ESA Climate Change Initiative
aerosol_cci2

System Verification Report - SVR
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CONTRIBUTING AUTHORS	Co-authors	all EO partners		
REVIEWED BY	Co-science leader review (without late additions)	Gerrit de Leeuw		
APPROVED BY	Technical officer (ESA)			
ISSUED BY	Project manager			

EXECUTIVE SUMMARY

This document provides evidence that the products conform to the specifications of the Product Specification Document (PSD) regarding content, format and metadata. Since no operational processing system has been developed and existing systems in research environment are used for the dataset processing, no system conformance checking between a development and an operational instance needed to be done.

This document starts with a short description of the objectives and scope of the processor (section 2), before a summary of the System Specification Document (SSD) is made in section 3 and the verification against the PSD (content, format metadata) is summarized in section 4.

Issue	Date	Modified Items / Reason for Change
0.9	17.09.2012	First draft issued
1.0	21.09.2012	Completion of document Issue of first version
Phase 2		
1.0	30.04.2015	Update for year 1 of phase 2
1.1	29.05.2015	Spell check Addition of tables to document format compliance checks in section 5
2.0	27.07.2016	Update with new product GRASP
2.1	23.02.2017	Final consistency check with latest CRDP-TN and PSD

2.2	04.04.2017	Revision based on ESA RIDs of 17/03/2017 Updated summary, cinsistency with PSD sensor lists anmd product table Update of all out-dated statements on planned work Spell-checking, minor layout updates Correction of miss-leading table entries Summary compliance statement at document end

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1 INTRODUCTION

The purpose of this System Verification Report is to summarize the system verification – in this case focusing on product format and metadata compliance with the Product Specification Document.

1.1 References

1.1.1 Applicable Documents

[AD1] The Statement of Work, reference CCI-PRGM-EOPS-SW-12-0012, issue 1, revision 2, dated June 7th, 2013, and its specific annex C (altogether the SoW).

[AD2] The Contractor's Proposal reference 3010317 revision 1.2 , dated 04 April 2014

1.1.2 Reference Documents

[RD1] Aerosol_cci2 Product Specification Document, v3.2, 12.03.2017

[RD2] Aerosol_cci System Specification Document, issue 3, v1.0, 30.11.2015

[RD3] Aerosol_cci CRDP Technical Note v2.2, 27.10.2016

2 OBJECTIVES AND SCOPE OF THE PROCESSOR

The objective of the processors is the production from several instruments of ECV products for multi-spectral Aerosol Optical Depth (ATSR-2, AATSR, MERIS, PARASOL, SCIAMACHY/ATSR), mineral dust AOD (IASI), for hourly AOD (SEVIRI), for Aerosol Absorbing Index (OMI), and stratospheric extinction profiles (GOMOS). In phase 1 (2010-2014) the scope was to produce single years of global data (2008, 2000); in phase 2 (2014-2017) is the goal was then the production of full mission time series for the respective instruments.

The scope of the system includes validation of the products against reference datasets (AERONET, MAN, NDACC) and comparison against state of the art satellite datasets (MODIS, MISR, SEAWIFS, OSIRIS) and model datasets (AEROCOM, MACC) to ascertain the maturity and quality of the products. The scope of the processor also encompasses a development component to assure continuous upgrade of algorithms and product quality in response to (evolving) user needs and a dissemination component to provide easy access for users to the products and their documentation.

3 OVERVIEW OF THE SYSTEM

The system consists of 4 major components:

- the production component (including all necessary input and the produced output datasets)
- the validation / inter-comparison component (including reference datasets)
- the development component (science team with external links, algorithm development, development priorities)
- the dissemination component (for products and documentation)

A decentralized production component has been implemented in the Aerosol_cci prototype including the distributed input data. Also auxiliary datasets necessary for each algorithm are available at the respective partner components. The production component consists of separate modules for each sensor / algorithm (input datasets, retrieval algorithm, aggregation algorithm). The sensor lines included are those for ATSR (nadir AOD), POLDER (nadir AOD), OMI (nadir absorbing aerosol index), IASI (mineral dust AOD) and GOMOS (occultation stratospheric extinction profiles). In development are sensor lines for MERIS and SYNAER (ATSR/SCIAMACHY) nadir AOD and SEVIRI hourly nadir AOD. Additionally for the ATSR sensor line a combination / ensemble algorithm has been implemented. All EO partners store their output datasets at the central ICARE server. It is important to note that the science team conducted a major effort to assure consistency within the Aerosol_cci production component. Firstly, it was assured that the de-central input databases used the same versions for identical sensors. Secondly, algorithm development included identifying common modules and auxiliary datasets to be used by several / all algorithms wherever this makes sense. Finally, the output products apply a harmonized netCDF format following the CF-1.6 convention for metadata and a common definition of name tags.

The validation component consists of 4 independent lines, each using their specific validation module and applying a work sharing (e.g. ICARE focusing on lv2, MPI focusing on spatial/temporal correlations, MetNo focusing on lv3 and NILU working on stratospheric extinction and uncertainties of nadir products). All relevant reference data are available at the validation modules: mainly AERONET (MAN) sun photometer multi-spectral AOD, NDACC lidar stratospheric profiles and derived products, but also inter-comparison data from other satellites / algorithms such as MODIS, MISR, SEAWIFS, OSIRIS, GlobAerosol and model data from AEROCOM median or MACC. The Aerosol_cci ECV products are downloaded from the ICARE server, where all EO partners store their products. The validation output is integrated into the validation reports and disseminated via the Project web portal.

The dissemination component consists of 2 modules. A central ftp archive provided by ICARE is used to store all output products (a public server with the latest validated ECV datasets and an internal server with the earlier and test versions) together with common auxiliary datasets (common cloud mask, ECMWF re-gridded ERA interim wind fileld datasets) and can be accessed by all EO and validation partners.

The Aerosol_cci web portal hosted by DLR / WDC-RSAT is the main window to ECV users. It provides all public information (overview, partners, major achievements, newsletters, coming events). It contains all documents issued by Aerosol_cci and it links to the ICARE server (password protected with one common password distributed at the website) as well as the online AEROCOM validation tool and the ICARE data visualisation and analysis tool, where the different ECV products are

graphically freely available. Furthermore links to the CCI program and all other CCI projects are made.

The development component consists of 3 major modules: the science team with its 3 groups of experts (algorithm / EO experts, validation / inter-comparison experts and ECV use experts), the development priorities defined by the entire science team and the algorithm development conducted by the EO experts. The key output of the validation component (validation report) and the key output of the test use of ECV products (assessment report) are the major input for the definition of algorithm development priorities. An intensive iteration between the 3 groups of experts has continuously been held to analyse round robin exercises (e.g. for IASI), further algorithm experiments, and validation results of each new prdocut version, all conducted in order to identify a next choice of algorithms mature for ECV production and imrpovements needed for the algorithms towards the next reprocessing. Annually, an algorithm work plan is agreed upon by consensus which determines the work for further algorithm improvement (e.g. cloud masks, surface treatment), qualification (e.g. pixel uncertainties) and operationalization (e.g. harmonized quality flags). The science team is also responsible for all external links into the science community, the CCI community, to the space agencies and their cal/val teams.

More detail on interfaces and the distributed implementation of the elements and components can be found in the System Specification Document (SSD).

4 VERIFICATION AGAINST PRODUCT SPECIFICATION

4.1 Product content

The PSD lists following parameters which are provided at the end of Aerosol_cci2 – the table comments in its last 2 columns on the compliance of the ECV products on 31 March 2017with the product specifications in the PSD .

Table 1: Compliance of Aerosol_cci products with the specification

Product name	Parameter(s)	sensors	level	period	Compliance
Tropospheric / total column products					
Single-sensor Total AOD / type	Multi-spectral AOD (fine mode AOD, dust AOD)	ATSR-2 / AATSR SLSTR MERIS ALAMO MERIS XBAER SeaWiFS4MERIS POLDER	Level2,3	1995-2012 1 year 2008, over ocean 2008 2008 2005 – 2013	Y (3 algorithms) In development Y In development In development Y (selected regions)
Single-sensor Extended aerosol characterisation	Multi-spectral SSA, Sphere fraction, BRDF parameters	POLDER	Level2,3	2005 – 2013	Y (selected regions)
Synergetic Total AOD / type	Multi-spectral AOD (fine mode AOD, dust AOD)	AATSR/ SCIAMACHY	Level2,3	2002-2012	In development
AAI	Absorbing aerosol index averaging kernel	TOMS GOME SCIAMACHY OMI GOME-2	Level3	1978-1993 1995-2003 2002-2012 2014-2016 2007-2016	Y Y Y Y Y
Dust AOD	Infrared and visible Dust	IASI	Level 2,3	2007-2015	Y (4 algorithms)

	AOD from IR spectra				
Aerosol type "climatology"	fine mode AOD, dust AOD	All AOD products	Level3	Separate products (FMAOD from ATSR and POLDER, SSA from POLDER)	Not integrated climatology feasible
SEVIRI Hourly total column AOD	Multi-spectral AOD, fine and coarse mode AOD	SEVIRI	Level2	2008, xxxx	In development
Stratospheric products					
Stratospheric extinction	Gridded extinction profile, stratospheric AOD and Angström coefficient, size information	GOMOS	Level2,3	2003-2012	Y (available in 2 different horizontal resolutions for different applications)

Overall the compliance of output variables with the PSD has been reached with the one exception of an integrated aerosol type climatology – here only separate products with some aerosol properties are available and no firm enough ground has yet been reached for such an integrated aerosol type climatology.

Obligatory auxiliary variables are contained in the products: latitude, longitude; time for lv2 (with exception for MERIS-ALAMO from phase 1), height for stratospheric profiles. All products (except PARASOL) contain uncertainties (or STD for ALAMO) for the major output variable. All products contain additional derived parameters and diagnostic variables.

4.2 Product metadata

Metadata are stored within the product files following the CF1.6 convention (however standard variable names for aerosol except aerosol optical depth are not defined). Global attributes have been agreed in the PSD (according to the CCI Data Standards) and are used in the Aerosol_cci2 products.

4.3 Product format

All Aerosol_cci products are provided in netCDF format as defined in the PSD. They do comply (with few exceptions for phase 1 products, e.g. for AAI) with the filenaming convention agreed between Aerosol_cci and the Data Standards Working Group of CCI.

All products are provided as lv2 and lv3 (daily and partly monthly for AOD, lv3 monthly only for stratosphere) products as defind in table 1. Variable names do use the CCI common definition.

The grid and projection defined in the PSD (sinusoidal for lv2 AOD, gridded lat-lon for lv3) is used in the products.

A common directory structure agreed within Aerosol_cci for the ftp server is applied for all the products.

5 FILE CHECK

Test files for each latest version of a mature product were collected and put through the CF compliance checker recommended by AEROCOM as our prior user (http://aerocom-test.met.no/upload). If any deviations were found these were corrected and re-formatting of output files was condcuted.

In most cases there is no CF standard name defined yet for Aerosol_cci variables (except AOD). In those variables no "standard_name" can be included as attribute. However, Aerosol_cci agreed on a common naming throughout the project for those variables, which was checked manually.

The file structure was agreed as follows. Level 2 files are organised as vector (of a monotonic pixel number as dimension) with coordiantes latitude, longitude and time associated. Level 3 files are organised as arrays of latitude and longitude; while the time is associated with the file (all measurements of one day or month or in case of thermal infrared sensors of one half day with all ascending / night and descending / day observations).

All files assure tracebility by containing a full list of all input files analysed (blank separated complete list of all data files).

Ångström coefficients are specified in their exact definition by adding to the vriable name the wavelength pai used (e.g. ANG440_670) and the type of variable it was derived from (in the case of stratosphere: extinction profiles or stratospheric column AOD).

All test files were manually checked for their content and variables against the specifications.
For global attributes a few missing entries were detected (some entries are overlapping), but none of them was critical to uniquely identify a file and to allow all relevant searching. Variable names showed few minor deviations (small deviations in variables names), few auxiliary variables were not contained as specified, but also several variables were additionally contained in the files. The detailed file check results are summarized in the following tables.

Global attributes compliance check

Attribute	compliance									
Attribute	ADV	ORAC	SU	GOMOS	IMARS	MAPIR	LMD	ULB	GRASP	
Title	x	x	x	x	x	x	x	x	x	
Institution		x		x	x	x	x	x	x	
Source		x		x	x	x	x	x	x	
History	x	x	x	x	x	x	x	x	x	
References	x	x	x	x	x	x	x	x	x	
Tracking_id	x	x	x	x	x	x	x	x		
Conventions	x	x	x	x	x	x	x	x	x	
[Product_]version	x	x	x	x	x	x	x	x	x	
summary	x	x	x		x	x	x	x	x	
keywords	x	x	x		x	x	x	x	x	
id	x	x	x		x	x	x	x		
naming authority	x	x	x		x	x	x	x	x	
keywords_vocabulary	x	x	x			x	x	x	x	
cdm_data_type		x	x		x	x	x	x	x	
comment						x	x	x		
date_created	x	x	x	x	x	x	x	x		
creator_name	x	x	x	x	x	x	x	x	x	
creator_url	x	x	x	x	x	x	x	x	x	
creator_email	x	x	x	x	x	x	x	x	x	
project	x	x	x	x	x	x	x	x	x	
geospatial_lat_min	x	x	x		x	x	x	x		
geospatial_lat_max	x	x	x		x	x	x	x		
geospatial_lon_min	x	x	x		x	x	x	x		
geospatial_lon_max	x	x	x		x	x	x	x		
geospatial_vertical_min							x	x	x	
geospatial_vertical_max							x	x		
time_coverage_start	x	x	x	x	x	x	x	x		
time_coverage_end	x	x	x	x	x	x	x	x		
time_coverage_duration		x				x	x	x		
time_coverage_resolution		x				x	x	x		
standard_name_vocabulary	x	x	x			x	x	x	x	
license	x	x	x		x	x	x	x	x	
geospatial_lat_units	x	x	x	x	x	x	x	x	x	
geospatial_lon_units	x	x	x	x	x	x	x	x	x	
geospatial_lon_resolution	x	x	x	x	x	x	x	x	x	
geospatial_lat_resolution	x	x	x	x	x	x	x	x	x	
inputFileList, productList	x	x	x	x	x	x	x	x	x	
startDate					x	x	x	x	x	
dateTime					x	x	x	x	x	
productID					x	x	x	x	x	
platform	x	x	x	x	x	x	x	x	x	
sensor	x	x	x	x	x	x	x	x	x	
Spatial resolution	x	x	x	x			x	x	x	
projection	x	x	x						x	
content				x			x		x	

Variables compliance check

x denotes full compliance, (x) denotes minor / unciritcal non-compliance (e.g. deviation in variable name or deviation in voluntary diagnostics)

Variables contained in the ATSR-2 / AATSR files of the three algorithms ADV, ORAC, SU (levels 2 and 3)						
Variable / **product**	**ADV L2**	**ADV L3**	**ORAC L2**	**ORAC L3**	**SU L2**	**SU L3**
For level 3 mean values within the grid box are provided if not specified otherwise; for some products also standard deviations within the grid box are provided						
geolocation, observation angles						
pixel_number	x		x		x	
latitude	x	x	x	x	x	x
longitude	x	x	x	x	x	x
pixel_corner_latitude1-4	x		x	x	x	
pixel_corner_longitude1-4	x		x	(x)	x	
time	x		x	x	x	
satellite_zenith_at_center	x		x	x	x	x
sun_zenith_at_center	x		x	x	x	x
relative_azimuth_at_center	x		x	x	x	x
instrument_view			x	x	x	x
aerosol optical depth and its uncertainties						
For level3 ORAC provides in addition to mean also median, lowerquartile, upperquartile, and interquartile_mean						
AOD550	x	x	x	x	x	x
AOD670	x	x	x	x	x	x
AOD870	x		x	x	x	x
AOD1600	x	x	x	x	x	x
AOD550_uncertainty	x		x	x	x	x
AOD670_uncertainty	x				x	x
AOD870_uncertainty			x	x	x	x
AOD1600_uncertainty	x				x	x
aerosol type information						
ANG550_670	x	(x)		x	~~x~~	
ANG550_870			x		x	x
FM_AOD550	x	x	x	x	x	x
FM_AOD_fraction						
D_AOD550			x	x	x	x
AAOD550			x	x	x	x
weak_absorbing_fraction					x	
dust_fraction					x	
aerosol_type			x	x		
REFF			x			
REFF_uncertainty			x	x		
quality information and diagnostics						
AOD_quality_index, quality_flag	x	x	x			
iterations			x			
iterations_mean				x		
fit_error			x			
fit_error_mean				x		
surface information and its uncertainties						
surface_type_number			x	x	x	x
surface_reflectance550	x	(x)	x	x	x	x
surface_reflectance 670			x	x	x	x
surface_reflectance 870			x	x	x	x
surface_reflectance 1600			x	x	x	x
surface_reflectance550_uncertainty			x	x		
surface_reflectance670_uncertainty			x	x		
surface_reflectance870_uncertainty			x	x		
surface_reflectance1600_uncertainty			x	x		
other geophysical conditions						
cloud_fraction	x		x	x	x	x
fraction_of_water	x	x				
pixel_count		x		x		x
aerosol_type_count				x		
interquartile_count				x		

Variables contained in the GOMOS stratospheric aerosol files (levels 3)	
Variable product	**AERGOM L3**
geolocation, observation angles	
latitude	x
longitude	x
altitude	x
aerosol variables and their uncertainties	
AEXT550	x
AEXT550_uncertainty	x
ANG400-800-AEX	x
ANG400-800-AEX_uncertainty	x
S_AOD550	x
S_AOD550_uncertainty	x
ANG400-800-AOD	x
ANG400-800-AOD_uncertainty	x
other diagnostics	
AEXT550_Ndata	x
S_AOD550_Ndata	x
Tropopayse_height	x
PSC_occ	x

Variables contained in the IASI mineral dust AOD files (levels 2/3)				
Variable product	**IMARS**	**MAPIR**	**LMD**	**ULB**
geolocation, observation angles				
latitude	x	x	x	x
longitude	x	x	x	x
time	x	x	x	x
Satellite_zenith_at_center	x	x	(x)	x
aerosol variables and their uncertainties				
D_AOD1100	x	x	x	x
D_AOD1000	x	x	x	x
D_AOD550	x	x	x	x
D_AOD1100_uncertainty	x	x	x	
D_AOD_10000_uncertainty		x		x
D_ALT		x	(x)	
D_REFF		x		
Diagnostic flags				
dust_flag		x	x	x
surface_type_number		x		(x)
pre_quality_flag	x	x	x	x
post_quality_fag	x	x	x	x
Cloud_flag	x		x	x
Various dust composition parameters	x			

Variables compliance check

Variables contained in the POLDER / GRASP files (levels 2 and 3)		
Variable product	**GRASP L2**	**GRASP L3**
For level 3 mean values within the grid box are provided if not specified otherwise		
geolocation, observation angles		
pixel_number	x	x
latitude	x	x
longitude	x	x
pixel_corner_latitude1-4	x	x
pixel_corner_longitude1-4	x	x
time	x	x
aerosol optical depth and its uncertainties		
AOD550	x	x
AOD670	x	x
AOD865	x	x
AOD443, 490, 565, 1020	x	x
AOD550_uncertainty	x	x
AOD_uncertainty		
aerosol type information		
ANG670_865	x	x
AAOD443, 490, 565, 670, 865, 1020	x	x
SSA443, 490, 565, 670, 865, 1020	x	x
CMAOD443, 490, 565, 670, 865, 1020	x	x
FMAOD443, 490, 565, 670, 865, 1020	x	x
quality information and diagnostics		
residual	x	x
SphereFraction	x	x
surface information and its uncertainties		
Surface_albedo443, 490, 565, 670, 865, 1020 (DHR)	x	x
NDVI670_865	x	x
BPDF	x	x
BRDF1_443, 490, 565, 670, 865, 1020	x	x
BRDF2_443, 490, 565, 670, 865, 1020	x	x
BRDF3_443, 490, 565, 670, 865, 1020	x	x
other geophysical conditions		
Ocean_land (percentage of land)	x	x

In summary it can be stated that all mature data products delivered by Aerosol_cci2 (latest versions by 31.03.2017) have been checked for compliance against the PSD with best effort and no critical deviations were found. No integrated aerosol type climatology has been produced with the few validated aerosol property datasets available; but those separate datasets provide useful information in this regards.

End of the document