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ESA Sea Level CCI

D3.2 System Verification Report

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Applicable documents

AD 1 Sea level CCI project Management Plan
CLS-DOS-NT-10-013

AD 2 ESA Climate Change Initiative Phase 1: Scientific User consultation and Detailed Specification – Statement of Work (SOW)
EOP-SEP/SOW/0031-09/SP issue 1.4 revision 1 – 09/11/2009

AD 3 ESA CLIMATE CHANGE INITIATIVE – PHASE 1 ECV Sea Level CORALS - Technical Proposal
CLS-DOS-PR-10-001 issue 2 revision 0 – 23/06/2010

Reference documents

RD 1 Software validation document for SSALTO/DUACS – Version 13.3.0, Issue 1.0, Reference CLS-DOS-12-030

RD 2 Algorithm Theoretical Basis Document (ATBDv1), SLCCI-ATBDv1-016, CLS-SLCCI-16-0008, issue 3.3

RD 3 Algorithm Selection Meeting Executive Summary – SL_cci Phase II (26-27 November 2015), SLCCI-MM-042, CLS-SLCCI-15-0015, issue 1.0, http://www.esa-sealevel-cci.org/webfm_send/400

RD 4 Product Specification Document, CLS-DOS-NT-11-015, issue 2.5

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1. Introduction

The first version of this report gave a synthetic view of the test activities performed on the SLCCI prototype which has ensured the generation of the required ECV data products.

During phase I of the project (2011-2013), a first version (V1.0) of the SL_cci ECV products has been produced and delivered to the users. In December 2013, an updated version V1.1 (covering the period 1993-2010) has been produced with the same SL_cci system of production.

The schedule of phase II of the project (2014-2016) includes temporal extension of the V1.1 SL_cci ECV time series every year (see Figure 1). The system of production is the same as the one used during phase I. At last, a full reprocessing of the ECV (v2.0) is planned in 2016 (see Figure 1).

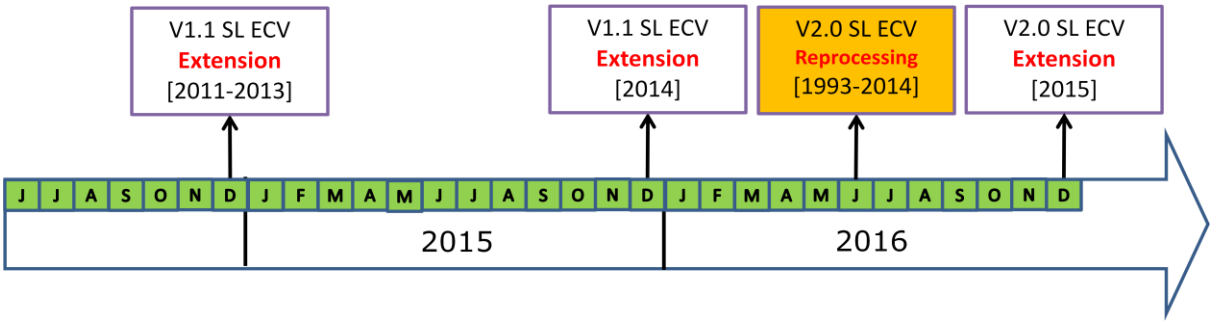

Figure 1: SL_cci ECV planning production during phase II

The satellite missions included in each version of the ECV are listed in Figure 2.

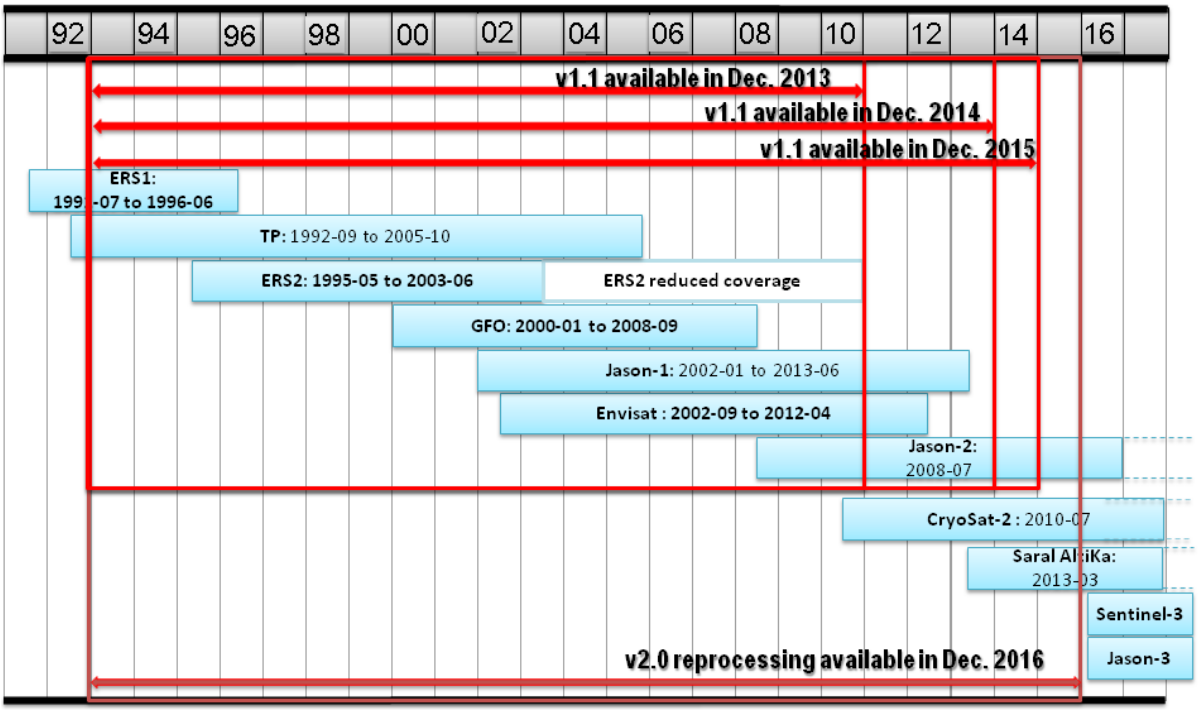

Figure 2: Level 2 GDR altimeter data used as input data of the FCDR and ECV products are included in the red squares according to the version of the product.

This report gives a synthetic view of the test activities performed on the SL_cci processing chain that ensures the production of the required ECV data products.

2. Description of the processing chain

The processing chain is composed of a production chain including the following steps:

- Acquire Data
- Pre-process data
- Perform input checks and Quality Control
- Generate Products
- Performs output checks and Quality Control
- Do measures and built indicators

The product generation is divided into three sub-steps:

- Inter calibrate & Unify
- Generate along track product
- Generate merged product

Each step has its sequence of algorithms that can be activated to generate the SL_cci ECV (see Figure 3).

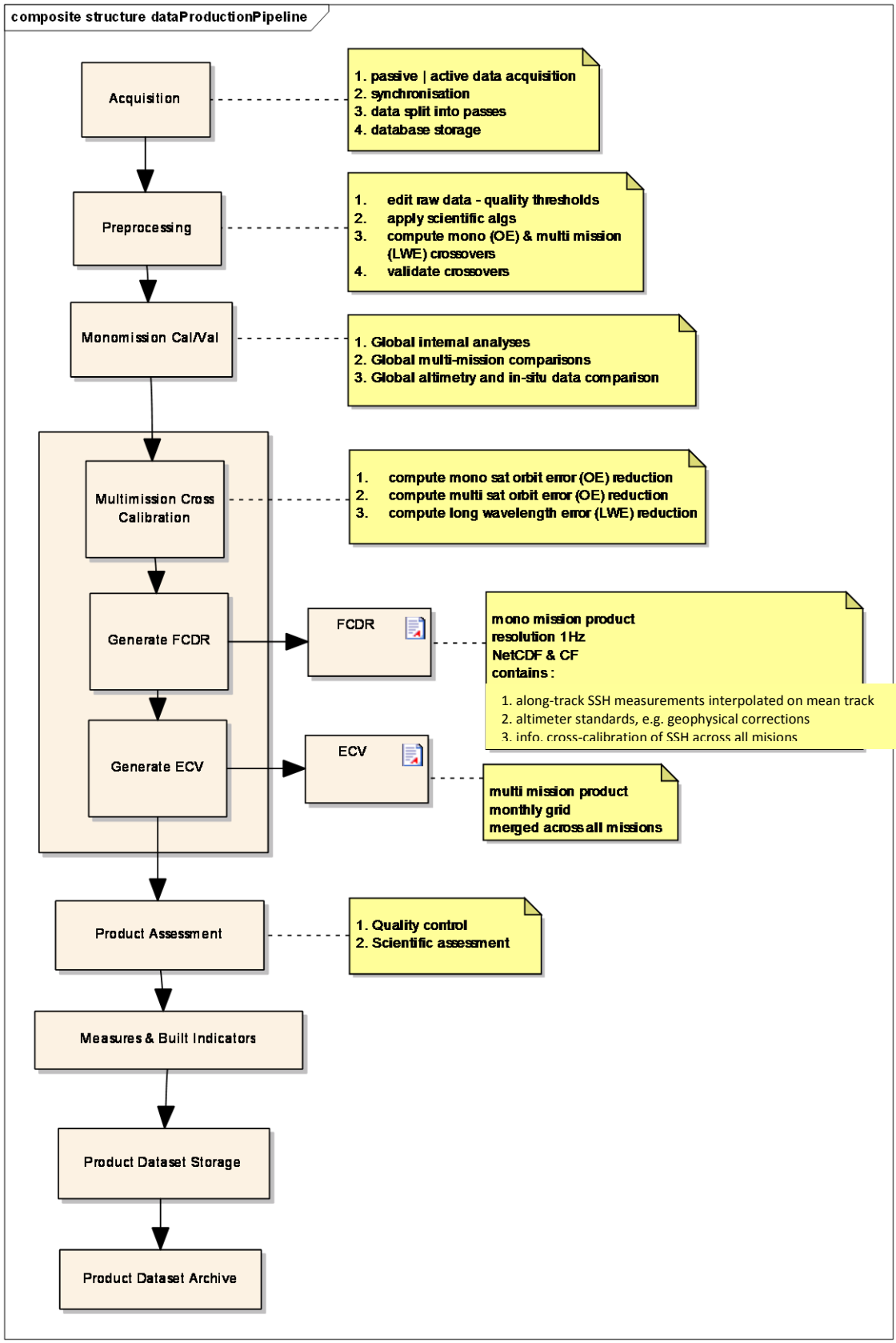

Figure 3 - SLCCI Prototype Macro Functionalities

3. Test description

The processing chain used in the SLCCI project is based on the Ssalto/Duacs system used to generate the Level 3 and Level 4 sea level Aviso products as part as the SALP/CNES project as well as the Sea Level products as part as the Myocean project.

The production chain of DUACS is operational and maintained in an operational condition. Tests are performed as part as the two aforementioned projects. Test documentation and tests results are available in the Software Validation report (RD1). This documentation defines a test for each functional component of the production chain. The list of tests is:

- Test of acquisition of altimeter data and auxiliary data
- Test of preprocessing of measurements
- Test of checking the values of different linear combinations.
- Test of validation of altimetry measurements.
- Test of product generation
- Test of the long wave error for global products.
- Test of the map of sea level anomaly for global products
- Test of the orbit error reduction.
- Test of the sea level anomaly for global products.

The production of the SL_cci ECV is compliant with this Software Validation Report (RD1). However, new algorithms and auxiliary files dedicated to the SL_cci project have been selected and implemented in the production system. These new algorithms, described in the Algorithm Theoretical Basis Document (RD2), have been selected during Phase II - WP2 activities of the SL_cci project over the whole altimetry period after comparison with other reference standards through a systematic validation process (Round Robin Data Package, RRDP). The assessment results have been presented during the Algorithm Selection Meeting (RD3) and are listed in Table 1.

The RRDPs and the validation reports associated with each ATBD are available on the project website (http://www.esa-sealevel-cci.org/PublicDocuments/technical) and are listed in Table 2.

ATBD	Algorithm Description	Altimeter standards	Pages
ATBD-1	To compute orbit altitude	GFZ orbit solutions CNES POE-E orbit solutions GSFC orbit solutions	RD2 Chap. 3 RD3 Chap. 2
ATBD-2	To compute Wet troposphere correction from GNSS-derived Path Delay (GPD+)	GNSS-derived Path Delay, Scanning Imager calibrated (GPD+) algorithm	RD2 Chap. 4 RD3 Chap. 4
ATBD-3	To compute the sea state biases	Sea State Bias Non-parametric solution	RD2 Chap. 5 RD3 Chap. 5.2
ATBD-4	To compute ionosphere correction	Ionosphere correction derived from the NIC09 model	RD2 Chap. 6 RD3 Chap. 5.2
ATBD-5	To compute the high frequency fluctuations	Dynamical atmospheric correction derived from ERA-interim model	RD2 Chap. 7 RD3 Chap. 3
ATBD-6	Dry troposphere derived from ERA-interim pressure fields	Dry troposphere derived from ERA-interim pressure fields	RD2 Chap. 8 RD3 Chap. 3
ATBD-7	To compute elastic ocean tide height and the load tide height	FES2014 ocean tide model	RD2 Chap 9 RD3 Chap. 6.1

ATBD-8	To compute gridded ECV products	Mapping procedure using optimal interpolation	RD2 Chap. 10
ATBD-9	To compute the mean sea surface height	DTU15 Mean Sea Surface	RD2 Chap. 11 RD3 Chap. 7

Table 1: SL_cci v2.0 algorithms

Standard	Description	Missions	Documents	Work Package
Orbit	GFZ vs REF	TP, J1, J2, E1, E2, EN	RRDP_WP2120_Impact_of_Orbit_GFZ_from_REF_2015-08-07.pdf WP2120_Impact_of_Orbit_GFZ_from_REF_E1.pptx WP2120_Impact_of_Orbit_GFZ_from_REF_E2.pptx WP2120_Impact_of_Orbit_GFZ_from_REF_EN.pptx WP2120_Impact_of_Orbit_GFZ_from_REF_J1.pptx WP2120_Impact_of_Orbit_GFZ_from_REF_J2.pptx WP2120_Impact_of_Orbit_GFZ_from_REF_TP.pptx WP2120_Synthesis_Impact_of_Orbit_GFZ_from_REF.pptx	WP2120
	GSFC std12 vs REF	TP, J1, J2	RRDP_WP2110_Impact_of_Orbit_GSFC_STD1204_from_REF_2015-11-10.pdf	WP2110
	GSFC std 15 vs REF	TP	RRDP_WP2110_Impact_of_Orbit_GSFC1504_from_GSFC1204_TP_2015-11-10.pdf	WP2110
	POE-E vs REF	J1, J2, AL, C2	RRDP_WP2110_Impact_of_Orbit_POE-E_from_GDR-D_J1_2015-11-10.pdf RRDP_WP2110_Impact_of_Orbit_POE-E_from_POE-D_AL_2015-11-10.pdf RRDP_WP2110_Impact_of_Orbit_POE-E_from_POE-D_C2_2015-11-10.pdf RRDP_WP2110_Impact_of_Orbit_POE-E_from_POE-D_J2_2015-11-10.pdf WP210_Impact_of_Orbit_POE-E_from_GDR-D_J1.pptx	WP2110
Ocean Tide	GOT4v10 vs REF (GOT4v8)	J1, J2, EN	RRDP_WP2110_Impact_of_OceanTide_GOT4V10_from_GOT4v8_2015-11-10.pdf	WP2110
	FES2014 vs REF (GOT4v8)	J1, EN	RRDP_WP2110_Impact_of_OceanTide_FES2014_from_GOT4v8_2015-11-10.pdf WP2110_Impact_of_Tide_FES2014_from_GOT4V8_EN.pptx WP2110_Impact_of_Tide_FES2014_from_GOT4V8_J1.pptx	WP2110
	FES2014 vs GOT4v10	J1, EN	RRDP_WP2110_Impact_of_OceanTide_FES2014_from_GOT4v10_EN_2015-11-10.pdf RRDP_WP2110_Impact_of_OceanTide_FES2014_from_GOT4v10_J1_2015-11-10.pdf	WP2110

Standard	Description	Mission	Document	Work Package
Wet Tropo.	ERA-Int vs ECMWF ope 2014	EN, J1, J2	RRDP_WP2110_Impact_of_WetTropo_ERA_Interim_from_ECMWF_OPE_2014_2015-11-10.pdf	WP2110

	Rad. P3 vs Rad. P2	AL	RRDP_WP2110_Impact_of_WetTropo_Rad_Patch3_from_Rad_Patch2_AL_2015-11-10.pdf	WP2110
	GPD 1.1 vs Rad. (Extensions 2013,2014)	EN, J1, J2	RRDP_WP2410_Impact_of_WTC_GPD_V1_1_from_Rad_2015-11-10.pdf	WP2410
	GPD 1.1 vs ERA	TP, J1, J2, E1, E2, EN	RRDP_WP2410_Impact_of_WTC_GPD_V1_1_from_ERA_Interim_2015-11-10.pdf	WP2410
	GPD 2.0 vs V1.1	TP, J1, J2, E1, E2, EN	RRDP_WP2410_Impact_of_WTC_GPD_V2_0_from_GPD_V1_1_2015-11-10.pdf WP2410_Impact_of_WTC_GPD_V2_from_GPD_V1_E1.pptx WP2410_Impact_of_WTC_GPD_V2_from_GPD_V1_E2.pptx WP2410_Impact_of_WTC_GPD_V2_from_GPD_V1_EN.pptx WP2410_Impact_of_WTC_GPD_V2_from_GPD_V1_J1.pptx WP2410_Impact_of_WTC_GPD_V2_from_GPD_V1_J2.pptx WP2410_Impact_of_WTC_GPD_V2_from_GPD_V1_TP.pptx WP2410_Synthesis_Impact_of_GPD_V2_from_V1.1.pptx	WP2410
	GPD 2.0 vs ERA	TP, J1, J2, E1, E2, EN, AL, C2	RRDP_WP2410_Impact_of_WTC_GPD_V2_0_from_ERA_Interim_2015-11-10.pdf	WP2410
	GPD 2.0 vs Rad.	TP, J1, J2, E1, E2, EN (V2.1b, V3), AL	RRDP_WP2410_Impact_of_WTC_GPD_V2_0_from_Radiometer_2015-11-10.pdf RRDP_WP2410_Impact_of_WTC_GPD_V2_0_from_Radiometer_V3_EN_2015-11-10.pdf WP2410_Impact_of_WTC_GPD_V2_from_RAD_AL.pptx	WP2410
	GPD 2.0 vs ECMWF ope	J2, C2	RRDP_WP2410_Impact_of_WTC_GPD_V2_0_from_ECMWF_OPE_2015-11-10.pdf	WP2410

Standard	Description	Missions	Documents	Work Package
Dyn. Atm.	JRA-55 vs ERA-Int (IB)	TP, J2, E2, EN	RRDP_WP2420_Impact_of_DynAtmo_InvertBaro_JRA-55_from_ERA_Interim_2015-11-10.pdf WP2420_Impact_of_IB_JRA-55_from_ERA_Interim_E2.pptx WP2420_Impact_of_IB_JRA-55_from_ERA_Interim_EN.pptx WP2420_Impact_of_IB_JRA-55_from_ERA_Interim_J2.pptx WP2420_Impact_of_IB_JRA-55_from_ERA_Interim_TP.pptx	WP2420
	ERA-Int vs ECMWF ope 2014	EN, J1, J2	RRDP_WP2110_Impact_of_DynAtmo_ERA_Interim_from_ECMWF_OPE_2014_2015-11-10.pdf	WP2110
Dry Tropo.	JRA-55 vs ERA-Int	TP, J2, E2, EN	RRDP_WP2420_Impact_of_DryTropo_JRA-55_from_ERA_Interim_2015-11-10.pdf WP2420_Impact_of_DTC_JRA-55_from_ERA_Interim_E2.pptx WP2420_Impact_of_DTC_JRA-55_from_ERA_Interim_EN.pptx WP2420_Impact_of_DTC_JRA-55_from_ERA_Interim_J2.pptx WP2420_Impact_of_DTC_JRA-55_from_ERA_Interim_TP.pptx	WP2420

Standard	Description	Mission	Document	Work Package
Iono.	Delta iono IsardSat vs REF	EN	RRDP_WP2130_Impact_of_Iono_CorrIsardSat_from_REF_EN_2015-11-10.pdf WP2130_Impact_of_DeltaIonoKu_CCI_from_REF_ENVISAT.pptx	WP2130
	Delta iono IsardSat vs GIM	EN	RRDP_WP2130_Impact_of_Iono_CorrIsardSat_from_GIM_EN_2015-11-10.pdf	WP2130
	Sloop filter vs REF	TP, J1, J2, EN	RRDP_WP2110_Impact_of_Iono_SLOOPFilter_from_REF_EN_2015-11-10.pdf RRDP_WP2110_Impact_of_Iono_SLOOPFilter_from_REF_J1_2015-11-10.pdf RRDP_WP2110_Impact_of_Iono_SLOOPFilter_from_REF_J2_2015-11-10.pdf RRDP_WP2110_Impact_of_Iono_SLOOPFilter_from_REF_TP_2015-11-10.pdf	WP2110
SSB	PEACHI 2015 3D vs GDR-D	AL	RRDP_WP2110_Impact_of_SSB_PEACHI2014_2D_from_GDR-D_AL_2015-11-10.pdf	WP2110
	PEACHI 2014 2D vs GDR-D	AL	RRDP_WP2110_Impact_of_SSB_PEACHI2015_3D_from_GDR-D_AL_2015-11-10.pdf	WP2110
	Tran 2012 vs GDR-D	J1, J2	RRDP_WP2110_Impact_of_SSB_Tran2012_from_GDR-D_J1_2015-11-10.pdf RRDP_WP2110_Impact_of_SSB_Tran2012_from_GDR-D_J2_2015-11-10.pdf	WP2110
	Tran 2015 vs Tran 2012	EN	RRDP_WP2110_Impact_of_SSB_Tran2015_from_Tran2012_EN_2015-11-10.pdf	WP2110
Pole Tide	Desai 2015 vs Wahr 1985	EN, J1	RRDP_WP2110_Impact_of_PoleTide_DESAI2105_from_Wahr1985_2015-11-10.pdf	WP2110

Table 2: List of the RRDPs and validation reports of the SL_cci v2.0 standards

4. Conclusion

During phase I of the project, one year of SL_cci ECV product had been generated, covering 1993, in order to verify the consistency with the Product Specification Document (RD4). Then, the SL_cci processing chain has generated the V1.0 and V1.1 ECV products. It is also used during phase II for the generation of the temporal extensions of the V1.1 ECV dataset as well as for the production of the reprocessed SL_cci ECV v2.0.

Appendix A - **List of acronyms**

AD	Applicable Document
AL	SARAL-AltiKa
ATBD	Algorithm Theoretical Basis Document
AVISO	Archiving, Validation and Interpretation of Satellite Oceanographic data. Aviso distributes satellite altimetry data from Topex/Poseidon, Jason-1, ERS-1 and ERS-2, and EnviSat, and Doris precise orbit determination and positioning products.
C2	CryoSat-2
Cal/Val	Calibration / Validation
CCI	Climate Change Initiative
CLS	Collecte Localisation Satellites
CNES	Centre National d'Etudes Spatiales
DUACS	Developing Use of Altimetry for Climate Studies
E1, E2	ERS-1, ERS-2 (European Remote Sensing)
ECMWF ope	European Centre for Medium-range Weather Forecasting operational model
ECV	Essential Climate Variable
EN	Envisat
ERA-Interim	ECMWF atmospheric ReAnalysis
ESA	European Space Agency
FCDR	Fundamental Climate Data record
FES2014	Finite Element System ocean tide model
FTP	File Transfer Protocol
GFZ	Geodetische Forschung Zentrum
GNSS	Global Navigation Satellite System
GOT	Goddard Ocean Tide
GPD, GPD+	GNSS Path Delay initial and updated model
GSFC	Goddard Space Flight Center
IT	Information Technology
J1, J2	Jason-1, Jason-2

JRA-55	Japanese atmospheric ReAnalysis covering 55 years
LWE	Low Wavelength Error
NIC	NOAA Ionosphere Climatology
OE	Orbit Error
OI	Optimal Interpolation
POE	Precise Orbit Determination
QC	Quality Control
Rad. P2/P3	Radiometer wet troposphere correction Patch 2 and Patch 3 for SARAL-AltiKa
RD	Reference Document
REF	Reference used in the RRDP
RRDP	Round Robin Data Package
SALP	Système d'Altimétrie et de Localisation Précise
SL	Sea Level
SSALTO	Segment Sol multimissions d'ALTimétrie, d' Orbitographie et de localisation précise
SSH	Secure Shell or Sea Surface Height
SVR	System Verification Report
T/P	Topex/Poseidon
TBC	To be confirmed
TBD	To be defined
WP	Work Package