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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. 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. These Earth Explorer missions in orbit (SMOS, CryoSat, Swarm) are all performing extremely well and the related data exploitation is based on continuous data of excellent quality. The three missions all feature strong elements of international collaboration and a growing synergy between them.

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 downloaded in the last 4 years exceeds 63 Petabytes, available to users free of charge and just for the Sentinel missions more than 144,000 users have self-registered.

CGMS is further informed of the status of the future European Space Agency Earth Observation missions. Two of them, MTG and 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-Aeolus, EarthCARE, BIOMASS and FLEX is described. The current launch date for Aeolus is 21 August 2018.

Earth Explorer 9: the Phase A activities for FORUM and SKIM have been initiated, in record time from approval of the selection of the candidates.

Copernicus represents the major new initiative of European efforts in Earth Observation. The first Copernicus dedicated satellite (“Sentinel-1A”) was launched on 3 April 2014, followed by Sentinel-2A in June 2015, Sentinel-3A in February 2016, Sentinel-1B in April 2016,Sentinel-2B in April 2017, Sentinel-5P satellite on 13 October 2017 and Sentinel-3B on 25 April 2018; other Sentinels will follow in the coming years. Sentinel missions are developed in partnership with the European Union. The Sentinel-4 and 5 instruments developed by ESA will fly respectively on the MTG-S and Metop-SG missions also developed by ESA in cooperation with EUMETSAT.

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 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, continued in Phase 2 starting since early 2014 and represents a strong source of ECV data sets for the Copernicus Climate Change Services. ESA's member states have extended the program to continue until 2024.

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, two small satellites of the Proba series, and six Sentinel satellites. 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, thousands of users still access the large ESA on-line 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	7:30 (D) 615 km	22/10/2001	Earthnet on line	CHRIS, SREM	The orbit is drifting from the original 10:30 desc. ECT.
SMOS (with CNES and CDTI)	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) 820 km	5/07/2013	Earthnet on line	VEGETATION-P	2nd flight unit of the PROBA programme. Main mission: vegetation monitoring
Swarm A & C (with CNES and CSA)	87.35° 460 km	22/11/2013	Earthnet on line	ACC, SM, EFI (SWARM), GPS (ESA), LRR (DLR), STR (SWARM), VFM	Earth magnetic field
Swarm B	87.75° 530 km	22/11/2013	Earthnet on line		
Sentinel-1A (with EC)	06:00 (D) 693 km	03/04/2014	Copernicus Space component data access	SAR-C	Radar imagery

Satellites	Equator Crossing Time Altitude	Launch date	Access to data or products	Instruments	Status, applications and other information
Sentinel-2A (with EC)	10:30 (D) 786 km	22/06/2015	Data available from centres of the Payload Data Ground Segment (PDGS). Real-time availability possible at appointed X-band stations.	MSI (Multispectral imager)	Land and vegetation observation
Sentinel-3A (with EC)	10:00 (D) 814.5 km	16/02/2016	Data available from centres of the Payload Data Ground Segment (PDGS). Real-time availability possible at appointed X-band stations.	DORIS, GPS, LRR, MWR, OLCI, SLSTR, SRAL	Primary mission: ocean observation. Secondary mission: atmosphere and land applications
Sentinel-1B (with EC)	06:00 (D) 693 km	25/04/2016	Data available from centres of the Payload Data Ground Segment (PDGS). Real-time availability possible at appointed X-band stations.	SAR-C	Radar imagery
Sentinel-2B (with EC)	10:30 (D) 786 km	06/03/2017	Data available from centres of the Payload Data Ground Segment (PDGS). Real-time availability possible at appointed X-band stations.	MSI (Multispectral imager)	Land and vegetation observation
Sentinel-3B (with EC)	10:00 (D) 814.5 km	25/04/2018	Commissioning	DORIS, GPS, LRR, MWR, OLCI, SLSTR, SRAL	Primary mission: ocean observation. Secondary mission: atmosphere and land applications
Sentinel-5P (with EC and NSO)	13:30 (D) 824 km	13/10/2017	Data available from centres of the Payload Data Ground Segment (PDGS). Real-time availability possible at appointed X-band stations.	TROPOMI	Atmospheric composition and air quality monitoring.

3 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.

3.1 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.

3.1.1 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.

3.1.2 Performance and results

All Level 1 and Level 2 data up to 1st October 2013, which marks the last instrument calibration activity, have been processed and released to the user community.

Detailed analysis of possible improvements to the Level 1b processing chain as well as Level 2 approaches has confirmed the potential to further improve the GOCE-based gravity field. The activity has recently been kicked off, and the related Level

1b and Level 2 reprocessing campaigns are taking place during 2018, leading to the delivery of the Release 6 gravity field products in early 2019.

The goal of the PolarGAP campaign was to acquire and process the first airborne gravity dataset covering the full polar gap in Antarctica in order to supplement the existing GOCE data. The data products will soon be released on the Cal/Val portal and will be incorporated in the GOCE Release 6 gravity field models.

A related three-year ESA study carried out by a University in Kiel-led consortium focusing on how to link a crust and upper mantle model (from seismology and geology) with gravity gradient information from GOCE is progressing nominally, and results are expected during the year 2018.

The scientific validation of the GOCE gravity field models, the studies on the use of gradients and the assessment of the error covariance matrices have also been completed.

3.2 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.: The review process for the SMOS mission extension beyond 2019 will start in Q3 2018 with final decision in Q1 2019,

3.2.1 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. Collision Avoidance Manoeuvres (CAM) are performed when necessary as well as Orbit Correction Manoeuvres (OCM) to maintain the mission performances.

3.2.2 Performance and results

Overall performance of SMOS mission is nominal: the instrument continues to be excellent, accounting for ~99 % of availability for generating observation data.
The data acquisition is split between the XBAS acquisition system at ESAC and Svalbard (operated by KSAT), due to the near-real time requirement for SMOS data. The SMOS payload is operating nominally, with the exception of some anomalies having a minor impact on data availability. In total, the anomalies and the manoeuvres caused 3 hours 23 min and 50 s of on-board data loss (0.16%) and 50 min of on-board degraded data (0.038%) from 1 January 2018 to 31 March 2018, with an overall mission performance of 99.80%, which lies within the system performance requirement of 98% for generating observation data. The cumulative data lost since 1 May 2010 amounts to 0.096% and the degraded data amounts to 0.609%, with an overall mission performance of 99.29%.

The data acquisition is split between the XBAS acquisition system at ESAC and Svalbard (operated by KSAT), due to the near-real time requirement for SMOS data. Globally, 99.84% of the dumped passes have been acquired with both stations. Due to the 2.2-orbit overlap between ESAC and Svalbard acquisitions, there is no data gap due to acquisition failure, i.e. all data are ingested in the Data Processing Ground Segment (DPGS) at ESAC. The acquired data were successfully processed to 99.5% for all product levels including near-real time (NRT) for the period between 1 January 2018 and 31 March 2018. The timeline of 165 minutes for the NRT products was met in 95.4%. For the whole reporting period the data dissemination of the nominal data has continued from ESAC.

The ESA SMOS data portal (https://smos-diss.eo.esa.int) provides a single entry point for all SMOS Level 1 and Level 2 data products (including NRT products), containing all operational and reprocessed data sets and auxiliary data. For Level 1 and Level 2 data products the web interface allows the selection by data type, acquisition date, and geographical area of interest. Level 2 data products are also available in NetCDF, in addition to the nominal Earth Explorer format. Since the opening of the service, more than 11 million products have been downloaded by more than 550 active accounts, with a total volume of 300 TB (Figure 1.1-1). The two SMOS data products available in NRT, the Level 1 brightness temperatures (NRT light data product) and Level 2 Soil Moisture based on a neural network approach, are also available from EUMETSAT's EUMETCast system and through the UK Met Office.

SMOS Level 3/4 data products are available from the national data centres in France (CATDS www.catds.fr/Products/Available-products-from-CPDC) and Spain (BEC: http://cp34-bec.cmima.csic.es/land-datasets). The daily sea ice thickness product is available from the University of Hamburg at http://icdc.zmaw.de.

The reprocessing data set for Level 2 sea surface salinity was released to users in May 2017. The major improvement was to deliver land-sea contamination corrected sea surface salinity data and their corresponding anomaly field with respect to climatology.

The SMOS Level 2 soil moisture reprocessed data set was released to the user community in November 2017. The major improvements are the better characterization of the soil moisture uncertainties and the use of refined auxiliary data files for land coverage, snow extensions and the re-scaling of the ECMWF soil moisture forecast.

The implementation and procurement process of an operational service to provide L-band surface wind speed over ocean, to be provided in NRT, has started, with first product planned to be available mid-2018.

The implementation for new operational SMOS products based on the outcome of STSE studies, namely for a soil freeze/thaw product and a combined SMOS/Cryosat product for sea ice thickness, is on-going and data should be systematically available by end Q2 2018.

Copernicus Emergency Management Service: the European Flood Awareness System (EFAS), the European Forest Fire Information System (EFFIS), and the Copernicus Atmosphere Monitoring Service (CAMS) expressed an interest in using SMOS observations in their operational monitoring systems.

The Copernicus Climate Change Service (C3S) and the Copernicus Marine Environment Monitoring Service (CMEMS) use SMOS data sets as input for their services.

3.3 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.

3.3.1 Status of spacecraft and mission

Overall, the space segment performed satisfactorily..

Routine maintenance on the Star Tracker took place in March 2018. In particular, one of the Star Tracker sensors was annealed. As a result, an immediate improvement in the performance was noticed.

The Antarctic Campaign was completed successfully in January. The objective was to replicate the KAREN (Ka and Ku radar band measurements) in the South Pole where the ice's thermo-mechanics and snow precipitation are different from the Arctic.

A new Digital Elevation Model (DEM) of the Antarctic ice sheet and ice shelves based on 250 million measurements between July 2010 and July 2016 has been produced and it is ready to be released to the public. The DEM uncertainty in on average 9.5 m, a value that is comparable to or better than that of other models derived from satellite radar and laser altimetry.

A total of about 30 kg of fuel is still remaining on-board, allowing adequate orbit maintenance manoeuvres to keep the satellite within the required dead-band and to perform necessary Collisions Avoidance Manoeuvres. Overall, considering the remaining propellant and the new consumption rate, the fuel will be sufficient for approximately another 30 years.

3.3.2 Performance and results

Overall, the ground segment performed nominally with no major issues.

During the reporting period, the end-to-end mission performance, namely the overall mission data return that takes into account the planned (0.58%) and unplanned unavailability (0.0%) of the space and ground segments, was 99.42%. Since the start of the mission, the overall

availability of the science data has been 98.44%, well above the design performance of 94.00%. The system availability, which considers only failures, has been 98.97%.

The reprocessing of the Ocean data [July 2010 - October 2017] will start before summer 2018 and it is estimated to be completed before the end of 2018. Data will be delivered in staggered intervals as soon as they become available. SSALTO (CNES) is in charge for reprocessing the entire dataset.

Overall daily quality and operational control of the CryoSat products are carried out by IDEAS+ (UK). Reports are available on https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/cryosat/daily-performance-reports

Quality control of the L2 ice products are carried out by Mullard Space Science Laboratory (UK). Reports are available on http://cryosat.mssl.ucl.ac.uk/qa/

Quality control of the L2 ocean products are carried out by the National Oceanographic Centre in Southampton (UK). Reports are available on https://earth.esa.int/web/sppa/mission-performance/esa-missions/cryosat/quality-control-reports/ocean-product-quality-reports.

Quality control of the on-board Calibration Products are carried out routinely by ARESYS (I).

An independent quality control of the SIRAL radar parameters is periodically performed by IsardSat (S) throughout the processing of the Transponder data over Svalbard and Crete.

The development of Baseline D ice products is progressing according to schedule. The start of production is planned for fall 2018.

A new set of CryoSat Products (i.e. Thematic), which will respond to specific scientific needs, is currently been discussed. The plan is to release the first set by the end of 2019.

A new Digital Elevation Model (DEM) of the Antarctic ice sheet and ice shelves, based on 250 million observations recorded by the CryoSat radar altimeter between July 2010 and July 2016, has been produced (T. Slater et al., 2018 in press). The DEM is formed from spatio-temporal fits to elevation measurements accumulated within 1, 2 and 5 km grid cells, and is posted at the modal resolution of 1 km. The DEM uncertainty in on average 9.5 m, a value that is comparable to or better than that of other models derived from satellite radar and laser altimetry. The DEM can be downloaded from https://bit.ly/2Gx01sE.

A new roll campaign for the calibration of the SIRAL interferometer took place in February. As for the previous runs, the nominal spacecraft attitude was modified to include two different roll biases: +/- 0.4 deg. For each configuration, several periods were commanded over specific geographical areas with SIRAL in its interferometric mode.

The routine independent SIRAL calibration measurements were performed over the Svalbard and Crete transponders according to the annual campaign plan.

The Antarctic CryoVex/KAREN 2017/18 was completed successfully in January. It was a joint collaboration with BAS (British Antarctic Survey), DTU, AWI and University of Leeds. The objective was to replicate the KAREN configuration in the South Pole area where the ice's thermo-mechanics and snow precipitation are – for example – different from in the Arctic. The campaign in Antarctica is expected to demonstrate the added value of two frequency radar altimeter missions (Ka and Ku) supporting options for future evolution in

capability of a CryoSat-like mission. The data processing is still on-going due to the large data volumes of the new Ka-band system (KAREN) and is expected to be completed by the end of 2018.

ESA and NASA have met as part of Program for *Arctic Regional Climate Assessment* (PARCA) and *Operation IceBridge (OIB)* meetings. The objective of the meeting was to review the collaboration on the next validation campaigns, to develop synergies between ICESat-2 and CryoSat-2 and to progress on cooperation activities related the NASA and ESA Snow On Sea Ice (NESOSI) project with the objective to improve the sea-ice thickness retrievals.

The primary web interface for users uses the CryoSat Mission pages within Earth Online http://earth.esa.int/cryosat. Its main purpose is to provide a one-stop shop for all matters regarding the CryoSat mission including data access.

Using data dating back to 1992 from the ERS- mission, together with information from ERS-2, ENVISAT, CryoSat and NASA's IceSat, scientists from the UK's Centre for Polar Observation and Modelling reconstructed surface heights along a series of glacial flow lines to see how thinning at the grounding lines had been passed further inland. In 1992, all three were already experiencing height loss at or near the grounding line, with Pine Island Glacier losing height by around 1 m every year – although the interior surface was stable. Thinning then spread steadily, first up the glacier's main trunk, and then further inland. While the pace at which it spread across the surface varied, rates of thinning reached up to 13 km/year. The study was published in Geophysical Research Letters and presented at the American Geophysical Union's Fall Meeting which was held in San Francisco (USA) in December 2016.

CryoSat revealed lake outbursts beneath Antarctic ice using a novel processing technique. An Antarctic digital elevation model using 250 million CryoSat points is now available to the scientific community.

3.4 SWARM

Swarm is the fourth 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.

3.4.1 Status of spacecrafts

All three platforms are performing extremely well, and essentially free of any anomalies, and the orbital geometry of the constellation evolves in line with expectation. Occasional minor gaps in dumped data and single events, mostly caused by radiation or plasma irregularities, have only a negligible impact on data availability and mission performance.

The preparations for the extended mission beyond 2019 until the end of 2021 are proceeding nominally. They include the preparation of the adjustments of the orbit parameters of the lower pair that likely will commence in early 2019.

3.4.2 Performance and results

The few remaining main technical challenges are the limited availability of high-quality accelerometer data from Alpha and Bravo and the search for optimised (and ideally near-

continuous) operations scenarios for the Thermal Ion Imagers. The constellation and its operations are otherwise in perfect shape.

Science highlights in Q1 2018 include the publication of the models for all contributors to the Earth's magnetic field based on four years of data. One particularly exciting finding is that the secular variation of the magnetic field is now resolved to significantly higher spatial resolution. This gives a better data set for the fundamental investigation into the outer core dynamics, a key challenge for Swarm's extended mission.

The introduction of CASSIOPE/e-POP mission as the fourth element of the Swarm constellation under the Third Party Mission scheme funded by Earthnet has been completed. Within the Swarm ecosystem, the mission is referred to as Swarm Echo. Expert groups for the joint coordination and exploitation of the four-satellite constellation have been formed and will from now on meet regularly to maximise the synergy.

The Swarm Data Innovation and Science Cluster (DISC) continues to provide essential services for the verification and validation of all data products, as well as the enhancement of processing algorithms. Improved version of the Level 1B and Level 2 Cat-2 processors are under final validation. Once the validation of these two deliveries is completed, the Swarm Level-1B and Level-2 Cat-2 comprehensive reprocessing campaign will follow.

4 STATUS OF CURRENT EARTH WATCH SATELLITES

The Earth Watch programme encompasses the development of the series of operational meteorological satellites of Eumetsat (not covered in this report), the Proba series of small satellites for medium-resolution imagery, and the Copernicus programme of Sentinel satellites designed to provide reliable, timely and accurate services to manage the environment, understand and mitigate the effects of climate change and help respond to crises.

4.1 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. The Proba-V mission is operating in its fourth year in orbit, in its extended mission lifetime currently foreseen until autumn 2019. The Proba-V overpass time is steadily drifting; the current prediction is that the Local Time at Descending Node crossing (LTDN) will approach 9:30 AM by end of 2019, reaching 9:00 AM by end of 2020. While the issue of ensuring a consistent archive of surface reflectance will be addressed with the a-posteriori BRDF correction, clear justifications need to be found to operate the Proba-V mission beyond 2019. In fact, at that time the full Sentinel-3 constellation (A+B) is expected to be ready to ensure continuity to the SPOT-VGT and Proba-V long-term archive and to address the needs of the land community, in particular of the Copernicus Global Land Service (CGLS).

Proba-V provides 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.

4.1.1 Status of spacecraft

During the reporting period the Proba-V spacecraft was operated nominally. However, a safe mode was recorded in March. It lasted less than 4 hours. The root cause of the problem was linked to a GPS on-board problem for which a corrective action has been identified and implemented on board.

All the key parameters on-board have been well within their design margins, i.e. power, thermal, pointing, processing and memory. No platform and payload degradations have been detected. The Vegetation Instrument acquisition and calibration requests have been performed nominally. The number of decompression errors remains very low and stable.

4.1.2 Performance and results

The sensor radiometric and geometric performances were stable during the reporting period with no sign of degradation.
The mission goal requirements for the radiometric performances (5% absolute and 3% inter-band and multi-temporal) are largely met for all spectral bands. The geometric accuracy is largely within the mission goal requirements, both in terms of absolute value, inter-band and multitemporal; the current absolute geometric accuracy is better than 70m in the VNIR central camera.

The Antarctica acquisition campaign, started during October 2017, was successfully completed at the end of February 2018. The full dataset was processed up to Level 2-A (TOA projected segment products) at different resolutions (1km, 333m and 100m). A dedicated processing workflow was implemented at VITO to deal with the specific DEM and projection to be used for Antarctica continent. The dataset was made available to the users within the Proba-V MEP. The objective of the campaign is to derive a seasonal composite of the Antarctica continent to be used as background information for cryosphere studies. The long-term goal is to repeat the same campaign next years to support change detection studies. VITO is responsible for the dedicated post-processing for the derivation of the seasonal cloud-free composite.

The Collection-2 baseline will also include improvements to the cloud and cloud shadows screening methods. Concerning the cloud screening, the background climatology derived from the MERIS 10-years surface reflectances dataset, which is used as input to the algorithm, will be replaced by a new climatology built using Proba-V archive. This will entail a new training and validation of the algorithm. For this purpose, the validation dataset of manually classified pixels, used in the frame of the Collection-1 validation, will be reused. The final issue being tackled is the cloud shadow mask, which still needs some improvements, as reported by several users. An investigation is ongoing at VITO to review the current algorithm for cloud shadow.

Further information about Proba-V products can be found in Earth Online portal[1].

4.2 The Copernicus Sentinel programme

4.2.1 Sentinel-1A and 1B

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 and commissioned in September 2014. The second Sentinel-1 B was launched on 25 April 2016 and commissioned in September of the same year.

The Sentinel-1A and Sentinel-1B routine operations are on-going and the overall operations mission performance has been nominal. The Sentinel-1 observation scenario supports the systematic coverage of Copernicus Services areas of interest, of European land and coastal waters, of global tectonic/volcanic areas, as well as of other specific areas worldwide for various applications. The observation plan also includes a regular mapping of all land areas worldwide, with a frequency largely increased with Sentinel-1B in operations. Starting on 26 September 2016, the Sentinel-1 observation plan is implemented with the combined use of Sentinel-1A and Sentinel-1B. Sentinel-1 contribution to emergency activations continues to be very high (~ weekly).

The EDRS service is operationally used for both Sentinel-1A and Sentinel-1B. The mission routinely generates a total daily production above 11 TB.

Sentinel-1 data can be accessed from https://sentinels.copernicus.eu.

World maps providing a high level description of the overall Sentinel-1 constellation observation scenario, in terms of SAR modes, polarisation, observation geometry, revisit and coverage frequency are available at:
https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario.

During SeaSAR 2018 workshop (7-10 May 2018, ESRIN), strong emphasis was put on Sentinel-1 mission, with many talks on operational maritime applications and scientific advances, in the domain of oceanography, including sea-ice, target detection, sea state (wind, wave), etc.

By 22 May 2018, a total of 144,972 users have self-registered on the Sentinels Scientific Data Hub; 8 million Sentinel product download have been made by users, corresponding to about 61.67 PB of data. 2.4 million Sentinel-1 products are available on-line for download, representing 3.8 PB of data. Statistics of last 24 hours are available in real time at the Data Hub home page: https://scihub.copernicus.eu. Figures concerning users accessing data via the Collaborative ground segments, the NASA-NOAA hubs in both the USA and Australia, and via the commercial data providers in the USA such as Google and Amazon, are not considered in the numerical figures provided just before.

[1]https://earth.esa.int/web/guest/data-access/browse-data-products/-/asset_publisher/y8Qb/content/proba-v-1km-333m-and-100m-products

4.2.2 Sentinel-2A and 2B

A pair of Sentinel-2 satellites will routinely deliver high-resolution optical images globally, with 5-day revisit, providing enhanced continuity of SPOT- and Landsat-type data. Sentinel-2 carries 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 satellite was successfully launched by VEGA (VV05) on 22 June 2015 and the Sentinel-2B also by VEGA (VV09) on 06 March 2017. The In-Orbit Commissioning Review (IOCR) should be terminated by the end of June 2017.

In accordance with the Copernicus data policy, Sentinel-2 data products are made available systematically and free of charge to all data users including the general public, scientific and commercial users. Sentinel-2 products are in Sentinel Standard Archive Format for Europe (SAFE) format, including image data in JPEG2000 format, quality indicators, auxiliary data and metadata.

A new version of Sen2Cor atmospheric correction processor was released (version 2.5.5). Changes include a product format change to align it with the operational Level-2A products. Regarding the algorithm, the main changes concern the improvement of cloud screening and scene classification, the extension of the visibility iterations from 80 to 120km, the exclusion of cloud shadow pixels for water vapour retrieval, and an improved aerosol optical thickness retrieval.

A study has been conducted for replacing the Digital Elevation Model (DEM) used for Sentinel-2 data processing in order to improve Level-1C products geolocation accuracy over mountainous regions.

EDRS service is being operationally used for both Sentinel-2A and Sentinel-2B. Since 26 March 2018, the systematic production and distribution of Level-2A core products has started over the Euro-Mediterranean region.

Via the Open Access Hub, users can access approximately 3,5 million Sentinel-2 core products, corresponding to 1,9 PB.

More information can be found at: https://sentinel.esa.int/web/sentinel/sentinel-data-access

4.2.3 Sentinel-3A and 3B

The main objective of the Sentinel-3 mission is to measure sea surface topography, sea and land surface temperature, and ocean and land surface colour with high accuracy and reliability to support ocean forecasting systems, environmental monitoring and climate monitoring. The mission definition is driven by the need for continuity in provision of ERS, Envisat and SPOT-Vegetation data, with improvements in instrument performance and coverage. Sentinel-3A was successfully launched on 16 February 2016 and the commissioning phase was terminated in August 2016. Sentinel-3A passed its Routine Operations Readiness Review on 16 October 2017 and is now officially in routine operations, having reached full operational capacity already in July 2017. The overall status of the spacecraft is nominal, with all subsystems performing as expected. All instruments, including OLCI, SRAL, SLSTR and MWR, are switched on and perform as expected. All Level 1 and 2 core data products have been released.

Release of the Sentinel-3 Aerosol Optical Depth and Fire Radiative Power products to all users, planned for Q2-2018. The reprocessing campaigns, including data from S-3A commissioning phase, are ongoing for optical and altimetry data

The first ESA/EUMETSAT performance review took place on 16 March 2018, reviewing the current status of the Sentinel-3A mission operations and data quality and concluded that Sentinel-3A is in excellent status Reprocessing activities are on-going. For SRAL, a full mission reprocessing (starting from 1 March 2016) has been completed for both the Land and the Marine products and made available to the Sentinel-3 Validation Team members.

The Flight Operations Segment (FOS) for Routine Operations is operating nominally. The Land PDGS activities in the reporting period were mainly focussed on the reprocessing activity for OLCI data since the beginning of the mission and the consolidation of the SLSTR processing baseline.

The successful Sentinel-3B launch on 25 April 2018, including implementation of the Tandem Phase (30 seconds separation) and orbit phase shift to 140 degree between Sentinel-3A and Sentinel-3B, is opening new applications areas. Sentinel-3B is currently in Commissioning phase.

Via the Open Access Hub, users can access approximately 1.1 million Sentinel-3 core products, corresponding to 471 TB.

4.2.4 Sentinel-5P

The Sentinel-5 Precursor mission will be a gap-filler, within the 2016-2023 timeframe, between the end-of-life of the current atmospheric chemistry mission (OMI on EOS/Aura) and the operational availability of Sentinel-5. As a joint initiative between ESA and the Netherlands, the mission will comprise a satellite and a UVNS instrument called TROPOMI.

The Sentinel-5P satellite has been launched by Rockot on 13 October 2017. The Sentinel-5P In Orbit Commissioning Review (IOCR) took successfully place on 24 April 2018.

The overall thermal stability and radiometric performance of the TROPOMI instrument is very good with all systems operating nominally, and the SWIR instrument is considered to be very stable and in excellent condition.

Recently, a short test using different signal co-addition settings was performed in order to reduce effects of occasional signal saturation observed over clouds in tropical areas. A corresponding change of the TROPOMI baseline settings would lead to a reduction of pixel size (near nadir) from 7 x 3.6 km2 to 5.5 x 3.6 km2 for spectral Bands 2-6. While such a change would also be of scientific benefit, it would lead to higher processing loads (approximately + 25 %) and storage requirements in the PDGS.

Use of the Inuvik ground station for routine downlinks of S-/X-Band telemetry starting on 15 January 2018. In the new acquisition scenario, Inuvik is used in addition to Svalbard (the primary acquisition station) for 4 daily passes thereby enhancing the timeliness for delivery of mission products to end users.

More than 120 registrations were received with the same approximate number of participants at the Second Sentinel-5 Precursor Validation Team (S5PVT) and Early Results Meeting (Feb. 2018). In addition to teams from 15 ESA member states, there was a large participation of scientists form the US, South Korea and China. The presentations included 35 Sentinel-5p

Cal/Val EO projects and overviews of the Sentinel-5p Project, ESA Cal/Val activities and tools, product status and campaigns.

In the coming period, contacts will continue between the S-5p Project at ESA and NASA/NOAA and maintain a loose in-orbit flight formation between S-5P and the Suomi-NPP spacecraft with a final time separation of 3.5 minutes.

5 FUTURE ESA SATELLITE SYSTEMS

5.1 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.

5.1.1 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.

At satellite level, the Prime (ADS-D) has integrated the first instrument (BBR) on a fully assembled platform.

The start of the Qualification and Acceptance campaign for the ATLID is planned for early Q4 2018.

The final delivery of the MSI if planned for Q4 2018.

Major delays on the CPR have been announced by JAXA due to difficulties encountered during the High Power Transmitter (HPT–A) repair. The CPR is now dictating the schedule critical path of the satellite completion. Assuming a CPR delivery end 2019, this would lead to a launch in mid-2021 but this the overall schedule is still to be consolidated.

The mission has a design lifetime of three years, including a six-months commissioning phase.

5.1.2 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.

All tests performed to date successful, and the satellite AIT completion is planned for 7 June. The investigations on TB/TV losses in the optical reception path of the ALADIN instrument, have found root causes and concluded that ALADIN instrument is ready for flight with a good level of performance. The satellite will be shipped to Kourou on mid-June, for an arrival on 1 July.

Launch date agreed with Arianespace is 21 August 2018.

5.1.3 BIOMASS

The Biomass mission was 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 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 understanding 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 qualification of the GaN power transistors has been completed successfully and the associated risk is retired. This is a major achievement given the potential impact of a delay in the qualification and related concern about the usability of the European technology.

PDRs of the Large Deployable Reflector (LDR) and the structure have been held in February 2018 with very good results.

The System PDR shall be formally closed in Q2 2018. The current planning calls for a launch in July 2022.

The BorealScat campaign is a tower based campaign in Sweden providing hypertemporal measurements of radar signatures to support the L2 product development. Measurements in P- and L-Band are ongoing since January 2017 and for C-Band since August 2017. Analyses so far have showed the backscatter and temporal coherence changes during different weather conditions.

AfriLidar is an airborne campaign in Gabon covering the same four sites as AfriSAR using a high resolution lidar to provide correlative data for forest biomass estimation and interpretation of P-band radar signatures in support of the L2 product development.

DesertSAR is a planned airborne SAR and ground campaign to assess the use of Biomass P-Band SAR over desert areas and suitability of deserts as potential calibration site. The Namibian desert has been identified as the ideal location.

The review of the special issue of the IEEE JSTARS journal on "Forest Structure Estimation in Remote Sensing" with a focus on presenting results from the AfriSAR campaign is ongoing. The special issue is foreseen to be published in October 2018.

Following the joint science workshop with the Biomass, GEDI (NASA), NISAR (NASA) and Tandem-L (DLR) science teams on "Measuring Forest Structure Parameters using Space-Based Observing Systems" a special issue in Reviews of Geophysics is planned.

5.1.4 FLEX

On 19 November 2015, ESA's Member States selected FLEX as the 8th Earth Explorer mission (also known as the 4th Opportunity Earth Explorer Mission of the EOEP), upon recommendation from the Earth Science Advisory Committee. The Fluorescence Explorer (FLEX) mission will map vegetation fluorescence to quantify photosynthetic activity.

The conversion of atmospheric carbon dioxide and sunlight into energy-rich carbohydrates through photosynthesis is one of the most fundamental processes on Earth – and one on which we all depend. Information from FLEX will improve our understanding of the way carbon moves between plants and the atmosphere and how photosynthesis affects the carbon and water cycles. In addition, information from FLEX will lead to better insight into plant health and stress. This is of particular relevance since the growing global population is placing increasing demands on the production of food and animal feed.

So far, it has not been possible to measure photosynthetic activity from space, but FLEX's novel fluorescence imaging spectrometer will observe this faint glow, which serves as an indicator of photosynthesis. The FLEX satellite will orbit in tandem with one of the Copernicus Sentinel-3 satellites, taking advantage of its optical and thermal sensors to provide an integrated package of measurements. Launch is planned for Q4 of 2022.

The Best Practices procurement process for FLORIS continues to progress. With the completion of the evaluation board for telescope and the scrambler, more than 80% of the procurement selection process is completed. The instrument PDR is confirmed for June and July with the board meeting in September 2018. The performance characterisation of the High and Low Resolution Spectrometer breadboards is completed. The results fully in line with predictions for the High Resolution Spectrometer whereas for the Low Resolution Spectrometer, optical alignment and straylight reduction need additional work.

The kick-off of the FLEX satellite contractor is planned in late September 2018.

The commissioning phase of Sentinel-3B expected in Q2 2018 provides the opportunity for a new dedicated campaign that will make use of reprogrammed OLCI bands to simulate the tandem mission concept. With the Sentinal-3B launch date on 25 April, the planning for the tandem phase campaign is now focusing on the summer months and four regions in Europe and one site the US.

For Q1 2019, it is planned to organise the next dedicated Fluorescence Workshops in Europe in Switzerland and Germany.

5.1.5 9th Earth Explorer mission

On 23 November 2015, ESA announced an opportunity for scientists involved in Earth observation to submit proposals for the next potential Earth Explorer satellite mission.

Traditionally, Earth Explorers use new measurement techniques to explore and understand different aspects of the Earth system. Reflecting the new Earth Observation Science Strategy for ESA, proposals for the ninth Explorer should not only demonstrate scientific excellence and innovative technology, but also address important scientific questions that have a direct bearing on societal issues humankind will face in the coming decades. This includes, for example, the availability of food, water, energy and resources, health, risk of disaster and climate change.

A revised Call for EE-9 'Fast-Track' Mission Proposals was released on 13 December 2016 (http://explorercall.esa.int/images/callee9documents/Revised_EE-9_Call_Text.pdf). The Agency was soliciting proposals for mission concepts fitting in a Vega-C dual-launch configuration that will not exceed a 260 M€ budget to ESA for implementation as EE-9.

In November 2017, ESA selected two concepts out of 13 proposals, FORUM and SKIM, to be developed further and compete to be the 9th Earth Explorer mission.

FORUM:

Thanks to new technical developments, the Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM) candidate would measure radiation emitted from Earth across the entire far-infrared part of the electromagnetic spectrum. Significantly, it measures in the 15–100 micron range, which has never been done from space before.

These observations are important because Earth emits infrared radiation to space, which is affected by water vapour and cirrus clouds, which, in turn, play key roles in Earth's temperature.

FORUM's benchmark measurements would improve our understanding of the greenhouse effect and, importantly, contribute to the accuracy of climate change assessments that form the basis for policy decisions.

SKIM:

The Sea-surface Kinematics Multiscale monitoring (SKIM) candidate would carry a novel wide-swath scanning multibeam radar altimeter to measure ocean-surface currents. Uniquely, it uses a Doppler technique, which offers more direct measurements than conventional satellite altimeters.

These new measurements would improve our understanding of vertical and horizontal ocean–surface dynamics over the global ocean every few days. This would lead to better knowledge of how the ocean and atmosphere interact – for example, how atmospheric carbon dioxide is drawn down into the ocean.

SKIM would have particular relevance for understanding the rapidly changing Arctic Ocean, and for observing equatorial regions where conventional satellite altimeters are unable to provide useful measurements of currents.

The Phase A activities for FORUM and SKIM have been initiated. The final selection between the two missions will take place in 2019, before the 2019 Ministerial Council. The launch of the 9th Earth Explorer mission is envisaged around 2025.

5.1.6 10th Earth Explorer mission

Twenty-one full proposals have been received at ESA. They are currently being evaluated. Three candidates (out of the 21) will be selected in September 2018 to go into phase 0.

5.2 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. The Jason-CS mission (now known as Sentinel-6) aims at continuing high-precision altimetry observations of the ocean beyond the current Jason-1, -2 and 3 series.

5.2.1 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. 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.

The next meeting of the Sentinel-4/-5 MAG is planned in June 2018.

5.2.1.1 Sentinel-4

Sentinel-4 is dedicated to air quality monitoring. To be carried on the geostationary Meteosat Third Generation satellites, the Sentinel-4 mission aims to provide continuous monitoring of the composition of the Earth's atmosphere at high temporal and spatial resolution and the data will be used to support monitoring and forecasting over Europe. It 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 Sentinel-4/UVN instrument is a high resolution spectrometer system operating with three designated bands in the solar reflectance spectrum, covering the ultraviolet (305-400 nm), visible (400-500 nm) and near-infrared (750-775 nm) bands. The central Sentinel-4/UVN instrument parameters are a spatial sampling of 8 km over Europe and a fast repeat cycle over Europe and North Africa (Sahara) of 60 minutes. The respective spectral resolution is 0.5 nm in the ultraviolet and visible bands, with the goal of 0.12 nm in near infra-red.

The two engineering models (Flat-EM and Enhanced-EM) have progressed nominally, in line with the respective schedules. No major schedule risks have been identified for the Flat-EM.

As far as PFM schedule is concerned, all PFM units have progressed with very little delay and are all planned to be delivered in 2018 except for the three optical assemblies (the Telescope Assembly, the Ultraviolet Spectrograph Assembly, the Near-Infrared Assembly). Integration planned to start in Q4 2018.

5.2.1.2 Sentinel-5

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).

Delays on the delivery of the FM SWIR detector and on the NIR spectrometer lens mounts impact the delivery date to MetOp-SG which schedule is anyway driven by the major delay on the METimage instrument. All the instrument sub-system Preliminary Design Reviews closed-out except Optical Ground Support Equipment. The sub-systems Critical Design Review cycle on-going (SWIR spectrometer sub-system ongoing).

The Sentinel-5 Acceptance Review is planned for December 2019.

5.2.2 Sentinel-6 (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. 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 Poseidon-4 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 Advanced Microwave Radiometer, Climate Quality (AMR-C) 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 Radio Occultation (RO) capability will be satisfied by a NASA-provided GNSS-RO. Additionally a DORIS Receiver and a NASA-provided Laser Retro-Reflector Array will be embarked.

The industrial contract for the procurement of the Sentinel-6/Jason-CS A satellite has been signed by ESA and Airbus DS. A The Copernicus Procurement Board accepted the Sentinel-6/Jason-CS contract proposal for the combined procurement of the recurrent B model. Within EUMETSAT, the optional Jason-CS programme entered into force on 9 September 2015. The EUMETSAT funding share is secured for both the A and B Sentinel-6/Jason-CS satellites procurement, as required to proceed with phase C1.

NASA and NOAA jointly acting as the US party will provide the launch services for both Sentinel-6 A and B satellite, US payload instruments and ground segment support, and will contribute to the operations. Through the MOU approved in 2016, the three Parties (NASA and NOAA, ESA and EUMETSAT) have agreed to manage jointly the mission performances; each partner taking ownership of the mission results. With their heritage in space altimetry, the CNES support will be essential to the mission success. The ESA/CNES collaboration scheme agreed for Sentinel-6 is now implemented and effective.

The EUMETSAT System Check Point part 1 took place in April 2018. The NASA instrument production is proceeding to plan. The second MAG meeting took place in NOAA on February 2018. The Technical Assistance Agreement (TAA) with SpaceX is approved and the technical

kick-off meeting is planned June 2018. Regular teleconferences have already started to consolidate inputs to the mission analysis and outline the joint development plan milestones and meetings. ESA produced inputs to the mission analyses to be performed by Space X, including the strategy to fly in tandem with Jason-3 during the first part of the mission (6-12 months, TBC).

The Satellite AIT schedule is being re-worked to cope with suppliers' delays while maintaining the FAR date (end April 2020).

A number of flight items have been delivered while others are still in production. The misspecification of the ECOR ASIC part of the Poseidon-4 altimeter induces about 5 months delay in the instrument delivery. The MMFU memory module PCB failed qualification. Production bottleneck impacts the PCDU PFM delivery by 9 months. An EM is available to proceed with satellite AIT.

5.3 The ESA Climate Change Initiative (CCI)

5.3.1 Background

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.

5.3.2 CCI Phase 1

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. In addition to the ten ECV_cci teams, a CCI Climate Modelling User Group (CMUG) consisting of major European climate modelling centres was set up. At all stages of the program, its task was 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. 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. All CCI projects have reached the end of Phase 1 of the programme and generated ECV data products. The CMUG project Phase 1 was also completed by its deadline at the end of March 2014. In 2014 the *Ice_Sheets_cci* was split into two parallel contractual activities, covering respectively the Greenland and the Antarctic Ice Sheets.

5.3.3 CCI Phase 2

The last project to complete Phase 1 was the Ice_Sheets_cci at the end of March 2015. The kick-off meeting for Phase 2 of its two parts were held at the end of April 2015.

As the ECV products matured, the focus of project teams expanded from the specifications of the data sets to looking at how the data can be used, both across the CCI programme and in broader climate and environmental research questions.

The CCI project teams continued to make scientific publications in high impact scientific journals. The projects have also had time to promote their data sets more widely within their research communities. This means that some products have been downloaded extensively. There are variations between the projects depending on the product maturity, competition from other products, size of the research community, and how international it is but all are seeing a sea increase in users of their data.

5.3.4 Current status

The ITT for 9 New ECVs (Water Vapour, Ocean Surface Salinity, Sea State, Snow, Permafrost, HR Land Cover, Lakes, Above Ground Biomass and Land Surface Temperature) in CCI+ closed on 27 October 2017. All proposals received have been evaluated, and negotiations for 9 large new ECV projects are now under way. The RFQ for CMUG was issued on 30 January 2018, with a closing date of 2 March. The next ITT for New R&D on the existing 13 CCI ECVs is being prepared. Most of the existing CCI ECV projects have been extended to bridge the gap to this new ITT.

The proposals for the “New ECVs” in the CCI programme extension have been evaluated by the Executive. Negotiations took place over Q1 2018 with the selected project teams and contracts are now in place for Biomass, Land Surface Temperature, Permafrost, Sea State, Sea Surface Salinity, and Water Vapour. The remaining three projects are still in negotiation.

The Statement of Work for CMUG has been completed and the evaluation of the proposal for an extension to the project is currently under negotiation.

The 8th CCI Collocation Meeting took place from 20-22 March 2018, this time in Oxford, UK at St. Hugh’s College. This was the first opportunity to bring together all of those involved in the extended CCI programme, including the current ECV projects, the new ECV projects, cross-project activities, some Living Planet Fellows, and the Knowledge Exchange projects. The meeting celebrated the achievements of the CCI to date and updated the community on the new programme structure. It was also an opportunity for the current projects to pass on any lessons learnt to the new projects and for the new projects to present their plan of work. A key proposal from the meeting was for a CCI conference to bring together the ECV community, in around 2020.