high-resolution optical images globally, providing enhanced continuity of SPOT- and Landsat-type data. Sentinel-2 will carry an optical payload with visible, near infrared and shortwave infrared sensors comprising 13 spectral bands: 4 bands at 10 m, 6 bands at 20 m and 3 bands at 60 m spatial resolution (the latter is dedicated to atmospheric corrections and cloud screening), with a swath width of 290 km.

The Sentinel-2A Flight Acceptance Review (FAR) has now been set to early 2015 for a Vega launch. The Sentinel-2B FAR is scheduled in early 2016 for a Rockot launch.

3.2.2 Sentinel-3

The Sentinel-3 mission's main objective is to measure sea-surface topography, sea- and land-surface temperature and ocean- and land-surface colour with high-accuracy and reliability in support of ocean forecasting systems, and for environmental and climate monitoring. Sentinel-3 builds directly on a proven heritage pioneered by ERS-2 and Envisat. Its innovative instrument package includes:

- A Sea and Land Surface Temperature Radiometer (SLSTR), based on Envisat's Advanced Along Track Scanning Radiometer (AATSR), to determine global sea-surface temperatures to an accuracy of better than 0.3 K.
- An Ocean and Land Colour Instrument (OLCI) based on heritage from Envisat's Medium Resolution Imaging Spectrometer (MERIS). With 21 bands, compared to 15 on MERIS, a design optimised to minimise sun-glint and a resolution of 300 m over all surfaces, OLCI marks a new generation of measurements over the ocean and land. The swath of OCLI and nadir SLSTR fully overlap.
- A dual-frequency (Ku and C band) advanced Synthetic Aperture Radar Altimeter (SRAL) based on CryoSat heritage and providing measurements at a resolution of ~300 m in SAR mode along track. SRAL is supported by a microwave radiometer for atmospheric correction and a DORIS receiver for orbit positioning.

The earliest date predicted for completing the Sentinel-3A QAR process is mid-2015 while the Sentinel-3B FAR completion is predicted by end-2016.

3.2.3 Sentinels-4/-5

The Sentinel-4 and Sentinel-5 missions are dedicated to monitoring the composition of the atmosphere for GMES Atmosphere Services. Both missions will be carried on meteorological satellites operated by Eumetsat.

To be carried on the geostationary Meteosat Third Generation satellites, the Sentinel-4 mission comprises an Ultraviolet Visible Near-infrared (UVN) spectrometer and data from Eumetsat's thermal InfraRed Sounder (IRS), both embarked on the MTG-Sounder (MTG-S) satellite. After the MTG-S satellite is in orbit, the Sentinel-4 mission also includes data from Eumetsat's Flexible Combined Imager (FCI) embarked on the MTG-Imager (MTG-I) satellite. The Flight Readiness Review of the first MTG-S1 satellite is expected to take place in Q1 2021. The recurrent Flight Model 2 will be embarked on board the second MTG-S satellite (MTG-S2) whose Flight Acceptance Review is presently planned in Q1 2029.

To be carried on the polar-orbiting MetOp Second Generation satellite, the Sentinel-5 mission comprises an Ultraviolet Visible Near-infrared Shortwave (UVNS) spectrometer and data from Eumetsat's IRS, the Visible Infrared Imager (VII) and the Multi-viewing Multi-channel Multi-polarization Imager (3MI). The first MetOp Second Generation satellite is expected to be launched in 2020.

In addition, a Sentinel-5 Precursor mission is being developed to reduce data gaps between Envisat, in particular the Sciamachy instrument, and the launch of Sentinel-5. As a joint initiative between ESA and the Netherlands, the mission will comprise a satellite and a UVNS instrument called Tropomi. Sentinel-5 Precursor is ready for launch on Rockot end-2015.

The Sentinel-4 and -5 missions will provide information on atmospheric variables in support of European policies. Services will include the monitoring of air quality, stratospheric ozone and solar radiation, and climate monitoring.

3.2.4 Jason-CS

The Jason-CS satellites will form the space component of the Jason Continuity of Service mission, within the Copernicus Space Component Segment 3[1]. Jason-CS will extend high-accuracy ocean topography measurements well into the 2020s, thanks to the participation of all partners (EUMETSAT, ESA, CNES, NOAA and NASA/JPL).

The altimeter will employ digital architecture and the simultaneous measurement in the advanced SAR mode as well as in the conventional pulse-width limited mode. The microwave radiometer will be an enhanced version of JPL’s instrument used on Jason-2 and Jason-3. A major programmatic decision has been the abandonment of the High Resolution Microwave Radiometer (HRMR) studies.

The GNSS receiver optimised for Precise Orbit Determination will be an instrument derived from the Sentinel-3b GNSS receiver, while the request, by EUMETSAT’s member states, for a Radio Occultation (RO) capability will be satisfied by a variant of JPL’s TriG Receiver, optimised for RO. Additionally a DORIS Receiver and a Laser Retro-Reflector Array, also from JPL, will be embarked. It should be noted that all of the JPL payload complement are funded by NOAA.

[1] In response to a request from the European Commission, Jason-CS may sometimes be designated as Sentinel-6, using the form “Sentinel-6 mission implemented by the Jason-CS satellite”.

NOAA is now working on a FY16 approval for a new-start for Jason-CS. The readiness for launch is now moved to the second half of 2020.

3.3 The ESA Climate Change Initiative (CCI)

Combined satellite and *in situ* data archives can be used to produce data products for climate monitoring, modelling and prediction. To this end, the ESA Climate Change Initiative (CCI) was launched in 2009. The CCI has been created to address the GCOS Essential Climate Variable (ECV) requirements for satellite datasets and derived products. Its principal objective is "*to realize the full potential of the long-term global Earth Observation archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the ECV databases required by the UNFCCC*". The CCI focuses on the exploitation of data records primarily, but not exclusively, from past ESA satellite missions, for the benefit of climate monitoring and climate research. It complements existing efforts in Europe (e.g. led by EUMETSAT through the CM SAF) and internationally which focus on datasets characterizing meteorological aspects of the climate system.

A competitive tender for proposals to generate climate-quality products addressing a first set of ECVs was released by ESA in the last quarter of 2009. As part of CCI phase 1, between August and December 2010, ten ECV_cci projects were launched. The ECV_cci teams are consortia of between six and 15 European partner institutions, including academia, government agencies and system engineering companies.

In addition to the ten ECV_cci teams, a CCI Climate Modelling User Group (CMUG) consisting of major European climate modelling centres has been set up. At all stages of the program, its task is to provide a climate modelling perspective on the CCI, and to test datasets generated in the CCI within their models. CMUG also aims to provide an interface between the CCI and the international climate modelling community. The existence of CMUG emphasizes the important role of climate modelling as a primary user of CCI output. Finally, a CCI project on sea ice was launched in January 2012, together with two other projects dedicated to ice sheets and soil moisture, though funded under a different scheme.

The majority of CCI projects have reached the end of Phase 1 of the programme; all of the projects that started in 2011 have generated ECV data products and nine completed Phase 1 by the end of 2013. The CMUG project Phase 1 was also completed by its deadline at the end of March 2014. The *Fire_cci* project was extended. The three projects that started later are all on course to finish Phase 1 by the end of 2014. In 2014 the *Ice_Sheets_cci* will be split into two parallel contractual activities, the current project on the Greenland Ice Sheet will continue and alongside this, a new project on the Antarctic Ice Sheet will be set up.

The ECV products for nearly all the projects are available publically, via the project websites, accessible from the main CCI website: http://www.esa-cci.org.

The proposals for Phase 2 of the CCI have been submitted from the nine completed projects. These have been evaluated by ESA and the contracts have been negotiated in early 2014. A 4th CCI Collocation meeting was held in February 2014 where results from Phase 1 were reviewed and plans for Phase 2 outlined. The Phase 2 proposal for CMUG has been evaluated and the contract will soon be implemented. The same process will be carried out in 2014 for Phase 2 of the remaining projects.

A number of programme-wide activities are planned for Phase 2, one of which – the CCI Visualisation Tool – has already begun. The CCI is producing a Visualisation Tool as a communication aid, to showcase the ECV data products from the programme. Animations have been put together for the key variable from each project where data is currently available. These help demonstrate to both a scientific and lay audience the global nature of the products, the temporal coverage achieved and can highlight climate phenomena or events in the data, such as El Niño years.

The CCI project teams continue to make scientific publications in high impact scientific journals. These report progress on the retrieval algorithms resulting from the round robin exercise, as well as new results related to climate process and trends, based on analysis of the ECV data sets being generated in CCI. CCI teams submitted numerous papers, reporting progress made on diverse topics addressed within CCI, to the ESA Living Planet Symposium held in September 2013 in Edinburgh.

CCI Project	Science Leader	GCOS-107 Product
Cloud	Deutscher Wetterdienst, Germany (*R. Hollmann*)	A.4
Ozone	BIRA-IASB, Belgium (*M. van Roozendael*)	A.7
Aerosol	DLR, Germany / FMI, Finland (*T. Holzer-Popp / G. De Leeuw*)	A.8
GHG	University of Bremen, Germany (*M. Buchwitz*)	A.9
Sea Level	LEGOS-CNES, France (*A. Cazenave*)	O.2
SST	University of Reading, UK (*C. Merchant*)	O.3
Ocean Colour	Plymouth Marine Laboratory, UK (*S. Sathyendranath*)	O.4
Sea Ice*	Nansen Environmental and Remote Sensing Centre, Norway (*S. Sandven*)	O.5
Glaciers	University of Zurich, Switzerland (*F. Paul*)	T.2.1
Ice Sheets*	Danish Technical University, Denmark (*R. Forsberg)*	T.4
Land cover	Université Catholique de Louvain, Belgium (*P. Defourny*)	T.5.1
Fire	University of Alcala, Spain (*E. Chuvieco*)	T.9
Soil Moisture*	Technical University, Wien, Austria (*W. Wagner*)	T.11
Climate Modelling User Group	UK Met Office Hadley Centre (*R. Saunders*)	-

* Shaded boxes denote CCI Projects initiated in January 2012.